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Giga-tronics

Operation & Maintenance Manual

Series 8540B
Universal Power Meters

The instrument has a 7-digit serial number, shown on a sticker on the rear panel.
This manual applies to all serial numbers beginning with 98, 99, or 00.

CE . . . . Certified Product
ISO 9001 . . . . Certified Process
Registra: BSI, Certification No. FM 34226, Registered 04 June 1996

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About This Manual

This manual contains the following chapters and appendices to describe the operation and maintenance of Series 8540B Universal 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 chapter is an introduction to the instrument and it's performance parameters.

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

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

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

Chapter 5: Performance Verification and Calibration: Procedures for inspection, performance verification and calibration 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: Sample Programs: Examples of programs for controlling the 8540B remotely over the GPIB.

Appendix B: Power Sensors: Selection data for power sensors, specifications, and calibration procedures.

Appendix C: Options: This chapter describes options available for the Series 8540B.

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

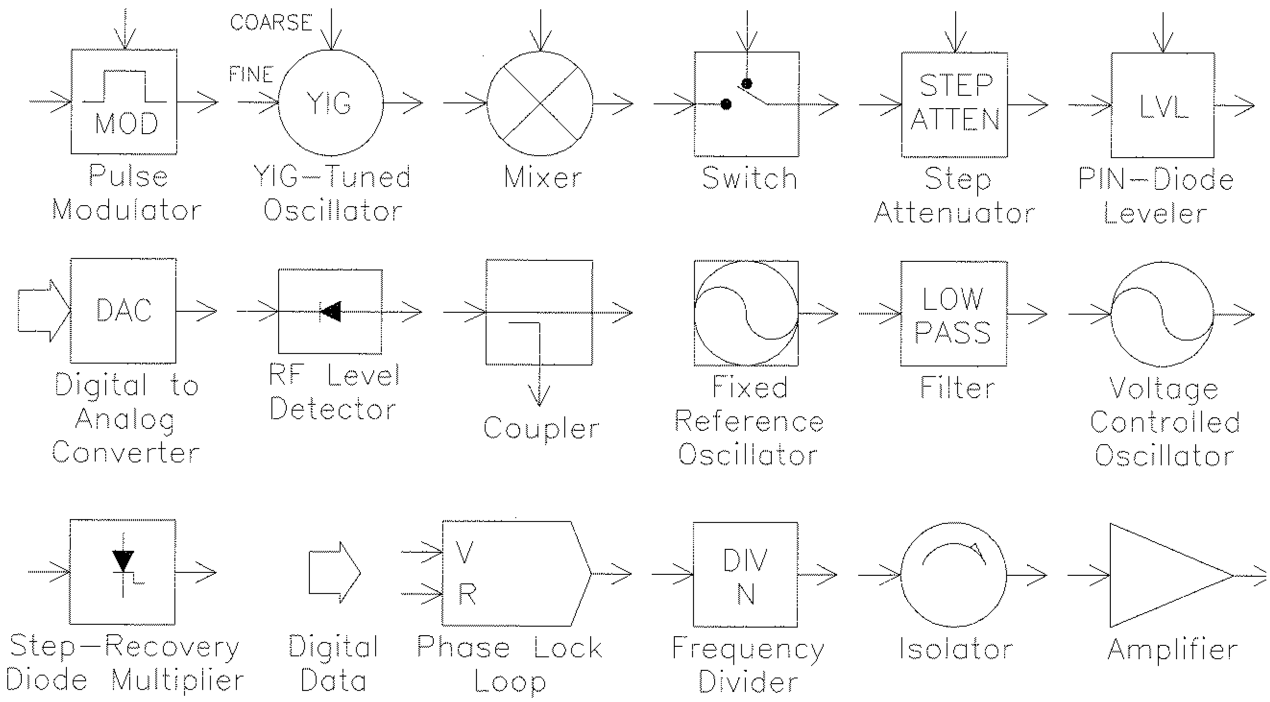
The CAUTION statement is enclosed within a single heavy line and centered in the page. This calls attention to a situation, or an operating or maintenance procedure, or practice, which if not strictly corrected or observed, could result in temporary or permanent damage to the equipment, or loss of effectiveness.

Notes

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

SYMBOLS

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



Record of Manual Changes

This table is provided for your convenience to maintain a permanent record of manual change data. Corrected replacement pages will be issued as Technical Publication Change Instructions, and will be inserted at the front of the binder. Remove the corresponding old pages, insert the new pages, and record the changes here.

Change Instruction Number	Change Instruction Date	Date Entered	Comments

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).

1

Introduction

1.1 Description

The Series 8540B Universal Power Meters are digital-controlled, self-calibrating instruments. They can measure the power of RF and microwave signals over a wide range of frequencies, levels, and in a variety of measurement modes, and can be operated manually from the front panel or remotely over the General Purpose Interface Bus (GPIB). See Section 1.3 for performance specifications.

The Series 8540B Universal Power Meters are available as the single-channel Model 8541B and the dual-channel Model 8542B, which can simultaneously measure and display signal data for two channels.

The 8540B and the Series 80300 and 80400 power sensors provide enhanced performance in the measurement of complex modulation signals used in the communication industry.

1.1.1 Features

- CW, modulated, and peak power sensors
- >2000 readings/second in the Fast Buffered Mode (GPIB only)
- 90 dB dynamic range CW sensors
- +0.5% linearity
- True dual-channel display
- HP 438A, 437B, and 436 simulation modes (GPIB only)
- EEPROM based CAL FACTOR correction sensors
- Modulated Average Power (MAP) mode
- Pulse Average Power (PAP) mode
- Burst Average Power (BAP) mode
- Password protection against unauthorized changes in data stored in EEPROMs.

1.1.2 Weight and Dimensions

Series 8540B instruments weigh 10 lbs (nominal).
Dimensions are 3.5 inches high x 8.4 inches wide x 14.5 inches deep.

1.1.3 Power Requirements

100/120/220/240 VAC ± 10%, 48-400 Hz, 20 W, typical. See Section 1.2 for details to set the voltage and install the correct fuse for the area in which the instrument will be used.

1.1.4 Environmental Requirements

Series 8540B instruments 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 -40 °C to +70 °C
- Relative humidity is limited to 95% non-condensing
- Altitude and EMI requirements are not specified
- No warm-up period is required

1.1.5 Items Furnished

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

1 ea. - Power Cord
1 ea. - Detachable Sensor Cable (for Model 8541B), or
2 ea. - Detachable Sensor Cables (for Model 8542B)
1 ea. - Operation and Maintenance Manual

1.1.6 Items Required

The 8540B requires an external power sensor; see Appendix B for power sensor selection and specifications.

1.1.7 Tools and Test Equipment

No special tools are required to operate the Series 8540B. Test equipment required for calibration or performance verification is described in Chapter 5.

1.1.8 Cooling

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

1.1.9 Cleaning

The instrument's 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.

1.1.10 Installation and Preparation for Use

The instrument is shipped in an operational condition and no special installation procedures are required. No warm-up period is required.

1.1.11 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.

1.1.12 Preparation for Reshipment

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.

☛ *NOTE:* If you are returning an instrument to Giga-tronics for 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.***

1.2 Safety Precautions

This instrument has a 3-wire power cord with a 3-terminal polarized plug for connection to the power source and safety-ground. The ground (or safety ground) is connected directly to the chassis.

WARNING

If a 3-to-2 wire adapter is used, connect the ground lead from the adapter to earth ground. Failure to do this can cause the instrument to float above earth ground, posing a shock hazard.

The 8540B is designed for international use with source voltages of 100, 120, 220, or 240 Vac, ±10% at 50-400 Hz. The 8540B uses an internationally approved connector that includes voltage selection, fuse, and filter for RFI protection (see Figure 1-1).

CAUTION

The instrument can be damaged if connected to a source voltage with the line voltage selector set incorrectly. Before connecting the instrument to power, make sure that the line voltage selector is set for the correct source voltage.

1.2.1 Voltage Selection & Fuse Installation

When the instrument is shipped from the factory, it is set for a particular power line voltage (120Vac for domestic destinations). The power line fuses (one on each side) for 100 to 120 Vac is 0.50 A Slo-Blo. If the source voltage is to be 220 to 240Vac, the fuses must be changed to 0.25 A Slo-Blo (see Figure 1-1).

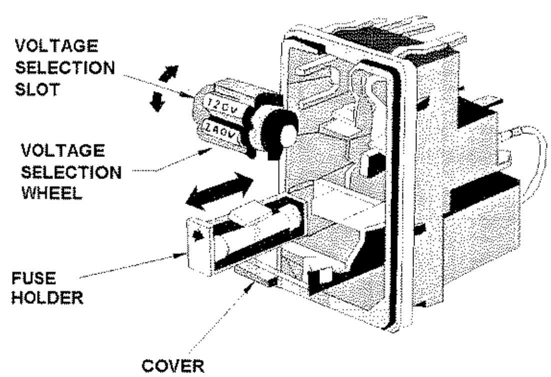


Figure 1-1. Voltage Selector and Fuse Holder

The voltage selector and fuse holder are both contained in a small covered housing directly above the ac power connecter. To gain access to them, open the cover using a small screwdriver or similar tool and proceed as follows:

1. 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 1-1).

2. To replace the fuse:

   Pull out the small drawer on the right side of the housing (it's marked with an arrow) and remove the old fuse. Replace with a new fuse, insert the drawer and close the housing cover (see Figure 1-1).

1.2.2 Power Sensor Precautions

Power sensor safety precautions, selection, specifications, and calibration are detailed in Appendix B to this manual.

1.3 Series 8540B Specifications

1.3.1 Power Meter

Frequency Range:	10 MHz to 40 GHz[1]
Power Range:	-70 dBm to +47 dBm (100 pW to 50 Watt)[1]
Single Sensor Dynamic Range:	
CW Power Sensors	90 dB
Peak Power Sensors	40 dB, Peak, 50 dB, CW
Modulation Sensors	87 dB CW; 80 dB MAP/PAP; 60 dB BAP
Display Resolution:	User-selectable from 1 dB to 0.001 dB in Log mode and from 1 to 4 digits of display resolution in Linear mode.

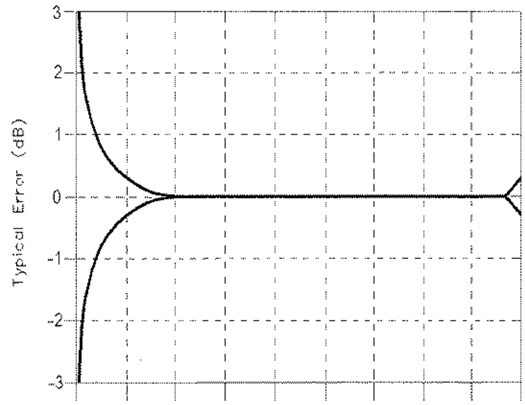
1.3.2 Accuracy

Calibrator:	Power Sweep calibration signal to dynamically linearize the sensors.
Frequency	50 MHz nominal.
Settability	The 1 mW (0.0 dBm) level in the Power Sweep Calibrator is factory set to ±0.7% traceable to the National Institute of Standards and Technology. Measure with 15 seconds of setting calibrator to 0.0 dBm.
0.0dBm Accuracy	±1.2% worst case for one year over temperature range of 5 to 35 °C.
Connector	Type N connector, 50 Ω.
VSWR	<1.05 (Return Loss >33 dB).
System Linearity at 50 MHz for Standard Sensors[3]:	±0.02 dB over any 20 dB range from -70 to +16 dBm ±0.02 dB (±0.05 dB/dB) from +16 to +20 dBm ±0.04 dB from -70 to +16 dBm
Temperature Coefficient of Linearity:	<0.3%/ °C temperature change following Power Sweep Calibration. 24-hour warm-up required.
Zeroing Accuracy (CW) (Standard Sensors):	
Zero Set	<±50 pW[2,3]
Zero Drift	<±100 pW during 1 hour[2]
Noise	<±50 pW measured over any 1 minute interval. Three standard deviations.[2]

Notes:

1. Depending on sensor used (see Power Sensor details in Appendix B).
2. Specification applies at -50 dBm for 8030XA Standard Sensors. When measuring power levels Po other than -50 dBm, divide noise and zero specifications by $(10^{-Po/10})/(10^{-5})$. For other 80300 Series CW Sensors, specification applies at 20 dB above the minimum specified reading level. For Peak Power Sensors, see Appendix B and the 80350A Series Peak Power Sensor Data Sheet. Specified performance applies with Maximum averaging and 24 hour warm-up with temperature variation <3 °C.
3. Instrumentation, relative to 0 dBm.

1.3.3 Uncertainty Due to Instrument Linearity & Zero Set vs. Input Power



SENSORS										
80301A	-70	-60	-50	-40	-30	-20	-10	0	10	20
80310A	-64	-54	-44	-34	-24	-14	-4	6	16	26
80320A	-60	-50	-40	-30	-20	-10	0	10	20	30
80321A	-50	-40	-30	-20	-10	0	10	20	30	40
80322A	-40	-30	-20	-10	0	0	20	20	40	44
80325A	-40	-30	-20	-10	0	10	20	30	40	50
80330A	-30	-20	-10	0	10	20				
80401A (CW)	-67	-57	-47	-37	-27	-17	-7	3	13	
80401A (MAP, PAP)	-60	-50	-40	-30	-20	-10	0	10	20	
80401 (BAP)	(See 80401 Modulated-related uncertainty graphs in Appendix B)									

Figure 1-2. Uncertainty Due to Linearity & Zero Set

1.3.4 Measurement Rates

Measurement speed increases significantly using the 8540B data storage capabilities. Storing data in the power meter's memory for later downloading to your controller reduces GPIB protocol overhead. Up to 128,000 readings can be buffered. Table 1-1 illustrates typical maximum measurement rates for different measurement collection modes. The rate of measurement depends on several factors including the controller speed and the number of averages. The Fast Buffered Mode speed shown below does not include bus communication time.

Table 1-1. Collection Modes Measurement Rates

Measurement Collection Mode	Readings per Second (CW Measurement)	Readings per Second (MAP, PAP, BAP Measurement)
Normal (TR3) Continuous Single Readings	>30	15
Swift Mode, Continuous or Buffered, Bus/TTL triggered	>175	N/A
Swift Mode, Continuous or Buffered, Free-run triggered	>200	N/A
Fast Buffered Mode, Buffered Data, Time Interval = 0	2600	N/A
Fast Modulated Mode, Continuous Single Readings	N/A	30

Individual data points are read immediately after measurement in the Normal mode. The Normal and the Swift modes slow down at low power levels (<-37 dBm for Standard Sensors) to average the effects of noise. The Swift mode allows triggering of individual data points and can store the data in the 8540B memory. The Fast Buffered mode also buffers measurement data. Measurement timing of individual data points is controlled by setting the time interval (1 to 5000 ms) between the data points following a trigger.

1.3.5 Remote Operation

GPIB Interface: Allows all front panel operations and some GPIB-only operations to be remotely programmed in either IEEE-488 or IEC-625 format.

Interrupts: SRQs are generated for the following conditions:
Power Up, Front Panel key actuation, Operation Complete, Illegal Command, and Instrument Self-Test error.

1.3.6 Fast Buffered Mode Controls

Trigger Source: TTL or GPIB

Data Buffer Control: Pre- or post-measurement data is collected immediately either before or after receipt of the TTL or GPIB trigger.

Time Interval: TIME ### - controls time interval in milliseconds between measurements. Accurate to 5%, typical.

1.3.7 Meter Functions

Averaging: User-selectable auto-averaging or manual, 1 to 512 readings.
Automatic noise compensation in auto averaging mode.

dB Rel and Offset: Allows both relative readings and offset readings. Power display can be offset by -99.999 dB to +99.999 dB to account for external loss/gain.

Configuration Storage Registers: Allows up to 20 front panel setups plus a last instrument state at power-down to be stored and recalled from non-volatile memory.

Power Measurements and Display Configuration: Any two of the following channel configurations simultaneously: A, B, A/B, B/A, A-B, B-A, DLYA, DLYB (provided that neither sensor is being used for MAP, PAP, or BAP measurements.

1.3.8 Remote Inputs/Outputs

V Prop F Input (BNC):	Corrects power readings for sensor frequency response using sweeper voltage output. Input resistance = 50 kΩ. Does not operate in the fast measurement collection modes (normal mode only).
Input Range:	0.0 V to 10.0 V
Accuracy:	1.0% ±25 mV
Analog Output (BNC):	Provides an output voltage of 0 to 10 V from either Channel A or Channel B in either Log or Lin units. Does not operate in the swift and fast measurement buffered modes.
Accuracy:	<0.5% ±32 mV, 0.0 V to 10 V
Linearity:	<0.5%
Blanking Output (BNC):	TTL high during power meter zero. Can be used to shut off RF output during sensor zero.
Trigger Input (BNC):	Accepts a TTL trigger input signal for swift and fast measurement buffered modes.
GPIB Connector:	Interfaces power meter to controller, IEEE-488 and IEC-625 remote programming

1.3.9 General Specifications

Temperature Range:	
Operating:	0 to 50 °C (32 to 122 °F)
Storage:	-40° to 70 °C (-40° to 158 °F)
Power Requirements:	100/120/220/240 Vac ±10%, 48 to 440 Hz, 20 VA typical
Physical Characteristics:	
Dimensions:	215 mm (8.4 in) wide, 89 mm (3.5 in) high, 368 mm (14.5 in) deep
Weight:	4.55 kg (10 lbs)

1.3.10 Accessories Included

1 ea 8540B Series Operation and Maintenance Manual

1 ea Power Cord

1 ea Detachable Sensor Cable (for Model 8541B)
or
2 ea Detachable Sensor Cables (for Model 8542B)

1.3.11 Options

Refer to Appendix C to this manual for a full description of options.

Option 01: Rack mount kit

Option 02: Adds 256k buffer for fast buffered power readings. Stores 128,0000 readings.

Option 03: 8541B rear panel connections (sensor & calibrator - deletes front panel connections)

Option 04: 8542B rear panel connections (sensor & calibrator - deletes front panel connections)

Option 05: Soft carrying case

Option 06: Second analog output on 8542B. (-10 V to +10 V)

Option 07: Side mounted carrying handle

Option 08: Transit case (includes soft carrying case)

Option 09: Dual rack mount kit (with assembly instructions)

Option 10: Dual rack mount kit (factory assembled)

1.3.12 Power Sensors

See Appendix B for power sensor selection, specifications, and calibration data.

2

Front Panel Operation

2.1 Introduction

This chapter describes the front panel operation of the Series 8540B Universal Power Meters. It includes descriptions of the front and rear panels, configuration, display menus, and practical applications. Section 2.2 describes the front panel; Section 2.3 describes the rear panel; Section 2.4 presents Configuration procedures; Section 2.5 describes the display submenus, and Section 2.6 offers guidelines for practical applications.

See Chapter 3 for information on remote operation over the General Purpose Interface Bus (GPIB).

2.2 The Front Panel

Although the 8540B has many modes of operation, its front panel design is very simple. The instrument is controlled and configured by means of displayed menus, which can be accessed and controlled with front panel pushbuttons.

The dual-channel Model 8542B front panel is illustrated in Figure 2-1. The single-channel Model 8541B is the same in appearance but does not include Channel B.

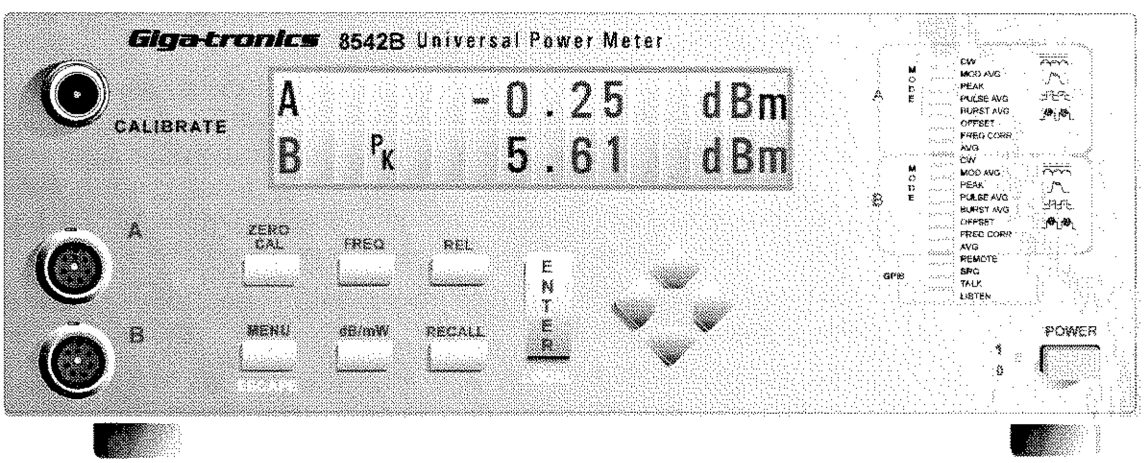


Figure 2-1. The 8542B Front Panel

2.2.1 Calibrator

The CALIBRATOR connector provides a reference power output for calibrating the amplitude response of a power sensor. The frequency of the output is fixed at 50 MHz. The level of the output is programmable. During a calibration run, the output level automatically sweeps from -30 dBm to +20 dBm in 1-dB steps.

2.2.2 Display Window

A two-line alphanumeric LCD screen displays measurement and configuration data.

2.2.3 LEDs

The LEDs to the right of the display window indicate operating modes and GPIB status. The column of LEDs can also be configured for use as a peaking meter display.

2.2.4 Power

The push-push power switch turns line power on and off.

2.2.5 Configuration Keys

The keys are located below the display window, and are used to configure the 8540B:

ZERO/CAL This key is for zeroing and calibration of a power sensor.

If zeroing and calibration are both required, the sensor must first be connected to the CALIBRATOR output connector. When [ZERO/CAL] is pressed, the sensor is zeroed, and then calibrated by an automatic program, which tests the sensor's response to different reference power levels and stores the resulting data in the 8540B memory.

The sensor does need not to be connected to the CALIBRATOR output for zeroing only. If [ZERO/CAL] is pressed when the sensor is not connected to that output, the 8540B performs the zeroing function only.

When zeroing a sensor, it is best to connect the sensor to the device under test exactly as it will be used in measurement, and deactivate the RF output of that device. Zeroing the sensor in place is the best way to counteract system noise which could significantly effect low-level measurements. The RF Blanking output signal, which goes low during sensor zeroing, is provided by a BNC on the rear panel; this can be used as a control signal to turn off the RF source.

All active sensors should be zeroed whenever any sensor (whether it is calibrated or not) is added or removed.

FREQ This key specifies the frequency of an input signal, so that the 8540B can apply the appropriate frequency-specific cal factor to the measurement. These cal factors are retrieved from the sensor's own EEPROM.

If the frequency of the input signal changes so often that it is impractical to keep entering the frequency using the FREQ key, the frequency information can be conveyed to the 8540B by the use of a voltage input that is proportional to frequency (see the VpropF connector on the rear panel). When the 8540B is controlled remotely over the GPIB, the frequency information can be sent over the bus.

REL This key selects relative measurements (that is, measurement values are not absolute; they are expressed in dB relative to a reference level). Pressing [REL] establishes the present measured power level as the reference for all subsequent measurements. Press [REL] a second time to disable relative measurement.

MENU/ESCAPE The MENU key accesses the configuration menus; it is also called the ESCAPE key because (when pressed a second time) it exits a configuration menu, abandoning any configuration choices that were made within the menu up to that point.

dBm/mW This key toggles between logarithmic measurement units (dBm, which is the default condition) and linear units (mW). The display can be configured to use both kinds of units simultaneously, but this must be done through the Meas Setup configuration menu).

RECALL The recall button retrieves a stored configuration of the 8540B (configurations are saved in registers 1 through 20, using the Save Setup configuration menu). Use the Left/Right cursor keys to choose between Preset and Reg#, and the Up/Down cursor keys to select a register number. Choosing the Preset configuration restores the 8540B default conditions (it does not undo the calibration of the sensors, however). Choosing register 0 restores the conditions which existed prior to the last configuration change.

ENTER/LOCAL The ENTER key makes menu selections and enters selected options or values. It is also called the LOCAL key because it switches from remote control to local control.

Cursor Keys These four keys are arranged in a diamond pattern and move the display cursor vertically and horizontally.

2.2.6 Sensor Inputs

The **A** and **B** sensor input connectors (located directly below the CALIBRATOR connector) are for the cables from the power sensors to the power meter chassis. In instruments with Option 03, the sensor inputs are relocated to the rear panel.

Caution

When connecting sensor cables to these inputs, be careful not to damage the connectors. The cable pins must be aligned properly (orient the cable so that the guide on the end of it aligns with the notch on the sensor input). If the connector does not seem to fit, forcing it will only damage the connector pins.

2.3 The Rear Panel

The rear panels for the 8541B and 8542B are identical, and are illustrated in Figure 2-2.

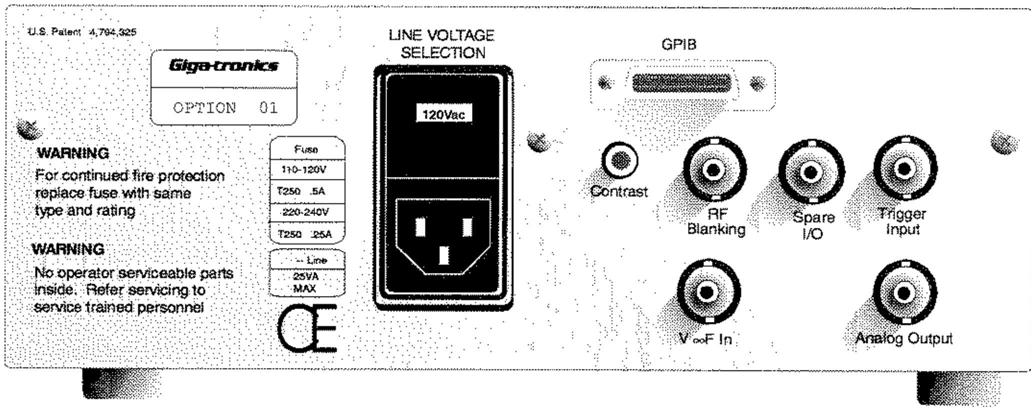


Figure 2-2. The 8540B Rear Panel

2.3.1 Inputs & Outputs

BNCs

Five BNC-type connectors to provide input and output signals for interfacing the 8540B to other equipment.

- **RF Blanking** provides a TTL output that goes high during zeroing of a sensor to send a temporary RF Off trigger to a signal source.
- *Trigger Input* accepts a TTL input for triggering of high speed measurements under GPIB control.
- *V* $\propto$ *F In* accepts a voltage input that is proportional to frequency and causes the 8540B to apply appropriate frequency-related cal factors.
- *Analog Output* provides an output voltage that is proportional to the measured power level.
- Spare I/O connector is for a second analog output when Option 06 is installed.

Others

- GPIB (a 24-pin connector to connect the 8540B to other equipment over the GPIB).
- Line Voltage Selection (this compartment houses the AC power connector and includes the fuse and voltage selector).

2.4 Configuring the 8540B

The 8540B front panel LCD window normally displays measurement data, but it also displays configuration menus. To select the menu mode, press [MENU]. Once the 8540B is in menu mode, it can be returned to the measurement mode by pressing [MENU] again (in this context, the MENU button is the ESCAPE button).

The 8540B can be password-protected to prevent unauthorized changes in Calibrator and Cal Factor data stored in EEPROMs in the 8540B or its sensors. It is activated with the front panel menus (see Section 2.4.3 for a description of passwod usage). The 8540B is shipped from the factory with no password specified.

2.4.1 How the Menus Work

There is a hierarchy of menus; each line on the main menu represents a submenu, and some of the items on those submenus are further submenus.

Menus are displayed one line at a time, with the word *more* accompanied by up or down arrows to indicate whether there are additional lines above or below the line currently displayed. The Up/Down cursor buttons are used to browse through the lines of a menu. Press [ENTER] to select the currently displayed line.

When an entry window is reached (that is, when the line that has been selected represents a configuration choice to be made, not a submenu), the left/right cursor buttons step through the list of choices. If a numeric value is to be entered, a base value is displayed, and the cursor buttons increment or decrement this value (the left/right cursor buttons selects a digit, and the up/down cursor buttons step the value of that digit up or down).

After the desired value is set, or the desired choice selected, press [ENTER].

NOTE: If you leave the menu mode without pressing [ENTER], the selections you made will not take effect.

Entering a selection usually returns the display window to the measurement mode. However, if the selection you made requires further configuration choices, another menu may be displayed.

The menus are dynamic rather than fixed; the display adapts itself to the current operating mode and the type of sensor or sensors connected. For example, the DLY measurement options are applicable only to peak power measurement; therefore, the menu displays these options only if a peak sensor is attached and is set up to measure peak power.

2.4.2 Menu Structure

Table 2-1 lists the 8540B menu structure. For specific information about the individual menu items, see Section 2.5. Please note that the format of these menus, as they are actually displayed, is context-dependent; some menu options shown here may not be displayed if they are not applicable to the sensors that are currently connected, or if they are not applicable to the measurement mode that is currently selected. For example, menu options related to the Pulse Average Power mode will not be displayed if a CW sensor is attached, because a CW sensor cannot be used in the PAP mode.

Table 2-1. 8540B Menu Structure

Main Menu Item	SubMenus	Entry Windows	
A, B, A/B, ..., OFF	Top Line Bot Line	Choose from: OFF, A, B, A/B, B/A, A-B, B-A, DLY_A, DLY_B *[The format of this entry window is particularly subject to context-dependent variations; see Section 2.5.1]*	
Meas Setup	Average	Avg A Avg B	Choose from: Auto, 1, 2, 4, 8, 16, 32, 64, 128, 256, 512
	Offset	A (dB) B (dB)	[increment or decrement the displayed value]
	Resolution	Top Line = x.xx Bot Line = x.xx	[adjust left or right as needed]
	Peak Hold	Choose from: OFF, ON	
	Crest Factor	Choose from: OFF, ON	
	Min/Max	Choose from: OFF, ON (and Bottom Line/Top Line if applicable)	
	Limits	Top Line Bot Line	Choose from: OFF, ON [if ON is chosen, the limits must be defined; increment or decrement]
	dBm/mW Setup	Top Line Bot Line	Choose from: Lin, Log
	Rel Setup	Top Line Bot Line	Choose from: ON, OFF
	Advanced	Burst Start Exclude Burst End Exclude	Num. of Samples: A Num. of Samples: B [increment or decrement]
		Burst Dropout	Time: A / Time: B Choose from: .017, .026, .035, etc (values in ms).
Sensor Setup: CW sensor	(No configuration is required if a CW sensor is connected.)		
Sensor Setup: Peak Sensor **[select A or B]**	CW	(No further configuration is required if CW is selected.)	
	Int	Set Trig Level (dBm) Set Samp Delay (ns) DLY Offset (ns)	[increment or decrement the displayed value]
	Ext	Set Trig Level (V) Set Samp Delay (ns) DLY Offset (ns)	

Main Menu Item	SubMenus	Entry Windows	
Sensor Setup: Modulation Sensor [80400 Series] **[select A or B]**	CW	(No further configuration is required if CW is selected.)	
	Modulated Avg	(No further configuration is required if Modulated Avg is selected.)	
	Pulse Avg	Duty Cycle [increment or decrement the displayed value]	
	Burst Avg	(No further configuration is required if Burst Avg is selected.)	
Ref Power On/Off	Choose from: On or Off		
Config	Peaking Meter	Choose from: Status, PkA, PkB	
	GPIB	Mode	Choose from: 8541, 8542, 436A, 437B, 438A
		Address	Choose from: 0-30 (listen & talk), 40 (listen only) and 50 (talk only).
	Analog Out	Std Output [if Option 06 is installed, there are two outputs; if so, select OFF in order to get to the menu for that option]	Choose from: Off, Bot Line, Top Line
		Mode	Choose from: Log, Lin
	V prop F [select A or B]	Choose from: OFF, ON If ON is selected, two values must be defined	Freq. at 0 Volts (GHz) Scale Factor (V/GHz) [increment or decrement the displayed values]
	Sound	Choose from: ON, OFF	
Service	Sensor ROM [select A or B]	Choose from a wide variety of parameters that can be set.	
	Calibrator	Power	Choose from: OFF, or a value in dBm [increment or decrement the displayed value].
		EEPROM [data to be entered: Serial#, Cal Factor, Date, Time, WRITE]	WRITE: CALIB Clear, or PASSWORD Set
	Test Functions	Choose from a wide variety of diagnostic tests.	
	Software Version	Displays information about the currently installed software.	
	Clear All Memory	Clear RAMs of configuration data.	
Save Setup	Save to Reg# [specify a number from 1 to 20]		

2.4.3 Password Protection

The password feature prevents unauthorized changes in Calibrator and Cal Factor data stored in EEPROMs in the 8540B or its sensors. It is activated with the front panel menus (see Table 2-1 for a description of the menus and their usage). The 8540B is shipped from the factory with no password specified.

To get to PASSWORD Set, select the Service menu, then the Calibrator submenu (or the Sensor ROM submenu to provide password protection of sensor memory). Then select EEPROM, then WRITE. At WRITE, the choice is between CALIB Clear and PASSWORD Set; select the latter. The password is a numeric code. To enter it, use the cursor keys to increment or decrement the digits displayed in the screen; press [ENTER] and then press [ENTER] again to confirm the password. The password is now entered in the 8540B memory, and EEPROM data cannot be changed without entering the password.

The password can be changed or cleared by repeating the above steps and entering the existing password; then set a new password by selecting SET, clear the password by selecting CLEAR, or just rewrite the data by selecting ON.

If a password was set previously and is not known, you can disable password protection by moving the A2W1 jumper on the Analog PC board (A2) from the factory set position B to position A (see sheet 4 of drawing # 21697 in Chapter 8).

2.5 The Submenus

2.5.1 A, B, A/B, ..., Off

This submenu determines what will be shown on the top and bottom lines of the display window. The existing measurement setup determines which choices are shown in the menu; options which do not apply to the power meter and its sensors, as they are currently configured, will not be shown.

The top and bottom lines of the display are configured independently; use the Up/Down cursor keys to choose the top or bottom line; then use the Right/Left cursor keys to choose one of the available display formats. Any of the options shown below can be selected for either the top line or the bottom line:

Display Line Formats for the CW Mode							
TOP or BOTTOM:	A	B	A/B	B/A	A-B	B-A	OFF

The top and bottom line settings are chosen as a unit for the PEAK mode. One line of the display shows the measurement, and the other line shows the delay value. The choices in this mode are:

Display Window Formats for the PEAK Mode				
TOP:	A	B	DLY_A	DLY_B
BOTTOM:	DLY_A	DLY_B	A	B

2.5.2 Meas Setup

This submenu defines conditions of measurement for each sensor. The items on the submenu are: Avg, Offset, Resolution, Min/Max, Limits, dBm/mW, and Relative. Use the Up/Down cursor keys to view these items, and the ENTER key to select one of them.

Average Measurements can be averaged over a period of time which is referred to as the filter time. Increasing the filter time increases the stability of the display, at the cost of increased time required for a measurement. The filter time is equal to 40 ms times the averaging factor (for an averaging factor of 1, the filter time is equal to 40 ms or the reading update time, whichever is greater). To increase measurement speed, choose a lower averaging factor. The choices are: AUTO, 1, 2, 4, 8, 16, 32, 64, 128, 256, and 512. Use the Up/Down cursor keys to view these choices, and the Enter key to select one of them. If AUTO is selected, the filter time is automatically adjusted for the ambient noise level.

Offset A specific offset in dB (positive or negative) can be added to the measured power. A beginning value of 0.000 dB is displayed. Use the Left/Right cursor keys to select a digit, and the Up/Down cursor keys to increment or decrement the selected digit. Use the ENTER key to select the adjusted offset value.

Resolution The display resolution can be set independently for the top line and bottom line of the display. Use the Up/Down cursor buttons to select the top line or the bottom line. Use the Right/Left cursor buttons to modify the resolution as symbolized by x's (the range of choices is *x* through *x.xxx*). Use the ENTER key to select the adjusted resolution.

Peak Hold In modulated measurement modes (MAP, PAP, or BAP), this feature holds the maximum value measured since it was enabled. The displayed value changes only when it is rising to a new maximum (or when it is reset by pressing [ENTER], in which case the displayed value drops to the present measured value and the process resumes).

Crest Factor This feature is very similar to the Peak Hold feature described above, except that what is displayed is the ratio of the held maximum value to the average value, expressed in dB.

Min/Max The Min/Max feature provides a continuously updated display of the highest and lowest values measured so far; both are displayed on one line, while the other line displays the current measurement of the channel being monitored. Use the Up/Down cursor buttons to select OFF, Bottom Line, or Top Line, and press [ENTER]. The line that is selected represents the channel to be monitored; the other line displays the minimum and maximum measured values. To reset these values to the current measurement, return to the Min/Max entry window and press [ENTER] twice.

Limits High and low limits can be defined for each channel; if the sound function is activated, an audible tone is generated when a limit is violated. Arrows pointing up or down are displayed during a limit violation, to indicate whether the upper limit or the lower limit was violated.

dBm/mW The top and bottom lines of the display can be configured for logarithmic (dBm) or linear (mW) display modes. Ratio measurements (A/B or B/A), are expressed in dBr (logarithmic) or %r (linear).

Rel Setup Normally, when the REL key is pressed, each line of the display shows a relative measurement (when the key is pressed, the present measured value is recorded, and all subsequent measurements are expressed in dB or % relative to that recorded value). The Rel Setup entry menu provides a means of selectively enabling or disabling the relative measurement mode for the top line, the bottom line, or both. Use the Up/Down cursor keys to select the top line or the bottom line; then use the Right/Left cursor keys to select ON or OFF, and press [ENTER].

Advanced This menu includes three special features which may be of use in certain applications of the Burst Average Power measurement mode.

Burst Start Exclude: This feature masks off a portion of the beginning of a burst, in order to exclude overshoot and other distortions from the measurement. The number of samples to be excluded must be defined; use the Up/Down cursor keys to select the desired number of samples, and press [ENTER] (selecting zero samples effectively disables this feature).

Burst End Exclude: This feature masks off a portion of the end of a burst, in order to exclude overshoot and other distortions from the measurement. The number of samples to be excluded must be defined; use the Up/Down cursor keys to select the desired number of samples, and press [ENTER] (selecting zero samples effectively disables this feature).

Burst Dropout: This feature modifies the definition of a burst, so that a brief dropout is not interpreted as the end of a burst. A dropout time must be defined; use the Up/Down cursor keys to select one of a series of values displayed in ms (.17, .26, .35, etc.), and press [ENTER].

2.5.3 Sensor Setup

This menu is dynamic; its contents are determined by the type of sensor which has been connected to the selected sensor input port (the 8540B is able to identify the sensor by reading its EEPROM data).

CW sensor setup If a CW sensor is connected, no sensor configuration is needed.

Peak Sensor Setup The Series 80350A peak sensor can be used in three modes: CW, Internally Triggered, and Externally Triggered. Use the Left/Right cursor buttons to select the desired mode, and press [ENTER].

CW No further configuration is required if the CW mode is selected.

Int In the Internally Triggered mode, peak power will be sampled at a point which is defined by a trigger level, a delay, and a delay offset. The delay offset feature is a convenience in some applications (for example, when measuring pulse width from a point other than the trigger level, or when comparing the levels of various pulses within a pulse train). When Set Trig Level is displayed, use the cursor buttons to adjust the displayed value (in dBm), and press [ENTER]. When Set Samp Delay is displayed, use the cursor buttons to adjust the displayed value (in ns, μs, or ms), and press [ENTER]. When Dly Offset is displayed, use the cursor buttons to adjust the displayed value (in ns, μs, or ms), and press [ENTER].

Ext The Externally Triggered mode is very similar to the Internally Triggered mode described above, except that the basis of triggering is a voltage input from an external source. Configuration of this mode is the same as for the internal mode, except that the trigger level is specified in volts rather than dBm.

Modulation Sensor Setup

CW No further configuration is required if the CW mode is selected.

Modulated Avg No further configuration is required if the Modulated Average mode is selected.

Pulse Avg The Pulse Average is similar to the Modulated Average mode, except that the user is able to specify a duty cycle (for pulse modulated inputs). When Set Duty Cycle is displayed, use the cursor button to adjust the displayed value (in %), and press [ENTER]. The range is 0.001% to 99.999%.

Burst Avg No further configuration is required if the Burst Average mode is selected.

2.5.4 RF Power On/Off

This entry window submenu activates and deactivates the front panel CALIBRATOR output (to adjust the value of the output, see the Service submenu). Use the left/right cursor buttons to select ON or OFF, and press [ENTER].

2.5.5 Config

Peaking Meter The 20 status LEDs on the front panel can be configured to serve as a peaking meter (that is, the stack of the LEDs turn on from the bottom up to give a rough visual indication of changes in the currently measured power level). The options are Status, PkA, and PkB. If PkA is selected, the LEDs serve as a peaking meter for Channel A. If PkB is selected, they serve as a peaking meter for Channel B. If Status is selected, the LEDs revert to their original role as status indicators.

GPIB This option gives the user an opportunity to specify the IEEE-488 GPIB address and the emulation mode for the 8540B. The choices of address are 0 through 30 (listen & talk), 40 (listen only), and 50 (talk only). The choices of emulation mode are 8541, 8542, 436A, 437B, and 438A.

Analog Out The analog output is an output voltage, proportional to measured power, that can be applied to auxiliary test equipment (such as a data recorder). The choices of output source are Top Line, Bottom Line, and Off. The choices of mode are Log and Linear. The output source choices are displayed under the heading Std Output. If Option 06 is installed, there are two outputs to be configured; in that case, select OFF under Std Output in order to reach the Option 06 configuration menu.

VprofF The VpropF (voltage proportional to frequency) connector accepts a voltage input in the range of 0 to +10V, which the 8540B uses to determine the frequency of the RF input, so that appropriate correction factors (stored in the probe's EEPROM) can be applied. The voltage input is supplied by a V/GHz output from the signal source. Select ON to activate this function. Two values must be defined for VpropF: the frequency at 0 Volts (specified in GHz) and the scale factor (specified in V/GHz). The V/GHz output connector on the frequency source is usually labeled with the scale factor.

Sound A speaker within the chassis produces audible clicks and tones, in order to register keystrokes, and to draw attention to certain conditions (for example, if a limit has been exceeded, or a calibration process has been completed). To activate or deactivate this speaker, select ON or OFF.

2.5.6 Service

Sensor ROM This menu records data in a power sensor's EEPROM. Select the sensor (A or B), and a series of entry windows appears. Normally, this menu is used only at the factory, for purposes of instrument configuration. It should not be used in the field, except under direction by the Giga-tronics customer service department. Carefully record all existing settings before changing them, so that they can be restored if necessary.

Calibrator The CALIBRATOR output produces a reference signal for calibrating power sensors. The reference signal is at 50 MHz (CW); its level is programmable in 1 dB increments over a range of -30 to +20 dBm. The level at 0 dBm is factory set to ±0.7%, traceable to the National Institute of Standards Technology (within 15 seconds of setting a 0.0 dBm level). Output levels are subject to drift over time, and are considered accurate during a calibration run or within a few minutes of setting a fixed reference level.

Test Functions This menu makes available a number of diagnostic tests which are normally used only by factory personnel. If you consult the Giga-tronics customer service department, you may be given instructions on how to use one or more of these tests.

Software Version Selecting this menu item causes the window to display the version of software that is installed in the instrument.

Clear All Memory Selecting this item causes all configuration data currently stored in the 8540B RAM to be cleared. Data stored in sensor EEPROMs is not affected.

2.5.7 Save Setup

Up to twenty different configurations can be stored in non-volatile memory. When Save Setup is selected, the entry window shows Save to Reg# 1. The Up/Down cursor buttons increment or decrement the number under which the current configuration will be saved. The range of numbers is 1 to 20. A setup that has been saved in memory can be retrieved by means of the RECALL button on the front panel.

2.6 Measurement Guide

This section of the manual presents simple guidelines for practical application of the 8540B. See Section 2.6.9 for mode restrictions.

2.6.1 Using the Power Sweep Calibrator

The Power Sweep Calibrator automatically calibrates the power sensor to the power meter. The power sweep operates from -30 to +20 dBm (the complete, non-square-law operating region) and transfers the inherent linearity of an internal, thermal-based detector to the balanced diode sensors. Output is NIST-traceable at 50 MHz, 0 dBm to an accuracy of ±0.7% (±1.2% over one year).
(Note: NIST is the *National Institute of Standards and Technology.*)

2.6.2 Sensor Calibration

The procedure for calibrating a sensor, which operates at levels of 1 Watt or less is:

1. Connect the power sensor to the 8540B power meter with the power sensor cable.
2. Connect the power sensor to the 8540B CALIBRATOR output.
3. Press [ZERO/CAL].

The 8540B will automatically verify that a sensor is attached to the CALIBRATOR connector. It will then zero and calibrate the sensor.

Sensors designed to operate above 1 Watt (for example, Models 80321, 80322, etc.) require a different calibration procedure because they are supplied with an external connectorized attenuator to protect the detector from high input power levels. The attenuator must be removed from the sensor during calibration. The following procedure is for calibrating sensors of this type:

1. Connect the power sensor to the 8540B Power Meter with the power sensor cable.
2. Remove the attenuator from the sensor.
3. Connect the power sensor to the 8540B CALIBRATOR output.
4. Press [ZERO/CAL]. The 8540B will automatically verify that the sensor is attached to the CALIBRATOR output. It will then zero and calibrate the sensor. The 8540B will automatically make adjustment in the calibration for the external attenuator.
5. Remove the sensor from the CALIBRATOR output and reattach the external attenuator. ***There are arrows printed on the attenuator label and the sensor label; be sure to attach the attenuator to the sensor so that these arrows align.*** The attenuator is characterized with the sensor for frequency response. At very high frequencies, the effectiveness of the characterization is dependent on the attenuator being connected to the sensor in the same way that it was during factory characterization; the arrows are included to ensure that the connection can be exactly duplicated.

Refer also to the Power Sensor Calibration Procedures in Appendix B of this manual.

2.6.3 Zeroing at Low Power Levels

The sensor should be zeroed just before recording final readings in the lower 15 dB of the power sensor's 90 dB dynamic range (that is, for readings below -55 dBm, in the case of standard sensors).

1. Turn off the source output before you zero the sensor. The microwave source must output less than -74 dBm of total noise power during RF Blanking for proper zeroing. The source signal power should be less than -90 dBm.
2. Press [ZERO/CAL] to start the zeroing process. If more than one sensor is connected to the power meter, a channel selection menu will appear.

The sensor should remain connected to the signal source during zeroing. By turning off the source instead of disconnecting the detector, the zeroing process automatically accounts for ground line voltages and connector interface EMFs.

Caution

Sensor diodes can be destroyed by momentary or continuous exposure to excess input power. The maximum power (peak or average) that can be applied to the detector elements without resulting damage is printed on the side of the sensor housing. For standard CW sensors, and peak power sensors, this maximum level is +23 dBm (200 mW). Standard sensors should not be used above +20 dBm (100 mW), because this may degrade the sensor's performance even if it does not burn out the diodes.

When measuring pulsed signals, it is important to remember that the peak power may be much greater than the average power (it depends upon the duty cycle). It is possible to overload the sensor with a pulsed signal, even though the *average* power of the signal is far below the maximum level.

To measure higher power levels, use a high power sensor, or else reduce the signal amplitude using a directional coupler or a precision attenuator.

2.6.4 Measuring Source Output Power

The procedure is:

1. Connect the power sensor to the RF output of the microwave source.
2. Verify that the microwave source's RF output is ON.
3. Press [FREQ] on the 8540B front panel; enter the operating frequency (using the cursor keys to adjust the value), and press [ENTER].
4. The 8540B is now displaying the microwave source's output power. Adjust the source's amplitude to the desired level.

The 8540B responds rapidly to amplitude changes. Ranging is automatically performed in real time through a 90 dB dynamic range, using CW or modulated sensors. The peak sensor dynamic range is 40 dB, Peak, and 50 dB, CW.

Entering the operating frequency enables the 8540B to automatically apply frequency calibration factors appropriate to the sensor being used. The operating frequency can be communicated to the 8540B using the front panel menus, the GPIB, or the VpropF voltage input. (The input connector for the VpropF function is labeled VαF IN on the 8540B rear panel.)

2.6.5 Using the Peaking Meter

The LEDs on the right side of the 8540B front panel can be configured for use as a 20-segment bar graph.

1. Press [MENU]. Select the Config menu. Select Peaking Meter.
2. Use the cursor to select PkA or PkB, and press [ENTER].
3. Adjust the source's amplitude control and observe the peaking meter.

The LED bar graph provides a linear display of power level on a decade range basis. For example, a power level of 3 dBm produces an approximate 50% response on the peaking meter.

2.6.6 High Power Level Measurements

High power amplifiers and transmitters can damage standard sensors. High power sensors make it possible to measure these devices without using attenuators and measurement offsets.

For example, if the output of an RF source is amplified to +30 dBm (1 Watt), this signal cannot be measured directly using a standard sensor, because the sensor's maximum input level is +23 dBm (and any level above +20 dBm is potentially harmful to a standard sensor). The signal would have to be attenuated, and the attenuation would have to be corrected for, by means of a measurement offset. However, if a 5 Watt high power sensor is used, any power level up to +37 dBm can be measured directly, without the use of an attenuator.

2.6.7 Modulated Measurement Modes

The 8540B series of power meters expands upon the capabilities of the previous 8540 power meters in a number of ways. In the past, power measurements of modulated signals (pulse, multi-tone, AM, etc.) required that the signals be attenuated to levels less than -20 dBm, to avoid errors due to sensor nonlinearity. The 8540B, when used with a 80401A series sensor, eliminates this restriction, and brings the speed and accuracy of diode sensors to the power measurement of modulated signals. Basic measurement procedures are presented below, along with some useful tips on how to get the most out of the new modulated measurement modes.

The new modulated measurement modes are available through the sensor setup menu when the active sensor is an 80401A. The 8540B features three modulated measurement modes:

- Modulated Average Power (MAP)
- Pulse Average Power (PAP)
- Burst Average Power (BAP)

MAP and PAP modes measure the true average power of modulated and pulsed signals. PAP mode differs from MAP mode only in that it allows you to specify a duty cycle figure, which is automatically factored into the measurement. In BAP mode, the true average power within the pulse is measured (the pulse pattern is detected automatically, so there is no need for you to specify the duty cycle).

MAP Mode

The Modulated Average Power (MAP) mode measures RF signals which are amplitude modulated, pulse modulated, or both. In the MAP mode the 8540B calculates the average RF power received by the sensor over a period of time controlled by the time constant of the internal digital filter. The result is comparable to measurement by a thermal power sensor.

In this mode, the 8540B measures the average power of CW and modulated signals, such as:

- AM
- Two-tone
- Multi-carrier
- Pulse modulation
- Digital modulation (QPSK, QAM, etc...)

For example, if an RF signal pulse modulated at 50 Hz with a 10% duty cycle is measured with the averaging factor set to 128, the filter settling time will be 5.12 seconds (40 ms times 128) and each reading will include 256 pulses (50 Hz times 5.12 seconds); the measured power reading will be 10% of the peak power during pulse ON periods. Because the signal is modulated at a low pulse rate (below about 1 kHz), the 8540B will synchronize the readings precisely with the start of a pulse so that each displayed reading is averaged over a whole number of pulses (that is, there are no fractional pulses included in the measurement). This eliminates a significant amount of noise from the readings. It is important to remember that even though the filter settling time has been set to a long time constant of 5.12 seconds, the update rate of the meter will be much faster, and even the first reading will be very close to the fully settled value.

PAP Mode

The Pulse Average Power (PAP) mode is similar to the MAP mode, but it is generally used to measure pulse modulated signals having a known duty cycle. You can specify this duty cycle and the 8540B will automatically correct the measurements so that the displayed readings indicate the peak RF power during pulse ON periods.

For example, when measuring a pulse modulated signal with 50% duty cycle, MAP mode would give a reading 3 dB lower than the reading that would be given by PAP mode with the duty cycle factor set to 50%.

NOTE: The duty cycle correction presumes a perfectly rectangular profile for the RF pulse shape. Any abnormality such as overshoot, undershoot, slow rise time or fall time, inaccuracy of the duty cycle, or deviation from a flat pulse response will cause errors in the indicated reading.

BAP Mode

The Burst Average Power (BAP) mode measures the average power during an RF burst. This mode is very useful for measurement of pulse modulated signals which are not flat or have amplitude modulation during the pulse ON period, as in the case of TDMA (Time Division Multiple Access) communications signals. In this mode, the 8540B recognizes the beginning and end of a burst of RF power and takes an average of the power during that burst. The RF level can vary over a wide range during the burst as long as it remains above a noise threshold, which is automatically calculated by the 8540B. As soon as the RF power drops below the noise threshold, the RF burst is complete and all further readings are discarded until the next burst starts.

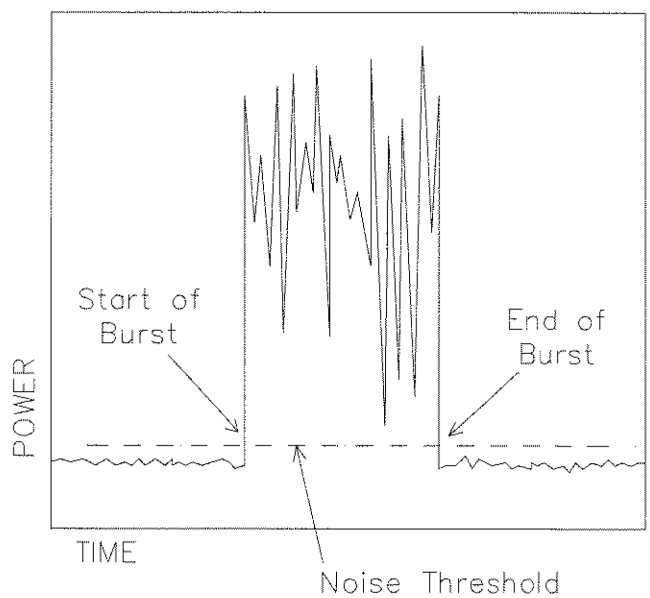


Figure 2-3. Burst Measurement

In BAP mode, the 8540B automatically determines which portions of the signal are in the pulse and which are not. In computing the average power, the 8540B uses only those portions that are within the pulse. The result is that, independent of the signal's pulse duty cycle, the meter always reads the average power in the pulse or burst. As with the PAP mode, when measuring a pulse modulated signal with 50% duty cycle, the reading in the BAP mode would be 3 dB higher than in the MAP mode. However, in the BAP mode, the signal's duty cycle can change dynamically in time without affecting the meter reading. In the PAP mode, the duty cycle factor must be entered to match the duty cycle of the pulsed signal.

2.6.8 Measurement Collection Modes

Using a wide range of CW and Peak Power Sensors and the GPIB fast measurement collection modes, the Series 8540B meters provide typical reading speeds of >200 readings per second in the free-run Swift mode, 30 readings per second in the Fast Modulated mode, and >2000 readings per second in the Fast Buffered mode. Three Swift mode triggering controls are available: Fast free-run, bus triggered, and TTL triggered modes. Bus and TTL allow triggering control of individual measurement points. Data can be stored in an internal data buffer or read immediately.

Fast buffered power readings are internally buffered for readout at the completion of the fast buffered interval. Maximum measurement rate is about 2600 readings per second. Data conversion and GPIB communication time are not included in this figure. The maximum buffer size is 5000 readings (or about 2.1 seconds at the maximum reading rate). The Option 02 buffer increases this to 128,000 readings.

CW Mode

This mode measures an unmodulated Continuous Wave (CW) signal. In this mode the RF signal level must be constant for accurate readings to be made. If the signal level changes, a settling time for the internal digital filter is required in order for measurements to be made to the specified accuracy.

The settling time (the time required for a measurement based on an averaging of samples to adapt to a changed condition and become accurate again) is affected by various factors. The maximum settling time is equal to 40 ms multiplied by the averaging factor (for example, if the averaging factor is 128, the maximum settling time is 5.12 seconds). In most situations the actual settling time is well below the maximum.

PEAK Mode (80350 Peak Power Sensor)

The Peak mode is used for instantaneous peak measurements of the RF power level of a pulse modulated signal during pulse ON periods. The measurement is based on an instantaneous sample taken at a particular point in time. Sampling is triggered by a pulse rising edge either in the modulated signal itself or in a supplied trigger input signal, followed by a programmable delay. The trigger/delay combination makes it possible for you to specify exactly what part of the pulse is sampled.

In the peak mode, each displayed reading can consist of a single sample or of an average of multiple samples, each taken at the exact same time relative to the pulse's rising edge. If the averaging factor is set to 1, single samples are used. If it is other than 1, the averaging factor will determine the filter settling time over which the multiple samples will be taken and averaged.

Because the peak mode measures the RF power instantaneously (at the top of the pulse, provided that the delay has been set correctly), no assumptions are made about the pulse shape or duty cycle. In fact, it is possible to profile the pulse by sweeping the delay time over a range of values to reveal the pulse shape from start to finish.

> **NOTE:** In the peak mode the 8540B does not know where the peak is. It samples the pulse where it is told to sample the pulse whether or not the point sampled is really the peak point. This mode is therefore less intelligent than the BAP mode and must be used carefully, but its flexibility makes it a powerful tool for studying modulated signals.

Peak power measurements are made by sampling the RF input at a point which is defined by a trigger level, a delay, and a delay offset (see Figure 2-4). The initial triggering event occurs when the power input (or in the case of external triggering, a voltage input) reaches a threshold which you have defined as the trigger level. The sample is then taken after a delay which you have defined. To this delay can be added a positive or negative delay offset.

The delay offset is not necessary for peak measurement, but in some applications it is a convenience. For example, a small offset (even a negative offset) might compensate for the difference between the trigger point and some other point of interest (such as the half-power point) especially in applications where pulse width is being measured. Or if it is necessary to measure the levels of various pulses within a pulse train, the pulses can be sampled successively by changing the delay. A fixed delay offset insures that each pulse is sampled at the same point in its cycle.

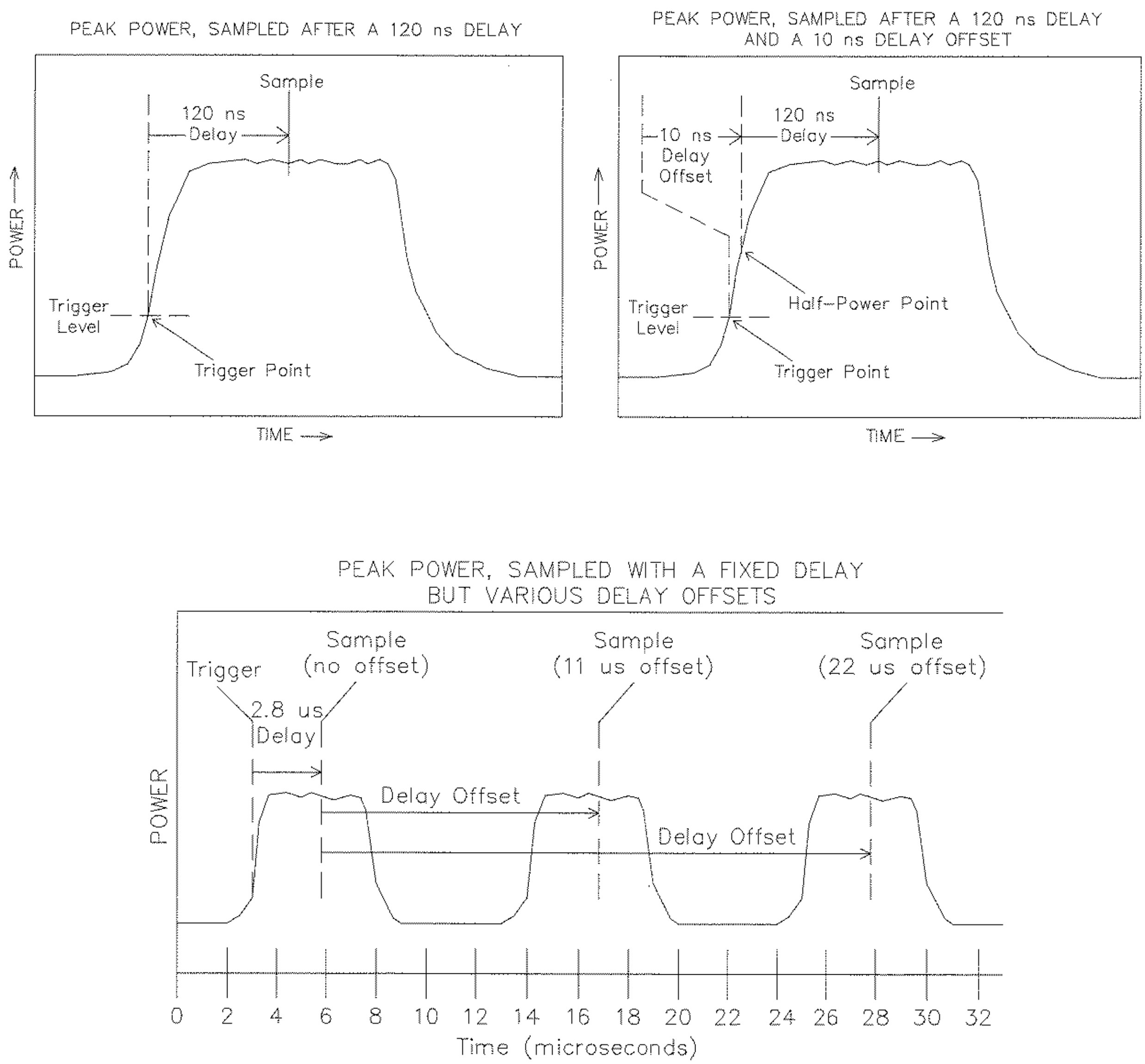


Figure 2-4. Delay and Delay Offsets

2.6.9 Mode Restrictions

In certain modes the 8540B has specific restrictions on its operation:

- In the PAP, MAP, BAP, and PEAK modes, only one sensor can be used at a time (it can be either A or B but not both). This is true regardless of the measurement collection mode being used.
- In the fast measurement collection modes (swift and fast buffered), it is not possible to make measurements which compare the two channels. In other words, it is possible to make measurements using sensor A, or B, or both, but measurements such as A/B and A-B are not permitted.
- In GPIB remote operation, only one reading can be sent over the bus (it can be A, or B, or a comparative measurement such as A/B, but it is not possible for separate measurements of A *and* B to be sent over the bus). The exception is that in the swift and fast buffered measurement collection modes, it is possible for both A and B to be sent over the bus.

2.6.10 When to use CW, MAP, and BAP

For measuring signals with any kind of modulation, MAP mode should be used. In this mode, the 8540B makes use of its digital signal processing algorithms to ensure that the reading is the correct average power level regardless of modulation type (see Section B.2.2 for limits on modulation rate, etc.).

Of course, CW signals may also be accurately measured in MAP mode. This raises the question, why use CW mode? CW mode offers a few more dB of dynamic range at low power levels when using a CW power sensor, such as the 80301A. In addition, in CW mode the 8540B is form fit and function compatible with its predecessor, Model 8540.

BAP mode should be used only for the measurement of signals which are pulse modulated. In this mode the meter will accurately measure the average power of the signal during the on-time of the pulse. This mode works equally well regardless of whether the signal is modulated during the pulse on-time.

2.6.11 Multi-Tone Tests

Multi-tone testing refers to more than one RF carrier combined into one signal to be measured. Two-tone intermodulation testing, for example, is a common test performed on a wide variety of RF components and subsystems. MAP mode should be selected for these applications. The 8540B test procedure is as follows:

1. Calibrate the sensor according to the procedure outlined earlier in this section.
2. Press [MENU] and select Sensor Setup. Select Modulated Avg. and press [ENTER].
3. Press [FREQ] and enter the operating center frequency.
4. Connect the sensor to the multi-tone source and record the power level.

For two-tone testing, small errors in the measurement will result when the carriers are separated by more than about 50 kHz. The amount of error is also a function of average power level. For average power less than about -20 dBm, there is no modulation-induced measurement error at any tone separation. Consult the error charts found in Section B.2.2.

Multi-carrier testing usually refers to more than two carriers combined into one signal. Common multi-carrier tests combine 10 to 20 carriers. In determining expected measurement error for these types of signals, the maximum difference in frequency between any two carriers should be used as the tone separation when applying the error charts in the manual.

Another important feature of multi-carrier signals is that they can have a high peak-to-average power ratio. This ratio can be as high as 10 dB for ten carriers, for example. The significance of this in terms of making power measurements is two-fold. First, care should be taken to keep the peak power level applied to the sensor below the maximum recommended level. Second, when trying to minimize modulation-induced measurement error for carriers separated by more than 50 kHz, it is the peak power level that should be kept below about -20 dBm.

2.6.12 Peak Hold

When the Peak Hold feature is selected, the 8540B displays the highest instantaneous power measured from the time the feature is enabled until it is reset by the user. In other words, the displayed value tracks the measured value only when the measured value is rising to a new maximum. When the measured value falls, the displayed value holds at the maximum. When the peak hold feature is reset, the displayed value falls to the current measured value and the process begins again.

The Peak Hold feature is available in the MAP, PAP, and BAP measurement modes; it may be enabled from the front panel under the measurement setup menu, or over the GPIB. Peak Hold is reset by pressing [ENTER] on the front panel (or, in remote control, by re-sending the command which activates the Peak Hold feature.

The reset function can be used to control the time resolution of the reading (that is, for finer resolution, reset more frequently).

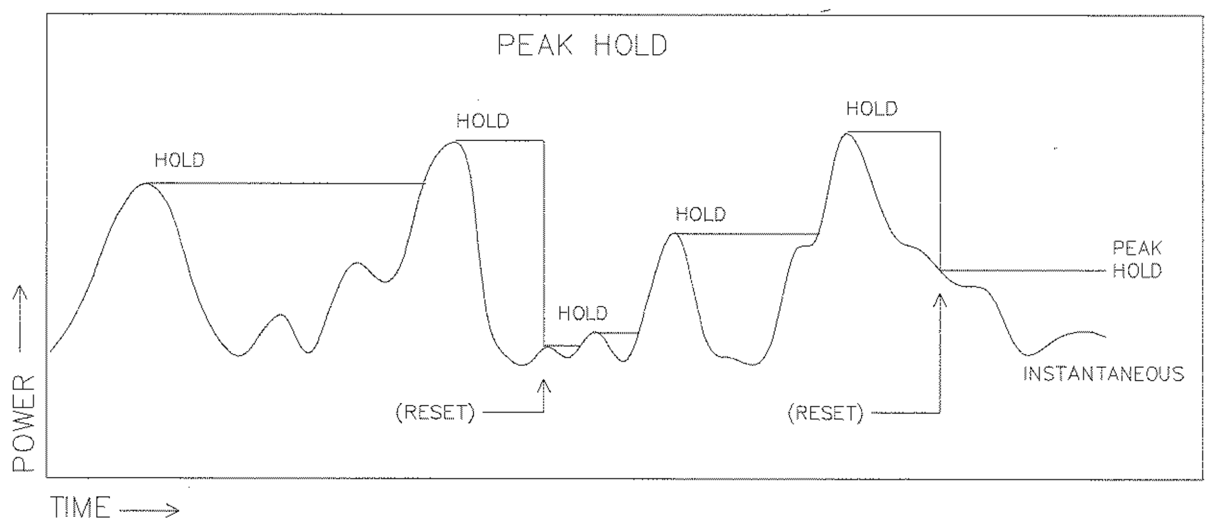


Figure 2-5. Peak Hold

2.6.13 Crest Factor

The Crest Factor feature is very similar to the peak hold feature, in that it holds on to the maximum level until a reset occurs, but in this case the displayed value is expressed (in dB) as a ratio of the held maximum power to the *average* power.

The Crest Factor feature is available in any measurement mode (CW, MAP, PAP, or BAP); it may be enabled from the front panel under the measurement setup menu, or over the GPIB. The Crest Factor feature is reset by pressing [ENTER] on the front panel (or, in remote control, by re-sending the GPIB command which activates the Crest Factor feature).

In the figure below, the same power input trace is used in two graphs to illustrate the effect of a drop in average power, with and without a reset. In the top graph, the power drop is followed by a reset. The held value drops to the current measured value, and the crest factor represents the ratio between the new maximum level and the new average level. In the bottom graph, there is no reset after the power drop, and the crest factor represents the ratio between the old maximum level and the new average level. For this reason, the crest factor feature should be reset after an input power level change.

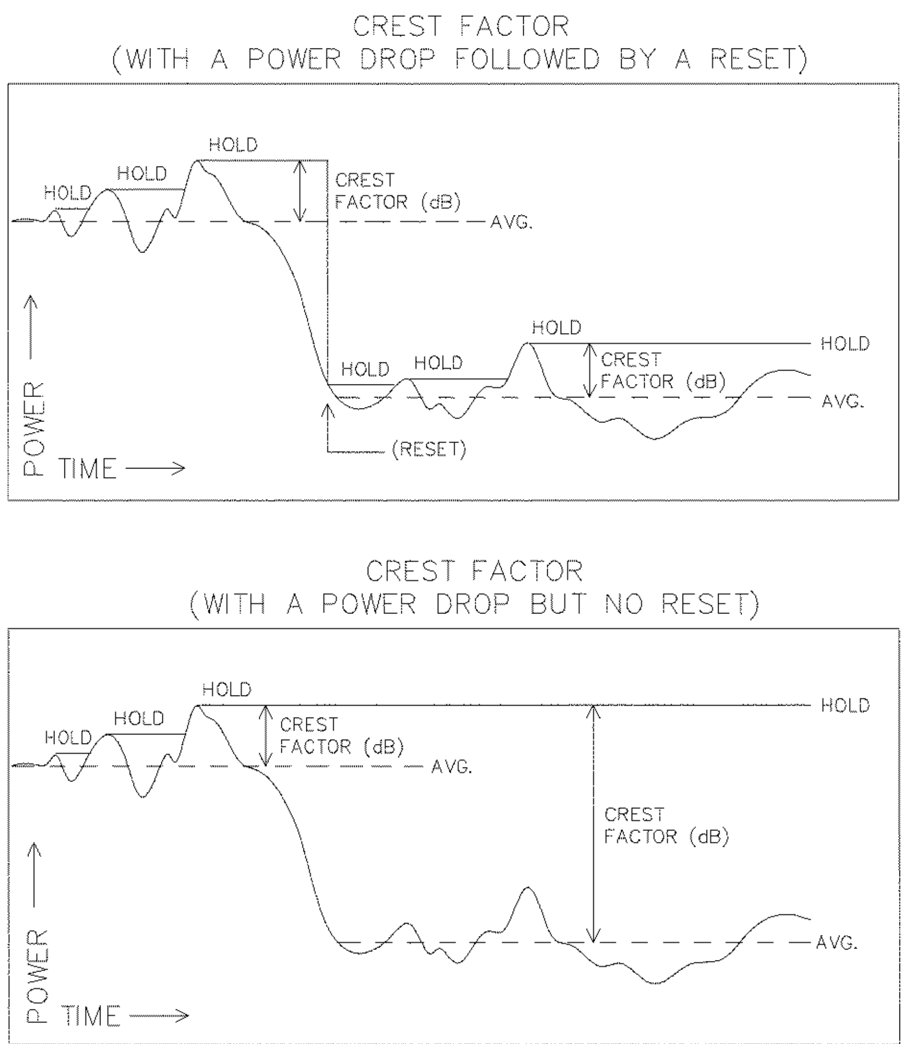


Figure 2-6. Crest Factor

2.6.14 Burst Signal Measurements

In a burst signal, the RF is pulsed on and off (i.e., pulse modulated). Often, the RF is modulated during the pulse on-time. Typical examples are TDMA digital cellular telephone formats such as NADC, JDC, and GSM. These formats and many others produce amplitude modulation of the RF during bursts.

Two types of power measurement can be made on these types of signals. If the total average power is desired, MAP mode should be used. Total average power includes both the off and on time of the pulses in the averaging. Often it is desired to know the average power just during the bursts. BAP mode makes this type of measurement very easy. The procedure is as follows:

1. Calibrate the sensor according to the procedure outlined earlier in this section.
2. Press [MENU] and select Sensor Setup. Select Burst Avg. and press [ENTER].
3. Press [FREQ] and enter the operating center frequency.
4. Connect the sensor to the burst signal source and record the power level.

The 8540B will automatically find the portions of the signal which are in the burst and include only those portions in the average.

Burst signals can have a high peak power-to-average power ratio depending on duty cycle. This ratio is proportional to the duty cycle and is given by:

$$10 \cdot \log\left(\frac{Duty\ Cycle\ [\%]}{100}\right)$$

This assumes no modulation during the burst. Modulation during the burst will increase this ratio by its own peak-to-average ratio. Due to this characteristic of burst signals, care must be taken to keep the peak power below the maximum rated input power of the sensor.

NOTE: If the burst average power is too low or if the bursts are too narrow, the 8540B may lose sync with the bursts and fail to display the burst average power. When this happens, the BAP mode indicator on the front panel will flash and the meter will display total average power as in MAP mode. The conditions under which the 8540B may lose sync are listed in Section B.2.2.

2.6.15 Burst Start Exclude, Burst End Exclude

When measuring burst signals, it is sometimes desirable to mask the beginning or the end of a burst so that overshoot and other distortions do not affect the reading. For example, the GSM test specification for burst power measurements requires exclusion of the first 5% of the burst.

The Burst Start Exclude and Burst End Exclude features make it possible for BAP mode measurements to exclude the beginning or the end of a burst in this way. Both features can be used simultaneously, but this requires caution: if the excluded periods overlap, there is nothing left of the burst to be measured. If the entire burst is excluded, the BURST AVG LED on the front panel will flash, and the meter will revert to average measurement in the style of the MAP mode.

The duration of the excluded period is not specified directly; instead, the number of samples to be excluded is specified, which yields a guaranteed minimum exclude time of 90 μs × (n + .5), where n is the number of samples. The actual amount of time excluded may substantially exceed this minimum. In typical applications, it is sufficient to exclude one sample, which yields a guaranteed minimum exclude time of 135 μs.

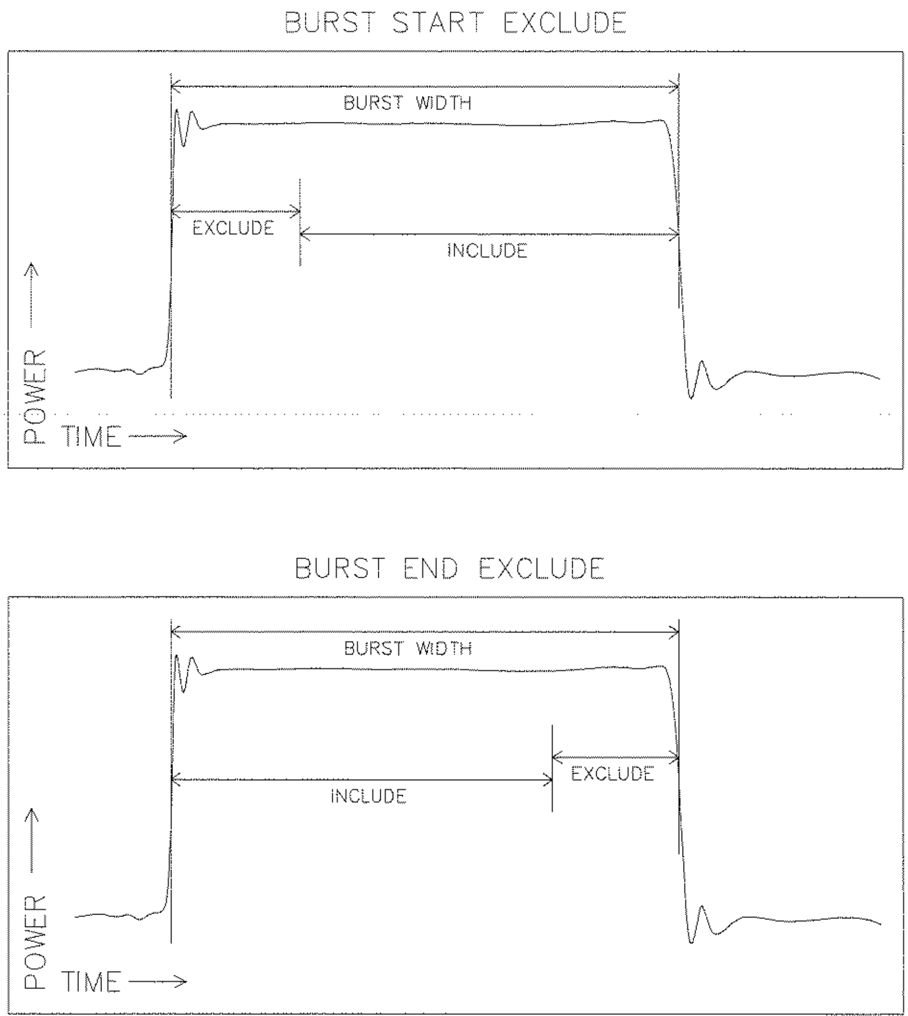


Figure 2-7. Burst Start Exclude & Burst End Exclude

2.6.16 Burst Dropout

In the BAP mode, average power is measured only during bursts. Because, in this mode, the bursts are automatically detected by the power meter, the user need not be aware of the burst repetition rate in order to make the measurement.

However, the BAP measurement algorithm defines bursts in a way which may be considered undesirable in some applications. In the example illustrated below, a 3.5 ms burst is followed by an OFF period of the same duration. During the burst, two brief dropouts occur. Normally, in BAP mode, each dropout would be interpreted as the end of a burst; the BAP algorithm would interpret the burst as three separate bursts, and the dropouts would be excluded from the average power measurement. As a result, the average power reading would be artificially raised.

When the Burst Dropout feature is enabled, the BAP algorithm is modified so that a dropout of sufficiently brief duration is not interpreted as the end of a burst. In the example below, dropout time is specified at 350 μs. The two dropouts which occur during the burst have a duration of less than 350 μs; therefore the entire burst is interpreted as a single burst, and the dropouts are included in the average power measurement. The 3.5 ms OFF period following the burst is interpreted as the end of the burst, because it exceeds 350 μs in duration.

This feature must be configured and interpreted with care. The dropout time is selected from a series of discrete values (.17 ms, .26 ms, .35 ms, and so on up to 31.96 ms); however, these are only the guaranteed minimum values. In practice, the BAP algorithm may tolerate dropouts up to 2.15 times as long as the minimum value. Therefore, the time between bursts must be at least 2.2 times as long as the selected dropout time (because, if the time between bursts is less than the tolerated dropout time, the BAP algorithm never recognizes the end of a burst, and the signal is simply averaged, as if the MAP mode had been selected). Also, dropouts occurring at the end of a burst are a problem, because the BAP algorithm cannot distinguish them from the end of the burst itself; there should be at least 250 μs of burst remaining after the last dropout within that burst.

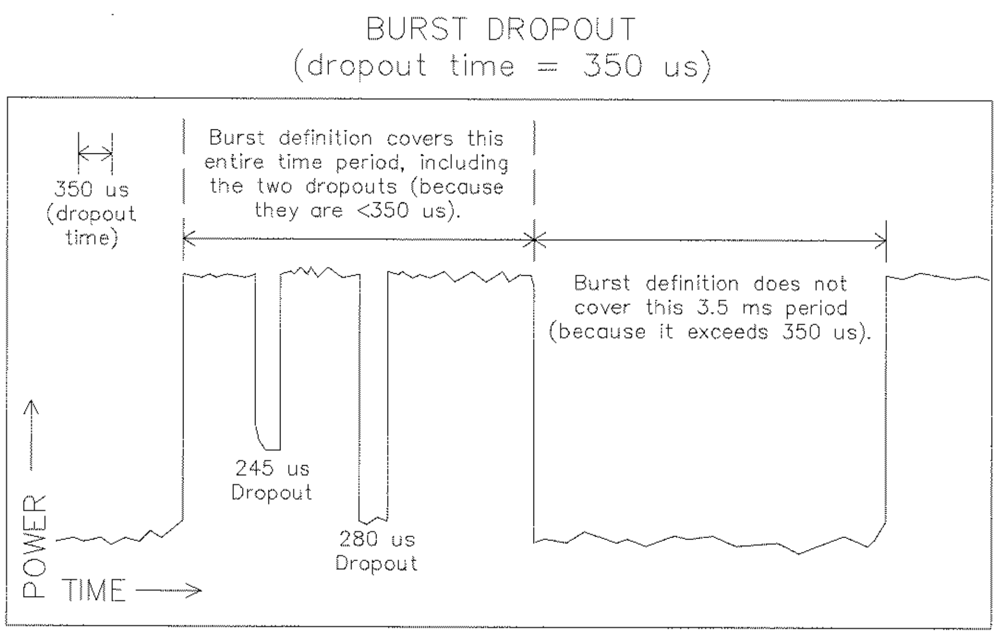


Figure 2-8. Burst Dropout

2.6.17 Optimizing Measurement Speed

In many power measurement situations, measurement speed is defined in terms of settling time following a step change in average power. In other words, it is desired to know the average power level within some specified tolerance as quickly as possible following a power level change. This is often accomplished by setting up the power meter in free-run mode over the GPIB and monitoring the collected measurement data with the host computer until it falls within the predetermined tolerance window.

The Auto average feature of the 8540B eliminates the need for the host computer to do any data monitoring and can be set up to automatically output measurement data when it has settled to within the specified tolerance. This is done by triggering each measurement with a TR2 command and waiting for the meter to signal the host with an SRQ. The SRQ is asserted and the data is put on the bus as soon as the power measurement has averaged long enough to be within the specified tolerance.

The tolerance is specified by including the measurement settling tolerance parameter with an FA command (Auto average on). This parameter is specified in terms of percentage. For example, if a measurement settling tolerance of 1% is specified, the 8540B Auto average algorithm will specify an averaging time just long enough so that the result put on the bus is within +/- 0.5% (that is, +/- .02 dB) of the average power. Thus, the settled measurement data is available on the bus in the minimum time necessary to be within the specified tolerance.

The tolerance specified in the FA command is a *target* tolerance. For example, it is possible that the peak-to-peak power variation of the signal being measured is so great that the maximum averaging time of 20 seconds is not long enough to reduce the variation to within the specified tolerance. It is also possible that the rate of power variation is so slow that more than 20 seconds of averaging is required. In these cases, further averaging would have to be done by the host computer.

The following example program shows how to set up a triggered measurement, optimized for speed using the auto averaging feature:

```
Tr2:                              ! Read using TR2 command
ON INTR 7 GOSUB Srq_interrupt     ! Set up SRQ interrupt
ENABLE INTR 7                     ! Enable SRQ interrupt
OUTPUT 713;*SRE41                 ! Set service request mask
OUTPUT 713;CS                     ! Clear status byte
OUTPUT 713;TR2                    ! Trigger measurement
Data_ready=0                      ! Clear flag
WHILE Data_ready=0                ! Wait for data ready
END WHILE
RETURN
Srq_interrupt:                    ! SRQ jumps here
State=SPOLL(713)                  ! Get status byte
IF BIT(State,0) THEN              ! If the Data Ready bit is set...
    Data_ready=1                  ! Set the flag
    ENTER 713;Tr2_reading         ! Read the measurement
    OUTPUT 713;CS                 ! Clear the status byte
    OUTPUT 713;*SRE0              ! Clear the service request mask
END IF
RETURN
```

2.6.18 Peak Power Measurements

Peak power sensors directly measure the amplitude of pulsed microwave signals. The direct sampling technique is more accurate than traditional duty cycle correction methods. The sample position can be displayed on an oscilloscope.

1. Calibrate a peak power sensor and connect it to a pulsed microwave source.
2. Press [MENU]. Go to the Sensor Setup menu, and select internal, external, or CW triggering.
3. Select the desired trigger level (for external or external triggering).
4. Select the desired sample delay (for internal or external triggering).
5. Optionally, set the desired delay offset (for internal or external triggering).
6. Connect the peak power sensor's Detector Out to an oscilloscope to view the sample position. For 80350A Peak Power Sensors, also connect the sensor's Sample Delay output to the oscilloscope and trigger on that channel.

2.6.19 Measuring an Attenuator (Single Channel Method)

Attenuators are useful for many applications. With the 8540B, attenuators can be calibrated quickly and accurately. The single channel calibration procedure outlined below is efficient for calibrating at a single frequency or at a limited number of frequencies.

1. Connect the power sensor to the signal source through a 6 dB attenuator (a matching pad) and adjust the source output power to about 0 dBm. Verify that the source output is stable.
2. Press [FREQ] on the 8540B front panel and enter the operating frequency (this step is optional).
3. Press [REL] to set the reference level.
4. Insert the attenuator to be calibrated between the matching pad and the power sensor.
5. Record the attenuator value.

2.6.20 Improving Accuracy

Mismatch uncertainty is the largest source of error in power measurement. The 6 dB pad that is used in the attenuator calibration procedure above reduces mismatch uncertainty by effectively improving the return loss (or reducing the SWR) of the source.

Mismatch uncertainty is large when a device has a poor impedance match relative to 50 Ω.

Poorly matched devices reflect a large proportion of incident signals and create standing waves along the transmission line. At various points along the transmission line, the standing wave will be at maximum or minimum amplitude. Mismatch uncertainty is a measure of the deviation between these maxima and minima.

Inserting an attenuator into the transmission line reduces mismatch uncertainty by reducing the amplitude of the reflected signal, thereby reducing the difference between a standing wave's maximum and minimum levels.

Compared to an attenuator, most microwave sources have poor impedance matching. Using the 6 dB attenuator during the calibration has the effect of lowering the SWR of the microwave source. The only compromise is a corresponding 6 dB reduction in the source's dynamic range when the 6 dB attenuator is attached.

2.6.21 Comparing Accuracy to a Traceable Standard

Verifying accuracy and calibrating test equipment are essential to microwave engineers and technicians. Accurate, repeatable measurements are required for validating designs, certifying calibrations, making engineering decisions, approving product components, certifying standards, and verifying performance specifications.

1. A 6 dB attenuator is placed at the input port of a power splitter to provide a good impedance match from the source. This effectively reduces the VSWR of the source. Depending on the signal quality of your source over frequency, additional attenuation may be desirable. A two resistor power splitter provides consistently matched power levels at its output ports, X and Y. The largest sources of error are power splitter tracking errors and mismatch uncertainty.
2. Connect the reference standard power meter to power splitter output X, and the power meter to be verified to splitter output Y.
3. Adjust the source frequency to a standard reference frequency (50 MHz for most power meters).
4. Enter the operating frequency or frequency cal factors into the power meters.
5. Adjust the source amplitude to the maximum sensor operating level (+20 dBm for standard sensors).
6. Zero each power meter and record the measurement values immediately after settling.
7. Adjust the source for +19 dBm output level and repeat Step 6.
8. Continue testing at 1 dB increments through the rest of the standard sensor's 90 dB dynamic range.
9. Calculate measurement uncertainty and compare the measured results to the specified tolerances.

At low power levels, be sure to zero the sensor prior to taking measurements. At levels below -55 dBm, the measurements should be recorded just after zeroing is completed. The zeroing process must be repeated periodically, depending on the operating level, due to drift characteristics.

2.6.22 Sources of Error

In the previous accuracy verification procedure, there are four sources of error:

- Source output level variation
- Power splitter output tracking
- Power meter X total measurement uncertainty
- Power meter Y total measurement uncertainty

Worst case uncertainty, which should be used for calibration purposes, is the arithmetic sum of all four of these sources of error.

Source output level variation occurs in all microwave sources. This happens when the signal source output level changes during the time it takes to record the displayed value on power meter X and then to read the displayed value on power meter Y. This source of error can be minimized by using a laboratory grade signal source.

Power splitter output tracking errors are the maximum signal level variation at the splitter X output as compared to the splitter Y output.

Total measurement uncertainty for each of the power meters is the worst case combination of mismatch uncertainty, instrument accuracy, and sensor accuracy.

Mismatch uncertainty is calculated from the reflection coefficients of the sensor and the splitter (source) according to the following formula:

$$M\,(dB) = 20 \log_{10}\,[1 \pm (\rho_{SENSOR})\,(\rho_{SOURCE})]$$

$$\text{where } \rho = \frac{VSWR - 1}{VSWR + 1}$$

For a source mismatch specified in terms of return loss (RL), the equation should be modified according to:

$$\rho_{SOURCE} = 10^{r}$$

$$\text{where} \quad \rho = \frac{-RL\,(dB)}{20}$$

The following factors affect instrument accuracy:

- Instrument linearity or instrumentation uncertainty
- Reference calibrator settability or power reference uncertainty

The following factors affect sensor accuracy:

- Calibration factor uncertainty
- Calibrator to sensor (or power reference to sensor) mismatch uncertainty
- Noise
- Zero set
- Calibration pad uncertainty (for thermal-based power meters only)
- Sensor linearity

3

Remote Operation

3.1 Introduction

The 8540B permits data control over the General Purpose Interface Bus (GPIB) in accordance with IEEE Standard 488-1978, *Digital Interface for Programmable Instruments*. Table 3-1 lists the functions of the standard that are implemented in the 8540B.

Table 3-1. Implemented IEEE Standards

Function	8540B Implementation
Source Handshake	SH1 (complete capability)
Acceptor Handshake	AH1 (complete capability)
Talker	T5 (basic talker, serial poll, talk only mode, unaddressed if MLA)
Extended Talker	TE0 (no capability)
Listener	L3 (basic listener, listen only mode, unaddressed if MTA)
Extended Listener	LE0 (no capability)
Service Request	SR1 (complete capability)
Remote/Local	RL1 (complete capability)
Parallel Poll	PP1 (remote configuration)
Device Clear	DC1 (complete capability)
Device Trigger	DT1 (complete capability)
Controller	C0 (no capability)

3.1.1 Sending Commands to the 8540B

The Giga-tronics 8540B Series Power Meters use standard protocols for communication over the GPIB. Commands conform to the IEEE-488.1 or IEEE-488.2 guidelines. Three emulation modes (436, 437, and 438) are available for users of older power meters who cannot re-write their application software.

The program examples shown in this chapter are written in HTBasic™ format (HTBasic is a trademark of TransEra Corporation). Other languages would use different commands but the string that is sent or received will always be the same. In HTBasic, the OUTPUT command sends a string to the GPIB. The number after the word OUTPUT is the GPIB address of the instrument.

The factory-set default address of the 8540B is 13 and the address of the GPIB is assumed to be 7; therefore, examples of command strings in this manual are preceded by OUTPUT 713;.

The GPIB address can be set from the front panel to any number from 0 to 30. GPIB address 40 will set the instrument to the listen only mode. Address 50 sets the instrument to the talk only mode. To change the GPIB operating mode or address, enter the menu system with the MENU key. Select the **SETUP** menu using the up/down arrow keys. Enter this sub menu system and select the GPIB setup menu key. The operating mode and GPIB address can be set in the GPIB setup menu using the arrow keys. Press [ENTER] to save your selection or press [ESCAPE] (the MENU key) to exit without saving.

3.1.2 Clear Device

The interface command CLEAR 713 may be used to reset the GPIB and set the 8540B to its preset condition.

3.1.3 Clear Interface

The interface command ABORT 7 may be used to reset the GPIB without setting the 8540B to its preset condition. The 8540B will not be addressed after the abort.

3.1.4 Local & Remote Control

The interface command LOCAL 713 may be used to place the 8540B in the local control mode. When the 8540B is in local mode, the front panel REMOTE LED is off and all front panel keys are enabled.

The interface command REMOTE 713 may be used to place the 8540B in the remote control mode. When the 8540B is in remote mode, the front panel REMOTE LED is on and all front panel keys except the ENTER key are disabled. Press [ENTER] to return the instrument to local mode.

The interface command LOCAL LOCKOUT 7 may be used to place the 8540B in the local lockout mode. This is a remote control mode in which all of the 8540B front panel keys including the remote control mode are disabled. The GPIB LOCAL command must be issued in order to return the 8540B to local mode (disconnecting the GPIB cable will also return the instrument to local mode).

3.1.5 Sensor Selection and Calibration

Power sensor selection data, specifications, and calibration (local and remote) are contained in Appendix B of this manual.

3.1.6 Polling

The GPIB supports parallel and serial polling. The example programs below show how to use the parallel and serial poll capabilities of the 8540B to determine when a requested zeroing operation is completed.

Parallel Polling

```
Ppoll_zero:                              ! zero using parallel poll
PRINT entering parallel poll zero routine
PPOLL CONFIGURE 713;8                    ! configure response on bit zero
OUTPUT 713;CSAEZE                        ! clear status byte, zero channel A
State=0                                  ! initialize variable
WHILE State 1                            ! stay here until zero done
    State=PPOLL(7)                       ! read the poll
    END WHILE
PPOLL UNCONFIGURE 713                    ! cancel parallel poll mode
PRINT parallel zero done
RETURN
```

Serial Polling

```
Srq_zero:                                ! zero with an srq interrupt
PRINT entering SRQ interrupt zero routine
ON INTR 7 GOSUB Srq_interrupt
OUTPUT 713;CS                            ! clear status byte
ENABLE INTR 7;2                          ! enable srq interrupts
OUTPUT 713;@1;CHR$(2)                    ! enable srq handshake
OUTPUT 713;AEZE                          ! execute zero command
Flag=0                                   ! test flag reset to false
WHILE Flag=0                             ! stay here until test flag set true
    WAIT 1
    PRINT Still inside while loop
END WHILE
PRINT SRQ interrupt zero done
RETURN
Srq_interrupt:                           ! SRQ interrupts jump here
PRINT an SRQ interrupt has occurred
OUTPUT 713;CS                            ! clear status byte
Flag=1                                   ! set control flag true
RETURN
```

3.1.7 Data Output Format (Standard Measurement Collection Mode)

The data output format is as follows:

±D.DDDDE±NNCRLF

±	Sign of the Mantissa
D.DDDD	Mantissa (5 digits)
E	Exponent (indicates that an exponent follows)
±	Sign of the Exponent
NN	Magnitude of the Exponent
CR	Carriage Return
LF	Line Feed

3.1.8 Data Output Formats (Fast Measurement Collection Modes)

Data output formats for the swift mode and fast buffered mode differ from the format described above. Data is expressed in the form of a signed five-digit number, with two digits to the right of the decimal, and no exponents. In some cases, multiple values are sent:

One sensor swift mode:	±DDD.DD CRLF
Two sensor swift mode:	±DDD.DD, ±DDD.DD CRLF
Fast buffered mode:	±DDD.DD, ... ±DDD.DD CRLF

3.1.9 Power-on Default Conditions

The interface's wake-up state is as follows:

GPIB Local Mode
Unaddressed, Service Request Mask Cleared
Status Byte Cleared
TR3 Free Run Trigger Mode Set
GT2 Group Execute Trigger Mode Set
Parallel Poll Data Line Unassigned
Display Enabled
Service Request Mask Cleared
Event Status Register = 128
Event Status Mask Clear

3.2 Command Syntax

The elements of the 8540B interface commands are introduced below. The discussion is general. Because some commands are included for the sake of compatibility with earlier models, there are some variations in syntax from one command to another which must be carefully accommodated.

3.2.1 Functions

At a minimum, the interface command includes a function code. The function indicates the nature and purpose of the command. Some commands contain a function code and nothing else. For example, the function AP, which causes the 8540B to measure power using the A sensor, stands alone as a command. Commands which consist only of a function code are referred to in this manual as simple commands. However, most commands consist of a function code combined with other elements.

Functions are listed alphabetically in the Command Set tables (see Section 3.3).

3.2.2 Prefixes

Some commands must begin with a prefix that identifies the sensor to which the command applies. For example, function code ZE (which causes a sensor to be zeroed) must be combined with a prefix in order to specify which sensor is zeroed. The full command is either AE ZE (for sensor A) or BE ZE (for sensor B).

Many of the commands described in this chapter are stated to require an AE or BE prefix, which specifies the sensor that will be affected by the command. In some situations, the prefix can be omitted.

When the 8540B receives a command containing a sensor-specific prefix, it assumes that all subsequent commands refer to the same sensor until a command is received which specifies the other sensor. Therefore, if a command prefixed by AE is received, subsequent commands can omit the prefix provided that they are intended for Sensor A.

Because Model 8541B supports only one sensor, the AE and BE prefixes can be omitted from any command issued to that model.

It does no harm to include the prefix even when it is superfluous; some users may find that the most convenient approach is to include the prefix in all applicable commands.

3.2.3 Variables

Some commands must include one or more variables to specify quantities or options for the command. For example, the function code ANALOG (which is used in commands that configure the analog output) is combined with many different variables to specify different aspects of the analog output. In the command **ANALOG STD TOP LOG -80.0, 20.0, 0.0, 10.0**, the variables are interpreted as follows:

STD	Specifies the standard analog output (as opposed to the optional second output).
TOP	Specifies the top line of the display.
LOG	Specifies that power is to be measured in logarithmic units (that is, dB or dBm).
-80.0	Specifies that the low end of the analog output voltage range represents -80 dBm in.
+20.0	Specifies that the high end of the analog output voltage range represents +20 dBm in.
0.00	Specifies that the low end of the analog output range is 0 volts.
10.0	Specifies that the high end of the analog output range is 10 volts.

In the above example, the numeric variables are strung together, with separator characters between them (see Separators below). However, in some commands, numeric variables are preceded in the command string by the variable name. For example, in the command FBUF PRE TTL BUFFER 200 TIME 1300, the numeric variables known as buffer and time are identified by name within the string.

Many variables are qualitative rather than quantitative; they select from among the various modes or options available for a particular function.

3.2.4 Suffixes

Some commands require a terminating suffix. For example, the function code DY specifies a duty cycle. It requires an AE or BE prefix (to indicate which channel is meant), and a numeric variable (to indicate the duty cycle as a percentage). Finally, the command must include a terminating suffix (the choices of suffix in this case are EN, PCT, and %). The command AE DY 50 % sets the duty cycle for channel A to 50 percent.

☛ **NOTE:** Some commands that include numeric variables require a terminating suffix. However, many other commands do not require terminating suffixes, and interface problems will occur if the suffixes are used in commands which do not need them. Each command must be used so that its particular syntax requirements are met.

3.2.5 Separators

Spaces, commas, colons, and semicolons can be used as separators between the various elements of a command (function codes, variables, etc.). Commands are usually spelled out in this manual with spaces inserted between the elements (for example, SWIFT PRE GET BUFFER 100), for the sake of readability. Although separators within a command are permitted, they are usually not required; in the command descriptions in this chapter (beginning with Section 3.4), required separators are noted.

3.2.6 Command Format Illustrations

A simple tabular format is used in this chapter to show the possible elements of a command. For example:

AE or BE	DY	*n*	EN or PCT or %

In this example, the prefix can be AE or BE, the function is DY, a numerical variable follows the function, and the suffix at the end can be EN, PCT, or %.

Possible commands which use this example format include AE DY 42 % and BE DY 29.5 EN.

3.3 Command Codes for the Series 8540B

3.3.1 IEEE-488.2 Common Commands

Table 3-2 lists the IEEE-488.2 common commands that are implemented in the 8540B. For further information refer to the manual sections cited in the table.

Table 3-2. 8540B Command Set

Command	Description	Section
*CLS	clear status byte	3.30.1
*ESE	set Event Status Enable Register	3.30.2
*ESE?	ask for current status of Event Status Enable Register	3.30.2
*ESR?	ask for and clear Event Status Register bits	3.30.2
*RST	software reset	3.26
*STB?	ask for status byte	3.30.1
*SRE	set the service request mask	3.30.1
*SRE?	ask for service request mask	3.30.1
*IDN?	ask for instrument ID	3.14

3.3.2 8540B Function Codes

Table 3-3 lists the function codes that are applicable when the instrument is in the 8541B mode or the 8542B mode. Most of these codes do not stand alone; commands; prefixes, variables, and suffixes must be combined with them. For further information refer to the manual sections cited in the table.

Table 3-3. 8540B Function Codes

Code	Description	Section
@1	set service request mask	3.30.1
@2	set learn mode 2 data	3.15.2
?ID	ask for instrument ID	3.14
AD	measure A-B	3.29
ANALOG	configure analog output	3.4
AP	measure sensor A	3.29
AR	measure A/B	3.29
BAP	BAP mode	3.19.4
BD	measure B-A	3.29
BP	measure sensor B	3.29
BR	measure B/A	3.29
BSPE	burst end exclude	3.20
BSTE	burst start exclude	3.20

Code	Description	Section
BTDP	burst dropout	3.20.3
CL	calibrate sensor	3.7
CRF	ask for crest factor value	3.9
CR	crest factor	3.9
CS	clear status byte	3.30.1
CW	CW mode	3.19
DA	test LEDs	3.10
DC0	duty cycle disable	3.11
DC1	duty cycle enable	3.11
DD	display disable	3.10
DE	display enable	3.10
DU	display user message	3.10
DY	set duty cycle	3.11
EEPROM	sensor EEPROM query	3.12
FA	auto averaging	3.5
FBUF	fast buffered mode	3.18.3
FH	hold current averaging number	3.5.1
FM	set averaging number	3.5.2
FMOD	fast modulated mode	3.18.5
FR	frequency	3.13
GT0	cancel GET	3.17.2
GT1	GET single measurement	3.17.2
GT2	GET full measurement with settling	3.17.2
ID	ask for instrument ID	3.14
KB	enter cal factor	3.6
LG	log units (dB or dBm)	3.32
LH	set high limit	3.16
LL	set low limit	3.16
LM0	disable limit checking	3.16
LM1	enable limit checking	3.16
LN	linear units (Watts or %)	3.32
LP1	ask for learn mode #1 string	3.15.1
LP2	ask for learn mode #2 output	3.15.2
MAP	MAP mode	3.19
MAX	ask for max value	3.21

Code	Description	Section
MEAS	ask for measurement mode	3.19.6
MIN	ask for minimum value	3.21
MN0	min/max disable	3.21
MN1	min/max enable	3.21
OC0	disable calibrator source	3.8
OC1	enable calibrator source	3.8
OF0	offset disable	3.22
OF1	offset enable	3.22
OS	set offset value	3.22.2 & 3.22.3
PAP	PAP mode	3.19
PEAK	peak sensor settings	3.24 & 3.25
PH	peak hold	3.23
PKH	ask for peak hold value	3.23
PR	preset the 8540B	3.26
RC	recall a saved instrument state	3.31
RE	display resolution	3.28
RL0	disable relative measurement	3.27
RL1	enable relative measurement	3.27
RL2	use old reference for relative measurement	3.27
RV	ask for service request mask	3.30.1
SM	ask for status message	3.30.3
ST	store instrument state	3.31
SWIFT	swift mode	3.18.4
TR0	trigger hold mode	3.17
TR1	Trigger single measurement	3.17
TR2	Trigger full measure with settling	3.17
TR3	Free run trigger mode	3.17
VPROPF	configure VpropF feature	3.33
ZE	sensor zeroing	3.34

3.3.3 437 Emulation GPIB Command Set

These are the GPIB commands that are available when the instrument is placed in the 437 emulation mode. Footnotes appear at the end of Table 3-4.

Table 3-4. 437 Emulation Command Set

Command	Description
CL	CAL[1]
*CLS	Clear all Status Registers[2]
CS	Clear the Status Byte
CT0 - CT9	clear sensor data tables 0 thru 9 [ignored]
DA	All display segments on
DC0	Duty Cycle on
DC1	Duty Cycle off
DD	Display disable
DE	Display enable
DN	down arrow emulation [ignored]
DU	Display user message
DY	Duty Cycle (enter duty cycle value)
ERR?	device error query
*ESE	set the event status enable mask[3]
*ESE?	event status register enable mask query[3]
*ESR?	event status register query[3]
ET0 - ET9	edit sensor cal factor table 0 thru 9 [ignored]
EX	exit [ignored]
FA	automatic filter selection
FH	filter hold
FM	manual filter selection[1]
FR	frequency entry
GT0	ignore Group Execute Trigger (GET) bus command
GT1	trigger immediate response to GET command
GT2	trigger with Delay response to GET command
ID	GPIB identification query
*IDN?	GPIB identification query[2]
KB	Cal Factor[1]
LG	Log display
LH	high limit[1]
LL	low limit[1]

Command	Description
LM0	disable limits checking function
LM1	enable limits checking function
LN	Linear display
LP2	437 learn mode
LT	left arrow [ignored]
OC0	reference oscillator off
OC1	reference oscillator on
OD	output display text [ignored]
OF0	offset off - Local
OF1	offset on - Local
OS	OFFSET (enter offset value)
PR	PRESET
RA	Auto range[4]
RC	Recall[1]
RE	resolution[1]
RF0 - RF9	enter sensor ref cal factor [ignored]
RH	range hold[4]
RL0	exit REL mode
RL1	enter REL mode using REL value
RL2	use old ref number
RM	Set range[1,4]
*RST	soft reset
RT	right arrow [ignored]
RV	read Service Request Mask value
SE	sensor [ignored]
SM	Status Message
SN0 - SN9	enter sensor serial number [ignored]
SP	special [ignored]
*SRE	set the Service Request Mask value[2]
*SRE?	Service Request Mask query
ST	Store instrument state
*STB?	read the Status Byte
TR0	trigger hold
TR1	trigger immediate
TR2	trigger with delay

Command	Description
TR3	trigger - free run
*TST?	self test query
UP	up arrow [up arrow]
ZE	Zero
@1	prefix for Status Mask
@2	learn mode prefix

Notes:

1. A numeric entry is required by these GPIB codes, followed by the code EN (ENTER).
2. This GPIB code uses the next 6 characters (0-9, A-Z, or an underscore) as input data.
3. The asterisk (*) must be included as part of the GPIB command string.
4. The 8540B can always measure over its entire dynamic range; there is no need to specify the range. Therefore, range-related commands have no effect on the measurement capability of the 8540B. The auto range, range hold, and set range commands only offset the analog output voltage, and only in 436, 437, or 438 GPIB emulation modes. In these emulation modes (when using a single sensor, and not measuring in a relative mode), the power will be scaled to a range of 0 to 1 volts, representing the relative power within the current 10 dB range of the 8540B. The range hold and set range commands will simulate locking the range of power represented by the output voltage.

3.3.4 438 Emulation GPIB Command Set

These are the GPIB commands that are available when the instrument is placed in the 438 emulation mode. Footnotes are at the end of the table.

Table 3-5. 438 Emulation Command Set

Command	Description
?ID	ask for ID (the old way)
@1	prefix for Service Request Mask
@1;CHR$(4)	set Service Request Mask to 4
AD	Measure A-B
AP	Measure sensor A
AR	Measure A/B
BD	Measure B-A
BP	Measure sensor B
BR	Measure B/A
CL[1]	Calibrate sensor (precede with AE or BE)
CS	clear status byte
DA	display all
DD	display disable
DE	display enable
FA	set auto average filtering (precede with AE or BE)
FH	hold present average number (precede with AE or BE)
FM	set averaging number
GT0	Group execute trigger cancel
GT1	Group execute trigger single measurement
GT2	Group execute trigger full measurement with settling
KB	Cal Factor
LG	set Log units (dB or dBm)
LH	High limit
LL	Low limit
LM0	disable limit checking
LM1	enable limit checking
LN	set linear units (Watts or %)
LP1	set learn mode #1
LP2	set learn mode #2
OC0	turn off calibrator source
OC1	turn on calibrator source
OS	OFFSET
PR	preset the instrument to a known state
RA[2]	resume autorange [not supported]

Command	Description
RC	recall previous instrument state
RH[2]	do a range hold
RL0	turn off rel mode
RL1	turn on rel mode
RM[2]	set manual range
RV	ask for status request mask
SM	ask for status message
ST	Store instrument state
TR0	Trigger hold mode
TR1	Trigger single measurement
TR2	Trigger full measurement with settling
TR3	Free run trigger mode
ZE	Zero sensor (precede with AE or BE)

Notes:

1. A numeric entry is required by these GPIB codes, followed by the EN suffix.
2. The 8540B is always able to measure over its entire dynamic range; there is no need to specify the range. Therefore, range-related commands have no effect on the measurement capability of the 8540B. The auto range, range hold, and set range commands only offset the analog output voltage, and only in 436, 437, or 438 GPIB emulation modes. In these emulation modes (when using a single sensor, and not measuring in a relative mode), the power will be scaled to a range of 0 to 1 volts, representing the relative power within the current 10 dB range of the 8540B. The range hold and set range commands will simulate locking the range of power represented by the output voltage.

3.3.5 436 Emulation GPIB Command Set

Table 3-6 lists the GPIB commands that are available when the instrument is placed in the 436 emulation mode:

Table 3-6. 436 Emulation Command Set

Command	Description
5[1]	set range 5
4[1]	set range 4
3[1]	set range 3
2[1]	set range 2
1[1]	set range 1
9[1]	set auto range
A	set linear units (Watts)
B	set relative mode
C	set relative value
D	set Log units (dBm)
Z	zero sensor
+	enable cal factors
-	disable cal factors (ignored)
H	set TR0 mode
T	set TR2 mode
I	set TR1 mode
R	set TR3 mode
V	set TR3 mode

Notes:

1. The 8540B is always able to measure over its entire dynamic range; there is no need to specify the range. Therefore, range-related commands have no effect on the measurement capability of the 8540B. The auto range, range hold, and set range commands only offset the analog output voltage, and only in 436, 437, or 438 GPIB emulation modes. In these emulation modes (when using a single sensor, and not measuring in a relative mode), the power will be scaled to a range of 0 to 1 volts, representing the relative power within the current 10 dB range of the 8540B. The range hold and set range commands will simulate locking the range of power represented by the output voltage.
2. In 436 emulation, the specified range is also indicated in the power data strings returned to the host.

3.4 Analog Output

3.4.1 Standard Output

Commands relating to the standard analog output (that is, the rear panel analog output which is installed in all instruments, not the optional second output) are based on the ANALOG function code, as described below.

Enabling and Disabling the Output

The ANALOG function can be used simply to enable or disable the analog output. The command format for this purpose is:

ANALOG	STD	STATE	ON or OFF

The variable STD indicates that the standard analog output (not the optional extra output) is being configured. The variable STATE indicates that the analog output's ON/OFF status is being configured. The variables ON and OFF indicate whether the analog output is to be enabled or disabled.

Examples:

```
OUTPUT 713;ANALOG STD STATE ON      ! Enable analog output
OUTPUT 713;ANALOG STD STATE OFF     ! Disable analog output
```

Setting Options for the Output

The ANALOG function can also be used to configure various aspects of the analog output. The command format is:

ANALOG	STD	TOP or BOT	LOG or LIN	a	b	c	d

The variable STD indicates that the standard analog output (not the optional extra output) is being configured. The TOP and BOT variables specify the top line of the display or the bottom line. LOG and LIN specify logarithmic (dBm) or linear (W) measurement. The command string ends with four numeric variables (with at least one separator character between each pair of them) which define the relationship between the input power range and the output voltage range:

a: the power level represented by the minimum output voltage,
b: the power level represented by the maximum output voltage,
c: the minimum output voltage,
d: the maximum output voltage.

Valid power range numbers are -100 to +100 [dBm] for LOG, or 0 to 1E15 [Watts] for LIN. Valid voltage range numbers are 0.00 to +10.00 [VDC].

Examples:

```
OUTPUT 713;ANALOG STD TOP LOG -80.0, 20.0, 0.0, 10.0
                        ! Configure the analog output top line display channel as follows:
                        ! logarithmic units, -80 to +20 dBm input, 0 to 10 volt output
OUTPUT 713;ANALOG STD BOT LIN 0.00, 1.00E-3, 0.0, 1.0
                        ! Configure the analog output bottom line display channel as follows:
                        ! linear units, 0 to 1.00 mW, 0 to 1 volt output
```

3.5 Averaging

3.5.1 Auto Averaging

The 8540B is normally used in the auto averaging mode. The power meter chooses an averaging factor that is appropriate for the ambient noise level.

Activating the Auto Filter Mode

The command which activates auto averaging for a sensor is based on the FA function. The command format is:

AE or BE	FA

The AE and BE prefixes specify sensor A or sensor B. The FA function activates the auto filter mode for the selected sensor.

Example:

```
OUTPUT 713;AE FA            ! activate auto averaging filtering for sensor A
```

Setting the Measurement Settling Target

In the auto averaging mode, the 8540B chooses the lowest averaging factor that will yield a stable measurement at the present resolution setting. Stability is defined in terms of peak to peak variation in the measurement; the variation target value is expressed as a percentage of average power. Default values for this Measurement Settling Target are:

Table 3-7. Measurement Settling Target Default Values

Resolution	Peak to Peak Variation
xx.	25% (~1 dB)
xx.x	4.7% (~.2 dB)
xx.xx	0.46% (~.02 dB)
xx.xxx	0.10% (~.004 dB)

Because the target value affects the speed of measurement, it is possible to increase measurement speed by increasing the target value (a small increase in the target value can result in a large increase in speed). If the auto averaging mode is selected using the front panel menus, or using the AE FA or BE FA commands as described above, the default target values shown in the table are used. However, it is possible to add a numeric variable after FA in order to specify a different target value:

AE or BE	FA	*t*	EN or % or PCT

The variable *t* represents the measurement settling target value, in per cent, and has a valid range of 0.10 to 100.00.

Example:

```
OUTPUT 713;BE FA .8 %       ! activate auto averaging filtering for sensor B, with
                            ! a measurement settling target of .8%
```

Freezing the Present Averaging Number

The command which causes auto filtering to hold its present averaging number is based on the FH function. The command format is

AE or BE	FH

The AE and BE prefixes specify sensor A or Sensor B. The FH function causes the 8540B to hold its present averaging number; auto averaging is deactivated.

Example:

```
OUTPUT 713;BE FH          ! hold present average number for sensor B
```

3.5.2 Manual Averaging

The averaging number can be specified directly by the user. The commands which serve this purpose are based on the FM function. The command format is:

AE or BE	FM	*v*	EN

The AE and BE prefixes specify sensor A or sensor B.

The FM function specifies manual averaging.

The variable *v* has ten permitted values (0 through 9), each of which represents a particular averaging number. The numbers are shown in Table 3-8.

Table 3-8. Number Averaging

Value of *v*	Averaging Number	Value of *v*	Averaging Number
0	1	5	32
1	2	6	64
2	4	7	128
3	8	8	256
4	16	9	512

A terminating suffix is required (EN).

Examples:

```
OUTPUT 713;AE FM 2 EN     ! set averaging number to 4
OUTPUT 713;AE FM 8 EN     ! set averaging number to 256
```

3.6 Cal Factors

You should not need to employ the command described below with the 8540B; it is included here for the sake of compatibility with remote programs written for older power meters.

When a sensor is attached to the 8540B, the power meter automatically loads calibration factors from an EEPROM in the sensor. This data is frequency related, and in order for the 8540B to make use of it, the user must supply frequency information to the power meter, either by means of the front panel FREQ key, by means of the GPIB FR command (see FREQUENCY, Section 3.13), or by means of the VpropF input. Once the frequency has been specified, the 8540B automatically applies the appropriate cal factor to each reading.

The KB function code specifies a cal factor which is to be used in place of the cal factors stored in the sensor EEPROM. The command format is:

AE or BE	KB	*n*	EN

The AE and BE prefixes are used to specify Sensor A or Sensor B. The variable *n* specifies a cal factor, expressed as a percentage (*n* has a valid range of 1.0 to 150.0). A terminating suffix is required (EN).

Examples:

```
OUTPUT 713;AE KB 96 EN     ! enter a 96% cal factor for sensor A
OUTPUT 713;BE KB 102 EN    ! enter 102% cal factor for sensor B
```

3.7 Calibration

Commands which cause the 8540B to calibrate a sensor are based on the CL function code. The command format is:

AE or BE	CL	*n*	EN or PCT or %

The AE and BE prefixes are used to specify Sensor A or Sensor B. The variable *n* represents a reference calibration factor of n%. The 8540B makes no use of this variable (it reads cal factors from the sensor EEPROM instead); the variable is included in the command format only for the sake of compatibility with power meters which require it. Any value between 50 and 120 can be entered for n. A terminating suffix is required (EN, PCT, or %).

Examples :

```
OUTPUT 713;AE CL 100 EN          ! Calibrate sensor A
OUTPUT 713;BE CL 100 EN          ! Calibrate sensor B
```

The appropriate sensor must be attached to the calibrator output in order for the calibration process to work. If the sensor is not attached, the calibration will fail, and operation will continue as before.

Calibration Routine

The following is an example of a GPIB program to calibrate a sensor. It is strongly recommended that this format be followed for remote calibration. Note that the service request feature is used to determine when the calibration has completed; this will result in the quickest calibration routine.

Example:

```
Calibrate:                       ! calibration routine
ON INTR 7 GOSUB Srq_interrupt    ! setup serial poll interrupt jump location
ENABLE INTR 7;2                  ! enable SRQ interrupts
OUTPUT 713;*SRE010               ! set service request mask to 2
OUTPUT 713;CS                    ! clear status byte
OUTPUT 713;CL100EN               ! start calibration
Flag=0                           ! reset control flag
WHILE Flag=0                     ! wait while calibrating
END WHILE
RETURN
Srq_interrupt:                   ! SRQ interrupts jump here
OUTPUT 713;*STB?
ENTER 713;State
IF BIT(State, 1) THEN
   PRINT GOOD CAL
   ELSE
      IF BIT(State, 3) THEN
         PRINT BAD CAL
         ENDIF
ENDIF
OUTPUT 713;CS                    ! clear status byte
Flag=1                           ! set control flag true
RETURN
```

3.8 Calibrator Source

The 8540B Calibrator output, a fixed 50 MHz signal at 0 dBm, is activated and deactivated by means of two simple commands:

OC1 or OC0

Example:

```
OUTPUT 713;OC1        ! turn on calibrator source
OUTPUT 713;OC0        ! turn off calibrator source
```

The output level of the 50 MHz signal is subject to drift over time, and is considered accurate only within ten minutes after it has been activated.

NOTE: This command is needed only for test purposes. The calibrator source is enabled automatically during calibration of a sensor.

3.9 Crest Factor

The Crest Factor feature holds on to the highest instantaneous power measured from the time the feature is enabled until it is reset; it is similar to the Peak Hold feature, except that the measurement is expressed as a ratio in relation to average power.

> **NOTE:** The Crest Factor feature can only be used in the standard measurement collections modes (not in the fast modes), and only in a modulated measurement mode (MAP, PAP, or BAP). Crest Factor is not recommended for use in combination with the VpropF function.

3.9.1 Enabling the Crest Factor Feature

The Crest Factor feature is enabled or disabled by simple commands consisting of one of two function codes:

```
CR0 or CR1
```

Examples:

```
OUTPUT 713;CR1          ! Enable the Crest Factor feature
OUTPUT 713;CR0          ! Disable the Crest Factor feature
```

> **NOTE:** Like the PH0 and MN0 commands, this command will disable Peak Hold and Min/Max measurements.

3.9.2 Reading the Crest Factor Value

The Crest Factor value is read over the bus using a simple command:

```
CRF
```

Example:

```
OUTPUT 713;CRF          ! Send the crest factor value
```

The Crest Factor feature monitors the maximum power as it is measured, but does not provide any feedback to the controller until a CRF command is received. To monitor for a limit violation, the Limits feature may be more useful (see Section 3.16).

The Crest Factor feature returns the current ratio between held power and average power, as displayed on the front panel. A CRF command does not initiate data collection in same manner as a trigger command, such as TR1. To get a good reading of the Peak Hold value, the procedure is:

1. Set up the signal being measured, and send CR1 to reset the Crest Factor measurement.
2. Send TR2.
3. Read the TR2 data, or wait for the data ready service request (this allows for settling).
4. Send CRF.
5. Read the Crest Factor value.

3.10 Display Control

Testing the Displays

The LCD display window and status LEDs on the 8540B front panel can be tested remotely, by means of three simple commands:

DA or DD or DE

Examples:

```
OUTPUT 713;DA          ! turn on all LCD display segments and status LEDs
OUTPUT 713;DD          ! turn off all LCD display segments and status LEDs
OUTPUT 713;DE          ! re-activate the LCD display and the status LEDs
                       ! (this has the effect of canceling a DA or DD command)
```

Displaying a Message

The DU function can be used to show a test message in the LCD display window. The command format for this purpose is:

DU	*string*

The test message string can contain up to 32 characters; the first sixteen characters will be shown on the top line of the LCD display window, and the remaining characters will be shown on the bottom line.

Example:

```
OUTPUT 713;DU THIS IS A TEST        ! show the message THIS IS A TEST on the
                                    ! LCD display window
```

3.11 Duty Cycle Commands

3.11.1 Activating or Deactivating a Duty Cycle

The commands which activate or deactivate a duty cycle are based on the DC0 and DC1 functions. The command format is:

AE or BE	DC0 or DC1

The AE and BE prefixes specify Sensor A or Sensor B.

The function DC0 turns the duty cycle off (for the specified sensor); if the sensor is in Pulse Average Power measurement mode, this command will change the sensor measurement mode to Modulated Average Power. If the sensor is not measuring Pulse Average Power at the time this command is received, then this command will have no effect.

The function DC1 turns the duty cycle on. This is equivalent to the PAP command (see Measurement Mode Commands).

Examples:

```
OUTPUT 713;AE DC0        ! turn off the duty cycle for sensor A
OUTPUT 713;BE DC1        ! turn on the duty cycle for sensor B
```

3.11.2 Specifying a Duty Cycle

The commands which specify a duty cycle are based on the DY function. The command format is:

AE or BE	DY	*n*	EN or PCT or %

The AE and BE prefixes specify Sensor A or Sensor B.

The DY function is used to specify a duty cycle value; it also configures the sensor to Pulse Average Power mode. Therefore, this function includes the capabilities (and entry error reporting) of the PAP function (see Measurement Mode Commands).

The variable *n* species the duty cycle value in percent (*n* has a valid range of .001 to 99.999).

A terminating suffix is required (EN, PCT, or %).

Examples:

```
OUTPUT 713;AE DY 50 %            ! set 50% duty cycle for sensor A
OUTPUT 713;BE DY 25.000 EN       ! set 25% duty cycle for sensor B
OUTPUT 713;BE DY 40.412 PCT      ! set 40.412% duty cycle for sensor B
```

3.11.3 Reading Duty Cycle Status

The status message byte O indicates whether the duty cycle function is active for the selected sensor. 0 indicates OFF; 1 indicates ON.

3.12 EEPROM

The EEPROM command is used to query the cal factor data in the sensor EEPROM. The cal factor data is typically stored in the EEPROM at 1 GHz steps over the frequency range of the sensor. Additional cal factors may also be stored at additional special frequencies. When a measurement frequency is specified which does not exactly match the frequencies at which cal factors have been stored, the power meter determines the appropriate cal factor via interpolation.

Commands to read EEPROM cal factor data are based on the EEPROM function code. The command format is:

EEPROM	A or B	CALF? or FREQ?

The A and B variables are used to specify sensor A or sensor B.

The variable *CALF?* queries the cal factors. The cal factor data is output as a table of cal factors expressed in dB, separated by commas.

The variable *FREQ?* queries the frequencies which correspond to the cal factors. The frequency data is output as a table of frequencies expressed in Hz, separated by commas.

Examples:

```
OUTPUT 713;EEPROM A CALF?
```

Response is:

```
0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00
                                        ! Query sensor A EEPROM whole cal factor table
                                        ! (This example is from an 80301A sensor)
OUTPUT 713;EEPROM A FREQ?
```

Response is:

```
5.000e7, 2.000e9, 3.000e9, 4.000e9, 5.000e9, 6.000e9, 7.000e9, 8.000e9, 9.000e9, 1.000e10,
1.100e10, 1.200e10, 1.300e10, 1.400e10, 1.500e10, 1.600e10, 1.700e10, 1.800e10
                                        ! Query sensor A EEPROM whole frequency table
                                        ! (This example is from an 80301A sensor)
```

3.13 Frequency

Cal factors are stored in the sensor's EEPROM by frequency. Specifying a frequency causes the 8540B to apply the cal factor appropriate to that frequency. To cancel the use of cal factors, specify a frequency of 50 MHz (this is the frequency of the front panel Calibrator reference output, and has a cal factor of zero).

Commands which specify a frequency are based on the FR function. The command format is:

AE or BE	FR	*n*	HZ or KZ or MZ or GZ

The AE and BE prefixes specify Sensor A or Sensor B.

The FR function is used to specify a frequency value.

The variable *n* species the frequency value (the units are Hz, kHz, MHz, or GHz, depending on the terminating suffix used).

A terminating suffix is required (HZ, KZ, MZ, or GZ).

Examples:

```
OUTPUT 713;AE FR 5.67 GZ      ! frequency for sensor A is 5.7 GHz
OUTPUT 713;AE FR 1.0E9 HZ     ! frequency for sensor A is 1E9 Hz (1 GHz)
OUTPUT 713;BE FR 84.6 MZ      ! frequency for sensor B is 84.6 MHz
OUTPUT 713;BE FR 4E6 KZ       ! frequency for sensor B is 4E6 kHz (4 GHz)
```

3.14 Instrument Identification

The 8540B can be queried over the GPIB for purposes of identification; user application programs make use of such queries in order to verify that the appropriate equipment is connected. The 8540B will reply to an ID query by sending back an identification string.

The simple commands which query the instrument ID consist of any of three function codes:

ID or ?ID or *IDN?

Example:

```
OUTPUT 713;*IDN?          ! ask for ID string
ENTER 713; Name           ! read ID into string variable Name
```

Identification Strings

The 8540B ID string is determined by the configuration choices that were made (from the front panel) under the Config/GPIB menu. In 8541 or 8542 mode, the ID string consists of four fields separated by commas:

Field 1 is the manufacturer (GIGA-TRONICS).
Field 2 is the model (8541B or 8542B).
Field 3 is the serial number field (it displays the serial number of the calibrator EEPROM)
Field 4 is the software version number.

Example strings:

8541 mode	Name = GIGA-TRONICS,8541B,9544112,3.00
8542 mode	Name = GIGA-TRONICS,8542B,9548024,3.00

However, the ID strings for the emulation modes are fixed, as follows:

437 mode	Name = HEWLETT-PACKARD,437B,,1.8
438 mode	Name = HP438A,VER1.10
436 mode	Not Applicable

Note:

HP and Hewlett Packard are registered trademarks of the Hewlett Packard Company.

3.15 Learn Modes

The 8540B has the ability to send information regarding its current configuration to the controller. The controller requests this information by sending a learn mode command. At a later time, the controller can send the configuration information back to the power meter in order to reconfigure the 8540B to the same state it was in when it received the learn mode command.

Conceptually this feature is similar to the store and recall capability of the 8540B but with several important differences:

- The configuration information is stored in the controller's memory and not in the 8540B memory.
- Learn Mode #1 returns information regarding the current GPIB operational configuration (such as the trigger mode) which would not be covered by the store/recall function.
- The learn modes do not support many of the advanced features of the 8540B.
- The learn modes involve transmission of long strings of data between the controller and the 8540B. These strings must be transmitted without interruption; transmissions cannot be considered complete until EOI is read.

The two learn modes are discussed under separate headings on the following pages.

The learn modes are provided for the sake of compatibility with remote programs written for older power meters. The configuration information returned to the host is not as complete as the information that would be stored in the 8540B memory using the store/recall function; the configuration data for many features of the 8540B are not included in the learn mode data.

3.15.1 Learn Mode #1

Learn Mode #1 is used to return the configuration of the 8540B to the controller in the form of a sequence of GPIB commands.

Requesting the String

The simple command which requests the Learn Mode #1 string has the following format:

```
LP1
```

Example:

```
OUTPUT 713;LP1          ! requests learn mode #1 string
```

After receiving the LP1 command, the 8540B will return the Learn Mode #1 string the next time it is addressed to talk. The string will consist of up to 128 ASCII characters. The last character is sent with EOI true. Table 3-9 shows the information contained in the Learn Mode #1 string, and the order in which it is sent.

Table 3-9. Learn Mode #1 Output Format

Parameter	Output from the Power Meter (± = sign; d = single digit)
Trigger Mode	TRd
Measurement Mode	AP, BP, AR, BR, AD, or BD
SENSOR A PARAMETERS Cal Factor Offset Range Filter Low Limit High Limit	AE KB ddd.d EN OS ±dd.dd EN RA d EN FA or FM d EN LL ±ddd.ddd EN LH ±ddd.ddd EN
SENSOR B PARAMETERS Cal Factor Offset Range Filter Low Limit High Limit	BE KB ddd.d EN OS ±dd.dd EN RA d EN FA or FM d EN LL ±ddd.ddd EN LH ±ddd.ddd EN
Active Entry Channel	AE or BE
Measurement Units	LG or LN
Reference Oscillator Status	OC0 or OC1
Group Trigger Mode	GTd
Limits Checking Status	LM0 or LM1
Carriage Return Line Feed	EOI

Sending the String

The power meter can be restored to the configuration described in the Learn Mode #1 string, by sending the string to the 8540B.

3.15.2 Learn Mode #2

Learn Mode #2 returns the 8540B configuration information to the controller in the form of a series of binary values.

Requesting the String

The simple command which requests the Learn Mode #2 string has the following format:

LP2

Example:

```
OUTPUT 713;LP2                 ! requests learn mode #2 string
```

After receiving the LP2 command, the 8540B will return the Learn Mode #2 string the next time it is addressed to talk. The string starts with two ASCII characters, @ and 2, followed by a string of 28 (58 for the 437 emulation mode) 8-bit binary bytes. The last byte is sent with EOI true. Learn Mode #2 requires a controller that can receive and send information in binary form.

The Learn Mode #2 string contains the following information:

- Measurement mode
- REL mode status (on or off)
- Reference oscillator status (on or off)
- Current reference value if in REL mode
- Measurement units (Log or Lin)
- Cal Factor for each sensor
- Offset for each sensor
- Range for each sensor
- Filter for each sensor

Sending the String

The command that sends the Learn Mode #2 data to the 8540B is based on the @2 function. The command format is:

@2	28 or 58 binary bytes

The 8540B will change its configuration to match the configuration defined by the Learn Mode #2 string.

3.16 Limits

3.16.1 Setting Limits

Commands which set limits are based on the LH and LL function codes. The command format is:

AE or BE	LH or LL	*n*	EN

For limit commands, the AE and BE prefixes specify a line of the display, rather than a sensor. AE specifies the top line of the display; BE specifies the bottom line.

The LH function is used to specify the high limit; the LL function is used to specify the low limit.

The variable *n is a limit value, expressed in dBm or dB as appropriate.*

A terminating suffix is required (EN).

Examples:

```
OUTPUT 713;AE LH 12.34 EN          ! set top line high limit to +12.34 dB
OUTPUT 713;AE LL -2.58 EN          ! set top line low limit to -2.58 dB
OUTPUT 713;BE LH 2.34 EN           ! set bottom line high limit to +2.34 dB
OUTPUT 713;BE LL -100.00 EN        ! set bottom line low limit to -100.00 dB
```

3.16.2 Checking Limits

Limit-checking is activated or deactivated by simple commands consisting of one of two function codes:

AE or BE	LM0 or LM1

For limit commands, the AE and BE prefixes specify a line of the display, rather than a sensor. AE specifies the top line of the display; BE specifies the bottom line.

The function code LM0 disables limit checking; LM1 enables it.

Examples:

```
OUTPUT 713;AE LM0                  ! disable limit checking for the top line
OUTPUT 713;BE LM1                  ! enable limit checking for the bottom line
```

Before enabling limit checking (LM1), you must set the high and low limits (LH and LL). Once enabled, the Status Byte (bit 4) will signal a too high or too low condition. The status message AA bytes will indicate a too high condition (error code 21), or a too low condition (error code 23). Status Message bytes L and M contain the limit status for the top line display and the bottom line display respectively. 0 indicates within limits, 1 indicates too high, and 2 indicates too low.

The LCD display will indicate a too high condition with an up arrow displayed to the left of the reading, and a down arrow displayed to the left of the reading for a too low condition. If the sound mode is enabled, a high or low pitched sound will be generated. Sound can be disabled using the Config menu.

3.17 Measurement Collection Modes (Standard)

3.17.1 Measurement Triggering

Trigger modes determine when a measurement will be made. Four simple commands (consisting of one of four function codes) are used to select the desired mode:

TR0 or TR1 or TR2 or TR3

All four of the modes discussed here are standard measurement collection modes (as opposed to the fast modes described in Section 3.18), and use the standard data output format.

Trigger Hold (TR0)

This command places the instrument in standby mode. The LCD display is frozen at the current values. The display will be updated when the instrument receives a TR1 or TR2 command. To resume the normal free run mode of the instrument and display, use the TR3 command. During the standby mode, the instrument continues to make measurements and update the internal digital filter, but does not update the display or the GPIB buffer.

Example:

```
OUTPUT 713;TR0          ! Select the trigger hold mode
```

Trigger Immediate (TR1)

This command triggers a single reading; the reading is added to the internal digital filter. An ENTER statement will return the updated filter power level. After a TR1 command, the instrument returns to the standby mode.

Example:

```
OUTPUT 713;TR1          ! Trigger a single measurement
```

Trigger Immediate with Full Averaging (TR2)

This mode triggers a new series of readings; enough to update the digital filter for a noise free reading at the current power level. An ENTER statement will return the fully updated filter power level. After a TR2 command, the instrument returns to the standby mode.

Example:

```
OUTPUT 713;TR2          ! Trigger a full measurement, with settling
```

Free Run (TR3)

This free run trigger mode (which is the default mode) allows the user to read the power at any time with an ENTER statement. There is no need to re-send the TR3 command. Multiple ENTER statements can be executed. The power meter will return the present power level just as if you had looked at the LCD display.

Example:

```
OUTPUT 713;TR3          ! Free run trigger mode
```

3.17.2 Group Execute Trigger

The GPIB GET command (group execute trigger) causes all the devices on the interface which are currently addressed to listen to start a device dependent operation (usually a measurement). Three simple commands (consisting of one of three function codes) regulate the 8540B response to a GET command:

GT0 or GT1 or GT2

Group Trigger Cancel (GT0)

This command disables the response of the 8540B to a GPIB GET command.

Example:

```
OUTPUT 713;GT0            ! Group execute trigger cancel
```

Group Trigger Immediate (GT1)

This mode is similar to the mode specified by the TR1 command (trigger immediate), except that the GT1 command causes the 8540B to wait for a GPIB GET command. When the GET command is received, it triggers a single reading which is added to the internal digital filter. An ENTER statement will return the updated filter power level. After a GT1 command, the instrument is placed in the standby mode.

Example:

```
OUTPUT 713;GT1            ! Group execute trigger single measurement
```

Group Trigger Immediate with Full Averaging (GT2)

This mode is similar to the mode specified by the TR2 command (trigger immediate with full averaging), except that the GT2 command causes the 8540B to wait for a GPIB GET command. When the GET command is received, it triggers a new series of readings; enough to update the digital filter for a noise free reading at the current power level. An ENTER statement will return the fully updated filter power level. After a GT2 command, the instrument is placed in the standby mode.

Example:

```
OUTPUT 713;GT2            ! Group execute trigger full measurement with settling
```

3.18 Measurement Collection Modes (Fast)

3.18.1 General

The 8540B offers three special fast measurement collection modes which are available only during remote operation over the GPIB. These fast modes make it possible to take more measurements per second, but at the cost of limited functionality compared to the standard measurement collection mode. The fast modes operate differently from the standard measurement collection mode in several important ways. The three fast modes are called Swift, Fast Buffered, and Fast Modulated.

Sensor Measurements Supported

One restriction on the 8540B functionality in the fast modes is that it cannot perform comparative measurements (that is, measurements consisting of a comparison between the two sensors, such as A/B or A-B). However, when the 8540B operates in the Swift and Fast Buffered modes, it does have an added capability which is not otherwise available: measurements from both sensors can be returned to the host. In the Fast Modulated mode, only one sensor measurement can be performed and returned to the host.

Averaging

The averaging feature has a unique implementation in the Swift and Fast Buffered modes. Note that in standard measurement collection modes, and in the Fast Modulated modes, the averaging factor is taken to indicate the amount of filtering desired. Each measurement which is returned to the host is a true running average for a period of time which is derived from the averaging factor.

In the Swift and Fast Buffered modes, the averaging indicates the exact number of samples to be taken for each returned measurement, with the proviso that a minimum of four samples are taken (even if a number below four is requested). Note that four samples are also taken if auto averaging is selected. Each measurement returned to the host reflects all new data. Therefore, operation will be much faster with an averaging number of four than with a higher number.

Disabled Features

The following features are disabled during operation in any of the three fast modes: over-range alert, limit checking, min/max power, relative measurements, peaking meter, analog output, and VpropF (voltage proportional to frequency) correction.

Measurement Changes

Other changes to the operation of the instrument during fast operation include the following: the temperature of the sensors is not re-read and updated, so the temperature correction will become inaccurate over time if the temperature of the sensor changes.

Warning Regarding Interruption and Reconfiguration

Another important consideration is that, while any of the three fast measurement modes is running, it should not be interrupted, and the measurement setup should not be changed. The measurement setup must be thoroughly configured before the command is sent to start the fast measurement mode. To reconfigure the instrument, or to zero a sensor, it is necessary to exit the fast mode and then restart it. If a measurement setup command is sent after a fast mode command, the results are undefined.

Fast Mode Setup

Prior to initiating a fast measurement collection mode, the host should select the measurement (i.e., AP or BP), select the measurement mode (i.e., CW, MAP, PAP, PEAK, or BAP), define the frequency correction (via the FR or KB command, but not via the VpropF function), define the offset (if any), define the averaging (via the FA or FM command), and define the duty cycle (if applicable). When a fast mode is initiated, the LCD display and the status LEDs will be blanked and a message will be displayed indicating the fast mode selected.

3.18.2 Data Output Formats for Fast Modes

The data output formats for fast measurement collection are illustrated below. Fast mode data is always returned in units of dBm. Each A or B represents a single digit (0 to 9).

For the Swift Free-Run Mode

If one sensor is used, the format is:

±AAA.AA CR LF
±AAA.AA CR LF etc.
or:
±BBB.BB CR LF
±BBB.BB CR LF etc.

If two sensors are used, the format is:

±AAA.AA, ±BBB.BB CR LF
±AAA.AA, ±BBB.BB CR LF etc.

For The Swift Triggered & Fast Buffered Modes

If one sensor is used, the format is :

±AAA.AA, ±AAA.AA, etc. CR LF
or:
±BBB.BB, ±BBB.BB, etc. CR LF

If two sensors are used, the format is:

±AAA.AA, ±AAA.AA, etc. [until the specified number of readings has been sent]
±BBB.BB, ±BBB.BB, etc. [until the specified number of readings has been sent],
CR LF

For the Fast Modulated Mode

In this mode, only one sensor can be used; the format is:

±AAA.AA CR LF
±AAA.AA CR LF etc.
or:
±BBB.BB CR LF
±BBB.BB CR LF, etc.

NOTE: If BAP is unable to sync, 200.00 is added to the actual value in order to flag this error condition.

3.18.3 Fast Buffered Mode

Fast Buffered Mode is a fast measurement collection mode which makes it possible for a series of measurements to be taken and buffered rapidly, without external triggering of each measurement. The measurement collection can consist of a buffer-load of measurements taken after a trigger, or a buffer-load of measurements taken prior to a trigger (that is, the trigger marks the beginning or the end of the measurement period, depending on the option selected). This mode also makes it possible to buffer a very large number of data points, if optional RAM is installed for the purpose. For the sake of speed, no chopped measurements are taken in the fast buffered mode.

The fast buffered mode cannot be entered if a modulated measurement (MAP, PAP, or BAP) is being performed.

Commands related to the fast buffered mode are based on the FBUF command. (For the sake of backward compatibility with earlier Giga-tronics power meter designs, the command BURST is accepted as a substitute for FBUF. However, this command has nothing to do with the burst average power measurement mode; it is a vestige of the terminology applicable to previous models.) For the FBUF commands, the command format is:

FBUF	PRE or POST	GET or TTL	BUFFER	*b*	TIME	t

The PRE and POST variables define the relationship between the measurement period and the trigger:

- If PRE is selected, the trigger marks the end of the measurement period. The 8540B will continuously take measurements and buffer them until a trigger is received. At that point, the 8540B will stop collecting data and output all of the previously collected data in a continuous data stream, the next time it is addressed to talk.
- If POST is selected, the trigger marks the beginning of the measurement period. The 8540B will wait for a trigger before taking and buffering the measurements. After the requested number of measurement have been taken and buffered, the 8540B will be ready to output all of the data in a continuous stream the next time it is addressed to talk. If the GPIB GET command is specified as the trigger, the 8540B will assert a service request at this time.

The TTL and GET variables define the trigger:

- If GET is selected, the expected trigger is a GPIB GET command.
- If TTL is selected, the expected trigger is a TTL high at the rear panel trigger input.

The buffer value (indicated by the word BUFFER, followed by the numeric variable *b)* specifies the number of measurements to be taken and stored in the buffer. The minimum value is one. The maximum value is normally 5,000. However, if optional extra RAM is installed, the maximum value is 64,000 (when two sensors are used), or 128,000 (if one sensor is used).

The time value (indicated by the word TIME, followed by the numeric variable *t)* is an optional variable which specifies a fixed delay between measurements. The time value specifies the time (in ms) to wait between measurements; the minimum value is zero. The maximum value is 5000 ms (five seconds). This delay is in addition to the relatively short time it takes to perform each measurement. If no time value is specified, *t* is assumed to be zero, and the measurements are taken as fast as possible.

Examples:

```
OUTPUT 713;FBUF PRE GET BUFFER 200             ! take measurements (as fast as possible)
                                               ! until GET is received then output the last
                                               ! 200 measurements taken
OUTPUT 713;FBUF POST TTL BUFFER 100 TIME 2     ! wait for a TTL trigger, then take readings at
                                               ! intervals of 2 ms until a total of 100
                                               ! measurements have been taken
```

Two simpler commands are also based on the FBUF function code:

FBUF	DUMP or OFF

If the DUMP variable is selected, the command stops the data measurement and buffering, and prepares to return the data taken so far to the host, even if fewer than the requested number of measurements have been taken. The requested number of measurements are still returned to the host (the extra measurements beyond those actually taken are represented by the number -300.00).

If the OFF variable is selected, the command causes the 8540B to exit the fast buffered mode. All unread data is lost.

Examples:

```
OUTPUT 713;FBUF DUMP     ! Stop measurement and buffering
OUTPUT 713;FBUF OFF      ! Exit the fast buffered mode
```

Notes on Speed in the Fast Buffered Mode

1. The fast buffered mode is the fastest method of collecting measurement data. Top speed in the fast buffered mode is achieved by using a low averaging number (≤4), the POST trigger mode, and no time delay between measurements.
2. The POST trigger mode is faster than the PRE trigger mode because in the latter mode the 8540B must check for a trigger between each measurement. In the POST mode, the 8540B is in freerun operation after the trigger is received.

3.18.4 Swift Mode

Swift mode is a fast mode which allows for fast continuous data taking and return of each measurement to the host as it is taken (the freerun mode). Swift mode also allows for triggered buffered measurements, in which a host or external trigger indicates when to take each measurement.

The swift mode cannot be entered if a modulated measurement (MAP, PAP, or BAP) is being performed.

Commands related to the swift mode are based on the SWIFT function code:

SWIFT	FREERUN or OFF

If the variable FREERUN is selected, the command initiates the freerun mode (continuous taking and returning of measurements). If the variable OFF is selected, the command causes the 8540B to exit the swift mode; all unread data is lost.

Examples:

```
OUTPUT 713;SWIFT FREERUN        ! Initiate swift freerun mode
OUTPUT 713;SWIFT OFF            ! Exit the swift mode
```

For commands which set up triggered measurements, the command format is:

SWIFT	GET or TTL	BUFFER	*b*

The variables GET and TTL define the trigger:

- If GET is selected, the expected trigger is a GPIB GET command. The 8540B signals the host by asserting SRQ every time it is ready to take a measurement.
- If TTL is selected, the expected trigger is a TTL high at the rear panel trigger input. The 8540B signals the host by setting the RF Blanking BNC output high every time it is ready to take a measurement.

For triggered measurements, the 8540B signals the host every time it is ready to take a measurement (consisting of a set of samples equal to the averaging number). The 8540B then waits for the trigger; when the trigger is received, the 8540B de-asserts the signal to the host, measures the data, and buffers the data. When the instrument is again ready to measure data, it again asserts the signal to the host. After the specified number of measurements, the 8540B is ready to output data.

The buffer value (indicated by the word BUFFER, followed by the numeric variable *b)* specifies the number of measurements to be taken and stored in the buffer. The minimum value is one. The maximum value is 5000.

Examples:

```
OUTPUT 713;SWIFT PRE GET BUFFER 200      ! take measurements until GET is received,
                                         ! then output the last 200 measurements
                                         ! taken
OUTPUT 713;SWIFT POST TTL BUFFER 100     ! wait for a TTL trigger, then take 100
                                         ! measurements
```

Example Programs

The following program can be used to measure, buffer, and print 30 readings on one sensor:

```
REAL Data(30)
OUTPUT 713;SWIFT GET BUFFER 30
WAIT 0.5                                 ! wait for instrument configuration
FOR I=1 to 30
    Srq_flag=0                           ! wait for ready condition
    TRIGGER 713                          ! trigger measurement
WHILE Srq_flag=0
    Srq_flag=SPOLL(713)
    END WHILE
NEXT I
    ENTER 713;Data(*)
    FOR I=1 TO 30
    PRINT I,Data(I)
NEXT I
```

NOTE: If your computer does not support matrix reads, you can read the entire buffer into a string and parse the data. Multiple ENTER commands will not work.

The following program can be used to perform 20 measurements on two sensors in swift freerun mode:

```
OUTPUT 713;APBP
OUTPUT 713;SWIFT FREERUN
WAIT 0.5
FOR I=1 to 20
    ENTER 713;ReadA,ReadB
    PRINT ReadA,ReadB
NEXT I
OUTPUT 713;SWIFT OFF
```

The following program can be used to measure, buffer, and print 30 readings on each of two sensors:

```
REAL DataA(30),DataB(30)
OUTPUT 713;SWIFT GET BUFFER 30
WAIT 0.5
FOR I=1 to 30
    srq_flag=0
    TRIGGER 713              ! send group execute trigger
WHILE srq_flag=0
    srq_flag=SPOLL (713)
    END WHILE
NEXT I
ENTER 713;DataA(*),DataB(*)  ! read the buffer
FOR I=1 to 30
    PRINT I,DataA(I),DataB(I)
NEXT I
```

3.18.5 Fast Modulated Mode

This is a fast mode which permits more frequent return of measurement data to the host, during operation in the modulated measurement modes (MAP, PAP, or BAP). The commands which activate or deactivate this mode are based on the FMOD function code:

FMOD	ON or OFF

The variables ON and OFF are used to enable or disable the fast modulated mode.

When the fast modulated mode is enabled, data will be taken and returned continuously. This is analogous to the swift freerun mode.

The fast modulated mode can not be initiated unless a modulated measurement (MAP, PAP, or BAP) is being performed.

Examples:

```
OUTPUT 713;FMOD ON      ! Enable fast modulated mode
OUTPUT 713;FMOD OFF     ! Disable fast modulated mode
```

3.19 Measurement Mode Commands

3.19.1 CW Mode

Commands which specify the CW measurement mode are based on the CW function code:

CW	A or B

The variables A and B are used to specify the sensor.

These commands can be used with any sensor (although it is superfluous in the case of a CW sensor). Possible GPIB entry errors: 60 (uncalibrated sensor), 61 (missing sensor).

Examples:

```
OUTPUT 713;CW A        ! select CW mode for sensor A
OUTPUT 713;CW B        ! select CW mode for sensor B
```

3.19.2 MAP Mode

Commands which specify the modulated average power measurement mode are based on the MAP function code:

MAP	A or B

The variables A and B are used to specify the sensor.

These commands will work only with a modulated sensor. Possible GPIB entry errors: 60/61 (uncalibrated or missing sensor A/B), 62/63 (not a modulated sensor, or two sensor operation active, A/B).

Examples:

```
OUTPUT 713;MAP A       ! select MAP mode for sensor A
OUTPUT 713;MAP B       ! select MAP mode for sensor B
```

If an irregularly modulated signal is measured in MAP mode, measurement settling time will vary as the power meter attempts to synchronize to the modulation. In such a situation, it may be desirable to disable synchronization for faster measurement. The commands which disable synchronization are based on the MAP function code.

MAP	A or B	0

The variables A and B are used to specify the sensor. The 0 specifies that synchronization is to be disabled.

Examples:

```
OUTPUT 713;MAP A 0     ! disable MAP mode synchronization for sensor A
OUTPUT 713;MAP B 0     ! disable MAP mode synchronization for sensor B
```

NOTE: To reactivate synchronization, send the MAP A or MAP B command again.

3.19.3 PAP Mode

Commands which specify the pulse average power measurement mode are based on the PAP function code:

PAP	A or B

The variables A and B are used to specify the sensor.

These commands will work only with a modulated sensor. Possible GPIB entry errors: 60/61 (uncalibrated or missing sensor A/B), 62/63 (not a modulated sensor, or two sensor operation active, A/B).

Examples:

```
OUTPUT 713;PAP A        ! select PAP mode for sensor A
OUTPUT 713;PAP B        ! select PAP mode for sensor B
```

3.19.4 BAP Mode

Commands which specify the burst average power measurement mode are based on the BAP function code:

BAP	A or B

The variables A and B are used to specify the sensor.

These commands will work only with a modulated sensor. Possible GPIB entry errors: 60/61 (uncalibrated or missing sensor A/B), 62/63 (not a modulated sensor, or two sensor operation active, A/B).

Examples:

```
OUTPUT 713;BAP A        ! select BAP mode for sensor A
OUTPUT 713;BAP B        ! select BAP mode for sensor B
```

3.19.5 PEAK Mode

The commands for Peak mode are discussed under separate headings for the 80340A and 80350A sensors (see Sections 3.20 and 3.21).

3.19.6 Measurement Mode Query

It is possible to query the 8540B over the bus to determine what measurement mode has been selected for a particular sensor. The 8540B will respond to a measurement mode query by returning one of the following strings to the controller:

NO SENSOR
UNCAL
CW
MAP (or MAP SYNC OFF)[1]
PAP
PEAK
BAP (or BAP a b c)[2]

Measurement mode query commands are based on the MEAS function code:

Notes:

1. MAP SYNC OFF will be returned if MAP mode synchronization has been disabled.
2. BAP *a b c* will be returned if any of the advanced features have been enabled. In this message, a represents the number of samples for burst start exclude, b represents the number of samples for burst end exclude, and c represents burst dropout time in ms. The value ranges are $0 \leq a \leq 512$; $0 \leq b \leq 512$; $0.00 \leq c \leq 31.96$

MEAS	A? or B?

The variables A? and B? specify the sensor.

Examples:

```
OUTPUT 713;MEAS A?        ! queries the measurement mode setting for sensor A
OUTPUT 713;MEAS B?        ! queries the measurement mode setting for sensor B
```

3.20 Advanced Features

3.20.1 Burst Start Exclude

Commands which cause the beginning of a burst to be excluded from measurement (this feature is applicable only in BAP mode) are based on the BSTE function code:

AE or BE	BSTE	*a*	EN

The AE and BE prefixes specify Sensor A or Sensor B.

The variable *a* specifies the number of samples to be excluded; it has an integer value in the range of 0 to 512. (Note: selecting a value of zero samples effectively disables this function).

A terminating suffix is required (EN).

Examples:

```
OUTPUT 713;AE BSTE 1 EN   ! exclude one sample from start of burst, for BAP
                          ! measurements on sensor A
OUTPUT 713;BE BSTE 3 EN   ! exclude three samples from start of burst, for BAP
                          ! measurements on sensor B
```

3.20.2 Burst End Exclude

Commands which cause the end of a burst to be excluded from measurement (this feature is applicable only in BAP mode) are based on the BSPE function code:

AE or BE	BSPE	*a*	EN

The AE and BE prefixes specify Sensor A or Sensor B.

The variable *a* specifies the number of samples to be excluded; it has an integer value in the range of 0 to 512. (Note: selecting a value of zero samples effectively disables this function).

A terminating suffix is required (EN).

Examples:

```
OUTPUT 713;AE BSPE 1 EN   ! exclude one sample from end of burst, for BAP
                          ! measurements on sensor A
OUTPUT 713;BE BSPE 3 EN   ! exclude three samples from end of burst, for BAP
                          ! measurements on sensor B
```

3.20.3 Burst Dropout Tolerance

Commands which define a tolerated burst dropout time (this feature is applicable only in BAP mode) are based on the BTDP function code:

AE or BE	BTDP	*a*	EN

The AE and BE prefixes specify Sensor A or Sensor B.

The variable *a* specifies the dropout time in milliseconds; it has a range of 0 to 31.96, and a resolution of .01 ms. However, the value entered will be rounded upwards to one of a series of discrete values (.017, .026, .035 etc.); the actual value can be checked by means of a MEAS query. The dropout time represents a guaranteed minimum time; the time actually tolerated will usually be greater, and can be up to 2.125 times greater. (Note: selecting a value of zero samples effectively disables this function).

A terminating suffix is required (EN).

Examples:

```
OUTPUT 713;AE BTDP .02 EN        ! set  time to .02 ms or next highest discrete
                                 ! value, for BAP measurements on sensor A
OUTPUT 713;BE BTDP .03 EN        ! set dropout time to .03 ms or next highest discrete
                                 ! value, for BAP measurements on sensor B
```

3.21 Min/Max Power Value

The Min/Max feature monitors the measurements being taken, and maintains a continuously updated record of the highest and lowest values measured so far.

> **NOTE:** The Min/Max feature can only be used in the standard measurement collections modes (not in the fast modes).

3.21.1 Enabling the Min/Max Feature

The Min/Max feature is enabled or disabled by simple commands consisting of one of two function codes:

```
MN0 or MN1
```

Examples:

```
OUTPUT 713;MN1        ! Enable the Min/Max feature
OUTPUT 713;MN0        ! Disable the Min/Max feature
```

The MN1 command, like the LG command, has the effect of specifying logarithmic measurement units (dB or dBm). Like the PH0 and CR0 commands, this command will disable crest factor and peak hold measurements.

3.21.2 Reading the Min/Max Values

Min/Max values are read over the bus using simple commands consisting of one of two function codes:

```
MIN or MAX
```

The MIN function specifies that the current minimum measured value should be sent; the MAX function specifies that the current maximum value should be sent.

Examples:

```
OUTPUT 713;MIN        ! Send the minimum measured value
OUTPUT 713;MAX        ! Send the maximum measured value
```

The Min/Max feature monitors the minimum and maximum powers as they are measured and displayed on the front panel. Transient drop-outs or spikes in the power may not be captured by this feature. If it is necessary examine transient or unusual events, the triggering capability of the peak power sensor, the fast measurement modes, or the Peak Hold feature may provide a better way to characterize the signal in question. The Min/Max feature monitors for the minimum and maximum power, but does not provide any feedback to the controller until a MIN or MAX command is received. To monitor for a limit violation, the Limits feature may be more useful (see Section 3.16).

The Min/Max feature returns the current Min/Max values as displayed on the front panel. A Min or Max commands does not initiate data collection in same manner as a trigger command, such as TR1. To get a good reading of Min/Max values, the procedure is:

1. Set up the signal being measured, and send MN1 to reset the Min/Max measurements.
2. Send TR2.
3. Read the TR2 data, or wait for the data ready service request (this allows for settling).
4. Send MIN or MAX.
5. Read the Min or Max value.

3.22 Offset Commands

Power offsets (in dB) can be specified, in order to provide a fixed correction for loss or gain in the test setup. The offset is added to, not a replacement of, the sensor's cal factors. All measurement data returned by the 8540B over the bus is corrected for the offset that has been specified (even in the fast measurement collection modes).

Be careful with offsets when you are using the analog outputs. The offset value is reflected in the analog output voltage. A change in the offset value may result in a measurement which is outside of the power range represented by the voltage range of the analog output.

3.22.1 Enabling/Disabling an Offset

The commands which enable and disable the offset function are based on the function codes OF0 and OF1:

AE or BE	OF0 or OF1

The AE and BE prefixes are used to specify Sensor A or Sensor B.

The OF0 function deactivates the offset; the OF1 function activates it.

Examples:

```
OUTPUT 713;AE OF0          ! Disable offset for sensor A
OUTPUT 713;BE OF1          ! Enable offset for sensor B
```

3.22.2 Setting an Offset Value

The commands which specify the offset value are based on the OS function code:

AE or BE	OS	*n*	EN

The AE and BE prefixes are used to specify Sensor A or Sensor B.

The OS function indicates that an offset is being specified for the sensor.

The variable *n specifies the offset in dB. The value of n can range from -99.999 dB to +99.999.*

A terminating suffix (EN) is required.

Examples:

```
OUTPUT 713;AE OS 20.00 EN      ! Set +20 dB offset for sensor A
OUTPUT 713;BE OS -15.12 EN     ! Set -15.12 dB offset for sensor B
```

NOTE: A change to the offset of a sensor will reset any Peak Hold or Crest Factor measurement involving that sensor.

3.22.3 Measured Offset Entry

A measurement can be saved and used as an offset. The command format for this purpose is:

AP, BP, AR, BR, AD, or BD	OS	DO	EN

The command begins with a function code which describes the measurement that is to be stored as an offset value. There are six possible function codes; they are interpreted as follows:

AP: A
BP: B
AR: A/B
BR: B/A
AD: A-B
BD: B-A

The function OS, followed by the variable DO, indicates that the difference between the current offset, and the current value of the measurement described in the prefix, is to be saved as an offset value.

A terminating suffix (EN) is required.

Examples:

```
OUTPUT 713;AP OS DO EN    ! Save measurement A as an offset
OUTPUT 713;BP OS DO EN    ! Save measurement B as an offset
OUTPUT 713;AR OS DO EN    ! Save measurement A/B as an offset
OUTPUT 713;BR OS DO EN    ! Save measurement B/A as an offset
OUTPUT 713;AD OS DO EN    ! Save measurement A-B as an offset
OUTPUT 713;BD OS DO EN    ! Save measurement B-A as an offset
```

3.23 Peak Hold

The Peak Hold feature causes the measured value to hold at the highest instantaneous power measured from the time the feature is enabled until it is reset (the measured value changes only when it is rising to a new maximum, or when it is reset).

The Peak Hold feature can only be used in the standard measurement collections modes (not in the fast modes), and only in a modulated measurement mode (MAP, PAP, or BAP). *Peak Hold is not recommended for use in combination with the VpropF function.*

3.23.1 Enabling the Peak Hold Feature

The Peak Hold feature is enabled or disabled by simple commands consisting of one of two function codes:

PH0 or PH1

Examples:

```
OUTPUT 713;PH1          ! Enable the Peak Hold feature
OUTPUT 713;PH0          ! Disable the Peak Hold feature
```

Like the MN0 and CR0 commands, this command will disable Crest Factor and Min/Max measurements.

3.23.2 Reading the Peak Hold Value

The Peak Hold value is read over the bus using a simple command:

PKH

Example:

```
OUTPUT 713;PKH          ! Send the peak hold value
```

The Peak Hold feature monitors the maximum power as it is measured, but does not provide any feedback to the controller until a PKH command is received. To monitor for a limit violation, the Limits feature may be more useful (see Section 3.16).

The Peak Hold feature returns the current held value as displayed on the front panel. A PKH command does not initiate data collection in same manner as a trigger command, such as TR1. To get a good reading of the Peak Hold value, the procedure is:

1. Set up the signal being measured, and send PH1 to reset the Peak Hold measurement.
2. Send TR2.
3. Read the TR2 data, or wait for the data ready service request (this allows for settling).
4. Send PKH.
5. Read the Peak Hold value.

3.24 Peak Power Sensor Commands (80350A Series)

Commands related to the peak power sensor are based on the function code PEAK.

3.24.1 Setting the Trigger Mode & Trigger Level

The command format for setting trigger modes and levels is:

PEAK	A or B	INT or EXT	TRIG	*n*

The A and B variables are used to specify the A or B sensor.

The INT and EXT variables are used to specify internal or external triggering.

The variable TRIG indicates that a trigger level is being set.

The numeric variable *n* specifies the trigger level, in units of dBm (in the case of internal triggering) or volts (in the case of external triggering).

Examples:

```
OUTPUT 713:PEAK A INT TRIG -10.00     ! Configure sensor A for internal triggering at
                                      ! a trigger level of -10.00 dBm
OUTPUT 713:PEAK B EXT TRIG 1.50       ! Configure sensor B for external triggering at
                                      ! a trigger level of 1.50 VDC
```

The command format for selecting the CW mode is:

PEAK	A or B	CW

The A and B variables are used to specify the A or B sensor.

The variable CW is used to specify the CW mode.

Example:

```
OUTPUT 713:PEAK A CW                  ! Configure sensor A for CW measurements
```

3.24.2 Setting the Delay

A delay between the trigger and the actual measurement can be specified (in the CW mode, delay settings have no effect). The command format for setting the delay is:

PEAK	A or B	DELAY	*n*

The A and B variables are used to specify the A or B sensor.

The variable DELAY indicates that a delay value is being set.

The numeric variable *n*, which specifies the delay in seconds, has a range of -20E-9 (-20 ns) to 104E-3 (104 ms).

Examples:

```
OUTPUT 713;PEAK A DELAY 1.20E-6     ! Configure sensor A for a delay of 120 µs
OUTPUT 713;PEAK B DELAY 33.5E-9     ! Configure sensor B for a delay of 33.5 ns
```

NOTE: The actual duration of the delay is the sum of this setting and the delay offset setting.

3.24.3 Setting the Delay Offset

An offset to the trigger delay can be specified (in the CW mode, delay settings have no effect). The command format for setting the delay offset is:

PEAK	A or B	OFFSET	*n*

The A and B variables are used to specify the A or B sensor.

The variable OFFSET indicates that a delay offset value is being set.

The numeric variable *n,* which specifies the offset in seconds, has a range of -20E-9 (-20 ns) to 104E-3 (104 ms). The default value of the offset is 0.

Examples:

```
OUTPUT 713;PEAK A DELAY 1.20E-6     ! Configure sensor A for a delay offset of 120 µs
```

3.24.4 Reading Values

Trigger

The query format for trigger settings is:

PEAK	A? or B?

The variables A? and B? are used to specify the A or B sensor.

Example:

```
OUTPUT 713;PEAK A?          ! Query the current sensor A trigger setting
ENTER 713;TRIG$             ! Enter the returned string into the string variable TRIG
```

The possible replies to the query are CW, INT_TRIG, and EXT_TRIG.

Delay and Delay Offset

The query format for delay and delay offset settings is:

PEAK	A or B	DELAY? or OFFSET?

The variables A and B are used to specify the A or B sensor.

The variable DELAY? indicates that delay is being queried; the variable OFFSET? indicates that delay offset is being queried.

Examples:

```
OUTPUT 713;PEAK A DELAY?    ! Query the current delay setting for sensor A
ENTER 713;Delay             ! Enter the returned number into the variable Delay
ENTER 713;PEAK B OFFSET?    ! Query the current delay offset setting for sensor B
ENTER 713;Offset            ! Enter the returned number into the variable Offset
```

3.25 Peak Power Sensor Commands (80340 Series)

Commands related to the peak power sensor are based on the function code PEAK. (For the sake of backward compatibility with earlier Giga-tronics power meter designs, the command PULSE is accepted as a substitute for PEAK). The command format for setting the trigger mode is:

PEAK	A or B	INT or EXT	TRIG or DLYTRIG

The A and B variables are used to specify the A or B sensor.

The INT and EXT variables are used to specify internal or external triggering.

The variable TRIG indicates the immediate triggering mode; the variable DLYTRIG indicates the delayed triggering mode.

Examples:

```
OUTPUT 713;PEAK A INT TRIG         ! Configure sensor A for internal triggering
                                   ! in the immediate triggering mode
OUTPUT 713;PEAK B EXT DLYTRIG      ! Configure sensor B for external triggering
                                   ! in the delayed triggering mode
```

The command format for selecting the CW mode is:

PEAK	A or B	CW

The A and B variables are used to specify the A or B sensor.

The variable CW is used to specify the CW mode.

Example:

```
OUTPUT 713:PEAK A CW               ! Configure sensor A for CW measurements
```

3.26 Preset

The simple command PR can be used to preset the 8540B to its default conditions (alternatively, the IEEE-488.2 common command *RST can be used for the same purpose). The preset conditions of the instrument are outlined in Table 3-10.

Table 3-10. Preset (Default) Conditions

Sensors (all parameters apply to both sensor A & sensor B)		General	
Parameter	**Condition**	**Parameter**	**Condition**
Cal Factor	100.0%	Sensor Selection	Sensor A
Offset	0.00 dB	Calibrator	Off
Filter	AUTO	Default Sensor Prefix	Sensor A
Range	AUTO	Resolution	2 (0.01 dB)
Low Limit	0.000 dBm	Limits Checking	Off
High Limit	0.000 dBm	Max/Min	Off
Frequency	50 MHz	REL	Off
Duty Cycle	OFF, 1.000%	Trigger Mode	TR3
Measurement Mode	See Note 1	Group Execute Trigger Mode	GT2
		Display Function	Display Enable
		LED Peaking Meter Mode	Status
		Pulse Sensor Mode	Internal Trigger
		Measurement Units	See Note 2
		Sound	On
		Analog Output	Off

Notes:

1. The default measurement mode depends on the sensor type. For a CW sensor, the default is CW. For an 80401 sensor, the default is MAP. For a peak sensor, the default is INT TRIG. Regardless of the sensor type, all advanced features are turned off.
2. There is a slight difference between the preset conditions as set by a remote command, and as set from the front panel menus. This difference has to do with measurement units. If the 8540B is preset from the front panel, this sets the measurement units to dBm in all cases. If the 8540B is preset over the bus, this sets the measurement units to Watts in the case of 438 emulation, and has no effect at all in the case of 436 emulation; otherwise, it sets the measurement units to dBm. This distinction is made in order to accommodate differences between emulations for remote programming purposes, without affecting the benchtop user.

3.27 Relative Measurements

In the relative measurement mode, the 8540B saves the current measured power level as a reference. Subsequent measurements will be expressed relative to this reference level; the measurement units become dBr (for logarithmic measurement) or % (for linear measurement).

The simple commands associated with relative measurement modes consist of one of three function codes:

```
RL0 or RL1 or RL3
```

The function code RL0 deactivates the relative measurement mode.

The function code RL1 activates the relative mode, and causes the current measured level to be recorded as the reference level.

The function code RL2 activates the relative mode, and causes the reference level that was saved under a prior RL1 command to be used as the reference level. (That is, if the relative mode is activated by an RL1 command, and then deactivated by an RL0 command, the effect of RL2 is to restore the reference level that was saved in response to the RL1 command).

Examples:

```
OUTPUT 713;RL0        ! Disable the relative mode
OUTPUT 713;RL1        ! Enable the relative mode; save the current level as a reference
OUTPUT 713;RL2        ! Replace the current reference level with the previous level
```

3.28 Resolution

Commands which specify measurement resolution are based on the function code RE. The command format is:

RE	*a*	EN

The function code RE indicates that resolution is being set.

The variable *a* indicates the resolution. Only four values of a are allowed (0, 1, 2, and 3); these specify the number of digits to the right of the decimal point.

A terminating suffix (EN) is required.

NOTE: This command affects measurements shown on both lines of the display.

Examples:

```
OUTPUT 713;RE 0 EN        ! Set the display resolution to xx.
OUTPUT 713;RE 1 EN        ! Set the display resolution to xx.x
OUTPUT 713;RE 2 EN        ! Set the display resolution to xx.xx
OUTPUT 713;RE 3 EN        ! Set the display resolution to xx.xxx
```

3.29 Sensor Selection

Six simple commands (consisting of one of six function codes) are used to specify how the sensors are used:

AP or BP or AR or BR or AD or BD

Examples:

```
OUTPUT 713;AP        ! Measure sensor A
OUTPUT 713;BP        ! Measure sensor B
OUTPUT 713;AR        ! Measure A/B
OUTPUT 713;BR        ! Measure B/A
OUTPUT 713;AD        ! Measure A-B
OUTPUT 713;BD        ! Measure B-A
```

These commands, like the prefixes AE and BE, are sensor-specific, and cause the 8540B to assume that subsequent commands are intended for the same sensor unless they specify otherwise. Also, these commands (like the MN0, CR0, and PH0 command) have the effect of disabling Min/Max monitoring, Crest Factor, and Peak Hold.

3.30 Status

3.30.1 Status Byte Message

The power meter responds to a Serial Poll Enable (SPE) bus command by sending an 8-bit byte when addressed to talk. If the instrument is holding the SRQ bus control line true (issuing the Require Service message), bit position 6 in the Status Byte and the bit representing the condition causing the Require Service message to be issued will both be true. The bits in the Status Byte are latched, but can be cleared by sending the Clear Status (CS) program code.

Table 3-11. Status Byte and Service Request Mask

Bit	Weight	Service Request Condition
7	128	0
6	64	RQS bit Require Service
5	32	Event Status
4	16	Over/Under Limit
3	8	Measurement or Cal Zero Error
2	4	Entry Error
1	2	Cal/Zero Complete
0	1	Data Ready

The condition indicated in Bits 1-5 must be enabled by the Service Request Mask to cause a Service Request Condition. The mask is set with the @1 program code followed by an 8-bit byte, or the *SRE program code followed by three ASCII characters. The value of the byte is determined by summing the weight of each bit to be checked (the three ASCII characters are the value of the byte in decimal). The RQS (bit 6) is true when any of the conditions of bits 1-5 are enabled and occur. Bits remain set until the Status Byte is cleared.

Examples:

```
OUTPUT 713;CS              ! clear SRQ and status byte
    or
OUTPUT 713;*CLS            ! clear SRQ and status byte (488.2)
State = SPOLL(713)         ! read status byte
    or
OUTPUT 713;*STB?           ! ask for status byte (488.2)
ENTER 713;State            ! read status byte with 3 ASCII digit numbers
OUTPUT 713;@1;CHR$(4)      ! set service request mask to 4
    or
OUTPUT 713;*SRE004         ! set service request mask to 4
OUTPUT 713;RV              ! ask for service request mask
    or
OUTPUT 713;*SRE?           ! ask for service request mask (488.2)
```

3.30.2 Event Status Register

The Event Status Register (ESR) is essentially a second status byte; it is an 8-bit byte, described in the table below. When a specified event occurs, the ESR bits are set true; they can be read by sending an *ESR? command. When the command is received, the 8540B responds by sending an ASCII 3 digit value (from 0 to 255) that describes the present state of the register. This ASCII value is arrived at by summing the weighted values of the transmitted bits.

The ESR bits consist of the following:

Power On This bit will always be set.

Command Error This bit is set when an improper GPIB code is sent to the instrument. The command WT would be considered a command error, for example.

Execution Error When incorrect data is sent to the instrument, this bit will be set. For example, the command FR-1.0MZ would be considered an execution error.

Device Dependent Error Errors 1 through 49 are measurement errors, and will set this bit true whenever they occur.

If an ESR bit is set true, this causes bit 5 of the Status Byte to be set only when a corresponding bit in the Event Status Enable Register is enabled. This register is similar to the Service Request Mask, in that it can be used to specify which bits in the ESR register will set bit 5 of the Status Byte.

The Event Status Enable Register is set by sending the program code *ESE, followed by an ASCII 3 digit value (the value is determined by summing the weights of the bits to be checked). To read the current setting of the Event Status Register, send the command *ESE?. The 8540B sends an ASCII 3 digit value that describes the current state of the register (the value is determined by summing the weights of the bits that are set).

Table 3-12. Event Status and Enable Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Power On	0	Command Error	Execution Error	Device Dependent Error	0	0	0
Value = 128	Value = 64	Value = 32	Value = 16	Value = 8	Value = 4	Value = 2	Value = 1

3.30.3 Status Message

Example:

```
OUTPUT 713;SM              ! ask for status message
ENTER 713;Statusmess$      ! read status message
```

Status Message Output Format

The output format is as follows:

AAaaBBCCccDDddEFGHIJKLMNOP<CR><LF>

AA	Measurement Error Code
aa	Entry Error Code
BB	Operating Mode
CC	Sensor A Range
cc	Sensor B Range
DD	Sensor A Filter
dd	Sensor B Filter
E	Measurement Units
F	Active Entry Channel
G	Oscillator Status
H	REL Mode Status
I	Trigger Mode
J	Group Trigger Mode
K	Limits Checking Status
L	Top Line Limits Status
M	Bottom Line Limits Status
N	Offset Status
O	Duty Cycle Units/Status
P	Measurement Units
<CR>	Carriage Return
<LF>	Line Feed

Each letter in the Status Message Output Format denotes a single ASCII character. For more information on the individual elements of this format, see the tables on the following pages.

Elements of the Status Message Output Format

Table 3-13. Error Codes in Position AA

Error Code	Message	Notes
00	All OK	
01	Cannot zero sensor A	Ensure no RF power to sensor A
02	Cannot zero sensor B	Ensure no RF power to sensor B
03	Sensor A not connected to Calibrator	Connect sensor A to Calibrator
04	Sensor B not connected to Calibrator	Connect sensor B to Calibrator
05	Cannot Cal Sensor A	Check sensor A connection to Calibrator; reference must be 1.00 mW.
06	Cannot Cal sensor B	Check sensor B connection to Calibrator; reference must be 1.00 mW.
21	Over limit	An over-limit condition has occurred (for either the top or bottom line of the display)
23	Under limit	An under-limit condition has occurred (for either the top or bottom line of the display)
26	Sensor A unable to synchronize burst average power measurements to a pulse stream.	Check measurement setup and RF signal.
27	Sensor B unable to synchronize burst average power measurements to a pulse stream.	Check measurement setup and RF signal.
31	No sensor on Channel A	Connect sensor A, or change channels if B is connected.
32	No sensor on Channel B	Connect sensor B, or change channels if A is connected.

Table 3-14. Error Codes in Position aa

Error Code	Message	Notes
00	All OK	
50	Entered Cal Factor out of range	Re-enter value between 1.0% and 150.0%
51	Entered Offset out of range	Re-enter value between -99.999 dB and +99.999 dB
53	Entered average number out of range.	Re-enter valid average number.
54	Entered recall memory number out of range.	Re-enter valid recall memory number between 0 and 20.
55	Entered store memory number out of range.	Re-enter valid store memory number between 1 and 20.
56	Entered ref cal factor out of range.	Re-enter ref cal factor between 50% and 120%.
57	Memory error or battery failure.	Check battery or perform cal procedure to check memory.
60	Unable to set requested measurement mode or sensor measurement because sensor A is unattached or uncalibrated.	This may be due to receipt of a MAP, PAP, BAP, DC1, or DY command.
61	Same as Error 60 above, but for sensor B.	
62	Unable to set up sensor A to perform a modulated measurement (MAP, PAP, or BAP), because the sensor is not a modulated sensor or because the instrument is currently set up to perform two-sensor measurement. OR: Unable to modify a BAP measurement because the sensor is not a modulated sensor.	This may be set due to receipt of a MAP, BAP, DC1, DY, BSTE, BSPE, or BTDP command. When one sensor is set up to perform a modulated measurement, only one sensor at a time may perform measurements (two-sensor operation is prohibited).
63	Same as Error 62, but for sensor B.	
67	Unable to activate Peak Hold or Crest Factor features.	This may be set due to receipt of a CR1 or PH1 command. Peak Hold and Crest Factor can be enabled only in MAP, PAP, or BAP modes.
68	Unable to initiate fast measurement collection mode.	Verify sensor and measurement mode selections.
69	Unable to perform a two-sensor operation because one sensor is currently set up to perform a modulated measurement (MAP, PAP, or BAP).	This may be due to receipt of an AD, AR, BD, or BR command.
70	Entered peak sensor A data error.	Check entered data.
71	Entered peak sensor B data error.	Check entered data.
72	Entered peak sensor A delay out of range.	Check entered delay.
73	Entered peak sensor B delay out of range.	Check entered delay.
74	Entered peak sensor A trigger out of range.	Check entered trigger value.
75	Entered peak sensor B trigger out of range.	Check entered trigger value.
76	Sensor EEPROM data entry has error.	Check entry data.
77	Sensor A does not exist.	Check sensor A. This error code refers only to the EEPROM command.
78	Sensor B does not exist.	Check sensor B. This error code refers only to the EEPROM command.
79	Measurement settling target for auto-average mode is out of range.	Value must be 0.10% to 100.00%.
81	Duty cycle out of range.	Value must be between 0.001% and 99.999%.
82	Frequency value out of range.	Value must be between 0 Hz and 100 GHz.
85	Resolution value out of range.	Value must be between 0 and 3.
90	GPIB data parameter error.	Check, then re-enter with valid prefix.
91	Invalid GPIB code.	Check, then re-enter with correct code.

Table 3-15. Other Codes in the Status Message

Position	Significance	Codes	
BB	Operating Mode	00 = Sensor A 01 = Sensor B 02 = A/B 03 = B/A 04 = A-B 05 = B-A 06 = Zeroing A 07 = Zeroing B	08 = Cal A 09 = Cal B 10 = Ext Cal A 11 = Ext Cal B 20 = Peak A delay 21 = Peak B delay
CC & cc	Sensor A range & Sensor B range	Manual Range: 01 = 1 02 = 2 03 = 3 04 = 4 05 = 5	Auto Range: 11 = 1 12 = 2 13 = 3 14 = 4 15 = 5
DD & dd	Sensor A filter & Sensor B filter	Manual Filter: 00 = 0 01 = 1 02 = 2 03 = 3 04 = 4 05 = 5 06 = 6 07 = 7 08 = 8 09 = 9	Auto Filter: 10 = 0 11 = 1 12 = 2 13 = 3 14 = 4 15 = 5 16 = 6 17 = 7 18 = 8 19 = 9
E	Measurement Units	0 = Watts, 1 = dBm	
F	Active Entry Channel	A = A, B = B	
G	Calibrator Output Status	0 = Off, 1 = On	
H	REL Mode Status	0 = Off, 1 = On	
I	Trigger Mode	0 = Freerun, 1 = Hold	
J	Group Trigger Mode	0 = GTO, 1 = GT1, 2 = GT2	
K	Limits Checking Status	0 = Disabled, 1 = Enabled	
L	Top Line Limits Status	0 = In limits 1 = Over high limit 2 = Under low limit	
M	Bottom Line Limits Status		
N	Offset Status	0 = Off, 1 = On	
O	Duty Cycle	0 = Off, 1 = On	
P	Measurement Units	0 = Watts, 1 = dBm, 2 = %, 3 = dB	

3.31 Store and Recall

The instrument's current configuration can be saved in a register for later recall.

3.31.1 Saving a Configuration

The commands for saving the instrument state are based on the ST function code:

ST	*r*	EN

The variable *r* identifies the register in which the instrument's configuration is to be saved (and from which it can later be retrieved). The value of *r* can be any number from 1 through 20.

A terminating suffix (EN) is required.

Example:

```
OUTPUT 713;ST12EN        ! Save the current instrument configuration in register 12
```

NOTE: Register 0 contains the previous state of the instrument; to recover from an accidental preset, recall the configuration from that register.

3.31.2 Retrieving a Configuration

The commands for recalling a configuration from a register are based on the RC function code:

RC	*r*	EN

The variable *r* identifies the register in which the instrument's prior configuration has been saved (and from which it is now to be retrieved). The value of *r* can be any number from 0 through 20.

A terminating suffix (EN) is required.

Example:

```
OUTPUT 713;RC3EN         ! Recall the configuration that was saved in register 3
OUTPUT 713;RC0EN         ! Recall the prior configuration (this command is used to
                         ! recover from configuration errors)
```

3.32 Units

Logarithmic or linear measurement units are specified by simple commands consisting of the function codes LOG and LIN.

Examples:

```
OUTPUT 713;LG            ! set Log units (dB or dBm)
OUTPUT 713;LN            ! set Linear units (Watts or %)
```

These commands affect all types of measurements, except for the fast measurement collection modes. These modes always return measurement readings in dBm.

3.33 VpropF Feature

The VpropF feature (voltage proportional to frequency) provides a means of indicating to the 8540B the approximate frequency of the signal that it is measuring, so that the appropriate cal factor can be applied. The frequency is indicated by means of a variable voltage input. The 8540B reads the voltage as an expression of frequency, and applies the proper cal factor from the table stored in the sensor EEPROM (interpolating for frequencies that fall between the stored values).

In order for the 8540B to interpret the input voltage input correctly, it is necessary to specify the starting point (that is, the frequency at zero volts) and the slope (the rate at which voltage increases with frequency).

3.33.1 Enabling & Disabling VpropF

Commands related to the VpropF function are based on the function code VpROPF. The command format, for purposes of activating or deactivating the VpropF feature, is as follows:

VPROPF	A or B	STATE	ON or OFF

The variables A and B are used to specify Sensor A or Sensor B.
The variable STATE indicates that the VpropF feature is being enabled or disabled.
The variables ON and OFF are used to enable or disable the VpropF function.

Examples:

```
OUTPUT 713;VPROPF A STATE ON      ! Enable VpropF for sensor A
OUTPUT 713;VPROPF B STATE OFF     ! Disable VpropF for sensor B
```

3.33.2 Configuring VpropF

The command format, for purposes of configuring the VpropF feature, is as follows:

VPROPF	A or B	MODE	*f*	s

1. The variables A and B specify Sensor A and Sensor B.
2. The variable *MODE* indicates that the VpropF feature is being configured (that is, the start frequency and slope are being specified).
3. The variable *f* indicates the start frequency (that is, the frequency at zero volts), expressed in Hz.
4. The start frequency must be less than the upper frequency limit of the sensor.
5. The variable *s* indicates the slope of the VpropF (that is, the ratio of input voltage to input frequency), expressed in V/Hz. The value must be between 1E-12 and 1E-8.

Example:

```
OUTPUT 713;VPROPF A MODE 2.00E9 1.00E-9     ! Configure the VpropF feature for sensor A
                                            ! as follows:
                                            ! 2.00 GHz start frequency
                                            ! 1.00 volt per GHz slope
```

3.34 Zeroing

The commands used for zeroing of a sensor are based on the function code ZE. The command format is:

AE or BE	ZE

The prefixes AE and BE are used to specify Sensor A or Sensor B.

Examples:

```
OUTPUT 713;AEZE                         ! Zero sensor A
OUTPUT 713;BEZE                         ! Zero sensor B
```

NOTE: If the sensor is attached to an RF source, the source must be turned off prior to zeroing. Zeroing before calibration is not necessary; zeroing of the sensor is part of the sensor calibration process.

The following is an example of a GPIB program to zero a sensor. It is strongly recommended that this format be followed for remote zeroing. Note that the service request feature is used to determine when the zero has completed; this will result in the quickest zeroing routine.

Example:

```
Zero:                                   ! zero routine
ON INTR 7 GOSUB Srq_interrupt           ! setup serial poll interrupt jump location
ENABLE INTR 7;2                         ! enable SRQ interrupts
OUTPUT 713;*SRE010                      ! set service request mask to 2
OUTPUT 713;CS                           ! clear status byte
OUTPUT 713;ZE                           ! start zero
Flag=0                                  ! reset control flag
WHILE Flag=0                            ! wait while zeroing
END WHILE
RETURN
Srq_interrupt:                          ! SRQ interrupts jump here
OUTPUT 713;*STB?
ENTER 713;State
IF BIT(State, 1) THEN
    PRINT GOOD ZERO
    ELSE
        IF BIT(State, 3) THEN
            PRINT BAD ZERO
            ENDIF
ENDIF
OUTPUT 713;CS                           ! clear status byte
 Flag=1                                 ! set control flag true
RETURN
```

4

Theory of Operation

4.1 General

This chapter provides a functional description of the circuits used in Series 8540B power meters. The circuits are contained in the four printed circuit boards listed in Table 4-1:

Table 4-1. Printed Circuit Board Assemblies

Reference Designation	Title	Assembly Drawing Part #	Schematic Part #
A1	CPU PC Bd Assembly	21693	21694
A2	8541B Analog PC Bd Assembly	21696	21697
A3	Front Panel PC Bd Assembly	21229	21230
A4	LCD Display Assembly	21240	

The 8540B Interconnection Diagram (DWG# 21703 on page 8-3) shows how the assemblies are interconnected. Also see Figure 4-1 for a block diagram of the CPU board interconnection. Most of the electrical circuitry resides on the CPU PC Board (A1) and the Analog PC Board (A2). The CPU interfaces with the Analog assembly through A1J1/A2P1. The CPU also connects to the Front Panel assembly (A3) that provides the keyboard interface and the LED status indicators, and to the LCD display assembly (A4).

Various cable connections are on the 8540B rear panel. The GPIB connector communicates with the CPU board through connector J3. Three rear panel BNCs connect to the CPU board, and two BNCs connect to the Analog board. J8 on the CPU assembly is in-house development and testing.

4.2 CPU Assembly (A1)

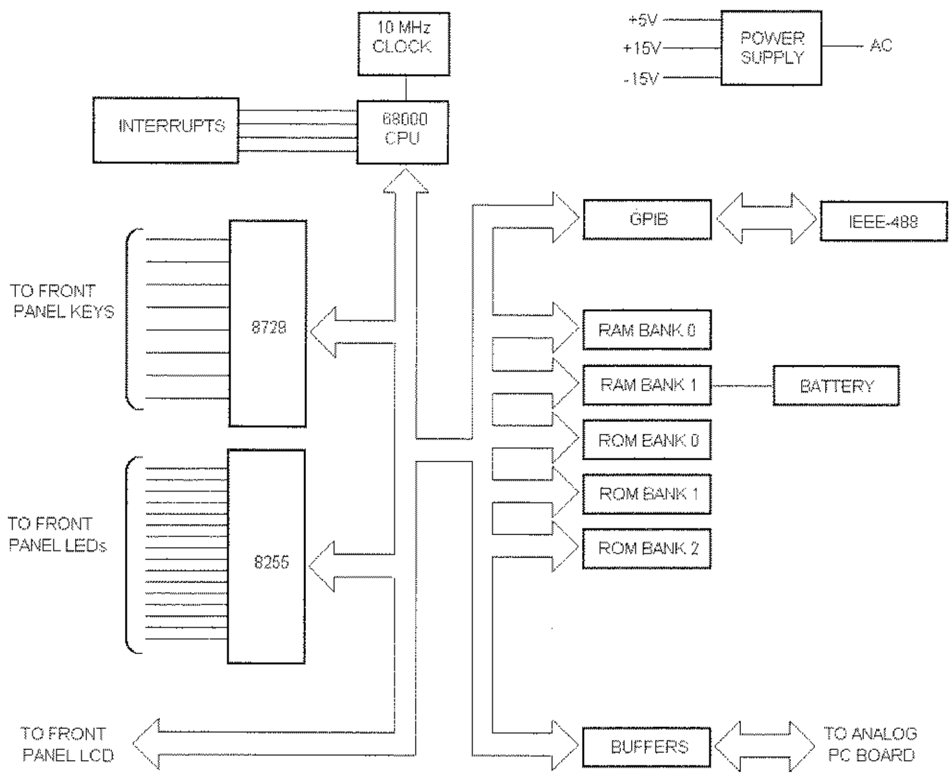


Figure 4-1. CPU Block Diagram

4.2.1 Power Supply

As shown in the diagram on page 8-6, ac main power (110 or 220 Vac) is applied to transformer T1. One 8.4 Vac and 19 Vac outputs from T1 are supplied to the dc power supply on the CPU board. The dc power supply produces the +5 Vdc and +15/-15 Vdc required by various circuits in the meter.

The T1 transformer's 10 Vac and 19 Vac enter the dc supply through J9. CR6 rectifies the 10 Vac to an unregulated 8 Vdc. C54 and C6 provide filtering, and the unregulated voltage is applied to regulators U37 and U38. The U37 regulator supplies 5 V (at 0.5A) required by the front panel LCD display's backlight. U38 supplies 5 V required by all of the digital circuitry. TP12 and TP13 are available to test the level of the 5 V supply. CR7 rectifies the unregulated voltage of the +19/-19 V filters which is applied to U39 and U40 through C9 and C12. U39 is the +15 V regulator, and U40 is the -15 V regulator. TP14 and TP15 are available to test these voltages.

4.2.2 Battery Back-Up

A 3.6V lithium battery is used for non-volatile RAM backup for system configuration storage registers. TP16 & TP17 and R29 are used as a current draw monitor for the battery. If the battery is supplying too much current, it will be shown as the voltage drop across R29. Typically, the non-volatile RAMs should draw about 3 μA from the battery. This will produce 3 mV across TP16 & 17.

4.2.3 CPU Circuit Description

Y1 (shown in the upper left corner of page 8-6) is a 24 MHz crystal oscillator that provides the main clock signals for the circuitry. U1A is a divide-by-two counter that outputs 12 MHz. This 12 MHz is used by the 68000 microprocessor, U9, so that U9 is running at a 12 MHz clock speed. The clock is further divided down for other uses at U2. U2 also provides wait states when accessing peripherals. U17D/E/F and U16C&D provide U9 with decoding of the status lines for auto vector interrupts. U16A provides an upper data byte write signal, and U16B furnishes the lower data byte write signal.

The 68000 microprocessor (U9) is a 16-bit component with a high 8 bits and a low 8 bits. Most 8 bit peripherals operate using the low 8 bits with only those devices requiring more than 8 bits using the high 8 bit data. (e.g. the ROM and RAM use both upper and lower).

U4 is a PAL (Programmable Logic Device) that provides address decoding for RAM Banks 0 and 1, and ROM banks 0, 1, and 2. U4 pin 15 is a chip select for all peripherals. The signal from U4 goes to U18 which further decodes address signals into various port chip selects. The U4 and U2 ICs provide the wait state function. When U4 decodes ROM or RAM it immediately passes back DTAK via pin 12 of U9. When it encounters a peripheral device address (when pin 15 is low for the chip select), DTAK is held off until a signal is received on pin 1. The pin 1 signal comes from the wait state generation of U2. The sequence is: The address strobe comes on, U4 looks at the address lines and detects that it is a peripheral being addressed, and the chip select from U4 pin 15 goes to pin 2 of U2. U2A then starts counting down until pin 6 comes true (through jumper D) which happens 8 clock cycles later (a wait state of 8). The signal gets passed to pin 1, and then U4 passes DTAK (pin 12) to the U9 processor. By this method, various wait states can be generated with jumpers A, B, C, and D (1, 2, 3, and 4 wait states). (ROM and RAM are always 0 wait states so DTAK passes right through.)

The RAM 1 chip select is passed through U10 which is a nonvolatile RAM controller. This chip will only chip select to pass through from pin 5 to pin 6 if pin 8 has a valid 5 V of power supplied to it. When the power supply is off and pin 8 no longer has 5 V applied to it, U10 will automatically stop chip selects from passing through. It automatically routes pin 2's power (instead of routing pin 8's power) from the backup battery to pin 1 which is the battery voltage for RAM Bank 1. This means that when power is turned off, no memory is lost and chip select is disabled to stop any memory writes from occurring that could corrupt the data.

U22 provides the reset for the processor, U9. When the power is turned on U9 asserts the reset line, pin 5, for 250 ms. That signal is buffered by U20A&B (open collector drivers) that cause the reset of U9. When U9 is reset it asserts pin 18, buffered by U17A, which provides the reset signal. This can be tested at TP8.

R2 and R3 divide down the unregulated supply voltage and provide pin 1 of U22 with a threshold voltage. When the power supply has been turned off, U22 will detect this by seeing a voltage change in the pin 1 voltage. When the voltage drops, it will assert the interrupt, pin 7 of U22. This tells U9 that the power is being turned off, and that it should complete any current operations before the power is removed.

U21 provides encoding of the interrupt signals by an 8 line to 3 line encoding routine. Interrupt 0 is not used. Interrupts 1 through 7 can be enabled or disabled by removing or replacing jumpers A through G. Jumper H disables all interrupts so that it is not necessary to remove A through G if this is desired. Interrupt 1 occurs when a sensor is connected or disconnected. Interrupt 2 is used with the rear panel BNC trigger. Interrupt 3 occurs when any GPIB bus activity is in progress. Interrupt 4 occurs when a front panel key is pressed, and interrupts 5 and 6 are available for programmable timing provided by U26 (currently not used). Interrupt 7 is used when the power supply is shut down.

U26 is one of three programmable times used in the system. These timers divide down the supply clock, clock 0, 1, and 2, which are all 0.75 MHz clocks that can be programmed to provide different clock signals. Presently, U26 is not used (for future development).

U8 (a Texas Instrument 9914 GPIB controller chip) is a peripheral chip used for GPIB affectivity. U6 and U7 provide buffering of GPIB signals before they are sent out over the bus. Pin 1 of U7 programs the GPIB bus to be a master controller or a talker/listener device. Presently, only talker/listener modes are used in the 8540B Series meters. U23 is an 8279 keyboard controller that provides keyboard scanning and key press detection. It also provides an 8 key buffer. U19 is a 3 to 8 line decoder used for column and row scanning which are detected by pins 1, 2, 38, 39, and U23. When U23 detects a key press, it asserts interrupt 4 from U24A. U22, U23, U24, and U25 provide pull ups for the keyboard matrix. U25 is a Peripheral Interface Adapter (PIA) to program the 20 front panel LEDs.

Pin 10 of U25 provides drive for the single LED on the CPU board, DS1, that is used for internal testing. Pins 11, 12, and 13 are auxiliary signals which are presently not used. The battery interfaces with U27 and U28. Each of these devices typically draw 1 μA, for a total battery dissipation of approximately 3 μA.

There are additional signals present at U3. Pin 4 drives Q1 which, in turn, drives a piezo-electric beeper for front panel audio signals. U3-3 resets the trigger latch, U1-2 is an output buffered by U24E which is the RF blanking signal used to turn off the source RF during zeroing. This is done automatically through J7. Pin 18 is the trigger latch input from U1B.

The following is the normal sequence of operation for the external trigger signal: The trigger input signal is applied through the TRIGGER INPUT BNC connector, J4, on the rear panel. R11, R12, CR2, and CR13 provide input protection for U24B which buffers the trigger signal and acts as a Schmitt trigger. The trigger can either assert Interrupt 2 to provide edge detection, or be latched by U1B for level detection. U1B can be set by asserting pin 13, and then unasserting pin 13 which sets the latch ready for a new trigger signal, which is read by pin 9. U3-19 is an input from U24D which is for future use. R11, R14, CR4, and CR5 also provide input protection.

The CPU Board connects to the Analog Board via J1. Bus signals are buffered by U12 and U13 which are bidirectional devices that buffer the 16 data lines, D0-D15. These tri-state buffers are only active when the Analog Board is chip selected via CS Analog (pin 12 of U18). All 16 data lines are sent to the Analog Board, but only 4 addresses (A0 - A3) are buffered by U14A. Reset, not read/write, read/not write, and the lower data write signals are also buffered.

The Chip Select Analog is further decoded into 8 additional chip selects for the Analog Board by U15 which then outputs ACS0 through ACS1.

Referring to Sheet 2 of the A1 Circuit Schematic (page 8-7), the DIP sockets that the ROMs and RAMs are mounted in are configured to accept either 512K or 1M devices. 512K devices are 28 pin components that have to go into 32 pin sockets. When this is done, pins 1, 2, 31, and 32 are not used, which means that the 512K device is occupying pins 3 through 30 of the socket. The difference in address decoding between 512K and 1M devices is provided by PAL U4.

The ROM and RAM banks are word addressed. The necessary reads and writes are done in 16 bit words. Each chip in the bank provides 8 bits (or 1/2 of the word). For example, ROM Bank 0 is composed of U35 and U36. U35 is the lower 8 bits, and U36 is the upper 8 bits of data. U33 and U34 are ROM Bank 1, and U31 and U32 are ROM Bank 2.

RAM Bank 0 is only loaded if Option 02 (128K Buffer) is specified. This option provides more memory buffer for the fast measurement collection. RAM Bank 0 is volatile RAM (loses memory when power is turned off). RAM Bank 1 is composed of U27 and U28 which are non-volatile because they are connected to the backup battery.

Connection J6 interfaces the LCD display with the CPU Board. R26, R27, and R28 provide current limiting for the LED backlight of the display (draws approximately 1/2 Amp). The resistor divider network, R16, is used to provide contrast adjustment for the LCD display. U11B buffered by U24F provides a decoded data strobe.

4.3 Analog PC Assembly (A2)

4.3.1 Analog Circuit Description

Sheet 1 of the schematic diagram for this circuit (see page 8-10) shows the channel A sensor amplifier circuitry (used with both the 8541B and 8542B models). Sheet 2 covers the channel B sensor amplifier circuits (used only with the 8542B). Since these are essentially duplicate circuits (the differences will be described), this discussion will mainly focus on the Sheet 1 components. The sensors are connected from the front panel through W6J1 which enters the Analog Board through J1 for sensor A and J2 for sensor B. The detected DC voltage from the sensor is a differential voltage applied to pins 3 and 4 of J1. This differential voltage goes to U27 which is a FET chopping circuit. The outputs are pins 8 and 9 of U27. An incoming signal can either be fed straight through or inverted. The signal is fed straight through when A1 and A0 are both low. It is fed through in the inverted mode when A1 is low and A0 is high. When A0 is low and A1 is high, the signal is shorted together and grounded. When A0 and A1 are both high, the input is open (floating). This provides chopper stabilized amplification when low power signals are being received by switching the FET switch from the inverting to non-inverting mode and back again at a rate of 300 times per second.

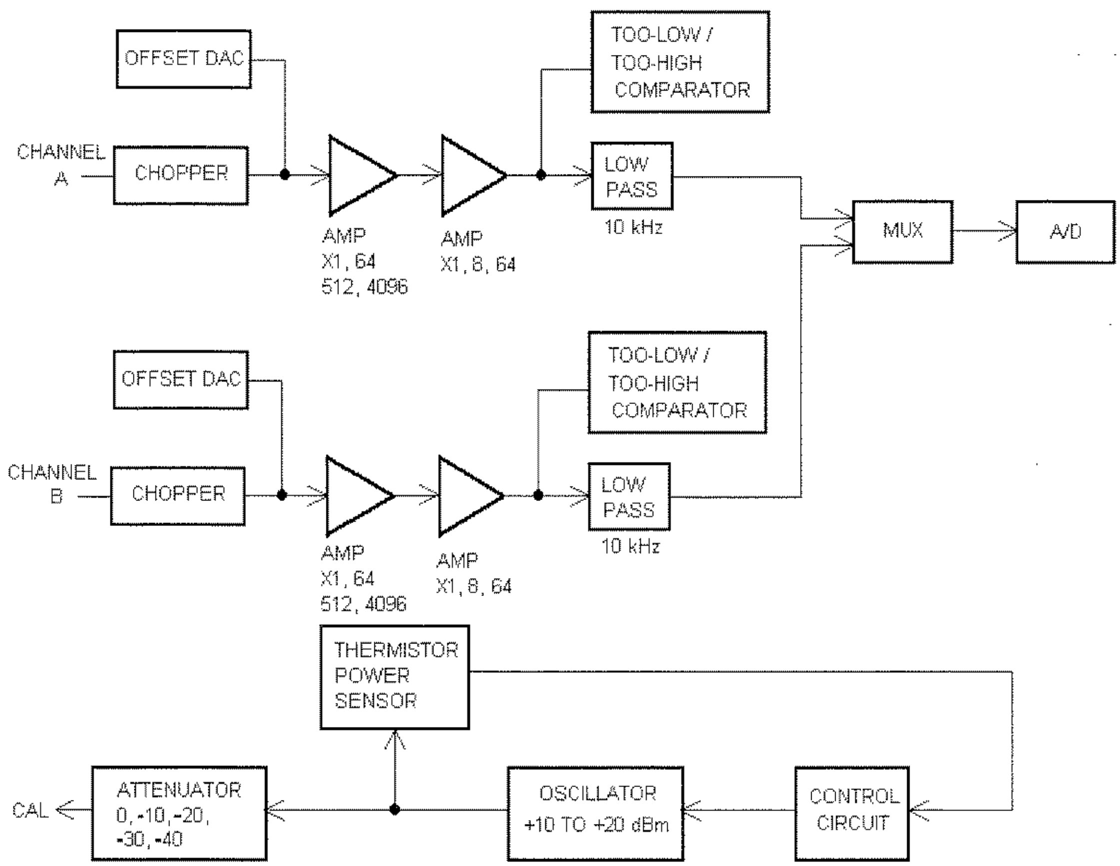


Figure 4-2. Analog PC Block Diagram

U29 is the 1st stage amplifier with programmable gain. The programmable gain is provided by U28 and the resistor ladder composed of R6 through 12, which will program gains of 1, 64, 512, and 4096. U30A is the 2nd stage amplifier that provides programmed gains of 1, 8, and 64 using FET switch U31 and resistor ladder R16, R17, and R18. Although they are shown on the schematic, C168, C167, R13, and R14 are not loaded on the board.

U30B/C/D and associated components provide a 6-pole bessel filter in the low pass configuration: 10 kHz with a 120 μS settling time. In normal operation, the signal will always go through this filter. Other paths such as unfiltered A, TP8, and 1st amp signals are provided for testing only and are not used in normal operation.

The 1st amplifier, U29, has an offset voltage injected into it at pin 7. This offset voltage comes from the 12-bit DAC, (U20 for channel A and U17 for channel B). Offset voltages range from +5 V to -5 V which can effectively remove about a ±1.2 mV offset at the detector. U32A/B are comparators which monitor the input signal for a too-high or too-low condition. The too-low comparator, U32B, will fire if the voltage is below 1 V, and the too-high comparator, U32A will fire if the voltage is above 9 V. This provides an A/D conversion range of 1 to 9 V. The too-high and too-low signals are used by the software to determine whether or not a range change should be made. There are seven ranges. Four are processed by U29 (1st Amp), and three by U30A. Appropriate gains are set to keep voltages at the A/D conversion point between 1 and 9 V. R45 and R46, divide the 12 V regulated voltage to 1 V such that the too low comparator will fire below 1 V to assert the too low signal. R36 and R37, divide the 12 V signal to 3 V, and R40 and R41 divide the incoming signal by 3 so that the too high comparator will always fire at 9 V.

Refer to Sheet 2 (channel B) of the A2 schematic drawing #21697, which is the same as channel A on the top 1/2 of the sheet (with different component numbers). The too-high and too-low comparators are separate, but function just like the A channel comparators.

Each detector has a thermistor included in its housing so that the power meter can read the temperature of the sensor. The voltage from that thermistor is applied through J1-6 (for channel A) and amplified by a gain of 2 by U39A (shown on Sheet 1). Channel B sensor's thermistor voltage comes in through J2-6 and is amplified by 2 at U39C. The thermistor voltages are also routed to U39D and U40A&B. This circuit is used to detect whether a sensor has been attached or disconnected. The connection or disconnection of a sensor causes a transient voltage which is passed through C10 (for channel A) or C11 (for channel B). This is detected by a window comparator consisting of U39A and U40A&B. Whenever the voltage is outside the normal DC bias range, the detector change will cause either a rise or a fall in the voltage that will be detected by the comparator. The comparator will output an interrupt to the U9 processor, IRQ, which will be the output of U40A&B.

U10A and U9A provide an enable or disable interrupt circuit so that the processor can disable interrupts. Pin 2 of U9A is used to enable or disable interrupts. U40C buffers the interrupt signal, and will allow the interrupt to either pass through or not pass through depending on the state of U9A. The interrupt 1 signal goes to the CPU Board.

The sensors also have EEPROMs that connect to the system through a serial interface. Channel A uses J1-13 for the clock and J1-12 for the data. This is a bidirectional device wherein data needs to be written to the sensor and also read to the sensor. U14B buffers incoming data, and U41C buffers outgoing data. Q1 provides the necessary open collector interface. U18 supplies the clock during a read or write action. The clock signal is buffered by U41A. Channel B has a duplicate circuit consisting of U41D/E/F and Q3. DC supplies of +5 V and ±15 V are also routed to the sensors. The 15 V supplies are routed through RT3 and RT4 which are used to provide solid state fusing in case of any shorts. These are resettable solid state fuses which do not need to be replaced. The +5 V can be switched on and off. This is buffered by Q8 which can enable or disable Q1, and is solid state fused by RT1.

Refer to Sheet 3 of the A2 schematic. To recap the preliminary actions of the incoming signals; they first go through the chopper, the 1st stage amplifier, the 2nd stage amplifier, and then the filter. The signals are then sent to U36, a 16 to 1 multiplexer. U36 can select 1 signal to route to U33, the A to D convertor. Most of the other signals are used for testing purposes only. During normal operation, the signal path will be through the other bessel filter. Channel A will enter through pin 11 of U36, and channel B will enter pin 19 of U36. (This is the path for measuring power.)

Thermistor voltages come in on pins 24 and 25 for channels A and B. The only other signal that is used for normal operation is the VpropF input that comes in through the J3 BNC on the rear panel. CR15 provides input protection, and U38A is a x1 amplifier/buffer. The VpropF signal can be read at pin 26 of the multiplexer. U33 is a 14 bit A/D which operates at an 11 µs conversion time. The input is via pin 6 on TP13, and this device can measure between 0 and 10V. U33's operating power supplies are limited to ±12V (pins 11 and 5). Those voltages are derived from ICs U35 and U34 which regulate the ±15 V to ±12V.

R105, R104, and C31 configure U33 to measure unipolar operation at 0 to 10V. U4 provides the start convert signal, and the U9 processor will assert this signal to start an A/D conversion. After the A to D conversion has completed, pin 3 can be asserted to output the data to the bus. These two functions are supplied by chip select ACS7 and ACS1. ACS1 is the output enable, and ACS7 is the start convert. EOC is end of convert, which occurs at pin 2 of U33. That is routed to data byte 15 so that the process can interrogate to see if the data conversion is complete. D15 will be asserted if the A/D has completed its conversion.

U20 is the offset D/A which provides the 1st stage amplifier (channel A) with ±5 V offset voltages. U17 provides channel B with its ±5 V offsets. These are 12 bit D/A converters. U37 is similar, but is configured for 0 to 10V. The output of U37 is buffered by U38B, current limited by R108, and is available at J4B&C for analog output.

U36 has a number of signals available for testing purposes. Offset voltages are available on pins 5 and 6. Output DAC voltage is available on pin 4, and switched 5 V signals on pin 7.

Sheets 4 and 5 of the A2 schematic cover the interconnections for the Calibrator circuitry and will be discussed starting on the next page, but U21 also serves the purpose of providing three 8-bit ports that are available for control of the multiplexers used in the Analog section, and an input port for the too high and too low comparators.

4.4 Calibrator Module

4.4.1 General

The Calibrator Module is located on the Analog PC Board. It is basically the heart of the 8540B Series Power Meters in that it is a patented system that allows the power sensors to be calibrated against an internal thermistor power standard (see Figure 4-3). In contrast to the conventional fixed-level calibrators, the 8540B calibrator produces a range of power levels over a 50 dB dynamic range to an accuracy of a few thousandths of a dB.

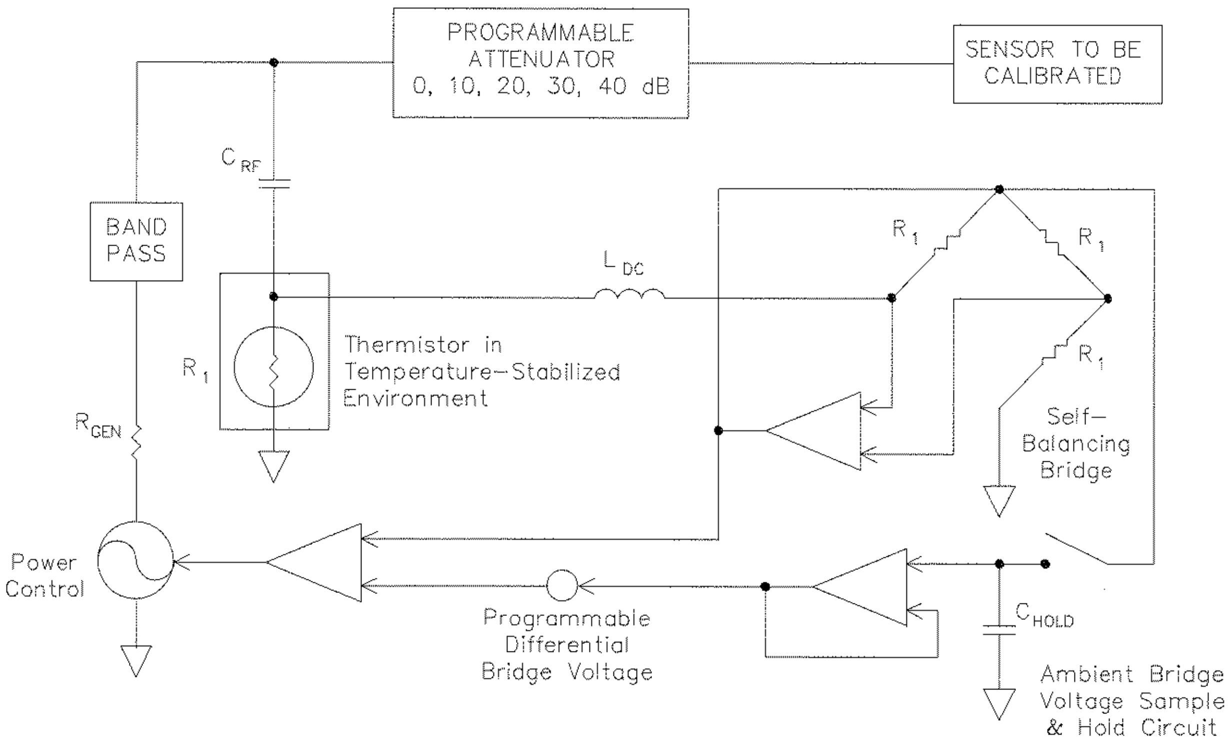


Figure 4-3. Calibrator Internal Power Standard

The thermistor is mounted in a self-balancing bridge configuration using DC substitution in the bridge. In this arrangement, the thermistor is maintained at a fixed operating point and the dc power in the thermistor, P_{dc}, is related to the RF power, P_{RF}, by the simple relationship:

$$P_{dc} + P_{RF} = P_{AMBIENT} = constant$$

The constant, $P_{AMBIENT}$, is found by turning the RF power off and measuring the ambient voltage, $V_{AMBIENT}$, to which the self-balancing bridge settles. The advantage of this approach is that the linearity of the thermistor-leveled oscillator is limited only by the accuracy with which DC voltages can be measured and the stability of the RF calibrator. To ensure exceptional stability, the thermistor assembly is enclosed in a temperature-stabilized environment and a low drift sampling circuit is used to hold the ambient bridge voltage. The RF power can then be programmed by controlling a difference voltage, δV, at the summing node. The power is related to the voltage by:

$$P_{RF} = \frac{V_{AMBIENT}\delta V - delta^2}{R_1} - \frac{delta^2}{2R_1}$$

This permits the RF power to be precisely controlled over a dynamic range of about 12 to 15 dB. The dynamic range is extended using a switched attenuator, the properties of which are determined using the thermistor-leveled oscillator itself. The effective attenuation (including all mismatch effects) of each attenuator relative to the next is measured by finding a pair of powers, one for each attenuator, that produces identical signals from the sensor under test. Because the sensor under test is used at a fixed operating point, no knowledge of its detection law is required.

The operation of the various circuitry functions of the Calibrator Module can be understood more easily if the circuits are discussed individually. The 11 functional sections of this module include the following:

1. The 50 MHz oscillator, Q4, and its current control circuit consisting of U16D, Q5, and U2C.
2. The RF output circuit consisting of the low pass filter, the stepped attenuator, and the connector and cable to the front panel of the 8540B meter.
3. The oven that maintains the control thermistor at a constant 60 °C is located on the small board attached to the bottom of the heater transistor, Q1. The board has two thermistors, RT1 and RT2, and Q7, the control transistor.
4. The thermistor bridge used to measure the RF power by DC substitution, consisting of RT1, U1, and Q6.
5. The track and hold circuit that remembers the ambient bridge voltage, using U2B, U8D, and U3A.
6. The 14-bit DAC and reference supply used to measure the ambient bridge voltage and control the RF output level, made up of U11, U7, U8A & B, U6, U16A, U13, U12, U4, and U15.
7. The correction circuit used to measure the temperature of the pin diode attenuator so that a correction for the temperature dependent loss of the diodes can be corrected, consisting of RT2 and U16C.
8. Sensor NV (Non-Volatile) RAM control circuit, U41D/E/F, Q3, and U18.
9. Calibrator NVRAM control circuit, U14 and U18.
10. Sensor interrupt control circuit, U9, U10A, U40A/B/C, and U39A.
11. The digital control circuit consisting of U18, U15B/C, U10B/C, U9B, and U15A.

4.4.2 50 MHz Oscillator

The first section of the Calibrator Module Assembly circuitry consists of a colpits oscillator circuit with a controllable power output. The output power is measured by the thermistor bridge and set by varying the DC current through Q4. This current is supplied by a voltage to current converter circuit consisting of U16D, Q5, and U4. The power generated by Q4 is nearly linearly related to the current through it. Thus, the voltage from U4 that is converted to current by U16D and Q5 is linearly related to the RF power generated. When the calibrator is set for 0 dBm, the voltage at U4-6 is near 0 volts.

4.4.3 RF Output

The 50 MHz oscillator output is capacity coupled to the low pass filter, L13, L14, L15, and associated capacitors. The resultant harmonic-free RF is applied to the switched pin attenuator, CR8 - 14, and associated resistors and control amplifiers U19 and U16B. The first section is 10 dB, the output section is 20 dB, and a resistor between sections adds another 10 dB. Thus, the output power can be programmed from +20 to -30 dBm.

4.4.4 Oven

The measuring thermistor is maintained at a constant 60 °C by being mounted on the heater transistor, Q1, which is driven from the sensing thermistor RT2 by way of the Q7 current amplifier. RT2 is mounted very close to RT1 so that both are maintained at the same temperature. When RT2 gets to a temperature of 60 °C, the voltage across it is just enough to maintain drive to the heater. This condition will be maintained regardless of the ambient temperature.

4.4.5 Thermistor Bridge

RT1 is connected in a self-balancing bridge circuit which will deliver just enough power to the thermistor to keep it at 500 ohms. Thus, if part of the power delivered to it is from the RF generated by the oscillator and the rest is from the DC current of the bridge, then by reducing the amount of DC power, the circuit will increase the drive to the oscillator as needed to keep the total power in RT1 constant. It is only necessary to measure the amount of DC power reduction to know the amount of RF power present. In this way, a precisely known RF output level can be established.

4.4.6 Track & Hold and DAC

In order to know how much power is being added by the oscillator, it is necessary to measure the power delivered to the thermistor with no RF present. This is done by turning off the oscillator power (closing switch U2C), and then measuring the voltage out of the control bridge. This is known as the ambient bridge voltage. To make this measurement, the following conditions are established: U8D and U2B are switched open, and U8A & C switch closed. Then, by using the DAC, U13, a successive approximation measurement of the voltage is made. Note that the output of the DAC is connected to one input of U4, and the bridge is connected to the other. Thus, it becomes a comparator that will make it possible for the computer to tell when the output voltage of the DAC is greater than the bridge voltage, and so complete the successive approximation. Once this is done, the DAC is set for 0V output, U8A is opened, U8B is closed, U8D and U2B are closed, and the track and hold capacitor, C39, will charge up to the voltage which represents the zero RF power condition of the bridge. When the oscillator is turned on by U9C, then the sampling switch, U2B, will open and allow C39 to supply this RF OFF condition to the measuring circuit. Any voltage from the DAC will now reduce the amount of DC power being delivered to the thermistor bridge, and the control circuit will add just enough current to the oscillator to cause its output to add back that much RF power into the bridge.

4.4.7 Correction Thermistor Circuit

The compensation thermistor is mounted near CR13 to sense the temperature of the 20 dB attenuator section that is used to produce the 0 dBm output. This is the only absolute power specified. All other power levels are measured by the software relative to 0 dBm.

4.4.8 Calibrator NVRAM Control Circuit

The calibrator serial number and the correction constant for the 0 dBm output level, as well as the date of calibration and password for rewrite access, is contained in a Non-Volatile RAM. The read and write for it is provided by the parallel peripheral interface (PPI) U18. Before allowing access to the NVRAM, the software looks for a logic 1 on port A, bit 0 of the PPI and, if that is present, it asks the operator for the password. If the correct password is supplied, then the collected data will be written into U14. If the jumper W1 is set to supply a logic 0 to the PPI, the operator will then have write access to U14 without needing a password.

4.4.9 Sensor NVRAM

Each sensor has a NVRAM which is used to store all of the calibration constants, the date of calibration, place of calibration, etc. This NVRAM is also password protected, but has no hardware switch to defeat it. The read/write control for it is furnished by U41A/B/C, U41D/E/F, Q2, and Q3 which control the 5 V supply in order to reduce the amount of heat in the sensor, as well as reducing the noise from the supply.

4.4.10 Sensor Interrupt

Each time a sensor is connected or disconnected from the 8540B, a CPU interrupt is generated by causing the thermistor voltage change to set a latch which signals the CPU that it needs to check for a sensor change. The latch is driven from a window comparator, U39D and U40A & B. This comparator is driven from capacitors which are connected to each of the thermistor lines from the sensors. The latch is enabled or cleared by a signal from the PPI, U18.

4.4.11 Digital Control Circuit

The digital control circuit is the interface between the CPU and the preceding functions.

4.5 Front Panel PC Assembly (A3)

(Refer to the Circuit Schematic on page 8-17.)

The front panel PC board contains a 4 x 4 keyboard matrix and circuitry to interface the 20 front panel LEDs to the CPU board (see Figure 4-4). The A4 LCD Display assembly is a manufacturer's purchased item and does not include a component diagram and circuit schematic in this manual.

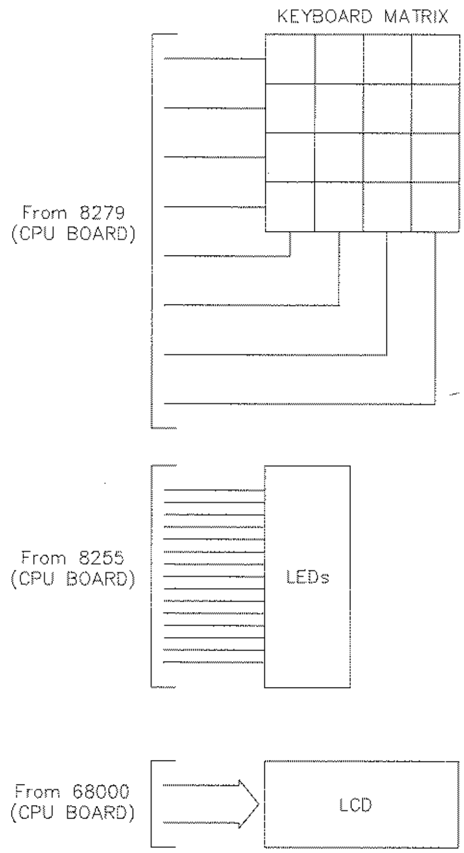


Figure 4-4. Front Panel PC Assembly