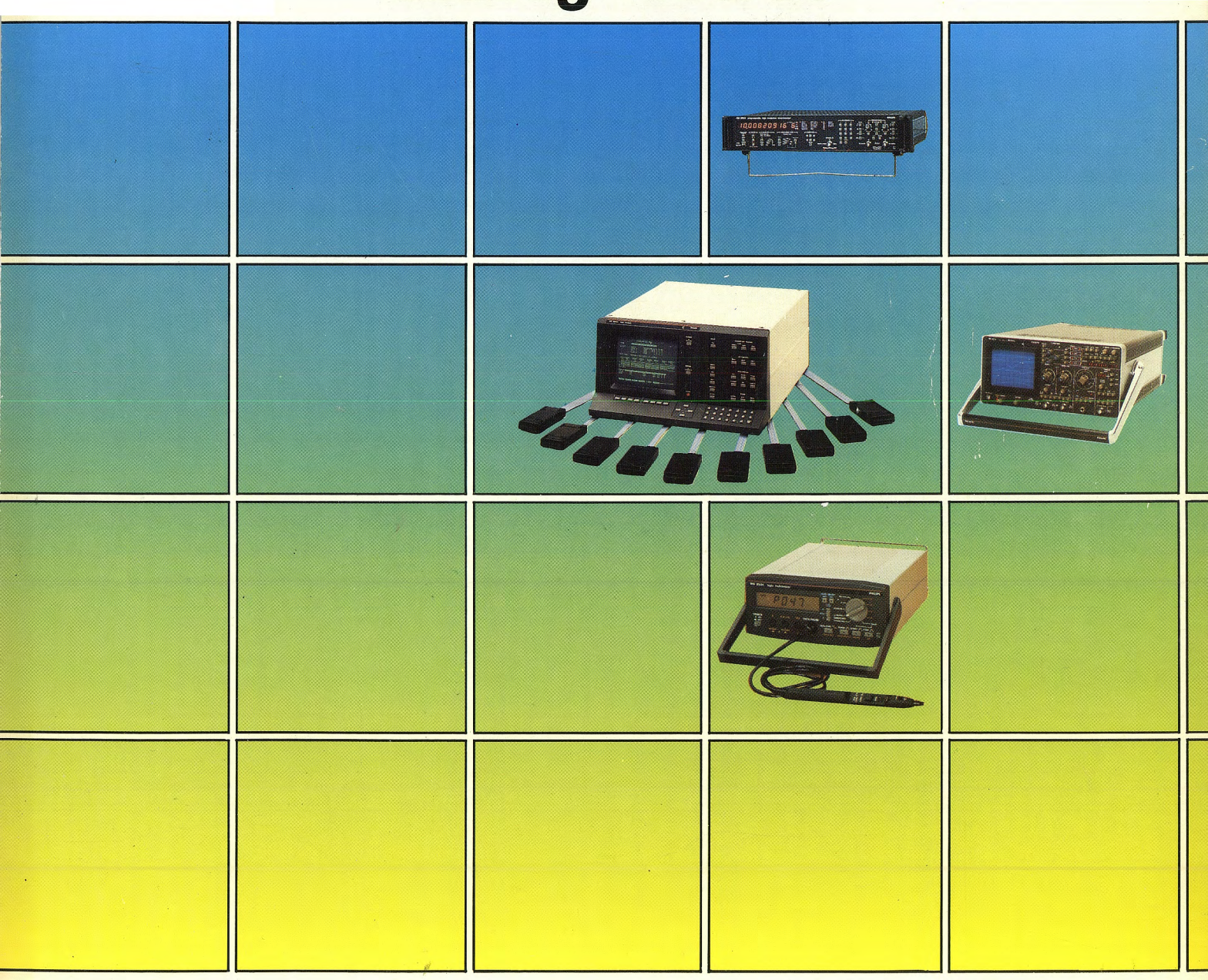
test and measurement catalog 1985/86



Test & Measurement

PHILIPS

test and measurement catalog 1985/86

This publication describes the 1985/86 programme of Philips Test and Measurement. Many new products are included. These are introduced briefly in the GENERAL INFORMATION section, page 7 and described fully within the classified product sections.

Information appears on after-sales and support services; also on the availability of further technical information on the products contained in this catalog. Enquiry cards will be found inside the back cover.

In addition to the normal contents list there is a products part number list at the back of this catalog to speed product identification from part number information.

A number of products have been supplied under NATO-stock numbers. Information is available on request.

Philips Test & Measurement Dept. reserve the right to modify and improve instrument performance specifications without notice.

Test & Measurement

PHILIPS

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Philips Test and Measurement Department

Since its inception during the 1950's within Philips Scientific and Industrial Equipment Division, the Test & Measurement Department ('T&M') has established itself as a reputable and determined contender in the test instrumentation market. In the intervening period, T&M has captured a considerable slice of that market, achieving in the process, the position as one of the leading suppliers of test and measurement instrumentation in the world.

Many strengths to meet a wide demand
T&M's individual strengths are many and varied and every T&M instrument represents a package of those strengths. These include advanced Research and Development facilities well-informed Product Design teams, quality-conscious manufacturing capabilities and dependable after-sales and support. All of which are channelled into a firm marketing policy designed to meet the widest possible demand for test and measurement applications.

Ever-available Research and Development
Research and Development is the backbone of modern electronics equipment design. A fundamental T&M strength is the availability of the vast resources of the famous Philips Research and Development Laboratories, the largest privately-funded R&D laboratories in Europe. Both pure and product-oriented research facilities are concentrated in several European centres. New materials, technologies and components such as in-house developed LSI circuits are made continously available. This formidable back-up, second to none in Europe, is a basic T&M strength, the backbone of every product.

Hardware and Software Development is a team effort
Close and continuous cooperation between Marketing, Research and Development and Field Service is a cornerstone of development. The use of thoroughly tested components, selected from a preferred suppliers' list, is mandatory. All new hardware must pass rigorous environmental tests: nothing is left to chance. Moreover, as one of the world's largest electronic equipment manufacturers, Philips is frequently forced to solve its own, internal, measurement problems. Continuous feedback of relevant information from these internal sources, plus accumulated Field

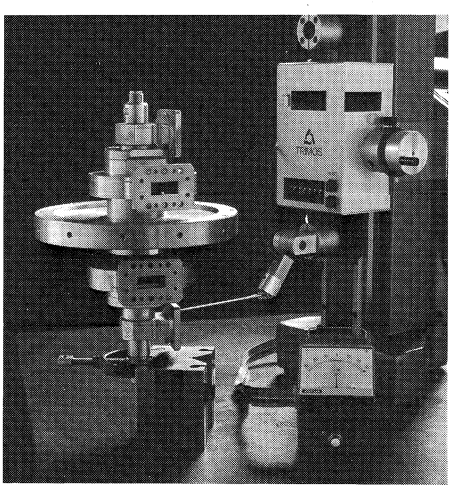
Ideal for use in low light levels the PM2518X with its electroluminescent display being used for routine checks on the flight deck of the European Airbus.

Service data are processed and analyzed. In this way, new ideas are converted into practical, easy-to-use, reliable products; an approach which applies equally to hardware and software. Also, even allowing for the wide diversification of products, the 15%-of-turnover investment in product development alone must be the envy of all T&M's competitors.

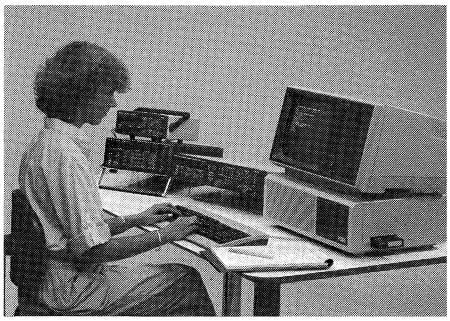
From innovation to quality manufacture
Production Centres manufacturing the various T&M products are located in several European countries. Each Centre concentrates on just one, or a few, only, product ranges, resulting in a high level of specialization. The most advanced forms of very strict quality control procedures feature prominently and all product designs are subjected to particularly stringent environmental testing. Only the highest quality components, materials and designs can survive these 'torture chamber' methods.

Worldwide Sales, Distribution and Field Service Centres
T&M's many products can be seen, demonstrated and purchased almost anywhere in the world. Direct T&M representation is undertaken by local Philips Organizations in most countries of the world. Each of these organizations is structured to **advise, inform, supply** and **support**. Demonstrations and exhibitions are a normal feature, backed by advice and information provided by both resident and visiting experts. And, very important, every Philips Organization can provide long-term preventitive maintenance and inspection contracts to keep equipment at the peak of its efficiency at all times. T&M's pre- and after-sales presence is strong, all over the world.

Informing the world market
As a multi-product, multi-national organization, T&M has to communicate information about its products and services to potential customers, worldwide. This is achieved by direct mail, press conferences and published articles, press advertising with supporting technical literature and regular bulletins. 'T&M News' is a popular bi-monthly bulletin dealing with new products and



A multi-channel, gas-tight microwave rotary joint undergoing precision dimensional checks during final stages of manufacture.



Preparing the required program for a fully automated test and measuring system using IEC/IEEE bus-compatible instruments.

applications, whilst 'T&M Report' concentrates on purely technological aspects. The total range of T&M's products is described in detail in the annual T&M Catalog. Most technical publications are made available in several languages. These activities are supported by both International and local exhibitions, including mobile demonstration units.

Keeping staff and customers abreast of technology

The T&M Training Centre in Eindhoven is perpetually busy. With the rapid advance of modern technology and the introduction of new concepts into equipment designs, or new and modified software programs, staff and customer training is essential. Field Sales and Service personnel and T&M's staff involved in direct customer liaison activities undergo regular refresher courses. For users of more sophisticated instruments, product familiarization training is given. When necessary these courses are provided on customers' own premises.

Every T&M product is a professional package–plus

It will now have become obvious that to purchase a T&M-produced instrument is to buy more than just a 'black box' with or without its associated software. It is to buy a professional package which has been carefully designed and painstakingly manufactured, fully documented and securely packed against the hazards of transportation, along with the **plus** of omnipresent, on-going, technical backup services. This being the last, but by no means, least, of T&M's many strengths, all combined together to provide a range of quality instruments giving an impeccable performance over a full operational lifetime. Which fullfils the basic T&M objective; that of supplying not just another instrument but a professional package-**plus!**

T&M can solve most measuring problems from its very wide range of products

The scope of T&M's overall applications capability in the test and measurement instrumentation field will be appreciated from the wide range of equipment described in this catalog. It is important to note that, due to the T&M design team fully supporting the international IEEE/IEC-bus standards for automatic testing systems, most items are designed to accept the recommended bus interfaces. Frequently, these are fitted as standard. The total product range covered is as follows:

A typical training session in progress.

Development and Test Systems

Data Test Equipment (including Logic Analyzers)

Microcomputer Development Systems

General Purpose Products

Oscilloscopes

Signal Generators and Audio/Video Test Equipment

Counters and Timer/Counters

Pulse Generators

Voltmeters and Multimeters

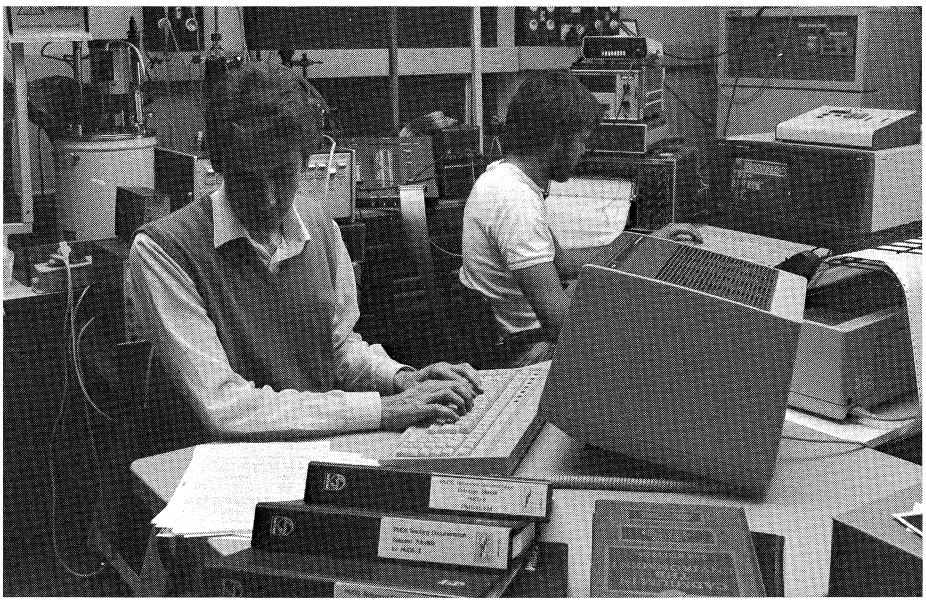
Recorders

Special Purpose Products

Power Supplies

Professional TV Test Equipment

Microwave Equipment



Debugging a microprocessor, specially designed for the operation of a process control system.

Philips Scientific & Industrial Equipment Division, Test & Measurement Department, Building TQ111-4, 5600 MD Eindhoven, The Netherlands.

Summary of other Philips T&M publications

Additional information
Full technical specifications and any other information that may be required will be gladly sent on request by the local Philips organization in your country. The addresses are included at the back of this catalog.
In countries where Philips is not represented, enquiries sent to N.V. Philips, Test and Measurement Department, Bldg. TQIII-4, MD5600, Eindhoven, Netherlands, will receive our prompt attention. In addition to this catalog, Philips T&M Dept. also provide the following publications in the field of electronic measuring and microwave instruments.

'T&M News'
Published four times a year, this 8-page news sheet features the latest information on new instruments and applications to keep readers up-to-date with the T&M programme. This is also available in a French language version, 'Philips Mesure'.

'T&M Report'
Covers one instrument in depth, dealing with both performance features and how it can be used to the best advantage. Issued at random intervals.

Technical data sheets and brochures
Comprehensive technical details on individual products are given in our range of data sheets and brochures. A few of these, only, are illustrated.

'Philips Instrumentation Systems Reference Manual'
Intended as a general guide to the problems of building up automatic testing systems from individual 'black boxes'. The functional approach to bus interfacing is presented in an uncomplicated manner.

A 'must' for the beginner and a useful reference work for the initiated. Obtainable on application to your local Philips Organization or direct from Test & Measurement Dept., Eindhoven.

Specialized product group publications
These cover such product areas as professional TV equipment, Microwave equipment, Process control equipment and Mechanical measuring apparatus. Publications include:

'Professional TV measuring equipment'

'Process control instrumentation'

'Instruments and components for microwaves'
'Microwaves, basic experiments' (4 booklets)
'Education in applied microwaves'

'Electrical measurement of mechanical quantities'

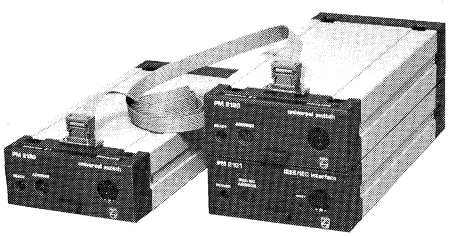
New products 1985

New items appearing in this issue are briefly reviewed in this section.

For more comprehensive data, turn to the page number, shown against each item.

INSTRUMENTATION SYSTEMS

Auxillary instrumentation device System PM 21

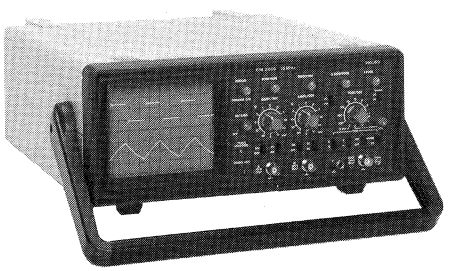


- **For small and medium sized automated setups**
- **Flexible and versatile**
- **Handles all switching of analog and in- and output of digital signals**
- **Master unit handles IEEE/IEC-bus connection and power supplies**
- **Use of μP plus memories in all units simplifies software requirements**
- **Excellent price/performance characteristics**

Designed to provide the various essential auxillary requirements for automatic testing setups. An extremely flexible system of individual modules which, once selected, can be clipped together into a functional, tidy, bench or rackmounted unit. Basic function is the switching of analog signals and/or the in- and output of digital signals. A 'master' unit connects to the IEEE-bus and handles the power supply for the selected system. A number of functional units can be connected to the master. Software for driving the systems is essentially simple due to the use of a microprocessor as well as individual memories in all units. Ideal for small-to-medium sized setups. **INSTRUMENTATION SYSTEMS p. 4.**

OSCILLOSCOPES

15MHz dual-trace general-purpose oscilloscope PM 3206

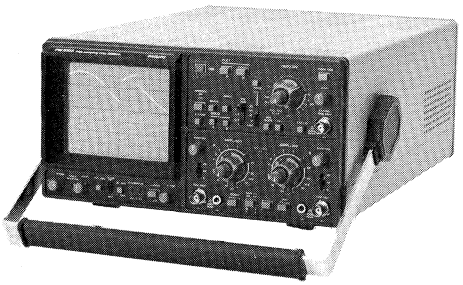


- **Professional 'scope for amateur price**
- **15MHz/5mV**
- **Full 80 sq. cm of useful screen**
- **Automatic, TV and external triggering**
- **Trigger channel selection**
- **External Z-modulation**
- **Compact, lightweight, sturdy**
- **Meets CSA/VDE safety standards**

PM 3206 exhibits a range of features normally associated with higher priced, 'professional' instruments. It provides a full 80 square centimeters of useful screen space, which, combined with a small, high-intensity spot, produces clear, well-defined oscillograms. The 5mV sensitivity is available across the full 15MHz bandwidth and is the same for both X and Y channels. Automatic triggering ensures a locked, stable trace and TV triggering is standard. Triggering is also possible from either channel A or B, or externally, by means of a front-panel switch. External Z-modulation is another inbuilt feature, as is the facility to vary the time base speed. Contained in a rugged, shock-resistant case and using moisture-resistant epoxy pcbs, it has a wide operating temperature range. Price-performance characteristics are excellent. **OSCILLOSCOPES p. 28**

OSCILLOSCOPES

20MHz Digital storage oscilloscope PM 3302

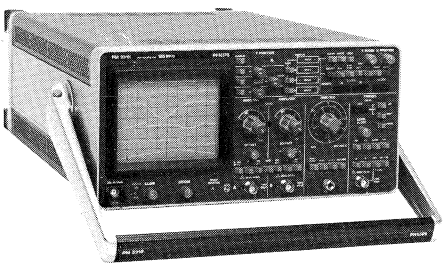


- **Max. sampling frequency 20MHz**
- **Max resolution 50ns**
- **2K memory**
- **2K back-up memory**
- **50s/div. roll mode**
- **1mV/div. inputs**

Combines the advantage of digital storage facilities plus the direct display facilities of a conventional 20MHz 'scope. Price/performance characteristics are exceptional and very attractive to the educational sector, with a high level of interest for mechanical measurement applications. (transducer outputs can be directly applied to the 1mV/div. input.) The high, 20MHz, sampling frequency stores signals with a high resolution and allows up to 5ns separation between samples. The 2Kx8-bit memory has a back-up memory; also 2Kx8-bit; signals from one channel can be stored whilst using the other channel for live displays. Semiconductor curves can be displayed as well as filter curves, lissajous figures and other non-time-related phenomena may be screened and stored. Curves can be hard-copied via a X-Y recorder. LF signals viewed in the roll mode can be frozen for detailed examination. **OSCILLOSCOPES p. 37**

OSCILLOSCOPES

60MHz digital storage oscilloscope PM 3315



- **Max. sampling rate 125MHz**
- **60MHz/10mV**
- **4 memories each 256 x 256**
- **Digital delay −9...+9999 div.**
- **Roll mode up to 60min/div.**
- **Display of stored signal parameters viewable simultaneously with stored signal**
- **Plot-output**
- **Fully IEC/IEEE-bus compatible**

PM 3315 complements the PM3310/11 series of digital storage 'scopes. Use of P²CCD technology allows storage of A/D-converted signal in the semiconductor memory. Permanent storage is possible as well as the opportunity to change certain display parameters **after** a signal has been captured. Different signals can be placed in one of four memories and displayed simultaneously. Since both channels can be stored, up to 8 traces can be displayed. Single-shot phenomenae up to 12.5MHz and non-sine wave signals up to 30MHz can be displayed. Full IEEE/IEC bus facilities are available. Two-way communication with the bus controller allows analysis of signals using the horizontal and vertical parameters as a reference. Extended bus facilities also allow trigger mode, trigger source and trigger level to be remotely programmed. **OSCILLOSCOPES p. 30.**

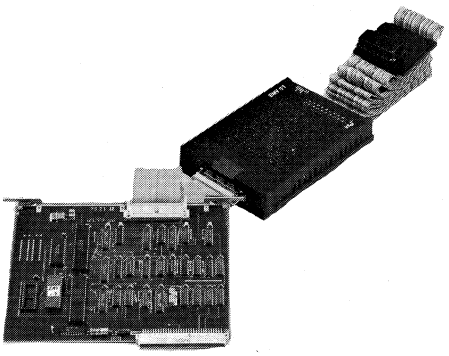
DATA TEST EQUIPMENT

Logic analyzer PM 3632

- **Up to 32 channels**
- **Up to 100MHz**
- **Disassembly**
- **Selective data acquisition**
- **Glitch catching**
- **ROM emulation**
- **Auto sequencing**
- **RS232C interface**
- **Easy to use**

Designed to meet high-tech applications on a limited budget PM 3632 has acquisition speeds up to 100MHz and data widths up to 32 channels. It allows a full range of problems, in the state/time domain to be examined and solved – in the laboratory, in the field or in the classroom. Its menu-driven operation and cursor prompting both shortens the learning curve and eases operation. The wide selection of pods and disassemblers allows its use with virtually any of the popular microprocessors whilst the powerful ROM emulator option extends this possibility. The addition of plug-in setup and data memory options makes for increased operator efficiency. The added feature of low cost makes this a universally attractive instrument. **DATA TEST EQUIPMENT p. 12**

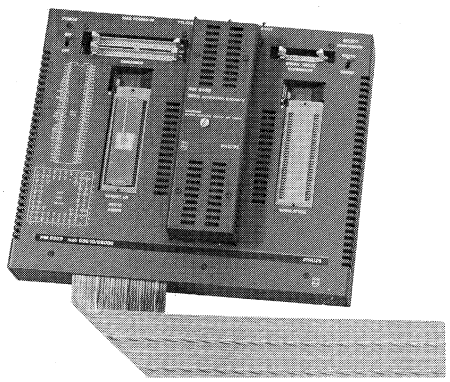
PMDS-2 support for 68000/68101



- **World record emulation speed: 16MHz**
- **Emulates realtime, transparent in prototype or emulation memory**

The complete support system for the 68000/68010 microprocessors consists of:
PM 8469M Cross assembler for 68000/68010
PM 8479M Pascal for 68000/68010
PM 8379M C for 68000/68010
PM 8388M Debug Processor for PM 8328M
PM 8328M Microcomputer
Adaptor Box (MAB) for 68000 (including PM 8388M)
PM 8389M Debug Processor for PM 8329M
PM 8329M Microcomputer
Adaptor Box (MAB) for 68000/68010 (including PM 8389M)
PM 8448 32Kb fast emulation memory for PM 8328/8329M

PMDS-2 support for 8051 family



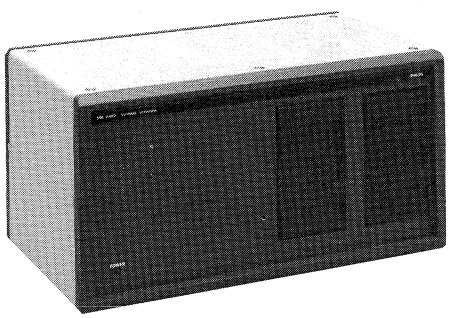
- **Transparent emulation**
- **12MHz emulation speed**
- **Uses standard Intel mnemonics**

The complete support system for the 8051 microcomputer family consist of:

PM 8362M Cross-assembler for 8051 family
PM 8385M Software for 8051 NMOS emulator
PM 8325M Emulator controller board (includes PM 8385M)
PM 8445 Emulator for 8051

The 8051 microcomputer family consists of 8051, 8031 and 8751.

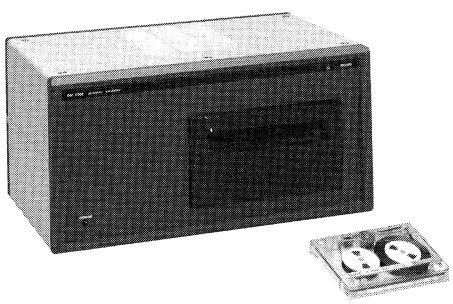
Hard disk extension units PM 4494/4495



- **Extends user disk space up to 156Mbyte**
- **Provides fast backup medium**
- **Speeds up to processing**

These two disk extension units will increase on-line storage by 22.3Mbyte (PM 4494) or 44.6Mbyte (PM 4495). The unit capacities can be used for direct copying from other disks, as backup, or to extend a Unix file system. Up to 3 units can be connected.
PMDS p.28

Streamer tape unit PM 4496M



- **Copies hard disk at 5Mbyte/min**
- **Low cost medium**
- **Easy to use**

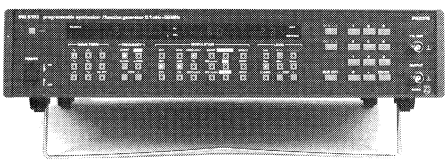
Using 20Mbyte cartridges PM 4483M, the PM 4496M Streamer Tape Backup Unit copies a hard disk's contents in about 1 minute (for the 5Mbyte) to 5 minutes (for 22Mbyte), a time so neglible that it pays off to make a backup daily. In this way, recovery not only from system breakdown, but also from user mistakes (e.g. removing an important file) is covered. **PMDS p. 28**

Hand-held precision digital multimeter PM 2518X

- **0.1% accuracy with 4 digits**
- **True RMS readings**
- **"Backlite" version for low lighting levels**
- **μP control for fast response**
- **Fast diode measurements directly in mV**
- **Direct readout in dBm for gain measurements**
- **Relative reference measurements**
- **Optional accessories extend performance**
- **Fully overload and short-circuit proof**

Designed for high-resolution measurements in workshop and difficult field environments, this compact hand-held multimeter is available in two versions. These are a high-contrast LCD version and a "Backlite" model with a luminescent green background for enhancing the LED display in dark areas. It is high-resolution, high-accuracy meter for its size and will read down to an accuracy of 0.001V. True-RMS, AC measurements can be made, even with non-sinusoidal waveforms. With a typical error of less than 1dB at 50kHZ, it will handle switched mode power supply measurements without problems. HF probes will extend the working range to 1GHz. The resistance capability of 100MOhm to 100mOhm is complemented by a diode and continuity measurement facility. Amplifier gain measurements can also be read directly in dBm, with a resolution of 0.1dB. Designed to exceed the UL, IEC and VDE safety requirements. **MULTIMETERS & VOLTMETERS p. 8**

Programmable synthesizer/function generator PM 5193



- **Nominal frequency range 0.1mH...50MHz over 11½ decades**
- **Precise μP control of parameters and functions**
- **Sine, havesine, triangle, square, pos/neg sawtooth, pos/neg pulse outputs**
- **Int/ext modulation for AM, FM, GATE, plus SWEEP (line/log), and programmable BURST**
- **3 LED displays plus key LEDs for immediate, unambiguous parameter, frequency and mode indication**
- **Up to 9 pre-set functions can be stored in non-volatile registers for immediate call-up**
- **Fully independent AC and DC settings**
- **TTL output**
- **Advanced IEEE/IEC facilities**

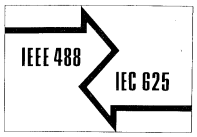
μP control makes all functions programmable, considerably easing the task of setting up. Moreover, up to 9 individual programmes can be stored in non-volatile registers for immediate call-up as required. Setting up is by means of key banks logically grouped as either menu selectors or numeric inputs. All settings are clearly displayed on 3 LED displays and individual LEDs in each key give an immediate indication of currently selected settings. AC output values can be selected either in V_{pp}, V_{RMS} or dBm as required. All parameter settings can also be made via the IEEE/IEC-bus. The IEEE/IEC address can be programmed via the numerical keyboard and displayed on the 3-digit LED panel. The synthesizer also operates as a pulse generator with unipolar pulses, having a nise/fall time from 3μs and a fixed duty cycle of 50%. TTL applications are also catered for and the TTL output is adjustable between 0 and 5V. The multi-waveform output and modulation possibilities are shown above. **LF & HF GENERATORS p. 22**

In addition to the new products described there are some additions to the range of PROFESSIONAL TELEVISION TEST EQUIPMENT which are itemised in the PTV Catalog which is available on request.

Also, there have been changes and additions to the wide range of Euro-switching POWER SUPPLIES which will be found at the end of this catalog.

Instrumentation systems

System applications	2
Auxilary instrumentation devices, System PM 21	5
IEC/IEEE bus-compatible T&M instruments list	8



Instrumentation systems

BLACK BOXES INTO SYSTEMS

With the availability of easily programmable compact desk controllers – which can be used as instrumentation controllers – there is a growing tendency to group individual 'black boxes' into automatic systems, for numerous applications.

Whilst this catalog provides information on a series of 'black boxes' many of them can become useful elements of such systems. These particular instruments are identifiable by the symbol above.

International standardized interfaces such as IEEE/IEC offer the users full freedom in their choice of controller and instruments and thus the opportunity to select optimum combinations.

Philips' support to system users is in making available a wide range of instruments with either built-in or optional systems interfaces. All these instruments may be described as "controller-friendly", i.e., suitable for use with all types of instrumentation controllers. Program examples for the more popular controllers are supplied in the instrument manuals.

However, even with standard hardware interfaces, building a system involves more than simply connecting instruments together with cables! Other system aspects need to be considered, some of which are: – software (programming examples) – interface protocols – grounding aspects – system building and fault diagnosis, etc., etc.

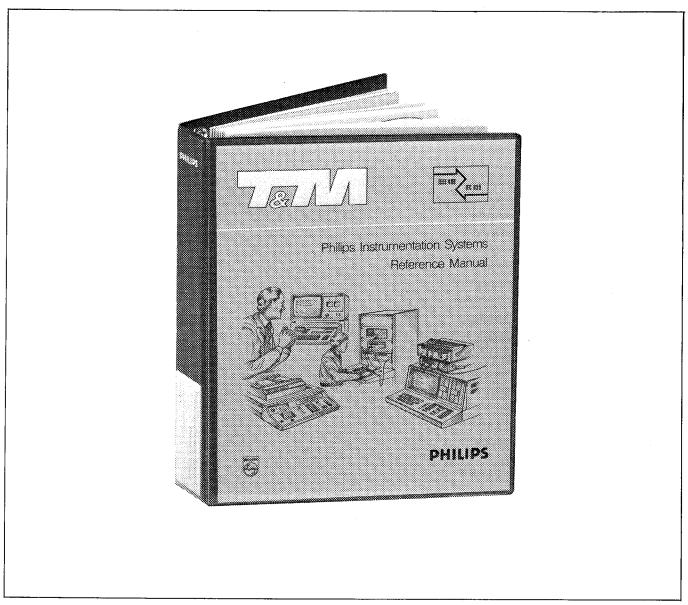
Instrumentation systems manual

To assist users of Philips Test & Measuring equipment with building systems, a specific, instrumentation systems manual is available for reference and general guidance.
This may be purchased from the appropriate Philips Organization in your country (see address list at the end of this catalog). The manual treats the subject of building automatic test systems in some depth.

The IEEE/IEC bus

There are different ways to connect measuring instruments in a system, but the most popular is IEEE or IEC bus interface. The reasons behind this popularity are its typical features that are well-suited to flexible measuring set-ups, such as;
- suitable for simple as well as complex systems
- easy to change or extend
- good speed performance
- a wide choice of instruments from several different manufacturers so that the user always select a combination of instruments that is the optimum for his application.

There is also a wide range of controllers that can drive such a system.



A controller is not always needed. When, say, only two instruments (e.g., a voltmeter and a printer, for data acquisition) are interconnected, the "system" can function without a controller.

In larger systems, the controller (and the program) will drive the system, replacing, in fact, the human function in a manually operated system. Depending on the complexity of the measurement the controller will perform a number of the following operations.
- setting of the signal sources for the correct output signal
- setting the measuring instruments for the parameters to be measured.
- starting the instruments in the right sequence
- outputting the measuring data

Since the controller is in general a mini- or microcomputer, data handling, such as averaging, comparing with limits and conversion of data is also possible.

Moreover, the measuring sequence can be made dependent on the finding of preceeding measurements and data can be stored to be used for later statistical operations, just to mention a few examples.

The output of the measuring results can be displayed on the screen of the controller or on a printer or plotter, when connected to the system.

Software
The complexity of a software program that controls a measurement is of course, dependent on the complexity of the measuring system and the measurements to be made. The basic rules are, nevertheless, simple.

Each instrument has a device address (set with switches on the instrument) and the controller uses this address to send coded instructions to that instrument.

These instructions contain the settings of the instrument and are specified for each individual instrument in its manual and for Philips instruments also on separate programming cards contained in a specially designed folder.

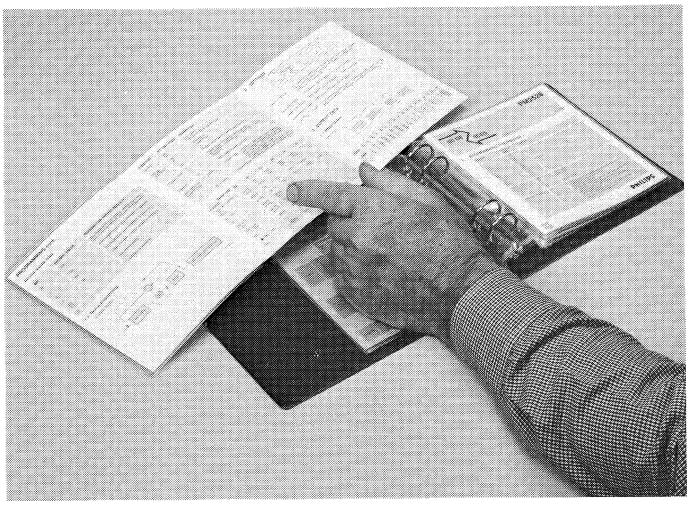
Applications

The ability to interconnect 15 instruments via IEEE488/IEC625 interface makes the bus suitable for most applications in instrumentation systems. Limitations are the maximum cable length (in total) of 20 meters that precludes the connection of instruments over long distances and the maximum operating speed which affects the suitability of the interface for really high-volume testing.

However, for most applications in research laboratories re quiring quality testing or sample testing the interface is an optimum choice, as it also is for low and medium quality production testing.

Due to the wide choice of instruments offered, the parameters that can be measured are the same as in hand-operated test set-ups. But thanks to the fact that far more data can be handled, more detailed and more accurate data can be obtained by combining results from several individual measurements.

Copying an oscilloscope screen display on a plotter via IEEE488/IEC625 interface in Talker-only/Listener-only mode. (No need for controller.)



Card pack: programming instructions for all instruments are ring-bound into an attractive, specially-designed binder.

T & M instruments with bus facilities/options
These are listed on pages 8 to 14 along with relevant interface information, etc. Details of the bus facilities for individual instruments appear in their specifications.

Accessories for IEC/IEEE bus systems

Cables
IEC-625 PM 9480/00 (1m); PM 9481/00 (2m); PM 9482/00 (4m).
IEEE-488 PM 9487/10 (1m); PM 9487/20 (2m); PM 9487/40 (4m).

Adapters (IEC to IEEE and vice versa)
PM 9483/50: Adapts an instrument with IEEE-488 socket to IEC-625 cable.
PM 9483/51: Adapts an instrument with IEC-625 socket to IEEE-488 cable.

19-in Rackmount kits
These are identified by letter codes on the list of instruments starting on page 8, as follows:

A	PM 9560
B	PM 9669/01 (1 instrument) or PM 9669/02 (2 instruments)
C	PM 9838/02
D	PM 9867
E	PM 8963/01
G	PM 8960
H	PM 9669/03
S	included in delivery

Ventilation units
Either natural convection (PM 9799) or forced-air cooling units (PM 1373) can be used. Both types measure 1E high x 19-in wide.

IEEE 488 IEC 625

NEW

For small/medium-size instrumentation systems

Applications areas include:

- **Research & development labs**
- **Quality control**
- **Small-series production**
- **Education**

Auxilary instrumentation devices system PM 21

Use of system PM 21

The IEEE 488/IEC 625-bus has proven to be an excellent interface for instrumentation systems. Users have a wide choice of instruments for nearly all measuring functions. However, a problem is met when simple functions, such as switching and In/Output facilities have to be added.

System PM 21 enables the easy connection of these auxiliary functions to the IEEE 488 bus via a single bus address. It offers a really flexible and low priced solution for these problems, especially for applications in laboratories where existing equipment for this purpose is in general not flexible enough.

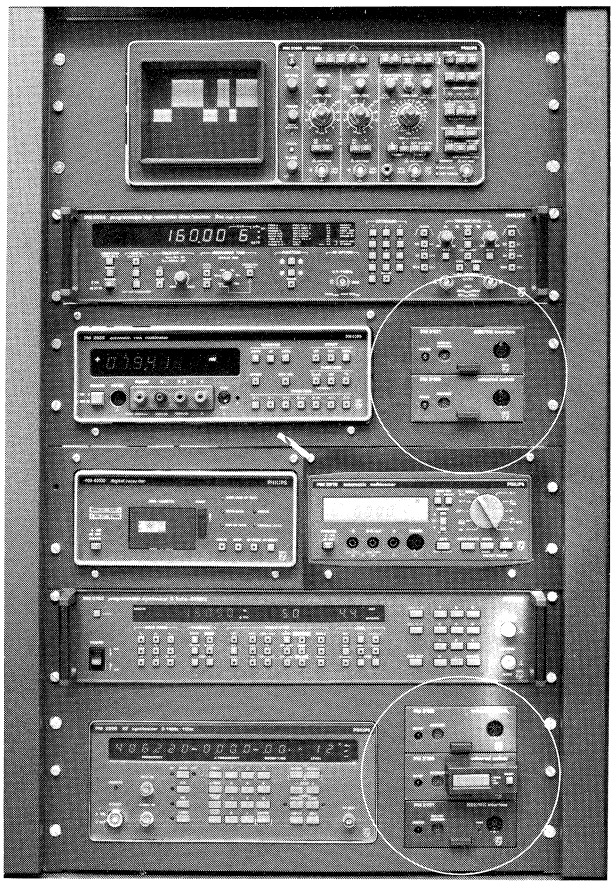
True modular system

System PM 21 is a combination of a master unit and a range of functional units, such as switching and digital in/output. The functional units all have their own control intelligence. The master takes care of IEEE-bus interfacing and power supply of all connected units. The units are interconnected by cables or by a direct electromechanical coupling.

Flexibility in hardware

All units (both master and slaves) have their own housing of an indentical size. Units can be stacked to one block by a lock construction in the feet, operated by a push button on the front. Electrical connection is made automatically with the physical stacking action, by means of connectors on the tops and undersides of each unit. For rack mounting a 3E high rack mount adapter is available with space for 8 units.

When for reasons of available space or the need to have shortest possible connections with a test object, units have to be used at different locations, interconnection cables up to a total length of 150m may be used.



One method of using the PM 21 series of modules is to integrate them into an instrument rack as illustrated here (circled).

Because of this full modular construction, adding or replacing a unit is extremely simple.

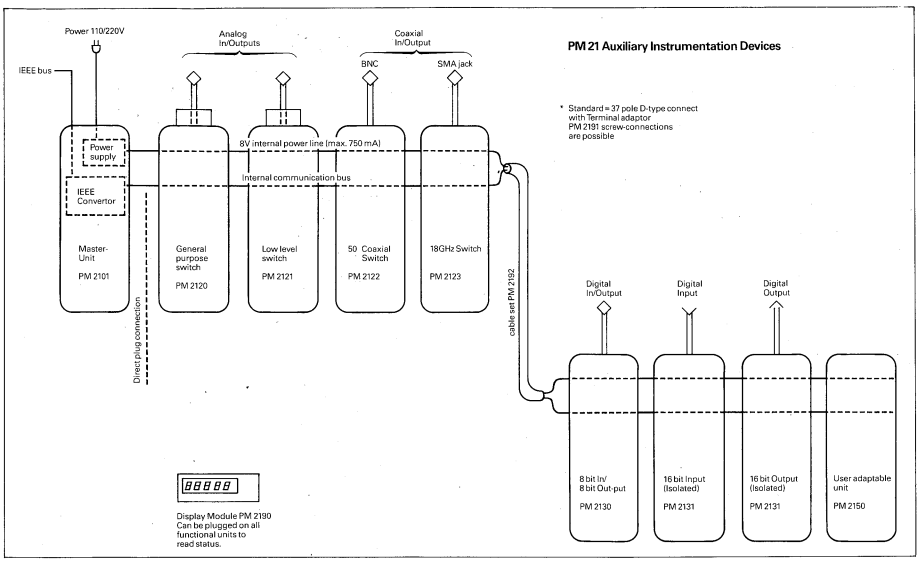
Flexibility in functions

Any combination of a master unit and one or more functional units may be used. The maximum number of units that may be used is only limited by the power capacity of the master unit. This means that a variety of functions can be driven via one single master.

Full timing facilities

System PM 21 offers several modes of operation and timing ranging from individual control of single actions to automatic scanning over several units. The facilities include:

- Programming of individual actions with immediate execution or with execution on a common trigger
- Call-off of pre-programmed individual actions with immediate execu-



Block diagram shows the basic principles of operation of the PM 21 system.

tion or execution on trigger
- Call-off of a pre-programmed sequence of actions in which each step is executed on a trigger
- Automatic scanning over several identical units

A microprocessor in each unit

Master, as well as functional units have their own microprocessor. The master takes care of the IEEE - bus interface handling and a transparent translation of the messages from IEEE - bus to the internal system PM 21 bus and vice versa. The microprocessors in the functional units keep track of programmed operation- and synchronisation modes, check incoming commands for validity and take care of execution or error messages. Moreover, all functional units have a facility to store 20 action commands for later call- off, at choice, in a sequence or at random.

Software

The Command Structure of System PM 21 is such that units do not influence each other except (when required) for synchronization. The subsequent adding of another unit does not influence the existing software. The structure of the command strings is simple and clear.

System PM 21 is addressed via the IEEE bus in the normal way. The messages to the individual units are preceeded by a unit address within the command string consisting of 3 alpha's "AID" plus 3 decimal characters of which the first two are equivalent to the last two decimals of the type number and the last one corresponds to the address switch setting on the front of the unit. In this way any combination of units can be addressed with up to a maximum of 10 units of the same type.

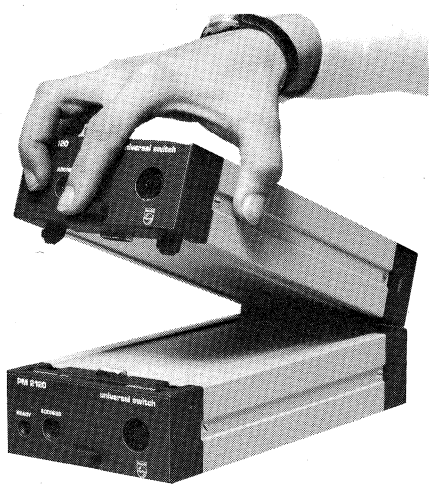
The required modes or actions can be programmed in clear language.

Several actions of several units can be programmed simultaneously (see example)

A display to read setting and status

In general there is no need to read switch or port settings and operating modes in an instrumentation system. But during certain experiments and in the debugging phase a check on these quantities may be required. A display module that can be plugged on the front panels of all functional units provides the solution.

On the display switch setting, input or output port setting or operation and synchronization modes can be chosen.



Units can be stacked without problems, due to a special locking arrangement in the feet.

SOFTWARE EXAMPLE

IEC PRINT # 7, "AID 203; CLOSE 4-6, OPEN 3" + CR$ +
"AID 201; MODE 3, OPEN 5, CLOSE 1" + CR$ +
"AID 310; STATUS?"

Is a command string (as given on a P2000C controller) to System PM 21 with IEEE bus address 7 and messages for:

Unit PM 2120 with address setting 3 to CLOSE contacts 4 to 6 and OPEN contact 3
Unit PM 2120 with address setting 1 to go to MODE 3 and OPEN contact 5 and CLOSE contact 1
Unit PM 2131 with address setting 0 to send STATUS

SURVEY OF AVAILABLE UNITS

MASTER

PM 2101 IEEE bus/ power unit
Handles IEEE bus interfacing and power supply of the PM System.

SLAVES

PM 2120 Universal switch unit
Containing 20 switching elements that can be used in several combinations.

The display module PM 2190 can be plugged into any functional unit to display the operating mode and status of switches and I/O.

PM 2121 Low level switch unit
For use in scanning applications at low signal levels with configurations for 20x1, 10x2 or 5x4 wire scanning.

PM 2122 50Ω coaxial switch unit
For signal distribution or

scanning at frequencies up to 250MHz.
4 inputs to 1 output.

PM 2123 18GHz switch unit
Basically provided with one 18GHz switch but extendable to 3 switches.

PM 2130 Digital I/O unit
Provided with 8 bit input + 8 bit output that can be sensed or controlled individually or in combination.

PM 2131 Digital Input unit
16 bit optical isolated input

PM 2132 Digital Output unit
16 bit optical isolated output

PM 2150 Customer adaptable unit
Provides space and power supply for a circuit build by the user on a standard "Eurocard board".

PM 2198 Additional Power Supply

ACCESSORIES

PM 2190 Display module
Can be plugged on any of the function units and displays the operating mode and status of switches and I/O.

PM 2191 User terminal adaptor
Adapts the standard user interface plug to a connection with screws.

PM 2192 Set of extension cables
To be used when the units cannot be used in a concentrated block.

PM 2193 Rack mount to accept up to 8 units in a 3E-high rack space

TECHNICAL SPECIFICATIONS

SYSTEM PM 21 (All units)

Configuration:
A PM 21 system consists of one master unit PM 2101 and one or more functional units. The maximum number of functional units is dependent on the current consumption of the individual units related to the maximum 750mA supplied by the master.

The units are connected directly or via cables. Maximum cable length is 150m in total with the limitation that synchronisation lines cannot be used for units at a distance of more than 0.5m from the master.

Internal bus:
The internal bus for interconnection of master and functional units consists of a balanced data line for serial data transport and lines for system reset, triggering and ready (command executed) messages.

The connector is a 9-pins D connector. The system's power supply is distributed via the same connectors.

Mechanical data:
All units have dimensions of: 44 x 106 x 228mm (hxwxl) (excluding connectors and feet)
Height of feet = 11mm
Mechanical interconnection of a unit on top of another is achieved by a bolt construction in the front feet of the units.

Environmental data:
Operating temp. 0...55°C
Storage temp. −40...75°C
Humidity 80% (0...55°C) dew point 25°C

PM 2101 IEEE/IEC INTERFACE and POWER SUPPLY (Master unit)

Function:
The unit provides the power supply of the system and the communication between IEEE- and the PM 21 system bus. An additional function is the hardware reset function resetting all connected functional units to power on conditions.

Power supply:
Mains connection:
110, 120, 220 or 240 ± 10% AC 50 or 60Hz
Power consumption: 16VA max.
Safety: Class II acc. to IEC 348
Secondary power for supply to functional units:
8V (at full load) to 10V unloaded
Maximum current load: 750mA

Bus communication:
Communication between IEEE bus and internal system bus is fully transparent. The only signal that can be added by PM 2101 is a general system reset on the internal bus resetting all units connected to power on condition. This signal is given manually via a recessed push-button on the front pannel.

IEEE 488/IEC 625 Interface data
Interface functions:

Description	Function	Capability
Source hand shake	SH1	Complete
Accepter hand shake	AH1	Complete
Talker function	T6	No talk only
Listener function	L4	No listen only
Service Request	SR1	Complete
Remote/Local	RL0	No local control
Device Clear	DC1	Complete
Device Trigger	DT1	Complete

Address setting: 0 up to 9

Accepted input data:
Control data for functional units
General multiline commands; DCL, SPE, SPD, GET, SDC

Output data: functional messages, status and error messages of the units.

Separators: Block and record separators can be software programmed to one or two characters.
At "Power on" record and block separator are "NL"

Service request:
The following reasons for service request can be enabled or disabled under software control:
Illegal header or body, ready line true, new data available, end of block, slave request, trigger seen and all slaves ready.

Connector:
Standard IEEE 488 connector

GENERAL DATA FOR FUNCTIONAL UNITS

All functional units (slave units) have the following specification points in common.

Programming of actions
Actions of the slave units can be programmed just before execution or preprogrammed and stored in a memory for later call-off. Each unit has a memory for storage of 20 actions and possibilities for at-random or sequential call-of.

Execution of actions
Actions can be executed at choice:
- Immediately after programming or call-of of pre-programmed action.
- On an execution start signal following on the programming or call-off instruction.

This execution mode is set per unit under software control.

Ready line
The Systems-bus ready line is pulled "false" by each unit during the time of execution of an action (this time of execution includes, when applicable, a period for stabilization). Return to ready line "true" can be used for generating an SRQ message (see IEEE interface) or to start execution of a succeeding action in another unit (see synchronization). The facility to move the ready line can be en-/disabled for each unit individually under software control.

Synchronization of actions
To allow for several different modes of synchronization, the following execution start signals can be used at choice to start the execution of an action.
- A start command on the data bus (for a single unit) generated by the controller
- A trigger on the trigger line (for more units) generated by the controller (group execute trigger)
- A false to true transition on the ready line generated by a preceeding action of an other unit

This synchronization mode can be set individually per unit under software control.

Block mode
In the block mode 1 up to 20 actions, stored in the memory by preprogramming, can be called-of sequentially by execution start signals. Resetting to the start of a block is executed by a new block mode command.

Scan mode (for switches only)
In the scan mode all inputs of a unit are sequentially activated by successive execution start signals. If more units of the same type number are used, scanning is automatically executed over all units starting at the unit with address setting 0 and continuing with the unit with next higher setting. Resetting to the start of a scan is executed by a new scan mode command.

Reading of Status
The actual status with respect to operating mode, synchronization mode, ready status and settings are returned by the units on a Send Status command.

Error Message
Wrong programming instruction will generate an SRQ message (when masked for) on the IEEE bus. To poll the units connected to the internal System PM 21 bus units can be asked to send an error message.

Addressing of the units
The address of a unit is within the programming string sent to the System PM 21 and consists of the alpha characters AID +3 decimals of which the first two are indentical to the last two of the type number and the last one to the address switch setting on the front pannel of the unit.

Display connection
The optional display module PM 2190 can be plugged on the front pannel socket provided for that purpose on each unit. Details on possible readings are given for each unit.

PM 2120 UNIVERSAL SWITCHING UNIT
Functions:
10 elements of 2 switches with a common output enable the following switching modes:

Mode 0; 20 individual switches for multiplexing or matrix switching
Mode 1; 10 times change-over (make-before-break)
Mode 2; 10 times change-over (break-before-make)
For details on switches see table 1
Connector: 37 pole female D-type
Power Consumption: 25 to 125mA depending on number of switches that are closed.
Optional display module:
When connected PM 2190 displays at choice:
- Switching mode, synchronization mode and ready-status
- Setting of the individual switches

PM 2121 LOW-LEVEL SWITCHING UNIT
Functions:
5 elements of 4 switches + guard at the input and a mode-switching unit at the output enable the following switching modes:

Mode 1; 1 wire (+ guard) scanning of 20 inputs
Mode 2; 2 wire (+ guard) scanning of 10 inputs
Mode 4; 4 wire (+ guard) scanning of 5 inputs

Note: A common guard for four contacts is used in all modes.
For details on switches see table 1
Connector: 37 pole female D-type
Power consumption: typical 25mA (max 50mA)
Optional display module: When connected PM 2190 displays at choice
- Switching mode, Synchronization mode and ready-status
- Selected input channel

PM 2122 COAXIAL SWITCHING UNIT (250MHz)
Functions:
4 switching elements allow scanning of 4 inputs to 1 common output.
Ground cq low is not switched.

For details on switches see also table 1
Characteristic impedance: 50Ω
VSWR: better then 2 at 250MHz
Connectors: 50Ω BNC
Power Consumption: typical 20mA (max 50mA)
Optional display module:
When connected PM 2190 displays at choice
- Synchronization mode and ready-status
- Selected input channel

PM 2123 COAXIAL SWITCHING UNIT (18GHz)
Function:
PM 2123 is delivered with a single switch; 2 additional switches (Type PM 7551) can be mounted. Each switch has 2 inputs and 2 outputs enabling straight-forward or cross connection.

For details on switches see also table 1
Characteristic impedance: 50Ω
VSWR: <1.1 at 1GHz, <1.5 at 18GHz
Connectors: 50Ω SMA jack
Power Consumption: typical 35mA, max. 60mA
Optional display module:
When connected PM 2190 displays at choice
- Synchronization mode and ready-status
- Switch setting

PM 2130 DIGITAL INPUT/OUTPUT UNIT
Function:
8 isolated inputs (that can be used as a latch) +8 isolated outputs

For details on input/outputs see table 2
Connector: 37 pole female D-type
Power consumption: 150mA
Optional display module:
When connected PM 2190 displays at choice
- Synchronization mode and ready-status
- Status of the gates

PM 2131 DIGITAL INPUT UNIT
Function:
16 isolated inputs

For details on inputs see table 2
Connector: 37 pole female D-type
Power consumption: 200mA
Optional display module:
When connected PM 2190 displays at choice
- Synchronization mode and ready-status
- Status of the gates

PM 2132 DIGITAL OUTPUT UNIT
Function:
16 isolated outputs

For details on outputs see table 2
Connector: 37 pole female D-type
Power consumption: 200mA
Optional display module:
When connected PM 2190 displays at choice
- Synchronization mode and ready-status
- Status of the gates

PM 2150 USER ADAPTABLE UNIT
Function:
This unit enables the connection of a user-build function to the IEEE 488/IEC 625 bus. For that purpose fixing facilities and a connector for a standard eurocard are provided in the unit.
Description:
Available on the euro connector are:
Power: 5V DC ±5% with a maximum load of 250mA
Signals: 16 input/output lines that can be used in any configuration of in and outputs
Address: 2 address bits for selection of up to 4 different functions on the card

Power consumption: up to 350mA depending on the current consumption of the user-build card.

ACCESSORIES FOR SYSTEM PM 21

PM 2190 Display module
Module with an 8 character liquid cristal display to show mode and setting of the functional units. The module can be plugged on the front pannel connector of each unit.
Character height 5mm.

PM 2191 Terminal adapter
Adapter to provide functional units with a 37 pole D-type connector with a terminal with screw connections.

PM 2192 Extension cable set
This set of flat cables and connectors enables extension of the internal bus of System PM 21 so that units can be used at different places in a rack.

PM 2193 Rackmount
This rackmount suites for mounting of up to 8 System PM 21 units in 3E high rack space. Blank pannels are supplied for space not occupied by units.

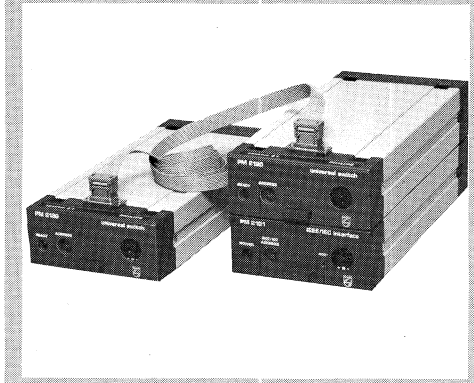
DETAILS ON SWITCH SPECIFICATIONS **Table 1**

	PM 2120	PM 2121	PM 2122	PM 2123
V_{max}	$30V_{RMS}$	24V	$24V_{RMS}$	$30V_{RMS}$
I_{max}	200mA	500mA	500mA	350mA
W_{max}(resistive load)	10VA	12VA	12VA	15VA
Frequency range	DC...100kAz	DC...1MHz	DC...250MHz	DC...18GHz
Crosstalk isolation	>60dB at Ro=500	>90dB (50Hz) >40dB (1MHz)		>60dB (18GHz) >80dB (1GHz)
Series resistance	<0.1Ω	<0.1Ω	<0.1Ω	—
Thermo voltage		<5μV		
Max Common Mode	$30V_{RMS}$	$24V_{RMS}$	$24V_{RMS}$	—
Voltage to other terminals or ground	$42V_{DC}$	$24V_{DC}$	$24V_{DC}$	$42V_{DC}$
Switching time Individual relay	<10ms	<10ms	<10ms	<40ms
Until last relay has settled in any mode	<25ms	<25ms	<25ms	<200ms
Break before make or make before break	>10 and <20ms	—	—	—

DETAILS ON IN-OUTPUT SPECIFICATIONS **Table 2**

	Input	Output
Voltage	5V ± 5% 12V ± 10% 24V ± 20%	(external source) 12V ± 10% to 24V ± 20%
Current per channel	10mA	up to 100mA
Return line	Common per group of 4 in/outputs	
Max. Common Mode Voltage	24V per group of 4 inputs	All loads have to be grounded
Interference Suppression	RC filter (3ms) and Schmitt trigger	
Galvanic isolation	by opto-couplers	

Auxillary instrumentation devices System PM21



Designed to provide the various essential auxillary requirements for automatic testing setups. An extremely a flexible system of individual modules which, once selected, can be clipped together into a functional, tidy, bench or rackmounted unit. Basic function is the switching of analog signals and/or the in- and output of digital signals. A 'master' unit connects to the IEEE-bus and handles the power supply for the selected system. A number of functional units can be connected to the master. Software for driving the systems is essentially simple due to the use of a microprocessor, as well as individual memories, in all units. Ideal for small-to-medium sized setups.

Master: For IEEE interfacing and power supply

Slaves: For analog switching and digital in- and output
Interconnection: By direct coupling or by cables
Control: All slaves can be controlled independently, from the IEEE-bus via the masters busaddress.
Timing/ synchronization: Actions of slave units can be executed directly after programming or on synchronization signals. A ready signal is given at end of execution.
Block-mode: Groups of pre-programmed actions can be started simultaneously
Scan-mode: Full scans of a series of identical inputs can be programmed.

IEEE/IEC (included)
Fully programmable
Status output
Interface functions: SH1, AH1, T6, L4, SR1, RL0, DC1, DT1

Rackmounts: Units mechanically stackable or in 3E-high rack: see PM 21 specification.

Digital storage oscilloscope 4k memory, 4-channel PM 3305

35MHz digital storage oscilloscope. Two front inputs with identical attenuators with a 2-5-10 range from 2mV to 10mV/div. Two extra inputs galvanically separated from instrument ground.

In the compare mode, previously recorded information (up to 4 signals) can be compared with 4 new (live) signals. All visible screen signals can be transferred via an analog X-Y output, IEEE/IEC bus or ADC output.

If spikes that are smaller than the sampling distance have to be recorded a MIN/MAX detector can be switched in. Transients shorter than 10ns can then be recorded, even at the lower sweep speeds.

Tube: 8 x 10cm, internal graticule, 10kV

Vert. defl:
Bandwidth: 0...35MHz (A and B ch.)
0...1MHz (C and D ch.)
Defl. coeff: 2mV/cm...10V/cm (A and B ch.)
10mV/cm and 1mV/cm (C and D ch.)
Input impedance: 1MΩ//20pF (A and B ch.)
10kΩ (floating) (C and D ch.)
Sample frequency: 2MHz max.
Memory: 4K 8 bit memory for display
4K 8 bit memory for pre-trigger

Hor. defl:
Time base: 5s/cm...100ns/cm (magnifier 10x)
Triggering: Y_A; Y_b; Composite; Line; Ext: Ext÷10

IEEE/IEC
Programmable functions:
Digital settings, memory data
Output data: settings, data status
Interface functions: SH1, AH1, T5, L3, SR1, RL2, DC1, DT1

Rackmount F

Digital storage oscilloscope PM 3310

(Clock frequency 50MHz)

Digital storage oscilloscope with high clock frequency (50MHz). The analog signals are taken, digitized and stored. The PM 3310 has 4 memories into each of which 2 channels can be recorded. This allows for the storage of 8 signals which can be transferred via the analog X-Y output.

- Memory contents are retained if line voltage falls
- Slow-moving phenomena can be recorded over 40 hours
- Parameters of the recorded signals can be made visible by a LED display
- IEEE/IEC bus option for remote control and data transfer

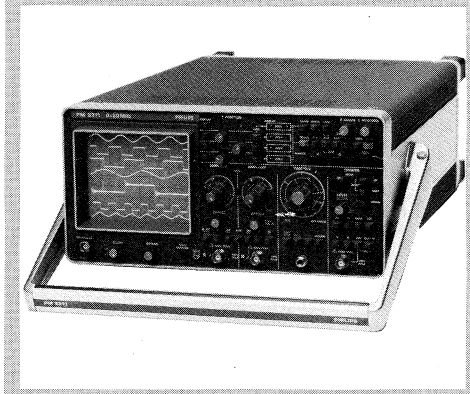
PM 3310
Tube: 8x10cm, internal graticule, 10kV
Vert. defl:
Bandwidth: 0...60MHz (−3dB); rise time ≥6ns
Defl. coeff: 2mV/cm...10V/cm (automatic adaption if 10:1 probe is used)
Input impedance: 1MΩ//25pF
Clock frequency: 50MHz max
Resolution: 256 x 8-bit words
Memory: 4 x 256 bytes
Hor. defl:
Time base: 60min/cm...5ns/cm (x 2.5 magnifier)
Triggering: Y_A; Y_B; Line; Ext; TV
Trigger delay: −9... +9999 cm
Storage:
Single-shot signals: max. 500ns/cm
Repetitive signals: max. 5ns/cm

IEEE/IEC
Programmable functions:
Digital settings, memory data
Output data: settings, data, status
Interface functions: SH1, AH1, T6, L4, SR1, RL2, DC1, DT1

Other:
Analog output, standard

Rackmount G

Digital storage oscilloscopes PM 3311 and PM 3315 (Clock frequency 125MHz)



Digital storage oscilloscopes with high clock frequency (125MHz). The analog signals are taken, digitized and stored. Each unit has 4 memories into each of which 2 channels can be recorded. This allows for the storage of 8 signals which can be transferred via the analog X-Y output.

- Memory contents are retained if line voltage falls
- Slow-moving phenomena can be recorded over 40 hours
- Parameters of the recorded signals can be made visible by a LED display
- IEEE/IEC bus option for remote control and data transfer
- Extended remote control facilities for PM 3315 allows remote control of trigger level, source and mode, in addition to all PM 3211 facilities

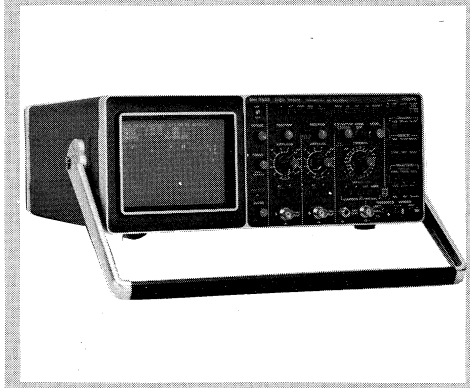
PM 3311	
Tube:	8x10cm, internal graticule, 10kV
Vert. defl:	
Bandwidth:	0...60MHz (−3dB); rise time ⩾6ns
Defl. coeff:	2mV/cm...50V/cm (automatic adaption if 10:1 probe is used)
Input impedance:	1MΩ//25pF
Clock frequency:	125MHz max
Resolution:	256 x 8-bit words
Memory:	4 x 256 bytes
Hor. defl:	
Time base:	60min/cm...5ns/cm (x 2.5 magnifier)
Triggering:	Y_A; Y_B; Line; Ext; TV
Trigger delay:	−9... +9999 cm
Storage:	
Single-shot signals:	max. 200ns/cm
Repetitive signals:	max. 5ns/cm

IEEE/IEC
Programmable functions:
Digital settings, memory data
Output data: settings, data, status
Interface functions: SH1, AH1, T6, L4, SR1, RL2, DC1, DT1

Other:
Analog output, standard

Rackmount G

Logic analyzer PM 3543



Versatile Logic Analyzer for μP-applications. With two external clocks these devices are very suitable for multiplexed systems: e.g. multiplexed microprocessor address- and data information, that appear sequentially in time on the same dataline, can now be represented on one screen (state) line. This means that with a 16-bit μP, e.g. Z8000, 32-bit long words will be captured, while only 16 lines are connected.

- 35MHz, two-channel oscilloscope function
- disassembly of microprocessor instructions (mnemonics)
- interface: serial (RS 232 C) or parallel (IEEE).

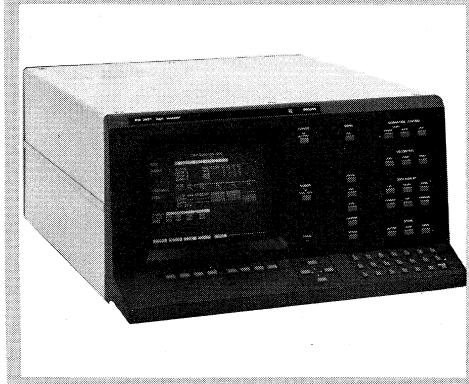
Logic analyzer section	
Data channels:	21/37
Input impedance:	4MΩ//6pF
Threshold:	TTL and variable −3...+9V
Memory:	255 bits/channel
Compare memory:	255 bits/channel
Clock:	external max. 10MHz
2 inputs	
Clock qualifiers:	2 x 3
Set up/hold time:	35ns/0ns
Trigger internal:	word recognizer of 2 words of 21 bits
Trigger external:	TTL input
Trigger delay:	max. 65535 clocks or trigger words
Display:	state list- binary, hexadecimal (optional- μP mnemonics)
Display size:	8 x 10cm

IEEE/IEC
Version PM 3543/80 or option PM 8843/80
Data input and output:
Status output:
Interface functions: SH1, AH1, TL6, L4, SR1, DT1, RL2, DC1

Other
PM 8843/20 or /60
V24/RS232C interface output only

Rackmount F

Logic analyzer PM 3551A



Modular logic analyzer system that can be adapted to an actual test situation by plugging in the relevant modules. Operating modes and settings are selected with the aid of softkeys, programme controlled keys. Up to 75 data inputs and speeds up to 250MHz are available.

- simple operation
- 15MHz state
- 50...300MHz timing
- extensive trigger facilities
- uP disassemblers
- interfaces
- transitional timing

Data channels:	max. 75
Input impedance:	1M//5pF
Threshold:	TTL, ECL, variable −3...+12V
Memory:	1023 words
Compare memory:	1023 words
Clocks:	15/50/300MHz, 3 clock inputs
Clock qualifiers:	3 x 4
Triggering:	word recognition in 8 steps
Display:	state list-bin, hex, oct, dec, ASCII
timing diagram graph display	
Display size:	23 cm
Size:	450 x 237 x 550mm
Weight:	17kg

IEEE/IEC
Option PM 8851/40
All functions programmable:
Data input and output:
Status output:
Interface functions: SH1, AH1, T6, L4, SR1, RL1, DC1

Other
PM 8551/20
V24/RS232C interface

Automatic digital multimeter PM 2519

In addition to a very wide range of conventional measuring capabilities PM 2519 offers comprehensive computation and control facilites, plus DC voltage resolution to 10μ V, true RMS AC voltage resolution of 100μV, with a bandwidth of 20kHz. AC and DC current measurements from 10μA to 20A (short term) are possible, as are resistance checks from 0.1Ω to 10MΩ. The absolute readings are displayed on 11mm, 4½-digit LC display and a log-scaled bar graph allows approximate comparisons. Other facilites include relative reference, frequency, temperature and the facility for expressing DC volts and true RMS volts in dB.

Meas. rate:	2.5 measurements/s
VDC:	1000mV, 10V, 100V, 400V (acc. 0.2% +5d)
VAC:	1000mV, 10V, 100V, 400V (acc. 0.5% + 10d − 40Hz...1kHz 1% + 10d − 1kHz...10kHz)
IDC:	100mA, 10A (rel.reference facility) (acc. 0.5% + 10d)
R:	1000Ω, 10kΩ, 100kΩ, 1MΩ, 10MΩ with switchable audio tone (acc. 0.5% + 10d)
Freq.:	1000Hz, 10kHz, 100kHz
Temp.:	−5°C...+200°
Resolution:	VDC - 100μV; VAC - 100μV; IDC - 10μV; R - 0.1Ω; Freq. - 0.1Hz; Temp. - 0.1°C

IEEE/IEC
PM 2519/51 version
Range programmable:
Data output:
Status output:
Interface functions: SH1, AH1, T5, L3, SR1, RL2, DC1, DT1

System-oriented digital multimeter PM 2528

Auto-ranging- Multimeter with a scale length of + 240000 digits for all standard parameters. Suitable for laboratory purposes, with 2, or 3 different measuring rates and full remote control of all functions across optional interface (IEC/IEEE). An effective guard system ensures precise measuring results.
"Real" rms value (AC or AC + DC coupling) with indication when the crest factor is exceeded, Pt 100- temperature measurement facility between −250°C and +850°C (in accordance with DIN 43760), 2 or 4-wire resistance measurements and "relative reference measurements" are part of the PM 2528 basic package.

3 measuring rates (max. 18 measurements/s
Aut. range features

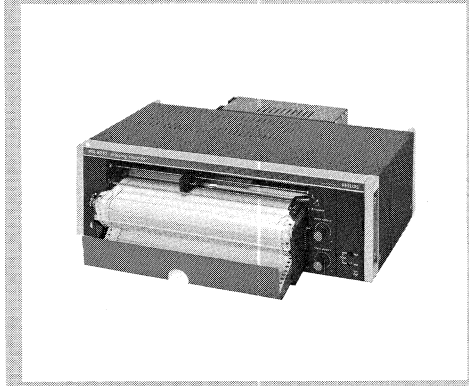
Meas. range:	±240000 digits LED display
V_{DC}:	200mV...1000V
Accuracy:	±(0.01% of reading +0.005% of range
V_{AC}:	200mV...600V (AC, AC+DC coupling)
Crest factor:	4.5/pass limit indication
I_{DC} and I_{AC}:	2μA...2000mA (AC+DC coupling) (Crest factor 2)
R:	200Ω...2GΩ/2 or 4-wire technique
Temperature:	−250°C...+850°C/Pt 100
Resolution:	1μV (DC), 100pA (DC) 1mΩ, 0.1°C

IEEE/IEC
PM 9291
All functions programmable:
Data output:
Status output:
Interface functions: SH1, AH1, T5, L4, SR1, DT1, RL2

Others
PM 9292
Parallel output
PM 9258
Analog output

Rackmount H

PM 8210/11 Printing recorder



In the printing-recorder PM 8210 two basic instruments are built together. The combination of a single channel analog recorder and digital printer allows digital information to be printed simultaneously with the analog plot.

The analog channel operates like a normal x-t recorder with a thermo sensitive writing system. The digital channel operates with a 7 point thermo print head.

Analog:	
Input:	Floating, symmetrical
Sensitivity:	1V fsd (others on request up to 10mV fsd)
Accuracy:	±3% fsd ±4% reading
Response time:	O.25s
Digital:	
Character font:	64 characters in 5x7 dotmatrix – max. 60ch/line – speed, 30ch/s (block mode) 12ch/s (character mode)
Chart speed:	0.05...100cm/min
Chart width:	250mm
Writing system:	Thermosensitive

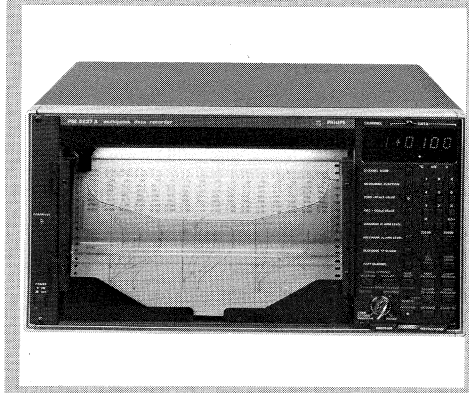
IEEE/IEC
PM 9891
Printer-function programmable 100 byte buffer
Interface functions: SH1, AH1, T5, L3, SR1, DC1

Others
PM 9890
V24/RS232C interface with standard 20mA current loop

PM 9892
8-bit parallel output

Rackmount D

Multipoint data recorder PM 8237



All measuring values can be printed graphically or numerically in a table form. 30 measuring channels are available in the PM 8237A and 12 channels in the PM 8237B version.

Operation of the PM 8237's is easy and can be achieved without any software knowledge. It is necessary only to select the desired parameter on the front panel.
It is not necessary to physically insert single measuring ranges or individual cards because 4 different thermocouples (with built-in linearisation) and Pt-100 elements are already incorporated in all ranges.

Channels:		max. 30 (2 wire) /15 (4-wire) or mix (PM 8237A) max. 12 (2 wire) /6 (4-wire) or mix (PM 8237B)
Voltage:	Range	Span
	−30mV...+30mV	1mV...30mV
	−300mV...+300mV	5mV...300mV
	−3V...+3V	50mV...3000mV
	−30V...+30V	0.5V...30V
Temp:	−200°C...+850°C	25°Cmin.
Thermocouples:		Fe/Contstantan (J), Chromel/Alumel (K) P-t 10% Rh/Pt (S), Cu/Constantan (T) (plus optional thermocouples)
Input:		Floating with guard: Impedance 10MΩ
Recording:		Graphical representation as dotted lines or numeral print-out in tabular form
Paper:		Thermosensitive chart paper

IEEE/IEC
PM 9891
Full-function programmable:
Data input and output:
Status output:
Interface functions: SH1, AH1, T5, L3, SR1, DC1, DT1

Other
PM 9890
V24/RS232C output standard 20mA current loop

Rackmount C

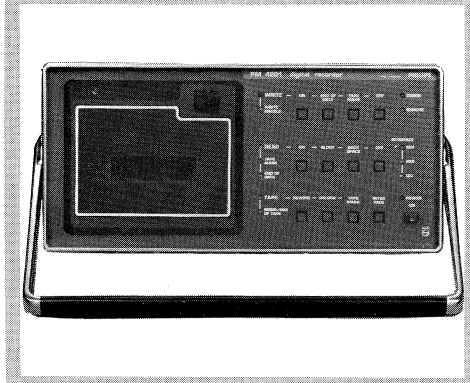
PM 8154 Intelligent X-Y plotter

PM 8154 has a DIN A4 format. Ideal for use within a systems set-up, it provides immediate graphical representation of collected data. It permits comparison of real versus nominal values and also shows a fast visual interpretation of otherwise complex or even confusing statistical print-outs. Curves or bar graphs can be programmed and direct copies of digital storage type oscilloscope screens can be capted without the need for a controller. Channel ident and switch settings can be included.

Paper:	DIN A4
Plotting area:	X-axis 230 mm Y-axis 180 mm
No. of pens:	6
Pen type:	Nylon tip or rotring
Accuracy:	≤± 0.3mm same pen ≤± 0.4mm different pens
Resolution:	0.1mm
Positioning speed:	60cm/s
Writing speed:	400mm/s along X/Y axis 200mm/s other directions
Char. plotting speed:	2ch/s (2mm high)

IEEE/IEC
Built-in interface with model **PM 8154B**
All functions programmable:
Interface functions: SH1, AH1, T6, L3, SR1, PPO, DC1

Digital cassette recorder PM 4201



PM 4201 is an intelligent digital data recorder capable writing and reading in accordance with several formats. With the useful tapemark different data strings can be separated.
The tape capacity of the normal digital tape is 260k bytes/track or even 390k bytes on a special T450 tape.

Hard error rate is $1:10^9$; with the optional power-failprotection the instrument continues in the same mode without losing data.
IEEE-, V24/currentloop and 8bit-parallel interfaces can be used together.

Format:	ECMA-34 and if selected, ECMA-41 (labelling) incl. pre/postamble CRC-16 tapemark end of data gap Silent-700® P-800
Block length:	2 x 256, 8-bits in 1byte increments
Tape speed:	7.5 ips (normal) 75 ips (rewind) motor shut off during pauses

IEEE/IEC
PM 9401E
Full-function programmable:
512 byte buffer storage
Interface functions: SH1, AH1, T5, L3, SR1, RL2

Other
PM 9401R
Built-in V24/RS232C
Interface standard 20mA current loop (passive/active)

Rackmount E

Mini digital cassette recorder PM 4202

A fully professional but very economic solution for serial data storage for incorporation into OEM products and systems. Handles NC code storage, program storage for logic analyzers, data storage for multipoint recorders, word processors, cash registers, etc., etc.
Very high capacity for small physical size - stores 59K bytes of data per digital cassette track, 120K bytes per dictophone cassette. Fully automatic tape formatting including CRC16. Data monster rates of up to 6000 bps are achieved: hard error rate is a low, 1in 10^{-9} bits.

Specification PM 4202

Tape drive:	Philips mini-digital cassette (MDC) recorder M-DCR220
Recording media:	Mini-digital cassette (MDC) or mini-audio cassette (MAC) both with write enable plug
Tracks:	Two - A and B side
Record method:	Bit-serial, phase-encoded
Data trans.rate:	6000 b.p.s.
Block length:	64-128-256-1024 8-bit bytes, or variable in the text mode with min. 64/max. 1024 bytes
Recording format:	Preamble, data and CRC16
Capacity:	MDC - 59Kbytes/track MAC - 120Kbytes/track
Data buffer:	2048 byte CMOS buffer, 2 x 1024 byte banks

IEEE/IEC
Version PM 2402/21
Interface functions: SH1, AH1, T5, L3, SR1, RL1

Other
PM 2402/01
V24/RS232C

Rackmount B

LF synthesizer PM 5190

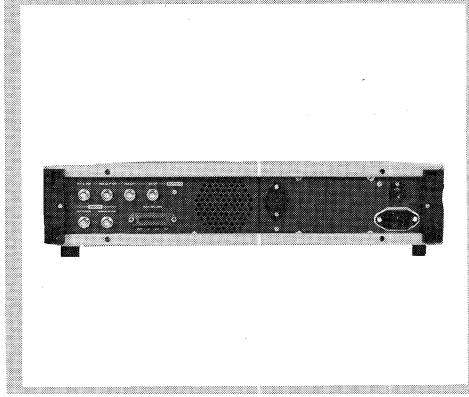
High accuracy and stability are underwritten by the extremely low frequency-setting error figure of $\pm$ 1 x 10^{-6} with an ageing characteristic of $<$1.5 x 10^{-6}/year. With a frequency range of 0.001Hz to 2.147MHz, PM 5190 provides square, sine and triangle waveforms, all time-symmetrical and with/without DC and TTL. Parameter selection is by "feather-touch" keys and is clearly indicated in a 6-digit LED display. Preselected waveforms and external amplitude modulation characteristics are also shown.

Frequency:	1mHz...2.147MHz
Range:	1mHz...2.147MHz for sine and square wave 1mHz...$<$100kHz for triangle
Setting:	– Local, by front panel keys – Remote, via IEC bus interface
Display:	6-digit, 7-segment LEDS 2 LEDs for dimension Hz, kHz
Setting error:	$\pm$1 x 10^{-6} (23°C)
Duty cycle:	50%
Waveforms:	Sine, square, triangle, TTL
Modulation:	AM external DC...20kHz Depth, 90%
Output:	0...20V (on 50Ω) or TTL level

IEEE/IEC (included)
Fully programmable:
Interface functions: AH1, L1, RL2, DC1

Rackmount A

Programmable synthesizer/function generator PM 5193



μP control makes all functions programmable, considerably easing the task of setting up. Moreover, up to 9 individual programmes can be stored in non-volatile registers for immediate call-up as required. Setting up is by means of key banks logically grouped as either menu selectors or numeric inputs. All settings are clearly displayed on 3 LED displays and individual LEDs in each key give an immediate indication of currently selected settings. AC output values can be selected either in V_{pp}, V_{RMS} or dBm as required. All parameter settings can also be made via the IEEE/IEC-bus. When used in a testing system the current address is indicated, allowing the user to continuously monitor the programme. The synthesizer also operates as a pulse generator. TTL applications are also catered for and the TTL output is adjustable between 0 and 5V.

Frequency:	0.1mHz...50MHz for sine wave and pulses max. 20MHz for square wave, max. 2MHz for haversine, max. 200kHz for triangle and max. 20kHz for sawtooth
Ouput voltage:	max. 10Vp or 20Vpp AC plus −10 to +10V DC on main output 5V on TTL output
Sine wave distorsion:	$<$0.4% up to 50kHz, $<$1% over 50kHz
Rise time:	$<$8ns for squarewave $<$3ns for pulses
Modulation:	AM, FM, Gate, Burst
Sweep:	0.1mHz...50MHz, sweeptime 10ms...1000s

IEEE/IEC (included)
Fully programmable:
Interface functions: SH1, AH1, T6, L3, SR1, RL2, DC1

1GHz RF synthesizer PM 5390

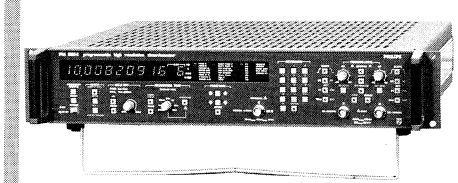
This fully programmable 1GHz RF generator provides AM, FM and video modulation, plus a wide range of sweep measurements, having both automatic and manual frequency-stepping facilities the 100kHz to 1020MHz output is highly stable and accurate. Frequency, signal amplitude, frequency increment and sweep time can be digitally selected and displayed, under the control of the built-in μP. An S version is available in which the nominal 100mV output (PM 5390) is increased to max. 1V output.

Frequency:	100kHz to 1019.99MHz
Indication:	6-digits 7-segment LED display
Resolution:	1kHz
Display error:	1×10^{-6}
Output voltage:	0.1μV...100mV (PM 5390) 0.1μV...1V (PM 5390 S) Keyboard-selectable dBm or μV/mV with LED indication
Modulation:	– RF carrier (unmodulated) – AM internal or external – FM internal or external – VIDEO external – SOUND carrier (AM or FM selectable) internal or external

IEEE/IEC (included)
Fully programmable:
Interface functions: AH1, L1, RL2, DC1

Rackmount A

Programmable universal timer/counter PM 6652



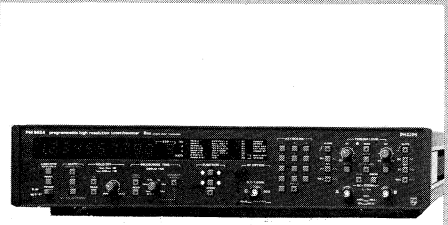
The Universal counter PM 6652 is fully programmable and meets all the requirements of frequency and time measuring. In all, there are 14 different modes of operation. The equipment offers the facility of storing up to 8 different settings. The settings remain stored even in the event of mains failure. With high-speed dump mode, high-resolution measurements with a speed of up to 400/s are possible.

Freq. meas.:	Channel A 0.1Hz...120MHz
Optional channel C:	100MHz...1.5GHz
Period:	100ns...100s
Single time interv.:	100ns...10^{10}s
Time interv. avge.:	0ns...100s
Pulse width, rise & fall time:	4ns...100s
Phase posn.:	0...360° (1-250ns x f)
Ratio A/B:	10^{-9}...10^{+10}
Ratio C/B:	10^{1}...10^{11}
Event counting:	1...10^{18}
Inputs A and B:	
Sensitivity:	20mV$_{RMS}$ to 60MHz 24mV$_{RMS}$ to 120MHz
Coupling:	AC, DC
Trigger level:	−5V...+50V/ −50V...+5V
Impedance:	1MΩ//35pF or 50Ω

IEEE/IEC
PM 9696
Fully programmable:
Output data in normal or dump mode
Status output:
Interface functions: SH1, AH1, T5, L3, SR1, RL1, DC1, DT1

Rackmount S

Programmable universal timer/counter PM 6654



The Universal counter PM 6654 differs from the PM 6652 in that it has a 50 times better resolution and precision. The PM 6654 is therefore eminently suitable for fast automatic test systems (ATE). Frequency and cycle-time measurements are done in 1sec with a resolution of up to 9 digits (PM 6652, 7 digits/sec)

Freq. meas.:	Channel A 0.01Hz...120MHz
Optional channel C:	100MHz...1.5GHz
Period:	8ns...100s
Single time interv.:	8ns...10^{10}s
Time interv. avge.:	0ns...100s
Pulse width, rise & fall time:	4ns...100s
Phase posn.:	0...360° (1-250ns x f)
Ratio A/B:	10^{-9}...10^{+10}
Ratio C/B:	10^{1}...10^{11}
Event counting:	1...10^{18}
Inputs A and B:	
Sensitivity:	20mV$_{RMS}$ to 60MHz 24mV$_{RMS}$ to 120MHz
Coupling:	AC, DC
Trigger level:	−5V...+5V −50V...+50V
Impedance:	1MΩ//35pF or 50Ω

IEEE/IEC
PM 9696
Fully programmable:
Output data in normal or dump mode
Status output:
Interface functions: SH1, AH1, T5, L3, SR1, RL1, DC1, DT1

Rackmount S

1GHz Universal timer/counters PM 6671/72

PM 6671 measures up to 120MHz and has trigger hold-off facilities. PM 6672 has an upper limit of 1GHz. Both models can be ordered with 5 different quartz oscillators having a stability of up to 5 x 10^{-11}/24 hours. Even the most stable version, with an oven oscillator, can be operated with the battery that can be supplied with the equipment.
An important property of both instruments is the triggering precision in frequency measurement with adjustable sensitivity and noise suppression, and in time measurement with adjustable triggering levels.

Frequency measurement:	0.1Hz...1GHz (PM 6672)
Frequency ratio:	Freq.A / Freq.B = 0...10MHz / 0...10MHz
Cycle time:	100ns...100s
Single time interv.:	100ns...10^8s
Time interv. average value:	0s...100s
Event counting:	1...10^{17}
RPM:	0.6RPM...10^8RPM
Measuring time:	10ms...96s
Input sensitivity:	10mV$_{RMS}$
Input attenuation:	x1 and x10
Input impedance:	1MΩ//35pF
Coupling:	AC/DC
Display:	8 digits, LED

IEEE/IEC
PM 9696
Fully programmable:
Data and status output:
Interface functions: SH1, AH1, T5, L3, SR1, RL1, DC1, DT1.

Others
PM 9694
BCD output with display offset
PM 9695 Analog output

Rackmount B

1.5GHz universal frequency counters PM 6673/4/5/6

All instruments of the PM 6673...PM 6676 series offer frequency measurements up to 120MHz on Channel A, with reciprocal mode up to 10MHz for highest resolution. Channel B features RF measurements up to 550MHz (PM 6674), 600MHz (PM 6675) or 1.5GHz (PM 6676). With the aid of the wide range of accessories, the meters in this family can be adapted to the most discrete applications.
The IEC 625- IEEE 488 bus interface PM 9696, offers full programming and data read-out facilities. The BCD output PM 9694 buffers the internal serial output data of the counter and brings them out in parallel form. The analog output PM 9695 makes possible the digital-to-analog conversion of any three consecutive digits. In offset operation, digital zero-point suppression is possible.

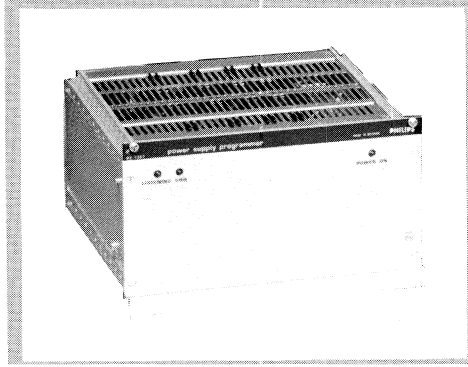
Freq. meas.:	10Hz...1.5GHz
Cycle time Avge. value:	100ns...100s
Frequency ratio:	10Hz...1.5GHz / 1kHz...10MHz
Event counting:	1 to 10_{17}
Measuring time:	10 ms...96s
Input sensitivity:	10mV$_{RMS}$
Input attenuation:	x1...x500
Input impedance:	LF channel A 1 MΩ//-25pF HF channel B 50Ω
Coupling:	AC
Time base:	10ms...96s
Display	9 digits, LED

IEEE/IEC
PM 9696
Fully programmable:
Data and status output:
Interface functions: SH1, AH1, T5, L3, SR1, RL1, DC1, DT1

Others
PM 9694
BCD output, display off-set
PM 9695
Analog output

Rackmount B

IEC bus power supplies programmer PE 1367/00 2-channel version PE 1367/01 1-channel version



The universal programmer PE 1367 makes it possible to digitally control power supply units with any computer compatible with the IEEE/IEC interface.
In principle the programmer is a microprocessor-controlled D/A converter which converts the computer signal into an analog voltage. This voltage can be used to drive any power supply unit which has a programming input.
In addition, the PE 1367 can also be used as a fast, digitally programmable voltage source.
A special feature, which increases the programming speed, is the power sink for one channel.
The PE 1367 has a complete range of Service Request functions.

Output voltage:
– high range
  unipolar operation: 0...10V
  bipolar operation: −10V...+10V
– low range
  unipolar operation: 0...1V
  bipolar operation: −1V...+1V

Resolution:

	unipolar	bipolar
high range	10mV	20mV
low range	1mV	2mV

Output current (unipolar and bipolar) 10mA
Program possibilities:
Percentage, or absolute value
Response time: typically 1V/μs

IEEE/IEC
Programmability of voltage and current
Interface functions: SH1, AH1, L1, DC1, SR1

Oscilloscopes

Unit	Sensitivity	Bandwidth	Features	Page
Introduction				2
REALTIME OSCILLOSCOPES				
PM 3262	2mV/div	100MHz	Dual-trace with trigger view-channel	7
PM 3267	2mV/div	100MHz	Dual-trace with trigger view and double-insulated power supply	9
PM 3264	2mV/div	100MHz	Four-channel with alternate time base	11
PM 3263X	2mV/div	100MHz	Dual trace with μ-P control, TV triggering	14
PM 3254	2mV/div	75MHz	Dual-trace super-portable	17
PM 3256	2mV/div	75MHz	As PM 3254 plus delayed time base	17
PM 3215	2mV/div	50MHz	Advanced dual-trace general-purpose	20
PM 3217	2mV/div	50MHz	As PM 3215 plus delayed time base	20
PM 3233	2mV/div	10MHz	Dual-beam with delay lines	22
PM 3211	2mV/div	15MHz	Dual-trace, general purpose	24
PM 3207	5mV/div	15MHz	Dual-trace with TV triggering	26
PM 3206	5mV/div	15MHz	Dual-trace, all purpose	28
DIGITAL STORAGE OSCILLOSCOPES				
PM 3310	10mV/div	60MHz	Digital storage	30
PM 3311	10mV/div	60MHz	Digital storage with 125MHz clock frequency	30
PM 3315	10mV/div	60MHz	Digital storage with 125MHz clock frequency	30
PM 3305	2mV/div	35MHz	Four-channel digital storage	34
PM 3302	5mV/div	20MHz	Two-channel digital storage	37
ANALOG STORAGE OSCILLOSCOPES				
PM 3266	2mV/div	100MHz	Dual-trace transfer storage	40
PM 3219	2mV/div	50MHz	Dual-trace storage with delayed sweep and alternate time base	43
PM 3234	2mV/div	10MHz	Dual-beam with delay lines and storage	45
ACCESSORIES				
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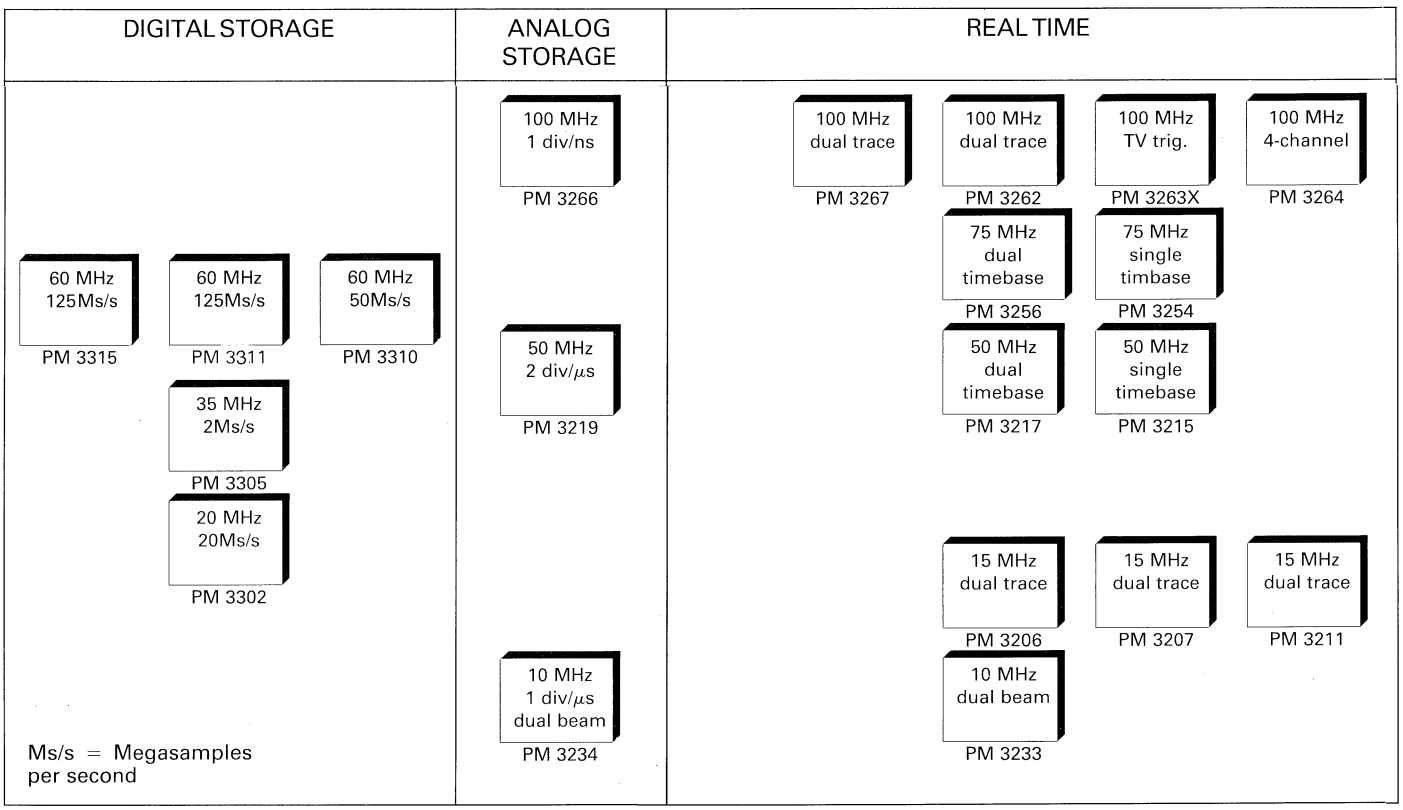
Introduction



The overall range of Philips oscilloscopes embraces three specific groups of instruments. These are classified as:

- Digital storage
- Analog storage
- Realtime

The schematic diagram shows the basic key characteristics of each individual unit within the specified groups along with the appropriate type numbers.

Image transfer storage
The technology employed for the analog storage series of oscilloscopes involves the use of image storage CRTs. The operation of a typical tube design is shown in Fig. 1.

The schematic diagram illustrates the three phases of operation.
In the WRITE phase input signals are captured on the high-speed storage mesh.
As the structure of this mesh is optimized for high sensitivity rather than long storage time, the charge pattern is subsequently transferred to a second mesh optimized for storage time (TRANSFER phase).
Floodguns convert this charge pattern into a visible display on the phosphor screen (DISPLAY phase).

Digital storage
The key to the price/performance breakthrough of the digital storage range is the unique, inhouse-developed "Profiled Peristaltic Charge-Coupled Device" (P^2CCD). Basically it allows data to be stored at rates up to 125Ms/s and then to be sampled at a much lower rate (78kHz) by a LF A/DC. To do this effectively replicates the signal in analog form by charging up 256 microminature semiconductor capacitiors in the device. They are often refered to as "wells". CCD devices perform three basic functions: storage, transfer and separation.
Signals are sampled at the clock rate (e.g. 125Ms/s for the PM 3311 and PM 3315) and each sample converted to a charge packet. The first packet enters the first well and by applying suitable clock pulses to the four groups of electrodes, it is possible to retain separation between wells and transfer the charge to the next well. The next sample then enters the device and the process repeats until the whole device is full. One then has a replica of the signal and this

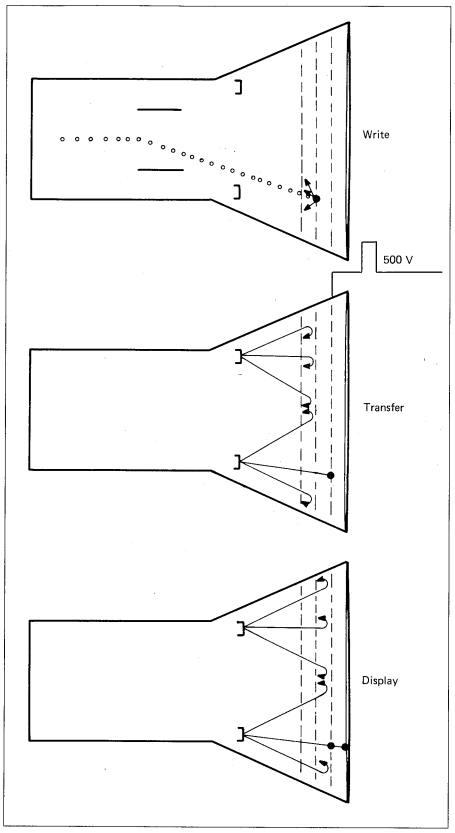


Fig. 1 Schematic of image transfer storage tube shows three phases in the operation. In the WRITE phase, the fast mesh is bombarded by writing gun electrons, subsequently the charge is transferred to the front end mesh and finally flood gun electrons convert the charge pattern of the front end mesh to a visible display.

analog-to-digital conversion.
It is the capability of A/D conversion at low frequency that creates the improved price/performance situation to give the user the best of both worlds – high technology at a reasonable price.

Applied technology

Philips Research Laboratories and component divisions providing, amongst other items, cathode ray tubes, integrated circuits and mechanical components, have facilitated the implementation of many new technologies and measuring facilities in oscilloscopes. These include:

- **P²CCD** allowing a high 125M samples/s resolution of input waveforms for digital storage oscilloscopes. It forms the alternative for expensive A to D converters.
- **MIN/MAX glitch detector,** capturing nanosecond spikes in relatively low speed signals.
- **Pre-trigger recording** combined with selective expanding of displayed waveforms.
- **Image transfer storage** resulting in 1div/ns writing speeds in analog storage scopes.
- **Event delay** combined with interval measuring to select details in complex data streams.
- **Double insulated power supply** following IEC 348 regulations to avoid ground loop measuring problems.
- **Ruggedized mechanical constructions** for applications in tough environments.
- **AUTO PP triggering,** allowing offhands triggering without loss of control facilities.
- **Dual beam display** where two beams are generated as an alternative for dual displays in a time sharing mode.
- **IEC/IEEE-bus** interface facilities for system operation involving remote control of parameters and data interchange with a controller.

Quality

Providing high quality instruments demands continuous professional vigilance at all stages, from the acquisition of components up to the delivery of the end product at the customers premises.
A consistent qualilty programme ensures that at all phases in the design and manufacturing processes, regular checks and controls are applied.

Design

During the design phase components are selected on MTBF figures provided by the supplier. Circuits are always designed with sufficient derating. Extensive type tests following MIL-T-28800 C and IEC specifications are carried out on all new product designs.

Production

Incoming components are tested following the design prescriptions. Automatic insertion, in-circuit component testing and automatic unit testing guarantee a constant, high-quality level of output.

After sales service

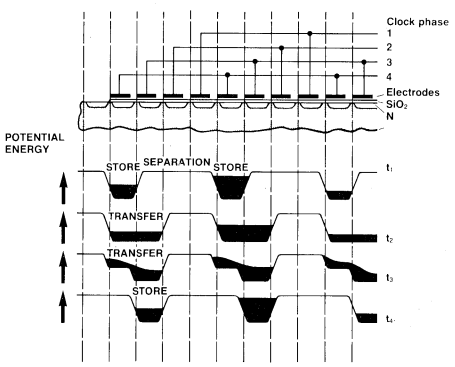
It goes without saying that quality involves considerably more than the delivery of good instruments.
One essential aspect is in the provision of easy-to-understand operating and service manuals which detail specifications, describe performance checks and give sound technical information well supported by visual oscillogram illustrations.
Furthermore an almost uninterrupted use of the product is assured by a worldwide network of service stations offering certified recalibration and, if necessary, repair of the product.
At the same time this service system provides Philips with up-to-date information feedback to further increase quality levels in development and production of new designs.

Safety

The international safety standards set by such bodies as IEC, UL (USA), VDE (Germany) and CSA (Canada) are applied appropriately in design and manufacturing stages.

The best of both worlds

The key PM 3311 price/performance breakthrough is the unique, inhouse-developed "Profiled Peristaltic Charge Coupled Device" (P²CCD). Basically it allows data to be stored at rates up to 125Ms/s and then to be sampled at a much lower rate (78kHz) by an LF ADC. To do this effectively replicates the signal in analog form by charging up 256 microminature semiconductor capacitiors in the device. They are often refered to as "wells". CCD devices perform three basic functions: storage, transfer and separation.



Signals are sampled at the clock rate (125Ms/s) and each sample converted to a charge packet. The first packet enters the first well and by applying suitable clock pulses to the four groups of electrodes, it is possible to retain separation between wells and transfer the charge to the next well. The next sample then enters the device and the process repeats until the whole device is full. One then has a replica of the signal and this can be retained long enough for LF analog- to- digital conversion.

POWER OPTIONS

Philips oscilloscopes are normally delivered in accordance with local power requirements. If an alternative power option is required, the instrument can be supplied fitted with a different power setting and power cord option. In such cases, purchase orders should specify one of the following options:

Universal Euro	**220V/16A**	**Option 001**
North American	**120V/15A**	**Option 003**
United Kingdom	**240V/15A**	**Option 004**

Oscilloscope Measuring Considerations

1. RISE TIME / BANDWIDTH

Oscilloscopes are primarily defined in terms of bandwidth. However, as there is a fixed relationship between bandwidth and rise time, each bandwidth can be easily converted into the shortest rise time which can be displayed on an oscillograph screen.

$$\text{Rise time (10...90\%)} = \frac{350}{\text{Bandwidth}\,(-3\text{dB})}$$

Where, rise time is nanoseconds and bandwidth is in MHz. Hence, a 50MHz oscilloscope will have a rise time of 7ns.

2. PULSE MEASUREMENT

The square law addition rule for rise times allows one to estimate the kind of display to be expected if a certain input is applied to an oscilloscope.

$$T_r \text{ observed} = \sqrt{t_r^2 \text{ oscilloscope} + t_r^2 \text{ input pulse}}$$

This illustrates why the oscilloscope rise time has to be taken into account if the input pulse rise time is in the same order of magnitude.

The specified rise times and bandwidths are measured with a source impedance of 25 Ohms, which, with the capacitive loading, can be disregarded.

3. INPUT CHARACTERISTICS

The input impedance of a medium frequency oscilloscope is typically 1MHz//15...30pF. The resistive component is only relevant for low frequency or DC input signals as the capacitive component will rapidly decrease the impedance at higher frequencies. For example a 20pF input at 10MHz means an impedance of 790 Ohms but at 100MHz it will reduce to 79 Ohms.

If a cable were connected directly from the measuring point to the oscilloscope the load impedance of the cable (usually 100pF / meter for coaxial screened cable) would add to the input capacitance which would, depending on the source impedance, dramatically limit the useable frequency band of the oscilloscope.

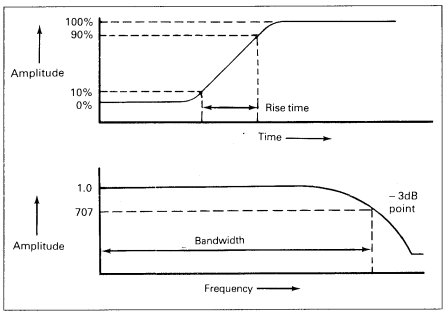


Figure 1 Rise time and bandwidth

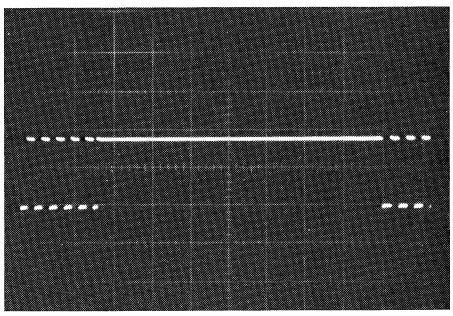


Figure 2 Complete waveform to be examined.

Thus, the normal approach is to use a resistive probe which which limits the capacitance to approximately 10pF but at the expense of a decrease in input sensitivity by a factor of 10.

4. TIME MEASUREMENT

Let us assume that the accuracy of both the main and delayed time bases of an oscilloscope is ±3% and the reading error is ±1/20div. Using these parameters, we will examine four common methods of making time measurements to determine the relative error inherent in each method.

Normal

Refer to the waveform in Fig. 2. The timebase speed is 20us/div., and the distance between the two large pulses is 7.6 divisions.

$$\text{Relative error} + \text{time base error} + \frac{2 \times \text{reading error}}{\text{measured value}} \times 100\%$$

$$= 3\% + \frac{20 \times 0.05}{7.6} \times 100\% = 4.3\%$$

The distance between the two small pulses of Fig. 2 is 1.2 divisions. The relative error in this case is:

$$3\% + \frac{20 \times 0.05}{0.6} \times 100\% = 19.6\%$$

Thus as the distance between measuring points is reduced, the relative error increases.

Magnified

As shown by the foregoing, increasing the distance between the two measuring points reduces the effect of the reading error, thereby improving the overall accuracy of the measurement. However, it must be noted that the time base error increases to 5% when a magnifier is

Table 1. Rise time error

Signal Rise time (ns)	Oscilloscope Bandwidth (MHz)	Oscilloscope Rise time (ns)	Observed Rise time (ns)	Error %
7	35	10	12.2	74
7	50	7	10.0	41
7	100	3.5	7.8	11.8
7	150	2.4	7.4	5.7
7	250	1.4	7.1	1.7
7	1000	0.35	7.0	0.1

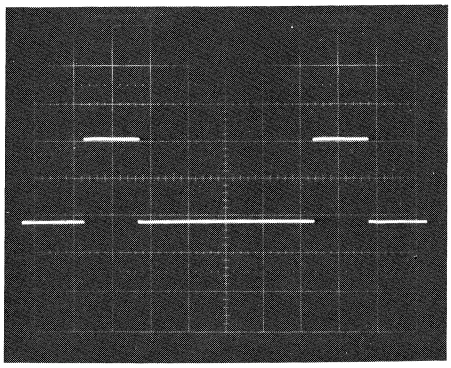


Figure 3. x10 magnification display

used. Referring to the waveform in Fig. 3, the distance between the smaller pulses is increased to 6.0 divisions and the relative error now is:

$$5\% + \frac{2 \times 0.05}{6.0} \times 100\% = 6.67\%$$

Delayed time base (Method A)
With the aid of the main time base, the delayed time base can be started shortly before the appearance of the first small pulse. The speed of the delayed time base is chosen so that the distance between the two small pulses is as large as possible. Referring to the waveform in Fig. 4, the distance between the points in question is 6.15 divisions and the relative error now is:

$$3\% + \frac{2 \times 0.05}{6.15} \times 100\% = 4.63\%$$

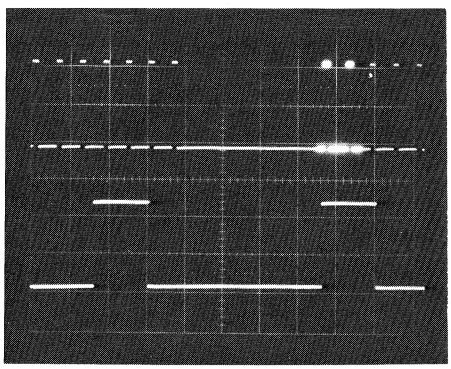


Figure 4 Delayed time base (Method A)

Delayed time base (Method B)
In this case, the delayed time base is triggered near the first small pulse similarly to method A. However, the speed of the delayed time base is chosen so that the distance between the two measuring points is 120 divisions.

The reference point of the first pulse is brought to a vertical graticule line by means of the delay-time multiplier, and the reading noted. The corresponding point on the second pulse is advanced to the same line by the delay-time multiplier, and the reading is noted again (refer to Fig. 5). If the two readings were 6.75 and 5.52, the time interval would be (6.75–5.52) x the speed of the main time base.

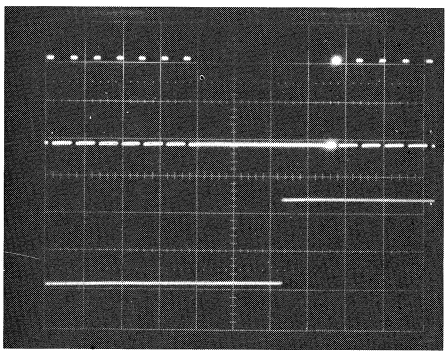


Figure 5 Delayed time base (Method B)

In the case the relative error is:
Time base error + time base reading error + delay-time. Multiplier error + delay-time multiplier reading error.

Time base reading error =
$$\frac{2 \times 0.05}{123} \times 100\% = 0.08\%$$

Delay-time multiplier error =0.2%.
Delay-time multiplier reading error = + ± 0.5 divisions, which corresponds to a relative error of:

$$\frac{2 \times 0.05}{500} \times 100\% = 0.2\%$$

Thus the total relative error now is:
3+0.08+0.20+0.2=3.48%

Relative accuracy of the various measuring methods.
Fig. 6 shows the measuring error plotted against the difference between the measuring points on the main time base axis for the various measurement methods described in the preceding paragraphs. From this it is clear that very large errors can be made in time measurements, and that careful consideration should be given to the measuring method employed.

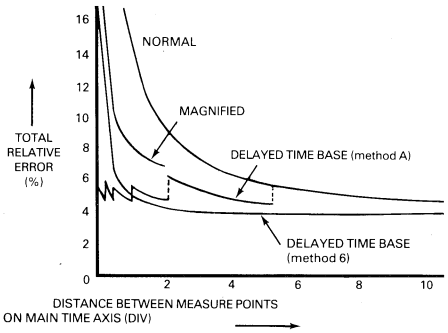


Figure 6. Total measuring error

5. CATHODE RAY TUBES

There is more in CRT's these days than meets the eye. Originally, a simple gun, a set of deflection plates, and a fluorescent screen were enough. Admittedly, there is little more than that in Philips mono-accelerator tubes except precision and a lot of experience. But, our other tubes are quite another matter!

Precision and experience are apparent there in even greater measure, as well as post-deflection accelerator systems, mesh screens, delay line systems or distributed Y-deflection plates, and built-in edge-illuminated internal graticules.

Philips oscilloscopes use post-deflection accelerator (pda) tubes equipped with a mesh between the deflection plates and pda electrodes. The mesh compensates for the lens effect of the post-acceleration field and allows a greater ratio of pda to acceleration voltages. The benefits are threefold; shorter tubes, larger usable viewing areas, and higher deflection sensitivites.

Another point worth mentioning is that from basic research to finished product, everything – glass, guns and phosphors – are all of Philips manufacture, all subject to exacting standards.

Table 2 provides a summary of the various screen phosphors used in Philips oscilloscopes.

Table 2. Oscilloscope screen phosphors

Phosphor U.S. Code	Fluorescence	Phosphorescence	Persistence	Burn resistance	Relative luminance	Comments
P7	Purplish/blue	Yellowish/green	100ms - 1s	Medium	35%	Low speed oscillography
P11	Blue	Blue	10us - 1ms	Medium	10%	Best photographic writing speed
P31	Green	Green	10us - 1ms	High	100%	General-purpose oscillography Brightest available phosphor

Storage oscilloscope selection criteria

With the present availability of first digital oscilloscopes (PM 3311/15, with analog to digital conversion speeds of up to 125M samples/second, giving a true 8ns resolution for single shot signals), and fast analog storage oscilloscopes (PM 3266, with 1000div./us writing speed), the choice between the two systems may be difficult, possibly confusing.

The following table provides for a comparison between the two systems listing the various selection criteria:

	Analog: PM 3266 PM 3219 PM 3234	**Digital:** PM 3302 PM 3305 PM 3310 PM 3311 PM 3315
	ANALOG CRT STORAGE	DIGITAL STORAGE
Speed	Highest speed available for single shots: 1div./ns (PM 3266).	Highest speed available for single shots: 200ns/div. at 8ns/sample (PM 3311/15).
Memories	One: the screen	PM 3310/11/15: 4 memories PM 3305 : 2 memories PM 3302 : 2 memories
Memory size	The screen 8 x 10div.	PM 3310/11/15: 256 x 8 bits for each memory PM 3305 : 4096 x 8 bits total PM 3302 : 2048 x 8 bits for each memory
Multichannel	Single shots limited by chop frequency (1 MHz in PM 3266) No limitation in dual beam storage, such as PM 3234.	Equivalent chop frequency is ½ sampling frequency used 62.5MHz in PM 3311/15 25MHz in PM 3310 1MHz in PM 3305
Outputs	Only one: the screen.	Four: 1. The CRT 2. X-Y Recorder Output 3. Digital plotter (PM 3305) 4. GPIB (IEC/IEEE Bus)
Hard Copy	Screen photos	1. Screen photos 2. X-Y Recorder 3. Plotter used by bus controller. 4. Mass storage (tape or disc) through controller.
Display	1. Normal, memory-off, P31 phosphor. 2. Variable persistence. 3. Integration of images by multiple shots for enhanced brightness. 4. Stored, variable brightness.	Uniform brightness, regardless of signal frequency and timebase speed.
Cost of Ownership	Every storage CRT is expensive and can represent major expense when damaged or abused.	CRT is low cost and easy to replace. Cannot be damaged by normal use, or operators error.
Storage time	Limited by CRT.	Indefinite
"Babysit"	Limited by CRT's storage time. (longest in PM 3219, 24 hours)	Indefinite
Remote Control	None	PM 3310/11/15 can be remotely controlled by IEC/IEEE bus. All display modes, attenuator settings, timebase speed and trigger delay remotely controllable.
Waveform Manipulation	None	Displays can be altered after having been to controller (PM 3302) or even stored. Waveforms can be communicated in either direction through IEC/IEEE bus (PM 3305/10/11/15)

100MHz/5mV (2mV at 35MHz)

Third channel for simultaneous viewing of trigger signal

Alternate time base display facility
New CRT gives bright display, high writing speeds

Composite trigger capability

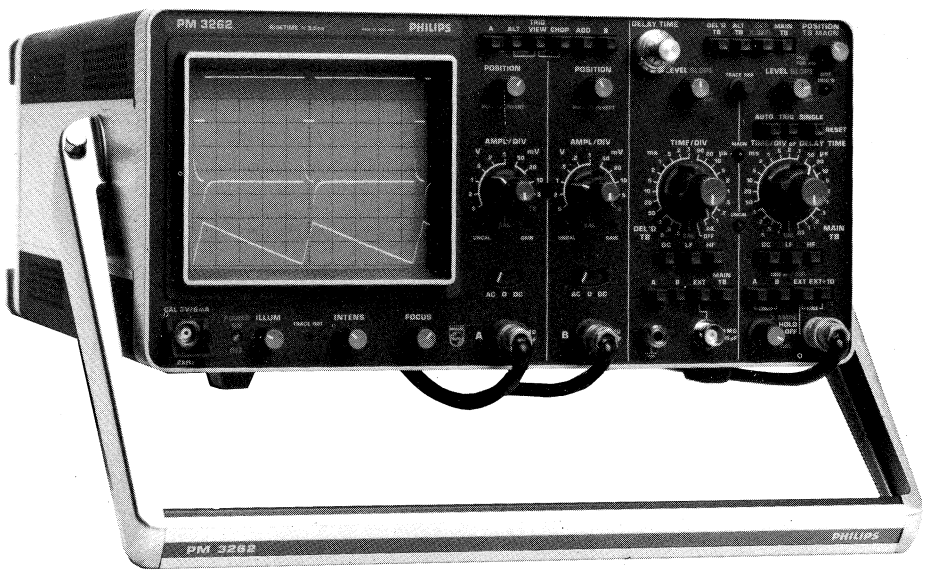
Out of calibration warning lamps

Compact lightweight package

100MHz dual-trace universal oscilloscope PM 3262

The PM 3262 will meet practically every measurement problem likely to be encountered in todays advanced or everyday electronics environments alike, be they sophisticated R & D labs, computer, telecommunications or general service workshops. Its 100MHz/5mV characteristics (35MHz at 2mV) are more than adequate for use with Schottky TTL and similar logic techniques while its wide trigger bandwidth allows the display of high-speed, current-mode logic signals. Its very attractive features include:

- **Trigger view** which allows the active trigger point to be observed on a third channel.
- **Alternate time base switching** allows simultaneous display of complete signal and magnified detail over the whole screen width.
- **Composite triggering** which facilitates display of non-time-related signals, without being affected by the vertical position controls.
- **Acceptance of most trigger inputs** due to the wide, 50mV...24V dynamic range which may be overloaded up to 400V in combination with a bandwidth of over 150MHz.
- **External Z-modulation facility** allows the instrument to cope easily with specifications adapted to TTL voltage levels (e.g. from logic analysers).
- **'Out of calibration' warning** indicated by front panel lamps.
- **New, improved-design Philips CRT** further uplifts all the improved facilities with its extra sharp focus, giving a clear, bright trace coupled with its very high writing speeds.



TECHNICAL SPECIFICATION

CRT

Type
Philips rectangular domed mesh type tube with 17kV acceleration potential and metal backed phosphor

Screen type
P31 (GH) phosphor standard

Useful screen area
8 x 10div of full centimeters

Graticule
Internal graticule with centimeter divisions and 2mm subdivisions along the central axes. 10% and 90% lines are indicated. Illumination continuously variable.

VERTICAL OR Y-AXIS

Response
DC: 0Hz...100MHz (35MHz at 2mV)
AC: 7Hz...100MHz

Risetime
3.5ns

Deflection coefficients
2mV...5V/div
in steps in 1-2-5 sequence. Uncalibrated continuous control between steps 1: > 2.5

Accuracy
± 3%

Display modes
- Channel A only
- Channel B only
- Alternate
- Chopped at approx. 1MHz
- Channels A and B added
- Trigger view
- Trigger view with channels A and B alternate
- Trigger view with channels A and B chopped
- Channels A and B can be inverted

CMRR
> 100 : 1 up to 2MHz
> 20 : 1 at 50MHz

Input impedance
1MΩ ± 2% in parallel with 15pF approx.
RC time, AC coupled: 22ms

Maximum input voltage
$400V_{DC+ACpk}$ derating above 500kHz

Maximum deflection
Undistorted deflection of 24div
Shift range 16div

Signal delay
15ns visible delay

Trigger view

Display	: External or internal trigger signal
External	: 100mV/div
External ÷10	: 1V/div
Trigger point	: Screen centre ± 0.3div

Time delay between vertical input and external input: 3ns

HORIZONTAL OR X-AXIS

Horizontal deflection can be obtained from either the main timebase or the delayed timebase or a combination of the two, or from the signal source selected for X-deflection. In this case X-Y diagrams can be displayed using Y_A, Y_B, the Ext connector or the Line as a signal source

Horizontal display modes
- Main timebase
- Main timebase intensified by delayed timebase
- Delayed timebase
- Main timebase and delayed timebase simultaneously displayed (alternate)
- X-Y or X-Y/Y operation with X-deflection by Y_A, Y_B, Line or Ext source

HORIZONTAL AMPLIFIER

Response
DC...2 MHz (−3dB)

Deflection coefficient
50mV/div using Ext connector and 500mV/div via Ext ÷10 switch
Uncalibrated continuous control 1: > 3. When Y_A or Y_B are used, sensitivities are 2mV...5V/div

Measuring accuracy
± 3% (Ext. X-input)

Phase error
3° at 100kHz

MAIN TIME BASE

Modes
- Auto (RC time 100ms)
- Triggered
- Single shot

Time coefficients
1s...50ns/div in 23 calibrated steps, in 1-2-5 sequence. Uncalibrated continuous control between steps, (with UNCAL warning lamp should main timebase slip out of calibration), x 10 magnifier extends max. sweep rate to 5ns/div

Accuracy
± 2% (+20°C...+30°C)
± 3% (+ 5°C...+40°C)
Additional error for x 10 magnifier ± 1%

Variable hold-off
Sweep hold-off time can be increased by a factor of 10

DELAYED TIME BASE

Modes
Delayed timebase starts, either immediately after the delay time or, upon arrival of the first trigger pulse after the delay time

Time coefficients
0.5s...50ns/div in 22 calibrated steps, 1-2-5 sequence. Uncalibrated continuous control between steps (with UNCAL warning lamp should delayed timebase slip out of calibration). x 10 magnifier extends max. sweep rate to 5ns/div

Accuracy
± 2% (+20°C...+30°C)
± 3% (+ 5°C...+40°C)
Additional error for x 10 magnifier ± 1%.

Calibrated sweep delay
Continuous calibrated control between 0 and 10 x main timebase setting

Incremental delay time accuracy
0.2% typical

Delay time jitter
Better than 1:30 000

MAIN TIME BASE TRIGGERING

Trigger source
Internal Y_A, Y_B, Composite, Line,
External, External ÷ 10

Slope
+ or −

Level range
Int: 24div
Ext: +1.2V...−1.2V
Ext: ÷10: +12V...−12V

Trigger sensitivity

	30 MHz	100 MHz
Int	0.5div	1.5div
Ext	50mV	150mV
Ext ÷10	500mV	1.5V

Trigger coupling
DC : DC...full bandwidth
HF : 30kHz...full bandwidth
LF : internal 0...30kHz
external 7Hz...30kHz

Ext. trigger input impedance
1 MΩ ± 2% in parallel with 15pF approx

Maximum allowable input voltage
$400V_{DC+ACpk}$

Trigger jitter
Better than 0.5ns

DELAYED TIMEBASE TRIGGERING

Trigger source
Internal : Y_A or Y_B
External : Other characteristics are identical to TRIGGERING OF THE MAIN TIMEBASE

CALIBRATION

Calibrated voltage
$3V_{p-p}$ ± 1% square wave

Calibrated current
$6mA_{p-p}$ ± 2% square wave

Z-MODULATION

Input
DC-coupled, TTL compatible 'High' Level blanks display

Input impedance
10kΩ

Maximum input voltage
50V

Response time
35ns

POWER REQUIREMENTS

Line voltages and frequencies
AC: 100...127V and 220...240V, 46...440Hz
DC: 250...350V

Power consumption
50W at nominal line voltage

DIMENSIONS AND WEIGHT
(w x h x d) 316 x 154 x 410mm
(12.4 x 6.1 x 16.1-in)
9.6kg (21lb)

ENVIRONMENTAL CAPABILITIES

The environmental data are valid only if the instrument is checked in acordance with the official checking procedure. Details on these procedures and failure criteria are supplied on request by the PHILIPS organization in your country, or by PHILIPS' TEST AND MEASURING DEPARTMENT, EINDHOVEN, HOLLAND.

Ambient temperatures
Rated range of use: +5°C to +40°C
Limits for operation: −10°C to +55°C
Storage and transport: −55°C to +75°C

Altitude
Operating: to 5000m (15000ft)
Non-operating: to 15000m (45000ft)

Humidity
21 days cyclic damp heat 25°C...40°C R.H. 95%

Shock
30g: half sine wave shock of 11ms duration:
2 shocks per direction for a total of 12 shocks.

Vibration
Vibrations in three directions with a maximum of 15min per direction
5...55Hz and amplitude of $0.7mm_{p-p}$ and 4g max acceleration
Unit mounted on vibration table without shock absorbing material

Recovery time
Operates within 30 minutes coming from −10°C soak, going into 60% relative humidity at +20°C room conditions

Electromagnetic interference
Meets VDE 0871 and VDE 0875
Grenzwertklasse B

Safety
Safety class I according to IEC 348

ACCESSORIES SUPPLIED

Front cover with storage space
Operating and service manual
BNC-Banana adapter
Contrast filter
2 x 10:1 attenuator probe
Collapsible viewing hood
Cal terminal – BNC adapter

ORDERING INFORMATION

PM 3262 100MHz oscilloscope
Power options: see Introduction, page 4

OPTIONAL ACCESSORIES

PM 8921	Passive probe 1:1 (1.5m)
PM 8921L	Passive probe 1:1 (2.5m)
PM 8927A	Passive probe 10:1, 11pF (1.5m)
PM 8927AL	Passive probe 10:1, 14pF (2.5m)
PM 8932	Passive probe 100:1, max. voltage 5600V; 2pF (1.5m)
PM 8935	HF passive probe 10:1 (1.5m)
PM 8935L	HF passive probe 10:1 (2.5m)
PM 8940	High voltage isolation amplifier for floating measurements at $650V_{RMS}$
PM 8943	FET probe 650 MHz, 1:1/10:1/100:1
PM 8960	19-in rackmount adapter
PM 9355	Current probe 12Hz...70MHz
PM 9381	Oscilloscope camera
PM 8976	Camera adapter for stationary use
PM 9366	Collapsible viewing hood
PM 8980	Long type viewing hood
PM 8994	Set of accessories for probes
PM 8991	Oscilloscope trolley
PM 8901	Battery pack for 3 hours continuous operation
PM 8910	Polaroid anti-glare filter
PM 8992	Accessory pouch

Wide input voltage range

Trigger view as third display channel

Alternate main and delayed time bases

Automatic triggering

Robust, fully enclosed cabinet for difficult environments

Double insulated power supply

100 MHz general-purpose oscilloscope PM 3267

PM 3267 has been designed for a wide range of applications – from the simple to the sophisticated – in workshops, laboratories or tough field conditions. In particular those engineers with non-specialist experience in electronics seeking easy-to-operate test equipment will find the PM 3267 a most useful, uncomplicated tool, well within the scope of their understanding.

Its vertical deflection characteristics make it more than adequate to use with modern logic techniques, whilst its wide trigger bandwidth allows the display of very high frequency, complex signals.

Its many attractive features include:
- **Trigger view** which allows the active trigger point to be observed on a third channel
- **Alternate time base switching** for simultaneous display of a complete signal and magnified detail over the full screen width
- **Independent triggering** of the main and delayed time bases, very important in digital applications
- **Automatic triggering** including video waveform applications
- **External Z-modulation** facility allowing an addtional timing facility via blanked markers
- **'Out of calibration'** warnings indicated by front panel lamps

The instrument will operate from an external 24V_{DC} power supply as well as standard line voltages between 90V and 270V (up to 440Hz). This facility, plus the completely sealed sturdy metal case, increase the application possibilities beyond the laboratory or workbench, into more hostile environments.

Flexible triggering

Main and delayed time bases can be triggered independently and composite triggering is possible. TV triggering with automatic changeover from line to frame is standard. Capturing single shot signals is simplified by a LED indicator which illuminates when the instrument has triggered.

TECHNICAL SPECIFICATION

CRT

Type: Philips rectangular tube with 10kV acceleration potential and metal-backed phosphor

Screen type:
P31(GH) phosphor standard

Graticule: Internal
8 x 10 div. (each equals 1cm).
Dotted lines to facilitate rise time measurements

Illumination continuously variable

Trace rotation: Screw-driver adjustment at front panel aligns X-trace with hor. graticule lines

VERTICAL OR Y-AXIS

Display modes
Two identical channels
Channel A only
Channel B only
Triggerview only
Channels A and B chopped
Channels A and B and triggerview chopped
Channels A and B and triggerview alternated
Channels A and B alternated
Channels A and B added

Polarity inversion
Both channels can be inverted

Chopping frequency: approx 500kHZ
Display time per channel in chopped mode: 900ns

CMRR: 100: 1 at 2MHz

Bandwidth
DC: 0...100MHz
AC: 2Hz...100MHz
In the 2, 5 and 10mV settings, upper bandwidth is 80MHz.

Risetime: ≤3.5 ns

Pulse aberration: ≤3% or 4% pp

Deflection coefficients
2mV/div...10V/div. calibrated in 1-2-5 steps

Deflection accuracy: ±3%

Continuous control: 1:>2.5 (non-calibrated)

Vert. positioning: + and −8 div. from screen centre

Input impedance: 1MΩ//25pF

Input coupling: AC, 0, DC

Max. input voltage
400V (DC + AC pk)
Test voltage: 500V (RMS)

Visible signal delay: 30 ns

TRIGGERVIEW

Bandwidth: 0...60 MHz

Sensitivity
Ext.: 200mV/div. ±3%
Int.: depending on setting of Y channel

Trigger point: Screen centre ± 0.3 div.

Delay between EXT trigger view and Y channels: 6ns

HORIZONTAL OR X-AXIS

Display
Main time base
Main time base intensified
Delayed time base
Alternated between time base intensified and delayed time base
X-Y operation

Trace separation in ALT TB mode: 5 div.

Horizontal positioning range: + and − 5 div.

TRIGGERING OF THE MAIN TIMEBASE

Coupling: DC, LF, HF, TV

Source: Y_A, Y_B, Composite, External and Line

Trigger bandwidth
DC: 0...100 MHz
LF: 10 Hz...25kHz
HF: 25kHz...100 MHz

Trigger sensitivity

	30 MHz	100 MHz
Int	0.5div	1.5div
Ext	100mV	300mV

TV: INT: 0.7 div sync pulse
EXT: 150mV sync pulse

Level range
in normal internal mode: +8 and −8div
in normal external mode: +1.6 and −1.6V
in $Auto_{pp}$ mode: related to peak-to-peak value of the trigger signal
in TV: fixed level

Triggering slope: + or −

External input impedance: 1 MΩ//25pF

Maximum input voltage: 400V (DC + AC pk)
Test voltage: 500V (RMS)

MAIN TIME BASE

Time coefficients
0.5s/div...50ns/div.
23 calibrated pos. in 1-2-5 sequence

Continuous control: 1: ⩾2.5 (non-calibrated)

Magnifier: x 10

Coefficients error: ⩽3% (5% including magn.)

Linearity error: ⩽5%

Mode: $AUTO_{pp}$, AUTO, TRIG, SINGLE

Variable hold off time
The sweep hold off time can be varied between 1 and 10 times the time/div. settings.

"Not triggered" LED
LAMP is on when sweep is in free run mode.
In single shot mode LAMP is on when sweep is waiting for trigger signal

TRIGGERING OF THE DELAYED TIMEBASE

Coupling: DC, LF, HF

Source: Y_A, Y_B

Trigger bandwidth
DC: /...100 MHz
LF: 10 Hz...25kHZ
HF: 25kHz...100 MHZ

Trigger sensitivity

	30 MHz	100 MHz
Int	0.5div	1.5div

Level range: In normal internal mode: −8 and +8div

Triggering slope: + or −

DELAYED TIMEBASE

Operation

Delayed timebase starts either immediately after delay time or is triggerable after the delay time

Time coefficients: 1ms/div...50ns/div.
15 calibrated pos. in 1-2-5 sequence

Continuous control: 1:⩾2.5 (non-calibrated)

Coefficients error: ⩽3% (5% including magn.)

Delay time
Variable between 5s and 500ns
Incremental accuracy 0.5%

Delay time jitter: 1: >20 000

X-Y OPERATION

Mode (X-deflection): Y_A, Y_B, External, Line

Deflection coefficients
In channel A or B mode as selected by A or B ampl./div. ± 10%
In external mode 0.5V/div. ± 10%
In line mode 8div. at 50 Hz...60 Hz

Magnifier: x 10

Bandwidth
DC: 0...100kHz (0.5dB)
LF: 10 Hz...25kHz
HF: 25kHz...100kHz

Phase shift between X and Y ampl.
<3° at 100kHz in DC mode

CALIBRATION UNIT

Amplitude: $1.2V_{pp}$ ± 1%

Frequency: approx. 2kHz square wave, output short circuit protected

POWER SUPPLY

Line voltages

110V: 90...130V
220V: 195...245V
240V: 210...270V

Line frequencies: 46...440 Hz

DC power source: 20...32V_{DC}

Power consumption: 45W

Safety: According to IEC 348 Class II requirements for power supply

Z-modulation
TTL compatible
"1" is normal intensily
"0" blanks display
(min. pulse width required: 10ns)

DIMENSIONS AND WEIGHT

(w x h x d) 335 x 137 x 445mm
(13.2 x 5.4 x 17.5-in)
10.6 kg (23.3lb)

ENVIRONMENTAL CAPABILITIES

N.B.:
The environmental data are valid only if the instrument is checked in accordance with the official checking, procedure. Details on these procedures and failure criteria are supplied on request by the PHILIPS, organisation in your country, or by PHILIPS' TEST AND MEASURING DEPARTMENT, EINDHOVEN, HOLLAND.

Ambient temperatures
Rated range of use: 0°C...+40° C
Limits for operation: −10°C...+55°C
Storage and transport: −55°C...+70°C

Altitude
Limit range of operation 5000m (15 000ft)
Limit range of transport 15000m (50 000ft)

Humidity: According to IEC 68Db

Shock
Operating: 30g, half-sine, 11ms duration, 3 shocks per axis per direction for a total of 18 shocks

Vibration: 20 minutes in each of 3 directions, 5...55 Hz; $1mm_{pp}$ and 4g max. accelaration

Recovery time
30 minutes if ambient temperature is raised from −10°C to +20°C at 60% relative humidity

Electromagnetic interference
Meets VDE 0871 and VDE 0875 grenzwertklasse B.

ACCESSORIES SUPPLIED

Operating manual
2 x 10:1 attenuator probe PM 8927A
Front cover
Contrast filter
Collapsible viewing hood
BNC-banana adapter 4mm

ORDERING INFORMATION

PM 3267 100 MHz oscilloscope

Instrument options
Option 30 - Rackmount version

Power options: see Introduction, page 4

OPTIONAL ACCESSORIES

PM 8935	HF Passive probe set 10:1 (1.5m)
PM 8935L	HF passive probe set 10:1 (2.5m)
PM 8927A	Passive probe set 1:1 (1.5m)
PM 8927AL	Passive probe set 1:1 (2.5m)
PM 8932	Passive probe set 100:1
PM 9355	Current probe
PM 9381	Oscilloscope camera
PM 8972	Camera adapter for stationary use
PM 8963	19-inch rack mount adapter
PM 8992	Accessory pouch
PM 8910	Polaroid anti-glare filter
PM 8980	Long type viewing hood
PM 8991	Oscilloscope trolley
PM 8901	Battery pack 24V_{DC} and 280V_{DC}
PM 8991	Oscilloscope trolley
PM 8994	Set of accessories for probes
PM 8943	Active FET probe 1:1, 10:1, 100:1
PM 9366	Collapsible viewing hood
PM 8940	Isolation amplifier

Service Manual 9 499.445.01111

Advanced display facilities for realtime analysis up to 100MHz

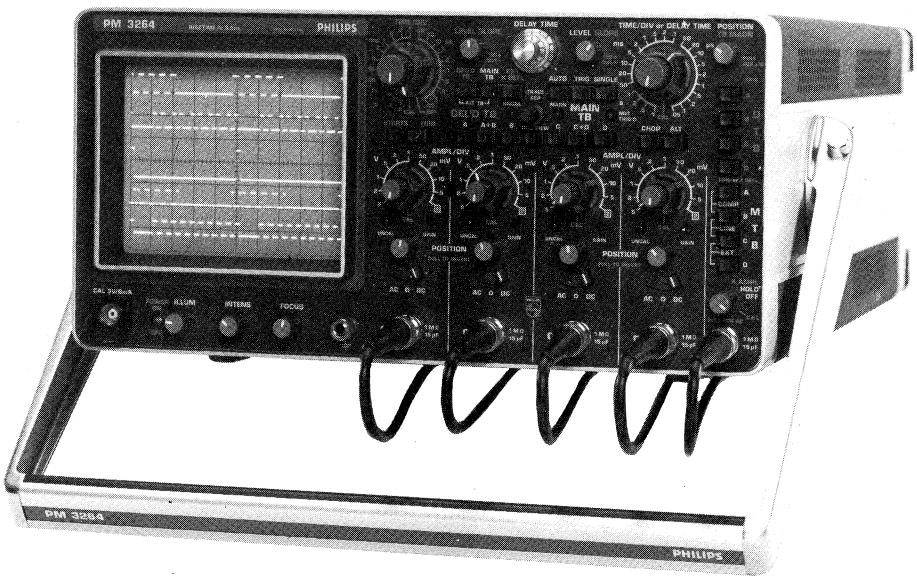
Multi-source triggering

Trigger view as fifh channel

Simultaneous display of MTB and DTB

Portable with battery operation for field use

100MHz four-channel multi-display oscilloscope PM 3264



The PM 3264 offers a unique solution to many timing problems in digital electronics. Simultaneous display of 4 or 5 input signals provides a quick and convenient method for realtime analysis of digital signals both at component and system level.
A versatile deflection system provides many user-benefits. For example, any combination of up to five input signals and two different modes can be selected by push-buttons. The sensitivity of the channels includes 2mV/div up to 400V per screen, using the standard 1:10 attenuator probes.'
A flexible triggering system allows the main and delayed time bases to be triggered independently by any of the four input channels. Also, an external trigger and composite trigger are provided.
The alternate time base facility permits a quick reference for magnified displays with respect to the original waveform.
The multiple trace display demands a CRT with very high light output. Philips has designed a special tube with 17kV pda which provides a more-than-adequate sharp, bright, spot.
With all the foregoing facilities, the PM 3264 remains a typically compact portable, oscilloscope which is also extremely simple to use.

The various facilities are summarized as follows:

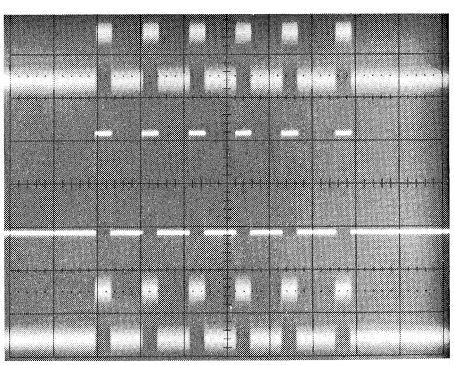
- four channels to show signal relationships in time
- multi-source triggering to add display flexibility
- trigger-view to relate triggering *directly* to the four channel display
- other features like differential displays and composite triggering to extend performance
- two timebases to allow signal detail to be picked out from the data stream
- alternative timebase mode to allow signal details to be *directly* related to data stream

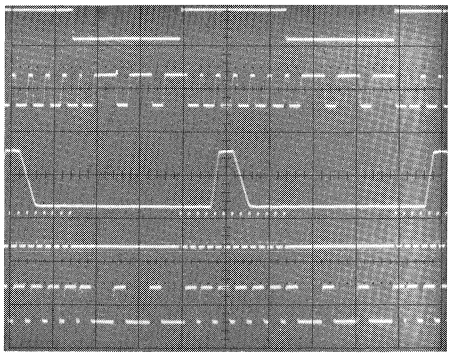
Moreover facilities can be permutated, with virtually no limitation. For example, main and delayed timebases can be *independently* triggered from any of the four channels. Or the alternate timebase mode can be employed with a differential display and the original four channels to give a 12-trace display.

Trigger view
PM 3264 features the ultimate in multi-sourced triggering, with independent selection of main and delayed timebases from any of the four channels plus composite, line and external triggering on the main timebase. It is therefore essential that the relationship between the various displays and the triggering signal is always clear and this provided by the trigger view facility. At the touch of a button the actual trigger signal is displayed as a "fifth" channel, so that there can be no possibility of display ambiguity.

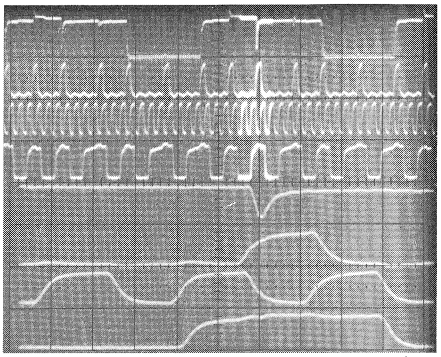
Alternate timebase mode
This mode is obtained simply by pushing both the main and delayed timebase controls together. It enables the delayed timebase signal details to be displayed at the same time as the intensified main timebase signals. In this way signal details can be *directly* related to the data stream.

All channels can be inverted and combined for obtaining differential displays.
The oscillogram shows how noise is suppressed by addition of two balanced signals displayed on channel A and -B.

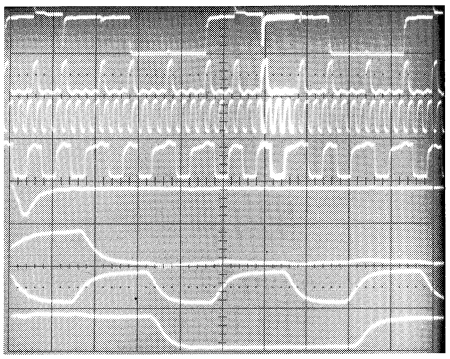




4-channel display with trigger view showing relationship of all signals to the external triggering source. Note the high light output levels.



Glitch has been picked out from channel A and is clearly displayed using the alternate timebase mode.



Fully independent triggering allows delayed timebase to be set to trigger on channel A, which allows detailed investigation at any time base speed.

X-Y displays

X-Y displays are further evidence of the advanced display capability of the PM 3264. The independent triggering facilities allow any one of four channels to be displayed against an X-input signal or against any of the four vertical inputs.

Composite triggering

Single-channel triggering shows the exact relationship between the displayed signals. Composite triggering, however allows signals that are not related in time or phase to be displayed and compared. This facility can be used in a variety of ways, for example rise-times or waveform abberations can be compared and measured regardless of the time span between signals or the frequency relationship.

Logic triggering too

The PM 3264 is the ideal compliment to a logic analyzer since it shows real-time relationships and signal details, such as glitches, in their actual, analog waveform. In addition, the instrument can be set to trigger from a logic word via external optional logic trigger probe PM 8810. This allows the PM 3264 to be triggered from a logic word of up to 16 bits at a max. clock rate of 20 MHz.

Very easy operation

PM 3264 is a highly sophisticated instrument but the front panel could not possibly be simpler or more logical. Channel selection is made, for example, directly above the relevant channel controls. Trigger selection for main and delayed timebases is also logically grouped. This simplifies and speeds up measurements and allows the oscilloscope to used for virtually all applications and production test.
In addition the PM 3264 is light, easy to transport and hence ideal for field work, a facility that can be extended via the optional battery pack.

TECHNICAL SPECIFICATION

CRT

Type
Philips rectangular domed mesh type tube with 17kV acceleration potential and metal backed phosphor

Screen type
P31 (GH phospor standard)

Useful screen area
8 x 10div. of full centimetres

Graticule
Internal graticul with centimetre divisions and 2mm subdivisions along the central axes.
10% and 90% lines are indicated. Illumination continuously variable.

VERTICAL OR Y-AXIS

Response
DC: 0 Hz...100 MHz (35 MHz at 2mV)
AC: 7 Hz...100 MHz

Risetime
3.5ns

Deflection coefficients
2mV...5V/div.
insteps in 1-2-5 sequence. Uncalibrated continuous control between steps 1: > 2.5

Display modes
- Channel A, B, C or D
  A + B, C + D,
  Trigger view
  any combination of these channels
- Multiple display chopped at 1 MHz or Alternate
- Any channel may be inverted except Trigger view

CMRR
>100:1 up to 2 MHz
> 20:1 at 50 MHz

Input impedance
1 MΩ ± 2% in parallel with 15pF approx. RC time, AC coupled: 22ms

Maximum input voltage
$400V_{DC} + AC_{pk}$, derating above 5000kHz

Maximum deflection
Undistorted deflection of 24div. up to 35 MHz Shift range 16div.

Signal delay
15ns visible delay

Trigger view
Display: External or internal trigger signal
Deflection coefficient external: 100 mV/div
Trigger point: Screen centre ± 0.3div.
Time delay between vertical input and external input: 3ns

HORIZONTAL OR X-AXIS

Horizontal deflection can be obtained from either the main timebase or the delayed timebase or a combination for the two, or from the signal source selected for X-deflection.
In this case X-Y diagrams can be displayed using A, B, C, or D the EXT connector or the Line as a signal source.

Horizontal display modes
- Main timebase
- Main timebase intensified by delayed timebase
- Delayed timebase
- Main timebase and delayed timebase simultaneously displayed (alternate)
- X-Y operation with X-deflection by A, B, C, D line or Ext source

HORIZONTAL AMPLIFIER

Response
DC...2 MHz (−dB)

Deflection coefficent
50mV/div. using EXT connector.
Uncalibrated continous control 1: > 3.
When A, B, C or D are used, sensitivity is 2mV...5V/div.

Measuring accuracy
± 3%

Phase error
3° at 100kHz

MAIN TIME BASE MODES

- Auto
- Triggered (RC time 100ms)
- Single shot

Time coefficient
1s...50ns/div. in 23 calibrated steps, in 1-2-5 sequence. Uncalibrated continuous control between steps (with UNCAL warning lamp should delayed timebase be set out of calibration). x 10 magnifier extends max. sweep rate to 5ns/div.

Accuracy
± 2% (+20°C...+30°C)
± 3% (+ 5°C...+40°C)
Additional error for magnifier ± 1%

Variable hold-off
Sweep hold-off time can be increased by a factor of 10

DELAYED TIME BASE

Modes
Delayed timebase starts, either immediately after the delay time or, upon arrival of the first trigger pulse after the delay time.

Time coefficients
0.5s...50ns/div. in 22 calibrated steps, 1-2-5 sequence. Uncalibrated continuous control between steps, (with UNCAL warning lamp should main timebase be set of calibration). x 10 magnifier extends max. sweep rate to 5ns/div.

Accuracy
± 2% (+20°C...+30°C)
± 3% (+ 5°C...+40° C)
Additional error for magnifier ± 1%

Calibrated sweep delay
Continuous calibrated control between 0 and 10 x main timebase setting.

Incremental delay time accuracy
0.2% typical

Delay time jitter
Better than 1:30000

MAIN TIME BASE TRIGGERING

Trigger source
Internal A, B, C, D Composite, line, External.

Slope
+ or −

Level range
Internal: 24div.
External: + 1.2V to − 1.2V

Trigger sensitivity

	30MHz	100MHz
Int	0.5div	1.5div
Ext	50mV	150mV

Trigger coupling
DC: DC...full bandwidth
AC: 100Hz...full bandwidth

Ext. trigger input impedance
1 MΩ ± 2% in parallel with 15pF approx.

Maximum allowable input voltage
$400V_{DC} + AC_{pk}$

Trigger jitter
Better than 0.5ns

DELAYED TIMEBASE TRIGGERING

Trigger source
Internal: A, B, C or D
For **Slope, Level range** and **Sensitivity** see MAIN TIME BASE TRIGGERING

CALIBRATION

Calibrated voltage
$3V_{pp}$ ± 1% square wave

Calibrated current
$6mA_{pp}$ ± 2% square wave

Z-MODULATION

Input
DC-coupled, TTI compatible, "HIGH" level blanks the display

Input impedance
10kΩ

Maximum input voltage
50V

Response time
35ns

POWER

line voltages and frequencies
AC: 100...127V and 220...240V, 46...440Hz
DC: 250...350V

Power consumption
50W at nominal line voltage

DIMENSIONS AND WEIGHT

(w x h x d) 316 x 154 x 460mm
(12.4 x 6.1 x 18-in)
11kg (24lb)

ENVIRONMENTAL CAPABILITIES

The environmental data are valid only if the instrument is checked in accordance with the official checking procedure. Details on these procedures and failure criteria are supplied on request by the PHILIPS' organization in your country, or by PHILIPS' TEST AND MEASURING DEPARTMENT, EINDHOVEN, HOLLAND.

Ambient temperatures

Rated range of use:	+5°C to + 40°C
Limits for operation:	−10°C to + 55°C
Storage and transport:	−55°C to + 75°C

Altitude
Operating: to 5000m (15000ft)
Non-operating: to 15000m (45000ft)

Humidity
21 days cyclic damp heat 25°C...40°C R.H. 95%

Shock
30g: half sine wave shock of 11ms duration:
2 shocks per direction for a total of 12 shocks

Vibration
Vibrations in three directions with a maximum of 15min per direction; 5...55Hz and amplitude of $0.7mm_{p-p}$ and 4g max. acceleration.
Unit mounted on vibration table without shock absorbing material.

Recovery time
Operates within 30 minutes coming from −10° C soak, going into 60% relative humidity at +20°C room conditions.

Electromagnetic interference
Meets VDE 0871 and VDE 0875
(Grenzwert klasse B)

Safety
Safety class I according to IEC 348

ACCESSORIES SUPPLIED

Front cover with storage space
Operating and service manual
BNC-banana adapter
Contrast filter
4 x 10:1 attenuator probe collapsible viewing hood
Cal terminal - BNC adapter

ORDERING INFORMATION

PM 3264 100MHz oscilloscope
Power options: see Introduction, pag 4

OPTIONAL ACCESSORIES

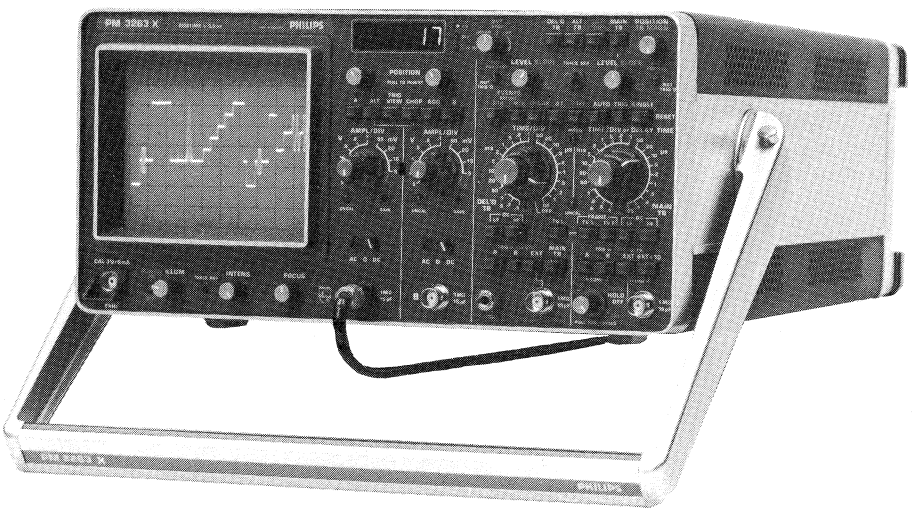
PM 8921	Passive probe 1:1 (1.5m)
PM 8921L	Passive probe 1:1 (2.5m)
PM 8927A	HF passive probe 10:1 (1.5m)
PM 8927AL	HF passive probe 10:1 (2.5m)
PM 8935	Passive probe 10:1 (1.5m)
PM 8935L	Passive probe 10:1 (2.5m)
PM 8932	Passive probe 100:1; max. voltage 5600V; 2pF (1.5m)
PM 8940	High voltage isolation amplifier for floating measurements at $650V_{RMS}$
PM 8943	FET probe 650MHz 1:1/10:1/100:1
PM 8960	19-in rackmount adapter
PM 9355	Current probe 12Hz...70MHz
PM 9381	Oscilloscope camera
PM 8976	Camera adapter for stationary use
PM 9366	Collapsible viewing hood
PM 8980	Long type viewing hood
PM 8994	Set of accessories for probes
PM 8991	Oscilloscope trolley
PM 8901	Battery pack for 3 hours continuous operation
PM 8910	Polaroid anti-glare filter
PM 8810	Logic trigger probe

100MHz 'scope with μp-controlled timing PM 3263X

100MHz/5mV (2mV at 35MHz)
Dual delay for time interval measurement
Delay by events 6-digit integral LED display
Alternate time base
Triggering on Line, Field or Frame
Delayed time base after analog or digital delay
Direct indication of Line number
Automatic TV trigger level setting

The PM 3263X provides an easy solution for complex measurements in sophisticated R&D environments, or field situations where its compactness and portability are particularly beneficial.

A very useful extension of the normal delay facility is presented by the possibility to combine both the analog time delay and the digital event delay. This allows selection of any particular event in a data stream, (such as TV lines in a video signal) whilst details of the selected signal can be displayed simultaneously.



Time interval measurement
The various time interval measuring facilities include:

Dual delay which permits the precise measurement of the time interval between two signals on a single trace, or between two events on different traces, using the 'alternate' display mode. This facility also allows.

Frequency measurement using markers located on the trace from which the microprocessor calculates the reciprocal value of the time interval to produce the frequency of the signal (1/T mode) which is shown on the LED display. In addition there is the facility of

Delay by events where any event in a series can be selected, using the integral 6-digit LED display, to start the delayed sweep. This facility can be introduced before either the delayed time base or the main time base. In addition, the delay-by-events feature, operated before the main time base, can also be combined with time interval or frequency measurements.
The LED display panel is also used as a warning device to advise the operator of situations involving out of calibration conditions or incorrect operating control settings and the words ERROR or UNCAL are indicated, as appropriate.

TV applications
The "Delay-by-events" mode is especially appropriate for complex TV measurements by making it possible to select any particular TV line. The desired line having been selected, any part of it can be displayed magnified on the screen, either as a single trace or simultaneously with the whole selected line. The line number is automatically shown on the LED display

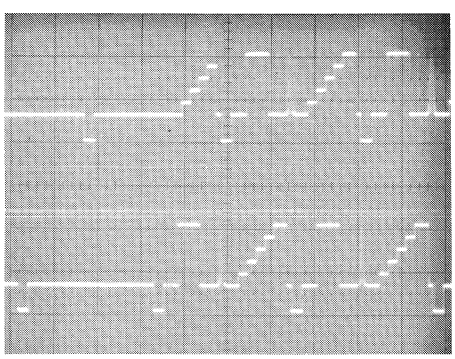
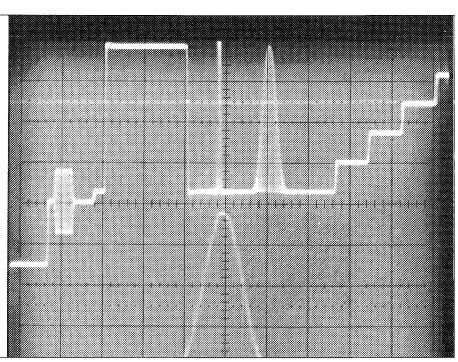


Fig. 2. Interlacing of fields is shown by applying ALT display of vertical channels.

In fig. 1 the event counter has been introduced before the main time base. In this mode a particular line has been selected and displayed on the main time base. The delayed time base is used to display a detail (2T pulse) of the selected line. ALT time base display shows both the selected line and the 2T pulse.



TECHNICAL SPECIFICATION

CRT

Type
Philips rectangular domed mesh type tue with 17kV acceleration potential and metal backed phosphor

Screen type
P 31 (GH) phosphor standard

Useful screen area
8 x 10div of full centimeters

Graticule
Internal graticule with centimeter divisions and 2mm subdivisions along the central axes. 10% and 90% lines are indicated. Illumination continuously variable

VERTICAL OR Y-AXIS

Response
DC: 0Hz...100MHz (35MHz at 2mV)
AC: 7Hz...100MHz

Risetime
3.5ns

Deflection coefficients
2mV...5V/div in steps in 1-2-5 sequence.
Uncalibrated continuous control between steps 1: > 2.5

Accuracy
± 3%

Display modes
Channel A only
Channel B only
Alternate
Chopped at approx. 1MHz
Channels A and B added
Trigger view
Trigger view with channels A and B alternate
Trigger view with channels A and B chopped
Channels A and B can be inverted.

CMRR
> 100:1 up to 2MHz
> 20:1 at 50MHz

Input impedance
1MΩ ± 2% in parallel with 15pF approx.
RC time, AC coupled: 22ms

Maximum input voltage
$400V_{DC + ACpk}$ derating above 500kHz

Maximum deflection
Undistorted deflection of 24div up to 35MHz.
Shift range 16div

Signal delay
15ns visible delay

Trigger view
Display: External or internal trigger signal
External: 100mV/div
External ÷10 : 1V/div
Trigger point: Screen centre ± 0.3div
Time delay between vertical input and external input: 3ns

HORIZONTAL OR X-AXIS

Horizontal deflection can be obtained from either the main timebase or the delayed timebase or a combination of the two, or from the signal source selected for X-deflection. In this case X-Y diagrams can be displayed using Y_A, Y_B, the EXT connector or the Line as a signal source.

Horizontal display modes

Main timebase
Main timebase intensified by one or two delayed timebases
Delayed timebase(s)
Main timebase and delayed timebase(s) simultaneously displayed (alternate)
X-Y or X-Y//Y operation with X-deflection by Y_A, Y_B, Line or Ext source

HORIZONTAL AMPLIFIER

Response
DC...2MHz (−3dB)

Deflection coefficient
50mV/div using EXT connector and 500mV/div in Ext ÷ 10 switch position. Uncalibrated continuous control 1: > 3. When Y_A or Y_B are used, sensitivities, are 2mV...5V/div

Measuring accuracy
± 3% (Ext. X-input)

Phase error
3° at 100kHz

MAIN TIME BASE

Modes
Auto (RC time 100ms)
Triggered
Single shot

Time coefficients
1s...50ns/div in 23 calibrated steps, in 1-2-5 sequence. Uncalibrated continuous control between steps, (with UNCAL warning lamp should main timebase be set out of calibration). x 10 magnifier extends max. sweep rate to 5ns/div

Accuracy
± 2% (+ 20°C...+ 30°C)
± 3% (+ 5°C...+ 40°C)
Additional error for magnifier ± 1%

Variable-hold-off
Sweep hold-off time can be increased by a factor of 10

DELAYED TIMEBASE

Time coefficients
0.5...50ns/div in 22 calibrated steps, 1-2-5 sequence. Uncalibrated continuous control between steps (with UNCAL warning lamp should delayed timebase be set out of calibration). x 10 magnifier extends max. sweep rate to 5ns/div

Accuracy
± 2% (+ 20°C...+ 30°C)
± 3% (+ 5°C...+ 40°C)
Additional error for magnifier ± 1%

DELAY MODES

Delay
Time between start of MTB and start of DTB

△T
Time between start of two successive DTB's (in Y-ALT mode the second DTB on channel A and the first DTB on channel B is suppressed)

1/T
Reciprocal value of △T mode
Events before delayed timebase
Events before main timebase
6-digit LED display shows measured quantity in engineering notation. Non calibrated or faulty operation is indicated by UNCAL or ERROR display.

Delay, △T, 1/T
Variable between 0 and 10 x main timebase setting

Resolution
5.10^{-4} of 10 x main timebase setting

Jitter
1:30000

Accuracy

Delay	△T	1/T
± 1% of range − A x 10^{-3} of range + initial delay of 20ns	± 1% of reading − A x 10^{-3} of range ± 0.25 x 10^{-3} of range	± 1% of reading − A x 10^{-3} of range ± 0.25 x 10^{-3} of range

A depends on main timebase setting
A = 1.5 in settings starting at 5
A = 0.5 in settings starting at 1
A = 0 in settings starting at 2

Additional error in main timebase positions 50ns/div and 100ns/div resp. ± 3% and ± 1%
Minimum screen distance between measuring points in 1/T mode.
0.1div (magnifier x 1) or
1 div (magnifier x 10)

Events before DTB
LED-display shows number of events between triggering of main timebase and delayed timebase

Events before MTB
LED-display shows number of events between release of counter and triggering of the main timebase.
Events before MTB mode may be combined with delay, △T or 1/T modes.

Number of events
Continuously controllable between 0 and 99999

Counter reset
By anticlockwise rotation of SET control

Display counter speed
Variable between 1 and 50 pulses/s or between 100 and 5000 pulses/s in steps of 100 pulses

Pulse conditions
Max. rate: 125MHz
Min. pulse width: 4ns
Min. pulse space: 4ns

Set up time
10ns

In the TV trigger mode, the LED display shows the line number. (Conforms EBU and CCIR standards.)

MAIN TIMEBASE TRIGGERING

(For TV modes see "TV TRIGGERING")
Trigger source
Internal Y_A, Y_B, Composite, Line, External, External ÷ 10.

Slope
+ or −

Level range
Internal: 24div
External: + 1.2V to − 1.2V
External: ÷ 10: + 12V to − 12V

Trigger sensitivity

	30MHz	100MHz
Int	0.5div	1.5div
Ext	50mV	150mV
Ext ÷ 10	500mV	1.5mV

Trigger coupling
DC: DC...full bandwidth
HF: 30kHz...full bandwidth
LF: internal 0...30kHz
external 7Hz...30Hz

Ext Trigger input impedance
1MΩ ± 2% in parallel with 15pF approx.

Maximum allowable input voltage
$400V_{DC + ACpk}$

Trigger jitter
Better than 0.5ns

TV TRIGGERING

Trigger input polarity
Switchable for positive and negative video.

Trigger input source
Via the main timebase channel.

Trigger mode
TV LINE: triggering, on any line
TV FIELD: on any field
TV FRAME: triggering on field 1 with slope switch at ' +', on field 2 with slope switch at '−'

Trigger sensitivity
INT: 0,5div
EXT: 50mV
EXT ÷ 10:500mV
(all employing sync. part of video signal).

Trigger level
Set automatically for TV triggering.

DELAYED TIMEBASE TRIGGERING

Trigger source
Internal: Y_A or Y_B
External
In the TV trigger mode the DTB can be triggered by the TV line.
Other characteristics are identical to MAIN TIME BASE TRIGGERING

CALIBRATION

Calibrated voltage
$3V_{p-p}$ ± 1% square wave

Calibrated current
$6mA_{p-p}$ ± 2% square wave

Z-MODULATION

Input
DC-coupled, TTL compatible, 'HIGH' level blanks the display

Input impedance
10KΩ

Maximum input volt.
50V

Response time
35ns

MAIN TIME BASE GATE

0 up to + 5V

Output impedance
1KΩ

DELAYED TIME BASE GATE

0 up to + 5V

Output impedance
1KΩ

POWER

Line voltages and frequencies
AC: 100...127V and 220...240V, 46...440Hz
DC: 250...350V

Power consumption
60W at nominal line voltage

DIMENSIONS AND WEIGHT

(w x h x d) 316 x 154 x 460mm
(12.4 x 6.1 x 18-in)
10.7kg (23.5lb)

ENVIRONMENTAL CAPABILITIES

The environmental data are valid only if the instrument is checked in accordance with the official checking procedure. Details on these procedures and failure criteria are supplied on request by the PHILIPS organization in your country, or by PHILIPS' TEST AND MEASURING DEPARTMENT, EINDHOVEN, HOLLAND.

Ambient temperatures
Rated range of use: + 5°C to 40°C
Limits for operation: − 10°C to + 55°C
Storage and transport: − 55°C to + 75°C

Altitude
Operating: to 5000m (15000ft)
Non-operating: to 15000 (45000ft)

Humidity
21 days cyclic damp heat 25°C...40°C R.H. 95%

Shock
30g: half sine wave shock of 11ms duration:
2 shocks per direction for a total of 12 shocks

Vibration
Vibrations in three directions with a maximum of 15min per direction; 5...55Hz and amplitude of $0.7mm_{p-p}$ and 4g max acceleration
Unit mounted on vibration table without shock absorbing material.

Recovery time
Operates within 30min, coming from − 10°C soak, going into room condition of 60% RH at 20°C

Electromagnetic interference
Meets VDE 0871 and VDE 0875
Grenzwertklasse B

Safety
Safety class 1 according to IEC 348

ACCESSORIES SUPPLIED

Front cover with storage space
Operating and service manual
BNC-Banana adapter
Contrast filter
2 x 10: 1 attenuator probe
Collapsible viewing hood
Cal terminal – BNC adapter

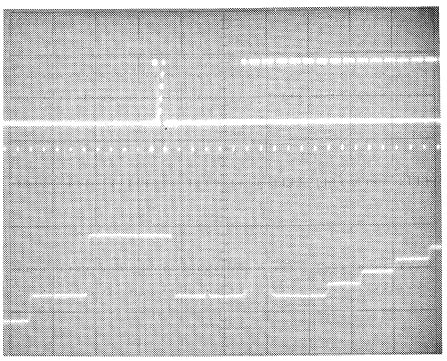


Fig. 3. ALT display of main and delayed time base shows part of first field and selected line.

ORDERING INFORMATION

PM 3263X 100MHz oscilloscope
Power options: see Introduction, page 4

OPTIONAL ACCESSORIES

PM 8921	Passive probe 1:1 (1.5m)
PM 8921 L	Passive probe 1:1 (2.5m)
PM 8927 A	Passive probe 10:1 (1.5m)
PM 8927 AL	Passive probe 10:1 (2.5m)
PM 8935	HF passive probe 10:1 (1.5m)
PM 8935 L	HF passive probe 10:1 (2.5m)
PM 8932	Passive probe 100:1 max. voltage 5600V; 2pF (1.5m)
PM 8940	High voltage isolation amplifier for floating measurements at $650V_{RMS}$
PM 8943	FET probe 650MHz, 1:1/10:1/100:1
PM 8960	19 inch rackmount adapter
PM 9355	Current probe 12Hz...70MHz
PM 9381	Oscilloscope camera
PM 8976	Camera adapter for stationary use
PM 9366	Collapsible viewing hood
PM 8980	Long type viewing hood
PM 8994	Set of accessories for probes
PM 8991	Oscilloscope trolley
PM 8901	Battery pack for 1.5 hours continuous operation
PM 8910	Polaroid anti-glare filter

Fully ruggedized and laboratory-standard specifications

Trigger view as third channel

Extremely versatile triggering with TV option

Extra-bright CRT for high ambient light conditions

Tough, lightweight compact package with shoulder strap

Compact, super-portable 75MHz service oscilloscopes PM 3254 and PM 3256

These instruments are basically high-grade oscilloscopes having performance specifications suitable for laboratory applications which have been ruggedized for tough service conditions. All elements of the 'scopes, both mechanical and electronic, have been specially selected to meet the most rigourous field servicing conditions likely to be encountered.

The user thus enjoys the joint benefits on a really high quality, high-performance 'scope within a compact, virtually shock-proof, package. Its comparatively light weight also allows it to be slung from the shoulder using the long strap provided, leaving the hands entirely free. Both instruments operate from AC line and DC sources.

Versatile triggering

Extremely versatile triggering is a feature of both instruments and can be achieved from Y_A, Y_B, composite, External or Line, in either automatic or normal mode. TTL triggering is standard but optional TV triggering is available.

The trigger-view facility can be used as a third channel if required, further extending the already versatile performance. Also, polarity inversion is available on both channels.

Bright CRT

The triggering frequency range exceeds 100MHz. This, combined with the specially developed CRT with a very small, bright spot will give extremely accurate and stable oscillograms; with the added advantage of the extra-bright CRT feature for use in high ambient light situations.

Choice of single or dual time base

Two versions are available; these are the single time base model PM 3254 and the dual time base unit PM 3256.

PM 3256

TECHNICAL SPECIFICATIONS

CRT

Type
Philips rectangular mesh type post deflection acceleration tube with 10kV accelerating voltage and metal backed phosphor.

Screen type
P31 (GH) phosphor standard

Graticule
Internal graticule with 8 x 10 divisions
Each division equals 8 mm.
Dotted lines are provided for accurate rise time measurements.

VERTICAL OR Y-AXIS

Frequency response
DC: 0 ... 75MHz
AC: 2Hz ... 75MHz

Rise time
≤4.7ns

Deflection coefficients
2mV/div ... 10V/div, 1-2-5 sequence
Uncalibrated, continuous control between steps 1:>2.5 (with UNCAL warning lamp)

Accuracy
±3%

Display modes
Channel A only
Channel B only
Channels A and B chopped at approx. 500kHz
Channels A and B alternate
Channels A and B added
Trigger view only
Trigger view with channels A and B alternate
Trigger view with channels A and B chopped
Channels A and B can be inverted

Input impedance
1MΩ//25pF

Maximum permissible input voltage
400 V (DC + AC peak)

Maximum deflection
Undistorted deflection of 24 divisions
Shift range 16 divisions

Signal delay
Built-in delay line permits viewing of leading edge of input signal.

CMRR
100:1 at 1 MHz

Trigger view

Display:	external or internal trigger signal
External:	500mV/div
Trigger point:	screen centre ± 0.3div
Band width:	internal 50 MHz; external 60 MHz

HORIZONTAL or X-AXIS

Horizontal deflections can be obtained from the main time base, the delayed time base, a combination of both, or from an external source. X-Y diagrams can therefore be displayed using Y_A and/or Y_B (vertical) versus Y_A or Y_B or EXT or Line (horizontal).

Display modes
Main time base
Main time base intensified by delayed time base
Delayed time base
Main time base intensified and delayed time base simultaneously displayed (alternate).
X-Y or X-Y/Y operation with X deflection by Y_A, Y_B, line or EXT source

HORIZONTAL AMPLIFIER

X Input

Response
DC...100 kHz (−0.5dB)

Deflection coefficients
500 mV/div using the EXT connector
When Y_A or Y_B are used, sensitivities are 2mV...10V/div

Measuring accuracy
±10%

Phase error
≤3° at 100kHz

MAIN TIME BASE

Modes
Auto p-p
Auto free run
Triggered
Single shot

Time coefficients
0.5s...50ns/div in 22 calibrated steps, in 1-2-5 sequence
Uncalibrated continuous control between steps 1:>2.5 (Main time base set out of calibration, UNCAL warning lamp is on)
× 10 magnifier extends max. sweep rate to 5ns/div.

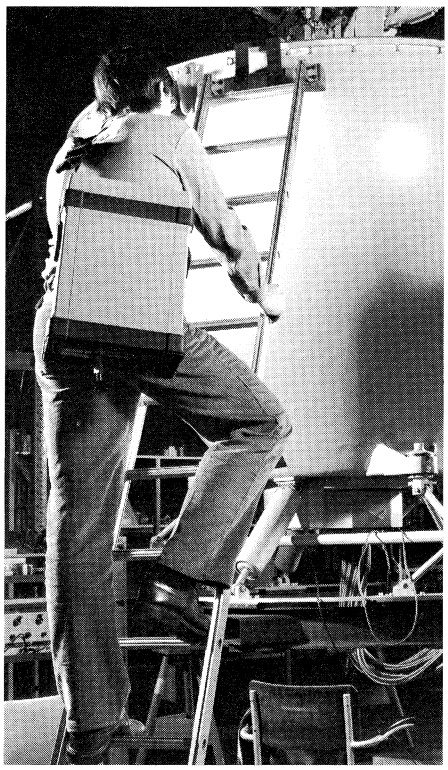
Accuracy
±3%
Additional error for magnifier ±2%

Variable hold-off
Sweep hold-of time can be increased by a factor of 10

DELAYED TIME BASE (for PM 3256 only)

Delayed time base starts either immediately after the delay time or upon arrival of the first trigger pulse after the delay time

Time coefficients
1ms/div...50ns/div in 14 calibrated steps, 1-2-5 sequence
Uncalibrated, continuous control between steps 1:>2.5 (Delayed time base set out of calibration, UNCAL warning lamp is on)
×10 magnifier extends max. sweep rate to 5 ns/div.



Because of its light weight and the shoulder strap provided PM 3254/56 can be slung from the shoulder leaving both hands free.

Accuracy
±3%
Additional error for magnifier ±2%

Sweep delay
Continuously calibrated control between O and 10 × main time base setting

Incremental delay time accuracy
0.5%

Delay time jitter
1:≥20,000

MAIN TIME BASE TRIGGERING

Trigger source
Internal: Y_A, Y_B, Composite, Line
External

Slope
+ or −

Coupling
DC-LF-HF-TTL
Optional TV or ECL instead of TTL

Level range
In Auto mode: related to peak to peak value of the trigger signal.
In normal Internal mode: +8div and −8div
In normal External mode: +4V...−4V
In TTL mode and in optional TV and ECL mode: fixed level

Trigger sensitivity

Internal:	1.5div at 100 MHz
External:	0.6Vpp at 100 MHz
Internal TTL:	TTL level in 2V/div
External TTL:	TTL level with 10:1 probe
TV (option)	
Internal TV:	0.3div sync pulse
External TV:	300mV sync pulse
Frame:	0.5...50μs main time base setting
Line:	20μs...50ns main time base setting
ECL (option):	ECL level in 0.5 V/div

Trigger frequency range
DC: 0...100 MHz
LF: 2 Hz...25kHz
HF: 25kHz...100 MHz

Input impedance
1 MΩ//25pF

Max. permissible input voltage
400V (DC+AC peak)

DELAYED TIME BASE TRIGGERING (for PM 3256 only)

Trigger source
Internal, Y_A, Y_B

Slope
+ or −

Trigger coupling
DC-LF-HF

Trigger frequency range
DC: 0...100 MHz
LF: 2 Hz...25kHz
HF: 25kHz...100 MHz

Trigger sensitivity
1div at 100 MHz

Level range
+8div and −8div

CALIBRATION

Voltage
1.2 Vpp ±1%

Frequency
2kHz approx

Z-modulation
TTL compatible
'1' is normal intensity; '0' is blanked

POWER

Line voltage and frequencies
110V AC −10% +20%, 220V and 240V AC ±10%, 50...400 Hz ±10%

DC power source
20...28V DC, negative side connected to chassis
1.5A max at 20V

Power consumption
38W when powered from nominal line voltage
30W from DC

DIMENSIONS AND WEIGHT

305 x 143 x 418 mm (12 x 5.6 x 16.5-in)
(w x h x d), incl. cover and feet
Weight: 9 kg (20 lb)

ENVIRONMENTAL CAPABILITIES

The environmental data are only valid if the instrument is checked in accordance with the official checking procedure. Details on the procedures and failure criteria are available on request from the Philips organisation in your country or from Philips' Test and Measuring Department, Eindhoven, The Netherlands.

PM 3254

Ambient temperatures
Rated range of use 0°...+40°C
Operating −10°C...+55°C
Storage −40°C...+70°C

Altitude
Operating: to 5000 m (15,000 ft)
Non-operating: to 15,000 m (45,000 ft)

Humidity
21 days cyclic damp heat 25°C−40°C, RH 95%

Shock
30g: half sine wave shock of 11 ms duration;
3 shocks per direction for a total of 18 shocks

Vibration
Vibrations in three directions with a maximum of 15 min per direction
5-55Hz and amplitude of 0.7mm$_{pp}$ and 4g max. acceleration
Unit mounted on vibration table without shock-absorbing material

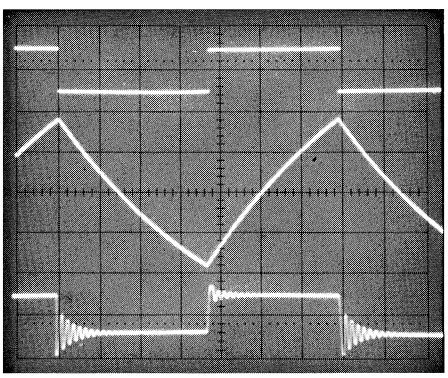
Recovery time
Operates within 30 minutes coming from −10°C soak, going into 60% relative humidity at +20°C room conditions

Electromagnetic interference
Meets VDE 0871 and VDE 0875; Grenzwertklasse B

Safety
The insulation between both oscilloscopes and line fulfills the safety requirements of IEC 348 first edition for safety class II instruments

ACCESSORIES SUPPLIED

Front cover
Operating manual
BNC −4 mm banana adapter
2×10:1 attenuator probe
PM 8981 Collapsible viewing hood



Example showing how the trigger view can be used as a third channel.

ORDERING INFORMATION

PM 3254	75MHz oscilloscope, single time base
PM 3256	75MHz oscilloscope, delayed & alternate time base

Instrument options
Option 20 - TV triggering replacing TTL triggering

Power options: See Introduction, page 4

OPTIONAL ACCESSORIES

PM 8921	Passive probe 1:1 (1.5m)
PM 8921 L	Passive probe 1:1 (2.5m)
PM 8927 A	Passive probe 10:1; 11pF (1.5m)
PM 8927 AL	Passive probe 10:1; 14pF (2.5m)
PM 8932	Passive probe 100:1; max. voltage 4000V; 2pF (1.5m)
PM 8940	High voltage isolation amplifier for floating measurements at 650V$_{RMS}$
PM 8943	FET probe 650 MHz, 1:1/10:1/100:1
PM 9355	Current Probe 12Hz...70MHz
PM 8994	Set of accessories for probes
PM 8991	Oscilloscope trolley
PM 8901	Battery pack for 4.5 hours continuous operation
PM 8992/54	Accessory pouch
PM 8997	Handle
9499.445.00911	Service manual for PM.3254
9499.445.00811	Service manual for PM 3256

50 MHz advanced general purpose oscilloscopes PM 3215 and PM 3217

High 2mV sensitivity across full 50MHz bandwidth

Easy auto-mode triggering plus level control

Automatic TV triggering on both line and frame

DC-coupled triggering

Variable trigger hold-off avoids double-writing

Full X-Y display facilities including X-X/Y

Compact size and low weight with battery option

Both models utilize to-day's most advanced circuit design and component technology to achieve an excellent, very reliable, all-round performance; for both analog **and** digital measurements.

Sensitivity remains a constant 2mV over the full 50 MHz bandwidth. The beam has a very small spot size for producing clear, crisp oscillograms on the large, 8 x 10cm display screen.

The easy, auto-mode triggering will ensure a continuous display at all times: the auto TV mode allows for automatic triggering on both line and frame.

A 200mV external triggering sensitivity permits stable triggering on TTL levels when using 10:1 probes.
The PM 3217, which in addition to the comprehensive PM 3215 specification features an extra, delayed, time base. It is fully calibrated can be used with or without the main time base intensified display and can be triggered either from the main time base or independently.

Battery options are available.

TECHNICAL SPECIFICATION

CRT

Type
Philips rectangular mesh-type post deflection accelerator tube with 10kV accelerating voltage and metal backed phosphor

Screen type
P31 (GH) phosphor standard
P 7 (GM) phosphor optional

Useful screen area
8 x 10cm

Graticule
Internal graticule with centimetre divisions and 2mm divisions along the central axes. 10% and 90% lines are indicated. Graticule illumination continuously variable.

VERTICAL OR Y-AXIS

Frequency response
DC: 0 Hz...50 MHz (−3dB)
AC: 2 Hz...50 MHz (−3dB)

Rise time
7ns

Deflection coefficients
2mV/div...10V/div 1-2-5 sequence. Uncalibrated, continuous control between steps 1: > 2.5

Accuracy
±3%

Display modes
Channel A, channel B, alternate, chopped at approx. 500kHz, added. Channel B can be inverted

Input impedance
1 MΩ//20pF

Maximum input voltage
400V (DC + AC peak)

Maximum deflection
Undistorted deflection of 24div
Shift range 16div

Signal delay
≥ 2 divisions with fastest sweep speed

CMR-factor
100:1 at 1 MHz
(A-B mode with 8 div. common mode signal)

HORIZONTAL OR X-AXIS

Horizontal deflection can be obtained from the main time base, the delayed time base, a combination of both, or from an external source. In this case X-Y diagrams can be displayed using Y_A, Y_B, the EXT connector or the mains as signal source for horizontal deflection

Display modes
X-Y or X-Y/Y operation with X-deflection by: Y_A, Y_B, External or Mains (line)

X-INPUT

Frequency response
DC...1 MHz (−3dB)

Deflection coefficients
200mV/div. using EXT connector
2V/div. using EXT ÷ 10 connector
Vertical attenuator coefficients apply when Y_A or Y_B is used for X-deflection

Measuring accuracy
± 10%

Phase error
3° at 100kHz

MAIN TIME BASE

Mode
Automatic or triggered

Time coefficients
0.5s/div...100ns/div. in 1-2-5 sequence
Uncalibrated continuous control between steps
1: > 2.5
x 10 magnifier extends max sweep rate to 10ns/div

Accuracy
± 3%
Additional error for magnifier ± 2%

DELAYED TIME BASE (for PM 3217 only)

The delayed time base either starts immediately after the delay time, or is triggerable after delay time by the selected delayed time base trigger source

Time coefficient
1ms/div...100ns/div. in 1-2-5 sequence
x 10 magnifier extends max. sweep rate to 10ns/div

Accuracy
± 3%
Additional error for magnifier ± 2%

Sweep delay
Variable in steps with main time base
Continuously variable with 10-turn potentiometer between 0 x and 10 x the time coefficient of the main time base

Incremental delay time accuracy
0.5%

Delay time jitter
1: ⩾ 20 000

MAIN TIME BASE TRIGGERING

Trigger source
Internal: Y_A, Y_B, Composite, Line
External
External ÷ 10

Slope
+ or –

Trigger modes
Auto, AC, DC, TV-frame, TV-line

Trigger sensitivity
Internal: 1.0 div at 50 MHz
External: 0.2Vpp at 50 MHz
External ÷ 10:2 Vpp at 50 MHz
TV int: 0.7 div. sync pulse
TV ext: 0.15 Vpp sync pulse
TV ext ÷ 10:1.5 Vpp sync pulse

Trigger frequency range
Auto: 20 Hz...> 50 MHz
AC: 5 Hz...> 50 MHz
DC: 0 Hz...> 50 MHz

Trigger level range
Auto: automatically adjusted between limits of signal amplitude
Internal (AC, DC): 8 div.
External (AC, DC): 1.6V
External ÷ 10 (AC, DC): 16V

Input impedance
1 MΩ//20pF

Maximum permissible input voltage
400V (DC + AC peak)

Variable hold-off
Sweep hold-off time can be increased by a factor of 10.

DELAYED TIME BASE TRIGGERING (for PM 3217 only)

Trigger source
Internal, Y_A, Y_B, Composite, External

Slope
+ or –

Trigger modes
AC, DC

Trigger frequency range
AC: 5 Hz...⩾ 50 MHz
DC: 0 Hz...⩾ 50 MHz

Trigger sensitivity
Internal: 2.0div at 50 MHz
External: 0.4Vpp at 50 MHz

Trigger level range
Internal (AC, DC): 14div
External (AC, DC): 2.8V
External ÷ 10 (AC, DC): 28V

Input Impedance
1 MΩ//20pF

CALIBRATION

Voltage
1.2Vpp ± 1% square wave

Frequency
2kHz approx.

POWER

Line voltage and frequencies
110, 127, 220 and 240V_{AC} ± 10%, 46...440 Hz

DC power source
22...27 V_{DC} negative side connected to chassis 1.1A max.

Power consumption
30W when powered from nominal line voltage for PM 3217
28W for PM 3215

Z-Modulation
TTL compatible: low level blanks the display

DIMENSIONS AND WEIGHT

PM 3217
(w x h x d) 330 x 135 x 420mm
(12.9 x 5.3 x 16.5-in)
8.4kg (18.4lb)

PM 3215
(w x h x d) 300 x 135 x 420mm
(11.8 x 5.3 x 16.5-in)
7.5kg (16.5lb)

ENVIRONMENTAL CAPABILITIES

The environmental data are valid if the instrument is checked in accordance with the official checking procedure. Details on these procedures and failure criteria are supplied on request by the Philips organisation in your country or by Philips' Test and Measuring Department, Eindhoven, Holland.

Ambient temperatures
Rated range of use +5°C...+40°C
Operating –10°C...+55°C
Storage –40°C...+70°C

Altitude
Operating: to 5000m (15,000 ft)
Non-operating: to 15,000m (45,000 ft)

Humidity
21 days cyclic damp heat 25°C-40°C, RH 95%

Shock
30g: half sine wave shock of 11ms duration:
3 shocks per direction for a total of 18 shocks

Vibration
Vibrations in three directions with a maximum of 15min per direction
5-55 Hz and amplitude of 0.7mm_{pp} and 4g max. acceleration.
Unit mounted on vibration table without shock-absorbing material

Recovery time
Operates within 30 minutes coming from –10°C soak, going into 60% relative humidity at +20°C room conditions.

Electromagnetic interference
Meets VDE 0871 and VDE 0875
Grenzwertklasse B

INSTRUMENT OPTIONS

– Main time base sweep output
– Main time base gate output
– Delayed time base gate output
Available as service modifications
Contact your local Philips field engineer for detailed information

ACCESSORIES SUPPLIED

Front cover
Operating manual
BNC –4 mm banana adaptor
Contrast filter
2 x 10:1 attenuator probe

ORDERING INFORMATION

PM 3215	50MHz oscilloscope single time base
PM 3217	50MHz oscilloscope delayed and alternate time base

Instrument options
Option 10 - P7 long-persistence CRT
Option 30 - rackmount version
Option 80 - battery version including charger
Power option: see Introduction, page 4

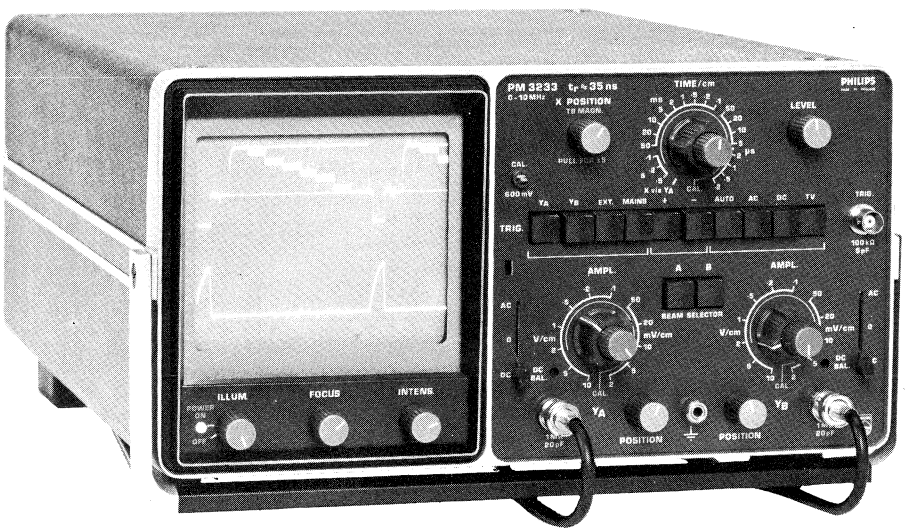
OPTIONAL ACCESSORIES

PM 8921	Passive probe 1:1 (1.5m)
PM 8921L	Passive probe 1:1 (2.5m)
PM 8927A	Passive probe 10:1; 11 pF (1.5m)
PM 8927AL	Passive probe 10:1; 14 pF (2.5m)
PM 8932	Passive probe 100:1; max. voltage 4000V; 2 pF (1.5m)
PM 8940	High voltage isolation amplifier for floating measurements at 650V_{RMS}
PM 8943	FET probe 650 MHz, 1:1/10:1/100:1
PM 8962	19-in rackmount adapter for PM 3215
PM 8963/01	19-in rack mount adapter for PM 3217
PM 9355	Current probe 12 Hz...70 MHz
PM 9381	Oscilloscope camera
PM 8972	Camera adapter for stationary use
PM 9366	Collapsible viewing hood
PM 8980	Long type viewing hood
PM 8994	Set of accessories for probes
PM 8991	Oscilloscope trolley
PM 8901	Battery pack for 12 hours continuous operation
PM 8910	Polaroid anti-glare filter
PM 8992	Accessory pouch
9499.445. 00511	Service manual for PM 3215
9499.445. 00611	Service manual for PM 3217

10MHz dual beam oscilloscope PM 3233

10MHz/2mV
True dual beam operation
Signal delay in both vertical channels
Comprehensive triggering facilities (Auto, AC, DC and TV)

The PM 3233 has a high 2mV sensitivity across the full bandwidth. It is a true dual beam instrument, so there is no possibility of phase errors as in timeshared oscilloscopes, and it has universal triggering facilities that include choice of source, DC coupling, automatic level and automatic TV line/frame positions.
The rectangular CRT has a large 8 x 10cm screen and excellent light output due to the 10kV post acceleration and the dual beam principle. This allows extremely low duty cycle signals to be displayed. In the automatic position the time base is free running (in the absence of a signal) for quick zero line references at all sweep speed settings. In the automatic mode the triggering level is derived from the signal. The 'scope also has DC as well as AC coupling, plus the special TV position that gives fully automatic line or frame-derived triggering.
The whole screen area can be covered by both beams and displays are extremely bright due to the use of a 10kV meshtype, dual-beam pda tube.



TECHNICAL SPECIFICATION

CRT

Type
Philips rectangular mesh type splitbeam tube, with 10kV acceleration potential and metal backed phosphor.

Screen type
P31 (GH) phosphor standard. For P7 (GM) long persistence phosphor, order PM 3233G

Useful screen area
8cm x 10cm for both beams.

Overlap of the two systems
100%

Graticule
External with centimeter devisions and subdivisions of 2mm along the central axes. 10% and 90% lines are indicated.

Graticule illumination
Continuously variable.

VERTICAL OR Y-AXIS

Two identical amplifiers, one for each deflection system. The input stages are provided with an active drift-feedback circuit, giving an extremely stable display.

Response
DC: 0Hz...10MHz (−3dB)
AC: 2Hz...10MHz (−3dB)

Risetime
35ns

Deflection coefficients
2mV/cm...10V/cm in twelve steps in 1-2-5 sequence. Uncalibrated, continuous control between the steps.

Measuring accuracy
± 3%

Over- (under-) shoot
≤ 2% (with a test pulse of 10ns risetime for 6cm of deflection at 1MHz).

Input impedance
1MΩ//20pF
Input RC time when AC coupled 100ms.

Maximum input voltage
400$V_{DC+ACpk}$

Maximum deflection
For sinewave signals with frequencies of up to 3MHz, the vertical deflection will be undistorted for a total amplitude of 24cm. With the aid of the positioning controls, the peaks of such a signal can be displayed.

Signal delay
150ns total, 80ns visible.

DC-drift at maximum sensitivity
¼cm/hour

HORIZONTAL OR X-AXIS

Horizontal deflection can be obtained from an internally generated, triggered time-base or from an external signal, connected to the Y_A input. In this case X−Y diagrams can be displayed with full sensitivities for both directions.

HORIZONTAL AMPLIFIER

Response
DC: 0Hz...1MHz (−3dB)
AC: 2Hz...1MHz (−3dB)

Deflection coefficients
2mV/cm...10V/cm in twelve calibrated steps in 1-2-5 sequence. Uncalibrated continuous control between steps.

Measuring accuracy
± 5%

Phase error
5° at 100kHz

For all other specifications see vertical amplifiers

TIME BASE

Time coefficients
0.5s/cm...0.2μs/cm in twenty calibrated steps in 1-2-5 sequence. Uncalibrated continuous control between steps.

Measuring accuracy
$\pm$ 5%

Time base magnifier
5 x, giving a display equivalent to 50cm, every 10cm of which can be made visible by using the horizontal positioning control. The measuring accuracy with magnified sweep is 7%.

Time base output
$6V_{p\text{-}p}$ (from -2V to $+4$V open output voltage).

Time base output into 50Ω
$300mV_{p\text{-}p}$

Internal resistance
1kΩ
The time base output may be short-circuited without affecting the accuracy of the time coefficients.

TRIGGERING

The time base generator operates in the triggered mode with adjustable level and slope when an input signal is applied. An autocircuit can be switched in, providing a bright zero line at all sweep speeds under no signal conditions. In this automode, triggering is possible at an adjustable trigger level, the level automatically being limited to the peak-peak amplitude of the signal.

Trigger source
Internal: Y_A
Y_B
Line

External

Trigger slope
+ or $-$

Trigger modes and coupling
Auto: 20Hz...10MHz
AC: 10Hz...$\geqslant$ 10MHz
DC: 0Hz...$\geqslant$ 10MHz
TV: Fully automatic triggering on TV-video signals, selection of 'frame' and 'line' automatically being made with the time base speed.

Trigger sensitivity
Internal: 1cm up to 10MHz
External: 1V up to 10MHz

Input impedance
100kΩ//5pF

Maximum input voltage
$400V_{DC+ACpk}$

Level range
Internal: 24cm (with continuous attenuator in 'CAL' position)
External: 24V.
In the automatic mode, the level range is automatically adjusted to the signal amplitude. The trigger level is **not** influenced by the vernier controls of the vertical deflection factors.

CALIBRATION

Calibrated voltage: 600mV $\pm$ 1%, square wave
Frequency: 2kHz approximately.

Intensity modulation
Blanking voltage: 20V
Input resistance: 47kΩ
Frequency range: 20Hz...1kHz
Maximum input voltage: $400V_{DC+ACpk}$

ENVIRONMETAL CAPABILITIES

The environmental data are valid only if the instrument is checked in accordance with the official checking procedure. Details on these procedures and failure criteria are supplied on request by the PHILIPS organization in your country, or by PHILIPS' TEST AND MEASURING DEPARTMENT, EINDHOVEN, HOLLAND.

Ambient temperatures
Rated range of use: +5°C...+40°C
Operating: $-$10°C...+55°C
Storage: $-$40°C...+70°C

Altitude
Operating: to 5000m (15000ft)
Non-operating: to 15000m (45000ft)

Humidity
21 days cyclic damp heat 25°C...40°C R.H. 95%

Bump
1000 bumps of 10g, ½ sine, 6ms duration, in each of 3 directions

Vibration
30 minutes in each of three directions, 10...150Hz; $0.7mm_{p\text{-}p}$ and 5g max. acceleration
Unit mounted on vibration table with shock absorbing material.

Recovery time
Operates within 30 minutes coming from $-$10°C soak, going into 60% relative humidity at +20°C room conditions.

Electromagnetic interference
Meets VDE 0871 and VDE 0875
Grenzwertklasse B

Safety
Safety class 1 according to IEC 348

POWER

Line voltages and frequencies
AC: 90V...140V and 180V...265V, 46...440Hz
DC: 22V...30V

Power consumption
AC: 40VA at 220V
DC: 0.85A at 24V

DIMENSIONS AND WEIGHT

(w x h x d) 326 x 185 x 503mm
(12.8 x 7.3 x 19.8-in)
9.5kg (21lb)

ACCESSORIES SUPPLIED

Front cover
Operating and service manual
BNC-Banana adapter
Contrast filter

OPTIONAL ACCESSORIES

PM 9326	Passive probe 1:1/10:1 (1.1m)
PM 9327	Passive probe 1:1/10:1 (2.1m)
PM 8923	Passive probe 1:1/10:1
PM 8921	Passive probe 1:1 (1.5m)
PM 8921L	Passive probe 1:1 (2.5m)
PM 8927A	Passive probe 10:1; 11pF (1.5m)
PM 8927AL	Passive probe 10:1; 14pF (2.5m)
PM 8932	Passive probe 100:1; max. voltage 5600V, 2pF (1.5m)
PM 8940	High voltage isolation amplifier for floating measurements are $650V_{RMS}$
PM 8943	FET probe 650MHz, 1:1/10:1/100:1
PM 9359	19-in rackmount adapter
PM 9355	Current probe 12Hz...70MHz
PM 9381	Oscilloscope camera
PM 8973	Camera adapter for stationary use
PM 9366	Collapsible viewing hood
PM 8980	Long type viewing hood
PM 8994	Set of accessories for probes
PM 8991	Oscilloscope trolley
PM 8901	Battery pack for 9 hours continuous operation

15MHz dual trace oscilloscope PM 3211

15MHz/2mV

Large, bright 8 x 10cm screen

Comprehensive trigger and display facilities, including TV triggering

Double insulation avoids ground loop interference

A ± B display

Designed for general-purpose, everyday, use in laboratories, service workshops and field applications the PM3211, whilst of compact dimensions, features a fullsize 8 x 10 cm screen. The A and B channels can be added and the B channel inverted so that A + B or A − B can be displayed.

The comprehensive trigger and display facilities include multi-sourced 'Auto' or 'Level' set modes (no need to reverse the probes and TV triggering.)

Channel B can also be used as an X-input allowing X-Y displays to be made at all attenuation settings.

The continuously variable timebase simplifies such measurements as, for example, phase, or timing comparisons.

A x5 magnifier extends the maximum sweep rate to 100ns/cm. Interference introduced by ground loops is eliminated by the double insulation technique, which allows a 2-wire line connection to be used. The unit will operate from 110...240V_{AC} at 46...440Hz, supplies.

A sturdy carrying handle protects both the CRT and controls during transportation. This very versatile, compact instrument weighs only 7.5kg (16.5lb).

TECHNICAL SPECIFICATION

CRT

Type
Philips rectangular mesh-type post deflection accelerator tube with 4kV accelerating voltage

Screen type
P31 (GH) phosphor standard

Useful screen area
8 x 10div of 1cm

Graticule
External graticule with centimeter divisions and 2mm divisions along the central axes.

VERTICAL

Response
DC: 0Hz...15MHz (−3dB)
AC: 10Hz...15MHz (−3dB)

Risetime
23ns

Deflection coefficient
2mV...10V/div calibrated steps, 1-2-5 sequence.

Accuracy
± 3%

Display modes
Channel A only
Channel B only
Alternate
Chopped at 250kHz approx.
Added
Channel B can be inverted

CMRR
100:1 at MHz
(A-B mode with 8div of common mode signal)

Input impedance
1MΩ//25pF

Input coupling
AC, DC, O

Maximum input voltage
400$V_{DC+ACpk}$

Maximum deflection
Display is undistorted for a maximum deflection of up to 24div for sine wave signals with frequencies of up to 5MHz.
Shift range ±8div.

HORIZONTAL

Horizontal display modes
– Time base
– X-Y operation with X deflection via Y_B input

HORIZONTAL AMPLIFIER

Response
DC: 0Hz...1MHz (−3dB)

Deflection coefficients
See Y-axes

Phase error
3° at 50kHz

TIME BASE

Modes
– Auto-free-run with automatic top detection
– Triggered

Time coefficients
0.2s/div...0.5μs/div in 18 calibrated steps in 1-2-5 sequence. Uncalibrated continuous control between steps 1: $\geqslant$ 2.5

Accuracy
$\pm$3%
Additional error for magnifier: $\pm$2%

TRIGGERING

Trigger source
Internal: Y_A
Y_B
Line

External

Slope
+ or –

Trigger sensitivity
Internal: 0.75div at 5 MHz
External: 0.4V at 5 MHz

Trigger modes and coupling
AFR: 20 Hz...15 MHz
Normal: 10 Hz...15 MHz
: TV triggering

External trigger input impedance
1 MΩ//25pF

Max. allowable input voltage
400$V_{DC+ACpk}$

CALIBRATION

Signal available for probe adjustment

POWER

Line voltages and frequencies
110, 127, 220 and 240V_{AC} $\pm$10% 46...440 Hz

Power consumption
20W at nominal line voltage

ENVIRONMENTAL CAPABILITIES

The environmental data are valid only if the instrument is checked in accordance with the official checking procedure. Details on these procedures and failure criteria are supplied on request by the PHILIPS organization in your country, or by PHILIPS' TEST AND MEASURING DEPARTMENT, EINDHOVEN, HOLLAND.

Ambient temperatures
Rated range of use: +5°C...+40°C
Limits for operating: –10°C...+55°C
Storage: –40°C...+70°C

Altitude
Operating: to 5000m (15000ft)
Non-operating: to 15000m (45000ft)

Humidity
21 days cyclic damp heat 25°C...40°C R.H. 95%

Shock
30g: half sine wave shock of 11ms duration: 3 shocks per direction for a total of 18 shocks.

Vibration
Vibrations in three directions with a maximum of 15min per direction; 5...55 Hz and amplitude of 0.7mm_{p-p} and 4g max. acceleration.
Unit mounted on vibration table without shock absorbing material.

Recovery time
Operates within 30 minutes coming from –10°C soak, going into 60% relative humidity at +20°C room conditions.

Electromagnetic interference
Meets VDE 0871 and VDE 0875
Grenzwertklasse B

Safety
The insulation between PM 3211 and line fulfills the safety requirements of IEC 348 for metal encased Class II instruments

DIMENSIONS AND WEIGHT

(w x h x d) 300 x 135 x 445mm
(11.8 x 5.3 x 17.5-in)
7.5kg (16.5lb)

ACCESSORIES SUPPLIED

Operating and service manual
Front cover
BNC-Banana adapter

OPTIONAL ACCESSORIES

PM 9326	Passive probe 1:1/10:1 (1.1m)
PM 9327	Passive probe 1:1/10:1 (2.1m)
PM 8923	Passive probe 1:1/10:1
PM 8921	Passive probe 1:1 (1.5m)
PM 8921L	Passive probe 1:1 (2.5m)
PM 8927A	Passive probe 10:1; 11pF (1.5m)
PM 8927AL	Passive probe 10:1; 14pF (2.5m)
PM 8932	Passive probe 100:1; max. voltage 5600V; 2pF (1.5m)
PM 8940	High voltage isolation amplifier for floating measurements at 650V_{RMS}
PM 8943	FET probe 650 MHz, 1:1/10:1/100:1
PM 8962	19-in rackmount adapter
PM 9355	Current probe 12 Hz...70 MHz
PM 9381	Oscilloscope camera
PM 8972	Camera adapter for stationary mounting PM 9381
PM 8992	Accessory pouch
PM 9366	Collapsible viewing hood
PM 8980	Long type viewing hood
PM 8910	Polaroid anti-glare filter
PM 8991	Oscilloscope trolley
PM 8994	Set of accessories for probes

15MHz dual trace oscilloscope PM 3207

15MHz/5mV
2000V acceleration voltage
Large 8 x 10 cm screen
Auto, TV triggering
Same sensitivity on X and Y channels
B-invert facility
Triggering from A or B channel
Double insulation

The PM 3207 exhibits many features associated with more sophisticated, expensive, oscilloscopes, yet remains an extremely compact and lightweight instrument. Whilst ideal for a very wide range of field applications, it is equally acceptable for workshop use, because of its small size.

The rectangular 8 x 10cm screen gives a bright, crisp display under all conditions of use, even in 'dirty' environments. Weak signals will be adequately handled by the 5mV sensitivity (e.g., even 1:100 and 1:10, at 50 or 500nV/div.). Moreover, sensitivity is the same for both directions in the X–Y mode, with X-deflection via the A input.

The B-invert switch allows signals with inverted polarity to be displayed in phase with the reference signal. It also operates in the X–Y mode, allowing direct comparison of traces by inverting the polarity of the Y signal.

Auto triggering ensures a stable trace, locked to the screen at all times, yet allows trigger level adjustment between the peaks of a signal. In addition, triggering is possible from either A or B channel to avoid frequent changing of input cables during a test.

Double insulation allows otherwise difficult measurements, where results can be seriously affected by the presence of hum from grounds loops. Electrical safety is also assured by the double-insulated power supplies.

The unit is fully environmentally tested for use in workshop, field or industrial environments.

TECHNICAL SPECIFICATION

CRT

Type
Philips rectangular tube with 2kV acceleration voltage

Screentype
P43 (GY) phosphor standard
P7 (GM) phosphor optional

Useful screen area
8 x 10div of 1cm

Graticule
Internal graticule with centimetre division and 2mm divisions along the central axes

VERTICAL OR Y-AXIS

Response
DC: 0Hz...15MHz (–3dB)
AC: 10Hz...15MHz (–3dB)

Risetime
23ns

Deflection coefficient
5mV...10V/div. calibrated steps, 1-2-5 sequence

Accuracy
± 5%

Display modes
A
A ± B
A& ± B
± B

Input impedance
1 MΩ//35pF

Input coupling
AC, DC

Rated input voltage
400V (DC + AC peak)

HORIZONTAL OR X-AXIS

Horizontal display modes
– Time base
– X-Y operation with X deflection via Y_A input

HORIZONTAL AMPLIFIER

Response
DC: 0 Hz...2 MHz (−3dB)

Deflection coefficients
See Y-axis

Phase error
3° at 10kHz

TIMEBASE

Time coefficients
0.2s/div...0.5μs/div in 2 x 9 calibrated steps in 1-2-5 sequence
x 5 magnifier extends max sweep rate to 100ns/div

Accuracy
± 5%
Additional error for magnifier: ± 2%

TRIGGERING

Trigger source
Internal: Y_A or Y_B
External

Trigger coupling
AC, TV

Slope
+ or −

Trigger sensitivity
Internal: 0.75div at 100kHz
External: 0.75V at 100kHz

Automatic trigger
Adjustable between peaks of signal

External trigger input impedance
1 MΩ//35pF

Rated input voltage
400V (DC + AC peak)

CALIBRATION

Signal available for probe adjustment

ENVIRONMENTAL CAPABILITIES

The environmental data are valid only if the instrument is checked in accordance with the official checking procedure. Details on these procedures and failure critera are supplied on request by the PHILIPS organisation in your country, or by PHILIPS' TEST AND MEASURING INSTRUMENTS DEPARTMENT, EINDHOVEN, HOLLAND.

Ambient temperatures
Rated range of use: +5°C...+40°C
Limits for operating: −10°C...+45°C
Storage: −40°C...+60°C

Altitude:
Operating: to 5000m (15000ft)
Non-operating: to 15000m (45000ft)

Humidity
21 days cyclic damp heat at 25°C...40°C, R.H. 95%

Shock
30g: half sine wave shock of 11ms duration:
3 shocks per direction for a total of 18 shocks.

Vibration
3g vibrations in three directions with a maximum of 15min per direction; 10 minutes with a frequency of 15...25 Hz and amplitude of 1mm_{p-p}. Unit mounted on vibration table without shock absorbing material.

Recovery time
Operates within 30 minutes coming from −10°C soak, going into 60% relative humidity at +20°C room conditions.

Safety
The insulation between PM 3207 and line fulfills the safety requirements of IEC 248 for Class II instruments.

POWER

Line voltage and frequencies
110, 220 and 240VAC ± 10%, 45...66 Hz

Power consumption
25W at nominal line voltage.

DIMENSIONS AND WEIGHT

(w x h x d) 300 x 130 x 370mm
(11.8 x 5 x 14.6-in)
4.9kg (10.8lb)

ACCESSORIES SUPPLIED

Operating manual

OPTIONAL ACCESSORIES

PM 9326	Passive probe 1:1/10:1 (1.1m)
PM 9327	Passive probe 1:1/10:1 (2.1m)
PM 8923	Passive probe 1:1/10:1
PM 8921	Passive probe 1:1 (1.5m)
PM 8921L	Passive probe 1:1 (2.5m)
PM 8927A	Passive probe 10:1; 11pF (1.5m)
PM 8927AL	Passive probe 10:1; 14pF (2.5m)
PM 8932	Passive probe 100:1; max voltage 5600V, 2pF (1.5m)
PM 8940	High voltage isolation amplifier for floating measurements at $650V_{RMS}$
PM 8943	FET probe 650 MHz; 1:1/10:1/100:1
PM 8967	19-in rackmount adapter
PM 9381	Oscilloscope camera
PM 9366	Collapsible viewing hood
PM 8980	Long type viewing hood
PM 8994	Set of accessories for probes
PM 8987	Front cover
PM 8995	Set of wire-wrap adapters
PM 9355	Current probe 12 MHz...70 MHz

NEW

Professional specification for 'amateur' cost
Large 8 x 10cm screen
Full 15MHz bandwidth with 5mV sensitivity
Automatic triggering for stable trace
TV triggering for TV and video applications
Choice of triggering from A or B channels or externally
External Z-modulation facility
Meets CSA, IEC, VDE safety standards
Light and compact with ruggedized case
Wide operating temperature range

15MHz low-cost general purpose oscilloscope PM 3206

The PM 3206 represents a unique commercial breakthrough by offering a professional-performance oscilloscope within a hobbyists price-range. The wide range of features, normally associated with more expensive instruments, are truly impressive.

Its 15MHz bandwidth with 5MHz sensitivity for both X and Y channels puts it into the professional class and the specially designed CRT with its small spot and high intensity ensures a clear, well-defined trace. The large 8 x 10cm screen provides a full 80 square centimeters of useful space, with an internal graticule to avoid parallex errors, even when viewing from the side.

Stable triggering
Another necessary feature for such a low-cost instrument is a triggering capability which ensures a really stable trace.

TV triggering
For TV and video applications, PM 3206 has a TV triggering facility allowing line and frame observations.

Trigger-channel selection
It is possible to trigger from either the A or B channel and also externally, significantly extending the overall measuring capability.

External Z-modulation
Blanking parts of the display at time intervals determined by the Z-modulation input allows the display of a third parameter. This is especially useful in the X-Y mode, when neither variable is a time-related measurement.

Many other features
In addition to these professional features, this inexpensive oscilloscope is compact and rugged, weighing only 4.9 kg. It will operate over a very wide temperature range and meets CSA, IEC and VDE safety requirements. All printed circuit boards are moisture-resistant and the scratch-resistant case is also fire-retardent.
Moreover, several units can be stacked one above the other without creating any temperature build-up problems.

High quality maintained
Design and production standards are equal to those applying to the more sophisticated range of oscilloscopes and include full vibration and shock tests plus climatic cycling checks, etc, etc.

TECHNICAL SPECIFICATION

DISPLAY

CRT
Rectangular tube
2kV Acceleration voltage

Screen
P31 (GH) phosphor
Internal graticule with 0%, 10%, 90% and 100% indications
Useful screen area 8 x 10cm

VERTICAL DEFLECTION

Frequency response
DC: 0Hz...15MHz (−3dB)
AC: 10Hz...15MHz (−3dB)

Rise time
23ns

Deflection coefficients
5mV/div...20V/div, 1-2-5 sequence

Accuracy
±5%

Display modes
Channel A, Channel B, AC or DC coupled

Input impedance
1MΩ // 35pF

Maximum input voltage
400V (DC + AC peak)

Dynamic range
16div at 1MHz

Pulse aberrations
3% at 6div - input pulse < 7ns

Crosstalk between channels
−35dB at 10MHz
−45dB at 1MHz

HORIZONTAL DEFLECTION

Horizontal deflection can be obtained from the timebase generator or from an external source via channel A.

TIMEBASE

Time coefficients
0.5 μs/div...200 ms/div, 2 x 9 calibrated steps in 1-2-5 sequence.
Uncalibrated continuous control between the steps 1:2.5

Accuracy
±5%

Magnifier
x 5, max. sweep speed 100ns/div
Additional error ±2%

TRIGGERING

Source
Channel A, channel B, EXT

Coupling
NORM, TV

Slope
+ or −

Level range
Internal: ±8div
External: ±6V

Sensitivity	100kHz	15kHz	TV-line/frame
Internal	0.75div	1.0div	0.5div sync.
External	0.75div	1.0V	0.5V sync.

Imput impedance
1 MΩ // 35pF

Maximum input voltage
400V (DC + AC peak)

EXTERNAL X-DEFLECTION

Input
Via channel A

Frequency response
DC... 1 MHz (−3dB)

Deflection coefficients
As for channel A

Accuracy
± 10%

Phase shift
3° at 0.1 MHz

MISCELLANEOUS

EXT. Z-MOD
TTL compatible, DC coupled
Logic "1" blanks display

PROBE ADJUSTMENT OUTPUT
Internal timebase gate pulse is available at front panel socket for probe adjustment.

POWER REQUIREMENTS

Line voltage
120V, 220V or 240V (±10%)

Frequency
45...66 Hz

Power consumption
28 VA

Safety
Class I (IEC348)

DIMENSIONS AND WEIGHT
(w x d x h)
378 x 348 x 142mm
(14.9 x 13.7 x 5.6in)
5kg (approx. 11lbs)

ENVIRONMENTAL CAPABILITIES

Ambient Temp.
Rated Range of use: + 5°c...+ 40°C
Limits for operating: −10°C...+55°C
Storage and transport: −40°C...+70°C

Altitude
Operating: 5000m
Non-operating: 1500m

Humidity
As per IEC 68 Db

Shock
30g half sinewave of 11ms duration
3 shocks per direction

Vibration
3g vibrations in three directions with a maximum of 15 min per direction;
10 minutes with a frequency of 15....25 Hz and amplitude of 1mm p-p
Unit mounted on vibration table without shock absorbing material.

Recovery time
Operates within 30 minutes coming from −10°C soak, going into 60% relative humidity at +20°C room conditions.

ACCESSORIES SUPPLIED
Operating manual

ORDERING INFORMATION

PM 3206 15MHz oscilloscope

Instrument options
Option 60: 24V_{DC} Power supply

Power options: see Introduction, page 4

OPTIONAL ACCESSORIES

PM 8922	Passive probe 1:1/10:1
PM 8921	Passive probe 1:1 (1.5m)
PM 8921L	Passive probe 1:1 (2.5m)
PM 8927A	Passive probe10:1; 11pF (1.5 m)
PM 8927AL	Passive probe 10:1; 14pF (2.5m)
PM 8932	Passive probe 100:1; max voltage 5600 V, 2pF (1.5 m)
PM 9381	Oscilloscope camera
PM 9366	Collapsible viewing hood
PM 8980	Long type viewing hood

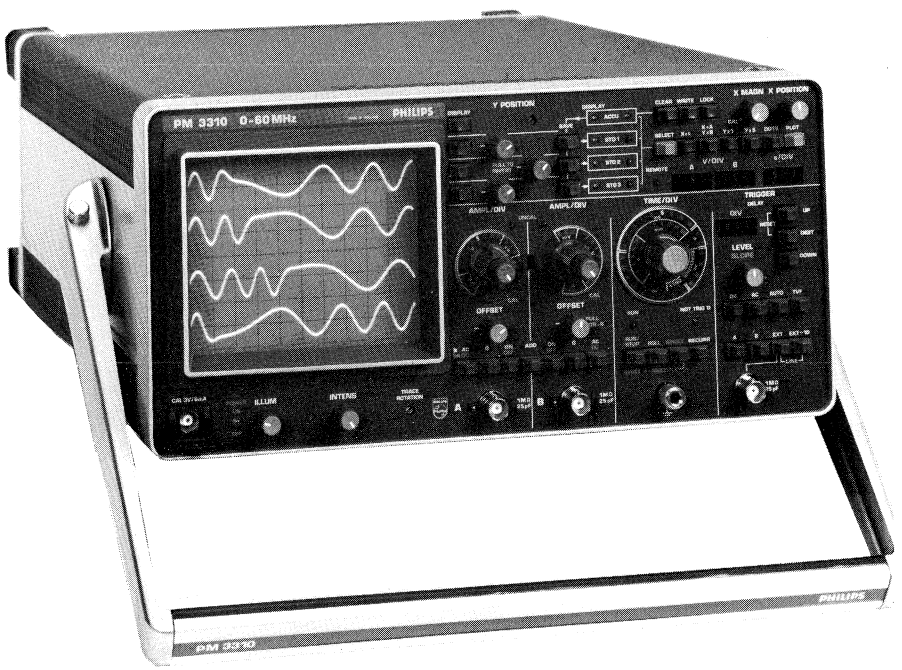
NEW

IEEE 488 IEC 625

60MHz digital storage oscilloscopes PM 3310, PM 3311 and PM 3315*

Max sampling rate 125MHz
60MHz/10mV
4 memories each 256 x 256
Digital delay −9... +9999 div.
Roll mode up to 60min./div.
Display of stored signal parameters viewable simultaneously with stored signal
Plot-output
Fully IEC/IEEE-bus compatible (PM 3315)

The PM 3310, PM 3311 and PM 3315 are digital storage oscilloscopes which offer a quite unique range of display and analysis facilities. Basically, they "sample" the signal in order to make the analog-to-digital conversion and then store the digital signal in a semiconductor memory. Unlike conventional storage which fades away, this technique offers the facility of **permanent** storage plus the ability to change certain display parameters **after** the signal has been captured.
In this type of instrument different signals, or different parts of the same signal, can be placed in one of four memories and be displayed simultaneously. And since both channels can be stored, this allows up to 8 traces to be displayed.



PM 3315

Analog-to-digital converter

The heart of the oscilloscope is the analog-to-digital converter (ADC).
In the PM 3310/11/15 it converts the analog signal into a 256 x 256 dot matrix. The horizontal position of the dots is determined by the clock frequency and the vertical by a series of binary digits, the values of which correspond to the analog value of the signal at the time of the relevant clock pulse.
The PM 3311 and PM 3315 can capture and display any single shot phenomenae up to 12.5MHz with only a limited risk of loosing signal details. However, in most cases a correct display is obtained for signals as high as 30MHz (125MHz ÷4) without the assumption that the signal is sine or square wave.
The track and hold circuit in the input circuit of the instrument ensures that a high vertical resolution can be achieved also higher time max. settings (6 bits at 5 ns/div.).

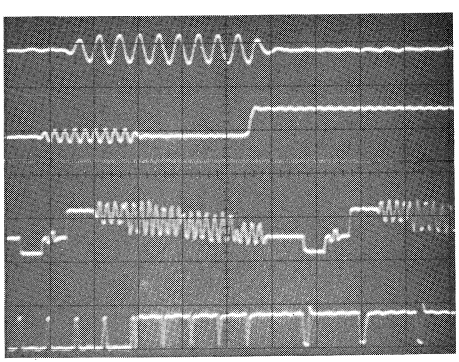
Full IEEE/IEC-bus compatibility

All three oscilloscopes are IEEE-488/IEC-625-bus compatible for use in automated systems. All three instruments have similar mechanical arrangements. The PM 3315 is equipped with an IEEE/IEC-bus interface, as standard. PM 3310 and 3311 are available in an IEEE/IEC version but may also be retrofitted in the field with an IEEE/IEC interface. Where these units are supplied already fitted, an IEC-IEE conversion adapter plug PM 9453/51 is supplied with the delivery.

Two-way data communication is possible between each of the instruments and an IEC/IEEE-bus controller. Thus, data containing measurements as well as parameter settings will allow analysis of a signal using the horizontal and vertical parameters as a reference. PM 3315 however, offers extended bus facilities which allow, in addition to those described, trigger source, trigger mode and trigger level to be remotely programmed.

All three oscilloscopes can thus be used in this two-way communicating mode, transmitting and receiving data to and from any computer, provided either IEC-625 or IEEE-488 standards are employed.

Where a signal is known to be a sine-wave the stored data can be transferred via the IEC-bus and the single-shot waveform calculated for frequencies up to 60MHz.



Versatile digital display facility allows TV colour burst to be picked out from selected line.

8 signals in 4 memories
The oscilloscopes offer the possibility to analyze signal details providing **four** memories and a −9 to +9999 digital delay, which effectively stretches the memory capacity of the instrument.
The combination of these two facilities can be used in a variety of ways to open up totally new display and measurement possibilities.

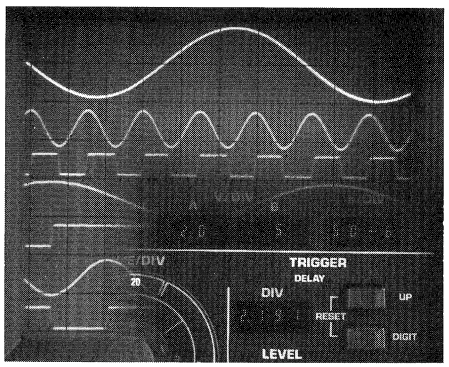
TV triggering example
Although it is somewhat specialised, the following TV triggering example illustrates the concept. The oscilloscope is set to trigger on the frame pulse and the conventional signal (bottom trace) is obtained. By setting the relevant delay, line can be picked out and displayed as in the second trace; for example one or more of the first or last 25 lines which carry VITs/Teletext and Viewdata. Also, by changing the time/div. setting, the highly detailed display of the colour burst in the third trace can be obtained. Moreover the delay can be adjusted to run up and down all 625 lines.
This latter feature is of particular value in data streams as it enables a display window to be moved forwards and back wards relative to the trigger signal. The similar but very limited facility called pre- and post-trigger should not be confused with the instruments' digital delay, which in fact renders these terms obsolete. Further digital features of the PM 3310/11/15 include the detailed display of front panel settings at the instant the signal was captured.

Self-diagnosis
Initially all LEDs light up as part of a self-diagnostic routine. Depending on the previous application the instrument will either show the last stored signal(s) or the LED display will indicate NOP (Not OPerative). It should be noted that stored signals are totally static.
"Live" signals in the "RECURR" mode, which refresh the memory following each trigger signal, have a miniscule movement to indicate the difference.

Parameter display
If different signals are captured in the "ACCU" memory and the stored, the instrument "remembers" both the attenuator and timebase settings. These can be recalled using the "SELECT" control and the appropriate memory display control. (An adjacent LED clearly indicates which stored signal parameters are being displayed).

PM 3311

Full screen displays
The contents of each of the four memories can be displayed over the whole screen. This facility enables signal details to be magnified and compared in a variety of modes, since once a signal has been captured and stored, its amplitude and position can be changed as required. In this operating mode the centre of the memory (offset control) and the centre of the screen (Y-position control) are the same.



The display parameters for each memory (i.e. at the time of capturing the signal) can be displayed at the touch of a button.

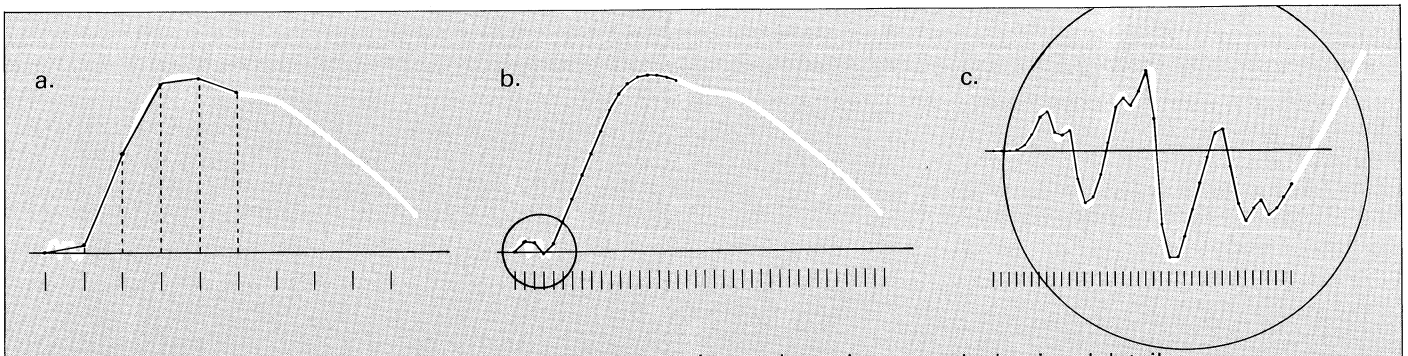
Dot display
Signals are compounded from a series of dots which the instrument "fills in" for display convenience.
If required the dots-only mode can be selected.

2-channel displays
Signals on channel A or B can be captured in the ACCU memory and stored in any of the other three memories. Alternatively the signals on A and B can be captured **together**, each occupying half the memory storage capacity, and stored in the same way. This facility enables up to eight signals to be captured, stored and analysed.

Multiple shot
In addition to the conventional single-shot facility, the PM 3310/11/15 feature the very useful "multiple-shot" mode. This enables more than one transient signal to be captured. The first is captured and transferred to STO3 automatically, the second diverted to STO2 and so on until all four memories are full. This makes it possible to capture the desired transient which can be related to other events.

Plot mode
This mode is used to give an output signal to an X-Y recorder. First one stored signal is plotted, then the other, the instrument giving a pen-lift signal between. For recorders without automatic pen lift, there is sufficient time for manual pen lift and return.

Roll mode
This useful facility enables each oscilloscope to function as a chart recorder. In this mode the signal runs from right to left, first in the ACCU memory which when full is copied into STO3, then into STO2 and 1, to give the equivalent of a continuous trace.
In the lowest time/div. setting this produces a display equivalent to a reading time of 40 hours.



Closing up the digits
The importance of resolution in digital storage is not always fully appreciated. All instruments make straight line (or calculated) approximations from each measurement point, as shown in a. Thus at x20 the repetition frequency, as in a, it is entirely possible to miss completely the signal disturbance shown in b. Even at x80, the result shown in b lacks signal detail. This means that effective measurements of signals as low as 100 kHz can need a sample frequency of 80 MHz (x800) if signal detail is to be detected and stored.

TECHNICAL SPECIFICATION

CRT

Type
Philips rectangular tube with 10kV acceleration potential and metal backed phosphor

Screen type
P31 (GH) phosphor

Useful screen area
8 x 10div. of full centimeters

Graticule
Internal graticule with centimeter divisions and 2mm divisions along the central vertical axis. Shorter 2mm divisions along the second, fourth, sixth and eight horizontal axes. Illumination continuously variable.

Focus
Automatically adjusted

INPUT VERTICAL

Response
DC: 0Hz...60MHz
AC: 10Hz...60MHz

Rise time
6ns

Deflection coefficients
10mV...50V/div. in steps 1-2-5 sequence Uncalibrated continuous control between steps 1: > 2.5

The stored data can be displayed in a x5 mode. The smallest deflection coefficient wil then be 2mV/cm.

Automatic range indication
Automatic correct indication of deflection coefficient referred to probe tip if 10:1 attenuator probe with range indication is used.

Accuracy
± 3%

Input selection
- Channel A only
- Channel B only
- Channel A and B
- Channels A and B added

Channel B can be inverted

CMMR
> 100:1 up to 2MHz

Dynamic range
2 x voltage range

DC offset
± 4 x voltage range

Maximum sample rate
50MHz for PM 3310
125MHz for PM 3311 and PM 3315

Signal delay
>10ns visible display

Input impedance
1MΩ in parallel with 25pF

Maximum input voltage
$400V_{DC} + AC_{pk}$

TIME BASE

Operation modes
a. *Single*
For single shot phenomena with sweep speeds from 0.2s/cm to 200ns/cm (500ns/cm for PM 3310): the accumulator will be overwritten with a new signal when the trigger level is passed and the adjusted trigger delay has been reached.
b. *Recurrent*
For repetitive signals with sweep speeds from 0.2s/cm to 5ns/cm: The contents of the accumulator memory is displayed on the screen. As soon as the trigger level is passed and the adjusted trigger delay has been reached the accumulator is overwritten with new data.
c. *Roll*
For strings of slow-moving signals with sweep speeds from 60min/cm to 0.5s/cm: the signal will be built up dot by dot from the right-hand side of the screen and moves in slowly. As soon sas the accumulator is completely filled up the contenets are copied in memory 3; the next time in memory 2, then memory 1 until the accumulator is filled up. When all four memories are completely filled the RUN LED's start blinking as an indication.
d. *Multiple*
Four successive single-shot signals are stored in the four different memories (dead time between two shots 20ms max.).

Time coefficient (for PM 3310)
Recurrent 5ns...0.2s/div.
Single shot 500ns...0.2s/div.
Roll 0.5s...60min/div.

Time coefficient (for PM 3311 and PM 3315)
Recurrent 5ns...0.2s/div.
Single shot 200ns...0.2s/div.
Roll mode 0.5s...60min./div.

Accuracy
± 2%

Resolution
25 samples/div.

DISPLAY MODES

Memories
Each memory is displayed over 2cm screen height

Display combinations
- Accumulator display depends on input selection
- Information as stored in accumulator can be selected for storage in each of the three register memories and is displayed when display button is depressed. Total information stored in STORE 1, 2 or 3 can be inverted.

Vertical position range
± 8div.

Vertical expand
5 x each memory covers 10cm screen height. Indication of vertical deflection coefficient via LED is automatically corrected.

Horizontal expand
Continuously adjustable between 1 x and 2.5 x

X-Y operation
Deflection in X direction can be derived from time base or from memory contents derived from A-input

Dot join
At choice dots only or joined dots can be displayed

TRIGGERING

Trigger source
Internal Y_A, Y_B, External ÷10, Line

Level range
Auto: proportional to peak-to-peak value of trigger signal
Internal: ±3div.
External: ±3V
External ÷10: ±30V

Trigger sensivity

	Internal	External	External ÷10
at 60MHz	0.3div	0.3V	3V
at 40MHz	0.15div	0.15V	1.5V

Slope
+ or −

Trigger modes and coupling
DC: DC...60 MHz
AC: 10 Hz...60 MHz
Auto: 20 Hz...60 MHz
TV-frame (1/1 picture): Acc to CCIR

External trigger input impedance
1 MΩ in parallel with 25pF

Maximum input voltage
$400V_{DC} + AC_{PK}$

TRIGGER DELAY

Range
−9...+9999div

Accuracy
0.2s...200ns(500ns)/div: ± 2mm
100ns(200ns)...5ns/div: ±2div. + visible delay

Indication
Accumulator and STORE 1.2.3 contain selected delay which can be displayed via LED display

PLOT OUTPUT

Horizontal
1V/full scale (±5%)

Vertical
1V/full scale (±5%)

Penlift
TTL compatible ("0" = pen down, "1" = pen up)

INTERFACE (optional)
Knob settings and memory contents (data as well as parameters) can be read and/or be controlled by a controller via IEC/IEEE instrument bus

CALIBRATION

Calibrated voltage
$3V_{pp}$ square wave 2.5kHz

Calibrated current
6mA square wave 2.5kHz

POWER

Line voltage and frequency
100...120V or 220...240V ± 10%, 50...400 Hz

Power consumption
65W at nominal line voltage

Batteries
Oscilloscope can be equipped with two 1.5V standard batteries (R6) for memory back-up

DIMENSIONS AND WEIGHT

(w x h x d) 316 x 154 x 460mm
(12.4 x 6.1 x 18-in)
12kg (26.3lb)

ENVIRONMENTAL CAPABILITIES

The following environmental data are valid only if the instrument is checked in accordance with the offical checking procedure. Details on these procedures and failure criteria are supplied on request by the PHILIPS organization your country, or by PHILIPS TEST AND MEASURING DEPARTMENT, EINDHOVEN, HOLLAND.

Ambient temperatures
Rated range of use: +5°C...+ 40°C
Limits of operation: −10°C...+ 40°C
Storage and transport: −40°C... +75°C

Altitude
Operating: to 5000m (15000ft)
Non operating: to 15000m (45000ft)

Humidity
21 days cyclic damp heat 25°C...40°C R.H. 95%

Shock
30g: half sine wave shock of 11ms duration: 3 shocks per direction for a total of 18 shocks

Vibration
Vibrations in three directions with a maximum of 20min. per direction; 10min with a frequency of 5...25 Hz and amplitude of $1.016mm_{pp}$ 10min with a frequency of 25...55 Hz and an amplitude of $0.5mm_{pp}$. Maximum acceleration 3g. Unit mounted on vibration table without shock absorbing material.

Recovery time
Operates within 30min. coming from −10°C soak, going into room conditions of 60% RH at 20°C

Safety
Safety class 1 according to IEC 348

ACCESSORIES SUPPLIED

Front cover with storage space 2 x 10:1 probe set with range indication
CAL terminal – BNC adapter
Contrast filter
Collapsible viewing hood
2 x BNC - 4mm banana adapter
Instruction manual

ORDERING INFORMATION

PM 3310	Digital Storage Oscilloscope 50 MHz sampling rate
PM 3311	Digital Storage Oscilloscope 125 MHz sampling rate
PM 3315	Digital Storage Oscilloscope 125 MHz sampling rate including IEEE/IEC interface

Instrument Options
Option 40 - IEEE-488/IEC-625 interface bus*
**Not required for PM 3315*

Power options: see Introduction, page 4

OPTIONAL ACCESSORIES

PM 8921	Passive probe 1:1 (1.5m)
PM 8921L	Passive probe 1:1 (2.5m)
PM 8976	Camera adapter for stationary use
PM 8980	Long type viewing hood
PM 8991	Oscilloscope trolley
PM 8994	Accessories for probes
PM 9051	BNC-4mm banana adapter
PM 9366	Collapsible viewing hood
PM 9381	Oscilloscope camera
PM 3325	IEC/IEEE interface (for IEEE PM 9483/51 is required)
PM 9483/51	IEC→IEEE adapter plug
PM 9480	IEC-bus cable (length 1m)
PM 9407/10	IEEE-bus cable (length 1m)
PM 8927AS	Passive probe with range indicator 10:1, 11pF (1.5m)
PM 8927AL	Passive probe 10:1; 14pF (2.5m)
PM 8932	Passive probe 100:1; max. voltage 4000V; 2pF (1.5m)
PM 8940	High voltage isolation amplifier for floating measurements at $650V_{RMS}$
PM 8943	FET probe 640 MHz, 1:1/10:1/100:1
PM 8910	Polaroid anti-glare filter
PM 8960	19-in rackmount adapter
PM 9355	Current probe 12 Hz...70 MHz

IEEE/IEC INTERFACE DATA
Included in PM 3315: IEC connector fitted and IEEE adapter supplied.
For modifying standard PM 3310 or PM 3311 an interface PM 3325 is optionally available. This also requires an IEC-to-IEEE adapter PM 9483/51 is used for IEEE cables which has to be ordered separately.

Interface functions

SH1	Source handshake fully compatible
AH1	Acceptor handshake fully compatible
T6	Basic function, serial poll unaddress if MLA *Output data:* settings, data including parameters; for PM 3315, also, trigger source, trigger mode and trigger level *Status data:* busy, ready/data, alarm ready
L4	Basic listening, unaddress if MLA Programming data: settings, memory data including parameters; for PM 3315, also, trigger source, trigger mode and trigger level
SR1	Capable of sending a service request
RL2	No local lockout
PP∅	No parallel poll
DC1	Complete device clear capability
DT1	Complete device trigger capability

IEEE 488 IEC 625

35MHz 4-channel digital storage oscilloscope PM 3305

4 channels
Memory size: 4096 x 8 bits
Pre-trigger 4096 bits max
MIN/MAX mode catches 10ns glitches
Direct display

The PM 3305 offers digital storage facilities combined with the direct display facilities of a conventional 35 MHz oscilloscope. With its four input channels, PM 3305 becomes an excellent measuring tool for applications, for example, in mechanical and physical environments.

General purpose
The oscilloscope offers all those unique and well-proven features which, for Philips 'scopes are virtually standard.

These include the excellent trigger facilities such as A/B/Composite/Line/÷10, combined with a trigger mode such as Auto/DC/AC. Moreover, the oscilloscope can be triggered from extremely complex signals.

The 35 MHz vertical bandwidth for both digital display mode and digital storage mode makes the unit a universal and genuinely multipurpose instrument.

Digital storage
If the MEMORY ON button is pressed the instrument functions as a powerful digital storage oscilloscope, offering an enormous number of measuring possibilities.

4 channels
In the digital storage-mode, except for the standard A and B inputs, two extra floating channels are available. These extra inputs are especially useful for signals from transducers in mechanical measurements, since the input can be used as a 20mA/cm or 200m/cm current input.

Low repetition rate signals
In the MEMORY ON mode, with the unit functioning as a digital storage oscilloscope, on each trigger, the memory contents are overwritten. A signal with a low repetition frequency is thus displayed with high light intensity.

Link to history
During operation a COMPARE mode can be selected. The live signal is then compared with a signal previously caught in the memory. If the latest signal is better and must be used as a reference it is only necessary to release the button and depress again, when the new signal is frozen as the reference signal.

Single events
If the SINGLE function is selected, non-repetitive signals with frequencies up to 250 kHz can be captured in a time window from 2ms up to 50 seconds. Depending on the time setting, a resolution of 500ns can be achieved. This single shot function can be combined with a CLEAR function. During waiting time (indicated on a LED) the latest stored signal is is visible on the screen.

If the CLEAR button has been depressed the zero reference line is visible on the screen. If the CLEAR button has been depressed twice, the zero line is no longer displayed on the screen.

Peaks and glitches of ⩾10ns
Heretofore, the disadvantage of digital oscilloscopes has always been the fact the the system is not lookink at the signal between two sample moments. Glitches and signal peaks shorter than the sampling distance can be missed. The PM 3305 overcomes this problem by means of a built-in MIN/MAX function. In the MIN/MAX mode any pulse longer than 50ns is stored and consequently displayed at the next moment of sampling. If the pulse is shorter than 50ns, the amplitude shown might not be representitive of the real amplitude, but even a 10ns pulse is still captured at 55% of its original level.

Modulated signals
In the MIN/MAX mode, signals with frequency components higher than the sampling rate can be stored and displayed so that the envelope of the modulated signals can be easily made visible.

35 MHz bandwidth
The digital storage operation does not stop at its maximum sampling frequency. From 0.1ms/div. to 0.1μs/div., the sampling oscilloscope operates as a sequential sampling system (indicated by LED labelled "Repetitive signals only"). By using this technique, at the full bandwidth of the oscilloscope, the full range of the time base settings can be used as a storage osilloscope with a minimum equivalent sample distance of 250 p.s. (4GH).

IEEE/IEC bus operation

The optionally available interface gives access to the digital part of the oscilloscope via IEEE/IEC bus lines. This means that the complete memory or a selected part of it can be transferred to a controller and the same is valid for filling the memories with new data. Time base and all switches related to the digital part of the oscilloscope can be controlled and read by an IEEE/IEC bus controller. If the interface is installed a memory dump function can be used to dump the memory contents to a storage device such as a digital cassette recorder, without a bus-controller.

Hard copies

Special versions are available if hard copies on an X-Y recorder or on the Digital plotter PM 8154* are required.

Many other plus features

Other attractive features of the PM 3305 should not be overlooked. For instance, there is the dual slope triggering, the possibility to expand a selected part of the memory four times, 10 times or even forty times. Other features include the X-Y display facility, the direct output from the A-D converter, the pre-trigger capability of 4096 bits and the possibility of external clock drive, etc.

** Not available in USA*

TECHNICAL SPECIFICATION

GENERAL

CRT

Type
Philips rectangular mesh-type post deflection accelerator tube with 10kV accelerating voltage and metal backed phosphor

Screen type
P31 (GH) phosphor standard
P 7 (GM) phosphor optional

Useful screen area
8 x 10cm

Graticule
Internal graticule with centimetre divisions and 2mm divisions along the central axes. 10% and 90% lines are indicated. Graticule illumination continuously variable.

VERTICAL OR Y-AXIS (For A and B channels) (For C and D channels see DIGITAL STORAGE OPERATION)

Frequency response
DC: 0 Hz...35 MHz (−3dB)
AC: 2 Hz...35 MHz (−3dB)

Rise time
10ns

Deflection coefficients
2mV/div...10V/div 1-2-5 sequence. Uncalibrated, continuous control between steps 1: > 2.5

Accuracy
±3%

Display modes
Channel A, channel B, alternate, chopped at approx. 500kHz, added. Channel B can be inverted

Input impedance
1 MΩ//20pF

Maximum input voltage
400V (DC + AC peak)

Maximum deflection
Undistorted deflection of 24div
Shift range 16div

Signal delay
⩾ 2 divisions at 10ns/div.

CMR-factor
100:1 at 1 MHz
(A-B mode with 8 div. common mode signal)

HORIZONTAL OR X-AXIS
Horizontal deflection can be obtained from the main time base, or from an external source. In this case X-Y diagrams can be displayed using Y_A, Y_B, the EXT connector or the mains as signal source for horizontal deflection

Display modes
X-Y or X-Y/Y operation with X-deflection by: Y_A, Y_B, External or Mains (line)

X-INPUT

Frequency response
DC...1 MHz (−3dB)

Deflection coefficients
200mV/div. using EXT connector
2V/div. using EXT ÷ 10 connector
Vertical attenuator coefficients apply when Y_A or Y_B is used for X-deflection

Measuring accuracy
± 10%

Phase error
3° at 100kHz

TIME BASE

Mode
Automatic or triggered

Time coefficients
0.5s/div...100ns/div. in 1-2-5 sequence
(or 5s/div...100ns/div; see DIGITAL STORAGE OPERATION)
Uncalibrated continuous control between steps 1: > 2.5
x 10 magnifier extends max sweep rate to 10ns/div

Accuracy
± 3%
Additional error for magnifier ± 2%

TRIGGERING

Trigger source
Internal: Y_A, Y_B, Composite, Line
External
External ÷ 10

Slope
+ or − or dual

Trigger modes
Auto, AC, DC, TV

Trigger sensitivity
Internal: 1.0 div at 35 MHz
Internal: 0.5 div at 5 MHz
External: 0.2Vpp at 35 MHz
External ÷ 10:2 Vpp at 35 MHz
TV int: 0.7 div. sync pulse
TV ext: 0.15 Vpp sync pulse
TV ext ÷ 10:1.5 Vpp sync pulse

Trigger frequency range
Auto: 20 Hz...> 50 MHz
AC: 5 Hz...> 50 MHz
DC: 0 Hz...> 50 MHz

Trigger level range
Auto: automatically adjusted between limits of signal amplitude
Internal (AC, DC): 8 div.
External (AC, DC): 1.6V
External ÷ 10 (AC, DC): 16V

Input impedance
1 MΩ//20pF

Maximum permissible input voltage
400V (DC + AC peak)

Variable hold-off
Sweep hold-off time can be increased by a factor of 10.

DIGITAL STORAGE OPERATION

MEMORY DATA

Memory size
4096 x 8 bits

Pre-trigger
4096 samples max (adjustable in steps of 25%)

Timebase
0.1μs/div. ... 5s/div.

Vertical resolution
256 steps over 8 cm

Horizontal resolution
Single trace 1:4096
Dual trace 1:2048
Four trace 1:1024
Compare + single trace 1:2048
Compare + dual trace 1:1024
Compare + four trace 1:512

Max sample frequency
2 MHz
1 MHz when external clock is used

FOUR CHANNEL OPERATION
With the button ABCD CHOP depressed the PM 3305 operates in the four channel mode. The signal is always captured in the chopped mode.

A and B channels
As specified for 2-channel operation

C and D channels
Frequency response
DC ... 1 MHz (−3 dB)

Deflection coefficients
0.1V/div. or 1V/div.

Input
Floating

Vertical positioning
10 divisions

Input impedance
10KΩ (DC-coupled)

Max. input voltage
42V (DC + AC peak)

CMRR
300:1 at 50 kHz

SPECIAL FEATURES

Peak detection
Pulses with pulse width of 50 ns are captured. Pulse of 10ns is caputred at 55% of original level

Extra time coefficients
In the storage mode three extra time base settings are available so that time is expanded to 5s/div

Compare
50% of the available memory capacity can be used for storage of a reference signal

DISPLAY MODES

Normal or smooth display
Smoothed picture can be made visible

X=A/Y=B
Signal stored in A is used as reference for horizontal display. Signal stored in B is used as reference for vertical display

Display expand
A selected part (¼ of memory) can be displayed over the screen

DIGITAL OUTPUT

ADC out
Output from ADC is available on external connector, 8 bits parallel. Conversion ready signal on 9th pin.

Memory dump
(When equiped with IEEE-bus interface)
Memory can be dumped via IEEE connector to external interface. Normal handshake procedure is used

IEEE/IEC. bus interface (optional)
Memory contents, time base and digital oscilloscope settings can be read or be sent

Analog output
If the oscilloscope is equipped with an analog output, a copy of the screen can be made on paper via an X-Y recorder (full-scale hor/vert 1 volt).
Pen lift at choice on logical level ∅ or 1.

Digital plot-out
An option is available for digital plot-out. In combination with the Digital plotter PM 8154* a 1:1 copy of the screen can be made.

** Not available in USA*

FURTHER GENERAL SPECIFICATION

CALIBRATION

Voltage
1.2Vpp ± 1% square wave

Frequency
2kHz approx.

POWER

Line voltage and frequencies
110, 120, 220 and 240V_{AC} ± 10%, 46...440 Hz

DC power source
24...27 V_{DC} floating max. 2A

Power consumption
70W when powered from nominal line voltage

Insulation
The insulation of the power supply fulfills the safety requirements of IEC 348 CL I for metal encased instruments.

DIMENSIONS AND WEIGHT

(w x h x d) 337 x 137 x 452mm
(13.2 x 5.4 x 17.8-in)
10kg (22lb) (approx)

ENVIRONMENTAL CAPABILITIES

The environmental data are valid if the instrument is checked in accordance with the official checking procedure. Details on these procedures and failure criteria are supplied on request by the Philips organisation in your country or by Philips' Test and Measuring Department, Eindhoven, Holland.

Ambient temperatures
Rated range of use +5°C...+40°C
Operating −10°C...+40°C
Storage −40°C...+70°C

Altitude
Operating: to 5000m (15,000 ft)
Non-operating: to 15,000m (45,000 ft)

Humidity
21 days cyclic damp heat 25°C-40°C, RH 95%

Shock
30g: half sine wave shock of 11ms duration:
3 shocks per direction for a total of 18 shocks

Vibration
Vibrations in three directions with a maximum of 15min per direction
5-55 Hz and amplitude of 0.7mm_{pp} and 3g max. acceleration.

Recovery time
Operates within 30 minutes coming from −10°C soak, going into 60% relative humidity at +20°C room conditions.

Electromagnetic interference
Meets VDE 0871 and VDE 0875
Grenzwertklasse B

Interface functions
SH1 Source handshake complete capability
AH1 Acceptor handshake complete capability
T5 Capabilities: Basic talker, serial poll, talk only, unaddress if MLA
Output data: settings, data
Status data: Busy/ready data, alarm conditions
L3 Capabilities: Basic listener, listen only, unaddress if MLA
Programming data: Digital settings, memory data.
SR1 Complete capability of sending service request
RL2 No local lockout
PP∅ No parallel poll
DC 1 Complete device-clear capability
DT 1 Complete device-clear capability

ACCESSORIES SUPPLIED

Front cover
Operating manual
Contrast filter
2 x 10:1 attenuator probe

ORDERING INFORMATION

PM 3305	4-channel digital storage oscilloscope

Instrument options
Option 40 - IEEE/IEC interface bus
Option 41 - IEEE bus plus DIGITAL plot out
Option 42 - IEEE bus plus ANALOG plot out
Option 43 - IEEE bus plus DIGITAL plus ANALOG plot out
Option 70 - ANALOG plot out
Power options: see Introduction, page 4

OPTIONAL ACCESSORIES

PM 8921	Passive probe 1:1 (1.5m)
PM 8921L	Passive probe 1:1 (2.5m)
PM 8927A	Passive probe 10:1; 11 pF (1.5m)
PM 8927AL	Passive probe 10:1; 14 pF (2.5m)
PM 8932	Passive probe 100:1; max. voltage 4000V; 2 pF (1.5m)
PM 8940	High voltage isolation amplifier for floating measurements at 650V_{RMS}
PM 8943	FET probe 650 MHz, 1:1/10:1/100:1
PM 8963/01	19-in rack mount adapter
PM 9355	Current probe 12 Hz...70 MHz
PM 9381	Oscilloscope camera
PM 8972	Camera adapter for stationary use
PM 9366	Collapsible viewing hood
PM 8980	Long type viewing hood
PM 8994	Set of accessories for probes
PM 8991	Oscilloscope trolley
PM 8901	Battery pack for 1 hour continuous operation
PM 8910	Polaroid anti-glare filter
PM 8992	Accessory pouch
9499.445. 01511	Service manual for PM 3305
9499.445. 23301	Operating manual for PM 3305
PM 9051	BNC - 4 mm adapter
PM 9483/50	IEEE/IEC adapter plug
PM 9487/10	IEEE cable 1m
/20	IEEE cable 2m
/40	IEEE cable 4m
PM 9585	50Ω terminator

NEW

Max sampling frequency 20MHz
Max resolution 50ns
2K memory
2K backup memory
50 s/div roll mode
1mV/div inputs

20MHz digital storage oscilloscope PM 3302

The PM 3302 offers digital storage facilities combined with the direct display capabilities of a conventional 20MHz oscilloscope. The performance/price characteristics make this instrument very attractive for the educational environment.

Education
In the world of electronics education, oscilloscopes are used to visually demonstrate, e.g., the characteristics of semiconductors, the electronic behaviour of circuits and for various kind of diagnostics. It is in this application area that the digital performance offers the possibility to achieve this kind of measurement without the risk of the oscillogram fading whilst being described and explained to the students.

Mechanical environments
In situations where very low level sigals only are available – normal in mechanical testing environments – the PM 3302 has special features designed to meet such problems. Moreover its sturdy construction allows it to be used in tougher environments with confidence.

Hard copy
The PM 3302 is equipped with the facility of producing hard copies of traces visible on the screen on ordinary paper, when used in conjunction with a suitable X-Y recoder. Recorder sensitivity can be adjusted to control the dimension of the recorded trace which can be 'tailored' to fit into standard size reports.

Low frequency signal registration
For the observation of low frequency phenomena, PM 3302 will produce a visual display lasting for 8 minutes, using the 50s/div roll mode. At any time during this viewing period the picture can be frozen by simply pressing a button.

High sampling frequency
The high, 20MHz sampling frequency provides the opportunity to store the signal with excellent resolution. If required, a spacing of 50ns between the samples is possible.

Long memory
A 2K x 8-bit memory is used for signal storage. In addition, it is also possible to store a signal from either channel whilst using the other channel as a live display of the conditions in the circuit under test.

Second memory available
The contents of the 2K x 8-bit memory can be transferred to a second 2k x 8-bit memory simply by pressing a button. This again allows for the separate storage of channels A and/or B.

Display of X-Y pictures
Semiconductor curves can be displayed using either analog or digital storage. Filter curves, lissajous pictures and other similar phenomena which are not time-related but have other reference voltages can be displayed and stored for further analysis.

For small signal measurement
In situations where very low level signals are present, such as in mechanical environments, the 1mV/div input allows a transducer output, for instance, to be directly input to the memory.

TECHNICAL SPECIFICATION

DISPLAY

C.R.T.

Type
Philips rectangular post deflection accelerator tube with 14kV accelerating voltage.

Screen type
P 43 (GY) phosphor

Useful screen area
8 x 10cm

Graticule
Internal graticule with centimeter divisions along the central axes. 10% and 90% lines are indicated. Graticule illumination in three levels.

ANALOG	DIGITAL
VERTICAL OR Y-AXIS	**VERTICAL OR Y-AXIS**
Frequency response DC: DC - 20MHz (−3dB) AC : 2Hz - 20MHz (−3dB)	**Frequency response** DC: DC - 10MHz (−3dB) AC : 2Hz - 10MHz (−3dB)
Rise time 18ns	**Rise time** 18ns
Deflection coefficients 5mV/div....20V/div. 1mV/div....4V/div. (5MHz) with vertical (x5) magnifier 1-2-5 sequence Uncalibrated, continuous control 1: > 2.5	**Deflection coefficients** 5mV/div....20mV/div. 1mV/div....4V/div. (5MHz) with vertical (x5)/ magnifier 1-2-5 sequence Uncalibrated, continuous control 1: > 2.5
Accuracy ±3%	**Accuracy** ±3%
Display modes Channel A, channel B, Alternate, chopped at approx. 500kHz, added, channel A can be inverted	**Display modes** Channel A, channel B, channel A and B, added. Channel A can be inverted

Input impedance
1MOhm // 25pF

Maximum input voltage
400V (DC + AC peak) below 1kHz

Maximum deflection
Undistorted deflection of 16 divisions.
Shift range 8div.

CMR-factor
40dB at 1MHz (−A+ B mode with 8div. common mode signal)

HORIZONTAL OR X-AXIS

Horizontal deflection can be obtained from the main timebase or from an external source. In this case X-Y diagrams can be displayed using Y_B as signal source for horizontal deflection.

X-Y - INPUT
Frequency response
DC: DC ... 2MHz (−3dB)
AC: 5Hz.. 2MHz (−3dB)

Deflection accuracy
±3%

Phase error
3° at 150kHz

TRIGGERING

Trigger source
Internal YA, YB, Line, External, External ÷ 10

Trigger slope
+ or −

Trigger modes
AUTO (free run in absence of triggering), AC, DC

Trigger bandwidth

	Bandwidth	
	Normal	Auto
AC	5Hz ...10MHz	30Hz ... 10MHz
DC	DC ... 10MHz	30Hz ... 10MHz
LF	DC ... 1kHz	30Hz ... 1kHz
HF	2kHz ... 40MHz	2kHz ... 40MHz

Trigger sensitivity
Internal <0.5div.
External <0.5V

Trigger level range
Auto : Triggering on peak of signal
Internal : ± div.
External : ± 3V
External ÷10 : ± 0.3V

ANALOG	DIGITAL
TIMEBASE	**TIMEBASE**
Time coefficients 0.1 s/div...200 ns/div 1-2-5 sequence. Uncalibrated continuous control 1: > 2.5 x 10 magnifier extends maximum sweep rate to 20ns/div	**Time coefficients** Normal mode: 50s/div. to 10μ/div. Roll mode: 50s/div... 100ms/div. 1-2-5 sequence. x10 magnifier extends maximum sweep speed to 1μs/div. in normal mode and to 10ms/div. for the the rolmode.
Accuracy ± 3% Additional error for magnifier ± 2%	**Accuracy** ± 3% Additional error for magnifier ± 1%
Mode Automatic, or triggered	**Mode** Automatic, triggered or single shot

Input impedance
1MOhm // 30pF

Maximum rated input voltage
100V (dc + ac peak) below 100kHz

DIGITAL STORAGE OPERATION

Two identical memories are available. At choice the contents of one of the memories can be displayed. The memory that is displayed can be updated.

Number of memories
2 identical memories, 2048 x 8 bit each

Pre-trigger
Trigger point can be set of beginning, 1/4, 1/2, 3/4 or end of the screen.

Vertical resolution
256 steps over 10cm (or 39μV in 1mV/div. setting)

Horizontal resolution
A only : 1:2048
B only : 1:1024
A and B : 1:1024 per channel
Add or Substract : 1:1024

Sampling distance accuracy
0.1%

Maximum sample frequency
±YA only : 20MHz
± YB, ± A and B or ± A+B : 10MHz

Analog output
At the rear, output for an analog X-Y recorder is provided
X is 100mV/div ±10%
Y is 100mV/div ±10%
Z is penlift TTL compatible
Pen down is "0"
Output speed can be selected internally

2 ch = 5 - 10 - 20sec./cm
1 ch = 10 - 20 - 40sec./cm

GENERAL SPECIFICATION

CALIBRATION

Voltage
2V or 0.2Vpp square wave

Accuracy
±1%

Frequency
±1MHz or ±1kHz

POWER REQUIREMENTS

Line Voltage and frequencies
110, 120, 220 or 240 Vac ± 10%
45 ... 400Hz

Power consumption
45W when powered form nominal line voltage

Insulation
The insulation of the power supply fulfils the safety requirements of I.E.C C1 I for metal encased instruments.

Dimensions and weight
(w x h x d) 285 x 145 x 380mm
(11.2 x 5.7 x 15.0-in)
9kg

ENVIRONMENTAL CAPABILITIES
The environmental data mentioned in this manual are based on the results of the manufacturer's checking procedures.
Details on these procedures and failure criteria are supplied on request by the PHILIPS organisation in your country or by PHILIPS EINDHOVEN, THE NETHERLANDS.

Ambient temperature

Rated range of use	+10°C to +35°C
Operating range	−10°C to +40°C
Storage and transit	+40°C to +70°C

Altitude
Operating to 5000m (1500ft)
Non-operating to 15000m (45000ft)

Humidity
21 days cyclic damp heat 25 °C - 40 °C, RH 95%

Shock
300m/s, half sine-wave shock of 11ms duration (3 shocks per direction for a total of 18 shocks)

Vibration
5-55Hz, 15 minutes per direction, amplitude 0.7mm (peak-to-peak) and 30m/s² (3g) acceleration

Electromagnetic interference
Meets VDE 0871 and VDE 0875 Grenzwert Klasse B

Safety
IEC 348 Class I

Warm up time
30 minutes at 23°C

Recovery time
Operates within 30 min. of being subjected to 10°C, soak then taken into room conditions of 60% rel. hum. at 20°C

ACCESSORIES SUPPLIED
1 x blue contrast filter
1 x operating manual

ORDERING INFORMATION

PM 3302	20MHz digital storage oscilloscope

Power options: see Introduction, page 4

OPTIONAL ACCESSORIES

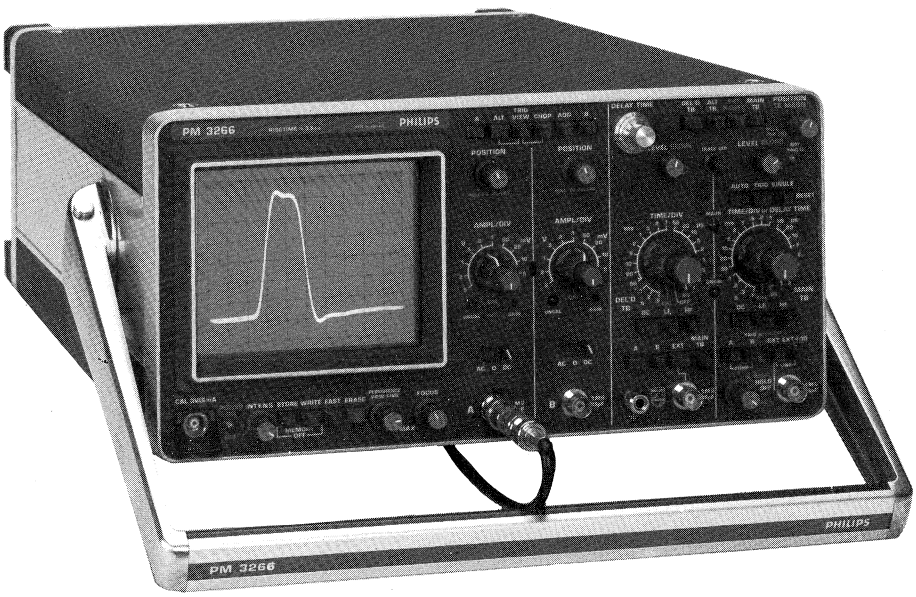
PM 8921	Passive probe 1:1 (1.5m)
PM 8921 L	Passive probe 1:1 (2.5m)
PM 8927 A	Passive probe 10:1; 11pF (1.5m)
PM 8932	Passive probe 100:1; max. voltage 4000V; 2pF (1.5m)
PM 8940	High voltage isolation amplifier for floating measurements up to 650Vrms
PM 8943	FET probe 650MHz. 1:1/10:1/100:1
PM 9355	Current probe 12Hz ... 70MHz
PM 9381	Oscilloscope camera
PM 8972	Camera adapter for stationary use
PM 8994	Set of accessories for probes
PM 8991	Oscilloscope trolley
PM 9051	BNC-4 mm adapter
PM 9585	50Ω-terminator

100MHz transfer storage oscilloscope PM 3266

100MHz/5mV (2mV at 35MHz)
1000div/μs writing speed over full screen
Adjustable background lighting level
Auto erase with variable viewing times
Storage times up to 1h
Alternate time base display
Trigger view usable as a third channel

100 MHz/5mV (2mV at 35 MHz)
1000div/μs writing speed over full screen
Adjustable background lighting level
Auto erase with variable viewing times
Storage times up to 1h
Alternate time base display
Trigger view useable as a third channel

The PM 3266 will capture repetitive or single high-speed events and store them for viewing, for up to 1 hour. Storage time is continuously variable from 15 seconds minimum. The two different storage modes include a **fast** mode utilizing a writing speed of 1000div/μs, and a **write** mode with a 0.25div/μs writing speed. A **max. write** position is included in the write mode circuit having a 2.5div/μs writing speed.
A variable control allows optimum setting of the contrast between the oscillogram and screen background when operating in the **fast** mode.
In fast mode for repetitive signals, an auto erase facility refreshes the signal being observed allowing variable viewing times between 3 and 8 seconds.
Typical applications include observation, using the single shot mode of, e.g., various phenomena in discharge tubes, relays, etc. Also, in digital systems the PM 3266 will capture glitches which occur randomly as interference signals.
Measurement accuracy has been increased to a high order by the extremely sensitive storage system combined with full screen display. Moreover operation of the various facilities have been made very easy. Controls are reduced to one variable control plus a single pushbutton for each function (i.e. four pushbuttons only).
Other facilities include alternate time base display plus composite triggering capability to allow the display of non time-related signals; the wide band trigger circuit operates well beyond the 100 MHz vertical bandwidth.



The trigger view system can also be used as a third display channel and vertical sensitivity ranges from 2mV (up to 35 MHz) through 5mV to 5V (at 100 MHz).

TECHNICAL SPECIFICATION

CRT

Type
Philips high speed image transfer storage tube with scan magnification in vertical direction.
Rectangular tube face, post accelerator and metal-backed phosphor.

Screen
P31 (GH) phosphor

Acc. voltage
10kV

Useful screen area
8 x 10div, each div equals 0.9cm.

Graticule
Internal with subdivisions along central axes. 10% and 90% lines are indicated.

Writing speed
Fast: 1000div/μs
Max. write: 2.5div/μs
Write: 0.25div/μs (measured after erasure)
Lower writing speeds at higher contrast level can be adjusted

Storage time
Up to 1 hour, in store mode depending on intensity setting.
At max. intensity: fast: 15s
max. write: 15s
write: 60s

Auto erase
In Fast mode.
View time continuously variable between 3 and 8s

Persistence
In Write mode, continuously variable between 0.3 and 60s

Erasure time
1.3s in Write mode
1.6s in Fast mode

VERTICAL OR Y-AXIS

Response
DC: 0 Hz...100 MHz (35 MHz at 2mV)
AC: 7 Hz...100 MHz

Risetime
3.5ns

Deflection coefficients
2mV...5V/div. in steps in 1-2-5 sequence. Uncalibrated continuous control between steps 1: > 2.5.

Accuracy
±3%

Display modes
Channel A only
Channel B only
Alternate
Chopped at approx. 1 MHz
Channels A and B added
Trigger view
Trigger view with channels A and B alternate
Trigger view with channels A and B chopped

Channels A and B can be inverted

CMRR
>100:1 up to 2 MHz
>20:1 at 50 MHz

Input impedance
1 MΩ ± 2% in parallel with 15pF approx.
RC time, AC coupled: 22ms

Maximum input voltage
$400V_{DC+ACpk}$ derating above 500kHz

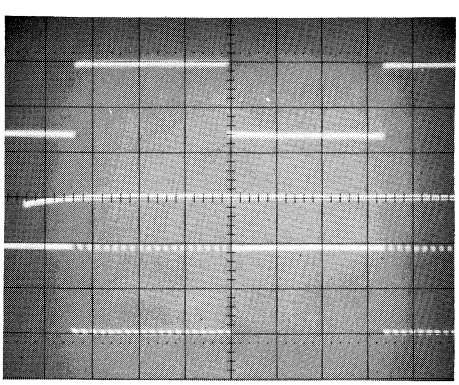
Maximum deflection
Undistorted deflection of 24div up to 35 MHz
Shift range 16div

Signal delay
15ns visible delay

Trigger view
Display: External or internal trigger signal
External: 100mV/div
External: ÷10: 1V/div
Trigger point: Screen centre ±0.3div
Time delay between vertical input and external input: 3ns.

HORIZONTAL OR X-AXIS

Horizontal deflection can be obtained from either the main timebase or the delayed timebase or a combination of the two, or from the signal source selected for X-deflection. In this case X-Y diagrams can be displayed using Y_A, Y_B, the Ext connector or the Line as a signal source.



Horizontal display modes
Main timebase
Main timebase intensified by delayed timebase
Delayed timebase
Main timebase and delayed timebase simultaneously displayed (alternate)
X-Y of X-Y/Y operation with X-deflection by Y_A, Y_B, Line or Ext source.

HORIZONTAL AMPLIFIER

Response
DC ⩾ 2 MHz (−3dB)

Deflection coefficient
50mV/div using Ext connector and 500mV/div in Ext ÷10 switch position. Uncalibrated continuous control 1: > 3. When Y_A, or Y_B are used, sensitivities are 2mV...5V/div

Measuring accuracy
± 3% (Ext. X-input)

Phase error
3° at 100kHz

MAIN TIME BASE

Modes
Auto, RC time 100ms
Triggered
Single shot

Time coefficients
1s...50ns/div in 23 calibrated steps, in 1-2-5 sequence. Uncalibrated continuous control between steps, (with UNCAL warning lamp should main timebase be set out of calibration). x 10 magnifier extends max. sweep rate to 5ns/div

Accuracy
±2% (+20°C...+30°C)
±3% (+ 5°C...+40°C)
Additional error for magnifier ± 1%.

Variable hold-off
Sweep hold-off time can be increased by a factor of 10.

DELAYED TIME BASE

Modes
Delayed timebase starts, either immediately after the delay time or, upon arrival of the first trigger pulse after the delay time.

Oscillogram demonstrates trigger view facility. The external trigger signal is displayed simultaneously with channel A and channel B.

Time coefficients
0.5s...50ns/div in 22-calibrated steps, 1-2-5 sequence. Uncalibrated continuous control between steps (with UNCAL warning lamp should delayed timebase be set out of calibration). x 10 magnifier extends max. sweep rate to 5ns/div

Accuracy
± 2% (+20°C...+30°C)
± 3% (+ 5°C...+40°C)
Additional error for magnifier ± 1%

Calibrated sweep delay
Continuous calibrated control between 0 and 10 x main timebase setting.

Incremental delay time accuracy
0.2% typical

Delay time jitter
Better than 1:30000

MAIN TIME BASE TRIGGERING

Trigger source
Internal Y_A, Y_B, Composite, Line, External, External ÷10

Slope
+ or −

Level range
Internal: 24div
External: +1.2V to −1.2V
External ÷10: +12V to −12V

Trigger sensitivity

	30 MHz	100 MHz
Int	0.5div	1.5div
Ext	50mV	150mV
Ext ÷10	500mV	1.5V

Trigger coupling
DC: DC...full bandwidth
HF: 30kHz...full bandwidth
LF: internal 0...30kHz
external 7 Hz...30kHz

Ext. trigger input impedance
1 MΩ ± 2% in parallel with 15pF approx.

Maximum allowable input
$400V_{DC+ACpk}$

Trigger jitter
Better than 0.5ns

DELAYED TIMEBASE TRIGGERING

Trigger source
Internal: Y_A or Y_B
External
Other characteristics are identical to MAIN TIMEBASE TRIGGERING

CALIBRATION

Calibrated voltage
$3V_{p-p} \pm 1\%$ square wave

Calibrated current
$6mA_{p-p} \pm 2\%$ square wave

Z-MODULATION

Input
DC-coupled, TTL compatible, 'HIGH' level blanks the display

Input impedance
10kΩ

Maximum input voltage
50V

Reponse time
35ns

POWER

Line voltages and frequencies
AC: 100...127V and 200...240V, 46...440Hz
DC: 250...350V

Power consumption
50W at nominal line voltage

DIMENSIONS AND WEIGHT

(w x h x d) 316 x 154 x 460mm
(12.4 x 6.1 x 18-in)
10.9kg (23.9lb)

ENVIRONMENTAL CAPABILITIES

The environmental data are valid only if the instrument is checked in accordance with the official checking procedure. Details on these procedures and failure criteria are supplied on request by the PHILIPS organization in your country, or by PHILIPS' TEST AND MEASURING DEPARTMENT, EINDHOVEN, HOLLAND.

Ambient temperatures
Rated range of use: +5°C to +40°C
Limits for operation: −10°C to +55°C
Storage and transport: −55°C to +75°C

Altitude
Operating: to 5000m (15000ft)
Non-operating: to 15000m (45000ft)

Humidity
21 days cyclic damp heat 25°C...40°C R.H. 95%

Shock
Operating: 30g, half sine, 11ms duration, 2 shocks per axis per direction for a total of 12 shocks

Vibration
Vibrations in three directions with a maximum of 15min per direction
5...55Hz and amplitude of $0.7mm_{p-p}$ and 4g max acceleration
Unit mounted on vibration table without shock absorbing material.

Recovery time
Operates within 30min coming from −10°C soak, going into room condition of 60% RH at 20°C

Electromagnetic interference
Meets VDE 0871 and VDE 0875
Grenzwertklasse B

Safety
Safety class 1 according to IEC 348

ACCESSORIES SUPPLIED
Front cover with storage space
Operating and service manual
BNC-Banana adapter
Contrast filter
2 x 10:1 attenuator probe
Collapsible viewing hood
Cal terminal – BNC adapter

ORDERING INFORMATION

PM 3266 100MHz oscilloscope
Power options: see Introduction, page 4

OPTIONAL ACCESSORIES

PM 8921	Passive probe 1:1 (1.5m)
PM 8921L	Passive probe 1:1 (2.5m)
PM 8327A	Passive probe 10:1 (1.5m)
PM 8327AL	Passive probe 10:1 (2.5m)
PM 8932	Passive probe 100:1, max. voltage 5600V; 2pF (1.5m)
PM 8935L	HF passive probe 10:1 (1.5m)
PM 8935	HF passive probe 10:1 (2.5m)
PM 8940	High voltage isolation amplifier for floating measurements at $650V_{RMS}$
PM 8943	FET probe 650MHz, 1:1/10:1/100:1
PM 8960	19-in rackmount adapter
PM 9355	Current probe 12Hz...70MHz
PM 9381	Oscilloscope camera
PM 8976	Camera adapter for stationary use
PM 9366	Collapsible viewing hood
PM 8980	Long type viewing hood
PM 8994	Set of accessories for probes
PM 8991	Oscilloscope trolley
PM 8901	Battery pack for 3 hours continuous operation
PM 8910	Polaroid anti-glare filter

2mV sensitivity at 50MHz
Auto erase between 1 and 10s
Auto store up to min. 24h on 'babysit' mode
Dual slope triggering
Advanced ergonomic design
Operation from most voltage/frequency line supplies and 21...30V_{DC}

50MHz analog storage oscilloscope PM 3219

The PM 3219 has been designed to provide comprehensive, cost-effective storage of single-shot transients, low-frequency phenomena and other signals. It combines sophisticated facilities such as a 'babysit' mode and auto erase with an excellent 50 MHz specification. The unique storage facilities provide a wealth of capture and display possibilities.

Variable persistence and storage

The PM 3219 combines the dual advantages of variable persistence and variable storage. This allows, for example, low frequency signals to be displayed without flicker and also gives clear displays of fast pulses with low repetition rates.

Its use effectively adds a 'tail' to a slow-moving signal and thereby gives a continuous, flicker-free display. The persistence control allows the timing of this tail to be adjusted between 0.5s and 0.5min.
Storage time is also adjustable: signals can be retained and viewed for one minute at maximum brightness or for one hour at minimum brightness.
When the instrument's variable persistense and storage facilities are not employed, the PM 3219 can be used for a wide range of analog and digital measurement applications.

The 'babysit' mode

In this mode the instrument can capture either positive or negative going transient signals and store the results within a 24 hour monitoring period, without operator attendance. It is therefore possible to display and analyze transient events that have occured over night, during the following morning.

Auto erase facility

Repetitive, low-frequency events are difficult to display. Setting the viewing time to coincide with the repetition time enables events to be captured and displayed one after another. Such a setting results in a virtually continuous signal of the events, but any change is seen immediately and if necessary that particular signal can be captured for a longer analysis simply by pushing the 'read' button before the next erase action occurs.

TECHNICAL SPECIFICATION

CRT

Type
Philips rectangular mesh type post deflection accelerator tube with 8.5kV accelerating voltage, half-tone storage

Screen
P31 phosphor, metal backed

Useful screen area
8 x 10 divisions of 0.9cm

Graticule
Internal graticule

Persistence
Normal: natural persistence of P31 phosphor
Variable: continuously variable from $\leq$ 0.5s to $\geq$ 1 min

Storage time
In 'write' mode: $\geq$ 1 min.
In 'read' mode: $\geq$ 1 h.
In 'auto store' mode: $\geq$ 24 h.

Writing speed
Normal: $\geq$ 0.2 div/μS
Max. write: $\geq$ 2 div/μS

Erase
Pushbutton operated: erasure time ~ 1.3s
Automatic: view time can be set between 1s and 10s
Scope automatically switches to single sweep operation

Auto store
Scope is automatically switched to single sweep operation and stores a single shot

VERTICAL OR Y-AXIS

Frequency response
DC: 0 Hz...50 MHz (−3dB)
AC: 2 Hz...50 MHz (−3dB)

Rise time
7ns

Deflection coefficients
2mV/div...10V/div. 1-2-5 sequence
Uncalibrated, continuous control between steps
1: > 2.5

Accuracy
± 3% (auto store ± 5%)

Display modes
Channel A, channel B, alternate, chopped at approx. 500kHz, added. Channel B can be inverted

Input impedance
1 MΩ//20pF

Max. input voltage
400V (DC + ACpk)

Maximum deflection
Undistorted deflection of 24 div
Shift range 16 div

Signal delay
Viewing of leading edge possible

CMRR-factor
100:1 at 1 MHz
(A-B mode with 8 div common mode signal)

HORIZONTAL OR X-AXIS

Horizontal deflection can be obtained from the main time base, the delayed time base, a combination of both, or from an external source. In this case X-Y diagrams can be displayed using Y_A, Y_B, the EXT connector or the mains as signal source for horizontal deflection

Display modes
X-Y or X-Y/Y operation with X-deflection by: Y_A, Y_B, External or Line

X-INPUT

Deflection coefficients
200mV/div using EXT connector
2V/div using EXT ÷ 10 connector
Vertical attenuator coefficients apply when Y_A or Y_B is used for X-deflection

Measuring accuracy
± 10%

Frequency response
DC...1 MHz (−3dB)

Phase error
3° at 100kHz

MAIN TIME BASE

Mode
Automatic, triggered or single shot

Time coefficients
0.5s/div...100ns/div in 1-2-5 sequence
Uncalibrated, continuous control between steps
1: > 2.5
x 10 magnifier extends max. sweep rate to 10ns/div.

Accuracy
±3%
Additional error for magnifier ± 2%

DELAYED TIME BASE

The delayed time base either starts immediately after the delay time, or is triggerable after delay time by the selected delayed time base trigger source

Time coefficient
1ms/div...100ns/div in 1-2-5 sequence
Uncalibrated continuous control between steps
1: > 2.5

Accuracy
± 3%

Sweep delay
Variable in steps with main time base
Continuously variable with 10-turn potentiometer between 0.1x and 9.9x the time coefficient of the main time base

Incremental delay time accuracy
0.5%

Delay time jitter
1: ≥ 20,000

MAIN TIME BASE TRIGGERING

Trigger source
Internal Y_A, Y_B, Composite, Line
External
External ÷ 10

Slope
+ or − (full bandwidth) dual; 0...10 MHz

Trigger modes
Auto: 20 Hz...50 MHz
DC: 0 Hz...50 MHz
AC: 5 Hz...50 MHz

Trigger sensitivity
Internal: 1 div at 50 MHz
External: 200mV at 50 MHz
External ÷ 10:2V at 50 MHz

Level range
Internal: ≥ 16div
External: ≥ 3.2V
External ÷ 10: ≥ 32V
Automatically adjusted between limits of signal amplitude in position Auto

Variable hold-off
Continuously variable trigger hold-off

External trigger input impedance
1 MΩ//20pF

DELAYED TIME BASE TRIGGERING

Trigger source
Internal, Y_A, Y_B, Composite: Int. 2 div at 50 MHz
Ext. 400mV at 50 MHz
Trigger sensitivity: 2 div at 50 MHz
Other trigger specifications of the delayed time base are identical to that of the main time base

CALIBRATION

Voltage
$1.2V_{pp}$ ± 1% square wave

Frequency
2kHz

POWER REQUIREMENTS

Line voltage and frequencies
110, 220 and 240VAC ± 10%, 50...400 Hz ± 10%

DC power source
21...30VDC, floating input, 1.5A max.

Power consumption
40W when powered from nominal line voltage

Z-Modulation
TTL compatible; "0" blanks the display

DIMENSIONS AND WEIGHT

(w x h x d) 335 x 137 x 470mm
(13.2 x 5.4 x 18.5-in)
10 kg (22lb)

ENVIRONMENTAL CAPABILITIES

The following environmental data are valid only if the instrument is checked in accordance with the official checking procedure. Details of these procedures and failure criteria are supplied on request by the Philips organisation in your country, or by Philips' Test and Measuring Department, Eindhoven, The Netherlands

Ambient temperatures
Rated range of use: + 5°C...+40°C
Limits for operation: −10°C...+55°C
Storage and transport: −40°C...+70°C

Altitude
Operating to 5000m (15 000 ft)
Non-operating: to 15 000m (45 000 ft)

Humidity
21 days cyclic damp heat 25°C...40°C, RH 95%

Shock
30g: half sine wave shock of 11ms duration;
3 shocks per direction for a total of 18 shocks

Vibration
Vibrations in three directions with a maximum of 20 min per direction; 10 min with a frequency of 5...25 Hz and amplitude of $1.016mm_{pp}$; 10 min with a frequency of 25-55 Hz and an amplitude of $0.5mm_{pp}$
Maximum acceleration 3g. Unit mounted on vibration table without shock-absorbing material

Recovery time
Operates within 30min, coming from −10°C soak, going into room conditions of 60% RH at 20°C

ACCESSORIES SUPPLIED

Front cover
2x BNC − 4mm banana adaptor
2x 10:1 passive probes
Operating manual

ORDERING INFORMATION

PM 3219	50MHz analog storage oscilloscope

Power options: see Introduction, page 4

OPTIONAL ACCESSORIES

PM 8921	Passive probe 1:1 (1.5 m)
PM 8921L	Passive probe 1:1 (2.5 m)
PM 8927A	Passive probe 10:1 (1.5 m)
PM 8927AL	Passive probe 10:1 (2.5 m)
PM 8932	Passive probe 100:1; max. voltage 4000V; 2 pF (1.5 m)
PM 8940	High voltage isolation amplifier for floating measurements at $650V_{RMS}$
PM 8943	FET rpobe 650 MHz, 1:1/10:1/100:1
PM 8910	Polaroid anti-glare filter
PM 8963/01	19'' rack mount adapter
PM 9355	Current probe 12 Hz...70 MHz
PM 8972	Camera adapter for stationary use
PM 8980	Long type viewing hood
PM 8991	Oscilloscope trolley
PM 8994	Accessories for probes
PM 9051	BNC − 4mm banana adapter
PM 9366	Collapsible viewing hood
PM 9381	Oscilloscope camera
PM 8992	Accessory pouch
9499.445.00411	Service manual

10MHz/2mV

True dual beam operation

Variable persistence and storage

Uninterrupted recordings and storage, even of single events

Signal delay in both vertical channels

Comprehensive triggering facilities (Auto, AC, DC and single-shot)

Line or 24V DC operation

10MHz dual beam storage oscilloscope PM 3234

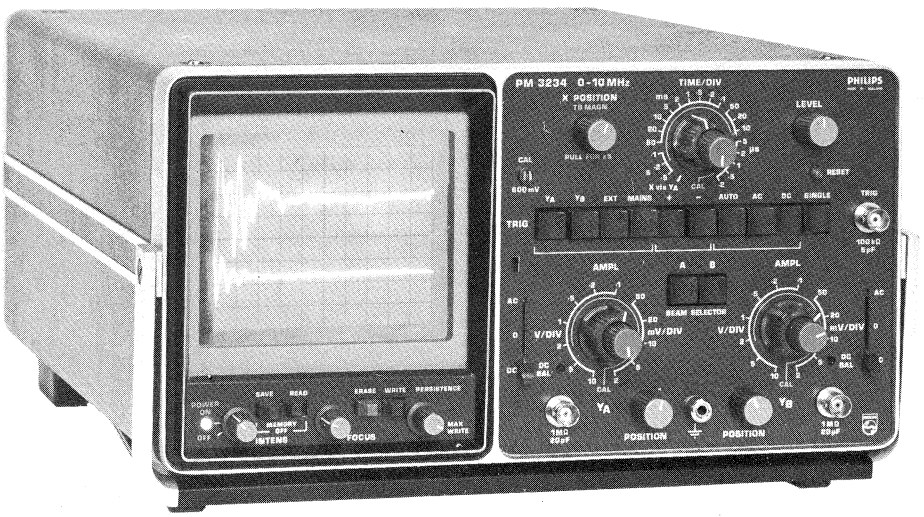
PM 3234 combines true dual-beam operation and 'half-tone' storage including variable persistence, resulting in an advanced and versatile performance. The instrument can thus be used to advantage for a very wide range of applications, often replacing more complex and expensive oscilloscopes.

Dual beam storage provides continuous, uninterrupted displays, unlike the chopped or alternate displays of dual-trace instruments.

Dual beam display, combined with the storage facilities, ensures true displays and recordings, including single-shot phenomena. (See figs. 1 and 2).

Half-tone storage has also proven its value. The half-tone tube is about the same size as a conventional CRT with an equivalent screen size and provides a versatile control of the storage function. For example: the persistence can be varied continuously from 0.3s to 1.5min. It can also be switched from 'high' to 'low' intensity viewing positions giving either minimum brightness for 15min or maximum brightness for 3 min. The PM 3234 is thus an extremely versatile instrument and of particular value for one-shot measurements which can be stored and subsequently analysed in detail.

As well as providing the unique combination of true dual-beam operation with halftone storage, the PM 3234 also has an excellent all-round performance. The 'auto' triggering position is a particularly useful feature as the trigger level is derived from the signal itself. And in the absence of a signal the time base is free running and a quick, accurate check of the zero line reference is obtained. The trace is also easy to find under normal operating conditions.



TECHNICAL SPECIFICATION

CRT

Type
Philips rectangular dual beam postaccelerator half-tone storage tube

Screen type
P31 phosphor

Total acceleration voltage
8.5kV

Useful screen area
8 x 10div. 1div equalling 0.9cm

Overlap for the two beams
100%

Graticule
Internal

Persistence
Normal: Natural persistence of P31 phosphor (10μs...1ms)
Variable: Continuously variable from $<$ 0.3s to $\geq$ 1.5min

Fig. 1. This oscillogram shows a single-shot phenomenon accurately displayed and recorded on the PM 3234.

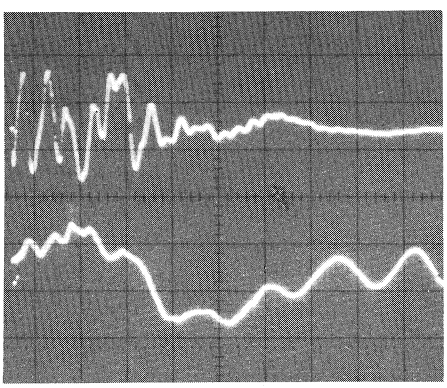
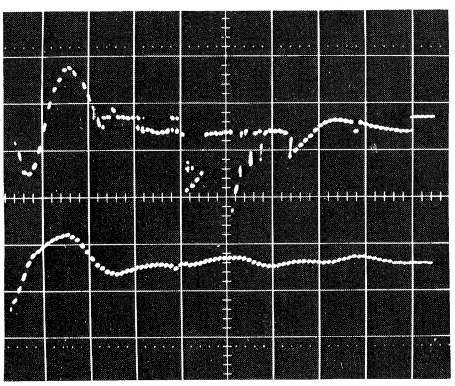


Fig. 2. This oscillogram was taken on a dual-trace instrument recording a same single-shot signal. The error and ambiguity that the chopped display mode has introduced is all too obvious.



Storage time
In maximum persistence mode: ≥ 1.5min.
In 'read' mode: ≥ 3m
In 'save' mode: ≥ 15m

Writing speed
Normal: ≥ 100div/ms
Max. write: ≥ 1div/μs

Erase
Push button operated, erasure takes approx. 600ms

VERTICAL OR Y-AXIS

Two identical amplifiers, one for each deflection system. The input stages are provided with an active drift-feedback circuit, giving an extremely stable display.

Response
DC: 0Hz...10MHz (−3dB)
AC: 2Hz...10MHz (−3dB)

Risetime
35ns

Deflection coefficients
2mV/div...10V/div in twelve steps in 1-2-5 sequence. Uncalibrated, continuous control between the steps.

Accuracy
3%

Over- (under-) shoot
≤ 2% (with a test pulse of 10ns risetime for 6div of deflection at 1MHz)

Input impedance
1MΩ/20pF
Input RC time when AC coupled 100ms

Maximum input voltage
$400V_{DC+ACpk}$

Maximum deflection
For sinewave signals with frequencies of up to 3MHz, the vertical deflection will be undistorted for a total amplitude of 24div. With the aid of the positioning controls, the peaks of such a signal can be displayed.

Signal delay
150ns total, 80ns visible

DC-drift at maximum sensitivity
< ¼div/hour

HORIZONTAL OR X-AXIS

Horizontal deflection can be obtained from an internally generated, triggered time-base, or from an external signal, connected to the Y_A input. In this case X−Y diagrams can be displayed with full sensitivities for both directions.

HORIZONTAL AMPLIFIER

Response
DC: 0Hz...1MHz (−3dB)
AC: 2Hz...1MHz (−3dB)

Deflection coefficients
2mV/div...10V/div in twelve calibrated steps in 1-2-5 sequence. Uncalibrated continuous control between steps

Measuring accuracy
5%

Phase error
5° at 100kHz

TIME BASE

Time coefficients
0.5s/div...0.2μs/div in twenty calibrated steps in 1-2-5 sequence. Uncalibrated continuous control between steps.

Measuring accuracy
5%

Time base magnifier
5 x, giving a display equivalent to 50div every 10div of which can be made visible by using the horizontal positioning control. The measuring accuracy with magnified sweep is 7%

Time base output
$6V_{p-p}$ (from −2 to +4 open output voltage)
$300mV_{p-p}$

Time base output into 50Ω

Internal resistance
1kΩ
The time base output may be short-circuited without affecting the accuracy of the time coefficients

TRIGGERING

The time base generator operates in the triggered mode with adjustable level and slope when an input signal is applied. An auto-circuit can be switched in, providing a bright zero line at an adjustable trigger level, the level automatically being limited to the peak-peak amplitude of the signal.

Trigger source
Internal: Y_A
Y_B
Line

External

Trigger slope
+ or −

Trigger mode
Auto: 20Hz...≥ 10MHz
AC: 10Hz...≥ 10MHz
DC: 0Hz...≥ 10MHz
Single

Trigger sensitivity
Internal: 1div up to 10MHz
External: 1V up to 10MHz

Input impedance
100kΩ/5pF

Maximum input voltage
$400V_{DC+ACpk}$

Level range
Internal: 24div (with continuous attenuator in 'CAL' position)
External: 24V. In the automatic mode, the level range is automatically adjusted to the signal amplitude.
The trigger level is *not* influenced by the vernier controls of the vertical deflection factors.

CALIBRATION

Calibrated voltage: 600mV ± 1% square wave
Frequency: 2kHz approximately

POWER

Line voltages and frequencies
AC: 90V...140V and 180V...265V, 46...440Hz
DC: 22V...30V

Power consumption
AC: 61VA at 220V
DC: 1.4A at 24V

ENVIRONMENTAL CAPABILITIES

The environmental data are valid only if the instrument is checked in accordance with the official checking procedure. Details on these procedures and failure criteria are supplied on request by the PHILIPS organization in your country, or by PHILIPS' TEST AND MEASURING DEPARTMENT, EINDHOVEN, HOLLAND.

Ambient temperatures
Rated range of use: +5°C...+40°C
Operating: −10°C...+55°C
Storage and transport: −40°C...+70°C

Altitude
Operating: to 5000m (15000ft)
Non-operating: to 15000m (45000ft)

Humidity
21 days cyclic damp heat 25°C...40°C R.H. 95%

Bump
1000 bumps of 10g, ½ sine, 6ms duration, in each of 3 directions

Vibration
30 minutes in each of three directions, 10-150Hz; $0.7mm_{p-p}$ and 5g max. acceleration.
Unit mounted on vibration table with shock absorbing material.

Recovery time
Operates within 30 minutes coming from −10°C soak, going into 60% relative humidity at +20°C room conditions

Electromagnetic interference
Meets VDE 0871 and VDE 0875
Grenzwertklasse B

Safety
Safety class 1 according to IEC 348.

DIMENSIONS AND WEIGHT

(w x h x d) 326 x 185 x 503mm
(12.8 x 7.3 x 19.8-in)
11.8kg (26lb)

ACCESSORIES SUPPLIED

Front cover
Operating and service manual
BNC-Banana adapter
Contrast filter

OPTIONAL ACCESSORIES

PM 9326	Passive probe 1:1/10:1 (1.1m)
PM 9327	Passive probe 1:1/10:1 (2.1m)
PM 8923	Passive probe 1:1/10:1
PM 8921	Passive probe 1;1 (1.5m)
PM 8921L	Passive probe 1:1 (2.5m)
PM 8927A	Passive probe 10:1; 11pF (1.5m)
PM 8927AL	Passive probe 10:1; 14pF (2.5m)
PM 8932	Passive probe 100:1; max. voltage 5600V; 2pF (1.5m)
PM 8940	High voltage isolation amplifier for floating measurements at $650V_{RMS}$
PM 8943	FET probe 650MHz 1:1/10:1/100:1
PM 9359	19-in rackmount adapter
PM 9355	Current probe 12Hz...70MHz
PM 9381	Oscilloscope camera
PM 8973	Camera adapter for stationary use
PM 9366	Collapsible viewing hood
PM 8980	Long type viewing hood
PM 8994	Set of accessories for probes
PM 8991	Oscilloscope trolley
PM 8901	Battery pack for 9 hours continuous operation

Survey of probes

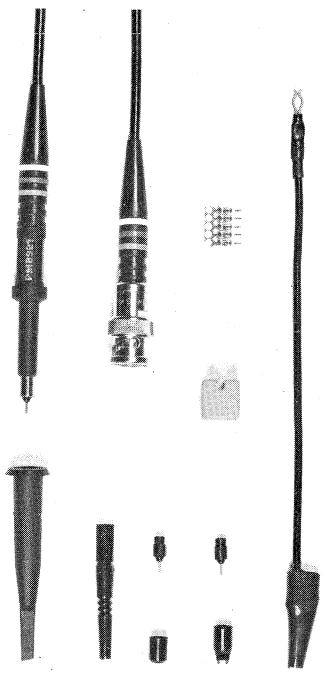
Type	Atten.	Length (m)	Loading (MΩ)	Loading (pF)	Zero ref	Range ind.	Max. input voltage d.c. +a.c. peak (V)	Useful BW (MHz)	Probe only rise time ns	Scope in pF
PASSIVE PROBES										
PM 8921	1x	1.5	1	42[1]	no	no	500	15 15 10	17 20 26	15 and 15...20 and > 20
PM 8921L	1x	2.5	1	64[1]	no	no	500	10 10 10	25 29 37	15 and 15...20 and > 20
PM 8922	1x	1.3	1	50[1]	no	no	600	10	35	any
	10x		10	15			600	50	3.5	10...60
PM 8927A	10x	1.5	10	11	yes	no	500	100 60 35	1.7 2.5 5	10...25 26...30 31...40
PM 8927AL	10x	2.5	10	14	yes	no	500	75 55 30	2 3 5.5	10...25 26...30 31...40
PM 8927AS[2]	10x	1.5	10	11	yes	yes	500	100 60 35	1.7 2.5 5	10...25 26...30 31...40
PM 8932	100x	1.5	20	2	yes	no	4000	175 60	1.2 3.5	10...21 and 21...30
PM 8935	10x	1.5	10	11	yes	no	500	250	0.6 0.9	10...11 and 11...16
PM 8935L	10x	2.5	10	14	yes	no	500	250	0.7 1.1	10...11 and 11...16
PM 9326	1x	1.1	1	32[1]	no	no	1000	15	20	any
	10x	1.1	10	8			1000	15	7	10...55
PM 9327	1x	2.1	1	58[1]	no	no	1000	15	35	any
	10x	2.1	10	8			1000	15	7	10...30
ACTIVE PROBES										
PM 8940	–	2.3	10	9	–	no	650 $_{RMS}$	1.5	230	any
Isolation ampl.			1	45						
PM 8943 FET probe	1x	1.5	1	3.5	–	no	100	650	0.55	
	10x		1	2.2			200			
	100x		1	1.4			200			
PM 9355 Current probe	–	1.5	–	–	–	–	–	12Hz...70MHz	8	any

[1]) Plus capacitance of oscilloscope

[2]) S=Probe indication

Passive and active probes

PM 8921(L)
General purpose passive 1:1 probe



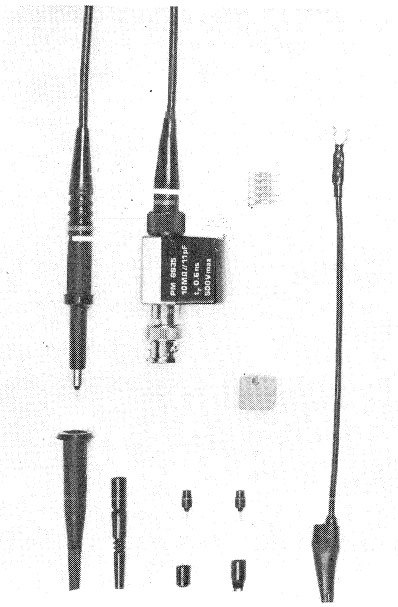
To be used with frequencies up to 15MHz, and with any measuring equipment having a BNC input connector.
Included parts: Retractable hook tip; wire wrap adapter; dual in-line adapter; two spare tips; ground lead; protective cap; two isolating sleeves; probe holder; 5 contact clips.

TECHNICAL SPECIFICATION PM 8921 (for 1MHz//20pF 'scope)

	PM 8921
Attenuation	1x
Input resistance	1 MΩ
Input capacity	42pF
Probe-only bandwidth	17 MHz
Probe-only rise time	20ns
Max. input voltage	500$V_{DC+ACpk}$
Cable length	1.5m

	PM 8921 L
Attenuation	1x
Input resistance	1 MΩ
Input capacity	64pF
Probe-only bandwidth	12 MHz
Probe-only rise time	29ns
Max. input voltage	500$V_{DC+ACpk}$
Cable length	2.5m

PM 8927A; PM 8927AL PM 8927AS; PM 8935(L)



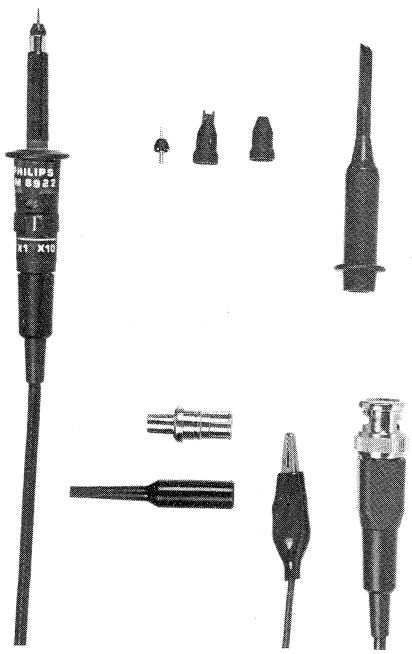
TECHNICAL SPECIFICATIONS PM 8927A, PM 8927AL, PM 8927AS and PM 8935(L)

	PM 8927A	PM 8927AL	PM 8927AS
Attenuation	10x	10x	10x
Inputresistance	10MΩ	10MΩ	10MΩ
Input capacity	11pF	14pF	14pF
Probe only rise time	1.7ns	2ns	2ns
Compensation range	14... 21pF	14... 21pF	14... 21pF
Max. input voltage (DC + ACpk)	500V	500V	500V
Cable length	1.5m	2.5m	2.5m

	PM 8935	PM 8935(L)
Attenuation	10x	10x
Inputresistance	10MΩ	10MΩ
Input capacity	11pF	14pF
Probe only rise time	0.6ns	0.7ns
Compensation range	10... 16pF	10... 16pF
Max. input voltage (DC + ACpk)	500V	500V
Cable length	1.5m	1.5m

Included parts: Retractable hook tip, wire wrap adapter, dual in-line adapter, isolating sleeve, 2 spare tips, probe holder, 5 contact clips, ground lead.

PM 8922
General purpose 10:1 and 1:1 probe

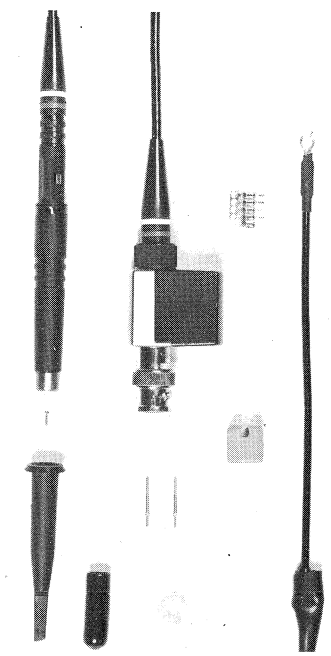


Included parts: Retractable hook tip, dual in-line adapter, isolating sleeve, spare tip.

TECHNICAL SPECIFICATION PM 8922

Attenuation	10x	1x
Input resistance	10M	1M
Input capacity	15pF	50pF
Probe only rise time	3ns	35ns
Compensation range	10...60pF	n.a.
Max. input voltage (DC + AC_{pk})	600V	600V
Cable length	1.5m	1.5m

PM 8932
High voltage passive 100:1 probe (with zero line reference)

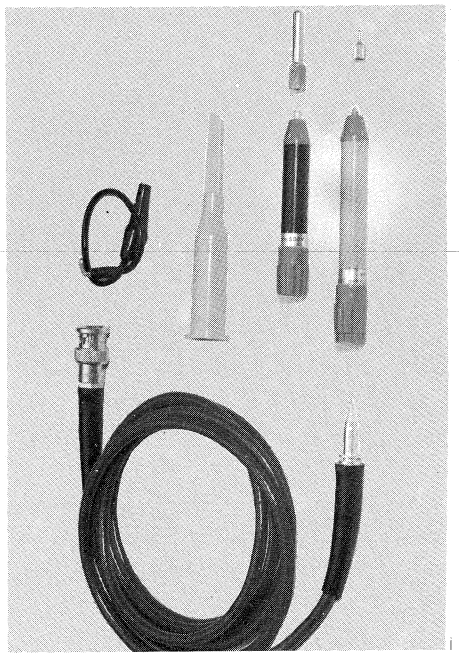


Included parts: Retractable hook tip, 2 spare tips, probe holder, 5 contact clips, ground lead, 3 sets of coloured rings.

TECHNICAL SPECIFICATION PM 8932

Attenuation	: 100x
Input resistance	: 20MΩ
Input capacity	: 2pF
Probe-only risetime	: 1.2ns
Compensation range	: 10...30pF
Max. input voltage (derating above 1MHz)	: 4kV $DC+AC_{pk}$ 5.6V AC_{pk-pk}

PM 9326
PM 9327
General purpose passive probes



These probes are designed for use in the frequency range DC to 15MHz. The probe head is removable and can be selected to give an attenuation of either 1:1 or 10:1
Included parts: Probe cable 1.5m; ground lead; probe heads; 10:1 and 1:1; measuring hook.

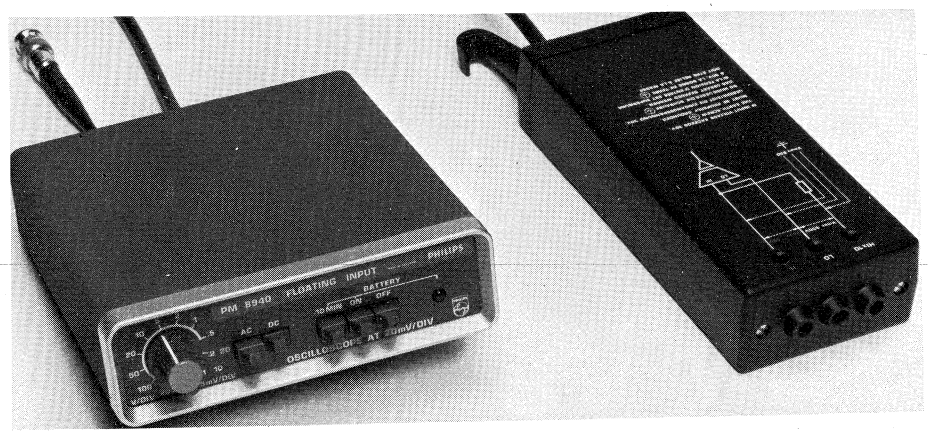
TECHNICAL SPECIFICATION PM 9326

With 1:1 attenuator	
Input resistance	1MΩ
Input capacitance	32pF
Rise time (probe only)	20ns
Max input voltage	$1kV_{DC+ACpk}$
Cable length	1.1m
With 10:1 attenuator	
Attenuation	10x ±3%
Input capacity when connected to 20pF scope input	8pF
Compensation range	10...55pF
Rise time (probe only)	7ns

TECHNICAL SPECIFICATION PM 9327

With 1:1 attenuator	
Input resistance	1MΩ
Input capacitance	58pF
Rise time (probe only)	35ns
Max. input voltage	$1kV_{DC+ACpk}$
Cable length	2.1m
With 10:1 attenuator	
Attenuation	10x ±3%
Input capacity when connected to 20pF scope input	8pF
Compensation range	10...30pF
Rise time (probe only)	7ns

PM 8940 Isolation amplifier



Bandwidth: DC...1.5MHz
Max. common mode voltage: $650V_{RMS}$
Max. differential input voltage: $650V_{RMS}$
Deflection coefficient: 5mV/div

PM 8940 accurately measures small signals floating on high potentials (up to $650V_{RMS}$), without risk to the operator.
A 15-step attenuator covers the range 5mV...200V/div to maximize oscilloscope screen use. This plus the high common mode rejection of 1:800,000 in the 5mV/div setting allows easy observation of minute details in complex waveforms.
The combination of the units input capacitance and low input impedance w.r.t. ground ensures good, reliable oscillograms of floating signals at frequencies up to 1.5MHz.

The separated amplifier and attenuator allows the probe to be used very close to the circuit under test whilst at a safe distance from high potentials.
Connection to the pre-amplifier is via a screw terminal recessed within the pre-amplifier housing. Disconnection thereafter requires a screwdriver, alerting users to the presence of high voltages and motivating them to remove the high voltage source before proceeding. The two amplifier inputs cover the ranges 5 to 20mV and 50mV to 200V per div. The amplifier is part-powered by batteries with an automatic switch-off after 10mins option; a line voltage step-down unit is contained inside the line plug.
The high voltage connecting cable will withstand up to 250°C max to avoid damage from high temperatures.

		Input 1	Input 2
Bandwidth:	DC:	0...1.5MHz	0...1.5MHz
	AC:	3Hz...1.5MHz	3Hz...1.5MHz
Abberations:		≤ ±3%	≤ ±3%
Max. wire diameter:		2mm	2mm
Defl. coefficient:		50mV...200V/div	5mV...20V/div
Defl. accuracy:		≤ ±3%	≤ ±3%
Max. diff. inp. voltage:		$650V_{RMS}$	$30V_{RMS}$
Diff. inp. impedance:		10MΩ//9pF	1MΩ//40pF
Common mode rejection (For $650V_{RMS}$ sine wave, common mode voltage; DC to 60Hz)		≤ 0.5div 500mV...200V/div	≤ 0.5div
Max. common mode inp. volt:		$650V_{RMS}$	$650V_{RMS}$
Input capacitance to ground:		60pF	25pF

OUTPUT

Load:	1mΩ//± 10...40pF
Dynamic range:	20div*
Output offset:	≤ 0.25div*
Drift:	≤ 0.05div/°C*
Noise:	≤ 0.05div*

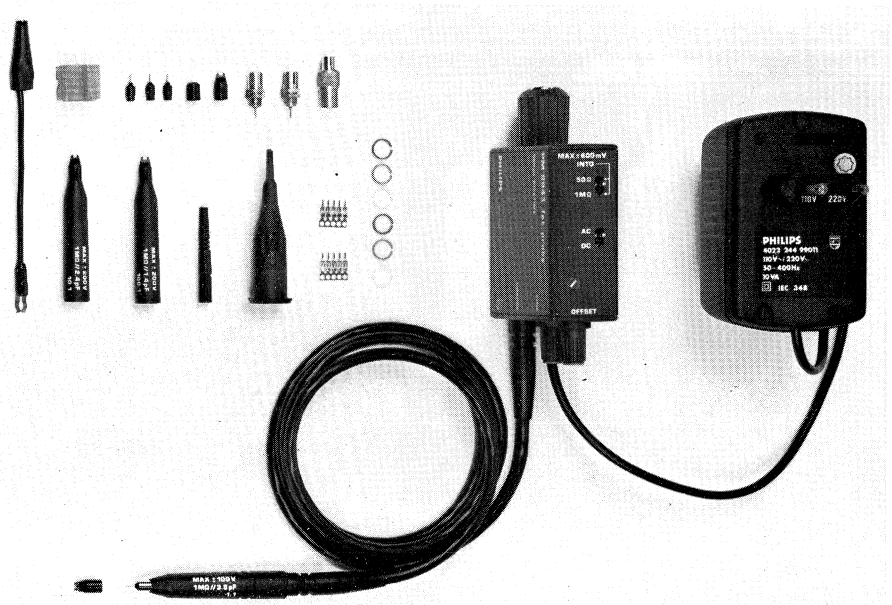
* Oscilloscope at 20mV/div and DC coupling

POWER SUPPLY:

AC supply:	220V (−10%/+20%)
Frequency:	50...400Hz (±10%)
Power consumption:	10VA max
DC supply:	two 9V batteries. (Giving two hours operating time)

PM 8943 FET probe

The PM 8943 is designed for the measurement of low level, high frequency signals. Using the probe makes it possible to measure high frequency signals with a 1:1 gain still having a good frequency response and a minimum loading of the circuit under test. The plug-on attenuator heads offer higher maximum input voltages and give an extra reduction of the input capacitance. DC-AC coupling can be selected by a switch without having to change the probe. The PM 8943 is invaluable for use in 50Ω and 1MΩ systems having a BNC input, such as oscilloscopes, counters, analyzers etc.



TECHNICAL SPECIFICATION PM 8943

Gain:	1x
Bandwidth:	DC to 650 MHz 1 Hz to 650 MHz
Rise time:	≤ 0.55ns
Input resistance:	1 MΩ
Input capacitance:	3.5pF
Dynamic range:	0.6V
Offset voltage:	±5V
Noise (tangential):	250μV
Max. input voltage:	$100V_{DC+ACpk}$
Power supply:	220, 100V +20%/−10%
Signal delay:	8.5ns
Output load:	50Ω or 1 MΩ

Attenuator 10x:	Input resistance: 1 MΩ Input capacitance: 2.2pF Dynamic range: 6V DC offset: ±50V
Attenuator 100x:	Input resistance: 1 MΩ Input capacitance: 1.4pF Dynamic range: 60V DC offset: ±200V

PM 9355/01 AC current probe

Bandwidth: 12Hz...70MHz
High 1mA/div. sensitivity
Low circuit loading
Low noise level: 150μV

The PM 9355 AC current probe and amplifier combination is ideal for measuring currents from 12Hz to 70MHz. The clip-on current transformer allows measurements on wires up to 3mm in diameter without disconnection. The 100:1 transformer gives signal measurements with minimum loading (0.005Ω//2.5μH).
The low 150μV noise level combined with a sensitivity of 1mA/mV (with scope set to 50mV/div) ensures accurate, clear reading of low-amplitude signals. Selection of the required sensitivity is done by means of a calibrated switch on the amplifier.

TECHNICAL SPECIFICATION PM 9355/01

Sensitivity
1mA/div to 1A/div in 10 steps with oscilloscope set at 20mV/div. Accuracy ±3%

Bandwidth
5mA/div to 1A/div 12Hz to 70MHz;
1mA/div to 1A/div 12Hz to 45MHz;

Risetime
5mA/div to 1A/div, 5ns;
1mA/div to 1A/div, 8ns;

Dynamic range
approx 6 divisions.
(oscilloscope set at 20mV/div)

Output load
50Ω (50Ω termination included for 1 MΩ systems).

Maximum Voltage
$600V_{DC+ACpk}$ (probe closed)

Maximum current
$12A_{p-p}$

Noise
150μA (referred to input)

Capacitive load
0.5pF to 2pF depending on wire diameter

Power
220, 100V (+20%, −10%)

Temperature range
+ 5°C to +40°C within specification,
−10°C to +55°C operating,
−40°C to +70°C storage and transport.

Accessory Selection chart

				PM 3206	PM 3207	PM 3211	PM 3215	PM 3217	PM 3219	PM 3226*	PM 3233*/34*	PM 3254/56	PM 3262	PM 3263(x)	PM 3264	PM 3266	PM 3267	PM 3302	PM 3305	PM 3310	PM 3311	PM 3315
Adapters																						
PM 9051																		+				
PM 9053																						
PM 9061																						
PM 9067																						
Battery pack																						
PM 8901	Battery pack $24V_{DC}$ and $260V_{DC}$						+	+			+	+	+	+	+	+	+		+			
Cables																						
PM 9071																						
PM 9072																						
PM 9074																						
PM 9075																						
Camera and camera adapters																						
PM 9381	Oscilloscope camera			+	+	+	+	+			+		+	+	+	+	+	+	+	+	+	+
PM 8973	Adapter for stationary use										+											
PM 8972	Adapter for stationary use					+	+	+	+								+	+	+			
PM 8976	Adapter for stationary use												+	+	+	+				+	+	+
Graticules and filters																						
PM 8910	Polaroid anti-glare filter					+	+	+					+	+	+	+	+		+	+	+	+
Probes (active)																						
PM 8940	Isolation amplifier				+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
PM 8943	1:1, 10:1 and 100:1	FET-probe			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
PM 9355	Current probe				+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Probes (passive)																						
PM 8921(L)	1:1	1.5 or	2.5m (L)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
PM 8922	1:1/10:1			+	+	+	+	+	+	+	+								+			
PM 8927A(L)	10:1	1.5m or	2.5m (L)	+	+	+	+	+	+	+	+	+						+	+	+	+	+	+
PM 8927AS	10:1 with range indication																			+	+	+
PM 8932	100:1 5600V		1.5m	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
PM 8935 (L)	10:1	1.5m or	2.5 (L)										+	+	+	+						
PM 9326	1:1 and 10:1	1.1m			+	+				+	+											
PM 9327	1:1 and 10:1	2.1m			+	+				+	+											
Rack mount adapters 19-in																						
PM 8960													+	+	+	+				+	+	+
PM 8962							+															
PM 8963/01								+									+		+			
PM 8965									+													
PM 8967					+																	
PM 9359											+											
Sundries							/15	/15	/15	/19			/54	/60	/66	/66	/66	/15		/15	/66	/66	
PM 8992/xx	Accessory pouches																					
PM 8994	Accessories for probes				+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
PM 8987	Front cover				+																	
PM 8995	Set of wire wrap adapters for probes				+	+	+	+	+	+	+	+	+	+	+	+				+	+	+
Trough-line terminations																						
PM 9581																						
PM 9585																						
Trolly																						
PM 8991							+	+	+	+		+	+	+	+	+	+	+	+	+	+	+
Viewing hoods																						
PM 8980	Closed, long type viewing hood			+	+		+	+	+		+		+	+	+	+	+		+	+	+	+
PM 9366	Collapsible viewing hood			+	+	+	+	+	+		+		+	+	+	+	+		+	+	+	+

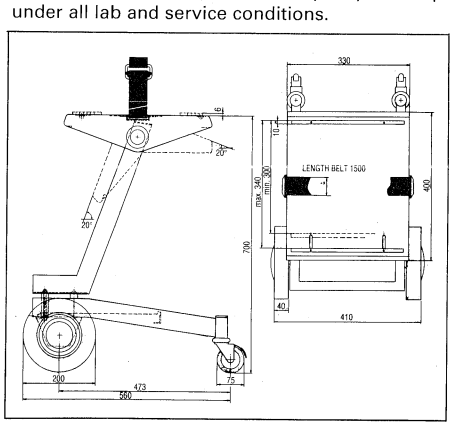
*no longer available

Oscilloscope accessories

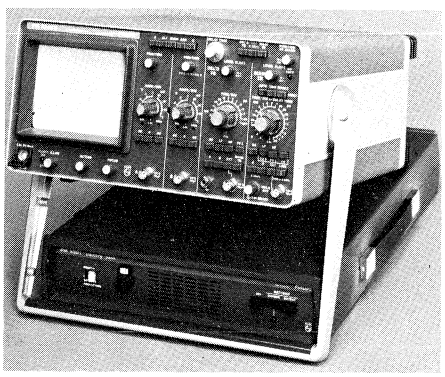
Trolley PM 8991

To make an optimum use of the lab features of the light weight oscilloscopes, a trolley PM 8991 is available for the following type numbers: PM 3211/12*/15/17/19, PM 3232*, PM 3243*/44*, PM 3262, PM 3263X, PM 3266, PM 3267, PM 3305, PM 3310/11/15.

The oscilloscope tray can be positioned from – 15° downwards to 70° upwards. This possibility together with the solid wheels (2 x 20cm and 2 x 7.5cm ∅) offers good mobility of your scope under all lab and service conditions.



Battery packs



PM 8901 330V/24V battery pack. Sealed lead acid batteries giving 180Wh from full charge. Charging time 10h. Protected against overload, short-circuit and excessive discharging.

Operation time:

PM 3212*/15	12 h
PM 3217	10 h
PM 3219	4.5h
PM 3233	9 h
PM 3234	5.5h
PM 3243*	3 h
PM 3244*	5 h
PM 3254	4.5h
PM 3256	4.5h
PM 3262	3 h
PM 3264	1.5h
PM 3266	2.5h
PM 3305	1 h

Note: PM 3215 and PM 3217 are also available in a 'B' version with a built-in battery unit having a 2½-hour capacity.

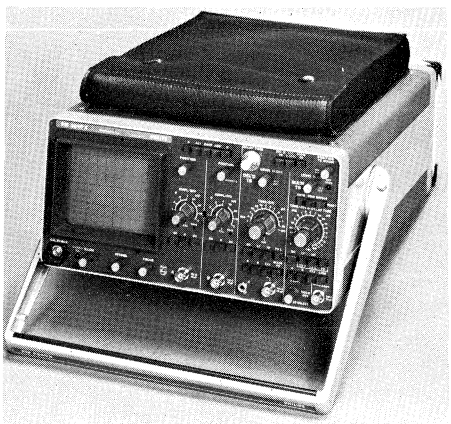
Graticules and filters

PM 8910 Polariod anti-glare for PM 3211/12*/15/17/19, PM 3243*/44*, PM 3262, PM 3263X, PM 3264, PM 3266, PM 3310/11/15.

Miscellaneous

PM 8987 Front cover for PM 3207
PM 8994 Set of probe accessories
1x ground cable 30cm
1x ground cable 15cm for wire-wrap
1x ground cable 30cm for wire-wrap
PM 8995 set of 10 wire-wrap adapters

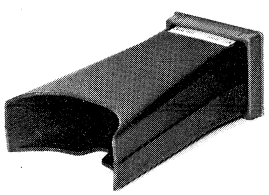
Accessory pouches



PM 8992/15 Accessory pouche for PM 3211/12*/15/17/67
PM 8992/60 Accessory pouche for PM 3244* and PM 3262
PM 8992/54 Accessory pouche for PM 3254/56

Viewing hoods

PM 9366



PM 8980

PM 9366 Collapsible viewing hood for PM 3207, PM 3211/12*/15/17/19, PM 3243/44, PM 3262, PM 3263X, PM 3264, PM 3266, PM 3267, PM 3305, PM 3310, PM 3311/15.

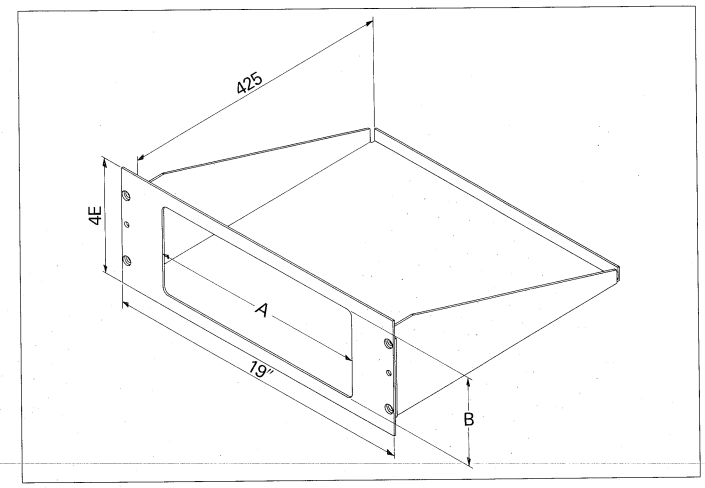
PM 8980 Closed, long type viewing hood PM 3207, PM 3211/12*/15/17/19, PM 3243*/44*, PM 3262, PM 3263X, PM 3264, PM 3266, PM 3267, PM 3305, PM 3310.

* no longer available

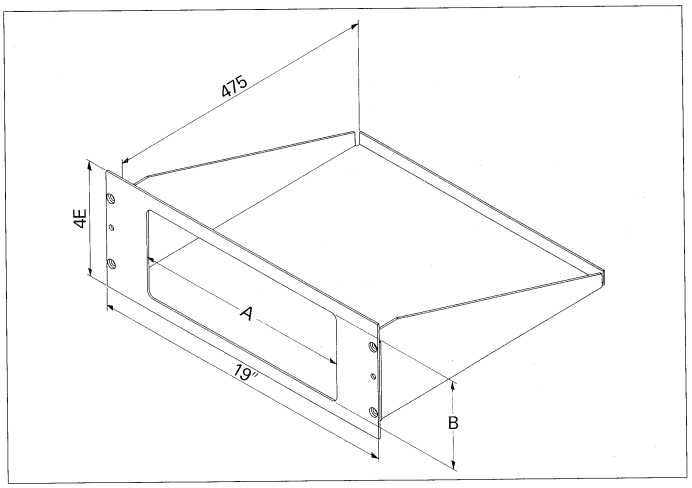
19-in Rackmounts for oscilloscopes

Oscilloscope	19″ rackmount	Dimension A		Dimension B	
Type No.	Type No.	mm	inches	mm	inches
PM 3207	PM 8967	298.5	11.75	128.4	5.05
PM 3211	PM 8962	300.6	11.8	137.4	5.61
PM 3212	PM 8962	300.6	11.8	137.4	5.61
PM 3214	PM 8963	336.8	13.25	137.4	5.61
PM 3215	PM 8962	300.6	11.8	137.4	5.61
	Option 30	300.6	11.8	137.4	5.61
PM 3216	PM 8962	300.6	11.8	137.4	5.61
PM 3217	PM 8963	336.8	13.25	137.4	5.61
	Option 30	336.8	13.25	137.4	5.61
PM 3218	PM 8963	336.8	13.25	137.4	5.61
PM 3219	PM 8965	336.8	13.25	137.4	5.61
PM 3232	PM 9359	313	12.32	161	6.33
PM 3233	PM 9359	313	12.32	161	6.33
PM 3234	PM 9359	313	12.32	161	6.33
PM 3240(X)	PM 8960	316	12.44	154.5	6.08
PM 3243	PM 8960	316	12.44	154.5	6.08
PM 3244	PM 8960	316	12.44	154.5	6.08
PM 3254	note 1	287.5	11.3	125.3	4.93
PM 3256	note 1	287.5	11.3	125.3	4.93
PM 3260	PM 8960	316	12.44	154.5	6.08
PM 3261	PM 8960	316	12.44	154.5	6.08
PM 3262	PM 8960	316	12.44	154.5	6.08
PM 3263(X)	PM 8960	316	12.44	154.5	6.08
PM 3265	PM 8960	316	12.44	154.5	6.08
PM 3266	PM 8960	316	12.44	154.5	6.08
PM 3267	PM 8963	336.8	13.25	137.4	5.61
	Option 30	336.8	13.25	137.4	5.61
PM 3305	PM 8963	336.8	13.25	137.4	5.61
PM 3310	PM 8960	316	12.44	154.5	6.08
PM 3311	PM 8960	316	12.44	154.5	6.08
PM 3315	PM 8960	316	12.44	154.5	6.08

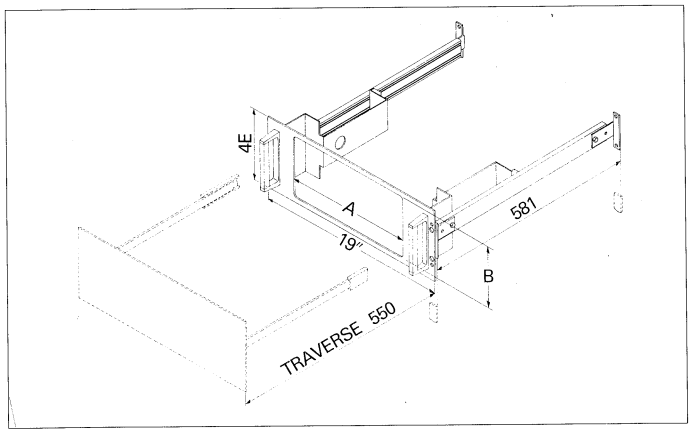
Notes: 1 Type number = 9444 989 63021
2 Height measurement: 1 x E = 44.4mm (1.75-in)



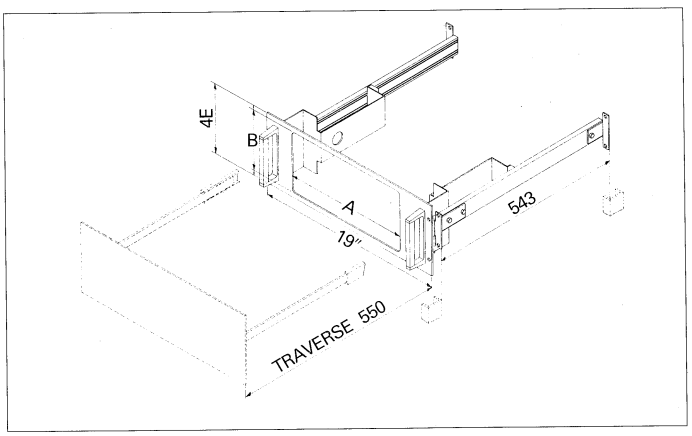
PM 8962, PM 8963, PM 8967, 9444 989 62031



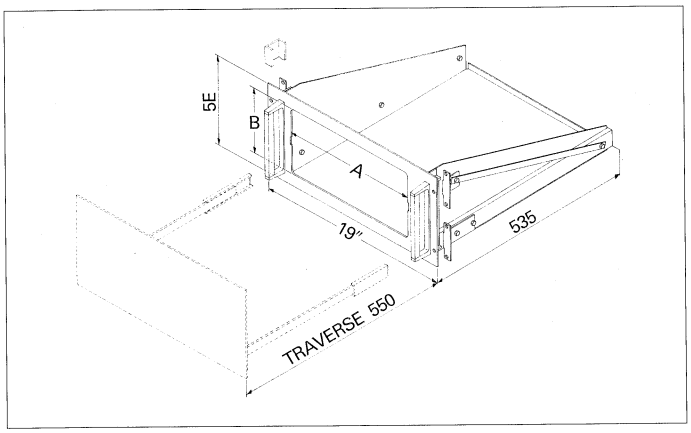
PM 8965



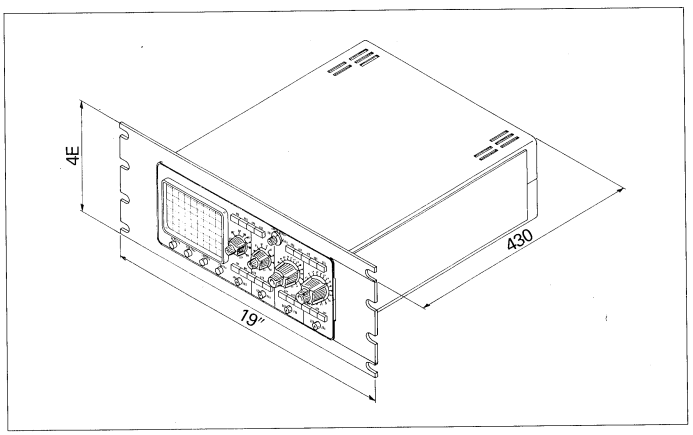
PM 8960 USA-VERSION



PM 8960



PM 9359



OPTION 30 (Factory installed, delivered without probes or cover.)

Terminations, cables, adapters and camera

Camera PM 9381 for instant oscillograms

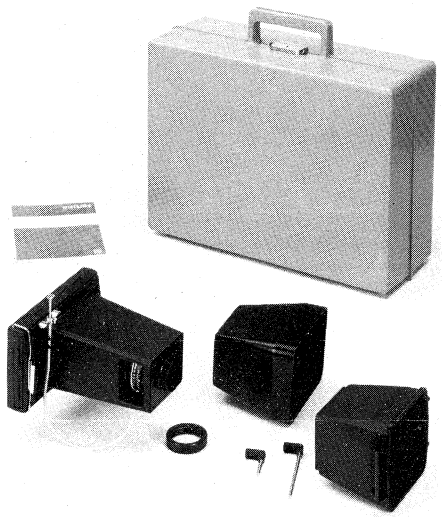


Fig. 1. PM 9381 kit which gives the user the option of a hand-held or fixed arrangement.

If photos of oscilloscope waveforms have to be taken, one operator prefers to have the camera pemanently fitted to the oscilloscope, whilst another may not wish to have this disturbing object on his measuring instrument.
With the PM 9381 both preferences can be met. The PM 9381 is delivered as a handheld camera together with those extra tools necessary for modifying it into a fitted camera (Fig. 1). Separate adapters for different type of oscilloscopes fit the camera to the required instrument (Fig. 2). The camera with the adapter for handheld operation is supplied in an attractive case which also offers storage space for the separate adapters for fitted use plus two extra film packs.

TECHNICAL SPECIFICATION

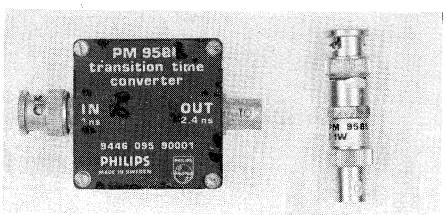
Oscilloscope camera including adapter for hand hold use.

Camera Body	: High quality ABS moulding with attached Polaroid 101 series film back.
Lens	: Moulded two element f3.5 70mm focal length with aperture control down to f32.
Shutter	: Self cocking, mounted between lens. Speeds from 1 second to 1/125th inclusive, with 'B' for time exposures. Built in 'X' contact for event triggering. Shutter actuated by cable release.
Focus	: Fixed by method of mounting for correct distance.
Object to Image Ratio	: Up to 8 x 10cm displays 1 < 0.85 fixed.
Film	: Polaroid Black and White 8 exposure film packs Type 107C 3000 ASA Type 665 75 ASA Pos./Neg.

Adapters for fixed use:
PM 8972 for PM 3211, 3212*, 3215, 3217, 3218*, 3219, PM 3267, PM 3305
PM 8973 for PM 3233, 3234
PM 8976 for 3243*, 3244*, 3262, 3263X, 3264, 3266, 3310/11/15

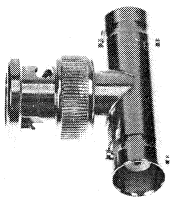
** Not in current range*

Trough-line terminations

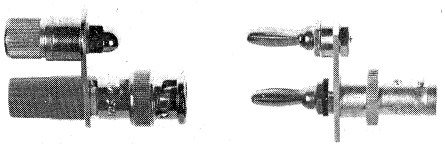


PM 9581 50Ω/3W **PM 9585** 50Ω/1W

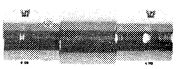
Adapters



PM 9067 T-piece adapter 1 x BNC (m) 2 x BNC (f)



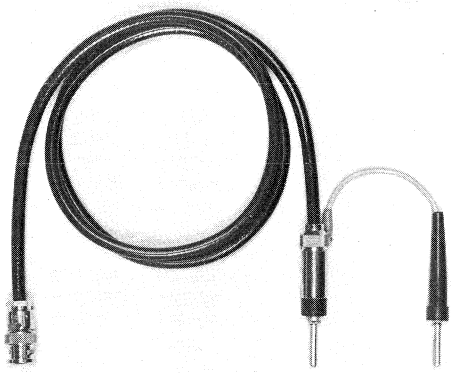
PM 9051 BNC (m) – Banana (f)
PM 9053 BNC (f) – Banana (m)



PM 9061 BNC (f) – BNC (f)

Cables

PM 9071 135Ω Banana-banana



PM 9072 BNC-Banana 135Ω

PM 9074 BNC-BNC 50Ω
PM 9075 Cable BNC-BNC 75Ω

Fig. 2. PM 9381 shown fitted to an oscilloscope.

Development and Test Systems

The rapid advance of microelectronics demands a range of a new type of dedicated, high-performance measuring instrumentation. Such instruments are produced by the DTS group, within the Test & Measurement Department.

Philips has all the tools needed for the development of advanced microcomputer systems. The complete range is a direct result of reacting quickly to, and anticipating, customer demands, as well as recognising advances in microchip designs. An example is the PM 3551 A logic analyzer, an instrument designed for the future, with its software and capacity for expansion in modular fashion up to 300MHz sampling rate. Another example is the PMDS-2, Philips' Microcomputer Development System, which is one of the most flexible and sophisticated design tools on the market. It is universal, supporting a wide variety of microprocessors from various manufacturers – including the most complex devices with clock speeds up to 16MHz. Moreover, it too is designed for expansion, in tune with the rapidly advancing field of microprocessor technology. Tools such as PM 3551A and PMDS-2 have become more sophisticated to cope with the increasing needs, since the available human resources – talented digital designers and developers – lags on the increasing demands for microprocessor-based products.

Philips supplies the required design tools through Philips' Development and Test Systems (DTS). This family combines data test equipment with the accent on logic analyzers and microcomputer development systems (PMDS-2) in order to support development at all stages from initial design, through hardware and software development, integration, system testing and debugging to trouble-shooting and maintenance. PMDS ensures software portability, prevents premature obsolescence by providing universal support and brings decreased development times, having all the development aids contained in one unit. Logic analyzers provide a user-friendly method of hardware testing and, with their new and unique features, can pin-point errors quickly and easily. Software and system performance measurement options show the designer where bottlenecks limit the speed or reaction time of a microcomputer-based product.

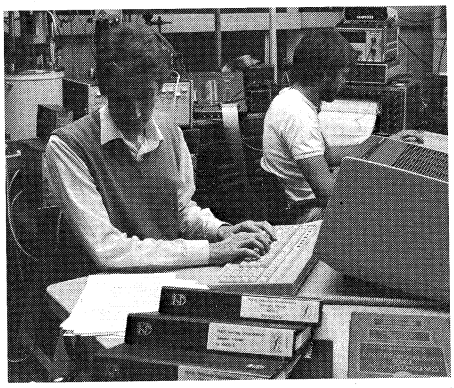
Speeding up the design process

Philips' DTS can help from the word go. When the need for a new product is identified, as always it is wise to think from the top, downwards; first to analyse and specify the functions required, including those of probable daughter products, then to choose the development tools before deciding to specify which microprocessors will be used in the product. In this way, several advantages are gained, viz:

(1) if the development system is universal, development support for an entire range of associated products is assured and also, the choice of chip is not restricted, giving the product definition wider scope;
(2) new and better devices can be designed in at later stages, ensuring low-cost upgrading;
(3) the particular application will not need functions not present in the design tools for the chip that has been selected.

Thus, by selecting powerful – and that almost certainly means universal – tools before selecting the microprocessor, product quality is improved, development time is reduced and support is long-term. Philips' systems are extremely well tailored to these needs, because being also a manufacturer of microprocessor based products, and being one of the biggest in the consumer market they are customers for their own tools!

Investing in Philips' high-quality development tools will also prove cost-effective – they substantially reduce time spent on development by scarce, and expensive, human resources.



Debugging a microprocessor, specially designed for operation of a process control system.

The quality tools

PMDS has many features important to hardware and software development – UNIX, the accepted industry standard operating system; real-time transparent in-circuit emulation; state and time analysis; high level symbolic debugging in Pascal and C; and, most important, software development, is modular. This modularity ensures PMDS-2 supports not only small-scale developments, by one or two designers, but also large scale projects, by specialist teams creating megabytes of code.

Development of a system though is of little use if back-up in the form of sophisticated testing and trouble-shooting is not provided. Philips' logic analyzers deliver just that, with unique features such as transitional timing analysis to help hardware engineers; disassemblers both for standard chips and to customer specifications to aid the software engineer; menudriven soft keys for ease of use, even to non-specialists, sync mode for simultaneous and cross-coupled state and timing analysis to aid the systems integration, and finally they will help to fine-tune a system by the powerful performance analysis feature.

Small scale developments
Small projects are often handled by just a few people, each with a general knowledge of MDS techniques – and PMDS-2, through its UNIX operating system, provides the ideal environment. Most important, its operating procedure is consistent – for example devices are treated as files, so the same notation is used to write to a user-created file, or to a device such as a terminal or a printer. Its user-interface is simple, but powerful, using only about 40 basic building blocks from which virtually any function can be created, stored and executed under a user-provided name. A hierarchical file system greatly reduces the search time required to find a given file.

The same design philosophy of 'simple yet powerful' has gone into the data test equipment. A non-specialist user will feel particular benefit from the menu-driven, cursor prompting and clear error messages displayed by Philips' logic analyzers and the user-friendly softkey operation on the PM 3551 A high performance logic analyzer.

Large scale developments
Here again, UNIX shows its power with its facilities for communication – perhaps the biggest problem in any team, and a crucial one. Improved communication decreases development times, ensuring products are introduced faster to the market.

Extensive electronic mail packages drastically reduce paper-written communications between group members; source control systems handle software-release administration, monitoring project progress and warning of deadlines; and UNIX utilities keep all code up to date. The file system hierarchy allows grouping of files in a logical way, for example software modules for a project, and the group of files can be given a name – a directory (which itself can be treated as a file). Security built into the kernel ensures that important files cannot be altered by unauthorised persons, while allowing sharing of files among the team members.
Again, Philips' Data Test Systems provide support with logic analyzers that are portable, so resources can easily be used as and where required in the team; their memory is non-volatile and up to 4 users can store particularly valuable settings. I/0 facilities range from printing of state listings and time displays, through dumping and loading of settings and data, up to fully automatic control of the instrument via standard serial or parallel interfaces.

Hardware development
With no development system, a chicken-and-egg situation occurs: with no software, hardware cannot be controlled or tested; with no hardware, software has no target on which to run. Using PMDS-2, which can provide either missing hardware or software, both can be undertaken independently.

Hardware is monitored and controlled with an emulator. It is transparent (no memory, I/0 or interrupt space within the target are used, all are available to the prototype), and it operates in real time at the true clock speed of the target. Philips' emulators also supply much useful information to the development engineer, for example indicating incorrect power levels, or if clock edges are not fast enough due to excessive loading from peripherals.

Trigger outlets are provided for connection to a Philips' logic state and timing analyzer, allowing PMDS and analyzer together to display malfunction in detail and show critical timings on the processor bus. Emulation for multi-processor targets is supported and emulators can be synchronised, allowing the processors to step simultaneously.

To see actual system timing, e.g. in case of an interrupt, logic analyzers are essential tools. Philips' analyzers are excellent magnifying glasses with glitch-capturing capability and sampling rates up to 300MHz. Timing of control signals in relation to address and data are shown clearly, as is the effect of I/0 on the bus, and action of chips outside the target systems kernel. Through extensive if-then-else triggering, Philips logic analyzers find the interesting spots with ease, and the synchronised display mode couples state and timing in one comprehensize display.

Software development
PMDS-2 supports languages such as Pascal and C, with their associated cross-compilers and assemblers. Popular for writing application software, these languages are highly transportable, even among chips from different manufacturers. This transportability, together with creating source code in a high level language brings obvious advantages in design flexibility and reduced development times.

There are two debugging modes; simulation and emulation. Simulation is used when no prototype hardware is available; but the software is still run on the target microprocessor in real time. Emulation is performed with the software running on an existing, possibly incomplete prototype, with missing hardware set up within a debug environment in PMDS-2 itself. In this case, mainly high level languages are used, though high level code and assembly code can be mixed to give a choice of ease of use or speed, as the application demands.

Even correctly functioning software can be far from optimal. Often-used code can be inefficient. Philips logic analyzers solve these bottlenecks and others by system performance analysis. Monitoring real-life operation produces extensive statistics, needed by the software engineer to make the necessary improvements.

Integrating hardware and software
Philips' tools really show their power at this point, allowing changes to be made at integration, rather than afterwards and then having to re-integrate. This helps eliminate costly time delays that prevent products reaching the market at the right time.

At integration, standard user interfaces show their value, ensuring the engineers in a team work together to pin-point errors not found in previous stages. High-speed hard-disk memory and symbolic debugging, (which automatically recalculates the address of a variable when it changes due to recompilation), speed up turn-round time, reducing time pressure and producing better products.

Also here Philips Logic Analyzers provide unique features like the sync mode. This facilitates capturing state and timing data simultaneously and cross-coupled via dedicated sections of the instrument. It allows to pin-point faults and study their effect both in hardware and software.

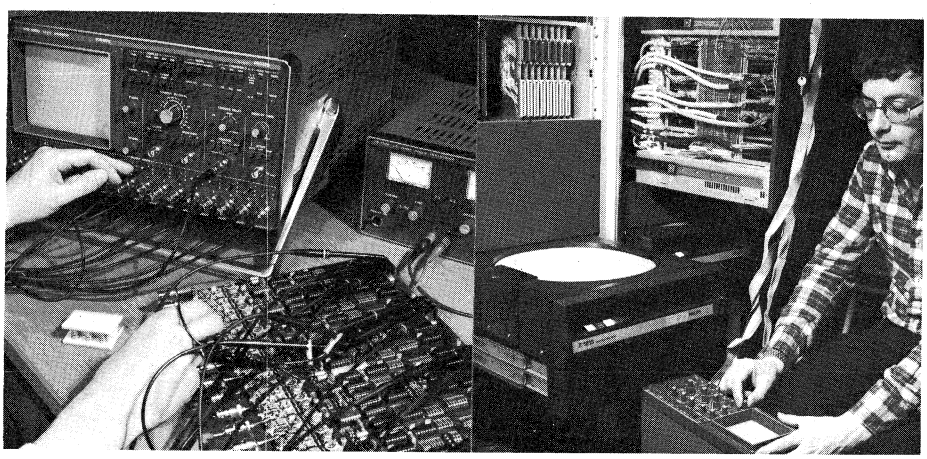
Documentation
A task no engineer likes. However, UNIX has tools to help produce the documentation required and produce some automatically – for example that associated with source code control systems. And every engineer will appreciate the benefit of that.

Data test equipment

Unit	Description	Features	Page
Introduction			2
PM 3540	Logic analyzer/oscilloscope	16-channel 10MHz analyzer plus 35MHz/2mV 'scope, 2-trace	5
PM 3543	Logic analyzer/oscilloscope	Dual-clocking 3-pod, 21 channel logic analyzer plus 35MHz/2mV 'scope, 2-trace	8
PM 3632	Logic analyzer	32 channel logic analyzer, state/time, 1 clock, up to 100MHz. Disassemblers. ROM emulator.	12
PM 3551 A	Logic analyzer	Configurable logic analysis system, min. 16, max. 75 channels, 3 clocks, state/time analysis up to 300 MHz. 8 & 16 bit disassemblers.	17
PM 8810	Logic trigger probe	16/18-channel trigger extender	25
PM 8811	Serial data pod	For test of RS232C/V24 communication together with a logic analyzer	26
Accessories			28

Introduction

The world of electronics is changing rapidly from analog to digital techniques. This can be seen in all areas, from customer products such as washing machines to professional products like avionic systems. To develop and test such digital products with conventional analog equipment can be a tedious, often impossible task. The only effective solution is to use digital test equipment. However, just as with analog fault finding it is not only necessary to identify a fault condition, the test equipment must also be capable of locating the origin of the fault.
Philips Logic Analyzers are designed to do just that. They provide both timing and state analysis capabilities to tackle software, hardware or compounded faults so that the user can solve all his problems with a single instrument. In addition, careful attention has been paid to the ergonomic aspect of all instruments to make this relatively complex instrumentation simple to use and understand. The use of soft keys on the PM 3551 A is a typical example.



Covering the whole spectrum of applications from laboratory to the factory and field servicing with Philips logic analyzers.

For all applications
Logic analyzers are needed at all levels of digital testing, from research and development to field service or education. For this reason Philips has approached this wide range of requirements with a range of equipment which offers the most cost effective solution for each application area.
The resulting instruments always combine both state and timing modes to give the user a total analysis capability. PM 3540 and PM 3543 have a realtime oscilloscope that can be triggered from their integral 10MHz state analyzers. PM 3632 and PM 3551 A provide full logic timing and state analysis at speeds up to 300MHz.
Continuously displayed summaries show the status of each instrument and considerably simplify the setting up of measuring parameters.

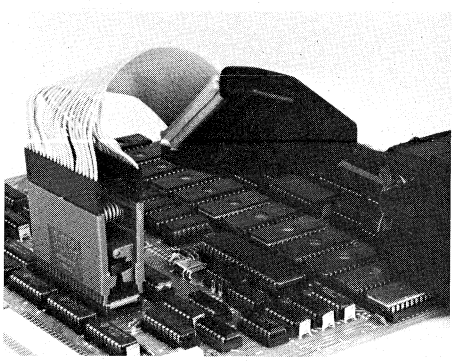
A variety of display formats, including a wide range of microprocessor disassembly mnemonics on the PM 3543 and PM 3551 A, allow the user to achieve the optimal display format for this particular application.
A selection guide on p. 4 will assist in defining the most suitable model for a particular application.

Logic analyzer operation
Any logic analyzer is made up of four basic sections; they are a data acquisition section, a data storage section, a control and trigger section and a display format section.

Data acquisition
The data acquisition section receives parallel data simultaneously from the system under test via its **test probes.** These probes are extremely important as electrically they must not interfere with the normal operation of the system under test nor must they mechanically strain the test points they are connected to.

These requirements are met by all Philips probes which in addition to being small and lightweight also present a very high input impedance of 1MΩ to the test circuit, combined with a very low capacitive load.
Connection to the actual test circuit can be touch, wire-wrap, dil clip, or low profile. Test leads are colour coded.

A **variable threshold level** is also necessary in the data acquisition section to cope with the various logic families which may be encountered. Apart from a standard TTL level setting all Philips instruments can handle ECL to 15V CMOS applications either by direct switch selection or threshold potentiometer adjustment.



PM 8818 is internally wired to adapt to a specific microprocessor. The user defines this wiring.

The **number of input channels** required varies from application to application. For **timing** analysis applications 8 or 16 will suffice. Timing is usually analyzed by comparing only a few signals with each other, since it is difficult for an operator to absorb more than 16 channels at one time. For **state** analysis, a higher number of channels is needed. PM 3543 has 24 input channels and can display up to 37 signals when used in the dual-clocking (internal demultiplexing) mode.
PM 3551 A can be expanded up to 59 state channels, each with three clocks.

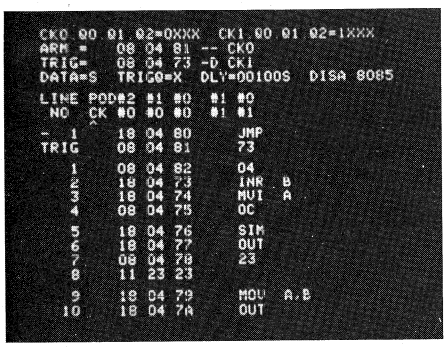
Two methods of data sampling can be used, either **synchronous** with the system under tests for state analysis or **asynchronous** with the system under test for timing analysis.

PM 3540 has only one synchronous **clock**. PM 3543 features two whilst PM 3551 A has three. PM 3632 uses external hardware to cope with more than 1 clock. A minimum of two clocks is essential when handling multiplexed bus processors like the 8085, 8086 and Z 8000 where both address and data are transmitted over the same bus lines. This dual clocking therefore enables both address **and** data information to be sampled from each individual connection, thus achieving the same economy in the physical number of probe connections, as these multiplexed processors have made on pins.

The multiple clocks can also be used to sample, e.g., both read and write data in a non-multiplexed Z80 or 8080.

Sampling speed
The 8085 A2 processor has a maximum clock speed of 5MHz, but in reality the maximum state sampling rate is three times less than this as the shortest machine cycle is three clock cycles. Even a fast microprocessor, such as 68000 needs only 6MHz for synchronous **state sampling.**
In the asynchronous sampling mode the sample rate of information into the analyzer is determined by its own internal clock. With the PM 3551A sample intervals as short as 3.3ns are possible. This **high speed sampling** and **glitch catching** makes it possible to accurately study the timing characteristics of control and interface hardware, even on ECL-based systems.
PM 3551A and PM 3632 feature glitch catching on top of a high asynchronous sampling rate. This allows the study of pulses shorter than the sampling interval.
As a general rule-of-thumb, the asynchronous sampling speed should be five to ten times that of the system under test so that accurate measurements of pulse widths and delays can be made.

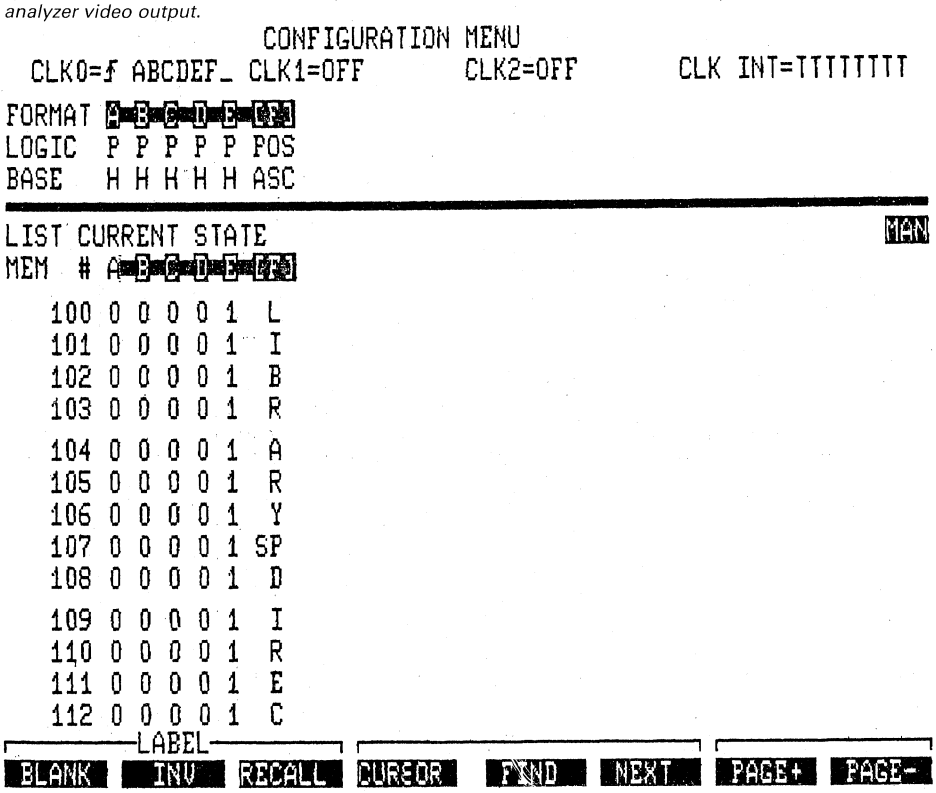
Data storage
The heart of all logic analyzers is the memory. This must be wide enough to store the parallel data input and fast enough to handle the sampling rate used on the application.
The 8K (per channel) memory of the PM 3632 allows it to store 1600 cycles of a 20MHz master clock at a resolution of 10ns. PM 3551 A uses a novel type of memory organization whereby only new **timing** data that is different from previous data is stored. As a result, the memory is effectively four times deeper than a conventional type. An explanation of this **transition memory** is given in the PM 3551 A section. With **state** analysis memory depth is also of importance. Philips logic analyzers offer from 64 to 1000 words of state analysis memory.
In addition extensive qualification capabilities are available which enable extremely **selective data sampling** on only the system actions which need to be monitored. This optimizes the use of the memory. Qualification can be done on clocks, words, triggers, or blocks of data.



The disassembler option makes process analysis faster and easier. This option automatically sets clock edges, qualifiers and display format to ensure accurate measurements.

Triggering
The most common form of triggering in logic analyzers is **word recognition.** This compares the incoming data with a specific word preset by the user.
If a match is found then triggering of the analyzer occurs. The trigger rate of a logic timing analyzer must be at least as fast as its maximum sampling speed. The PM 3551 A can trigger on even shorter events using the glitch triggering mode.
For many logic state applications triggering on a single word is sufficient. However, to trigger on conditional events at least two word recognizers as found on the PM 3543 are needed. PM 3632 offers a selection of preset single- and multi-word trigger conditions as well as full user-defined trigger conditioning.
Unsurpassed trigger performance is available with PM 3551 A, involving **if-then-else branching** and up to 7 trigger words.
External triggering is provided on most

Display on PM 3551A screen of data caprured by PM 8811, as produced by a video printer directly from the analyzer video output.



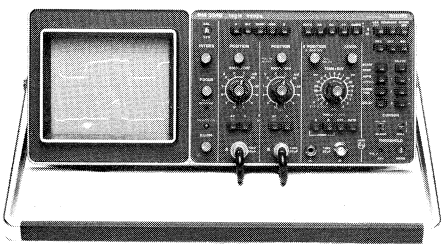
Philips logic analyzers by using a separate trigger input. This external input can also be used to provide additional trigger qualification, that is, it provides additional conditions that must be met before triggering can take place.

If **PM 8810 logic trigger probe** is attached to this input it gives 39 channel wide triggering with the PM 3543 or 34 channel wide triggering with the PM 3540; or increases the number of trigger words.
With the use of built-in **counters** it is possible to capture data after the trigger condition has been fulfilled. Another application is to count a preset number of states after the first word in a sequence of trigger words is found, before recognition of the next word may be accomplished.

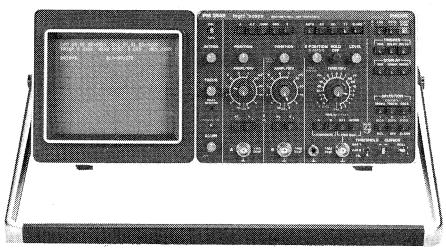
Display Format
The two main types of display format are **timing diagrams** and **state tables.** The PM 3540/43 family provides a real time oscilloscope display of timing information whilst the PM 3632 and PM 3551 A provide a pseudo waveform display, however in both cases the relative timing and logic level is displayed. The state tables provide a choice of state formats to meet the users requirements. Whilst **binary** displays provide astandard logic output most microprocessor users require either a **hexadecimal** format or the actual processors **mnemonics,** and mini computer users often prefer an **octal** display.
Additional **display manipulation** like inverted logic, channel blanking and mixed state table displays are also required to achieve the optimum display format. All these capabilities are available within the Philips logic analyzer range.
PM 3543 and PM 3551 A also offer **map** or **graph mode** capability which displays the entire memory contents as a series of dots on a single display. This gives the user an overview of the total memory contents at a single glance. All Philips instruments also have **compare mode** capabilities. This involves the use of two memories, one containing the stored reference data whilst the other contains the most recently captured data. The contents of the two memories are compared and if an inequality is found a message to that effect is displayed in the screen heading, as well as the actual inequality being intensified. If this compare mode is used in conjunction with automatic restart the analyzer continuously compares until an inequality is found. It then stops all further data acquisition until reset by the operator.

The finishing touches
The fact that all Philips logic analyzers are microprocessor controlled also facilitates self-testing of the instrument circuitry.
The microprocessor self-test routines are automatically triggered at switch-on. In addition, more comprehensive diagnostic service routines can be called by the operator to check the whole instrument down to a functional level.
The power of the microprocessor is also used to its full in the PM 3543 and PM 3551 A. These instruments are fully controllable via the IEEE 488 interface bus. Alternatively they are also available with an RS 232 (V 24) serial interface for dumping and loading of data and parameter settings.
RS232 interface is available on PM 3632 as well. The ROM emulator option on this instrument makes use of this serial interface for loading and dumping emulation memory.

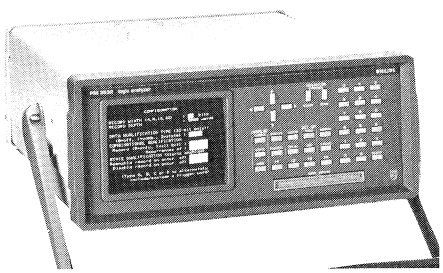
WHICH PHILIPS LOGIC ANALYZER IS BEST FOR YOUR APPLICATION?



As a general purpose workhorse
PM 3540 – for both analog and digital trouble shooting on discreet logic or processor based systems. Simple to use, easy to understand. Ideal for **small system development, service applications** and **education. Low price.**



For microprocessors
PM 3543 for **8-bit and 16-bit microprocessor based systems**. With input/output capabilities and dissassembly options and a 2-trace oscilloscope, this instrument is ideal for combined digital/analog testing and for service use.



Price/performance
PM 3632, state up to 32k, time up to 100MHz, microprocessor support up to 16 bits. Options include ROM emulation. Easy to use. Superior price/performance ratio.

Highest performance
PM 3551 A configurable up to **59-channel state,** up to 16 channels/50MHz and 4 channels/300MHz timing, a total of 75 channels. Ease of use by soft keys. For microprocessor applications up to 32 bits and high-precision time-analysis. Features include time compare and performance analysis. Top class instrument.

Analyzer:

16 channels with 64-word memory

Inverted logic

10MHz synchronous clock rate

Clock qualifiers

Good ergonomics for easy operation

Display in binary, hex, octal or inverted

Compare mode facility

Built-in diagnostic routines

Serial analysis option

Unique combination of logic analyzer and oscilloscope

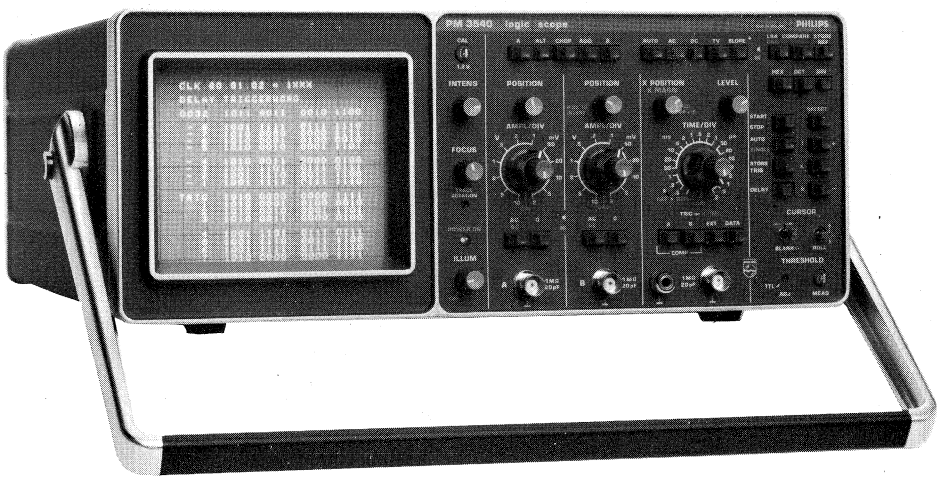
Oscilloscope:

Full 2mV sensitivity over full 35MHz bandwidth

Trigger sources, A, B, Composite, Ext and from logic analyzer

Logic analyzer/ oscilloscope PM 3540

The PM 3540 logic analyzer/oscilloscope combines a 16-channel 10MHz logic analyzer with a versatile two-channel 35MHz oscilloscope to ensure complete, true logic testing.
Fault location is achieved by the logic analyzer section and the realtime oscilloscope display enables faults to be analyzed and corrected.
The result is a compact, portable, test and service instrument, capable of handling both software and hardware problems.



Operation as a logic analyzer

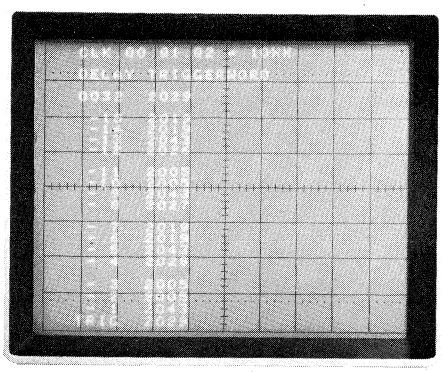
The instrument will work either as a logic analyzer with integral display, as an oscilloscope or as a powerful combination of the two. The logic analyzer section is a 10MHz state analyzer – with microprocessor control to provide maximum display versatility and minimum hardware.
It acquires data simultaneously over 16 channels. This data is stored in the 64-word memory and then displayed independently of the acquisition process. The trigger system stops data acquisition-freezing data present in the memory at that instant.
The data is obtained using specially designed probes for connection to the circuit being tested. Input to the logic sections of the PM 3540 is through three multi-lead probe pods PM 8820 each providing for eight inputs plus one earth connection. Two probe pods are used for the data and one for the clock and clock qualifiers. They are of dedicated digital design with high impedance to cut 'inter' ference and loading.
Miniature probes allow easy connection to the circuit being tested and each is colour-coded using resistor code for easy identification. Difficult access points can be reached with a flexible probe to ensure minimum mechanical strain. Each probe can be split from the stackable pods and left in the system being tested. A wide variety of probe terminations is available with wire-wrap or hook tips.

Choice of threshold levels

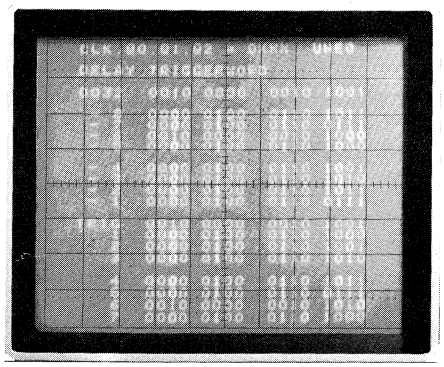
In the PM 3540 the incoming signal passes through a threshold level selector into an input latch. This provides a choice of threshold levels (either fixed TTL or variable from – 3V up to 10V) to allow matching to a variety of logic families.
Sampling is synchronous and thus dependent on the clock rate of the circuit being tested. This is used to look at the series of states present in the circuit under test. Such state analysis is mainly used to check through system software.
The PM 3540 can handle rates up to 10MHz and clock qualifiers allow conditioned sampling. For example, using a read signal from the system can ensure that only read statements will be recorded. This ensures optimum use of the memory.
Data storage is in a 64 word memory. Versatility can be increased by using a 'compare' mode. A second 64-word memory is used as a reference memory. New, incoming data is compared with the total contents of the reference memory. Any inequalities thus identified are indicated by a message in the display heading plus intensified digits in the table. In the automatic mode the refresh cycle is stopped automatically when an inequality occurs.

Word recognition triggering

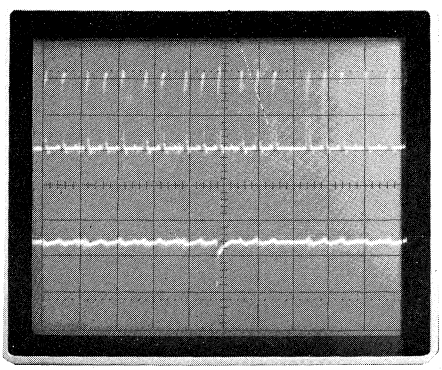
The sampling process is stopped by a trigger pulse which causes the flow of data passing through the data memory to be halted. The pulse can be supplied in several ways but the most common is word recognition triggering.
Word recognition consists of defining a certain association of binary states required in the incoming parallel data. When the incoming signals match the word set, the trigger circuit puts out a trigger pulse.
The trigger word is normally made up of the number of channels being displayed. Data acquisition can be made more selective by increasing the trigger word using additional trigger probes.
Trigger delay facilities allow examination of the data stream after the trigger point. Triggering can be internal, using word recognition, or manual, from the front panel. The trigger word is set using the front panel controls, in any format preferred by the operator.
The trigger pulse can be delayed by up to 999 samples or events by selecting an internal delay counter. Trigger word expansion is also possible using additional trigger probes such as PM 8810. It is also possible to select a word from the data display for storage as a new trigger point.



Logic display in binary, octal or hexadecimal



Logic comparisons for quick and convenient fault analysis



Real-time displays for meaningful fault detection and correction.

Selection of this as a new trigger word allows examination of a new block of captured data down or upstream. This paging facility can, for instance, be easily incorporated into a programmed service fault-finding system.
An automatic mode allows the instrument to retrigger periodically to update the display, providing a pseudo realtime display.

Integral display

Three types of state table formatting are provided, binary, hexadecimal and octal, all of which can be displayed as inverted logic. The microprocessor is also responsible for all logic control. This allows simple ergonomic instrument control: for example pushbutton setting and continuously-displayed status information on the display. A cursor is provided which can be moved both vertically and horizontically. A special roll function allows paging through the entire 64 word data store – 16 words are displayed at a time.

Matching analyzer to oscilloscope

The logic analyzer/oscilloscope combination in Philips logic scope provides state analysis together with oscilloscope timing display. Considerable attention has been paid to matching the two sections to achieve precise cross-referencing between data- and timing-analysis.
The oscilloscope section is a sophisticated service instrument providing high 2mV sensitivity up to 35 MHz. It has two vertical inputs separate from those of the logic analyzer.
Trigger sources can be either vertical input, composite, external or the logic analyzer section.
The design of the instrument ensures that when the oscilloscope is triggered from the analyzer, the signal delay is reduced to a minimum. This ensures that the selected channels of the trigger word itself are displayed.
The edge of the signal on which the analyzer is triggered is displayed in the timing mode which provides an exact and easy cross-reference between state and timing analysis. This is necessary in digital testing and cannot be achieved by separate oscilloscope and logic analyzer.
Apart from simplifying control and reducing the hardware requirement the microprocessor also provides comprehensive selftest facilities. These ensure functional operation at every switch-on and provide a set of switch-selectable service tests for routine maintenance and trouble-shooting.
Nine comprehensive self-test routines provide maximum reliability and minimum downtime.

A unique trouble-shooting tool

The combination of logic analyzer and versatile oscilloscope in one portable instrument provides a unique instrument for a wide range of digital trouble-shooting applications in small system development, service and education.

Serial analysis

The PM 8811 Serial data pod can be used with the PM 3540, thus allowing for analysis of RS232 communication links.

TECHNICAL SPECIFICATION

STATE ANALYZER

All values specified at probe tips of PM 8820

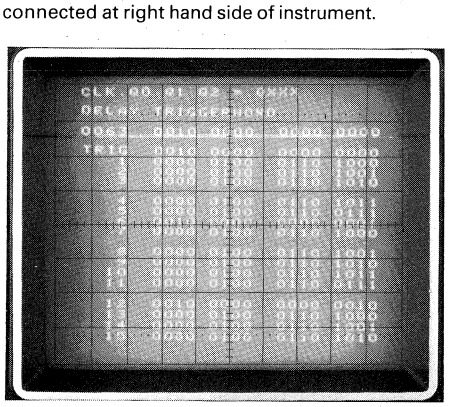
Data input
16 data channels via two multi-lead probes PM 8820 connected at right hand side of instrument.

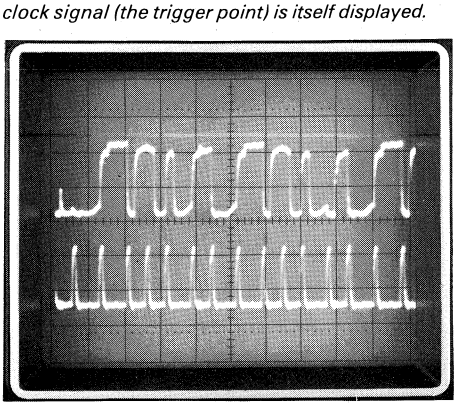
Impedance
4MΩ//6pF
Max. voltage
−50... +50V
Threshold
TTL fixed +1.4V
Variable: −3V to +10V continuously adjustable, front panel monitor point.
Max. sensitivity
500mV$_{p-p}$ signal swing
Set up and hold times
40ns set up time, 20ns hold time with respect to external active clock edge at probe tip
Clock
Input via third multilead probe PM 8820. Threshold selection same as for data inputs. External sampling clock rate 10 MHz max. Minimum clock pulse width 20ns. Sampling selectable on positive or negative going clock edge.
Clock qualifiers
Numbers: 3 clock qualifiers. Input via clock probe (3rd PM 8820). Sampling only occurs when qualifier input is 'True' at the clock edge.
'True' is selected for high '1' or low '0' level.
In the 'X' position the qualifier is not used. 20ns set up time and 5ns hold time with respect to actual clock edge at probe tip.

TRIGGER

Source
Internal, external or manual

Internal
Triggerword recognition on 16 channels and trigger qualifier.
Triggerword determined
– by specifying from the captured data by operating STORE TRIG control. The first word of the display will become new trigger word.





Exact cross-reference between state and time analysis is provided by the PM 3540 logic scope. The real time oscillogram (upper signal) shows channel No. 0 (the right-hand data channel) and the corresponding clock signal. The negative-going edge of the clock signal (the trigger point) is itself displayed.

– by selection via CRT display, cursor and controls 1/+, X and 0/– in the required formats (Hex, Oct, or Bin)

External, trigger qualifier
Choice external or trigger qualifier depends on trigger word selection.
EXT. trigger BNC connector when Logic Scope is in DATA and EXT. mode. Triggering only occurs when trigger qualifier input is TRUE at clock edge. TRUE is at high level (not connected is high level).

Manual
Via front panel push button.

Trigger extension
The trigger qualifier can be used with trigger probes PM 8810 to extend the trigger word in multiples of eight.

Trigger delay
Triggering can be delayed by 0...9999 clock pulses controlled via CRT and selection buttons + and – ON/OFF switching of trigger delay by push button

START

Source
Automatic or manual

Automatic
The instrument starts itself automatically after a display time of approx. 1s to allow pseudo real time observations.

Manual
Via front panel push button

Memory
The memory format is 64 serial bits X 16 parallel channels. In the compare mode a second memory of the same size is used.

OPERATING MODES

Logic analyzer mode
By activating push button LSA/OSC the input signals are simultaneously clocked into the memory at the sample clock transitions with respect to the selected threshold level.

Oscilloscope mode
Logic scope is acting as an oscilliscope in its own right, plus selectable triggering from logic state analyzer

Compare mode
A second 64 word memory is used to store reference data. A captured data block is compared with the reference data block. Any inequality between the two blocks is indicated in the heading by the message 'UNEQ' and in the input table by intensified digits. In the HEX and OCT mode both the input and reference table are displayed. In the BIN mode only the input data is displayed.

Store ref.
Data is transferred from input memory into reference memory

Select
In the select mode the parameters can be specified using the cursor and selection controls 1/+, X and 0/–

Display
CRT of oscilloscope. In the top part of the screen a continuous heading is given containing the parameters and the status of the instrument.

Display modes
Hexadecimal, octal or binary, with inverted logic. State tables of 16 words are displayed in 4 groups of words. All words are identified by their relative position to the trigger word. The continuously displayed trigger word can be specified in the selected format.

Cursor
In the select mode the cursor is identified by an intensified digit and is positioned by the controls in horizontal or vertical directions.

Roll
When the instrument is not in the select mode, the vertical cursor control is used as a roll function to provide paging through the entire 64-word memory.

Blank
The horizontal cursor control is used to suppres channels. In the sequence starting with channel 15.

OSCILLOSCOPE

CRT

Type
Philips D 14-125 rectangular mesh-type post deflection accelerator tube with 10kV accelerating voltage and metal backed phosphor.

Screen type
P 31 (GH) phosphor standard
P 7(GM) phosphor optional

Useful screen area
8 x 10cm

Graticule
Internal graticule with centimeter divisions and 2mm divisions along the central axes. 10% and 90% lines are indicated. Graticule illumination continuously variable.

Y-AXES

Frequency response
DC: 0Hz...35 MHz (–3dB)
AC: 2Hz...35 MHz (–3dB)

Risetime
10ns

Deflection coefficients
2mV/div...10V/div 1-2-5 sequence. Uncalibrated continuous control between steps 1: > 2.5

Accuracy
±3%

Display modes
Channel A, Channel B, Alternate. Chopped at approx. 500kHz, Added, Channel B can be inverted.

Input impedance
1MΩ//20pF

Maximum input voltage
400V (DC+AC peak)

Maximum deflection
Undistorted deflection of 24 div. Shift range 16 div

Signal delay
20ns visible

CMR-factor
100:1 at 1 MHz (A-B mode with 8 div common mode signal)

HORIZONTAL

Horizontal deflection can be obtained from either the time base or from the signal source selected for X deflection. In this case X-Y diagrams can be displayed using Y_A, Y_B, the Ext. connector as a signal source for horizontal deflection

Display modes
X-Y or X-Y/Y operation with X-deflection by: Y_A, Y_B, External

X-INPUT

Frequency response
DC...1 MHz (–3dB)

Deflection coefficient
500mV/div using Ext. connector. Vertical attenuator coefficients apply when Y_A, or Y_B is used for X-deflection

Measuring accuracy
±10%

Phase error
3° at 100 MHz

TIME BASE

Modes
Auto-triggered

Time coefficients
0.5s/div...100ns/div 1-2-5 sequence. Un calibrated continuous control between steps 1:>2.5; X 10 magnifier extends max. sweep rate to 10ns/div.

Accuracy
±3% Additional error for magnifier ±2%

TRIGGERING

Trigger source
Internal: Y_A, Y $_B$, Composite, Word (via logic analyzer) External

Slope
+ or –

Trigger mode
Auto: 20 Hz...50 MHz
DC : 0 Hz...50 MHz
AC : 5 Hz...50 MHz

TV
Fully automatic triggering on TV video signals, automatic selection of 'frame' and 'line' via time base speed selector

Trigger sensitivity
Internal 1div or word triggering. External 500mV

Level range
Internal 16div typical. External –4V to +4V typical. Automatically adjusted between limits of signal amplitude in position Auto

External trigger input impedance
1MΩ//20pF

Maximum allowable input voltage
400V (DC+AC peak)

CALIBRATION

Calibrated voltage
$1.2V_{p-p}$ ±1% square wave

Frequency
2kHz approx

POWER SUPPLY

Line voltages and frequencies
110, 127, 220 and 240V_{AC} ±10%, 46...440 Hz. The insulation between PM 3540 and line fulfils the safety requirements of IEC 348 for metal encased class II instruments.

DC power source
22-27, V_{DC} floating input, 1.1$A_{max.}$

Power consumption
40W

ENVIRONMENTAL CAPABILITIES

The environmental data ara valid only if the instrument is checked in accordance with the official checking procedures. Details on these procedures and failure criteria are supplied on request by the Philips organisation in your country or by N.V. PHILIPS' GLOEILAMPENFABRIEKEN, TEST AND MEASURING DEPARTMENT, EINDHOVEN, HOLLAND

Ambient temperatures
+ 5°C...+40°C rated range of use
–10°C...+55°C operating
–40°C...+70°C storage and transport

Altitude
to 5000m (15000ft) operating
to 15000m (45000ft) not operating

Humidity
21 days cyclic damp heat 25°C-40°C R.H. 95%

Bump
1000 bumps of 10g, ½sine, 6ms duration, in each of 3 directions.

Vibrations
3g vibrations of 15min in three directions. 0.5mm_{p-p} displacements with 10Hz-55Hz one minute cycle

Electromagnetic interference
Meets VDE, Grenzwertklasse B

Recorvery time
Operates within 15 minutes coming from –10°C soak, going intp 60% relative humidity at +20°C room conditions

DIMENSIONS AND WEIGHT

Height: 150mm incl. feet
Width: 330mm
Depth: 445mm
Weight: 8kg (17.6lb) approx

ACCESSORIES SUPPLIED WITH THE INSTRUMENT

Front cover. BNC-banana adapter. Operating and service manual. Two probes PM 8927. Three multilead probes PM 8820

OPTIONAL ACCESSORIES

See table on p 94
PM 8810 Trigger probe
PM 8811 Serial data pod

IEEE 488 IEC 625

- 10MHz State analyzers with 255 word memory
- Ideally suited for multiplexed bus processor applications
- Unique sampling method eliminates connection problems
- Sophisticated trigger capabilities
- Horizontal and vertical display formatting
- Disassembly and interface options
- Realtime hardware analysis from software triggering
- Serial analysis option

Logic analyzer PM 3543

Introduction

The PM 3543, like PM 3540, employs the logic analyzer with oscilloscope concept to give the user both state analysis capabilities for software debug and real time analysis for hardware debug. Whilst PM 3540 covers general purpose applications, PM 3543 offers more sophisticated microprocessor analysis power yet with simple test connection.

The instrument is ideally suited to multiplexed microprocessor applications where its excellent sampling capabilities enable it to gather both the address and data information from each single connection.

Optional interface and disassembly packages make the instrument an efficient solution for general micro system analysis.

Dual Clock Sampling

With a processor having separate address and data buses a single control signal is needed to effect the sampling of both the address and data into a logic analyzer. With multiplexed bus processors the same bus lines are used to transmit both address and data on a time shared basis. To indicate the contents of the multiplexed bus two control lines, one for the address and one for the data are used.

By using these two lines to control the sampling of information into the analyzer, it is possible to sequentially gather both address and data information from the same connections.
This dual clock approach gives definite user advantages, e.g. in that fewer connections need to be made to the system under test reducing both electrical and mechanical circuit loading and eliminating the frustation involved in making large numbers of circuit connections.

As an example if the PM 3543 is used with the 8086 16 bit microprocessor a total of 27 connections, including clocks, qualifiers, ground leads and data inputs are made.
This yields qualified sampling from 20 address, 16 data and status lines, a total of 37 recorded channels. To achieve the same result with a one-clock analyzer 45 connections would need to be made to the 8086 system. Thus a saving of 18 connections is realized.

Triggering

In addition to manual, external and single word trigger modes found on PM 3500, PM 3540 and PM 3543 offer **2-word triggering.** This allows to stop data recognition by recognition of a specified sequence of 2 words found on either of the 2 clocks. When the 2 words are specified to be on 2 different clocks immediately following each other the special quasi-parallel mode of triggering is used. This facilitiates the triggering, e.g., on unique address and data combination when monitoring multiplexed bus systems.

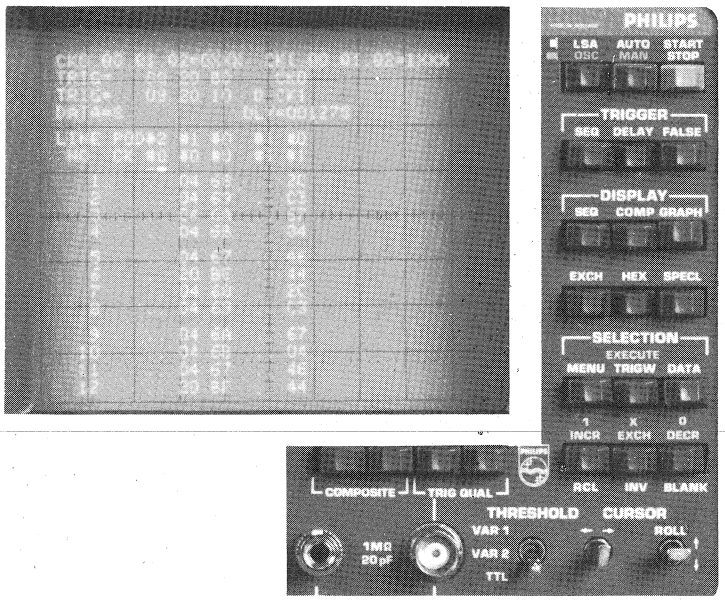
If it is desired to trigger if a conditional jump to a subroutine is done, one word recognizer is specified as jump address the other as subroutine start address, so-called **immediate sequential triggering,** if the 2 addresses are specified to be immediately following each other.

Using 2-word triggering, the second word can also be set as FALSE, so triggering then occurs when either the address does not contain certain data or the jump to certain routine does not occur.

In order to position the captured data block with respect to the trigger a **delay counter** is used, thus covering pre, centre, post and delayed trigger requirements. Additionally this delay counter can be placed between the two trigger words to facilitate **delayed sequential triggering.** When set to delay by states it inhibits triggering on the second word until the preset number of qualified samples has occured.
The delay counter can also be set to delay by triggers which then permits

arming on the first word yet triggering, after a preset number of occurances of the second. An application of this is to monitor the action of a certain sub-routine after it has completed the preset number of passes.

Just as the delay value can be set only for triggers so can the data sampling be set only to acquire trigger occurances independent of the trigger delay settings. This provides **selective data acquistion** and is especially useful when only a particular action (e.g. stack operations) or a particular device (e.g. an I/O port) needs to be monitored.



The display and control section of the PM 3543.

Convenient display formatting
The display of a logic analyzer should resemble as closely as possible the way the data was sampled and the software was originally written. This is achieved on the PM 3543 by a dedicated **display format control** section which enables the user to rapidly set the exact display format needed for his particular application.
When operating with a single clock source or two unrelated clocks (e.g. read and write) a **sequential display** of information with an indication of which clock sampled the data is utilized so that the order in which events actually occur in the system, is directly represented on the display. However, when operating with the related clocks for address and data collection on multiplexed processors, it is more meaningful to display the collected data beside its respective address. This vertical formatting of the collected data to give a **parallel display** is achieved by a single push button.

The **horizontal formatting** of the display is also extremely flexible. The user can select either BIN or HEX format on a byte basis and so view status signals as BIN values whilst address and data are in HEX. In addition blanking and inverted logic, make it possible to attain the optimum display format for any application. With the use of optional **disassemblers** the mnemonics for a wide variety of microprocessors and microcomputers can be displayed and this makes these instruments ideally suitable for microprocessor applications.

To move quickly through the full 255 word captured data memory depth, both instruments provide **single line scroll** and an automatic **page scrolling** facility. The captured data memory works as a wrap round memory which enables the user to scroll out at one end and in at the other thus eliminating moves through the total memory depth.

With both instruments the top four lines of the display are dedicated to the sampling and triggering parameter settings, so that the user knows exactly how the captured data was obtained without having to access a separate "MENU" display.
If changes are needed then direct access to these parameter settings is possible without losing the captured data display as it is often needed as a reference.

The **logic analyzer control panel** is divided into four logical sections for ease of use. These deal with the start modes, trigger modes, display modes and the parameter settings.

The **start command** for data sampling can be given either manually or automatically. In the automatic mode the refresh rate can be selected at either 1 or 3 seconds.

Trigger mode selection is by a direct access push button which allows the user to rapidly change to the desired trigger method.

Display formatting gives the user the power to reformat immediately to the optimum display, using direct access push buttons.

Changes of the **parameter settings** are simply achieved by pressing the MENU key which allows the user to enter the top four lines of the display without losing the captured data display. An intensified cursor can then be positioned on the parameter to be changed by use of the cursor control keys. The change is effected by the use of the 1,0 and X keys for binary value changes. For non-binary value changes the 1 and 0 keys act as incremental and decremental counter keys respectively.
For even faster setting or trigger words it is also possible to directly copy a word from the captured data with just two key actions.

Comparison and graph capabilities
The instrument has a separate 255 word comparison memory which can be loaded either by copying from the main memory or via an optional interface. This **compare mode** can be used in conjunction with the automatic start facility to babysit a system which has an intermittent fault.
If a fault should occur then the compare mode automatically halts and the differences between the two memories are intensified for easy operator identification in addition to the message NEQ in the heading.
If logic level faults are suspected then this compare mode in conjunction with the threshold level selection switch can rapidly identify them. The threshold setting for all inputs has two user definable levels in addition to the fixed TTL level. If these two variable thresholds are set for logic high (TTL + 2.4V) and logic low (TTL 0.8V) and the analyzer is started in the compare mode, a single switch action then isolates any logic level fault in the system operation.
The PM 3543 also has a **graph capability** which gives an overview of the captured data by plotting the analyzers memory location with respect to the trigger word against the binary value of the captured word at that location. This is extremely useful for viewing the overall program

flow as it can show the total memory contents on a single display.

Interface options RS232 and IEEE 488

The instrument is available with RS 232 (V 24) or IEEE 488 interface.
It is possible to dump both memory and control settings over the RS 232 interface at a software-selectable baud rate. This serial interface also has an audio cassette input-output capability which permits low cost storage and retrieval of information.
IEEE 488 interface is available on PM 3543 which then becomes a fully controllable listener-talker.

Dissassembly option

In addition to these input-output interfaces, 3 optional dissassembly packages can be installed. These packages contain both the dissassembly control software and the mnemonic codes for the most common 8-bit and 16-bit microprocessors and microcomputers and their directly related families. Each of these packages contains disassemblers for the RS232 interface (using PM 8811 Serial data pod) and the IEEE 488 bus; this provides a powerful tool for debugging these standard interfaces.
Upon selecting the required processor type clock edges, qualifier states and the display format are automatically set to ensure correct data collection and display.
These options also include detachable probe noses and a 40-pin DIL clip connected to a hardware programmable adapter PM 8818 which can be wired and changed by the user to cover all supported processor applications. The disassembly and probing package makes processor analysis fast and easy.

For PM 3543, three multiprocessor disassembler packages are available
- Disassembler A for 8048, 8080, 8085 6800/02/03/09/09E, 1802, 6502/12, Z80, IEEE 488 bus, RS232 interface
- Disassembler N for 8048, 8080, 8085, 8086, IEEE-488 bus, RS232 interface
- Disassembler Z for Z80, Z8001/02, IEEE 488 bus, RS232 interface

Timing Analysis

In addition to the sophisticated software analysis powers the PM 3543 also contains a 35 MHz dual trace oscilloscope section. This unit has a rise time of 10ns and is thus fast enough to examine all hardware actions within a micro based system. In addition to its normal oscilloscope triggering capability and use as a general purpose instrument in its own right it can also be triggered directly from the logic analyzer section. Careful matching of the delays in both instruments has resulted in the oscilloscope actually being capable of showing the state sample following the moment of triggering in the logic analyzer. This makes it possible to do realtime hardware analysis from multichannel software triggering without time mismatches, which is important when investigating timing relationships within a system.

TECHNICAL SPECIFICATION

LOGIC ANALYZER SECTION

All values specified at probe tips unless otherwise stated.

INPUTS

Clocks, clock qualifiers and data input via PM 8821 multilead probe pod.
PM 3543 has three probe pods connected at rear of instrument.

Input Impedance	: 4 MΩ//6pF
Max. Voltage	: −50V to +50V
Threshold	: Selectable by three position switch on front panel
TTL	: fixed at 1.4V
VAR 1 and VAR 2	: independently adjustable between −3V and +12V by recessed potentiometer on right hand side panel
Max. Sensitivity	: 500mV$_{p-p}$ signal swing about the threshold

Clock Inputs

Two independent clocks via two input leads of PM 8821. Clocks are independently edge selectable.

Repetition time	: min. 100ns
Min. clock pulse width	: 25ns

Clock qualifiers

Up to three clock qualifier inputs. One input is dedicated whilst the other two are interchangeable with the most significant data channels.

Each qualifier can be set as 1 (high level), 0 (low level) or X (don't care).

Set up time: < 25ns.
Hold time: 0ns.

With respect to
active clock edge

Data input

PM 3543 has a maximum of 21 psysical data input channels

Set up time: < 35ns.
Hold time: 0ns.

With respect to active clock edge

Memory

Fast data capture memory 255 words deep.
Additional reference memory of similar size.

TRIGGERING

Source: Internal, External or Manual
Internal: By two word recognizers
Selection for: – single word
– sequential two words
– immediate sequential two words
– parallel two words

The second word of any sequence can be selected from either clock source.

Trigger qualifier: Additional input channel for either one or both trigger words.
Input via EXT BNC connector on front panel when both WORD and EXT keys depressed.
Selectable for "1" "0" and "X" on TTL level.

External trigger
input: BNC connector at rear.
True is high TTL level.
External trigger input for connecting extra devices such as trigger probe PM 8810.

Manual: Push button control. Overrules all other trigger modes and forces display of the memory contents at the moment of manual triggering.

Delay Counter

For use with Internal and External triggering.
Can be set between 0 and 65535 events.
Positionable either between the two words or after the trigger event.
Delay by either qualified states or trigger word occurances.

Trigger count

Number of trigger occurances can be preset and counted.

False

Last trigger word can be set for "true" or "false" triggering

DATA SAMPLING

Selectable to collect either states or trigger occurances independently of the delay state/trigger setting.

DISPLAY

By CRT of oscilloscope. Vertical, horizontal and intensity controls for the logic analyzer section are independent of the oscilloscope settings. The display can be split into two sections; a continuous displayed heading and the captured data field.

The heading consists of 4 lines constantly displayed giving status of instrument and in which parameters can be set.

The captured data field is 12 lines of captured data plus clock probe pod and word number labelling.

Vertical format modes

Parallel	: with one clock gives 21 display channels per line on the PM 3543.
Sequential	: with two clock gives the same result as parallel one clock but with indication of which clock made which sample.
Parallel	: with two clocks gives 37 display channels per line on the PM 3543.

Horizontal format modes

With PM 3543 display can be in BINARY or HEX or a combination of both by interchanging on a byte level.

The optional dissassembly packages allow other formats such as ASCII, and mnemonic displays of many microcomputers and processors to be realized.

Blanking

Each channel can be individually blanked and recalled. If a channel is blanked it is excluded from the compare mode.

Inverted logic

Inverted Logic display is selectable on a per nibble basis.

Compare mode

Data of the entire fast captured memory is compared with that stored in the reference memory. Any inequality between the two memories is indicated by a display heading of "NEQ" and intensification of the bits different in the data field.
If used with AUTO start then an inequality halts any further data sampling. Data can be stored in the reference memory either by copying from the main memory or loading via an optional interface.
Reference memory can also be filled with all "1" or all "0" by use of "1" and "0" button respectively.

Graph

With the PM 3543 data can be displayed in a graph.

SELECTION FIELD

Continuously displayed independently of captured data field.

Parameter Setting

Access to the parameter field is achieved on pressing the MENU key. All changes are effected by use of the cursor controls and 1, X and 0 keys.

Trigger word

A new trigger word can be directly copied from the captured data display using TRIGW and EXEC controls.

Data
Data is copied from main to reference memory using DATA and EXEC controls.
If 0 and EXEC or 1 and EXEC are used this fills the reference memory with either all "0" or all "1" respectively.

START MODES

Start/Stop
Data acquistion commences on push button start command. If trigger conditions are not found within one second, display message of "Not triggered" appears. Manual triggering is effected a second push of this button.

Auto/Man
Data acquistion can be achieved on a single shot or automatic repeat basis.
In AUTO mode repetition is selectable between 1 and 3 seconds by recessed side panel push button control.

Output
TRIG OUT: BNC on rear panel (TTL low to high transition).

Oscilloscope triggering
The oscilloscope can be directly triggered from the logic analyzer. This is achieved by selecting the WORD trigger source on the oscilloscope. The oscilloscope sweep starts at the moment of state sampling following analyzer triggering.

Logic analyzer/oscilloscope
Push button selection of either logic analyzer or oscilloscope instrument function.

OSCILLOSCOPE

CRT

Type
Philips rectangular mesh-type post deflection accelerator tube with 10kV accelerating voltage and metal blacked phosphor.

Screen type
P 31 (GH) phosphor standard
P 7 (GM) phosphor optional

Useful screen area
8 x 10 cm

Graticule
Internal graticule with centimeter divisions and 2mm divisions along the central axes.
10% and 90% lines are indicated. Graticule illumination continuously variable.

VERTICAL OR Y-AXES

Frequency response
DC: 0 Hz...35 MHz (−3dB)
AC: 2 Hz...35 MHz (−3dB)

Risetime
10ns

Deflection coefficients
2mV/div...10V/div 1-2-5 sequence.
Uncalibrated continuous control between steps 1: > 2.5

Accuracy
± 3%

Display modes
Channel A, Channel B, Alternate. Chopped at approx. 500kHz, Added, Channel B can be inverted.

Input impedance
1 MΩ/20pF

Maximum input voltage
400V (DC + AC peak)

Maximum deflection
Undistorted deflection of 24 div. Shift range 16 div.

Signal delay
120ns visible

CMR-factor
100:1 at 1 MHz (A−B mode with 8 div common mode signal)

HORIZONTAL OR X-AXES
Horizontal deflection can be obtained from either the time base or from the signal source selected for X deflection. In this case X-Y diagrams can be displayed using Y_A, Yb, the EXT. connector as a signal source for horizontal deflection.

Display modes
X-Y or X-Y/Y operation with X-deflection by Y_A, Y_B, External.

X-INPUT
Frequency response
DC...1 MHz (−3dB)

Deflection coefficient
200 mV/div using Ext. connector. Vertical attenuator coefficients apply when Y_A, or Y_B is used for X-deflection.

Measuring accuracy
± 10%

Phase error
7° at 100kHz

TIME BASE

Modes
Automatic or triggered

Time coefficients
0.5s/div...100ns/div 1-2-5 sequence.
Uncalibrated continuous control between steps 1: > 2.5; x 10 magnifier extends max. sweep rate to 10ns/div.

Accuracy
± 3% Additional error for magnifier ± 2%

TRIGGERING

Trigger source
Internal: Y_A, Y_B, Composite, Word (via logic analyzer)
External

Slope
+ or −

Trigger mode
Auto: 20 Hz...50 MHz
DC: 0 Hz...50 MHz
AC: 5 Hz...50 MHz

TV
Fully automatic triggering on TV video signals, automatic selection of "frame" and "line" via time base speed selector.

Trigger sensitivity
Internal 1 div or word triggering. External 200mV.

Level range
Internal 16 div typical. External 3.2V typical. Automatically adjusted between limits of signal amplitude in position AUTO.

External trigger input impedance
1 MΩ//20pF

Maximum allowable input voltage
400V (DC + AC peak)

CALIBRATION

Calibrated voltage
$1.2V_{p-p}$ ± 1% square wave

Frequency
2kHz approx.

POWER

Line voltages and frequencies
110, 127, 220 and 240V_{AC} ± 10%, 46...440 Hz. The insulation between PM 3542/3 and line fulfils the safety requirements of IEC 348 for metal encased class II instruments.

DC power source
24.5V...27V_{DC} floating input, 1.7 Amax (1.8 A max with options).

Power consumption
60W (64W with options)

ENVIRONMENTAL CAPABILITIES
The environmental data are valid only if the instrument is checked in accordance with the official checking procedures.
Details on these procedures and failure criteria are supplied on request by the Philips organisation in your country or by N.V. PHILIPS', TEST AND MEASURING DEPARTMENT, EINDHOVEN, HOLLAND.

Ambient temperatures
+5°C...+40°C rated range of use
−10°C...+45°C operating.
−40°C...+70°C storage and transport

Altitude
to 5000m (15000 ft.) operating
to 15000m (45,000 ft.) not operating

Humidity
Rated range of use 20%...30% RH
Storage and transport 5%...95% RH

Bump
1000 bumps of 10g, ½sine, 6ms duration, in each of 3 directions.

Vibration
3g vibrations of 15 min in three directions.
0.5mm_{p-p} displacements with 10 Hz...55 Hz one minute cycle.

Recovery time
Operates within 15 minutes coming from −10°C soak, going into 60% relative humidity at +20°C room conditions.

Electromagnetic interference
Meets VDE, Grenzwertklasse B

GENERAL

DIMENSIONS AND WEIGHT

(w x h x d) 330 x 150 x 445mm
(12.9 x 5.9 x 17.5-in)
9.8kg (21.6lb)

ACCESSORIES SUPPLIED

Front cover.
BNC-banana adapter.
Operating manual.
Three probes PM 8927.
Three multilead probes PM 8821 with PM 3543.
Service manual available on request

OPTIONAL ACCESSORIES

PM 8818 Hardware-programmable μP adapter
PM 8819 Connection options
PM 8810 Logic trigger probe
PM 8811 Serial data pod
PM 8843/80 IEC-625 interface with IEC to IEEE adapter

ORDERING INFORMATION

Options

Standard	**PM 3543/00**
With built-in:	
Serial I/O (RS232/V24 + audio)	PM 3543/20
Parallel I/O (IEEE488)	PM 3543/40
Serial I/O + DISA A	PM 3543/60A
Serial I/O + DISA N	PM 3543/60N
Serial I/O + DISA Z	PM 3543/60Z
Parallel I/O + DISA A	PM 3543/80A
Parallel I/O + DISA N	PM 3543/80N
Parallel I/O + DISA Z	PM 3543/80Z
Standard	
Serial I/O interface (RS232/V24)	PM 8843/20
Parallel I/O interface (IEEE488)	PM 8843/40
Serial I/O + DISA A	PM 8843/60A
Serial I/O + DISA N	PM 8843/60N
Serial I/O + DISA Z	PM 8843/60Z
Parallel I/O + DISA A	PM 8843/80A
Parallel I/O +DISA N	PM 8843/80N
Parallel I/O + DISA Z	PM 8843/80Z

IEEE/IEC INTERFACE DATA

IEC-625 interface with IEC to IEEE adapter can be factory or retro-fitted. See "Ordering information".

SH1, AH1	Service and acceptor handshake capability
T6	Talker with serial poll, unaddress if MLA: Output is measuring data instrument setting
L4	Listener, unaddress if MTA: Input is instrument setting, acquistion control, reference data
SR1	Service request capability
RC2	No local lock-out
PP0	No parallel poll capability
DC1	Device clear capability
DT1	Device trigger capability
Separator	CR or ETB or ETX or NL (default)

NEW

- Up to 32 channels
- Up to 100MHz
- Disassembly
- Selective data acquisition
- Glitch catching
- ROM emulation
- Auto sequencing
- RS232C interface
- Easy to use

Logic analyzer PM 3632

High in performance – low in cost
The PM 3632 Logic Analyzer offers a remarkable combination of features – at an even more remarkable low price. With acquisition speeds up to 100MHz and data widths up to 32 channels, the PM 3632 personal Logic Analyzer encompasses all the usual and interesting state/time applications in digital systems. A full range of problems in the state/time domain can thus be examined and solved – in the lab, the field and the classroom. Its menu-driven operation and cursor prompting – plus overall ease of use – shortens the learning curve and the job in hand.

Its wide selection of pods and disassemblers allows its use with virtually any of the popular microprocessors. Its powerful ROM emulator option extends this versatility even further – for both engineer and prospective engineer. And extensive time labelling is vital for recognition of many signals in digital systems. With the addition of plug-in Setup and Data Memory options, each user – student, field engineer or production tester – can perform his task more simply, efficiently and quickly. And finally, its exceptionally high performance-to-price ratio puts the PM 3632 within reach

the capability of this analyzer puts it in the middle of the logic analyzer arena.

The instrument offers 32 channels that can be used for state analysis at speeds of up to 12.5MHz-suitable to handle the fastest microprocessors on the market. Switching between state analysis (external clock) and timing analysis (internal clock) is achieved by pressing a button.

As 12.5MHz is generally too slow for timing analysis, the user can select a different operating mode which increases the acquisition speed to 25MHz, 50MHz and 100MHz respectively. As the number of channels required for timing analysis is generally less and memory depth requirements increase with acquisition speeds, channel width is decreased and memory depth is increased up to 8K bits per channel. The optional PM 8862 allows glitches of 5ns to be captured.

Thus 4 operating modes are available, covering applications from state analysis on 8- and 16-bit CPUs up to timing analysis with 10ns resolution all in the same instrument.

Channels	Speed	Memory depth
32	12.5	1K bits/channel
16	25	2K bits/channel
8	50	4K bits/channel
4	100	8K bits/channel

The capability of the instrument is represented also in its trigger capabilities. Four-level sequential, offering 19 predefined trigger conditions to cover most applications, as well as a user-defined trigger sequence, using 4 trigger words and 4 trigger levels.

The already adequate memory depth of 1Kbyte per channel at 32 channels width, can be virtually extended by means of powerful selective data acquisition.

Except for these standard features, a wide range of options is available for this instrument.
This allows it to be tailored to the users specific application. These options include a complete 8-bit microprocessor disassembly support, RC232C serial interfacing, set-up and data non-volatile memory offering 8 data and set-up stores as well as compare and search functions and a unique ROM-emulation offering interactive software debugging.

Operation
All functions of the PM 3632 are controlled from the front keyboard. A complete hexadecimal keypad is on the right. The CRT display is menu-driven.

Four arrow keys move the cursor and scroll through the displayed data. Three keys under DISPLAY select the data display mode.

The remaining 12 keys, under SETUP, access setup screens for specifying recording and formatting parameters.

To access any setup screen, only a single keystroke is needed. Any item on a screen may be specified or changed by positioning the cursor over it, then entering the desired parameter.

To use the PM 3632, it is first connected to the system under test with the appropriate pod. The sampling rate and recording width are then selected, using the CLOCK and CONFIGURATION setup screens. The triggering condition is selected next, using the TRIGGER, DELAY and SEQUENCE screens. It is then possible to either accept the default format or select one's own, using the FORMAT screen.

When data is displayed in the TIMING mode it is expressed in a waveform diagram; in the STATE mode as a formatted word list; or in the DISASSEMBLY mode as microprocessor assembly instructions.

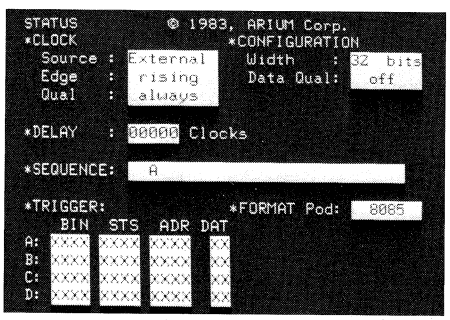


Fig. 1

The displays tell the story

System Status (Fig.1)
This display gives a quick overview of all current major system parameters. Greater detail can be found in other screen displays.

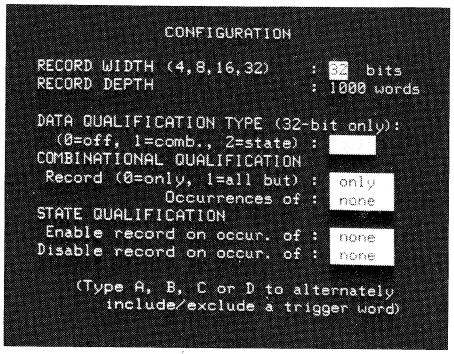


Fig. 2

Configuration (Fig. 2)
This setup screen shows word width and memory depth, and data qualification options. As word width is entered, memory depth for each channel is displayed. Data qualification permits determination, on an individual or sequential basis, whether or not any word will be recorded. This is available only in the 32-channel mode.

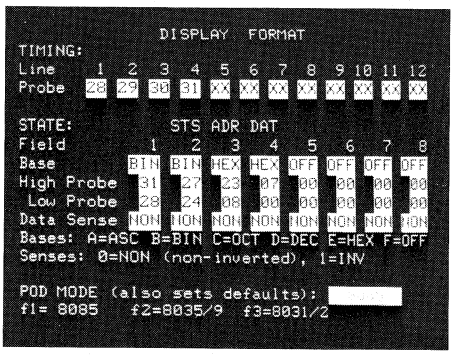


Fig. 3

Format (Fig. 3)
This setup screen determines bit groupings and number base for data fields used in TIMING, STATE, and DISASSEMBLY displays. In this example, probe numbers for each timing line appear at the top. Next are probe groupings for conversion and display in the STATE mode. At the bottom is the microprocessor pod mode choice. Captured data may be displayed in binary, decimal, octal, hexadecimal or equivalent ASCII values.

Sequence (Fig. 4)
This screen defines the trigger condition formed by combinations of the selected trigger words. A menu gives the various possibilities. Up to four different trigger levels can be set, while also 19 preset trigger sequences are available.

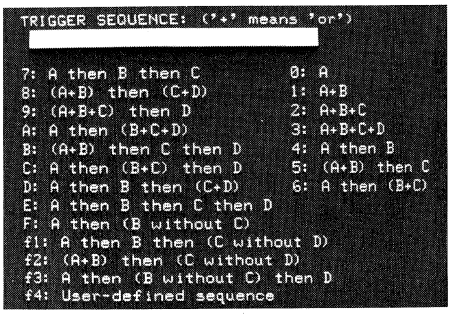


Fig. 4

User defined trigger levels (Fig. 5)
There are four sequential trigger levels available. In each level, four trigger words can be interconnected by means of Boolean expressions.

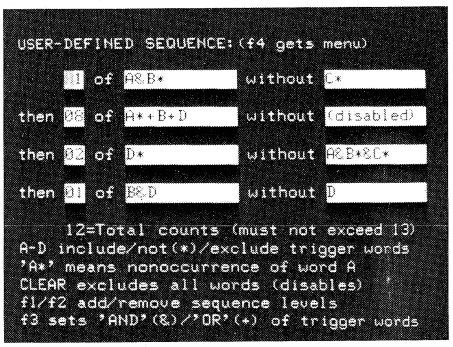


Fig. 5

Trigger (Fig. 6)
This screen defines four trigger words, or events, labelled A through D. Each word is displayed on two lines, and either line may be modified. A cursor shows the item to be entered. If a binary "X" entry is made on the lower line, any resulting indeterminate character on the upper line will be shown by a "?".

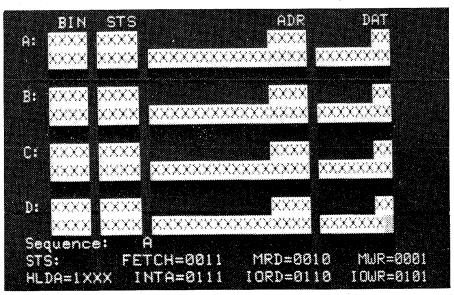


Fig. 6

Delay (Fig. 7)
This setup screen shows the number of clocks to be recorded before or after the trigger condition occurs. The entire recording interval may be placed after the trigger condition by selecting a sufficiently long trigger delay.

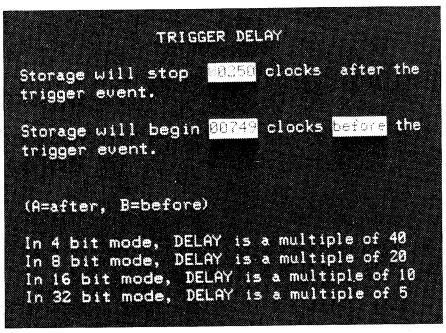


Fig. 7

gives high-speed clock qualification and glitch capture on four channels.

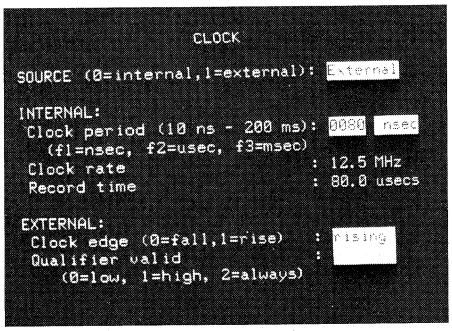
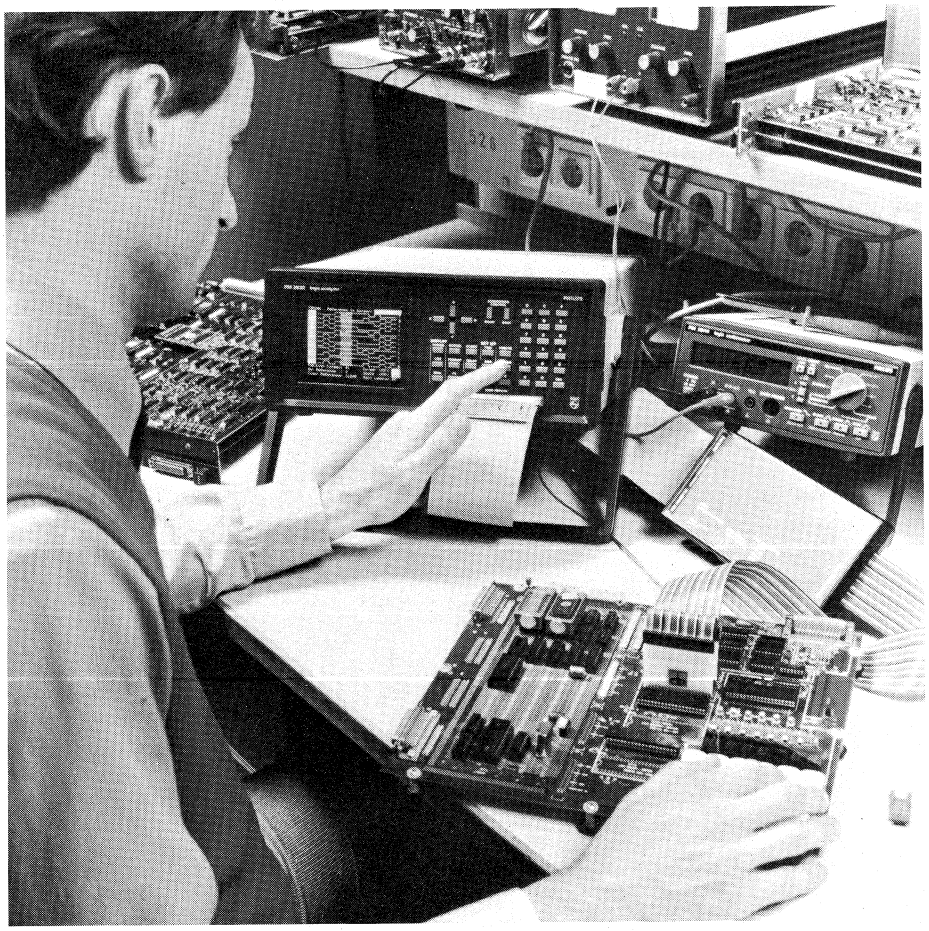


Fig. 8

Clock (Fig. 8)
This setup screen shows details of the instrument's internal and external clocking. To specify the value, the internal clock period is set with the numerical keypad. To specify the units, the f1, f2 and f3 keys are used. The corresponding clock frequency is displayed. Data may be sampled on the rising or falling edge of the external clock. An optional pod

State (Fig. 9)
The fields in this display are grouped and converted as specified by the FORMAT screen. The trigger event is labelled "TRIG". The up or down arrow keys will scroll through all captured data. Direct addressing and fast scroll are available with the f1 and f2 keys.



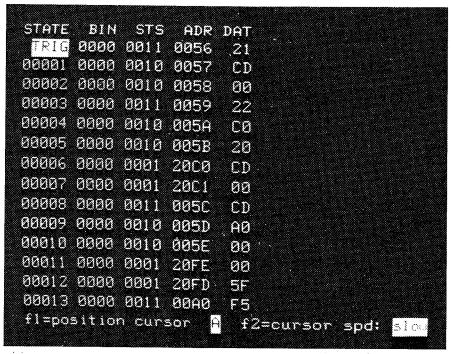


Fig. 9

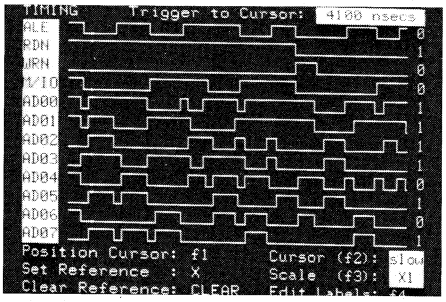


Fig. 12

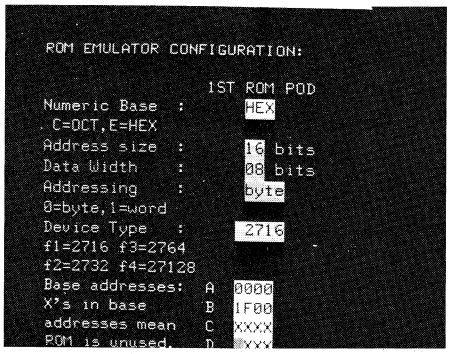


Fig. 14

Disassembly (Fig. 10)

Selecting the disassembly key displays data collected by means of optional microprocessor pods. This option displays the recorded data interpreted as assembly language instructions. It is a powerful tool for tracing microprocessor programs.

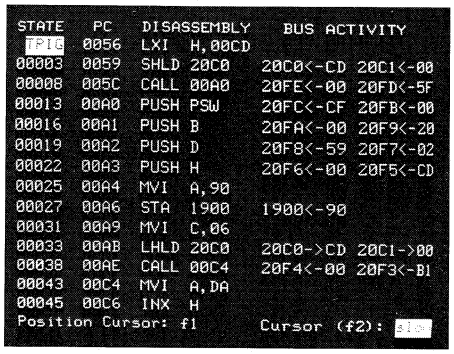


Fig. 10

Selective data acquisition (Fig. 11)

Selective data acquisition allows optimizing of memory usage. There are two possibilities:

– a toggle function on selected trigger words, i.e. storage starts on one and stops on the next selected trigger word

– combinational, i.e. storage of selected words only.

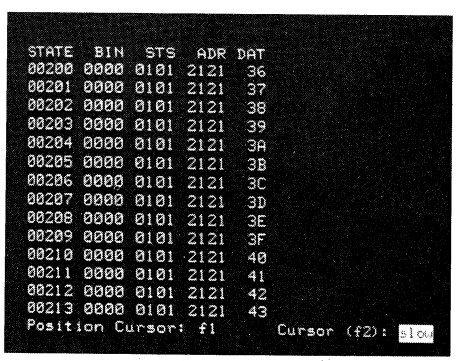


Fig. 11

Timing (Fig. 12)

This display shows data from any active probe. The 12 channels displayed are selected through the FORMAT screen. They can be placed in any order and/or repeated. Data lines can be scrolled horizontally. The area around the cursor can be magnified 10x by pressing a key. The "X" key places a reference line at the cursor. Repositioning the cursor allows accurate time measurement. Data can be reformatted or redisplayed in any display mode without recapture. Extensive time labelling facilities are provided.

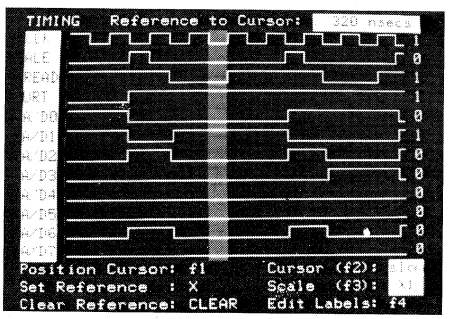


Fig. 13

OPTIONS

ROM Emulation (Fig. 14)

An optional ROM emulator plugs directly into ROM sockets of the system under test. It emulates one to four ROMS, up to 16 kbytes of memory. It is configurable for 2716s, 32s, 64s, or 128s. The simulated ROM memory can be uploaded or downloaded to or from the system under test, via a ROM emulator pod. Memory can than be examined or modified from the front panel.

Setup/Data Memory (Fig. 15)

An optional Setup Memory option stoes eight complete machine setups in non-volatile memory. These are not lost when power is turned off. The Setup/Data Memory option is an expanded version which includes data reference memory as well. This provides the instrument with the ability to copy, save, recall and edit a captured data set 1000 samples deep at 32 channels wide, and up to 8000 samples deep at four channels wide.

With this option, the PM 3632 can also compare and search captured data, automatically sequence through machine setups, perform corresponding tests, and then count and display the number of tests passed and failed.

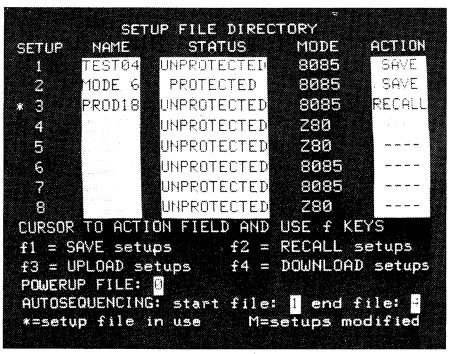


Fig. 15

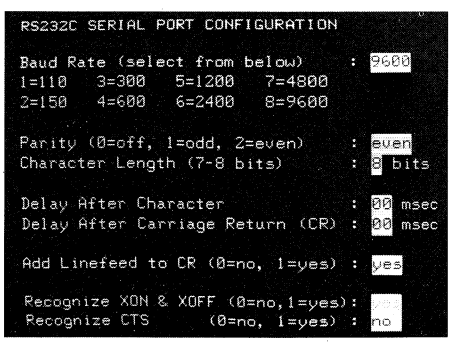


Fig. 16 RS232C serial port configuration menu showing choice of interface parameters.

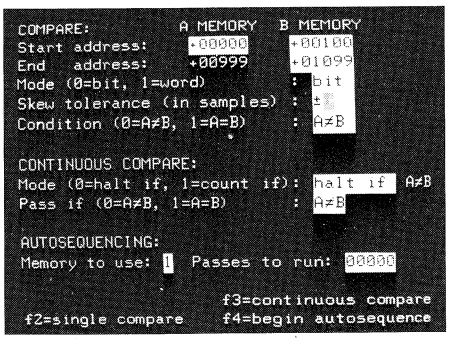


Fig. 17 Compare menu showing, amongst others, auto sequence mode.

TECHNICAL SPECIFICATIONS

DATA INPUTS
32-channel logic pod
4, 8, 16 or 32 channels, mode selectable
Input voltage:
Minimum +/− 600mV
(from threshold)
Maximum +/− 16V
Threshold:
TTL or variable +/−9-volt range
Input impedance 100 kohms//6pF

CLOCK (single)
Internal (asynchronous): 5Hz to 100MHz

(4 channels max at 100MHz)
External (synchronous):
Data setup time 5nsec max
Data hold time 1nsec max
Period 14nsec min
Pulse width 7nsec min
One clock qualifier: Same timing and voltage specifications as data input

TRIGGERING
Trigger words (events) 4
Trigger word width 32 bits max
(consistent with recording width)
Sequential & combinational methods: 19 predefined combinations 1 userdefined combination (see trigger screen)
Trigger delay: 0 to 50.000 clocks

DATA QUALIFICATION
Record select:
State: Toggle on selected words
Combinational: Determined by word

MEMORY
32Kbits, arranged as follows:

4 channels	8000 samples/chan.
8 channels	4000 samples/chan.
16 channels	2000 samples/chan.
32 channels	1000 samples/chan.

STATE DISPLAY
Data shown in formatted word list recorded words in up to 8 fields
Each field formattable in BIN, HEX, DEC, ASCII or OCT
Data repeatable in different formats

TIMING DISPLAY
Any 12 channels at once (channels may be repeated)
Cursors: 2 (reference & current position)
Time measurement: In clocks (cursor-to-trigger or cursor-to-reference)
Times-ten:expansion (Centered on cursor)

DISPLAY
5-in internal CRT

DISASSEMBLY DISPLAY (optional)
Formatted display: Microprocessor cycles displayed with address, mnemonic for opcode, operand(s), I/O and memory operations

MICROPROCESSOR SUPPORT
Intel, Motorola, Zilog etc.

SCROLLING (all display modes)
Continuous scrolling, left/right, fast/slow

PHYSICAL
300x125x375 mm plus handle & feet 10 kg

INPUT POWER
100, 110, 127, 220, 240V AC±10%,
50-60Hz

ENVIRONMENT
0 to 40°C operating
5 to 95%RH noncondensing

ROM EMULATOR (optional)
ROMs supported: 2716, 2732, 2764, 27128
Plugs for ROM sockets: 4
Address bus: (all ROMs) 14 lines assumed common
Data bus: 2 independent 8-bit busses; usable for 8- or 16-bit targets

T_{acc}	200nsec
T_{ce}	200nsec
T_{oe}	75nsec
I_{ol}	2.1mA
V_{ol}	0.5V

Data interface: RS232C (V24) on rear of PM 3632; upload and download in hex formats
Data editing: PM 3632 keypad

ORDERING INFORMATION

Main instrument

PM 3632	32 channel logic state/timing analyzer + 32 channel logic pod.

Model is supplied with operating manual and logic pod as detailed above.

Available option boards
(Maximum 3 different option boards can be installed per instrument)

PM 8880/00	ROM-Emulator module, consists of RS232C comm. card PM 8880/20 and Romemulator pod PM 8864; *)
PM 8880/20	RS232C communication card
PM 8880/30	Disa Romboard, this board is required once when ordering the first microprocessor pod. It holds up to 12 disassemblers and should be ordered separately.
PM 8880/40	Set up memory board
PM 8880/50	Set up/data memory board

*) his module is minimally required for ROM-emulation

Available pods

Type No.	Description
PM 8860	32 Chan. Logic pod
PM 8862	4 Chan. fast pod/glitch capture
PM 8863	Standard bus pod
PM 8864	ROM emulator pod
PM 8865	Microprocessor pod for 8085; 8031 8032; 8035; 8039; 8040
PM 8866	Microprocessor pod for 6800; 6802; 6808
PM 8867	Microprocessor pod for 6809
PM 8868	Microprocessor pod for 6502
PM 8869	Microprocessor pod for Z80A
PM 8870	Microprocessor pod for NEC 800

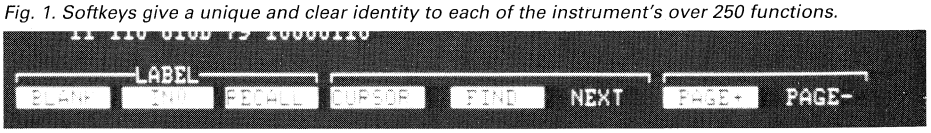
Configurable to application
Softkey operation
Up to 75 channels
IF, THEN, ELSE trigger language
Highly selective data acquisition
Unique transitional timing analysis
Multi-processor support, 8 and 16 bits and custom
300MHz timing capability
Performance analysis
Full interface facilities

Logic Analyzer PM 3551A

The PM 3551A presents a new era in logic analysis by combining innovative and comprehensive analysis power with easy and efficient operation. The use of cursor prompting and softkey entry, for example, enables each of the analyzer's more than 350 functions to be uniquely and clearly identified. This approach produces a user interface with significant advantages over conventional analyzers, the most obvious being that the PM 3551A is immediately understandable. Moreover, the softkey approach reveals the PM 3551A's capabilities step by step, enabling the user to exploit the analyzer's power without any training.
Menus or data displays are selected via single-function keys on the front panel. The menus give the complete operating set-up, while the data displays show not only captured data but also a user defined 'condensed menu'. This condensed menu details the most important operating parameters in the main menu and it can be accessed directly and modified at any time.

Easy, efficient operation extends from the front panel through the complete instrument. The PM 3551A's non-volatile memory, supplied as standard, stores the latest user settings and allows the analyzer to be reused immediately, when it is switched on. An individual label can be assigned to any 50MHz or 300MHz time channel, thus making the time display easy to understand.
The physical side of the operator interface has been designed for long periods of continuous use. All keys have a tactile feedback action and the most frequently used are located on the 'nose' of the instrument, allowing a comfortable, typewriter keyboard style of entry that cuts out user fatigue. In addition the 9-in video display is of a professional terminal standard. Its green phosphor is easy

Fig. 1. Softkeys give a unique and clear identity to each of the instrument's over 250 functions.



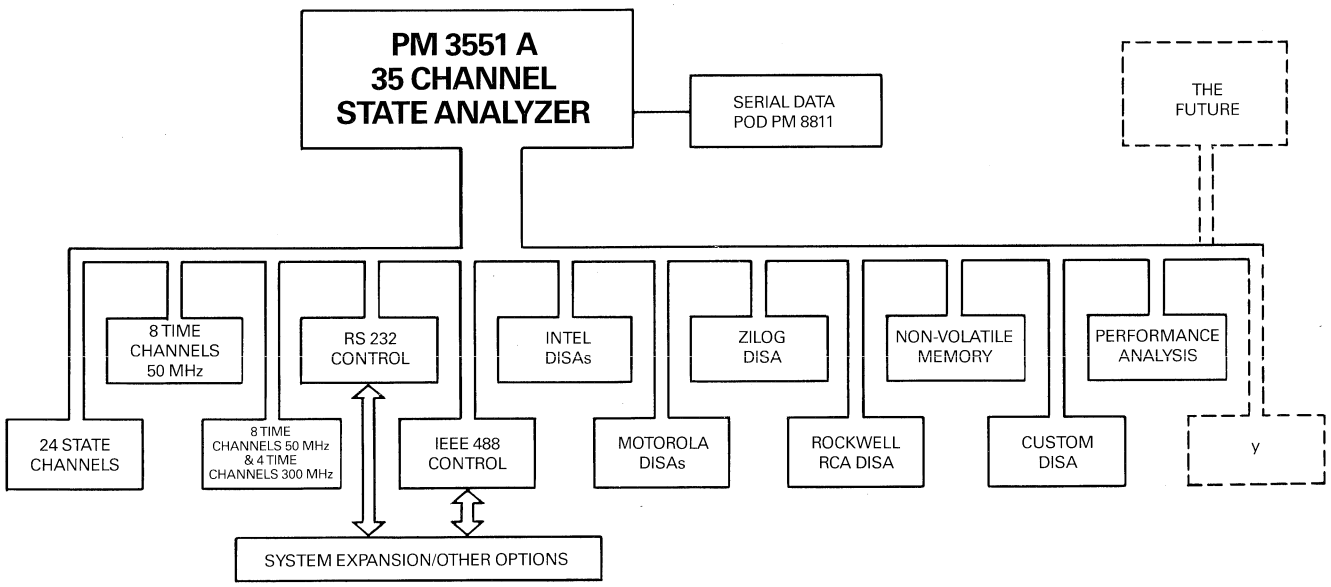


Fig. 2. The PM 3551A is configured to match not only current but also future requirements.

on the eye... it has a split-screen capability... and it features soft scrolling, thereby providing pleasant viewing.

Configurable power

The PM 3551A can be configured to match current applications and upgraded to prevent technical obsolescence. For example, the user may currently be developing. Z 80B-based systems. In this case the 35 channel PM 3551A with the Zilog disassembly package is the best configuration. But what about the future? Next year it may be required to go 16 bits PM 3551A can then be expanded to 59 state channels with 50MHz or 300MHz timing capabilities. It is also possible to add resident multiprocessor disassembly packages that currently support the Intel, Motorola. Zilog and RCA/Rockwell families.

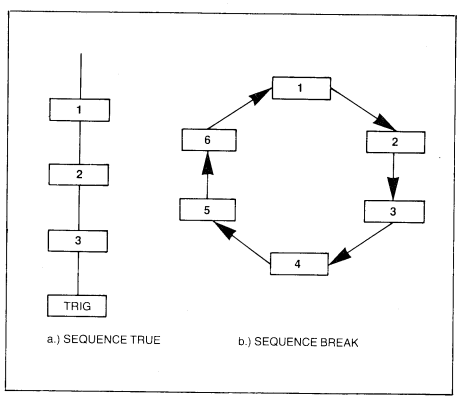


Fig. 3. To date all logic analyzers have triggered on the correct completion of a sequence, as shown in Fig. 3a. The PM 3551A, however sets an entirely new standard by offering the additional facility of triggering on a break in the specified sequence.

Optional RS 232C and IEEE 488 interfaces give both data input/output and full remote control. Expansion of the non-volatile memory to store up to four more of your often used set-ups (store/recall with single key).

Looking even further into the future, more card-compatible modules for PM 3551A are being developed. This will allow current PM 3551A to go on being upgraded to match the pace of microelectronic development and thereby ensure efficient, highly cost-effective operation in the future.

Matchless triggering

The PM 3551A sets an entirely new standard in advanced triggering. Its IF, THEN, ELSE structured language enables the most complex trigger routes to be realised easily and efficiently by a simple series of softkey entries. In operation, a special high-speed sequence controller makes the real time decisions as defined in the trigger menu. This technique has many significant advantages, as conditional branches can be made at any stage in the trigger route and not merely on a single restart word.

Another example of the instrument's matchless triggering is its unique 'trigger on sequence break' facility. This is a true landmark in triggering. To date all logic analyzers have triggered on the successful completion of the defined trigger route. This new facility, however, enables a repetitive sequence to be defined e.g. a polling sequence. If this sequence is executed correctly, no triggering occurs; if the sequence is broken, however, then triggering occurs at the first false step.

Pre-trigger memory of infinite depth

Until now an analyzer's data acquisition memory could only be located with respect to the final trigger event. This meant that the maximum amount of pre-trigger data that could be captured was determined by the instrument's memory depth. However, with the PM 3551A one can define a block of data to be captured that is then followed by a specific sequence of events. This, in effect, stretches the basic 1023 word memory depth to one of infinity.

This is just one example of the PM 3551A's many advances in making highly-selective data acquisition. The analyzer can also capture a defined number of samples which follow a specific word... or count occurances of particular word types... or even make subroutine time measurements.

Transitional timing... memory efficiency

To date, logic timing analyzers have always 'featured' large memory depths, but only because the memory was used inefficiently. This was because they captured data continuously. However, PM 3551 A uses a different method called transitional timing.

In transitional timing two memories are employed, side by side. One for data and the other for time. The data is sampled at a constant 20ns interval (50MHz) or 3.3ns interval (300MHz). If there is a

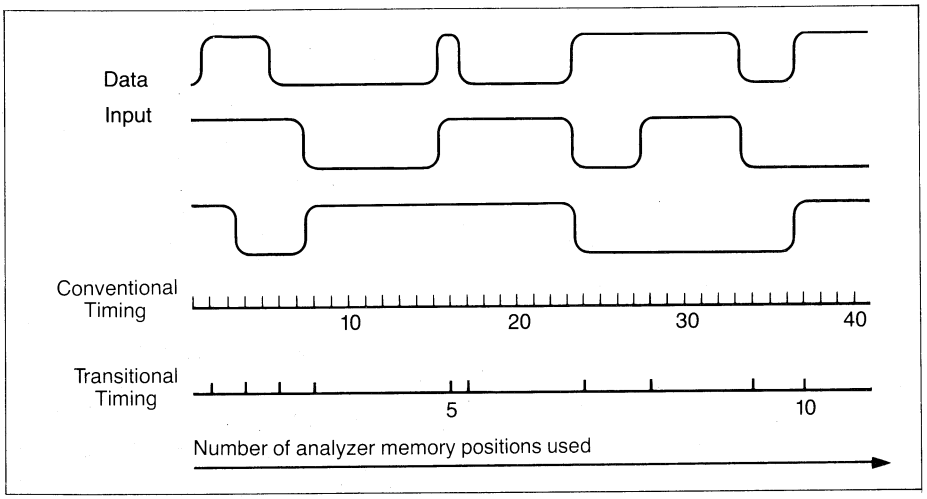


Fig. 4. Both transitional and conventional timing analyzers give the same time resolution, but a conventional analyzer needs four times the memory depth.

change on any of the channels between one sample and the next, then the old data is loaded into the data memory and simultaneously the duration that the old data was true is loaded into the time memory. In this way the smallest pulses are captured, but not at the expense of wasting memory by capturing the same information several times.

The PM 3551A therefore only captures transitions, even though it samples at a fixed interval. Knowing the time at which the transition occured allows the instrument to reconstitute the complete timing picture. For example, the 50MHz unit can precisely record two 20ns pulses which occur 5 seconds apart. There is therefore no longer the traditional dilemma of trading off poor resolution and long memory depth against good resolution but short memory depth. The PM 3551A provides both! Other timing features include triggering and arming from the state section, glitch triggering on a defined word or in a defined time window and cross- referencing with the state sampled data.

The menu modes

The various menu modes are accessed by pressing the appropriate menu key on the front panel. Once the required menu is selected the settings are realised by either the softkeys, for a choice of parameters, or by the HEX pad for numerical entries. As the softkeys labelling is dependent on the cursor position within the menu, it ensures unique labelling of keys and simple editing.
Additionally, the screen areas next to the menu title contain user prompts and error messages, so assisting the self learning process and elmininating erroneous entries.

The configuration menu

This menu details the mode of operation and the configuration. The PM 3551A has various modes of operation. It can be used as a pure state analyzer, a pure timing analyzer, a combination state and timing analyzer, or as a state coupled timing analyzer.
This latter mode is known as the SYNC mode and exactly cross references the actions on the timing channels to the state sampling, so enabling critical state/time relationships to be accurately traced.
The Configuration menu also has refined labelling possibilities, not only on a channel basis but also on a clock basis. This enables information to be gathered on a single channel by various sampling clocks yet displayed in a clock dependent format. This labelling technique makes it very easy to attain logic display formats for multiplexed bus μPs. Fig. 5 shows the format for the 8086 where CLKO = ALE, CLK 1 = RD and CLK 2 = WR. The label A = status, B = 20 address bits, C = 16 data bits (read and write).

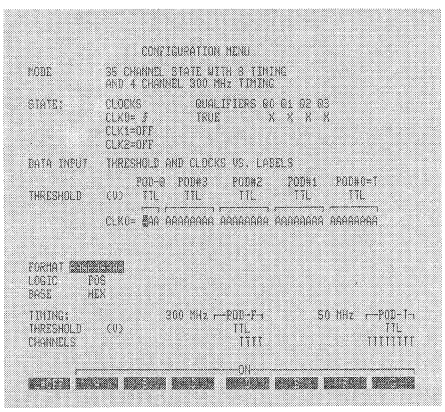


Fig. 5. The configuration menu

The trigger menu

The state triggering capability of the PM 3551A is simple to use and understand yet incomparably powerful in its execution. The IF, THEN, ELSE based language is used to form trigger steps. These steps can be simple 'in line' steps or intricate conditional branches involving several words and delays.
In either case the step is described in simple, plain English and entered by the uniquely defined softkeys. These softkeys also enable editing within a step. In conjunction with the cursor they can also insert or delete steps or the complete menu.

The trigger menu
– trigger on sequence break

Unlike the two previous examples where triggering occurs on the successful completion of a sequence, the 'Trigger on Sequence Break' mode now enables triggering on the unsuccessful completion of a sequence. It is best described with reference to a polling sequence as shown in Fig. 6. A master polls each of the five slaves in turn and services their requirements. This cycle continues until, as a result of a service action, the sequence is broken, resulting in one or more of the slave devices not being serviced. Using the Trigger on Sequence Break mode of the PM 3551A, triggering occurs on the first erroneous step. The menu setting for this mode is as shown.

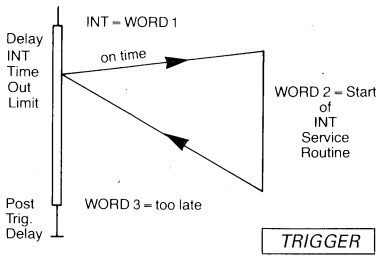
The trigger menu
– 50MHz timing

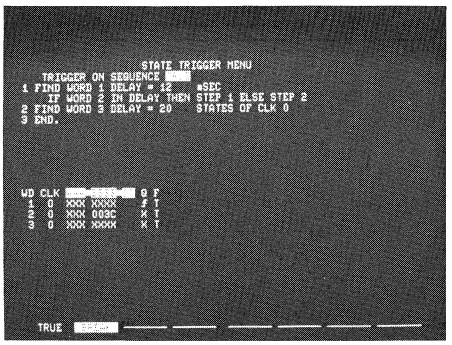
The timing section of the PM 3551A is not only unique in its transitional data acquisition, but also in its refined triggering.
In addition to the more conventional features like word and glitch triggering with variable filter times, it also offers glitch window triggering. This entails the finding of a specified word which opens a user defined time window. Triggering occurs if during this time window a glitch of less than a specified length occurs on a certain channel. If not, the timing analyzer searches for the word again. This mode enables a specific area of the logic flow to be tested and so eliminates the problem of false triggering on a similar glitch condition in another unrelated area.

The timing trigger can be enabled from the state section and then, if required, inhibit the state trigger sequence until its own trigger is found. Alternatively the state and time analyzers can be internally synchronized for exact cross referencing of state/timing action. Time labels are defined via this menu.

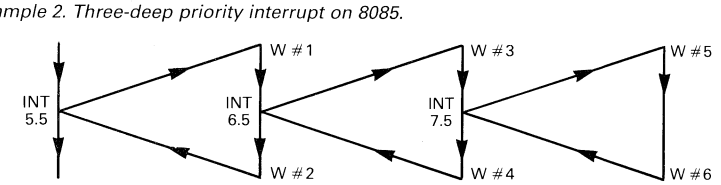
Example 1.
Simple interrupt time-out.

WORD 1 recognises the interrupt and starts the time-delay counter. If WORD 2 is encountered (i.e., the interrupt is serviced) before the end of the delay, the trigger is reset to await the next interrupt. If the delay counter times out, WORD 3 triggers the analyzer. Post-trigger delay ensures that both post and pre-trigger data is captured.

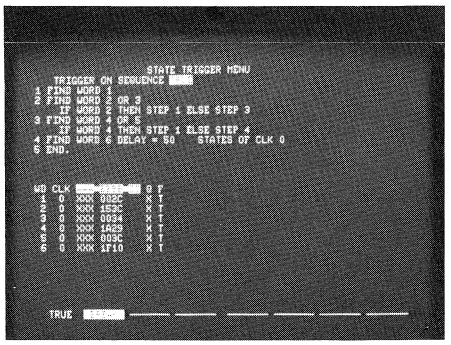




Example 2. Three-deep priority interrupt on 8085.

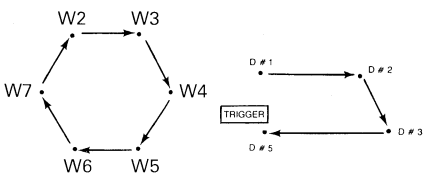


WORD 1 identifies that the INT 5.5 service routine has been called, WORD 2 identifies the end of the routine. WORD 3 identifies the start of the INT 6.5 routine. If WORD 2 is encountered before WORD 3 the trigger is reset to step 1 to await a further INT 5.5 service routine. The same is true if WORD 4 is encountered before WORD 5, but the trigger is set to step 2 to await the next INT 6.5 interrupt. The PM 3551 A is only triggered on WORD 6, when the full three-deep interrupt has occurred. That is, when INT 5.5 is interrupted by INT 6.5 which is, in turn, interrupted by INT 7.5.



Example 3. Trigger on sequence-break

The two previous examples triggered on successful completion of a sequence. In this example it is the non-completion of a sequence that acts as trigger.
For example, a master polls each of 6 slaves. At a given moment the polling sequence is broken so that one or more slaves are not serviced. With the PM 3551 A the first erroneous step is detected and the problem pin-pointed.



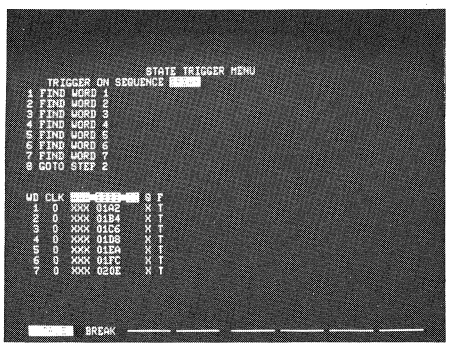


Fig. 6. The trigger menu – trigger examples one and two and trigger on sequence break.

Selective data acquisition menu

It is often necessary to sample only specific state actions from the total data flow. The Selective Data Acquisition Menu gives ultimate capturing capabilities.
Not only is it possible to do sub-routine real-time measurements, specific event counting or single word qualification, it is also possible to define a specific block of data to be captured. The start and stop points of this block may be any of the words or delays used in the trigger menu. This enables blocks of data to be captured which occur before the final trigger point, thereby effectively extending the pre-trigger memory depth. Further definition of what sort of data from the total block should be captured is also possible. This can be based on, not only clock 'sources' and word types, but also a word type followed by a defined number of clock samples. An example of this would be to define the word type as a branch instruction and then to collect the three following samples.

The result is that the analyzer collects all branch instructions and the resultant branch address, thereby giving a rapid overview of the total program flow.

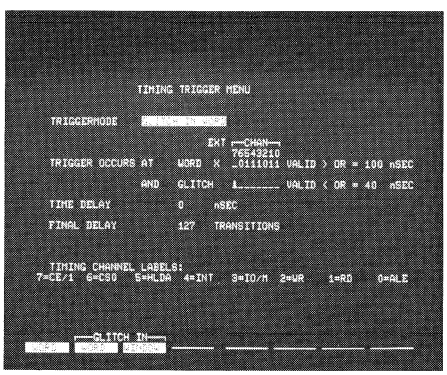


Fig. 7. The trigger menu – timing

Compare menu: state and time

Comparison capabilities in logic state analyzers often reveal problem areas in program flow. The PM 3551A offers comparison capabilities over a defined 'masked' section of the captured data memory. This 'masked' section can be even further qualified on a channel-by-channel basis and on a sampling clock basis.

In the state list display inequalities between the current and reference memories are shown in reverse video.
Comparisons are also possible in the timing mode where a skew window may

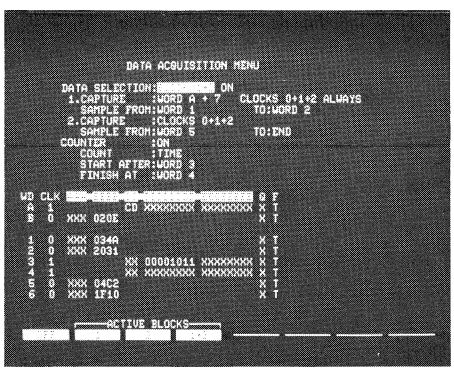


Fig. 8. Selective data acquisition menu

be defined in order to eliminate the inherent problems of timing comparisons. The comparison may also be made over a masked section of the memory, with additional qualification on a channel-by-channel base possible. In the time display inequalities between the current and reference memories are underlined.

Display modes

When any of the data display modes are selected, a condensed version of the most recently displayed main menu appears at the top of the screen. These condensed menus not only give a review of the main parameters, but can also be directly accessed, allowing alterations to be made without tiresome back-and-forth switching between display and main menu modes.
It is in the display modes that the video section really shows its performance, not only in its split-screen display, but also in the data scrolling modes, where soft scrolling eliminates the irritating flicker found on hard scrolling equipment.

State list display

In addition to the normal analyzer features of channel blanking, inverted logic and scrolling, the PM 3551A gives advanced data manipulation facilities enabling an area of specific interest to be located rapidly. The PAGE + and PAGE −softkeys enable simple paging through the entire captured memory.

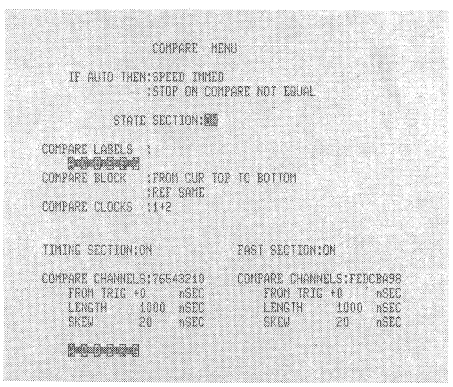


Fig. 9. Compare menu

The more advanced capabilities allow direct definition of where the display should be centered. This is achieved either by defining a new cursor position or by defining a particular word: this can either be a word used in the triggering or a freely defined word. The user can step the display to the next occurrence by the use of a single key.

State graph display

The Graph Display gives an overview of the memory contents, which is often useful in specific applications such as A to D monitoring. In many logic analyzers this facility unfortunately suffers from a combination of limited capability and difficult operation. The PM 3551A, however, makes the Graph mode extremely useful by offering a high resolution display combined with simple operation. In use it is possible to see the full memory depth, then zoom in on a particular area by use of the cursor and EXPAND softkey. If investigation to state level is then warranted, pressing the LIST function key gives the state listing located on the same cursor position.

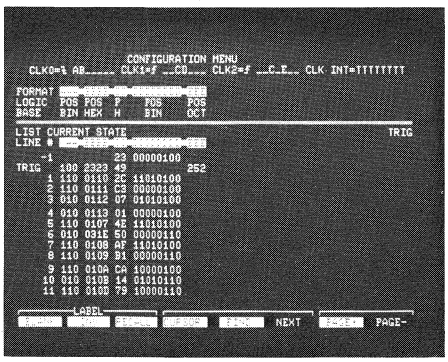


Fig. 10. List display

The PM 3551A even has a single softkey called BEST, which automatically gives the optimum vertical axis scaling and readout of the upper and lower limits. This eliminates the need for manual, time-wating adjustment.

Time display

The transitional timing capability of the PM 3551A is transparent to the user in the timing display mode. It is still possible to expand the scaling of the time display on a 1, 2, 5 sequence by means of the MORE and LESS softkeys. The BEST softkey automatically scales the display so that the full memory contents are visible.

This enables rapid positioning of the cursor on an area of interest, which can then

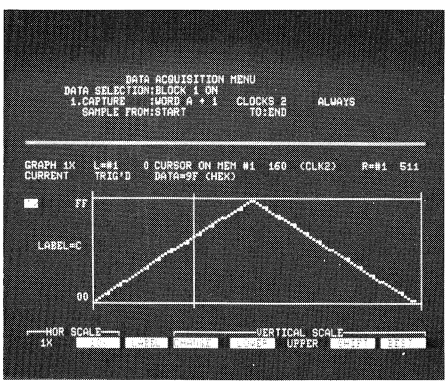


Fig. 11. Graph display

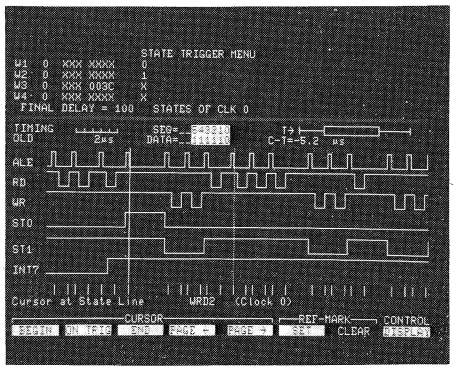


Fig. 12. Time display in SYNC mode

be magnified by use of the MORE softkey. The resultant scaling factor is displayed on screen, as is the current displayed area, with respect to the total memory depth.
Channel blanking and user definable channel sequence displays are quickly entered by means of the softkeys which also control the two cursors used for timing measurements.
Channel labels are entered via the time trigger menu.

In the SYNC mode the state and time display are exactly cross-referenced. Fig. 12 shows a typical time display in the SYNC mode with 6 channels shown plus information on the cursor position.

Options

The PM 3551A's performance can be enhanced by the addition of various options.

These include facilities for input, output control, disassembly, custom connection and additional non-volatile memory. For simple output the RS 232C printer interface enables analyzer setting and/or data to be hard copied. A second RS 232C interface makes it possible to remotely control a PM 3551A by one's own computer. Alternatively, this interface can be used for the dumping and loading of data and/or settings.
In an automatic test environment, the IEEE 488 interface makes the PM 3551A a fully controllable listener/talker. Programming of the instrument is possible at three levels – on a key base, on a menu or display base, or at total instrument level. In the latter two modes, the control requirement is reduced by some 90% and first time operation is guaranteed.

The multiprocessor disassembly packages are family-oriented providing the full support to an application in a single firmware package. These support the Intel, Motorola and Zilog families. Another package supports Rockwell, RCA and National processors. To comple-

ment these disassembly packages, and enable rapid connection to any system, several personality adaptors are available for most popular 8- and 6-bit microprocessors. The PM 8817/40 enables connection of up to five logic pods to 40 pin DIL packages. For larger applications, the PM 8817/64 enables up to eight logic pods to be connected to the test object. This enables up to 64 connections to be made easily, even to custom circuits.

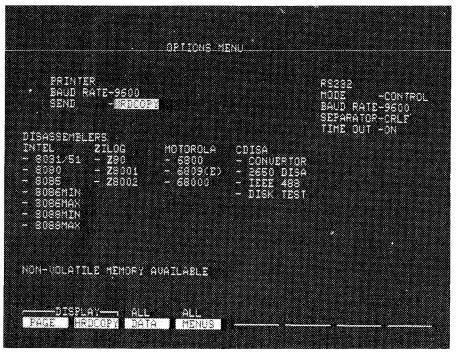


Fig. 13. Options menu, I/O and disassembler choice

It is also possible to extend the non-volatile memory capability so that in addition to the latest setting four more settings may be retained and recalled when required.

If Serial Data analysis is required this can be simply achieved by the addition of The PM 8811 Serial Data Pod (See p. 26 for further details).

Option: more and faster timing channels

The first 8 channels 50MHz timing capability can be increased by extra channels. With this option the user obtains the choice between 2 timing configurations at his fingertips.

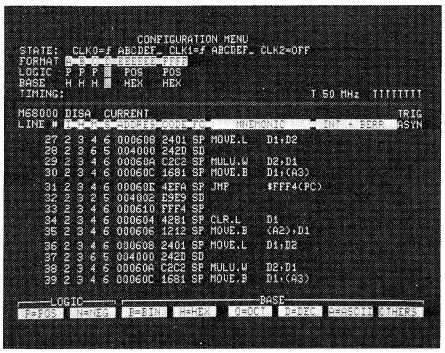


Fig. 14. Option display, disassembly of 68000

First he can decide to work in a full 16 channel timing mode with the sampling rate of 50MHz.

Secondly, the user may decide to use the option to work with a combination of 8 channels 50MHz and 4 channels 300MHz.

Some of the applications of this timing option are:
- monitoring the timing of a 16 bit data bus
- analysing the detailed effects of control signals anywhere in a system at 3.3ns sampling rate.

The unique features of the PM 3551A timing section are extended by this option. It has its own dual transition memory, which is effecient both in operation and memory use. Moreover, in the SYNC mode the state and timing sections can be coupled to perform accurate cross-referenced state and timing measurements simultaneously.

Performance analysis option (PM 8883/00)

An important feature that further enhances the analytical power of the PM 3551A is the Performance Analysis option. Generally, this comes into use when an electronic (microprocessor-controlled) system is to be optimized for its S W operation. That is, where there are certain routines in the system that must wait too long to be accessed, or a specific routine is not properly structured and must be recoded. The Performance Analysis option PM 8883/00 offers many features in the process of locating these 'bottlenecks.'

First of all, up to 12 address ranges can be monitored for the system time they occupy, with possible deterioration of routine (=address range), mean execution time, mean repetition time and frequency of occourence of all ranges. It then becomes possible to consecutively focus on one specific routine and do an accurate statistical measurement, producing a clear histogram with the (time) distribution of, e.g., the routine executution time over a certain period of time (or clocks).

A further feature is that, if during a routine an interrupt occurs, this occurence can be skipped, thus preventing the interrupt time from being added to the routine time, and the statistical information being distorted. Furthermore the PM 8883/00 is able to measure successive routines to give a full picture of program function.

Display facilities are present in either tabular or histogram form, the master display showing all measured ranges at the same time in an overview, whilst in the graph mode, individual ranges can be shown in a histogram giving detailed statistical information.

The option is organized in two EPROM

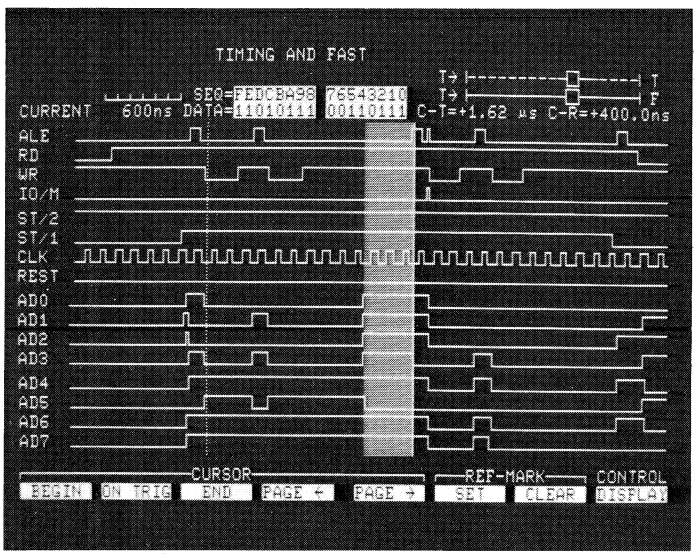


Fig. 15. Timing analysis on 16 channels

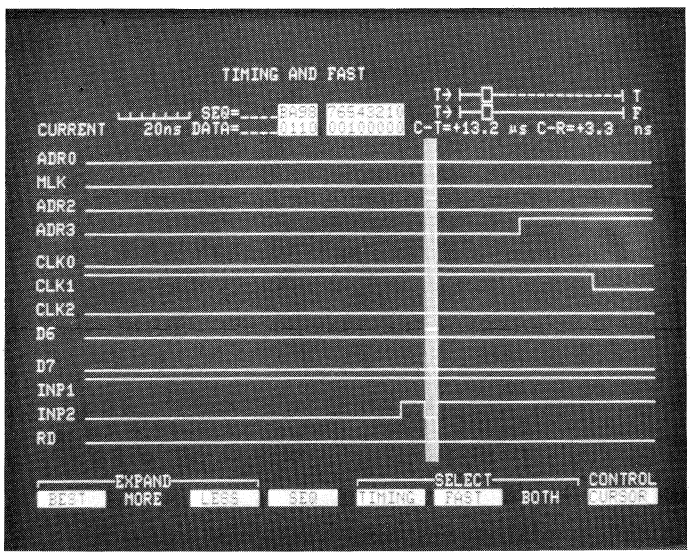


Fig. 16. 8-50MHz and 4-300MHz channels

packages which are plugged on to an interface board and requires the latest main S W release.

TECHNICAL SPECIFICATION

STATE SECTION

Input
Via PM 8821 or PM 8825 multilead active pods
input impedance

PM 8821:	4MΩ//6pF
Max. input:	−50V...+50V
Max. sensitivity:	250mV threshold overdrive
Threshold:	selectable TTL, ECL or variable per pod
TTL:	+1.4V
ECL:	−1.3V
VAR:	−3V...+12V in 100mV steps

Clocks and qualifiers
Three independent clocks
Min. repetition time: 7ns
Min. clock pulse width: 20ns
Up to four clock qualifiers

Set up time:	<25ns	with respect to active
Hold time:	0ns	clock edge

Data input

Set up time:	<25ns	with respect to active
Hold time:	0ns	clock edge

Memory
Depth: 1023 words
Width: 35 bits or 59 bits
Reference memory of similar size

8 CHANNEL 50MHz TIMING SECTION

Input
All inputs via one PM 8825 multilead active pod

Input impedance:	1MΩ//5pF
Max. input:	−50V...+50V
Max. sensitivity:	200mV threshold overdrive
Threshold:	selectable TTL, ECL or variable
TTL:	+1.4V
ECL:	−1.3V
VAR:	−3V...+12V in 100mV steps

Clock
Internal: fixed 20ns sampling

Data input
Maximum non detectable pulse: 24ns
(=set up +hold time+sample interval.)
Channel-to-channel skew: 2ns

Glitch
Min. detectable glitch width: 5ns

Memory
From 256 to 256 x 10^6 samples
Reference memory of similar size

4 CH/300MHz+8 CH/50MHz SECTION
OPTION PM 8852/80

Input
As per 8 CH/50MHz section

Clock	300MHz	50MHz
Fixed	3.3ns	20ns

Data input

Max. non detectable pulse	4ns	24ns
Channel-to-channel skew	1ns	4ns

Memory
From 256 to 128 x 10^6 samples

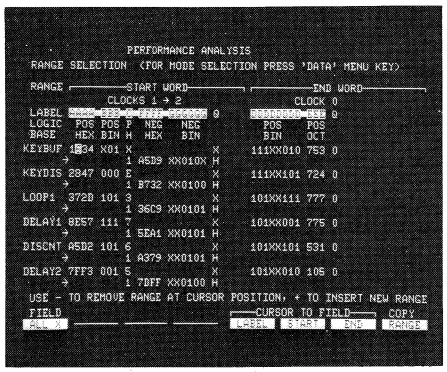


Fig. 17. Performance analysis-range selection menu.

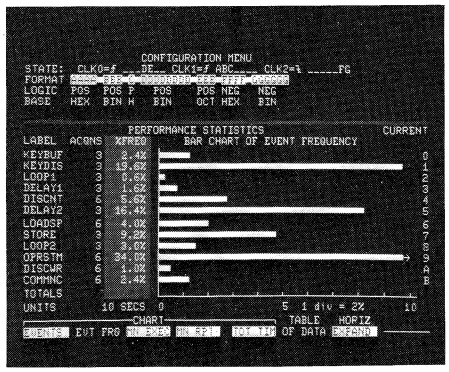


Fig. 18. Histogram of event frequencies.

OPERATION

THE MENUS
Upon menu selection, all parameters are entered by softkey and hex pad.
User prompting and error messages appear on screen. The menus are:

Configuration; the organisation of clocks, channels, threshold and state labels

Triggering; the definition of where data acquisition is to stop. Time labelling.

Compare; the definition of which data is to be compared in the main and reference memories

Selective data acquisition; the definition of which data from the data stream is to be captured

Options;
the selection of a required option

Microprocessor type		**PM 3551A options** Disassembler package	Personality adapter PM 8817/XX
Intel	8080 8085 8031 8051 8086 Min. 8086 Max. 8088 Min. 8088 Max.	PM 8850/10 (Disa N)	PM 8817/28 PM 8817/20 PM 8817/30 PM 8817/30 } PM 8817/27
Intel	8035 8048	PM 8850/50 (Disa X)	PM8817/40
Motorola	6800/02/08 6809 (E)	PM 8855/00 (Disa M1)	PM 8817/10 PM 8817/26
Motorola	68000	PM 8855/10 (Disa M2)	PM 8817/19
Zilog	Z80 Z8001 Z8002	PM 8850/30 (Disa Z)	PM 8817/22 PM 8817/40 PM 8817/23
Rockwell RCA NSG	6502/12 1802/04 800	PM 8850/40 (Disa R)	PM 8817/24 PM 8817/15 PM 8817/12
User defined		PM 8850/60	PM 8817/40

Custom disassembler PM 8850/60 Disa C.
Universal disassembler package with user-definable mnemonics to be used in case above table shows no particular disassembler for your microprocessor. Also for bus mnemonics.
User can specify e.g.:
- PM 3551 A configuration incl. clocks qualifiers.
- Translation table and mnemonics (max. 256 per disassembler)
- Disassembler name (max. 4).

Delivered as one disa board with one empty socket. All user-defined data to be stored in one 2764 which fits in socket.

PERSONALITY ADAPTERS
To give easy connection of the PM 3551A to target system, compatible with PM 8821.
and PM 8825. Two types can be handwired by user.
PM 8817/40:5 pods to 40 pin DIL clip
PM 8817/64:8 pods to 64 pin DIL clip
For many microprocessors prewired adaptors are available.
All pluggable parts of PM 8817/xx can be ordered separately.
PM 8815/40 flat cable and 40 pin DIL clip
PM 8815/64 flat cable and 64 pin DIL clip
PM 8815/00 5 pod noses for PM 8817
PM 8816/xx personality housing for
PM 8817/xx same range as
PM 8817/xx.
In case the 40 pin DIL clip can not be used for lack of space, order PM 8815/50 low profile connector to 40 pin DIL.

THE DATA DISPLAYS
List: the listing of the state captured data
Time: a timing diagram representing the contents of the timing analyzer memories
Graph: an X-Y display plotting the value against the state sequence

THE DATA DISPLAYS WITH COMPARE
List: inequalities between current and reference memories are highlighted
Time: inequalities between current and reference memories are underlined

GENERAL

POWER SUPPLY
110, 127, 220 or 240V AC ±10%, 50/60Hz ±10% (400Hz on request)
Conforms with IEC 348 safety class 1 and ECMA 57

DIMENSIONS and WEIGHT
(wxhxd) 450 x 237 x 570mm
(17.7 x 10 x 22.8-in)
Weight: 17kg (37.4lb) approx.

ENVIRONMENTAL CAPABILITIES
The environmental data are valid only if the instrument is checked in accordance with the official checking procedures. Details on these procedures and failure criteria are supplied on request by the Philips organisation in your country or by PHILIPS SCIENCE AND INDUSTRY, TEST AND MEASURING DEPARTMENT, EINDHOVEN, HOLLAND

Ambient temperatures
+ 5°C...+40°C rated range of use
−10°C...+55°C operating
−40°C...+70°C storage and transport

Altitude
to 5000m operating
to 15000m not operating

Humidity
20%...80% (non condensing) operating
5%...95% not operating

Electromagnetic interference
Conforms with VDE 0871
Level N −12dB

Recovery time
Operates within 30 minutes coming from −10°C soak, going into 60% relative humidity at + 20°C room conditions

NON-VOLATILE MEMORY PM 8850/82
Stores up to four additional user settings, in addition to standard non-volatile memory for 1 setting.

INTERFACES
RS232C – Printer dump
Prints alphanumeric data to any RS232 compatible printer. Prints graphical data to any Epson FX 80 compatible printer.
Format: 1 start, 7 data, 1 parity(E), 1 stop bit
Speed: 110, 150, 300, 600, 1200, 2400, 4800, 9600 bits/s

RS232C – Control interface
Format and speed as Printer interface. Modes:
– load, dump with PM 4202 cassette drive.
– full control with any RS232C Control unit.
Control mode may operate on key level, menu level or full instrument level.
Data transferred may be settings and/or reference memory.

IEEE488/IEC625 Interface
Implements SH1, AH1, T6, L4, SR1, RL1, DC1, DT1.
Control may be on key level, menu level or instrument level. Data transferred may be settings and/or reference memory.
Separator: CRLF and EOI default
CR, LF, ETX, ETB selectable
Transfer speed: 1Kbyte/s

See ordering information for combinations of interfaces (RS232 and IEEE488/IEC625).

Video output
Composite video output (standard, not optional), 50Hz refresh, BNC connector, 1V peak-to-peak over 75Ω.

PERFORMANCE ANALYSIS: PM 8853/00
Divides code in max. 12 ranges, identifiable by start word and stopword via Range selection menu.

Modes:
– Event Frequency for occurence of ranges
– Range Period for average execution time or average repetition time per range
– Complement Period for range period of system activity outside four ranges.

Special features
– Ignore: excludes exeptional events
– Continue: recognises recursive routines.

Display formats
– table
– histogram
Physical appearance: 2 plug-on boards

ORDERING INFORMATION
MAIN INSTRUMENTS
The following types are factory configured:
All are supplied complete with operating manual and probes as detailed.

Number of	state channels	time channels 50MHz	300MHz	pods PM 8821	PM 8822
PM 3551 A/10	35	–	–	5	–
PM 3551 A/30	35	8	–	4	1
PM 3551 A/40	–	16 (8)	0 (4)	–	2
PM 3551 A/50	59	–	–	8	–
PM 3551 A/70	59	8	–	7	1

For upgrading the following are available:		Installable in gives same number of state of time channels as:	
PM 8821:	state pod for separate use of 8 state and 8 time channels.		
PM 8852/31:	8 x 50MHz time channels	PM 3551 A/10 PM 3551 A/50	PM 3551 A/30 PM 3551 A/70
PM 8852/51:	24 state channels	PM 3551 A/10 PM 3551 A/30	PM 3551 A/50 PM 3551 A/70
PM 8852/60:	35 state channels	PM 3551 A/40	PM 3551 A/30+PM 3551 A/80
PM 8852/80:	4 x 300MHz and 8 x 50MHz time channels	PM 3551 A/10 PM 3551 A/30 PM 3551 A/50 PM 3551 A/70	– PM 3551 A/40+PM 3551 A/60 – PM 3551 A/40+PM 3551 A/60 +PM 8852/51

OPTIONS
The following option boards are available:
PM 8851/20: Printer+RS232 interface
PM 8851/40: Printer+IEEE488 interface

The following options are board pluggable and therefore require one of the above option boards: (see note)

PM 8850/10:	disassembler N (intel)
PM 8855/00:	disassembler M1 (motorola)
PM 8855/10:	disassembler M2 (motorola)
PM 8850/30:	disassembler Z (zilog)
PM 8850/40:	disassembler R (others)
PM 8850/50:	disassembler 8048
PM 8850/60:	custom disassembler
PM 8853/00:	performance analysis
PM 8853/82:	non-volatile memory (max. 1 per instrument).

NOTE
Max. 4 disassemblers packages per instrument.
PM 8853/00 performance analysis counts as 2 disassembler packages.

ACCESSORIES AND CONSUMABLES:

PM 8811	Serial data pod for RS232 analysis
PM 8819	Extension kit for PM 8821 or PM 8825 pod
PM 8819/10	54 coloured leads for PM 8821 (25 cm)
PM 8819/20	35 measuring clips
PM 8819/30	50 mini clips
PM 8819/40	54 coloured leads (for PM 8825 at 50MHz, 15 cm)
PM 8819/50	30 coloured leads (for PM 8825 at 300MHz, 6 cm).

For retrofit options, compatibility rules apply. Consult Philips T&M offices for instructions.

For wider parallel or sequential triggering

16/18 channel synchronous or asynchronous operation

Suitable for all logic families

Continuous or latched trigger output

Selectable output logic level and polarity

Logic trigger probe PM 8810

The PM 8810 is used in combination with an oscilloscope (to trigger it on an event in the digital data stream) or with a logic analyzer, in two distinct ways:

1. If connected to the same signals as the analyzer it offers two-word sequential triggering on 16 channels;
2. If connected to other signals, the width of the analyzer's trigger word is extended by 16.

Several PM 8810s can be combined for even more complex trigger conditions.

TECHNICAL SPECIFICATION

TRIGGERING

Trigger word recognition on 16 channels. Trigger word determined by switch selection of '0' for low, '1' for high or 'X' for don't care, on each channel.

Synchronous triggering
Trigger output occurs when trigger word and clock qualifiers are 'true' with respect to active clock edge.
Delay between active clock edge at probe tip and trigger output:
ECL output <43ns
TTl output <54ns
VAR output <64ns

Asynchronous triggering
Trigger output occurs as soon as trigger word and clock qualifiers are 'true'.
Delay between true condition at probe tips and trigger output:
ECL output: <43ns
TTL output: <54ns
VAR output: <64ns

Glitch filter
Asynchronous mode only. Trigger condition must stay 'true' for an additional preset 'filter' time before trigger output occurs.

Filter time
15, 50, 65, 150, 500, 650ns by switch selection.

Continuous or Latched Trigger Output
Latch mode: Once triggered output stays true until manually or externally reset

Continuous mode: Each trigger event produces an output pulse.

Pulse width synchr. trig.
One sample interval

Pulse width asynchr. trig.
Duration of trigger condition minus<15ns.
e.g. 20ns trigger condition duration ensures≥5ns output pulse.
Trigger output state indicated by LED on front panel.

DATA INPUT

16 data channels via two PM 8821 multi-lead probes.

Impedance
4MΩ//6pF

Maximum Input Voltage
−50V...+50V

Threshold
TTL+1.4V fixed, ECL −1.3V fixed, VAR −3 to +12V continuously adjustable

Maximum sensitivity
500 mVp-p signal swing

Set up and hold times:
≤14ns set up ≤12ns hold-time with respect to active clock edge at probe tip

CLOCK AND QUALIFIERS

One clock and two qualifier inputs via PM 8800 probes connected to front panel.

Impedance
681kΩ//40pF

Maximum Input Voltage threshold, set up and hold times
Same as DATA INPUT

Clock
Pos. or neg. edge selectable rate: max. 20 MHz pulse width; min. 25ns

TRIGGER OUTPUT

Output via BNC connector on rear panel.

Output impedance
50Ω

Output level
TTL, ECL, VAR 12Vpp output centred on a variable level. Variable level is continuously adjustable between −3V and +12V via front panel measuring output socket.

Output polarity
Normal or Inverted

DIMENSIONS (w x h x d)
230 x 110 x 210mm
(9 x 4.3 x 8.3-in)

WEIGHT
2.5kg (5.5lb)

POWER
Voltage 115...230V ±15%
Frequency 50...60 Hz
Power consumption 15W

ACCESSORIES SUPPLIED

Operating manual
2 x PM 8821 Multilead probe pods
1 x PM 8800 Probe set (4 probes)
1 x BNC/Probe adapter

OPTIONAL ACCESSORIES

PM 8810 to PM 8810 flat cable
PM 8810 to PM 3540 flat cable

Serial Data Pod
PM 8811

Enables logic state analyzers to monitor RS232C/V24 data lines

Both TX and RX data captured

Adjustable speed and character formats

LED indication of control line status

The PM 8811 Serial Data Pod enables a parallel data sampling logic state analyzer to monitor the serial asynchronously transmitted data present on RS232C/V24 communication lines. By means of its front panel switches the PM 8811 is easily adjusted to cope with all common transmission formats found on RS232C lines. These enable word lengths of 5, 6, 7 or 8 bits with odd, even or no parity bits. 1, 1.5, or 2 stop bits may be selected and the 16 crystal controlled speed settings ensure accurate data capture.

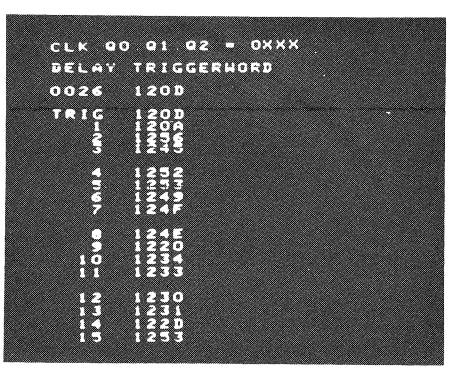
Connection to the RS232C/V24 line is simply made using a special 'T' connector supplied. The high input impedance of this pod avoids any possibility of excess line loading which could result in erroneous measurement.

The PM 8811 monitors both the TX (PIN2) and RX (PIN3) lines simultaneously. This capability permits the action and immediate reaction of a system to be followed and, for example, enables rapid identification of 'echo' faults.

Framing error and parity error faults are also identified by the PM 8811. In addition the two BNC outputs enable a counter to be connected so that simple error rate measurements can be made.

Should multiple consecutive errors be identified by the PM 8811 it is possible that, via some other fault condition, synchronisation with the RS232C/V24 line being monitored has been lost. To overcome this the PM 8811 will automatically re-synchronize itself. It is also possible to manually re-synchronize the PM 8811 by pressing the RESYNC button. The status of the RTS, CTS, DSR, DTR and DCD control lines are indicated by means of five LEDs. This information is also available at one of the output connectors should it need to be monitored in conjunction with the captured serial data.
Serial data triggering and data display is dependent on the logic analyzer with which the PM 8811 is used.

PM 3540 Display



CAPABILITIES with PM 3540

One character triggering
64 captured characters
Captured data display in HEX, BIN or OCT

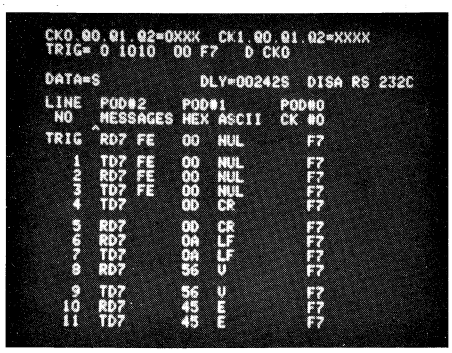
CAPABILITIES with PM 3543

(including DISA option):

Two character triggering
255 captured characters
Code translation 5 bit to Baudot
6 bit to BCDIC/ISO-6
7 bit to ASCII7
8 bit to ISO-8

Table Mode Display

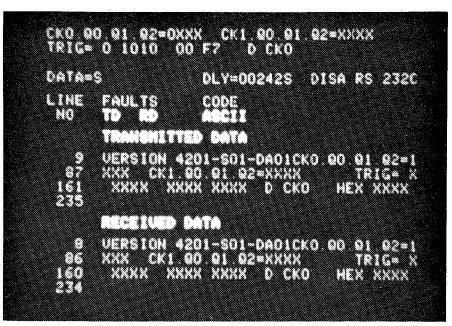
Parallel display of captured information indicating word length, TX or RX data, framing error (FE) or parity error (PE). Captured data value displayed in HEX and translated into a character according to the above list.



The table display mode of the PM 3543 when used with the PM 8811. Only two pods are used leaving the third pod (0) free for capturing related parallel information.

Text Mode display – All captured data translated to its respective character and then written accross the screen. Non-printable and error characters are omitted.
(More detailed information appears in T&M Report no. 58.)

PM 3543 Text Display



The text mode enables all serial information captured by the analyzer to be seen on a single display.

CAPABILITIES with PM 3551A

(Standard instrument)
Seven character triggering with if-then-else branching 1023 captured characters
Captured data displayed in HEC, BIN, OCT or ASCII-7
(More detailed information appears in T&M Report no. 60.)

TECHNICAL SPECIFICATION

Specifications refer to both TX and RX inputs of the PM 8811

Speed
Selectable at 50, 75, 110, 134.5, 150, 300, 600, 1200, 1800, 2000, 2400, 3600, 4800, 7200, 9600 and 19,200 bits/s

Character Length
Selectable 5, 6, 7 or 8 bits

Parity
Selectable odd, even or none

Stop Bits
1 or 2 bits for 6, 7 and 8 bit characters
1 or 1.5 bit for 5-bit characters

Input impedance
$\geq 1M\Omega / <50pF$

Threshold
0V

Sensitivity
± 3V Threshold overdrive

Total BNC Output
Gives TTL output pulse on each character

Error BNC Output
Gives TTL output pulse on error characters

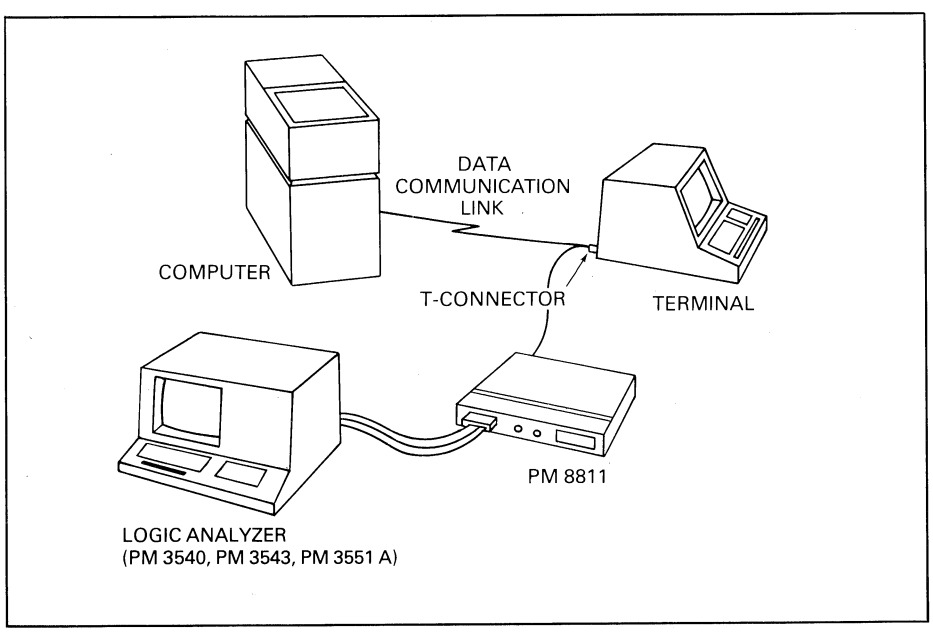
Power Requirements
+12V <10mA
+5V <200mA
−12V <10mA
(supplied from logic analyzer)

Dimensions
(wxhxd) 215 x 45 x 160mm
(8.5 x 1.8 x 6.3-in)

Weight
0.75kg (approx. 1.6lb)

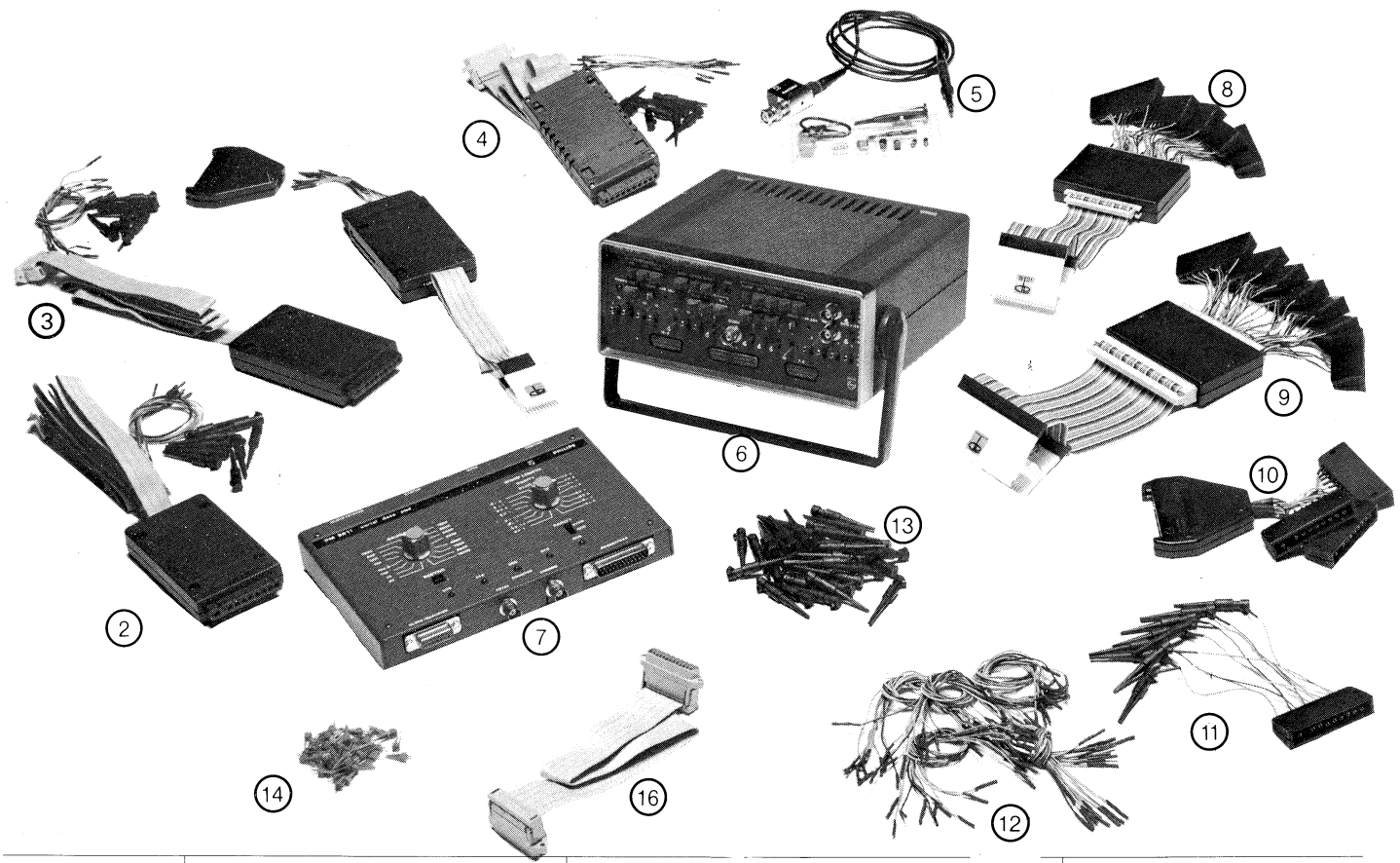
Accessories Supplied
T connector for connection to RS232C/V24 interface
Connection cables PM 8811 to PM 3543
Manual

Accessories on Request
Connection cables PM 8811 to PM 3540



Typical test configuration

Accessories for data test equipment



Type no.	Description	For use with PM 3540	PM 3543	PM 3551	PM 3632[4]	PM 8810	
– PM 8800	Probe kit of 4 miniprobes + accessories	–	–	–	–	1	
2 PM 8820	Multilead probe pod	3	–	–	–	–	supplied as standard with the instruments, or as option
3 PM 8821	Multilead probe pod	–	3	4-8	–	2	
4 PM 8825	Fast timing pod.	–	–	0-2	–	–	
5 PM 8927	Oscilloscope probe	2	3	–	–	–	
6 PM 8810	Logic trigger probe [1]	•	•	•	–	•	supplied as options
7 PM 8811	Serial data pod [1]	•	•	•	–	–	
8 PM 8817/40	Person, adapter for 40 pin DIL[2]	•	•	•	–	•	
9 PM 8817/64	Person, adapter for 64 pin DIL[2]	•	•	•	–	•	
10 PM 8818	Hardware progr.μP adapter	–	•	–	–	–	
11 PM 8819/00	Extension kit [3]	•	•	•	–	•	
12 PM 8819/10	54 coloured leads	•	•	•	–	•	
13 PM 8819/20	35 measuring clips black	•	•	•	•	•	
14 PM 8819/30	50 mini clips red	•	•	•	•	•	
15 PM 8822	8086 disassembly pod	–	•	–	–	–	
16	Flat cable PM 8810 to PM 8810	–	–	–	–	•	supplied on request
—	Flat cable PM 8810 to PM 3540	•	–	–	–	•	
—	Adapter cable PM 8811 to PM 3540	•	–	–	–	–	

[1] Standard cabling not shown.
[2] For many micros pre-wired versions available, type no. PM 8817/xx.
[3] Consists of one connector (to be mated with PM 8820, PM 8821, or PM 8825) + 9 coloured leads + 9 measuring clips.
[4] More accessories will be found in the PM 3632 section.

Philips microcomputer development systems

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Introduction

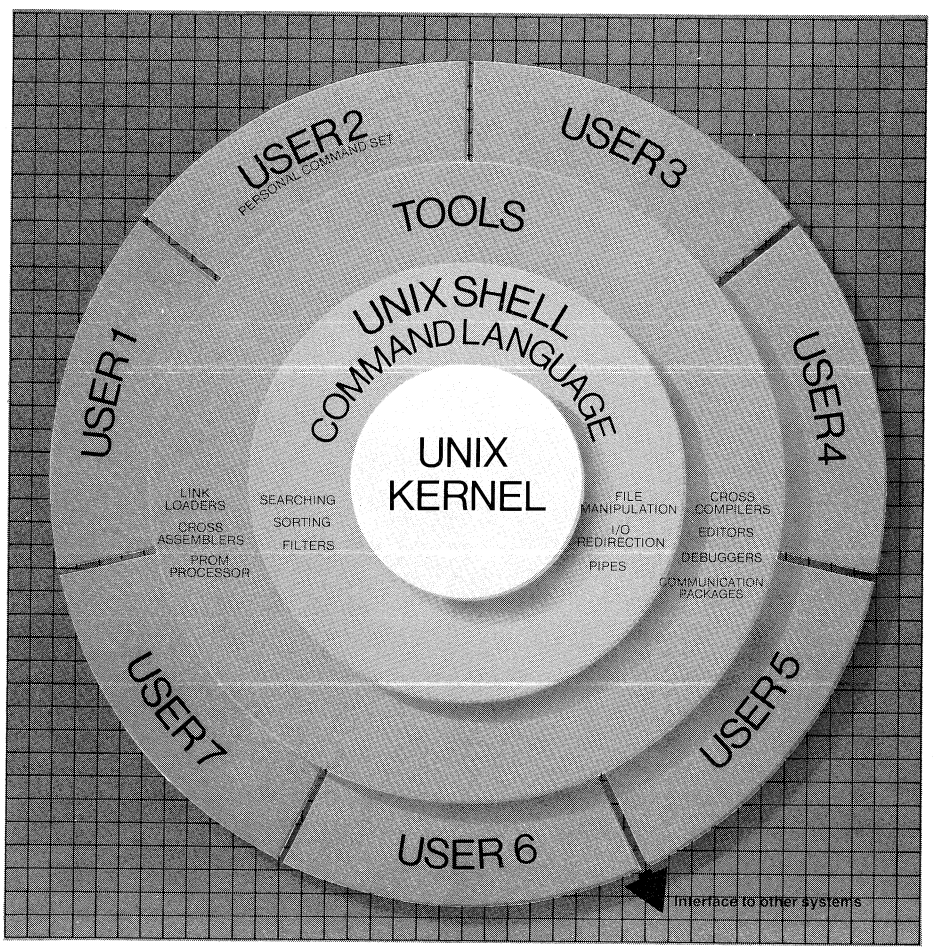
The Philips Microcomputer Development System (PMDS) is a complete development system for microcomputer/microprocessor-based products, providing for both software and hardware development.

The software development environment is a UNIX*-based operating system - widely regarded as the industry standard. UNIX was implemented on PMDS specifically to bring high efficiency to microcomputer development, by speeding up the development process and thus cutting costs. For on-going projects, the optional Source Code Control System PM 8396 M provides a means to handle software maintenance, which can so easily become a major problem.

Hardware debugging and the all-important software/hardware integration phase of the development cycle are efficiently covered by powerful real-time in-circuit emulation of single or multiple microprocessors.

Philips can claim a unique record of progressive advancement in the PMDS product range; for instance, the single-user PMDS I introduced in 1979 can be economically updated to become a multi-user system with all of the features described in the following pages.

PMDS-2 provides a software development environment of the highest quality through the use of a UNIX-based operating system already widely regarded as the standard for the industry. The PMDS implementation of UNIX has been specifically designed to bring a new efficiency to microcomputer development, to cut programming costs and therefore those of both software and hardware development.
The UNIX hierarchical file system encourages logical, modular development of programs. A programmer can produce software tools which are tailored to a particular application, while utility programs allow the 'pipelining' of the output one process to the input of another.
All files are tagged with the date and time of the last modification made. Using the 'make' utility enables the most up-to-date version of a complete program to be produced, while recompiling or reassembling only those modules which have been altered, or those dependent on such changes.
A further major benefit of the system is the 'C' compiler for the host (described on page 22) which makes it possible to produce all kinds of utility programs tailored to the user's own requirements.



UNIX is a trade-mark of Bell Laboratories

The following table lists currently available PMDS support packages. Since this range is being continuously expanded, any items of interest not shown may nevertheless be available. The local Philips T & M Organisation will be pleased to supply up-to-date information.

PMDS support may include

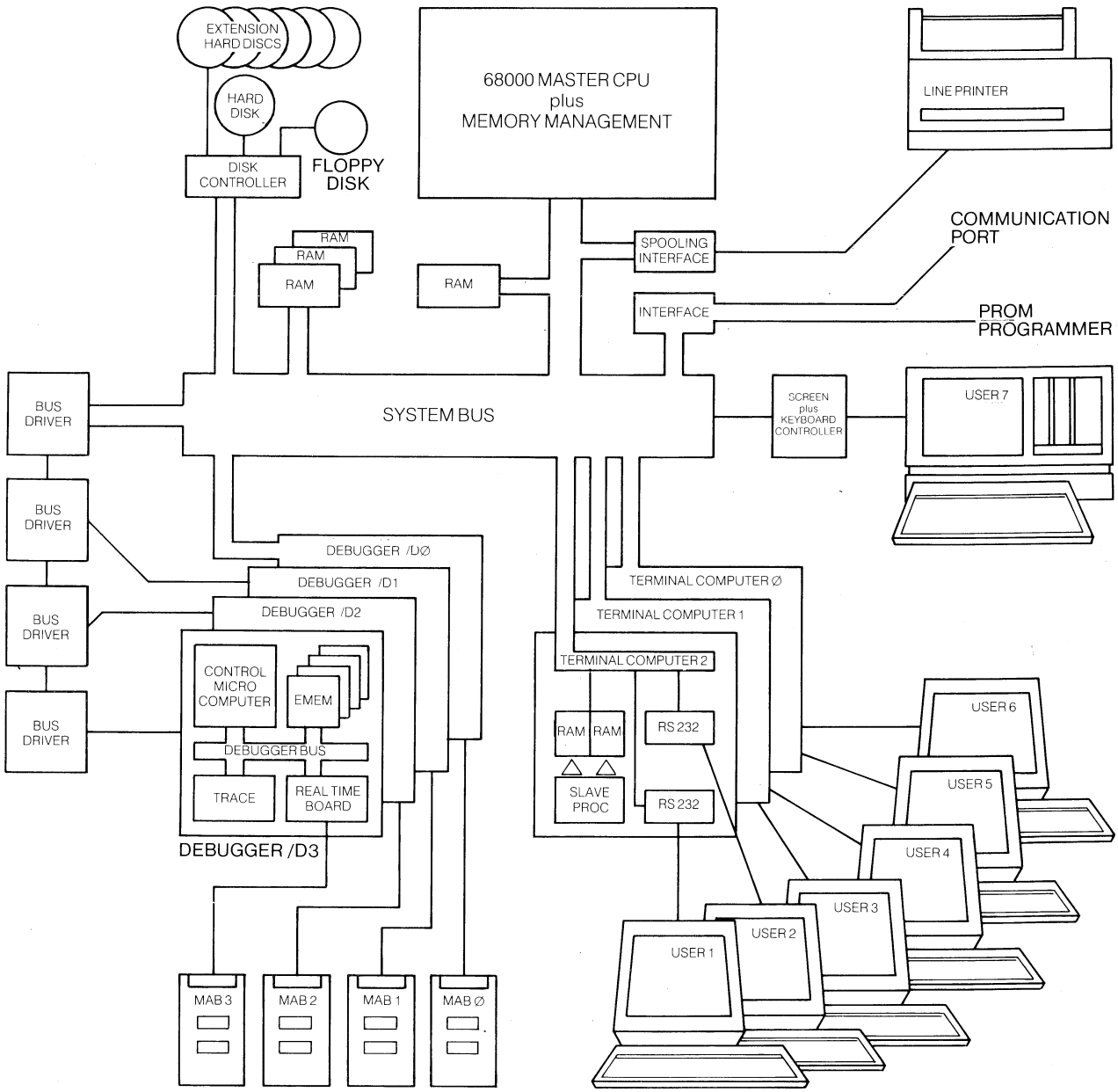
- Cross-assemblers
- High level language compilers
- Debugger software and Microcomputer Adapter Boxes (MAB)

Table of Microprocessor Support for use on PM 4422/PMDS II

μP/μC	Cross-assembler	High Level Language: Pascal	C	Other	Debug S/W	MAB
8080	PM 8460 M	PM 8470 M	–	–	–	–
8085	PM 8460 M	PM 8470 M	–	–	PM 8484 M	PM 8424 M
8021	PM 8461 M	–	–	–	–	–
8022	PM 8461 M	–	–	–	–	–
8035	PM 8461 M	–	–	–	PM 8481 M	PM 8421 M
8039	PM 8461 M	–	–	–	PM 8481 M	PM 8421 M
8040	PM 8461 M	–	–	–	PM 8481 M	PM 8421 M
8041	PM 8461 M	–	–	–	–	–
8048	PM 8461 M	–	–	–	PM 8481 M	PM 8421 M
8049	PM 8461 M	–	–	–	PM 8481 M	PM 8421 M
8050	PM 8461 M	–	–	–	PM 8481 M	PM 8421 M
8051	PM 8362 M	+	+	+	x	x
8086	PM 8467 M	PM 8477 M	PM 8377 M	p	PM 8487 M	PM 8427 M
8087	PM 8467 M	PM 8477 M	PM 8377 M	p	PM 8487 M	b
8088	PM 8467 M	PM 8477 M	PM 8377 M	p	PM 8487 M	PM 8427 M
8089	PM 8363 M	–	–	–	PM 8487 M	b
6800	PM 8466 M	–	–	–	PM 8380 M	PM 8320 M
6801	PM 8466 M	–	–	–	–	–
6802	PM 8466 M	–	–	–	PM 8380 M	PM 8320 M
6803	PM 8466 M	–	–	–	–	–
6805	PM 8366 M	–	–	–	y	y
6808	PM 8466 M	–	–	–	PM 8380 M	PM 8320 M
6809	PM 8466 M	PM 8476 M	–	–	PM 8486 M	PM 8426 M
68000	PM 8469 M	PM 8479 M	PM 8379 M	–	PM 8388 M	PM 8328 M
68010	PM 8469 M	PM 8479 M	PM 8379 M	–	PM 8389 M	PM 8329 M
Z80	PM 8462 M	PM 8470 M	–	–	PM 8482 M	PM 8422 M
NSC 800	PM 8462 M	PM 8470 M	–	–	PM 8382 M	PM 8322 M
8410	PM 8367 M	–	–	–	PM 8387 M	PM 8327 M
8420	PM 8367 M	–	–	–	PM 8387 M	PM 8327 M
8440	PM 8367 M	–	–	–	PM 8387 M	PM 8327 M
2650	PM 8465 M	–	–	–	PM 8485 M	PM 8425 M
6502	PM 8464 M	–	–	–	PM 8484 M	PM 8424 M
6503	PM 8464 M	–	–	–	PM 8484 M	PM 8424 M
6504	PM 8464 M	–	–	–	PM 8484 M	PM 8424 M
6505	PM 8464 M	–	–	–	PM 8484 M	PM 8424 M
6506	PM 8464 M	–	–	–	PM 8484 M	PM 8424 M
6507	PM 8464 M	–	–	–	PM 8484 M	PM 8424 M
6512	PM 8464 M	–	–	–	PM 8484 M	PM 8424 M
6513	PM 8464 M	–	–	–	PM 8484 M	PM 8424 M
6514	PM 8464 M	–	–	–	PM 8484 M	PM 8424 M
6500/1	PM 8464 M	–	–	–	PM 8484 M	PM 8424 M +PM 8444
TMS 1000	PM 8468 M	–	–	–	–	d –
TMS 1100	PM 8468 M	–	–	–	–	d –
TMS 1200	PM 8468 M	–	–	–	–	d –
TMS 1300	PM 8468 M	–	–	–	–	d –
NEC 7500A	PM 8364 M	–	–	–	–	– –
NEC 7500B	PM 8364 M	–	–	–	–	– –
NEC 7501	PM 8364 M	–	–	–	–	– –
NEC 7502	PM 8364 M	–	–	–	–	– –
NEC 7503	PM 8364 M	–	–	–	–	– –
NEC 7506	PM 8364 M	–	–	–	–	– –
NEC 7507	PM 8364 M	–	–	–	–	– –
NEC 7507S	PM 8364 M	–	–	–	–	– –
NEC 7508	PM 8364 M	–	–	–	–	– –
NEC 7518	PM 8364 M	–	–	–	–	– –
NEC 7519	PM 8364 M	–	–	–	–	– –
NEC 7520	PM 8364 M	–	–	–	–	– –

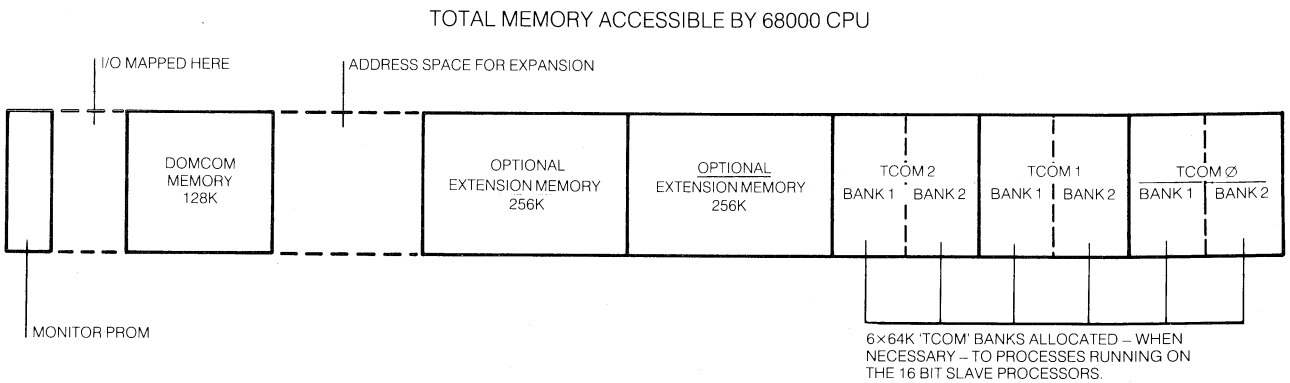
Key:

– not available
x PM 8235 M emulator and PM 8385 debug software
\+ one or more high level languages available 1984
p PL/M86 available from specialist S/W supplier
d cross-assembler includes down-loader to dedicated debug system
b debugger shows bus activity relative to 8087 and 8089.
y emulation/debug possible with additional equipment



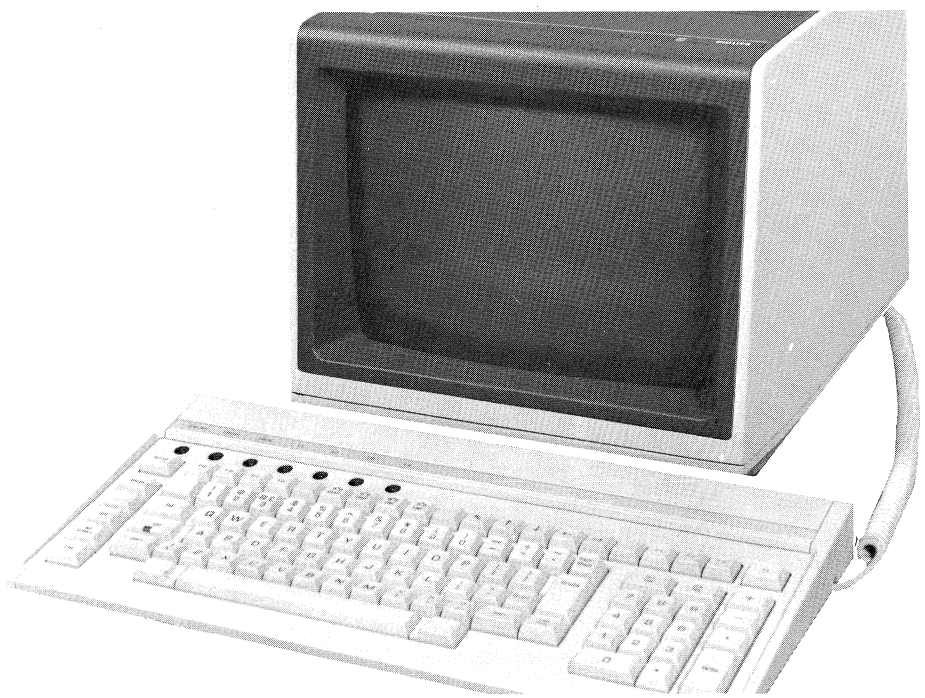
Hardware architecture

A typical memory map



UP to 7 users
UNIX*-based operating system
Multi-tasking
256kbyte to 1.57Mbyte RAM
5.6 to 156Mbyte mass storage
Up to 4 emulation units
Field-expandable
Support for wide range op MPU's/MCU's

Multi-user development system PM 4422



Configuration of system

The PM 4422 multi-user development system consists of a PM 4402 master system plus, optionally:

- mounted within the master system
  - Additional terminal computer cards
  - Additional system memory cards
  - Interface cards
  - Universal debug unit cards
  - Bus extender card
- connected externally:
  - Terminals
  - Printers
  - Microcomputer adaptor box
  - Eprom programmers
  - Extension debug units
  - Extension disk units
  - Streamer tape back-up unit

PMDS II Hardware architecture

PMDS II is a distributed processor system, there always being a 68000 master CPU running UNIX and at least one SP16C/10 slave CPU on a 'Tcom' card. As the system is expanded to accommodate more users, additional 'Tcom' cards are added, up to a maximum of three. In addition to the slave processor, each 'Tcom' card carries 128Kbytes of memory and two RS232 ports.

Memory can be used directly by the 68000, if it is not allocated to a slave processor at any time. Some processes run on the 68000 itself, while others it allocates to the first available SP16C/10 slave.

Both master and slave processors can operate in multi-tasking mode, the disk controller handling the built-in Winchester hard disk and minifloppy disks, plus up to six external Winchesters. The main system will house one universal debug unit, with further units, up to a maximum of four, able to be used externally. Each debug unit includes a control microcomputer board, a real time board looking after memory and I/O mapping and its own emulation memory. A real-time trace facility is optional.

PMDS II has a line printer interface as standard and other RS232 interface cards can be installed if required. In addition, there is a parallel interface allowing connection of the optional fast tape back-up unit.

The PM 4402 master system includes:
An integral VDU, 12 inch diagonal screen, 24 lines each 80 characters, a video output is provided for connection to an external monitor.
A free-standing keyboard, standard QWERTY layout plus numeric pad, also control keys and 8 user-definable function keys.
One mini floppy disk drive, formatted capacity 322 kbytes, average access time 185ms.
One hard disk unit:
Formatted capacity 5.59 Mbyte
(PM 4402/00) 22.3 Mbyte
or (PM 4402/20).
Latency 8.3ms, head setting time 15ms, t.t.t. step time 3ms.
Interface for printer, RS 232 subset, 9600 baud.
Interface for PM 4496 streamer tape unit.
Two RS 232 interfaces for terminals or peripherals.
One terminal computer card 'TCOM' (see PM 4477 M details below).
A domestic computer 'DOMCOM' with 68000 CPU, clock 8 MHz, with memory management unit controlling RAM of 256 kbytes (PM 4402/00) or 512 kbytes (PM 4402/20).
A converted PMDS I has 192 kbytes (PM 4401/20).
A real-time/date clock with battery back-up.

Allocation of resources

The DOMCOM (68000) can access all system RAM (but not emulation memory). UNIX runs on the DOMCOM and processes called by UNIX can run on the 68000 or can be allocated to the first available TCOM where they run on one of

The Card Cage has 21 slots allocated as follows:

Slot No.	Standard		Option
1 2 3 4	no	for emulation memory card(s) see debugger data	yes
5 6	no	for universal debug PM 8400 (cmc card) see debugger datasheet (realtime card)	yes
7	no	for trace card PM 8410 see debugger	yes
8	no	for TCOM PM 4477 M or memory PM 8418	yes
9	no	for Bus ext. PM 4475 or memory PM 8418	yes
10	no	for TWINSEC PM 4472 M †	yes
11 12	yes yes	DOMCOM (memory card 128 kbytes) (cpu card)	— —
13	yes	Disk controller card	—
14	no	Memory PM 8418	yes
15	yes	TCOM PM 4477 M	—
16	no	for TCOM PM 4477 M or memory PM 8418	yes
17	§	for memory PM 8418	§
18	yes	ITC card	—
19	yes	Mains input unit	—
20	yes	Power supply unit (for main system)	—
21	no	Power supply unit (PM 8400 debugger)	yes

† A PM 4473 TSEC may also be fitted in slot 10.
§ A PM 4402/20 is fitted with one PM 8418 as standard.

the SP16C/10 cpu's, depending on the process type. The RS 232 interfaces on the TCOM card(s) are not connected with the SP16C/10, they connect directly to the system bus. As the system is expanded with additional TCOM cards, both cpu and memory resources are increased to cope with the possible additional demands of extra users.

Specification of options
PM 4472 M double serial interface TWINSEC
This card provides two RS 232 interfaces with characteristics identical to those of the PM 4477 M TCOM card, see below.
PM 4475 bus extender card IOTZ.
This card provides an interface to the first extension debug unit.
(See p. 101 for information on PM 8400 universal debugger.)
PM 4477 M terminal computer card TCOM
CPU: 16 bit type SP16C/10.
RAM: 128 kbytes (also accessible to DOMCOM).
Two RS 232 ports for terminals/peripherals/communication; software-settable for: speed 110-9600 baud, parity and other characteristics.
Note that one TCOM card is included in the master system as standard.
PM 8400 universal debug unit
PM 8405 extension debug unit
PM 8410 trace card
PM 8411...PM 8419 emulation memory cards
(PM 8400 universal debugger is described on p. 101)
PM 8418 256 kbyte RAM card
This card type may be used to provide additional system memory, as well as being one of the emulation memory options. One PM 8418 is included in the PM 4402/20 master system as standard.

Peripherals
PM 4492/10 high speed printer (see p. 117)
PM 4499/20 User terminal with 12-in diagonal green phosphor screen, 80cm x 24 lines. QUERTY keyboard plus numerical keypad and 8 function keys.
Any terminal connected to PMDS can control any debugger on the system.
PM 4494 M External cabinet containing 22 Mbytes Winchester disk.
PM 4495 M External cabinet containing 2 x 22 Mbytes on Winchester disks.
PM 4496 M streamer tape backup
Uses digital tape cartridges; capacity 20 Mbytes. Streaming time for 5 Mbytes; approx. 2 minutes and for 20 Mbytes; 7...8 minutes.
PM 4497 eprom programmer (see p. 118)
PM 4499 M/20 terminal

Software
UNIX-based operating system provides:
multi-tasking for each user
hierarchical file system
password protection
nine levels of file access permission: read/write/execute for file-owner, members of his group, and others.
spooling of printer output
input/output redirection
'make' utility
Other 'universal' software (supplied as standard):
Linker, producing microprocessor load-files from object code files.
Prom processor, Text editor (ed)

Cross-assemblers, cross-compilers, debug software (option):
(See support data for the relevant micro-processors/microcomputers, p. 103)
Utility software (option):
PM 8394 M screen editor
PM 8396 M Source control code system (SCCS)
PM 8399 M general purpose communication package.
Details of other utility packages are available on request.

GENERAL SPECIFICATION

Card format
Double Eurocard. Bus: GPB 'S'/UPL

Power supply
111...127 or 200...240V 48/62 Hz

Power consumption
450W max at nominal line voltage

Safety
Conforms to IEC348 safety class 1

High voltage test
In accordance with IEC435.

Dimensions and weight
(w x h x d) 588 x 305 x 540 mm
35 kg incl. keyboard

Environmental characteristics
The following environmental data is valid only if the instrument is tested in accordance with the specified test procedures. Details of these procedures and failure criteria can be supplied on request to the appropriate Philips organisation in your country

Ambient temperature

Storage:	−40...+70°C
Rated range of use:	+10...+35°C
Humidity:	5...95% RH (storage) 20...8% RH (operating) (no condensation)
Altitude:	to 2000m operating to 15000m non-operating

Electromagnetic interference
Conforms to VDE0871, level B − 12dB

Compact, ergonomic design

Free standing, low profile keyboard

Adjustable display

Two screen colors: green (PM 4499/20M) and white (PM 4499/40M)

Hall effect keys

8 function keys

Numeric keypad with touch mark

N-key rollover

Auto repeat function, margin bell and audible keyclick (optional)

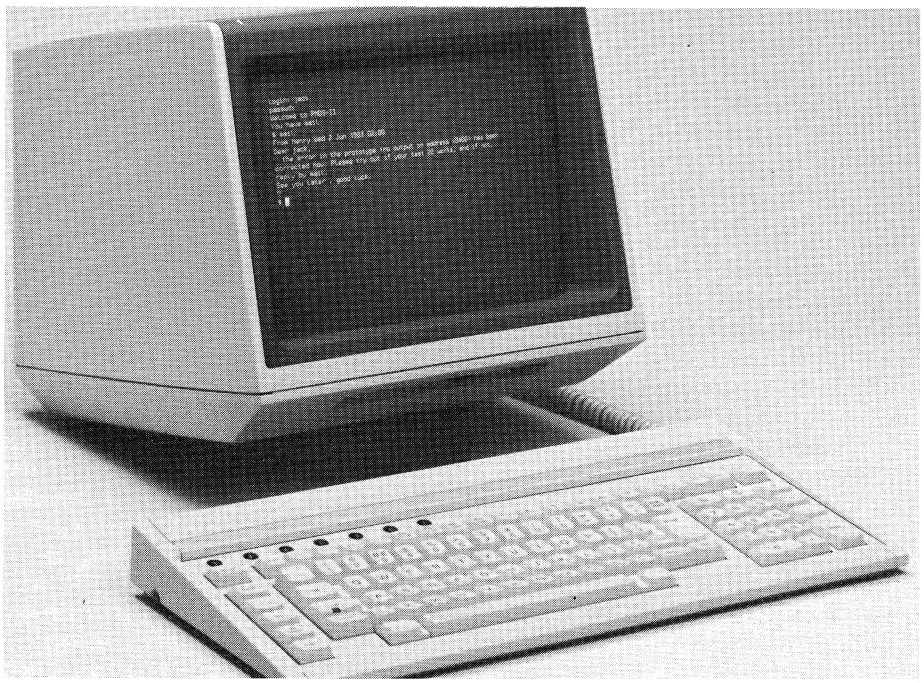
10 meter cable included

Development workstation PM 4499M

The PM 4499M workstation is specially designed for use with the PM 4402 Micro computer Development System. It doubles as a software development terminal and as hardware debug station. All functions of the main workstation are equally available with the PM 4499M workstation, avoiding possible loss of valuable time to adjust software functions or to learn the specifics of other terminals.

The 8 function keys act as tiggers to specify 8 free settable strings, each of which can consist of simple words (e.g. a file name) to a several-line command. These strings are unique for each user, or even for each task executed by a user. The cursor movement keys are valid for the screen-oriented editor, for all debug-processors and other mds-related programs. They allow information on the screen to be re-used or corrected without unnecessary re-entering of text. The debug-processors, for example, often make use of this feature by displaying the state of the microprocessor in such a way that, after editing, the output can be used as input again. Important information can be highlighted by inverse-video fields. Other character-attributes are blinking, low intensity or underlined.

To minimise operator fatigue, the keyboard has been designed on the newest ergonomic principles. Keys are sculptured, require only a little pressure and have a very short travel. N-key rollover allows for fast entry of keys, as the next key can be pressed before the previous one is released. Keytops are manufactured in such a way that wear of the text is prevented. If desired, an audible keyclick accompanies each accepted key.



A 10 meter connection cable is included. A longer distance between main unit and workstation is possible using low-capacitance cable. With reduced baud rate maximum distance is in the order of 0.5-1 km, depending on electrical noise level. Connection using modems gives an unlimited range.

TECHNICAL SPECIFICATION

Screen size
12 inch diagonal
24 lines of 80 characters

Visual attributes
Reverse video, underline, low intensity, blinking, double height and width

General Features
Tab setting per column, split screen, self test, auto wrap around (switchable), cursor positioning, line- and screen erase, UK- and ASCII character set, graphic character set, supports X-ON/X-OFF protocol

Phosphor
P31 (green, order PM 4499/20M) or P4 (white, order PM 4499/40M)

Transmission mode and speed
50...19200 baud, asynchronous, character or block, 7... or 8 bit, parity off, even, odd

Dimensions and weight
28 x 32 x 37 cm (hxbxd) for display unit
4 x 45 x 22 cm for keyboard
1.5m cable (coiled) display unit-keyboard
10m cable display unit-main system weight 14kg

Power
200...240V +/− 10%
100...127V +/− 10%
65W

Temperature Range
+5 ... +40°C operating
−40 ... +65°C storage

Relative Humidity
10...90% non condensing operating
5...90% storage

Microcomputer/ Microprocessor Emulation with PMDS

PM 8400 Universal Debug Unit
PM 8405 Extension Debug Module
PM 8410 Trace Card
PM 8411-8419 Emulation Memory
PM 8440 No-break MAB Switch
PM 8820 Multilead Probe Pod
PM 4475 Bus Extender Card

Emulation is the operation of the prototype cpu under PMDS control. The cpu is removed from the prototype, and replaced by an emulation probe connected to the Microcomputer Adaptor Box (MAB). The MAB containes an equivalent cpu (in some cases a special version is used).
Simulation: If no prototype is available, the emulation probe may be plugged into a simulation socket on the MAB, allowing software testing. These actions are achieved by using the PM 8400 Universal Debug Unit together with an MAB which is specific to the target cpu-or to the cpu family, and with the debug software, which is supplied with the MAB. When the optional PM 8410 Trace/Counter Card is present, additional functions are also provided.
Certain features of the debugger specification are target-dependent, and details are described in the relevant support information.

PM 8400 Universal Debug Unit

The debug unit controls the operation of the target cpu; the following facilities are provided:

- Memory Map: The address space is partitioned into segments (typically 256 bytes for 8-bit cpu's and 4 kbytes for 16-bit cpu's). Each segment can be defined as being guarded, in emulation memory, or in the prototype, and separately defined as ROM or RAM.

Emulation memory is not limited to use at its physical address, but each segment may be freely mapped to a logical address. Emulation or prototype memory can be examined, and except for prototype ROM its contents may be changed at will.

- I/O map: For target cpu's having a separate I/O space, input and output are each divided into 256 parts (e.g. individual ports for cpu's such as the Z80); these can be defined as being guarded, in the prototype, or allocated to resources such as keyboard, screen, printer, disk file, or queues in host memory. I/O ports may be read, or written to, by specific commands, as well as by running a user program.
- Clock source can be defined as being in the prototype, provided from the MAB at a choice of frequencies, or external. For some target cpu's, a crystal may be connected at the MAB.
- Trigger settings: The two trigger registers can each be set to break emulation, to produce an external pulse, for one to arm the other, or off.
- Trigger conditions: Each trigger register has a 256 times match counter and is 48 bits wide. Each bit can be specified as 1, 0 or X (don't care). Address and data may be set in hex or binary, and may also be given symbolically, provided PMDS debug files are present. Control may be specified in binary or in mnemonics such as MR, MW, OPC, etc.
- Break conditions: emulation break will occur on Trigger Match, access to Guarded Memory or I/0, or on Event Counter count-down if set in this mode. Other break conditions such as Power-fail, Reset, Not Ready, are target-dependent, and most of these may be selectively turned off.
- Registers: The cpu registers may be examined and changed at will.
- Run: The cpu may be instructed to run from any specific address.
- Step: The cpu registers and flags are displayed at every step. Dependent on the target cpu, various options are available for stepping on jumps, calls, qualified steps, or external events, with the cpu running in real time between steps.
- Emulation speed: depends on the target cpu. For instance, the 8085A-2 can run at up to 5 MHz clock (10 MHz crystal) without addition of wait states even when mapped to emulation memory. For other target cpu's, see details on relevant support data pages.
- Resource transparency: The PM 8400 does not use any of the target cpu's address space or I/0 space, and all interrupt facilities of the target cpu are available for the system under test.
- The PM 8400 consists of two cards which may be mounted either in the Master System or in a PM 8405 Extension Debug Unit. The MAB is connected to the Universal Debug Unit by a pair of ribbon cables, 2m long.

PM 8405 Extension Debug Module

Up to four Universal Debug Units may be operated simultaneously. All debug parameters described above may be set independently for each Debug Unit. Two or more Debug Units may be controlled from a PMDS I or from a single workstation of a PMDS II, or they may be controlled separately from different workstations. When two or more different target cpu's are to be controlled from a single workstation, the appropriate multi-debug software must be loaded (available combinations on request).
Multi-debug facilities: Two additional features are provided for optional use in the multi-debug mode of operation:

- Master/Slave: One target cpu may be defined as a 'Master' and one or more as 'Slaves'. Linking the Debug Units (by BNC cables) allows the slaves to run synchronously with the master.
- Force Trace: A second link between the Debug Units will force a synchronised trace entry for each slave, even if the slave's own Trace Condition is not true.

Specifications of PM 8405/20 Extension Debug Module:

The PM 8405/20 must be fitted with a PM 8400 Universal Debug Unit, plus optionally a PM 8410 Trace Card and upt to four PM 8411-8419 Emulation Memory Cards. A prerequisite for the connection of the first PM 8405 is the presence of a PM 4475 Bus Extender Card in the Master System.
Connection of the first Extension Debug to the Master System is by a pair of ribbon cables. Additional Extension debug Modules connect from the first in

'daisy chain' fashion. A pair of 2m long cables is supplied with each Extension debug Module. Longer cables (not supplied) may be used, up to a maximum total cumulative length of 15m from the Master System to the most distant Extension Debug Module.
Power supply: 100-127 or 200-240V 48/62 Hz 120W max.
Safety: conforms to IEC348 safety class I
High Voltage Test: in accordance with IEC435.
Dimensions (HxWxD) 230 x 450 x 490mm, 14.5 kg
Environmental characteristics: The following environmental data is valid only if the instrument is tested in accordance with the specified test procedures. Details of these procedures and failure criteria can be supplied on request to the appropriate Philips organisation in your country.
Ambient temperature: storage −40 +70°C, rated range of use +10 +35°C.
Humidity: 5-95% RH storage, 20-80% RH operating (no condensation)
Altitude: to 2000m operating, to 15000m not operating
Electromagnetic interference: conforms to VDE0871, level B −12dB

PM 8410 Trace Card
This card provides a 'history' of events relating to an emulation break.
The Trace Memory is 255 words deep x48 bits wide. Allocation of the 48 bits depends on the target cpu, typically:
- For 8 bit cpu's: 16 bits address, 8 bits data, 8 bits control, 16 bits user-definable from two PM 8820 probe pods.
- For 16 bit cpu's: 16 to 24 bits address, 16 bits data, 8 bits control, 8 bits user definable either from a PM 8820 probe pod or as high-order address bits.

The 48 bits are displayed as: Hex address and data, binary control. In addition, the operation is displayed in the target cpu's assembler mnemonics plus a standard descriptive mnemonic such as OPC (opcode fetch) MR or MW (memory read/write) or INA (interrupt acknowledge).
Trace clock: Machine Cycle, Instruction Cycle, Opcode Fetch, transition of PM 8820 probe pod signal.
Trace event: All, Qualifier Register (QR0, QR1, QR0 or QR1), External.
Trace history relative to breakpoint: PRE (default) or in the case of a Debugger-controlled break, trace history may be centred on the breakpoint or POST.
Trace qualifiers: Two 48-bit wide Qualifier Registers. Address may be set symbolically or in hex or binary, 'don't care' bits allowed. Trace entry may be qualified to occur only when one, or either, of the Qualifiers is true.
Alternatively the Qualifier Registers may be used to qualify the STEP mode of operation of the PM 8400 Universal Debug Unit.
Event counter: The PM 8410 Trace Card includes a 24 bit Event Counter capable of counting: microseconds, clock cycles, machine cycles, instruction cycles, interrupt acknowledge, pulses from either trigger register, or external high/low transitions at an input of a PM 8820 probe pod. The count window can be from emulation start to break, between trigger matches, or the counter can count down from a preset number and cause an emulation break on reaching zero.

PM 8411-8419 Emulation Memory Cards
Each Universal Debug Unit, whether in the Master System or in an Extension Debug Module, has four slots available for Emulation Memory cards.
The two basic types of emulation memory are:
- Fast static: access time 130ns including mapping time
- Dynamic: access time 450ns

Use of the Fast memory will provide Real Time Emulation, without wait states, up to the values given in the support' data for each target cpu. With Dynamic memory, wait states may be inserted both on account of the memory access time and to allow refresh.
For certain target cpu's, only the Fast Emulation Memory is usable, as specified in the relevant 'support' data.
The two types of emulation memory may be mixed, subject to certain restrictions. These restrictions do not affect the possibilities of mapping to different logical addresses for the target cpu.
The following Emulation Memory Cards are available:

PM 8411	32 kbytes	Dynamic
PM 8412	64 kbytes	Dynamic
PM 8413	8 kbytes	Fast
PM 8414	16 kbytes	Fast
PM 8415	8 kbytes	Dynamic
PM 8416	16 kbytes	Dynamic
PM 8418	256 kbytes	Dynamic
PM 8419	64 kbytes	Fast

PM 8440 No-break MAB Switch
The PM 8440 is a switch which may be connected at the Microcomputer Adaptor Box (MAB) and allows the MAB to be disconnected while the system is still powered, thus permitting a user to exchange the MAB for one of a different type without disturbing other users.

PM 8820 Multilead Probe Pod
One or two pods may be usable, depending on the target cpu and system configuration. Each pod provides 8 connections to user defined points.
Input impedance: 4MΩ/6pF Max. Input ±50V
Threshold: default 1.5V, software settable per pod −3V..+11V in 0.1V steps
Sensitivity: max 250mV threshold overdrive

PM 4475 Bus Extender Card
This card must be included in the Master System if one or more Extension Debug Modules are fitted. Only one PM 4475 is required, irrespective of how many Extension Debug Modules are connected.

PMDS TRAINING COURSES
Training courses for users and potential users of PMDS are available in most European countries in addition to those held in Eindhoven, Holland. Details may be obtained from local Philips organisations or from Philips Test and Measuring Dept., Eindhoven. (See address list at the back of this catalog.)

Specific microprocessor support facilities for Philips microcomputer development systems

Introduction
The Philips microcomputer development systems can be supplemented by a number of hardware and software options to provide realtime emulation capabilities for a range of different microprocessors.
The currently available range of support packages is being continuously developed and updated. Information on additional support facilities will be issued from time-to-time.Up-to-date information can be obtained on application to the local Philips Test and Measuring Organisation. A table of available support packages appears on p. 3.
A support package consists, generally, of three or more parts:
- Cross assembler
- Microcomputer adapter box (MAB)
- Debugger
- High level language compilers

Cross-assembler
The cross-assembler translates assembly language input into object code and debug files.
A range of cross-assemblers is provided for the various microprocessors available and in common use today.
Some of the many advanced features common to all PMDS cross-assemblers are:
- Modular support to allow structured programming
- MACRO facilities
- Conditional code generation
- Memory type specification
- Paging support
- Cross reference listing
- Extensive set of error messages

The standard instruction mnemonics of the supplier of the microprocessor/computer are used when creating source programs.

Microcomputer adapter box (MAB)
The MAB is the hardware unit acting as an interface between the PMDS and the user's prototype. It is connected to the PMDS via two flat cables and to the user's prototype via a flexible cable (approximately 48cm) and the emulation probe which is inserted in place of the microprocessor on the prototype.

The MAB provides:
- a zero insertion force socket for the target microprocessor. Generally, the highest speed microprocessor is inserted to guarantee realtime emulation.
- a zero insertion force socket (simulation socket) to provide fixed input levels to the emulation probe when no prototype is available.
- two trigger outputs for an oscilloscope via BNC connectors
- BNC clock input for an external pulse generator
- a socket for a PM 8820 test pod (only in the case of 8-bit microprocessors/computers)

In order to reach the top emulation speeds without insertion of WAIT STATES when addressing memory located in the PMDS, the fast static memory boards (PM 8413, PM 8414 or PM 8419) should be used.

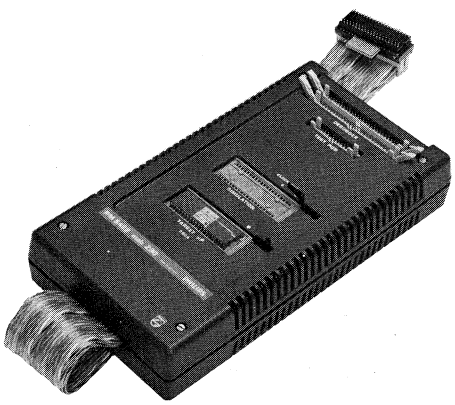
Debugger
The debugger is a software package which controls all the debug hardware contained in the PMDS and the MAB. Most of the debugger commands are universal. However some provide information dependent on a given microprocessor architecture.
The microprocessor-dependent conditions will be stated hereafter for all specific debuggers.

Systems software and high level languages
See p. 23 for descriptions of the UNIX-based operating system, PASCAL and C compiler.

```
PMDS CROSS ASSEMBLER 8085       REL: 3.1

LOC    OBJECT   M  STAT E LINE SOURCE LINE

                              89 *
00005C F1              67     90 GETON  POP     PSW          RESTORE LOOP
00005D 3D              68     91        DCR     A            COUNT DOWN
00005E C23300    R     69     92        JNZ     LOOPD        LOOP BACK
                              93 *
000061 210000    E     70     94        LXI     H,RTEST
000064 5E              71     95        MOV     E,M
000065 23              72     96        INX     H
000066 56              73     97        MOV     D,M          GET LAST
000067 EB              74     98        XCHG
000068 09              75     99        DAD     B            ADD CURRENT
000069 7C              76    100        MOV     A,H
00006A 1F              77    101        RAR
00006B 57              78    102        MOV     D,A
00006C 7D              79    103        MOV     A,L
00006D 1F              80    104        RAR
00006E 5F              81    105        MOV     E,A          GET MEAN
00006F 210000    E     82    106        LXI     H,ITCT
000072 35              83    107        DCR     M
000073 C21D00    R     84    108        JNZ     ITER         NEXT
                              109 *
000076 E1              85    110        POP     H            CLEAN
000077 F1              86    111        POP     PSW          RECOVER
000078 42              87    112        MOV     B,D
000079 4B              88    113        MOV     C,E
00007A 5F              89    114        MOV     E,A
00007B CD0000    E     90    115        CALL    NORM8
00007E 3A0100    E     91    116        LDA     (ITCT+1)
000081 1F              92    117        RAR                  INSPECT
000082 DA8E00    R     93    118        JC      ENDRT
000085 63              94    119        MOV     H,E          EXPONENT OF
000086 110585          95    120        LXI     D,H'8505'    NORMALISED
000089 2E81            96    121        MVI     L,129        EXPONENT
00008B CD0000    E     97    122        CALL    MULT16
00008E C9              98    123 ENDRT  RET
00008F                       124        END

  NO ERRORS DETECTED
```

PMDS support for 8080, 8085

Intel 8080, 8085 Support PM 8420, PM 8460, PM 8470 and PM 8480



The complete support system for the Intel 8080, 8085 microprocessors consists of:

- **PM 8460** Cross-assembler 8080, 8085
- **PM 8420** Microcomputer adapter box (MAB) 8085
- **PM 8480** Debugger 8085
- **PM 8470** PASCAL for 8080, 8085, Z80

PM 8460 Cross-Assembler for the 8080 and 8085

The PM 8460 cross-assembler can handle either the Intel 8080 or 8085. Standard Intel instruction mnemonics are used when creating source programs. Therefore the symbols A, B, C, D, E, H, L, M, SP, PSW cannot be used as labels for the 8080 and 8085.

PM 8420 Microcomputer adapter box (MAB) for the 8085

As target microprocessor a 8085A-2 is inserted in the MAB.

PM 8480 Debugger for the 8085

The microprocessor specific conditions are described here.

Internal registers

When executing a program in the STEP mode or when a breakpoint is encountered, the contents of the internal registers are displayed on the PMDS screen as in Table A:

Table of emulation support 8085

µP Emulated	Emulation speed
8085A	6.25 MHz
8085A-2	10 MHz

Both 40-pin packages with addressable memory of 64 Kbytes (K = 1024)

Clock

If the user chooses to use the clock generator provided by the PMDS, the available frequencies are: 0.521 MHz, 1.612 MHz, 3.125 MHz, 4.687 MHz. The default value is 3.125 MHz. The crystal frequency is twice the clock frequency.

Break Conditions

If enabled by the user the different Break conditions are:

RESET: Hardware RESET from the user's prototype

NOT READY: RDY line held more than 8ms

POWER FAIL: If VCC goes outside 5VDC ±10%

CLOCK FAIL: If clock too slow (below 0.5 MHz)

DMA: Direct Memory Access

HALT: Halt instruction

PMDS debug display after stepping or breaking emulation — **Table A**

```
DO    DISASSEMBLY              REGISTERS                              FFFFF  SIIIIMMM
ADDR  DATA   OPC   OPERAND     PC   SP    A  B  C  D  E  H  L  SZAPC  I765E765
00FE  AA     XRA   D           00FF FF58  00 21 AD 78 00 12 68 01010  00000111
```

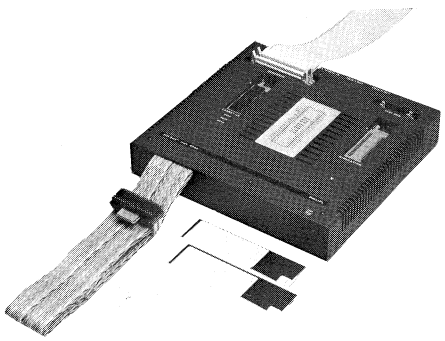
Where

PC	Program counter
SP	Stack pointer
A	Accumulator
B, C, D, E, H, L	Registers
FS	Sign flag
FZ	Zero flag
FA	Auxilliary carry flag
FP	Parity flag
FC	Carry flag
SI	Serial input
I7, I6, I5	Pending interrupts 7.5, 6.5 and 5.5
IE	Interrupt Enable
M7, M6, M5	Mask RST 7.5, RST 6.5, RST 5.5
SO	Serial Output Data
R7	Reset Interrupt 7.5 flip flop

Any of the above registers or flag bits except SI, I7, I6 and I5 can be individually examined and changed.

PMDS support for 8048 family

Intel 8048, 8049, 8035, 8039, 8748, 8749, 8021, 8022, 8041 and National Semiconductor 8040, 8050 Support, PM 8461, PM 8421 and PM 8481



The complete support system for the Intel 8048, 8049, 8035, 8039, 8748, 8749, 8021, 8022, 8041 and the National Semiconductor 8040 and 8050 microcomputer consists of:

- **PM 8461** Cross-assembler 8048, 8049, 8035, 8039, 8748, 8749, 8021, 8022, 8041, 8040, 8050
- **PM 8421** Microcomputer adapter box (MAB) 8048, 8049, 8035, 8039, 8748, 8749, 8040, 8050
- **PM 8481** Debugger 8048, 8049, 8035, 8039, 8749, 8040, 8050

PM 8461 Cross assembler for the 8048, 8049, 8035, 8021, 8022, 8041, 8040 and 8050

For emulation the static memory boards (PM 8413 or PM 8414) are required; dynamic boards cannot be used.

PM 8481 Debugger for the 8048, 8049, 8035, 8039, 8748, 8749, 8040 and 8050

The microprocessor specific conditions are described here:

Internal registers
When executing a program in the STEP mode or when a breakpoint is encountered, the contents of the microcomputer's internal registers are displayed on the PMDS screen as in table B:

Clock
If the user chooses to use the clock generator provided by the PMDS, the available frequencies are: 1 MHz, 3 MHz, 6 MHz and 9 MHz. The default value is 3 MHz.

Break conditions
If enabled by the user the different Break conditions are:

RESET:	Hardware RESET from the user's prototype
POWER FAIL:	If VCC goes outside of 5VDC ± 10%.
CLOCK FAIL:	If the clock is too slow (below 1 MHz).

Table of emulation support 8048 family

µP Emulated	Addressable memory
8048	1K byte
8049	2K bytes
8035	—
8039	—
8748	1K byte
8749	2K bytes
8040	—
8050	4K bytes

All 40-pin packages: emulation speed 1...11 MHz (K = 1024)

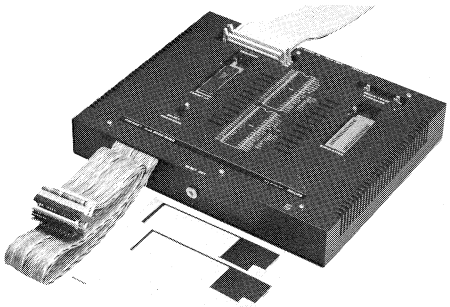
PMDS debug display after stepping or breaking emulation **Table B**

```
DO   DISASSEMBLY                    REGISTERS (BANK 0 SELECTED)                    TT
ADDR DATA OPC    OPERAND    PC  RA R0 R1 R2 R3 R4 R5 R6 R7 TC SW SS P0 P1 P2 01
0000 0410 JMP    H'010'     010 F0 B6 08 00 00 00 00 36 0D A5 02 02 FF FF B4 01
                                A5 4E 00 07 00 00 00 03
```

Where				
PC	Program counter	TC	Timer/counter	If TØ is clock out, the value of TØ does not resemble the actual value (it is just a sample).
RA	Accumulator	SW	Status word	
RØ, R1, R2	Registers (the upper	SS	Supplementary status word	
R3, R4, R5	displayed row	PØ, P1, P2	Port Ø, 1, 2	Any of the above registers or flag bits except for TØ and T1, can be individually examined and changed.
R6, R7	contains the registers in register bank Ø; the lower contains them in register bank 1)	TØ	Value of TØ pin	
		T1	Value of T1 pin	

PMDS support for 8086, 8087, 8088, 8089

Intel 8086 family Support, PM 8467 F/M, PM 8477M, PM 8377 M, PL/M86, PM 8427 and PM 8487



The complete support system for the Intel 8086 and 8088 microprocessor consists of:

- PM 8467 F Cross-assembler 8086/8088
- PM 8467 M Cross-assembler 8086/8087/8088*
- PM 8477 M Pascal 8086/8087/8088*
- PM 8377 M C compiler 8086/8087/8088*
- PL/M86 Compiler 8086/8087/8088*
- PM 8427 Microcomputer Adaptor Box (MAB) 8086/8088
- PM 8487 Debugger 8086/8088

Options marked* are applicable only for PM 4422/PMDS II.

PM 8467 Cross-assembler 8086/8088 and PM 8363 Cross-assembler 8089

The cross-assemblers translate assembly language input into object code and debug files.

In common with all PMDS crossassemblers, they provide features such as:

- Modular support to allow structured programming
- MACRO facilities, including nesting
- Conditional code generation
- Memory type specification
- Paging support
- Cross reference listing
- Extensive set of error messages

PM 8477 M Pascal 8086/8087/8088

Please see the information on p. 114 on PMDS Pascal.

PM 8377 C Compiler 8086/8087/8088

Please see information on PMDS C support

PL/M86 Software Package 8086/8087/8088

Please consult the data sheet for further details

NOTE: The PM 8467 M is a pre-requisite if PM 8477 M, PM 8377 M or the PL/M86 compiler are employed.

PM 8427 Microcomputer Adaptor Box (MAB) FOR 8086 and 8088

The MAB is the hardware unit acting as an interface between the users prototype and the Universal Debug Unit of the PMDS. **The PM 8427 supports both the 8086 and the 8088; both CPU chips are supplied. All memory, I/O and interrupt resources of the 8086/8088 are available to the user program.**

PM 8487 Debugger for the 8086 and 8088

The microprocessor specific conditions are described here:

Internal registers

When executing a program in the STEP mode, or when a breakpoint is encountered, the contents of the 8086/8088 internal registers are displayed as in table C.

Clock

The clock source for the target microprocessor may be selected from:

- The prototype
- External (BNC connector on MAB)
- MDS clock (internal clock generator of MAB) at 2, 4 or 8MHz

Break conditions

Emulation will by default break on the following conditions:

RESET:	Hardware reset from prototype
NOT READY:	Ready line held for >12msec
POWERFAIL:	Vcc not within limits 5V ±10%
CLOCKFAIL:	Clock frequency <ca. 1.6MHz
HALT:	Halt instruction in program
INTERRUPT:	Interrupt line active
NMI INTERRUPT:	Non-maskable interrupt

These break conditions may be selectively turned off from the PMDS keyboard. Furthermore, it is possible to select whether a break will occur on:

DMA:	Direct memory access.
BUS MATCH:	Bus interface unit fetches trigger match address, and/or data and control
EXECUTION MATCH:	Trigger matches address of an instruction actually executed

Memory mapping

The full 1Mbyte address space may be mapped in 256 blocks of 4 kbytes. Each block may be mapped to prototype, to emulation memory at the same or a different physical address, or guarded.

I/O mapping

A segment of 64 bytes (and/or 32 words for 8086) can be pre-mapped out of the total I/O space, the remaining I/O space is automatically mapped to prototype. The pre-mapped space may then be mapped port by port (in bytes or words for the 8086) either to prototype, guarded or to the PMDS. In the latter case, the keyboard, screen, disk, printer or queue may be specified.

Emulation speed

The MAB is always used with the high speed version of the cpu (8086-2 or 8088-2). Real-time emulation without additional wait states is possible up to 8MHz.

Additional features and restrictions

Both MAX and MIN modes are supported.
Both Request/Grant lines are supported in MAX mode, one only in MIN mode.
In MAX mode, DMA channels can operate up to 5MHz.
Addressing modes available for debug commands:
Addresses may be specified as absolute, symbolic, relative to a segment register, or relative to a 16-bit base value. For RUN and STEP commands, both CS and IP registers may be specified as the base.

PMDS debug display on stepping or after emulation break **Table C**

```
DO
REG   IP=0024   SR=F002   CS=0000   DS=0000   SS=0000   ES=0000   SP=FFF9
REG   BP=FFFF   SI=FFFF   DI=FFFF   AX=FFFF   BX=FFFF   CX=FFFF   DX=FFFF
DO    ADDR  DATA      OPC   OPERAND
Next  0024  EA240000  JMP   H'00024'
+           00
```

(Valid when all registers are 'ON')

Where				
IP	Instruction pointer	SP	Stack pointer	Any of the above registers can be individually examined and changed (except the trap flag in SR).
SR	Flags	BP	Base pointer	
CS	Code segment	SI	Source index	
DS	Data segment	DI	Destination index	
SS	Stack segment	AX	Accumulator	
ES	Extra segment	BX	Base register	
		CX	Count register	
		DX	Data register	

PMDS support for 6800, 6802, 6808 and 6809

Motorola 6800, 6801, 6802, 6803, 6805, 6808, 6809 Support, PM 8320, PM 8366, PM 8380, PM 8426, PM 8466 and PM 8486

The complete support system for the MOTOROLA 6800, 6801, 6802, 6803, 6805, 6808, 6809 microprocessors consists of:

- **PM 8366** Cross-assembler 6805 (N-MOS and C-MOS version)
- **PM 8466** Cross-assembler 6800, 6801, 6802, 6803, 6808, 6809
- **PM 8320** Microcomputer adapter box (MAB) 6800/2/8
- **PM 8380** Debugger 6800/2/8
- **PM 8426** Microcomputer adapter box (MAB) 6809
- **PM 8486** Debugger 6809
- **PM 8476** PASCAL for 6809

PM 8466 Cross-assembler for the 6801, 6802, 6803, 6808 and 6809

PM 8366 Cross-assembler for the 6805

Standard Motorola instruction mnemonics are used when creating source programs.

Microcomputer adapter box (MAB)
PM 8320 for 6800/2/8
PM 8426 for 6809

In order to reach the top emulation speeds without insertion of WAIT STATES when addressing memory located in the PMDS the fast static memory boards (PM 8413 or PM 8414) should be used for the 6802/8/9. For emulation of the 6800, static memory boards are required; dynamic boards cannot be used.

Debugger
PM 8380 for the 6800/2/8
PM 8486 for the 6809

The microprocessor specific conditions are described here:

Internal registers

When executing a program in the STEP mode or when a breakpoint is encountered, the contents of the microprocessor's internal registers are displayed on the PMDS screen as in the table D.

Clock

If the user chooses to use the clock generator provided by the PMDS, the available frequencies are:
for 6800/2/8 – 0.5MHz, 1MHz, 2MHz, 4MHz, and the default value is 2MHz; for 6809 – 0.5MHz, 4MHz, 6MHz, 8MHz, with a default value of 4MHz.
The clock frequency is two times the crystal frequency for the 6800 and four times the crystal frequency for the 6802/8/9.

Table of emulation support for 6800/2/8/9

μP Emulated	Emulation speed
6800	1MHz
68A00	1.5MHz
68B00	2MHz
6802	1MHz
6808	1MHz
6809	1MHz
68A09	1.5MHz
68B09	2MHz

All 40-pin packages with addressable memory 64Kbytes (K = 1024)

Break conditions

If enabled by the user the different Break conditions are:

RESET:	Hardware RESET from the user's prototype
TRISTATE: (6800 only)	The tristate line is activated (TSC pin = 1)
NOT READY: (6802/8/9 only)	RDY line held more than 10ms
POWER FAIL:	If VCC goes outside 5 VDC ±10%
CLOCK FAIL:	Clock too slow (below 0.1 MHz)
HALT:	Halt input encountered
INVALID OPCODE:	When an invalid opcode is encountered (cannot be disabled)
SYNBR: (6809 only)	Break on sync acknowledge
INTERRUPTWAIT: (6800/2/8 only)	Break on wait for interrupt instruction

PMDS debug display after stepping or breaking emulation for 6800/2/8 **Table D**

```
        DO    DISASSEMBLY            REGISTERS                FFFFFF
        ADDR  DATA   OPC OPERAND     PC   SP   X    A  B     HINZVC
        FC44  8EFC35 LDS #H'FC35'    FC47 FC35 0000 00 00 11011000
```

For 6809

```
DO    DISASSEMBLY                    REGISTERS                          FFFFFFFF
ADDR  DATA       OPC    OPERAND      PC   S    U    Y    X    DP A  B   EFHINZVC
F834  5F         CLRB                F835 E075 E0E0 E3C0 E3E0 00 00 00  11010100
```

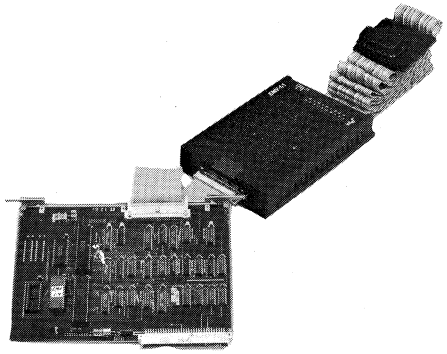
Where

PC	Program Counter	FE	Undefined
SP	Stack Pointer	FB	Break Command
A	Accumulator	FD	Decimal mode
X, Y	Index Registers	FI	Interrupt disable
FN	Sign Flag	FZ	Zero flag
FV	Overflow Flag	FC	Carry flag

Any one of the above registers or flag bits except for FE and FB can be individually examined and changed.

PMDS support for 68000 and 68010

Motorola 68000 and 68010 Support, PM 8328, PM 8329 M, PM 8388, PM 8389 M, PM 8469, PM 8479 and PM 8448



The complete support system for the 68000 microprocessor consists of:

- **PM 8329 M** Microcomputer adapter box (MAB) 68000/68010
- **PM 8379 M** C cross-compiler for 68000/68010
- **PM 8389 M** Debugger 68000/68010 for use with PM 8329 M
- **PM 8469** Cross-assembler 68000/68010
- **PM 8479** Pascal compiler for 68000/68010

PM 8469 M Cross-assembler/linker for 68000

The cross-assembler translates assembly language input into relocatable or absolute object code and labelfiles. The assembler/linker generates automatically the shortest possible representation of an instruction.

PM 8328M Microcomputer Adaptor Box (MAB) for 68000

PM 8329M Microcomputer Adaptor Box (MAB) for 68000/68010

Internal registers

When executing a program in the STEP mode or when a breakpoint is encountered, the contents of the 68000/68010 internal registers are displayed on the PMDS screen as in table E. Any of these registers can be switched off for the display.

Clock

The clock source for the target microprocessor may be selected from:

- the prototype
- external input
- the PMDS 2/PEDS itself at 2, 4*, 8 and 12.5MHz. (* is default)

Mapping

The user can map one segment of 128Kbytes for each mode. The other segments are assumed into prototype. Within the mapped segment the user has blocks of 4Kbytes, which he can map in emulation memory, prototype or declare guarded.

Break Conditions

If enabled by the user the different Break conditions are:

BUSERROR:	Buserror line was activated
CLOCKFAIL:	No clock edges within 10msec
DMA:	Bus Request line was activated
HALTLINE:	Halt line was activated
NOTREADY:	Data Acknowledge line still high 9msec after falling edge of S4 Clockpulse.
POWERFAIL:	Vcc not within 10% of 5V
RERUN:	Buserror and Halt line activated simultaneously
RESET:	Reset line was activated

Ordering Information

Type number	Description
PM 8469M	Cross assembler 68000/68010
PM 8479M	Pascal for 68000/68010
PM 8379M	C for 68000/68010
PM 8328M	MAB for 68000
PM 8388M	Debug Processor for PM 8328M
PM 8329M	MAB for 68000/68010
PM 8389M	Debug Processor for PM 8329M
PM 8448	32Kb static emulation memory

The PM 8469M is a prerequisite if a PM 8379M or PM 8479M compiler is employed.
PM 8328M includes PM 8388M, and PM 8329M includes PM 8389M.

PMDS debug display after stepping or breaking emulation

Table E

```
DO   EMULATION HALTED        : MATCH TR1
REG  PCT=00F2010C  USP=00C00120  SSP=00001FDC  SR =2700
REG  D0 =0006388A  D1 =0CF00F02  D2 =00000000  D3 =19FFA000
REG  D4 =00FFFFFF  D5 =00000101  D6 =00F2AE9D  D8 =0000002A
REG  A0 =0001F000  A1 =0001F010  A2 =0C0C0C0C  AJ =00000000
REG  A4 =FF000000  A5 =00000000  A6 =00000000  VBR=00000000
REG  SFC=0         DFC=0         FOW=0000
DO   MO ADDR   DATA          OPC      OPERAND
Next UP F2010C B619          CMB.B    (A1)+,D3
```

Any of the above registers can be individually enabled/disabled and changed.

Where:

PCT	Program counter
SSP	Supervisor Stack Pointer
USP	User Stack Pointer
SR	Status Register
AØ...A6	Address Register Ø-6
DØ...D6	Data Register Ø-6
VBR	Vector Base Register
SFC	Source Function Code Register
DFC	Definition Function Code Register
FOW	Format Offset Word
MO	Mode which can be: UP (User Program) SP (Supervisor Program) UD (User Data) SD (Supervisor Data)

PMDS support for Z80

Zilog Z80 Support PM 8422, PM 8462, PM 8470 and PM 8482

The complete support system for the Zilog Z80 microprocessor consists of:

- **PM 8462** Cross-assembler Z80
- **PM 8422** Microcomputer adapter box (MAB) Z80
- **PM 8482** Debugger Z80
- **PM 8470** PASCAL for Z80

PM 8462 Cross-assembler for the Z80
Standard Zilog instruction mnemonics are used when creating source programs. Therefore the symbols A, B, C, D, E, H, L, BC, DE, HL, SP, IX, IY, R, I cannot be used as labels.

PM 8422 Microcomputer adapter box (MAB) for the Z80
As a target microprocessor a Z80A is inserted in the MAB.

PM 8482 Debugger for the Z80
The microprocessor specific conditions are described here:

Internal registers
When executing a program in the STEP mode or when a breakpoint is encountered, the contents of the Z80 internal registers are displayed on the PMDS screen as in Table F:

Clock
If the user chooses to use the clock generator provided by the PMDS, the available frequencies are: 0.25 MHz, 1 MHz, 2 MHz, 2.5 MHz, 4 MHz. The default value is 2.5 MHz.

Break Conditions
If enabled by the user the different Break conditions are:

RESET:	Hardware RESET from the user's prototype
NOT READY:	RDY line held more than 8ms
POWER FAIL:	If VCC goes outside 5VDC ± 10%
CLOCK FAIL:	If clock too slow (below 0.25 MHz)
DMA:	Direct Memory Access
HALT:	Halt instruction

Table of emulation support for Z80

μP Emulated	Emulation speed
Z80	2.5 MHz
Z80A	4 MHz

All 40-pin packages with addressable memory 64 Kbytes (K = 1024)

PMDS debug display after stepping or breaking emulation **Table F**

```
DO   DISASSEMBLY                REGISTERS      FFFFFF
                                PC   SP    A   SZHPNC   B  C  D  E  H  L  IF RA
ADDR DATA     OPC  OPERAND      IX   IY    AA  SZHPNC   BB CC DD EE HH LL IM IV
                                C7B2 FFFD >04  011100<  00 DA FF CF C9 6F  0 67
C7B0 DBDE     IN   A,(H'DE')    CB35 0000  6F  000000  >00 00 00 00 00 00< 0 00
```

Where

PC	Program counter		parity/overflow, add/subtract, carry flags of main bank
SP	Stack pointer		
IX, IY	Index registers	AA	Accumulator of alternate bank
A	Accumulator of main bank	BB, CC, DD, EE, HH, LL	Registers of alternate bank
B, C, D, E, H, L	Registers of main bank		
RA	Refresh address register	FSS, FZZ, FHH, FPP, FNN, FCC	Sign, zero, half-carry, parity/overflow, add/substract, carry flags of alternate bank
FS, FZ, FH, FP, FN, FC	Sign, zero, half-carry,		
		IE	Interrupt enable
		MC, MB, MA	Masks RSTC, RSTB, RSTA
		IF	IFF2 flip-flop
		IM	Interrupt mode
		IV	Interrupt vector, register

National Semiconductor NSC800 Support PM 8462, PM 8470, PM 8322 and PM 8382

The complete support system for the National Semiconductor NSC800 microprocessor consists of:

- **PM 8462** Cross-Assembler NSC800/Z80
- **PM 8470** Pascal NSC800/Z80/8085
- **PM 8322** Microcomputer Adaptor Box (MAB) NSC800
- **PM 8382** Debugger NSC800

PM 8462 Cross-Assembler for the NSC800

Standard National Semiconductor instruction mnemonics are used for the assembler source program.

PM 8470 Pascal for NSC 800

Please see p. 24 for details.

PM 8322 Microcomputer Adaptor Box (MAB) for the NSC800

In order to reach the top emulation speeds without insertion of wait states when addressing memory located in the PMDS, the fast static emulation memory boards (PM 8413, PM 8414, PM 8419) should be used.

The emulation probe signals are buffered via 74LS, therefore input and output levels are to TTL specifications. Although a CMOS device, the NSC800 itself operates only from a nominal 5V supply. The NMI input only is via a CMOS buffer for timing purposes.

PM 8382 Debugger for the NSC800

The microprocessor specific conditions are described here.

Internal registers

When executing a program in the STEP mode, or when a breakpoint is encountered, the contents of the NSC800 internal registers are displayed on the PMDS screen as in table, and also in the log file if enabled. The display is formatted as in the table. Because of the large number of registers involved, the display for any register(s) which may not be of interest may be selectively disabled by use of the REGISTER OFF command.

Table of emulation support for NSC800

μP Emulated	Emulation speed
NSC800-2	4 MHz
NSC800-4	8 MHz*

*Subject to confirmation.

PMDS support for NSC 800

Clock

The clock source for the target microprocessor may be selected from:

- The prototype
- External (BNC connector on MAB)
- MDS XTAL (crystal mounted on simulation socket)
- MDS clock (from internal clock generator of MAB)

In the last case, the frequency may be selected at 1, 2, 4 or 8 MHz.

Break conditions

Emulation will by default break on the following conditions:

RESET: Hardware RESET from prototype
NOT READY: Ready line held for >8msec

POWER FAIL:	Vcc not within limits 5V±10%
CLOCK FAIL:	Clock frequency <500kHz
DMA:	Direct Memory Access
HALT:	Halt instruction in program
POWERSAVE:	Processor brought into power save mode
RETIEMEM:	Return from interrupt mapped in emulation memory

Memory mapping

256 blocks each 256 bytes may be mapped to prototype, to emulation memory at the same or a different physical address, or guarded.

I/O mapping

255 input ports and 255 output ports may be individually mapped to prototype, to the PMDS (keyboard/screen, disk, printer or queue) or guarded. Port BB is not usable for I/O as it is dedicated to setting of the interrupt mask.

ACCBANK/REGBANK

Commands allow reading or switching between main and alternate accumulator and register banks.

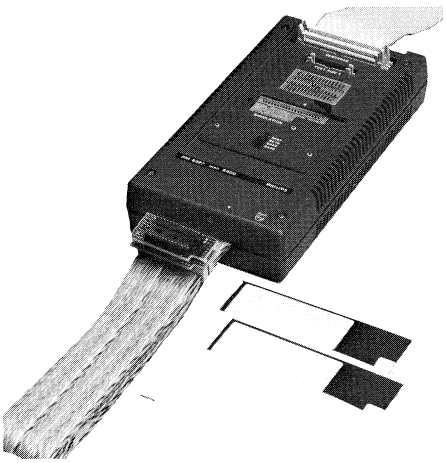
PMDS debug display on stepping or after emulation break — Table G

```
DO      REGISTERS (REGBANK: MAIN      , ACCBANK: MAIN     )
REG     PC        SP =FFC2  IX =3352  IY =5500  A  =55   B  =EF
REG     C         D  =AB    E  =04    H  =56    L  =06   RA =F3
REG     FS        FZ =0     FH =1     FP =0     FN =1    FC =1
REG     AA        BB =00    CC =00    DD =00    EE =00   HH =00
REG     LL        FSS=0     FZZ=0     FHH=0     FPP=0    FNN=0
REG     FCC       IE =1     MC =0     MB =0     MA =0    IF =0
REG     IM        IV =00
DO      DISASSEMBLY
ADDR    DATA      OPC   OPERAND
JA13    13        INC   DE
```

Where					
PC	Program counter	FZ/FZZ	Zero flag of main/alt. bank	B, C, D, E, H, L	Registers of main bank
SP	Stack pointer	FH/FHH	Half-carry flag of main/alt. bank	BB, CC, DD, EE, HH, LL	Registers of alt. bank
IX, IY	Index registers	FP/FHH	Parity/overflow flag of main/alt. bank	IF	Interrupt enable flag
A	Accumulator of main bank	FN/FNN	Add/subtract flag of main/alt. bank	IM	Interrupt mode
AA	Accumulator of alternate (alt.) bank	FC/FCC	Carry flag of main/alt. bank	RA	Refresh address register
FS/FSS	Sign flag of main/alt. bank			IV	Interrupt vector register

PMDS support for 8400 family

Philips 8400 family Support PM 8327, PM 8367 and PM 8387



The complete support system for the 8400 microcomputer family consists of:

- **PM 8367** Cross-assembler 8410, 8420, 8440
- **PM 8327** Microcomputer adapter box (MAB) 8410, 8420, 8440
- **PM 8387** Debugger 8410, 8420, 8440

PM 8367 Cross-Assembler for the 8410, 8420 and 8440
Standard Philips' instruction mnemonics are used when creating source programs.

Therefore the symbols A, C, CNT, I, MBØ, MB1, MB2, MB3, PØ, P1, P2, PSW, RØ, R1, R2, R3, R4, R5, R6, R7, RBØ, RB1, SI, SØ, S1, S2, T, TCNT, TCNTI cannot be used as labels for the 8410, 8420, 8440.

PM 8327 Microcomputer adapter box (MAB) for the 8410, 8420, 8440.
The MAB provides a four-position switch to indicate the emulated microcomputer type.

PM 8387 Debugger for the 8410, 8420 and 8440
The microprocessor specific conditions are described here:

Internal registers
When executing a program in the STEP mode or when a breakpoint is encountered, the contents of the 8410, 8420 or 8440 internal registers are displayed on the PMDS screen as in table H.

Clock
If the user chooses to use the clock generator provided by the PMDS, the available frequencies are: 1.11 MHz, 2.22 MHz and 4.43 MHz. The default value is 4.43 MHz.

Table of emulation support for 8400 family

μP Emulated	Addressable memory
8410	1K byte
8420	2K bytes
8440	4K bytes

All 28-pin packages with emulation speed 4.43 MHz (K = 1024)

Break Conditions
If enabled by the user the different Break conditions are:

RESET:	Hardware RESET from the user's prototype
POWER FAIL:	If VCC goes outside 5VDC ±10%
CLOCK FAIL:	If clock too slow (below 600 kHz).

PMDS debug display after stepping or breaking emulation **Table H**

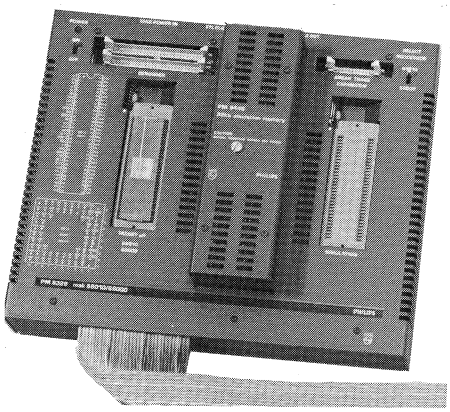
```
DO   DISASSEMBLY                    REGISTERS (BANK 0 SELECTED)      P0 P1  P2 T0
ADDR DATA OPC  OPERAND   PC   RA R0 R1 R2 R3 R4 R5 R6 R7 TC SW SS S0 S1  S2 T1
0022 17   INC  A         0023 56 E0 FF FF FF FF FF FF FF 00 84 00 FF FF   F  1
                                  E0 FF FF FF FF FF FF FF          00 100 00  0
```

Where

PC	Program counter
RA	Accumulator
RØ, R1, R2 R3, R4, R5 R6, R7	Registers (the upper displayed row contains the registers bank Ø; the lower contains them in register bank 1)
TC	Timer/counter
SW	Status word
SS	Supplementary status word
PØ, P1, P2	Port Ø, 1, 2
SØ, S1, S2	Serial I/O register Ø, 1, 2
TØ	Value of TØ pin
T1	Value of T1 pin

Any of the above registers or flag bits can be individually examined and changed.

Intel 8051 family support PM 8362M, PM 8385M, PM 8325M and PM 8445



The complete support system for the 8051 micro-computer family consist of:

- **PM 8362 M** Cross-assembler for 8051 family
- **PM 8385 M** Software for 8051 NMOS emulator
- **PM 8325 M** Emulator controller board (includes PM 8385 M)
- **PM 8445** Emulator for 8051

The 8051 microcomputer family consists of 8051, 8031 and 8751.

PM 8362 M Cross-assembler for 8051 family

The cross-assembler translates assembly language input into object code and debug files.
In common with all PMDS cross-assemblers, it provides features such as:

- Modular support to allow structured programming
- MACRO facilities, including nesting
- Conditional code generation
- Memory type specification
- Paging support
- Cross reference listing
- Extensive set of error messages

Standard Intel instruction mnemonics are used for the assembler source program. Therefore, none of the standard register identifiers can be used as labels within the source program.
Assembler directives are standard for all PMDS-assembles

PM 8325 M Emulator controller board

The emulator controller board acts as an intelligent interface between the PMDS-2 and the emulator for the 8051. Up to four emulators for the 8051 can be supported by the PMDS-2. One emulator controller board can be installed in the PMDS-2; for each succeeding emulator controller board a PM 8405 debug extension must be installed.

PM 8445 Emulator for 8051 family

The emulator for the 8051 family provides real-time emulation capabilities for the 8031, 8051 and 8751. The emulator consists of the controller and the emulation probe.
The controller contains:

- 4 Kbytes of emulation memory
- breakpoint logic for up to four hardware breakpoints
- 4 pins supplying user test signals (EMUL, DSENE, ALE, CLK).
- EXTBRK pin for breaking on an external signal.

The emulation probe contains:

- a 8051 microprocessor
- 12 MHz crystal
- jumper connections to define:
  1) Power supplied by prototype or by emulator
  2) clock supplied by prototype or by emulator
  3) simulation or emulation

PM 8385 M software for 8051 NMOS emulator

After invocation of the software for the 8051 the emulator runs under control of the PMDS-2.

PMDS support for 8051 family

Table of emulation support for the 8051 family

uP emulated	internal ROM
8031	no
8051	4 Kb
8751	4 Kb EPROM

All 40-pin packages with emulation speed 12MHz

The commands can be split up in four groups:

- the utility commands, to load the program, establish symbolic names, save a debugged program and operate the emulator hardware
- the display/modify commands, to display or modify memory and register contents including an in-line assembler
- the emulation commands, to start, control and stop the emulation
- the advanced commands, to build macros and set up conditional control structures

During an emulation session an UNIX command can be executed by using the UNIX shell escape mechanism. (When a command line begins with an '!' the remainder of that line will be executed as an UNIX command).

Response on the REG. command

Table I

PC = 000H	TM0 = 0000H	RBS = 0	R0 = 86H	R4 = A7H
SP = 07H	TM1 = 000H	BASE = H	R1 = 66H	R5 = EAH
DPTR = 0000H	B = 00H	SUFFIX = H	R2 = 58H	R6 = 66H
ACC = 00H	PSW = 00000000Y		R3 = 3AH	R7 = 86H

Where

PC	= program counter	PSW	= program status word
SP	= stock pointer	RBS	= register bank select
DPTR	= data pointer	R0-R7	= general purpose registers
TM0	= counter/timer 0		
TM1	= counter/timer 1		

PMDS support for TMS 1000

The support system for the TMS 100 consist of:

- **PM 8468 M** Cross-assembler

(Additional information and specifications will be available soon.)

PMDS support for NEC 7500

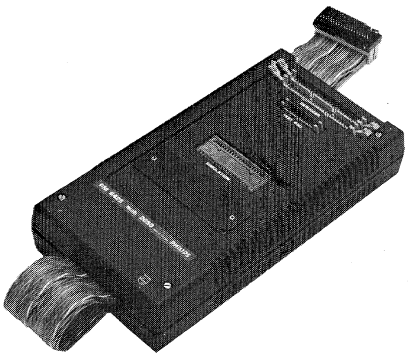
The support system for the NEC 7500 consist of:

- **PM 8364** Cross-assembler

(Additional information and specifications will be available soon.)

PMDS support for 2650

Signetics 2650 Support
PM 8425, PM 8465 and PM 8485



The complete support system for the 2650 microprocessor consists of:

- **PM 8465** Cross-assembler 2650
- **PM 8425** Microcomputer adapter box (MAB) 2650
- **PM 8485** Debugger 2650

PM 8465 Cross-assembler for the 2650A
Standard Signetics instruction mnemonics are used when creating source programs.

PM 8425 Microcomputer adapter box for the 2650A
The MAB has no target microprocessor socket as a special emulator chip is used.

PM 8485 Debugger for the 2650A
The microprocessor specific conditions are described here:

Internal registers
When executing a program in the STEP mode or when a breakpoint is encountered, the contents of the 2650 internal registers are displayed on the PMDS screen as in Table J:

Clock
If the user chooses to use the clock generator provided by the PMDS, the available frequencies are: 0.1 MHz, 1 MHz, 2 MHz. The default value is 1 MHz.

Table of emulation support for 2650

μP Emulated	Emulation speed
2650A	1.25 MHz
2650A-1	2 MHz

All 40-pin packages with addressable memory 32 Kbytes (K = 1024)

Break Conditions
If enabled by the user the different Break conditions are:

RESET:	Hardware RESET from the user's prototype
NOT READY:	RDY line held more than 8ms
POWER FAIL:	If VCC goes outside 5VDC ±10%
CLOCK FAIL:	Either clock too slow (below 100 kHz) or clock too fast for the slow emulation memory

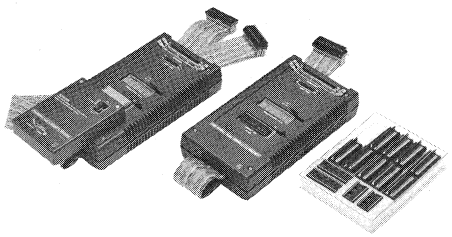
PMDS debug display after stepping or breaking emulation **Table J**

```
DO    DISASSEMBLY                    REGISTERS
ADDR  DATA    OPC      OPERAND       PC   R0 R1 R2 R3 R4 R5 R6 PSU      PSL
0024  F87E    BDRR,R0  H'7E'         0024 1D 66 72 2F 00 00 00 00100000 01000000
```

Where

R0, R1, R2, R3, R4, R5, R6	Registers	PC	Program Counter	Any one of the above registers or Program status bits can be individually examined and changed.
		PSU	Program Status Upper	
		PSL	Program Status Lower	

Rockwell 6502, 6503, 6504, 6505, 6506, 6507, 6512, 6513, 6514, 6515, and 6500/1 Support PM 8424, PM 8444, PM 8464 and PM 8484



The complete support system for the Rockwell 6502, 6503, 6504, 6505, 6506, 6507, 6512, 6513, 6514, 6515 microprocessors, and 6500/1 microcomputer consists of:

- **PM 8464** Cross-assembler 6502, 6503, 6504, 6505, 6506, 6507, 6512, 6513, 6514, 6515 and 6500/1
- **PM 8424** Microcomputer adapter box (MAB), for all types listed above
- **PM 8484** Debugger, for all types listed above
- **PM 8444** Extension box 6500/1

PM 8464 Cross-assembler for the 6502, 6503, 6504, 6505, 6506, 6507, 6512, 6513, 6514, 6515 and 6500/1
Standard Rockwell instruction mnemonics are used when creating source programs. Therefore the symbols A, X, Y cannot be used as labels.

PM 8424 Microcomputer adapter box for the 6502, 6503, 6504, 6505, 6506, 6507, 6512, 6513, 6514, 6515, 6500/1
Emulation of all microprocessors listed above (except the 6500/1) is done with the same target microprocessor (6512A). A key adapter is therefore used for the others. A message will appear on the PMDS screen to identify which microprocessor is being emulated.
The MAB will only accept a single phase clock input.

PM 8484 Debugger for the 6502, 6503, 6504, 6505, 6506, 6507, 6512, 6513, 6514, 6515, 6500/1
The microprocessor specific conditions are described here:

Internal registers
When executing a program in the STEP mode or when a breakpoint is encountered, the contents of the specific μP/μC internal registers are displayed on the PMDS screen as shown in Table K:

Table of emulation support for 6500 family

μP Emulated	Package	Addressable memory	Emulation speed
6502	40 pins	64 Kbytes	2 MHz
6503	28 pins	4 Kbytes	2 MHz
6504	28 pins	8 Kbytes	2 MHz
6505	28 pins	4 Kbytes	2 MHz
6506	28 pins	4 Kbytes	2 MHz
6507	28 pins	8 Kbytes	2 MHz
6512	40 pins	64 Kbytes	2 MHz
6513	28 pins	4 Kbytes	2 MHz
6514	28 pins	8 Kbytes	2 MHz
6515	28 pins	4 Kbytes	2 MHz
6500/1	40 pins	64 Kbytes RAM 2 Kbytes ROM	1 MHz

(K=1024)

PMDS support for 6502

Clock
If the user chooses to use the clock generator provided by the PMDS, the available frequencies are: 0.1 MHz, 1 MHz, 2 MHz. The default value is: 1 MHz.

Break Conditions
If enabled by the user the different Break conditions are:

RESET:	Hardware RESET from the user's prototype
NOT READY:	RDY line held more than 10ms
POWER FAIL:	If VCC goes outside 5VDC $\pm$10%
CLOCK FAIL:	If clock too slow (below 1 kHz)
HALT:	HALT instruction executed
DMA:	PAUSE line activated

PM 8444 MAB Extension 6500/1
It will be physically placed on top of the MAB 6500.
Upon detecting the 6500/1, the software debugger automatically sets the address MAP appropriately. Maximum emulation speed is 1 MHz.

PMDS debug display after stepping or breaking emulation

```
DO    DISASSEMBLY                REGISTERS          FFFFFFFF
ADDR  DATA    OPC   OPERAND      PC    SP  A  X  Y  NVEBDIZC
0CFE  2123    AND   (H'23',X)    0D00  83  00 00 6B 00  0110
```

Where

PC	Program counter	SP	Stack pointer	FZ	Zero flag
S	Hardware stack pointer	FE	Entire flag	FV	Overflow flag
U	User stack pointer	FF	Fast interrupt request mask	FC	Carry flag
X, Y	Index register	FH	Half carry flag		
DP	Direct page register	FI	Interrupt request mask		
A, B	Accumulator A, B	FN	Negative flag		

Any of the above registers or flag bits can be individually examined and changed.

UNIX-based operating system, Source code control system, PASCAL and C compilers

UNIX-BASED OPERATING SYSTEM PM 8491

Introduction

UNIX is a trademark for a family of multi-user, multi-tasking operating systems, incorporating a flexible, powerful command programming language. It was originally developed in 1969 by a team of programmers at Bell Laboratories, on a PDP 7 computer. UNIX was quickly adopted by some of the leading university programming and scientific departments in the USA and subsequently world-wide. This in turn led to further improvements and refinements to the original concept, a process which is still continuing. The advent of 16-bit and 32-bit microprocessors brought UNIX into the commercial limelight and it is rapidly becoming the industry standard for these products.

UNIX features

The mains features of UNIX on the PMDS II system are as follows:

Up to seven time-sharing users.

High productivity.

Hierarchical file structure.

Numerous software tools.

Portability: the conflicting factors of portability and machine dependency have been substantially resolved by UNIX.

Standardisation: the UNIX system and its associated tools - almost all written in C - are becoming a 'de-facto' standard in many countries.

The UNIX operating system

This is the 'kernel' of resident code which supports all system calls and maintains the file system. The main features of the kernel are:

Re-entrant code for user processes.
Separate data and instruction areas.
Owner/group/other user access permissions to files (separate read/write/execute permissions) and to directories (separate read/write/search permissions).
Alarm clock timeouts.
Timer-interrupt sampling and inter-process monitoring for debugging and measurement.
Logically synchronous I/O with drivers for printers (including spooling), magnetic tape units, ASCII terminals, disk units, etc.

The UNIX shell

The shell command language interpreter includes the following features:
Runs and supplies necessary arguments to all executable programs.
Standard input, output and error redirection.
'Piping' output of one program to input of another program
Compound commands using if/then/else, case switches, while loops, for loops, break/continue/exit and grouping within parentheses.
Background processes.
Executable command scripts with substitutable arguments.
Generation of file-names which match specified pattern(s).
Traps and interrupts.
User-defined profile executed at login.
Individual users may readily define additional commands.
Mail service between users.
Default variable and parameter settings.

UNIX tools

The PMDS II implementation of UNIX includes all UNIX tools which are required to develop microprocessor-based systems. In addition to the normal start-up, access control, terminal-handling commands a wide range of tools is provided. The following list includes some of the more commonly-used tools in each category:

Text processing
Text editor.
Optional screen editor.
Formatting tools.
Encryption/decryption.

Basic file manipulation
The most commonly used basic tools are outlined below:
cat: concatenate file(s)
cmp: compare two files
cp: copy file(s)
lpr: line printer spooler
pr: print files
split: split files into parts
touch: update file(s) timestamp
cd: change working directory
find: find specified file(s)
mv: move (rename) file(s)
rm: remove files
rmdir: remove empty directory
wc: line, word, character count
tr: translate text
In addition to the basic tools the following more advanced and powerful tools are available:
sed: stream editor
awk: pattern-scanning and processing language
join: merge files
sort: sort files
grep: pattern-searching tool

Program control
at: execute commands at later time
echo: echo arguments
expr: evaluate arguments as an expression
kill: terminate processes
sh: command programming language
tee: pipe fitting
test: condition command

Status inquiries
df: print free blocks on file system
du: summarise disk usage
ls: list specified directory contents
ps: print process status
pwd: print working directory
who: who is on the system

Maintenance and backup
clri: clear i-node
dcheck: check file system directory consistency
dump: dump incremental file-system
icheck: check file-system storage consistency
fsck: check and repair file system
mount: mount removable file system
restor: restore incremental file system
su: temporarily substitute super-user ID
sync: update super-block
tar: tape archives
umount: unmount removable file system
mfxx: copy/save/manipulate files from/to/on PMDS-type minifloppy diskette

Communications commands
mail: send or receive mail
write: immediate write message to other user
mesg: permit or deny write messages
putport/getport: send/receive programs between systems

Program development tools
PMDS-2 Compiler Tool Kit: allows either 'C', Pascal or PL/M to be cross-compiled to various supported microprocessors
make: controls creation of large programs from modular source files and optimises creation of new versions
m4: general purpose, stream-oriented macro processor
sccs: Source Code Control System to control changes to program source code or documents
lint: 'C' program verifier. Reports on any questionable or non-portable usages
yacc: a compiler-writer system
lex: lexical analyser

SOURCE CODE CONTROL SYSTEM PM 8396M

Software Management
As software is developed, it usually consists of quite a number of modules and the associated project documentation. Then, at the introduction, all these files are effectively frozen to generate the first release. However, as the product evolves, these files are frequently changed to solve problems or to implement enhancements. The changes need not necessarily be done by the author of a given program, especially if a team of software engineers is involved.

SCCS manages all these changes in an efficient manner. The burden of managing all these interrelated changes by hand is removed from the project manager, as SCCS:

- can store, update and retrieve any version of a textfile
- controls access to a version of a file
- records who made changes, when and why they were done
- indicates which files are still open for changes.

Space compression
With the first release, SCCS stores a copy of the original source- and documentation files. After that, new versions of files are not recorded in total, but only in the form of their differences from the original. Two branches from release 1.1 are possible: new versions (1.2, 1.3 ..) and new releases (2.1). From a version, as well as the next version, also a specific branch can be taken to accommodate a specific solution for a particular problem, not general enough to justify a complete version or release. Such a branch is defined as 1.2.1. Even a fourth level is possible.
By successively applying the changes to the original, SCCS is able to generate any file that has been also produced, without needing space for all the files that have existed during the lifetime of a project.

Multiple acces control
A file needing update is delivered to a user, and afterwards the generated version is locked. This ensures that another user, wanting to update the same release/version is notified of the pending change in that file. The user then can either generate a branch-node, to give himself exclusive control over a version other than the locked one, or use write or mail commands to discuss the situation with the owner of the locked release/version.
The lock mechanism is applied to each release/version individually. So it is possible to work on the next release, while at the same time updates are made to an existing version that is in use.

Audit trail
After a locked release/version is returned to SCCS, SCCS prompts the user for the reason why the file has been changed. The reason, together with the date and the name of the user is then stored as part of the changes that are recorded. This allows for a complete trail of changes made to a particular file, be it a source file or a file containing documentation.

PASCAL COMPILERS PM 8470, PM 8476, PM 8477 and PM 8479 for PMDS

The family of PASCAL compilers can be used to develop programs for various

```
Login sccs
Passwd:
adm> admin s.clock -ajohn -iprog.c

* Create storage for software project clock.
* Initialise it from source file prog.c .
* Only user john is allowed to update s.clock.


Login: john
Passwd:
$ get clock
ERROR [clock]: not an SCCS file (co1)
$ help co1
co1:
"not an SCCS file"
A file you think is an SCCS file
does not begin with the characters "s.".

* Asking for the original with the wrong
* command generates an easy to understand
* message. For further help, an help
* function gives detailed messages.


$ get s.clock
1.1
23 lines

* Rebuild original for printing (read only).

$ get -e s.clock
1.1
new delta 1.2
23 lines

* Rebuild source for update to version 1.2.
* Correct a problem and present sccs new version.

$ delta s.lang
comments? I/O bug fixed
1.2
2 inserted
5 deleted
15 unchanged
```

Some sample commands with SCCS

microprocessors supported on the PMDS and for the PMDS itself. All compilers are written to guarantee real portability of PASCAL programs within the PMDS. The language is implemented as described in the ISO report, ISO/TC97/SC5 N565 of February 1980 extended with some important features.
Extensions are made to permit independent compilation of program parts and to allow static initialization of data (SCONST).
Furthermore an interpreter is available on the PMDS with extensive debug facilities and the same source language specification as the PASCAL compilers of the system. This interpreter is meant to test the user's program logic before combining it with the prototype hardware.

FEATURES

- Structured programming, in accordance with best software practice
- Easy to learn
- Compile time and runtime checking for convenient evaluation in all stages of program development.

EXTENSIONS TO STANDARD PASCAL

- **Independent compilation**
  With PMDS PASCAL, programs can be broken down into modules which can be compiled and tested individually and subsequently linked together using the powerful PMDS linker.

- **Structured constants**
  SCONST provide the possibility to define constant data of structured type (e.g. records, arrays, sets).

- **I/O features**
  Inputs and outputs for micros are essentially hardware-dependent.
  Therefore no "standard" compiler can produce code for every application.
  PMDS PASCAL provides a calling sequence which allows interfacing with assembly language written routines and the PMDS linker will then incorporate these routines into the microprocessor/microcomputer executable program.

- **Code segmentation**
  By producing seperate code segments for executable code, structured constants and variables, the PMDS linker can be instructed on memory mapping and memory type (ROM, RAM, battery-backed RAM, etc.). This means that program parts (routines or variables) which may change from one version of a final product to another version can be mapped into a single ROM or RAM chip.

TESTING OF PASCAL PROGRAMS

To test the program logic of an application written in PASCAL, a separate environment is developed. On the PMDS a PASCAL interpreter is available with extensive debug facilities. This interpreter can also be used to run programs specifically written to run on the PMDS.

Debug facilities in PMDS PASCAL interpreter include:

Control commands:

- FMAP to allocate the files to be used during the program execution to peripherals of the PMDS.
- STEP to sequence the program manually through a series of PASCAL statements.
- QUIT to terminate program interpretation.

Debugging commands:

- TRACE to trace line numbers, procedure names, stack or heap information at the exit of procedures.
- BREAK to define up to 5 breakpoints.
- EXAMINE to show and change in hexadecimal format the specified memory contents.
- MEMORY to show the specified memory area in the hexadecimal format, or in their declared format
- CLEAR to reset the specified or all debug options currently active.

COMPILER FEATURES

Compiled programs are listed to provide useful information about program size and structure.
Information shown:

- Line number
- Statement number
- Procedure level
- Block begin counter
- Block end counter
- Error number, plus error message, plus, when necessary, additional information depending on the type of error
- Compilation summary
  - Name of the procedure
  - Stack size for one invocation
  - Code size portion of the procedure

Compile time statements
The options to be used by the programmer to control his compilation are called compile time statements. Compile time statements are recognized by the special character: % that starts the statement.

% INCLUDE	= other modules
% TITLE	= page headings
% EJECT	= listing
% SPACE	= listing
% LISO	= list object code
% NOLISO	
% LISS	= list source
% NOLISS	
% LISI	= list includes
% NOLISI	
% CHECK	= array indices, etc.
% NOCHECK	

COMPILER SPECIFICS

These specifics are applicable to all PMDS PASCAL compilers, independent of the microprocessor supported.

- For all calls to I/O functions a control block and a standard calling sequence is generated to allow the user to write his own I/O routines depending on his configuration.
- Sets are limited to a maximum of 256 elements.
- Maxint is defined to be 32767.
- Reals and mathematical functions are supported according to the standard.

IMPLEMENTATION ON TARGET MICRO

Implementation is target-dependent. For the 8085, Z80 and 6809 the linked loadfile will include an interpreter. This is selectively loaded, i.e. only those functions required by the actual user program are linked. This ensures that minimum target memory space is used for each application. The maximum size of this interpreter depends on the architecture and addressing modes of the target micro, but is typically a few kilobytes.
For the more powerful target micros, such as the 68000 and 8086, compilation into executable code is done.

ORDER NUMBERS

PM 8470	PASCAL for 8080, 8085, Z80 and NSC 800
PM 8476	PASCAL for 6809
PM 8477	PASCAL for 8086/8088
PM 8479	PASCAL for 68000

PASCAL for PMDS is included in all these type numbers.

C COMPILERS

C is a general purpose programming language, originally designed by Dennis M. Ritchie in 1972 and implemented on the UNIX operating system.
Subsequently, UNIX was largely re-written in C.

C can be used effectively for writing operating systems as well as for numerical, text, data base and other applications programs.

General features

C contains many high level language features, but also allows low level programming when required. It is not a strongly typed language, therefore the programmer is less constrained than he is by (for instance) Pascal. Although C is in principle machine-independent, it provides efficient tools for the programmer to manipulate data at machine level. Programs written in C are transportable, subject to variations in the representation of data as implemented on different computers.

Advantages

Because C is not a 'large' language, it is relatively easy to learn to the level of ability necessary to write programs which function correctly. C is efficient in terms of code size and execution speed, the runtime overhead compared with assembler is quite low, usually a factor less than 2, which is considerably smaller than Pascal or other high level languages.

Overview of C language

C provides the necessary flow-control constructs needed for well structured programs:

Conditional: if/else
Multiple choice: switch/case
Looping: while/for

C can work with pointers, and can perform address arithmetic. Functions can be constructed, and may be called recursively. Basic types used are character, integer and float (= real).

Numerical values may be qualified as short or long integers, and as double precision floats, and may also be signed or unsigned. In addition, arrays, structures and unions of these basic types are employed. User-defined types are also possible.
The syntax of C is in relatively 'shorthand' format, which reduces the labour content of program creation as compared with most other high level languages.

C support on PMDS

The various PMDS C compilers are developed from Philips Compiler Package (PCP). Because C is an evolving language, there is at present no international standard. The PMDS compilers follow closely the language as described in ref. 1.

The compilers produce assembler source, which is used as the input for the corresponding assembler. The assemblers can be invoked with a wide choice of listing and debug options.

PM 8395 M C compiler for PM 4422 host

This compiler produces code to run on the 68000 CPU of the PMDS II. With this compiler, it is possible to write all kinds of utility programs, and these programs may include system calls which utilise all the features of the UNIX operating system. Furthermore, all PMDS II system resources such as screen, keyboard, line printer and disk(s) will be accessible via system calls.

The following support software relates to the PM 8395 M:

- Support libraries: libec, libem
- Syntax checker: lint
- Symbol listings: nm, xref
- Listing format: cb
- Compiler utilities: lex, yacc
- Runtime profile: prof
- Clean to executable code: strip
- Program debug utility: em interpreter (available 1984)

PM 8379 M C compiler for 68000

This compiler produces code to run on a 68000 target machine. Dependent on the application, such a target CPU may require an operating system which may be written in C, assembler, or a combination of both, or bought. 'C' allows easy linking into external entry points of any operating system.

The following support software relates to the PM 8379 M:

- Support libraties: libec, libem
- Syntax checker: lint
- Symbol listings: nm, xref

PM 8377 M C compiler for 8086/8088

This compiler produces code to run on an 8086 or 8088 target machine.
Dependent on the application, such a target may require an operating system which may be written in C, assembler, or a combination of both, or could for instance be RMX86. 'C' allows easy linking into external entry points of such an operating system.

The following support software relates to the PM 8377 M:

- Support libraries: libec, libem
- Syntax checker: lint
- Symbol listings: nm, xref

Ref. 1. 'The C programming language', by Brian W. Kerninghan & Dennis M. Ritchie. Prentice-Hall Software Service 1978.

Philips Matrix Printer PM 4492

Two standard character sets: 9 x 9 (DATA) and 18 x 25 (Gothic) dot matrix

Selectable print speed: 300 or 150 to 180 characters per second (9 x 9 matrix and 80 characters per second (18 x 25 matrix)

Serial interface V24/RS232C

Built-in diagnostic routine

The Philips Matrix Printer PM 4492 is based on a high resolution needle matrix print technique. This technique gives:

- high print quality, accepted for business correspondence and other word processing applications, two character designs and pitches are available,
- high print speed as required in data processing applications. The printing speed varies from 300 to 80 characters per second dependent on the print quality,
- high number of print characters.

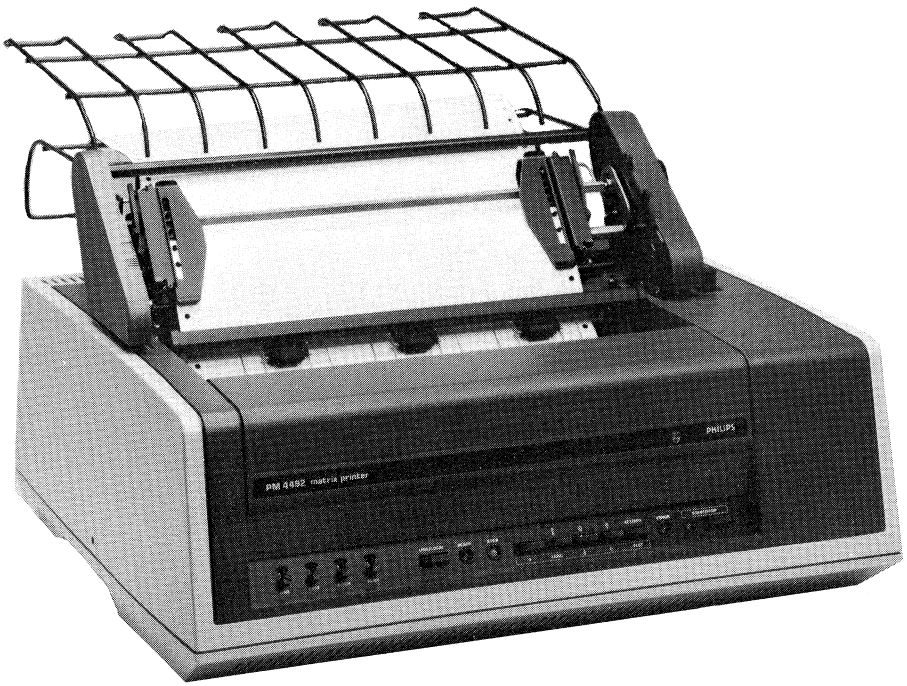
Provided with these properties the PM 4492 finds applications where data processing and word processing are merging and is therefore ideal for printing during microprocessor development work.
The PM 4492 is equipped with tractor feed for printing continuous forms. The easy change of character sets and speed permits a fast print-out (300 characters/second, medium print quality) e.g. during the draft phase in preparing a document. After making corrections, the final print-out can be printed with high print quality and slower speed (80 characters per second).

9 x 9 matrix, DATA, 12 cpi, 300 cps

```
ABCDEFGHIJKLM
NOPQRSTUVWXYZ
abcdefghijklm
nopqrstuvwxyz
0123456789:;@
!"#$%&'()*+,-
<=>?{}^~./\[]
```

18 x 25 matrix, GOTHIC, 12 cpi, 80 cps

```
ABCDEFGHIJKLM
NOPQRSTUVWXYZ
abcdefghijklm
nopqrstuvwxyz
0123456789:;@
!"#$%&'()*+,-
<=>?{}^~./\[]
```



TECHNICAL SPECIFICATION

Print head
18 needles

Print matrix
9 x 9, 18 x 25 (single pass printing)

Type styles
DATA, GOTHIC

Pitch
10, 12 cpi

Print speed
9 x 9: 300 cps max. } bidirectional
18 x 25: 80 cps } printing

Tabulation speed
300 cps max.

Character sets
141 characters, upper and lower case

Character height
DATA-2.46mm, GOTHIC-2.29mm

Print format
12-in line length, maximum paper width 340mm

Line spacing
1, 2, 3, 4, 6, 8, 12, 16, 24, 48 lpi

Paper control
Automatic copy control, paper-in/out detection

Ribbon
PHILIPS fabric ribbon cassette

Copies
3 to 5 copies (depending on paper)

Paper feed
Tractor feed, table top model

Paper
Continuous paper

Interface
7- or 8-bit serial RS232C/V24, V28 300...9600 baud, full duplex

Buffer
380-character buffer (FIFO)

Diagnostics
Off-Line Test, selftest diagnostic and device status

Standard 2K x 8 (16K bits) RAM for data storage

Universal NMOS: programs all NMOS EPROMS available

Remotely operated via serial interface

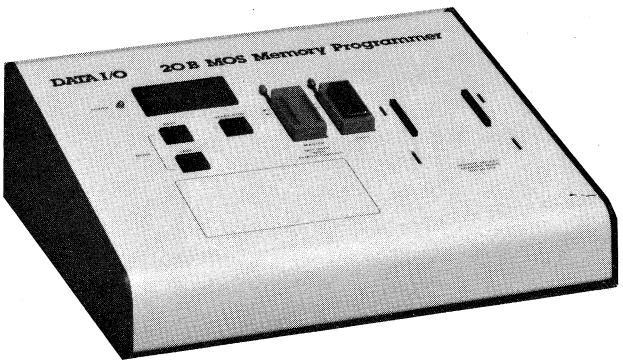
Automatic self-test and error detection

Automatic bit for bit verification after programming

Switch-selectable baud rates to 9600 bits/s

Universal PROM programmer PM 4497

The PM 4497 Universal PROM programmer complements the versatility of the Philips Microcomputer Development Systems, and gives the user full freedom of choice of the PROMs to be used in a prototype system.
The PM 4497 is made by Data I/O, acknowledged leaders in the field of programming equipment, and the functions include loading, copying and verifying PROMs, patching and examining data, and insertion of PROM checksums.



The PM 4497 is a low-cost programmer capable of programming NMOS EPROMS and Intel single chip microcomputers.

TECHNICAL SPECIFICATION

Programming Electronics
Programming parameters are software-controlled. All voltages are current-limited and monitored to meet PROM manufacturers' programming specifications.

Serial port
- RS232C or 20mA current loop, full or half duplex
- Baud rate switch-selectable 110, 300, 600, 1200, 2400, 4800 or 9600 bits/s
- ASCII character format definition by internal switch: parity ON/OFF, EVEN/ODD parity, ONE/TWO stop bits
- Data transfer format: Intel-hex

POWER REQUIREMENTS
Mains (line) voltages
100, 120, 200 or 240V_{AC} within +5% or −10%

Power consumption
30W nominal

Mains (line) frequency
50 to 60 Hz

Temperature range
0 to +40°C operating
−40°C to +55°C storage

Humidity
Up to 90% (non-condensing)

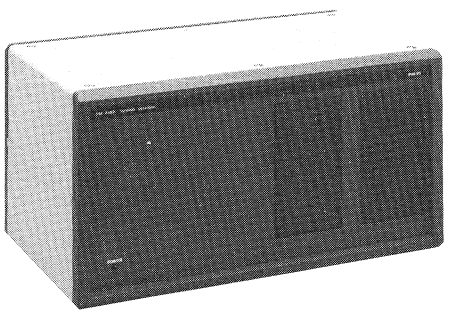
DIMENSIONS AND WEIGHT
(w x h x d) 312 x 269 x 104mm
(12.3 x 10.6 x 4.1-in)
3.7kg (8.1 lb)

Array Size Technology	Pinout	PROM Type Number
Advanced Micro Devices		
1024x8 MOS	24	2708
2048x8 MOS	24	4716
Electronic Arrays		
1024x8 MOS	24	2708
2048x8 MOS	24	2716
Fairchild Semiconductor		
1024x8 MOS	24	2708
Fujitsu		
1024x8 MOS	24	8518 (2708)
2048x8 MOS	24	8516 (2716)
Hitachi		
2048x8 MOS	24	462716
2048x8 MOS	24	48016
4096x8 MOS	24	462532
4096x8 MOS	24	462732
Intel		
512x8 MOS	24	2704/8704
1024x8 MOS	24	2708/8708
1024x8 MOS	24	2758
1024x8 MOS	24	2758 S 1865
1024x8 MOS	40	8741
1024x8 MOS	40	8748
1024x8 MOS	40	8748H
2048x8 MOS	24	2716
2048x8 MOS	40	8749H
2048x8 MOS	40	8755A
4096x8 MOS	24	2732
4096x8 MOS	24	2732A
4096x8 MOS	40	8751
8192x8 MOS	28	2764
Intersil		
1024x8 MOS	24	2708
Maruman Integrated Circuits		
2048x8 MOS	24	2716
Mitsubishi		
1024x8 MOS	24	58732S (2708)
1024x8 MOS	24	2708
2048x8 MOS	24	2716

Array Size Technology	Pinout	PROM Type Number
Mostek		
2048x8 MOS	24	2716
8192x8 MOS	28	2764
Motorola		
1024x8 MOS	24	68708/2708L
1024x8 MOS	24	2708P
2048x8 MOS	24	TMS2716
2048x8 MOS	24	MCM2716
4096x8 MOS	24	2532
4096x8 MOS	24	68732-0
4096x8 MOS	24	68732-1
8192x8 MOS	24	68764
National Semiconductor		
1024x8 MOS	24	2708
1024x8 MOS	24	2758A
1024x8 MOS	24	2758B
2048x8 MOS	24	2716
4096x8 MOS	24	2532
4096x8 MOS	24	2732
Nippon Electric Co., Ltd.		
2048x8 MOS	24	2716
Oki		
2048x8 MOS	24	2716
Signetics		
1024x8 MOS	24	2708
Texas Instruments		
1024x8 MOS	24	2508
1024x8 MOS	24	2708/27L08
2048x8 MOS	24	2716
2048x8 MOS	24	2516
4096x8 MOS	24	2532
8192x8 MOS	28	2564
Toshiba		
512x8 MOS	24	321
1024x8 MOS	24	322
2048x8 MOS	24	323

NEW

Options for PMDS



PM 4494/4495 M hard disk extension units

To increase the amount of on-line storage Philips provides two disk extension units: the PM 4494 M giving 22.3Mbyte and the PM 4495 M giving 44.6Mbyte extra formatted disk space. This space can be used for backup copying of existing disks or be incorporated into the UNIX file system. A maximum of 3 units (PM 4494 M or PM 4495 M) can be connected.

Each disk drive can be configured as 2 logical drives of different sizes. Each logical disk is handled independently. To integrate a logical disk in the UNIX file hierarchy, a (usually empty) directory is replaced by the root-directory on the extension disk. As an example, one can take the /usr directory, and move it to the extension disk. Doing so, all user files will reside on the extension, but for all normal purposes the device on which a file resides is not visible to the user. In particular, no command changes occur when moving /usr to the extension. As arm-seeks on different physical drives overlap each other, a considerable speed improvement takes place when usr is moved to an extension, because arm movements to UNIX utilities and the swapping area do not interfere with access to user files.

By using only half the disk for a particular directory tree, the other half can be used to copy another physical disk. If a disk drive fails, one only has to change the configuration to continue the activity from the point where the last backup was made.

* UNIX is a trademark of Bell Laboratories

TECHNICAL DATA

Formatted space:
22.3Mbyte (PM 4494 M) or 44.6 (PM 4495 M) soft sectored in 17 sectors of 512 bytes per track dividable into 2/4 logical units, if desired

Recording density:
8900bpi

Latency:
8.3ms

Head settling time:
15ms

Track-to-track seek time:
1.5-3ms

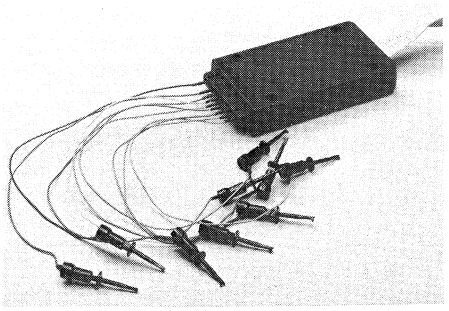
Temperature:
+5 to +35°C (operating)
−30 to +60°C (storage)

Relative humidity:
8-80% non-condensing

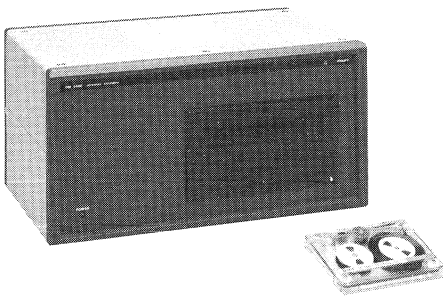
Voltage:
110, 127, 220, 240V

Power consumption:
max 120W

Dimensions and weight
(w x h x d) 450 x 230 x 270mm
14.5kg (PM 4494 M)
12kg (PM 4495 M)



PM 8820 *is an 8-bit wide pod for user-definable inputs. Two can be used with 8-bit processors, one with a 16-bit processor.*



PM 4496 M Streamer Tape Unit

Multi-user development systems need a reliable backup facility. Such a facility should be both fast and easy to use, or else users tend to forget about making regular backups. For small projects, use of the built-in floppy disk drive together with intelligent dump/restore programs is practical. For projects with code sizes in excess of 1Mbyte, the PM 4496 M is excellent.

Using 20Mbyte cartridges PM 4483 M, the PM 4496 M Streamer Tape Backup Unit copies a hard disk's contents in about 1 minute (for the 5Mbyte) to 5 minutes (for 22Mbyte), a time so negligible that it pays off to make a backup daily. In this way, recovery not only from system breakdown, but also from user mistakes (e.g. removing an important file) is covered.

The PM 4496 M can also be used to save and restore individual files instead of a disk image. Used in this mode, the user does not need any special permissions, and can copy files without bringing the system in single-user mode.

Another use of the PM 4496 M is to reorganise file systems. Files are extended block by block, and these blocks tend to get scattered around the disk surface. When a total file backup is reloaded onto an empty disk, a file system results in which files are allocated consecutive blocks. Such a reorganised file system speeds up response time.

The control program allows storage of more than one disk per cartridge, and for multi cartridge backups if more than 20Mbyte is copied. Error recovery is automatic, if possible. The PM 4496 M is connected to a dedicated interface located on the domestic computer board, and uses its own controller.

TECHNICAL DATA

Recording mode:
4 track read-after-write with separate erase

Recording density:
7500 bpi

Temperature:
+5 to +35°C (operating)
−30 to +60°C (storage)

Relative humidity:
20-80% non-condensing

Voltage
110, 127, 220, 240V

Power consumption:
70W

Dimensions and weight:
(w x h x d) 450 x 230 x 270mm
14.5kg

Low-cost universal prototyping, servicing and debugging tool for new microcomputer applications

Microcomputer instructor PM 4300

Universal

The microcomputer instructor is a universal tool that can handle today's popular μPs including 8086, Z8002, Z80, 8048, 8049, M6801, 8088 and MAB8400. Changing from one to another is by plugging-in a new μP-specific personality module. Command and data-entry operations are standard for all μPs, making it unnecessary to learn new command formats for different types.

Hardware/software integration

The personality module contains the target microprocessor. Signals are brought out through the μP emulation cable – a flat cable whose plug matches the pinout of the test microprocessor.
This cable can therefore be plugged into the μP socket of a prototype system.
All microcomputer instructor commands may then be used for real-time execution and single-stepping of programs in the test system environment, and to check hardware and software functions and integration.

A hardware breakpoint can be set at any desired point and the program is then executed up to the breakpoint. By single-stepping through the program from the breakpoint, its running can be examined in detail allowing faults to be identified and corrected. The contents of a specific memory location or of a target μP register can be shown on the alphanumeric display as the program is executed in single-step mode. At the same time, the contents of all the registers are dumped via the RS232C interface to a line-printer, for example. An AUTO STEP function allows fast program stepping with preprogrammed delay intervals from 20ms to 6s.

Exercising I/Os

Checking peripheral IC operation, and in particular I/O devices, is facilitated by using the μP emulation cable together with the breadboard panel to create I/O configurations for test.

Microcomputer instructor commands can read and write I/O data, allowing I/Os to be checked without the need to write special programs for this purpose. A built-in 8-bit parallel I/O port allows input and output routines to be written without the need to build a special circuit. Input words can be created by means of 8 switches. When the port is used for output, the output word is shown on 8 LEDs.

Handling interrupts

Interrupt keys allow manual generation of interrupts for entry and execution of user-written interrupt routines.

Measuring code execution time

Operating of the TIME key allows the time taken for execution of a block code in the target μP to be measured.

TECHNICAL SPECIFICATION

Microprocessors supported:
8086, Z8002, Z80, 8048, 8049, M6801, 8088, 8410, 8420, 8440

Operating speeds:
Full rated speeds of the microprocessors

Programming panel:
16-digit, 14-segment alphanumeric display, 32-key data entry and command keyboard

Internal memory:
1K bytes/words standard. Can be incremented to 4K bytes/words

External memory
Expansion to 64K bytes through an expansion connector and/or emulation cable

I/O ports:
1 serial I/O port wired for RS232C and standard audio cassette interface. 1 parallel I/O port wired to 8 input switches and 8 LED outputs.

Interrupts:
2 can be manually generated

Data transfer rates:
110 to 9600 baud, switch-selectable

μP emulation cable:
When using the μP emulation cable in a user system, user memory or I/O cannot overlap with the internal microcomputer instructor memory or I/O. Also, the drive capability of some of the μP signals is limited to 2.5 LS loads. If common design rules are followed in the user system these are not serious restrictions.

Solderless breadboard panel:
Can hold up to thirteen 16-pin devices plus μP emulation cable

Plug-in μP-specific personality modules are quickly interchangeable.

Breakpoint:
One, hardware compare on address, can be used to trigger scope or logic analyzer

Step:
Single step or continuous step, variable rate can be set from 20ms to 6s. Default value is 0.5s

Monitor:
Occupies 2K bytes or 2K words depending on processor type

Power supply:
110, 115, 220 or 240V AC (specify on order), 50 to 60Hz

Operating temperature:
0 to 40°C

Storage temperature:
−40 to +75°C

Humidity:
95% RH 15 to 40°C

Safety standards:
IEC 348 class 1

DIMENSIONS AND WEIGHT
(w x h x d): 362 x 95 x 356 mm
(14.3 x 3.7 x 14-in)
4.5kg (9.9lb)

The microprocessors/computers supported by the PM 4300 microcomputer instructor are:

uP/uC	Personality module
8086	PM 4327
8088	PM 4335
Z8002	PM 4323
Z80	PM 4322
8048 8049	PM 4321 PM 4321
8410 8420 8440	PM 4337 PM 4337 PM 4337

Personality Module PM 4337 for PM 4300

In-line assembler

Built-in PROM programmer for 2716, 2732 and 2732 A

Flexible file-transfer to and from host systems

All MAB8400 family members supported

The MAB8400 microcomputer chip family from Philips now has a development tool at its disposal that will assist in the design and debugging of the processor and in the creation of prototypes. The PM 4300 stand-alone system, with the PM 4337 personality module, operates in the machine language of the target microprocessor.
The PM 4300 requires only the personality module to fully emulate the dc and ac behavior of an actual 8400 microcomputer. In fact, the emulation is so close that the only detectable difference is the extra capacitance introduced by the emulation cable.
Features of the development system and its personality module include hardware break-point, single-step, and automatic-step operation; manual interrupt, T1 input to the processor, and port and data-memory examination. A disassembler has also been built-in, and the results of a disassembly can be displayed on the alphanumeric readout of the PM 4300 or on a separate CRT terminal or printer. The personality module also has a built-in PROM programmer that accepts 2716, 2732, and 2732A memories.

Although the development system can operate in a stand-alone configuration, the PM 4300's RS-232C port can be connected to a host computer or development system, such as the PMDS. Then the host computer can edit and assemble the source program editing, and the assembled program can be downloaded via the RS-232C port to the PM 4300 for debugging of the program in combination with the prototype system.

Normally, cassette files or data from the serial RS-232C port are loaded into the PM 4300 in TEKHEX format. The PM 4337, however, can also load object code files in the Intel MDS format. This enables the PM 4300 to connect directly to the Intel MDS system for assembly of 8400 source code, with the 8048 macroassembler, and for downloading of the assembled code into the PM 4300 for debugging. Either format is selected with a port switch.
Once a program has been checked and debugged using the PM 4300, the corrected program version can be uploaded to the host computer (in TEKHEX format) or written to an EPROM for use with a piggyback version of the MAB8400B. The personality module can address up to 6kbytes, which enables the user to develop a 4-kbyte program that is partitioned into a 6-kbyte space.

Specifics for MAB8400 personality module PM 4337

Internal memory:	2K bytes extra RAM located on personality module (total 3K bytes expandable to 6K bytes)
In-line dissassembler:	Executed instructions and memory contents can be displayed in mnemonics format either on alphanumeric display or on CRT or printer connected to RS232C interface of PM 4300
I/O ports:	Parallel I/O port not available. Used for other features
Transfer format of load files:	Either TEKHEX or INTELHEX format can be chosen to download microprocessor load files into PM 4300. DUMP of microprocessor load files performed in TEKHEX format.
PROM programmer:	Built-in PROM programmer able to read, write and verify 2716, 2732, 2732A EPROM's.

Recorders

Unit	Features	Function	Accuracy	Page
Introduction				2
LINE RECORDERS				
PM 8251A	Standard compact, single line	X-t	0.25% (0.5%)	4
PM 8252A	Standard compact, double line	X1, X2-t	0.25% (0.5%)	4
PM 8202	Modular compact, single line	X-t	0.25% (0.5%)	6
PM 8222	Modular compact, double line	X1, X2-t	0.25% (0.5%)	6
PM 8224	4-line compact recorder	X1...X4-t	0.3% (0.5%)	9
PM 8226	6-line compact recorder	X1...X6-t	0.3% (0.5%)	9
PM 8110	Minirecorder, single line	X-t	1%	12
PRINTING RECORDER				
PM 8210/11	Printing recorder	X-t plus alphanumeric print-out	0.25% (0.5%)	13
MULTIPOINT DATA RECORDERS				
PM 8234	Multipoint recorder	X-t	0.25%	15
PM 8237	Multipoint X-t data recorder	X-t	0.15% (0.3%)	18
X-Y RECORDERS				
PM 8042	OEM-type DIN A4: single range input	X-Y	0.25%	21
PM 8043	Standard DIN A4: 9 input ranges	X-Y	0.25%	21
PM 8143	DIN A4: 18 input ranges + zero suppression	X-Y	0.25%	21
PM 8033	Standard DIN A3: 9 input ranges	X-Y	0.25%	21
PM 8133	DIN A3: 18 input ranges + zero suppression	X-Y	0.25%	21
PM 8134	DIN A3: two-pen version of PM 8133	X-Y_1, Y_2	0.25%	21
INTELLIGENT DIGITAL X-Y PLOTTERS				
PM 8154	Multipen, intelligent plotter DIN A4 format	X-Y from digital input	Addressable resolution 0.1mm	24
DIGITAL RECORDERS				
PM 4201	Digital data cassette recorder	Capacity: 520K/digital cassette	Error rate: 1 bit in 10^9	28
PM 4202	Digital data cassette recorder	Capacity: 118K/digital cassette	Error rate: 1 bit in 10^9	26
CONSUMABLES				
Consumables, various				31

Introduction

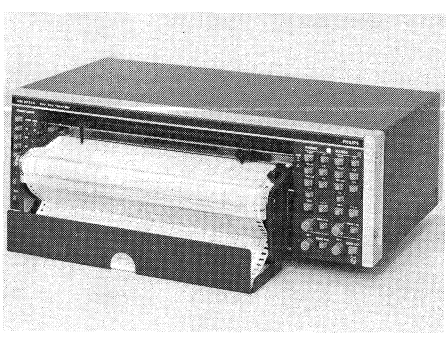
Complete range
The range of Philips instruments offered covers practically every requirement to be found in R & D labs, specialized research and observation, production line and field operation. Without overlooking the needs of the OEM sector.

There are many options to choose from. The X-t group embraces several different styles and types which include single-, double-, four- and six-pen models, a programmable, 12-channel multipoint recorder plus an extremely versatile μP-controlled digital data recorder offering up to 30-channel operation and featuring the combined advantages of both graphical and numerical printout. Also included in the range are an analog-plus-digital printing recorder and a mini-model for general back-up work.

The Philips X-Y recorders introduced recently have already proved their new design concepts to be highly succesful in the field.

The better overall performances, including higher speeds and built-in timebase (as standard) have become favourite amongst the many well-accepted features.

The total range consists of DIN A4 and DIN A3 models in single, two-pen and OEM versions.



PM 8252 A

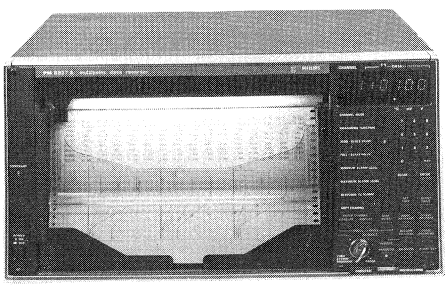
Which X-t recorder?
There are four types of X-t recorders to choose from:
The *Compact* family offering one-, two-, four- or six-pen recording on 250mm wide chart, for conventional analytical work, through to applications which demand a remotely controllable instrument. The **Compact** design concepts were based on the desire to telescope together the major benefits of both vertical and flatbed styles. The resulting instrument therefore allows the user to enjoy the better features of both types.

Multiline instruments which complement the **Compact** family of X-t recorders. These are the PM 8224 and PM 8226 for 4- and 6-line recording applications. Both high-precision units, they are designed for laboratory or industrial situations. Standard features include dipmarker, electrical pen lift, remote control, etc. and an optional multiline synchronizer PM 9889 is available.

The **Minirecorder** is ideal for back-up work. It uses 120mm chart width, yet retains all the features of a conventional laboratory recorder PLUS portability.

The **Multipoint** recorder PM 8234 measures up to twelve channels of information, which may be a mixture of voltages and temperatures. PM 8234 is available in a 6- or 12-channel version.

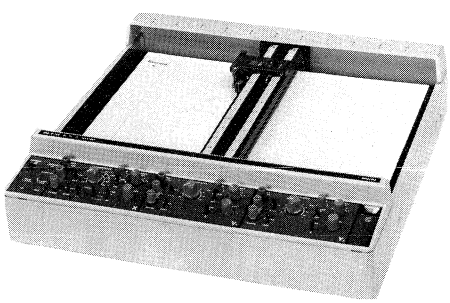
The **Multipoint data** recorder PM 8237 offers the unusual facility of a choice of either graphical or numerical printout. It will record up to 30 channels and will accept a mix of 2- and 4-wire connections. Useable as a stand-alone unit, it can be interfaced with a bussable system (IEC/IEEE hardware is optional). It measures differential temperatures with very high accuracy, having a wide choice of thermocouple linearization. The very flexible zero suppression gives high resolution and the thermal print head has few moving parts, resulting in excellent reliability in use. Useable in a stand-alone function or within more sophisticated systems.



Operating PM 8237A requires no software knowledge. All programs are μP controlled and input is via a simple keyboard.

The **Printing recorder** PM 8210/11 produces an analog trace simultaneously with digital information.

Which X-Y recorder?
There is an X-Y recorder in the current range which should meet virtually any user requirement, be it in the laboratory, for field work or an OEM situation. This range, which includes a sophisticated two-pen model, several single-pen types (choice of five) including an OEM version for dedicated operation, will fulfil many different recording functions. There is a choice of DIN A3 or DIN A4 paper size.



The PM 8134 is the two-pen, DIN A3 size X-Y recoder which allows the simultaneous recording of three variables.

The present range offers many advantages. These include higher pen acceleration and speed which themselves underwrite high-fidelity results in addition to very faithful recordings of fast phenomena.

All models (except the OEM version) have a built-in time base for making Y-t recordings in addition to many other useful features. These include, overload protection, input noise filters (controlled from front panel), servo-kill, automatic pen lift to prevent blotting, etc.

Intelligent X-Y plotter
Intended to cover most plotter requirements, the 6-pen, DIN A4X-Y plotter, PM 8154 is also available with IEEE/IEC and V24/R232C interface options. For multiple plotting with the PM 8154, a chart transport unit is available.

PM 8154 intelligent X-Y plotter withg its DIN A4 size charts is IEEE/IEC-compatible.

This plotter is a useful aid for making drawings, bar graphs or overhead sheets and will reproduce screen plots from a digital storage oscilloscope (e.g. PM 3305). A programmable choice of 8 pens and 5 standard national character sets are available in upper and lower case. An integrated microprocessor controls the overall operation of the instrument and provides automatic self-test routines at switch-on.

Digital cassette recorders
The PM 4201 with an extremely large storage capacity for this type of recorder allows it to be used in a wide range of off- and on-line data processing applications. Its very low error rate of one bit in 10^9 is some 100 times better than other models.

The PM 4202 with its even larger storage capacity of 59Kbytes on a digital cassette track and 120Kbytes on a dictaphone cassette track make it ideal for many industrial and business applications.

Compact dimensions for early system or equipment integration and IEEE/V-24 interface capabilities fitted as standard provide maximum instrument flexibility.

PM 4202 is an extremely compact yet powerful data storage recorder.

Quality – the common denominator
In the world of electronic equipment production, quality standards have been established over the years by various national and international institutions. With the common aim of constantly improving instrument design and the manufacturing processes to ensure good product **performance,** a high level of **reliability** and long-term **stability**.

These three essentials create 'spin-offs' in other product aspects, but remain the essential, basic ingredients of the **'quality formula'**

Philips is totally dedicated to quality: at all stages of design, development and production. Apart from reasons for its own survival in the competitive technological instrument world, there is an inherent attidue of mind by Philips personnel involved in the various processes. Personal pride in producing the best quality product, consistent with their particular eventual application, is the normal approach. From basic design, through development, through production, right down to protective packaging!!

Another Philips 'first'!
The familiar IEC, UL, VDE, AQAP standards have been generated in various countries all over the world. These are internationally recognized and adhered to by many, but not necessarily all, electronic instrument manufacturers. Holland has also made its contribution to these standards. The Dutch Quality Assurance Standard NEN2646 was recently promulgated. Its requirements are **identical** with those of AQAP1. Its application requires careful analysis of all the relevant processes involved in designing and producing. (For this reason some parts of industry have been slow to adopt it!!)

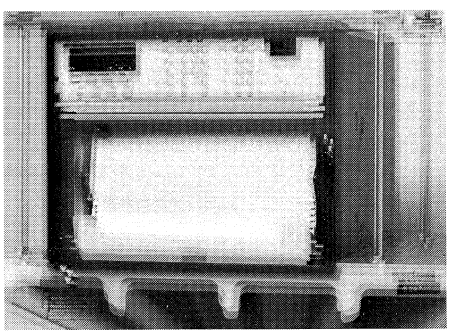
However, the already high standards which were the everyday norm in Philips own internal processes required little change. A few refinements, on only, were necessary to comply with the stringent demands of NEN2646.

As a result it was one of Philips own factories that achieved the unique distinction of receiving the very first Dutch Quality Assurance Certificate for complying with NEN2646.

This was the Philips T & M, Almelo-based factory which produces recorders and multimeters. The Almelo operation now becomes the first of many Philips production units to be structured to meet NEN2646, as well as being the first ever in Holland.

What does this means to the buyer?
The fundamental and obvious benefit is that the customer can have confidence built on the knowledge that instrumentation meeting such high standards of quality must be very good investment.

But not only in basic "value-for-money" terms: such a purchase will give the performance specified, continuously and reliably. More important, it will not give the user any embarrassment whilst being applied within his own operation! The key aspect for the buyer is simply, **confidence:** in the **product,** in the **supplier,** in the **wisdom** of his own choice!



Only one of the many severe tests to which all recorder designs are subjected. Picture shows PM 8237 undergoing vibration tests.

Standard compact recorders PM 8251A and PM 8252A

Wide sensitivity range: 1mV...50V in 15 steps
Zero suppression −110% ... +210%
Reproducability within 0.1%
Dipmarker
Inverter switch
Remote control of Chart start/stop, ext drive pulses, servokill, etc.
Analog output
Meets stringent IEC standard
Easy stacking or 19-in rackmounting

The long and successful performance of the PM8251 and PM8252 has been significantly enhanced and incorporated into the updated versions, PM8251A and PM8252A.

As with their predecessors, both models have been designed to withstand the rigours of everyday use in tough laboratory environments.

Although rugged in construction, they are both high-precision instruments with electromechanical and electronic features that combine to produce extremely accurate recordings. In particular, the wide sensitivity range for each instrument, from 1mV to 50V in 15 steps, makes them ideal for virtually all modern laboratory recording applications.

In analytical work, for instance, the fast response time of 0.6s plus a 0.1% accuracy will provide extremely accurate recording traces of the narrowest peaks. The ultimate high-grade recordings are also due to the stable, reliable, writing system combined with the electromechanical stepping motor (mechanical gearboxes are eliminated) which drives the Z-fold chart.

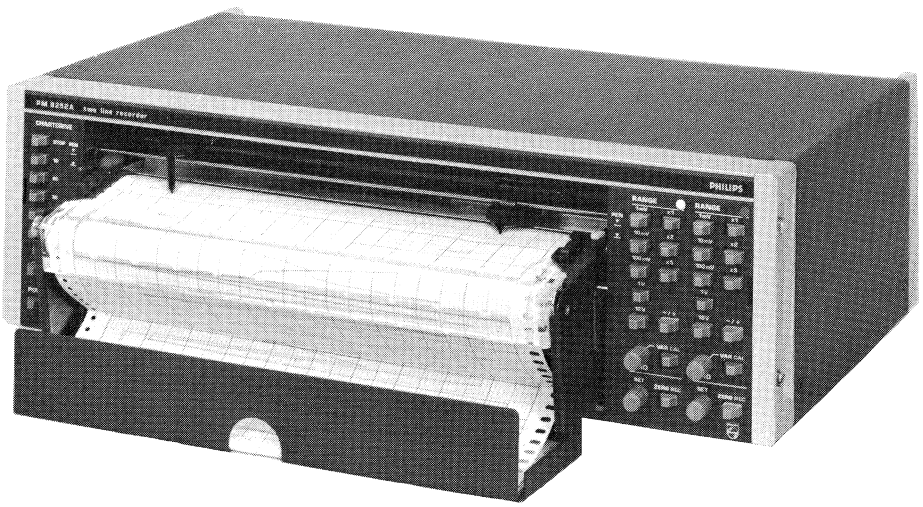
Moreover, for optimum chart resolution, continuously variable zero suppression can be set between −110% and + 210% of span.

For user-convenience, all controls are mounted on the front panel, whilst inputs are at the rear. This allows for easy rackmounting when required.

Standard remote control facilities for chart start/stop, external drive pulses and servokill allow for easy interfacing to other equipment, such as a host system.

Other special features include an inverter switch, an analog output signal which can be used to provide a direct pen-position readout (or alarm) and calibration check. The standard electronic marker on the recorder signal and the servo system, can be externally controlled with logic TTL levels. A $9V_{DC}$ supply is available at the rear for powering accessories, such as the Pt-100 temperature measuring unit.

Other standard features include the ability to make hand-written notes on the flatbed configuration, easy stacking without convection problems and suitability for 19-in rackmounting.



ACCESSORIES SUPPLIED

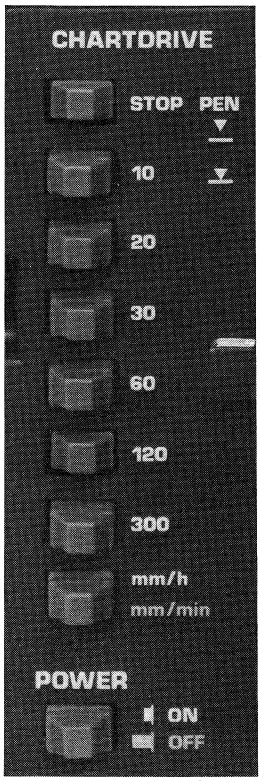
Chart collection tray
Mains cable
1 x 5-pole plug (for external chart drive)
1 x 9-pole plug (PM 8251A)
2 x 9-pole plug (PM 8252A) for remote control
Operating manual
Chart paper (5 books of folded charts 0...100 lin.)
PM 9920
For PM 8251A 2 nylon pen cartridges, red (type PM 9857/05)
For PM 8252A 2 nylon pen cartridges, red (type PM 9857/05) and 2 nylon pen cartridges, blue (type PM 9856/05)
Service box containing:
Pens: 2 for PM 8251A
4 for PM 8252A
4 fuses
1 bottle contact oil
2 brushes

CONSUMABLE SUPPLIES

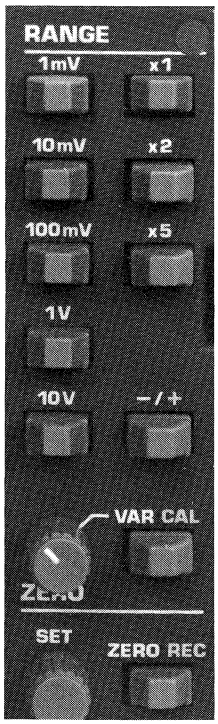
PM 9856/05	Nylon pen cartridge set of 10, blue (PM8252A)
PM 9857/05	Nylon pen cartridge set of 10, red (PM 8251A + PM 8252A)
PM 9857B/05	Set of 10 pen cartridges, blue, for use in top channel instead of PM 9857/05 red
Z-fold chart paper	(one pack contains 5 books, each 20 m long)
PM 9920/01	Scaled 100....0 linear, lines at 10mm
PM 9920/04	Scaled 0....100 linear, time lines at 15 and 30mm
PM 9920/05	Scaled 0....100 linear, time lines at 2, 10, 20mm

OPTIONAL ACCESSORIES

PM 9867	19-in rackmout brackets
PM 9873A	Linearizing unit for 2 thermocouples FE-CuNi (Type J) with power supply (−200°C to +750°C)



Detail of front panel showing the chart drive speed controls, pen lift and power on/off selectors.



Detail of range selection push buttons and zero setting controls.

PM 9874 A Linearizing unit for 2 thermocouples, for thermocouples NiCr-Ni A 1 (Type K) (−200°C to +1200°C)

PM 9877 Linearizing unit for Pt 100Ω (−100°C to +700°C)

HOW TO ORDER

Available versions

- PM 8251A - 1 pen
- PM 8252A - 2 pens
- For OEM applications single span options and different chart speeds are available on special request.

TECHNICAL SPECIFICATIONS

Type number	PM 8251A	PM 8252A
Recording width	**250 mm**	
Number of channels	**1**	**2**
Inputs	floating, asymmetrical, HI-LO and earth	
– Measuring ranges	multirange unit, 15 ranges in 1-2-5 sequence 1mV...50V f.s.d. variable control of span with 0.59 to 2.5 x increase of sensitivity	
– Input impedance	1 MΩ ± 1%	
– Isolation resistance	⩾ 2000 MΩ between HI-LO and earth at reference conditions (23°C ±1°C at 45....75% R.H.)	
– Max. input voltage	⩽500mV: $30V_{DC}$ pr $20V_{RMS}$ >500mV: $42V_{DC}$ or $30V_{RMS}$	
Accuracy		
– incl. non linearity and dead band	± 0.3% f.s.d. ± 0.2% of defl. 10mV...500mV ± 0.5% f.s.d. ±0.4% of def. 1V...50V	
– dead band	⩽ 0.2% f.s.d. (⩽ 0.5 mm)	
– zero drift	2μV/°C typical (4μV/°C worst case)	
Response time	0.6s for f.s.d.	
Overshoot	⩽ 1% f.s.d.	
Frequency response for sinusoidal signals	– 10% at 1.25 Hz at 66% of f.s.d. – 10% at 5 Hz at 10% of f.s.d.	
Common mode rejection	DC CMMR ⩾ 150dB AC < 100kHz CCMr ⩾ 130dB > 100kHz CMMR ⩾ 100dB > 50kHz SMMR ⩾ 56dB	
Zero setting	−110%...+210% of span	
Chart transport		
– speeds	12 speeds 10, 20, 30, 60, 120 and 300mm per min and per hour	
– control	remote control and external triggering	
Pen lift	manual for each channel	
Writing system	disposable felt pens	
Chart paper	Z-fold, effective recording width 250mm folds 75mm, length 20m	
Mains		
– voltage	switchable 115 and 230 V ±15%, 50/60 Hz ± 1.5%	
– consumption	one line version, 23VA nom, 15VA max: two line version, 28VA nom.	
Safety	IEC 348/VDE 0411 class I	
Radio interference	CISPR 14 Class II -– 0875 K Curve	
Dimensions and weight	h x w x d = 133mm x 44mm x 350mm, average 10kg (22lb) (5.2-in x 17.4 in x 13.7-in)	

Modular compact recorders
PM 8202 Single pen
PM 8222 Dual pen

Choice of single range or multirange sensitivity versions

0.25s full scale response time

11 speed stepper chart motor drive

Wide range of remote control options and accessories

Linearization units for accurate temperature recording

The PM 8202 single pen and PM 8222 double pen recorders are designed as general purpose instruments. Their rationalized construction, utilizing many well proven components from established Philips instruments, ensures their fast response time – just 0.25 seconds for 250mm full scale deflection–and permits accurate recording of even the high speed, narrow peaks found in analytical chemistry, for example. The sensitivity can be selected to give any desired signal sensitivity from 0.4mV to 50V, by means of single or multirange attenuator modules.

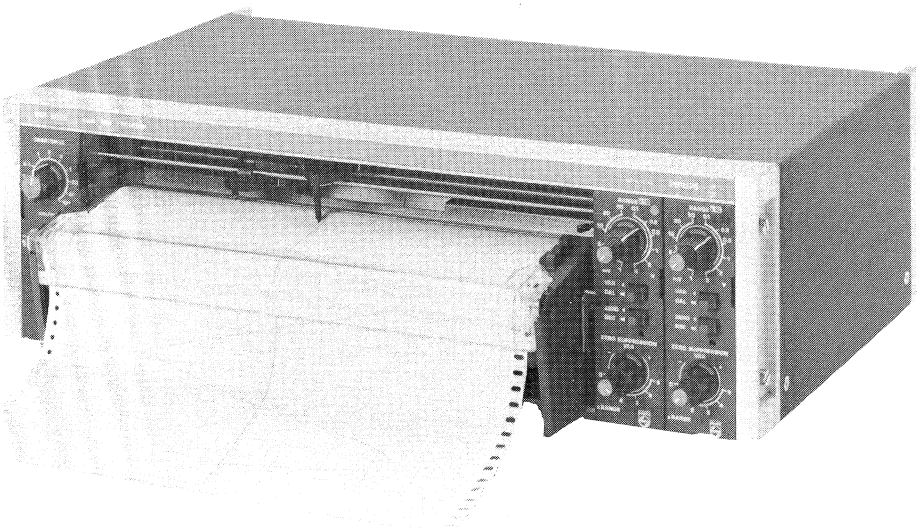
Thermocouple units with automatic cold junction compensation and linearization of output widen application in engineering and research.

Thus, by adding the required accessories it is possible to choose the recorder to meet any precise requirement.

This allows maximum versatility for maximum economy. And the mix of options can be changed at a later date should it become necessary to adapt the instrument to a different function.

Chart drive can be remotely controlled and synchronised with physical phenomena other than time. One of the control interfaces also provides for various types of output pulse–which can be used to synchronise external equipment with the recorder itself.

Front mounted controls and rear connections, plus a low 133mm profile, permit convenient rack mounting.



TECHNICAL SPECIFICATIONS OF ACCESSORIES

All accessories have to be factory-fitted in the case of initial orders or by a Philips Service Dept., if ordered thereafter. The electrical pen lift can only be fitted in the factory (see Combinations of interfaces, opposite).

INTERFACES

a. **Remote control interface PM 9861/01 (TTL level)**

- Control of:
  - Chart drive forward/reverse and start/stop at both normal and fast chart operation
  - Chart drive internal/external
- Supplies:
  - 300 Hz internal clock pulse
  - Motor pulse, freq. depending on chart speed chosen
- Possibility to connect 2 slave potentiometers PM 9865/01 with one side common
- Level:
  TTL "1" +2V...+5.5V/"0" +0.8V...–0.5V

  Ext. trigger freq: 100kHz max.

b. **Remote control interface PM 9862/01 (TTL level)**

- Control of:
  - Servo kill (channels 1 and 2 separately)
  - Electrical pen lift PM 9866/01
  - Left and right hand event markers PM 9868/05 and.../10
- Possibility to connect 2 slave potentiometers PM 9865/01 with one side common.
- Level: (see a)

c. **Remote control interface PM 9863/01 (contact closure)**

- Control of:
  - Chart start/stop
  - Chart forward/reverse
  - Electrical pen lift PM 9866/01
  - Left and right and event markers PM 9868/05 and.../10
  - Chart speed by applying external pulses
- Possibility to connect 2 slave potentiometers PM 9865/01 independently.

OTHER OPTIONS

d. **Min/max alarm units PM 9864/01 one channel – PM 9864/02 two channels.**
Permits minimum and maximum limit setting over the full scale, independently for the two channels. Slave potentiometers are included in delivery.

e. **Slave potentiometer PM 9865/01.**
Can be connected via the aforementioned interfaces. In the two line version two slave potentiometers can be fitted. Resistance approx. 3.8kΩ, max. voltage 42V

f. **Electrical pen lift PM 9866/01**
A solenoid system with appropriate fittings.
In the two line versions both pens are lifted simultaneously. Automatic pen lift when switching off the recorders.

g. **Event markers PM 9868**
Right hand PM 9868/05 and left hand PM 9868/10, mounted on the chart cassette, records in the margin between grid of paper and sprocket holes.

h. **Brackets for 19'' rack mounting PM 9867/01**

i. **Transparent front cover PM 9860/01**

j. **Linearization amplifiers**
- PM 9873/01 for thermocouple Fe-Const type J
- PM 9874/01 for thermocouple NiCr-NiAl, type K (Chromel Alumel)

One or two of these units can easily be mounted to the single- or dual-pen recorders to achieve linearised output from two types of thermocouples.

– Temperature ranges:
PM 9873/01 −200°C...+750°C
PM 9874/01 −200°C...+1200°C

– Cold junction compensation:
automatic, with moulded copper resistor, can be disconnected

– Temperature stability:
±0.06°C/°C ambient

– Non-linearity:
±1°C, with respect to IPTS 68

– Output voltage:
1mV/°C, short circuit protected

– 0°C corresponds to 0mV

CONSUMABLES

Felt pen cartridges

Packages of 10 each, 1500min. writing length,

- PM 9857/05 (red) or PM 9857B/05 (blue) for PM 8202 or upper channel of PM 8222
- PM 9856/05 (blue) for lower channel of PM 8222
- PM 9857/15 (red) for event markers PM 9868

Chart paper

Type number	Zero	Vert. lines numbered	Vert. lines divs.	Horiz.lines divs.
PM 9920/				
.../00	left	0...10	100lin.	10mm
.../01	right	10...0	100lin.	10mm
.../04	left	0...10	100lin.	15mm

ORDERING PROCEDURE

	Single range	Multirange 10mV...50V	Multirange 1mV...5V
One-line PM 8202	.../01	.../21	.../32
Two-line PM 8222	.../01	.../21	.../32

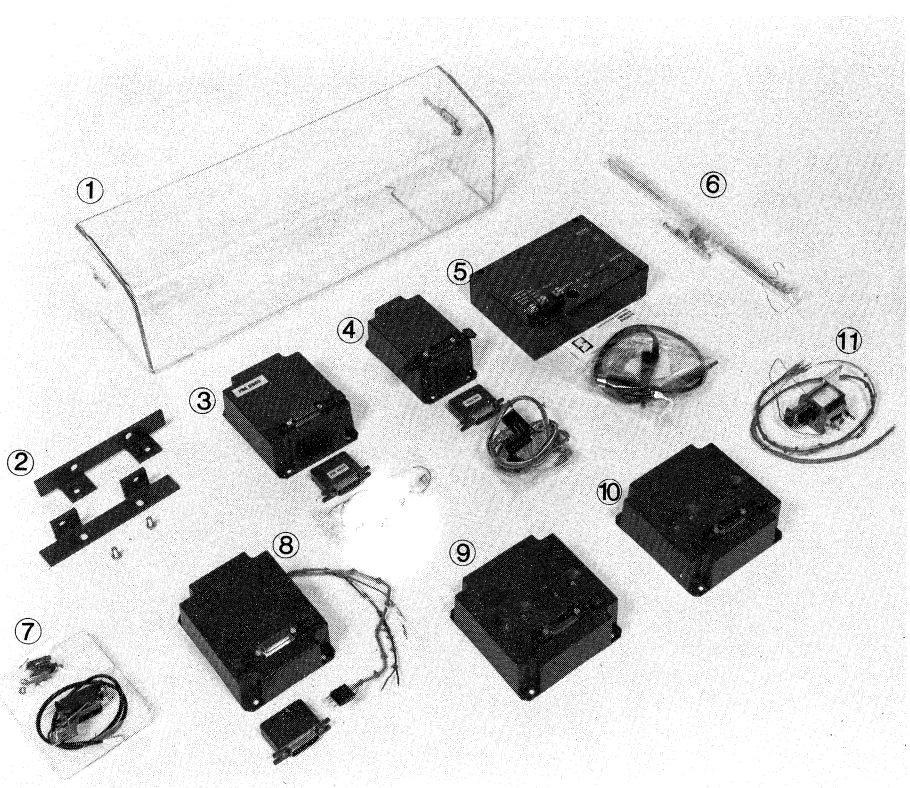
N.B. When ordering the single range .../01 version the input range unit has to be stated separately:

f.s.d.	PM 9870 M/	f.s.d.	PM 9870 M/
10mV	.../04	1V	.../10
20mV	.../05	2V	.../11
50mV	.../06	5V	.../12
100mV	.../07	10V	.../13
200mV	.../08	20V	.../14
500mV	.../09	50V	.../15

Combinations of interfaces

The following seven combinations of interfaces, alarm and linearization units are possible:

	Interface PM 9861/01	Interface PM 9862/01	Interface PM 9863/01	Alarm units PM 9864/01 or /02	Linearization unit PM 9873/01	Linearization unit PM 9874/01
1	X	X		X		
2	X		X	X		
3	X			X		
4		X		X		
5				X	X	X
6				X	X	
7				X		X



Accessories for PM 8202 and PM 8222 recorders

1 PM 9860 dust cover
2 PM 9867 rack mounting brackets
3 PM 9863 remote control unit
4 PM 9861 remote control unit
5 PM 9873 and PM 9874 temperature linearization units
6 PM 9865 slave potentiometer
7 PM 9868/05 and .../10 event markers
8 PM 9862 remote control unit
9 PM 9864/01 setpoint unit
10 PM 9864/02 setpoint unit
11 PM 9866 pen lift solenoid

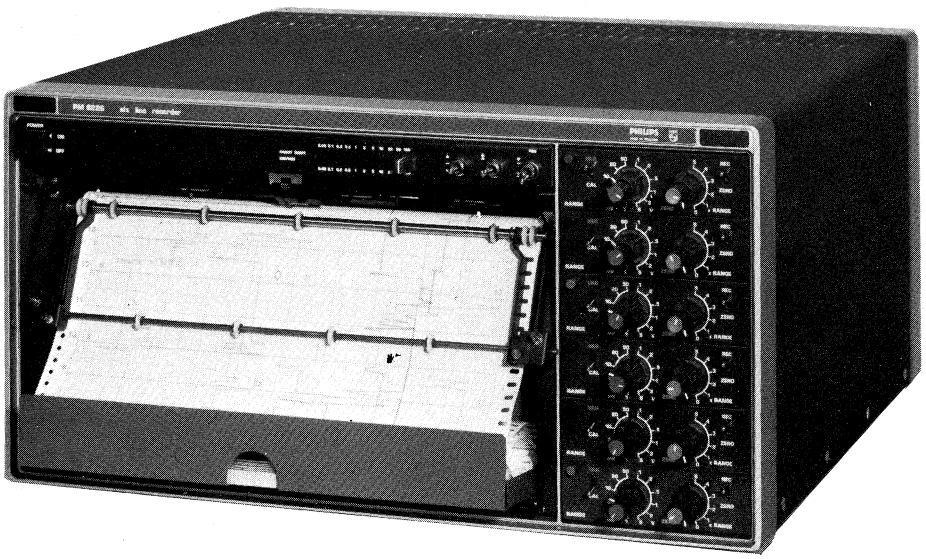
(Technical specification for PM 8202/22 appears overleaf.)

TECHNICAL SPECIFICATION

Type number	**PM 8202**	**PM 8222**	**PM 8202**	**PM 8222**
Version	.../01		.../21 and .../32	
Number of pens	**1**	**2**	**1**	**2**
Input	floating, asymmetrical, HI-LO and earth			
– Measuring ranges	1 at choice between 10 mV and 50 V f.s.d. (see ordering procedure)		multirange unit, 12 ranges in 1-2-5 sequence .../21: 10mV...50V .../32: 1mV... 5V variable control of span with 3 x increase of sensitivity	
– Input impedance	1 MΩ ± 1%			
– Isolation resistance	2000 MΩ between HI-LO and earth at reference conditions			
– Max. input voltage	$30V_{AC}$ or $60V_{DC}$ between HI-LO or HI-LO and earth			
Accuracy			.../21	.../32
– incl. non linearity and dead band	± 0.3% f.s.d. ± 0.2% of deflection from 10mV...500mV		± 0.3% f.s.d. ± 0.2% of defl. 10mV...500mV	1mV...50mV
	± 0.3% f.s.d. ± 0.4% of deflection from 1V...50V		± 0.3% f.s.d. ± 0.2% of defl. 1V...50V	100mV...5V
– dead band	0.2% f.s.d. (0.5mm)			
– zero drift	≤ 0.25μV/K			
Response time	0.25s for f.s.d.			
Overshoot	1%			
Frequency response for sinusoidal signals	–10% at 3.5 Hz at 66% of f.s.d.		–10% at 3.5 Hz (2 Hz for .../21 version) at 66% of f.s.d.	
	–10% at 5 Hz at 10% of f.s.d.		–10% at 5 Hz (2 Hz for .../21 version) at 10% of f.s.d.	
Common mode rejection – 1 KΩ between HI and LO				
AC 50 Hz CMRR	> 96dB		> 116dB	
SMRR	> 32dB		> 52dB	
DC CMRR	> 126dB		> 126dB	
Zero point				
– shift, when switching			± 0.5% f.s.d.	
– adjustment	–20%...+120% f.s.d.		continuously, ± 70% f.s.d. with respect to middle of span	
– suppression			5 steps of 100%, calibrated, acc. ± 0.4%/100%	
Chart transport				
– speeds	11 speeds, 0.05-0.1-0.2-0.5-1-2-5-10-20-50 and 100cm/min.			
– control	front panel control of start/stop, (fast)forward/reverse and speed selection (remote control optional)			
Pen lift	manual, electrical as option			
Writing system	disposable felt pens			
Chart paper	Z-fold, effective recording width 250mm, folds 75mm, length 20m			
Mains				
– voltage	switchable 110, 127, 220 and 245V –12%, +10%, 50/60 Hz, ± 1.5%			
– consumption	one line version, abt. 40VA – two line version, abt. 75VA			
Safety	IEC 348, Class I			
Radio interference	CISPR 14 Class II – VDE 0875 K-Curve			
Dimensions	440 x 133 x 350mm (17.3 x 5.2 x 13.7in) 10kg (22lb) approx.			

0.25s response time
Galvanic separation between all channels
Crystal-controlled chart transport
Very low chart speed adjustment
2.5mm mutual pen spacing
Electronic dip marker
Minimal-drift chopper-stabilized amplifiers
Optional pen synchronization unit

Multiline recorders 4-pen PM 8224 and 6-pen PM 8226



These four-(PM 8224) and six-(PM 8226) line recorders are a logical extension of the well-proven range of Philips **Compact** recorders.
Both instruments have bench-type styling but can also be rack-mounted. The cabinets occupy only a 5E height (222mm).
They are intended for use in laboratories, linked with various types of transducers and analyzers, also in quality control and material test stations as well as in industrial applications.
The major elements of overall design are the pre-amplifiers, servo-amplifiers, crystal-controlled chart transport and power supply unit. These all contain the same circuit components and basic technology already used in the **Compact** range, and include the Z-fold chart system and very reliable felt pens.
Other features include a high input sensitivity of 1mV (with continuous control increasing to 400μV), the +20% to −120% zero control and the 5×100% zero suppression, to meet the requirements of most measurement problems.
Standard features include dipmarker, electrical pen lift and remote control; an analog monitoring output is provided.

Servo amplifier
The chopper-stabilized input amplifier has been designed to ensure high-precision recording. It has a zero drift of less than 0.25μV/K and a zero shift when switching sensitivity ranges of 0.5% over the temperature range +5°C to +40°C.

Crystal-controlled chart mechanism
Special attention has been given to the basic design of the chart transport, resulting in a crystal-controlled stepper motor system with a very low max. error of ±75ppm. In practice, this represents only 1.5mm over the total 20m length of the folding chart.
Another feature caters for the desirability of a chart speed outside the standard selectable range. By a simple adjustment on the print board any of the standard speeds can be decreased by a factor of between 1 and 15.

Dipmarker
If it is required to mark an event (e.g. the identification of the actual time a phenomenon occurs) in any channel, the dipmarker facility can be operated. By means of a TTL level signal applied to the channel(s), a ± 2.5mm excursion of the pen takes place.

Recording pens
Disposable, felt-tip pens are used, being of the same type for all channels. This avoids the complications of having to use many different pen styles. For the convenience of the user, locating holes are provided on the front panel adjacent to each set of panel controls. This provides immediate visual channel colour identification and avoids loss of the caps.

Pen lift
Automatic pen lift occurs at switch-off, also when chart direction is being reversed during chart cassette replacement. Pen lift is also remotely controllable, by means of a TTL-level input applied via the external connector.

Remote control
Remote control is applicable to the servo-kill and dip marking on each channel in addition to pen lift, chart forward, stop or reverse and external chart enable. All drive signals are at TTL level and appropriate input sockets are provided.

Multiline synchronizer PM 9889
The PM 9889, designed for use with the recorders PM 8224 or PM 8226 compensates electronically for the pen distances of these recorders so that the different channels can be recorded with a common time axis.
Synchronization is obtained by delaying the recorder signals such a time that the chart paper has covered chart distances equal to the respective pen distances. This delay time is derived from chart drive pulses generated in the recorder for driving the stepper motor.
Under control of a 8035 microprocessor the analog signals applied to the recorder inputs are converted into their digital equivalent, put into the memory and at the right moment applied to the servo drive amplifiers again in an analog state.
Analog/digital conversion as well as the subsequent digital/analog conversion are carried out in the same converter which include the galvanic separation circuitry resulting in a very accurate signal reproduction.

A built-in reference signal allows for a quick visual check of correct synchronization. Any deviation from the factory-adjusted mutual pen distance of 2.5 mm can be corrected by front-panel controls.

Linearization units for thermocouples and Pt 100 resistance thermometers

In order to extend the use of Philips (and other) recorder and millivoltmeters a range of temperature units has been developed for thermocouples as well as for resistance thermometers.

The combination of the units with recorders having a zero suppression facility provides virtually any temperature recording in the full ranges of the thermocouples and Pt 100 thermometers.

The characteristic features for these units are:

- linearization units for different types of thermocouples
- two versions: free standing or suitable for building in (to PM 8202/22)
- plug-on Pt100 resistance thermometer unit
- high accuracy, low drift

Thermocouple linearization units

These units have been provided with automatic cold-junction compensation facility. This, together with the 8-segment linearization characteristic of the amplifier in order to compensate for the non-linear response of the thermocouples, gives a very high accuracy of $\pm 1^{\circ}C$.

The units are available for 2 types of the most used thermocouples, PM 9873 for thermocouple Fe-Const, type J and PM 9874 for thermocouple NiCr-NiAl, type K (Chromel Alumel).

Pt 100 resistance thermometers

The PM9877 Pt-100 linearization unit has been specially developed on behalf of the Philips multiline recorder PM 8224 or PM 8226, but can be used equally well with any other recorder. In the latter case a separate 9V power supply (mains adapter e.g. PM 9218) is necessary.

TECHNICAL SPECIFICATION FOR PM 8224 AND PM 8226

Versions

4 line recorder PM 8224/01
PM 8224/84
6 line recorder PM 8226/01
PM 8226/84

Input

Type of input: floating, asymmetrical
Meas. ranges, 12:
PM 8224/01 1mV...5V
PM 8224/84 10mV...50V
PM 8226/01 1mV...5V
PM 8226/84 10V...50V
} 2.5 x increased sensitivity by cont. control
Input resistance: 1 MΩ
Max. input voltage: $30V_{AC}$ or $60V_{DC}$ between HI and LO or between HI/LO and ground

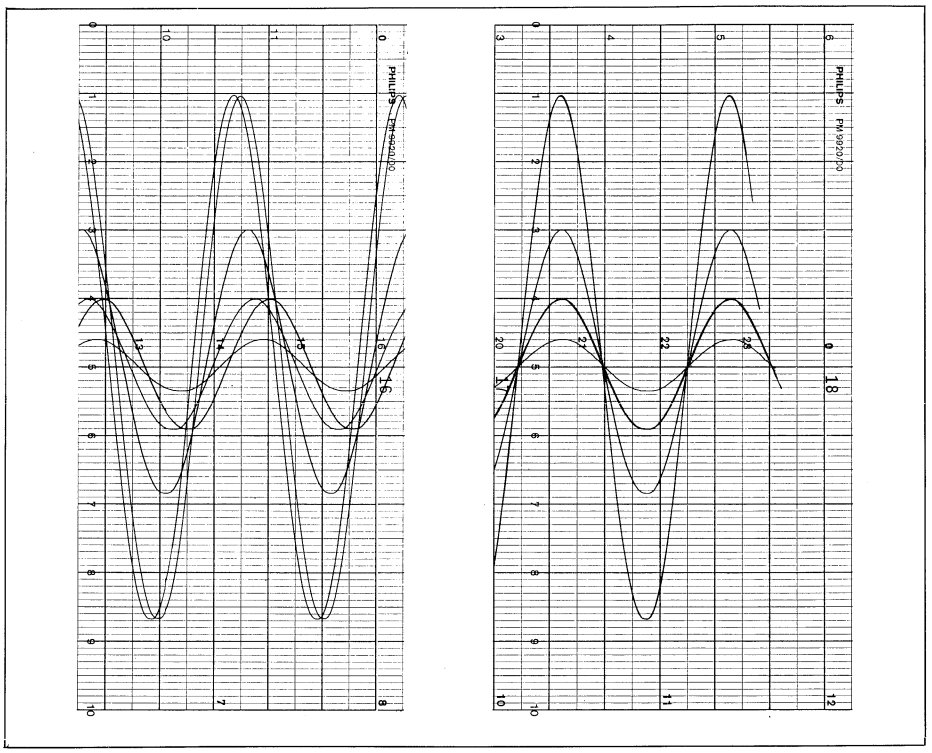


Fig. 1 Although the traces should pass through the same zero point, the pen displacement creates time-spaced results.

Fig. 2 Using the PM 9889, the time-displacement effect is time-corrected, producing a true record of events.

Isolation resistance: > 2000 MΩ between HI, LO and ground.

Static behaviour

Inaccuracy of span (incl. dead band, incl. non linarity):
≤ 50mV: ± 0.3% of f.s.d. ± 0.2% of reading
> 50mV: ± 0.3% of f.s.d. ± 0.4% of reading
Dead band: 0.2% f.s.d.
Zero drift: ≤ 0.25μV/K
Zero suppression:
Variable, +20%...−120% f.s.d.
Calibrated, 0%...500% in 5 discrete steps, inaccuracy/step ± 0.4% f.s.d.

Zero shift: Shift by switching through the ranges < ± 0.5% f.s.d. (5°...40°C)

Dynamic behaviour

Step response: < 0.25s from 5%...95%
Overshoot: < 1% f.s.d.
Frequency response (sinusoidal): −10% at 2.5 Hz at 66% f.s.d. and −10% at 3 Hz at 10% f.s.d.
Crosstalk: −60dB max.
Common mode rejection:
DC: CMRR ≥ 120dB
AC: CMRR ≥ 96dB
(> 50 Hz) SMRR ≥ 32dB

Analog output

Voltage: For each channel the conditioned signal (excl. zero shift) is available, −0.5V...+0.5V corresponds to 0%...100% f.s.d., max. error 0.6%

Chart transport

Type: Crystal controlled
Speeds: 11 speeds from 0.05cm/min...100cm/min.
Inaccuracy: ± 75 ppm max. = 1.5mm max. on 20m chart (5°...40°)
Direction: Forward as well as reverse
Division factor: Additional factor can be set viz 1, 2, 3...15
Fast transport: Both for forward and reverse = 166.6cm/min

External control: By applying externally supplied pulses

Registration

Pen distance: 2.5mm at 50% f.s.d.
Parallelism: ± 0.2mm
Pen lift: Simultaneous lift by manual or remote control; automatic lift in case of reverse transport, removal of cassette and power off. Possibility to have automatic lift at fast forward transport.
Dip marker: For each channel ± 2.5mm pen deflection triggered by negative edge of externally applied control signal.

Remote control

For each individual channel remote control of
- servo kill
- dip marker and

for general use remote control of
- pen lift
- forward, stop and reverse
- enable external chart control. All drive signals on TTL level, galvanically separated with respect to the HI/LO input correctors.

Drive and output signals

For each individual channel:
- output of the conditioned signal
- input/output for the multiline synchronizer PM 9889

On behalf of the chart transport:
- input for external control of chart speed

$$\text{chart speed} = \frac{\text{position front switch x applied freq.}}{300}$$

- output of stepper motorpulses

POWER REQUIREMENTS

Voltages: 110, 127, 220 and 245V ± 10%, switchable
Consumption: 90VA all channels in balance
110VA all channels driven by 1 Hz 100% f.s.d. signal

Warming up time

1h worst case

Climatological and safety conditions
Climate:
Working condition according to IEC 359
temperature 5°...40°C at humidity of 20%...80% R.H.
Reference condition
temperature 23° ± 1°C at humidity of 45%...75% R.H.
Storing condition
temperature −40°...+70°C at humidity of 5%...95% R.H.
Safety: According to IEC 348 Class I
Mains interference: According to CISPR 14 Class II, VDE 0875/N curve and DIN 57875.

DIMENSIONS AND WEIGHT

(h x w x d): 222 (excl. feet) x 445 x 405mm
(8.7 x 17.5 x 16-in)
approx. 21kg (46lb) PM 8224
approx. 23kg (50lb) PM 8226

ACCESSORIES AND CONSUMABLES

Accessories
- Multiline synchronizer PM 9889
- Rackmount brackets PM 9838/01
  (when mounting in 19-in rack 6 E space has to be reserved)

Consumables
- Felt pens, set of 10 pens, writing length >500m.

  PM 9875 R/01 Red
  B/01 Blue
  A/01 Black
  G/01 Green
  U/01 Brown
  V/01 Violet
- Chart paper, packet of 5 books, each 20m length
  – PM 9920/00 left hand zero 0...10.
  100 divisions linear. Time lines 10mm
  – PM 9920/01 Right hand zero 10...0.
  100 divisions linear. Time lines 10mm
  – PM 9920/04 Left hand zero 0...10.
  100 divisions linear. Time lines 15mm
  – PM 9920/05 Left hand zero 0...10.
  100 divisions linear. Time lines 2mm
  – PM 9929/... Specially calibrated, on request

Chart paper

Type number	Zero	Vert. lines numbered	Vert. lines divs.	Horiz.lines divs.
PM 9920/				
.../00	left	0...10	100lin.	10mm
.../01	right	10...0	100lin.	10mm
.../04	left	0...10	100lin.	15mm

TECHNICAL SPECIFICATION FOR PM 9889

Reproduction inaccuracy
Incl. non-linearity and noise: ± 0.1% at reference condition
Temp. influence: 0.005%/K

Drift
In "no analog delay" function ≤ 50μV/K (0.005%/K)
In "analog delay" function ≤ 200μV/K (0.02%/K)

Cross talk
Mutual cross talk between the various channels is less than 72dB

Common mode rejection
DC: CMRR ≥ 120dB
AC: CMRR ≥ 96dB
(≥ 100 Hz)

Power requirements
Voltages: 110, 117, 220 and 245V ± 10%
Frequency: 50/60 Hz
Consumption: 60VA

CLIMATOLOGICAL AND SAFETY CONDITIONS

Climatic
according to IEC 359-C1
Working conditions: 5°C...40°C at 20...80% RH, dew point 26°C max.
Reference conditions: 23°C ± 1°C at 45...75% RH
Storing conditions: −40°C...70°C at 5...95% RH

Safety
According to IEC 348 Class I
Mains interference: according to CISPR Class II and VDE 0875 K curve
Warming up time: 60min.

DIMENSIONS AND WEIGHT

(w x h x d): 280 x 90 x 325mm (11 x 3.5 x 12.8-in)
4 kg (8.8lb) approx.

Accessories
– interconnection cable between recorder and synchronizer, length 1m.
– option: rack mount unit PM 9669/03

TECHNICAL SPECIFICATIONS FOR PM 9873, PM 9874, PM 9873A and PM 9874A

Versions
- PM 9873/PM 9874: for incorporating into recorders PM 8202/PM 8222
- PM 9873A/PM 9874A: stand-alone units.

Temperature range
PM 9873/9873A: −200°C...+750°C (Type J)
PM 9874/9874A: −200°C...+1200°C (Type K)

Output voltage
1mV per °C of hot junction

Accuracy: ± 1°C with respect to IPTS-68

Drift: ±0.1mV/°$C_{amb.}$ at the output

Max. common mode voltage
$30V_{AC}$ or $60V_{DC}$

Common mode rejection
DC CMRR 126dB
AC CMRR 116dB (50 Hz or higher)
SMRR 55dB

Maximum distance between unit and recorder
100 m (A versions only)

Power supply
PM 9873/9874: from recorder PM 8202 or PM 8222
PM 9873A/9874A: 110, 127, 220 or 245V ±10%, 50/60 Hz; consumption 6VA

HOUSING, DIMENSIONS AND WEIGHT
PM 9873/9874: housing for max. 2 units
(w x h x d): 155 x 110 x 90mm (6 x 4.3 x 3.5-in)
1kg (2.2lb)

PM 9873A/9874A: free-standing housing, dustproof
(w x h x d) 165 x 115 x 90mm (6.5 x 4.5 x 3.5-in)
1.2kg (2.6lb)

TECHNICAL SPECIFICATION FOR PM 9877

Temperature range
−100°C...+700°C

Output voltage
1mV per °C of hot junction

Accuracy: ±0.3°C ±0.1% of deflection at reference conditions with respect to DIN 43760 (excl. own accuracy of Pt-100 thermometer). In the range +700°C...+800°C max. deviation of −3°C

Temperature coefficient
±100 ppm/°$C_{amb.}$ max. at the output

Drift: ±0.04°C/°$C_{amb.}$ max. at the output

Max. common mode voltage
$24V_{AC}$ or DC

Common mode rejection
DC: DMRR 120dB
AC CMRR 92dB

Influence of connection cable
4-wire connection: −0.12% of deflection/ohm
3-wire connection: 2.56°C/ohm minus 0.13% of deflection/ohm
2-wire connection: 5.15°C/ohm plus 1.87% of deflection/ohm

Measuring current through Pt100 resistor
220μA

Influence of supply voltage
0.03°C/V_{DC} with respect to nominal voltage of + 9 volt

Power supply
– when using unit with multiline recorders PM 8224/26: + 9V from recorder via cable supplied with unit.
– in any other case e.g. from mains adapter suitable for + 9V −45% +70%

HOUSING, DIMENSIONS AND WEIGHT
Plug-on unit on recorder input:
(w x h x d) 54 x 23 x 56 mm
(incl. plugs 76mm)
Weight ±400gr.

Top left and right TC linearizers PM 9873 and PM 9874A. Below left Pt-100 unit PM 9877.

Single line minirecorder PM 8110

120 mm chart width
Four calibrated input ranges and variable span adjustment
2 Standard chart speeds (3 options)
Adjustable zero setting
Built-in calibration
Compact dimensions and low weight
Mains or battery operation
Ideal for OEM

Most R & D labs will find the PM 8110 an ideal back-up recorder to support the more sophisticated types, especially where trends, rather than instantaneous values need to be seen. Industry too needs compact portable recorders for onsite monitoring or for incorporation in OEM equipment. The very compact and light weight PM 8110 will fulfil these and many other varied applications.

Used with suitable transducers, for instance, it will monitor mechanical or physical parameters: it can also find application in pollution monitoring, gas chromatography or similar chemical analyses.

The 120mm chart width achieves a 20% better resolution than conventional 100mm types and the various options for chart speed enhance the general performance. The convenient Z-fold chart allows full access to all recordings over its full length and the nylon pen ink cartridge is easily fitted or removed.

All controls are located on the front panel and a calibration facility is built-in. Easy servicing is assured by a modular design which gives easy access to all components.

TECHNICAL SPECIFICATION

Accuracy
Maximum error ± 1% of f.s.d.

Reproduceability
< 0.5% of f.s.d.

Temperature drift
< 20μV/°C max.

Input sensitivity
Push-button control, 4 positions: 10mV, 100mV, 1V and 10V
Variable span control between the ranges increases span to $100V_{f.s.d.}$

Zero setting
Continuous zero adjustment over full scale and zero check switch

Step response time
< 0.5s for f.s.d.

Frequency response
10% amplitude decrease for sinusoidal voltage with amplitude of 66% of scale: 2Hz

Chart' speeds
Two speeds, on/off switch on front panel.
(See 'options')

Chart
Z-fold chart, refolding automatically
Effective recording width: 120mm
Length per book: 15m

Writing systems
Disposable nylon pen cartridge
Recording length 1500m min.
Manual pen lift
The chart and writing system is protected by a transparent front cover.

Potentiometer
Straight rod, with direct coupling to measuring carriage
Linearity: ± 0.15% of f.s.d.

Input impedance
1MΩ

Source impedance
10kΩ max.

Damping
Factory adjusted. Overshoot < 1mm

Stray voltage rejection
With 1kΩ between HI and LO
AC CMRR 80dB
AC SMRR 15dB (40dB with optional filter PM 9881)
DC CMRR 90dB

Max. input voltage
Between HI and LO
$100V_{DC} + ACpk$ for 10mV and 100mV ranges
$300V_{DC} + ACpk$ for 1V and 10V ranges

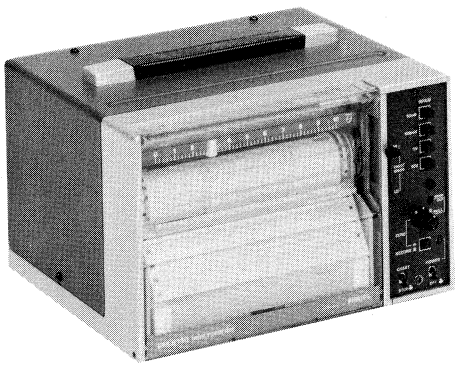
Max. voltage between LO and ground
$24V_{DC}$ (Test voltage $500V_{eff}$)

Isolation resistance
> 5MΩ between input terminals and earth

Power requirements
100-117-217-234V ±10%

DIMENSIONS AND WEIGHT

(w x h x d) 214 x 130 x 170mm
(8.4 x 5.1 x 6.9-in)
3kg (6.6lb)



PM 8110

Measuring system
Null balance potentiometric servo system with DC-amplifier and servo motor

Calibration voltage
At the rear a switch is provided which connects a 50mV calibration voltage to the input of the instrument. This voltage serves to calibrate the variable span setting.

OPTIONAL ACCESSORIES

PM 9859	DC-AC inverter. Operates from 12V or 24V (± 10%) DC supply, internal or external
PM 9397	Rechargeable battery (2 required) sealed lead acid 6V 3Ah
PM 9398	Battery charger
PM 9880	19-in rackmount kit
PM 9881	Input signal filter AC SMRR 40dB

INSTRUMENT OPTIONS

Standard versions
PM 8110/02 chart speed 0.5...2cm/min
PM 8110/22 chart speed 2...8cm/h
PM 8110/42 chart speed 2...8cm/min
Versions with chart speeds of 0.25...1cm/min., 1...4cm/min, 1...4cm/h, 4...16cm/min, 4...16 cm/h and 8...32cm/min also available on request.

CONSUMABLES

PM 9856/05	Nylon pen cartridges blue, set of 10
PM 9910	Pack of Z-fold charts, 5 books each 20m lenght, scale 0...10lin.

Provides two independent instrument functions in one compact package

Records analog and alphanumeric data on same chart

Silent operation using thermosensitive chart paper

Easily readable print font by means of microprocessor controlled print head

Service text for check of correct functioning

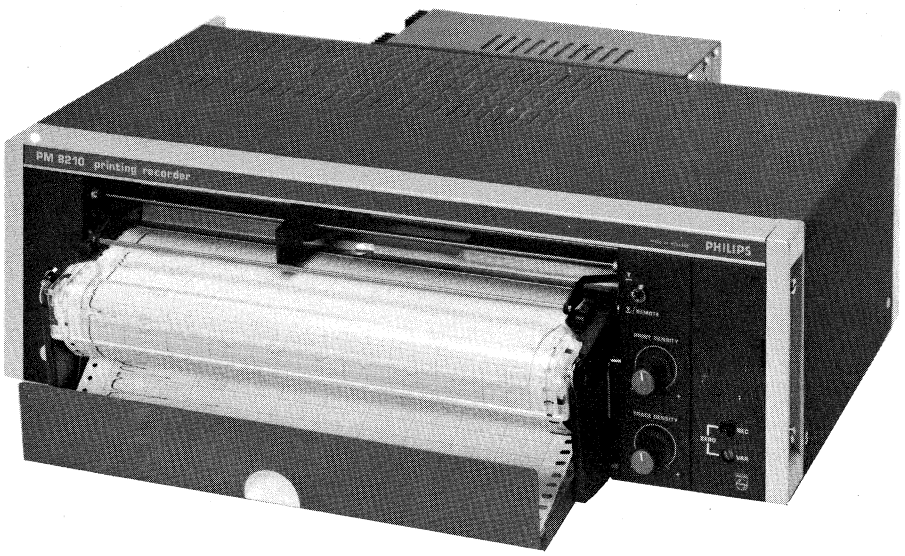
Alphanumeric print-out can be positioned anywhere on chart in the desired format by programming via the interface

High printing speed: 30 characters/s in the block mode

IEEE 488 IEC 625

Printing recorder PM 8210/11

In many analytical applications analog information remains the basis for many analysis. The information is frequently presented as a series of curves traced by a recorder; from these curves the constituent elements of a specimen and their concentration levels are deduced.
Elements are normally identified by their time relationships, concentrations are quantified by surveying the areas under the appropriate curves.
This arithmetic operation is nowadays mostly achieved using digital integrators or microprocessors, the results being hard copied by a line printer or teletype.
This invariably demands two discrete pieces of equipment; a recorder and a printer.
The Philips PM 8210/11 printing recorder combines both analog recorder and digital printer in a single, inexpensive instrument. It also offers the added advantage of positioning the print-out on any desired part of the trace. Furthermore, on the completion of an analysis, specific records of an evaluation can be printed in any desired format (as programmed) on the chart.
Typically, this facility can be used to highlight or pinpoint certain events e.g., the effect of injections of other elements during an experiment. Other possibilities include labelling of compounds, patient identity in clinical applications and of course, basic quantitative information.
The PM 8210/11 will therefore be of great interest to the OEM, supplying analytical equipment to metallurgical, physical, chemical, medical/clinical and many other specialist laboratories for experimental or routine applications.
Operation is very simple. The analog output from the analytical device is fed directly to the PM 8210/11 recorder channel. The resolved information from the processor is correctly formatted and fed via a suitable interface as a digital instruction to the PM 8210/11 printing recorder. Since the print head is moveable along the whole X-axis and the instructions contain printing and positioning information, the digital data can be overprinted on any desired part of the recorded trace. Unlike existing printing plotters the PM 8210/11 has independent operation of the recording channel and printing function. Hence the recording is not interrupted for annotation of the trace. Recordings are made on thermosensitive chart paper, which produces an easily readable trace and alphanumeric print-out. The recording/printing technique provides both silent operation and long-term reliability. Since the PM 8210/11 is one of the Philips Compact Recorder series, it occupies minimal space and can be either 19-in rackmounted or easily fitted into any OEM cabinet.



TECHNICAL SPECIFICATION

HARDWARE

ANALOG SECTION

Input
Floating, asymmetrical
Sensitivity: 1Vf.s.d. Other sensitivities on request with a maximum of 10mVf.s.d.

Accuracy incl. non-linearity and dead band
± 0.3% f.s.d ± 0.4% of reading

Response time
≤ 0.25s for full scale

Overshoot
≤ 1%

Dead band
≤ 0.2% of full scale (= 0.5mm)

Reference voltage drift
Zener diode ± 100ppm/°C

Zero drift
≤ 1μV/°C

Input resistance
1MΩ ± 1%

Isolation resistance
2000MΩ between LO and ground

Max. input voltage
$42V_{RMS}$ between HI and LO
$42V_{RMS}$ between HI/LO and ground

Stray voltage rejection
DC CMRR 126dB
AC CMRR 96dB
AC SMRR 32dB

DIGITAL SECTION

Input/Output
Serial input to be used as
– TTY 4-wire 20mA current loop ($R_{Ext} \leq 100\Omega$)
– Simplified V24
N.B. For interface options see page 134
Received characters will be echo'ed

Word composition
1 start bit
7 data bits
1 parity bit (no parity check)
2 stop bits

Baud rate
110 or 300 baud, adjustable

Input buffer capacity
100 bytes

REGISTRATION

RECORDING PEN

Type
Heated stylus

Heating time
~ 1min.

Control
Temperature and thus line thickness can be controlled from the front panel

PRINTING HEAD

Type
Semi-conductor 7 dot

Character dimensions
Horizontal and vertical dot distance
0.42mm
Height 2.9mm

Contrast
Dot temperature (and thus contrast) can be adjusted from the front of the apparatus.
Automatic correction of print head temperature by means of thermistor

Character font
64 characters in 5 x 7 dot matrix according to ISO 646

Number of characters/line
80

Print speed
– character mode 12ch/s
– in block mode 30ch/s

Carriage return time
Max. 1.4s from 100%...0%

Distance between printed information and pen position
10mm

CHART DRIVE

Chart speed
0.05 - 0.1 - 0.2 - 0.5 - 1 - 2 - 5 - 10 - 20 - 50 - 100cm/min.

Speed control
– By switch at the front, in local mode
– Via the interface in the remote mode
– Via external trigger pulses
(TTL level, width $\geq 10\mu s$ and duration $\geq 33ms$)

Positioning of the chart
Via switch at the front without influencing the software counter

Reverse chart transport
– Via switch at the front of the instrument
– Via interface commands (backwards form feed and backwards vertical tabulation)

End-of-paper detector
When no paper is left stylus and print head are lifted and input and execution of commands are stopped

GENERAL INFORMATION

Environmental conditions
According to IEC 359

Climatic conditions
Ambient temperature: reference 23°C ± 1°C
Rated range of use: + 5°...+ 40°C
Limit range of storage: – 40°C...+ 70°
Relative humidity: 20%...80%

Safety
Class 1 according to IEC 348

Radio frequency interference
According to CISPR II

POWER SUPPLY

Voltage
110, 127, 220 and 245V ± 10%, switchable

Frequency
50 and 60 HZ ±1.5%

Power consumption
200VA

Dimensions
(wxhxd) 440 x 133 x 420mm
(17.3 x 5.2 x 16.5-in)

Weight
15kg (33lb)

ACCESSORIES

Sundries
PM 9860: Transparent front cover
PM 9867: 19-in mounting brackets (set of two)

Interface options
PM 9890: CCITT V 24/standard RS 232 C
Switch selectable baud rates to 120 baud in the character mode and 9600 baud in the block mode
PM 9891: IEC-625
PM 9892: 8-bit parallel interface

Consumables
Z-fold chart thermo-sensitive paper (one pack contains 5 books, each 20m length)
PM 9930A/03: Scaled 0...10 linear, time lines at 2.5 and 10mm
(Relative humidity when using this paper 20%...70%)

SOFTWARE

CONTROL FUNCTIONS
Control functions are coded with either one code or with a code string.

Single code functions (ISO-7)
carriage return
back space
end of text
form feed
line feed
start of text
horizontal tabulation
vertical tabulation

Code string functions (preceeded by ESC-code)
backwards form feed
backwards vertical tabulation
pen up
pen down
recorder on
recorder stand-by
remote control
local control
semi X-Y
Xt mode
stop
forward
call of custom function

Programmable parameters
chart speed
horizontal tabulation definition
form feed definition

DATA TRANSMISSION
There are two modes for sending data to the printing recorder:

The character mode
When data is continuously transferred to the printer, the received character or command will be executed immediately. In case of simple serial data transmission (TTY or simplified V 24), the sending end must ensure that this is done at a correct speed. This can be done:

– by transmitting at a low enough rate (≤120 baud)
– when a format effector (carriage return, line feed, horizontal tabulation, etc.) has been sent.

In case of data transmission with handshake (complete V24, IEC-625 or 8-bit parallel) the transmission rate will be determined by the printing recorder.

The block mode
In the block mode transmission it is possible to send a text block or a sequence of control commands at a high transmission rate. After receiving the block terminator the control commands will be interpreted or a text printed at printer speed (30 characters/s).
The maximum block length is 100 characters.

INITIALISATION PROCEDURE
When switching on the instrument or when applying the "reset" control a "U" will be sent by the TTY output at a transmission speed of both 110 and 300 baud and the text "PM 8210 READY" will be printed preceeded by a line feed and followed by a vertical tabulation and a carriage return. The message can be skipped by a simple internal action.
If an optional I/O card is fitted then with the PM 9890 V 24 interface card a "☆" will be sent and with PM 9891 IEC-625 card a "SRQ" will be asked.

Six colours for channel identifications

Separate, exchangeable scale strips

Simple operation and maintenance

Sturdy metal housing

Low cost per channel

Novel linear motor without electrical connections to moving parts

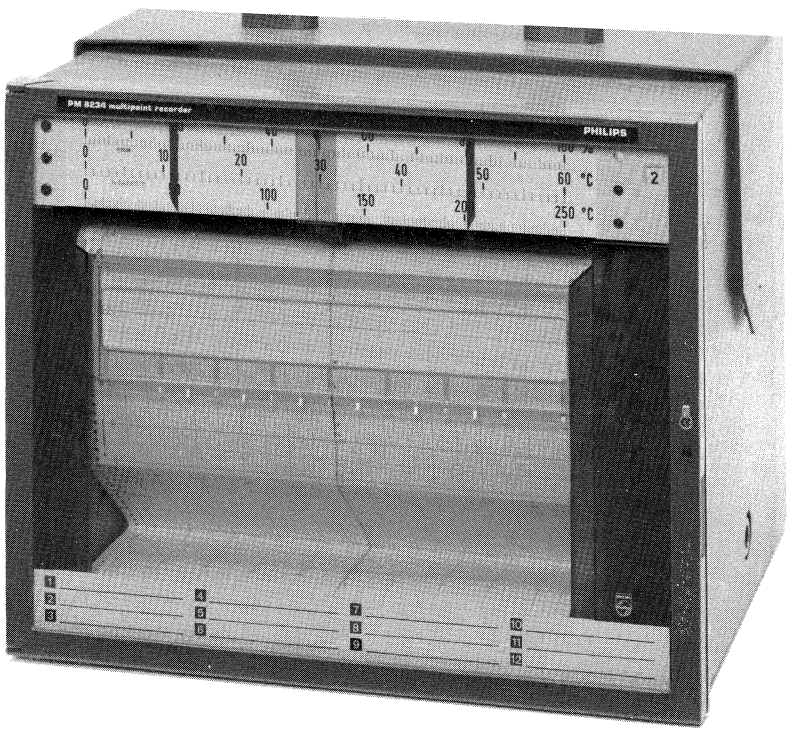
Contactless, capacitive feedback system

Hermetically protected reed contacts for channel and range switching

Quartz-stabilized stepping motors for chart drive and printing

Easy-to-use range cards for changing measuring ranges

Multi-point recorder for 6 or 12 channels PM 8234



Description

The servo-system for recording head traverse consists of a linear motor with capacitive feedback. The linear motor is a new development from Philips with a notable improvement: permanent magnets move along a stator coil, i.e. the problem of electrical connections to moving parts has been eliminated.

With an effective length of 250 mm, the capacitive displacement pick up is contactless and thus maintenance-free.
Six or twelve input channels can be allocated to 3 (max.) measuring ranges. By means of a cross connection distributor with selector plugs, allocation of measuring range to input channel is made very simple. Thermocouple measurements with or without automatic temperature compensation, a TC break protection, resistive inputs as well as current/voltage inputs are possible in any combination.

Recording is by means of dots using six colours with a channel identification on the twelve-channel recorder which produces a channel number print out at every 25th point. The electronic motor control provides six print intervals and ten chart speeds.

Measurements

Voltage measurements are possible from spans of 2mV upwards. A constant voltage source is fitted to provide zero suppression. Current measurements are derived from a voltage measurement accross a shunt resistor which is fitted on the input terminal. With a plug-in constant current source, which can be easily retrofitted, resistance measurements are possible.

The PM 8234 can be equipped with built-in temperature compensation, which is suitable for all thermocouple types. However, the recorder can also be used with external temperature compensation when the reference temperature is specified.

Mechanical construction

Accessible from the front are the door with lock, channel number indication and the panel with the controls for print interval, and chart speed selection. A moulded terminal compartment at the rear of the metal housing is protected by a cover plate and contains the connecting terminals, mains connector and fuses.

Recording and channel selection

LEDs are used to indicate the selected range (scale strip). Recording can be interrupted by an interval switch with the possibility of switch off and external control.

Limit contacts

Two optional limit contacts can be fitted. The switching state of the relays is indicated by LED's which light up when the limit value is reached.

Event marker

To record certain (timed) events, an optional event marker can be retrofitted. When the event marking relay is energized by its external contact a fibre pen is moved approx. 2 mm to the left.
If the event marker is fitted, the printing carriage movement is automatically limited to 90% of scale.

TECHNICAL SPECIFICATION

INPUT

Voltage

Span: 2mV...2V
Input resistance: $\geqslant 1G\Omega$
Quiescent current: 1nA approx.
Zero suppression: 0...2 x span, but not more than 2V.

Span: 2...40V
Input resistance: ≥10kΩ/V
Zero suppression: 0...2 x span, but not more than 33V.

Source resistance R_S ≤100Ω/mV.
max. 30kΩ

Thermocouples
Spans: see 'INPUT RANGES' p. 137.
Options (for all thermocouple types):
Built-in temperature compensation:
reference temperature 20°C; additional error ≤2K.

Built-in TC break protection; upscale action (standard) or downscale action; additional error approx. 0.02%/10Ω external resistance.

Current
Measurement derived from voltage dropped across a shunt resistor (one shunt needed across terminals of each current input).
Standard values of shunt: 10Ω, 50Ω, 1000Ω, ±0.05%, max. 0.2W temp.coeff. 25ppm/K.

Resistance thermometer Pt 100
Thermometer to DIN 43760
Measurement with built-in constant current source.
Measuring span: △R =7.8...400Ω
Span start: 10...250Ω
Thermometer current: 2mA
Resistance per lead: ≤200Ω
Lead resistance: adjustment to 10Ω with 2-wire connection; not critical with 3-wire connection.
Temperature difference measurement:
both lead resistances must be equal

Potentiometric transducer
Measurement with built-in constant current source.
Measuring span: △R = 30...500Ω
Span start: 0...0.5 x total resistance
Total resistance: ≤1500Ω (including 3 x lead resistance)
Current through sensor: 2mA
Lead resistance: no equalization necessary

RECORDING

Input channels, measuring ranges
Six or twelve-channel recorder with 1...3 measuring ranges

Basic error to IEC 484 (DIN 43 782)
≤0.25% of span, but not less than 12.5μV referred to the recorded value.

Dead band: ≤0.1% of span

Linearity error: ≤0.1%

Response time
<1s for 95% of final value

Print interval
Selectable 2, 4, 8, 16, 32 or 64s.
Internal stop switch for print drive. Print drive can also be started and stopped by an external contact.

Colour sequence
Violet, red, black, green, blue, brown

Scale
Consists of 3 strips, each with a different graduation, if required
Length: 250mm

Chart drive
Quartz controlled stepping motor
Chart speeds: 1⅔, 5, 10, 20, 60, 120, 200, 600, and 1200mm/h.
Internal stop switch for chart drive.
Chart drive can also be started and stopped by an external contact.
Additional high-speed drive: 15 360mm/h (not for continuous operation)
Error of chart drive: ≤5 minutes/month

Chart paper
Z-fold charts
Chart width: 270 mm
Recording width: 250 mm
Chart length: 32 m
Fold depth: 80 mm

POWER REQUIREMENTS

AC versions
Supply voltage: 110/120/220/240V, selectable (normal setting 220V) 48...62Hz.
Voltage tolerance: −15%...+10%
Power consumption: 18...32VA

Power supply effect
±0.1% of span (within specified voltage limits)

ENVIRONMENTAL CONDITIONS

Temperature limits
For specified accuracy: 0...40°C
For operation: −10...+50°C
For storage: −25...+60°C

Temperature effect
±0.15% of span/10K (within specified temperature limits)
±0.05% of span start/10K additionally, if zero suppression is fitted.

OPTIONS AND ACCESSORIES

Releasing contact
Semiconductor switch (open collector) fitted as standard. Switch closes approx. 0.5s before next channel is selected.
Switch rating: ≤30V_{DC} ≤40mA

Additional channel selector
Depending on versions, 6 or 12 additional relays with contacts rated at ≤100VA; ≤250V~; ≤1A~. (not suitable for low-level signals)

Limit contacts
1 min. and 1 max. limit contact possible on all versions. Electronic limit value sensing. Signalling: 1 relay per limit value with passive, normally open contacts rated at ≤100VA; ≤250V~; ≤1A~.
Adjustment: (0)1...100% of scale with screwdriver
Switching hysteresis: <1%
Two index pointers are supplied for making the selected value. LED's indicate when a limit value is reached (relay de-energized).

Event marker
Event marker is fitted to right of scale, and marking is done with violet fibre-tip pen at 100% of scale (2 mm deflection to left). Triggering is with external, normally open contact rated at ≤35V; ≤30mA.

Pen attachement
Available as mounting kit for retro-fitting.
Pen attachment enables a continuous (line) recording to be made of a single input channel. The attachment is clipped to the printing carriage and makes a violet trace with a fibre-tipped pen.

GENERAL

Dimensions and weight
(wxhxd) 360 x 288 x 295mm
(14 x 11.4 x 11.6-in)
18kg appox. (39.6lb)

Accessories supplied
1 operating instruction manual
2 recording charts
1 mains cable
2 inking wheels
2 door keys
1 channel identifying label
1 fuse each of type M 0,16 C, M 0,315 C.

ORDERING INFORMATION

Versions

Depending on the recording requirements, a correct order includes following points:
- the basic recorder (without measuring set)
- one measuring set per recording range (consisting of 1 conditioning module, 1 scale strip, 1 chart reading rule)
- one shunt resistor per current input

The required correlation of input channels to ranges must be specified. The recorder is then supplied with built-in conditioning modules, scale strips and shunt resistors. Range and channel correlation is as specified.

6 channels PM 8234/00
max. 3 measuring ranges **9404 368 50001**

6 channels PM 8234/10
max. 3 measuring ranges, 2 limit contacts and optional channel switch **9404 368 51001**

12 channels PM 8234/20
max. 3 measuring ranges **9404 368 52001**

12 channels PM 8234/30
max. 3 measuring ranges, 2 limit contacts and optional channel switch **9404 368 53001**

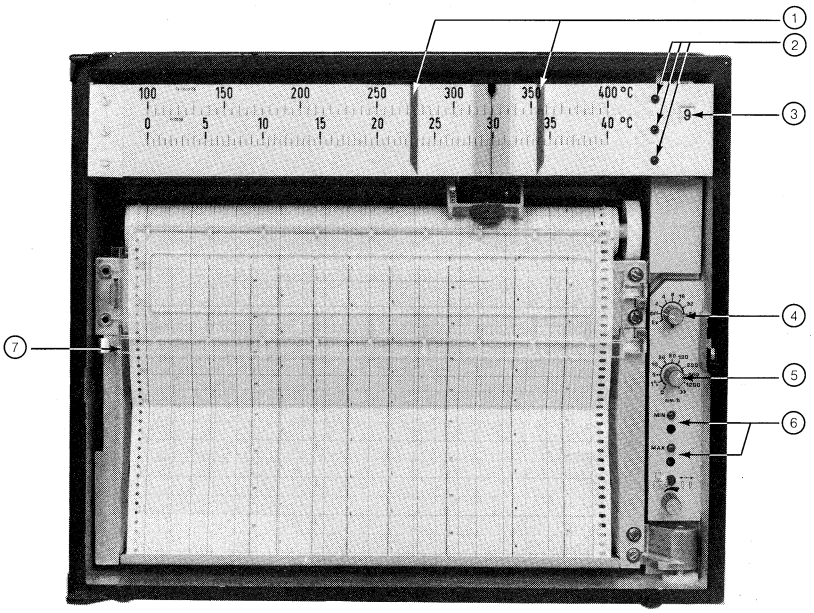
CONSUMABLES

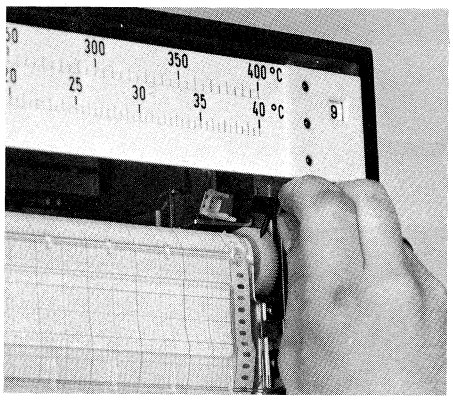
Z-fold charts
For chart speed 20/60/120mm/h: linear graduation and time lines (min. qty. 10 rolls), 32m long
4012 142 90091

• **Measuring set** (Conditioning module, scale, chart reading rule)	Order no. **9404 392 6 . . . 1**
Conditioning module	
For all inputs, including thermocouples without extras.	**1**
Thermocouple input with TC break protection	**2** [2]
Thermocouple input with temperature compensation	**3**
Thermocouple input with temp. comp. and TC break protection	**4** [2]
Code no. from table of "Input ranges"	
• **Shunt resistor**	
10Ω	**4012 151 57311**
50Ω	**4012 151 57321**
1000Ω	**4012 151 57331**
to specification	**4012 151 62301**

[1]) Complete the Order no. with the Code no. from table of input ranges.
[2]) Specify upscale or downscale action on TC break.

1 *Print interval selector*
2 *Range indication LEDs*
3 *Channel indicator*
4 *Print interval selector*
5 *Chart speed selector*
6 *Adjustment potentiometers*





Fitting the event marker.

Z-fold charts
Chart speed and graduation to specification; time lines for ≤600mm/h (min. qty 25 rolls), 32m long
9404 392 54 ..1[1]

Inking wheel
Colour sequence to DIN 43 831 **4012 151 58011**

Fibre tipped pen
(Spares for pen attachment and event marker)
2812 062 21001

Resistance thermometer Range & scale Pt 100ΩDIN	2-wire connection Ra=10Ω Code no.	3-wire connection Code no.
−30...+60°C	**50**	**60**
0... 40°C	**51**	**61**
0... 60°C	**52**	**62**
0... 100°C	**53**	**63**
0... 150°C	**54**	**64**
0... 200°C	**55**	**65**
0... 300°C	**56**	**66**
0... 400°C	**57**	**67**
To specification	**58**	**68**

LICI-humidity sensor (2-wire connection; R_a=10Ω)	Code no.
0...60°C (only Type 9404 152 01001)	**70**
To specification	**71**

Potentiometric transducer	Code no.
50-30-50Ω	**72**
To specification	**73**

Temperature-difference 2 x Pt 100Ω DIN	Code no.
(−K)...0...(+K)	**74**
0...(+K)	**75**

INPUT RANGES

Direct voltage (special thermocouple please indicate reference temperature) **Direct current** (via shunt or matching module)		Scale 0...100% Code no.	Scale to spec. Code no.
Span	2mV up to 2000mV (Suppressed zero possible)	**01**	**11**
Span	2V up to 40V (Suppressed zero possible)	**02**	**12**
0...1V	(= 0...20mA with 50Ω shunt)	**03**	**13**
0.2...1V	(= 4...20mA with 50Ω shunt)	**04**	**14**

Thermocouple	Reference temperature 20°C Fe-CuNi DIN Code no.	NiCr-Ni DIN Code no.	PtRh-Pt DIN Code no.
0... 150°C	20	–	–
0... 250°C	21	30	–
0... 400°C	22	31	–
0... 600°C	23	32	–
0... 900°C	–	33	–
0...1200°C	–	34	40
0...1400°C	–	–	41
0...1600°C	–	–	42
To specification	11	11	11

ACCESSORIES

Description		Order no.
Conditioning module for changing a range	for all inputs, including thermocouples without accessories	**9404 392 71 . .1**[1][2]
	for thermocouple input with break protection circuit	**9404 392 72 . .1**[1]
	for thermocouple input with temperature compensation	**9404 392 73 . .1**[1][2]
	for thermocouple input with break protection and temperature compensation	**9404 392 74 . .1**[1]
Scale strip for changing a range	graduation to specification	**9404 392 75 . .1**[1]
	graduation 0...100%	**9404 392 75011**
	blank scale strip	**4012 140 13551**
Chart reading rule	graduation as specified	**4012 140 32731**
Plug-in temperature compensating module	for all thermocouple types	**4012 151 57951**
Plug-in constant current source	for resistive measurements	**4012 151 57931**
Plug-in preamplifier	for all input signals	**4012 151 57891**
Shunt resistor for current inputs	10Ω	**4012 151 57311**
	50Ω	**4012 151 57321**
	1000Ω	**4012 151 57331**
	to specification	**4012 151 62301**
Compensating resistor	for lead resistance adjustment, with 6,3 mm flat-pin connectors	**9404 209 31101**
Pen attachment	for retro-fitting, complete with 2 pens	**4012 151 57701**
Event marker	for retro-fitting, complete with 2 pens	**4012 151 57681**
Signal memory unit	for correlating alarm signals to particular channels 6 channels	**9404 309 20011**
	Dimension drawing 4012 150 62611; Connecting diagram 4012 150 73841 2 channels	**9404 309 20021**

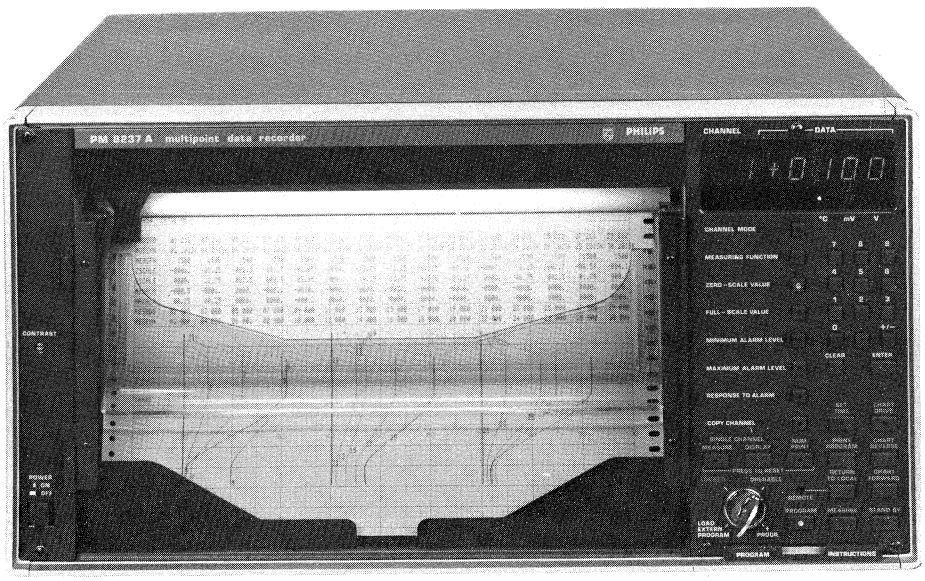
[1] Complete the Order no. with the Code no. from table of input ranges.
[2] Specify upscale or downscale action on TC break.

IEEE 488 IEC 625

Choice of graphical or numerical recordings
Up to 30-channel operation
Wide voltage and temperature ranges
Very high zero suppression
Accurate measurement of temperature differences
Stand-alone or system operation via optional bus interfaces
Remote control facilities
Max./min alarm
Transparent door for dust protection

Multipoint data recorder PM 8237

The PM 8237 is an extremely versatile digital multipoint data recorder which offers the combined advantages of traditional graphical recording with the flexibility of digital techniques.



PM 8237A version

The PM 8237A can be used as a 30-channel recorder for 2-wire applications such as voltage or temperature measurements with a common guard, or as a 15-channel instrument operating in a 4-wire mode. Typically this would be for measurements with a Pt-100 thermometer or for measurements with individually switched guards. The PM 8237B offers the same facilities, but in a 12/6-channel configuration. Both recorders will also handle any mixture of 2- and 4-wire measurements, providing **up to 30-channel** operation, depending on the mix that is used. The various connections are shown on p 141 (Fig. 3)

The values measured can be outputted either in graphical form or formatted in numeric tables. Whilst the graphs directly display trends and irregularities, printing out the values numerically (e.g., at the beginning and end of a measurement, only) gives the absolute values, directly. These values are also continuously indicated on a 7-segment LED display whilst the instrument is functioning. This display is also used for verifying input settings.

System potential

PM 8237 will operate not only as a stand-alone instrument but also in conjunction with e.g., data loggers within a data acquisition system. For system operation, two bus interface options, IEC/IEEE, RSC232C/V24 are available. Over the interface, the PM 8237A/B can output the measured values and the programmed data. The controller may synchronize the recorder measurements with other instruments in the system and has full remote control; loading new channel parameter settings, changing the chart speed, switching from graphical to numerical mode, etc. Preceeding or following a measurement, the controller can also print additional text on the chart, possibly for identification of the test, or the results of the analysis of the measured values.

Connecting the recorder directly with the digital cassette recorder PM 4202 the measurement data can be simultaneously dumped on cassette. This makes the data available for computer analysis later on. Such a set -up also allows for reading in new channel parameter settings from cassette and achieving a quick and accurate (re)programming of the PM 8237.

Ease of operation

The operator does not need any software knowledge to use the PM 8237. The built-in microprocessor-controlled series of programs allows the user to fully exploit the very wide application potential of this extremely versatile, yet uncomplicated recorder. And because all the circuitry required for all functions that both recorders offer are incorporated as standard for all models, the tedium of having to change range cards, etc., has been rendered unnecessary.

For example, the mixing of Pt-100 on any of the channels can be mixed with voltage measurements on the channels, whilst simultaneously undertaking measurements with thermocouples on other channels.

Linearization of thermocouple and Pt-100 thermometer measurements automatically provide for a direct reading in °C to select the measuring function. It is only necessary for the operator to enter all the desired parameters, e.g., zero and full-scale values, via the function keys on the front panel. (See Fig. 1).

All functions or parameters entered are verified on the LED panel, clearly labelled with the appropriate channel number. Also, all entered values can be printed out on the chart, if required.

Various output facilities

Printout can either be graphical, employing a dot pattern with individual channel identification, or it can be selected to be formatted, numerically. Standard thermal chart paper is used

(Z-fold 250mm wide X 20m long).
Results are recorded with a very high resolution of 1000 dots (maximum resolution is 1μV at a span of 1mV). The chart speed is programmed by specifying scan or print interval times. In the graphical mode the recorder calculates the measuring interval time to optimize the dot density. Chart speed is thus related to the number of measuring scans per unit of time. In the numerical mode it is the print interval time which is optimized.
Any pre-selected channel(s) may be accentuated by arranging for the printing of thicker or thinner lines, by dot density control. As previously mentioned, channel identification is by means of six different dot patterns, where each channel has its own pattern and printed numbers at regular intervals on the individual traces. In addition, any untoward event, such as power off/on, change in chart speed, etc., result in the automatic recording of the precise time of that event, on the chart.

Alarm responses
The user has the choice of several different alarm responses which can be varied for individual channels.

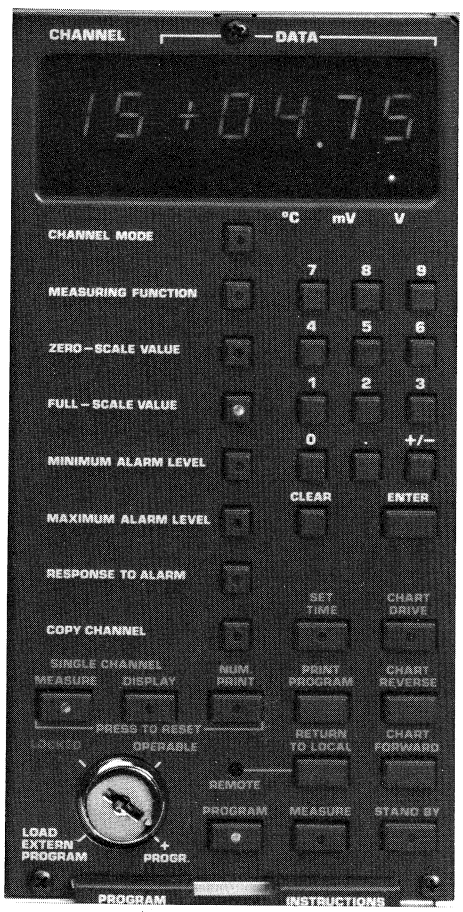


Fig. 1. A view of the operator's control panel of the PM 8237A showing the input keyboard and LED panel.

These include:
– increased line intensity
– printing on alarm conditions, only
– increase in chart speed to 'magnify' the irregularity on the printout for examination
Furthermore, there is a facility which allows the continuous measuring and recording of all channels in use but allowing one, only, selected channel to be displayed on the LED's.

Trends or facts
The user has the unique choice of employing the instrument either for interpretting behaviour patterns and trends, such as peaks or irregularites, or recording numerally. When used in the systems mode, utilizing any of the optional bus interfaces, all measuring results are available for further interpretation, calculation, or storage. Also, a complete survey of all programmed parameters can be outputted via the interface(s).

Alarm relays
In the PM 8237A it is easy to install two cards with a minimum and maximum relay for each channel. Two slots are already reserved for the PM 9895/01, one each for the even and odd numbered channels.
With this useful option the standard alarm facilities remain.

Voltage measuring
Any voltage range between –30V and +30V can be selected and with suitably selected ranges, spans can vary from 1mV up to 30V. The powerful zero suppression facility allows a selected span to be located as a 'window' anywhere over its corresponding range. The setting of span/range is achieved quite easily by simply entering zero and full-scale values of the 'window'. (See range span tables, p. 141)

Temperature measurement
Special design concepts have achieved very high levels of accuracy in temperature measurements, especially between individual channels. In the PM 8237A this has been achieved by the introduction of 'isothermal' input blocks which ensure a temperature difference between any two terminals of less than 0.25°C. Three methods of cold junction compensation are possible. These are:
– automatic compensation using a built-in Pt-100 probe
– fixed compensation at 0, 20 or 50°C
– measurement via any of the other channels (e.g., remote cold junctions).
As with voltage measurement a powerful zero suppression is offered. Thus, the span can be placed as a 'window' over the corresponding range, by setting zero and full-scale values, directly in °C.
Linearization is automatically applied as standard for the four most commonly used thermocouples, viz:
– J-type (iron/constantan)
– K-type (chromel/alumel)
– S-type (platinum –10% rhodium/platinum)
– T-type (copper constantan).

Optional linearization for 5 special types of thermocouple are available. These are:
– Type R (pt/pt, 13% Rh)
– Type B (pt/pt, 30% Rh)
– Type E (Chromel/Constantan)
– Nicrosil/Nisel
– Ni/Ni, 18% Mo
Should a break occur in a thermocouple connection, this is detected and an error message is given.
One of the important features of the PM 8237A is the difference measurement facility which produces even more accurate results. Differences can be read directly and common errors, such as cold-junction errors, are virtually eliminated.

Extended/remote control
A standard connector at the rear of the PM 8237A provides facilities for:

– external chart speed clock (which may be divided by a factor entered via the keyboard)
– command pulse to increase chart speed by 10 times (provided normal speed is less than 60mm/h)
– external scan and step commands for measuring and recording
– command to print an event marker.

Sound mechanical construction
The recorder is robust and the PM 8237A is supplied fitted with a transparent window for use in 'less clean' environments; it can be fitted into a standard 19-in rackmount. Its thermal printing head which is positioned by a stepper motor, greatly reduces the number of moving parts, significantly improving the overall reliability of the instrument and eliminating the need for regular maintenance.

TECHNICAL SPECIFICATION

Channels
PM 8237A
Maximum 30 channels for 2-wire measurements or 15 channels for 4-wire measurements or a combination of 2- and 4-wire connections.

PM 8237A/89
PM 8237/02 with date/time option including battery back-up for continuous running time with power off.

PM 8237B
Maximum 12 channels for 2-wire measurements or 6 channels for 4-wire measurement or combinations. (4-wire measurements allow for switched guard and thermoresistance measurements.)

Ranges and accuracies
Individual programming of the channels for:

Input
HI-LO and guard. Floating with respect to earth
Input impedance: 10 MΩ
Input current: <100pA
Input offset voltage: <4μV
Input offset voltage drift <0.4μV/°C
Common mode rejection ratio: >132dB for DC
Series mode rejection ratio: >47dB for 50Hz ±1%
>67dB for 50Hz ±0.1%
Maximum voltage between any input terminal and earth 60V DC or 30VAC
Input protection (between HI/LO) 100V
Test voltages between HI/LO and guard; HI/LO/guard and earth: 500V

Recording
Either graphical representation of measured values as lines (dot mode) or a numeral print out of data in tables (numeral mode), the functions selected per channel (e.g. as table heading preceeding data) and for recording of time at special events.

Z-fold chart, length 20m.
Effective recording width 250mm.

Chart drive:
- Chart speed (in dot mode)
  from 0...60mm/min and
  from 0...60mm/h
  resolution 0.25mm
- Print interval times (in numeral mode)
  1...99 min between two subsequent numeral outputs (0=min. interval time)
- fast forward and reverse
- extended control
- end of paper detection

Extended control
Standard connector at rear to provide:
- external chart speed clock (if so specified, divided by a keyboard-entered constant).
- command pulse to increase chart speed 10 times (if normal speed < 60mm/h)
- external scan and step commands for measuring and recording
- command to print an event marker

Supply Voltages
198...270V and 99...140V_{AC}
50/60 Hz ± 5%
Power consumption max. 90 VA

Dimensions and weight
(w x h x d) 444 x 222 x 435mm
(17.4 x 8.7 x 17-in)
20kg (44lb)

Climatic conditions:
(Where instrument complies with specifications based on IEC 359)
Ambient temperature +5...+40°C
(Where instrument still functions):
−10...+40°C
(Storage and transport)
−40...+70°C
Relative humidity 20...80% RH, non-condensing

Electrical safety
According to IEC 348: class I; VDE 411: class I.

Accessories and options
PM 9930A/03 1 set thermosensitive paper (5 books)
PM 9838/10 19-in rack mounting brackets

Alarm card PM 9895/01
Characteristics
1 max. and 1 min. alarm relays per channel (1 card for 15 channels)
Relay characteristics
- normally open, closed if alarm is activated
- switched power: 10W max.
- switched voltage: 200V_{DC} max., 110V_{AC}(RMS)
- switched current: 500mA max. DC or AC (RMS)
- current through closed contacts: 2A max. DC or AC

IEEE/IEC interface data

IEEE/IEC bus interface PM 9891/01
Optional: mounted inside instrument.

Interface functions
SH1 Service handshake complete capability
AH1 Acceptor handshake complete capability
T5 Serial poll possible: function TALK ONLY possible: Auto. unaddress possible
L3 Function LISTEN ONLY and auto. address possible
SR1 Service request complete capability
RL1 Complete remote/local function
PP0 No capability
DC1 Complete reset capability
DT1 Complete trigger capability
Data output in ISO 7-bit code
Service request can be marked: 1
Block and record delimiter programmable

V24 interface PM 9890/01
Functions as offered with PM 9891/.. above.
Additional commands to 'simulate' type IEC signals, e.g., group execute trigger.

1. Voltage measurements

Range	min. span	max. span	Accuracy	Measuring time (ms)
−30mV...+30mV −300mV...+300mV	1mV 5mV	10mV 100mV	±0.15% of input value + ±0.005% of range	70...1120
−3V...+3V −30V...+30V	50mV 0.5mV	1000mV 30mV	±0.25% of input value + ±0.005% of range	70...1120

2. Thermo resistance (Pt-100 measurements)

Range	min. span	Accuracy	Measuring time (ms)
−100°C...+850°C	25°C	±0.25°C +(±0.1% of input value)	1004

3. Thermocouples (with linearization)

Type	Range	min. span	Measuring time (ms)
Fe-constantin ("J") (DIN or NBS)	−200°C...+ 500°C −100°C...+ 750°C	25°C 250°C	508 485
Chromel-Alumel ("K")	−200°C...+ 700°C −100°C...+1372°C	30°C 300°C	547 515
Pt-10% Rh/Pt ("S")	0°C...+1600°C	250°C	445
Cu-constantan ("T") (DIN or NBS)	−200°C...+ 400°C	35°C	450

4. Optional thermocouples (with linearization)

Type	Range	min. span
"R" pt/pt, 13% Rh	0...+1768°C	150°C
"B" pt/pt, 30% Rh	+250°C...+1820°C	250°C
"E" chromel/constantan	−200°C...+400°C	20°C
"E" chromel/constantan	−100°C...+1000°C	200°C
Nicrosil/nisil	0...+800°C	50°C
Nicrosil/nisil	0...+1200°C	400°C
Ni/Ni 18% Mo	0...+1400°C	300°C

Note:
For thermocouple measurements the accuracy depends on thermocouple used and value measured. E.g., accuracy of chromel/alumel over range 0...70°C is ±(0.05% of temp. measured ±0.4°C). This excludes accuracy of thermocouple and error contribution of cold junction compensation; includes linearization error.

Cold junction compensation possibilities
- automatic cold junction compensation by means of a built-in Pt 100 measurement on Isothermal input block.
  Accuracy 0.5°C for the PM 8237A, at ambient temperature.
- fixed (constant) at 0°C, 20°C or 50°C.
- by temperature measurement via one of the other channels.

Full range of DIN A3 and DIN A4 recorders

High speed with acceleration for all models

5-speed time base units incorporated as standard (exept PM 8042 and PM 8032)

Multi-purpose, standard and OEM versions

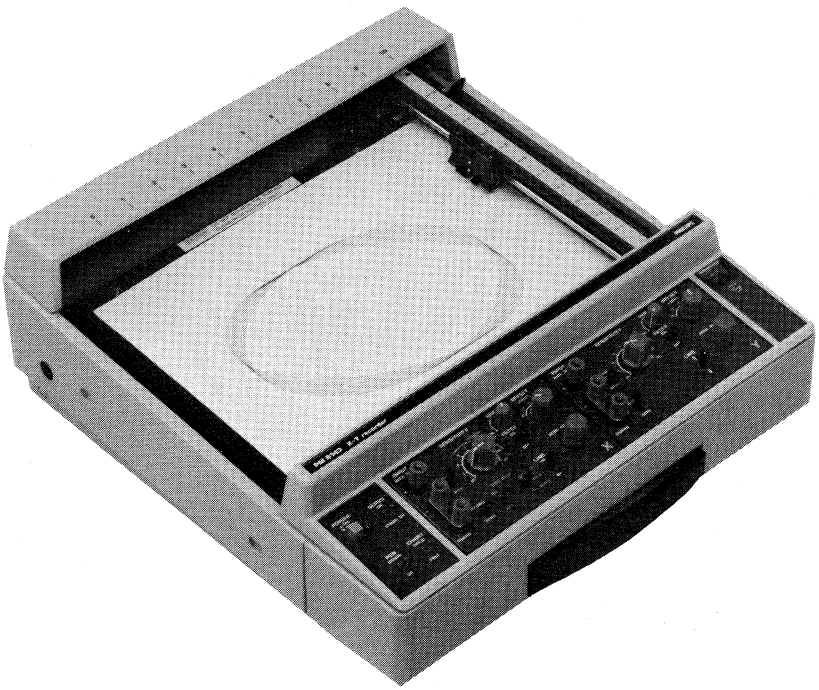
High-rigidity lightweight chassis for long-term dimensional accuracy

Modern styling ergonomically designed control layouts for easy operation

X-Y Recorders A4 size: PM 8042, PM 8043 and PM 8143 A3 size: PM 8032, PM 8033, PM 8133 and PM 8134

Each one of this family of X-Y recorder exhibits high speed and acceleratio combined with high accuracy resultin in an excellent overall response. Th recording of extremely fast phenomen for example, is easily and faithfull accomplished. Moreover, performanc is not materially affected should they b used in adverse ambient conditions.

The family of 6 units offers a choice c input ranges and sensitivities in bot DIN A3 and DIN A4 versions, plus a OEM model for use in "dedicated recording situations. There is also a twc pen unit in the DIN A3 styling.



PM 8143

Input circuitry

There is a choice between normal an high-sensitivity input unit modules. The latter offers the added advantage of up to –400% zero suppression for magnifying dynamic signals superimposed on a static signal, for example, or setting the zero point at any desired position.
A front-panel controlled filter suppresses any unwanted signal content, such as noise or high frequency components, producing a clean, interference-free recording. An added feature is the provision of limiters to protect the input circuitry in the event of too high input voltages or unduly long offscale values.

Time base

A 5-speed calibrated integral Y-t timebase is provided in all models, except the OEM version. This can be controlled from the front panel, or remotely, as required.
This variable Y-t facility, or the optional chart transport unit (A3 or A4) allows the user to make lengthy, unattended recordings.

Fast response and high accuracy

The overall performance of this series has been enhanced through increased pen speed and acceleration. The pen speeds exceed 80cm/s (X) and 120cm/s (Y) with accelerations up to 2g (X) and 5g (Y).

Easy drawing of coordinates

Results readout and interpretation are speeded and simplified by the instant line-drawing function which allows horizontal and vertical lines to be drawn accurately (up to full horiz./vert. direction) from any pen position. This is particularly useful for projecting coordinate values to the axes, or marking min/max value 'envelopes', etc. This facility is controlled from the front panel.

Robust construction

The use of integral moulded chassis for all models gives the combined benefits of exceptional strength and light weight. Most important, it makes every model highly resistant to accidental shock or damage in use. The user can thus anticipate very long-term dimensional accuracy.

Chart transport units

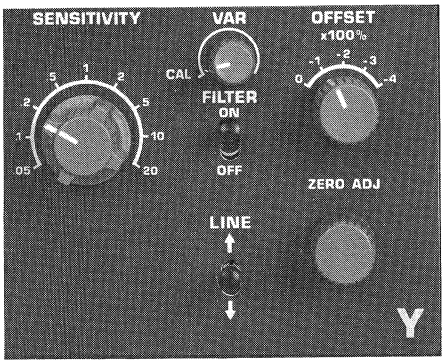
Chart transport units are optionally available for all models. They can be used for either 'single-frame' or continuous operational modes. As previously mentioned, they will allow long-term, unattended recording, if required.

All models (except PM 8042) have a built-in variable time-base facility that allows many Y-t recording functions to be carried out. 5 timebases are provided: 0.5, 1, 2, 5 and 10 cm/s on the X axis.

Many other features

Other features, common to all units, include an ergonomically-designed front panel layout, with X, Y and general controls located in clearly sub-divided zones; easily accessible front panel-mounted X and Y input sockets for fast, convenient connection; servo-kill; no-mess disposable felt pens in a wide range of colours, etc.

The individual units are described in more detail, as follows:



The models with additional input ranges (PM 8133 and PM 8143) feature built-in zero-point suppression variable between 0 and –400% in 5 ranges.

A4 models PM 8043 and PM 8143

PM 8043 – the cost-effective "standard"

PM 8043 is an economical standard-specification model that offers 9 standard ranges from 2mV to 1V/cm, plus all the other benefits of Philips new X-Y generation such as built-in Y-t capability, and a switchable low-pass filter to eliminate spurious high-frequency signals. Remote control of recording start, pen lift and time-base reset is possible, and the DC servo system for pen control permits accurate, high-speed pen movements, particulary where rapid signal changes are involved.

PM 8143 – for multipurpose A4 recording

Wide-ranging input signals from only 50μ V/cm right up to 20V/cm are handled by PM 8143, divided into 18 individual measuring ranges. PM 8143 also offers the important benefit of a variable zero offset from –100% to –400% allowing precise examination of the particular signal range that is of interest. Other features are as for PM 8043, making this model a highly versatile general-purpose instrument.

A3 models PM 8033, PM 8133 and PM 8134

PM 8033 – economy plus A3 resolution

Where the inherent extra resolution of the A3 chart format is required, PM 8033 combines this with all the other new X-Y generation benefits as in the corresponding A4 model PM 8043. Inputs are from 2mV to 1V/cm, divided between 9 separate ranges, and the high pen speeds and accelerations combined with precision construction ensure a sustained high degree of accuracy. As in all new-generation models, the convenient front-panel signal inputs are duplicated at the back for more permanent installations.

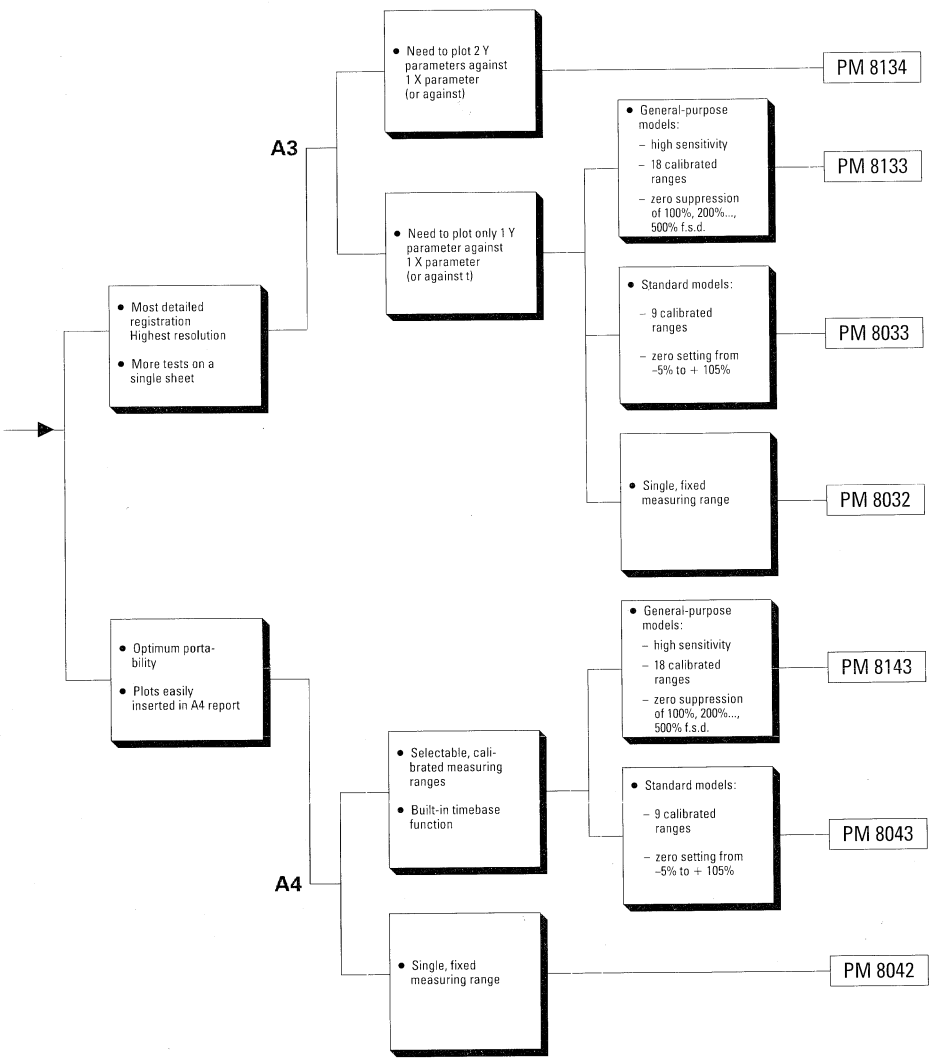
PM 8133 – A3 recording plus wide input choice

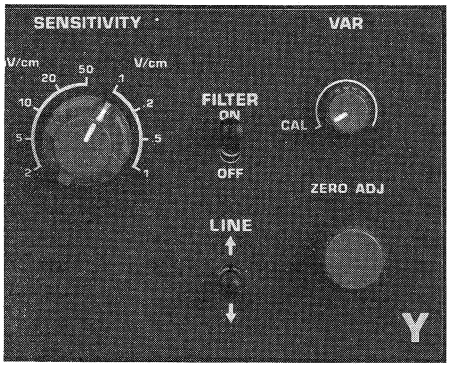
Where a wider range of signal inputs have to be covered, such as in general-purpose laboratory work, and A3 recording is demanded, PM 8133 is the ideal answer. 18 voltage ranges from 50 μ V/cm right up to a full 20V/cm cover virtually every laboratory X-Y recording need, and the standard built-in timebase gives additional, versatile Y-t recording facilities. Plus the optional chart transport unit for extended recording requirements.

PM 8134 – for 2-pen recording versatility

Even greater versatility is offered by PM 8134, which combines all the features of the A3 recorder PM 8133 with the important additional advantage of 2-pen recording, thereby allowing simultaneous recording of three related events, or plotting of two independent parameters against time using the built-in Y-t capability. Also, different pen colours can be used to enhance discrimination and interpretation of results, and pens can be quickly interchanged at any time without the need for messy and time-consuming refilling.

Performance selection chart





A wide choice of sensitivities is provided to meet the needs of varying types of measurements: 9 ranges from 2 mV/cm to 1 V/cm on the 'standard' models PM 8033 and PM 8043, and 18 range from 50 uV/cm to 20 V/cm on the extended-range models PM 8133 and PM 8143.

How to order

XY-recorders:		A4-size	A3 size
Fixed range XY-recorder, OEM-version		PM 8042	PM 8032
Standard XY-recorder		PM 8043	PM 8033
General purpose XY-recorder		PM 8143	PM 8133
Two line, general purpose XY			PM 8134
Options:			
Transparent dust cover		PM 9878/04	PM 9878/03
Chart transport unit		PM 9882	PM 9883
19" rack mount brackets		PM 9887/04	PM 9887/03
Accessories:			
5 rolls of chartpaper	(page grid)	PM 9940/02	PM 9950/02
	(continuous grid)	PM 9940/03	PM 9950/03
10 pens (same colour)	black	PM 9875 A	
	blue	PM 9875 B	
	brown	PM 9875 U	
	green	PM 9875 G	
	violet	PM 9875 V	
	red	PM 9875 R	

TECHNICAL SPECIFICATIONS FOR X-Y RECORDERS

SPECIFICATION	PM 8042	PM 8043	PM 8033	PM 8143	PM 8133	PM 8134
Recording area	DIN A4 (250 x 180mm)		DIN A3 (380 x 250mm)	DIN A4 (250 x 180mm)	DIN A3 (380 x 250mm)	
Number of pens	1 felt pen					2 felt pens
Input sensitivity for both X and Y channels	Fixed span	Multi-range in 1 - 2 - 5 sequence				
	1V f.s.d. variable 0.5...1.2V f.s.d. NB. other values on request	9 calibrated ranges 2mV to 1V/cm with increasing variable control (x 2.5)		18 calibrated ranges 50μV to 20V/cm with decreasing variable control (x 2.5)		
Accuracy/Dead band	Max. error ± 0.25% of f.s.d. (ref. temp. 23°C ± 1°C, excl. dead band, incl. non-linearity)/max. 0.2% of f.s.d.					
Linearity	Max. error ± 0.1% of f.s.d. (linearity of potentiometer)					
Writing/Vector speed	Writing speed: X : ⩾80cm/s Y : ⩾120cm/s Vector speed: ⩾145cm/s					X : ⩾ 75cm/s ⩾140 Y : ⩾120cm/s cm/s
Acceleration	X : 2000cm/s² Y : 5000cm/s²		X : 1800cm/s² Y : 5000cm/s²	X : 2000cm/s² Y : 5000cm/s²	X : 1800cm/s² Y : 5000cm/s²	X : 1400cm/s² Y_1: 5000cm/s² Y_2: 4000cm/s²
Zero adjustment	−5%...+105%					
Zero suppression				0 to −400% in 5 ranges, inaccuracy ±0.1%/100%		
Impedances	Input impedance : 1 MΩ ±10%, source impedance : 10 KΩ or less					
Damping	Overshoot max. 1%					
Inputs	Floating and guarded. Inputs parallel at rear connector (PM 8042 rear only)					
Stray voltage rejection DC CMRR AC CMRR AC SMRR		⩾ 140dB typical ⩾ 70dB typical ⩾ 40dB typical		120dB typical 80dB typical 50dB typical		
Max. overload voltage	$100V_{ppAC}/50V_{DC}$	$400V_{ppAC}/200V_{DC}$		$100V_{ppAC}/50V_{DC}$ for mV/cm ranges $500V_{ppAC}/500V_{DC}$ for V/cm ranges		
Leakage resistance	500 MΩ between input terminals and earth at $500V_{DC}$					
Safety (IEC 348 class 1; VDE 411)	Max. voltage : Guard/earth $24V_{DC}$; HI/LO and earth $42V_{DC}$; Test voltage $500V_{DC}/700V_{DC}$					
Chart hold	Electrostatic with pin-point light guides					
Pen lift	Front panel, or remotely controllable via the rear connector					
Timebase	n.a.	5 ranges 0.5 - 1 - 2 - 5 and 10s/cm on X-axis, accuracy ± 3% of f.s.d. and linearity of ± 0.5% of f.s.d.				
Chart transport units	PM 9882: 12 ranges 60...1.5cm/h and per min., continuous or one-frame mode		PM 9883	PM 9882	PM 9883: as PM 9882, but, A-3 size	
Power	110, 115, 220 and $240V_{AC}$ ± 10%, switchable by selector, 50/60 Hz. Power consumption 100VA (A4) or 120VA (A3) maximum					
Temperature range	Rated: +5...+40°C, operation −5...+50°C, storage/transport: −40...+70°C					
Dimensions: (hxwxd)	170 x 360 x 410mm (6.7 x 14 x 16.1-in)		170 x 480 x 485mm (6.7 x 19 x 19-in)	170 x 360 x 410mm (6.7 x 14 x 16.1-in)	170 x 480 x 485mm (6.7 x 19 x 19.1-in)	
Weight	9kg approx. (19.8lb)		11kg approx. (24.2lb)	9kg approx. (19.8lb)	11kg approx. (24.2lb)	12kg approx. (26.4lb)
Accessories	19-in rackmount: PM 9887/04 (DIN A4) PM 9887/03 (DIN A3) Dust cover : PM 9878/04 (DIN A4) PM 9878/03 (DIN A3)					

IEEE 488 IEC 625

Intelligent X-Y plotter (DIN A4) PM 8154

6 pens, nylon tip or Rotring Isograph

Scaled X- and Y-axes and full grids

English, German, Swedish, Finnish, Spanish, Danish, Norwegian and Greek alphabets

Extensive instruction repertoire simplifies programming

Optional programmable paper transport unit

More than 2K bytes of buffer input

IEEE488/IEC625 or V24/RS232C interface options

Manual override facility

PM 8154 is an ideal tool for use within a system set-up and allows immediate graphical representation of collected data, in various forms. Typically, it can be used to compare real values against nominal ones, show trends, give immediate visual interpretation of otherwise complex- and sometimes, confusing, statistical print-outs.
Curves or bar graphs (useful for business statistics) may be programmed. Moreover, copies of the screens of digital storage oscilloscopes can be faithfully reproduced even without the intervention of a controller. In addition, channel identification and switch settings can be included in the plot. (A typical application would be in conjunction with the Philips model PM 3305 digital storage oscilloscope.) The DIN A4 charts can be easily included in reports without folding.

Extensive instruction repertoire for easy programming

No previous computer knowledge is required to programme the PM 8154. Basic characters are used to represent one command each. For example, "H" for 'pen up', "I" for 'pen down', "F5" for 'select pen number 5', etc., etc. Similar commands are available to move the pen(s), define the character size of selected characters, and so on. Every single operation requirement is catered for in this manner. Programming is therefore made very easy and requires no special skills.
The extensive instruction repertoire caters for every possible application of this extremely verstaile plotter.

Interfacing with V24 or IEEE/IEC

Two versions of the PM 8154 are available. PM 8154B is the IEEE488/IEC625 bus-compatible version and PM 8154S is equipped with a V24/RS232C interface. These alternative model configurations allow the plotter to operate with virtually any computer. The 'S' version can be set for baud rates from 110 to 2400 baud, whilst the characters used for 'Transmit on' or 'Transmit off' can be programmed as well as those characters that will automatically (or on request) signal input buffer 'full' or 'empty'. PM 8154S can also be used in a 20mA current loop link.
The input buffer can store up to 2300 characters allowing plot commands from the computer to be sent in batches. Thus the computer is freed from its plotting task long before the plotter has completed its defined programme.

Manual intervention

Manual control of the plotter is accomplished by depressing the PAUSE key. This interrupts the computer commands and allows the user to intervene using other keys. These include:
- Pen-lift
- Pen 1-6
- Paper hold
- Pen movement: moves the pen in one of 8 directions, either fast or slowly, for accurate positioning.
- Print mode: makes the plotter act as a character printer, plotting all text received over the interface.
- Test: runs a self-test to verify that all functions are operating correctly.

Programmable chart transport

A programmable chart transport, PM 9882P, uses 15-meter long DIN A4 chart rolls. This optional unit can be programmed to advance in multiples of 1 cm. This allows a programmed plotting sequence to be made unattended, allowing the user to concentrate fully on other activities.

Wide range of character sets

Plots and drawings can be labelled in upper- and lower-case alphanumerics and there is a choice of five different National European character fonts. These are, standard ASCII English, German, Spanish, Swedish, Finnish, Danish, Norwegian and Greek.

Total package

The PM 8154 is delivered complete with all basic items, including pens and chart-paper. The package also includes a dust-cover which protects the instrument against modest levels of dust, dirt and moisure and further reduces the already low noise level of the moving parts.

TECHNICAL SPECIFICATION

Paper size
DIN A4 format

Plotting Area
X-axis 230mm
Y-axis 180mm

Number of pens
up to 6

Pen type
Nylon tip pens or
Rotring pens (1 adapter supplied)

Accuracy
less than ±0.15% ±0.3mm

Repeatability
less than ±0.3mm same pen
less than ±0.4mm different pen

Resolution
0.1mm

Positioning speed
60cm/s

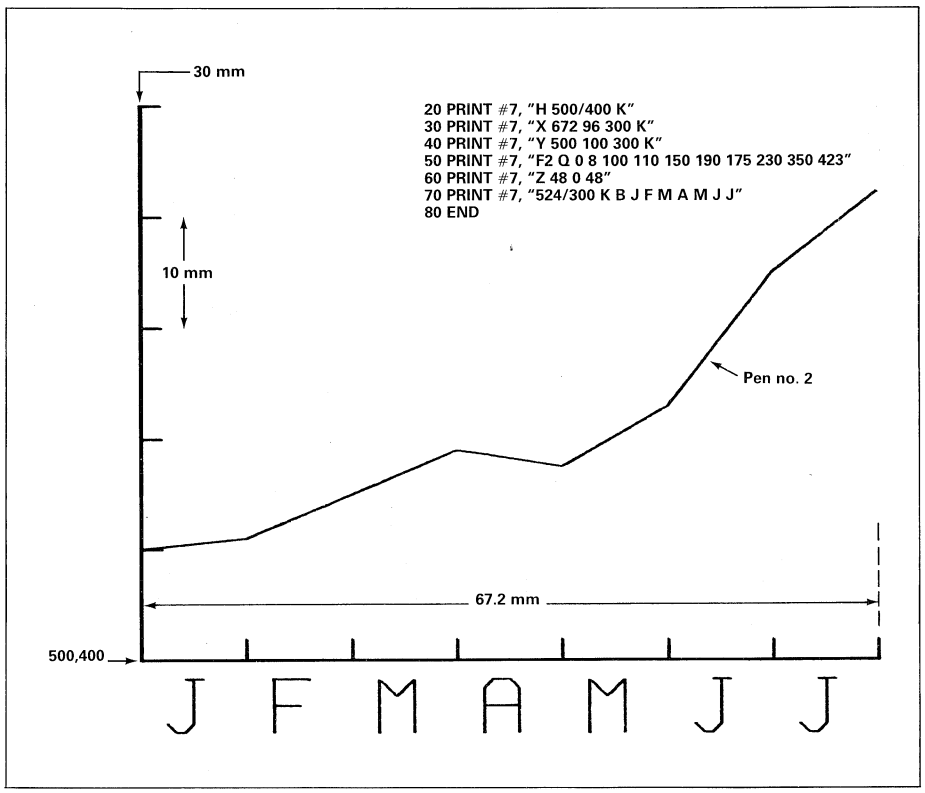
Writing speed
400mm/s along X and Y axis
200mm/s in all other directions

Penlift frequency
5 times/s

Character plotting speed
2 char/s (2mm high)

Programmable offset
−32768 ≤offset ≤32767

Progr. variable scale
1:10 (reduced); 2:1 (enlarged)



The curve shown here was created by the simple program example above.

Off-scale data handling
Pen lifted when offscale data is plotted
Alarm sounds and error light is lit

POWER REQUIREMENTS
50/60Hz; 100/115/220/240V

DIMENSIONS AND WEIGHT
(wxhxd) 360 x 150 x 410mm
(14.2 x 5.9 x 16-in)
9kg (19.826)

INTERFACE DATA
Interfaces:
IEC/IEEE (PM 8154B)
SH1 source handshake complete capability
AH1 acceptor handshake complete capability
T6 Full talker capability
L3 Full listener capability
SR1 Complete service request capability
PPO no parallel poll capability
DC1 Complete device clear capability
V24/RS232C (PM 8154S)
– asynchronous
– baudrate: 110; 300; 600; 1200; 2400 bps
– 7 or 8 data bits
– 1 or 2 stop bits
– parity off/odd/even

SUPPLIED WITH INSTRUMENT
User manual with operating and programming instructions
Set of 6 pens (one of each colour)
Set of A4 sheets
Dust cover
1 Rotring pen adapter

CONSUMABLES
PM 9869/01 set of 12 pens (2 each of 6 colours)
PM 9869/21 6 Rotring pen adapters
PM 9869/90 set of 12 pens for use on overhead sheets (2 each of 6 colours)
PM 9940/00 5 rolls blank paper, A4

Optional accessories
PM 9882 P Programmable chart transport
PW 1340 V24 cable, 5m: male-female 25-pole

Versions
PM 8154 B plotter with IEEE488/IEC625 interface
PM 8154S plotter with V24/RS232C interface

IEEE 488 IEC 625

Mini-digital cassette recorder PM 4202

Large capacity: 59K bytes per MDC track 120K bytes per MAC track

Extremely low error rate of 1 in 10^9 bits

Low-cost re-usable cassettes

Automatic error check

Simple operation with 4 front-panel keys

Selectable transmission rates with data speeds up to 6 000 bits/s

Choice of IEEE/IEC-bus compatible or V24/RS232C built-in interfaces

Remote control facility

Operates from nominal line supply or 12V battery

Lightweight and compact

PM 4202 provides a fully professional yet highly economic solution to demands for serial data storage that can easily be incorporated into OEM products and systems. The use of the now well known mini-cassette format makes the PM 4202 ideal for use in many industrial and business applications; for example many forms of serial data input systems such as NC code storage, program storage for logic analysers, data storage for multipoint recorders, word processors, cash registers etc. PM 4202 provides the user with complete remote control by means of a V24/RS232 or an IEEE/IEC interface for maximum flexibility in connection. Two versions are available giving a choice of built-in interface.

Small size with large capacity

Although an extremely compact digital recorder the PM 4202 offers very high storage capacities, amongst its other notable features. It will store up to 59K bytes of data per digital cassette track and 120K bytes per dictaphone cassette track. This allows recording of several program settings as well as blocks of measuring data. Tape formatting – including CRC 16 data – is fully automatic. Different groups of records on the same track can be seperated by an end-of-data gap, if selected. Security of recorded data is virtually absolute, with a buffer that stores all input data until after recording and successful completion of the CRC procedure (if selected). In addition, hard error rate is an extremely low 1 in 10^9 bits.

Data transfer rates of up to 6000 bits/s are achieved.

Simple, straight forward operation is another important PM 4202 advantage – particularly where operation within an overall system means data recording must be easy to initiate and control. There are only four front-panel keys (plus power on/off and cassette eject), plus nine clear indications.

TECHNICAL SPECIFICATION

Control keys

Write (1x)	leave idle mode enter write mode
Write (2x)	create EOD gap
Write (held)	erase tape
Read (1x)	leave idle mode enter read mode
Read (2x)	skip EOD gaps while reading
Reverse (1x)	leave idle mode enter reverse mode
Reverse (2x)	skip EOD gaps and rewind to begin of tape
Stand-by (1x)	leave present mode enter idle mode
Standby (1x)	in the idle mode clear buffer

Indicators

Disable keys	keys not operable
Error	error situation
Busy	tape in motion
End of tape	end of tape reached
Read data	recorder reading data
End of data	an end of data gap written or detected
Write	write mode active
Read	read mode active
Reverse	reverse mode active
Stand-by	recorder in idle mode

General specification

Tape drive	Philips Mini-Digital Cassette Recorder M-DCR 220
Recording Media	Philips Mini Digital Cassette (MDC) or Philips Mini Audio Cassette (MAC) both with Write Enable Plug
Tracks	Two, A and B side
Recording method	Bit-Serial Phase-Encoded
Data transfer Rate	6000 bits per second
Block length	64-128-256-1024 8 bit bytes, or variable in the text-mode with a minimum of 64 and a maximum of 1024 bytes
Recording Format	Preamble, data and CRC 16
Recording Density	MDC, BOT = 524 bpi EOT = 358 bpi MAC, BOT = 717 bpi EOT = 324 bpi
Capacity	MDC, 59K bytes/track: 118K bytes/cassette MAC, 120K bytes/track: 240K bytes/cassette each measured with data blocks of 1024 bytes
Tape Speed	MDC, BOT = 11.5 ips EOT = 16.8 ips MAC, BOT = 8.4 ips EOT = 18.5 ips
Rewind Time	MDC = < 96 s. MAC = <120 s.

Data Buffer	2048 byte CMOS buffer, 2x 1024 byte banks
Error Rate	<1 in 10^9 bits
Temperature operation	+5°C to +55°C
Option Switches	sw 1 disable keys sw 2 remote control sw 3 block length 64 sw 4 block length 128 sw 5 block length 256 sw 6 CRC check sw 7 auto rewind sw 8 text mode sw 9 not used
Serial	V24/RS232C interface with handshake 6 baud rates 300 - 9600, 7/8 bits word length, parity on/off, parity even/odd, stop bits 1/2, switch selectable Current loop active passive, optical isolated
Parallel	IEEE/IEC interface, with IEEE connector interface functions: -SH 1 -DC 1 -AH 1 -E 1 -T 5 -L 3 -SR 1 -RL 2
Dimensions	270x200x90mm (10.6x7.9x3.5 in) table top
Weight	2.5 kg (5.5 lbs)
Power	110-120-220-240 V_{AC}, +15%/−15%, 50-60Hz; or 11.5-15 V_{DC} (battery); 5VA;

Ordering information:
PM 4202/01 with V24/RS232 C interface
PM 4202/21 with IEC/IEEE interface
LDB 4401 digital mini cassette; 8920 440 10101
LFH 004/00 Mini audio cassette 8935 000 21001

Program instructions
The system recognises nine commands of two characters that can be given over the interface: an introductory character escape (ISO 7-bit code ESC, dec. equivalent 27) and the command character itself.

ESC C or ESCc 1x : leave idle-mode, enter write mode
ESC C or ESCc 2ex : create EOD gap
ESC D or ESCd 1x : leave idle-mode, enter read-mode
ESC D or ESCd 2ex : skip EOD gaps, while reading
ESC A or ESCa 1x : leave idle-mode, enter reverse mode
ESC A or ESCa 2ex : skip EOD gaps, while reversing
ESC B or ESCb 1x : leave present mode, enter idle-mode
ESC B or ESC B*2ex : clear buffer
* only necessary in other than idle mode.

ESC P or ESCp : reset system
ESC W or ESCw : give status
ESC @ : leave idle mode start rewind

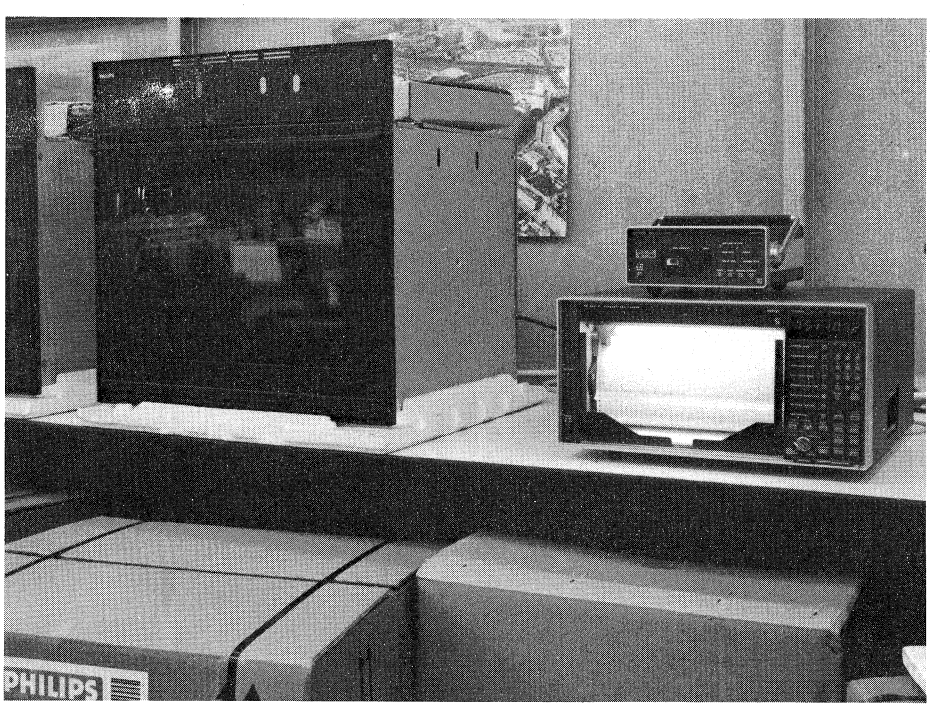
Status information
The system always answers the 'give status' request with the introductory escape (ESC) character and a set of three characters.

The first character tells the mode in which the system operates. The second character shows the status of the system. The last character reflects the status of the cassette.

The first character has five possibilities.
ESC Cxx : write-mode active
ESC Dxx : read-mode active
ESC Axx : reverse-mode active
ESC Bxx : recorder is in the idle-mode and accepts commands
ESC @ xx : recorder is in the idle-mode but does not accept commands

The second character has six possibilities.
ESC xFx : rewind-fast reverse
ESC xEx : error
ESC xDx : data is actually read
ESC xCx : end of data gap-clear tape
ESC xBx : Begin, end of tape
ESC xAx : busy-active, tape is moving
ESC x@x : nothing to report

The third character has three possibilities.
ESC xxF : cassette Free
ESC xxE : cassette Write Enabled
ESC x@D : cassette Write Disabled



PM 4202 storing measurement data obtained from PM 8237.

IEEE 488 IEC 625

Digital Data Cassette Recorder PM 4201

Intelligent digital recorder for operation with or without controlling computer

Directly connectable to bussable instruments, teletypes, VDU's, digital oscilloscopes, counters, multimeters, data loggers, printers and logic analysers etc.

Computer and key-board controllable

Binary operation mode

Lowest error rate: less than one bit in 10^9 bits

Interface options – IEC Bus (IEC 625/IEEE 488); V-24 (RS232-C); current loop (20mA/TTy); 8-bit parallel with handshake

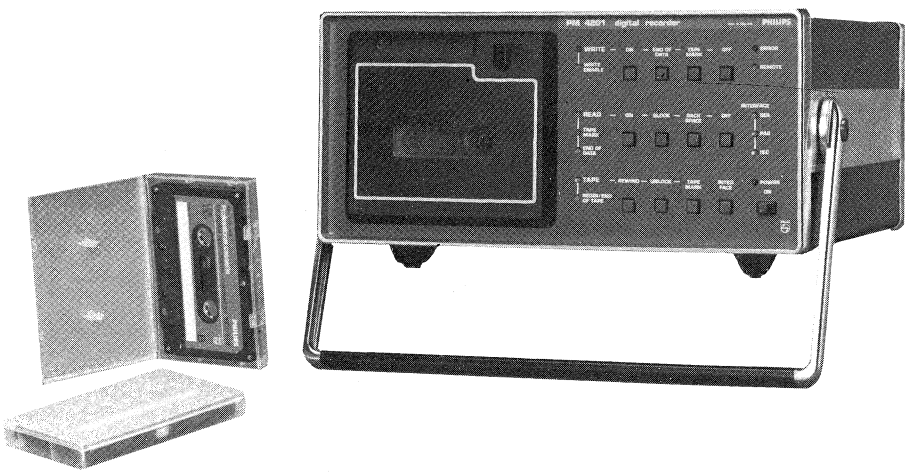
Applications

The PM 4201 is a data recorder featuring full front panel control facilities and state-of-the-art techniques, including a microprocessor, that are used to produce an extremely low error rate of one bit in 10^9: a figure some 100 times better than that of other data recorders. This is achieved by using cyclic redundancy checks and repeated writing and reading cycles.

The recorder uses the well-proven Philips professional digital cassette system. This meets both ECMA 34 and ISO 3407 standards and has been universally adopted by leading computer manufacturers, thereby allowing the PM 4201 to be used for a wide variety of on- and off-line data processing applications.

Because of its magnificent off-line facilities the PM 4201 can operate as a self-controlling stand-alone device, e.g. in factories, laboratories, offices and shops. It is an important component of data acquisition and test and measuring systems, e.g. as storage for multipoint data recorder, digital oscilloscopes, counters and multimeter values to enable later data processing.

PM 4201 is also a versatile computer peripheral in desk top computer, mini-computer, small business computer and other applications.



General description

The PM 4201 is an intelligent digital data cassette recorder, capable of writing and reading data in accordance with ANSI/ECMA-34/41 specification, the SILENT format (see Fig. 1) or P 800 text editing facilities.

The PM 4201 is a self contained unit.

The hardware consists of:

- digital cassette recorder
- central processor unit
- cassette controller unit
- up to three interfaces
- keyboard/display unit
- mains supply unit
- housing (portable tabletop or rack-mount).

The tape medium is a Philips digital cassette with begin-of-tape and end-of-tape holes. Tape speed is 7.5 ips for normal operation and 75 ips for rewind. The capstan motor is switched off, if during more than 10s no writing or reading is performed. A dual gap write/read head permits read-after-write check so that error free writing is achieved.

The PM 4201 can be operated manually via the keyboard/display unit with status display via LED's. Remote operation is accomplished via the activated interface by command character sequences embedded in the entered data (see command list).

Binary operation is also possible via a command that predetermines a number of characters that should be treated as data only.

The central processor unit contains a microprocessor, 2k static RAM and 8k PROM with the operating system.

The data entry buffer has a capacity of 2 x 256 bytes excl. command sequences so input can continue during write on tape. In case of entry buffer overflow the data transfer is temporarily suspended via the handshake lines of the interface.

If the power-fail option is installed, data integrity is maintained during write with the use of CMOS-RAMS and repositioning the tape at the last block written. Writing recommences when power is reinstated.

The cassette control unit contains several DIP switches which define the operating mode and data-formatting after power-on. Remote commands can alter these settings dynamically.

The interfaces are contained on easily accessible Eurocards.

The PM 4201 can contain up to three interfaces for data communication: serial V24/RS232C and current loop (20mA) parallel 8 bit with handshake and/or IEC-625/IEEE-488.

Switching from one interface to another is possible both remotely and manually, i.e., via the keyboard.

Immediate commands are executed immediately upon entry independent of current command execution. Examples are: "inhibit local", interface with IEC-card. These commands correspond with internal switch settings.
Stacked commands are stored, queued and executed one at a time in order of their entry. Example: entry of "rewind", "search tapemark forward", "read block", "rewind", "unlock" will be processed and executed in the given order without further attention necessary.
Immediate commands can be converted to stacked commands by a command preceding them. Example: switching to another interface can be ordered to be executed after completing a search for tapemark.

There are three different operating modes:
– IDLE mode
– WRITE mode
– READ mode

In the IDLE mode tape motion commands are allowed. From the IDLE mode the PM 4201 can be switched to the WRITE mode or to the READ mode.
In the READ mode no write commands and some tape motion commands are allowed. In the WRITE mode no read commands or tape motion commands are allowed.
Data entered in the IDLE mode or in the READ mode is checked for command sequences only. All other data is ignored and not stored.
Data entered in the WRITE mode is also checked for command sequences. These sequences are processed separately. All other data is stored in the write buffer.
The PM 4201 is fully compatible with ECMA 34 and ISO 3407 standards for data interchange on 3.81 mm magnetic tape cassettes. These standards define details such as tape quality, codes, format, cyclic redundancy checks, etc., and are being adopted increasingly by all computer manufacturers.

Philips digital cassettes

The Philips professional, twin-hub, coplanar type digital cassette is used. The tape is certified as having been tested for 1600 flux changes/inch for drop-outs, drop-ins and amplitude. Beginning and end-of-tape markers are built in.

Construction for framework and guides allows the highest possible precision in tape guidance and handling over long lifetimes.
Cutouts are also provided for write-enable plugs.

FORMATS

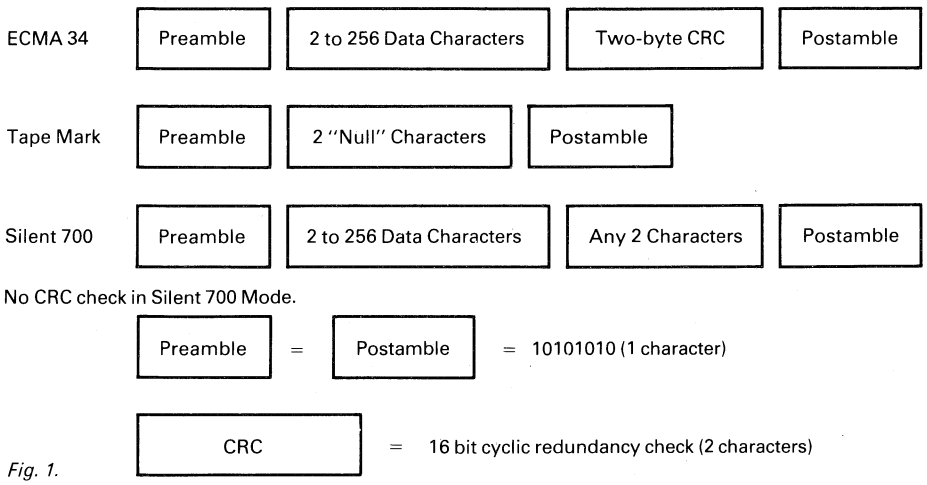


Fig. 1.

Digital cassette system

The Philips digital cassette system is a high-performance professional tape deck, specially developed for electronic data processing applications. Its versatility and reliability have already been proven in many other instruments and systems. The drive system is three-motor, bidirectional and capstan controlled. The deck itself is a metal pressing giving the advantages of rigidity and low weight. It is fitted with a high performance single track, read-after-write head.

STATUS CHARACTERS AFTER 'GIVE STATUS' Esc W

Char.	Function
0	ready for new command
1	busy with command execution
2	READ mode active
3	WRITE mode active
4	2nd write buffer not empty
5	tapemark written/detected
6	end of data gap written/detected
7	irrecoverable write/read error
8	tape is rewinding
9	search for tapemark in progress
A	A-side of cassette present
B	Begin/end of tape (transparent leader) present
C	Cassette not inserted
D	local control Disabled
E	write-Enable plug in cassette present
F	Free cassette: cassette not locked
H	BOT/EOT hole detected

STATUS CHARACTERS AFTER 'ENABLE AUTO STATUS REPORT' Esc X

Char.	Function
Esc:	the status of the PM 4201 has changed. more information can be obtained by entering 'give status' Esc W
Esc =	the execution of a command has been completed
Esc ?	the command cannot be executed and is not accepted

AUTONOMOUS STATUS CHARACTERS

Char.	Function
Esc;	The EOT hole has been detected. The WRITE mode should be left.
Esc!	An irrecoverable write error has occured.

OPERATION CONTROL

Manual front keys:
WRITE ON
WRITE END OF DATA
WRITE TAPEMARK
WRITE OFF

READ ON
READ BLOCK
BACKSPACE
READ OFF

REWIND
UNLOCK CASSETTE
EJECT CASSETTE
SEARCH TAPEMARK FORW./BACKW.

SELECT INTERFACE

POWER

TECHNICAL AND ORDER DATA

PM 4201 MAINFRAME

Format:
ECMA-34 and if selected ECMA-41 (labelling)
incl. pre/postamble
CRC-16
tapemark
end of data gap
SILENT-700®
P 800

Block length:
2-256 8 bits bytes in increments of 1 byte

Tape speed:
7.5 ips normal operation
75 ips rewind
Motor shut-off during pauses

Physical
Size W x H x D:
280 x 135 x 335 mm table top or rackmount

Weight:
7.5 kg

Power:
110-120-220-240 VAC + 10% – 10%
50-60 Hz
50VA

Environmental
Temperature:
+ 5 ... + 45°C

COMMAND LIST: SHORT FORM

Command	Key	Type	Function Stacked (S)/Immediate (I)
	Tape motion		
Esc C	REWIND	S	rewind tape to leader
Esc U	TAPEMARK (2x)	S	skip forward up to next tapemark
Esc V	TAPEMARK + BACKSPACE	S	skip backwards to next tapemark
Esc A	BACKSPACE	S	backspace tape one block
Esc O	UNLOCK	S	unlock cassette
	WRITE mode		
Esc C	WRITE ON	S	enter WRITE mode, write contents of buffer on tape with variable block length (min. 2 bytes)
Esc B	WRITE OFF	S	leave WRITE mode, write contents of buffer on tape with fixed block length, if necessary padded with zero bytes
Esc E	WRITE END OF DATA	S	write contents of buffer on tape, followed by a EOD-gap 400 mm
Esc M	WRITE TAPEMARK	S	write contents of buffer on tape, followed by a tapemark
Esc J	local only	I	transparent write: the given number of bytes following will not be
+1–4	digits		checked for commands
+			
Esc Q		I	change data format:
+1–3	digits block length		change fixed block length and/or
+.			
+1–4	characters line		change add-on characters
+.			
Esc R	block length line	I	return to standard block conditions in accordance with internal switches setting
Esc S	crc	I	enable CRC generation and check
Esc T	crc	I	disable CRC generation and check
	READ mode		
Esc D	READ ON	S	enter READ mode + read continuously
Esc G	READ OFF	I	leave READ mode immediate, stop outputting data
Esc L	READ BLOCK	S	enter READ mode + read one block
Esc F	READ BLOCK	S	reset error condition + output faulty data
Esc A	BACKSPACE	S	backspace tape one block
Esc U	TAPEMARK	S	skip forward up to next tapemark
Esc V	TAPEMARK + BACKSPACE	S	skip backwards to next tapemark
Esc S	crc	I	enable CRC generation and check
Esc T	crc	I	disable CRC generation and check
	Miscellaneous		
Esc H	–	S	the following command is stacked
Esc (	–	I	enable Hex mode
Esc)	–	I	disable Hex mode
Esc +	local	I	enable local control
Esc –	remote only	I	disable local control
Esc I	INTERFACE	I	interface with IEC card
Esc K	INTERFACE	I	interface with PARallel card
Esc N	INTERFACE	I	interface with SERial card
Esc P	READ OFF (2x) + WRITE OFF	I	general reset equivalent to power-on reset
Esc W	–	I	give status
Esc X	auto status	I	enable auto status report
Esc Y	auto status	I	disable auto status report
Esc Z	–	I	change lead-in character from Esc to the given
+ 2	characters		Hex character
+.			
Esc [	P 800	I	enable P 800 mode
Esc]	P 800	I	disable P 800 mode
Esc \	SILENT-700	I	enable SILENT-700 mode
Esc ←	SILENT-700	I	disable SILENT-700 mode
Esc ↑	–	I	clear write buffer
Esc ·xxx·			String search max. 16 characters
Esc ·yyy·			String length for IEC-bus
Esc *zzz			IEC-bus delimited parameter
Esc /			Clear command buffer

The commands may also be given in Hex Code.

FRONT PANEL INDICATORS:

WRITE	WRITE mode active
READ	READ mode active
REMOTE	remote only, no local control possible
ERROR	an irrecoverable read/write error has occured
WRITE ENABLE	a cassette with write enable plug is present
TAPEMARK	a tapemark has been written/detected
END OF DATA	an end of data gap has been written/detected
TAPE	the tape is in motion
BEGIN/END OF TAPE	the begin-of-tape/end-of-tape hole or the transparent leader has been detected
SER	the serial interface is active
PAR	the parallel interface is active
IEC	the IEC interface is active
POWER ON	the PM 4201 is switched on and connected to the mains

Thermal shock:
11°C/hour

Relative humidity:
20-80% without condensation

Air pressure:
780-1100 millibar

Heat radiation:
direct sunlight radiation not allowed

MEDIUM

LDB 4301
Philips cassette ECMA-34 compatible two tracks A/B write enable plug

Method:
800 BPI phase encoded single track

Capacity:
260 k bytes/track
520 k bytes/cassette

BOT/EOT holes:
photo electric detection

INTERFACES PM 9401 (1...3 possible)

PM 9401 R SERIAL INTERFACE
V24/RS 232 C (DTE) with handshake.
Current loop passive/active.
All lines optically isolated/
ISO characters 7/8 bits, parity on/off/
even/odd, stopbit: 1/2
14 Baud rates 50-19200

Connector: DB-25 (male)

PM 9401P PARALLEL INTERFACE
ISO 7-bit code and BCD
8 bits/byte input
ISO 7-bit code
8 bits/byte output
handshake on input and output
enable/disable line for cascading of several PM 4201 (FACIT 4070 compatible)
BCD input, all lines optically isolated

Connector: DB-25 (male)

PM 9401 E IEC 625 INTERFACE
8-bit parallel data and address
8 control lines
address 00-15

Bus commands: SH1, AH1, L3, T5, SR1, RL2.

Connector: to DIN IEC 6622, 25-poles

PM 9401 F POWERFAIL PROTECTION
Battery back up for all functions, battery capacity 1 year

PM 9401 M RACK MOUNTING SET
19-in-Rack mount, 4HE

PM 9480 IEC CABLE
length 1 m.

PM 9482
Same as PM 9480, length 4 m.

PM 9483/50
IEEE/IEC Adapter (male)

PM 9483/51
IEC/IEEE Adapter (female)

PM 9487/10 IEEE
Acc. IEEE 488, length 1 m.

PM 9487/20
Same as PM 9487/10, length 2 m.

PM 9487/40
Same as PM 9487/10, length 4 m.

Consumables for recorders

PEN CARTRIDGES FOR PHILIPS X-Y RECORDERS, LINE RECORDERS AND PLOTTERS

	Description				Line recorders							X-Y recorders				Plotters	
	Type number	./	/...	colour	8110	8202/8222 channel		8224 8226	8251/8252 channel		9868 event marker	8040 8041 8131	8033,8042, 8043,8133, 8134, 8143	8132 channel		8151	8154
						upper	lower		upper	lower				upper	lower		
	PM 9856[1]	–	01	blue								•					
	9857[1]	–	01	red								•					
	9856	–	05	blue	•		•			•							
	9857	–	05	red		•			•								
		B	05	blue		•			•								
	9857	–	15	red							•						
	9856	A	10	black								•		•[2]			
		–	10	blue								•		•[2]			
		R	10	red								•		•[2]			
		S	10	set of colours								•		•[2]			
	9857	–	10	red											•[2]		
	9875	A	01	black				•					•	•	•		
		B	01	blue				•					•	•	•		
		U	01	brown				•					•	•	•		
		G	01	green				•					•	•	•		
		V	01	violet				•					•	•	•		
		R	01	red				•					•	•	•		
	9876	A	01	black												•	
		B	01	blue												•	
		G	01	green												•	
		R	01	red												•	
		S[3]	90	set of 5 colours												•	
	9869		01	Set of 2x6 cols.													•
			09[3]														•[3]

[1] To be used with penholder PM 9858/01 [2] Former writing system [3] For overhead sheets

Also available: set of 4 ink wheels PM 9839/02 for PM 8236

Chart paper table

REVIEW OF CHART PAPER FOR PHILIPS MULTIPOINT, PRINTING, LINE, X-Y RECORDERS AND PLOTTERS

			Line recorders				Multipoint (data) recorders			Printing recorder	X-Y-recorders				Plotters	
											A4		A3			
	Type no.	/..	8110	8251A 8252A	8202 8222	8224 8226	82.. 34	82.. 36	82.. 37	8210	8040 8041 8141	8042 8043 8143	8131 8132	8033 8133 8134	8151	8154
120mm Z-fold paper	9910	01	•													
250mm Z-fold paper	9920	00*		•	•	•		•								
250mm Z-fold thermosensitive	9930A															
blanc		02							•	•						
grid 0-100		03							•	•						
grid 0-10		05							•	•						
Roll paper blanc	9940	00														•
A4 page grid		02									•	•				
A4 cont grid		03									•	•				
A3 pag grid	9950	02												•		
A3 cont grid		03												•		
A3 grid roll	9951	03												•		
Roll A3 paper (blanc)	9950	02													•	
Chart roll	9901	00														
flatbad recorders	9902	00														
	9905	00														
Z-fold charts 4012 142 90091							•									
Paper																
0-100 lm	9901		8000													
0-10 lm	9902	for	8100													
-10-0-100 lm	9905		8010													

* See p. 7.

Multimeters and voltmeters

Unit	Description	Voltage ranges	Current ranges	Resistance ranges	Other facilities	Page
Introduction						2
ANALOG MULTIMETERS						
PM 2504	High accuracy	10mV...1kV$_{DC/AC}$	1mA...30A$_{DC/AC}$	10Ω...100MΩ linear scale		5
PM 2505	Electronic	100mV...1000V$_{DC}$ 100mV...600V$_{AC}$	1μA...10A$_{DC/AC}$	100Ω...30MΩ linear scale	Continuity	6
DIGITAL MULTIMETERS						
PM 2518X	Hand-held true RMS multifunction meter (4-digit)	1V...1000V$_{DC/AC}$	20mA...2A$_{DC/AC}$	1kΩ...100MΩ	Relative ref., diode, direct dBm, continuity temp.	8
PM 2519	Automatic multimeter	100mV...1000V$_{DC}$ 1V...600V$_{AC}$	20mA...2A$_{DC/AC}$	1...10MΩ	Frequency, relative ref., V$_{AC/DC}$ as dBm, temp.	11
PM 2521	Multifunction meter (4½ digit)	200mV...1kV$_{DC}$ 200mV...600V$_{AC\,RMS}$	2μA...10A$_{DC/AC}$	200Ω...20MΩ	Temp, dB, frequency, time	14
PM 2528	True-RMS meter (5½-digit)	200mV...1kV$_{DC}$ 200mV...600V$_{AC\,RMS}$	2μA...2A$_{DC/AC}$	200Ω...2000MΩ 4-wire	Temp, Vpk, V$_{HF}$, analog output IEC-bus	16
	Signal analysis					19
PM 2544	Logic meter with signature analyzer	1V...400V$_{DC}$ 1V...400V$_{AC\,RMS}$	100mA...100A$_{DC}$	1kΩ...10mΩ	Frequency, time V$_{pk}$, events logic probe	21
Accessories for PM 2544						23
VOLTMETERS						
PM 2554	High sensitivity Analog AC	1mV...300V$_{AC}$ (2Hz...12MHZ)			AC and DC output	25
GENERAL ACCESSORIES						
Accessory specifications						26
General accessories						27
Accessory selection chart						28

Introduction

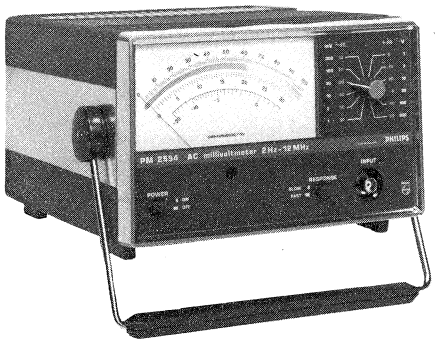
It is a curious combination of facts that finds multimeter design becoming increasingly more complex while the instruments themselves become much easier to use! Levels of accuracy, stability, reliability and versitility continue to improve, yet front panel layouts have become less crowded, controls have become fewer, operation simpler and useability extended.
All these improvements are a direct result of Philips ever growing experience as designer, manufacturer and user. These benefits will become evident from a study of the current range of volt and multimeters.
This contains analog and digital units to cover most measurement problems in laboratories, work-shops or field situations calling for varying degrees of precision.

Analog meters
Whilst the demand for digital meters exceeds that for analog meters, this latter group still occupies a substantial proportion of the total demand.

PM 2505

The PM 2505 is a versatile compact meter featuring high repeatability and sensitvity. Its constant 10Mohm input impedance ensures very high measuring accuracies when compared to 20Kohm/volt instruments, and automatic polarity indication makes it unnecessary to reverse test leads and considerably eases zero adjustments. With 62 measuring ranges including diode testing and audible continuity testing this battery operated meter stands in a class by itself.
The PM 2504 is a quality bench instrument with an overall 1 to 2% accuracy. This meter has only 3 linear scales, and with its antiparallex mirror, makes for unambigous readings. Overvoltage protection allows the unit to be subjected to 1.5kV on all voltage ranges without damage and full mains line voltage on all resistance ranges.

MULTIMETER APPLICATIONS REVIEW		Analog			Digital				
		PM 2505 Battery	PM 2504 Mains	PM 2554 AC mV	PM 2518X Handheld	PM 2519 Bench system	PM 2521 Bench	PM 2528 System Bench	PM 2544 Bench SA
APPLICATION AREA	TYPICAL REQUIREMENTS								
Portable Service	Complete multimeter functions, battery operation, high reliability.	•			•	•	•		
Bench Top Service	Complete or extended multimeter functions wider ranges, high reliability, mains operation.		•		•	•	•		•
Education	Good basic functions, extremely well protected, easy to use.	•	•	•	•	•	•		•
Industrial	Good specification, high reliability, specific minimum requirements.		•	•	•	•	•		•
Simple System use	System compatibility, low cost, reliability.					•			
Extended System use	Full system programmability, high performance and reliability							•	
Laboratory	Wide functional capability, good accuracy and reliability.			•	•	•	•	•	

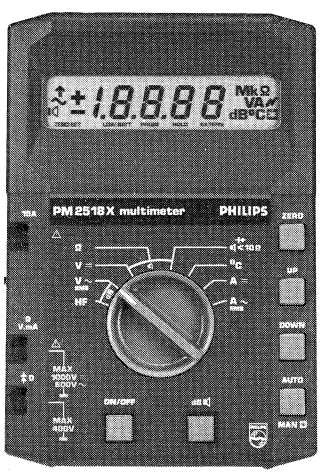


PM 2554

The PM 2554 is a wideband AC millivoltmeter which will measure signals between 100μV and 300V over its full bandwidth of 2Hz to 12MHz. Its high accuracy, up to 1% fsd +1% of reading is underwritten by its inherent high stability (such that the instrument never needs to be recalibrated). All ranges are protected against overloads of up to 300V RMS (or 400V DC). Applications cover a wide range from sub-audio phenomena such as mechanical vibrations to HF and beyond.

Digital meters offer new possibilities

The novel low power flourescent back lighting strip in the new PM 2518X enables the LCD display to be read in low light conditions as found in aircraft cockpits or behind racks of equipment yet gives ten times the battery life of conventional LED instruments. The PM 2518X provides comprehensive bench-top specifications including 0.1% accuracy in a compact and highly portable package. DC voltage and current measurements, resistance measurements up to 100Mohm, and RMS voltage and current measurements over a wide bandwidth are possible. In addition dB measurements, diode voltage drop, audible continuity testing, and temperature measuring facilities are included. A simple Zero Set facility permits direct reading of tolerances or variation on all ranges. For large volume users there is an IEEE 488 interface which enables automated calibration testing of the PM 2518X to be realised.



One version of the PM 2518X has an electroluminescent background lighting strip to allow problem-free readings in very low lighting conditions.

PM 2519

The PM 2519 not only offers a comprehensive range of facilities but also displays most measured values in an analog form by means of a bargraph in addition to its digital representation. Also simple integration into a low cost IEEE system environment is possible by means of its optional interface. As standard it measures DC voltages to a 10μV resolution, and RMS AC voltages to a 100μV resolution. DC and RMS AC currents as large as 10A or as small as 10μA can be monitored whilst the 100mOhm to 10MOhm resistance ranges cover almost all applications.

In addition to these standard DMM facilities the PM 2519 also offers dB measurements on both AC and DC voltages with a selectable reference resistance between 50 and 8000Ohms. Frequency measurements to 1MHz are possible as are temperature measurements by means of a Pt-100 resistance bulb. Continuity and diode testing are also standard. To enable tolerance readings to be quickly made, relative reference measurements are possible on all ranges. This extremely versatile instrument is ideal for high grade applications as well as general purpose fault finding and in simple automatic system environments.

For those seeking a higher general specification instrument than the PM 2519 then the PM 2521 will provide the solution.

The PM 2521 offers the possibility of AC RMS voltage measurements over a bandwidth of 100kHz with a resolution of 10μV. Its frequency measuring range extends to 10MHz, and also enables time measurements to be made against user defined trigger levels.

For portability both the PM 2519 and the PM 2521 are available with integral battery packs.

For bench or system precision

Whilst the PM 2519 covers the lower performance system requirements the really high grade applications are covered by the PM 2528.

This 5½ digit bench or system instrument offers a 1μV resolution combined with a 0.01% accuracy. Its three modes of operation include high resolution, normal and high speed measurements.

PM 2521

DC, AC or DC+AC voltage and current measurements are standard, as is the 1mohm to 2000MOhm resistance measurement possibility in two wire or four wire configurations. AC voltage measurements can be made over a band-

width from 30Hz to 500kHz and temperature measurements by means of a Pt-100 resistance bulb are also possible.

To further extend the possibilities of this meter two options enabling HF measurements up to 700MHz and peak voltage measurements are available. This latter option enables positive, negative or peak-peak measurements to be made on either a periodic basis or an absolute basis. These multi-facilities plus the full system compatible operation place the PM 2528 in a class of its own.

Digital testing

The PM 2544 incorporates not only the basic functions of V, I and R measurements but goes considerably beyond these with its additional facilities directed at digital measurements.
Its frequency counter capability extends to 20MHz whilst time interval measurements can be made to a 100nsec resolution. Event counting between defined start and stop points is possible and for transient detection a special peak hold measurement facility enables pulse height measurements on pulses as short as 20nsec.
The real digital testing power of the PM 2544 can be seen in its Signature Analysis possibilities. This facility extends the power of the PM 2544 beyond that of the ordinary testers in that it can automatically compare measured signatures from a suspect board with those previously stored from a known good board. This catch and compare considerably reduces the documentation required for signature analysis. A detailed description of Signature Analysis is to be found later in this section.

PM 2544

Catering for accidents

A major feature of every multimeter in the Philips program is the exceptionally good instrument protection arrangements. All units are well protected against overloads on all ranges including nominal mains voltage on resistance ranges. Newer instruments have been designed with saftey in mind. For example the PM 2518 and PM 2519 indicate the presence of more than 110V on the input leads by means of a 'lightning flash' on the display. And with the attention that has been paid to the ruggedness of construction the Philips range is well suited to the rigours of long-term use in workshops, laboratories, education and field use.

PM 2528

Approved factory

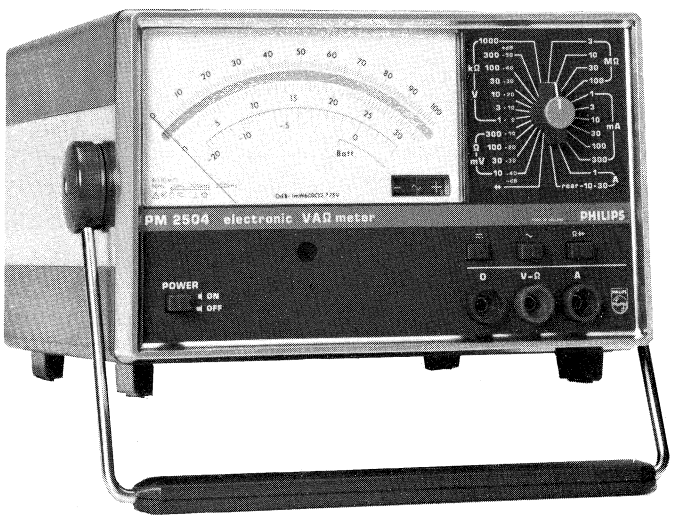
All multimeters described in this section are manufactured at the modern Philips factory in Almelo, Holland. This factory is both CSA and NEN2646 (equivalent to AQAP-1) approved to produce instrumentation which conforms to the highest specification and quality levels.

A view of the CSA and AQAP-1-approved factory at Almelo where Philips multimeters as well as recorders are manufactured.

1...2% accuracy on all ranges
Unique linear resistance scale
Compact, portable performance
Complete overload protection
1000h battery life; line supply option
High 200kHz bandwidth
Automatic polarity indication

High accuracy portable multimeter PM 2504

The PM 2504 combines a high accuracy with extensive overload protection and ease of operation. This latter feature includes the unique linear resistance scale as well as an attractive and ergonomically layed out front panel. Moreover this high accuracy is available for each and every application due to the instrument's portable performance. When battery power is low, and replacement inconvenient, the PM 2504 can be quickly recalibrated using the internal calibration facility.
It also provides a meter system with the same accuracy in both horizontal and vertical positions.
The meter has only three scales which makes for easy, unambiguous reading. They are 0–30, 0–100 and dB. Extensive overload protection is provided.



TECHNICAL SPECIFICATION

DC- voltage

Ranges	10mV, 30mV, 100mV, 300mV, 1V, 3V, 10V, 30V, 100V, 300V, 1000V
Polarity	automatic by extra meter
Sensitivity	100μV
Accuracy	1%
Input resistance	10 MΩ//70...115pF
SMRR	60dB
CMRR	100dB
Protection up to	1500V_{DC} or V_{pk}

AC-voltage

Ranges	10mV, 30mV, 100mV, 300mV, 1V, 3V, 10V, 30V, 100V, 300V, 1000V
Sensitivity	100μV
Frequency range	20Hz...200kHz
Accuracy	1.5% f.s.d. at 50...60 Hz. Additional error: 20 Hz...100kHz ± 1%; 10 Hz...20 Hz: ± 2%; 100kHz...200kHz: ± 3% (1000 V range < 10% for 100 Hz...10kHz)
Input impedance	10 MΩ//70...115pF
Protection up to	1500V_{DC} or V_{pk}

Resistance

Ranges	10Ω, 30Ω, 100Ω, 300Ω, 1kΩ, 3kΩ, 10kΩ, 30kΩ, 100kΩ, 300kΩ, 1 MΩ, 3 MΩ, 10 MΩ, 30 MΩ, 100 MΩ
Sensitivity	0.1Ω
Accuracy	1.5% f.s.d. for 1kΩ...300kΩ ranges 2.5% f.s.d. for 30Ω...300Ω and 1 MΩ...10 MΩ ranges 5% f.s.d. for 10Ω, 30 MΩ and 100 MΩ ranges
Max. open input voltage	1V
Measuring current	1mA for 10Ω...300Ω; 31.6μA for 1KΩ...10kΩ; 1μA for 30KΩ...300kΩ; 100nA for 1 MΩ... 10MΩ 3.16nA for 30 MΩ...100 MΩ
Testing semi-conductors	current 1mA; test volt. 1V
Protected up to	250V

dB measurements

Ranges	10mV/− 40dB...1000V/+ 60dB

DC-current

Ranges	1mA, 3mA, 10mA, 30mA, 100mA, 300mA, 1A, 10A, 30A
Sensitivity	10μA
Accuracy	1.5%
Voltage drop	100mV...300mV
Protected up to	250V by fuse (10A and 30A unprotected)

AC-current

Ranges	1mA, 3mA, 10mA, 30mA, 100mA, 300mA, 1A, 10A, 30A,
Sensitivity	10μA
Accuracy	± 1.5% for AC 50/60 Hz ± 2.5% for 10 Hz...1kHz
Voltage drop	100mV...300mV
Frequency range	10 Hz...1kHz
Protected up to	250V by fuse (10A and 30A unprotected)

General

Meter system tautband suspension 50μA
Reference conditions 23° ± 2°C
Temp coeff < 0.1%/°C
Limit range operating temp. −10°C...+55°C
Storage temp. −40°C...+70°C
Rel. humidity 20%...80%
Power supply batteries 6 x 1.5V; external supply via 9V inputsocket
Dimensions mm (w x h x d) 236 x 145 x 298
(9.3 x 5.7 x 11.7-in)
Weight 2.7kg (5lb)

Accessories supplied with instrument

Measuring leads; Operation manual; Spare fuses

Optional accessories

HT-probe PM 9246
Current transformer PM 9245
HF-probe PM 9210 or PM 9213
Line supply unit PM 9218
DC current probe PM 9101

Electronic multimeter
PM 2505

62 measuring ranges, high V and A sensitivity

10MΩ input impedance

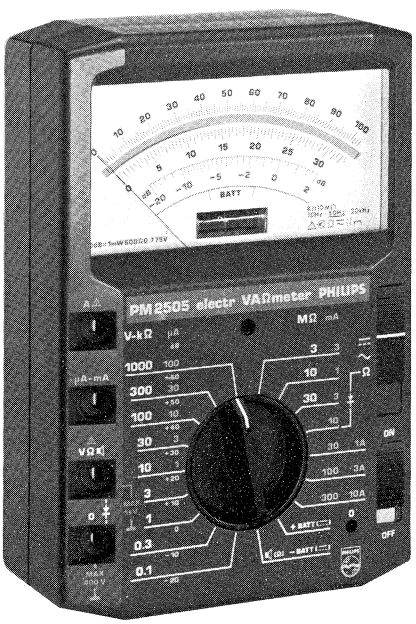
Continuity check by sound signal

Linear resistance ranges

Automatic polarity indication

Unique meter movement for high accuracy and repeatability

Low power consumption



The PM 2505 is an extremely versatile, yet remarkably compact multimeter. In-built features include very high accuracy and repeatability, high sensitivity and a constant input impedance of 10MΩ. Unlike conventional multimeters, which tend to use non-linear reversed scales for resistance measurement, PM 2505 has an easy-to-read *linear* scale giving accuracies well in advance of the usual 7 to 10% levels. Moreover, continuity checks (having less than 20Ω aprox point-to-point resistance) are simplified by means of a built-in sound signal. A diode measuring facility is provided.

Automatic polarity indication makes it unnecessary to reverse test leads when undertaking different polarity checks. This feature also helps the user when making zero adjustments. Much attention has been given to the design of the new moving coil system, which has only 15 components.

The resulting movement is quite unique and has eliminated backlash and realized very high orders both of accuracy and repeatability. Moreover, it is physically robust, immune from external magnetic interference and does not radiate magnetic fields. The advanced electronic circuitry consumes minimal power giving an estimated 1000 hours operating life to the two 9V supply batteries (approximately six months of continuous everyday use).

Full overload protection is provided on all ranges. The voltage ranges, for instance, will accept 1000V continuously and peaks up to TV booster level, whilst the current and resistance ranges will accept up to 265V.

A full range of accessories is available.

TECHNICAL SPECIFICATION

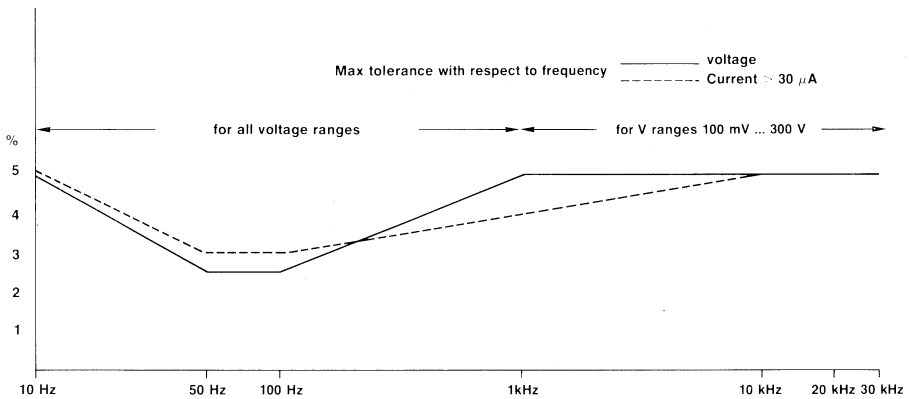
Model PM 2505

DC Voltage

Ranges: 100mV, 300mV, 1V, 3V, 10V, 30V, 100V, 300V, 1000V
Polarity automatic by extra meter
Sensitivity: 1mV
Accuracy 1.5% (f.s.d.)
Input impedance: 10MΩ
SMRR: > 60dB (50...60Hz)
Maximum input voltage: $1000V_{DC}$ or pk ($2000V_{pk}$ from high ohmic sources)

AC Voltage

Ranges: 100mV, 300mV, 1V, 3V, 10V, 30V, 100V, 300V, 600V
Sensitivity: 1mV
Accuracy 2.5% (f.s.d.) at 50...60Hz
Input impedance: 10MΩ//75pF
Maximum input voltage: $1000V_{pk}$ or $600V_{RMS}$ ($2000V_{pk}$ from high ohmic sources)



Frequency response curve for PM 2505.

DC current

Ranges: 1μA, 3μA, 10μA, 30μA, 100μA, 300μA, 1mA, 3mA, 10mA, 30mA, 100mA, 300mA, 1A, 3A, 10A
Sensitivity: 0.01μA
Accuracy: 1.5% f.s.d.
Voltage over shunt: < 100mV + I x 3.1Ω
Protection: Ranges up to 300mA with fuse (max. voltage 265V) 1A...10A not protected
Max. current 16A for 1min.

AC current

Ranges: 1μA, 3μA, 10μA, 30μA, 100μA, 300μA, 1mA, 3mA, 10mA, 30mA, 100mA, 300mA, 1A, 3A, 10A
Sensitivity: 0.01μA
Accuracy: 3% f.s.d. 50...60 Hz
Voltage over shunt: < 100mV + I x 3.1Ω
Protection: Ranges up to 300mA with fuse (max. voltage 265V) 1A...10A not protected
Max. current 16A for 1min.

Resistance

Ranges: 100Ω, 300Ω, 1kΩ, 3kΩ, 10kΩ, 30kΩ, 100kΩ, 300kΩ, 1 MΩ, 3 MΩ, 10 MΩ, 30 MΩ
Sensitivity: 1Ω, in 100Ω range
Accuracy: 3% f.s.d. up to 10 MΩ, 10% f.s.d. in 30 MΩ range
Max. measuring voltage: 100mV up to 100kΩ, 1V over 100kΩ
Max. measuring current 316μA

Continuity check

Audio signal at < 20Ω point-to-point resistance value
Protection up to $265V_{RMS}$ or $350V_{pk}$

Diode checks

Measurement of voltage over junction at 0.316mA. (Protection up to $265V_{RMS}$ or $350V_{pk}$.)

Battery check

Individual checks of + and − battery

GENERAL

Meter system: 100μA tautband suspension, centre magnet.
Separate polarity indication
Scales: Mirror scale: 0...100 and 0...300 for V, I and R measurements, dB scale, battery check.
Input: Combined for V and R
Separate for mA and A
CMRR 100dB at 50...60 Hz 120dB at DC
Max. CM voltage 400V
Reference conditions: 23° ± 2°C
Temp. Coeff. 0.1%/°C for all ranges except 30 MΩ
Operating temp.: 0°C...± 55°C
Storage temp.: −25°C...+70°C
Rel. Humidity: 10%...90% at 25°C
Power supply: 2 x 9V batteries
Current consumption 600μA (1.5mA in Ω ranges and 6mA at continuity check). Battery check provided
Dimensions (mm) 118 x 170 x 62 (w x h x d)
(4.6 x 6.7 x 2.5-in)
Weight 0.7kg (1.5lb)

Accessories supplied

Measuring leads
Operating manual
Spare fuses

Optional accessories

Ever-ready case PM 9278
HT probe PM 9246
Current transformer PM 9245
Current shunt PM 9244
HF probe PM 9210 and PM 9213
DC current probe PM 9101

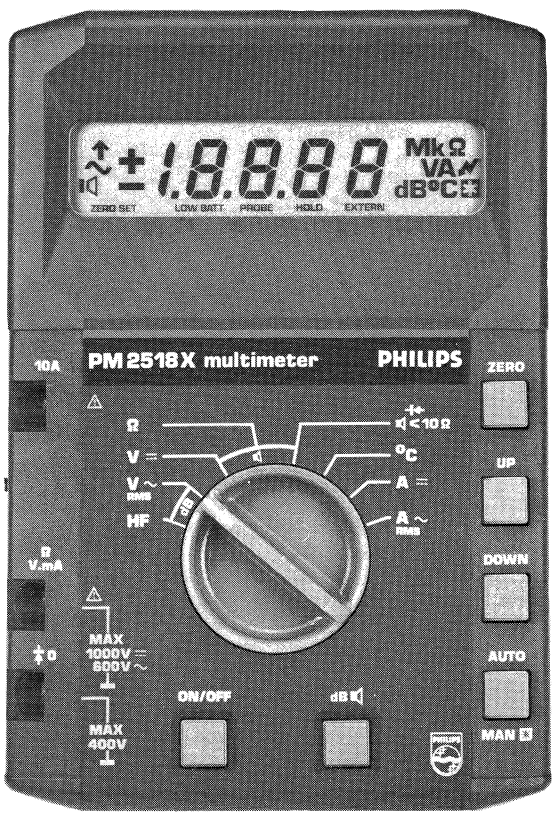
High-resolution portable digital multimeter PM 2518X

0.1% accuracy with 4-plus digits
True RMS readings
"Backlite" version for low lighting levels
Microprocessor control for fast response
Fast diode measurements directly in mV
Continuity measurements with audio bleeper; 100MΩ resistance measurements
Direct readout in dBs for gain measurements
Relative reference measurements
Many optional accessories extend basic performance
Fully overload and short circuit-protected

Measurements anywhere, any time

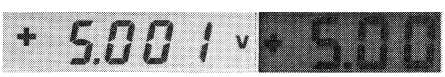
The hand-held digital multimeter PM 2518X has been designed for very high resolution measurement applications in all conditions of use, from the harsher field environments to everyday workshop bench operating conditions.

Two versions are available. These are a high-contrast LCD display model and a "Backlite" LCD version which automatically switches on in very low light levels. This model caters for measurement situations in dark areas such as the rear of tall racks, or inside aircraft. When illuminated, luminescent green background enhances the LCD display for clear, easy reading.



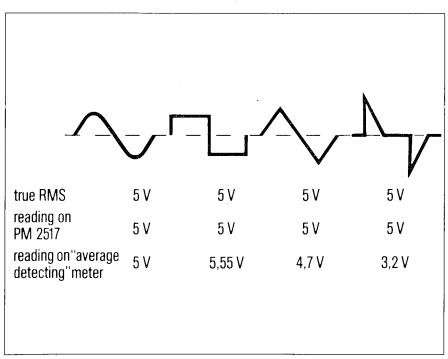
High resolution

Whereas an ordinary 3½-digit multimeter used to measure, say, 5V provides a reading accuracy of 0.01V, the PM 2518X will read down to an accuracy of 0.001V–one order better!



PM 2518 *3½ digit DMM*

Moreover, when used for AC measurements, a true RMS measurement is given, even if the signal is not a pure sinewave. The special circuit employed has many advantages over the conventional "average detection" method which is liable to incorporate significant reading errors.



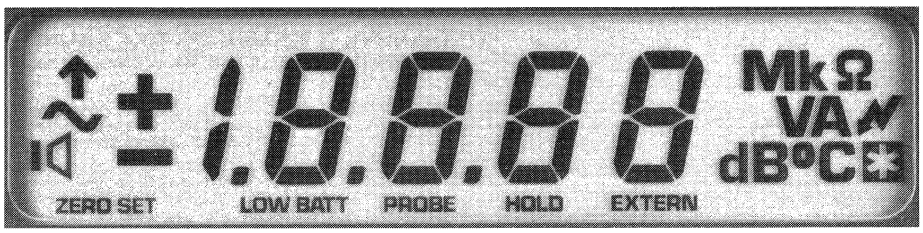
The user is thus assured of a more accurate AC measurement over the full audio bandwidth and more. With a typical error of less than 1 dB at 50kHz the PM 2518 comfortably handles switched mode power supply trouble shooting and often eliminates the need for extra 'scope measurements.
Moreover, for measuring at the higher frequencies the PM 9213 and PM 9210 probes extend the range to 100MHz and 1 GHz respectively.

For speed and convenience

With auto ranging on all its functions, it is only necessary to select the parameter to be measured, using a single rotating function selector. Microprocessor control quickly sets up the selected range to produce a stable display of both the measured value and the measured parameter. Volts, ohms and milliamps are all measured from the same inputs. This eliminates the need to constantly change over leads when making a series of different measurements.

Passive component measurements are comfortably handled by the PM 2518's

100MOhm to 100mOhm resistance capability. Moreover, two separate modes are available specifically for speeding up diode and continuity testing. While diode measurements are given directly in mV voltage drop the continuity test gives not only a mOhm readout, but also operates an audio bleeper to indicate short circuit conditions.



Detail of the LCD panel demonstrating the wide diversity of range and message characters.

To allow the user to concentrate on locating a difficult test-point and read the display simultaneously an optional data hold probe can be used. This "freezes" the display at the push of a button.

More versatility

An extremely useful feature of the PM 2518X is, for instance, in making amplifier gain measurements, which may be read directly in dBs, with a resolution of 0.1dB.
Moreover where it is required to measure a tolerance or deviation from a norm and not an absolute zero, the users own reference level may be selected, by pressing the zero button. Thereafter the instrument will display either a variation or deviation.

Temperature measurements present no problem. When using the optional low-cost, fast-response Pt-100 probe (PM 9249), measurements from −60°C to +200°C can be made with a 0.1°C resolution.

A light in the dark

While LCD's give an ideal high contrast display in normal light conditions (e.g., the workshop bench) measurement problems may extend into "dark" areas such as aircraft cockpits or behind racks of equipment.

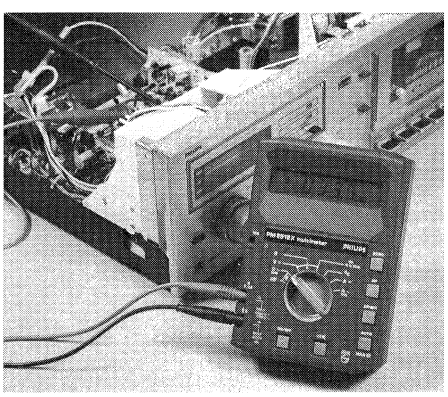
The special "Backlite" version of PM 2518X is available to overcome such problems.

This "Backlite" model automatically switches itself on in the dark. Its uniform illumination avoids corner shadows and to conserve battery life it is automatically switched off if no measurement is made for 30 seconds. A subsequent measurement switches it on again, automatically. This feature combined with very low battery consumption provides hundreds of hours of use from a single set of batteries.

Ideal for use in low light levels, the PM 2518X "Backlite" version being used for routine checks on the flight deck of the European Airbus.

Fully guaranteed safety and reliability

With its high-voltage warnings, its protective leads and many other safety features, the PM 2518 is probably the safest handheld multimeter of its kind on the market, being designed to exceed the UL, IEC and VDE safety requirements.



PM 2518X being used in a typical workshop application.

Few instruments are as well protected as the PM 2518 to combat accidental overloads. For example, normal mains voltage can be connected to any multifunction input without fear of damage. The extremely robust yet elegantly styled case plus the 'designed for reliability' internal electronics combine to give the PM 2518 an early MTBF (Mean Time Between Failure) of more then 20000 hours.

TECHNICAL SPECIFICATION PM 2518X

Function	VDC	VAC_{RMS}	VACdB	IDC	IAC_{RMS}	R	°C	DIODE	CONTI-NUITY	HF
Max Display Value	11000	11000	99.9	2200	2200	11000	11000	11000	11000	11000
Ranges (autoranging except*)	1V 10V 100V 1000V	1V 10V 100V 1000V	−51dB to +43dB	20mA 200mA 2A 10A	20mA 200mA 2A 10A	1kΩ 10kΩ 100kΩ 1MΩ 10MΩ 100MΩ*	−60°C to +200°C	1V	1kΩ	10V
Max. Resolution	100μV	100μV	0.1dB	10μA	10μA	100mΩ	0.1°C	100μV	100mΩ	1mV
Accuracy (%reading+ % range)	0.1+0.02	0.5+0.1, for 1.0+0.1, for 5.0+0.5, for	40Hz to 1KHz 1KHz to 10KHz 10KHz to 20KHz	0.5+0.1	0.8+0.1 at 50Hz	0.3+0.1 (≤100kΩ>) 0.5+0.1 (≤10MΩ>) 5.0+0.1	1%+0.5°C (0 to 100°C)	0.3+0.1	0.3+0.1	5%<6MHZ −3dB at 1GHz
Temperature Coefficient of reading per °C	0.015	0.03	0.03	0.05	0.05	0.02				
Input characteristics	10MΩ	>2MΩ	>2MΩ Reference to 1mW/600Ω	Voltagedrop 20mA and 2A - 25mV 200mA and 10A - 250mV		Open circuit voltage 3V Measuring I from 10nA to 1mA	1mA drive current	1mA drive current	1mA drive current	2pF
Overload protection		1000VRMS 2.5KV spike		20mA, 200mA fused		$250V_{RMS}$	–	$250V_{RMS}$	$250V_{RMS}$	$60V_{AC}$
Response Time Response Time including ranging	<1s <1.5s	<1s <2s	<1s <2s	<1s <1.5s	<1s <2s	<1s <3s	dependent on probe	<1s	<0.2s	<1s
Relative Reference Max. display	YES 19999	YES 19999	YES 99.9	YES 4400	YES 4400	YES 11000	YES 11000	YES 19999	YES 19999	YES 19999
Additional Information		Crest Factor 2 AC coupled Max V*Hz = 10 ↑ 7	1.0dB resolution for signals <10V	20A for max 30s Crest factor 9			Pt100			Using PM 9210 probe. dB HF measure-ments possible

GENERAL

Display
LCD, 12cm tall with range and message characters

ADC System
Delta modulation with auto zeroing, 11000 counts

Reading rate
2.5 measurements/s

CMRR DC
>100dB

CMRR 50Hz AC
>80dB

SMRR 50HZ±1%
>60dB

Ranging
Fully Auto ranging except 100Mohm

Range Selection
Auto range up at 110% fs
Auto range down at 10% fs
Manual ranging by UP/DOWN keys

Data hold
By PM 9267 probe

Overload
Indicated by OL on display

Underload: (dB)
Indicated by UL on display

Crest Factor Overload
Indicated by ↑ on display

High voltage>110V
Indicated by ⚡ on display

Beeper Function
Selectable on >100% V_{dc} or <1% ohms

Max V×Hz product
10^7

Reference Conditions
23°C±2°C Humidity 20-80% Dew point 28°C

Rated range of use
−10°C to +55°C

Specified range of use
0°C to +45°C

Storage range
−40°C to +70°C

Calibration Interval
1 year

Power supply
4×R14 type batteries or PM 9218 power supply

Battery life
For PM 2518 X/01>400h
For PM 2518 X/11>200h

Safety
Class II according to IEC 348/VDE 0411

Guarantee Period
1 year

Accessories supplied
Set of PM 9266 safety measuring leads and probes, operating manual and spare fuses

Dimensions (wxhxd)
170 x 55 x 118mm (6.7 x 2.2 x 4.7-in)

Weight
0.7kg (1.6lb)

Ordering information
PM 2518X/01 for the standard version or PM 2518X/11 for the "backlite" display version

Bargraph Analog display
Electronic calibration
IEEE 488/IEC 625 system compatible
V_{AC} and V_{DC} as dB with selectable reference resistance
Relative reference measurements
Frequency measurement to 1MHz
Fast autoranging
Battery version available

IEEE 488 IEC 625

Digital multimeter PM 2519

The compact PM 2519 offers an extremely wide range of measuring capabilities, computation and control facilities and data presentation methods in addition to its standard V, I and R ranges. The basic specification enable DC V resolution of 10μV and true RMS AC V resolutions of 100μV with a bandwidth of 20KHz. AC and DC current measurements from 10μA to 20A (short term) are possible as are resistance measurements from 0.1Ω to 10MΩ. The 11mm 4½ - digit LCD displays the absolute reading whilst a logarithmically scaled bar graph enables approximate comparisons to be quickly made. Measuring function selection is by a single rotary control which in conjunction with the fast auto ranging enables rapid measurement. Manual ranging is also possible.

Extended measuring functions

Both DC V and TRMS AC V measurements can be expressed in terms of dB using one of the 16 selectable reference resistance values between 50 an 8000Ω. Frequency measurements to 1MHz with resolutions down to 0.1Hz are possible as standard. The simple addition of a Pt-100 probe enables temperature mesurements from −60°C to +200°C to be made to a resolution of 0.1°C.

Displaying the measurement

The PM 2519 gives not only an absolute digital readout but also an easily read analog display of the measured parameter by means of its 50 point logarithmically scaled bar graph which ensures high sensitivity at the zero point. The bar graph reading is related to the digitally displayed value, so when using the relative reference mode the bar graph can be effectively used for peak value settings. The relative reference mode is possible on all ranges and is an ideal method of measuring offsets rather than absolute values. The required zero point can either be 'dialled up' from the front panel or copied from a measurement. All further measurements are then expressed as a variation from this set point.

Measurement integrity

The PM 2519 makes extensive use of its microprocessor to ensure accurate and safe measurements are made. The incorporation of electronic calibration makes calibration possible without even opening the instrument covers whilst the incorporation of I²C (Inter integrated circuit) bus reduces component pin count considerably and so increases reliability. A wide range of display warning messages ensure operator confidence for example if voltages greater than 110V are present at the input a ⚡ sign is displayed whilst if the AC crest factor of the PM 2519 is exceeded a C is displayed.

System compatibility

The PM 2519 offers an extremely cost effective method of system compatibility but not at the expense of measurement integrity. The interface is galvanically separated from the measuring circuits to prevent faults in one affecting the other.

It can measure at upto 4 measurement per second including controller transfer time. Its fully programmable for ranging, trigger mode, start measurement, measuring speed and even the zero offset value can be programmed. Its also possible to calibrate the PM 2519 via its bus interface.

Other options

For portable applications the PM 2519 can be supplied complete with an inbuilt battery pack. The PM 9267 data hold probe enables single measurements to be made and frozen on the display and can also be used on conjunction with the IEEE488/IEC625 interface for guided probing testing. A full range of HF, High Voltage and current measuring options are detailed at the end of this section.

TECHNICAL SPECIFICATION

Measuring Quantity	V_{DC}	VAC	VDC, dB	VAC, dB	IDC	IAC	R	Hz	°C	Continuity
Max. Display value	11000	11000	99.9	99.9	2200	2200	11000	11000	2000	11000
Ranges (autoranging-except*)	100mV* 1V 10V	 1V 10V	−57 to +43 dB (at 600Ω)	−51 to +43 dB (at 600Ω)		20mA 200mA 2A	1000Ω 10kΩ 100kΩ	1000Hz* 10kHz 100kHz	−5°C to +200°C Pt100 probe)	1V
	100V 1000V	100V 600V				10A (20A max. for 20 secs)	1MΩ 10MΩ	1MHz		
Max. resolution	10μV	100μV	0.1dB	0.1dB		10μA	100mΩ	0.1Hz	0.1°C	100μV
Accuracy (% reading + range)	0.1%+ 0.02	0.5%+ 0.1 (40Hz to 1kHz) 1% +0.1 (1kHz to 10kHz) 5%+0.1 10kHz to 20kHz	0.2dB Signal >10mV) 1dB Signal ≤10mV)	Signal≥ 80mV 0.3dB 40Hz to 10kHz 1.0dB 10kHz to 20kHz	0.5% +0.1	0.8% +0.1 40Hz to 1kHz 5% + 0.1 1kHz to 10kHz	0.3%+ 0.1 1kΩ to 100kΩ 0.5% + 0.1 1MΩ to 10MΩ	0%+0.02	1%+0.5°C 0 to 100°C	0.3%+0.1
Temperature coefficient/°C	0.015%	<0.03%	0.0013dB	0.003dB	0.05%	0.05%	0.02%	—	—	—

Measuring Quantity	V_{DC}	VAC	VDC, dB	VAC, dB	IDC	IAC	R	Hz	°C	Continuity
Input characteristies	Input impedance Range 100mV 1.10V 100V	 DC 1MΩ 10MΩ 4MΩ	 AC — 2MΩ 1.8MΩ	 20mA, 2A <60mV 10A <200mV	Voltage drop at end of range 200mA <300mV		Open input voltage ≤3V	Input Impedance 2MΩ		Open input Voltage 3V I=1mA
CMRR DC AC 50Hz SMRR 50Hz ±0.1%	>100dB >100dB 60dB	>100dB >100dB 60dB	>100dB >80dB —	>100dB >80dB —	—	—	—	—	—	—
Max. CM voltage	350V peak	350V peak	350V peak	350V peak	350V peak	350V peak	350V peak			
Response time Response time (incl. ranging) Overload protection	<0.5s <1.0s 1000V	<1.0s <2.0s 1000V	<1.0s 1000V	<2.0s 600Vrms	<0.5s <1.0s 350V	<1.0s <2.0s 350V	<1.0s <2.0s 350V	1.0s — 600Vrms	1.0s —	0.25s 250Vrms
Relative reference Range reference Max. reading	yes one range 22000	yes one range 11000	yes full range 99.8	yes full range 99.8	yes one range 4400	yes one range 2200	yes one range 11000	yes one range 11000	yes — 260°C	yes one range 22000
Additional information	In 100mV range max input 250 Vrms Audible alarm	Crest factor 2 max V*Hz=107 AC coupled	Reference resistance of 50, 75, 93, 110, 125 135, 150, 250, 300, 500 600, 800, 900, 1000, 1200 8000Ω selectable		Max. continuous input current 16 A	Crest factor 9		10s gate time in 1000Hz range AC coupled		Audible alarm

GENERAL

Display
LCD, 11mm high value display with range and message characters plus 50 point analog bargraph

ADC System
Delta modulation

Reading rate
2.5s

Range selection
Automatic and manual (limits upper: 100% fs lower: 10% fs)

Data hold
with optional PM 9267 Data hold probe

Range hold
by automatic manual switch

Overlfow indication
'OL' on display

Reference conditions
23°C±1°C RH20-80% D.P. 26°C

Rated range of use
0°C to +40°C

Storage temperature
−40°C +70°C

Calibration interval
1 year

Warming-up Time
30s

Safety
IEC348 Class 2 (class 1 with IEEE488 interface)

Power supply
220V ±10% (47-63Hz)
Adaptable for 240V and for battery operation

Dimensions (w x h x d)
95 x 235 x 280 mm
(3.7 x 9.3 x 11-in)

Weight
2 kg approx. 4.4 lb)

Accessories supplied
Mains cable
PM 9266 set of measuring leads with probes.
Spare Fuses
Operating Manual

Battery option (PM 2519/21)
Battery life ±20hrs
Low battery warning ±>2hrs battery left

Example of the fully detailed display capability of the PM 2519.

IEEE 488 option PM 2519/51
Supported functions

SH1	Source handshake
AH1	Acceptor handshake
T5	Talker with talk only, serial poll and automatic unaddress if MLA
	Output data: Measuring data including polarity data and range Status data generated by serial poll including parameter, range and error conditions, overload crest factor exceeded and wrong programming
L3	Listener with automatic unaddress if MTA and listen only
SR1	Service request. SRQ in generated in event of overload, crest factor exceeded, data available and illegal range programming
RL2	(pse leave 5 line space)
DC1	Please leave 5-line space)
DT1	Device trigger by GET and data bytes E1.

Input data:
Programming data for all manually controllable functions, except input trigger functions
Time specification (excluding analog functions of voltmeter):
Programming time 10ms/byte
Output time 8ms+4.5ms/byte
Response to serial poll 5.5ms

Programmable functions

Function	Code		Description
Measuring speed	Vj	j=0	2 meas/s
		j=1	4 meas/s (only even values sent)
Range	Ri	i=0	Auto ranging where possible
		i=1	to 5 Most sensitive to least sensitive range selection
Trigger mode	Tt	t=1	Measurement to be started from Bus
		t=2	Measurement to be started from Bus or data hold probe
Execute	X1		Start measurement
Zero setting	Zid	i=	range code
		d=	5-digit zero set value

Digital multimeter PM 2521

V_{DC} accuracy 0.03%
V_{AC} in volts and dB (AC-coupled RMS)
Current measurements with extremely low voltage drop
Frequency measurements up to 10MHz
Time measurements up to 10^5s
Relative reference measurements
Fast autoranging
Battery version PM 2521/22 available

Whilst of small dimensions, the PM 2521 offers an unusually comprehensive range of facilities not normally found in modern multimeters. Its unique measurement capabilities are further enhanced by microprocessor control which both speeds and simplifies operation.
The attractive basic specification includes AC_{RMS} and DC voltage with 10μV resolution, AC_{RMS} and DC current ranges having 0.001μA resolution (up to 10A) plus a full resistance range from 10mΩ to 20MΩ. In addition, there is a special setting for semiconductor measurements. Bandwidth is 100kHz.
All results are displayed on a 4½ digit LCD panel, having 13mm numerals. Parameter selection is by means of a single rotary selector knob and is indicated, together with polarity, on the display panel. Ranging is automatic in the normal mode; manual range selection is also possible.

Even more features
In addition to the basic measuring facilities, PM 2521 will handle AC volts either directly in volts, or in dB, both AC-coupled RMS. Frequency/time measurements can also be made, up to 10MHz and 10^5s, respectively. Moreover, temperature measurements can be made, using Pt-100 probes.

Relative reference measurements
Another useful feature which can be applied in several ways, is the reference measurement capability for V_{DC}, dB, resistance, temperature and diode applications. Any selected value can be used as the reference "zero". This reference level having been set, all subsequent readings are displayed as either a positive or negative deviation. One typical use of this facility is checking high ohmic value components for long-term stability.

dB measurements
V_{AC} measurements can be expressed in dB by depressing a button. The display will then indicate the value, directly in dB, with 1mW into 600Ω as the 0dB reference. By applying the previously described relative reference technique, any desired "zero" point may now be selected and the measurements will be shown as a dB gain or loss. The fast auto-ranging allows for direct ratio measurements between 1mV and 600V.

Temperature
PM 2521 accepts standard Pt-100 probes which allow direct temperature readings between −60° and +200°C.

Frequency/time
Frequency can be measured up to 10MHz, with a max. resolution of 0.1Hz, and time up to 10^5s. Measurement of the signal voltage is first made which causes the input sensitivity of the counters to become automatically adjusted to the level of the applied signal. This setting is then maintained for the subsequent frequency measurement, which is displayed as a direct frequency value. In the time position, both pulse width and pulse repetition time measurements are possible on both positive- and negative-going pulses. The trigger level is adjustable over the whole (internally attentuated) trigger amplitude range and is displayed when selected. At the instant the trigger fires a 'GATE' sign appears on the display. By adjusting the trigger level (using a thumb-wheel) and observing the 'GATE' signal, pulse peak values may be obtained.

Other options
The already comprehensive facilities described may be further extended by the use of optional accessories. Such options include a HOLD probe which will "freeze" the display and allow, e.g., the operator to concentrate on locating the test points. Also, an HF probe is available which extends the frequency range to 700MHz. For high tension work, an HT probe permits measurements up to 30kV_{DC} and heavy currents up to 200A may be handled using the current shunt, current probe and transformers. All of which further enhance the already highly versatile capabilities of this very compact instrument.

TECHNICAL SPECIFICATION PM 2521

Function	VDC	VAC_{RMS}	VACdB	IDC	IAC_{RMS}	R	Hz	TIME	°C	LEVEL
Max Display Value	20000	20000	99.9	2000	2000	20000	99999	99999	2000	2000
Ranges (autoranging except*)	200mV 2V 20V 200V 1000V	200mV 2V 20V 200V 600V	−57.7dB to +57.7dB	2μA 20μA 200μA 2mA 20mA 2A 10A	2μA 20μA 200μA 2mA 20mA 2A 10A	200Ω 2kΩ 20kΩ 200kΩ 2MΩ 20MΩ	10kHz* 100kHz 1MHz 10MHz	10s 100s 1000s 10000s 100000s	−50°C to +200°C	2V* 20V* 200V* 1000V*
Max Resolution	10μV	10μV	0.1dB	1nA	1nA	10mΩ	0.1Hz	100μs	0.1°C	1mV
Accuracy (% reading +range).	0.03+0.01	0.3+0.15 (40-500Hz) 1.0+0.15 (500Hz−20KHz) 5.0+1.0 (20KHz-100KHz)	±0.2dB (−31.7 to +47dB) ±1dB (+47 to +57.7dB) ±1.5dB (−31.7 to −57.7dB)	0.2+0.05	0.4+0.1	0.2+0.1 (≤200kΩ) 1.0+0.1 (≥2MΩ)	0.005+0.001 (<1MHz) 0.01+0.001 (>1MHz)	0.005+0.001	1.0+0.2°C (0-100°C) 3.0+0.2°C (−50-+200°C)	As VAC
Temperature Coefficient of reading per °C	0.01%	0.03%	0.03%	0.02%	0.03%	0.02% (≤200KΩ) 0.05% (≥2MΩ)	—	—	—	As VAC
Input characteristics	Input impedence ≤ 2V 20MΩ/60pF 20V 11MΩ/85pF ≥200V 10MΩ/95pF			voltage drop ≤2mA - 2.5mV 20mA, 200mA - 25mV ≥2A - 250mV		Max open circuit voltage 4V Measuring currents from 10mA to 100nA	Sensitivity 150mV ≤1MHz> 300mV	Sensitivity 100mV ≥1μs≤ 200mV	—	Input Impedence as VAC
CMRR DC AC 50Hz SMRR 50Hz±1%	100dB 100dB 86dB	100dB 80dB	as VAC							
Max CM Voltage	560Vpk	560Vpk	560Vpk							
Response time	0.7s	1.5s	1.5s	0.7s	1.5s	0.7s	—	—	—	—
Response time Including ranging	1.5s	3s	3s	1.5s	3.0s	2.5s	—	—	—	—
Overload protection		1000 V peak		250Vrms ≥200nA	≤20mA not protected	250Vrms	1000Vpk	1000Vpk	—	1000Vpk
Relative Reference	YES	YES	YES	NO	NO	YES	NO	NO	YES	NO
Max Display	40000	40000	99.9	2200	2200	22000	99999	99999	2200	2200
Additional Information		Crest factor 2 Max V x Hz= 10 ↑ 7 AC coupled	Reference- 1mW/600Ω	Maximum	Crest Factor 2 20A for 20s		Gate times from 10ms to 10s Adjustable trigger level	Adjustable trigger level	Pt 100	

GENERAL

Display	LCD 13 mm digits with range and measuring parameter display
ADC system	integrating (delta modulation)
Read rate	2.5 measurements/s
Data hold	with optional data hold probe PM 9263
Range hold	by manual/automatic switch
Range limits	upper 20200 lower 01800
Overflow indication	"OL"
Reference conditions	23°C ±1°C; RH 20%...80% dewpoint 26°C
Operating temperature	0°C...+40°C
Storage temperature	−40°C...+70°C
Calibration interval	1 year
Warming up time for calibration	30min
Safety	Class I according to IEC 348
Power supply	mains 220V±10% (47...63Hz) instrument can be adapted for 110 and 240V Power consumption 10VA
Dimensions	95 x 235 x 280mm (3.7 x 9.3 x 11-in)
Weight	2kg (4.4lb)

Accessories supplied

Mains cable
Set of test leads PM 9266 (incl. probes)
Spare fuses
Operation manual

Optional accessories

PM 9210	HF probe
PM 9212	Accessory set for HF probe
PM 9244	Current shunt
PM 9245	Current transformer
PM 9246	EHT probe
PM 9249	Temperature probe
PM 9263	Data hold probe
PM 9279	Carrying case

IEEE 488 IEC 625

5½-digit meter with max. reading ±240.000
1μV resolution and 0.01% ±1 digit accuracy
AC- and DC-coupled RMS at 100kHz
16 measurements/s in high-speed mode
Resistance up to 2.4GΩ plus 4-wire method achieving 1mΩ resolution
Low level current measurement down to 10pA resolution
Relative reference measurements
Options for temperature, V_{HF} and V_{PK}
Full systems capability, including remote control

Digital multifunction meter PM 2528

The 5½-digit, system-orientated PM 2528 is a high-grade, highly accurate digital multifunction meter featuring many sophisticated facilities. In the basic configuration it measures DC voltage, AC voltage (AC- or DC-coupled true RMS), DC and AC (DC-coupled true RMS) current, temperature (using Pt-100 probes) and resistance. Highly accurate measurement of extremely small resistance values can be achieved using a 4-wire technique which realizes a 1mΩ resolution. This 4-wire method neutralizes all those inaccuracies normally introduced by test-leads and connectors.
The current ranges are extremely sensitive. This makes the instrument capable of displaying a reading of 1μA with a resolution of 1 in 100000.
The fully guarded circuitry exhibits an excellent CMRR which ensures and maintains the very high levels of accuracy, stability and resolution which are the major features of this meter. Examples include the levels of 1μV for voltage, 10pA for current and the 1% accuracy achieved in the 2.4GΩ resistance range.
Optional accessories are available which add to the already extensive capabilities of the PM 2528. These include a Pt-100 temperature probe, peak voltage and HF measurement up to 700 MHz.
PM 2528 has three modes of operation. These are;
- **high resolution mode** (HRM) providing about 2 measurements/s at 5½-digits for DC and Ohm measurements.
- **Normal mode** (NM) achieving about 4 measurements/s with 4½-digits
- **high-speed mode** (HSM) operating at 12 to 18 measurements/s

Auto ranging is standard, but manual ranging is possible using range 'touch'-button selection.
Conventional mechanical push buttons have been dispensed with and replaced with 'touch'buttons which illuminate when 'active'. This further simplifies operation and gives an instant indication of control settings.

Polarity display is automatic, also the scale lenth for each of the parameters is automatically adapted to the specified accuracy and varies between 5½-digits for DC and resistance measurements and 3½-digits for peak voltage readings.

Relative measurements feature
Any measurement may be stored and then used as a 'zero' reference. This having been done, all subsequent readings are shown as either a positive or negative deviation from that value. This could be used to monitor stability, for instance, since even minute differentials could be identified.

Peak voltage option
The option PM 9259 extends the measuring facilities to positive and negative peak voltage measurements at repetition rates of 0 to 100kHz and peak-to-peak measurements between 10 Hz and 100kHz.

In the 'periodical peak value' mode, changes in peak value are followed at a rate of two to three measurements per second each displaying the highest value in a preceding period of 200 ms.
In the absolute peak value mode the highest value between start and stop of the measurement is displayed, with an update of the display each time a higher peak is detected.
In this mode start and stop of the measuring period are controlled manually or by an external electrical signal.
Any signal of which peak value can be reached in one or more periods by a slew rate of 7-digit/μs (in NM) is measured with full accuracy.

This includes nearly all periodical signals with frequency components up to 100kHz and single shot phenomena with a rise time down to about 500 μs.
The peak voltage measurement facility also offers an excellent method of measuring amplitudes of signals below 10 Hz and down to the mHz region that cannot be measured with conventional multimeters.

System interfaces
System interfaces for PM 2528 include IEC-busline interface and BCD parallel and an analog output. Full remote control of all front panel functions is possible.
The analog output offers 1mV/digit over a maximum of any three selected decades and can be connected in parallel with one of the digital interfaces

TECHNICAL SPECIFICATION

Model PM 2528

Digits	5½
Type of display	LED (11mm)
Range selection	automatic or manual
Range limits autoranging	up at 110% full scale down at 10% full scale

Operating modes

HRM: High resolution mode
1.6 to 2.7 measurements/s
NM: Normal mode
3.3 to 5.4 measurements/s
HSM: High speed mode
13 to 18 measurements/s
(Max. speed via interface PM 9291 is 6 measurements/s)

DC Voltage

Measuring modes	HRM, NM and HSM		
Ranges	200mV, 2V, 20V, 200V, 1000V		
Polarity	automatic '+' and '−' sign		
Resolution in lowest range:	in HRM 1μV, in NM and HSM 10μV		
Maximum display:	in HRM 239999, in NM and HSM 23999		
Accuracy	± (0.01% rdng + 0.005% rng)		
Temp. coeff.	(0.002% rdng + 0.0005% rng)		
Input impedance:	up to 2V > 1GΩ//20pF		
	over 2V 10 MΩ//20pF		
Offset current	< 10pA (with front panel zero setting)		
	HRM	**NM**	**HSM**
CMRR DC	140dB	140dB	140dB
AC (50 or 60 Hz ± 1%)	140dB	130dB	120dB
SMRR (50 or 60 Hz ± 1%)	60dB	50dB	40dB
(50 or 60 Hz ± 0.1%)	80dB	70dB	60dB

Max. CM signal $250V_{RMS}$ or $400V_p$ between guard and ground
Max. $60V_{RMS}$ or $85V_p$ between '0' and guard
Max. SM signal: peak value < 180% full scale

Response time

Mode	Ranging	Asynchr. start	Synchr. start
HSM	hand	0.15s	0.08s
	auto	0.45s	0.38s
NM	hand	0.6 s	0.33s
	auto	1.0 s	0.93s
HRM	hand	1.2 s	0.65s
	auto	1.2 s	1.2 s

Maximum input voltage:
Ranges up to 2V: 600V continuous, 1000V for 30s
over 2V: 1000V continuous
1400V peak for all ranges

AC voltages RMS AC- or DC-coupled

Measuring modes	NM and HRM	
Ranges	200mV, 2V, 20V, 200V, 600V	
Resolution in lowest range	10μV in HRM, 100μV in NM	
Max. display	23999 in HRM, 2399 in NM	
Accuracy	(in % rdng ± % of rng)	
	200V and 2V	**other ranges**
30 Hz-20kHz	0.2% + 0.07%	0.1% + 0.05%
20kHz-100kHz	0.4% + 0.07%	0.3% + 0.05%
100kHz-300kHz		1% + 0.05%
300kHz-500kHz		5% + 0.05%

Additional error for DC component 0.05% + 0.01%
Limit of lowest reading 1% of range
Temp. coeff. (0.01% rdng + 1 digit)/°C
Input impedance 1 MΩ//55pF
CMRR; for DC 120dB, for AC (50 or 60 Hz ± 1%) 80dB
Max. CM signal $250V_{RMS}$ or $400V_p$ between guard and ground.
Max. $60V_{RMS}$ or $85V_p$ between '0' and guard.
Crest factor RMS converter > 4.5 at full scale, warning in display when exceeded
Response time
excluding ranging < 1s
including ranging < 2.6s
Maximum input voltage $600V_{AC}$ or DC with max. 900V peak.
Maximum V.Hz product 2.10^7

RESISTANCE, 2-WIRE and 4-WIRE

Measuring modes HRM, NM and HSM.
Ranges 200Ω, 2kΩ, 20kΩ, 200kΩ, 2 MΩ and 2 wire only 20 MΩ, 200 MΩ, 2GΩ
Resolution in lowest range: in HRM 0.001Ω, in NM and HSM 0.01Ω
Max. display; in HRM 239999, in NM and HSM 23999, above 20 MΩ 2399
Accuracy in % rdng + % rng and temperature coefficient in % rdng/°C

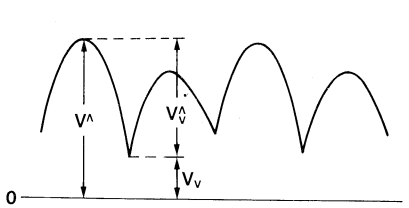
Ranges	Accuracy	Temp. coeff.
up to 200kΩ	0.03% + 0.005%	0.005%
2 MΩ-20 MΩ	0.1% + 0.005%	0.01%
200 MΩ	0.2% + 0.05%	0.02%
2000 MΩ	1% + 0.05%	0.1%

Max. voltage at open input < 12V up to 200kΩ, < 4.5V over 200kΩ
Measuring current = 2V divided by range-end value
Response time at normal mode:
up to 2 MΩ 0.6s excl. ranging and 1s including autoranging increasing up to 2.7s at 200 MΩ and 22s at 2000 MΩ.
Protected up to $250V_{RMS}$ or $350V_{pk}$ in the 2-wire resistance mode and $30V_{RMS}$ or $42V_{pk}$ on the 4-wire input.

DC current and AC + DC current

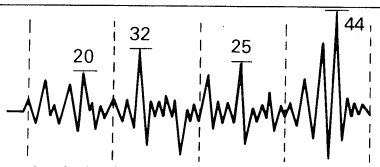
Measuring modes NM and HRM and HSM for DC only
Ranges, 2μA, 20μA, 200μA, 2mA, 20mA, 200mA, 2000mA
Resolution in lowest range 10pA for DC in HRM mode
Maximum display 239999, for DC, HRM mode 23999
Accuracy
For DC ± (0.1% rdng + 0.02% rng)
30 Hz...5kHz ± (0.2% rdng + 0.07% rng)
Limit of lowest reading for AC 1% of range
Temperature coeff.
DC (0.005% rdng)/°C
AC (0.01% rdng + 0.005% rng)/°C
Crest factor of AC RMS converter 2 at full scale
Voltage drop at input:
in 2000mA range < 500mV
in 2...200mA range < 250mV
in 200μA range < 25 mV
in 20μA range < 2.5mV
in 2μA range < 0.25mV
SMRR for DC current measurements 40dB at 50 and 60 Hz ± 1%
Max. SM signal: peak value < 180 full scale
Max. CM signal $250V_{RMS}$ or $400V_p$ between guard and ground.
Max. $60V_{RMS}$ or $85V_p$ between '0' and guard.
Response time as for voltage measurements
Protected up to $250V_{RMS}$ or $350V_p$ by fuse.

Peak voltage measurements



Measured are:

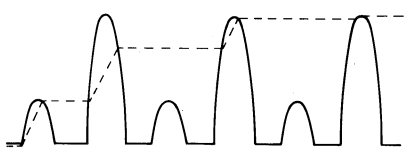
$V^{\wedge}$ = most positive peak of signal (DC-coupled)
V_v = most negative peak of signal (DC-coupled)
Both $V^{\wedge}$ and V_v can have pos. as well as neg. polarity
$V^{\wedge}_v$ = peak to peak value (AC-coupled)



Reading at 'periodical' mode
A 00 20 32 25 44
Reading at 'absolute mode
B 00 20 32 32 44

Measuring modes:

A. Periodical peak value indicating highest peak in preceding period (see line A)
B. Absolute peak value indicating highest peak value since the start of the measurement (see line B)



Accuracy:

Any signal of which peak value can be reached in one or more cycles by a slew rate of 7 digit/μs in normal mode or 70 digit/μs in high resolution mode can be measured with full accuracy. (Slew rate is indicated by dotted line)

Temperature measurements

Type of probe Pt 100 e.g. Philips PM 9249
Range depending on probe used between −250°C and +850°C
Resolution 0.1°C
Max. display 8500
Accuracy referred to DIN 43760 and excluding probe ± (0.3% rdng + 0.2°C)
Temperature coefficient (0.01% rdng + 0.003% rng)/°C
Measuring current 1mA
Response time excluding probe < 1s

HF voltage

With optional unit PM 9258 and HF probe set PM 9211
Ranges 200mV, 2V, 20V and 200V
Resolutions 10μV in 200mV range (HRM)
Limit of lowest reading 5mV
Accuracy

100kHz...3 MHz	2.5% rdng + .1% rng
3 MHz...6 MHz	5% rdng + 0.1% rng
6 MHz...25 MHz	10% rdng
25 MHz...700 MHz	3dB

Input capacitance 2pF
Maximum input voltage
AC 30V, with attenuator 200V
DC 200V, with attnuator 500V
50Ω T-piece and attenuator included in delivery of PM 9211

Peak voltage

(With option PM 9259)
Measuring modes NM and HRM
Ranges 2V, 20V, 200V and 900Vpk
Resolution in lowest range 100μV (HRM)
Maximum display 2399 in NM; 23999 in HRM
Input impedance 1 MΩ//15pF
Maximum VHz product 2.10^7
Maximum input voltage $900V_{pk}$ or $600V_{RMS}$

Periodical peak value
Two of three times per second the peak value over a preceding period of 200ms is displayed.
Start of measuring cycle is automatic.
Repetitive signals with a rise time not faster than 0.5% of signal period time or a peak value during at least 0.5% of period time are measured with the following accuracy.
+Vpeak and −Vpeak (DC-coupled)
± (0.2% rdng + 0.2% rng) for 5 Hz...100kHz
Vpeak-to-peak (ac-coupled)
± (0.5% rdng + 0.2% rng) for 10 Hz...10kHz
± (1% rdng) + 0.2% rng for 10kHz...100kHz

Absolute peak value
At any time during the measurement the maximum peak value from the start of the measurement is displayed.
Start and stop controlled manually or by external contact.
Repetitive signals:
With a measuring period, equal to 1 s or 1 period time (whichever largest) and a duty cycle of > 0.5%, repetitive signals are measured with the following accuracy.
+Vpeak and −Vpeak (DC-coupled)
± (0.2% rdng + 0.2% rng) for 0 to 100kHz.
Single Shots:
Each signal with a rise time not faster than 1ms or a peak value during at least 1ms is measured with the following accuracy.
+Vpeak and −Vpeak (DC-coupled)
± (1% rdng + 0.2% rng).

Relative reference measurements

In the "Relative reference" mode of the instrument the difference between any value and a previous measured reference value can be displayed.
Ranges are as for absolute measurements but only within one preselected range.
The max. error is equal to the sum of the errors of reference and subsequent measurements.
Max. reading equal to the total span of the ranges
other data same as that for absolute measurements.

System interfaces (optional)

IEC bus interface	PM 9291
BCD parallel output	PM 9292
Analog output	PM 9254

The analog output can be installed in parallel to one of the digital interfaces.
All front pannel functions can be remotely controlled via the interfaces.
The high speed mode can be controlled via the interfaces
For further details see 'optional accessories'

General

Type of input; guarded
ADC system; integrating
Recalibration interval; 6 months.
Read rate depending on measuring mode between 1.6 and 18 measurements/s
Data hold function by manual start or optional datahold probe
Overflow indication by 'OL'
Reference conditions according to IEC 359 23°C ± 1°C; relative humidity 45...75%
Rated range of use 0°C...50°C, 20-80% RH
Limit range of operation 0°C...55°C; 20-80% RH
Limit range of storage −40°C...+70°C; 5-95% RH
Warming up time 30 min worst case
Power supply mains voltage 220V ± 10% can be altered to 110, 120 and 240V.
Frequency 50 or 60 Hz, power consumption 30VA approx.
Dimensions (w x h x d) 280 x 90 x 328mm (11 x 3.5 x 13-in)
Weight approx. 5.5kg (12lb)
Safety according to IEC 348 class 1

Accessories supplied

Shielded measuring cable
Mains cable
4-wire testlead
Set of testleads
Spare fuses
Interconnection strip
Operating manual

Optional accessories

PM 9211	HF probe set
PM 9258	HF option
PM 9249	Temperature probe
PM 9259	Peak voltage option
PM 9254	Analog output option
PM 9291	IEC bus interface
PM 9292	BCD parallel interface
PM 9263	Datahold probe
PM 9244	Current shunt 30A
PM 9245	Current transformer 100A
PM 9246	HT probe
PM 9669/03	Rack mounting unit

IEEE/IEC Interface data

IEEE interface option PM 9291
Interface connector 25-pole IEC connector
Address settabler by switches
Interface functions
SH 1 Source handshake
AH 1 Acceptor handshake
T 5 Talker with talk only, serial poll and automatic unaddress if MLA
Ouput data
Measuring data including polarity data and range
Status data generated by serial poll including parameter, range and error conditions overload, crest factor exceeded and wrong programming
L 4 Listener with automatic unaddress if MTA
Input data
Programming data for all manual controllable functions + high speed setting
SR 1 Service Request (can be switched off with local switch) SRQ is generated in case of overload, crest factor exceeded, data available and illegal range programming
RL 1 Local-Remote control
DT 1 Device trigger by GET and data bytes E1
Time specification (excluding analog functions of voltmeter)
Programming time 10ms/byte
Output time 8ms + 4.5ms/byte
Response to serial poll 5.5ms
Codes ISO 7 bit code
Input delimiter (all characters of column 0 of ISO 7-bit coding table) Output delimeter: ETX, ECI

Signature analysis

The solution to a problem
During the past few years the effect of the microprocessor on almost all equipment types has become apparent. This has not only lead to the products becoming more sophisticated in their capabilities but also more complex in their testing an repair.

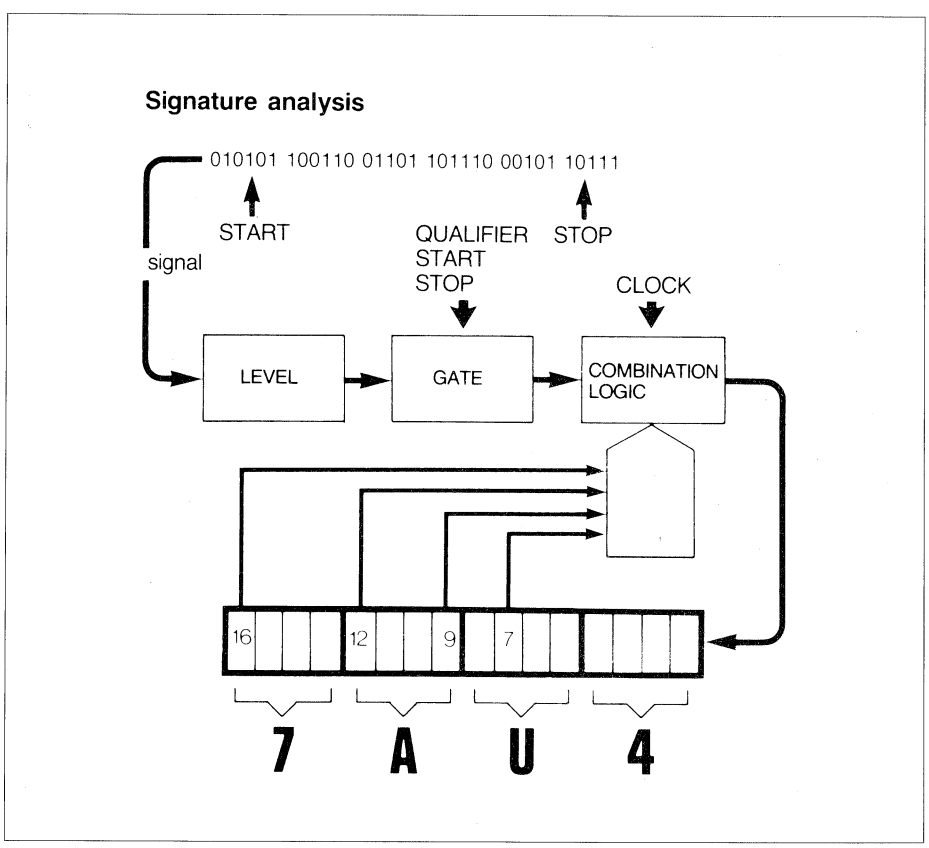
Analog circuitry could be checked using a voltmeter and oscilloscope by simply tracing the signal flow through a system. Microprocessor based equipment with its complex bus structures, bidirectional lines and combinatorial logic device testing in this way and requires more dedicated tools.

Whilst the Logic Analyzer and A.T.E. systems solved these testing problems in the development and large scale production areas, service still had to rely on its multimeters and oscilloscopes. As these tools were unable to test microprocessor based equipment the only repair method available was that of board swapping and returning the faulty board to a central service department where suitable test equipment and detailed board knowledge was available. The effect of this board swapping service was an ever increasing service stock of both good and bad boards which tied up company capital an lead to increased service costs.

This situation demanded the discovery of a new sort of testing technique that could be used in low scale production and depot and onsite service. Above all this technique had to be inexpensive, and requires a minimum training time to be effectively used. These needs were answered by the Signature Analysis technique first introduced some six years ago.

Stimulate and compress
The Signature Analysis method consists of controlled repetative circuit node stimulation and the measurement of that stimulus signal by means of a data compression technique. The stimulation is best achieved in the product itself by forcing the system into a known program loop which repetitively exercises a specific section of the total system. Measurements can then be made using the data compression technique contained in the Signature Analyzer. Such measurements on a good board will give for each node a reproducable characteristic signature which consists of a 4 digit psuedo hexadecimal code. By collecting signatures from the same nodes on a suspected faulty board and comparing these against the known good values a simple GO - NO GO fault location technique is realized.

The signature analyzer
The Signature Analyzer consists of a 16 bit shift register with four feedback paths. The data from a stimulated node is sampled into this shift register under the control a clock edge (either rising or falling) derived from the system under test. This system clock must be chosen so that the data present at the active edge is stable and meets the set-up and hold time requirements of the signature analyzer.



The period over which the data is sampled is determined by the start and stop signals. These are also edge active signals derived from the system under test and must be so chosen to ensure that the number of sampling clock edges which they enclose is perfectly repeatable for each test. The same signal can often be used for both start and stop as this reduces the number of connections to be made. In some applications (e.g. ROM testing) the use of a qualifier is also needed. This is a level active signal derived from the system under test which when active inhibits the sampling clock so masking unwanted data from the data stream.

When the stop edge is detected the sampling clock stops and the 16 bit data value present in the shift register is displayed as four psuedo hexadecimal digits called the signature. This method of data compression is extremely reliable, the risk of identifying bad data stream as correct being 50.000 to 1 whilst a 100% guarantee is given for identifying good data streams as correct.

Designing requirements and test procedure

As Signature Analysis relies on the stimulation of each circuit node under controlled and repeatable conditions, this capability must be designed into the product. The most important of the design requirements is that of functional division which breaks the total system down into smaller minimally interdependent modules. This ensures easier understanding and repair and should be considered as a standard design practise rather than a specific requirement for signature analysis.

Working from the basis of a total system failure the S.A. technique starts testing from the centre of the system and works its way outwards only using one functional module for stimulation of another after it has been verified as correct itself. The first functional module to be checked is the Kernel (processor, ram, rom).

To ensure repeatable testing of the Kernel certain hardware modifications are needed. The possibility of "free running" of the microprocessor enables all addressing and decoding circuitry to be checked. This is simply achieved by the addition of switches across the data bus which then force a no operation code on to the bus at each processor address. In addition all interrupts need to be disabled as these will emoneous affect both S.A. stimulation programs and free running.

Once the addressing and decoding circuits are verified each prom location can be tested whilst the processor is still in the free run mode. Should this prove error free then the data bus may be reconnected and a test prom containing stimulation programs may be inserted. These programs are unique to the system under test and should exercise specific functional areas of the system.

Should these functional areas contain feedback (interactive) loops then these may need to be set in a fixed condition by means of switches to ensure repeatable testing.

At each stage of the testing the correct signatures need to be known. This involves the generation of signature lists, or what is often simpler is the addition of the signatures to the circuit diagrams.

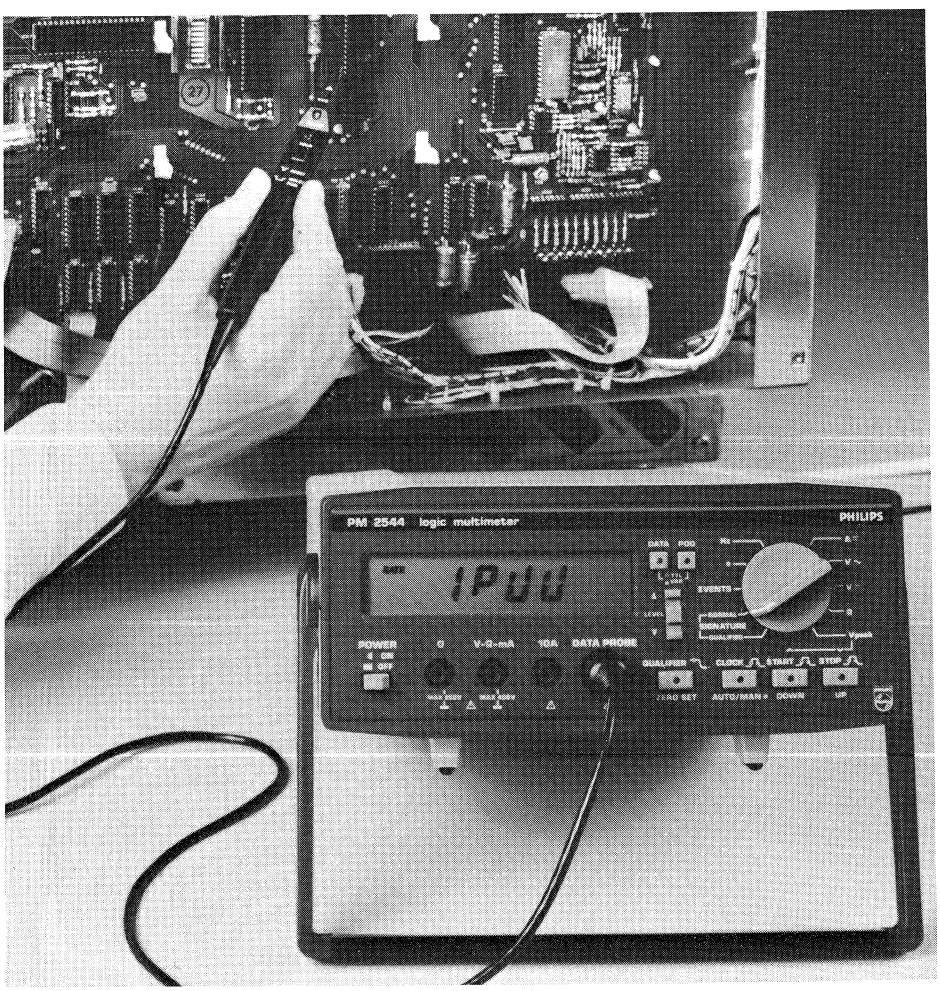
Return on investment

The cost of implementing Signature Analysis in a product is approximately 1% of its total development time. This involves:

- Hardware modifications for S.A. (free running switches etc.)
- Software stimulation programs
- Documentation (Signature lists)

The return on this investment comes in the following forms:

- Lower "spare board" stocks
- Reduced board transport and administration costs
- Reduced central service or factory loading in repairing faulty boards
- On site servicing possible



A typical application using the data hold probe which allows a measurement to be "frozen".

Industry standard signature analysis
Memory modules store 125 signatures
Full V.I.R. capabilities
20MHz frequency counter
Event counting and time measurement
Peak detection
Relative reference measurements
4½-digit display

Logic multimeter with signature analysis PM 2544

The Logic multimeter PM 2544 combines measurement of all standard electrical parameters, including time, event counting and peak voltage with a signature analysis facility. This permits data flow comparison making it the ideal tool for those difficult servicing problems posed by modern LSI circuit boards.

In addition to these valuable features are facilities for relative reference measurements, and excellent overload protection.

Signature analysis
The PM 2544 compresses the data flow at a point to produce an industry-standard four-digit signature. All inputs to the signature analyzer are threshold-selectable and the inbuilt logic data probe enables rapid identification of stuck nodes. The multimeter also offers an optional plug-in memory module capable of storing the user's own signatures for future use. Signatures can be loaded into the memory module whilst testing a known good circuit.
This fast, easy to use "catch and compare" system is invaluable for speeding up fault-finding in the repair of digital equipment.

Standard multimeter functions
Both DC volts and AC_{RMS} voltage measurements offer a resolution of 100μV with full-scale readings of 450V.

DC current measurements between 10μA and 20A (short-term) are possible, whilst resistances between 0.1Ω and 10MΩ can be measured. In all these modes, relative reference measurements can be made either by using an already measured value, or 'dialling-up' the required reference setting.

Peak voltage measurements
Push button selection allows positive or negative peaks with pulse widths as short as 20ns and repetition rates down to 20Hz to be measured to a 0.1V resolution in the range +12.6 to −12.6 volts.

Frequency measurements
After selecting the data probe trigger level to match the circuit under test, frequency measurements from 1Hz to 20MHz are fully automatic, requiring both the high and low thresholds to be crossed. The data probe indicates this by means of a LED which blinks with each transition below 3Hz, or at 3Hz for higher frequencies.

Time measurement
Time measurement between 100ns and 100000s are automatically made between user-defined start and stop edges. Signal connection is made via the timing pod whilst edge selection is made via the front panel.

Event counting
Low to high transitions up to a maximum of 10-in are counted from the data probe during a gate time defined by the start and stop edges applied to the timing pod.

Data hold
The logic data probe supplied also doubles as a data hold probe. It is only necessary to press the button on the probe to freeze the measured current value for easy reading.

Other options
In addition to the memory module and adapter a wide range of HF, high current, and high voltage probes can be used to extend the measuring range of the PM 2544. These are detailed in the instrument specification.

TECHNICAL SPECIFICATION

Performance characteristics
This specification is valid after the instrument has warmed up for 15 minutes (reference temperature 23°C ±2°C).

Signatures
Measuring modes : with or without qualifier, repetitive or single measurement with data-hold and 'latch unstable signature' mode
Display : 4 characters (0 to 9, ACFHPU)
Unstable indication : with '~' sign
Display refreshment : each 300ms except for unstable signatures, which are shown immediately

Inputs
Data input : via data probe provided with 'hold' switch and indicators for hold mode and logic state
Clock, Start, Stop and Qualifier : via POD
Input impedance : data probe 142kΩ to logic 0//25pF 77kΩ to 0.78 (dL+dH) V
: POD 100kΩ to logic 0//25pF
V open data probe : mean value of dL and dH, between +9.2 and −7.2V
Protection : 150V continuously 250V for 10s (max. peak 350V)

Trigger Levels and Edges
Selection : TTL or VARiable

	TTL	VAR	
		default CMOS	setting range independently adjustable
Data low	<0.8V	<1.5V	
Data high	<2.0V	<3.5V	Between + and −
POD	1.4V	2.5V	12.7V in 0.1V steps

The default value for VARiable setting is for CMOS 5V and is automatically set at switching on.
All levels can be shown in the display.
The trigger edges for clock start and stop and the low/high level of the qualifier can be selected and are indicated by LEDs.

Timing Data
Clock : maximum frequency 20 MHz minimum pulse width 20 ns
Gate length : min. 1 clock cycle, max. no limit
Time between gates : min. 1 clock cycle

	Data probe	Start, Stop, Qualifier
Set-up time	10ns	20ns
Hold time	0	0

Logic State Indicator
Indicator : LED on data probe bright for > dH off for < dH dim for > dL, < dH
Minimum detectable pulse width : 20ns shown on LED for at least 100ms
Trigger levels : as for signatures

Safety characteristics
Conforms to IEC 348 Class I and VDE 0411

Climatic conditions
In accordance with Group 1 of IEC 359 with extension of the temperature limits.

Reference temperature : 23°C ±1°C
Rated range of use : 0°C...45°C
Limit range of storage and transport : −40°C...+ 70°C
Relative Humidity : 20...80% non-condensing max. dew-point 25°C

Mechanical requirements
In accordance with Group 2 of IEC 359.

DIMENSIONS AND WEIGHT
(w x h x d) 225 x 107 x 305mm
(8.8 x 4.2 x 12-in)
2.8kg (6.2lb)

Power requirements
Mains supply voltage : $220V_{AC}$ (instrument can be adapted for 92V, 110V, 128V, 202V and 238V
Rated range of use : ±10%
Mains supply frequency : 50Hz ±1%
Rated range of use : 48Hz to 63Hz
Power consumption : 20VA

Electromagnetic interference
This instrument meets the requirements of CISPR-Publ. 11.

Calibration
Calibration interval : 6 months
Warm-up time before calibration : 1 hour

TECHNICAL SPECIFICATION PM 2544 - MULTIMETER SECTION

Measuring Quantity	VDC	VAC	IDC	R	Hz	TIME	EVENTS	V_{PEAK}
Ranges (all auto ranging)	1V 10V 100V 450V	1V 10V 100V 450V	100mA 10A	1kΩ 10kΩ 100kΩ 1MΩ 10MΩ	100kHz 1MHz 10MHz 20MHz	10ms to 10^5 s in eight ranges	10^5 to 10" events in 7 ranges	−12.6 volts to +12.6 volts
Max resolution	100μV	100μV	10μA	100mΩ	1Hz	100ns	1 event	100mV
Accuracy (% reading + % range)	0.2+0.05	0.5+0.1 (40Hz to 1kHz) 1.0+0.1 (1kHz to 10kHz) 5.0+0.1 (10kH to 20kHz)	0.5+0.1	0.5+0.1 for kΩ ranges 1.0+0.1 for MΩ ranges	0.01+0.02	0.01+0.02	0.01 at <10MHz 0.02 at >10MHz	2.0±0.2V
Input characteristics	9.8MΩ ≤10V range 8.85MΩ >10V range	2MΩ/50pt ≤10V range 1.8MΩ/50pt >10V range	Voltage drop <200mV	Open input voltage<3V	as data probe	as data pod	as data probe and pod	as data probe
CMRR DC	>100dB	>100dB						
AC 50Hz	>100dB	> 80dB						
SMRR 50Hz ±0.1%	80dB							
Maximum CM voltage	250V	250V						
Response time including ranging	<0.8s <1s	<1s <2s	<0.8s	<0.8s <2s	<1s <1s	<1s <1s	<1s <1s	<1s
Overload Protection	630Vp	630Vp	100mA range fused	$250V^{RMS}$	250V for 10s	250V for 10s	250V for 10s	250V for 10s
Relative Reference	YES	YES	YES	YES				
Additional Information			20A for Max 10s	Beeper at <100 counts in MAN ranging	Min pulse width 20ns	Min pulse width 100ns		Min pulse width 20ns Max repeat time 50ms

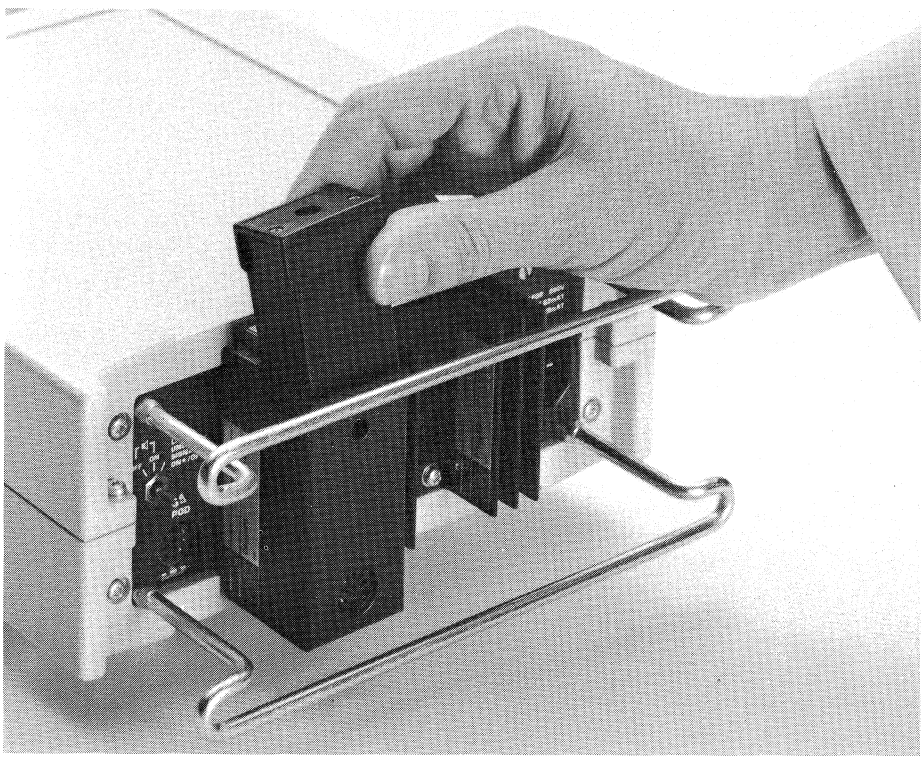
Accessories for Signature analyzer PM 2544

Memory Module Adapter PM 9140

Mass Storage of Signatures

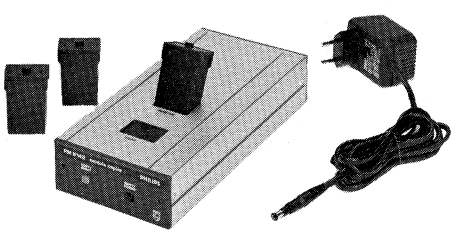
The PM 9140 memory module adaptor enables the storage and recall of signatures from the PM 9141 memory modules by the PM 2544. This enables direct comparison of measured signatures previously stored in a memory module. Any incorrect signature detected during measurement gives an error indication in the display and an audible alarm signal.

These options enables larger service organizations to centrally prepare documentation and memory modules containing signatures which considerably shortens the trouble shooting time at individual service depot level.



TECHNICAL SPECIFICATION

Storage capacity	: trigger levels for probe and pod separate trigger edges for normal and qualified mode maximum of 125 signatures
Read time	: 1ms/signature
Loading	: via PM 2544, using 'store' mode
Supply	: Li battery (lifetime 5 years)



Memory Module Copier PM 9142

Simple and Fast Operation

After placing the centrally prepared memory module in the MASTER socket and an empty module in the COPY socket the duplication action is started by pressing the COPY button on the front panel. The start of this duplication is indicated by the lighting of the BUSY LED on the front panel.

Following a correct copy action this LED is extinguished and a single short audible tone is given. Should the copy action not pass the verification test this is indicated by a continuous flashing of the LED and two individual tone bursts. Before continuing the flashing LED needs to be cancelled by pressing the COPY/RESET Button.

TECHNICAL SPECIFICATION

Programming Time
1.5 sec.

Power Supply
9V ±1V at 150mA (via PM 9218)

Temperature Limits
0 to 45°C for use
−25 to +70°C for storage and transport

Humidity Limits
20-80% RH non condensing for use
5-95% RH for storage and transport

Dimensions
44.5 x 105 x 226mm

Weight
0.5kg approx.

Accessories Supplied
PM 9218 9V power supply
Direction for use

ROM emulation
Signature storage
Programmable stimulus lines
Bus test facility
Microprocessor independent
Large resident storage capacity

PM 9143 Universal exerciser for signature analysis

Introduction

The PM 9143 offers a unique solution to the problem of digital system trouble shooting by providing both the test software for the circuit under test and in parallel the known good measuring results in the form of signatures. When used in conjunction with the PM 2544 Signature Analyzer this enables GO/NO GO fault analysis to be performed without reference to extensive documentation by just listening for the fault indication beeper on the PM 2544.

Large test storage capacity

The novel hardware design of the PM 9143 can be split into two functions, those of mass storage (upto 32Kb) and operational memory (2k). The operational memory permits both developement and execution of test software by means of its ROM emulation capability which also makes it microprocessor independent. In parallel to the test software this memory also contains stimulus data control information making easy programming of START and STOP edges for Signature Analysis and ensuring that stimulus signal inputs to the system under test are synchronous with the memory addressing. This avoids any risk of timing problems and ensures repeatable testing.

Once the test software and stimulus lines have been programmed signatures may be collected from the system under test using the PM 2544 Signature Analyzer. The measured signatures are transmitted over a simple serial connection to the PM 9143 where they are stored together with the test software and stimulus data.

The complete contents of the operational memory can be transferred to EEPROM in the mass memory under a specified test number. Recalling this test number at a later date loads the test software, stimulus data and signatures into the operation memory so that testing may be immediately started. In this mode the signatures are available to the PM 2544 in the same way as with the PM 9141 memory modules.

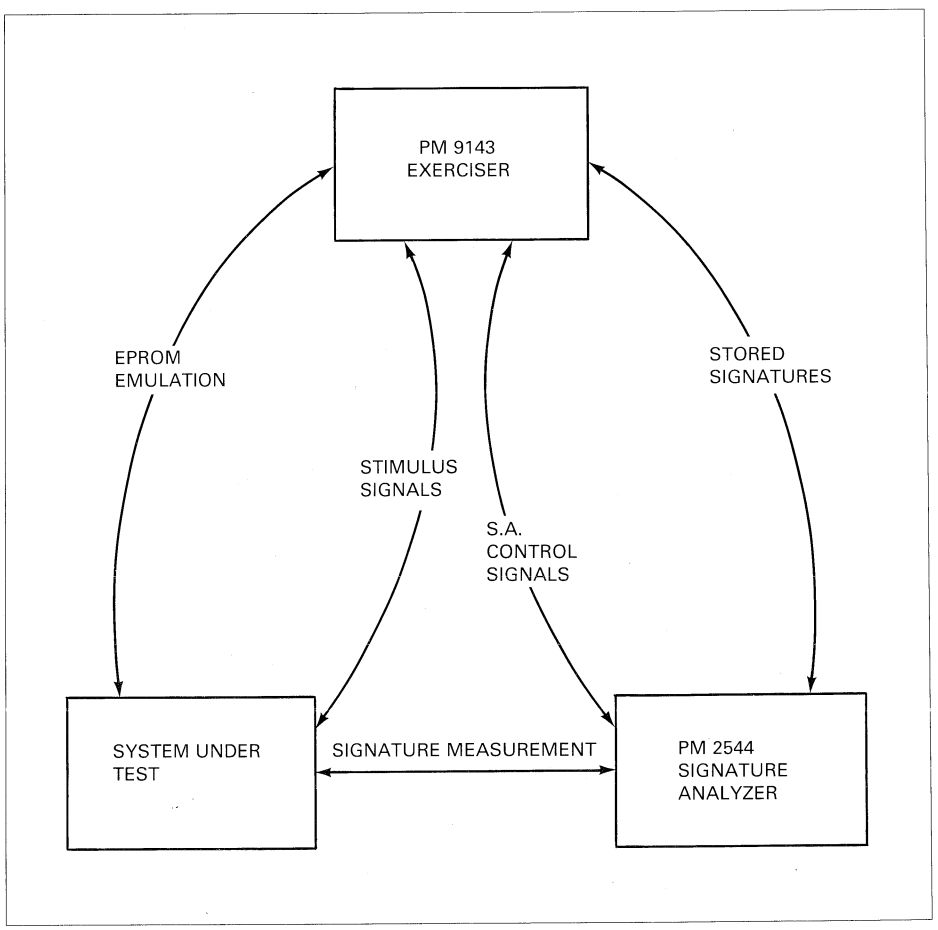
Bus Test

To quickly identify short circuits a preprogrammed bus test exercises each line of the emulated ROM. In this mode and in test operation hardwired status lines are available to control the RESET/HALT operation of the tested system.

TECHNICAL SPECIFICATION PM 9143

Emulated ROM types - 2716, 2732, 2764
Mass Storage - ROM Types - 2816, 2716, 2732
- ROM Supplied - 1 x 2816
- No of sockets - 4 x 28 pins

Number of stimulus Data Outputs - 8
Number of stored signatures per test = Max 125 plus clock, start, stop edges and threshold levels
Power supply - 5V @ 250mA
Accessories supply - Power supply, PM 2544 to PM 9143 signature connection cable, directions for use, test leads and hooks.
Dimensions (wxdxh)
136 x 240 x 70mm (5.3 x 9.4 x 2.7-in)
Weight 1kg (2.2lb)



Closed loop testing of digital equipement

Sensitivity 1mV (fsd) to 300V
Bandwidth 2Hz...12MHz
High accuracy up to 1% fsd ±1% of reading
140dB CMRR at 50Hz (1mV range)
DC recorder output or AC output

Wide bandwidth AC millivoltmeter PM 2554

PM 2554 combines good accuracy with an extremely wide bandwidth (12 MHz) and voltage range (100μV-300V). It is therefore ideal for all measurements from audio frequencies to the HF and beyond. All ranges are protected from overloads of up to 300V_{RMS} (400V_{DC}). Mains voltage variations of ± 10% give no more than 0.1% change in accuracy.

TECHNICAL SPECIFICATION

Measuring ranges
0-300V_{RMS} in 12 ranges from 0–1mV to 0–300V
dB scale ranging from −80dB to +52dB (0dB = 1mV into 600Ω)

Frequency range
2 Hz–12 MHz

Input
Floating
Input impedance 1 MΩ//33pF
Max. voltage low-ground 500V_{peak}
Impedance low-ground 1GΩ/1.4nF
For reduction of capacitive loading, PM 2554 can be used with PM 8925 Oscilloscope Probe, input impedance 10 MΩ//11pF
Common mode rejection 140dB at 1kHz in 1mV range
120dB at 100kHz in 1mV range.

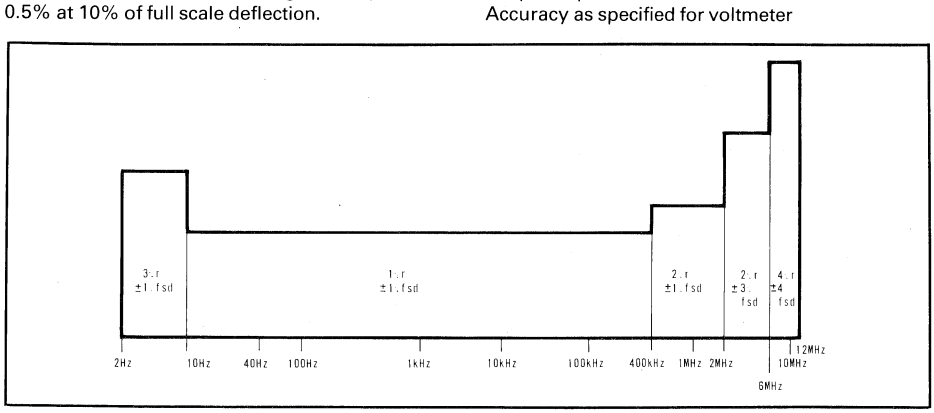
Accuracy
1% f.s.d. + 1% of reading
Additional error for frequencies outside flat part of bandwidth – see graph.

Stability
A line voltage variation of ± 10% will give an additional error of 0.1% max.
Long term stability ± 0.1% over 90 days

Noise
At short-circuited input < 30μV.
Influence of noise on measuring accuracy less than 0.5% at 10% of full scale deflection.

Overload
Protected against overloads up to 300V_{RMS} or 400V_{DC}

Recorder output
DC voltage: 1V at full scale
Output impedance 1kΩ
Accuracy as specified for voltmeter



AC output
Output impedance 600Ω in serial with 47μF
Output voltage 50mV
Short-circuit proof

Supply
Mains: 90V...132V or 180V...265V; 50/60Hz

Temperature range
Reference temp. 23°C ± 5°C
Operating temperature 0°C...45°C
Temperature coefficient 0.1%/°C

DIMENSIONS AND WEIGHT
(w x h x d) 236 x 145 x 298 mm
(9.3 x 5.7 x 11.7-in)
3.5kg (7.7lb.)

ACCESSORIES

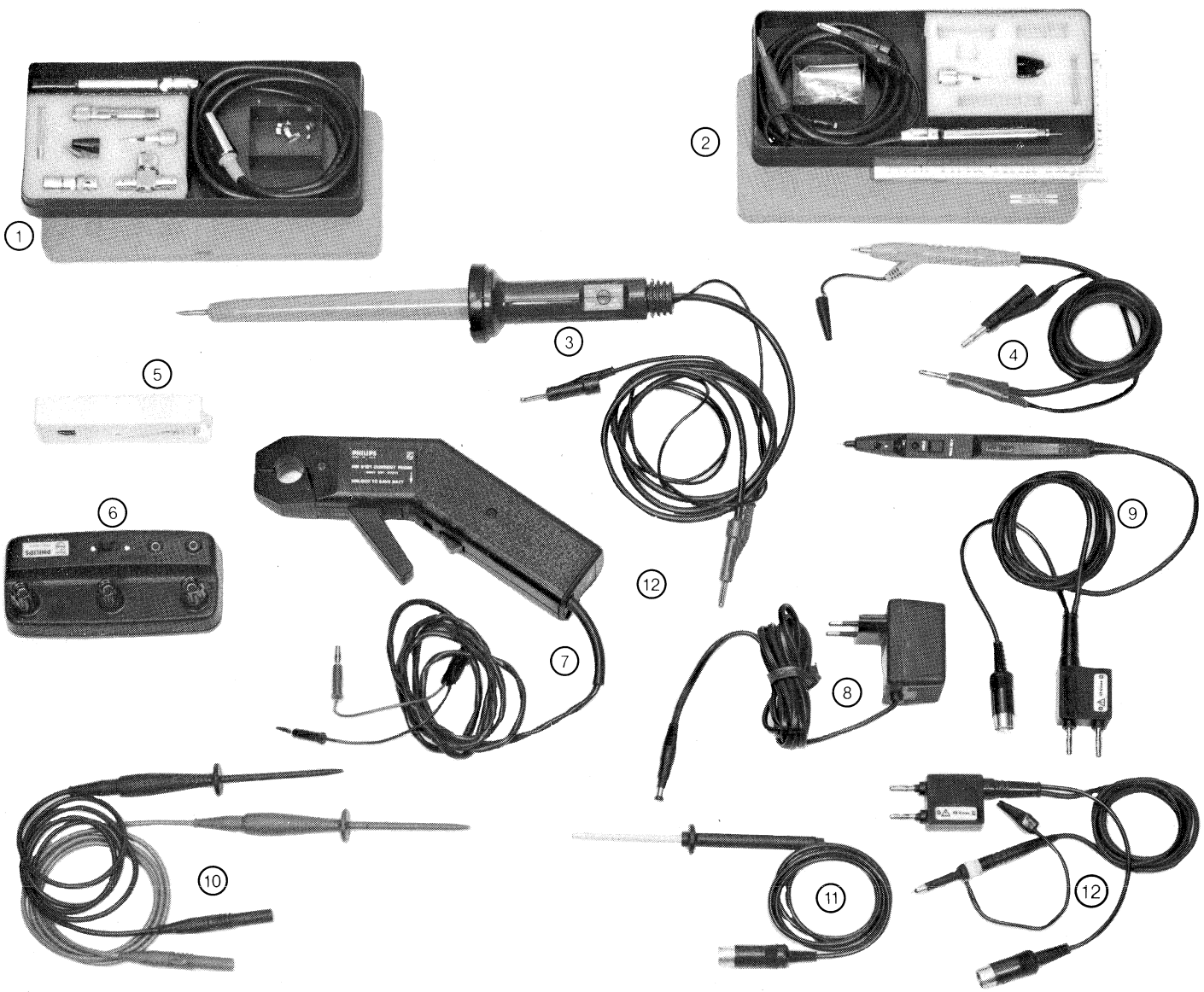
Supplied with instrument
Mains Connection Cable
Measuring cable
Manual

Optional
PM 9072 Measuring cable Banana, BNC, 135Ω
PM 8925 Passive probe 10:1
PM 9051 Adapter BNC-Banana

Technical specifications for PM 9210, PM 9211, PM 9212 and PM 9213

	PM 9211	PM 9211 + att.	PM 9210	PM 9210 + PM 9212	PM 9213
Frequency range	100kHz-1GHz	100kHz-1GHz	100kHz-1GHz	100kHz-1GHz	10kHz-100MHz
Straight line within 5%	100kHz-6MHz	100kHz-6MHz	100kHz-6MHz	100kHz-6MHz	30kHz-30MHz
Max. deviation	3dB	3.5dB	3dB	3.5dB	3dB
Voltage ranges (f.s.)	2mV-2V	2V-200V	*150mV-15V	15V-200V	10mV-15V
Max. voltage AC	30V	200V	30V	200V	30V
Max. voltage DC	200V	500V	200V	500V	350V
Input capacitance	2pF	2pF	2pF	2pF	40pF
T-piece	Included in delivery		Optional in PM 9212		Not available
Frequency range	100kHz-1.2GHz			100kHz-1.2GHz	
Impedance	50Ω			50Ω	
Standing wave ratio	1.25 at 700MHz	1.15 at 1GHz		1.25 at 700MHz With attenuator 1.15 at 1GHz	

*using calibration chart below 150mV



① **PM 9211** HF Probe.
② **PM 9210** HF Probe.
③ **PM 9246** HF Probe.
④ **PM 9213** HF Probe.
⑤ **PM 9245** Current transformer.
⑥ **PM 9244** Current Shunt.
⑦ **PM 9101** Current Probe.
⑧ **PM 9218** Mains Adapter.
⑨ **PM 9267** Data Hold Probe.
⑩ **PM 9266** Safety Test Loads and Probes.
⑪ **PM 9249** Temperature Probe.
⑫ **PM 9263** Data Hold Probe.

Multimeter accessory specifications

PM 9101 DC Current probe
Clip on probe for DC and AC current measurements up to 200A.
- Output voltage 1mV/A
- Recommended load ≥ 3k
- Accuracy 2% up to 100A
  3% 100A...200A
  for DC to 1kHz
- Max. voltage to ground 250 V_{RMS} or 350Vp
- Power requirements 4x "AA" batteries or 9V mains adapter e.g. PM 9218

PM 9111 Mains adapter
Provides mains operation for PM 2505
- Mains voltage 220V ± 10%

PM 9218 Mains adapters
Provides mains operation for PM 2517 and PM 2504.
- Mains voltage available
  220V ± 10%
  110V ± 10%
  240V ± 10%

PM 9244 DC and AC Current shunt
- Ranges: 10A and 31.6A
- Output voltage: 100mV output or 31.6mV at choice
- Accuracy: for DC and AC up to 1kHz
  1% for 100mV output; 2% for 31.6mV output
- Max. voltage to ground: 400$V_{DC\ or\ AC}$

PM 9245 AC Current transformer
- Range 10A to 150A
- Transfer tactor 1000x
- Accuracy at 50Hz + 0.5% for 40Hz to 10kHz ± 2%
- Max. voltage to ground: 400$V_{AC\ or\ DC}$

PM 9246 High tension probe
For measurement of DC Voltage up to 30kV. The probe may be used with instruments having 100MΩ, 10MΩ or 1.2MΩ input resistance.
- Max. input voltage 30kV
- Attenuation 1000x
- Input impedance 600MΩ
- Accuracy 3% at 100MΩ or 10MΩ input impedance; 5% at 1.2MΩ input impedance, both ± 6ppm/V

PM 9248 and PM 9248A Temperature probe
PM 9248 is a contact probe suitable for measurements of surface temperatures.
PM 9248A is an indentical probe for measurements of liquids.
- Temperature range −60 to +200°C
- Resolution 0.1°C
- Accuracy including instrument specification
  − 60...+100°C ± (1% rdng + 2°C)
  +100...+200°C ± (3% rdng + 2°C)
- Max. voltage on probe tip 60V

PM 9249 Temperature probe
For measurement of surface temperatures and of liquids
- Temperature range −60 to +200°C
- Resolution 0.1°C
- Accuracy excluding multimeter specification: (0.5% rdng + 0.5°C)

PM 9254 Analog output
- Output isolated from input up to max. 250V_{RMS}
- Output voltage 1mV/digit over a maximum of 3 digits that can be selected at choice
- Output resistance 200Ω
- Accuracy ± (0.2% rdng + 0.1 rng) excluding voltmeters

PM 9255 Analog output
- Output isolated from input up to max. 250V_{RMS}
- Output voltage 2V at end of range
- Resolution, steps of 1mV
- Output resistance 200Ω
- Accuracy ± (0.2% rdng + 0.1% rng) excluding voltmeters

PM 9263 Data hold probe
For use in combination with multimeters having data hold facilities on the DIN probe input. A switch on the probe is pushed forward to hold the data in the display.
- Max. input voltage 30V_{RMS} (test voltage 500V_{AC})
- Max. input current 200mA

Several probe tip adapters are supplied with the probe.

PM 9278 Ever-ready case
Sturdy shock resistant case of plastic with paddings on the inside for shock absorption and space for accessories.

PM 9291 IEC-625 Busline interface
Interface functions:
- T5: Talker capability with serial poll, talk only and unaddress if MLA
- L4: Listener capability with unaddress if MTA
- SR1: service request capability
- RL1: Remote-local capability
- DT1: Full device trigger capability

Output data: Parameter measured,
Measuring range
Polarity and measuring data
Input data: Parameter to be measured
Range
Measuring mode
Start command

PM 9292 BCD parallel output
- Output isolated from input up to 250V_{RMS}
- System: Word parallel – bit parallel
- Code: positive BCD
  0" = 0...+0,4V, "1" =5 or +15V
- Output data:
  measuring result including overload and range indication, parameters and polarity
- "Print command":
  500μs output pulse
- Start command:
  With negative pulse of 15μs...100ms

Multimeter Accessory chart

• Included in delivery ○ Optional			PM 2504	PM 2505	PM 2518X	PM 2519	PM 2521	PM 2528	PM 2544	PM 2554
Measurements cables	PM 9071	Banana-Banana 135Ω	○	○	○	○	○	○	○	
	PM 9072	Banana-BNC 135Ω	○	○	○	○	○	○	○	○
	PM 9074	BNC-BNC 50Ω								○
	5322 320 14093	BNC-Banana								•
Adapters	PM 9051	Adapter BNC-Banana								○
	PM 9053	Adapter Banana-BNC	○		○	○	○	○	○	○
	PM 9061	Adapter BNC-BNC								○
	PM 9067	T-piece BNC								○
Test leads	PM 9260	Pair of testleads	•	•						
	PM 9266	Pair of saftey testleads			•	•	•	•	•	
	5322 321 20506	4-wire-testleads						•		
	5322 321 24376	measuring cable						•		
Probes	PM 8921	1:1 passive probe								○
	PM 9326	10:1 passive probe								○
	PM 9263	Hold probe					○	○		
	PM 9267	Hold probe			○	○				
HF accessories	PM 9258	HF option						○		
	PM 9210	HF probe	○	○	○	○	○		○	
	PM 9211	HF probe set (linear)						○		
	PM 9212	Accessory set for PM 9210	○	○	○	○	○		○	
	PM 9213	Low cost HF probe	○	○	○	○	○		○	
HT probe	PM 9246	30kV probe	○	○	○	○	○	○	○	
Peak voltage	PM 9259	Peak voltage option						○		
Temp. probes	PM 9249	Temp. probe			○	○	○	○		
	PM 9248	Temp. probe −60...+200°C								
	PM 9257	Temp. option								
Current accessories	PM 9244	30A shunt		○	○	○	○	○	○	○
	PM 9245	100A transformer	○	○	○	○	○	○	○	
	PM 9101	DC current probe	○	○	○	○	○	○	○	
Supply units	PM 9216	Rechargeable batt. unit								
Mains supplies	PM 9218	Mains adapter	○							
	PM 9111	Mains adapter		○						
Ever-ready cases	PM 9672	Carrying case								
	PM 9278	Ever-ready case		○	○					
	PM 9279	Carry case				○	○		○	
Rack mount	PM 9669/01	Rack mount unit								
	PM 9669/03	Rack mount unit						○		
Parallel interfaces	PM 9237	BCD output								
	PM 9292	BCD output						○		
	PM 9220	50 pole cable						○		
Serial interfaces	PM 9238	Bus-line interface								
IEC-625	PM 9280	Bus-line cable						○		
	PM 9282	Bus-line cable						○		
	PM 9191	Bus-line interface				○				
	PM 9291	Bus-line interface						○		
	PM 9254	Analog output						○		
Mains cables	PM 9011	Mains cable Europe				•	•	•	•	
	5322 231 14001	Mains cable Europe								•

LF and HF generators

Unit	Description	Frequency	Special features	Page
Introduction				2
RC OSCILLATORS				
PM 5107	Low distortion RC oscillator	10Hz...100kHz	$6V_{pp}$ output Very low distortion	6
PM 5109	Low distortion RC oscillator	10Hz...100kHz	Monitored $10V_{pp}$ symmetrial and $30V_{pp}$ asymmetrical output	7
PM 5109S	Low distortion RC oscillator	10Hz...100kHz	Monitored $30V_{pp}$ asymmetrical output	7
FUNCTION GENERATORS				
PM 5131	Function generator	0.1Hz...2MHz (logarithmic)	Sine/square/triangle with $30V_{pp}$ output	9
PM 5132	Function generator	0.1Hz...2MHz (linear)	Sine/square/triangle/pos. pulse/ neg. pulse/DC with $30V_{pp}$ output	11
PM 5133	Function generator	0.01Hz...2MHz (log/linear)	Digital display for frequency and voltage	13
PM 5133S	Function generator	0.01Hz...2MHz (log/linear)	As PM 5133 plus special sweep according to DIN standards	13
PM 5134	Function generator	0.001Hz...20MHz	Sine/square/triangle/pulses/DC, Digital display, X-tal mode	16
LF SYNTHESIZERS				
PM 5190	LF synthesizer with μP control	0.001Hz...2.147MHz	Feather-touch keyboard frequency selection with LED display	19
PM 5190X	LF synthesizer with μP control	0.001Hz...2.147MHz	As PM 5190 plus enter facility	19
PM 5193	Programmable synthesizer/ function generator with μP control	0.0001Hz...50MHz	Multi-programme storage: Sine/ haversine/triangle/square/pos/neg sawtooth/pos-neg pulses	22
HF SYNTHESIZERS				
PM 5390	RF synthesizer with μP control	0.1MHz...1020MHz	Sweep, AM, FM and video modulation	26
PM 5390S	RF synthesizer with μP control	0.1MHz...1020MHz	As PM 5390 with 2V output	26
AMPLIFIERS/CONVERTERS				
PM 5171	Amplifier, AC/DC and linear/ log converter	DC...1MHz	Amplifier plus AC/DC and linear/log conversion; dynamic range 80dB	30

Introduction

LF generators in telecoms testing
In spite of the increase in digital circuitry used for modern telephone equipment, the bulk of the circuitry is still analog and much of it operates at low frequencies. In particular, every speech connection starts and finishes with audio frequency lines. So the need for low frequency analog test equipment is important.

Whilst sophisticated test sets are available for both stimulation and measurements of many line and switching parameters, the routine service task is often eased using relatively simple equipment - such as low frequency generators.

In particular, the high spectral purity of the RC oscillator makes it particularly suited to telecommunications work for both speech and audio programme line testing.

Such instruments supply both sine and square wave outputs which can be used for a wide variety of tests. These vary from the frequency characteristics of balanced pairs to alignment of line amplifiers and filters.

PM 5109 is an ideal instrument for measuring the characteristics of physically long lines.

Adapted to application
Although general purpose equipment can be selected, ideally the instrument chosen should be adapted to the requirements of this type of work.

In particular, facilities such as balanced floating outputs for cable checking, choice of output impedance to simplify line matching and high signal purity are essential. And as service equipment is being considered, the instruments should be easy to use.

But before going any further it is probably worth defining what is meant by low frequency. In telephone terms this covers the 300 to 3,400Hz bandwidth used for speech circuits and the 30 to 15,000Hz required for audio programme lines.

Most low frequency equipment is in fact capable of working up to at least 100kHz. The lowest frequency that can be produced depends however on the type of equipment selected - but is at least below 1Hz.
There are several methods for generating low frequencies in wide use. The final system choice must depend on the applications. Factors to be considered include frequency accuracy, signal repeatability and output waveform spectral purity.

High frequency accuracy
For very high frequency accuracy and repeatability it is necessary to select either a crystal-controlled function generator or a frequency synthesizer. The latter finds wide use in laboratories and in production control where it can provide very high frequency accuracy - typically up to $\pm 1 \times 10^{-6}$.

MF INSTRUMENTS SURVEY

Classification	Type number	Frequency range Hz MHz	Output Vp-p	DC	Waveforms ∿ ⊓ ⩘ ⊓ 1) ⊿ 2) ∩	Variable duty cycle	DC-offset	Output characteristics 600Ω	50Ω	TTL	Sweep linear Int	Sweep linear Ext	Sweep log Int	Sweep log Ext	Burst	Single	Gating	Int AM	Int FM	Int PM	IEEE / IEC
R-C oscillators	PM 5107	10-0.1	6		• •			•		•											
	PM 5109	10-0.1	30/10		• •			•	•	•											
	PM 5109S	10-0.1	30		• •			•	•	•											
Function generators	PM 5131	0.1-2	30	•	• • •		•		•	•			•	•							
	PM 5132	0.1-2	30	•	• • • •	•	•	•	•	•	•	•									
	PM 5133	0.01-2	20	•	• • • •	•	•	•	•	•	•	•	•	•	•	•			•		
	PM 5133S	0.01-2	20	•	• • • •	•	•	•	•	•	•	•	•	•	•	•			•		
	PM 5134*	0.001-20	20	•	• • • •	•	•	•	•	•	•	•			•	•		•	•		
LF and MF synthesizers	PM 5190**	0.001-2	20	•	• • • •		•		•	•								•			IEC
	PM 5190X**	0.001-2	20	•	• • • •		•		•	•								•			IEC
	PM 5193***	0.0001-50	20	•	• • • • • •		•		•	•	•	•	•	•	•	•	•	•	•	•	IEEE
Amplifier AC/DC converter log	PM 5171	0-1																			

* PM 5134 also provides X-tal mode and X-tal AM mode
** PM 5190 ext. AM
*** PM 5193 incl. real pulse generator of 3ns

1) pos. and neg.
2) pos. and neg.

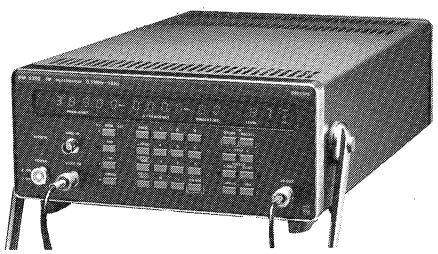
Direct digital synthesis is the preferred method as it allows fine frequency resolution and short switching times.

With the use of microprocessor control, direct digital synthesis has now become cost effective with phase-locked loop systems. The microprocessor has also simplified instrument operation.

Function generators are the most widely used form of low frequency signal source. They are based normally on a triangular waveform generator which allows provision of sine and square wave signals. The triangular generator works by linking two current sources to an integrator. One source delivers current to the integrator, the other removes it.

When the supply source is on, the integrator is charged linearly. The output of the integrator is sensed by a voltage comparator which cuts off the supply current source when the correct level is reached. The integrator discharges through the current source until it arrives at its correct level when it is again switched.

Varying the charge current changes the frequency. The voltage comparator supplies the square wave output whilst a diode sine shaper provides the sinewave. No signal bounce when switching, a wide frequency spectrum and the large choice of waveforms are Major advantages of such a system are Crystal reference locking can provide improved accuracy.



PM 5390 is a μP-controlled RF synthesizer which offers many features including video modulation.

High signal purity

However, to meet the need for high signal purity often demanded in telephone work - a pure, noise-free sinewave is essential for many measurements - another approach is required: the RC oscillator.

The RC oscillator is, in fact, the simplest form of generator. It consists of an RC network linked to an amplifier. The frequency of the output sinewave can be determined using the usual $\frac{1}{2\pi RC}$ formula. The attenuation of the RC network is compensated for by the amplifier. Loop gain for oscillation must be unity.

The very high signal purity obtained from such a system - typically distortion at 1kHz can be as low as 0.02 percent - makes it ideal for checking all elements of a transmission line system, from the subscriber connection through to any digital interface.

The low distortion of the RC oscillator of course also makes it ideal for checking amplifiers and filters. Fast checks of line amplifiers and other similar elements can be simplified using a square wave - again available from an RC oscillator, normally using a Schmitt-trigger type clipper circuit.

But of course signal purity is not the only specification to check when selecting such equipment. Output signal stability is equally important - particularly when checking the frequency characteristics of a balanced pair, the basis of all speech circuits.

The standard test for this characteristic is to apply a signal to one end of the pair and measure the voltage across the terminating impedance at the other end. The attenuation of the line which is defined as 20 log ($\frac{1}{2}e_1/e_2$) is then plotted against frequency.

But the applied signal level must be very constant for a meaningful result. The standard specifications for stability in this type of measurement are in the region of $\pm$0.5dB from 10Hz to 10kHz.

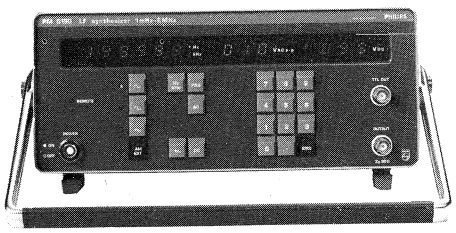
Higher accuracy possible

Higher level research, development and quality control need more sophisticated equipment. High accuracy, stability and reproducibility are required as well as an extended frequency range. Mechanical phenomena for example need signals in the range of 1mHz to 10mHz for simulation and easy checking.

The accuracy, stability and reproducibility criteria can be met either using crystal-controlled references for the generator output or by applying a frequency synthesizer.

The accuracy of crystal-controlled operation with an analog frequency generator can be high. The system depends on a phase-locked loop. Typically, Philips PM 5134 generator can give accuracies of $\pm 5 \times 10^{-6}$ using its frequency-lock facility. And this accuracy is available for the carrier in AM operation as well.

Frequency synthesizers, based on digital generation of output waveforms, offer an even higher level of accuracy and, more importantly, reproducibility of output. The only limitation is the stability of the basic crystal oscillator.



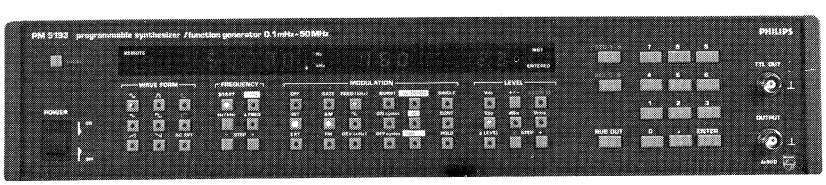
The PM 5190 LF synthesizer provides very stable signals between 1mHz and 2MHz. It is supplied fitted with an IEEE/IEC bus interface, as standard.

For example, with Philips PM 5190 microprocessor-controlled synthesizer, accuracies of $\pm 1 \times 10^{-6}$ are possible.

Extended use of microprocessors

The use of microprocessors has greatly improved instrument performance. Moreover, whilst performance has been upgraded, setting up has been simplified considerably. A typical example of the μP-controlled synthesizer is the Philips PM 5193 which represents a further advance in modern synthesizer design.

Microprocessor control not only simplifies setting up, but, in conjunction with internal non-volatile registers, allows the storage of up to nine pre-set programmes for immediate call-up as required. It offers a wide range of waveforms and int/ext. modulation facilities as well as TTL output and full IEEE/IEC-bus capabilities.



PM 5193 provides a wide range of waveform outputs with extensive internal and external modulation facilities. It features advanced IEEE/IEC facilities.

Selecting low frequency test equipment
The different types of low frequency signal generating equipment available can be confusing. Many parameters need to be considered when selecting such equipment, not least the type of application.

The most important parameters are probably frequency range, waveforms, output voltages and output impedance. Additional facilities such as duty cycles, sweep functions and dc offset are also important. And for high level work, accuracy, stability and reproducibility must be considered.

With the wide range of applications of such instruments, no single instrument can meet all needs. Requirements can be divided into two main areas however. These are general purpose test equipment for both education and industry and special high accuracy models for R&D and quality control.

To meet all these needs, instrument makers provide a wide range of RC-oscillators, function generators and frequency synthesizers. Philips has a particularly full range of such equipment, especially with the PM 5133 and PM 5134 function generators and the PM 5109 RC-oscillator.

General purpose applications
General purpose instruments in the 0.1Hz to 2MHz range are the most common and widely–used low frequency function generators. Applications include all levels of education from secondary school to university research as well as R&D and production quality control in industry.

Apart from a choice of waveforms, facilities should include dc offset and a variable duty cycle. A separate TTL–compatible output is also useful. The output voltage should be sufficiently high to drive the circuitry being tested – typically 20 or 30V peak to peak. Stepped and variable attenuation are also needed.

Sweep facilities should be versatile and easy to use. Preferably it should be possible to have both internal and external sweep facilities. Start and stop frequencies should be settable independently and the sweep period should vary over a sufficiently wide range.

A particular advantage of the PM 5131 instrument for example is a three-and-a-half decade internal sweep range. This allows sweeping of the entire 20Hz to 20kHz audio range in one go.

Apart from a high output voltage, the output impedance should be matchable to the circuitry being tested – typically a choice of 50 or 600 ohm termination should be available.

General purpose instruments of this type find wide application in education at all levels where there is need to explain signal forms and duty cycles of pulses and make simple sweep measurements. Professional uses such as in industry or audio servicing are also well served by such instruments.

Important design considerations
There are several important design considerations to look out for when choosing an instrument. Not least is the advantage of a metal rather than a plastic cabinet. The resulting instrument is not only more robust but also has full protection against electrical interference.

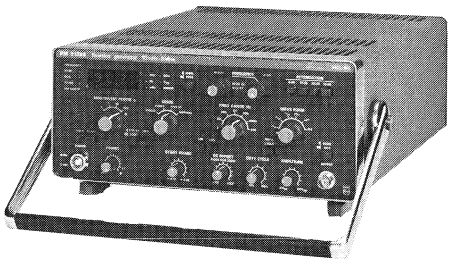
Increasing integration of the electronics brings many benefits. The lower component count increases reliability for example. Also it is possible to add features to the instrument often with little increase in overall cost.

One facility which is found increasingly in more sophisticated generators is LED display for frequency, output voltage as well as for indication of selected parameters. The added expense of such a system can often be worthwhile in the increase of readout accuracy – avoiding parallax setting errors.

Ease of use is essential with whatever type of function generator is selected. Preferably frequency, voltage and sweep facilities should be well distinguished on the instrument panel. Philips achieves this by using separate colours for each section for instance.

Apart from colour coding, Philips has also simplified the operations themselves. For example, in the PM 5133 and PM 5134 high level instruments, only one button is required to give both frequency and output voltage on the digital display.

With frequency synthesizers, especially the modern generation of microprocessor-controlled models, operation should be very simple. Typically on Philips PM 5190 all parameters can by keyed in directly on the front panel and separate LEDs are provided for each output value.



PM 5133 is a Function generator which provides output frequencies from 10mHz up to 2MHz and has linear and logarithmic sweep facilities. The complementary unit, PM 5134 with an output range between 1mHz and 20MHz with FM modulation also incorporates a X-tal lock to give high stability signals. PM 5134 is shown above.

Some specification points
A final area worth considering concerns some of the more confusing specification points and what they mean exactly. Stability figures are a typical case, especially the difference between long and short-term stability drift.

Long-term stability is normally defined per day and depends on electrical characteristics of the frequency generation circuitry. For a crystal-controlled system, it is the stability of the crystal itself. Short-term drift comes from random circuit changes and is averaged over much shorter periods.

Spectral purity is another term sometimes seen. This refers to all signal contaminants such as noise and spurious signals. Frequency jitter should also be checked – Philips PM 5190 synthesizer for example offers very low jitter figures.

Finally, when looking at facilities on function generators, some points to check are:

- Start and stop frequencies for sweep measurements – frequency setting must be very accurate;
- Variable start phase for single wave or single shot facilities – essential for simulating interference or other one-off phenomena;
- Provision of both internal and external burst possibilities for applications such as loudspeaker tests; and
- For AM and FM facilities, both internal and external modulation should be possible with variable modulation depth and deviation.

RECORDING OF THE FREQUENCY RESPONSE OF HIFI EQUIPMENT

Conventional measuring methods for plotting a frequency characteristic by point-by-point measurements, are too cumbersome and time-consuming when testing modern HiFi equipment. Dynamic measuring methods employing square-wave signals give fast results although the accuracy is not sufficiently high. However, they are useful e.g., for comparison of the transmission properties of the two channels of a stereo amplifier or for rapid diagnosis of amplitude and phase errors, however.

Where measurements demanding both speed and accuracy are required, a different approach is necessary. By using a Philips sweep generator PM 5133 and the amplifier AC/DC logarithmic converter PM 5171, together with an X-Y recorder such as the PM 8043, excellent results can be obtained. In view of the wide bandwidth and amplitude ranges to be covered, it is desirable to record the frequency characteristic with logarithmic scales along both axes. The PM 5133 and PM 5171 both provide logarithmic outputs.

The measuring set-up

The block diagram of the measuring set-up is shown in Fig. 1.
The sweep generator PM 5133 delivers a sinusoidal signal of constant amplitude, the frequency of which is swept logarithmically in the range from 10 Hz up to 100kHz. This signal is applied to the R input of the stereo amplifier. The L input is terminated with an RC network (47kΩ//220 pF), the impedance of which corresponds to the internal impedance of a typical source. The outputs of the amplifier under test are each terminated with a 4.7Ω impedance.

The sweep generator drives the X input of the X-Y recorder PM 8043 via its INT MOD output, so that the excursion of the pen of the recorder in the X direction is proportional to the logarithm of the frequency of the sinusoidal signal.

The voltage drop across the 4.7Ω load resistor is used to drive the PM 5171. The latter has three outputs: amplifier, AC-to-DC conv. (linear output) and LOG CONV. In this application, the LOG CONV output is connected to the Y input of the X-Y recorder, while the AMPLIFIER output can be connected to an oscilloscope for checking the waveform of the signal. When the amplitude range to be covered is relatively narrow, the Y input of the recorder can be connected to the linear output of the

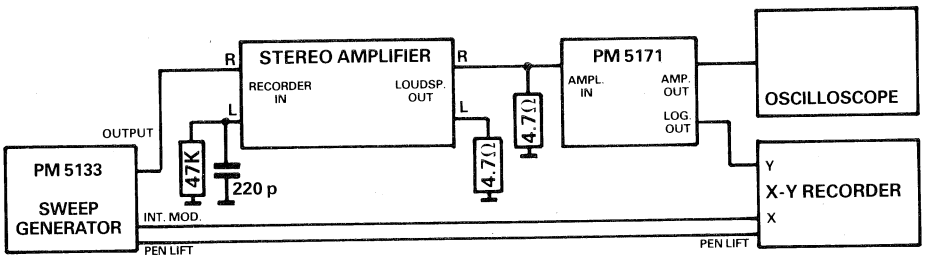


Fig. 1

PM 5171; this thus gives a choice between a logarithmic and linear excursion of the pen of the recorder.

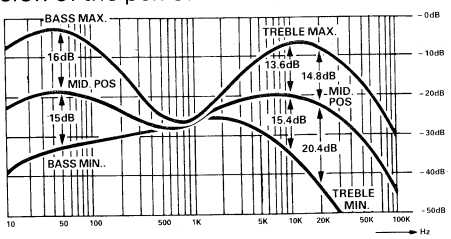


Fig. 2

THE APPLICATION

Recording the amplitude response

Fig. 2 shows the amplitude response plotted as a function of the frequency (using logarithmic scales in both the X and Y directions).

These curves are recorded with the setting of the tone controls as parameter. It will be seen that this has no noticeable influence on the amplitude at mid-range frequency.

The amplitude response of the other channel may be recorded in the same way, and the two sets of curves compared as described below.

The effect of tone-compensated volume control

Fig. 3 shows how the output amplitude of the stereo amplifier is used as parameter instead of the tone-control setting. The measuring set-up is the same as for Fig. 1. The dip in the middle of the response curves at lower volumes corresponds to the frequency response curve of the human ear.

During the recording of these curves, the tone controls were set at an intermediate position.

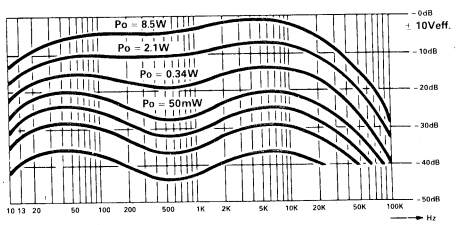


Fig. 3

Cross-talk

Fig. 4 shows the cross-talk from the R channel to the L channel.
The input of the L channel is bypassed with an impedance of 47kohm//220pF (see fig. 1). The top curve shows the amplitude response of the R channel with a power dissipation of 6.7W and the tone controls set to their mid-way position, while the third curve from the top shows the amplitude response of the L channel under these conditions, due to cross-talk from the R channel. Similarly, the second curve from the top is for the R channel with an output power of 0.1W, while the bottom of the curve shows the cross-talk in the L channel under these conditions.

Fig. 4 this shows that the cross-talk is frequency-dependent, varying from about 30 to 50dB as a function of the frequency in the range from 50 Hz to 15kHz. The cross-talk increases quite strongly at frequencies above 10kHz, but this is important since the amplitudes at these frequencies are relatively low, in the reproduction of music.
The cross-talk is minimum at mid-frequency. The rise in cross-talk at low frequencies is caused by the limited resistance of the common power supply, while that at high frequencies is due to the presence of stray capacitances and inductances.

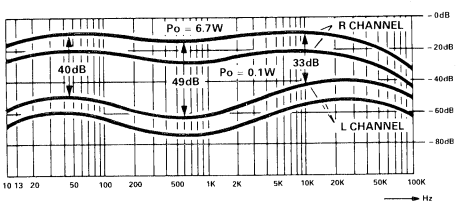


Fig. 4

Low distortion
LF generator PM 5107

Frequency range 10Hz...100kHz
Very low distortion 0.02%
Sine and square wave signals
Compact dimensions and low weight
Separate TTL output
Switchable 20dB and continuous attenuation

The PM 5107 has been designed for both educational applications and service workshops. It provides square and sine wave signals, the latter having a special 'low distortion' position for use on HiFi development as well as alignment and maintenance. Another useful service feature is the switchable 20dB attenuation.
The generator is 1kg light and has very compact dimensions. The layout of the front panel is attractive and functional, a feature which is of particular value for educational applications.

TECHNICAL SPECIFICATION

FREQUENCY AND CHARACTERISTICS

Nominal range
10 Hz...100kHz
(4 subranges, selectable by pushbuttons)

Indication
Dial (1...10)

Setting error
< 4% ± 1 Hz

Temperature coefficient
< 0.05%/K (1000 Hz)

Long-term drift (< 7h)
$< 1.5 \times 10^{-3}$ (1000 Hz)

Duty cycle
50% fixed

WAVEFORMS

Sine wave
Square wave

OUTPUT

Attenuation
20dB calibrated step plus 40dB continuously adjustable

Impedance
600 Ω

Short circuit proof
Yes

SINEWAVE

Low distortion mode
Total harmonic distortion
0.02% at 1kHz
0.03% (300 Hz...20kHz)

Fast settling mode
Total harmonic distortion
0.5% (300 Hz...20kHz)

Max. open circuit voltage
$2V_{RMS}$

Frequency response of amplitude
< 2% (1000 Hz)

SQUARE WAVE

Max. open circuit voltage
4Vpp

Rise and fall time
< 0.5μs

Sag
< 1% (50 Hz)

Duty cycle
50%

TTL

Amplitude high level
4.5V ± 0.7V

Amplitude low level
< 0.3V

Sag
< 1%

Frequency response
3% (1000 Hz)

Rise time
< 30ns

Fall time
< 15ns

Fan out
20

POWER REQUIREMENTS

Voltage
115, 230V ± 15%

Power consumption
4W

Frequency
50...100 HZ ±5%

DIMENSIONS AND WEIGHT

Dimensions
(w x h x d) 230 x 110 x 220mm
(9 x 4.3 x 8.3-in)

Weight
1.25kg (2.75lb)

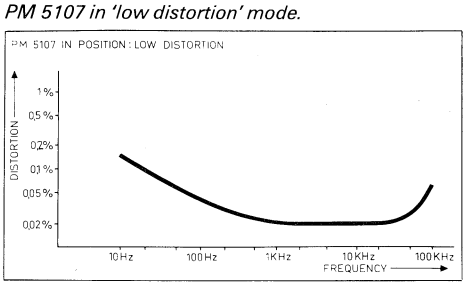
ACCESSORIES SUPPLIED

Instruction manual
Mains cable

OPTIONAL ACCESSORIES

PM 9075 Cable BNC-BNC

Curve demonstrating low distortion characteristic of PM 5107 in 'low distortion' mode.



Symmetrical floating output

10Hz...100kHz frequency range

Low distortion 0.02%

Output voltage:
$30V_{pp}$ (asymmetrical)
$10V_{pp}$ (symmetrical)

Output level indication

Separate TTL and DIN loudspeaker output

Selectable output impedances

Variable and stepped attenuation

Low distortion LF generators PM 5109 and PM 5109S

PM 5109 is a RC oscillator offering a low distortion (0.02% at 1kHz) yet high, $30V_{pp}$ (open circuit) output voltage in the asymmetrical mode. It can also be used in a fast settling mode-useful for fast, routine work. These features, plus the facility to select asymmetrial or dual floating symmetrical outputs, makes it ideal for telecommunications applications as well as for education, R & D, manufacturing and audio equipment servicing. Both output voltages can be attenuated by a continuous control; the asymmetrical output can also be attenuated in steps of 10dB down to 60dB. Both pure sine waves or square wave signals are available at frequencies from 10Hz to 100kHz; output impedance is switchable for either 600Ω or 50Ω in the asymmetrical mode and 600Ω or LOW Z in the symmetrical mode (see specification).
A DIN loudspeaker connection is provided, which has an impedance similar to the symmetrical low impedance output. This allows direct testing of loud speakers, regardless of their impedance.
A special TTL output for direct connection to TTL circuitry or for synchronization purposes, is also provided.
The open circuit output is monitored by a meter on the front panel and the output range in use is indicated by the appropriate LED, from the seven provided.
For applications where the symmetrical output is not required, a special, economical, version, PM 5109S is available.

TECHNICAL SPECIFICATION (PM 5109)

FREQUENCY AND CHARACTERISTICS

Nominal range
10 Hz...100kHz
(4 subranges, selectable by pushbuttons)

Indication
Dial (1...10)

Setting error
$< \pm 5\% \pm 1$ Hz

Temperature coefficient
$< 0.05/K$

Long term drift (< 7h)
$< 1.5 \times 10^{-3}$

Short term drift (< 15 min)
$< 0.5 \times 10^{-3}$

Duty cycle
50% fixed

WAVEFORMS

Sine wave
Square wave (output B only)

OUTPUT

Separate outputs selectable with pushbuttons

A. Symmetrical output (4 x 4 mm connector on front panel)
a. 2 x 300Ω
b. 300Ω + 300Ω
c. 2 x low Z
d. low Z + low Z
} not earthed

B. Asymmetrical output (BNC connector at front panel)
a. 600Ω
b. 50Ω

Loudspeaker output (DIN connector at rear panel)
Only active when output Ad is selected

TTL Output (BNC connector at rear panel)

Open circuit output voltage (RMS)
0.03...3.16V (output A)
0.1...10V (output B)

Indication
Meter (7 ranges indicated by LED)

Attenuation
10, 20, 30dB calibrated steps selectable in any combination (output B only) plus 30dB continuously adjustable

SINEWAVE

Total harmonic distortion
(for output Aa, Ab and B)

– low distortion mode
< 0.7% (10 Hz...100kHz)
< 0.03% (300 Hz...20kHz)

– fast settling mode
< 1.5% (10 Hz...100kHz)
< 0.5% (100 Hz...100kHz)

Total harmonic distortion
(for output Ac and Ad)

– low distortion mode
< 0.7% (open circuit 20 Hz...100kHz)
< 0.03% (open circuit, 300 Hz...20kHz)
< 0.15% (4Ω load, 20 Hz...100kHz)

– fast settling mode
0.5% (0...4Ω load, 100 Hz...100kHz)

Frequency response of amplitude
± 0.2dB (1000 Hz, outputs A & B, open circuit)
± 0.5dB (10 Hz...10kHz, outputs Ac & Ad, 4Ω load)
– 6dB (70kHz, outputs Ac & Ad, 4Ω load)

SQUARE WAVE

Rise and fall time
< 0.5μs

Overshoot and ringing
< 2% (> 20 Hz)
< 1% (> 50 Hz)

TTL

Duty cycle
50%

Fan out
20

POWER REQUIREMENTS

Line voltages
110, 128, 220, 238 V ± 10%.

Frequency
50...100 Hz

Power consumption
17 W

DIMENSIONS AND WEIGHT

Dimensions (w x h x d)
310 x 140 x 330mm
(12.2 x 5.5 x 13-in)

Weight
PM 5109 6.5kg (14.3lb)
PM 5109S 5kg (11lb)

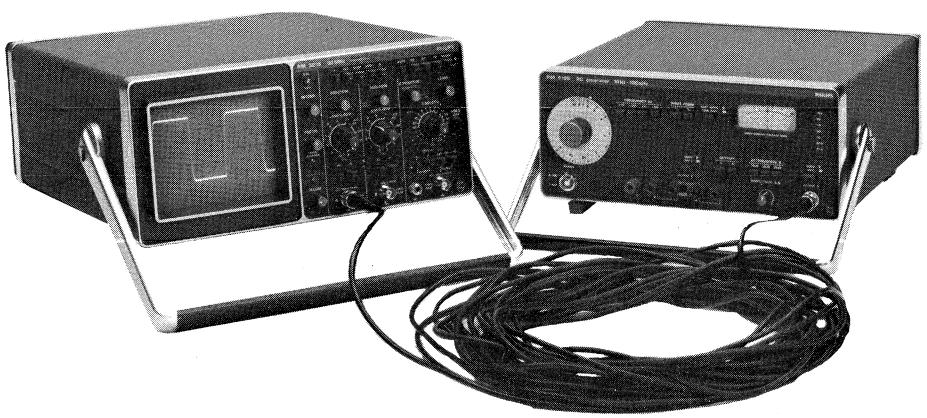
The specification for PM 5109 S is as for PM 5109, without the symmetrical output facility.

ACCESSORIES SUPPLIED

Instruction manual

OPTIONAL ACCESSORIES

PM 9075 Coax. Cable BNC-BNC
PM 9560 19-in Rackmount adapter



PM 5109 being used to check the bandwidth characteristic of a long coaxial cable.

0.1 Hz...2 MHz frequency range
Logarithmical sub-ranges
Sine, square, triangular waveforms, plus DC
Stepped & variable output attenuation over 80dB range
Variable DC offset
Vernier frequency adjustment
Internal & external sweep facility
TTL output

Function generator PM 5131

The PM 5131 function generator is an instrument designed for applications extending from educational to the broad general purpose area. Its many features make it an extremely versatile instrument for a modest price. Among these are the high, 30V_{pp} output voltage and the facilities for both internal and external sweep. This latter feature covers the audio frequency range in a single shot. The frequency is adjustable in three logarithmical sub ranges from 0.1 Hz to 2 MHz. The frequency vernier allows the frequency setting to be varied from −20% to +20%. The maximum output voltage is 30V_{pp} (open circuit) on the main outlet having a 50Ω impedance. The attenuation can be set over a wide range, either in calibrated steps of 10dB to a maximum of 60dB or in combination with the 20dB continuous attenuator.

A sine, triangle or square wave signal is selected by simply pressing the appropriate push-button. DC voltage can be selected separately without any wave form or whenever used as DC offset can be varied between −10V and +10V.

PM 5131 also provides a 3⅓ decade internal sweeping facility with adjustable sweep range and a variable sweep period from 10 to 150 seconds.
This is especially useful when sweeping in the audio range to cover the frequency range of 20 Hz...20kHz in a single sweep. Added to the versatlity of this instrument are an external sweep facility and a TTL output.
Good ergonomic design makes operation simple while the instrument occupies minimal bench space.

TECHNICAL SPECIFICATION

FREQUENCY AND CHARACTERISTICS

Nominal range
0.1 Hz...2 MHz

Indication
Logarithmic dial

Setting error
± 10%

Vernier frequency adjustment
−20...20% of frequency setting

Temperature coefficient
< 0.5%/K

Short term drift (< 15 min)
< 0.5%

Long term drift (< 7h)
< 0.7%

WAVEFORMS

Sine wave
Square wave
Triangular wave
} with or without DC offset

DC voltage without AC

OUTPUT

AC VOLTAGE

Max. open circuit voltage
30V_{pp}

Attenuation
10, 20, 30dB calibrated steps selectable in any combination plus 20dB continuously adjustable

Impedance
50Ω

Short circuit proof
Yes

DC VOLTAGE

Offset voltage
−10...10V (open circuit)

SINEWAVE

Total harmonic distortion
< 0.5% (0.1 Hz...20kHz)
< 3.0% (0.1 Hz...2 MHz)

Frequency response of amplitude
< 0.1dB (0.1 Hz...20kHz)
< 0.3dB (0.1 Hz...1 MHz)
< 1.0dB (0.1 Hz...2 MHz)

TRIANGLE WAVE

Linearity
> 99%

SQUARE WAVE

Rise and fall time
< 75ns

Overshoot and ringing
< 2%

TTL

Duty cycle
50%

Fan out
> 20

INTERNAL SWEEP

Characteristics
Logarithmic

Max. sweep range
3⅓ decade

Mode
Single

Period time
< 10...150s
Continuously adjustable

Frequency analog voltage
1V/frequency decade

EXTERNAL SWEEP

Input
SWP voltage

Characteristic
Logarithmic

Max. sweep range
3⅓ decade

Input resistance
1kΩ

Max. sweep frequency
approx 5kHz

Sensitivity
1V/frequency decade

POWER REQUIREMENTS

Voltage
115, 230V ± 15%

Power consumption
21W

Frequency
50...100 Hz

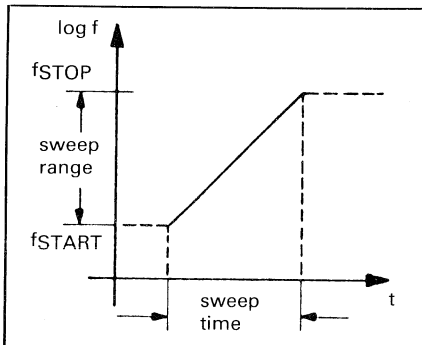
DIMENSIONS AND WEIGHT

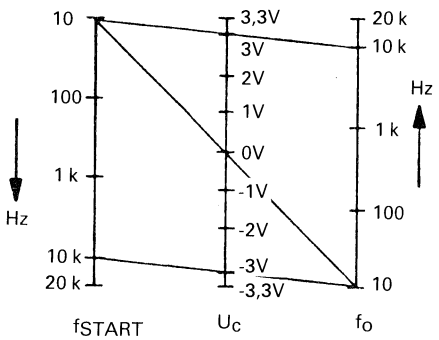
Dimensions (w x h x d)
310 x 140 x 330mm
(12.6 x 5.5 x 13-in)

Weight
4.5 kg (10lb)

Accessories supplied
Instruction manual

Optional accessories
PM 9075 Cable BNC-BNC
PM 9560 19-in rackmount adapter
PM 9551 50...600Ω impedance transformer





Example of internal single sweep
Internal single sweep from the start- to the stop frequency is started by pressing the button SGLE SWEEP. The characteristic is exponential following the relation

$f_o = f_{START}\ 10^{UC}$

where

f_o = instantaneous signal frequency at the output
f_{START} = frequency at the beginning of the sweep represented by the frequency setting
U_C = voltage at the socket SWP VOLTAGE IN/OUT.

Thus a control voltage difference of 1V results in a frequency ratio of 10:1.
At the end of the sweep the output remains at the stop frequency which can be set by the SWP STOP/START control. Resetting the SGLE SWEEP button effects the frequency to fly back to the start frequency. The sweep time is adjusted with the SWP PERIOD potentiometer.
Pre-adjustment of the stop frequency may be performed at the end of the sweep with minimum period, prior to setting the final sweep operation.
The example shown is for the x10k frequency range; the other two ranges should be regarded similarly, with U_C scale reading unchanged.

A typical educational application with PM 5131 being used in conjunction with oscilloscope PM 3215.

0.1 Hz...2 MHz in 7 overlapping subranges

Sine, square, triangular waveforms, positive- and negative-going pulses plus DC

Output: $30V_{pp}$ (sine, triangle, square) ($15V_{pp}$ for pulses)

Stepped and variable attenuation over 80dB range

Variable DC-offset

Internal and external sweep facility

Variable duty cycle

TTL output

Function generator PM 5132

The PM 5132 function generator is a general-purpose instrument that will be very attractive for educational applications as well as for laboratory use. It is an extremely versatile generator and produces sine triangle and square waveforms plus positive and negative pulses, plus DC. It exhibits a high, $30V_{pp}$ output for all waveforms and $15V_{pp}$ for pulses. Output impedance is switchable with a choice of 50Ω or 600Ω.

The duty cycle for all waveforms is variable between 10% and 90% and DC-offset can be selected independently for any waveform. This is adjustable from −10V to +10V.

The frequency range of 0.1 Hz to 2 MHz is adjustable through 7 overlapping subranges and the vernier control allows dial settings of ± 2% of the maximum subrange frequency setting.

Sweep facilities are varied and include:
- choice of linear single or continuous sweep
- adjustable start frequency in the selected sub-range which is independent of stop frequency
- maximum linear sweep range of 2½ decades
- sweep period setting between 50ms and 100s
- control functions with HOLD or RESET by push-button
- electronic triggering

A pen lift output is provided and the instrument is short-circuit proof.

Good ergonomic design makes the operation simple while the instrument occupies minimal bench space.

TECHNICAL SPECIFICATION

FREQUENCY AND CHARACTERISTICS

Nominal range
0.1 Hz...2 MHz

Indication
Linear dial

Setting error
± 2% ± 0.2% of max subrange frequencies

Vernier frequency adjustment
−5%...+5% of frequency setting.

Temperature coefficient
< 0.15%/K

Short term drift (< 15 min)
0.10% (Warm-up time 30 min)

Long term drift (< 7h)
< 0.25%

Duty cycle
50% fixed
< 10%...> 90% continuously adjustable

WAVEFORMS

Sine wave
Square wave
Triangular wave
Positive pulse
Negative pulse
DC voltage without AC

} with or without DC offset

OUTPUT

AC VOLTAGE

Max. open circuit voltage
$30V_{pp}$ ($15V_{pp}$ for pulse)

Attenuation
10, 20, 30dB calibrated steps selectable in any combination plus 20dB continuously adjustable.

Impedance
50Ω or 600Ω selectable

Short circuit proof
Yes

DC VOLTAGE

Offset voltage
−10...+10V (open circuit)

SINEWAVE

Total harmonic distortion
< 0.5% (0.1 Hz...20kHz)
< 1.0% (20kHz...200kHz)
< 3.0% (200kHz...2 MHz)

Frequency response of amplitude
< 0.1dB (0.1 Hz...20kHz)
< 0.3dB (0.1 Hz...1 MHz)
< 1.0dB (0.1 Hz...2 MHz)

TRIANGLE WAVE

Linearity
> 99% (0.1 Hz...100kHz)

SQUARE WAVE

Rise and fall time
< 75ns

Overshoot and ringing
< 2%

TTL

Duty cycle
as main output

Fan out
> 20

PEN LIFT

SWEEP OUTPUT

INTERNAL SWEEP

Characteristics
Linear

Max. sweep range
2½ decades

Mode
Single or continuous

Period time
50ms...100s
Continuously adjustable in 3 subranges

Control functions
HOLD, RESET, TRIG (manually and electronically)

Frequency control voltage
0...5V (depending on start- and stopfrequency)

EXTERNAL SWEEP

Input
SWEEP TRIG

Characteristic
Linear

Max. sweep range
2½ decades

Input resistance
47 kΩ

Max. sweep frequency
15kHz approx.

Sensitivity
5V for maximum range

POWER REQUIREMENTS

Voltage
110, 128, 220, 238V ± 10%

Power consumption
25W

Frequency
50...100 Hz

DIMENSIONS AND WEIGHT

Dimensions (w x h x d)
310 x 140 x 330mm
(12.6 x 5.5 x 13-in)

Weight
5kg (11lb)

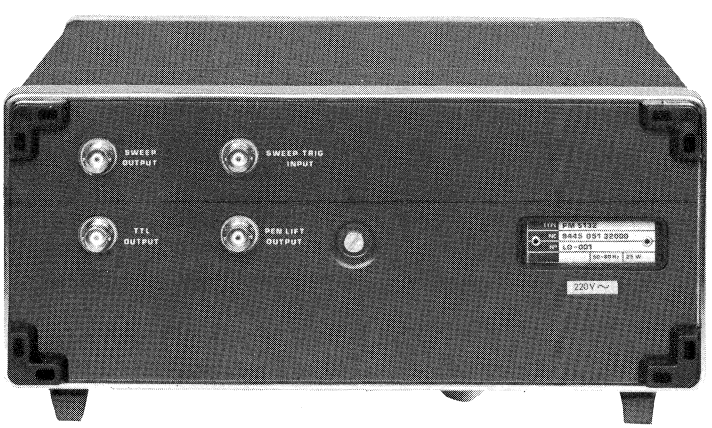
ACCESSORIES SUPPLIED

Instruction manual

OPTIONAL ACCESSORIES

PM 9075 cable BNC-BNC
PM 9560 19-in rackmount adapter

Rear view of PM 5132 showing location of sweep, TTL and pen lift ouputs and the sweep trigger input



0.01 Hz...2 MHz frequency range

Frequency and open circuit output voltage indicated on 3½-digit LED display

Output 20V_{pp}

Selectable 50Ω or 600Ω impedance

Sine, square, and triangular waveforms, positive- and negative-going pulses plus DC

Single and burst with variable start phase

Manual and electronic sweep trigger

Hold and reset facility

Logarithmic or linear sweep

Internal or external sweep facility

Function generator PM 5133

The versatile function generator PM 5133 offers both linear and logarithmic sweep facilities in addition to a wide range of other features. Outputs include sine, triangle and square waveforms as well as positive or negative pulses, and DC. The duty cycle is variable between 10% and 90%.

The wide frequency range of 10mHz to 2 MHz is selected by means of a 7-position rotary switch with an over-riding coarse/fine adjustment. A high-precision, electronic system, using a 3½-digit LED provides very accurate, clearly readable setting conditions and eliminates those human errors (e.g., parallex) likely to occur with more conventional mechanical dials. The display is also used to monitor the open-circuit output voltage, sweep limit values and incompatible setting-up conditions.

The output voltage (20V_{pp} max., except for pulses at 10V_{pp} max.) is available at the front-panel mounted socket; there is a pushbutton choice of 50Ω or 600Ω output impedance. Output attenuation of more than 80dB is selectable in any combination of calibrated steps of 3-10-20-30dB with an overriding 20dB continuous control. The output voltage level can be checked by simply depressing a pushbutton, and appears on the LED panel.

Linear or logarithmic subranges

Sweep facilities include single-shot and continuous operation, with the choice of linear or logarithmic mode. Frequency ranges are divided into either seven **linear** or five **logarithmic** subranges with continuous coarse and fine adjustment. The logarithmic sweep ranges cover more than four decades, making the instrument extremely useful for sweeping within the audio range.

The single sweep can be triggered either manually, or electronically, from an external source. The sweep period is continuously adjustable between 5ms and 100s. The START and STOP frequencies are non-interactive and can be set independently of each other. Also, a HOLD facility allows a sweep to be stopped at any desired frequency – useful for checking phenomena which may appear during a sweep – by means of a pushbutton.

An interrupted sweep is re-started by simply releasing the HOLD button. Again, if required, a sweep can be reset back to the start freuqency using the RESET button. When used in the sweep mode, the start, stop and run frequencies are all indicated clearly on separate LEDs.

Moreover, as previously mentioned, an error warning lamp automatically flashes in the event of any incompatible setting being made by the operator.

The generator also offers an internally or externally controlled burst, or single waveform signal, having a continuously adjustable start/stop phase, between −90° and +90°.

Other input/output facilities available at the rear panel include a TTL output and pen-lift control, internal modulation voltage and frequency control voltage.

The PM 5133 is designed for maximum electrical and mechanical protection. Careful attention has been given to ergonomic considerations, making the instrument easy to use. Its overall versatility makes it suitable for use within a wide range of applications, such as research, design, education and manufacturing. It occupies minimal bench space and is short-circuit-proof.

TECHNICAL SPECIFICATION

FREQUENCY AND CHARACTERISTICS

Nominal range
10mHz...2 MHz

Display
3½ digits
7 segment LED
4 dimension LEDs mHz, Hz, kHz, MHz.

Setting error
± 2% ± 1 digit (10mHz...200kHz)
± 3% ± 1 digit (200kHz...2 MHz)

Temperature coefficient
< 1.0 x 10^{-3}/K (linear mode)
< 2.5 x 10^{-3}/K (log mode)

Short term drift (< 15 min)
$< 1 \times 10^{-3}$ (10mHz...20kHz)
$< 3 \times 10^{-3}$ (20kHz...2 MHz)

Long term drift (< 7h)
$< 3 \times 10^{-4}$

Duty cycle
50% fixed
< 10%...> 90% continuously variable

WAVEFORMS

Sine wave
Square wave
Triangular wave
Positive pulse
Negative pulse
} with or without DC offset
DC voltage without AC

OUTPUT

AC VOLTAGE

Max. open circuit voltage
$20V_{pp}$ ($10V_{pp}$ for pulse)

Indication (EMF)
Alt. mode frequency display

Attenuation
3, 10, 20, 30dB calibrated steps selectable in any combination plus 20dB continuously adjustable

Impedance
50Ω or 600Ω selectable

Short circuit proof
Yes

DC VOLTAGE

Offset voltage
0...± 5V (open circuit)

SINEWAVE

Total harmonic distortion
< 0.5% (10mHz...200kHz)
< 2 % (200kHz...2 MHz)

Frequency response of amplitude
< 0.1dB (10mHz...20kHz)
< 0.3dB (20kHz...1 MHz)
< 1.0dB (1 MHz...2 MHz) (Max. amplitude)

TRIANGLE WAVE

Linearity
> 99% (10mHz...100kHz)

SQUARE WAVE

Rise and fall time
< 60ns

Overshoot and ringing
< 2% (max. amplitude into 50Ω)

POSITIVE/NEGATIVE PULSES

See SQUARE WAVE

TTL

Duty cycle
as main output

Fan out
> 20

PEN LIFT

INTERNAL MODULATION

FREQUENCY CONTROL VOLTAGE

SWEEP FACILITIES

INTERNAL SWEEP

Characteristics
Linear or logarithmic

Max. sweep range
2½ decades (linear mode)
4 decades (log mode)

Mode
Single or continuous

Indication
3½ digits
7 segment LED
3 LEDS STOP, RUN and START

Period time
5ms...100s
Continuously adjustable in 4 subranges

Control functions
HOLD, RESET, TRIG (manually and electronically)

Internal modulation output
0V startfrequency
5V stopfrequency

Frequency control voltage output
0...5V (depending on start- and stopfrequency)

EXTERNAL SWEEP/FM

Input
SWEEP/FM

Characteristic
Linear or logarithmic

Linear Characteristic
1V/0.2 max. freq.

Logarithmic characteristic
1V/freq. decade

Max. sweep range
> 2½ decades (linear mode)
> 4 decades (log mode)

Input resistance
5kΩ

Max. sweep rate
> 4kHz (1½ decade range)

Sweep voltage
Sawtooth, duty cycle 90%

BURST FACILITIES

INTERNAL BURST

CONTINUOUS OPERATION

On/Off-ratio
approx. 1:1 (last cycle ends at START-PHASE level)

Repetition time
5ms...100s
continuously adjustable in 4 subranges

SINGLE OPERATION

Repetition time
See INTERNAL BURST

Triggering
manually or electronically via TRIG & BURST input

Start phase
$-90°...+90°$ ($-\pi/2...+\pi/2$), continuously adjustable

EXTERNAL BURST

Input
TRIG & BURST

Control voltage
TTL-level

Start
Low/high-transition

Stop
High/Low-transition.
(when output signal reaches start phase)

Max. control frequency
2 MHz

Start phase
$-90°...+90°$ ($-\pi/2...+\pi/2$), continuously adjustable

SINGLE FACILITIES

INTERNAL SINGLE

Repetitive mode
Same as INTERNAL BURST

Single triggering
same as INTERNAL BURST

Start phase
$-90°...+90°$ ($-\pi/2...+\pi/2$), continuously adjustable

EXTERNAL SINGLE

Input
TRIG & BURST

ERROR INDICATION

POWER REQUIREMENTS

Voltage
110, 128, 220, 238V ± 10%

Power consumption
55W

Frequency
50/60 Hz

DIMENSIONS AND WEIGHT

Dimensions (w x h x d)
310 x 140 x 390mm
(12.2 x 5.5 x 15.4-in)

Weight
6.5kg (14.3lb)

ACCESSORIES SUPPLIED

Instruction manual

OPTIONAL ACCESSORIES

PM 9075	Coax. cable BNC
PM 9581	50Ω/3W termination
PM 9051	Adapter BNC/4mm
PM 9560	19-in rackmount adaptor

Specially adapted for Hi-Fi testing according to DIN standard 45 541

Fixed 50s sweep, 20Hz...20kHz selectable

Sweep started manually or by 1kHz burst signal

26dB attenuation facility included

2MHz function generator PM 5133S

The PM 5133S is a special version of the PM 5133, with extra features specifically included to permit the testing of Hi-Fi equipment to DIN standards.

Used in conjunction with an X-Y recorder, it permits the frequency characteristics of e.g. record players, cassette and tape recorders to be plotted. This instrument has wideranging applications in R&D and quality control. It is also ideal for use by audio service workshops – permitting them to show customers whether their equipment is performing according to specification.

The PM 5133S includes all the facilities of the standard PM 5133, plus a single sweep with fixed 50s duration. Start and stop frequencies should be set at respectively 20 Hz and 20kHz.

The sweep is preceded by a 1kHz burst lasting 6 seconds when manually triggered. A similar signal fed in via the TRIG and BURST input will automatically start the generator sweep (without burst), as an alternative to manual start.

With this feature it is possible to start a sweep on a record, cassette or tape (provided this is preceded by the burst) synchronously with the sweep of the generator.

The special sweep is selected by means of the MOD SWEEP PERIOD switch (position 100s) and the PERIOD adjustment (fixed position) with the generator in the logarithmic sweep mode.

TECHNICAL SPECIFICATION

(additional to technical specification of PM 5133 or typical for the special sweep)

OUTPUT

Attenuation - fixed
0,6, 10, 20, 30dB, selectable in any combination

Sweep, Internal
50s sweep

Mode
- single sweep with fixed period and 1kHz burst, started by push-button TRIG
- single sweep with fixed period, electronically started by an external 1kHz burst applied at input TRIG & BURST.

Characteristic
logarithmic

Start frequency
20 Hz set by means of potentiometer START FREQUENCY

Stop frequency
20kHz set by means of potentiometer STOP FREQUENCY

Burst frequency
1kHz (depending on the setting of the start frequency).

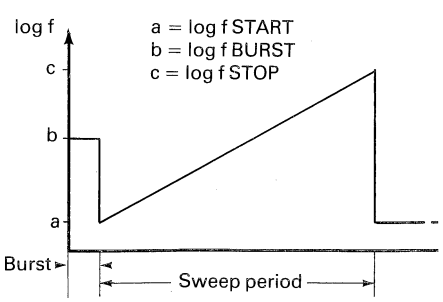
Burst period
6s

Sweep period
50s ± 0.2s when
- SWEEP PERIOD in pos. 100 (S)
- PERIOD in fixed pos. "S"

Trigger signal
1kHz ± 100 Hz

Trigger sensitivity
$0.5V_{RMS}$

Reset trigger
By a 1kHz burst possible after 40s sweep period.



Function generator PM 5134

1mHz...20MHz frequency range

Frequency and open circuit voltage indicated on 3½-digit LED display

Indications for dimensions, sweep situations and incompatible settings

Normal or high accuracy X-tal controlled operation

Internal or external sweep and AM/FM modulation facilities

Burst and single with variable start phase

Output 20V_{pp}

Stepped and variable attenuation over 60dB range

The PM 5134 is an easy-to-use yet extremely sophisticated function generator embodying an unusually wide range of facilities in a single instrument.
It will produce sine, square and triangle waveforms as well as positive and negative pulses and DC. The duty cycle is variable between 10% and 90%.
The wide, 1mHz to 20MHz frequency range is divided into 10 subranges, which are selected by means of a rotary switch with an overriding coarse/fine adjustment. This fine adjustment, combined with the 3½-digit LED display, gives an immediate, highly accurate readout of the selected frequency. Setting up procedures are thus very much simplified compared with the traditional dial setting and any human errors (e.g. parallax) are eliminated.
In addition, the 3½-digit display can be used to monitor the open-circuit output voltage by depressing a push button. Also, when used in the sweep mode, the start, stop and run frequencies are indicated by separate LEDs. Moreover, an error warning lamp automatically indicates any incompatible setting-up conditions.
The high, nominal accuracy (see technical specification) of ± 2% ± 1 digit, can be further improved to ± 5 x 10^{-6} by operating the instrument in the crystal-control mode. This facility is useful, for example, for identical repetitive measurements requiring high accuracy, or for narrow band filter tests.
The X-TAL AM mode offers a stable carrier wave with defined frequency. One particular application is when using a 10.7 MHz carrier frequency to check that the discriminator section of a radio receiver is suppressing the AM waveform.
The continuously variable 20V_{pp} max. output (10V_{pp} for pulses) is available at the front panel-mounted socket; there is a push button choice of 600Ω or 50Ω output impedance. Output attenuation is selectable in any combination of 3-6-10-20dB push buttons with an overriding continuous 20dB control.

Sweep facilities include single and continuous operation. The single sweep can be triggered either manually, or electronically from an external source. The sweep period is continuously adjustable between 5ms and 100s. The START and STOP frequencies are non-interactive and can be set independently of each other. A HOLD facility allows a sweep to be stopped at any desired frequency – useful for checking phenomena occurring during a sweep – by means of a push button. An interrupted sweep is continued by simply releasing the HOLD button. If required a sweep can be reset to the start frequency using the RESET push button.
The generator offers an internally or externally controlled burst or single-cycle signal. The start/stop phase is continuously adjustable between −90° and +90°.
The internal AM is adjustable between 0 and 100% modulation depth. The modulation frequency can be set over a wide range from 10mHz to 20kHz. The AM facility can be used with crystal control, if desired. External AM inputs in the range from DC to 20kHz can be applied via a rear-mounted BNC-socket.

The internal FM can be adjusted, continuously, between zero and ± 10% frequency deviation.
Other input/output facilities available on the rear panel include a TTL output and pen lift control.
The well-considered design of the PM 5134 has resulted in a clean, simple front panel layout which allows the operator to become familiar with all control functions very quickly. Its overall versatility makes it suitable for a very wide range of applications within research design or educational organisations. The instrument occupies minimal bench space and is short-circuit proof.

TECHNICAL SPECIFICATION

FREQUENCY AND CHARACTERISTICS

Nominal range
1mHz...20 MHz

Display
3½ digits
7 segment LED
4 dimension LEDs mHz, Hz, kHz, MHz.

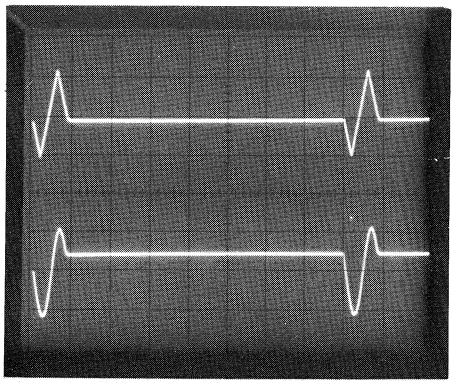
Setting error
± 2% ± 1 digit (1mHz...2 MHz)
± 5% ± 1 digit (2 MHz...20 MHz)

Temperature coefficient
$<1.0 \times 10^{-3}$/K (20 MHz range excluded)

Short term drift (< 15 min)
$<1 \times 10^{-3}$ (1mHz...2 MHz)
$<2 \times 10^{-3}$ (2 MHz...20 MHz)

Long term drift (< 7h)
$< 3 \times 10^{-4}$

Duty cycle
50% fixed
< 10%...> 90% continuously variable (20 MHz range excluded)



Repetitive single sine wave signal

WAVEFORMS

Sine wave
Square wave
Triangular wave
Positive pulse
Negative pulse
DC voltage without AC

} with or without DC offset

OUTPUT

AC VOLTAGE

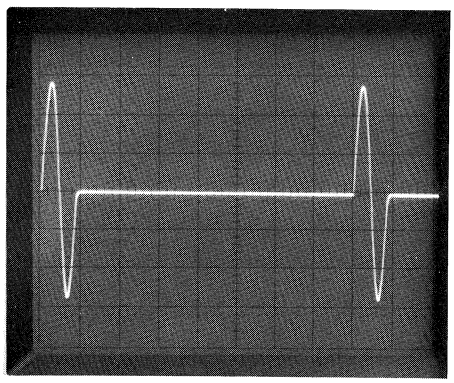
Max open circuit voltage
$20V_{pp}$ ($10V_{pp}$ for pulse)

Indication open circuit output voltage
Alt. mode frequency display

Attenuation
3, 6, 20, 30dB calibrated steps selectable in any combination plus 20dB continuously adjustable

Impedance
50Ω or 600Ω selectable

Short circuit proof
Yes



Repetitive single sine wave and triangle shown with different start phase

DC VOLTAGE

Offset voltage
−5V...+5V (open circuit)

SINE WAVE

Total harmonic distortion
< 0.5% (1 Hz...200kHz)
< 3% (1mHz...2 MHz)
All harmonics more than 26dB below fundamental (1 MHz...20 MHz)

Frequency response of amplitude
< 0.1dB (0.1 Hz...200kHz)
< 0.5dB (1mHz...2 MHz)
< 1.5dB (1 MHz...20 MHz, for max. amplitude)

TRIANGLE WAVE

Linearity
> 99% (> 100kHz)

SQUARE WAVE

Rise and fall time
< 18ns

Overshoot and ringing
< 3%

POSITIVE/NEGATIVE PULSES

See SQUARE WAVE

TTL

Duty cycle
as main output

Fan out
> 5

PEN LIFT

INTERNAL MODULATION

SWEEP FACILITIES

INTERNAL SWEEP

Characteristics
Linear

Max. sweep range
2 decades

Mode
Single or continuously

Indication
3½ digits
7 segment LED
3 LEDs STOP, RUN and START

Period time
5ms...100s
Continuously adjustable in 4 subranges

Control functions
HOLD, RESET, TRIG (manually) and electronic triggering

Frequency control voltage at modulation output
0...5V (depending on start and stop frequency setting)

EXTERNAL SWEEP/FM

Input
SWEEP/FM

Characteristic
Linear

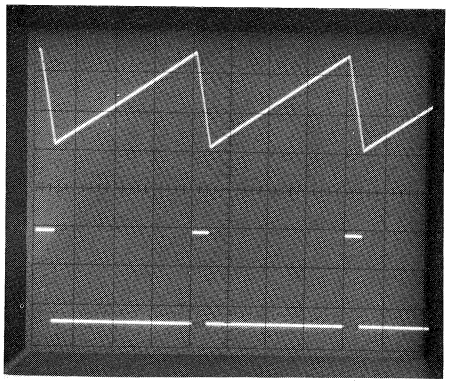
Voltage/frequency characteristic
1V/0.2 max. frequency

Max. sweep range
> 2½ decades for subranges above 2 Hz

Input resistance
5kΩ

Max. sweep rate
>200 Hz (1½ decades range)

Sweep voltage
Sawtooth, duty cycle 90%



Variable duty cycle shown in triangular and square wave signal

BURST FACILITIES

INTERNAL BURST

CONTINUOUS OPERATION

On/off ratio
approx. 1:1 (last cycle ends at START-PHASE level)

Repetition time
0.05ms...100s
Continuously adjustable in 6 subranges

SINGLE OPERATION

Duration
See CONTINUOUS OPERATION, Repetition time

Triggering
manually or electronically via TRIG & BURST input

Start phase
−90°...+90° ($-\pi/2...+\pi/2$), continuously adjustable

EXTERNAL BURST

Input
TRIG & BURST

Control voltage
TTL-level

Start
Low/high-transition

Stop
High/Low-transition.
(when output signal reaches start phase)

Max. control frequency
2 MHz

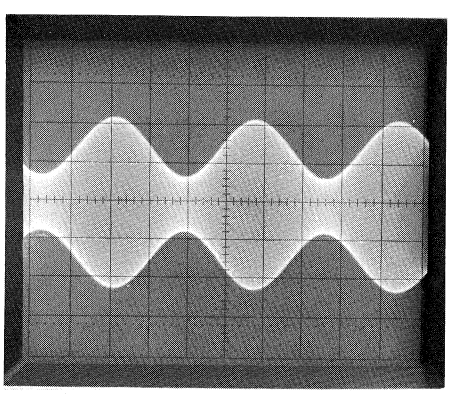
Start phase
−90°...+90° ($-\pi/2...+\pi/2$), continuously adjustable

SINGLE FACILITIES

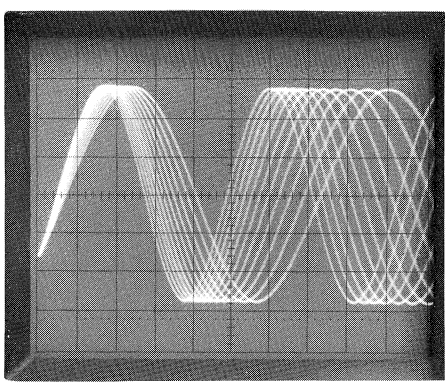
INTERNAL SINGLE

CONTINUOUS OPERATION

Repetition time
0.05ms...100s
continuously adjustable



Carrier wave with AM modulation



Frequency sweep or frequency modulation

SINGLE OPERATION

Triggering
Manually or electronically via TRIG & BURST input

Start phase
$-90°...+90°$ $(-\pi/2...+\pi/2)$, continuously adjustable

EXTERNAL SINGLE

Input
TRIG & BURST

MODULATION

INTERNAL FM

Modulation waveform
Sine wave

Deviation
Approx. −10%...+10%
continuously adjustable

Modulation frequency
0.01 Hz...20kHz
continuously adjustable in 6 subranges

Modulation voltage
Available at modulation output

EXTERNAL FM

Input
SWEEP/FM

INTERNAL AM

Modulation waveform
Sine wave

Modulation depth
0...> 100%
continuously adjustable

Modulation frequency
See internal FM

Modulation voltage
See internal FM

EXTERNAL AM

Input
AM

Modulation waveform
Arbitrary with spectral components up to 20kHz

Modulation depth
0...>100%
continuously adjustable

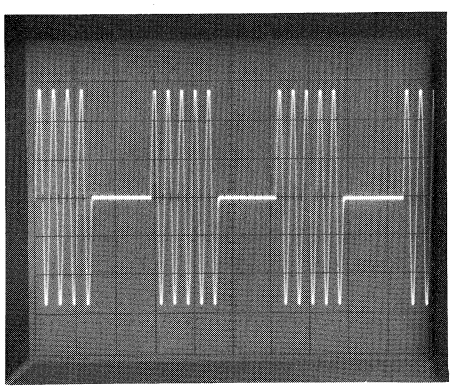
X-TAL MODE

Frequency lock
Freezes the momentary frequency display (frequency setting inhibited)

Accuracy
$\pm 5 \times 10^{-6}$

X-TAL AM MODE

See X-tal mode with additional facilities of internal and external AM



Burst signal

POWER REQUIREMENTS

Voltage
110, 128, 220, 238V ± 10%

Power consumption
55W

Frequency
50/60 Hz

DIMENSIONS AND WEIGHT

(w x h x d) 310 x 140 x 390mm
(12.2 x 5.15 x 15.4-in)
6.5kg (14.3lb)

ACCESSORIES SUPPLIED

Instruction manual

OPTIONAL ACCESSORIES
PM 9075 Coax. cable BNC.
PM 9581 50Ω/3W termination.
PM 9051 adapter BNC/4mm.
PM 9560 19-in rackmount adapter

0.001 Hz...2.147 MHz frequency range

Microprocessor-controlled with LED indication

Extremely accurate frequency setting to within ± 1 x 10^{-6}

Very high short- and long-term stability

Fast "feather-touch" parameter selection

Sine, triangle, square waveforms plus TTL output

External AM facility

IEC-bus interface standard for total remote control in automatic test systems

IEEE 488 IEC 625

LF synthesizer PM 5190

This microprocessor-based LF synthesizer includes many unique features that lift it into a special class of medium priced signal sources for most professional applications, including instrument calibration. Typical design criteria include ± 1 x 10^{-6} frequency setting error and an ageing characteristic of < 1.5 x 10^{-6}/year, which clearly underwrites the inherently high accuracy and stability of this instrument.

It will thus be of interest to design or research laboratories seeking such a highly accurate, stable signal source in the range 0.001 Hz to 2.147 MHz for both routine bench use and inclusion in automatic test systems. Its high-grade, virtually zero-error performance, plus simplicity and speed of operation make it equally attractive for use in advanced educational programmes.

The output frequency of the crystal-controlled oscillator is shown on a bright 6-digit LED display together with the AC (2½ digits) and DC (2 digits) outputs. DC polarity is also displayed.

In addition, the preselected waveforms and external amplitude modulation characteristics are indicated on this panel.

The user has a choice of sine, square and triangle waveform outputs which are available from a 50Ω front panel socket (BNC connector).

In addition, there is an adjacent TTL socket. External amplitude modulation signals, from 0...> 90% modulation depth can be connected via a rear input socket.

A very clear, simply designed front panel makes operation extremely easy. Fast selection of the desired parameters is assured by 'feather-touch' input push buttons. An 'erase' facility allows equally fast correction of any input errors.

Maximum AC output, for all waveforms is 19.9Vpp. A DC offset voltage of up to 9.9V max., is available for setting this output to the desired DC level, up to 19.9V total amplitude. Voltage levels can be set in minimum increments of 1mV.

All functions are fully remotely controllable via the built-in IEC-bus interface, enabling the unit to be used within an automatic testing system, if desired, (no modifications or extra accessories are needed). This facility is further enhanced by the generally high switching speeds resulting from a direct digital signal synthesis technique.
All these comprehensive facilities are contained in a very compact, portable package.

Typical applications in an automated system include, for example:
- accurate testing of audio filters when checking bandpass curves.
- as a standard, when checking servo motor speed control systems or for audio/video tape stress testing, etc.

Also, when employed as a signal source for calibrating instruments (e.g. frequency meters) its highly accurate and stable output signal may itself be used as a modulation source.

An alternative version, PM 5190X, features an ENTER, instead of ERS (erase) button. This enables the user to set up the next test frequency, before actually applying it at the output. This is useful for e.g. checking servo-loops and phase-locked loops.

TECHNICAL SPECIFICATION

FREQUENCY AND CHARACTERISTICS

Nominal range
1mHz...2.147 MHz

Measuring range
1mHz...2.147 MHz for sine and square wave
1mHz...< 100kHz for triangular wave

Setting
local: via front panel keyboard
remote: via IEC bus interface

Display
6-digit 7-segment LED display;
6 decimal points;
2 LEDS for dimension Hz, kHz

Setting error
$\pm$ 1 x 10^{-6} at 23°C

Temperature coefficient
$<$ 1 x 10^{-6}/K

Ageing
$<$ 1.5 x 10^{-6} per year

Duty cycle
50%

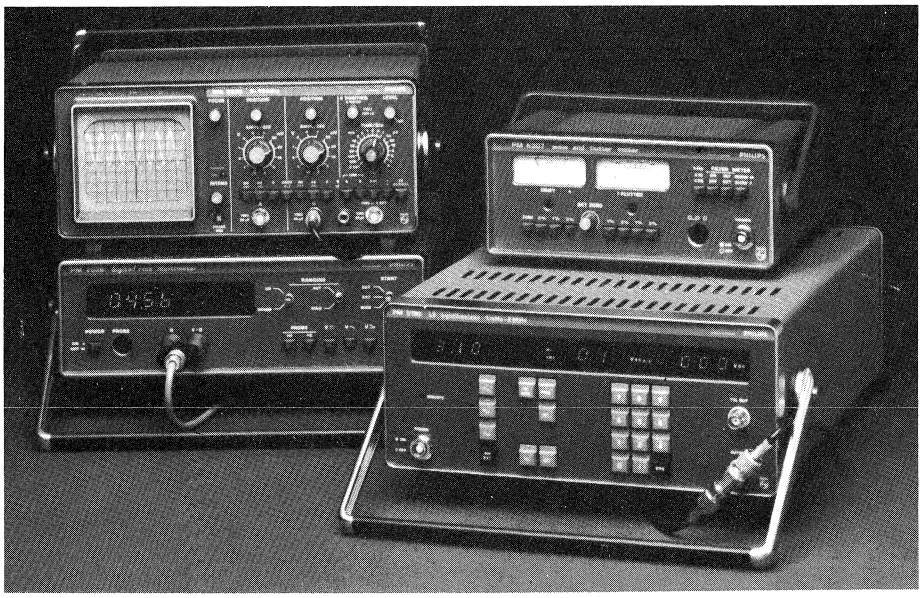
Tolerance
$<$ 0.5% (f = 1kHz)

WAVE FORMS

Sine wave
Square wave
Triangular wave
All time-symmetrical
All with or without DC offset
DC voltage without AC

Selection
local: via front panel keyboard
remote: via IEC bus interface

Indication
LEDs for the selected wave forms



The PM 5190 provides a very accurate and stable signal source to check and calibrate this wow and flutter meter.

SINE WAVE

Total harmonic distortion
$<$ 0.4% (1mHz...50kHz)
$<$ 1.5% (50kHz...2.147 MHz)

Non-harmonic components at max. amplitude
$<$ $-$46dB

Phase noise
$<$ $-$50dB within 30kHz bands, centered to the output frequency; (frequencies $>$ 50kHz)

SQUARE WAVE

Rise time, fall time
$<$ 50ns

Duty cycle
50%

Tilt
$<$ 3% (f $<$ 100kHz)

Overshoot
$<$ 3%

TRIANGULAR WAVE

Frequency range
1mHz...$<$ 100kHz

Linearity
$>$ 99% for frequencies $<$ 10kHz

MODULATION

Mode
Amplitude modulation, external

Indication
LED

Carrier
Sinusoidal and triangular waveform
frequency $>$ 10 Hz

Modulation frequency
DC...20kHz

Modulation coefficient
0.1 V per 10% AM

Modulation depth
0...90%

Connector
BNC socket AM EXT (rear side)

Input impedance
20kΩ

Max. external voltage
$\pm$ 30V

Reference potential
External contact of BNC socket

OUTPUT CHARACTERISTICS

Connector
BNC socket (front side)

Impedance
50Ω $\pm$ 2%

Short circuit proof
Yes

Max. external voltage
$\pm$ 5V

Reference potential
External contact of BNC socket

AC VOLTAGE

Range
19.9 V_{ACpp} open circuit

Sub-ranges
I .000...0.199 V_{AC}
II 0.00...1.99 V_{AC}
III 00.0...19.9 V_{AC}

Minimum increments
1mV in sub-range I
10mV in sub-range II
100mV in sub-range III

Setting
Local: via front panel keyboard
remote: via IEC bus interface

Display
2½ digit, 7-segment LED

Setting error
3% for settings 2.0V $<$ AC $<$ 19.9V
for frequencies $<$ 100kHz

Temperature coefficient
0.1%/K

DC OFFSET VOLTAGE

Range
0...9.9V_{DC} open circuit

Sub-ranges
I .000...0.099V_{DC}
II 0.00...0.99V_{DC}
III 00.0...09.9V_{DC}

Sub-range selection
Determined by sub-range setting

Minimum increments
1mV in sub-range I
10mV in sub-range II
100mV in sub-range III

Polarity
Positive or negative selectable via keyboard

Setting
local: via front panel keyboard
remote: via IEC bus interface

Display
2-digit, 7-segment LED
decimal point, position determined by AC decimal point setting

Setting error
4% (10%...100% of each subrange)

Temperature coefficient
$<$ 0.1%/K (10%...100% of each subrange)

Max. DC voltage setting
Depending on AC voltage setting:
DC indication $\leq$ 100 $-$(AC indication)/2;
decimal points ignored

TTL OUTPUT

Connector
BNC socket TTL OUT

Duty cycle
50%

Fan out
$\geqslant 10$

Level
Standard TTL-level

OUT-OF-RANGE INDICATION

Display flashes, if
– frequency setting > 2.147kHz
– frequency setting $\geqslant$ 100kHz for triangle
– frequency resolution < 1mHz
– DC voltage exceeds in max AC voltage setting

REMOTE CONTROL

Conformity
IEC-625: interface system of programmable measuring apparatus

Interface
Built-in IEC bus interface

Remote state indication
Front panel LED

Programmable parameters
frequency
AC voltage
DC voltage
wave form

Response time
– 4ms for wave form
–10ms for AC voltage
– 7ms for frequency
–12ms for DC voltage

Interface functions
AH1: acceptor handshake
L2: listener only
RL1: remote-local capability

CONNECTOR

25-pole standard interface connector (rear side)

Max. external voltage
–0.5...+5.5V, standard TTL level

Reference potential
Measuring earth

Connector housing
Connected to protective conductor

PROGRAMMING EXAMPLE

F 1.25 A 10.0 D 05 W 1 EXT

- EXT — "end of text"; character no. 3 of ASCII code
- 1 — sine wave
- W — wave form indication
- 05 — dc value (0.5V)
- D — dc voltage identification
- 10.0 — ac value (10.0V)
- A — ac voltage identification
- 1.25 — frequency value (1.25kHz)
- F — frequency identification

POWER REQUIREMENTS

Voltage
110, 122, 220, 238V ± 10%

Power consumption
47W

Frequency
50/60 Hz

DIMENSIONS AND WEIGHT

Dimensions (w x h x d)
310 x 140 x 365mm
(12.5 x 5.5 x 14.5-in)

Weight
6kg (13.2lb)

ACCESSORIES SUPPLIED

Instruction manual

OPTIONAL ACCESSORIES

PM 9075	coaxial cable BNC BNC
PM 9480	IEC bus cable (1 meter)
PM 9481	IEC bus cable (2 meter)
PM 9482	IEC bus cable (4 meter)
PM 9483	IEC/IEEE cable adapter 1 meter
PM 9560	19-in rackmount adapter
PM 9551	50Ω...600Ω impedance adapter

IEEE/IEC INTERFACE DATA

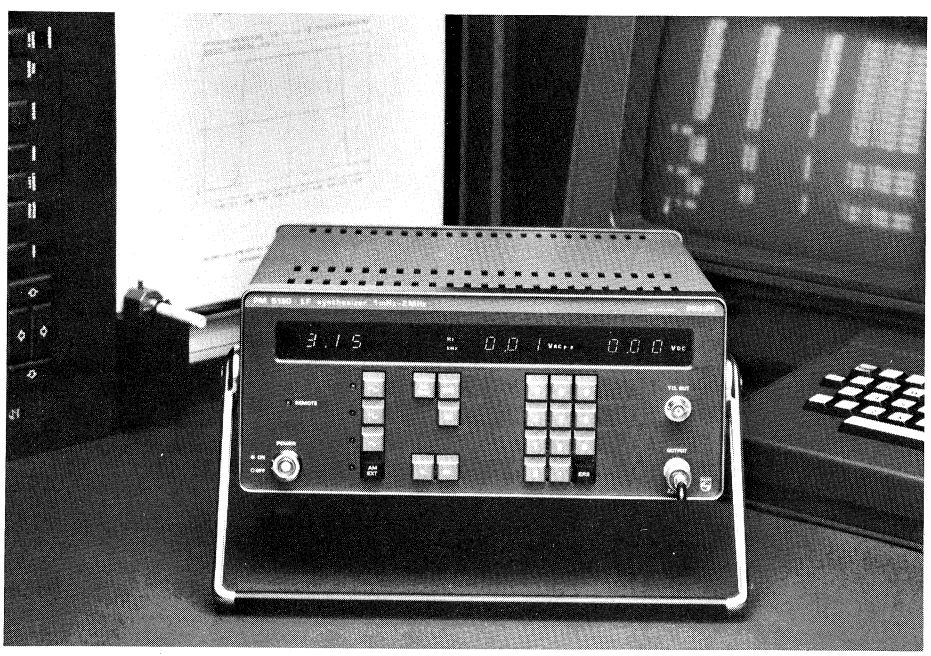
An IEC-625 interface is supplied, being built into the instrument, with rear access.

Connector
25-Pole IEC standard connector.

Interface functions

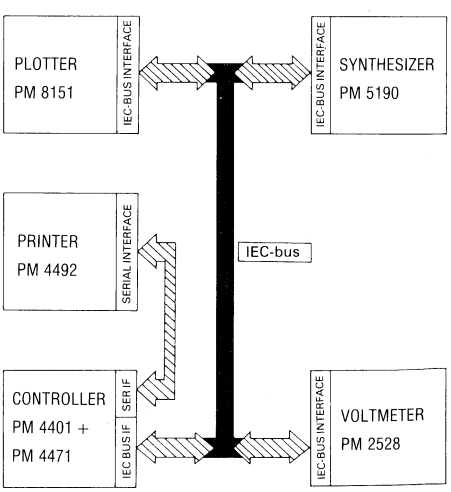
AH1	Acceptor handshake
L2	No additional functions possible
RL1	Remote/local total capability

Code
ISO 7-bit code



Automatic measuring and plotting of frequency response is made easier using the PM 5190.

Block diagram of set up



IEEE 488 IEC 625

NEW

Programmable synthesizer/function generator PM 5193

Nominal frequency range 0.1mHz...50MHz over 11½ decades

Precise uP-control of all parameters and functions

Sine, haversine, triangle, square, pos/neg sawtooth, pos/neg pulse

Int/ext modulation for AM, FM, GATE, plus internal SWEEP (log/lin) and programmable BURST

3 main LED displays plus integral key LEDs for immediate, unambiguous parameter, frequency and mode indication

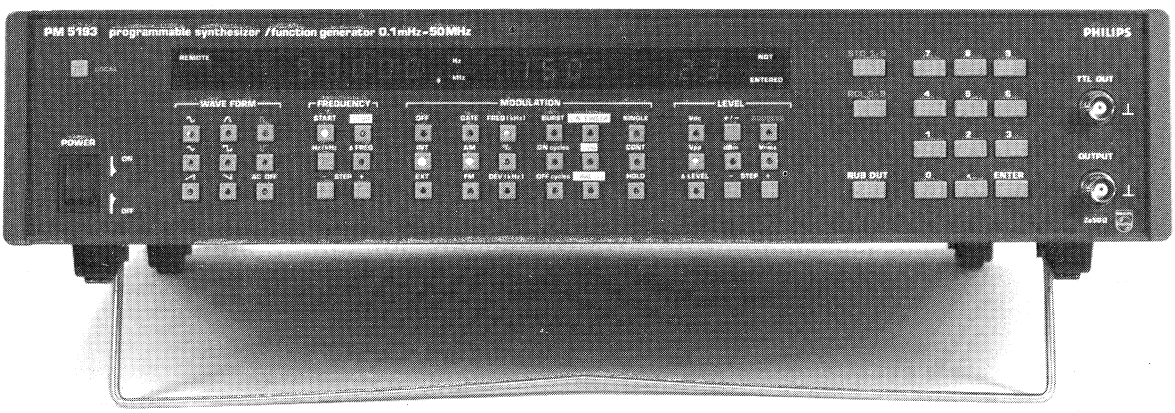
Up to 9 pre-set functions can be stored in non-volatile requisters for immediate call-up

Fully independent AC and DC settings

TTL output

Advanced IEC/IEEE facilities

Built-in pulse generator



Inbuilt versatility

PM5193 offers a remarkable versatility in its primary function as a precision programmable, frequency synthesizer. Microprocessor control has considerably extended the instrument's basic capabilities, at the same time simplifying the operator's task of setting up.
Other, unique features, which put this instrument well ahead in its class, include the facility for selecting AC-output values in either V_{pp}, V_{RMS} or dBm; phase-continuous sweep over all 11½ decades; independent AC and DC settings and TTL output (0 to 5V)

Fast setting up with multi-program storage

All functions are programmable: moreover, up to 9 individual operational programmes may be pre-set, stored in non-volatile registers, then called up for each desired operation. Setting up is by means of push buttons grouped either as parameter selectors or numerical inputs. The selected values are indicated on bright, clear LED displays, giving an immediate, and unambiguous readout. Individual function keys have built-in LEDs to indicate which operating modes have been activated. All settings can also be made remotely, via the IEEE-488/IEC-625 bus interface.

Waveform selection and frequencies

The nominal 0.1mHz to 50MHz frequency range allows for a wide range of operational capabilities. The available waveform outputs are listed below. Waveforms are push-button selected from the front panel (key LEDs indicate the currently selected waveform).

Modulation modes

The various internal modulation facilities are listed below. External modulation is also possible for AM, FM and GATE. All settings are made by either functional or numerical keys.

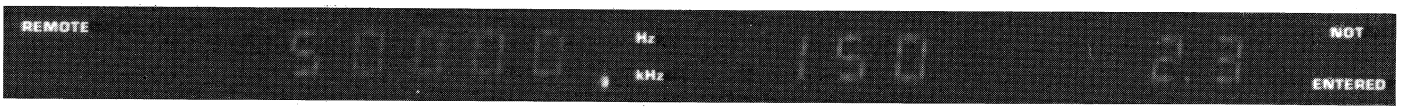
Output characteristics

The short-circuit-proof 50Ω signal output is located on the front panel (BNC socket). The selected open-loop output voltage is indicated on the 3-digit display. Also located on the front panel is the TTL (0 to 5V) output.

It is possible to set the output level either in V_{pp}, V_{RMS}, or dBm. Quick changes in programmable steps for all three dimensions is achieved using the step function. The nominal maximum output voltage is waveform-dependent.

WAVEFORM OUTPUT LEVELS

Key symbol	Waveform type	Max. frequency	Output voltage (pp)
∿	sine wave	50MHz	0...20V
⊓	positive pulse	50MHz	1...10V
⊔	negative pulse	50MHz	1...10V
⊓⊔	square	20MHz	0.2...20V
◺	positive sawtooth	20kHz	0...10V
◿	negative sawtooth	20kHz	0...10V
∧	haversine	50kHz	0...10V
△	triangle	200kHz	0...20V



The LED panel provides three dimensions of the selected operational mode. These are, frequency (8 digits), the modulation characteristic (4 digits) and output or offset voltage (3 digits). The relevant IEEE/IEC address can also be displayed on the last 3 digits in computer control mode.

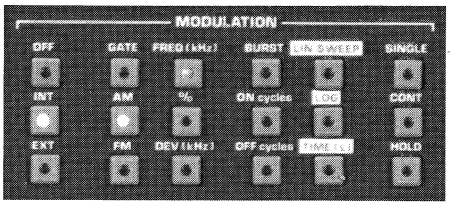
Independent AC and DC settings
Specially developed circuitry prevents any interaction between AC and DC settings within the ±10V output voltage window.

Simplified programme setting
The push-buttons are grouped into four function-selecting arrays, plus a common numerical key-board (0 to 9), as illustrated. The function groups relate to:
- waveform
- frequency
- modulation mode
- output level

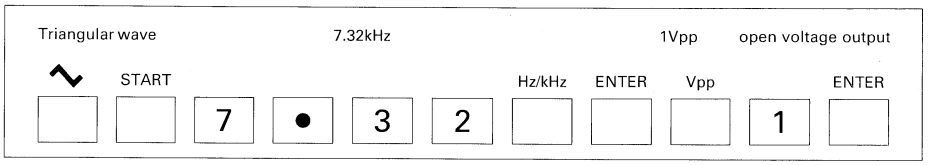
Three numerical LED panels indicate:
- frequency (8 digits)
- modulation characteristic (4 digits)
- output level or offset voltage (3 digits)

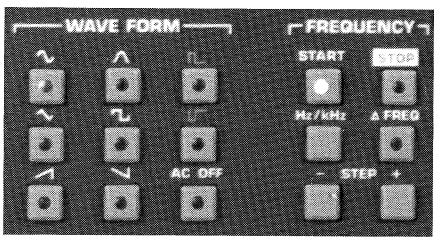
The 3-digit display is also used to indicate the relevant IEEC/IEC address when the instrument is being used under computer control conditions.

Up to 9 individual programme settings can be preselected and stored in non-volatile registers (with battery backup) for calling up when required, by a single push button. A typical setting might be:



The wide choice of modulation modes are easily selected from this uncomplicated arrangement of push buttons.



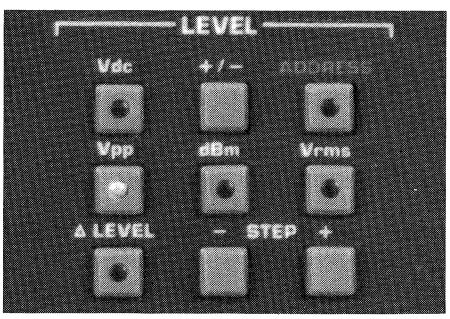


Waveform selection and operating frequency are set using push buttons with LED inserts to indicate the chosen conditions.

Built-in pulse generator
What may be considered to be the secondary function of the PM 5193 is its ability to operate as a 'stand-alone' pulse generator. In this mode it offers a frequency range up to 50MHz with a typical rise-and-fall time of 3ns. The pulse generator can be programmed for positive or negative pulses. The duty cycle is fixed at 50%.

Facility	Details
AM	Internal modulation frequency range from 10Hz to 200kHz. Modulation depth adjustable between 0 and 100%. Resolution, 1%.
FM	Frequency range from 10Hz to 200kHz. Deviation from 0 to 200kHz. Overall resolution, 1kHz.
SWEEP	Sweep range from 0.1mHz to 50MHz (phase-continuous). Programmable sweep time between 10ms and 1000s. Resolution, 1000 steps. Minimum step time is 1ms. Available sweep functions include: – linear – logrithmic – up/down – single/continuous – hold/release
GATE	Modulation frequency range, from 10Hz to 200kHz (internal, 50% duty cycle). Non-phase coherent signal keying.
BURST	Independently programmable for ON/OFF cycles between 1 and 200. The nominal max. signal frequency is 2MHz. Phasecoherent signal keying. Burst function can be triggered for single-shot or continuous operation, as required.

Advanced IEEE/IEC facilities
In addition to the many features of PM 5193 are the sophisticated facilities for operation within an automatic testing system. The instrument operates as a listener and can be remotely programmed for all its manual functions as well as SWEEP and BURST. Moreover, the SERVICE REQUEST function can be generated to give error indication and END messages (e.g., for SWEEP, BURST, SINGLE-SHOT). A push-button operated remote lockout facility is also



The output level selection panel also allows for decimal programming of the listener address when PM 5193 is under computer control.

provided. This allows the operator to lock out the controller when making manual changes to the currently active setting. The listener address is programmed via the numerical keyboard and can be indicated on the 3-digit LED display if required.

SURVEY OF APPLICABLE CODES

SIGNAL GENERATORS

1. Mode headers
MA : amplitude modulation (AM)
MF : frequency modulation (FM)
BS : single burst
BC : continuous burst
GC : continuous gate
SS : single sweep
SC : continuous sweep
MO : modulation off

Body : 0 = off
1 = intern
2 = extern
3 = linear
4 = logarithmic
5 = wait

2. Frequency headers
F : carrier frequency, basic frequency
FM : modulating frequency
FS : start frequency (of sweep)
FF : final (stop) frequency (of sweep)
FD : frequency deviation
Body : see rules under point 8

3. Levels, amplitudes, modulation depths etc.
LA : amplitude peak-peak
LR : rms voltage
LL : logarithmic level in dBm
LD : dc level
LM : modulation depth

Body : see rules under point 8

4. Headers for times
TS : sweep time (period)

Body : see rules under point 8

5. Numbers
NB : number of signal periods per burst
NO : number of signal-off periods

Body : see rules under point 8

6. Wave form headers
WS : sine wave
WT : triangular wave
WQ : square wave
WH : haversine
RP : pos. ramp
RN : neg. ramp
PP : pos. pulse
PN : neg. pulse
AC0 : AC off
AC1 : AC on

7. Storage register commands
RLn : load storage register no. n with preceeding instruction block
RRn : recall (execute) data from register no. n

8. Body
Numeric representation :
sign, mantissa and exponent (multiples of 3) + sign may be omitted exponent 0 may be omitted example: 5.6 E + 03 (5600)
Dimensions :
Hz, s, V these dimensions are mandatory and implicily related to numeric values of frequency (rates), times (periods) and voltages.

TECHNICAL SPECIFICATION

FREQUENCY CHARACTERISTICS

Nominal range 0.1mHz...50MHz

Operational range
Sine wave 50MHz
Haversine 2MHz
Triangle 200KHz
Square 20MHz
Positive sawtooth 20KHz
Negative sawtooth 20KHz
Positive pulse 50MHz
Negative pulse 50MHz

Setting
Local via front panel keyboard
Remote via IEEE bus interface +/– stepping function with programmable stepwidth

Resolution 8 digits

Display 8 digit LED display
Hz/kHz dimension LED's

Setting error $< 1 \times 10^{-6}$

Frequency jitter <0.02%

Temperature coefficient $< 0.2 \times 10^{-6}$/K

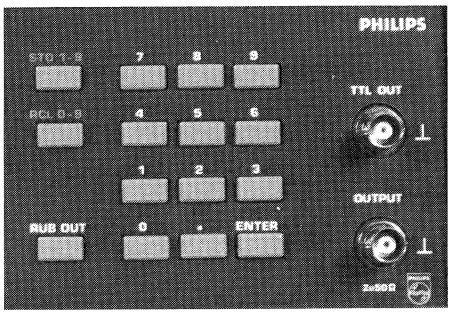
Aging $< 1 \times 10^{-6}$ per year

Synchronisation 2 (or more) generators PM 5193 can be synchronised by rear-side socket connection

WAVEFORMS

Sine wave
Square wave
Triangular wave
Haversine
Sawtooth (positive - going ramps)
Sawtooth (negative - going ramps)
Positive pulse
Negative pulse

Selection
Local via front panel keyboard
Remote via IEEE bus interface



Detail of the numerical input panel, normal and TTL output sockets.

Indication
Key led's

SINE WAVE (measured between 2...20Vpp)

Total harmonic distortion
< 0.4% 10Hz...50kHz
< 1.0% 50kHz...2MHz

Harmonic components
< –30dB 2...50MHz

Spurious
< –52dB 0.1mHz...2MHz
< –40dB 2MHz...50MHz

SQUARE WAVE

Rise/fall time < 9ns

Duty cycle 50%

POS./NEG. PULSES

Rise time < 3ns (typical 4ns)

Duty cycle 50%

OUTPUT CHARACTERISTICS

MAIN OUTPUT

Connector BNC socket front side

Impedance Zo = 50Ω

Load capability Short circuit proof

Max. external voltage ± 15Vpp

AC voltage Independent of DC setting (with ±10V output voltage window)

Ranges
0...20Vpp Sine-triangular wave forms
0...10Vpp Sawtooth, haversine
0.2...20Vpp Square wave
1...10Vpp Pulses

Resolution
1/10/100mV depending on sub-range

Setting
Remote or local
+/– stepping function for all dimensions
Programmable step width
Alternative settings; V_{RMS}, dBm

Setting error, sine wave
< 1.5% ±0.3mV at 1kHz

Setting error
< 1.5%

DC voltage
Independent of AC setting

Range
+/– 10V open circuit voltage

Smallest resolution
0.1V

Offset error
< 0.1V

Setting
Remote or local
+/– stepping function
Programmable step width

TTL OUTPUT

Connector
BNC front panel

FAN out
< 5 TTL inputs

Level
0/5V

MODULATION

MODES
AM int/ext
FM int/ext
lin/log sweep
gate int/ext
burst

INTERNAL AM

Modulation frequency 10Hz...200kHz

Modulation depth 0...100%

Resolution 1%

EXTERNAL AM
0...200kHz (DC-coupling)

INTERNAL FM

Modulation frequency 10Hz...200kHz

Deviation 0...200kHz

Resolution 10Hz...1kHz (depends on Sub-range)

EXTERNAL FM

Internal sweep

Range 0.1mHz...50MHz phase continuous

Sweep time 10ms...1000s

Resolution 1000 steps

Min. step time
1s

Sweep functions
lin/log
up/down
single/continuous
hold/release

INTERNAL GATE

Modulation frequency 10Hz...200kHz

Duty cycle 50%
Non-phase coherent signal keying

BURST

On-cycles 1...200 programmable

Off-cycles 1...200 programmable

Max. signal frequency
2MHz (dependent on waveform)
Phase - coherent signal keying

Burst functions Single/continuous

IEEE BUS REMOTE CONTROL

Control capability
All signal functions and characteristics

Listener address
Decimal programmable via keyboard, indicated by LED display

Service request
Error and single burst/sweep end message

Remote lock-out
Go-to-local front panel key

MISCELLANEOUS

Non-volatile memory
1 actual setting storage register
9 arbitrary settings storage register

Rear connectors
Modulation output BNC
Sweep output BNC
Pen-lift output BNC
Clock output BNC
Modulation input BNC
Clock input BNC
IEEE bus connector
Mains connector

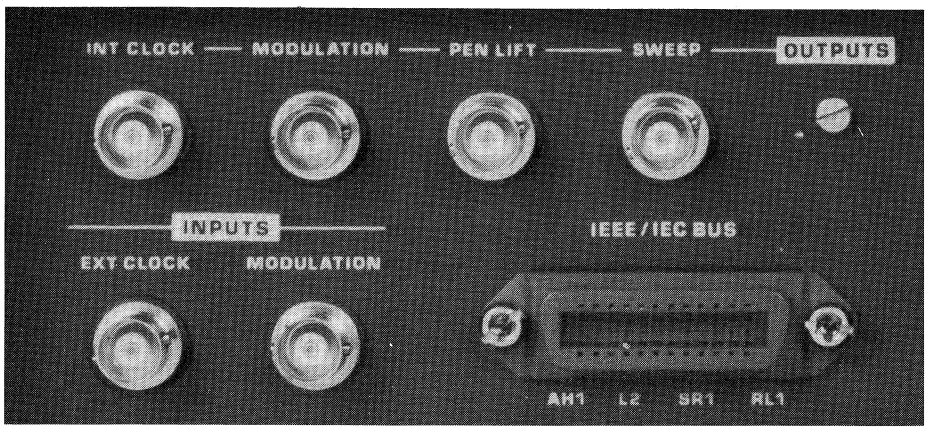
Accessories supplied
Cabinet 19-in x 2 units high
Rack mounting facility accessory

Dimensions and weight
(w x h x d) 440 x 89 x 440mm
(17.3 x 3.5 x 17.3-in)
8kg approx. (17.6lb)

Power requirements
Line voltage 110, 128, 220, 238V ±10%
Line frequency 50...60°C
Power consumption 100W

Environmental conditions
Reference temperature 23°C ±1%
Operating temperature +5°C...+40°C

View of rear panel showing the various output and input connectors



IEEE 488 IEC 625

1GHz RF synthesizer PM 5390

Frequency range 100kHz...1019.99MHz

Fast, accurate parameter settings via numerical keyboard

Storage and instant recall of 8 settings

4-section, bright LED display for frequency, incremental frequency, sweep time and RF output level

Output level selectable in dB, μV or mV

Single or continuous sweep

Push-button adjustment of carrier frequency in pre-selected increments

Internal or external AM, FM or video modulation

Integral IEEE/IEC bus facilities for system operation

The PM 5390, operating beyond 1GHz, will find wide application in the generation of carrier and subcarrier frequencies for TV, radio and communications, in sensitivity tests and radiation measurements.
Sweep measurements on broadband amplifiers and IF filters, plus signal simulation such as gain/bandwidth and conversion loss or antenna gain, can easily be accommodated.
It will be of especial interest for applications associated with cable TV bands, currently increasing UHF ranges and (ultimately) satellite TV. Moreover, the trend towards using programmable generators in automated testing systems, further extends its application potential.

PM 5390 is a fully-programmable 1GHz RF generator and provides AM, FM and video modulation, plus a wide range of sweep measurements and both automatic and manual frequency-stepping facilities. The output (100kHz to 1020MHz) is highly stable and accurate, and frequency, signal amplitude, frequency increment and sweep time can be digitally selected and displayed.

The heart of the PM 5390 is the main RF oscillator which is used for mixing frequencies generated by voltage controlled oscillators (VCOs) under phase-locked loop control. A 5MHz crystal oscillator provides a highly stable reference source.

The main oscillator comprises four separate voltage-controlled oscillators (VCOs) from which six discrete frequency bands are produced. Two of these are developed within the main oscillator by a frequency-mixing process. The generated bands cover the ranges 340 to 510MHz, 510 to 680 MHz, 680 to 850 MHz and 850 to 1020 MHz. Fig. 1 shows a block schematic of this circuitry.

Frequency control is achieved by comparing the output signal from VCO1 mixed with the relevant frequency generated by oscillator VCO2 to a signal from the reference oscillator.

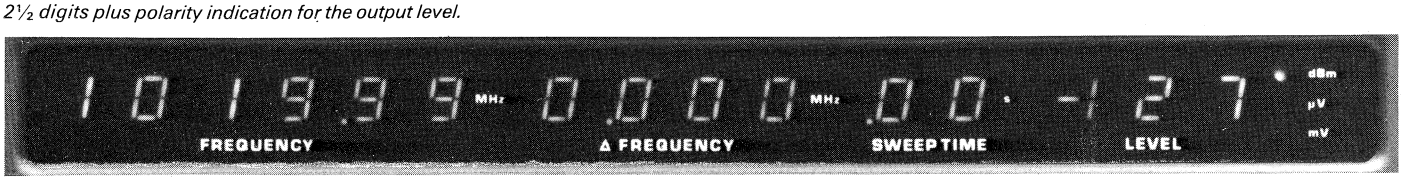
Signals divided down

Both signals are divided down to 1kHz (the reference signal) by a fixed reference divider and the output signal by a programmable divider controlled by the microprocessor. A phase detector ensures that the signals agree in both phase and frequency.

The output from the main oscillator is then fed out to an automatic level control. Amplitude modulation can be added after this stage. Video modulation is also applied here. The final section provides fine and coarse attenuation.

The lower two frequency bands are obtained by mixing the output of the main oscillator with the 510MHz output of oscillator VCO3. Frequency modulation is applied to this oscillator to ensure constant deviation at different output frequencies.

Detail of the LED panel. The display is subdivided into four parts: 6 digits for the selected RF frequency, 4 digits for the incremental frequency, 2 digits for sweep time and 2½ digits plus polarity indication for the output level.



Standard integrated circuits are used in the phase-locked loop control system. These were developed initially for similar applications in television and broadcoast work. These LSIs are designed for use in microprocessor circuits and need few peripheral components.

Careful attention to shielding

Particular care has been taken to ensure negligible RF interference. The RF circuitry is split into two separately shielded sections – oscillators in one part and the digital control circuitry in the other – to reduce any possible crosstalk.
As the accuracy of the output frequency is directly related to that of the crystal-controlled reference oscillator, this is contained in a specially shielded compartment in the control box. The circuitry is designed to ensure stability of better than 10^{-6}.

Built-in microprocessor

The built-in microprocessor enables simple and rapid selection of parameters and values via front-panel-mounted push-buttons, and permits the storage of up to 8 sets of parameters for subsequent use. All values are clearly displayed on four separate LED displays. Full remote control is assured via the integral IEEE/IEC interface.
Internal and external AM and FM modulation are important features.

Unique video modulation

AM modulation is effective over the full 1GHz range, FM modulation is up to 340 MHz.
Video modulation facilities are possible over the full video band with the choice of internal or external AM or FM sound. This makes the instrument an invaluable tool in, for example, video equipment production testing.

Internal or external sweep

Single and continuous sweep modes can both be internally or externally controlled; sweep time can be varied from 0.05 to 20 seconds. Manual or automatic incremental frequency-changing is also provided in the range 1 kHz to 50 MHz, positive or negative. This latter facility is ideal for random sequence testing of TV and/or radio channels.

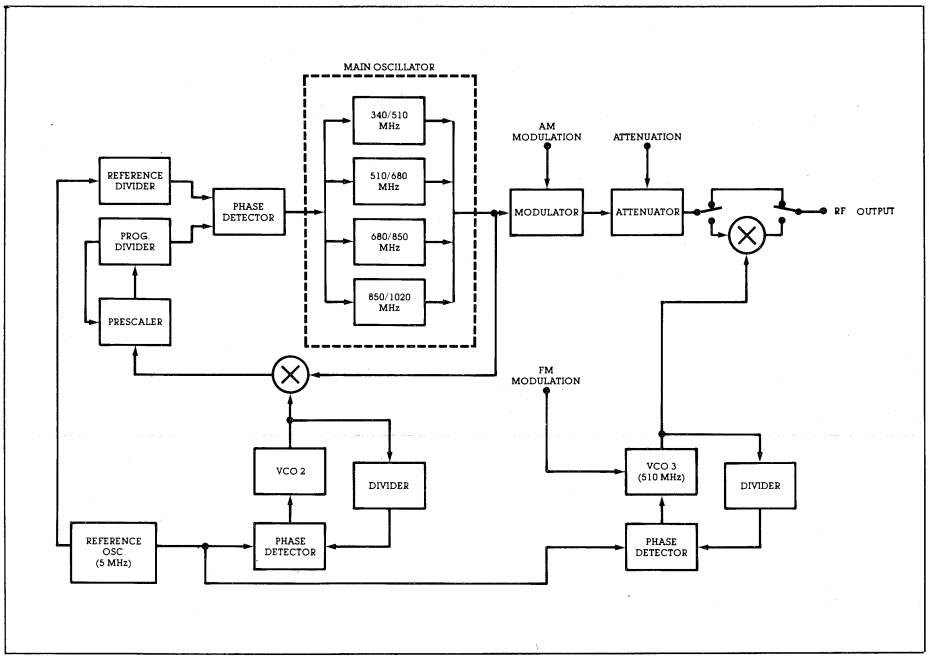


Fig. 1 The PM 5390 RF synthesizer functions by mixing frequencies from several oscillators derived from a 5 MHz crystal source.

Extremely wide application potential

The PM 5390 is thus designed to cater for almost every possible application in industrial electronics including audio, video and communications. As such, it meets todays need for a versatile, easy-to-use RF signal source having the most comprehensive modulation facilities; with reserve performance for tomorrow.

TECHNICAL SPECIFICATION

FREQUENCY

Frequency range
100 kHz...1019.99 MHz

Setting
Keyboard, IEEE/IEC bus

Display
6 digits
7-segment LED display (11 mm)

Resolution
1 kHz

Setting error
$\leq 1 \times 10^{-6}$
(20°C)

Reference oscillator
– temperature effect: $\leq 1 \times 10^{-6}$/K
– crystal ageing: $\leq 1 \times 10^{-6}$/month

Spectral purity
(at −7dBm output level)
– harmoics
<−30dB (typical −35dB)
– non harmonics
<−40dB ⩾340MHz (typical <−45dB)
– residual FM
⩽75...50Hz RMS (measuring range 0.3...3kHz) typical

SSB phase noise
−100dBc/Hz
(measured at 20 kHz offset from 100 MHz)

RF OUTPUT

Impedance
50Ω

Output level (into 50Ω)
−127dBm...−7dBm (PM 5390)
−127dBm...+13dBm (PM 5390S)

Output voltage rms
0.1μV...100mV (PM 5390)
(into 50Ω)
0.1μV...1V (PM 5390S)

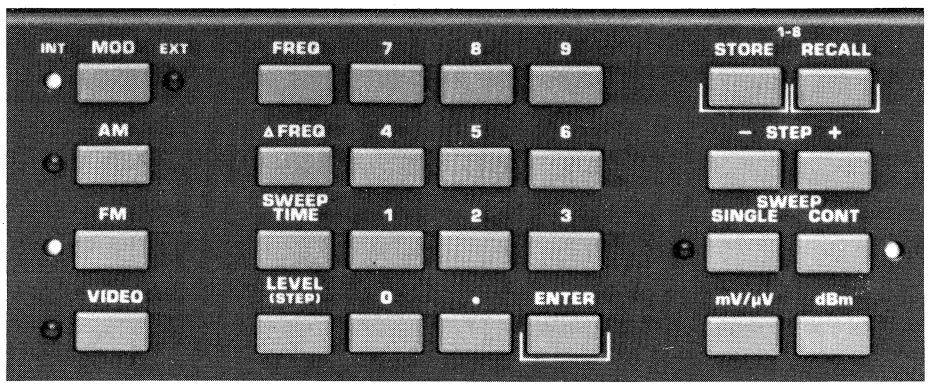
Setting
Keyboard, IEEE/IEC bus
pushbuttons dBm, mV/μV

Display
2½ digits
7-segment LED-display (11 mm)

Dimension
dBm, μV, mV

Resolution
1 dB

Detailed view of control panel.



Level accuracy

	PM 5390	PM 5390S	output level
– frequency response	±2dB	±2dB	max. level
	typ ±1.5dB	typ ±1.5dB	max. level
– flatness	±0.8dB	±0.8dB	in frequency subranges III, IV, V, VI
	±1dB	±1dB	in frequency subranges I, II
– attenuation error per 1dBm step	±0.3dB	±0.3dB	
– additional	±0.3dB	±0.3dB	<680MHz } transitions +4 to +3dBm
	±0.5dB	±0.5dB	≥680MHz } and each −10dB further

Connection
BNC, RF OUT, front panel

Load capability
short-circuit proof
constant short-circuit proof to ground

Max. external voltage
±3.5V
AC/DC-voltages

MODULATION

Modulation modes

RF carrier unmodulated
100kHz-1019.99MHz

Amplitude modulation, AM
100kHz-1019.99MHz

Frequency modulation, FM
<340MHz

video without sound carrier
video sound carrier AM int./ext.
video sound carrier FM int./ext.
} ≥30MHz

Amplitude modulation, internal

Modulated frequency range
100kHz - 1019.99MHz

Modulation frequency
1kHz, sine wave

Modulation depth
30%

Accuracy
≤5%

Amplitude modulation, external

Modulated frequency range
100kHz-1019.99MHz
RF level reduced by 6 dB

Modulation frequency
20 Hz...20kHz

Modulation depth
0...≥80%

Modulation coefficient
10mV/%

Connection
BNC socket
MOD IN, front panel
– input impedance 10kΩ
– max. external voltage ±5V

Frequency modulation, internal

Modulated frequency range
100kHz-339.999MHz
≥340MHz for FM on sound subcarrier

Modulation frequency
1kHz, sine wave

Deviation
±25kHz

Frequency modulation, external
(Stereo modulation is also possible, if multiplex signal is applied)

Bandwidth
20Hz...100kHz

Max. deviation
±80kHz (0.1...339.999MHz)

Modulation coefficient
100mV/7.5kHz

Connection
BNC socket
MOD IN, front panel
– input impedance 10kΩ
– max. external voltage ±5V

Video

Modulated frequency range
0.1-1019.99MHz
Note: At frequencies below 30MHz the LED display blinks as a warning

Band width
8MHz

Amplitude ext. CVBS-signal
$1V_{pp}$ into 75Ω
– polarity negative sync. signal
– modulation negative (or positive)
selectable by menas of soldering links

Residual RF carrier
10%

Connection
BNC socket
VIDEO INPUT, front panel
– input impedance 75Ω
– max. external voltage ±5V

Sound

Sound carrier internal
switched on by pushbuttons AM or FM

Spacing of vision/sound carrier
5.5MHz (4.5; 6; 6.5MHz)
selectable by means of soldering links
– tolerance <0.2%

Vision/sound carrier ratio
13dB

Type of modulation
FM or AM

Internal sound modulation

Modulation frequency
1kHz, sinewave

Deviation
±40kHz
mode FM, carrier f=5.5MHz

Modulation depth
30%
mode AM, carrier f=5.5MHz

External sound modulation

Bandwidth
50 Hz...20kHz

Pre-emphasis
50μs

Modulation coefficient FM
100mV/8kHz

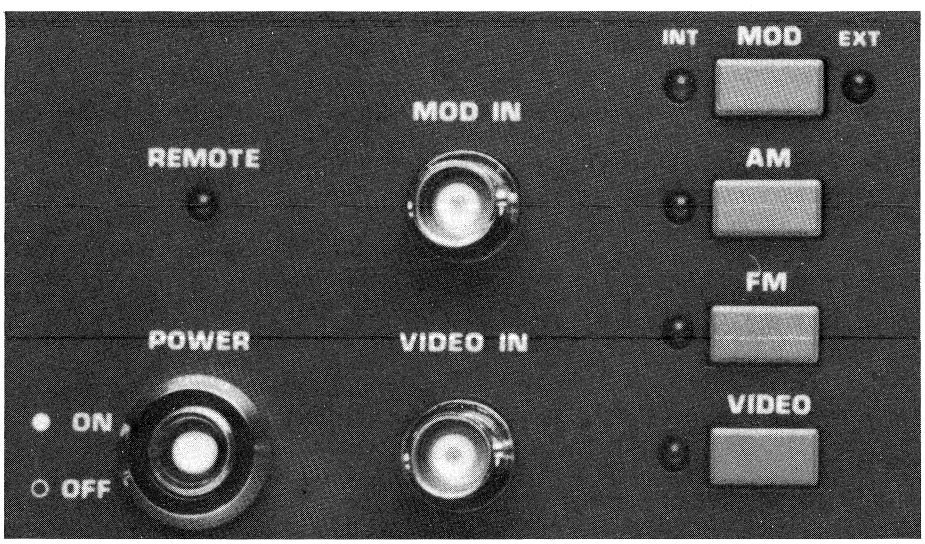
Max. deviation
±75kHz

Modulation coefficient AM
100mV/6%

Connection
BNC socket
MOD IN, front panel
– input impedance 0.5MΩ
– max. external voltage ±5V

FREQUENCY INCREMENT (△ FREQUENCY)

Frequency range
100kHz...1019.99 MHz



External modulation over the full video band (30 to 1020 MHz) is possible, with or without internal or external AM or FM sound.

Increment range I
1 kHz...9,999 MHz
– resolution 1 kHz

Increment range II
10,00...99,99 MHz
– resolution 10 kHz

Indication
4 digits
7-segment LED-display (11mm)

Mode single STEP
FREQ±1·△FREQ
Activate button once

Mode continuous STEP
FREQ±X·△FREQ
If button is pressed:
2 x △FREQ/s for first 3 steps
4 x △FREQ/s for following steps

FREQUENCY SWEEP
Within a selectable sweep time the frequency passes a selectable range △ FREQUENCY by 50 steps from the start frequency (FREQUENCY) to the stop frequency (FREQUENCY + △FREQUENCY).

Frequency Range
100 kHz...1019.99 MHz

Subrange:
I 0.1 MHz...169.999 MHz
II 170 MHz...339.999 MHz
III 340 MHz...509.999 MHz
IV 510 MHz...679.999 MHz
V 680 MHz...849.999 MHz
VI 850 MHz...1019.99 MHz
Sweep is possible within one of the 6 subranges

Sweep width
50 kHz...50 MHz
≙ value of △ FREQUENCY

Step width
1kHz-1 MHz
Min. resolution 1kHz; step width is internally calculated and rounded to △FREQ/50.

Number of frequency increments per sweep
50

Indication
4 digits
7-segment LED-display (11mm)

Sweep modes
Single sweep, continuous sweep

Sweep time
50ms...20s
Min. sweep time for FREQ≥5 MHz
10ms · △FREQ/MHz
– resolution 0.01s...1s
– indication 2 digits
7-segment LED-display (11mm)

Fly-back time
200ms

Sweep time out
Increasing ramp during sweep time
– amplitude 50 steps of 10mV each
0(f START)...+500mV(f STOP)
– impedance 10kΩ
– max. external voltage ± 10V
BNC socket at the rear

STORAGE OF PARAMETER SETTINGS

Memory locations
8
Complete parameter settings consisting of frequency, △frequency, sweep time, level and modulation modes

Storage
Buttons STORE 1...8

Store time
Min. 5 days

Battery
NiCd-cell

Setting
Keyboard, IEEE/IEC bus
Buttons STORE/RECALL 1...8

REMOTE CONTROL

Conformity
IEEE488/IEC625
Interface system of programmable measuring apparatus

Connection
24-pole IEEE bus standard interface connector, rear

Device address
ADDRESS switch, rear

Remote indication
LED
REMOTE, front panel

Interface functions
AH1 Acceptor handshake capability
L1 Basic listener, listen only
RL2 Remote/local, no local lock out
DC1 Device clear capability

Delimiters
Komma, LF (NL=New Line)
ETX, ETB

Control functions
Fully remotely controllable

Setting time

Interface reaction time
2...20ms (typical 5ms)

Frequency setting time
15...120ms
△frequency 1 kHz...10 MHz

Level setting time
5ms

Overflow, misoperation
When overflow, incorrect or insufficient settings occurs, the relevant part of the display starts flashing.

ENVIRONMENTAL CAPABILITIES

Ambient temperatures
Reference value +23°C ±1K
Nominal working range +5°C...+40°C
Limits for storage and transport –40°C...+70°C

Cabinet

Protection type (to DIN 40 050)
IP 20

Protection class (to IEC348)
Class I, protective conductor

Shielding
RF-unit double screened

DIMENSIONS AND WEIGHT

Dimensions (w x h x d)
310 x 140 x 660 mm
(5.5 x 12.5 x 26-in)

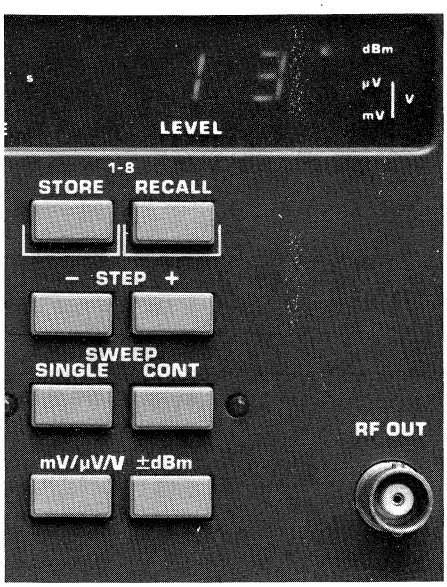
Weight
9.9 kg (22 lb)

ACCESSORIES SUPPLIED

Operating manual, mains cable (2 meters)

OPTIONAL ACCESSORIES

PM 9075 Coaxial cable BNC-BNC
PM 9585 50Ω termination, 1W
PM 9487/10 IEEE bus cable (1 meter)
PM 9487/20 IEEE bus cable (2 meters)
PM 9487/40 IEEE bus cable (4 meters)
PM 9483/50 IEEE/IEC adapter
PM 9483/51 IEC/IEEE adapter
PM 9560 19-in rackmount adapter



Detail from PM 5309 S model showing controls and indication of extended output facility.

PROGRAMMING EXAMPLE

F 10E6 FD 20E6 L-50 T 5 SC <Delimiter>

- LF, ETX, ETB
- Continues sweep on
- Sweep time 5s
- Sweep time indication
- Level of –50dBm
- Level indication
- △frequency 20 MHz
- △frequency indication
- frequency indication 10 MHz
- frequency identification

Amplifier, AC/DC and linear/log converter PM 5171

AC/DC Converter:
Dynamic range 80dB
Response time 0.35s
Error ± 0.5dB at 1kHz

Log Converter:
Dynamic range 80dB
Slewing speed 100dB/s
Error 1dB at 60dB

Amplifier:
Gain 60dB
Rise/Fall time 100ns
Distortion 0.2% at 60dB

This versatile laboratory instrument combines the three distinct functions – wideband amplifier, AC-to-DC converter and linear-to-logarithmic converter, in a single instrument.

Measuring amplifier

The measuring amplifier covers the range from DC to 1 MHz and will accept an AC- or DC-coupled input. Maximum permissible input voltage is $100V_{pp}$ and the output is between 0 and $10V_{RMS}$. Gain is adjustable in switchable 10dB steps, between 0 and 60dB, with an accuracy of 0.1dB at 1kHz.

AC-to-DC converter

The DC output for a $10V_{RMS}$ input is 10V. With a dynamic range of 80dB, the conversion error is only 0.5dB at 1kHz. A good response time of 0.35 seconds has been achieved and the frequency range is between 10 Hz and 100kHz for an output of $10V_{RMS}$ and between 10 Hz and 20kHz for an output of $1V_{RMS}$.

Linear-to-logarithmic converter

This has a dynamic range of 80dB, with a slewing speed of 100dB/second. Output voltage is, typically, 2V for a $10V_{RMS}$ amplifier output. A continuously adjustable DC shift from 0 to 2V is provided. Conversion factor is 1V/20dB and frequency ranges are as for the AC-to-DC converter.

TECHNICAL SPECIFICATION

MEASURING AMPLIFIER

Input: AC or DC coupled (switchable)
Input impedance: 1 MΩ//20pF
Maximum operating: $30V_{pp}$
Maximum permissable input voltage: $100V_{pp}$
Output voltage: 0...$10V_{RMS}$ (open circuit)
Internal resistance: 50Ω
Gain: 0-10-20-30-40-50 or 60dB (switchable)
Inaccuracy: ± 0.1dB at 1kHz
Bandwidth: at G = 20dB; R load = 600Ω;
DC coupling: 0...1 MHz
(0.5dB points): at G = 60dB; R load = 600Ω;
DC coupling = 0...10kHz
Bandwidth: at G = 60dB; R load = 600Ω;
DC coupling = 0...30kHz
(3dB points): at G = 60dB; R load = 600Ω;
AC coupling = 2 Hz...30kHz
Rise and fall time: 100ns at R load 600Ω and a gain of 20dB
Distortion: 0.2% at R load 600Ω and a gain of 60dB (f = 50kHz)
Drift: 50μV/°C
Noise: 15μV

AC TO DC CONVERTER

DC output voltage: 10V at $10V_{RMS}$ at amplifier output (load resistor 10kΩ)
Internal resistance: 10Ω
Conversion error: ± 0.5dB at 1kHz
Dynamic range: 80dB
Response time: 0.35s
Frequency range: 10 Hz...100kHz at $10V_{RMS}$ at amplifier output
10 Hz...20kHz at $1mV_{RMS}$ at amplifier output

DC TO LOG CONVERTER

Output voltage: + 2V at $10V_{RMS}$ at amplifier output
−1V at $10mV_{RMS}$ at amplifier output
DC shift: 0...−2V continuously adjustable
Conversion factor: 1V/20dB
Conversion error: 1dB (at 1kHz from 0 to 60dB)
Dynamic range: 80dB
Slewing speed: 100dB/s (from 0 to −60dB)
Frequency range: 10 Hz...100kHz at $10V_{RMS}$ at amplifier output
10 Hz...20kHz at $1mV_{RMS}$ at amplifier output

OPERATING CONDITIONS

Reference temperature: 23°C ± 1°C
Operating temperature: 5°C...40°C

DIMENSIONS AND WEIGHT

(w x h x d) 230 x 110 x 200mm
(9 x 4.3 x 7.9-in)
1.6kg (3.5lb)

POWER SUPPLY

Line voltage: 115/230V ± 15%
Line frequency: 50...100 Hz
Consumption: 8W

Audio and video test equipment

Unit	Description	Page
Introduction		2
AUDIO EQUIPMENT		
PM 5326	RF generator	4
PM 6307	Wow and flutter meter	6
PM 6309	Distortion meter	8
PM 6456	Stereo generator	10
PM 6303	Automatic RCL meter	12
VIDEO EQUIPMENT		
PM 5503	PAL colour TV pattern generator	14
PM 5519	PAL or NTSC colour TV pattern generator	16
PM 5215	SECAM colour TV pattern generator	19
PM 5217	SECAM and PAL colour TV pattern generator	19

Introduction

The reliability of modern electronic equipment has improved immeasurably over the years. However, time, intensive use or accidents necessitate realignment or repair at some period in the life of most radio and HiFi set ups, black and white, colour TV, cable and closed circuit TV sets. Within industry production test equipment is subject to long, continuous use and must always be maintained at its peak performance. In education and training environments, electronic equipment is probably most liable to accidental misuse and needs to be well protected against such eventualities.
So, the test equipment especially designed to cope with all these situations must itself exhibit high orders of performance and reliability and be consistently accurate.

Philips, as one of todays largest manufacturers of radio, audio and TV equipment have had considerable, everyday experience of the special problems related to testing and servicing. Information on the practical aspects of employing test equipment has been fed back continuously from Philips' many in-house users to the design teams along with recommendations for improved product specifications.

It follows that the test and measuring equipment described in this section embodies the best practical features that will satisfy the most stringent demands of all service and educational requirements.

For field service – compactness and low weight: for industrial applications – consistency of performance over long periods: for education – simplicity of operation and physical robustness.

Whatever the application, whatever the environment, Philips audio and video service equipment will give longterm and absolutely reliable performance.

Choosing the right instrument
This survey is designed to assist the user to select the best combination of instruments related to a particular application and instrument performance.

It is subdivided into audio or video applications and proposes alternative instruments for some situations.

There follows a brief review of those instruments considered to the basic essentials for inclusion in the modern service departments inventory and which will complement the specialized audio and video equipment for education and service.

Audio and video service equipment

MULTIMETERS FOR RADIO AND TV

The wide selection of multimeters includes a range of hand-held models, both analog and digital. PM 2502, for instance is an analog unit for AC, DC and resistance measurement. PM 2518X is a sophisticated and compact digital design which is available in two versions. One for everyday applications in normal ambient lighting condition the other ('Backlite') version has a specially illuminated display for use in dark areas. Microprocessor control greatly enhances overall performance. Measurements to 0.1% accuracy can be made with the 4-digit readout. True RMS readings are possi-

Description	Type No.	Audio		Video		
		Hi-Fi AM-FM Stereo	Record players/Recorders	Colour TV	B/W TV/CCTV	VCR/VLP
Low distortion LF Gener ·r	PM 5107	●	●			●
R-C oscillator symm. output	PM 5109	●	●			
R-C oscillator	PM 5109S	●	●			
RF synthesizer (1GHz)	PM 5390			●	●	●
RF Generator	PM 5326	●				●
Function Generator	PM 5133S	●				
Amplifier/Log converter	PM 5171	●	●			
PAL colour pattern Generator CTV	PM 5503			●	●	
PAL colour pattern Generator*	PM 5519*			●		●
SECAM colour pattern generator	PM 5215			●		●
PAL SECAM colour pattern gen.	PM 5217			●		●
Automatic RCL meter	PM 6303	●	●	●	●	●
Wow and flutter meter	PM 6307		●			●
Distortion meter	PM 6309		●			
Stereo Generator	PM 6456	●				

* Also for RTMA, NTSC-TV systems used e.g. in U.S.A., Canada, Mexico and Japan.

In addition to the above list there is a wide choice of complementary instruments including multimeters, voltmeters, recorders, power supplies, etc. details of which appear elsewhere in this catalog.

PM 2519

ble, and other features include diode measurements, direct readout in dBm for gain measurements, a relative reference capability and audio bleeper for continuity measurements.

PM 2519 is a compact digital multimeter with a wide range of measuring capabilities, computation and control facilities, plus data presentation. In addition to conventional V,I,R ranges it also measures frequency to 1MHz.

DC volts can be measured to a 10μV, true RMS AC volts to 100μV resolution; AC and DC current measurements from 10μA to 20A and resistance measurements from 0.1Ω to 10Ω are possible.

Other features include a log-scaled bar graph display as well as LEDs enabling fast comparisons to be made. A relative reference mode is also included and the meter is IEEE/IEC bus compatible.

POWER SUPPLIES

The Philips range of power supplies offers a very wide choice of power sources for practically every servicing requirement – bench models, modular types, Euro-switchers in 3V and 6V mechanical configurations, all at competitive prices. A range of AC voltage stabilizers and constant voltage transformers (line conditioners) is also available.

LF and HF GENERATORS

One instrument in the signal generator programme of most interest in service applications is the very compact PM 5107 which features a 'low distortion' setting for HiFi applications, development or alignment and maintenance requirements. It provides sine and square wave signals plus a separate TTL output.

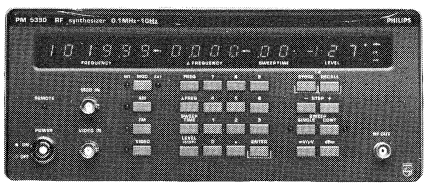
AUTOMATIC RCL METER

The PM 6303 automatic RCL meter will rapidly determine the value, electric dimension and the equivalent circuit of passive components to a very high order of accuracy.

As well as the 4-digit LCD indication of the component value, the unit of measurement, plus an equivalent circuit diagram, are all shown simultaneously.

Readout is automatic and connection is by 2- or 4-wire arrangement or an optional test attachment. If required, manual operation is possible when nine different parameters may be selected using only two push buttons.

PM 5390 is an extremely advanced RF synthesizer: it is uP-controlled and fully system compatible. Its 100kHz to 1020MHz capability includes AM, FM



PM 5390

and video modulation plus a wide range of sweep measurements with manual or automatic frequency-stepping. External video modulation over the full band is available, with or without sound. Setting-up parameters, as well as output (dBm, μV or mV), frequency, frequency increments and sweep time are indicated on LEDs.

For measuring and recording audio response curves, the combination of LF generator PM 5133, Amplifier/log converter PM 5171 and an X-Y recorder is a versatile, practical, set-up.

Educational applications will be well-suited by the function generators PM 5131 and PM 5132 whilst the PM 5109, with its monitored output giving a choice of 50 or 600Ω impedance (symmetrical or asymmetrical) is ideally suited to telecommunications. The more sophisticated function generators PM 5133 and PM 5134 complement the earlier units of this family-of-four series. These models feature 3½-digit LEDs for displaying EMF, frequency, sweep-state and operator errors in setting-up, in addition to many other attractive facilities such as crystal-locked operation (including AM). Thus, the total range of Philips generators covers virtually every application liable to be encountered in education, servicing, research and industry.

DISTORTION METER

The PM 6309 distortion meter offers the advantage of housing two instruments in one, compact, unit. The very accurate distortion meter has its own low-distortion generator for providing either total or third harmonic distortion with a resolution of 0.01%. Both analog and digital readouts are included and measurement is automatic.

TV COLOUR PATTERN GENERATORS

The pattern generators PM 5503, PM 5519, PM 5215 and PM 5217 match nearly all TV systems used over the world. Furthermore it is possible to fulfil nearly all user requirements with this complete range. The instruments can be used for alignment and service on location or for highly professional application areas.

The PM 5503 colour pattern generators is a portable, light and compact instrument for mobile maintenance. It offers signals according to CCIR 625-line TV standard.

The PM 5519, offering more than 20 test patterns, can be used for CTV, TV, VCR, VTR or VLP with CCIR TV or RTMA TV standards.

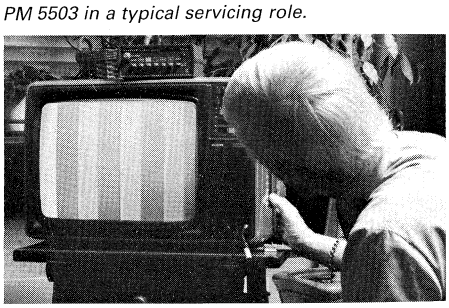
To meet the various TV systems there is a choice of several different versions. For cable TV there is a special version as well as for stereo sound or a second sound channel.

The PM 5215 is a SECAM generator; the PM 5217 a PAL/SECAM generator. The latter has been especially designed for countries adjacent to other countries having a different TV system.

Both generators have a high quality X-tal controlled RF output which makes them ideal for use in professional areas as well as production and quality control.

In addition to the foregoing list of instruments, the many other types covered in this catalog will meet practically any audio or video testing requirement, however sophisticated the product may be. All have been specially designed for ease of operation and employ advanced components to meet the demands of modern technology used in HiFi, radio and TV.

The extremely compact Colour TV generator PM 5503 in a typical servicing role.



RF signal generator PM 5326

100kHz to 125MHz in 9 overlapping ranges

Built-in 5 digit counter displays RF-carrier, marker and external frequencies to $10^{-4} \pm 1$ digit

50mV RF output at 75Ω can be attenuated to over 100dB

Output level electronically stabilized

Wobbulator facility for IF amplifiers AM/FM, radio and TV receivers

The RF signal generator PM 5326 has been specially designed for radio and television development laboratories and those involved with receiver sensitivity and selectivity measurements. For service workshops and education the generator also provides four wobbulator ranges for the alignment of IF amplifiers and FM receivers.

Colour coded controls

The generator is divided into three functions: main RF oscillator; sweeper; and marker generator. Controls for each function are differently colour-coded, being grouped for operator convenience.

Main RF oscillator

The output frequency extends from 100kHz to 125 MHz in 9 push-button selected ranges amply covering the domestic AM/FM radio spectrum. A built-in 5-digit display enables frequencies to be easily set to 1 part in 10 000, essential for precise alignment procedures, selectivity and filter tests. This counter can also measure frequencies from external oscillators to 999.99kHz, extendable to 99.999 MHz. Typical uses for the counter include alignment of TV remote control units and checking line and frame timebase frequencies.

The output level is electronically stabilized for all ranges eliminating resetting and the need for meter reading and can be continuously attenuated to over 80dB from the maximum of 50mV into 75Ω.

This may be set to levels calibrated at −3dB and −40dB with a separate attenuator. A particular feature of the generator is the special attention given to spurious RF radiation. A 'double-box' construction gives a high degree of screening keeping RF radiation very low and ensuring that low level outputs in the region of 0.5μV can be used with full confidence.

AM/FM modulation

A choice of CW or MCW output AM or FM and internal or external modulation signals are quickly selected by push-buttons. All AM signals can be internally modulated by a 1kHz tone to a depth of 30% which is adequate for most applications. This can be increased to 100% over the range 20 Hz to 20kHz (3dB) by an external source. Frequency modulation may be applied to the 10/11 MHz and 75-110 MHz ranges allowing complete alignment checks to be made on FM receivers. Internal frequency modulation at 1kHz is equivalent to a 22.5kHz deviation. External signals can be applied to a maximum deviation of 75kHz over the frequency range 20 Hz to 60kHz (3dB).

A swept frequency oscillator (wobbulator) output is available to measure the dynamic response of intermediate frequency amplifiers in AM/FM and TV receivers. Four frequency ranges are selectable by push buttons. The maximum sweep widths are 40kHz for AM/IF, 1.2 MHz for FM/IF and Band II and up to 10 MHz for the video IF ranges. Sweep rate is either by a linear saw-tooth between 3-30 Hz or at a line frequency with phase adjustment.

Marker generator

Markers are available in each RF sweep range to indicate a precise frequency value and provide a calibrated frequency scale over the complete spectrum. The position of the variable marker is controlled by the main frequency control and the setting is displayed on the internal counter. Fixed markers at regular intervals may be added to the output signal by pulling the marker amplitude switch.

TECHNICAL SPECIFICATION

FREQUENCY

Range
100kHz...125 MHz
(9 subranges, selectable with push buttons)

Subranges
1. 100kHz... 250kHz
2. 250kHz... 500kHz
3. 500kHz...1000kHz
4. 1 MHz... 2.5 MHz
5. 2.5 MHz... 5 MHz
6. 5 MHz... 10 MHz
7. 10 MHz... 25 MHz
8. 25 MHz... 50 MHz
9. 50 MHz...125 MHz

Display
5-digits
7-segment 11mm LED
2-dimension LEDs kHz, MHz

Setting error
$< 10^{-4} \pm 1$ digit (typical)

Temperature coefficient
$< 10^{-5}/K$

Short term drift
1×10^{-6}

RF OUTPUT

Voltage
50mV at 75Ω

Impedance
75Ω

Frequency response
< 2dB in each RF range (1dB typical)

Attenuation
80dB continuous with indication
40dB and 3dB calibrated and switchable

MODULATION

Amplitude modulation (in all ranges)
Unmodulated
Internal with 1kHz sinewave (depth 30%)
External with signals 20 Hz...20kHz (3dB) (depth 0...100%)

Modulation coefficient
200mV/10% modulation depth

Frequency modulation
In ranges 10...11 MHz and 75...110 MHz
Unmodulated
Internal with 1kHz sinewave (deviation 22.5kHz)
External with signals 20 Hz...60kHz (3dB)
(deviation 0...± 75kHz)

Modulation coefficient
200mV/± 7.5kHz deviation

Input
BNC connector MOD/IN

Impedance
> 10kΩ

RF Sweep ranges
400kHz...500kHz
10 MHz... 11 MHz
75 MHz...110 MHz
36 MHz... 41 MHz

Frequency response
> 0.2dB in sweep ranges

Sweep frequency
3...30 Hz continuously variable
50 Hz or 60 Hz mains, phase variable

Sweep widths (fully variable)
0...4kHz in range 400kHz...500kHz
0...1.2 MHz in range 10 MHz...11 MHz
0...1.2 MHz in range 75 MHz...110 MHz
0...10 MHz in range 36 MHz...41 MHz.

Linearity
> 95%

Centre frequency
Fully adjustable between minimum and maximum

Output
BNC connector Sweep out

Voltage
$2...10V_{pp}$ (varied by internal sweep)
2V at 1kHz at AM or FM (internal)

Impedance
1kΩ

MARKER GENERATOR

Fully variable over all four RF sweep ranges and indicated by LED display.

Marker
Marker mixing, AF beat frequency markers

Amplitude
Adjustable to $2V_{p-p}$

Output
Marker addition via loop through BNC connections
$Y_{in}-Y_{out}$

Impedance
> 500kΩ

FIXED MARKERS

Obtained by pulling marker amplitude switch. Distance between the fixed markers dependent on selected range.

COUNTER

Selected by COUNTER EXT push-button

Input
BNC-connector

Frequency range
1 999.99kHz

Input voltage
30mV...50V

Input impedance
1 MΩ

POWER REQUIREMENTS

Voltage
115, 230V

Power consumption
18W

Frequency
48...63 Hz

DIMENSIONS AND WEIGHT

(w x h x d) 310 x 140 x 330mm
(12.6 x 5.5 x 13-in)
6.5kg (14.3lb)

AVAILABLE VERSIONS

PM 5326X As PM 5326 with a counter facility up to 100 MHz

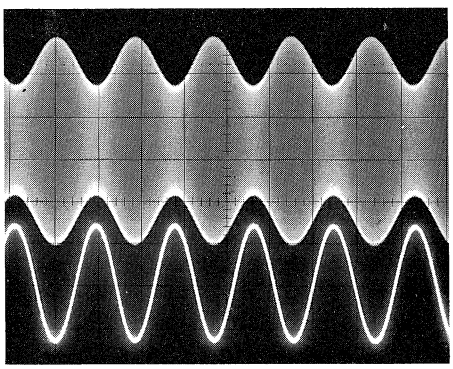
ACCESSORIES SUPPLIED

PM 9537 Cable with impedance transformer
Instruction manual
Mains cable

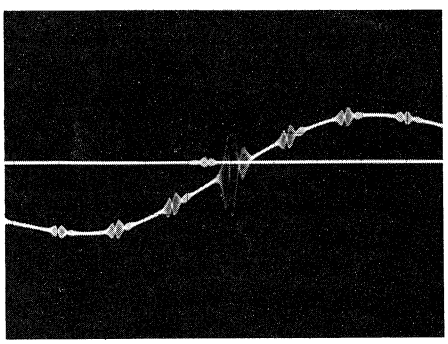
OPTIONAL ACCESSORIES

75Ω/300Ω
PM 9072 Cable BNC 4mm
PM 9075 Cable BNC-BNC
PM 9560 19-in rackmount adapter

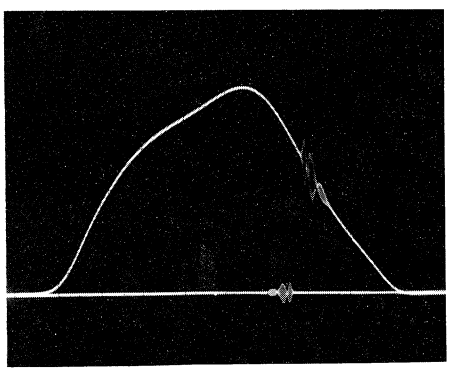
Internal AM signal, 1kHz and 30% modulation depth at a carrier frequency of 27 MHz.



S curve with variable marker at 10.7 MHz and fixed markers at regular intervals of 100kHz.



The luminance IF curve is aligned at its frequency of 38.9 MHz.



Wow & flutter meter
PM 6307

X-tal controlled oscillator
High accuracy and frequency stability
3150Hz and 3000Hz selectable
Separate 'Drift' and 'Flutter' indication
In/Output connector to DIN 41 524
Easy to operate

Previously reserved as a special tool for the audio design laboratory, the wow and flutter meter has today become a must for every audio and video service workshop. The easy-to-operate PM 6307 is designed to identify and quantify unwanted speed variations in audio and video tape recorders, record players and movie projectors. With its X-tal controlled oscillator giving the choice of 3.15kHz (DIN) or 3kHz frequencies, it is possible to make very accurate wow and flutter checks and alignments.
Readout of speed fluctuations of, for example, a recorder, is indicated on two separate analog meters, one for drift and one for wow and flutter. Calibration of the drift indicator is simple, being achieved by depressing the ZERO button, while the SET ZERO control is adjusted for zero indication. The use of the X-tal oscillator eliminates the long warm-up time associated with normal RC types with the advantage that the instrument can be used immediately after switch-on. The measuring ranges for drift and flutter are separately selectable by pushbuttons. There is also a convenient choice of three positions for wow and flutter measurements. With the filter switched ON, the frequency response is 'weighted', according to DIN Standard 45 507.
In the filter OFF position a linear frequency response 0.5Hz to > 500Hz (−3dB) is available and the 'unweighted' flutter is indicated.
For special measurements beyond the normal everyday usage there is a connector on the rear panel to apply any desired external filter.
Ideal for fast checks and alignment procedures, the PM 6307 is especially favoured in servicing applications, because it will differentiate between mechanical and electrical problems.
Generally, the wow/flutter meter indicates a mechanical failure whilst the drift meter is associated with electronically sourced faults.

Small in size, light in weight and extremely easy to operate thanks to good ergonomics design, this instrument is a real asset for today's audio and video service requirements.

To detect extremely slow speed variations, the SLOW RESPONSE setting is selected. A range of input and output connectors is available which will meet the requirements of service workshops and development laboratories alike. Because the majority of wow and flutter measurements are made on consumer HiFi, record players, tape and cassette recorders, the in/output standard DIN connector is conveniently located on the front panel.

TECHNICAL SPECIFICATION

Oscillator
Frequency: 3150 Hz and 3000 Hz. Selectable (X-tal controlled)
Accuracy: $< 10^{-4}$ (ref. 23°C)
Stability: 1×10^{-5}

Output 1: DIN connector at front panel (DIN 41 524)
Signal voltage: $400mV_{pp}$ Open circuit
$100mV_{pp}$ at 47kΩ load
$20mV_{pp}$ at 10kΩ load
Internal resistance: 430kΩ

Output 2: BNC connector at rear panel
Signal voltage: $1V_{pp}$
Output impedance: 600Ω

Measurement section
Input 1: Same as output 1 at front panel
Input 2: BNC connector at rear panel
Input voltage: 2mV...10V
Input impedance: 10kΩ
Test frequencies: 3150 Hz or 3000 Hz selectable
Calibration: With zero set pushbutton and control on front panel

Drift-measuring range: ± 0.3%, ± 1%, ± 3%
Indication: Analog meter, with zero at midpoint
Flutter-measurement range: 0.1%, 0.3%, 1%, 3%
Indication: Analog meter

Frequency response flutter indication

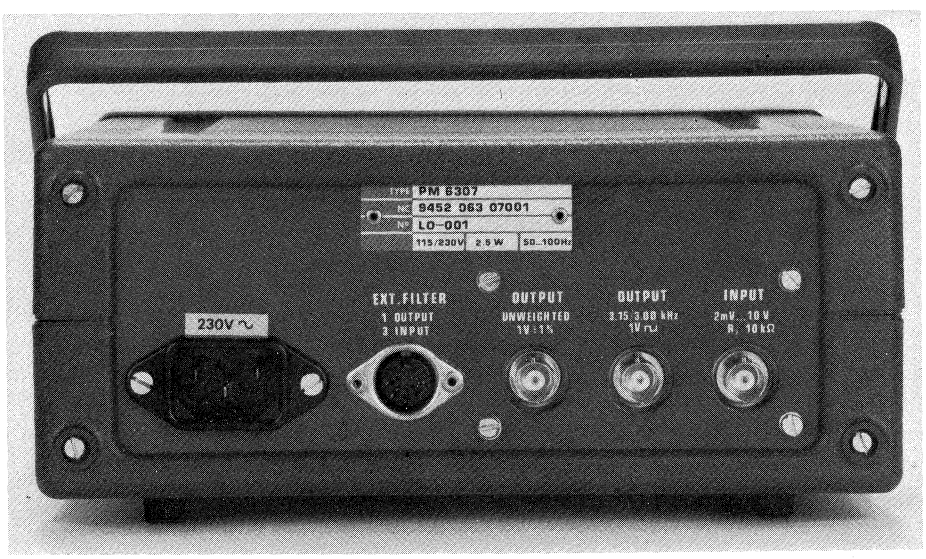
Selectable
A. weighted: according to DIN Standard 45 507 (filter on)
B. unweighted: 0.5 Hz...500 Hz (−3dB) bandpass (filter off)
C. external: Connector at rear panel for use of an external filter (filter ext.)

Reading speed
Normal: According to DIN 45 507
Slow: Slow response (e.g. to measure the average value to fast speed variations)

Output 3: BNC connector (on rear panel)
Bandwidth: 0.5 Hz...500 Hz (−3dB)
(For fast recording on oscilloscope display)
Output impedance: 10kΩ
Frequency variation coefficient: For 'Drift'
1V corresponds with 1%
For 'Flutter' $2V_{pp}$ corresponds with 1%

PM 6307 being used to check a Philips HiFi cassette deck for wow and flutter

POWER REQUIREMENTS
Line voltage: 115, 230V
Power consumption: 2W
Line frequency: 50/60 Hz



Rear view of PM 6307 showing output/input socket

DIMENSIONS AND WEIGHT
(w x h x d) 230 x 110 x 200mm
(9 x 4.3 x 8.3-in)
2kg (4.4lb)

ACCESSORIES SUPPLIED
Mains cable
Operating manual

OPTIONAL ACCESSORIES
Test cassette 3150 Hz
Record 3150 Hz (33⅓ rpm)
Both items are to DIN 45 507

Distortion meter
PM 6309

Accurate, fast and automatic measurements to DIN standards

Total and third harmonic measurements 0.01 to 19.9%

Direct readout on 3½-digit LED display plus analog trend indicator

Integral oscillator with adjustable output from 1mV to 1V

Four selectable test frequencies: 40, 333, 1000 and 5000 Hz

Built-in volts $_{RMS}$ meter

Easy DIN connection to device under test

The PM 6309 has been specially designed to provide appropiate signal generation plus an accurate distortion measuring capability within a single instrument. It is capable of very fast automatic measurements to DIN specifications.

PM 6309 thus has a very wide application potential in audio and HiFi servicing since it can be used to check cassettes, tape recorders, amplifiers and record players. A 'trend meter' simplifies the alignment of FM stages in stereo tuners.

The instrument provides either third harmonic or total harmonic distortion readings on an integral 3½-digit LED display or simple analog trend meter. The test signal is generated by a built-in very low distortion oscillator.

Four fixed test frequencies are provided; DIN standard 40, 333, 1000 and 5000 Hz to meet all basic service applications. Output is provided on a front panel connector, with output voltage continuously adjustable from 1mV to 1V.

There is a choice of BNC or DIN connectors – the latter particularly for recorders – on the front panel for signal measurements. Input range can be selected from 200mV to 20V; input LEDs indicate the need to change range. With the DIN input, DIN levels 0.2 to 2V are selected and it is possible to check either right or left channels.

Input filtering
The incoming signal is filtered to remove the first harmonic (the original signal) and distortion is indicated as a percentage of this harmonic. The measurement can either be the total harmonic distortion, normally with 40, 1000 or 5000 Hz, or only the third harmonic distortion, particularly at 333 Hz used for cassette and tape recorder testing.
Moreover, the input range having been selected, the instrument automatically maintains the input signal to a fixed level. Thus, fluctuating inputs cannot influence a measurement.
Resolution with the LED display is 0.01 percent up to 19.99 percent distortion. The separate analog meter allows adjustments such as setting minimum levels. The LED display can also function as an RMS voltage meter, ideal, for example, to set the gain of an amplifier to a required value.

A separate output on the rear of the instrument provides the distortion signal; that is, the incoming signal minus the first harmonic, for any further analysis.

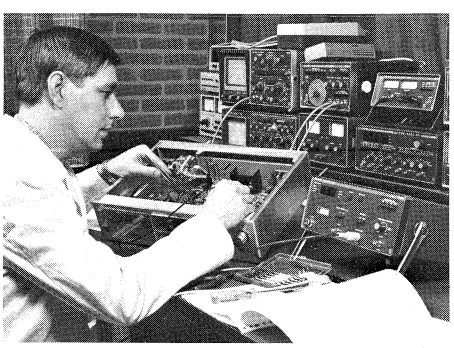
Simple to use
Practically complete automation of operation makes the PM 6309 particularly easy to use. It is virtually impossible to make mistakes when using the instrument.

TECHNICAL SPECIFICATION

MEASURING MODES
Distortion and Voltage Measurement

DISTORTION MODE

Nominal Test Frequencies
40, 333, 1000 and 5000 Hz (selectable with pushbuttons)



PM 6309 in service workshops: professional equipment for professional service.

Tolerance
±1.5% (admissable difference between input frequency and selected nominal test frequency)

Measured quantities
Total harmonic distortion (THD) at 40, 1000 and 5000 Hz
Third harmonic distortion (3rdHD) at 333 Hz

Input
1. BNC connector on front side,
2. DIN connector on front side, (Left and right channel selectable with pushbuttons)

Input impedance
1MΩ (for both inputs)

Input Capacitance
30pF for input 1.25pF for input 2

Input voltage range
0.2...2V for input 1.2
2...20V for input 1.
(selectable with pushbuttons)

Range indication
2 red LED's for 'Above Range' and 'Below Range', 1 green LED for 'In Range'

Digital display
3½ digit 7 segment LED display

Maximum indicated value
19.99%

Resolution
0.01%

Max. measuring error
±5% ±1 digit of display value

Hum attenuation (50...180 Hz)
>20dB (at 1 and 5kHz)

Analog indication
0...20%

Characteristic
0....0.2% linear
0.2...20% approx logarithmic

Distortion output
BNC connector at rear side

Output voltage
0.1 V_{RMS}/% distortion

Output impedance
1kΩ

Oscillator output
BNC connector at front side or DIN connector at front side

Voltage range
1mV...0.1V
10mV...1V (pull knob for x 10)

Frequency
determined by test frequency selection

Maximum Frequency Error
±0.5%

Temperature coefficient
<300 ppm/K

Distortion
<0.01% for 333/1000/5000 Hz
<0.015% for 40 Hz

Output impedance
600Ω for BNC connector
47kΩ for DIN connector

VOLTAGE MODE

Input
as distortion input, if plug is inserted into INPUT/OUTPUT socket this input is automatically selected

Measuring Ranges
0...2V
0...20V
(selectable with pushbuttons)

Input impedance
1MΩ

Digital display
3½ digits 7 segments LED display

Maximum value
19.99V

Resolution
0.01V in 20V range
0.001V in 2V range

Frequency range
10 Hz...100kHz

Error (for sinewaves with THD <2%)
±5% ±1 digit (10 Hz...20kHz)
±10% ±1 digit (10 Hz...100kHz)
for voltages >5% of range

ENVIRONMENTAL CAPABILITIES

Ambient temperatures
Range of use: +5°C...+40°C
Storage and transport: −40°C...+70°C

Humidity
Relative humidity 20%...80%

Max. altitude for operation
2200m

Vibration
5g (10...150 Hz)
0.35mm

Shock
10g

DIMENSIONS AND WEIGHT

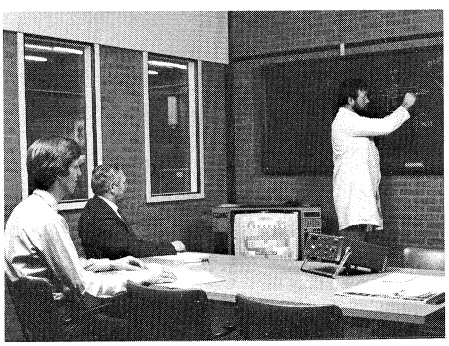
Dimensions (w x h x d)
310 x 140 x 333mm
(13.1 x 5.5 x 13.1-in)

Weight
5kg (11lb)

POWER

Line voltage
110, 128, 220 or 238V ±10%

Frequency
50...100 Hz



PM 6309 in education: training with the same equipment as used in professional service.

Complete stereo signal with low crosstalk
Separate L and R signals
External modulation facility
X-tal controlled pilot
Adjustable multiplex signal
Tunable 100 MHz RF signal

Stereo generator PM 6456

The PM 6456 meets the requirement for a fast and efficient method of checking and aligning FM tuners and receivers. What used to be a somewhat complex procedure has now been changed to a logical sequence of operations using professional signals (FCC and IBU).
Modern service establishments using the PM 6456 can also benefit from the external stereo modulation facility, which allow a record player or tape recorder to be used in order to demonstrate FM tuners. This is extremely useful as many areas suffer from poor FM reception and suitable transmissions are not always continuously available. This feature can also be used to make an audio check-out after alignment.
The multiplex signal to the decoder of the tuner or receiver has continuous amplitude adjustment and in addition to the external modulation facility, the generator also has two internal 1kHz and 5kHz signals for testing in the low and middle part of the audio spectrum. For complete receiver check-outs and to speed-up fault location the PM 6456 is supplied with a separate 100 MHz RF signal that is tunable over ± 1 MHz.

TECHNICAL SPECIFICATION

Sequence of signals, selectable with pushbuttons

Pilot
Pilot of 19kHz

1kHz
Internal modulation of 1kHz

5kHz
Internal modulation of 5kHz

EXT
External modulation e.g. from stereo recorder or record player.

R
Only right channel

L
Only left channel

R = − L
S signal

RF
RF output of 100 MHz ± 1 MHz

LF MODULATION

Internal
Frequency: 1kHz or 5kHz switchable
Distortion: ≤ 3%

External
Modulation with signal from stereo recorder or record player.
Input: DIN socket 5 pins (rear)
Frequency range: 30 Hz...15kHz
Input impedance: ≈ 500kΩ according to DIN 45 500
Max. input voltage: $20V_{pp}$
Pre-emphasis: 50μ sec
Modulation coefficient: $0.1kHz/mV_{RMS}$

The modulation coefficient can be altered by internal change of a resistor if required.

LF MULTIPLEX OUTPUT

Voltage
$0–5V_{p-p}$ ± 10% continuously adjustable

Load resistance
2.5kΩ

Internal resistance
200Ω

Pilot
19kHz ± 2 Hz X-tal controlled

Subcarrier
38kHz ±4 Hz

Phase difference between pilot and subcarrier
< ± 3°

Subcarrier suppression
> 40dB

Crosstalk suppression between L and R signal
(At ambient temperature of 23°C)

For internal signals
1kHz and 5kHz: > 40dB

For external signals
Freq. response of 0.25–6.3kHz: > 40dB
Freq. response of 1kHz–10kHz: > 40dB

Suppression between M and S signal
At ambient temperature of 23°C
Internal signals of 1kHz and 5kHz: > 32dB

RF OUTPUT

Output
BNC connector

Voltage
$3mV_{p-p}$ into 75Ω load

Frequency
100 MHz tunable ± 1 MHz

Impedance
75Ω

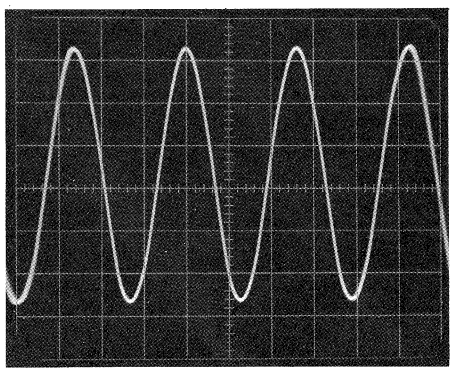


Fig. 1. Shows the 19kHz pilot tone from the PM 6456 applied to the input of the stereo decoder. Pilot tone and subcarrier frequency are checked and aligned.

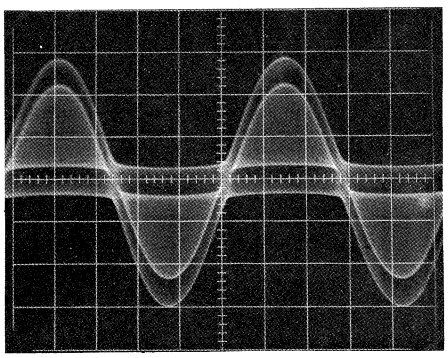


Fig. 2. To align for minimum crosstalk, the push-buttons for the R signal, a 1 or 5kHz tone and pilot are depressed. Shown is the resulting multiplex signal applied to the input of the decoder.

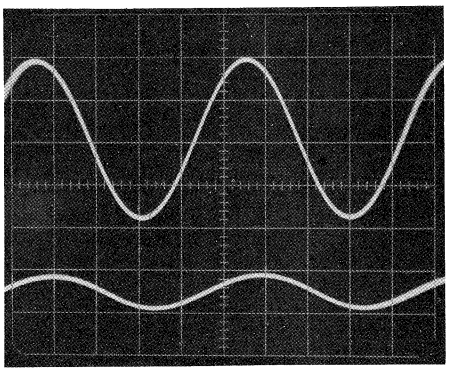


Fig. 3. At the output of the decoder crosstalk between the left and right channel is made visible using a dual beam oscilloscope. Displayed are: upper beam; right channel signal, lower beam; crosstalk on left channel.

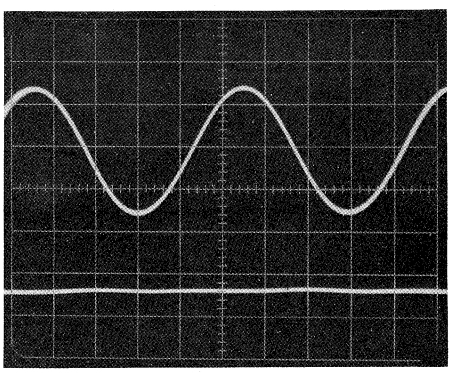


Fig. 4. After alignment, the crosstalk between the L and R channel has been minimized, as indicated by lower beam.

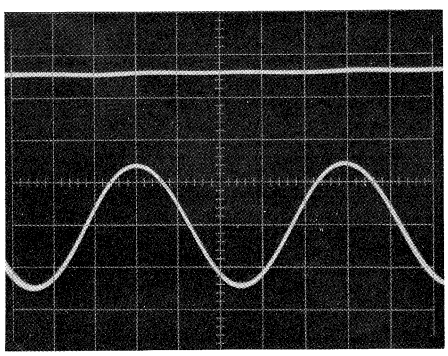


Fig. 5. A similar procedure is carried out to obtain minimum crosstalk between the R and L channel.

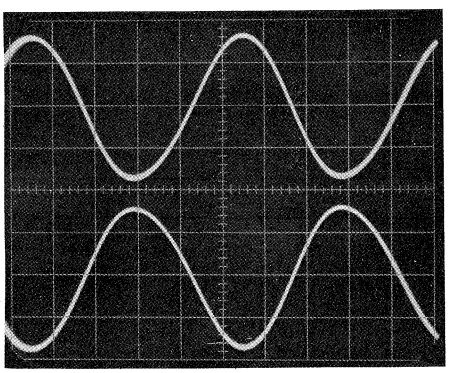


Fig. 6. Shows a full stereo decoded signal at the output of the decoder.
Note: Both signals have equal amplitude and opposite phase. To obtain this display, the pilot, 1 or 5kHz and R = − L push button are depressed.

INTERNAL MODULATION

FM

Freq. deviation
40kHz

Freq. deviation by Pilot tone
6.75kHz

EXTERNAL MODULATION

FM

Freq. deviation
0...75kHz

SYNCHRONISATION OUTPUT

Output
BNC connector

Voltage
$\approx 3V_{p\text{-}p}$

Internal impedance
10kΩ

Frequency
1kHz and 5kHz

POWER REQUIREMENTS

Line voltages
115/230V

Consumption
2.5VA

Line frequencies
50/60 Hz

DIMENSIONS AND WEIGHT

(w x h x d)
230 x 145 x 285mm
(9 x 5.6 x 11.2-in)
3kg (6.6lb)

ACCESSORIES SUPPLIED

Mains cable
Operating manual

OPTIONAL ACCESSORIES

PM 9538 BNC connector/Belling plug

PM 9537 BNC connector/impedance transformer
75 to 300Ω

Automatic RCL meter PM 6303

Easy-to-read crystal display

Extremely fast automatic operation

Simultaneous display of:

– Measured value

– Appropriate unit of measurement

– Graphic representation of equivalent circuit

One or two pushbutton selection of nine different parameters

Two-or four-wire connection or via optional test attachment

Fast operation, clear display

The PM 6303 automatic RCL meter will rapidly determine the value, electric dimension and equivalent – circuit of passive components to a very high order of accuracy, and over a wide range. The measured value, together with the appropriate unit of measurement and the equivalent circuit-graphics, are easily read on a large 4-digit liquid-crystal display.

Rapid connection

Connection of a component to be tested is effected easily and rapidly, using either a two- or four-wire connector or an optional test attachment. Less than one second after connection, the dominate component's measured value, its effective dimension and its equivalent circuit, will be clearly displayed. For example: when measuring a coil having a Q-factor of 1, both the series inductance and resistance and the equivalent circuit-graphics will be displayed almost instantly. Apart from using the auto mode of the PM 6303, it is possible to select from a maximum of nine differing parameters (D, Q, Rp, Rs, Z, Ls or Lp, Cs or Cp and Cs 2V bias), using only two pushbuttons.

Universal capability

Features like these make the PM 6303 an ideal instrument for a very wide range of applications; educational-institutes laboratories specialised service centres, and in general-purpose workshops. Its automatic operation, coupled with a direct digital readout, also makes the PM 6303 a most attractive proposition for use in research, development, and in quality-control; setmakers too, will find the PM 6303 a most useful aid in batch-sampling techniques.

Connection facilities

- 2 sockets for measuring voltage (HI) Drive and Sense connection
- 2 sockets for measuring current (LO) Drive and Sence connection
- 1 socket guard connection

Parameter Selection

- 2 pushbuttons for stepping from item to item in the parameter menu.
- 1 pushbutton to reset to RCL AUTO mode in which the dominant component is measured.

Parameters

- Dominating component R, C or L (autoselection)
- Q
- D
- Rp
- Rs
- Z
- Cp, Lp
- Cs, Ls
- Cp Biased (internally generated DC voltage)

Optional accessories

When making measurements of already mounted components, connection between the PM 6303 and the component to be tested can be difficult. The problem is easily overcome by the use of the 4-wire test cable PM 9541. This consists of a cable fitted at one end with Kelvin clips, the other end fitted with a Kelvin connector which plugs into the front panel socket on the PM 6303.

In addition, and especially useful for testing batches of individual components of all different physical sizes, there is the 4-wire RCL adapter, PM 9542. This is a box-mounted set of 'slide-in' connectors having a similar cable end to PM 9541. Both accessories are illustrated overleaf.

TECHNICAL SPECIFICATION

Display
Large 18 mm, 4 digits LCD

Dimension Indications
– Ω, kΩ, MΩ, pF, nF, μF, mF, μH, mH, H, kH

Out of Range Indication
– 4 middle digit segments flashing

Measuring Ranges
- Resistance Rp, Rs, Z 0.000Ω...200MΩ
- Capacitance Cp, Cs 0.0pF...100mF
- Inductance Lp, Ls 0.0 μH...32kH
- Quality Factor Q 0.002...500
- Dissipation Factor D 0.002...500

Maximum Resolution per Range
- Resistance 1mΩ
- Capacitance 0.1pF
- Inductance 0.1μH
- Quality/Dissipation Factor 0.001

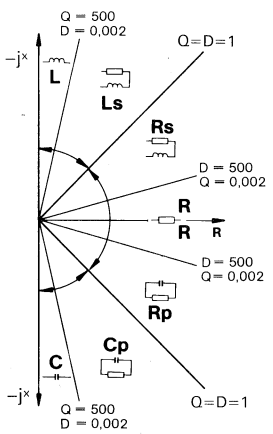
Equivalent circuits
- 7 Equivalent circuits

D > 500

D < 0.002, Q > 500

Q > 500, no display of the secondary parameter

	D or Q Q=D=1	parameter selection
	≤ 500	RCL AUTO, Cp, Rp, D, Z
	≤ 500	Cs, Rs
	≤ 500	RCL AUTO, Ls, Rs, Q, D, Z
	≤ 500	Lp, Rp



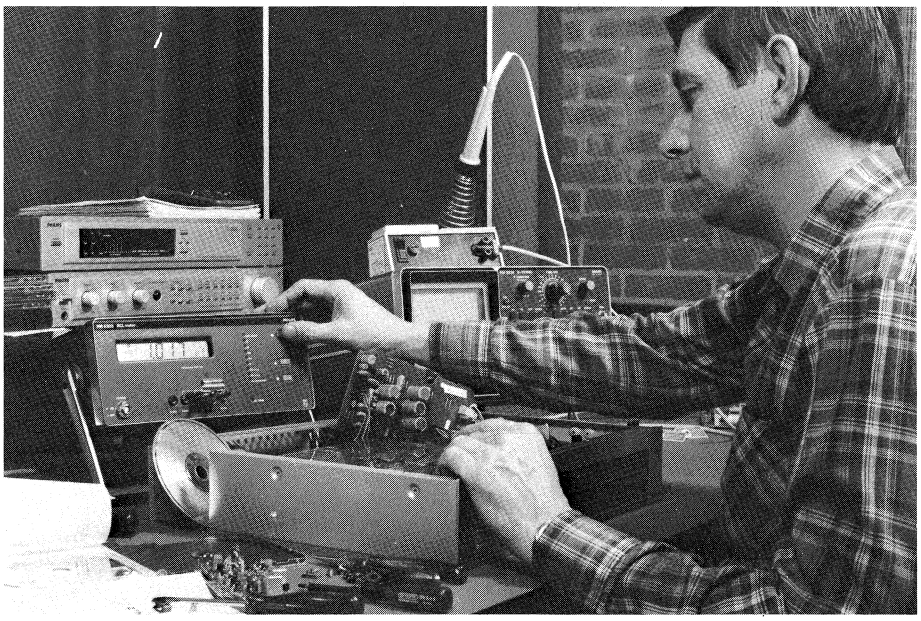
Measuring Accuracy
Basic Error ±0.25% ±1 digit

Measuring Frequency
1kHz ±0.025%

DUT Stress
≤5mA, ≤2V
(linked to a $2V_{RMS}$ Source with an internal resistance of 400Ω)

Type of Connectors
4 mm sockets
- 2 sockets for measuring voltage (HI) Drive and Sense connection
- 2 sockets for measuring current (LO) Drive and Sense connection
- 1 socket guard connection

Measurement update rate
approx. 2 measurements per second



PM 6303 is extremely versatile making it a valuable measurent tool in industry, service workshop or education.

Zero Capacitance Adjustment
Co trim by means of screwdriver adjustment on front panel. Maximum adjustable capacitance: 5pF

POWER REQUIREMENTS
Voltage: 110, 128, 220, 238V ±10%
Frequency: 50...100Hz ±5%
Power-Consumption: 13W

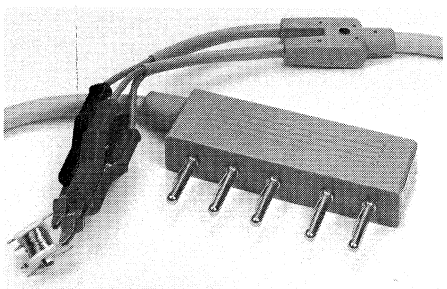
ENVIRONMENTAL CAPABILITIES

Ambient Temperatures
Reference Value: +23°C ± 1°C
Operation: +5°C +40°C
Storage and Transport: −40°C...+ 70°C

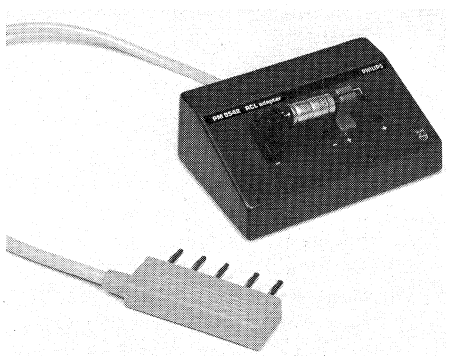
DIMENSIONS AND WEIGHT
(w x h x d) 310 x 140 x 310mm
(12.2 x 5.15 x 12.2-in)
4.8kg (10.6lb)

ACCESSORIES SUPPLIED
Two-terminal fixture
Operating manual
Fuse 250mAT

OPTIONAL ACCESSORIES
PM 9541 Four-wire test cable
PM 9542 RCL test adapter
Service manual



4-wire test cable PM 9541 (optional)



4-wire RCL adapter PM 9542 (optional)

	PM 9541	PM 9542
Performance characteristics:		
DUT-connection	by two Kelvinclips	by Kelvin contacts in the test pods
Short-circuit inductance	0.1 μH typical ≤0.3μH max.	<0.1μH max.
Mechanical specifications:		
Cable length	600mm	600mm
Case dimension	—	50 x 145 x 95mm
Weight	0.2kg	0.6kg

Extremely light and compact instrument for mobile maintenance

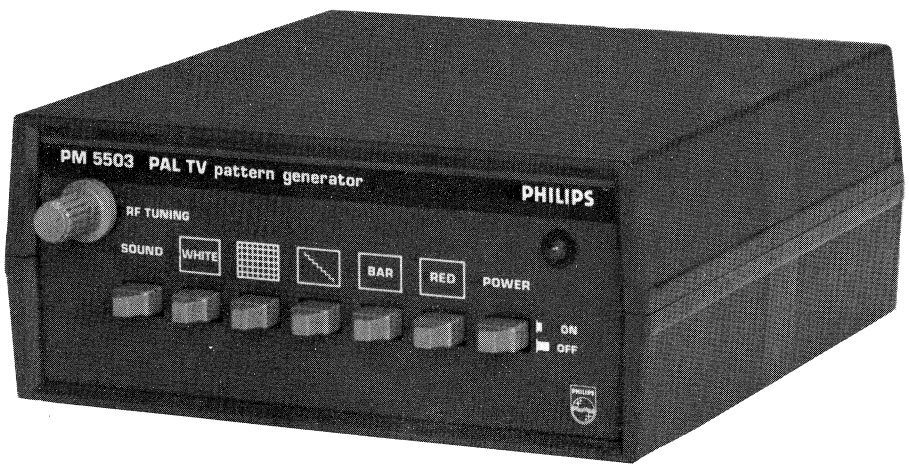
5 Different test patterns for colour and black/white TV installation and service

RF output signal in VHF range and UHF range

1kHz tone for sound performance checks (sine wave)

Colour bar pattern generator PM 5503

The PM 5503 colour pattern generator has been specially designed for black/white and colour TV alignment and service at the customer's house. The generator operates according to the PAL TV standard, system G, internally changeable to system I. Although the PM 5503 is a low priced instrument, it produces RF carrier signals tunable within two frequency ranges: VHF= 189...205 MHz and UHF=567...615 MHz. RF output is adjustable in VHF range (189 to 205 MHz) and UHF range (567 to 615 MHz).
Especially for checking, e.g., CCTV and monitors the instrument offers a video output facility.



For accurate tuning and checking the sound performance of a CTV receiver, the generator has a 1 kHz tone available. This tone also makes checks on interference between luminance and sound, as well as chroma/sound, possible.

The generator provides 5 different test patterns, selectable by push-buttons, for installation, quick fault diagnosis, servicing and alignment of colour and monochrome TV sets.

The first pattern is an eight-step grey scale for checking the linearity of the luminance amplifier, setting the focus and adjusting for correct grey scale.

A cross-hatch pattern is for centreing and vertical and horizontal linearity checks and in addition, for dynamic and static convergence.

A 100% white pattern with alternating burst is used when the beam current has to be adjusted, for checking the white setting to garantee good colour performance and for observing the overall purity of the screen.

The red pattern is used for setting the colour purity or making sound-chroma carrier interference checks. The last of the five patterns is the standard colour bar.

It is used to check the overall performance, the burst keying, delay colour versus luminance and the PAL delay line circuitry.

The instrument is extremely light and portable and because of the small dimensions it can easily be carried in a service tool kit.

TECHNICAL SPECIFICATION

TEST PATTERNS

A. Grey scale	Staircase signal with 8 equal steps from white to black level
B. Cross hatch	15 vertical white lines (0.2 μsec. wide) 13 horizontal white lines (one active line period wide)
C. Red	G-version (EBU standard) 100% saturation and 75% amplitude Internally changeable by solder link
D. White	100% luminance with burst
E. Standard colourbar	100% saturation and 75% amplitude (EBU standard) Internally changeable to 95% saturation and 100% amplitude by solder link

VIDEO CARRIER

Frequency	
– VHF	189...205 MHz
– UHF	567...615 MHz (3rd harmonic of VHF)
RF tuning	Adjustable at front panel
Modulation	AM negative

SOUND CARRIER

Frequency	G-version: 5.5 MHz I-version: 6.0 MHz (Internally adjustable)
Tolerance	±20kHz (typical)
Sound carrier relative to vision carrier	–12dB

SOUND MODULATION

Type of modulation	FM
Frequency	1kHz, sinewave
Deviation	±25kHz (internally adjustable)

RF OUTPUT

Voltage	1mV
Impedance	75Ω
Connection	Coaxial flying lead from rear of unit (coaxial plug fitted)
Cable length	1.5m

SYNCHRONISATION

Line frequency	15625 Hz
Number of lines	624
Line sync duration	4.8 μs
Field frequency	50 Hz
Frame sync duration	180 μs

CHROMA

Systems	Acc. to PAL B, G, H, I
Frequency subcarrier	4.433619 MHz
– Tolerance	$\pm$10 Hz
Burst width	10 cycles $\pm$1 cycle subcarrier
Burst amplitude	equal to sync
Burst phase	line sequential 180°$\pm$45°
Burst position	5.6 μs after leading edge of line sync pulse

VIDEO OUTPUT

Voltage	1Vpp (AC coupled) into 75 Ω
Polarity	Positive
Impedance	75 Ω
Connection	BNC connector at rear panel

POWER SUPPLY

Voltage	240 or 220V
Tolerance	–10%...+6%
Frequency	50 Hz
Power consumption	4VA
Mains cable	Fixed to instrument
Cable length	1.75m

DIMENSIONS AND WEIGHT

Dimensions (w x h x d)	155 x 65 x 180 mm
Weight	1.1kg

TEMPERATURE

Reference temperature	20°C
Operating range	0...50°C

STANDARD ACCESSORIES

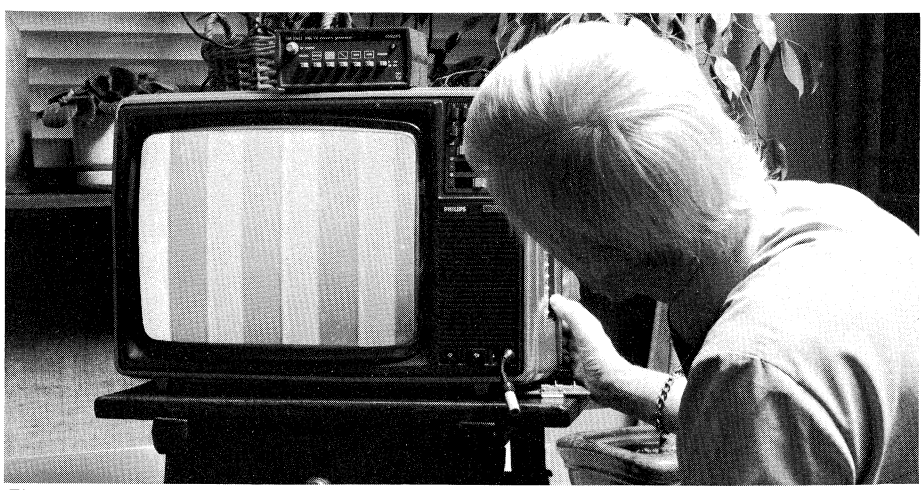
Instruction Manual

OPTIONAL ACCESSORIES

PM 9075	Coaxial cable BNC-BNC 75 Ω

FIVE TEST PATTERNS FOR FAST CHECKS, ALIGNMENTS AND ADJUSTMENTS IN COLOUR AND MONOCHROME TV

Signal content	B/W	Colour	For checking and/or adjustment
Grey scale	O	●	Focus adjustment
Staircase signal with 8 steps	O	●	Horizontal and vertical synchronisation
		●	Greyscale tracking
	O	●	Linearity of video amplifier
	O	●	Brightness and contrast circuit
	O	●	Mains hum interference in synchronisation
Crosshatch	O	●	Picture centreing
13 horizontal and		●	Static & Dynamic convergence
15 vertical lines	O	●	Pincushion correction
		●	E/W-N/S adjustments in 110° colour receivers
	O	●	Overall linearity
	O	●	Overall geometry
White pattern		●	White colour
100% white signal with burst	O	●	Constant brightness
	O	●	Beam current of picture tube
Red		●	Purity
Red signal with 100% saturation	O	●	Interference between sound and colour carrier
Colour bar		●	Overall colour performance
100% contrast standard		●	Burst keying
colour bar		●	Subcarrier regenerator
		●	PAL identification circuit
		●	Special matrix circuits
		●	RGB amplifiers
		●	Delay colour versus B/W
		●	Saturation
		●	PAL delay line circuit



The very small, compact PM 5503 can be carried in the service engineers tool kit for use on the customers premises.

PAL or NTSC colour TV pattern generator PM 5519

Over 20 combinations of test patterns (colour and b/w) for CTV, TV, VCR and VLP

All signals to TV standard CCIR, System D-G-I-M and N PAL (RTMA-NTSC version available)

Full RF coverage: TV IF, Band I-III-IV and V

Electronic tuning with six pre-set channels

Synchronisation according to TV standard, also obtainable as comp. and frame sync.

The versatile PM 5519 offers the extensive choice of more than twenty different b/w and colour test pattern combinations.
It can be used with CTV, TV, VCR or VLP operating with practically all international TV broadcast systems and standards.

The engineer is able to select a series of test patterns in the sequences he intends to use. This time-saving facility coupled with an inherently high quality output plus the wide versatility make the PM 5519 ideal for fast, accurate video measurements almost anywhere in the world.

The generator normally operates in accordance with the CCIR TV standard, system D, G, I, M or N PAL. Also another version is available for operating in accordance with the RTMA TV standard, system M and the NTSC colour system. There is also a cable TV version, PM 5519 GS.

It is electronically tuned to almost any available TV channel (IF; band I, III, IV and V) and any one of six channel presettings can there after be selected by push button.

The high quality 10mV$_{RMS}$ RF output can be continuously attenuated over more than 60dB for sensitivity checks on CTV and TV. The use of separate oscillators for VHF and UHF plus a special IC for RF modulation virtually eliminates harmonics and gives and excellent 12.5dB (approx.) sound/vision ratio.

The video output is nominally 1V into 75Ω (adjustable 0...1.5V) and the RF carrier can be modulated with a signal from an external video source. Chroma and burst signals are selectable in calibrated steps of 0-25-50-75 and 100%. An internal 1kHz sinewave is available for both sound performance and accurate tuning checks. The sound carrier can be switched off when not required or when selecting an externally applied signal (from cassette recorder, record player, etc.).
Normally 5.5 MHz, the sound carrier frequency can be operated at 4.5, 6, 6.5 MHz by changing an internal soldered connection.

Line and frame synchronisation is achieved by a special IC which incorporates interlacing. A second IC ensures that the colour subcarrier and line frequency are locked according to the TV standard. The correct colour offset is thus applied to guarantee bright and interference-free colour test patterns.

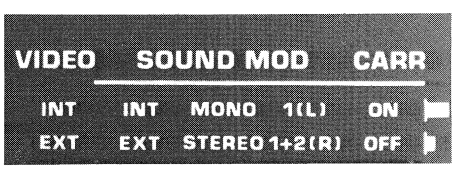
Other features include special colour patterns to align the chroma delay line in amplitude and phase or to check the subcarrier phase. The combined eight step linear grey-scale pattern with five bars of multiburst in the frequencies 0.8, 1.8, 2.8, 3.8 and 4.8 MHz achieve maximum obtainable resolution. There is also a further special test pattern to meet the latest VCR requirements, with or without receiver recognition pulse.

Stereo/second-sound channel version PM 5519 GX

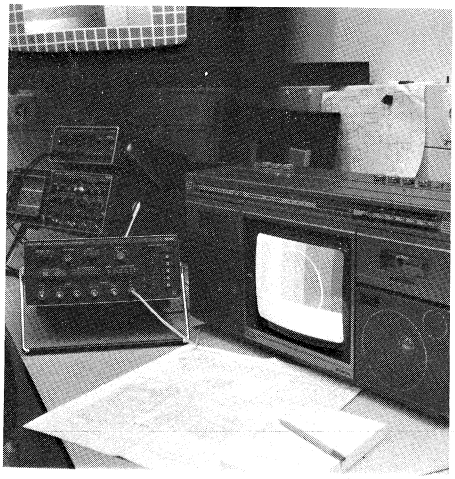
Several European countries are now ready to start regular CTV transmissions with stereo sound or alternative second sound channel (e.g. for choice between synchronised or orginal voice tracks).
PM 5519 GX meets the need for a portable colour pattern generator for test and realignment of these new receivers, and will be a valuable tool in service, manufacture, R & D, quality control and video training.

PM 5519 GX operates according to the TV standard G, with two sound carriers—for use in one- and two-channel mono modes, or to select the right or left channels of a stereo signal. The instrument also allows external modulation of a full stereo signal, by connecting a stereo tuner/amplifier, tape or cassette recorder or record player, with PM 5519 GX acting as RF modulator.

PM 5519 GX is therefore ideal for daytime use when few or no stereo transmissions are available.



Detail of PM 5519 GX version showing different arrangement of front panel controls for mono or stereo operation.



PM 5519 GX in use in a video service workshop.

TECHNICAL SPECIFICATION (Basic version PM 5519)

Test signals
a. circle (white or black)
b. checker board (6 x 8 squares)
c. dots
d. cross-hatch
e. eight step linear grey scale multiburst: 0.8–1.8–2.8–3.8–4.8 MHz
f. 100% white pattern (with or without burst)
g. purity patterns, red-green-blue + 3 complementary colours
h. DEM pattern for alignment of the chroma delayline, subcarrier and demodulators
i. VCR pattern, chroma staircase; eight bars of increasing saturation 3 bars of multiburst of 2.8, 3 and 3.2 MHz 100% white horizontal bar
j. standard colour bar with white reference

Video carrier
TV system CCIR (changeable to RTMA)
IF + Band I, 38-90 MHz
Band III, 170-250 MHz
Band IV/V, 470-820 MHz
6 preset channels with electronic tuning

RF output
BNC connector at front panel
Voltage: > 10mV
Attenuation: > 60dB, continuous
Impedance: 75Ω

Video Modulation
Mode: AM negative
(or positive, with internal change of soldered connection)

Video input
BNC connector at front panel
Voltage: $1V_{pp}$
Polarity: negative
Max. permissible voltage: ± $10V_{pp}$
Impedance: 75Ω

Video outputs
BNC connector at front panel
DIN connector for VCR at rear panel (pin 2)
Voltage: $1V_{pp}$ fixed, or 0...$1.5V_{pp}$ continuously variable
Polarity: negative

Sound carrier
Frequency: 5.5 MHz (or 4.5/6/6.5 MHz, with internal change of soldered connection)
Accuracy: < 0.2%
Ratio of sound/vision carrier approx. 12.5dB
Sound switch: carrier on/off

Internal sound modulation
Modulation: FM (or AM by internal change)
Internal signal: 1kHz on 5.5 MHz
FM deviation: approx. 40kHz on 5.5 MHz
AM modulation depth approx. 30%
Sound output: DIN connector for VCR at rear panel

External sound modulation
External signal: $0.2V_{RMS}$ for same modulation as internal signal
Bandwidth: 100 Hz...10kHz
Pre-emphasis: 50μs
Sound input: DIN connector (at rear)
Input impedance: 0.5 MΩ
Modulation on/off (switch)
Modulation internal/external (switch)

Chroma
Systems: PAL (according to system D-I-G-M or N)
Carrier frequency for TV system PAL: X-tal controlled 4.433619 MHz ± 2 Hz
(For other versions see Table A)
Drift: ± 5.10^{-6}
Burst: according to PAL system
Amplitude: (burst and chroma) in calibrated steps selected of 0-25-50-75-100%
System: NTSC (internally changeable)

Synchronisation
Line frequency: 15625 Hz (or 15750 depending on TV system)
Frequency tolerance: ± 5 Hz
Lines: 625 or 525
Field frequency: 50 Hz or 60 Hz
Frame sync signal: according to TV standard, interlacing

Composite TV synchronisation
BNC connector at front panel
Signal: frame and line sync pulses
Voltage: > $4V_{pp}$
Impedance: 10kΩ
Polarity: negative

Frame synchronisation
BNC connector at front panel
Voltage: > $4V_{p-p}$
Impedance: 10kΩ
Polarity: negative

Power supply
Voltage: 110-127-220-240V
Tolerance: 10%
Frequency: 50...60 Hz
Tolerance: 5%
Power consumption: 18W

DIMENSIONS AND WEIGHT

(w x h x d) 310 x 140 x 330mm
(12.2 x 5.5 x 13-in)
4.8kg (10.6lb)

Standard accessories
Operating manual
Mains cable
PM 9538 Cable, BNC-TV connector, 75Ω

Optional accessories
PM 9075 Cable, BNC-BNC 75Ω
PM 9539 Cable, BNC-impedance transformer, 75-300Ω
PM 9560 19-in rackmount adapter
Service manual

TECHNICAL SPECIFICATION (PM 5519 GX)

As for standard model PM 5519, except for:

	Sound channel 1	Sound channel 2
Frequency	5.5 MHz	5.7421875 MHz
Sound/vision carrier ratio	13dB	20dB
Modulation	FM	FM
Internal signal	1kHz sinewave	0.8/1kHz sinewave pilot
FM deviation	30kHz ± 2kHz	30kHz ± 2kHz pilot: 2.5kHz

External signal: 0.2Vrms for 30kHz deviation at 1kHz signal
Bandwidth: 100 Hz... 10kHz
Preemphasis: 50μs
Input: DIN connector at rear pin 3 and 5
Input impedance: 0.5 MΩ
Max. input voltage: ± $40V_{dc}$
Sound selector: CARRIER ON/OFF
MOD MONO/STEREO
1 (left), 1+2 (right)
INT/EXT

Operation mode detection
Pilot: 54.6875kHz
Carrier frequency: ±0.2%
Modulation: AM
Modulation depth: 50%
Detection frequencies: $f_H/133 \hat{=} 117.5$ Hz
$f_H/57 \hat{=} 274.1$ Hz

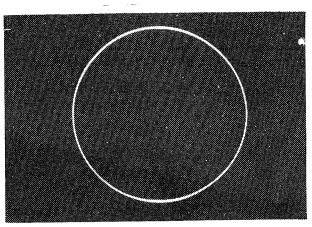
Table A: Performance details of various versions of PM 5519

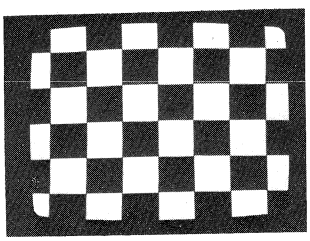
Series	−D**	−G	−I	−N	−M	−GS*	−MM
TV standard	CCIR, PAL	CCIR, PAL	CCIR, PAL	CCIR, PAL	RTMA, PAL	CCIR, PAL	RTMA, NTSC
No. of lines per ficture frame	625	625	625	625	525	625	525
Field frequency (Hz)	50	50	50	50	60	50	60
Line frequency (lines/5)	15625	15625	15625	15625	15734	15625	15734
Chrominance sub-carrier (MHz)	4.433618	4.433618	4.433618	3.582056	3.575611	4.433618	3.579545
Sound carrier to vision carrier (MHz)	6.5	5.5	6	4.5	4.5	5.5	4.5
Sound modulation	FM	FM	FM	FM	FM	FM	FM
Pre-emphasis (μs)	56	50	50	75	75	50	775

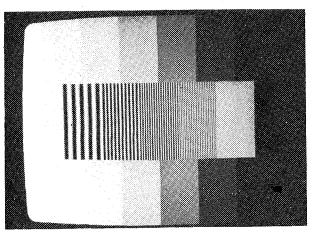
* For cable TV the PM 5519GS is available with a RF range covering channels S1 to S20 and VHF/UHF ranges as PM 5519.
** The PM 5519D is equipped with different VHF and UHF channels.

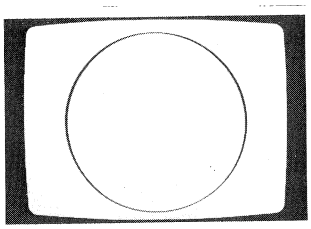
Pattern survey

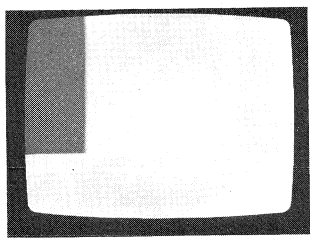
Signal content	B/W	Colour	VCR	For checking
1. **Circle**				
a. White circle on grey	O	O		Overall linearity
b. Black circle if combined with white pattern	O	O		Overall geometry
c. Combination with all patterns possible	O	O		Reflections
2. **Checkerboard**				
6 x 8 rows	O	O		Focus adjustment
	O	O		Hor/Vert. sync
	O	O		Hor/Vert. linearity
	O	O		Hor/Vert. deflection
	O	O		Amplitude/aspect ratio geometry ringing
	O	O		Bandwidth by observation of vert. transitions
	O	O		Mains hum interference in synchronisation
			O	Black/white transitions
3. **Dots**				
11 horizontal lines of 15 dots		O		Static convergence
4. **Crosshatch**				
11 horizontal and		O	O	Dynamic convergence
15 vertical lines	O	O		Pincushion correction
		O		E/W-N/S corrections in 110 CTV receivers
5. **Grey scale and definition lines**				
Linear staircase signal	O	O		Brightness and contrast circuit
with 8 identical steps	O	O	O	Video bandwidth
combined with definition	O	O		Grey signal tracking
pattern of 5 vertical bars 0.8-1.8-2.8-3.8-4.8 MHz	O	O	O	Linearity of video amplifier
6. **White pattern**				
100% white signal	O	O		White
(with or without		O		Constant brightness
(burst)		O		Beam current of picture tube
			O	Adjustment of white level + writing current adjustment
7. **Purity patterns**				
Selectable are 3 primary colours:	O	O		Purity checks and adjustment
a. red with 75% saturation		O	O	Interference between sound and chromacarrier
b. green				
c. blue			O	Colour A.G.C.
or 3 complementary colours; yellow, magenta, cyan			O	Writing currents of video head
8. **DEM Pattern**				
Special bars		O		PAL Delay-line (phase & amplitude)
		O		Subcarrier to the (R-Y) and (B-Y) demodulators 90° phase differences
4 vertical bars + white ref.		O		PAL switch
Special encoding		O		Subcarrier oscillator
Bar 1 (G-Y) = 0				
Bar 2 Y signal				
Bar 3 + (R-Y)				
Bar 4 ± (B-Y)				
9. **VCR pattern**				
a. Saturation step		O	O	Linearity of chroma amplifiers
8 steps of linear increasing saturation (red signal)			O	Sensitivity colour amplifiers
b. Definition lines 2.8-3-3.2 MHz		O	O	Resolution of the VCR and other video recorders
c. One horizontal bar 100% white			O	Adjustment of white level
10. **Colour Bar with white pattern**				
75% contrast, standard		O		Overall colour performance
colourbar with white		O		Burst keying
reference field in		O		Subcarrier regenerator
lower part of		O		PAL identification circuit
screen		O		Matrix circuit
		O		RGB amplifiers
		O	O	Delay Colour versus B/W Signal
		O	O	Saturation check
			O	562.5kHz interference check

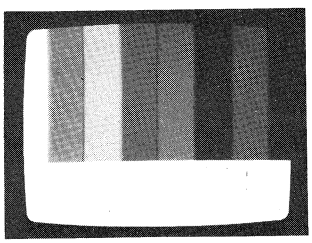












X-tal controlled RF-output, single or multi-channel

Compatible for different TV systems

Large choice of various test patterns

Synchronization according to TV standard

Automatic blinking for testing portier circuits

Choice of positive or negative video polarity and variable video amplitude

Colour TV pattern generators PM 5215 – SECAM PM 5217 – SECAM/PAL

PM 5215

Both generators PM 5215-SECAM and PM 5217-SECAM/PAL offer a wide choice of test patterns and are especially designed for after-sales service of CTV, TV, colour monitors and video recorders. The inherently high quality X-tal controlled RF output, plus their versatility, make these instruments ideal for fast, accurate video measurements both in professional areas as well as production and quality control.

Depending on the customer requirements both types can be fitted with one up to three different X-tal RF oscillators. In the VHF range band III there is a choice of the channels 5...12 and for UHF band IV...V the RF channels 21...69 can be chosen.
The instruments are designed for 2 different systems of sound modulation.
The 10 position selector permits to use e.g. the same RF channel for various TV systems having different sound/vision spacing.

For testing the portier circuits there is a pushbutton selector for automatic blinking. All sub-carrier frequencies are X-tal controlled and the rest frequencies f_0B and f_0R are gen. locked for SECAM functions.

The video output is adjustable from 0–2.4V (open circuit) and the video polarity can be changed by simply pressing the indicated pushbutton. The PAL/SECAM version PM 5217 has a continuously adjustable burst from 20...150%. Synchronization, according to TV standard, includes interlacing and a very good picture stability is obtained by digital techniques combined with memory circuits.

TECHNICAL SPECIFICATION

TEST SIGNALS

a. **Standard colour bar** (with 75% contrast)

b. **Grey scale** (linearized staircase of 8 steps)

c. **Dots** (11 horizontal lines of 15 dots)

d. **Cross hatch** (12 x 16 squares with center indication)

e. **Cross hatch** (6 x 8 squares)

f. **White pattern** (with or without burst)

g. **Black pattern** (with or without burst)

h. **Purity patterns** (choice of 6 different colours)

i. **Primary colours** (red, green and blue)

j. **Complementary colours** (yellow, magenta and cyan)

k. **Combined testpattern** (standard colour bar – with 25% saturated horizontal bar for SECAM alignments – an 8 step grey scale, w/b and b/w transitions)

VIDEO CARRIER

Dependable on requirements for the SECAM or SECAM/PAL version there is a choice of TV systems B, G, H, I, D, K, K1 and L.
Band III VHF channel 5 to 12 (X-tal controlled)
Band IV-V UHF channel 21-69 (X-tal controlled)

RF OUTPUT

RF output
BNC connector

Output voltage
50mV at 1 RF channel
25mV at 3 RF channels

RF attenuation
Continuous 0-25mV

Impedance
75Ω

VIDEO OUTPUT

Video output
BNC connector

Output voltage
1.2V (with 75Ω load)

Attenuation
Continuous 0 to 1.2V

Polarity
Positive or negative, selectable by pushbutton at front panel

Impedance
75Ω

SOUND CARRIER

Frequency (see Table A)
5.5 MHz or 6 MHz or 6.5 MHz. Dependable on TV system

Accuracy
1×10^{-6}

Modulation
AM or FM (see Table A)

Internal signal
1kHz

Sound switch
Modulation 1kHz on/off

CHROMA PM 5215

Systems (see Table A)
SECAM according to systems D, L, K and K1

Signals
$D'_R = -1.9\,(E'_R - E'_Y)$
$D'_B = 1.5\,(E'_B - E'_Y)$

Frequencies
$D'_R = 4.40625$ MHz ± 2kHz
$f_O = \pm 0.3$kHz
$D'_B = 4.25000$ MHz ± 2kHz

Identification
According to TV system in line and frame (see fig. 1)

CHROMA PM 5217

Systems (see Table A)
SECAM according to System D, L, K, and K1
PAL according to System B-G-I-H

Sub-carrier frequency for TV system PAL is X-tal controlled

Frequency
4.443619 MHz

Burst
According to PAL system

Burst amplitude
Continuously adjustable 20...150%

SYNCHRONIZATION

Line frequency
15625 Hz

Frequency tolerance
± 5 Hz

Lines
625

Field frequency
50 Hz

Frame sync. signal
According to TV standard, interlacing

POWER REQUIREMENTS

Voltage
110-250V automatic adaptation to required mains voltage by a double voltage stabilizer

Frequency
50 Hz

Power consumption
30W

DIMENSIONS AND WEIGHT

(w x h x d)
280 x 110 x 310mm
(11 x 4.3 x 12.2-in)
5kg (11lb)

ACCESSORIES SUPPLIED

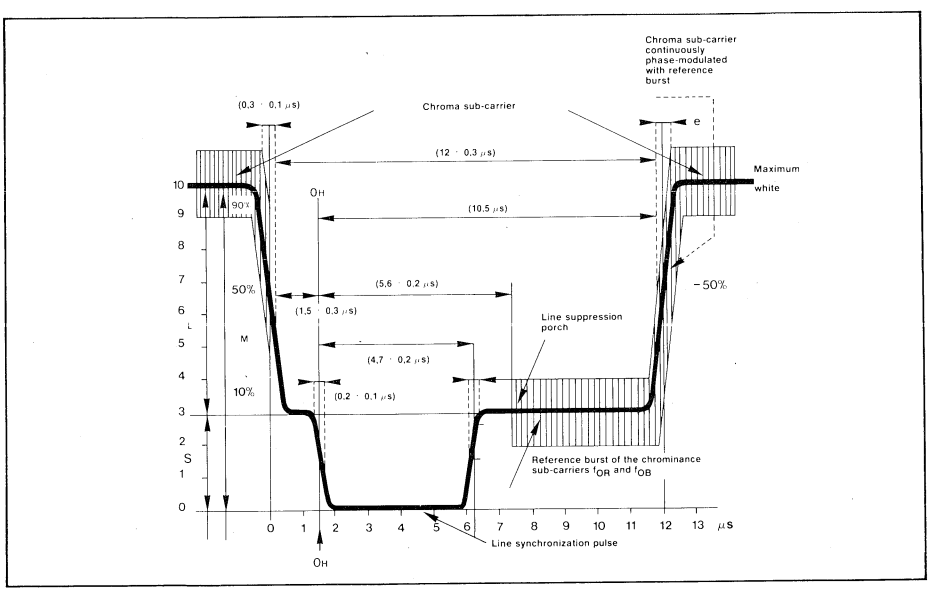
PM 9538 BNC output RF cable – TV 75Ω
Instruction manual
Mains cable

TABLE A

	PM 5217				
			PM 5215		
	PAL B, G, H	PAL I	SECAM B, G, H	SECAM D, K, K1	SECAM L
Chrominance subcarrier (Hz)	4 433 618.75	4 433 618.75	f_0B 4 250 000 f_0R 4 406 250		
Sound carrier relative to vision carrier (MHz)	5.500 000	5.999 600	5.500 000	6.500 000	6.500 000
Line frequency (line/second)	15 625	15 625	15 625	15 625	15 625
Field frequency (fields/second)	50	50	50	50	50
Type and polarity of video modulation	A5C neg.	A5C neg.	A5C neg.	A5C neg.	A5C pos.
Type of sound modulation	FM	FM	FM	FM	AM
Type of chrominance sub-carrier modulation	Suppressed carrier amplitude modulation of two sub-carriers in quadrature		Frequency modulation		
Transmitted chrominance information	1. Line sequential E'_V and $-E'_V$ 2. E'_U		Line sequential D'_R and D'_B		

PM 5217

Fig. 1.



ORDERING PROCEDURE

Depending on the customer requirement both types can be fitted with one up to four different X-tal RF oscillators (maximum of three channels is suggested). In the VHF range band III there is a choice of channels 5 to 12 and for UHF band IV to V the RF channels 21 to 69 can be chosen.

Please state clearly:
- typenumber of the instrument and descriptions SECAM-or SECAM/PAL-generator.
- required RF-channel or channels
- Indication of each RF-channel by letter according to which TV system it should operate.

If placing your order, please consider:
To guarantee to get the right instrument it is very important to determine exactly for which TV system the generator should operate. The following TV systems exist:

SECAM generator PM 5215 and SECAM part of PM 5217
System L, D, K, and K1 having 625 lines, 6.5 MHz sound/vision spacing.

L corresponds with the French SECAM system
UHF only
positive video modulation
AM sound

D VHF only
K UHF only
K1 both VHF and UHF
} corresponds with the OIRT TV system negative video modulation FM sound

SECAM/PAL generator PM 5217
(SECAM part similar to PM 5215)
Systems B, G, H and I are all according to CCIR, PAL have 625 lines and negative video modulation and FM sound.

B VHF only
G both VHF and UHF
H UHF only
} 5.5 MHz sound/vision spacing

I both VHF and UHF
} 6 MHz sound/vision spacing

- 3 standard versions are available:
1. PM 5215/100 L30
2. PM 5217/200 B5 G/L 30
3. PM 5217/201 B5 G/K/L 30

For professional applications, a RF filter can be ordered which gives high purity. If this is required, the term "RF filter" must be added after the type number.

ORDERING EXAMPLES

It is important to state the letter corresponding to the proper TV system as mentioned above, together with the required RF channel.
The channels in VHF band III have different frequencies for the various systems. The UHF channels have the same frequencies for the various systems.
Some examples:

PM 5215/A0B C
A = 1, 2, 3 or 4 (number of channels)
PM 5215 only: B = 0 (1 sound carrier, standard)
B = 1 (2 sound carriers)
PM 5217 only: B = 0 (2 sound carriers, standard)
B = 1 (3 sound carriers)
C = desired system(s) and channel(s)

Example 1 — PM 5215/100 D9
1 RF channel
1 sound carrier 6.5
SECAM system D
VHF channel 9

Example 2 — PM 5215/201 D9 L31
2 RF channels
2 sound carriers (6.5 AM +
(one for AM sound and one for FM sound)
SECAM system D
VHF channel 9
SECAM system L
UHF channel 31

Example 3 — PM 5217/200 G21 D12
2 RF channels
2 sound carriers (5.5 + 6.5)
PAL system G
UHF channel 21
SECAM system D
VHF channel 12

Example 4 — PM 5217/301 L30 B6 G/K38
3 RF channels
3 sound carriers (5.5 FM + 6.5 AM + 6.5 FM)
SECAM system L
UHF channel 30
PAL system B
VHF channel 6
PAL system G + SECAM system K
UHF channel 38

Concern service equipment

Power supply SBC 519

Application
The power supply can provide an output voltage from 1.5 to 30V and deliver output currents up to 3A. It is rugged enough to withstand mistreatment to which most bench supplies are subjected.

TECHNICAL SPECIFICATION

Line voltage	110-127-220-240V/ 50-60Hz
Consumption	110VA max.
Protection	Fuses in series with the primary windings of the transformer
Earthing	Mains plug with RIM earthing
Separate voltmeter-ammeter Polarity	The output terminals are insulated from the chassis: either the positive or the negative terminal may be earthed
Series connection	Two more units can be connected in series
Permitted voltage between any one of the output terminals and earth	300V ⎓ max.
Ambient temperature (max.)	40°C
Dimensions (wxhxd)	275x130x205mm
Weight	3.9kg
Constant voltage operation	
Output voltage ranges	continuously adjustable coarse using switch and fine using potentiometer 1.5...30V
Stability against line variations	with ±10% line variations the max. change of output voltage (27V...2.5A) ≤0.5%
Stability against load variations	with load variations of 0...100% the max. change of the output voltage is ≤0.5%
Ripple voltage	the ripple voltage will be ≤10mVrms. This is valid for nominal line voltage and for any load between no load and full load.
Output current	0...3A
Current limiter/short-circuit protection	Current limit adjustable with potentiometer. The protection circuit is self-recovering when overload is removed.

LF function generator SBC 520

Applications
The SBC 520 is a high-quality general-purpose unit. Not only is it suitable for all the usual LF testing purposes, but it also has particular advantages in such applications as comparison testing, checks on stereo audio amplifiers, and rate and speed checks on cassette recorders and similar equipment.

TECHNICAL SPECIFICATION

Frequency range		10Hz...100kHz (10-100Hz x1, x10, x100, 1000)
Frequency display		6-digit, 8mm LEDs
Output channels		Two, with independent waveform and level adjustment
Output waveforms		
– Sine	– max. level	$2V_{RMS}$
	– THD	<1% at 315Hz
– Triangular	– max. level	5.6Vpp
	– linearity	
– Square	– max. level	5.6Vpp
	– rise/fall time	<0.2μs
Output impedance		50Ω
Attenuation		
– Continuous		0....20dB
– Calibrated steps		0-3-10-20-40-60dB
Sync output		300mVpp sq. wave
Frequency counter		
– Range		10Hz-1MHz (999999Hz)
– Input sensitivity		100mV RMS into 1MΩ/50pF
Power supply		110-127-220-240V AC 50/60Hz
Power consumption		12VA max.
Dimensions		275x130x205mm (wxhxd)
Weight		1kg

Universal counter SBC 550
The universal counter SBC 550 is a high quality unit for all general frequency and timing measurements. The unit contains the function of a frequency counter, a frequency ratio counter unit, an event counter, a time interval counter and a period counter and is designed and tested in accordance with the requirements of IEC 348 safety class 1.
The universal counter is particularly designed for servicing and training departments, schools, colleges and home workshops.

TECHNICAL SPECIFICATION

Frequency
Range: 10Hz...450MHz

$$\text{Resolution: } \frac{1 \times \text{prescaling factor (P)}}{\text{gate time}} \text{ Hz}$$

Inputs: A 10Hz...10MHz (P=1)
B 10MHz...450MHz (P=100)
Gate times: 0.01, 0.1, 1 and 10s
Accuracy: ±1 count ±time base error

Multiple ratio

$$\text{Ratio } \frac{f_A}{f_B} : \frac{10\text{Hz...}10\text{MHz}}{10\text{Hz...}2.5\text{MHz}} \quad (f_A > f_C)$$

Multiplier (N): 1, 10, 100 and 1000
Accuracy:

$$\pm 1 \text{ count} \pm \frac{\text{Trigger error* of the lower freq.}}{N}$$

Oscillator
10MHz clock frequency from crystal oscillator is interconnected with input A.
Note: Only for functional test purposes

Count
Range: 1...10^8
Count accumulation: During extern manual start/stop interval
Pulse pair resolution: 100ns
Input: channel A

Time interval average
Range: 1μs...10s
Time intervals averaged (N): 1, 10, 100 and 1000

$$\text{Resolution: } \frac{100\text{ns}}{N}$$

Accuracy: ±140ns ±time base error

$$\pm \frac{100\text{ns} + \text{Trigger error**}}{\sqrt{N}}$$

Time interval repetition rate: max...1MHz
Min. Time from stop to start: 500ns
Input: channel A and C

Period average
Range: 10Hz...2.5MHz for sine waves. Periods averaged (N): 1, 10, 100 and 1000

$$\text{Resolution: } \frac{100\text{ns}}{N}$$

Accuracy: ±1 count ±time base error

$$\pm \frac{\text{trigger error*}}{N}$$

Input: channel A
*trigger error is $\leq \pm 3 \times 10^{-3}$ for sine waves with signal to noise ratio of ≥40dB.
** trigger error for any waveshape is

$$\leq \pm \frac{2.5 \times 10^{-3}}{\text{signal slope (V/ns)}} \text{ns}$$

Input characteristics

Input A
Frequency range: 10Hz...10MHz
Sensitivity:
Sine: $15mV_{RMS}$ (20Hz...5MHz)
$35mV_{RMS}$ (10Hz...10MHz)
Pulse: 200mVpp (at pulse width 100ns and 0.1>duty factor<0.9)
Max. operating input voltage: $10V_{RMS}$
Coupling: AC
Trigger level: fixed 0V
Impedance: 100kΩ//47nF
Max input voltage without damage: $260V_{RMS}$

Input B
Frequency range:
Sensitivity: $15mV_{RMS}$ (2MHz...50MHz)
$25mV_{RMS}$-1MHz
$65mV_{RMS}$-450MHz
see input voltage characteristcs
Max. operating input voltage: $1V_{RMS}$
Coupling: AC
Impedance: 120Ω//47pF
Max input voltage without damage: $260\ V_{RMS}$

Input C
Frequency range: 10Hz...2.5MHz
See further specification input A

Time base characteristics
X-tal frequency 10MHz
Temperature stability:
15°...35°C refer to 25°C<2×10^{-5}

Counters and timer/counters

Unit	Description	Frequency range	Sensitivity	Page
Introduction				2
PORTABLE & BENCH TOP INSTRUMENTS				
PM 6652	Timer/counter, programmable	120MHz...1.5GHz/100ns		6
PM 6654	Timer/counter, programmable	120MHz...1.5GHz/2ns		6
PM 6667	Automatic counter	10Hz...120MHz	15mV	16
PM 6668	Automatic counter	10Hz...1GHz	15mV	16
PM 6670	Timer/counter	0.1Hz...120MHz	10mV	18
PM 6671	Timer/counter	0.1Hz...120MHz	10mV	18
PM 6672	Timer/counter	0.1Hz...1GHz	10mV	18
PM 6673	Reciprocal universal counter	10Hz...120MHz	10mV	23
PM 6674	Reciprocal universal counter	10Hz...550MHz	10mV	23
PM 6675	Reciprocal frequency counter	10Hz...120MHz	10mV	23
PM 6676	Reciprocal universal counter	10Hz...1.5GHz	10mV	23
OPTIONS				
Options for counters and timers				27
Specifications for options				28

Introduction

The right choice
Error-free frequency counting applications vary considerably. Many differing requirements can include counting on noisy signals, frequency measurement on narrow pulses, or HF, VHF and UHF signals.
Or it may be required to make high resolution frequency counting on low frequency signals. Another application may call for time interval averaging. All of these, plus the many other possible applications demand various criteria in an instrument's design specification, such as, for example, maximum frequency, sensitivity and crystal oscillator characteristics.

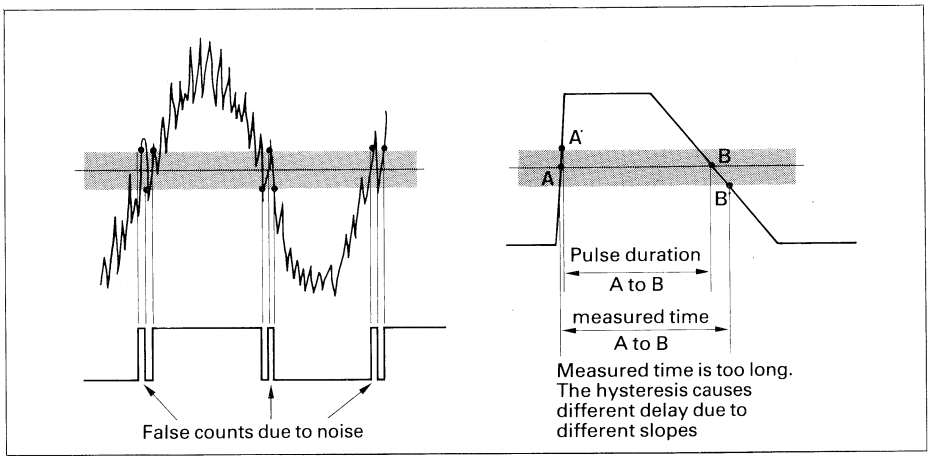


Fig. 1a.

Fig. 1b.

Optional accessories
The conditions of use are important. Use in the field, on a laboratory bench or in an automatic test system require different options such as: battery supply, BCD output, analog output (for recording on a strip-chart recorder), IEEE-488 BUS interface, rackmount facilities, ultra-high stability oven oscillators etc.
In selecting a counter, the availability of a wide range of such options is of greatest importance especially when the type of application may change after some time in use.

Frequency counter or Timer/Counter
For basic frequency measurements, the choice of instument will be from the **frequency-only** counter range, i.e., PM 6661, PM 6667 and PM 6668; unless a 7 or more digits accuracy is essential when the PM 6673...76 series should be considered.

A **universal frequency counter** offers the added benefits of period measurements, totalizing of input events (COUNT mode) and frequency ratio measurements. These facilities are provided by the PM 6673, PM 6674, PM 6675 and PM 6676.

A **timer/counter** is optimized for accurate time interval measurements as well as frequency measurements. The PM 6670, PM 6671 and PM 6672 (benchtop models) plus the high-performance system timer/counters PM 6652 and PM 6654 will easily satisfy these requirements.

Front-end circuitry requirements
The requirements for input signal-conditioning when making frequency and time measurements are somewhat contradictory as the following observations will illustrate.

Frequency counting
Figure la shows a sinewave signal crossing the hysteresis band of the input circuit. Each period of the sinewave that crosses the hysteresis band causes a clean pulse that can be counted by the digital circuitry.
Noise on the sinewave, however, causes the signal to pass through the hysteresis band more than once per sinewave-period giving false counts. Figure 2a shows how this type of error can be prevented.

Time interval measurement
Figure 1b shows a pulse, the duration of which is to be measured. Triggering at 50% of amplitude should start the time measurement at A and stop it at B.
The hysteresis of the input circuit, however, causes triggering to occur at A' and B'. The different slopes of leading and trailing edges causes different delays, resulting in a faulty measurement. A very narrow hysteresis band as shown in fig. 2b will reduce these errors.

The solution to error-free triggering
Figure 2a shows that "error-free" frequency counting is obtained by a wider hysteresis band or, in other words, by an attenuated input signal.
Thus for frequency measurement a **continuously variable** input attenuator permits optimum matching of the input signal to the counter's trigger sensitivity.
Figure 2b shows that a lower hysteresis voltage will minimize the time measurement error.
Thus a low hysteresis voltage (narrow trigger window) together with a continuously variable trigger level

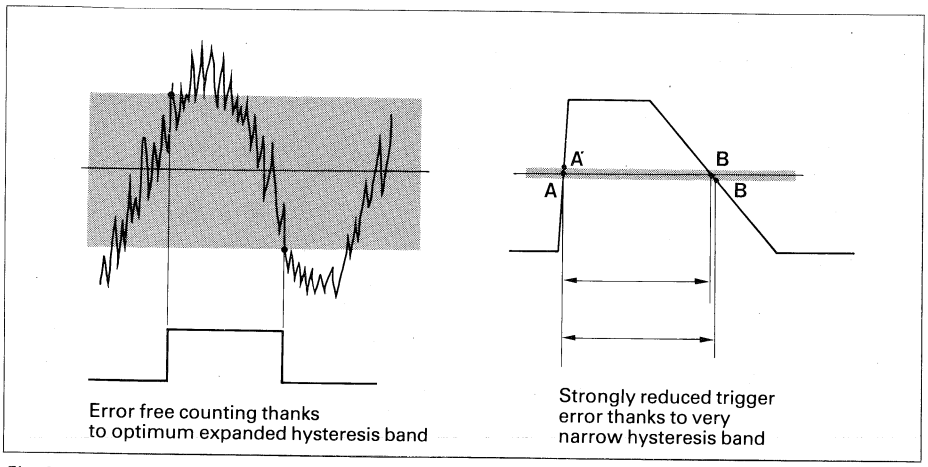


Fig. 2a. *Fig. 2b.*

setting permits accurate time interval measurements.

AC-coupling

Frequency counting on sinewaves or on generally symmetrical signals is best achieved with AC-coupled inputs. AC coupling has no temperature drift problems, while added DC signal components are eliminated. This assures simple, stable, and thus, reliable triggering.

Universal frequency counters also need to measure on narrow pulses or other waveforms.

Triggering on any waveform, having any duty factor can be performed by means of a trigger level off-set in the final amplifier stage. The input channels on the PM 6673...76 instruments have 3 fixed trigger level positions to cover all duty factors (see fig. 3).

DC-coupling

Time interval measurements with accurately set trigger levels, or those that are wave form-independent, require DC-coupling. This might be e.g., a rise time measurement on a pulse, requiring 10% to 90% level setting, or a pulse duration measurement with accurate setting of trigger levels at 50% of the pulse amplitude.

Such measurements can only be made accurately if a trigger level output is available to measure the set level. Such trigger level monitors are found on the timer/counters PM 6671, PM 6672, PM 6652 and PM 6654.

HIGH RESOLUTION COMPUTING COUNTING

Measuring resolution

The controlling and computing power of modern microcomputers enables frequency measurements to be made in the most logical way. The frequency definition follows below.

$$\text{Frequency} = \frac{\text{Number of cycles}}{\text{Time}}$$

Modern microcomputer-based frequency-counters do precisely that which is given in the frequency definition.

1. They count the number of complete input cycles.
2. They measure the effective gate-time, which is the time duration of the totalized number of input cycles.
3. Thereafter, they compute the value of:

$$\frac{\text{NUMBER OF CYCLES}}{\text{TIME}}$$

Finally the microcomputer computes the resolution to define the number of digits to be displayed.

Figure 4 shows that a computing frequency counter contains two counting registers. One counting register counts the number of input cycles, while the other register counts the number of 10 MHz reference clock pulses, to measure the time duration.

The required measuring time can be selected independently and can be varied continuously as well as in fixed steps.

The actual measuring time is synchronized with the input signal and is therefore exactly a multiple of complete cycles. This way, the traditional ±1 input cycle error is avoided.

During the same time, the time counter has totalized the number of 100ns (10^{-7}s) reference clock pulses or 2ns in the case of PM 6654. The count error is ± one clock pulse. The total gate-time is the number of clock pulses x 10^{-7}s or x 2.10^{-9} for the PM 6654.

To obtain the frequency or period value, only a simple division has to be made.

$$\text{Frequency} = \frac{\text{Counted Input cycles}}{\text{Time counts x } 10^{-7}\text{s*}}$$

$$\text{Period} = \frac{\text{Time counts x } 10^{-7}\text{s*}}{\text{Counted input cycles}}$$

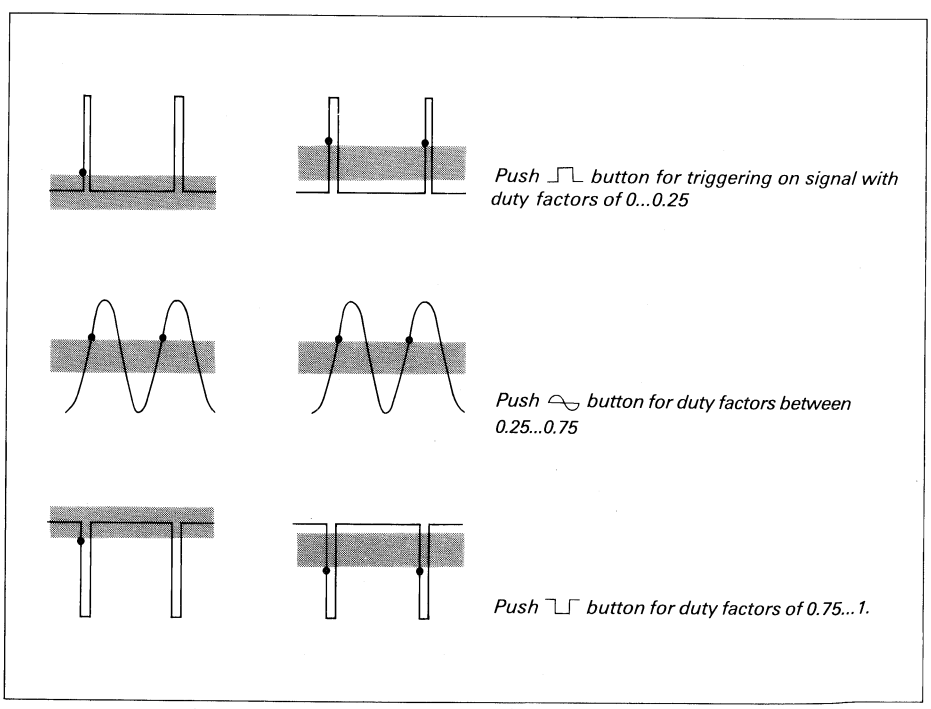


Fig. 3

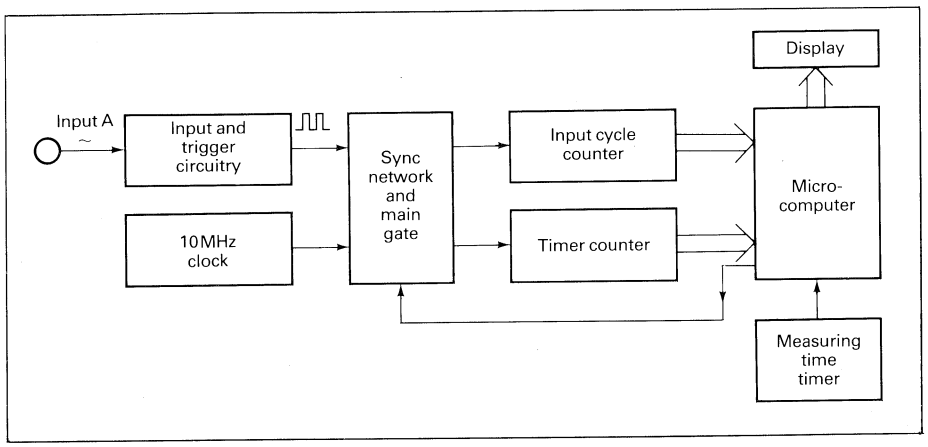


Fig. 4

The ±1 count error is ±100ns* (10^{-7}s)*. The resolution or relative count error is:

$$\text{Rel. resolution} = \frac{\pm 10^{-7}\text{s}^*}{\text{Measuring time}}$$

Note that the resolution is independent of the frequency value. When measuring for example, a line frequency with 1s of measuring time, a readout of a least 7 accurate digits e.g., 50.78349Hz, will result.
A conventional counter would in this case only display 2 digits, e.g., 51Hz. This is because conventional counters are **not** synchronized with the input signal, but with the internal time-base. The ±1 count error is now found in the input cycle counting register, which implies that the resolution for conventional counters is:

$$\text{Rel. resolution} = \frac{\pm 1}{\text{Frequency x gate time}}$$

One obvious advantage with microprocessor-based computing counters is thus the very good resolution even at low frequencies.
Another advantage is the possibility to mathematically process the measuring data such as displaying counts per minute (RPM) instead of counts per second, display phase delay in degrees based on the relative time delay between two signals etc.

X-TAL OSCILLATORS

A wide range of timebase oscillator options are available. All medium/high performance counters (PM 665X and 667X) offer five stability versions ranging from the standard /01 (uncompensated x-tal) up to the ultra-high stability /05 (oven oscillator).

The low-cost frequency counters PM 6667/68 have two stability versions /01 (standard) and /02 (temperature compensated x-tal oscillator, TCXO).

What's the difference?

A simplified schematic diagram of a crystal oscillator is shown in fig. 5.
The component that determines frequency is the quartz crystal. The two major factors affecting crystal frequency accuracy is temperature variations and ageing.

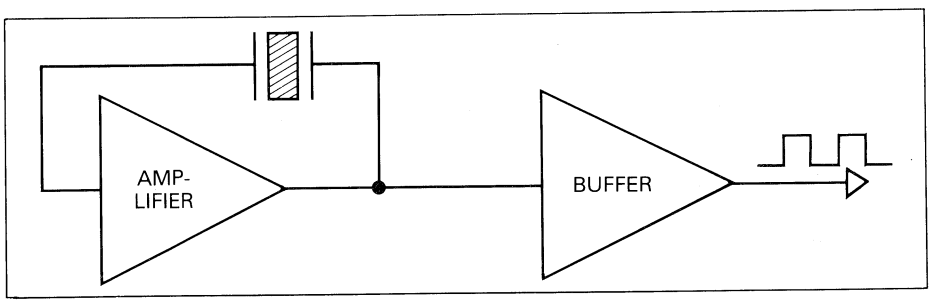


Fig. 5

X-tal oscillators can be divided in three groups, depending on the demand for temperature stability.

1. Uncompensated room temperature oscillators
2. Temperature-compensated oscillators (TCXO)
3. Oven-stabilized oscillators (OCXO)

Uncompensated oscillators give sufficient accuracy in most room temperature applications (about 5 or 6 meaningful digits).

Temperature compensated oscillators (TCXO) are preferred when there is a need for more reliable digits (6 or 7 digits) or when the counter is used in applications where the ambient temperature is not stable (e.g. field service).

A TCXO uses a temperature-dependent compensating network for frequency correction of the oscillator.

Oven stabilized oscillators give still higher accuracy (7 to 9 meaningful

X-tal oscillator summary

PM 66../0. version including timebase option	/01 standard version	/02 version PM 9678	/03 version PM 9679	/04 version PM 9690	/05 version PM 9691
Stability against	Standard	TCXO	Oven	Oven	Oven
Ageing: /24h /month /year	n.a. $< 5 \times 10^{-7}$ $< 5 \times 10^{-6}$	n.a. $< 1 \times 10^{-7}$ $< 5 \times 10^{-7}$	n.a. $< 1 \times 10^{-7}$ $< 5 \times 10^{-7}$	$< 1.5 \times 10^{-9}$* $< 3 \times 10^{-8}$ $< 1.5 \times 10^{-7}$	$< 5 \times 10^{-10}$* $< 1 \times 10^{-8}$ $< 7.5 \times 10^{-8}$
Temperature: 0...50°C ref. to + 23°C	$< 1 \times 10^{-5}$	$< 1 \times 10^{-6}$	$< 1 \times 10^{-7}$	$< 3 \times 10^{-8}$	$< 5 \times 10^{-9}$
Change in measuring and supply mode: line/int. battery/ext. DC 12V...26V	$< 3 \times 10^{-7}$	$< 5 \times 10^{-8}$	$< 1 \times 10^{-8}$	$< 3 \times 10^{-9}$	$< 3 \times 10^{-9}$
Line voltage: ± 10%	$< 1 \times 10^{-8}$	$< 1 \times 10^{-9}$	$< 1 \times 10^{-9}$	$< 5 \times 10^{-10}$	$< 5 \times 10^{-10}$
Warm-up time to reach 10^{-7} of final value	n.a.	n.a.	< 10min	< 15min	< 15min

* *after 48 hours of continuous operation*

* *For the ultra high resolution PM 6654 the figures are 2ns and 2×10^{-9}s respectively.*

digits) and are used where very accurate frequency measurements are required, e.g. in telecommunication.

The crystal is kept in an enclosure ("oven") which is kept at a constant temperature, normally around 70°C. The temperature is regulated so that temperature variations inside the oven will be kept at a minimum (typical ±0.01°C).

Crystals in high-stability oven oscillators are normally overtone crystals with higher mass and a lower fundamental frequency. These crystals, which are forced to oscillate on an overtone in the oscillator circuit, feature better aging rates than smaller crystals, oscillating at their fundamental frequency.

OPTIONS

A wide range of options are available for the PM 6670- and PM 6650-series of counters. All options are specially designed for uncomplicated internal mounting, avoiding unnecesary fitments on the outside of the cabinet.
The low-cost PM 6661-counter has no options other than a panel mounting kit.
The frequency counters PM 6667/68 have a battery option, carrying case and a rack-mount adapter.
The currently available counter options are shown in the table above. The options are specified on page 28.

Summary of options

Options and accessories available	Counter type PM 66 . .				
	61	67/68	70	71 . . .76	52/54
Battery pack		x		x	
BCD-output				x	x
Analog output				x	x
IEEE-488-bus				x	x
Ext. ref. freq. multiplier				x	x
Carrying case		x	x	x	
Rackmount adapter	x	x	x	x	x
Fan					x
Rear panel wiring inputs					x

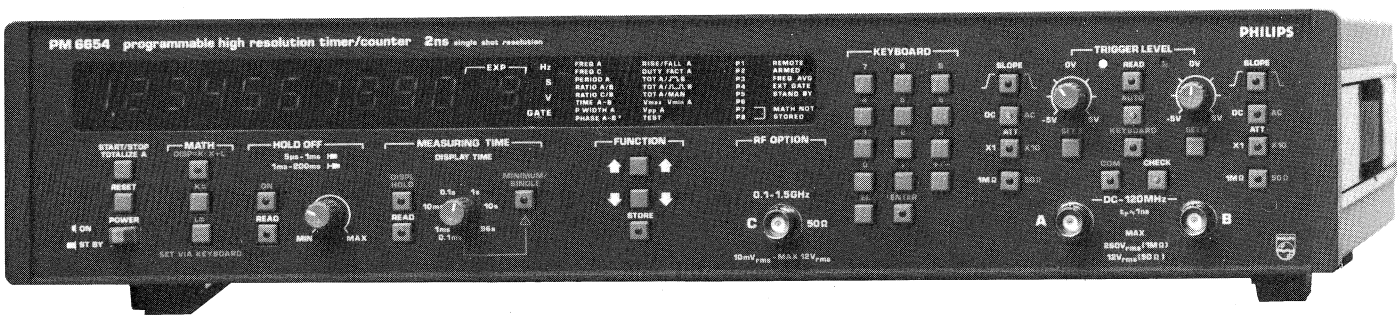
Quick-reference performance survey

			MEASURING FUNCTIONS				TRIGGERING				OPTIONS				
Type No.	Freq. range	Sensi-tivity	Freq. only meas.	Freq. Perod Ratio Count	Time int. single Time int. avg. Phase, RPM, Pulse width	Rise time Duty factor $Volt_{pp}$ Math. funct.	Trigger Hold-Off	Fixed +0− offset	Var. level offset	Auto level offset	X-tal Oscillator options TCXO	Oven	Battery option	IEEE-Bus option	Remarks
PM 6652	120 MHz/ 1.5GHz	20mV		x	x	x	x		x	x	x	x		x	High performance system timer/counters. PM 6654 :2ns single-shot resolution. (PM 6652:100ns)
PM 6654	120 MHz/ 1.5GHz	20mV		x	x	x	x		x	x	x	x		x	
PM 6661	80 MHz	20mV	x												Low cost Frequency-only counters
PM 6667	120 MHz	15mV	x							x	x		x		
PM 6668	1GHz	15mV	x							x	x		x		
PM 6670	120 MHz	10mV		x	x				x		x	x	x	x	Medium price timer/counters
PM 6671	120 MHz	10mV		x	x		x		x		x	x	x	x	
PM 6672	1GHz	10mV		x	x				x		x	x	x	x	
PM 6673	120 MHz	10mV		x				x			x	x	x	x	Medium price universal frequency counters
PM 6674	550 MHz	10mV		x				x			x	x	x	x	
PM 6675	600 MHz (dir. gated)	5/10mV		x				x			x	x	x	x	
PM 6676	1.5GHz	10mV		x				x			x	x	x	x	

NOTE! All counters except PM 6661 are μc-based and perform high resolution reciprocal counting

IEEE 488 IEC 625

High performance fully programmable timer/counters 120 MHz/1.5GHz/2ns PM 6654 120 MHz/1.5GHz/100ns PM 6652



High accuracy FREQUENCY AND PERIOD measurements of 9 digits in one second.

High sensitivity 1.5GHz input with wide 10 mV_{RMS} -12V_{RMS} dynamic range

TIME-INTERVAL resolution down to 0.5ps averaged and 2ns single shot.

New measuring modes incl.: PHASE, RAMP TIME, DUTY FACTOR, V_{max}, V_{min} and V_{pp} of input signal

Digital read-out of trigger levels

8 pre-programmable front panel menus, memorized even during unlimited line voltage interruptions

Fully IEEE 488 bus programmable

Mathematical functions

Powerful trigger facilities incl. ARMING, HOLD-OFF, EXTERNAL GATING and AUTO TRIGGER LEVEL SETTING.

Introduction

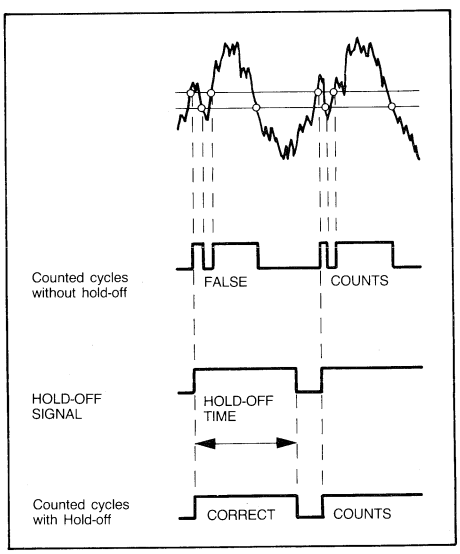
Philips' PM 6652 and PM 6654 high performance, fully programmable timer/counters satisfy virtually all frequency and time measurement requirements especially in R & D laboratories and automatic test systems applications. The measuring functions and appearance of both instruments look the same. The difference is found in resolution, accuracy and measuring speed. The PM 6652 has a 10MHz (100ns) clock frequency, whereas the extra high resolution PM 6654 features a 500MHz (2ns) real time clock resolution. Thus, the PM 6654's measuring circuitry gives some 50 times better resolution or measuring speed than found in the PM 6652 and in most other counters on the market. Thanks to its short measuring cycle times, the extra high resolution PM 6654 is particularly well suited to high speed automatic test systems. For OEM ATE purposes, lower cost blind panel versions of PM 6652/6654 are also available for use exclusively via the IEEE-488 interface bus.

Both PM 6652/6654 timer/counters offer extremely powerful measuring capabilities. With 14 frequency, time- and voltage measuring modes, 100% IEEE-488 Bus programmability, up to over 400 readings/second Bus speed, 2ns single shot resolution and 1.5GHz frequency range, PM 6654 challenges most other timer/counters.

VOLT measurements

These timer/counters offer standard Volt measurements: Vmax, Vmin, V_{DC}, Vpp or even V_{RMS}, whether on LF sinewaves or high speed pulses.

In combination with the time measurements: DUTYFACTOR PERIOD, PULSE WIDTH, DELAY, RISE-AND-FALL TIME and PHASE, these new PULSE VOLTAGE measurements allow automatic test systems to measure pulse and other input parameters, that could only be viewed previously on an oscilloscope. In addition to which, both models will complete their tasks extremely quickly- and for a low cost.



The trigger hold-off can be used as a digital low-pass filter, with variable cut-off frequency. Hold-off time is set to approx. 3/4 of the period of the input signal.

Powerful FREQUENCY measuring capabilities

High accuracy FREQUENCY and PERIOD measurements can be made with a one second measuring time resolution of 9 digits in the PM 6654 and 7 digits in the economy version PM 6652. Both models perform advanced frequency measurements, including externally gated frequency measurements, burst frequency and multiple burst frequency average measurements on down to 200ns narrow bursts (500ns for PM 6652).
Trigger HOLD-OFF, when activated in the FREQUENCY and PERIOD modes, acts as a digital low-pass filter to ignore noise and interference, thereby preventing erroneous measurements.

Mathematics

The MATH (mathematics) facility allows scaling and/or off-setting of measured results before display. This significantly extends the range of application by enabling calibration or unit conversion as in the following examples:
V_{pp} measurements can be converted to V_{RMS}; frequency readings from a transducer can be calibrated as RPM, liters/s, gallons/min or m/s; phase measurements can be converted from degrees to radians and pulse reflections in faulty cables can be directly calibrated for fault location finding in meters of cable length.

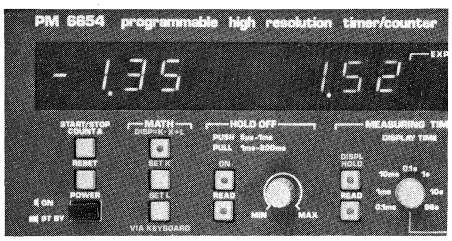
THE ULTIMATE IN TIME INTERVAL MEASURING ACCURACY

A unique combination of high resolution, high trigger accuracy and special trigger control facilities puts these instruments among the most powerful timers on the market.

The high technology PM 6654 with its **2ns single shot resolution** allows time interval measurements to be made to an accuracy and resolution well beyond those of normal timer/counters.
Repetitive signals allow significantly improved resolution by averaging of measuring results. Time intervals, pulse widths, rise and fall times can be measured this way down to sub-picosecond resolution with the PM 6654 and down to 10ps resolution with the PM 6652.

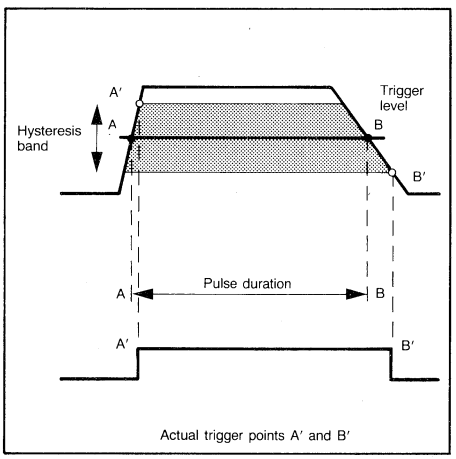
Trigger accuracy

Ultimately, no timer measures more accurately than its trigger accuracy. Therefore extra attention has been to the following parameters: high speed/high sensitivity input stages, high trigger level setting accuracy and shortest possible trigger delays.

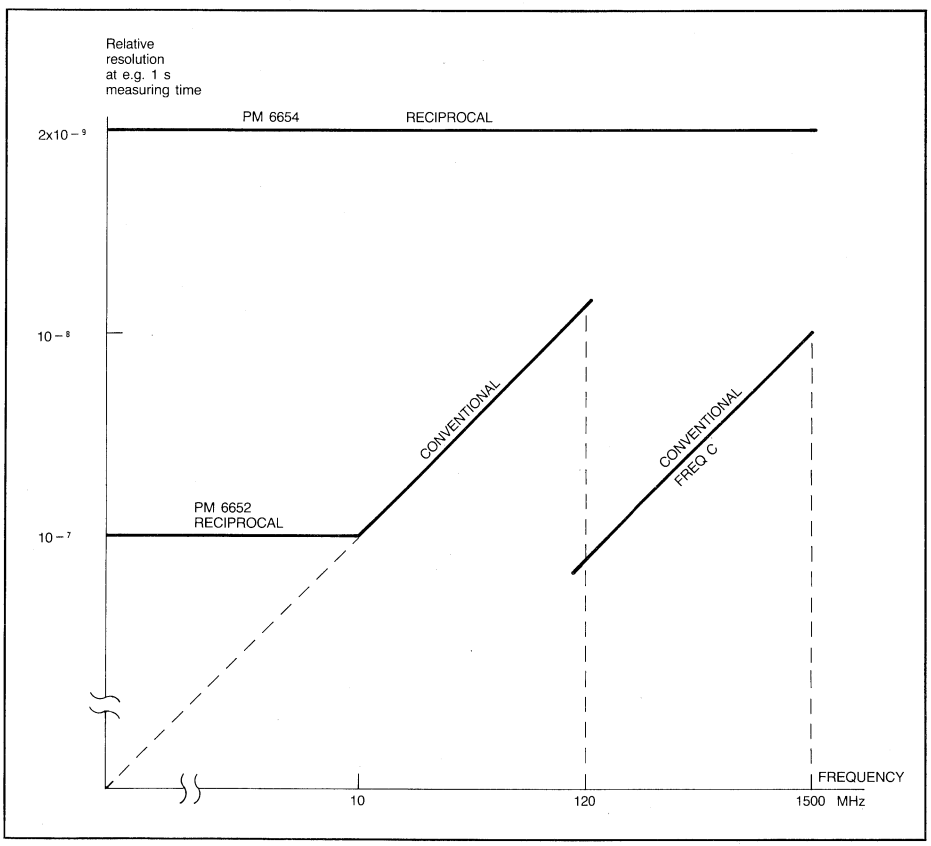


The trigger level READ function displays simultaneously the trigger levels of both the A and B channels, whether being set manually with a vernier or via the keyboard or in the AUTO trigger mode.

The PM 6652's and PM 6654's inputs feature very fast 1ns rise times and 20mV$_{RMS}$ sensitivity over a wide −5V...+5V dynamic range. Trigger level accuracy is assured by the digital setting and readout. At the push of a button, the counter displays, simultaneously, the set trigger levels of both the A and B channels with a 10mV resolution.

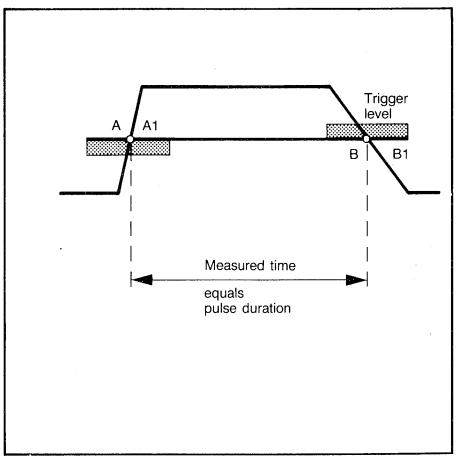


A wide hysteresis band would normally introduce time measurement errors.



The PM 6654 benefits from the 500MHz internal clock, by utilizing RECIPROCAL counting for all frequencies.

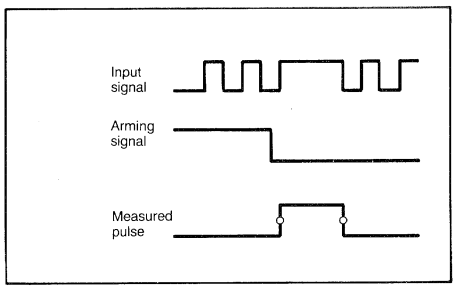
The PM 6652 selects, automatically, RECIPROCAL or CONVENTIONAL counting in order to achieve the highest possible resolution, for any frequency.



PM 6652/6654 feature hysteresis compensation. The trigger level is lowered on positive slopes and raised on negative slopes, resulting in a residual hysteresis band which is virtually 10mV$_{pp}$.

The REAL trigger points are displayed
Automatic hysteresis compensation ensures that the actual triggering occurs at the set trigger level and not delayed by the input hysteresis. Systematic trigger errors are thus kept to an extremely low level.

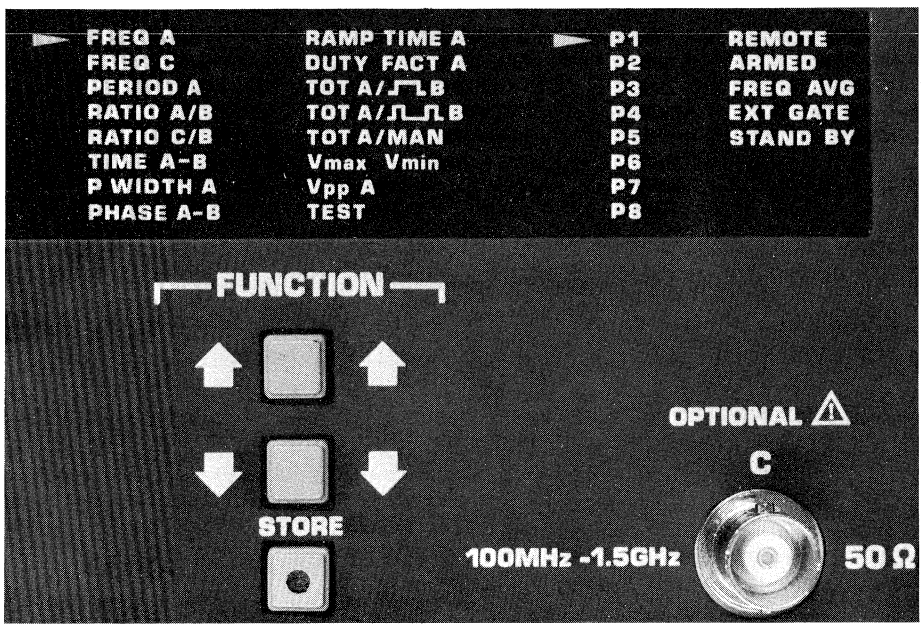
Powerful extra trigger controls
The PM 6652/6654 provide full control over start and stop triggering. Arming and trigger hold-off enable unwanted signals to be ignored which would otherwise trigger the counter. Arming avoids false starts while a wide range variable trigger hold-off prevents false stops. The set hold-off time can be read on the display.



The arming input facility prevents the counter from being triggered as long as this input is kept high. Releasing this input arms the counter, which is then ready for triggering, immediately on the first incoming signal.

operation and for communication with the front panel, the other for fast measuring control and data handling.

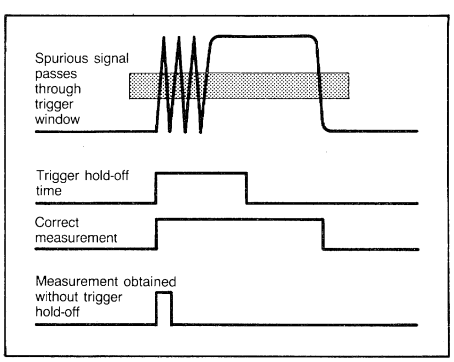
Simple function selection
Function selection is achieved by means of only one single control. The up/down function selector with moving cursor in the display window indicates clearly which measuring mode is selected. See figure below.



Detail of front panel showing up/down moving cursor for clear indication of selected function.

Automatic triggering
The PM 6652/6654 have three different trigger level setting modes:
- AUTO selection for foolproof operation and maximum convenience.
- Digital selection via the key-board for maximum setting accuracy.
- Manual potentiometer setting for increased flexibility.

In the AUTO mode, the counter measures first the maximum and minimum voltages of the input signals. Thereafter, the microcomputer calculates the 50% values to set the trigger levels. When measuring rise or fall times, the 10% and 90% levels are calculated.

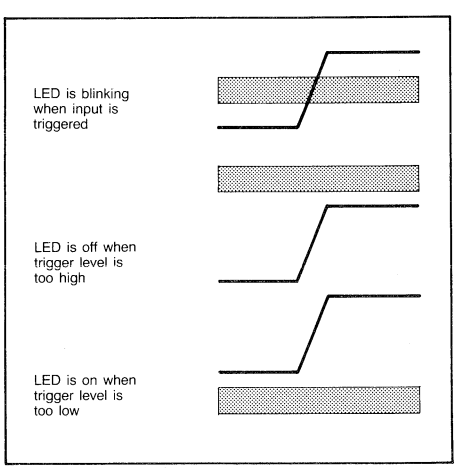


Use of the variable trigger hold-off prevents false stops due to spurious signals such as ringing or relay contact bounce. It also enables, time measurements to be made on double pulses, bursts or other complex signals.

Stored front panel 'menus' P1...P8
Once all front panel controls have been set, all the settings can be stored in a memory for later recall. There is storage capacity for eight such pre-programmable front panel menus in the non-volatile (EAROM) memory. This means these programs are not lost during line voltage interruptions and no batteries are needed for memory back-up.

The stored programs memorize even numeric values such as trigger level voltages, measuring time and the mathematical conversion factors K and L. Recalling such programmed front panel menus is as simple as the selection of a measuring function: just pushing **one button.**
Moving the up/down selection cursor can also be achieved remotely with a short-circuit to ground signal (connector on rear panel). This way one can select from the P1...P8 programs remotely, with very simple control provisions. In addition, the control panel settings can be stored and recalled via the IEEE-488 bus.

Trigger indicators
Tri-state trigger indicator LED's on the PM 6652/6654 blink to indicate that the



Tri-state LED-trigger indicators facilitate quick trigger level setting.

GOOD DESIGN FOR EASY USE
For user-convenience, the PM 6652/6654 have more intelligence than other counters. Both counters contain two microprocessors, one to automate the

inputs are triggered. This feature is of great help when setting the trigger levels manually or via the keyboard.

Variable measuring time

Another microcomputer benefit is the continuously variable measuring time, which is no longer limited to decade steps. It is possible, for example to select 2.4 seconds if one second does not give sufficient resolution. This avoids the need to select a time-wasting 10 second measuring period. Pressing the READ button shows instantaneously the measuring time selected.
For a microsecond measuring time or measurements of one-shot phenomena, it is only required to press the MINIMUM/SINGLE button.

Trigger level outputs

Trigger level outputs on the rear panel are available for read out on an oscilloscope. Set trigger levels can then be viewed with respect to the input signals. They can also be used as bus programmable DAC's.

Choice of crystal oscillators

The timebase crystal oscillator determines the accuracy limit of the timer/counters. Table 1 shows which of the five stability versions best fits the user's requirements. The choice ranges from an economy standard oscillator to the 5 x 10^{-10}/24h high-stability ovenized oscillator PM 9691 for high accuracy measurements and fewer recalibrations. The high-stability crystal oscillators are also available as retrofittable options for later upgrading of the counter performance. By means of the external reference input, it is possible to utilize the user's own frequency standard, when available.

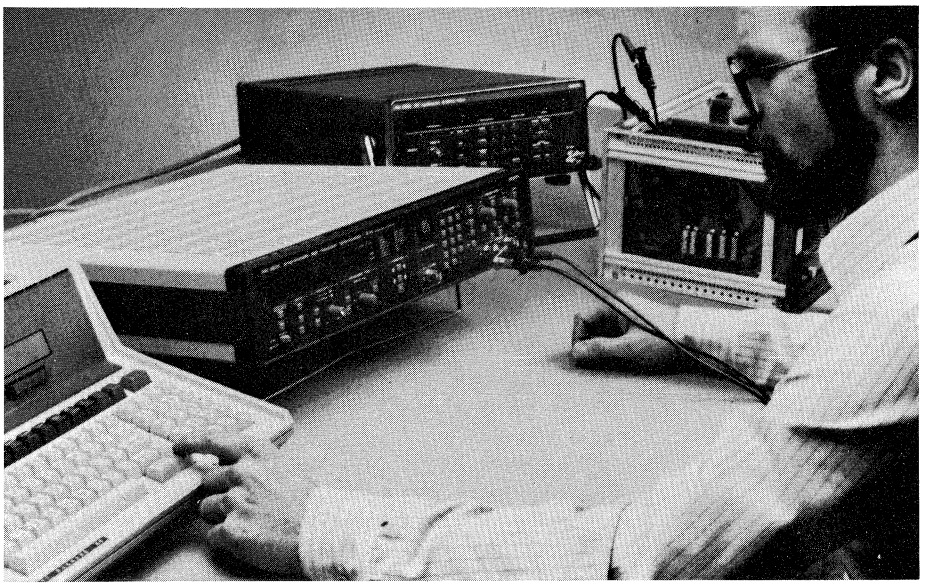
Table 1

PM 665 ./. . version including timebase option / Stability against	/ .1 . version Standard	/ .2 . version TCXO PM 9678	/ .3 . version Oven PM 9679	/ .4 . version Oven PM 9690	/ .5 . version Oven PM 9691
Ageing: /24h /month /year	n.a. $< 5 \times 10^{-7}$ $< 5 \times 10^{-6}$	n.a. $< 1 \times 10^{-7}$ $< 5 \times 10^{-7}$	n.a. $< 1 \times 10^{-7}$ $< 5 \times 10^{-7}$	$< 1.5 \times 10^{-9}$* $< 3 \times 10^{-8}$ $< 1.5 \times 10^{-7}$	$< 5 \times 10^{-10}$* $< 1 \times 10^{-8}$ $< 7.5 \times 10^{-8}$
Temperature: 0...50°C ref. to + 23°C	$< 1 \times 10^{-5}$	$< 1 \times 10^{-6}$	$< 1 \times 10^{-7}$	$< 3 \times 10^{-8}$	$< 5 \times 10^{-9}$
Line voltage: ± 10%	$< 1 \times 10^{-8}$	$< 1 \times 10^{-9}$	$< 1 \times 10^{-9}$	$< 5 \times 10^{-10}$	$< 5 \times 10^{-10}$
Warm-up time to reach 10^{-7} of final value	n.a.	n.a.	< 10min	< 15min	< 15min

* after 48 hours of continuous operation

POWERFUL IEEE-488 BUS CAPABILITIES

Both the PM 6652 and PM 6654 are fully programmable, including all front-end controls and trigger level voltages. The optional PM 9696 interface board makes the counters IEEE-488/IEC-625 bus-compatible at a small additional cost.
Advanced software features are available, including bus learn mode and programmable delimiters, In addition, the high-speed dump mode allows the user to fully exploit the high resolution/high-measuring speed of the PM 6654, allowing up to 400 - 500 measurements



The ultimate in bus operation simplicity
It is only required to manually set and store all desired timer/counter controls in one of the counter's own memory locations P1...P8, then recall via the bus the manually stored 'menu' with a **single** bus command. Example command from an HP-85 desk-top computer to a PM 6652/6654.

```
540 OUTPUT 710; "LP3"
```

- 540 — BASIC program line number.
- OUTPUT — Bus instruction.
- 710 — Computer's bus interface select code.
- ; — PM 6652/54's set address.
- "LP3" — Load program 3 from PM 6652/54's own memory.

per second. Pre-set limit monitoring is another useful feature.

Powerful, flexible software for user convenience
The PM 6652/6654's bus interface fully complies with IEEE-488/IEC-625-1 hardware standards; as well as with the new code and format conventions (software) of IEEE-728/IEC-625-2. To satisfy application needs for both temporary interfaced instrument clusters - and for permanent test systems, the PM 6652/6654 feature a new flexible and powerful software approach. Three different programming modes give ease and simplicity of programming and powerful, high-speed bus operation.

Other friendly features include:
- Acceptance of all available input delimiters as well as output of any delimiter (hardware and/or software selectable) to suit any controller.
- In the 'normal' programming mode, only modifications to the current programming status need to be sent as program messages.
- The mnemonics used are short (maximum three characters) for maximum communication and interpretation speed - but they are easily recognized and can be sent in any sequence. For instance "SM 1.5" means: set measuring time to 1.5s.
- Numerical values for trigger levels, measuring times and conversation factors K and L are accepted in all three standardized formats: NR 1, NR 2 and NR 3 (IEEE-728, IEC-625-2, ANSI-X3.42).

Built for ATE system
Particular system requirements are met by the inclusion of some factory installed options:

Rear panel input connectors
With the option PM 9611, the counter is supplied wired with rear panel measuring input connectors instead of the front panel inputs.

Blind-panel OEM version
For OEM automatic test equipment purposes, with exclusively remote operation, the PM 6652/6654 are also available in an economy blind panel version, without display and front panel controls. (See ordering information).

Bus LEARN mode
Ease of programming is further enhanced by the bus 'learn' mode, which lets the counter write its own program messages, thereby eliminating programming errors and the need for debugging. In LOCAL mode the counter can be set manually to check whether the measurement is correctly performed. The controller can then ask the counter for the corresponding program string by sending the 'PROGRAM DATA OUT' mnemonic 'PØ' or 'P1'.

'PØ' returns the program data with all mnemonics in an uncompressed and 'readable' format. 'P1' returns the same data, in an unreadable, compressed, 43-character string. The returned data can be 'copied' by the controller and used for reprogramming the counter.

Speedy output data
Depending on the measuring function, the PM 6652/6654's high bus speed allows 30–50 measurements per second to be made when used in the normal data output mode. To record very high-speed phenomena, the high-speed dump mode enables some 400-500 measurements per second to be made. In this mode, the raw measuring data from the counting registers are output without being processed by the counter's micro-computer. The algorithms for subsequent processing in the bus controller are given in the manual.
A third output data mode is for monitoring processes or for 'go/no-go' testing. It completely eliminates the need for bus communication, as long as the measurement results are within set limits. An SRQ-alarm is given by the counter as soon as a measuring result exceeds the set limits, which values can be stored in the counter's own memory.

System reliability testing
Reliable system operation is greatly enhanced by the built-in facility of both hardware and software testing. The self-diagnostic TEST 1...5 can be activated via the bus, when the counter is not busy with measurements. Frequent checks can be made to ensure dependable hardware performance.
System hang-ups caused by, for instance, the absence of an input signal can easily be identified by the comprehensive status byte information. The PM 6652/6654 feature over 30 different status byte messages.

MEASURING MODES

PM 6652

Frequency A

Range: 0.1 Hz...120 MHz (0.01 Hz...200 kHz when HOLD-OFF is selected).

Mode: Reciprocal below 10 MHz and when HOLD-OFF, EXT GATE or AVERAGE is selected. Conventional above 10 MHz

LSD displayed:

$\frac{2.5\text{x}10^{-7}\text{s x FREQ}}{\text{measuring time}}$ (reciprocal)

$\frac{2.5}{\text{measuring time}}$ (conventional)

Resolution: 1 or 2 LSD units.

Inaccuracy:

$\pm\frac{\text{resolution}}{\text{FREQ}} \pm \frac{\text{trigger error}}{\text{measuring time}} \pm$ ±time base error.

Signal mode: CW, SINGLE BURST, MULTIPLE BURST AVG.

Ext. controls: EXT GATE, AVERAGE, ARMING.

Frequency C optional

Range: 100 MHz...1.5 GHz

Mode: Conventional. (Reciprocal when EXT GATE or AVERAGE is selected).

LSD displayed:

$\frac{40}{\text{measuring time}}$ (conventional)

$\frac{2.5\text{x}10^{-7}\text{s x FREQ}}{\text{measuring time}}$ (reciprocal)

Resolution: 1 or 2 LSD units.

Inaccuracy:

$\pm\frac{\text{resolution}}{\text{FREQ}}$ ± time base error.

Signal mode: CW, SINGLE BURST, MULTIPLE BURST AVG.

Ext. controls: EXT GATE, AVERAGE, ARMING.

Period A

Range: 100ns...100s

LSD displayed:

$\frac{2.5\text{x}10^{-7}\text{s x PERIOD}}{\text{measuring time}}$

Resolution: 1 or 2 LSD units, LSD and resolution is 100ns when SINGLE PERIOD is selected.

Inaccuracy:

$\pm\frac{\text{resolution}}{\text{PERIOD}} \pm \frac{\text{trigger error}}{\text{measuring time}} \pm$ ±time base error.

Number of cycles averaged:

$\frac{\text{measuring time}}{\text{PERIOD}}$ or a single period

Ext. controls: EXT GATE, AVERAGE, ARMING.

PM 6654

Frequency A

Range: 0.01 Hz...120 MHz (0.01 Hz...200 kHz when HOLD-OFF is selected).

Mode: Reciprocal.

LSD displayed:

$\frac{5\text{x}10^{-9}\text{s x FREQ}}{\text{measuring time}}$

When HOLD-OFF or EXT GATE is selected, see spec. for PM 6652.

Resolution: 1 or 2 LSD units.

Inaccuracy:

$\pm\frac{\text{resolution}}{\text{FREQ}} \pm \frac{\text{trigger error}}{\text{measuring time}} \pm$ ±time base error.

Signal mode: CW, SINGLE BURST, MULTIPLE BURST AVG.

Ext. controls: EXT GATE, AVERAGE, ARMING.

Frequency C optional

Range: 100 MHz...1.5 GHz

Mode: Reciprocal.

LSD displayed:

$\frac{5\text{x}10^{-9}\text{s x FREQ}}{\text{measuring time}}$

When EXT GATE is selected, see specification for PM 6652.

Resolution: 1 or 2 LSD units.

Inaccuracy:

$\pm\frac{\text{resolution}}{\text{FREQ}}$ ± time base error.

Signal mode: CW, SINGLE BURST, MULTIPLE BURST AVG.

Ext. controls: EXT GATE, AVERAGE, ARMING.

Period A

Range: 8ns...100s

LSD displayed:

$\frac{5\text{x}10^{-9}\text{s x PERIOD}}{\text{measuring time}}$

When HOLD-OFF or EXT GATE is selected, see spec. for PM 6652.

Resolution: 1 or 2 LSD units, LSD is 1ns and resolution 2ns, when SINGLE PERIOD is selected.

Inaccuracy:

$\pm\frac{\text{resolution}}{\text{PERIOD}} \pm \frac{\text{trigger error}}{\text{measuring time}} \pm$ ±time base error.

Number of cycles averaged:

$\frac{\text{measuring time}}{\text{PERIOD}}$ or a single period

Ext. controls: EXT GATE, AVERAGE, ARMING.

PM 6652

Time interval A-B, Pulse width A, Rise/Fall A; Single

Range: 100ns...10^{10}s

LSD displayed:

100ns (TIME $<10^3$s)

$\frac{5 \text{ x TIME}}{10^{10}}$ (TIME $\geq 10^3$s)

Resolution: 1 LSD unit.

Inaccuracy:

$\pm\frac{\text{resolution}}{\text{TIME}} \pm \frac{\text{trigger error}}{\text{TIME}} \pm$ ± time base error

Min. amplitude for RISE/FALL TIME measurements:

500mV$_{pp}$

Ext. controls: ARMING.

Time interval A-B, Pulse width A, Rise/Fall A; Averaged

Range: *Time Interval:* 0ns...100s
Pulse Width: 4ns...100s
Rise/Fall Time: 8ns...100s

LSD displayed: $\frac{2.5\text{x}10^{-8}\text{s}}{\sqrt{N}}$

Resolution: $\frac{100\text{ns}}{\sqrt{N}}$ or

1 LSD unit, whichever is greatest.

Inaccuracy:

$\pm\frac{\text{resolution}}{\text{TIME}} \pm \frac{\text{trigger error}}{\sqrt{N}\text{xTIME}} \pm$ ± time base error $\pm\frac{\text{syst. error}}{\text{TIME}}$

Min. dead time stop to start: 250ns

Number of samples averaged (N):

$\frac{\text{measuring time}}{\text{pulse repetition time}}$

Min. amplitude for RISE/FALL TIME measurements:

500mV$_{pp}$

Ext. controls: AVERAGE, ARMING.

PM 6654

Time interval A-B, Pulse width A, Rise/Fall A; Single

Range: 8ns...10^{10}s

LSD displayed:

1ns (TIME <10s)

$\frac{5 \text{ x TIME}}{10^{10}}$ (TIME ≥10s)

Resolution: 2ns (TIME <10s). 1 LSD unit (TIME ≥10s).

Inaccuracy:

$\pm\frac{\text{resolution}}{\text{TIME}} \pm \frac{\text{trigger error}}{\text{TIME}} \pm$ ± time base error $\pm\frac{\text{syst. error}}{\text{TIME}}$

Min. amplitude for RISE/FALL TIME measurements:

500mV$_{pp}$

Ext. controls: ARMING.

NOTE: When HOLD-OFF is selected, see spec. for PM 6652.

Time interval A-B, Pulse width A, Rise/Fall A; Averaged

Range: *Time Interval:* 0ns...100s
Pulse Width: 4ns...100s
Rise/Fall Time: 8ns...100s

LSD displayed: $\frac{2.5\text{x}10^{-9}\text{s}}{\sqrt{N}}$

Resolution: $\frac{10\text{ns}}{\sqrt{N}}$ or

1 LSD unit, whichever is greatest.

Inaccuracy:

$\pm\frac{\text{resolution}}{\text{TIME}} \pm \frac{\text{trigger error}}{\sqrt{N}\text{xTIME}} \pm$ ± time base error $\pm\frac{\text{syst. error}}{\text{TIME}}$

Min. dead time stop to start: 50ns

Number of samples averaged (N):

$\frac{\text{measuring time}}{\text{pulse repetition time}}$

Min. amplitude for RISE/FALL TIME measurements:

500mV$_{pp}$

Ext. controls: AVERAGE, ARMING.

NOTE: When HOLD-OFF or AVERAGE is selected, see specification for PM 6652.

PM 6652 and PM 6654

DUTY FACTOR A

Range:
0...(1−250ns x Pulse rep. rate)

Example: 0...0.9999 at 50 Hz
0...0.9997 at 1 kHz
0...0.5 at 2 MHz

Frequency range: 0.03 Hz...2 MHz

LSD displayed: $\frac{2.5 \times 10^{-7}s}{\text{measuring time}}$

Resolution: 100ns x pulse rep. rate/$\sqrt{N}$ or 1 LSD unit, whichever is greatest

Inaccuracy:

$$\pm \frac{4ns \times FREQ}{DUTY\ FACTOR} \pm \frac{resolution}{DUTY\ FACTOR} \pm$$

$$\pm \frac{trigger\ error}{\sqrt{N} \times PULSE\ WIDTH}$$

Number of cycles averaged (N):
Measuring time x pulse rep. rate

Ext controls: None

TOTALIZE A

Range: 1...10^{18}

Frequency range: 0...120 MHz and 0.01 Hz...200 kHz when HOLD-OFF is selected.

Pulse pair resolution: 8ns

Manual mode: Controlled by pushbutton START/STOP

External mode: Totalizing on A during pulse duration on B or between start/stop pulses on B.

Inaccuracy:

$$\pm \frac{\text{pulse rep rate A x trigger error B}}{\text{total counts}}$$

Ext controls: ARMING (not valid in manual mode).

RATIO A/B

Range: 10^{-9}...10^{10}

Frequency range:
0.1 Hz...120 MHz/0.01 Hz...10 MHz
(0.01 Hz...200 kHz/0.01 Hz...10 MHz when HOLD-OFF is selected).

LSD displayed:

$$\frac{2.5 \times RATIO}{\text{measuring time} \times FREQ\ A}$$

Resolution: 1 or 2 LSD units.

Inaccuracy:

$$\pm \frac{resolution}{RATIO} \pm \frac{\text{trigger error B}}{\text{measuring time}}$$

Ext. controls: ARMING.

RATIO C/B

Range: 10^{1}...10^{11}

Frequency range: 100 MHz...1.5 GHz /0.01 Hz...10 MHz

LSD displayed:

$$\frac{40 \times RATIO}{\text{measuring time} \times FREQ\ C}$$

Resolution: 1 or 2 LSD units.

Inaccuracy:

$$\pm \frac{resolution}{RATIO} \pm \frac{\text{trigger error B}}{\text{measuring time}}$$

Ext. controls: ARMING.

PHASE A - B

Range: 0...360° x (1−250ns x FREQ)
Example: 0...360° at 50 Hz
0...359.9° at 1 kHz
0...180° at 2 MHz

Frequency range: 0.03 Hz...2 MHz

LSD displayed:
1° Measuring time ≤180us
0.1° Measuring time 180us...1.8ms
0.01° Measuring time ≥1.8ms

Resolution: 1 LSD unit

Inaccuracy:

$$\pm \frac{4ns \times 360° \times FREQ}{PHASE} \pm \frac{Resolution}{PHASE} \pm$$

$$\pm \frac{FREQ \times 360° \times \text{trigger error}}{\sqrt{N} \times PHASE} \pm$$

$$\pm \frac{\text{systematic error}}{PHASE}$$

Input voltage:
100mV...3.5V or 1V...35V (RMS sine).

Number of cycles averaged (N):
Measuring time x FREQ A.

Ext. controls: None.

V_{max}, V_{min}, V_{pp} A

Range: −50V...+50V

Frequency range: 100 Hz...20 MHz and DC with specified performance. 20...120 MHz with reduced performance.

LSD displayed:
10mV for signals within ±5V
100mV for signals outside ±5V

Inaccuracy:
Input signals within ±5V:

$$\frac{\pm 30mV \pm 1\% \text{ of reading} \pm 1\% \text{ of } V_{pp}}{V_{max} \text{ or } V_{min}}$$

Input signals outside ±5V:

$$\frac{\pm 300mV \pm 2\% \text{ of reading} \pm 1\% \text{ of } V_{pp}}{V_{max} \text{ or } V_{min}}$$

DC-values within ±5V:

$$\frac{\pm 50mV \pm 1\% \text{ of reading}}{\text{DC-value}}$$

DC-values outside ±5V:

$$\frac{\pm 500mV \pm 2\% \text{ of reading}}{\text{DC-value}}$$

V_{pp} displayed: The result of simultaneous V_{max} and V_{min} measurements.

High-freq. error: 20 MHz...100 MHz deviation is typically ±3dB.

Ext. controls: None.

DEFINITIONS

Synchronization modes

Conventional mode means that the gate time is synchronized with an integer number of clock pulses. The error is ±1 input cycle. (Only used in the PM 6652 above 10 MHz).

Reciprocal mode means that the gate time is synchronized with an integer number of input cycles. The error is ±1 clock pulse, i.e. ±100ns (PM 6652) or ±2ns (PM 6654). The use of this mode gives 7 digits (PM 6652) or 9 digits (PM 6654) resolution for a one second measuring time.

LSD displayed

Unit value of the Least Significant Digit displayed. All calculated LSD's (see section Measuring modes) should be rounded to the nearest decade before display (e.g. 5ns will be 10ns and 0.4 Hz will be 0.1 Hz) and cannot exceed the 10th digit.

Inaccuracy

The inaccuracy (relative error) of a measurement is dependent on 4 factors:

- rel. resolution
- rel. time base error (if any)
- rel. trigger error (if any)
- rel. systematic error (if any)

Inaccuracy = ± rel. resolution ± rel. time base error ± ± rel. trigger error ± rel. systematic error.

Resolution

For multiple event measurements: FREQUENCY, PERIOD and RATIO, the resolution is the smallest increment between two measuring results. The measuring resolution is due to the ±1 count error. After calculation, the result to be displayed is truncated to include only significant digits, giving a measuring resolution of 0.2...2 LSD units. Total resolution, including LSD resolution is therefore 1 LSD unit (70% probability) or 2 LSD units (30% probability) but can always be reduced to 1 LSD unit by increasing the measuring time somewhat.

For single event measurements: PERIOD SINGLE and TIME INTERVAL SINGLE, resolution is one clock pulse period, regardless of the measuring time.

For statistical measurements: TIME INTERVAL AVERAGE, RISE/FALL TIME, PULSE WIDTH, PHASE and DUTY FACTOR, the resolution is the smallest increment between two measuring results with a confidence level of 95%.

Time base error

The relative time base error is the relative deviation of the clock pulse frequency from 10 MHz. Rel. time base error = △f/10 MHz. See spec. for oscillators.

Trigger error

Trigger error (T.E.) is the absolute measurement error due to input noise causing triggering which is too early or too late.

FREQUENCY, PERIOD, RATIO
T.E. = ± Noise Voltage (V_{pp})/Signal slew rate (V/s)
T.E. ±1/FREQ x π x S/N-ratio (sine wave)

TIME INTERVAL, RISE/FALL TIME, PULSE WIDTH, DUTY FACTOR
T.E. = ± Noise Voltage (V_p)/slew rate at START point ± Noise Voltages (V_p)/slew rate at STOP point

PHASE
T.E. = ±1/(FREQ x π x S/N-ratio) (sine wave, same S/N-ratio for both channels).

Systematic errors

When a systematic error is known, the measured value can be compensated by using the MATH function.

TIME INTERVAL, PULSE WIDTH
Syst. error < ±2ns (PM 6654) or
< ±4ns (PM 6652)

RISE/FALL TIME
Syst. error = TIME INTERVAL Syst. error ±

$$\pm \frac{2\% \text{ of } V_{pp} \text{ (A)} + 5mV}{\text{slew rate (A) at 10\% (V/s)}} \pm$$

$$\pm \frac{2\% \text{ of } V_{pp} \text{ (A)} + 5mV}{\text{slew rate (A) at 90\% (V/s)}}$$

PHASE (AC-coupling, trigger level = 0V)
Sine wave:
Syst. error < arcsin (5mV/U_{max} A)-
-arcsin (5mV/U_{max} B)

Triangular wave:

$$\text{Syst. error} < \frac{5mV \times 90°}{U_{max}\ A} - \frac{5mV \times 90°}{U_{max}\ B}$$

INPUT SPECIFICATION

Inputs A and B

Frequency range:
DC coupled: 0...120 MHz
AC coupled: 20 Hz...120 MHz

Rise time: Approx 1ns

Sensitivity: $20mV_{RMS}$ sine wave or
$60mV_{pp}$ (0...60 MHz)
$30mV_{RMS}$ sine wave or
$90mV_{pp}$ (60...120 MHz)

Min. pulse duration: 4ns

Attenuation: x1, x10 (fixed)

Hysteresis band: Approx. $40mV_{pp}$
Hysteresis compensation is automatically performed in TIME A-B, P WIDTH A, RISE/FALL A, PHASE A-B and DUTY FACTOR measuring modes; resulting in a residual hysteresis band which is virtually $10mV_{pp}$.

Dynamic input voltage range:
$60mV_{pp}$ within $\pm 5V_{pp} \pm 5V_{DC}$ (x1)
$600mV_{pp}$ within $\pm 50V_{pp} \pm 50V_{DC}$ (x10)

Trigger level selection:
Manually via keyboard (10mV steps).
Manually via potentiometers.
Auto trigger.

Trigger level range: − 5V...+ 5V (x1)
−50V...+50V (x10)

Trigger slopes: Positive or negative.

Trigger level output: Set trigger levels for channel A and B, −5V...+5V, available at rear panel (BNC-connectors).

Trigger level read-out: Set trigger levels for channel A and B are displayed with a resolution of 10mV (x1) or 100mV (x10)

Trigger indicators: Tri-state LED indication.
On: Signal is above the set trigger level.
Blinking: Triggering occurs.
Off: Signal is below the set trigger level.

AUTO trigger: The AUTO trigger will automatically set A and B trigger levels to 50% of input signal amplitude (10% and 90% for rise/fall time measurements).

Frequency range: 100 Hz...120 MHz

Measuring cycle time: Approx. 300ms + measuring time.

NOTE: Auto trigger requires a repetitive signal. Input signal may have any duty factor.

Coupling: DC/AC

Channel input: Separate A and B or common via A.

Impedance:
Separate A and B: 1 MOhm//35pF or 50Ohm nominal (A and B).
Common A: 0.5 MOhm//70pF nominal or 50Ohm nominal (A). Open input (B).

Max. voltage without damage:
1 MOhm (x1): 260V_{RMS} ≤20 kHz, declining to $12V_{RMS}$ at ≥1 MHz.
1 MOhm (x10): 260V_{RMS} ≤20 kHz, declining to $100V_{RMS}$ at 1 MHz and to $25V_{RMS}$ at 120 MHz.
50 Ohm: $12V_{RMS}$ DC...120 MHz.

Input C (Optional)

Frequency: 100 MHz...1.5GHz

Operating input voltage range:
$10mV_{RMS}$...$12mV_{RMS}$(100 MHz...1GHz)
$30mV_{RMS}$...$12mV_{RMS}$(1...1.5GHz)

Coupling: AC

Impedance: 50 Ohm nominal; VSWR ≤2

Am tolerance: 98%; minimum signal must exceed minimum operating input voltage.

Max. voltage without damage: $12V_{RMS}$; overload protection with PIN diodes.

Input D (Ext. standard in)

Range: 100 kHz...10 MHz

Coupling: AC

Impedance: 1.5 kOhm nominal

Sensitivity: $400mV_{RMS}$

Max. voltage without damage: $25V_{RMS}$

NOTE: As external reference frequency, only 10 MHz will give correct decimal point and unit indication. With the optional frequency multiplier PM 9697 references of 1 and 5 MHz can also be accepted.

Input E (Ext. reset)

Electrical reset, equivalent to front panel RESET pushbutton. Counter is reset when input E is high. A new measurement can be made after input E has returned low. The measurement will start after a delay of approx. 50ms to 100ms (depending on selected function) plus time needed for synchronization with the input signal.

Active high level: ≥2V

Passive low level: ≤0.5V

Impedance: 2 kOhm nominal

Max. voltage without damage: ±25V

Min. pulse duration: 50ns

Input F (Arming, Ext. gate, Average)

A 4-position rear panel switch gives choice of external control of the counter.

OFF: No function selected.

ARMING: The counter is prevented from starting a new measurement when input F is high. A high-to-low transition arms the counter to start a new measurement.
Arming is not applicable in TOT A (manual), PHASE and DUTY FACTOR measurements.

AVERAGE: Frequency (channel A or C), period A and time interval A-B measurements are interrupted when input F is high. The measurement is continued again when input F is low.

EXT. GATE: The signal on input F defines start and stop of the measuring time and overrides the set MEASURING TIME. The measurement will start when input F goes high, after a synchronization delay. The measurement will stop when input F returns low, after a synchronization delay.

High level: ≥2V

Low level: ≤0.5V

Impedance: 2 kOhm nominal

Max. voltage without damage: ±25V

Min. pulse duration (Arming): 200ns

Min. pulse duration (Ext. gate): 500ns

Min. pulse duration (Average), channel A:
PM 6652: 500ns
PM 6654: 200ns

Internal delay: Approx. 50ns

OUTPUT SPECIFICATIONS

Output G (10 MHz out)

Output frequency: 10 MHz

Output level: $1.3V_{pp}$ in 50Ohm load

Output protection: Short circuit proof.

Output H (Gate Open)

The gate status output allows monitoring on an oscilloscope of the actual measuring time and the trigger hold-off time.

Output levels:
Main gate closed: Approx. 4.5V
Main gate open: Approx. 0V
Hold-off time: Approx. 1.2V

Output impedance: Approx. 1.5 kOhm

internal delay: Approx. 150ns

Output protection: Short circuit proof.

Outputs I and J (Trigg level out)

Buffered output for set trigger levels on channels A and B. The range is −5V...+5V unaffected by the input attenuator setting (×1 or ×10). The outputs can be used as two independent bus programmable DACs.

Output levels: −5V...+5V

Output impedance: Approx. 2 kOhm

Output protection: Short circuit proof.

Nonlinearity error: Less than ±5mV

DC-offset: Less than ±7mV

Setting time: Less than 1ms

AUXILIARY FUNCTIONS

MEASURING TIME/DISPLAY TIME
The measuring time can be selected in three different ways:

VARIABLE: The measuring time is continuously variable 0.1ms...96s, with clear setpoints at 0.1ms, 1ms, 10ms, 0.1s, 1s, 10s and 96s. Selected variable measuring time is displayed, without any delay, when depressing the measuring time "READ" pushbutton.

MINIMUM/SINGLE: With minimum/single activated the counter will perform **single event** measurements for: PERIOD A, RATIO A/B, RATIO C/B, TIME A-B, P WIDTH A and RISE/FALL A.

A **minimum** measuring time of approx. 2μs is performed for FREQ A, FREQ C in PM 6654.

A **minimum** measuring time of approx. 1μs is performed for FREQ A, FREQ C in PM 6652 and for PHASE A-B and DUTY FACTOR A in both PM 6652 and PM 6654.

The variable MEASURING TIME/DISPLAY TIME control will now act only as display time control. The measured result is displayed during the set display time and a new measurement will start at the next input signal.

The MINIMUM/SINGLE function is useful for measurements of single-shot phenomena and measurements of signals present during a short time, e.g. single burst frequencies.

EXT GATE: The use of EXT GATE (see INPUT F specifications) will override the set measuring time. The external gate duration must be in the range 500μs...96s.

Actual measuring time: The actual measuring time equals the selected measuring time (whether being set continuously, via MINIMUM/SINGLE or via EXT GATE) plus the time needed to synchronize the measurement with an integer number of cycles of the input signal, for all reciprocal measurements.

DISPLAY HOLD: Depressing the DISP HOLD pushbutton sets display time to infinity and freezes the last measurement result. A new measurement can be initiated using RESET.

HOLD-OFF

With trigger HOLD-OFF activated the counter ignores retriggering (channel A) or stop triggering (channel B) during the set hold-off time.
The hold-off function is applicable in all channel A measuring modes and also on channel B in the TIME A-B mode. The hold-off function can be used as a lowpass filter with variable cut-off frequency between 5 Hz...150 kHz for FREQUENCY and PERIOD measurements.

Range: 5μs...200ms or 0 (OFF)

Read-out: The hold-off time is measured and displayed by pressing the READ pushbutton.

Monitor: The set hold-off duration is visible via the GATE OPEN output.

NOTE: When hold-off is active, the frequency measurements are limited to 0.01 Hz...200 kHz (PM 6652 and PM 6654) and clock resolution in all measuring modes will always be 100ns (PM 6654).

MATHEMATICS

The mathematical functions of PM 6652/PM 6654 makes it possible to offset a measuring value or to change scale factor (normalizing).

The **offset** facility allows adding or subtracting a reference value to the measured value before display, e.g. measurement of tuned reciever frequency, by measuring the local oscillator frequency (IF-offset).

The **scaling** facility allows multiplying of the measured value by a constant before display, e.g. conversation of frequency to RPM.

The scaling and offset features may be combined, so that the displayed value equals K*X+L.
X is the measured value and K and L are constants.

CHECK

10 MHz internal reference is connected to the counting logic of input channels A and B. Self-test of most measuring functions can be selected.

RESET

Manual via pushbutton or electrical via input E. Reset will clear keyboard entry status, clear an active STORE state, and/or start a new measurement.

POWER ON/STAND BY

In "ST BY" position, power is available to maintain an ovenized crystal oscillator.

TEST FUNCTION

The counter performs a choice of 5 self test routines of the logic and computing functions. The functions tested are: ROM (No. 1), RAM (No. 2), EAROM (No. 3), measuring logic (No. 4) and display (No. 5). Test No. 6 when selected will perform all tests 1...5 in a sequence.

At power-up a limited test sequence is performed.

PROGRAMS P1...P8

Eight front panel "menus" can be stored in and recalled from a non-volatile memory. All front- and rear panel settings can be stored, except hold-off value (but status of pushbutton "HOLD-OFF on/off" is stored). Programs P7 and P8 can not store the mathematical functions.

GENERAL

DISPLAY

Read out: 10 digits, sign and exponent (engineering notation) 11 mm high-efficiency LED.

Unit indicators: 3 LEDs indicating Hz, s or V.
Any prefix (kHz, μs) is indicated by the exponent on the display.

Gate lamp: Indicates that main-gate is opened and measurement takes place.

ST BY: Stand-by indication with LED when instrument is not switched ON.

REMOTE: Indicates that the counter is remotely controlled via the BUS interface option (IEC 625 - IEEE 488).

ARMED/FREQ AVG/EXT GATE: Indicates position of rear panel EXT CONTROL switch (LOCAL mode) or programmed setting of EXT CONTROL function (REMOTE mode).

Cursor: Indicates selected measuring function and/or selected front panel menu (Programs P1...P8).

POWER REQUIREMENTS

In addition to the normal line voltage supply, the PM 6652 and PM 6654 can also be powered by an external DC voltage.

Line: 115/230V ±15%; 45...440 Hz 60VA

External DC Source:
Voltage: 17V...29V; (max 2A at 24V).
Connector: Mounted on request.

Line interference: Below VDE 0871 (B) and MIL STD 461.

Safety: According to IEC 348 and CSA 556 B.

DIMENSIONS AND WEIGHT

Width: 440 mm (excl. 19'' brackets)

Height: 89 mm

Depth: 440 mm

Weight:
Net: Approx. 8 kg
Shipping: Approx. 10 kg

ENVIRONMENTAL CONDITIONS

Ambient temperature:
Storage and transport: −40°C...+70°C
Rated range of use: −5°C...+50°C
To allow air convection, at least 2 cm free space is required above and below the counter. Without any free air space around the counter (tightly packed 19 inch racks), the built-in fan option PM 9612 is necessary at ambient temperatures above 40°C.

Humidity:
Operating: 10...90% RH, no condensation
Storage: 5...95% RH

Altitude/Barometric pressure:
Operating: 5000m (1500ft) −53.3 kN/m²
Storage: 15000m (50000ft) −15.2 kN/m²

Vibration test: According to IEC 68 Fc.

Bump test: According to IEC 68 Eb.

Handling test: According to IEC 68 Ec.

Transport test: According to NLN-L88.

IEEE-488 BUS DATA (PM 9696 installed)

The PM 6652/6654 timer/counters are intrinsically IEEE-488-bus programmable. They need the built-in optional hardware interface PM 9696 to be able to communicate via the IEEE-488 bus.

INTERFACE CHARACTERISTICS

Description	Function	Capability
Source handshake	SH1	Complete
Acceptor handshake	AH1	Complete
Control function	CØ	No controller
Talker function	T5	Complete incl: Basic Talker Serial poll Talk only Unaddress if MLA
Listener function	L4	Including: Basic Listener Unaddress if MTA
Service request	SR1	Complete
Remote/local	RL1	Complete
Parallel poll	PPØ	No
Device clear	DC1	Complete
Device trigger	DT1	Complete

Addressing: The device address is switch selectable at rear panel between 0 and 30. Factory preset at 10.

Code used: 7-bit ISO-code; DI08: Passive false.

Output connector: IEEE recommended type Amphenol 57 series "Micro ribbon".

PROGRAMMING INSTRUCTIONS

Programming modes: The counter can be programmed in 3 different ways: *Remote recall of P1...P8:* Manually stored front panel menus are recalled with one single bus-command (LP1...LP8).

Bus learn mode: The programming codes for all manually set controls are sent from the counter and stored in the controller's memory with one single bus-command.
The string of codes can later be returned to the counter for reprogramming.

Normal mode: Only changes in the current programming status need to be programmed, and can be sent in an arbitrary order. Any number of spaces can be inserted anywhere in the programming string. The counter complies with IEC-625-2 and IEEE-728 and accepts all standardized formats for numeric values: NR1, NR2 and NR3.

Input delimiter: The counter accepts the following delimiters: ETX, ETB, CR, LF, CR + LF "," (comma), ";" (semicolon).

Programmable device functions

Function	Mnemonics
Meas. modes:	
Freq A...V_{pp}	F1...F15
Tests 1...6	TS1...TS6
Set meas. time	SM...
Read meas. time	RMx
Set single/min meas. time	SSx
Select trig. level mode	TLØ...TL2
Set trig. levels	AL..., BL...
Read trig. levels	RLx
Slope A, B	ASx, BSx
Attenuator A, B	AAx, BAx
Coupling A, B	ACx, BCx
Termination A, B	ATx, BTx
Com via A enable	CEx
Check	CHx
Set math constants	SK..., SL...
Math enable	MEx
Hold off enable	HEx
Read hold off time	RHx
TOT A manual gate	TOx
Store P1...P8	SP1...SP8
Load P1...P8	LP1...LP8
Ext. controls	GØ...G3
SRQ and limit monitoring	SQØ...SQ3

Trigged mode	TEx
Trigger (start new measurement)	X
Program data out	PØ, P1
Default setting (device clear)	D
High speed dump	HSx
Leading zero suppression	LEx
Set output delimiter	SDØ...SD3
Message separator EOI	MSx

NOTE: x means Ø or 1 and denotes the choice between two alternatives, e.g. on/off, pos/neg slope etc.

OUTPUT MESSAGES

Output message format: Measuring result will be sent as: FF0XXXXXXXXXXE±XD
F = Function code
0 = Normally space. "0" on overflow
X = Measuring result
(1Ø digits and a floating decimal point)
± = Exponent sign (+ or −)
X = Exponent value Ø...9
D = Delimiter

NOTE: With leading zero suppression enabled, only significant digits are sent.

High speed dump mode: The contents of the counting registers is sent to the controller without being processed by the internal microcomputer. The processing must be done in the controller instead.

Output format:
CXXXXXXXXXXXXXXXXXXXXXD
C = code specifying calculation algorithm
X = 22 decimal digits (register contents)
D = set delimiter

Limit monitoring: The MATH constants K and L will specify upper and lower limits for the measurement. When the input signal exceeds either of the limits, an SRQ-alarm is sent to the controller, Limit monitoring is not applicable in the V_{max} V_{min} measuring mode.

Output data delimiter:
Delimiters: CR, LF, CR + LF, ETX or ETB.
The default delimiter at power on or at a device clear is hardware programmed with jumpers, but can be software reprogrammed by a single bus command. Factory preset at LF.

EOI-line: The EOI line can be made active simultaneously with the last byte sent, by a single bus command.

Programming status: Current status of all programmable functions is sent to the controller as a result of "program data out" command.

Format no. 1: A sequence of 8 strings; readable; 133 ASCII-characters + delimiters.

Format no. 2: One compressed string; not readable; 43 ASCII-characters.

Status byte: The status byte is sent out as a result of a serial poll sequence.
It gives e.g. information on the following:
– Is there a service request?
(Bit 7 true/false)
– Is there an error/alarm?
(Bit 6 true/false)
– Is the counter busy or ready?
(Bit 5 true/false)
There are totally 37 possible status bytes.

TIMING CHARACTERISTICS

Max. data output rate:
Normal mode: 30–50 readings/sec.
High speed dump mode: Approx. 420 readings/sec.
V_{max}, V_{min} or V_{pp}: 3–4 readings/sec.

NOTE: The highest output rate is obtained at minimum measuring time and MATH and AUTO trigger disabled.

Output time for measuring data:
Normal mode: Approx. 5ms (18 bytes)
High speed dump mode: Approx. 2ms (24 bytes).

Response time for addressing: Approx. 5μs

Response time for trigger command (GET):
Normal mode: 500μs
High speed dump mode: 200μs

NOTE: The counter must be programmed for trigged mode and ready for measurement.

Nominal read time for programming data:
0.5...2ms/byte (average) except Test, Store and Load functions.
Test no. 1...6: 8ms/byte (average)
Store P1...P8: 240ms/byte (average)
Load P1...P8: 20ms/byte (average)

Last command in string: 0.5ms/byte (average) irrespective of command type.

OPTIONAL ACCESSORIES

ANALOG RECORDER OUTPUT PM 9695

The digital-to-analog converter PM 9695 provides a high resolution analog output e.g. for recording frequency stabilities of oscillators, filters and crystals on a strip chart recorder. In frequency control systems having analog feed-back, the DAC serves as an extremely accurate frequency-voltage converter. The PM 9695 permits conversion of any three consecutive digits; as such it functions as a magnifying glass to focus on the most important part of the read-out.

Decade conversion: Any 3 consecutive digits can be selected. The value of the least significant of the 3 digits can be selected with a 12-position switch.

LSD range: 10^{-13}...10^{-2} (s) or 10^{-4}...10^{-7} (Hz, V, degrees, counts or ratios).

Normal mode: Analog output is directly proportional to digital input. 000 produces 0.000V. 999 produces 0.999V.

Offset mode: Adds 500 to digital input to obtain half scale offset. 500 produces 0.000V. 499 produces 0.999V.

Output:
Zero output: 0V
Full scale deflection: 0.999V
Connector: BNC

Accuracy: ±2mV

Nonlinearity: ±0.5mV

Delay: Output voltage setting time <100ms after end of measurement.

Temperature coefficient: ±(0.1mV +0.03% of reading)/°C.

Output impedance: 100Ohm ±1%

EXT. REFERENCE FREQUENCY MULTIPLIER PM 9697

To accept external reference frequencies other than 10mHz, the frequency multiplier PM 9697 can be ordered.
With this option installed, the PM 6652 or PM 6654 can accept external reference frequencies of 1MHz, 5MHz or 10MHz. All other input specifications as for "Input D".

ORDERING INFORMATION

PM 6652 AND PM 6654 VERSIONS AND OPTIONS

The PM 6652/6654 ordering number exists of the basic type number and a 3 digit XYZ suffix, specifying the required customer version.

indicating maximum frequency
indicating reference oscillator
indicating interface

PM 6652/X Y Z

Type No				Description
PM 6652/0	1	1		programmable high resolution timer/counter; 120MHz basic frequency range, 100ns single shot resolution, standard oscillator 5 x 10^{-7}/month, incl. 19'' rack mount brackets, excl. IEEE-488 bus interface board.
PM 6654/0	1	1		idem, but with 2ns single shot resolution
	/5	.	.	including 1.5GHz input channel PM 9610
	/.	2	.	including crystal oscillator PM 9678
	/.	3	.	including crystal oscillator PM 9679
	/.	4	.	including crystal oscillator PM 9690
	/.	5	.	including crystal oscillator PM 9691
	/.	8	.	including standard crystal oscillator and external reference frequency multiplier PM 9697
	/.	.	2	blind panel version, including IEEE-488 bus interface PM 9696.
	/.	.	5	normal panel version, including analog recorder output PM 9695.
	/.	.	6	normal panel version including IEEE-488 bus inter face PM 9696.

OPTIONS AND ACCESSORIES

PM 9610: 1.5GHz option (input C)

PM 9611: built-in rear panel input wiring option.

PM 9612: built-in fan option.

PM 9678: TCXO time base oscillator (version /.2.)

PM 9679: ovenized time base oscillator (version /.3.)

PM 9690: ovenized time base oscillator (version /.4.)

PM 9691: ovenized time base oscillator (version /.5.)

PM 9695: analog recorder output

PM 9696: IEEE-488 bus interface

PM 9697: External reference frequency multiplier

PM 9483/50: IEEE-to-IEC adapter

PM 9487/10: IEEE cable; 1m

PM 9487/20: IEEE cable; 2m

PM 9487/40: IEEE cable; 4m

PM 9581: 50Ohm feed-through termination; 3W.

PM 9585: 50Ohm feed-through termination; 1W.

PM 8923: 120MHz; 1MOhm probe-set; 1:1 and 1:10.

PM 9639: 1.5GHz; 500Ohm probe-set; 1:10.

PM 8943: 650MHz; 50OhM/1MOhm FET probe-set.

The timebase oscillators PM 9678 to PM 9691 can also be ordered separately for later upgrading of the counters.

The PM 9611 and PM 9612 options are not customer retro-fittable, but must be ordered factory installed.

The PM 9697 multiplier can be installed only in the /.1. versions.

High resolution counters
120MHz PM 6667
1GHz PM 6668

Microprocessor-control
High resolution computing counters
Built-in intelligence for easy operation
Auto triggering on all waveforms and duty cycles
Self-diagnosis routine
15mV$_{RMS}$ sensitivity
High-stability X-tal oscillators: 10^{-7}/mth
Line and battery operation
Clear high-contrast crystal display

The microprocessor-controlled, high resolution counters PM 6667 and PM 6668 span a wide frequency range of 10Hz to 120MHz and 10Hz to 1GHz, respectively, with excellent economy. Operation is fast and the available computing power provides very high resolution capabilities normally associated with more expensive instruments.

The design incorporates an advanced technology microprocessor and dependable, large-scale C-MOS digital circuitry with fully integrated front ends which will handle a wide range of input signal voltages. Thus, the benefits of electronic performance are accompanied by a vastly reduced component count. As a result reliability and performance are increased, size and cost reduced.

Automatic triggering on all waveforms
No counter is better than its front-end circuitry, therefore special attention has been given to facilitate accurate and easy triggering. The multi-step attenuator allows attenuation of noisy input signals, giving a noise-immunity up to 10dB better than with normal x 10 attenuators.

Another state-of-the-art feature is automatic trigger level setting. Depending on the input signal waveform, the counter sets automatically the required (+, 0, −) trigger level. Correct triggering is ensured without tiresome manual adjustments, for sinewaves and also for both high and low duty cycle pulses. In addition to these advanced features, the PM 6668 front-end has automatic PIN-diode attenuation, featuring automatic triggering and excellent excessive input signal tolerance.

High resolution computing counter
By making a multiple period measurement and computing the reciprocal value, these counters perform high resolution frequency measurements on low frequency signals. The microcomputer thus eliminates the traditional ± 1 cycle error and avoids the need for long gate times or period measurements or the limitations of phase-locked frequency multipliers.

Choice of two measurement times optimizes the measurement rate to the application. In the NORMAL mode, a seven digit resolution measurement is made every one second.

The FAST mode allows the user to follow changing frequency values (as for circuit trimming) and gives a full six digit resolution every 200ms.

Greater user convenience
In addition to automatic triggering, these counters bring excellent read-out convenience by eliminating manual range selection. Independent of the input frequency, maximum resolution is assured, without any risk of overflow.

This type of manipulation, including Hz, kHz, MHz and proper decimal point indication is accomplished by the microprocessor. Easy readout is ensured by the clear, high-contrast liquid crystal display with large 11.5mm digits.

Ideal for field use
Both counters are packed in a rugged, high temperature and impact resistant polyphenylenoxide case, containing a perfectly shielding metal inner construction.
The light weight yet compact construction together with an optional battery pack and carrying case make these counters ideal for portable field use. A full battery charge gives approx. 5 hours of uninterrupted operation.

Some 15 minutes before recharging is needed, a low battery indication 'LO BAT' is given on the LCD display.

Self diagnosis

After switch-on a self test routine is executed. Should an error be detected, it is shown on the display by a diagnostic code, explained in the manual.

Quality without compromise

These compact counters have been designed to the highest possible reliability standards. They employ a PHILIPS C-MOS LSI and a single chip microcomputer that contribute to the excellent MTBF of 40 000 hours.

TECHNICAL SPECIFICATION

Frequency range
PM 6667: 10 Hz...120 MHz
PM 6668: 10 Hz...1GHz

Input sensitivity
(in 15mV$_{RMS}$ position)

LF-input: 15mV$_{RMS}$ sinewave; 100 Hz...75 MHz
25mV$_{RMS}$ sinewave; 10 Hz...120 MHz
45mV$_{pp}$ for pulses with a pulse duration of $\geq$ 7ns

RF-input: (PM 6668 only)
15mV$_{RMS}$ sinewave; 70 MHz...800 MHz
25mV$_{RMS}$ sinewave; 800 MHz...1GHz
(see input voltage characteristics)

Input attenuation
LF-input: x 1 to x 300 in 6 positions.
RF-input: automatic attenuation

Trigger level
A fixed (+, 0 or −) voltage is automatically applied to ensure proper triggering on any waveform and duty cycle.

Coupling
AC

Input impedance
LF-input: 1 MΩ//$\approx$ 25pF
RF-input: 50Ω nominal with VSWR < 2 (PM 6668 only)

Max. input voltage without damage
DC: 300V
AC: 260V$_{RMS}$ at $\leq$ 440 Hz, falling to 12V$_{RMS}$ at 1 MHz (see input voltage characteristics)

Measurement rate
Normal, (out): approx 1 measurement/s
Fast, (in): approx 5 measurements/s; at frequencies below 100 Hz, the measurement rate gradually slows down to one measurement per second to reduce the trigger error influence.

Display
7 digits, 11.5mm, liquid crystal display with unit indication of Hz, kHz, MHz and LO BAT.

Inaccuracy (relative frequency error)

$$\pm \frac{\text{LSD}}{\text{input frequency}} \pm \text{rel. trigger error} \pm \text{time base error}$$

Rel. trigger error:

For any waveshape:

$$\frac{\text{Measurement rate}}{\text{Signal slope (V/s)}} \times \text{peak-to-peak noise voltage}$$

For sinewaves:

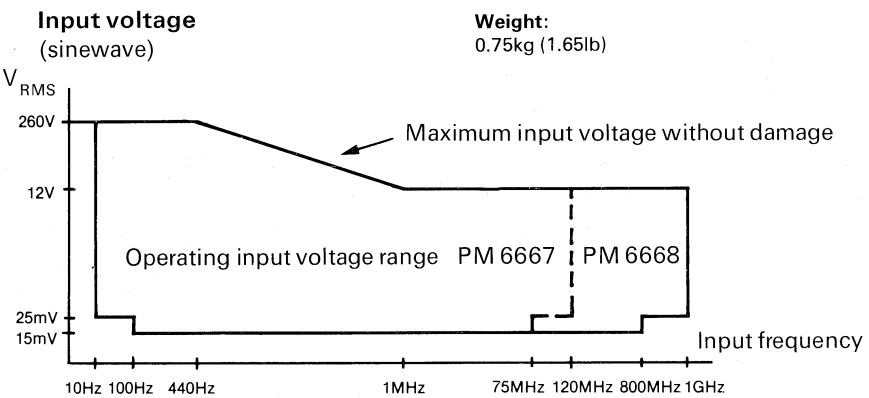
$$\frac{\text{Measurement rate}}{\text{Input frequency} \times \pi \times \text{S/N ratio}}$$

Example: for S/N ratio of 100 (40dB) and sample rate of 1 measurement/s, the trigger error is

$$\frac{3 \times 10^{-3}}{\text{input frequency}}$$

Resolution
For the least significant digit (LSD) and relative resolution see graph.

Ext. reference input
Frequency: 10 MHz
Input voltage range: 0.5V$_{RMS}$...12V$_{RMS}$
Input impedance: approx. 2kΩ



Power requirements
115/230V, ± 15%, 50...60 Hz; 15VA or by built-in optional battery pack PM 9601 or by external 12V battery.

Safety
According to IEC 348 and CSA 556 B.

Line interference
Below class II CENELEC/CISPR

DIMENSIONS AND WEIGHT

(w x h x d) 160 x 77 x 180mm
(6.3 x 3 x 7.1-in)
1.2kg (2.6lb)

ENVIRONMENTAL CONDITIONS

Temperature
Storage: −40°C...+70°C
Operating: 0°C...+45°C

Altitude/barometer pressure
Storage: 15 000m (50000ft)/15.2kN/m²
Operating: 5000m (15 000ft)/53.3kN/m²

Humidity
10%...90% RH, (26°C dew point)
Vibration test: according IEC 68 Fc
Bump test: according IEC 68 Eb
Handling test: according IEC 68 Ec
Transport test: according NLN-L88

OPTIONAL ACCESSORIES

PM 9601 Battery unit
The PM 9601 is a rechargeable battery unit for mounting inside the counters. This unit contains a standard 6V, 3Ah sealed battery of solid gel leadacid type and is provided with charging and overcharge-protection circuitry.

Capacity (typical at 20°C)
PM 6667: 6h of continuous operation
PM 6668: 4h of continuous operation

Recharging time (typical at 20°C)
10h to 90% of full capacity
5h to 70% of full capacity
Trickle change during operation (Power on).

Weight:
0.75kg (1.65lb)

ORDERING INFORMATION

PM 6667/01	120 MHz counter with standard osc.
PM 6667/02	120 MHz counter with TCXO
PM 6668/01	1GHz counter with standard osc.
PM 6668/02	1GHz counter with TCXO
PM 9601	Battery pack
PM 9602	Carrying case
PM 9603	19-in rack/panel mount adapter
PM 9665B	50kHz low pass filter BNC-BNC
PM 9326	15 MHz, 10 MΩ attenuator probe set
PM 8935	250 MHz, 10 MΩ attenuator probe set

Time base characteristics

Time base version	/01 (standard)	/02 (TCXO)
X-tal frequency	10 MHz	10 MHz
Ageing	$\leq 5 \times 10^{-7}$/month	$\leq 1 \times 10^{-7}$/month
Temperature stability		
0...50°C, ref. to +25°C	$\leq 1 \times 10^{-5}$	$\leq 1 \times 10^{-6}$
20...30°C, ref. to +25°C	$\leq 3 \times 10^{-6}$(typical)	$\leq 3 \times 10^{-7}$(typical)

IEEE 488 IEC 625

High resolution timer/counters PM 6670/6671/6672

High accuracy frequency measurements
High resolution counting
High stability X-tal oscillators up to 5 x 10^{-10}/24h
Time interval average with down to 10ps resolution
High trigger accuracy
Excellent 10mV sensitivity
Burst frequency average, Phase and RPM
Many options

These microcomputer-based timer/counters satisfy virtually all frequency and time measurement requirements. Their general-purpose versatility, wide frequency ranges, high accuracy crystal oscillators and new powerful measuring features make them ideal for research and development applications.

Lightweight, compact construction results from the dramatically reduced number of components – now down to only a few state-of-the-art Isi circuits, including a purpose-designed counter-on-a-chip and a one-chip microcomputer. Philips advanced R&D capability allows size and cost reduction while still providing the ultimate in reliability and performance.
A choice of interfaces, including the IEC 625/IEEE 488 bus puts this capability at the users' disposal for production and quality assurance testing. In addition, the optional battery unit extends the use of the instruments to field service applications.

Choice of timebase oscillator

The timebase crystal oscillator determines the accuracy limit of the counters. See summary of Xtal oscillators on p. 230.
Note that even the most stable version (5 x 10^{-10}/24h) can be operated from internal batteries. This unique feature is achieved by specially developed oven-stabilized crystal oscillators with extremely low power consumption. Thus laboratory accuracy is now available for field applications – without irritatingly long warm-up times after changing location.
By means of the external reference input, the user's own frequency standard can be used, when available.

Quick reference performance survey

Functions	Basic functions:	Extra facilities:	Options:	Trigger Hold-off	1GHz Input C
Types	Frequency: 120 MHz Period, Pulse width, Time interval; single + average, Count, Phase, RPM, Ratio Choice of 5 crystal oscillators, Sturdy metal cabinet with RFI shielding.	LED trigger indicators, Trigger level outputs, Burst frequency average, Arming, Ext. reset/start, Gate open monitor, Reference frequency input/output, Ext. DC supply 12...28V	IEC 625/IEEE 488 bus talker/listener interface, BCD output, Analog recorder output, Internal battery supply, Ext. reference frequency multiplier.		
PM 6670					
PM 6671					
PM 6672					

High resolution computing frequency counting

By making a synchronized multiple-period measurement and computing the reciprocal value these timer/counters perform high resolution frequency measurements on all low frequency signals. The built-in microcomputer eliminates traditional ± 1 cycle errors and as a result gives at least seven digits resolution per second of measuring time. This avoids the need for long gate times, period measurements or phase-locked frequency multipliers, normally required to obtain a high resolution.

High time resolution

For time interval measurements these instruments also feature a very high measuring resolution. By using the time interval **averaging** technique, these timer/counters greatly improve both the measuring accuracy and resolution.
Compared to single time interval measurements, the basic 100ns resolution is improved by a factor of $\sqrt{N}$, where N is the number of time intervals being averaged.
With the PM 6670/71/72, N can be more than 10^8. The resolution then becomes:

$$\frac{100\ ns}{\sqrt{10^8}} = 10ps$$

High trigger accuracy

Ultimately, no counter is better than its front-end circuitry. Therefore the PM 6670 series employs the best front-end circuit concept available.

These timer/counters feature special input signal conditioning configurations, which are optimized for both frequency and time interval measurements, e.g. either adjustable trigger levels for time interval measurements or adjustable sensitivity and noise immunity for frequency measurements.

For time measurements

Meaningful use of the averaging technique is made through the high-speed synchronizers and equalized input channels. Amplifiers and Schmitt-trigger circuits for both start and stop channel are all on the one IC-chip, thereby avoiding differences in delay and rise-times, such as are found in conventional counters. This reduces systematic trigger errors which cannot be eliminated by averaging.
Systematic trigger errors are further reduced by the low hysteresis via the use of high sensitivity input amplifiers, as shown in Fig. 1b.
The PM 6671 and 6672 feature trigger level outputs on the front panel, allowing accurate measurements to be made of the set trigger level with a DVM. The trigger level can also be positioned accurately with respect to the waveform using an oscilloscope.

For frequency measurements

For frequency measurements, the trigger control can be selected to act as a wide-band, **continuously variable** input attenuator (x 1...x 100) to allow optimum matching of trigger sensitivity and noise immunity.

Noise rejection filter

To obtain full benefit from the high resolution reciprocal design, noise and interference can be excluded by a switchable built-in noise-rejection filter for low frequency measurements. This filter even rejects HF noise or interference that is stronger than the input signal itself (see fig. 2).

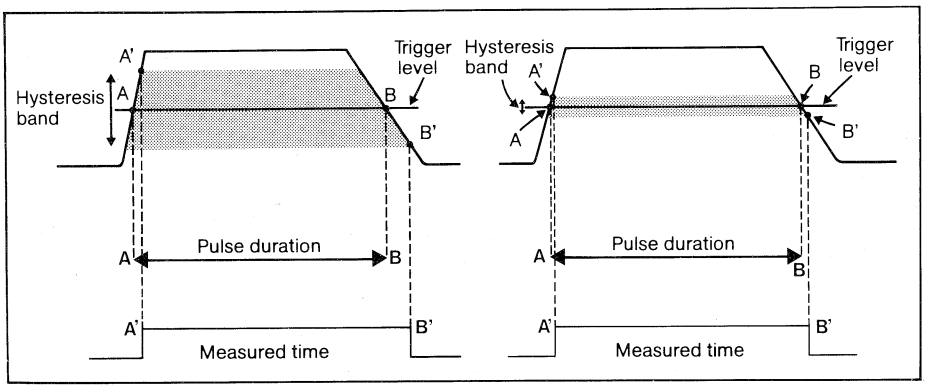


Fig. 1a. A wide hysteresis band (poor sensitivity) introduces measurement errors, as illustrated.

Fig. 1b. In the PM 6670/71/72, the low hysteresis voltage (typ. 10mV$_p$) minimises the error.

Automatic triggering on RF signals

The 1GHz model PM 6672 has a special RF input with front-end circuits that feature advanced RF techniques, including automatic PIN-diode attenuators that bring a number of user benefits:
– Automatic triggering
– Excellent overload protection; 12V$_{RMS}$
– High AM tolerance: up to 98%
– Wide dynamic range:
15mV$_{RMS}$...12V$_{RMS}$

RFI suppression

Effective precautions have been taken to reduce radiation and susceptibility to radio frequency interference (RFI) to minimum levels. For example, all the counters are encased in sturdy metal cabinets, which provide excellent RFI shielding. Reduction of RFI radiation far below the most severe requirements, including VDE 0871 (B) and MIL STD 461, contributes to the superior accuracy of the range.

Variable measuring time

A valuable microcomputer benefit is the continuously variable measuring time, which is no longer limited to decade steps. It is possible, for example, to select a measuring time of 2.4 seconds if one second does not give sufficient resolution. This avoids the need to switch directly to a time-wasting 10 second measurement period.

Phase and RPM

Another microcomputer benefit in these timer/counters is the possibility of new measuring functions – such as phase and RPM (revolutions/minute) – which are not normally found in counters.
A simultaneous measurement of period duration and the phase delay between two signals allow the microcomputer to calculate and display phase delays directly in degrees.

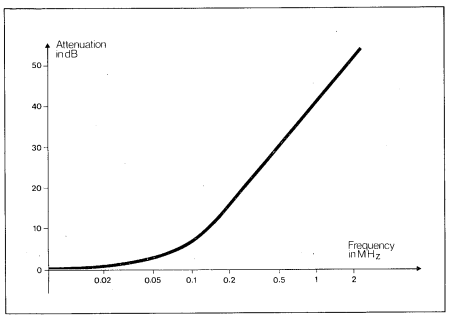


Fig. 2. Noise rejection filter characteristic. When switched on, all HF noise and interference signals are suppressed as indicated.

Trigger Hold-Off and Arming

The PM 6671/72 give full control over the start conditions of a measurement. With an external gate signal, one can prevent the timer/counter from being triggered by unwanted signals. An **arming** pulse then enables the timer/counter to trigger on the first input signal.

Another useful feature, found on the PM 6671 is **trigger hold-off**, which avoids false stop triggering on spurious or unwanted signals. A typical example is the pulses from relay contact bounce, see fig. 3.

Trigger indicators

Tri-state **trigger indicator** LED's on the PM 6671/72 facilitate quick setting of the trigger level. LED's for channel A and B blink to indicate that these inputs are triggered. Lights on/off indicate that the trigger level is too low/high (see Fig. 4).
This feature is of great help particularly when making time interval measurements, where both channels have to be triggered correctly.

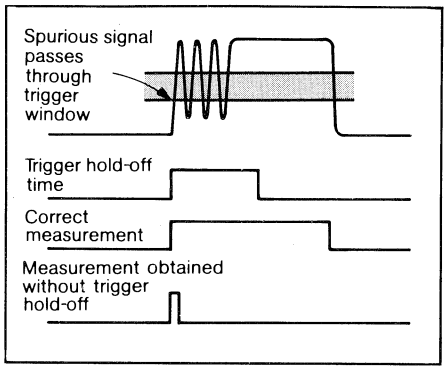


Fig. 3. The use of the PM 6671 variable trigger hold-off enables the influence of spurious signals such as ringing or relay bounce to be ignored and correct measurements obtained.

TECHNICAL SPECIFICATION

MEASURING MODES

FREQUENCY

Range:
0.1 Hz...120 MHz (PM 6670, 6671)
0.1 Hz...1GHz (PM 6672)

Mode: Input-signal synchronized, high resolution computing measuring method (reciprocal).

Signal mode:
CW, SINGLE BURST, MULTIPLE BURST FREQUENCY AVERAGE. In the FREQUENCY AVERAGE mode (rear panel selectable), the counter measures the average of a multiple of frequency samples. Samples are taken with external gate control (≥ 500 ns) and totalized during the selected measuring time (10 ms...96 s) to allow multiple burst frequency measurements or to sample frequency sweep profiles.

LSD displayed:
10^{-7} Hz...10^{3} Hz (PM 6670, 6671). 10^{-7} Hz...10^{4} Hz (PM 6672), depending on measuring time and input frequency. At least 7 digits displayed per second of measuring time.

Resolution: LSD*

Inaccuracy (rel. error):

$$\pm\frac{\text{resolution}}{\text{FREQ}}\pm\frac{\text{trigger* error}}{\text{measuring time}}\pm\text{rel. time base error.}$$

PERIOD AVERAGE

Range: 100 ns...100 s

LSD displayed:
10^{-15}...10^{-6} s, depending on measuring time and period duration. At least 7 digits displayed per second of measuring time.

Resolution: LSD*

Inaccuracy (rel. error):

$$\pm\frac{\text{resolution}}{\text{PERIOD}}\pm\frac{\text{trigger* error}}{\text{measuring time}}\pm\text{rel. time base error}$$

TIME INTERVAL A TO B; SINGLE

Range: 100 ns...10^{8}s

LSD displayed: 10^{-7}s...10^{0}s

Resolution: LSD*

Inaccuracy (rel. error):

$$\pm\frac{\text{resolution}\pm\text{trigger* error}}{\text{TIME INT}}\pm\text{rel. time base error}$$

PULSE WIDTH A

Pulse width measurements are similar to single time interval measurments. Both start and stop triggering take place in channel A, with common trigger level setting and automatic trailing edge trigger slope inversion with respect to selected leading edge trigger slope.

All other specifications are identical to single time interval. High resolution, pulse width measurements on narrow pulses can be made in the time interval average mode with manual selection of common source and stop slope polarity.

TIME INTERVAL A TO B; AVERAGE

Range: 0 ns...100s

LSD displayed: 10^{-15}s...10^{-6}s, depending on measuring time and time interval.

Resolution

$$\frac{10^{-7}\text{ s}}{\sqrt{N}}$$ or 1 LSD unit, whichever is greater.

Inaccuracy (rel. error):

$$\pm\frac{4\text{ ns}\pm\text{resolution}}{\text{TIME INT}}\pm\frac{\text{trigger* error}}{\sqrt{N}\times\text{TIME INT}}\pm\text{rel. time base error.}$$

Number of intervals averaged (N)
Measuring time x interval repetition rate.

Minimum dead time from stop to start: 300 ns

Note: Input signal must be repetitive and asynchronous with respect to the time base.

COUNT A

Totalize range: 1...10^{17}, with indication of M-pulses and G-pulses beyond the 10^{8} display range.

Pulse pair resolution: 80 ns

Mode:
Manual: Start-stop by DISPL. HOLD push button. Sequential start-stop periods are accumulated or individually totalized after reset.
External: Totalizing interval controlled via input B, selectable: count A gated during pulse duration on B or count A gated between start and stop pulse on B.

Inaccuracy: Pulse repetition rate A x trigger* error B.

PHASE A-B

Phase is the result of a simultaneous time interval average and period average measurement. The maximum phase range is therefore limited, due to the 300 ns dead time between stop and start of the next time interval, and consequently frequency dependent. For phase measurements between 180° and 360° on high frequency signals measure the complementary phase 0°...180° by changing the input leads (phase B to A).

Phase range: 0.1°...360° x [1 – (300 ns x FREQ)]

Example: 0.1°...359.995° at 50 Hz
0.1°...357.3° at 25kHz
0.1°...180° at 1.666 MHz

Frequency range: 0.03 Hz...1.6 MHz

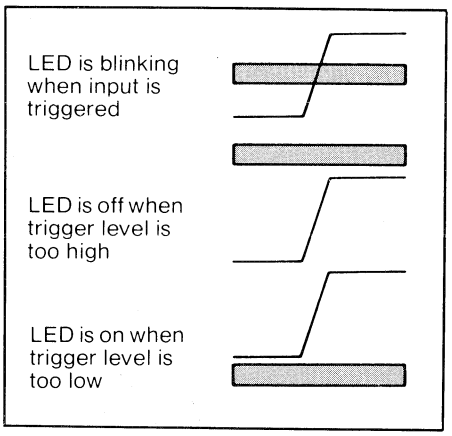


Fig. 4. Tri-state LED trigger indicators facilitate quick trigger level setting.

LCD displayed: 10^{-6}...10^{-2} degrees, depending on measuring time and phase difference.

Resolution:

$$\frac{10^{-7}\text{ s x FREQ x }360^{\circ}}{\sqrt{N}}$$

Inaccuracy (rel. error)

$$\pm\frac{4\text{ ns x }360^{\circ}\text{ x FREQ}}{\text{PHASE}}\pm\frac{\text{resolution}}{\text{PHASE}}\pm$$

$$\pm\frac{\text{trigger* error x FREQ x }360^{\circ}}{\sqrt{N}\text{ x PHASE}}$$

Number of input cycles averaged (N)
Measuring time x FREQ. A.

Minimum input signal: 100 mV_{RMS}.

Phase jitter tolerance: The tolerated phase jitter peak-value ≤ phase difference, i.e. phase jitter around 0° should not cause consecutive measurement results of slightly above 0° and slightly below 360°, since the total measurement result is the statistical average of all individual results.

RATIO

Range

$$\frac{\text{FREQ A}}{\text{FREQ B}}=\frac{0...10\text{ MHz}}{0...10\text{ MHz}}\text{ (all models)}$$

LSD displayed: 10^{-7}...10^{0}

Resolution: LSD*

Inaccuracy (rel. error)

$$\pm\frac{\text{resolution}}{\text{RATIO}}\pm\text{rel. trigger* error B.}$$

Note: Frequency ratio measurements

$$\frac{\text{FREQ A (or C)}^{**}}{\text{FREQ D}}=\frac{0.1\text{ Hz...120 MHz (or 1 GHz)}^{**}}{50\text{kHz...10 MHz}}$$

can also be made in the frequency mode, by making use of the external reference input D. However, this arrangement does not give correct decimal points.

RPM

The RPM (revolutions per minute) mode is similar to the frequency mode. The measured frequency is multiplied x 60 before being displayed.

Range: 0.6 RPM...10^{8} RPM (with one pulse per revolution).

LSD displayed: 10^{-7} RPM...10^{0} RPM, depending on measuring time and RPM.

Resolution: LSD*

Inaccuracy (rel. error):

$$\pm\frac{\text{resolution}}{\text{RPM}}\pm\frac{\text{trigger* error}}{\text{measuring time}}\pm\text{rel. time base error.}$$

AUXILIARY FUNCTIONS

MEASURING TIME

The measuring time is "continuously" variable (33 steps/decade): 10 ms...96 s, with clear setpoints at 10 ms, 100 ms, 1s, 10s and 96s. Selected measuring time is displayed, without any delay, when depressing the measuring time control.

The actual measuring time equals the selected measuring time plus the time needed to synchronize the measurement with an integer number of cycles of the input signal. (Reciprocal measurements are synchronized with multiples of 10 input cycles).

In the FREQUENCY AVERAGE mode, the measuring time can be externally controlled to make burst frequency average measurements.

HOLD-OFF PM 6671 only
With trigger hold-off activated, the counter ignores re-triggering (channel A) or stop triggering (channel B) during the set hold-off time. The hold-off time can be digitally measured by pressing CHECK.
Applicable in all time modes.

* *See definitions*
** *C only on PM 6672*

Range: 200μs...200 ms, in period, time interval and pulse width mode, the set hold-off time is visible with CHECK depressed.

On/off indication: LED indicates when hold-off is activated.

Monitor: The selected hold-off duration can be made visible via the gate monitor output.

ON STAND BY
In "ST BY" position, power is available to maintain an ovenized crystal oscillator heated and to recharge the optional battery pack.

CHECK
10 MHz internal reference connected to logic circuitry. Self-test of most measuring functions can be selected. By using this mode, the COUNT function provides a stop-watch facility.

DISPLAY HOLD
Depressing "DISP HOLD" button sets display time to infinite and freezes the last measurement result. A new measurement can be initiated using reset.
In the COUNT mode, the "DISP HOLD" control is used to start and stop manual totalizing.

RESET
Manual via pushbutton or electrical via input E.

—— INPUT AND OUTPUT SPECIFICATIONS ——

INPUTS A AND B

Frequency range
DC coupled: 0...120 MHz
AC coupled: 50 Hz...120 MHz

Rise time: Approx. 4 ns

Sensitivity
DC coupled: 10 mV_{RMS} sine wave or
30 mV_{pp} (0...75 MHz)
20 mV_{RMS} sine wave or
60 mV_{pp} (75...120 MHz)
AC coupled: 10mV_{RMS}...100mV_{RMS} sine wave (0...75 MHz)
20mV_{RMS}...100mV_{RMS} sine wave (75...120 MHz)

Attenuation: x 1/x 10 fixed.
For frequency related measurements, the fixed attenuator can be used in combination with the continuously variable attenuator x 1...x 10 (AC coupled position).

Noise immunity/hysteresis band
DC coupled: approx. 20mV_{pp}/200mV_{pp}.
AC coupled: approx. 20mV_{pp}...2V_{pp}.

Dynamic input voltage range
DC coupled: 30mV_{pp}...5V_{pp}/300mV_{pp}...50V_{pp}.
AC coupled:
10mV_{RMS}...2V_{RMS}/100mV_{RMS}...20V_{RMS}.

Trigger level:
DC coupled: −2.5V...+2.5V/−25V...+25V
AC coupled: fixed 0V; level control acts as continuously variable attenuator, which is more suitable for frequency related measurements.

Trigger level output, not available on PM 6670
Set trigger voltages − 2.5V...+ 2.5 V, available on 1 mm jacks at the front for monitoring of set trigger level.

Trigger indicators, not available on PM 6670
Tri-state LED trigger lights to indicate trigger status:

On: trigger level is too low.
Blinking: triggering occurs, input signal crosses hysteresis band.
Off: trigger level is too high.

Coupling: DC/AC.

Impedance: Approx. 1 MΩ//35pF, independent of sep/com switch position.

Channel input: Separate A and B or common A.

Noise filter: Switchable 50kHz Low pass filter in channel A. Noise suppression approx. 40dB at 1 MHz

Maximum voltage without damage
DC: 300V.
AC: 260V_{RMS} at ≤ 440 Hz declining to 12 V_{RMS} at ≥ 1 MHz (in ATT x 1 position), 260V_{RMS} (in ATT x 10 position).

INPUT C PM 6672 only

Frequency range: 70 MHz...1GHz

Operating input voltage range
15mV_{RMS}...12V_{RMS} (70 MHz...800 MHz).
25mV_{RMS}...12V_{RMS} (800 MHz...1GHz).

Impedance: 50Ω nominal; VSWR < 2.

Coupling: AC

AM tolerance:98%; minimum signal must exceed minimum operating input voltage.

Maximum voltage without damage
12V_{RMS}; overload protection with PIN diodes.

EXT. REFERENCE AND RATIO INPUT (CHANNEL D)
not available on PM 6670

Frequency range: 50kHz...10 MHz

Sensitivity: 500mV_{RMS}

Impedance: Approx. 2kΩ

Coupling: AC

Max. voltage without damage: 25V_{RMS}

Note: As external reference frequency, only 10 MHz will give correct decimal point and unit indication. With the optional frequency mulitplier PM 9697 references of 1 and 5 MHz can also be accepted.

INTERNAL STANDARD OUTPUT (CHANNEL D)
not available on PM 6670

Crystal frequency: 10 MHz

Output level: LS-TTL compatible

Output impedance: Approx. 400Ω

Coupling: DC

Overload protection: Short-circuit proof

EXT. ARMING/FREQ-AVG/RESET (CHANNEL E)
not available on PM 6670
A 3-position rear panel switch gives choice of external control over:

ARMING: In this position, the counter is prevented from starting a new measurement when input E is high. A high-to-low going pulse arms the counter to start a new measurement.

Note
Arming not applicable in COUNT A, manual mode.

FREQUENCY AVERAGE: Frequency measurements (max. 100 MHz) and period measurements are interrupted when input E is high. The measurement is continued again when input E is low. Each individual frequency sample must contain at least 20 pulses (FREQ mode) or 2 pulses (PERIOD mode).

The effective measurement time (defining resolution and accuracy) is the sum of external gate times that occurs during the selected measurement time.

EXT. RESET – START: Electrical reset, equivalent to the front panel RESET pushbutton. (See HOLD and RESET). Counter is reset when input E goes high. A new measurement can be made after input E has returned low.

Input levels
High: ≥ 2V
Low: ≤ 0.5V

Input impedance: Approx 2kΩ

Max. input voltage without damage: ± 25V

Minimum pulse duration
Arming and frequency avg: 500ns
External reset: *200 μs*

GATE MONITOR OUTPUT (REAR)
not available on PM 6670

The gate status monitor output permits observation on an oscilloscope of the measured time interval and the trigger hold-off time (PM 6671 only).

Output level
Main gate open: approx. 0.4V
Hold-off active: approx. 1.2V
Main gate closed: approx. 2.5V

Output impedance: Approx. 1.5kΩ

Delay: Internal delay between actual triggering and gate monitor output is approx. 150 ns.

Overload protection: Short circuit proof.

—— GENERAL ——

DISPLAY

Read out: 8 digits, 7.6 mm high-efficiency LED's. Microprocessor control of display format, decimal point and unit indication: Hz, kHz, MHz, GHz, ns, μs, ms and s.

Display time: Continuously variable 80 ms...96 s plus DISP HOLD.

Gate lamp: Indicates that main-gate is opened and measurement takes place.

ST BY: Stand-by indication with LED when instrument is not switched ON.

REMOTE*: Indicates when control over counter is taken by the installed BUS interface option (IEC 625-IEEE 488).

Low-battery*: Indication by blinking display some 15 min. before recharging is needed.

POWER REQUIREMENTS
In addition to the normal line voltage supply, the PM 6671 and PM 6672 can also be powered from an optional battery pack or external DC voltage.

Line: 115/230V ± 15%; 45...440 Hz; < 25 VA

Internal battery unit*: PM 9693

External DC Source*
Voltage: 11.8V...28V; 4.5...8W depending on version and options installed.
Connector: Battery jack fitting DIN 45323.

Line interference: Below VDE 0871 (B) and MIL STD 461

Safety: According to IEC 348 and CSA 556 B

DIMENSIONS AND WEIGHT

(w x h x d) 210 x 89 x 280
(8.25 x 3.8 x 11-in)
2.5kg (5.5lb)

ENVIRONMENTAL CONDITIONS

Temperature
Rated range of use: −5°C...+50°C
Storage and transport: −40°C...+70°C

Humidity
Operating: 10...90% RH, no condensation.
Storage: 5...95% RH.

Altitude/Barometric pressure
Operating: 5000 m (15000 ft) −53.3 kN/m².
Storage: 15000 m (50000 ft) −15.2 kN/m².

Vibration test: According to IEC 68 Fc

Bump test: According to IEC 68 Eb

Handling test: According to IEC 68 Ec

Transport test: According to NLN-L88

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* *Not available on PM 6670*

DEFINITIONS

LSD DISPLAYED
Unit value of least significant digit, displayed.

For FREQUENCY, PERIOD AVERAGE, RPM and PHASE

$$LSD = \frac{2.5}{\text{measuring time}} \times \frac{\text{FREQ or PERIOD or RPM or } 360^\circ}{10^{-7}\ \text{Hz}}$$

For RATIO

$$LSD = \frac{2.5 \times \text{prescaling factor (P)} \times \text{RATIO}}{\text{measuring time} \times \text{FREQ A or C}}$$

(P) = 1 Channel A, all models
(P) = 256 Channel C, PM 6672

For SINGLE TIME INTERVAL and PULSE WIDTH
LSD = 100 ns (for times < 10s).

$$LSD = \frac{5 \times \text{TIME}}{10^8} \text{ (for times} \geqslant \text{10s).}$$

For TIME INTERVAL AVG

$$LSD = \frac{2.5 \times 10^{-7}\ \text{s}}{\text{meas. time} \times \text{time int. rep. rate in Hz}}$$

All calculated LSD's shall be rounded to nearest decade (e.g. 5 ns will be 10 ns and 0.4 Hz will be 0.1 Hz) and cannot exceed the 8th digit.

RESOLUTION

For multiple event measurements
FREQUENCY, PERIOD AVERAGE, RPM and RATIO, the resolution is the smallest increment between two measuring results, being most often 1 LSD unit. Due to arithmetic truncation, the resolution can be 2 LSD units if:

$$\frac{\text{LSD} \times \text{measuring time}}{\text{FREQ or PERIOD or RPM or RATIO}} < 10^{-7}\ \text{s}$$

but can then be reduced to 1 LSD unit, by doubling the measuring time.

For single event measurements
PULSE WIDTH and SINGLE TIME INTERVAL, the measuring resolution is 100 ns (one clock pulse). The counter can accumulate up to 10^{15} clock pulses, of which only the 8 most significant digits are shown.

For statistical measurements
TIME INTERVAL AVERAGE and PHASE, the measuring resolution is the smallest increment between two measuring results, with confidence level of 95%.

TRIGGER ERROR
Trigger error is the absolute measurement error due to noise on the input signal causing a too early or too late triggering.

For any waveform (FREQ, PERIOD, RATIO, RPM and PULSE WIDTH):

$$\frac{\text{peak-to-peak noise voltage}}{\text{signal slope (V/s)}}$$

For sinewave (FREQ, PERIOD, RATIO, RPM)

$$\frac{1}{\text{FREQ} \times \pi \times \text{S/N ratio}}$$

Example: For S/N ratio of 100 (40 dB) and 1 second measuring time, the trigger error is: $\frac{3 \times 10^{-3}}{\text{FREQ}}$

For separate source TIME INTERVAL

$$\frac{\text{peak noise voltage (input A)}}{\text{signal slope A (V/s)}} \pm \pm \frac{\text{peak noise voltage (input B)}}{\text{signal slope B (V/s)}}$$

For PHASE

$$\frac{1}{\text{FREQ} \times 2\pi} \times \left[\frac{1}{\text{S/N ratio (input A)}} \pm \frac{1}{\text{S/N ratio (input B)}} \right]$$

Note: S/N ratios calculated with peak-to-peak signal and noise values.

ORDERING INFORMATION

PM 6670/01: 120 MHz timer/counter*
PM 6671/01: 120 MHz timer/counter* (extended facilities).
PM 6672/01: 1GHz timer/counter*

PM 667./02: idem, but including PM 9678
PM 667./03: idem, but including PM 9679
PM 667./04: idem, but including PM 9690
PM 667./05: idem, but including PM 9691

The timebase oscillators PM 9678 to PM 9691 can also be ordered separately for later upgrading of the counters.

Options, PM 6671 and 6672 only

PM 9693: battery unit
PM 9694: BCD output and display offset unit
PM 9695: analog recorder output
PM 9696: IEEE 488-BUS interface
PM 9483/50: IEEE-to-IEC adapter
PM 9487/10: IEEE cable; 1 m
PM 9487/20: IEEE cable; 2 m
PM 9487/40: IEEE cable; 4 m
PM 9697: external reference frequency multiplier.

Attention
The counters can NOT simultaneously be equipped with more than one of the following options: PM 9693, PM 9694, PM 9695 and PM 9696.

The muliplier PM 9697 can only be installed simultanously with the /01 oscillator.
For installation in other versions, the oscillator first has to be removed.

OPTIONAL ACCESSORIES

These are listed on p. 251.

IEC/IEEE INTERFACE DATA

IEEE interface option PM 9696

Can be supplied fitted (to order), or retrofitted in the field.

Connector
24-pole: address set by switches

Interface functions

SH1	Source handshake
AH1	Acceptor handshake
T5	Talker with talk only, serial poll and automatic unaddress if MLA **Output data:** Measuring data including function code, overflow and range. Status data, generated at serial poll or after instruction, including full programming status data and function status.
L4	Listener with automatic unaddress if MTA **Input data:** Programming data for all manually controllable functions except input trigger functions
SR1	Service request, generated in case of data available
RL1	Local-remote control by system
DC1	Device clear; default position = Frequency A, no hold-off, repetitive measurements, service request disable and measuring time 0.3s
DT1	Device trigger by GET and data byte X
Codes	ISO 7-bit code; DIO8 passive false. Input delimiter, ETX, LF, CR, ETB'','' Output delimiter ETB/ETX, CR, LF or CR + LF

* *Incl. standard time base oscillator*

High resolution counting
Error-free triggering
High stability crystal oscillators up to 5 x 10^{-10}/24h
Programmable
High 10mV sensitivity
Multiple burst frequency average
Battery operation
19-inch rackmount adapter
BCD or analog output

IEEE 488 IEC 625

Reciprocal universal frequency counters PM 6673/PM 6674/ PM 6675/PM 6676

Philips' new microcomputer-based universal frequency counters satisfy virtually all frequency measurement requirements. Their high accuracy concept, wide frequency ranges and new powerful measuring features make these counters ideal for research and development of telecommunication, broadcast, TV, radio control and navigation equipment.
Lightweight, compact construction results from the dramatically reduced number of components – now down to only a few state-of-the-art lsi circuits, including a purpose-designed counter-on-a-chip and a one-chip microcomputer.
Philips advanced R & D capability yields reduction, size and cost while still providing the ultimate in reliability and performance.
A choice of interfaces, including the IEC 625/IEEE 488 bus put this capability at the user's disposal for production and quality assurance testing. In addition, the optional battery unit extends the use of the instruments to field service applications.

High resolution computing counting

By making a synchronized multiple-period measurement and computing the reciprocal value, the counters perform **high resolution** frequency measurements on all low frequency signals. The built-in microcomputer eliminates traditional ± 1 cycle errors and as a result gives at least seven digits resolution per second of measuring time. This avoids the need for long gate times, period measurements or phase-locked frequency multipliers, normally required to obtain a high resolution. Above 10 MHz, the conventional counting method is automatically selected, to give improved resolution at the higher frequencies (see Fig. 1).

Error-free triggering

Ultimately, no counter is better than its front-end circuitry. Therefore the PM 6670 series employs the best front-end circuit concept available. A wideband, **continuously variable** input attenuator allows optimum matching of trigger sensitivity and noise immunity over a wide dynamic range from 20mV_{pp} to 10V_{pp}.

To obtain full benefit from the high resolution reciprocal design, meaningless digits can be excluded by a switchable built-in noise-rejection filter for low frequency measurements. This filter even rejects HF noise or interference that is stronger than the input signal itself (see Fig. 2).

Automatic triggering on RF signals

The UHF counter models PM 6674, 6675 and 6676 have special RF inputs up to 550 MHz, 600 MHz and 1.5GHz respectively. Their front-end circuits feature advanced RF techniques, including automatic PIN-diode attenuators, that bring a number of user benefits:
– Automatic triggering
– Excellent overload protection; 12V_{RMS}
– High AM tolerance: up to 98%
– Wide dynamic range: 10mV_{RMS}...12V_{RMS}

For high-speed/high accuracy measurements, the „extra powerful" 600 MHz model PM 6675 offers special features, such as direct gating (non-prescaled) and a high 5mV_{RMS} sensitivity.

RFI suppression

Effective precautions have been taken to reduce radiation and susceptibility to

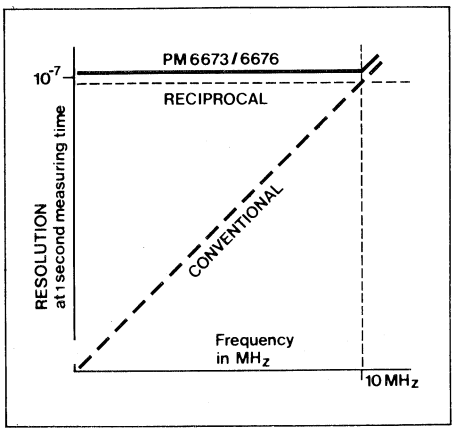


Fig. 1. The PM 6670 series benefits from both RECIPROCAL and CONVENTIONAL measuring principles. Automatic selection of the measuring mode always gives the best possible resolution.

radio frequency interference (RFI) to minimum levels. For example, all the counters are encased in sturdy metal cabinets, which provide excellent RFI shielding. Reduction of RFI radiation far below the most severe requirements, including VDE 0871 (B) and MIL STD 461, contributes to the superior accuracy of the range.

Variable measuring time

Another microcomputer benefit is the continuously variable measuring time, which is no longer limited to decade steps. It is possible, for example, to select a measuring time of 2.4 seconds if one second does not give sufficient resolution. This avoids the need to switch directly to a time-wasting 10-second measurement period.

Choice of timebase oscillators

The timebase crystal oscillator determines the accuracy limit of the counters. (See the summary of X-tal oscillators on p. 4).

Note that even the most stable version (5 x 10^{-10}/24h) can be operated from internal batteries. This unique feature is achieved by specially developed oven-stabilized crystal oscillators with extremely low power consumption. Thus laboratory accuracy is now available for field applications – without irritatingly long warm-up times after changing location.
By means of the external reference input, the user's own frequency standard can be used, when available.

Frequency average

The use of microcomputers provides new opportunities in frequency measurements. The computing measuring principle, with synchronized sample-taking, enables frequency and period measurements to be made during one or a great number of measuring intervals. Start and duration of these intervals are controllable via an external gate input.
Individual samples may be as short as 500ns or as long as 96 seconds.
Multiple burst frequency measurements or sampling **frequency sweep profiles** can be activated by a single control.

Quick reference performance survey

Functions / Types	FREQUENCY – High resolution reciprocal method + PERIOD + COUNT	FREQUENCY + RATIO	
		channel A	RF channel B
PM 6673/0	10 MHz	120 MHz	n.a.
PM 6674/0	10 MHz	120 MHz	550 MHz, 6 x prescaled
PM 6675/0	10 MHz	120 MHz	600 MHz, direct gating
PM 6676/0	10 MHz	120 MHz	1.5 GHz, 16 x prescaled

TECHNICAL SPECIFICATION

MEASURING MODES

FREQUENCY
Range
Sine: 10 Hz...120 MHz (PM 6673)
10 Hz...550 MHz (PM 6674)
10 Hz...600 MHz (PM 6675)
10 Hz...1.5GHz (PM 6676)
Pulse: Minimum frequency down to 0.1 Hz

Mode: RECIPROCAL and CONVENTIONAL.
For the highest possible resolution for both LF and HF measurements, the counter employs the RECIPROCAL mode for LF signals. Above 10 MHz it automatically uses the CONVENTIONAL mode.

For special applications, one can select either RECIPROCAL or CONVENTIONAL.

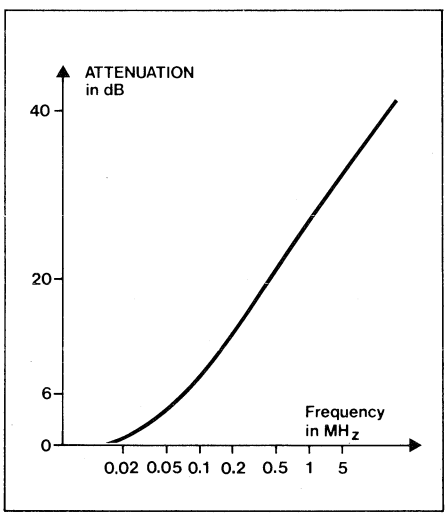


Fig. 2. Noise rejection filter characteristic. When switched on, all HF noise and interference signals are suppressed as indicated.

Signal mode:
CW, SINGLE BURST, MULTIPLE BURST FREQUENCY AVERAGE. In the FREQUENCY AVERAGE mode (rear panel selectable), the counter measures the average of a multiple of frequency samples. Samples are taken with external gate control (≥ 500ns) and totalized during the selected measuring time (10ms...96s) to allow multiple burst frequency measurements or to sample frequency sweep profiles.

LSD displayed:
10^{-8} Hz...10^{2} Hz (PM 6673 and PM 6675), 10^{-8} Hz...10^{3} Hz (PM 6674 and PM 6676), depending on measuring time and input frequency. At least 7 digits displayed per second of measuring time.

Resolution: LSD*

Inaccuracy (rel. error):
$\pm \frac{\text{resolution}}{\text{FREQ}} \pm$ rel. trigger* error
$\pm$ time base error

PERIOD AVERAGE

Range: 100ns...100s

LSD displayed: 10^{-16}...10^{-6}s; depending on measuring time and period duration. At least 7 digits displayed per second of measuring time.

Resolution: LSD*

Inaccuracy (rel. error):
$\pm \frac{\text{resolution}}{\text{PERIOD}} \pm$ rel. trigger* error
$\pm$ time base error

RATIO

Range:

$\frac{\text{FREQ A}}{\text{FREQ D}} = \frac{\text{10 Hz...120 MHz}}{\text{1kHz...10 MHz}}$ (PM 6673)

$\frac{\text{FREQ A or B}}{\text{FREQ D}} = \frac{\text{10 Hz...550 MHz}}{\text{1kHz...10 MHz}}$ (PM 6674)

$\frac{\text{FREQ A or B}}{\text{FREQ D}} = \frac{\text{10 Hz...600 MHz}}{\text{1kHz...10 MHz}}$ (PM 6675)

$\frac{\text{FREQ A or B}}{\text{FREQ D}} = \frac{\text{10 Hz...1.5GHz}}{\text{1kHz...10 MHz}}$ (PM 6676)

LSD displayed:
10^{-8}...10^{-1} (A/D all models and B/D; PM 6675)
10^{-8}...10^{0} (B/D; PM 6674)
10^{-8}...10^{0} (B/D; PM 6676); depending on measuring time and ratio

* *See definitions*

Resolution: LSD*

Inaccuracy (rel. error):
$\pm \frac{\text{resolution}}{\text{RATIO}} \pm$ rel. trigger* error D

COUNT

Totalize range:
1...10^{17}, with indication of k-pulses, M-pulses and G-pulses beyond the 10^9 display range

Frequency range:
Sine: 10 Hz...10 MHz
Pulses: 0 Hz...10 MHz

Sequential start-stop periods are accumulated or individually totalized after reset.

AUXILIARY FUNCTIONS

MEASURING TIME
The measuring time is „continuously" variable (33 steps/decade): 10ms...96s, with clear setpoints at 10ms, 100ms, 1s, 10s and 96s. Selected measuring time is displayed, without any delay, when depressing the measuring time control.

The actual measuring time equals the selected measuring time plus the time needed to synchronize the measurement with an integer number of cycles of the input signal. (Reciprocal measurements are synchronized with multiples of 10 input cycles).

In the FREQUENCY AVERAGE mode, the measuring time can be externally controlled to make burst frequency average measurements.

ON STAND BY: In „ST BY" position, power is available to maintain an ovenized crystal oscillator heated and to recharge the optional battery pack.

CHECK: 10 MHz internal reference connected to logic circuitry. Self-test of most measuring functions can be selected. By using this mode, the COUNT function provides a stop-watch facility.

DISPLAY HOLD: Depressing „DISP HOLD" button sets display time to infinite and freezes the last measurement result. A new measurement can be initiated using reset.

In the COUNT mode, the "DISPL HOLD" control is used to start and stop totalizing.

RESET: Manual via pushbutton or electrical via input E.

INPUT AND OUTPUT SPECIFICATIONS

LF-INPUT (CHANNEL A)

Frequency range: 10 Hz...120 MHz

Sensitivity
Sine: $10mV_{RMS}$ (20 Hz...120 MHz), 6dB down at 10 Hz
Pulse: $30mV_{pp}$ (0 Hz...120 MHz), minimum pulse duration 4ns

Attenuation: Continuously variable in two ranges between x 1...x 500. Noise immunity band (hysteresis band) can be continuously adjusted over the range: $20mV_{pp}$...$10V_{pp}$ nominal.

Noise filter: Switchable 50kHz Low Pass filter. Noise suppression ≥ 20dB at 500kHz

Impedance: 1 MΩ//≤ 25pF

*see definitions

Trigger level
Switchable with waveform selectors for optimum triggering on signals of various duty factors.

: for duty factor of < 0.25
: for duty factor of 0.25...0.75
: for duty factor of > 0.75

Coupling: AC

Maximum voltage without damage
DC: 300V
AC: $260V_{RMS}$ at ≤ 440 Hz declining to $12V_{RMS}$ at ≥ 1 MHz (in $10mV_{RMS}$ range), $260V_{RMS}$ (in $200mV_{RMS}$ range)

RF-INPUT (CHANNEL B)

Frequency range:
PM 6674: 50 MHz...550 MHz; 6 x prescaled
PM 6675: 50 MHz...600 MHz; direct gating
PM 6676: 100 MHz...1.5GHz; 16 x prescaled

Operating input voltage range:
$10mV_{RMS}$...$12V_{RMS}$
PM 6675: sensitivity is $5mV_{RMS}$ (100 MHz...500 MHz)
PM 6676: sensitivity above 1GHz decreases to $30mV_{RMS}$ (worst-case) or $15mV_{RMS}$ (typical) at 1.5GHz.

Impedance: 50Ω nominal; VSWR < 2

Coupling: AC

AM tolerance
98%; minimum signal must exceed $30mV_{pp}$

Maximum voltage without damage
12V; overload protection with PIN diodes

EXT. REFERENCE AND RATIO INPUT (CHANNEL D)

Frequency range: 1kHz...10 MHz

Sensitivity: $500mV_{RMS}$

Impedance: Approx. 2kΩ

Coupling: AC

Max. voltage without damage: $25V_{RMS}$

Note
As external reference frequency, only 10 MHz will give correct decimal point and unit indication. With the optional frequency multiplier PM 9697 references of 1 and 5 MHz can also be accepted.

EXT. ARMING/FREQ-AVG/RESET (CHANNEL E)

A 3-position rear panel switch gives choice of external control over:

ARMING: In this position the counter is prevented from starting a new measurement when input E is high. A high-to-low going pulse arms the counter to start a new measurement.
NOTE: Arming not applicable in COUNT mode

FREQUENCY A AVERAGE: When making reciprocal frequency or period measurements, the measurement is interrupted when input E is high. The measurement is continued again when input E is low.
To allow frequency average measurements up to 100 MHz, the automatic switching to the CONVENTIONAL mode above 10 MHz is omitted.
The effective measurement time (defining resolution and accuracy) is the sum of external gate times that occurs during the selected measurement time.

EXT. RESET-START: Electrical reset, equivalent to the front panel RESET pushbutton. (See HOLD and RESET). Counter is reset when input E goes high. A new measurement can be made after input E has returned low.

Input levels:
High: ≥ 2V
Low: ≤ 0.5V

Input impedance: Approx. 2kΩ

Max. input voltage without damage: ± 25V

Minimum pulse duration:
Arming and frequency avg: 500ns
External reset: 200μs

TIMEBASE OSCILLATOR OUTPUT

Crystal frequency: 10 MHz

Output level: LS-TTL compatible

Output impedance: Approx. 400Ω

Coupling: DC

Overload protection
Short-circuit proof

GENERAL

DISPLAY

Read out: 9 digits, 11mm high-efficiency LED's. Microprocessor control of display format, decimal point and unit indication: Hz, kHz, MHz, GHz, ns, μs, ms and s.

Display time: Continuously variable 80ms...96s plus DISP HOLD

Gate lamp: Indicates that main-gate is opened and measurement takes place

ST BY: Stand-by indication with LED when instrument is not switched ON

REMOTE: Indicates when control over counter is taken by the installed bus interface option (IEC 625/IEEE 488)

Low-battery: Indication by blinking display some 15min. before recharging is needed

POWER REQUIREMENTS

These counters can be powered from: the line voltage, and optional battery or external battery voltage.

Line: 115/230V ± 15%; 45...440 Hz; < 25VA

Internal battery unit: PM 9693

External DC Source:
Voltage: + 11.8V; 4.5...8W depending on version and options installed.
Connector: Battery jack fitting DIN 45323

Line interference: below VDE 0871 (B) and MIL STD 461

Safety: According to IEC 348 and CSA 556B

DIMENSIONS AND WEIGHT

(w x h x d) 210 x 89 x 280mm
(8.25 x 3.8 x 11-in)
2.5kg (5.5lb)

ENVIRONMENTAL CONDITIONS

Temperature
Rated range of use: −5°C...+50°C
Functional operation: −10°C...+55°C
Storage and transport: −40°C...+70°C
Humidity
Operating: 10...90% RH, no condensation
Storage: 5...95% RH

Altitude/Barometric pressure
Operating: 5000m (15000ft) −53.3kN/m²
Storage: 15000m (50000ft) −15.2kSN/m²

Vibration test: According to IEC 68 Fc

Bump test: According to IEC 68 Eb

Handling test: According to IEC 68 Ec

Transport test: According to NLN-L88

DEFINITIONS

LSD displayed
Unit value of Least Significant Digit displayed

For frequency < 10 MHz or Period Average:

$$LSD = \frac{2.5}{\text{measuring time}} \times \frac{\text{FREQ. or PERIOD}}{10^7\ \text{Hz}}$$

For Frequency > 10 MHz:

$$LSD = \frac{2.5 \times \text{prescaling factor}^{(p)}}{\text{measuring time}}$$

For ratio:

$$LSD = \frac{2.5\text{x prescaling factor}^{(p)} \times \text{RATIO}}{\text{measuring time x FREQ A or B}}$$

The resolution is 2 LSD units: if

$$LSD < \frac{1}{\text{measuring time}}\ (\text{Freq.} > 10\ \text{MHz})$$

or if $\frac{\text{LSD x measuring time}}{\text{FREQ or PERIOD or RATIO}} < 10^{-7}\text{s}$
(Freq. ≤ 10 MHz, Period or Ratio).

In all other cases the resolution is 1 LSD unit.

All calculated LSD's shall be rounded to nearest decade (e.g. 5ns will be 10ns and 0.4 Hz will be 0.1 Hz) and cannot exceed the 9th digit.

(p) = 1 Channel A, all models
(p) = 6 Channel B, PM 6674
(p) = 1 Channel B, PM 6675
(p) = 16 Channel B, PM 6676

Resolution
Smallest increment between two measuring results, being most often 1 LSD unit. Due to arithmetic truncation the resolution can be 2 LSD units, but can then be reduced to 1 LSD unit, by doubling the measuring time.

REL. TRIGGER ERROR

For any waveform:

$$\frac{\text{peak-to-peak noise voltage}}{\text{signal slope (V/s) x measuring time}}$$

For sinewave:

$$\frac{1}{\text{FREQ x measuring time x } \pi \text{ x S/N ratio}}$$

Example
For S/N ratio of 100 (40dB) and 1 second measuring time, the trigger error is:

$$\frac{3 \times 10^{-3}}{\text{FREQ}}$$

ORDERING INFORMATION

PM 6673/01: 120 MHz counter*
PM 6674/01: 550 MHz conter*
PM 6675/01: 600 MHz counter*; direct gating
PM 6676/01: 1.5GHz counter*
PM 667./02: idem, but including PM 9678
PM 667./03: idem, but including PM 9679
PM 667./04: idem, but including PM 9690
PM 667./05: idem, but including PM 9691
PM 9669/01: 19-in rack mount adapter to fit one instrument.
PM 9669/02: 19-in rack mount adapter to fit two instruments.
PM 9672: carrying case
PM 9693: battery unit
PM 9694: BCD output and display offset unit
PM 9695: analog recorder output
PM 9696: IEEE 488-bus interface
PM 9483/50: IEEE-to-IEC adapter
PM 9487/10: IEEE cable; 1m
PM 9487/20: IEEE cable; 2m
PM 9487/40: IEEE cable; 4m
PM 9697: external reference frequency multiplier
PM 9581: 50Ω feed-through termination 3W
PM 9585: 50Ω feed-through termination 1W
PM 8923: 120 MHz**; 1 MΩ probe-set 1;1 and 1:10.
PM 9639: 1.5GHz**; 500Ω probe-set, 1:10.
PM 8943: 650 MHz; 50Ω/1 MΩ FET probe-set.

For amplitude measurements, a limited frequency range is specified in this catalogue.

The timebase oscillators PM 9678 to PM 9691 can also be ordered separately for later upgrading of the counters.

Please note:
PM 6670 cannot be equiped with options PM 9693, PM 9694, PM 9695 and PM 9696.
PM 6671...PM 6676 can be equiped with max. one of these options.
The PM 9697 multiplier can only be installed similtaneously with the /01 oscillator. For installation in other versions the oscillator has first to be removed.

A range of optional accessories appears on p. 251.

IEC/IEEE INTERFACE DATA

IEEE interface option PM 9696

Can be supplied fitted (to order), or retrofitted in the field.

Connector
24-pole: address set by switches

Interface functions

SH1	Source handshake
AH1	Acceptor handshake
T5	Talker with talk only, serial poll and automatic unaddress if MLA **Output data:** Measuring data including function code, overflow and range. Status data, generated at serial poll or after instruction, including full programming status data and function status.
L4	Listener with automatic unaddress if MTA **Input data:** Programming data for all manually controllable functions except input trigger functions
SR1	Service request, generated in case of data available
RL1	Local-remote control by system
DC1	Device clear; default position = Frequency A, no hold-off, repetitive measurements, service request disable and measuring time 0.3s
DT1	Device trigger by GET and data byte X
Codes	ISO 7-bit code; DIO8 passive false. Input delimiter, ETX, LF, CR, ETB'','' Output delimiter ETB/ETX, CR, LF or CR + LF

* *Incl. standard time base oscillator*
** *Indicated frequency with limited loss of sensitivity suitable for frequency measurements.*

Options and accessories for counters and timer/counters

Options marked** are described in more detail on p. 28.

PM 8923
120 MHz*; 1mΩ probe set; 1:1 and 1:10.

PM 8935
250 MHz, 10MΩ attentuator probe set

PM 8943
650 MHz; 50Ω/1mΩ FET probe set

PM 9326
15 MHz, 10MΩ attenuator probe set

PM 9483/50
IEEE-to-IEC adapter

PM 9487/10
IEEE cable; 1m

PM 9487/20
IEEE cable; 2m

PM 9487/40
IEEE cable; 4m

PM 9581
50Ω feed-through termination 3W

PM 9585
50Ω feed-through termination 1W

PM 9601
Battery pack. This battery pack fits in the counters PM 6667 and PM 6668, thus providing portable and line-independent operation. The battery charging circuit is included.

PM 9602
Carrying case. This hard-shell high inpact ABS-carrying case fits the PM 6667 and PM 6668 and gives protection during transportation.

PM 9603
19'' rack/panel mount adapter for the PM 6667 or PM 6668 to fit into a 19'' rack system or for panel mounting.

PM 9610
1.5GHz input channel to be used in PM 6652/54

PM 9611
Built-in rear panel input wiring in PM 6652/54

PM 9612
Built-in fan in PM 6652/54

PM 9639
1.5GHz*; 500Ω probe set; 1:10

PM 9665B
Low-passfilter. The 50kHz filter suppresses all high frequency signal components due to noise and interference if LF measurements are made.

PM 9666
Set of trigger level output cables for PM 6652/54 and PM 6671/72

PM 9669/01/02**
Rack mount adapter for one (/01) or two (/02) units of the PM 6670-series of counters for mounting in a 19-in rack system.

PM 9669/09
Rack mounting kit for mounting PM 6661 in, e.g., a 19-in rack panel.

PM 9672
Carrying case. This ever-ready case fits all models in the PM 6670 series to give protection during transportation.

PM 9678
X-tal time base oscillator. This temperature compensated X-tal oscillator is included as standard in the /02 models of the PM 6652/54 and the PM 6670-series of counters. It can also be ordered separately to upgrade the /01 versions.

PM 9679
X-tal time base oscillator. This oven controlled X-tal oscillator is included as standard in the /03 models of the PM 6652/54 and the PM 6670-series of counters. It can also be ordered separately to upgrade the /01 and /02 versions.

PM 9690
X-tal time base oscillator. This high stability oven controlled X-tal oscillator is included as standard in the /04 models of the PM 6652/54 and the PM 6670-series of counters. It can also be ordered separately to upgrade /01, /02 and /03 versions.

PM 9691
X-tal time base oscillator. The high stability oven controlled X-tal oscillator is included as standard in the PM 6652/54 and the PM 6670-series of counters. It can also be ordered to upgrade the /01, /02, /03 and /04 versions.

PM 9693**
Battery unit. This unit fits into the PM 6671...76 series for providing possibility with line-free operation. A recharging circuit is included.

PM 9694**
BCD-output and display offset unit. For mounting into PM 6671...76 to provide a BCD data output, plus display offset. A programmable value can be added or subtracted from the measured value before display/output.

PM 9695**
Analog recorder output (DAC). This converter provides a high-resolution analog output for recording frequency stability of oscillators, filters and X-tals on an X-t chart recorder. To be used in PM 6652/54 and PM 6671...76.

PM 9696**
IEC-625/IEEE 488 bus interface
This option adds to the full bus-compatibility of the PM 6652/54 and PM 6671...76 series. Talker/listener functions allow bi-directional communication, including programmability of all major functions.

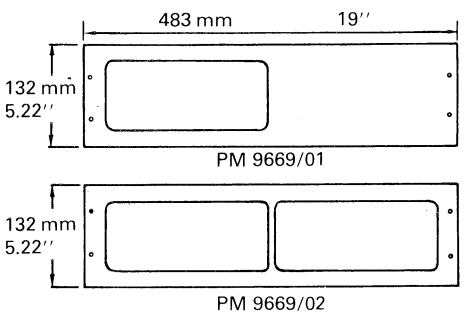
PM 9697**
External reference frequency multiplier. Allows PM 6652/54 and PM 6671...76 series to accept external reference frequencies of 1 or 5 or 10 MHz.

* Indicated frequency with limited loss of sensitivity for frequency measurements. For amplitude measurements a limited frequency range is specified in this catalog.

Specifications for options

(A more comprehensive list of options appears on p. 27).

Rack mounting PM 9669/01/02
The PM 6670-series counters can be fitted into a standard 19 in rack, using adapter PM 9669/01 or PM 9669/02 for one or two instruments respectively.



Battery unit PM 9693
The PM 9693 is a rechargeable battery unit for mounting inside the PM 6671...76 counters. The unit contains two standard 6V, sealed batteries of lead-acid type.

Battery capacity (typical at 20°C): 30 Wh; sufficient for 4 hours operation for the /01 and /02 models. For the high stability /03, /04 and /05 models, the capacity is sufficient for 3 hours operation or 20 hours stand-by.

Battery voltage: 12V nominal.

Recharging time: 8 h to approx. 75% or 12 h to > 90% of full capacity.

Recharging power: From counter < 12W.

Battery low indication:
By blinking display, 10...15 min. before recharging is needed.

Temperature:
Operating: 0...+40°C.
Storage: −40...+50°C.

Other environmental conditions as for PM 6670-series of counters.

Weight: 1.4 kg (3.1 lb).

BCD-output and Display offset unit PM 9694
The PM 9694 converts and buffers the counters serial BCD output data into parallel form. The unit offers also the possibility of adding or subtracting a programmable value of the measured value before being displayed and output. This latter feature allows adding or subtracting a reference frequency to the measured frequency e.g. measurement of tuned receiver frequency, by measuring the local oscillator **(IF offset).**

Installation:
Inside the counter, BCD-output and offset inputs available on rear panel.

Output signals:
8 x 4 parallel data lines for 7 most significant digits plus decimal point; 8-4-2-1 BCD, TTL positive true logic plus 6 lines for exponent.

Ready: A low going pulse is given when measurement and data conversion have been finished; TTL level; pulse duration: approx. 40μs.

Input command signals:
Ext. start: A low level on EXT START disables counting. When returned high, a new measurement will be initiated.

Inhibit: Data transfer is inhibited when signal is low.

Offset:
Two different values can be programmed by soldering diodes on circuit board.

External selection by logic levels to select: offset on-off and offset value 1 or 2.

Connectors:
BCD-output: Amphenol or Cinch Series 57 Micro-ribbon.

Offset selection inputs: 2 mm banana sockets.

Analog recorder output PM 9695
The digital-to-analog converter PM 9695 provides a high resolution analog output e.g. for recording frequency stabilities of oscillators, filters and crystals on a Y-t chart recorder. In frequency control systems, having analog feed-back, the DAC serves as an extremely accurate frequency-voltage converter. The PM 9695 permits conversion of any three consecutive digits out of the total of nine, as such it functions as a magnifying glass to focus on just that part of the read-out which is most important. In the **normal mode** 000 is converted in a zero analog output and 999 into a full scale deflection.

In the **offset mode,** however, 500 gives a zero output and 000 a mid-scale deflection. Thus, for a display changing between 9.9999999 and 10.0000000 MHz, it is possible to record the frequency on the center of the strip chart, rather than shooting between zero and full scale.

Installation:
Inside the counter, output connector and NORMAL/OFFSET-mode switch available on rear panel.

Decade conversion:
Any 3 consecutive digits can be selected. The value of the least significant of the 3 digits can be selected with a 12 position switch.

Normal mode:
Analog output is directly proportional to digital input. 000 produces 0.000V. 999 produces 0.999V.

Offset mode:
Adds 500 to digital input to obtain half scale offset. 500 produces 0.000V. 499 produces 0.999V.

Output:
Zero output: 0V.
Full scale deflection: 0.999V.
Connector: BNC.

Accuracy:
± 2mV.

Nonlinearity:
± 0.5 mV.

Delay:
Output voltage settling time < 100ms after end of measurement

Temperature coefficient:
± (0.1 mV + 0.03% of reading)/°C.

Output impedance:
100 Ohm ± 1%.

Weight:
Approx. 160 g. (0.35 lb).

IEC 625-IEEE 48 8 BUS interface PM 9696
When provided with this interface option, the PM 6652/54 and PM 6671...76 are fully BUS compatible. Talker and listener functions in these counters allow bi-directional bus communication, including programmability of all major functions.

Installation:
Inside the counter, connector and address switch available on rear panel.

Programmable functions PM 6671...76
All measuring functions plus hold-off on-off, Display hold, Measuring time, Trigger (start measurement), Device clear, Program data out, Service request disable/enable.

Programmable functions PM 6652/54
All front and rear panel functions plus Trigger (start measurement), Service request disable/enable, Upper/lower limit monitoring alarm, Dump mode, Load/store front panel data, Program data out, Device clear, Single/repetitive measurements.

Interface function repertoire:
SH1, AH1, T5, L4, SR1, RL1, DC1 and DT1.

Connector:
IEEE recommended type.
Amphenol or Cinch Series 57 Micro-ribbon. Compatibility with IEC recommended type is obtained via the optional screw-on IEEE-to-IEC connector transition PM 9483/50.

Ext. reference frequency multiplier PM 9697
To accept external reference frequencies other than 10 MHz, the frequency multiplier PM 9697 can be ordered.

With this option installed, the PM 6652/54 and PM 6671...76 can accept external reference frequencies of 1 MHz, 5 MHz or 10 MHz. All other input specifications as for external reference input.

Pulse generators

Unit	Description	Frequency range	Amplitude range	Rise/fall time	Page
PM 5786	Dual output variable rise/fall times	1Hz...125MHz	0.2V...5V + or − and bipolar	2ns...0.1s (variable)	2
PM 5716	High frequency MOS general purpose	1Hz...50MHz	2V...20V + or −	6ns...100ms (variable)	5
PM 5715	High frequency TTL general purpose	1Hz...50MHz	200mV...10V + or −	6ns...500ms (variable)	8
PM 5712	High frequency TTL general purpose	1Hz...50MHz	200mV...10V +	4ns	10
PM 5705	General purpose	0.1Hz...10MHz	1V...15V +	10ns	12
PM 5705E	PM 5705 plus educational package	0.1Hz...10MHz	1V...15V +	10ns	14

Dual output, 125 MHz pulse generator PM 5786

1 Hz...125 MHz; 0.2...5V into 50Ω

2ns...0.1s variable rise/fall times; from 1.4ns for 20%...80% transition times (ECL)

Excellent 50Ω backmatching absorbs over 90% of mismatching reflections

Dual outputs give normal and inverted/ complementary pulses simultaneously

Wide choice of external control facilities
– ext. triggering
– ext. gating
– ext. duration
– ext. start of pre-set burst

External control input with slope- and trigger level controls and correct trigger indicator LED

Burst option with pre-settable burst length: 0...9999 pulses

Time setting error indicators

The new PM 5786 dual output, variable rise- and fall-time pulse generator satisfies high-speed, general purpose requirements for both linear and digital applications. The high speed performance of 125MHz/2ns (into 50Ω), makes this generator particularly ideal for testing of fast digital circuitry.

Versatility is provided by the wide choice of external trigger and gate facilities, various output modes and the thumbwheel settable internal burst facility (optional).

The front panel with logic function layout, facilitates the operation. Ease of operation is further enhanced by LED indicators, that warn for time-setting-errors. Erroneous pulses due to incorrectly interrelated settings of pulse delay time, pulse duration, rise- and fall-time are thus avoided.

Clean, high-speed pulses

The PM 5786 features high-speed, high-pulse-fidelity outputs. The 125MHz/2ns characteristics makes this generator ideal for all high speed TTL and ECL circuit testing. The 20-80% transition times for ECL testing are variable even down to 1.4ns.

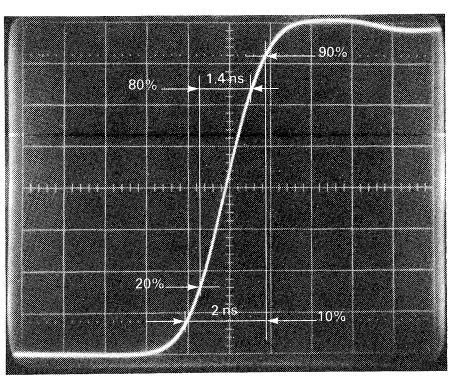


Fig. 1.

The bipolar output mode and the high quality 4 range output attenuator make this generator also very suitable for all kinds of linear applications. Clean pulses are guaranteed by the excellent 50Ω backmatching, that absorbs over 90% of all reflections coming from mismatched (non-50Ω) loads (see Fig. 1).

Dual outputs

Mode selection on the outputs A and B enables simultaneous positive and negative pulses for bipolar and linear applications, as well as positive or negative normal/complementary pulses for digital applications. Pulses on A and B are synchronous and have identical pulse amplitudes, while the DC-offset is individually variable ±2.5V into 50Ω.

Output mode flexibility

Selection of bipolar, positive or negative complementary dual output pulses offer an easy selection of the desired pulse type, thereby eliminating the need for tiresome adjustments of both inverter and off-set controls. The COMPL (normal/ complementary) switch further allows the change of logic levels without having to change cables.

Table A illustrates the selection of possible pulse 'pairs'; the ±2.5V DC off-set range allows further DC shift.

EXT IN

The external input enables a number of external control facilities such as **ext. triggering, gate, burst and external**

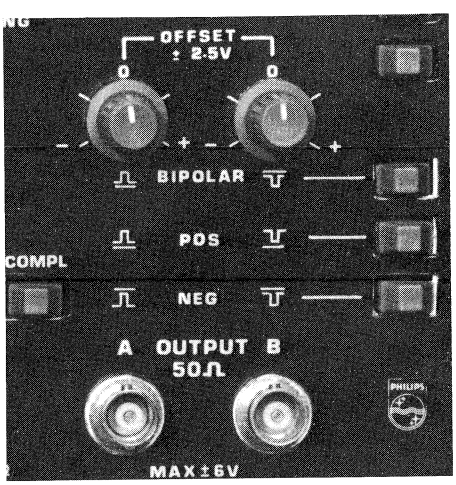


Fig. 2. Shows dual output arrangements with output and pulse mode selectors.

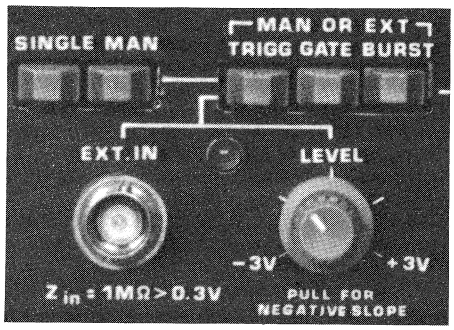


Fig. 3. Shows selection of various external control functions and the external control input.

duration. An external control signal can define the start (and duration) of the various control facilities. The start/stop conditions can be adjusted with the +/− slope selection and the −3V...+3V trigger level controls. Correct triggering is indicated by a blinking LED.

Manual control, equivalent to EXT IN is also provided.

External triggering

External triggering enables the PM 5786 to operate frequency and phase synchronously with another clock-pulse signal. All other parameters, like pulse duration, amplitude, etc. are set on the pulse generator itself.
External trigger signals can vary from 0 – 125 MHz, or 0 – 62.5 MHz in the double pulse mode.

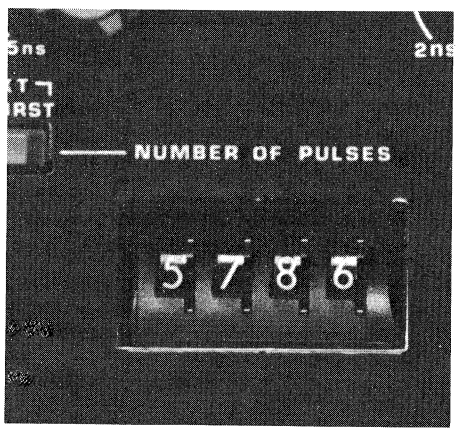


Fig. 4. Option burst function and thumbwheel control.

External gate

The external gate mode gives external "ON/OFF" control over the generator. During the presence of the ext. gate signal, the pulse generator delivers pulses with the pre-set pulse parameters. This mode thus gives an external burst control facility.

Table A

Mode	Normal		Complementary	
Output	A	B	A	B
Bipolar				
Pos				
Neg				

Burst

The optional burst mode (PM 5786B only) enables generation of a burst containing a pre-settable number of pulses: 0 – 9999.

This burst can be started either manually or with an electric start signal on the EXT IN input. This feature is ideal for testing memories, shift registers, counters and other digital circuits.

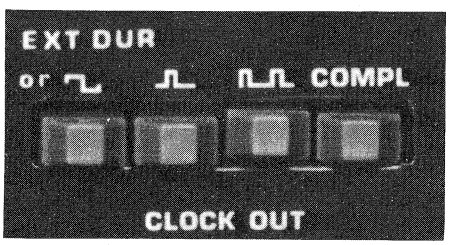


Fig. 5. Pulse mode selectors.

EXT DUR

The external duration mode allows the generator to function as a Schmitt-trigger and pulse booster.

The external input signal defines frequency and pulse duration, whereas amplitude, DC-offset, rise-and-fall time, normal/complementary mode are defined by the pulse generator settings.

⊓⊔⊓ 'Square wave'

The square wave mode gives pulses with a constant 0.5 duty factor. Use of this mode facilitates quick searching for the required repetition rate; or when the PM 5786 is used as clock generator.

Warning LED's against operation errors

Proper setting of all the interrelated time parameters on a pulse generator demands the full operator attention. Consequently, improper settings formerly used to be a frequent reason for erroneous pulses. This problem has been overcome on PM 5786; time-setting-error indicator LED's indicate the selection of too long pulse delays, pulse durations, leading and trailing edges.

TECHNICAL SPECIFICATION

TIME PARAMETERS

Pulse repetition period: 8ns...1s (1Hz...125MHz)
Pulse delay: 8ns...100ms
Pulse duration: 3.5ns...100ms or fixed square wave
Transition times: 2ns...100ms, corresponding to 10% – 90% of pulse amplitude. For ECL testing, the minimum transition time is 1.4ns, corresponding to 20% – 80% levels.
Jitter: <0.1% of setting ±50ps

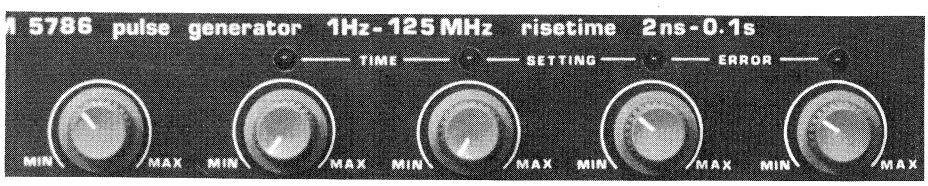


Fig. 6. Time setting errors are indicated an LEDs.

MAIN PULSE OUTPUT CHARACTERISTICS

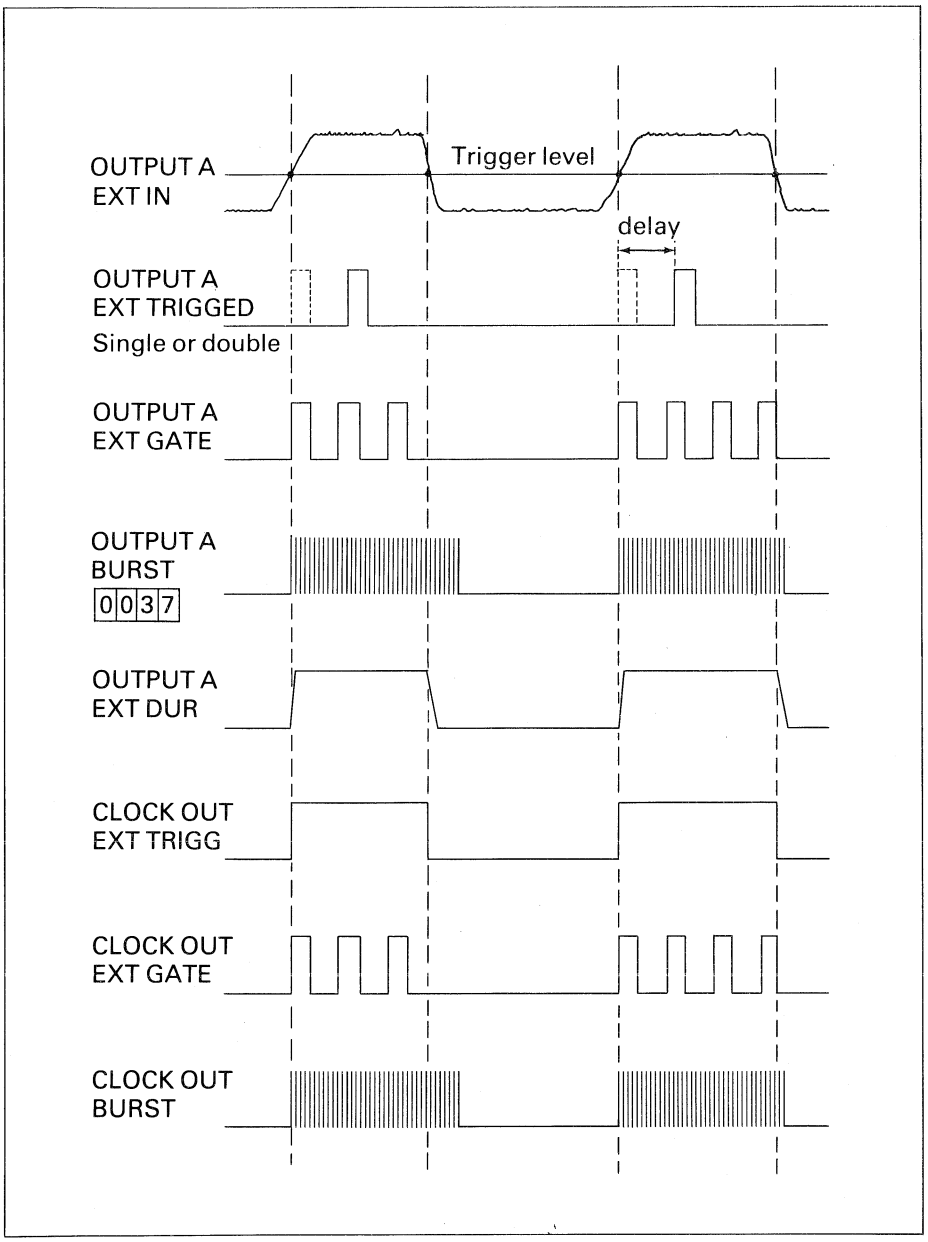
Outputs: 2 channels, A and B
Transition times (at Z_L=50Ω): 2ns...100ms (10% – 90% levels), down to 1.4ns (20% – 80% levels)
Pulse amplitude: 0.2V...5V (at Z_L=50Ω), double amplitude at open output
DC off-set: −2.5V...+2.5V (at Z_L=50Ω), ±5V at open output
Max. output voltage: pulse amplitude plus DC off-set is ±6V. Maximum 10V open output voltage cannot surpass the −6V...+6V range
Waveform aberations: <5%; <10% for transition times <2ns...5ns
Source resistance: 50Ω ±5%
Source impedance: 50Ω ±10%
Output protection: against short – or open- circuit and transients
Pulse modes: single pulse (delayable), double pulse or square wave; 50% ±1% (1Hz...1MHz), 50% ±10% (1MHz...125MHz). Normal or complementary switchable
Output modes: Bipolar: simultaneously positive and negative polarity
Pos: positive polarity, normal and complementary
Neg: negative polarity, normal and complementary

EXTERNAL OPERATING MODES

TRIGG: ext. triggered pulse repetition: DC...125MHz or manual single shot
GATE: Synchronous gating. Ext. input signal starts and stops the generator
BURST: Internally generated burst with digital switch selection of number of pulses: 0...9999, started by ext. input signal or manual control
EXT DUR: External duration gives pulses with same duration and repetition rate as external input signal, all other pulse parameters are set via the generator

EXTERNAL INPUT

Range: DC...125MHz; min. pulse duration 3.5ns
Operating input voltage range: 0.5...15V_{pp}
Coupling: DC.
Input impedance: 1MΩ//25pF
Trigger level: −3V...+3V
Trigger slope: + and −
Trigger indicator: tri-state LED indicator for correct trigger level setting
Max. input voltage without damage: 260V_{RMS} at ≤440Hz, declining to 15V_{pp} at 125MHz



INTERNAL CLOCK OUTPUT

Main output pulse is delayable with respect to internal clock output, which can thus be used as pre-trigger
Amplitude: +2.5V into 50Ω
Output impedance: 50Ω (typ)
Transition time: approx. 1ns
Pulse duration: square wave, 50% ±1% (1Hz...1MHz), 50% ±10% (1...125MHz)
Output protection: against short- or open- circuit and transients

TIME-SETTING-ERROR INDICATORS

Warning for erroneous settings of too long times for pulse delay, pulse duration, leading- and trailing transition times, indication with 4 LED's

POWER REQUIREMENTS

Line: 100V, 120V, 220V and 240V_{RMS} ±10%; 120VA, 50/60Hz
Safety: according to IEC 348 and CSA 556B.

DIMENSIONS AND WEIGHT

Width: 300mm (11.8-in)
Height: 145mm (5.7-in)
Depth: 470mm (18.5-in)
Weight: Net: 9.5 kg (21lb)
Shipping: 11.5 kg (25lb)

ENVIRONMENTAL CONDITIONS

Temperature:
Rated range of use: 0°C...+50°C
Storage and transport: −40°C...+ 70°C
Humidity:
Operating: 10...90% RH, no condensation
Storage: 5...95% RH
Altitude/Barometric pressure:
Operating: 5000m (15000ft) - 53.3kN/m²
Storage: 15000m (50000ft) - 15.2kN/m²

MECHANICAL TESTS

Vibration: IEC 68-2-6 Fc
Bump: IEC 68-2-29 Eb
Handling: IEC 68-2-31 Ec
Transport: UN-D 1400
Shock: MIL-T-28800

CLIMATIC TESTS

Steady dry heat: IEC-68-2-2 Bb
Steady cold: IEC-68-2-1 Ab
Cyclic damp heat: IEC-68-2-30 Db
Steady cold and dry heat: IEC-68-2-1 Ab
IEC-68-2-2 Bb

ORDERING INFORMATION

PM 5786 generator; excluding burst unit
PM 5786B generator; including burst unit

OPTIONAL ACCESSORIES

PM 8923: 120MHz; 50Ω probe-set for connection to external input
PM 9581: 50Ω feed-through termination; 3W
PM 9585: 50Ω feed-through termination; 1W
PM 9584: 50Ω T-piece (matched power-splitter)
PM 9588: 50Ω coaxial cable set with calibrated delay times: 5 x 1ns, 4 x 2ns, 3 x 3ns, 3 x 10ns

1 Hz...50 MHz repetition rate

6ns...100ms rise and fall times

2V...20V amplitude, within the range of −20V...+20V

Independent control for upper and lower pulse levels

Pulse amplitude limiter to protect device under test

Built-in 50Ω backmatch, no need for external termination

Versatile facilities for external triggering, gating and pulse amplifying

50MHz; ± 20V Pulse generator PM 5716

This truly universal pulse generator has been purpose-designed to meet all MOS logic testing requirements as well as TTL and other HNIL circuits.
It meets the exacting performance criteria demanded by this wide range of devices without any sacrifices of, for instance, fast transition times or special outputs for TTL.
Moreover, the wide range of repetition rates, delay, duration and transition times makes PM 5716 an ideal pulse source also for analog applications.
This instrument therefore introduces a new dimension to the existing range of Philips pulse generators and new standards in pulse generator design and performance.

Pulse amplitudes to 20V

The main pulse amplitude from the PM 5716 is continuously adjustable between 2V and 20V.
The pulse level setting is done with two independent sliding potentiometers with ranges from −20V to +20V. The two sliders are mechanically interlocked in such a way that they cannot pass each other and the maximum separation corresponds to a 20V pulse amplitude. (Fig. 1)
The generator has a source impedance of 50Ω and the maximum output amplitude is 20V into ⩾ 5kΩ. Into 50Ω this value is 10V. The front panel scale is graduated for both cases. The very good output stage of the PM 5716 maintains the 20V pulse amplitude over the whole frequency range.
The PM 5716 is designed for ease of operation. The square wave pulse mode gives freedom from selecting delay and duration; the operator need only set the repetition time, amplitude and shortest trasition time and the pulse is there.
As can be seen from the illustration it is easy to read pulse amplitude directly from the scales.
By systematically avoiding the use of double function controls the PM 5716 has become an instrument which is very convenient to operate.

Amplitude limiter

The PM 5716 has as standard an amplitude limiter to protect the device under test. (Fig. 2)
When the MOS supply voltage is connected to the limiter inputs your circuits are automatically safeguarded against excessive pulse levels.
The pulse levels can not exceed the upper/lower levels of the limiting voltages. This makes it possible also to remotely control the output levels within the range set by the sliders.

Backmatched 50Ω output

The built-in 50Ω termination in the PM 5716 is compensated for the reactive impedance components of the output stage.
Fig. 3 which shows a 20V pulse with 6ns rise time fed into a 1 meter open ended cable, illustrates how the internal termination absorbs the reflection. The residual reflection from the PM 5716 is guaranteed to be less than ±3% with this set-up.
This backmatch makes it possible to work with unterminated cables and high ohmic loads without spending time on checking the waveform.

The benefits gained from this specially designed output are summarized, as follows:
- reflections from all kind of mismatches are absorbed in the generator
- gives a better waveform, less dependent on external load
- the fixed load means protection of the output stage
- ideal for high ohmic loads such as MOS circuits
- no need for external termination – easier to use

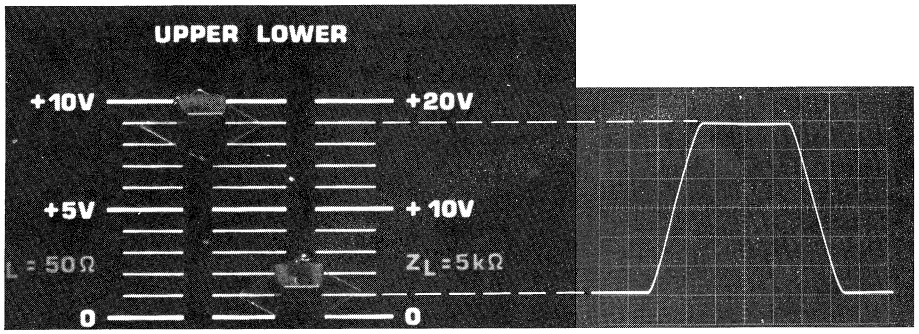


Fig. 1. Independent slide potentiometers for setting maximum and minimum pulse levels.

Transition times
In the PM 5716 the transition time is not dependent on the amplitude.
This gives freedom to vary the amplitude during a test sequence without having to check and readjust the rise and fall time.
The repetition and transition time ranges in the PM 5716 far exceed the requirements for the MOS logic of today. This makes the generator a suitable pulse source for new developments in MOS in the years to come. Fig. 4a shows how the rise time is varied from 6ns to 60ns. The very good characteristics of the rise time circuit are obvious. Linearity is excellent and the pulse has hardly any overshoot.
Both parameters contribute to the high measuring accuracy of the PM 5716. As the transition time range starts at 6ns it enables not only MOS to be tested but also most other logic families such as TTL, RTL and DTL.
The very long transition time of 100ms enables threshold testing and drive of operational amplifiers.
Changing from normal to complementary pulse means, in the PM 5716, that besides the duty factor change rise and fall times are reversed. Figure 4b indicates the effect of the change. This is a convenient facility because of the conformity with IC temrinology.

Thus:
- transition times are variable over a very wide range
- shortest transition time 6ns relates to TTL logic
- the linear ramp increases measurement accuracy
- transition times are independent of set amplitude

High ohmic trigger input
In logic testing it is often desirable to trigger a pulse generator from the circuit under test. The trigger take-off must then be of sufficiently high ohmic value to avoid overloading the circuit under test. The PM 5716 has for that reason got a trigger input impedance of 1MΩ//20pF which is suitable for MOS logic.

The trigger level in the PM 5716 is variable from −2V to +2V enabling triggering from all kinds of logic and most analog sources.
The high input impedance is compatible with most attenuator probes enabling a further decrease of the circuit loading to 10MΩ//11pF with the PM 9350 as shown in Fig. 5.

Clock and auxiliary outputs
The auxiliary output of the PM 5716 gives a +2.5V pulse into a 50Ω load. As the source is backmatched by 50Ω a +5V

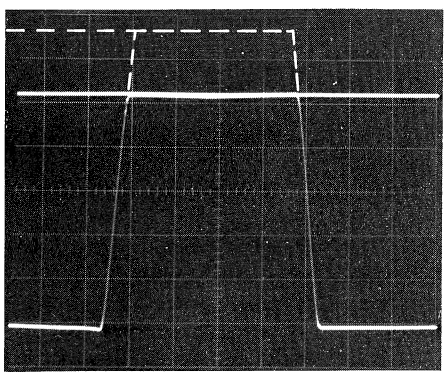


Fig. 2. Pulse limiter protects MOS circuit under test against excessive input pulse amplitudes.

amplitude across high ohmic loads is available.
The pulse always has set delay and duration and a 6ns transition time. Fig. 6 shows how it can be used together with a complementary pulse from the main output for differential drive of circuits under test.
The clock output always gives symmetrical pulses which are suitable for use as a time reference, because of the fixed duty factor. The resetting of delay and duration is therefore avoided when sweeping over a wide frequency range.

Output protection
The reliability of a signal source is most important. But pulse generator outputs exposed to all kind of reflections, external DC-levels and transients, have always been difficult to safeguard.

The PM 5716 includes an output protection system of diodes shorting any external transients applied to the internal supply voltage. In the case of external DC-levels, the whole internal voltage supply (which is floating) is shifted to avoid overload of the output transistors. The two 5V outputs are also protected with diodes against external transients.

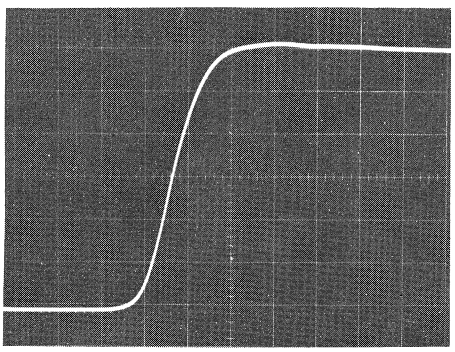


Fig. 3.

TECHNICAL SPECIFICATION

REPETITION RATE

Internal: 1Hz...50MHz variable in 8 ranges with continuous control within the ranges.
Jitter: ≤ 0.1% or 50ps whichever is greater
External: DC...50MHz

PULSE DELAY

10ns...100ms. Variable in 7 ranges with continuous control within the ranges.
Jitter: ≤ 0.1% or 50ps whichever is greater.

PULSE DURATION

10ns...100ms. Variable in 7 ranges with continuous control within the ranges.
Jitter: ≤ 0.1% or 50ps whichever is greater.
Duty factor: more than 50%. Duty factor over 99% possible with complementary mode.

MAIN OUTPUT PULSE CHARACTERISTICS

Amplitude: 2V...20V between −20V and +20V with 5kΩ load
1V...10V between −10V and +10V with 50Ω load
Rise and fall times: ≤ 6ns...100ms, (at amplitudes below 4V (2V) from 8ns).
Independent continuous controls within 8 selectable ranges. The transition time remains constant when the pulse amplitude is varied.
Source impedance: 50Ω compensated, ideal for driving MOS circuits without terminating load. A total reflexion of a 6ns rise time pulse gives less than ±3% distortion.
Waveform aberrations: ≤ 5% for all transition times
Amplitude limiter: The upper (lower) pulse level may be limited by an external DC-source to any value between +20V and −18V (+18V and −20V). With high ohmic load the max. output level is equal to the limiter levels. With 50 ohm load 50% of the levels.
The input resistance of the limiter measured between upper or lower terminals and earth is ≥ 1kΩ.

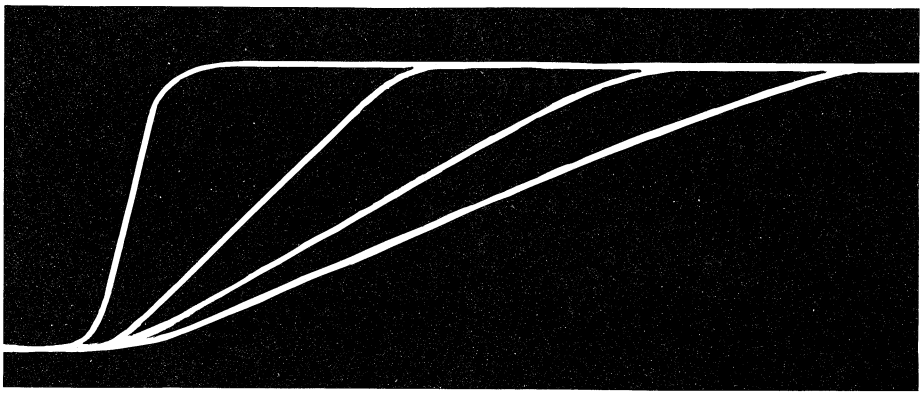
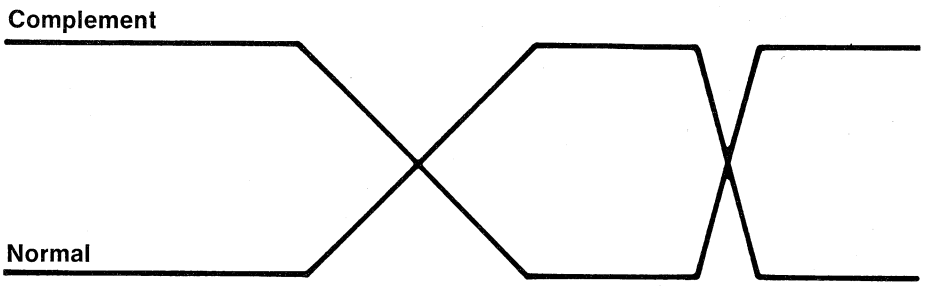


Fig. 4a.

Fig. 4b.



Protection: Short and open circuit safe
Protected against external DC-voltages between + and −20V. Special transient protection circuits have been built in.
Timing: The pulse is delayed 50ns plus set delay from an external trigger pulse.

CLOCK PULSE CHARACTERISTICS

Amplitude: +2.5V into 50Ω and +5V into 5kΩ
Source impedance: 50Ω
Rise and fall times approx 6ns
Duty factor: 50% ± 5% (in fastest range 25-45% duty factor)
Protection: Short and open circuit safe, diode protection against transients
Timing: Pulse occurs approx 35ns plus set delay ahead of main pulse and 15ns after external trigger pulse

AUXILIARY PULSE CHARACTERISTICS

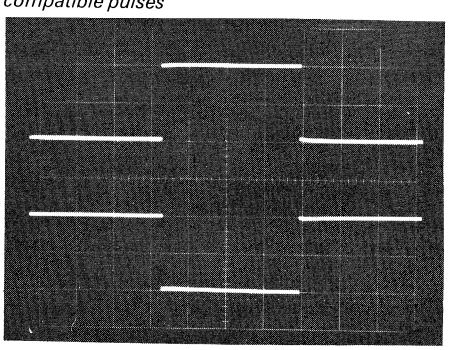
Amplitude: +2.5V into 50Ω and +5V into 5kΩ
Source impedance: 50Ω
Rise and fall times: approx 6ns
Duty factor: As set by 'DURATION'
Pulse mode: Single or double pulses
Protection: Short and open circuit safe, diode protection against transients
Timing: Pulse occurs approx 15ns plus set delay ahead of main pulse and 35ns after external trigger pulse

EXTERNAL TRIGGERING/GATING

Electrical: Frequency range: DC...50 MHz
Sensitivity: 200mV
Trig level: variable −2V to +2V, with 10:1 probe −20 to +20V
Trig slope: selectable leading or trailing edge
Max. external voltage: ±20V
Input impedance: 1 MΩ//20pF suitable for probes
PM 9327 DC to 15 MHz
PM 8927 DC to 50 MHz
Manual: Single shot by means of push button

Fig. 5.

Fig. 6. Additional outputs give complementary TTL compatible pulses



MODES OF OPERATION

1	INT CLOCK	Internal clock gives repetition rates from 1 Hz to 50 MHz.
2	MAN TRIGG	Manual trigger gives one single/double pulse with set duration or one pulse with same duration as the manual trigger pulse.
3	EXT GATE	Gated pulses. First pulse coincides with leading/trailing edge of gate pulse.
4	EXT TRIGG	Triggering on leading/trailing edge of external pulse.
5	EXT DUR	Pulses with same duration and repetition rate as external pulses.

PULSE MODES

1		Gives a square wave on main output (50% ± 5%; approx 25% duty factor in fastest range.) And gives single pulses with set duration on aux. output.
2		Gives single pulses with set duration on both main and aux output
3		Gives double pulses with set duration on both main and aux output.
4	NORM	'Normal' gives pulses as previously described.
5	COMPL	'Complementary' gives the complement to the set pulse on main output only.

POWER

Line voltages: 200...265V, 85...115V, 100...130V } switchable

Mains frequency: 50 Hz or 60 Hz solderable
Power consumption: 90VA

DIMENSIONS AND WEIGHT

(w x h x d) 280 x 133 x 360mm
(11 x 5.2 x 14.2-in)
9kg (19.8lb)

ACCESSORIES SUPPLIED

1 line cable
1 manual

OPTIONAL ACCESSORIES

PM 9581 50Ω feed through termination 3W
PM 9584 50Ω T-piece (power splitter)
PM 9585 50Ω feed through termination 1W
PM 9588 Coaxial cable set (5x1ns, 4x2ns, 3x3ns, 3x10ns)
PM 9327 10 : 1 attenuator probe DC...15 MHz
PM 8927 10 : 1 attenuator probe DC...80 MHz

50MHz: ⩽ 6ns Pulse generator PM 5715

1Hz to 50MHz frequency range

⩽ 6ns to 500ms transition times with independent fine adjustment of rise and fall times

Wide amplitude range 200mV...10V

10ns to 100ms pulse delay/duration

Variable DC offset ± 2.5V

TTL compatible auxiliary output

Facilities for:
- **External triggering**
- **Synchronous gating**
- **Single shot operation**
- **Pulse shaping**
- **Double pulse operation**
- **Square wave operation**
- **Sync output**
- **± polarity, normal or inverted output**

Compact, lightweight construction

The PM 5715 is a universal generator that is ideal for a wide range of applications. The versatile control of transition times from less than or equal to 6ns to 500ms, for example, allows digital circuits and components to be examined for responses to either fast and/or slow rise and fall times. The generator can operate direct into circuits using high level logic components and the noise thresholds can be tested with an adjustable DC offset of ±2.5V. A second output is also available, providing the same signals as the main output but at fixed TTL levels.

Operation

Three pulse modes are available – single pulse, double pulse and T/2 mode. One of three mechanically interlocked pushbutton switches must be depressed to select the required mode. Normal or inverted pulses are obtained by appropriate positioning of the 'normal/inverted' switch. Similarly, the required polarity is selected using the 'positive/negative' pushbutton switch. When using inverted pulses, a duty cycle of almost 100% can be achieved. However, a duty cycle of better than 50% can be obtained when normal pulses are generated. Pulse amplitude is variable from 200mV to 10V in four ranges (500mV, 1.5V, 5V and 10V) each having continuous vernier control throughout. A vernier control provides continuous offset of the DC baseline from −2.5V to +2.5V.

A square wave 'synchronous output' is available, which remains unaffected by the settings of the delay and duration switches. This output is 3V open output and its frequency is determined by the setting of the 'repetition time' switch.

An 'auxiliary' output provides the same pulses as the normal output, but at levels suitable for direct feed into TTL circuitry. The pulses at this output are of positive polarity and have a fixed transition time. Operation of the 'normal/inverted' switch, setting of amplitude or DC off-set do not affect the auxiliary output. Coarse adjustment of the pulse rise and fall times (6ns to 500ms) is effected by means of a six-position switch. The rise and fall times have separate vernier controls for fine adjustment in each range.

The 'output' pulses can be synchronously gated by an external signal. The first pulse coincides with the traling edge of the gating signal, the last pulse is completed even if the gating signal ends during the pulse.

Single pulse mode

Single pulses are continuously generated at a frequency, set by the 'repetition time' switch.

Pulse delay, transition time are other variable parameters in this mode.

Double pulse mode

Twin pulses are generated at a frequency determined by the setting of the 'repetition time' switch, with the time between pulses set by the 'delay' switch. Both pulses have the same duration which is controlled by the 'duration' switch.

Transition time control influences both pulses.

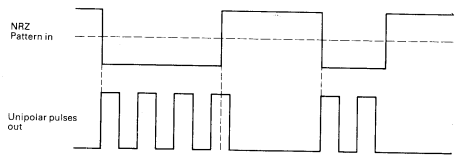
T/2 square wave mode

At the output a square wave signal whose frequency (1Hz to 50MHz) is determined by the setting of the 'repetition time' switch. Adjustments to the pulse delay, duration and transition time settings do not affect the output.

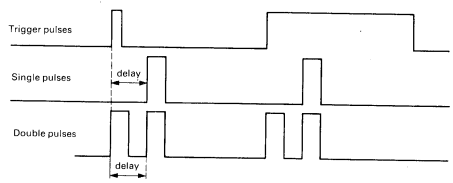
The auxiliary output provides single or double pulses with set delay and duration.

External triggering
The 'repetition time' switch must be set to the 'external' position. The repetition rate is then determined by the external trigger signal, but delay, duration and transition time by the PM 5715 controls.

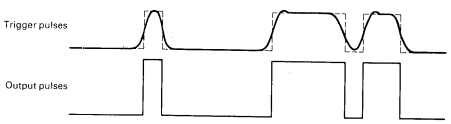
External gating
The output pulses can be synchronously gated by an external signal. The first pulse coincides with the trailing edge of the gating signal, the last pulse is completed even if the gating signal ends during the pulse.



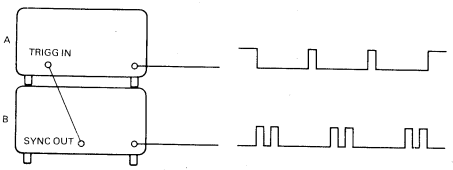
Single shot mode
A single or twin pulse is generated either on receipt of a pulse at the 'trigger/gate' input or on operation of the single shot pushbutton.



Pulse shaping
In the T/2 mode, and externally triggered, the repetition time, delay and duration switches have no effect. The pulses at the output of the generator, are of the same duration and repetition time as those received at the 'trigger/gate' input. The amplitude, DC offset and transition times are determined by the generator controls (At the auxiliary output, however, the signal is available with delay and duration as set with the PM 5715 control).



Dual channel arrangement
Two PM 5715 can be interconnected to form a true dual channel pulse generator. Complex pulse patterns can be generated by mixing the outputs of two generators using the mixing piece PM 9584.



TECHNICAL SPECIFICATION

REPETITION RATE

Internal repetition rate
1 Hz...50 MHz. Variable in 8 ranges with continuous control within the ranges

PULSE DELAY

Range
10ns...100ms. Variable in 7 ranges with continuous control within the ranges

Jitter
$\leq$ 0.1% or 50ps whichever is greater

PULSE DURATION

Range
10ns...100ms. Variable in 7 ranges with continuous control within the ranges

Jitter
$\leq$ 0.1% or 50ps whichever is greater

Duty cycle
More than 50% normal and inverted mode using the inverted pulse mode, the duty cycle will approach 100%

MAIN OUTPUT PULSE CHARACTERISTICS

Amplitude
0.2V...10V into 50Ω. Variable in 4 ranges, (500mV, 1.5V, 5V and 10V) with continuous control within the ranges.

Polarity
Positive or negative (switchable).

Rise- and fall times (at 5V and lower positions)
$\leq$ 6ns...0.5s. Independant continuous control within 6 ranges. The time remains constant when pulse amplitude is varied.

Source impedance
Current source at 10V, terminated with internal 50Ω in the 5V, 1.5V and 500mV positions.

Waveform aberrations
$\leq$ 5% of set amplitude

DC-offset
Continuously variable from −2.5V to +2.5V into 50Ω. Pulse amplitude plus DC-offset max ±10V.

AUXILIARY OUTPUT PULSE CHARACTERISTICS

Amplitude
Fixed output level, TTL compatible, +4.5V open circuit

Source impedance
50Ω

Times
Pulse delay – and duration are set: with the controls DELAY and DURATION. Single – or double pulse (not T/2).
The pulse appears approx. 12ns ahead of the main pulse.

SYNC OUTPUT

Pulse duration
Square wave appears approx 40ns ahead of the main pulse with the pulse delay set to 10ns.

Amplitude
+1.5V into 50Ω

Source impedance
50Ω

EXTERNAL TRIGGERING

Electrical triggering
Input voltage: > +1V to trigger the generator. Input current min 6mA.
Max. voltage: ±12V
Repetition rate: 0...50 MHz
Input impedance: < 1.5V approx 220Ω
> 1.5V approx 800Ω
Delay from trigger input to the main-pulse output with pulse delay set to 10ns: approx. 50ns.

Manual triggering
Single shot facility by means of pushbutton.

EXTERNAL GATING

Input voltage
> +1V to gate the generator. The gating signal turns the generator off. The first pulse coincides with the trailing edge of the gating pulse. Input current min 6mA.

Input impedance
< 1.5V: approx 220Ω
> 1.5V: approx 800Ω

Delay from trigger input to the main pulse output with pulse delay set to 10ns:
approx. 50ns. Manual gating by means of single shot pushbutton.

MODES OF OPERATION

Pulse modes
Single pulse, double pulse or square wave (T/2). Double pulse mode provides 'twin' pulses at set delay with simultaneously controlled pulse duration.

Pulse shaping
In the external triggering position the generator can be used as a pulse conditioner. The pulses at the output of the generator are of the same duration and repetition time as those received at the 'trigger/gate' input. The amplitude and DC offset are determined by the generator controls.

GENERAL

Temperature range
0...+40°C

Supply
Line voltage: 100...130V and 200...260V (switchable)
85...115V and 170...230V solderable
Line frequency: 50...400 Hz
Power consumption: 70VA

DIMENSIONS AND WEIGHT

(w x h x d) 210 x 130 x 275mm
(8.3 x 5 x 10.8-in)
4kg (8.8lb)

ACCESSORIES SUPPLIED

1 mains cable
1 manual

OPTIONAL ACCESSORIES

PM 9581 50Ω-termination (3W)
PM 9585 50Ω-termination (1W)
PM 9588 Coaxial cable set (5x1ns, 4x2ns, 3x3ns, 3x10ns)
PM 9584 50Ω T-piece

50MHz: ⩽ 4ns Pulse generator PM 5712

1Hz to 50MHz frequency range
Fast rise and fall times (⩽ 4ns)
Wide amplitude range: 200mV...10V
10ns to 100ms pulse duration and delay
Variable DC offset: −5V...+2V
TTL compatible auxiliary output

The PM 5712 is a complementary instrument to the previously described PM 5715, having a faster fixed rise time of ⩽ 4 ns. It is therefore ideal for carrying out the more standard type on test on high speed components and circuitry such as TTL and ECL integrated circuits, electronic counters, shift registers and delay lines. It can be used to examine the responses of circuits under test to changes in pulse duration and repetition rate. The instrument can also be used to measure the effect of double pulses, with a variable delay, on the circuits under test. Bursts of pulses can be derived using an external signal to gate the generator. An external signal can be used to initiate the output of pulses which are delayed and shaped according to the switch settings.

Two outputs are available. One is TTL compatible, and the other is variable up to 10V. The latter permits the unit to operate with high level, noise immune logic.
The PM 5712 is primarily intended to supply an output of positive polarity. However, negative polarity pulses (up to −5V) can be obtained by appropriate use of the normal/inverted switch and the DC offset control.

Operation
Three pulse modes are available – single pulse, double pulse and T/2 mode. When using inverted pulses, a duty cycle of almost 100% can be achieved. However, a duty cycle of better than 50% can be obtained when normal pulses are generated. Pulses have fixed transition times of ⩽ 4ns.
Pulse amplitude is variable from 200mV to 10V in four ranges (500mV, 1.5V, 5V and 10V) each having continuous vernier control throughout. By means of a vernier control, the DC baseline may be offset between −5V and +2V.
A square wave 'syncronous output' is available, which remains unaffected by the settings of the delay and duration switches. This output is 3V open output and its frequency is determined by the setting of the 'repetition time' switch.
An 'auxiliary' output generates the same pulses as the normal output, but at a level suitable for direct feed into TTL circuitry. It is unaffected by the position of the 'normal/inverted' switch, the amplitude setting and the DC offset control.
The generator can be synchronously gated by an external signal. The first pulse coincides with the trailing edge of the gating signal, the last pulse is completed even if the gating signal ends during the pulse.

Single pulse mode
In this mode, the generator has an output of single pulses, whose duration, delay and repetition rate are determined by the related switch settings.

Double pulse mode
Twin pulses are generated at a repetition rate variable from 1Hz to 25MHz. The interpulse delay is variable from 10ns to 100ms. The duration of each pulse is the same and it is possible to simultaneously vary the duration of the two pulses.

T/2 square wave mode
The output is a square wave signal with repetition rate variable from 1Hz to 50MHz. The operation is unaffected by the setting of the pulse delay and duration controls. The auxiliary output still provides single or double pulses with variable delay and duration.

TECHNICAL SPECIFICATION

REPETITION RATE

Internal repetition rate
1 Hz...50 MHz. Variable in 8 ranges with continuous control within the ranges.

PULSE DELAY

Range
10ns...100ms. Variable in 7 ranges with continuous control within the ranges

Jitter
≤ 0.1% or 50ps, whichever is greater.

PULSE DURATION

Range
10ns...100ms. Variable in 7 ranges with continuous control within the ranges.

Jitter
≤ 0.1% or 50ps, whichever is greater.

Duty cycle
More than 50%, normal and inverted mode. Using the inverted pulse mode, the duty cycle will approach 100% (limited only by the minimum duration).

MAIN OUTPUT PULSE CHARACTERISTICS

Amplitude
+200mV...+10V into 50Ω. Variable in 4 ranges, (500mV, 1.5V, 5V and 10V) with continuous control within the ranges.

Rise- and- fall times (at 5V and lower positions)
≤ 4ns with internal and external 50Ω termination.

Source impedance
Current source 200 mA at 10V, terminated with internal 50Ω in the 5V, 1.5V and 500mV positions.

Wave form aberrations
≤ ±5% of set amplitude

DC-offset
Continuously variable from −5V to +2V into 50Ω. Pulse amplitude plus DC-offset max +10V

AUXILIARY OUTPUT PULSE CHARACTERISTICS

Amplitude
Fixed output level, TTL compatible +4.5V open circuit

Source impedance
50Ω

Times
Pulse delay- and duration are set with the controls DELAY and DURATION Single – or double pulse (not T/2)
The pulse appears approx. 12ns ahead of the main pulse.

SYNC OUTPUT

Pulse duration
Square wave appears approx 40ns ahead of the main pulse with the pulse delay set to 10ns.

Amplitude
+1.5V into 50Ω

Source impedance
50Ω

EXTERNAL TRIGGERING

Electrical triggering
Input voltage: > +1V to trigger the generator with input current min 6mA.
Max. voltage: ±12V
Repetition rate: 0...50 MHz
Input impedance: approx. 1kΩ
Delay from trigger input to the main-pulse output with pulse delay set to 10ns: approx. 50ns.

Manual triggering
Single shot facility by means of push-button.

EXTERNAL GATING

Input voltage
> +1V to gate the generator. The gating signal turns the generator off. The first pulse coincides with the trailing edge of the gating pulse. Input current min 6mA.

Input impedance
< 1.5V: approx 220Ω
> 1.5V: approx 800Ω

Delay from trigger input to the main pulse output with pulse delay set to 10ns:
approx. 50ns. Manual gating by means of single shot push button.

MODES OF OPERATION

Pulse modes
Single pulse, double pulse or square wave (T/2). Double pulse mode provides 'twin' pulses at set delay with simultaneously controlled pulse duration.

Pulse shaping
In the external triggering position the generator can be used as a pulse conditioner. The pulses at the output of the generator are of the same duration and repetition time as those received at the 'trigger/gate' input. The amplitude and DC offset are determined by the generator controls.

GENERAL

Temperature range
0...+40°C

Supply
Line voltage: 100...130V and 200...260V (switchable)
85...115V and 170...230V solderable
Line: 50...400 Hz
Power consumption: 70VA

DIMENSIONS AND WEIGHT

(w x h x d) 210 x 130 x 275mm
(8.3 x 5 x 10.8-in)
4kg (8.8lb)

ACCESSORIES SUPPLIED

1 mains cable
1 manual

OPTIONAL

PM 9581	50Ω-termination (3W)
PM 9585	50Ω-termination (1W)
PM 9588	Coaxial cable set (5x1ns, 4x2ns, 3x3ns, 3x10ns).
PM 9584	T-piece 50Ω

10MHz: 15V output Pulse generator PM 5705

0.1 Hz to 10 MHz frequency range

TTL-compatible outputs, both normal and complementary

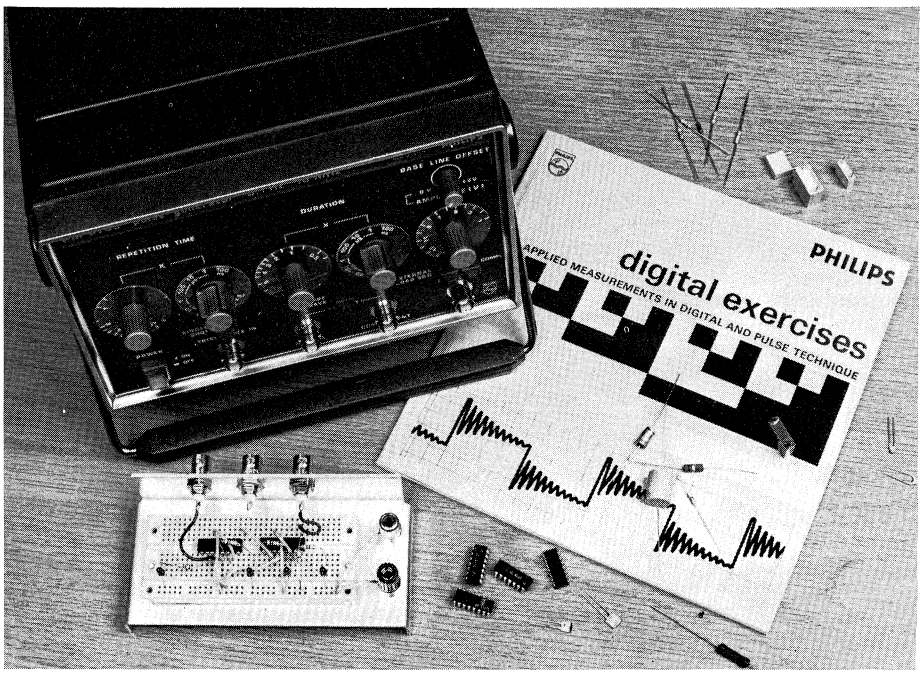
1.0V to 15V into 50Ω for TTL, HNIL and MOS applications

Baseline offset from 0 up to +2V

Resettable, engraved scales

External triggering on positive or negative slope; gating and single shot facilities

The PM 5705 is an ideal low-cost generator for a wide range of TTL MOS and HNIL applications. There are two TTL outputs, normal and complementary with sufficient power for up to 30 gates. For MOS and HNIL logic there is a 1 to 15V output. For current sink applications a 50Ω internal switchable load is included. This all-round performance is complemented by a logical front panel layout and the use of engraved, resettable scales.
These allow the pulse parameters to be set to a high degree of accuracy without employing an oscilloscope. This feature is particularly useful for educational applications. When the PM 5705 is used as a clock generator only the repetition time has to be set and the square wave pushbutton depressed.
The baseline offset of up to 2V is an additional useful feature, used to test biased circuits and components – for example the 'O' level in TTL.
Pulse bursts can be produced using an LF generator connected to the trig/gate input. The PM 5705 can also be triggered by an external pulse source, on either the positive or negative slopes.



TECHNICAL SPECIFICATION

15 V PULSE OUTPUT

Repetition rate
0.1 Hz...10 MHz variable in 8 ranges with continuous control within the ranges. *Jitter* less than 0.1%.

Duration
50ns to 500ms variable in 7 ranges with continuous control within the ranges.
Jitter: less than 0.1%
Duty factor approaching 100% using complementary pulse. More than 50% in normal pulse mode

Delay
In square wave mode the positive edge of the TTL complementary is delayed from the complementary main pulse. The delay time is the set duration subtracted from half the repetition time.

Amplitude
Continuously variable from +1V to +15V into 50Ω. Max. current 300mA.

Source impedance
Voltage source with about 300Ω or 50Ω termination

Polarity
Positive

Modes of operation
Normal or complementary

Baseline offset
Continuously variable from 0 to +2V Max. offset current 80mA. Only the baseline is shifting.

Ramp time
≤ 10ns at 5V and lower amplitudes with 50Ω internal or external termination. Typically 10ns at 10V and 15ns at 15V. (Typical rise time 6ns).

Waveform aberration
Less than ±5% between 3V and 15V into 50Ω and base line offset 0V.

Protection
Short and open circuit safe.

TTL PULSE OUTPUTS

Repetition rate
0.1 Hz...10 MHz variable in 8 ranges with continuous control within the ranges.
Jitter: less than 0.1%

Duration
50ns to 500ms variable in 7 ranges with continuous control within the ranges

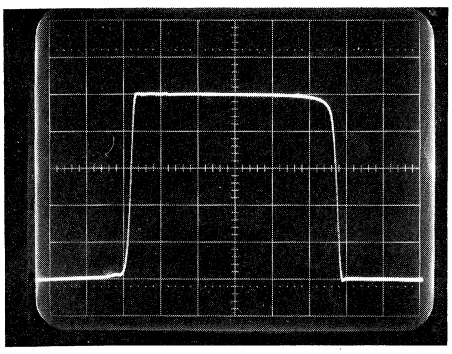


Fig. 1. Square wave at 5 MHz

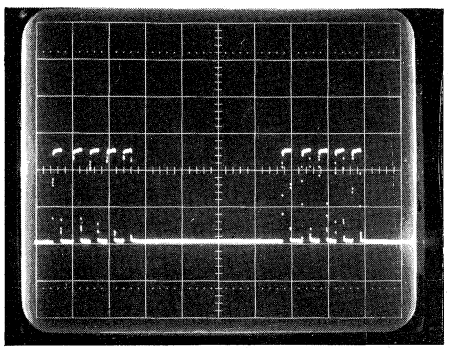


Fig. 2. Gated pulses

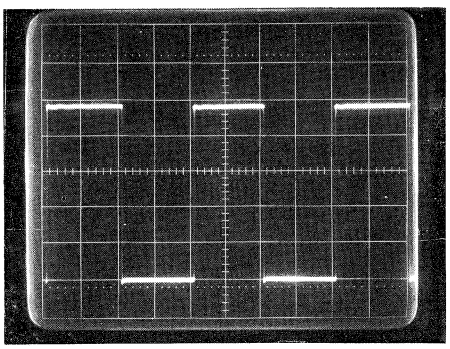


Fig. 3. TTL output

Jitter: less than 0.1%
Duty factor approaching 100% using complementary pulse. More than 50% in normal operation.

Delay
In square wave mode the positive edge of the TTL complementary is delayed from the main complementary pulse. The delay time is the set duration subtraced from half the repetition time.

Amplitude
TTL level. Fan out 30 gates.
About 4.5V open circuit

Polarity
Positive

Modes of operation
Normal and complementary

Ramp time
About 10ns

Waveform aberration
Less than 5% into 50Ω

Protection
Short and open circuit safe

Pulse output
50Ω TTL linedriver with filter for waveform correction, designed for 50Ω load.

GENERAL

External triggering and gating
Level: > +1V to trigger or gate the generator. Max. ±20V
Slope selection: positive or negative slope
Frequency: 0...10 MHz
Input impedance: approx 1kΩ
Gating signal turns the generator 'off'. First pulse coincides with trailing edge of gating pulse

Pulse shaping
In square wave mode with repetition time set to external the frequency and duration of the output pulse are determined by the trigger pulses.

Single shot
Single shot facility by means of pushbutton. In square wave mode the TTL pulse duration is determined by the time the push-button single shot is depressed.

Manual gating
Depressing the single shot pushbutton inhibits pulses when the generator is internally triggered.

Temp. range
0...40°C

Supply
Line voltage: 90...110, 100...130, 180...210 and 200...260V solderable
Frequency: 50...400 Hz
Consumption: 40VA

DIMENSIONS AND WEIGHT

(w x h x d) 210 x 130 x 275mm
(8.3 x 5 x 10.8-in)
3.5kg (7.7lb)

ACCESSORIES SUPPLIED

1 mains cable
1 manual

OPTIONAL

PM 9581	50Ω-termination (3W)
PM 9585	50Ω-termination (1W)
PM 9588	Coaxial cable set (5x1ns, 4x2ns, 3x3ns, 3x10ns).
PM 9584	50Ω mixing piece

Educational package PM 5705E

The Philips Educational package PM 5705E consist of:
– The booklet, 'Digital exercises'
– components
– a breadboard unit
which are described in detail on this page plus a Pulse generator PM 5705

'Digital Exercises' is a practical publication that supplements a theoretical education in digital techniques.
'Digital Exercises' contains 35 measuring exercises of varying degrees of complexity. Use is made of common integrated circuits from the two dominating logic families: TTL and C-MOS. It gives the student a good feeling for the components themselves. Comparison of measurements yields a clear understanding of the distinct difference between these important types of logic circuit.

EASY MOUNTING

The exercises make use of connecting strips in which the integrated circuits are simply plugged-in without the need for soldering. The advantage is that the same component can be used many times. They further reduce the time needed for changing from one exercise to another. Such an arrangement is very common for the "breadboarding" of circuits in industry and the student will therefore become familiar with this practice.

INSTRUCTIONS

The book, Digital Exercises, is based on the original work by civ.ing. Tommy Kjellander of the Royal Institute of Technology, Stockholm and it employs a step - by - step approach.
An introduction explains the principles of the pulse generator and the influence of the oscilloscope on pulse technique measurement accuracy. Next follows measurement of pulse parameters, time domain reflectometry and the influence of matched/mismatched cables. The measurements on integrated circuits start with TTL-logic in different applications then C-MOS logic is introduced and compared with TTL.
Finally there are some specific C-MOS exercises.

THE EQUIPMENT

To make the exercises self-instructional, all adjustment information has to be related to specific measuring instruments. We have chosen the 10MHz oscilloscope PM 3233 (alt. PM 3232) and the pulse generator PM 5705. Additionally one needs a 15 V_{DC} power supply (e.g. PE 1535) and one electronic multimeter (e.g. PM 2502/PM 2522 A).
The Philips educational package for digital techniques PM 5705E consists of:*

2 copies of the book 'Digital Exercises, Applied measurements in digital and pulse technique' containing 35 measuring exercises.

A set of components including 11 integrated circuits, 1 diode, 4 LED's, 1 reed relay in Dual-in-line package, 18 resistors, 1 potentiometer, 13 capacitors and 1 inductance. Datasheets for these components are also supplied. In addition, the set contains a plug-in board of connecting strips mounted on a chassis.

A pulse generator. The package PM 5705E includes a pulse generator PM 5705 which covers all exercises. It has two fixed TTL level pulse outputs and one 1...15V pulse output.

* The book 'Digital Exercises' and generator PM 5705 are also available separately.

Professional TV measuring equipment

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Introduction

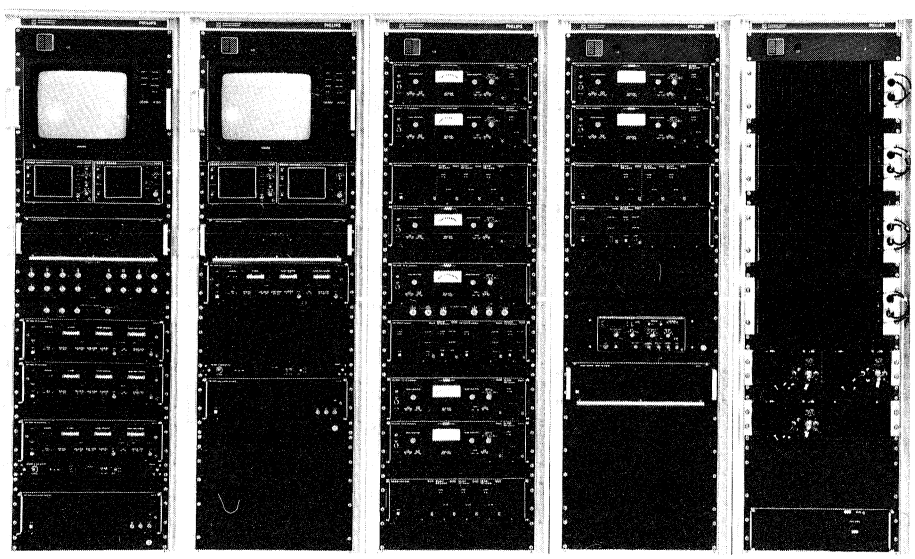
This section of the catalog describes only part of the extensive range of Philips professional television measuring equipment (PTV). More details are available in the comprehensive PTV catalog and separate data sheets.
The Philips PTV activity is among the largest in the world. PTV test equipment is in use in almost all areas of television, i.e. TV broadcasting, cable TV, closed-circuit TV, engineering, manufacturing and repair of consumer and professional TV products. Philips PTV test equipment is found in broadcasting studios, telecine and video tape recorder centres, main terminals, microwave and satellite link stations, and transmitting stations. Large cable TV and closed-circuit TV systems use PTV equipment for testing and monitoring the system performance, and for distribution of the signals.
Most of the worlds TV receivers are produced with the involvement of some Philips test gear. Also in the manufacturing process of video tape recorders, video cassette recorders, television transmitters, television cameras, mixers, colour monitors and other television test gear, Philips PTV equipment is widely used.

The total range of PTV equipment has a reputation for very high quality and excellent reliability. These are important factors in equipment selection where the failure of a single piece of equipment can shut down the whole operation.

Systems

The PTV factory also offers system work and special customer modification of standard products. The increasing complexity of television systems and the demand for special knowhow and test equipment is encouraging many users of TV test equipment to seek professional assistance for planning and installation of their systems. The ordering of a complete system rather than the individual unit offers the user the following advantages:
- guaranteed system performance
- design and planning by experienced PTV specialists
- only a single supplier to negotiate with.

The Philips PTV systems group has the expertise and the experience after many years of succesful system designs, in particular for TV set and video cassette recorder factories.



COLOUR GENERATOR, PO PM 5630
(parallel outputs)

Generates six different video signals on parallel outputs

All video signals are generated digitally

Provides all synchronization signals necessary for TV studios and OB vans

High stability through the use of TCXO as reference oscillator

The new Colour Generator, PO (Parallel Outputs), type PM 5630, is a combined colour sync pulse generator and colour test signal generator. "PO" indicates that all test signals are available simultaneously at separate outputs.
The sync pulse generator is in confirmity with the latest EBU and RS-170A standards for broadcasting, and it supplies all necessary synchronization signals for driving television studios and other television systems. Special custom-made integrated circuits and carefully selected crystal oscillators ensure unsurpassed accuracy and stability.

The signal generator works digitally, i.e. all test signals are stored in programmable read-only memories as digital information. This information feeds digital to analog converters in such a way that the required analog waveforms are obtained. This principle guarantees very accurate and stable output signals. The signals comprise the following important studio alignment signals:
- Colour bars (several versions)
- PLUGE with grey scale
- Convergence pattern (grid-dots-checker board, several versions available)
- Red pattern
- Grey scale (5 or 10 riser)
- Window (10%-100% white) in steps of 10%
- Black burst

COLOUR GENERATOR, MP PM 5631
(multi pattern)

Generates up to 99 different video signals selectable from the front panel.

Provides all necessary synchronization signals for TV studios and OB vans.

All main functions remotely controlable via optional IEEE bus interface.

Colour field reference pulse available.

Can be genlocked to other video sources.

The new Colour Generator, MP (Multiple Pattern), type PM 5631 is a combined colour sync pulse generator and colour pattern generator. "MP" indicates that a large number of signals can be selected on a single output.
The sync pulse generator is in conformity with the latest EBU and RS-170A standards for broadcasting, and supplies all necessary synchronization signals for driving television studios and other television systems. Special custom-made integrated circuits and carefully selected crystal oscillators ensure unsurpassed accuracy and stability.

The signal generator works digitally, i.e. all test signals are stored in programmable read-only memories as digital information. This information feeds digital to analog converters in such a way that the required analog waveforms are obtained. This principle guarantees very accurate and stable output signals. The generator has a standard library of some 90 pre-programmed patterns that include:
- Colour bars
- Composite colour patterns
- Colour test signals
- Monochrome signals

In the manual mode, pattern selection is done with push-buttons (up/down counter with display) and modifications are available for testing purposes. The instrument can also be controlled remotely via an IEC/IEEE interface (optional).

The PM 5631 is available for all PAL systems (PAL-G, PAL-M and PAL-N).

The PM 5631 are recommended where a number of test signals are needed on a single output, by manual or computer control, such as in broadcast studios, CCTV and CATV studios, outside broadcast vans, factories for manufacturing of high quality consumer TV products and professional colour equipment.

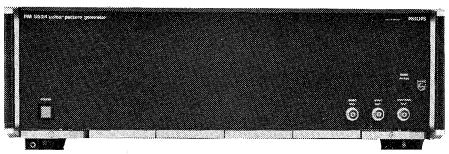
COLOUR GENERATOR, SECAM PM 5632

This generator is the SECAM version of the PM 5631. All test signals and features are essentially identical with those of the PM 5631. The output signal is in accordance with the colour system SECAM.

COLOUR GENERATOR, RGB PM 5633

This generator is an RGB I Y;R-Y, B-Y version of the PM 5631. All test signals and features are essentially identical with those of the PM 5631. The generator has three output sockets for either RGB output or Y, R-Y, BY output as selected internally on the instrument.

COLOUR PATTERN GENERATORS PM 5534 AND PM 5535



Most recognized receiver test pattern in the world

Used intensively by broadcasting authorities and TV setmakers

Extended performance by optional text generator and time clock

Built-in coder and sync pulse generator for all colour systems (PM 5534)

YRGB output (PM 5535)

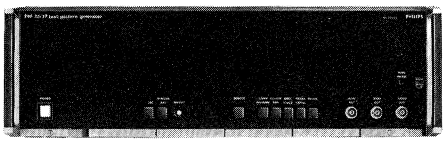
The colour pattern generator PM 5534 is a selfcontained instrument generating the well-known PHILIPS circle pattern. This pattern, recognized all over the world, offers the unique feature that most important characteristics of a TV receiver can be visually checked on the screen. The pattern of the PM 5534 is identical with the pattern produced by its predecessor PM 5544.

This test pattern has been adopted by the television authorities in more than 25 countries in all parts of the world as the test pattern to be transmitted outside the programme hours. The pattern is composed in such a way that almost all relevant parameters for a TV receiver or colour monitor can be checked by observation of the various signal elements of the pattern, right from the screen of the receiver or TV monitor.

The PM 5535, with its YRGB output will drive different coders for multi-standard applications (eg, PAL & SECAM)

In addition there is room for optional print cards to extend the performance of the instrument.
These include a text generator, clock generator, an oven-controlled crystal oscillator and a 10MHz input card.

TEST PATTERN GENERATOR PM 5537



Composite pattern based upon international insertion test signals

Used in eurovision network as a standby and link test pattern

Pattern composition allows both off-screen and waveform monitor evaluation of the transmission quality

Built-in encoder for most colour systems

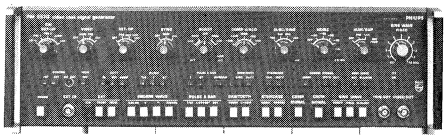
The PM 5537 is the successor to extended performance through the PM 5547 test pattern generator, and it generates the same composite pattern, which is ideal for checking all sorts of internal and external transmission paths in broadcast TV system and networks.

The pattern is designed in such a way that it gives a fairly good impression of the transmission quality, when displayed on a colour monitor. Besides authority identification can be shown in alpha-numeric display.

All the signal elements of the pattern except the colour bar, are the same as those composing the insertion test signals viz. white reference bar, multi-burst, 2T sine-squared pulse, 20T pulse carrierborn and grey scale signal. This means that the pattern represents a full-field VIT signal, and by proper selection of the time base controls, the TV engineer can check the most important transmission characteristics on his waveform monitor. On top of that the colour bar signal gives valuable information that is not available from the VITS.

The comprehensive PTV catalog is available on request.

VIDEO TEST SIGNAL GENERATOR PM 5570



Most versatile signal generator for testing transmission characteristics of video systems

Generates all necessary signals for aligning and checking TV studios, transmission links and transmitters

All levels are continuously variable with preset positions

Sweep signal from 100kHz up to 10MHz in one sweep with marker indication for each MHz

The PM 5570 is the most versatile video test signal generator available nowadays. It generates a wide variety of test signals necessary for measuring the system parameters of all kinds of video transmission equipment. It also enables the user to vary all signal levels so that level dependent parameters can be detected as well.
The generator has its own standard SPG built-in, which can be genlocked to an external composite video – or black burst signal. A choice of the following test signals can be made: squarewave signals of different frequencies and with different rise times, pulse-and-bar signals, sawtooth- and staircase signals with and without superimposed sine wave/subcarrier and various sine wave signals, viz. video sweep, multiburst and fixed frequencies. All signals can be superimposed with hum, and white noise can be added to check among others sync separators, clamp circuits, processing amplifiers, etc. A flat field signal (APL) can be added to the sawtooth and staircase signals forming the so-called duty signals (alternating 3 lines APL, 1 line sawtooth/staircase).

TELETEXT TEST GENERATOR PM 5645

Complete 4-page teletext generator in conformity with British teletext standard

Transmission of 1, 10 or 100 pages per magazine selectable from front panel

Adjustable eye-height of data signal with two pre-set positions.

Adjustable white noise as well as co-channel sinewave interference available.

The PM 5645 teletext test generator is a precision instrument designed for testing of teletext decoders, TV receivers with teletext decoder, as well as any equipment or part of a TV + teletext transmission system.

The instrument is selfcontained in the terms that it consists of a sync pulse generator (SPG), a full field video generator (cross-hatch) and a teletext generator with distortion possibilities. The teletext part has the following key facilities:
- 8 selectable magazines
- magazine length of 1, 10 and 100 pages
- 4 different pages
- eye-height reduction by echos, co-channel interference and noise.

The PM 5645 is recommended for use in production and professional repair plants for test, calibration and evaluation of TV receivers/monitors with teletext facilities. In the transmission path, in particular at transmitter stations, the PM 5645 is very useful for test of the degradation of the decoding margin as a result of incorrect amplitude and group delay response.

SYNC TEST GENERATOR PM 5634

Jumping line signal with offset up to ±8% from nominal line frequency

Jumping subcarrier signal with offset up to ±800Hz from nominal subcarrier frequency

Anti-PAL signal for adjustment and control of PAL decoders

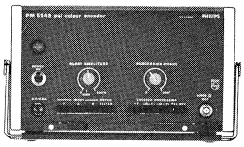
External reference inputs for other line and subcarrier frequencies

The PM 5634 sync test generator is an extremely versatile tool for the test and evaluation of the synchronization circuitry incorporated in most types of television equipment, such as monitors, receivers, video tape recorders, sync pulse generators, etc.

The instrument supplies two main signals and two auxiliary signals. The monochrome test signal has variable horizontal (and vertical) frequency, which can be off-set from nominal in steps or jumped automatically from plus to minus the selected off-set. The colour test signal has a variable subcarrier frequency, which can be off-set in the same way as the horizontal frequency of the monochrome signal. The auxiliary signals (red and anti-PAL) are used for monitor and receiver alignment.

The PM 5634 is recommended for all sorts of television production, repair and quality control. In engineering and design laboratories the instrument offers speedy evaluation of the synchronization characteristics of new equipment.

COLOUR ENCODER PM 5545



Precision colour encoder of high class

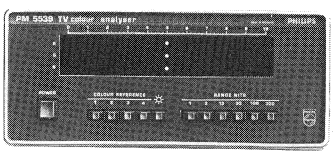
Two inputs: (Y) RGB and Y, R-Y, B-Y giving the choice of optimal quality of the encoded signal

Separate colour and bl/wh outputs are available

Switchable luminance and chrominance information facilitates testing of encoding/decoding characteristics

The PM 5545 colour encoder is a precision instrument designed for the encoding of critical signal sources, like for instance the RGB signals of the PM 5546 video calibration generator and the PM 5535 colour pattern generator. The colour encoder is also very well suited for encoding the signals of RGB and YRGB colour cameras.
The PM 5545 has (Y) RGB as well as Y, B-Y, R-Y inputs, so that all types of signals can be encoded. The following signal elements are switchable in order to provide testing possibilities: luminance, B-Y part, R-Y part, colour burst, and phase alternation (PAL versions). A notch filter can be inserted in the luminance path. The amplitude of the colour burst is variable from 0% to 200% of nominal amplitude.

TV COLOUR ANALYZER PM 5539



First practical solution to the problem of 'objective setting' of colour monitors

Optional battery makes operation possible where mains connection is impossible or inconvenient

The three LED bars mounted over each other ensure quick and accurate reading of the colour levels and balance

High sensitivity allows accurate setting of the colour white at low luminance levels

The Philips TV colour analyser PM 5539 has been developed to meet the increasing demand for measurement and adjustment of the 'colour' white of

colour TV-sets and colour monitors.
The light emitted by a colour picture tube consists of the three primary colours red, green and blue. White is obtained by additive mixing of these colours in the appropriate proportions. The PM 5539 has three independent LED displays so that the intensities of the three primary colours can be measured simultaneously.

To cope with different white standards or different brands of picture tubes, the PM 5539 has four matrix circuits which can be adjusted to give correct readings. The white level is normally adjusted at both high and low brightness levels, but the ratio of the three primary colours should also stay the same at 'grey' levels. To permit this 'grey scale tracking', the PM 5539 has a wide sensitivity range (1 to 300 NIT full scale).

VIDEO LEVEL METER PM 5548

Precise video level measurement

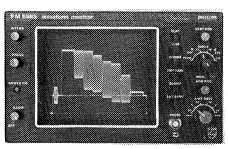
Controls for line selection and position on the selected line(s) allow measurement of the video level at any place of a TV signal or pattern including insertion signals

Optional BCD output

Complementary to PM 5633 colour generator, RGB

The digital video level meter is specially designed for aligning and checking of all kinds of video equipment such as pattern and test signal generators, encoders, decoders, mixers, etc.
The instrument is using a sampling method enabling it to measure levels at any point of the television signal. The position of the sampling pulse is determined by four frontplate controls: - thumbwheel switches, directly indicating the line number for the sampling to start, - control "height" determining how many lines will be sampled, - multiturn potentiometer "delay" giving the sampling point on the selected line(s), - control "width" determining the width of the sampling pulse.

WAVEFORM MONITOR PM 5565



Designed for use in broadcast studios and OB vans

Input at the front for a standard oscilloscope probe

Internal graticule for accurate level readings

Low power consumption

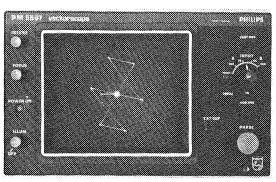
Compatible with other brands of waveform monitors

The PM 5565 waveform monitor was designed for use in television studios, VTR and telecine centres and OB vans. The main application of the instrument is to set-up and check the signals of b/w and colour cameras, videotape recorders, film and slide scanners etc.
As a unique feature for an instrument of its price class, the PM 5565 has a probe input at the front. This enables the PM 5565 to be used for fault finding in the equipment to which it is allocated, thus eliminating the need for an extra oscilloscope for servicing purposes.

The PM 5565 has two video inputs and a monitor output at the rear plus the facility for synchronization from a third video or composite sync input. The vertical sensitivity is $1V_{p\text{-}p}$ or $0.2V_{p\text{-}p}$ full screen size. Filters for display of luminance only or chrominance only are provided. Differential gain measurement is also possible with one separate button.

Horizontal deflections are one or two lines as well as one or two fields, full screen size. Also 20 times magnification is possible. For the convenience of adjusting colour cameras, the PM 5565 accepts the signals from a 'parade display' switcher.

VECTORSCOPE PM 5567



Designed for use in broadcast studios and OB vans

Internal graticule for accurate vector readings

Low power consumption and high reliability

Very easy acces to servicing

Compatible with other brands of vectorscopes

Easy to operate because of logic ergonomy

The PM 5567 vectorscope was designed for use in television studios, VTR and telecine centres and OB vans. The main application is for setting-up and checking the colour content of signals from colour cameras, video taperecorders, film- and telecine scanners etc.
The colours of the selected signal are displayed as vectors.
Vector length represents the saturation of the colours; vector angle represents the hue of the colours (the latter with reference to the colour burst).
PM 5567 has two video inputs plus a further facility for synchronization from a third video colour subcarrier signal. In the PAL version the R-Y alternation can be switched off when checking the 180 degrees PAL switching of the displayed signal. An NTSC display also turns all the $-(R\text{-}Y)$ vectors positive.
The internal graticule makes vector readings easier and more accurate, because parallax errors cannot occur. The graticule has special tolerance lines for reading both the amount of differential gain and phase distortion.

STUDIO VITS GENERATOR PM 5651

Selfcontained unit with insertion and generation of the CCIR or NTC 7 specified VIT signals

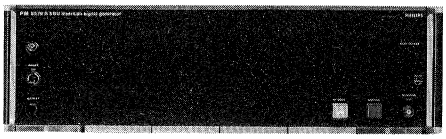
Programme path is protected via by-pass relay

Insertion of VIT signals selectable by internal matrix from line 8 to line 22 (321-335)

Optional source code generator available

The PM 5651 is designed for application in broadcasting studios, video tape recording and telecine centres.
The PM 5651 offers the professional EBU and NTC 7 signals at an attractive price such that it is now economically feasible to introduce a VITS generator/inserter/deleter at each video source. In additon the PM 5651 has an optional source code generator which makes the identification of signal-source or program material easy or even automatic. The EBU source code is standard in the European version, other codes on request.
The generator has extreme accuracy and stability due to its digital generation principle, where the signals are stored in a digital format in PROMs and turned into analog waveforms by means of a high-speed precision D/A converter. By-pass relay protection, easy programming and serviceability are selfevident features of this type of equipment.

INSERTION SIGNAL GENERATOR PM 5576A



In full conformity with the EBU performance specification for insertion signal equipment except that the PM 5576 has no full-field facility

Ideal for use in TV studios and OB vans, where simple and reliable operation is important

Easy programmability via internal matrix board

The PM 5576 insertion signal generator has been developed for those applications, where insertion signals are inserted into programme signals as routine operations that require no attention nor operation of the inserting equipment. The PM 5576 can be considered a simplified version of the fully EBU specified ITS generator PM 5575, since the ITS generating part and the inserter are identical in the two apparatus. Only the full-field signal part is omitted in the PM 5576, whilst the front plate controls of the PM 5575 have been placed inside the PM 5576.

The PM 5576 is particularly useful in OB vans, TV studios and switching centres because of its reliable and study construction and simple operation. Once the routine of using insertion signals within a broadcast authority has been established, the setting of the ITS generator is very rarely changed. The equipment thus requires minimal adjustment by the operational staff.

EBU INSERTION SIGNAL GENERATOR PM 5575A

Authorized by the EBU for use in the Eurovision network

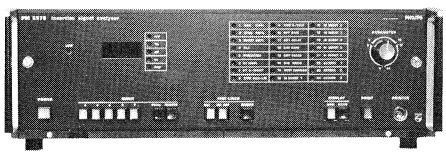
Easy programmability through front plate controls and matrix board

Keyed-in inputs for external insertion signals to be used for data signals, command codes or special insertion signals.

This universal insertion signal generator and inserter has been specially developed to meet the growing need for 'in transmission' testing and automatic analysis. The PM 5575 is a precision instrument that generates, inserts and erases insertion signals in accordance with the EBU specifications for international transmissions, and it can also be used for data signals. It is easily and conveniently programmed from the front panel pinboard matrix.

The PM 5575A is particularly attractive for use in main terminals of broadcast and PTT switching centres as well as in advanced laboratories and maintenance workshops. This because it is easily programmed from the front panel, which has the advantage that the various settings can be seen directly at the frontplate. The instrument can be switched to full-field operation and this signal is available at all times. Moreover the full-field signal can be generated in various combinations, including a special 50Hz squarewave signal that is very useful for testing the low frequency response.

INSERTION SIGNAL ANALYZER PM 5578



Up to 21 parameters can be measured

Outstanding accuracy of measuring results

Presentation by means of digital display

Adjustable limit selection with out-of-tolerance alarm facility

Data print-out possible (serial code ASCII)

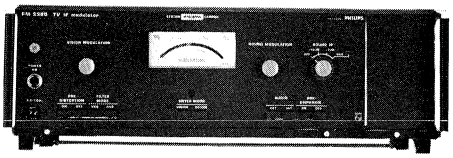
Output for data transmission to monitoring centre

Additional inputs facilitate transmission of alarm functions

One 19-in rack cabinet. 3E high contains all circuitry

This system is a precision instrument for carrying out continuous measurements of the distortion on television chains or other television equipment. It may be used wherever video equipment (from amplifiers and equalizers to transmission links and transmitters or the whole broadcast network from programme studio to transmitters) has to be checked, adjusted or constantly supervised in broadcast studios, switching centres and transmitter stations. Up to 21 different distortions can be measured with it, the results being extremely accurate. Presentation is by means of a digital display. The system includes adjustable limit selection with out-of-tolerance facility. Data print-out is possible (serial code ASCII). A special data transmitter output is incorporated for transmitting the measuring results and alarm signals to a distant centre for remote monitoring. In combination with a minicomputer, several systems may be used for supervising a whole broadcast network.

IF MODULATOR PM 5580



Narrow limits for bandpass and group delay profiles

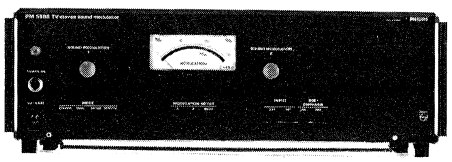
Switchable DSB and VSB modes

Switchable linear and pre-corrected group delay characteristics

Synthesized carrier frequency generator

The PM 5580 is a compact combined vision and sound modulator that uses a highly stable 10MHz X-tal oscillator in order to derive the IF carrier. Synthesizing the signal in this way also allows other intermediate frequency to be provided. The modulator is used to supply either combined or separate IF vision and sound carrier to the VHF and UHF converters described on this page. In turn this combination can be used for signal distribution systems. The DSB mode facility of the modulator also allows it to be employed for testing, for example Nyquist receivers for pulse and frequency response.

TV STEREO MODULATOR PM 5588



Self contained sound modulator for 2 channels or stereo transmission

In conformity with the for German broadcast service

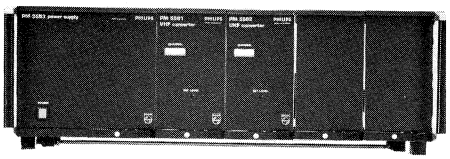
Options for inter-carrier output and internal vision carrier

Easy to use with existing vision modulators, in particular PM 5580

The PM 5588 TV stereo modulator contains all the circuits needed to generate the FM modulated sound signals for normal television transmissions (mono), two-channel sound transmissions (dual) and stereo phonic sound transmissions (stereo). Together with a

vision modulator, for instance the PM 5580, a composite vision/sound signal is generated (IF frequency), which can then be converted to any VHF or UHF channel with one or more RF converters (PM 5581 for VHF, PM 5582 for UHF).
The two sound carriers are produced by synthesizers using the incoming video as reference, are FM modulated by the incoming audio signals in accordance to the selected mode of operation: mono, dual or stereo.

VHF/UHF CONVERTERS PM 5581-PM 5583



Easy change of channel

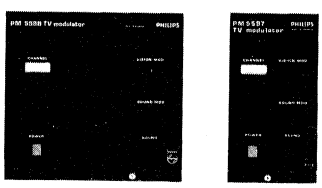
Directional coupler in the IF output

Covers all VHF/UHF as well as S channels

High stability, very low distortion

The PM 5581 converts IF signals to signals in the VHF band whilst the PM 5582 converts to the UHF band. They are designed for use together with the IF modulator PM 5580. One converter can be plugged into the same 19-in cabinet as the PM 5580, from which it also is driven.
If more converters are used one has to use the PM 5583 base unit, which can contain up to four converters. The directional coupler unit enables the user to connect many converters in series, which is necessary in a IF distribution network.

TV MODULATORS PM 5597/98



Self-contained TV modulators for distribution and universal purposes

Double side-band modulation with special filter that reduces partly the lower side-band, and suppresses spurious and harmonic signals

Built-in indicators for overmodulation of the video as well as the sound carriers

The output of several modulators can be combined by means of simple combiners

The PM 5597 and PM 5598 TV modulators are small one-channel, combined vision/sound 'transmitters' of professionel quality, well suited for colour and monochrome TV. The carrier frequency is crystal controlled, and all channels from 35MHz to 300MHz (PM 5597) and 470MHz to 960MHz (PM 5598) are available.
The output signal is in principle a double side-band modulated RF signal, but a band-pass filter in front of the output stage partly suppresses the lower side-band and the frequency content of the higher side-band above the sound carrier. Besides, this filter suppresses any spurious and harmonics outside the band-pass range. Thanks to wide-band output stage (75Ω output impedance over the complete frequency range) the outputs of several modulators can be connected to a single cable for distribution by means of simple combiners without any mutual disturbance of the signals. Only every other channel has to be kept free of signal.

Mechanically the modulators are plug-in units fitting into the PHILIPS 19-in rack/table cabinet. The PM 5597 is a 1/6 unit, while the PM 5598 is a 2/6 unit.

TV TEST MODULATOR PM 5669

Very accurate display of rest carrier with digital meter

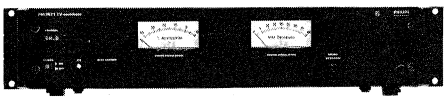
Extremely high stability of modulator balance

Double side-band video modulator with output signals on IF as well as in band I

Three different modes of DC restoration

The main application of the PM 5669 is test and evaluation of professional TV demodulators and receivers. These products are in themselves measuring instruments so to test them, a modulator with extreme accuracy and stability is mandatory. The PM 5669 delivers a double side-band modulated signal both on IF basis and on a TV channel in band I. The flatness of the response, the accuracy of the group delay precorrection response, and the very low level of distortions and spurious signals, satisfy fully the needs for demanding demodulator test and calibration. The instrument has a precision, digital modulation meter so that evaluations can be performed with well defined modulation depths.

TV MODULATOR PM 5671



Combined vision and sound modulator with output signal in VHF of UHF bands

Very high stability due to use of SAW filters.

Pre-corrected group delay and vestigial side-band characteristics.

Very low content of harmonics and spurious at the output

Ideal for low power transmitters and distribution systems in TV factories

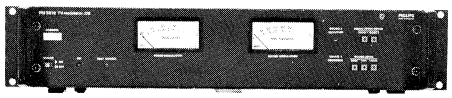
The TV modulator PM 5671 is a complete television modulator (transmitter) which has inputs for video and audio and output for VHF or UHF radio frequencies.
Extreme accuracy and stability are obtained by the use of new technology, such as synthesized carrier generation and surface-acoustic wave-filter (SAW) for the amplitude response shaping. Although the PM 5671 is very economically priced, it features the following broadcasting characteristics only found in more expensive modulators:
- Vestigial side-band characteristics
- Group delay pre-correction
- Low distortion
- Channel output with very low spurious and harmonic content
- Precision meters, front mounted, for modulation control.

The PM 5671 is ideal for television distribution systems such as those used in TV and video cassette recorder factories, closed-circuit and cable TV networks, etc. The SAW filter ensures that adjacent channel operation is possible without interference. The PM 5671 is also ideal as a cost effective exciter in low power TV transmitters. The instrument is available for TV systems B/G, D/K, I and M.

TV MODULATOR, IF PM 5670

This modulator is an IF version of the PM 5671 TV modulator. The modulator gives the option of either a composite vision/sound IF signal or vision and sound signals on separate output connectors (selected internally).
The PM 5670 is recommended when IF signals are required or sound and vision have to be converted separately into VHF or UHF channels. Recommended converters: PM 5581 and 82 (PM 5583 power supply for PM 5581/82)

TV MODULATOR PM 5672 DS
(dual sound)



Combined vision and dual/stereo sound modulator with RF output in the VHF range and UHF range

Dual/stereo sound in conformity with the German system

Pre-corrected group delay and vestigial side-band characteristics

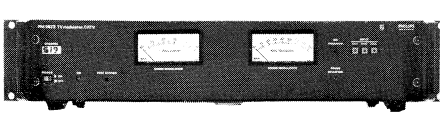
Ideal for low power dual sound/stereo transmitter in CATV networks as well as central transmitter in TV factories

The PM 5672 TV modulator, DS is a complete television modulator (transmitter) which has inputs for video and two audio channels and output for VHF or UHF radio frequencies.

Extreme accuracy and stability are obtained by the use of new technology, such as synthesized carrier generation and a surface-acoustic wave-filter (SAW) for the amplitude response shaping. Although the PM 5672 is very economically priced, it features the following broadcasting characteristics only found in more expensive modulators:
- Vestigial side-band characteristics
- Group delay pre-correction
- Low distortion
- Channel output with very low spurious and harmonic content
- Precision meters, front mounted, for modulation control
- Stereo or two-channel sound.

The PM 5672 is ideal for television distribution systems such as those used in TV and video cassette recorder factories, closed-circuit and cable TV networks, etc., The SAW filter ensures that adjacent channel operation is possible without interference. The PM 5672 is also ideal as a cost effective exciter in low power TV transmitters.

TV MODULATOR PM 5673, CATV



Designed for adjacent channel operation in cable systems and other distribution systems

Automatic or manual substitution of video and audio

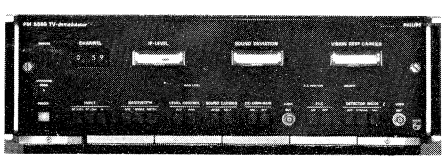
Pre-corrected group delay and vestigial side-band characteristics

Very high stability due to the use of SAW filters and synthesized carriers

The PM 5673 TV modulator, is a complete television modulator (transmitter) which has inputs for video and audio and output for VHF or UHF radio frequencies.
Extreme accuracy and stability are obtained by the use of new technology, such as synthesized carrier generation and a surface-acoustic wave-filter (SAW) for the amplitude response shaping. Although the PM 5673 is very economically priced, it features the following important characteristics only found in more expensive modulators:
- Vestigial side-band characteristics
- Group delay pre-correction
- Low distortion
- Channel output with very low spurious and harmonic content
- Precision meters, front mounted, for modulation control
- Automatic substitution for video and audio.

The PM 5673 is specially designed for television distribution systems such as cable TV systems, etc. The SAW filter ensures that adjacent channel operation is possible without interference. The automatic substitution circuitry changes to stand-by video and audio signals, when the incoming programme signals disappear. Manual control is also possible.

TV DEMODULATOR PM 5560



Both synchronous and envelope detection modes give possibility of measuring more parameters than previously and with improved accuracy

Unique ROM and synthesizer circuits facilitate straight forward dialling of the wanted channel

Separate inputs for UHF and VHF channels at low and high levels plus IF input

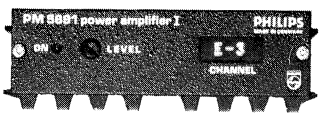
Channel and input selection can be remotely controlled

The Philips PM 5560 TV demodulator is a compact precision Nyquist demodulator containing both the tuner and the IF demodulator.
The tuner is a combined VHF-UHF tuner using double conversion to obtain a good selectivity. The tuning is done by means of thumbwheels, indicating the selected channel number. Provisions have been made to cover also the S-channels, special VHF channels and to tune to transmitters using an off-set frequency.
The IF demodulator can be used in two modes:
a. synchronous detection
b. envelope detection

The modes can either be selected manually or automatically with a preference for the synchronous mode. Sound detection is also possible in two modes:
a. intercarrier sound
b. splitcarrier sound

Three meters are mounted at the front-plate enabling simultaneous checks of IF level, sound deviation and vision rest carrier.

POWER AMPLIFIERS PM 5691/93/94



1 Watt RF power into 75Ω

Usable with natural cooling or forced air cooling

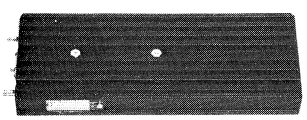
Very low distortion and intermodulation

Small mechanical dimensions

The PM 5691/93/94 power amplifiers are designed for high quality, high power distribution systems in, for instance, TV set and video recorder factories. The amplifiers are supplied for a specific channel in band I VHF (PM 5691), band III VHF (PM 5693) and the UHF band (PM 5694).

The amplifiers have very flat amplitude response/group delay response and very low intermodulation/distortion. They are therefore ideal for use in high quality low power transmitters.

The standard output level is 1 Watt, however, if slightly more intermodulation is acceptable or a linearity corrector is applied the amplifier can deliver substantially more power.



The comprehensive PTV catalog is available on request.

Microwave equipment

	Page
Catalog and product range	2
Microwave education	3
Basic experiments I	4
Basic experiments II and III	4
Basic experiments IV and V	5
Mini sweeper X-band PM 7022X	6

For complete information send for our microwave catalog

Catalog and product range

SPECIAL CATALOGS

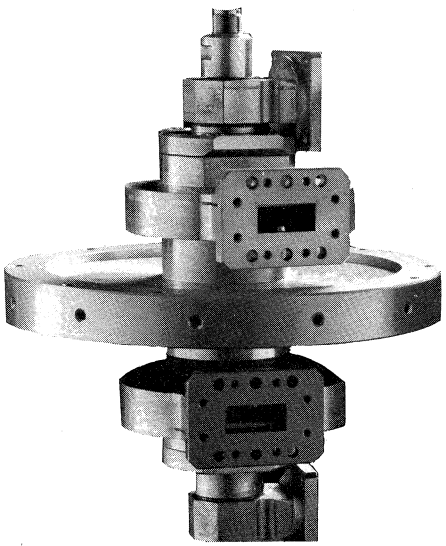
For detailed information on microwave products the following catalogs are available:
MAIN CATALOG "Microwave Products"

Catalog on YIG capability: "Microwave High Tech"

Catalog on electromechanical capability "Rotary Joint Venture"

Catalog on VCO capability "Varactor Varsity"

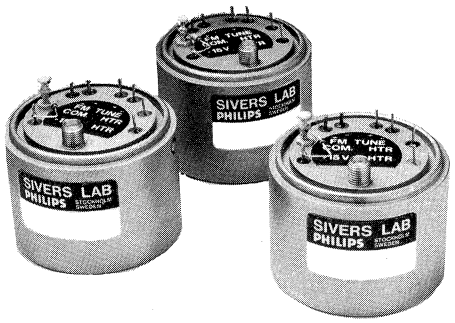
ROTARY JOINTS



3-channel X-band rotary joint.

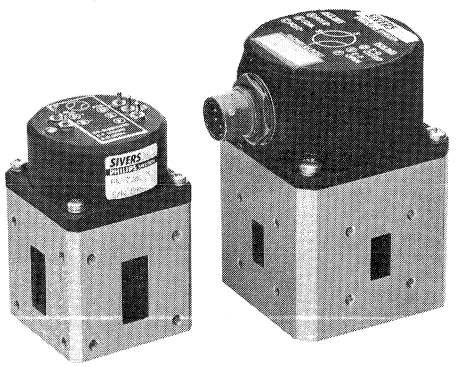
Single and multichannel
waveguide and coaxial
covering most frequency bands
DC-18GHz, most models available with integral sliprings
high-performance design

YIG-PRODUCTS



Bipolar and FET oscillators
Bandpass filters
Bandstop filers
Tracking filters/oscillators
assemblies for superhet applications

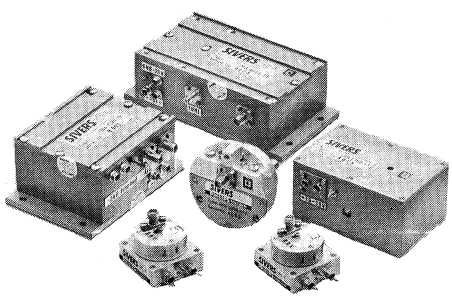
WAVEGUIDE SWITCHES



PM 7288 *PM 7286*

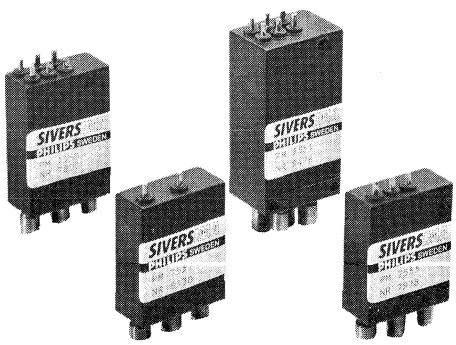
All frequency bands 1-18GHz
transfer and three-channel
latching and failsafe
automatic and manual
solenoid and motor driven actuators
position indication

OSCILLATORS



Varactor tuned, narrow band wide band
Dielectric stabilized
Cavity stabilized

COAXIAL SWITCHES



PM 7555-7557.

DC-18GHz frequency coverage
transfer and SPDT
SMA and N-type connectors
latching and failsafe

Microwave education

A series of easy-to-understand booklets is available in English, French, German, Spanish and Swedish, which describe five different microwave experiments. The brief treatment of the theoretic background virtually eliminates mathematics and references to other theoretical books are included. The comprehensive brochure 'Education in applied microwaves' describes these booklets, the specially designed bench equipment for each experiment and all associated components.
Each of the experiments 1 to V are designed for the following studies:

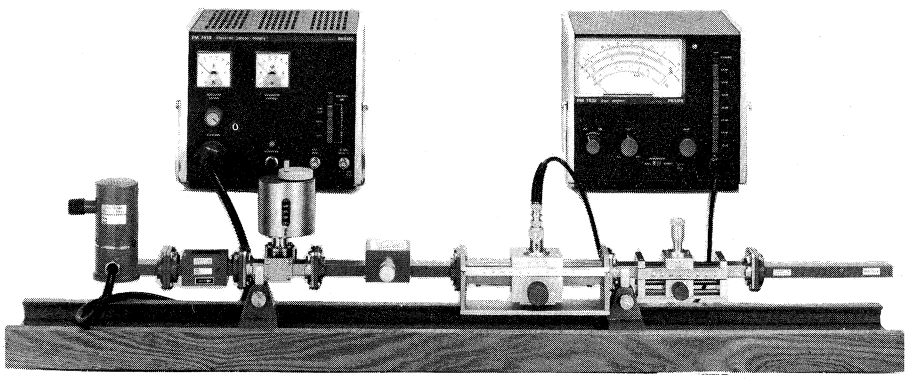
Basic Experiments I
1. Study of a reflex klystron
2. Frequency, wavelength and attenuation measurements
3. SWR measurements
4. Impedance measurements. The Smith Chart
5. Antenna measurements

Basic Experiments II
1. Study of a Gunn-oscillator
2. Power measurements
3. The directional coupler
4. Matching with the sliding screw tuner
5. Crystal detectors

Basic Experiments III
1. Swept frequency measurements
2. Nonreciprocal ferrites
3. The YIG-filter
4. The Doppler effect

Basic Experiments IV
1. Study of a waveguide hybrid-T
2. Frequency conversion
3. A simple frequency-modulated microwave link
4. Injection phase locking of a microwave oscillator

Basic Experiments V
1. Horn antenna
2. Parabolic antenna, slotantenna
3. Helex antenna, Polarization theory
4. Microstrip antenna, Phased array antenna



Equipment
The instruments and components needed to perform the experiments have been grouped as follows:

Basic Experiments I:	Bench PM 7000X
Basic Experiments II:	Bench PM 7001X
Basic Experiments III:	Bench PM 7002X
Basic Experiments IV:	Bench PM 7003X
Basic Experiments V:	Bench PM 7004X

The benches are composed of standard items widely used by research, developments and service people all over the world. This means that the students are trained on modern equipment and achieve a good feeling for the practical aspects of microwaves.

Basic Experiments I
Microwave bench PM 7000X
This is the first bench in our series of comprehensive set-ups for microwave education.
The bench, called PM 7000X, uses a low power klystron as signal source and standard high quality components throughout. The power supply for the klyston has a built-in modulator section with either sine- or square-wave. The frequency meter is of the famous direct reading type PM 7070X with a direct reading accuracy of ± 0.1%. The SWR-meter used, is a sensitive amplifier/voltmeter calibrated in VSWR and dB.
For the performing of antenna measurements, a rotary joint and two antenna horns are included.

Components list PM 7000X

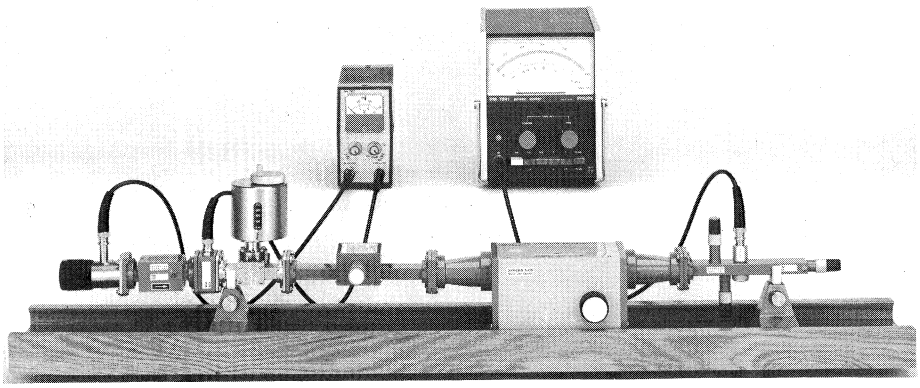
1 Klystron oscillator	PM 7011X
1 Ferrite isolator	PM 7045X
1 Frequency meter	PM 7070X/bg
1 Variable attenuator	PM 7110X
1 Standing wave detector	PM 7142X
1 Slide screw tuner	PM 7151X
1 Detector	PM 7195X
1 Movable short	PM 7216X
1 Termination	PM 7220X
2 Horn antenna	PM 7320X/01
2 Waveguide bend	PM 7345X
1 Straight waveguide section	PM 7366X
2 Waveguide carrier	PM 7700
2 Waveguide clamp	PM 7701X
1 Klystron power supply	PM 7815
1 SWR-meter	PM 7832
1 Rotary joint	PM 7888X
1 Oak bench	SL 80300
1 Laboratory stand	SL 80364

Additional equipment required (not included in PM 7000X)

1 Oscilloscope single-trace e.g	PM 3207

Basic Experiments II
Microwave bench PM 7001X
This second bench, PM 7001X, uses a Gunn-oscillator, a solid state replacement of the klystron. The Gunn-oscillator, PM 7015X consists of a semiconductor diode in a high Q waveguide cavity, which is mechanically tunable over a wide frequency range. To achieve the best modulated signal from the Gunn-oscillator, it is used together with a separate diode modulator. Both are, however, supplied from the same power supply/modulator PM 7813.
The photo also shows the direct reading frequency meter and the directional coupler together with the rotary vane attenuator PM 7101X. This high precision attenuator has an easy readable scale 0-60dB.
For accurate power measurements a thermistor mount and a power bridge are included.

Experiments
1. Study of a Gunn-oscillator
2. Power measurements
3. The directional coupler
4. Matching with the slide screw tuner
5. Crystal detectors



Components list PM 7001X

1 Gunn oscillator	PM 7015X
1 Modulator	PM 7026X/01
1 Ferrite isolator	PM 7045X
1 Frequency meter	PM 7070X/bg
1 Rotary vane attenuator	PM 7101X
1 Variable attenuator	PM 7110X
1 Slide screw tuner	PM 7151X
1 Detector	PM 7195X
1 Thermistor mount	PM 7201X
1 Movable short	PM 7216X
1 Termination	PM 7220X
1 Directional coupler 10dB	PM 7241X
2 Waveguide carrier	PM 7700
2 Waveguide clamp	PM 7701X
1 Gunn oscillator power supply	PM 7813
1 SWR-meter	PM 7832
1 Power meter	PM 7841
2 Adapter BNC-Banana	PM 9051
1 T-piece BNC	PM 9067
1 Oak bench	SL 80300

Additional equipment required (not included in PM 7001X)

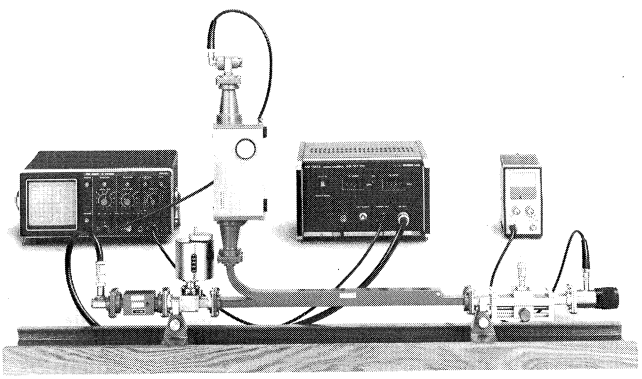
1 DC-voltmeter e.g.	PM 2412
1 DC-mA meter e.g.	PM 2412
1 Oscilloscope single-trace e.g.	PM 3207

Basic Experiments III
Microwave bench PM 7002X
This is slightly different from the two previous experiments. Swept frequency measurements using a sweep generator PM 7022X from the subject of the first chapter, which concerns measurement of insertion loss and return loss on both active and passive devices.
Nonreciprocal ferrite devices (isolator, circulator) are presented in the second chapter, and the third investigates the YIG-tuned filter. This device is being swept in the frequency domain by sweeping the tuning current. Most typical features are covered.
Finally, a simple Doppler radar set-up is discussed.

Experiments
1. Swept frequency measurements.
2. Non reciprocal ferrite devices.
3. The YIG-filter
4. A study of the doppler effect.

Basic Experiments III is based on the same instruments as Basic Exp. I and II, with the following additions:

Sweep oscillator PM 7022X
A YIG-tuned Gunn-oscillator which can be swept between any two frequencies within the range 8–12.4GHz. The output power is > 10mW.



YIG-filter unit PM 7440/01
This is a X-band bandpass YIG-filter combined with the necessary driving and tuning circuits. The frequency can be tuned manually and the frequency read on a scale.

Circulator PM 7050X
The three-port circulator transmits a wave only in one direction. A wave incident of port 1 is only coupled to port 2 and so on.

Components list 7002X

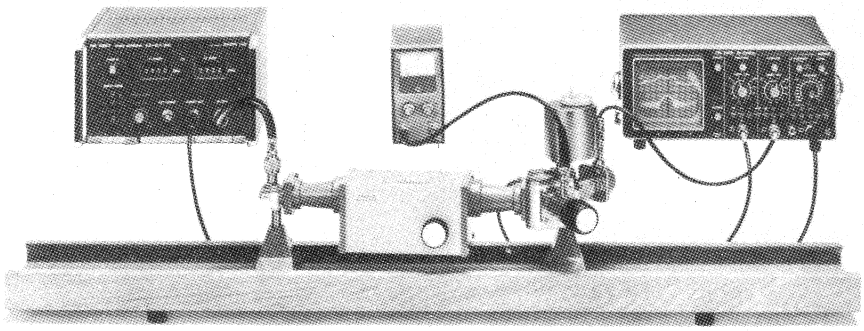
1 Gunn oscillator	PM 7015X
1 Sweep oscillator	PM 7022X
1 Modulator	PM 7026X/01
1 Ferrite isolator	PM 7045X
1 Ferrite circulator	PM 7050X
1 Frequency meter	PM 7070X/bg
1 Rotary vane attenuator	PM 7101X
1 Variable attenuator	PM 7110X
1 Slide screw tuner	PM 7151X
1 Detector	PM 7195X
1 Movable short	PM 7216X
1 Termination	PM 7220X
1 Directional coupler 10dB	PM 7241X
1 Horn antenna	PM 7320X/01
1 Transition wg/coax.	PM 7325X
2 Transition wg/coax.	PM 7328X
2 Waveguide carrier	PM 7700
2 Waveguide clamp	PM 7701X
1 Waveguide clamp	PM 7702X
1 YIG-filter unit	PM 7440/01
1 Gunn oscillator power supply	PM 7815
1 SWR-meter	PM 7832
1 Oak bench	SL 80300

Additional equipment needed (not included in the PM 7003X)

1 Oscilloscope dual trace e.g.	PM 3207

Additional equipment required (not included in PM 7002X)

1 Oscilloscope e.g.	PM 3207
1 DC power supply e.g.	PE 1536
2 Horn antenna	PM 7320X/01
1 Transition wg/coax.	PM 7325X
2 Waveguide carrier	PM 7700
2 Waveguide clamp	PM 7701X
2 Waveguide clamp	PM 7702X
1 Gunn oscillator power supply	PM 7815
1 SWR-meter	PM 7832
1 T-piece BNC	PM 9067
1 Cable termination	PM 9585
1 Function generator	PM 9710
1 Oak bench	SL 80300



Basic Experiments IV
Microwave bench PM 7003X

This set-up is directed towards applied microwave measurements. The first chapter covers the operation and characteristics of a hybrid-T, the microwave analogy of the low frequency balanced bridge. Frequency mixing in a microwave diode is the next subject. Here, the frequency from the sweep oscillator PM 7022X is mixed with the Gunn oscillator PM 7015X frequency in the detector PM 7197X.
A simple experiment of frequency modulation/demodulation is presented using PM 7022X as a source and the frequency meter PM 7070X/ag as a detector. The last experiment reveals the fundamentals around frequency injection locking. A Gunn oscillator PM 7015X is locked and locking bandwidth verses injected power is determined.
Basic Experiments IV is based on the equipment used in Basic Exp. 1-3 with a few additions.

Experiments

1. Study of a waveguide hybrid-T.
2. Frequency conversion.
3. A simple frequency-modulated microwave link.
4. Injection locking a microwave oscillator.

Components list PM 7003X

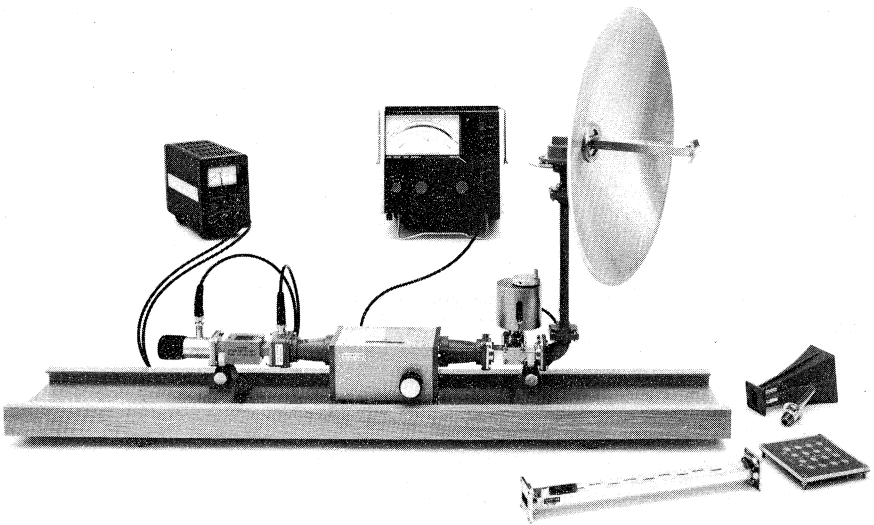
1 Gunn oscillator	PM 7015X
1 Varactor tuned oscillator	PM 7017X
1 Sweet oscillator	PM 7022X
1 Modulator	PM 7026X/01
1 Ferrite isolator	PM 7045X
1 Ferrite circulator	PM 7050X
1 Frequency meter	PM 7070X/bg
1 Rotary vane attenuator	PM 7101X
1 Variable attenuator	PM 7110X
1 Detector	PM 7197X
1 Movable short	PM 7216X
2 Termination	PM 7220X
1 Directional coupler 10dB	PM 7241X
1 Hybrid-T	PM 7260x

Additional equipment needed (not included in the PM 7003X)

1 Oscilloscope dual trace e.g.	PM 3207

Basic Experiments V
Microwave bench PM 7004X

The 5th booklet in our series of Basic Experiments is totally focused on antennas. Typical microwave antennas are described and the basic radiation features are measured. The experiments start with determination of a standard gain with the help of two horn antennas; the gain of a parabolic- and a broad-side slot antenna is obtained with the 3-antenna method. Helix antennas and polarization theory is studied in experiment 3 and in experiment 4, finally, modern technique represented by a microstrip antenna is described and a simple phased-array antenna is demonstrated. In all experiments the pattern of the specific antenna is also measured.



Components list PM 7004X

Gunn oscillator	PM 7015X
Modulator	PM 7026X/01
Ferrite isolator	PM 7045X
Frequency meter	PM 7070X/bg
Rotary vane attenuator	PM 7101X
Detector	PM 7195X
Movable short	PM 7216X
Antenna kit:	PM 7317X
Parabolic antenna, waveguide rear feed	SL 19700
Broadside slot antenna	SL 19701
Helix antenna, right-hand winded	SL 19702/01
Helix antenna, left-hand winded	SL 19702/02
Microstrip antenna	SL 19703
Metal plane	SL 19704
Antenna stand	SL 19705
Horn antenna	PM 7320X/01
Transition, type N	PM 7325X
Waveguide, E-bend	PM 7345X
Waveguide, H-bend	PM 7350X
Straight waveguide section	PM 7366X
Adaptor, type N-male x 2	PM 7580
Waveguide carrier	PM 7700
Waveguide clamp	PM 7702X
Power supply	PM 7815
SWR-meter	PM 7832
Rotary joint	PM 7888X
Oak bench	SL 80300
Measuring-tape	SL 80599

Sweep oscillator 8.0-12.4GHz PM 7022X

Compact design

Compatible with network analysing equipment

Slow single sweep for recording purposes

Easy to operate

Light weight (7kg)

Swept frequency measurements at low cost but still with highest accuracy is what the sweep oscillator PM 7022X is designed for. Only necessary functions have been included in order to keep the cost down. The result is a compact, reliable instrument, easy to operate giving a min. output power of 10mW over the whole frequency range. It has variable sweep speed for use with both oscilloscopes and pen recorders.

TECHNICAL SPECIFICATION

FREQUENCY

Frequency range
8.0–12.4GHz

Frequency accuracy (25°C)
CW-mode F_1: ± 40 MHz
Sweep linearity: ± 1% of sweep width

Frequency stability
−10°C to +45°C total: 100 MHz
10% mains voltage variation: 1 MHz
Residual FM (CW-mode): 15kHz peak at 10KHz BW
With load VSWR 3:1, all phases: 1 MHz

GENERAL

CW
Sweep from F_1 to F_2 as set in 10 MHz increments with the two thumbwheel settings. These are calibrated and independent. The sweep can be either up or down in frequency.

CW manual scan
Single frequency output
The frequency can be set anywhere between F_1 and F_2 by MANUAL SCAN knob.

Fast auto
Recurrent sweep
Continuously variable sweep speed from 20ms to 200ms

Slow single
Single sweep triggered by TRIGG button. Continuously variable from 5 seconds to 50 seconds.

External sweep
When the CW-button is pressed (MANUAL SCAN set to F_1) the frequency can be swept externally with a sweep voltage applied to EXT. SWEEP connector. Zero volts for F_1 and +10 volts for F_2. Input impedance 1kΩ.

Sweep out
Zero volts corresponds to F_1 and +10 volts corresponds to F_2. The output voltage is proportional to the instant output frequency (Also operating in the CW-mode).

Display blanking
One positive and one negative output each giving a pulse of 5 volts coincident in time with sweep retrace.

Pen lift
NO: Contact normally open
NC: Contact normally closed

RF blanking
ON: The RF turns off automatically during sweep retrace and remains off until next sweep starts.
OFF: The RF is on also during retrace. The sweep and retrace times are equal.

Reference sweep out
Direct coupled voltage proportional to instantaneous frequency.
Zero volts at 8.0GHz and +5 volts and 12.4GHz.
Compatible with Hewlett Packard Network Analyzer HP 84105

CW filter
To give low incidental PM (CW operation only)

DIMENSIONS AND WEIGHT

235 x 130 x 265mm excl. handles
(9.3 x 5.1 x 10.5-in)
7kg (15.4lb)

Power
Line voltages: 110-127-220-240V ± 10%, 50-60 Hz
Consumption: 50VA
Min. output: 10mW
Power variation, max.: 6dB
Spurious signals:
Harmonics: −30dB
Nonharmonics: −50dB

DC power supplies, AC voltage stabilizers and UPS systems

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Introduction

Philips, by investing considerable capital, involving suitably skilled personnel and by producing very large product volumes, can offer power supplies and voltage stabilizers at attractive prices, from a few to thousands per order.
All products embody the latest design concepts, utilize state-of-the-art technologies and exhibit extremely high levels of reliability, each design having been subjected to exhaustive life testing throughout all stages of development.
It certainly pays to purchase, rather than make; it REALLY pays to buy PHILIPS.

A broad range
This catalog deals with a restricted range of bench and laboratory types, as well as magnetic and electronic-magnetic stabilizers, which will be of particular interest to end-users.
The OEM DC power supplies listed on p. 295 are also available in leaflet form on request.

New to the Philips range of power supplies is a range of uninterruptable power units (UPS). These are designed for heavy-duty operation to protect and maintain essential power supplies against mains failures. They automatically produce nominal mains power intantaneously in the event of failure. Full supply power can be maintained for varying periods of time, depending on the application.
Also, large transients created by noise-producing equipment (welding, lifts, etc.) as well as lightning strikes are 'conditioned' by the UPS units. Powers between 150 and 2500VA can be provided from the standard range. Special units can be considered by the Philips design team.

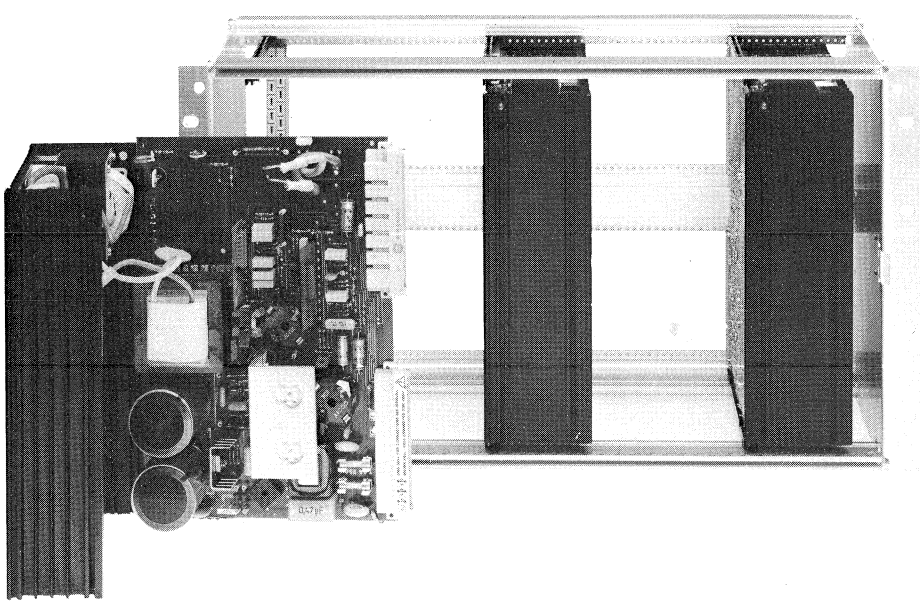
OEM switching modules
A range of more than 80 euro-switchers, from 25 to 500 watts (measured at an ambient temperature of 55°C with convection cooling) is now available.
Those types of power supplies are ideal for a very wide range of applications. For example, their mechanical flexibility enables the units to be mounted direct into equipment, into 19-in racks according to DIN 41494 or into special one-off systems, such as those often developed for production test applications.

Bench and systems types
For bench use, the line comprises ultra stable units, giving outputs from 20 to 120 watts at varying voltage and current levels, in single- or triple-output versions.
A long term reliability is definitely ensured by an extremely high MTBF of 75000 operating hours.
The modern lab/systems power supply is a precision instrument, the outputs of which can be easily set and read. It is also an instrument that can function in either constant voltage or constant current modes. If higher outputs are needed, the units can operate in series or parallel.

IEC/IEEE bus power supplies programmer
For use in automatic test systems, a universal IEC/IEEE bus power supplies programmer is available.
It is essentially a digital-to-analog converter (DAC) fitted with a microprocessor and usable as an interface between a standard microcomputer and bench or laboratory power supplies.

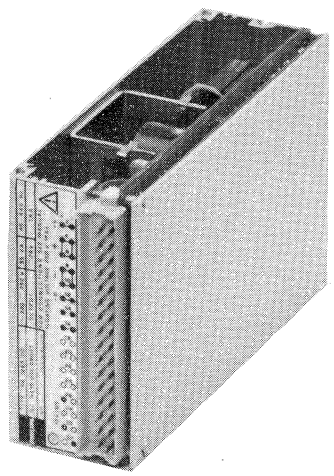
AC stabilizers
Again Philips offers a broad choice of 25 magnetic stabilizers or line conditioners, valid for 50/60Hz and 220V or 240V mains. The range covers power ratings between 200 and 6000VA. Open and closed versions are available.
In addition, Philips offers electronic/magnetic stabilizers offering a high 0.1% stability combined with good transient suppression.
Unlike the magnetic approach, this technique is not frequency dependent and can also handle inductive loads.

View of 6U Euro-mechanical format AC/DC power supply, showing other similar units in standard rack-



Power supplies for OEM

30 W



AC/DC EURO-SWITCHERS 3U

- highly reliable forward converters: efficiencies to 77%,
- nominal power at 55°C with convection cooling,
- compliance with IEC, UL and VDE safety norms,
- line regulation better than 0.1% and load regulation better than 0.2% for the main outputs, even with 10 to 100% load variations,
- rfi on source according to VDE 0875 level N, or to VDE 0871 level B with an external filter, e.g. EICHHOFF BV 10531,
- effective protection by adjustable current limiter, adjustable overvoltage protection, mains and primary dc voltage fuses.
- front LED indication of the main output voltage,
- power failure TTL signal on dual and triple units,
- remote on-off by external voltage,
- resistor and voltage programming for the single output units,
- remote sensing for the main outputs,
- easy parallel and series connection.

UL 478 and 544 recognized models

Single output

PE 1267/00	5V	6A	10T	220V
PE 1267/10	5V	5A	10T	110/220V
PE 1268/00	12 (15)V	3A	10T	220V
PE 1268/10	12 (15)V	2A	10T	110/220V
PE 1269/00	24V	1.6A	10T	220V
PE 1269/10	24V	1.0A	10T	110/220V

Available as option: power failure indication (TTL) unit PE 1396

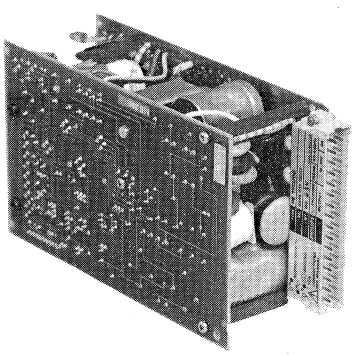
Multi-output

PE 1138/50	±12 (15)V	1.3 A 10T	220/110V
PE 1140/50	5V 4A; ±15 (12)V	0.25A 10T	220/110V
PE 1890/40	5V 5A; ±12V	0.3 A 8T	220V

The last unit is a low-cost euro-card of 32 watts at 40°C, fitted with many features. A lower cost version PE 1890/00 is also available.
For the first eight units, dimensions are:
100.0 (H) X 50.3 (W) X 176.2 (D) mm.

1U = 44.45mm
1T = 5.08mm

60W



- highly reliable forward converters: efficiencies to 73%,
- nominal power at 55°C with convection cooling,
- higher power at 40°.,
- compliance with IEC, UL and VDE safety norms,
- line regulation better than 0.1% and load regulation better than 0.2% for the main outputs, even with 100% load variations,
- creepage distances of 8mm between primary and secondary parts of the printed boards,
- rfi on source according to VDE 0871 level B for the enclosed versions,
- full protection by adjustable, foldback type, current limiting with full short-circuit protection, overvoltage protection, overtemperature protection, mains voltage fuses, sense protection,
- front LED indication of the main output voltage,
- power failure TTL (LS) signal,
- remote on-off with TTL logic,
- resistor and voltage programming,
- remote sensing terminals,
- easy parallel and series connection,
- front panel adjustment of the main output voltage with a potentiometer.

UL 478 and 544 recognized models

* VDE 0806 recognized models.

Single output

PE 1112/00	5V	14A	13T	110/220V o*
PE 1112/50	5V	12A	17T	110/220V c*
PE 1113/00	15 (12)V	4.6A	13T	110/220V o*
PE 1113/50	15 (12)V	4.0A	17T	110/220V c*
PE 1114/00	24V	2.9A	13T	110/220V o*
PE 1114/50	24V	2.5A	17T	110/220V c*

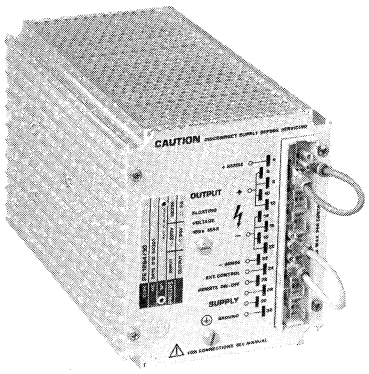
o: open c: closed
Available on request: 48V output units.

Multi-output

PE 1113/00	±15 (12)V	2.3A	13T	110/220V o*
PE 1113/50	±15 (12)V	2.0A	17T	110/220V c*
PE 1141/00	5V 6A; ±15V	1A	15T	110/220V o*
PE 1141/50	5V 4A; ±15V	1A	17T	110/220V c*
PE 1143/00	5V 7A; ±12V	1A	15T	110/220V o*
PE 1143/50	5V 5A; ±12V	1A	17T	110/220V c*
PE 1144/00	5V 6A; +12V	2.5A	13T	110/220V o*
	−12V	1A		
PE 1144/50	5V 6A; +12V	25A	17T	110/220V c*
	−12V	1A	17T	110/220V

o: open c: closed
Available on request: other dual units such as 5V/12V or 5V/24V, triple units or quadruple units.
Dimensions (3U):
Single open versions 100.0(H) X 178.9(D)mm
Multi-output open versions 110.6(H) X 178.9(D)mm
Closed versions 110.6(H) X 176.6(D)mm

100W



AC/DC EURO-SWITCHERS 3U

Valid for single output models:

- highly reliable forward converters: efficiencies to 78%,
- nominal power at 55°C with convection cooling,
- higher power at 40°C and up to 172 watts at 55°C with forced-air cooling (PE 1122),
- compliance with IEC, UL and VDE safety norms,
- line and load regulation better than 0.2%, even with 10 to 100% load variations,
- rfi on source according to VDE 0875 level N-12, or VDE 0871 level B with an external filter such as EICHHOFF BV 10531,
- effective protection by current limiter, overvoltage protection, sense protection, thermal protection and mains fuses,
- front LED indication of the output voltage for closed versions,
- power failure or energy reserve TTL (LS) signal,
- remote on-off with TTL logic,
- resistor and voltage programming,
- remote sensing terminals,
- easy parallel and series connection.

UL 478 and 544 recognized models

Single output

• Open-frame units

PE 1120/00	5V	20A	13T	220V open
PE 1121/00	12 (15)V	9A	13T	220V open
PE 1122/00	24V	5.5A	13T	220V open

Dimensions: 110.6(H) X 65(W) x 337(D)mm.

• Enclosed units

PE 1258/30	5V	18A	20T	220V closed
PE 1261/30	12 (15)V	8A	20T	220V closed
PE 1264/30	24V	5A	20T	220V closed

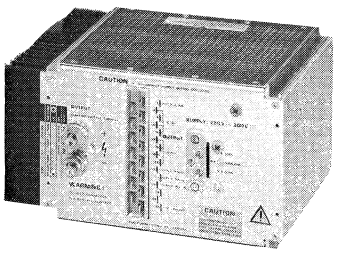
Dimensions: 110.6(H) X 97.5(W) X 175.3(D)mm.

Multi-output

PE 1727/00	5V/10A; ±12V 2A; 110/220V open	
	– 5V/0.5A	
PE 1727/50	5V/10A; ±12V 2A; 110/220V closed	
	– 5V/0.5A	

Both multiple models are low-cost units, completely different from the single output models. Ask for specifications.

200W



- highly reliable forward converters: efficiencies to 82%,
- nominal power at 55°C with convection cooling,
- power up to 348 watts at 55°C and up to 396 watts at 40°C with forced-cooling for 24V output,
- compliance with IEC, UL and VDE safety norms,
- line and load regulation better than 0.2% even with load variations of 10 to 100%,
- rfi on source according to VDE 0875 level N-12,
- effective protection by current limiter, overvoltage protection, sense protection and mains fuses,
- power failure or energy reserve TTL (LS) signal,
- remote on-off with TTL logic,
- resistor and voltage programming,
- remote sensing terminals,
- easy parallel and series connection (a power output up to 1200 watts can be obtained at 40°C with forced-air cooling by connecting 3 PE 1265/20 in parallel).

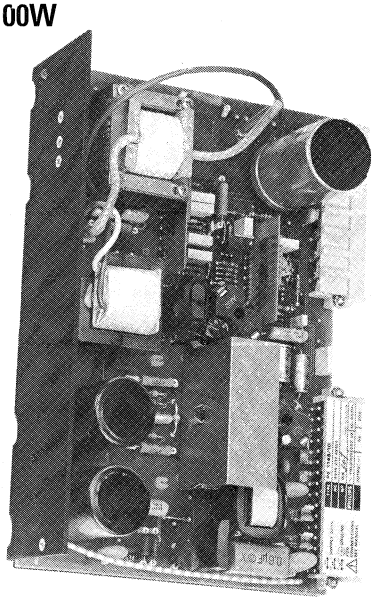
UL 478 and 544 recognized models

Single output

PE 1259/20	5V	40A	40T	220V closed
PE 1262/20	12 (15)V	18A	40T	220V closed
PE 1265/20	24V	11A	40T	220V closed

Available on request: UL recognized models valid for data processing equipment, graphic arts equipment, office appliances and business equipment: PE 1259/60, PE 1262/60, PE 1265/60.
For all units, dimensions are: 110.6(H) X 196.2(W) X 197(D)mm.

100W



AC/DC EURO-SWITCHERS 6U

- highly reliable forward converters with efficiencies to 85%,
- nominal power at 55°C, with convection cooling,
- higher power at 40°C,
- compliance with IEC, UL and VDE safety norms,
- line regulation better than 0.1% and load regulation better than 0.2%, even with 100% load variations,
- rfi on source according to VDE 0871 level B with an external filter,
- full protection by adjustable current limiter and short-circuit protection, overtemperature protection, adjustable overvoltage protection and mains voltage fuses,
- front LED indication of output voltage,
- power on and power failure TTL signal,
- remote on-off with TTL logic,
- resistor and voltage programming,
- remote sensing terminals,
- easy parallel and series connection.

UL 478 and 544 recognized models

Single output

PE 1145/10	5V	20A	12T	110/220V
PE 1146/10	12 (15)V	9A	12T	110/220V
PE 1147/10	24V	5A	12T	110/220V
PE 1148/10	48V	2.5A	12T	110/220V

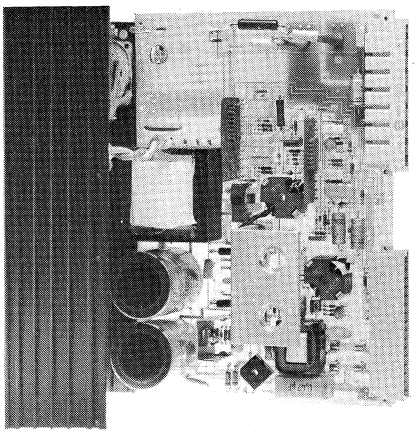
Dimensions: 233.4(H) X 173(D) X 60(W)mm,

Multi-output

PE 1150/20	5V	10A	12T	110/220V
	±12V	1A	12T	110/220V
	24V	1.5A	12T	110/220V
PE 1150/30	5V	10A	12T	110/220V
	±12V	2A	12T	110/220V
	5V	1A	12T	110/220V

Dimensions: 233.4(H) X 173(D) X 60(W)mm

150/200W



AC/DC EURO-SWITCHERS 6U

- highly reliable forward converters: efficiencies to 85%,
- nominal power at 55°C with convection cooling,
- higher power at 40°C, up to 360W for PE 1128,
- compliance with IEC, UL and VDE safety norms,
- line regulation better than 0.1% and load regulation better than 0.2%, even with 100% load variations,
- very compact 200W units,
- rfi on source according to VDE 0871 level B with an external filter such as FELLER 3712-65-6-3,
- full protection by adjustable current limiter and short-circuit protection, overtemperature protection, adjustable overvoltage protection and mains voltage fuses,
- front LED indication of output voltage,
- power on and power failure TTL signal,
- remote on-off with TTL logic,
- resistor and voltage programming,
- remote sensing terminals,
- easy parallel and series connection.

UL 478 and 544 recognized models

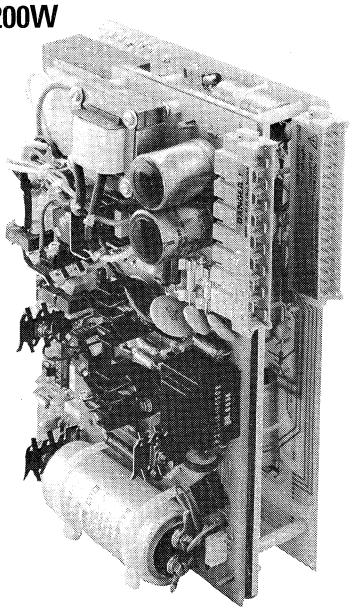
* VDE 0806 recognized models

Single output

PE 1123/00	5V	30A	14T	110/220V*
PE 1124/00	12 (15)V	12.5A	14T	110/220V*
PE 1125/00	24V	6A	14T	110/220V*
PE 1148/15	48V	3A	14T	110/220V
PE 1126/00	5V	40A	14T	110/220V*
PE 1127/00	12 (15)V	18A	14T	110/220V*
PE 1128/00	24V	10A	14T	110/220V*
PE 1148/20	48V	5A	14T	110/220V

For both power ranges:
Dimensions: 233.4(H) X 173(D) X 75.2(W)mm.

140/200W



- highly reliable forward converters: efficiencies to 70%,
- effective regulation on several outputs by using a dummy output,
- nominal power at 55°C with convection cooling,
- compliance with IEC, UL and VDE safety norms,
- line regulation better than 0.10% and load regulation better than 0.15% for one, two or three outputs, depending on the model,
- rfi on source according to VDE 0871 level B with an external filter AEG EF 9888 (140W) or CORNELL DUBILIER APFS 600 L (200W),
- effective protection by foldback type current limiting and overvoltage protection on several outputs, as well as by mains fuses,
- remote sensing terminals for certain outputs depending on the model.

UL 478 and 544 recognized models

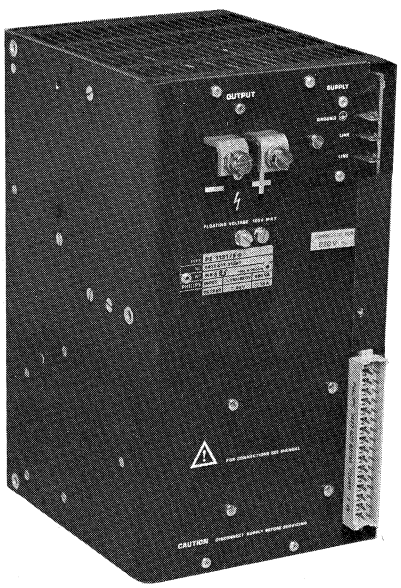
Multi-output

PE 1203/50	5V/20A; 12V 2A; 12V 4A; 24V/2A; −5V 0.2A
PE 1203/60	5V/20A; 12V 4A; 12V 2.5A; 5V/4A
PE 1203/70*	5V/20A; 15V 2.5A; 15V 2.5A; 5V/2.5A; ±12V 0.2A
PE 1203/80*	5V/20A; 15V 2.5A; 15V 2.5A; 24V/1.5A; ±12V 0.2A
PE 1203/00*	5V/20A; 15V 4A; 15V 4A; 24V/2A; ±12V 0.2A
PE 1203/10*	5V/20A; 15V 4A; 15V 4A; 5V/2.5A; ±12V 0.2A
PE 1203/20	5V/20A; 12V 2A; 12V 4A; 24V/2A; −5V 0.2A
PE 1203/30	5V/20A; 12V 4A; 12V 2.5A; 5V/4A

Dimensions: 233.4(H) X 88.9(W) X 173.5(D)mm

For all units the first four outputs are galvanically separated and usable positively or negatively. Input voltages of 110/220 V and features such as remote on-off and power failure signal are available on models marked by* (input 220V on other models). A closed cabinet can be delivered on request for minimum quantities of 25 units.

300W



Valid for single output versions

- highly reliable forward converters: efficiencies to 85%,
- nominal power at 55°C with convection cooling,
- higher power at 40°C,
- compliance with IEC, UL and VDE safety norms,
- line regulation better than 0.1% and load regulation better than 0.2% even for 100% load variations,
- rfi on source according to VDE 0871 level B for the enclosed versions,
- full protection by adjustable, foldback type, current limiting with full short-circuit protection, adjustable overvoltage protection, overtemperature protection, sense protection and mains voltage fuses,
- power on-failure TTL signal,
- remote on-off with TTL logic,
- resistor and voltage programming,
- remote sensing terminals,
- front LED indication of the output voltage,
- easy parallel and series connection,
- front panel adjustment of voltage and current by means of potentiometers.

UL 478 and 544 recognized models

* VDE 0806 recognized models

Single output

PE 1129/00	5V	60A	26T	110/220V o*
PE 1129/50	5V	60A	27T	110/220V c*
PE 1130/00	12 (15)V	25A	26T	110/220V o*
PE 1130/50	12 (15)V	25A	27T	110/220V c*
PE 1131/00	24V	15A	26T	110/220V o*
PE 1131/50	24V	15A	27T	110/220V c*
PE 1132/00	48V	8A	26T	110/220V o
PE 1132/50	48V	8A	27T	110/220V c

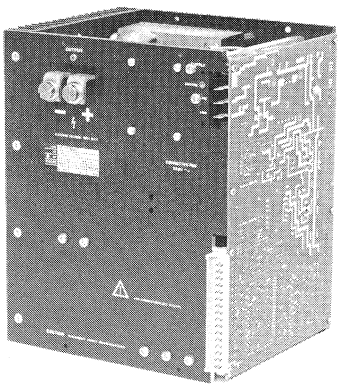
o: open c: closed
dimensions
245(H) X 129(W) X 180.5(D)mm (open)
245(H) X 133(W) X 180.5(D)mm (closed)

Multi-output

PE 1142/00	5V/30A; 15V 4A; 15V 4A; 110/220V 24V/2A; ±12V 0.2A
PE 1142/20	5V/30A; ±12V/4A; 24V/2A; 110/220V
PE 1142/30	5V/30A; ±12V/4A; 5V/4A; 110/220V

Dimensions: 233.4(H) X 111.7(W) X 173.5(D)mm

500W



AC/DC EURO-SWITCHERS 6U

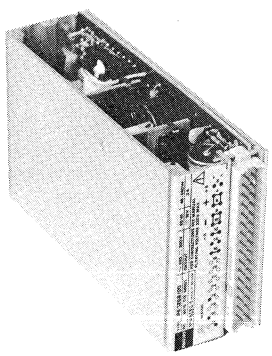
- highly reliable forward converters with efficiencies to 85%,
- nominal power at 55°C with convection cooling,
- higher power at 40°C,
- compliance with IEC, UL and VDE safety norms,
- line regulation better than 0.1% and load regulation better than 0.2% even for 100% load variations,
- rfi on source according to VDE 0871 level B for the enclosed versions,
- full protection by adjustable, foldback type, current limiting with full short-circuit protection, adjustable overvoltage protection, overtemperature protection, sense protection and mains voltage fuses,
- power on-failure TTL signal,
- remote on-off with TTL logic,
- resistor and voltage programming,
- remote sensing terminals,
- front LED indication of the output voltage,
- easy parallel and series connection,
- front panel adjustment of voltage and current by means of potentiometers.

PE 1133/00	5V	100A	41T	110/220V o
PE 1133/50	5V	100A	42T	110/220V c
PE 1134/00	12 (15)V	42A	41T	110/220V o
PE 1134/50	12 (15)V	42A	42T	110/220V c
PE 1135/00	24V	22A	41T	110/220V o
PE 1135/50	24V	22A	42T	110/220V c
PE 1136/00	48V	11A	42T	110/220V c
PE 1136/50	48V	11A	41T	110/220V o

o: open c: closed

Dimensions: 245(H) X 205(W) X 160(D) mm

30W



DC/DC EURO-SWITCHERS 3U

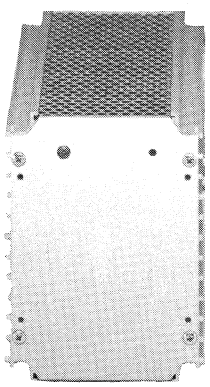
- highly reliable forward converters: efficiencies to 73%,
- nominal power at 55°C with convection cooling
- compliance with IEC, VDE and UL norms,
- source regulation better than 0.1% and load regulation better than 0.2% even with 100% load variations,
- rfi on source according to VDE 0875 level N,
- effective protection by adjustable overcurrent and overvoltage (crowbar) protection, input polarity error and sense protection,
- remote on-off by external voltage,
- resistor and voltage programming,
- easy parallel and series connection.

Single output

PE 1100/00	5V	6A	10T 24V input
PE 1100/10	5V	6A	10T 48V input
PE 1101/00	12 (15)V	3A	10T 24V input
PE 1101/10	12 (15)V	3A	10T 48V input

For all units, dimensions:
100.0(H) X 50.3(W) X 176.2(D) mm.
Available as option: power failure indication (TTL) unit PE 1396.

100 W



- highly reliable forward converters: efficiencies to 72%,
- nominal power at 55°C with convection cooling,
- compliance with IEC, VDE and UL safety norms,
- source regulation better than 0.1% and load regulation better than 0.2% even with 100% load variations, for main outputs,
- effective protection of main outputs by adjustable current limiter and overvoltage protection, input polarity error, sense and temperature protection,
- remote on-off and remote sensing,
- resistor and voltage programming,
- easy parallel and series connection,
- low battery voltage indication (TTL).

Single output

PE 1104/00	5V	18A	20T	24V input
PE 1105/00	12 (15)V	8A	20T	24V input

For both units, dimensions:
110.6(H) X 97.4(W) X 175.3(D) mm.
Available on request /10 models with 48V input.

Multi-output

PE 1108/00	5V 10A; ±15 (12)V 1A	22T	24V input
PE 1108/10	5V 10A; ±15 (12)V 1A	22T	48V input

For both units, dimensions:
110.6(H) X 106.7(W) X 176.2(D) mm.

Excellent stability
Adjustable constant voltage/current
Series/parallel operation
MTBF 75000 operating hours
Advanced styling

Power supplies for bench use

This range of power supplies for bench use comprises a series of stand-alone units giving outputs from 20 to 120W at varying voltage and current levels. They will be of interest to laboratory personnel, educational establishments and service organisations. The design incorporates the most modern concepts of universal power supply equipment to achieve high conversion efficiency and exceptional price/performance ratios.

Reliability
Long-term reliability is assured by careful selection of components and materials and units are subjected to full mechanical, climatic and safety tests to IEC 68 and IEC 348. AC line interference conforms to VDE 0875, N-12 curve. The predicted MTBF is 75000 operating hours for max. load, stationary use, environmental temperatures between 0 and 40°C.

Output power ratings vary from 20W to 120W, depending on the model.
A performance table for the range appears on page 8.

PERFORMANCE TABLE FOR BENCH UNITS

	PE 1535	PE 1536	PE 1537	PE 1539	PE 1540	PE 1541	PE 1542 I	PE 1542 II	PE 1542 III
CONSTANT VOLTAGE OPERATION									
Output voltage ranges Continuously adjustable (V)	**0...40**	**0...20**	**0...40**	**0...20**	**0...40**	**0...75**	**0...20**	**0...20**	**0...7**
Stability against line variations With ± 10% line variations max. change of output voltage incl. short term drift	⩽ 0.05% or 4mV*	⩽ 0.01% or 1mV*	⩽ 0.01% or 2mV*	⩽ 0.01% or 1mV*	⩽ 0.01% or 2mV*	⩽ 0.01% or 4mV*	⩽ 0.05% or 2mV*	⩽ 0.05% or 2mV*	⩽ 0.05% or 2mV*
Recovery time For a sudden increase from 80% load to max. load or for a corresponding decrement (μs)	⩽ 10	⩽ 25	⩽ 25	⩽ 50	⩽ 50	⩽ 50	⩽ 25	⩽ 25	⩽ 25
Ripple voltage (mV_{RMS})	⩽ 1.5	⩽ 1	⩽ 1	⩽ 1	< 1	< 1	< 1.5	< 1.5	< 1.5
Temperature coefficient (0...40°C) (%/°C)	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CONSTANT CURRENT OPERATION									
Output current ranges Continuously adjustable (A)	**0...05**	**0...2**	**0...1**	**0...6**	**0...3**	**0...1.6**	**0...1**	**0...1**	**0...3**
Stability against line variations With ± 10% line voltage variations max. change of output current incl. short term drift	⩽ 0.05% or 0.5mA*	⩽ 0.05% or 0.4mA*	⩽ 0.05% or 0.2mA*	⩽ 0.05% or 1.0mA*	⩽ 0.05% or 0.5mA*	⩽ 0.05% or 0.3mA*	⩽ 0.5% or 3mA*	⩽ 0.5% or 1mA*	⩽ 0.5% or 1mA*
Stability against load variations With load variations of 0...100% max. change of output current (mA)	⩽ 4	⩽ 3	⩽ 3	⩽ 3	⩽ 4	⩽ 4	⩽ 5	⩽ 5	⩽ 5
Ripple current (mA_{RMS})	⩽ 1	⩽ 2	⩽ 1	⩽ 2	⩽ 1	⩽ 1	⩽ 1.5	⩽ 0.5	⩽ 0.5
Temperature coefficient (0...40°C) (mA/°C)	⩽ 0.05	⩽ 0.2	⩽ 0.1	⩽ 0.6	⩽ 0.3	⩽ 0.15	⩽ 2	⩽ 0.2	⩽ 0.6
GENERAL									
Parallel and series connection	●	●	●	●	●	●		●	
Remote programming/sensing	–	–	–	●	●	●		●	
Master/slave operation	–	–	–	●	●	●		●	
Ambient temperature (max)	40°C	40°C	40°C	40°C	40°C	40°C		40°C	
Line supply	110; 127; 220; 240V 50/60 Hz	110; 127; 220; 240V 50/60 Hz	110; 127; 220; 240V 50/60 Hz	110; 127; 220; 240V 50/60 Hz	110; 127; 220; 240V 50/60 Hz	110; 127; 220; 240V 50/60 Hz		110; 127; 220; 240V 50/60 Hz	
Dimensions (w x h x d) (mm)	88 x 133 x 210	210 x 153 x 265	210 x 153 x 265	210 x 153 x 271	210 x 153 x 271	210 x 153 x 271		210 x 153 x 271	
(-in)	3.5 x 5.2 x 8.3	8.3 x 6 x 10.4	8.3 x 6 x 10.4	8.3 x 6 x 10.7	8.3 x 6 x 10.7	8.3 x 6 x 10.7		8.3 x 6 x 10.7	
Weight (kg)	2	5.1	5.2	7.8	8	8		7	
(lb)	4.4	11.2	11.4	17.2	17.6	17.6		15.4	

* whichever is the greater. *Specifications for stability against line variations include settling effect*

Choice of 400W or 1000W capacity

Adjustable constant voltage/current operation with automatic crossover and visual LED indication

Systems facilities:
remote control, sensing, master/slave, etc.

Separate volt and ammeters

Built-in over-voltage protection

19-in rack or cabinet mounting

MTBF of 50 000 operating hours

400W and 1000W lab/system series

These 400W and 1000W power supplies use the thyristor, pre-regulation technique and a unique design feature that increases efficiency and reliability whilst reducing cost. They are ideal for both laboratory and OEM applications, having comprehensive systems facilities.
Separate volt and ammeters, coarse and fine potentiometers, bright LED displays for mode indication and automatic indication of crossover also make the units simple and convenient to use.
The comprehensive over-voltage and overload protection is standard.

Systems facilities

Simple jumper connections are made to provide the required systems facilities. These cover remote sensing, operation in series or parallel, master/slave operation plus remote programming of both voltage and current outputs.

High efficiency

The units employ the standard antisurge choke on the **primary**, not secondary side of the mains transformer. This way

PERFORMANCE TABLE FOR 400W AND 1000W SERIES

	400W series				1000W series			
AS A CONSTANT VOLTAGE SOURCE	**PE 1642**	**PE 1644**	**PE 1646**	**PE 1648**	**PE 1643**	**PE 1645**	**PE 1647**	**PE 1649**
Output voltage Continuously adjusted with coarse and fine potentiometer	**0–20V**	**0–40V**	**0–75V**	**0–150V**	**0–20V**	**0–40V**	**0–75V**	**0–150V**
Resolution	0.5mV	1mV	2mV	4mV	0.5mV	1mV	2mV	4mV
Stability against mains variations With mains voltage variations of + or − 10% the max. change of the output voltage is:	⩽ 0.02%* or 1mV	⩽ 0.02%* or 1mV	⩽ 0.013%* or 2mV	⩽ 0.013%* or 2mV	⩽ 0.02%* or 1mV	⩽ 0.02%* or 1mV	⩽ 0.015%* or 1.5mV	⩽ 0.01%* or 1.5mV
Stability against load variations With load variations of 0...100% the max. change of the output voltage is:	⩽ 20mV	⩽ 20mV	⩽ 25mV	⩽ 25mV	⩽ 50mV	⩽ 40mV	⩽ 25mV	⩽ 25mV
Internal resistance dynamic For sinusoidal load variations from 80% to 100% of full load at frequencies up to 250kHz the unit will have the following internal resistance values: 1kHz 10kHz 100kHz 250kHz	 0.01Ω 0.04Ω 0.1Ω 0.2Ω	 0.02Ω 0.06Ω 0.1Ω 0.2Ω	 0.02Ω 0.1Ω 0.1Ω 0.2Ω	 0.02Ω 0.1Ω 0.1Ω 0.2Ω	 0.005Ω 0.02Ω 0.1Ω 0.3Ω	 0.01Ω 0.03Ω 0.15Ω 0.5Ω	 0.005Ω 0.05Ω 0.15Ω 0.1Ω	 0.005Ω 0.05Ω 0.1Ω 0.15Ω
Ripple voltage The ripple voltage will be This is valid for any input voltage between 90% and 110% nominal and for any load between no load and full load	⩽ $1mV_{RMS}$	⩽ $1mV_{RMS}$	⩽ $1mV_{RMS}$	⩽ $1mV_{RMS}$	⩽ $1mV_{RMS}$	⩽ $1mV_{RMS}$	⩽ $1mV_{RMS}$	⩽ $1mV_{RMS}$
Temperature coefficient The temperature coefficient for any ambient temperature variation in a range of 0-40°C will be	⩽ 0.01%/°C or 0.2mV/°C	⩽ 0.005%/°C or 0.2mV/°C	⩽ 0.005%/°C or 0.5mV/°C	⩽ 0.005%/°C or 1.5mV/°C	⩽ 0.01%/°C or 0.2mV/°C	⩽ 0.01%/°C or 0.4mV/°C	⩽ 0.005%/°C or 1mV/°C	⩽ 0.005%/°C or 2mV/°C
Recovery time For a sudden increase from 50% load to maximum load or for a corresponding decrement, the recovery time is:	⩽ 25μs	⩽ 50μs	⩽ 50μs	⩽ 25μs	⩽ 50μs	⩽ 50μs	⩽ 25μs	⩽ 25μs
AS A CONSTANT CURRENT SOURCE								
Output current The output current is continuously adjustable in one range by means of a coarse and a fine potentiometer between	**0–20A**	**0–10A**	**0–6A**	**0–3A**	**0–45A**	**0–25A**	**0–14A**	**0–7A**
Resolution	10mA	5mA	3mA	1.5mA	25mA	15mA	10mA	5mA
Stability against mains variations With mains voltage variations of + or − 10% the max. change of the output current is:	6mA	3mA	2.5mA	1mA	30mA	10mA	7mA	4mA
Stability against load variations With load variations of 0...100% the max. change of the output current is	⩽ 5mA	⩽ 3mA	⩽ 4mA	⩽ 3mA	⩽ 30mA	⩽ 15mA	⩽ 15mA	⩽ 10mA
Ripple current In all circumstances the ripple current will be	⩽ $10mA_{RMS}$	⩽ $5mA_{RMS}$	⩽ $5mA_{RMS}$	⩽ $3mA_{RMS}$	⩽ $100mA_{RMS}$	⩽ $15mA_{RMS}$	⩽ $10mA_{RMS}$	⩽ $10mA_{RMS}$
Temperature coefficient With temperature variations in the range of 0...40°C the temperature coefficient of the output current is:	⩽ 2mA/°C	⩽ 1mA/°C	⩽ 0.5mA/°C	⩽ 0.3mA/°C	⩽ 12mA/°C	⩽ 2.5mA/°C	⩽ 1.5mA/°C	⩽ 1mA/°C

* which ever is the greater *Specifications for stability against mains and load variations include thermal setting drift effects*

the mains supply makes up the losses directly, instead of having them compounded via the transformer. The overall result is a lighter, more compact design with greater reliability, lower price.

Ultra reliable

The high MTBF figure of 50000 operating hours in the result of many factors: *experience,* Philips being the leading European power supply manufacturer; *research,* into components and connection techniques, which in turn is backed by extensive quality control facilities and finally, *conservative, worst-case designs,* which ensure that under normal operating conditions there is considerable reserve in the Philips specification.

Stable outputs

All units feature very stable outputs with high resolution and low ripple. They can work on a variety of line supplies and can cope with mains variations of up to 10%.

GENERAL SPECIFICATION

Input voltage
Suitable for mains voltages 110-127-220-240V/ 50...60 Hz. The units are delivered pre-connected for 220V.

Ambient temperature
The ambient temperature is allowed to have any value between 0...40°C.

Polarity
The output terminals are insulated from the chassis; either the positive or the negative terminal may be earthed. The electrical data are valid with earthed output.

Protection
The units are protected against overvoltage by an adjustable o.v.p. which interrupts the drive of the power transistors. The units are also protected against overload and short circuits.

Indication
LEDs indicate whether the units are used as a constant voltage or as a constant current source and also if the output voltage exceeds the preset overvoltage level.

Efficiency

62% PE 1642	at nominal mains voltage and max. output power
73% PE 1644	
81% PE 1646	
81% PE 1648	

Remote voltage/current control
The output voltage/current can be programmed (remotely adjusted) with a resistance or by a voltage source.

Remote sensing
Separate sensing terminals at the rear enable specified voltage regulation to be maintained directly at the load by compensating for voltage drops across the load.

Quality
The units are mechanical, climatic and safety tested referred to IEC 68 and IEC 348 (Class I). The predicted MTBF is 50 000 operating hours for maximum load and stationary use.

Inrush current
40A at 220V mains voltage
Duration 10ms valid for all units.

Series/parallel connection
Two or more power supply units can be connected in parallel or in series.

Master/slave operation
One unit (master) can control the connected units (slaves) when more units are used in series or parallel connection. The terminal block at the rear of the unit eliminates the need to rewire internally for this function.

Design
The units have been designed for use as table model as well as for 19-in rack mounting.

Meters
The units feature *separate* volt and amp. meters.

Mains interference
Conforms to VDE 0875 N-level

Dimensions and weight
(w x h x d) 444 x 132 x 360mm (1000W 477mm)
(19 x 5.1 x 12.4-in) (1000W 18.8-in)
400w 21kg (46lb) 1000w 37kg (81.4lb)

IEEE 488 IEC 625

IEC-bus power supplies programmer PE 1367

Programming speed 1 μs/V (programmer only)

Simultaneous two-channel triggering

Single-channel option available

Internal microprocessor control for greater flexibility, diagnostic routines

IEC/IEEE-bus compatibility

Multiple programming with auto and % mode (basic statements)

Two channel galvanic separation by fast opto-coupler

Fast, accurate unipolar or bipolar mode facilities

Automatic ranging: 0-1V, 0-10V; high resolution of 1mV for 1V, 20mV for 10V

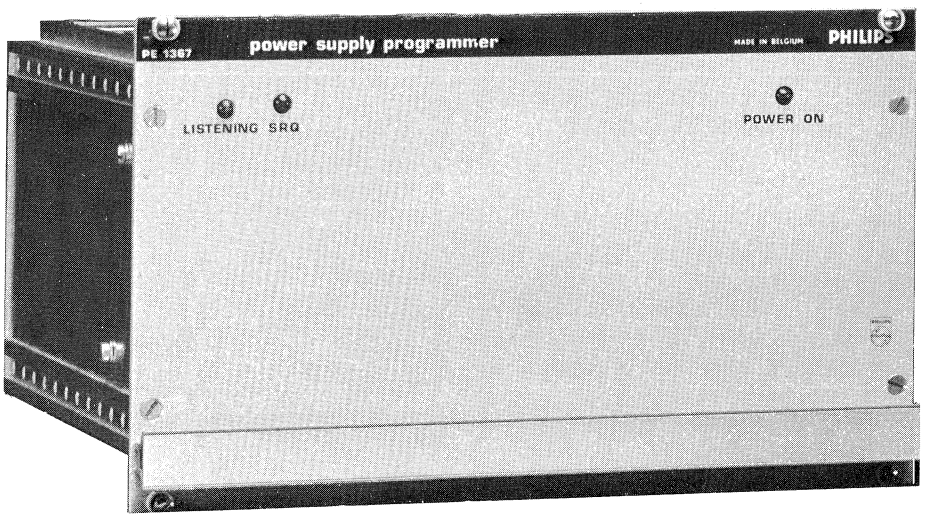
The PE 1367 is designed to be run by any controller or computer using the IEC-625 instrument bus. It is essentially a dual-channel digital-to-analog converter fitted with a microprocessor (8085).

An IEC/IEEE bus interface chip allows conversion of bus line instructions to control signals for the DAC unit.

Two galvanically separated outputs are available, switchable for 0V to +1V and 0V to +10V unipolar or −1V to +1V and −10V to +10V for bipolar operation. The output current is 10 mA.
A resolution of 1000 steps is provided by the converter in any range, with auto-ranging in the unipolar and bipolar mode. PE 1367 also acts as a listener on the IEC-625 bus and responds to serial poll.

A simultaneous triggering is provided for the two channels, one of which has an adjustable current sink facility. All digital data can be stored internally; simple diagnostic routines are built-in. Basic statements can be used for programming by means of any computer keyboard with ASCII 7-bit code.

The programming speed of the programmer alone, is 1μs/V. In addition, PE 1367 can generate service request messages, such as wrong character/parameter, overshoot, etc.



The standard version has two channels; an optional single-channel version, PE 1367/01 is available; card, channel 2 is available on request (PE 1367/11).

Wide application range

PE 1367 will satisfy a very wide range of applications, either as a stand-alone unit or as a bus line interface for voltage-controlled power supplies. In this latter function the two outputs may be used to control two independent power supplies or two separate functions of a single power supply, e.g., output voltage and current. This offers many possibilities in test and control systems.

The following Philips power supplies can be controlled with the PE 1367 programmer via the IEC bus			
PE 1539	0... 20V	0... 6 A	120W Lab types
PE 1540	0... 40V	0... 3 A	
PE 1541	0... 75V	0... 1.6A	
PE 1642	0... 20V	0...20 A	400W and/or lab 1000W types and 19-in rackmount versions
PE 1643	0... 20V	0...45 A	
PE 1644	0... 40V	0...10 A	
PE 1645	0... 40V	0...25 A	
PE 1646	0... 75V	0... 6 A	
PE 1647	0... 75V	0...14 A	
PE 1648	0...150V	0... 3 A	
PE 1649	0...150V	0... 7 A	

TECHNICAL SPECIFICATION

OUTPUT

– high range: unipolar mode 0V...+10V
bipolar mode −10V...+10V

– low range: unipolar mode 0V...+1V
bipolar mode −1V...+1V

Resolution	unipolar mode	bipolar mode
– high range:	10mV	20mV
– low range:	1mV	2mV

Output current
10mA (unipolar and bipolar)

Output impedance
< 0.1Ω (DC)

Linearity error
± ½ LSB (least significant bit)

Zero adjust
± 500mV

Full scale adjust
± 5%

Programming speed
1μs/V (typical)

Number of channels
2 (single-channel version optional)

Galvanic isolation
$1000V_{DC}$

Interface functions
AH1, L1, SH1, DC1, SR1

Programming modes
Auto, %

Calibration
Off-line possible

Current sink*
For channel 1

Temperature coefficient
150 ppm/K max.

MTBF
50 000h

POWER REQUIREMENTS

Line voltages and frequencies:
110-120-220-240V_{AC} (± 10%) 48...62 Hz

ENVIRONMENTAL CAPABILITIES

Ambient temperatures
Limits for operating: 0...+55°C
Storage and transit: −40°C...+70°C

Vibration and shock:
In accordance with IEC 68

Safety
In accordance with IEC 348 safety class 1

Interference
In accordance with VDE 0875N (RFI level transferred from mains)

DIMENSIONS AND WEIGHT

(w x h x d) 213 x 128 x 220mm
(8.3 x 5 x 8.7-in)
3.25 kg (7.2lb)

ORDERING INFORMATION

PE 1367/00 two-channel version
PE 1367/01 single-channel version

IEC/IEEE INTERFACE DATA

IEEE INTERFACE OPTION PM 9483
Can be supplied fitted (to order) or retrofitted in the field

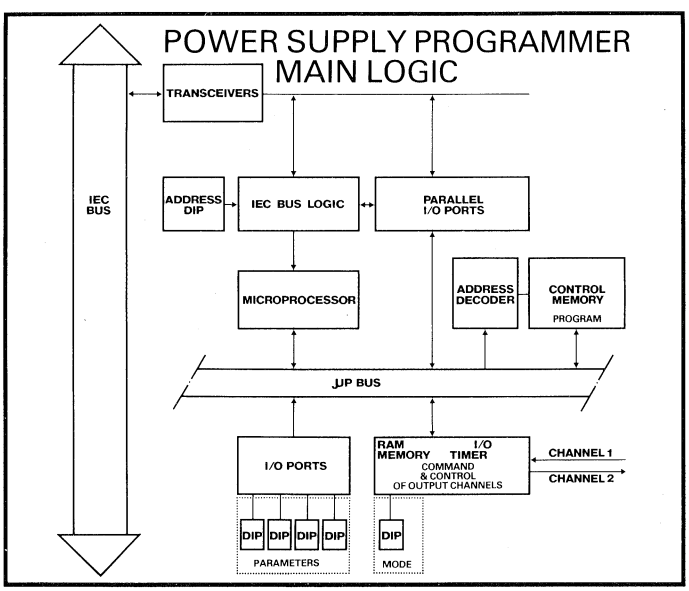
Connector
24-pole

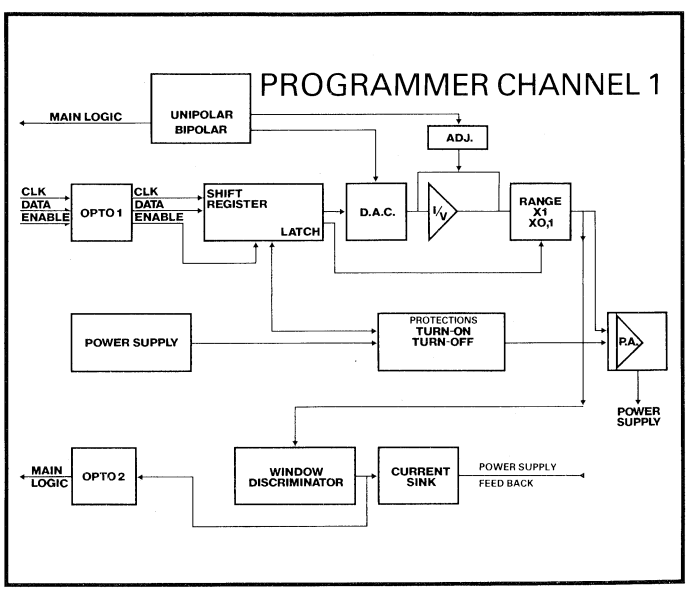
Interface functions

SH1	Source handshake
AH1	Acceptor handshake
L1	Listener: receives device-dependent data over the interface
SR1	Service request, generated in case of data available
DC1	Device clear: provides capability to reset a device to initial state (both channels OV) by remote message

Time specifications
Programming speed: 1μs/V

Codes
ISO 7-bit code
Input delimiter, ETX, CRLF, NL...





Line conditioners
PE 1411...PE1419
50/60Hz and 220/240V

Optimum combination of line stability and transient suppression

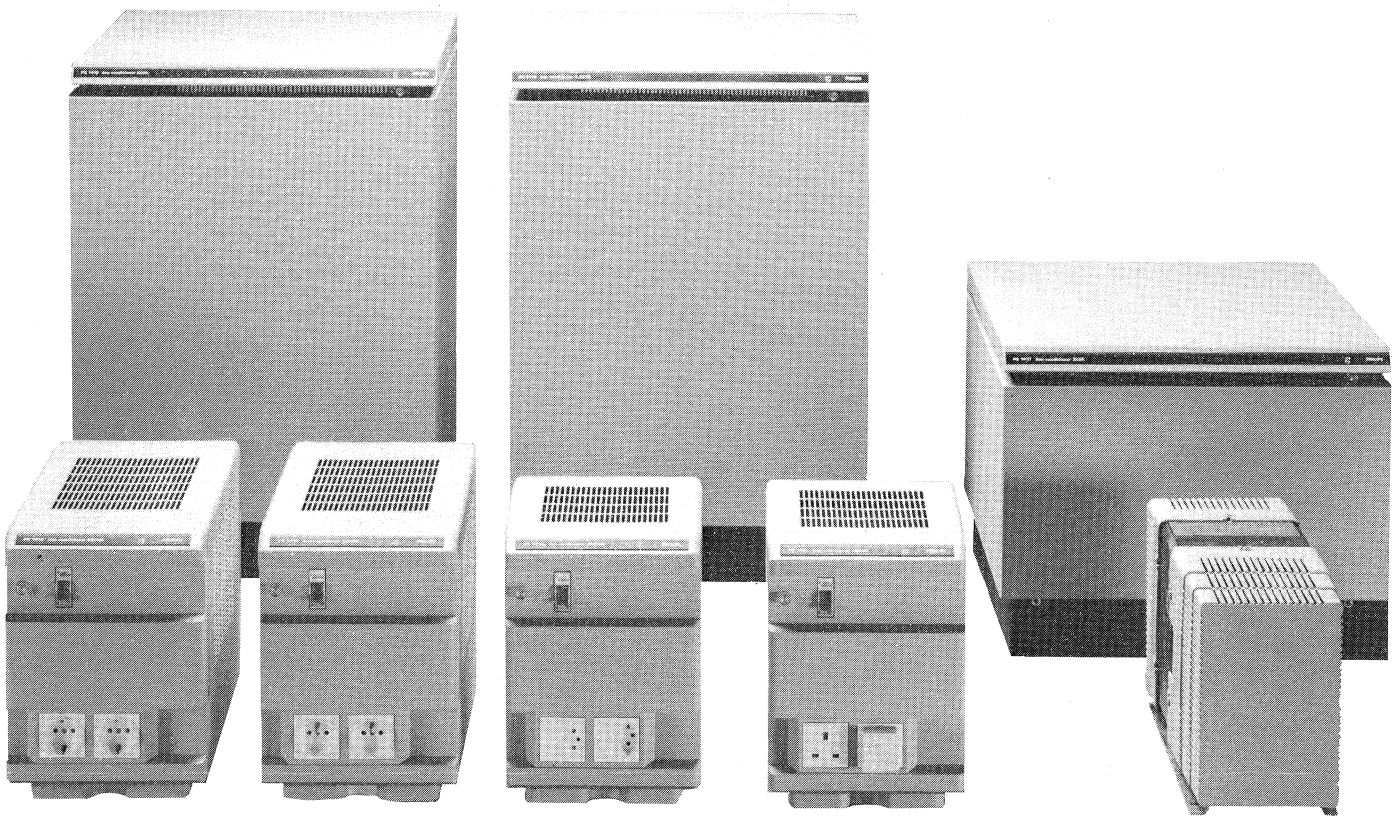
More than 100dB transient suppression for short pulse widths

Output stability of 1% even for very low input voltages

Sinewave output with distortion lower than 4% even for square wave inputs

Short-circuit proof output due to automatic overload protection

Mean time between failure in excess of 200.000 operating hours



In many electronic equipments such as computer systems, automatic test equipment, control systems, bank terminals, telecommunications, security systems, analytical instruments, point-of-sale equipment, etc., mains borne disturbances often cause serious problems.

Frequently, these disturbances include excessive voltage variations, troublesome spikes and transients, brutal power interruptions and frequency changes.

In order to offer a complete and universal range of protection equipment, Philips has developed a new range of line conditioners valid for 50/60 Hz and 220/240 V operation. By means of simple wiring changes, these units can be used either as a filter, or as a stabilizer.

Configurations

Power rating	Input voltage	Open types	Open with caps	Closed types
200VA	220/240	PE 1411/10	PE 1411/15	PE 1411/20
400VA	220/240	PE 1412/10	PE 1412/15	PE 1412/20
850VA	220/240	PE 1413/10	PE 1413/15	PE 1413/20
1500VA	220/240	PE 1414/10	PE 1414/15	PE 1414/20
3000VA	220/240	PE 1417/10		PE 1417/20
4500VA	220/240	PE 1418/10		PE 1418/20
6000VA	220/240	PE 1419/10		PE 1419/20

TECHNICAL SPECIFICATION

INPUT DATA

Input voltage
220V nominal (198V...242V) or
240V nominal (216V...264V)
by wiring (110V possible).

Mains frequency
50Hz (+/−2%) or 60Hz (+/−2%) by wiring.

OUTPUT DATA

Output voltage
220V or 240V, depending on how the unit is connected.

Stability

AS A STABILISER
• Against mains voltage variations only.
At mains voltage variations of 198V to 242V (or 216V to 264V), a constant resistive load and a frequency of 50 (60) Hz +/− 1%, the output voltage remains within: + and −1% for all models.

• For combined mains voltage variations (198V to 242V respectively 216V to 264V) together with resistive load variations from no load to full load and vice-versa, the output voltage remains within:
PE 1411 + 3.0% to − 1.9%
PE 1412 + 2.8% to − 1.6%
PE 1413 + 2.3% to − 1.2%
PE 1414 + 2.0% to − 1.0%
PE 1417 + 2.3% to − 1.5%
PE 1418 + 2.3% to − 1.5%
PE 1419 + 2.3% to − 1.5%

AS A FILTER
• Against mains voltage variations only. At mains voltage variations of 198V to 242V (or 216V to 264V), a constant resistive load and a frequency of 50 (60)Hz +/− 1%, the output voltage remains within: + 2 and −2% for all models.

• For combined mains voltage variations (198V to 242V respectively 216V to 264V) together with resistive load variations from no load to full load and vice-versa, the output voltage remains within:
PE 1411 + 6.0% to − 2.9%
PE 1412 + 4.9% to − 2.5%
PE 1413 + 4.5% to − 2.1%
PE 1414 + 4.2% to − 1.8%
PE 1417 + 4.5% to − 2.1%
PE 1418 + 4.5% to − 2.1%
PE 1419 + 4.5% to − 2.1%

Distortion
Less than 4% of its rms value (valid only if the distortion of the input voltage is less than 5% of its rms value).

Energy reserve (hold up time) ≥10ms (at full load).

Response time
Less than 30ms.

Interference suppression
Between 50 and 110dB (see fig. 3 and 4).

Overload protection
If a short circuit occurs in the load, the output voltage will collapse and the current will be limited to approx. 200% of the maximum rated value.

Parallel operation
The stabilizer provides galvanic separation between input and output, parallel use of two or three stabilizers is permitted and 3 phase configuration is possible.

Efficiency
At full load better than:
For PE 1411 76%
For PE 1412 81%
For PE 1413 88%
For PE 1414 89%
For PE 1417 89%
For PE 1418 89%
For PE 1419 89%

Noise level

Type nr.	Level dBA
PE 1411/10/15/20	40 max.
PE 1412/10/15/20	40 max.
PE 1413/10/15/20	50 max.
PE 1414/10/15/20	50 max.
PE 1417/10/20	50 max.
PE 1418/10/20	50 max.
PE 1419/10/20	50 max.

VERSIONS
• PE 1411/10 to 1419/10 completely open types, intended for in-building or rack-mounting, fitted with input and output terminal blocks,

• PE 1411/15 to 1414/15 identical to /10 versions but fitted with plastic caps, as a substitute for /00 and /01 models,

• PE 1411/20 to 1414/20 completely enclosed types, contained in metal housing with plastic covers, fitted with mains switch, power on/off indicator, two output sockets*, and one mains cable (2m) with plug*,

• PE 1417/20 to 1419/20 completely enclosed types, contained in metal cabinet, fitted with power on/off indicator, input and output terminal blocks and cable entries.

* The following plugs and sockets are available:
/201 German types, valid in Austria, Germany, Holland, Italy, Sweden,...
/202 French types, valid in Belgium, France,...
/203 British types, valid in Great Britain, Hong Kong,...
/204 Swiss types, valid in Switzerland

HOW TO ORDER
PE 1411 to 1414/20 units fitted with the right output sockets (receptacles) and mains plug?
Add the figure 1, 2, 3 or 4 to /20 according to the detailed list on P. 16.
For instance: PE 1414/201 is a completely enclosed unit of 1500VA, fitted with a German mains plug and two Schuko output sockets.

STABLISER MODE

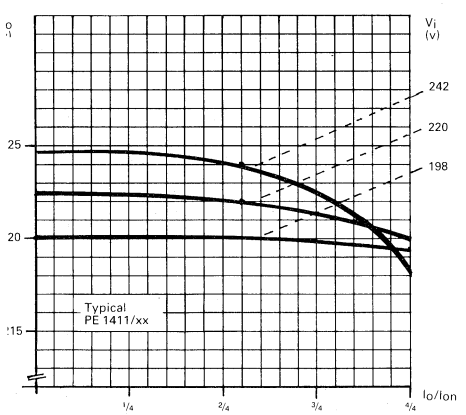


Fig. 1 Typical values

FILTER MODE

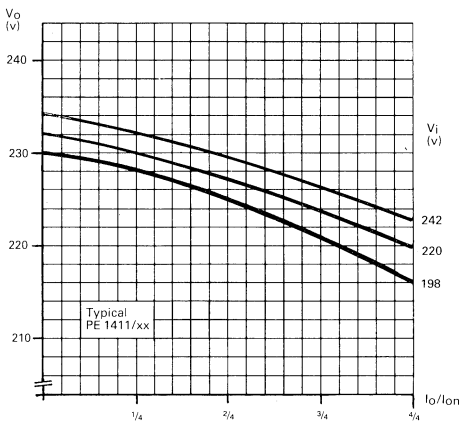


Fig. 2 Typical values

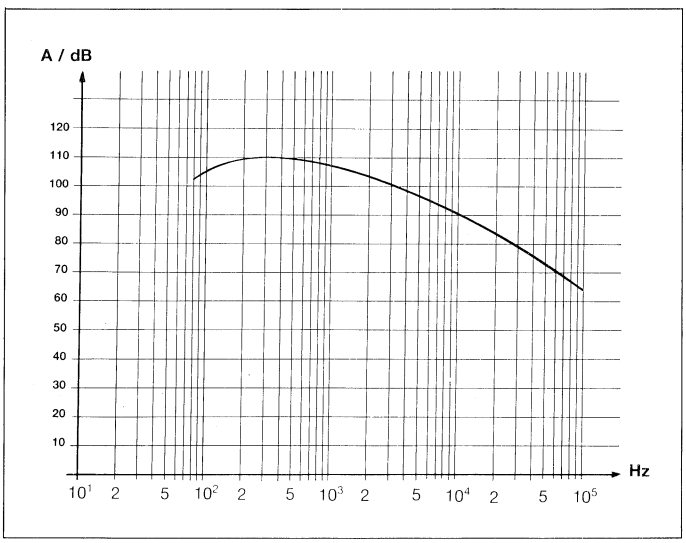


Fig. 3: Transient suppression as filter

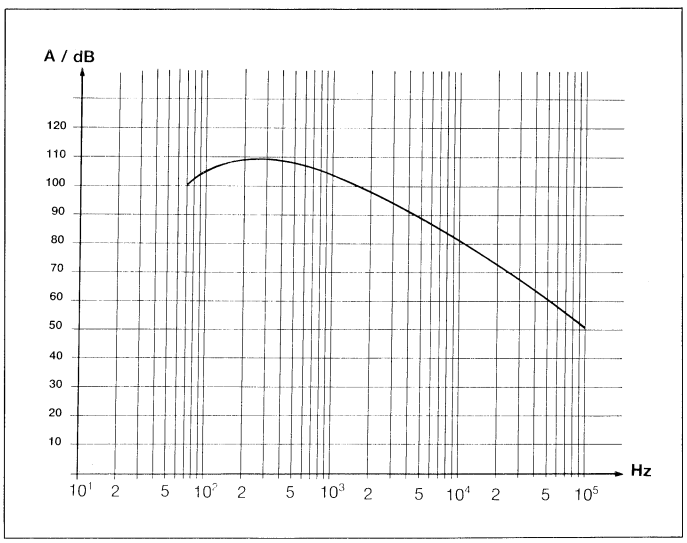
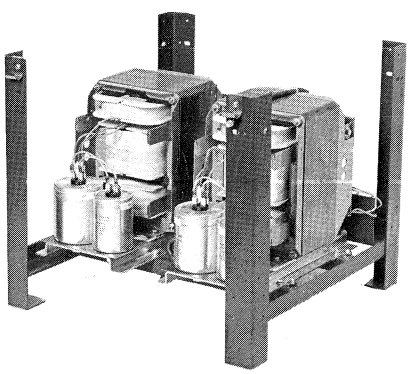


Fig. 4: Transient suppression as stabiliser

DIMENSIONS AND WEIGHT

Type no.	Height	x	Width	x	Depth/mm	Weight/kg
PE 1411/10	178	x	160	x	212	7
/15	183	x	158	x	226	8
/20	310	x	220	x	270	9
PE 1412/10	178	x	160	x	240	10.5
/15	183	x	158	x	252	11.5
/20	310	x	220	x	270	13.0
PE 1413/10	249	x	163	x	286	20
/15	256	x	206	x	315	21
/20	310	x	220	x	383	22
PE 1414/10	249	x	163	x	332	31
/15	256	x	206	x	360	32
/20	310	x	220	x	429	33.5
PE 1417/10	396	x	447	x	447	70
/20	397	x	480	x	470	75
PE 1418/10	692	x	447	x	447	106
/20	694	x	480	x	470	112
PE 1419/10	692	x	447	x	447	137
/20	694	x	480	x	470	143



Line conditioner in the OEM version.

PE 1610/01, PE 1611/01, PE 1612/01:

Electronic/magnetic system

High 0.1% output stability regardless of line voltage, frequency and load variations

Mains transient suppression

Output distortion completely independent of line distortion

Galvanic separation between input and output

Fast response time

Automatic operation

PE 1604/50:

High, 10kVA output

Electronic/magnetic system

Excellent, 0.1% stability

Full overload protection

Can operate in 3-phase system

AC voltage stabilizers PE 1610/01, PE 1611/01, PE 1612/01 and PE 1604/50

The Philips electronic AC voltage stabilizers PE 1610...1612 have been designed to cope with worst-case power supply conditions. They provide a high 0.1% output stability with input variations between −15% and +10%.
Maximum output powers of 1, 2, and 4kVA are available. The output voltage is adjustable from 215 to 225V_{RMS}. Distortion is less than 4%, and is practically independent of mains distortion. Even a squarewave input is converted to a sinewave output with very low distortion.

Mains transient suppression of up to 40dB symmetric and 60dB asymmetric spikes makes the PE 1610 series ideal for working with TTL or CMOS circuitry, where spikes on the line have to be avoided.

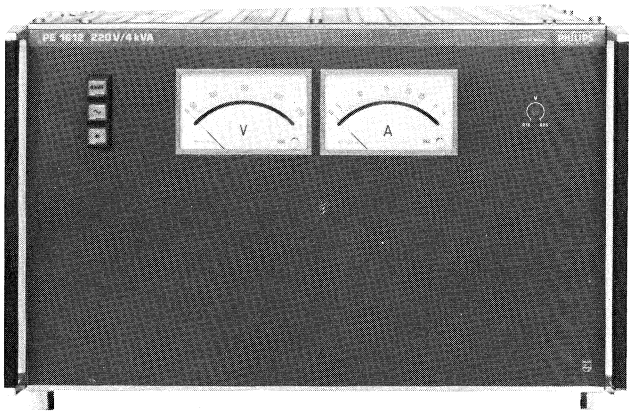
Built-in overvoltage protection switches off the stabilizer if the output exceeds a preset limit, and there is overload protection through current limiting. Remote sensing is possible if the voltage drop in the current-carrying leads is less than 1V. Units can be operated in parallel without special coupling arrangements; three phase combinations require an optional coupling unit.

Automated control

The units are operated through magnetic contactors, allowing remote control of all functions, using a separate automation box PE 1694.

Operation

The stabilizers are designed as constant voltage transformers, and incorporate a special feedback control circuit. A sensing circuit provides a DC voltage which is proportional to the rms value of the stabilizer output.
This DC voltage is compared to a fixed reference voltage in a differential amplifier, and the resulting output signal is fed to a triac control circuit. The triac is built



into a resonant circuit at the secondary side of the transformer, and its firing angle is varied in such a way as to counteract any change.

TECHNICAL SPECIFICATION (PE 1610/01, PE 1611/01, PE 1612/01)

INPUT

Voltage
187...242V_{RMS}

Frequency
50 Hz ± 3% or 60 Hz ± 3% (adjustable)

Current

	PE 1610/01	*PE 1611/01*	*PE 1612/01*
Full load, max.	8A	15A	30A
Short circuit max.	13A	25A	55A

Power consumption
PE 1610/01: 1150W
PE 1611/01: 2200W
PE 1612/01: 4450W

Mains protection
General fuse:
PE 1610/01: 10A
PE 1611/01: 16A
PE 1612/01: 35A
Remote control fuse: 2A

OUTPUT

Voltage
215...225V_{RMS}; adjustable with controls on front panel

Resolution
±100mV

Power
PE 1610/01: 1kVA
PE 1611/01: 2kVA
PE 1612/01: 4kVA
} resistive load

Current limiting
Max. short circuit current:
PE 1610/01: 8A
PE 1611/01: 20A
PE 1612/01: 40A

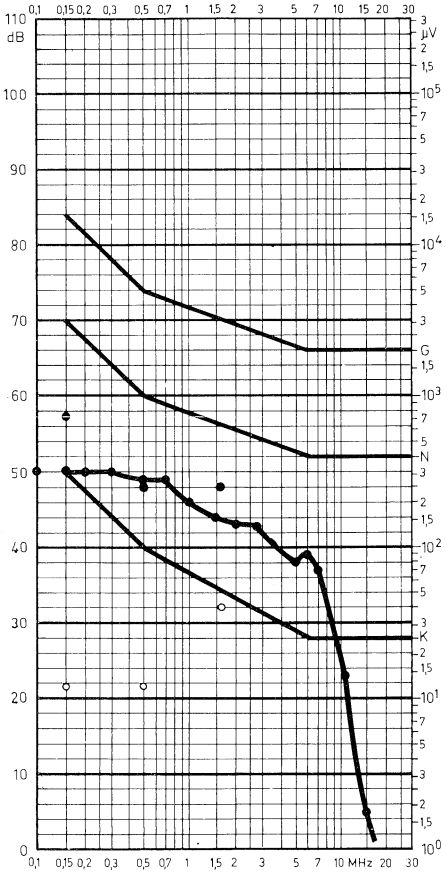
Overvoltage protection
If the output voltage increases to more than 245V the stabilizer is switched off.

Transient suppression
For pulses of 10μs pulse width and load between half load and full load, the suppression of asymmetric transients is typ. 60dB; the suppression of asymmetric transients is typ. 40dB

Stability
In case of individual variation of one of the following electrical magnitudes and a constant value of the other, within the limits indicated, the maximum deviation of the output voltage is ± 0.1%
– Line voltage, between 187 and 242V
– Line frequency variation + or −3%
– Load, between no load and full load

Temperature coefficient
< 0.01%/°C at an ambient temperature between 0 and 45°C

Distortion
< 4% independent of line distortion



Mains interference level according to VDE 0875

GENERAL

Ambient temperature
0...45°C

Cooling
By natural air circulation

Signalization
Lamps in the pushbuttons 'kVA' and '~' indicate respectively that the stabilizer is working or that the mains is connected directly to the output.

Meters
V and A meters indicate the true RMS value of the output voltage and current.

Remote sensing
The apparatus can work in remote sensing with appropriate connections. Voltage loss in the lead between load and stabilizer should not exceed 5V.

Mains switch
Two magnetic relays
– one for switching on the stabilizer
– one for connecting the mains directly to the output

Parallel and three-phase operation
The stabilizer provides a galvanic separation between input and output. Parallel use of two stabilizers is permitted with the master-slave method (without coupling unit). A three-phase coupling unit serves to couple three single phase AC stabilizers in order to stabilize the coupled voltages of a three-phase line.

Stabilizer

output power	type of stabilizer	coupling transformer
1.73kVA	3 x PE 1610/01	PE 1692
3.46kVA	3 x PE 1611/01	PE 1692
6.92kVA	3 x PE 1612/01	PE 1693

Environment
In accordance with IEC 66, publication 359 and IEC 68

Safety
In accordance with IEC 348

Mains interference
Conforming VDE 0875 (N level)

Mechanical aspects
Delivered as table model. Can be mounted in a 19-in rack.

Dimensions and weights

	PE 1610/01	PE 1611/01	PE 1612/01
Height:	4E	4E	6E
Width:	444mm	444mm	444mm
Depth:	300mm	405mm	520mm
Weight	37kg	62kg	113kg

Accessories
Brackets for 19-in rack mounting plug for connecting remote control box or automation box.

In addition to the PE 1610/01...PE 1612/01 family of AC stabilizers there is the 10kVA model PE 1604/50.

TECHNICAL SPECIFICATION (PE 1604/50)

Output voltage: 210...240V; screwdriver adjustment on the frontpanel

Output power: 10kVA at mains variation of −15%...+10%
20kVA at mains variation of −8%...+5%

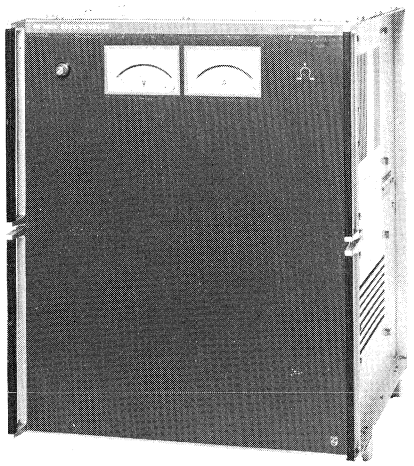
The tolerances of the mains voltage variations apply to the set output voltage and are valid for the following limits:

Stability: 0.1% with load variations ranging from no load to full load or with mains variations from −15% to +10% or −8% to +5% depending on the output power rating selected.

Response time: Any variation in the output voltage due to an instantaneous variation in the mains voltage of 5% or a step change in the load of 20% will be regulated within 80ms to less than 37% of its peak variation.

Distortion: The harmonic distortion of the output voltage will be less than 3% at any mains voltage in the specified range and any load between no load an full load. the mains frequency may have any value between 48.5 and 51.5Hz.

Overvoltage protection: An electronic protection unit will block the amplifier, whenever the output voltage exceeds a preset value between 220V and 260V, adjustable at the rear of the instrument. The result will be that the output voltage drops to a low value, depending on the load and input voltage conditions.



PE 1604/50

Overload protection: The feed-back amplifier unit is protected from overloads by means of fuses. In addition, transformers have thermal overload protection.

Remote sensing: The instruments are fitted with extra terminals for remote sensing, in order to compensate voltage drops in long supply lines between the stabilizer and the load.

Ambient temperature: The stabilizers are suitable for continuously supplying the rated power at an ambient temperature of 45°C, within the specified limits of the mains voltage (−15% to +10% or −8% to +5%).

Temperature coefficient: The temperature coefficient will be less than 0.01%/°C.

Three-phase operation: To stabilise a three-phase network with neutral, three stabilizers may be starconnected, each stabilizing one phase. In the case of asymmetrical loads, however, the opposite phase angles change and consequently the line voltage changes as well. To keep both the phase angle and the line voltage stable, a three-phase coupling unit, PE 1693, is available.

Dimensions and weight:

Width	482mm	(19-in)
Height	532mm	(21-in)
Depth	456mm	(18-in)
Weight	148kg	(325lb)

−8%...+5%	Nominal output voltage	−15%...+10%
193...220.5V	210V	178.5...231V
202.5...231V	220V	187...242V
211.5...241.5V	230V	195.5...253V
221...252V	240V	204...264

Real uninterruptible systems
Extremely reliable
Fully protected
Entirely safe
Adequate for all types of mains failures
Especially valid for critical applications

Heavy-duty uninterruptible power supplies 150 to 2500VA

In situations where mains sources must remain totally reliable and constant, Philips series of uninterruptible power supplies (UPS) will ensure the required level of mains continuity.

Computers and peripherals, bank terminals, life-critical equipment such as operating theatres, aircraft landing systems, emergency lighting systems, to mention but a few, are typical applications.

Other areas include traffic control signalling systems, offshore platforms, industrial robots, intensive care wards, etc., etc.

Uninterruptible power systems are available with various power capacities and mains-provision periods. The latter can be tailored to meet most situations, to provide power - automatically, at the instant of mains supply failure - for sufficient time to allow the failure to be corrected, or to introduce local emergency power systems (e.g. diesel-electric generators).

Built to meet heavy-duty requirements
This range of UPS offers power capacities from 150VA up to 2500VA, this being the standard series. Special requirements for higher capacities can be considered for other heavy-duty applications.

Not only do the UPS ensure absolutely reliable mains but they will neutralize otherwise damaging transients, e.g. from lightning, noise-inducing equipment (lifts, welders, etc.,), mains demand fluctuations and most other mains aberrations likely to be encountered, protecting user's apparatus at all times.

Since an uninterruptible power supply must be more reliable than the mains supply, the basic circuitry utilizes the well-proven ferro-resonant technology. This is utilized for the most critical part of the system – the AC-to-DC converter – ensuring inherent effective voltage regulation, harmonic filtering and a highly reliable overall performance.

Moreover, the ferro-resonant transformer can withstand load short circuits without damage.

The use of minimum components, all of very high quality, produces MTBF in excess of 60000 hours for the UPS without batteries.

Install and forget!
The Philips range of UPS are virtually maintenance-free, due to careful design and construction. All systems are fully

calibrated before shipment and are supplied complete with high-capacity battery backup packs suitable for the application.

Once installed to meet the user's power continuity requirement, they need little attention and do not require any special skills for their operation.

TECHNICAL SPECIFICATION

INPUT

Voltage : 220V ±10% (±15% non destructive)
Frequency : 50Hz ±2% (60Hz on request)
Power factor (cos φ): 0.8 lagging minimum

OUTPUT

Power : 150, 250, 500, 1000, 1600, 2500VA
Voltage : 220V
Frequency : 50Hz±0.5% max. in autonomy (±2% when synchronized to the mains)
Voltage regulation : ±10% all-in maximum, over all ranges of mains and loads, for dynamic or instantaneous deviations, with a recovery time less than 10ms

Harmonic distortion: <6% over full load and input ranges (resistive load)
Load power factor : full output VA from 0.8 lagging to unity
Full load efficiency : higher than
60% for 150, 250 VA
62% for 500, 1000 VA
65% for 1600, 2500 VA
Admissible overload: 200% of rated power during a few minutes

BATTERY PACK

Voltage : 48V
Included type : maintenance-free sealed lead acid, sized at 0.8 power factor
Backup time : ≥20 minutes (by adding external batteries, a total standby time of 60 minutes can be obtained) at 25°C ambient
Life (expected) : 5 to 7 years

ENVIRONMENTAL DATA

Ambient
temperature : operating −10°C to +40°C
: storage and transport −20°C to +50°C (50°C with batteries)
Humidity (relative) : 20 - 80% non condensing
Audible noise : ≤45dB (A) at a distance of 1 meter from the cabinet
Shock and vibration : normal transportation and handling

MECHANICAL DATA

Free-standing steel cabinet (150 and 250 VA units designed for wall mounting)
Accessoires: each unit is fitted with a 2-meter mains cord with standard plug, an output socket on the front panel and in addition, units of 500 to 2500 VA are mounted on appropriate casters.

PROTECTIONS AND CONTROLS

Mains circuit breaker
On/off switch with lamp
Battery fuse
Automatic battery current limiting
Reverse battery protection
Low voltage battery alarm (buzzer)
Automatic inverter shut down at too low battery voltage
Output current limiting
Output short circuit protection (inherent to ferro-resonant)
Output indicating lamp

Model (1)	Output Rating (2)	Input Current	Inverter Current (3)	Battery Capacity	Dimensiosn W x D x H (mm)	Weight with Batteries
PE 5203	150VA	3A	4.8A	6.5Ah	493 x 260 x 385	41kg
PE 5206	250VA	4A	7.7A	6.5Ah	493 x 260 x 385	51kg
PE 5209	500VA	8A	15 A	16 Ah	450 x 612 x 800	101kg
PE 5212	1000VA	15A	29 A	24 Ah	450 x 612 x 800	155kg
PE 5215	1600VA	24A	46 A	36 Ah	700 x 885 x 1100	259kg
PE 5218	2500VA	36A	70 A	63 Ah	700 x 885 x 1100	365kg

(1) Basic versions are delivered with batteries (B).
(2) At 0.8 to 1.0 power factor.
(3) Input current at 46V DC (battery).

Measuring Mechanical Quantities

Description	Page
Introduction	2
Transducers	2
Stroboscopes	3
Industrial converter system	3
Contactless transmission system	3
Web tension measurement	3
Rotational machinery supervision	4
Industrial data logger PR 2011	5

Introduction

Philips offer a complete range of equipment specially designed for measuring mechanical parameters. This equipment forms the subject matter of a separate catalog: *Electronic Measurement of Mechanical Quantities.* Some items from this catalog are briefly mentioned here, as in many instances the measurement of mechanical parameters complements the test and measuring functions. For complete information, please order the above mentioned catalog from your local Philips organisation or write to: Philips GmbH Werk für Meßtechnik, 2000 Hamburg 73, Meiendorferstrasse 205, P.O. Box 730 370, Dept. HMM.

A comprehensive, modular range

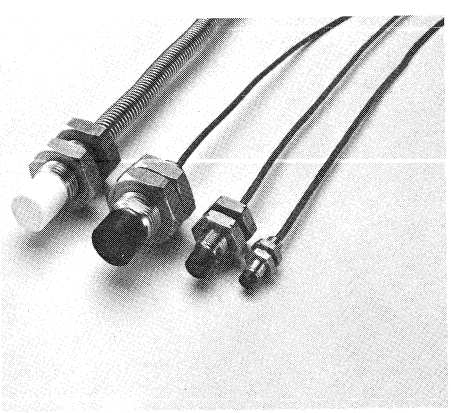
As explained in the table alongside, the Philips equipment for measuring mechanical quantities is built up in a modular way, and measuring chains can be easily assembled to meet the exact application requirement.

The complete range of general purpose transducers for detection of the mechanical quantities can be used either with general purpose, high accuracy, laboratory type measuring bridges, or with special, extremely compact industrial signal converters which are designed for trouble-free operation also in the harshest environment. Special purpose transducers and electronics are available for solving specific measuring problems in particular fields. Switching units may be used for connecting a large number of measuring points to the same measuring bridge amplifier and contactless transmission systems enable a problem-free transfer of the transducer output from rotating or moving machine parts. The output signals of the measuring bridges or bridge amplifiers may be displayed or recorded on a wide range of equipment, as described in this Test and Measuring catalog.

Detection	**Measurement Switching**	**Indication Recording Data Logging**	**Application**
General Purpose Transducers for: Torque Force Strain Pressure Temperature Displacement Acceleration Vibration Rotational speed		Digital voltmeters Indicators Recorders Oscilloscopes Magnetic tape Data loggers etc.	**Industrial measuring Chains** Mechanical engineering General industry OEM's etc.
	Universal Electronics Frequency modulated Contactless signal transmission system		**General Purpose** **Measuring** Research and development labs. Education General industry In the field etc.
Special Purpose Transducers for: Relative displacement Eccentricity Radial or axial displacement Web tension etc.	**Special Purpose Electronics** Displacement amplifiers Web tension signal converters etc.		**Rotational Machinery Supervision** **Web Tension Measurement**

Transducers

Philips have a very complete range of general purpose and special purpose signal transducers for the measurement of all mechanical parameters, dynamic and static. These signal transducers convert any change in the mechanical quantity into a proportional change of electrical quantity, e.g. resistance, inductance or capacitance, which is evaluated by the measuring bridge or bridge amplifier. Illustrated here are the PR 6422...25 series of displacement transducers.



Stroboscopes
A choice of stroboscopes is available, either with battery or mains power supply. They are lightweight and offer wide flash frequency ranges. A new pocket-sized mini-stroboscope.

Industrial measuring systems
Equipment from this range has been specially designed for reliable, accurate and trouble-free operation, also in the most difficult environment. It includes modular plugin units for a variety of applications within industry.

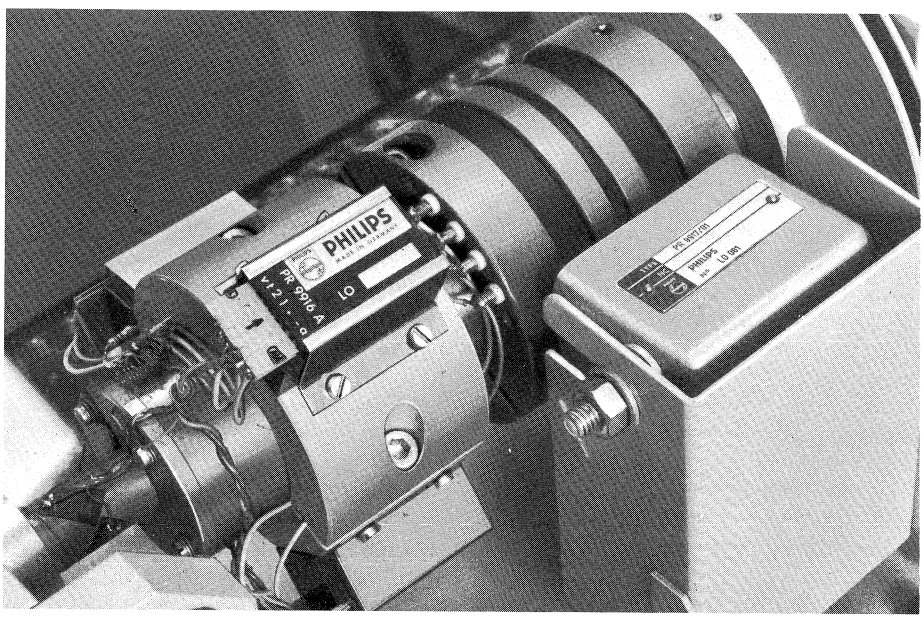
Data acquisition
A completely new series of industrial data loggers for a wide range of applications is now available from Philips.
These instruments are low priced, compact and versatile enough to handle the complete spectrum of mechanical, physical and digital measurements, e.g. pressure, strain, thickness, temperature, voltage, current and resistance etc., etc.
In addition to being ideal for use in a host of idustrial applications, their ease of operation and high performance makes them specifically suitable for integration into process control and machine monitoring systems of all descriptions.

Contactless transmission system
This system is used for amplification and contactless transmission of very small signals from a rotating part to a stationary part.
The change in the transducer resistance alters an oscillator frequency, and the resulting signal is transmitted through a coil wound around the moving or rotating part.
The receiving part consists of a receiving coil and a discriminator which demodulates the frequency change to provide a DC voltage directly proportional to the original resistance change in the transducer. Battery and mains operated systems are available.

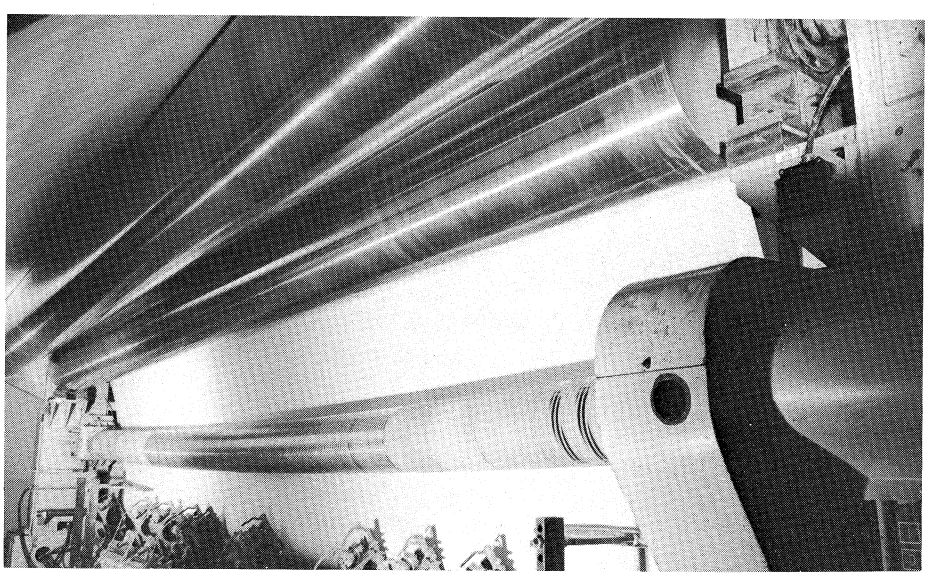
Web tension measurement
Accurate supervision of tensile strength is of vital importance in the production and processing of paper, textiles, plastic, wire and similar products. Only if the tension is held correct, is it possible to maintain the quality of the finished product at a consistantly high level.
Philips have developed a special range of equipment which provides an ideal way to monitor, indicate and control web tension at all stages of production.

This equipment is very accurate and reliable, extremely robust, and is easy to

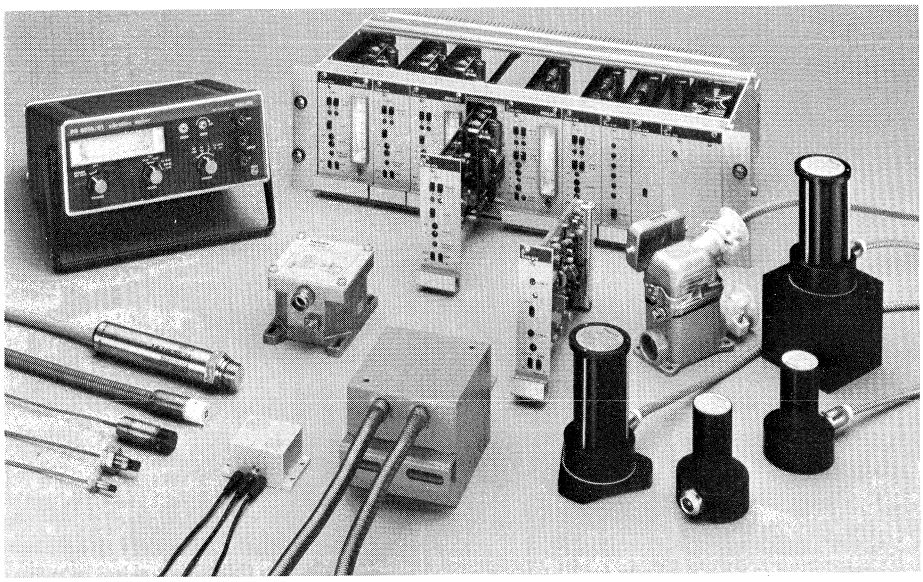
Stroboscope PR 9113



Torque measuring setup using the small size building blocks of the contactless transmission system for continuous operation.



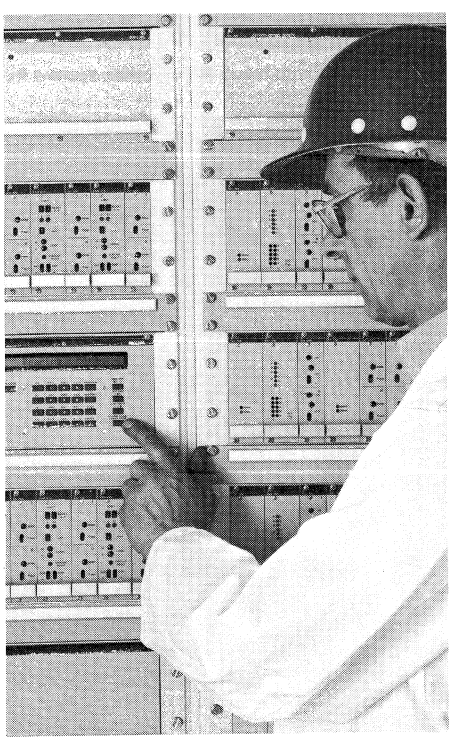
Web tension measurement on a paper-making machine



Some items used in the Philips RPM 700 supervisory system.

install in any production line – old or new.

Philips web tension measuring systems are based on force transducers which produce an electrical signal that is proportional to the mechanical force applied. Two such transducers are normally used to support the pulley or roller over which the web passes. They operate according to the magneto-elastic principle and include no moving parts.
Force transducers are available for measuring tensile strengths from 0...10000N. They are very robust, with stand high overloads and operate reliably under the severest environmental conditions.

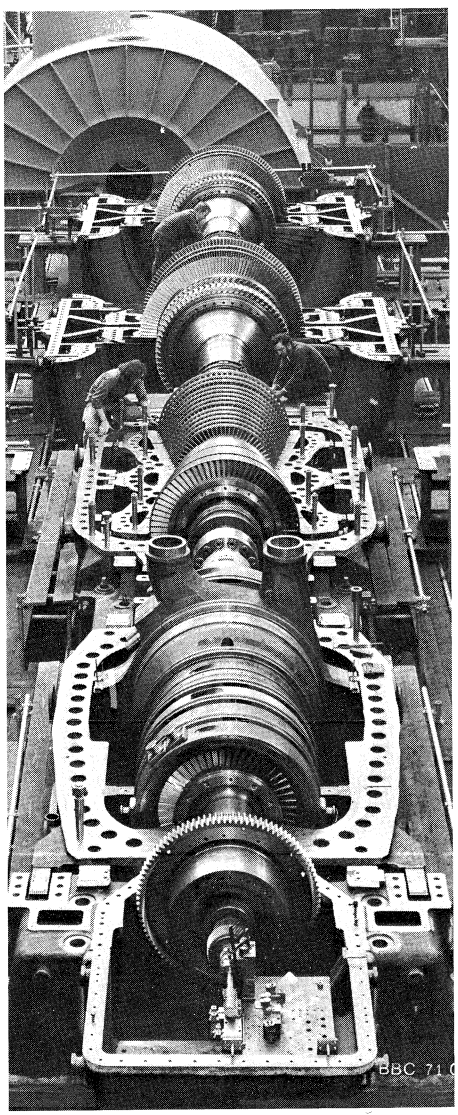


Rotational machinery supervision
High speed rotational machinery such as turbines, compressors, pumps, diesel engines, fans, gear boxes, etc., requires constant supervision of displacement and vibration levels of shafts, bearings and housings. Philips have a complete range of transducers, amplifiers and associated equipment that can be used to form inexpensive measuring chains, tailored to the exact requirement of such monitoring systems. This equipment provides the information which is needed to take remedial action before serious faults develop, to generate alarm when pre-set levels are exceeded or to automatically control the shut-down of the machine before dangerous situations are realized. It can also be used as an aid to machine development or to simplify fault finding.

A supervisory system for all kinds of turbomachinery
The Philips RMS 700 system is designed for supervision and protection of turbo-machinery of any size and speed. This is achieved by measurement of all vital parameters governing the running status and supervision of ensuing data. The RMS 700 system is equally suitable for the largest turbines used in power stations and in industry, down to compressors, pumps, engines, water-, gas- and small steam turbines, fan blowers, ventilators, centrifuges, generators and other industrial rotating machinery. With a single system it is possible to supervise static or dynamic conditions. This includes the absolute and relative, axial and radial shaft displacement, relative shaft and absolute bearing vibration, foundation vibration, housing and shaft expansion, as well as relative displacement between shaft and housing, thrust bearing wear, rpm, bearing and oil temperatures, steam and oil pressures, valve positions and wear and tear of all other bearings.

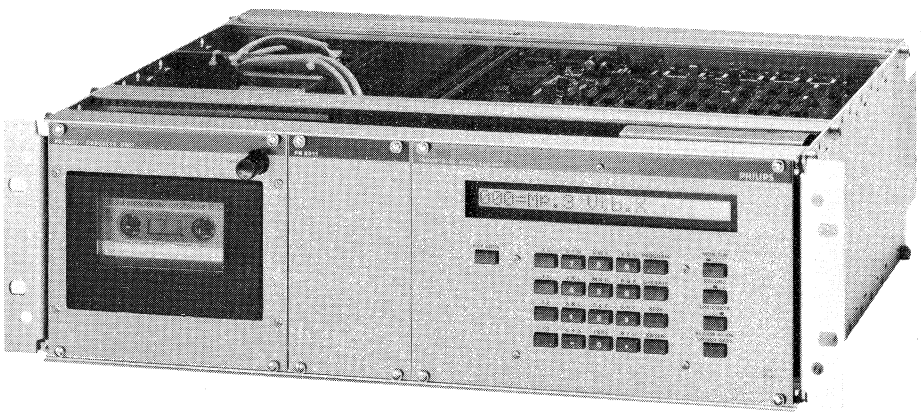
Measuring chain
The output signals from the transducers are modulated onto a 5kHz carrier frequency and fed to a signal converter, which provides a DC output from 0 to 100mV, suitable for display on an indicating instrument. The converter features two controls for tare and sensitivity adjustment. By plugging in an additional printed circuit board into the converter module, an amplified output signal is made available for control purposes. A second plug-in card can be added if a contact signal is required at a predetermined level of web tension. It can be used to actuate an alarm when a web breakage occurs.

RPM 700 sensors being fitted to a turbine under construction.



Industrial data loggers PR 2011 series

The PR 2011 Series of Industrial Data Loggers are low-priced, compact independently operating data acquisitioning and monitoring systems for various applications in industry.



PR 2011/01

Features for industrial capability
Besides all features which are generally offered by modern data loggers the Industrial data loggers PR 2011 are equipped with facilities for unattented 24 hours a day continuous operation.
They are designed with complete automatic error detecting facilities, e.g. cyclic check of program parameters, adc, microprocessor and power supply function, watchdog etc.; in case of microprocessor and/or power supply failure, two independent alarm lines are set, so an active alarm can be given.

All models are directly mountable in all types of 19-in racks and cabinets. Unlike other data loggers, the ultra low power consumption, low heat dissipation and 24 V DC supply also allows mounting in waterproof industrial cabinets.

Alarm monitoring
All measuring points can be checked against six different alarm levels per point. If a measuring point goes out of limits other special points are automatically measured in addition, to obtain a representative alarm situation report. Event triggered scans are also performed easily. Up to 10 different alarm messages can be sent in an alarm situation.

Menu operation
Control of the instruments is via a line or video display orientated English dialogue. In addition to absolute measuring values, rate of change values can be outputted to allow the monitoring of trends.

Average value calculation of channel measurements of up to 3 different channels, average value calculation over a maximum of three different time intervals with minimum and maximum value output are recorded and logged. Addition, subtraction and multiplication of the values of any two channels is possible. Trend (Rate of change) indication may be selected and 2 out of 3 alarm selection on alarm output lines suppress unwanted incidental alarms.

Additional facilities
Clear identification of operator controls, such as monitor channel, alarm acknowledge push button etc. and password protected parameter setting controls ensure easy process integration of the system. Complete remote control by video display unit (vdu), teletype, computer and various contacts etc., is possible. Superior output formatting facilities allow printing of decision relevant information in an easy-to-read way with ample explanatory text on all types of printer, vdu's etc...

Industrial Data Logger for rack mounting
A cost-effective version PR 2011/11 has essentially the same basic features as the PR 2011/01, but is without keyboard and LCD (display). Data output on VDU's, printers or via computers can be automatic or on request only. The PR 2011/11 can be implemented into computer systems as a universal component for a wide range of applications.

Intrinsically safe connection unit for Industrial Data Logger
With the combination of the relay scanner card PR 2046/01 and the A/D converter PR 2039, models PR 2011/01 and PR 2011/11 can be fitted with up to 240 intrinsically safe input circuits. Certificate of conformity: PTB No. Ex-84-2007.

Part number index

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AUDIO & VIDEO EQUIPMENT (1)

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(Items also listed under 5000 Series)

6000 SERIES

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COUNTERS & TIMER/COUNTERS

(Accessories also listed under 9000 Series)

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PM 6668	1GHz fast frequency counter	16
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(Items also listed under 9000 Series)

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ACCESSORIES AND MISCELLANEOUS

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Data test equipment:	D–
Recorders:	R–
Multimeters/Voltmeters:	M–
Counter/timers:	C–
Mechanical measurements:	X–

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MECHANICAL MEASUREMENT

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PR 9877	Limit detector	X-3
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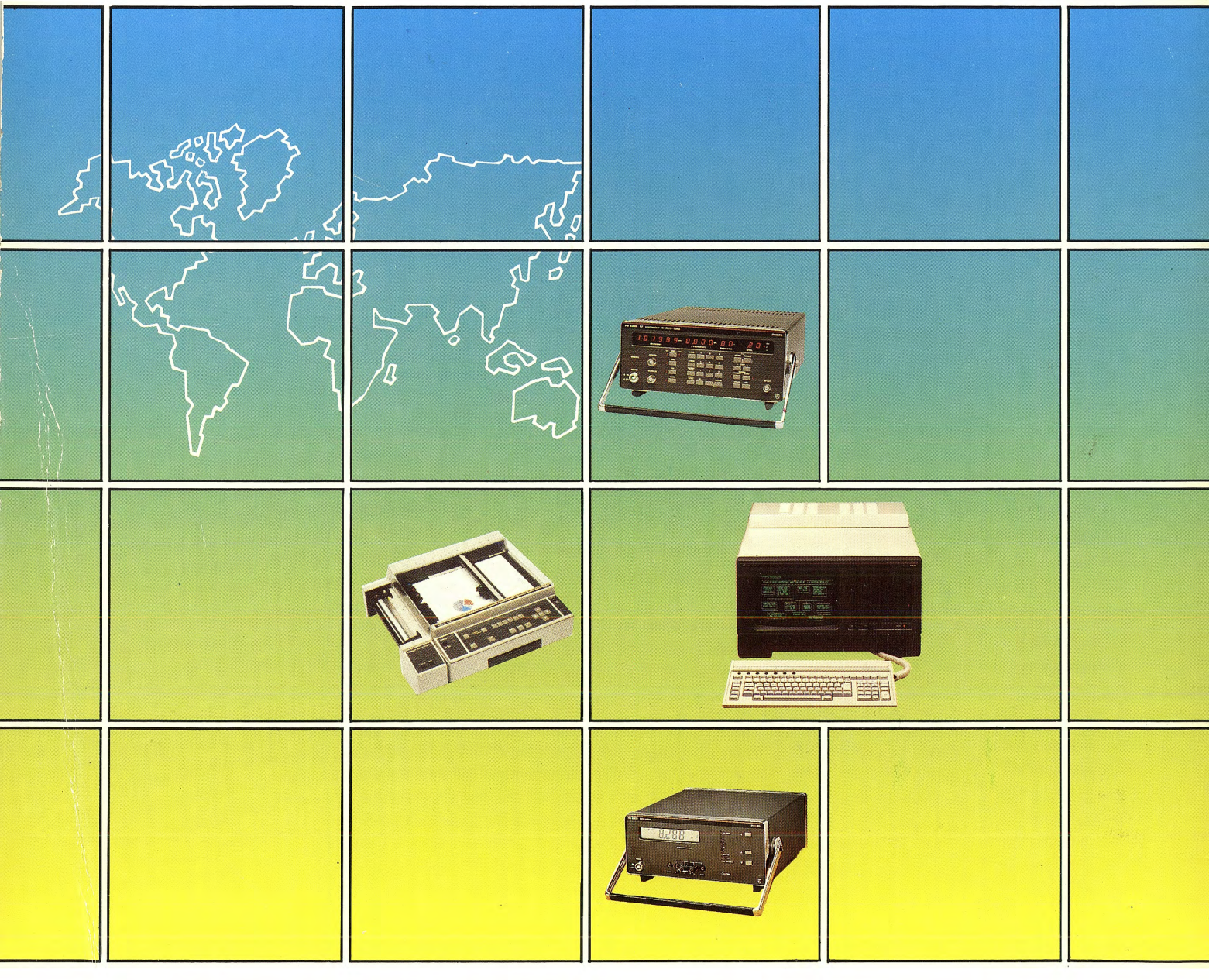

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