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Operation & Maintenance Manual

**Series 8500A
Peak Power Meters**

CE Certified Product

ISO 9001 Certified Process

Registra: BSI, Certification No. FM 34226, Registered 04 June 1996

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Model Numbers

The Series 8500A includes two models: The single-channel Model 8501A and the dual-channel Model 8502A. Apart from the number of sensors they support, the two models are identical. Both models are referred to in this manual by the general term 8500A, except where it is necessary to make a distinction between the models.

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About This Manual

This manual contains the following chapters and appendices to describe the operation and maintenance of Series 8500A Peak Power Meters:

Preface: In addition to a comprehensive Table of Contents and general information about the manual, the Preface also contains a record of changes made to the manual since its publication, and a description of Special Configurations. If you have ordered a user-specific manual, please refer to page xv for a description of the special configuration.

Chapter 1: Introduction: This is an introduction to the instrument and performance parameters.

Chapter 2: Operation: This is a guide to the instrument front panel keys, display and configuration menus.

Chapter 3: Remote Operation: This is a guide to the GPIB remote control interface.

Chapter 4: Theory of Operation: This chapter a block diagram level description of the instrument and its circuits for maintenance and applications.

Chapter 5: Calibration and Testing: procedures for inspection, calibration, and performance testing are outlined in this chapter.

Chapter 6: Maintenance: This chapter contains procedures for maintenance and troubleshooting.

Chapter 7: Parts Lists: This chapter lists all components and parts and their sources.

Chapter 8: Diagrams: This chapter contains schematics and parts placement diagrams for all circuits.

Appendix A: Summary of Commands: A summary of the commands used to operate the Series 8500A front the front panel.

Appendix B: Menu and Memory Keys: A summary of the menus and functions that can be accessed with the MENU and MEMory keys.

Appendix C: Data Display Formats: A summary of the data display formats with the corresponding mode and detector selection switches.

Appendix D: RF Detectors: Selection data for power detectors, specifications, and calibration procedures.

Appendix E: Options: This appendix will be included only when necessary to describe options that are available for the Series 8500A power meters.

Changes that occur after publication of the manual, and special configuration data will be inserted as loose pages in the manual binder. Please insert and/or replace the indicated pages as detailed in the Technical Publication Change Instructions included with new and replacement pages.

Conventions

The following conventions are used in this product manual. Additional conventions not included here will be defined at the time of usage.

Warning

WARNING

The **WARNING** statement is enclosed in double lines and centered in the page. This calls attention to a situation, or an operating or maintenance procedure, or practice, which if not strictly corrected or observed, could result in injury or death of personnel. An example is the proximity of high voltage.

Caution

CAUTION

The **CAUTION** statement is enclosed within a single heavy line and centered in the page. This calls attention to a situation, or an operating or maintenance procedure, or practice, which if not strictly corrected or observed, could result in temporary or permanent damage to the equipment, or loss of effectiveness.

Notes



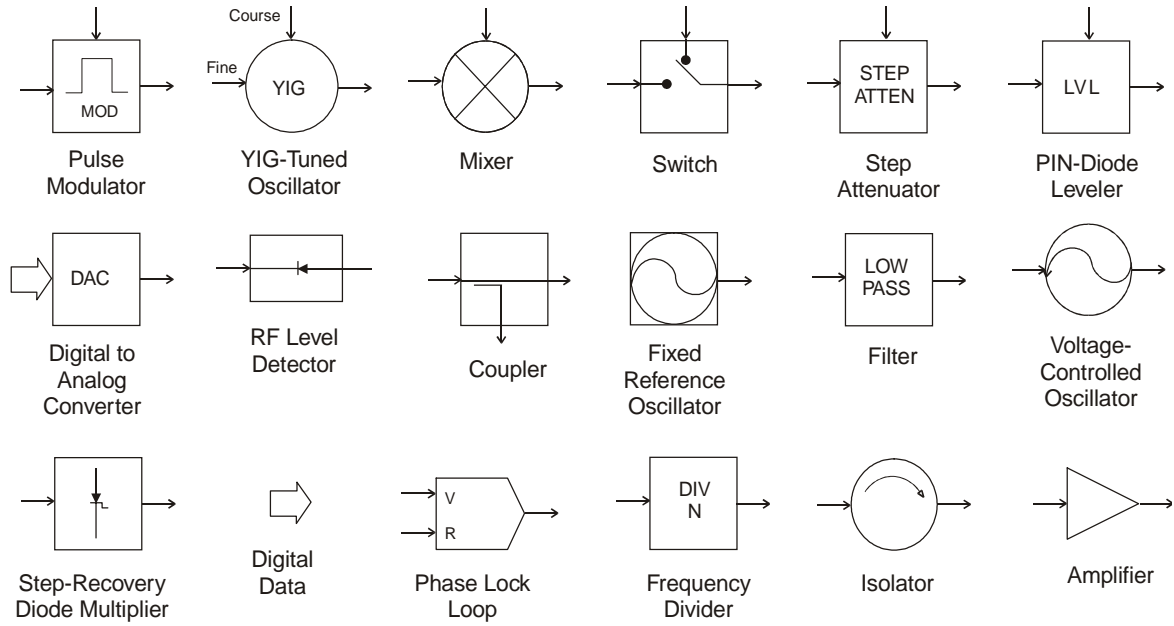
NOTE: A NOTE highlights or amplifies an essential operating or maintenance procedure, practice, condition or statement.

Keys

Front panel keys intended to be pressed are contained within brackets, such as [MENU], which means to press the MENU key. The Menu and Memory keys may be followed by a number in parenthesis. This means to press the key that number of times to reach a specific level.

Symbols

Block diagram symbols frequently used in the manual are illustrated below.



Special Configurations

When the accompanying product has been configured for user-specific application(s), supplemental pages will be inserted at the front of the manual binder. Remove this page and replace it with the furnished Special Configuration supplemental page(s).

Introduction

1.1 Description

The Giga-tronics 8500A Series Peak Power Meters (PPM) are designed for the analysis and power measurement of pulsed RF and microwave signals produced by microwave component devices.

The PPM converts RF energy to dc voltage by using balanced (dual Schottky diode), zero-biased, detectors with very fast rise times. The dc voltage is measured with an autoranging dc amplifier, and an A/D converter provides the digitized voltage to a MC68000 microprocessor. The microprocessor accomplishes the required log functions, diode linearization, frequency response, and other mathematical functions.

The PPM can measure the power in both single and repetitive pulses as well as the power in a CW signal. Power measurements are presented on an Electro Luminescent (EL) screen to display both alphanumeric and graphic information. Modes of operation are indicated both by information on the display and by LED lights on the front panel. Changes in mode or test parameters can be accomplished with the front panel keypad or, for some operations, the large spin knob on the front panel, which can be used as an analog adjustment for certain parameters.

GPIB (IEEE Bus) setup and measurement operation are standard in the 8500A power meters. It enables various other functions, such as reporting of errors, malfunctions, operational status, and self test diagnostics.

The Model 8501A has a single detector input; Model 8502A has dual detector inputs for making ratio measurements. All technical and operation descriptions in this manual apply equally to both models unless otherwise stated.

Performance specifications for the Series 8500A are in Section 1.2. Detector specifications are contained in Appendix D. Options, if any will be detailed in Appendix E.

Power requirements are 100/120/220/240 Vac \pm 10%, 48-400 Hz. See Section 2.2 for Safety Precautions and details to set the voltage and install the correct fuse for the area in which the instrument will be used.

Series 8500A Peak Power Meters

1.1.1 Environmental Requirements

Series 8500A power meters are type tested to MIL-T-28800E, Type III, Class 5, Style E for Navy shipboard, submarine, and shore applications except as follows:

- Operating temperature range is 0 °C to 50 °C (calibrator operating temperature range is 5 °C to 35 °C).
- Non-operating (storage) temperature range is -4 0°C to +7 0°C.
- Relative humidity is limited to 95% non-condensing.
- Altitude and EMI requirements are not specified.

1.1.2 Items Furnished

In addition to options and/or accessories specifically ordered, items furnished with the instrument are:

1 ea. - Power Cord
1 ea. - Detachable Detector Cable (for Model 8501A), or
2 ea. - Detachable Detector Cables (for Model 8502A)
1 ea. - Operation and Maintenance Manual

1.1.3 Items Required

The 8500A requires an external power detector; see Appendix D for power detector specifications.

1.1.4 Tools and Test Equipment

No special tools are required to operate the Series 8500A. Test equipment required for calibration or performance verification is described in Chapter 4.

1.1.5 Cooling

No cooling is required if the instrument is operated within its specified operating temperature range (0 to 50 °C).

1.1.6 Cleaning

The front panel can be cleaned using a cloth dampened with a mild detergent; wipe off the detergent residue with a damp cloth and dry with a dry cloth. Solvents and abrasive cleaners should not be used.

1.1.7 Receiving Inspection

Use care in removing the instrument from the carton and check immediately for physical damage, such as bent or broken connectors on the front and rear panels, dents or scratches on the panels, broken extractor handles, etc. Check the shipping carton for evidence of physical damage and immediately report any damage to the shipping carrier.

Each Giga-tronics instrument must pass rigorous inspections and tests prior to shipment. Upon receipt, its performance should be verified to ensure that operation has not been impaired during shipment. The performance verification procedure is described in Chapter 5 of this manual.

1.1.8 Returning an Instrument

If you are returning an instrument to Giga-tronics for any reason, including service, first contact Giga-tronics Customer Service at (800) 444-2878 or Fax at (925) 328-4702 so that a return authorization number can be assigned. You can also contact Customer Service over their e-mail address repairs@gigatronics.com.

To protect the instrument during reshipment, use the best packaging materials available. If possible use the original shipping container. If this is not possible, a strong carton or a wooden box should be used. Wrap the instrument in heavy paper or plastic before placing it in the shipping container. Completely fill the areas on all sides of the instrument with packaging material. Take extra precautions to protect the front and rear panels.

Seal the package with strong tape or metal bands. Mark the outside of the package **"FRAGILE — DELICATE INSTRUMENT"**. If corresponding with the factory or local Giga-tronics sales office regarding reshipment, please reference the full model number and serial number. If the instrument is being reshipped for repair, enclose all available pertinent data regarding the problem that has been found.

1.2 System Specifications

Frequency Range 30 MHz to 40 GHz depending on detectors
(See the Detector Specifications in Appendix D)

Power Range (Direct input to detector):

Pulse Mode: -20 to +20 dBm

CW Mode: -40 to +20 dBm

Absolute Maximum Limit: +23 dBm (200 mW)

Accuracy The uncertainty of microwave power measurements depends on several factors, the most important is the effective mismatch of both the power detector and the RF source. Excluding mismatch effects, the measurement uncertainties of the instrument and its power detectors are as follows:

Calibrator Power Uncertainty
(at 0 dBm): $\pm 1.5\%$ (0.065 dBm)

Linearity after Automatic
Calibration: $\pm 3\%$ (at stable temperature)

Temperature coefficient of
linearity at ambient $\pm 5^\circ\text{C}$, CW
and Peak, typical:
>-10 dBm negligible, 0 to 50°C
<-10 dBm $\pm 0.5\%/^\circ\text{C}$, 15 to 50°C
 $\pm 1.0\%/^\circ\text{C}$, 0 to 15°C
(The instrument indicates if the $\pm 5^\circ\text{C}$ calibration range is exceeded)

Uncertainty
(due to zeroing and noise):
CW: $< \pm 10\text{ nW}$, 15 to 50°C (Avg. = 500) $< \pm 20\text{ nW}$, 0 to 15°C
Peak: $< \pm 3.5\text{ mW}$, 15 to 50°C (Avg. = 100) $< \pm 5.0\text{ mW}$, 0 to 15°C

Single Pulse:
 $< \pm 15\text{ mW}$, 15 to 50°C (typical)
 $< \pm 30\text{ mW}$, 0 to 15°C (typical)

Time Base Range

Graph Mode: 1.2 ns/DIV to 20 ms/DIV (12 ns to 20 0ms time window using either the Data Entry keyboard or the spin knob)

Resolution: 0.1 ns

Accuracy: 0 to 10 ms, $\pm 0.2\% \pm 1\text{ ns}$; 10 ms to 5 ms, $\pm 0.1\%$; 5 ms to 200 ms, $\pm 0.01\%$

Trigger Delay

Range:	0 to 200 ms, using either the Data Entry keyboard or the spin knob
Resolution:	0.1 ns
Accuracy:	0 to 10 ms, $\pm 0.2\% \pm 1$ ns; 10 ms to 5 ms, $\pm 0.1\%$; 5 ms to 200 ms, $\pm 0.01\%$

Triggering Modes

Internal:	-20 dBm to +16 dBm limited to >2 dB and <20 dB below the peak level of the signal.
Duty Cycle:	$<50\%$
Trigger Rate:	10 Hz to 10 MHz
External:	TTL levels, Max PRF = 1 MHz

Graph Display Mode

Plots the outline of the detected pulse on the EL display. Also provides readout of amplitude and timing information.

Fast Measurement Mode

Available under GPIB control to provide fast data acquisition and output.

For an averaging number = 1, typically will be between 70 and 120 measurements/second.

Also can be used to provide fast data acquisition and throughput via a rear panel analog output for using an 8500A with a network analyzer to make swept frequency response tests.

Calibrator Specifications

Frequency:	1 GHz $\pm 5\%$
Power Uncertainty at 1mW:	$\pm 1.5\%$
Return Loss at 1 mW:	Greater than 25 dB
Self Calibration Time:	Less than 1 minute
Connector:	Type N

Series 8500A Peak Power Meters

Auxiliary Inputs/Outputs

Monitor:	Provides a voltage proportional to the detected RF envelope. Rise time is typically 20 ns, output impedance is nominally 50 ohms.
Analog Output Coefficient:	100 mV/dB \pm 0.5 mV (0 V = 0 dBm)
Offset:	\pm 10 mV
Trigger Input:	TTL
RF Blanking:	TTL open collector low during zeroing. Used to control power source.
V_{PROP} :	(V/GHz) Allows direct entry of frequency from RF power sources equipped with a V_{prop} output.
GPIB Interface:	Per IEEE STD 488-1978
GPIB Indicators:	REM, TLK, LSN, SRQ, LLO

Remote Operation

Complete setup and measurement capabilities accessible via GPIB (IEEE 488). Reporting of errors, malfunctions, operational status, and self-test diagnostics available through serial poll capability.

Direct Plot Output:	Outputs hardcopy pulse profile plots, with time, date and part identification, to a GPIB plotter.
GPIB Address:	Selectable from front panel
IEEE Interface Functions:	SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT1, TE0, LE0

General Specifications

Stored Setups:	Saves settings at power down, and has 10 additional setups in non-volatile memory.
Power-On Self-Test (POST):	POST is optionally performed at any time. A diagnostic code indicates the cause and location of any errors.
Reset Control (rear panel):	Returns the instrument to preset (default) condition.
Design and Construction:	To the intent of MIL-T-28800C, Type III, Class 5, Style E or F, Color R
Power Requirements:	100, 120, 220, or 240 Vac \pm 10%, 50, 60, or 400 Hz \pm 5%
Power Consumption:	Approximately 100 VA
Operating Temperature:	0 to 50 °C (32 to 122 °F)
Non-operating Temperature:	-40 to +65 °C (-40 to +149 °F)

Operating Humidity
(without precipitation): 95%, ±5% to 30 °C
75%, ±5% to 40 °C
45%, ±5% to 50 °C

Dimensions:

Bench Mount: *With Feet:* 148.3 x 425.7 x 355.6 mm (5.84 x 16.76 x 14.00 in.)
Without Feet: 132.6 x 425.7 x 355.6 mm (5.22 x 16.76 x 14.00 in.)

Rack Mount: 132.6 x 482.6 x 355.6 mm (5.22 x 19.00 x 14.00 in.)
Conforms to EIA RS-310 Standard for a 19-inch rack.

Weight: *Model 8501A:* 12 kg (26 lbs)
Model 8502A: 13 kg (28 lbs)

Depending upon requirements, the following software versions and enhancements apply (See Table 1-1).

Table 1-1: 8500A Functions Related to Software Versions

S/W Version	Sound Works	Fast Analog	S-Mode (FAA)	Menu Wrap
2.10A		YES		
2.11A				
2.13A			YES	YES
2.14A	YES		YES	YES

1.3 Default Settings

Factory-programmed settings of various user definable functions have the following defaults whenever there have been no changes made in the settings by the operator during any testing routines.

Function	Default Setting
Averaging	CW: 4 samples; Peak: 4 samples
Internal Trigger Level (A & B)	-10 dBm
Frequency	1.00 GHz
Offset	0 dB
Cursor Delay (A & B)	1.0000 microseconds
Start Delay	0.0000 nanoseconds
Delay Window (A & B)	10.0000 microseconds
Reference Power Level (A & B)	0 dBm
Reference Delay (A & B)	0.0000 microseconds
Cal Factor	0 dB
Mode	Channel A, CW power, dBm
Trigger Mode	Channel A, Internal
Pulse Width Start	50%
Pulse Width End	50%
Rise Time Start	10%
Rise Time End	90%
Fall Time Start	90%
Fall Time End	10%
Marker 1	2.5% (A and B)
Marker 2	17.8% (A and B)
Marker 3	46.9% (A and B)
Marker 4	90% (A and B)

The following settings are not affected by power-on, initialization, and setup store or recall:

Maximum Power	+20.5 dBm
Minimum Power	-45.0 dBm
Autoscale Average Number	4
Autoscale Initial Delay	75 μ s
Plotter Address	6
PPM Address	4
Source of Frequency Correction	a) User supplied (as input, default = 1GHz) b) VpropF - parameters not subject to store/recall or initialization c) Cal Factor - not subject to store/recall or initialization
Frequency Display	Displayed

Operation

2.1 General

The Series 8500A Peak Power Meters are very simple to operate. You only need to follow the instructions given in the prompts and menus shown in the display window to set up the parameters for making a measurement. Eleven levels of operational menus are available. Each can be accessed with the MENU key. The type of measurement (Peak or CW) being made will also be shown in the lower right corner of the display to identify the mode in use.

Along with the menus and prompts in the display, the power meters produce audible clicks and beeps to indicate the occurrence (or non-occurrence) of certain events during setup and testing. The tones are defined as follows:

- Click:** When a key is pressed and a click is heard, this means that the key is active and its function will be included in the parameters being entered. If no click is heard, the key is not active and not performing any function at that time.
- Beep:** A single beep indicates that the calibration, zeroing, or self-test functions have successfully completed when they are performed. A double beep means that the function failed to complete. The discussion of these functions later in this chapter will detail what problems might cause the function to fail.

There is a volume control on the rear panel of the instrument. It adjusts the audio tones to a comfortable level, or the audio can be turned off if desired.



NOTE: In the remainder of this chapter except where specified as the Model 8501A or 8502A, the instrument may be referred to as the PPM (Peak Power Meter).

2.2 Installation

The unit is set at the factory for operation at the normal supply voltage for the country in which it is sold. The input frequency must be 50, 60, or 400 Hz $\pm 5\%$. The combination of the module and transformer design allows instrument operation of 100/120 volts with a 2.0 A Slo-Blo fuse, or 220/240 volts with a 1.0 A Slo-Blo fuse.

WARNING

Before applying ac power to the instrument, be sure that the instrument is set for the correct line voltage and that the fuses are of the correct rating.

Figure 2-4 illustrates the rear panel. Before operating the instrument, make sure the input voltage is correctly set and that the fuses are compatible with the applied line voltage.

NOTE: The 8500A may be furnished with the PC-oriented voltage selector and fuse holder described next, or the VDE-approved fuse holder described in the following pages. Refer to the appropriate type of voltage selector and fuse holder for your power meter.

CAUTION

The instrument may be damaged if you turn it on while the voltage selector and fuses are incorrect for the applied line voltage.

The power meter is supplied with a three-conductor NEMA type power cord for connection to the power source and safety ground, as illustrated in Figure 2-1. The current carrying conductor is black and its return is white. The green wire of the power cord is for connection to earth ground. The instrument will be properly grounded if the plug is connected to a properly installed three-prong receptacle. If a three-prong to two-prong adapter is used, be sure that the pigtail lead of the adapter is earth-grounded.

WARNING

The safety ground is connected directly to the chassis. If a 3-to-2 wire adapter is to be used, be sure to connect the ground lead from the adapter to earth ground. Failure to do this could cause the instrument to float above ground, posing a shock hazard.

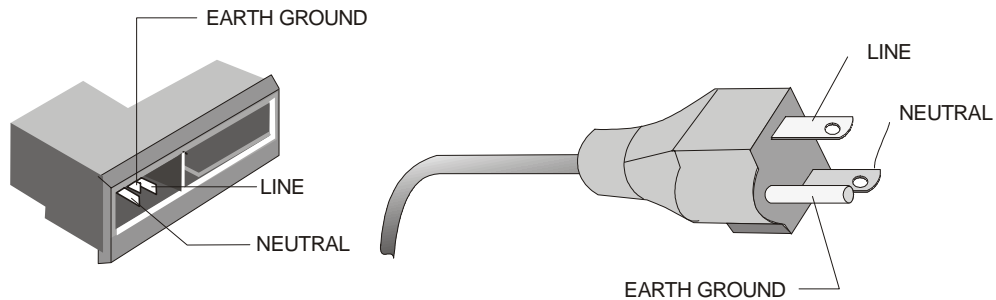


Figure 2-1. Power Connector

2.2.1 PCB-Oriented Voltage Selector and Fuse Holder

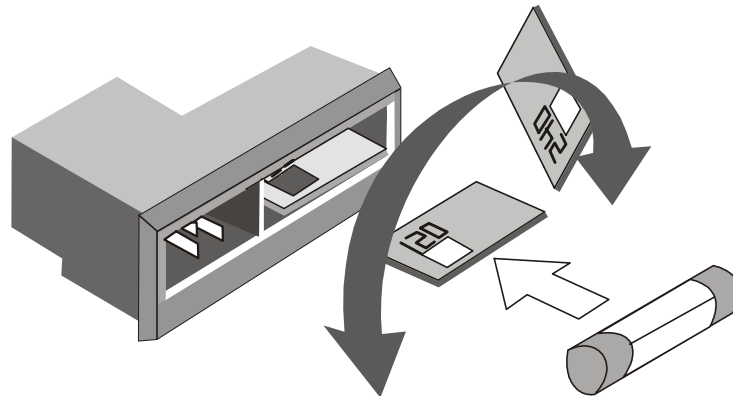
The number on the selector card, visible through the window, indicates the nominal line voltage to which the power meter must be connected.

The line voltages and fuse ratings are:

Line Voltage	Fuse Rating
100/120 Vac, $\pm 10\%$, 50, 60 or 400 Hz $\pm 5\%$	1.0 AMP Slo-Blo
220/240 Vac, $\pm 10\%$, 50, 60 or 400 Hz $\pm 5\%$	2.0 AMP Slo-Blo

To select a different operating line voltage and fuse, refer to Figure 2-2 and proceed as follows:

1. Open the cover door, rotate the fuse-pull to the left, and remove the fuse.
2. Select the operating voltage by orienting the PC board so that the correct voltage label is on the top left side.
3. Push the board firmly back into the module slot.
4. Rotate the fuse-pull back into the normal position and reinsert the fuse into the holder. Use care to select the correct fuse value.



**Operating voltage is shown
in the module window**

Figure 2-2. PCB Voltage Selector and Fuse Holder

2.2.2 VDE Type Voltage and Fuse Holder

The VDE-approved voltage selector and fuse holder are contained in a covered housing directly above the ac power connector.

The line voltages and fuse ratings are:

Line Voltage	Fuse Rating
100/120 Vac, $\pm 10\%$, 50, 60 or 400 Hz $\pm 5\%$	1.0 AMP Slo-Blo
220/240 Vac, $\pm 10\%$, 50, 60 or 400 Hz $\pm 5\%$	2.0 AMP Slo-Blo

To gain access to the voltage selector and fuse, open the cover with a small screwdriver or similar tool and proceed as follows:

To change the voltage setting:

Use the same tool to remove the voltage selector (a small barrel-shaped component marked with voltage settings). Rotate the selector so that the desired voltage faces outward and place the selector back in its slot. Close the housing cover; the appropriate voltage should be visible through the window (see Figure 2-3).

To replace the fuse:

With the housing cover open, pull out the small drawer on the right side of the housing (marked with an arrow) and remove the old fuse. Replace with a new fuse, insert the drawer and close the housing cover (see Figure 2-3).

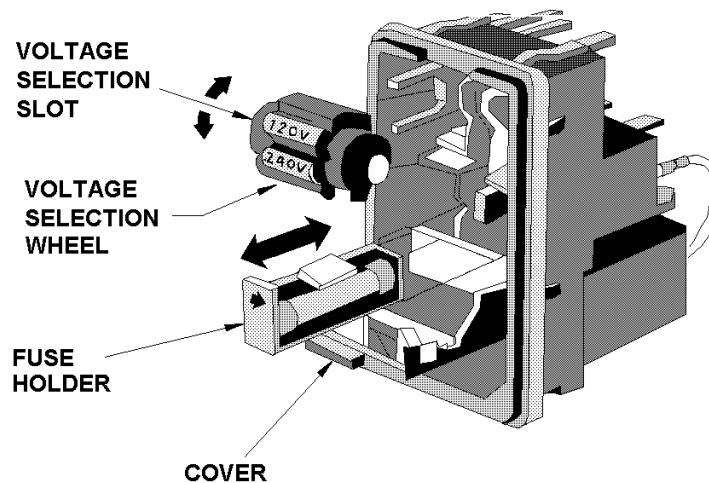


Figure 2-3. VDE Voltage Selector and Fuse Holder

2.3 Rear Panel Description

The Series 8500A power meter rear panel controls and interface connections are described in this section. The boxed numbers in the diagram correspond to the boxed numbers in the description. The Model 8501A will have single-channel inputs while Model 8502A will have Channel A and Channel B inputs as shown in Figure 2-4.

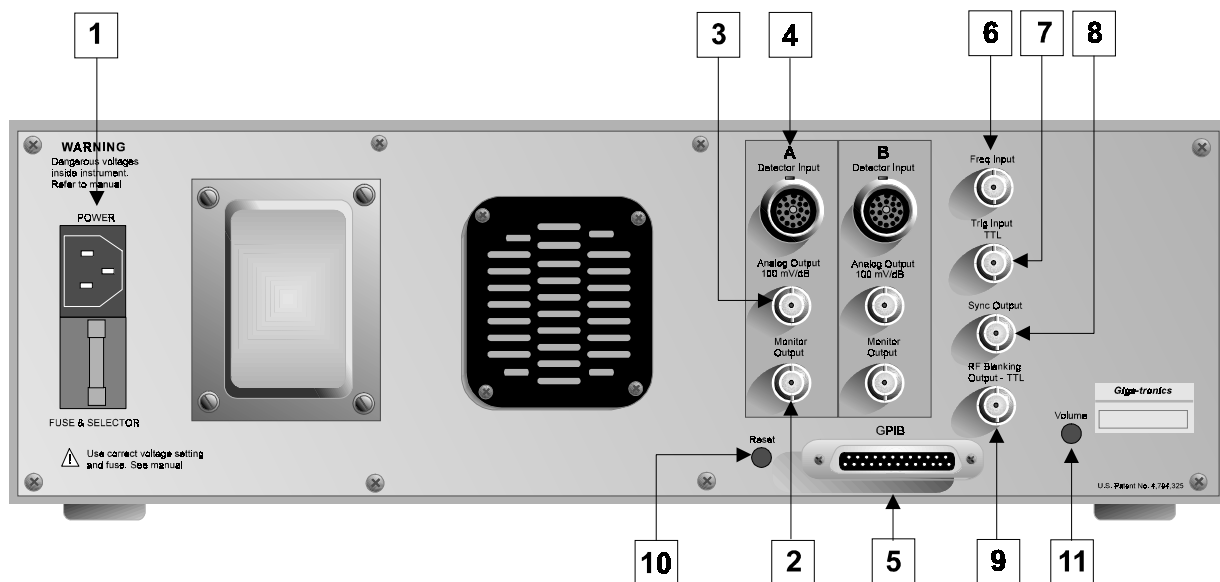


Figure 2-4. Model 8502A Rear Panel

- 1** **Input Power and Fuse** Refer to Section 2.2 for the details to select the correct input voltage and fuse.
- 2** **Monitor Output** This output connection interconnects to a test instrument such as an oscilloscope to externally monitor the detected signals entering the PPM. The Model 8502A has a monitor input for Channel A and Channel B.
- 3** **Analog Output** This connector outputs 100 mV/dB signal to interface the PPM with the Giga-tronics Model 8003 Precision Scalar Analyzer for making swept peak power measurements (see Measuring Peak Power Under Swept Conditions in Section 2.14). The Model 8502A has an analog input for Channel A and Channel B.

CAUTION

When using the PPM in the 1018B Emulation Mode, it should be kept in mind that the 1018B instrument has a 10 mV/dB analog output while the PPM has 100 mV/dB. If the 10 mV/dB output of the 1018B is required, a 10:1 resistive divider network should be employed to reduce the PPM's 100 mV/dB output.

- 4** **Detector Input** These channel A and B inputs (single input in the 8501A) will be hole cover plates unless Option 03 (Rear Panel Connection) has been ordered. With Option 03, the Detector Input and Calibrator will be relocated from the front to the rear panel. The Calibrator connection will be above the Serial/Code number label on the right side of the rear panel.
- 5** **GPIB Interface** This is the interface connection for controlling the instrument through the GPIB (IEEE bus).
- 6** **FREQ Input** This is the voltage-proportional-to-frequency (V_{propF}) input connection that receives the Frequency Reference or V/GHz ($V \propto F$) output signal from an external signal generator. This signal provides frequency information to the PPM for detector frequency response correction when required.
- 7** **TRIG Input - TTL** This connection interfaces a TTL signal source to provide an external trigger when this mode of operation is selected.
- 8** **SYNC Output** This output connection provides access to the sample pulse for synchronizing the PPM to an external counter.
- 9** **RF Blanking Output - TTL** This output interfaces a blanking TTL signal to turn off the external RF power signal source when you want to autozero or calibrate the detectors. It is at a TTL high level during execution of these functions.
- 10** **Reset** This control resets the PPM to its initial power-on condition without having to turn off the instrument.
- 11** **Volume Control** This control adjusts the volume level of the audio tones generated by the PPM. The audio can be turned off with this control.

2.4 Front Panel Description

The front panel controls, display, and connections are described in this section. The boxed numbers in Figure 2-5 correspond to the boxed numbers in the description. The Peak, CW, and Graph keys in both power meter models, and the Detector Select A and B keys of the Model 8502A contain lights in the center of the buttons to indicate when the functions are active.

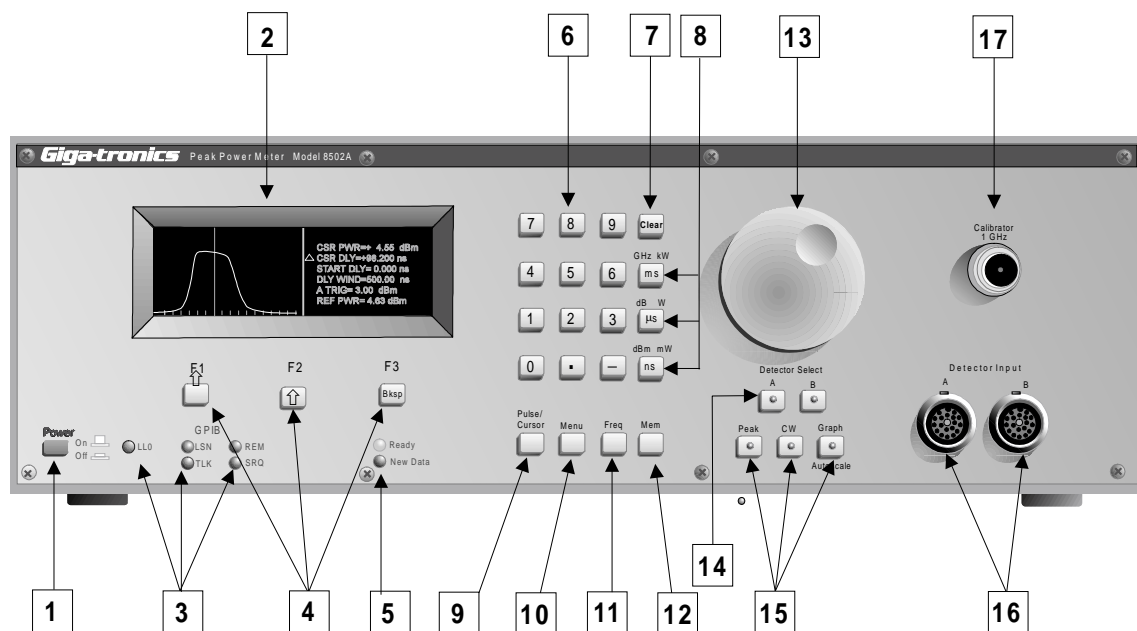


Figure 2-5. Model 8502A Front Panel

- | | | |
|----------|--|--|
| 1 | Power | This is the push-on push-off ac power switch to the PPM. |
| 2 | Display | This is an Electro Luminescent (EL) alphanumeric and graphic display screen. It presents data and shows pulse waveform profiles. |
| 3 | GPIB Indicators | These LEDs indicate whether the PPM is under local or remote control and the current GPIB status (REM = remote control on, LSN = listen, TLK = talk, SRQ = service request, and LLO = local lockout.) |
| 4 | F1, F2, F3 Directional keys Backspace | The F1 (up) and F2 (down) directional keys are used in the Graph Mode to move the cursor (Δ icon) up and down to select any pulse or cursor parameters that are to be changed. The F3 (backspace) key is for correcting entered text or numbers.

A secondary function of these keys is to select menu functions as the various menus are displayed. |
| 5 | Ready, New Data Indicators | These LEDs flash whenever the system is receiving a trigger. If the Ready light is steadily on and the New Data light is off, it would indicate that a trigger was not being received. |
| 6 | Data Entry | Use this 12-button keypad to enter parameter data when instructed in the applicable procedure. |

- 7 Clear** The CLEAR key exits from a menu, but it clears erroneous entries while entering data.
- 8 Units:**
- ns/dBm mW** This key enters pulse timing parameters in nanoseconds. The dBm mW function enters a power parameter in either dBm or milliwatts.
- μs/dB W** This key enters pulse timing parameters in microseconds. The dB W function enters a power parameter in either dB or Watts.
- ms/GHz kW** This key enters pulse timing parameters in milliseconds. The GHz kW function enters a frequency in GHz or (with offsets) a power parameter in kilowatts.



NOTE: Each of the unit keys have a secondary function. At various points in these instructions, the procedures will state to press any units key. This is to enter a parameter without units (average number), to enter units other than those listed above (start voltage), or to start a function.

- 9 Pulse/Cursor/Marker** This key is active only in the Graph Mode. Pressing the key cycles the PPM through the three sub-modes: Pulse, Cursor, and Marker. The Cursor sub-mode is convenient for changing the time base parameters, scaling, trigger level, and cursor position. The Pulse sub-mode displays the rise time, fall time, and pulse width of the current pulse. The Marker sub-mode displays the time between four user-defined power levels on the pulse.
- 10 Menu** The MENU key enables access to the eleven main menus of the PPM. Depending on the mode of operation, other keys can display sub-menus that pertain to the particular function of that key. However, the MENU key will cause the routine to step through each of the main menus each time it is pressed. As an example, if it were pressed three times, then Menu 3 would be displayed.
- Appendix B contains a description of each menu that will be accessed at each keystroke of the MENU key. Wherever possible, commands or user selections that would be used more often are located at the top of the menu structure (Menu-1 through Menu-4). Less commonly used menus are located toward the bottom of the menu structure (Menu-5 through Menu-11).
- 11 Freq** This key enters the signal frequency for the channel A and B detectors. When the PPM default setting is used, all that is required is the entry of the frequency of the specific signal being tested.
- If the PPM is in the Cal Factor or V/GHz setting, the FREQ key will allow you to change these parameters by following the prompts.
- 12 MEM** This key activates three memory menus. Press the key once to display memory Menu-1. Press the key twice to display memory Menu-2, and three times for memory Menu-3. Press [CLEAR] to return the routine to the Data Display mode.
- The memory menus control the non-volatile setup memories. The contents of the ten memory locations can be stored, recalled, initialized, and displayed. The menus also give you the option to return to the current test setup (the test in use just before the MEM key was pressed), as well as the option to return to the initial power-on status.

See the Non-Volatile Memory discussion in Section 2.17 for more information on the PPM memory capabilities.

- 13 Spin Knob** The spin knob changes the value of selected parameters. The usability of the knob is indicated in the display by the appearance of a delta symbol (Δ) next to the name of the parameter of interest. For instance, when in the Peak mode, a Cursor Delay entry will cause the delta symbol to appear next to DLY in the power reading display. This means that the spin knob can be used to change the Cursor Delay setting.
- 14 Detector Select A or B** (8502A only) These keys select which channel should display data on the Model 8502A display. They also tell the instrument which channel a trigger level entry is intended for. In the CW and Peak Modes it is possible to display measurements for either channel A or B, or both at the same time. In the Graph Mode, only one channel at a time can be viewed.
- 15 Peak, CW, Graph** These mode keys select whether the PPM will be used for CW or Peak power measurements. GRAPH is used when making Peak power measurements to allow the graphic display of the detected pulse and easy determination of pulse timing factors. In addition to the readout display indications, the selected mode is identified by which LED in the center of the PEAK, GRAPH, and CW keys is lit. If the Model 8502A is being used for dual channel operation and all of the mode LED's are out, then it is in the Ratio Mode (see the Power Ratio Measurement Procedures in Section 2.10.5).
- When the 8502A Ratio Mode is in use, the A and B keys call up a menu so that the type of signal (CW or Peak) can be specified for the selected channel. This is useful for determining the ratio between a CW and a Peak signal. For example, a radar TWT might have a pulsed output but its input could be CW. To measure its gain, the Peak output would have to be divided by the CW input. The 8502A does this instantly and automatically.
- 16 Detector Input** These receptacles provide the input from the A and B channel detectors in the Model 8502A. The Model 8501A has a single input.
- 17 Calibrator** The CALIBRATOR connection performs an amplitude response calibration of the detector from -30 dBm to +20 dBm, as well as standardizing the absolute power level readings (see the Self-Calibration Procedure in Section 2.7).

2.5 Operation

Single-channel operation is essentially the same dual-channel for standard peak power and CW measurements. The single channel 8501A does not have a ratio measurement capability. The following instructions define the operation of both instruments. If a Model 8501A is being used, ignore references to A and B keys, distinctions between the A and B channels, and reference to two detectors. The single channel of the 8501A is channel A for definition purposes. If the instructions require that a distinction be made between the two instruments, the specific model number will be given rather than PPM.

2.5.1 Power On Self-Test (POST)

1. Before turning on the power to the PPM, be sure that it is set for the correct input voltage. Procedures for setting the operating voltage are given in Section 2.2.
2. Connect a detector (detector) to the **DETECTOR INPUT** at channel A, using the Giga-tronics detector cable (P/N 16956-XXX, where XXX defines the specified length of the cable) supplied with the system. If a Model 8502A is to be used, detectors should be connected to channel A and B inputs for dual channel operation.

To connect the cable to the detector housing, pull back on the metal sleeve at the detector end of the cable, align the red dots, and make the connection. To connect the other end of the cable to the front panel **DETECTOR INPUT** receptacle, again pull back the metal sleeve, align the red dots on the cable and input receptacle, and make the connection.



NOTE: The detector must be connected to the Calibrator connection on the front panel, to a 50-ohm termination, or to a signal source before initiating the POST function.

3. Turn on the power by pressing the power switch on the front panel. The PPM will perform a self-test to verify that it is operating properly.

The self-test is not identical to the one performed by selecting [MENU] (11) [F2], or by sending the SELT command over the GPIB. The POST will not report errors 5 or 6 because you may not have removed the RF power from the detectors, or error 10 because it sometimes fails erroneously soon after power on (see Self-Test Failure Indications in Section 2.15).

The PPM will automatically return to the last setup before the instrument was powered off.

2.5.2 Warm Up Time and Temperature

When initially operating the PPM, it is common to see a prompt on the display stating

RECAL: dT XXX DEGS-C.

The number of degrees shown is the difference between the present temperature of the detector and the temperature at which it was last calibrated.

The prompt occurs only if the change in detector temperature is more than 5 °C. When this prompt is displayed, sufficient time should be allowed for the instrument to warm up so that accurate readings can be taken. Variations of less than 5 °C from the calibration temperature do not result in a temperature prompt display because minor temperature changes in the detector are monitored and compensated by the 68000 microprocessor.

If the PPM continues to display the temperature prompt after 30 minutes warm up, or if the room ambient temperature changes by more than 5 °C, a Self-Calibration will be required (see the Self Calibration Procedures in Section 2.7).

2.6 Mode Selection

Follow these procedures to select the desired operating mode. The modes are CW, PEAK and GRAPH.

Throughout this chapter, you will be instructed to press the MENU and MEM keys. The instruction may be followed by a number in parenthesis. This number corresponds to the menu number and indicates the number of times you need to press the key to reach the necessary menu.

2.6.1 CW Mode

If in the Peak or Graph mode, press [CW] to access the CW Mode.

If a menu is being displayed and you want to exit it and go to the CW Mode press [CLEAR] [CW].

If the 8502A is in the Ratio mode, selecting CW will cancel RATIO and the 8502A will display the CW power of channel A.

In certain instances the option will be given to select the CW Mode if there is some reason that another mode is not operating properly. For example, if a trigger had not been provided as required in the Peak Mode. The purpose is to allow an escape from erroneous modes of operation.

Very few adjustments or menu selections are required to set up the unit for CW measurements. The two major settings that must be specified are defined as follows:

Frequency

Press [FREQ] to select the operating frequency at which the power will be measured. Normally, the PPM automatically adjusts for detector frequency response variations by using the factory measured frequency response data stored in the PROM in the detector housing. Other options are available as detailed in PROM Frequency Correction Section 2.8.2. Not compensating for the frequency response of the detector could result in an error in the power measurement reading.

CW Averaging

This setting selects how many samples of the signal being measured will be taken and averaged to reduce noise effects at low power levels. To adjust the averaging number, press [Menu] (2) [F1]. A number between 1 and 999 averages must then be entered. The number of averages presently in effect is not indicated until the averaging menu has been entered.

Low Power Level Measurements

When the PPM is used in the CW mode for power levels below -30 dBm, its dynamic range is extended to below -40 dBm. Under low power testing conditions it is necessary to observe the correct auto-zeroing procedures to obtain the highest measurement accuracy. Zeroing should be done more often in environments where temperature changes are more drastic. See the Auto-Zero procedures in Section 2.7.3.

2.6.2 Peak Mode

While you are in the CW or Graph Mode, press [PEAK] to access the Peak mode.

If a menu is displayed and you want to exit and go to the Peak mode, press [CLEAR] [PEAK].

After this, follow the trigger setting guidelines given below. Lack of a trigger can freeze the display. To exit either of these situations either the trigger can be set, or the CW Mode can again be accessed by pressing [CW].

To make measurements in the Peak or Graph Mode, first ensure that the system is receiving a trigger signal that will drive its timebase and crystal-based delay generator. The delay generator accurately places a sampling window at the desired time on the pulse to be measured. The different triggering methods are detailed below.

Internal Triggering

The PPM can generate its own internal trigger from the detected RF video envelope at the detector output. This triggering mode requires that the power of the RF pulse be greater than the internal trigger level. The trigger level is an adjustable threshold at which the leading rising edge of a pulse will cause the PPM to take a reading. The precise time at which a reading is taken following the trigger is determined by the delay generator. This function of the PPM is called Cursor Delay. See the Cursor Delay functions in Section 2.8.8.

There are two trigger amplifiers in the PPM, one for the range -20 dBm to -10 dBm and another for the range -10 dBm to +16 dBm. Selecting trigger levels in the lower range (below -10 dBm) can cause the trigger to be delayed on the order of 100 ns due to the filtering required to improve trigger stability at these low levels. The absolute accuracy of the trigger level is about $\pm 1/2$ dB near the top of these ranges, but degrades to about ± 2 dBm near the bottom.

Normally, the Trigger Level is set at -10 dBm (default). The internal trigger level can be adjusted by pressing [MENU] (1) [F1]. A trigger level value between -20 and +16 dBm can then be entered.

If there is no RF pulse present at the detector input or if the pulse amplitude is too low, the PPM will not internally trigger. When this occurs the display will freeze, the New Data light will not be lit, and the Ready light will not be on.

If a Model 8502A is being used, the routine will ask whether internal triggering is to be driven by inputs from channel A or channel B. Press the appropriate Detector Select [A] or [B] key. To select the Internal Trigger Mode and set the level press:

8501A: [MENU] (1) [F1] [nn.nn] [UNITS]
8502A: [MENU] (1) [F1] [A] (or B) [nn.nn] [UNITS]

(nn.nn = selected trigger level numbers)

Autoscaling changes the internal trigger channel to the displayed channel.

External Triggering

For some test routines it may be desirable to provide an external trigger to the system. This can be especially useful if the trigger pulse from the external source leads the RF pulse at the detector input by a small amount of time. Readings can then be taken just prior to the arrival of the RF pulse, allowing close inspection and measurement of the pulse leading edge.

To use the External Trigger Mode, connect a BNC cable from the TTL sync pulse output of the system under test (or pulse generator) to the Ext Trigger input on the rear panel of the PPM. To select the External Trigger Mode, press [MENU] [F2]. Correct operation of the External Trigger Mode can be verified by noting that the Ready and New Data lights on the front panel are flashing.



NOTE: If you attempt to operate in the External Trigger Mode without supplying the required trigger as described above, the display will freeze, the Ready light will be on, and the New Data light will be out.

To select External Trigger, press [MENU] (1) [F2].

2.6.3 Graph Mode

The Graph Mode of the PPM provides graphic capabilities for the display, plotting, and analyses of RF pulse profiles. Most instrument pulse parameters can be set and changed directly from information presented in menus. Features are available which allow measurement of commonly required pulse parameters such as rise time, pulse width, and so forth.

When the system is operating satisfactorily in the Peak or Graph Mode, it is possible to toggle back and forth between the two modes by pressing [PEAK] or [GRAPH] whenever desired. The only exception to this is when an 8502A is being used in the dual channel mode of operation since the Graph Mode does not allow dual channel operation. If a dual channel function is being used and it is desired to switch to the Graph Mode, single channel operation must first be selected. See Dual Channel Operation in Section 2.10.

The ability to toggle back and forth between Peak and Graph Modes is useful for a number of reasons. For example, in the single channel Peak Mode, the display produces large distinct power read-out characters that can be read from a distance (see Figure 2-6). In addition, while in the Peak Mode, the current frequency being used for the test is directly visible on the display. In the Graph Mode, the display is primarily for inspection of the pulse profile and the frequency is not displayed to allow room on the display for other important pulse profile parameters (see Figure 2-7 for a typical Graph Mode display).

All operating parameters such as trigger mode, frequency, and cursor delay are maintained in both the Peak and Graph Modes. The Graph Mode can place the cursor at a specific point on the pulse, and then the PEAK key can be pressed to see the power reading using the large readout characters.

Selecting the Graph Mode:

If in the Peak, CW Mode, or Ratio Modes (previous Graph or Peak Mode settings will apply), press [GRAPH]. If a menu is being displayed and you want to exit to the Graph Mode, press [CLEAR] [GRAPH]. Then, to Autoscale the pulse, press [AUTOSCALE]



NOTE: While in the Graph Mode, the Autoscale function of the GRAPH key will be active.

Under some conditions, autoscaling cannot take place due to the complex shape of the pulse or other timing factors. The PPM will then display only a part of the pulse. The reference level will be correct for rectangular pulses. The PPM will not have been able to set an appropriate Delay Window for the pulse. It may be possible to subsequently autoscale by changing the initial delay value for autoscaling to be closer to twice the actual pulse width for the pulse in question. This is done by pressing [MENU] (9) [F2] [n.nnnn] [UNITS].

To use the Graph Mode, the triggering selection guidelines discussed Section 2.6.2 must be followed.

2.7 Self-Calibration and Auto-Zeroing

The purpose of the PPM's Self-Calibration function is to ensure that measurement accuracy will be maintained despite changes in detectors, changes in detector diode temperature, or other changes that might occur in the PPM's analog circuits.

During the time the instrument is performing its Self-Calibration routine, the RF output of the 1 GHz calibrator is accurately stepped from +20 to -30 dBm. Each step is measured by an internal standard and, at each point, the calibrator output power as measured by the RF detector is compared to the standard. The power readings are then digitally adjusted by the PPM microprocessor and stored in memory. For power levels below -30 dBm, the system relies on the Auto-Zero function as well as the inherent repeatability of the detector voltage output versus input power at these levels. (Refer to Section 4.2.7 for a complete description of the automatic calibration system.)

To make any type of power measurements with the PPM it will be necessary to use the appropriate calibration and zeroing procedures to ensure the highest accuracy.

After the instrument has warmed up for 30 minutes and the mode of operation has been selected, a detector self-calibration should be performed. In addition, if the ambient room temperature changes more than 5 °C from the temperature at which the system was last calibrated, self-calibration should also be done. If there has been a change in the temperature of the detector of more than 5 °C since it was last calibrated, the difference will be shown.

2.7.1 Self-Calibration Procedure

Connect the channel A detector to the 1 GHz Calibrator output. Press [MENU] [F3] to call up the Cal or Zero Detectors menu. The menu offers the following choices:

- F1 to Calibrate the Detectors
- F2 to Auto-Zero the Detectors
- F3 to Return to Data Display

Select F1 for the Detector Self-Calibration.



NOTE: The CLEAR key as well as F3, can also be used to return to data display.

The display will show the last date and time the detector was calibrated. To proceed with the calibration, press any Units key. The Self-Cal process takes about 50 seconds, during which time the statement

A (or B) CALIBRATION IN PROGRESS

will be displayed.

If a Model 8501A is in use, press [CLEAR] to return the routine to the data display (the last mode of operation). If the Model 8502A is being used, press [CLEAR] to bypass the channel A calibration and go to the channel B calibration.

After successful completion of the Self-Cal function, the instrument will go back to displaying data in the last mode of operation. With the Model 8502A, either bypassing or successfully completing the channel A calibration will take the routine to the channel B calibration.

Channel B calibration is done in the same manner as the channel A calibration. The date and time of the last B channel calibration will be presented, and the option will be given to either press any Units key to start the cal procedure or press [CLEAR] to return to the data display.

2.7.2 Self-Calibration Failures

In the event of a malfunction such as a burned out detector diode or if you forget to connect the detector to the calibrator, the Self-Cal function will fail. If this occurs, the following error menu will be displayed:

**A Calibration Error Exists
Press [CLEAR] to continue
Press any Units key to repeat cal**

Press [CLEAR] to return the instrument to the last mode of operation.

Selecting any Units key gives you the opportunity to correct a simple error such as not connecting the detector to the calibrator. This can be accomplished, and then the Self-Cal procedure can be repeated.

See Input/Output & Calibration Failure descriptions in Section 6.3.2 for the procedure to follow if the PPM fails the Self-Cal.

2.7.3 Auto-Zero Function

To initiate the Auto-Zero function, turn off the RF power to the detector to be zeroed and then press [MENU] [F3] to get to the Self-Cal/Auto-Zero menu. Then press [F2] to Auto-Zero and follow the displayed prompts.

If the Model 8502A is in use, channel A must be auto-zeroed before channel B. If desired, channel A can be bypassed by pressing [CLEAR] and going directly to channel B.

2.8 Measurement Procedures

2.8.1 Frequency Correction, Cal Factor, and dB Offset

The Frequency Correction and Offset functions enhance measurement accuracy, and compensate for detector amplitude and frequency response variations as well as devices residual to the test setup.

Frequency correction is selected in Menu-3. Three methods of frequency correction are available and will be described in detail in this section. These are:

- PROM Table — User Supplied Frequency (default mode).
- PROM Table — External Frequency Input (uses the $V \propto F$ output of the sweeper)
- User Supplied Calibration Factor — (allows direct entry in dB)

To select the desired mode, press [MENU] (3) [F3].

Then select F1, F2, or F3 respectively, for items a, b, or c. This will determine the functioning of the FREQ key of the instrument.

Whenever a mode is selected that uses the PROM table in the detector assembly for frequency correction, the PPM will interpolate between the discrete amplitude correction points stored in the detector PROM. This allows entry of frequencies other than those stored in the PROM, and reduces the need for operator interpretation and manual correction of power readings.

All of the information stored in the PROM of the detector currently in use can be reviewed by accessing Menu-10 and pressing [F2] for channel A, and/or [F3] for channel B.

2.8.2 PROM Frequency Correction

User-Supplied Frequency

This is the User-Supplied Frequency mode. It is the default mode of the instrument. Factory measured frequency correction data is stored in a PROM inside the detector housing, thus eliminating the need for you to refer to a frequency correction chart and then make manual adjustments to the system for each discrete frequency point. The PROM data is used by the PPM to correct for all of the detector's amplitude variations across its entire frequency range. When the system is first turned on, the PROM data stored in the detector is transferred to the main memory of the PPM.

To select the **PROM Table - User Supplied Frequency** mode, press [MENU] (3) [F3] [F1].

The display will then prompt for the frequency of operation to be entered. The default frequency is 1 GHz, the same as that of the Calibrator. Press any Units key to complete the entry.

After selecting the **PROM Table - User Supplied Frequency** mode, use of the FREQ key allows entry of the carrier frequency and gives the microprocessor the ability to correct any detector frequency response deviations.

External Frequency

The purpose of the **PROM Table - External Frequency** input function is to allow entry of the operating frequency by means of an externally applied voltage. The voltage level will be proportional to the frequency, and will be used by the PPM to correct power readings for detector frequency response.

When this function is active, the RF frequency of a sweep generator or signal source can be changed and the PPM will convert the analog voltage input (through the rear panel FREQ Input connection) to a digital representation of the frequency. The PPM's microprocessor uses this information to correct power readings according to the frequency correction table stored in the detector's PROM.

If the sweep generator (sweeper) is equipped with a rear panel output providing frequency information, this information will usually consist of an analog voltage proportional to the RF frequency output of the sweeper at any given time. Some sweeper manufacturers refer to this voltage as Frequency Reference, Volts/GHz (V/GHz), or Voltage-Proportional-to-Frequency (VpropF or $V \propto F$). The most common coefficients for this output are 1V/GHz and 0.5V/GHz.

Once the VpropF frequency correction function has been activated, the **FREQ** key can change the parameters for use by the VpropF function.

To activate the VpropF frequency correction function, perform the following:

1. Connect a BNC cable from the V/GHz output of the sweeper to the Frequency Input on the rear of the PPM.
2. Press [MENU] (3) [F3] [F2].
3. The instrument will then ask for the sweeper V/GHz value (normally 1 or 0.5). Press [n.n] [UNITS] (where n.n is volts and UNITS is any units key).
4. The Sweeper Start Voltage is required next. If the sweeper frequency range is from 2 to 18 GHz and the sweeper V/GHz coefficient is 0.5V/GHz, then this value would normally be $2 \times 0.5 = 1$. Press any Units key to complete this entry.

The above steps set the frequency scaling factor for the PPM so that the analog voltage coming in from the FREQUENCY INPUT connection can be interpreted to the correct frequency by the PPM's microprocessor.

2.8.3 User-Supplied Cal Factor

If you prefer to use your own detector frequency response correction factors, the PPM provides a means to manually correct for any detector frequency response variations (in dB). An example of when this could be necessary is if the data stored in the detector's PROM might be out of date.

To activate the Cal Factor feature of the system, press [MENU] (3) [F3] [F3].

If the dual channel 8502A is being used, you will be asked to select a channel. Select A or B as appropriate.

Next, the value of the desired Cal Factor must be entered in dB. Complete the entry by pressing any Units key.

When using the Cal Factor mode, the frequency of operation is unknown to the PPM. Therefore, the Cal Factor will be shown on the display instead of Frequency. This also serves to notify you that this mode is in effect. The readout will display the Cal Factor as CF = nn.nn dB.



NOTE: In the Cal Factor mode of operation the **FREQ** key alters the Cal Factor (dB), not the frequency.

Offset

The Offset feature of the instrument digitally offsets the displayed power value within a range of -40 to +90 dB. The offset will be in effect whether the measurement is in dBm or linear power in milliwatts.

The Offset function is useful for two main purposes. (1) It provides the ability to add or subtract minor correction factors to correct errors that might be introduced by attenuators or other devices in the test setup, and (2) It provides the ability to adjust the reading in high power measurement situations where it is desirable to read the correct power directly on the display despite the fact that the unattenuated power being tested is well above the measurement range of the detectors.

In the latter case, a high power coupler is required to attenuate the signal to a level that can be safely measured by the detectors (less than +20 dBm). If the exact coupling factor of the coupler being used is known, the Offset feature can then be used to subtract it out. Then the display will accurately show the high power present at the device under test. However, the detectors only see the coupled power which has been attenuated to avoid burning out the detector diode.

To offset the displayed power reading, press

8501A: [MENU] (3) [F1]
8502A: [MENU] (3) [F1] (ch A) or [F2] (ch B).

After the Offset function has been selected, enter the desired offset in dB and then press any Units key.

When the Offset function has been activated, an asterisk (*) will appear next to the **FREQ** indication in the display to indicate that an offset is in use. (If the Cal Factor function is in use, the asterisk will be next to the **CF** indication.)

The display will appear as:

***FREQ = nn.nGHz or *CF = n.nndB**

2.8.4 CW Power Measurement

To make a CW measurement be sure that the PPM has warmed up for at least 30 minutes, and then perform the following steps:

1. Select the CW Mode as described in Section 2.6.1.
2. Self-Calibrate the PPM as described in Section 2.7.
3. Determine that the power range to be measured will not exceed the maximum power capability of the instrument (less than +23 dBm). If it will, connect an attenuator or coupler to the output of the device under test to bring the power down into the range of the PPM, and use the attenuator or coupler output as the measurement point for the detector attachment. If in doubt, use a 10 dB attenuator. This should prevent a mild overload that might result only in detector degradation rather than burn out.
4. Be sure the RF power of the source is completely OFF.
5. Connect the detector to the power source being measured.
6. Auto-Zero the detector by pressing [MENU] (1) [F3] [F2] [UNITS], or, if only channel B of a Model 8502A is to be zeroed, press [MENU] (1) [F3] [F2] [CLEAR] [UNITS].

A beep indicates that a successful auto-zero has been accomplished. A double beep indicates either there was RF power present at the detector input or there could be a failure. If a failure is suspected, then run the Self-Test procedure in Section 2.15.

7. Upon successful completion of the auto-zero function, turn on the RF power of the source to be measured.
8. Take into account the detector frequency response so that an accurate reading can be made at the frequency of operation. If the External Frequency mode (i.e. PROM Table and Sweeper Back Panel) is being used, this step is unnecessary. (See PROM Frequency Correction in Section 2.8.2). The keystrokes are [FREQ] [nn.nn] [GHz]

If the PPM is in the PROM Table - User Supplied Frequency mode, nn.nn is the Carrier Frequency in GHz. If the PPM is in the User Supplied Calibration Factor mode, nn.nn is the Cal Factor in dB.

9. If a coupler or attenuator is being used at the detector input, enter the attenuation value as a positive offset. For example, if an attenuator with a value of 30.2 dB at the frequency of

operation were being used, the required offset would be entered as follows:

8501A: [MENU] (3) [F1]

8502A: [MENU] (3) [F1] (ch A) or [F2] (ch B).

10. Enter the value of the offset in dB, followed by the dB Units key:

[30.2] [dB]

The PPM will now be reading CW power, and the display will look something like:

A: +35.26 dBm
***FREQ=10.78 GHz CW**



NOTE: +35.26 dBm represents the power at the input of the attenuator which is connected to the detector input. The actual power at the detector input would be +35.26 - 30.2 = +5.06 dBm.

11. Select the number of samples to be taken to arrive at an average reading (default is 4 readings). Press [MENU] (2) [F1].
12. Enter the desired number followed by pressing any Units key. The number of samples that can be taken to arrive at an average can be between 1 and 999. For power levels below -30 dBm, it is recommended that more than 100 samples be taken to reduce noise effects.
13. To change the displayed power reading from dBm to milliwatts or vice versa, press [MENU] (4) [F3].

2.8.5 Peak Power Measurement

Method 1: Peak Mode via Graph Autoscale

There are several methods that can be used to make Peak Power measurements with the system. The easiest method is to use the Autoscaling function in the Graph Mode. The Autoscaling function only operates on pulses greater than the selected trigger level. Complex pulse shapes such as double pulses cannot always be successfully autoscaled. Methods for these situations will be covered later.

After the pulse to be measured has been successfully autoscaled, it is only necessary to press [PEAK] and the system will read the power at the center point of the pulse. The readout will be displayed in large alphanumeric characters. For the following procedure, assume that either a single channel Model 8501A is being used or just channel A or channel B of the dual channel 8502A.

Autoscaling Procedure - Internal Trigger

1. Connect the detector(s) to the PPM and allow it to warm up for 30 minutes. Then conduct the Self-Cal procedure as described in Section 2.7.
2. When Self-Cal has completed, connect the channel A (or B) detector input to a pulsed signal greater than -10 dBm (the default trigger level). Press [GRAPH] to select the Graph Mode, and then press it again to start the Autoscaling function.

When the Autoscaling function is initiated the PPM will change to internal triggering off of the displayed channel. Then it will attempt to automatically select the correct Window Delay time and Reference Power which will center the pulse on the display. The Start Delay will be set to zero. If the signal at the detector RF input is less than the trigger level (or there is no pulse present at the input), then the system will not trigger and the following display will appear:

Waiting for trigger on A (or B) Detector Signal
F1 for Trig Mode or Level Change
F3 for CW Data Display

If you still desire to Autoscale at this point, the easiest thing to do is to increase the RF power until the power at the detector input is greater than the trigger level. Then the system will start to trigger and the autoscaling process will begin.

The factory-set default initial delay is 75 μ s (pulses wider than 75 μ s or pulses less than 75 μ s apart cannot be Autoscaled when using the default setting), and the default pulse averaging is four samples for the Autoscaling function. This can be changed to allow the user to enter a different pulse width and averaging number by accessing Menu-9 (press the MENU key 9 times), and then following the prompts given in that menu. Once the pulse width and/or pulse averaging has been changed from the default setting, the values will remain at the new setting whenever the instrument is turned off and on again. The values are not affected by recalling set-ups, nor at power-on.

3. If the previous triggering requirements have been met, the PPM will display the statement,

AUTOSCALING IN PROGRESS

4. When the Autoscaling has successfully completed, the pulse profile will be centered in the graphics display area on the left side of the window and the top of the pulse will line up with the 100% tic mark. The Cursor (displayed as a vertical line with spaces just above and below the point where it crosses the pulse) will be located at the center of the pulse profile. If all of the above has occurred, you can go to the Power Display instructions given below.

Due to the many varieties of pulse widths, pulse shapes, and duty cycles that might be encountered, it is not always possible for the PPM to autoscale. If the failure to autoscale is the result of a pulse being present at the 75 μ s default setting, the setting can be changed by accessing Menu-9, making the change, and then repeating the autoscaling procedure detailed in this section. It is necessary to keep the initial delay less than the time from the trigger to the start of the second pulse since the Autoscale routine cannot handle multiple pulses in the delay window.

Autoscaling Procedure - External Trigger

When pulses are autoscaled on an external trigger, the PPM uses the internal trigger level of the selected detector to find the pulse. For this reason, the internal trigger level of the selected detector must be lower than the maximum power of the pulse. A good test is to first select internal trigger and verify that the PPM is triggering before trying external trigger autoscaling.

The external triggered autoscale will set the Start Delay to center the pulse in the delay window. However, autoscaling may not work properly if the pre-trigger is more than ten times the pulse width.

1. Press [PEAK]. The PPM will now display the power reading at the Cursor location in large alphanumeric characters, similar to the display shown in Figure 2-6. The statement

DLY = n.nnn μ s

will be at the bottom of the display. This is the Cursor Delay which indicates the time difference between the pulse's initial triggering point and the point where the reading was taken. If the triggering method is changed, a given Cursor Delay does not necessarily guarantee that the power reading will be taken at exactly the same point on the pulse as it was before.

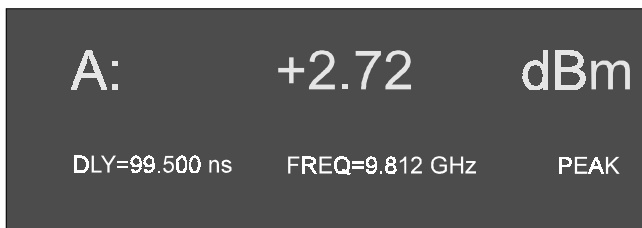


Figure 2-6. Typical Single Channel Peak Power Display

2. Press [FREQ] and enter either the RF operating frequency or the Cal Factor in dB. (This step is not required if the External Frequency input mode is being used.)
3. Enter any required offset as described in Section 2.8.3.
4. If desired, the Peak Averaging can be changed by pressing [MENU] (2) [F2] [nnn] [Units].
(nnn = number of samples to be averaged - must be between 1 and 999. Default is 4)
5. The power will then appear on the display.
6. To change the time at which the power readings are taken, adjust the spin knob on the front panel.

Alternatively, Delay entries can also be made through the keypad. After the desired numeric entry has been made, pressing the appropriate Units key will enter the delay in either nanoseconds, microseconds, or milliseconds. Pressing any UNITS key without entering any numbers will cause the cursor symbol (Δ) next to the DLY indication on the screen (CSR DLY = N.NN ns) to disappear. This indicates that the keypad and spin knob are inactive and keeps the spin knob from being accidentally bumped and moving the cursor to some undesired delay time. To reactivate the Delay time entry, press either the up or down arrow key.

Method 2: Peak Mode - Direct Access

For the purposes of this procedure, assume that either the single channel 8501A or only channel A of the dual channel 8502A is being used. The procedures for channel B of the 8502A are almost the same as those for channel A. However, if it is desired to use the Internal Trigger function with channel B, this must be selected by using the MENU key as described under Internal Triggering in Section 2.6.2.

1. Allow the PPM to warm up for 30 minutes, then conduct the Self Calibration procedure (see Section 2.5).
2. Select the Peak Power Mode of operation. Observe the triggering guidelines. If there is no external trigger available or if there is any uncertainty as to which method to use, use the Internal Trigger (see Section 2.6.2).
3. To verify that the PPM is in the desired mode and that it is receiving the proper triggering, check the following:
 - a. The light in the center of the PEAK key should be lit. (If not, this means that the Peak Mode has not been entered.)
 - b. The Ready and New Data lights should be flashing. (If not, then the system is not receiving a trigger. If external was selected and no triggering indication is observed, try the Internal Trigger function. The RF pulse power level must be greater than -10 dBm.)
4. Once Step 3 has been successfully accomplished, the PPM should be taking readings in the Peak Power Mode. However, the cursor might not be positioned on the specific pulse of interest at this

time.

The easiest way to ensure that all of the Peak Mode settings are at their default values is to select Peak operation after initializing the current setup. Press [MEM] (3) [F1] [PEAK]. The display should be similar to Figure 2-6.

A display of hyphens in place of a number in the power read-out portion of the display indicates that the power being sampled is below the measurement range of the system. Either the overall power of the pulse is too low, or the cursor has not been placed on a sufficiently high powered section of the pulse of interest. Another possibility could be no RF present. However, in this case, the PPM would not be triggering if Internal Triggering were being used and there was not enough RF at the detector input.)



NOTE: If the External Trigger mode is being used, the likelihood of obtaining a meaningful power reading at this point depends on the timing relationship between the RF pulse at the detector input and the external trigger pulse coming in through the rear panel input connection of the instrument.

If the trigger pulse and the RF pulse are coincident in time, then the default Cursor Delay time of 1 μ s will probably result in the Cursor being located somewhere on the pulse. This depends on the pulse width exceeding 1 μ s.

It is recommended that Internal Trigger is used before using the External Trigger mode so that pulse information such as pulse width can be obtained. This can save the effort of having to search for the pulse using the Cursor Delay function — Using the Graph Mode makes searching much easier.

5. As already mentioned, the cursor (Δ symbol) next to the DLY indication on the display means that the spin knob is active and, if turned, will alter the value of the Cursor Delay (CSR DLY). To locate the highest power point on the pulse, it is best to start at the rising edge of the pulse and move the cursor gradually up in time until the power reading reaches its maximum point. This can be done as follows:
 - a. Turn the spin knob counter clockwise until the Cursor Delay is zero (i.e. DLY = 0.000 ns on the display).
 - b. Slowly rotate the spin knob clockwise while monitoring the power readout display. Note that the increments that the spin knob causes the DLY to step through will change faster as the knob is turned faster. Rotate the knob until the power readings increase. This indicates that the leading edge of the measured pulse being is being monitored.
 - c. Continue increasing the Cursor Delay until the power readings go through a peak or stay at a high level. If the maximum power point is passed, turn the knob counterclockwise slowly, thus reducing the cursor delay until the maximum reading is once again reached.
 - d. Press [FREQ] and enter either the desired RF operating frequency or the Cal Factor in dB as required. (This step is not necessary if the external frequency input mode is in use.)
 - e. Enter any required dB Offset (see Section 2.6.2).
 - f. The power will be displayed similar to Figure 2-6. The desired unit of power measurement can be selected by pressing [dB/mW].
6. If difficulties arise in locating the pulse to be measured, use the Graph Mode with Autoscale.

2.8.6 Peak Power Measurements Using the Graph Mode

It is recommended that you read the basic information pertaining to the Graph Mode in Section 2.6.3 for a better understanding of this function. The initial Graph Mode (Cursor sub-mode) display looks something like that shown in Figure 2-7. Pulse profiles are shown graphically on the left side of the display while the right side displays the power and timing parameters pertinent to the pulse.

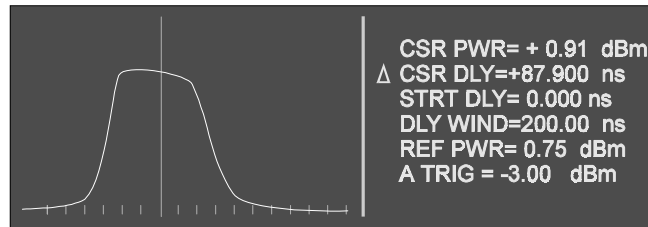


Figure 2-7. Typical Initial Graph Mode Display

To use the Graph Mode for peak power measurements, follow the instructions given next for accessing the Graph Mode:

1. Connect the detector(s) to the detector connection(s) on the front panel, and allow the system to warm up for 30 minutes. Then conduct a Self Cal as described in Section 2.7.
2. After ensuring that the pulse power of the RF source to be measured is not high enough to cause damage to the detectors (limit to less than +20 dBm), connect the channel A detector to the source.
3. Select the Graph Mode of operation by pressing [GRAPH]. Press [AUTOSCALE] and the PPM will attempt to autoscale the pulse on the display. If there is no pulse present at the detector input or if the pulse power is below -10 dBm, then the PPM will not trigger (the New Data light will be out).

While the PPM is Autoscaling, the display will indicate Autoscaling in Progress. When autoscaling is complete, the pulse will be centered in the graphics area of the display and the vertical cursor will be positioned at the center of the pulse profile.

If the display does not indicate a pulse centered in the graphics area of the display with the vertical cursor positioned at the center of the pulse profile, then the autoscaling process was not successful.

One possible reason that the PPM might not be able to autoscale is that the RF pulse might be too wide. The default setting of the PPM for the maximum pulse width that can be autoscaled is 75 μ s. If desired, this maximum setting can be changed by pressing [MENU] (9) [F2].

2.8.7 Pulse, Cursor, and Marker Readouts

On the 8500A, the Graph display mode has been enhanced to: 1) Simplify entry of timebase, triggering, and display scaling (CURSOR sub-mode), 2) Allow automatic readout of rise time, fall time, and pulse width (PULSE parameter sub-mode), and 3) Allow automatic readout of time differences between custom marker settings on the pulse (MARKER sub-mode).

These three functions can be accessed by pressing [PULSE/CURSOR/MARKER] to cycle the display through the three sub-modes.

2.8.8 Cursor Sub-Mode Functions

The Cursor sub-mode is convenient for changing the timebase parameters of the display (the CurSoR DeLaY, the STaRT DeLaY, and the DeLaY WINDow), the scaling of the display (the REFEreNce PoWeR), and the trigger level if the PPM is in internal trigger mode.

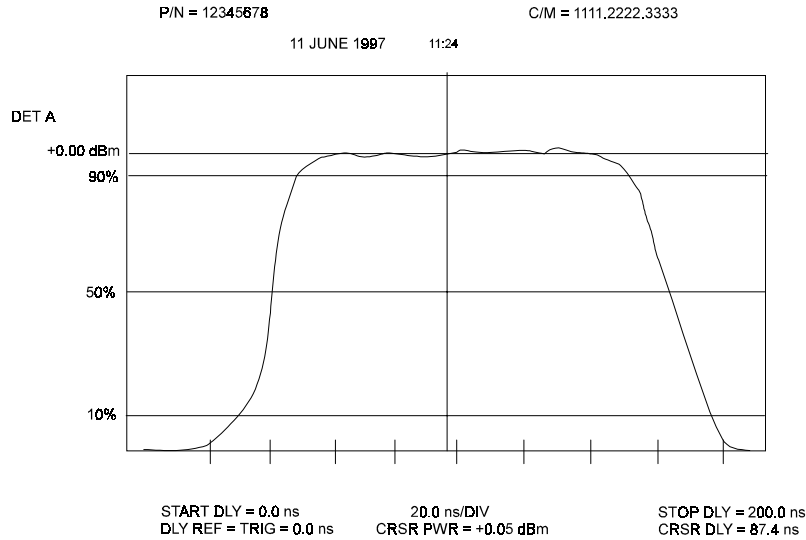


Figure 2-8. Typical Cursor Sub-Mode Digital Plot

CSR PWR

Indicates the power level at the location of the cursor. By pressing [MENU] (4) [F3], this can be indicated in either dBm or in Watts. This is a read-only function, and cannot be changed with the spin knob or numeric entry keypad. Placing the cursor here will prevent an accidental movement of the spin knob from changing a parameter.

CSR DLY

The Cursor Delay indication shows the amount of time after triggering has occurred that the Cursor will sample the power of the pulse. The time at which the trigger occurs is dependent on either the Trigger Level or, if External Triggering has been activated, on the triggering signal provided by the external source. The delta symbol next to CSR DLY means that the Cursor Delay is adjustable by using either the spin knob or the keypad. The cursor is placed by using either the up or down arrow key.

STRT DLY

This is the Start Delay of the graphics display area on the readout. It signifies the amount of time between the occurrence of the trigger and when readings begin at the left side of the graphics display. If the default value is still set, then the Start Delay would be set to 0.0000 ns and the left edge of the display will be coincident with the timing of the trigger. However, the Start Delay may be at whatever value was used the last time the Graph Mode was accessed. The cursor next to STRT DLY means that the spin knob or keypad can be used to adjust the Start Delay value.

DLY WIND

The Delay Window is the amount of time between the left and right sides of the graphics display area. The default value is 10.000 μ s. When the Autoscale function is used, the PPM will adjust the Delay Window to display the pulse profile so that the trailing edge of the pulse can be seen. Autoscaling will

decrease the Delay Window in a 1, 2, 5 sequence as required until the trailing edge no longer disappears from view off of the right side of the graphics area. The cursor next to DLY WIND means that the spin knob or keypad can be used to adjust the Delay Window value.

REF PWR

The PPM's Reference Power nomenclature refers to the manner in which the pulse profile is displayed. Referring to the graphics area of Figure 2-7, there are four horizontal tic (division) marks on the left vertical axis of the display. These tic marks correspond from top to bottom to the 100%, 90%, 50%, and 10% power points on the pulse profile with respect to the Reference Power. The pulse profile is always displayed in linear units. The default Reference Power is 1 mW. However, once the Autoscale function has been used, the Reference Power is automatically adjusted to whatever the power level is at the middle of the pulse. Therefore, the Autoscale feature not only serves to center the pulse on the time (or horizontal) axis, it also optimizes the display positioning on the power (or vertical) axis by setting the highest power level as the 100% Reference point.

The adjustable Reference Power level is provided to give the user flexibility in displaying the pulse, and measuring pulse timing parameters using the markers. This is important because it means that the PPM can be set up to accommodate the various types of test parameters that different users might need for their specific measurement requirements.

NOTE: The reference power level is used as the 100% power level in the marker sub-mode, but is not used in the cursor or pulse parameter sub-modes. See the descriptions of marker sub-mode in Section 2.8.10 and cursor sub-mode in Section 2.8.8 for a more detailed explanation.

There are two ways to set the Reference Power Level on the PPM.

The first way is to move the cursor to the REF PWR (next to last) line of the displayed parameters (use either the up or down arrow key). Then, enter the desired Reference Power level and press the appropriate Units key (dBm for logarithmic units; mW, W, or kW for linear units).

The second way is to move the cursor to the CSR DLY line and move the cursor to the point on the displayed pulse profile that is desired to be 100% reference. Next, move the cursor to the REF PWR line of the display. Then pressing any Units key will shift the pulse vertically on the screen, resulting in the selected point lining up with the 100% tic mark on the display.

Reference Power cannot be changed with the spin knob.

TRIGGER

This display indicates the present triggering mode of the PPM. TRIG LEV = -10 dBm (A TRIG = -10 dBm in the 8502A) is the default setting. It means that the PPM will trigger when the leading edge of the RF pulse rises above -10 dBm at the (channel A) detector input. B TRIG = (8502A only) indicates that the PPM is triggering off the channel B detector.

To change the Trigger Level, use either the up or down arrow key to move the cursor beside the TRIG LEV indication. The spin knob can then be used to alter the Trigger Level, or a desired number can be entered through the keypad and terminated with the dBm or mW key.

EXTERNAL means that the PPM is triggering off the TTL trigger input on the back panel regardless of which channel is being displayed.

Selecting External Trigger or changing the internal trigger channel is accessed through Menu-1. See Triggering in Section 2.6.2.

2.8.9 Pulse Parameters Sub-Mode Functions

Commonly used timing measurements required when analyzing pulsed RF/microwave signals are:

- Pulse Width
- Rise time
- Fall time
- Peak Power
- Repetition Rate

The pulse parameter readout allows the first four of these parameters to be measured directly by the PPM and displayed on the readout window. Auxiliary equipment may sometimes be required to measure repetition rate.

While in the GRAPH Mode, the Pulse sub-mode routine is entered by pressing [PULSE/CURSOR/MARKER].

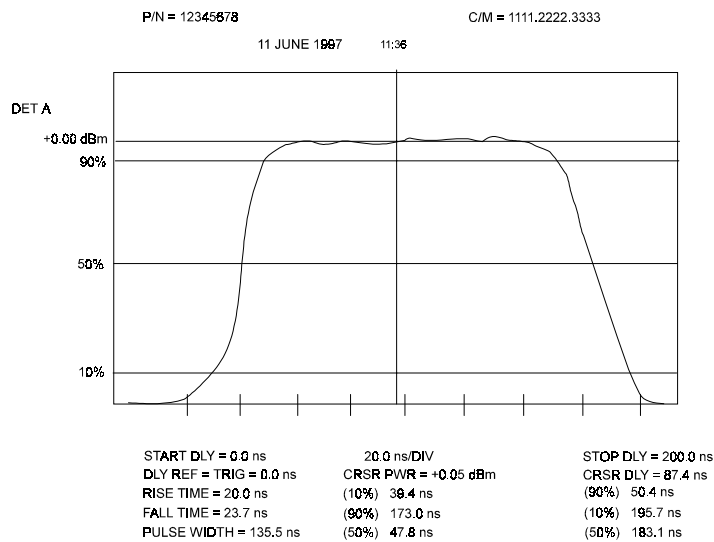


Figure 2-9. Typical Pulse Sub-Mode Digital Plot

Pulse Rise Time, Width, and Fall Time

The PPM displays the time between three pairs of start and stop power percentages. The default values for start and stop percentages are:

Measurement	Start %	Stop %
Rise time	10% rising edge	90% rising edge
Fall time	90% falling edge	10% falling edge
Pulse Width	50% rising edge	50% falling edge

These parameters can be set or changed as follows:

1. Press [PULSE/CURSOR/MARKER] to display the pulse parameters.
2. Move the cursor (using either the up or down arrow key) to the Pulse Width line on the display. The current Start % setting will be displayed.

3. The last line of the display will show the prompt:

Enter Start %.

4. Enter the desired Start % setting through the numeric keypad.
5. Press [UNITS].
6. The Enter Start % indication will change to:

Enter End %.

7. Enter the desired End % value and press [UNITS].

(Repeated pressing of any Units key will toggle the display between the Start and End values.)

8. To change the start and stop percentages for rise and fall times, move the cursor to the appropriate line and repeat Steps 3 through 7.

The relationship of 10% to 90% rise or fall time equals 2.198 time constants for a single pole circuit. Similarly, a 10% to 90% power rise or fall time equals 1.098 time constants.

For some applications it is desirable to measure rise, fall, and width in terms of the voltage waveform instead of the power waveform. This can be done by simply modifying the appropriate start and stop percentages. The power waveform is proportional to the square of the voltage waveform. Therefore, to measure the voltage pulse parameters you would change the default percentages to the following:

Measurement	Start %	Stop %
Rise time	1% rising edge	81% rising edge
Fall time	81% falling edge	1% falling edge
Width	25% rising edge	25% falling edge

The pulse rise time, fall time, and width are displayed with the appropriate time units. A display consisting of all dashes indicates that:

- a. the instrument failed to find the peak power point, or
- b. the instrument failed to find a start percentage point, or
- c. the instrument failed to find a stop percentage point.

The method used to find pulse parameters is as follows. On each trace sweep, the instrument:

- A. finds the 100% pulse level. Starting from the trailing edge of the pulse, the instrument looks earlier and finds the largest flat section (± 1 pixel on the screen) on the top of the pulse. This level is chosen as the 100% level. If no area is flat, (such as with gaussian shaped pulses) the maximum level found is used as the 100% level. This algorithm helps ignore the ringing and overshoot that sometimes accompanies rectangular pulses. Note that the display scaling (i.e., the REFERENCE PoWER) is not reset and is independent of the 100% level found in this step.
- B. finds the rise time, fall time and width of the pulse. In order to improve the accuracy of timing measurements. You should set the delay window so that the pulse fills at least 20% of the screen.

2.8.10 Marker Sub-Mode Functions

The Marker sub-mode is another completely independent way to read the time difference between user defined points on the pulse waveform. It may, at first, seem redundant with the Pulse parameter mode. The Marker sub-mode, however, treats the 100% power point differently, and reads the differences between four user-defined points on the waveform. It is intended for use in specialized applications (such as measuring the linearity of the leading edge skirt of a navigation pulse) where the user is interested in something other than standard rise, fall, and width measurements. This Marker sub-mode is also most similar to the Marker Mode offered in the original 8500 Peak Power Meter.

The Marker sub-mode uses the user-set REFERENCE PoWeR as the 100% power point of the pulse. This allows the user to set the 100% point at other than the flat spot at the top of the pulse. For instance, the 100% point can be set at the top of the pulse overshoot. The 100% point can also be set 10 dB lower than the top of the pulse to scale all the user-set marker percentages by 1/10. This is particularly useful to set marker percentages to resolutions better than 0.1% of the peak power.

The default settings for marker sub-mode are set for the measurement of linearity on the leading edge of a navigation pulse. In this particular measurement, the time between the 5%, 13.3%, 21.7%, and 30% points on the voltage waveform are compared. Equal times indicate a linear voltage waveform between the 5% and 30% point on the waveform. Because markers are entered in terms of % power, the corresponding power percentages would be 0.25%, 1.78%, 4.69%, and 9.00%. Because markers can only be entered to 0.1% resolution, the actual marker values are set 10 times greater or 2.5%, 17.8%, 46.9% and 90.0%. Then, to get the maximum resolution from the markers the REFERENCE PoWeR is set to exactly 10 dB less than the peak power of the pulse, effectively scaling all marker values by 1/10. (This action must be done manually.)

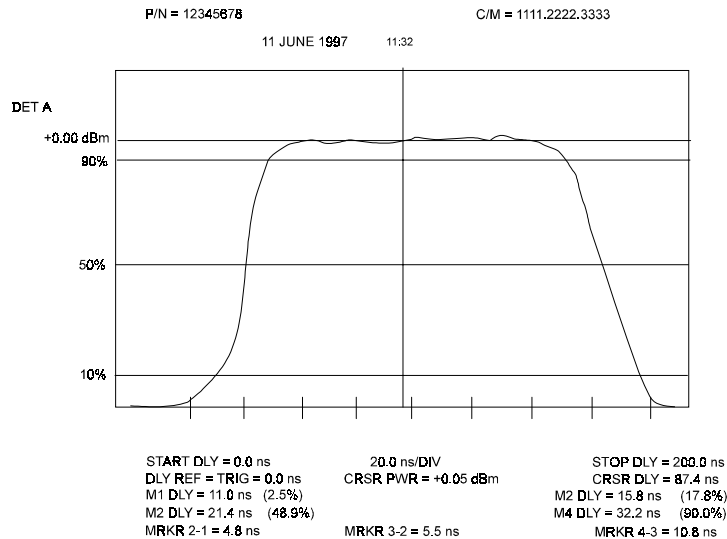


Figure 2-10. Typical Marker Sub-Mode Digital Plot

To change a marker percentage setting:

1. In GRAPH mode, press [PULSE/CURSOR/MARKER] until you see a display on the right side of the screen similar to:

```

ΔCSR PWR = +0.91 dBm
MKR 2 - 1 = 4.9000 ns
MKR 3 - 2 = 5.4000 ns
MKR 4 - 3 = 10.5000 ns
    
```

2. Move the cursor (using the up or down arrow keys) to the MKR 2-1= line on the display. The current marker percentage setting for marker 1 will be displayed.
3. Enter the desired Marker 1 percentage through the numeric keypad, using any Units key to terminate the entry.
4. Repeat steps 2 and 3 at the MKR 3-2 = line to change the Marker 2 percentage, and the MKR 4-3 = line to change the Marker 3 percentage. To change the Marker 4 percentage, move the cursor to the blank line just below the MKR 4-3 = line.

2.9 Digital Plotting of Graphic Data

2.9.1 Plotters Supported

The PPM is configured to provide direct output of Graph Mode information for hardcopy recording on a digital plotter. This is done without the necessity of using a computer or GPIB controller. The following plotters (and any other 100% compatible plotters) are supported:

Hewlett-Packard Model 7440A

Hewlett-Packard Model 7470A

Hewlett-Packard Model 7475A

All of the above plotters must be configured with the option for GPIB usage.

2.9.2 Procedure for Making Plots

The procedure for making plots with the PPM is quite simple. Plots can be made when in the Graph Mode and Marker sub-mode, and the plots will be essentially duplications of the information shown on the PPM display at the time the plot function is activated.

Two different plotting speeds can be selected by the PPM. These are: a Fast Plot for use with normal plotting paper, and a Slow Plot for making plots using transparent paper (film).

To make a (fast) paper plot, press [MENU] (2) [F3] [F1]

To make a (slow) transparency plot, press [MENU] (2) [F3] [F2].

When the PPM has drawn a complete pulse profile on its display, it is ready to act as a GPIB controller. If the PPM is part of a GPIB system, it is up to the user to be sure that no front panel plot function is initiated to ensure correct operation of the system.

The following steps are required to generate an X-Y hardcopy plot:

1. Connect a GPIB cable from the PPM's rear panel GPIB connection to the plotter's GPIB input connection.
2. Choose a GPIB address for the plotter, and set its address switches according to the instructions in its operating manual. (Address 6 is recommended; see Step 3.)
3. Select the plotter address for the PPM by pressing [MENU] (6) [F2] [nn] [UNITS].

Where nn is the plotter address. The default address to which the PPM sends data is 6. If the plotter address is changed from the default value of 6, it will remain at the new value until another value is entered. That is, it is not reset at power-on or any other time until intentionally changed again.

4. Check that the plotter pens are installed and operating properly. Following the manufacturer's instructions, insert paper into the plotter and prepare it to plot.
5. If it is required or desired, enter a Code number or Part number to be printed on the plot. If no Code and Part numbers are selected, numbers previously entered will be plotted. The default numbers are blank.
 - a. Enter the Code number as follows:

[MENU] (5) [F1] [n] [UNITS]

(n is a number up to 12 digits.)

- b. Enter the Part number as follows:

[MENU] (5) [F2] [n] [UNITS]

(n is a number up to 12 digits).

6. The date and time are always plotted. The date and time are obtained from the internal, real-time clock of the PPM which is kept alive by a battery when the instrument is turned off. If it is desired to check and/or change the date and time before plotting, press [MENU] (5) [F3] [F3] (if clock is correct)

or, to change the clock, [MENU] (5) [F3] [F1] [mmddyy] [UNITS] [hhmmss] [UNITS] [F3]

where mmddyy = month, day, year; and hhmmss = hours, minutes, seconds

7. Enter the Graph Mode. The Delay Difference Timing will be plotted if it has been activated on the readout. See Figures 2-8, 2-10, and 2-9 for examples of the types of plots available from the PPM.
8. Before the PPM can make a plot, it must first complete one sweep of the pulse profile. Assuming the profile is completed, press [MENU] (2) [F3] [F1] for a paper plot or [MENU] (2) [F3] [F2] for a transparency plot.
9. If there is any GPIB bus error, an alarm will sound. This indicates that when the PPM checked the IEEE Bus, it was unable to activate the plotter. Some possible causes for this might be an incorrect address setting, the plotter not set up correctly, or the plotter is turned off or out of paper. If this situation occurs, press [F2] to return the PPM to its previous mode of operation. This feature allows PPM operation to continue despite bus hang-ups.

The GPIB bus error alarm consists of 2 audible beeps and a display of **GPIB BUS ERROR**

A single beep indicates that there are no problems, and that plotting will begin as soon as the trace has been drawn on the display screen.

Once the plot has started, control of the PPM can be regained before the plot has finished. This gives the ability to proceed with further testing without having to wait for the plotter to complete its task.

If it is necessary to Abort the plot for some reason, press [MENU] (6) [F1]. The plot will be terminated as soon as possible.

2.10 Dual Channel Measurements

Dual channel measurements are available only when using the Model 8502A power meter. The dual channel capability of the Model 8502A provides two very useful functions. These are:

- Display of power measured by two channels simultaneously.
- Display of the power ratio between two channels.

Applications for these two functions are many and varied. Dual channel measurements allow two points in a system to be measured with one power meter. The PPM can simultaneously measure both channels in either the CW or Peak Power Modes.

The Ratio function allows relative measurements to be made in either CW or Peak. It is also possible to ratio Peak to CW or CW to Peak. These functions are useful for gain and loss measurements under CW or Peak conditions (or a combination of the two).

2.10.1 CW, CW Measurements

The following procedure is used for making dual channel CW measurements:

1. After power-on, press [CW] to access the CW Mode. Press [MEM] (3) [F1] for the PPM to use its default values, if desired. Wait approximately 30 minutes for the PPM to warm up.
2. Self-Calibrate both channels. Press [MENU] (1) [F3] [F1].
3. Follow the instructions displayed by the PPM to connect the appropriate detector to the Calibrator when prompted.
4. Connect the detectors to the device(s) or system to be tested.
5. The PPM will now be displaying the CW power for channel A. To display the CW power for both channels, press [B].
6. Select the frequency of operation or cal factor as necessary for detector response correction by pressing [FREQ].
7. Enter any required display offsets.
8. To return to single channel operation, use the Detector Select A and B keys as required.

2.10.2 Peak, Peak Measurements: Method 1

1. Follow the procedure given in Section 2.10.1, except press [PEAK] in Step 1 instead of CW.
2. If the PPM is triggering, it will display the peak power in both channels. The following default settings are in effect if the PPM has been initialized.
 - a. Internal Trigger from channel A set at -10 dBm (i.e. pulse at channel A causes trigger if greater than -10 dBm)
 - b. Frequency = 1.00 GHz
 - c. Chan A Cursor Delay = 1.0000 μ s
 - d. Chan B Cursor Delay = 1.0000 μ s
 - e. Spin knob active on channel A Cursor Delay as indicated by Δ next to CSR DLY
3. If the PPM's New Data and Ready lights are flashing, a trigger is occurring and measuring should be possible. Try adjusting the channel A Cursor Delay by turning the spin knob until the CSR DLY reads 0.0000 ns. The Delay can then be increased slowly until the reading is being taken on the desired part of the pulse.

4. To change the Cursor Delay for channel B, press the up or down arrow key. The spin knob can then be used to alter the channel B Cursor Delay. To lock out the spin knob and keyboard, press any UNITS key. To reactivate the spin knob and keyboard, press the up or down arrow key.
5. If there are any difficulties due to timing factors, it is recommended that External Triggering be used. The trigger signal should occur slightly before the RF pulses to be measured. The Cursor Delays can then be used to place the Cursors on the pulses to allow readings to be taken.

2.10.3 Peak, Peak Measurements: Method 2

This method utilizes the Graph Mode to facilitate placing Cursors on the pulses of interest. Signal timing should be considered first of all. For purposes of discussion, assume the timing of the signals to be measured are similar to those shown in Figure 2-11.

As can be seen in Figure 2-11, the Measurement Port 1 pulse occurs before the Measurement Port 2 pulse. If Measurement Port 2 were used to generate an Internal Trigger, it would be impossible to set the Cursor on the leading edge of the displayed Measurement Port 1 pulse because the minimum Cursor Delay of 0 ns would be the trigger point (leading edge of the Measurement Port 2 pulse).

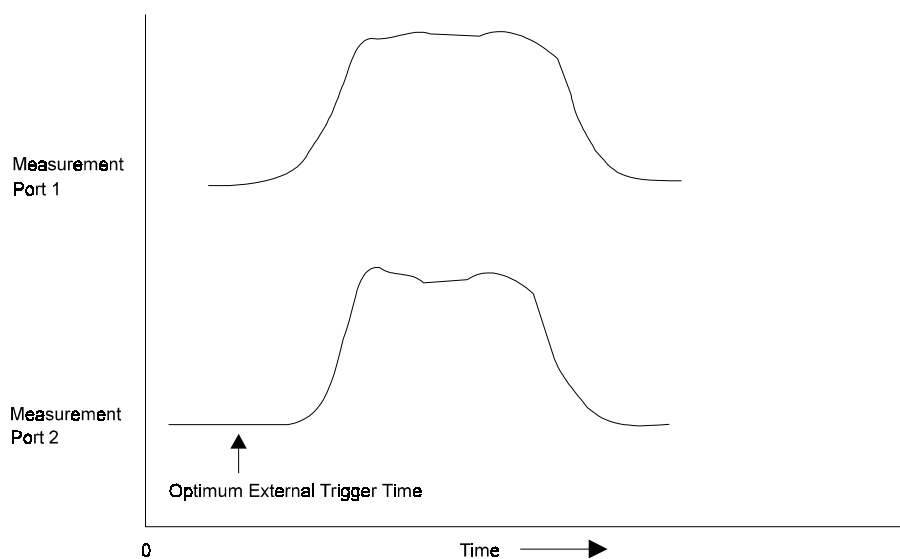


Figure 2-11. Typical Signal Timing

Therefore, this situation would require that either Measurement Port 1 be used to generate an Internal Trigger, or that an External Trigger be used. Doing this would ensure that readings could be taken at any desired points on the pulses being measured.

In cases where the pulses at each detector input are essentially occurring at the same time, this problem could be ignored. However, it is generally the case that using the External Trigger results in more satisfactory performance.

The preceding information is provided mainly to emphasize the importance of knowing the timing relationships of the signals to be measured. If there is any doubt or confusion, the rear panel Monitor Output of the PPM can be connected to an oscilloscope to quickly ascertain the timing relationships.

Assuming an autoscalable pulse greater than the current trigger level is to be measured by channel A for this example, the procedure for Dual Channel operation in the Peak Mode via the Graph Mode would be:

1. Connect the channel A detector to the RF source (port) that is believed to be generating a pulse before the second source (port) to be measured (i.e. Measurement Port 1). If the pulses of the two sources are coincident, use either port.
2. Connect the channel B detector to the second source (port).
3. Select the Graph Mode in channel A, and press [GRAPH] to Autoscale.
4. After the pulse has been successfully Autoscaled, set the Cursor to the desired measurement point.
5. Make a note of the Window and Cursor Delays. (The Start Delay will be 0.0000 ns after Autoscaling.)
6. Press Detector Select [B] to switch to the channel B Graph Mode.
7. Set the Window and Cursor Delays to the same values as were noted in Step 5. If the pulse is not visible on the readout, gradually increase the Start Delay until the entire pulse is on the screen.
8. Set the Cursor Delay to the point on the pulse where it is desired to take a measurement. Channel A and B Cursors should now be placed wherever dual channel readings are to be taken. This can be verified by pressing Detector Select [A] or [B] as necessary to check that the Cursors are properly positioned.
9. Select the Peak Mode of operation by pressing [PEAK].
10. Select Dual Channel operation by pressing Detector Select A. Make sure that the LEDs in the center of the Detector Select A and B keys are lit. This signifies that the PPM is in the Dual Channel Mode. The display should be similar to the following:

A: +0.65 dBm, 30.600 ns
B: -4.65 dBm, 39.700 ns

FREQ = 1.00 GHz, PEAK

2.10.4 Peak, CW Measurements

If it is desired to measure Peak power on one channel and CW on the other channel, the procedure is the same as when measuring Peak Power on both channels with some minor differences. These differences are:

1. The channel used to make the Peak power measurement determines the triggering of the PPM. For low amplitude signals (below -20 dBm in the Peak Mode), use external triggering.
2. It is not necessary to use the Graph Mode or any Delay settings on the channel that will be measuring CW as the power will be continuous, and it makes no difference at what time the CW is sampled.
3. Even though one channel is displaying CW power, the PPM operates as though both channels were in the Peak Mode. CW averaging has no effect on the reading. The rate at which the RF is sampled and averaged is determined by the characteristics of the Peak power channel.

2.10.5 Power Ratio Measurements

To make ratio measurements, the power measured by both channels must be within the specified power measurement range of the PPM system. When operating in CW, this power range is -40 to +20 dBm. In the Peak Mode, this power range is -20 to +20 dBm. Power readings taken in the Ratio Mode outside of these ranges will result in an error display.

The Ratio Mode only provides the ratio of A/B, not vice versa. The PPM can ratio two CW signals, two Peak signals, or a combination of both. The following procedures show how to perform each of these ratio'ing operations.

Ratio'ing Two CW Signals

This is the easiest ratio function of the PPM. Proceed as follows:

1. Allow the PPM to warm up for at least 30 minutes. Then Self-Calibrate both channels. From power-on, press [CW] [MENU] (1) [F3] [F1].
Follow the displayed prompts to complete the Self-Cal. After Self-Cal has completed, the PPM will be measuring CW power in channel A.
2. Select the Ratio Display Mode by pressing [MENU] (7) [F2].
3. The default mode for power ratio measurements is for Peak power on both channels. To set both channels for CW operation, press [A] [F2] [B] [F2].

The PPM will now be reading the ratio of A/B. Normally this is expressed in dB, however, it can also be expressed as a linear reading (such as 19654 EXP=-4) by pressing [dB/mW]. The display indicates that two CW signals are being ratio'ed by displaying CW/CW in the lower right hand corner of the display.

Remember that the frequency of operation or Cal Factor must be entered using the FREQ key, and any desired Offsets should also be included. These two functions are described in Sections 2.8.3 and 2.8.4.

Ratio'ing Two Peak Signals

The point in time at which readings of Peak power are taken in both channels for ratio'ing purposes is determined by the setting of the Cursor Delay. Although it is most desirable that both pulses being monitored occur at exactly the same time, in practice this would be a very rare event. Therefore, the signals to be measured must be carefully evaluated to ensure that accurate readings are taken.

The Cursor Delay must be set so that samples are being taken on both the channel A and B pulses. See Figures 2-12 and 2-13 for an examples of good and bad Cursor Delay settings in this situation.

The following are guidelines that can be used when ratio'ing two Peak signals:

1. Make a single channel Peak measurement using the Graph Mode (Autoscaling is recommended).
2. Set the Cursor Delay so that the power reading (CSR PWR) is being taken close to the center of the pulse (see Figure 2-12).

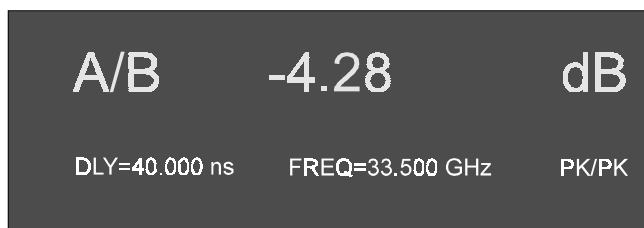


Figure 2-12. Typical Peak Power Ratio Display

3. Verify that the Cursor Delay setting is adequate for both channels by switching to the other channel. Use the same Start, Window, and Cursor Delays as in the first channel. If the pulses occurred at the same time, the Cursor would be close to the center of the pulse sampled by the other channel (see Figure 2-13).

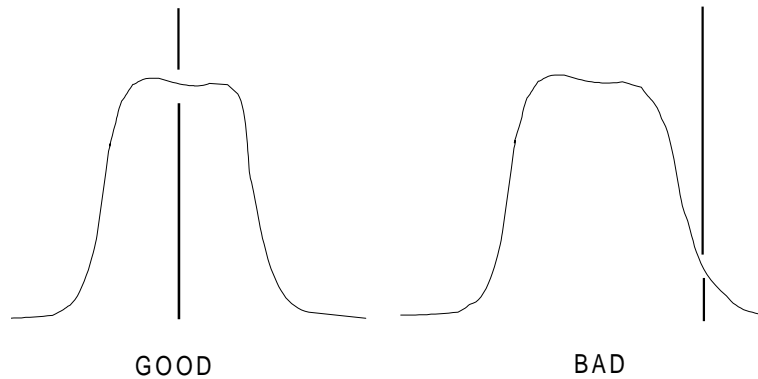


Figure 2-13. Typical Good & Bad Cursor Delay Settings

4. Switch channels, checking to be sure that the Cursor is not placed close to the edge of either of the pulses being sampled.
5. Once the Cursor has been satisfactorily set, to activate the Ratio Display Mode press [MENU] (7) [F2].

The default setting for the type of signal being used by both channels is Peak. This is verified by PK/PK being displayed in the lower right hand corner of the readout. If this is not the case, select Peak operation by pressing [A] [F1] [B] [F1].

The PPM should now be displaying the ratio of the two pulses (similar to Figure 2-12). Be sure to use the FREQ key and Offset function if necessary.

Ratio'ing Peak to CW Signals

This function is very useful in many applications such as traveling wave tube (TWT) testing that require the measurement of gain under pulsed conditions. This could be a problem when the TWT has a CW input and a pulsed output. The PPM easily performs this type of measurement using the following procedure:

1. Make a single channel Peak measurement at the port of the device under test that has the pulsed signal.
2. Set the Cursor at the desired point on the displayed pulse profile. Using the Graph Mode is the simplest way to do this.
3. Select the Ratio Mode by pressing [MENU] (7) [F2].
4. Set which channel will be CW by pressing [B] [F2] (if channel B is to be CW) or [A] [F2], (if channel A is to be CW).
5. Set which channel is to be Peak by following the same procedure as above, only press [F1] instead of [F2].

The lower right hand corner of the readout will indicate which channel is CW and which is PEAK. Whichever indication is farthest to the right side will be channel B.

2.11 High Power Measurements

One of the most important things to remember when using the PPM is that it employs balanced, zero bias, Schottky diode detectors as power detectors. Due to this highly sensitive, highly accurate configuration, the maximum power that the detectors can handle before burning out is +23 dBm (200 mW). This limitation is regardless of duty cycle.

2.11.1 Power Warning - Max/Min Power Limits

The PPM has a built-in warning system to advise you of mild overloads to the detectors. Large overloads which are usually the result of a failure in the device under test or leaving an attenuator out of the test setup, cannot be prevented because of the speed at which these failures happen. However, you will be advised by a prompt when the power level exceeds the preset power warning level.

The default value for the MAX Power warning point is +20.5 dBm. You can set this to anywhere between -10 and +21 dBm.

The PPM also has a lower level limit (MIN). This is mainly used to avoid displaying power readings outside the lower power range of the instrument. When the power level being measured by the PPM is below the lower level limit, the readout will display a series of dashes to indicate that the power being measured is too low for the PPM to take an accurate measurement.

The default value for the MIN Power warning point is -45.0 dBm. You can set this anywhere between -15 and -50 dBm. To change the MAX and MIN power limits, press [MENU] (7) [F1] [mm.mm] [dBm] [nn.nn] [dBm], where mm.mm is the maximum power limit, and nn.nn is the minimum power limit.

2.12 High Power Measurement Procedures

The procedure for making absolute CW or Peak power measurements under high power conditions is as follows:

1. Approximate the Peak power of the signal to be measured.
2. After 30 minutes warm-up, Self-Cal the PPM detectors.
3. Choose an appropriate attenuator or coupler to be used in the test setup to reduce the power being measured to a safe level for the detectors. The power at the detector input must be less than +20 dBm.
4. When making this approximation, be sure to use worst case power levels. If in doubt, a 10 dB attenuator can be used directly on the detector input in addition to the selected high power coupler or attenuator.
5. Ensure that the RF power of the source to be measured is turned OFF.
6. Connect the high power coupler to the RF source to be measured as shown in Figure 2-14. If a high power attenuator is used, connect as shown in Figure 2-15.
7. Connect the PPM detector with its attenuator to the coupled output of the high power coupler (Figure 2-14), or to the output of the high power attenuator (Figure 2-15).

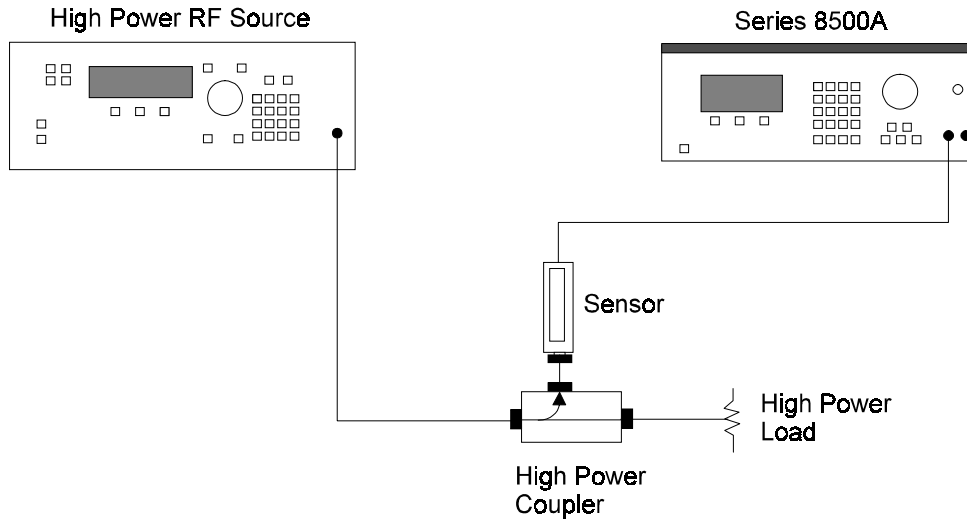


Figure 2-14. Detector to a High-Power Coupler Setup

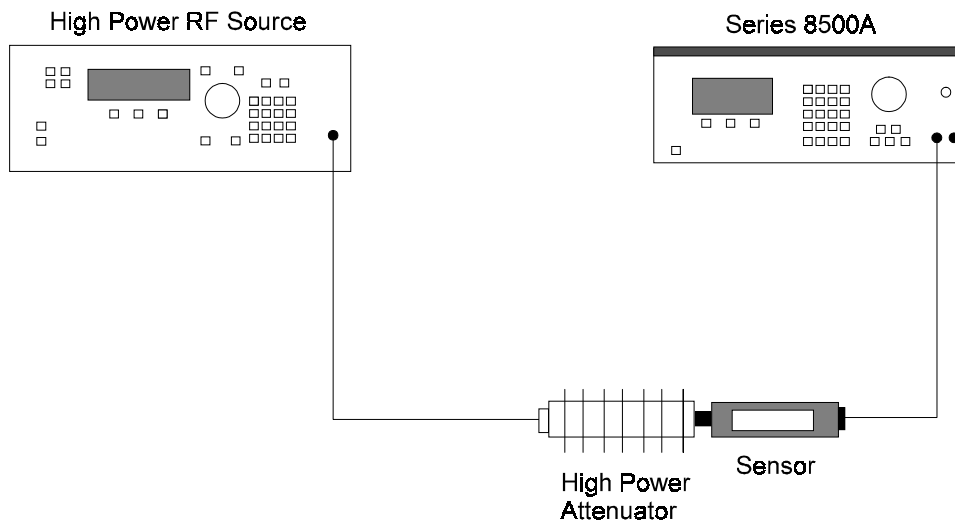


Figure 2-15. Detector to High Power Attenuator Setup

8. Auto-Zero the PPM by pressing [MENU] (1) [F3] [F2] [UNITS].

If a dual channel 8502A is being used, follow the prompts given on the display. Select any Units key or CLEAR as necessary to Zero the desired channel(s).

9. Turn on the RF power of the source under test.
10. If measuring a pulsed signal, it is important that the Cursor be placed on the pulse. This can be done by using the PPM's Autoscale feature which is activated in the Graph Mode by pressing [AUTOSCALE]. If this method is not possible, try using the Internal Trigger with the level set at -20 dBm. Then set the Cursor at 0.0000 ns and increase the Cursor Delay gradually until the CRS PWR is at its maximum.

If the New Data light on the front panel of the PPM does not flash, then the instrument is not triggering. If the trigger level is at -20 dBm and no trigger occurs, there might not be enough power at the detector input to be able to measure. If this is the case, recheck the calculations that were made to decide what attenuation levels were required to prevent detector burnout. If necessary, reduce the attenuation at the detector input by 10 dB to increase the power so that the PPM will trigger.



NOTE: If a TTL Trigger signal is available from the source being measured, then using the External Trigger Mode is advisable. If an oscilloscope is available, the PPM's rear panel MONITOR OUTPUT(s) can be used to determine the proper timing settings for the instrument.

11. Once the PPM is reading power as desired, press [FREQ] and enter the frequency of operation (or Cal Factor).
12. To obtain the absolute power output of the RF source being measured, use the PPM's Offset feature to offset the displayed values by the combined attenuation values of the coupler and/or attenuators being used in series with the detectors. Most couplers and attenuators have attenuation versus frequency response curves supplied that can be used for exact entry of the required offset. To enter the Offset, press [MENU] (3) [F1] [nn.nn] [dBm].

Where nn.nn is the Offset desired. For channel B offset on the 8502A, use F2 instead of F1. When the Offset feature is in use, this will be shown on the display by an asterisk (*) next to the FREQ or CF indication.

2.12.1 High Power Relative Measurements (8502A only)

The procedure for making a gain or loss measurement is the same as for absolute power, but requires activating the Ratio Display function of the 8502A. The Offset feature compensates for external devices before entering the Ratio Mode (see Power Ratio Measurement Procedures in Section 2.12 for more information on ratio'ing).

2.13 Special Capabilities of the PPM

2.13.1 Reference Delay

To facilitate making timing measurements relative to some event other than the trigger (such as the falling edge of a pulse), it is possible to shift the PPM time coordinates by using Reference Delay. The PPM subtracts the Reference Delay from the Cursor Delay and Start Delay, in effect shifting the zero time reference from the trigger time to a time after the trigger by the amount of the Reference Delay. To set the Reference Delay press [MENU] (4) [F1] (for Ch A or [F2] for Ch B) [nn.nn] [UNITS].

2.13.2 Single Pulse Measurements

Measurement of a single pulse can be done with the PPM by operating in the Peak Mode. (The Graph Mode cannot be used for single pulse measuring.)

Two methods are available for making single pulse power measurements. These are discussed in the next two sub-sections.

2.13.3 Single Pulse Measurement Using Internal Trigger

To make a single pulse measurement using the Internal Trigger, it must first be decided how long after the trigger has occurred that the measurement should be taken. For example, in the single pulse shown in Figure 2-16, the PPM trigger level is set to -10 dBm. If the Cursor Delay were set to 0.0000 ns, then the power measurement would be taken at the trigger point. In this case, this is not on the top of the pulse being measured.

To measure power at the top of the pulse as required in most applications, the Cursor Delay needs to be set at around 5 μ s. Therefore, to accurately make Peak power measurements using the Internal Trigger mode of operation, you must have some idea of the pulse width boundaries to be tested.

In cases where the rise time of the pulse is known to be repeatable and the pulse width is known never to be below, say, 8 μ s, you could set the Cursor Delay to 5 μ s. This decision would allow measurement of all pulse widths greater than 5 μ s without the necessity of altering the Cursor Delay.

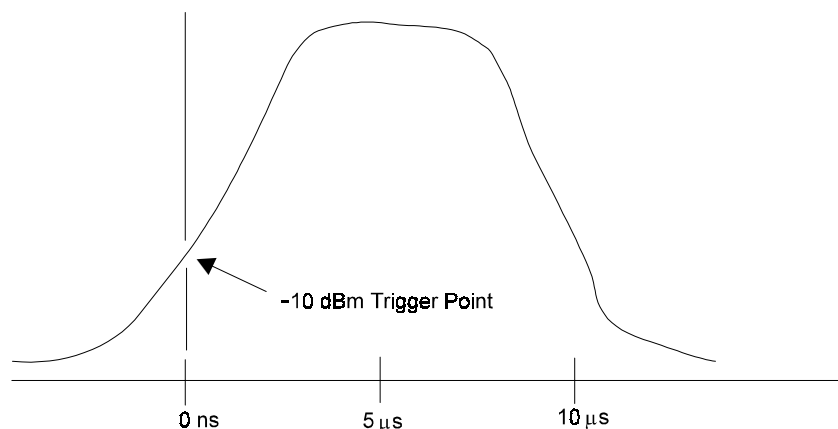


Figure 2-16. Typical Pulse with -10 dBm Trigger Level

Single pulse measurements cannot be made with the same accuracy as repeating pulse trains. This is primarily due to the fact that there is no way to eliminate noise that might be present in the test setup. For repetitive pulse trains, averaging can be used to eliminate errors due to noise.

The procedure for making a single pulse measurement is as follows:

1. Allow the PPM to warm up for 30 minutes, then conduct a Self-Cal.
2. Select the Peak Mode of operation. If there is no pulse at the detector input there will be no trigger. If this is the case, the display will either be blank or frozen with the last data that was taken. The Ready light should be lit, the New Data light will be dark.
3. Set the Trigger Mode to Internal, and then set the trigger level as desired.
4. Set the Cursor Delay to the desired time following the trigger that the measurement is to be taken. Press [GRAPH]. Move the cursor to CSR DLY. Enter the desired delay (for this example, use 5 μ s) through the keypad, and terminate with the ms, μ s, or ns key. Then press [PEAK].
5. Set the Peak Pulse Averaging number to 1.
6. Connect the detector to the RF source to be measured.
7. When a pulse of sufficient amplitude to cause a trigger enters the detector input, the PPM (in this case) will take a reading 5 μ s later. The Peak power being measured at the time of the Cursor Delay will then be frozen on the display until the next pulse or trigger occurs.

2.13.4 Single Pulse Measurement With an External Trigger

Making a single pulse measurement using an External Trigger is done with the same limitations as with the Internal Trigger. However, it is possible to control exactly when the power reading is taken by supplying a TTL trigger to the PPM's rear panel trigger input at the appropriate time.

The PPM is set to External Trigger by pressing [MENU] (1) [F2].

The trigger signal must arrive coincident with or before the RF pulse to be measured when measuring with the External Trigger. If the power reading needs to be taken exactly at the time that the trigger occurs, then the Cursor Delay is set to 0.0000 ns. If the pulse to be measured arrives after the trigger, then set the Cursor Delay so that the power reading will be taken at the desired point on the pulse.

2.14 Swept Peak Power Measurements

The frequency response and power level characteristics of pulsed signals can be measured under swept frequency conditions by combining the capabilities of the Giga-tronics PPM with those of the Giga-tronics Model 8003 Scalar Network Analyzer.

The Analyzer's normalization memory can be used to subtract out residual test setup responses, thus allowing direct readout of the frequency response of the device under test. There are a variety of applications where this ability can be very useful such as:

- Pulsed TWT testing
- Microwave frequency performance of pulsed radar systems
- Return Loss
- VSWR Measurements under Pulsed Conditions
- and others.

Figure 2-17 illustrates a typical setup for measuring swept peak power.

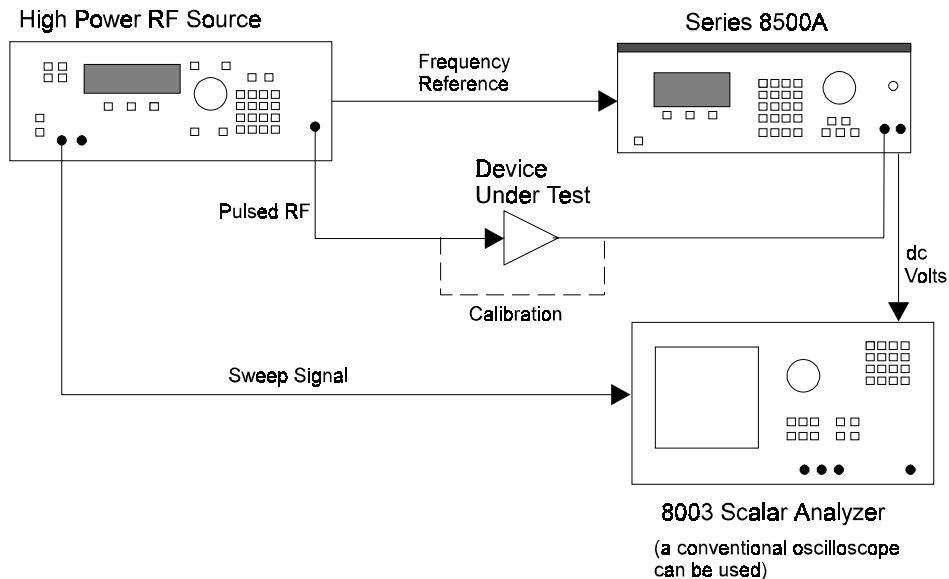


Figure 2-17. Typical Pulsed Swept Measurement System

If a Giga-tronics Scalar Analyzer system is not available, a conventional oscilloscope can be used by first displaying the PPM's output, and then marking the system tracking errors on the CRT in grease pencil for visual correction.

The PPM is normally used in the Peak Mode for this type of testing. Most PPM settings would be the same as when measuring a single frequency pulsed signal. In order to use the Swept/Pulse system with any degree of accuracy, the pulse repetition rate must be considerably faster than the speed at which the RF sweep takes place. This is determined mostly by the setting of the sweep generator's sweep speed.

The PPM is capable of reading better than 100 pps, and the output level will be at 100 mV/dB. Swept measurements can also be made simultaneously from channels A and B of the 8502A, but the PPM's reading rate will be somewhat slower.

It is very convenient to use the sweep generator's Frequency Reference signal to continually inform the PPM as to what the RF frequency is at any given time. (Frequency Reference is synonymous with V/GHz, VpropF, etc.) Using this feature ensures that, as the sweep generator changes frequency, the PPM

knows to alter its frequency correction accordingly. The PPM then uses the proper frequency correction accordingly. The PPM then uses the proper frequency correction for the detector(s) at each discrete frequency point without necessitating any operator input or any calculations (see Section 2.8.2 more information on the interfacing of external frequency signals.)

To make swept frequency measurements under pulsed conditions, equipment should be set up similar to Figure 2-17. The measurement routine is initiated by pressing [MENU] (10) [F1].

During the time that the fast analog output mode is active, the display window will indicate:

**FAST ANALOG OUTPUT
MEASUREMENT MODE**

Press [MENU] to exit

2.15 Self-Testing the 8500A

Prior to performing a self-test during a testing routine (at some point after the instrument has been turned on), the detector must either be connected to the Calibrator Output on the front panel, to a 50-ohm termination, or to a signal source which has the RF power turned OFF.

The Self-Testing feature of the PPM is provided as a quick health check of the instrument. The PPM performs a Self Test each time it is powered on. To initiate the Self-Test function at other times:

First remove all RF power from the detector. Then press [MENU] (11) [F2]. While the Self-Test is in progress, the following will be displayed:

Performing Self-Test
CLOCK/CALENDER INDICATES
(day) (date) (time) (year)
System version # = n.nn

At the successful completion of the Self-Test, the PPM will display Self Test Completed: Passed. A beep will then sound, and the PPM will return to its previous display mode.

If some type of failure is detected by the PPM's microprocessor during the Self-Test, the display will indicate:

SELF TEST FAILED! - PRESS CLEAR
ERROR NUMBER(S): 11, 8, etc.

Table 2-1 gives a listing of the error numbers and their associated meanings.

Table 2-1. Self-Test Error Flags

Error	Cause
01	-5.2 V Supply
02	Memory Bad
03	Excessive A Channel Offset
04	A Channel Gain Error
05	Excessive B Channel Offset
06	B Channel Gain Error
07	A Channel Analog Output DAC
08	B Channel Analog Output DAC
09	Delay 8555s (ICs)
10	Delay Time Error
11	Calibrator Bridge Voltage Error

Press [CLEAR] to bring back the display of the last setup before Self-Test. However a failed Self-Test indicates a problem of some kind, and it is recommended that the PPM not be used for measuring until it is checked according to the procedures given in the Troubleshooting instructions in Chapter 6.

2.16 Frequency Display Disable/Enable

If there is some reason (such as classified testing) why it might be desired not to have the frequency of operation displayed while measurements are being taken, this can be done by using the F3 key of MENU (7) as a toggle for this function.

Pressing [MENU] (7) [F3] the first time will replace the frequency numbers at the bottom of the display window with asterisks.

When you desire to return to the normal frequency display mode, press [MENU] (7) [F3] again and the numbers indicating the frequency will return.

2.17 Non-Volatile Memory

The PPM Non-Volatile Memory is intended to Store front panel settings for later Recall. This is particularly useful when complicated setups are in use. Usage of this feature can save many menu selections that might otherwise have to be entered every time the instrument is used.

The PPM stores all front panel information pertaining to the present setup in a memory location called Current Setup. When the PPM is turned off, Stored setups and the Current setup in memory are kept alive by a Lithium battery (exceptions are detailed in Section 1.3). The battery will ensure that the contents of the memory will be preserved for about six months.

When the PPM has been turned on and Self-Test either completed or bypassed, the opportunity will be presented to select Last Setup at Turn-Off. If it is desired to use the PPM in the same manner as when it was last used, this feature of the Non-Volatile Memory is very convenient. Other features of the Non-Volatile Memory will be discussed next.

2.17.1 Memory Features

To access the Memory features of the PPM, press [MEM]. There are three levels of menus accessible by sequentially pressing the MEM key. The menus accessed through the Memory key are detailed in Appendix B. If you mistakenly access the Memory menu, press [CLEAR] to return to the Data Display Mode.

Store Setup

The PPM has 10 Non-Volatile Memories for storing front panel setups. These are numbered from 1 through 10. To store the present PPM front panel setup in one of these 10 memories, press [MEM] (1) [F2] [nn] [UNITS].

Where nn is the number of the memory where the setup is to be stored (between 1 and 10). If no number were entered, the operation would be aborted when any Units key was pressed and the PPM would return to data display.

Recall Setup

To Recall a previously stored setup, press [MEM] (1) [F1] [nn] [UNITS].

Where nn is the number of the memory to be recalled (from 1 to 10). If no number is pressed, the operation is aborted when any Units key is pressed and the PPM will return to data display.

Get Power-On Setup

To retrieve from memory the front panel setup that was operative the last time the instrument was used before power-off or the rear panel RESET button was used, press [MEM] (1) [F3]



NOTE: This selection will erase the Current selection. It is advisable to store the setup in a numbered memory before executing the command.

Display Setups

When one of the Display Setup features of the PPM is activated, the panel settings of the selected setup are shown on the display. This is useful if it is desired to determine the exact parameters that were used for a particular setup, and allows checking whether or not the various settings are correct before making any measurements.

1. To Display the contents of the Current setup, press [MEM] (2) [F1]. The PPM will then display the current instrument status readout in a screen by screen display mode. To scroll to the next screen display, press the F1 key for More. To exit and return to the Data Display Mode, press F3.
2. To Display the contents of the Power-On setup, press [MEM] (2) [F2]. The PPM will then display the Power-On instrument status readout screen by screen. To scroll to the next screen, press [F1] for More. To exit and return to data display, press [F3].
3. To Display a numbered memory setup, press [MEM] (2) [F3] [nn] [UNITS], where nn is the number of the memory (between 1 and 10) that is to be displayed. If no number is entered, the operation is aborted when any Units key is pressed and the PPM returns to data display.

The PPM will display the instrument status readout of the Memory screen by screen. To scroll to the next screen display, press [F1] for More. To exit and return to data display, press [F3].

Initializing Setups

This feature of the PPM allows the initializing of the current setup, a numbered memory setup, or all but the current setup (see Section 1.3). Initializing resets the selected setup's parameters to the factory default settings. Certain parameters are not initialized. The Initializing function can be useful if, for some reason, you get lost or have difficulty interpreting readings due to the complexity of a particular setup. Initializing also allows parameter settings to be made from a known status.

1. To Initialize the Current setup, press [MEM] (3) [F1].



NOTE: This selection will erase the Current setup. It is advisable to store the setup in a numbered memory before executing the command.

2. To Initialize all memory setups except for the Current setup, press [MEM] (3) [F2]. It is a good idea to Display the contents of the numbered memory setups before executing this command to see if it is desired to retain any of the setups in question.
3. To initialize a numbered Memory setup, press [MEM] (3) [F3] [nn] [UNITS], where nn is the number of the memory (between 1 and 10) to be initialized. If no number is entered, the operation is aborted when any Units key is pressed and the routine will return to data display.

2.18 1018B Peak Power Meter Emulation

2.18.1 General

The Giga-tronics Model 1018, 1018A, and 1018B series of peak power meters were the predecessors to the Model 8501A/8502A meters. This 1018 series was first produced in 1969, and has had several design up-grades. In 1978 Pacific Measurements, Inc. (now known as the Giga-tronics Power Measurements Division) added limited IEEE Bus capability to the 1018, but no provision was available for controlling front panel states. Only the cursor delay, trigger or reset, and the taking of data was remotely controllable.

The purpose of the 1018B emulation mode is to provide a means for current users of the 1018B to quickly adapt to using the 8501A/8502A meters in automatic systems. While perfect emulation is not possible, the PPM can mimic certain operations of the 1018B. This emulation relates only to GPIB (IEEE Bus) operations. That is, the ability to reset, trigger, alter the cursor delay, and take a power reading over the bus. See Section 3.5 for detailed information on GPIB operations with the PPM.

Although software written for the 1018B series would not take advantage of many of the new features of the PPM, the emulation capability can allow work to continue while new software is being written for the PPM.



NOTE: To use the 1018B software with the PPM in the 1018B Emulation Mode, the software must be written so that the talk and listen addresses of the PPM are both the same. For further information, see Section 3.5.

2.18.2 Initiating the 1018B Emulation Mode

To initiate the 1018B Emulation Mode, press [MENU] (8) [F2].

Thereafter, MENU (8) selects settings relating to the way in which the PPM will emulate the 1018B. See the Menu-8 listing in Appendix B for a listing of available settings. To know which selections to make, three questions must be answered regarding how the 1018B is presently being used on the IEEE Bus. These are:

1. Is SRQ Enabled or Disabled?
2. Is the instrument set up to output data upon being talk-addressed (automatic trigger reset), or does the instrument require a trigger reset (a GET or ? command) to take a data point?

The 1018B emulation is incompatible with the Ratio Mode, and once the routine is in the 1018B Emulation Mode, the Fast Analog Output function cannot be accomplished. For further information, see Section 3.5.

3. What is the Talk/Listen address? (they must be the same.)

Based on these questions, use MENU (8) to select the appropriate settings. Press [MENU] (6) [F3] to set the PPM listen and talk addresses.

Once the above has been done, it should be possible to swap a Model 1018B with option 05 (GPIB) with a Model 8501A or 8502A meter and continue operations.

To terminate the 1018B Emulation Mode, press [MENU] (10) [F2].

Remote Operation

3.1 Introduction

This chapter describes remote operation of the Series 8500A Peak Power Meters using the General Purpose Interface Bus (GPIB), and provides all of the basic information required to begin programming as easily as possible. After you are familiar with the Model 8501A/8502A Peak Power Meter (PPM) commands and functions, controlling the instrument through the GPIB should be fairly simple. A first-time user of the PPM should read the General Information in Section 3.2 before attempting to operate the PPM over the GPIB.

Appendix A to this manual contains a summary of command codes.

This chapter contains the following information:

- General Information; Bus Functions; Menus; Modes of Operation; IEEE Output Modes; String Formats; Data Formats; Descriptive material on how the PPM functions over the GPIB; Simple Sample Programs
- Command Descriptions by Function; Command Syntax; Sample Programs
- Service Request (SRQ) Functions; Error Conditions
- Giga-tronics Model 1018B Emulation; Limitations; Explicit and Implied 1018B Emulation
- Status Code Values - Normal; Command Errors; Operation Errors; Task Completion Codes, Normal and Abnormal; Critical Errors
- Summary of Bus Functions Implemented on the Model 8501A/8502A Power Meters
- Command Summary Table (Alphabetical Listing)

The PPM allows several modes of GPIB operation. Power measurements can be taken in a variety of modes and formats. These range from simple CW measurements to complex graphic display capabilities of pulse profiles, complete with timing information.

The 1018B emulation feature allows the 8501A/8502A to be installed in most test systems where the 1018B was previously used, without the need for immediate reprogramming. The emulation can facilitate the usage of the PPM with the older 1018B software while writing new codes is under way.

3.2 Remote Operating Modes

This section describes the various methods and modes that are used for remotely controlling the PPM through the GPIB. Typical sample programs illustrating the use of commands are provided.

3.2.1 PPM IEEE Bus Functions

Remote operation of the PPM is accomplished through the GPIB under the control of a remote controller/calculator. Bus functions are implemented using the notation of the IEEE-488 1978 specification. These are given in the Bus Functions Summary in Section 3.7.

The following is the general order of events when operating through the GPIB:

1. Parsing of Command String.
2. Actions taken:
 - a. Autoscale, if requested.
 - b. Power measurement, and so forth.
 - c. Output of data upon TACS (Talker Active State)

It is necessary to wait for certain events to complete before sending new commands. Examples of such commands are AUTO and Marker Placement. If the PPM is placed in TACS and then untalked or if a new command string is sent, then the taking of data will be terminated as will the autoscale function if it is not yet complete. Failure of autoscale will result in a service request and the error condition of 60.

Completion will be signaled by the SRQ reporting either success or failure. If the command is AUTO and Marker Placement, it is necessary to wait for AUTO success or failure, and then Marker Placement success or failure before expecting any time measurement output data from the PPM.

The controller should time out if the PPM does not complete the appropriate service requests in a reasonable amount of time; allowing for the autoscale average number, pulse repetition rate, etc.

It is recommended that commands be sent after Device Clear from the controller to guarantee the state of the instrument. See Section 1.3 for the default settings.

Any pulse profile related command (DUMG, Plot commands, and marker placement commands) will perform their operation on the collected data when they are received.

Throughout this IEEE Bus operation, delays handled as arguments to commands sent to the PPM are listed as nnnnnn.nn μ s. The PPM will accept resolution down to 0.1 ns or 0.0001 μ s. A total of eight digits are allowed. The position of the decimal point can vary. Arguments should not be sent with excess digits to the right of the decimal point.

3.2.2 Front Panel Menus

See Appendix B for a listing of menus that can be accessed with the front panel MENU and MEM keys. Appendix C contains illustrations of top level menu formats.

Before attempting to control the PPM over the GPIB, it should be kept in mind that there are various front panel menu selections that will affect bus activity. The front panel menu selections relating to the GPIB will include the following capabilities:

1. Enter the PPM address

[MENU] (6) [F3] [nn] [UNITS]



NOTE: This is most important as the PPM will not respond to bus commands unless this has been correctly accomplished.

2. Enter the plotter address

[MENU] (6) [F2] [nn] [UNITS]

The address entries are self-explanatory; valid values are 0 to 30. The addresses entered are stored in non-volatile memory and need to be entered only when they change, but not when power is turned off and on again.

3. Emulate 1018B (see Section 3.5). The instrument will always power-on in the normal PPM mode and not the 1018B emulation mode.
4. Plot (see Plot Output Mode in Section 3.2.5).
5. Stop current plotting activity (see Stand Alone Plot Output Mode in Section 3.2.5).

3.2.3 Power-On Condition

When the PPM is first turned on, it will automatically go into its Power-On Self-Test (POST) function. When POST has completed, the routine returns to the last setup before the instrument was powered off. After POST, the instrument will be ready to receive instructions from the GPIB controller to go to the Remote state.

The address to place the PPM in Remote at power-on will be the same address that was used before power-off (the default address is 4).

3.2.4 Remote and Local Lockout Functions

The PPM accepts commands or output data only through the bus when it is in the Remote state. It is placed in the Remote state by listen-addressing the instrument with REN asserted, per the IEEE-488 1978 standard. The PPM will ignore talk-addressing when it is not in the Remote state. Any Group Execute Trigger (GET) command or any data sent to the instrument when it is addressed while not in Remote will result in an error condition, and a service request will be generated if SRQ is enabled.

When in the Remote state, the front panel keys will not be active except for an escape sequence to return to local control. The escape sequence is initiated by pressing [MENU]. At that time the PPM will suspend all operations, including IEEE Bus interaction. The measurement being displayed on the front panel will be replaced with a prompt to press F1 to return to local control, or F2 to abort the local escape sequence. The instrument will not respond to any other keystrokes. If F1 is pressed, the instrument will return to local control and resume normal manual operation. If F2 is pressed, the instrument will resume normal operations in the Remote state as though no action had occurred. Once the unit has been returned to Local control, it will return to Remote control the next time it is Listen-Addressed (LADS) with REN asserted.

Another method to return to Local is achieved by sending a GTL (Go To Local) command from the GPIB controller. The PPM will return to the Local control state when it receives this command, and can then be returned to the Remote state the next time it is listen-addressed with REN asserted.

Besides the return to local escape sequence and the GTL universal command, the PPM will also exit the Remote state when the REN line goes low.

After the PPM has entered the Remote state, a Local Lockout command can be sent to disable the use of the front panel. This feature is intended to prevent accidental changes in front panel settings or interruption of the program.

When the instrument is in the Local Lockout mode, the Return to Local escape sequence activated by the MENU key is disabled. There is no way to regain control from the front panel once Local Lockout has been commanded.

To go to the Local Lockout mode, the Local Lockout (LLO) bus command must be sent to the PPM. The LLO light on the PPM's front panel will not be turned on at that time, but the instrument will be in the LLO state. At the next change in the state of the instrument, either a change in the addressed state of the PPM on the GPIB or any keystroke made on the front panel, the LLO light will turn on. If a front panel keystroke is made, it is ignored and will not affect the state of the instrument. Subsequent attempts to control the unit from the front panel will also be ignored.

3.2.5 Output Modes

The PPM outputs data over the GPIB in the following six output modes:

- Update Trigger Reset
- Update Data Continuously
- Plot
- Temperature Difference
- Status Byte
- Stand Alone Plot

The PPM can be in only one output mode when it is talk-addressed. For example, the unit cannot be programmed to plot and then immediately output the difference in temperature since the last calibration. If the PPM receives more than one output mode instruction, the most recent command will supersede all previous output commands.

The instrument must always be in an output mode. It sends output information when it receives a command to initiate another output mode, or when a current output mode is completed and terminates itself. The self terminating modes are Plot, Output Temperature Difference Since Calibration, Output Status Byte, and Stand Alone Plot. When these modes complete, the PPM will not send any more data until it is untalked (the Stand Alone Plot untalks itself). When untalked, the default output mode becomes either Update Data Trigger Reset or Update Data Continuously, depending on which mode was last initiated. When power is first applied to the instrument, the default output mode is Update Data Trigger Reset.

Before selecting any of the PPM Output Modes described above, required parameters should be set so that the PPM data that is taken will be valid. For example, plotting commands will not work unless the PPM has been set to the Graph Mode.

Update Trigger Reset Output Mode

A string of four characters (UPDT) must be sent over the bus to the PPM to access this mode of operation. If you are using BASIC on an HP Series 200 computer, the command might look like:

```
OUTPUT 704; UPDT
```

where:

OUTPUT is the GPIB command to send the letters following the semicolon.

The 7 in 704 is the HP instruction that the output is to go via the GPIB interface.

The 04 in 704 is the Listen/Talk address of the PPM. The Listen/Talk address must be set with the MENU key on the PPM's front panel (see the Menu (6) description in Appendix B).

In the Update Trigger Reset Mode, the PPM will not send any data until it receives a trigger reset. When the trigger reset is received through the GPIB, the instrument is set to record the next measurement. If the instrument is in the Peak or Graph Mode, the measurement (power reading at the cursor location) will be taken the next time the instrument is triggered. Triggering can be either internal or external, depending on how the instrument has been configured. The recorded measurement data will be output through the GPIB when the PPM next enters TACS (Talker Active State).

The trigger reset can take one of the following two forms:

- A. The universal GPIB command, GET (Group Execute Trigger), can be sent over the bus when the PPM is listen-addressed, or
- B. The controller can send the UPDN (Up-date Data Now) command to transfer the last data taken to the GPIB buffer (e.g. OUTPUT 704; UPDN).

When the PPM completes the measurement and has the data ready to output, it will request service if it is not in TACS and has SRQ enabled. Entering TACS will clear the service request if the instrument has not already been serviced directly by the GPIB controller program.

The procedure to trigger reset the PPM with the GET command consists of the following steps:

1. Listen-address the PPM.
2. Send the GET universal command.
3. Talk-address the PPM.
4. Release ATN to set the PPM in TACS.

If in the Peak Mode, send the pulse to trigger the PPM.

If the pulse is sent before the PPM is in TACS, an SRQ will be generated if SRQ has been enabled. Entering TACS will clear the SRQ.

5. Read the power measurement string as it is sent by the PPM. The string will be terminated with a carriage return followed by a line feed character sent with EOI.

The procedure to trigger reset the PPM with the UPDN command is the same as using the universal GET command except that after Step 1 when the PPM has been listen-addressed, the command string UPDN should be sent. The power measurement data output format is discussed in Section 3.2.7.

Sample Program:

```
10 PRINT CHR$(12);
20 ! THIS PROGRAM USES THE
30 ! UPDATE TRIGGER RESET MODE
40 ! OF THE PPM TO COLLECT
50 ! POWER MEASUREMENT DATA.
60 ! UPDN RESETS THE PPM. IT
65 ! IS THEN READY OR ARMED.
70 ! THE PPM WILL SEND DATA
80 ! AFTER RECEIVING THE UPDN
90 ! COMMAND.
100 !
110 ! DATA ENTERED AS A STRING
120 ! D$ IS DISPLAYED, AND THEN
130 ! REPEATED CONTINUOUSLY.
140 !
150 OUTPUT 704; UPDT
160 OUTPUT 704; UPDN
170 ENTER 704;D$
180 DISP D$
190 GO TO 160
200 END
```



NOTE: In the Dual Channel Mode, it is necessary to read the IEEE Bus twice to get A and B channel data.

Update Data Continuously Output Mode

A string of four characters (UPDC) must be sent to the PPM to access this mode of operation:

If you are using BASIC with an HP Series 200 computer, the command might look like:

```
OUTPUT 704; UPDC
```

where:

OUTPUT is the GPIB command to send the letters following the semicolon.

The 7 in 704 is the HP instruction that the output is to go via the GPIB interface.

The 04 in 704 is the Listen/Talk address of the PPM. This address must be set from the front panel with the MENU key (see the MENU (6) description in Appendix B).

In the Update Data Continuously Mode, the PPM is ready to send a continuous stream of data points while it is in TACS (Talker Active State). Upon entering TACS, the PPM will initiate a trigger reset and be ready to record the next measurement. If the instrument is in the Peak or Graph Modes, the measurement (power reading at the cursor location) will be taken the next time the instrument is triggered. Triggering can be either internal or external, depending on how the PPM has been configured.

Upon continuous triggering, measurement data points separated by commas will be sent by the PPM. Measurement data will continue to be sent through the GPIB, separated by commas, every time a trigger occurs until the instrument has been untalked.

Sample Program:

```
10 ! THIS PROGRAM USES UPDC
20 ! UPDATE DATA CONTINUOUSLY.
30 ! THE DATA IS SENT BY THE PPM
40 ! WHEN IT IS TALK ADDRESSED
50 ! WITH THE ENTER STATEMENT
60 !
70 OUTPUT 704; UPDC
80 !
90 ! TAKE 10 READINGS AND
100 ! DISPLAY THEM:
110 FOR I=1 TO 10
120 ENTER 704 USING K, #; A$, A(I)
130 DISP A(I)
140 NEXT I
150 END
```

Plot Output Mode

In this mode the PPM sends HPGL plotter commands to plot a pulse on a compatible plotter. The PPM command PLOT initiates the capturing of a pulse and relevant information that will be plotted when the PPM enters TACS. The procedure to plot a graph over the GPIB consists of the following steps:

1. Prepare the PPM by entering the Graph Mode and obtaining the desired pulse profile to be plotted as shown in the PPM's display window. Also select which sub-mode you want because the data shown on the plot is different for each sub-mode. For example, selecting the Marker sub-mode will cause the marker values to be shown at the bottom of the plot.
2. Send the PLOT command to the PPM.
3. Listen-address the plotter.
4. Talk-address the PPM.
5. Release ATN, putting the PPM in TACS.

The PPM will terminate the plot with a carriage return followed by a line feed sent with EOI. If necessary, the plot can be aborted by the untalking of the PPM during transmission of the plot.

Whenever the PLOT command is sent to the PPM while it is in the Graph Mode, the PPM will plot a graph of the selected Cursor, Pulse, or Marker sub-mode. See Figures 2-8, 2-10 and 2-9 for typical plots of Graph sub-mode pulse profiles.

The following commands are used when it is desired to have any serial or code numbers appear on a hardcopy plot.

PLPNxxxxxx.....

(x = string of 12 or less characters
Plot part number, ASCII string)

PLCNxxxxxx.....

(x = string of 12 or less characters
Plot code number, ASCII string)

Any printable character is allowed, including spaces, except that all leading spaces prior to the first non-space character are stripped off, and not included in the number of characters in the string. The string must be terminated by a semicolon which is not printed. Therefore, no semicolons can be contained within a label string.

Sample Program:

```
10 ! THIS PROGRAM DEMONSTRATES
20 ! HOW TO MAKE THE PPM OUTPUT
30 ! A PULSE PROFILE DISPLAYED
40 ! IN THE GRAPH MODE TO A
50 ! DIGITAL PLOTTER.
60 !
70 ! C$ AND P$ ARE STRINGS
80 ! THAT CAN BE SENT SO THAT A
90 ! CODE NUMBER & PART NUMBER
100 ! ARE PRINTED ON THE PLOT BY
110 ! THE PPM.
120 !
130 C$=ABCDEFGHJKLM
140 P$=123456789012
150
160 ! AFTER ENTRY INTO THE GRAPH
170 ! MODE, THE FOLLOWING
```

```
180 ! COMMANDS WILL INITIATE THE
190 ! PPM'S PLOT ROUTINE. THE
200 ! ADDRESS OF THE PLOTTER AND
210 ! PPM MUST BE SET CORRECTLY -
220 ! IN THIS CASE THE PPM IS AT 704,
230 ! AND THE PLOTTER IS AT 706.
240 OUTPUT 704;PLCN&C$
250 ! SEND CODE NUMBER TO PPM
260 OUTPUT 704;PLPN&P$
270 ! SEND PART NUMBER TO PPM
280
290 ! THESE ARE THE COMMANDS TO
300 ! INITIATE THE PLOT ROUTINE:
310
320 OUTPUT 704;PLOT
330 ! (PUTS PPM IN PLOT OUTPUT MODE)
340
350 SEND 7;UNL
360 SEND 7;LISTEN 6
370 ! (LISTEN ADDRESSES THE PLOTTER)
380 SEND 7;TALK 4
390 ! (TALK ADDRESSES THE PPM)
400
410 SEND 7;DATA
420 ! (RELEASES ATN LINE ALLOWING
430 ! PLOTTING TO BEGIN)
440
450 WAIT 180
460 ! WAIT UNTIL PLOTTING HAS
470 ! FINISHED BEFORE UNTALKING
480 ! THE PPM. PLOT TAKES ABOUT
490 ! 3 MINUTES
500
510 ! UNTALK AND UNLISTEN ALL BUS
520 ! DEVICES
530 SEND 7;UNT UNL
540 END
```

Temperature Difference Output Mode

This mode determines the difference in temperature for each detector since it was last calibrated. The mode provides a means to maintain measurement accuracy by allowing the software to determine when a detector Self-Cal is required. If detector temperature difference information is desired, the command DTMP is sent to the PPM. The instrument will then be ready to output a data string in the following format (x and y = temperature reading digits; s = polarity):

DTPAsxx.x,DTPBsyy.y(CR)(LF-EOI)

This will be true with both the Model 8501A and 8502A instruments. If a detector is not present, the digit portion of the string will read +00.0. The zeros can either mean no change in temperature difference or no detector present. With the 8501A, the B reading will always be zeros.

Sample Program:

```
10 ! THIS PROGRAM EXTRACTS
20 ! TEMPERATURE INFORMATION
30 ! FROM THE PPM SO THAT A
40 ! CONTROLLER CAN DETERMINE
50 ! IF A SELF-CAL IS REQUIRED.
60 ! IF THE TEMP SINCE LAST SELF-
70 ! CAL IS MORE THAN +/-5 DEG-C,
80 ! SELF-CAL IS RECOMMENDED
90 DIM A$(19)
100
110
120 OUTPUT 704;DTMP
130 ENTER 704;A$
140 DISP A$
150 END
```

Status Byte

The PPM uses this mode to send its status byte as a character string. The value sent is the internal status value. It is not exactly the same as the byte sent during a serial poll in which bit-7 is high when service is being requested (see Service Requests in Section 3.4). The character string sent out to represent the status value will consist of a four character head, STAT, followed by three digits. This output mode can only be active when SRQ is disabled. Service request status bytes are not buffered when SRQ is disabled, so only the most recent status value will be output. The status value is followed by a carriage return, followed by a line feed sent with EOI.

Stand Alone Plot Output Mode

Plotting Without Using a Controller:


The PPM uses this mode to send HPGL digital plotter commands to plot a pulse, much as it does in the Plot Mode. The difference is that stand alone plots are initiated by commands from the front panel of the PPM. This is to allow plotting without the use of a controller (see Digital Plotting of Graphic Data in Section 2.9).

Stand Alone Plot Output Mode: PPM Internal Procedures:

These actions are performed by the PPM when the Stand Alone Plot is initiated from the front panel. Before the PPM can output plotter information, it is necessary to first enter the Graph Mode of operation. Chapter 2 of this manual contains the information required to prepare for and produce digital plots of Graph Mode and Marker sub-mode data. The following paragraphs describe the PPM's internal procedures for GPIB interaction when front panel plots are to be made.


When the PPM has drawn a complete pulse profile on its display, it is ready to act as a GPIB controller. When the plot routine is activated, the PPM checks to make sure that there is no other active controller on the bus. If the PPM is in the Remote state, it implies that a controller is present and registers as a GPIB bus error. Also, all PPM service requests are generated by action on the GPIB, and are cleared when REN is not asserted (see Remote and Local Lockout in Section 3.2.4). Therefore, if the PPM internally detects any abnormal status condition in its status byte, it will assume that there was recent activity on the bus involving a controller and refuse to proceed further with the plot. It will also attempt a service request to see if there is any response from the controller.

If the PPM does not detect an indication of another controller, it will assume that it is the only controller-capable device on the bus, and will act as the system controller. Depending on the system configuration, these checks made by the instrument may not be perfect.

 **NOTE:** For proper system operation, no active controller can be on the bus when the front panel function is initiated.

While the PPM is checking the state of the bus, it will display the message Checking GPIB Interface, and the keyboard will be inactive.

If the PPM does detect an indication of a controller on the bus, or if the PPM takes control of the bus and attempts to address the plotter but does not get a handshake, a GPIB bus error message will be displayed and a prompt will require F2 to be pressed to continue. If the PPM does not detect a bus error, a beep will sound and normal operation will resume while the plot is being sent over the GPIB. Once plotting has begun, control of the front panel will be returned to local.

 **NOTE:** If you want to add serial and code numbers to the plot, use the procedure for Making Plots in Section 2.9.

3.2.6 Command String Format

Control of the PPM is accomplished by using four-character mnemonic commands. Some of these require one or more numerical entries (arguments). The command structure is intended to be taken literally; there are no optional formats. Thus, if two arguments are specified for a command, both must be given for the command to be processed.

A character string is terminated with a line feed character and/or an EOI. Carriage returns are ignored. Therefore, a carriage return/line feed sequence will act as a string terminator and will be treated as a line feed. More than one command (and respective arguments) can be sent in a command string as long as the string does not exceed 128 characters, including the terminator. If an EOI is sent and the last character is not a line feed, only 127 characters can be sent. None of the commands can be processed until the string is terminated, and then they will be processed in the order they were given (see Output Modes in Section 3.2.5 regarding conflicting output commands).

When the command string is received, it is first checked for syntax and numerical values, and commands are reviewed to make sure they are valid. If a syntax error or an invalid data error is detected, or the execution of the command string would lead to an operation error, then none of the commands will be executed and a service request will be generated if SRQ is enabled.

A very forgiving syntax is allowed since the PPM can distinguish between any command and any argument, with no separator character required between commands or a command and its argument. The only time a separator character is required is between arguments when the command has two or more arguments. A separator is defined to be a space, a comma, or a semi-colon. Any number of separators are allowed before the first command, between a command and an argument, between arguments, between the last argument of a command and the next command, or at the end of the string without effecting the PPM's interpretation of the command string. Commands can be in upper or lower case format.

An argument consists of a digit string which can optionally be preceded by a positive (+) or negative (-) sign. If no sign is present, the number is assumed to be positive. The digit string can also contain a decimal point if desired. The dimension of each argument is fixed, therefore no dimensional identifier is needed or allowed, only a number. This will be described in the command description to follow. 1018B command arguments follow a different format as is discussed in Section 3.5.

3.2.7 Power Measurement Data Output Format

The measurement data output formats transmitted by the PPM over the GPIB depend on whether the PPM is in the dBm or W power mode of operation. These modes are entered by using GPIB commands as described in Section 3.3.3 or, when the PPM is not in the Remote mode, by pressing [dB/mW] on the front panel.

Power measurements over the GPIB are taken only during the Update Trigger Reset or Update Data Continuously output modes (see Section 3.2.5).

To initiate a power measurement over the GPIB, a command is sent to the PPM from the controller and then talk-addressed. When the PPM is triggered, it will transmit its data through the GPIB to the controller. See the following command descriptions for the commands required to take data. The measurement data strings are discussed in subsequent sections.

Log (dBm) Data Format

When the PPM is in the dBm mode (as indicated in the display), the first three letters of the data string are DBM. This indicates that the data represents a dBm value. The following letter indicates which detector (channel A or B) was taking the measurement. This is followed by a polarity sign, and then a string of five digits with a decimal point after the third digit.

Each measurement taken in the Update Trigger Reset Mode will be terminated by a carriage return followed by a line feed sent with EOI. Measurements taken in the Update Trigger Continuously Mode will be separated with commas. Examples are:

Update Trigger Reset Mode:

DBMA-012.73(CR)(LF-EOI)
DBMB+002.47(CR)(LF-EOI)

Update Data Continuously Mode:

DBMA+016.74
DBMA+018.23
DBMA+017.34
(and so on)

The actual measurement string (less terminating and delimiting characters for each data point) will always be 11 characters long.

Linear Power Data Format

When the PPM is in the linear power mode (as indicated in the display), the first three characters of the data string will be PWR. This indicates that the measurement is a linear value, with the units always in WATTS. As with DBM, the next character indicates which detector (channel A or B) was taking the measurement. This is always followed by a value in engineering notation. The value consists of four digits and a decimal point. These are followed by an E, then a polarity sign and two more digits. The digits following the E are always multiples of three. This makes it easier to determine if the data is being given in terms of microwatts, milliwatts, nanowatts, etc.

Each measurement taken in the Update Data Trigger Reset mode will be terminated by a carriage return followed by a line feed sent with EOI. Measurements taken in the Update Data Continuously mode will be separated by commas. Examples are:

Update Data Trigger Reset mode:

PWRA31.61E-06(CR)(LF-EOI)
for 31.61 microwatts

PWRB634.7E-03(CR)(LF-EOI)
for 634.7 milliwatts

Update Data Continuously mode:

PWRA64.98E-06,
PWRA65.23E-06,
PWRA89.32E-06,

and so on

The actual measurement string (less terminating or delimiting characters for each data point) will always be 13 characters long.

3.3 GPIB Command Descriptions

There are approximately 100 different commands available to program the 8500A for use on the GPIB. This section provides functional information pertaining to the commands with the least complex material covered first.

For most applications the automatic features of the PPM provide easy methods of making pulsed measurements. However, a great deal of flexibility and control is available if you prefer to work with raw data.

An alphabetical listing of all commands is in the Command Summary in Table 3-3.

The PPM has the following general capabilities:

- The ability to measure and output CW or Peak power, or a Ratio of two signals in Linear (Watts) or Log (dBm) format.
- In some applications, the PPM can output the microwave frequency at which the power measurement is being taken.
- Graphically display pulse profiles automatically.
- Markers can be defined on the pulse.
- Rise time, fall time, and pulse width can be measured and output automatically.
- Time differences between selected markers can be measured and output automatically.
- Self-test capabilities are built in.
- The PPM Calibration function automatically linearizes the detector over a 50 dB power range for the most accurate power measurements.
- The temperature of the detectors can be monitored to verify whether the detector should be calibrated.
- The PPM makes use of a PROM with stored frequency response data contained in the RF detector assembly. The instrument uses the stored data to automatically compensate for detector frequency response variations. A rear panel connector is available on the unit to connect a V/GHz ($V \propto F$) signal to allow for automatic frequency selection and correction of measured power.
- The use of balanced detectors enhances accuracy when used in situations where even harmonics are present.
- Setups can be stored or recalled to and from the PPM's non-volatile memory by GPIB commands as well as manually through the front panel.
- Graph displays can be plotted on digital plotters. In addition, data pertaining to a pulse profile can be output to the controller.
- A Data Fast mode disables the front panel display, allowing faster bus operation.
- Frequency information can be hidden when the PPM is used for classified testing.



NOTE: The Model 8501A instrument will respond to the same command sets as the Model 8502A. The only exception is that the 8501A responds only to commands relating to channel A.

Instrument functions that take a specific amount of time to complete will be noted with an asterisk (*) in the following discussion.

During the time the PPM is processing a function such as calibration, zeroing, or self test, the instrument will continue to be active on the bus. Any new commands may not be received if previous activity is not already completed. No output will be given and, if any commands are sent by the controller, only the first byte will be accepted. The PPM will then send Not Ready for Data until the function is complete.

When the particular function completes, the PPM will request service and send SRQ if SRQ has been enabled. Successful completion of the task is verified by checking the value of the status byte. A listing of Status Codes is given in Section 3.6. If SRQ has not been enabled, the controller can only learn the result of the operation by asking for the status byte with the STAT command.

3.3.1 Common Mode Functions

Calibration Commands

It is advisable to use the PPM's SRQ capabilities to monitor whether the calibration has completed and is successful or not. A serial poll can be conducted and the returned Status value interpreted. See Section 3.4 for SRQ features, and Section 3.6 for applicable Status Code values.

- * CALA Calibrate channel A detector
- * CALB Calibrate channel B detector

Temperature Difference Since Last Calibration Commands

- DTMP Output the Difference in the temperature of each detector since calibration. This command causes the temperature to be read from each detector (or whatever detector is connected). It will be formatted as described under *Temperature Difference Output Mode* in Section 3.2.5, and is useful for determining whether recalibration of detectors should take place. Normally the PPM can maintain accuracy within ± 5 °C of the temperature of calibration.

Autozero Detectors Commands

- * ZERA Zero channel A detector
- * ZERB Zero channel B detector

Store or Recall Setup Commands

- STORnn Store current PPM settings in non-volatile setup memory number n.
n = number between 1 and 10.
- RECLnn Recall PPM setting from non-volatile memory n, and make it the current setting.
n = number between 0 and 10. Setup number 0 cannot be used for storage. It is the last setup before power was turned off or the PPM received a Device Clear from the GPIB controller.

Hide and Unhide Frequency Information Commands

- FQHD Hide the frequency information
- FQDS Display the frequency information

Output Status Byte Information Command

STAT Output status byte. This command will only be effective when SRQ is disabled. If it is received while SRQ is enabled, a service request will be generated.

Typical Program Lines:

```
OUTPUT 704;STAT
ENTER 704;A$
PRINT A$
```

SRQ Related Commands

SRQE Enable SRQ

SRQD Disable SRQ

UNDD Disable SRQ only for under-range conditions. (Permits continuing data output without undesired SRQ interference.)

UNDE Enable SRQ for under-range conditions.

Power Limits

The purpose of setting power limits is to alert the controller of two possibilities having occurred. These are:

- A. Over-range: Warns that the detector (or other component) may have been damaged, and data taken may be invalid.
- B. Under-range: Warns that the power level being measured is low and may be inaccurate.

The PPM can be enabled to generate an SRQ for under-range conditions. The point at which the PPM sends an SRQ is determined by the MINP command. Data output during an under-range condition is as follows:

Log Mode: -99.99dBm

Linear Mode: 0.000E-99

Over-range conditions always generate an SRQ (if SRQ is enabled), but normal data is still output. It should be kept in mind that if the detector is exposed to power levels in excess of +23 dBm, not only will the PPM's measurement accuracy be degraded, but damage or complete destruction of the detector's diode element can occur.

The commands for setting power limits are:

MAXPsnn.nn Set power level (in dBm) for over-range condition.
 s = polarity; n = dBm; +21.00 max, -10.00 min.

MINPsnn.nn Set power level (in dBm) for under-range condition.
 s = polarity; n = dBm; -15.00 max, -50.00 min.

3.3.2 Measurement Data Correction

The manner in which the PPM is able to make very fast peak power measurements is dependent on the usage of zero bias schottky diode detectors as power sensing elements. These diodes have typical rise-times of less than 10 nanoseconds making them useful for pulsed RF applications. However, at microwave frequencies, it is necessary to compensate for the detector's non-linearity with frequency.

Each Giga-tronics detector used in the PPM has a built-in PROM which contains frequency correction data. Depending on the mode of operation, the PPM can be instructed to automatically subtract out the frequency non-linearity error from the power measurement being made.

The PPM needs to know the frequency of operation for this automatic correction to take place. This can be done at the front panel, over the GPIB, or by the use of the Voltage Proportional to Frequency feature ($V \propto F$). The $V \propto F$ is an analog voltage connected to the PPM's rear panel EXTERNAL FREQUENCY input connection. A voltage is usually available from most sweepers called V/GHz with a coefficient of 1V/GHz. This voltage can be converted to digital information by the PPM, and used as a frequency input instead of having to enter it by some other means.

In addition to automatic frequency correction, it may be desired in some applications to use manual corrections based on specific measurements rather than the factory-supplied data in the detector's PROM. This is known as Cal Factor. (Some power meters on the market use the term % efficiency, but it is basically the same thing.) Cal Factor is expressed in dB, and is the amount of power that must be added to or subtracted from the measurement so that the data will be correct.

Another Data Modifier called Offset can also be used. Complex microwave test setups sometimes include attenuators or couplers to reduce high power signals to safe levels that can be measured by delicate instruments such as the PPM. The Offset feature allows the subtraction of residual attenuator or coupler errors from the measurement.

The preceding Data Correction commands will be discussed in the following sections.

Detector PROM Correction: User Supplied Frequency

FREQff.ff

(Where ff.ff is the frequency of the correction.)

Correction is determined by taking a user-supplied frequency (ff.ff) and referencing data in a PROM in the detector.

Min Value: 0.01 GHz

Max Value: 110.00 GHz

Sample Program:

```

10 ! THIS PROGRAM SETS THE
20 ! FREQUENCY FOR DETECTOR
30 ! RESPONSE CORRECTION FOR
40 ! THE PPM
50 !
60 F=5.25      ! PPM FREQUENCY SETTING
70 !
80 ! SEND COMMAND TO PPM
90 OUTPUT 704 USING 100; FREQ,F
100 IMAGE 4A,DDD.DD
110 END

```

Detector PROM Correction: External Frequency

(V/GHz/Freq Ref)

FPRVvv.vv,ss.ss,mm.mm

(Where v, s and m are the arguments to scale the voltage input at the PPM FREQUENCY INPUT connection.)

Correction to be applied for the frequency response of the detector will be determined from three user-supplied values to properly reference data in the PROM in the detector. The three arguments are respectively:

- A. A coefficient representing the voltage proportional to frequency of the sweeper's V/GHz or Freq Ref output:

Min Value: 0.10V/GHz
Max Value: 10.00V/GHz

The most common values for this coefficient are 0.5 and 1.00V/GHz. Consult the instruction manual for the sweeper being used to obtain the correct coefficient.

- B. The minimum coefficient voltage corresponding to the minimum frequency of the sweeper:

Min Value: 0.0V
Max Value: +19.000V

Example: If the sweeper's V/GHz is 0.5V and the minimum start frequency is 2.0 GHz, then this value would be $2 \times 0.5 = 1V$.

- C. The minimum frequency of the sweeper:

Min Value: 0 GHz
Max Value: 110.00 GHz

Sample Program:


```
10 ! PPM EXTERNAL FREQUENCY MODE
20 G=5      ! VOLTS/GHZ
30 V=1      ! V/GHZ START FREQUENCY
40 F=2      ! SWEEPER START FREQUENCY
50 OUTPUT 704 USING 60;FPRV,G,V,F
60 IMAGE 4A,3(DD.DD)
70 END
```

External Frequency (V/GHZ) and Output Frequency to Controller Command

FPVOvv.vv,ss.ss,mm.mm

(Where v, s, and m are the arguments required to scale the voltage input at the PPM's rear panel FREQUENCY INPUT connection.) These are the same as described previously for FPRV.

This command causes the same action as the FPRV command but in addition, asks the PPM to output to the controller the converted frequency information from the PPM's rear panel external frequency input.

 **NOTE:** When using FPVO and operating in the UPDC mode, there will be a stack build up. Old frequency and power data will be output in applications such as swept power measurements.

Sample Program:

```

10 ! PPM EXTERNAL FREQUENCY PLUS
20 ! FREQUENCY OUTPUT MODE
30 OUTPUT 704;UPDT ! SELECT OUTPUT
40 ! MODE. SELECT EXTERNAL FREQ
50 ! MODE AND COLLECT A DATA
60 ! POINT AND ITS FREQUENCY
70 G=5 ! VOLTS/GHZ
80 V=1 ! V/GHZ START FREQUENCY
90 F=2 ! SWEEPER START FREQUENCY
100 IMAGE 4A,3(DD.DD)
110 OUTPUT 704 USING 100;FPVO,G,V,F
120 TRIGGER 704
130 ENTER 704 USING 4A,7D,X,4A,6D;A$,B,C$,D
140 PRINT USING K,;POWER ,A$, IS ,B
150 PRINT USING K,;FREQ ,C$, IS ,D, GHZ
160 END

```

User-Defined Detector Calibration Factor Commands

Detector calibration factor for channel A in dB (cc.cc):

DCFAcc.cc
Min Value: -9.99 dB
Max Value: +9.99 dB

Detector calibration factor for channel B in dB (cc.cc):

DCFBcc.cc
Min Value: -9.99 dB
Max Value: +9.99 dB

Sample Program:

```
10 ! THIS PROGRAM SHOWS HOW TO USE
20 ! THE PPM CAL FACTOR FEATURE
30 !
40 ! CHANNEL A CAL FACTOR
50 ! COMMAND FOR 2.56 dB:
60 OUTPUT 704;DCFA;2.56
70 !
80 ! CHANNEL B CAL FACTOR
90 ! COMMAND FOR 2.56 dB
100 OUTPUT 704;DCFB;2.56
110 !
120 END
```

Offsetting Measured Data: dB Offset Commands

Channel A offset:

OFFAsnn.nn
(s = polarity; nn.nn = dB value)
Min Value: -40.00 dB
Max Value: +90.00 dB

Channel B offset:

OFFBsnn.nn
(s = polarity; nn.nn = dB value.)
Min Value: -40.00 dB
Max Value: +90.00 dB

3.3.3 Mode Selection and Control

This section describes the various modes of operation available with the PPM, with the exception of the sub-mode functions of the Graph Mode. These are described in Section 3.3.5.

Commands or functions that affect a specific mode of operation are either given or referred to in the following command listings. It should be kept in mind that it is sometimes possible to combine modes, therefore care must be taken to observe the rules and arguments set forth.

Select Log or Linear Power Measurement Format Commands

DBMW dBm measurement format display and GPIB output.
 WATT Linear measurement format (mW) display and GPIB output.

Typical Program Line:

```
OUTPUT 704;WATT
```

Select Measurement Mode Commands

(Except Graph and Ratio Modes)

CW Power Commands
 CWPA CW power, channel A
 CWPB CW power, channel B
 CWAB CW power, channels A & B

A CW related command is:

```
AVCWnnn
```

Select number of averages n for CW power measurements. Higher numbers reduce noise effects and stabilize readings at low power levels.

(n = number between 1 and 999)

Peak Power Commands

The Peak Power Mode must be used very carefully. Power measurements in this mode depend on the occurrence of a trigger, and the positioning of the cursor on the pulse to be measured. For more information, refer to Selecting Peak Power Operation in Section 3.2.5.

To enter the Peak Power Mode use:

PKPA Peak Mode for Channel A only
 PKPB Peak Mode for Channel B only
 PKAB Peak Mode for Channels A & B

Related Peak Power Commands

AVPK Select number of averages, n, for Peak power measurements. Higher numbers will reduce noise effects and provide more stability at low power levels.

(n = number from 1 to 999 - higher than 4 is recommended).

TRGAsnn.nn Internal trigger level, channel A

TRGBsnn.nn Internal trigger level, channel B
(s = polarity; n = dBm)
Min Value: -10.00 dBm
Max Value: +16.00 dBm

TRGE External triggering



NOTE: It is important to remember that no data can be taken in the Peak Mode unless a trigger is occurring. This is indicated by the flashing of the New Data light on the front panel. See External Triggering in Section 3.2.5.

RDLAnnnnnn.nn Set channel A reference delay. (Arbitrary timing point to which other timing measurements are related.) (n = microseconds)

RDLBnnnnnn.nn Set channel B reference delay. (Arbitrary timing point to which other timing measurements are related.) (n = microseconds)
Min Value: 0 μ s
Max Value: 213999.97 μ s

CDLAsnnnnnn.nn Set channel A cursor delay. Sets timing position of the Cursor on the graphic display. The Cursor is the vertical line located where the power reading (CSR PWR) is being taken. [Timing is related to the Reference Delay (REF DLY)].
(n = microseconds; s = polarity)

CDLBsnnnnnn.nn Set cursor delay for channel B. Sets timing position of the Cursor on the graphic display. The Cursor is the vertical line located where the power reading (CSR PWR) is being taken. [Timing is relative to the Reference Delay (REF DLY)].
(n = microseconds; s = polarity)
Min Value: 0 - Reference Delay
Max Value: 213999.97 μ s - Reference Delay

Sample Program:

```
10 D=1            ! CURSOR DELAY IN
20 ! MICROSECONDS
30 !
40 ! CHANGE CHANNEL A CURSOR
50 ! DELAY
60 OUTPUT 704;CDLA;D
70 !
80 ! CHANGE CHANNEL B CURSOR
90 ! DELAY
100 OUTPUT 704;CDLB;D
110 END
```


3.3.4 Commands for Retrieving Data From the PPM

UPDC Select Update Data Continuously Mode. The PPM will output a continuous stream of power measurement data points separated by commas. Every time the PPM receives a trigger a new data point is added to the stream. The formats discussed in A and B below can then occur:

- A. When using the **FREQ**, **CALA** (A Cal Factor), **CALB** (B Cal Factor), or **FPRV** (Rear Panel Frequency Input) methods for detector frequency response correction (NOT **FPVO**), the PPM's Linear Mode data output string for Channel A will be:

PWRAnn.nnEsnn,PWRAnn.nnEsnn,PWRAnn.nnEsnn

(n = linear power in watts; Esnn = exponent)

This example shows a data string for 3 triggers. Subsequent triggers will produce more data points separated by commas in the form of PWRAnn.nnEsnn. If channel B is in use, the header before the data points would be PWRB instead of PWRA.

The PPM's dBm mode data output string for channel A will be:

DBMAsnnn.nn,DBMAsnnn.nn,DBMAsnnn.nn

(s = polarity; n = dBm)

This example shows a data string for 3 triggers. Subsequent triggers will produce more data points separated by commas in the form of DBMAnn.nnEsnn. If channel B is in use, the header before the data points would be DBMB instead of DBMA.

- B. When using the **FPVO** (Rear Panel Frequency Input and Frequency Output) method for detector frequency response correction, the PPM's Linear Mode data output string for Channel A will be in the following form:

PWRAmn.mmEsee,FRQAfff.ffE+09,PWRAnn.nnEsee,FRQAagg.ggE+09

(m = first power data point;
f = first frequency data point;
n = second power data point;
g = second frequency data point;
Esee = exponent for power in watts;
E+09 indicates frequency is in GHz.)

This example shows a data string for 2 triggers. Subsequent triggers will produce more data points separated by commas in the form of PWRAnn.nnEsnn,FRQAfff.ffE+09. If Channel B is being used, the headers before the data points would be PWRB and FRQB. See above for a description of dBm header and data formats.

UPDT Select Update Data Trigger Reset Output Mode. Prepares the PPM for power measurement data taking routines using UPDN.

UPDN Update Data Now. Take a power reading when the next trigger occurs. This command is only operational if the PPM is in the Update Trigger Reset Mode. See UPDT.

The PPM will output a single data point each time UPDN is received. The output formats are the same as those described under UPDC. If FPVO is being used, the frequency at which the power measurement was taken is also output. See UPDC and FPVO.

3.3.5 Graph Mode GPIB Operation

Using the Graph Mode instead of the Peak Mode allows autoscaling of a pulse, and provides you with a display of the pulse. The Pulse and Marker sub-modes allow automatic timing measurements to be made. You must first place the PPM in the appropriate sub-mode before using the timing measurement command.

In the Graph Mode, the PPM can use a plotter to draw the shape of the pulse. In the Cursor sub-mode, the delay and trigger parameters are written on the plot. The Pulse and Marker sub-modes add the results of their respective timing measurements.

Delay values used by the instrument (Cursor, Start, and Marker, but not Window) are all displayed and output relative to the Reference Delay at the time the delays are specified. When the Reference Delay is changed, it will effect all of the other indicated delay values.

The real timing of the functions described above (relative to the trigger) remains the same, but the displayed and GPIB output times of these functions are all in relation to the Reference Delay. When the Reference Delay changes, the other delays change accordingly. For example, if the Cursor Delay was 5 ns and the Reference Delay was increased by 2 ns, the Cursor Delay would decrease to 3 ns. Therefore, Reference Delay entries should always be made first. Most applications and measurements will not require changing the Reference Delay from its default setting of 0.000 nanosecond.

The information to be given next is in ascending order of complexity. All functions that provide results on an automatic basis will be covered first. This should reduce programming time by allowing the PPM's internal software to take care of various tasks such as rise time.

Obviously, there are some types of pulses that cannot easily be measured automatically. If it is required that algorithms be devised to extract pulse information, the PPM should serve this purpose well by using the manual commands and functions which will be covered later in this section.

Graph Sub-Mode Selection Commands

GRFA	Select Graphic display mode (Cursor sub-mode), channel A.
GRFB	Select Graphic display mode (Cursor sub-mode), channel B.
MRKA	Select Marker sub-mode display, channel A.
MRKB	Select Marker sub-mode display, channel B.
PULA	Select Pulse Parameters sub-mode, channel A.
PULB	Select Pulse Parameters sub-mode, channel B.

Automatic Functions of the Graph Mode

The following commands will instruct the PPM to automatically carry out a procedure of some kind. In most cases, only instrument settings are made. In some cases, settings are made and appropriate information is output to the controller.

When using the PPM's graphic capabilities, it should be kept in mind that any operations are only applicable to Pulse measurements. All pulse operations require a trigger of some kind. Therefore, before attempting GPIB operations it is advised to become familiar with the manual operation of the PPM. To ensure that the instrument will trigger properly, the Internal Channel A, Internal Channel B, or the External Trigger function must be selected.



NOTE: Failure to trigger for any pulse operation over the GPIB will result in placing the PPM in a Waiting for Trigger state.

Reading and Defining Pulse Parameters

The following commands read the current values set for the pulse parameters:

* PUFT Get Pulse Fall Time. The unit will respond with:

FALAdddddE-e (If channel A selected)

FALBddddddE-e (If channel B selected)

(d = seconds; e = exponent)



NOTE: *PUFT, *PURT, and *PUWD operate only in the Graph Mode.

* PURT Get Pulse Rise Time. The unit will respond with:

RISAdddddE-e (If channel A selected)

RISBddddddE-e (If channel B selected)

(d = seconds: e = exponent)

* PUWD Get Pulse Width. The unit will respond with:

WIDAdddddE-e (If channel A selected)

WIDBddddddE-e (If channel B selected)

(d = seconds: e = exponent)

The following commands set new values for the pulse parameters:

PUFSddd Set Pulse Fall Time - Start %.

Where d = % expressed in 0.1% units. Allowable range is 1 to 999 (0.1% to 99.9%)

PUFEddd Set Pulse Fall Time - End %

Where d = % expressed in 0.1 % units. Allowable range is 1 to 999 (0.1% to 99.9%)

PURSddd Set Pulse Rise Time - Start %

Where d = % expressed in 0.1% units. Allowable range is 1 to 999 (0.1% to 99.9%)

PUREddd Set Pulse Rise Time - End %

Where d = % expressed in 0.1 % units. Allowable range is 1 to 999 (0.1% to 99.9%)

PUWSddd Set Pulse Width - Start %

Where d = % expressed in 0.1 % units. Allowable range is 1 to 999 (0.1% to 99.9%)

PUWEddd Set Pulse Width - End %

Where d = % expressed in 0.1% units. Allowable range is 1 to 999 (0.1% to 99.9%)

Automatic Window Delay Selection Related Commands (Autoscaling)

* AUTO Autoscale Current Pulse Profile. If SRQ is enabled, it will be sent at the completion of Autoscaling. Successful Autoscaling can be determined by checking the value of the Status byte.

AVASnnn Select the Number of Averages, n, for Autoscaling (1 to 999). This command can be useful when attempting to Autoscale a pulse in a noisy environment. The more stable the pulse to be Autoscaled is, the less averages required. This setting is independent of other averaging settings such as AVCW or AVPK.

The number of averages set by this command is never reset to a default value (not even by a Device Clear command). Therefore, it is advisable to set the desired value prior to commencing the Autoscaling function, or to set it once at the beginning of the program and not change its value again.

ASDLnnnnnn.n Select Maximum Expected Pulse Width for Autoscaling. The purpose of this command is to allow autoscaling of narrow pulses with high repetition rates. (n = 0.5 to 200,000 microseconds).

The maximum expected pulse width set by this command is never reset to a default value (not even by a Device Clear command). Therefore, it is advisable to set this to the desired value prior to activating the Autoscale function.

3.3.6 Marker Timing Measurements

A trigger must occur on a consistent basis to make repeatable pulse measurements for profiling operations. Erratic pulse trains or profiles can lead to errors or confusion. In situations where pulse widths or repetition rates are likely to continually vary, it would be better to make single pulse measurements in the Peak Mode. However, to make single pulse measurements, you should know where the Cursor Delay should be set to make the measurement.

The commands in the Automatic Timing description in this section allow for easy measurement of the most commonly desired pulse parameters. These include rise time, fall time, pulse width and combinations thereof. The automatic measurements are determined by conventions commonly used in the microwave industry. For example, rise time would be from the 10% to 90% power points on the leading edge of the pulse. However, there are still some gray areas which must be taken into account when you use these automatic timing functions.

These gray areas include deciding what point on the pulse should be considered as the 100% power reference point for the PPM to use when determining the rise time, fall time, and pulse width.

It is obvious that, in most situations, it is more desirable to use the center of the pulse as the reference point. Special situations can, of course, occur where the setting of the reference point would be somewhat arbitrary.

The PPM handles the above problems in two ways. The first method is when Autoscaling is used. The Reference Power level is automatically set to a point more or less centered in time between the 3 dB points on the pulse. The power axis of the display is also adjusted so that the point selected as the reference point is set to the top of the display as 100%.

The second method is to allow you to set the Reference Power at some desired level. Power measurements can be taken at different points along the top of the pulse to find the optimum point at which to set the Reference Power. These decisions are based on the types of pulses it is expected will be encountered.

Reference Power Related Commands

- PRFAsnn.nn Set Channel A Reference Power for graphic display. Sets 100% power reference point as a reference for automatic timing measurements. It also serves to center the pulse on the power axis so that displays and plots of pulses with low amplitudes are expanded to show more resolution.
(s = polarity; nn.nn = dBm value)
- PRFBsnn.nn Set Channel B Reference Power for graphic display. Sets the 100% power reference point as a reference for automatic timing measurements. It also serves to center the pulse on the power axis so that displays and plots of pulses with low amplitudes are expanded to show more resolution.
(s = polarity; nn.nn = dBm value)
Min Value: -60.00 dBm, Max Value: +110.00 dBm

Sample Program:

```

10 P=0 ! CHANNEL A REFERENCE
20 ! POWER IN DBM
30 !
40 ! CHANGE CHANNEL A REFERENCE
50 ! POWER
60 OUTPUT 704;PRFA;P
70 !
80 ! CHANGE CHANNEL B REFERENCE
90 ! POWER
100 OUTPUT 704;PRFB;P
110 END

```



NOTE: RPOA and RPOB are operable only in the Graph Mode.

RPOA Output Current Reference Power for Channel A. If the PPM is in the linear mode it will output:

RFALnn.nnEsnn
(nn.nn = Watts; Esnn = exponent)

If the PPM is in the dBm mode it will output:

RFADsnn.nn
(nn.nn = dBm; s = polarity)

RPOB Output Current Reference Power for Channel B. Linear mode output is:

RFBLnn.nnEsnn
(nn.nn = Watts; Esnn = exponent)

The dBm mode output is:

RFBDsnn.nn
(nn.nn = dBm; s = polarity)

Automatic Timing Measurement Commands

When making timing measurements, the delay window should be set so that the time to be measured corresponds to at least one third of the total delay. For example, do not use a delay window of 10 μ s to measure rise times faster than 3 μ s; go to a shorter delay window.

(Note: *RISE, *FALL, *PLWD, *RSFL, and *RSWD are operable only in the Marker Mode)

***RISE** Measure and output rise time of the displayed pulse profile. Rise time is from the 10% power point to the 90% power point on the rising edge of the pulse. Output format for channel A is:

RISAnn.nnnEsnn

(n = seconds; Esnn = exponent)

Output format for channel B is:

RISBnn.nnnEsnn

***FALL** Measure and output fall time of the displayed pulse profile. Fall time is from the 90% power point to the 10% power point on the falling edge of the pulse. Output format for channel A is:

FALAnn.nnnEsnn

(n = seconds; Esnn = exponent)

Output format for channel B is:

FALBnn.nnnEsnn

***PLWD** Measure and output pulse width of the displayed pulse profile. Pulse width is the time between the 50% power points on the rising and falling edges of the pulse. Output format for channel A is:

WIDAnn.nnnEsnn

(n = seconds; Esnn = exponent)

Output format for channel B is:

WIDBnn.nnnEsnn

***RSFL** Measure and output rise time and fall time of the displayed pulse profile. For definitions, see *RISE and *FALL descriptions. Output format for channel A is:

RISAnn.nnnEsnn,FALAnn.nnnEsnn

(n = seconds; Esnn = exponent)

Output format for channel B is:

RISBnn.nnnEsnn,FALBnn.nnnEsnn

***RSWD** Measure and output rise time and pulse width of displayed pulse profile. For definitions of rise time and pulse width, see ***RISE** and ***PLWD** descriptions. Output format for channel A is:

RISAnn.nnnEsnn,WIDAnn.nnnEsnn

(n = seconds; Esnn = exponent)

Output format for channel B is:

RISBnn.nnnEsnn,WIDBnn.nnnEsnn

***WDFL** Measure and output pulse width and fall time of displayed pulse profile. For definition of fall time and pulse width, see ***FALL** and ***PLWD** descriptions. Output format for channel A is:

WIDAnn.nnnEsnn,FALAnn.nnnEsnn

(n = seconds; Esnn = exponent)

Output format for channel B is:

WIDBnn.nnnEsnn,FALBnn.nnnEsnn

3.3.7 Manual Marker Placement/Timing Measurement Commands

The PPM has a very forgiving command syntax. It is possible to send many commands in one string. For example, it is possible to use one string to place four different markers and then have the PPM output two pairs of delay differences.

Due to the upgrading of the software functions in the 8500A instruments, some of the commands shown in this section will not be required when new code is written for the 8501A/8502A meters. The commands are retained in this manual for users with programs written for older 8500 instruments, and who want to cross-reference for the new 8500A instruments. If old code has been written for an 8500 instrument and includes some of these commands, the program will still operate with the 8500A but the commands will have no function. The term No Op is used in the descriptions for these commands. The commands that fall into this category will be defined.

The MRKA (or B) command must always be executed before any other marker bus commands will be accepted.

MKPRn,xx.x

Place Marker n (1 to 4) on the rising edge of the pulse at the % reference power defined by xx.x, and output the delay. The specified % reference must be between 0.1% and 99.9%. If channel A is in use, the PPM will output:

MRKAm,snn.nnnEsnn

If channel B is in use, the PPM will output:

MRKBm,snn.nnnEsnn

(m = marker number; s = polarity; nn.nnn = delay in seconds; Esnn = exponent)

MKPFm,xx.x

Place marker n (1 to 4) on the falling edge of the pulse at the reference power defined by xx.x, and output the delay. The specified reference power must be between 0.1% and 99.9%. If channel A is in use, the PPM will output:

MRKAm,snn.nnnEsnn

For channel B, the output is:

MRKBm,snn.nnnEsnn

(m = marker number; s = polarity; nn.nnn = delay in seconds; Esnn = exponent)

Because markers are always placed in the 8500A, the MKDF and MKPA commands described next will take only the latest computation and send it over the bus if they are included in the command string for the 8500A. The MKDF-1 command is a No Op command because markers are always placed.

MKDFm,n

Place marker numbers m and n according to their previously defined % reference powers and positions on the pulse profile, and output the difference between their respective delays. If channel A is in use, the PPM will output:MDFA,m-n,nn.nnnEsnn.

If -1 is the argument for MKDF, markers m and n must have been previously defined for automatic placement. Otherwise the default settings will be used. The defaults are:

- M1 = 2.5%
- M2 = 17.8%
- M3 = 46.9%
- M4 = 90%

If channel B is in use, the PPM will output:

MDFB,m-n,nn.nnnEsnn

(m = first marker number defined;
n = second marker number defined;
nn.nnn = the delay of m minus n in seconds;
Esnn = exponent)

MKPA Place all four markers according to their previously defined % reference powers and positions on the pulse profile and output their respective delays. For channel A, the output is:

MRKA1,snnn.nnEsnn;2,snnn.nnEsnn;3,snnn.nn Esnn;4,snnn.nnEsnn

If channel B is in use, the output is:

MRKB1,snnn.nnEsnn;2,snnn.nnEsnn;3,snnn.nn Esnn;4,snnn.nnEsnn

The numbers 1, 2, 3 & 4 represent the marker numbers to be used. The snn.nnEsnn following each marker number is the delay time of that marker with respect to the reference delay.
(s = polarity; nnn.nn = delay in seconds; Esnn = exponent.)

The arguments between each set of marker information are separated by a semi-colon.

If a marker number cannot be used for some reason or if the PPM could not place the marker, an SRQ will be generated and the marker will not be placed. Then the instrument will output a delay of 0.00 00E-99 seconds for that marker. If all markers are placed successfully, a service request will be generated and the status condition will be 31. If one or more markers are not placed for the reasons described above, then the status condition will be 37 after SRQ.

Since markers are set at percentages of reference power and then the delay is computed by the 8500A instruments, the MKDA and MKDB commands described next are classed as No Op with the 8500A instruments.

MKDAm,snnnnnn.nn

Set Marker Number m to Desired Delay, n, in microseconds on Channel A. (200,000 microseconds maximum)

MKDBm,snnnnnn.nn

Set Marker Number m to Desired Delay, n, in microseconds on Channel B. (200,000 microseconds maximum)

Since marker information is constantly being updated in the 8500A, the MKCA and MKCB commands described below are No Op with the 8500A instruments.

MKCAm Clear Marker Number m on Channel A.

MKCBm Clear Marker Number m on Channel B.

The preceding two commands clear both the current marker delay and any definition of automatic marker placement. In other words, they define the marker not to be placed.

3.3.8 Window and Cursor Control Commands

Some commands can be used in the Graph Mode as well as the Peak Mode of operation. Peak power measurements are made by placing the Cursor at the desired time point on the pulse to be measured. The Cursor Delay is with respect to the Reference Delay. Therefore, in the Peak Mode of operation, it is possible to set the Reference Delay and the Cursor Delay. These two commands are repeated here for use in the Graph Mode of operation.

Reference Delay is primarily used only in situations where you want to pick an arbitrary point on the pulse as the reference to which all other timing measurements are to be made. One example might consist of a gaussian shaped TACAN radar pulse that is slightly distorted. You might want to make timing measurements with respect to the highest point on the pulse. You might also want to know the timing of the 3 dB point of the pulse with respect to its peak. When in doubt, the Reference Delay should be set to 0.0000 nanoseconds.

Besides the Reference Delay and Cursor Delay, the Start Delay and Window Delay can also be controlled. When the Reference Delay is 0, the Start Delay is the time between the occurrence of a trigger and the beginning of the display of information on the PPM's graphic display. The Window Delay is the time window shown on the PPM display. By expanding or contracting the window, it is possible to view a wider or narrower pulse as desired. If Autoscaling is used, the PPM makes these settings automatically.

RDLAnnnnnn.nn Set Channel A Reference Delay. This is an arbitrary reference point for referencing other timing measurements.

Min. Value: 0 μ s, Max. Value: 213999.97 μ s

(n=microseconds)

RDLBnnnnnn.nn Set channel B Reference Delay. This is an arbitrary reference point for referencing other timing measurements.

Min. Value: 0 μ s, Max. Value: 213999.97 μ s

(n = microseconds)

CDLAsnnnnnn.nn Set Cursor Delay for Channel A. Sets the timing position of the Cursor on the graphic display, or for Peak measurements. The Cursor is the vertical line on the display where the power reading (CSR PWR) is taken. (Timing is relative to the Reference Delay.)

	(n = microseconds; s = polarity) Min. Value: 0 - Reference Delay, Max. Value: 213999.97 μ s - Reference Delay
CDLBSnnnnnnn.nn	Set Cursor Delay for Channel B. Sets the timing position of the Cursor on the graphic display, or for Peak measurements. The Cursor is the vertical line on the display located where the power reading (CSR PWR) is taken. (Timing is relative to the Reference Delay.) (n = microseconds; s = polarity) Min. Value: 0 - Reference Delay, Max. Value: 213999.97 μ s - Reference Delay
CDOA	Output Current Channel A Cursor Delay. The PPM will output: CDLAsnn.nnnEsnn (s = polarity; nn.nnn = delay in seconds; Esnn = exponent)
CDOB	Output Current Channel B Cursor Delay. The PPM will output: CDLBSnn.nnnEsnn (s = polarity; nn.nnn = delay in seconds; Esnn = exponent)
SDLASnnnnnnn.nn	Start Delay for Channel A. Sets timing position of left side of graphic display. Timing is relative to the Reference Delay. (n = microseconds; s = polarity) Min. Value: 0 - Reference Delay, Max. Value: 213999.97 μ s - Window Delay - Reference Delay
SDLBSnnnnnnn.nn	Start Delay for Channel B. Sets timing position of left hand side of graphic display. Timing is relative to the Reference Delay. (n = microseconds; s = polarity) Min. Value: 0 - Reference Delay, Max. Value: 213999.97 μ s - Window Delay - Reference Delay
WDLAnnnnnn.nn	Delay Window for Channel A. Sets the amount of time from the left side to the right side of the graphic display.
WDLBnnnnnnn.nn	Delay Window for Channel B. Sets the amount of time from the left to the right side of the graphic display. (n = microseconds; s = exponent) Min. Value: 12 ns, Max. Value: 213999.97 μ s - Start Delay - Reference Delay

3.3.9 Commands to Output Graphic Data to a Controller

The PPM can be programmed to output data in several ways as described in Section 3.2.5. When working with graphic displays it may be useful to enter the entire pulse profile into the controller. Once data has arrived at the controller, various programmed operations can be conducted. For example, you can program the controller to calculate the peak-to-peak pulse flatness. The advantage of this method of data acquisition is that it is not necessary to go through the procedure of placing the cursor, taking a power reading, and then repeating the procedure until all points of interest are entered into the controller.

The PPM graphic display dump capability allows the controller to use one command to fetch 118 data points along the pulse profile, as well as any pertinent timing settings relating to the profile being examined.

DUMG

Output All 118 Power Measurement Points of the Displayed Pulse Profile. If Channel A is in use, the PPM will output:

```
RDLAnn.nnnEsnn,  
SDLAnn.nnnEsnn,  
WDLAnn.nnnEsnn,  
PWRAnnn.nnEsnn,nnn.nnEsnn, (repeats until all 118 data points have been output)
```

(Esnn = exponent)

The PPM outputs the Reference Delay (RDLA) in seconds (nn.nnn), then the Start Delay (SDLA), and then the Window Delay (WDLA). This information is followed by the 118 power readings representing the pulse profile. All fields and data points are separated by commas. The header for the power readings is PWRA. The power readings take the form of nnn.nnEsnn; where nnn.nn is always in Watts, and Esnn is the exponent.

When the PPM outputs using Channel B, the headers change to indicate B channel:

```
RDLB      SDLB  
  
WDLB      PWRB
```

3.3.10 Plotting Commands

As previously mentioned, there is very little reason to plot or conduct graphic operations in the Graph Mode. All of the operations conducted through the GPIB can be accomplished in the Marker Mode. (This is not completely true in the manual mode of operation.) Therefore, it is assumed that the PPM is in the Marker Mode of operation when executing any of the commands listed in this section for making hardcopy plots.

As described in the Stand Alone Plot Output Mode description, the PPM has two different plotting modes. The Stand Alone Plot mode should not be used when the instrument is under the control of a remote controller. Also, the Stand Alone Plot mode should not be initiated from the front panel of the PPM when the instrument is under GPIB control.



NOTE: For proper system operation, make sure that no active controller is on the bus when the front panel function is initiated.

Before a plot is made, you might want to enter a part number or code number that can be used for reference. These commands are summarized in the following description.

PLCNaaaaaaaaaaaa

Set Code Number for plot to ASCII string represented by up to 12 characters (a).

PLPNbbbbbbbbbbbb

Set Part Number for plot to ASCII string represented by up to 12 characters (b).

PLOT Plot pulse profile currently displayed. Marker information will be plotted if the PPM is in the marker sub-mode. Pulse information will be plotted if the PPM is in the pulse sub-mode.

There is also a sample program in Section 3.2.5 showing how to format the required listen and talk addressing procedures.

PLTT This is the same as the PLOT command, but at a slower speed for transparency plots.

PLTM Change to Marker sub-mode, and then Plot.

PTTM Same as PLTM, but at a slower speed for transparency plots.



NOTE: If you want to save a plot on disk exactly as it would have been plotted by a digital plotter, the entire HPGL plot string can be entered into a variable in the GPIB controller using the following program:

```
10 DIM A$(CCCCC) ! NEED VARIABLE SIZE
20 ! HERE
30 OUTPUT 704;PLOT
40 ENTER 704;A$ ! ENTER PLOT HPGL
50 ! COMMANDS.
60 ! ADD PROGRAM LINES HERE TO
70 ! STORE A$
.
.
100 END
```

A\$ can be recalled later from the disk file for plotting.

When plots are output from the PPM, the pulse profile will always be in a linear format including when the reference power is labeled in dBm.

3.3.11 Programming Notes

The programming commands for the PPM can be strung together as long as the maximum length limitations specified in the General Information discussion are not exceeded.

This feature enables procedures to be formatted in a logical manner, and reduces the overall number of programming lines required. The following sample program shows how this can be done.

```
10 CLEAR 704! DEVICE CLEAR
20 OUTPUT 704;ASDL200,AVAS25,AUTO
30 OUTPUT 704;PLCNabcdefg;PLPNqwerty;
40 RSFL,PLTM
50 SEND 7;UNL
60 SEND 7;LISTEN 6
70 SEND 7;TALK 4
80 SEND 7;DATA
90 WAIT 180
100 SEND 7;UNT UNL
110 END
```

Line 20: Sets the maximum pulse width for autoscaling to 200 microseconds; sets the averaging for autoscaling to 25 averages; instructs the PPM to autoscale.

Lines 30 & 40: Set the code numbers for the plot to abcdefg; sets the part number for the plot to qwerty; instructs the PPM to find the rise and fall times of the displayed pulse; instructs the PPM to place the markers as defined and to plot the displayed pulse profile.

The remaining lines in the sample program are used for bus handling.

Care should be exercised when grouping commands. If conflicting commands are sent in the same string, the last one to be received will be implemented. For example:

```
OUTPUT 704;MRKA,CDLA5,PKPA
```

This program line would result in the cursor delay being set at 5 μ s, but the PPM would enter the channel A Peak Mode, not the Marker Mode as indicated by the MRKA portion. In other words, the PPM does not execute any of the commands until (CR) (LF) are received at the end of the program line.

3.4 Service Requests and Serial Poll

The ability of the PPM to request service over the GPIB can be enabled or disabled by a GPIB command. The PPM's power-on default status enables the SRQ function of the instrument. Usually a service request is generated to report a significant condition to the controller, and the status byte will not be cleared until it is read; REN is disasserted; or the instrument is reset. The exception to this is the output-ready condition which will also be cleared when the data is read. If SRQ is disabled the status bytes are not saved, but the current condition is available to be read using the STAT command.

All SRQs are buffered in the PPM. If another error condition is detected after the first value has been read, then the SRQ will remain asserted with the second value in the status byte. Up to 16 status conditions can be buffered in this way. Once a non-zero condition is read from the PPM, the status byte should be read until it becomes zero by taking appropriate action. For example, if the error were over-range power, over-range SRQs will continue until the error is fixed.

When the controller reads the status byte through the GPIB via a serial poll, the 7th bit will always be high if the PPM was requesting service. Thus, the actual value of the PPM status will be the byte that is read minus the 7th bit. When the PPM's status is read by the STAT command (when SRQ is disabled), the byte that is sent out always has the 7th bit as zero (see 3.2.5). Any status condition that has the sixth bit high will indicate abnormal device operation. In decimal form, this is the case for any status code of value greater than or equal to 32.

Sample Program:

```
10 ! THIS PROGRAM USES SERIAL POLL
20 ! AND SRQ TO DETERMINE IF THE
30 ! PPM SUCCESSFULLY AUTOSCALED
40 ! AS INSTRUCTED.
50 !
60 A=0
70 ! ENABLE GPIB INTERRUPT
80 ON INTR 7 GOSUB 180
90 ENABLE INTR 7;2
100 !
110 ! ENABLE PPM SRQ
120 OUTPUT 704;SRQE
130 ! INSTRUCT PPM TO AUTOSCALE
140 OUTPUT 704;AUTO
150 !
160 ! SRQ WAIT LOOP
170 GOTO 160
180 ! SRQ HANDLING ROUTINE:
190 ! CONDUCT SERIAL POLL, AND
200 ! PUT STATUS BYTE VALUE IN
210 ! VARIABLE A
220 A=SPOLL(704)
230 ! SUBTRACT 64 FROM STATUS
240 ! BYTE TO GET STATUS CODE
250 ! NUMBER CORRECT. AUTOSCALING
260 ! RETURNS A CODE OF 27.
270 !
280 A=A-64
290 IF A=27 THEN GOTO 330
300 DISP AUTOSCALING PROBLEM
310 GOTO 340
320 RETURN
330 DISP AUTOSCALING OK
340 BEEP
350 END
```

3.4.1 Error Conditions

When it is first activated, the PPM will check to see if there has been a change in its internal software. An SRQ will be sent over the bus if any change is detected. The PPM will attempt to capture the PROM data from the detector(s), and will also check the detector's serial number(s) to see if there has been a detector change. The instrument will also detect a change in detectors that occurs at any time during a test and measurement operation. When detectors are changed, the instrument will request service and calibration will be required. No data can be taken over the GPIB until recalibration has been completed, or the detector has been removed or changed for the detector that was last calibrated.

If the instrument detects a power over range condition, it will send an SRQ. If data is being collected to be output over the bus, the data will still be available in memory and can be read out. However, if the power level was outside the PPM's normal range the data may not be accurate. This data may still give some idea of what power was being measured. If a serious over-range condition occurred, detector damage may have resulted.

If an under-range condition occurs when the PPM is operating under bus control and it is not collecting data to be sent over the bus in the Update Data Trigger Reset, or Update Data Continuously Modes, then the instrument will not signal the controller (with a service request) that the under range condition has occurred. Instead, the data display will display the standard under range message of ———. However, if the instrument is collecting data to send over the bus and the data is under range, then the PPM will request service (if SRQ is enabled) to report the condition if you asked for it to be reported. If the instrument is in the Update Data Trigger Reset Mode, the under range condition will be reported (via a serial poll) before the output ready condition. The data that will be output over the bus, if the data is still requested, will be an impossible value to indicate to the controller that an under range condition has occurred and that the data is not valid. If the log (dBm) mode were in use, the instrument would output a reading of -999.99 dBm. In the linear mode, the reading will be 000.00E-99.

3.5 1018B Emulation

Emulation of the 1018B instrument is accessed through the front panel.

The differences in the 1018B emulation mode to standard 8501A/8502A PPM operation are as follows:

Commands

The command set is limited to the three following 1018B commands:

Command	Argument
?	Update data, behaves exactly as the UPDN PPM command
< nnn	Sets cursor delay to a value between 0 and 9.99 μ s
> nnn	Sets cursor delay to a value between 0 and 99.9 μ s One to three digits are required, no sign or decimal point is allowed.

The instrument will only read the first 1018B command it receives and ignore the balance of any command string it receives. If the string does not start with a valid 1018B command, the instrument will ignore the entire string and take no action.

Output Data Modes

There are two output data modes in the 1018B Emulation Mode. These are Update Data Trigger Reset and Update Data Continuously. The default state upon entering the 1018B Emulation Mode is Update Trigger Reset. After that, the output mode can be changed from the front panel (see the Front Panel Menus description Section 3.2.2). The two modes work in exactly the same way as with the PPM except that the data output format is different.

Output Format

The data will always be output in a string consisting of a polarity sign, four digits, a comma, one last digit with a value of 0 - 3, a carriage return, and then a line feed character (all data lines low) sent with EOI. The first four digits represent the measurement, and the last digit after the comma indicates the range.

Range	Data Format
0	snnn.n dBm
1	snnn.n microwatts
2	snn.nnn milliwatts
3	sn.nnn milliwatts



NOTE: The sign will always be positive for linear values.

Examples:

-0147.0(CR)(LF)(NULL - EOI) = -14.7 dBm

+1257.3(CR)(LF)(NULL - EOI) = +1.257 mW

In the Update Continuously Mode, a continuous string of these measurements will be sent, including the terminating characters, until the PPM is untalked.

Remote State

As in the regular PPM operation mode, the instrument must be in the REMOTE state to accept any commands over the GPIB or to output any data. However, unlike the standard PPM operation, the front panel is fully active while in the REMOTE state and more Menu options will become active in 1018B emulation (see the Front Panel Menus discussion in this section). This imposes two requirements for the operator. One is the fact that a cursor delay will be accepted on either the front panel or over the GPIB. The most recent cursor delay will determine the measurement. The other difficulty is that a measurement and not a menu prompt must be displayed on the screen for the instrument to be able to collect data. If the controller tries to collect data while the PPM has a front panel menu displayed, the PPM will take no action until it returns to displaying data on the front panel. Then it will collect and output the data. Also, there is no return to local escape sequence while in REMOTE since the front panel is not locked out. There is no local lockout feature either.

Serial Poll

The serial poll feature operates similar to the 1018B serial poll function. The only time SRQ is asserted is if an output is ready and the value of the status byte is zero.

Front Panel Menus

The front panel menu will include three options regarding GPIB control when in the 1018B emulation mode. These options represent capabilities which can be set on the 1018B front panel, but not on the PPM in general usage. This is because each of these options are directly controllable over the GPIB in normal PPM usage.

Disable/Enable SRQ:	This allows the SRQ capability to be enabled or disabled with the same effects as the SRQE and SRQD PPM GPIB commands. Whatever option is offered, enable or disable, will be the opposite of the current state.
Update on Trigger Reset/Continuous:	This sets the Output Mode. The choice offered will be the opposite of the current mode. Upon entering the 1018B emulation mode, the Output Mode will be set to Update on Trigger Reset.
End 1018B Emulation Mode:	This prompt will replace the menu prompt that initiated the 1018B Emulation Mode.

Analog Output

When using the PPM in the 1018B Emulation Mode, it should be kept in mind that the 1018B instrument has a 10 mV/dB Analog Output while the PPM has 100 mV/dB. If the 10 mV/dB output of the 1018B is required, a 10:1 resistive L attenuator can be placed on the PPM's output.

Two Detectors

The Model 8502A has two detectors instead of only one as does the 1018B. When in the 1018B Emulation Mode, either detector can be used with the choice made through the front panel. It is up to the operator to know which detector is active when the command is given over the GPIB to change cursor delay or to take a measurement. If both detectors are active, the instrument will ignore any GPIB commands and not be able to output any data.

Reference Delay, Correction of Carrier Frequency, and Offset vs 1018B Direct Mode

A correction will always be made on the carrier frequency. However, to simulate the 1018B direct mode if desired, the reference delay and offset features of the PPM can be negated by setting both to zero via the front panel.

Over and Under Range Conditions

The maximum value that the 1018B can output is 19.99 mW. Any power reading over that will just result in a reading of 19.99 mW when in the linear mode. In the log mode, the reading could be displayed up to 099.99 dBm. The minimum values are 000.0 μ W in the linear mode or a reading of -099.9 dBm indicating an under range condition in the log mode.

1018B Features Not Emulated by the PPM

Following is a list of the differences in GPIB operation when the Model 1018B Peak Power Meter is replaced on the bus with a Model 8501A or Model 8502A Peak Power Meter (PPM):

1. The PPM has no ability to be directly triggered with a GET command. It can only reset its trigger to capture the next pulse that will trigger the instrument.
2. The PPM has no talk only mode.
3. Whereas the 1018B allowed completely independent talk and listen addresses, the PPM must have the same talk and listen addresses. The addresses are set as one via the front panel.
4. The 1018B locks out the front panel delay setting capability while in the REMOTE state. The front panel delay setting ability remains active on the PPM when in the REMOTE state of the 1018B Emulation Mode.
5. The 1018B will take commands and output data even if it is not in the REMOTE state. This requires the instrument to be in REM.

3.6 Status Code Decimal Values

The decimal values of the various status codes minus the 7th bit are as listed below.

To determine the value with the 7th bit high, add 64 to the values listed in Table 3-1.

Table 3-1. Status Code Values and Conditions

Decimal Value	Condition
0	Operation normal, no condition to report
1	Output ready to be sent over GPIB
10	Self test passed
20	Calibration passed
25	Autozero passed
27	Autoscaling completed and passed
31	If RISE, PLWD, FALL, RSFL, RSWD, WDFL, PUFT, PURT, OR PUWD all measurements successfully made
33	Command string syntax error, command(s) not processed
34	Command string has invalid argument, command(s) not processed
35	Command string(s) incomplete when unlistened, string(s) sent so far are lost, command(s) not processed
36	PPM command buffer overflow. Limit of 128 character string exceeded. String lost, no commands processed
37	Cannot execute MKDF, markers to be measured are undefined. No command(s) processed
38	Command not executed, PPM not in REMOTE state
39	Command not implemented, no commands processed
40	GET sent when not in REMOTE
41	GET or UPDN command sent when not in the Update Data Trigger Reset Output Mode. If UPDN command, no command(s) processed
43	Not in Graph Mode or Marker sub-mode, must be in Graph Mode for AUTO (Autoscale Graph), or PLOT commands to function. Must be in Marker sub-mode for marker commands to function. No command(s) processed
44	Autoscaling, PLOT, DUMG, pulse parameter, or a marker placement command has been specified in the command string and a mode change requested later at some point in the same command string. Mode change not processed
45	STAT command sent while SRQ enabled, STAT command not active
46	SRQ buffer overflow, SRQ enabled and not being read quickly enough by the controller
48	Cannot enter Fast Measurement Mode. Either in linear, graph, or marker mode. No command(s) processed
49	Cannot execute RECL or WATT commands, or any graph or marker commands in the Fast Measurement Mode. No command(s) processed
50	Error in reading PROM data from detector A
51	Error in reading PROM data from detector B

Decimal Value	Condition
52	Calibration aborted for lack of a detector
53	Calibration passed, but with PROM read error
54	Calibration failed with PROM read error
55	Calibration failed
57	Autozero aborted for lack of detector
58	Autozero fail
59	Autoscaling aborted for lack of detector
60	Autoscaling interrupted by GPIB bus command, no trigger received
61	Unable to Autoscale
63	Unable to place markers specified or required to make a pulse parameter measurement
170	Self test failed
See Self-Test Failure Indications in Section 3.6 for a description and possible causes pertaining to Error Numbers 01 through 11. These will be decimal values 170 through 180, respectively	
184	New software detected. Must recalibrate both detectors
185	Serial numbers don't match. Must recalibrate A and B detectors.
186	Serial number doesn't match. Must recalibrate detector A
187	Serial number doesn't match. Must recalibrate detector B
189	Instrument operation failure. PPM will probably need to be reset
190	Under range. Measurement not accurate
191	Over range. Damage to instrument may have occurred

3.7 Summary of Bus Functions

3.7.1 Normal PPM Operation

The bus functions for normal PPM operation (under GPIB control) are defined in Table 3-2:

Table 3-2. Summary of Bus Functions

Code	Function
SH1	Complete source handshake capability
AH1	Complete acceptor handshake capability
T6	Basic talker and serial poll capability, unaddressed as a talker if listen addressed, no talk only mode
TE0	No talk-address extension capability
L4	Basic listener capability; unaddressed as a listener if talk-addressed — no listen-only mode
LE0	No listen-address extension capability
SR1	Complete service request capability (when SRQ enabled)
RL1	Complete remote local interface capability with local lockout capability
PP0	No parallel poll capability
DC1	Complete device clear capability [responds to device clear (DCL) and selective device clear (SDC)]
DT1	Complete device trigger capability [responds to group execute trigger (GET)]
C0	No controller capability

3.7.2 PPM Stand Alone Plot Operation

When the PPM is in the Stand Alone Plot mode, two functions will exhibit different capabilities. The Talker and Controller functions are redefined as follows:

T5: Same as T6 capability except it has talk-only capability while plotting.

C1, C3, & C28: System controller capability with the ability to send REN and interface messages, but with no capability to send IFC, respond to SRQ, conduct parallel poll, or pass control.

3.8 GPIB Command Summary

A summary of the GPIB commands referenced in this chapter are listed alphabetically in Table 3-3. When arguments are not required, the argument column is blank. If the command is not intended to make the PPM output a data string, the output string will indicate 'none'. Arguments are represented by lowercase characters while commands and output string headers (always four characters) are uppercase. The position of the decimal point can vary in Delay commands.

Table 3-3. GPIB Commands Format

Command	Argument
ACBC	Select Ratio Mode - Channel A (CW) to Channel B (CW) / none
ACBP	Select Ratio Mode - Channel A (CW) to Channel B (Peak) / none
APBC	Select Ratio Mode - Channel A (Peak) to Channel B (CW) / none
APBP	Select Ratio Mode - Channel A (Peak) to Channel B (Peak) / none
ASDLnnnnnn.n	Select Initial Delay Used for Autoscaling Pulse Profile / none (n = microseconds; 200,000 maximum)
AUTO	Autoscale Current Pulse Profile / none
AVASnn	Select Averaging Value Used for Autoscaling Pulse Profile / none (n = 1 to 999)
AVCWnn	Select Number of Averages for CW Power Measurement / none (n = 1 to 999)
AVPKnn	Select Number of Averages for Peak Power Measurement / none (n = 1 to 999)
CALA	Calibrate Channel A Detector. Takes time to complete - SRQ can monitor successful (or unsuccessful) completion / none
CALB	Calibrate Channel B Detector. Takes time to complete - SRQ can monitor successful (or unsuccessful) completion / none
CDLAnnnnnn.n	Set Channel A Cursor Delay / none (n = microseconds; 213,999.97 - Ref Dly maximum; 0 - Ref Dly minimum) Position of decimal point may vary. Cursor Delay is in respect to the Reference Delay. If Reference Delay = 0, then the Cursor Delay is with respect to the trigger.
CDLBnnnnnn.n	Set Channel B Cursor Delay / none (see CDLA)
CDOA	Read Out Current Channel A Cursor Delay / PPM will output: CDLAsnn.nnnEsnn s = polarity; n = Cursor Delay in seconds (decimal point may shift); Esnn = exponent value in engineering notation
CDOB	Read Out Current Channel B Cursor Delay / PPM will output: CDLBSnn.nnnEsnn (see CDOA)
CWAB	Select Dual Channel Mode: CW Both Channels / none
CWPA	Select Channel A Only: CW Power / none
CWPB	Select Channel B Only: CW Power / none

Command	Argument
DATF	Select Data Fast Operation (No EL Display) / none <i>NOTE:</i> Graph, Marker or Linear Power Modes cannot be used while operating in DATF. Conversely DATF cannot be used while in the Graph, Marker or Linear Power Modes. Do not use commands related to these modes when the DATF function is in use.
DATN	Select Data Normal Operation (Exit Data Fast) / none
DBMW	Select dBm Power Format / none
DCFAc.cc	Select Channel A Cal Factor / none (c.cc = Cal Factor; -9.99dB min, +9.99 dB max)
DCFBc.cc	Select Channel B Cal Factor / none (See DCFA)
DTMP	Read Out Temperature Difference of Detectors Since Last Calibration / PPM will output: DTPAsxx.x, DTPBsyy.y
DUMG	Graphic Display - Read Out Reference Delay, Start Delay, Window Delay, and 118 Displayed Data Points of Current Pulse Profile / When PPM is displaying channel A, it will output: RDLAnn.nnnEsnn,SDLAnn.nnnEsnn WDLAnn.nnnEsnn,PWRApp.ppEspp,pp.ppEspp..... (Ref.Dly, Strt. Dly, Wind Dly, Power - 118 points separated by commas. Delays (n) are in seconds; Powers are always in Watts)
FALL	Measure and Output Fall Time of Displayed Pulse Profile (90% to 10% on the falling edge of the pulse profile). This command erases previously set markers. The PPM will output the following string when operating in channel A: FALAnn.nnnEsnn For channel B: FALBnn.nnnEsnn (n = seconds; Esnn = exponent; s = polarity)
FPRVvv.vv,ss.ss,mm.mm	Select External Frequency Input Mode. Sweeper Connected to Rear Panel Input Determines Detector Frequency Response Correction / none (v = volts/GHz; 0.1 to 10.00; s = Start Voltage; 0 to 19.00; m = Start Frequency; 0 to 110.00 GHz)
FPVOvv.vv,ss.ss,mm.mm	Select FPVO mode. i.e. Selects the External Frequency input mode and causes output of current operating RF frequency with each power measurement taken while using UPDN or UPDC / none (see FPRV)
FQDS	Enable (Unhide) Frequency Information Display on PPM Front Panel / none
FQHD	Disable (Hide) Frequency Information Display on PPM Front Panel / none
FREQff.ff	Select Frequency for Detector Frequency Correction / none (f = frequency; 0.01 to 110.00 GHz)
GRFA	Select Graph Mode - Channel A / none
GRFB	Select Graph Mode - Channel B / none
MAXPsnn.nn	Set Power for Overrange Condition / none (s = polarity; n = power in dBm; +21.00 max -10.00 min)

Command	Argument
MINPsnn.nn	Set Power for Underrange Condition / none (s = polarity; n = power in dBm; -15.00 max -50.00 min) <i>NOTE:</i> Some of the following marker commands are no longer necessary when writing code pertaining to markers for the 8500A instruments. See Section 3.3.7
MKCA _n	(No Op command with the 8500A) Clear Marker Number Selected on Channel A / none (n = marker number to clear; 1 to 4)
MKCB _n	(No Op with the 8500A) Clear Marker Number Selected on Channel B / none (n = marker number to clear; 1 to 4)
MKDA _{n,dddddd.dd}	(No Op with the 8500A) Select Channel A Marker Delay number n and set the delay to d / none (n = marker number to clear; 1 to 4; d = marker delay in microseconds; 200,000 max)
MKDB _{n,dddddd.dd}	(No Op with the 8500A) Select Channel B Marker Delay number n and set the delay to d / none (See MKDA)
MKDF _{a,b}	Place Markers (a and b) which were previously selected and Output Their Delay Difference (a - b) Marker differences can also be de-selected - See MKDF-1 / When the PPM is in channel A it will output: MDF _{a,b,nn.nnnEsnn} (a = first marker; b = second marker; result will be the marker a delay minus the marker b delay)
MKDF-1	(No Op with the 8500A) Deselect all Marker Difference Pairs / none
MKPA	Autoplace All Four Markers as previously selected and Output Their Delays / If the PPM is in Channel A it will output: MRKA _{1,nn.nnnEsnn;2,nn.nnnEsnn;3,nn.nnnEsnn;4,nn.nnnEsnn} If the PPM is in channel B it will output the same as above only with MRKB header. (1, 2, 3 and 4 = marker numbers; n = delay in seconds; Esnn = exponent)
MKPF _{a,xx.x}	Place Given Marker on Falling Slope of Pulse Profile at the Selected % Power Reference and Output Its Delay / When the PPM is in channel A it will output: MRKA _{a,nn.nnnEsnn} When the PPM is in channel B it will output: MRKB _{a,nn.nnnEsnn} (a = marker number; 1 to 4; x = percent of reference power to place marker; 0.1% min 99.9% max; n = delay in seconds; Esnn = exponent)
MKPR _{a,xx.x}	Place Given Marker on Rising Slope of Pulse Profile at the Selected % Power Reference and Output Its Delay / When in channel A the PPM will output: MRKA _{a,nn.nnnEsnn} When in channel B the PPM will output: MRKB _{a,nn.nnnEsnn} (See MKPF)
MRKA	Select Channel A Marker Sub-Mode / none
MRKB	Select Channel B Marker Sub-Mode / none

Command	Argument
OFFAsnn.nn	Set Channel A Offset / none (s = polarity; n = dB offset; -40.00 min +90.00 max)
OFFBsnn.nn	Set Channel B Offset / none (See OFFA)
PKAB	Select Dual Channel Mode: Peak Power Both Channels / none
PKPA	Select Channel A Only: Peak Power Mode / none
PKPB	Select Channel B Only: Peak Power Mode / none
PLCNx	Set Code Number to be Plotted / none (x = ASCII string of 12 characters or less)
PLOT	Plot Pulse Profile Currently Displayed GPIB interface must be managed correctly. PPM will output pulse profiles with relevant marker information (or without if desired) using HPGL graphics codes to a compatible digital plotter. See <i>Plot Output Mode</i> in Section 3.2.5 for plotting instructions.
PLPNx	Set Part Number to be Plotted / none (x = ASCII string of 12 characters or less)
PLTM	Change to Marker Sub-Mode and immediately begin plotting / See PLOT (This command ensures that the placement of markers is based on the same power measurement data as is sent to the plotter for increased accuracy of marker placement on the hardcopy plot.)
PLTT	Plot Pulse Profile Currently Displayed at Slower Speed for Transparencies / Same as PLOT but slower pen speed.
PLWD	Measure and Output Pulse Width of Pulse Profile Currently Displayed (50% point on rising edge of pulse to 50% point on the falling edge of the pulse). This command erases previously set markers / The PPM will output the following string when operating in channel A: WIDAnn.nnnEsnn For channel B: WIDBnn.nnnEsnn
PRFAsnn.nn	Set Channel A Reference Power for Graphic Display / none (s = polarity; n = dBm value; +110.00 max -60.00 min)
PRFBsnn.nn	Set Channel B Reference Power for Graphic Display (s = polarity; n = dBm value; +110.00 max -60.00 min)
PTTM	Change to Marker Sub-Mode and plot at Slower Speed for Transparencies / Same as PLTT but with slower pen speed.
PUFE	Set Pulse Fall Time - End % / none [n = % expressed in 0.1% units; 1 to 999 (0.1% to 99.9%)]
PUFS	Set Pulse Fall Time - Start % / none [n = % expressed in 0.1% units; 1 to 999 (0.1% to 99.9%)]
PUFT	Measure and output fall time of the pulse profile displayed in the Pulse Parameters sub-mode. / The PPM will output the following string when operating in Channel A: FALAnnnnn.nEsnn For Channel B: FALBnnnnn.nEsnn (n = seconds; Esnn = exponent; s = polarity)
PULA	Select Channel A only: Pulse Parameter submode / none

Command	Argument
PULB	Select Channel B only: Pulse Parameter submode / none
PURE	Set Pulse Rise Time - End % / none [n = % expressed in 0.1% units; 1 to 999 (0.1% to 99.9%)]
PURS	Set Pulse Rise Time - Start & / none [n = % expressed in 0.1% units; 1 to 999 (0.1% to 99.9%)]
PURT	Measure and Output Rise time of Pulse Profile Displayed in the Pulse Parameters sub-mode./ The PPM will output the following string when operating in Channel A: RISAnnnnn.nEsnn (n = seconds; Esnn = exponent; s = polarity) For Channel B: RISBnnnnn.nEsnn (n = seconds; Esnn = exponent; s = polarity)
PUWD	Measure and Output Pulse Width of Pulse Profile Displayed in the Pulse Parameters sub-mode. / The PPM will output the following string when operating in Channel A: WIDAnnnnn.nEsnn For Channel B: WIDBnnnnn.nEsnn (n = seconds; Esnn = exponent; s = polarity)
PUWE	Set Pulse Width - End % / none [n = % expressed in 0.1% units; 1 to 999 (0.1% to 99.9%)]
PUWS	Set Pulse Width - Start % / none [n = % expressed in 0.1% units; 1 to 999 (0.1% to 99.9%)]
RDLAnnnnnn.nn	Set Channel A Reference Delay / none
RDLBnnnnnn.nn	Set Channel B Reference Delay / none (n = microseconds; 213,999.97 max)
RECLnn	Recall Non-Volatile Set Memory Number n / none (n = memory location; 0 to 10; 0 is the last setup before device clear or power off. The remainder are user memories in which setups can be stored from the front panel or see STOR command)
RISE	Measure and Output Rise time of Pulse Profile Currently Displayed (10% to 90% on the rising edge of the profile). This command erases previously set markers / The PPM will output the following string when operating in channel A: RISAnn.nnnEsnn For channel B: RISBnn.nnnEsnn (n = seconds; Esnn = exponent; s = polarity)

Command	Argument
RPOA	<p>Read Out Current Channel A Reference Power / The PPM will output channel A reference power in the following format:</p> <p>If operating in the Linear Power Mode:</p> <p style="padding-left: 40px;">RFALxx.xxEsnn</p> <p>(x = power in Watts; Esnn = exponent)</p> <p>If operating in the dBm power format:</p> <p style="padding-left: 40px;">RFADsnnn.nn</p> <p>(s = polarity; n = reference power in dBm)</p>
RPOB	<p>Read Out Current Channel B Reference Power. (Readout is the same as RPOA, substituting B or A)</p>
RSFL	<p>Measure and Output Rise and Fall Times of Pulse Profile Currently Displayed. See FALL and RISE for definitions used for fall and rise times / When operating in channel A the PPM will output:</p> <p style="padding-left: 40px;">RISAnn.nnnEsnn,FALAnn.nnnEsnn</p> <p>When operating in channel B:</p> <p style="padding-left: 40px;">RISBnn.nnnEsnn,FALBnn.nnnEsnn</p> <p>(n = delay in seconds; Esnn = exponent)</p>
RSWD	<p>Measure and Output Rise time and Pulse Width of Pulse Profile Currently Displayed. See RISE for definition of rise time. Pulse width is the time between the 50% power point on the pulse's rising edge and the 50% point on it's falling edge / Channel A readout is:</p> <p style="padding-left: 40px;">RISAnn.nnnEsnn,WIDAnn.nnnEsnn</p> <p>Channel B readout is:</p> <p style="padding-left: 40px;">RISBnn.nnnEsnn,WIDBnn.nnnEsnn</p>
SDLAnnnnnn.nn	<p>Set Channel A Start Delay / none</p> <p>(n = microseconds; position of decimal may vary. Max = 213,999.97 μs - Window Delay - Reference Delay; Min = 0 - Reference Delay. Start Delay is with respect to the Reference Delay. If Reference Delay is 0 then Start Delay is coincident with the trigger.)</p>
SDLBnnnnnnn.nn	<p>Set Channel B Start Delay / none (see SDLA)</p>
SELT	<p>Initiate Self-Test. Can be used with SRQ for a health check. See Service Requests in Section 3.4.</p>
SRQD	<p>SRQ Disable. See Service Requests in Section 3.4</p>
SRQE	<p>SRQ Enable. See Service Requests in Section 3.4</p>
STAT	<p>Output Status Byte. This command is only effective when SRQ is disabled. If sent while SRQ is enabled an SRQ will be generated. The PPM will output:</p> <p style="padding-left: 40px;">STATnnn</p> <p>(n = decimal number representing current Status Byte. See Status Byte Output in Section 3.2.5 and Service Requests in Section 3.4)</p>

Command	Argument
STORnn	Store Current PPM Settings in Non-Volatile Set-Up Memory Number n / none (n = number between 1 and 10)
TRGAsnn.nn	Select Channel A Internal Trigger and Set Level in dBm / none (s = polarity; n = trigger level - +16 dBm max -20 dBm min)
TRGBsnn.nn	Select Channel B Internal Trigger and Set Level in dBm / none (See TRGA)
TRGE	Select External Trigger Mode / none
UNDD	Disable PPM SRQ for Underrange Conditions. See Service Requests in Section 3.4 / none
UNDE	Enable PPM SRQ for Underrange Conditions. An SRQ will be generated if the power level measurement data is below the level set by MINP / none
UPDC	<p>Select Update Data Continuously Output Mode. The PPM will output a continuous stream of power measurement data points separated by commas. Every time the PPM receives a trigger a new data point is added to the stream. The formats described below can occur.</p> <p>When using the FREQ, DCFA (A Cal Factor), DCFB (B Cal Factor), or FPRV (Rear Panel Frequency Input) methods for detector frequency response correction, the PPM's Linear Mode data output string for channel A will be:</p> <p style="padding-left: 40px;">PWRAnn.nnEsnn,PWRAnn.nnEsnn,PWRAnn.nnEsnn</p> <p>(n = linear power in Watts; Esnn = exponent)</p> <p>This example shows a data string for 3 triggers. Subsequent triggers will produce more data points separated by commas in the form of PWRAnn.nnEsnn. For channel B the header before the data points would be PRWB instead of PWRA.</p> <p>The PPM's dBm Mode output for channel A would be:</p> <p style="padding-left: 40px;">DBMAsnnn.nn,DBMAsnnn.nn,DBMAsnnn.nn</p> <p>(s = polarity; n = dBm)</p> <p>This example shows a data stream for 3 triggers. Subsequent triggers will produce more data points separated by commas in the form of DBMAsnn.nn. For channel B the header before the data points would be DBMB instead of BDMA.</p> <p>When using the FPVO (Rear Panel Frequency Input and Output) method for detector frequency response correction, the PPM's Linear Mode data output string for channel A will be in the form:</p> <p style="padding-left: 40px;">PWRAmn.mmEsee,FRQAff.ffE+09,PWRAnn.nn Esee,FRQAggg.ggE+09</p> <p>(m = first power data point; f = first frequency data point; n = second power data point; g = second frequency data point; Esee = exponent for power in Watts; E+09 indicates frequency is in GHz)</p> <p>This example shows a data stream for 2 triggers. Subsequent triggers will produce more data points separated by commas in the form of PWRAnn.nnEsnn,FRQAff.ffE+09. If the PPM is in channel B the headers before the data points would be PWRB and FRQB. See preceding NOTE for description of dBm header and data formats.</p>

Command	Argument
UPDN	Update Data Now. i.e: Take a power reading when the next trigger occurs. This command is only operational if the PPM is in the Update Trigger Reset Mode. See UPDT./ The PPM will output a single data point each time UPDN is received. The output formats are the same as those described under UPDC except that each data point is not followed by a comma. Instead each point is followed by a carriage return followed by a line feed sent with EOI. If FPVO is being used, the frequency at which a power measurement was taken is output also. See UPDC and FPVO.
UPDT	Select Update Date Trigger Reset Output Mode. Prepares the PPM to take power readings using UPDN or GET / none
WATT	Select Linear Power Format / none
WDFL	Measure and Output Pulse Width and Fall-times of Pulse Profile Currently Displayed. See FALL for definition of fall time. Pulse width is the time between the 50% point on the pulse's rising edge and the 50% point on it's falling edge / When operating in channel A the PPM will output: WIDAnn.nnnEsnn,FALAnn.nnnEsnn For Channel B the output is: WIDBnn.nnnEsnn,FALBnn.nnnEsnn (n = delay in seconds; Esnn = exponent)
WDLAnnnnnn.nn	Set Channel A Delay Window / none (n = microseconds; position of decimal point may vary. 0.012 μ s min; 213,999.97 - Start Delay - Reference Delay max)
WDLBnnnnnn.nn	Set Channel B Delay Window / none (See WDLA)
ZERA	Autozero Channel A Detector. Takes time to complete - SRQ can monitor successful (or unsuccessful) completion / none
ZERB	Autozero Channel B Detector. Takes time to complete - SRQ can monitor successful (or unsuccessful) completion / none
*IDN?	Identification Query - Output Model; Software Version. The PPM will output: Giga-tronics,8501A,0,VERnn.nn 8501A = model number; 0 = N/A; VER = software version; n = number of the software version. If using a Model 8502A, 8501A would be replaced by 8502A

3.9 1018B Emulation Commands

1018B Emulation commands will be in the following format:

Table 3-4. 1018B Emulation Commands Format

Command	Argument
<NNN	Set Delay 0 to 9.99 microseconds (1018B Emulation) / none (nnn = delay in hundredths of microseconds) <i>NOTE:</i> A decimal point cannot be sent in the argument string.
>NNN	Set Delay 0 to 99.9 microseconds (1018B Emulation) / none (nnn = delay in tenths of microseconds.) <i>NOTE:</i> A decimal point cannot be sent in the argument string.
?	Update Data (1018B Emulation). Causes a trigger reset when in the update or trigger modes. The PPM will output power measurement data the next time a trigger occurs.

3.10 Data Formats

Data will be in the following formats:

dBm Mode:

snnnn,0(CR)(LF)(NULL EOI)
(Interpret snnnn,0 as nnn.n dBm)

Range 1: (microwatts)


snnnn,1(CR)(LF)(NULL EOI)
(Interpret snnnn,1 as nnn.n μ W)

Range 2: (milliwatts)

snnnn,2(CR)(LF)(NULL EOI)
(Interpret snnnn,2 as nn.nn mW)

Range 3: (milliwatts)

snnnn,3(CR)(LF)(NULL EOI)
(Interpret snnnn,3 as n.nnn mW)
(s = polarity; linear always +; n = power value)

 **NOTE:** When operating in the Linear Mode, the range is determined from the linear range that has been set from the front panel.

Theory of Operation

4.1 Introduction

This chapter presents a functional description of the electrical assemblies in the Model 8501A and 8502A Peak Power Meters (PPM). Table 8-1 in Chapter 8 lists the circuit assemblies by reference designation and includes the schematic diagram and assembly number for each board. Schematic diagrams and component layouts are in Chapter 8.

The method to properly ground all PC boards is common throughout the PPM. Each PC board contains both input and output isolator stages to transfer the reference or ratio common ground when signals are passing between the PC boards to an on-board common ground. When any signals leave the boards, they pass through another isolator stage, which transfers them back to the between-the-boards reference ground.

4.2 System Description

The following is a general description of the PPM circuit, with reference to Figure 4-1.

The detected RF signal enters the PPM as an analog voltage and is received by the circuits of the Analog PC board (A6/A7). The single channel Model 8501A uses only A6 whereas the dual channel 8502A uses both A6 and A7. Both boards are identical.

The Analog board circuits use an RC network to compensate the signal for frequency dependent losses in the delay line. The signal is sampled and held until the completion of the data conversion cycle. A/D conversion occurs to supply digital data to the Central Processing Unit (CPU).

The Trigger Amplifier of the Analog board senses the detector output voltage before it reaches the Delay Line. It uses the signal to provide an Internal Trigger, controlled and conditioned by the A5 Digital Delay board, when the internal trigger is selected.

The Peripheral Interface circuits interface read and write signals under the control of the CPU board.

The Analog board also receives temperature information sensed by the thermistor in each detector.

The programmable delay function of the A5 Digital Delay board establishes the time delays when measuring RF pulses. Trigger inputs can come from either the CPU (internal), through the Trigger Amplifier, from the pulse itself as it is detected, or from an external source connected to the rear panel of the instrument. The Delay board also supplies a synchronized output signal to a rear panel connector for an external meter to read the pulse at the point where the sample is taken.

The A4 CPU board provides (through the CPU Bus Line) the interface between the other PC boards, and generates all of the control signals for timing and controlling the various functions of the boards. Apart from the bus, the CPU has two other lines from the power supply and the delay board. These inputs tell the CPU if there has been a power failure of any kind, and when it should halt its activity until a sample of the incoming pulse is taken. This allows the sample to be unaffected by CPU generated interference.

The A9 Keyboard and A10 Display PC boards interface keystroke and hand wheel movement information, and display indication signals to and from the front panel components. These functions are controlled by the A8 Front Panel Interface board, which is controlled by the CPU. The front panel interface also has a

high voltage switching power supply for the Electro-Luminescent (EL) display. The Ready and New Data lights on the front panel are turned on and off by control signals sent through A9 from the delay board.

The A3 GPIB/Cal Control board provides the interface to the GPIB, and contains the circuitry required for controlling the operation of the automatic detector Calibrator (A12). It also interfaces with the PROMs in the detectors, contains the sound generator circuits, and provides an RF blanking output to turn off RF power when zeroing the instrument.

The A12 Calibrator assembly contains the 1 GHz Programmable Calibration Source that furnishes a precise signal for automatic calibration of the PPM detectors.

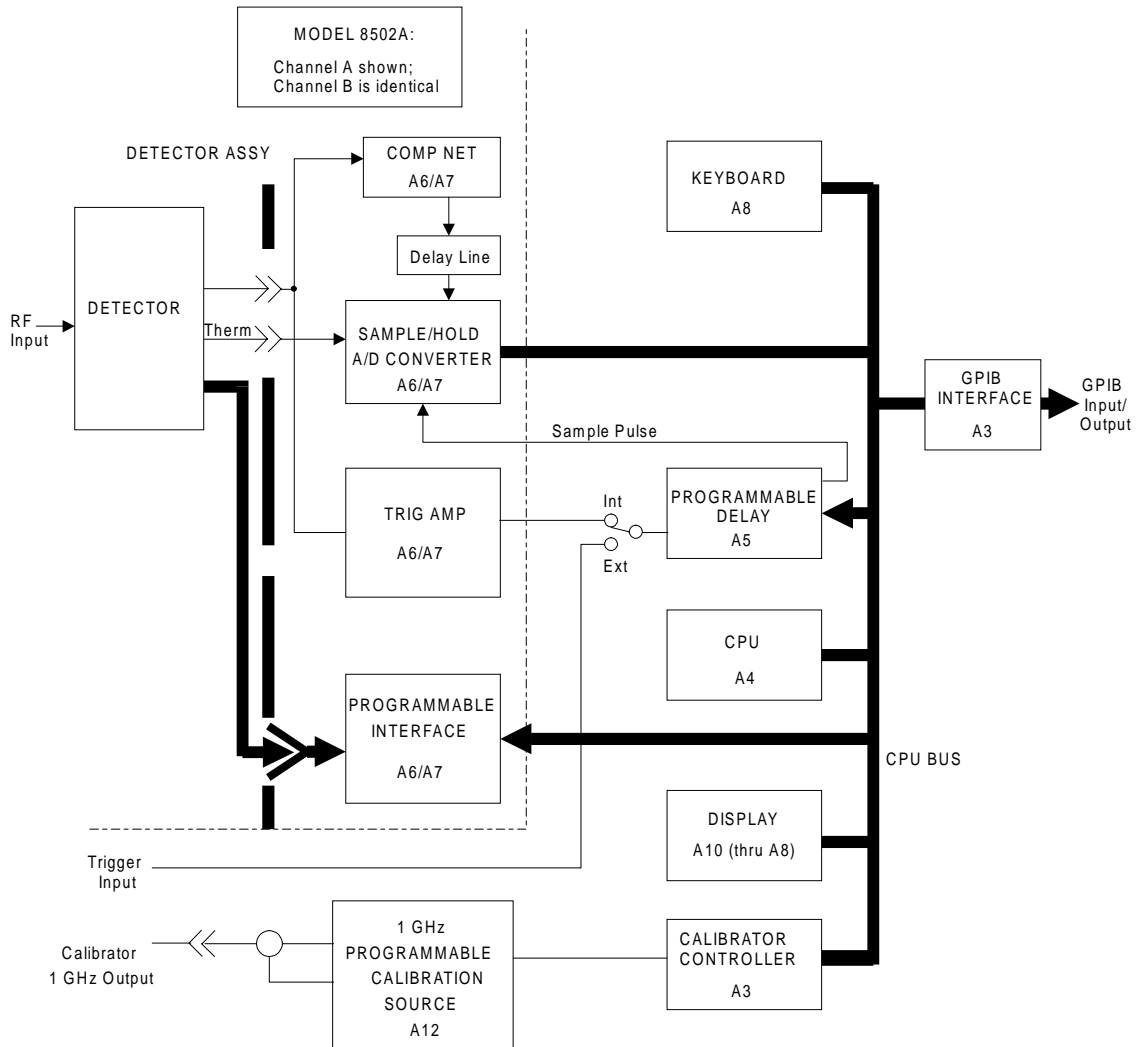


Figure 4-1. Series 8500A System Block Diagram

4.2.1 Power Supply PC Assembly (A2)

(See schematic diagram #16996 in Chapter 8.

The Power Supply PC board generates the +5 Vdc and +15 Vdc power sources required by the instrument. Since both voltages are produced in a similar manner, this discussion will cover only the +5 V circuitry.

The +5 Vdc produced on the board is the master voltage regulator for the system. It takes its reference from CR21 and compares it with the output voltage between the +5 V Sense and +5 V Common lines. Sensing is in the circuit composed of R41, R43, R66, and adjustable at R42. Q7 and Q5 are regulating transistors with the regulation voltage available at TP9 for checking.

-5 V is slaved from the +5 V and regulated through Q9 and Q10. Both the plus and minus voltages are compared with ground, and both have current limiting. The +5 V circuit is sensitive to the voltage drop across R29, which is controlled in parallel through Q6. U2A is the current limiter for +5 V, and U3A is the current limiter for -5 V. U4 compares the unregulated +5 V with the reference from U5. If its output is too low, the AC Fail signal will tell the CPU that the power is about to fail. R61, CR19, and C21 will keep the voltage supply at U4 up long enough for the +5 V to drop to a logic zero threshold after the instrument goes to a power-off state.

A2 Test Points

The test points in Table 4-1 can be checked for the correct signals on the A2 Power Supply board:

Table 4-1. A2 Test Points

Test Point	Description
TP1	Reads the current in the +15 V drive circuitry
TP2	Reads the current in the -15 V drive circuitry
TP3	+15 V
TP4	+15 V Common Sense
TP5	-15 V
TP6	+15 V Common
TP7	Reads the current in the +5 V drive circuitry
TP8	Reads the current in the -5 V drive circuitry
TP9	+5 V Sense
TP10	-5 V Sense
TP11	5 V Common Sense

4.2.2 GPIB/CAL Control PC board (A3)

See Figure 4-2 and schematic diagram #21015 in Chapter 8.

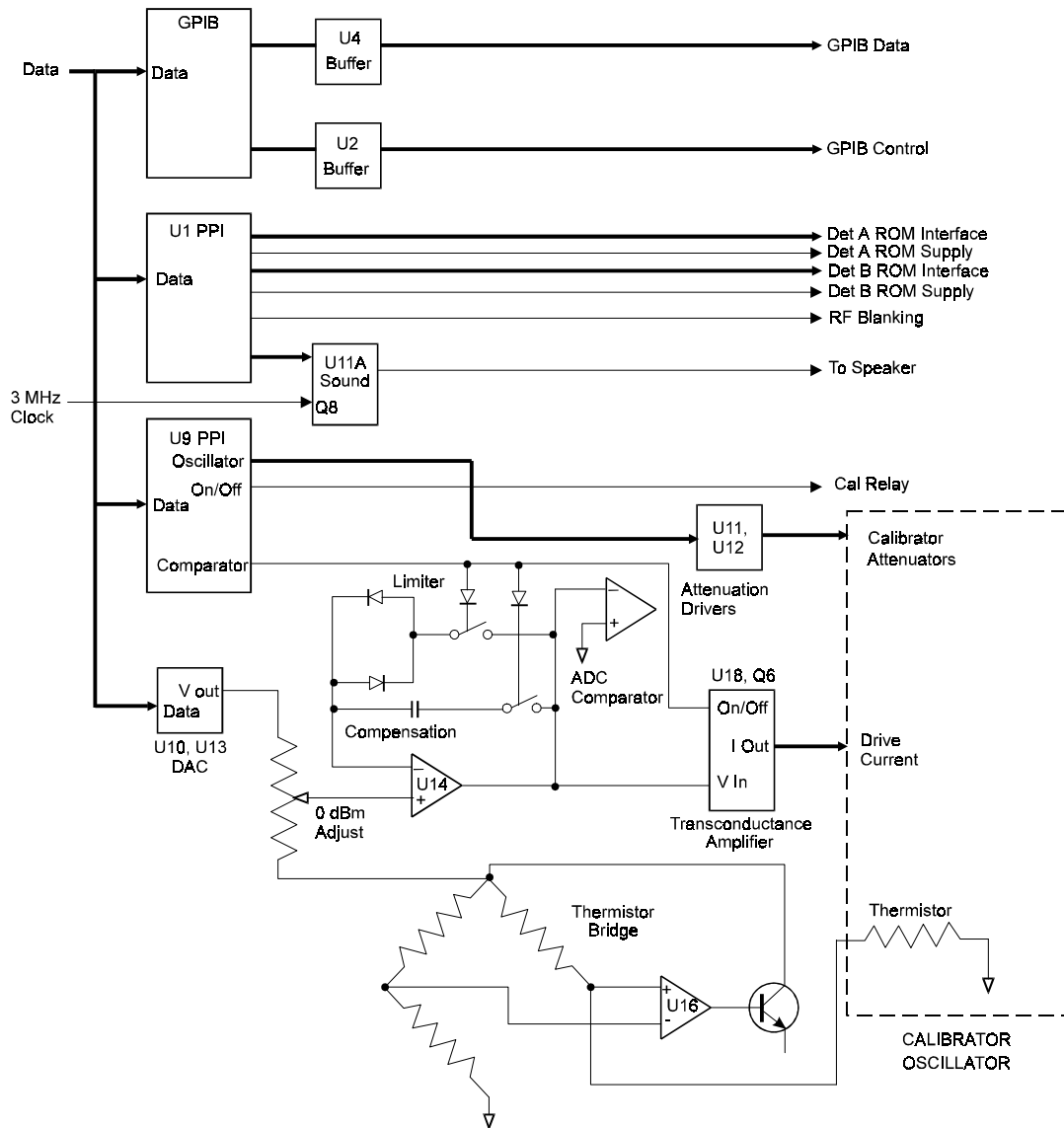


Figure 4-2. GPIB/Cal Control (A3) Block Diagram

The GPIB/Cal Control PC board circuitry performs a number of functions. The board is the interface to the detector PROMs. It contains the sound generator for clicks and beeps as described in Chapter 3, and it also has the GPIB interface and calibrator control circuitry.

With reference to Sheet 1 of DWG# 21015, the GPIB interface is through U1, buffered by U2 and U4. U1 performs the proper interfacing between the GPIB and the data and address lines, and the chip select

and read/write lines. Control signals to activate the sound generator come through U8, which also interfaces with the PROMs in each detector. A special 4-bit-wide data bus is connected to each detector, and a clock signal common to both detectors sequentially counts the address from 0 to 2048.

Q1 and Q2 switch on and off the +5 V supply to the channel A detector PROM, and Q3 and Q4 do the same for the channel B detector PROM. When the +5 V is switched on, the address counter at the detector is reset to zero.

U8 also has an RF Blanking output signal used during a calibration routine to turn off any input from the RF source. The sound generator is controlled by U8 through an amplifier consisting of U11A and Q8, with the volume adjustable at R2. U7 is a frequency divider that takes a 3 MHz input and divides it by two so that the sound generator gets the 1.5 MHz input it needs for proper operation.

A major function performed by the GPIB/Cal Control board circuitry is to provide the control signals required to operate the automatic RF detector Calibrator.

With reference to DWG# 21015, Sheet 2, and Figure 4-2, PPI U9 performs several functions. One is the control of switches U12A, B, & C and U11B, C & D. These switches are drivers for the pin diode switches in the Calibrator, which switch in or out the required attenuation (as shown by the lines on the right side of the schematic). Since the three sets of two switches each operate the same, we will look at the action of U12A & B.

When a logic signal is generated from the B0 output of U9, the signal is applied to two inputs of opposite polarity (U112A, pin 6, is the minus input and U12B, pin 3, is the plus input). If the logic signal is high, this will force pin 7 of U12A to be driven negative and pin 1 of U12B will be driven positive. This will turn on the pin diode switch in the Calibrator, which will switch in the desired attenuation (in this case, the 10 dB attenuator). If a logic zero comes from the B0 output of U9, then the reverse condition will be true and the attenuator will be switched out because current will be forced through the attenuator in the opposite direction.

PPI U9 also interfaces the U10 14-bit DAC with the incoming data bus lines. The interface consists of a byte wide data bus from U9 port A, two control lines from U9 ports C0 and C1 to U10 ports A0 and A1, and a write enable signal from U9 port C3 to U10 WR. The CS port on U10 is not used. Signals from A0 and A1 control the operation of U10 so that a write operation can either load the data into the DAC internal register's least significant byte or through DB0 to DB5 to the most significant byte or to transfer the register data to the DAC output.

U13 and U10 work together as a standard inverting operational amplifier. The loaded data connects the V_{REF} input through a resistive network to an internal summing junction. The data is also connected to the feedback signal from the RFB input through an internal fixed value resistance, and to the inverting input of U13. Since V_{REF} has a value of -10 V, the output of U13 pin 6 will range from 0 to 10 V.

Shown to the lower right of U10 on the schematic is a summing junction which receives one signal from U13 through R15, and potentiometer R16 (CALIB SET), which is in parallel with R74. A second signal then comes from the thermistor bridge circuit of U16 and Q5. The bridge circuit uses the thermistor in the Calibrator as one leg of a bridge. The bridge is self-balancing, and always seeks a voltage level that will keep it in balance. When the system is first turned on, the thermistor will have a high resistance because it is cold. This unbalanced condition will cause a maximum voltage level to be present at TP9. The voltage level will stay high until the thermistor warms up to a point where the bridge is balanced. Then the voltage level at TP9 will drop. Due to negative feedback, it will seek a level just sufficient to maintain a balance in the bridge. The bridge voltage is fed back into the summing junction through R18.

The system has two modes of operation controlled by U17A & B which are, in turn, controlled by either a high or low output from the B7 connection of U9. In one mode, the circuit measures the voltage of the bridge (initiated by a low output from B7); in the other mode of operation, the circuitry controls the bridge voltage (initiated by a high output from B7). When it is required to measure the bridge voltage, the Calibrator must be turned off so the voltage that selects the measuring mode also turns off the oscillator. The reason for this is that the ambient voltage of the bridge must be measured with no RF applied. U17B has two parts, one of which serves to invert the logic signal through pin 14 which is the

inverse of what comes in through pin 16. The other half of U17B switches the signal into the oscillator control circuit which causes the oscillator to turn off. This is done when the switch is closed by causing the signal to unbalance the oscillator control circuit in such a way that no current can flow to the oscillator. Under that condition, C9 is disconnected from the circuit during the measuring period and the diode pair, CR1 and CR2, act to clamp the circuit to prevent U14's output from going more than 1V from ground independent of the applied signal. U15 is a comparator that detects whether the output of U14, pin 6, is either positive or negative. The output of U15 then goes to the C port of U9 as an input. This tells the CPU whether U14's output is either high or low as determined by the comparator. In the measurement mode, there is also a CPU driven successive approximation routine which puts a series of words out to the DAC, U10. Then, using standard successive approximation, the voltage level at TP9 is determined and placed in memory. On the basis of the voltage placed in memory and knowing the desired power out, the CPU can then calculate the voltage that must be written to U10 to control the oscillator for the desired output power. To briefly recap, the process is to measure the bridge voltage with no RF applied, determine the desired output power, and then write voltage corresponding to that power to the U10 DAC.

When it is required that the oscillator be controlled, the B7 output of U9 will supply a high voltage signal to close the switch at C9 and open the switch on CR1 and CR2. C9 then serves to stabilize the complete control loop while the thermistor bridge system controls the oscillator. The control system operates in the following way. The oscillator provides RF power to the thermistor and, the more RF applied, the less dc power is required in the self-balancing bridge. Consequently, as the RF power increases the voltage at TP9 will decrease. This voltage feeds into the summing junction at U14. Since diodes CR1 and CR2 are switched out of the loop, the feedback circuit then goes from pin 6 of U14 through R51 to the input of U18D. Pin 11 of U17B is open now, so there is no current fed to U18D from that point, and the voltage applied through R51 directly controls the current through Q6.

R47, R48, R49, R51, R52, U18D, and Q6 form a voltage to current converter. The voltage over R49 will equal the input voltage present at R51, but will be shifted to be relative to -15 V (can be read at TP7). See Figure 4-3, the current through R49 will be V_{in}/R_{49} . Assuming that Q6 has a current gain much greater than 1, the current driving the oscillator can be approximated to V_{in}/R_{49} . As the voltage increases, the oscillator output power and the RF power dissipated in the thermistor will increase resulting in a decrease of the bridge voltage at TP9.

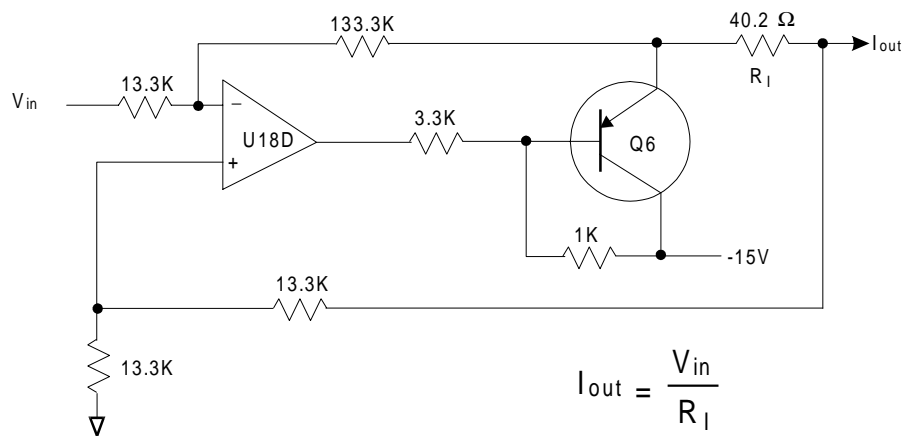


Figure 4-3. Voltage to Current Converter

The decrease of voltage will reflect as a decrease in the level of current and, finally equilibrium will be obtained where there is just enough power being supplied to the oscillator to bring the summing junction to a balance at U14. The oscillator will then regulate at that level. The net result is that whatever is

written into the U10 DAC will force the voltage at the thermistor bridge to the desired level to produce the required power level from the oscillator.

U18A is the buffer for the incoming +10V reference voltage. Q10 and Q11 are controlled by the B6 connection of U9 to provide a signal which can supply current to turn on a relay external to the PPM for special applications.

A3 Test Points

The test points in Table 4-2 can be checked for the correct signals on the A3 GPIB/Cal Control board:

Table 4-2. A3 Test Points

Test Point	Description
TP1	+5 V
TP2	5 V Common
TP3	-15 V
TP4	15 V Common
TP5	Output of the control amplifier for the Calibrator control. Its voltage (ranging from a few hundred mV to 10 V) will be related to the power required by the Calibrator.
TP6	+15 V
TP7	Measure from TP7 to TP3 to give an indication of the current through the oscillator. Will be between 1 and 30 mA.
TP8	+10 V
TP9	Output of the thermistor bridge. Typically will have a voltage of about 7 V under ambient conditions.

4.2.3 CPU PC Assembly (A4)

See Figure 4-4 and schematic diagram #16879 in Chapter 8.

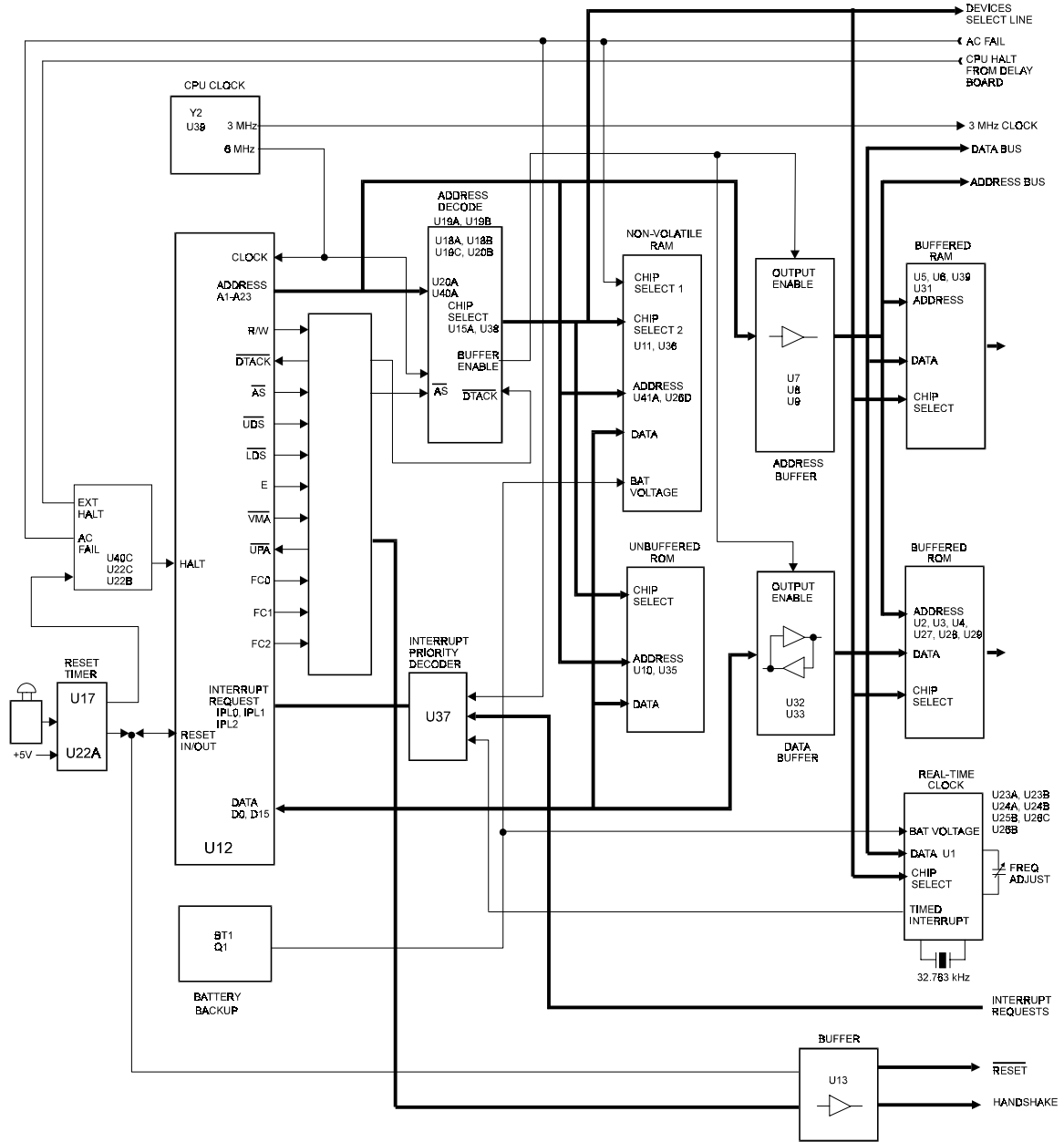


Figure 4-4. CPU (A4) Block Diagram

The CPU (Central Processing Unit) PC board controls all of the functions of the instrument. The CPU is logically divided between those circuits shown on Sheet 1 of DWG# 16879 and those shown on Sheet 2 of DWG# 16879.

Sheet 1 of DWG# 16879 shows the following CPU functions:

- The Microprocessor (MPU)
- Address Decoding and Handshake
- Unbuffered Memory
- Reset Timer
- Interrupt Priority Decoder
- Data Buffers

Sheet 2 of DWG# 16879 shows the following CPU functions:

- External Memory
- Real Time Clock
- Backup Battery circuit

Starting with Sheet 1 of DWG# 16879 and going in the same sequence as shown above, the functional operation of each CPU sub-circuit is described as follows:

The Microprocessor

The Microprocessor is a Motorola 68000 MPU. It has a 16-bit data bus, 32-bit internal registers, and runs on a 6-MHz clock frequency. If you need to see the timing of the MPU in its various modes of operation, it is recommended that you refer to the manufacturer's manual.

Address Decoding and Handshake

This circuit performs the address decoding for the memories and other devices included on the CPU board and elsewhere in the instrument. It generates the device select signals for the various components, creates the proper timing for each device, and performs the necessary handshaking for the transfer of data between the CPU and the different devices.

U18A & B, U20B, and U19C decode address lines 20 through 23 to select the multiplexer U34. The address strobe AS is active when the address lines hold a valid address.

Address lines 16, 17, 18, and 19 select one of the 16 outputs of the multiplexer, which will be used as the device select line (CS0 through CS15). CS0 through CS7 address the memories; CS8 through CS13 address different I/O devices; and CS15 addresses devices that require a handshake according to the 6800 protocol.

U15A, U38, U19A, D & E, and U16 create the proper timing and handshaking for each device category. When selecting one of the memories, U15A will produce a direct DTACK (Data Transfer ACKnowledge) signal to U12 through NAND gate U21C. The MPU will then execute the data transfer without introducing any additional wait states. When selecting one of the I/O devices (CS8 through CS13), the output of U38D goes high thus enabling the shift register, U16, which is clocked by the 6 MHz system clock. After three clock pulses, output QC goes high creating an active CE signal that is used by the Analog PC board circuitry. After another clock pulse QD goes high, is inverted in U19A, and creates a delayed DTACK through U21C. The MPU responds by inserting a corresponding number of wait states in the data transfer which allows the device to time the data transfer. DTACK can also be received from any external device connected to the CPU bus that has its own address decoding circuits.

When CS14 or CS15 are selected, U19E will generate a VPA (Valid Peripheral Address) signal through NAND gate U21B. This tells the MPU that a valid 6800 device has been addressed, and the MPU will respond by generating a data transfer according to the 6800 protocol. The E and VMA (Valid Memory

Address) outputs are used in this protocol. There is an external input to the VPA, and the VPA is also used in the interrupt process.

NAND gate U20A and inverter U40A provide an active low signal when a device outside the buffers is addressed.

Unbuffered Memory

The memory inside the buffers consists of two 8Kx8 bits of RAM and two 32Kx8 bits of ROM with the RAMs kept alive by a battery when the instrument is turned off. NAND gate U26D (also battery powered) is deselected by the AC FAIL signal when the instrument is off to protect the contents of the memory. Each pair of memories use the 16-bit wide data bus and are addressed with one device select signal. The upper and lower data bytes are selected in OR gate U14 by letting the Upper Data Strobe (UDS) and Lower Data Strobe (LDS) gate the R/W output from the MPU to produce the Lower data Write Enable (L.WE), Upper data Write Enable (U.WE), Lower data Output Enable (L.OE), and Upper data Output Enable (U.OE) signals.

Reset Timer

The U17 reset timer consists of a 555 monostable pulse generator. When the instrument is turned on or when the reset button on the back panel is pressed it generates a 0.5 second pulse to reset the MPU. U22A & B give separate open collector inputs to the RESET and HALT inputs. U22C provides the HALT signal which comes from the Delay board. The RESET pin of the MPU is a bidirectional line, and the MPU can generate its own resets. Diode CR1 enables the AC Fail to Halt the MPU. This is necessary to ensure that the MPU is not trying to make a data transfer to the non-volatile RAMs or Real Time Clock when they are being deselected by the AC Fail signal.

Interrupt Priority Decoder

The U37 Interrupt Priority Decoder interfaces the three interrupt priority lines (IPL0, IPL1, and IPL2) to the seven interrupt request lines (IRQ1 through IRQ7). The three output lines of U37 will have encoded the number of the highest priority input line that has been driven low. As can be seen on the schematic, the AC Fail line is connected to the highest priority interrupt input. The lowest priority interrupt input is connected to the Real Time Clock for timed interrupts.

Data Buffers

Data buffers U7, U8, U9, U13, U32, and U33 give an increased drive capability to all of the signals on the CPU bus that require the increased capacity. They are enabled by U40A from the Address Decoder circuit. This will happen each time none of the Unbuffered Memories have been selected. The R/W signal determines the direction of data flow in the bidirectional buffers used with the data bus lines.

External Memory

The External Memory interfaces the buffered CPU bus. It consists of two pairs of 8Kx8 bits of RAM (U5, U6, U30, and U31), and three pairs of 32Kx8 bits of ROM (U2, U3, U4, U27, U28, and U29).

Real Time Clock

The Real Time Clock, U1, interfaces the Buffered CPU bus. Data transfer follows the 6800 compatible protocol with the E and VMA signals to produce the handshaking required for the transfer. U23A & B, U24A & B, U25B and U26B control U1. To see the timing used in the data transfer, it is recommended that the manufacturer's data sheet for U1 (Motorola Type MC-146818P) be consulted. C47 adjusts the frequency of the internal clock of U1. The 32.768 kHz frequency can be monitored at TP6. The Real Time Clock also provides a timed Interrupt Request signal (IRQ1) used by the CPU operating system. Its frequency is software programmable, and can be monitored at TP7. The Real Time Clock is deselected by the AC Fail line through U26B.

Backup Battery Circuit

The CPU board is supplied with backup power from the on-board battery, BT1, whenever the line voltage is off or too low to supply the instrument with the required input voltage. Transistor Q1 is turned on by the +15 V supply to supply +5 V to the circuits connected to the battery with a minimum drop in voltage. While the instrument is turned on, CR2 keeps the battery from being back charged.

A4 Test Points

The test points in Table 4-3 can be checked for the correct signals on the A4 CPU board:

Table 4-3. A4 Test Points

Test Point	Description
TP1	System Clock. 12MHz
TP2	Read/Write signal from U13
TP3	5 V Common
TP4	+5 V
TP5	Reset Signal from U17
TP6	Real Time Clock (U1) Output. Used for Calibration
TP7	Interrupt Request Signal from U1
TP8	Battery Voltage
TP9	15 V Common
TP10	+15 V

4.2.4 Digital Delay PC Assembly (A5)

See Figure 4-5, Figure 4-6, and schematic diagram #16686 in Chapter 8.

The Digital Delay PC board circuitry establishes time delays that may be desired when examining sample pulses. Delays can be set in increments of 0.1 ns up to about 430 ms.

As can be seen in Figure 4-5, there is a complex interaction between each of the sub-functions of the delay board circuitry. This section describes the sequence of events that occur in the delay board starting with the reset of the circuits, and continuing through the generating of the pulse sample outputs. A detailed description of individual circuitry blocks on the Digital Delay PC board follows the sequence of events.

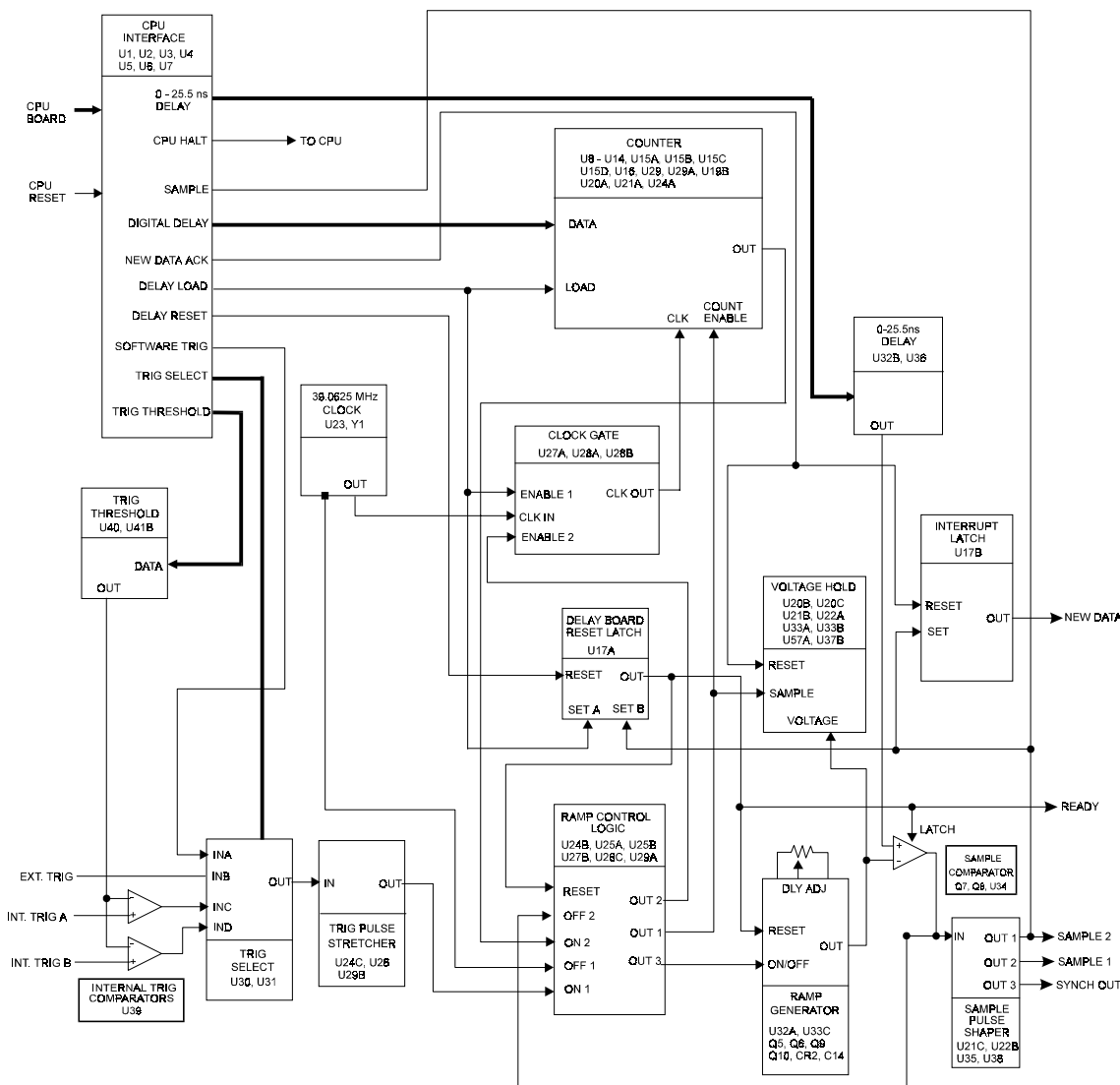


Figure 4-5. Digital Delay (A5) Block Diagram

The positive edge of the Delay Reset signal at U17A pin 11 will clock the Delay Reset Latch whose output will enable the Ramp Control Logic, the Ramp Generator, and the Sample Comparator. The reset input of the ramp control flip-flops (pin 13 of U29A and U29B) is released so that another trigger input can be accepted. The Ramp Generator switch, U33C, that is holding the output voltage at its initial value will open and the Sample Comparator latch, U34, will be released.

At the time the trigger pulse occurs, the Pulse Stretcher will ensure that only the first positive edge of the pulse will be able to trigger the Ramp Control Logic. The ON 1 input will clock flip-flop U29A and its output (monitored at TP1) will then activate the following events:

- A. Turn on the Ramp Generator.
- B. Trigger the Voltage Hold circuit to take a 3.3 microsecond duration sample of the Ramp Generator's output voltage and then to hold it.
- C. Enable the Ramp Control Logic flip-flop, U25B so that it can accept the Clock signal for the required timing.
- D. Enable the U14 counter.

The first positive edge of the pulse from the Clock-inverted output at U23B pin 14 will time flip-flop U25B to turn off the Ramp Generator and also to enable the Clock Gate. The Ramp Generator output voltage will then remain stable while the Voltage Hold function is taking a sample of it. The next clock pulse then starts the Counter counting down. When it has counted down to zero, it will cause an inverted clock pulse to be gated at its output, U24A pin 6, which will in turn clock flip-flop U25A to turn on the Ramp Generator.

As the output voltage reaches the level determined by the selected delay, the Sample Comparator U34 will flip and trigger the Pulse Shaper to produce the sample pulses. The output will also turn off the Ramp Generator by resetting U25A in the Ramp Control Logic circuit. The Sample 2 leading edge then sets the Delay board Reset Latch and the Interrupt Latch, and resets the CPU Interface Halt signal. When the instrument is first powered on, the Delay board Reset Latch is set by the Load signal because no Sample 2 signal is generated at that time.

Activation of the Delay board Reset Latch will then cause the following events:

1. The Ramp Control Logic flip-flops, U25B and U29A, will be reset.
2. The Ramp Generator output voltage will be reset to +3 V.
3. A ready signal will be sent to the front panel Ready lamp.

After the CPU has processed the requested interrupt, it will send a New Data Ack signal to reset the Interrupt Latch and the Voltage Hold circuits.

A very important function in the operation of the delay board is the ability to precisely set a delay using a very stable clock with a frequency lower than the resolution of the board, and still be able to accept trigger signals that are not in synch with the clock. As can be seen on the Ramp Output Voltage timing line in Figure 4-6, the time A from the trigger to the negative clock edge plus the time B from the count out negative edge to the set threshold point is always the same. This is one clock period plus the fine delay set by the 0 to 25.5 ns Delay DAC plus eventual gate and other delays. These delays are independent of the exact timing between the trigger signal and the clock.

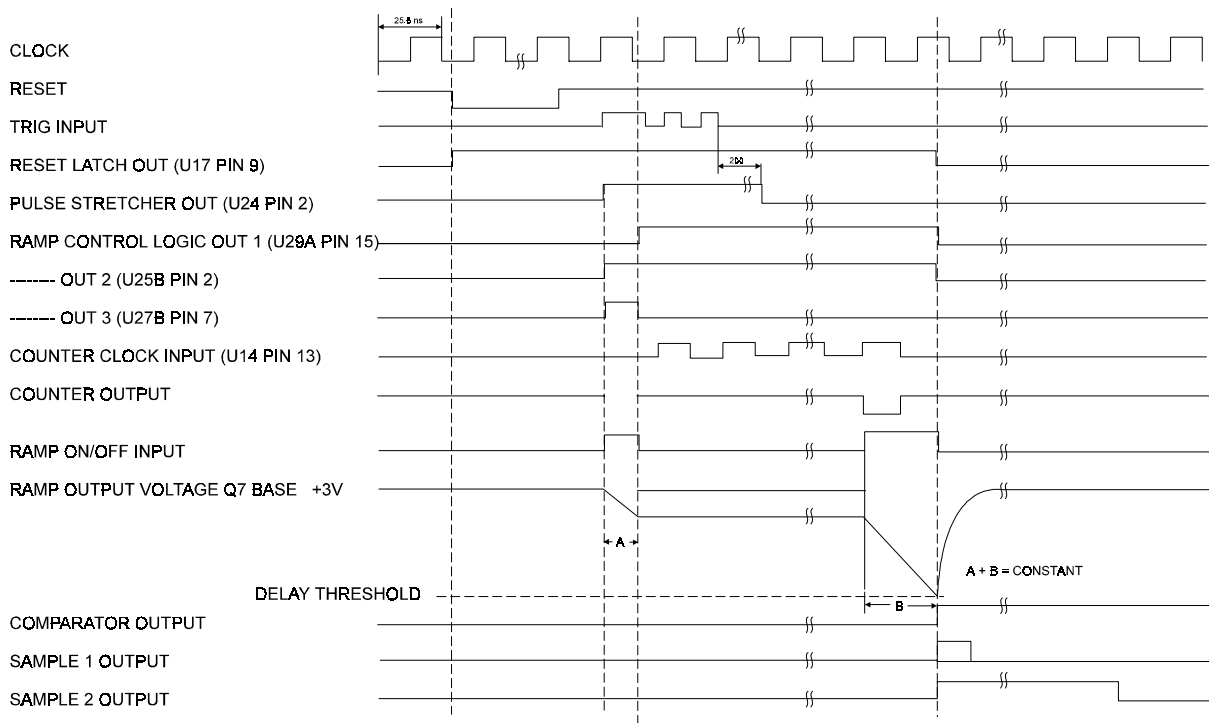


Figure 4-6. Timing Diagram - Delay Board Functions

The circuitry on the delay board uses both TTL and ECL circuits. Where very high speed of operation and/or low propagation delay is required, ECL circuits are used. The logic voltage levels for the ECL circuits are -0.81 V to -0.98 V for a logic 1, and -1.64 V to -1.85 V for a logic 0. When an input is connected to ground it has a logic 1, and when it is connected to -5.2 V it has a logic 0. (ECL circuits use the -5.2 V supply.) Special translators are required to translate between ECL and TTL signal levels. A high or low ECL output is always in reference to its non-inverted output.

CPU Interface

The CPU Interface forms the link between the CPU bus and all of the sub-functions on the board that are controlled by the CPU. The Interface also controls the CPU Halt signal to turn off all action by the CPU microprocessor from the time the delay board is triggered until a sample is taken. This serves to minimize the noise normally generated by the CPU when an analog signal sample is taken.

All of the control of the delay board is accomplished through the two PPIs (Parallel Peripheral Interface), U6 and U7. They are configured so that all of their total of 48 ports are outputs. Both PPIs are selected through the CS10 line. Selection of U6 is done by having the write signal, WR, and the read signal, RD, gated by the lower data byte strobe, LDS, signal going to U4A. Selection of U7 is accomplished by the action of the upper data byte strobe, UDS, which goes to U4B. Address lines A1 and A2 select one of the output ports, A, B, or C, or the PPI control register.

The delay is determined by the Delay DAC Bus from U6 port A, and by the Digital Delay Bus from U6 port B and U7 ports A and B. The delay can be set by one single long integer written to the board. The selected delay will be the inverted value of that integer. In other words, Delay = the maximum delay

minus the set value. The trigger level is determined by the Trig Level Bus. It requires 10 bits of data which are sent from U6 port C and U7 ports C0 and C1. The trigger is selected by Trig Select 0 and Trig Select 1 from U7 ports C2 and C3. The delay board's interrupt acknowledgment, New Data Ack, comes from U7 port C7.

The Load, Reset, and CPU Halt signals are generated by U1, U2, and U3. If U2 multiplexes U7 ports C2 and C3 into the Y0 line, it tells the circuit to do nothing. Into the Y1 line means to reset, into the Y2 line tells it to load, and into the Y3 line indicates Halt Enable. To set the Halt signal, Halt Enable sets the latch U3A. Then, when Y1 is addressed, the following will happen:

1. The monostable pulse generator, U1, will generate a reset signal at the point where the negative edge of the signal at Y1 occurs.
2. After that, the positive edge of the signal at Y1 will clock U3B which will produce the Halt signal.

The Halt function will be reset by a signal through the Sample 2 line. If no sample has been triggered, it can be reset by the CPU Reset or the interrupt requests corresponding to data received from the keyboard or through the GPIB. This is done by resetting latches U3A and U3B. The Reset also activates the Software Trigger. This will be ignored by the delay circuits unless soft trigger has been selected.

Trig Threshold

The Trig Threshold circuit sets the level for the internal Trig Comparators. It accepts data from the Trig Level Bus, and produces a voltage between 0 and 2.5 V, which is sent to the comparators.

The Trig Threshold circuitry consists of the 10-bit DAC, U40, amplifier U41B, and associated components. Its output is determined by the data present on the Trig Level Bus, and can be monitored at TP15. The amplitude range is 0 to 10.23 V with 10 mV resolution. Registers R16 and R17 form a voltage divider to give a level between 0 and 2.56 V which is sent to the Trig Comparators.

Internal Trig Comparators

The Internal Trig Comparators consist of one fast comparator each for channel A and channel B Internal Trigger Signals. The comparators also contain over-voltage protection at each of the inputs to protect them against voltages higher than a maximum of 3.0 V.

The Internal Trig Comparators function is accomplished by using one dual, fast ECL output comparator. Its recommended maximum input voltage is 3 V. Each input is protected against over-voltage by an identical circuit. On channel A, the input is connected to the emitter of Q13. The base of Q13 is connected to 2.1 V which is derived from the +15 V supply through R8 and R9. When the voltage is greater than 2.1 V plus the VBE(ON) of Q13, Q13 will then have a low resistance to ground that will serve to limit the comparator input voltage. The non-inverted outputs of the channel A and channel B comparators can be monitored at TP14 and TP15.

Trig Select

The Trig Select is a digital multiplexer that selects either the Internal trigger from channel A or B, a software trigger generated by the CPU, or an external trigger from a source connected to the instrument rear panel, all controlled through the CPU interface.

The Trig Select circuitry consists of an ECL 4-wide 4-3-3-3 input, AND/OR gate U30, and a TTL-ECL translator, U31, for the trigger select lines. The trigger inputs are active lows, and are selected when the two remaining inputs of the OR gate are low. The output goes low when the selected trigger input goes low.

Trig Pulse Stretcher

The Trig Pulse Stretcher makes sure that the delay board is triggered only by the first leading edge of each trigger pulse. It stretches the pulse to 200 ns after the last trailing edge of the pulse. In this way, all glitches shorter than 200 ns will be removed from the pulse. Its input comes from the Trig Select circuit, and its output goes to the Ramp Control Logic.

The Pulse Stretcher function is initiated by the monostable multivibrator, U26, which is configured through its E+ and E- inputs by flip-flop U29B to accept only a negative sloping trigger, and by the 2-input OR gate U24C. All action takes place in the ECL format.

To better understand the operation of the Pulse Stretcher, assume that the output of U29B has been clocked but not reset. The input would then be low. When the input goes high, the first thing that happens is that the output of the OR gate goes high. Then, the output of U29B will be reset causing the second input of the OR gate to go high. When the input goes low it will trigger U26 into generating a 200 ns output pulse. U26 can be triggered so that if the input signal contains more pulses that are less than 200 ns apart, the output will stay low until 200 ns after the last negative edge. When the output of U26 goes back to the high condition (the reset input of U29A is then low). U29A is clocked and the inverted output goes low. Since this means that both inputs of U24C are low, the output of the Pulse Stretcher will now go low.

After the PPM is first turned on, it is necessary to give the Pulse Stretcher one trigger input pulse (generated by the soft trigger function) to initialize it.

Clock

The Clock is a stable crystal controlled square wave generator. It operates at 39.0625 MHz to give a 25.6 ns period.

The Clock consists of U23A,B & C, and Y1. U23A is a positive feedback amplifier with the Y1 crystal. U23C provides a dc bias to the input and U23B is an output buffer. The frequency is adjusted with C79. The clock frequency can be measured with a high impedance probe at TP5.

Clock Gate

The Clock Gate provides the timing to the Counter when either in the count mode or in the delay data mode. When counting, the clock is enabled with a clock enable signal from the Ramp Control Logic and, when loading, it is enabled by a load signal from the CPU Interface.

The Clock Gate consists of AND gates U28A and U28B whose outputs are OR'd in U27C. The clock is connected to both U28A and U28B, and can be gated by either the load signal on U28A pin 4 or by the Ramp Control Logic Out 2 on U28B pin 7.

Counter

The Counter establishes a coarse delay time. It is controlled by the Digital Delay Bus and the load signal from the CPU Interface. The clock gives it a resolution from 25.6 ns to a maximum delay of about 430 ms. The output is the selected clock pulse with just one gate delay with respect to the clock.

The Counter consists of high speed ECL binary counter U14, five TTL binary counters U9, U12, U11, U10, and U9 (with the first one being S-TTL), and the clock input. ECL delay data is translated from TTL by U13. It is clocked from the Clock circuitry. During the delay count, the multiplexer U16 selects the Terminal Count (TC connection) of U14 as the clock input to U8, and the Carry Out (CO connection) of U8 as the clock input to U12, U11, U10, and U9. U11, U10, and U9 operate in a look-ahead, carry mode. U19A, U20A, and U24A are using the U8 Terminal Count and the U8 and U9 Carry Out to select the first clock pulse after the counter has counted up to a full count.

When all of the counters are loaded, they have to be provided with one clock pulse while the Load input is low (Parallel Enable for U14) to execute the load. In U14, this is done by the Clock Gate circuit. For

the other counters, the load signal will be executed by having the multiplexer U16 delay the negative edge of the signal and inverting the signal using U15A, B & C.

Delay Board Reset Latch

The Delay board reset latch resets the board to accept the first trigger pulse after the reset is accomplished. The reset signal comes from the CPU through the Interface. The Latch resets the Ramp Control Logic, the Ramp Generator, the Voltage Hold, the Sample Comparator latch, and the Ready output that controls the Ready and New Data lamps on the front panel of the instrument.

The Delay board Reset Latch function is accomplished by flip-flop U17A. Inverter U15E and NAND gate U20D are used so that U17A can be set by both the Sample 2 and Reset signals.

Ramp Generator

The Ramp Generator produces an accurate ramp for the 0 to 25.6 ns delay. The Reset input presets the voltage at the output to a 3.0 V bias. When turned on by the ON/OFF input, the voltage drops at a rate that can be adjusted with the Delay Adjust potentiometer. The output voltage can be held at a fixed value for a long period of time with the Voltage Hold circuit.

The Ramp Generator is driven by a dc current sink consisting of U32A, Q9, and Q10. U32 compares the voltage at R32 with a voltage reference provided by CR2, R29, R30, and R31. The output of U32, boosted in darlington configuration, will regulate the current through R32 to $I = V_{ref}/R32$. The current which forms the slope of the ramp is adjusted by R30 (DELAY ADJ). Q5 and Q6 are configured as a differential pair driven by the differential outputs of the ECL gate U27B. When the Ramp Generator is off, the current flows from ground. When it is on, it discharges C14 at a rate equal to $dV/dT = I/C$. The starting voltage is provided by the +10 V reference through R44 and R45 when switch U33C is closed.

Voltage Hold

The Voltage Hold circuit holds the output voltage of the Ramp Generator during the time it is waiting for the count output from the Counter. It consists of a double buffered sample and hold amplifier with input and output tied together. It is reset by the New Data Ack signal from the CPU Interface. The Sample input from the Ramp Control Logic samples the voltage for 33 μ s and then holds the voltage. The hold mechanism only prevents the voltage from increasing, not from decreasing. A controlled current leakage ensures that the droop of the voltage is positive, and thus is taken care of by the Voltage Hold circuit.

The Voltage Hold circuit consists of amplifiers U37A & B, analog switches U33A & B, monostable vibrator U22A, and NAND gates U20B & C. The output of U37B sinks all leakage current injected to the Ramp Generator output voltage mode. R46 provides a controlled leakage to ensure that the leakage is positive. Diode CR1 ensures that U37B will not prevent the voltage from decreasing when the Ramp Generator is turned on. U37's output voltage can be monitored at TP9. U37A serves as a buffer amplifier. Its output can be sampled and held by analog switches U33A & B. Before the sample is taken, U33B is closed to keep the voltage at 3.0 V. When the sample is triggered, U22A produces a 3.3 μ s pulse closing U33A. The leading edge of the pulse will also set the flip-flop formed by U22B & C whose output will open U33B. During the sampling period, C9 will be charged and will then hold the voltage.

Sample Comparator

The Sample Comparator compares the output from the Ramp Generator with the output voltage from the 0 to 25.6 ns Delay circuit. It has a latch input from the Delay board Reset Latch. The latch prevents any change in the output of the comparator from the time the sample is triggered to the time the delay board is reset so that no spurious samples will be taken.

The Sample Comparator consists of ECL comparator U34, Q7, and Q8. Q7 and Q8 increase the input impedance of the comparator, and to stabilize the input bias current. U34 has a latch input that will keep the output of the comparator from changing when driven ECL low. U34's output can be monitored at TP11.

Ramp Control Logic

The Ramp Control Logic controls the sequence of events that are required to generate the selected time delay. The Reset input enables the circuit to accept the first positive edge from the trigger pulse. The ON 1 input accepts the trigger pulse to turn on the Ramp Generator, enable the Counter, and to initiate the Voltage Hold. The OFF 1 input, consisting of the first negative edge of the clock signal after the trigger, turns off the Ramp Generator and enables the Clock Gate. The ON 2 signal comes from the Counter's count output and turns on the Ramp Generator. The OFF 2 signal consists of the Sample Comparator output which turns off the Ramp Generator when the sample is taken.

TP1 can be used as an oscilloscope trigger when testing the Delay board.

Zero to 25.5 ns Delay

This circuit consists of a DAC controlled by the Delay DAC Bus through the CPU Interface circuitry. It sets the proper levels for a delay between 0 and 25.5 ns with an accuracy of 0.1 ns. Its output goes to the Sample Comparator.

The 0 to 25.5 ns Delay is set by the 8-bit DAC U35 and amplifier U32B. The output is biased by R37 from the +10 V reference, and has a range of -0.5 V to +0.994 V full scale with 5.86 mV resolution. The output voltage can be measured at TP6.

Pulse Shaper

The Pulse Shaper is triggered by the Sample Comparator and provides the sample signals to the samplers on the analog boards. It also provides a synch signal to the rear panel SYNCH OUTPUT connector of the instrument. The synch signal is simultaneous with the 15 ns wide Sample 1 signal. The Sample 2 signal is also used in the CPU Interface to end the halt signal to the CPU. Sample 2 also goes to the Interrupt Latch and the Delay board Reset Latch to prevent any triggering from occurring until after the delay board has been reset.

The Pulse Shaper consists of an ECL monostable multivibrator, U38, which will provide a 15 ns pulse. U35 provides buffered differential outputs to the Sample 1 line and the Synch Out signal. U22 provides a 4.3 ms Sample 2 pulse.

Interrupt Latch

The Interrupt Latch output goes directly to the CPU interrupt request input to alert the CPU that a sample has been taken. It is reset by the New Data Ack signal coming from the CPU Interface when the analog board has finished with the sampled voltage.

The Interrupt Latch consists of a D-type flip-flop, U17B. It is clocked by the Sample 2 line to produce an interrupt request New Data signal to the CPU, and is reset through the New Data Ack. line.

A5 Test Points

The test points in Table 4-4 can be checked for the correct signals on the A5 Delay Line board:

Table 4-4. A5 Test Points

Test Point	Description
TP1	Output of U29A. Trigger signal that tells when the board has been triggered and reset. Can trigger a scope when testing the board. Signal goes low at trigger and high at sample time.
TP2	-5.2 V
TP3	5 V Common
TP4	+5 V
TP5	Clock Frequency (C79 adjusts)
TP6	Output of U36, U37 DAC, which determines the 0 to 25.5 ns threshold.
TP7	U34 comparator input
TP8	U34 comparator input
TP9	U37B hold amplifier output
TP10	10 V Reference
TP11	U34 comparator output
TP12	5 V Common
TP13	U39 comparator output (trigger signal)
TP14	U39 comparator output (trigger signal)
TP15	U40. Trigger level DAC
TP16	+15 V
TP17	15 V Common
TP18	-15 V

4.2.5 Analog PC Assembly (A6/A7)

The Analog PC circuitry accepts, converts to digital, and conditions the analog voltage coming from the channel A and B RF detectors. A6 is the reference designation for the channel A board, and A7 is the designation for the channel B board. Both boards are configured the same. The Model 8501A meter uses only A6.

Refer to Figure 4-7 and sheet 1 of schematic diagram #20742 in Chapter 8.

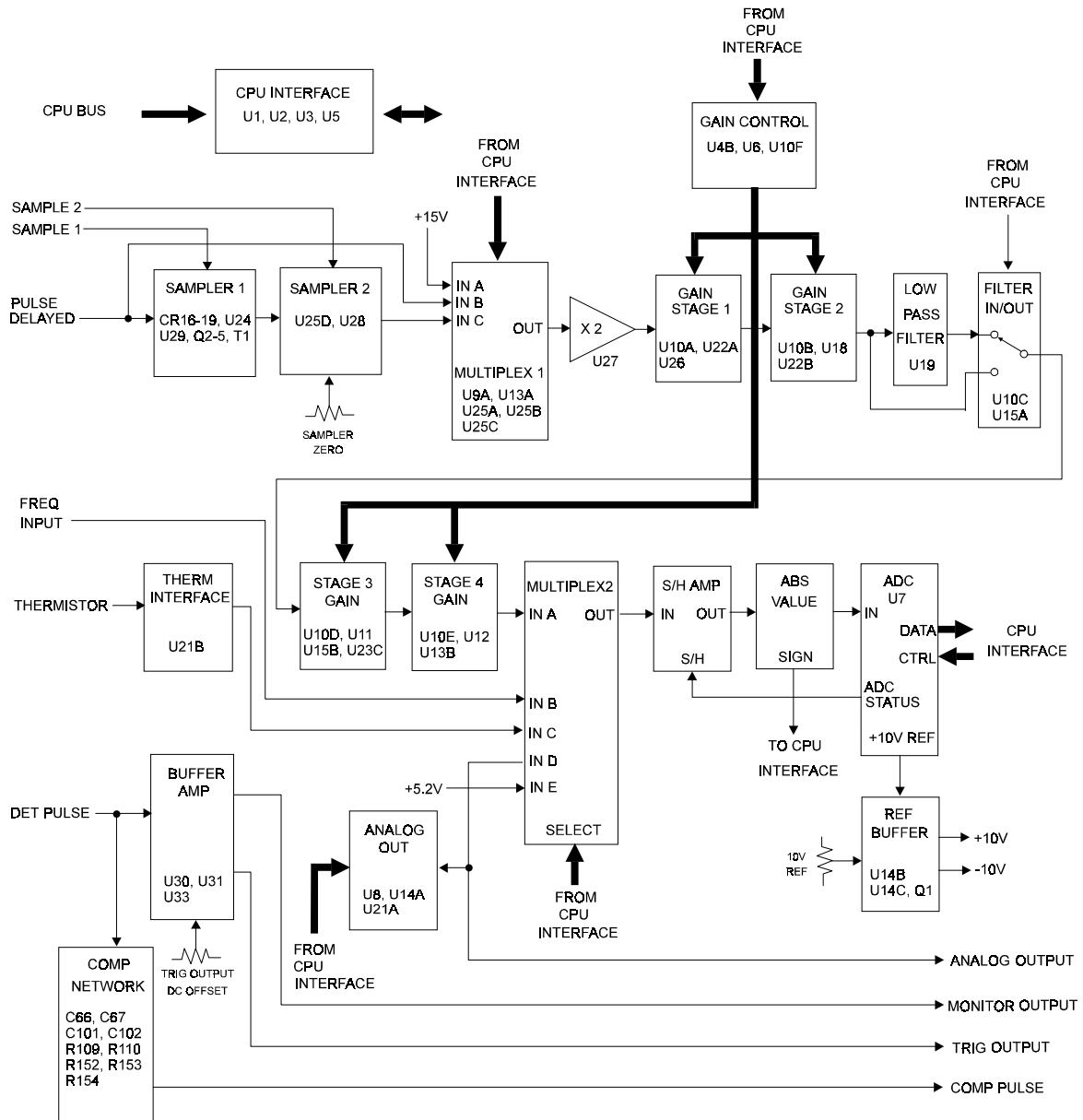


Figure 4-7. Analog PC (A6/A7) Block Diagram

The signal from the delay line is applied to a fast sample and hold circuit (CR16 to 19 and U29) with a sample pulse width of 15 ns. Next is a second sample and hold circuit (U28) with a pulse width of approximately 4 μ s. The second sample and hold circuit is to ensure that the sampled signal that is present will not change in amplitude while it is being held. The signal is held during the time from when the sample is taken to the completion of the data conversion cycle. U28 can either use the sampled signal, or take the signal directly from the input without using the sampling circuitry.

There are four stages of gain available after the signal reaches U28. The gain can be either 1 or 8 through each stage. The circuits are composed of U27 with a fixed gain of 2, amplifier U26, U18, low pass filter U19, U11 which is the third gain stage, and U12 which is the amplifier for the fourth gain stage. All four stages are used only in the CW mode and give a total gain of just over 8,000. In the peak pulse mode the last two amplifiers (U11 and U12) are not used, so the total gain will be 64.

After the four gain stages, there is a multiplexer circuit that allows the selection of either the measured signal from the detector or the voltage from the thermistor in the detector. U21B will generate a voltage proportional to the thermistor temperature. This voltage goes to U20, and then to the ADC.

U16, U17A, B & C, and U9 comprise a circuit that will give the absolute value and determine the polarity sign of the signal. U16 ensures that the voltage is steady during the conversion time. It receives the status (when conversion is occurring) from A to D converter U7. The D to A conversion circuit formed by U8, U14A, and U21A give an analog output proportional to the power level being sensed by the detector.

The system 10 V reference voltage comes from the U7 A to D converter. U14C gives the +10 V reference, and U14B gives the -10 V reference. During the automatic self test routine of the instrument, the signal from the DAC (U8, U14, and U21) is tested to assure that these components are operating properly.

As an example of signal flow through the analog circuitry, when the first signal sample is directed to the fast sample and hold circuit, it comes in through the Sample 1 line (on the left side of the schematic) as a balanced ECL signal, and then goes to differential receiver Q2 and Q3.

When a trigger is sent, Q2 produces a current pulse to trigger blocking oscillator Q4. The blocking oscillator generates a 20 V pulse approximately 30 ns long at the secondary of T1. This pulse overcomes the reverse bias normally applied to the sampling bridge (CR16 - CR18), and drives a heavy current through it, thus connecting sampling capacitor C72 to the input signal during the sampling interval.

R120 gives a controlled discharge of C72 between the samples. This is done so that whenever a sample is to be taken, C72's voltage is close to zero to set it to the same condition for each of the samples. The reason for this is to assure repetitive accuracy for every sample of the specific signal being measured. U29 is a high impedance amplifier.

The second signal sample comes into the board through the line labeled Sample 2, and goes to a circuit which includes switch U25D, holding capacitor C70, and isolation amplifier U28. R136 serves the same purpose as R120 (to control C70's discharge). Setting the zero (or close to zero) dc offset level required while sampling is in progress is controlled at R112 (Sample Zero), and can be monitored at TP5.

Selection between the CW or peak power mode signals is through the U25A & B switches. U25A & B can also select the +15 V signal through U13A. This allows the gain of the various stages to be separately checked using a known input. U27 has a fixed gain of 2. U25C (on the negative input of U27) is permanently closed, and improves the common mode rejection of the amplifier.

Each of the four selectable gain stages are identical. The first is a comparator (U23) where the input signal is compared with a fixed level. Then, the signal from each of the stages is sent to the U6 latch. U6 can operate in several different modes. When measurements are being taken, the latch is in the autoranging mode. This means that the inputs for the latch are the signals from the comparators. The outputs, which directly follow the inputs in the autoranging mode, are controlling the switch and the gain circuits. The first gain stage, U22A, determines whether the gain will be 1 or 8 by selecting different

feedbacks. If the routine is in a mode where several samples are being averaged, the first sample will be in the autorange mode and be amplified by the selected gain.

When autoranging is inactive (latch output is high impedance), the latch interfaces with outputs from the CPU to allow the CPU to control the gain. This mode is used during calibration or self test to allow the gain to be manually selectable.

U19 is a filter that can be selected to be either in or out of the gain loop. In the CW mode it is in the loop, but in the pulse mode it is not used to allow for a faster settling time during the analog to digital conversion. U19 is switched in or out of the loop by U15A.

U16 is an integrated sample and hold amplifier directly controlled by the status signal from the U7 A/D converter. When U7 is given the command to convert, the status signal goes active and stays active until the conversion has completed. Then U17B, C, and D rectify the signal to give a positive output that is sent to one of the inputs of the U6 latch. Input 2D1 of U6 determines the positive or negative status of the signal. U7 interfaces directly to the data bus, and has a built-in 10 V voltage reference used throughout the system. R13 adjusts the value of the 10 V reference.

The thermistor interface circuit, U21B, uses the resistance of the detector's thermistor in conjunction with the 10 V reference to determine the temperature of the detector diodes. This output is then sent to the U20 multiplexer.

U8 is a 12 bit DAC. U21 gives a fixed offset so that there will be a resolution of exactly 2 mV corresponding to 0.02 dB when R47 is adjusted to the proper gain setting. The total range is from +30 to -50 dBm.

Refer to sheet 2 of schematic diagram #20742. The board first has an RC network that compensates for the frequency dependent losses in the delay, to assure correct pulse response. The signal is sent from the board to the delay line. Sheet 2 also shows the buffer amplifiers used with the trigger signals and monitor outputs. The input to these amplifiers comes from the detector output voltage before it reaches the delay line (at the point where the detector cable interfaces with the instrument). PPI U1 has all of the output control signals and status inputs as well as an interface to the CPU bus.

The trigger amplifier consists of OpAmp U30, high speed buffer U31, analog switch U32, and peripheral circuitry. U30 and U31 form a composite amplifier with U31 transmitting the ac information through C106, and U30 transferring the dc information through R165. R113 adjusts the dc offset of U30. Analog switch U32 sets the gain of U30 either to unity or to 10. In the X10 gain range the rise time of the trigger signal is slower. The monitor output is taken from U33, and is not corrected for offset.

U2A, B, C & D and U3A, B, C & D are the final address decoders. The chip select line, the Address line (A14), and data strobes choose whether to activate the A to D or D to A converter, or to activate PPI U1 which is controlled by the data bus and will interface read or write signals through the A1 and A2 lines.

Sheet 3 of DWG# 20742 shows the voltage input and grounding configurations for all of the IC's on the Analog PC board.

A6/A7 Test Points

The test points in Table 4-5 can be checked for the correct signals on the A4 CPU board:

Table 4-5. A6/A7 Analog Test Points

Test Point	Description
TP1	Reference Common
TP2	+10 V Reference
TP3	Output of the analog DAC
TP4	Analog output as seen on the rear panel connection
TP5	Output of the 2nd sample and hold
TP6	+5 V
TP7	5 V Common
TP8	-5 V
TP9	+15 V
TP10	-15 V
TP11	15 V Common
TP12	Can be used as scope trigger
TP13	0 Vdc adjust readout point

4.2.6 Front Panel Interface PC Assembly (A8)

The Front Panel Interface PC board powers and controls the instrument display (through U1, U2, U3, and U7); provides the interface to the keyboard and front panel indicator lamps (through U2, U4, and U7); and interfaces with the spin knob on the front panel.

Refer to Figure 4-8 and sheet 1 of schematic diagram #20196.

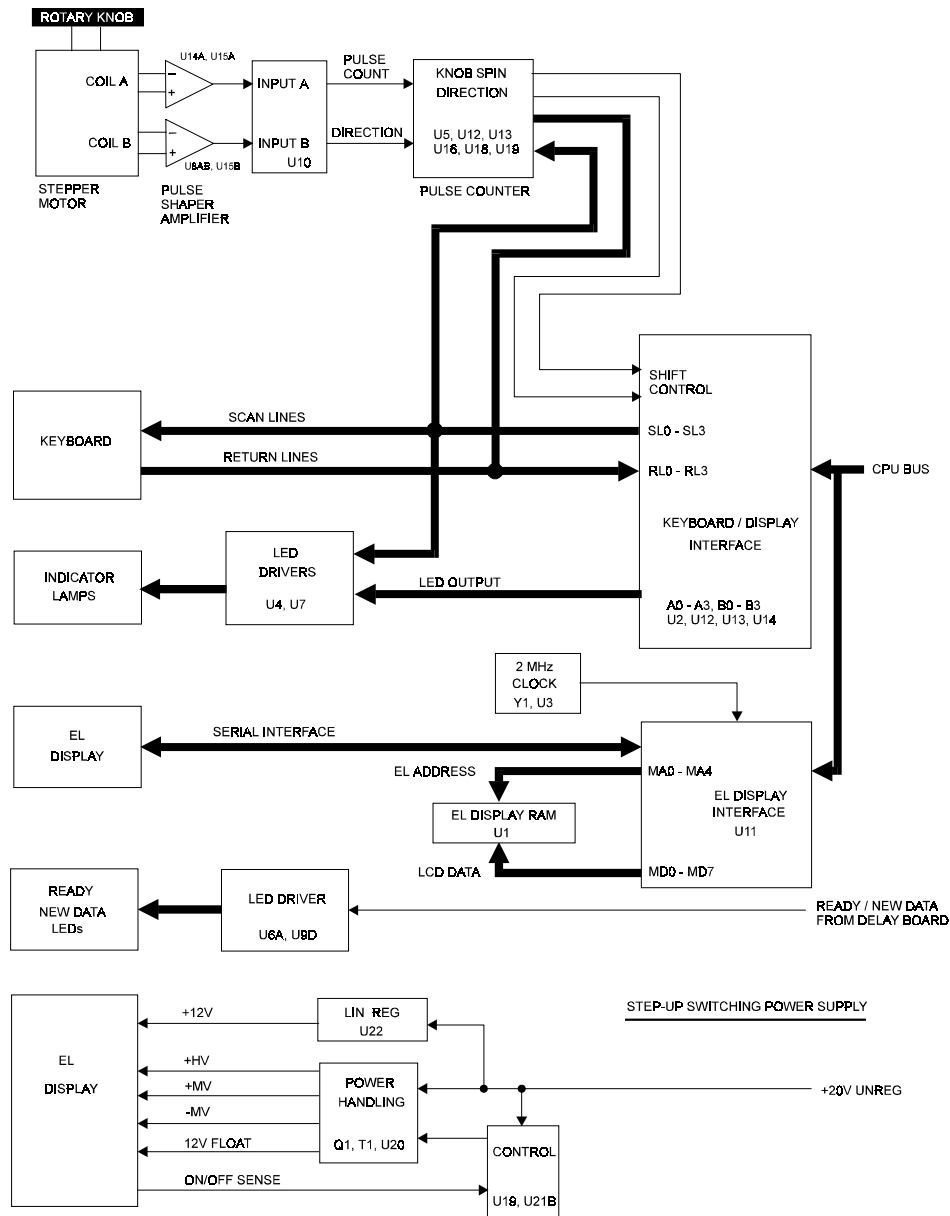


Figure 4-8. Front Panel Interface (A8) Block Diagram

U11 interfaces with the CPU, the data bus, chip select lines, read/write lines, the A1 address line, and the clock input line. The output of U11 goes directly to the display. U1 is a 69K RAM to store what is being shown on the display. This means that there is a separate data address and data bus between U11 and the U1 memory. U2 (the display and keyboard interface) has logic for the selection of the read and write functions. It has a number of scan lines (outputs) designated SL0, SL1, SL2, and SL3 that go to the keyboard. Connection is made between one of the lines and one of the return lines (RL) to tell the circuitry which key was pressed. The scan lines are also connected to the peripheral drive circuit so that, together with the output lines A0 through B3 (connected to U7), the control of which indicator lamp is to be turned on is accomplished.

Refer to Sheet 2 of schematic diagram #20196. The circuit receives its input from the stepper motor that interfaces with the spin knob on the front panel. The output is a signal that corresponds to 16 different keys in the keyboard interface circuitry. Each one is equal to a speed at which the stepper motor is being turned. Also, there are two other lines on the interface IC (U17B) that sense that the spin knob is in use and what direction it is being turned (U12B through RL0 through 7, and SL0 & 1). This signal is input to U14A & B.

The stepper motor creates two sinusoidal signals that are 90 degrees out of phase with each other. The voltages of these signals are proportional to the speed of rotation of the spin knob. That is, the higher the frequency (speed of rotation), the higher the voltage. U14A & B are low pass filters with the cut-off frequency determined by the slowest speed the spin knob can be turned (a small fraction of a Hertz). As the frequency increases, the level builds until it reaches a constant amplitude. The amplitude is input to timers U8A & B and used so that if the input level is above 2/3 of the level of the supply voltage, then the output will be high. If the input goes below 1/3 of the supply voltage level, it will go to zero. The function is similar to a Schmitt trigger with levels of 1/3 and 2/3 of the supply voltage.

U8A & B output a train of square waves which are also 90 degrees out of phase with each other. The square waves go through RC networks, and then give four inputs to U10. Each one of the inputs represents an up or down-going edge of one of the U8A & B square waves. The output is a pulse train of short pulses that indicate when the spin knob is being moved. U21A receives the pulse train, and U17A, B, C & D decode the direction of movement. If the knob is turned in one direction, U21B will have the same pulse train. When the knob is turned in the other direction, the pulse train will not be present.

Flip flop U18A is a gate controlled by the data input signal. From U12A the signal goes to monostable oscillator U17A so that when the knob is first turned an approximate 100 ms pulse is generated (read at TP6). While this pulse is high, the U16 4-bit counter counts the number of pulses from the spin knob. The more pulses that are counted, the faster the rotation of the knob. When the count reaches 15, a carry out is generated and U9B stops the counter from starting back at zero. Thus the maximum count of 15 is preserved, indicating the fastest spin knob rotation. When the U17A 100 ms timer ends, the U17B monostable outputs a SHIFT signal for approximately 20 ms. This tells the U2 keyboard decoder that the spin knob was moved. The four bit count from U16 is coded onto RL0 - RL7 by the U5 demultiplexer and part of PAL U10. PAL U10 gates the scan lines SL0 and SL1 with the highest order bit from U16 to control U5. If the count is 0 - 7, the three lower order bits from the counter are coded onto R0 - R7 by U5 when SL0 goes high. If the count is 8 - 15, the three lower order bits are coded out when SL1 goes high. The state of the CNTRL signal from flip-flop U18B indicates whether the spin knob was turning clockwise or counterclockwise.

Refer to sheet 3 of schematic diagram #20196. This is the circuitry which supplies power to the display. Linear regulator U22 regulates the +12 V down from the unregulated +20 V. The higher voltages are stepped up from the unregulated +20 V by a switching fly-back power supply. U19 is a current mode switching regulator IC which runs the supply. U19 controls the output voltages by varying the duty cycle of FET Q1, the power switch. The current through Q1 is limited by U19-3 which monitors the voltage across sense resistor R44. The rise time of the flyback voltage is controlled by a damping network composed of C60, R32, and R41. The frequency of U19 operation is fixed at about 100 kHz by timing components R37 and C53.

A8 Test Points

The test points in Table 4-6 can be checked for the correct signals on the A8 Interface Assembly:

Table 4-6. A8 Interface Assembly Test Points

Test Point	Description
TP1	5 V Common
TP2	Clock - 2 MHz
TP3	+5 V
TP4	Shift Signal
TP5	I Sense
TP6	Timer (100 ms pulse from spin knob movement)
TP7	Flyback
TP8	-HV
TP9	+HV
TP10	+20 V Unregulated
TP11	+MV
TP12	A Ground

4.2.7 Calibrator PC Assembly (A12)

Refer to Figure 4-9 and schematic diagram #17097 in Chapter 8.

The RF Diode Detector Automatic Calibrator uses a computer-controlled calibration circuit to generate precise calibration data using a simple power meter (thermistor) as a reference. This permits diode detectors to be used for absolute power measurements with the same accuracy usually associated with thermistor power meters.

Since the automatic calibration system is a new concept developed by Giga-tronics for calibrating diode detectors, the first portion of this discussion will be a general description of the overall theory involved in the system operation. The last part of the discussion will cover the operation of the specific components contained in the calibrator assembly.

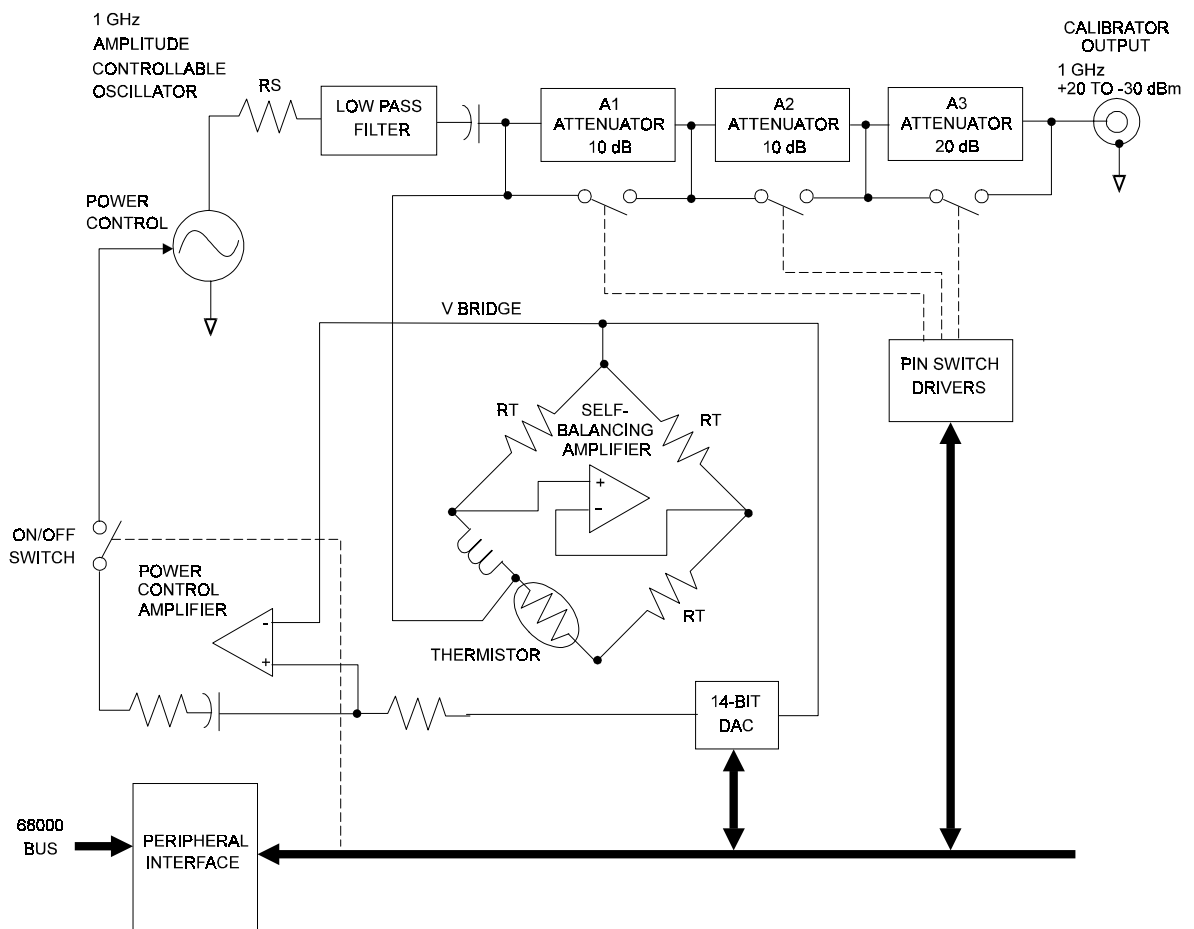


Figure 4-9. Detector Calibrator (A12) Block Diagram

The system consists of an amplitude-controllable oscillator operating at a fixed frequency of 1 GHz. A portion of the RF output is coupled into a thermistor leveling circuit which is physically mounted inside the metal housing of the calibrator assembly. Referring to Figure 4-9, the thermistor is maintained at a fixed resistance by applying a dc bias current through it. This is achieved by using a self-balancing Wheatstone bridge with the thermistor inserted in one leg of the bridge. The amount of power required to maintain the thermistor at the fixed resistance, R_T , is constant so that the RF power plus the dc power dissipated at the thermistor equals a constant. This constant can be determined by switching the RF power off and measuring the bridge voltage.

The oscillator output power can then be set by measuring this ambient bridge voltage and calculating the dc voltage which would balance the bridge when the oscillator has the required power output. When this required bridge voltage is written to the DAC on the GPIB/Cal Control PC board, the feedback causes the oscillator to settle to the selected RF power.

The above technique allows the calibrator output power to be precisely controlled over a dynamic range of approximately 15 dB. The dynamic range is increased by passing the oscillator power through a set of switched attenuators. The attenuators are designed to allow attenuation values of 0, 10, 20, 30, and 40 dB. The overall gain is adjusted so that the 20 dB stage will provide a precise 0 dBm reference with a specific power level out of the oscillator.

Integrated control of the calibrator and detector permits errors in the other attenuator stages to be completely removed in the following manner.

With a particular attenuator switched in, the processor sets the oscillator output power to precisely 9 mW and measures the detector voltage. The next level of attenuation is switched in, and a successive approximation algorithm finds the oscillator power (about 90 mW) which will give precisely the same detector voltage. By dividing the two powers, the relative attenuation of the two ranges is obtained. Since the 20 dB range is adjusted to give a 0 dBm absolute reference, the absolute effective attenuation of each range can be calculated.

The automatic calibration system generates a table of detector voltages that are equivalent to a known level of input power. This is done by applying many different input powers to the detector, measuring the amplified detector output, and storing the result. The calibration procedure is completely automatic, and the entire process including the range switching, attenuator measurements, and detector calibration takes less than one minute.

Since there is 15 dB of dynamic range in the thermistor leveled oscillator and 40 dB of attenuation available for insertion, the calibrator operates over a total 55 dBm dynamic range. Below -33 dBm, the diode detector itself is linear (square law), so the total dynamic range of the system will be 60 dB (-40 to +20 dBm).

The frequency response of each individual RF detector is measured over its entire specified range at the factory, and the information is stored in a ROM that is an integral part of the detector. Then, during the measurement of an unknown signal, the frequency response information contained in the detector's ROM and the amplitude table generated by the calibration system are combined so that if a voltage equal to, say, -10 dBm is generated by the calibrator, the instrument looks at that voltage, compares it to its table, and by interpolating between data points knows that specific voltage level equals -10 dBm. In this way, offset and gain errors in the detector amplifiers are removed and the system has the capability of measuring power over the full dynamic range of the detector with just as much accuracy as the power that is produced from the calibrator.

Refer now to DWG# 17097. Q1, together with the Base and Emitter Resonators, is the 1 GHz controllable oscillator. A portion of the signal from Q1 is coupled to a thermistor leveling circuit through the Low Pass Filter to remove harmonics, and through the quarter wave choke to allow connection to one end of the thermistor, RT1. The other end of the thermistor is connected to RF ground through an RF bypass line labeled FL5. RT1 samples the RF signal at the output of the low pass filter, and that sample is sent to the control circuitry on the GPIB/Cal Control PC board. The control circuit has a feedback system involving some amplifiers and associated circuitry as described in the GPIB/Cal Control board

discussion. The output from this feedback system controls the Q1 oscillator so that the total power in RT1 is maintained at a constant level.

Following the thermistor leveling circuit is a series of pin diode attenuators comprising three stages of attenuation (10 dB, 10 dB, and 20 dB) for a total capability of 40 dB. These stages are switched in and out by control signals from the GPIB/Cal Control board. In the first 10 dB stage, if the current through the attenuator is flowing in the direction required to turn on the series diode, CR2, then the attenuator is bypassed and minimum attenuation occurs. If the control current is in the other direction, CR2 is turned off and CR1 and CR4 will conduct so that 10 dB of signal will be lost. The other stages are similarly switched in and out to allow attenuation from 0 to 40 dB in 10 dB stages. The output then goes to the CAL connector.

R3 supplies current from the -10 to -13 V control voltage source to the emitter of Q1, and R1 and R2 are bias resistors to provide a -10 V bias to the base of Q1.

Testing and Calibration

5.1 General

This chapter is a procedural guideline for performance evaluation and calibration of the 8501A and 8502A Peak Power Meters (PPM) and power detectors. These tests can also be used for performance testing when the instrument is first received.

The Information in this chapter can be used to calibrate and/or confirm calibration of the PPM and its detectors, using the built-in automatic detector calibration system.

The performance tests are valid only if the detector has been automatically calibrated at an ambient temperature between 15 and 35 °C (59 and 95 °F), and is operating within ± 5 °C (± 9 °F) of this temperature at the time of calibration.

If the PPM has not been previously used, you should review Chapter 2 of this manual to ensure that power requirements and detector precautions have been complied with before the instrument is turned on. The instrument has been factory-calibrated and should not be re-calibrated before the performance tests detailed in this chapter have been completed. Before starting the performance test procedures, the instrument should be warmed up for at least 30 minutes for maximum stability during testing.

Performance test data and calibration recording sheets are located at the end of this chapter. These sheets can be copied and used for recording the results each time performance tests and calibration are performed on the instrument.

5.2 Performance Testing

The tests in this section are to determine that the performance of the Model 8501A or 8502A Peak Power Meters (PPM) is within the parameters of the specifications given for the instrument. Assemble all of the required test equipment and the PPM to be tested. Connect all equipment to the ac power line, turn it on, and allow at least 30 minutes for it to warm up before starting the test.

5.2.1 Equipment Required

The equipment listed in Table 5-1 is required for Performance Testing. Equivalent or similar test equipment can be substituted.

Table 5-1. Required Test Equipment

Description	Representative Model	Key Characteristics
CW Thermistor Power Meter	HP Model 432B	Instrument accuracy of at least 0.5%
Thermistor Mount	HP Model 8478B	≤ 1.1 SWR @ 1 GHz
Digital Voltmeter (DVM)	Fluke Model 8600A	$\pm 0.05\%$ accuracy
Directional Coupler	Narda Model 3002, 10 dB	≤ 1.15 SWR @ 1 GHz
Step Attenuator, 0 to 50 dB in 10 dB increments	Weinschel Model 1	≤ 1.15 SWR @ 1 GHz Accuracy <0.1 dB
RF Source (Signal Generator)	Wavetek Model 2510A Option XP	$> +20$ dBm @ 1 GHz & pulse mod
Low Pass Filter	HP Model 360B	> 30 dB attenuation @ 2 GHz
Precision Pulse Generator	Wavetek Model 178	10 ppm Frequency Accuracy
Return Loss Bridge	Wiltron 63N50 or 97NF50	Directivity 36 dB. Freq. Range from 1 GHz to max. freq. of detector in use
Scalar Network Analyzer	Giga-tronics Model 8003	Frequency Range as above
Precision DC Source	Datel Model DVC 8500A	0.05% Accuracy
Graphics Plotter	HP Colorpro Model 7440A	GPIB compatible

5.2.2 Calibrator Return Loss Test

Set up the scalar analyzer, signal generator, and the Return Loss Bridge to measure 0.95 to 1.05 GHz. Connect the bridge to the Calibrator output on the front panel of the PPM. The return loss must be >25 dB over the frequency range.

5.2.3 Calibrator Output Level Test

The following test will check the absolute level of the Calibrator function of the PPM. Note that verifying the level is not the same as setting the level. When the calibrator was previously adjusted, it was done using equipment capable of setting it to a level within the specifications of the instrument. The equipment used to verify the value also has its own uncertainties. Due to the nature of the measurement, equipment does not exist to make it practical to require a ten times (or even 3 times) accuracy difference between the specified performance and the specified accuracy of the measuring equipment. Therefore, the uncertainty allowed for this test reflects both the uncertainty of the calibrator and the uncertainty of the power meter used to verify it.

1. Place the PPM in the CW Mode by pressing [CW], then press [MENU] and select Calibration. When the Calibration/Zeroing menu appears, press [F1] and then immediately press [7]. Be sure that the Thermistor Power Meter is zeroed. Connect it to the Calibrator output connection and set it to the 1 mW range. The calibrator should read 1 mW. To be sure that the measurement is correct, the following steps must be performed exactly as given. Under no circumstances should any key be pressed other than the ones specified.

CAUTION

Do not press any UNITS key when the thermistor detector is connected to the calibrator. This would cause the calibrator to output 100 mW, and would possibly destroy the thermistor detector.

2. Press [CLEAR], then zero the Thermistor Power Meter.
3. Press [7] and read the Thermistor Power Meter. Take note of the meter reading.
4. Repeat Steps 1 and 2. Average six readings if successive readings are taken.
5. Disconnect the Thermistor Power Meter from the Calibrator connection.

The average reading in Step 3 should be 1.000 mW \pm 4.5% after correcting for the calibration factor of the thermistor mount at 1 GHz. Note that an uncertainty smaller than 4.5% can be supported by this technique if the calibration factor of the detector has been determined by a primary standards laboratory such as the NIST (formerly NBS). This value merely reflects standard current commercial practice.

5.2.4 Instrument Plus Power Detector Linearity Test

Connect the test setup as shown in Figure 5-1. The linearity will be tested in a series of 10 dB steps over the range of the instrument. At low power levels, the linearity measurement will reflect the uncertainty due to the noise specification. Measurements will be made in both the CW and Peak Modes.

Refer to the CW Linearity Data and the Peak Linearity Data sections of the Test Data recording sheets at the end of this chapter. These sections will facilitate the collection of data for the CW and Peak power linearity test. The tolerance is already entered in each section for the various steps, and includes an allowance for specified noise errors at low power levels.

5.2.5 Power Linearity Test Setup

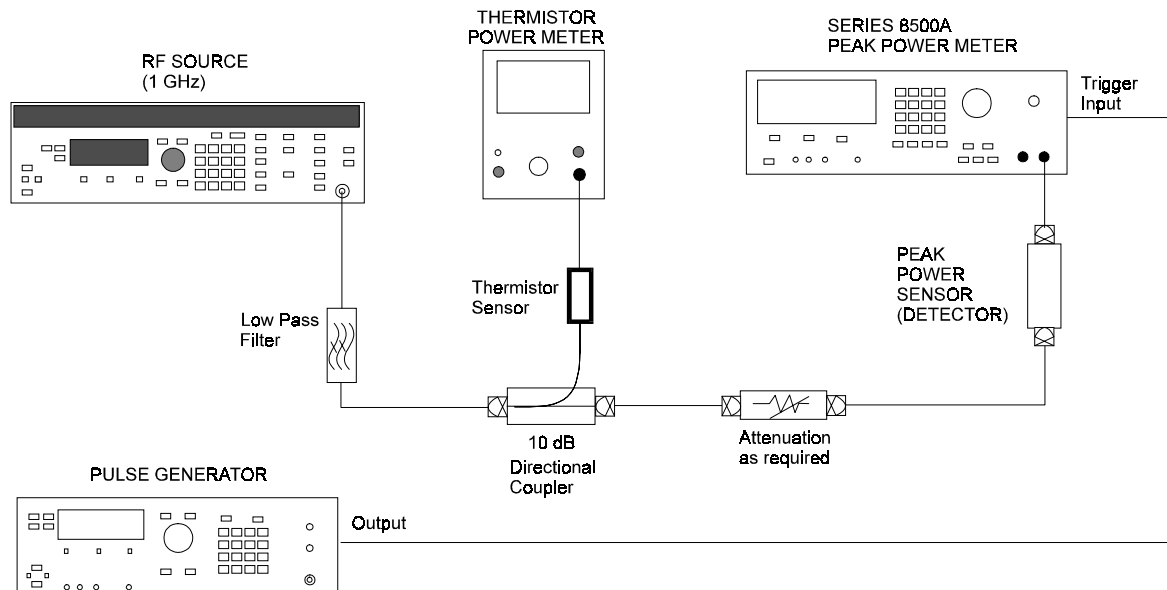


Figure 5-1. Power Linearity Test Setup

To make accurate measurements using the thermistor power meter, it is essential that it be zeroed properly. This should be checked frequently, keeping in mind that the instrument must be zeroed again if any drift has occurred.

For each value of attenuation the following steps are to be performed:

1. After initial power-on and warm up, set the PPM to read CW power in milliwatts, with the CW averaging number set to 500. This is done by pressing [CW] [MENU] (2) [F1] [500] [UNITS]
2. Check that the display indication is in milliwatts. If not, press [MENU] (4) [F3].
3. Be sure that the RF source is set to 1.0 GHz.
4. Perform an automatic calibration on the detector (use channel A for an 8502A). Use this detector for the rest of the test.
5. Automatic calibration is performed by first attaching the detector to the 1 GHz Calibrator connection on the front panel of the PPM, and then pressing [MENU] (1) [F3] [F1] [UNITS]
6. Be sure that the Thermistor Power Meter is zeroed correctly. Adjust the RF source for a reading of 10.0 mW \pm 0.25 mW.
7. Record the Power Meter Reading and the PPM Reading in the corresponding columns of the CW Linearity Data section of the Performance Verification Test Data recording sheet.
8. Adjust the source to read 1.0 mW \pm 0.025 mW.
9. Record the Power Meter Reading and the PPM Reading in the corresponding columns of the Test Data recording sheet.
10. Calculate the power ratio and reading ratio (using P1/P2 and R1/R2), and record these values in the indicated columns of the Test Data recording sheet.
11. Calculate the linearity error using the formula:

$$\text{Linearity error (\%)} = [(R1/R2) / (P1/P2) - 1] * 100$$

12. Record this value in the Linearity Error column (above the Accumulated Error figure given for each attenuation value) in the Test Data recording sheet. This value should be less than the value specified for Accumulated Error for each attenuation level.
13. Add an additional 10 dB of attenuation between the coupler and the Peak Power Detector, and repeat Steps 6 through 12. The next lower rows of the CW Data section of the Test Data sheet will be used to record the readings taken for the 20, 30, 40, and 50 dB attenuations as Steps 6 through 12 are repeated for each level of attenuation. Add the previous and current linearity errors to determine the accumulated error.
14. Set the Pulse Generator to generate 5 V pulses (TTL) with 10 μ s duration and a repetition rate of 1 kHz. Connect the Pulse Generator output to the TRIG Input on the rear panel of the PPM.
15. Set the PPM to use an external trigger in the Peak Mode, milliwatts display, and peak averaging set to 100. This is done by pressing [PEAK] [MENU] (1) [F2] [MENU] (2) [F2] [100] [UNITS] (If the display indication is not in milliwatts, press [MENU] (4) [F3]).
16. Remove all attenuators and repeat Steps 2 through 9 for the Peak Mode, recording the test indications in the Peak Linearity Data section on the Test Data recording sheet.

5.2.6 Delay Accuracy Test

Be sure that a Pulse Generator with at least 10 ppm frequency accuracy is used for this test.

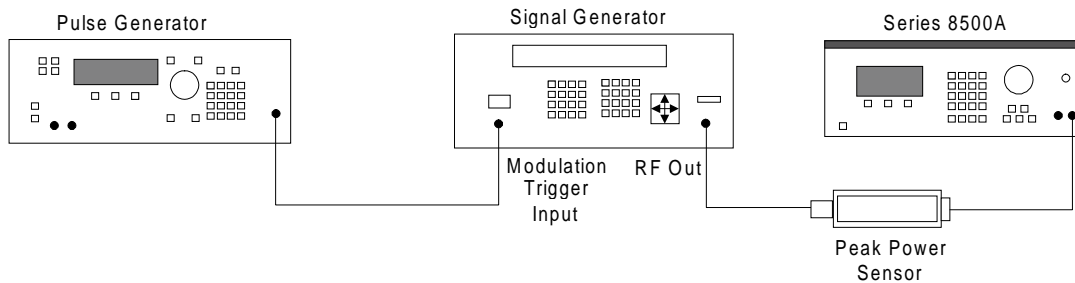


Figure 5-2. Delay Accuracy Test Setup

1. Set the peak average value to 20 by pressing [MENU] (2) [F2] [20] [UNITS]. Set the internal delay for 75 μs by pressing [MENU] (9) [F2] [75] [μs].
2. Set the Pulse Generator to generate a 10 μs wide pulse with a repetition rate of exactly 10 kHz. Adjust the amplitude to 5 V. Connect the Pulse Generator to the RF source (Signal Generator) as shown in Figure 5-2. Set the Source to generate a 50 μs pulse when triggered by the Pulse Generator. Adjust the amplitude of the Source to 0 dBm or greater. The frequency of the Source is not important. Any Source operating within the range of the PPM will be satisfactory if it can be modulated with an external pulse signal and has a rise time less than about 30 ns.
3. Set the PPM to read in the Graph Mode by pressing [GRAPH]. Press [GRAPH] again to cause the autoscale function to be performed after the PPM has been connected to the Pulse Generator. A graph of the pulse profile should now be displayed.
4. Select a delay window of 0.2 μs and set the cursor delay to place the cursor at the 50% point on the rising edge of the pulse. Note the Cursor Delay Value.
5. Press [MENU] (4) [F1]. Set the Reference Delay to be the value read at the 50% point of the first pulse (causing the cursor delay to be zero).
6. Set the start delay to 99.90 μs . Set the cursor delay to place the cursor on the 50% point of the rising edge of the pulse. The cursor delay should read 100.00 $\mu\text{s} \pm 0.01 \mu\text{s}$.

5.2.7 Analog Output Accuracy Test

Set the RF Source to generate 0 dBm CW and connect the channel A detector to the output. Connect the DVM to the channel A analog output on the rear of the PPM and, using the procedure in step 1 of the Power Linearity Test, set the PPM to read CW with an averaging factor of 900. Perform the following steps:

1. Adjust the RF Source so that the PPM reads exactly 0.00 dBm. Record the reading of the DVM. It should be less than 10 mV.
2. Adjust the RF Source so that the PPM reads exactly -10.00 dBm. Subtract the DVM reading recorded in Step 1 from the current reading. The magnitude of the difference should be $1.000V \pm 5 \text{ mV}$.
3. If a Model 8502A is being tested, repeat Steps 1 and 2 after moving the DVM to the channel B analog output.

5.2.8 Voltage Proportional to Frequency Test

Press [MENU] (3) [F3] to choose the source of frequency correction. Then press [F2] to select the rear panel input. The input characteristics will then be specified as follows:

Voltage/GHz = 1.00
Sweeper Start Voltage = 0.000
Sweeper Start Frequency = 0.000

Adjust the Precision DC Source to 0.00 V and connect it to the frequency input on the rear panel of the PPM. Select the CW Mode display. The FREQ readout at the bottom of the display should read 0.000 GHz. Set the Precision DC Source to exactly 10.00 V. The display should read $10.000 \text{ GHz} \pm 0.050 \text{ GHz}$.

5.2.9 Detector Return Loss Test

Use the 8003 or another return loss test setup appropriate to the frequency range of the detectors to be used with the PPM. Measure the return loss of the detector(s) used with the PPM. Specifications depend on the type of detector, its frequency range, and the type of connector being used. Refer to Appendix D to determine the specifications for the particular detector under test. When using this equipment, be sure to allow for the bridge directivity contribution to measurement uncertainty (in dB); this must be subtracted from the value of return loss specified for the detector.

5.2.10 Plotter Output/IEEE-488 Interface

Connect the signal generator to the PPM and display a pulse waveform in the Graph Mode. The pulse parameters, frequency, etc. are arbitrary for the purposes of testing the GPIB plot output of the PPM.

1. Use an IEEE-488 cable to connect the graphics plotter to the GPIB output connection on the rear panel of the PPM. Note the plotter address as selected on the plotter.
2. Press [MENU] (6) [F2] to enter the plotter address. If the current address is different from the desired address, enter the correct address number.
3. Press [MENU] (2) [F3] to begin the plot.

This completes the Performance Verification Tests of the PPM. If the instrument performed as given in this procedure, it is correctly calibrated and within published specifications.

5.3 Calibration Procedures

Using all solid state components, the Model 8501A/8502A meters are extremely rugged and reliable. Consequently, there is very little drift due to component aging, and adjustments to the units are rarely required. If measurements indicate that an adjustment is set within the indicated range, do not attempt to make it exact. It is often the case that variations in the equipment being used to make the test account for small differences in measured values. Since some adjustments can be interactive, be absolutely sure that an adjustment is required before making it.

These procedures should be performed whenever the instrument is due for routine calibration, or at any time calibration is required due to environmental or physical conditions. All test points and adjusting components are labeled and are accessible at the top of the PC boards. It is not necessary to remove any PC boards from the unit to perform these calibration procedures.

Figure 5-3 is a reference locator for the various components required for adjusting purposes during the calibration procedure.

If you need to calibrate any of the RF detectors used with the PPM (such as after replacing the diode element), you can do it in the field with the Giga-tronics PROM Programming Accessory Kit, P/N 16976. This kit contains all of the necessary components and instructions required for proper detector calibration. If the kit is not available, the detector can be returned to the factory for calibration.

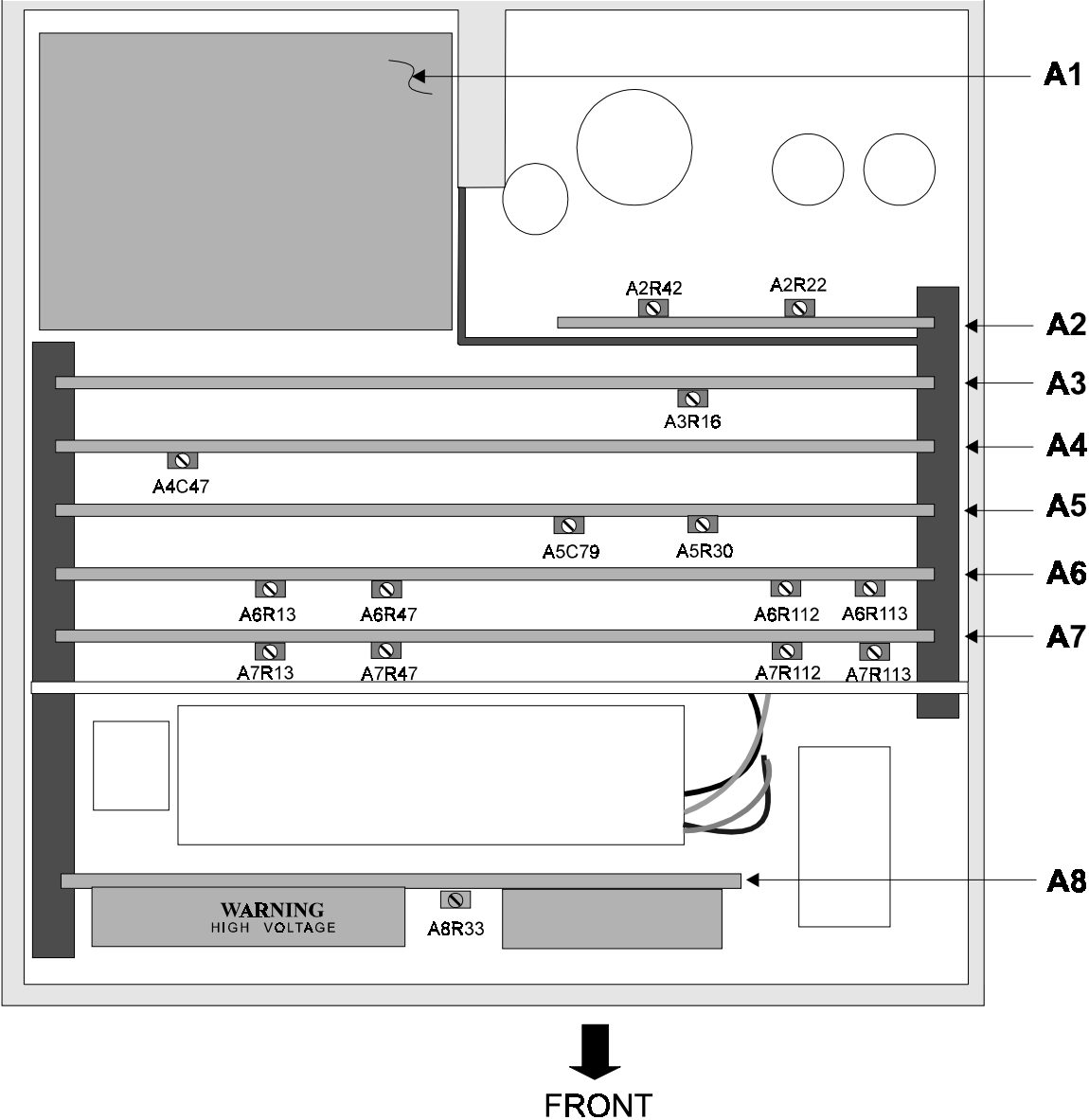


Figure 5-3. Model 8501A/8502A Calibration Components

5.3.1 Calibration Equipment Required

Test equipment required to calibrate the Models 8501A and 8502A power meters is listed in Table 5-2. Equivalent or similar test equipment can be substituted.

Table 5-2. Required Calibration Test Equipment

Description	Representative Model	Key Characteristics
Digital Voltmeter (DVM)	Fluke Model 8800	5 digit display, 0.01% accuracy
Frequency Counter	EIP Model 548	10 digit readout. At least 1 GHz
Frequency Counter/Timer	Tektronix Model DC509	30 μ s period, 1 ppm
Oscilloscope (Scope)	Tektronix Model 465	5 mV/DIV & 50 MHz bandwidth
Power Meter	HP Model 432	0.95 to 1.05 GHz at 0 dBm, 1.3%
Precision Voltage Source	Digitec Model 3110	5.000V with 0.02% accuracy
Pulsed RF Signal Generator	Giga-tronics Model 907	Trig. Modulator
Variac	General Radio Model W5MT3A	Metered
RF Detector	Giga-tronics Model 16936	High Speed (15 ns)

5.3.2 Preset Conditions

Before stating the calibration procedures, the PPM should be placed into a preset condition. The Information given in this chapter can be used to calibrate and/or confirm calibration of the PPM and its detector(s) using the built-in automatic detector calibration system.

A. Frequency Counter/Timer

1. Set FUNCTION switch to PERIOD A.
2. Set AVERAGES switch to 10 to the 6th power.
3. Set SLOPE switch to +.
4. Set ATTEN switch to X1.
5. Set SOURCE switch to EXT.
6. Set COUPL switch to dc.
7. Set TRIG LEVEL switch to AUTO.

B. Signal Generator

1. Select MODE - PM (Pulse Modulation).
2. Select PULSE MODE - INT -PULSE.
3. Select RATE (HZ) - 1K.
4. Select PULSE DELAY - X1.
5. Select PULSE WIDTH - X1.
6. Adjust RATE to midway between MIN and MAX.
7. Adjust DELAY to approx. 3 μ s (minimum).
8. Adjust WIDTH to a point midway between 0.2 μ s and 10 μ s (approx. 5 μ s).
9. Connect a cable from the SYNC NORMAL OUTPUT of the Signal Generator to the TRIG INPUT on the back of the PPM.
10. Connect the PPM to the Variac, set the Variac to 115 Vac, and turn the power on.

5.3.3 A2 Regulator Board

A. +5 V Adjust

1. Connect the DVM LO test lead to A2TP11.
2. Connect the DVM HI test lead to A2TP9.
3. Adjust A2R42 (+5V ADJ) for a DVM reading of $+5.000\text{V} \pm 100\text{ mV}$.
4. Vary the Variac voltage from 100 Vac to 130 Vac. The DVM reading must not change more than $\pm 5\text{ mV}$.

B. -5.2 V Check.

1. Connect the DVM HI test lead to A2TP10. The DVM must read $-5.200\text{ V} \pm 200\text{ mV}$.
2. Vary the Variac voltage from 100 to 130 Vac. The DVM reading must not change by more than $\pm 5.2\text{ mV}$.
3. Set the Variac to 115 Vac.

C. -15 V Adjust.

1. Connect the DVM LO test lead to A2TP6.
2. Connect the DVM HI test lead to A2TP5.
3. Adjust A2R22 (-15 V ADJ) for a DVM reading of $-15.000\text{V} \pm 15\text{ mV}$.
4. Vary the Variac voltage from 100 to 130 Vac. The DVM reading must not change by more than $\pm 15\text{ mV}$.

D. +15 V Check.

1. Connect the DVM HI test lead to A2TP3. The DVM must read $+15.000\text{ V} \pm 45\text{ mV}$.
2. Vary the Variac voltage from 100 to 130 Vac. The DVM reading must not change by more than $\pm 15\text{ mV}$.

Turn OFF the power.

Disconnect the Variac and connect the power meter to the ac power source.

5.3.4 Initialization

A. Turn the instrument on.

The PPM will automatically perform a self-test. At the completion of the self-test, the PPM will return to the last setup before power down. If the self-test failed, note the failure number and proceed by pressing [CLEAR].

B. Calibrate the Detector.

The following portion of the Calibrator procedure needs to be done only if the detector being used is different than the one that was last used with the PPM.

1. Press [CLEAR].
2. Connect the detector to the Calibrator output (use channel A detector if the unit is an 8502A).
3. Press [UNITS] and wait for the calibration cycle to complete.
4. Disconnect the detector from the Calibrator output.
5. If the unit is an 8502A and a channel B detector is connected, perform the following steps.
 - a. Connect the channel B detector to the Calibrator output.
 - b. Press [CLEAR] [UNITS] and wait for the calibration cycle to complete.
 - c. Disconnect the detector from the Calibrator output.

C. Set the Internal Clock

The Internal Clock can be set as follows:

1. Press [MENU] (5) [F3] [F1].
2. Enter the correct date ([mmddy] [UNITS]).
3. Enter the correct time ([hhmmss] [UNITS] [F3]).

5.3.5 A8 Front Panel Interface Board

A. Display Brightness Adjust

1. Connect the DVM HI lead to A8TP9 (+HV).
2. Connect the DVM LO lead to chassis.
3. Read the VWrite+ voltage shown on the sticker located on the back of A10 (the back of the display).
4. Adjust A8R33 until the DVM reads within ± 1 V of VWrite+. The display should be of even brightness across the screen without any smearing.
5. Disconnect the DVM leads.

5.3.6 A6/A7 Analog Board

Analog PC Board Nos. A6 and A7 are identical. The Model 8501A uses just the A6 board; the Model 8502A uses both A6 and A7. When testing a Model 8502A, all A6 reference designations listed in this section will become A7 when the A7 board is tested.

A. +10 V Reference Adjust

1. Connect the DVM LO lead to A6TP1 (REF COMMON).
2. Connect the DVM HI lead to A6TP2 (+10 V).
3. Adjust A6R13 (10V REF ADJ) for $10.000V \pm 3 \text{ mV}$.
4. If the unit is an 8502A, repeat Steps 1 through 3 for the A7 Analog board.
5. Disconnect the DVM.

B. Sampler Zero Adjust.

1. Set the Peak Averaging Number to 20 by pressing [MENU] (2) [F2] [20] [UNITS]
2. Connect the sync output from the back of the PPM to the Ext Trig IN on the scope, the Scope HI lead to A6TP5, and the scope ground lead to A6TP11.
3. Set the pulse generator to generate a $10 \mu\text{s}$ wide pulse with repetition rate of 1 kHz and amplitude at 5 V (TTL). Connect the pulse generator to the TRIG INPUT (TTL) on the rear panel of the PPM.
4. Press [PEAK] [MENU] [F2].
5. Adjust A6R112 (SAMPLER ZERO) for $0V \pm 2 \text{ mV}$ offset at the end of the sample time.

C. Trigger Offset Adjust.

1. Set the trigger to channel A, Internal, -15 dBm by pressing [MENU] (1) [F1] (channel A if unit is an 8502A) [-15] [dBm].
2. Connect the DVM HI lead to A6TP13 (TRIGGER OFFSET).
3. Adjust A6R113 (TRIG OUT DC OFFSET) for $0V \pm 1 \text{ mV}$ offset.
4. If the unit is an 8502A, repeat Steps B and C for board A7.
5. Disconnect the DVM test leads.

D. Analog Output Adjust.

1. Press the RESET button on the back of the PPM.
2. Press [MENU] (11) [F1] [1] [F2].



NOTE: If the PPM required detector calibration when the PPM prompts CONNECT DETECTOR TO CALIBRATOR, THEN PRESS ANY UNITS KEY, press [7] to access the service functions.

3. Connect a cable from the DVM to the ANALOG OUTPUT on the back of the PPM (ANALOG A output if the unit is an 8502).
4. Adjust A6R47 (LIN GAIN) for $0.000V \pm 10 \text{ mV}$ reading on the DVM.
5. Press [F3].
6. The DVM should read $3.000V \pm 25 \text{ mV}$.

7. Press [F1].
 8. The DVM should read $-5.000\text{ V} \pm 35\text{ mV}$.
 9. If the unit being tested is an 8502A, press [F2] and repeat Steps 3 through 8 after moving the rear cable to the ANALOG B output.
- E. Thermistor Sense Circuit.
1. Press [CLEAR] [4] [F1]
 2. The reading should be approximately 5000 mV at a detector temperature of 30 °C (82.4 °F). The reading will vary about $\pm 0.2\text{ V}/^\circ\text{C}$ with any increase or decrease in temperature from the 30 °C level (a new reading is taken each time F1 is pressed.)
 3. Press [CLEAR] [CLEAR].

5.3.7 A3 GPIB/CAL Control Board

CAUTION

The maximum output power of the Calibrator is over 100 mW. Be sure it is working properly before connecting the power meter.

A. Calibrator Frequency Check.

1. Connect the Frequency Counter to the PPM Calibrator output.
2. Select Calibrator TEST MODE by pressing [MENU] [F3] [F1] [7].
3. The frequency must be 1 GHz \pm 50 MHz.
4. Disconnect the Frequency Counter from the Calibrator output.
5. Press [CLEAR].

B. Calibrator Output Adjust.

1. Zero the Power Meter.
2. Connect the Power Meter detector to the Calibrator output on the PPM and press [7].
3. Adjust A3R16 (CALIB SET) for 0 dBm.
 - a. Press any numeric key. If the power meter indication is negative (e.g. -0.2 dBm), adjust A3R16 clockwise to approximately twice the error.
 - b. Press any of the numeric keys to take a reading.
 - c. Repeat Steps a and b until the power meter reads 0.00 dBm.
4. Disconnect the detector from the PPM.
5. Press [CLEAR].

C. Power Meter Calibrate.

1. Connect the Detector to the Calibrator output (use channel A if the unit is an 8502A).
2. Press [UNITS].
3. Wait for the PPM to calibrate itself (about 1 minute).
4. Disconnect the detector from the Calibrator output.
5. If the unit is an 8502A, repeat Steps 1 through 4 for channel B.

5.3.8 A4 CPU Board

A. Time Oscillator Adjust.

1. Connect the Frequency Counter/Timer common lead to A4TP3 (COMMON).
2. Connect the Frequency Counter/Timer test lead to A4TP6.
3. Adjust A4C47 for 30.517578 μ s \pm 0.000100 μ s.
4. Disconnect the Frequency Counter/Timer test leads.

5.3.9 A5 Digital Delay Board

A. Delay Oscillator Adjust.

1. Connect the Frequency Counter common lead to A5TP3 (5 V common)
2. Connect the Frequency Counter test lead to A5TP5.
3. Adjust A5C79 for 39.062500 MHz \pm 100 Hz.
4. Disconnect the Frequency Counter test lead.

B. Vernier Delay Adjust.



NOTE: This adjustment requires the use of the high speed (15 ns) detector. Do not attempt it with a low speed (750 ns) detector.

1. Connect the detector to the signal generator (use channel A if the unit is a 8502A).
2. Place the PPM in the Graph mode by pressing [GRAPH].

The left half of the PPM display should look similar to Figure 5-4. Each of the division marks at the bottom of the display represent 1/10th of the total display window. The left edge of the display is equal to the Start Delay, and the right edge is equal to the Delay Window plus the Start Delay. The division marks on the left side of the display represent the 10%, 50%, 90% and 100% Reference Power levels.

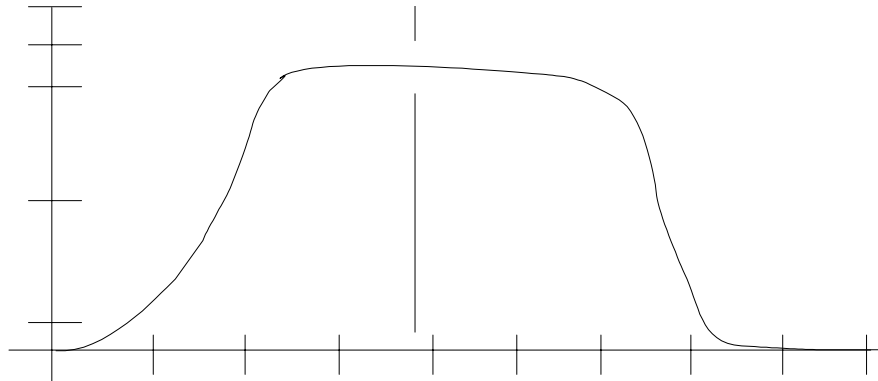


Figure 5-4. Typical PPM Digital Delay Display

3. Select External Trigger by pressing [MENU] [F2].
4. Adjust the Start Delay to move the start of the pulse near the beginning of the graphics display.
 - a. Move the cursor to the STRT DLY line.
 - b. Rotate the spin knob clockwise until the start of the pulse is within 1/4 of a division of the start of the graphics display. Press [UNITS].
5. Adjust the Delay Window to 0.05 μ s by moving the cursor to DLY WIND, entering 0.05 through the keypad, and then pressing [μ s].
6. Set the Cursor Delay to the 25.6 ns multiple (see Table 5-3) that occurs after the start of the displayed pulse by moving the cursor to CRS DLY, entering the multiple value, and then pressing [ns] or [μ s].

7. Set the Start Delay to the value in the column to the right of the 26.5 ns that was selected in Step 6 above by moving the cursor to STRT DLY, entering the number (e.g. 0.0196 which is 0.0256 minus 0.006), and then pressing [μ s].
8. Set the Pulse Delay on the Signal Generator so that the rising edge of the pulse on the PPM display crosses through the cursor at approximately the input pulse 50% point.
9. Set the Delay Window for 12 ns by moving the cursor to DLY WIND, entering [12], and pressing [ns].
10. Set the Reference Power. Move the cursor to the REF PWR line and press [UNITS].
11. Adjust A5R30 (Vernier Delay) to its maximum ccw position.
12. The display should look similar to Figure 5-5.

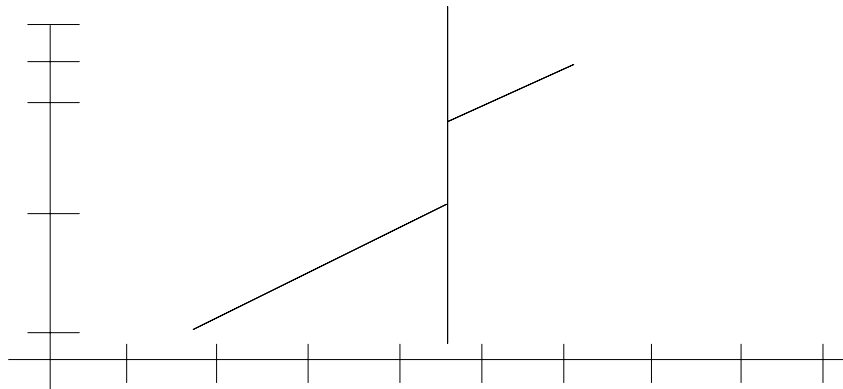


Figure 5-5. Typical PPM Display with A5R30 at Max cw

13. Adjust A5R30 ccw until the rise time of the displayed pulse is smooth (see Figure 5-6).
14. Set the peak averaging number to 50 by pressing [MENU] (2) [F2] [50] [UNITS].
15. The rising slope of the pulse must still look smooth. If not, readjust A5R30.
16. Press [GRAPH].

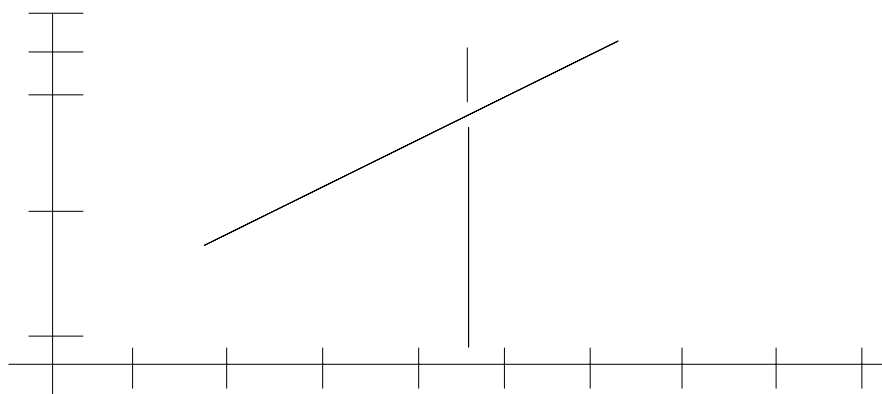


Figure 5-6. Typical PPM Display w/Smooth Rise Time

Table 5-3. Multiples of 25.6 ns

Cursor Delay (ns)	Start Delay (ns)	Cursor Delay (ns)	Start Delay (ns)	Cursor Delay (ns)	Start Delay (ns)	Cursor Delay (ns)	Start Delay (ns)
25.60	19.60	1.0240	1.0180	2.0224	2.0164	3.0208	3.0148
51.20	45.20	1.0496	1.0436	2.0480	2.0420	3.0464	3.0404
76.80	70.80	1.0752	1.0692	2.0736	2.0676	3.0720	3.0660
102.40	96.40	1.1008	1.0948	2.0992	2.0932	3.0976	3.0916
128.00	122.00	1.1264	1.1204	2.1248	2.1188	3.1232	3.1172
153.60	147.60	1.1520	1.1460	2.1504	2.1444	3.1488	3.1428
179.20	173.20	1.1776	1.1716	2.1760	2.1700	3.1744	3.1684
204.80	198.80	1.2032	1.1972	2.2016	2.1956	3.2000	3.1940
230.40	224.40	1.2288	1.2228	2.2272	2.2212	3.2256	3.2196
256.00	250.00	1.2544	1.2484	2.2528	2.2468	3.2512	3.2452
281.60	275.60	1.2800	1.2740	2.2784	2.2724	3.2768	3.2708
307.20	301.20	1.3056	1.2996	2.3040	2.2980	3.3024	3.2964
332.80	326.80	1.3312	1.3252	2.3296	2.3236	3.3280	3.3220
358.40	352.40	1.3568	1.3508	2.3552	2.3492	3.3536	3.3476
384.00	378.00	1.3824	1.3764	2.3808	2.3748	3.3792	3.3732
409.60	403.60	1.4080	1.4020	2.4064	2.4004	3.4048	3.3988
435.20	429.20	1.4336	1.4276	2.4320	2.4260	3.4304	3.4244
460.80	454.80	1.4592	1.4532	2.4576	2.4516	3.4560	3.4500
486.40	480.40	1.4848	1.4788	2.4832	2.4772	3.4816	3.4756
512.00	506.00	1.5104	1.5044	2.5088	2.5028	3.5072	3.5012
537.60	531.60	1.5360	1.5300	2.5344	2.5284	3.5328	3.5268
563.20	557.20	1.5616	1.5556	2.5600	2.5540	3.5584	3.5524
588.80	582.80	1.5872	1.5812	2.5856	2.5796	3.5840	3.5780
614.40	608.40	1.6128	1.6068	2.6112	2.6052	3.6096	3.6036
640.00	634.00	1.6384	1.6324	2.6368	2.6308	3.6352	3.6292
665.60	659.60	1.6640	1.6580	2.6624	2.6564	3.6608	3.6548
691.20	685.20	1.6896	1.6836	2.6880	2.6820	3.6864	3.6804
716.80	710.80	1.7152	1.7092	2.7136	2.7076	3.7120	3.7060
742.40	736.40	1.7408	1.7348	2.7392	2.7332	3.7376	3.7316
768.00	762.00	1.7664	1.7604	2.7648	2.7588	3.7632	3.7572
793.60	787.60	1.7920	1.7860	2.7904	2.7844	3.7888	3.7828
819.20	813.20	1.8176	1.8116	2.8160	2.8100	3.8144	3.8084
844.80	838.80	1.8432	1.8372	2.8416	2.8356	3.8400	3.8340
870.40	864.40	1.8688	1.8628	2.8672	2.8612	3.8656	3.8596
896.00	890.00	1.8944	1.8884	2.8928	2.8868	3.8912	3.8852
921.60	915.60	1.9200	1.9140	2.9184	2.9124	3.9168	3.9108
947.20	941.20	1.9456	1.9396	2.9440	2.9380	3.9424	3.9364
972.80	966.80	1.9712	1.9652	2.9696	2.9636	3.9680	3.9620
998.40	992.40	1.9968	1.9908	2.9952	2.9892	3.9936	3.9876

5.3.10 External Interface

A. Monitor Outputs.

1. Connect a terminated coaxial cable from the MONITOR output on the back of the PPM to the Scope (channel A if the unit is an 8502A).
2. The Scope display should look like the pulse displayed on the PPM Graphics display with the amplitude representing the buffered detector signal.
3. If the unit being tested is an 8502A:
 - a. Disconnect the channel A detector from the Signal Generator.
 - b. Connect the channel B detector to the Signal Generator.
 - c. Select B channel AUTOSCALE by pressing [B] [GRAPH].
 - d. Move the coaxial cable from the A channel MONITOR output to the B channel MONITOR output on the 8502A.
 - e. The Scope display should be the same as Step 2.
4. Disconnect the terminated coaxial cable from both the 8502A and the Scope.

B. Sync Output.

1. Connect a coaxial cable (no termination) from the SYNC output on the back of the PPM to the Scope.
2. The Scope display should be similar to Figure 5-7.

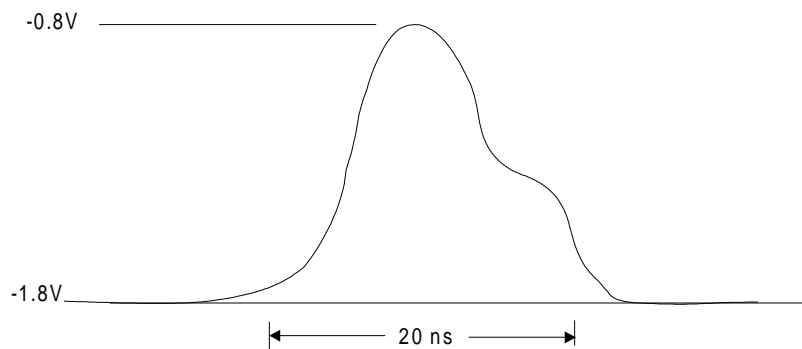


Figure 5-7. Typical PPM Sync Output Scope Display

3. Disconnect the coaxial cable from both the PPM and the Scope.

C. Frequency Input.

1. Connect a coaxial cable from the voltage source to the FREQUENCY INPUT connection on the back of the PPM.
2. Set the voltage source to +5.000V.
3. Select the External Frequency input by pressing [MENU] (3) [F3] [F2] [UNITS] [UNITS] [GHz]

4. Place the system into the Peak Mode by pressing [PEAK].
 5. The $FREQ = XXXX$ portion of the PPM display must read $5.000\text{ GHz} \pm 0.020\text{ GHz}$.
- D. RF Blanking Output.
1. Connect a coaxial cable from the Scope to the RF BLANKING output on the PPM.
 2. Disconnect the Detector from the Signal Generator.
 3. The Scope should display a dc level of +5 V.
 4. Enter the Autozero function by pressing [MENU] [F3] [F2] [UNITS].
 5. During the Autozero cycle the Scope display must drop to near 0 V, and then return back to +5 V.

5.3.11 Volume Adjust

1. Adjust the VOLUME ADJ on the back of the PPM fully ccw.
2. Press several keys. Very little (if any) sound (clicks) should be heard from the speaker when the keys are pressed.
3. Adjust the VOLUME ADJ fully clockwise.
4. Press several keys. The clicks should be very easy to hear when the keys are pressed.

The volume of the beeps used to indicate success or failure of zeroing, calibration, and self-test will be set to the same level as the adjustment for the clicks.

Giga-tronics Series 8500A

Performance Verification Test Data Sheet

Make copies of this Data Sheet and use the copies for recordings. While proceeding through the Calibration procedures, if any specification cannot be met by performing the given adjustments, go immediately to Troubleshooting in Chapter 6 and follow the procedures to identify the problem.

Date: _____

Model 8501A or 8502A S/N: _____

Operator: _____

Test Number: (if required): _____

CW Linearity Data							
Step Attenuator Value	Power Set Point	Power Meter Reading (P)	8540C (DUT) Reading (R)	Reference Power Ratio	Reading Ratio	Linearity Error (%) ¹	
						Linearity Specification	Accumulated Linearity Error ²
0 dB	10.00 mW ±0.25 mW	P1 =		P1/P2 =	R1/R2 =		
	1.00 mW ±0.025 mW	P2 =				±4%	Same as Lin. error above
10 dB	10.00 mW ±0.25 mW	P1 =	R1 =	P1/P2 =	R1/R2 =		
	1.00 mW ±0.025 mW	P2 =	R2 =			±4%	
20 dB	10.00 mW ±0.25 mW	P1 =	R1 =	P1/P2 =	R1/R2 =		
	1.00 mW ±0.025 mW	P2 =	R2 =			±4%	
30 dB	10.00 mW ±0.25 mW	P1 =	R1 =	P1/P2 =	R1/R2 =		
	1.00 mW ±0.025 mW	P2 =	R2 =			±4%	
40 dB	10.00 mW ±0.25 mW	P1 =	R1 =	P1/P2 =	R1/R2 =		
	1.00 mW ±0.025 mW	P2 =	R2 =			±5%	
50 dB	10.00 mW ±0.25 mW	P1 =	R1 =	P1/P2 =	R1/R2 =		
	1.00 mW ±0.025 mW	P2 =	R2 =			±14%	

1. Linearity Error (%) = [(R1/R2) / (P1/P2) - 1] * 100

2. Accumulated error is the sum of the current dB segment linearity error plus the previous accumulated error.

Peak Power Linearity Data							
Step Attenuator Value	Power Set Point	Power Meter Reading (P)	8540C (DUT) Reading (R)	Reference Power Ratio	Reading Ratio	Linearity Error (%) ¹	
						Linearity Specification	Accumulated Linearity Error ²
0 dB	10.00 mW ±0.25 mW	P1 =	R1 =	P1/P2 =	R1/R2 =		
	1.00 mW ±0.025 mW	P2 =	R2 =			±4%	
10 dB	10.00 mW ±0.25 mW	P1 =	R1 =	P1/P2 =	R1/R2 =		
	1.00 mW ±0.025 mW	P2 =	R2 =			±4%	
20 dB	10.00 mW ±0.25 mW	P1 =	R1 =	P1/P2 =	R1/R2 =		
	1.00 mW ±0.025 mW	P2 =	R2 =			±7%	
30 dB	10.00 mW ±0.25 mW	P1 =	R1 =	P1/P2 =	R1/R2 =		
	1.00 mW ±0.025 mW	P2 =	R2 =			±39%	

3. Linearity Error (%) = [(R1/R2) / (P1/P2) - 1] * 100

4. Accumulated error is the sum of the current dB segment linearity error plus the previous accumulated error.

Other Test Results

(Listed in the same order as given in the performance test)

Test	See Section	Specifications	Reading
Calibration Output Level	5.2.3	0.995 to 1.045 mW	
Delay Accuracy	5.2.6	799.92 to 800.08 μs	
Analog Output Accuracy	5.2.7	0.995 to 1.005 V	
V prop F Test	5.2.8	9.95 to 10.05 GHz	

Giga-tronics Series 8500A Calibration Data Recording Sheet

Make copies of this Data Sheet and use the copies for recordings. While proceeding through the Calibration procedures, if any specification cannot be met by performing the given adjustments, go immediately to Troubleshooting in Chapter 6 and follow the procedures to identify the problem.

Date: _____ Model and Serial No: _____

Operator: _____ Test Number (if required): _____

Temperature: _____ Humidity: _____

Manual Section	Section	Step	Specification	Reading	
Regulator Board	5.3.3	A.3	+4.900 V to +5.100 V		
	5.3.3	A.4	Within 5 mV of A.3 reading		
	5.3.3	B.1	-5.000 V to -5.400 V		
	5.3.3	B.2	Within 5.2 mV of B.1 reading		
	5.3.3	C.3	-14.985 V to -15.015 V		
	5.3.3	C.4	Within 15 mV of C.3 reading		
	5.3.3	D.1	+14.995 V to +15.045 V		
	5.3.3	D.2	Within 15 mV of D.1 reading		
				A6	A7 (8502A Only)
Analog Board	5.3.6	A.3	+9.997 V to +10.003 V		
	5.3.6	B.5	-2 mV to +2 mV		
	5.3.6	C.3	-1 mV to +1 mV		
	5.3.6	D.4	-10 mV to +10 mV		
	5.3.6	D.6	+2.975 V to +3.025 V		
	5.3.6	D.8	-4.965 V to -5.035 V		
	5.3.6	E.2	Approx. 5000 mV (±0.2 V/°C dev. from 30 °C)		
GPIB/Cal Ctrl Board	5.3.7	A.3	950 to 1050 MHz		
CPU Board	5.3.8	A.3	30.517478 to 30.517678 μs		
Digital Delay Board	5.3.9	A.3	39.062400 to 39.062600 MHz		
Ext. Interface	5.3.10	C.5	4.98 to 5.02 GHz		
	5.3.10	D.3	+5 Vdc		
	5.3.10	D.5	Approx. 0 Vdc		

Maintenance

6.1 Introduction

This chapter defines maintenance practices and troubleshooting procedures required for fault isolation down to PC board level.

Problems can occur that might be produced by equipment or components peripheral to the 8501A/8502A units. Preliminary checks should be made to be sure that a malfunction of external equipment or components is not causing what appears to be a problem within the instrument.

6.2 Periodic Maintenance

The following maintenance procedures should be performed once each year unless the meter is operated in an extremely dirty or chemically contaminated environment. More frequent periodic maintenance may then be required.

1. Blow out all accumulated dust and dirt with forced air under moderate pressure. Also, the air filter for the cooling fan on the rear panel of the PPM should be checked every 3 months for accumulated dust. A dirty filter can restrict air flow into the unit and cause the instrument to overheat, which may cause the thermal sensor to shut the instrument off in the middle of a test routine. If dirty, the filter should be removed and cleaned with a mild detergent and water solution. Replacement filters can be ordered from the factory.
2. Remove the filter from its holder by snapping the retainer out of the holder. Do not remove the screws from the filter holder.
3. Inspect the unit for loose wires or damaged components. Check that the PC boards are properly seated in their receptacles, and that all wire connectors are properly attached to their PC board pins.
4. The front panel and housing of the unit can be cleaned with a cloth dampened in a mild detergent. Do not use abrasive cleaners, scouring powders, or any harsh chemicals. Wipe the soap residue off with a clean, damp cloth, then dry with a clean dry cloth.
5. If calibration is required, refer to Chapter 5 of this manual for procedures.
6. Make a performance verification test in accordance with the procedures in Chapter 5. If the performance is within the required specifications, no further service is necessary.

6.2.1 Required Test Equipment

The following test equipment is required to perform these procedures. Equivalent models and types can be substituted.

Table 6-1. Required Test Equipment

Description	Representative Model	Key Characteristics
Digital Voltmeter (DVM)	Fluke Model 8800	5 digit display, 0.01% accuracy
Frequency Counter	EIP Model 548	10 digit readout. At least 1 GHz
Frequency Counter/Timer	Tektronix Model DC509	30 μ s period, 1 ppm
Oscilloscope (Scope)	Tektronix Model 465	5 mV/DIV & 50 MHz bandwidth
Power Meter	Giga-tronics Series 8540	0.95 to 1.05 GHz at 0 dBm, 1.3%
Precision Voltage Source	Digitec Model 3110	5.000 V with 0.02% accuracy
Pulsed RF Signal Generator	Giga-tronics Model 907	Trig. Modulator
Variac	General Radio Model W5MT3A	Metered
RF Detector	Giga-tronics Model 16936	High Speed (15 ns)

6.3 Troubleshooting

The information in this section should enable a technician to locate a malfunction and determine specifically which PC board is causing the problem. The instructions given in this section trace a problem to a specific board. Then, the electrical description of the board contained in Chapter 5 and the applicable diagram in Chapter 8 can be employed to assist the technician in circuit tracing the suspected board. Ensure that devices or components external to the PPM are not the cause of the problem before starting the Troubleshooting procedure.

In general, troubleshooting of the PPM is divided into three parts. First, the display is observed for any error flags (numbers) that might pinpoint the specific faulty section of the circuitry (after performing the self-test function). Second, a known and specific pulse or CW signal is applied and varied as required to allow a general determination of the severity and parameters of the problem. Third, suspect PC boards are placed on extenders, and waveform and dc voltage indications are traced and checked. By following the initial approach, the steps in this section can help to isolate and locate the PC board causing a particular problem.

6.3.1 Equipment Required

The equipment in Table 6-1 is also required for the Troubleshooting procedures in this section. Additionally, the Giga-tronics Extender board (P/N 17075) or equivalent is needed for troubleshooting the A2 Power Supply PC board, and the Giga-tronics Extender board (P/N 17076) or equivalent is required for troubleshooting the A3 GPIB/Cal, A4 CPU, A5 Digital Delay, and A6/A7 Analog PC boards to component level.

6.3.2 Power-On Failure

1. No indication that the power is turned on when the ON button is pressed (fan not running and no lights on the front panel.)
 - a. Ensure that the power cord is plugged into an ac source with the correct voltage and frequency for the PPM. (See Power Requirements in Section 2.2 of this manual.)
 - b. Check the ac input fuse (F1) on the rear panel to be sure that it is in place and not blown.
 - c. Ensure that the ac Select Plate is installed in the rear of the instrument.
 - d. Ensure that the A2 Power Supply Regulator PC board is properly seated in its socket.
 - e. Check the thermal shut-off switch located on board A2. (Also, see step 1 of Section 6.2)
 - f. Check the 5 V (CR1) and 15 V (A1CR1) Bridge Rectifiers.
2. Front panel apparently works (the display turns on and lights flash when power is applied), but the fan is not running.
 - a. Check the 15 V supplies.
 - b. Check the fan motor.
 - c. Check the Fan Filter Circuit consisting of A1R1 through A1R4, A1C13, and A1C14.
3. Fan is running, but nothing on the front panel is working.
 - a. Check the +5 V and -5.2 V power supplies.
 - b. Ensure that the A8 Front Panel Interface PC board is properly seated in its socket.
4. Front panel lights are flashing and the display is dark.
 - a. Ensure that the A4 CPU PC board is properly seated in its socket.

- b. Press [RESET] on the rear panel. If this clears the problem, check the output of the Reset Timer (A4U17) for a pulse width of approximately 750 ms when the RESET button is pressed.
- c. Check the 6 MHz CPU clock at A4TP1.
- d. Check the CPU Halt signal at A4U12, pin 17 (low digital level = a Halt condition).
- e. Check the Address and Data I/O on the CPU at A4U12.
- f. Check the Address Buffers on the CPU at A4U7, A4U8, and A4U9.
- g. Check the Data Buffers on the CPU at A4U32 and A4U33.
- h. Check the Address Decoder on the CPU at A4U34.
- i. Ensure that all of the PROMs on the CPU board are installed in their proper locations.

Self-test Failure Indications & Possible Causes

Information given in this section assumes that the PPM was working properly when it was initially turned on, that self-test was selected, a failure occurred, and an Error Number was shown in the instrument's display window. Note that during the self-test, all of the front panel LEDs are lit.

Each of the self-test checks will be described briefly, and then possible causes of the problem (as indicated by the displayed Error Number pertaining to the specific test) will be listed.

Self-Test #1 (Error Number 01): -5.2 V Out of Tolerance

This test applies -5.2 V to the Analog A/D Converter (A6U7) through switch A6U13. The -5.2 V must be between -4.94 and -5.46 V.

1. Check the -5.2 V regulator circuit on PC board A2.
2. Check the switches (A6U13C and A6U20) on the A6 Analog board.
3. Check the PPI chip (A6U1).

Self-Test #2 (Error Number 02): Memory Bad

This test performs a walking 1's test on the volatile RAM. (Clears the memory, then writes and reads a 1 to each memory location. Then writes and reads a 2, etc.)

Check the volatile RAM chips A4U5, A4U6, A4U30, and A4U31.

Self-Test #3 (Error Number 03): Excessive A Channel Offset

This test sets the A channel on the A6 Analog PC board to its maximum gain of 8192, and measures the total offset voltage present at the input to the Analog A/D Converter (A6U7). The allowable range for the voltage at the input to the Analog PC board is 0.5 mV which would mean a range of 4.096 V at the input to the A/D Converter.

1. Swap the detector and run the self-test again.
2. Check the amplifiers in the Analog PC board.
3. Check the Analog Switches A6U25, A6U20, A6U15, and A6U13.
4. Check the PPI chip A6U1.

Self-Test #4 (Error Number 04): A Channel Gain Error

The self-test sets the first variable gain stage to a gain of 8 and measures the offset. Then, 0.5 V is applied to the input of the x2 amplifier and the overall gain is measured. The first variable gain stage is

then reset to unity gain, and the second stage is tested, then the third, and then the fourth in the same way. The tolerance for each stage is 2% of the gain.

1. Check the amplifiers in the Analog PC board.
2. Check the Analog Switches A6U22, A6U15, and A6U13.
3. Check the PPI chip A6U1.

Self-Test #5 (Error Number 05): Excessive B Channel Offset

Use the same description and Troubleshooting procedures as given in Self-Test #3. All reference designations are changed to A7. Applies only to the Model 8502A.

Self-Test #6 (Error Number 06): B Channel Gain Error

Use the same description and Troubleshooting procedures as given in Self-Test #4. All reference designations are changed to A7. Applies only to the Model 8502A.

Self-Test #7 (Error Number 07): A Channel Analog Output DAC

This test routes the output of the Analog Output DAC circuit to the input of the Analog A/D Converter. The DAC is stepped through 81 steps from low to high (each step is 0.1 V). The tolerance is 0.5% \pm 10 mV.

1. A6R47 (LIN GAIN) is not adjusted properly. See Section 5.3.6.
2. Check DAC circuit A6U8, A6U14A, and A6U21A.
3. Check analog switches A6U20 and A6U13C.
4. Check the PPI chip A6U1.
5. Check the decoder circuit consisting of A6U2C & D, A6U3C, and A6U5D.

Self-Test #8 (Error Number 08): B Channel Analog Output DAC

Use the same description and Troubleshooting procedures as given in Self-Test #7, preceding. All reference designations are changed to A7. Applies only to the Model 8502A.

Self-Test #9 (Error Number 09): Delay 8255s

This test writes a hex AA to the first port of A5U6 and reads back the data. It then writes a hex 55 to the same port and reads back the data. These tests are then performed on the remaining two ports of A5U6, and on all three ports of A5U7.

1. Check A5U6 and A5U7.
2. Check A5U4.
3. Check Address Decoder A4U34.

Self-Test #10 (Error Number 10): Delay Time Error

This test sets the PPM into the Peak Mode with a delay of 200 ms. It then triggers the delay circuit and measures the time until the delay is complete. The tolerance is 7 ms.

Make a thorough check of all circuits on the A5 Digital Delay PC board.

Self-Test #11 (Error Number 11): Calibrator Bridge Voltage Error

This test uses the same software as the Calibration cycle to check the bridge voltage.

1. Check A3TP9. Must be between +3 and +10 Vdc.
2. Check PPI chip A3U9.
3. Check A3U14, A3U15, A3U10, A3U13, and A3U18A.
4. Check the Calibrator (A12).
5. Check Address Decoder A4U34.

Input/Output & Calibration Failures

1. The External Trigger input is not functioning.
 - a. External Trigger not selected. See External Triggering in Section 2.6.2.
 - b. Check A5Q1.
 - c. Check A5U31 and A5U30.
 - d. Check A5U7.
2. The External Frequency input is not functioning.
 - a. The External Frequency input has not been selected. See PROM Frequency Correction in Section 2.8.2.
 - b. Check A6U20 (or A7U20 if this is a B channel problem).
 - c. Check A6R81, A6R140, and A6C94.
 - d. Check A6U1.
3. The SYNC OUTPUT is not functioning.
 - a. Check A5U35C.



NOTE: This is an ECL level pulse with a width of approximately 20 ns.

4. The RF BLANKING OUTPUT is not functioning properly.
 - a. Check A3Q7.
 - b. Check A3U8.
5. The MONITOR OUTPUT is not working.
 - a. Check A6U30, A6U32 (or A7U30, A7U32 if it is a B channel problem).
6. The PPM passes self-test, but fails when attempting to calibrate the detector.
 - a. Replace the detector.
 - b. Replace the detector cable.
 - c. Refer to the GPIB/Cal control board instructions in Section 5.3.7 to check the Calibrator output.

Parts Lists

7.1 Introduction

This chapter contains the parts lists for all major and minor assemblies in the Series 8500A Peak Power Meters. Parts lists for available Options, when applicable, are in Appendix E under the respective option heading. A list of Manufacturers is included in Section 7.2.

7.2 Parts Lists for Series 8500A Peak Power Meters

If not otherwise specified, the following parts lists apply to both the Model 8501A and 8502A power meters.

8501A PEAK POWER METER, Rev: C

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	20512-A00	1	58900	20512-A00	8501A CHASSIS ASSY
2	20508-001	1	58900	20508-001	FRONT PANEL, 8501A
3	20790	1	58900	20790	OPER MANUAL KIT, 8500A SERIES
4	HFFB-63201	2	21604	PP40013	REAR FOOT
5	WMPO-03007	1	16428	17250	7.5' IEC POWER CORD
6	13592	2	58900	13592	RIGHT HANDLE CAP
7	13593	2	58900	13593	LEFT HANDLE CAP
8	HFBI-00014	1	21604	MP40008-10	14" INSIDE MOUNT BAIL
9	15134-002	1	58900	15134-002	LABEL "A2" PER DWG
10	15134-003	1	58900	15134-003	LABEL "A3" PER DWG
11	15134-004	1	58900	15134-004	LABEL "A5" PER DWG
12	15134-005	1	58900	15134-005	LABEL "A6" PER DWG
13	15134-010	1	58900	15134-010	ID LABEL "A4"
14	15295	1	58900	15295	LABEL, BOTTOM DECK
15	16536-003	2	58900	16536-003	HANDLE STRAP, 12.75" LG
16	16956-001	1	58900	16956-001	8500 SERIES DET EXT CABLE 1.5M
17	16957	1	58900	16957	TOP COVER
18	16958	1	58900	16958	BOTTOM COVER
19	17018	1	58900	17018	RIVETED PS COVER ASSY
20	17028-001	8	58900	17028-001	SCR TRUSS HD 4-40X.25 LT GREY
21	17324-001	1	58900	17324-001	HOLDDOWN, PCB 8501A
22	19975-003	1	58900	19975-003	SHIPPING BOX, 275# DW 30x24x12
23	20601	1	58900	20601	FILTER, EL DISPLAY
24	20602	1	—	20602	BEZEL, EL DISPLAY
25	20635	1	58900	20635	SHIELD, HIGH VOLTAGE
26	20636	1	0ABX4	20636	LABEL, WARNING
27	20738	1	58900	20738	DIE CUT TRANSFER TAPE, DISPLAY
28	21098	1	58900	21098	KNOB, 48mm - .25 COLLET
29	HFFL-63202	1	21604	1S001201	LEFT FRONT FOOT
30	HFFR-63202	1	21604	1S001202	RIGHT FRONT FOOT
31	70112	REF	58900	70112	PROCEDURE, MODEL 8501A

8502A DUAL INPUT PEAK POWER METER, Rev: C

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	20513-A00	1	58900	20513-A00	8502A CHASSIS ASSY
2	20510-001	1	58900	20510-001	FRONT PANEL, 8502A
3	HFFB-63201	2	21604	PP40013	REAR FOOT
4	WMP0-03007	1	16428	17250	7.5' IEC POWER CORD
5	13592	2	58900	13592	RIGHT HANDLE CAP
6	13593	2	58900	13593	LEFT HANDLE CAP
7	HFBI-00014	1	21604	MP40008-10	14" INSIDE MOUNT BAIL
8	15134-002	1	58900	15134-002	LABEL "A2" PER DWG
9	15134-003	1	58900	15134-003	LABEL "A3" PER DWG
10	15134-004	1	58900	15134-004	LABEL "A5" PER DWG
11	15134-005	1	58900	15134-005	LABEL "A6" PER DWG
12	15134-010	1	58900	15134-010	ID LABEL "A4"
13	15295	1	58900	15295	LABEL, BOTTOM DECK
14	16536-003	2	58900	16536-003	HANDLE STRAP, 12.75" LG
15	16956-001	2	58900	16956-001	8500 SERIES DET EXT CABLE 1.5M
16	16957	1	58900	16957	TOP COVER
17	16958	1	58900	16958	BOTTOM COVER
18	17018	1	58900	17018	RIVETED PS COVER ASSY
19	17027-001	8	58900	17027-001	SCR TRUSS HD 4-40X.25 MED GREY
20	17028-001	8	58900	17028-001	SCR TRUSS HD 4-40X.25 LT GREY
21	17325	1	58900	17325	HOLDDOWN, PCB
22	19975-003	1	58900	19975-003	SHIPPING BOX, 275# DW 30x24x12
23	20601	1	58900	20601	FILTER, EL DISPLAY
24	20602	1	—	20602	BEZEL, EL DISPLAY
25	20635	1	58900	20635	SHIELD, HIGH VOLTAGE
26	20636	1	0ABX4	20636	LABEL, WARNING
27	20738	1	58900	20738	DIE CUT TRANSFER TAPE, DISPLAY
28	20790	1	58900	20790	OPER MANUAL KIT, 8500A SERIES
29	21098	1	58900	21098	KNOB, 48mm - .25 COLLET
30	HFFL-63202	1	21604	1S001201	LEFT FRONT FOOT
31	HFFR-63202	1	21604	1S001202	RIGHT FRONT FOOT
32	70113	REF	58900	70113	PROCEDURE, MODEL 8502A

20512-A00 8501A CHASSIS ASSY, Rev: R

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	10129	1	58900	10129	LABEL, CODE AND SERIAL NUMBER
2	12701-004	1	58900	12701-004	GUIDE, 4.90"
3	12701-012	1	58900	12701-012	GUIDE, 1.00"
4	SPA0-00012	1	31918	FSC-BLACK	BLACK BUTTON
5	14913	1	58900	14913	LABEL, H.V. SHIELD
6	HGP0-03000	11	32559	E-300	3" CARD GUIDE
7	16869	1	58900	16869	DELAY LINE ASSEMBLY
8	16949	1	58900	16949	LEFT CABINET SIDE
9	16950	1	58900	16950	RIGHT CABINET SIDE
10	16951	1	58900	16951	FRONT FRAME 8500
11	16952	1	58900	16952	REAR FRAME 8500
12	16953	1	58900	16953	BASE PLATE
13	16954	1	58900	16954	LEFT PCB MTG BRACKET
14	16955	1	58900	16955	RIGHT PCB MOUNTING BKT
15	16964	1	58900	16964	AC SWITCH SHAFT
16	16999	1	58900	16999	AC SWITCH COVER
17	17012	1	58900	17012	POWER SUPPLY ENCLOSURE
18	17217	4	58900	17217	RF SHIELD
19	17218	8	58900	17218	INSULATOR, RF SHIELD
20	17311	1	58900	17311	SUPPORT BRACKET, PCB
21	20196	REF	58900	20196	SCHEMATIC, FRONT PNL INTERFACE
22	20522	REF	58900	20522	SCHEMATIC 8501A & 8502A INSTR
23	20527	REF	58900	20527	SCHEMATIC, FRONT PANEL
24	XARC-00002	0	58900	XARC-00002	SILVER-FILLED RTV
25	21118	1	58900	21118	LABEL, TESTED BY
26	70112	REF	58900	70112	PROCEDURE, MODEL 8501A
31	60334	REF	58900	60334	8500A CALIBRATION PROC
27	60304	REF	58900	60304	8500A PRETEST PROC
29	60348	REF	58900	60348	MODEL 850X/850XA SYS TEST PRO
30	30019	REF	58900	30019	8500 & 8500A JIT FLOW CHART
A1	16932-001	1	58900	16932-001	INTERCONNECT PCB ASSY
A2	16995	1	58900	16995	PCB ASSY, POWER SUPPLY
A3	21014	1	58900	21014	PCB ASSY GPIB/CAL CONTROL 8500
A4	16878	1	58900	16878	PCB ASSY., CPU
A5	16685	1	58900	16685	P.C. BRD. ASSY., DIGITAL DELAY
A6	20741	1	58900	20741	ANALOG PCB ASSY
A8	20195	1	58900	20195	PCB ASSY, FR PNL INTERFACE
A12	20055-001	1	58900	20055-001	ASSY, 1GHZ CALIBRATOR TYPE N
A13	21145	1	58900	21145	FRONT SUB PANEL ASSY 8501A
A14	21146	1	58900	21146	REAR PANEL ASSY 8501A
CR1	DBMC-00980	1	58900	DBMC-00980	MDA980-2 BRIDGE RECT
LS1	ISS0-00001	1	58900	ISS0-00001	2" 8 OHM SPEAKER
W7	17056	1	58900	17056	SPEAKER CABLE ASSY
W9	17091-001	1	58900	17091-001	W9 W-R DISC CABLE ASSY
W10	17163-001	1	58900	17163-001	W-PR DISC CABLE ASSY

20513-A00 8502A CHASSIS ASSY, Rev: N

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	10129	1	58900	10129	LABEL, CODE AND SERIAL NUMBER
2	12701-004	2	58900	12701-004	GUIDE, 4.90"
3	12701-012	1	58900	12701-012	GUIDE, 1.00"
4	SPA0-00012	1	31918	FSC-BLACK	BLACK BUTTON
5	14913	1	58900	14913	LABEL, H.V. SHIELD
6	HGP0-03000	13	32559	E-300	3" CARD GUIDE
7	16869	2	58900	16869	DELAY LINE ASSEMBLY
8	16949	1	58900	16949	LEFT CABINET SIDE
9	16950	1	58900	16950	RIGHT CABINET SIDE
10	16951	1	58900	16951	FRONT FRAME 8500
11	16952	1	58900	16952	REAR FRAME 8500
12	16953	1	58900	16953	BASE PLATE
13	16954	1	58900	16954	LEFT PCB MTG BRACKET
14	16955	1	58900	16955	RIGHT PCB MOUNTING BKT
15	16964	1	58900	16964	AC SWITCH SHAFT
16	16999	1	58900	16999	AC SWITCH COVER
17	17012	1	58900	17012	POWER SUPPLY ENCLOSURE
18	17217	5	58900	17217	RF SHIELD
19	17218	10	58900	17218	INSULATOR, RF SHIELD
20	17311	1	58900	17311	SUPPORT BRACKET, PCB
21	20196	REF	58900	20196	SCHEMATIC, FRONT PNL INTERFACE
22	20522	REF	58900	20522	SCHEMATIC 8501A & 8502A INSTR
23	20527	REF	58900	20527	SCHEMATIC, FRONT PANEL
24	XARC-00002	0	58900	XARC-00002	SILVER-FILLED RTV
25	21118	1	58900	21118	LABEL, TESTED BY
26	70113	REF	58900	70113	PROCEDURE, MODEL 8502A
31	60334	REF	58900	60334	8500A CALIBRATION PROC
27	60304	REF	58900	60304	8500A PRETEST PROC
29	60348	REF	58900	60348	MODEL 850X/850XA SYS TEST PRO
30	30019	REF	58900	30019	8500 & 8500A JIT FLOW CHART
A1	16932-001	1	58900	16932-001	INTERCONNECT PCB ASSY
A2	16995	1	58900	16995	PCB ASSY, POWER SUPPLY
A3	21014	1	58900	21014	PCB ASSY GPIB/CAL CONTROL 8500
A4	16878	1	58900	16878	PCB ASSY., CPU
A5	16685	1	58900	16685	P.C. BRD. ASSY., DIGITAL DELAY
A6	20741	1	58900	20741	ANALOG PCB ASSY
A7	20741	1	58900	20741	ANALOG PCB ASSY
A8	20195	1	58900	20195	PCB ASSY, FR PNL INTERFACE
A12	20055-001	1	58900	20055-001	ASSY, 1GHZ CALIBRATOR TYPE N
A13	21147	1	58900	21147	FRONT SUB PANEL ASSY 8502A
A14	21148	1	58900	21148	REAR PANEL ASSY 8502A
CR1	DBMC-00980	1	58900	DBMC-00980	MDA980-2 BRIDGE RECT
LS1	ISS0-00001	1	58900	ISS0-00001	2" 8 OHM SPEAKER
W7	17056	1	58900	17056	SPEAKER CABLE ASSY
W9	17091-001	1	58900	17091-001	W9 W-R DISC CABLE ASSY
W10	17163-001	1	58900	17163-001	W-PR DISC CABLE ASSY

21145 FRONT SUB PANEL ASSY 8501A, Rev: A

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	ETIM-02062	1	2R182	862	2 LUG TERMINAL STRIP
2	HSTH-41104	12	06540	8217-46-B-0440-28	4-40 X 23/32 HEX SPACER
3	14955-065	1	58900	14955-065	LABEL "TO A1J16"
4	20509	1	58900	20509	FRONT SUB PANEL, 8501A
5	20736	2	58900	20736	GUARD, FLAT CABLE
6	20879	1	58900	20879	EL DISPLAY MODULE ASSEMBLY
7	21039	1	58900	21039	BRKT, STRAIN RELIEF
A9	20526-001	1	58900	20526-001	PC BOARD ASSY, FRONT PANEL
B2	21100	1	58900	21100	ROTARY ENCODER ASSY
C1	11573-001	1	3W023	CW15C102K	CAP MIN CER .001MF 20% 50VDC
W1	17051	1	58900	17051	DETECTOR INPUT CABLE ASSY
W4	20570	1	58900	20570	CABLE ASSY, FR PANEL-INTCON
W8	20721	1	—	20721	CABLE ASSY, EL DSPL-FP INTFC

21147 FRONT SUB PANEL ASSY 8502A, Rev: A

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	ETIM-02062	1	2R182	862	2 LUG TERMINAL STRIP
2	ETIM-02063	1	2R182	820	2 LUG TERMINAL STRIP
3	HSTH-41104	12	06540	8217-46-B-0440-28	4-40 X 23/32 HEX SPACER
4	14955-065	1	58900	14955-065	LABEL "TO A1J16"
5	14955-069	1	58900	14955-069	LABEL "TO A1J17"
6	20511	1	58900	20511	FRONT SUB PANEL 8502A
7	20736	2	58900	20736	GUARD, FLAT CABLE
8	20879	1	58900	20879	EL DISPLAY MODULE ASSEMBLY
9	21039	2	58900	21039	BRKT, STRAIN RELIEF
A9	20526-002	1	58900	20526-002	PC BOARD ASSY, FRONT PANEL
B2	21100	1	58900	21100	ROTARY ENCODER ASSY
C1	11573-001	1	3W023	CW15C102K	CAP MIN CER .001MF 20% 50VDC
C2	11573-001	1	3W023	CW15C102K	CAP MIN CER .001MF 20% 50VDC
W1	17051	1	58900	17051	DETECTOR INPUT CABLE ASSY
W4	20570	1	58900	20570	CABLE ASSY, FR PANEL-INTCON
W8	20721	1	—	20721	CABLE ASSY, EL DSPL-FP INTFC
W12	17051	1	58900	17051	DETECTOR INPUT CABLE ASSY

21146 REAR PANEL ASSY 8501A, Rev: A

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	17141	1	58900	17141	REAR PANEL
2	HPM0-00687	2	57771	D3047	11/16 HOLE PLUG
3	HPM0-00500	1	18310	790-3008	1/2 HOLE PLUG
4	JIB0-01089	5	56501	RA-250	FEMALE QUICK DISCONNECT
5	16966	1	58900	16966	AC SWITCH MTG BKT
6	16973	4	58900	16973	INSULATING FLAT WASHER
7	BHF0-13000	1	9Y422	FF325G	3" FAN FILTER
8	17161	1	31918	51985	PLUNGER, EXTENDER
9	19976	1	58900	19976	COVER PLATE, 8500 CALIBRATOR
10	JLFL-01503	1	05245	JA413	2A 120V LABEL
11	HPM0-00375	3	2R182	652	3/8 HOLE PLUG
F1	FSAC-00200	1	—	MDL-2	2A SB FUSE 3AG
J1	JLFF-06250	1	05245	6J4	LINE FILTER/CONNEC
J2	JRDF-00001	1	09769	31-221-RFX	BNC F PANEL MOUNT
J3	JRDF-00005	1	58900	JRDF-00005	BNC F PANEL MOUNT
J4	JRDF-00001	1	09769	31-221-RFX	BNC F PANEL MOUNT
J6	JRDF-00001	1	09769	31-221-RFX	BNC F PANEL MOUNT
J7	JRDF-00001	1	09769	31-221-RFX	BNC F PANEL MOUNT
R2	RABA-01001	1	01121	WA1NO24S101MZ	100 OHM POT PANEL MOUNT
S1	13260	1	2W053	001399	SWITCH PUSHBUTTON POWER
T1	16762	1	58900	16762	TRANSFORMER PWR
W2	17280	1	58900	17280	FAN ASSY
W3	17131	1	58900	17131	REAR PANEL CABLE ASSY 8502
W11	17259-001	1	58900	17259-001	BNC TO SMC RG178B/U CABLE ASSY

21148 REAR PANEL ASSY 8502A, Rev: A

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	HPM0-00687	2	57771	D3047	11/16 HOLE PLUG
2	HPM0-00500	1	18310	790-3008	1/2 HOLE PLUG
3	JIB0-01089	5	56501	RA-250	FEMALE QUICK DISCONNECT
4	16966	1	58900	16966	AC SWITCH MTG BKT
5	16973	4	58900	16973	INSULATING FLAT WASHER
6	BHF0-13000	1	9Y422	FF325G	3" FAN FILTER
7	17141	1	58900	17141	REAR PANEL
8	17161	1	31918	51985	PLUNGER, EXTENDER
9	19976	1	58900	19976	COVER PLATE, 8500 CALIBRATOR
10	JLFL-01503	1	05245	JA413	2A 120V LABEL
11	HPM0-00375	1	2R182	652	3/8 HOLE PLUG
F1	FSAC-00200	1	—	MDL-2	2A SB FUSE 3AG
J1	JLFF-06250	1	05245	6J4	LINE FILTER/CONNEC
J2	JRDF-00001	1	09769	31-221-RFX	BNC F PANEL MOUNT
J3	JRDF-00005	1	58900	JRDF-00005	BNC F PANEL MOUNT
J4	JRDF-00001	1	09769	31-221-RFX	BNC F PANEL MOUNT
J6	JRDF-00001	1	09769	31-221-RFX	BNC F PANEL MOUNT
J7	JRDF-00001	1	09769	31-221-RFX	BNC F PANEL MOUNT
J8	JRDF-00001	1	09769	31-221-RFX	BNC F PANEL MOUNT
J9	JRDF-00001	1	09769	31-221-RFX	BNC F PANEL MOUNT
R2	RABA-01001	1	01121	WA1NO24S101MZ	100 OHM POT PANEL MOUNT
S1	13260	1	2W053	001399	SWITCH PUSHBUTTON POWER
T1	16762	1	58900	16762	TRANSFORMER PWR
W2	17280	1	58900	17280	FAN ASSY
W3	17131	1	58900	17131	REAR PANEL CABLE ASSY 8502
W11	17259-001	1	58900	17259-001	BNC TO SMC RG178B/U CABLE ASSY

20879 EL DISPLAY MODULE ASSEMBLY, Rev: D

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	20879-A00	1	58900	20879-A00	EL DISPLAY MODULE SUB ASSY
2	30086	REF	58900	30086	PRELIM TP FOR EL DISPLAY

20879-A00 EL DISPLAY MODULE SUB ASSY, Rev: D

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	HNSS-44004	14	58900	HNSS-44004	4-40 HEX NUT
2	HSDH-41004	4	57177	164-07-BR-4-40-T	4-40 X 5/8 M/F SPACER
3	20829	1	58900	20829	EL DISPLAY GLASS, 1 X 5
4	20875	1	58900	20875	HOLDER, CONNECTOR
5	20876	1	58900	20876	SEAL, EL DISPLAY
6	20877	1	58900	20877	FRAME, EL DISPLAY
7	20878-001	2	58900	20878-001	CONN ELASTOMER 1.440 LG.
8	20878-002	2	58900	20878-002	CONN ELASTOMER 5.065 LG.
9	70128	REF	58900	70128	EL DISPLAY ASSY PROC
A1	20832	1	58900	20832	EL DISPLAY DRIVER PCB ASSEMBLY
A2	20835	1	58900	20835	EL DISPLAY LOGIC PCB ASSEMBLY

16869 DELAY LINE ASSEMBLY, Rev: D

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	WCB0-00179	83	62277	RG179B	RG179B/U 50 OHM COAX
2	JRBF-18802	2	58900	JRBF-18802	SMC F FOR RG188
3	10415	1	58900	10415	LABEL, OPTION IDENTIFICATION
4	HSTH-41004	6	2R182	8835	4-40 X 5/8 HEX SPACER
5	16960	1	58900	16960	DELAY LINE BOX
6	16963	1	58900	16963	DELAY LINE BOX COVER

16932-001 INTERCONNECT PCB ASSY, Rev: H

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
6	HNSS-63205	1	58900	HNSS-63205	6-32 HEX NUT
7	HBPP-A3206	8	58900	HBPP-A3206	10-32 X 3/8 PAN
8	HWSS-40300	2	58900	HWSS-40300	#4 X 3/16 SPLIT LOCK
9	HWSS-60400	1	58900	HWSS-60400	#6 X 1/4 SPLIT LOCK
10	HBUP-40006	2	46467	#4 X .375 SLFTAP	#4 x 3/8" SELF TAPPING
11	JMSF-00003	1	09769	552633-3	IEEE CONN MOUNTING
12	HGP0-04000	1	32559	VG2-4	4" VERTICAL CARD GUIDE
13	17249	1	58900	17249	SUPPORT BRACKET
14	HBPP-44003	2	26233	NS137CR440R3	4-40 X 3/16 PAN
15	HBPP-63208	1	58900	HBPP-63208	6-32 X 1/2 PAN
16	16932-A01	1	58900	16932-A01	PCB ASSY PRE-WAVE,INTERCONNECT
C1	CE15-09260	1	58900	CE15-09260	26,000 UF 10 V ELECT.
C2	CE15-09450	1	58900	CE15-09450	45,000 UF 15 V ELECT
C3	CE40-08150	1	58900	CE40-08150	5,100 UF 40 V ELECT
C4	CE40-08150	1	58900	CE40-08150	5,100 UF 40 V ELECT
C13	CE35-08100	1	55680	TLB1H102M	1000 UF 35 V AXIAL
C14	CE35-08100	1	55680	TLB1H102M	1000 UF 35 V AXIAL
J13	JMFP-02403	1	09769	552791-1	24 PIN IEEE CONNECTOR
S1	SPP0-00101	1	09353	TP11SHABE	SPST PC MT PUSHBUTTON

16932-A01 PCB ASSY PRE-WAVE,INTERCONNECT, Rev: F

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	20762	1	58900	20762	PC BD, INTERCONNECT
2	21088	REF	58900	21088	SCHEMATIC, INTERCONNECT 8500A
3	HWSS-40300	24	58900	HWSS-40300	#4 X 3/16 SPLIT LOCK
4	HSCR-40304	24	2R182	8703	#4 X 3/16 CLEAR SPACER
5	HBPP-44008	24	58900	HBPP-44008	4-40 X 1/2 PAN
C5	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C6	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C7	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C8	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C9	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C10	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C11	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C12	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C15	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C16	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C17	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
CR1	DBMC-00010	1	58900	DBMC-00010	PE10 5A 100V BRIDGE RECTIFIER
CR2	DRAE-00823	1	04713	1N823	1N823 6.3V REF DIODE
J1	JPS1-20036	1	0HFJ2	MPS-0100-36-DW-6HK	72 PIN PC EDGE CONN
J2	JPS1-20036	1	0HFJ2	MPS-0100-36-DW-6HK	72 PIN PC EDGE CONN
J3	JPS1-20036	1	0HFJ2	MPS-0100-36-DW-6HK	72 PIN PC EDGE CONN
J4	JPS1-20036	1	0HFJ2	MPS-0100-36-DW-6HK	72 PIN PC EDGE CONN
J5	JPS1-20036	1	0HFJ2	MPS-0100-36-DW-6HK	72 PIN PC EDGE CONN
J6	JPS1-20036	1	0HFJ2	MPS-0100-36-DW-6HK	72 PIN PC EDGE CONN
J7	JPS1-20036	1	0HFJ2	MPS-0100-36-DW-6HK	72 PIN PC EDGE CONN
J8	JPS1-20036	1	0HFJ2	MPS-0100-36-DW-6HK	72 PIN PC EDGE CONN
J9	JPS1-20036	1	0HFJ2	MPS-0100-36-DW-6HK	72 PIN PC EDGE CONN
J10	JPS1-20036	1	0HFJ2	MPS-0100-36-DW-6HK	72 PIN PC EDGE CONN
J11	JPS1-20036	1	0HFJ2	MPS-0100-36-DW-6HK	72 PIN PC EDGE CONN
J12	JPS1-20036	1	0HFJ2	MPS-0100-36-DW-6HK	72 PIN PC EDGE CONN
J19	JIA0-01371	1	75263	1287	QUICK DISCONNECT TAB
J20	JIA0-01371	1	75263	1287	QUICK DISCONNECT TAB
J21	JIA0-01371	1	75263	1287	QUICK DISCONNECT TAB
J22	JIA0-01371	1	75263	1287	QUICK DISCONNECT TAB

16932-A01 PCB ASSY PRE-WAVE,INTERCONNECT, Rev: F

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
J23	JIA0-01371	1	75263	1287	QUICK DISCONNECT TAB
J24	JIA0-01371	1	75263	1287	QUICK DISCONNECT TAB
J25	JRBM-00101	1	09769	903-373J-51A	SMB M RTANG PC MOUNT
J26	JRBM-00101	1	09769	903-373J-51A	SMB M RTANG PC MOUNT
J27	JRBM-00100	1	58900	JRBM-00100	SMB M PC MOUNT
J28	JRBM-00100	1	58900	JRBM-00100	SMB M PC MOUNT
J29	JRBM-00100	1	58900	JRBM-00100	SMB M PC MOUNT
J30	JRBM-00100	1	58900	JRBM-00100	SMB M PC MOUNT
J37	JRBM-00100	1	58900	JRBM-00100	SMB M PC MOUNT
R1	RC20-00056	1	01121	RC20GF5R6J	5.6 OHM 5% 1/2 W CARBON
R2	RC20-00056	1	01121	RC20GF5R6J	5.6 OHM 5% 1/2 W CARBON
R3	RC20-00056	1	01121	RC20GF5R6J	5.6 OHM 5% 1/2 W CARBON
R4	RC20-00056	1	01121	RC20GF5R6J	5.6 OHM 5% 1/2 W CARBON
R5	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R6	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
RP2	RM9S-21001	1	58900	RM9S-21001	10K OHM X 9 SIP NETWORK
RP3	RM9S-21001	1	58900	RM9S-21001	10K OHM X 9 SIP NETWORK
W1	WJIB-05024	1	63058	JO.500X0.125-PVC-24	.5" INSULATED JUMPER
W5	WJIB-05024	1	63058	JO.500X0.125-PVC-24	.5" INSULATED JUMPER
W6	WJIB-05024	1	63058	JO.500X0.125-PVC-24	.5" INSULATED JUMPER

16995 PCB ASSY, POWER SUPPLY, Rev: G

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
7	HWSS-40300	4	58900	HWSS-40300	#4 X 3/16 SPLIT LOCK
8	HSCR-40304	2	2R182	8703	#4 X 3/16 CLEAR SPACER
9	HQH0-10050	2	30161	323005B00000	TO5 HEATSINK
10	HHE0-00002	2	32559	CP-36	PC CARD EJECTOR LEVER
11	HWHN-40301	4	04713	B51547F015	#4 NYLON SHOULDER WASHER
12	18597	4	8W262	60-11-8302-1674	INSULATOR(T0-220)
13	20639	1	58900	20639	HEATSINK, POWER SUPPLY
14	HBPP-44004	6	26233	NS137CR440R4	4-40 X 1/4 PAN
15	HBPP-44008	2	58900	HBPP-44008	4-40 X 1/2 PAN
16	16995-A00	1	58900	16995-A00	PCB ASSY PRE-WAVE, PWR SUPPLY
C21	CE35-07100	1	55680	TLB1V101M	100 UF 35 V AXIAL
F1	FMAC-01000	1	75915	312-010	10A MB FUSE 3AG
F2	FMAC-01000	1	75915	312-010	10A MB FUSE 3AG
Q1	QBPP-06489	1	58900	QBPP-06489	2N6489 15A 40V 75W PNP
Q4	QBNP-06486	1	04713	2N6486	2N6486 15A 40V 75W NPN
Q5	QBPP-06489	1	58900	QBPP-06489	2N6489 15A 40V 75W PNP
Q10	QBNP-06486	1	04713	2N6486	2N6486 15A 40V 75W NPN
S1	17185	1	59270	OA-250-QCV-3	SCD, SWITCH, THERMAL
U1	UFN1-00324	1	01295	LM324N	LM324AN QUAD OP AMP
U2	UFN0-00358	1	58900	UFN0-00358	LM358 OP AMP
U3	UFN0-00358	1	58900	UFN0-00358	LM358 OP AMP
U4	ULN0-00393	1	01295	LM393P	LM393N VOLT COMPARATOR

16995-A00 PCB ASSY PRE-WAVE, PWR SUPPLY, Rev: F

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	16994	1	58900	16994	PC BOARD, POWER SUPPLY 8500
2	16996	REF	58900	16996	SCHEMATIC, POWER SUPPLY
3	HQIP-00050	4	13103	7717-22-N	TO5 NYLON INSULATOR
4	FHC0-00001	4	75915	102071	FUSE CLIP
5	JSP0-10008	3	09769	2-640463-1	8 PIN DIP SOCKET
6	JSP0-10014	1	09769	2-641609-1	14 PIN DIP SOCKET
C1	CC99-01220	1	3W023	DD221	220 PF 1000V CERAMIC X5F
C2	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C3	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C4	CT25-R6680	1	31433	T354L686K025AS	68UF 25V RADIAL
C5	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C6	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C7	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C8	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C9	CT25-R6680	1	31433	T354L686K025AS	68UF 25V RADIAL
C10	CT25-R6680	1	31433	T354L686K025AS	68UF 25V RADIAL
C11	CT25-R6680	1	31433	T354L686K025AS	68UF 25V RADIAL
C12	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C13	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C14	CC98-01100	1	56289	10TCC-T10	100 PF 1 KV CERAMIC NPO
C15	CT25-R6680	1	31433	T354L686K025AS	68UF 25V RADIAL
C16	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C17	CC98-01100	1	56289	10TCC-T10	100 PF 1 KV CERAMIC NPO
C18	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C19	CT25-R6680	1	31433	T354L686K025AS	68UF 25V RADIAL
C22	CT35-R5100	1	31433	T356A105M035AS	1UF 35V TANTALUM
C23	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
CR1	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR2	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR3	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR4	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE

16995-A00 PCB ASSY PRE-WAVE, PWR SUPPLY, Rev: F

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
CR5	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR6	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR7	DRAE-00823	1	04713	1N823	1N823 6.3V REF DIODE
CR8	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR9	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR10	DPAD-04383	1	58900	DPAD-04383	1N4383 1A 200V RECTIFIER
CR11	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR12	DPAD-04383	1	58900	DPAD-04383	1N4383 1A 200V RECTIFIER
CR14	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR15	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR19	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR20	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR21	DZAC-05229	1	04713	IN5229B	IN5229 4.3 V ZENER
CR22	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR23	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
Q2	QBNP-03053	1	04713	2N3053	2N3053 .7A 40V NPN
Q3	QBPS-04314	1	58900	QBPS-04314	2N4314 65V .15A PNP
Q6	QBNS-03565	1	27014	PN3565	PN3565 25V 300HFE NPN
Q7	QBPS-04314	1	58900	QBPS-04314	2N4314 65V .15A PNP
Q8	QBPS-04250	1	58900	QBPS-04250	2N4250 40V 2DB NF PNP
Q9	QBNP-03053	1	04713	2N3053	2N3053 .7A 40V NPN
R1	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R2	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R3	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R6	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R7	RN57-12000	1	58900	RN57-12000	2.00 KOHM .1% METAL FILM
R8	RW01-00002	1	59124	M01R24J	.24 OHM 1 W WIREWOUND
R9	RN57-22000	1	58900	RN57-22000	20.0 KOHM .1% MET FILM
R10	RN57-11745	1	58900	RN57-11745	1.745 KOHM .1% MET FILM
R11	RN57-22000	1	58900	RN57-22000	20.0 KOHM .1% MET FILM
R12	RC32-01000	1	—	SPR1-101-J	100 OHM 10% 1 W CARBON
R13	RC32-01000	1	—	SPR1-101-J	100 OHM 10% 1 W CARBON
R14	RN55-12210	1	91637	RN55C2211F	2.21 K OHMS 1% MET FILM
R15	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R16	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R17	RN55-14990	1	91637	RN55C4991F	4.99 K OHMS 1% MET FILM
R18	RN55-12100	1	91637	RN55C2101F	2.1K OHMS 1% MET FILM
R19	RN55-41000	1	91637	RN55C1004F	1 M OHMS 1% MET FILM
R20	RN55-11100	1	91637	RN55C1101F	1.1K OHMS 1% MET FILM
R21	RN55-13480	1	91637	RN55C3481F	3.48K OHMS 1% MET FILM
R22	RAPK-05000	1	5Y491	66XR500	500 OHM 10% 20T PC MNT
R23	RN55-14990	1	91637	RN55C4991F	4.99 K OHMS 1% MET FILM
R24	RN57-11182	1	58900	RN57-11182	1.182 KOHM .1% MET FILM
R25	RW01-00002	1	59124	M01R24J	.24 OHM 1 W WIREWOUND
R26	RN57-22000	1	58900	RN57-22000	20.0 KOHM .1% MET FILM
R27	RN57-22000	1	58900	RN57-22000	20.0 KOHM .1% MET FILM
R28	RN57-11000	1	91637	RN55C1001B	1K OHM .1% MET FILM
R29	RW05-00001	1	91637	RW67VR10	0.1 OHM 5 W WIREWOUND
R31	RN55-18250	1	91637	RN55C8251F	8.25 K OHMS 1% MET FILM
R32	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R33	RN57-23000	1	58900	RN57-23000	30.0 KOHM .1% MET FILM
R34	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R35	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R36	RN55-31400	1	91637	RN55C1403F	140 K OHMS 1% MET FILM
R37	RN55-14750	1	91637	RN55C4751F	4.75 K OHMS 1% MET FILM
R38	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R39	RG03-00150	1	91637	FP215R0 5%	15 OHM 10% METAL GLAZE
R40	RN55-14750	1	91637	RN55C4751F	4.75 K OHMS 1% MET FILM
R41	RN55-11780	1	91637	CCF55-2-1.78K1%T2T/R	1.78 KOHM 1% MET FILM
R42	RAPK-15000	1	5Y491	66XR5K	5 K 10% 20T PC MNT
R43	RN55-22370	1	91637	RN55C2372F	23.7 K OHMS 1% MET FILM
R44	RN55-24990	1	91637	RN55C4992F	49.9 K OHMS 1% MET FILM
R45	RN55-12740	1	91637	RN55C2741F	2.74K OHMS 1% MET FILM

16995-A00 PCB ASSY PRE-WAVE, PWR SUPPLY, Rev: F

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
R47	RW05-00001	1	91637	RW67VR10	0.1 OHM 5 W WIREWOUND
R48	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R49	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R50	RG03-00150	1	91637	FP215R0 5%	15 OHM 10% METAL GLAZE
R51	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R53	RN55-22000	1	91637	RN55C2002F	20 K OHMS 1% MET FILM
R55	RN55-14750	1	91637	RN55C4751F	4.75 K OHMS 1% MET FILM
R57	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R59	RN55-21050	1	91637	RN55C1052F	10.5 K OHMS 1% MET FILM
R60	RN55-13830	1	91637	RN55C3831F	3.83K OHMS 1% MET FILM
R61	RN55-00100	1	91637	RN55C10R0F	10 OHMS 1% MET FILM
R64	RN55-14750	1	91637	RN55C4751F	4.75 K OHMS 1% MET FILM
R65	RN55-12210	1	91637	RN55C2211F	2.21 K OHMS 1% MET FILM
R66	RN55-00825	1	91637	RN55C82R5F	82.5 OHMS 1% MET FILM
R67	RN55-23010	1	91637	RN55C3012F	30.1 K OHMS 1% MET FILM
R68	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
TP1	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP2	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP3	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP4	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP5	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP6	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP7	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP8	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP9	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP10	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP11	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
U5	UVP0-00385	1	04713	LM385BZ1.2	LM385BZ-1.2 1.2V REF

21014 PCB ASSY GPIB/CAL CONTROL 8500, Rev: C

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
9	HNKS-44004	1	58900	HNKS-44004	4-40 KEP NUT
10	17240-001	1	27264	15-38-1024	JUMPER,INSULATED,2 POS
11	17320	2	32559	CP-56-PA	EJECTOR, PC CARD 1.50" LONG
12	HBPP-44005	1	26233	NS137CR440R5	4-40 X 5/16 PAN
13	21014-A00	1	58900	21014-A00	PCB ASSY PRE-WAVE,GPIB
Q8	QBNP-00029	1	01295	TIP29	TIP29 1A 40V 30W NPN
U1	UGN0-09914	1	01295	TMS9914NL (ANL)	TMS9914NL IEEE-488
U2	UIN0-75162	1	01295	SN75162BN	SN75162N IEEE BUFFER
U3	UTN0-00321	1	01295	SN74LS32N	SN74LS32N QUAD OR
U4	UIN0-75160	1	01295	SN75160BN	SN75160N IEEE BUFFER
U6	UTN0-00001	1	01295	SN74LS00N	SN74LS00 QUAD NAND
U8	UGN0-08255	1	34335	8255A-5	8255A-5 PROG PIA
U9	UGN0-08255	1	34335	8255A-5	8255A-5 PROG PIA
U10	UIN0-07534	1	24355	AD7534JN	AD7534JN 14 BIT DAC
U11	UFN1-00324	1	01295	LM324N	LM324AN QUAD OP AMP
U12	UFN1-00324	1	01295	LM324N	LM324AN QUAD OP AMP
U13	UFN0-05135	1	01295	OP-07/CP	HA5135-5 PRECISION OP AMP
U14	UFN0-05135	1	01295	OP-07/CP	HA5135-5 PRECISION OP AMP
U15	ULN0-00311	1	01295	LM311P	LM311N COMPARATOR
U16	UFN0-05135	1	01295	OP-07/CP	HA5135-5 PRECISION OP AMP
U17	ULN0-00201	1	24355	ADG201AKN	ADG201AKN SPST SWITCH
U18	UFN0-34074	1	04713	MC34074L	MC34074P QUAD OP AMP

21014-A00 PCB ASSY PRE-WAVE, GPIB, Rev: C

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	21013	1	58900	21013	PC BOARD, GPIB/CAL CONTROL
2	21015	REF	58900	21015	SCHEMATIC, GPIB/CAL CONTROL
3	JSP0-11022	1	09769	2-641603-3	22 PIN DIP SOCKET
4	JSP0-10008	4	09769	2-640463-1	8 PIN DIP SOCKET
5	JSP0-10014	5	09769	2-641609-1	14 PIN DIP SOCKET
6	JSP0-10016	1	09769	2-614610-2	16 PIN DIP SOCKET
7	JSP0-10020	2	09769	2-641612-1	20 PIN DIP SOCKET
8	JSP0-10040	3	09769	2-641616-1	40 PIN DIP SOCKET
C6	CC98-00330	1	—	CCD-330	33 PF 1KV CERAMIC NPO
C7	CT35-R5470	1	31918	TAPS4. 7M35	CAP TANTALUM 4.7MF 20% 35VDC
C8	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C9	CC50-04220	1	31433	C322C224M5U5CA	.22 UF CERAMIC Z5U
C10	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C11	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C12	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C13	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C15	15776-028	1	90201	C20C101K5R5CA	100 PF CERAMIC X7R
C16	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C17	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C18	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C19	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C20	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C21	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C22	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C23	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C24	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C25	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C26	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C27	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C28	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C29	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R

21014-A00 PCB ASSY PRE-WAVE, GPIB, Rev: C

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
C30	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C31	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C34	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C35	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C36	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C37	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C38	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C47	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C50	CC50-02220	1	04222	SR155C222KAA	2200PF CERAMIC X7R
C56	CC50-02220	1	04222	SR155C222KAA	2200PF CERAMIC X7R
C57	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
CR1	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR2	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR3	DSA0-04448	1	58900	DSA0-04448	1N4448 SWITCHING DIODE
CR4	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR5	DPAD-04383	1	58900	DPAD-04383	1N4383 1A 200V RECTIFIER
CR6	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR7	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
Q1	QBNS-03569	1	4U751	2N3569	PN3569 .5A 40V NPN
Q2	QBPS-03644	1	58900	QBPS-03644	2N3644 .3 A 45 V PNP
Q3	QBNS-03569	1	4U751	2N3569	PN3569 .5A 40V NPN
Q4	QBPS-03644	1	58900	QBPS-03644	2N3644 .3 A 45 V PNP
Q5	QBNS-03569	1	4U751	2N3569	PN3569 .5A 40V NPN
Q6	QBPS-03644	1	58900	QBPS-03644	2N3644 .3 A 45 V PNP
Q7	QBNS-03569	1	4U751	2N3569	PN3569 .5A 40V NPN
Q10	QBNS-03565	1	27014	PN3565	PN3565 25V 300HFE NPN
Q11	QBPS-03644	1	58900	QBPS-03644	2N3644 .3 A 45 V PNP
Q13	QBPS-03644	1	58900	QBPS-03644	2N3644 .3 A 45 V PNP
R1	RN55-21210	1	91637	RN55C1212F	12.1 K OHMS 1% MET FILM
R2	RN55-21210	1	91637	RN55C1212F	12.1 K OHMS 1% MET FILM
R3	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R4	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R12	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R13	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R14	RN55-24750	1	91637	RN55C4752F	47.5 K OHMS 1% MET FILM
R15	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R16	RAPK-15000	1	5Y491	66XR5K	5 K 10% 20T PC MNT
R17	RN55-14750	1	91637	RN55C4751F	4.75 K OHMS 1% MET FILM
R18	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R19	RN55-08450	1	91637	RN55C8450F	845 OHMS 1% MET FILM
R20	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R21	RN55-11620	1	91637	RN55C1621F	1.62K OHMS 1% MET FILM
R22	RN55-34750	1	91637	RN55C4753F	475 K OHMS 1% MET FILM
R28	RN55-15620	1	91637	RN55C5621B	5.62 K OHMS 1% MET FILM
R29	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R38	RN57-31000	1	58900	RN57-31000	100 K OHM .1 % MET FILM
R39	RN57-31000	1	58900	RN57-31000	100 K OHM .1 % MET FILM
R40	RN57-31000	1	58900	RN57-31000	100 K OHM .1 % MET FILM
R41	RN57-31000	1	58900	RN57-31000	100 K OHM .1 % MET FILM
R42	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R44	RN55-12210	1	91637	RN55C2211F	2.21 K OHMS 1% MET FILM
R45	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R46	RN55-13320	1	91637	RN55C3321F	3.32 K OHMS 1% MET FILM
R47	RN55-21330	1	91637	RN55C1332F	13.3 K OHMS 1% MET FILM
R48	RN55-21330	1	91637	RN55C1332F	13.3 K OHMS 1% MET FILM
R49	RN55-00402	1	91637	CCF55-2-40.2 [±] 1%T2T/R	40.2 OHM 1% MET FILM
R50	RN55-13320	1	91637	RN55C3321F	3.32 K OHMS 1% MET FILM
R51	RN55-21330	1	91637	RN55C1332F	13.3 K OHMS 1% MET FILM
R52	RN55-21330	1	91637	RN55C1332F	13.3 K OHMS 1% MET FILM
R60	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R61	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R62	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R63	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM

21014-A00 PCB ASSY PRE-WAVE, GPIB, Rev: C

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
R64	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R65	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R66	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R67	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R68	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R69	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R72	RN55-22210	1	91637	RN55C2212F	22.1 K OHMS 1% MET FILM
R74	RN55-14990	1	91637	RN55C4991F	4.99 K OHMS 1% MET FILM
R75	RN55-14750	1	91637	RN55C4751F	4.75 K OHMS 1% MET FILM
R77	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R78	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R79	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R86	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R90	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R91	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R92	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R93	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R94	RN55-13320	1	91637	RN55C3321F	3.32 K OHMS 1% MET FILM
R95	RN55-22210	1	91637	RN55C2212F	22.1 K OHMS 1% MET FILM
R96	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R97	RN55-14990	1	91637	RN55C4991F	4.99 K OHMS 1% MET FILM
R98	RN55-24990	1	91637	RN55C4992F	49.9 K OHMS 1% MET FILM
R113	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R114	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R115	RN55-14990	1	91637	RN55C4991F	4.99 K OHMS 1% MET FILM
R116	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R117	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R118	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R119	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R120	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
RP1	RM9S-21001	1	58900	RM9S-21001	10K OHM X 9 SIP NETWORK
TP1	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP2	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP3	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP4	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP5	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP6	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP7	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP8	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP9	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN

16878 PCB ASSY., CPU, Rev: E

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
10	WSB0-22000	0	16428	8021-C1000-22AWG	22 GAUGE BUS WIRE
11	HWSS-40300	2	58900	HWSS-40300	#4 X 3/16 SPLIT LOCK
12	17320	2	32559	CP-56-PA	EJECTOR, PC CARD 1.50" LONG
13	GL00-00001	8	58900	GL00-00001	1" x .5" LABEL
14	19973	1	65249	BH-AA	HOLDER, AA BATTERY, PC PINS
15	19974	1	58900	19974	MOUNTING BLOCK, BATTERY HOLDER
16	20803	1	58900	20803	PROM SET 8500A-STANDARD
17	HBFP-44006	2	58900	HBFP-44006	4-40 X 3/8 FLAT
18	HBPP-44006	2	26233	NS137CR440R6	4-40 X 3/8 PAN
19	16878-A00	1	58900	16878-A00	PCB ASSY PRE-WAVE, CPU
BT1	19972	1	31586	LS14500	BATTERY, LITHIUM AA 3.6V 1.8Ah
U1	UGN0-46818	1	04713	MC146818P	MC146818P REAL TIME CLOCK
U5	UMN0-06264	1	58900	UMN0-06264	HM6264LP-15 8K X 8 RAM
U6	UMN0-06264	1	58900	UMN0-06264	HM6264LP-15 8K X 8 RAM
U7	UTN0-02441	1	01295	SN74LS244N	SNL4LS244N 8X DRIV/RECV
U8	UTN0-02441	1	01295	SN74LS244N	SNL4LS244N 8X DRIV/RECV
U9	UTN0-02441	1	01295	SN74LS244N	SNL4LS244N 8X DRIV/RECV
U11	UMN0-06264	1	58900	UMN0-06264	HM6264LP-15 8K X 8 RAM
U12	UGN0-68000	1	04713	MC68HC000P-12	HD68HC000P-8 COMPUTER
U13	UTN0-02441	1	01295	SN74LS244N	SNL4LS244N 8X DRIV/RECV
U14	UTN0-00321	1	01295	SN74LS32N	SN74LS32N QUAD OR
U15	UTN0-00321	1	01295	SN74LS32N	SN74LS32N QUAD OR
U16	UTN0-01641	1	01295	SN74LS164N	SN74LS164N SHIFT REGISTER
U17	ULN0-00555	1	04713	MC1455P1	MC1455P 200MA TIMER
U18	UTN0-00271	1	01295	SN74LS27N-TI	74LS27N 3X3 INPUT NOR
U19	UTN0-00041	1	01295	SN74LS04N	SN74LS04 HEX INVERTER
U20	UTN0-00081	1	01295	SN74LS08N	SN74LS08 QUAD AND
U21	UTN0-00101	1	01295	SN74LS10N	SN74LS10 TRIPLE NAND
U22	UTN0-00051	1	01295	SN74LS05N	74LS05;HEX INVERTER
U23	UTN0-00081	1	01295	SN74LS08N	SN74LS08 QUAD AND
U24	UTN0-00021	1	01295	SN74LS02N	SN74LS02 QUAD NOR
U25	UTN0-00321	1	01295	SN74LS32N	SN74LS32N QUAD OR
U26	UTN0-00003	1	58900	UTN0-00003	74HCT00N QUAD 2 IN NAND
U30	UMN0-06264	1	58900	UMN0-06264	HM6264LP-15 8K X 8 RAM
U31	UMN0-06264	1	58900	UMN0-06264	HM6264LP-15 8K X 8 RAM
U32	UTN0-02451	1	01295	SN74LS245N	SN74LS245N 8X TRANSCEIVE
U33	UTN0-02451	1	01295	SN74LS245N	SN74LS245N 8X TRANSCEIVE
U34	UTN0-01541	1	58900	UTN0-01541	SN74LS154N 4 TO 16 DECODE
U36	UMN0-06264	1	58900	UMN0-06264	HM6264LP-15 8K X 8 RAM
U37	UTN0-01481	1	01295	SN74LS148	74LS148 PRIORITY ENCODER
U38	UTN0-00081	1	01295	SN74LS08N	SN74LS08 QUAD AND
U39	UTN0-00741	1	04713	74LS74N	74LS74 DUAL D FLIP FLOP
U40	UTN0-00041	1	01295	SN74LS04N	SN74LS04 HEX INVERTER
U41	UTN0-00041	1	01295	SN74LS04N	SN74LS04 HEX INVERTER
Y1	Y380-00003	1	58900	Y380-00003	32.768 KHZ CRYSTAL

16878-A00 PCB ASSY PRE-WAVE, CPU, Rev: E

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	16877	1	58900	16877	PC BOARD, CPU 8500
2	16879	REF	58900	16879	SCHEMATIC, CPU
3	JSP0-10064	1	09769	643575-3	64 PIN DIP SOCKET
4	JSP0-10008	1	09769	2-640463-1	8 PIN DIP SOCKET
5	JSP0-10014	16	09769	2-641609-1	14 PIN DIP SOCKET
6	JSP0-10016	1	09769	2-614610-2	16 PIN DIP SOCKET
7	JSP0-10020	6	09769	2-641612-1	20 PIN DIP SOCKET
8	JSP0-10024	2	09769	2-641266-1	24 PIN DIP SOCKET
9	JSP0-10028	14	09769	2-641615-1	28 PIN DIP SOCKET
C1	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C2	CC99-02470	1	56289	5GA-D47	4700 PF 1000V CERAMIC
C3	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C4	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C5	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C6	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C7	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C8	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C9	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C10	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C11	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C12	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C13	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C14	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C15	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C16	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C17	11501-007	1	3W023	CW20C103K	CAP CER .01UF 10% 50V
C18	11501-007	1	3W023	CW20C103K	CAP CER .01UF 10% 50V
C19	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C20	CC50-04470	1	04222	SR301E474MAA	.47 UF CERAMIC Y5V
C21	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C22	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C23	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C24	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C25	CC98-00220	1	56289	10TCC-Q22	22 PF 1KV CERAMIC NPO
C26	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C27	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C28	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C29	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C30	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C31	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C32	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C33	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C34	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C35	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C36	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C37	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C38	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C39	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C40	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C41	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C42	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C43	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C44	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C45	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C47	CV00-R9035	1	58900	CV00-R9035	9-35 PF VARIABLE
C52	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C53	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C54	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C55	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C56	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C57	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
CR1	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P DIODE
CR2	DSA0-02900	1	28480	5082-2811	5082-2900 SCHOT DIODE

16878-A00 PCB ASSY PRE-WAVE, CPU, Rev: E

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
Q1	QBNS-03565	1	27014	PN3565	PN3565 25V 300HFE NPN
R1	RN55-01000	1	91637	RN55C1000F	100 OHMS 1% MET FILM
R2	RC07-52200	1	01121	RC07GF226J	22 MEG 5% 1/4 CARBON
R3	RN55-33320	1	91637	RN55C3323F	332 K OHMS 1% MET FILM
R4	RN55-12210	1	91637	RN55C2211F	2.21 K OHMS 1% MET FILM
R5	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R6	RN55-41000	1	91637	RN55C1004F	1 M OHMS 1% MET FILM
R7	RN55-41000	1	91637	RN55C1004F	1 M OHMS 1% MET FILM
R8	RN55-41000	1	91637	RN55C1004F	1 M OHMS 1% MET FILM
R9	RN55-24750	1	91637	RN55C4752F	47.5 K OHMS 1% MET FILM
R10	RN55-02210	1	91637	RN55C2210F	221 OHMS 1% MET FILM
R11	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R12	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
RP1	RM7S-14700	1	58900	RM7S-14700	4.7 KOHM X 7 SIP NETWORK
RP2	RM7S-14700	1	58900	RM7S-14700	4.7 KOHM X 7 SIP NETWORK
TP1	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP2	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP3	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP4	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP5	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP6	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP7	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP8	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP9	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP10	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
Y2	YX01-00012	1	04713	RASC03	12 MHZ OSCILLATOR

16685 P.C. BRD. ASSY., DIGITAL DELAY, Rev: U

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
7	17320	2	32559	CP-56-PA	EJECTOR, PC CARD 1.50" LONG
8	17240-001	1	27264	15-38-1024	JUMPER,INSULATED,2 POS
9	16685-A00	1	58900	16685-A00	PCB ASSY PRE-WAVE,DIG. DELAY
C9	CF00-03100	1	90201	SXM110	.01UF 160V POLYSTYRENE
C14	CF00-01220	1	90201	SXM322	220PF 160V POLYSTYRENE
L1	17175	1	58900	17175	INDUCTOR, 3.5 TURNS
L3	17174	1	58900	17174	CHOKER, 1.5 TURN
U1	UTN0-02211	1	01295	SN74LS221N	74LS221 MONOSTABLE SCHMT
U2	UTN0-01381	1	01295	SN74LS138N	SN74LS138N 3 TO 8 DEC
U3	UTN0-00741	1	04713	74LS74N	74LS74 DUAL D FLIP FLOP
U4	UTN0-00321	1	01295	SN74LS32N	SN74LS32N QUAD OR
U5	UTN0-00201	1	01295	SN74LS20N	74LS20N DUAL 4 IN NAND
U6	UGN0-08255	1	34335	8255A-5	8255A-5 PROG PIA
U7	UGN0-08255	1	34335	8255A-5	8255A-5 PROG PIA
U8	UTN0-01637	1	01295	SN74S163N	SN74S163N 4 BIT COUNTER
U9	UTN0-01631	1	01295	SN74LS163N	SN74LS163N SYNCH COUNTER
U10	UTN0-01631	1	01295	SN74LS163N	SN74LS163N SYNCH COUNTER
U11	UTN0-01631	1	01295	SN74LS163N	SN74LS163N SYNCH COUNTER
U12	UTN0-01631	1	01295	SN74LS163N	SN74LS163N SYNCH COUNTER
U13	UEN0-10124	1	04713	MC10124P	MC10124P QUAD TTL TO ECL
U14	13620-009	1	04713	MC10H016P	I.C. - DIGITAL TTL
U15	UTN0-00043	1	01295	SN74HCT04N	74HCT04 HEX INVERTER
U16	UTN0-01571	1	58900	UTN0-01571	SN74LS157 QUAD 2 TO 1 MU
U17	UTN0-00741	1	04713	74LS74N	74LS74 DUAL D FLIP FLOP
U19	UEN0-10124	1	04713	MC10124P	MC10124P QUAD TTL TO ECL
U20	UTN0-00001	1	01295	SN74LS00N	SN74LS00 QUAD NAND
U21	UEN0-10125	1	04713	MC10125P	MC10125P QUAD ECL TO TTL
U22	UTN0-02211	1	01295	SN74LS221N	74LS221 MONOSTABLE SCHMT
U23	UEN0-10105	1	04713	MC10105P	MC10105P TRIPLE OR/NOR
U24	UEN1-10105	1	04713	MC10H105P	MC10H105P TRIPLE OR/NOR
U25	UEN0-10131	1	04713	MC10131L	MC10131P DUAL D F/F
U26	UEN0-10198	1	04713	MC10198L	MC10198P MONOSTABLE MULTI
U27	UEN1-10105	1	04713	MC10H105P	MC10H105P TRIPLE OR/NOR
U28	UEN1-10104	1	04713	MC10H104P	MC10H104P 2 IN AND
U29	UEN1-10131	1	04713	MC10H131P	MC10H131P DUAL D F/F
U30	UEN1-10121	1	04713	MC10H121P	MC10H121 4X AND/OR/AND
U31	UEN0-10124	1	04713	MC10124P	MC10124P QUAD TTL TO ECL
U32	UFN0-00358	1	58900	UFN0-00358	LM358 OP AMP
U33	ULN0-00201	1	24355	ADG201AKN	ADG201AKN SPST SWITCH
U35	13620-003	1	04713	MC10101P	INTEGRATED CKT MC10101P
U36	UIN1-00008	1	58900	UIN1-00008	DAC08EQ 8 BIT DAC
U37	UFN0-00072	1	01295	TL072CP	TL072CP DUAL FET OP AMP
U38	UEN0-10198	1	04713	MC10198L	MC10198P MONOSTABLE MULTI
U39	ULN0-96687	1	24355	AD96687BQ	AD96687BQ COMPARATOR
U40	UIN0-00561	1	24355	AD561JN	AD561JN 10 BIT DAC
U41	UFN0-00358	1	58900	UFN0-00358	LM358 OP AMP
U42	UTN0-02211	1	01295	SN74LS221N	74LS221 MONOSTABLE SCHMT
U43	UTN0-00021	1	01295	SN74LS02N	SN74LS02 QUAD NOR
U44	UTN0-01231	1	01295	SN74LS123N	SN74LS123N DUAL ONE SHOT
Y1	Y250-03906	1	52847	CR-117/U 39.062500MHZ	39.0625 MHZ OVEN XTAL

16685-A00 PCB ASSY PRE-WAVE,DIG. DELAY, Rev: U

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	16684	1	58900	16684	DIGITAL DELAY PC BOARD
2	16686	REF	58900	16686	SCHEMATIC, DIGITAL DELAY
3	JSP0-10008	3	09769	2-640463-1	8 PIN DIP SOCKET
4	JSP0-10014	6	09769	2-641609-1	14 PIN DIP SOCKET
5	JSP0-10016	30	09769	2-614610-2	16 PIN DIP SOCKET
6	JSP0-10040	2	09769	2-641616-1	40 PIN DIP SOCKET
C1	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C3	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C4	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C5	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C6	CC98-00220	1	56289	10TCC-Q22	22 PF 1KV CERAMIC NPO
C10	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C11	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C15	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C16	CC98-00470	1	—	CCD470	47 PF 1KV CERAMIC NPO
C18	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C21	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C22	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C23	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C24	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C25	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C26	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C27	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C28	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C29	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C30	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C31	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C32	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C33	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C34	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C35	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C36	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C37	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C38	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C39	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C40	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C41	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C42	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C43	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C44	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C48	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C49	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C50	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C51	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C52	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C53	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C54	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C55	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C56	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C57	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C58	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C59	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C60	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C61	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C62	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C63	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C64	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C66	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C67	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C68	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C69	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C70	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C71	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P

16685-A00 PCB ASSY PRE-WAVE,DIG. DELAY, Rev: U

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
C72	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C76	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C77	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C78	CC50-04470	1	04222	SR301E474MAA	.47 UF CERAMIC Y5V
C79	CV00-R9035	1	58900	CV00-R9035	9-35 PF VARIABLE
C80	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C81	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C82	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C83	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C84	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C85	CC99-01100	1	3W023	DD101	100 PF 1000V CERAMIC X5F
C86	CC99-01100	1	3W023	DD101	100 PF 1000V CERAMIC X5F
C87	CC99-01100	1	3W023	DD101	100 PF 1000V CERAMIC X5F
C88	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C89	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C90	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C93	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C94	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C95	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C96	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C97	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C100	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C101	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C102	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C103	CT35-R5220	1	31433	T356C225K035AS	2.2UF 35V TANTALUM
C104	CC98-00100	1	—	CCD100	10 PF 1000 V CERAMIC NPO
C105	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C106	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C107	CC51-01470	1	51642	150-50-X7R-471K	470 PF CERAMIC X7R
C108	CC51-01470	1	51642	150-50-X7R-471K	470 PF CERAMIC X7R
CR1	DSA0-02900	1	28480	5082-2811	5082-2900 SCHOT DIODE
CR2	DRAE-00823	1	04713	1N823	1N823 6.3V REF DIODE
CR3	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P DIODE
Q1	QBNS-03646	1	04713	MPS3646	2N3646 40V 350 MHZ NPN
Q5	QBNS-03563	1	27014	PN3563	PN3563 15V 600MHZ NPN
Q6	QBNS-03563	1	27014	PN3563	PN3563 15V 600MHZ NPN
Q7	QBPS-04121	1	58377	PN4121	2N4121 .05A 40V PNP
Q8	QBPS-04121	1	58377	PN4121	2N4121 .05A 40V PNP
Q9	QBNS-03563	1	27014	PN3563	PN3563 15V 600MHZ NPN
Q10	QBNS-03563	1	27014	PN3563	PN3563 15V 600MHZ NPN
Q13	QBPS-04121	1	58377	PN4121	2N4121 .05A 40V PNP
Q14	QBPS-04121	1	58377	PN4121	2N4121 .05A 40V PNP
R2	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R3	RN55-14750	1	91637	RN55C4751F	4.75 K OHMS 1% MET FILM
R4	RN55-14750	1	91637	RN55C4751F	4.75 K OHMS 1% MET FILM
R5	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R6	RN55-01620	1	91637	RN55C1620F	162 OHMS 1% MET FILM
R8	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R9	RN55-01620	1	91637	RN55C1620F	162 OHMS 1% MET FILM
R10	RN57-31000	1	58900	RN57-31000	100 K OHM .1 % MET FILM
R11	RN57-31000	1	58900	RN57-31000	100 K OHM .1 % MET FILM
R12	RN57-31000	1	58900	RN57-31000	100 K OHM .1 % MET FILM
R13	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R14	RN57-31000	1	58900	RN57-31000	100 K OHM .1 % MET FILM
R15	RN55-02210	1	91637	RN55C2210F	221 OHMS 1% MET FILM
R16	RN55-04990	1	91637	RN55C4990F	499 OHMS 1% MET FILM
R17	RN55-11500	1	91637	RN55C1501F	1.5 K OHMS 1% MET FILM
R18	RN55-12210	1	91637	RN55C2211F	2.21 K OHMS 1% MET FILM
R19	RN55-01000	1	91637	RN55C1000F	100 OHMS 1% MET FILM
R20	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R21	RN55-01620	1	91637	RN55C1620F	162 OHMS 1% MET FILM
R22	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R23	RN55-15110	1	91637	RN55C5111F	5.11 K OHMS; METAL FILM

16685-A00 PCB ASSY PRE-WAVE,DIG. DELAY, Rev: U

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
R26	RN55-01000	1	91637	RN55C1000F	100 OHMS 1% MET FILM
R27	RN55-01000	1	91637	RN55C1000F	100 OHMS 1% MET FILM
R28	RN55-04750	1	91637	RN55C4750F	475 OHMS 1% MET FILM
R29	RN55-14990	1	91637	RN55C4991F	4.99 K OHMS 1% MET FILM
R30	RAPK-05000	1	5Y491	66XR500	500 OHM 10% 20T PC MNT
R31	RN55-11240	1	91637	CCF55-2-1.24K1%T2T/R	1.24 KOHM 1% MET FILM
R32	RN57-01000	1	58900	RN57-01000	100.0 OHM .1% MET FILM
R33	RN57-15000	1	58900	RN57-15000	5.00 KOHM .1% MET FILM
R34	RN55-14990	1	91637	RN55C4991F	4.99 K OHMS 1% MET FILM
R35	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R36	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R37	RN57-21500	1	58900	RN57-21500	15.0 K OHM .1 % MET FILM
R38	RN57-07500	1	58900	RN57-07500	750.0 OHM .1% MET FILM
R39	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R40	RN55-02210	1	91637	RN55C2210F	221 OHMS 1% MET FILM
R41	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R42	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R43	RN55-14750	1	91637	RN55C4751F	4.75 K OHMS 1% MET FILM
R44	RN55-03010	1	91637	RN55C3010F	301 OHMS 1% MET FILM
R45	RN55-06980	1	91637	RN55C6980F	698 OHMS 1% MET FILM
R46	RF07-44700	1	65940	R25X-R02-J-475	4.7M OHMS 5% CARB FILM
R47	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R48	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R49	RN55-31000	1	91637	RN55C1003F	100 K OHMS 1% MET FILM
R50	RN55-31000	1	91637	RN55C1003F	100 K OHMS 1% MET FILM
R51	RN55-22000	1	91637	RN55C2002F	20 K OHMS 1% MET FILM
R52	RN55-22000	1	91637	RN55C2002F	20 K OHMS 1% MET FILM
R53	RN55-00511	1	91637	RN55C51R1F	51.1 OHMS 1% MET FILM
R54	RN55-15110	1	91637	RN55C5111F	5.11 K OHMS; METAL FILM
R55	RN55-16190	1	91637	RN55C6191F	6.19 K OHMS 1% MET FILM
R56	RN55-00511	1	91637	RN55C51R1F	51.1 OHMS 1% MET FILM
R57	RN55-00511	1	91637	RN55C51R1F	51.1 OHMS 1% MET FILM
R58	RN55-00511	1	91637	RN55C51R1F	51.1 OHMS 1% MET FILM
R59	RN55-00511	1	91637	RN55C51R1F	51.1 OHMS 1% MET FILM
R60	RN55-16810	1	91637	RN55C6811F	6.81 K OHMS 1% MET FILM
R62	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R63	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R64	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R65	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R66	RN55-02740	1	91637	RN55C2740F	274 OHMS 1% MET FILM
R67	RN55-22210	1	91637	RN55C2212F	22.1 K OHMS 1% MET FILM
R68	RN55-22210	1	91637	RN55C2212F	22.1 K OHMS 1% MET FILM
R69	RN55-00499	1	91637	RN55C49R9F	49.9 OHMS 1% MET FILM
R70	RN55-21400	1	91637	RN55C1402F	14 K OHMS 1% MET FILM
R71	RN55-25230	1	91637	RN55C5232F	52.3 K OHMS 1% MET FILM
R72	RN55-00499	1	91637	RN55C49R9F	49.9 OHMS 1% MET FILM
R73	RN55-21400	1	91637	RN55C1402F	14 K OHMS 1% MET FILM
R74	RN55-25230	1	91637	RN55C5232F	52.3 K OHMS 1% MET FILM
R75	RN55-11500	1	91637	RN55C1501F	1.5 K OHMS 1% MET FILM
R76	RN55-04990	1	91637	RN55C4990F	499 OHMS 1% MET FILM
R77	RN55-32800	1	91637	RN55C2803F	280 K OHMS 1% MET FILM
R78	RN55-32800	1	91637	RN55C2803F	280 K OHMS 1% MET FILM
R79	RN55-22000	1	91637	RN55C2002F	20 K OHMS 1% MET FILM
R80	RN55-12000	1	91637	RN55C2001F	2.00 K OHMS 1% MET FILM
R81	RAPK-22000	1	5Y491	66XR20K	20K 10% 20T PC MNT
R82	RAPK-22000	1	5Y491	66XR20K	20K 10% 20T PC MNT
RP1	RM9S-03900	1	71450	750-101-R390	390 X 9 SIP NETWORK
RP2	RM7S-03900	1	71450	750-81-R390	390 OHM X 7 SIP NETWRK
RP3	RM7S-03900	1	71450	750-81-R390	390 OHM X 7 SIP NETWRK
RP4	RM7S-03900	1	71450	750-81-R390	390 OHM X 7 SIP NETWRK
RP5	RM7S-03900	1	71450	750-81-R390	390 OHM X 7 SIP NETWRK
RP6	RM7S-03900	1	71450	750-81-R390	390 OHM X 7 SIP NETWRK
RP7	RM7S-03900	1	71450	750-81-R390	390 OHM X 7 SIP NETWRK

16685-A00 PCB ASSY PRE-WAVE,DIG. DELAY, Rev: U

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
RP8	RM9S-06800	1	58900	RM9S-06800	680 OHM X 9 SIP NETWORK
RP9	RM7S-03900	1	71450	750-81-R390	390 OHM X 7 SIP NETWORK
RP10	RM9S-03900	1	71450	750-101-R390	390 X 9 SIP NETWORK
RP11	RM7S-03900	1	71450	750-81-R390	390 OHM X 7 SIP NETWORK
TP1	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP2	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP3	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP4	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP5	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP6	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP7	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP8	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP9	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP10	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP11	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP12	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP13	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP14	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP15	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP16	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP17	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP18	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP19	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP20	ETTO-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
U34	UEG0-09685	1	58900	UEG0-09685	AD9685BH COMPARATOR

20741 ANALOG PCB ASSY, Rev: M

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
9	17320	2	32559	CP-56-PA	EJECTOR, PC CARD 1.50" LONG
10	20741-A00	1	58900	20741-A00	PCB ASSY PRE-WAVE, ANALOG
C23	CF00-03100	1	90201	SXM110	.01UF 160V POLYSTYRENE
C70	CF00-02240	1	90201	SXM224	2400PF 160V POLYSTYRENE
T1	20131	1	58900	20131	TRANSFORMER,SAMPLER
U1	UGN0-08255	1	34335	8255A-5	8255A-5 PROG PIA
U2	UTN0-00041	1	01295	SN74LS04N	SN74LS04 HEX INVERTER
U3	UTN0-00271	1	01295	SN74LS27N-TI	74LS27N 3X3 INPUT NOR
U4	UTN0-00001	1	01295	SN74LS00N	SN74LS00 QUAD NAND
U5	UTN0-00321	1	01295	SN74LS32N	SN74LS32N QUAD OR
U6	UTN0-08735	1	01295	SN74ALS873ANT	SN74ALS873ANT DUAL LATCH
U7	UIN0-00574	1	58900	UIN0-00574	AD574AJ 12 BIT ADC
U8	UIN0-07542	1	1ES66	MX7542KN	AD7542KN 12 BIT D/A
U9	14632	1	58377	CD4069UBCN	INTEGRATED CKT MM74CO4N
U10	14632	1	58377	CD4069UBCN	INTEGRATED CKT MM74CO4N
U11	UFN0-05135	1	01295	OP-07/CP	HA5135-5 PRECISION OP AMP
U12	UFN0-05135	1	01295	OP-07/CP	HA5135-5 PRECISION OP AMP
U13	ULN0-00201	1	24355	ADG201AKN	ADG201AKN SPST SWITCH
U14	UFN1-00324	1	01295	LM324N	LM324AN QUAD OP AMP
U15	ULN0-00201	1	24355	ADG201AKN	ADG201AKN SPST SWITCH
U16	UIN0-00398	1	58900	UIN0-00398	LF398AN SAMPLE/HOLD
U17	UFN0-34074	1	04713	MC34074L	MC34074P QUAD OP AMP
U18	UFN0-05135	1	01295	OP-07/CP	HA5135-5 PRECISION OP AMP
U19	UFN0-05135	1	01295	OP-07/CP	HA5135-5 PRECISION OP AMP
U20	ULN0-00201	1	24355	ADG201AKN	ADG201AKN SPST SWITCH
U21	UFN1-00324	1	01295	LM324N	LM324AN QUAD OP AMP
U22	ULN0-00201	1	24355	ADG201AKN	ADG201AKN SPST SWITCH
U23	ULN0-00339	1	04713	LM339N	LM339N COMPARATOR
U25	ULN0-00444	1	17856	DG444DJ	DG444DJ QUAD SPST SWITCH
U26	UFN0-05135	1	01295	OP-07/CP	HA5135-5 PRECISION OP AMP
U27	UFN0-05135	1	01295	OP-07/CP	HA5135-5 PRECISION OP AMP
U28	UFN0-00356	1	04713	LF356BN-MOT	LF356BN OP AMP
U29	UFN0-00356	1	04713	LF356BN-MOT	LF356BN OP AMP
U30	UFN0-00847	1	24355	AD847JN	AD847JN OP AMP
U31	UAN0-05002	1	2M881	HA3-5002-5	HA3-5002-5 VIDEO BUFFER
U32	ULN0-00201	1	24355	ADG201AKN	ADG201AKN SPST SWITCH
U33	UAN0-05002	1	2M881	HA3-5002-5	HA3-5002-5 VIDEO BUFFER

20741-A00 PCB ASSY PRE-WAVE, ANALOG, Rev: M

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	20740	1	58900	20740	PC BOARD, ANALOG
2	20742	REF	58900	20742	SCHEMATIC, ANALOG
3	JSP2-10024	1	09769	2-641932-1	24 PIN DIP SOCKET
4	JSP0-10008	12	09769	2-640463-1	8 PIN DIP SOCKET
5	JSP0-10014	10	09769	2-641609-1	14 PIN DIP SOCKET
6	JSP0-10016	6	09769	2-614610-2	16 PIN DIP SOCKET
7	JSP0-10028	1	09769	2-641615-1	28 PIN DIP SOCKET
8	JSP0-10040	1	09769	2-641616-1	40 PIN DIP SOCKET
C1	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C2	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C3	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C4	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C5	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C6	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C7	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C8	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C81	CC50-01100	1	04222	SR151A101JAA	100 PF CERAMIC NPO
C9	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C10	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C11	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C12	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C13	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C14	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C15	CC50-B4470	1	04222	SR305C474KAA	.47 UF CERAMIC X7R
C16	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C17	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C18	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C19	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C20	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C21	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C22	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C24	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C25	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C26	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C27	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C28	CC98-00470	1	—	CCD470	47 PF 1KV CERAMIC NPO
C29	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C30	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C31	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C32	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C33	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C34	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C35	CC99-02470	1	56289	5GA-D47	4700 PF 1000V CERAMIC
C36	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C37	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C38	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C39	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C40	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C41	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C42	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C43	CC98-00470	1	—	CCD470	47 PF 1KV CERAMIC NPO
C44	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C45	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C46	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C47	CD99-01470	1	—	CM06FD471F03	470 PF DIP MICA
C48	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C49	CC50-02100	1	04222	SR155C122MAT	.001 UF CERAMIC Y5P
C51	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C52	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C53	CT20-R6150	1	04222	TAP156K020CCS	15UF 20V TANTALUM
C54	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C55	CC98-00470	1	—	CCD470	47 PF 1KV CERAMIC NPO
C56	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R

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Item	Part Number	Qty	Cage	Mfr's Part Number	Description
C57	CD99-01470	1	—	CM06FD471F03	470 PF DIP MICA
C60	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C62	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C63	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C64	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C65	CC50-02220	1	04222	SR155C222KAA	2200PF CERAMIC X7R
C66	CC50-02470	1	31433	C315C472K1R5CA	4700 PF CERAMIC X7R
C67	CC50-02270	1	31433	C315C272K1R5CA C9248	2700 PF CERAMIC X7R
C68	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C69	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C71	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C72	CC98-00680	1	90201	CPC680J	68 PF 1 KV CERAMIC NPO
C78	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C79	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C80	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C93	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C94	CC50-02220	1	04222	SR155C222KAA	2200PF CERAMIC X7R
C97	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C99	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C100	CC51-01220	1	3W023	CW15C221K	220 PF CERAMIC X7R
C102	CC00-02220	1	04222	SR201A222KAA	2200 PF CERAMIC COG
C106	CC50-02470	1	31433	C315C472K1R5CA	4700 PF CERAMIC X7R
C107	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C108	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C109	CE50-R5330	1	55680	UVX1H3R3MAA	3.3UF 50V RADIAL
C110	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C111	CE50-R5330	1	55680	UVX1H3R3MAA	3.3UF 50V RADIAL
C112	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C113	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C114	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C115	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C116	15776-028	1	90201	C20C101K5R5CA	100 PF CERAMIC X7R
CR1	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR2	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR3	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR4	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR5	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR6	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR7	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR8	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR10	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR11	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR12	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR13	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR14	DSA0-02800	1	28480	1N5711	5082-2800 SCHOT DIODE
CR16	DSA0-02800	1	28480	1N5711	5082-2800 SCHOT DIODE
CR17	DSA0-02800	1	28480	1N5711	5082-2800 SCHOT DIODE
CR18	DSA0-02800	1	28480	1N5711	5082-2800 SCHOT DIODE
CR19	DSA0-02800	1	28480	1N5711	5082-2800 SCHOT DIODE
CR20	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR21	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR22	DSA0-02800	1	28480	1N5711	5082-2800 SCHOT DIODE
Q1	QBNS-03569	1	4U751	2N3569	PN3569 .5A 40V NPN
Q2	QBNS-03646	1	04713	MPS3646	2N3646 40V 350 MHZ NPN
Q3	QBPS-04121	1	58377	PN4121	2N4121 .05A 40V PNP
Q4	QBNS-03646	1	04713	MPS3646	2N3646 40V 350 MHZ NPN
R1	RN55-13320	1	91637	RN55C3321F	3.32 K OHMS 1% MET FILM
R2	RN55-13320	1	91637	RN55C3321F	3.32 K OHMS 1% MET FILM
R3	RN55-13320	1	91637	RN55C3321F	3.32 K OHMS 1% MET FILM
R4	RN55-13320	1	91637	RN55C3321F	3.32 K OHMS 1% MET FILM
R5	RN55-00499	1	91637	RN55C49R9F	49.9 OHMS 1% MET FILM
R6	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R7	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM

20741-A00 PCB ASSY PRE-WAVE, ANALOG, Rev: M

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
R8	RN55-02210	1	91637	RN55C2210F	221 OHMS 1% MET FILM
R9	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R10	RN55-03320	1	91637	RN55C3320F	332 OHMS 1% MET FILM
R11	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R12	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R13	RAPK-05000	1	5Y491	66XR500	500 OHM 10% 20T PC MNT
R14	RN57-12681	1	58900	RN57-12681	2.681 KOHM .1% MET FILM
R15	RN57-21875	1	58900	RN57-21875	18.75 KOHM .1% MET FILM
R16	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R17	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R18	RN55-02210	1	91637	RN55C2210F	221 OHMS 1% MET FILM
R19	RN55-24750	1	91637	RN55C4752F	47.5 K OHMS 1% MET FILM
R20	RN55-14990	1	91637	RN55C4991F	4.99 K OHMS 1% MET FILM
R21	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R22	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R23	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R24	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R25	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R26	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R27	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R28	RN57-21875	1	58900	RN57-21875	18.75 KOHM .1% MET FILM
R29	RN57-12681	1	58900	RN57-12681	2.681 KOHM .1% MET FILM
R30	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R31	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R32	RN55-14750	1	91637	RN55C4751F	4.75 K OHMS 1% MET FILM
R33	RN55-14990	1	91637	RN55C4991F	4.99 K OHMS 1% MET FILM
R34	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R35	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R36	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R37	RN55-14990	1	91637	RN55C4991F	4.99 K OHMS 1% MET FILM
R38	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R39	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R40	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R41	RN55-14990	1	91637	RN55C4991F	4.99 K OHMS 1% MET FILM
R42	RN55-27500	1	91637	RN55C7502F	75.0 K OHMS 1% MET FILM
R43	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R44	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R45	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R46	RN55-21500	1	91637	RN55C1502F	15 K OHMS 1% MET FILM
R47	RAPK-11000	1	5Y491	66XR1K	1K 10% 20T PC MNT
R48	RN55-17500	1	91637	RN55C7501F	7.5 K OHMS 1% MET FILM
R49	RN55-18660	1	91637	RN55C8661F	8.66K OHMS 1% MET FILM
R50	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R51	RN55-21100	1	91637	RN55C1102F	11 K OHMS 1% MET FILM
R52	RN55-21330	1	91637	RN55C1332F	13.3 K OHMS 1% MET FILM
R53	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R54	RN55-22370	1	91637	RN55C2372F	23.7 K OHMS 1% MET FILM
R55	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R56	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R57	RN57-23058	1	58900	RN57-23058	30.58 KOHM .1% MET FILM
R58	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R59	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R60	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R61	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R62	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R63	RN57-21875	1	58900	RN57-21875	18.75 KOHM .1% MET FILM
R64	RN57-12681	1	58900	RN57-12681	2.681 KOHM .1% MET FILM
R65	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R66	RN55-32210	1	91637	RN55C2213F	221 K OHMS 1% MET FILM
R67	RN55-32210	1	91637	RN55C2213F	221 K OHMS 1% MET FILM
R68	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R69	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R70	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM

20741-A00 PCB ASSY PRE-WAVE, ANALOG, Rev: M

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
R71	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R72	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R73	RN55-22000	1	91637	RN55C2002F	20 K OHMS 1% MET FILM
R74	RN57-22000	1	58900	RN57-22000	20.0 KOHM .1% MET FILM
R75	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R76	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R77	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R78	RN55-00274	1	91637	RN55C27R4F	27.4 OHMS 1% MET FILM
R79	RN55-00274	1	91637	RN55C27R4F	27.4 OHMS 1% MET FILM
R80	RN55-21500	1	91637	RN55C1502F	15 K OHMS 1% MET FILM
R81	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R82	RN57-21600	1	58900	RN57-21600	16.00 KOHM .1% MET FILM
R83	RN57-23996	1	58900	RN57-23996	39.96 KOHM .1% MET FILM
R84	RN57-18000	1	58900	RN57-18000	8.00 K OHM .1 % MET FILM
R85	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R86	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R87	RN55-32210	1	91637	RN55C2213F	221 K OHMS 1% MET FILM
R88	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R89	RN55-32210	1	91637	RN55C2213F	221 K OHMS 1% MET FILM
R90	RN57-21875	1	58900	RN57-21875	18.75 KOHM .1% MET FILM
R91	RN57-12681	1	58900	RN57-12681	2.681 KOHM .1% MET FILM
R93	RN55-21500	1	91637	RN55C1502F	15 K OHMS 1% MET FILM
R94	RN55-21500	1	91637	RN55C1502F	15 K OHMS 1% MET FILM
R95	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R97	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R98	RN57-12000	1	58900	RN57-12000	2.00 KOHM .1% METAL FILM
R99	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R100	RN57-12000	1	58900	RN57-12000	2.00 KOHM .1% METAL FILM
R101	RN57-09533	1	58900	RN57-09533	953.3 OHM .1% MET FILM
R102	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R103	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R104	RN55-00750	1	91637	RN55CMF25T75E	75.0 OHMS 1% MET FILM
R109	RN55-00365	1	91637	RN55C36R5F	36.5 OHMS 1% MET FILM
R110	RN55-00365	1	91637	RN55C36R5F	36.5 OHMS 1% MET FILM
R111	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R112	RAPK-31000	1	5Y491	67XR100K	100K 10% 20T PC MNT
R113	RAPK-21000	1	5Y491	67XR10K	10K 10% 20T PC MNT
R114	RN55-31000	1	91637	RN55C1003F	100 K OHMS 1% MET FILM
R115	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R116	RN57-11000	1	91637	RN55C1001B	1K OHM .1% MET FILM
R117	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R119	RN55-12210	1	91637	RN55C2211F	2.21 K OHMS 1% MET FILM
R120	RN55-42210	1	91637	RN55C2204F	2.21 M OHM 1% MET FILM
R122	RN55-31100	1	91637	RN55C1103F	110 K OHMS 1% MET FILM
R123	RN55-01000	1	91637	RN55C1000F	100 OHMS 1% MET FILM
R125	RN55-23320	1	91637	RN55C3322F	33.2 K OHMS 1% MET FILM
R131	RN55-00499	1	91637	RN55C49R9F	49.9 OHMS 1% MET FILM
R132	RN55-00249	1	91637	RN55C24R9F	24.9 OHMS 1% MET FILM
R135	RN55-00464	1	91637	RN55D 46.4 OHM 1%	46.4 OHM 1% MET FILM
R136	RC07-52200	1	01121	RC07GF226J	22 MEG 5% 1/4 CARBON
R138	RN57-22928	1	58900	RN57-22928	29.28 KOHM;.1% MET FILM
R139	RN55-12210	1	91637	RN55C2211F	2.21 K OHMS 1% MET FILM
R140	RN57-21000	1	58900	RN57-21000	10K OHM .1% MET FILM
R141	RN55-01000	1	91637	RN55C1000F	100 OHMS 1% MET FILM
R142	RN55-12210	1	91637	RN55C2211F	2.21 K OHMS 1% MET FILM
R143	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R144	RN55-33320	1	91637	RN55C3323F	332 K OHMS 1% MET FILM
R145	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R146	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R147	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R148	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R149	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R152	WJIB-05024	1	63058	JO.500X0.125-PVC-24	.5" INSULATED JUMPER

20741-A00 PCB ASSY PRE-WAVE, ANALOG, Rev: M

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
R155	RN55-00100	1	91637	RN55C10R0F	10 OHMS 1% MET FILM
R156	RN55-13320	1	91637	RN55C3321F	3.32 K OHMS 1% MET FILM
R158	RN55-03740	1	91637	RN55C3740F	374 OHMS 1% MET FILM
R160	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R161	RN55-00475	1	91637	RN55C47R5F	47.5 OHMS 1% MET FILM
R163	RN55-04990	1	91637	RN55C4990F	499 OHMS 1% MET FILM
R164	RN55-03740	1	91637	RN55C3740F	374 OHMS 1% MET FILM
R165	RN55-00249	1	91637	RN55C24R9F	24.9 OHMS 1% MET FILM
R166	RN55-01000	1	91637	RN55C1000F	100 OHMS 1% MET FILM
R167	RN55-14990	1	91637	RN55C4991F	4.99 K OHMS 1% MET FILM
TP1	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP2	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP3	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP4	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP5	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP6	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP7	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP8	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP9	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP10	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP11	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP12	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP13	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
XR141	LCR0-13801	1	02114	56-59065/3B	FERRITE BEAD
XR166	LCR0-13801	1	02114	56-59065/3B	FERRITE BEAD

20195 PCB ASSY, FR PNL INTERFACE, Rev: D

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
8	HNKS-44004	2	58900	HNKS-44004	4-40 KEP NUT
9	HIBR-00440	3	53387	SP5303-GRAY	MOLDED BUMPER
10	18597	2	8W262	60-11-8302-1674	INSULATOR(T0-220)
11	HQH0-62200	2	30161	5771B	TO220 HEATSINK
12	HBPP-44006	2	26233	NS137CR440R6	4-40 X 3/8 PAN
13	20195-A00	1	58900	20195-A00	PCB ASSY PRE-WAVE,FRT PNL INT
L1	20566	1	58900	20566	INDUCTOR, 15uH 1.2A
Q1	QMNP-00540	1	66958	IRF540	IRF540 100V 28A NMOS FET
T1	20634	1	58900	20634	TRANSFORMER, FLYBACK
U1	UMN0-06264	1	58900	UMN0-06264	HM6264LP-15 8K X 8 RAM
U2	UGN0-08279	1	34335	AM8279DC	8279 KEY/DISPLAY INTERFACE
U3	UTN0-01751	1	01295	SN74LS175N	SN74LS175 QUAD D F/F
U4	UIN0-75451	1	01295	SN75451BP	SN75451BP DUAL DRIVER
U5	UTN0-01561	1	01295	SN74LS156N	SN74LS156N 2 TO 4 DECDR
U6	UTN0-02211	1	01295	SN74LS221N	74LS221 MONOSTABLE SCHMT
U7	ULN0-03082	1	58900	ULN0-03082	CA3082 TRANSISTOR ARRAY
U8	ULN0-00556	1	01295	NE556N	LM556N DUAL TIMER
U9	UTN0-00041	1	01295	SN74LS04N	SN74LS04 HEX INVERTER
U10	20761	1	58900	20761	PAL, FRONT PANEL KNOB LOGIC
U11	UGD0-61830	1	61485	HD61830B00H	HD61830 LCD CONTROLLER
U12	UTN0-00321	1	01295	SN74LS32N	SN74LS32N QUAD OR
U13	UTN0-00043	1	01295	SN74HCT04N	74HCT04 HEX INVERTER
U14	UTN0-00021	1	01295	SN74LS02N	SN74LS02 QUAD NOR
U15	UFN1-00358	1	01295	LM358AP	LM358AN DUAL OP AMP
U16	UTN0-01611	1	01295	SN74LS161AN	SN74LS161AN COUNTER
U17	UTN0-02211	1	01295	SN74LS221N	74LS221 MONOSTABLE SCHMT
U18	UTN0-00744	1	01295	SN74F74N	MC74F74N 100MHZ DUAL D
U19	UIN0-03845	1	66958	UC3845N	UC3845 PWM CONTROLLER
U21	UFN0-00358	1	58900	UFN0-00358	LM358 OP AMP
U22	URC1-07812	1	04713	MC78T12CT	MC78T12CT 3A 12V REG

20195-A00 PCB ASSY PRE-WAVE,FRT PNL INT, Rev: C

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	20194	1	58900	20194	PC BOARD FR PNL INTERFACE
2	JSP0-10008	4	09769	2-640463-1	8 PIN DIP SOCKET
3	JSP0-10014	6	09769	2-641609-1	14 PIN DIP SOCKET
4	JSP0-10016	6	09769	2-614610-2	16 PIN DIP SOCKET
5	JSP0-10020	1	09769	2-641612-1	20 PIN DIP SOCKET
6	JSP0-10028	1	09769	2-641615-1	28 PIN DIP SOCKET
7	JSP0-10040	1	09769	2-641616-1	40 PIN DIP SOCKET
C2	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C3	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C4	CE50-R6220	1	55680	ULB1H220MAA	22UF 50V RADIAL
C6	CC50-B4470	1	04222	SR305C474KAA	.47 UF CERAMIC X7R
C11	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C12	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C19	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C20	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C21	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C25	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C26	CC50-B4470	1	04222	SR305C474KAA	.47 UF CERAMIC X7R
C27	CC50-B4470	1	04222	SR305C474KAA	.47 UF CERAMIC X7R
C28	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C30	CE50-R5100	1	55680	ULB1H010MAA	1UF 50V RADIAL
C31	CC51-01470	1	51642	150-50-X7R-471K	470 PF CERAMIC X7R
C32	CC51-01470	1	51642	150-50-X7R-471K	470 PF CERAMIC X7R

20195-A00 PCB ASSY PRE-WAVE,FRT PNL INT, Rev: C

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
C33	CC51-01470	1	51642	150-50-X7R-471K	470 PF CERAMIC X7R
C34	CC51-01470	1	51642	150-50-X7R-471K	470 PF CERAMIC X7R
C35	CC50-B4470	1	04222	SR305C474KAA	.47 UF CERAMIC X7R
C36	CC50-B4470	1	04222	SR305C474KAA	.47 UF CERAMIC X7R
C37	CC51-01470	1	51642	150-50-X7R-471K	470 PF CERAMIC X7R
C38	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C40	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C41	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C42	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C43	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C44	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C45	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C46	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C47	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C50	CF50-R5100	1	65964	MMK5105K50L4C	1UF 50V POLYESTER
C51	CF63-R4100	1	68919	MKS2-0.1UF-10%-63	.1UF 63V POLYESTER
C52	CC50-03220	1	31433	C315C223K5R5CA	.022 UF CERAMIC X7R
C53	CC50-02270	1	31433	C315C272K1R5CA C9248	2700 PF CERAMIC X7R
C55	CF63-R4100	1	68919	MKS2-0.1UF-10%-63	.1UF 63V POLYESTER
C56	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C57	CE25-R7470	1	55680	UVX1E471M	470 UF 25V RADIAL
C58	CC50-02220	1	04222	SR155C222KAA	2200PF CERAMIC X7R
C59	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C60	CC50-02470	1	31433	C315C472K1R5CA	4700 PF CERAMIC X7R
C61	CE25-R7100	1	00656	AMR101M025	100 UF 25V RADIAL LEAD
C62	CF50-R5100	1	65964	MMK5105K50L4C	1UF 50V POLYESTER
C63	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C65	CE00-R6470	1	58900	CE00-R6470	47UF 100V RADIAL
C66	CE00-R6470	1	58900	CE00-R6470	47UF 100V RADIAL
C67	CE00-R5471	1	55680	UVX2E4R7MTP	4.7 UF 250V RADIAL
C68	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C70	CE00-R5471	1	55680	UVX2E4R7MTP	4.7 UF 250V RADIAL
C71	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C72	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C73	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
C74	CC50-03100	1	54583	RD30HX7R103K	.01 UF CERAMIC X7R
C75	CC51-04100	1	04222	SR205C-104KAA	.1 UF CERAMIC X7R
CR1	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR2	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR5	DPAF-04937	1	04713	1N4937	1N4937 1A 600V DIODE
CR8	DSA0-04148	1	58900	DSA0-04148	1N4148 G.P. DIODE
CR9	DPAE-00140	1	04713	MUR140	MUR140 1A 400V RECTIFIER
CR11	DPAE-00140	1	04713	MUR140	MUR140 1A 400V RECTIFIER
CR14	DPAF-04937	1	04713	1N4937	1N4937 1A 600V DIODE
J1	JIA2-26318	1	09769	1-87227-3	26 PIN STRIPLINE PLUG
Q2	QJNS-07000	1	04713	2N7000	2N7000 5 OHM N CH JFET
R2	RN55-00100	1	91637	RN55C10R0F	10 OHMS 1% MET FILM
R4	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R5	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R6	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R7	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R17	RN55-14990	1	91637	RN55C4991F	4.99 K OHMS 1% MET FILM
R18	RN55-41000	1	91637	RN55C1004F	1 M OHMS 1% MET FILM
R23	RN55-14990	1	91637	RN55C4991F	4.99 K OHMS 1% MET FILM
R24	RN55-41000	1	91637	RN55C1004F	1 M OHMS 1% MET FILM
R27	RN55-32210	1	91637	RN55C2213F	221 K OHMS 1% MET FILM
R28	RN55-03320	1	91637	RN55C3320F	332 OHMS 1% MET FILM
R29	RN55-03320	1	91637	RN55C3320F	332 OHMS 1% MET FILM
R30	RN55-32210	1	91637	RN55C2213F	221 K OHMS 1% MET FILM
R31	RN55-26810	1	91637	RN55C6812F	68.1 K OHMS 1% MET FILM
R32	RN55-02210	1	91637	RN55C2210F	221 OHMS 1% MET FILM
R33	RAPK-12000	1	5Y491	67XR2K	2K 10% 20T PC MNT
R34	RN55-14640	1	91637	RN55C4641F	4.64K OHMS 1% MET FILM

20195-A00 PCB ASSY PRE-WAVE,FRT PNL INT, Rev: C

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
R35	RN55-00221	1	91637	RN55C22R1F	22.1 OHMS 1% MET FILM
R36	RN55-34020	1	91637	RN55C4023F	402 K OHMS 1% MET FILM
R37	RN55-13010	1	91637	RN55C3011F	3.01 K OHMS 1% MET FILM
R38	RN55-00221	1	91637	RN55C22R1F	22.1 OHMS 1% MET FILM
R39	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R40	RN55-00100	1	91637	RN55C10R0F	10 OHMS 1% MET FILM
R41	RN55-02210	1	91637	RN55C2210F	221 OHMS 1% MET FILM
R42	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R43	RN55-03920	1	91637	RN55C3920F	392 OHMS 1% MET FILM
R44	RW00-00003	1	91637	NS-1/4-0.25 OHM 1%	.25 OHM .25 W WIREWOUND
R49	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R50	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R52	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
R55	RN55-00100	1	91637	RN55C10R0F	10 OHMS 1% MET FILM
R57	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R58	RN55-34640	1	91637	RN55C4643F	464 K OHMS 1% MET FILM
R59	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R60	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R61	RN55-11000	1	91637	RN55C1001F	1 K OHMS 1% MET FILM
R62	RN55-31000	1	91637	RN55C1003F	100 K OHMS 1% MET FILM
R63	RN55-31000	1	91637	RN55C1003F	100 K OHMS 1% MET FILM
R64	RN55-21000	1	91637	RN55C1002F	10 K OHMS 1% MET FILM
RP1	RM4S-00220	1	71450	750-83-R220	22 OHM X 4 SIP NETWORK
RP2	RM4S-00220	1	71450	750-83-R220	22 OHM X 4 SIP NETWORK
RP3	RM5S-11001	1	58900	RM5S-11001	1 KOHM X 5 SIP NETWORK
RP4	RM5S-11001	1	58900	RM5S-11001	1 KOHM X 5 SIP NETWORK
RP5	RM7S-04700	1	58900	RM7S-04700	470 X 7 SIP NETWORK
TP1	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP2	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP3	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP4	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP5	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP6	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP7	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP8	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP9	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP10	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP11	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
TP12	ETT0-00001	1	63345	330.100W/ TIN PLATE	TEST JACK PIN
U20	URP0-78120	1	04713	MC78L12ACP	MC78L12CP .1A 12V REG
Y1	YX00-00004	1	61429	F1100E-4.000MHZ	4 MHZ OSCILLATOR

20526-001 PC BOARD ASSY, FRONT PANEL, Rev: A

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	20525	1	58900	20525	PC BOARD, FRONT PANEL
2	HSCR-41103	7	32559	908-680	.12 ID NYLON SPACER
3	16943-001	1	58900	16943-001	KEYCAP ENGRAVED "1"
4	16943-002	1	58900	16943-002	KEYCAP ENGRAVED "2"
5	16943-003	1	58900	16943-003	KEYCAP ENGRAVED "3"
6	16943-004	1	58900	16943-004	KEYCAP ENGRAVED "4"
7	16943-005	1	58900	16943-005	KEYCAP ENGRAVED "5"
8	16943-006	1	58900	16943-006	KEYCAP ENGRAVED "6"
9	16943-007	1	58900	16943-007	KEYCAP ENGRAVED "7"
10	16943-008	1	58900	16943-008	KEYCAP ENGRAVED "8"
11	16943-009	1	58900	16943-009	KEYCAP ENGRAVED "9"
12	16943-010	1	58900	16943-010	KEYCAP ENGRAVED "0"
13	16943-011	1	58900	16943-011	KEYCAP ENGRAVED "."
14	16943-012	1	58900	16943-012	KEYCAP ENGRAVED "-"
15	16943-032	1	58900	16943-032	KEYCAP ENGRAVED "Clear"
16	16943-033	1	58900	16943-033	KEYCAP ENGRAVED "ms"
17	16943-034	1	58900	16943-034	KEYCAP ENGRAVED "us"
18	16943-035	1	58900	16943-035	KEYCAP ENGRAVED "ns"
19	16943-036	1	58900	16943-036	KEYCAP ENGRAVED "Bksp"
20	16943-037	2	58900	16943-037	KEYCAP ENGRAVED ""
21	SPPL-K0104	4	04426	80-390134	BONE GRAY KEYCAP
22	17030	3	58900	17030	MODIFICATION LIGHTED KEYCAP
CR1	ILYR-00125	1	28480	HLMP-1440	YELLOW LED
CR2	ILYR-00125	1	28480	HLMP-1440	YELLOW LED
CR3	ILYR-00125	1	28480	HLMP-1440	YELLOW LED
CR4	ILYR-00125	1	28480	HLMP-1440	YELLOW LED
CR5	ILYR-00125	1	28480	HLMP-1440	YELLOW LED
CR6	ILYR-00125	1	28480	HLMP-1440	YELLOW LED
CR7	ILYR-00125	1	28480	HLMP-1440	YELLOW LED
CR8	ILYR-00125	1	28480	HLMP-1440	YELLOW LED
CR9	ILYR-00125	1	28480	HLMP-1440	YELLOW LED
CR10	ILYR-00125	1	28480	HLMP-1440	YELLOW LED
S1	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S2	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S3	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S4	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S5	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S6	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S7	SPPL-L0100	1	04426	80-390100	LIGHT PIPE
S8	SPPL-L0100	1	04426	80-390100	LIGHT PIPE
S9	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S10	SPPL-L0100	1	04426	80-390100	LIGHT PIPE
S11	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S13	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S14	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S15	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S16	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S17	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S18	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S19	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S20	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S21	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S22	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S23	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S24	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S25	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S26	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S27	SPPL-22500	1	04426	39-22100	PUSH BUTTON SWITCH
S10L	SPPL-L0100	1	04426	80-390100	LIGHT PIPE
S7L	SPPL-L0100	1	04426	80-390100	LIGHT PIPE
S8L	SPPL-L0100	1	04426	80-390100	LIGHT PIPE

20055-001 ASSY, 1GHZ CALIBRATOR TYPE N, Rev: C

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	20055-A01	1	58900	20055-A01	CALIBRATOR SUB ASSY,TYPE N
2	30087	REF	58900	30087	8500/8500A CAL TEST PROC

20055-A01 CALIBRATOR SUB ASSY,TYPE N, Rev: B

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	17694	1	58900	17694	PC BOARD, CALIBRATOR 1 GHZ
2	ETIT-44038	1	58900	ETIT-44038	INSULATED TURRET TERMINAL
3	17067	1	58900	17067	HOUSING, CAL, 1 GHz
4	17068	1	58900	17068	COVER, CAL, 1 GHz
5	17165	1	58900	17165	COVER PLATE TRANSISTOR
6	HICP-00001	1	06383	FCMI-A-14	CABLE HOLD DOWN CLIP
AT1	19192-001	1	66126	PCAW-9	ATTEN CHIP LOW PWR 4GHZ 9dB
AT2	19192-001	1	66126	PCAW-9	ATTEN CHIP LOW PWR 4GHZ 9dB
AT3	19192-002	1	66126	PCAW-20	ATTEN CHIP LOW PWR 4GHZ 20dB
C1	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C2	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C3	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C4	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C5	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C6	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C7	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C8	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C10	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C11	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C12	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C13	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C14	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C16	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C17	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C18	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
C19	CK50-01100	1	58900	CK50-01100	100 PF CERAMIC NPO
CR1	13618	1	58900	13618	DIODE,uWAVE PIN SW,.3PF,100ns
CR10	13618	1	58900	13618	DIODE,uWAVE PIN SW,.3PF,100ns
CR2	13618	1	58900	13618	DIODE,uWAVE PIN SW,.3PF,100ns
CR4	13618	1	58900	13618	DIODE,uWAVE PIN SW,.3PF,100ns
CR5	13618	1	58900	13618	DIODE,uWAVE PIN SW,.3PF,100ns
CR6	13618	1	58900	13618	DIODE,uWAVE PIN SW,.3PF,100ns
CR8	13618	1	58900	13618	DIODE,uWAVE PIN SW,.3PF,100ns
CR9	13618	1	58900	13618	DIODE,uWAVE PIN SW,.3PF,100ns
CR11	13618	1	58900	13618	DIODE,uWAVE PIN SW,.3PF,100ns
CR12	13618	1	58900	13618	DIODE,uWAVE PIN SW,.3PF,100ns
FL1	LFT0-83219	1	58900	LFT0-83219	FEED THRU FILTER
FL2	LFT0-83219	1	58900	LFT0-83219	FEED THRU FILTER
FL3	LFT0-83219	1	58900	LFT0-83219	FEED THRU FILTER
FL4	LFT0-83219	1	58900	LFT0-83219	FEED THRU FILTER
FL5	LFT0-83219	1	58900	LFT0-83219	FEED THRU FILTER
FL6	LFT0-83219	1	58900	LFT0-83219	FEED THRU FILTER
FL7	LFT0-83219	1	58900	LFT0-83219	FEED THRU FILTER
FL8	LFT0-83219	1	58900	LFT0-83219	FEED THRU FILTER
FL9	LFT0-83219	1	58900	LFT0-83219	FEED THRU FILTER
FL10	LFT0-83219	1	58900	LFT0-83219	FEED THRU FILTER
FL11	LFT0-83219	1	58900	LFT0-83219	FEED THRU FILTER
J1	17000	1	09769	WMI DWG 17000	CONN,TYPE N,FEMALE,PANEL MOUNT
Q1	QBNS-05108	1	04713	2N5108	2N5108 30V 1200 MHZ NPN
R1	RN55-12490	1	91637	RN55C2491F	2.49 K OHMS 1% MET FILM
R2	RN55-04020	1	91637	RN55C4020F	402 OHMS 1% MET FILM

20055-A01 CALIBRATOR SUB ASSY,TYPE N, Rev: B

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
R3	RN55-00301	1	91637	RN55C30R1F	30.1 OHMS 1% MET FILM
R4	RN50-11000	1	91637	RNC50H1001F	1.00 K OHMS 1% MET FILM
R7	RN50-11000	1	91637	RNC50H1001F	1.00 K OHMS 1% MET FILM
R8	RN50-04990	1	58900	RN50-04990	499 OHMS 1% METAL FILM
R11	RN50-11000	1	91637	RNC50H1001F	1.00 K OHMS 1% MET FILM
R12	RN50-04990	1	58900	RN50-04990	499 OHMS 1% METAL FILM
R14	RN50-11000	1	91637	RNC50H1001F	1.00 K OHMS 1% MET FILM
R15	RN50-11000	1	91637	RNC50H1001F	1.00 K OHMS 1% MET FILM
R16	RN50-04990	1	58900	RN50-04990	499 OHMS 1% METAL FILM
R20	RN50-11000	1	91637	RNC50H1001F	1.00 K OHMS 1% MET FILM
R21	RN50-04990	1	58900	RN50-04990	499 OHMS 1% METAL FILM
R23	RN50-11000	1	91637	RNC50H1001F	1.00 K OHMS 1% MET FILM
R24	RN50-04990	1	58900	RN50-04990	499 OHMS 1% METAL FILM
R30	RN50-11000	1	91637	RNC50H1001F	1.00 K OHMS 1% MET FILM
R31	RN50-11000	1	91637	RNC50H1001F	1.00 K OHMS 1% MET FILM
R32	RN50-04990	1	58900	RN50-04990	499 OHMS 1% METAL FILM
R33	RN55-01000	1	91637	RN55C1000F	100 OHMS 1% MET FILM
RT1	RTB0-26800	1	58090	BR16PB683K	68 KOHM THERMISTOR BEAD
W1	17098	1	58900	17098	CABLE ASSY, CALIBRATOR 1 GHz

7.3 List of Manufacturers

The names and addresses of manufacturers cited in the preceding parts lists are shown in Table 7-1. Each manufacturer is listed under its CAGE number (COMMERCIAL AND GOVERNMENT ENTITY), as noted in the parts lists. In a few cases, no CAGE number has been assigned; these manufacturers are referenced by Giga-tronics codes which are shown at the end of the list.

Table 7-1. Manufacturer's List

CAGE	NAME	ADDRESS
0ABX4	Comptec Inc	7837 Custer School Rd Custer WA 98240
0AG18	Hirose Electric USA Inc	Chatsworth CA
0AX52	Ditom Microwave Inc	1180 Coleman Ave #103 San Jose CA 95110
0BE81	Aerovox-Mallory	20 Aberdeen Dr Glasgow KY 42141
0B0A9	Dallas Semiconductor Corp	6350 Beltwood Pky S Dallas TX 75244
0B549	Siemens Components Inc Semiconductor Group	2191 Laurelwood Rd Santa Clara CA 95054
0D2A6	Mitsubishi Electronics Inc	1050 East Arques Ave Sunnyvale CA 94086
0D3V2	Menlo Industries Inc	44060 Old Warm Springs Blvd Fremont CA 94538
0EUK7	All American Transistor of California Inc	369 Van Ness Way Suite 701 Torrance CA 90501
0GP12	Radiall Inc	150 Long Beach Blvd Stratford CT 06497
0GYA7	Signal Transformer Co	500 Bayview Ave Inwood NY 11696
0HS44	Pacific Millimeter	189 Linbrook Dr San Diego CA 92111
0HFH6	Futaba Corporation of America	555 West Victoria St Compton CA 90220
0HFJ2	Microplastic	9180 Gazette Ave Chatsworth CA 91311
0HIN5	Marcon America Corp	998 Forest Edge Dr Vernon Hills IL 60061
0H379	Aerowave Inc	344 Salem St Medford MA 02155
0J7V3	Amp Inc	19200 Stevens Creek Blvd Suite 1 Cupertino CA 95014
0JNR4	Dupont Eelectronics Customer Service Center	825 Old Trail Rd PO Box 80019 Wilmington DE 19880-0019
0KA21	Stetco Inc	3344 Schierhorn Ct Franklin Park IL 60131
00443	Waveline Inc	160 Passaic Ave West Caldwell NJ 07006
00656	Aerovox Inc	740 Belleville Ave New Bedford MA 02745
00750	Air Track Mfg Corp	College Park MD
00809	Croven Crystals	500 Beech St Whitby Ontario CAN L1N5S5
00815	Midland - Ross	357 Beloit St Burlington WI 53105
01121	Allen-Bradley Co	1201 South 2nd St Milwaukee WI 53204
01295	Texas Instruments Inc	13500 N Central Expwy Dallas TX 75265
01963	Cherry Electrical Products Corp	3600 Sunset Ave Waukegan IL 60087
02113	Coilcraft Inc	1102 Silver Lake Dr Cary IL 60013-1658
02490	Electronic Devices Inc	Hampden MA
02660	Amphenol Corp	358 Hall Ave Wallingford CT 06492
02735	RCA Corp	Route 202 Somerville NJ 08876
03614	Bussman Mfg	114 Old St Rd PO Box 144 St Louis MO 63178
04222	AVX Ceramics Div of AVX Corp	19th Ave South PO Box 867 Myrtle Beach SC 29577
04426	ITW Switches	6615 West Irving Park Rd Chicago IL 60634
04552	Grace W R and Co	869 Washington St Canton MA 02021
04713	Motorola Inc	5005 East McDowell Rd Phoenix AZ 85008
05236	Jonathan Manufacturing Corp	1101 South Acacia Ave Fullerton CA 92631
05245	Corcom Inc	1600 Winchester Rd Libertyville IL 60048
05276	ITT Pomona Electronics Div	1500 E 9th St PO Box 2767 Pomona CA 91766
05791	Lyn-Tron Inc	3150 Damon Way Burbank CA 91505
05820	EG and G Wakefield Engineering	60 Audubon Rd Wakefield MA 01880
05905	Jerobee Industries Inc	Redmond WA
06049	Topaz Inc	9192 Topaz Way San Diego CA 92123

CAGE	NAME	ADDRESS
06090	Raychem Corp	300 Constitution Dr Menlo Park CA 94025-1111
06349	Cam-Lok Div Empire Product Inc	10540 Chester Rd Cincinnati OH 45215
06383	Panduit Corp	17301 Ridgeland Tinley Park IL 60477
06540	New Haven Mfg Corp Amatom Div	446 Blake St New Haven CT 06515
06776	Robinson Nugent Inc	800 East 8th St New Albany IN 47150
06915	Richco Plastics Co	5825 N Tripp Ave Chicago IL 60646-6013
07115	Corning Glass Works	Houghton Pk Corning NY 14830
07180	Sage Laboratories Inc	East Natick Industrial Park 3 Huron Dr Natick MA 01760
07263	Fairchild Semiconductor Corp	Cupertino CA
07512	Oak Materials Group Inc	McCaffery St Hoosick Falls NY 12090
07556	Calabro Industries Inc	1372 Enterprise Dr West Chester PA 19380
09022	Cornell-Dubilier Electronics	1605 East Rodney French Blvd New Bedford MA 02741
09353	C and K Components Inc	15 Riverdale Ave Newton MA 02158
09922	Burndy Corp	1 Richards Ave Norwalk CT 06856
09969	Dale Electronics Inc	East Highway 50 PO Box 180 Yankton SD 57078
1AU47	Lucas Weinschel Inc	1 Weinschel Ln PO Box 6001 Gaithersburg MD
1BH13	Fenwall Electronics Inc	64 Fountain St Framingham MA 01701-6211
1BR23	CW Industries Inc	Atlanta GA 04000
1CY63	Sierra Microwave Technology	11295-B Sunrise Gold Circle Rancho Cordova CA 95670
1DS68	Sumner Mfg Inc	Hwy 411 S-Sumner Dr PO Drawer A Rome GA 30162
1ES66	Maxim Intergrated Products	510 North Pastoria Ave Sunnyvale CA 94086
1E584	Electrical Wire Products Bay Associates Inc	150 Jefferson Dr Menlo Park CA 94025-1115
1FN41	Atmel Corp	2125 Onel Dr San Jose CA 95131
1JJ60	Applied Tooling and Mfg Inc	1115 Industrial Ave Escondido CA 92025
1W232	Spacek Labs	528 Santa Barbara St Santa Barbara CA 93101
1Y147	Virtech	805 G University Ave Los Gatos CA 95030
11532	Teledyne Relays	12525 Daphne Ave Hawthorne CA 90250
11769	Elco/Dyntech Div of Elco Corp	1225 East Wakeham Ave Santa Ana CA 92702
12020	Ovenaire Div of Electronic Tech	706 Forrest St Charlottesville VA 22901
12457	Merrimac Industries Inc	41 Fairfield Pl West Caldwell NJ 07006
13103	Thermalloy Co Inc	2021 W Valley View Lane PO Box 810839 Dallas TX 75381
13511	Amphenol Cadre Div Bunker Ramo Corp	Los Gatos CA
13708	Allied Components	Inglewood CA
13919	Burr-Brown Corp	6730 S Tucson Blvd Tucson AZ 85734
14482	Watkins-Johnson Co	3333 Hillview Ave Palo Alto CA 94304
14552	Microsemi Corp	2830 S Fairview St Santa Ana CA 92704-5948
14604	Elmwood Sensors Inc	500 Narragansett Park Dr Pawtucket RI 02861
14936	General Instrument Corp Power Semiconductor Div	600 West John St Hicksville NY 11802
15268	RHG Electronics Laboratory Inc	161 East Industry Ct Deer Park NY 11729
15450	Erie Specialty Products Inc	645 W 11th Street Erie PA 16512
15542	Mini-Circuits Laboratory	2625 East 14th St Brooklyn NY 11235
15915	Tepro of Florida Inc	2608 Enterprise Rd Clearwater FL 33517
16179	M/A-Com Omni Spectra Inc	21 Continental Blvd Merrimack NH 03054
16352	Codi Semiconductor Inc	144 Market Street Kenilworth NJ 07033
16428	Cooper Industries Inc	350 NW N St Richmond IN 47374
16453	Western Microwave Inc	495 Mercury Dr Sunnyvale CA 94086
16508	Aerovox Corp	19th Ave S PO Box 867 Myrtle Beach SC 29577
16733	Radio Frequency Systems Inc Cablewave Systems Div	60 Dodge Ave North Haven CT 06473
17217	Gore W L and Associates Inc	555 Paper Mill Rd Newark DE 19714
17540	Alpha Industries Inc	20 Sylvan Rd Woburn MA 01801
17856	Siliconix Inc	2201 Laurelwood Rd Santa Clara CA 95054
18041	Diodes Inc Power Components Div	21243 Ventura Blvd Woodland Hills CA 91364-2109

Series 8500A Peak Power Meters

CAGE	NAME	ADDRESS
18310	Concord Electronics Corp	30 Great Jones St New York NY 10012
18324	Signetics Corp	4130 South Market Ct Sacramento CA 95834
18364	Mag-Tool Co	940 American St San Carlos CA 94070
18714	RCA Corp Findlay Plant	1700 Fostoria Rd Findlay OH 45840
18736	Voltronics Corp	West St East Hanover NJ 07936
19701	Mepco/Electra Inc	PO Box 760 Mineral Wells TX 76067
2J873	Celeritex Inc	617 River Oaks Pky San Jose CA 95134
2J899	Dynawave Inc	94 Searle St PO Box 938 Georgetown MA 01833
2M734	Panasonic Co	PO Box 1502 Secaucus NJ 07094
2M881	Harris Corp Harris Semiconductor	883 Stierling Rd Suite 8120 Mountain View CA 94043-1930
2R182	Smith H H Co	325 N Illinois St Indianapolis IN 46204-1703
2V941	Microsource Inc	1269 Corporate Ctr Pky Santa Rosa CA 95407
20550	Engineering Mfg Co	Sheboygan WI
20944	Wiltron Co	805 East Middlefield Rd Mountain View CA 94042
20999	Minnesota Mining and Mfg Co	3M Center St Paul MN 55101
21604	Buckeye Stamping Co	555 Marion Rd Columbus OH 43207
21847	TRW Microwave Inc	825 Stewart Dr Sunnyvale CA 94086
22519	Data Delay Devices	385 Lakeview Ave Clifton NJ 07011
23499	Judd Wire Inc	870 Los Vallecitos Blvd San Marcos CA 92069
23899	Van Petty Mfg Inc	1168 Tourmaline Dr Newbury Park CA 91320
23936	Pamotor	770 Airport Blvd Burlingame CA 94010
24355	Analog Devices Inc	Rt 1 Industrial Park Norwood MA 02062
24539	Avantek Inc	3175 Bowers Ave Santa Clara CA 95054
24759	Lenox-Fugle Electronics Inc	100 Sylvania Place South Plainfield NJ 07080-1448
24931	Specialty Connector Co Inc	2100 Earlywood Dr PO Box 547 Franklin IN 46131
24995	Environmental Container System	3560 Rouge River Hwy Grants Pass OR 97526
26066	Minnesota Mining and Mfg. Co	3M Center St Paul MN 55101
26629	Frequency Sources Inc	16 Maple Rd Chelmsford MA 01824
26692	B and S Tool & Die Company	2300 Sulphur Spring Rd Baltimore MD 21227
26922	Cetec Corp	9900 Baldwin Place El Monte CA 91731
26923	Control Master Products Inc	1062 Shary Circle Concord CA 94518
27014	National Semiconductor Corp	2900 Semiconductor Dr Santa Clara CA 95051
27264	Molex Inc	2222 Wellington Ct Lisle IL 60532
27802	Vectron Laboratories Inc	166 Gover Ave Norwalk CT 06850
27851	Film Microelectronics	17 A St Burlington MA 01803
28480	Hewlett Packard Co	3000 Hanover St Palo Alto CA 94304
28520	Heyco Molded Products	750 Boulevard PO Box 160 Kenilworth NJ 07033
29005	Storm Products Co	112 South Glasgow Ave Inglewood CA 90301
29111	Trak Microwave Corp	735 Palomar Ave Sunnyvale CA 94086
29990	American Technical Ceramics	One Nordon Lane Huntington Stn NY 11746
3A054	McMaster-Carr Supply Co	9630 Norwalk Blvd Santa Fe Springs CA 90670
3E364	Vemaline	333 Strawberry Field Rd Warwick RI 02887
3W023	Philips Components Discrete Product Div	5083 Kings Hwy Saugerties NY 12477
3Z990	Tech Pro Inc	6243 E US Hwy 98 Panama City FL 32404-7434
30035	Jolo Industries Inc	13921 Nautilus Dr Garden Grove CA 92643-4026
30817	Instrument Specialties Co Inc	Exit 53 Route 80 PO Box A Delaware Water Gap PA 18327
31433	Kemet Electronics Corp	2835 Kemet Way Simpsonville SC 29681
31703	Gudrun Frederickson Co	Oakland CA
31757	Micropac Industries Inc	905 E Walnut St Garland TX 75040
31781	Edac Inc	40 Tiffield Rd Scarborough Ont CAN M1V 5B6
31918	ITT Schadow Inc	8081 Wallace Rd Eden Prarie MN 55344
32293	Intersil Inc	2450 Walsh Ave Santa Clara CA 95051
32559	Bivar Inc	4 Thomas St Irvine CA 92718

CAGE	NAME	ADDRESS
32767	Griffith Plastics Corp	1027 California Dr Burlingame CA 94010
32997	Bourns Inc Trimpot Division	1200 Columbia Ave Riverside CA 92507
33592	Miteq Inc	100 Davids Dr Huappauge NY 11787
34031	Analog Devices	7810 Success Rd Greensboro NC 27409
34078	Midwest Microwave Inc	3800 Packard Rd Ann Arbor MI 48104
34335	Advanced Micro Devices Inc	901 Thompson Place Sunnyvale CA 94086
34553	Amperex Electronic Corp	Hauppauge NY 32732
34576	Rockwell International Corp	4311 Jamboree Rd Newport Beach CA 92660
34781	MCW Industries	129 Southside Drive Charlotte NC 28210
34785	Dek Inc	3480 Swenson Ave St Charles IL 60174
36437	Star Stainless Products Ltd	Montreal Que CAN H4T1N8
4F708	Hammond Mfg Co US Inc	1690 Walden Drive Buffalo NY 14225
4R125	Magnetec Corp	61 W Dudleytown Rd Bloomfield CT 06002
4S028	Brady W M Co Industrial Products Div	Milwaukee WI
4T165	NEC Electronics USA Inc Electron Div	401 Ellis St P.O. Box 7241 Mountain View CA 94039
4U402	Roederstein Electronics Inc	2100 W Front St Statesville NC 28677-3651
4U751	Advanced Semiconductors Inc	7525 Etmel Ave Unit 6 North Hollywood CA 91605-1912
46384	Penn Engineering & Mfg Corp	Old Easton Rd PO Box 1000 Danboro PA 18916
5H281	Allmetal Screw Products	Arlington TX
5J927	Interface Technology Div of Dynatech Corp	2100 E Alcosta Ave Glendora CA 91740
50721	Datel Inc	11 Cabot Blvd Mansfield MA 02048
51167	Aries Electronics Inc	62 Trenton Ave Frenchtown NJ 08825
51284	Mos Technology Inc	950 Rittenhouse Rd Norristown PA 19401
51642	Centre Engineering Inc	2820 East College Ave State College PA 16801
51705	Ico-Rally Corp	2575 East Bayshore Rd Palo Alto CA 94303
52063	Exar Integrated Systems	2222 Gume Dr PO Box 49007 San Jose CA 95161-9007
52072	Circuit Assembly Corp	18 Thomas St Irvine CA 92718
52648	Plessey Trading Corp	1641 Kaiser Ave Irvine CA 92714
52683	Baytron Co Inc	344 Salem St Medford MA 02155
52763	Stettner Electronics Inc	6135 Airways Blvd Chattanooga TN 37421
52840	Western Digital Corp	3128 Red Hill Ave Costa Mesa CA 92626
53387	Minnesota Mining & Mfg Co Electronic Products Div 3M	Austin TX
53421	Tyton Corp	7930 N Faulkner Rd PO Box 23055 Milwaukee WI 53223
53673	Thomson-CSF Components Corp	6660 Variel Ave Canoga Park CA 91304
54186	Micro Power Systems Inc	3100 Alfred St Santa Clara CA 95050
54343	Riedel M W and Co	300 Cypress Ave Alhambra CA 91801
54487	Micronetics Inc	36 Oak St Norwood NJ 07648
54516	National Cable Molding Corp	136 San Fernando Rd Los Angeles CA 90031
54558	SDI Inc	North Billerica MA
54583	TDK Electronics Corp	12 Harbor Park Dr Port Washington NY 11550
55153	Dielectric Laboratories Inc	69 Albany St Cazenovia NY 13035
55261	LSI Computer Systems Inc	1235 Walt Whitman Rd Melville NY 11747
55285	Bergquist Co Inc	5300 Edina Industrial Blvd Minneapolis MN 55435
55322	Samtec Inc	810 Progress Blvd PO Box 1147 New Albany IN 47150
55387	Pamtech	8030 Remmet Ave Canoga Park CA 91304
55566	RAF Electronic Hardware Inc	95 Silvermine Rd Seymour CT 06483-3915
55576	Synertek	3001 Stender Way Santa Clara CA 95051
55680	Nichicon America Corp	927 E State Pky Schaumburg IL 60195
55801	Compensated Devices Inc	166 Tremont St Melrose MA 02176-2204
55989	Semicon Inc Div of the Lorvic Corp	8810 Frost Ave St. Louis MO 63134-1002
56248	Consolidated Refining Co	115 Hoyt Ave Mamaroneck NY 10543
56289	Sprague Electric Co	87 Marshall St North Adams MA 01247
56501	Thomas & Betts Corp	1001 Frontier Rd Bridgewater NJ 08807

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CAGE	NAME	ADDRESS
56563	Alatec Products	12747 Saticoy St North Hollywood CA 91605
56866	Quality Thermistor Inc	2147 Centurion Pl Boise ID 83709
57032	Daden Associates Inc	23011 Moulton Pky A-12 Laguna Hills CA 92653
57793	United Microwave Products Inc	185 West 205th St Torrance CA 90503
57834	Brim Electronics Inc	120 Home Pl Lodi NJ 07644-1514
58090	Thermometrics Inc	808 Rt 1 Edison NJ 08817-4624
58202	Innowave Inc	15555 Concord Circle Morgan Hill CA 95037
58361	General Instrument Corp Optoelectronics Div	3400 Hillview Ave Palo Alto CA 94304
58377	National Electronics	11731 Markon Dr Garden Grove CA 92641
58684	Magnetec Corp	61 W Dudleytown Rd Bloomfield CT 06002
58756	CTS Corp Electromechanical Div	1142 W Beardsley Ave Elkhart IN 46514
58758	Zambre Co Inc	2134M Old Middlefield Way Mountain View CA 94043-2404
58900	Giga-tronics Inc	4650 Norris Canyon Road San Ramon CA 94583
59124	KOA Speer Electronics Inc	Bolivar Dr PO Box 547 Bradford PA 16701
59365	Metelics Corp	975 Stewart Dr Sunnyvale CA 94086
59660	Tusonix Inc	2155 N Forbes Blvd #107 Tucson AZ 85745
59942	AVX Filters Corp	11144 Penrose St Sun Valley CA 91352
59980	Midwest Polychem Ltd	1502 N 25th Ave Melrose Park IL 60160
6A566	Tecknit Corp	320 North Nopal St Santa Barbara CA 93103
6V806	Frammar Mfg Inc (formerly Omni Spectra Corp)	6859 Tujunga Ave North Hollywood CA 91605
6Y341	Microwave Technology Inc	4268 Solar Way Fremont CA 94538
60393	Precision Resistive Products	655 Main St Mediapolis IA 52637
60395	Xicor Inc	851 Buckeye Ct Milpitas CA 95035
60450	Microwave Components Inc	7 Meehan Dr Chelmsford MA 01824
60583	Narda Microwave Corp	11040 White Rock Rd Suite 200 Rancho Cordova CA 95670
60644	CSDC	PO Box 2116 Wayne NJ 07470
61104	Aris Engineering Corp	30 Bond St Haverhill MA 01830
61429	Fox Electronics Inc	5570 Enterprise Pky Ft. Myers FL 33905
61485	Hitachi Denshi America Ltd	175 Crossways Park W Woodbury NY 11797
61529	Aromat Corp	629 Central Ave New Providence NJ 07974
61638	Advanced Interconnections	5 Energy Way West Warwick RI 02893
61772	Integrated Device Technology	3236 Scott Blvd PO Box 58015 Santa Clara CA 95052
61802	Toshiba International	13131 West Little York Rd Houston TX 77041
61964	Omron Electronics Inc	1E Commerce Schaumburg IL 60173
62277	Atlas Wire and Cable Corp	133 S Van Norman Rd Montebello CA 90640
62331	Krytar Inc	1292 Anvilwood Ct Sunnyvale CA 94086
62559	Schroff Inc	170 Commerce Dr Warwick RI 02886
62643	United Chemicon Inc	9806 Higgins St Rosemont IL 60018
63058	McKenzie Socket Technology Inc	44370 Old Warm Springs Blvd Fremont CA 94538
63132	Time Microwave	398 Martin Ave Santa Clara CA 95050
63345	Overland Products Co Inc	1687 Airport Rd Fremont NE 68025
63468	Electro Dynamics	5625 Foxridge Dr Shawnee Mission KS 66201
63542	Hall-Mark Electronics Corp	11333 Pagemill Rd Dallas TX 75243
64135	Filter Concepts	2624 S Rousselle St Santa Ana CA 92707
64155	Linear Technology Corp	1630 McCarthy Blvd Milpitas CA 95035
64671	Inmet Corp	300 Dino Dr Ann Arbor MI 48103
64859	AP Products Inc	9325 Progress Parkway Mentor OH 44061
65032	Rogers Corp	PO Box 700 Chandler AZ 85224
65449	Amtex Intl Inc	1878 Star Batt Rochester MI 48063
65517	Ayer Engineering Co	1250 West Roger Rd Tucson AZ 85705
65664	Catamount Mfg Inc	158 Governor Dr PO Box 720 Orange MA 01364
65940	Rohm Corp	8 Whatney Irvine CA 92714

CAGE	NAME	ADDRESS
65964	EVOX-RIFA Inc	100 Tri-State Intl. Suite 290 Lincolnshire IL 60069
66039	Kaycor International	1732 Central St Evanston IL 60201
66148	Fairlane Fluid/Air Products	23435 Industrial Park Dr Farmington MI 48024
66449	Microsource Inc	1269 Corporate Center Pky Santa Rosa CA 95407
66466	Standard Instrumentation Inc	3322 Pennsylvania Ave Charleston WV 25302
66544	Continental Microwave & Tool Co	10 Merrill Industrial Dr Hampton NH 03842-0998
66579	Waferscale Intergraton	47280 Kato Rd Fremont CA 94538
66958	SGS Semiconductor Corp	7117 E 3rd Ave Scottsdale AZ 52251
67297	Herotek Inc.	222 N Wolfe Rd Sunnyvale CA 94086
68459	River Run Enterprises Inc	2001 Jefferson Davis Ave Selma AL 36701
68630	Tadiran Electronics Industries Inc	3000 Dundee Rd Northbrook IL 60062
7E222	Littlefuse Tracor Inc	800 E Northwest Hwy Des Plaines IL 60016
7E585	Zero Mfg	777 Front St Burbank CA 91303
7M800	Analog Devices Inc	2444 Moorpark Ave San Jose CA 95128
7U905	Seastrom Inc	2351 Kentucky Ave Indianapolis IN 46241-4827
7W263	Huber and Suhner Ltd	Tumleinstrass 20 Pfaffikon Switz CH-8330
70364	American Electric Switch Corp	Route 4 Rocky Hill Hwy Lancaster SC 29720
70903	Belden Corp	200 South Batavia Ave Geneva IL 60134
71034	Bliley Electric Co	2545 W Grandview Blvd Erie PA 16508
71218	Bud Industries	4605 E 355th St Willoughby OH 44094
71450	CTS Corp	1201 Cumberland Ave West Lafayette IN 47906
71468	ITT Corp ITT Cannon Div	666 E Dyer Rd Santa Ana CA 92702
71785	Labinal Components and Systems Inc	1521 Morse Ave Elk Grove Village IL 60007
72259	Nytronics Inc	475 Park Ave South New York NY 10016
72982	Murata Erie North America Inc	645 West 11th St Erie PA 16512
73138	Beckman Industrial	4141 Palm St Fullerton CA 92635
73734	Federal Screw Products Inc	3917 N Kedzie Ave Chicago IL 60618-3415
74840	Illinois Capacitor Inc	3757 W Touhy Ave Lincolnwood IL 60645
74970	Johnson E F Co	299 10th Ave South West Waseca MN 56093
75263	Keystone Carbon Co Inc	1935 State St St Marys PA 15857
75332	Kings Electronics Co Inc	Brooklyn NY (relocated; see CAGE 91836)
75378	CTS Knights Inc	400 Reimann Ave Sandwich IL 60548
75915	Tracor Littlefuse Inc	800 East Northwest Hwy Des Plains IL 60016
78553	Eaton Corp Engineered Fasteners Div	14701 Detroit Ave Lakewood OH 44107-4101
79963	Zierick Mfg Co	Radio Circle Mt Kisko NY 10549
8B649	Intel Corp	3065 Bowers Ave Santa Clara CA 95051
8E631	Solitron-MIC	Port Salerno FL (relocated; see CAGE 95077)
8G639	Wavecom	Sunnyvale CA 94086
8K805	Omni Spectra Inc	Los Altos CA
8Z313	LMS Electronics	34101 Monroe Rd Charlotte NC 28205
81073	Grayhill Inc	561 Hillgrove Ave La Grange IL 60525
81312	Winchester Electronics	400 Park Rd Watertown CT 06795
81349	Military specification promulgated by military departments/agencies under authority of Defense Standardization Manual 4120 3-M	
81703	Mulberry Metal Products Inc	2199 Stanley Terrace Union NJ 07083
81774	Carol Wire and Cable Corp	249 Roosevelt Ave Pawtucket RI 02860
82152	Transco Products Inc	4241 Glenco Ave Marina Del Ray CA 90295
82199	Polarad Electronics Inc	5 Delaware Drv Lake Success NY 11042
82877	Rotron Inc	7 Hasbrouck Lane Woodstock NY 12498
83330	Kulka Smith Inc	1913 Atlantic Ave Manasquan NJ 08736
84084	American Iron and Machine Work	720 Industrial Blvd Oklahoma City OK
84171	ARCO Electronics	400 Moreland Rd Commack NY 11725-5707
84411	American Shizuki Corp	301 W O St Ogallala NE 69153
86797	Rogan Corp	3455 Woodhead Dr Northbrook IL 60062

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CAGE	NAME	ADDRESS
88245	Winchester Electronics	13536 Saticoy St Van Nuys CA 91409
89110	Amp Inc	1595 South Mt Joy St Elizabethtown PA 17022
9B003	Dynamics Corp of America Electronics Systems Div	Encino CA
9W826	EZ Form Cable Corp	315 Peck St Bldg 24 New Haven CT 06513
9Z397	Fujitsu Component of America Inc	3320 Scott Blvd Santa Clara CA 95054-3101
90201	Mallory Capacitor Co	4760 Kentucky Ave Indianapolis IN 46206
91303	KOL Inc	St Paul MN
91506	Augat Inc	452 John Dietsch Blvd Attleboro Falls MA 02763
91637	Dale Electronics Inc	1122 23rd St Columbus NE 68601-3632
91662	Elco Corp	Industrial Park Huntington PA 16652
91833	Keystone Electronics Corp	31-07 20th Rd Astoria NY 11105
91836	Kings Electronics Co Inc	40 Marbledale Road Tuckahoe NY 10707-3420
92194	Alpha Wire Corp	711 Lidgerwood Ave Elizabeth NJ 07207
93459	Weinschel Engineering Co	1 Weinschel Lane Gaithersburg MD 20877
94696	Magnecraft	1910 Techny Rd Northbrook IL 60062
95054	Sermax Corp	Milwaukee WI
95077	Solitron Devices Inc Solitron/Microwave Div	1177 Blue Heron Blvd Bldg 2 Riviera Beach FL 33404
95146	Alco Electronics Products Inc	1551 Osgood St North Andover MA 01845
95275	Vitramon Inc	Box 544 Bridgeport CT 06601
95348	Gordos Arkansas Inc	1000 N 2nd St PO Box 824 Rogers AR 72757
95987	Weskesser Co Inc	727 West Glendale Ave Milwaukee WI 53209
96341	Microwave Associates Inc	NW Industrial Park S Ave Burlington MA 01803
96733	San Fernando Electric Mfg Co	1501 First St San Fernando CA 91341
98291	ITT Seaelectro	585 E Main St New Britain CT 06051
99800	American Precision Industries Inc Delevan Div	270 Quaker Rd East Aurora NY 14052-2114
99899	Narda Microwave/Loral Corp	435 Moreland Rd Hauppauge NY 11788

Diagrams

8.1 Introduction

Diagrams for the following assemblies and circuits are included in this chapter:

Table 8-1. Series 8500A Diagrams

Reference Designation	Description	No. of Sheets	Drawing Number	Rev. Level	Page Number
	Model 8501A/8502A Peak Power Meter	2	20522	C	8-3
A1	Interconnect PC Assembly	1	16932-001	G	8-5
A1	Interconnect Circuit Schematic	3	21088	A	8-6
A2	Power Supply PC Assembly	1	16995	G	8-9
A2	Power Supply Circuit Schematic	2	16996	E	8-10
A3	GPIB/Cal Control PC Assy	1	21014	C	8-12
A3	GPIB/Cal Control Circuit Schematic	2	21015	D	8-13
A4	CPU PC Assy	1	16878	E	8-15
A4	CPU Circuit Schematic	2	16879	C	8-16
A5	Digital Delay PC Assy	1	16685	U	8-18
A5	Digital Delay Circuit Schematic	3	16686	H	8-19
A6/A7	Analog PC Assy	1	20741	M	8-22
A6/A7	Analog Circuit Schematic	3	20742	N	8-23
A8	Front Panel Interface PC Assy	1	20195	D	8-26
A8	Front Panel Interface Circuit Schematic	3	20196	E	8-27
A9	Front Panel PC Assy	1	20526-001	A	8-30
A9	Front Panel Circuit Schematic	1	20527	1	8-31
A12	1 GHz Calibrator Assy	1	20055-001	B	8-32
A12	1 GHz Calibrator Schematic	1	17097	K	8-33

8.2 Applicability

The component assemblies and circuit schematics in this chapter are valid for both Model 8501A and Model 8502A. The 8501A has only one channel, therefore all references to Channel B in the assembly and circuit diagrams pertain only to the 8502A. Parts lists for all assemblies are contained in Chapter 7. Parts lists for options, when applicable, will be in Appendix E.

Summary of Commands

A.1 Introduction

This appendix provides a summary of the commands required to activate all of the various functions of the Series 8500A Peak Power Meters (PPM). The commands are listed for each of the different modes of operation of the PPM (All, CW, Peak, Graph, Dual Channel, and 1018B Emulation).

A laminated Quick Reference card is included with the Series 8500A manuals. This card shows all of the functional commands in each testing mode as well as how to get from one mode to another. The reverse side of the card gives a quick reference to all of the major menus shown in Appendix B.

Keys that are to be pressed for the command sequence are enclosed in brackets. For simplicity, values are given as a single command rather than as individual numbers (for example, 0.1 is shown as [0.1] rather than [0].[.][1]). The [UNITS] command at the end or included with some of the command keystroke sequences means to press any of the three units keys (ms, μ s, or ns) to enter the values of the keyed sequence.

Numbers in parenthesis after a MENU or MEM key means to press the key that number of times to reach a specific menu level.

A.2 Commands Applicable to All Modes

Function	Command Sequence
Auto Zero Detectors	[MENU] (1) [F3] [F2]
Calibrate Detectors	[MENU] (1) [F3] [F1]
Self-Test the PPM	[MENU] (11) [F2]
Detector Offset (Channel A)	[MENU] (3) [F1] [sn.nn] [dB]
Detector Offset (Channel B, 8502A only)	[MENU] (3) [F2] [sn.nn] [dB]
Frequency Correction	[FREQ] (follow prompts)
Change Frequency Correction to User Freq/PROM	[MENU] (3) [F3] [F1] [nnn.nnn] [GHz]
Change Frequency Correction to V/GHz/PROM	[MENU] (3) [F3] [F2] [vv.vv] [UNITS] [ss.ss] [UNITS] [ff.ff] [GHz]
Change Frequency Correction to Cal Factor (dB)	[MENU] (3) [F3] [F3] [A] or [B] [sn.nn] [dB]
Change Display Units Between dBm and mW	[MENU] (4) [F3] (toggle)
Hide/Display Frequency Information	[MENU] (7) [F3] (toggling occurs by pressing MENU seven times after hiding or displaying frequency)

Function	Command Sequence
Review Detector PROM Information	[MENU] (10) [F2] (for A) or [F3] (for B)
Check Date and Time then Exit	[MENU] (5) [F3] [F3]
Change Date and Time then Exit	[MENU] (5) [F3] [F1] [mmddyy] [UNITS] [hhmmss] [UNITS] [F3]
Set Max and Min Power Limits	[MENU] (7) [F1] [nn.nn] [UNITS] [nn.nn] [dBm]
Frequency or Cal Factor or V/GHz	[FREQ] (follow prompts)
Recall Setup in Memory (n)	[MEM] (1) [F1] [n] [UNITS]
Store Setup in Memory	[MEM] (1) [F2] [n] [UNITS]
Recall Power-On Setup	[MEM] (1) [F3]
Display Current Setup	[MEM] (2) [F1] [F1] or [F3] (F1 = more, F3 = exit)
Display Power-On Setup	[MEM] (2) [F2] [F1] or [F3] (F1 = more, F3 = exit)
Display Setup in Memory	[MEM] (2) [F3] [nn] [UNITS] [F1] (more) or [F3] (exit)
Reinitialize Current Setup	[MEM] (3) [F1]
Reinitialize All But Current Setup	[MEM] (3) [F2]
Reinitialize a Numbered Setup (nn)	[MEM] (3) [F3] [nn] [UNITS]

A.3 CW Mode Commands

Function	Command Sequence
Select CW Mode	[CW]
CW Averaging	[MENU] (2) [F1] [nnn] [UNITS]
Fast Analog Output	[MENU] (10) [F1]

A.4 Peak Mode Commands

Function	Command Sequence
Select Peak Mode	[PEAK]
Select 8501A Internal Trigger and Level	[MENU] (1) [F1] [nn.nn] [dBm] [mW]
Select 8502A Internal Trigger and Level	[MENU] (1) [F1] [A] or [B] [nn.nn] [dBm] [mW]
Select External Trigger	[MENU] (1) [F2]
Fast Analog Output	[MENU] (10) [F1]
Peak Averaging	[MENU] (2) [F2] nnn [UNITS]
Enable Cursor Delay	[↑] or [↓]
Disable Cursor Delay	[UNITS]
Enter Reference Delay	[MENU] (4) [F1] (for ch A) or [F2] (for ch B) [nn.nn] [UNITS]
Clear Reference Delay	[MENU] (4) [F1] (for ch a and/or [F2] for ch b of the 8502A) [0] [UNITS]

A.5 Graph Mode Commands

Function	Command Sequence
Select Graph Mode (from single channel operation only)	[GRAPH]
Autoscale	[AUTOSCALE]
Select 8501A Internal Trigger and Level	[MENU] (1) [F1] [nn.nn] [dBm] [mW]
Select 8502A Internal Trigger and Level	[MENU] (1) [F1] [A] or [B] [nn.nn] [dBm] [mW]
Select External Trigger	[MENU] (1) [F2]
Peak Averaging	[MENU] (2) [F2] nnn [UNITS]
Enter Reference Delay	[MENU] (4) [F1] (for ch A) or [F2] (for ch B) [nn.nn] [UNITS]
Clear Reference Delay	[MENU] (4) [F1] (for ch A) or [F2] (for ch B) [0] [UNITS]
GPIB Plot (Paper)	[MENU] (2) [F3] [F1]
GPIB Plot (Transparency)	[MENU] (2) [F3] [F2]
Code Number Entry for Plot	[MENU] (5) [F1] [nnnn] [UNITS] (nnnn = up to 12 digits)
Part Number Entry for Plot	[MENU] (5) [F2] [nnnn] [UNITS] (nnnn = up to 12 digits)
Abort (Stop) Plotting Activity	[MENU] (6) [F1]
Enter Plotter GPIB Address	[MENU] (6) [F2] [nn] [UNITS]
Set Initial Delay for Autoscaling (normal PPM operation)	[MENU] (09) [F2] [nn.nn] [UNITS]
Set Averaging Value for Autoscaling (normal PPM operation)	[MENU] (09) [F3] [nnn] [UNITS]
*Set Initial Delay for Autoscaling (1018B emulation operation)	[MENU] (11) [F2] [nn.nn] [UNITS]
*Set Averaging Value for Autoscaling (1018B emulation operation)	[MENU] (11) [F3] [nnn] [UNITS]

*Valid only after 1018B Emulation has been entered

A.5.1 Change Between Cursor, Marker, and Pulse Sub-Modes

PULSE/CURSOR/MARKER Triple toggle

A.5.2 Cursor Sub-Mode Commands

Function	Command Sequence
Change Start Delay Move cursor to STRT DLY line on display, enter change using	[nn.nn] [UNITS] or spin knob
Change Window Delay Move cursor to DLY WIND line on display, enter change using	[nn.nn] [UNITS] or spin knob

Change Cursor Delay Move cursor to CSR DLY line on display, enter change using	[nn.nn] [UNITS] or spin knob
Change Internal Trigger Level Move cursor to TRG LEV line on display, enter change using	[nn.nn] [UNITS] (or spin knob), or use [MENU] (1) [F1] [nn.nn] [UNITS]
Change Reference Power (100% Point) Move cursor to REF PWR line on display, enter change using	[nn.nn] [UNITS]

A.5.3 Pulse Sub-Mode Commands

Function	Command Sequence
Change Pulse Width Start and End Percentages Move cursor to PULSE WID line	[nn.n] [UNITS] [nn.n] [UNITS]
Change Rise Time Start and End percentages Move cursor to RISE TIME line on display	[nn.n] [UNITS] [nn.n] [UNITS]
Change Fall Time Start and End Percentages Move cursor to FALL TIME line on display	[nn.n] [UNITS] [nn.n] [UNITS]

A.5.4 Marker Sub-Mode Commands

Function	Command Sequence
Change Marker 1 Percentage Move cursor to MRKR 2-1 line on display	[snn.n] [UNITS]
Change Marker 2 Percentage Move cursor to MRKR 3-2 line on display	[snn.n] [UNITS]
Change Marker 3 Percentage Move cursor to MRKR 4-3 line on display	[snn.n] [UNITS]
Change Marker 4 Percentage Move cursor to 4th line on display	[snn.n] [UNITS]

NOTE: Entering nn.n (positive) places the marker on the rising edge. Entering -nn.n (negative) places the marker on the falling edge.

A.6 Dual Channel Operation

A.6.1 CW Mode Commands

From Initial Power-On select [cw] [B]

If the Dual Channel state is being entered from some other state, use the channel A and B keys. When both A and B keys are lit, the Dual Channel state has been activated.

A.6.2 Peak Mode Commands

Assuming that there is an Autoscalable pulsed signal greater than the current trigger level at the channel A detector input, from initial Power-On select:

[GRAPH] [AUTOSCALE ...PEAK] [B]

This method uses the Graph Mode to ensure that the cursor is placed on the pulse measured by channel A.

The [GRAPH] [AUTOSCALE] keystrokes can be omitted, but this method does not guarantee that the cursor will be placed on the pulse. To find the pulse, use the procedures outlined in Method 1 of the Peak Power Measurements in Chapter 6.

A.6.3 Other Dual Channel Commands

Detector Offset (Channel B)	[MENU] (3) [F2] [nn.nn] [dB]
Display Ratio A/B Power Mode	[MENU] (7) [F2]
Select Peak Mode for Channel A	[A] [F1] (when using the Ratio Mode)
Select CW Mode for Channel A	[A] [F2] (when using the Ratio Mode)
Select Peak Mode for Channel B	[B] [F1] (when using the Ratio Mode)
Select CW Mode for Channel B	[B] [F2] (when using the Ratio Mode)
Exit Ratio Mode	[CW] or [PEAK]

A.6.4 IEEE & 1018B Emulation Commands

Select PPM Listen and Talk Address	[MENU] (6) [F3] [nn] [UNITS]
Initiate 1018B Emulation Mode	[MENU] (8) [F2]
Disable/Enable Service Request*	[MENU] (8) [F1] (toggle)
Automatic/Bus Command Trigger Reset*	[MENU] (8) [F2]
Get Data Fast (No EL Display)*	[MENU] (8) [F3]
Set Measurement Range*	[MENU] (9) [F1] (for nnn.n μ W) [MENU] (9) [F2] (for nn.nn mW) [MENU] (9) [F3] (for n.nnn mW)
End 1018B Emulation Mode*	[MENU] (10) [F2]

* Valid only after initiating 1018B Emulation Mode.

Menu and Memory Keys

B.1 Introduction

This appendix is a quick reference to the menus that can be accessed through the MENU and MEMory keys. The number in parenthesis after the key is the number of times the key must be pressed to reach the designated menu. MENU (1) means to press the key one time; MENU (2) means to press the key two times, etc.

The key display information in this appendix is duplicated on the laminated Quick Reference card shipped with the manual. The opposite side of the card contains a Summary of Commands described in Appendix A.

Two levels of menu displays are available. The first level includes menus for normal 8500A functions. The second level are the menus used during 1018B emulation. MENU (8) in the normal mode enables or toggles the 1018B Emulation mode.

B.2 MENU Key Displays

B.2.1 Normal 8500A Functions

Keystrokes	Menu Displayed
MENU (1)	Menu = NEXT MENU F1 set Int Trig and Level F2 set Extrn Trigger F3 to Cal or Zero Detectors
MENU (2)	Menu = NEXT MENU; Minus = PREV MENU F1 to Enter CW Averaging Number F2 to Enter Peak Averaging Number F3 for GPIB Plot
MENU (3)	Menu = NEXT MENU; Minus = PREV MENU F1 to Enter Detector A Offset F2 to Enter Detector B Offset F3 to Enter Source of Frequency Correction

NOTE: F2 does not apply to the Model 8501A

- MENU (4) Menu = NEXT MENU; Minus = PREV MENU
- F1 to Enter Detector A Ref Delay
 F2 to Enter Detector B Ref Delay
 F3 to Select mW Format
- NOTE: F2 does not apply to the Model 8501A*
- MENU (5) Menu = NEXT MENU; Minus = PREV MENU
- F1 to Enter Code Number
 F2 to Enter Part Number
 F3 for Read and Set Time
- MENU (6) Menu = NEXTR MENU; Minus = PREV MENU
- F1 to Abort Current Plotting Activity
 F2 to Enter Plotter Address
 F3 to Enter 8500A Listen and Talk Address
- MENU (7) Menu = NEXT MENU; Minus = PREV MENU
- F1 to Set Max and Min Power Limits
 F2 to Select Ratio Display Mode
 F3: Hide (or Display) Frequency Information
- NOTE: F2 does not apply to the Model 8501A*
- MENU (8) Menu = NEXT MENU; Minus = PREV MENU
- F2: Emulate 1018B
- MENU (9) Menu = NEXT MENU; Minus = PREV MENU
- F1 to Program Detector PROM
 F2 to Set Initial Dly Value for Autoscaling
 F3 to Set Averaging Value for Autoscaling
- NOTE: The MENU (9) F1 function is designed to be used only in conjunction with
 the Giga-tronics PROM Programming Accessory Kit*
- If F1 is pressed without any requirement for using the PROM programming device,
 a long series of sub-menus must be stepped through to escape from the routine. To
 circumvent this, press the RESET button on the rear of the instrument to escape
 back to the last measurement mode.
- MENU (10) Press CLEAR to return to data display
- F1 for Fast Analog Output
 F2: Review A Detector PROM
 F3: Review B Detector PROM (8502A only)

MENU (11) Minus = PREV MENU

Be Sure No RF is Applied to Detector
Press CLEAR to Skip All Tests

F1 for Service Fncts
F2 for Self Test

B.2.2 1018B Emulation Mode Functions

MENU (8) 1018B Emulate Mode, Bus Trigger Reset, SRQ *Enabled*

Press CLEAR to return to data display

F1 to Disable SRQ (Service Request)
F2 for Automatic Trigger Reset
F3 to Get Data Fast; No EL Data Display

SUB-MENU (8) 1018B Emulate Mode, Auto Trigger Reset, SRQ *Disabled*

Press CLEAR to return to data display

F1 to Enable Service Request
F2 for Bus Command Trigger Reset
F3 to Get Data Fast; No EL Data Display

NOTE: Pressing [MENU] (8) [F1] and then [MENU] (8) again will enable SRQ; other SUB-MENU (8) items remain the same. Pressing [MENU] (8) [F2] and then [MENU] (8) again will change Automatic Trigger to Bus Command in SUB-MENU (8). All other SUB-MENU (8) commands remain the same.

MENU (9) Menu = NEXT MENU; Minus = PREV MENU

Current Range Value is X

F1 for Range 1 (XXX.X μ W)
F2 for Range 2 (XX.XX mW)
F3 for Range 3 (X.XXX mW)

MENU (10) Press CLEAR to return to data display

Press MENU for next lower level menu

F2 to end 1018B Emulation

MENU (11) 1018B Emulate mode only. Same as MENU (8) for the normal 8500 mode.

MENU (12) 1018B Emulate mode only. Same as MENU (9) for the normal 8500 mode.

MENU (13) 1018B Emulate mode only. Same as MENU (10) for the normal 8500 mode.

B.3 MEMory Key Displays

The following menus are activated by repeatedly pressing the MEM key. MEM (1) indicates to press the key once. MEM (3) indicates to press the MEM key three times.

MEM (1) Press [MEM] for additional selections

- F1 to Recall Setups
- F2 to Store Setups
- F3 to get Power-On Setup

MEM (2) Press [CLEAR] to return to data display

- F1 to Display Current Setup
- F2 to Display Power-On Setup
- F3 to Display a Numbered Setup

MEM (3) Press [CLEAR] to return to data display

- F1 to Initialize the Current Setup
- F2 to Initialize All but Current Setup
- F3 to Initialize a Numbered Setup



Display Formats

C.1 General

This appendix illustrates the major display formats that will be presented in each operating mode. The front panel function keys are illustrated that will produce the corresponding display. Darkened keys in the following illustrations will be turned on to produce the corresponding display at the left.

C.2 Data Displays

MODE	DATA DISPLAY	MODEL 8501A	MODEL 8502A
CHANNEL A CW MODE			
CHANNEL A PEAK MODE			
CHANNEL A GRAPH MODE			
Model 8502A channel B displays are same as above, except with the B key turned on and B : shown on the display.			
DUAL CHANNEL CW MODE		NA	

MODE	DATA DISPLAY	MODEL 8501A	MODEL 8502A
DUAL CHANNEL PEAK MODE		NA	
DUAL CHANNEL RATIO MODE (A = PK Signal) (B = PK Signal)		NA	
<p>For ratio'ing various types of signals to each other, the indication in the lower right corner would be: A = Peak; B = CW = PK/CW: Both A & B = CW = CW/CW: A = CW; B = Peak = CW/PK</p>			
ANY MODE SELECT A OR B CHANNEL	<p>Error Indicated Display Blank or Frozen No Trigger Occurring</p>	<p>Ready = ON New Data = OFF</p> <p>NA</p>	<p>Ready = ON New Data = OFF</p>



RF Detectors

D.1 Introduction

The detectors used with the Series 8500A Peak Power Meters (PPM) are dual diode. They contain a preamplifier/line driver, a correction PROM with an address counter, and a thermistor to measure the temperature of the detector mounting. Since diode detection is used, there is an inherent non-linearity that must be compensated before the detector can be used for power measurements. Compensation is done automatically by a special calibration routine performed by the PPM that steps the power output of an internal RF source from -30 dBm to +20 dBm, and then records the resultant output voltage of the detector at each step. A conversion table is automatically calculated and stored in non-volatile RAM so that the detectors will remain calibrated when the PPM is turned off and back on again. This process takes less than a minute and can be performed at any time.

The detectors are either high or low speed. The high speed has a rise time of 15 ns and a minimum frequency of 750 MHz for accurate measurements. The low speed detector has a rise time of 750 ns and a minimum frequency of 30 MHz. The difference between the two is totally in the diode element. The low speed element contains an additional filter capacitor that slows the pulse response time and allows lower RF frequency operation.

The diode element is field replaceable. After replacement, the correction PROM must be replaced with one that has been programmed with the diode's new video resistance and frequency characteristics.

D.2 Detector Specifications

Det. Model	Frequency Range	Power Range	Max. Power (Peak or Avg)	Maximum VSWR	RF Conn
HIGH SPEED — 15 ns					
16936	750 MHz to 18.5 GHz	-20 dBm to +20 dBm (Pulse) -40 dBm to +20 dBm (CW)	+23 dBm (200 mW) (Damage Limit)	1.12: 750 MHz to 2 GHz 1.22: 2 to 12.4 GHz 1.37: 12.4 to 18 GHz	Type N (m)
16937	750 MHz to 18.5 GHz	-20 dBm to +20 dBm (Pulse) -40 dBm to +20 dBm (CW)	+23 dBm (200 mW) (Damage Limit)	1.12: 750 MHz to 2 GHz 1.22: 2 to 12.4 GHz 1.37: 12.4 to 18 GHz	APC-7 (mm)
17266	750 MHz to 26.5 GHz	-20 dBm to +20 dBm (Pulse) -40 dBm to +20 dBm (CW)	+23 dBm (200 mW) (Damage Limit)	1.12: 750 MHz to 2 GHz 1.22: 2 to 12.4 GHz 1.37: 12.4 to 18 GHz 1.50: 18 to 26.5 GHz	Type K (m)
17071	750 MHz to 40.0 GHz	-20 dBm to +20 dBm (Pulse) -40 dBm to +20 dBm (CW)	+23 dBm (200 mW) (Damage Limit)	1.12: 750 MHz to 2 GHz 1.22: 2 to 12.4 GHz 1.37: 12.4 to 18 GHz 1.50: 18 to 26.5 GHz 1.92: 26.5 to 40 GHz	Type K (m)
LOW SPEED — 750 ns					
16934	30 MHz to 18.5 GHz	-20 dBm to +20 dBm (Pulse) -40 dBm to +20 dBm (CW)	+23 dBm (200 mW) (Damage Limit)	1.12: 30 MHz to 2 GHz 1.22: 2 to 12.4 GHz 1.37: 12.4 to 18 GHz	Type N (m)
16935	30 MHz to 18.5 GHz	-20 dBm to +20 dBm (Pulse) -40 dBm to +20 dBm (CW)	+23 dBm (200 mW) (Damage Limit)	1.12: 30 MHz to 2 GHz 1.22: 2 to 12.4 GHz 1.37: 12.4 to 18 GHz	APC-7 (mm)
17267	30 MHz to 26.5 GHz	-20 dBm to +20 dBm (Pulse) -40 dBm to +20 dBm (CW)	+23 dBm (200 mW) (Damage Limit)	1.12: 30 MHz to 2 GHz 1.22: 2 to 12.4 GHz 1.37: 12.4 to 18 GHz 1.50: 18 to 26.5 GHz	Type K (m)

- The dimensions and weight are identical for all detectors:
 Length = 133 mm (5.25 in)
 Diameter = 37 mm (1.44 in)
 Weight = 0.3 kg (0.7 lbs)

Frequency Range:

High Speed: 750 MHz to 18.5 GHz
 750 MHz to 26.5 GHz
 750 MHz to 40 GHz
 (High speed detectors can be used down to 500 MHz.)

Low Speed: 30 MHz to 18.5 GHz
 30 MHz to 26.5 GHz

Rise Time:

High Speed: <15 ns (Typical = 12 ns)
 Step Response: Ringing <5% p-p settling to <2% p-p in 200 ns
 Low Speed: <750 ns (Typical = 250 ns)

Power Range:

Measurement: -20 to +20 dBm (Pulse)
 -40 to +20 dBm (CW)

Absolute Maximum
(Peak or Avg): +23 dBm (200 mW)
(Damage Limit)

Return Loss (SWR):

	Type N, APC-7	Type K
Below 2 GHz	25 dB (1.12)	25 dB (1.12)
2 to 12.4 GHz	20 dB (1.22)	20 dB (1.22)
12.4 to 18 GHz	16 dB (1.37)	16 dB (1.37)
18 to 26.5 GHz		14 dB (1.50)
26.5 to 40 GHz		10 dB (1.92)

Calibration Factor Uncertainty:

Frequency	Sum of Uncertainties (%)¹	Probable Uncertainties (%)²
Below 10 GHz	2.6%	1.2%
10 to 18 GHz	6.4%	3.7%
18 to 26.5 GHz	10%	6.5%
26.5 to 40 GHz	20%	10%

NOTES:

1. Includes uncertainty of reference standard and transfer uncertainty. Directly traceable to NIST (formerly NBS).
2. Square root of the sum of the individual uncertainties squared (RSS).

D.3 Electrical Description

D.3.1 Preamplifier PC Assembly

Refer to Figure D-2

The circuitry on this PC board is used to amplify the voltage produced when the detected RF power has been converted to dc. The circuit is similar to a two stage operational amplifier with the non-inverting input at the base of Q2 and the inverting input at the base of Q1 (see Figure D-2).

The overall gain of the circuit is set by the ratio of R1 to R5 and R2 to R3. C9 is the compensation capacitor. R26 provides the match to the cable impedance. The output for the circuit can be measured between TP2 (DET Pulse), and TP1 (ground).

The first stage of the amplifier is formed by transistors Q1 through Q6. Q3 and Q4 form a constant current source which sets the current that is drawn through the first stage. C1 and C2 are used to AC couple the signal to Q1 and Q2, the input devices of the amplifier. Q5 and Q6 provide high impedances which are driven by Q1 and Q2. The gain of the first stage is set by the ratio of R34 and R33 to R11. R9 and C3 provide adjustments to optimize the step response of the amplifier. U1 is a low offset and low bandwidth op-amp that provides the DC signal path by controlling the current through Q6.

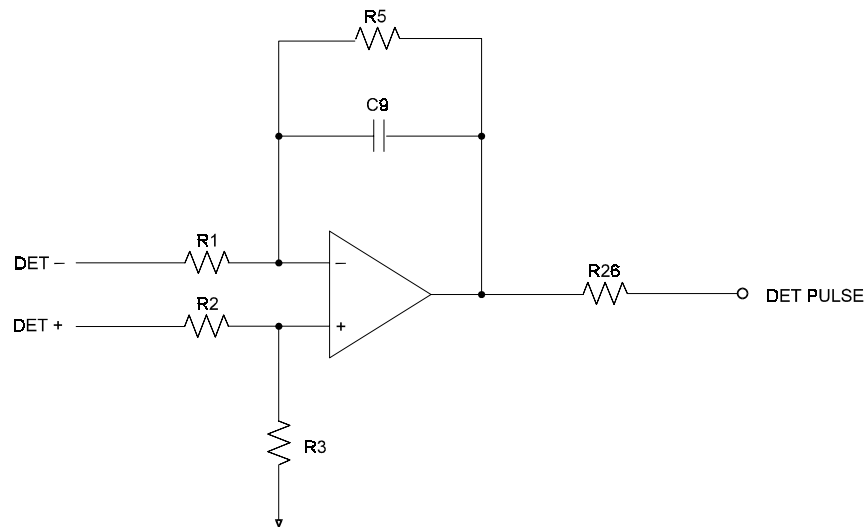


Figure D-1. Op-Amp Equivalent of Pre-Amp Circuit

The second stage of the amplifier is formed by Q7 through Q10. Q9 and Q10 provide a constant current source for the second stage of the amplifier. Q7 and Q8 form a differential amplifier. The gain of the second stage is set by the ratio of R18 and R19 to R24.

Q11 is an emitter follower to drive the necessary high currents required by the circuit.

The difference between the low speed and high speed detectors is diode element. The high speed detector has a very small output capacitance, which produces a rise time of 15 ns while the low speed detector has a large output capacitance to produce a 750 ns rise time. This causes a change in the minimum frequency at which the detector can accurately convert RF power to dc voltage.

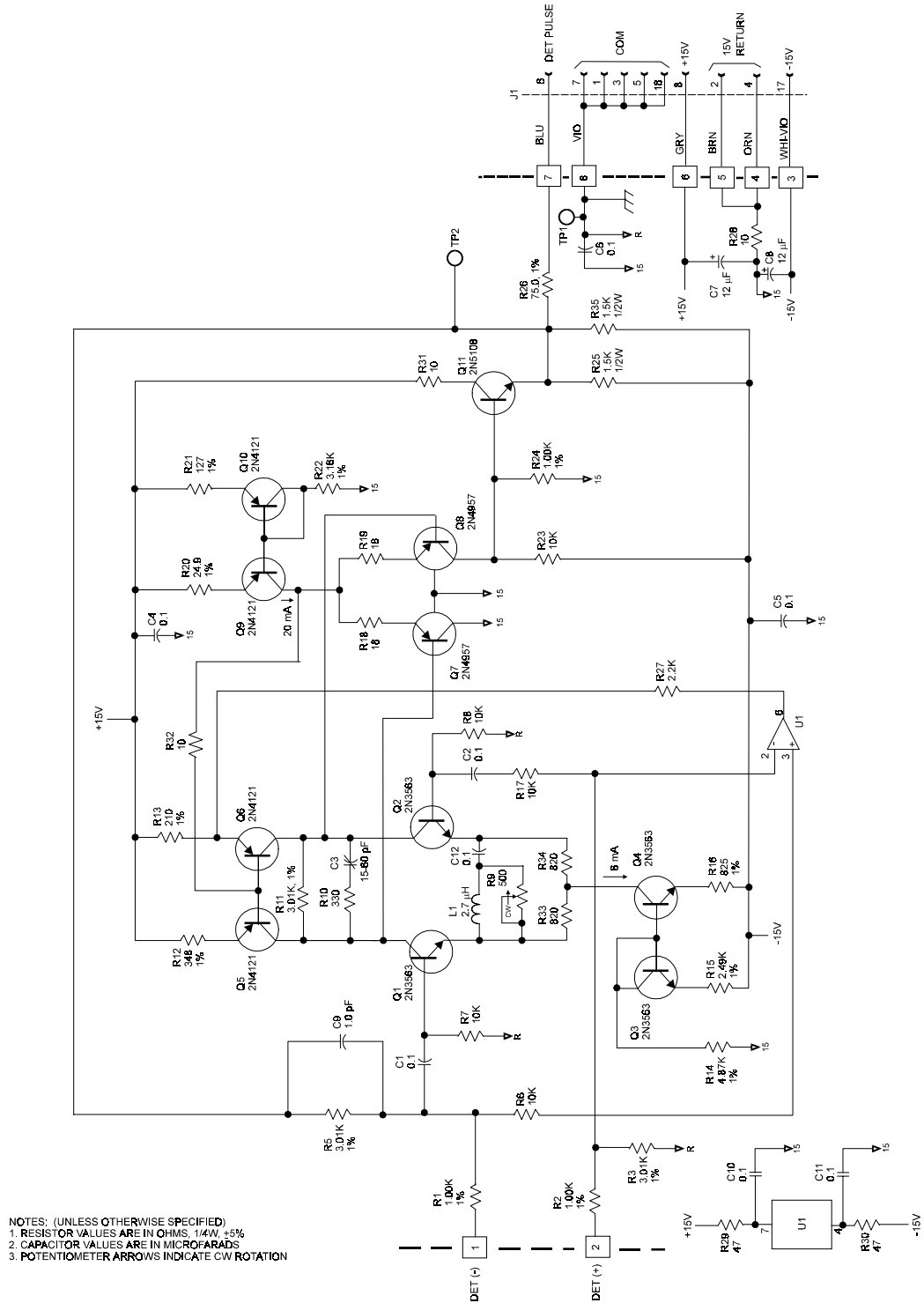


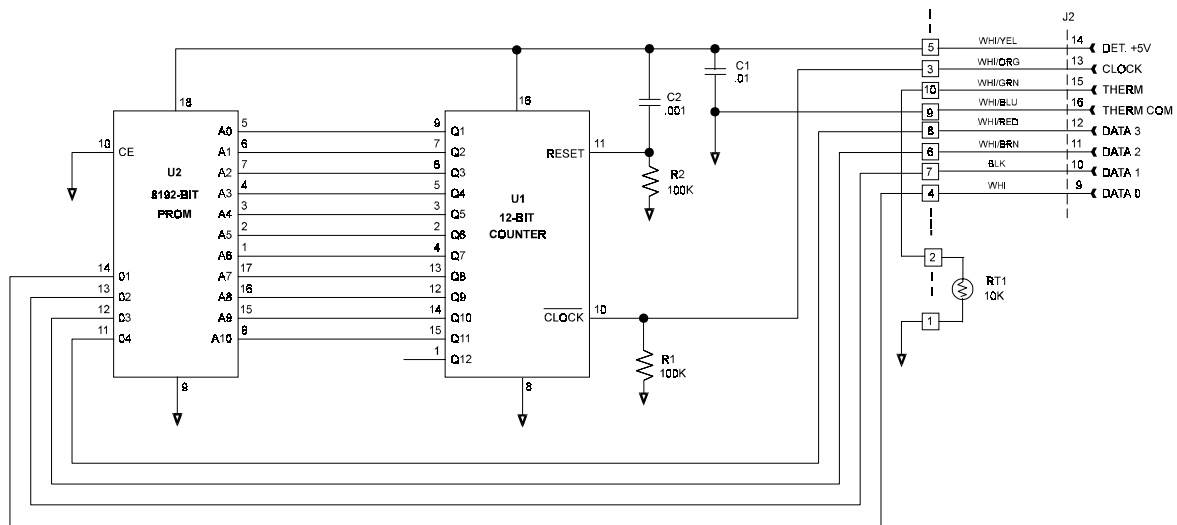
Figure D-2. Pre-Amplifier/Line Driver Schematic

D.3.2 PROM PC Assembly

Refer to Figure D-3

The other PC board located in the detector housing contains the PROM and its associated driver. The fusible link PROM contains RF calibration data for the specific diodes used in the detector. This data includes the serial number, type, date and place of calibration, and frequency response correction information. The PROM is read four bits at a time by addressing it with the 12 bit counter, U1. The PROM cannot be erased. If the response data changes, the PROM must be removed and replaced with a new one. It must be programmed externally since the PPM by itself has no programming ability. However, Giga-tronics offers an optional PROM Programmer Accessory Kit, #16976, which works in conjunction with the PPM to reprogram the PROM.

The thermistor RT1 measures the temperature of the diode mount to correct for the temperature dependence of the diodes in the detector.



NOTES:

Unless otherwise specified:

1. Resistor values are in Ohms, 1/4W, ±5%
2. Capacitor values are in microfarads

Figure D-3. PROM PC Assembly Schematic

D.4 Detector Maintenance

There is no regular maintenance required for the detectors. It might become necessary to open the detector mount to correct a fault either in the diode element or in the amplifier/PROM circuit, or to replace the PROM.

D.5 Detector Troubleshooting

The most common cause of failure is the application of too much power, which may destroy the diode element. This will most likely result in the detector failing to autocalibrate. Since there are several faults that can cause the calibration routine of the PPM to fail, it is recommended that you have an understanding of the calibration process, described in Chapter 2 of the Series 8500A manual. Understanding the calibration process allows you to narrow the number of fault possibilities if the history of the detector is unknown. If the detector has been connected to a source of power in excess of +23 dBm (200 mW), an autocalibration should be performed before further use. If the detector fails this process, it should be removed from service until a new diode element has been installed and the unit recalibrated.

If a component in the preamplifier/line driver fails, the detector will also fail autocalibration. To verify that the problem is in the amplifier and not the diodes, a measurement of the voltage can be performed by first removing the outer cover from the detector (see Disassembly of the Detectors in Section D.5.1).

Refer to the circuit description and Figure D-2 in order to proceed with troubleshooting. It is best to connect the detector to a source of RF power at a level of about 0 dBm to trace the signal level through the amplifier. The signal can be pulse modulated if tracing is done with an oscilloscope, or CW if tracing is being done with a voltmeter. With no signal applied, the voltage at the output of the amplifier should be $0\text{ V} \pm 0.1\text{ mV}$. The output voltage with 0 dBm applied will typically be about 0.5 V. This reading is taken at the emitter of the output transistor, not at the output end of the $75\ \Omega$ resistor that feeds the coax cable.

The PROM and address counter circuit is very reliable, but in the event that it does fail, the PPM will be unable to correctly read the PROM, and an error message to that effect will be displayed. The most likely failure in that case would be a broken wire in the cable or in the connectors at each end of the cable. If a PROM read failure occurs, connect the detector to a different channel or to a different PPM. If a failure occurs again, it will be necessary to troubleshoot the PROM circuit. After verifying that there are no broken wires in the detector, proceed to check the active components. Since the PROM is mounted in a socket, the simplest check is to first try a different PROM to determine if the circuit is functioning. It is necessary to use a programmed PROM to accomplish this check, such as one from working detector. Note that this will produce incorrect RF power readings, but it is otherwise a valid test.

The other component that can be checked is the thermistor. The thermistor has two purposes. The PPM checks the voltage at the thermistor to determine if the detector is present. If the voltage is above 10 V the PPM makes the assumption that there is no detector present. If the voltage is in the normal working range, the voltage level is converted to a temperature reading which is compared with the temperature of the detector when it was last calibrated. If the difference in the two readings is more than 5 degrees Celsius, a message will display showing the difference. Therefore if the thermistor is open, possibly due to a broken wire, the PPM will not recognize that the detector is connected. If the thermistor has somehow been shorted, perhaps due to twisted wires, then it will indicate a very large positive change in the temperature reading from the reading taken during calibration. It will also indicate an impossibly large temperature on the detector. The resistance of the thermistor should normally measure 10K at 25 °C.

D.5.1 Disassembly of Detectors

Follow these instructions to disassemble a detector (see Figure D-4).

CAUTION

The detectors contain CMOS components and are subject to static electricity damage. Use correct safety procedures, protective devices and clothing to prevent static discharge before opening a detector enclosure.

1. Remove screws (1) and (2). Take off the sleeve holder plate and slide the sleeve off the cap assembly.
2. Position the detector so that the Pre-Amp assembly (the board with components) is visible. Locate the detector element leads. They are on the end of the PC board nearest to the detector housing assembly. Remove the solder from the leads of the detector element, and remove the leads from the holes in the PC board. Straighten the leads.
3. Unscrew the detector housing assembly from the cap assembly. Use the wrench flats on the housing assembly which are located closest to the cap assembly to remove the housing assembly. The detector element will remain attached to the housing assembly.

If the Spring Washers fall out when the detector housing assembly is removed, they should be replaced as shown in Detail A of Figure D-4.

D.5.2 Replacement of Detector Element

These are instructions to replace the detector element (see Figure D-4). A detector element should be replaced in the field only if a Giga-tronics Programming Accessory Kit (P/N 16976) is on hand to program a new PROM with the characteristics of the new element, and if the required equipment for measuring Cal Factor is available. If either or both of the above items are not available, the entire detector should be returned to the factory for element replacement.

The Cal Factor is the frequency response of the detector with respect to the 1 GHz response, expressed in dB. If the Cal Factor at 10 GHz is -0.2 dB, it means that the detector output voltage at any applied power level is 0.2 dB lower at 10 GHz than at 1 GHz.

1. Remove the old detector element from the detector housing assembly by pulling the element straight out from the Assembly.

CAUTION

Do not twist the element as you remove it. Doing so could damage the center conductor of the detector housing assembly.

2. Take the new detector element out of its protective packaging and carefully straighten the leads. Do not pull sharply on the leads or they may come off.
3. Carefully insert the new detector element into the detector housing assembly. Gently push on the detector element to press the detector element pin into the center conductor of the detector housing assembly. Once the element has been inserted, try gently to pull it back out of the housing assembly. If there is resistance, the element is inserted correctly. If the element comes out easily, the element has not been correctly inserted into the center conductor. Remove the

detector element, make sure that the center conductor is centered in the housing and then reinsert the element.

CAUTION

Do not twist the element as you insert it. Doing so could damage the detector element pin or the center conductor of the detector housing assembly.

4. Remove and discard the old PROM. Use the instructions furnished with the PROM Programming Accessory Kit to program the new PROM.
5. Insert the new PROM into the PROM PC board so that pin #1 is in the position marked on the PC board (see Figure D-4).

D.5.3 Reassembly of Detectors

Follow these instructions to reassemble the detector (see Figure D-4).

CAUTION

Do not twist the detector element while inserting it. This can damage the detector element pin or the detector housing assembly center conductor.

1. Make sure that the detector element leads are straight. Screw the detector housing assembly into the cap assembly. Be very careful not to damage the leads of the element.
2. Insert the element leads into the proper holes in the Pre-Amp board as shown in Detail B of Figure D-4. The lead from the center pin goes to hole 1, and the other lead goes to hole 2. Solder the leads in place.
3. After the element has been installed, it may be necessary to readjust the pulse response of the amplifier due to a possible difference in the video resistance of the new element diodes in relationship to the old element diodes.

To adjust the pulse response, connect the detector to a pulsed microwave source of about 0 dBm. The pulse must be very clean as this procedure assumes a perfect input pulse. The rise time of the pulse must be less than 6 ns, and it should have no overshoot or ringing. If the shape of the pulse is not perfect but is accurately known, this will do.

Set the PPM in the Graph mode with the Internal Trigger at -10 dBm. Autoscale the display by pressing [GRAPH] and set the window to a width of 0.1 μ s. If the pulse shape is wrong, adjust C3 on the Pre-Amp board in small increments and wait for the trace on the screen to redraw. After finding an optimum setting for C3, adjust R9 until the best shape is obtained. Do not move either control very far from the original setting. The end result for this procedure is to set the maximum rise time consistent with no overshoot or ringing. If the rise time cannot be set below 15 ns, a small overshoot of less than 5% is acceptable.

4. Slide the sleeve onto the cap assembly. Replace the sleeve holder plate. Insert and tighten screws (1) and (2), and return the detector to service.

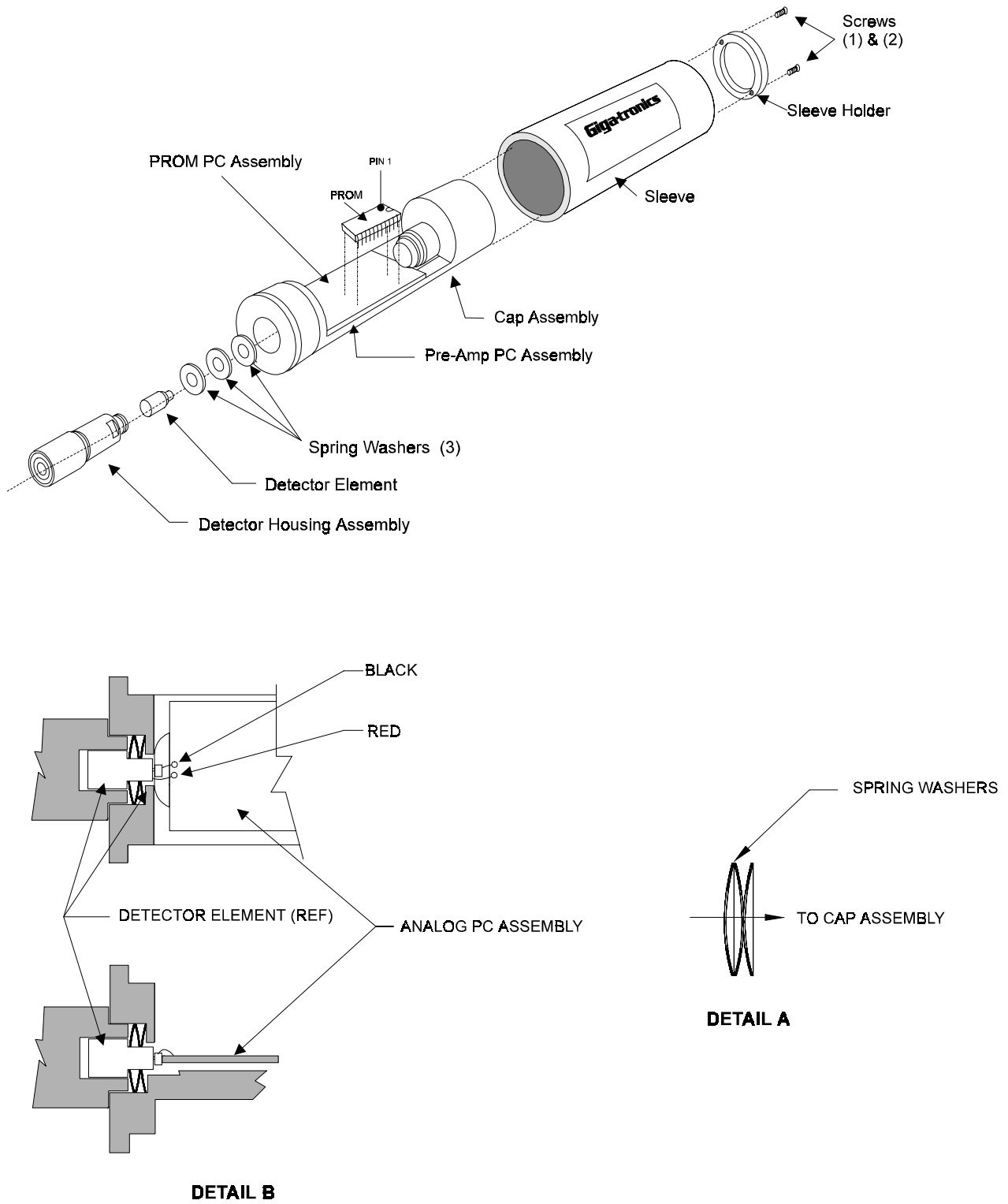


Figure D-4. Detector Disassembly and Assembly Details



Options

E.1 Introduction

The following options are available for Series 8500A, and are discussed under respective headings:

Option 01: Rack Mount Kit, 16657

Option 03: Rear Panel Connections

Parts lists are included with the applicable option in this appendix. Diagrams for options, when applicable, are in Chapter 8.

E.2 Option 01: Rack Mount Kit

Option 01 is a 19-inch standard equipment rack mounting kit for the Series 8500A power meter. It includes slides and wall mounting brackets.

16657 OPT 01 RACK MT 5 1/4 (8501/02), Rev: B

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	12678-002	1	58900	12678-002	SLIDE-RACK SECTIONS (PAIR)
2	12678-001	1	58900	12678-001	SLIDE-CHASSIS SECTION (PAIR)
3	10351-001	2	58900	10351-001	ROUND NICKEL HANDLE
4	20077	1	58900	20077	BRACKET,RACK MOUNT, 5.25 (L)
5	20078	1	58900	20078	BRACKET,RACK MOUNT, 5.25" (R)
6	10352	4	58900	10352	HANDLE FERRULE
7	13854	6	58900	13854	SPACER, .172IDX.500ODX.31LG
8	20074	1	58900	20074	MOUNTING BLOCK, LEFT
9	20075	1	58900	20075	MOUNTING BLOCK, RIGHT
10	10415	1	58900	10415	LABEL, OPTION IDENTIFICATION
101	10111-005	6	58900	10111-005	8-32 X 5/8 PAN
102	13603-001	2	58900	13603-001	8-32 X 1/2 FLAT 100 DEG
103	HWSS-80400	6	58900	HWSS-80400	#8 X 1/4 SPLIT LOCK
104	HBFP-A3206	4	58900	HBFP-A3206	10-32 X 3/8 FLAT
105	HBPP-83206	4	26233	NS137CR832R6	8-32 X 3/8 PAN

E.3 Option 03: Rear Panel Connections

When Option 03 is installed, the Calibrator and Detector connectors are relocated from the front panel to the rear panel.

20794 MODEL 8501A OPTION 03 REV A:

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	17051-001	1	58900	17051-001	DET. INPUT CABLE ASSY, OPT. 03
2	17283	1	58900	17283	BRACKET, CLAMP DET INPUT CABLE
3	HTM0-00003	3	06383	ABMM-A-D	CABLE TIE ANCHOR
4	20508-002	1	58900	20508-002	FRONT PANEL, 8501A-OPT 03
5	16884	1	58900	16884	LABEL,MISC.

20795 MODEL 8502A OPTION 03, Rev: B

Item	Part Number	Qty	Cage	Mfr's Part Number	Description
1	20510-002	1	58900	20510-002	FRONT PANEL, 8502A OPT03
2	17051-001	2	58900	17051-001	DET. INPUT CABLE ASSY, OPT. 03
3	17283	1	58900	17283	BRACKET, CLAMP DET INPUT CABLE
4	16884	1	58900	16884	LABEL,MISC.
5	10414-001	1	2R182	864	3 LUG TERMINAL STRIP
101	HTM0-00003	4	06383	ABMM-A-D	CABLE TIE ANCHOR
102	10384-002	2	95987	F6NY-312NA	CABLE CLAMP 5/16"DIA 1/2" WIDE

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