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Giga-tronics

Series 8540C Universal Power Meters

Operation & Maintenance Manual

CE .... **Certified Product**
ISO 9001 .... **Certified Process**

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WARRANTY

Giga-tronics Series 8540C instruments are warranted against defective materials and workmanship for one years from date of shipment. Giga-tronics will at its option repair or replace products that are proven defective during the warranty period. This warranty DOES NOT cover damage resulting from improper use, nor workmanship other than Giga-tronics service. There is no implied warranty of fitness for a particular purpose, nor is Giga-tronics liable for any consequential damages. Specification and price change privileges are reserved by Giga-tronics.

Model Numbers

The series 8540C has two model numbers: The single-channel Model 8541C and the dual-channel Model 8542C. Apart from the number of sensors they support, the two models are identical. Both models are referred to in this manual by the general term 8540C, except where it is necessary to make a distinction between the models.

DECLARATION OF CONFORMITY

Application of Council Directive(s)

Standard(s) to which Conformity is Declared:

89/336/EEC and 73/23/EEC	EMC Directive and Low Voltage Directive
EN50081-1 (1992)	EMC – Emissions
EN61010-1 (1993)	Electrical Safety

Manufacturer's Name:

Giga-tronics Incorporated

Manufacturer's Address:

4650 Norris Canyon Road
San Ramon, California 94583
USA

Type of Equipment:

Universal Power Meter

Model Series Number:

8540C

Model Number(s) in Series:

8541B
8542B
8541C
8542C
With Sensor Series 803XXA, 804XXA, 806XXA

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s) and Standard(s).

Thomas A. Kramer (Full Name)	(Signature)	Director of Quality Assurance (Position)
San Ramon, California (Place)		October 30, 1999 (Date)

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About This Manual

This manual contains the following chapters and appendices to describe the operation and maintenance of Giga-tronics Series 8540C 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 xvii for a description of the special configuration.

Chapter 1 – Introduction:

This chapter contains a brief introduction to the instrument and its 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 an instrument block diagram level description and its circuits for maintenance and applications.

Chapter 5 – Calibration & Testing:

This chapter provides procedures for inspection, calibration and performance testing.

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:

This appendix provides examples for controlling the 8540C remotely over the GPIB.

Appendix B – Power Sensors:

This appendix provides selection data, specifications and calibration procedures.

Appendix C - Options:

This appendix describes options available for the Series 8540C.

Index:

A comprehensive word index of the various elements of the 8540C manual.

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

Conventions

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

Warning

WARNING

The WARNING statement is enclosed in dashed 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

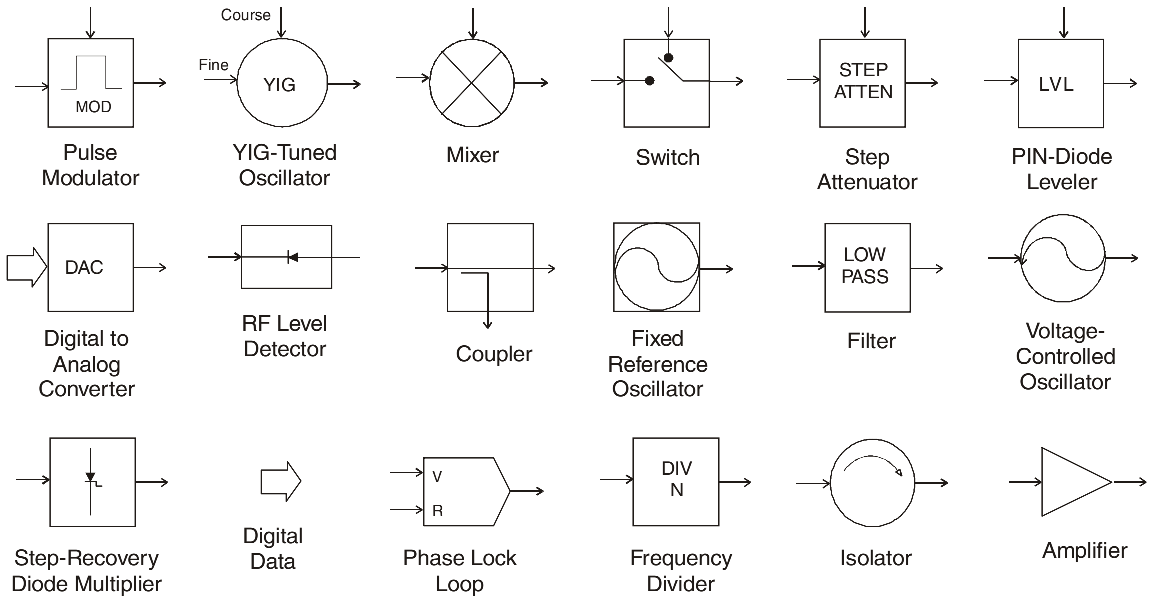
The CAUTION statement is enclosed with single lines and centered in the page. This calls attention to a situation, or an operating or maintenance procedure, or practice, which if not strictly corrected or observed, could result in temporary or permanent damage to the equipment, or loss of effectiveness.

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 the indicated page(s) and replace it (them) with the furnished Special Configuration supplemental page(s).

1

Introduction

1.1 Description

The Series 8540C is a digital-controlled, self-calibrating power meter. It can measure RF and microwave signal power over a wide range of frequencies and levels in a variety of measurement modes. They can be operated locally from the front panel or remotely over the General Purpose Interface Bus (GPIB). See Section 1.3 for performance specifications.

The Series 8540C is available as the single-channel Model 8541C or the dual-channel Model 8542C, which can simultaneously measure and display signal data for two channels.

The 8540C and the Series 80600 line of power sensors offer enhanced performance in the measurement of complex modulation signals in the communication industry. The 8540C maintains all the functionality of Giga-tronics 8540B power meters as well as compatibility with all existing power sensor models.

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 native mode emulation (GPIB only)
- EEPROM based CAL FACTOR correction sensors
- Modulated Average Power (MAP) mode
- Pulse Average Power (PAP) mode
- Burst Average Power (BAP) mode
- Wide modulation bandwidth – The 8540C is capable of accurately measuring signals with modulation frequencies up to 1.5 MHz with the 80601A sensor
- Dual-channel modulated measurements with the 8542C and 80400 or 80600 series power sensors
- Time-gating (Option 11) allows you to specify a time period referenced to a rear panel trigger during which power measurements are taken
- Password protection against unauthorized changes in data stored in EEPROMs

1.1.2 Performance Characteristics

Performance specifications for models in the 8540C are presented in Section 1.3. Sensor specifications are contained in Appendix B. Options are detailed in Appendix C.

1.1.3 Weight and Dimensions

Series 8540C instruments weigh 10 lbs. (nominal).

Dimensions are 3.5" high x 8.4" wide x 14.5" deep.

1.1.4 Power Requirements

100/120/220/240 Vac ±10%, 48-440 Hz, 20 W, typical. See Section 1.2.1 for details to set the voltage and install the correct fuse for the area in which the instrument will be used.

1.1.5 Environmental Requirements

The Series 8540C instruments are type tested to MIL-T-28800E, Type III, Class 5 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.

1.1.6 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 8541C), or
2 ea. - Detachable Sensor Cables (for Model 8542C)
1 ea. - Operation Manual

1.1.7 Items Required

The 8540C requires an external power sensor; see Appendix B for Power Sensor Specifications.

1.1.8 Tools and Test Equipment

No special tools are required to operate the 8540C. Test equipment required for calibration or performance verification is described in Chapter 4.

1.1.9 Cooling

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

1.1.10 Cleaning

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

1.1.11 Installation and Preparation for Use

The instrument is shipped in an operational condition and no special installation procedures are required.

1.1.12 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.

1.1.13 Preparation for Reshipment

Follow these instructions if it is necessary to return the product to the factory.

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 via our 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 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 8540C is designed for international use with source voltages of 100, 120, 220, or 240 Vac, ±10% at 50 to 400 Hz. The 8540C 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 Line Voltage and Fuse Selection

The instrument is shipped in an operational condition and no special installation procedures are required except to check and/or set the operating voltage and fuse selection as described in the following.

When the instrument is shipped from the factory, it is set for a power line voltage (120 Vac for domestic destinations). The power line fuse for this setting is 0.50 A Slo-Blo. If the source voltage is to be 220 to 240 Vac, the fuse must be changed to 0.35 A Slo-Blo (see Figure 1-1).

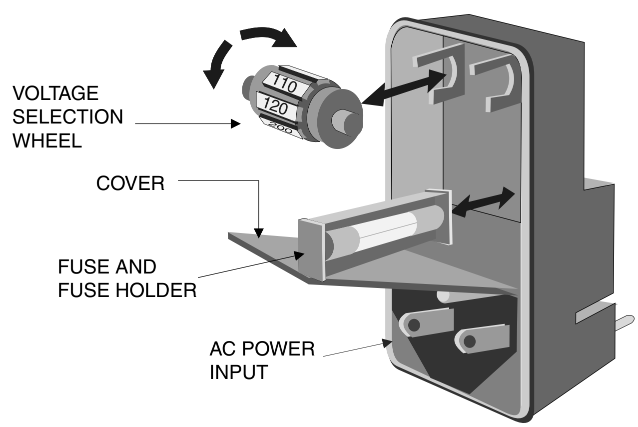


Figure 1-1: Voltage Selector and Fuse Holder

The voltage selector and fuse holder are both contained in the covered housing directly above the AC power connector on the rear panel. To gain access to them, use a small screwdriver or similar tool to snap open the cover 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 replace 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 (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 8540C System 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[1]
Peak Power Sensors:	40 dB Peak, 50 dB CW
Modulation Sensors:	87 dB CW; 80 dB MAP/PAP; 60 dB BAP
Display Resolution:	User-selective 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

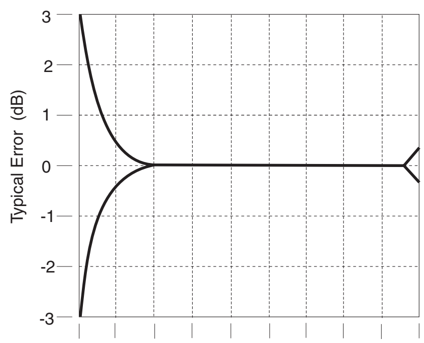
Calibrator	Power Sweep calibration signal to dynamically linearize the sensors
Frequency:	50 MHz nominal
Settability:	The 1 mW (0.0dBm) level in the Power Sweep Calibrator is factory set to ±0.7% traceable to National Institute of Standards and Technology. Measure with 15 seconds of setting calibrator to 0.0 dBm.
0.0dBm Accuracy:	±1.2% worst case for one year over a temperature range of 5 to 35 °C
Connector:	Type N, 50 Ω
VSWR:	<1.05 (Return Loss >33 dB)
System Linearity at 50 MHz for Standard Sensors:	±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] <±100 pW with 80400A and 80600A Series Modulation Power Sensors
Zero Drift	<±100 pW during 1 hour [2, 3] <±200 pW with 80400A and 80600A Series Sensors
Noise	<±50 pW measured over any 1 minute interval. Three standard deviations.[2] <±100 pW with 80400A and 80600A Series Sensors

Notes:

1. Depending on sensor used (see Power Sensor details in Appendix B).
2. Specifications applies at -50 dBm for 803XXA 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 Sensors, see Appendix B and the 80350A Series Peak Power Sensor Data Sheet. Specified performance applies with Maximum averaging and 24 hour warm-up temperature vision <3 °C.

3. Zero Drift Measurement
   a. Set the meters Average to 512. Perform Calibration. Connect a 50-ohm load to the sensor after Calibration and Zero meter.
   b. Temperature stabilize at 25 °C for 24 hours.
   c. After the 24 hour stabilization at 25 °C, perform a Zero Drift test.
   d. Zero meter and take an initial measurement reading.
   e. Take one reading every 10 minutes until the one hour period elapses.
   f. Plot the 6 readings, Zero Drift should be ±100pW.

1.3.3 Uncertainty Due to Instrument Linearity & Zero Set vs. Noise



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)	-40	-33	-27	-21	-15	-9	-33	9	15	20
80601 (CW)	-60	-50	-40	-30	-20	0	10	20		
80601 (MAP, PAP)	-55	-45	-35	-25	-15	-5	5	15		
80601 (BAP)	-40	-33	-27	-21	-15	-9	-33	9	15	20

Input (dBM)

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

1.3.4 Measurement Rates

Measurement speed increases significantly using the 8540C 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 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 mode and the Swift mode both 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 8540C 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:	All front panel operations and some GPIB-only operations to be remotely programmed in IEEE 488.2 or IEC-625 formats.
Interrupts:	SRQs are generated for the following conditions: Power Up, Front Panel key actuation, Operation Complete and 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 Function

Averaging:	User-selectable auto-averaging or manual, 1 to 512 readings. Automatic noise compression 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 Requirements and Display Configuration:	Any two of the following channel configurations simultaneously: A, B, A/B, B/A, A-B, B-A, DLY_A, DLY_B (provided that neither sensor is being used for MAP, BAP, 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 = 50K. Does not operate in the fast measurement collection modes (normal mode only).
Analog Output (BNC):	Provides an output voltage of 0 to 10V from either Channel A or Channel B in either Log or Lin units. Does not operate in the swift and fast measurement buffered modes.
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 Interface:	Interfaces power meter to controller, IEEE 488.2 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:	100/120/220/240Vac ±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 8540C Operation Manual (P/N 31470)

1 ea Power Cord

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

1.3.11 Options

Refer to Appendix C for a full descriptions of options.

OPTION 01: Rack Mount Kit.

OPTION 02: Add 256K buffer for Fast Buffered Power Readings. Stores 128,000 readings.

OPTION 03: 8541C Rear Panel Connections (Sensor & Calibrator - Deletes front panel connections)

OPTION 04: 8542C Rear Panel Connections (Sensor & Calibrator - Deletes front panel connections)

OPTION 05: Soft Carrying Case

OPTION 06: Second Analog Output on 8542C (-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)

OPTION 11: Time Gating Measurement

OPTION 13: 8541C Rear Panel Connection (Sensor only - Deletes front panel sensor connection)

OPTION 14: 8542C Rear Panel Connections (Sensor only - Deletes front panel sensor connections)

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 how to operate the Series 8540C 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 with the General Purpose Interface Bus (GPIB).

2.2 The Front Panel

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

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

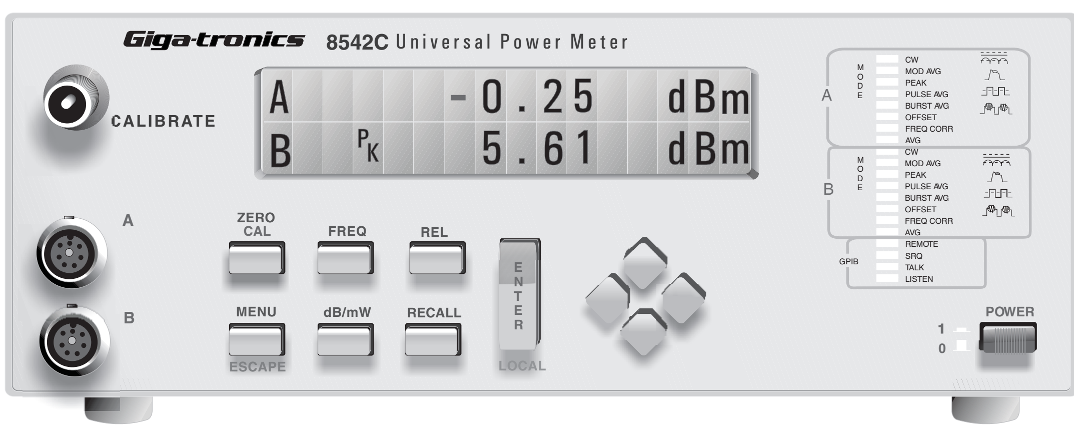


Figure 2-1: 8542C Front Panel

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 measurements 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 Front Panel Keys

The front panel keys are located below the display window, and function as described below:

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 the ZERO/CAL key 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 8540C memory.

For zeroing only, the sensor does need not to be connected to the CALIBRATOR output. If the ZERO/CAL key is pressed when the sensor is not connected to that output, the 8540C 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 8540C can apply the appropriate frequency-specific cal factor to the measurement. These cal factors are retrieved from the sensor EEPROM.

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

REL

This key is for relative measurements (measurement values are not absolute but are expressed in dB relative to a reference level). The REL key establishes the currently 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 also functions as the ESCAPE key because 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 units simultaneously, but this must be done through the Meas Setup configuration menu).

RECALL

The recall button retrieves a stored configuration of the 8540C (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 8540C 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 option 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 vertically through available submenus, and move the display cursor (underline) horizontally within specific menus.

2.2.6 Sensor Inputs

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

CAUTION

When connecting sensor cables to these inputs, 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 panel for the 8541C and 8542C are identical and are illustrated in Figure 2-2.

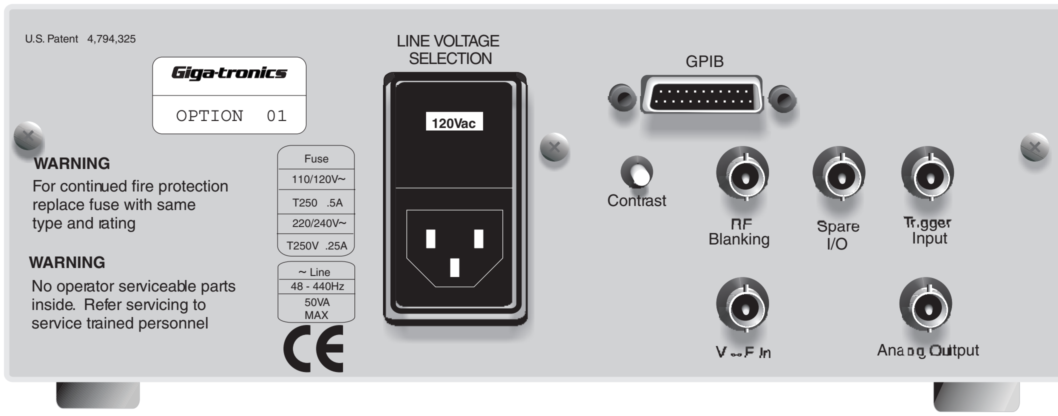


Figure 2-2: 8540C Rear Panel

2.3.1 Inputs & Outputs

BNCs

Five BNC-type connectors provide input and output signals for interfacing the 8540C 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 α F In** accepts a voltage input that is proportional to frequency and causes the 8540C to apply appropriate frequency-related cal factors.
- **Analog Output** provides an output voltage that is proportional to the measured power level.
- **Spare I/O** is for a second Analog Output when Option 06 is installed.

Others

- **GPIB** (a 24-pin connector to connect the 8540C to other equipment over the GPIB).
- **Line Voltage Selection** houses the ac power connector and includes the fuse and line voltage selector (see Section 1.2.1 for setting the voltage and fuse).

2.4 Configuring the 8540C

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

The 8540C can be password-protected to prevent unauthorized changes in Calibrator and Cal Factor data stored in EEPROMs in the 8540C or its sensors. It is activated with the front panel menus (see Section 2.4.3 for a description of the menus and their usage). The 8540C 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 also browse through the lines of a menu. To select the currently displayed line, press [ENTER].

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 cursor buttons (usually the Left/Right buttons) are 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 select a digit, and the Up/Down cursor buttons then 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 illustrates the menu structure. For specific information about the individual menu items, see Section 2.5. 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 PAP 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: Configuration Menu Structure

Main Menu Item	Subsequent Menus / 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	Num. of Samples: A Num. of Samples: B [increment or decrement]
		Burst End Exclude	
		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)	[increment or decrement the displayed value]
		Set Samp Delay (ns)	
		DLY Offset (ns)	
	Ext	Set Trig Level (V)	
		Set Samp Delay (ns)	
		DLY Offset (ns)	

Table 2-1: Configuration Menu Structure (Continued)

<table>
<tr><th>Main Menu Item</th><th colspan="3">Subsequent Menus / Entry Windows</th></tr>
<tr><td rowspan="4">Sensor Setup: Modulation Sensor [80400 Series]

[select A or B]</td><td>CW</td><td colspan="2">(No further configuration is required if CW is selected.)</td></tr>
<tr><td>Modulated Avg</td><td colspan="2">(No further configuration is required if Modulated Avg is selected.)</td></tr>
<tr><td>Pulse Avg</td><td colspan="2">Duty Cycle [increment or decrement the displayed value]</td></tr>
<tr><td>Burst Avg</td><td colspan="2">(No further configuration is required if Burst Avg is selected.)</td></tr>
<tr><td>Ref Power On/Off</td><td colspan="3">Choose from: On or Off</td></tr>
<tr><td rowspan="8">Config</td><td>Peaking Meter</td><td colspan="2">Choose from:
Status, PkA, PkB</td></tr>
<tr><td rowspan="2">GPIB</td><td>Mode</td><td>Choose from:
8541, 8542, 436A, 437B, 438A</td></tr>
<tr><td>Address</td><td>Choose from:
0-30 (listen & talk), 40 (listen only) and 50 (talk only).</td></tr>
<tr><td rowspan="2">Analog Out</td><td>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]</td><td>Choose from:
Off, Bot Line, Top Line</td></tr>
<tr><td>Mode</td><td>Choose from: Log, Lin</td></tr>
<tr><td>V prop F [select A or B]</td><td>Choose from: OFF, ON

If ON is selected, two values must be defined</td><td>Freq. at 0 Volts (GHz)
Scale Factor (V/GHz)
[increment or decrement the displayed values]</td></tr>
<tr><td>Sound</td><td colspan="2">Choose from: ON, OFF</td></tr>
<tr><td colspan="3" style="display:none"></td></tr>
<tr><td rowspan="6">Service</td><td>Sensor ROM [select A or B]</td><td colspan="2">Choose from a wide variety of parameters that can be set.</td></tr>
<tr><td rowspan="2">Calibrator</td><td>Power</td><td>Choose from: OFF, or a value in dBm
[increment or decrement the displayed value].</td></tr>
<tr><td>EEPROM
[data to be entered:
Serial#, Cal Factor, Date, Time, WRITE]</td><td>WRITE:
CALIB Clear, or
PASSWORD Set</td></tr>
<tr><td>Test Functions</td><td colspan="2">Choose from a wide variety of diagnostic tests.</td></tr>
<tr><td>Software Version</td><td colspan="2">Displays information about the currently installed software.</td></tr>
<tr><td>Clear All Memory</td><td colspan="2">Clear RAMs of configuration data.</td></tr>
<tr><td>Save Setup</td><td colspan="3">Save to Reg#
[specify a number from 1 to 20]</td></tr>
</table>

2.4.3 Password Protection

The password feature prevents unauthorized changes in Calibrator and Cal Factor data stored in EEPROMs in the 8540C 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 8540C 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 and press [ENTER]. Press [ENTER] again to confirm the password. The password is now stored in the 8540C 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 A to position B.

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.

A the display line for Sensor A

B the display line for Sensor B (Model 8542C only)

A/B the reading of Sensor A divided by the reading of Sensor B (Model 8542C only)

B/A the reading of Sensor B divided by the reading of Sensor A (Model 8542C only)

A-B the reading of Sensor A less the reading of Sensor B (Model 8542C only)

B-A the reading of Sensor B less the reading of Sensor A (Model 8542C only)

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 is 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 is 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 [REL] 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 a portion of the beginning of a burst 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 is masks off a portion of the end of a burst 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 is 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 8540C 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 8540C. 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.

$V_{PROF}F$

The $V_{PROP}F$ (voltage proportional to frequency) connector accepts a voltage input in the range of 0 to +10V, which the 8540C 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 $V_{PROP}F$: 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 is 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 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 to calibrate 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 8540C 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 8540C. See Section 2.6.10 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 806XX Sensor Operation

The Series 806XX power sensors are designed for the precise measurement of signals with wide modulation bandwidths (up to 1.5 MHz). In terms of the various measurement modes (i.e., MAP, BAP, etc), the 806XX sensors are operated exactly as the Series 804XX sensors described in Section B.1.

There is one distinction regarding the operation of the 806XX sensors. Below 200 MHz, the modulation bandwidth of the sensor is limited by a filter which is electronically switched in the sensor. This is done to keep the RF signal out of the base band signal processing circuitry. When a 806XX sensor is calibrated on the meter for the first time (the meter reads UNCALIBRATED before calibration), the unit is set to the default setting of MAP mode with frequency correction set to 1 GHz. This allows the sensor to measure signals with wide-bandwidth modulation. For frequencies of 200 MHz or below, the frequency correction must be set to the measurement frequency to avoid measurement error.

The Series 806XX sensors are compatible with the 8541C and 8542C and later configurations.

2.6.3 Sensor Calibration

The procedure for calibrating a sensor is:

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

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

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

2.6.4 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 the ZERO/CAL key 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 EMF.

☛ ***NOTE:** Sufficient time must be allowed for the module to reach thermal equilibrium with the source. This could be up to 15 minutes for moderate initial temperature differences.*

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.

2.6.4.1 Low Level Performance Check

This procedure provides a quick-check list for evaluating meter/sensor performance for low-level measurements. It is not intended to verify performance of specifications such as Noise, Temperature Coefficient and Zero Set. For complete verification, please refer to sections one and five in the power meter operation manual.

1. This test is meant to check the low level performance of the meter and sensor. In order to do so, the meter and sensor should first be separated from any external amplifiers, test systems, etc. Turn the meter on and allow stabilization at ambient for 30 minutes. Connect the sensor to the meter but not connected to the test port.

2. **Calibration.** Connect the power sensor to the calibrator port on the power meter and press Zero/Cal.

☛ ***NOTE:** During calibration an approximate zero is established for calibration purposes only. This zero is not valid for actual measurements and can limit the measurement range as high as -50 dBm. For proper low-level measurements, the sensor must be zeroed at the test port of the system being tested.*

3. **Zeroing.** Validation of meter and sensor noise floor will be checked using an attenuator or termination. Connect the attenuator or termination to the sensor and allow the unit to stabilize for 3 minutes. The sensor must be thermally stabilized for proper zeroing. If the thermal condition of the sensor varies during the zero procedure, the zero will not be valid.

4. Set averaging to 512 and configure for CW operation. After the unit has thermally stabilized, push the Cal/Zero button.

5. Immediately after zeroing, confirm that the meter reading is at least 3 dB below the minimum CW operating range of the sensor. This checks the noise floor and zero set capabilities of the meter and sensor.

6. **Zero Drift.** Zero Drift is a measure of the change in noise over time. Each family sensor will have a specified expectation of drift over a one-hour period. To confirm, set the meter to linear display (Watts) after verifying noise floor and check that the display does not drift beyond specification over a one-hour period.

Verification for specifications such as noise, zero drift and temperature coefficient of linearity are difficult, time consuming tests. This checklist is useful to quickly determine if there is a catastrophic system failure. Failure to meet the above guidelines is not necessarily an indication of specification failure. Final confirmation of system specification performance is achieved using the verification procedures found in the meter operation manual.

2.6.5 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 RF output is ON.

3. Press [**FREQ**]; enter the operating frequency (use the cursor keys to adjust the value), and press [*OK*].

4. The 8540C will now display the microwave source output power. Adjust the source amplitude to the desired level.

The 8540C 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 8540C to automatically apply frequency calibration factors appropriate to the sensor being used. The operating frequency can be communicated to the 8540C using the front panel menus, the GPIB, or the $V_{PROP}F$ voltage input. (The input connector for the $V_{PROP}F$ function is labeled V α F In on the 8540C rear panel.)

2.6.6 Using the Peaking Meter

The LEDs on the right side of the 8540C front panel can be configured 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.

2.6.7 High Power Level Measurements

High power amplifiers and transmitters can damage standard sensors. Use only high power sensors to measure these devices without using attenuators and measurements.

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.

2.6.8 Modulated Measurement Modes

The 8540C 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 8540C 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 modulated measurement modes.

The new modulated measurement modes are available through the sensor setup menu when the active sensor a modulated series. The 8540C 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 8540C 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 8540C 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 setting time will be 5.12 seconds (40 ms times 128) and each reading will include 256 pules (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 8540C 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 measures pulse-modulated signals having a known duty cycle. You can specify this duty cycle and the 8540C 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 8540C 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 8540C. 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.

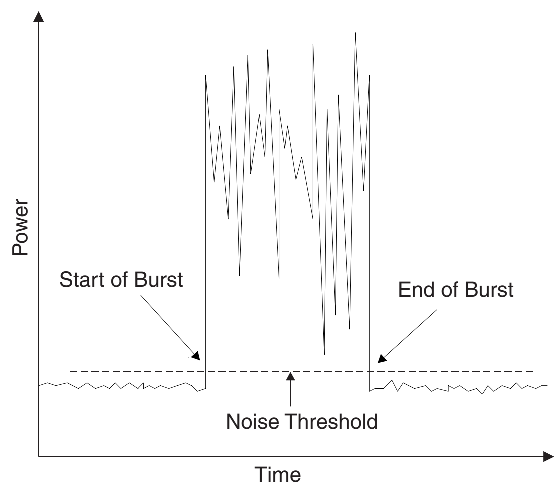


Figure 2-3: Burst Measurement

In BAP mode, the 8540C automatically determines which portions of the signal are in the pulse and which are not. In computing the average power, the 8540C 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.

2.6.9 Measurement Collection Modes

Using a wide range of CW and Peak Power Sensors and the GPIB fast measurement collection modes, the Series 8540C meters provide typical reading speeds of >200 readings per second in the free-run Swift mode, 800 readings per second in the Fast Modulated mode, and >2,000 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 2,600 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. Option 02 buffer increases this to 128,000 readings.

CW Mode

This mode is for measuring 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 20 ms multiplied by the averaging factor (for example, if the averaging factor is 128, the maximum settling time is 2.56 seconds). In most situations the actual settling time is well below the maximum.

PEAK Mode (80350A Peak Power Sensor)

The Peak mode is 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 8540C 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 offset. A fixed delay insures that each pulse is sampled at the same point in its cycle.

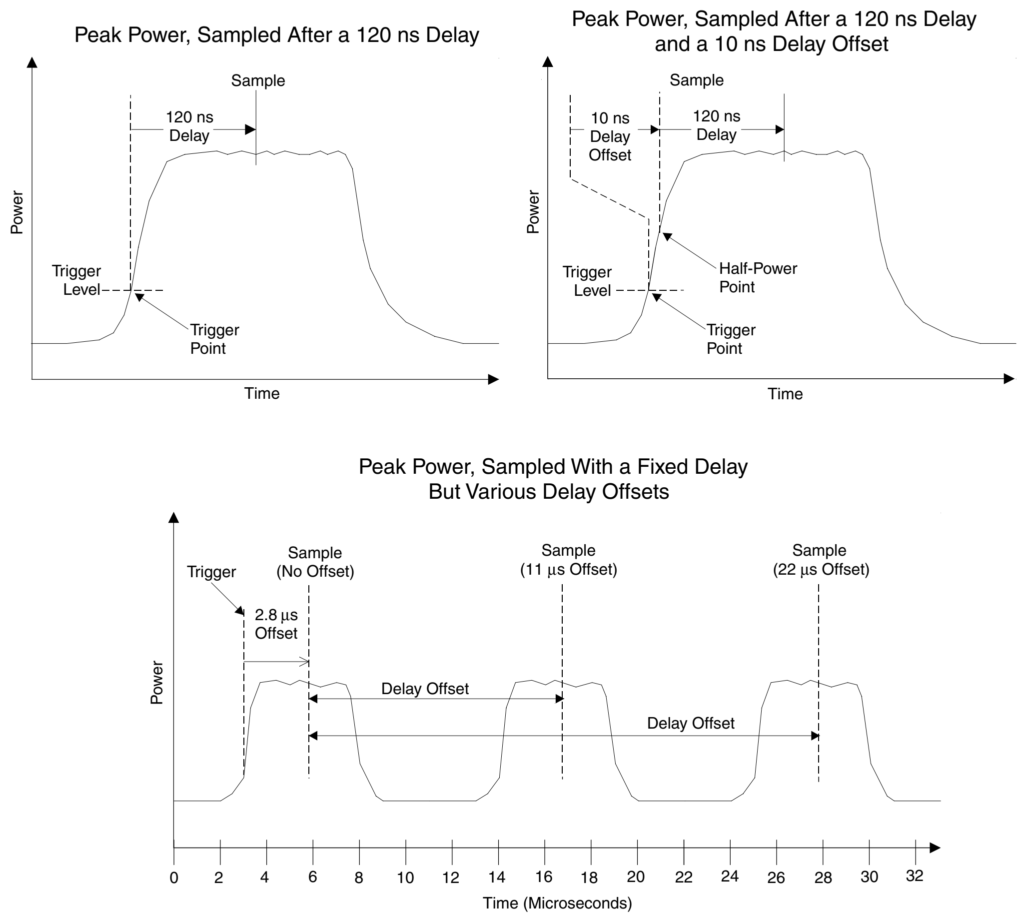


Figure 2-4: Delay and Delay Offsets

2.6.10 Mode Restrictions

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

- 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.

2.6.11 When to use CW, MAP and BAP

For measuring signals with any kind of modulation, MAP mode should be used. In this mode, the 8540C 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 8540C 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.

2.6.12 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 8540C test procedure is as follows:

1. Calibrate the sensor according to the procedure outlined earlier in this section.
2. From the Main Menu press [*Sensor Setup*]. From the Sensor Setup menu, press [*Modulated Sensor*] and then select the MAP mode by pressing [*MAP*].
3. Press [*FREQ*] and enter the operating carrier 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. 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.

2.6.13 Peak Hold

When the Peak Hold feature is selected, the 8540C 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 Display Data Line Configuration setup menu, or over the GPIB. Peak Hold is reset by pressing [*Reset Line n*] (or, in remote control, by sending the command which activates the Peak Hold feature.

The reset function controls the time resolution of the reading (that is, for finer resolution, reset more frequently).

☛ ***NOTE:*** *[Reset Line n] for Peak Hold also resets the Crest Factor*

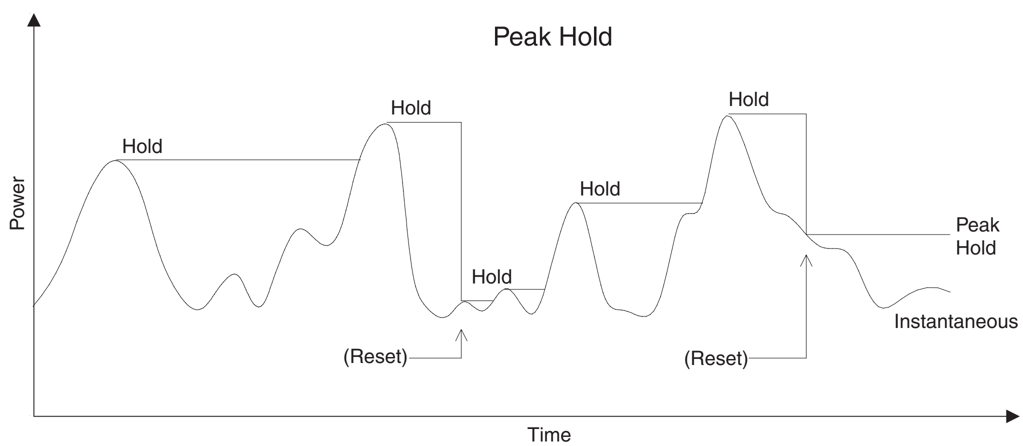


Figure 2-5: Peak Hold

2.6.14 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 the CW, MAP, PAP, or BAP modes only. It can be enabled from the front panel under the Display Data Line Configuration setup menu, or over the GPIB. The Crest Factor feature is reset by pressing [*Reset Line n*] of the appropriate line or, in remote control, by sending the GPIB command which activates the Crest Factor feature (see Section 3.9).

In Figure 2-6, 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.

☛ ***NOTE:*** *[Reset Line n] for the Crest Factor also resets Peak Hold.*

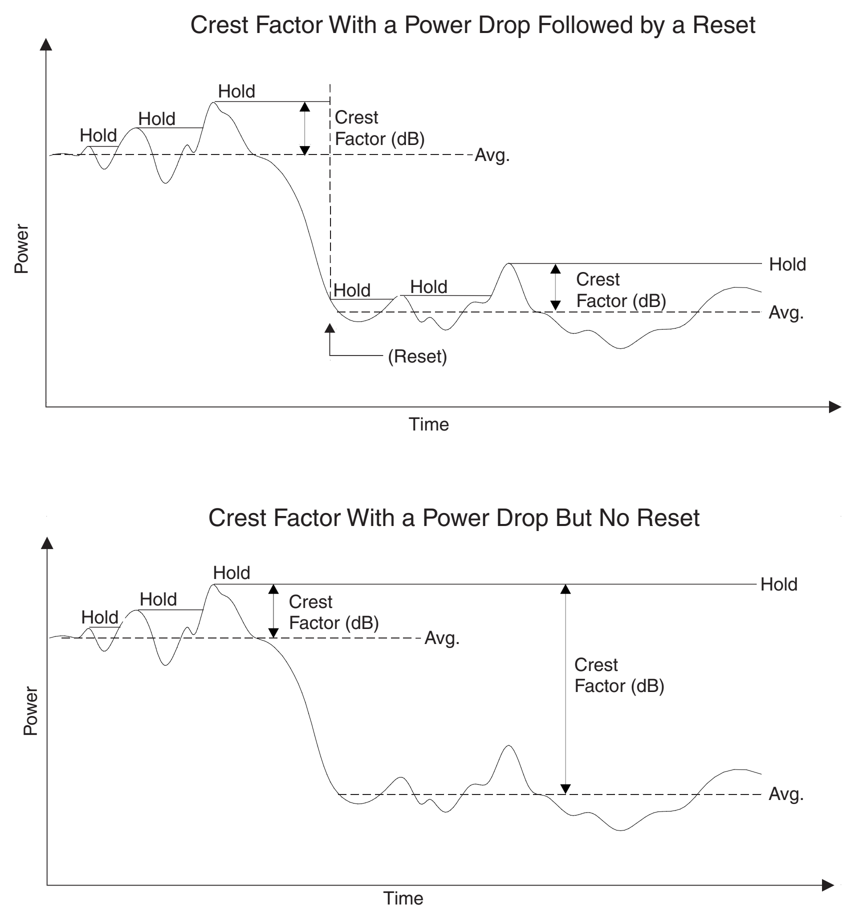


Figure 2-6: Crest Factor

2.6.15 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 carrier frequency.
4. Connect the sensor to the burst signal source and record the power level.

The 8540C 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 8540C 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 8540C may lose sync are listed in Section B.2.2.*

2.6.16 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 on the screen to the right of the sensor power units, 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 $\times$ $(n + .5)$ 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.

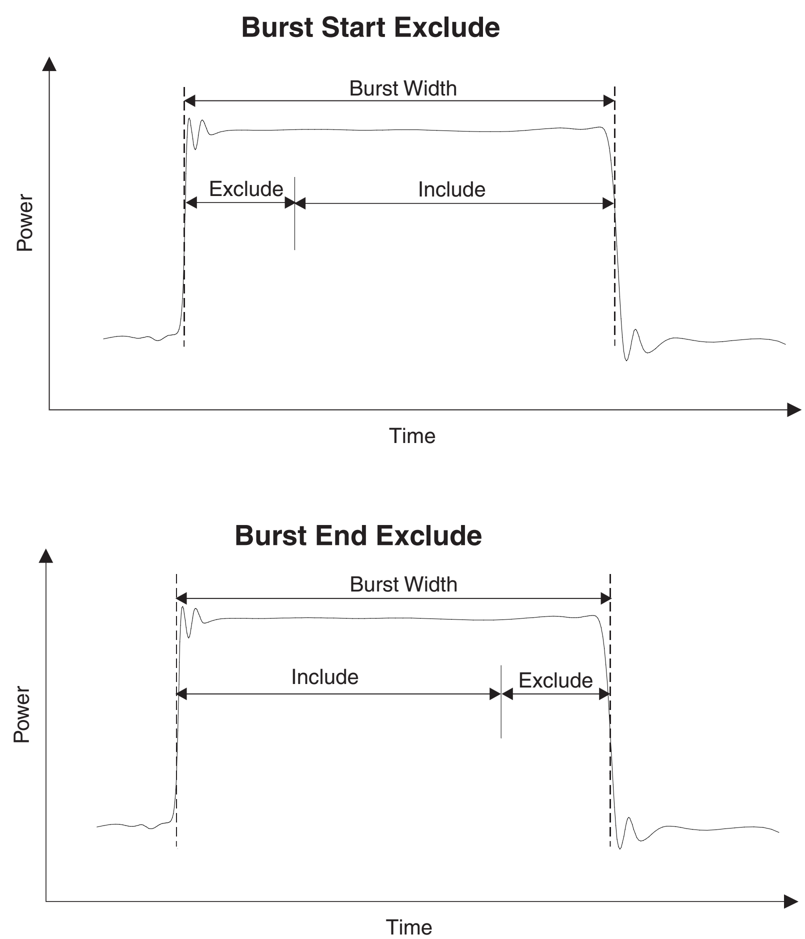


Figure 2-7: Burst Start Exclude & Burst End Exclude

2.6.17 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.

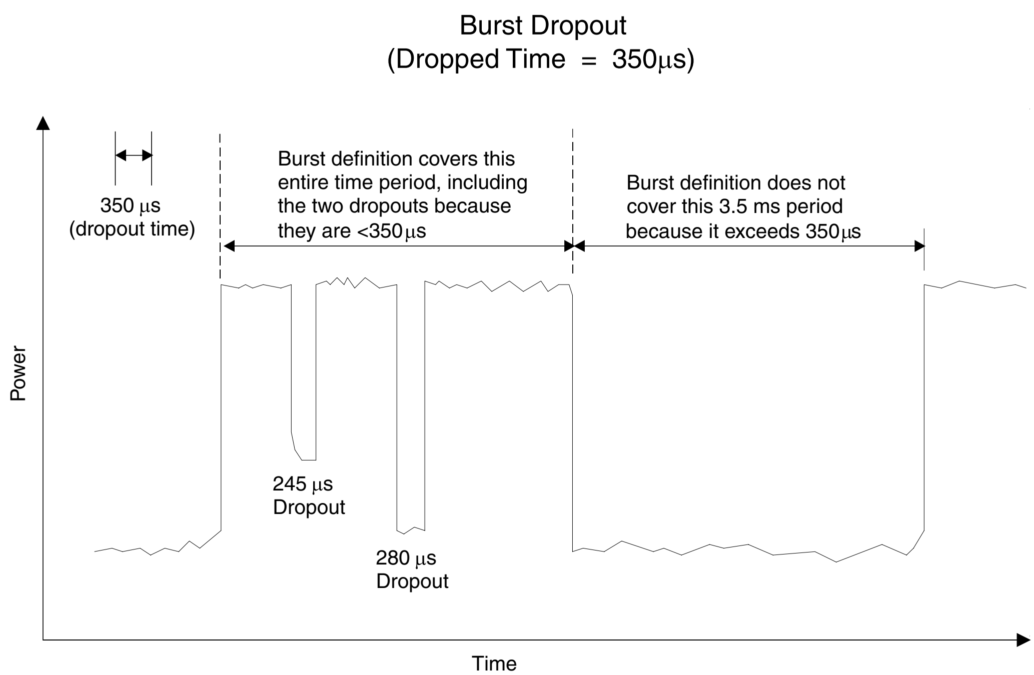


Figure 2-8: Burst Dropout

2.6.18 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 8540C 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 8540C 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, ±0.02 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
```

2.6.19 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 Sensor Setup, and select internal, external, or CW triggering.
3. Select the desired trigger level (for internal 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.

2.6.20 Measuring an Attenuator (Single Channel Method)

Attenuators are useful for many applications. With the 8540C, 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] and enter the operating frequency (this step is optional).
3. From the Main menu, 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.

2.6.21 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 amplitude levels.

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.

2.6.22 Performance Verification

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.

2.6.23 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:

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

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

The following factors affect instrument accuracy:

- Instrument linearity or instrumentation uncertainty
- Reference calibrator setability 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