Errata

Title & Document Type: **2804A Quartz Thermometer Operating and Service Manual**

Manual Part Number: **02804-90014**

Revision Date: **September 1986**

About this Manual

We've added this manual to the Agilent website in an effort to help you support your product. This manual provides the best information we could find. It may be incomplete or contain dated information, and the scan quality may not be ideal. If we find a better copy in the future, we will add it to the Agilent website.

HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, life sciences, and chemical analysis businesses are now part of Agilent Technologies. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A. We have made no changes to this manual copy.

Support for Your Product

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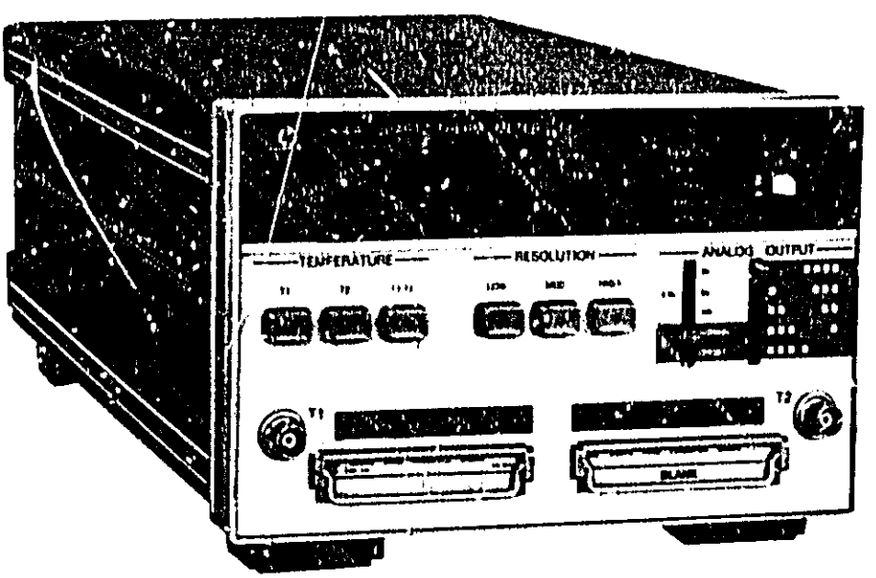
Search for the model number of this product, and the resulting product page will guide you to any available information. Our service centers may be able to perform calibration if no repair parts are needed, but no other support from Agilent is available.

Agilent Technologies

OPERATING AND SERVICE MANUAL

2804A

QUARTZ THERMOMETER



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SAFETY

This product has been designed and tested according to International Safety Requirements. To ensure safe operation and to keep the product safe, the information, cautions, and warnings in this manual must be heeded. Refer to Section I for general safety considerations applicable to this product.

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard product is warranted against defects in material and workmanship for a period of one year from date of shipment [, except that in the case of certain components listed in Section I of this manual, the warranty shall be for the specified period] [1]. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

HP warrents that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

HEWLETT PACKARD

OPERATING AND SERVICE MANUAL

2804A

QUARTZ THERMOMETER

Serial Prefix: 2620

This manual applies directly to 2804A instruments with Serial Prefix 2620. For instruments having serial prefixes higher than 2620, a manual change sheet is included.

WARRANTY EXCEPTIONS

Probe warranty is void if probe is subjected to handling or operational shock sufficient to damage the crystal. Also, if the probe is shipped in any container other than the probe container surrounded by 15,25 cm (6 in) of shock absorbing material, the warranty is void. Operation of the HP 2804A beyond its published specifications will also void the warranty.

WARNING

LINE SWITCH DOES NOT TURN OFF AC POWER AND SOME DC POWER CIRCUITS

5301 Stevens Creek Blvd., Santa Clara, CA 95051-7299

MANUAL PART NO. 02804-90014
Microfiche part No. 02804-90015

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WARNING

SAFETY

If this instrument is to be energized via an autotransformer for voltage reduction, make sure the common terminal is connected to the earthed pole of the power source.

BEFORE SWITCHING ON THIS INSTRUMENT, the protective earth terminals of this instrument must be connected to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by use of an extension cord (power cable) without a protective conductor (grounding).

Make sure that only fuses with the required rated current and of the specified type (normal blow, time delay, etc.) are used for replacement. The use of repaired fuses and the short-circuiting of fuse holders must be avoided.

Whenever it is likely that the protection offered by fuses has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

GROUNDING

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal can make this instrument dangerous. Intentional interruption is prohibited.

HIGH VOLTAGE

Any adjustment, maintenance, and repair of the opened instrument under voltage should be avoided as much as possible and, when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

Adjustments and service described herein are performed with power supplied to the instrument while protective covers are removed. Energy available at many points, if contacted, result in personal injury.

CAUTION

LINE VOLTAGE

BEFORE SWITCHING ON THIS INSTRUMENT, make sure instrument requirements match the voltage of the power source.

GROUNDING

BEFORE SWITCHING ON THIS INSTRUMENT, ensure that all devices connected to this instrument are connected to the protective (earth) ground.

BEFORE SWITCHING ON THIS INSTRUMENT, ensure that the line power (mains) plug is connected to a three-conductor line power outlet that has a protective (earth) ground. (Grounding one conductor of a two-conductor outlet is not sufficient.)

IEC SYMBOLS

The following is a list of key IEC symbols used by Hewlett Packard. All symbols are normally applied adjacent to the device requiring the symbol. They shall not be placed on removable parts likely to be detached or lost.

Instruction Manual symbol. If necessary, to preserve the apparatus from damage it is necessary for the user to refer to the instruction manual, then shall the apparatus be marked with this symbol (IEC 348,16a).

Terminal devices fed from the interior by live voltages that may be dangerous when connecting to or disconnecting from those devices shall be marked with the flash shown when the voltage exceeds 1 KV. The flash shall be red (IEC 348,16c).

Earth Terminals. If the use of this symbol for the protective earth terminal is not permitted by National Standards, it may be modified, for example, by being placed inside a circle (IEC 348,16a).

AC current (IEC 117-1, symbol No. 3).

DC current (IEC 117-1, symbol No. 2).

AC or DC current (IEC 117-1, symbol No. 8).

Frame or chassis connection. The hatching may be completely or partly omitted if there is no ambiguity. If the hatching is omitted, the line representing the frame or chassis shall be thicker (IEC 117-1, symbol No. 87).

A — Ampere (IEC 117-4, symbol No. 366).

V — Volt (IEC 117-4, symbol No. 367).

VA — Voltampere (IEC 117-4, symbol No. 368).

W — Watt (IEC 117-4, symbol No. 369).

Wh — Watthour (IEC 117-4, symbol No. 361).

VAh — Voltamperehour (IEC 117-4, symbol No. 362).

Hz — Hertz (IEC 117-4, symbol No. 365).

Contactor, normally closed. In order to avoid confusion with the symbol for a capacitor, the distance between the horizontal (as drawn here) lines should be at least equal to the length of those lines (IEC 117-3, symbol No. 216-2).

In addition the following describes the use of Warnings, Cautions and Notes used in HP Automatic Test System Manuals.

Warnings, cautions and notes. (All) Warnings and cautions shall precede the text to which each applies but notes may precede or follow applicable text depending on the material to be highlighted. Warnings, cautions, and notes shall not contain procedural steps nor shall they be numbered. When a warning, caution, or note consists of two or more paragraphs, the heading WARNING, CAUTION, NOTE, shall not be repeated above each paragraph. If it is ever necessary to precede a paragraph by both a warning and a note, or a caution and a note, etc, they shall appear in the sequence as noted, namely, warnings cautions, notes. Such inserts in the text shall be short and concise and be used to emphasize important and critical instructions.

WARNING

An operating procedure, practice, etc, which, if not correctly followed, could result in personal injury or loss of life.

CAUTION

An operating procedure, practice, etc which, if not strictly observed, could result in damage to, or destruction of, equipment.

NOTE: An operating procedure, condition, etc which it is essential to highlight.

Health hazards precaution data. (All) When hazardous chemicals or adverse health factors, in the environment or use of the equipment cannot be eliminated, appropriate precautionary requirements shall be included.

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CONTENTS (Cont'd)

ILLUSTRATIONS

TABLES

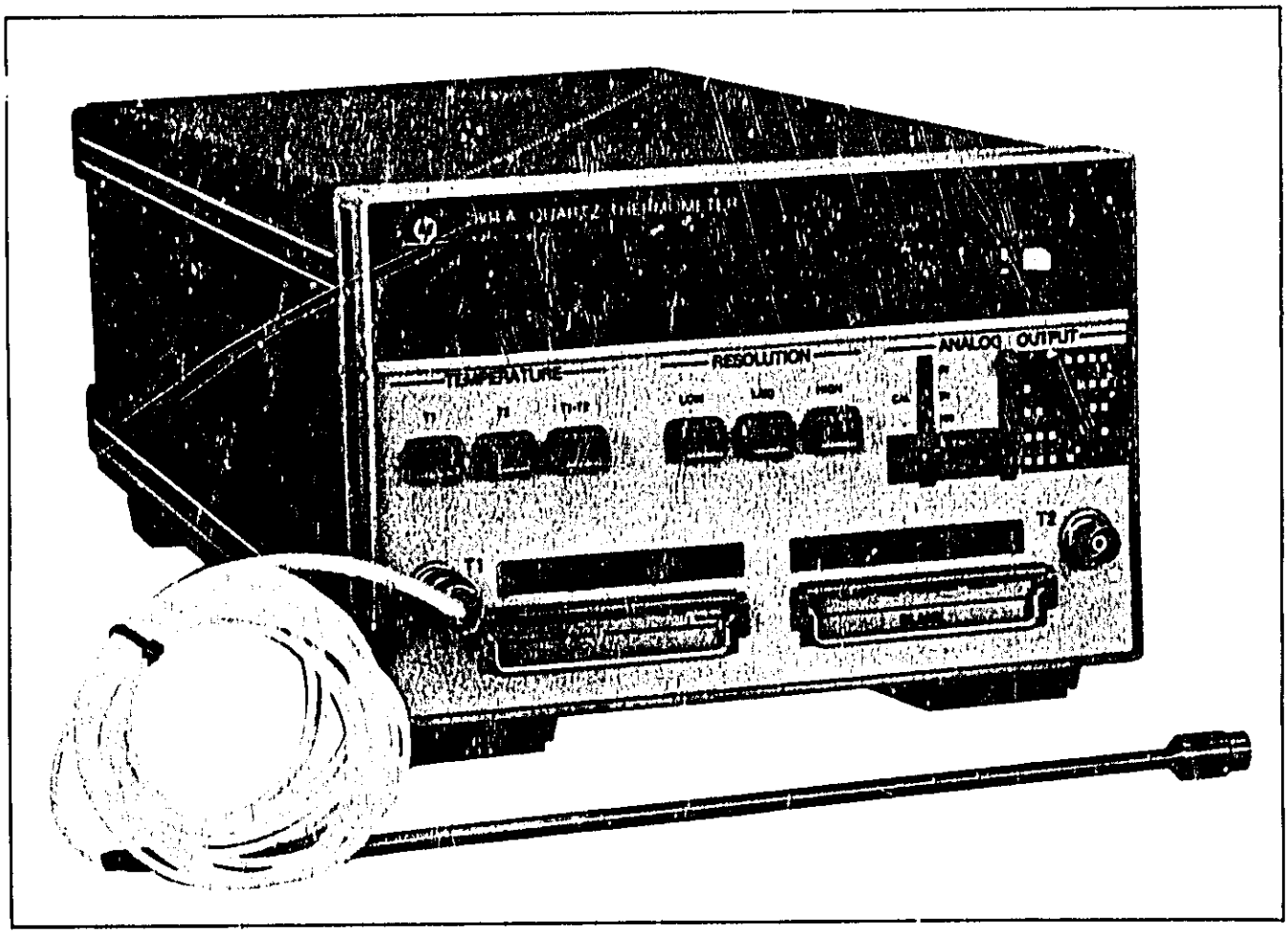


Figure 1-1. Model 2804A Quartz Thermometer

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION

1-2. This manual provides operating and service information for the HP Model 2804A Quartz Thermometer. Included is information on Hewlett-Packard Interface Bus, (HP-IB), Signature Analysis (SA), installation, operation, maintenance and service. Manual sections are:

Section I. General Information. Provides identification, specifications, safety considerations, related manuals or documentation, general description and options information.

Section II. Installation. Provides unpacking and inspection information, power requirements, packaging-for-shipments and storage information.

Section III. Operation. Provides an explanation of controls, connectors and indicators, operating considerations, operators' checks, general temperature information and reference temperature adjustment information. Also included is HP-IB programming information.

Section IV. Performance Tests. Provides test procedures which may be used as part of an incoming inspection, or to verify electrical performance following repair.

Section V. Adjustments/Calibration. Provides adjustment and calibration information.

Section VI. Replaceable Parts. Lists and identifies instrument assemblies and parts as well as mechanical and chassis parts drawings.

Section VII. Backdating. Provides information to backdate the manual for any earlier instruments if applicable.

Section VIII. Service. Provides HP-IB and Signature Analysis information, service and troubleshooting information including signature lists, diagnostic kit use, component locators and schematic diagrams.

1-3. SPECIFICATIONS

1-4. Instrument specifications are listed in Table 1

1-5. SAFETY CONSIDERATIONS

1-6. Before applying power, verify that the rear panel power input module (LMI), is set to the same line voltage value to be used, and that the correct fuse is installed (see paragraph 2-6). Whenever internal circuits are exposed, caution must be exercised. Observe all warnings and cautions marked on the instrument or listed in the procedures.

Make sure that all test equipment chassis/case is connected to earth ground.

1-7. INSTRUMENTS COVERED BY MANUAL

1-8. Attached to the instrument is a serial number plate. The serial number is in the form: 0000A-00000 and is in two parts. The first four digits and the letter is the serial prefix and the last five digits is the suffix. The prefix is the same for all identical instruments and changes only when a change is made to the instrument. The suffix is unique to each instrument. The contents of this manual apply to instruments with serial numbers prefixes listed on the title page.

Table 1-1. Specifications

SPECIFICATIONS

Range
-80 to 250°C.

Absolute Accuracy
(2804A with 18110A, 18111A Quartz Probe)
±0.040°C from -50 to 150°C.
±0.075°C from -80 to 250°C.
NBS traceable to IPTS-68 when the following conditions are met:

1. Reference temperature adjustment is made within 30 days;
2. The 2804A is at the same ambient temperature during the measurement as it was when the reference temperature adjustment was made.

("Accuracy Considerations" following describes requirements for higher accuracy measurements.)

Inputs
Two inputs, T1, T2, or T1-T2 can be measured.

Resolution
(Three levels can be selected)

Selection	Resolution		Nominal time between readings (in seconds)	
	°C	°F	T1 or T2	T1-T2
Low	0.01	0.1	0.1	0.2
Medium	0.001	0.01	1	2
High	0.0001	0.001	10	20

Display
7 digit LED with minus sign, decimal, and degree C or F annunciator.

Power Required
100, 120, 200, or 240 VAC, +5%-10%, 48 to 66 Hz, 50 VA maximum.

Instrument Operating Temperature
0 to 55°C.

Dimensions
177mm high, 212mm wide, 457mm deep. (6.9 in x 8.3 in x 17.8 in)

Approximate Weight:
Net 6.9 kg (13 lbs)
Shipping 6.8 kg (15 lbs)

External Time Base
For high accuracy measurements an external time base may be used. The 2804A Quartz Thermometer requires an input voltage 1.0 V rms into 1 kOhm via rear panel BNC from source of 1 MHz. Input may be sine or square wave. Switch selects either internal or external time base.

Analog Output
Front panel switches for zero and full scale adjustment of recorder, left or center zero on chart, and variable chart span. Five selectable full scale ranges from 1000°C to 0.1°C. Output voltage range 0 to +10 volts. Minimum load resistance 10 kOhms. Accuracy ±0.2% of full scale (±0.02 volts).

HP-IB System Interface
Provides digital output of measurement data ("Talker") as well as input for remote program control ("Listener").

Programmable features: temperature selection (T1, T2, T1-T2), resolution selection, system status read, write to analog output, configure for group execute trigger, sample and hold, configure for interrupt operation, serial number verification of probes, and read adjustment thumbwheel switch setting.

SUPPLEMENTAL CHARACTERISTICS

Accuracy Considerations
The following guidelines are given to show sources of error and ways of obtaining the maximum accuracy from the HP 2804A Quartz Thermometer.

Sources of error for absolute accuracy measurement
Hysteresis of Quartz Probe
±0.05°C from -80 to 250°C.
±0.02°C from -50 to 150°C.
±0.001°C over any 10° span from -20 to 120°C.

Long Term Stability of Quartz Probe
±0.004°C per month.

Ambient Temperature Stability of Quartz Thermometer (Mainframe only)
±0.030°C from 0 to 55°C.
±0.005°C from 18 to 23°C.

Long Term Stability of Quartz Thermometer (Mainframe only)
±0.003°C per month.

Reference Temperature Adjustment Error
Equals the accuracy to which the reference temperature can be determined (e.g., ±0.0002°C if a triple point of water cell is used to provide a reference temperature). Note that adjustment resolution is 0.001°C.

Thermal History Error From Usage Above 150°C
When quartz probes are subjected to temperatures above 150°C, thermal history error starts to become significant. In the worst case when a quartz probe is subjected to 250°C and then is brought down to less than 150°C, the display will read about 0.020°C too high, plus hysteresis. After one day the thermal history error will decay down to 0.010°C, and after five days the error will be negligible. Immediately after returning from a high temperature, the decay rate is about 0.002°C/hour.

Table 1-1. Specifications (cont.)

Relative Temperature Measurements
Sources of error for ΔT measurements made by the same probe over time are the same as for absolute measurements except there is no reference adjustment error. For most applications, hysteresis will be very small ±0.001°C over any 10°C span from -20 to 120°C. Over small ranges, ΔT measurements can be very accurate. Under normal laboratory conditions, accuracy of ±0.01°C over a 10° span is attainable. If an external time base is used, accuracy better than ±0.003°C is attainable.

Temperature Difference Between Two Points
Sources of error for T1-T2 measurements are the same as for absolute measurements except that errors due to long term and temperature stability of the Quartz Thermometer cancel and are therefore negligible.

METHODS FOR MAXIMIZING ACCURACY

Reference Temperature Adjustment
A reference temperature adjustment eliminates hysteresis and long term stability error of the probe and thermometer. If the reference temperature is made close to the measured temperature, factory calibration error and hysteresis are minimized. This involves preparing a bath at a known temperature and adjusting the display of the quartz thermometer to read the same temperature as the bath. This adjustment takes about one minute after the bath is ready and the probe is immersed and stabilized. Any temperature within the -80 to +250°C range will work as a reference temperature, but the ice point or triple point of water is generally the most accurate and easiest to prepare.

Monotonic Measurement
If measurements are made at increasing (or decreasing) temperatures from the temperature used for the reference temperature adjustment, hysteresis is minimized. In other words, if a measurement is to be made at about 50°C and about 200°C and a reference temperature adjustment was just made at 0°C, then for most accurate results, the measurement at 50°C should be made first and the one at 200°C made second. This technique is helpful when making measurements above 50°C. It should be noted that this technique is only important when the differences are more than 50°C. For example, if all measurements of a certain test were to be made between 50 and 100°C, there would be little advantage to making measurements monotonically.

External Time Base
Every quartz thermometer provides the option of operating on either an internal or an external time base. If a 1 MHz external time base is used, ambient temperature stability is greatly improved, as is the long term stability of the 2804A Quartz Thermometer. With an external time base, the contribution from the 2804A mainframe to ambient temperature stability is ±0.0002°/°C and long term stability error is negligible.

The external time base should have a short term stability of better than 5×10^{-10} for 1 second averaging, and long term stability of 1×10^{-7}/month, which corresponds to 0.003°C per month.

Thermal History Error From Usage Above 150°C
Compensation for thermal history error can be made in two ways. One way is to make a reference temperature adjustment after the quartz probe returns from a high temperature. The quartz probe will continue to drift for five days, but if the measurement is made immediately after the reference temperature adjustment, the drift will have little effect. The other way, of course, is to wait five days after subjecting the quartz probe to temperatures above 150°C.

1-9. An instrument manufactured after the printing of this manual may have a serial number prefix not listed on the title page. An unlisted serial number prefix indicates differences between the instrument and the manual. Manuals for newer instruments have a yellow, Manual Changes Supplement included. This supplement contains "change information" that explains the differences between the manual and the newer instrument.

1-10. The supplement may also contain information to correct errors in the manual. To keep the manual as current and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Changes Supplement. The supplement is identified with the manual print date and part number, both of which appear on the manual title page.

1-11. Complimentary copies of the supplement are available from Hewlett-Packard. For information concerning serial number prefixes not listed on the title page or in the Manual Changes Supplement, contact your nearest Hewlett-Packard office.

1-12. DESCRIPTION

1-13. Model 2804A Quartz Thermometer is a two channel, digital quartz thermometer. It enables high accuracy, high resolution temperature measurements to be made from -80°C to +250°C. Separate temperature measurements can be made through either of the instrument's input channels, or temperature difference measurements can be made using both channels simultaneously.

1-14. Temperature sensing can be made from remote sources up to about 60 meters (198 ft). Matched Quartz Probes/Calibration Modules are interchangeable from channel-to-channel and instrument-to-instrument by making a temperature reference adjustment for each channel or instrument.

1-15. The Analog Output allows temperatures to be plotted on a strip chart recorder. The Hewlett-Packard Interface Bus System Interface enables the instrument to be used as part of a system controlled by a computer or calculator.

1-16. OPTIONS

1-17. Optional equipment is listed in Table 1-2.

1-18. EQUIPMENT AVALABLE

1-19. Equipment available is listed in Table 1-2. Supplemental characteristics for these accessories are also listed in this table.

1-20. RECOMMENDED TEST EQUIPMENT

1-21. Recommended test equipment is listed in Table 1-3. Equipment with equivalent characteristics may be substitued.

1-22. WARRANTY

1-23. Instrument and probe warranties are as specified on the inside of this manual's front cover. Probe warranty is void if the probe is subjected to handling or operational shock sufficient to damage the crystal.

Table 1-2 Options and Equipment Available

Item	Description
2804A	Quartz Thermometer
18107A	External Oscillator Two internal oscillators are permanently mounted inside the 2084A Quartz Thermometer. The 18107A External Oscillator generally is used only if the Quartz Probe is to be operated remotely more than 3.7 metres from the Quartz Thermometer.
K96-59991A	Diagnostic Kit
18110A*	Lab Probe w/calibration module, 26 mm long
18111A	Lab Probe w/calibration module, 232 mm long
Opt 001	For 18110A, 18111A add extra calibration module to new order

*NOT RECOMMENDED FOR LIQUID IMMERSION

Quartz Probes

18110A

18111A

18107A External Oscillator

Table 1-2. Options and Equipment Available (cont.)

SUPPLEMENTAL CHARACTERISTICS

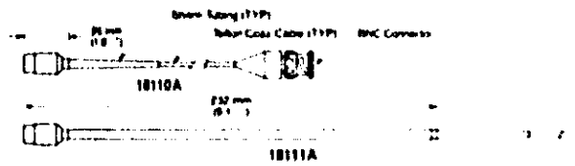
18107A External Oscillator

WEIGHT
110 gm (4 oz.) net, 230 gm (8 oz.) shipping.
SIZE
30.2 x 30.2 x 100 mm (1.19 x 1.19 x 3.94 in.)
CONNECTORS
Female BNC on both ends.
OPERATING FREQUENCY
28-29 MHz.
POWER
12 V at 42 mW (supplied by 2804A).

Quartz Probes

PROBE MATERIAL
Probe body is 304 stainless steel.
APPROXIMATE PROBE WEIGHT
90 gm (3 oz.) net, 0.5 kgm (1 lb.) shipping.
PROBE LENGTH
3.7 m (12 ft.) including integral cable.
SHOCK
Quartz probes will withstand mechanical shock of ≤ 5000g per MIL-STD-883A Method 2002.1, Test Conditions A through D, without catastrophic damage. Shifts in calibration may be experienced. (Note: 5000g is approximately equivalent to an 8 inch drop onto a hard surface).
VIBRATION
Quartz probes will withstand sinusoidal acceleration of 20g, 5 Hz to 2 kHz without catastrophic damage. Shifts in calibration may be experienced.

Quartz Probes



IMMERSION DEPTH
Quartz probes may be immersed up to but not including the cable connection.
Immersion deeper than the cable connection may damage the probes. 18110A NOT RECOMMENDED FOR LIQUID IMMERSION.

CABLE HEAT LEAK
From stagnant water:

18110A 18111A	$.55 \times 10^{-3} \frac{cal}{sec°C}$

THERMAL MASS
Equivalent mass of water, in grams at full usable immersion

18110A	1.3 ± 0.3
18111A	4.5 ± 0.5

RESPONSE TIME
For water flowing axially to the probe at 30 cm per second
63.2% completeness < 2 seconds
99.0% completeness < 10 seconds
99.9% completeness < 16 seconds
IMMERSION ERROR
In a stirred bath at 0°C

Immersion Error	Immersion Depth 18111A
0.0001°C	15 cm
.001 °C	9 cm
.01 °C	3.5 cm

Note: For most applications, the 18111A offers the best combination of thermal properties for high accuracy measurements.

IMMERSION CHARACTERISTICS

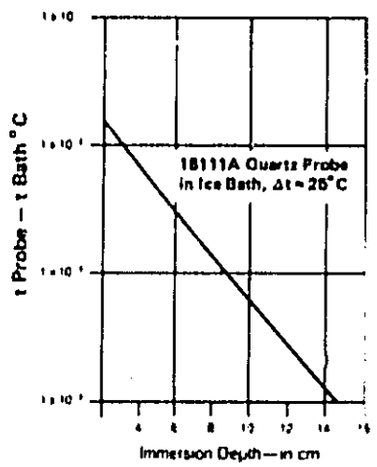


Table 1-3. Recommended Test Equipment

INSTRUMENT	CRITICAL SPECIFICATIONS	RECOMMENDED MODEL	USE*
Triple Point of Water Cell (Temp. Standard)	ACCURACY: Equilibrium temperature must be within +0.000,00, and -0.000,15°C of the triple-point of pure water which has the isotopic composition of ocean water. REPRODUCIBILITY: The equilibrium temperature of a cell must repeat to within ±0.000,05°C of the mean equilibrium temperature. STABILITY: After equilibrium is reached, the temperature of the inner melt of an ice mantle must remain constant to within ±0.000,03°C for as long as the mantle can be preserved.	Jarrett Instrument Co. Model A13	P A
Frequency Counter	Frequency Range: >30 MHz Time Base Stability: Better than 1 part in 10^8 (or "house standard")	HP 5345A	PAT
Vector Voltmeter	Frequency Range: >30 MHz Phase Resolution: 0.1° Phase Range: 360°	HP 8405A	A
Frequency Synthesizer	Resolution: 1 Hz Frequency Range: 0 to >30 MHz Output Level: 0 to +0.5 dBm @ 50Ω	HP 8660A/86601A	PAT
DC Digital Voltmeter	Accuracy: ±0.01%	HP 3480A/B/C/D HP 3490A	PAT
Oscilloscope	Bandwidth: >30 MHz	HP 180A/1801A/1820A	AT
Diagnostic Kit		K96-59991A	AT
Isolator Test Fixture	See Appendix A for instructions to build		AT
Dewar Flask	Min: 505 mm (20") deep 620 mm (24") wide		A

*P = Performance Test A = Adjustments T = Troubleshooting

3-21. The International Practical Temperature Scale of 1968 (IPTS-68) was adopted by the International Committee of Weights and Measures in 1968 according to the power given to it by Resolution 8 of the 13th

1-24. SUPPLEMENTAL DOCUMENTS

1-25. Information available to assist in the operation and use of the HP 2804A available equipment is contained in the following Operating Notes:

OPERATING NOTES	PART NUMBER
18107A External Oscillator	18107-90001
18110A	5950-3862
K06-50091A Diagnostic Kit	18109-90002

3-32. ADDRESS SELECTION

SECTION II
INSTALLATION

2-1. INTRODUCTION

2-2. This section contains information on initial inspection, preparation for use, power requirements and storage and shipment. Also contained in this section are instructions on how to install the calibration modules and quartz probes.

2-3. INITIAL INSPECTION

2-4. Inspect the shipping container for damage. If the container or cushioning material is damaged, keep it. Check the contents of the shipment for completeness, then check the unit mechanically and electrically. Refer to Section IV for electrical checks.

2-5. If the unit is mechanically damaged or fails electrical tests, notify the carrier and the nearest HP office (listed at the rear of this manual). Hewlett-Packard will arrange for repair or replacement of the instrument without waiting for claim settlement.

2-6. PREPARATION FOR USE

CAUTION

Before connecting this instrument to an AC power source, be sure that the rear panel line module is set to the same voltage as the AC source and that the correct fuse for that AC voltage is installed (.5 Amp for 120 Vac, .25 Amp for 220 Vac).

2-7. POWER REQUIREMENTS

2-8. This instrument requires a power source of 100, 120, 220, or 240 Vac, +5%-10%, 48 to 66 Hz single phase. Power consumption is no more than 50 Va.

2-9. LINE VOLTAGE SELECTION

2-10. Figure 2-1 provides instructions for line voltage selection. Card and fuse are factory installed for 120 Vac operation.

2-11. POWER CABLE

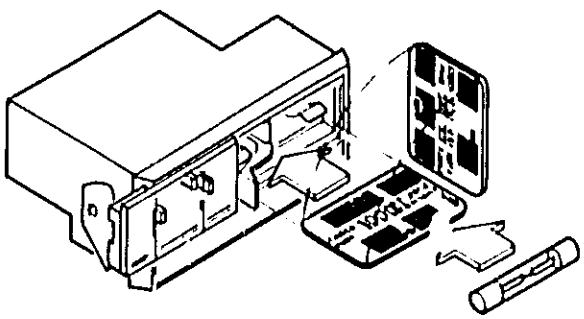
2-12. This instrument is supplied with a three-wire power cable. When connected to an appropriate ac power receptacle, the cable grounds the instrument cabinet.

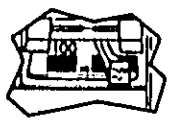
2-13. INTERCONNECTIONS

2-14. The HP 2804A and its quartz probes are integral parts of a temperature measurement system. Before any measurements can be made the HP 2804A and at least one quartz probe must be connected together and the calibration module for that probe must be installed in the appropriate channel. Following this, a temperature reference adjustment must be made.

NOTE

Quartz Probe must be connected directly to front panel T1 or T2, or to HP 18107A External Oscillator for proper operation.





Operating voltage is shown in module window.

PROCEDURE

1. Slide cover door to left (the line power cord must be disconnected).
2. Rotate FUSE PULL to left. Remove the fuse.
3. Remove the PC board by pulling it out. Select operating voltage by positioning PC board to show the desired voltage on top-left side.
4. Reinsert the PC board.
5. Rotate FUSE PULL back into normal position and reinsert fuse. Use caution to select correct fuse value.

Figure 2-1. Line Voltage Selection

2-15. OPERATING ENVIRONMENT

CAUTION

Quartz thermometer probes are very fragile and can be permanently damaged by physical shock or vibration in excess of 5000 g's. For example, a drop of approximately 20,32 cm (8 inches) onto a hard surface can cause sufficient damage to break the crystal or cause a permanent change in calibration.

2-16. TEMPERATURE. The instrument may be operated in temperatures from 0°C to 55°C.

2.17. HUMIDITY. The instrument may be operated in environments with humidity from 5% to 95% R.H. @ 40°C. However, the instrument should be protected from temperature extremes which cause condensation within the instrument.

2-18. STORAGE AND SHIPMENT

2-19. ENVIRONMENT

2-20. The instrument may be stored and shipped within the following environmental limits:

Temperature:	−40°C to +75°C	Do not store or ship where temperature extremes will cause condensation within the instrument.
Humidity:	90% R.H. @ 65°C.	

2-21. INSTRUMENT PACKAGING

2-22. ORIGINAL PACKAGING. Containers and packing material used in factory packaging can be obtained through Hewlett-Packard sales and service offices listed at the rear of this manual. If the instrument is returned to HP for repair, attach a tag listing the type of service or repair needed. Include return address, model number, option number (if applicable) and complete serial number. Also, mark the container "FRAGILE" to ensure careful handling. In any letters, refer to the instrument by model number, option number (if applicable) and complete serial number.

2-23. OTHER PACKAGING. Use these general instructions for packaging with commercially available materials:

a. Wrap the instrument in heavy paper or plastic. If shipping to an HP Sales or Service Office, include a tag listing type of service needed, return address, model number, option number (if applicable) and complete serial number.

b. Use a strong shipping container such as a double-wall carton with 276 lbs. burst test.

c. Use a layer of shock absorbing material, 70-100 mm (3-4 in.) thick. This provides a firm cushion and prevents movement inside the container. Protect the front panel with cardboard.

d. Seal the carton securely and mark it "FRAGILE" to ensure careful handling.

2-24. PROBE PACKAGING

2-25. There is only one acceptable method of packing a probe. It must be contained in the original factory packing case. The case must then be placed in a strong shipping container filled with 15,25 cm (6 inches) thick of shock absorbing material on all sides. Seal the carton and mark it FRAGILE. Ensure that all appropriate correspondence is included with the shipment. Improperly packaged probes will void the warranty.

SECTION III
OPERATION

3-1. INTRODUCTION

3-2. This section contains a description of front and rear panel controls, connectors and indicators and their operation. General temperature information, high accuracy calibration procedures, ice bath construction and use, triple point-of-water cell use are also included. Additionally, Operator Checks (power-on and initial instrument indications), reference temperature adjustments using a triple point cell or ice bath, use of the Analog Output and HP-IB System Interface and information on HP-IB are also included.

3-3. OPERATING CONSIDERATIONS

3-4. To ensure instrument accuracy, a reference temperature adjustment must be made when received from the factory or within the last 30 days preceding the use of the instrument. This adjustment minimizes the errors due to thermal history and quartz probe aging rate.

3-5. Any temperature within the −80 to +250°C range can be used as a reference temperature. Normally, the ice-point or the triple-point-of-water is the most accurate and easiest to prepare. If a reference temperature close to the measured temperature is used, the calibration errors and hysteresis of the quartz probe are minimized.

3-6. When using a known temperature other than the ice-point or triple-point-of-water, the instrument thumbwheel switches are adjusted for a display which is the same as the known reference temperature.

3-7. For the ice point reference temperature, the instrument thumbwheel switches are adjusted for 0.000°C. For the triple point of water reference temperature, the instrument thumbwheel switches are adjusted for 0.010°C. When a triple point of water cell (temperature standard) is used, the reference temperature adjustment error is limited by the accuracy of the cell (approx. 0.0002°C).

3-8. When a reference temperature adjustment is made in one channel, the thumbwheel switch settings for the probe/calibration module used cannot be used in the other channel or in another instrument. Don't make the reference temperature adjustment on channel T1 and use the probe/calibration module in channel T2 with settings of channel T1.

3-9. In use, for maximum accuracy, the instrument ambient temperature must be the same as when the reference temperature adjustment was made.

3-10. SELF-CHECK

3-11. A self check is automatically performed whenever the LINE switch is pressed ON. See paragraph 3-16 Operator Checks for power-on and indications of self-check.

3-12. ERROR MESSAGES

3-13. Under certain conditions, the HP 2804A will abort or fail to achieve a normal display. An error message is displayed if this occurs. Messages and conditions causing them are listed in table 3-1.

NOTE

Instrument will not operate if INT-EXT Switch is in EXT and no 1 MHz input is applied to CLOCK connector.

3-14. PANEL FEATURES

3-15. Front and rear panel features are described in Figure 3-1 and Figure 3-2.

Table 3-1. 2804A Error Messages

An error that is "bypassable" may be circumvented by selecting the other measurement channel.

MESSAGE	DESCRIPTION	BYPASSABLE?
"Error 1"	System Malfunction (Described more fully in Note 1)	No
"Error 2"	Channel 1 Calibration Module absent	Yes
"Error 3"	Channel 2 Calibration Module absent	Yes
"Error 4"	Channels 1, 2 Calibration Modules absent	No
"Error 5"	Calibration Module 1 Checksum error	Yes
"Error 6"	Calibration Module 2 Checksum error	Yes
"Error 7"	Channel 1 Signal Dropout	Yes
"Error 8"	Channel 2 Signal Dropout	Yes
"Probe 1"	Channel 1 Out-of-range (Note 2)	No
"Probe 2"	Channel 2 Out-of-range (Note 2)	No

NOTE 1:

"Error 1", denoting system malfunction, occurs for the following situations.

(1) Inability to properly access MPU registers or RAM during Self-Check.

(2) Inability to properly access front panel pushbutton switches during Self-Check.

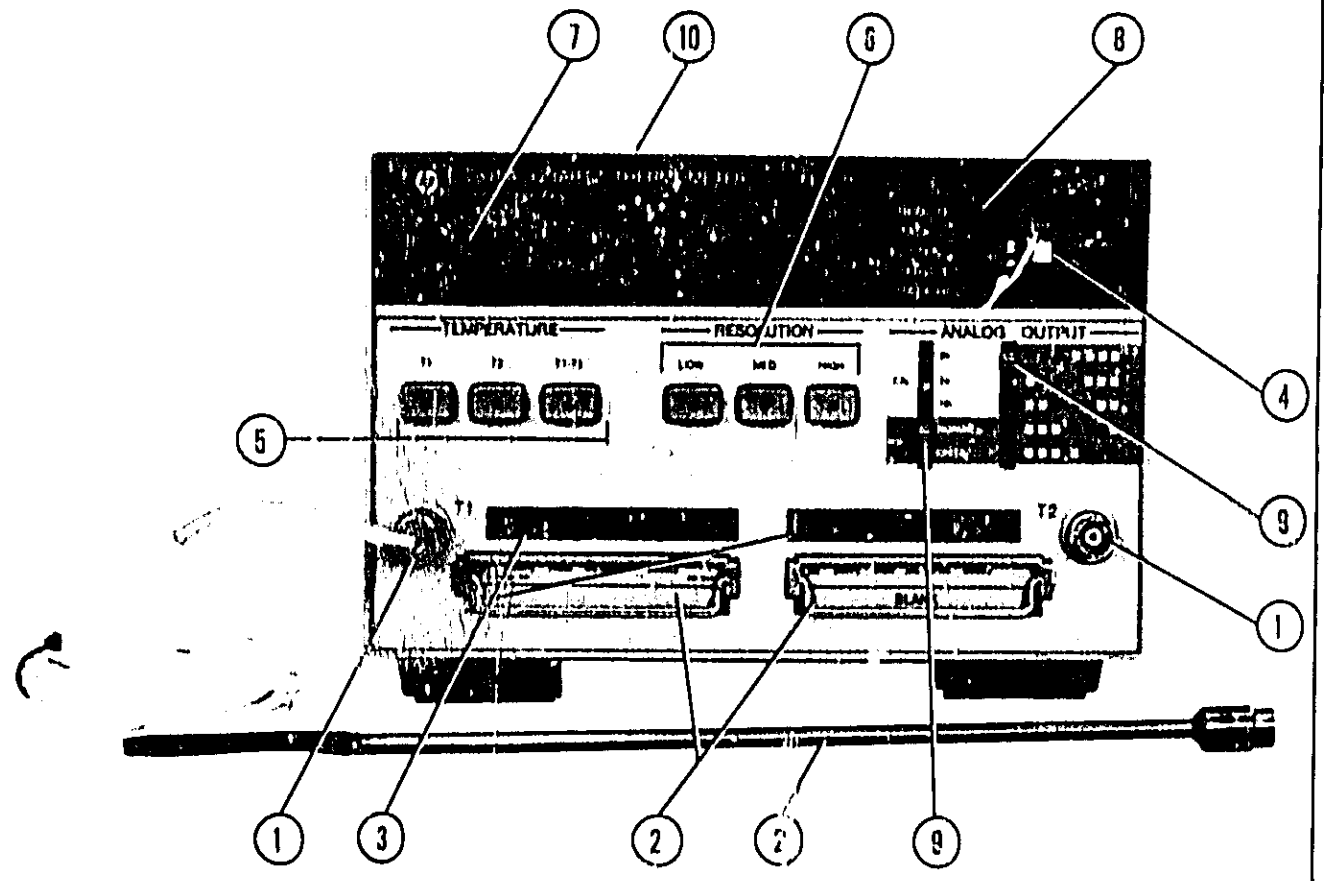
(3) Inability to properly access °C/°F switch during Self-Check.

(4) No output from counter in response to an internal 1 MHz test signal (during Self-Check and Error routines).

(5) Computational overflows.

NOTE 2:

"Probe 1" and "Probe 2" are "self-recoverable" errors in the sense that normal measurement resumes if the measured temperature is brought back within the permitted range. Excessive temperature over-range for prolonged periods may change probe temperature/accuracy response. If the probe has been exposed to temperatures of lower than −100°C or higher than 260°C for more than 1 minute, the probe and calibration module should be returned to the factory for recalibration and a new calibration module.



FRONT PANEL

1. T1, T2 Input connectors. Input BNC's provide sensor probe connection to the instrument. T1 is left channel, T2 is right channel when facing the instrument.

2. Quartz Probes/Calibration Modules. Enables high accuracy temperature measurements to be made. Probes and calibration modules are calibrated pairs and must be used together in the same channel. Matched pair enables the quartz probe/calibration module to be used in other HP 2804A instruments if a new reference temperature adjustment is made prior to a measurement.

3. Reference Temperature Adjustments. Three 10-digit thumbwheel switches for each channel enables compensation for probe crystal aging to be made. For highest accuracy a triple point of water cell should be used when making this adjustment. Probe is immersed in an ice bath and thumbwheel switches are adjusted for 0.01°C (when using a triple point cell) and 0.000°C (32.00°F) (when using an ice bath) indication on the display. See paragraph 3-25 for additional information. Also see paragraph 3-3.

4. LINE Switch. In the ON position dc voltage is applied to all instrument circuits. In the STANDBY position, only the dc voltages to the display assembly and to the A3 processor are turned off. This switch does not control ac line voltages. To completely power-down the instrument, the rear panel ac power cord must be disconnected.

Figure 3-1. Front Panel Controls, Connectors, Indicators

5. TEMPERATURE Mode T1, T2, T1-T2. Pushbutton switches used to select the input mode (Channel T1 or T2) or a temperature difference mode (T1-T2).

NOTE

Quartz Probe must be connected directly to front panel T1 or T2, or to HP 18107A External Oscillator for proper operation.

6. RESOLUTION LOW, MED, HIGH. Three levels of resolution can be selected:

SELECTION	RESOLUTION		NOMINAL TIME BETWEEN READINGS (IN SECONDS)	
	°C	°F	T1 or T2	T1-T2
Low	0.01	0.1	0.1	0.2
Medium	0.001	0.01	1	2
High	0.0001	0.001	10	20

7. Digital Display. Displays all temperature measurements in °C or °F. Also displays seven "8"s and "E" when automatic self-check passes at initial power-on. Quartz probe/calibration module failures or out-of-range temperature conditions are also displayed as one-of-ten error codes. The HP-IB address (factory preset at address 13) is displayed preceding automatic self-check. To change the HP-IB address, see paragraph 3-61.

8. HP-IB System Interface Status Indicators:

REMOTE, TALK, LISTEN, SERVICE, DATA HOLD annunciators provide an indication of the instrument status.

9. ANALOG OUTPUT
CAL switch. 0V, 5V, 10V. Provides calibrated output voltage at rear panel ANALOG connectors of 0V, 5V, 10V for a stripchart recorder use.

OP Switch, NORMAL, OFFSET. In NORMAL the analog output voltage at the rear panel is 0 to +10V and directly corresponds to three display digits. In OFFSET the analog output voltage at the rear panel is offset by +5V which moves the 0V to the center of the stripchart recorder paper. This provides a +5V to +10V and 0V to +5V excursion.

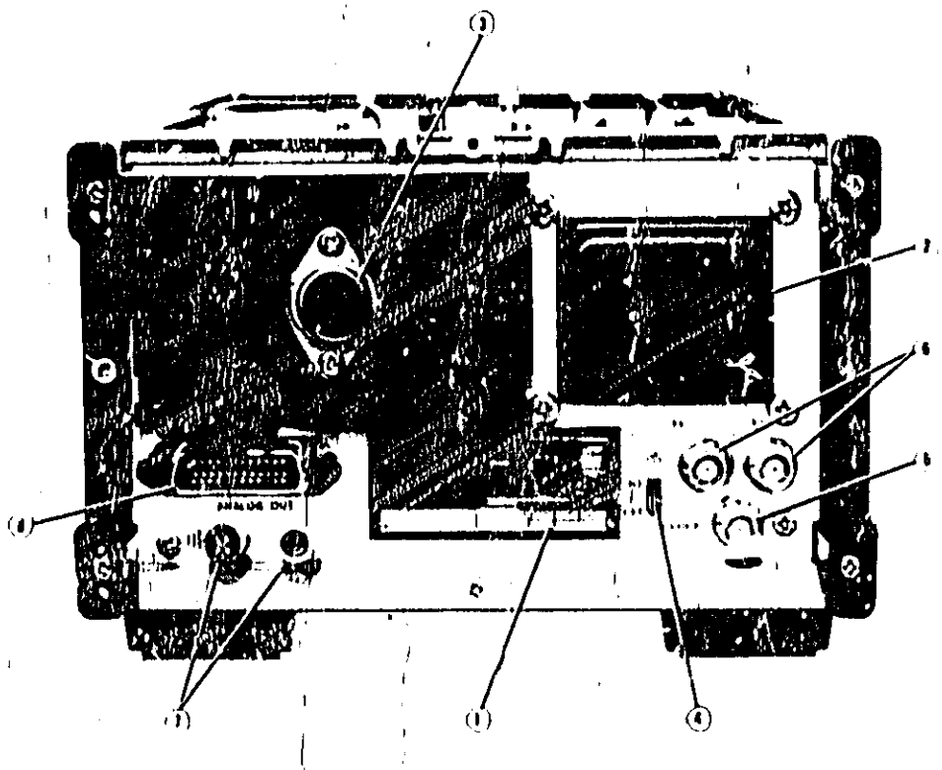
Digit selection Switch. Three digits of the displayed temperature are selected for conversion by this switch. The value of the selected digits ranges from 000 to 999. The analog output voltage is a de level ranging from 0.00 volts to 9.99 volts and directly corresponds to the value of the selected digits. The OFFSET mode provides a more readable recording when the three selected digits are near 000 and 999

10. °C/°F Switch (Internal to Instrument)
This switch is located inside and near the front of the instrument (S7 on A2 Assembly). Top cover must be removed to change the setting which enables the digital display to indicate temperature in °C or °F.

Examples of analog output voltages for NORMAL and OFFSET Modes:

DISPLAYED TEMPERATURE [XXX] = SELECTED DIGITS	ANALOG Vdc OUT NORM MODE	ANALOG Vdc OUT OFFSET
+12[3.04]43°C	3.04	8.04
+123 0[443]°C	4.43	9.43
+123[044]3°C	0.44	4.44
+123[000]0°C	0.00	4.00
+124[000]0°C	0.00	5.00
+124 0[100]°C	0.10	5.10
0.[001]0°C	0.001	5.01
+0.[000]0°C	0.00	5.00
0[001]0°C	0.00	4.00

Part of Figure 3-1



REAR PANEL

1. Line Module provides ac power connection, fuse holder, and operating input voltage selection.
2. Power Transformer. Input ac power transformer.
3. +5 Vdc regulator. Supplies +5 Vdc to displays and processor assembly.
4. CLOCK INT-EXT Switch. INT selects internal 10 MHz oscillator, or EXT in conjunction with a 1 MHz input to CLOCK connector, selects an external 1 MHz signal source.

   NOTE

   Instrument will not operate if INT-EXT Switch is in EXT and no 1 MHz input is applied to CLOCK connector.

5. CLOCK Connector. External 1 MHz signal input. Used in conjunction with CLOCK INT-EXT switch and enables higher accuracy measurements to be made (dependent on accuracy of external 1 MHz input.)
6. T1, T2 Input Connectors. Input BNC's provide inputs from sensor probes when used with HP 18107A External Oscillators. T1 corresponds to left input channel and T2 corresponds to right input channel.

   CAUTION

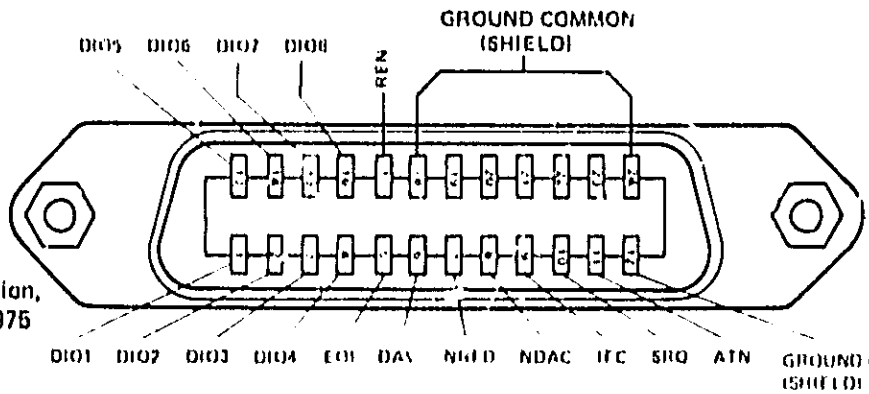
   Only an HP 18107A Oscillator or an HP 18108A Amplifier should be connected to these BNC's. Damage to the instrument may result if any other device is connected.

7. ANALOG OUTPUT
   A dc voltage from 0 to +10V corresponding to three display digits selected for conversion to an analog voltage.
8. HP-IB connector. Provides signal connections and control to the HP-IB bus according to the Hewlett-Packard implementation of IEEE-488, 1975 for controlling the HP 2804A with a calculator or computer.

8 CONTROLS, CONNECTORS, AND INDICATORS

NOTE:
HP-IB LABELED ACCORDING TO IEEE-488 1975

For further information, refer to IEEE-488-1975



HP 'B Address

HP-IB Address is factory set to 13. Address may be changed to another value. See paragraph 8-61 for Address Selection information.

LOGIC LEVELS

HP-IB logic levels are low true and TTL compatible (LO = 0.0 to +0.4 Vdc, HI = +2.5 to +5.0 Vdc).

Example: SRQ is LO active.
NRFD is HI active.

Input Signals:

Each input line is terminated with 3000 ohms to +5V and 6200 ohms to ground (one TTL load).

Output Signals:

Each output can drive 15 HP-IB loads. The output is an open-collector driver capable of sinking 48 mA at 0.4V output.

SIGNALS

NRFD

Ready For Data. Indicates HP 2804A will accept data when NRFD is HIGH.

NDAC

Data Accepted. Indicates HP 2804A has accepted data. Returns to LOW when HP 2804A is finished processing data.

DAV

Data Valid. Indicates valid output data is available from HP 2804A if addressed to talk. Input data is available if 2804A is addressed to listen and ATN is HIGH. Address is valid if ATN is LOW.

ATN

Attention. A LOW state indicates commands are present on the DIO lines. A HIGH state indicates data is present on the DIO lines.

DIO1 thru DIO8

Data Input-Output lines. Message bytes are carried on the DIO signal lines in a bit-parallel byte-serial form, asynchronously and generally in a bidirectional manner.

REN

Remote Enable. Used by the controller to cause the HP 2804A to be placed in the remote mode.

SRQ

Service Request. Indicates the HP 2804A wants the attention of the controller.

IFC

Interface Clear. Used by the controller to terminate all activity on the bus.

EOI

End or Identify. For further information, refer to IEEE-488-1975

Part of Figure 3-2.

3-16. OPERATOR CHECKS

3-17. These checks enable the operator to make quick evaluation of the instrument's functions prior to use and requires that a quartz probe and its companion Calibration Module is installed in one of the input channels (T1 or T2). To operate the instrument use the following procedure:

CAUTION

Do not install or remove calibration modules without pressing LINE switch to STANDBY.

a. Determine the voltage of the ac power source to be used. Ensure that the rear panel Line Module is set to the correct line voltage. Also, ensure that the correct fuse (.5 Amp for 120 Vac, .25 Amp for 220 Vac) is installed, (Line Module is set at the factory for 120 Vac operation). Connect the instrument to the ac line voltage available.

b. Install the calibration module into T1 channel and connect the quartz probe to front panel channel BNC.

c. Ensure that rear panel INT-EXT Switch is set to INT. Press instrument front panel LINE switch to ON position. This switch does not control ac power. It controls the +5Vdc to the A1 display circuits and to the A3 MPU/Time Base Assembly.

NOTE

Instrument will not operate if rear panel INT-EXT Switch is in EXT and no 1 MHz input is applied to CLOCK connector.

d. At power-on, the HP-IB address location (shipped from factory, set to address location 13) is displayed (Addr 13). The eight alpha-numeric indicators will then display 88888888 and all other indicators will be on for about 1-2 seconds. This means that automatic self-check has passed.

e. Following "all indicators on" the instrument automatically makes a measurement from T1 channel at LOW RESOLUTION.

f. To meet the accuracy specifications, the thumbwheel switches must be set to the value obtained from a reference temperature adjustment. This adjustment must be made within the last 30 days preceding the use of the instrument. (See paragraphs 3-3 and 3-25). The reference temperature adjustment corrects for sources of error due to:

a. Quartz probe crystal aging.
b. Individual oscillator circuits characteristics.
c. Variations in ambient temperature.
d. Reference oscillator aging.

g. A Reference Temperature Adjustment has not been made at the factory and should be done before the instrument is used. If a quartz probe and its companion Calibration Module is installed in T1 channel, the instrument display will be the temperature the quartz probe is subjected to. If an error message is displayed, see Table 3-1 for the message and description.

3-18. Whenever a TEMPERATURE or RESOLUTION control is selected (manual or automatic) the LED, in the pushbutton cap, lights.

3-19. GENERAL TEMPERATURE INFORMATION

3-20. The basic temperature scale is the thermodynamic temperature scale (T) measured in kelvin (K) and is defined as 1/273.16 of the thermodynamic temperature of the triple point of water. The Celsius thermodynamic temperature (t) is defined as $t = T - T_0$ where $T_0 = 273.15$ K.

3-21. The International Practical Temperature Scale of 1968 (IPTS-68) was adopted by the International Committee of Weights and Measures in 1968 according to the power given to it by Resolution 8 of the 13th General Conference of Weights and Measures. An amended text of this 1968 scale was adopted in 1975. The 1968 scale replaces the International Practical Temperature Scale of 1948 (amended edition of 1960). The International Practical Temperature Scale of 1968 (IPTS-68) has been chosen in such a way that the temperature measured on this scale closely approximates the thermodynamic temperature. Note, however that the IPTS-68 defines only practical scales of temperature and not thermodynamic temperatures.

3-22. The IPTS-68 signifies practical Kelvin temperature with T_{68} and practical Celsius Temperatures with t_{68}. The relationship between T_{68} and t_{68} is: $t_{68}=T_{68}-273.15K$.

3-23. The IPTS-68 is based on the assigned values of the temperatures of a number of reproducible equilibrium states (defining fixed points) and on standard instruments calibrated at those temperatures. Interpolation between the fixed point temperatures is provided by formulae used to establish the relation between indications of the standard instruments and values of International Practical Temperature. Additional detailed information is available in the U.S. Department of Commerce, National Bureau of Standards, NBS Monograph 126.*

3-24. In the United States, the IPTS-68 is maintained by the National Bureau of Standards. The accuracy of the HP Model 2804A Quartz Thermometer is traceable to IPTS-68 through NBS. In countries other than the United States, the HP 2804A is traceable to IPTS-68 through the National Standards organization of the respective countries.

3-25. REFERENCE TEMPERATURE ADJUSTMENT

3-26. Reference Temperature Adjustments are simple, requiring inexpensive equipment and eliminating the necessity of a second fixed-point temperature reference. For highest accuracy, a temperature reference adjustment using a triple point of water cell should be made. See paragraphs 3-3 through 3-9 for Operating Considerations. Immerse the probes in an ice bath (see Checking Calibration, paragraph 3-27) and adjust the thumbwheel switches on the front panel for display of 0.000°C/32.00°F indication or 0.01°C indication when using a triple point cell. The reference temperature adjustment takes just a few minutes and is the only adjustment for maximum accuracy. A reference temperature adjustment must be made within the last 30 days preceding the use of the instrument. Factory recalibration is recommended no more than once a year.

3-27. HP-IB INSTALLATION

3-28. Table 1-2 lists the standard interface cables used for hookup between the HP 2804A and the controller. Cables are available in different lengths to suit user requirements. The connectors at either end of the cable are identical. The plugs will mate with the rear panel connector on the HP 2804A. The receptacle on the back of the cable connector will receive another cable plug.

3-29. A Bus Interface Kit is needed to use a Hewlett-Packard calculator as the HP-IB controller. Information about this kit may be obtained from the nearest Hewlett-Packard Sales and Service Office.

3-30. MAXIMUM CABLE LENGTH

3-31. As many as 15 instruments can be connected in parallel. (Be sure to count the calculator when counting the number of devices in the system). However, observe the following rules:

a. The total cable length for the system must be less than or equal to 20 meters (65 ft.).

b. The total cable length for the system must be less than or equal to 2 meters (6 ft.) times the total number of devices connected to the bus.

For instance, a system with one calculator and one HP 2804A would allow 4 meters (12 ft.) of cable.

*NBS Monograph 126, Platinum Resistance Thermometry by: John L. Riddle, George T. Furukawa, and Harmon H. Plumb.

3-32. ADDRESS SELECTION

3-33. The HP-IB address selector switch is located on the HP-IB PC board assembly A7. The switch is preset at the factory for:

	ASCII	Binary
Talk Address	M	1001101
Listen Address	-	0001101

MSB LSB

The last five bits in the binary code are switch selectable. The first two digits (most significant) are "hard wired" into the HP-IB circuitry.

3-34. To change the address of the HP 2804A, follow this procedure:

a. Turn off the power switch and unplug the power cord.

b. Release the top cover by unscrewing one screw located at the rear and center-edge of the top cover.

c. Remove the top cover.

d. The address selector switch is seven SPST switches contained in a dual-in-line (DIP) package. Figure 3-3 shows the switch with the factory preset values.

e. The switch settings may now be changed with a pointed instrument (like a pencil or pen).

NOTE

Do not set all address switches to the "1" position. This code is reserved for special use.

MSB				LSB	ASCII LISTEN ADDRESS	ASCII TALK ADDRESS
0	0	0	0	0	SP	@
0	0	0	0	1	!	A
0	0	0	1	0	"	B
0	0	0	1	1	#	C
0	0	1	0	0	$	D
0	0	1	0	1	%	E
0	0	1	1	0	&	F
0	0	1	1	1	'	G
0	1	0	0	0	(	H
0	1	0	0	1	)	I
0	1	0	1	0	*	J
0	1	0	1	1	+	K
0	1	1	0	0	,	L
0	1	1	0	1	-	M
0	1	1	1	0	.	N
0	1	1	1	1	/	O
1	0	0	0	0	0	P
1	0	0	0	1	1	Q
1	0	0	1	0	2	R
1	0	0	1	1	3	S
1	0	1	0	0	4	T
1	0	1	0	1	5	U
1	0	1	1	0	6	V
1	0	1	1	1	7	W
1	1	0	0	0	8	X
1	1	0	0	1	9	Y
1	1	0	1	0	:	Z
1	1	0	1	1	;	[
1	1	1	0	0	<	\
1	1	1	0	1	=	]
1	1	1	1	0	>	^

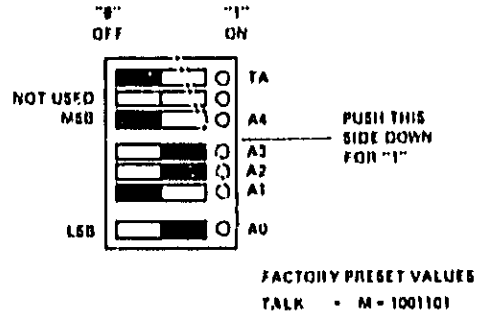


Figure 3-3. HP-IB Address Selection

3-35. CHECKING CALIBRATION

3-36. Checking the calibration of the quartz probe/calibration module may be done by performing a reference temperature adjustment. Two methods can be used which yield nominal accuracies of ±0.5m°C and ±5m°C. These are:

a. Triple point of water using a Triple-Point-of-Water Cell which provides a probe/instrument setting accuracy of ±0.5m°C.

b. High quality ice bath prepared with de-ionized water and ice which provides a probe/instrument setting accuracy of ±5.0m°C.

3-37. Large differences (>200) in thumbwheel switch settings from previous settings may be indicative of one or more of the following:

a. Quartz probe/calibration module installed in the wrong channel for the switch settings used.

b. Probe damage has occurred.

c. Instrument degradation has occured.

d. Probe Thermal History error resulting from high temperature use.

e. Ambient temperature during measurement is substantially different from the ambient temperature when a reference temperature adjustment was made.

3-38. Following the preparation of the ice bath or the triple-point-cell and the insertion of the quartz probe the thumbwheel switches can be adjusted. Watch the display and allow a minimum of 10 minutes for the quartz probe temperature to stabilize.

3-39. USING A TRIPLE POINT CELL

3-40. The temperature of the triple-point-of-water is the temperature of pure water, ice and water vapor in thermal equilibrium. It is one of the fundamental defining fixed points of the International Practical Temperature Scale (IPTS-68), and the one defining fixed point of the Kelvin thermodynamic temperature scale. This temperature has been assigned a value of +0.01°C on the International Practical Temperature Scale, and a value of 273.16 K on the Kelvin thermodynamic scale. Triple-point-of water cells are used in the calibration of thermometers. Although most commonly used for the determination of the R_0 of standard-grade platinum resistance thermometers, they are also used for calibration of quartz thermometers, thermistors, liquid in glass thermometers. They are also used to establish the zero, and evaluate the stability of other temperature sensing devices.

3-41. Checking calibration using the Triple Point of Water (Following text extracted in part or whole from U.S. Department of Commerce, NBS Monograph 126).

3-42. The triple point of water (0.01°C) is the most useful and important of the defining fixed points for calibrating. The triple point is realized in a sealed glass cell (such as Jarrett Instrument Co., Model No. A13,) containing ice, water, and water vapor. When the cell is in use it may be placed in an ordinary bath of chipped or crushed ice, and water. Figure 3-4 shows the cell and ice-bath system.

3-43. The cell is first immersed in the ice bath with the mouth of the re-entrant thermometer-well above the surrounding ice-water level. The well is thoroughly dried, then filled with crushed dry ice and maintained full for about 20 minutes by replacing the sublimed dry ice. The initial freezing of water within the triple-point cell occurs several degrees below the triple-point temperature because water easily supercools.

3-44. When the water does start to freeze, fine needles of ice crystals (dendrites) initially form and protrude from the wall of the well into the liquid. The fine needles quickly cover the well but soon disappear to form a clear coating of ice on the well that will grow to a 4 to 8 mm thick mantle in about 20

1. Heavy black felt shield against ambient radiation.
2. Polyethylene tube for guiding the quartz probe into the thermometer well.
3. Water vapor.
4. Borosilicate glass cell.
5. Water from ice bath.
6. Thermometer well (precision bore).
7. Ice mantle.
8. Air-free water.
9. Polyurethane sponge.
10. Finely divided ice and water.
11. Dewar Flask

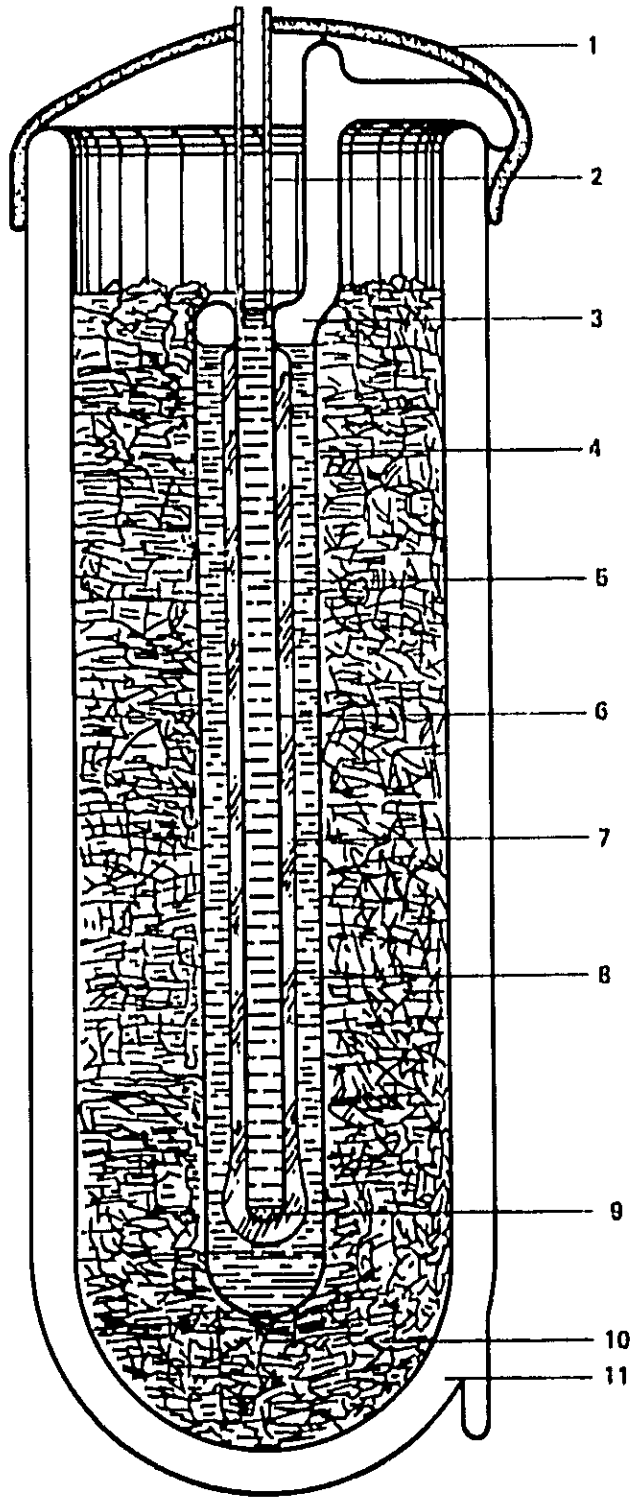


Figure 3-4. Triple-point-of-water Cell

minutes. It is important to keep the well completely full of dry ice during this period. (If the dry ice level in the well is allowed to drop several inches and then the well is refilled,the ice mantle may crack. The desired triple-point temperature may not be achieved if a crack in the ice mantle extends from the well surface into the surrounding liquid water.

3-45. In the process of introducing dry ice into the well some of the dry ice may be deposited around the top of the cell, causing the water within the cell to freeze solidly across the top. The ice at the top of the cell should be melted immediately to avoid the possible breaking of the cell glass. Whenever ice is frozen solidly across the top surface of the cell water and a strong bond is formed between the thermometer well and the outer cell wall, any subsequent freezing of water below the surface ice can result in sufficient pressure to rupture the cell. The surface ice can be melted by raising the cell slightly and warming the top of the cell with the hands briefly while gently shaking the top of the cell sideways to "wash" the region with the cell water which facilitates the melting of the layer of ice.

3-46. After 20 minutes no additional dry ice should be added and the remaining dry ice in the well should be allowed to sublime completely. Finally, when the dry ice in the well is completely gone, the cell is lowered deeper into the ice bath and the well allowed to fill with water.

3-47. An immersion type cooler may be used instead of dry ice for freezing the ice mantle. However, care must be taken to avoid admitting the auxiliary heat-transfer liquid, e.g., alcohol, into the surrounding ice bath.

3-48. A second ice-water interface is formed by melting the ice immediately adjacent to the well surface. This is referred to as the "inner melt." The inner melt is made by inserting a glass tube at ambient temperature into the well for a few seconds. A test for the existence of the ice-water interface over the entire interior surface of the mantle is to give the cell a small rotational impulse and determine whether or not the ice mantle rotates freely around the axis of the thermometer well.

3-49. Some evidence exists that the temperature of the triple-point cell is sometimes slightly low (about 2×10^{-4}°C) immediately after freezing, therefore, the cell should be prepared at least one day prior to its use. The reason for this low initial temperature and the subsequent gradual increase during one or two days to a steady value is not clearly established but is believed to be connected with structural strains that are produced when the ice is first frozen; presumably the strains are relieved with time as the ice anneals. The magnitude of the lower initial temperature and the rate of increase to a steady temperature value is dependent upon the specific technique that is employed in freezing the cell.

3-50. To eliminate the ambient room radiation (from ceiling lights in particular) a heavy black felt cloth (1) covers the top of the cell except for a hole through which the thermometer may be inserted. The thermometer is precooled in the ice bath that surrounds the cell before it is inserted into the cell. A polyethylene plastic tube (2) from the hole in the felt cloth to the re-entrant well provides a guide for inserting the sensor probe.

3-51. CHECKING CALIBRATION USING AN ICE BATH

3-52. A high quality ice bath prepared with great care and using deionized water and ice will yield an accuracy of ±5m°C. Accuracy is dependent upon water and ice purity and on the technique used in preparation.

3-53. Deionized or distilled water and ice. Deionized water and ice, or ice made from distilled water in conjunction with distilled water is used to prepare an ice bath.

3-54. A practical 0°C reference can be constructed using the following procedure.

Figure 3-5 illustrates the ice-bath:

a. Ice-Bath Preparation.

1. Wash your hands thoroughly to remove any salts, then wash the Dewar flask if it is dirty.

2. Rinse the Dewar flask in deionized or distilled water.

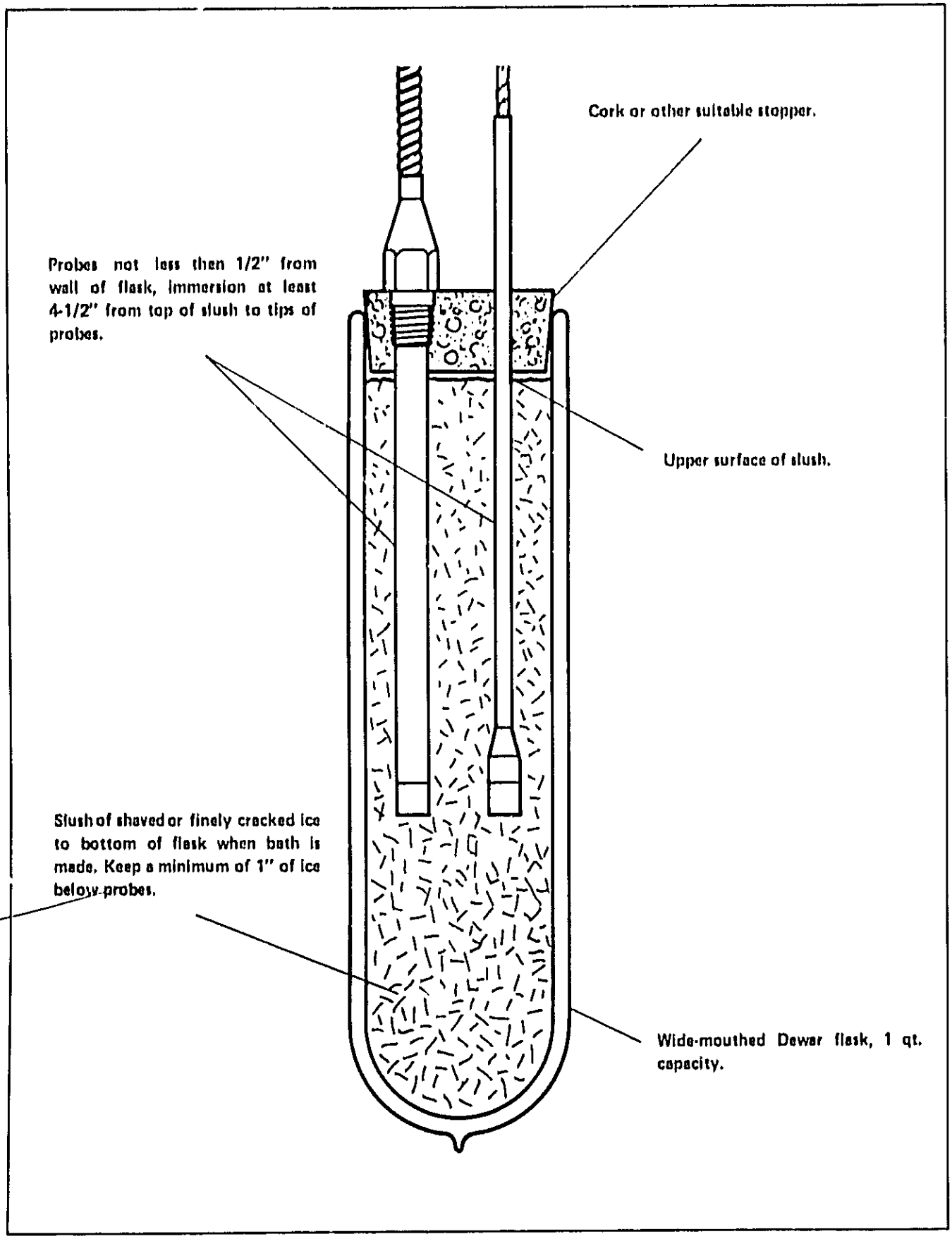


Figure 3-5. Practical Ice Bath for Calibrating Quartz Thermometers

3. Crush as much deionized - distilled-water ice as is needed to pack the Dewar flask full.

4. In a separate container that has been rinsed in deionized or distilled water, mix deionized or distilled water and ice until the mixture is precooled close to the freezing point.

5. Pour this water into the Dewar flask, filled in step 3, until the water level is just below the top of the Dewar flask. This water fills the voids in the ice pack.

b. Ice Bath Use.

1. Wash the sensor probe to be used in deionized or distilled water. This is very important to minimize contamination of the ice bath.

2. If the sensor probe temperature is greater than ±25°C, precool the sensor probe in a separate ice bath (using procedures listed in item a.) before placing it in the main ice bath.

3. Insert the sensor probe in the ice pack by first using a prerinsed glass rod to form a pilot hole in the ice pack, then insert the sensor probe into the pilot hole.

c. Ice Bath Refreshing.

1. Siphon the water out of the bottom of the Dewar flask when a significant melt has occurred.

2. Repack the Dewar flask with more deionized - or distilled-water ice.

3. If needed, add more water (as prepared in item a, step 4.)

3-55. Tap water and ice. The most practical of all ice baths is ice made from tap water. Reproducibility and accuracy will depend on many variables (geographical location, water impurities etc). To determine if the accuracy meets your minimum requirements, ice baths prepared according to paragraph 3-33 or 3-43 must be used as a comparison

3-56. Procedures for preparing a tap water ice bath are the same as procedures listed in paragraph 3-43 except that tap water is used.

3-57. OPERATION USING HP-IB SYSTEM INTERFACE

3-58. HP-IB is Hewlett-Packard's implementation of IEEE-488-1975, "Digital Interface For Programmable Instrumentation". It enables the HP 2804A to be controlled, in a system environment, by an independent controller. To fully utilize the HP-IB capabilities of the HP 2804A, you should be familiar with the contents of IEEE-STD-488-1975. Information is also available from Hewlett-Packard by ordering "Condensed Description of the Hewlett-Packard Interface Bus", HP Part Number 59401-90030. The HP-IB document is also included as Appendix B at the rear of this manual.

3-59. The HP Interface Bus transfers data and commands, on 16 signal lines, between components of an instrumentation system. Interface functions for each system component are performed within each component so only passive cabling is needed to connect the system. The cables connect all instruments, controllers, and other components of the system in parallel to the signal lines.

3-60. The data lines (DIO1-DIO8) are reserved for the transfer of data and other messages in a byte-serial, bit-parallel manner. Data and message transfer is asynchronous, coordinated by the three control lines (DAV, NRFD, NDAC). The other five lines are for control of bus activity. The control lines are ATN, IFC, REN, SRQ, EOI. Figure 3-2, item 8 provides an explanation of these signals. Figure 3-6 shows the lines.

3-61. Devices connected to the bus may be talkers, listeners, or controllers. The controller dictates the role of each of the other devices by setting the ATN line true and sending talk or listen addresses on the data lines (DIO1-DIO8). Addresses are set into each device at the time of system configuration either by switches built into the device or by jumpers on a PC board. While the ATN line is true, all devices must listen to the data lines. When the ATN line is false, only devices that have been addressed will actively send or receive data. All others ignore the data lines.

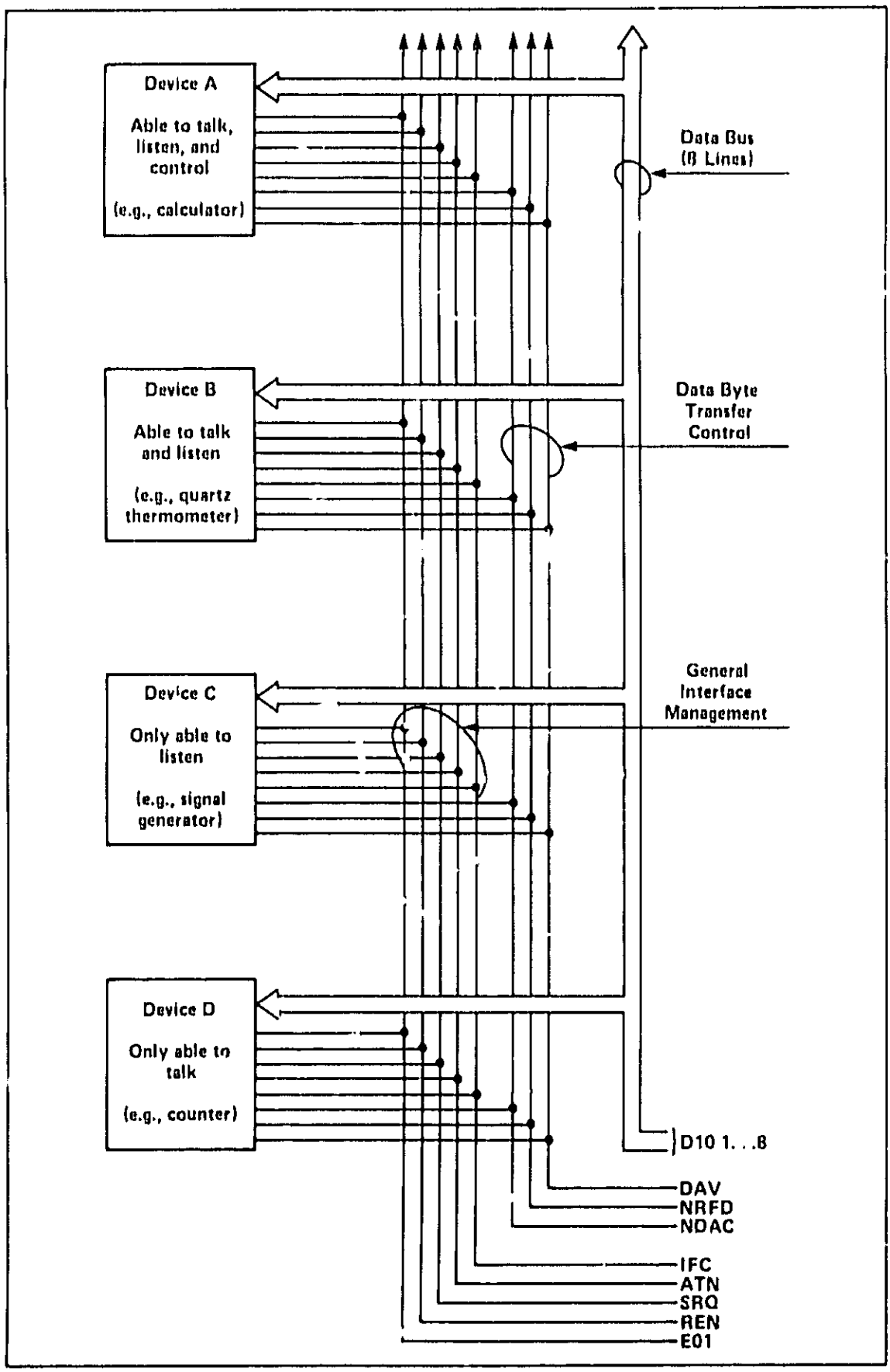


Figure 3-6. Bus Signal Lines

3-62. Information is transmitted on the data lines under sequential control of the three control lines. No step in the sequence can be initiated until the previous step is completed. Information transfer can proceed as fast as devices can respond, but no faster than the slowest device presently addressed as active. This permits several devices to receive the same message byte concurrently.

3-63. The operation of the interface is generally controlled by one device equipped to act as controller. It uses a group of commands to direct the other instruments on the bus in carrying out their functions of talking and listening. The controller has two ways of sending interface messages. Multiline messages, which cannot exist concurrently with other multiline messages, are sent over the eight data lines and the three transfer-bus lines. Uniline messages are transferred over the five individual lines of the management bus.

3-64. The commands serve several different purposes:

a. Addresses, or talk and listen commands, select the instruments that will transmit and accept data. They are all multiline messages.

b. Universal commands cause every instrument equipped to do so to perform a specific interface operation. They include multiline messages and three uniline commands, interface clear (IFC), remote enable (REN), and attention (ATN).

c. Addressed commands are similar to universal commands, except that they affect only those devices that are addressed and are all multiline commands. An instrument responds to an addressed command, however, only after an address has already told it to be a talker or listener.

d. Secondary commands are multiline messages that are always used in series with an address, universal command, or addressed command (also referred to as primary commands) to form a longer version of each. Thus they extend the code space when necessary.

3-65. The operational facility through which a device can receive, process, and send information over the bus is a set of Interface Functions. IEEE-488-1975 defines each Interface Function in terms of state diagrams that exactly express all possible interactions. The HP 2804A implements the following IEEE-488 interface functions:

AH1 — Accept handshake
SH1 — Source handshake
T1 — Talker
L1 — Listener
SR1 — Service Request (Status byte=constant)
RL1 — Remote/Local
PP1 — Parallel Poll
DC1 — Device Clear
DT1 — Device Trigger

3-66. The HP 2804A is programmed through messages on the HP-IB. The device dependent messages to which the HP 2804A responds are:

T1, T2, T3,	Temperature select
R1, R2, R3,	Resolution select
D0, D1	DAC ignore flag
G0, G1	Configure for group Execute Trigger
H0, H1	Sample/Hold mode
J0, J1	Interrupt mode
X	Delimiter for Controllers which are not self-delimiting

3-67. The HP 2804A uses secondary addressing to implement additional features. Secondary addressing appears to the controller, as a set of registers external to the HP 2804A that provide the following:

SECONDARY ADDRESS	FUNCTION
01	Read status string
02	Read channel 1 Preset
03	Read channel 2 Preset
04	Read channel 1 calibration module identification number (Note)
05	Read channel 2 calibration module identification number (Note)
06	Write to DAC

NOTE

The calibration module identification number is the last six digits of its serial number.

3-68. The device-dependent characteristics of the HP 2804A message set are:

D0/D1 DAC Ignore flag.

When D0, the DAC will be updated from the display in accordance with the front panel switch settings. When D1, the DAC will freeze with the last update, and will be refreshed only by reversion to D0, or by a secondary address (06) write to the HP 2804A. The latter requires a BCD string to be sent by the controller to secondary address 06. The HP 2804A will take the last three digits of the string to update the analog output. Non-numeric information (including decimal point) will be ignored. The HP 2804A provides leading-zero insertion for BCD strings less than three digits.

G0/G1 GET Configure.

When G0, the HP 2804A will ignore the GET command from the bus. When G1, the HP 2804A will wait for a GET command, displaying HOLD on the HP 2804A display. After receiving GET, the HP 2804A will commence reading. If the S/H mode is true (H1), the HP 2804A will take one reading, display the result and light the DATA HOLD annunciator. The instrument will wait for a new GET before taking another reading. If S/H is not asserted (H0), the HP 2804A will read continuously, and will not wait for a new GET until another configure message is received.

H0/H1 S/H Mode.

If H0, the HP 2804A will read continuously.

If H1, the HP 2804A will make one reading, display the result and light the DATA HOLD annunciator. (See G0/G1,).

J0/J1 SRQ Mode.

If J0, the HP 2804A will not generate a service request.

If J1, the HP 2804A will generate a service request (SRQ asserted) and light the SERVICE annunciator when new data is available for transfer. When the data has been accepted, the SERVICE annunciator will be extinguished.

X An ASCII X serves as a delimiter for those controllers which do not delimit data transfers automatically. The HP 2804A will respond to the following delimiters: X, CR/LF, EOI bit-tag on final byte.

Secondary Address 01; status-string

When a secondary address 01 read is performed the HP 2804A places a message string on the bus as follows:

E xx Tx Rx Gx dx Hx Dx CR/LF

Where x is the numeric information associated with each alpha character.

The 'E' character gives error status of the HP 2804A. The string is fixed format 15-character (+ CR/LF terminator) long.

Secondary Address 02(03), ( ) - rear panel input

A read of secondary address 02(03) returns a 3-digit BCD string from the channel 1 (2) thumbwheel presets.

Secondary Address 04(05)

A read of secondary address 04(05) returns a 6-digit BCD string from the channel 1 (2) Calibration Module Identification number field in the Calibration Module.

Secondary Address 06

With the DAC Ignore Flag asserted (D1), the HP 2804A updates the analog output based on information sent to secondary address 06. The HP 2804A uses the last three digits of a string, ignoring non-numeric data. For less than three digits of data, the HP 2804A inserts leading zeros. Example:

1. A transfer of "500" will result in an analog output of 5.00 Vdc.

2. A transfer of "81", will result in an analog output of 0.81 Vdc.

Data Transfer

A data read from the primary address, returns a fixed format string of 11 bytes (including sign, decimal and terminator). The HP 2804A provides leading and trailing blanks as a function of selected resolution and DISPLAYED TEMPERATURE. Message string is as follows:

S D_1 D_2 D_3 dp D_4 D_5 D_6 D_7 CR/LF

For Example: With T1 and R2 selected, for a temperature of -0.01°C the data string is: -SS0.01SS CR/LF.

Error Conditions

When an HP 2804A error condition occurs, the instrument will transmit a reading of 999, CR/LF which for most controllers is accepted as 999. The burden is therefore on the user to detect this out-of-range reading and perform a status read (SEC address 01) to determine the error condition and take corrective action.

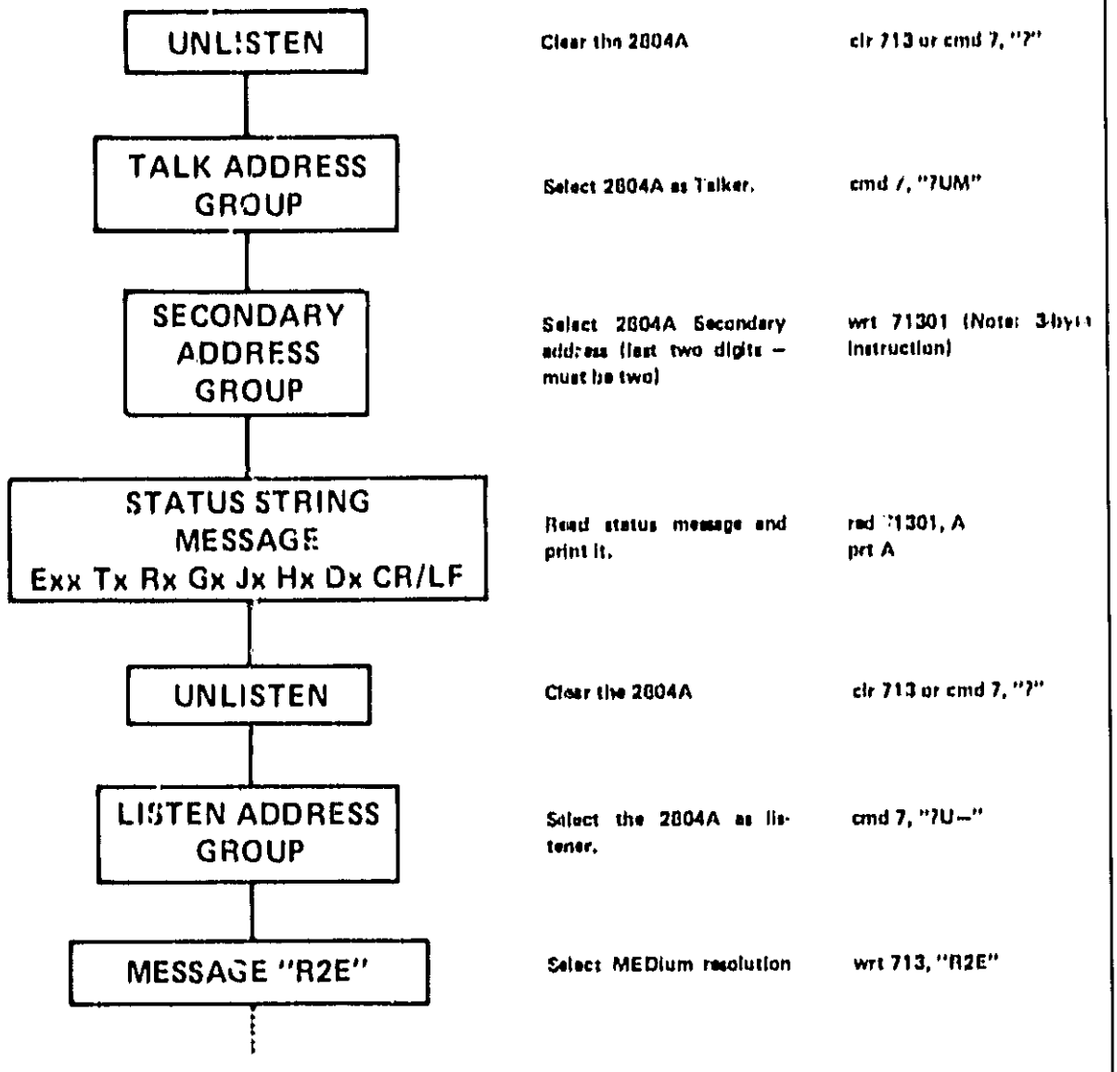
3-69. The HP 2804A, HP-IB option has two modes of operation:

a. Controlled device.

b. Talk Always device.

3-70. The Talk Always (TA) mode is selected by the HP-IB Address Switch (A7S1-1). In its "1" position, the HP 2804A assumes that no controller is on the bus and tries to transfer data after each measurement. The TA mode is designed for outputting to a digital printer. Data format is the same as described in paragraph 3-60. The HP 2804A remains in local control so that mode and resolution are controlled from its front panel.

3-71. Operation of the HP 2804A. HP-IB is a function of the controller and the device-dependent message-set to which the HP 2804A responds. The sequence of messages on the HP-IB defines the operation of the HP 2804A. For example, the instrument operator may do a Status String Read from secondary address 01, and reprogram the HP 2804A for the next highest resolution. Message sequence on the HP-IB should then be:



Note: All above examples refer to the HP Model 9825A used as the controller. Refer to "Condensed Description of the Hewlett-Packard Interface Bus", HP Part No. 59401-90030, for more general information.

SECTION IV
PERFORMANCE TESTS

4-1. INTRODUCTION

4-2. Tests in this section verify the instrument's electrical performance. Table 1-1 lists the instrument specifications. These tests may be used as part of incoming inspection, and can be done without accessing the instrument's internal circuits. If the instrument fails to perform as indicated in this section, refer to the troubleshooting procedure in Section VIII.

4-3. EQUIPMENT REQUIRED

Test equipment required for the tests is listed in Table 1-3.

4-4. TEST RECORD

4-5. Results of tests may be recorded on the Test Record located at the end of this section. Results of these tests recorded during incoming inspection can be used for comparison in maintenance, troubleshooting or following repairs and/or adjustments.

4-6. CALIBRATION CYCLE

4-7. Factory calibration of the quartz probe/calibration module combination is recommended no more than once each year. A reference temperature adjustment must be made when the instrument is first received from the factory and then, within the last 30 days preceding the use of the instrument.

4-8. PERFORMANCE TESTS

4-9. The complexity and expense of performance testing 100% to the instrument's specifications as listed in Table 1-1 are such that "Operation Verification" tests are recommended. These tests are easily done and check at least 90% of the instrument capabilities. Also these tests can be used as incoming inspection tests or tests to be made following repair.

4-10. OPERATION VERIFICATION

4-11. Operation Verification consists of:

a. Operators Checks.

b. Error Message Tests.

c. Reference Temperature Adjustments.

d. Internal-External Clock Test.

e. Digital-to-Analog Test.

f. HP-IB Test.

4-12. To verify instrument operation without testing all of the specifications listed in Table 1-1, do the following:

NOTE

Instrument will not operate if INT-EXT Switch is in EXT and no 1 MHz input is applied to CLOCK connectors.

a. Do the Operator's Check in Section III, paragraph 3-16.

b. Do the following Error Message Tests. To do these tests, the instrument must be powered down before removing the calibration modules and powered up to test for the error message. Power up or down is done by pressing the LINE switch to ON or to STANDBY, respectively.

NOTE

"ERROR 1, 5, and 6" cannot be simulated. "PROBE 1 and 2" are quartz probe out-of-range conditions (temperature specifications exceeded) and should not be simulated.

1. Power-down the instrument and pull out channel T1 Calibration Module, then power-up the instrument. Display should be ERROR 2.

2. Power-down the instrument, reinstall the T1 Calibration Module and power-up the instrument. Disconnect the T1 quartz probe. Display should be ERROR 7.

3. Repeat steps 1 and 2 for T2 channel. Display should be ERROR 3 and ERROR 8 respectively.

4. Power-down the instrument and remove the Calibration Modules from T1 and T2 channels, then power-up the instrument. Display should be ERROR 4.

5. Power-down the instrument, reinstall the Calibration Module(s) and reconnect the quartz probe(s) then power-up the instrument (if only one channel is used, use channel T1). Temperature indication on the display will be the T1 channel quartz probe ambient temperature. Press MED RESOLUTION; display temperature resolution should increase to X.XXX°C and readings should change at a 1-second rate. Press HIGH RESOLUTION; display temperature should increase to X.XXXX°C and readings should change every 10 seconds.

6. Press T2 and repeat procedures of step 5.

7. If both channels are used, press T1-T2. Display will be temperature difference between T1 and T2 quartz probes, Resolution will change as in step 5.

c. Do the Reference Temperature Adjustment using information in section III, paragraph 3-25 and 3-27. Accuracy desired will determine the method of checking calibration to use.

d. To do the INT-EXT CLOCK Test, an external 1 MHz, at 1 VRMS/1KOhm must be connected to the instrument rear panel CLOCK connector. Ensure quartz probe and Calibration Module are installed in T1 channel.

Set INT-EXT Switch to EXT. Display should be ambient temperature of T1 channel quartz probe.

e. Do the Digital-To-Analog Test as follows:

1. With the instrument powered-up and operating normally, connect a voltmeter (set to its 10 volt range) to the HP 2804A rear panel ANALOG output (observe polarity).

2. Connect an oscilloscope to the ANALOG output (observe polarity).

3. Set the instrument front panel CAL-OP switch to the positions listed in the following table. Voltmeter reading should be as listed.

CAL-OP Switch	Voltmeter Reading
0V	0 Volts ± .004 Vdc.
5V	+ 5 Volts ± .012 Vdc.
10V	+10 Volts ± .008 Vdc.

No oscillations should be evident in each switch position.

4. Set CAL-OP to OP-NORMAL and set the digits selected switch to XXX. (uppermost position).

5. For the displayed temperature, the voltmeter reading will range from 0 to 10 volts (depending on temperature). Example temperatures and voltages are listed below:

Examples of analog output voltages for NORMAL and OFFSET Modes:

DISPLAYED TEMPERATURE [XXX] = SELECTED DIGITS	ANALOG Vdc OUT NORM MODE	ANALOG Vdc OUT OFFSET
+12[3.94]43°C	3.94	8.94
+123.9[443]°C	4.43	9.43
+123.[944]3°C	9.44	4.44
+123.[999]9°C	9.99	4.99
+124.[000]0°C	0.00	5.00
+124.0[100]°C	0.10	5.10
+ 0.[001]0°C	0.001	5.01
0.[000]0°C	0.00	5.00
- 0.[001]0°C	9.99	4.99
(No oscillations evident on oscilloscope)		

6. Repeat Step 5 with the CAL-OP switch set to OP-OFFSET. Voltmeter reading should be offset by +5 volts. Step 5 lists example temperatures and voltages.

f. Do the HP-IB Test as follows:

1. Power up the instrument.
2. Observe the HP-IB set address (factory set at "Addr 13") following automatic self-check.
3. Observe that the instrument passes self-check.
4. Read the status-string from Secondary Address 01. This performs both read and write operations. The controller should now have the status-string as defined in paragraph 3-68 which will verify HP-IB operation.
5. A sample program using an HP 9826A calculator is provided in the following Figures and Tables.

```
0: spc                                  40: prt "T1R1",Z
1: prt "******************"             41: fxd 3
2: prt "2804A HP-IB TEST"               42: wrt "2804","T1R2E"
3: prt "******************"             43: wait 2000
4: spc                                  44: red "2804",Z
5: prt "THIS PROGRAM"                   45: wait 1000
6: prt "TESTS THE 2804A"                46: prt "T1R2",Z
7: prt "WITH PROBE AND"                 47: fxd 4
8: prt "CALIB. MODULE IN"               48: wrt "2804","T1R3E"
9: prt "THE T1 POSITION"                49: wait 12000
10: prt "FIRST, THEN THE"               50: red "2804",Z
11: prt "T2 POSITION."                  51: wait 1000
12: spc                                 52: prt "T1R3",Z
13: prt "MAKE SURE THAT"                53: spc
14: prt "PROBE AND MODULE"              54: prt "SET 2804A TO"
15: prt "ARE IN THE T1"                 55: prt "STAND-BY. PLACE"
16: prt "POSITION."                     56: prt "PROBE AND MODULE"
17: prt "SET THE 2804A TO ON"           57: prt "IN T2 POSITION."
18: prt "AND NOTE THE"                  58: prt "WHEN DONE, SET"
19: prt "HP-IB ADDRESS."                59: prt "THE 2804A TO ON"
20: spc                                 60: prt "AND WAIT FOR"
21: prt "WAIT UNTIL TEM-"               61: prt "ERROR 2, THEN"
22: prt "PERATURE IS DIS-"              62: prt "PRESS 'CONTINUE'"
23: prt "PLAYED, THEN"                  63: spc
24: prt "PRESS 'CONTINUE'"              64: stp
25: stp                                 65: prt "ARE YOU SURE THE"
26: spc                                 66: prt "2804A IS ON?"
27: prt "HP-IB ADDRESS?";ent A          67: prt "PRESS 'CONTINUE'"
28: spc                                 68: spc
29: 700+A→A                             69: stp
30: dev "2804",A                        70: wrt "2804","D0G0H1J1E"
31: fxd 2                               71: wait 1000
32: wrt "2804","D0G0H1J1E"              72: wrt "2804","T2R1E"
33: wait 1000                           73: wait 500
34: wrt "2804","T1R1E"                  74: fxd 2
35: wait 500                            75: red "2804",Z
36: red "2804",Z                        76: wait 1000
37: wait 1000                           77: if Z>=999;gto 53
38: if Z>=999;gto 12                    78: gto 80
39: gto 40                              79: spc
```

Figure 4-1. 2804A, HP-IB Sample Program

```
80: prt "T2R1",Z              91: wait 1000
81: fxd 3                     92: prt "T2R3",Z
82: wrt "2804","T2R2E"        93: wrt "2804","D0G0H0J0E"
83: wait 2000                 94: wait 1000
84: red "2804",Z              95: lcl "2804"
85: wait 1000                 96: wait 1000
86: prt "T2R2",Z              97: spc
87: fxd 4                     98: prt "END OF TEST"
88: wrt "2804","T2R3E"        99: spc
89: wait 12000                100: end
90: red "2804",Z
```

Lines 0 thru 26	Print instructions to user. Printed on the 9826A printer.
Line 27	Allows user to enter the HP-IB address displayed at turn-on of the 2804A.
Lines 28 and 30	Converts the HP-IB address to a number understood by the 2804A. Assigns the label "2804" to the variable "A".
Line 31	Fixes the displayed number at two decimal places. Used only to make the printout "pretty".
Line 32	Sets up the 2804 for the desired measurement modes. See the description of the 2804A measurement commands.
Line 33	Allows a wait or delay of one second to allow the instrument to settle. This time delay can be changed to a shorter time, and should be tested to find the minimum time required.
Line 34	Selects the T1 input and LOW resolution.
Line 35	Provides a time delay to allow the measurement to be made. LOW resolution measurements are 0.1 second.
Line 36	The controller makes a reading from device "2804", and assigns it to variable "Z".
Line 37	Provides a delay of 1 second to permit the user to see the TALK annunciator.
Lines 38 and 39	Tests for an error condition. One such condition would be no probe connected to the T1 input channel.
Line 40	Prints the measurement result on the 9826A printer.
Lines 42 thru 46	Selects the T1 input and MEDium resolution. Waits for two seconds for measurement to be made. Medium resolution requires one second to make the measurement. Prints the result on the 9826A printer.
Lines 48 thru 62	Selects the T1 input and HIGH resolution. Waits 12 seconds for measurement to be made. High resolution mode requires 10 seconds to make the measurement. Prints the result on the 9826A printer.
Lines 63 thru 69	Instructions to user to permit changing the probe and calibration module to the T2 channel.
Lines 70 thru 92	Do the same things as for the T1 channel. The measurements are still LOW, MEDium, and HIGH.
Lines 93 thru 96	Places the 2804A in a different function (turns off some annunciators), and places the instrument in the local mode.

Figure 4-2. Explanation of 2804A Sample HP-IB Program

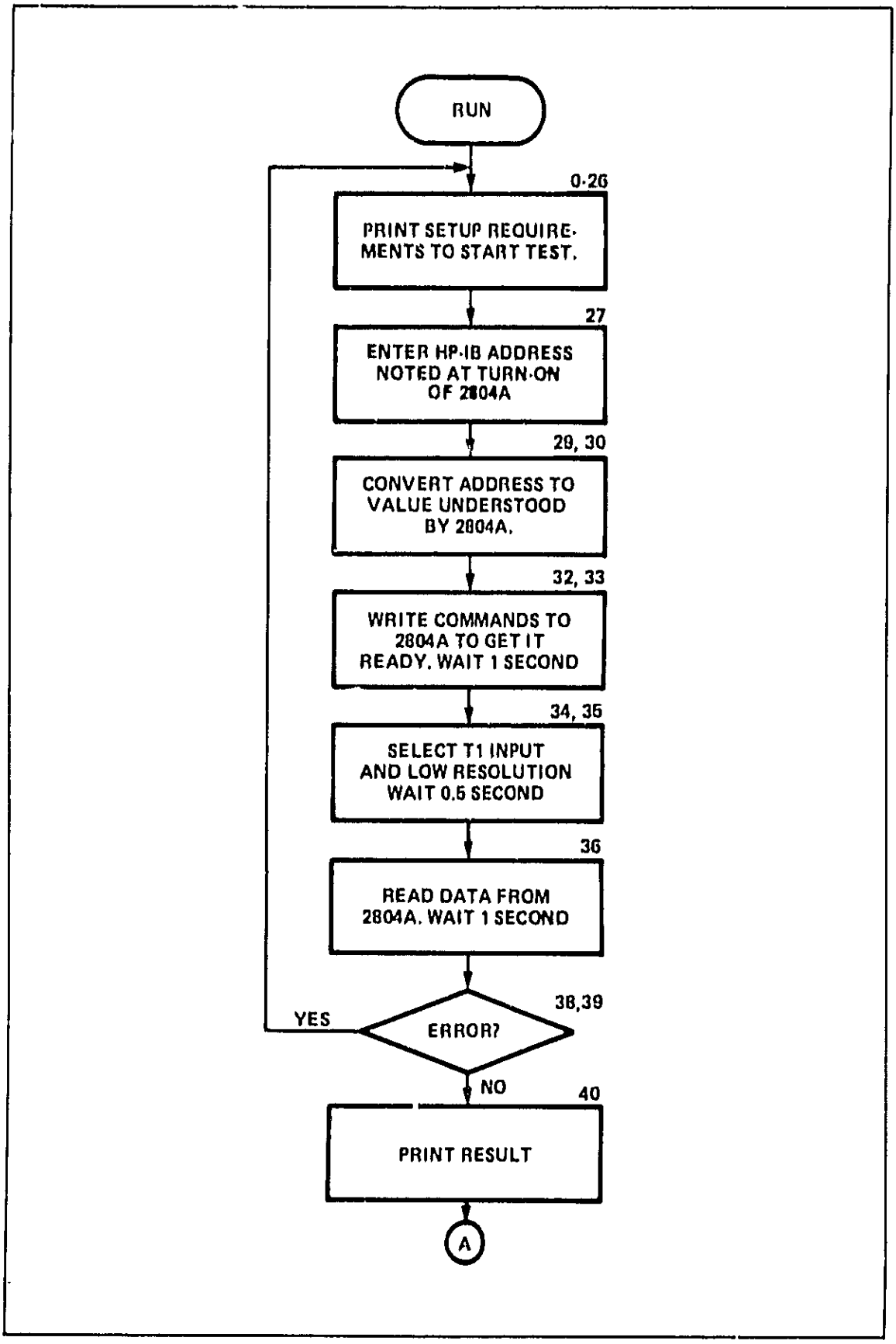


Figure 4-3
2804A HP-IB Sample Program Flow Chart

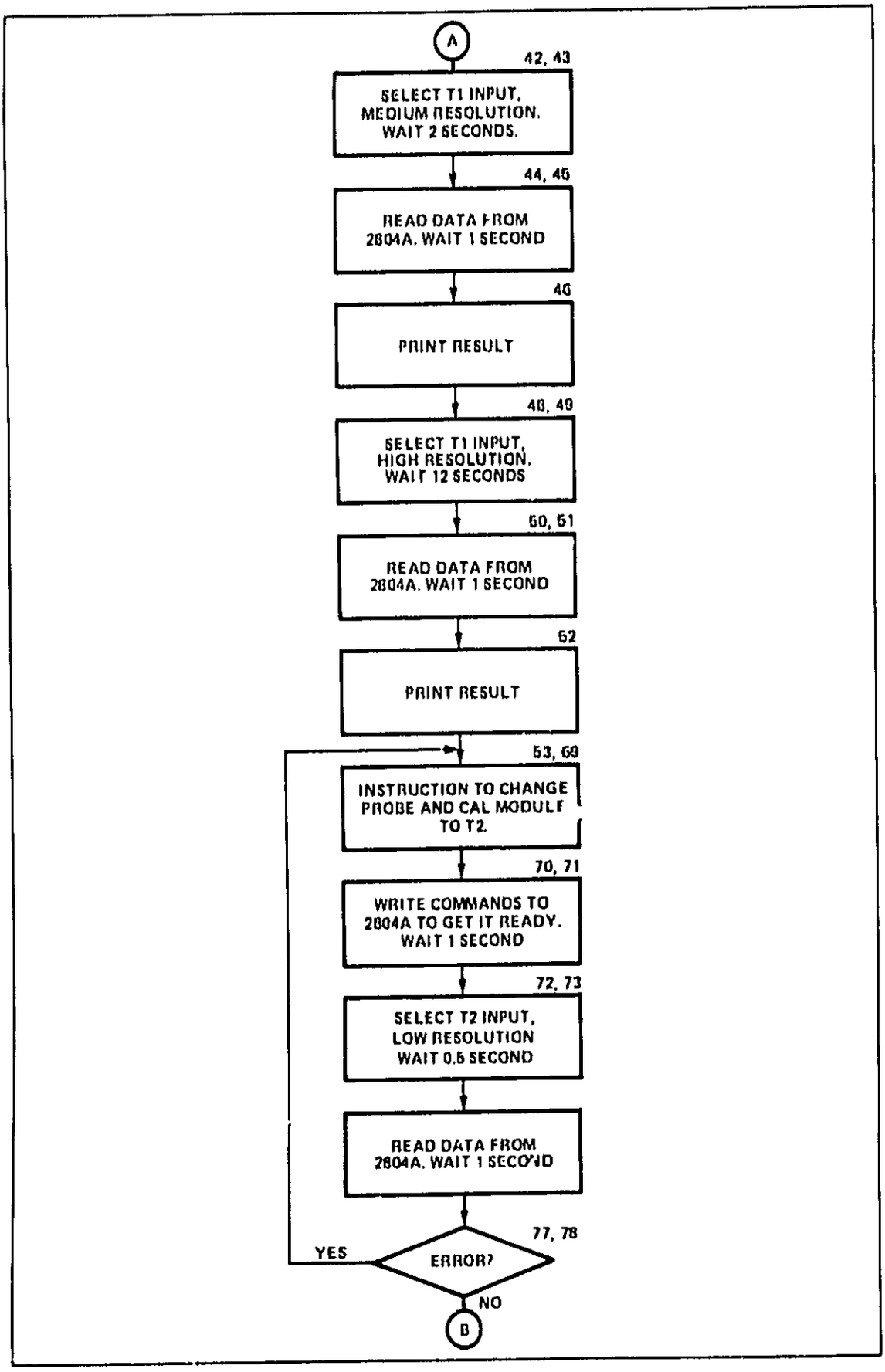


Figure 4-3. 2804A HP-IB Sample Program Flow Chart (Cont.)

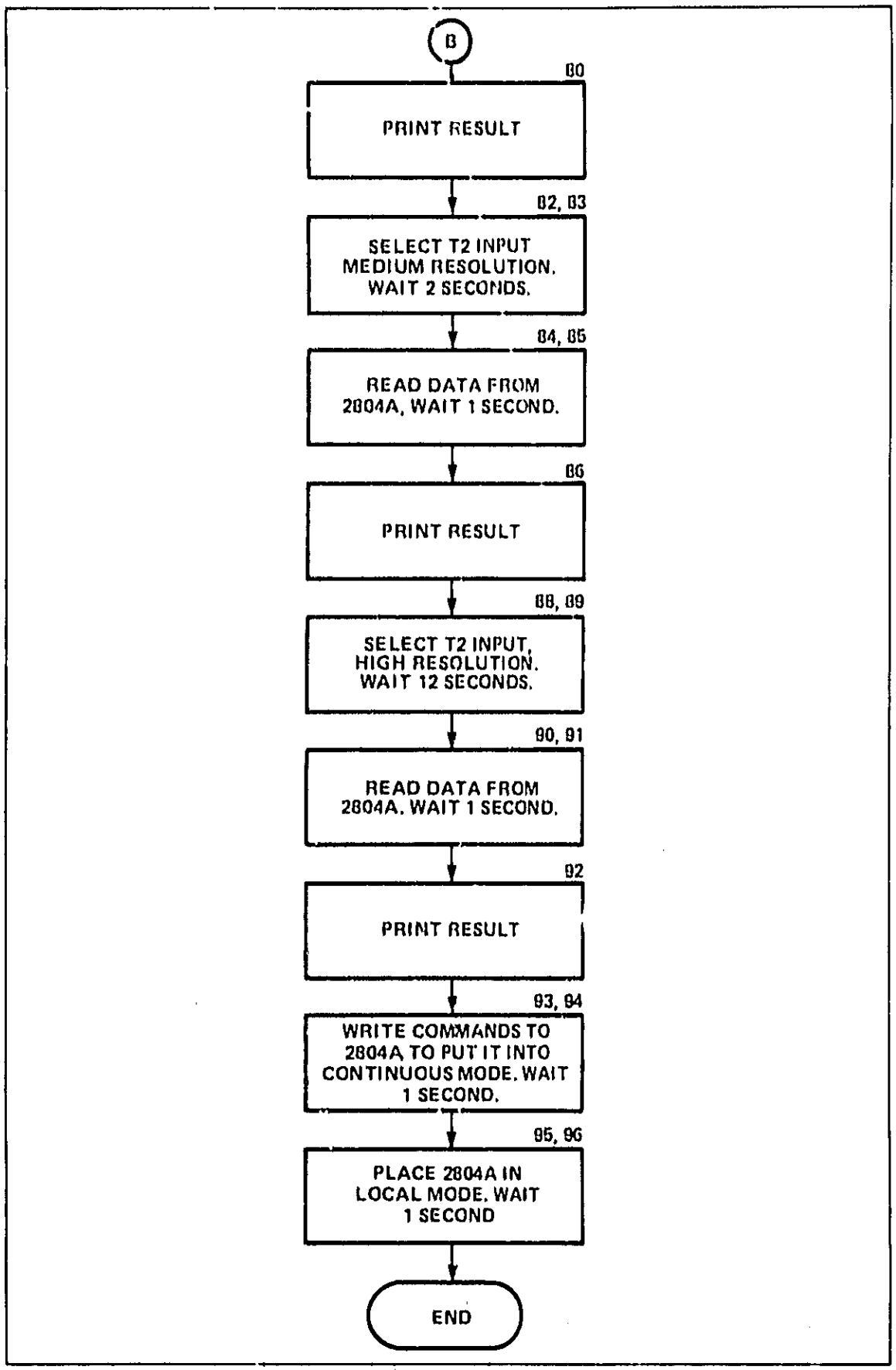


Figure 4-3. 2804A HP-IB Sample Program Flow Chart (Cont.)

Table 4-1. Sample HP-IB Operations with the 9825A Calculator

Message Name	Description	Sample Operations[1]
Data	Output text and variables to single devices	`wrt 701, "total=",A` `wrt "Printer",A,B,C`
	Output single characters	`wtb 701,H`
	Input data from a device Input single characters	`red 711,A$,B$` `rdb(711)→A`
	Specify device address and send data in the form of ASCII characters	`cmd 7, "?U-", "L10"` `cmd "dum", "L10"`
	Output data to multiple listeners	`wrt "dum,printer", "L10"` `cmd "?UK", "L10"`
	Transfer data from device to device.	`cmd "?K"`
Trigger	Send a Group Execute Trigger to all instruments	`trg 7`
	Send a GET to selected devices.	`trg 711`
Clear	Clear all devices	`clr 7`
	Clear selected device.	`clr 711`
Remote	Enable remote mode on all devices. Switching the calculator on also sends a Remote message.	`rem 7`
	Set remote mode on selected device.	`rem 711`
Local	Return selected device to local mode.	`lcl 722`
Local Lockout	Prevent all devices from returning to local mode.	`llo 7`
Clear Lockout/Set Local	Set local mode and disable local lockout on all devices. [illegible] also sends this message.	`lcl 7`
Pass Control	Transfer bus control to a selected device.	`pct 723`
Require Service Status Byte	Request Service from the controller and send an 8-bit status byte for response to a Serial Poll.	`rqs 7,105`
Status Bit	Bit and logic level for responses to a Parallel Poll.	`rqs 7,64`
Abort	Clear all bus operations and return control to the original system controller. [illegible] also sends an abort message.	`cli 7`

[1] In each case, a device name can be assigned and substituted for the select code parameter. See "The Device Statement"

SECTION V
ADJUSTMENTS

5-1. INTRODUCTION

5-2. This section contains complete field adjustment information for the Model 2804A Quartz Thermometer. The adjustments are presented in the recommended order for a complete instrument calibration.

5-3. SAFETY CONSIDERATIONS

5-4. This section contains warnings and cautions that must be followed for your protection and to avoid damage to the equipment. Whenever internal instrument circuits are exposed, caution must be exercised. 115 Vac is present at the rear panel, bottom side of the instrument. When using ac-operated test equipment, make sure that the test equipment chassis/case is connected to earth ground. With the instrument LINE switch in STAND-BY ac power is still applied to the instrument and some dc voltages are still present. To completely power-down the instrument, disconnect the ac power from the instrument.

WARNING

LINE SWITCH DOES NOT TURN OFF AC POWER AND SOME DC POWER CIRCUITS

5-5. EQUIPMENT REQUIRED

5-6. Test equipment needed for adjustments is listed in Table 1-3. Test equipment that satisfies the critical specifications given in Table 1-3 may be substituted.

5-7. INSTRUMENT ACCESS (SEE WARNING OF PARAGRAPH 5-4)

5-8. The instrument's internal circuits and assemblies are accessed by removing the top and bottom covers. Top and bottom covers are secured by one screw each at the rear edge of each cover.

CAUTION

When LINE switch is in STANDBY, ac power is still applied to the instrument and some dc voltages are still present. Disconnect ac power from the instrument before removing any assemblies.

5-9. ADJUSTMENT LOCATIONS

5-10. Adjustment locations are shown in Figure 5-4.

5-11. CALIBRATION CYCLE

5-12. An annual calibration is suggested for the quartz probe/calibration module combination. The HP 2804A can be calibrated annually. Test equipment required is listed in Table 1-3.

5-13. POWER SUPPLY CHECKS

5-14. Prior to making any internal adjustments, the power supply voltages should be checked as follows:

a. With the instrument in normal operation, use a dc voltmeter to measure the voltage at A8XA7 pins:

A8XA7 PIN NUMBER	DC VOLTS	MAXIMUM RIPPLE: AC VOLTS
1	+5 ± .25	6 mV
11	+5 ± .25	6 mV
21	≥ 17 (+15 to +20)	450 mV
10	-12 ± .6	6 mV
9	-5 ± .25	6 mV

b. Use an oscilloscope and check the ripple voltage at A8XA7 pins listed in step a. Values should be as listed in step a.

5-15. ADJUSTMENT PROCEDURES

5-16. The adjustment procedures are listed in the recommended order of performance. The A3, TCXO and A2 Sensor Oscillator adjustments normally should not require adjustments. The A6 DAC Output adjustment may occasionally need to be adjusted.

A. TEMPERATURE-COMPENSATED CRYSTAL OSCILLATOR (TCXO) ADJUSTMENT

NOTE

This adjustment need not be made as a periodic calibration step. The microprocessor on the A3 Assembly takes into account small differences in time base frequency from instrument to instrument, and compensation is made via the front panel thumbwheel switches. The TCXO should never need adjustment throughout the life of the instrument. Unless there is reason to believe the TCXO has been tampered with, it is not necessary to make this adjustment.

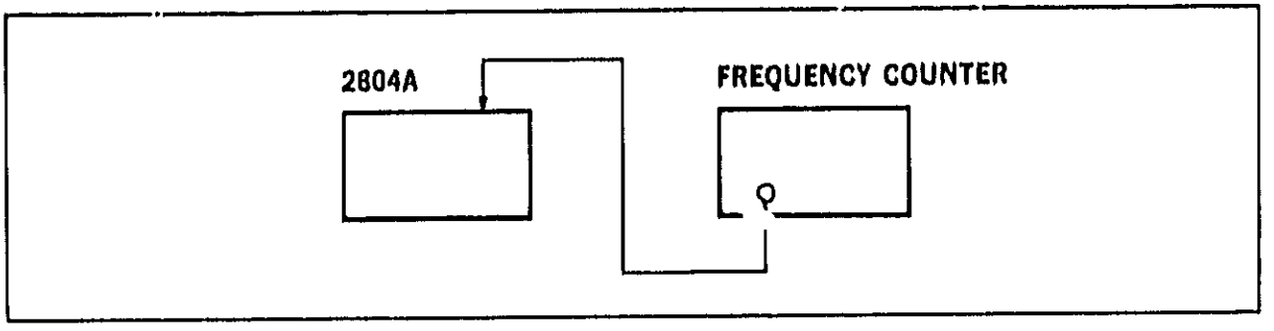


Figure 5-1. A3 TCXO Adjustment

Test Equipment Required:

Frequency Counter.

PC Board Affected:

A3

Setup Conditions:

2804A

TEMPERATURE T1
RESOLUTION ..... LOW

Frequency Counter

RESOLUTION ..... 0.1 Hz

Procedure:

1. Connect frequency counter to A3TP4 (HI) and chassis (LO).
2. Adjust trimmer on top of TCXO can for the frequency marked on the front of the can.

NOTE

The TCXO has a long-term stability of 1 part in 10^7 per month. The frequency counter used to adjust the TCXO must have a time base at least an order of magnitude better (or a "house standard").

3. Disconnect frequency counter. After this adjustment, it will be necessary to perform a reference temperature calibration as shown in Section III of this manual.

B. SENSOR OSCILLATOR ADJUSTMENT

NOTE

This adjustment need not be made as a periodic calibration step. The sensor oscillators should never have to be adjusted throughout the life of the instrument. If adjustment is required, the symptom will be that the sensor oscillator will not oscillate across the entire range of -80° to +250°C (-112°F to +482°F), but will be accurate across the portion that does work.

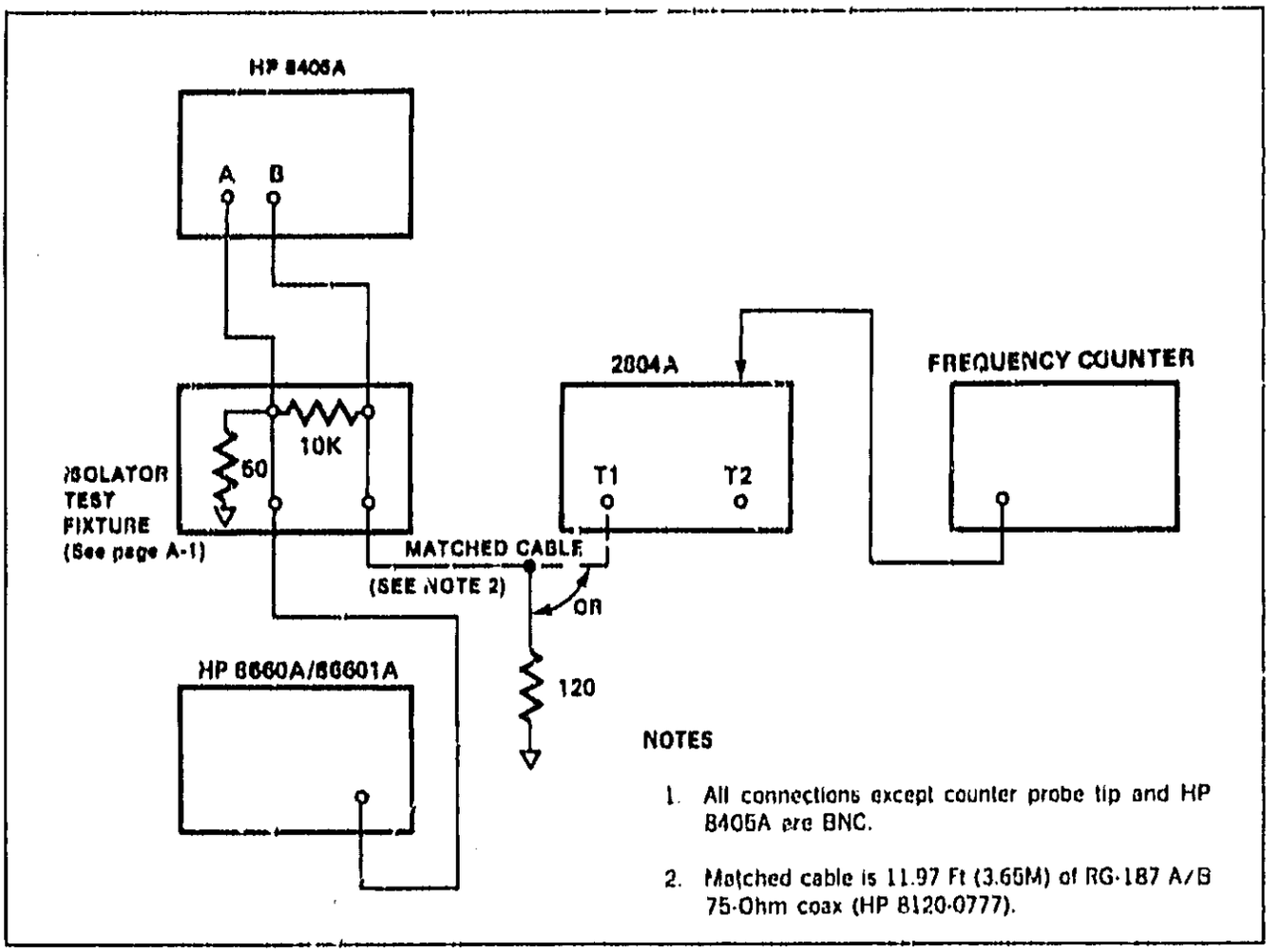


Figure 5-2. A2 Sensor Oscillator Adjustment

Test Equipment Required (with BNC connector at each end):

HP 8660A/86601A Synthesizer, HP 8405A Vector Voltmeter, frequency counter, extender board Isolator Test Fixture, 120 ohm resistor (on BNC connector), 1 M-ohm scope probe, matched cable.

PC Board Affected:

A2.

Setup Conditions:

2804A

TEMPERATURE T1
RESOLUTION ..... LOW

HP 8630A/86601A Synthesizer

FREQUENCY ..... 28.485 MHz
OUTPUT LEVEL ..... 100 mVrms

HP 8405A Vector Voltmeter

PHASE RANGE ..... 0°
CHANNEL ..... A
AMPLITUDE RANGE ..... 100 mV

Frequency counter — connect to A5U1 pin 6 with scope probe.

Procedure:

1. Set 8660A/86601A Synthesizer frequency to 28.485 MHz. Adjust 8405A Vector Voltmeter for 0° phase reference.

2. Remove 120 ohm resistor from matched cable. Connect matched cable to T1 connector on 2804A front panel.

3. Short A2TP1 and A2TP2 together. Adjust A2C4 for 0° phase.

4. Remove A2TP1 and A2TP2 short. Disconnect matched cable from T1 connector. Connect 120 ohm resistor to T1 connector. Adjust A2C11 for frequency of 28.485 ± .005 MHz.

5. Connect frequency counter to A5U1 pin 8. Disconnect 120 ohm resistor from T1 connector. Connect matched cable to T2 connector. Press T2 pushbutton.

6. Short A2TP3 and A2TP4 together. Adjust A2C16 for 0° phase.

7. Remove A2TP3 and A2TP4 short. Disconnect matched cable from T2 connector. Connect 120 ohm resistor to T2 connector. Adjust A2C22 for frequency of 28.485 ± .005 MHz.

C. DIGITAL-TO-ANALOG CONVERTER OUTPUT ADJUSTMENT

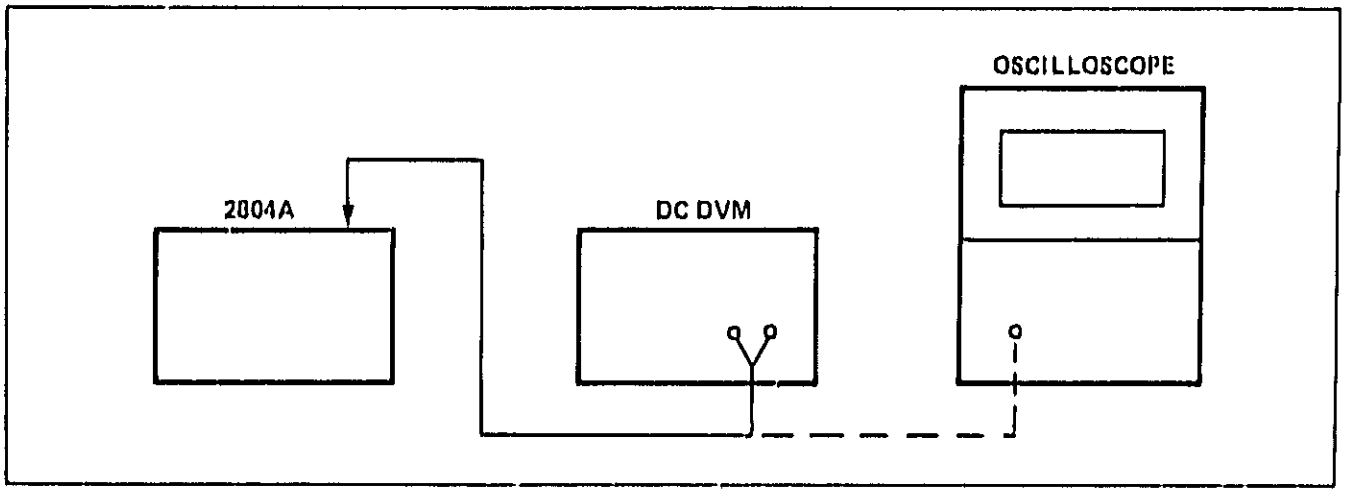


Figure 5-3. A6 DAC Output Adjustment.

Test Equipment Required:

DC DVM, oscilloscope

PC Board Affected:

A6.

Setup Conditions:

2804A

TEMPERATURE T1
RESOLUTION . . . . . LOW

DC DVM

RANGE . . . . . 10 Vdc

Connect DC DVM to rear panel ANALOG OUT jacks.

Procedure:

1. Set 2804A ANALOG OUTPUT switch to CAL 0V.
2. Adjust A6R8 for DC DVM reading of 0.000 ±.001 Vdc.
3. Set 2804A ANALOG OUTPUT switch to CAL 10V.
4. Adjust A6R5 for DC DVM reading of +10.000 ±.001 Vdc.
5. These two adjustments interact somewhat. Repeat steps 1 through 4.
6. Set 2804A ANALOG OUTPUT switch to CAL 5V.
7. Verify DC DVM reading of +5.000 ±.005 Vdc.
8. Disconnect DC DVM and connect oscilloscope in its place.
9. Verify that the dc voltage is clean and not oscillating.

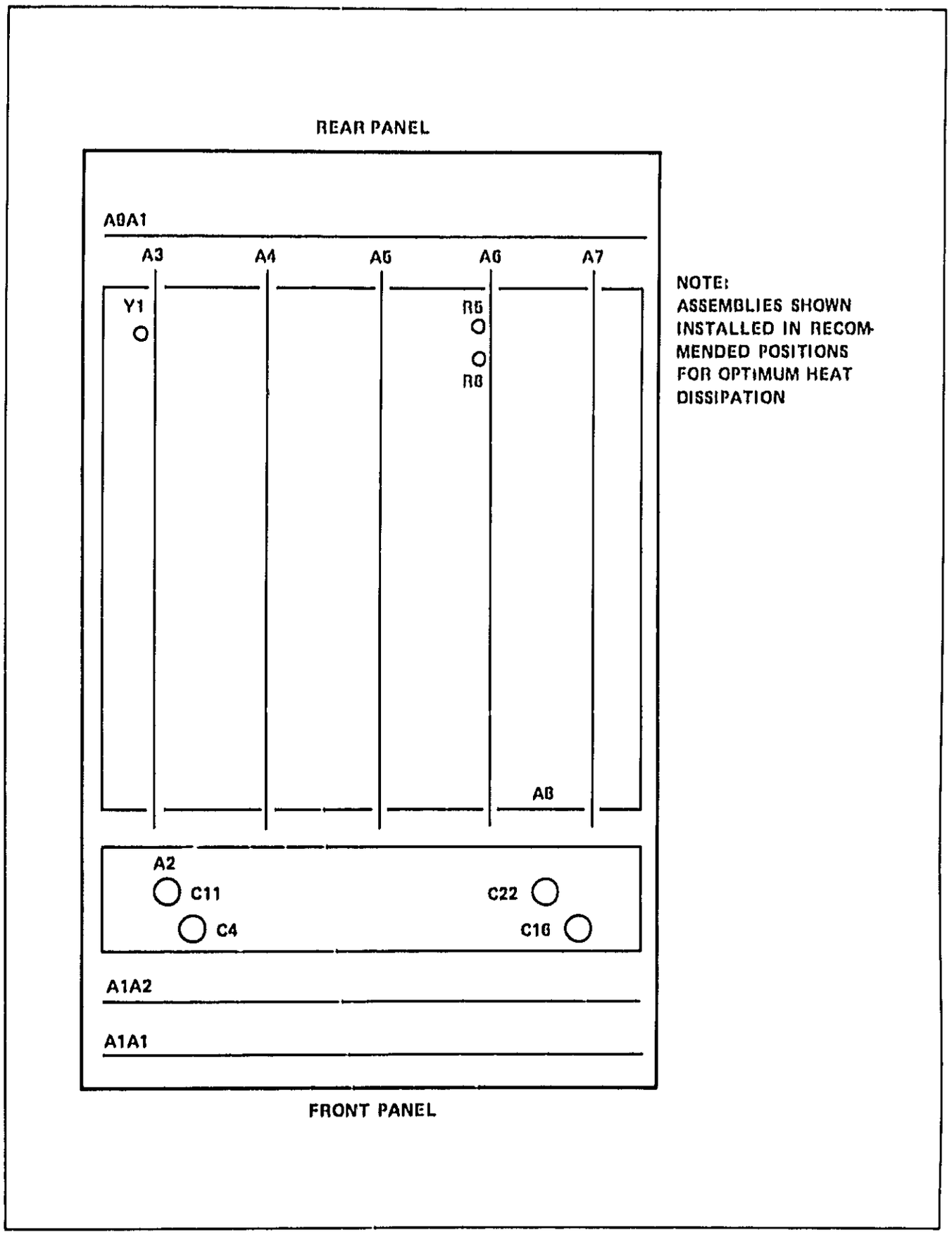


Figure 5-4. Adjustments Location

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION

6-2. This section contains information for ordering replacement parts. Table 6-1 lists abbreviations used and Table 6-2 is a list of replaceable parts in the 2804A. Tables 6-3 and 6-4, are lists of replaceable chassis parts. These parts are also listed in Table 6-2 as miscellaneous parts. Figures 6-1 and 6-2 are exploded views of the instrument. Table 6-5 is a manufacturers' code list.

6-3. ABBREVIATIONS

6-4. Table 6-1 lists abbreviations used throughout the manual.

6-5. REPLACEABLE PARTS LIST

6-6. Table 6-2 is the list of replaceable parts. Parts are listed in alphanumerical order. Included is the description, quantity (total used in the instrument), HP Part Number and manufacturers' part number. Chassis and mechanical parts are also listed in Table 6-3, 6-4 and Figures 6-1 and 6-2.

6-7. ORDERING INFORMATION

6-8. To order a listed part, quote the HP Part Number indicate the quantity needed and address the order to the nearest Hewlett-Packard Office. When ordering a non-listed part include the instrument model number, serial number and a description and function of the part. Address the order to the nearest Hewlett-Packard Office.

Table 6-1. Reference Designations and Abbreviations (1 of 2)

REFERENCE DESIGNATIONS

A	assembly
B	motor, synchro, fan
BP	binding post
BT	battery
C	capacitor
CB	circuit breaker
CR	diode
DL	delay line
DS	indicator, display
E	Misc electrical parts
F	fuse
FL	filter
J	receptacle connector, jack
JU	jumper
K	relay
L	inductor
M	meter
OE	optical encoder
P	plug connector
Q	transistor
R	resistor
RT	thermistor
S	switch
T	transformer
TB	terminal board
TP	test point
U	integrated circuit, non repairable assembly
V	vacuum tube, photocell, etc
VR	voltage regulator
W	jumper wire, cable assembly
X	socket
Y	crystal
Z	tuned cavity, network

ABBREVIATIONS

A	amperes
AC	alternating current
ADD	address
ADJ	adjust, adjustment
AL	aluminum
AR	as required
ASM	algorithmic state machine
ASSY	assembly
B	base
BCD	binary coded decimal
BeCu	beryllium copper
BIN	binary
BLK	black
BLU	blue
BP	band pass
BRN	brown
BRS	brass
BTU	British thermal unit
C	collector
CATH	cathode
CCW	counterclockwise
CD PL	cadmium plate
CER	ceramic
CERMET	ceramic met film
CKTS	circuits
C FLM	carbon film
CLK	clock
CLR	clear
CMOS	complementary metal oxide semiconductor logic
COM	common
COML	commercial
COMP	composition
COMPL	complete
COND	conductor
CONN	connector
CONT	contact
CPRSN	compression
CTL	complementary transistor logic
CW	clockwise
D	diameter
DC	direct current
DEPC	deposited carbon
DIA	diameter
DIP	dual in line package
DPDT	double pole, double throw
DPST	double pole, single throw
DR	drive
DRVR	driver
DSPL	display
DTL	diode transistor logic
E	emitter
ECL	emitter coupled logic
ELECT	electrolytic
ENCAP	encapsulated
EXT	external
EXTR	extractor
F	female, farads
FF	flip flop
FLM	film
FRNT	front
FXD	fixed
G	giga (10^9);
GE	germanium
GL	glass
GND	grounded
GP	General Purpose
GRA	gray
GRN	green
H	henries
HDW	hardware
HEX	hexagon, hexagonal, six
HP	high pass
HR	hour(s)
HZ	Hertz
IC	integrated circuit
ID	inside diameter
IF	intermediate frequency
IN	inch, inches
INCAND	incandescent
INCL	include(s)
INSUL	insulation, insulated
INT	internal
INTL	internal
K	kilo (10^3), kilohm
LED	light emitting diode
LFT	left
LG	long
LH	left hand
LKWR	lockwasher
LP	low pass
LS	low power Schottky
LSB	least significant bit
M	milli (10^{-3}), male, mega (10^6), megohm
MET FLM	metal film
MET OX	metal oxide
MHZ	megahertz
MFR	manufacturer
MINTR	miniature
MISC	miscellaneous
MOM	momentary
MOS	metal oxide semiconductor
MSB	most significant bit
MTCHD	matched
MTG	mounting
MTLC	metallic
N	nano (10^{-9})
NC	normally closed, no connection
NE	near
NO	number
NO	normally open
NP	No Polarity
NPN	negative positive negative
NPO	negative positive zero (zero temperature coefficient)
NRFR	not recommended for field replacement
NS	normally shorting, nanosecond
NSR	not separately replaceable
NYL	nylon
OBD	order by description
OD	outside diameter
ORN	orange

Table 6-1. Reference Designations and Abbreviations (2 of 2)

ABBREVIATIONS

P	pico (10^{-12})	
PC	printed circuit	
PCA	printed circuit assembly	
PF	picofarad	
PIV	Peak Inverse Voltage	
PK	peak	
PNL	panel	
PNP	positive-negative-positive	
P-P	peak-to-peak	
PPM	parts per million	
POLYC	polycarbonate	
POLYE	polyethylene	
POLYSTY	polystyrene	
PORC	porcelain	
POSN	position(s)	
POZI	pozidrive	
PRV	peak reverse voltage	
PWV	peak working voltage	
P/O	part of	
R	ring	
RAM	random access memory	
ROM	read only memory	
RECT	rectifier	
RF	radio frequency	
RH	right hand	
RMS	root-mean-square	
RND	round	
RT	right hand	
RTL	resistor-transistor logic	
RTNT	retainer	
RTRY	rotary	
RVT	rivet	
RWV	reverse working voltage	
S	second	
SB	slow blow	
SCR	silicon controlled rectifier	
SE	selenium	
SGL	single	
SI	silicon	
SHK	shank	
SIP	single in line package	
SKT	socket	
SLDR	solder	
SPCG	spacing	
SPDT	single pole, double throw	
SPST	single pole, single throw	
SST	stainless steel	
STL	steel	
SZ	size	
T	tip	
TA	tantalum	
TEL	telephone	
TC	Temp Compensated, temp coefficient	
THKNS	thickness	
TI	titanium	
TGL	toggle	
THD	thread	
THK	thick	
TOL	tolerance	
TRMR	trimmer	
TRN	turn	
TTL	transistor transistor logic	
TYP	typical	
U (µ)	micro (10^{-6})	
UF	microfarad	
US	microseconds	
V	volt(s)	
VAR	variable	
VCO	voltage controlled oscillator	
VDCW	direct current working volts	
VIO	violet	
VNP	no polarity voltage	
W	watts	
WT	weight	
WW	wirewound	
WHT	white	
WIP	wiper	
WIV	working inverse voltage	
WSHR	washer	
X	times, multiple	
YEL	yellow	
ZNR	zener	
Ø	phi, phase	

Table 6-2. HP2804A Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
01	02804-60010	0	1	DISPLAY SWITCH ASSEMBLY (SERIES 1744)	28480	02804-60010
A1C1	0160-0174	3	12	CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A1C2	0160-3461	1	10	CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3461
A1C3	0160-0174	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A1C4	0160-3461	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3461
A1C5	0160-3461	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3461
A1C6	0160-2204	0	2	CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204
A1C7	0160-0576	6	11	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576
A1C8	0160-3461	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3461
A1C9	0160-0576	6		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576
A1C10	0160-3461	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3461
A1DS1	1990-0592	5	8	DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7653
A1DS2	1990-0592	5		DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7653
A1DS3	1990-0592	5		DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7653
A1DS4	1990-0592	5		DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7653
A1DS5	1990-0592	5		DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7653
A1DS6	1990-0592	5		DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7653
A1DS7	1990-0592	5		DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7653
A1DS8	1990-0592	5		DISPLAY-NUM-SEG 1-CHAR .43-H	28480	5082-7653
A1DS9	1990-0547	0	11	LED-LAMP LUM-INT=6.4MCD IF=30MA-MAX	28480	5082-4684,SEL IV
A1DS10	1990-0547	0		LED-LAMP LUM-INT=6.4MCD IF=30MA-MAX	28480	5082-4684,SEL IV
A1DS11	1990-0547	0		LED-LAMP LUM-INT=6.4MCD IF=30MA-MAX	28480	5082-4684,SEL IV
A1DS12	1990-0547	0		LED-LAMP LUM-INT=6.4MCD IF=30MA-MAX	28480	5082-4684,SEL IV
A1DS13	1990-0547	0		LED-LAMP LUM-INT=6.4MCD IF=30MA-MAX	28480	5082-4684,SEL IV
A1DS14	1990-0547	0		LED-LAMP LUM-INT=6.4MCD IF=30MA-MAX	28480	5082-4684,SEL IV
A1DS15	1990-0547	0		LED-LAMP LUM-INT=6.4MCD IF=30MA-MAX	28480	5082-4684,SEL IV
A1DS16	1990-0547	0		LED-LAMP LUM-INT=6.4MCD IF=30MA-MAX	28480	5082-4684,SEL IV
A1DS17	1990-0547	0		LED-LAMP LUM-INT=6.4MCD IF=30MA-MAX	28480	5082-4684,SEL IV
A1DS18	1990-0547	0		LED-LAMP LUM-INT=6.4MCD IF=30MA-MAX	28480	5082-4684,SEL IV
A1DS19	1990-0547	0		LED-LAMP LUM-INT=6.4MCD IF=30MA-MAX	28480	5082-4684,SEL IV
A1J1	1251-3025	9	3	CONN-POST TYPE .100-PIN-SPCG 34-CONT	28480	1251-3025
A1R1	1810-0065	5	2	NETWORK-RES 8-SIP 10.0K OHM X 8	28480	1810-0065
A1R2	1810-0151	2	6	NETWORK-RES 7-SIP 10.0K OHM X 6	01697	CSP07C07-103J
A1R3	0757-0442	9	5	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A1R4	0698-3162	0	1	RESISTOR 46.4K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4642-F
A1R5	0698-0084	9	9	RESISTOR 2.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2161-F
A1R6	0698-0084	9		RESISTOR 2.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2161-F
A1R7	0698-0084	9		RESISTOR 2.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2161-F
A1R8	0698-0084	9		RESISTOR 2.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2161-F
A1R9	0698-0084	9		RESISTOR 2.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2161-F
A1R10	0698-0084	9		RESISTOR 2.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2161-F
A1R11	0698-0084	9		RESISTOR 2.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2161-F
A1R12	0698-0084	9		RESISTOR 2.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2161-F
A1R13	0757-0160	2	8	RESISTOR 31.6 1% .125W F TC=0+-100	28480	0757-0160
A1R14	0757-0160	2		RESISTOR 31.6 1% .125W F TC=0+-100	28480	0757-0160
A1R15	0757-0160	2		RESISTOR 31.6 1% .125W F TC=0+-100	28480	0757-0160
A1R16	0757-0160	2		RESISTOR 31.6 1% .125W F TC=0+-100	28480	0757-0160
A1R17	0757-0160	2		RESISTOR 31.6 1% .125W F TC=0+-100	28480	0757-0160
A1R18	0757-0160	2		RESISTOR 31.6 1% .125W F TC=0+-100	28480	0757-0160
A1R19	0757-0160	2		RESISTOR 31.6 1% .125W F TC=0+-100	28480	0757-0160
A1R20	0757-0160	2		RESISTOR 31.6 1% .125W F TC=0+-100	28480	0757-0160
A1S1	5060-9436	7	6	PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
	5041-0128	6	6	KEY-HALF LITED	28480	5041-0128
A1S2	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
	5041-0128	6		KEY-HALF LITED	28480	5041-0128
A1S3	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
	5041-0128	6		KEY-HALF LITED	28480	5041-0128
A1S4	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
	5041-0128	6		KEY-HALF LITED	28480	5041-0128
A1S5	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
	5041-0128	6		KEY-HALF LITED	28480	5041-0128
A1S6	5060-9436	7		PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436

See introduction to this section for ordering information
*Indicates factory selected value
†Backdating information in Section VII

Table 6-2. HP2804A Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1P1	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A1P2	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A1P3	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A1P4	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A1P5	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A1U1	1820-1670	3	2	IC DRVR TTL DSPL LED HEX	27014	DS75492N
A1U2	1820-1670	3		IC DRVR TTL DSPL LED HEX	27014	DS75492N
A1U3	1858-0014	6	2	TRANSISTOR ARRAY 14-PIN PLSTC DIP	28480	1858-0014
A1U4	1858-0014	6		TRANSISTOR ARRAY 14-PIN PLSTC DIP	28480	1858-0014
A1U5	1820-1423	4	2	IC MV TTL LS MONOSTBL RETRIG DUAL	01295	SN74LS123N
A1U6	1820-1195	8	4	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N
A1U7	1820-1195	7	4	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N
A1U8	1820-1195	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N
A1U9	1820-1195	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N
A1U10	1820-1216	3	2	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A1U11	1820-1640	7	2	IC DRVR TTL LS BUS HEX 1-INP	01295	SN74LS366AN
A1U12	1820-1640	7		IC DRVR TTL LS BUS HEX 1-INP	01295	SN74LS366AN
A1XDS1	1200-0638	7	8	SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0638
A1XDS2	1200-0638	7		SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0638
A1XDS3	1200-0638	7		SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0638
A1XDS4	1200-0638	7		SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0638
A1XDS5	1200-0638	7		SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0638
A1XDS6	1200-0638	7		SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0638
A1XDS7	1200-0638	7		SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0638
A1XDS8	1200-0638	7		SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0638
	0361-0028	8	8	RIVET-SEMITUB OVH .089 DIA .312 LG	00000	ORDER BY DESCRIPTION
	0380-0993	6	6	SPACER-RVT-ON .188-IN-LG .162-IN-ID	28480	0380-0993
	1600-1169	9	30	STAMPING-BE-CU CONNECTOR STRIP	28480	1600-1169
	4040-1095	4	6	STANDOFF-LED .107-IN-HD .107-IN-LG	28480	4040-1095
	02804-20200	6	4	GUIDE	28480	02804-20200
A2	02804-60021	3	1	OSCILLATOR/PRESET ASSEMBLY (SERIES 2437)	28480	02804-60021
A2C1	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A2C2	0160-3878	7	2	CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0161-3878
A2C3	0160-3878	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0161-3878
A2C4	0121-0402	4	4	CAPACITOR-V TRMR-CER 3-10PF 350V PC-MTG	73899	DV11PS10C
A2C5	0160-3167	4	2	CAPACITOR-FXD 12PF +-5% 500VDC CER	28480	0160-3167
A2C6	0160-4040	6	12	CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4040
A2C7	0160-4040	6		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4040
A2C8	0160-4040	6		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4040
A2C10	0160-4040	6		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4040
A2C11	0121-0402	4		CAPACITOR-V TRMR-CER 3-10PF 350V PC-MTG	73899	DV11PS10C
A2C12	0160-4382	9	2	CAPACITOR-FXD 3.3PF +-.25PF 200VDC CER	28480	0160-4382
A2C13	0160-4040	6		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4040
A2C14	0160-2097	8	2	CAPACITOR-FXD 8.2PF +-.5PF 1KVDC CER	28480	0160-2097
A2C15	0160-4040	6		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4040
A2C16	0121-0402	4		CAPACITOR-V TRMR-CER 3-10PF 350V PC-MTG	73899	DV11PS10C
A2C17	0160-3167	4		CAPACITOR-FXD 12PF +-5% 500VDC CER	28480	0160-3167
A2C18	0160-4040	6		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4040
A2C19	0160-4040	6		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4040
A2C20	0160-4040	6		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4040
A2C21	0160-2251	7	1	CAPACITOR-FXD 6.6PF +-.25PF 500VDC CER	28480	0160-2251
A2C22	0121-0402	4		CAPACITOR-V TRMR-CER 3-10PF 350V PC-MTG	73899	DV11PS10C
A2C23	0160-4382	9		CAPACITOR-FXD 3.3PF +-.25PF 200VDC CER	28480	0160-4382
A2C24	0160-4040	6		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4040
A2C25	0160-2097	8		CAPACITOR-FXD 8.2PF +-.5PF 1KVDC CER	28480	0160-2097
A2C26	0160-4040	6		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4040
A2C27	0160-4040	6		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4040
A2J1	1250-0257	1	8	CONNECTOR-RF SMB M PC 50-OHM	28480	1250-0257
A2J2	1250-0257	1		CONNECTOR-RF SMB M PC 50-OHM	28480	1250-0257
A2J3	1251-3026	J		CONN-POST TYPE .100-PIN-SPCG 34-CONT	28480	1251-3026
A2J4	1250-0524	6	2	CONNECTOR-RF BNC FEM SGL-HOLE-FR 50-OHM	28480	1250-0524
A2J5	1250-0524	6		CONNECTOR-RF BNC FEM SGL-HOLE-FR 50-OHM	28480	1250-0524

See introduction to this section for ordering information
*Indicates factory selected value
†Backdating information in Section VII

Table 6-2. HP2804A Replaceable Parts

Reference Designation	HP Part Number	CD	Qty	Description	Mfr Code	Mfr Part Number
A2L1	9100-2269	8	4	INDUCTOR RF-CH-MLD 1.8UH 10%	28480	9100-2269
A2L2	9140-0181	6	2	INDUCTOR RF-CH-MLD 22UH 5%	28480	9140-0181
A2L3	9100-2269	8		INDUCTOR RF-CH-MLD 1.8UH 10%	28480	9100-2269
A2L4	9140-0181	6		INDUCTOR RF-CH-MLD 22UH 5%	28480	9140-0181
A2Q1	1854-0073	0	4	TRANSISTOR NPN SI TO-72 PD=200MW	28480	1854-0073
A2Q2	1854-0073	0		TRANSISTOR NPN SI TO-72 PD=200MW	28480	1854-0073
A2Q3	1854-0073	0		TRANSISTOR NPN SI TO-72 PD=200MW	28480	1854-0073
A2Q4	1854-0073	0		TRANSISTOR NPN SI TO-72 PD=200MW	28480	1854-0073
A2R1	1810-0161	2		NETWORK-RES 7-SIP 10.0K OHM R 6	01637	CSP07C07-103J
A2R2	1810-0161	2		NETWORK-RES 7-SIP 10.0K OHM R 6	01637	CSP07C07-103J
A2R3	1810-0161	2		NETWORK-RES 7-SIP 10.0K OHM R 6	01637	CSP07C07-103J
A2R4	1810-0161	2		NETWORK-RES 7-SIP 10.0K OHM R 6	01637	CSP07C07-103J
A2R5	0757-0442	0		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R6	0683-1055	6	3	RESISTOR 1M 5% .25W CF TC=0-800	01121	CB1055
A2R7	0698-3136	8	2	RESISTOR 17.8K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1782-F
A2R8	0757-0444	1	4	RESISTOR 12.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1212-F
A2R9	0757-0394	0	2	RESISTOR 61.1 1% .125W F TC=0+-100	24546	C4-1/8-T0-61R1-F
A2R10	0757-0278	0	2	RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A2R11	0757-0443	0	2	RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1102-F
A2R12	0698-0083	8	3	RESISTOR 1.06K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1061-F
A2R13	0757-0444	1		RESISTOR 12.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1212-F
A2R14	0757-0199	3	3	RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A2R15	0683-1055	6		RESISTOR 1M 5% .25W CF TC=0-600	01121	CB1055
A2R16	0698-3136	8		RESISTOR 17.8K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1782-F
A2R17	0757-0444	1		RESISTOR 12.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1212-F
A2R18	0757-0394	0		RESISTOR 61.1 1% .125W F TC=0+-100	24546	C4-1/8-T0-61R1-F
A2R19	0757-0278	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A2R20	0757-0443	0		RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1102-F
A2R21	0698-0083	8		RESISTOR 1.06K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1061-F
A2R22	0757-0444	1		RESISTOR 12.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1212-F
A2R23	0757-0199	3		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A2S1	3100-1691	4	6	SWITCH-THUMBWHEEL 10 POS BINARY CODED	28480	3100-1691
A2S2	3100-1691	4		SWITCH-THUMBWHEEL 10 POS BINARY CODED	28480	3100-1691
A2S3	3100-1691	4		SWITCH-THUMBWHEEL 10 POS BINARY CODED	28480	3100-1691
A2S4	3100-1691	4		SWITCH-THUMBWHEEL 10 POS BINARY CODED	28480	3100-1691
A2S5	3100-1691	4		SWITCH-THUMBWHEEL 10 POS BINARY CODED	28480	3100-1691
A2S6	3100-1691	4		SWITCH-THUMBWHEEL 10 POS BINARY CODED	28480	3100-1691
A2S7	3101-2199	1	1	SWITCH-SL SPDT MINIR 6A 125VAC PC	28480	3101-2199
A2T1	9100-2269	8		INDUCTOR RF-CH-MLD 1.8UH 10%	28480	9100-2269
A2T2	9100-4032	9	2	TRANSFORMER 28 MHZ OSCILLATOR	28480	9100-4032
A2T3	9100-2269	8		INDUCTOR RF-CH-MLD 1.8UH 10%	28480	9100-2269
A2T4	9100-4032	9		TRANSFORMER 28 MHZ OSCILLATOR	28480	9100-4032
A2TP1	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A2TP2	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A2TP3	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A2TP4	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A2U1	1820-1206	1	4	IC GATE TTL LS NOR TPL 3-INP	01295	SN74LS27N
A2U2	1820-1238	9	4	IC MUXR/DATA-SEL TTL LS 4-TO-1-LINE DUAL	01295	SN74LS253N
A2U3	1820-1238	9		IC MUXR/DATA-SEL TTL LS 4-TO-1-LINE DUAL	01295	SN74LS253N
A2U4	1820-1238	9		IC MUXR/DATA-SEL TTL LS 4-TO-1-LINE DUAL	01295	SN74LS253N
A2U5	1820-1238	9		IC MUXR/DATA-SEL TTL LS 4-TO-1-LINE DUAL	01295	SN74LS253N
	0403-0265	5	6	GUIDE-PC BD BLK NYL .078-BD-THKNS 3-LG	32559	E-300
	0520-0134	5	8	SCREW-MACH 2-56 .562-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	0590-0105	8	8	NUT-HEX-PLSTC LKG 2-56-THD .141-IN-THK	00000	ORDER BY DESCRIPTION
	2200-0091	7	4	SCREW-MACH 4-40 .562-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2260-0009	2	8	NUT-HEX-W/LKWR 4-40 THD .094-IN-THK	00000	ORDER BY DESCRIPTION
	2950-0035	8	7	NUT-HEX-DBL-CHAM 15/32-32-THD	00000	ORDER BY DESCRIPTION
	3050-0105	6	4	WASHER-FL MTLC NO 4 .125-IN-ID	28480	3050-0105
	02804-00019	3	2	BRACKET-SWITCH	28480	02804-00019
A3	02804-60030	4	1	MICROPROCESSOR/TIME BASE ASSEMBLY (SERIES 1928)	28480	02804-60030

See introduction to this section for ordering information
*Indicates factory selected value
†Backdating information in Section VII

Table 6-2. HP2804A Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3C1	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A3C2	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A3C3	0140-0210	2	1	CAPACITOR-FXD 270PF +-5% 300VDC MICA	72136	DM15E271J0300WV1CR
A3C4	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A3C5	0160-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A3C6	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A3C7	0180-0197	8	2	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A3C8	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A3C9	0160-3060	8	2	CAPACITOR-FXD .1UF +-20% 25VDC CER	28480	0160-3060
A3C10	0160-3060	8		CAPACITOR-FXD .1UF +-20% 25VDC CER	28480	0160-3060
A3C11	0160-2307	4	2	CAPACITOR-FXD 47PF +-5% 300VDC MICA	28480	0160-2307
A3C12	0160-2307	4		CAPACITOR-FXD 47PF +-5% 300VDC MICA	28480	0160-2307
A3C13	0160-2204	0		CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204
A3C14	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A3C15	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A3C16	0160-3064	6	4	CAPACITOR-FXD .1UF +-10% 100VDC CER	28480	0160-3064
A3C17	0160-3064	6		CAPACITOR-FXD .1UF +-10% 100VDC CER	28480	0160-3064
A3C18	0160-3064	6		CAPACITOR-FXD .1UF +-10% 100VDC CER	28480	0160-3064
A3C19	0160-3064	6		CAPACITOR-FXD .1UF +-10% 100VDC CER	28480	0160-3064
A3CR1	1901-0535	9	2	DIODE-SM SIG SCHOTTKY	28480	1901-0535
A3CR2	1901-0535	9		DIODE-SM SIG SCHOTTKY	28480	1901-0535
A3J1	1250-0257	1		CONNECTOR-RF SMB M PC 50-OHM	28480	1250-0257
A3JU1	1261-4787	2	1	SHUNT-DIP 8 POSITION, DUAL INLINE PKG	28480	1261-4787
A3Q1	1853-0058	8	2	TRANSISTOR PNP SI PD=300MW FT=200MHZ	07263	S32248
A3Q2	1853-0058	8		TRANSISTOR PNP SI PD=300MW FT=200MHZ	07263	S32248
A3Q3	1854-0071	7	2	TRANSISTOR NPN SI TO-92 PD=300MW	27627	CP4071
A3Q4	1854-0071	7		TRANSISTOR NPN SI TO-92 PD=300MW	27627	CP4071
A3R1	0757-0280	3	1	RESISTOR 1K 1% .125W F TC=0+-100	24546	CT4-1/8-T0-1001-F
A3R2	0757-1004	9	6	RESISTOR 1.47K 1% .125W F TC=0+-100	24546	CT4-1/8-T0-1471-F
A3R3	0698-0084	0		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	CT4-1/8-T0-2151-F
A3R4	0698-0085	0	6	RESISTOR 2.61K 1% .125W F TC=0+-100	24546	CT4-1/8-T0-2611-F
A3R5	0683-1055	6		RESISTOR 1M 5% .25W CF TC=0-600	01121	CB1055
A3R6	0698-0085	0		RESISTOR 2.61K 1% .125W F TC=0+-100	24546	CT4-1/8-T0-2611-F
A3R7	0698-0085	0		RESISTOR 2.61K 1% .125W F TC=0+-100	24546	CT4-1/8-T0-2611-F
A3R8	0757-0465	6	1	RESISTOR 100K 1% .125W F TC=0+-100	24546	CT4-1/8-T0-1003-F
A3R9	0698-0082	7	2	RESISTOR 464 1% .125W F TC=0+-100	24546	CT4-1/8-T0-4640-F
A3R10	0698-0082	7		RESISTOR 464 1% .125W F TC=0+-100	24546	CT4-1/8-T0-4640-F
A3R11	0698-3438	3	2	RESISTOR 147 1% .125W F TC=0+-100	24546	CT4-1/8-T0-147R-F
A3R12	0757-0378	1	2	RESISTOR 12.1 1% .125W F TC=0+-100	19701	5033R-1/8-T0-12R1-F
A3R13	0698-3438	3		RESISTOR 147 1% .125W F TC=0+-100	24546	CT4-1/8-T0-147R-F
A3R14	0757-0378	1		RESISTOR 12.1 1% .125W F TC=0+-100	19701	5033R-1/8-T0-12R1-F
A3R15	0698-3430	5	2	RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R16	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R17	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	CT4-1/8-T0-1951-F
A3R18	0698-0085	0		RESISTOR 2.61K 1% .125W F TC=0+-100	24546	CT4-1/8-T0-2611-F
A3R19	0698-0085	0		RESISTOR 2.61K 1% .125W F TC=0+-100	24546	CT4-1/8-T0-2611-F
A3R20	1810-0055	5		NETWORK-RES 9-SIP 10.0K OHM X B	28480	1810-0055
A3TP1	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-DSC-SZ	28480	1251-4707
A3TP2	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-DSC-SZ	28480	1251-4707
A3TP3	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-DSC-SZ	28480	1251-4707
A3TP4	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-DSC-SZ	28480	1251-4707
A3TP5	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-DSC-SZ	28480	1251-4707
A3TP6	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-DSC-SZ	28480	1251-4707
A3TP7	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-DSC-SZ	28480	1251-4707
A3TP8	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-DSC-SZ	28480	1251-4707
A3U1	1820-1199	1	2	IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A3U2	1820-1287	8	1	IC GFR TTL LS AND QUAD 2-INP	01295	SN74LS37N
A3U3	1820-1437	0	1	IC MV TTL LS MONOSTBL DUAL	01295	SN74LS221N
A3U4	1820-1482	7	3	IC GFR TTL LS INV HEX 1-INP	01295	SN74LS368AN
A3U5	1820-1691	1	2	IC CNTR TTL LS DECD DUAL 4-BIT	07263	74LS390PC
A3U6	1820-1112	6	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A3U7	1820-1480	3	1	IC MICPROC NMOS 8-BIT	04713	MC6800L
A3U8	1820-1018	2	8	IC DRVR TTL LS LINE OCTL	01295	SN74LS241N
A3U9	1820-1691	1		IC CNTR TTL LS DECD DUAL 4-BIT	07263	74LS390PC
A3U10	1820-1470	1	1	IC MUXR/DATA-SEL TTL LS 2-TO-1 LINE QUAD	01295	SN74LS157N

See Introduction to this section for ordering information
*Indicates factory selected value
†Backdating information in Section VII

Table 6-2. HP2804A Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3U11	1820-1018	2		IC DRVR TTL LS LINE OCTL	01295	SN74LS241N
A3U12	1820-1018	2		IC DRVR TTL LS LINE OCTL	01295	SN74LS241N
A3U13	1820-1018	2		IC DRVR TTL LS LINE OCTL	01295	SN74LS241N
A3XU1	1200-0473	8	1	SOCKET-IC 16-CONT DIP DIP-SLDR	28480	1200-0473
A3XU7	1200-0616	1	1	SOCKET-IC 40-CONT DIP SLDR	28480	1200-0616
A3Y1	0960-0318	0	1	CRYSTAL-OSCILLATOR 10.0 MHZ	28480	0960-0318
	1460-0116	8	10	PIN-GRV .062-IN-DIA .26-IN-LG STL	28480	1460-0116
	5040-6065	0	2	EXTRACTOR-RED	28480	5040-6065
A4	02804-60040	6	1	MEMORY ASSEMBLY (SERIES 1843)	28480	02804-60040
A4C1	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A4C2	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A4C3	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A4C4	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A4C5	0160-3451	1		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-3451
A4C6	0160-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A4R1	1810-0041	9	1	NETWORK-RES 9-SIP 2.7K OHM X 8	28480	1810-0041
A4TP2	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-DSC-SZ	28480	1251-4707
A4TP3	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-DSC-SZ	28480	1251-4707
A4TP4	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-DSC-SZ	28480	1251-4707
A4TP5	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-DSC-SZ	28480	1251-4707
A4TP6	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-DSC-SZ	28480	1251-4707
A4TP7	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-DSC-SZ	28480	1251-4707
A4U1	1820-1197	0	2	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A4U2	1820-1197	0		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A4U4	1818-0135	8	2	IC NMOS 1...4 (1K) STAT RAM 350-NS 3-S	04713	MCM6810L
A4U5	1820-1202	7	2	IC GATE TTL LS NAND TPL 3-INP	01295	SN74LS10N
A4U6	1820-1206	1		IC GATE TTL L NOR TPL 3-INP	01295	SN74LS27N
A4U7	1200-0616	0	1	SOCKET-IC 24-CONT DIP-SLDR	28480	1200-0616
A4U7	1818-0738	5	1	IC NMOS 32768 (32K) ROM 600-NS 3-S	04713	MCM68332P MASKED
A4U8	1818-0135	8		IC NMOS 1024 (1K) STAT RAM 350-NS 3-S	04713	MCM6810L
A4U9	1820-1200	5	3	IC INV TTL LS HEX	01295	SN74LS05N
A4U10	1820-1201	6	2	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N
A4U11	1820-1206	1		IC GATE TTL LS NOR TPL 3-INP	01295	SN74LS27N
A4U12	1820-1018	2		IC DRVR TTL LS LINE OCTL	01295	SN74LS241N
A4U13	1820-1018	2		IC DRVR TTL LS LINE OCTL	01295	SN74LS241N
	1460-0116	8		PIN-GRV .062-IN-DIA .26-IN-LG STL	28480	1460-0116
	5040-6066	1	2	EXTRACTOR PC	28480	5040-6066
A5	02804-60050	8	1	COUNTER ASSEMBLY (SERIES 2332)	28480	02804-60050
A5C1	0160-4557	0	7	CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
A5C2	0160-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
A5C3	0160-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
A5C4	0160-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
A5C5	0160-4822	7	8	CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A5C6	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A5C7	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A5C8	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A5C9	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A5C10	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A5C11	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A5C12	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A5C13	0160-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
A5C14	0160-0100	3	1	CAPACITOR-FXD 4.7UF+-10% 35VDC TA	56289	150D475X9035B2
A5C15	0160-4554	7	5	CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A5C16	0160-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A5C18	0160-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
A5C19	0160-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A5C21	0160-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
A5C22	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554

See Introduction to this section for ordering information
*Indicates factory selected value
†Backdating information in Section VII

Table 6-2. HP2804A Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A6C23	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A6C24	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A6C25	0160-4801	7	1	CAPACITOR-FXD 100PF +-5% 100VDC CER	28480	0160-4801
A6C26	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A6CR1	1901-0040	1	1	DIODE-SWITCHING 30V 50MA 2NS DO-35	04713	1N4148
A6J1	1250-0257	1		CONNECTOR-RF SMB M PC 50-OHM	28480	1250-0257
A6J2	1250-0257	1		CONNECTOR-RF SMB M PC 50-OHM	28480	1250-0257
A6J3	1250-0257	1		CONNECTOR-RF SMB M PC 50-OHM	28480	1250-0257
A6J4	1250-0257	1		CONNECTOR-RF SMB M PC 50-OHM	28480	1250-0257
A6L1	9100-1626	V	4	INDUCTOR RF-CH-MLD 330UH 5%	28480	9100-1626
A6L2	9100-1626	0		INDUCTOR RF-CH-MLD 330UH 5%	28480	9100-1626
A6L3	9100-1626	0		INDUCTOR RF-CH-MLD 330UH 5%	28480	9100-1626
A6L4	9100-1626	0		INDUCTOR RF-CH-MLD 330UH 5%	28480	9100-1626
A6R1	0698-3156	1	4	RESISTOR 4.64K 1% .125W F TC+0+-100	24546	C14-1/8-T0-4641-F
A6R2	0698-3156	1		RESISTOR 4.64K 1% .125W F TC+0+-100	24546	C14-1/8-T0-4641-F
A6R3	0698-3156	1		RESISTOR 4.64K 1% .125W F TC+0+-100	24546	C14-1/8-T0-4641-F
A6R4	0698-3156	1		RESISTOR 4.64K 1% .125W F TC+0+-100	24546	C14-1/8-T0-4641-F
A6R5	0757-1094	9		RESISTOR 1.47K 1% .125W F TC+0+-100	24546	C14-1/8-T0-1471-F
A6R6	0757-1094	9		RESISTOR 1.47K 1% .125W F TC+0+-100	24546	C14-1/8-T0-1471-F
A6R7	0757-1094	9		RESISTOR 1.47K 1% .125W F TC+0+-100	24546	C14-1/8-T0-1471-F
A6R8	0757-1094	9		RESISTOR 1.47K 1% .125W F TC+0+-100	24546	C14-1/8-T0-1471-F
A6R9	0757-0442	9		RESISTOR 10K 1% .125W F TC+0+-100	24546	C14-1/8-T0-1002-F
A6R10	0757-0199	3		RESISTOR 21.5K 1% .125W F TC+0+-100	24546	C14-1/8-T0-2152-F
A6R11	1810-0135	2	1	NETWORK-RES 8-SIP 10.0K OHM X 5	28480	1810-0135
A6T1	9100-4060	1	4	TRANSFORMER-RF; 28 MHZ INTERFACE	28480	9100-4060
A6T2	9100-4060	1		TRANSFORMER-RF; 28 MHZ INTERFACE	28480	9100-4060
A6T3	9100-4060	1		TRANSFORMER-RF; 28 MHZ INTERFACE	28480	9100-4060
A6T4	9100-4060	1		TRANSFORMER-RF; 28 MHZ INTERFACE	28480	9100-4060
A6TP1	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A6TP2	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A6TP3	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A6TP4	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A6U1	1820-1307	3	1	IC SCHMITT-TRIG TTL S NAND QUAD 2-INP	01295	SN74S132N
A6U2	1826-0276	4	3	IC 74LS27A V RGLTR 10-92	04713	MC74LS27ACP
A6U3	1820-1105	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N
A6U4	1820-1310	7	1	IC MUXR/DATA-SEL TTL S W-TO-1-LINE W-INP	01295	SN74S151N
A6U5	1820-1261	6	1	IC CNTR TTL LS DECD ASYNCHRO	01295	SN74LS196N
A6U6	1820-2316	6	1	IC CNTR TTL DECD HEX	28480	1002-4
A6U7	1820-1423	4		IC INV TTL LS MONOSTBL RETRIG DUAL	01295	SN74LS123N
A6U8	1820-1112	U		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A6U9	1820-1281	2	2	IC DCDR TTL LS 2-TO-4-LINE DUAL	01295	SN74LS139AN
A6U10	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A6U11	1820-1018	7		IC DRVR TTL LS LINE OCTL	01295	SN74LS241N
A6U12	1820-1274	3	1	IC GATE TTL LS NAND DUAL 4-INP	01295	SN74LS22N
A6AU1	1200-0483	9	1	SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0483
	1480-0116	8		PIN-GRV .062 IN-DIA .26-IN-LG STL	28480	1480-0116
	5040-6067	7	2	EXTRACTOR PC	28480	5040-6067
A6	02804-60060	0	1	DIGITAL TO ANALOG ASSEMBLY (SERIES 1744)	28480	02804-60060
A6C1	0121-0676	6		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576
A6C2	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A6C3	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A6C4	0180-0291	3	4	CAPACITOR-FXD 10UF+-10% 35VDC TA	56289	150D106X0035A2
A6C5	0160-0174	9	1	CAPACITOR-FXD .47UF +80-20% 50VDC CER	28480	0160-0174
A6C6	0160-0576	6		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576
A6C7	0160-2264	2	1	CAPACITOR-FXD 200PF +-5% 500VDC CER 0+-30	28480	0160-2264
A6J2	1250-0257	1		CONNECTOR-RF SMB M PC 50-OHM	28480	1250-0257
A6R1	0757-0820	7	1	RESISTOR 1 K 1% .5W F TC+0+-100	28480	0757-0820
A6R2	0757-0401	0	2	RESISTOR 100 1% .125W F TC+0+ 100	24546	C14-1/8-T0-101-F
A6R3	0757-0401	0		RESISTOR 100 1% .125W F TC+0+ 100	24546	C14-1/8-T0-101-F
A6R4	0757-0438	3	3	RESISTOR 5.11K 1% .125W F TC+0+ 100	24546	C14-1/8-T0-5111-F
A6R5	2100-3122	9	1	RESISTOR TRMR 100 10% C SIDE-ADJ 17-TRN	73138	66PR100

See introduction to this section for ordering information
*Indicates factory selected value
†Backdating information in Section VII

Table 6-2 HP2804A Replaceable Parts

Reference Designation	HP Part Number	CD	Qty	Description	Mfr Code	Mfr Part Number
A6R6	0683-1065	7	1	RESISTOR 10M 5% .25W CC TC=-900/+1100	01121	CB1065
A6R7	0683-3365	0	1	RESISTOR 3.3M 5% .25W CC TC=-900/+1100	01121	CB3355
A6R8	2100-3034	6	1	RESISTOR-TRMR 50K 10% C SIDE-ADJ 17-TRN	73138	90PR50K
A6TP1	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A6U1	1820-0477	1	1	IC GP AND GP 8-DIP-P PKG	50565	UPC301AC
A6U2	1826-0276	4		IC 78L12A V REGLTR TO-92	04713	MC78L12ACP
A6U3	1820-1064	2	1	D/A 10-BIT 16 CERZ/SOR GRLF	24355	AD561AD
A6U4	1820-1196	6		IC FF TTL LS D-TYPE POS EDGE TRIG CON	01295	SN74LS174N
A6U5	1820-1218	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A6U6	1820-1196	4		IC FF TTL LS D-TYPE POS EDGE TRIG CON	01295	SN74LS174N
A6U7	1820-1201	6		IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N
A6U8	1820-1196	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG CON	01295	SN74LS174N
A6XU3	1200-0482	9	1	SOCKET-IC 16-CONT DIP-SLDR	28480	1200-0482
	1460-0116	8		PIN GRV .062-IN-DIA .26-IN LG STL	28480	1460-0116
	6040-6008	3	1	EXTRACTOR PC	28480	6040-6008
	1251-4707	6	45	CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A7	02804-60070	7	1	MP IO ASSEMBLY (SERIES 2870)	28480	02804-60070
A7C1	0180-0291	2		CAPACITOR-FXD 10UF+-10% 25VDC TA	56289	150D106X0025A2
A7C2	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576
A7C3	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576
A7C4	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576
A7C5	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576
A7C6	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576
A7C7	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576
A7C8	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576
A7C9	0160-3448	6	2	CAPACITOR-FXD 1000PF +-10% 1KVDC CER	28480	0160-3448
A7J2	1251-4058	0	1	CONNECTOR 26-PIN M RECTANGULAR	28480	1251-4058
A7R1	1810-0161	2		NETWORK-RES 7-SIP 10.0K OHM X 6	01697	CSP07C07-1003
A7R2	0698-3160	5	1	RESISTOR 26.1K 1% .125W F TC=0+-100	24546	CT4-1/8-T0-2612-F
A7R3	0698-3163	8	2	RESISTOR 3.83K 1% .125W F TC=0+-100	24546	CT4-1/8-T0-3831-F
A7R4	0698-3163	8		RESISTOR 3.83K 1% .125W F TC=0+-100	24546	CT4-1/8-T0-3831-F
A7R5	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	CT4-1/8-T0-1002-F
A7R6	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	CT4-1/8-T0-1002-F
A7S1	3101-1826	0	1	SWITCH-DIP DIP-PKG-ASSY 7-1A .1A 6VDC	28480	3101-1826
A7TP1	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A7TP2	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A7TP3	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A7TP4	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A7TP5	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A7TP6	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A7TP7	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A7U1	1820-2058	3	4	IC TRANSCEIVER TTL S INSTR-BUS IEEE-488	04713	MC3448AL
A7U2	1820-2058	3		IC TRANSCEIVER TTL S INSTR-BUS IEEE-488	04713	MC3448AL
A7U3	1TL1-0002	2	1	IC-ABI 68 PIN	28480	1TL1-0002
A7U4	1820-1402	7		IC BFR TTL LS INV HEX 1- INP	01295	SN74LS368AN
A7U5	1820-2058	3		IC TRANSCEIVER TTL S INSTR-BUS IEEE-488	04713	MC3448AL
A7U6	1820-2058	3		IC TRANSCEIVER TTL S INSTR-BUS IEEE-488	04713	MC3448AL
A7U7	1820-1018	2		IC DRVR TTL LS LINE OCTL	01295	SN74LS241N
A7U8	1826-0276	4		IC 78L12A V REGLTR TO-92	04713	MC78L12ACP
A7U9	1820-1018	2		IC DRVR TTL LS LINE OCTL	01295	SN74LS241N
A7U10	1820-1402	7		IC BFR TTL LS INV HEX 1-INP	01295	SN74LS368AN
A7U11	1820-1281	2		IC DCDR TTL LS 2-TO-4-LINE DUAL	01295	SN74LS139AN
A7U12	1820-1202	7		IC GATE TTL LS NAND TPL 3-INP	01295	SN74LS10N
A7U13	1820-1206	1		IC GATE TTL LS NOR TPL 3-INP	01295	SN74LS27N
A7XU3	1200-0982	4	1	ADAPTER BOARD 48-PIN	28480	1200-0982
	1460-0116	8		PIN-GRV .062-IN-DIA .26-IN LG STL	28480	1460-0116
	6040-6001	4	2	EXTRACTOR-PC	28480	6040-6001

See introduction to this section for ordering information
*Indicates factory selected value
†Backdating information in Section VII

Table 6-2. HP2804A Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A0	02804-60060	4	1	MOTHERBOARD ASSEMBLY (SERIES 1744)	28480	02804-60060
A0J1	1251-6044	7	2	CONNECTOR-PC EDGE 16-CONT/ROW 2-ROWS	28480	1251-6044
A0J2	1251-6044	7		CONNECTOR-PC EDGE 16-CONT/ROW 2 ROWS	28480	1251-6044
A0J3	1251-3025	9		CONN-POST TYPE .100-PIN-SPCG 34-CONT	28480	1251-3025
A0TP1	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A0TP2	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A0TP3	1251-4707	6		CONNECTOR-SGL CONT PIN .031-IN-BSC-SZ	28480	1251-4707
A0XA3	1251-1365	6	5	CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-1365
A0XA4	1251-1365	6		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-1365
A0XA5	1251-1365	6		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-1365
A0XA6	1251-1365	6		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-1365
A0XA7	1251-1365	6		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-1365
	0380-0328	1	2	STANDOFF-HEX .25-IN-LG 6-32-THD	28480	0380-0328
	1251-1115	4	6	POLARIZING KEY-PC EDGE CONN	28480	1251-1115
	2360-0193	2	2	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
A0	02804-60000	6	1	POWER SUPPLY ASSEMBLY (SERIES 2108)	28480	02804-60000
A0C1	0160-0261	3		CAPACITOR-FXD .1UF +-10% 250VDC TA	56289	1C0D106P0035A*
A0C2	0160-4065	5	1	CAPACITOR-FXD .1UF +-20% 250VAC(RMS)	28480	0160-4065
A0F1	2110-0302	1	1	FUSE .6A 250V TD 1.25X.25 UL	75915	312.600
A0LM1	0960-0443	1	1	LINE MODULE-FILTERED	28480	0960-0443
A0S1	3101-0555	0	1	SWITCH-PB DPDT ALTNG 4A 250 VAC	28480	3101-0555
A0S2	3101-0070	3	1	SWITCH-SL DPDT MINTR .5A 125VAC/DC	28480	3101-0070
A0T1	9100-4027	2	1	TRANSFORMER-POWER 100/120/220/240V	28480	9100-4027
A0U1	1826-0181	1	1	IC V RGLTR-FXD-POS 4.8/5.2V TO-3 PKG	27014	LM323K
A0W1	02804-60120	3	3	CABLE ASSY	28480	02804-60120
A0W6	02804-60170	3		CABLE ASSY	28480	02804-60170
A0W8	02804-60180	0		CABLE ASSY	28480	02804-60180
A0W9	02804-60160	9		ANL OUT CBL ASSY	28480	02804-60160
A0W10	02804-60140	7		CBL AY-HPIB	28480	02804-60140
A0XU1	1200-0536	4	1	SOCKET-DIP 3-CONT TO-3 SLDR-EYE	28480	1200-0536
	0340-0732	7	8	INSULATOR-DG5 POST POLYC	28480	0340-0732
	0340-0832	8	4	INSULATOR NYLON	28480	0340-0832
	0360-0001	5	1	TERMINAL-SLDR LUG LK-MTG FOR-#6-SCR	28480	0360-0001
	0360-0063	7	1	TERMINAL-SLDR LUG LK-MTG FOR-#10-SCR	28480	0360-0063
	0360-0378	9	1	TERMINAL-SLDR LUG LK-MTG FOR-#6-SCR	28480	0360-0378
	0380-0643	1	2	STANDOFF-HEX .265-IN-LG 6-32-THD	28480	0380-0643
	0380-1116	7	1	STANDOFF-HEX .875-IN-LG 10-32-THD	28480	0380-1116
	0380-1117	8	3	STANDOFF-HEX 2.25-IN-LG 6-32-THD	28480	0380-1117
	0520-0128	7	4	SCREW-MACH 2-56 .25-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	0570-0920	2	1	STUD-PRS-IN 6-32 UNC-2A .312-IN-LG SST	46384	FHS-632-6
	0610-0001	6	2	NUT-HEX-DBL-CHAM 2-56-THD .062-IN-THK	00000	ORDER BY DESCRIPTION
	0610-0009	4	2	NUT-HEX-MET LKG 2-56-THD .107-IN-THK	28480	0610-0009
	0624-0213	1	1	SCREW-TPG 6-32 .5-IN-LG 82 DEG	28480	0624-0213
	1205-0340	8	1	HEAT SINK SPCL-HOLE-PATT	28480	1205-0340
	1610-0076	4	2	BINDING POST ASSY SGL SGL-TUR JGK	28480	1610-0076
	1610-0087	7	2	BINDING POST SGL THD STUD JGK BLK	28480	1610-0087
	2190-0007	2	6	WASHER-LK INTL T NO. 6 .141-IN ID	78189	1906-00-00-2680
	2190-0009	4	4	WASHER-LK INTL T NO. 8 .169-IN-ID	28480	2190-0009
	2190-0014	1	4	WASHER-LK INTL T NO. 2 .089-IN-ID	78189	1902-00-00-2680
	2190-0017	4	4	WASHER-LK HLCL NO. 8 .168-IN-ID	28480	2190-0017
	2190-0034	6	3	WASHER-LK HLCL NO. 10 .194-IN-ID	28480	2190-0034
	2190-0102	8	3	WASHER-LK INTL T 15/32 IN .472-IN-ID	28480	2190-0102
	2360-0121	2	8	SCREW-MACH 6-32 .5-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2360-0195	0	12	SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2360-0220	1	2	SCREW-MACH 6-32 .562-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2420-0002	6	2	NUT-HEX-DBL-CHAM 6-32-THD .109-IN-THK	28480	2420-0002
	2420-0015	1	5	NUT-HEX-W/LKWR 6-32 THD .094-IN-THK	00000	ORDER BY DESCRIPTION
	2510-0109	5	4	SCREW-MACH 8-32 .625-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2680-0051	5	1	SCREW-MACH 10-32 .375-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2680-0071	0	4	SCREW-MACH 10-32 1.75-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION

See introduction to this section for ordering information
*Indicates factory selected value
†Backdating information in Section VII

Table 6-2. HP2804A Replaceable Parts

Reference Designation	HP Part Number	CD	Qty	Description	Mfr Code	Mfr Part Number
	3740-0002	4	3	NUT-HEX-DBL-CHAM 10-32 THD .125-IN-THK	00000	ORDER BY DESCRIPTION
	2950-0035	8		NUT-HEX-DBL-CHAM 15/32-32-THD	00000	ORDER BY DESCRIPTION
	3050-0002	7	4	WASHER-FL MTLC NO. 10 .203-IN-ID	28480	3050-0002
	3050-0010	2	2	WASHER-FL MTLC NO. 6 .147-IN-ID	28480	3050-0010
	3050-0227	3	6	WASHER-FL MTLC NO. 4 .140-IN-ID	28480	3050-0227
	02804-00003	5	1	REAR PANEL	28480	02804-00003
	02816-00060	8	1	TRIM COVER	28480	02816-00060
A9A1	02804-60091	7	1	REGULATOR ASSEMBLY	28480	02804-60091
A9A1C1	0160-2629	5	1	CAPACITOR-FXD .01F+75-10% 16VDC AL	56289	43D103G016LP1
A9A1C2	0180-0487	9	2	CAPACITOR-FXD 100UF+75-10% 25VDC AL	28480	0180-0487
A9A1C3	0180-0487	6		CAPACITOR-FXD 1000UF+75-10% 25VDC AL	28480	0180-0487
A9A1C4	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A9A1C5	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A9A1C6	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A9A1C7	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A9A1C8	0180-2207	6	1	CAPACITOR-FXD 100UF+-10% 10VDC TA	56289	150D107X9010R2
A9A1C9	0160-3448	8		CAPACITOR-FXD 1000PF +-10% 1KVDC CER	28480	0160-3448
A9A1C10	0160-3448	8		CAPACITOR-FXD 1000PF +-10% 1KVDC CER	28480	0160-3448
A9A1CR1	1901-0673	6	4	DIODE-PWR RECT 100V 6A SUS	03508	A16A
A9A1CR2	1901-0673	6		DIODE-PWR RECT 100V 6A SUS	03508	A16A
A9A1CR3	1901-0673	6		DIODE-PWR RECT 100V 6A SUS	03508	A16A
A9A1CR4	1901-0673	6		DIODE-PWR RECT 100V 6A SUS	03508	A16A
A9A1CR5	1906-0060	4	7	DIODE-FW BRDG 400V 1A	28480	1906-0060
A9A1CR6	1906-0060	4		DIODE-FW BRDG 400V 1A	28480	1906-0060
A9A1CR7	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	GN171	1N4150
A9A1CR8	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	GN171	1N4150
A9A1CR9	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	GN171	1N4150
A9A1CR10	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	GN171	1N4150
A9A1CR11	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	GN171	1N4150
A9A1CR12	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	GN171	1N4150
A9A1CR13	1901-0696	3	1	DIODE-PWR RECT 400V 3A 200NS	03508	A114D
A9A1CR14	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	GN171	1N4150
A9A1F1	2110-0318	0	1	FUSE .125A 250V TD 1.25X.25 UL	75915	313.125
A9A1R1	0757-0159	6	2	RESISTOR 1K 1% .6W F TC+0+-100	28480	0757-0159
A9A1R2	0757-0438	1		RESISTOR 6.11K 1% .125W F TC+0+-100	24546	CT4-1/8-T0-6111-F
A9A1R3	0757-0438	3		RESISTOR 6.11K 1% .125W F TC+0+-100	24546	CT4-1/8-T0-6111-F
A9A1R4	0757-0159	5		RESISTOR 1K 1% .6W F TC+0+-100	28480	0757-0159
A9A1U1	1826-0496	1	1	IC V REGLTR TO-39	04713	MC78L08ACG
A9A1U2	1826-0495	0	1	IC V REGLTR TO-39	04713	MC78L12ACG
A9A1U3	1826-0367	5	1	IC V REGLTR FXD-POS 4.8/5.2V TO-33 PKG	04713	MC7805CG
A9A1XA8	1251-2035	0	1	CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS	28480	1251-2035
A9A1XF1	2110-0269	0	2	FUSEHOLDER-CLIP TYPE,250-FUSE	28480	2110-0269
	1200-0173	5	3	INSULATOR-ASTR DAP-GL	28480	1200-0173
	1205-0033	6	1	HEAT SINK TO-5/TO-39-CS	28480	1205-0033
				QUARTZ THERMOMETER CHASSIS & MISC PARTS		
XJ1	5060-9462	9	1	HPIB EXTENDER AY	28480	5060-9462
	0340-0732	7		INSULATOR-DOG POST POLYC	28480	0340-0732
	0370-2626	5	1	BEZEL-PUSHBUTTON 0.330-IN SQ; MOSS GRY	28480	0370-2626
	0370-2662	1	1	PUSHBUTTON 0.230 IN SQ; 0.475 IN HGT	28480	0370-2662
	0380-0058	4	6	STANDOFF-HEX .438-IN-LG 6-32 THD	28480	0380-0058
	0380-1123	6	1	STANDOFF-HEX 1.6-IN-LG 10-24THD	00000	ORDER BY DESCRIPTION
	0403-0264	4	2	GUIDE-PC BD BLK NYL .078 BD-THKNS 3.6-LG	32559	E-250
	0403-0265	5		GUIDE-PC BD BLK NYL .078-BD-THKNS 5-LG	32559	E-300
	0515-1065	0	4	SCREW-MACH M4 X 0.7 6MM-LG 90-DEG-FLH-HD	28480	0515-1065
	0515-1233	6	4	SCREW-MACH M3.5 X 0.6 20MM-LG PAN-HD	28480	0515-1233
	0515-1331	5	8	SCREW-METRIC SPECIALTY M4 X 0.7 THD; 8	28480	0515-1331
	0590-0012	5	2	NUT-KNRLD-R 15/32-32-THD .062-IN-THK	00000	ORDER BY DESCRIPTION
	1460-1345	5	2	TILT STAND SST	28480	1460-1345
	1510-0076	4		BINDING POST ASSY SGL SGL-TUR JGK	28480	1510-0076
	1510-0087	7		BINDING POST SGL THD-STUD JGK BLK	28480	1510-0087
	1600-1028	9	2	STAMPING-BE-CU CLIP WINDOW	28480	1600-1028

See introduction to this section for ordering information
*Indicates factory selected value
†Backdating information in Section VII

Table 6-2. HP2804A Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
	2260-0009	3		NUT-HEX-W/LKWR 4-40-THD .064-IN-TH	01000	ORDER BY DESCRIPTION
	2360-0116	4	14	SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	0 000	ORDER BY DESCRIPTION
	2360-0121	2		SCREW-MACH 6-32 .5-IN-LG PAN-HD-POZI	0 000	ORDER BY DESCRIPTION
	2360-0130	0	4	SCREW-MACH 6-32 1-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2360-0195	0		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2360-0106	1	4	SCREW-MACH 6-32 .375-IN-LG 100 DEG	00000	ORDER BY DESCRIPTION
	2510-0102	6	16	SCREW-MACH 8-32 .25-IN-LG 100 DEG	28480	2510-0102
	2950-0036	8		NUT-HEX-DBL-CHAM 15/32-32-THD	00000	ORDER BY DESCRIPTION
	3050-0160	3	2	WASHER-FL MTLC 7/16 IN .47-IN-ID	28480	3050-0160
	3050-0227	3		WASHER-FL MTLC NO. 6 .149-IN-ID	28480	3050-0227
	3050-0807	5	4	WASHER-FL MTLC 7/16 IN .406-IN-ID	28480	3050-0807
	8120-0698	6	1	CABLE ASSY 18AWG 3-CNDCT BLK-JKT	28480	8120-0698
	8120-1378	1	1	CABLE ASSY 18AWG 3-CNDCT JGR-JKT	28480	8120-1378
	8120-1626	1	1	CABLE ASSY 18AWG 3-CNDCT BLK-JKT	28480	8120-1626
	8160-0277	1	1	RFI SHLD GSKT 0.137-IN-WD .009-IN-TH	28480	8160-0277
	5001-0439	6	2	TRIM-SIDE FRT	28480	5001-0439
	5020-3440	7	2	SPRG-DETENT	28480	5020-3440
	5021-5815	6	1	FRAME-FRONT	28480	5021-5815
	5021-5816	7	1	FRAME-REAR	28480	5021-5816
	5021-5836	1	4	STRUT-CDR 16 LG	28480	5021-5836
	5040-5027	3	1	DIVIDER STRIP	28480	5040-5027
	5040-7201	8	4	FOOT	28480	5040-7201
	5040-7203	0	1	TRIM-TOP 1/2	28480	5040-7203
	5040-7213	2	4	REAR CRD GDP-PNL	28480	5040-7213
	5060-7162	0	2	SW-SLIDE AY	28480	5060-7162
	5061-0430	3	1	TOP COVER	28480	5061-0430
	5061-0442	7	1	BOTTOM COVER	28480	5061-0442
	5061-0511	1	2	COVER-PERF SIDE	28480	5061-0511
	02804-00006	8	1	PC BD BRKT	28480	02804-00006
	02804-00007	9	1	MB BRKT LEFT	28480	02804-00007
	02804-00008	0	1	MB BRKT RIGHT	28480	02804-00008
	02804-00009	1	1	CARD CAGE LEFT	28480	02804-00009
	02804-00010	4	1	CARD CAGE RIGHT	28480	02804-00010
	02804-00015	0	1	SUB PANEL	28480	02804-00015
	02804-00018	2	1	OLAY-SID AM/HPIB	28480	02804-00018
	02804-00020	5	*	POD-SWITCH	28480	02804-00020
	02804-20001	5	1	LENS	28480	02804-20001
	02804-60110	1	2	RF CABLE ASSY	28480	02804-60110
	02804-60130	6	1	FLT MEM CBL ASSY	28480	02804-60130
	02804-60140	7	2	CBL AY-HPIB	28480	02804-60140
	02804-60150	9	2	ANL OUT CBL ASSY	28480	02804-60150
	02804-60160	1	2	PROM ASSY	28480	02804-60160

See introduction to this section for ordering information
*Indicates factory selected value
†Backdating information in Section VII

Table 6-3. Code List of Manufacturers

Mfr Code	Manufacturer Name	Address	Zip Code
00648	NEC ELECTRONICS LTD	MTN VIEW CA US	94043
00000	ANY SATISFACTORY SUPPLIER		
01121	ALLEN-BRADLEY CO INC	EL PASO TX US	79936
01295	TEXAS INSTRUMENTS INC	DALLAS TX US	75265
03508	GE CO SEMICONDUCTOR PROD DEPT	AUBURN NY US	13201
03888	K D I PYROFILM CORP	WHIPPANY NJ	07981
04713	MOTOROLA INC SEMI-COND PROD	PHOENIX AZ US	85008
07263	FAIRCHILD CORP	MOUNTAIN VIEW CA US	94042
16299	CORNING ELECTRONICS	RALEIGH NC US	27604
19701	MEPCO/ELECTRA INC	MINERAL WELLS TX US	76067
2MC27	ROHM CORP	IRVINE CA US	92716
24355	ANALOG DEVICES INC	NORWOOD MA US	02062
24546	CORNING ELECTRONICS	SANTA CLARA CA US	95050
27014	NATIONAL SEMICONDUCTOR CORP	SANTA CLARA CA US	95052
28480	HEWLETT-PACKARD CO CORPORATE HQ	PALO ALTO CA	94304
32559	BIVAR INC	SANTA ANA CA	92705
46384	PENN ENGINEERING & MFG CORP	DANBORO PA US	18916
56289	SPRAGUE ELECTRIC CO	NORTH ADAMS MA	01247
72136	ELECTRO MOTIVE CORP	FLORENCE SC	29226
73138	BECKMAN INDUSTRIAL CORP	FULLERTON CA US	92632
73899	J F D ELECTRONICS CORP	BROOKLYN NY	11219
75915	LITTELFUSE INC	DES PLAINES IL US	60016
78189	ILLINOIS TOOL WORKS INC SHAKEPROOF	ELGIN IL	60120
8N171	UNITRODE CORP	LEXINGTON MA US	02173
91637	DALE ELECTRONICS INC	EL PASO TX US	79936

Table 6-4. HP 2804A Mechanical Parts, Exploded View

INDEX NUMBER	HP PART NUMBER	DESCRIPTION	UNITS PER ASSY
1	5021-5815	Frame-Front (Metric)	1
2	5040-7203	Top Trim	1
3	2360-0194	Screw 6-32 x 5/16	4
4	5001-0439	Side Trim	2
5	0515-1055	Screw-MACH M4 x 0.7, 6mm long	8
6	0515-1331	Screw-MACH M4 x 0.7	8
7	5061-9442	Bottom Cover (Metric)	1
8	5040-7201	Foot	4
9	1460-1345	Tilt Stand	2
10	5021-5836	Corner Struts (Metric)	4
11	5061-9511	Side Panel (Metric)	2
12	—	Part of Item 11	2
13	0515-1233	Screw-MACH M4 x 0.7	4
14	5040-7213	Foot, Rear Panel	4
15	5021-5816	Rear Frame (Metric)	1
16	—	Part of Item 17	2
17	5061-9430	Top Cover (Metric)	1

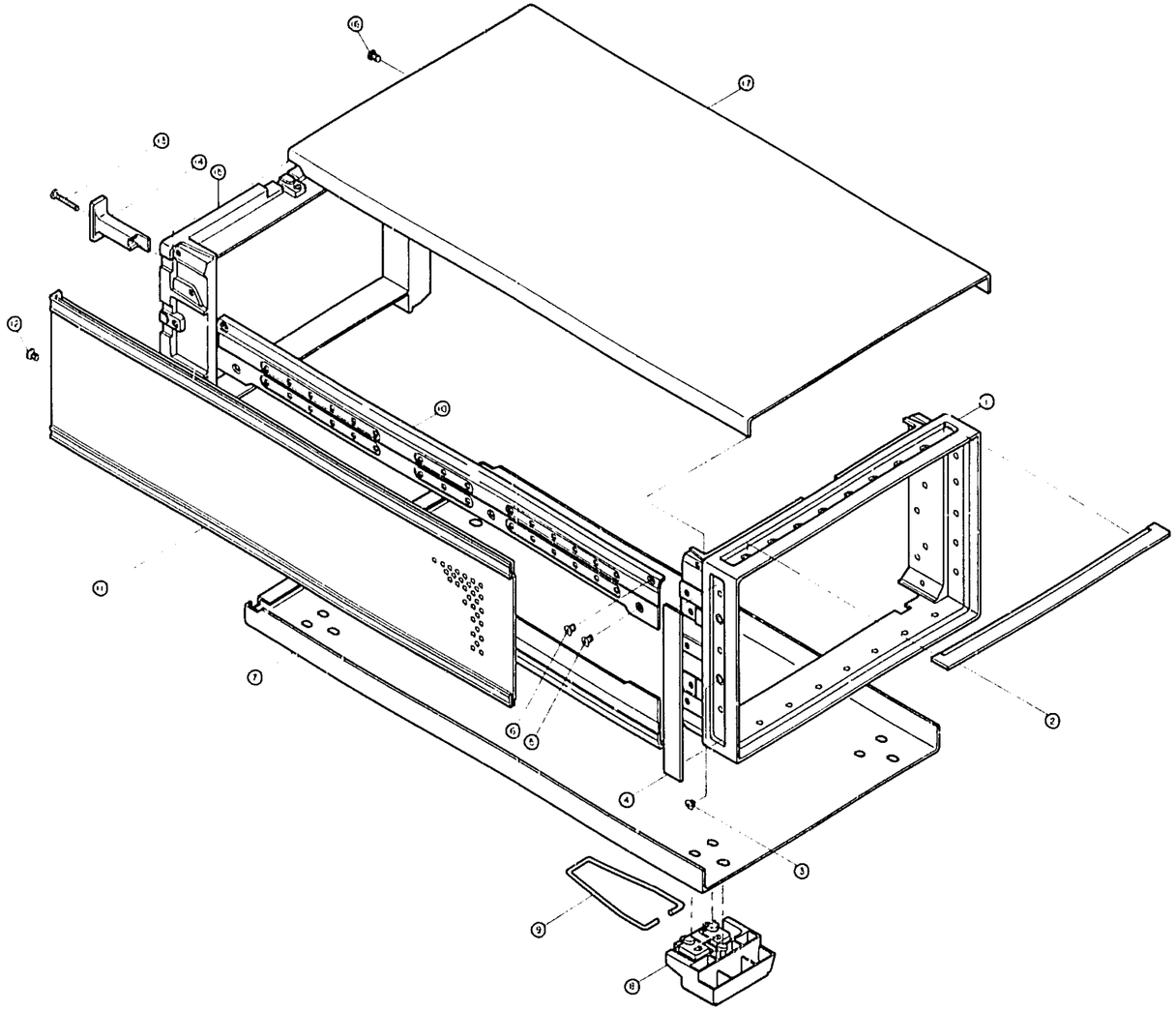


Figure 6-1. HP 2804A Mechanical Parts, Exploded View

Table 6-5. HP 2804A Chassis Parts, Exploded View (Sheet 1 of 2)

INDEX NUMBER	HP PART NUMBER	DESCRIPTION	UNITS PER ASSY
1	0590-0012	Knurled Nut	2
2	3050-0160	Flat Washer	2
3	2950-0035	Hex Nut 15/32	2
4	02804-60020	A2 Oscillator/Preset Assy	1
5	0590-0157	Locknut, 6-32	3
6	02804-00006	Printed circuit board bracket	1
7	2260-0012	Nut, 4-40	4
8	2360-0115	Screw 6-32 x .312	14
9	02804-00007	Motherboard bracket, right side	1
	02804-00008	Motherboard bracket, left side	1
10	02804-60130	Cable Assy, W2 (A1, A2, A8 Interconnect)	1
11	0380-0328	Spacer 6-32 x .250	2
12	2360-0113	Screw 6-32 x .250	2
13	02804-60050	A5 Counter Assy	1
14	02804-60110	Cable Assy W3 (Chan. T1, Front)	1
15	02804-60110	Cable Assy W4 (Chan. T2, Front)	1
16	02804-60080	A8 Motherboard Assy	1
17	02804-60030	A3 MPU/Time Base Assy	1
18	02804-60120	Cable Assy W5 (Ext Clock)	1
19	02804-60010	Card Cage, Rear	1
20, 21	02804-60120	Cable Assy, W6 and W7 (Chan. T1 and T2, Rear)	1
22	02804-60090	A9A1 Power Supply Board	1
23	02804-60150	Cable Assy W8 (Analog Output)	1
24	0380-1116	Standoff, 10-32 x .875 In.	1
	2680-0051	Secured with 10-32 x .375" Screw and Lock Washer	
25	Reference only	Transformer	1
26	02804-00003	Rear Panel	1
27	2950-0035	BNC Nut	3
	2190-0102	BNC Lock Washer, Used with Item 27	
28	0960-0443	Line Module AC Power Input	1
29	1205-0340	Heatsink	1
30	0340-0832	Standoff. Used with Item 29	4
31	0380-1117	Standoff, 2.25 In. Secured with 3, 6-32 x .250 Screws (2360-0113)	3
32	0380-1123	Coupler, 10-24 x 1.5"	1
33	Reference only	Spring, used with A9A1S1	1
34	0520-0128	Screw, 2-56 x .250	2
35	Reference only	Switch Mounting Plate	1
36	0610-0001	Nut, 2-56	2
37	01607-23201	Extender Rod	1
38	02804-60140	Cable Assy W9 (A7, HP-IB Interconnect)	1
39	02804-60040	A4 Memory Assy	1
40	02804-60060	A6 D/A Converter Assy	1
41	02804-60070	A7 HP-IB Assy	1
42	02804-00009	Card Cage Front	1
43	2360-0115	Screw, 6-32 x .312"	6
44	02804-60010	A1A2 Part of A1	1
45		A1A1 Display Assy	

Table 6-5. HP 2804A Chassis Parts, Exploded View (Sheet 2 of 2)

INDEX NUMBER	HP PART NUMBER	DESCRIPTION	UNITS PER ASSY
46	02804-00004	Front Sub-Panel	1
47	1460-1028	Retaining Clip	2
48	8160-0277	RFI Screen	1
49	02804-20001	Display Lens	1
50	0370-2626	Bezel (Line Switch)	1
51	0370-2862	Button (Line Switch,	1
52	02804-00002	Front Panel Overlay (Standard Instrument)	1
	02804-00001	Front Panel Overlay (Analog)	1
53	02804-60160	Quartz Probe Calibration Module Blanks for Reference Only	2
54, 62	0340-0732	Binding Post Insulator	4
55	1510-0087	Binding Post (negative side)	1
56	1510-0076	Binding Post (positive side)	1
57	0380-0643	Spacer	2
58	1251-3283	Connector, 24-pin HP-IB	1
59, 60	2420-0015	Nut 6-32	4
61	3050-0227	Flat Washer .149 ID	2

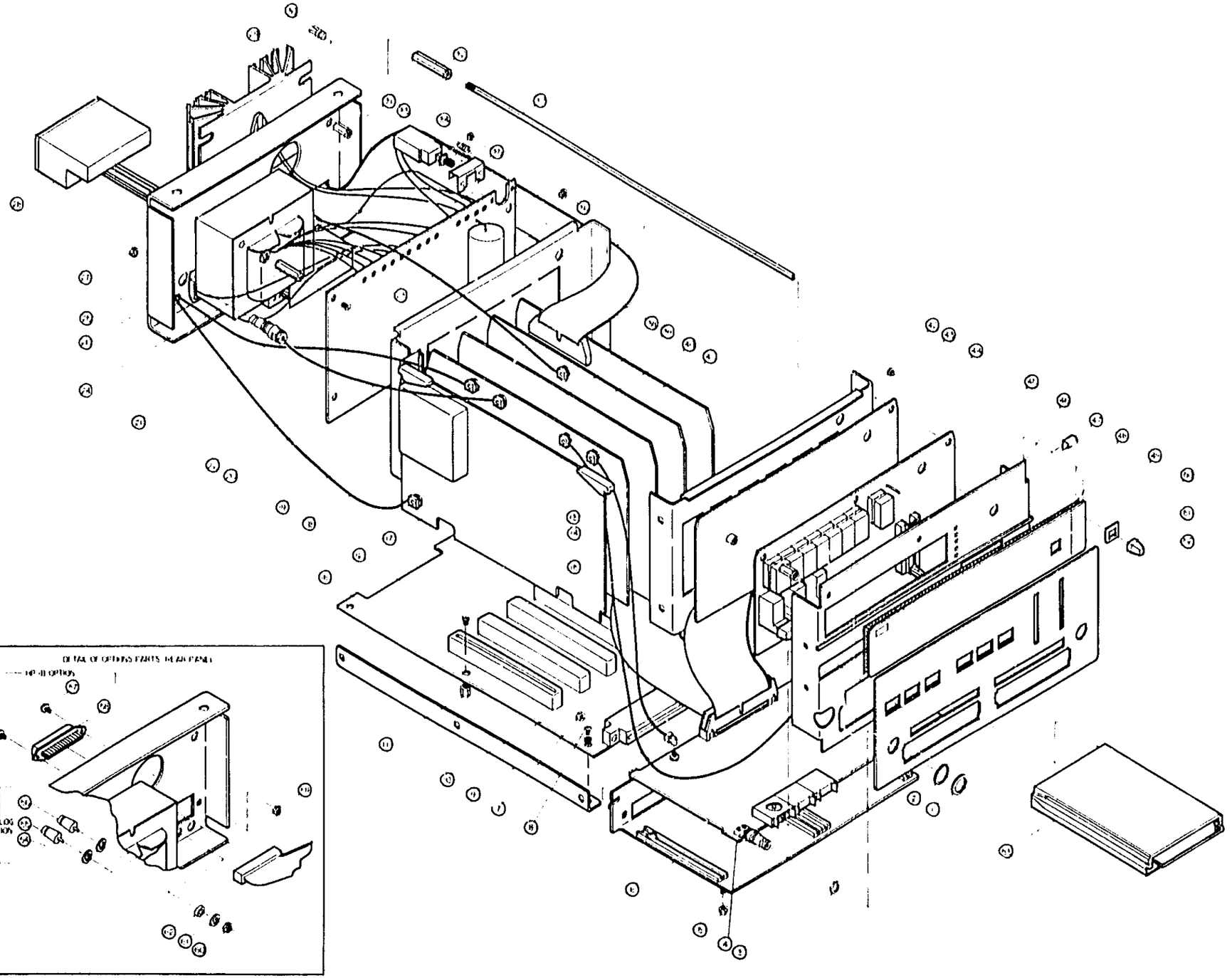


Figure 6-2. HP 2804A Chassis Parts, Exploded View

SECTION VII
MANUAL CHANGES

7-1. INTRODUCTION

7-2. This section contains manual changes information backdating this manual for instruments with serial prefix numbers lower than the listing on the title page.

7-3. MANUAL CHANGES

7-4. To adapt this manual to older instruments, make changes listed in Table 7-1.

7-5. For instrument serial prefixes greater than the number listed on the title page, changes are included in a yellow, MANUAL CHANGES supplement.

Table 7-1. Manual Changes

If your Instrument has Serial Prefix	Make Change Number
2516	1
2432	1, 2
2428	1, 2, 3
2332	1, 2, 3, 4
2308	1, 2, 3, 4, 5
2244	1, 2, 3, 4, 5, 6
2236	1, 2, 3, 4, 5, 6, 7
2120	1, 2, 3, 4, 5, 6, 7, 8
1938	1, 2, 3, 4, 5, 6, 7, 8, 9
1918	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
1901	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
1843	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
1834	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
1807	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
1744	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

CHANGE 1 (Serial 2516)

Table 6-2, A7 HP-IB Assembly Replacement Parts:
Add 1200-0844 Retaining Clip (for U3).
Change A7U3 to 1AA6-6004.
Delete A7XU3.

CHANGE 2 (Serial 2432)

Table 6-3:
Change Item 1 to 5020-8815, Front Frame.
Change Item 5 to 2510-0102, Screw 8-32 x 1/4", Qty-16.
Change Item 6 to 2360-0115, Screw 8-32 x 5/16", Qty-14.
Change Item 7 to 5060-9842, Bottom Cover.
Change Item 10 to 5020-8836, Corner Struts, 15".
Change Item 11 to 5060-9911, Side Panel.
Change Item 13 to 2360-0120, Screw 6-32 x 1".
Change Item 15 to 5020-8816, Rear Frame.
Change Item 17 to 5060-9830, Top Cover.

CHANGE 3 (Serial 2428)

Table 6-2:
Change A2 to 02804-60020.
Change A2C2/C3 to 0160-3451, Capacitor-Fxd, 0.01 μf +80 -20%, 100 VDC CER, 28480, 0160-3451.
Change A2C6, C8, C10, C13, C15, C18, C22, C24, C26, C27 to 0160-3456, Capacitor-Fxd, 100 pF ±10%, 200 VDC CER, 28480, 0160-3456.
Change A2C7 to 0160-2097, Capacitor-Fxd, 1000 pF ±10%, 200 VDC CER, 28480, 0160-3456.
Change A2C12, C23 to 0160-2995, Capacitor-Fxd, 3 pF ±.5 pF, 1K VDC CER, 28480, 0160-2995.
Change A2S1 through S6 to 02804-4001.

Table 6-2, Miscellaneous Parts:
Change Front Panel Overlay to 02804-00001, Front Panel Overlay (used with Analog option only).
Change Subpanel to 02804-0004.
Add 02804-00011, Analog Overlay (Std. Instrument only).
Add 02804-00012, HP-IB Overlay (Std. Instrument only).

Figure 8-7:
Change A2C9, C21 values to 6.8 pF.
Change A2 part number to 02804-60020.
Change A2C12, C23 to 3 pF.

CHANGE 4 (Serial 2332A)

Table 6-2:
Change A2C9, C21 to 0160-0993, Capacitor-Fxd, 6.8 pF ± .25 pF, 500 VDC CER, 28480, 0160-0993.

Figure 8-7:
Change A2C9, C21 to 6.8 pF.

CHANGE 5 (Serial 2308)

Table 6-2:
Change C6, C8, C10, C13, C15, C18, C20, C24, C26, C27 to 0160-2097, Capacitor-Fxd, 1000 pF ±10%, 200 VDC CER, 28480, 0160-2097.
Change A3TP1-TP4 to 1251-4259.

Figure 8-10:
Add A5C17, C20. C17 connects from -12V to ground at P1-10. C20 connects from -5V to ground at P1-9.

CHANGE 6 (Serial 2244)

Table 6-2:
Add to A0 Miscellaneous Parts:
2100-0017 Lockwasher, Split.
02804-60140 Cable Assy HP-IB.

CHANGE 7 (Serial 2236)

On the following pages, indicate that A6 and A7 were optional assemblies:
1-2, 1-4, 1-5, 3-7, 6-9, 6-10, 8-21, 8-22, 8-25.

CHANGE 8 (Serial 2120)

Table 6-2:
Change A1A1XDS1 to D38 to 1200-0674.

CHANGE 9 (Serial 1938)

This serial prefix change does not affect the contents of the manual.

CHANGE 10 (Serial 1918)

A3 Assembly:
Change C9, C10 to 0160-3461, Capacitor-Fxd .01 μf.
Change R2 to 0698-4626.
Change XJU1 to 1200-0410.

CHANGE 11 (Serial 1901)

A7 Assembly:
Change A7U3 to 1AA6-6001.

CHANGE 12 (Serial 1843)

A4 Assembly:
Change A4U7 to 1818-5032.
Delete A4XU7, 1200-0615.

CHANGE 13 (Serial 1834)

A7 Assembly:
Change A7U1, U2, U5, U6 to 1820-1972.
Add A7XS1 1200-0474, Socket IC, 14 contact DIP.
Delete A7C9, 0160-3448.
Delete A7C9, 1000 pF from UG14).

CHANGE 14 (Serial 1807)

A0 Assembly:
Change component locator and schematic series to 1807.

CHANGE 15 (Serial 1744)

A2 Assembly:
Change A2TP1-TP4 to 0360-0124.

SECTION VIII
SERVICE

8-1. INTRODUCTION

8-2. This section contains a block diagram, individual assembly schematic diagrams and component locators. Also included is a functional description of operation at a block level, individual assembly theory of operation, service and troubleshooting information including signature lists. Expanded description of assemblies and functioning circuit-groups is also included with the schematic diagrams of the individual assemblies. Table 8-1 lists terminology (mnemonics) used in the HP 2804A.

8-3. GENERAL DESCRIPTION

8-4. HP Model 2804A Quartz Thermometer is a microprocessor based precision temperature measuring instrument. A quartz crystal sensor probe designed to have a constant relationship to temperature and used with the HP 2804A, enables precision measurements to be made.

8-5. The instrument uses a stable 10 MHz TCXO clock, (or an external 1 MHz clock), which provides an accurate time interval for operation. The accurate time interval allows direct counting for the probe input frequency change as a result of measured temperature.

8-6. The HP 2804A operates from a stored program located in read-only-memory (ROM) within the instrument. The program is automatically entered at a "Restart Address" when instrument power is applied. The main program initiates a measurement and the NMI (Non-Maskable Interrupt) service routine in conjunction with the time-base generator actually control the instrument circuits. This program also automatically refreshes the display through an "Interrupt Service Routine", initiated by the instrument's 1 kHz time base signal. The front panel switches are scanned at a 1 kHz rate to update any switch information changes.

8-7. BLOCK DIAGRAM OPERATION

8-8. The HP 2804A Quartz Thermometer is a temperature measuring instrument capable of measuring temperatures from -80°C to +250°C. It uses quartz sensor probes to generate frequency changes with temperature changes, processes these changes and displays the temperature in °C or °F.

8-9. Nine printed circuit boards comprise the instrument. These are:

A1 Front Panel Assembly (consists of A1A1 Display/Switch Assembly and A1A2 Display Driver Assembly.

A2 Oscillator/Preset Assembly.

A3 MPU/Time Base Assembly.

A4 Memory Assembly.

A5 Counter Assembly

A6 Digital-to-Analog Assembly.

A7 HP-IB Assembly.

A8 Motherboard Assembly.

A9 Power Supply/Rear Panel Assembly.

Table 8-1. 2804A Terminology

MNEMONIC	LOCATION (ORIGIN)	MNEMONIC	LOCATION (ORIGIN)
DAC0 thru DAC6	DAC Switch data – Low TRUE A1A1S8	VRWA	Valid Read/Write Address – Low TRUE A3U5C
DS0 thru DS7	Digit Select lines – Low TRUE – A1A2U9, 10	VROA	Valid Read Only Address – Low TRUE A3U5B
DSL1	Digit Select latch 1 – Low TRUE A1A2U11	VRD	Valid RAM Disable – Low TRUE
DSL2	Digit Select latch – Low TRUE A1A2U11	IRA	Invalid RAM Address
DACR	DAC Switch Read – Low TRUE A1A2U11	LAB	Lower Addressed Block
DLR	Digit Latch Reset – Low TRUE A1A2U12B	WEN	Write Enable – High TRUE
VIO	Valid I/O – Low TRUE A4U5A	BWE	Bus Write Enable – Low TRUE A4U5
R/$\overline{W}$	Read/$\overline{\text{Write}}$ – A3U8F	BRE	Bus Read Enable – Low TRUE A4UC
RES	RESET (System) – A3U4D – Low TRUE	ENM	Enable Memory – High TRUE A4U10A
SDL	Segment Driver Latch – Low TRUE A1A2U11	PBW	Processor Bus Write
PBTR	Pushbutton Read – Low TRUE A1A2U11	NMI	Non Maskable Interrupt – Low TRUE A3U3A
PBT1	T1 Pushbutton – Low TRUE A1A1S1	NMIR	Non Maskable Interrupt Request High TRUE
PBT2	T2 Pushbutton – Low TRUE A1A1S2	RRQ	Reset Request – Low TRUE A3U7A
PBDT	T1-T2 Pushbutton – Low TRUE A1A1S3	IRQ	Interrupt Request – Low TRUE A3U11
PBLO	LO Pushbutton – Low – TRUE A1A1S4	EXCK	External Clock – Low TRUE A3U6
PBMD	MED Pushbutton – Low – TRUE A1A1S5	NMID	Non Maskable Interrupt Disable Low TRUE A3U3A
PBHI	HI Pushbutton – Low – TRUE A1A1S6	ARM	Arm A5U9B
SA thru SDP	Segments a thru g and DP – High TRUE A1A2U5, 6	DARM	Dis Arm A5U9B
ANSL	Annunciator Select – Low TRUE A1A2U7	SEL	Select A5U9B
DBUG	Factory Test Only	CLR	Clear A5U9B
VMA	Valid Memory Address – High TRUE – A3U8D	RCT	Read Count A5U9A
		FNS	Function Select A5U9A
		ISEL	Input Select A5U8B
		T1F	T1 Front A5U1B
		T2F	T2 Front A5U1C
		T1R	T1 Rear A5U1A
		T2R	T2 Rear A5U1D
		NINP	No Input A5U12A
		LHW	Low Half Write A6U5
		HHW	High Half Write A6U5

8-10. Figure 8-1 is a simplified block diagram of the instrument and Figure 8-2 is a simplified program flowchart for the instrument. The HP 2804A is a bus organized instrument where assemblies which plug into the A8 Motherboard are position-independent. Each of the assemblies in the instrument can be considered an independent block with which the A3 MPU/Time Base Assembly communicates individually.

8-11. The basic measurement made in the HP 2804A is frequency. The frequency to be measured is determined by a quartz crystal in the probe and sensor oscillators located externally or in the A2 Oscillator/Preset Assembly. Two channels are available for separate temperature measurements or temperature difference measurements. Frequency of the A2 oscillator(s) is determined by the temperature to which the quartz probe is subjected and is about 30 MHz (typically 28.3 MHz).

8-12. The frequency to be measured by the instrument can come from four possible sources. Two sources are the front panel T1 and T2 quartz probe inputs. Two other sources of frequency are rear panel inputs to the instrument. However, the rear panel inputs must be from external sensor oscillators since the inputs go directly to a signal multiplexer in the A5 Counter assembly.

8-13. The instrument program selects on a priority basis, the front panel inputs before the rear panel inputs for either channel. As an example: With the input at the rear panel T1 connector, if T1 pushbutton switch is pressed, the instrument automatically selects front panel T1 input. With the front panel T1 probe input missing, the instrument automatically selects rear panel T1 input. If both front and rear panel T1 inputs are missing, an error message is displayed, (See Table 8-2 for a list of error messages). Instrument operation is identical when channel T2 is selected.

8-14 QUARTZ PROBES AND CALIBRATION MODULES

8-15. A quartz probe must be used with a matched calibration module in order to make any temperature measurements. The calibration module memories contain the characteristics of the crystal frequency, at all temperatures from -80°C to +250°C, as well as other calibration data specific to the associated quartz temperature sensor. The calibration modules also contain address decoding circuits which cause them to answer to a particular address space, when installed in T1 channel, and to another address space when installed in T2 channel. Quartz probes must always be used with their associated calibration modules. Exchange of probes from one channel to another, or to another HP 2804A must always be accompanied by the exchange of calibration modules.

8-16. At 0°C, the oscillation frequency of the probe crystal is typically 28.208 MHz and is slightly different with each probe. Since the frequency-vs-temperature characteristics are stored in the calibration module, the A3 Processor subtracts this information as a "major offset" from the frequency actually being measured.

8-17. The crystal characteristics (frequency-versus-temperature) are stored in the calibration module as a group of coefficients used by the conversion algorithm to ensure the specified accuracy over the operating temperature range (-80°C to +250°C). These coefficients are uniquely determined for each individual probe by means of an extensive calibration process. The calibration modules for each input channel are inserted just below the A2 assembly and plug into connectors on motherboard A8.

8-18. Three components enable the matched probe/calibration module to be used in any HP 2804A.

These are:

a. Quartz Probe.

b. Calibration Module.

c. Reference Temperature Adjustment

The quartz probe and calibration module were previously mentioned. The reference temperature adjustment, on the instrument front panel, compensates for any change in frequency of the probe crystal, due to aging. This setting must be transferred to the proper channel when probes are exchanged. For maximum accuracy when exchanging probes or instruments, a new reference temperature adjustment should be made as described in the operation section.

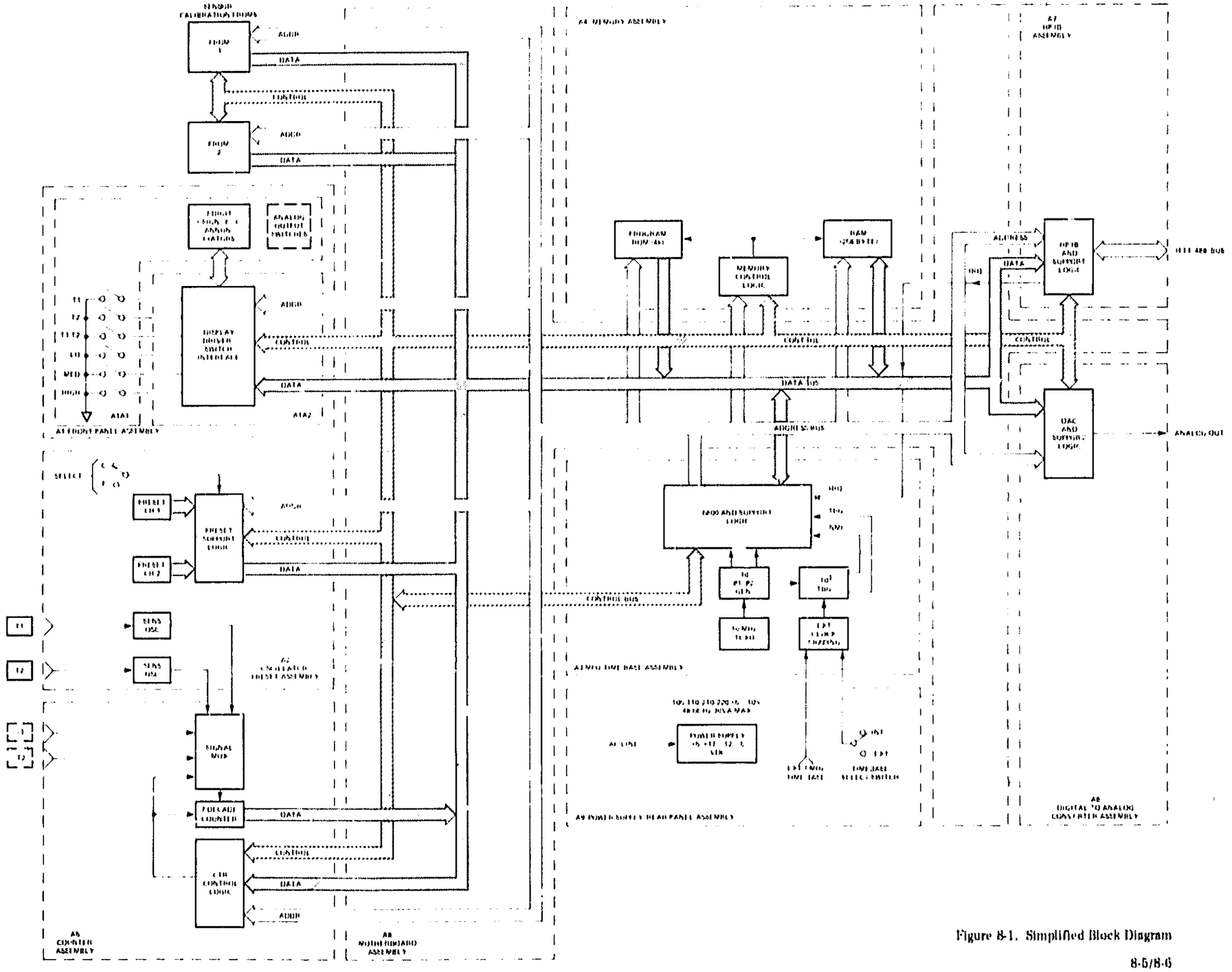


Figure 8-1. Simplified Block Diagram

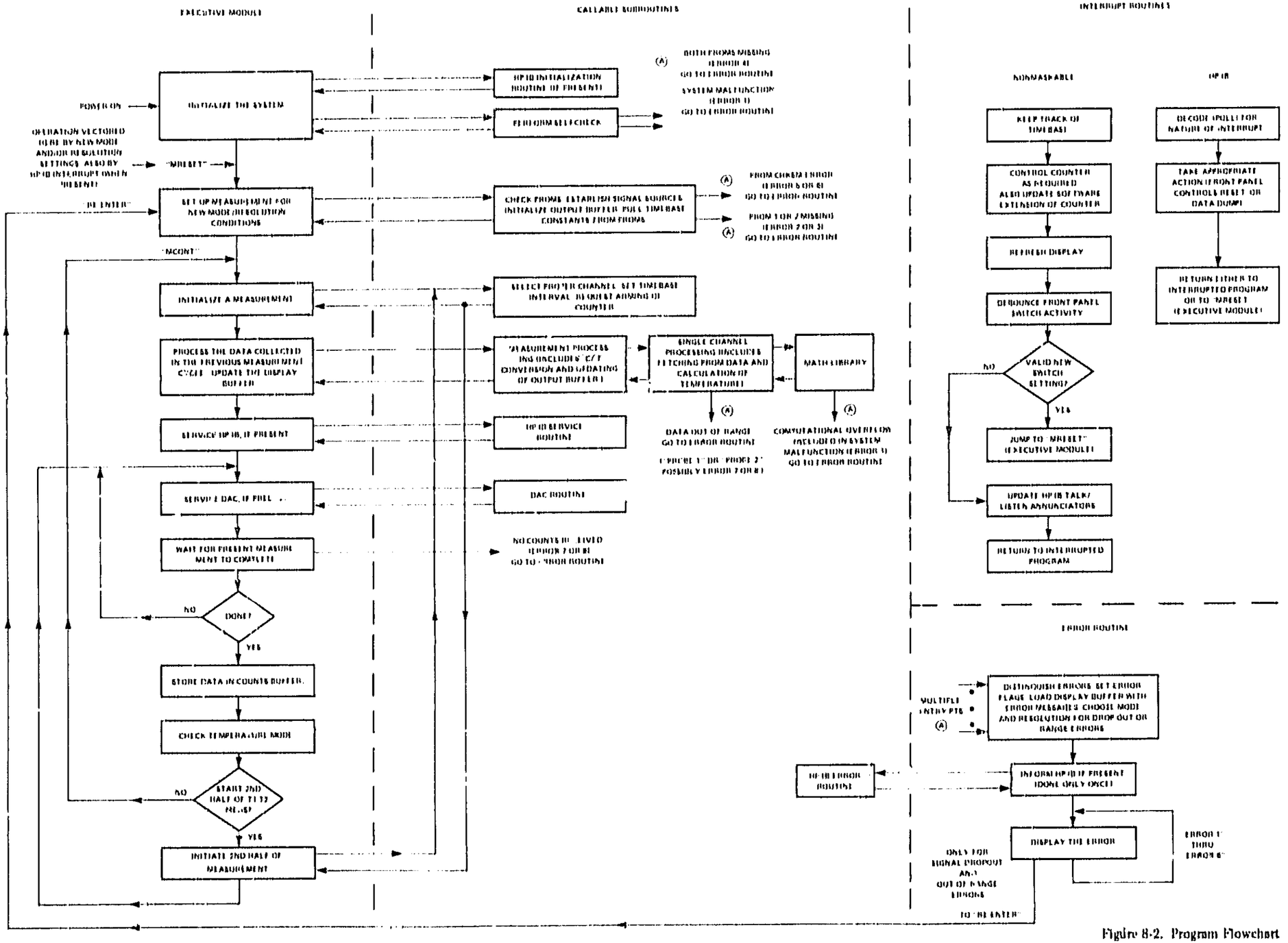


Figure 8-2. Program Flowchart

Table 8-2. Error Messages

An error that is "bypassable" may be circumvented by selecting the other measurement channel.

MESSAGE	DESCRIPTION	BYPASSABLE?
"Error 1"	System Malfunction (Described more fully in Note 1)	No
"Error 2"	Channel 1 Calibration Module absent	Yes
"Error 3"	Channel 2 Calibration Module absent	Yes
"Error 4"	Channels 1, 2 Calibration Modules absent	No
"Error 5"	Calibration Module 1 Checksum error	Yes
"Error 6"	Calibration Module 2 Checksum error	Yes
"Error 7"	Channel 1 Signal Dropout or Blown Fuse A9F1	Yes
"Error 8"	Channel 2 Signal Dropout or Blown Fuse A9F1	Yes
"Probe 1"	Channel 1 Out-of-range (Note 2)	No
"Probe 2"	Channel 2 Out-of-range (Note 2)	No

NOTE 1:

"Error 1", denoting system malfunction, occurs for the following situations.

(1) Inability to properly access MPU registers or RAM during Self-Check.

(2) Inability to properly access front panel pushbutton switches during Self-Check.

(3) Inability to properly access °C/°F switch during Self-Check.

(4) No output from counter in response to an internal 1 MHz test signal (during Self-Check and Error routines).

(5) Computational overflows.

NOTE 2:

"Probe 1" and "Probe 2" are "self-recoverable" errors in the sense that normal measurement resumes if the measured temperature is brought back within the permitted range. Excessive temperature over-range for prolonged periods may change probe temperature/accuracy response. The probe and calibration module should be returned to the factory for recalibration and a new calibration module.

8-19. A1 DISPLAY ASSEMBLY

8-20. The A1 Display Assembly consists of two printed circuit boards:

a. A1A1 Display/Switch Assembly.

b. A1A2 Display Driver Assembly.

8-21. A1A1 serves two purposes:

a. As a readout of information written to it by programs and controlling circuits.

b. Provides annunciators which indicate where the instrument is in a particular measurement cycle.

8-22. Data, relating to the status of front panel pushbutton switches, is read from A1A1 into A1A2. A3 processor scans these switches during a measurement cycle. Any switch activity is then detected and acted upon by the A3 circuits.

8-23. A2 PRESET/OSCILLATOR ASSEMBLY

8-24. A2 Assembly consists of preset switches and associated logic, sensor oscillators for each input channel, and the °C/°F switch. The preset switches and the logic circuitry provide ice-point calibration adjustments for the sensor probes.

8-25. The °C/°F switch position determines whether temperature will be displayed in °C or °F.

8-26. When sensor probes are connected to the input of the sensor oscillators, the basic measurement frequency (approximately 28.208 MHz at 0°C) is generated. Oscillator outputs are then routed to the A5 Counter Assembly via coaxial cables.

8-27. A3 MPU/TIME BASE ASSEMBLY

8-28. The A3 Assembly, with its microprocessor, is the heart of the instrument. This assembly provides all the timing and control for the instrument, and communicates individually with each of the other assemblies over several buses.

8-29. Three buses are common to all assemblies (except the power supplies) in the instrument. These are:

a. Control Bus.

b. Address Bus.

c. Data Bus.

3-30. The Control source of these buses is the A3 MPU/Time Base Assembly (the processor). The A3 processor has two functions:

a. To control instrument timing for high accuracy measurements.

b. To perform any needed computations directed by programs stored on the Memory Assembly A4.

The A3 assembly contains a stable 10 MHz clock and various dividers to provide an accurate 1 kHz time base signal for the A3 microprocessor and the remaining instrument circuits.

8-31. This 1 kHz signal is applied, through the control bus, to A5 Counter Assembly to generate accurate gate-times. A3 Processor communicates with the A5 logic control circuits and gates A5 on and off in synchronism with the 1 kHz signal.

The 1 kHz signal originates from one of two possible sources:

a. From the internal 10 MHz quartz oscillator.

b. From an external 1 MHz quartz oscillator applied to the instrument rear panel input. (See Table 1-1 specifications for suggested minimum requirements of the external time base.)

8-32. There are two interrupts to the A3 Processor:

a. NMI (non-Maskable Interrupt) This interrupt has highest priority and cannot be masked out.

b. IRQ (Interrupt Request). This interrupt is a request for service and can be masked out.

8-33. One edge of the A3 time-base generator signal is used to generate the NMI signal so that the main program flows as shown in the "Executive Module" portion of Figure 8-2.

8-34. A4 MEMORY ASSEMBLY

8-35. Programs needed to make measurements are contained in a ROM located on the A4 Memory Assembly. This assembly is controlled by the A3 processor, through the A4 memory control logic. Commands from the A3 processor, to select address locations for processing of data, are implemented by the Memory Assembly.

8-36. A5 COUNTER ASSEMBLY

8-37. As mentioned in the paragraph 8-11, measurement is a frequency measurement. The A5 Counter Assembly performs this measurement, under control of the A3 processor. A5 Counter Assembly operates as a frequency counter and consists of a seven-decade counter, control logic circuits and an input multiplexer. The available gate-times are nominally 0.1, 1, or 10 seconds and will vary slightly with different probes. Variations are due to probe characteristics. Specific gate times are specified in their companion calibration modules. The crystal characteristics of frequency-versus-temperature, as characterized in the calibration module, provide an effective characteristic slope of 1000 Hz/°C, through the temperature range.

8-38. Measurement accuracy is dependent on two things:

a. The internal or external clock accuracy.

b. The characterization of each probe crystal and the storing of this information in its companion calibration module to provide a characteristic slope of 1000 Hz/°C. The calibration module stores parameters necessary for the frequency-to-temperature conversion algorithm which are specific to the individual probe.

8-39. Measurement resolution is achieved through the instrument's capability of measuring frequency in the Hz and tenths-of-Hz ranges. As an example, assume that the basic frequency is 28.208000 MHz:

a. With a selected gate-time of 0.1 second (LOW RESOLUTION), the contents of the seven-decade counter in A5 would be 2820800. This is a 10 Hz resolution which provides 10 milli-degrees temperature resolution.

b. With a selected gate-time of 1 second (MED RESOLUTION), the contents of the seven-decade counter in A5 would be 8208000. This is 1 Hz resolution which provides 1 milli-degree temperature resolution.

c. With a selected gate-time of 10 seconds (HIGH RESOLUTION), the contents of the seven-decade counter in A5 would be 208000.0 Hz. This is 1/10 Hz resolution which provides 100 micro-degrees temperature resolution.

8-40. Temperature measurements from two channels cannot be made simultaneously. Only one frequency-temperature measurement is made at one time. When two channels are used, or when temperature difference measurements are made, a time-skew of up to 20 seconds occurs in the HIGH RESOLUTION Mode. In Medium Resolution a time skew of nominally 2 seconds is experienced, and in Low Resolution the time skew is approximately 0.2 seconds.

8-41. A6 DIGITAL-TO-ANALOG CONVERTER

8-42. A6 Assembly converts digital temperature information on the instrument bus to an analog output at the instrument rear panel. The analog output voltage can be set to a calibrated value by the CAL switch on the instrument front panel. The CAL positions are 0V, 5V and 10V.

8-43. In the 0V position the analog output is zero volts dc which enables a strip-chart recorder pen to be adjusted for a precise left margin position. In the 10V position, the analog output is +10 volts dc, which enables a strip-chart recorder pen to be adjusted for a precise right margin position.

8-44. In the 5V position, the analog output is +5 volts, which enables a strip-chart recorder pen to be centered or adjusted for a 0V to 5V deflection range or a 5V to 10V deflection range.

8-45. There are two modes of operation for the analog output:

a. NORM Mode.

b. OFFSET Mode.

In the NORM Mode, the analog output voltage has a 0.00V to +9.99V range for digital data ranging between 000 and 999. In the OFFSET Mode, the analog output voltage is offset by +5V and has a 0.00V to +9.99V range for digital data ranging between 500 and (1)499.

8-46. In both the NORM and OFFSET Modes, a five-position front panel switch allows the selection of groups of three digits of displayed temperature, from 1 degree resolution to .0001 degree resolution.

8-47. A7 HP-IB ASSEMBLY

8-48. The A7 HP-IB Assembly provides remote programming and data output capability to the HP 2804A. A controller such as a computer or calculator feeds program control information, through the A7 Assembly, to the HP 2804A and performs calculations on temperature data from the Quartz Thermometer. Programmable features are:

Temperature Selection
Resolution Selection
System Status Read
Write To Analog Output
Configure for Group Execute Trigger
Sample and Hold
Configure for Interrupt Operation
Quartz Probe Serial Number Verification
Read of Thumbwheel Switch Settings

8-49. The HP-IB command implements the following interface functions, as defined in the HP-IB User's Guide:

Untalk
Unlisten
Remote/Local
Service Request

Parallel Poll
Device Clear
Device Trigger
Talk Only
Serial Poll

8-60. A8 MOTHERBOARD ASSEMBLY

8-61. A8 Motherboard interconnects the various assemblies in the instrument and has no active circuits.

8-62 A9 POWER SUPPLY/REAR PANEL ASSEMBLY

8-63. Assembly A9 consists of a power supply board and the rear panel mechanical parts assembly which together form one assembly. The rear panel portion of this assembly contains the power transformer, a 5 volt regulator, and connectors for the HP-IB and DAC options, external T1, T2 channel inputs and external clock input.

8-64. The A9 Power Supply Board generates all dc voltages needed by the instrument circuits.

Voltages are:

+5 Vdc regulated at 2.3 Amp maximum.
+5 Vdc standby at 17 mA maximum.
−5 Vdc at 40 mA maximum.
−12 Vdc at 22 mA maximum.
+17 Vdc unregulated at 62 mA maximum.

8-65. In the STANDBY position of front panel power switch, all supplies except the main +5 Vdc remain on. Operating ac power is not turned off.

8-66. HP-IB INSTALLATION

8-67. Cables are available in different lengths to suit user requirements. The connectors at either end of the cable are identical. The plugs will mate with the rear panel connector on the HP 2804A. The receptacle on the back of the cable connector will receive another cable plug.

8-68. A Bus Interface Kit is needed to use a Hewlett-Packard calculator as the HP-IB controller. Information about this kit may be obtained from the nearest Hewlett-Packard Sales and Service Office.

8-69 MAXIMUM CABLE LENGTH

8-60. As many as 15 instruments can be connected in parallel. (Be sure to count the calculator when counting the number of devices in the system). However, observe the following rules:

a. The total cable length for the system must be less than or equal to 20 meters (65 ft.).

b. The total cable length for the system must be less than or equal to 2 meters (6 ft.) times the total number of devices connected to the bus.

For instance, a system with one calculator and one HP 2804A would allow 4 meters (12 ft.) of cable.

8-61. ADDRESS SELECTION

8-62. The HP-IB address selector switch is located on the HP-IB PC board assembly A7. The switch is preset at the factory for:

	ASCII	Binary
Talk Address	M	1001101
Listen Address		0001101

MSB LSB

The last five bits in the binary code are switch selectable. The first two digits (most significant) are "hard wired" into the HP-IB circuitry.

8-63. To change the address of the HP 2804A, follow this procedure:

a. Turn off the power switch and unplug the power cord.

b. Release the top cover by unscrewing one screw located at the rear and center-edge of the top cover.

c. Remove the top cover.

d. The address selector switch is seven SPST switches contained in a dual-in-line (DIP) package. Figure 8-3 shows the switch with the factory preset values.

e. The switch settings may now be changed with a pointed instrument (like a pencil or pen).

NOTE

Do not set all address switches to the "1" position. This code is reserved for special use.

8-64. SIGNATURE ANALYSIS

8-65. Signature Analysis is an easy method of testing complex microprocessor-based circuits. It is comprised of "data compression" and "circuit generated stimulus" refined to provide greater ease in locating faults.

8-66. The Signature Analyzer displays a unique four digit "fingerprint" of the data stream present at each node in the circuit under test. By comparing these measured signatures to the correct ones, a service technician can back-trace to a faulty node. Additional detailed information on Signature Analysis is available from Hewlett-Packard. Order Application Note 222 "A Designer's Guide to Signature Analysis", HP Part Number 02-5952-7466.

8-67. MECHANICAL ACCESS AND DISASSEMBLY

CAUTION

Power is present in instrument regardless of "LINE" switch position.

WARNING

115 Vac is exposed at the rear panel, bottom side of the instrument when bottom cover is removed and ac power is applied.

8-68. In order to perform any adjustments, troubleshooting or removal of Front Panel/Display or Rear Panel/Power Supply Assemblies, instrument covers must be removed. Both top and bottom covers are secured by one screw each, located at the rear of the instrument and in the center of the cover rear-edge (see Figure 6-1).

NOTE

AC POWER DOES NOT HAVE TO BE REMOVED FOR COVER REMOVAL.

MSB				LSB	ASCII LISTEN ADDRESS	ASCII TALK ADDRESS
0	0	0	0	0	SP	@
0	0	0	0	1	!	A
0	0	0	1	0	"	B
0	0	0	1	1	#	C
0	0	1	0	0	$	D
0	0	1	0	1	%	E
0	0	1	1	0	&	F
0	0	1	1	1	'	G
0	1	0	0	0	(	H
0	1	0	0	1	)	I
0	1	0	1	0	*	J
0	1	0	1	1	+	K
0	1	1	0	0	,	L
0	1	1	0	1		M
0	1	1	1	0	.	N
0	1	1	1	1	/	O
1	0	0	0	0	0	P
1	0	0	0	1	1	Q
1	0	0	1	0	2	R
1	0	0	1	1	3	S
1	0	1	0	0	4	T
1	0	1	0	1	5	U
1	0	1	1	0	6	V
1	0	1	1	1	7	W
1	1	0	0	0	8	X
1	1	0	0	1	9	Y
1	1	0	1	0	:	Z
1	1	0	1	1	;	[
1	1	1	0	0	<	\
1	1	1	0	1	=	]
1	1	1	1	0	>	^

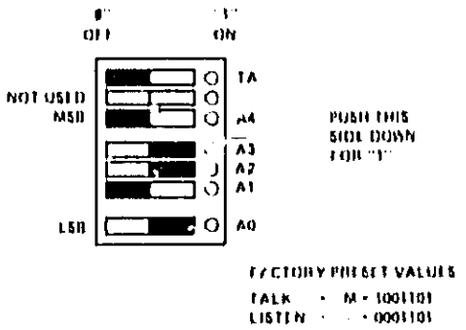


Figure 8-3. HP-IB Address Selection

8-63. FRONT PANEL ASSEMBLY REMOVAL

8-70. To remove the A1A1 and A1A2 assemblies, do the following:

a. Disconnect ac power and remove the calibration modules.

b. Remove the top cover.

c. Disconnect the flat ribbon connectors from A1A2 and A2 Assemblies.

d. Remove the right and left side-trims and then four side-screws securing the Front Panel/Display Assembly to the instrument frame.

e. Pull the Front Panel Assembly forward until it is free of the instrument frame. The LINE Switch pushbutton cap will come free.

f. Remove three retaining clips securing the plastic lens to the sub-panel. The RFI shield will be released with the lens.

g. The A1A1 Display Assembly and the A1A2 Driver Assembly are interconnected through J1 and J3 pins. The interconnected assemblies are secured to the front panel by six screws. Remove these screws to remove A1 assembly.

h. To reassemble and reinstall the Front Panel Assembly reverse the procedure of steps a through g.

8-71. REAR PANEL ASSEMBLY REMOVAL

8-72. To remove the Rear Panel/A9 Power Supply Assembly, do the following:

a. Disconnect the ac power cord.

b. Remove the top and bottom covers and the four rear feet.

c. Disconnect the HP-IB flat ribbon connector from A7.

d. Disconnect the coaxial cables from A3, A5 and A6.

e. Carefully ease the Rear Panel/A9 Power Supply Assembly out of the instrument frame.

f. To remove the A9A1 printed circuit board, unsolder all wires except the wires connected to the A9A1 "SW" circuit pads.

g. Remove four screws securing A9A1 to the rear panel standoffs.

h. To reassemble and reinstall A9A1, and the Rear Panel Assembly, reverse the procedures of steps a through g.

8-73. MAINTENANCE

8-74. Maintenance consists of Periodic-type and Failure-type maintenance.

8-75. PERIODIC MAINTENANCE

8-76. Periodic maintenance should be done at least once-per-year. It consists of preventive maintenance and Adjustment. Preventive maintenance consists of incorporating any modifications to the instrument and cleaning of all assemblies to minimize leakage paths etc.

8-77. Following any preventive maintenance, do the tests of Section IV.

8-78. As part of the Periodic Maintenance cycle, do the Adjustment procedures of Section V.

8-79. FAILURE-TYPE MAINTENANCE

8-80. This type of maintenance identifies the failure and troubleshoots the instrument to locate the defective part. See the troubleshooting procedures starting with paragraph 8-86.

8-81. COMPONENT REPLACEMENT

8-82. Failed components can be replaced by any of three methods:

a. CLIP-OUT. Failed component is clipped from the circuit board and the lead remains are then desoldered and removed.

b. VACUUM DEVICE. A vacuum device, such as the "Soldapullt®[1]" Model DS-017, is used in conjunction with a soldering iron to remove melted solder from the terminals.

c. DESOLDERING BRAID. A copper braided-wire, such as "Solder Wick®[2]" #2 size, is used in conjunction with the soldering iron, to absorb the melted solder.

®[1] Edsyn Co.

®[2] Solder Removal Co.

8-83. SOLDERING

8-84. Integrated circuits or the printed-circuit boards can be damaged by excess heat. IC's can also be damaged by static charges (from handling or from the soldering iron) when installing them. The recommended soldering iron to use is the "Ungar, 3-wire" type with a 35-watt maximum heat element and the "Ungar, Micro-Spade" tip. The recommended solder is "Kester Rosin-Core 60/40" with a diameter of .032 inches. This diameter works very well with IC pins and leaves minimum residue.

8-85. CLEANING. Cleaning the board and component after soldering is important. Use a cleaning solution such as Relinsolv No. 563*3. Apply the solution with a small, stiff-bristle brush and scrub the area previously soldered. No residue remains after the solution dries.

8.86 TROUBLESHOOTING

8-87. To troubleshoot the HP 2804A, use the procedures of paragraph 8-90. When one of the tests (0-9) fail, go to the appropriate subassembly indicated in the test. Signatures found on each assembly are listed in a table located adjacent to the respective schematic diagram of that assembly.

WARNING

With the bottom cover removed, 115 Vac is exposed at the rear of the instrument.

8-88. USING THE K96-59991A DIAGNOSTIC KIT

8-89. PRELIMINARY SETUP

NOTE

Throughout the remainder of the manual the K96-59991A will be referred to as the "Diagnostic Kit".

8-90. To begin testing or troubleshooting the HP 2804A with the Diagnostic Kit and HP 5004A Signature Analyzer, perform the following:

a. Disconnect ac line cord.

CAUTION

Damage to the instrument may result if connecting cables or PC assemblies are inserted or removed with the line cord connected to an energized outlet, EVEN IF THE LINE SWITCH IS IN THE STANDBY POSITION. Only +5 Vdc is disabled by the LINE switch, and hazardous voltages may be present within the instrument in STANDBY.

b. Remove the A3 Microprocessor Assembly. Disconnect RF cable to A3 and place cable end clear of all instrument assemblies.

c. Remove the A7 HP-IB Assembly (if instrument is equipped with Option 010). Remove flat ribbon cable from A7.

d. Place Diagnostic Kit in right-most slot of the 2804A.

e. Place A3 Microprocessor Assembly on top of Diagnostic Kit in connector provided.

f. Connect a GND test point on the Diagnostic Kit to TP2 on A3 Assembly, using jumper provided. This inhibits the time base generator interrupt to the microprocessor.

g. Connect control lines from the 5004A Signature Analyzer to the labeled test points on the Diagnostic Kit. Turn power on to the 5004A, then set front panel controls as follows:

*3 Alpha Metals Inc.

START (In)	HOLD (Out)
STOP (In)	SELFTEST (Out)
CLOCK (In)	

h. Verify 2804A LINE switch is in STANDBY position. Re onnect line cord to an energized outlet of the correct voltage for the instrument under test.

8-01. The Diagnostic/Functional Test should proceed from Test 0 through Test 9 in sequence. This is important because later tests assume functionality of other assemblies, and a given test result may be inconclusive if prior test results are not all positive.

8-02. The instructions given here assume that the instrument under test/repair works. If any tests fail, refer to the troubleshooting procedure opposite the schematic diagram of the assembly that fails. These troubleshooting procedures include all necessary information for signature analysis troubleshooting with the 5004A.

TEST NUMBER: 0

Assembly Under Test:

A3 Microprocessor Assembly

Explanation of Test:

This test consists of three parts:

1) Diagnostic Board RAM Test.

2) Diagnostic Board ROM Checksum Test.

3) Microprocessor circuitry exercise.

Following the Pass/Fail indication as displayed on the test annunciators on the Diagnostic Kit, the software causes the microprocessor to exercise the circuit under test. This occurs regardless of the test results, allowing the service technician to use the HP 5004A to locate faulty signatures.

The test may be repeated by pressing the RESET pushbutton on the Diagnostic Kit.

Procedure:

1. Select Test "0" on the thumbwheel selector switch of the Diagnostic Kit.

2. Press the RESET pushbutton on the Diagnostic Kit.

3. The three test annunciators (Red, Yellow, Green) should light momentarily, then extinguish for approximately two seconds.

4. One test annunciator should then light for approximately two seconds indicating test results:

   RED = "Fail" functional self-test.
   GREEN = "Pass" functional self-test.

5. All three test annunciators should now light and remain lighted. This enters the signature analysis loop.

6. If this test fails refer to the suggested troubleshooting sequence opposite the schematic diagram of the A3 Microprocessor Assembly.

TEST NUMBER: 1-3

Assembly Under Test:

A4 Memory Assembly

Explanation of Test:

The three tests are as follows:

1) RAM Memory Pattern Test.

2) Program ROM Checksum Test.

3) Address Decoding Test.

Following the Pass/Fail indication as displayed on the test annunciators on the Diagnostic Kit, the software causes the microprocessor to exercise the circuit under test. This occurs regardless of the test results, allowing the service technician to use the HP 5004A to locate faulty signatures.

The test may be repeated by pressing the RESET pushbutton on the Diagnostic Kit.

Procedure:

1. Select Test "1" on the thumbwheel selector switch of the Diagnostic Kit.

2. Press the RESET pushbutton on the Diagnostic Kit. The IN PROCESS annunciator (YELLOW) should light for approximately 3 seconds.

3. Observe the three test annunciators as follows:

   GREEN lamp only = "Pass", go on to step 4.
   RED and YELLOW lamps both = "Fail", suspect RAM A4U4 or possible address decoding fault. Refer to the suggested troubleshooting sequence opposite the schematic diagram of the A4 Memory Assembly.
   RED lamp only = "Fail", suspect RAM A4U8. Refer to the suggested troubleshooting sequence opposite the schematic diagram of the A4 Memory Assembly.

4. Select Test "2" on the thumbwheel selector switch of the Diagnostic Kit.

5. Press the RESET pushbutton on the Diagnostic Kit. The IN PROCESS annunciator (YELLOW) should light for approximately 1 second.

6. Observe the three test annunciators as follows:

   GREEN lamp only = "Pass", go on to step 7.
   RED lamp only = "Fail", suspect ROM A4U7. Refer to the suggested troubleshooting sequence opposite the schematic diagram of the A4 Memory Assembly.

7. Select Test "3" on the thumbwheel selector switch of the Diagnostic Kit.

8. Press the RESET pushbutton on the Diagnostic Kit. The IN PROCESS annunciator (YELLOW) should light for approximately 2 seconds.

9. Observe the three test annunciators as follows:

   GREEN lamp only = "Pass", test is complete.
   RED lamp only = "Fail", suspect address decoding circuitry. Refer to the suggested troubleshooting sequence opposite the schematic diagram of the A4 Memory Assembly.

TEST NUMBER: 4

Assembly Under Test:

A1 Display/Switch Assembly

Explanation of Test:

This procedure is a combined functional/diagnostic test. It requires manipulation of front panel switches to increment each portion of the test. The sequence is as follows:

1) All LED's illuminated.

2) Individual 7-segment displays illuminated.

3) Individual LED annunciators illuminated.

4) Pushbutton switches tested.

5) Analog Outputs slide switches tested.

The test may be repeated by pressing the RESET pushbutton on the Diagnostic Kit.

Procedure:

1. Select Test "4" on the thumbwheel selector switch of the Diagnostic Kit.

2. Press the RESET pushbutton on the Diagnostic Kit.

3. Observe the 7-segment displays and annunciator LED's. All decimal points (to the right of each digit) and all segments of each display should illuminate. The right-most digit should appear as an "E" without right-hand decimal point. All annunciator LED's should illuminate. It is normal for the left-most digit to be slightly brighter than the rest.

4. If all digits illuminate as expected, press any front panel pushbutton to advance test. If test does not advance, refer to the suggested troubleshooting sequence opposite the schematic diagram for the A1A2 Driver Assembly.

5. The right-most digit (before the °C/°F digit) should illuminate "8". All other digits should be blanked.

6. Press any front panel pushbutton switch to increment test. Each time the digit to the left should illuminate instead. Do this six times until all digits have been checked.

7. The 6 pushbutton LED's and the 5 annunciator LED's should illuminate in sequence — top-to-bottom, right-to-left, with only a single LED illuminated at a time.

8. Press any pushbutton switch to advance to the next test. The right-most pushbutton should have its LED illuminated — all others will be blanked.

9. Press the pushbutton switch with the lighted LED momentarily, with a pause between each button. Continue until all six pushbuttons are pressed.

10. The sixth pushbutton advances to the optional part of the test.

    Display will read S-7. An annunciator will illuminate, reflecting the position of the left-most ANALOG OUTPUT switch. Moving the switch to each of its 5 positions will check switch contact integrity. Pressing any pushbutton switch will advance the test.

11. Same as step 10, except the right-most ANALOG OUTPUT switch is tested.

Display will read S-8. An annunciator will illuminate, reflecting the position of the right-most ANALOG OUTPUT switch. Moving the switch to each of its 5 positions will check switch contact integrity. Pressing any pushbutton switch will restart the test.

TEST NUMBER: 5

Assembly Under Test

A5 Counter Assembly

Explanation of Test:

This test consists of three parts:

1) Signal dropout detector test.

2) Counter performance test.

3) Sensor oscillator interface circuit test.

Following the Pass/Fail indication as displayed on the test annunciators on the Diagnostic Kit, the software causes the microprocessor to exercise the circuit under test. This occurs regardless of the test results, allowing the service technician to use the HP 5004A to locate faulty signatures.

The test may be repeated by pressing the RESET pushbutton on the Diagnostic Kit.

Procedure:

1. Select Test "5" on the thumbwheel selector switch of the Diagnostic Kit.

2. Press the RESET pushbutton on the Diagnostic Kit. The IN PROCESS annunciator (YELLOW) should light for approximately 2 seconds.

3. Observe the three test annunciators as follows:

   GREEN lamp only = "Pass", go on to next test.
   RED and YELLOW lamps both = "Fail", suspect signal dropout detector. Refer to the suggested troubleshooting sequence opposite the schematic diagram of the A5 Counter Assembly.
   RED LAMP ONLY = "Fail", suspect counter circuitry. Refer to the suggested troubleshooting sequence opposite the schematic diagram of the A5 Counter Assembly.

4. Press any pushbutton switch to advance to the next portion. A digit will appear on the display indicating the channel or channels upon which frequencies (greater than 1 MHz) are present. The channels are related to the counter board as follows:

   1 — T1 front panel input
   2 — T2 front panel input
   3 — T1 rear panel input
   4 — T2 rear panel input

5. Any combination of these may be present. Typically if T1 and T2 quartz temperature probes are attached to the sensor oscillators, and they are correctly cabled to the A5 Counter Assembly, the display will read "1 2 ".

TEST NUMBER: 6

Assembly Under Test:

A2 Preset/Oscillator Assembly

Explanation of Test

This is a combined functional/diagnostic test of the Preset portion of A2. This test consists of two parts:

1) Functional check of °C/°F switch.

2) Display of preset values.

Following the Pass/Fail indication as displayed on the test annunciators on the Diagnostic Kit, the software causes the microprocessor to exercise the circuit under test. This occurs regardless of the test results, allowing the service technician to use the HP 5004A to locate faulty signatures.

The test may be repeated by pressing the RESET pushbutton on the Diagnostic Kit.

Procedure:

1. Select Test "6" on the thumbwheel selector switch of the Diagnostic Kit.

2. Press the RESET pushbutton on the Diagnostic Kit.

3. Observe the three test annunciators as follows:

   GREEN lamp only = "Pass", go on to step 4.
   RED lamp only = "Fail", suspect bad preset circuitry. Refer to the suggested troubleshooting sequence opposite the schematic diagram of the A2 Preset/Oscillator Assembly.

4. Observe the instrument display and compare the numerical values to the thumbwheel settings of the front panel. These must be in agreement.

5. Record the settings of the front panel thumbwheel switches for use after this test. Rotate each thumbwheel switch through its range and compare the digits to the displayed value.

6. For signature analysis testing, set T1 switches to 966, and T2 switches to 178.

TEST NUMBER: 7

Assembly Under Test:

A6 Analog Output Assembly

Explanation of Test:

This is a combined calibration/functional/diagnostic test of the A6 Analog Output Assembly. This test consists of three parts:

1) 0V calibration.

2) 10V — full scale calibration.

3) Ramp generation for linearity, noise or "glitch" evluation.

The test results must be interpreted using external equipment.

Additional Test Equipment Required:

1) DC Digital Voltmeter

2) Oscilloscope

Procedure:

1. Connect DC DVM and oscilloscope (in parallel) to ANALOG OUT jacks on 2804A rear panel. Set DC DVM to 10V range. Set 2804A front panel ANALOG OUTPUT slide switch to 0V CAL position.

2. Select Test "7" on the thumbwheel selector switch of the Diagnostic Kit.

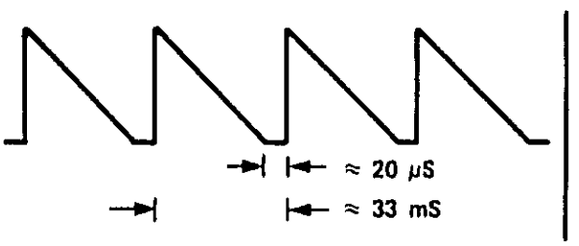
3. Press the RESET pushbutton on the Diagnostic Kit. The YELLOW annunciator will light and remain lit.

4. Observe DC DVM. Adjust A6R8 ZERO ADJUST potentiometer for DC DVM reading of 0.000 ±.001 Vdc.

5. Set 2804A front panel ANALOG OUTPUT slide switch to 10V CAL position.

6. Observe DC DVM. Adjust A6R5 FULL-SCALE ADJUST potentiometer for DC DVM reading of +10.000 ±.001 Vdc.

7. Set 2804A front panel ANALOG OUTPUT slide switch to OPerate NORMAL position. Observe oscilloscope waveform:



8. Failure of any test can be further diagnosed by selecting OPerate NORMAL to exercise the digital portion of the A6 Assembly. Refer to the suggested troubleshooting sequence opposite the schematic diagram of the A6 Analog Output Assembly.

TEST NUMBER: 8

Assembly Under Test:

A7 HP-IB Interface Assembly

Explanation of Test:

This is a combined functional/diagnostic test of the A7 HP-IB Interface Assembly. Test results are displayed as a series of H-codes on the 2804A display combined with the test annunciators on the Diagnostic Kit.

Following the Pass/Fail indication as displayed on the test annunciators and the instrument display, the software causes the microprocessor to exercise the circuit under test. This occurs regardless of the test results, allowing the service technician to use the HP 5004A to locate faulty signatures.

The test may be repeated by pressing the RESET pushbutton on the Diagnostic Kit.

Procedure:

1. Select Test "8" on the thumbwheel selector switch of the Diagnostic Kit.

2. Press the RESET pushbutton on the Diagnostic Kit.

3. Observe the three test annunciators as follows:

   GREEN lamp only = "Pass", go on to next test.
   RED lamp only = "Fail", error codes as follows:

   H-1 = Option not installed or circuitry failed gross functional test.
   H-2 = FIFO test fails on slave processor.
   H-3 = Group-Execute-Trigger (GET) fails to clear flip-flop.
   H-4 = GET fails to set flip-flop.

   Refer to the suggested troubleshooting sequence opposite the schematic diagram of the A7 HP-IB Interface Assembly.

4. Press any pushbutton switch to advance to the next portion.

5. The settings of the rocker switches on the A7 Assembly are shown on the front panel display. NOTE: There is one "don't care" switch, whose position is blanked in the display.

6. The test may be restarted at any point by pressing the RESET pushbutton on the Diagnostic Kit.

TEST NUMBER: 0

Assembly Under Test:

A3 Microprocessor Assembly

Explanation of Test:

This tests the interrupt processing capability of the A3 Microprocessor Assembly. No signature analysis capabilities are utilized. The Pass/Fail indication is displayed only with the test annunciators on the Diagnostic Kit.

Procedure:

1. Select Test "0" on the thumbwheel selector switch of the Diagnostic Kit.
2. Press the RESET pushbutton on the Diagnostic Kit.
3. Observe the three test annunciators as follows:

   GREEN lamp only = "Pass".
   RED lamp only = "Fail". Check the IRQ line to the microprocessor (stuck at logic "1"). Ensure program ROM is installed. Possible defective microprocessor.

4. Upon completion of Test 0, the instrument display should read "HP 2804A".

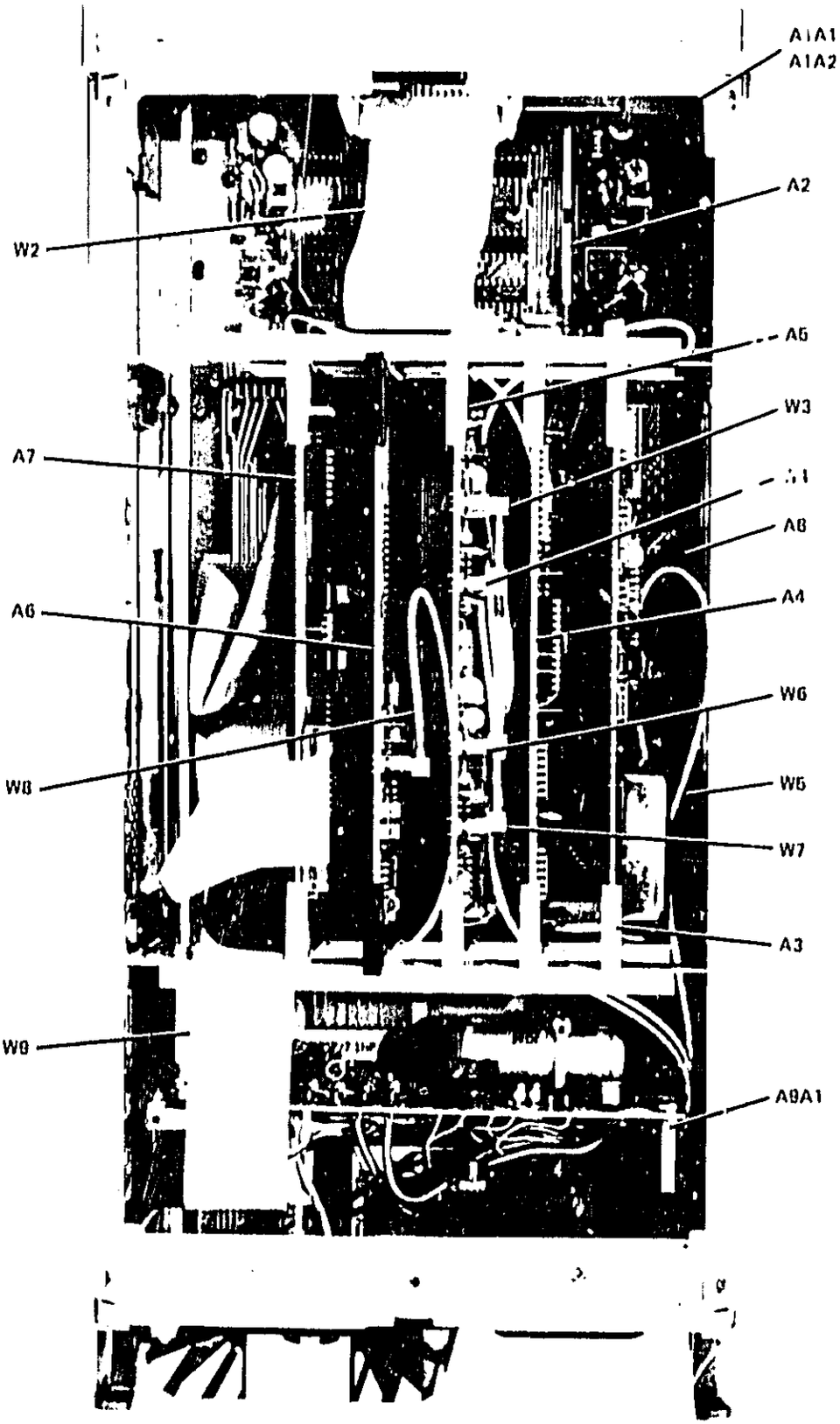


Figure 8-4. Replaceable Assembly Locator

Table 8-3. General Schematic Notes

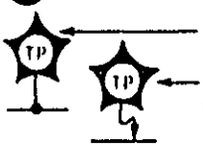
1. Component values are shown as follows unless otherwise noted:

   Resistance in ohms.
   Capacitance in microfarads.
   Inductance in millihenrys.

2. P/O - part of.

3.  Denotes wire color. Color code same as resistor color code. First number identifies base color, second number identifies wide strip, third number identifies narrow strip (e.g., 924 denotes white base, red wide strip, yellow narrow strip).

4.  Screwdriver adjustment.

5.  Test point. (Test points shown in this way are gold plated male pins.)

   Test point. (Test points shown in this way are accessible at the PC board tongue connector using a service extender board.)

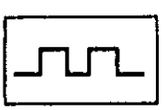
6. PC board assembly outline.

   Circuit stage outline

   Other assembly outline. Also used to indicate mechanical interconnection (ganging).

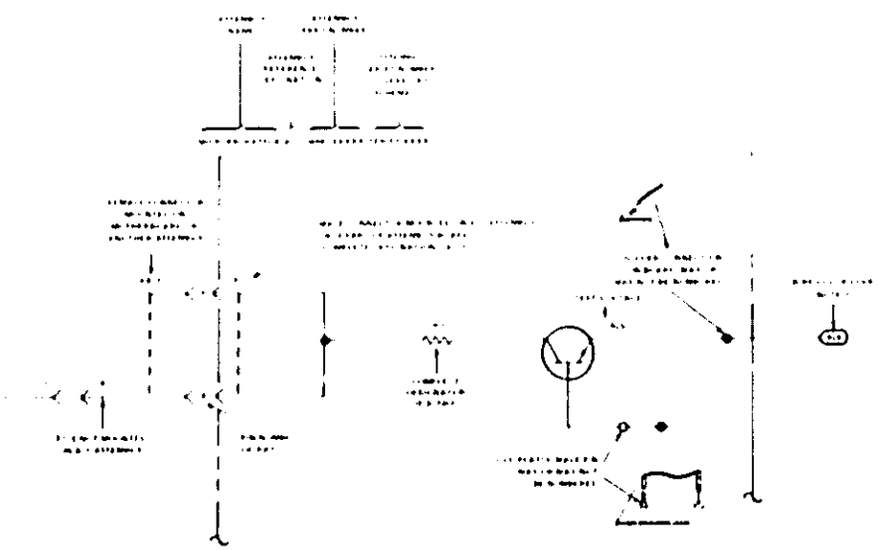
7.  Circuit common.

8.  Denotes front panel marking

9.  Waveforms and ac voltage measurements were made with respect to circuit common using an oscilloscope. The voltage levels shown on the waveforms are actual voltage levels and are not to be confused with oscilloscope setting. The voltage levels shown are nominal and may vary from one instrument to another. A variation of ±10% should be allowed.

10. +2.02V DC voltage levels were measured with respect to circuit common using a VTVM with 10 megohm input impedance. The voltage levels shown are nominal and may vary from one instrument to another. A variation of ±10% should be allowed.

11. A16R3 Reference designations. Partial reference designations are shown. Prefix with assembly designation for complete reference. See following drawing.



A1 DISPLAY ASSEMBLY

The A1 Assembly consists of two sub-assemblies – the A1A1 Display/Switch Board and the A1A2 Display Driver Board. The seven-segment displays and front panel switches are located on A1A1; the logic circuitry needed to decode the information to be displayed is located on A1A2.

The A1 Display Assembly performs two basic functions:

a. Updates the displayed information

b. Recovers switch status data from front panel switches

When the A3 MPU/Time Base Assembly generates a non-maskable interrupt (NMI) signal, an interrupt service routine operating at 1 kHz updates the displays and scans the front panel switches. One digit at a time is refreshed. As long as data is sent at about a 1 kHz rate, retriggerable one shot U5 allows digit-select data in registers U6 and U7 to remain stored. If the display is not refreshed at 1 kHz, U5 will time out, which resets U6 and U7, and blanks the display.

Seven-segment information is stored in registers U8 and U9. There are eight, seven-segment displays; seven are used for numerical temperature data, and the eighth is used for °C or °F indication. A ninth line controls seven of the ten annunciators; the remaining annunciators are controlled by unused segments of the °C/°F digit. The table below illustrates how this is accomplished:

SIGNAL	DS1-DS7	DS8 and Annunciators		Annunciators	
SA-H	Segment A	DS8	Segment A	DS11	LISTEN
SB-H	Segment B	DS12	SERVICE	DS10	TALK
SC-H	Segment C	DS12	DATA HOLD	DS14	T1
SD-H	Segment D	DS8	Segment D	DS15	T2
SE-H	Segment E	DS8	Segment E	DS16	T1-T2
SF-H	Segment F	DS8	Segment F	DS17	LOW
SG-H	Segment G	DS8	Segment G	DS18	MED
SDP-H	Decimal Point	DS9	REMOTE	DS19	HIGH

U11 and U12 buffer front panel switch information into the instrument data bus. The instrument address bus sends control signals through address decoder U10 which enable the segment and digit registers to update the display.

TROUBLESHOOTING/REPAIR

To use the table of signatures which follows, the information and instructions of paragraphs 8-90 through 8-92 and subsequent tests must have directed you to this assembly. Since the tests of paragraph 8-92 proceed from Test 0 through Test 9 in sequence, do not proceed to a particular assembly unless directed by instructions of Test 0 through Test 9.

If the Diagnostic Kit Test Card is suspect, refer to its Operating Note, HP Part Number 18109-90002 for test information.

Following repair, repeat the tests of paragraph 8-92.

NOTE 1: Recommended order of performing each test is as follows: (1) Set LINE switch to STANDBY, (2) select Test number on Diagnostic Kit, (3) set LINE switch to ON, and (4) push RESET switch on Diagnostic Kit.

NOTE 2: A clocking pulse with the same signature as the +5V reference means a leading edge triggered clock. A clocking pulse with a 0000 signature means a trailing edge triggered clock. It is normal if the 5004A Signature Analyzer interchanges these two signatures.

* = Voltage Level

+5V Reference Signature: P836

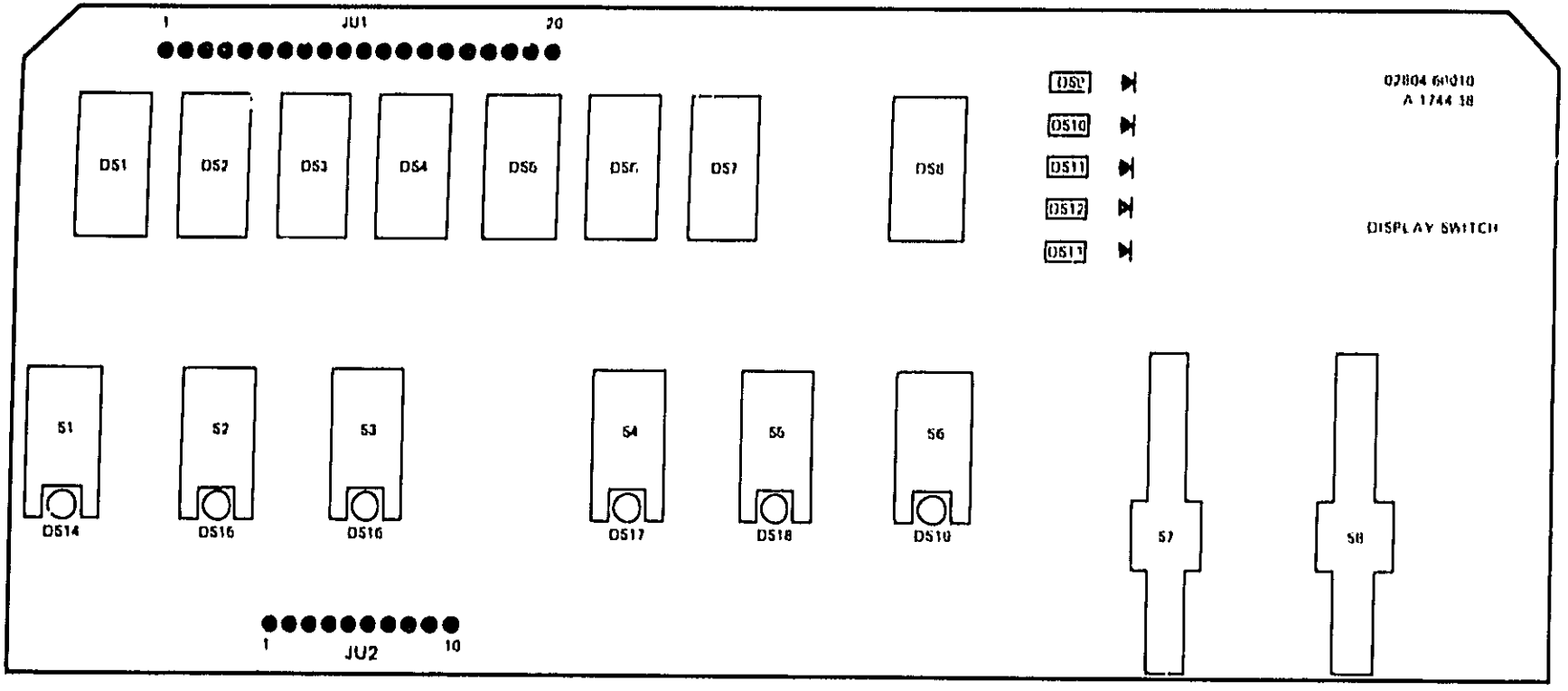
A1A2U1	Pin 1	P836*	8	CFP3
	2	UNST	9	UNST
	3	7663	10	77C4
	4	0000*	11	P836*
	5	3UUC	12	H1A4
	6	UNST	13	UNST
	7	UNST	14	0000*
A1A2U2	Pin 1	P836*	8	0000*
	2	UNST	9	UNST
	3	H7A2	10	P88F
	4	0000*	11	P836*
	5	992F	12	3A45
	6	UNST	13	UNST
	7	P836*	14	0000*

A1A2U3 – Segment Driver

A1A2U4 – Segment Driver

A1A2U5	Pin 1	0000*	9	0000*
	2	350A	10	P836
	3	P836*	11	26A3
	4	P836	12	FP95
	5	26A3	13	0000
	6	0000*	14	0000*
	7	0000*	15	0000*
	8	0000*	16	P836*
A1A2U6	Pin 1	26A3	9	CA43
	2	3UUC	10	H1A4
	3	C682	11	1886
	4	3077	12	77C4
	5	CFP3	13	PP07
	6	0UA2	14	0000*
	7	7663	15	0000*
	8	0000*	16	P836*
A1A2U7	Pin 1	26A3	9	4P46
	2	992F	10	P88F
	3	711A	11	00CA
	4	1886	12	3077
	5	0UA2	13	C682
	6	H273	14	3U94
	7	3A45	15	H7A2
	8	0000*	16	P836*

A1A2U8	Pin 1	P836*	9	350A
	2	46U0	10	2786
	3	APF6	11	FUC3
	4	HFA3	12	4P2U
	5	A623	13	PP07
	6	194C	14	3PC7
	7	U17H	15	H681
	8	0000*	16	P836*
A1A2U9	Pin 1	P836*	9	350A
	2	9704	10	75H8
	3	7U32	11	9HPP
	4	1886	12	3077
	5	0UA2	13	C6P2
	6	6646	14	P3PH
	7	CH73	15	OCHC
	8	0000*	16	P836*
A1A2U10	Pin 1	H352	9	P836*
	2	984F	10	P836*
	3	874C	11	P836*
	4	H0UC	12	P836*
	5	0U9A	13	CA43
	6	671F	14	4P46
	7	26A3	15	350A
	8	0000*	16	P836*
A1A2U11	Pin 1	P836*	9	C682
	2	P836*	10	0000*
	3	4P2U	11	3077
	4	0000*	12	0000*
	5	PP07	13	1886
	6	P836*	14	0000*
	7	0UA2	15	P836*
	8	0000*	16	P836*
A1A2U12	Pin 1	26A3	9	1886
	2	P836*	10	P836*
	3	0UA2	11	A623
	4	P836*	12	P836*
	5	PP07	13	HFA3
	6	P836*	14	P836*
	7	4P2U	15	26A3
	8	0000*	16	P836*


1
JU1
20
DS1
DS2
DS3
DS4
DS5
DS6
DS7
DS8
DS9
DS10
DS11
DS12
DS13
02804 60010
A 1744 38
DISPLAY SWITCH
S1
S2
S3
S4
S5
S6
S7
S8
DS14
DS15
DS16
DS17
DS18
DS19
1
JU2
10

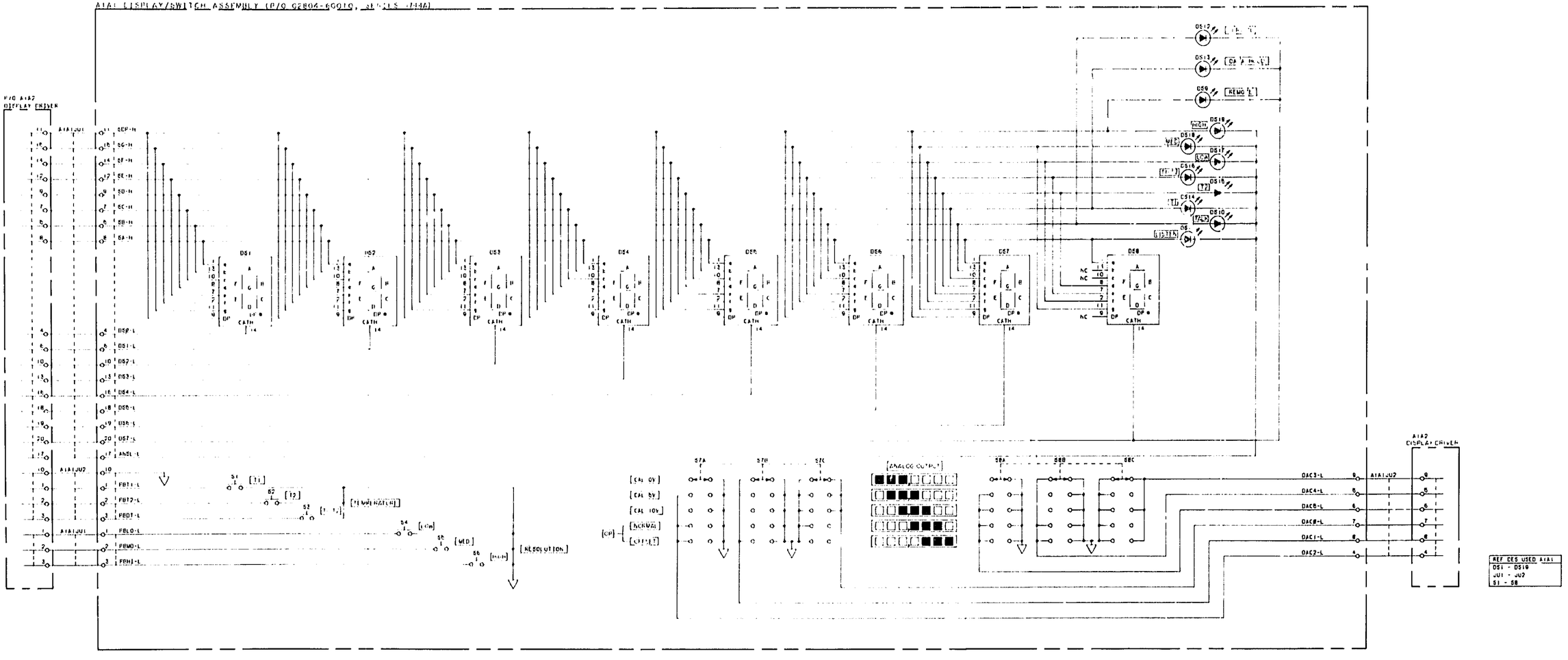
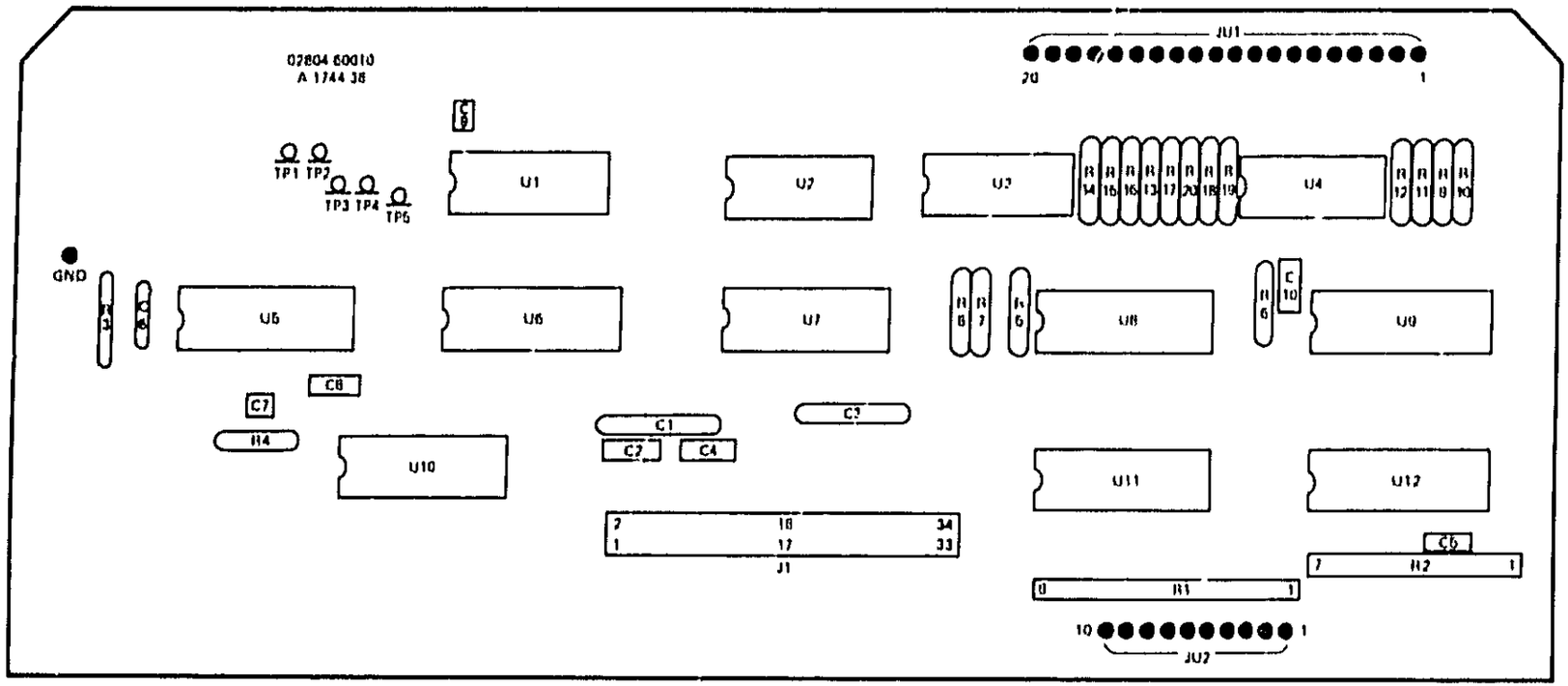


Figure 8-5. A1A1 Display Switch Assembly


02804 60010
A 1744 36
J01
20
1
TP1 TP2 TP3 TP4 TP5
GND
U1
U2
U3
U4
U5
U6
U7
U8
U9
U10
U11
U12
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
R1
R2
J1
J02
10

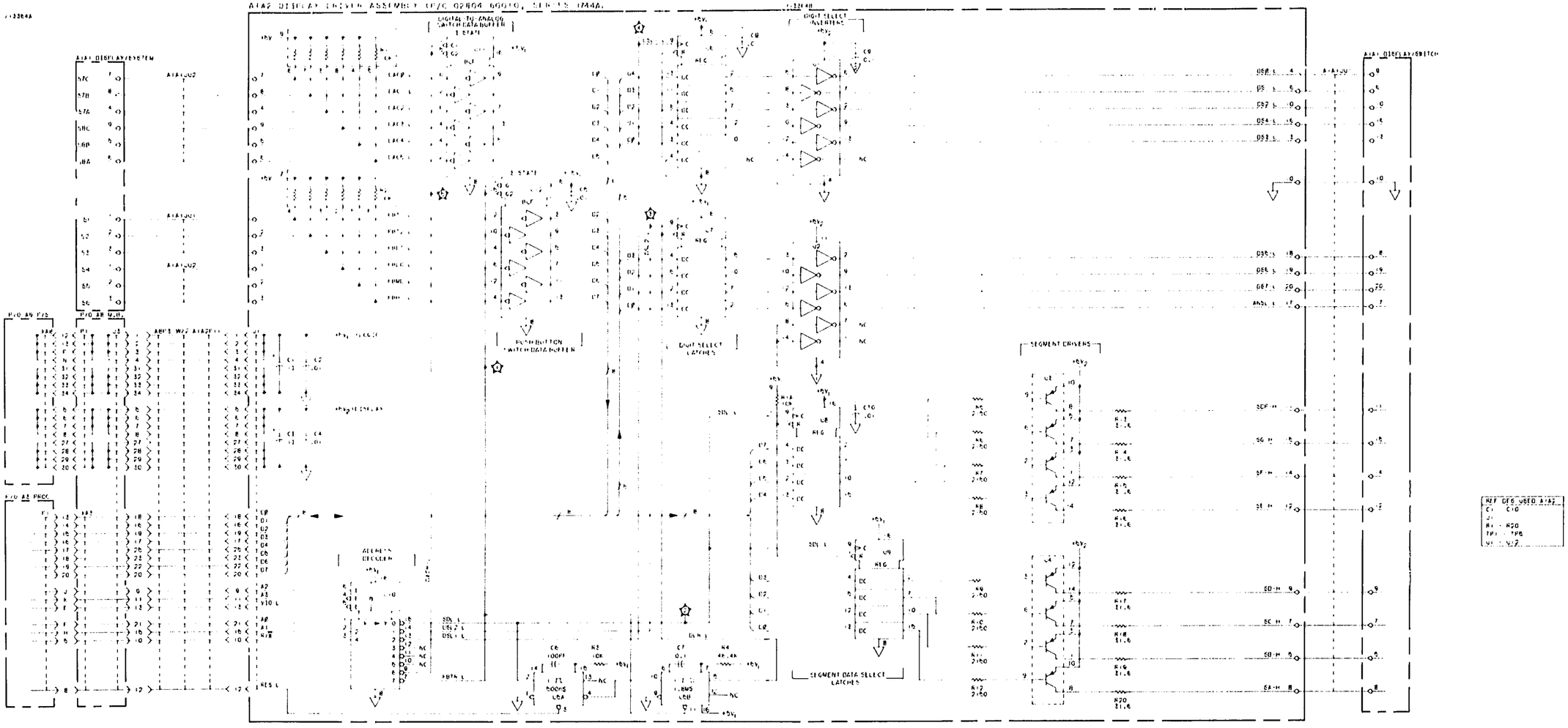


Figure 8-6. A1A2 Display Driver Assembly

A2 OSCILLATOR/PRESET ASSEMBLY

The A2 Assembly provides two sensor oscillators (one for each channel) for the quartz temperature probes, the °C/°F switch, and six 10-digit thumbwheel switches (three for each channel) to compensate for quartz probe aging. The thumbwheel switches are user-adjusted during a temperature reference adjustment.

Switches S1-S3 are connected to multiplexers U2 and U4 and switches S4-S6 are connected to multiplexers U3 and U5. The °C/°F switch is connected to U3. The multiplexers have three-state outputs connected directly to the instrument data bus. Address lines A2, A3 and Valid Input/Output (VIO-L) through address decoder U1 generate the low enable strobe signal for each multiplexer. Address lines A1 and A0 select data inputs from the thumbwheel switches and the °C/°F select switch as follows:

ADDRESS LINES		U2-U5 INPUT PORTS	SWITCH OUTPUTS
A1	A0		
0	0	0	S1/S4 outputs
0	1	1	S2/S5 outputs
1	0	2	S3/S6 outputs
1	1	3	°C/°F switch

LC sensor oscillators Q3 and Q4 are frequency-controlled by the quartz temperature probe (when connected). The oscillator outputs are routed through broad-tuned RF amplifier/buffers Q1 and Q2 to output connectors J1 and J2. Coaxial cables carry the 28 MHz RF to the A5 Counter Assembly.

The A5 Assembly provides the operating voltage for the sensor oscillators via the same coaxial cables carrying the 28 MHz RF. Assuming the quartz temperature probes are connected, the sensor oscillators will continue to oscillate even if the front panel LINE switch is in STANDBY position.

TROUBLESHOOTING/REPAIR

To use the table of signatures which follows, the information and instructions of paragraphs 8-90 through 8-92 and subsequent tests must have directed you to this assembly. Since the tests of paragraph 8-92 proceed from Test 0 through Test 9 in sequence, do not proceed to a particular assembly unless directed by instructions of Test 0 through Test 9.

If the Diagnostic Kit Test Card is suspect, refer to its Operating Note, HP Part Number 18109-90002 for test information.

Following repair, repeat the tests of paragraph 8-92.

NOTE 1: Recommended order of performing each test is as follows: (1) Set LINE switch to STANDBY, (2) select Test number on Diagnostic Kit, (3) set LINE switch to ON, and (4) push RESET switch on Diagnostic Kit.

NOTE 2: A clocking pulse with the same signature as the +5V reference means a leading edge triggered clock. A clocking pulse with a 0000 signature means a trailing edge triggered clock. It is normal if the 5004A Signature Analyzer interchanges these two signatures.

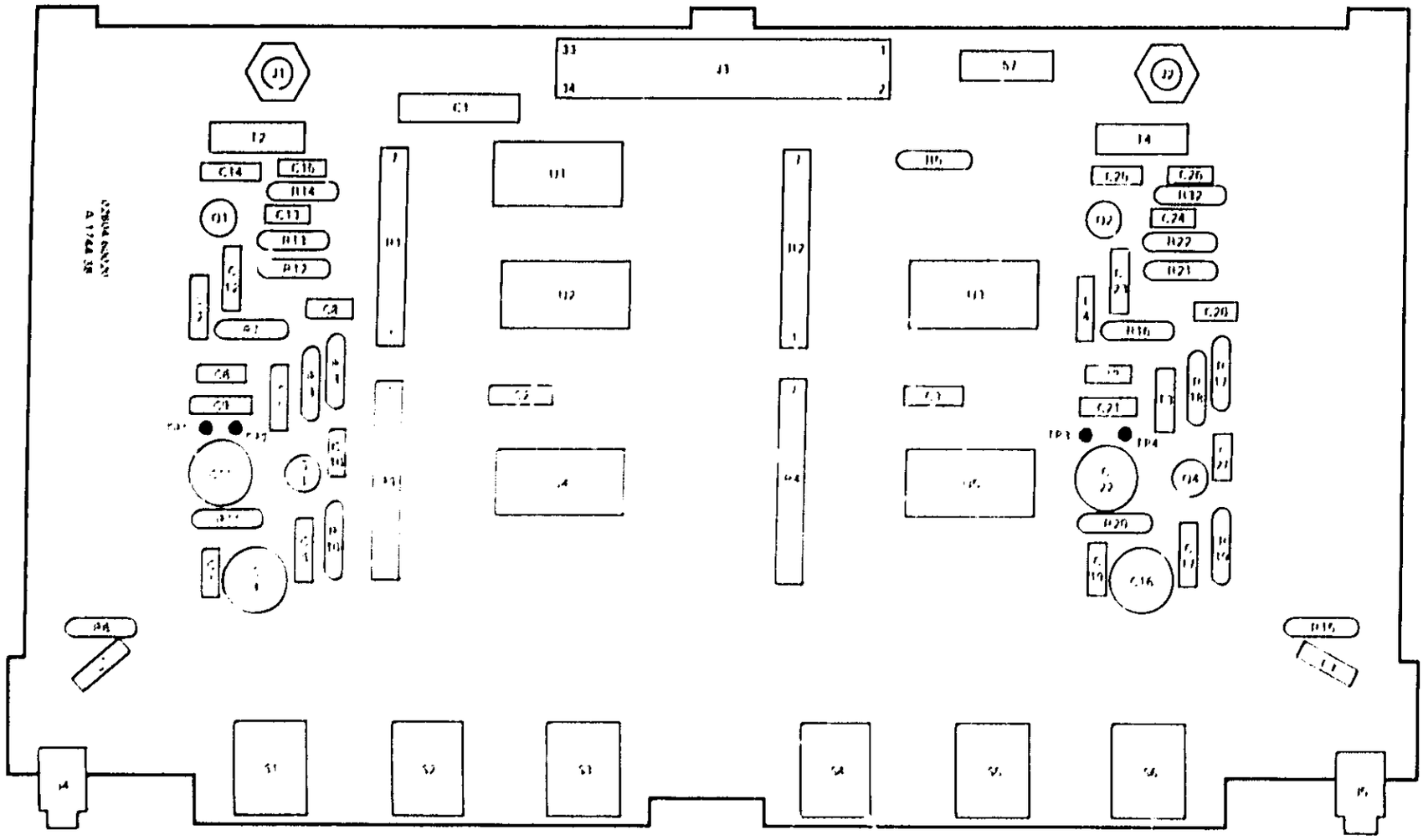
NOTE 3: 2804A front panel thumbwheel settings: T1-966, T2-178.

* = Voltage Level

+5V Reference Signature: 96F6

Press Diagnostic Kit RESET switch and HP 5004A data probe's RESET switch; then press any pushbutton on 2804A front panel.

U1	Pin 1	0000*	8	6660			
	2	0000*	9	U3A6			
	3	0000*	10	5F84			
	4	6660	11	UU9C			
	5	0000*	12	96F6*			
	6	U3A6	13	0000*			
	7	0000*	14	96F6*			
U2	Pin 1	U3A6	9	C4C4			
	2	A878	10	96F6*			
	3	0000*	11	0000*			
	4	96F6*	12	0000*			
	5	96F6*	13	0000*			
	6	0000*	14	7366			
	7	2326	15	U3A6			
	8	0000*	16	96F6*			
U3	Pin 1	U3A6	9	FAUF			
	2	A878	10	96F6*			
	3	0000*	11	96F6*			
	4	96F6*	12	0000*			
	5	0000*	13	0000*			
	6	96F6*	14	7366			
	7	H619	15	U3A6			
	8	0000*	16	96F6*			
U4	Pin 1	U3A6	9	70F0			
	2	A878	10	0000*			
	3	0000*	11	96F6*			
	4	0000*	12	96F6*			
	5	0000*	13	0000*			
	6	96F6*	14	7366			
	7	29A2	15	U3A6			
	8	0000*	16	96F6*			
U5	Pin 1	U3A6	9	499A			
	2	A878	10	96F6*			
	3	0000*	11	0000*			
	4	96F6*	12	96F6*			
	5	0000*	13	0000*			
	6	0000*	14	7366			
	7	5H6P	15	U3A6			
	8	0000*	16	96F6*			



A2 OSCILLATOR/PRE-SET ASSEMBLY (02804-60021, SERIES 2428)

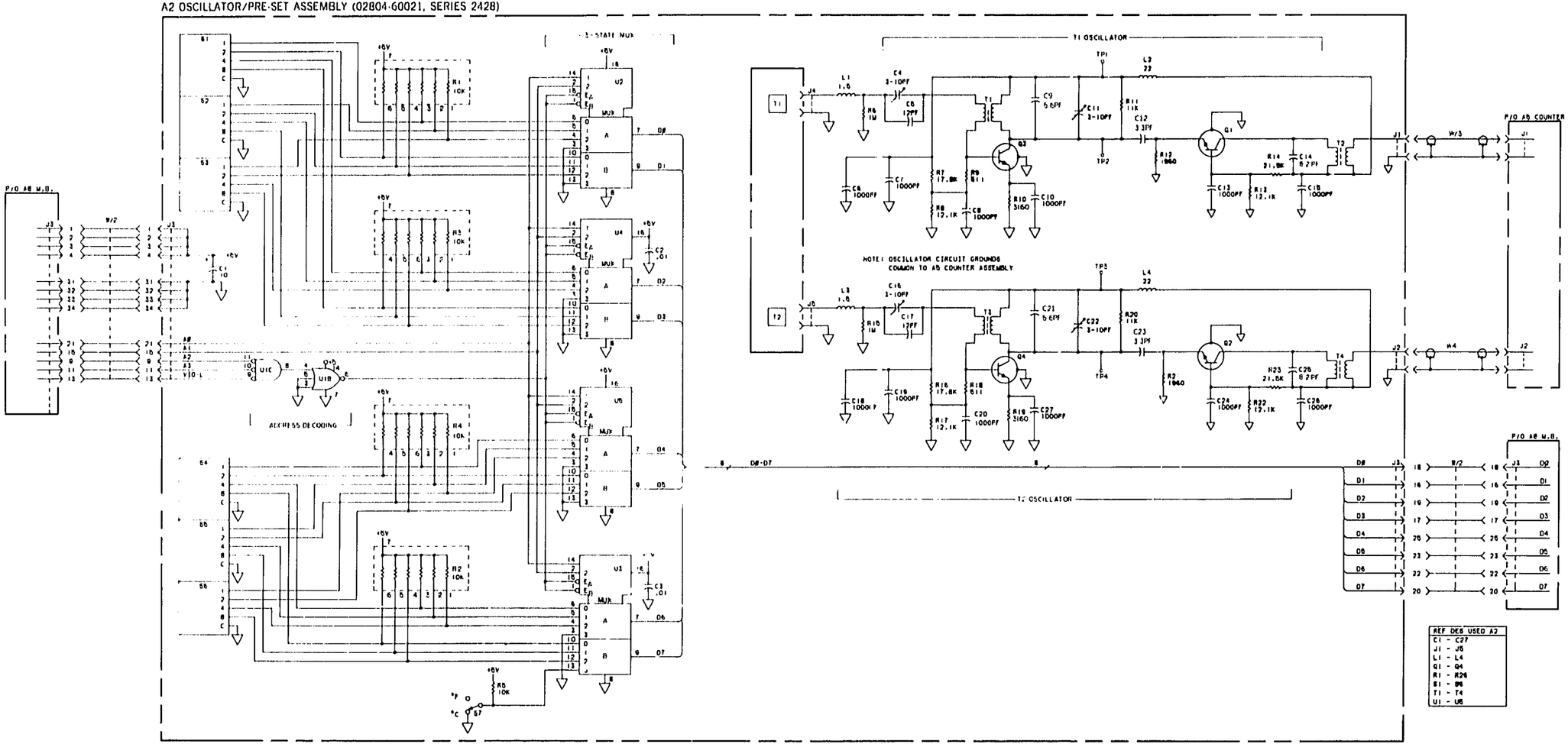


Figure 8-7. A2 Oscillator/Preset Assembly

A3 MICROPROCESSOR/TIME BASE ASSEMBLY

The A3 Assembly consists of five functional blocks:

a. Time base generator
b. Restart circuitry
c. Microprocessor and surrounding circuitry
d. Clock generator
e. Data-bus-enable circuitry

The microprocessor requires a two-phase 1 MHz clock for operation. Depending on the position of rear panel INT/EXT switch, multiplexer U10 chooses from either an internal TCXO, or an external frequency standard.

The internal time base begins with 10 MHz temperature-compensated crystal oscillator (TCXO) Y1. The TCXO is powered from independent +5V and -5V sources, which keep power applied even when the front panel LINE switch is in the STANDBY position. The 10 MHz TCXO signal is divided by ten in counter U9A, then applied to one input of multiplexer U10.

If an external 1 MHz time base is desired, it is connected to the rear panel EXT CLOCK jack J . The external 1 MHz is shaped and level-shifted through Q3 and Q4 and applied to multiplexer U10.

The 1 MHz output of multiplexer U10 is applied to a divide-by-1000 chain to produce the front panel switch-scan and display-refresh signals and system timing for counter control circuits. The divide-by-1000 chain is composed of counters U9B and U5A/B and synchronizing flip-flops U6A/B. This 1 kHz signal becomes the non-maskable interrupt (NMI) signal for the microprocessor.

Restart circuit U3A is a 200 mS one-shot multivibrator. The restart pulse is applied to the divide-by-1000 chain to provide a time delay between restart and the first NMI signal to allow the program to start over again. Any measurements in progress are restarted automatically to prevent any errors. The restart pulse is triggered in one of two ways:

a. When the front panel LINE switch is set to ON, the R5-C6 delay as the +5V power supply comes up to voltage generates a restart pulse.
b. When the rear panel INT/EXT switch position is changed, it momentarily disconnects the ground from the Restart Request (RRQ-L) line, then grounds it again, which triggers U3A and generates a restart pulse.

Three state buffers U8 and U13 allow bi-directional data transfer between microprocessor U7 and the instrument data bus. The direction of data flow is determined by the inverted Read/Write (R/W) pulse from U7. To allow signature analysis troubleshooting with the Diagnostic Kit, shunt JU1 can be removed to disconnect the data bus (for free-run test). Address buffers U11 and U12 allow microprocessor U7 to control other instrument circuitry (via address bus A0-A15).

The clock generator is composed of U1A/E/F, U2, Q1 and Q2. This circuit is basically a toggle flip-flop which changes the 1 MHz input signal into two, out-of-phase, non-overlapping 1 MHz clocks ϕ1 and ϕ2. The propagation delays of U1 and U2 ensure that ϕ1 and ϕ2 signals do not overlap. Q1 and Q2 are level boosters which ensure +5V levels to microprocessor U7. The combinations of CR1/C11 and CR2/C12 ensure a fast level change. The ϕ2 clock at TTL levels is also applied to other circuitry through inverter U4E.

Data-bus-enable one-shot U3B is a high stability 150 nS multivibrator. The trailing edge of clock ϕ1 triggers U3B, which keeps data output from microprocessor U7 on the data bus for a minimum of 40 nS after the trailing edge of clock ϕ2 goes low.

TROUBLESHOOTING/REPAIR

To use the table of signatures which follows, the information and instructions of paragraphs 8-00 through 8-02 and subsequent tests must have directed you to this assembly. Since the tests of paragraph 8-02 proceed from Test 0 through Test 9 in sequence, do not proceed to a particular assembly unless directed by instructions of Test 0 through Test 9.

If the Diagnostic Kit Test Card is suspect, refer to its Operating Note, HP Part Number 18109-00002 for test information.

Following repair, repeat the tests of paragraph 8-02.

NOTE 1: Recommended order of performing each test is as follows: (1) Set LINE switch to STANDBY, (2) select Test number on Diagnostic Kit, (3) set LINE switch to ON, and (4) push RESET switch on Diagnostic Kit.

NOTE 2: A clocking pulse with the same signature as the +5V reference means a leading edge triggered clock. A clocking pulse with a 0000 signature means a trailing edge triggered clock. It is normal if the 5004A Signature Analyzer interchanges these two signatures.

• = Voltage Level

+5V Reference Signature: P874

U1	Pin 1	P874	8	P874•
	2	0000	9	0000•
	3	P874•	10	P874
	4	0000•	11	0000
	5	P874•	12	0000
	6	0000•	13	P874
	7	0000•	14	P874•

U2	Pin 1	P874	8	P874
	2	0000	9	P874
	3	P874	10	P874
	4	0000	11	0000
	5	P874•	12	P874
	6	P874	13	P874•
	7	0000•	14	P874•

U3	Pin 1	0000•	9	P874
	2	P874•	10	P874•
	3	P874•	11	P874•
	4	P874•	12	P874
	5	0000	13	0000•
	6	P874	14	P874•
	7	0000•	15	0000•
	8	0000•	16	P874•

U4	Pin 1	0000•	9	P874
	2	0000•	10	0000
	3	P874•	11	0000
	4	P874	12	P874
	5	0000	13	9291
	6	9291	14	7AP5
	7	7AP5	15	0000•
	8	0000•	16	P874•

U5	Pin 1	UNST	9	UNST
	2	0000•	10	UNST
	3	UNST	11	UNST
	4	UNST	12	UNST
	5	UNST	13	UNST
	6	UNST	14	0000•
	7	UNST	15	UNST
	8	0000•	16	P874•

U6	Pin 1	0000•	8	UNST
	2	UNST	9	UNST
	3	P874	10	P874•
	4	P874•	11	P874
	5	0000•	12	UNST
	6	P874•	13	P874•
	7	0000•	14	P874•

U7	Pin 1	0000*	21 0000*
	2	P874*	22 P874
	3	0000	23 P874*
	4	P874*	24 P874*
	5	P874	25 P874*
	6	P874*	26 1A9C
	7	0000*	27 193P
	8	P874*	28 92H4
	9	A1P4	29 UU6U
	10	521F	30 6UC1
	11	767H	31 A1A4
	12	9858	32 9802
	13	6PA8	33 2U33
	14	7UFP	34 9291
	15	3060	35 0000
	16	86UA	36 P874
	17	PA96	37 0000
	18	C072	38 P874*
	19	1H29	39 0000*
	20	92H1	40 P874*

U8	Pin 1	7AP5	11 2U33
	2	6UC1	12 2U33
	3	6UC1	13 9802
	4	A1A4	14 9802
	5	A1A4	15 A1A4
	6	9802	16 A1A4
	7	9802	17 6UC1
	8	2U33	18 6UC1
	9	2U33	19 7AP5
	10	0000*	20 P874*

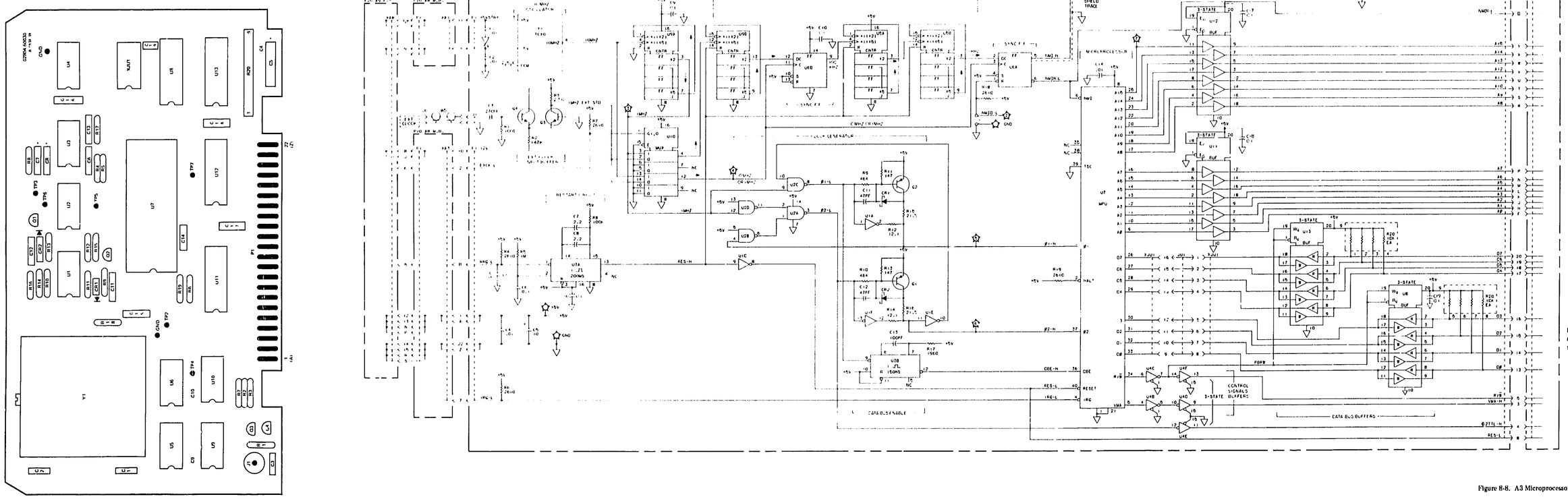
U9	Pin 1	0000	9 UNST
	2	0000*	10 UNST
	3	P874	11 UNST
	4	P874	12 P874
	5	0000	13 UNST
	6	0000	14 0000*
	7	0000	15 UNST
	8	0000*	16 P874*

U10	Pin 1	P874*	9 0000*
	2	P874*	10 0000*
	3	P874	11 0000*
	4	P874	12 P874
	5	0000*	13 P874
	6	0000*	14 P874*
	7	0000*	15 0000*
	8	0000*	16 P874*

U11	Pin 1	0000*	11 9858
	2	6PA8	12 86UA
	3	A1P4	13 767H
	4	7UFP	14 3060
	5	521F	15 521F
	6	3060	16 7UFP
	7	767H	17 A1P4
	8	86UA	18 6PA8
	9	9858	19 P874*
	10	0000*	20 P874*

U12	Pin 1	0000*	11 P874*
	2	PA96	12 92H1
	3	P874	13 P874*
	4	C072	14 1H29
	5	P874*	15 P874*
	6	1H29	16 C072
	7	P874*	17 P874
	8	92H1	18 PA96
	9	P874*	19 P874*
	10	0000*	20 P874*

U13	Pin 1	7AP5	11 UU6U
	2	1A9C	12 UU6U
	3	1A9C	13 92H4
	4	193P	14 92H4
	5	193P	15 193P
	6	92H4	16 193P
	7	92H4	17 1A9C
	8	UU6U	18 1A9C
	9	UU6U	19 7AP5
	10	0000*	20 P874*



CAUTION

Power is present in instrument regardless of "LINE" switch position.

Figure 8-8. A3 Microprocessor/Time Base Assembly

A4 MEMORY ASSEMBLY

The A4 Assembly consists of three functional blocks:

a. Address decoding
b. Program ROM
c. "Scratch-pad" RAMs

The address decoding circuitry detects three distinct blocks of addresses and provides control and enable signals to other instrument circuitry. The blocks are as follows:

a. Addresses 0000_{16} to $000F_{16}$ for Input/Output circuitry
b. Addresses 0010_{16} to $00FF_{16}$ for RAMs U4 and U8
c. Addresses 7000_{16} to $7FFF_{16}$ for ROM U7

To see how the above circuitry fits into the overall instrument software structure, refer to Figure A4-1:

K96-59991A Diagnostic Kit Addresses $F000_{16}$ to $FFFF_{16}$
UNUSED SPACE Addresses 8000_{16} to $EFFF_{16}$
ROM U7 Addresses 7000_{16} to $7FFF_{16}$
Calibration Module #2 Addresses 6800_{16} to $6FFF_{16}$
Calibration Module #1 Addresses 6000_{16} to $67FF_{16}$
Analog Output Option Addresses 5000_{16} to $5FFF_{16}$
HP-IB Option Addresses 4000_{16} to $4FFF_{16}$
UNUSED SPACE Addresses 0100_{16} to $3FFF_{16}$
RAM U8 Addresses 0080_{16} to $00FF_{16}$
RAM U4 Addresses 0010_{16} to $007F_{16}$
I/O Circuitry Addresses 0000_{16} to $000F_{16}$

Figure A4-1. 2804A Software Map

Gates U11B/C and U10 detect the upper six address lines (A10-A15). When A10-A15 are simultaneously low, a Lower Address Block (LAB-H) signal is generated. LAB-H is a partial chip select for RAMs U4 and U8. Gates U6A/B and U2A detect address lines A4-A9. When A4-A9 are simultaneously low, an Invalid RAM Address (IRA-H) signal is generated. If address bits A4-A15 are all simultaneously low, the NANDed signal Valid RAM Disable (vRD-L) keeps data from being inputted to or outputted from RAMs U4 and U8, since they are not being addressed. If the RAMs are being addressed, RAM page boundary is detected at pin 11 of U4 and U8. U4 responds to addresses 0010_{16} through $007F_{16}$; U8 responds to addresses 0080_{16} through $00FF_{16}$.

Gates U10A and U5A detect address lines A4 through A15 being simultaneously low, and the presence of Valid Memory Address (VMA-H) and 02TTL-H clock signals. If these conditions are satisfied, U5A generates a Valid Input/Output (VIO-L) instruction to other instrument circuitry.

Gates U10B/B and U5B detect address lines A12-A14. When A12-A14 are simultaneously high, a Valid ROM Address (VROA-L) signal is generated, indicating that ROM U7 is being addressed. Since address line A15 is not decoded, ROM U7 responds to addresses $7XXX_{16}$ or $FXXX_{16}$ (assuming DBUG-L line is held high). DBUG-L is used for troubleshooting with the Diagnostic Kit, and allows the Diagnostic Kit to take over as main memory, while allowing access to the programs stored in ROM U7.

U12 and U13 are bi-directional three-state buffers which isolate RAMs U4 and U8 and ROM U7 from the instrument data bus. Data direction is controlled by Bus Write Enable (BWE-L) and Bus Read Enable (BRE-L) signals from U1C/D. WRITE means data flows from the microprocessor on the A3 Assembly to RAMs U4 or U8; READ means data flows from RAMs U4 or U8 or ROM U7 to the microprocessor on A3.

TROUBLESHOOTING/REPAIR

To use the table of signatures which follows, the information and instructions of paragraphs 8-90 through 8-92 and subsequent tests must have directed you to this assembly. Since the tests of paragraph 8-92 proceed from Test 0 through Test 9 in sequence, do not proceed to a particular assembly unless directed by instructions of Test 0 through Test 9.

If the Diagnostic Kit Test Card is suspect, refer to its Operating Note, HP Part Number 18109-90002 for test information.

Following repair, repeat the tests of paragraph 8-92.

NOTE 1: Recommended order of performing each test is as follows: (1) Set LINE switch to STANDBY, (2) select Test number on Diagnostic Kit, (3) set LINE switch to ON, and (4) push RESET switch on Diagnostic Kit.

NOTE 2: A clocking pulse with the same signature as the +5V reference means a leading edge triggered clock. A clocking pulse with a 0000 signature means a trailing edge triggered clock. It is normal if the 5004A Signature Analyzer interchanges these two signatures.

• = Voltage Level

+5V Reference Signature: 1UC8

U1	Pin 1	1UC8•	8	4F81
	2	P60U	9	44P9
	3	U9C7	10	9C99
	4	71U7	11	H718
	5	PA6P	12	9C99
	6	9C99	13	5C61
	7	0000•	14	1UC8•

U2	Pin 1	70UH	8	H81P
	2	PA12	9	4367
	3	5FHU	10	A9P9
	4	1UC8•	11	4367
	5	PA5A	12	5FHU
	6	U6P2	13	1UC8•
	7	0000•	14	1UC8•

U3 – NORMALLY EMPTY SPACE

	Pin 1	P60U	13	6P84
	2	A324	14	AU25
	3	P629	15	8PP8
	4	54UF	16	H95A
	5	9060	17	3628
	6	83A7	18	UF54
	7	F496	19	825A
	8	A0AF	20	PA6P
	9	H58H	21	1UC8•
	10	865H	22	PP5U
	11	HUFC	23	P726
	12	0000•	24	1UC8•

U4	Pin 1	0000•	13	A9P9
	2	H58H	14	PP5U
	3	865H	15	P726
	4	HUFC	16	44P9
	5	6P84	17	A324
	6	AU25	18	P629
	7	8PP8	19	54UF
	8	H95A	20	9060
	9	3628	21	83A7
	10	H81P	22	F496
	11	P60U	23	A0AF
	12	U6P2	24	1UC8•

U5	Pin 1	A9P9	8	PA6P
	2	PA5A	9	A49H
	3	PA5A	10	F746
	4	A9P9	11	PA5A
	5	4367	12	71U7
	6	H81P	13	5FHU
	7	0000•	14	1UC8•

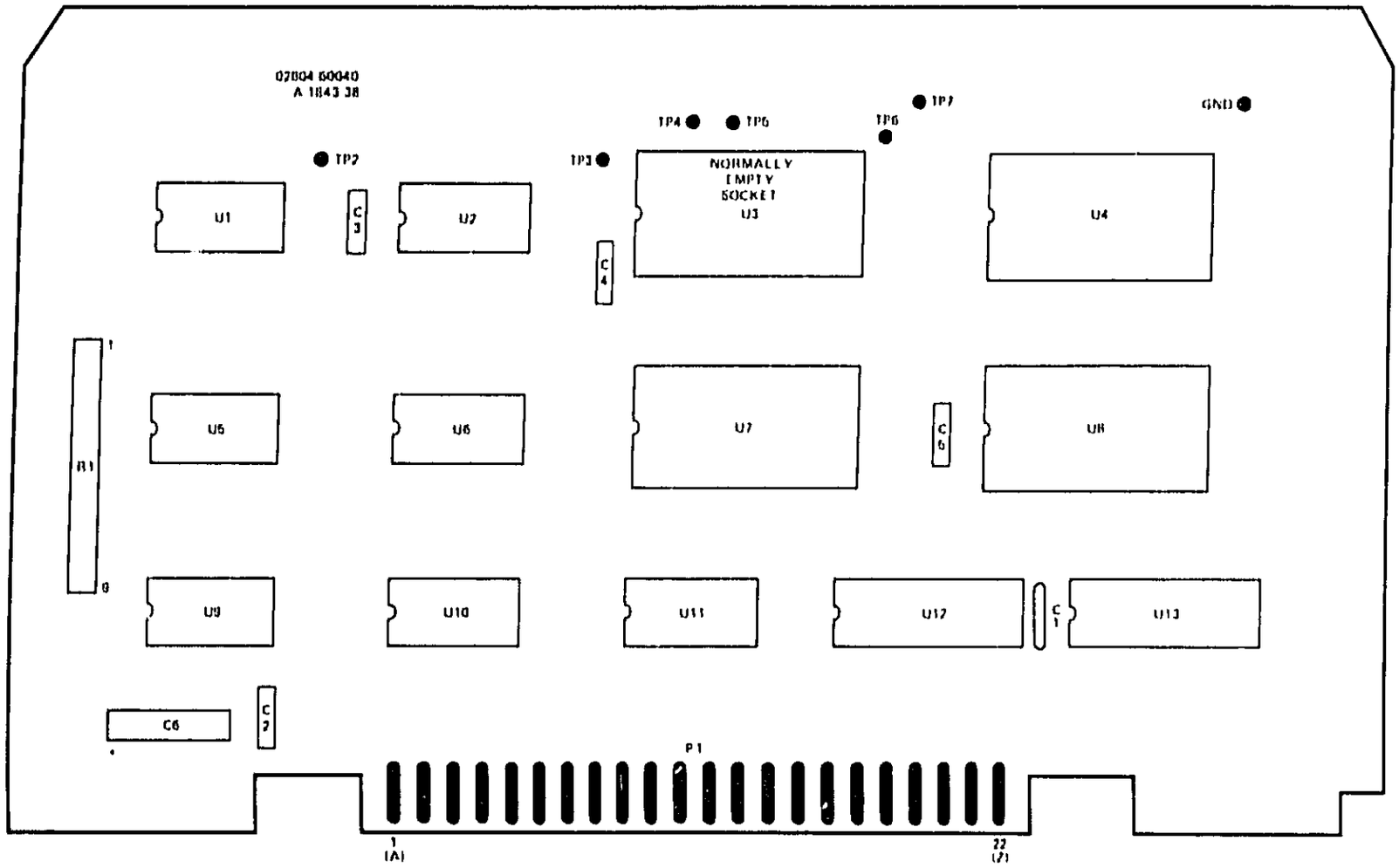
U6	Pin 1	P629	8	0000•
	2	A324	9	1UC8•
	3	P60U	10	1UC8•
	4	P726	11	1UC8•
	5	PP5U	12	70UH
	6	PA12	13	54UF
	7	0000•	14	1UC8•

U7	Pin 1	P60U	13	6P84
	2	A324	14	AU25
	3	P629	15	8PP8
	4	54UF	16	H95A
	5	9060	17	3628
	6	83A7	18	P3PF
	7	F496	19	825A
	8	A0AF	20	PA6P
	9	H58H	21	1UC8•
	10	865H	22	PP5U
	11	HUFC	23	P726
	12	0000•	24	1UC8•

U8	Pin 1	0000•	13	A9P9
	2	H58H	14	PP5U
	3	865H	15	P726
	4	HUFC	16	44P9
	5	6P84	17	A324
	6	AU25	18	P629
	7	8PP8	19	54UF
	8	H95A	20	9060
	9	3628	21	83A7
	10	H81P	22	F496
	11	U9C7	23	A0AF
	12	U6P2	24	1UC8•

U9	Pin 1	6FHU	8	6339	
	2	4367	9	4FB1	
	3	0000*	10	UF54	
	4	OPEN	11	P3PF	
	5	0000*	12	6C61	
	6	OPEN	13	44P8	
	7	0000*	14	1UC8*	
U10	Pin 1	1UC8	8	A48H	
	2	P73P	9	3F6C	
	3	PA6A	10	66UH	
	4	UA77	11	A8P8	
	5	U662	12	C8A1	
	6	F746	13	98UH	
	7	0000*	14	1UC8*	
U11	Pin 1	0000*	8	C8A1	
	2	0000*	9	U662	
	3	UA77	10	P3PF	
	4	960H	11	826A	
	5	23H8	12	0000*	
	6	98UH	13	1UC8*	
	7	0000*	14	1UC8*	

U12	Pin 1	H718	11	6P84	
	2	P2F8	12	6P84	
	3	P2F8	13	HUFC	
	4	4C88	14	HUFC	
	5	4C88	15	866H	
	6	93A6	16	866H	
	7	93A6	17	H68H	
	8	A129	18	H68H	
	9	A129	19	6339	
	10	0000*	20	1UC8*	
U13	Pin 1	H718	11	3628	
	2	6P9P	12	3628	
	3	6P9P	13	H86A	
	4	P1C8	14	H86A	
	5	P1C8	15	8PP8	
	6	86U3	16	8PP8	
	7	86U3	17	AU26	
	8	0AU2	18	AU26	
	9	0AU2	19	6339	
	10	0000*	20	1UC8*	


02804 60040
A 1843 38
TP1
TP2
TP3
TP4
TP5
TP6
TP7
GND
NORMALLY
EMPTY
SOCKET
U3
U1
U2
U4
U5
U6
U7
U8
U9
U10
U11
U12
U13
C1
C2
C3
C4
C5
C6
R1
P1
1
(A)
22
(Z)

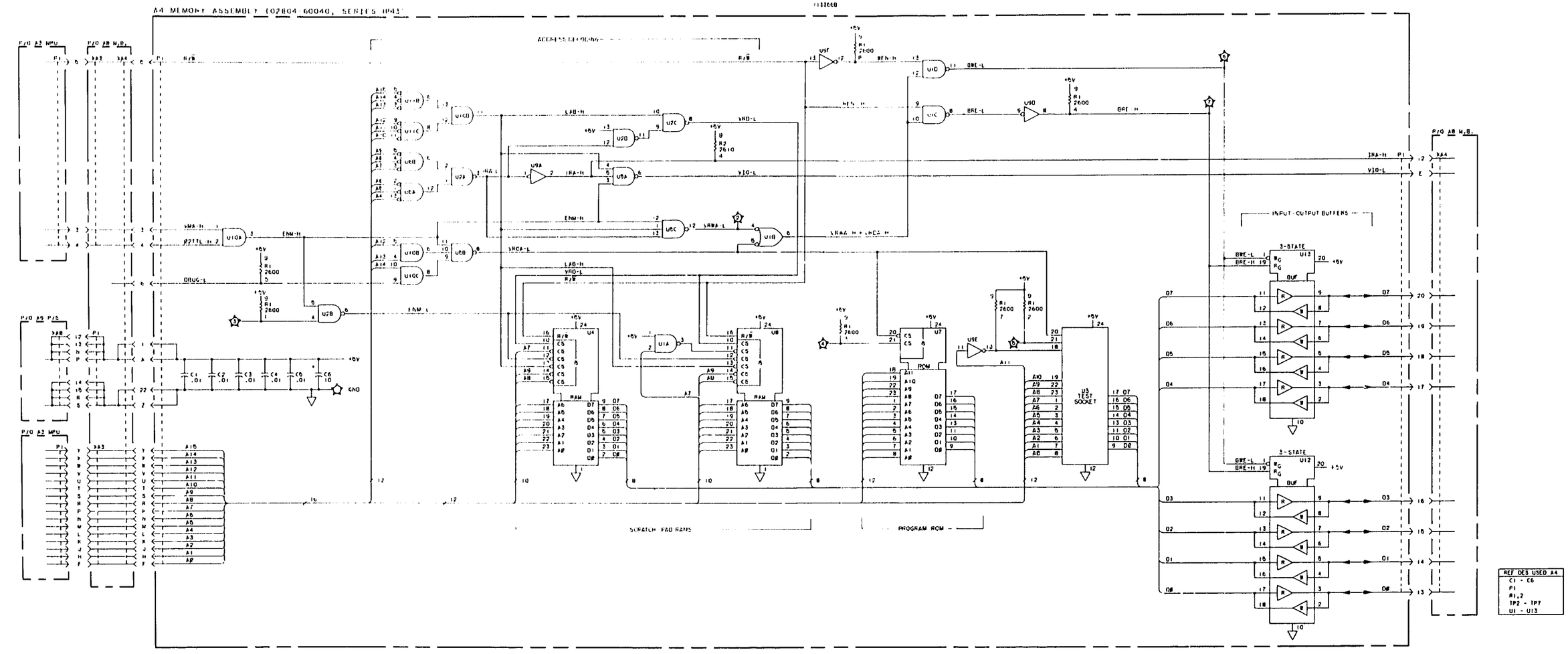


Figure 8-9. A4 Memory Assembly

A5 COUNTER ASSEMBLY

The A5 Assembly consists of four functional blocks:

a. RF input circuitry

b. Control circuitry

c. Counter chain

d. Sensor signal dropout detection

The RF input section consists of four identical circuits which provide level-shifting, impedance matching and dc operating voltage to the sensor oscillators. A T1 input signal from the sensor oscillator on the A2 Assembly enters via coaxial cable at J1. Schmitt-trigger U1B changes the 28 MHz signal into a TTL-level square wave and applies it to multiplexer U4. Filter network C1/L1/C5 provides isolation between oscillators connected to a common power supply voltage. T2 operation is identical through U1C. The rear panel T1 and T2 inputs also operate the same, but they MUST be provided with a Model 18107A External Sensor Oscillator for each channel used.

Regulator U2 provides operating voltage for all sensor oscillators. For maximum stability, the sensor oscillators will continue to oscillate (assuming the quartz sensor probe is connected) even if the front panel LINE switch is in STANDBY position.

The control circuitry consists of decoders U9A/B and synchronizing flip-flops U8A/B. The lower four address bits (A0 through A3) and the Valid Input/Output (VIO-L) control multiplexer U4 and counters U5 and U6 to make a temperature measurement. Assuming address lines A4 through A15 are simultaneously low and A3 is high (A2 has no effect), the sequence is as follows:

a. Address lines A1 and A0 change to a 00_2 configuration. A "WRITE" instruction from the A3 Assembly generates a Clear (CLR-L) signal from U9B, which resets counters U5 and U6 to zero.

b. Address lines A1 and A0 change to a 11_2 configuration, generating a Select (SEL-L) signal from U9B. This allows data bits D0, D1 and D2 to determine which sensor oscillator is selected.

c. Address lines A1 and A0 change to a 01_2 configuration, generating a Counter Arm (ARM-L) signal. The next 1 kHz TBG-H signal sends the ARM-L to multiplexer U4, which allows data to pass through U4 and allows counters U5 and U6 to accumulate counts. The ARM-L signal to multiplexer U4 becomes the "frequency gate".

d. After the specified measurement period (.1 sec, 1 sec or 10 sec, determined by software timer), address lines A1 and A0 change to a 10_2 configuration. This generates a Counter Disarm (DARM-L) signal. The next 1 kHz TBG-H signal disables multiplexer U4, thereby closing the "frequency gate". Counters U5 and U6 stop accumulating and retain their information.

e. Prescaler U5 contains the least significant digit of the counter data. U6 is a six-decade counter which accumulates the upper six significant digits. A "READ" instruction from the A3 Assembly, and the manipulation of address lines A0, A1 and A2, in conjunction with A3 high and A4-A15 low, multiplexes data out of U5 and U6.

f. The "READ" instruction also enables three-state buffers U11A/B to send counter data to the microprocessor on A3 via the instrument data bus.

If a quartz sensor probe is connected to the selected front panel input and that channel is selected, one-shot multivibrator U7A is continually retriggered. However, if no RF is flowing through U4 and U5 (because the quartz sensor probe is disconnected), U7A will time out, generating a No-Input (NINP-L) signal. The instrument software senses NINP-L and automatically checks for a signal at the rear panel input. If no quartz sensor probe and/or external sensor oscillator is connected to the rear panel input either, U7A continues to generate an NINP-L signal. This will cause an error message on the display.

TROUBLESHOOTING/REPAIR

To use the table of signatures which follows, the information and instructions of paragraphs 8-60 through 8-92 and subsequent tests must have directed you to this assembly. Since the tests of paragraph 8-92 proceed from Test 0 through Test 9 in sequence, do not proceed to a particular assembly unless directed by instructions of Test 0 through Test 9.

If the Diagnostic Kit Test Card is suspect, refer to its Operating Note, HP Part Number 18109-90002 for test information.

Following repair, repeat the tests of paragraph 8-92.

NOTE 1: Recommended order of performing each test is as follows: (1) Set LINE switch to STANDBY, (2) select Test number on Diagnostic Kit, (3) set LINE switch to ON, and (4) push RESET switch on Diagnostic Kit.

NOTE 2: A clocking pulse with the same signature as the +5V reference means a leading edge triggered clock. A clocking pulse with a 0000 signature means a trailing edge triggered clock. It is normal if the 5004A Signature Analyzer interchanges these two signatures.

NOTE 3: All measurements taken with Calibration Modules removed and Quartz Probes disconnected.

* = Voltage Level

+5V Reference Signature: 2754

U1	Pin 1	OPEN	8	0000*
	2	2754*	9	OPEN
	3	0000*	10	2754*
	4	2754*	11	0000*
	5	OPEN	12	2754*
	6	0000*	13	OPEN
	7	0000*	14	2754*

U2 – Voltage Regulator

U3	Pin 1	2754*	9	2FC7
	2	C54C	10	AP8U
	3	921U	11	89HC
	4	8U79	12	901H
	5	HU12	13	0000*
	6	2A6A	14	2754*
	7	0H3P	15	0000*
	8	0000*	16	2754*

U4	Pin 1	0000*	9	AP8U
	2	0000*	10	0H3P
	3	0000*	11	C54C
	4	0000*	12	0000*
	5	P203	13	2754*
	6	F557	14	OPEN
	7	U935	15	2754
	8	0000*	16	2754*

U5	Pin 1	2754*	8	F557
	2	C9FA	9	1F2C
	3	0000*	10	0000*
	4	0000*	11	0000*
	5	64UP	12	24H1
	6	64UP	13	0A22
	7	0000*	14	2754*

U6	Pin	1	P995	9	CFUP
		2	0H6C	10	UA49
		3	0000*	11	2H76
		4	0000*	12	0000*
		5	0000*	13	2764*
		6	2764*	14	0385
		7	OPEN	15	B097
		8	1H35	16	FU34

U7	Pin	1	0000*	9	2764*
		2	0385	10	2764*
		3	2764*	11	2764*
		4	9U93	12	0000*
		5	2764*	13	C8F7
		6	0000*	14	0000*
		7	OPEN	15	0000*
		8	0000*	16	2764*

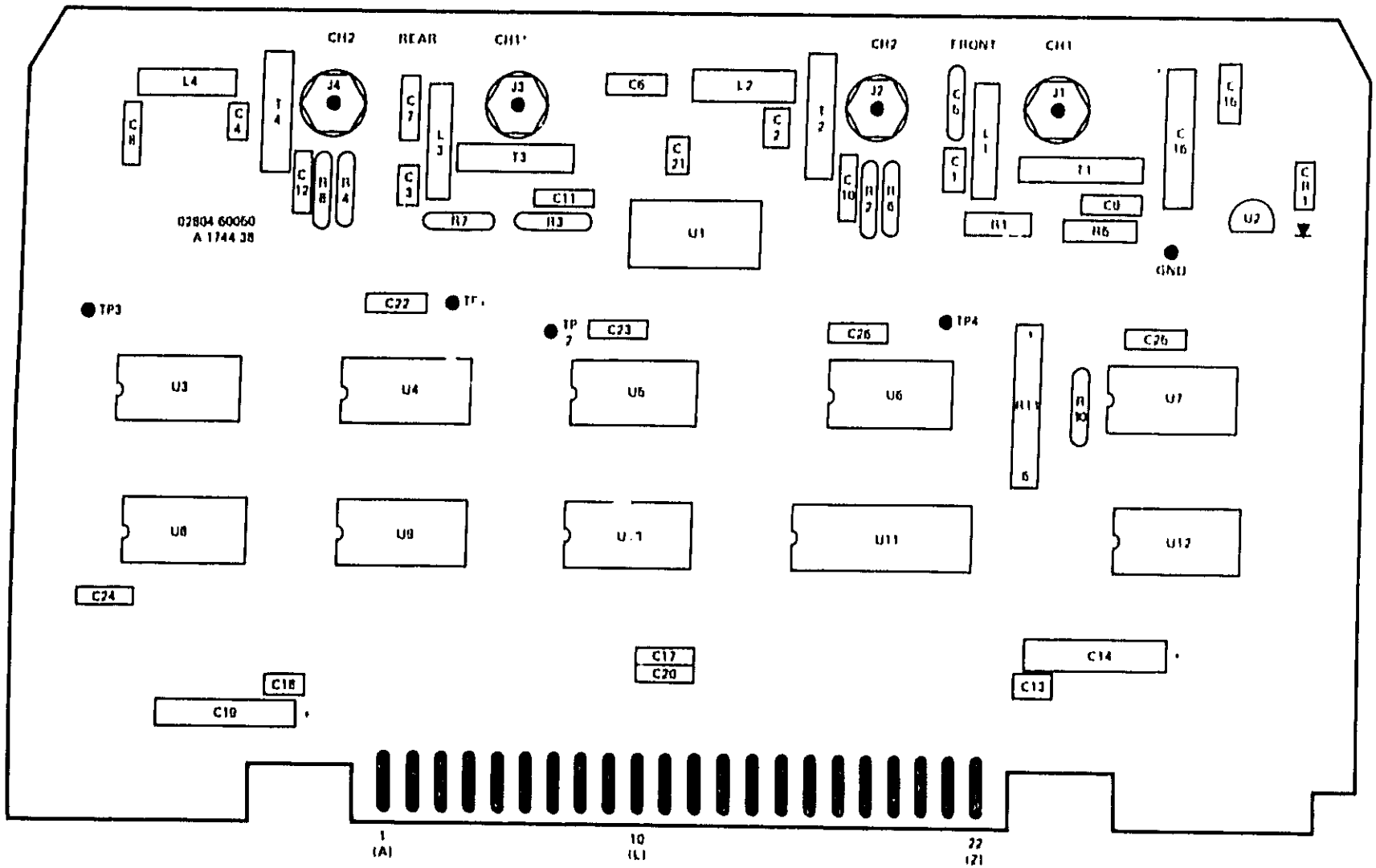
U8	Pin	1	U919	8	U835
		2	0000*	9	HP61
		3	0000*	10	2764*
		4	H5HF	11	HPH3
		5	2F3C	12	2F3C
		6	0C6U	13	2764*
		7	0000*	14	2764*

U9	Pin	1	U67A	9	2FC7
		2	0180	10	U919
		3	6852	11	H5HF
		4	2764*	12	0A22
		5	2H04	13	9CAA
		6	2764	14	HH1H
		7	UF2A	15	2H04
		8	0000*	16	2764*

U10	Pin	1	9CAA	8	UA49
		2	CFUP	9	HH1H
		3	3A61	10	2H76
		4	1H35	11	0A22
		5	UF2A	12	0385
		6	HC7P	13	24H1
		7	0000*	14	2764*

U11	Pin	1	UF2A	11	B097
		2	24F1	12	AA54
		3	CH7P*	13	FU34
		4	C9FA	14	PPC7
		5	901H	15	P995
		6	1F2C	16	23AP
		7	HU12	17	0H6C
		8	G4UP	18	739P
		9	8U79	19	HC7P
		10	0000*	20	2764*

U12	Pin	1	CFUP	8	0000*
		2	9U93	9	2764*
		3	OPEN	10	2764*
		4	HC7P	11	OPEN
		5	1H35	12	2764*
		6	B097	13	2764*
		7	0000*	14	2764*


CH2
REAR
CH1
CH2
FRONT
CH1
L4
C8
C4
T4
J4
C7
L3
J3
C6
L2
T2
J2
C5
T3
C21
C2
C10
R7
R8
C1
L1
J1
C16
C16
C12
R5
R4
C11
R7
R3
U1
T1
C9
R1
R6
U2
CR1
02804 60060
A 1744 38
GND
TP3
C22
TP
TP
7
C23
C26
TP4
C26
U3
U4
U5
U6
R11
R10
U7
U8
U9
U.1
U11
U12
C24
C17
C20
C14
C13
C18
C19
1
(A)
10
(L)
22
(Z)

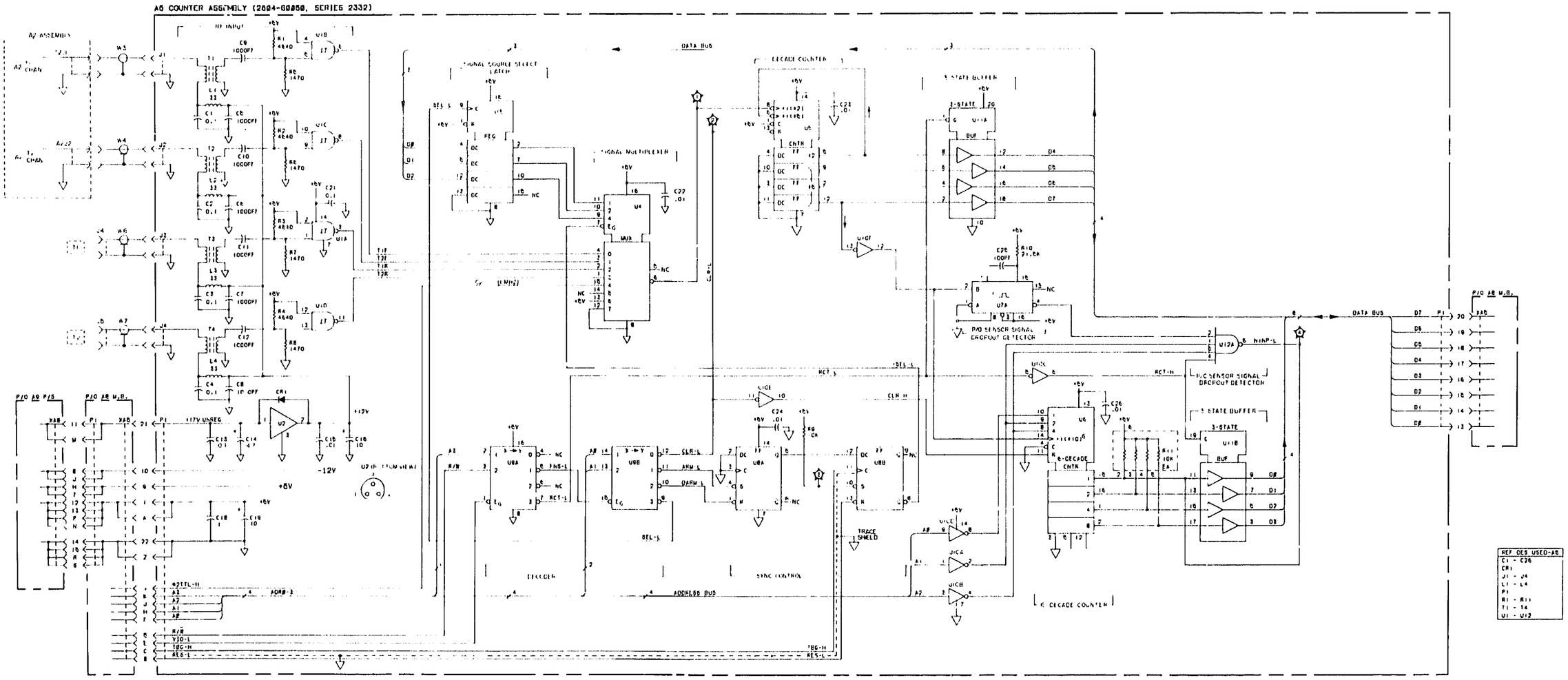


Figure 8-10. A5 Counter Assembly

A6 DIGITAL-TO-ANALOG CONVERTER ASSEMBLY

The A6 Assembly converts digital information on the instrument data bus to an analog voltage available at rear panel jacks J2 and J3. Any three consecutive digits of the seven are front panel selectable. Analog output voltage is from 0.00 Vdc to +9.99 Vdc.

Binary data is inputted to A6 from the instrument data bus in two consecutive data words. Address decoder U5 clocks low-order bits (D0-D5) into data latch U6 by a Low Half Write (LHW-L) pulse. The high-order bits (D6-D9) are clocked into data latch U8 at the same instant that the low-order bits in U6 are transferred to U4. The high-order bits are transferred by a High Half Write (HHW-L) pulse. All ten binary bits appear simultaneously at the input to D/A Converter U3. If data latch U4 were not present, bits D0-D5 would appear at the input to U3 several microseconds before bits D6-D9 would arrive. This would cause a "glitch" at the D/A Converter output as the data was updated.

The D/A Converter output voltage is determined by a resistor internal to U3 in conjunction with R3 and R5. Full Scale Adjust potentiometer R5 allows output voltage to be set to +10.00 Vdc with front panel ANALOG OUTPUT switch in the CAL 10V position. Zero Adjust potentiometer R8 allows output voltage to be set to exactly zero volts in the CAL 0V position.

Voltage regulator U2 provides a regulated +13.5 Vdc for D/A Converter U3. The +13.5 Vdc ensures that current amplifier U1 can reach +10V with loads as low as 10K ohms. Connector J1 is for future use. It extends the bus structure from the A8 Motherboard to allow future options to be added.

TROUBLESHOOTING/REPAIR

To use the table of signatures which follows, the information and instructions of paragraphs 8-90 through 8-92 and subsequent tests must have directed you to this assembly. Since the tests of paragraph 8-92 proceed from Test 0 through Test 9 in sequence, do not proceed to a particular assembly unless directed by instructions of Test 0 through Test 9.

If the Diagnostic Kit Test Card is suspect, refer to its Operating Note, HP Part Number 18109-90002 for test information.

Following repair, repeat the tests of paragraph 8-92.

NOTE 1: Recommended order of performing each test is as follows: (1) Set LINE switch to STANDBY, (2) select Test number on Diagnostic Kit, (3) set LINE switch to ON, and (4) push RESET switch on Diagnostic Kit.

NOTE 2: A clocking pulse with the same signature as the +5V reference means a leading edge triggered clock. A clocking pulse with a 0000 signature means a trailing edge triggered clock. It is normal if the 5004A Signature Analyzer interchanges these two signatures.

* = Voltage Level

+5V Reference Signature: C20F

When ANALOG OUTPUT OP switch is in NORMAL position.

U1 – Linear IC

U2 – Voltage Regulator

U3	Pin 1	0000*	9	AHAU
	2	C20F*	10	4466
	3	0000*	11	C9C0
	4	2UH2	12	0P68
	5	9HA8	13	3HPP
	6	667U	14	C20F*
	7	H672	15	0000*
	8	HH66	16	UNST

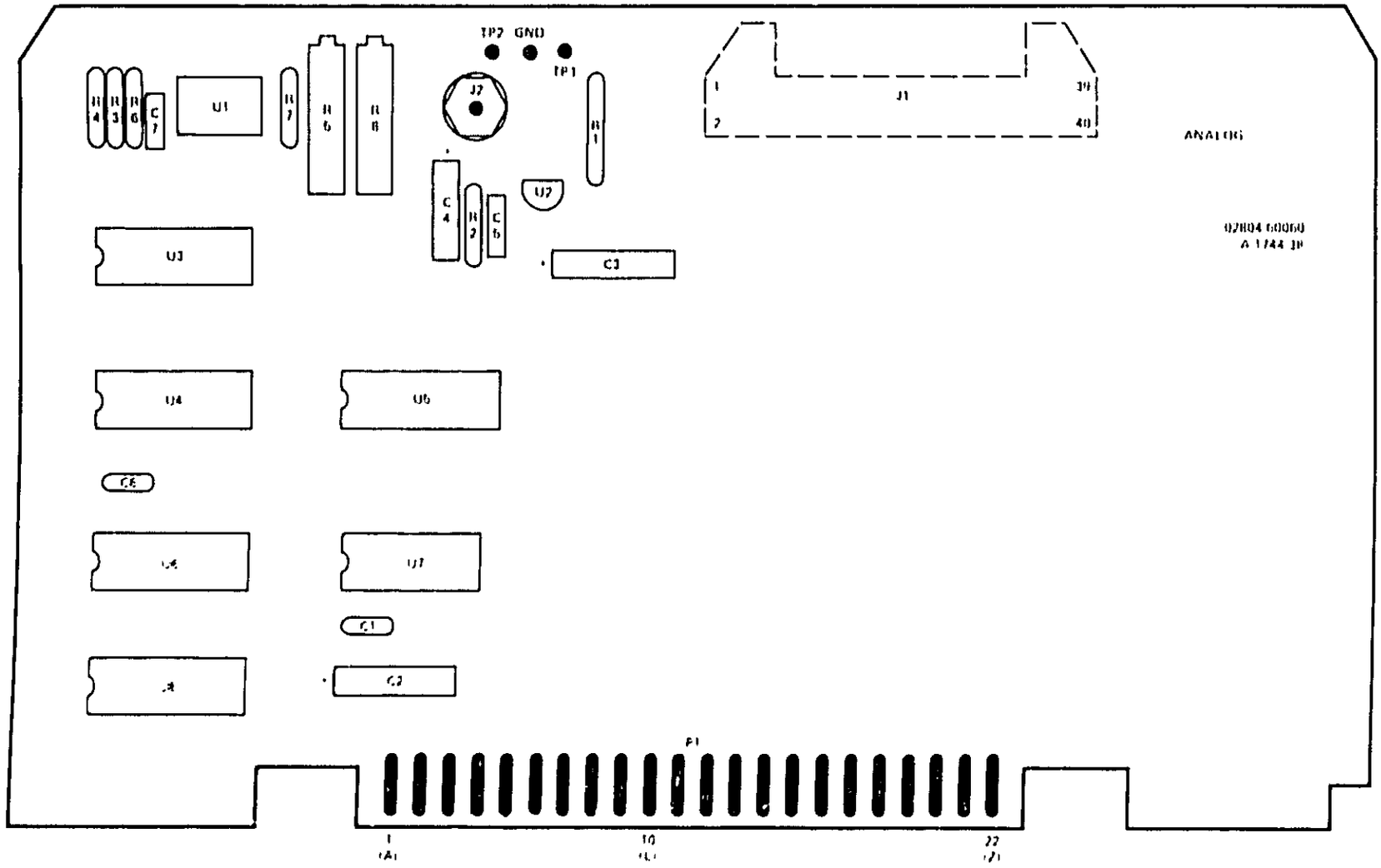
U4	Pin 1	C20F*	9	146P
	2	2UH2	10	H672
	3	FA40	11	F9C2
	4	A30C	12	HH66
	5	9HA8	13	99H3
	6	UU07	14	CUUH
	7	667U	15	AHAU
	8	0000*	16	C20F*

U5	Pin 1	5UA8	9	C20F*
	2	7P58	10	3AH8
	3	50PP	11	146P
	4	U742	12	C20F*
	5	7P58	13	C20F*
	6	C20F	14	C20F*
	7	C20F*	15	UU95
	8	0000*	16	C20F*

U6	Pin 1	C20F*	9	3AH8
	2	FA40	10	F9C2
	3	1UUU	11	84H7
	4	52FH	12	99H3
	5	A30C	13	3943
	6	84CF	14	U6F1
	7	UU07	15	CUUH
	8	0000*	16	C20F*

U7	Pin 1	C20F	8	C20F*
	2	C20F	9	C20F*
	3	C20F	10	C20F*
	4	50PP	11	C20F*
	5	50PP	12	C20F*
	6	50PP	13	C20F*
	7	0000*	14	C20F*

U8	Pin 1	C20F*	9	146P
	2	4466	10	3HPP
	3	U376	11	52FH
	4	238A	12	C20F*
	5	C9C0	13	C20F*
	6	1UUU	14	C20F*
	7	0P58	15	C20F*
	8	0000*	16	C20F*


TP2
GND
TP1
J2
J1
1
39
2
40
ANALOG
02H04 60060
A 1744 JP
U1
U2
U3
U4
U6
U7
C1
C2
C3
C4
C5
C6
C7
R1
R2
R3
R4
R5
R6
R7
R8
P1
1
10
22

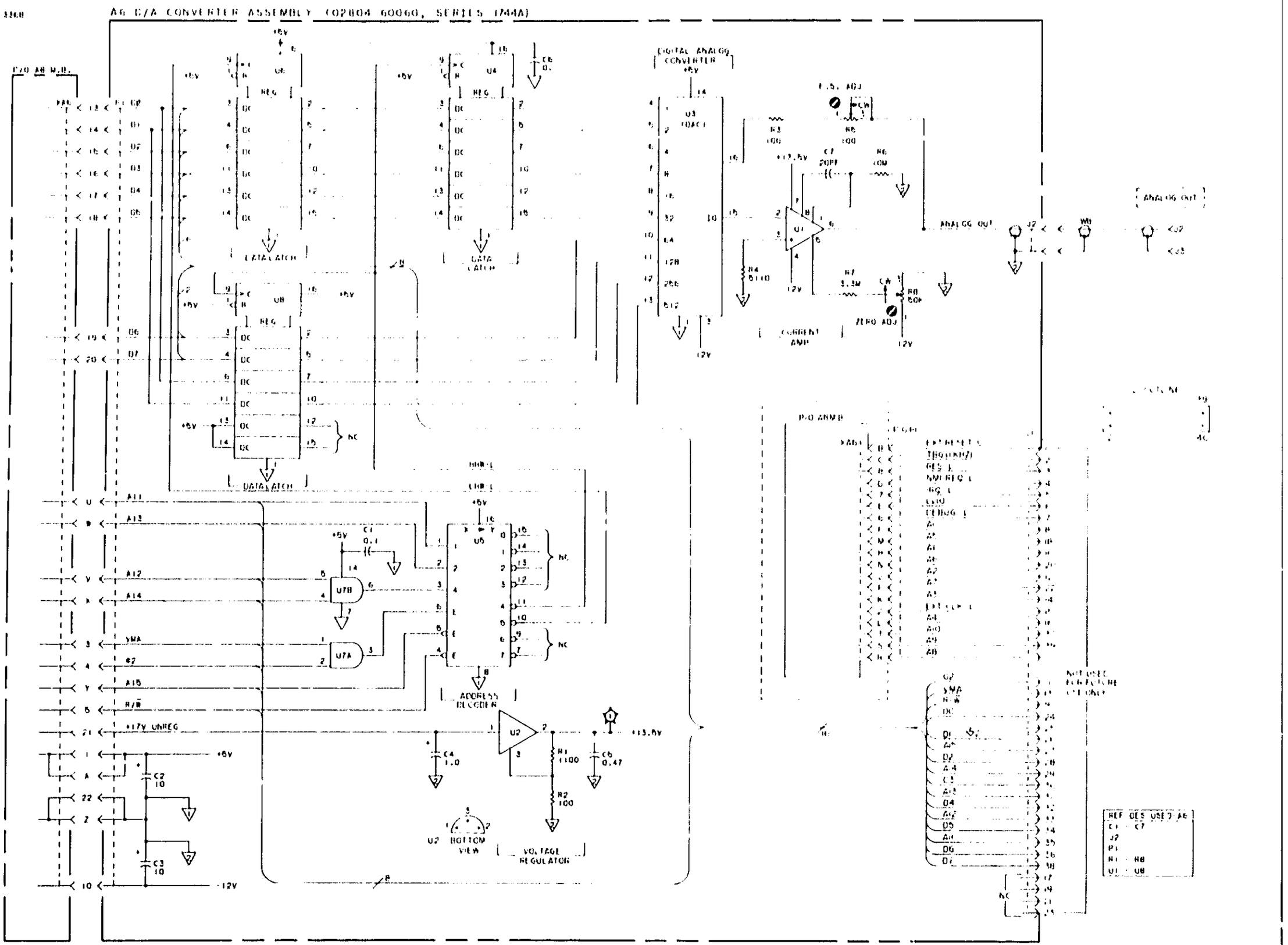


Figure 8-11. A6 Digital-to-Analog Converter Assembly

A7 HP-IB ASSEMBLY

The A7 Assembly consists of six functional blocks:

a. Address Decoding and Address Buffers

b. Data Buffers

c. Microprocessor

d. Group Execute Trigger flip-flop and RESET circuits.

e. HP-IB 3-state Buffers

f. +12 Vdc Regulator

Address decoding circuit U11A and U11B in conjunction with U13C and U12A controls Data Buffers U7 and U9, Address Buffer U4 and, through U12C and U12B, controls Group Execute Trigger flip-flop U13A, B. The decoding of address locations is dependent on address lines A10-A15 and the VMA lines from A3 microprocessor. Four address locations can be addressed:

1. 4000_{16}-$43FF_{16}$; Chip Select-LOW to A7U3(23) [output from U11(7)]

2. 4400_{16}-$47FF_{16}$; HP-IB Address Buffer Enable to A7U4(1, 15) [output from U11(5)].

3. 4800_{16}-$4BFF_{16}$(48FF); Group Execute Trigger flip-flops data-read to A7U10(15) [output from U11(6)].

4. 4600_{16}-$4FFF_{16}$; Group Execute Trigger flip-flop reset to A7U13(11) [output from U11(7)].

Data buffers U7, U9 are set to their Read or Write states by the $R/\overline{W}$ line from A3 microprocessor in conjunction with the decoded address signals through U11B. With the Read state enabled, data is read from A7U3 to the A3 microprocessor; with the Write state enabled, data is written to A7U3 from the A3 microprocessor.

Address buffer U4 is enabled through U11A by a decoded address location determined from address lines A10 and A11. The A7S1 switch position information is outputted onto the instrument data bus through U4, U7 and U9.

Group Execute Trigger flip-flop U13A, B is triggered by a pulse from U3(37) in response to an HP-IB command. The flip-flop status is read into U3(27) by the decoded address output from U11(6). The flip-flop is reset by the decoded address output from U11(7) applied through various gates to U13(11).

HP-IB buffering is implemented by 3-state buffers U5, U1, U6, U2 and interfaces all HP-IB bus input/outputs to the A7U3 microprocessor.

Local regulation for A7U3 is provided by linear regulator U8.

TROUBLESHOOTING/REPAIR

To use the table of signatures which follows, the information and instructions of paragraphs 8-90 through 8-92 and subsequent tests must have directed you to this assembly. Since the tests of paragraph 8-92 proceed from Test 0 through Test 9 in sequence, do not proceed to a particular assembly unless directed by instructions of Test 0 through Test 9.

If the Diagnostic Kit Test Card is suspect, refer to its Operating Note, HP Part Number 18109-90002 for test information.

Following repair, repeat the tests of paragraph 8-92.

NOTE 1: Recommended order of performing each test is as follows: (1) Set LINE switch to STANDBY, (2) select Test number on Diagnostic Kit, (3) set LINE switch to ON, and (4) push RESET switch on Diagnostic Kit.

NOTE 2: A clocking pulse with the same signature as the +5V reference means a leading edge triggered clock. A clocking pulse with a 0000 signature means a trailing edge triggered clock. It is normal if the 5004A Signature Analyzer interchanges these two signatures.

NOTE 3: All measurements should be taken with HP-IB address switches on the A7 HP-IB board set to 0001101 (decimal 13).

* = Voltage Level

+5V Reference Signature: PHHH

U1	Pin	1	0000*	9	0000*
		2	PHHH*	10	PHHH*
		3	PHHH*	11	PHHH*
		4	H204	12	H204
		5	PHHH*	13	PHHH*
		6	PHHH*	14	PHHH*
		7	0000*	15	0000*
		8	0000*	16	PHHH*

U2	Pin	1	PHHH*	9	PHHH*
		2	PHHH*	10	PHHH*
		3	PHHH*	11	PHHH*
		4	0000*	12	0000*
		5	PHHH*	13	PHHH*
		6	PHHH*	14	PHHH*
		7	PHHH*	15	0000*
		8	0000*	16	PHHH*

U3 – Phi Chip

U4	Pin	1	PHHH	9	H8C0
		2	0000*	10	0000*
		3	283P	11	0A8C
		4	PHHH*	12	PHHH*
		5	0186	13	P264
		6	0000*	14	PHHH*
		7	2909	15	PHHH
		8	0000*	16	PHHH*

U5	Pin	1	0000*	9	0000*
		2	PHHH*	10	PHHH*
		3	PHHH*	11	PHHH*
		4	H204	12	H204
		5	PHHH*	13	PHHH*
		6	PHHH*	14	PHHH*
		7	0000*	15	0000*
		8	0000*	16	PHHH*

U6	Pin	1	0000*	9	0000*
		2	PHHH*	10	PHHH*
		3	PHHH*	11	PHHH*
		4	H204	12	0000*
		5	PHHH*	13	PHHH*
		6	PHHH*	14	PHHH*
		7	0000*	15	0000*
		8	0000*	16	PHHH*

U7	Pin	1	7A02	11	H8C0
		2	6423	12	H8C0
		3	6423	13	2909
		4	F63P	14	2909
		5	F63P	15	0186
		6	0FAH	16	0186
		7	0FAH	17	283P
		8	2109	18	283P
		9	2109	19	C14C
		10	0000*	20	PHHH*

U8 – Voltage Regulator

U9	Pin	1	7A02	11	P264
		2	U332	12	P264
		3	U332	13	U480
		4	9C6P	14	U480
		5	9C6P	15	8987
		6	C360	16	8987
		7	C360	17	0A8C
		8	P264	18	0A8C
		9	P264	19	C14C
		10	0000*	20	PHHH*

U10	Pin	1	0000*	9	4676
		2	6F86	10	A8AC
		3	C14C	11	0000*
		4	0000*	12	PHHH*
		5	PHHH*	13	P264
		6	PHHH	14	631P
		7	0000	15	0708
		8	0000*	16	PHHH*

U11	Pin	1	FC40	9	PHHH*
		2	6F86	10	A8AC
		3	C14C	11	0000*
		4	0000*	12	PHHH*
		5	PHHH*	13	P264
		6	PHHH	14	631P
		7	0000	15	0708
		8	0000*	16	PHHH*

U12	Pin	1	A8AC	8	A8AC
		2	A8AC	9	PHHH
		3	PHHH	10	4676
		4	C0A3	11	4676
		5	72PA	12	4676
		6	FC40	13	PHHH*
		7	0000*	14	PHHH*

U13	Pin	1	647P	8	BPF3
		2	647P	9	631P
		3	07P7	10	631P
		4	BPF3	11	4676
		5	BPF3	12	C0A3
		6	631P	13	647P
		7	0000*	14	PHHH*

Table A7-1. A7U3 Input-Output Signals

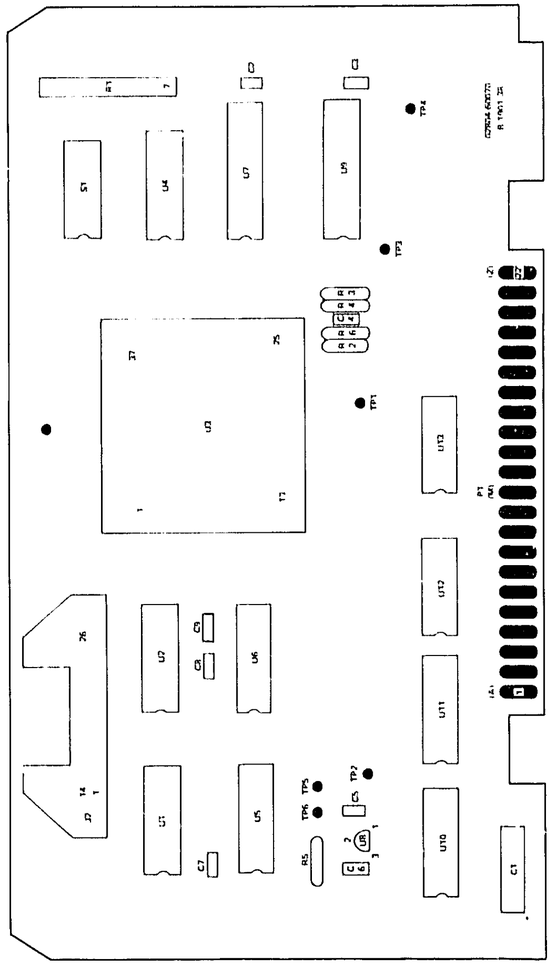
PIN	SYMBOL	NAME	DESCRIPTION
1	SCTRL	System Controller	When asserted, this input provides the chip with System Control capabilities as defined by the HP-IB standard (i.e., it can drive the HP-IB's IFC and REN lines). Only one device in any system should have this pin asserted.
2	DAV	Data Valid	This bidirectional pin ties to the HP-IB DAV line via a 3-state buffer.
3	EOI	End or Identify	This bidirectional pin ties to the HP-IB EOI line via a 3-state buffer.
4-11	DIO8-1	Data I/O Bit 8 Through Bit 1	These bidirectional pins tie to the HP-IB DIO lines via eight 3-state buffers.
12	V_{DD}	Power Supply Pin	Supplies 12V to the chip.
13	RS	Delay Stabilizing Resistor	This pin should be tied to ground through a 26KΩ resistor.
14	DMARQ	DMA Request	This output can be used to request DMA cycles to transfer data to the outbound FIFO or from the inbound FIFO within the chip.
15	PON	Power On	This input when not asserted will cause all circuits within the chip to be initialized.
16	W	Write	This input when asserted specifies that a WRITE rather than READ operation is being performed by the processor.
17	INT	Interrupt	This output provides a level which should be used to interrupt the host processor.
18	IOEND	I/O END	This output is used to handshake all chip reads and writes within asynchronous systems. It can be ignored within synchronous systems.
19	IOGO	I/O GO	This input is used to cause a read from or a write to a specified register within the chip. It is ignored if the Chip Select input is not asserted.
20-22	A15-13	Address Bits 15 thru 13	These inputs are used to specify the number of a register being read from or written to. A13 is the high order bit.
23	CHSEL	Chip Select	When this input is asserted, it allows the chip to respond to read or write cycles initiated by the processor via the IOGO line.

Table A7-1. A7U3 Input-Output Signals (Cont.)

PIN	SYMBOL	NAME	DESCRIPTION
24	V_{DC}	Power Supply Pin	This pin should be tied to a 12V power supply if the chip is interfacing to a 12V CMOS compatible I/O system, or a 5V power supply if the chip is interfacing to a LS TTL compatible I/O system. This pin affects only the processor side of the chip since the HP-IB side always operates with LS TTL compatible levels.
25-3	D0-15	Processor Data Bits 0, 1, 8-15	These bidirectional pins carry data during reads from or writes to the chip by the host processor. D0 and D1 are used only for registers 0, 1 and 2 and remain at high impedance during reads of registers 3, 4, 5, 6 or 7.
35	RTL	Return to Local	This input carries the "rtl" message for the REMOTE/LOCAL interface function as defined in IEEE 488-1975. It should be tied to a pushbutton within devices utilizing this function. All other devices can tie it high or low.
36	GND	Ground	Ground used for all three power supply pins.
37	TRIG	Trigger	This output is asserted with a pulse any time the device is triggered via the HP-IB's Group-Execute-Trigger interface command.
38	$\overline{ATN}$	$\overline{Attention}$	This bidirectional pin ties to the HP-IB ATN line via a 3-state buffer.
39	$\overline{SRQ}$	$\overline{Service\ Request}$	This bidirectional pin ties to the HP-IB SRQ line via a 3-state buffer.
40	RFD	Ready For Data	This bidirectional pin ties to the HP-IB NRFD line via a 3-state buffer.
41	DAC	Data Accepted	This bidirectional pin ties to the HP-IB NDAC line via a 3-state buffer.
42	REN	Remote Enable	This bidirectional pin tier to the HP-IB REN line via a 3-state buffer.
43	$\overline{IFC}$	$\overline{Interface\ Clear}$	This bidirectional pin ties to the HP-IB IFC line via a 3-state buffer.
44	CIC	Controller In Charge	This output is asserted when the host device is the current Controller In Charge of the HP-IB. It is used as an enable for the ATN line driver. If CIC is false the SRQ driver will be enabled instead.

Table A7-1. A7U3 Input-Output Signals (Cont.)

PIN	SYMBOL	NAME	DESCRIPTION
45	HSE	High State Enable	This line is asserted whenever the DIO, DAV, or EOI lines are required to have active pullups if they are driving a high level. It should be tied to the high state enable inputs of the corresponding 3-state buffers.
46	DEE	DAV/EOI Enable	When asserted, this output enables the DAV and EOI line drivers. When it is unasserted, it enables the RFD and DAC line drivers.
47	DIOE	DIO Enable	This output, when asserted, enables the eight DIO 3-state buffers
48	Vcc	Power Supply Pin	Supplies 5V to the chip.



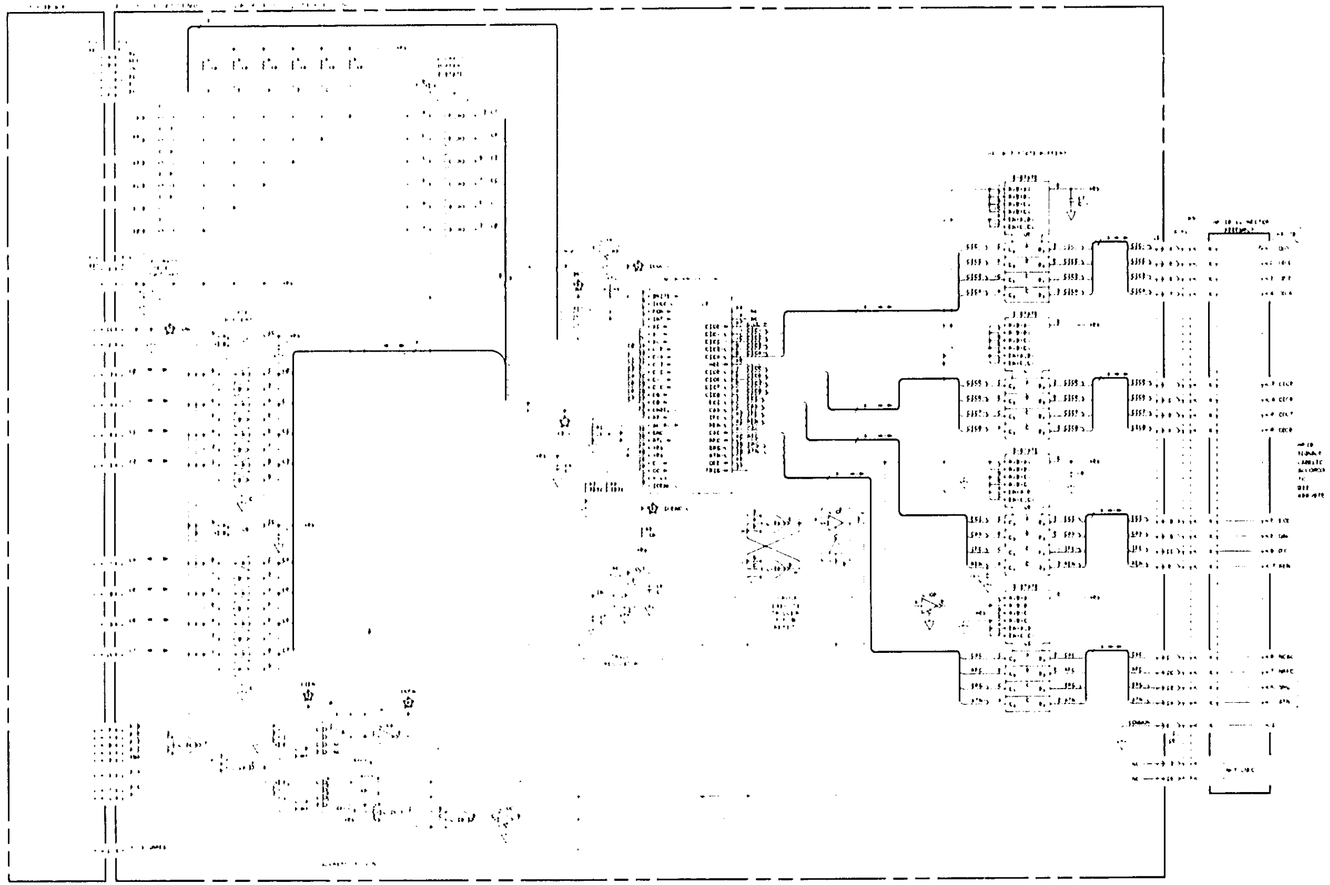


Figure 8-12. A7 HP-IB Assembly

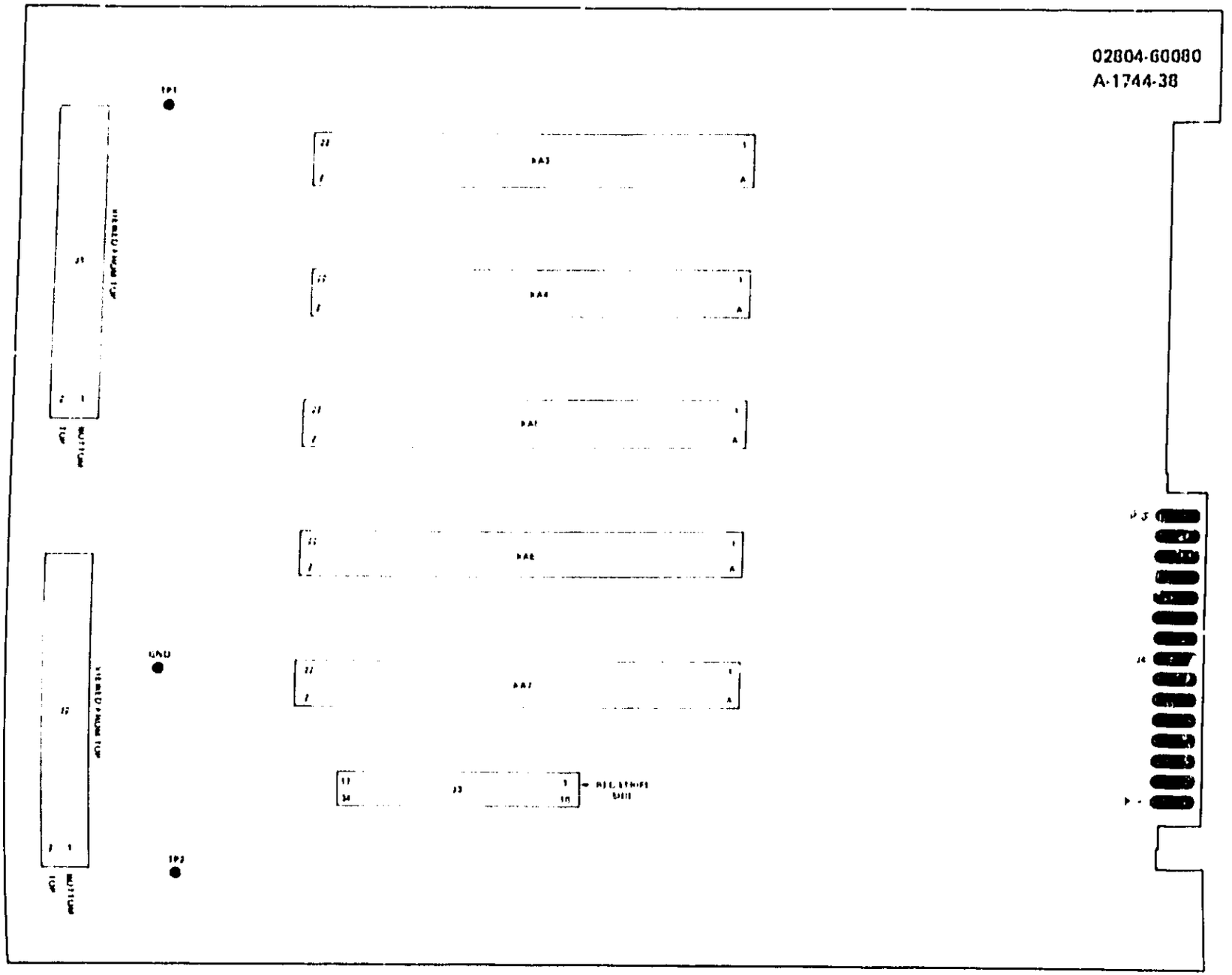
A8 MOTHERBOARD ASSEMBLY

The A8 Assembly interconnects all the other instrument printed-circuit assemblies. It has five connectors (XA3-XA7) for assemblies A3, A4, A5, A6, and A7. These assemblies are arranged as shown in Figure 8-4 for optimum heat dissipation, but each assembly is position independent.

J1 and J2 allow the connection of the Calibration Modules to the instrument. J4 plugs into the A9 Power Supply Assembly to provide operating voltage to the instrument. 34-pin flat-ribbon connector J3 is used to interface signals from the rest of the instrument to the A1 Display and A2 Preset/Oscillator Assemblies.

TROUBLESHOOTING REPAIR

Since there are no components on A8 Assembly and it is an interconnection board only, no troubleshooting or repair procedures are provided.


02804-60080
A-1744-38
TP1
TP2
GND
J1
J2
J3
J4
J5
RA3
RA4
RA5
RA6
RA7

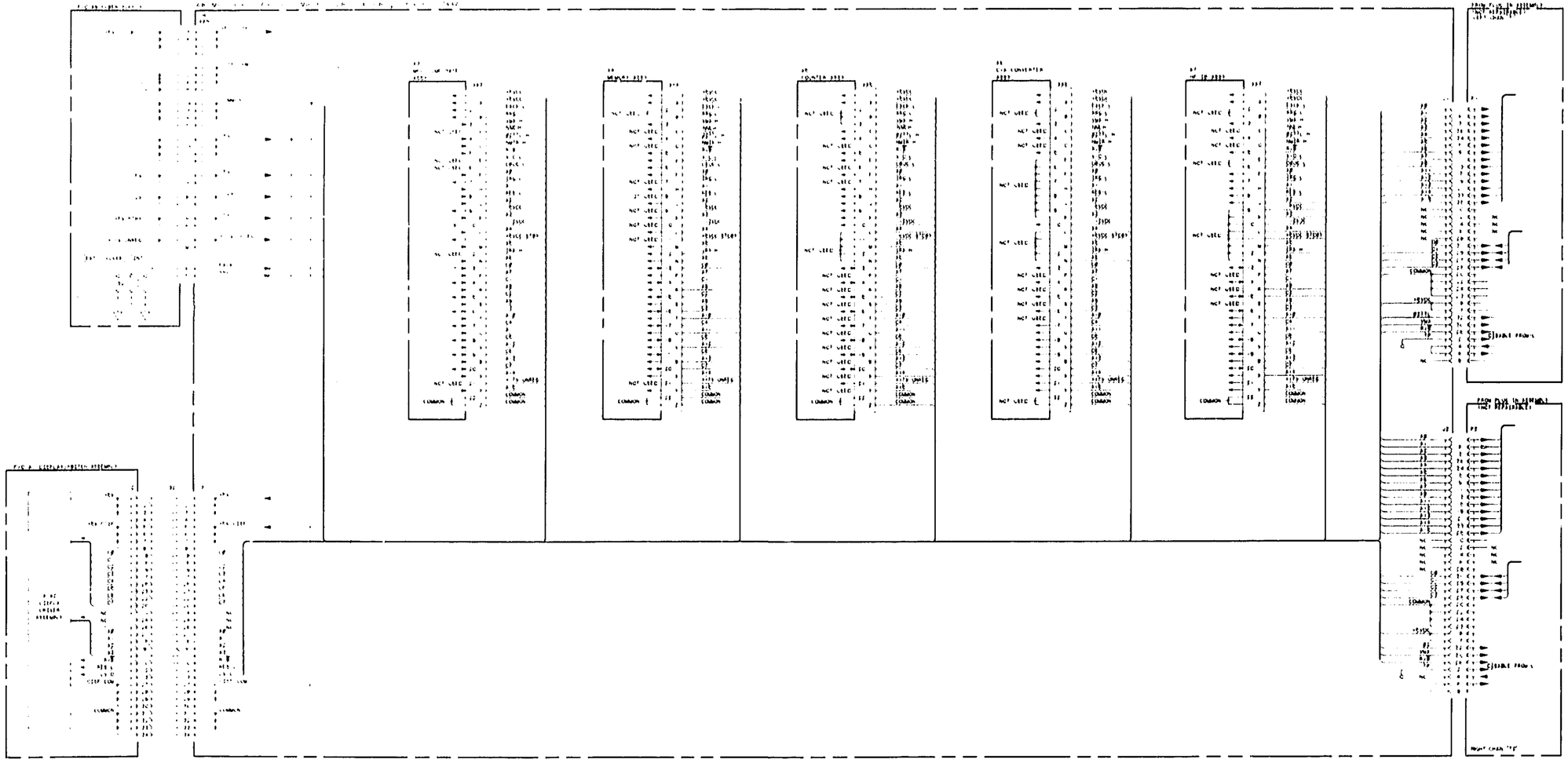


Figure 8-13. A8 Motherboard Assembly

A9 POWER SUPPLY ASSEMBLY

The A9 Assembly consists of the line module/filter LM1, power transformer T1, INT/EXT CLOCK switch S2, and the A9A1 Regulator Board. The instrument operates from 100, 120, 220 or 240 Vac at line frequencies from 48 to 66 Hz. Output voltages provided are as follows:

a. Regulated +5Vdc (±5%) at 2.3 A maximum.

b. Regulated +5Vdc (±5%) standby at 17 mA maximum.

c. Regulated -5Vdc (±5%) at 40 mA maximum.

d. Regulated -12Vdc (±5%) at 22 mA maximum.

e. Unregulated +17Vdc nominal (+15V to +20V) at 62 mA maximum.

All power supplies except the main +5V supply (through U1) remain active when front panel LINE switch is in the STANDBY position.

Each of the series regulators has fold-back current-limit protection. A short circuit on any of the outputs can be maintained without damage to the A9A1 Board. Each regulator has two types of diode protection. The diodes across each regulator (CR7, 8, 11 and 13) ensure that a short circuit condition does not cause the filter capacitor charge to pass back through the regulator. The diodes to ground at the output of each regulator (CR9, 10, 12 and 14) prevents damage if a voltage of opposite polarity is inadvertently connected to the regulator output.

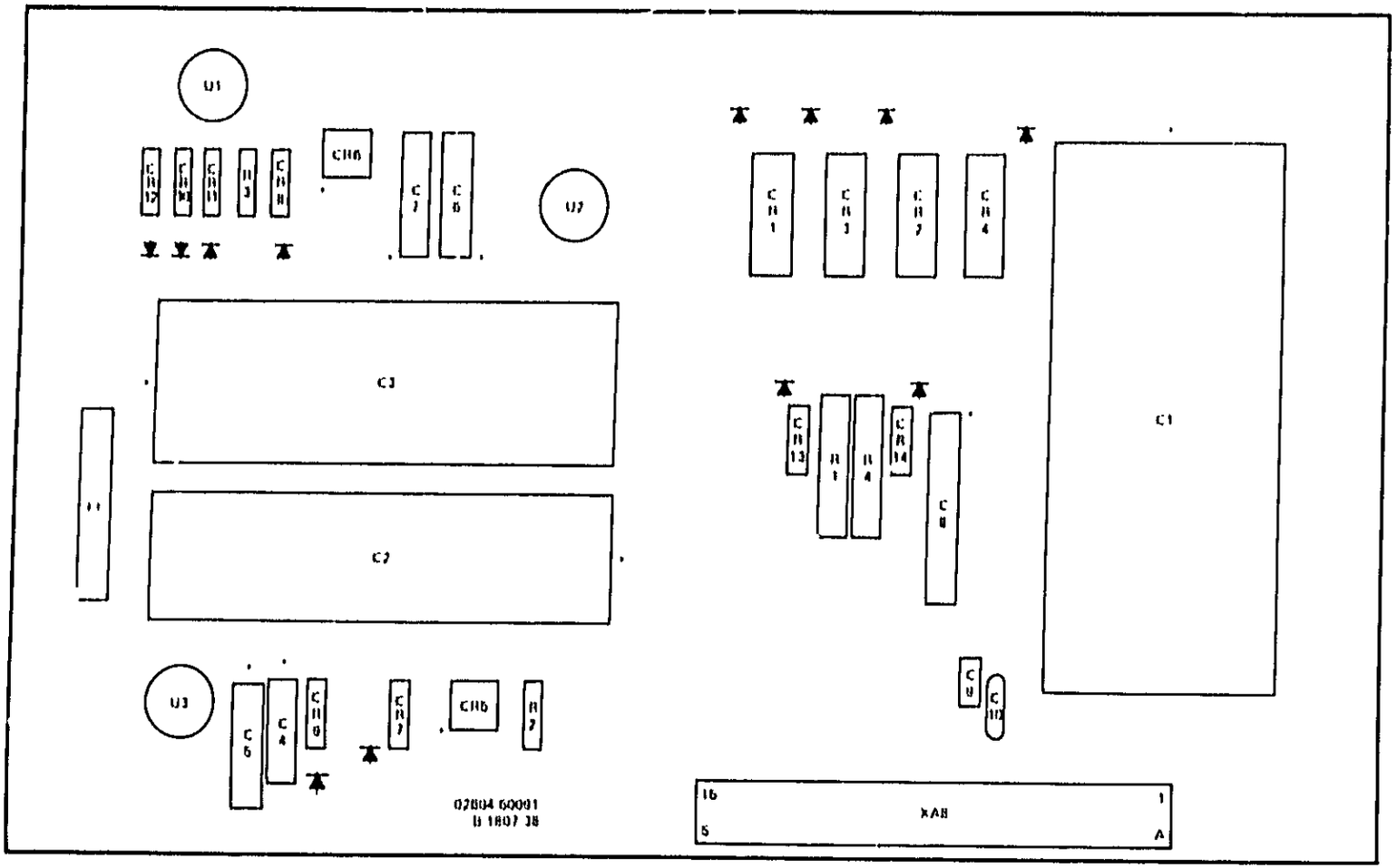
TROUBLESHOOTING/REPAIR

a. With the instrument in normal operation, use a dc voltmeter to measure the voltage at A8XA7 pins:

A8XA7 PIN NUMBER	DC VOLTS	MAXIMUM RIPPLE: AC VOLTS
1	+5 ± .25	6 mV
11	+5 ± .25	6 mV
21	≥17 (+15 to +20)	450 mV
10	-12 ± .6	6 mV
9	-5 ± .25	6 mV

b. Use an oscilloscope and check the ripple voltage at A8XA7 pins listed in step a. Values should be as listed in step a.

c. Conventional troubleshooting procedures may be used to isolate and locate defective components.


U1
CR6
C7
C6
U7
C3
C2
J1
U3
C5
C4
CR8
CR7
CR5
R7
C1
CR1
CR3
CR2
CR4
CR13
R1
R4
CR14
C8
C9
C10
XA8
16
1
5
A
02804 60001
B 1807 38

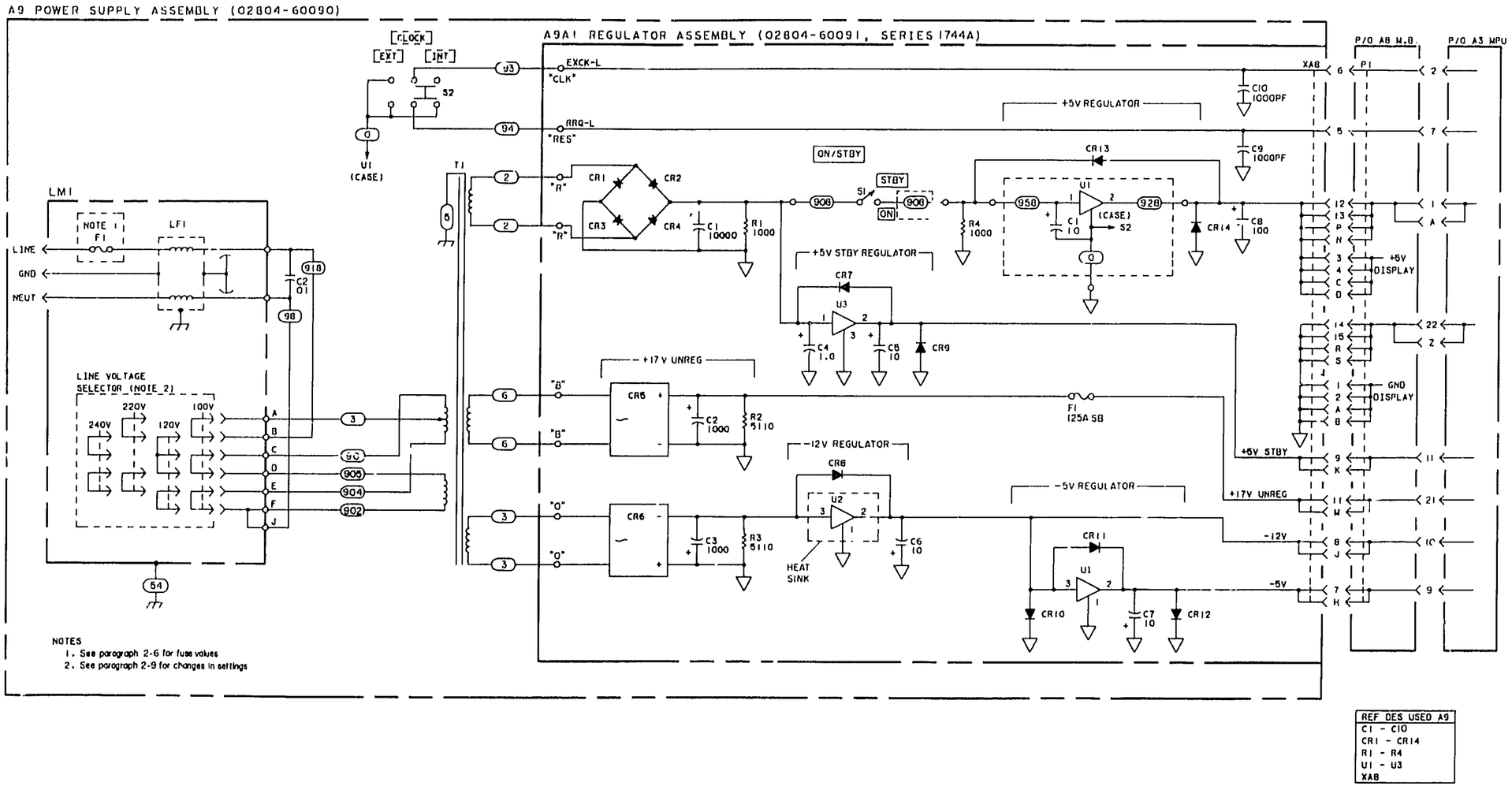


Figure 8-14. A9 Power Supply Assembly

APPENDIX A

This appendix provides information for the calibration modules and the text fixture needed to operate or service the Model 2804A. The calibration modules and test fixture uses are explained, where appropriate, in this manual.

Isolator Test Fixture for A2 Sensor Oscillator Adjustment.

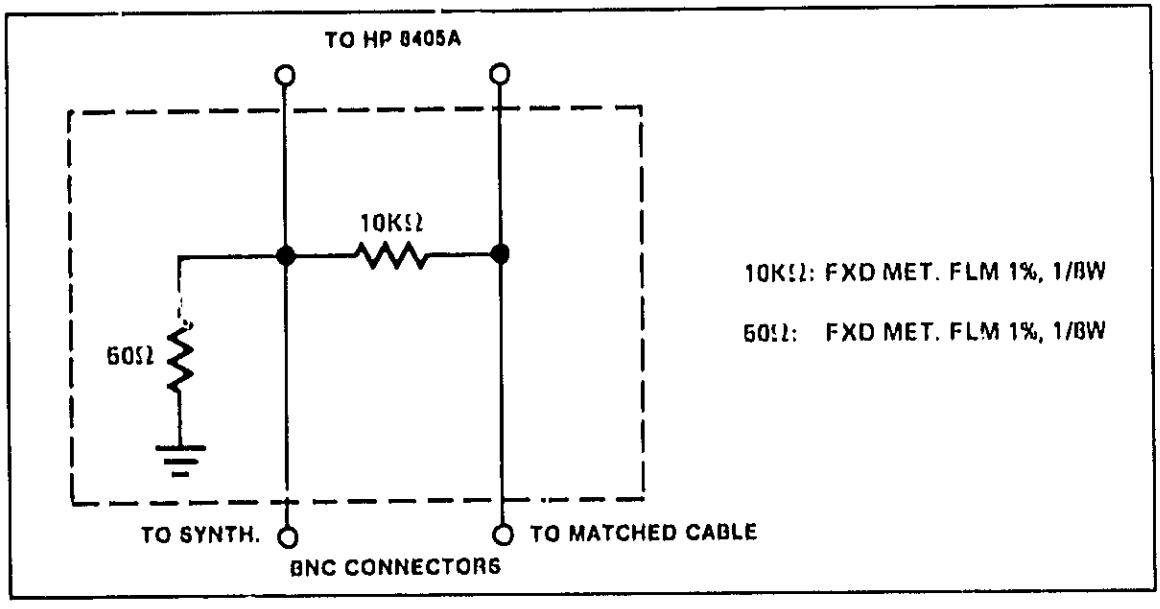


Figure A-1. Isolator Test Fixture

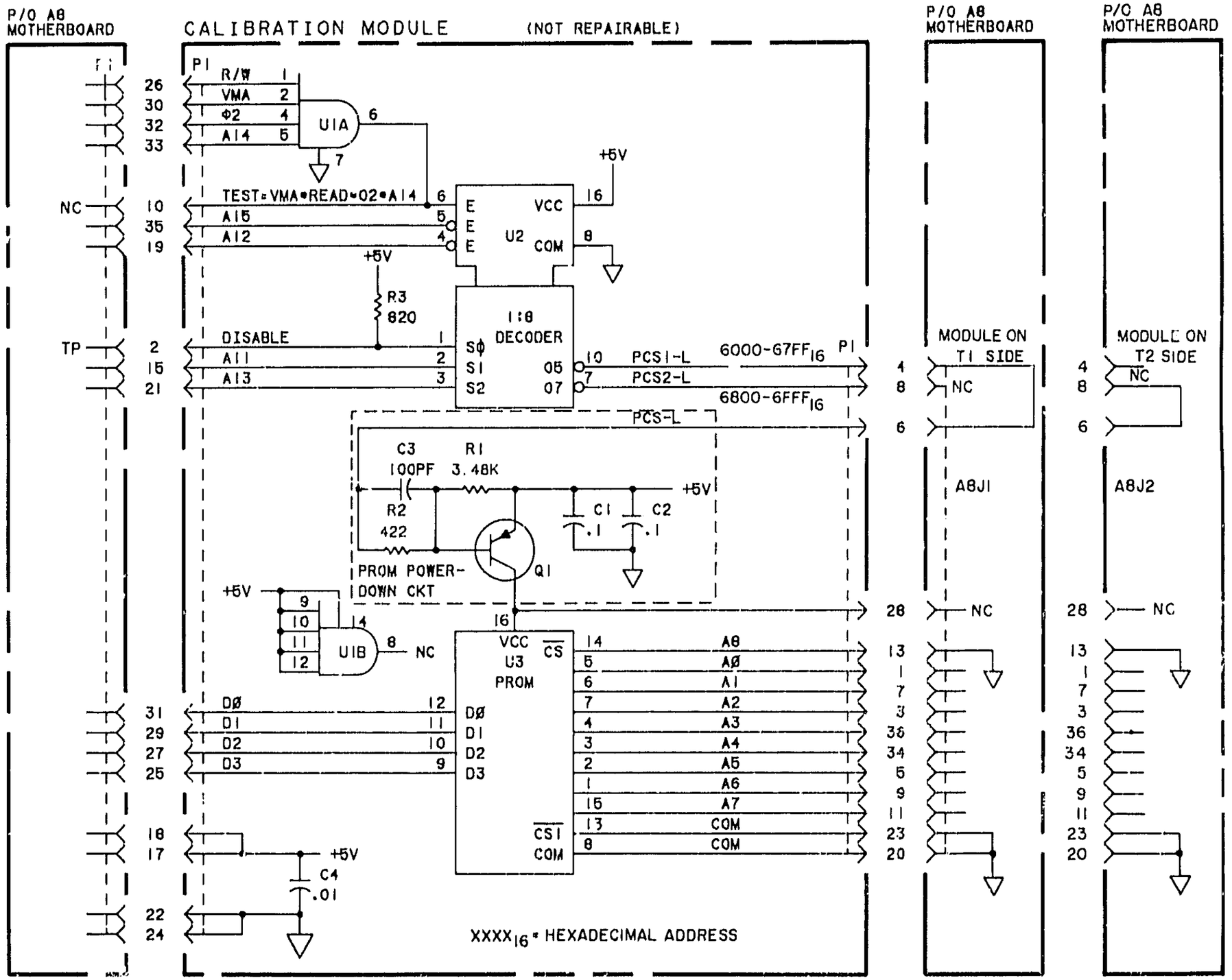


Figure A-2. Calibration Module (NOT REPAIRABLE for informational use only)

APPENDIX B

This appendix is a copy of the "Condensed Description of the Hewlett-Packard Interface Bus".

GENERAL BUS DESCRIPTION.

The Hewlett-Packard Interface bus (HP-IB) is a carefully defined instrumentation interface which simplifies the integration of instruments, calculators, and computers into systems. It minimizes compatibility problems between devices and has sufficient flexibility to accommodate future products. The Hewlett-Packard Interface Bus has been formally proposed to the International Electrotechnical Commission (I.E.C.), as an international standard, and to the Institute of Electrical and Electronic Engineers (I.E.E.E.) as an American standard.

The HP-IB employs a 16 line Bus to interconnect up to 15 instruments. This Bus is normally the sole communication link between the interconnected units. Each instrument on the Bus is connected in parallel to the 16 lines of the Bus. Eight of the lines are used to transmit data and the remaining eight are used for communication timing (Handshake), and control.

Data is transmitted on the eight HP-IB data lines as a series of eight-bit characters referred to as "bytes". Normally, a seven-bit ASCII (American Standard Code for Information Interchange) code is used with the eighth bit available for a parity check, if desired. Data is transferred by means of an interlocked "handshake" technique. This sequence permits asynchronous communication over a wide range of data rates.

Communication between devices on the HP-IB employs the three basic functional elements listed below. Every device on the Bus must be able to perform at least one of these functions.

a. LISTENER - A device capable of receiving data from other instruments. Examples of this type of device are: printers, display devices, programmable power supplies, programmable signal sources and the like.

b. TALKER - A device capable of transmitting data to other instruments. Examples of this type of device are: tape readers, voltmeters that are outputting data, counters that are outputting data, and so on.

c. CONTROLLER - A device capable of managing communications over the HP-IB such as addressing and sending commands. A calculator or computer with an appropriate I/O interface is an example of this type of device.

An HP-IB system allows only one device at a time to be an active talker. Up to 14 devices may simultaneously be listeners. Only one device at a time may be an active controller.

BUS STRUCTURE.

The HP-IB interface connections and Bus structure are shown in Figure B-1.

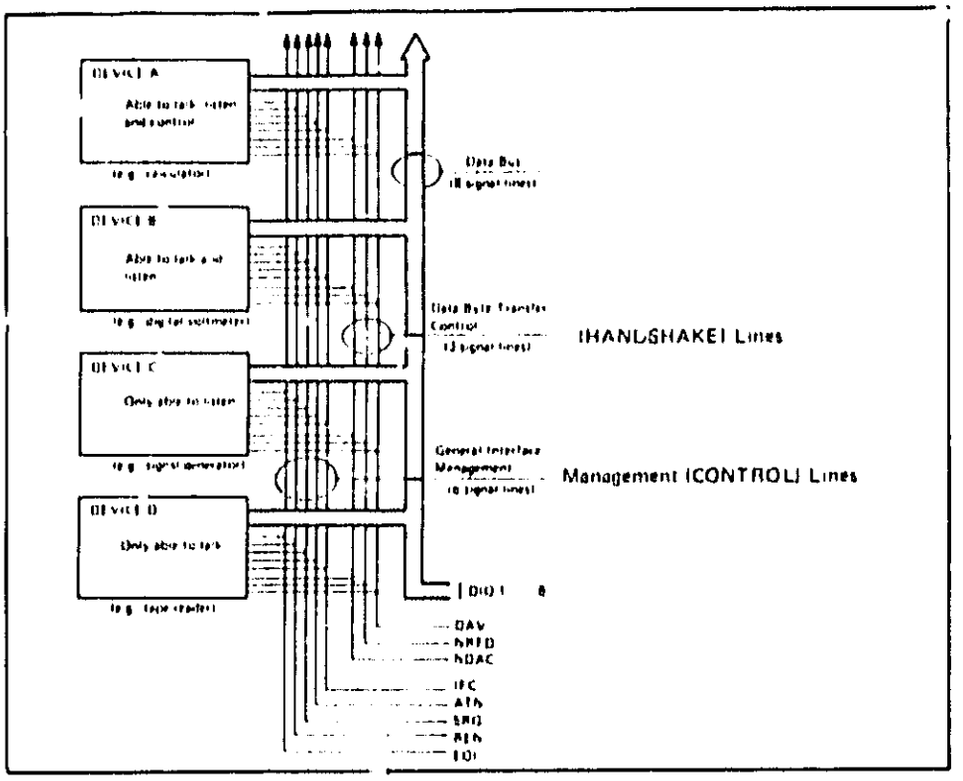


Figure B-1. Interface Connections and Bus Structure

Management (CONTROL) Lines.

The active controller manages all Bus communications. The state of the ATN (attention) line, determined by the controller, defines how data on the eight data (DIO) lines will be interpreted by the other devices on the Bus. When ATN is low (true), the HP-IB is in Command Mode. In Command Mode the controller is active and all other devices are waiting for instructions. Command Mode instructions which can be issued by the Controller in "Command Mode" include:

a. Talker Address

A seven bit code transmitted on the HP-IB which enables a specific device to talk. Only one Bus device at a time may act as the talker. When the controller addresses a unit to talk the previous talker is automatically unaddressed and ceases to be a talker. Confusion would result if more than one device were allowed to talk at a time.

b. Listener Address -

A seven-bit code transmitted on the HP-IB which enables a specific device to listen. Several Bus devices at a time (up to 14) may be listeners.

c. Universal Commands -

Bus devices capable of responding to these commands from the controller will do so at any time regardless of whether they are addressed. These commands will be covered in more detail later.

d. Addressed Commands -

These commands are similar to universal commands except that they are recognized only by devices that are addressed as listeners.

e. Unaddress Commands

1. "Unlisten" Address Command

This command unaddresses all listeners that have been previously addressed to listen.

2. "Untalk" Address Command

This command unaddresses any talker that had been previously addressed to talk.

Bus Commands.

In "Command Mode" one or more special codes known as "bus commands" may be placed on the HP-IB. These commands have the same meaning in all Bus systems. Each device is designed to respond to those commands that have a useful meaning to the device and will ignore all others. The operating manual for each device will state which Bus commands it will obey.

Bus commands fall into three categories.

1. Universal commands affect all responding devices on the Bus, whether addressed or not.

2. Addressed commands affect only responding devices which are addressed to listen. Addressed commands allow the controller to initiate a simultaneous action from a selected group of devices on the Bus.

3. Unaddress commands are obeyed by all addressable devices. These commands unaddress devices that are currently addressed.

The Bus commands are summarized in Table B-1.

Service Request and Serial Polling.

Some devices that operate on the interface bus have the ability to request service from the system controller. A device may request service when it has completed a measurement, when it has detected a critical condition, or for any other reason. Service request is initiated when a device sets the HP-IB line labeled SRQ low. The controller has the option of determining when or if a service request will be serviced. The following sequence is used to respond to a service request:

a. The controller checks for the presence of a service request.

b. If a service request is present, the controller sets the serial poll mode. *The serial poll mode is initiated by the controller transmitting the Universal Command "SPE" (ASCII character "CAN" [Octal 030]) in the "Command Mode".*

c. The controller polls one of the devices that may have requested service. It then polls the next device, and so on. *Once the serial poll mode has been enabled, responding devices on the Bus are prepared to accept a serial poll. This is done by setting ATN, addressing the device as a talker, and then removing ATN. If the device has requested service, it will respond by setting DIO line 7 low. Other DIO lines may also be set low indicating the nature of the service request.*

d. For each device that has requested service, the controller takes appropriate action.

Table B-1 Summary of Bus Commands

	COMMAND	ASCII Character	OCTAL CODE	PURPOSE
UNADDRESS COMMANDS	UNL UNLISTEN	?	077	Clears Bus of all listeners
	UNT UNTALK		137	Unaddresses the current talker so that no talker remains on the Bus *
UNIVERSAL COMMANDS	LLO Local Lockout	DC1	021	Disables front panel local reset button on responding devices
	DCL Device Clear	DC4	024	Returns all devices capable of responding to pre-determined states, regardless of whether they are addressed or not
	PPU Parallel Poll Unconfigure	NAK	025	Sets all devices on the HP-IB with Parallel Poll capability to a predefined condition
	SPE Serial Poll Enable	CAN	030	Enables Serial Poll Mode on the Bus
	SPD Serial Poll Disable	EM	031	Disables Serial Poll Mode on the Bus.
ADDRESSED COMMANDS	SDC Selective Device Clear	EOT	004	Returns addressed devices, capable of responding to pre-determined states
	GTL Go to Local	SOH	001	Returns responding devices to local control
	GET Group Execute Trigger	BS	010	Initiates a simultaneous pre-programmed action by responding devices.
	PPC Parallel Poll Configure	ENQ	005	This command permits the DIO lines to be assigned to instruments on the Bus for the purpose of responding to a parallel poll.
	TCT Take Control	HT	011	This command is given when the active controller on the Bus transfers control to another instrument.

*NOTE

Talkers can also be unaddressed by transmitting an unused talk address on the Bus.

e. When all devices have been polled, the controller terminates the serial poll mode by issuing the Universal Command SPD (ASCII Character "EM", [Octal 031]).

The full sequence of operations is not necessary in all cases. For example, a system may have only one device that requests service and then only for a single purpose. When the controller detects a service request, the source of the request and the appropriate action is known immediately. Thus the use of the service request and the serial poll depends entirely on the make-up of each system and the devices involved.

Table B-2. Code Assignments for "Command Mode" of Operation

(SENT AND RECEIVED WITH ATN TRUE)

b_4	b_3	b_2	b_1	COLUMN → / ROW ↓	0 0 0	MSG (1)	0 0 1	MSG	0 1 0	MSG	0 1 1	MSG	1 0 0	MSG	1 0 1	MSG	1 1 0	MSG	1 1 1	MSG
					0		1		2		3		4		5		6		7	
0	0	0	0	0	NUL		DLE		SP	MLA ASSIGNED TO DEVICE	0	MLA ASSIGNED TO DEVICE	@	MTA ASSIGNED TO DEVICE	P	MTA ASSIGNED TO DEVICE		MEANING DEFINED BY PCG CODE	p	MEANING DEFINED BY PCG CODE
0	0	0	1	1	SOH	GTL	DC1	LLO	!		1		A		Q		a		q	
0	0	1	0	2	STX		DC2		"		2		B		R		b		r	
0	0	1	1	3	ETX		DC3		#		3		C		S		c		s	
0	1	0	0	4	EOT	SDC	DC4	DCL	$		4		D		T		d		t	
0	1	0	1	5	ENQ	PPC (1)	NAK	PPU	%		5		E		U		e		u	
0	1	1	0	6	ACK		SYN		&		6		F		V		f		v	
0	1	1	1	7	BEL		ETB		'		7		G		W		g		w	
1	0	0	0	8	BS	GET	CAN	SPE	(		8		H		X		h		x	
1	0	0	1	9	HT	TCT	EM	SPD	)		9		I		Y		i		y	
1	0	1	0	10	LF		SUB		*		:		J		Z		j		z	
1	0	1	1	11	VT		ESC		+		;		K		[		k		{	
1	1	0	0	12	FF		FS		,		<		L		\		l		|	
1	1	0	1	13	CR		GS		-		=		M		]		m		}	
1	1	1	0	14	SO		RS		.		>		N		^		n		~	
1	1	1	1	15	SI		US		/		?	UNL	O		←	UNT	o	DEL		

(4)

ADDRESSED COMMAND GROUP (ACG)

UNIVERSAL COMMAND GROUP (UCG)

LISTEN ADDRESS GROUP (LAG)

TALK ADDRESS GROUP (TAG)

PRIMARY COMMAND GROUP (PCG)

SECONDARY COMMAND GROUP (SCG)

NOTES
(1) MSG = INTERFACE MESSAGE
(2) b_1 = DIO1 ... b_7 = DIO7
(3) REQUIRES SECONDARY COMMAND
(4) DENSE SUBSET (COLUMN 2 THROUGH 5). ALL CHARACTERS USED IN BOTH COMMAND & DATA MODES.

Parallel Poll.

Parallel polling permits the status of up to eight devices on the HP-IB to be checked simultaneously. The operator assigns each device a data line (DIO1 thru DIO8) which the device sets low during the parallel poll routine if it requires service. More devices can be handled, if desired, by sharing the use of each DIO line.

The parallel polling function requires the controller to periodically poll the instruments connected to the Bus. The controller interrogates (polls) the instruments by sending an EOI with ATN activated. When either EOI or ATN is removed, the controller stops polling.

Code Summary.

A code assignment summary is shown in Table B-2. These assignments apply only when operating in "Command Mode".

In "Data Mode" there are no specific code assignments. However, the devices communicating in this mode must agree on the meaning of the codes they use.

The set of codes labeled "Primary Command Group" are the codes commonly used to communicate on the HP-IB. The "Secondary Command Group" is used when addressing extended listeners and talkers, or enabling the Parallel Poll Mode.

Other Bus Lines.

The three remaining HP-IB lines and their functions are:

REN (Remote Enable) The system controller sets REN low and then addresses the devices to Listen before they will operate under remote control.

IFC (Interface Clear) Only the system controller can activate this line. When IFC is set (true) all talkers, listeners and active controllers go to their inactive states.

EOI (End or Identify) This line is used to indicate the end of a multiple byte transfer sequence or, in conjunction with ATN, to execute a parallel polling sequence.

NOTE

Individual instruments, at power-on, can momentarily set the IFC line to a true state.

Address Codes.

Devices with the functional capability of talker normally recognize a single byte address*. A certain group of ASCII seven-bit bytes is reserved for talk addresses (refer to Table B-3). The state of the eighth bit is ignored in the "Command Mode" when addresses are being transmitted. Each device has a unique talk address which can normally be modified. The Talk Address, bits one through five, are individually selected in each device to be either high or low. The selection of these bits allows changing the device talk and/or Listen address.

Devices with the functional capability of Listener normally recognize a single character address**. The seven-bit codes reserved for Listen addresses are listed in Table B-3. Each device has a unique listen address which can normally be modified.

NOTE

Bits 6 and 7 determine whether the "address" is a "listen" or "talk" address (see Table B-3).

*An "extended talker" is capable of recognizing a two byte talk address.

**An "extended listener" is capable of recognizing a two byte listen address.

Devices with both talk and listen addresses have these addresses assigned in pairs, e.g., if the fourth address in the column of listen addresses "#" is selected, the talk address is "C", the fourth address in the talker address column. The talk address is automatically changed whenever the listen address is changed and vice versa. Addresses are normally alterable by the use of switches or jumpers within the instrument.

Table B-3. Talk and Listen Address

Listen Addresses									Talk Addresses								
Bits								ASCII	Bits								ASCII
b_8	b_7	b_6	b_5	b_4	b_3	b_2	b_1	Character	b_8	b_7	b_6	b_5	b_4	b_3	b_2	b_1	Character
X	0	1	0	0	0	0	0	SP	X	1	0	0	0	0	0	0	@
X	0	1	0	0	0	0	1	!	X	1	0	0	0	0	0	1	A
X	0	1	0	0	0	1	0	"	X	1	0	0	0	0	1	0	B
X	0	1	0	0	0	1	1	#	X	1	0	0	0	0	1	1	C
X	0	1	0	0	1	0	0	$	X	1	0	0	0	1	0	0	D
X	0	1	0	0	1	0	1	%	X	1	0	0	0	1	0	1	E
X	0	1	0	0	1	1	0	&	X	1	0	0	0	1	1	0	F
X	0	1	0	0	1	1	1	'	X	1	0	0	0	1	1	1	G
X	0	1	0	1	0	0	0	(	X	1	0	0	1	0	0	0	H
X	0	1	0	1	0	0	1	)	X	1	0	0	1	0	0	1	I
X	0	1	0	1	0	1	0	*	X	1	0	0	1	0	1	0	J
X	0	1	0	1	0	1	1	+	X	1	0	0	1	0	1	1	K
X	0	1	0	1	1	0	0	,	X	1	0	0	1	1	0	0	L
X	0	1	0	1	1	0	1	-	X	1	0	0	1	1	0	1	M
X	0	1	0	1	1	1	0	.	X	1	0	0	1	1	1	0	N
X	0	1	0	1	1	1	1	/	X	1	0	0	1	1	1	1	O
X	0	1	1	0	0	0	0	0	X	1	0	1	0	0	0	0	P
X	0	1	1	0	0	0	1	1	X	1	0	1	0	0	0	1	Q
X	0	1	1	0	0	1	0	2	X	1	0	1	0	0	1	0	R
X	0	1	1	0	0	1	1	3	X	1	0	1	0	0	1	1	S
X	0	1	1	0	1	0	0	4	X	1	0	1	0	1	0	0	T
X	0	1	1	0	1	0	1	5	X	1	0	1	0	1	0	1	U
X	0	1	1	0	1	1	0	6	X	1	0	1	0	1	1	0	V
X	0	1	1	0	1	1	1	7	X	1	0	1	0	1	1	1	W
X	0	1	1	1	0	0	0	8	X	1	0	1	1	0	0	0	X
X	0	1	1	1	0	0	1	9	X	1	0	1	1	0	0	1	Y
X	0	1	1	1	0	1	0	:	X	1	0	1	1	0	1	0	Z
X	0	1	1	1	0	1	1	;	X	1	0	1	1	0	1	1	[
X	0	1	1	1	1	0	0	<	X	1	0	1	1	1	0	0	\
X	0	1	1	1	1	0	1	=	X	1	0	1	1	1	0	1	]
X	0	1	1	1	1	1	0	>	X	1	0	1	1	1	1	0	^

X = don't care

Handshake Lines.

Each character byte transferred on the HP-IB data lines employs the three-wire handshake sequence. This sequence has the following characteristics:

1. Data transfer is asynchronous – Data can be transferred at any rate suitable for the devices operating on the Bus. (Data rates up to 500 kilobytes per second are typical; with a maximum of 1 megabyte per second).

2. Devices with different input/output speeds can be interconnected. Data transfer rate automatically adjusts to slowest active device.

3. More than one device can accept data at the same time.

The following definitions are used throughout the remaining text.

Source – A device transmitting information on the Bus in either the Command or Data Mode.
Talker – An "addressed" source in the Data Mode only.
Acceptor – A device receiving information on the Bus in either the Command or Data Mode.
Listener – An "addressed" acceptor in the Data Mode only.

The Data Transfer or "HANDSHAKE" lines are shown in Figure B-1. The mnemonics of each line have the following meanings:

DAV – Data Valid
NRFD – Not Ready for Data
NDAC – Not Data Accepted

The handshake timing sequence is illustrated in Figure B-2.

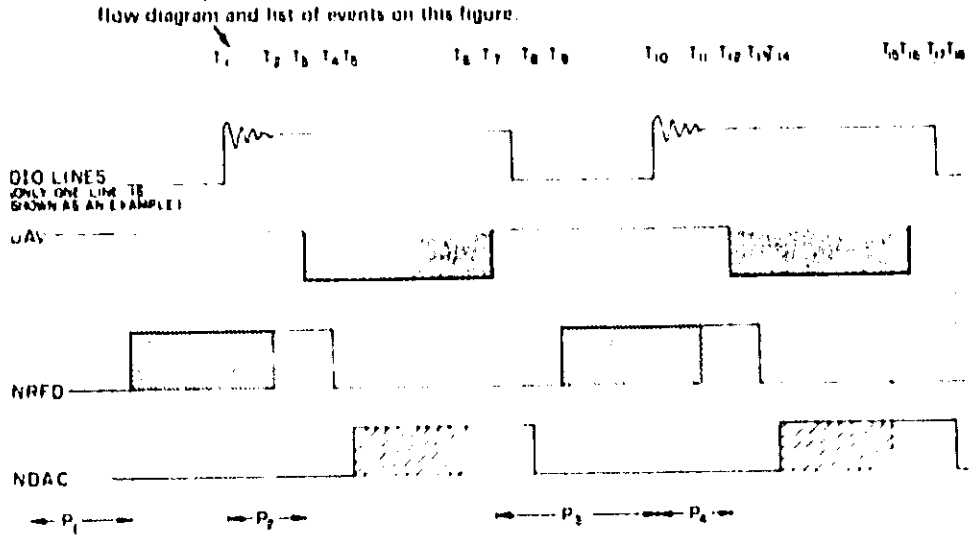
Each data byte transferred by the interface system uses the handshake process when exchanging data between source and acceptor. The handshake timing sequence is illustrated in Figure B-2. In Data Mode, the source is a Talker and the acceptor is a Listener.

The timing diagram illustrates the handshake process by indicating the actual waveforms on the DAV, NRFD, and NDAC lines. The NRFD and NDAC signals each represent composite waveforms resulting from two or more Listeners accepting the same data byte at slightly different times. This is usually due to variations in the transmission path length and individual instrument response rates (delays).

The flow chart represents the same sequence of events in a different form.

The subscripted letters on the flow chart and the timing diagram refer to the same event on the list of events.

HANDSHAKE line timing diagram for one talker and multiple listeners using the handshake process. Two cycles of the handshake sequence are shown. Also refer to the flow diagram and list of events on this figure.



Period in which data is guaranteed to be valid.

Period in which all listeners become ready for data.

Period in which all listeners accept data.

List of Events for Handshake Process

P_1 Source initializes DAV to high (False - data not valid).

Acceptors initialize NRFD to low (True - none are ready for data), and set NDAC to low (True - none have accepted the data).

T_1 Source checks for error condition (both NRFD and NDAC high), then places data byte on DIO lines.

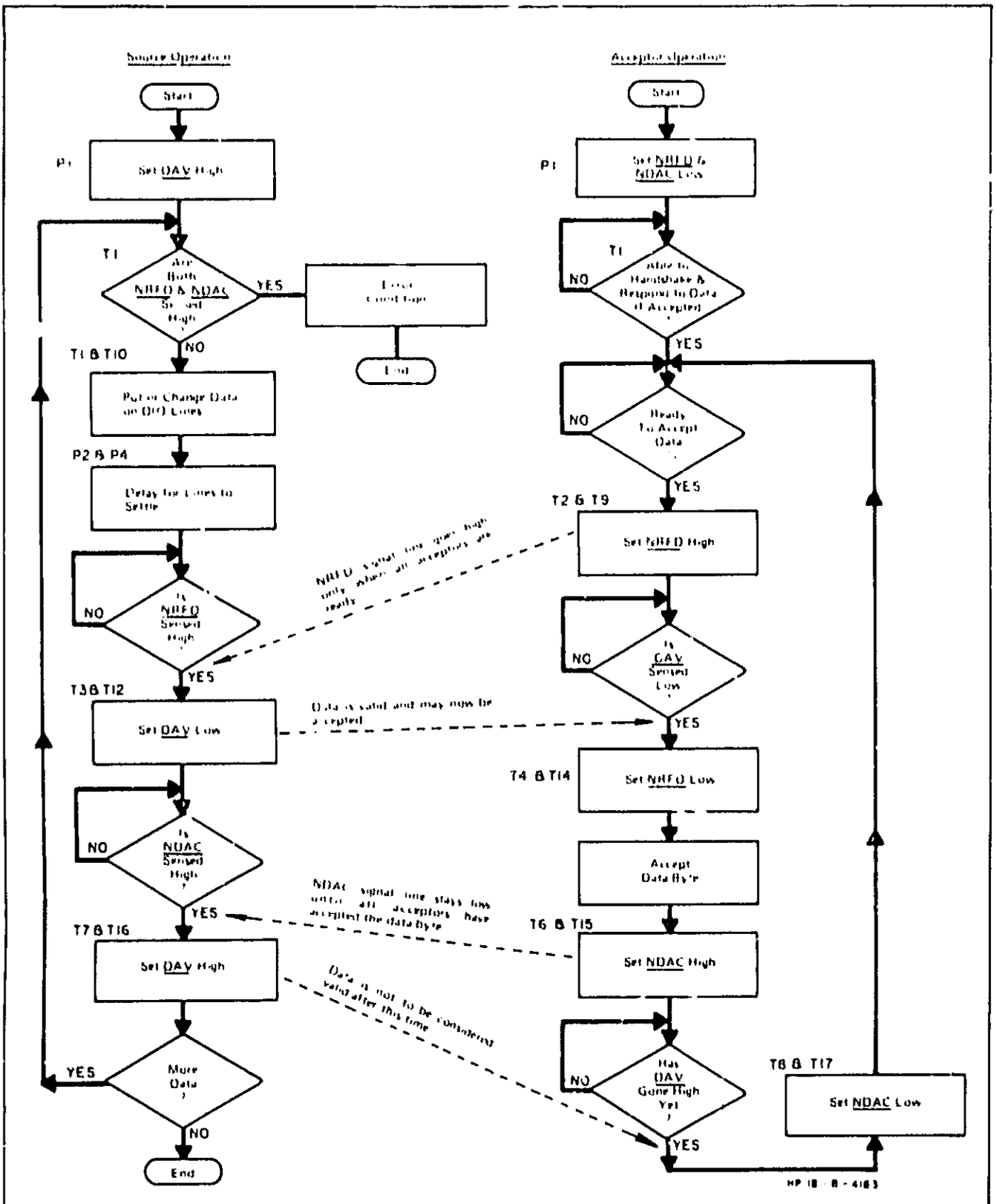
P_2 Source delays to allow data to settle on DIO lines.

Figure B-2. Handshake Timing Sequence

T_2	Acceptors have all indicated readiness to accept first data byte; NRFD goes high.
T_3	When the data is settled and valid, and the source has sensed NRFD high, DAV is set low.
T_4	First acceptor sets NRFD low to indicate that it is no longer ready, then accepts the data. Other acceptors follow at their own rates.
T_5	First acceptor sets NDAC high to indicate that it has accepted the data. (NDAC remains low due to other acceptors driving NDAC low).
T_6	Last acceptor sets NDAC high to indicate that it has accepted the data; all have now accepted and NDAC goes high.
T_7	Source, having sensed that NDAC is high, sets DAV high. This indicates to the acceptors that data on the DIO lines must now be considered not valid. Upon completion of this step, one byte of data has been transferred.
P_3 ($T_7 - T_{10}$)	Source changes data on the DIO lines.
T_8 *	Acceptors, upon sensing DAV high set NDAC low in preparation for next cycle. NDAC goes low as the first acceptor sets it low.
T_9	First acceptor indicates that it is ready for the next data byte by setting NRFD high. (NRFD remains low due to other acceptors driving NRFD low).
T_{10}	Source checks for error condition (both NRFD and NDAC high), then places data byte on DIO lines (as at T_1).
P_4 ($T_{10}-T_{12}$)	Source delays to allow data to settle on DIO lines.
T_{11}	Last acceptor indicates that it is ready for the next data byte by setting NRFD high; NRFD signal line goes high.
T_{12}	Source, upon sensing NRFD high, sets DAV low to indicate that data on DIO lines is settled and valid.
T_{13}	First acceptor sets NRFD low to indicate that it is no longer ready, then accepts the data.
T_{14}	First acceptor sets NDAC high to indicate that it has accepted the data.
T_{15}	Last acceptor sets NDAC high to indicate that it has accepted the data (as at T_6).
T_{16}	Source, having sensed that NDAC is high, sets DAV high (as at T_7).
T_{17}	Source removes data byte from DIO signal lines after setting DAV high.
T_{18} *	Acceptors, upon sensing DAV high, set NDAC low in preparation for next cycle.

* Note that all three handshake lines return to their initialized states, as at T_1 and T_2.

Figure B-2. Handshake Timing Sequence (Cont.)



Logical flow of events for Source and Acceptor when transferring data using the hand shake process. See list of events on next page.

Figure B-2. Handshake Timing Sequence (Cont.)

Data Lines.

A set of eight interface lines is available to carry all seven bit interface messages and device dependent messages. These are DATA INPUT OUTPUT lines, DIO1 through DIO8. Only seven lines are required for transfer of data. The eighth line is usually used for a parity check. The data on the DIO lines is transferred in a bit parallel, byte serial form, asynchronously and bidirectionally.

a. Data Mode

When ATN (attention) goes high (false), the HP-IB is in the "Data Mode". In this mode data may be transferred between devices that were addressed when the HP-IB was in "Command Mode". Messages that can be transferred in "Data Mode" include.

1. Programming Instructions

Codes are seven bit bytes placed on the HP-IB data (DIO) lines. The meaning of each byte is device dependent and is selected by the equipment designer. These types of messages are usually between the controller acting as the talker and a single device that has been addressed as a listener.

2. Data Codes

Data codes are seven-bit bytes placed on the data lines. The meaning of each byte is device dependent. For meaningful communication to occur, both the talker and listener must agree on the meaning of the codes they use.

Data Byte.

Individual data bytes transmitted on the HP-IB can be described in an octal code. The binary bits are separated into groups of three starting from the right-hand side (see Table B-4). Within the groups each binary bit is assigned a weight "1", "2" and "4" respectively. The octal numbers corresponding to each group of bits is the summation of the weights of the binary ones in each group.

NOTE

In Table B-4 the hundreds group has two bits rather than three since there are eight data lines. When seven-bit character ASCII code is used the hundreds group contains only one bit which can take on the octal value of "0" or "1".

Table B-4. Octal Code Conversion

Bits	b_8	b_7	b_6	b_5	b_4	b_3	b_2	b_1	Octal Code		
Weights	"2"	"1" (Hundreds)	"4"	"2"	"1" (Tens)	"4"	"2"	"1" (Ones)			
	1	0	0	1	1	0	1	0	2	3	2
	1	1	1	1	1	0	0	0	3	7	0
	0	1	0	0	1	0	1	1	1	1	3
	0	0	0	1	0	1	1	1	0	2	7

INTERFACE.

A list of the available functions is given in Table B-5. Every HP-IB compatible device is able to perform at least one function on the HP-IB. Devices ignore all commands relating to functions they do not have.

Example:

An HP-IB compatible programmable voltage source includes the "listen function" so that it can be programmed to accept data. However, it does not output information so it does not include a "talk function". Therefore, the programmable voltage source would ignore all information on the HP-IB pertaining to the "talk function"

Table B-5. HP-IB Instrument Interface Functions

Interface Functions that may be included in an HP-IB device.	Comments
Source Handshake	This functional capability must be included in any device that can be a "talker" on the bus.
Acceptor Handshake	This functional capability must be included in all devices that can be "listeners".
Talker or Extended Talker*	Capability required for a device to be a "talker".
Listener or Extended Listener*	Capability required for a device to be a "listener".
Service Request	This capability permits a device to asynchronously request service from the controller.
Remote/Local	Provides capability to select between two sources of input information. Local corresponds to front panel controls and remote to the input information from the bus.
Parallel Poll	Provides capability for a device to uniquely identify itself if it requires service and the controller is requesting a response. This capability differs from service request in that it requires a commitment of the controller to periodically conduct a parallel poll.
Device Clear	This function allows a device to be initialized to a pre-defined state. A device with this capability will have the effect of this command described in its operating manual.
Device Trigger	This function permits a device to have its basic (measurement) operation initiated by the talker on the Bus.
Controller	This function permits a device to send addresses, universal commands and addressed commands to other devices on the HP-IB. It may also include the ability to conduct parallel polling to determine devices requiring service.

*Extended Talker and Extended Listener provide increased address capability. Devices with this functional capability recognize addresses that are two bytes in length rather than just one byte.

Bus Operating Considerations.

a. When a device capable of activating IFC is powered on during system operation, it may cause the active controller on the Bus to relinquish control, resulting in errors. The Controller must transmit IFC to regain active Control.

b. Prior to addressing new listeners it is recommended that all previous listeners be unaddressed using the Unlisten Command (?).

c. Only one talker can be addressed at a time. When a new talker is addressed the former talker is automatically unaddressed.

d. The maximum accumulative length of the HP-IB cable in any system must not exceed more than 2 meters of cable per device or 20 meters, whichever is less.

e. For additional programming information consult the HP-IB User Guide for the appropriate calculator.

HP-IB Connector.

Figure B-3 shows the pin configuration of the HP-IB Connector.

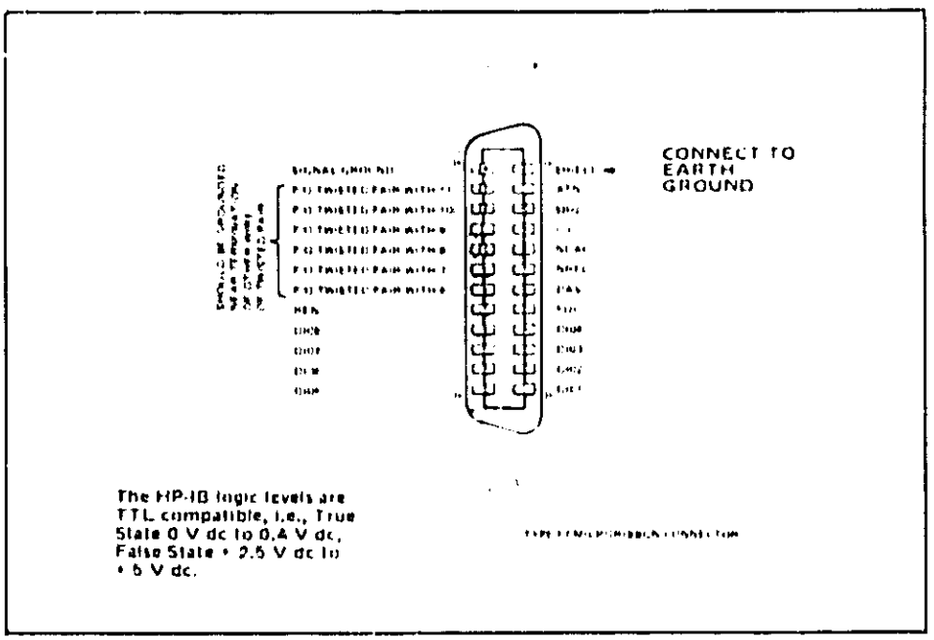


Figure B-3. HP-IB Connector

System Configurations.

HP-IB Systems can be categorized into three types

1. Systems with no controller

The mode of data transfer is limited to a direct transfer between one device manually set to "talk only" and one or more devices manually set to "listen only" to form a very basic fixed network system.

2. Systems with a single controller

The modes of data transfer for these systems are:

a. Direct transfer between talkers and listeners (Data Mode).
b. Transfer from a device to a controller (Data Mode).
c. Transfer from a controller to a device (Command Mode).

3. Systems with multiple controllers

The modes of data transfer for these systems are the same as those listed in 2. In addition a method of passing control from one controller to another is required. One controller must be designated as the system controller. The system controller is the only device that can control the HP-IB lines designated IFC (Interface Clear) and REN (Remote Enable). When the system controller sets IFC low, all I/O operations cease and all talkers, listeners and controllers are unaddressed. Control is passed to a different controller by addressing it as a talker and commanding it to "take control" (Octal code 011).

GLOSSARY OF TERMS

ACCEPTOR A device receiving information on the Bus in either the Command or Data Mode (Also, see Source)

ADDRESS A 7-bit code applied to the HP-IB in "Command Mode" which enables instruments capable of responding to listen and/or talk on the Bus

ADDRESSED COMMANDS These commands allow the Bus controller to initiate simultaneous actions from addressed instruments which are capable of responding

ATN Mnemonic (Attention) referring to the "Command Mode" of operation on the HP-IB, or the control line which places the HP-IB in this mode

BIT The smallest part of an HP-IB character (Byte) which contains intelligible information

BUS COMMANDS A group of Special Codes which initiate certain types of operation in instruments capable of responding to these codes. Each instrument on the HP-IB is designed to respond to those codes that have useful meaning to the device and ignore all others (see Table 4)

BYTE An HP-IB character sent over the DIO lines, normally consisting of seven-bits

COMMAND MODE In this mode devices on the HP-IB can be addressed or unaddressed as talkers or listeners. Bus commands are also issued in this mode

CONTROLLER Any device on the HP-IB which is capable of setting the ATN line and addressing instruments on the Bus as talkers and listeners. (Also see System Controller.)

DEVICE CLEAR (DCL) ASCII character "DC4" (Octal 024) which, when sent on the HP-IB will return all devices capable of responding to pre-defined states.

DATA MODE The HP-IB is in this mode when the control line "ATN" is high (false). In this mode data or instructions are transferred between instruments on the HP-IB.

DAV Mnemonic referring to the control line "Data Valid" on the HP-IB. This line is used in the HP-IB "Handshake" sequence.

DIO Mnemonic referring to the eight "Data Input/Output" lines of the HP-IB

EOI Mnemonic referring to the control line "End or Identify" on the HP-IB. This line is used to indicate the end of a multiple byte message on the Bus. It is also used in parallel polling.

EXTENDED LISTENER An instrument which requires two HP-IB bytes to address it as a listener. (Also see Listener.)

EXTENDED TALKER An instrument which requires two HP-IB bytes to address it as a listener. (Also see Talker.)

GO TO LOCAL (GTL) ASCII character "SOH" (Octal 001) which, when sent on the HP-IB, will return devices addressed to listen and capable of responding back to local control.

GROUP EXECUTE TRIGGER (GET) ASCII character "BS" (Octal 010) which, when sent on the HP-IB, initiates simultaneous actions by devices addressed to listen and capable of responding to this command.

HANDSHAKE Refers to the sequence of events on the HP-IB during which each data byte is transferred between addressed devices. The conditions of the HP-IB handshake sequence are as follows:

a. NRFD, when false, indicates that a device is ready to receive data.

b. DAV, when true, indicates that data on the DIO lines is stable and available to be accepted by the receiving device.

c. NDAC, when false indicates to the transmitting device that data has been accepted by the receiver.

HP-IB An abbreviation that refers to the "Hewlett-Packard Interface Bus"

IFC Mnemonic referring to the Control line "Interface Clear" on the HP-IB. Only the system controller can activate this line. When IFC is set (true) all talkers and listeners on the HP-IB are unaddressed, and controllers go to the inactive state.

LISTENER A device which has been addressed to receive data or instructions from other instruments on the HP-IB. (Also see Extended Listener.)

LOCAL LOCKOUT ASCII character "DC1" (Octal 021) which, when sent on the HP-IB, disables the front panel controls of responding devices.

NDAC Mnemonic referring to the control line "Data Not Accepted" on the HP-IB. This line is used in the "Handshake" sequence.

NRFD Mnemonic referring to the control line "Not Ready For Data" on the HP-IB. This line is used in the HP-IB "Handshake" sequence.

PARALLEL POLLING A method of simultaneously checking status on up to eight instruments on the HP-IB. Each instrument is assigned a DIO line with which to indicate whether it requested service or not.

PRIMARY COMMANDS The group of ASCII characters which are typically used on the HP-IB (see Table 5).

REN Mnemonic referring to the control line "Remote Enable" on the HP-IB. This line is used to enable Bus compatible instruments to respond to commands from the controller or another talker. It can be issued only by the system controller.

SECONDARY COMMANDS The group of ASCII characters which are used to increase the address length of extended talkers and listeners to two bytes.

SELECTIVE DEVICE CLEAR ASCII character "EOT" (Octal 004) which, when sent on the HP-IB, returns addressed devices capable of responding to a predetermined state.

SERIAL POLLING The method of sequentially determining which device connected to the HP-IB has requested service. Only one instrument is checked at a time.

SERIAL POLL DISABLE (SPD) ASCII character "EM" (Octal 031) which, when sent on the HP-IB, will cause the Bus to go out of serial poll mode.

SOURCE A device transmitting information on the Bus in either the Command or Data Mode (also see Acceptor).

SRQ Mnemonic referring to the control line "Service Request" on the HP-IB. This line is set low (true) by any instrument requesting service.

SYSTEM CONTROLLER This is an instrument on the HP-IB which has all the features of a standard controller with the added ability to control the IFC and REN lines. (Also see Controller.)

TALKER A device that has been addressed to transmit data on the HP-IB. (Also see Extended Talker.)

UNADDRESS COMMANDS These commands are obeyed by all addressable devices. This category consists of the Unlisten Command (?) and the Untalk Command (_). When the Unlisten Command (?) is transmitted on the HP-IB, all devices on the Bus will be unaddressed as listeners. When the Untalk Command (_) is transmitted, all devices will be unaddressed as talkers.

UNIVERSAL COMMANDS These commands affect every device capable of responding on the HP-IB, regardless of whether they have been addressed or not, e.g., Serial Poll Enable (SPE) and Serial Poll Disable (SPD).

UNLISTEN COMMAND See "UNADDRESS COMMANDS".

UNTALK COMMAND See "UNADDRESS COMMANDS".