3

Remote Operation

3.1 Introduction

The Series 8540C can be operated from a remote host over the General Purpose Interface Bus (GPIB) using either Standard Commands for Programmable Instruments (SCPI) or IEEE Standard 488-1978 (Digital Interface for Programmable Instruments)commands.

Table 3-1 shows which functions of the IEEE 488 standards are implemented in the 8540C.

Table 3-1: Implemented IEEE Standards

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

3.1.1 Sending Commands to the 8540C

The 8540C power meter uses standard protocols for communication over the GPIB. Commands conform to IEEE 488.1 or IEEE 488.2 guidelines. Three emulation modes (HP436, HP437, and HP438) are available for users of power meters who cannot rewrite their application software.

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

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

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

3.1.2 Clear Device

The interface command CLEAR 713 resets the GPIB and sets the 8540C to its preset condition.

3.1.3 Clear Interface

The interface command ABORT 7 resets the GPIB without resetting the 8540C to its preset condition. The 8540C will not be addressed after the abort.

3.1.4 Local and Remote Control

The interface command LOCAL 713 places the 8540C into the local control mode.

The interface command REMOTE 713 places the 8540C into the remote control mode. Enter LOCAL 713 to return the instrument to local mode.

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

3.1.5 Sensor Selection and Calibration

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

3.1.6 Polling

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

Parallel Polling

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

Serial Polling

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

3.1.7 Data Output Formats (Standard Measurement Collection Mode)

The data output format for the standard measurement collection mode is:

±D.DDDDE±NNCRLF

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

3.1.8 Data Output Formats (Fast Measurement Collection Modes)

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

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

3.1.9 Power-On Default Conditions

The interface wake-up state is:

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

3.2 Command Syntax

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

3.2.1 Functions

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

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

3.2.2 Prefixes

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

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

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

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

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

3.2.3 Variables

Some commands must include one or more variables to specify quantities or options for the command. For example, the function code ANALOG (which is used in commands that configure the analog output) is combined with many different variables to specify different aspects of the analog output. In the command

ANALOG STD TOP LOG -80.0, 20.0, 0.0, 10.0

the variables are interpreted as follows:

STD Specifies the standard analog output (as opposed to the optional second output).

TOP Specifies the top line of the display.

LOG Specifies that power is to be measured in logarithmic units (that is, dB or dBm).

-80.0 Specifies that the low end of the analog output voltage range represents -80 dBm in.

+20.0 Specifies that the high end of the analog output voltage range represents +20 dBm in.

0.00 Specifies that the low end of the analog output range is 0 volts.

10.0 Specifies that the high end of the analog output range is 10 volts.

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

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

3.2.4 Suffixes

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

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

3.2.5 Separators

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

3.2.6 Command Format Illustrations

A command format is used in this chapter to show the possible elements of a command, as shown below:

[AE or BE] DY [n] [EN or PCT or %]

Variables are shown within brackets. In this example, the prefix can be AE or BE, the function is DY, a numerical variable [n] follows the function, and the suffix at the end can be EN, PCT, or %. Possible commands which use this example format include AE DY 42 % and BE DY 29.5 EN.

3.3 Series 8540C Command Codes

3.3.1 IEEE 488.2 Common Commands

Table 3-2 lists the IEE 488.2 common commands that are implemented in the 8540C. For further information refer to the manual section cited in Table 3-2.

Table 3-2: IEEE 488.2 Command Set

Command	Description	Section
*CLS	Clear status byte	3.30.1
*ESE	Set Event Status Enable Register	3.30.2
*ESE?	Ask for current status of Event Status Enable Register	3.30.2
*ESR?	Ask for and clear Event Status Register bits	3.30.2
*IDN?	Ask for instrument ID	3.14
*RST	Software reset1	3.26
*SRE	Set the service request mask	3.30.1
*SRE?	Ask for service request mask	3.30.1
*STB?	Ask for status byte	3.30.1

3.3.2 8540C Function Codes

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

Table 3-3: 8540C Function Codes

Command	Description	Section
@1	Set service request mask	3.30.1
@2	Set learn mode 2 data	3.15.2
?ID	Ask for instrument ID	3.14
AD	Measure A-B	3.29
ANALOG	Configure analog output	3.4
AP	Measure sensor A	3.29
AR	Measure A/B	3.29
BAP	BAP mode	3.19.4
BD	Measure B-A	3.29
BP	Measure sensor B	3.29
BR	Measure B/A	3.29
BSPE	Burst end exclude	3.20
BSTE	Burst start exclude	3.20
BTDP	Burst dropout	3.20.3
CH	Select active measurement line for subsequent commands	3.4.1
CL	Calibrate sensor	3.7
CRF	Ask for crest factor value	3.9
CR	Crest factor	3.9
CS	Clear status byte	3.30.1
CW	CW mode	3.19
DA	Test LCD display	3.10
DC0	Duty cycle disable	3.11
DC1	Duty cycle enable	3.11
DD	Display disable	3.10
DE	Display enable	3.10
DU	Display user message	3.10
DY	Set duty cycle	3.11
EEPROM	Sensor EEPROM query	3.12
FA	Auto averaging	3.5
FBUF	Fast buffered mode	3.18.3
FH	Hold current averaging number	3.5.1
FM	Set averaging number	3.5.2
FMOD	Fast modulated mode	3.18.5
FR	Frequency	3.13
GT0	Cancel GET	3.17.2
GT1	GET single measurement	3.17.2
GT2	GET full measurement with settling	3.17.2

Table 3-3: 8540C Function Codes (Continued)

Command	Description	Section
ID	Ask for instrument ID	3.14
KB	Enter cal factor	3.6
LG	Log units (dB or dBm)	3.32
LH	Set high limit	3.16
LL	Set low limit	3.16
LM0	Disable limit checking	3.16
LM1	Enable limit checking	3.16
LN	Linear units (Watts or %)	3.32
LP1	Ask for learn mode #1 string	3.15.1
LP2	Ask for learn mode #2 output	3.15.2
MAP	MAP mode	3.19
MAX	Ask for max value	3.21
MEAS	Ask for measurement mode	3.19.6
MIN	Ask for minimum value	3.21
MN0	Min/max disable	3.21
MN1	Min/max enable	3.21
OC0	Disable calibrator source	3.8
OC1	Enable calibrator source	3.8
OF0	Offset disable	3.22
OF1	Offset enable	3.22
OS	Set offset value	3.22 & 3.22.3
PAP	PAP mode	3.19
PEAK	Peak sensor settings	3.24 & 3.25
PH	Peak hold	3.23
PKH	Ask for peak hold value	3.23
PR	Preset the 8540C1	3.26
RC	Recall a saved instrument state	3.31
RE	Display resolution	3.28
RL0	Disable relative measurement	3.27
RL1	Enable relative measurement	3.27
RL2	Use old reference for relative measurement	3.27
RV	Ask for service request mask	3.30.1
SM	Ask for status message	3.30.3
ST	Store instrument state	3.31
SWIFT	Swift mode	3.18.4
TR0	Trigger hold mode	3.17
TR1	Trigger single measurement	3.17
TR2	Trigger full measure with settling	3.17
TR3	Free run trigger mode	3.17
$V_{PROP}F$	Configure $V_{PROP}F$ feature	3.33
ZE	Sensor zeroing	3.34

3.3.3 HP437 Emulation GPIB Command Set

The GPIB commands that are available when the instrument is placed in the HP437 emulation mode. Footnotes appear at the end of Table 3-4.

Table 3-4: 8540C Command Set for HP437 Emulation

Command	Description
*CLS	Clear all Status Registers[2]
*ESE	set the event status enable mask[3]
*ESE?	event status register enable mask query[3]
*ESR?	event status register query[3]
*IDN?	GPIB identification query[2]
*RST	Software reset
*SRE	Set the Service Request Mask value[2]
*SRE?	Service Request Mask query
*STB?	Read the Status Byte
*TST?	Self test query
@1	Prefix for Status Mask
@2	Learn mode prefix
CL	CAL[1]
CS	Clear the Status Byte
CT0 - CT9	clear sensor data tables 0 thru 9 [ignored]
DA	All display segments on
DC0	Duty Cycle on
DC1	Duty Cycle off
DD	Display disable
DE	Display enable
DN	down arrow emulation [ignored]
DU	Display user message
DY	Duty Cycle (enter duty cycle value)
ERR?	device error query
ET0 - ET9	edit sensor cal factor table 0 thru 9 [ignored]
EX	exit [ignored]
FA	automatic filter selection
FM	manual filter selection[1]
FR	frequency entry
GT0	ignore Group Execute Trigger (GET) bus command
GT1	trigger immediate response to GET command
GT2	trigger with Delay response to GET command
ID	GPIB identification query
KB	Cal Factor[1]
LG	Log display
LH	High limit[1]
LL	Low limit[1]
LM0	Disable limits checking function
LM1	Enable limits checking function
LN	Linear display

Table 3-4: 8540C Command Set for HP437 Emulation (Continued)

Command	Description
LP2	HP437 learn mode
LT	Left arrow [ignored]
OC0	Reference oscillator off
OC1	Reference oscillator on
OD	Output display text [ignored]
OF0	Offset off - Local
OF1	Offset on - Local
OS	Offset (enter offset value)
PR	Preset
RA	Auto range[4]
RC	Recall[1]
RE	Resolution[1]
RF0 - RF9	Enter sensor ref cal factor [ignored]
RH	Range hold[4]
RL0	Exit REL mode
RL1	Enter REL mode using REL value
RL2	Use old ref number
RM	Set range[1, 4]
RT	Right arrow [ignored]
RV	Read Service Request Mask value
SE	Sensor [ignored]
SM	Status Message
SN0 - SN9	enter sensor serial number [ignored]
ST	Store instrument state
TR0	Trigger hold
TR1	Trigger immediate
TR2	Trigger with delay
TR3	Trigger - free run
UP	Up arrow [up arrow]
ZE	Zero

Notes:

1. A numeric entry is required by these GPIB codes, followed by the code EN (ENTER).
2. This GPIB code uses the next 6 characters (0-9, A-Z, or an underscore) as input data.
3. The asterisk (*) must be included as part of the GPIB command string.
4. The 8540C can always measure over its entire dynamic range; there is no need to specify the range. Therefore, range-related commands have no effect on the measurement capability of the 8540C. The auto range, range hold, and set range commands only offset the analog output voltage, and only in HP436, HP437, or HP438 GPIB emulation modes. In these emulation modes (when using a single sensor, and not measuring in a relative mode), the power will be scaled to a range of 0 to 1 volts, representing the relative power within the current 10 dB range of the 8540C. The range hold and set range commands will simulate locking the range of power represented by the output voltage.

3.3.4 HP438 Emulation GPIB Command Set

These are the GPIB commands that are available when the instrument is placed in the HP438 emulation mode. Footnotes appear at the end of Table 3-5.

Table 3-5: 8540C Command Set for HP438 Emulation

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

Table 3-5: 8540C Command Set for HP438 Emulation (Continued)

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

Notes:

1. A numeric entry is required by these GPIB codes, followed by the EN suffix.
2. The 8540C is always able to measure over its entire dynamic range; there is no need to specify the range. Therefore, range-related commands have no effect on the measurement capability of the 8540C. The auto range, range hold, and set range commands only offset the analog output voltage, and only in HP436, HP437, or HP438 GPIB emulation modes. In these emulation modes (when using a single sensor, and not measuring in a relative mode), the power will be scaled to a range of 0 to 1 volts, representing the relative power within the current 10 dB range of the 8540C. The range hold and set range commands will simulate locking the range of power represented by the output voltage.

3.3.5 HP436 Emulation GBIP Command Set

Table 3-6 lists the GPIB commands that are available when the instrument is placed in the HP436 emulation mode:

Table 3-6: 8540C Command Set for HP436 Emulation

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

Notes:

1. The 8540C is always able to measure over its entire dynamic range; there is no need to specify the range. Therefore, range-related commands have no effect on the measurement capability of the 8540C. The auto range, range hold, and set range commands only offset the analog output voltage, and only in HP436, HP437, or HP438 GPIB emulation modes. In these emulation modes (when using a single sensor, and not measuring in a relative mode), the power will be scaled to a range of 0 to 1 volts, representing the relative power within the current 10 dB range of the 8540C. The range hold and set range commands will simulate locking the range of power represented by the output voltage.

   In HP436 emulation, the specified range is also indicated in the power data strings returned to the host.

3.4 Analog Output

3.4.1 Standard Output

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

Enabling and Disabling the Output

The ANALOG function can enable or disable the analog outputs. The command format for this purpose is:

Syntax: ANALOG STD STATE [ON or OFF]

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

Example:

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

Setting Options for the Output

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

Syntax: ANALOG STD [TOP or BOT] [LG or LN] [a b c d]

STD indicates the standard analog output (not the optional output) is being configured.
[TOP or BOT] specifies the top or bottom line of the display.
[LG or LN] specifies logarithmic (dBm) or linear (Watts) measurement.

The command string ends with four numeric variables (with at least one separator character between each pair of them), which define the relationship between the input power range and the output voltage range:

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

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

Examples:

```
OUTPUT 713;ANALOG STD TOP LOG -80.0, 20.0, 0.0, 10.0
                  ! Configure the analog output top line display channel as follows:
                  ! logarithmic units, -80 to +20 dBm input, 0 to 10 volt output

OUTPUT 713;ANALOG STD BOT LIN 0.00, 1.00E-3, 0.0, 1.0

                  ! Configure the analog output bottom as follows
                  ! linear units, 0 to 1.00 mW, 0 to 1 volt output
```

3.4.2 Optional Speed Count

Commands relating to the optional second analog output (also see Option 06 in Appendix C) are based on the ANALOG function code, as described below.

Enabling and Disabling the Output

The ANALOG function can enable or disable the optional analog output. The command format for this purpose is:

Syntax: ANALOG OPT STATE [ON or OFF]

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

Example:

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

Setting Options for the Output

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

Syntax: ANALOG OPT [TOP or BOT] [LG or LN] [a b c d]

OPT indicates the standard analog output (not the optional output) is being configured.
[TOP or BOT] specifies the top or bottom line of the display.
[LG or LN] specifies logarithmic (dBm) or linear (Watts) measurement.

The command string ends with four numeric variables (with at least one separator character between each pair of them), which define the relationship between the input power range and the output voltage range:

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

Valid power range numbers are -100 to +100 [dBm] for LOG, or 0 to 1E15 [Watts] for LIN. Valid voltage range numbers are 0.00 to +10.00 [VDC] (or -10.00 to +10.00, depending on Option 06 configuration).

Examples:

```
OUTPUT 713;ANALOG OPT TOP LOG -80.0, 20.0, 0.0, 10.0
        ! Configure the second analog output top line display channel
        ! as follows:
        ! logarithmic units, -80 to +20 dBm input, 0 to 10 volt output

OUTPUT 713;ANALOG OPT BOT LIN 0.00, 1.00E-3, 0.0, 1.0
        ! Configure the second analog output bottom line display
        ! channel as follows:
        ! logarithmic units, -80 to +20 dBm input, 0 to 10 volt output
```

3.5 Averaging

3.5.1 Auto Averaging

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

Activating the Auto Filter Mode

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

Syntax: [AE or BE] FA

[AE or BE] prefix specifies Sensor A or Sensor B.
FA activates the auto filter mode for the selected sensor.

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

Setting the Measurement Settling Target

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

Table 3-7: Measurement Setting Target Default Values

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

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

Syntax: [AE or BE] FA [t] [EN % or PCT]

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

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

Freezing the Present Averaging Number

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

Syntax: [AE or BE] FH

[AE or BE] prefix specifies sensor A or Sensor B.
FH causes the 8540C to hold its present averaging number; auto averaging is deactivated.

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

3.5.2 Manual Averaging

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

Syntax:[AE or BE] FM [v] EN

[AE or BE] prefix specifies Sensor A or Sensor B.
FM specifies manual averaging.
[v] has allowable values of 0 through 9. Each value represents a particular averaging number. The numbers are shown in Table 3-8.
A terminating suffix is required (EN).

Table 3-8: Numbering Averaging

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

Examples: OUTPUT 713;AE FM 2 EN ! set averaging number to 4

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

3.6 Cal Factors

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

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

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

Syntax: [AE or BE] KB [n] EN

[AE or BE] prefix specifies Sensor A or Sensor B.
[n] specifies a cal factor, expressed as a percentage with a valid range of 1.0 to 150.0.
A terminating suffix is required (EN).

Examples: OUTPUT 713;AE KB 96 EN ! enter a 96% cal factor for sensor A

OUTPUT 713;BE KB 102 EN ! enter 102% cal factor for sensor B

3.7 Calibration

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

Syntax: [AE or BE] CL [n] [EN or PCT or %]

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

Examples:

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

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

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

Calibration Routine

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

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

3.8 Calibrator Source

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

Syntax:	[OC1 or OC0]	
Examples:	OUTPUT 713;OC	! turn on calibrator source
	OUTPUT 713;OC0	! turn off calibrator source

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

3.9 Crest Factor

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

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

3.9.1 Enabling the Crest Factor Feature

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

Syntax: [CR0 or CR1]

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

☛ ***NOTE:*** Like the PH0 and MN0 commands, the CR0 command will disable Peak Hold and Min/Max measurements.

3.9.2 Reading the Crest Factor Value

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

Syntax: CRF

Example: OUTPUT 713;CRF ! Send the crest factor value

The Crest Factor feature monitors the maximum power as it is measured, but does not provide any feedback to the controller until a CRF command is received. To monitor for a limit violation, the Limits feature may be more useful (see Section 3.1.6).

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

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

3.10 Display Control

Testing the Displays

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

Syntax:	DE (Enable the display) DA (Test the display) DD (Disable the display)	
Examples:	OUTPUT 713;DE	! activate the LCD display ! (this has the effect of canceling a DA or DD command)
	OUTPUT 713:DA	! Performs a test of the display
	OUTPUT713;DD	! Disable the display

Displaying a Message

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

Syntax: DU [string]

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

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

3.11 Duty Cycle Commands

3.11.1 Activating or Deactivating a Duty Cycle

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

Syntax: [AE or BE] [DC0 or DC1]

[AE or BE] prefix specifies Sensor A or Sensor B.
[DC0] turns the duty cycle off (for the specified sensor); if the sensor is in Pulse Average Power measurement mode, this command will change the sensor measurement mode to Modulated Average Power. If the sensor is not measuring Pulse Average Power at the time this command is received, then this command will have no effect.
[DC1] turns the duty cycle on. This is equivalent to the PAP command (see Measurement Mode Commands in Section 3.19).

Examples: OUTPUT 713;AE DC0 ! turn off the duty cycle for sensor A

OUTPUT 713;BE DC1 ! turn on the duty cycle for sensor B

3.11.2 Specifying a Duty Cycle

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

Syntax: [AE or BE] DY [n] [EN or PCT or %]

[AE or BE] prefix specifies Sensor A or Sensor B.
DY specifies a duty cycle value; it also configures the sensor to Pulse Average Power mode. Therefore, this function includes the capabilities (and entry error reporting) of the PAP function (see Measurement Mode Commands in Section 3.19).
[n] species the duty cycle value in percent with a valid range of .001 to 99.999).
A terminating suffix is required (EN, PCT, or %).

Examples: OUTPUT 713;AE DY 50 % ! set 50% duty cycle for sensor A

OUTPUT 713;BE DY 25.000 EN ! set 25% duty cycle for sensor B

OUTPUT 713;BE DY 40.412 PCT ! set 40.412% duty cycle for sensor B

3.11.3 Reading Duty Cycle Status

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

3.12 EEPROM

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

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

Syntax: EEPROM [A or B] [CALF? or FREQ?]

[A or B] specifies Sensor A or Sensor B.
[CALF?] queries the cal factors. The cal factor data is output as a table of cal factors expressed in dB, separated by commas.
[FREQ?] queries the frequencies which correspond to the cal factors. The frequency data is output as a table of frequencies expressed in Hz, separated by commas.

Examples: OUTPUT 713;EEPROM A CALF? ! Query sensor A EEPROM whole cal factor
! table
! (This example is from an 80301A sensor)

Response: 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00

OUTPUT 713;EEPROM A FREQ? ! Query sensor A EEPROM whole
! frequency table
! (This example is from an 80301A sensor)

Response: 5.000e7, 2.000e9, 3.000e9, 4.000e9, 5.000e9, 6.000e9, 7.000e9, 8.000e9, 9.000e9, 1.000e10, 1.100e10, 1.200e10, 1.300e10, 1.400e10, 1.500e10, 1.600e10, 1.700e10, 1.800e10

3.13 Frequency

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

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

Syntax: [AE or BE] FR [n] [HZ or KZ or MZ or GZ]

[AE or BE] prefix specifies Sensor A or Sensor B.
FR specifies a frequency value.
[n] specifies the frequency value (the units are Hz, kHz, MHz, or GHz, depending on the terminating suffix used).
A terminating suffix is required (HZ, KZ, MZ, or GZ).

Examples:

```
OUTPUT 713;AE FR 5.67 GZ        ! frequency for sensor A is 5.7 GHz

OUTPUT 713;AE FR 1.0E9 HZ       ! frequency for sensor A is 1E9 Hz (1 GHz)

OUTPUT 713;BE FR 84.6 MZ        ! frequency for sensor B is 84.6 MHz

OUTPUT 713;BE FR 4E6 KZ         ! frequency for sensor B is 4E6 kHz (4 GHz)
```

3.14 Instrument Identification

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

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

Syntax:	[ID or ?ID or *IDN?]	
Example:	OUTPUT 713;*IDN?	! ask for ID string
	ENTER 713; Name	! read ID into string variable Name

Identification Strings

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

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

Example strings:

8451C mode	Name = GIGA-TRONICS,8451C,9544112,3.00
8452C mode	Name = GIGA-TRONICS,8452C,9548024,3.00

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

HP437B mode	Name = HEWLETT-PACKARD,437B,1.8
HP438A mode	Name = HP438A,VER1.10
HP436A mode	Not Applicable

3.15 Learn Modes

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

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

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

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

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

3.15.1 Learn Mode #1

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

Requesting the String

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

Syntax: LP1

Example: OUTPUT 713;LP1 ! requests learn mode #1 string

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

Table 3-9: Learn Mode #1 Output Format

Parameter	Output from the Power Meter[1]
Trigger Mode	TRd
Measurement Mode	AP, BP, AR, BR, AD, or BD
SENSOR A PARAMETERS Cal Factor Offset Range Filter Low Limit High Limit	AE KB ddd.d EN OS±dd.dd EN RA d EN FA or FM d EN LL ±ddd.ddd EN LH ±ddd.ddd EN
SENSOR B PARAMETERS Cal Factor Offset Range Filter Low Limit High Limit	BE KB ddd.d EN OS ±dd.dd EN RA d EN FA or FM d EN LL ±ddd.ddd EN LH ±ddd.ddd EN
Active Entry Channel	AE or BE
Measurement Units	LG or LN
Reference Oscillator Status	OC0 or OC1
Group Trigger Mode	GTd
Limits Checking Status	LM0 or LM1
Carriage Return Line Feed	EOI
[1]± indicates sign; d indicates a single digit.	

Sending the String

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

3.15.2 Learn Mode #2

Learn Mode #2 is used to return the 8540C configuration information to the controller in the form of a series of binary values.

Requesting the String

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

Syntax: LP2

Example: OUTPUT 713;LP2 ! requests learn mode #2 string

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

The Learn Mode #2 string contains the following information:

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

Sending the String

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

```
binary bytes
```

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

3.16 Limits

3.16.1 Setting Limits

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

Syntax: [AE or BE] [LH or LL] [n] EN

For limit commands, the [AE or BE] prefix specifies a line of the display rather than a sensor.

[AE] specifies the top line of the display.
[BE] specifies the bottom line.
[LH] specifies the high limit; LL specifies the low limit.
[n] is a limit value, expressed in dBm or dB as appropriate.
A terminating suffix is required (EN).

Examples:

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

☛ ***NOTE:*** *These commands must be preceded by CH [n] EN command.*

3.16.2 Activating Limits

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

Syntax: [AE or BE] [LM0 or LM1]

For line commands, the [AE or BE] prefix specifies a line of the display rather than a sensor.

[AE] specifies the top line of the display.
[BE] specifies the bottom line.
[LM0] disables limit checking.
[LM1] enables limit checking.

Examples:

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

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

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

☛ ***NOTE:*** *These commands must be preceded by CH [n] EN command.*

3.16.3 Measuring with Limits

For Sensor A or B, measurements with limits are enabled by the command

Syntax: LM1.

Example: OUTPUT 713; AP LM1 ! Measure sensor A and enable limit checking

This measures Sensor A with the previously set AE, LL and LH limits.

Example: OUTPUT 713; BP LM1 ! Measure sensor B and enable limit checking

This measures Sensor B with previously set BE, LL and LH limits.

To measure Sensor A and B simultaneously (Model 8542C only) with limits enabled (LM1),

1. Press [ENTER]
2. Press [MENU]
3. Enter the menu format (**A, B, A/B..., OFF**).
4. Select **Top Line** and press the left/right cursor keys until A appears.
5. Select **Bottom Line** and press the left/right cursor keys until B appears.
6. Press [ENTER].

Example: OUTPUT 713; AE LM1 ! Enable limit checking for the top line

OUTPUT 713; BE LM1 ! Enable limit checking for the bottom line

This allow the power meter to display both sensor readings and enables both of the previously set AE and BE, LL and LH limits for Sensors A and B.

3.17 Measurement Collection Modes (Standard)

3.17.1 Measurement Triggering

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

Syntax: [TR0 or TR1 or TR2 or TR3]

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

Trigger Hold (TR0)

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

Example: OUTPUT 713;TR0 ! Select the trigger hold mode

Trigger Immediate (TR1)

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

Example: OUTPUT 713;TR1 ! Trigger a single measurement

Trigger Immediate with Full Averaging (TR2)

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

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

Free Run (TR3)

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

Example: OUTPUT 713;TR3 ! Free run trigger mode

3.17.2 Group Execute Trigger

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

Syntax: [GT0 or GT1 or GT2]

Group Trigger Cancel (GT0)

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

Example: OUTPUT 713;GT0 ! Group execute trigger cancel

Group Trigger Immediate (GT1)

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

Example: OUTPUT 713;GT1 ! Group execute trigger single measurement

Group Trigger Immediate with Full Averaging (GT2)

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

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

3.18 Measurement Collection Modes (Fast)

3.18.1 General

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

Sensor Measurements Supported

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

Averaging

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

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

Disabled Features

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

Measurement Changes

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

Warning Regarding Interruption and Reconfiguration

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

Fast Mode Setup

Prior to initiating a fast measurement collection mode, the host should select the measurement (i.e., AP or BP), select the measurement mode (i.e., CW, MAP, PAP, PEAK, or BAP), define the frequency correction (via the FR or KB command, but not via the $V_{PROP}F$ function), define the offset (if any), define the averaging (via the FA or FM command), and define the duty cycle (if applicable). When a fast mode is initiated, the display will blank and a message will display indicating the fast mode selected.

3.18.2 Data Output Formats for Fast Modes

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

For the Swift Free-Run Mode

If one sensor is used, the format is:

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

If two sensors are used, the format is:

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

For The Swift Triggered & Fast Buffered Modes

If one sensor is used, the format is:

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

If two sensors are used, the format is:

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

For the Fast Modulated Mode

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

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

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

3.18.3 Fast Buffered Mode

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

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

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

Syntax: FBUF [PRE or POST] [GET or TTL] BUFFER [b] TIME [t]

[PRE or POST] define the relationship between the measurement period and the trigger:
[PRE] the trigger marks the end of the measurement period. The 8540C will continuously take measurements and buffer them until a trigger is received. At that point, it will stop collecting data and output all of the previously collected data in a continuous data stream the next time it is addressed to talk.

[POST] the trigger marks the beginning of the measurement period. The 8540C will wait for a trigger before taking and buffering the measurements. After the requested number of measurement have been taken and buffered, it will be ready to output all of the data in a continuous stream the next time it is addressed to talk. If the GPIB GET command is specified as the trigger, the 8540C will assert a service request at this time.

[GET or TTL] define the trigger:

[GET] the expected trigger is a GPIB GET command.

[TTL] the expected trigger is a TTL high at the rear panel trigger input.
The buffer value (numeric variable [b]) specifies the number of measurements to be taken and stored in the buffer. The minimum value is one. The maximum value is 5,000.

The time value (numeric variable [t]) is an optional variable which specifies a fixed delay between measurements. The time value specifies the time (in ms) to wait between measurements; the minimum value is zero. The maximum value is 5000 ms (five seconds).

☛ ***NOTE:*** *This delay is in addition to the relatively short time it takes to perform each measurement. If no time value is specified, [t] is assumed to be zero, and the measurements are taken as fast as possible.*

Examples: OUTPUT 713;FBUF PRE GET BUFFER 200

! take measurements (as fast as possible) until GET is received
! then output the last 200 measurements taken

```
OUTPUT 713;FBUF POST TTL BUFFER 100 TIME 2

                    ! wait for a TTL trigger, then take readings at intervals of 2 ms
                    ! until a total of 100 measurements have been taken
```

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

Syntax: FBUF [DUMP or OFF]

[DUMP] stops the data measurement and buffering, and prepares to return the data taken so far to the host, even if fewer than the requested number of measurements have been taken. The requested number of measurements are still returned to the host (the extra measurements beyond those actually taken are represented by the number -300.00). [OFF] causes the 8540C to exit the fast buffered mode. All unread data is lost.

Examples:

```
OUTPUT 713;FBUF DUMP          ! Stop measurement and buffering

OUTPUT 713;FBUF OFF           ! Exit the fast buffered mode
```

Notes on Speed in the Fast Buffered Mode

The fast buffered mode is the fastest method of collecting measurement data. Top speed in the fast buffered mode is achieved by using a low averaging number (≤ 4), the POST trigger mode, and no time delay between measurements.

The POST trigger mode is faster than the PRE trigger mode because in the latter mode the 8540C must check for a trigger between each measurement. In the POST mode, the 8540C is in freerun operation after the trigger is received.

3.18.4 Swift Mode

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

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

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

Syntax: SWIFT [FREERUN or OFF]

[FREERUN] initiates the freerun mode (continuous taking and returning of measurements).
[OFF] causes the 8540C to exit the swift mode; all unread data is lost.

Examples:

```
OUTPUT 713;SWIFT FREERUN            ! Initiate swift freerun mode

OUTPUT 713;SWIFT OFF                ! Exit the swift mode
```

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

Syntax: SWIFT [GET or TTL] BUFFER [b]

[GET or TTL] define the trigger:
[GET] the expected trigger is a GPIB GET command. The 8540C signals the host by asserting SRQ every time it is ready to take a measurement.
[TTL] the expected trigger is a TTL high at the rear panel trigger input.

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

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

Examples:

```
OUTPUT 713;SWIFT PRE GET BUFFER 200

                          ! take measurements until GET is received
                          ! then output the last 200 measurements taken

OUTPUT 713;SWIFT POST TTL BUFFER 100

                          ! wait for a TTL trigger, then take 100 measurements
```

Example Programs

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

```
REAL Data(30)7
OUTPUT 713;SWIFT GET BUFFER 30WAIT 0.5
                                        ! wait for instrument configuration

FOR I=1 to 30
    Srq_flag=0                          ! wait for ready condition
    TRIGGER 713
                                        ! trigger measurement
WHILE Srq_flag=0
    Srq_flag=SPOLL(713)
    END WHILE
NEXT I
    ENTER 713;Data(*)
    FOR I=1 TO 30
    PRINT I,Data(I)
NEXT I
```

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

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

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

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

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

3.18.5 Fast Modulated Mode

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

Syntax: FMOD [ON or OFF]

[ON or OFF] enables or disables the fast modulated mode.
When the fast modulated mode is enabled, data will be taken and returned continuously.
This is analogous to the swift freerun mode.
The fast modulated mode cannot be initiated unless a modulated measurement (MAP, PAP or BAP) is being performed.

Examples:

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

3.19 Measurement Mode Commands

3.19.1 CW Mode

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

Syntax: CW [A or B]

[AE or BE] specifies Sensor A or Sensor B.

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

Examples: OUTPUT 713;CW A ! select CW mode for sensor A

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

3.19.2 MAP Mode

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

Syntax: MAP [A or B]

[AE or BE] specifies Sensor A or Sensor B.

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

Examples: OUTPUT 713;MAP A ! select MAP mode for sensor A

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

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

Syntax: MAP [A or B] 0

[AE or BE] specifies Sensor A or Sensor B.
0 specifies that synchronization is to be disabled.

Examples: OUTPUT 713;MAP A 0 ! disable MAP mode synchronization for sensor A

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

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

3.19.3 PAP Mode

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

Syntax: PAP [A or B]

[A or B] specifies Sensor A or Sensor B.

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

Examples:	OUTPUT 713;PAP A	! select PAP mode for sensor A
	OUTPUT 713;PAP B	! select PAP mode for sensor B

3.19.4 BAP Mode

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

Syntax: BAP [A or B]

[A or BE] specifies Sensor A or Sensor B.

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

Examples:	OUTPUT 713;BAP A	! select BAP mode for sensor A
	OUTPUT 713;BAP B	! select BAP mode for sensor B

3.19.5 Peak Mode

The commands for Peak mode are discussed under separate headings for the 80350A and 80340A sensors (see Sections 3.24 and 3.25 respectively).

3.19.6 Measurement Mode Query

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

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

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

Notes:

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

Syntax: MEAS [A? or B?]

[A? or B?] specifies Sensor A or Sensor B.

Examples: OUTPUT 713;MEAS A? ! queries the measurement mode setting for sensor A

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

3.20 Advanced Features

3.20.1 Burst Start Exclude

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

Syntax: [AE or BE] BSTE [a] EN

[AE or BE] prefix specifies Sensor A or Sensor B.
[a] specifies the number of samples to be excluded; it has an integer value in the range of 0 to 512 (Selecting a value of zero samples effectively disables this function).
A terminating suffix is required (EN).

Examples:

```
OUTPUT 713;AE BSTE 1 EN

                    ! exclude one sample from start of burst, for BAP
                    ! measurements on sensor A

OUTPUT 713;BE BSTE 3 EN

                    ! exclude three samples from start of burst, for BAP
                    ! measurements on sensor B
```

3.20.2 Burst End Exclude

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

Syntax: [AE or BE] BSPE [a] EN

[AE or BE] prefix specifies Sensor A or Sensor B.
[a] specifies the number of samples to be excluded; it has an integer value in the range of 0 to 512 (Selecting a value of zero samples effectively disables this function).
A terminating suffix is required (EN).

Examples:

```
OUTPUT 713;AE BSPE 1 EN

                    ! exclude one sample from end of burst, for BAP
                    ! measurements on sensor A

OUTPUT 713;BE BSPE 3 EN

                    ! exclude three samples from end ofburst, for BAP
                    ! measurements on sensor B
```

3.20.3 Burst Dropout Tolerance

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

Syntax: [AE or BE] BTDP [a] EN

[AE or BE] prefix specifies Sensor A or Sensor B.
[a] specifies the dropout time in milliseconds with a range of 0 to 31.96, and a resolution of .01 ms. However, the value entered will be rounded to the nearest one of a series of discrete values (.017, .026, .035); the actual value can be checked by means of a MEAS query. The dropout time represents a guaranteed minimum time; the time actually tolerated will usually be greater, and can be up to 2.125 times greater (Selecting a value of zero effectively disables this function). A terminating suffix is required (EN).

Examples: OUTPUT 713;AE BTDP .02 EN

! set dropout time to .02 ms or next high discrete
! value, for BAP measurements on sensor A

OUTPUT 713;BE BTDP .03 EN

! set dropout time to .03 ms or next highest discrete
! value, for BAP measurements on sensor B

3.21 Min/Max Power Value

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

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

3.21.1 Enabling the Min/Max Feature

☛ ***NOTE:*** *These commands must be preceded by CH [n] EN command.*

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

Syntax: [MN0 or MN1]

Examples: OUTPUT 713;MN ! Enable the Min/Max feature

OUTPUT 713;MN0 ! Disable the Min/Max feature

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

3.21.2 Reading the Min/Max Values

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

Syntax: [MIN or MAX]

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

Examples: OUTPUT 713;MIN ! Send the minimum measured value

OUTPUT 713;MAX ! Send the maximum measured value

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

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

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

3.22 Offset Commands

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

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

3.22.1 Enabling/Disabling an Offset

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

Syntax: [AE or BE] [OF0 or OF1]

[AE or BE] prefix specifies Sensor A or Sensor B.
[OF0] deactivates the offset; [OF1] activates the offset.

Examples:

```
OUTPUT 713;AE OF0          ! Disable offset for sensor A

OUTPUT 713;BE OF1          ! Enable offset for sensor B
```

3.22.2 Setting an Offset Value

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

Syntax: [AE or BE] OS [n] EN

[AE or BE] specifies Sensor A or Sensor B.
[OS] indicates that an offset is being specified for the sensor.
[n] specifies the offset in dB. The value of n can range from -99.999 dB to +99.999.
A terminating suffix (EN) is required.

Example:

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

OUTPUT 713;BE OS -15.12 EN         ! Set -15.12 dB offset for sensor B
```

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

3.22.3 Measured Offset Entry

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

Syntax: [AP, BP, AR, BR, AD, or BD] OS DO EN

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

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

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

A terminating suffix (EN) is required.

Examples:

```
OUTPUT 713;AP OS DO EN        ! Save measurement A as an offset

OUTPUT 713;BP OS DO EN        ! Save measurement B as an offset

OUTPUT 713;AR OS DO EN        ! Save measurement A/B as an offset

OUTPUT 713;BR OS DO EN        ! Save measurement B/A as an offset

OUTPUT 713;AD OS DO EN        ! Save measurement A-B as an offset

OUTPUT 713;BD OS DO EN        ! Save measurement B-A as an offset
```

3.23 Peak Hold

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

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

3.23.1 Enabling the Peak Hold Feature

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

Syntax: [AE or BE] [PH0 or PH1]

Examples: OUTPUT 713;AE PH1 ! Enable the Peak Hold feature for sensor A

OUTPUT 713;BE PH0 ! Disable the Peak Hold feature for sensor B

Description: Like the MN0 and CR0 commands, the PH0 command will disable Crest Factor and Min/Max measurements. Sending the PH1 command after Peak Hold is enabled will reset it. Peak Hold will also reset when you send a CR1 command (see Section 3.9).

3.23.2 Reading the Peak Hold Value

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

Syntax: [AE or BE] PKH

Example: OUTPUT 713;AE PKH ! Send the peak hold value for sensor A

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

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

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

3.24 Peak Power Sensor Commands (80350A Series)

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

3.24.1 Setting the Trigger Mode & Trigger Level

The command format for setting trigger modes and levels is:

Syntax: PEAK [A or B] [INT or EXT] TRIG [n]

A or B specifies Sensor A or Sensor B.
[INT or EXT] specifies internal or external triggering.
TRIG indicates that a trigger level is being set.
[n] specifies the trigger level in units of dBm in the case of internal triggering, or volts in the case of external triggering.

Examples:

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

The command format for selecting the CW mode is:

Syntax: PEAK [A or B] CW

[A or B] specifies Sensor A or Sensor B.
CW specifies the CW mode.

Example:

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

3.24.2 Setting the Delay

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

Syntax: PEAK [A or B] DELAY [n]

[A or B] specifies Sensor A or Sensor B.
DELAY indicates that a delay value is being set.
[n] is a numerical variable which specifies the delay in seconds. It has a range of -20E-9 (-20 ns) to 104E-3 (104 ms).

Examples:

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

OUTPUT 713;PEAK B DELAY 33.5E-9      ! Configure sensor B for a delay of 33.5 ns
```

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

3.24.3 Setting the Delay Offset

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

Syntax: PEAK [A or B] OFFSET [n]

[A or B] specifies Sensor A or Sensor B.
OFFSET indicates that a delay offset value is being set.
[n] is a numerical variable which specifies the offset in seconds. It has a range of -20E-9 (-20 ns) to 104E-3 (104 ms). The default value of the offset is 0.

Example: OUTPUT 713;PEAK A OFFSET 1.20E-6 ! Configure sensor A for a delay offset of ! 120 µs

3.24.4 Reading Values

Trigger

The query format for trigger settings is:

Syntax: PEAK [A? or B?]
[A? or B?] Sensor A or Sensor B.

Example: OUTPUT 713;PEAK A? ! Query the current sensor A trigger setting

OUTPUT 713;TRIG$! Enter the returned string into the string variable TRIG

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

Delay and Delay Offset

The query format for delay and delay offset settings is:

Syntax: PEAK [A or B] [DELAY? or OFFSET?]

[A or B] specifies Sensor A or sensor B.
[DELAY?] indicates that delay is being queried.
[OFFSET?] indicates that delay offset is being queried.

Examples: OUTPUT 713;PEAK A DELAY? ! Query the current delay setting for sensor A

ENTER 713;Delay ! Enter the returned number into the variable Delay

OUTPUT 713;PEAK B OFFSET?! Query the current delay offset setting for sensor B

ENTER 713;Offset ! Enter the returned number into the variable Offset

3.25 Peak Power Sensor Commands (80340A Series)

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

Syntax: PEAK [A or B] [INT or EXT] [TRIG or DLYTRIG]

[A or B] specifies Sensor A or Sensor B.
[INT or EXT] specifies internal or external triggering.
[TRIG] indicates the immediate triggering mode.
[DLYTRIG] indicates the delayed triggering mode.

Examples:

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

The command format for selecting the CW mode is:

Syntax: PEAK [A or B] CW

[A or B] specifies Sensor A or Sensor B.
CW specifies the CW mode.

Examples:

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

3.26 Preset

The PR command resets the 8540C to its default settings, leaving the user settings intact as *Previous Settings* if they were different from the default settings. This command does not function while in the SWIFT, FMOD or CM modes.

Alternatively, the IEEE 488.2 command *RST also resets the 8540C to it's default settings, and functions in the SWIFT, FMOD and CM modes. These modes must be re-entered either over the GPIB or from the front panel.

The preset conditions of the instrument are outlined in Table 3-10.

Table 3-10: Preset (Default) Conditions

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

Notes:

1. The default measurement mode depends on the sensor type. For a CW sensor, the default is CW. For an 80401 sensor, the default is MAP. For a peak sensor, the default is INT TRIG. Regardless of the sensor type, all advanced features are turned off.
2. There is a slight difference between the preset conditions as set by a remote command, and as set from the front panel menus. This difference has to do with measurement units. If the 8540C is preset from the front panel, this sets the measurement units to dBm in all cases. If the 8540C is preset over the bus, this sets the measurement units to Watts in the case of HP438 emulation, and has no effect at all in the case of HP436 emulation; otherwise, it sets the measurement units to dBm.

   This distinction is made to accommodate differences between emulations for remote programming purposes without affecting the benchtop user.

3.27 Relative Measurements

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

☛ ***NOTE:*** *These commands must be preceded by the CH [n] EN command.*

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

Syntax: RL0 or RL1 or RL2

[RL0] deactivates the relative measurement mode.
[RL1] activates the relative mode, and causes the current measured level to be recorded as the reference level.
[RL2] activates the relative mode and causes the reference level that was saved under a prior RL1 command to be used as the reference level. That is, if the relative mode is activated by an RL1 command, and then deactivated by an RL0 command, the effect of RL2 is to restore the reference level that was saved in response to the RL1 command.

Examples:

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

3.28 Resolution

☛ ***NOTE:*** *These commands must be preceded by CH [n] EN command.*

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

Syntax: RE [a] EN

RE indicates that resolution is being set.
[a] indicates the resolution with four values allowed (0, 1, 2, and 3). These specify the number of digits to the right of the decimal point.
A terminating suffix (EN) is required.

☛ ***NOTE:*** *This command affect measurements shown on both lines of the display.*

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

3.29 Sensor Selection

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

Syntax: [AP BP AR BR AD BD]

Examples:	OUTPUT 713;AP	! Measure sensor A
	OUTPUT 713;BP	! Measure sensor B
	OUTPUT 713;AR	! Measure A divided by B
	OUTPUT 713;BR	! Measure B divided by A
	OUTPUT 713;AD	! Measure A less B
	OUTPUT 713;BD	! Measure B less A

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

3.30 Status

3.30.1 Status Byte Message

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

Table 3-11: Status Byte and Service Request Mark

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

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

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

3.30.2 Event Status Register

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

The ESR bits consist of the following:

Power On	This bit will always be set.
Command Error	This bit is set when an improper GPIB code is sent to the instrument. The command WT would be considered a command error, for example.
Execution Error	When incorrect data is sent to the instrument, this bit will be set. For example, the command FR-1.0MZ would be considered an execution error.
Device Dependent Error	Errors 1 through 49 are measurement errors, and will set this bit true whenever they occur.

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

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

Table 3-12: Event Status & Event Status Enable Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Power On	0	Command Error	Execution Error	Device Dependent Error	0	0	0

3.30.3 Status Message

Examples: OUTPUT 713;SM ! ask for status message

ENTER 713;Statusmess$! read status message

Status Message Output Format

The output format is as follows:

AAaaBBCCccDDddEFGHIJKLMNOP<CR><LF>

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

Each letter in the Status Message Output Format denotes a single ASCII character. See the list of codes in Tables 3-13 through 3-15 on the following pages for expanded definitions of the individual elements in this format.

Elements of the Status Message Output Format

Table 3-13: Error Code Returned in Position AA

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

Table 3-14: Error Code Returned in Position aa

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

Table 3-15: Other Codes in the Status Message

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

3.31 Store and Recall

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

3.31.1 Saving a Configuration

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

Syntax: ST [r] EN

ST is the Save function code.
[r] identifies the register in which the instrument's configuration is to be saved (and from which it can later be retrieved). The value of [r] can be any number from 1 through 20.
A terminating suffix (EN) is required.

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

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

3.31.2 Retrieving a Configuration

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

Syntax: RC [r] EN

RC is the Recall function code.
[r] identifies the register in which the instrument's prior configuration has been saved and from which it is now to be retrieved. The value of [r] can be any number from 0 through 20. A terminating suffix (EN) is required.

Examples:

```
OUTPUT 713;RC3EN        ! Recall the configuration that was saved in register 3

OUTPUT 713;RC0EN        ! Recall the prior configuration (this command recovers
                        ! from configuration errors)
```

3.32 Units

☛ ***NOTE:*** *These commands must be preceded by CH [n] EN command.*

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

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

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

3.33 $V_{PROP}F$ Feature

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

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

3.33.1 Enabling & Disabling $V_{PROP}F$

Commands related to the $V_{PROP}F$ function are based on the function code $V_{PROP}F$. The command format, for purposes of activating or deactivating the $V_{PROP}F$ feature, is as follows:

Syntax: VPROPF [A or B] STATE [ON or OFF]

[A or B] specifies Sensor A or Sensor B.
STATE indicates that the VPROPF feature is being enabled or disabled.
[ON or OFF] enable or disable the VPROPF function.

Examples: OUTPUT 713;VPROPF A STATE ON ! Enable VPROPF for sensor A

OUTPUT 713;VPROPF B STATE OFF ! Disable VPROPF for sensor B

3.33.2 Configuring $V_{PROP}F$

The command format, for purposes of configuring the $V_{PROP}F$ feature, is as follows:

Syntax: VPROPF [A or B] MODE [f] [s]

[A or B] specifies Sensor A and Sensor B.
MODE indicates that the VPROPF feature is being configured (that is, the start frequency and slope are being specified).
[f] indicates the start frequency (the frequency at zero volts), expressed in Hz.
The start frequency must be less than the upper frequency limit of the sensor.
[s] indicates the slope of the VPROPF(the ratio of input voltage to input frequency), expressed in V/Hz. The value must be between 1E-12 and 1E-8.

Example: OUTPUT 713;VPROPF A MODE 2.00E9 1.00E-9

! Configure the VPROPF feature for sensor A
! as follows:
! 2.00 GHz start frequency
! 1.00 Volt per GHz slope

3.34 Zeroing

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

Syntax: [AE or BE] ZE

[AE or BE] prefix specifies Sensor A or Sensor B.

Examples: OUTPUT 713;AE ZE ! Zero sensor A

OUTPUT 713;BE ZE ! Zero sensor B

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

The following is an example of how to zero a sensor with the GPIB program. The service request feature determines when the zero has completed; this results in the quickest zeroing routine.

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

4

Theory of Operation

4.1 General

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

Table 4-1: 8540C Circuit Board Assemblies

Reference Designation	Title	Assembly Drawing Part #	Schematic Part #
A1	CPU PC Bd Assembly	21693	21694
A2	8541C Analog PC Bd Assembly	30164	30165
A2	8542C Analog PC Bd Assembly	30173	30165
A3	Front Panel PC Bd Assembly	21229	21230
A4	LCD Display Assembly	21240	NA

The 8540C Interconnection Diagram (see drawing no. 30161) on page 8-3 shows how the assemblies are connected to one another. Also see Figure 4-1 for a block diagram of the CPU board interconnection. Most of the electrical circuitry resides on the CPU PC Board (A1) and the Analog PC Board (A2). The CPU interfaces with the Analog assembly through connection A1J1/A2P1. The CPU also connects to the Front Panel assembly (A3) that provides the keyboard interface and the LED status indicators, and to the LCD display assembly (A4).

Various cable connections are provided on the 8540C rear panel. The GPIB connector communicates with the CPU board through connector J3. Three rear panel BNCs connect to the CPU board, and two rear panel BNCs connect to the Analog board. J8 on the CPU assembly is used for in-house development and testing, and for the Time Gating (Option 11) PC board.

The LCD Display (A4) is an OEM purchased part and does not include a circuit schematic in this manual.

4.2 CPU PC Board (A1)

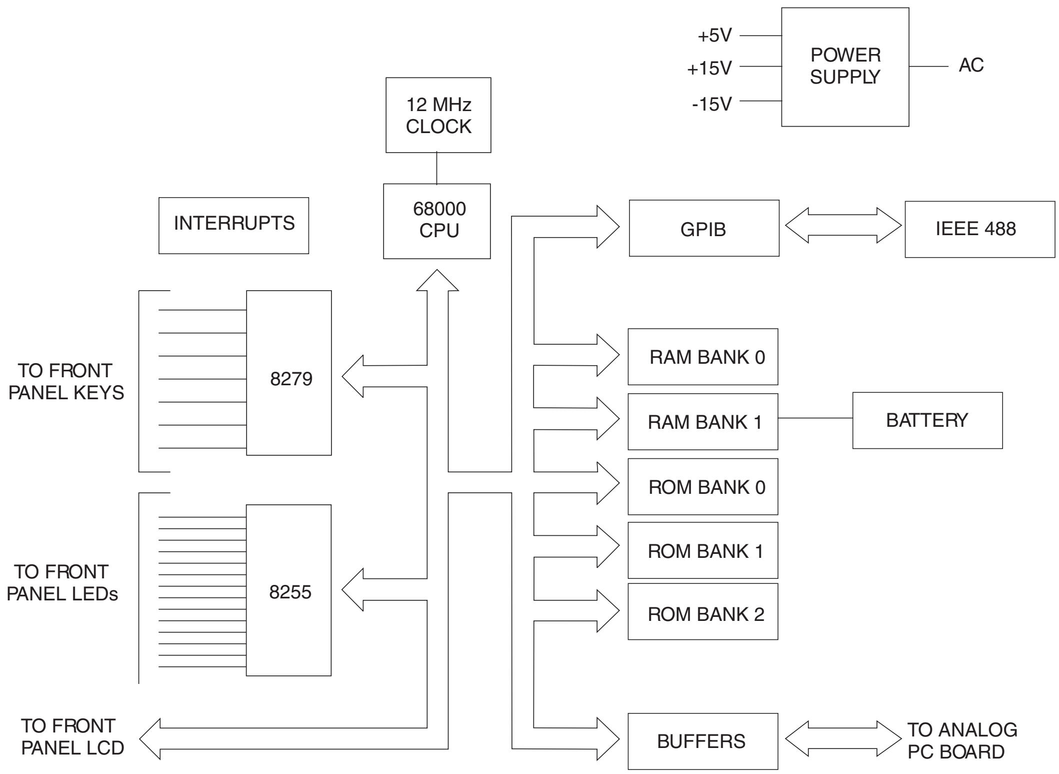

Figure 4-1: CPU Block Diagram

4.2.1 Power Supply

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

The T1 transformer's 8.4 Vac and 33 Vac enter the dc supply through J9. CR6 rectifies the 8.4 Vac to an unregulated 8 Vdc. C54 and C6 provide filtering, and the unregulated voltage is applied to regulators U37 and U38. The U37 regulator supplies 5 V (at 0.5 A) required by the front panel LCD display's backlight. U38 supplies 5 V required by all of the digital circuitry. TP12 and TP13 are available to test the level of the 5 V supply. CR7 rectifies the unregulated voltage of the +16.5/-16.5 V filters which is applied to U39 and U40 through C9 and C12. U39 is the +15 V regulator, and U40 is the -15 V regulator. TP14 and TP15 are available to test these voltages.

4.2.2 Battery Back-Up

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

4.2.3 Circuit Description

Y1 (shown in the upper left corner of page 8-9) is a 24 MHz crystal oscillator that provides the main clock signals for the circuitry. U1A is a divide-by-two counter that outputs 12 MHz. This 12 MHz is used by the 68000 microprocessor, U9, so that U9 is running at a 12 MHz clock speed. The clock is further divided down for other uses at U2. U2 also provides wait states when accessing peripherals. U17D/E/F and U16C&D provide U9 with decoding of the status lines for auto vector interrupts. U16A provides an upper data byte write signal, and U16B furnishes the lower data byte write signal.

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

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

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

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

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

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

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

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

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

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

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

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

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

Referring to Sheet 2 of the A1 Circuit Schematic (drawing #21694), the DIP sockets that the ROMs and RAMs are mounted in are configured to accept either 512K or 1M devices. 512K devices are 28 pin components that have to go into 32 pin sockets. When this is done, pins 1, 2, 31, and 32 are not used, which means that the 512K device is occupying pins 3 through 30 of the socket. The difference in address decoding between 512K and 1M devices is provided by PAL U4.

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

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

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

4.3 Analog PC Board (A2)

4.3.1 Circuit Description

Sheet 1 of the Analog Circuit Schematic (drawing #30165) shows the Channel A sensor amplifier used with both the 8541C and 8542C. Sheet 2 of Analog Circuit Schematic covers the Channel B sensor amplifier circuits used with the 8542C only. Also see Figure 4-2 for a block diagram of the Analog board interconnection. Since these are essentially duplicate circuits (the differences will be described), this discussion will mainly focus on the Sheet 1 components. The sensors are connected from the front panel through W6J1 which enters the Analog Board through J1 for sensor A and J2 for sensor B. The detected dc voltage from the sensor is a differential voltage applied to pins 3 and 4 of J1. This differential voltage goes to U25, which is a FET chopping circuit. The outputs are pins 7,10 and 2,15 of U25. An incoming signal can either be fed straight through or inverted. The signal is fed straight through when CHAMCHP is high; it is fed through in the inverted mode when CHAMCHP is low. This provides chopper stabilized amplification when low power signals are being received by switching the FET switch from the inverting to non-inverting mode and back again at a rate of 300 times per second.

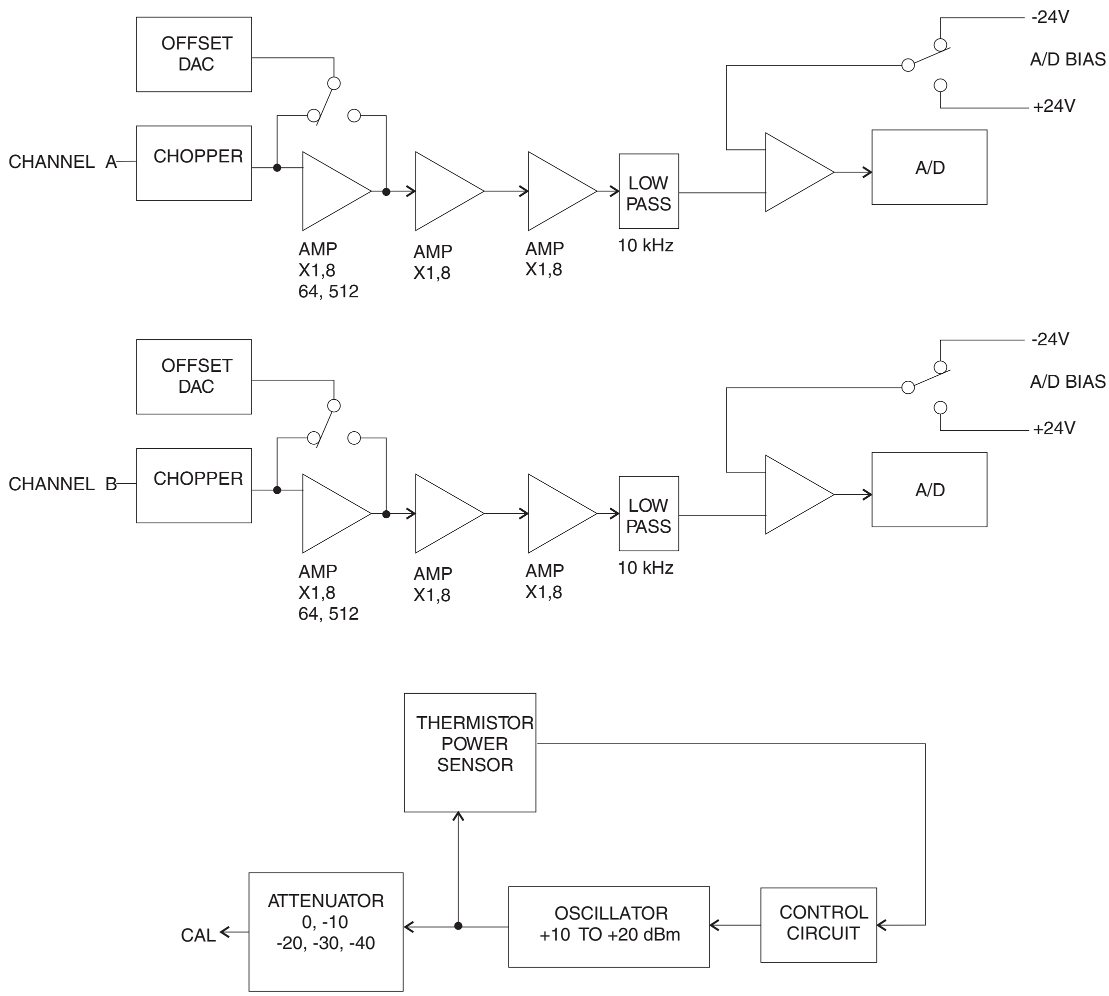

Figure 4-2: Analog PC Block Diagram

There are three stages of gain in the analog processing chain. All three stages are gain programmable and fully differential. Stage 1 is made up of two identical composite amplifiers. The positive half of stage 1 is composed of amplifiers U29, U46, U48 and RF JFETs Q13-16. U29 is a precision amplifier, which handles the dc and low frequency portion of the signal. The high frequencies are handled by U48, which is buffered by the two JFET source follower stages and ac coupled at about 30 Hz by C94 and C98.

The outputs of U29 and U48 are combined in U46, a high speed unity-gain buffer. The gain of the stage is selected by feeding the output back through different points on the resistor ladders. Analog switch U31 connects different points on the resistor ladders back to the inverting input of the composite amplifier. The resistor ladder consisting of R12, R25, R26, R36 and R270 is used for gains of 1, 8, and 64. The ladder made up of R21, R112 and R190 is used for the 512 gain setting.

The U47 analog switch performs two functions. For low bandwidth sensors such as 80300 or 80400, the high amplifier is switched out to reduce noise and achieve good pulse response at high gain. The other half of U47 switches in band-limiting resistor R42 when the high-speed amplifier is switched in and it is set for unity gain.

Stages 2 and 3 are identical differential amplifiers. Each can be set for gains of 1 and 8. For stage 2, analog switch U62 selects one of two points on the resistor ladder consisting of R43, R243 and R145. C231 and C246 on stage 3 limit the bandwidth when that stage is set to a gain of 8.

An offset voltage from DAC, U17 (sheet 3) is injected into the amplifier chain at two different points. For all but the highest gain setting of stage 1, the offset is injected at the input of stage 2. When stage 1 is set for a gain of 512, the offset is injected at the input to stage 1. Analog switch U56 routes the offset voltage tot he proper path. U54C and B buffer the offset voltage path to stage 2 input. U54A and D buffer the path to stage 1 input. U56 switches the deselected path to analog ground so that no offset or noise is injected at that point.

Sheet 6 of the A2 Circuit Schematic shows the last stage in the analog chain and the analog-to-digital converter. U26 is a unity gain differential-to-single-ended stage, which drives the input of the A/D converter, U91. A bias voltage from amplifier U25 is also summed into U26. This bias voltage sets the A/D input at -2.4V. The A/D input voltage range is -2.5 V to +2.5 V. The bias voltage allows negative excursions in voltage due to noise. When the chopper is enabled, analog switch U90 synchronously alternates the bias voltage between -2.4V and +2.4V. This allows the A/D to measure the inverted signals during chopping. The bias voltage is derived from the A/D 2.5 V reference voltage using resistive dividers R63 and R68, and R73 and R261 in the non-inverted and inverted modes respectively.

Refer to Sheet 2 (Channel B) of the A2 Circuit Schematic (drawing #30165) which is exactly the same as Channel A (with different component numbers).

Each detector has a thermistor included in its housing so that the power meter can read the temperature of the sensor. The voltage from that thermistor is applied through J1-J6 (for channel A) and amplified by a gain of 2 by U39D. Channel B sensor voltage comes through J2-J6 and is amplified by U39A. The amplified versions of the thermistor voltages are applied to different inputs of the multiplexed A/D, U22 (sheet 3). The software continuously monitors those inputs to check for the presence of a sensor. When a sensor is present, the software uses the thermistor voltage in a temperature compensation algorithm.

U22 also reads the voltage from the J3 V_{PROP}F connector. CR15 provides input protection and U38A is a unity-gain buffer. The output of U38A is applied to the U22 A/D through voltage divider R51 and R52. This attenuates the maximum V_{PROP}F voltage of 10V down to the 2.5 V that the A/D requires. U23 is a 5 volt regulator and supplies U22 with Vdd.

The sensors also have EEPROMs that connect to the system through a serial interface. Channel A uses J1-13 for the clock and J1-12 for the data. This is a bidirectional device wherein data needs to be written to the sensor and also read to the sensor. U41:2 buffers incoming data, and U41:3 buffers outgoing data. Q2 provides the necessary open collector interface. U18 supplies the clock during a read or write action.

The clock signal is buffered by U41:1. Channel B has a duplicate circuit consisting of U41:3,4,5 and Q3. DC supplies of +5 V and ±12V are also routed to the sensors. The 12V supplies are routed through RT3 and RT4 which are used to provide solid state fusing in case of any shorts. These are resettable solid state fuses which do not need to be replaced. The +5 V can be switched on and off. This is buffered by Q8 which can enable or disable Q1. U113:1 and :2 buffer sensor control lines for gain and chop respectively. U113:3 and :4 perform the same function on channel B.

4.3.2 Analog Board Control Lines

This section describes the various control lines on the analog board. The names of the control lines are identical for channels A and B except for the letter B, which is shown in parenthesis.

Stage 1 Gain

Control of stage 1 gain requires setting two sets of switches. One set of switches sets the gain. The control lines are CHA(B)MX1A1 and CHA(B)MX!A0 and come from U104. The other set of switches adjusts the frequency compensation for the amplifier in unity gain to keep it reliably stable, and disconnects the high speed amplifier for low bandwidth sensors. The control line CHA(B)COMP controls the compensation of stage 1. CHA(B)WBWR controls the connectivity of the high speed amplifier. These control lines come from U21. The following defines the settings and gain of Stage 1.

CHA(B)MX1A1	CHA(B)MX1A0	Gain	CHA(B)COMP	CHA(B)WBWR
		80600 and Higher Sensors		
0	0	512	0	0
0	1	64	1	0
1	0	8	1	0
1	1	1	0	0
		All Other Sensors		
0	0	512	0	1
0	1	64	1	1
1	0	8	1	1
1	1	1	0	1

Stages 2 and 3 Gain

Each of these gain stages has its own gain setting switch. Control line CHA(B)MX3A1 controls stage 2 gain, and CHA(B)MX3A0 controls stage 3 gain. These control lines come from U21. The following defines the settings and gain of stages 2 and 3.

CHA(B)MX3A1	CHA(B)MX3A0	Stage 2 Gain	Stage 3 Gain
0	0	8	8
1	0	1	8
1	1	1	1

CW Filter (Gain Range 6)

This filter is switched in (logic high) when all gain stages are at maximum gain. Its control line, CHA(B)FILT, is a 4-input NAND function of the four gain control lines. This control lines comes from U21.

Chopping

There are two control lines for chopping. The CHA(B)MCHP line performs the chopping function by switching the U28 analog switch (channel A). This control line comes from U104. The other line, CHA(B)BIAS flips the polarity of the A/D bias voltage to match the chopping polarity. This line comes from U21.

CHA(B)MCHP	CHA(B)BIAS	CHOPPER POLARITY
0	1	Invert
1	0	Non-invert
0	1	Invert
1	0	Non-invert

Sensor Gain

The amplifier in the sensor has two gain settings. This is controlled by a line from U21 called CHA(B)SGN. The assignment is as follows:

CHA(B)SGN	Gain
0	1
1	8

Sensor Chopper Control

The chopper in the sensor is controlled by a line from U104 called CHA(B)SCHP. The assignment is as follows:

CHA(B)SCHP	Chopper Polarity
0	Non-invert
1	Invert

4.4 Calibrator Module

Sheets 4 and 5 of the A2 Circuit Schematic (drawing #30165) cover the interconnections for the Calibrator circuit. The Calibrator Module is located on the Analog PC Board. It is basically the heart of the 8540C Series Power Meters in that it is a patented system that allows the power sensors to be calibrated against an internal thermistor power standard (see Figure 4-3). In contrast to the conventional fixed-level calibrators, the 8540C calibrator produces a range of power levels over a 50 dB dynamic range to an accuracy of a few thousandths of a dB.

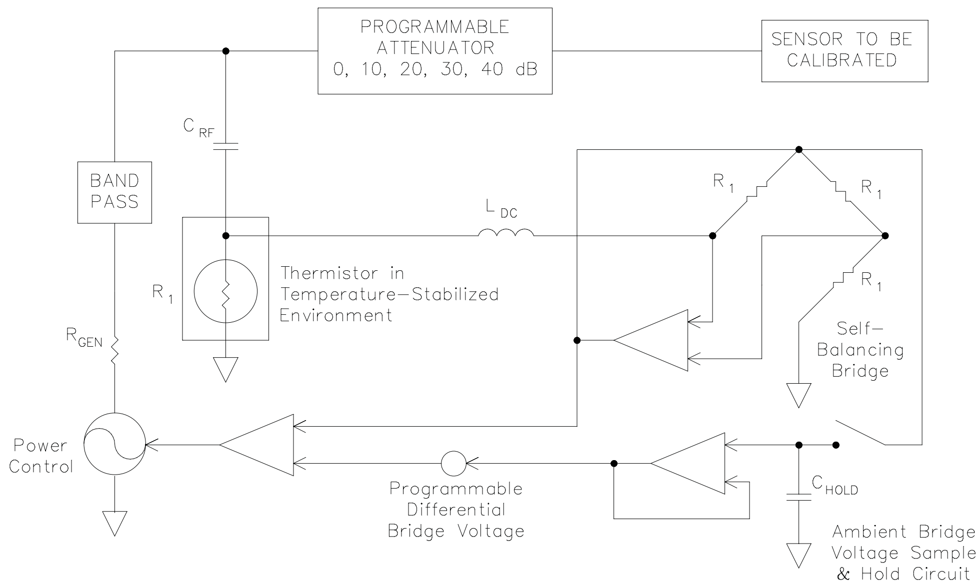

Figure 4-3: Calibrator Internal Power Standard

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

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

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

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

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

4.4.1 General

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

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

4.4.2 50 MHz Oscillator

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

4.4.3 RF Output

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

4.4.4 Oven

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

4.4.5 Thermistor Bridge

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

4.4.6 Track & Hold and DAC

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

4.4.7 Correction Thermistor Circuit

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

4.4.8 Calibrator NVRAM Control Circuit

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

4.4.9 Digital Control Circuit

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

4.5 Front Panel PC Assembly (A3)

(Refer to the A3 Front Panel Circuit Schematic on page 8-21.)

The Front Panel PC assembly consists of a 4 X 4 keyboard matrix and circuitry to interface the 20 front panel LEDs to the CPU board (see Figure 4-4). The LCD Display (A4) is an OEM purchased part and does not include a circuit schematic in this manual.

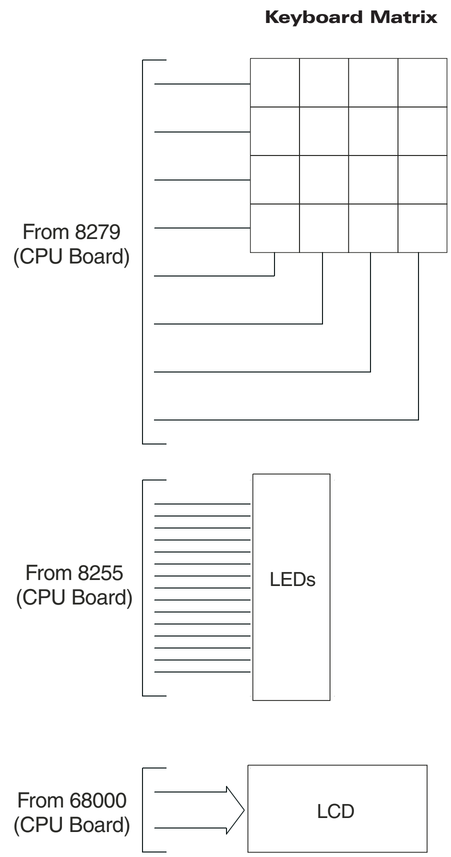

Figure 4-4: Front Panel PC Assembly