MODEL 8150

PRECISION PHASE COMPARATOR

INSTRUCTION MANUAL

SPECTRACOM CORPORATION
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THIS MANUAL APPLIES TO UNITS WITH SERIAL NUMBERS 8150-0553 AND ABOVE

Revisions, if any, are located at back
January 1992

WARRANTY

Spectracom Corporation warrants to the original purchaser each new instrument to be free from defects in material and workmanship for a period of one year after shipment. Repair or replacement, at our option, will be made when our examination indicates that defects are due to workmanship or materials. Electron tubes, batteries, fuses, and lamps that have given normal service are excluded from warranty coverage. All warranty returns must first be authorized by the factory.

This warranty does not apply to any of our products which have been repaired or altered by persons not authorized by Spectracom Corporation or not in accordance with instructions furnished by us. If the instrument is defective as a result of misuse, improper repair, or abnormal conditions or operations, or if any serial number or seal has been removed or altered, the warranty is void and repairs will be billed at cost.

This warranty is in lieu of all other obligations or liabilities expressed or implied and Spectracom Corporation neither assumes nor authorizes any person to assume for them, any other liability in connection with sales of its products.

REPAIR AND MAINTENANCE

Instruments should be returned only upon prior authorization from Spectracom Corporation or its authorized sales and service representative. Warranty repair will be made upon request. Please provide the following information in order to enable us to serve you efficiently:

1. Model Number and type
2. Serial Number
3. Description of trouble
4. Conditions and hours of use

Transportation to the factory is to be prepaid by purchaser.

For assistance contact your nearest Spectracom sales representative.

SPECTRACOM CORPORATION
101 Despatch Drive
E. Rochester, New York 14445

WARRANTY REGISTRATION

Dear Customer,

Spectracom occasionally contacts customers regarding our products. We must know to whom we should send manual updates, change notices, and new product information. Because people sometimes change job assignments, we request department, mail station, and title information to ensure that correspondence in future years will reach either the user of our products or his/her supervisor. In filling out the registration, please use the title/mail station/department of the supervisor most interested in keeping the equipment and its documentation up-to-date. Thank you.

- -

Name_____Title_____

Department_____Mail Stop_____

Company_____Model Number_____

Address_____Serial No._____

City_____Date Installed_____

State_____Zip_____

Phone_____Ext._____

Remarks: (Problems, Suggestions, etc.)_____

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INSTALLATION

SECTION 1 INSTALLATION

1.0 INTRODUCTION

The Model 8150 Precision Phase Comparator, one of a family of Spectracom plug-in modules, is designed to compare the phase of two nearly equal frequencies. Typical applications are:

- o Adjustment of an oscillator to exactly the same frequency as a local standard.
- o Provide long-term phase tracking of oscillators and atomic standards with an external strip chart recorder, such as the Spectracom Model 8212 Plug-In Chart Recorder.
- o Compare T1 wander against another T1 line or cesium standard in conjunction with a Spectracom Model 8140VT-46 Clock Extractor.

The Model 8150 gives continuous readings of phase difference, expressed as relative time between two input signals. The panel meter is scaled in microseconds of relative time. Meter needle movement represents phase drift between the two input signals. The rate of phase change yields fractional frequency difference or error. If the panel meter needle is made to stay still, there is no frequency error between the reference input and local input.

1.1 UNPACKING

Upon receipt, the carton and its contents should be carefully examined. If there is damage to the carton which results in damage to the unit, contact the carrier immediately so his representative may witness such damage. If you fail to report shipping damage immediately, you may forfeit any claim against the carrier. You should also notify Spectracom Corporation of shipping damage or shortages so that we can help you obtain a replacement or repair the damaged equipment.

Carefully open the shipping carton and remove the packing list from the envelope on the outside of the carton. Check the packing list against the contents to be sure all items have been received.

The Model 8150 Ancillary Kit should contain the following:

QTY	DESCRIPTION	SPECTRACOM P/N
1	Fuse 1/2 Amp 3 AG	F00R50
1	Fuse 1/8 Amp 3 AG	F00R12
1	Phone Plug	P01030

Be certain to complete and return the Warranty Registration.

Retain the carton and packing materials in the event the unit needs to be reshipped or returned to the factory.

1.2 RESHIPMENT

Use the original shipping carton if it is necessary to return the unit to the factory. If it is not available, a carton of at least 250 pound test corrugated paper with at least two inches of polyethylene foam surrounding the unit must be used. Seal the unit in a plastic bag for moisture protection and include a note stating the reason for the return. Return authorization must be obtained from Spectracom.

1.3 TEKTRONIX MAINFRAME

The Model 8150 is designed for use in the Tektronix TM-500 or TM-5000 mainframe. The following mainframes are offered by Spectracom:

TM-501	Single Compartment
TM-503	Three Compartments
TM-504	Four Compartments
TM-506	Six Compartments
TRM-506	Six Compartments with rack mount
TM-515	Five Compartments, suitcase style

Mainframes operate on 115/230 VAC ±10%, 60 Hz.

The Model 8150 provides an external meter output to be fed through the mainframe. This output enables the Model 8150 to drive a Model 8212, Plug-In Strip Chart Recorder without an external cable. Refer to Section 6, Service Information for instructions on mainframe jumpers required to use the external meter output.

MODEL 8150

SECTION 2

OPERATION

SECTION 2 OPERATION

2.0 INTRODUCTION

This chapter describes the Model 8150 Precision Phase Comparator front panel functions and operation information. Refer to Figure 2-1 for the Model 8150 front panel layout.

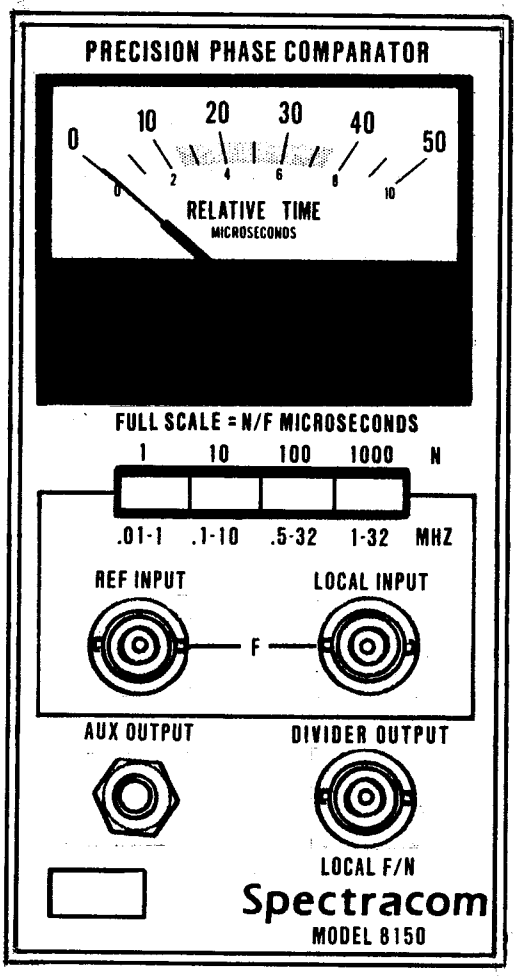


FIGURE 2-1 MODEL 8150 PRECISION PHASE COMPARATOR

2.1 FRONT PANEL FUNCTIONS

2.1.1 Panel Meter

The front panel meter scale displays microseconds of relative time between the phase of two input signals of almost equal frequency. Meter needle movement represents phase drift between the two signals. The rate of phase change between the two signals yields frequency difference, or error. If the panel meter needle is made to stay perfectly still, there is no frequency error between the **REF INPUT** and the **LOCAL INPUT.** If the meter drifts downscale to the left, the local input frequency is low compared to the reference. Upscale drift indicates a positive frequency error. The meter scale factor depends on two things; (1) the frequency of the input signals and (2) the selector switch depressed just underneath the meter.

2.1.2 Selector Switches

These four pushbuttons choose the frequency range of operation for the instrument and set the scale factor for the panel meter. The input frequencies must lie within the frequency range that is printed justed below the button. The factor **N**, printed just above the button, establishes the factor by which the input frequencies are divided before entering the phase detector, the readout of which is shown on the the panel meter. The full scale meter reading is determined by dividing N by F, where N is the factor printed above the chosen pushbutton, and F is the frequency in MHz of the input signals. For example, if the input signals are 1.0 MHz and the N = 1 pushbutton is depressed, the meter reads 1.0 microsecond full scale. If the N = 10 pushbutton is depressed, full scale is 10 microseconds. For a more detailed description, see the "Frequency Error Calculation" in paragraph 2.3.

2.1.3 Reference Input

This connector, **REF INPUT**, accepts any input signal level between 0.1 and 5 volts rms, at frequencies between 4 kHz and 32-MHz. The signal applied here becomes the reference standard against which the phase of the local input is compared. This connector has an input impedance of 100 ohms.

2.1.4 Local Input

The **LOCAL INPUT** connector accepts any test signal between 0.1 and 5 V rms at frequencies between 4 kHz and 32 MHz. This connector has an input impedance of 100 ohms.

2.1.5 Auxiliary Output

The **AUX OUTPUT** connector provides an output for driving an external strip chart recorder or meter. The output will drive any 0 - 1 mA meter movement or strip chart recorder.

2.1.6 Divider Output

The **DIVIDER OUTPUT** connector provides an output signal derived from the frequency applied to the **LOCAL INPUT** connector, divided by the **N** value chosen by the selected pushbutton.

2.2 USING THE PRECISION PHASE COMPARATOR

This section describes the operation and usage of the Model 8150.

Connect a 1-MHz reference frequency to the **REF INPUT** connector.

Connect a 1-MHz test frequency to the **LOCAL INPUT** connector.

Set the instrument to the least sensitive setting by selecting the highest **N** value permitted by the frequency range listed below each pushbutton. For a 1-MHz signal the maximum N value is N = 1000.

The front panel meter displays the relative phase difference between the two signals. The meter will move to the right whenever the local input is higher in frequency than the reference input, and to the left whenever it is lower in frequency.

When the meter needle reaches one end of the scale, it will return to the opposite end of the scale and begin again its travel in the same direction. The rate at which the meter moves is proportional to the rate of phase change or frequency error between the two signals.

The fractional frequency error, F, may be determined from the formula:

$$F = \frac{\Delta t}{T}$$

where Δt = amount of phase change between the signals expressed in seconds.

T = time interval in seconds over which the phase change measurement occurred.

Example: Determine the frequency error between two 1-MHz signals which causes the meter to move end to end and to the right in 10 seconds.

The full scale setting of the instrument must be found. Use the formula:

$$\text{Full Scale} = \frac{N}{F}$$

where: N = selector switch depressed, for this example assume that N = 1000.

F = measurement frequency, 1.0 MHz in this example.

$$\text{Full Scale} = \frac{1000}{1\text{x}10^{6}} = 1{,}000 \text{ microseconds.}$$

The fractional frequency error, F, for this example is:

$$F = \frac{\Delta t}{T} = \frac{1{,}000 \text{ microseconds}}{10 \text{ seconds}} = 1\text{x}10^{-4}$$

In this example, the local input is higher in frequency than the reference input by $1\text{x}10^{-4}$ or 100 Hz. The meter movement to the right indicates that the local input is greater in frequency than the reference input.

Adjust the test frequency so that the meter slows and eventually stops its movement. To increase the resolution of the measurement, select lower values of N. This will decrease the full scale settings, thus increasing the sensitivity of the instrument. Be certain not to choose an N value too low for the measurement frequency. Refer to the frequency range listed below each pushbutton.

2.3 FREQUENCY ERROR CALCULATION FROM A CHART RECORDING

The potential precision of a calibration may be improved by increasing the time a phase drift is monitored. The chart recorder allows practical long term observations over hours or days.

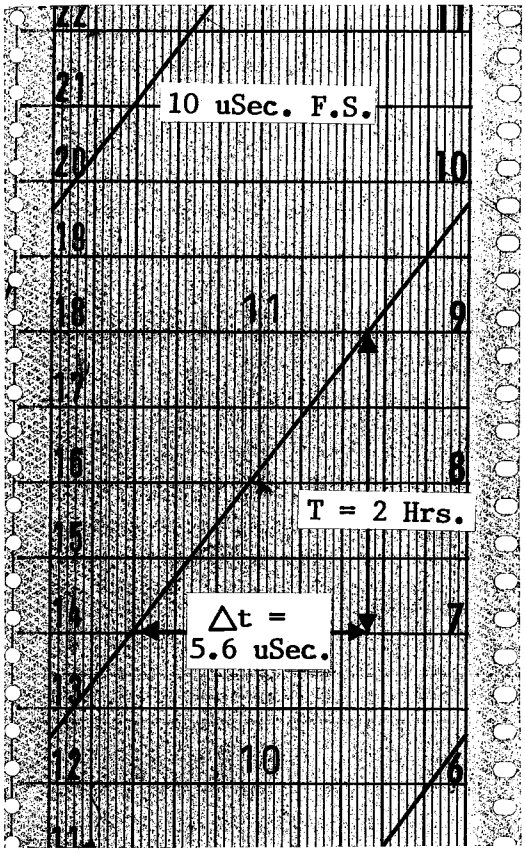
Frequency error is measured by noting the speed with which the meter deflects in its slow travel across the scale. In other words, noting the slope of the recorder trace on the chart paper.

Figure 2-2 is a resultant phase comparison between two 1-MHz signals recorded on a Model 8212 Chart Recorder. To determine the frequency error from a chart recording, both the full scale setting and the chart recorder speed must be known.

In the following example the N = 10 button was depressed. The full scale deflection may be determined from the formula:

$$\text{Full Scale} = \frac{N}{F} = \frac{10}{1\text{x}10^{6} \text{ Hz}} = 10 \text{ microseconds}$$

The Model 8212 Chart recorder used in this example had a chart speed of 20mm/hr which may be changed to 10 or 60 mm/hr by substituting cams supplied with the unit. The chart paper is scaled in hours for all three speeds of operation.



The left to right slope indicates the local input is higher in frequency than the reference input.

Full scale = 10 uS

Phase change = 5.6 uS

Measurement interval = 2 hrs

FIGURE 2-2 ERROR CALCULATION FROM A CHART RECORDING

The error calculation is made by dividing the phase movement expressed in seconds by the time in seconds during which the movement occurred.

$$\text{Frequency error} = \frac{\text{Phase Change (seconds)}}{\text{Time Interval (seconds)}} = \frac{\Delta t}{T}$$

From the example in Figure 2-2, over a 2 hour period a 5.6 microsecond phase change occurred. The resultant fractional frequency error is:

$$\text{Frequency error} = \frac{5.6 \times 10^{-6} \text{ seconds}}{2 \text{ hours} \times 3600 \frac{\text{seconds}}{\text{hour}}} = 7.8 \times 10^{-10}$$

In this example the local input is higher in frequency than the reference input by 7.8×10^{-10}.

The error calculation chart shown in Figure 2-3 may be used to find the frequency error as a function of phase change and time.

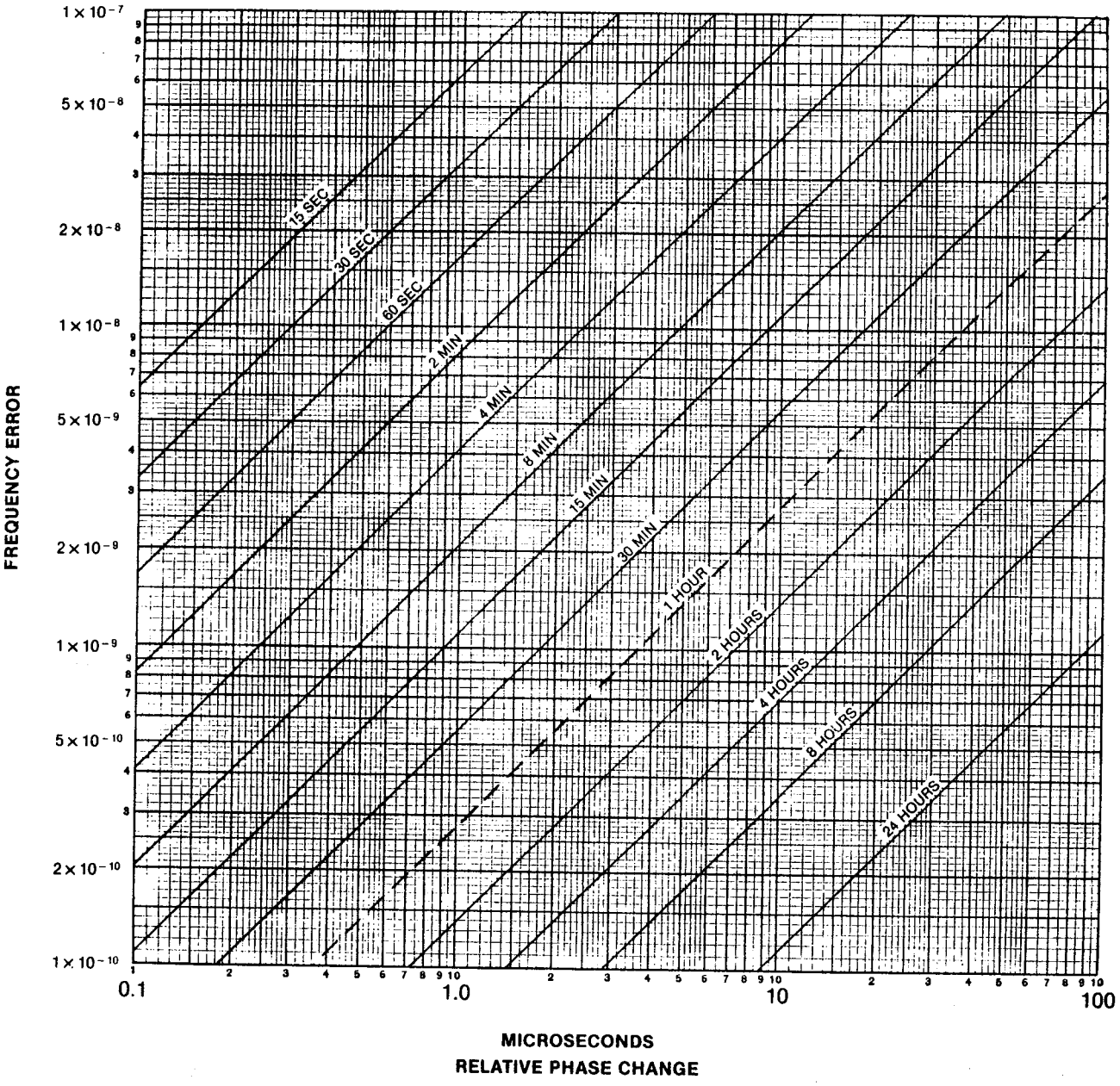


FIGURE 2-3 ERROR CALCULATION CHART

MODEL 8150

SECTION 3

SPECIFICATIONS

SECTION 3 SPECIFICATIONS

3.0 INTRODUCTION

This chapter provides the operational and environmental specifications for the Model 8150 Precision Phase Comparator. The specifications published in this section apply to units with serial numbers 8150-0573 and higher. These units offer an improved low end frequency response, which lowers the minimum input frequency from 10 kHz to 4 kHz. Units built prior to 8150-0573 may be retrofit for operation down to 4 kHz. Retrofit instructions can be found in the Service Information Section of this manual.

3.1 DISPLAY

The front panel meter indicates phase changes of the **LOCAL INPUT** signal with respect to the **REF INPUT** signal. The meter is scaled in microseconds of phase difference between the two input signals.

The Meter Range is determined by the formula; Full scale is equal to N/F, where N is the input divider ratio chosen by the front panel pushbuttons, and F is the input frequency in Hz.

The Linearity is $\pm$2% of full scale. The Resolution is 1% of full scale (10 nanoseconds on a 1.0 microsecond scale).

3.2 INPUTS

The input frequency range is 4 kHz to 32 MHz.

The signal level range is 0.1 to 5 volts rms into 100-ohms.

3.3 OUTPUTS

The **AUX OUTPUT** is designed to drive a 0-1 mA strip chart recorder. The connector is a miniature phone jack. A mating miniature phone plug is furnished in the ancillary kit.

The external meter output is a 0-1 mA signal located on Pin 24A of the rear connector. The external meter output signal is used to drive a Spectracom Model 8212 Chart recorder.

The **DIVIDER OUTPUT** signal is the LOCAL INPUT frequency divided by N. Where N is selected by the front-panel pushbuttons. The connector is BNC, the signal is TTL compatible with a 100 ohm source. The pulse duty cycle is the same as the input when N = 1. The duty cycle is 80% for N = 10, N = 100, and N = 1000.

3.4 ENVIRONMENTAL SPECIFICATIONS

The equipment is designed to operate in a range of 0° to 50°C. Operation of the equipment outside this temperature range may cause malfunction or damage to the equipment.

MODEL 8150

SECTION 4

THEORY OF OPERATION

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SECTION 4 THEORY OF OPERATION

4.0 INTRODUCTION

The Spectracom Model 8150 Precision Phase Comparator makes precision phase comparisons of two nearly equal frequencies. It can be used to quickly adjust an oscillator to exactly the same frequency as a local standard. The Model 8150 also enables you to do long-term phase tracking of oscillators and atomic frequency standards, with an external chart recorder providing a permanent record.

The Model 8150 gives continuous readings of phase difference expressed as relative time between the two input signals. The panel meter shows microseconds of relative time, with change in the meter reading representing phase drift between the two signals. The rate of change of phase between the two signals yields fractional frequency difference or error. If the meter is made to stay perfectly still, there is no frequency error between the Reference Input and the Local Input. If the meter drifts downscale to the left, the Local Input frequency is low compared to the Reference Input, and upscale drift indicates a positive frequency error.

Using this comparator, oscillators and signal sources can be adjusted to within 1×10^{-9} of each other in real time. High precision clocks and oscillators can be tracked with resolution approaching 1×10^{-13} in 24 hours, and longer times provide even higher resolution.

Although most often used to monitor frequency standards at the usual frequencies of 1.0 or 10 MHz, this instrument may be used over the entire range of 4 kHz to 32 MHz.

A "Divider Output" yields the Local Input frequency divided by either 1, 10, 100, or 1000. If the divide-by-1 function is chosen, the unit serves as an amplifier, boosting the Local Input signal from a minimum of 100 millivolts rms up to TTL levels.

4.1 8150 MAINFRAME ASSEMBLY

The 8150 Mainframe Assembly houses the major subassemblies that comprise the Model 8150 Precision Phase Comparator. Refer to Figures 4-1 and 4-2 for the Model 8150 Functional Block Diagram and Mainframe Schematic.

The 8150 Mainframe Assembly provides the interconnection between the 8150 Phase Detector PC Board Assembly and the front panel meter and input/output connectors. The front panel REF INPUT is applied through plug P2, pins 4 & 5 to header J2, pins 4 & 5 on the 8150 Phase Detector PCB Assembly. The LOCAL INPUT signal is applied through plug P2, pins 11 & 10 to header J2, pins 11 & 10 on the 8150 Phase Detector PCB Assembly. These two signals are used to make the phase comparison displayed on the front panel meter M1.

The positive terminal of the panel meter M1 is connected through plug P2-8 to header J2-8 on the 8150 Phase Detector PCB Assembly. The negative terminal is connected to chassis ground and to ground via plug P1-3 to header J1-3 on the 8150 Phase Detector PCB Assembly. The AUX OUTPUT connector provides a phase detector output capable of driving an external 0 - 1 mA strip chart recorder or meter. The tip part of the AUX OUTPUT connector is connected through plug P2-6 to header J2-6 on the 8150 Phase Detector PCB Assembly. The ring of the AUX OUTPUT Connector is ground.

The DIVIDER OUTPUT connector provides an output signal derived from the frequency applied to the LOCAL INPUT jack divided by N. The value of N is chosen by depressing one of the pushbutton selector switches (S1A, S1B, S1C, or S1D) located on the front panel assembly.

The pushbutton selector switches choose the frequency of operation of the Model 8150 and set the scale factor for the meter panel. The input frequencies applied to the REF INPUT and the LOCAL INPUT connectors must lie within the frequency range printed just below the pushbuttons. The factor "N", printed just above the pushbuttons, establish the factor by which the input frequencies are divided before entering the phase detector. The output of the phase detector is displayed on the front panel meter M1. The full-scale meter reading is determined by dividing N by F, where N is the factor printed above the chosen pushbutton, and F is the frequency in MHz of the input signals. The pushbutton N factors and frequency ranges are shown below:

PUSHBUTTON	S1A	S1B	S1C	S1D
N FACTOR	1	10	100	1000
FREQUENCY RANGE IN MHZ	.004-1	.1-10	.5-32	1-32

The pushbutton selector switches are interlock, single-pole, double-throw switches. The mainframe ground is connected to the normally closed side of each of the pushbutton selector switches and through plug P1-2 to header J1-2 on the 8150 Phase Detector PCB Assembly. +5 Vdc is connected from header J1-1, on the 8150 Phase Detector PCB Assembly, through plug P1-1 to the normally open side of each pushbutton selector switch. The common contacts of S1A, S1B, S1C, and S1D are connected through plug P1-8, P1-9, P1-10, and P1-7 respectively, to header J1-8, J1-9, J1-10, and J1-7 respectively, on the 8150 Phase Detector PCB Assembly.

Mainframe connector J3 provides ground (GND), external meter (EXT METER) output, +33.5 Vdc, and +11.5 Vdc from the Tektronix TM-500 series mainframe to the 8150 Phase Detector PCB Assembly.

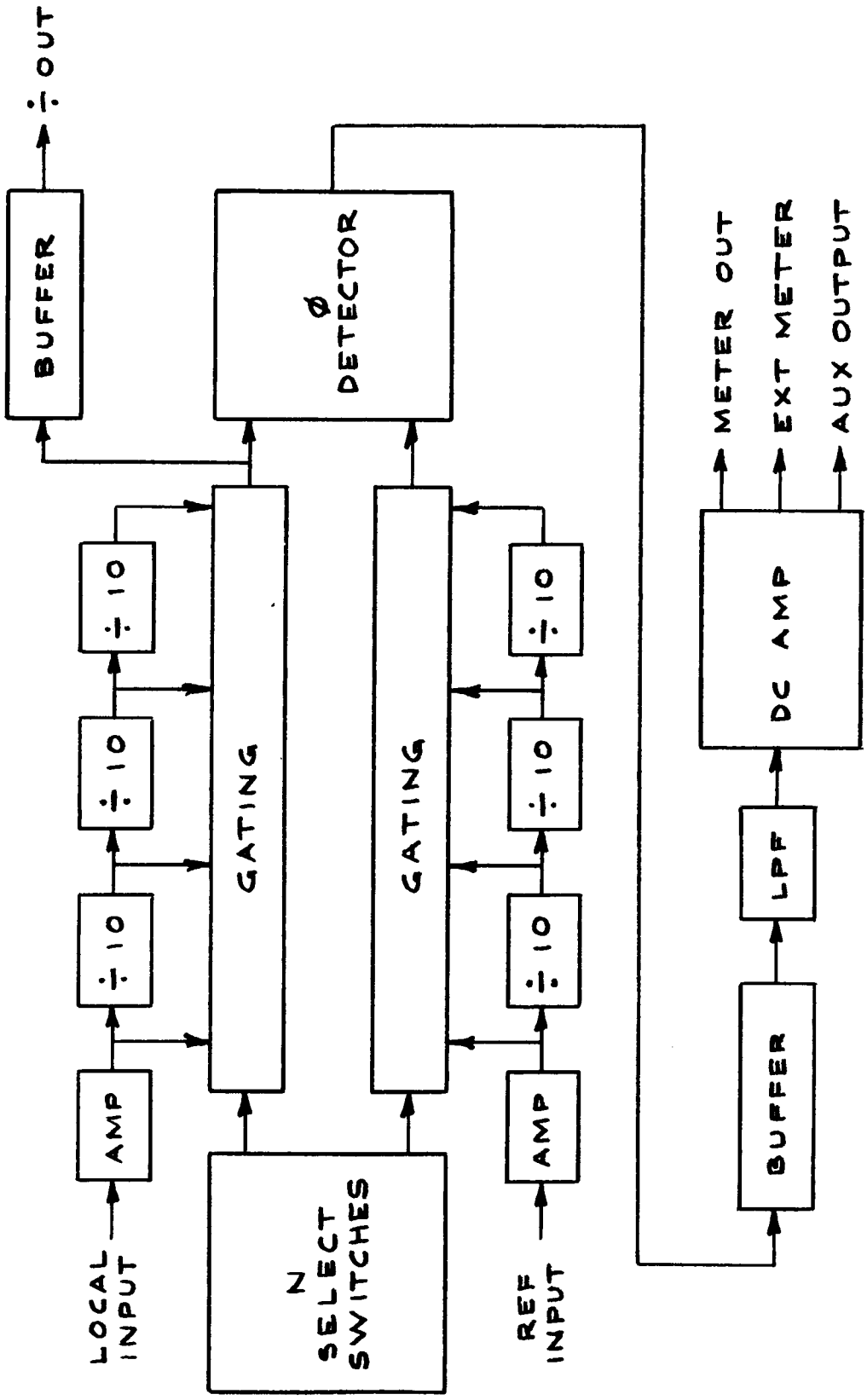

FIGURE 4-1 MODEL 8150 PRECISION PHASE COMPARATOR FUNCTIONAL BLOCK DIAGRAM

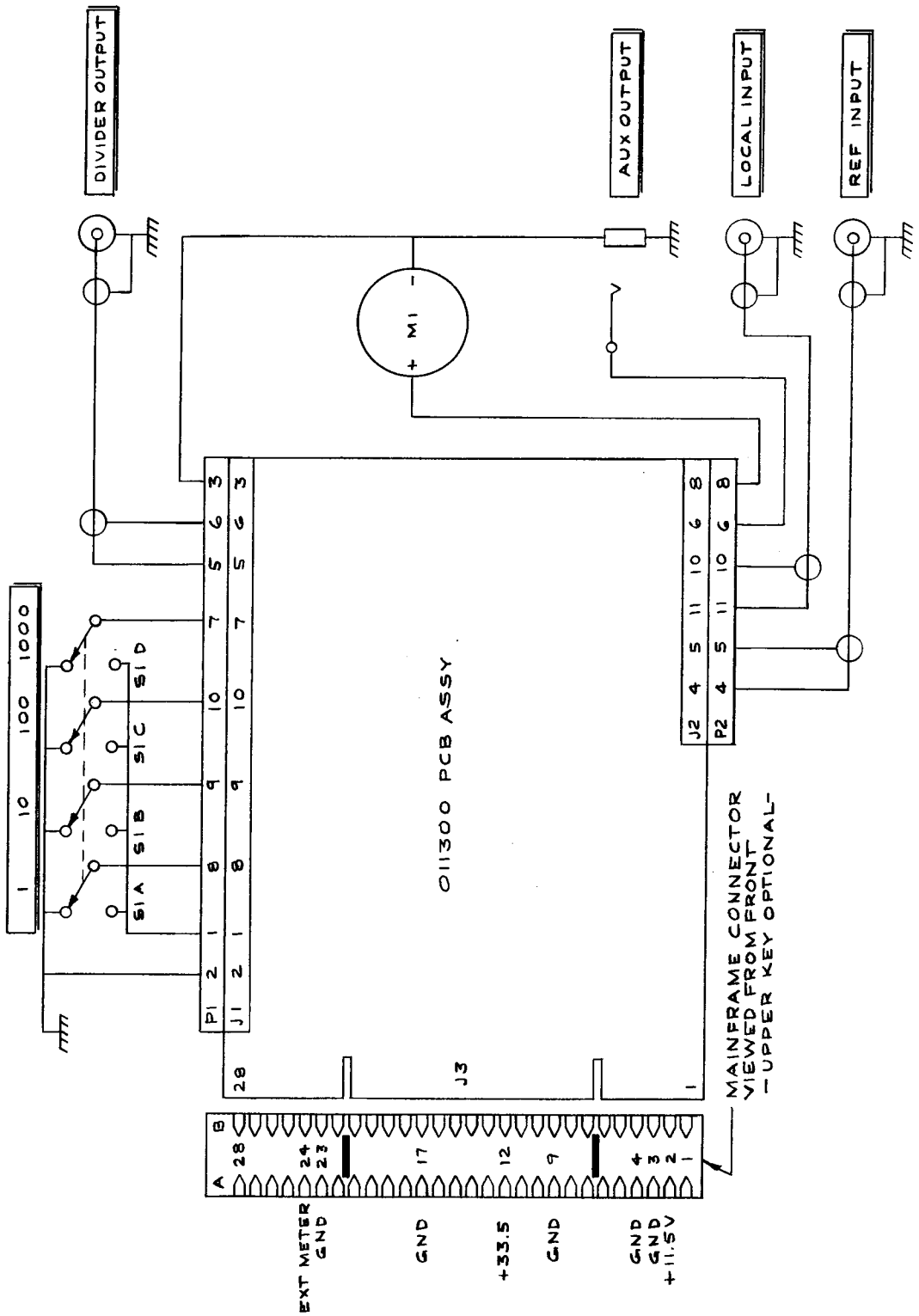

FIGURE 4-2 MODEL 8150 MAINFRAME SCHEMATIC DIAGRAM

4.2 8150 PHASE DETECTOR PC BOARD ASSEMBLY

The 8150 Phase Detector PC Board Assembly contains the phase detector circuit and divider circuits necessary to develop the EXT METER, AUX OUT, METER+, and DIVIDER OUT signals. (See Figure 4-3 for the schematic, and Figure 4-4 for the Assembly Drawing.)

The REF INPUT signal is applied to the REF INPUT connector J2-4. The REF INPUT signal is amplified by a differential amplifier comprised of transistors Q5 and Q3 and their associated components. The output of the differential amplifier is squared-up by U9D a 2-input NAND Schmitt Trigger. The output of U9D is a TTL compatible signal that is routed through one of two paths depending upon which N factor pushbutton is selected on the front panel of the Model 8150. The signal will either be gated directly through U4A (a 2-input NAND) or it will go through the divide-by-10 dividers U10, U11A, and U11B and then be gated through U4B, U4C, or U4D to the input of the select gate U3B. U3B is a 4-input NAND that selects the REF INPUT signal divided by N=1, N=10, N=100, or N=1000 and applies it to the input of flip-flop U5A, part of the digital phase comparator.

The output of select gate U3B is controlled by one of four selected N factor signals (N=1, N=10, N=100, or N=1000) applied to the PCB through J1-8, J1-9, J1-10, and J1-7 respectively. The selected N factor signal is a +5 Vdc level derived from the common switch voltage sent to the front panel through J1-1. Selecting the N=1 pushbutton enables gate U4A applying the REF INPUT signal divided by 1 to the U3B select gate. Selecting the N=10 pushbutton enables gate U4B applying the REF INPUT signal divided by 10 to the U3B select gate. Selecting the N=100 pushbutton enables gate U4C applying the REF INPUT signal divided by 100 to the U3B select gate. Selecting the N=1000 pushbutton enables gate U4D applying the REF INPUT signal divided by 1000 to the U3B select gate. Since only one N factor can be selected at a time, the selected REF INPUT signal at U3B (N=1, N=10, N=100, or N=1000) becomes the REF INPUT to the digital phase comparator.

In a similiar fashion, the LOCAL INPUT signal is brought into the PCB on connector J2-11. The LOCAL INPUT signal is amplified by the differential amplifier comprised of transistors Q4 and Q2 and their associated components. The output of the differential amplifier is squared-up by U9A, a 2-input NAND Schmitt Trigger. The output of U9A is a TTL-compatible signal that is routed through one of two paths depending upon which N factor pushbutton is selected on the front panel of the Model 8150. The signal will either be gated directly through U2D (a 2-input NAND) or it will go through the divide-by-10 dividers U8, U7A, and U7B and then be gated through U2C, U2A, or U2B to the input of the select gate U3A. U3A is a 4-input NAND that selects the LOCAL INPUT signal divided by N=1, N=10, N=100, or N=1000 and applies it to the input of flip-flop U5B, part of the digital phase comparator.

The output of select gate U3A is controlled by one of four selected N factor signals (N=1, N=10, N=100, or N=1000) applied to the PCB through J1-8, J1-9, J1-10, and J1-7 respectively. The selected N factor signal is a +5 Vdc level derived from the common switch voltage

sent to the front panel through J1-1. Selecting the N=1 pushbutton enables gate U2D applying the LOCAL INPUT signal divided by 1 to the U3A select gate. Selecting the N=10 pushbutton enables gate U2C applying the LOCAL INPUT signal divided by 10 to the U3A select gate. Selecting the N=100 pushbutton enables gate U2A applying the LOCAL INPUT signal divided by 100 to the U3A select gate. Selecting the N=1000 pushbutton enables gate U2B applying the LOCAL INPUT signal divided by 1000 to the U3A select gate. Since only one N factor can be selected at a time, the selected LOCAL INPUT signal at U3A (N=1, N=10, N=100, or N=1000) becomes the LOCAL INPUT to the digital phase comparator.

The outputs of the select gates U3B (REF INPUT) and U3A (LOCAL INPUT) are applied to a digital phase comparator comprised of flips-flops U5A and U5B, and exclusive OR gate U6B. The output at U6B is a squarewave whose symmetry is a function of the phase relationship between the LOCAL INPUT and the REFERENCE INPUT. The squarewave is buffered by Q1 and integrated by a low pass filter comprised of R8 and C16. This circuit develops a DC voltage input to U12B that is representative of the relative phase difference between the REF INPUT and the LOCAL INPUT. U12 acts as a voltage-to-current converter that provides a 0-1MA output at U12-8. This output is applied to the the front panel meter as the METER+ signal at J2-8, the AUX OUT at J2-6, and the EXT METER at J3-24. There are three calibration pots (R13, R12, and R14, respectively) for full scale adjustment of the three outputs. All three outputs may be used concurrently.

The DIVIDER OUT signal is picked off the U3B select gate, routed through NAND gate U1A and connector J1-5 to the front panel as the DIVIDER OUTPUT. This signal represents the LOCAL INPUT signal divided by the selected N factor.

+33.5 Vdc from the Tektronix TM-500 series mainframe is applied through connector J3-12 and protected by fuse F1. The +33.5 Vdc is applied to voltage regulator U13 which provides the +12 Vdc used on the PCB.

+11.5 Vdc from the Tektronix TM-500 series mainframe is applied through connector J3-2 and protected by fuse F2. The +11.5 Vdc is applied to voltage regulator U14 which provides the +5 Vdc used on the PCB.

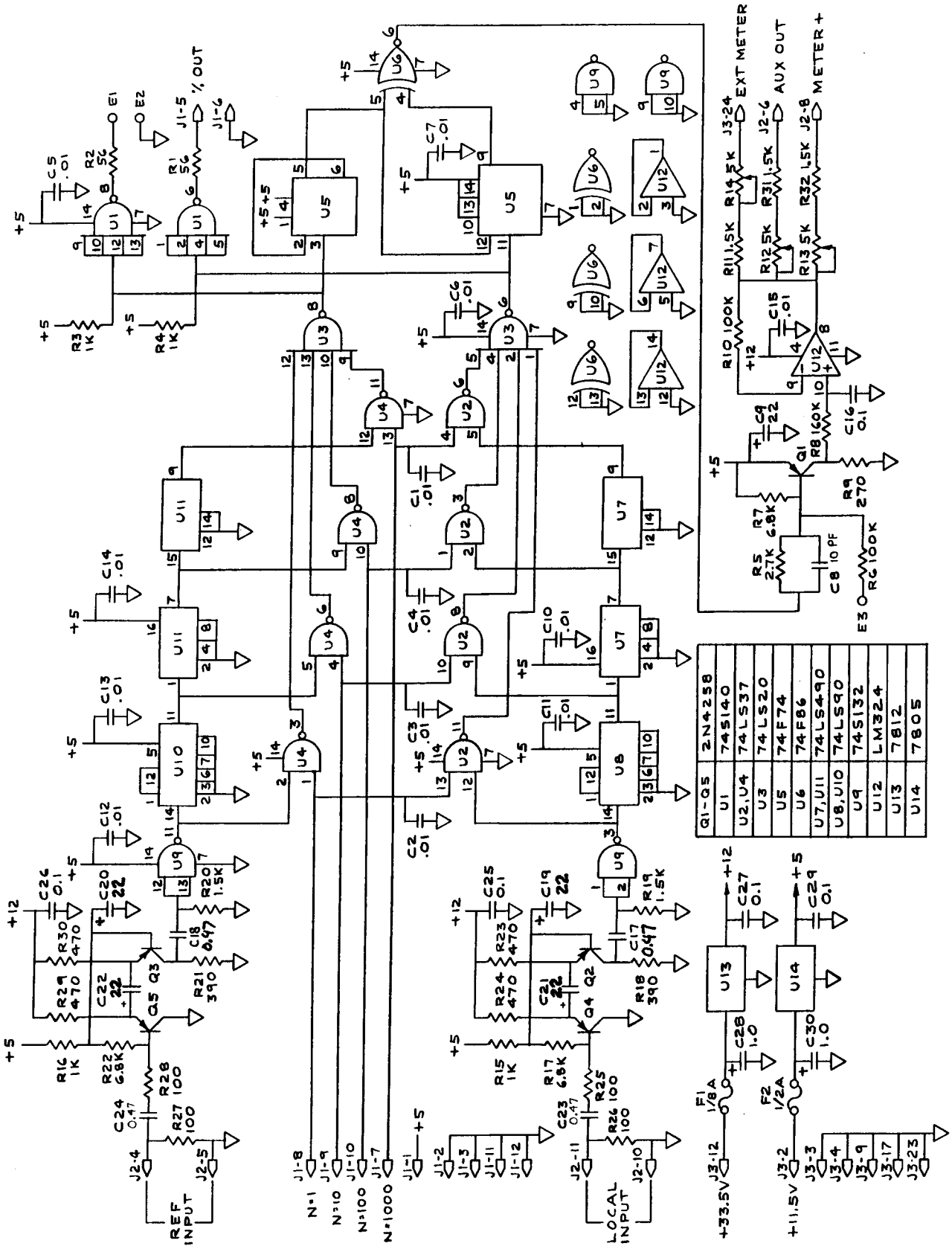

FIGURE 4-3 MODEL 8150 PHASE DETECTOR SCHEMATIC DIAGRAM

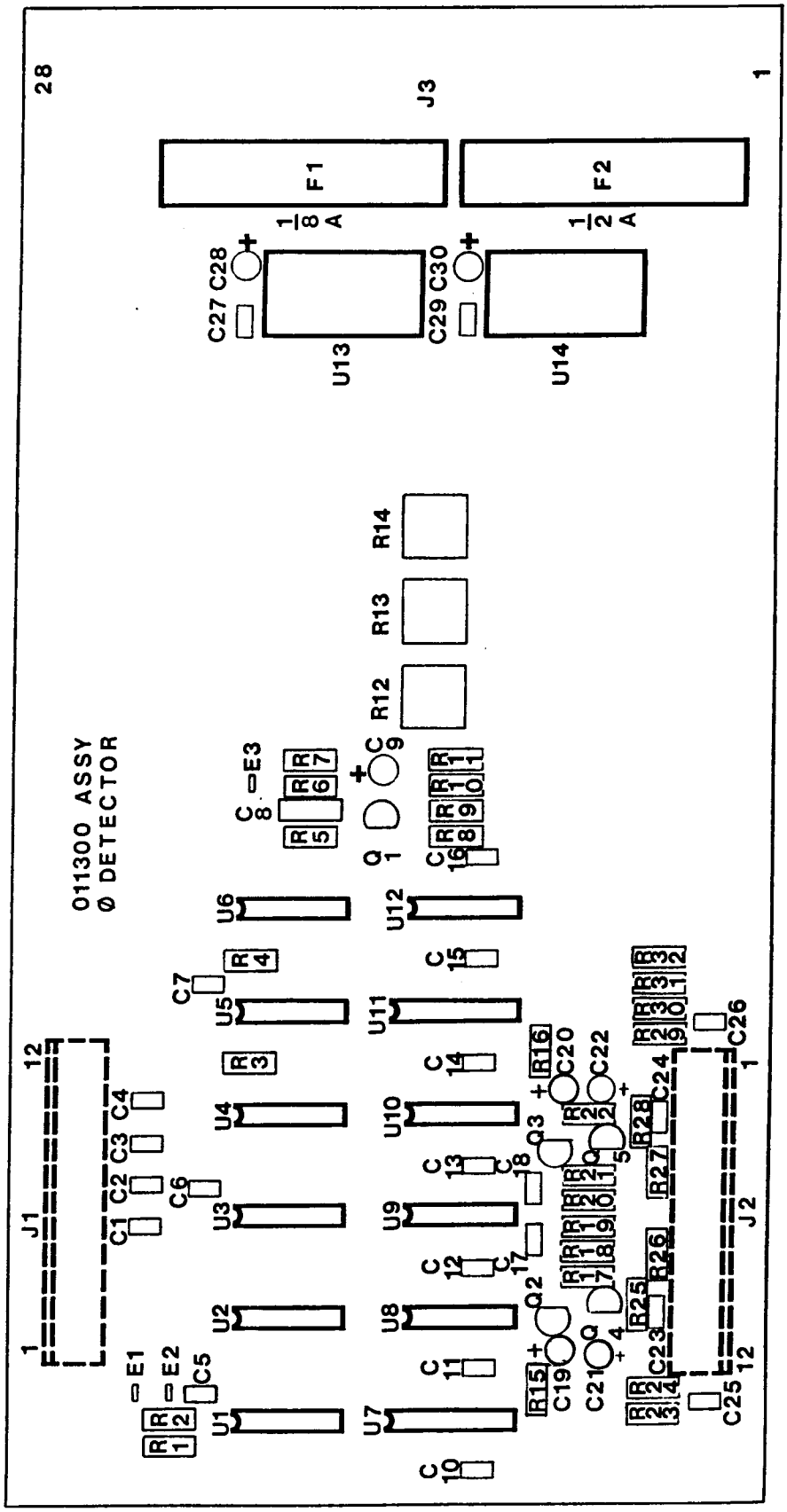

FIGURE 4-4 MODEL 8150 ASSEMBLY DRAWING

MODEL 8150

SECTION 5

RELATED EQUIPMENT

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SECTION 5 OPTIONS AND ACCESSORIES

5.0 INTRODUCTION

This section describes the chart recorders and mainframes available from Spectracom Corporation. A chart recorder provides a permanent record of a phase comparison and makes it practical to extend the measurement interval. A longer measurement interval increases the resolution of the measurement.

5.1 MODEL 8212 PLUG-IN CHART RECORDER

This recorder uses two slots in the Tektronix TM-500 or TM-5000 mainframe. The Model 8212 is powered by the mainframe. An internal mainframe jumper allows connection of the recorder to the output of a Model 8150 Phase Comparator without using external wires. If an input is fed into the front panel jack, the rear panel input is disconnected.

SPECIFICATIONS

Range:	0-1 mA DC
Accuracy:	±1.5% of F.S.
Scales:	0-10 & 0-50 usec; 0-1 mA
Scale Length:	60 mm
Response Time:	< 2 sec
Chart Speeds:	10mm/hr. 20mm/hr. 60mm/hr.
Record Length:	About one month of continuous recording at 20mm/hr.
Operating Temperature Range:	32° to 104°F (0° to 40°C)
Chart Paper:	MP00025, ten rolls

5.2 MODEL 8210 STRIP CHART RECORDER

This compact stand alone chart recorder is driven from the Model 8150 Aux Out jack. The Model 8210 may be configured in a "tear-off" mode or a "re-roll" mode.

SPECIFICATIONS

Range:	0-1 mA DC
Accuracy:	±2% of F.S.
Scales:	0-10 & 0-50 usec
Scale Width:	2-5/16"
Response Time:	1 second maximum
Chart Speeds:	1 inch/hr
Record Length:	About one month continuous recording/roll
Dimensions:	3-5/8"W x 5-5/8"H x 4-5/16"D
Weight:	3-3/4 pounds
Chart Paper:	MP00024, six rolls

5.3 TEKTRONIX MAINFRAMES

Provide power and enclosure for plug-in instruments. The following mainframes are offered by Spectracom:

TM-501	Single Compartment
TM-503	Three Compartments
TM-504	Four Compartments
TM-506	Six Compartments
TRM-506	Six Compartments with rack mount
TM-515	Five Compartments, suitcase style

MODEL 8150

SECTION 6

SERVICE INFORMATION

LT. Blue

SECTION 6 SERVICE INFORMATION

6.0 INTRODUCTION

This section provides information on the mainframe interface, meter adjustments, and performance tests.

6.1 MODEL 8212 CHART RECORDER INTERFACE

The Model 8150 Phase Comparator can be interfaced with the Model 8212 Chart Recorder by installing jumpers on the mainframe interface board. Tektronix reserves Pins 14 through 28, both A and B, for special functions. Pins 1 through 13 are power supply outputs and access to chassis mounted transistors.

Disassemble the mainframe per Tektronix Manual instructions to access the interface board. Refer to Figure 6-1, Model 8150 Interface, for connector numbering. The internal meter connection is made by jumpering the following:

MODEL 8150 SLOT	MODEL 8212 SLOT	FUNCTION
24A	24A	Meter Signal
23A	23A	Signal Ground

It is recommended that the Model 8150 be installed to the right of the Model 8212 to facilitate full scale meter adjustments. Refer to Section 6.2 for meter adjustments before reassembling the mainframe.

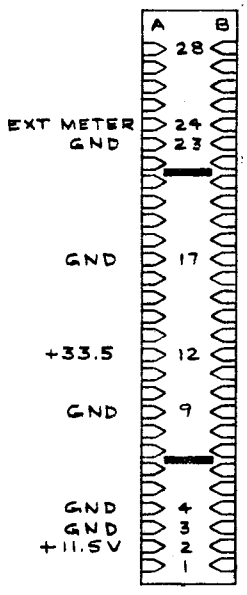

FIGURE 6-1 MODEL 8150 INTERFACE

6.2 CALIBRATION AND ADJUSTMENT

The Model 8150 does not require any routine calibration cycle. There are provisions for front panel meter zero and full scale adjust, **AUX OUTPUT** and EXTERNAL METER full scale adjust. The **AUX OUTPUT** and the EXTERNAL METER output are factory preset to 1 mA for a full scale deflection. Connecting a chart recorder to these outputs may require a full scale adjustment.

Equipment needed:

1-MHz source with a signal level between .1 and 5V rms.
Tektronix Mainframe
Coax Cable
BNC "TEE" Connector
Small slotted screwdriver

6.2.1 FRONT PANEL METER ZERO ADJUST

- Install the unit into a mainframe and power on
- Depress the N=1 pushbutton
- Connect the same 1-MHz signal to the **LOCAL INPUT** and **REF INPUT.** Accomplish this by using a BNC "T" connector and a short length (12") of coax.
- Zero the meter as needed by turning the meter adjust screw found on the meter face.

6.2.2 FULL SCALE ADJUST

- Remove the right hand side cover from the Model 8150. Install into a mainframe in a right hand slot so that R12, R13 and R14 can be accessed. In a TM-501 application remove the mainframe cover.
- Turn on the mainframe
- Depress the N=1 pushbutton
- Connect a 1-MHz signal to the **LOCAL INPUT.** Observe a full scale deflection on the front panel meter.
- Front panel meter full scale calibration is made by adjusting R13.
- Adjusting R12 calibrates the full scale deflection of a chart recorder connected to the **AUX OUTPUT.**
- Adjusting R14 calibrates the full scale deflection of a chart recorder connected to the mainframe interface.

6.3 PERFORMANCE TEST

The following test verifies the performance of the input circuits, dividers, and pushbuttons.

Test Equipment

Signal Generator - 4 kHz to 32 MHz
Output - 100 mV rms
Oscilloscope
Tektronix Mainframe

Procedure:

- Remove the right hand side cover from the Model 8150. Install into a mainframe in a left hand slot. This allows test points E1 and E2 to be connected to an oscilloscope. A TM-501 application requires removal of the mainframe cover.

- Connect an oscilloscope to test point E1. Connect the probe ground to E2.

- Connect a 4 kHz signal to the **REF INPUT** connector. The scope should display a TTL compatible waveform with a frequency and duty cycle dependent on the "N" pushbutton depressed. Repeat with a 32 MHz input. Use table 6-1 to verify oscilloscope measurements.

- Remove oscilloscope probe from points E1 and E2 and connect to the front panel **DIVIDER OUTPUT.**

- Connect a 4 kHz signal to the **LOCAL INPUT.** Depress each pushbutton and verify oscilloscope reading from Table 6-1. Repeat with a 32 MHz input signal.

BUTTON DEPRESSED	FREQUENCY OBSERVED AT E1 AND **DIVIDER OUTPUT**	PULSE DUTY CYCLE
N=1	Same as Input Frequency	Same as Input Frequency
N=10	Input Frequency - 10	80%
N=100	Input Frequency - 100	80%
N=1000	Input Frequency - 1000	80%

TABLE 6-1 PERFORMANCE TEST

MODEL 8150

SECTION 7

PARTS LIST

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INTRODUCTION

The parts list on the following pages include mainframe components, PC board components and ancillary items. The lists may be used to purchae components from Spectracom or as a guide to purchase parts locally.

REPLACEABLE PARTS - MAINFRAME

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION
0001	CH00008	LATCH
0002	CH00009	KNOB, LATCH
0003	CH00010	BAR, LATCH RELEASE
0004	CH00007	SHIELD, SIDE COVER (2)
J002	J00010	RECEPTACLE, BNC SHORT SHANK
J003	J00010	RECEPTACLE, BNC SHORT SHANK
J004	J00010	RECEPTACLE, BNC SHORT SHANK
J005	J01030	JACK, PHONE
M001	M00001	METER,0-1MA,1-1/2"
S001	S00004	SWITCH, PUSHBUTTON

REPLACEABLE PARTS - PC BOARD ASSEMBLY

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION
A1	011300	8150 PC BOARD ASSEMBLY
C001	C26103	CAP, .01 UF CERAMIC MONO
C002	C26103	CAP, .01 UF CERAMIC MONO
C003	C26103	CAP, .01 UF CERAMIC MONO
C004	C26103	CAP, .01 UF CERAMIC MONO
C005	C26103	CAP, .01 UF CERAMIC MONO
C006	C26103	CAP, .01 UF CERAMIC MONO
C007	C26103	CAP, .01 UF CERAMIC MONO
C008	C05100	CAP, 10PF MICA
C009	C07220	CAP, 22 UF 25V LITIC
C010	C26103	CAP, .01 UF CERAMIC MONO
C011	C26103	CAP, .01 UF CERAMIC MONO
C012	C26103	CAP, .01 UF CERAMIC MONO
C013	C26103	CAP, .01 UF CERAMIC MONO
C014	C26103	CAP, .01 UF CERAMIC MONO
C015	C26103	CAP, .01 UF CERAMIC MONO
C016	C26104	CAP, .1 UF 50V CERAMIC MONO
C017	C26474	CAP, .47 UF 50V CERAMIC MONO
C018	C26474	CAP, .47 UF 50V CERAMIC MONO
C019	C12226	CAP, 22 UF 16V TANT
C020	C12226	CAP, 22 UF 16V TANT
C021	C12226	CAP, 22 UF 16V TANT
C022	C12226	CAP, 22 UF 16V TANT
C023	C26474	CAP, .47 UF CERMAIC MONO
C024	C26474	CAP, .47 UF CERMAIC MONO
C025	C26104	CAP, .1 UF 50V CERAMIC MONO
C026	C26104	CAP, .1 UF 50V CERAMIC MONO
C027	C26104	CAP, .1 UF 50V CERAMIC MONO
C028	C09010	CAP, 1.0 UF 50V LITIC
C029	C26104	CAP, .1 UF 50V CERAMIC MONO
C030	C09010	CAP, 1.0 UF 50V LITIC
F001	F00R12	FUSE, 1/8A, 3AG
F002	F00R50	FUSE, 1/2A, 3AG
J001	J10014	HEADER, 6 PIN (2)
J002	J10014	HEADER, 6 PIN (2)
Q001	Q04258	TRANSISTOR, PNP, PN 4258-18
Q002	Q04258	TRANSISTOR, PNP, PN 4258-18
Q003	Q04258	TRANSISTOR, PNP, PN 4258-18
Q004	Q04258	TRANSISTOR, PNP, PN 4258-18
Q005	Q04258	TRANSISTOR, PNP, PN 4258-18
R001	R01560	RES, 56 OHMS 1/4W 5% C.FILM
R002	R01560	RES, 56 OHMS 1/4W 5% C.FILM
R003	R01102	RES, 1 K OHMS 1/4W 5% C.FILM
R004	R01102	RES, 1 K OHMS 1/4W 5% C.FILM
R005	R01272	RES, 2.7K OHMS 1/4W 5% C.FILM
R006	R01104	RES, 100K OHMS 1/4W 5% C.FILM

REPLACEABLE PARTS - PC BOARD ASSEMBLY

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION
R007	R01682	RES, 6.8K OHMS 1/4W 5% C.FILM
R008	R01164	RES, 160K OHMS 1/4W 5% C.FILM
R009	R01271	RES, 270 OHMS 1/4W 5% C.FILM
R010	R01104	RES, 100K OHMS 1/4W 5% C.FILM
R011	R01152	RES, 1.5K OHMS 1/4W 5% C.FILM
R012	R05502	POT, 5K OHM TRIM
R013	R05502	POT, 5K OHM TRIM
R014	R05502	POT, 5K OHM TRIM
R015	R01102	RES, 1 K OHMS 1/4W 5% C.FILM
R016	R01102	RES, 1 K OHMS 1/4W 5% C.FILM
R017	R01682	RES, 6.8K OHMS 1/4W 5% C.FILM
R018	R01391	RES, 390 OHMS 1/4W 5% C.FILM
R019	R01152	RES, 1.5K OHMS 1/4W 5% C.FILM
R020	R01152	RES, 1.5K OHMS 1/4W 5% C.FILM
R021	R01391	RES, 390 OHMS 1/4W 5% C.FILM
R022	R01682	RES, 6.8K OHMS 1/4W 5% C.FILM
R023	R01471	RES, 470 OHMS 1/4W 5% C.FILM
R024	R01471	RES, 470 OHMS 1/4W 5% C.FILM
R025	R01101	RES, 100 OHMS 1/4W 5% C.FILM
R026	R01101	RES, 100 OHMS 1/4W 5% C.FILM
R027	R01101	RES, 100 OHMS 1/4W 5% C.FILM
R028	R01101	RES, 100 OHMS 1/4W 5% C.FILM
R029	R01471	RES, 470 OHMS 1/4W 5% C.FILM
R030	R01471	RES, 470 OHMS 1/4W 5% C.FILM
R031	R01152	RES, 1.5K OHMS 1/4W 5% C.FILM
R032	R01152	RES, 1.5K OHMS 1/4W 5% C.FILM
U001	U4S140	4 INPUT DRIVER, 74S140
U002	U4LS37	QUAD 2 INPUT NAND, 74LS37
U003	U4LS20	DUAL NAND, 74LS20
U004	U4LS37	QUAD 2 INPUT NAND, 74LS37
U005	U74F74	DUAL "D" F.F., 74F74
U006	U74F86	EXCLUSIVE OR, 74F86
U007	ULS490	DUAL 4-BIT DECADE COUNTER, 74LS490
U008	ULS490	DUAL 4-BIT DECADE COUNTER, 74LS490
U009	U4S132	QUAD SCHMITT NAND, 74S132
U010	U4LS90	DECADE COUNTER, 74LS90
U011	ULS490	DUAL 4-BIT DECADE COUNTER, 74LS490
U012	U00324	QUAD OP AMP, LM324
U013	U07812	REGULATOR, 12V 1.5 AMP, 7812UC
U014	U07805	REGULATOR, 5V 1.5 AMP, TL780-05CKC
XF01	X00041	FUSE CLIP (2)
XF02	X00041	FUSE CLIP (2)

ANCILLARY KIT

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION
0001	P01030	PLUG, MINI PHONE
F001	F00R12	FUSE, 1/8A, 3AG
F002	F00R50	FUSE, 1/2A, 3AG