

MODEL 9230 SERIES RF VOLTMETER INSTRUCTION MANUAL

BOONTON

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IMPORTANT NOTICE

JANUARY 22, 1999

INSTRUCTION MANUAL-ADDENDUM: MODEL 5230, RF VOLTMETER SECTION & 9230

Instruction manual addenda are issued to adapt the manual to changes and improvements made after this printing. Please review the following text and retain with your manual for future reference. These changes will be applied in the next printing of the manual.

Thank you for selecting BOONTON ELECTRONICS for your Test and Measurement needs.

GENERAL INFORMATION

Page 1-1, Paragraph 1-2. Description. (sub-paragraph 1)

Replace "300 volts" with "10 volts RMS".

Page 1-1, Paragraph 1-3. Design Features. (sub-paragraph 3)

Replace "the voltage range can be extended to 300 V"
with "the RF voltage range can be extended to 50 volts RMS"

Page 1-4, Table 1, Performance Specifications, Voltage Range

Replace "(20 mV to 300V with 100:1 Divider)" with

"(20 mV to 50 V with 100:1 Divider when applicable)"

Page 1-5, Table 1-1, Performance Specifications, Maximum AC Input

Replace "10 V, all frequencies and ranges" with

"Sensor dependent:

Model 952001B 10 V RMS 100 kHz to 1.2 GHz

Model 952016 10 V RMS 10 Hz to 100 MHz

Model 952009 2 V RMS 100 kHz to 2.5 GHz

Other - Refer to sensor specification."

Page 1-5, Table 1-1, Performance Specifications, Maximum DC Input

Replace "200 V, all ranges" with
"Sensor dependent:
Model 952001B 60 V
Model 952016 60 V
Model 952009 50 V
Other - Refer to sensor specification."

Page 1-10, Table 1-1, Performance Specifications(cont'd), CE MARK
Add: Installation Category II

SECTION IV
APPLICATION NOTES

Page 4-1, Paragraph 4-3. Overload Limits.

Replace sub-paragraph 1. with the following:

1. The maximum voltage which can be applied to a voltage probe Model 952001B or Model 952016 is limited to 60 VDC and 10 VAC (RMS). If the applicable 100:1 Divider is attached to the probe, the maximum AC voltage is increased to 50 VAC (RMS).

WARNING

A safety hazard exists if voltage probes are connected to voltages which exceed the maximum ratings.

Page 4-1, Paragraph 4-3. Overload Limits, sub-paragraph 2.

Replace "10 volts" with "3 volts"

Page 4-1, Paragraph 4-3. Overload Limits, sub-paragraph 3.

Replace sub-paragraph 3 with the following:

3. When using the Model 952003 Tee Adapter and other 50 ohm accessories, do not exceed the power ratings of the 50 ohm terminations and attenuators.

IMPORTANT NOTICE

September 17, 1999

OPERATION AND MAINTENANCE MANUAL-ADDENDUM: MODEL 9230

Operation and Instruction manual addenda are issued to adapt the manual to changes and improvements made after this printing. Please review the following text and retain with your manual for future reference. These changes will be applied in the next printing of the manual.

Thank you for selecting BOONTON ELECTRONICS for your Test and Measurement needs.

Page 4-13 ,Table 4-8, GPIB COMMANDS

DELETE: "PW-Watts select"

ADD:

CODE	DESCRIPTION
DMV	dBmV units selection
DV	dBV units selection
DW	dBW units selection

IMPORTANT NOTICE

June 10, 2004

INSTRUCTION MANUAL-ADDENDUM: MODEL 9230

Operation and Instruction manual addenda are issued to adapt the manual to changes and improvements made after this printing. Please review the following text and retain with your manual for future reference. These changes will be applied in the next printing of the manual.

Thank you for selecting BOONTON ELECTRONICS for your Test and Measurement needs.

Page 4-8, paragraph 4-41, line 6 – change text “paragraph 4-85” to “paragraph 4-42”.

Page 4-8, paragraph 4-43, line 3 – change text “paragraph 4-75” to “paragraph 4-32”.

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation and maintenance of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instruments. Boonton Electronics Corporation assumes no liability for the customer's failure to comply with these requirements.

THE INSTRUMENT MUST BE GROUNDED.

To minimize shock hazard the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three conductor, three prong AC power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to a two-contact adapter with the (green) grounding wire firmly connected to an electrical ground at the power outlet.

DO NOT OPERATE THE INSTRUMENT IN AN EXPLOSIVE ATMOSPHERE.

Do not operate the instrument in the presence of flammable gases or fumes.

KEEP AWAY FROM LIVE CIRCUITS.

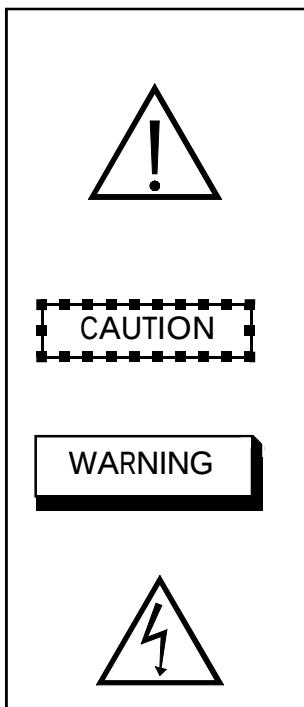
Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with the power cable connected. Under certain conditions dangerous voltages may exist even though the power cable was removed; therefore, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE.

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.

Do not install substitute parts or perform any unauthorized modification of the instrument. Return the instrument to Boonton Electronics for repair to ensure that the safety features are maintained.



This safety requirement symbol has been adopted by the International Electrotechnical Commission, Document 66 (Central Office) 3, Paragraph 5.3, which directs that an instrument be so labeled if, for the correct use of the instrument, it is necessary to refer to the instruction manual. In this case it is recommended that reference be made to the instruction manual when connecting the instrument to the proper power source. Verify that the correct fuse is installed for the power available, and that the switch on the rear panel is set to the applicable operating voltage.

The CAUTION sign denotes a hazard. It calls attention to an operation procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the equipment. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

The WARNING sign denotes a hazard. It calls attention to an operation procedure, practice, or the like, which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a warning sign until the indicated conditions are fully understood and met.

This SAFETY REQUIREMENT symbol has been adopted by the International Electrotechnical Commission, document 66 (Central Office)3, Paragraph 5.3 which indicates hazardous voltage may be present in the vicinity of the marking.

WARRANTY

Boonton Electronics (Boonton) warrants its products to the original Purchaser to be free from defects in material and workmanship for a period of one year from date of shipment for instrument, and for one year from date of shipment for probes, power sensors and accessories. Boonton further warrants that its instruments will perform within all current specifications under normal use and service for one year from date of shipment. These warranties do not cover active devices that have given normal service, sealed assemblies which have been opened or any item which has been repaired or altered without Boonton's authorization.

Boonton's warranties are limited to either the repair or replacement, at Boonton's option, of any product found to be defective under the terms of these warranties.

There will be no charge for parts and labor during the warranty period. The Purchaser shall prepay shipping charges to Boonton or its designated service facility and shall return the product in its original or an equivalent shipping container. Boonton or its designated service facility shall pay shipping charges to return the product to the Purchaser. The Purchaser shall pay all shipping charges, duties and taxes if a product is returned to Boonton from outside of the United States.

THE FOREGOING WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. BE shall not be liable to any incidental or consequential damages, as defined in Section 2-715 of the Uniform Commercial Code, in connection with the products covered by the foregoing warranties.

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SECTION I GENERAL INFORMATION

1-1. INTRODUCTION.

This instruction manual provides general information, installation and operating instructions for the Model 9230 Series of RF Voltmeters. The 9230 Series includes single channel Model 9231 and dual channel Model 9232. The terms 9230 and Model 9230 used throughout this manual refer to both configurations unless otherwise noted.

1-2. DESCRIPTION.

The Model 9230 is a DSP (digital signal processor) based RF Voltmeter capable of measuring RF voltage levels from 200 microvolts to 300 volts (probe dependent) over a frequency range from 10 Hz to 2.5 GHz (probe dependent).

The voltage levels can be displayed in V, mV, dBV or dBmV. When the measured voltage is across a known impedance (5 ohms and 2500 ohms), the calculated power can be displayed in dBm or dBW.

1-3. DESIGN FEATURES.

Wide Frequency Range. The calibrated frequency range of the instrument is determined by the probe model used. The 952001B standard RF Probe provides calibrated measurements from 10 kHz to 1.2 GHz with usable indications beyond 4 GHz. The optional 952016 low frequency RF Probe provides calibrated response from 10 Hz to 100 MHz. The optional 952009 RF (50 ohm terminated) sensor provides calibrated a range from 100 kHz to 2.5 GHz.

Shaping and calibration data for each probe is contained in EEPROM within its 951090 Sensor Data Adapter. When the probe with its Data Adapter is plugged into the 9230 RF Voltmeter, the shaping and calibration data is downloaded and applied to the measurement automatically. It is not necessary to enter any data manually. Existing voltage probes can be used with the 9230 by loading a blank Data Adapter with calibration data. No further calibration of the probe is needed.

Voltage Range. The 9230 uses three internal hardware ranges to achieve a dynamic range of 90 dB. The input levels can range from less than 200 microvolts to 10 volts. Display resolution is selectable to 0.001 dB. Using the appropriate 100:1 Voltage Divider accessory, the voltage range can be extended to 300 Volts. For the 952001 RF Probe, use adapter Model 952005 to extend the voltage range to 300 V over a frequency range of 10 kHz to 20 MHz. The 100:1 divider cannot be used with the 952009 (50 ohm) RF Sensor.

For the purpose of compatibility with previous models and preexisting calibration procedures, the input range is divided into 9 virtual ranges which correspond to previous practice.

True RMS Response. The waveform response of the RF voltage probe is true RMS for voltages below 30 mV. This characteristic provides accurate measurements for all types of waveforms with levels up to 30 mV or 3 V with the appropriate 100:1 Voltage Divider. The waveform response of the probe gradually changes to a peak detecting response above 30 mV. Computer generated shaping allows the instrument to display RMS readings above 30 mV. This is valid for nearly sinusoidal waveforms.

For modulated signals, accurate results can be obtained at high levels if the modulation envelope is relatively flat, (e.g. FM, QPSK). For other modulation types (e.g. Am, Pulse, CDMA), accurate results can be obtained below 30 mV. The equivalent peak sinewave voltage can be displayed. It is 1.414 times the RMS voltage and 3.01 dB greater than the reading in decibel units.

Low Noise. The 9230 has been designed and constructed to minimize noise from all sources. A line filter and RF tight enclosure reject outside interference. The probe cables are a special low noise design; vigorous flexing causes only minor disturbances, even on low level measurements. Non-microphonic probes are used to lessen probe sensitivity to shock and vibration.

1-4. Simple Instrument Setup and Operation. The front panel membrane keypad provides access to menus which control instrument operation. The MENU key selects channel, setup and diagnostic menus.

The <SENSOR> key selects sensor related function.

The <AVG> key selects filter time averaging controls. Setting the filter time to zero will select the auto-filter mode. This selects an appropriate filter time without operator intervention.

The <REF LEVEL> key is used for making relative measurements in dB or percent. The values for these parameters are displayed and can be adjusted by using the arrow and enter keys.

The <ZERO> key is used to zero the selected measurement channel. The <FREQ> key is not currently used.

1-5. Display. The backlit, 4 line, alphanumeric LCD display simultaneously displays both channels on Model 9232. A bar graph analog indication of level is also selectable.

1-6. Selectable Ranging. The normal mode of operation is Auto-Ranging. For special situations, any of the 8 measurement ranges can be held until the range setting is changed or the instrument is turned off. When measuring signals that fall within a narrow level range, holding at a specific range may reduce measurement time by eliminating range changes when test signals are switched. These 8 ranges are virtual ranges and only three hardware ranges are used.

1-7. Selectable Filtering. Measurement speed and display stability can be optimized by the use of the adjustable averaging filters. The averaging time, selected with the <AVG> key, can be increased to 20 seconds maximum in 50 millisecond increments. The number of stages in the filter is shown below the time setting, but cannot be set directly. Set the filter time to zero to activate the normal Auto-filtering mode.

1-8. Zeroing. The <ZERO> key independently controls the automatic zeroing of each probe and measurement channel. The RF probe must be disconnected from all signal sources during zeroing.

1-9. Chart Recorder Output. A 0 - 10 volt dc output proportional to the measurement is available for chart recorder or similar applications. The Chart Recorder Output is a BNC connector located on the rear panel.

1-10. Interface Options. The standard 9230 configuration includes an IEEE-488 (GPIB) bus interface for full programmable control of all instrument functions. The 9230 may be configured with an RS-232 interface which uses the same string commands as the GPIB. It is not possible to have both interfaces installed.

1-11. HIGH/LOW Limit Alarms. The ALARM function provides a means to monitor the power level in each channel independently. When the ALARM is "ON" (enabled) the level on the channel is continuously compared with the HI and LO Limit values. These limits are entered and treated as numerical values without regard to units. For example if you enter 10 for a limit while VOLT is selected in the units menu, the limit is 10 volts. If the units are then changed to dBm, the limit is now set at 10 dBm. The 9230 sets indicator flags (up and down arrows) on the channel display when the limit values are exceeded. There are 4 status bits in the service request byte which, when unmasked, can be used to request service over the IEEE-488 interface bus when the selected alarm condition occurs. Note that choosing overlapping limit

conditions is not an error, but may result in confusing alarm indications.

1-12. ACCESSORIES.

1-13. A Sensor Data Adapter for each installed channel along with the AC power cord is supplied with the 9230. One or more Boonton series 952000 series RF Voltage Probes is required and must be ordered separately. Probes are available with accessory kits and separately.

- a. 952063 Standard RF Probe Kit, 10 kHz to 1.2 GHz
Includes: 952001 RF Probe
95200201B 50 Ohm BNC(F) Adapter
95200401A Probe tip
95200501A 100:1 Voltage Divider
41-2A Probe Cable, 5 ft (1.5m)
- b. 952064 Low Frequency Probe Kit, 10 Hz to 100 MHz
Includes: 952016 Low Frequency RF Probe
95200201B 50 Ohm BNC(F) Adapter
95200401A Probe tip
95205801A 100:1 Voltage Divider
41-2A Probe Cable, 5 ft (1.5m)

- c. 952009 50 Ohm Voltage Sensor, 100 kHz to 2.5 GHz

Other available accessories include the following:

- d. Model 41-2A/10 Probe/Sensor Interconnecting Cable, 10 ft. (3m)
- e. Model 41-2A/20 Probe/Sensor Interconnecting Cable, 20 ft. (6m)
- f. Model 41-2A/50 Probe/Sensor Interconnecting Cable, 50 ft. (15m)
- g. Model 41-2A/100 Probe/Sensor Interconnecting Cable, 100 ft. (30m)
- h. Model 91-15A 50 Ohm Termination.
- i. Model 91-15A/1 75 Ohm Termination.
- j. 95004701A F/F Adapter, 41-2A, (for end-to-end connection of 41-2A Cables)
- k. 95004901A F/F Bulkhead Adapter (for end-to-end connection of 41-2A Cables)
- l. 95200301A 50 Ohm Type N Tee Adapter.
- m. 95200601B 75 Ohm BNC Adapter for use up to 500 MHz.

- n. 95200701A 75 Ohm Type N Tee Adapter.
- o. 95200801B Unterminated BNC Adapter (Female).
- p. 95201101A 50 Ohm Accessory Kit for 952001B RF Probe.
Includes 95200301A, 95200501A, 95200801B,
95201301A, 91-15A.
- r. 95201201A 75 Ohm Accessory Kit for 952001B RF Probe.
Includes 95200501A, 95200701A, 95200801B,
95201301A, 91-15A/1.
- s. 95201202A 75 Ohm Accessory Kit for 952001B Rf Probe.
Includes 95200701A, 95200801B, 95201301A,
91-15A/1.
- t. 95201301A Accessory Case.
- u. 95403001A Rack Mounting Kit for single or dual unit
mounting.

1-14. OPTIONS. Applies to Model 9231 single channel
and Model 9232 dual channel instruments with standard
IEEE-488 interface.

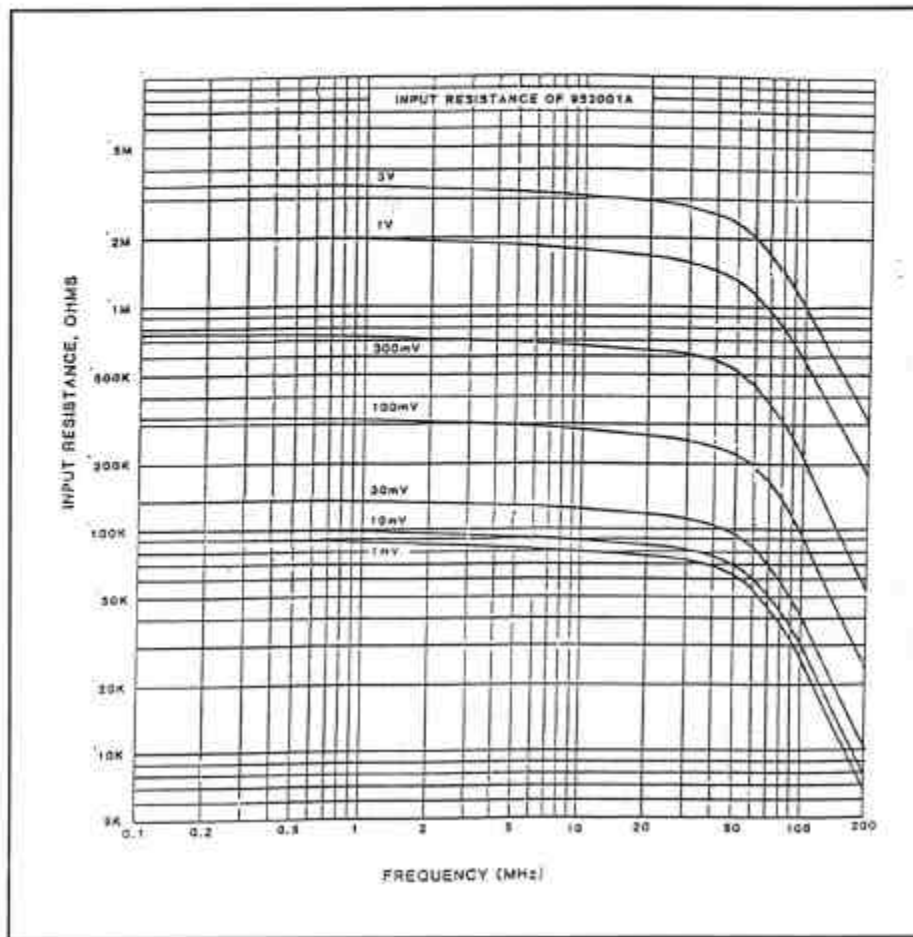
- 01 Move sensor inputs to the rear panel location.
- 03 Replace the IEEE-488 interface with the RS-232
interface.
- 30 Extend the Warranty to 3 years.

TABLE 1-1. PERFORMANCE SPECIFICATIONS

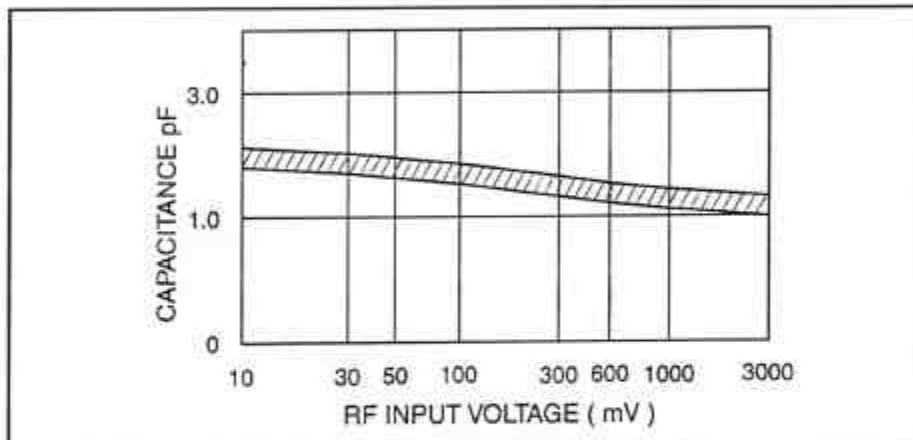
Parameter	Specification												
Voltage Range	200 μV to 10 V in 8 ranges (20 mV to 300V with 100:1 DIVIDER)												
Voltage Display	Voltage - 3 to 5 digits Decibel												
Decibel Range	90 dB in 8 ranges, measurements												
Decibel Display													
dBmV	0 dBmV=1mV												
dBV	0 dBV= 1V												
dBr	Relative to any level, limited to ± 99.999 dB												
dBm	0 dBm=1mW calculated from V ² /Z ₀ where Z ₀ is the selected reference impedance												
dBW	0 dBW= 1 W as above												
Z ₀ IMPEDANCE:	Any selected reference value from 5 to 2500 Ω												
PEAK DISPLAY:	1.414times VOLTAGE DISPLAY or 3.01 dB added to dB DISPLAY												
RANGING:	Autoranging, plus hold-on-range												
REFERENCE dB OFFSET:	Any offset can be selected to 0.001 dB resolution provided that the display range of ± 99.99 dB is not exceeded												
FREQUENCY RANGE:	MODEL 952001B RF PROBE 100 kHz to 1.2 GHz MODEL 952016 LF PROBE 10 Hz to 100 MHz MODEL 952009 SENSOR 100 kHz to 2.5 GHz												
WAVEFORM RESPONSE:	RMS to 30 mV, calibrated in rms of a sinewave above 30 mV (RMS to 3V and 700 MHz with Divider)												
CREST FACTOR:	<table><tr><td>Direct Input: Level</td><td>300 mV</td><td>1mV</td><td>3mV</td><td>10 mV</td><td>30 mV</td></tr><tr><td>CF</td><td>140</td><td>42</td><td>14</td><td>4.2</td><td>1.4</td></tr></table>	Direct Input: Level	300 mV	1mV	3mV	10 mV	30 mV	CF	140	42	14	4.2	1.4
	Direct Input: Level	300 mV	1mV	3mV	10 mV	30 mV							
	CF	140	42	14	4.2	1.4							
<table><tr><td>With Divider: Level</td><td>30 mV</td><td>100 mV</td><td>300mV</td><td>1V</td><td>3V</td></tr><tr><td>100:1 CF</td><td>140</td><td>42</td><td>14</td><td>4.2</td><td>1.4</td></tr></table>	With Divider: Level	30 mV	100 mV	300mV	1V	3V	100:1 CF	140	42	14	4.2	1.4	
With Divider: Level	30 mV	100 mV	300mV	1V	3V								
100:1 CF	140	42	14	4.2	1.4								
INPUT IMPEDANCE:	Refer to Fig. 1-2.												
MAXIMUM AC INPUT:	10 V, all frequencies and ranges												

TABLE 1-1. PERFORMANCE SPECIFICATIONS (CONT.)

Parameter	Specification
MAXIMUM DC INPUT: RECORDER OUTPUT:	200 V, all ranges. For linear voltage readout, 10 V full scale proportional to indicated voltage over each decade. Ranging occurs at 10% of full scale. For decibel readouts, scale factor is 1V per 10 dB change over the entire dynamic range.



INPUT RESISTANCE VS. FREQUENCY,
MODEL 952001B



INPUT CAPACITANCE VS. INPUT VOLTAGE,
MODEL 952001B RF PROBE

Figure1-2. Input Impedance

TABLE 1-1. PERFORMANCE SPECIFICATIONS (CONT.)

Parameter	Specification																																												
ACCURACY:	The maximum uncertainty is the sum of the 1. BASIC UNCERTAINTY 2. FREQUENCY EFFECT 3. TEMPERATURE EFFECT																																												
1. Basic Uncertainty:	UNCERTAINTY VS. INPUT LEVEL Voltage 3 mV - 10 V 1%rdg $\pm$ 1 count 1 mV - 3 mV 2%rdg $\pm$ 2 counts 0.2 mV - 1 mV 3%rdg $\pm$ 3 counts FOR dBV, dBmV, dBm, and dBW <table><tr><td>dBmV</td><td>-10</td><td>0</td><td>10</td><td>20</td><td>30</td><td>40</td><td>50</td><td>60</td><td>70</td><td>80</td></tr><tr><td>dBV</td><td>-70</td><td>-60</td><td>-50</td><td>-40</td><td>-30</td><td>-20</td><td>-10</td><td>0</td><td>10</td><td>20</td></tr><tr><td>dBm</td><td>-57</td><td>-47</td><td>-37</td><td>-27</td><td>-17</td><td>-7</td><td>3</td><td>13</td><td>23</td><td>33</td></tr><tr><td>dBW</td><td>-87</td><td>-77</td><td>-67</td><td>-57</td><td>-47</td><td>-37</td><td>-27</td><td>-17</td><td>-7</td><td>+3</td></tr></table> MODEL 9230 UNCERTAINTY VS. INPUT LEVEL FOR dBV, dBmV, dBm, and dBW	dBmV	-10	0	10	20	30	40	50	60	70	80	dBV	-70	-60	-50	-40	-30	-20	-10	0	10	20	dBm	-57	-47	-37	-27	-17	-7	3	13	23	33	dBW	-87	-77	-67	-57	-47	-37	-27	-17	-7	+3
dBmV	-10	0	10	20	30	40	50	60	70	80																																			
dBV	-70	-60	-50	-40	-30	-20	-10	0	10	20																																			
dBm	-57	-47	-37	-27	-17	-7	3	13	23	33																																			
dBW	-87	-77	-67	-57	-47	-37	-27	-17	-7	+3																																			
2. Frequency Effect:	Model 952001B Probe with Model 952002 50Ω BNC Adapter or Model 952003 Tee Adapter. <table><tr><th>Frequency</th><th>mV</th><th>dBV, dBmV, dBm</th></tr><tr><td>1 MHz (cal freq)</td><td>0</td><td>0</td></tr><tr><td>10 kHz - 100 MHz</td><td>1%rdg</td><td>0.09 dB</td></tr><tr><td>100 MHz - 1 GHz</td><td>3%rdg</td><td>0.27 dB</td></tr><tr><td>1 GHz - 1.2 GHz</td><td>7%rdg</td><td>0.63 dB</td></tr></table>	Frequency	mV	dBV, dBmV, dBm	1 MHz (cal freq)	0	0	10 kHz - 100 MHz	1%rdg	0.09 dB	100 MHz - 1 GHz	3%rdg	0.27 dB	1 GHz - 1.2 GHz	7%rdg	0.63 dB																													
Frequency	mV	dBV, dBmV, dBm																																											
1 MHz (cal freq)	0	0																																											
10 kHz - 100 MHz	1%rdg	0.09 dB																																											
100 MHz - 1 GHz	3%rdg	0.27 dB																																											
1 GHz - 1.2 GHz	7%rdg	0.63 dB																																											

TABLE 1-1. PERFORMANCE SPECIFICATIONS (CONT.)

Parameter	Specification		
2. Frequency Effect: (Continued)	Model 952003 Tee Adapter 1.2 G H z - 2.0 G H z 7% ± .01% mV		
	SWR: 1.05 to 300 MHz, 1.10 to 1 GHz, 1.15 to 1.2 GHz		
	Model 952009 Terminated Voltage Sensor.		
	Frequency	mV	dBV, dBmV,dBm
	1 MHz (cal freq)	0	0
	100 kHz - 1 GHz	1%rdg	0.09 dB
	1 GHz - 2 GHz	3%rdg	0.27 dB
	2 GHz - 2.5 GHz	5%rdg	0.45 dB
	SWR: 1.05 to 2 GHz, 1.10 to 2.5 GHz		
	Model 952016 Low Frequency Probe with Model 952002 BNC Adapter.		
	Frequency	mV	dBV, dBmV,dBm
	1 MHz (cal freq)	0	0
	50 Hz - 20 MHz	1%rdg	0.09 dB
	20 Hz - 50 Hz	2%rdg	0.17 dB
	10 Hz - 100 MHz	5%rdg	0.45 dB
	SWR: 1.05 to 100 MHz		
	Model 952001B Probe with Model 952006 75W BNC Adapter.		
	Frequency	mV	dBV, dBmV,dBm
	1 MHz (cal freq)	0	0
	10 kHz - 100 mHz	1%rdg	0.09 dB
	100 MHz - 300 MHz	3%rdg	0.27 dB
	300 MHz - 500 MHz	6%rdg	0.54 dB
	SWR: 1.05 to 150 MHz, 1.10 to 300 MHz, 1.20 to 500 MHz		

TABLE 1-1. PERFORMANCE SPECIFICATIONS (CONT.)

Parameter	Specification																																														
2. Frequency Effect: (Continued)	Model 952001B Probe with Model 952007 75Ω Tee Adapter.																																														
			dBV, dBmV,dBm																																												
	Frequency	mV																																													
	1 MHz (cal freq)	0	0																																												
	10kHz - 100 MHz	1%rdg	0.09 dB																																												
	100 MHz - 700 MHz	3%rdg	0.27 dB																																												
	700 MHz - 1 GHz	7%rdg	0.63 dB																																												
	SWR: 1.05 to 150 MHz, 1.10 to 750 MHz, 1.25 to 1 GHz																																														
	Model 952016 Low Frequency Probe with Model 952058 100:1 Divider.																																														
			dBV, dBmV,dBm																																												
Frequency	mV																																														
3. Temperature Effect:	1 MHz (cal freq)		0	0																																											
	1MHz - 20 MHz		5%rdg	0.45 dB																																											
	50 Hz - 1 MHz		3.5%rdg	0.31 dB																																											
	20 Hz - 50 Hz		4.5%rdg	0.40 dB																																											
	10 Hz - 20 Hz		7.5%rdg	0.68 dB																																											
	Model 952001B Probe or Model 952009 Sensor at 10 kHz to 1.2 GHz.																																														
	<table><tr><td colspan="2"></td><td colspan="2">mV</td><td colspan="2">dBV,d BmV, dBm</td></tr><tr><td>Temp</td><td>Inst</td><td>Probe/</td><td>Inst</td><td>Probe/</td><td></td></tr><tr><td>Degree C</td><td></td><td>Sensor</td><td></td><td>Sensor</td><td></td></tr><tr><td>21 - 25</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td></tr><tr><td>18 - 30</td><td>0</td><td>1%rdg</td><td>0</td><td>0.09 dB</td><td></td></tr><tr><td>10 - 40</td><td>1%rdg</td><td>3%rdg</td><td>0.09 dB</td><td>0.26 dB</td><td></td></tr><tr><td>0 - 55</td><td>2%rdg</td><td>7%rdg</td><td>0.18 dB</td><td>0.63 dB</td><td></td></tr></table>							mV		dBV,d BmV, dBm		Temp	Inst	Probe/	Inst	Probe/		Degree C		Sensor		Sensor		21 - 25	0	0	0	0		18 - 30	0	1%rdg	0	0.09 dB		10 - 40	1%rdg	3%rdg	0.09 dB	0.26 dB		0 - 55	2%rdg	7%rdg	0.18 dB	0.63 dB	
			mV		dBV,d BmV, dBm																																										
	Temp	Inst	Probe/	Inst	Probe/																																										
	Degree C		Sensor		Sensor																																										
21 - 25	0	0	0	0																																											
18 - 30	0	1%rdg	0	0.09 dB																																											
10 - 40	1%rdg	3%rdg	0.09 dB	0.26 dB																																											
0 - 55	2%rdg	7%rdg	0.18 dB	0.63 dB																																											

TABLE 1-1. PERFORMANCE SPECIFICATIONS (CONT.)

Parameter	Specification
LINE STABILITY:	Less than 0.2% rdg with $\pm 10\%$ line voltage change at reference line conditions of 115 to 120 V, 50 to 400 Hz
ZERO:	Automatic, operated by panel key switch.
DISPLAY:	4 line by 20 character LCD with LED backlight.
ENVIRONMENTAL:	Conforms to the requirements of Mil-T28800C for Type 11, Class 5, Style E equipment
CE MARK	Conformity to European Community (EC) Council Directives: 89/336/EEC//93/68/EEC, 73/23/EEC//93/68/EEC & Standards: EN61326-1, EN61000-4/-2, 3, 4, 5, 6, 11, EN55022, EN61010-1
POWER:	100, 120, 220, 240, V $\pm 10\%$, 50-100 Hz, 15 VA
TEMPERATURE:	Operating: 0 to +55°C Non-operating: -10 to -75 °C
ALTITUDE:	Operating: 10,000 ft
HUMIDITY:	95% (Non-condensing)
WEIGHT:	7 lbs (3.2 kg)
DIMENSIONS:	8.26 in . (21.0 cm) wide, 3.48 in. (8.9 cm) high, 13.5 in. (34.3 cm) deep

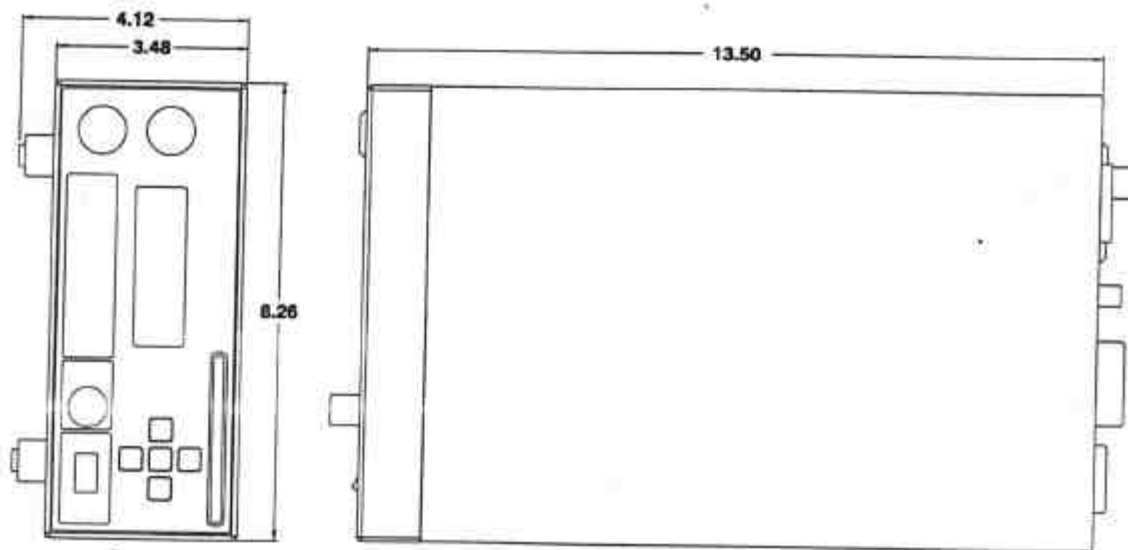


Figure 1-3. Outline Dimensions

SECTION II INSTALLATION

2-1. INTRODUCTION.

This section contains the installation instructions for the Model 9230 Series RF Voltmeter. It includes unpacking, mounting, power connections, cable connections and preliminary checkout procedures.

2-2. UNPACKING. The instrument is shipped complete and ready to use upon receipt. Unpack the instrument from its shipping container and inspect it for damage that may have occurred during shipment. Refer to figure 2-1.

NOTE

Save the packing material and container for possible use in re-shipment of the instrument.

2-3. MOUNTING. For bench use, choose a clean, dry and uncluttered surface. For rack mounting, an accessory kit is available which contains the necessary parts for mounting a single half-width Model 9230 or two side-by-side half-width Model 9230's (or a compatible product) in a single 19 inch rack.

2-4. POWER REQUIREMENTS. The Model 9230 has a tapped transformer and a power entry module containing a line voltage selector switch and two fuses. Operation is permitted from 100, 120, 220 and 240 Volt $\pm 10\%$, 50 to 60 Hz, single phase AC power supplies.



Always make certain that the setting of the line voltage selector switch most nearly corresponds to the voltage of the AC power source, and that fuses of the correct rating according to the chart just above the power entry module, are installed.

To change the line voltage selector switch or the fuses, follow this procedure:

1. REMOVE the power cable from the power entry module.
2. To open the power entry module, place a small screwdriver or coin in the slot at the top of the module and gently pry the cover open.
3. Using a small screwdriver gently pry the voltage selector cylinder from the module. Turn the cylinder

so that when it is re-inserted into the module, the desired voltage will appear in the small window in the cover.

4. To remove the fuses, move the fuseholder tabs in the direction of the arrow and pull the holder out. Place a new fuse in the holder and put it back in the slot, restoring the tab to its original position.

5. After all changes are completed, close the cover. Make sure the alignment of the selector cylinder and window is correct and that the cover snaps into place.

VOLTAGE	FUSE	IEC TYPE
100/120V	0.315A	T
220/240V	0.160A	T

2-5. CONNECTIONS. An AC power cable is supplied with the instrument and a standard interconnecting cable or cable/adaptor combination is supplied with each RF Probe. Longer RF Probe cables are available as accessories. All other cables required must be supplied by the user.

2-6. Sensor. Connect the RF Probe that is to be used for measurement to the cable or Data Adapter-Cable combo supplied with the sensor. If the Data Adapter is a separate item, also connect the cable to the adapter. Make sure that the serial number on the Data Adapter matches the serial number of the RF Probe. Insert the 10-pin adapter plug into one of the two sensor inputs. For Model 9231, only Sensor input number 1 is active.

2-7. Recorder. A data recorder or other similar device can be connected to the Recorder BNC connector on the rear panel. The output is a DC voltage proportional to the Channel 1 display value. The voltage range is 0 to 10 volts with an output impedance of approximately 9 kohms.

2-8. GPIB. The standard instrument is equipped with an IEEE-488 bus interface for remote operation. The connector is located on the rear panel.

2-9. RS-232. The optional RS-232 interface can be supplied in place of the standard IEEE-488 interface. This interface also provides remote operation using the same command strings. The DB-25 connector is located on the rear panel.

2-10. PRELIMINARY CHECK.

2-11. The following preliminary check verifies that the Model 9230 is operational. It should be performed before the instrument is placed in service. Proceed as follows:

- a. Ensure that the voltage selector switch and fuses correspond to the AC power source voltage to be used.
- b. Connect the AC power cable to the instrument and to the power source.
- c. Connect one or two RF Probes to the instrument as described above.
- d. Set the front panel OFF/ON power switch to the ON position..

e. Verify that BOONTONELECTRONICS
 923X RF VOLTMETER
 Rev. X.XX

is momentarily displayed.

f. Verify that the measurement display showing "CH 1" only for Model 9231 or "CH 1" and "CH 2" for Model 9232. Other data on the display will depend upon previous settings.

g. Press the <MENU> key and select DIAGNOSTICS with the down arrow key. Press <ENTER>. Verify the following submenu:

DIAGNOSTICS
 RIN
 SELFTEST <
 SWITCHES
 RECORDER

h. Press <ENTER> to execute the selftest. The items tested are:

1. Processor
2. SRAM Memory
3. EEPROM

Each test will display the OK message if it passed. When the test is completed the menu will reappear.

i. Use the <Down Arrow> key to move the "<" cursor to SWITCHES and press <ENTER>. Press each front panel key, avoiding <MENU> until last. Each key press will result in an identifying message; <MENU> will exit the test and return to the MENU.

j. Use the <Down Arrow> key to select RECORDER and press <ENTER>. This test will sequentially send a DC voltage in 1 volt steps to the recorder output BNC connector on the rear panel. The test will continue until <MENU> is pressed. Use a DC voltmeter to verify correct operation.

k. Press <MENU> to return to the measurement display.

l. Press the <Sensor> key and verify that the RF Probe serial number(s) appear under the channel heading(s). An active channel with no probe installed will report a table number.

m. Press the <AVG> key and verify that the filter time and number of samples appear for each active channel.

n. Press the <REF Level> key and verify that a reference level and mode is shown for each active channel.

o. With all installed RF Probes disconnected from any source of RF voltage, press the <ZERO> key and select the ZERO function for each active channel and probe in turn. Verify that the zeroing operation is successfully completed for each active channel and each RF Probe.

p. For standard instruments equipped with the IEEE-488 interface, connect a GPIB controller to the Model 9230. Verify that the instrument can be addressed to Listen at its IEEE bus address, and set to Remote. The display must show the correct status on the bottom line of the display. For message passing, the line terminators for the controller and the Model 9230 must be compatible for both Listen and Talk. Use <MAIN> <SETUP> <IEEE> to set address and terminators for the 9230. Address the 9230 to Listen/Remote and send the command "?ID" or "*IDN?" EOL. Then address the Model 9230 to Talk (controller to listen) and verify that the correct identification string is returned.

q. For instruments equipped with the optional RS-232 interface, connect a dumb terminal or PC serial terminal to the Model 9230. Use a null modem if the terminal is wired as DCE. For message communication to take place, the parameters of the serial connection and message strings must agree between the terminal and the Model 9230. Use <MAIN> <SETUP> <RS-232> to set parameters for the 9230. Send the command "?ID" or "*IDN?" EOL and verify that the correct identification string is returned.

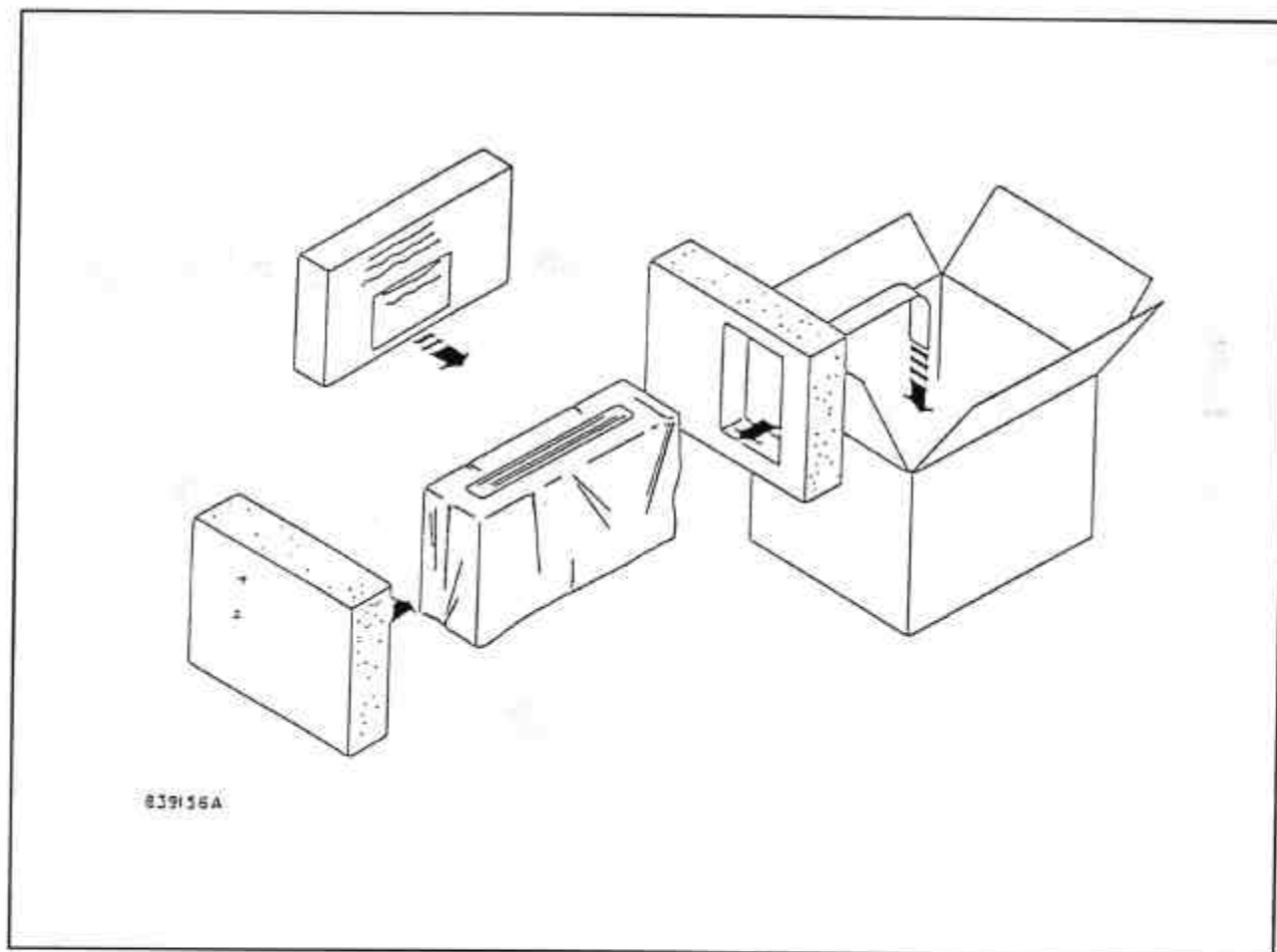


Figure 2-1. Packing and Unpacking Diagram

SECTION III OPERATION

3-1. INTRODUCTION.

3-2. This section contains operating instructions for the Model 9230. It is strongly recommended that the operator become familiar with all the material in this section and with the application notes in Section IV before attempting to operate the instrument; otherwise, the full capabilities of the instrument may not be realized.

3-3. OPERATING CONTROLS, INDICATORS, AND CONNECTORS.

3-4. See Figures 3-1 and 3-2 for the location of the operating controls and connectors. Refer to Table 3-1 for the function of each of these items.

3-5. OPERATING THE INSTRUMENT.

3-6. Energize the instrument by setting the OFF/ON switch to the ON position. The instrument will perform a self test routine and initialize the operating parameters to the power-up values.

3-7. MEASUREMENT DISPLAY.

3-8. The measurement screen shown in Figure 3-3 can be configured to display one or two channels along with the corresponding bar graph. In alarm mode, the $\wedge$ and the $\vee$ symbols are displayed before the channel mode to indicate that the measured value is above or below the defined limits. An asterisk is displayed before the channel mode when in the manual range mode and the measured value is below the lower range limit indicating an uncalibrated measurement. The alarm indicators have precedence over the range limit display. In peak mode, the P_K symbol is displayed after the measurement unit. The Δ symbol is displayed when the measurement is associated with an offset. When the instrument is configured for remote operations over the IEEE-488 or RS-232 bus, the last line, as shown in Figure 3-4, is always used for the bus indicators.

3-9. MENU STRUCTURE.

TABLE 3-1. OPERATING CONTROLS, INDICATORS, AND CONNECTORS

Index and Fig. No.	Nomenclature	Function
1, 3-1	Sensor Connector, Channel 1	Provides the means for connecting the voltage sensor to channel 1 of the instrument.
2, 3-1	Sensor Connector, Channel 2	Provides the means for connecting the voltage sensor to channel 2 of the instrument.
3, 3-1	Display	LCD readout of the measurements and user interface for editing of the instrument's operating parameters.
4, 3-1	Left Arrow Key	In entry mode, advances the cursor to the left.
5, 3-1	Up Arrow Key	In entry mode, advances the cursor upwards. In parameter entry mode, scrolls forward through the parameter list. In numerical entry mode, advances the value to the next higher digit.
6, 3-1	Enter Key	In entry mode, initiates the procedure to change a parameter. In parameter entry mode, terminates the current command and changes the parameter to the last displayed value.
7, 3-1	Right Arrow Key	In entry mode, advances the cursor to the right.
8, 3-1	Down Arrow Key	In entry mode, advances the cursor downwards. In parameter entry mode, scrolls backwards through the parameter list. In numerical entry mode, advances the value to the next lower digit.
9, 3-1	Power Switch	Turns the instrument off and on.

TABLE 3-1. OPERATING CONTROLS, INDICATORS, AND CONNECTORS (CONT.)

Index and Fig. No.	Nomenclature	Function
11, 3-1	<REF Level> Key	Selects the reference level menu for relative measurements.
12, 3-1	<Zero> Key	Selects the zeroing function.
13, 3-1	<AVG> Key	Selects the filter averaging display for the measurement value.
14, 3-1	<FREQ> Key	Not used.
15, 3-1	<Sensor> Key	Displays the serial number of the installed sensors and allows for editing of the sensor parameters.
16, 3-1	<Menu> Key	Displays and allows editing of the instrument's operating parameters. Returns instrument to local mode when operating in the bus remote mode. Escapes back to measurement screen from any menu.
17,3-2	Power Entry Module with receptacle, and fuse	Provides means for connecting the AC power cord to the instrument.
18,3-2	Fuse	Protects the power circuits from overload.
19,3-2	Voltage Selector Switch	Switches the power circuits of the instrument to accommodate 100, 120, 220 or 240 volt AC power sources.
20, 3-2	GPIB Connector or RS-232	Provides means for connecting the instrument to the IEEE-488 or RS-232 bus for remote operation.
21, 3-2	Recorder Connector	Provides a DC voltage proportional to the measured values for use by an external recorder.
24,3-2	Optional location of Sensor Connector, Channel 1	Provides the means for connecting the power sensor to channel 1 of the instrument.
25,3-2	Optional location of Sensor Connector, Channel 2	Provides the means for connecting the power sensor to channel 2 of the instrument.

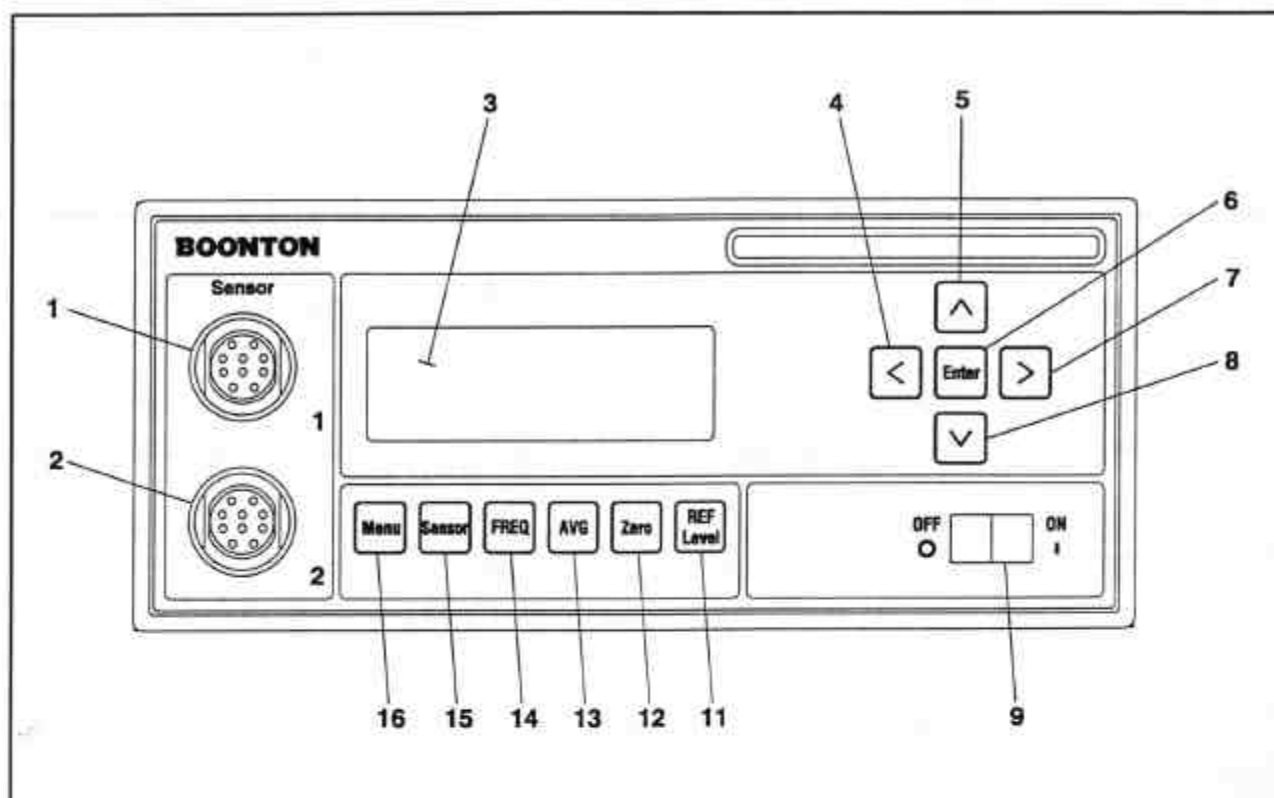


Figure 3-1. Model 9230, Front Panel Controls and Connectors

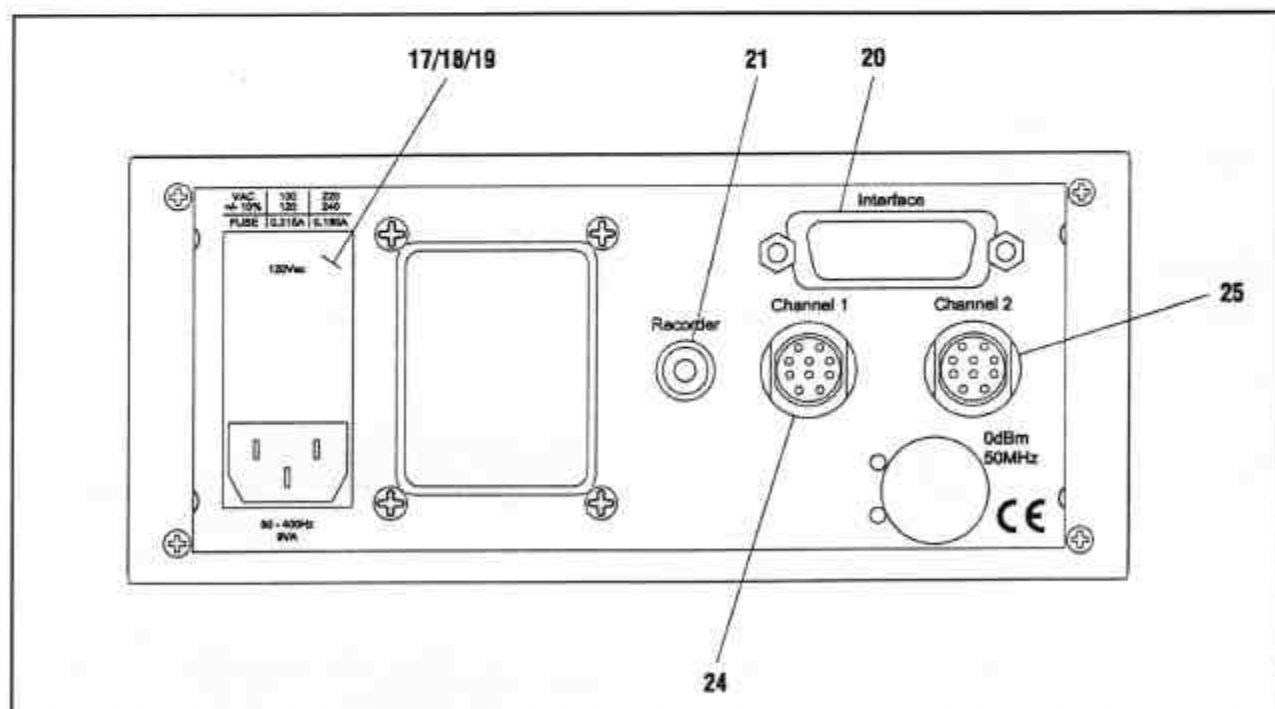


Figure 3-2. Model 9230, Rear Panel Controls and Connectors

Section III

Operation

3-10. The Model 9230 can be configured for operation via the six switches on the front panel; <Menu>, <Sensor>, <FREQ>, <AVG>, <Zero> and <REF Level>. Pressing a key will bring the instrument to the next submenu. A flow chart of the instrument's command structure is shown in Figure 3-5. The <Menu> key also serves as an ESCAPE key to cancel the current operation from any point and return to the measurement screen.

3-11. To change a value, use the arrow keys to position the cursor to the desired parameter. Press the <Enter> key and then use the up/down arrow keys to scroll through the parameter list. When a number is to be entered, use the left/right arrow keys to position the cursor under the number that is to be changed, then use the <Up/Down Arrow> keys to increment/decrement the number. Holding the up/down

arrow key will initiate repeat mode to allow rapid movement through the selections. The <Enter> key must be pressed to accept the current selection.

3-12. Within a submenu, the ^v indicators are displayed in the upper right portion of the display when the current screen has additional information that can be obtained by scrolling with the up/down arrow keys. Three conditions are possible:

- a.^ Use the <Up Arrow> key to scroll the screen upward for additional information.

- b.v Use the <Down Arrow> key to scroll the screen downward for additional information.

- c.^v Use the <Up/Down Arrow> keys to scroll the screen upward/downward for additional information.

DUAL CHANNEL

L	M	M	M	M	M		±	D	D	D	D	D	D	U	U	U		P _K	Δ
				(	B	A	R		G	R	A	P	H	)					
L	M	M	M	M	M		±	D	D	D	D	D	D	U	U	U		P _K	Δ
				(	B	A	R		G	R	A	P	H	)					

SINGLE CHANNEL

L	M	M	M	M	M		±	D	D	D	D	D	D	U	U	U		P _K	Δ
				(	B	A	R		G	R	A	P	H	)					

Key: O = 0 through 9 or a decimal point
L = ^, v, (alarm mode), * (range hold-low)
MMMMM = CH1, CH2, CH1+2, CH1/2
UUU = V, mV, μV, dBm, dBw, dBmV, dBV, %, dBr

Figure 3-3. Measurement Display, Local Mode

L	M	M	M	M	M		±	D	D	D	D	D	D	U	U	U		P _K	Δ
				(	B	A	R		G	R	A	P	H	)					
L	M	M	M	M	M		±	D	D	D	D	D	D	U	U	U		P _K	Δ
	R	E	M			L	S	N			T	L	K			S	R	Q	

Key: REM = Remote mode enabled
LSN = Listen addressed
TLK = Talker addressed
SRQ = Service request activated

Figure 3-4. Measurement Display, Remote Mode

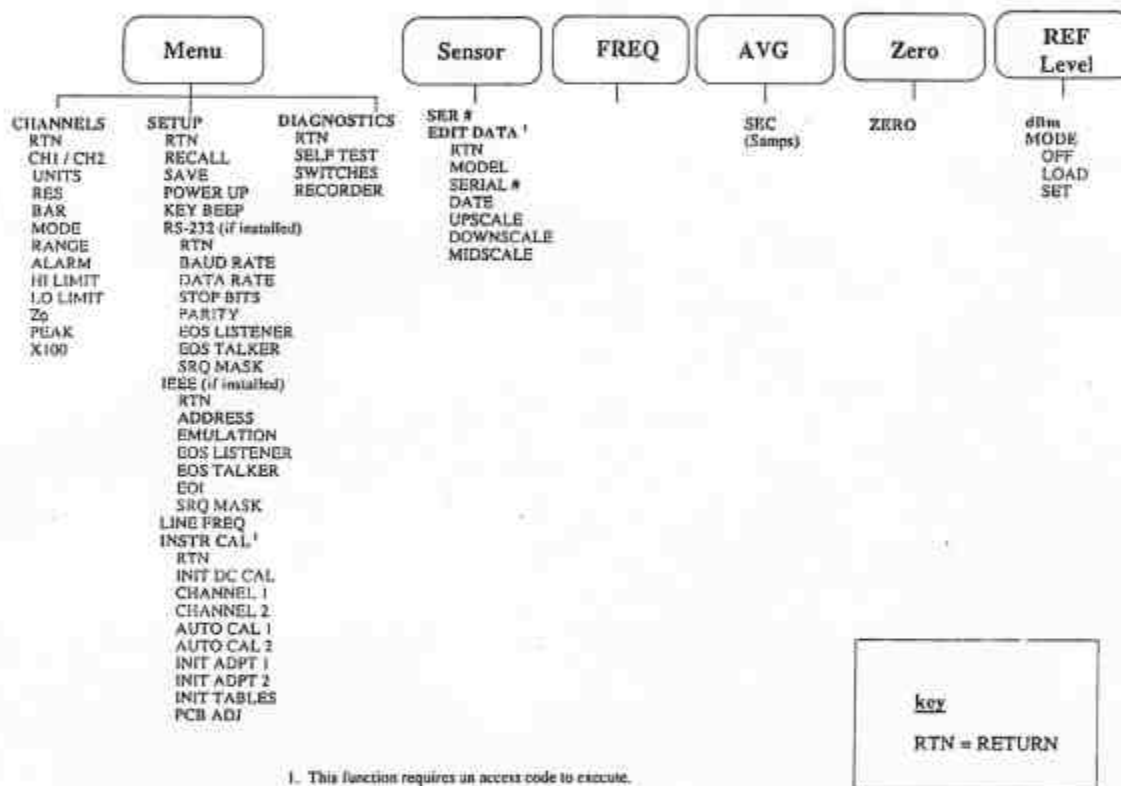


Figure 3-5. Model 9230, Command Set

3-13. MENUKey.

3-14. The instrument's, CHANNELS, SETUP and DIAGNOSTIC commands are accessed when the <Menu> key is pressed.

3-15. Using the <Up Arrow> and <Down Arrow> keys, the cursor can be positioned to select from the three submenus.

3-16. Channel Menu. An example of the display for the Channels menu, when two channels are installed in the Model 9230, is shown in Figure 3-7. Although the figure shows eleven lines, the instrument can only display four at a time. Therefore, it will be necessary to use the up/down arrow keys to sequence through the commands. When viewing the commands, the instrument will retain the first line as a header and use the next three lines to scroll through the remaining commands.

3-17. Table 3-2 gives a description of the commands available from the Channels menu. The associated parameters, and factory default settings are also given.

3-18. Setup Menu. An example of the display for the Setup menu, when the Model 9230 is configured with an IEEE interface, is shown in Figure 3-8. Figure 3-9 is an example of the instrument when equipped with the RS-232 option. It will be necessary to use the up/down arrow keys to sequence through the commands since there are more than four lines of information to be displayed. When sequencing through the commands, the instrument will retain the first line as a header and use the next three lines to scroll through the command list.

C	H	A	N	N	E	L	S				<						
S	E	T	U	P													
D	I	A	G	N	O	S	T	I	C	S							

Figure 3-6. Main Menu Display

R	T	N					C	H	1				C	H	2		∨	^
U	N	I	T	S		>	W	A	T	T	S		d	B	m			
R	E	S					X	X	X	X			X	.	X	X		
B	A	R					O	F	F				O	N				
M	O	D	E										C	H	2			
R	A	N	G	E			A	U	T	O			4					
A	L	A	R	M			O	N					O	F	F			
H	I		L	M	T		1	0	.	0	0		0	.	0	0		
L	O		L	M	T		1	.	0	0			0	.	0	0		
Z	0						5	0	.	0	0		2	5	0	0		
P	E	A	K				O	F	F				O	N				
X	1	0	0				O	F	F				O	N				

Figure 3-7. Channels Menu Display

TABLE 3-2. CHANNEL MENU FUNCTIONS <MENU> < CHANNELS>

Function	Description	Parameters	Default
RTN	Returns the instrument to the previous menu.	n/a	n/a
UNITS	Units used for measurement display.	dBm, VOLTS, dBV, dBmV, dBW	dBm
RES	Display resolution	X.X, X.XX, X.XXX decibel XXX, XXXX, XXXXX VOLTS	X.XX
BAR	Enables the bar graph on the measurement display.	ON, OFF	ON
MODE	Sets the display mode for channel 2; only available when two channels are installed. The units for the sum and ratio modes track the units selected for Channel 2.	CH2, CH1+2, CH1/2, OFF	CH2
RANGE	Selects and holds the instrument's measurement range. If repetitive measurements are to be made over a narrow range of levels, selecting the appropriate instrument range may speed measurements.	Auto, 0, 1, 2, 3, 4, 5, 6, 7	AUTO
ALARM	Enables alarm mode; the v or ^ symbol is displayed before the channel mode designator on the measurement display to indicate when the upper or lower threshold limit is exceeded.	ON, OFF	OFF
HI LIMIT	Upper threshold limit for the alarm function.	-99.99 to 99.99 dBmV	99.99
LOLIMIT	Lower threshold limit for the alarm function.	-99.99 to 99.99 dBmV	-99.99
Z0	Characteristic impedance used to calculate power.	5 to 2500 Ohms	50 Ohms
PEAK	Displays sinewave peak instead of RMS. Equal to a factor of 1.414 or + 3dB.	ON, OFF	OFF
X100	Used with 100:1 divider accessory	ON, OFF	OFF

R	T	N															∇	^
R	E	C	A	L	L						>	1						
S	A	V	E									2						
P	O	W	E	R	-	U	P					D	E	F	A	U	L	T
K	E	Y		B	E	E	P					O	F	F				
I	E	E	E															
L	I	N	E	F	R	E	Q											
I	N	S	T	R		C	A	L										

Figure 3-8. Setup Menu Display, (IEEE Installed)

R	T	N															∇	^
R	E	C	A	L	L							1						
S	A	V	E								>	2						
P	O	W	E	R	-	U	P					D	E	F	A	U	L	T
K	E	Y		B	E	E	P					O	F	F				
R	S	-	2	3	2													
L	I	N	E	F	R	E	Q											
I	N	S	T	R		C	A	L										

Figure 3-9. Setup Menu Display, (RS-232 Installed)

3-19. Table 3-3 gives a description of the commands, parameters and default settings of the Setup menu.

TABLE 3-3. SETUP MENU FUNCTIONS <MENU> <SETUP>

Function	Description	Parameters	Default
RTN	Returns the instrument to the previous menu.	n/a	n/a
RECALL	Recalls one of ten user defined instrument configurations or the factory setup.	Default, 1-10	Default
SAVE	Saves the current instrument configuration to one of ten non-volatile memory locations.	1-10	1
POWER-UP	Instructs the instrument to power-up to the specified configuration.	Default, 1, 2, 3, 4	Default
KEYBEEP	Turns on/off the key beep.	ON, OFF	ON
IEEE ¹⁾	Brings the instrument to the IEEE menu. (if installed)	see table 3-4	n/a
RS-232 ¹⁾	Brings the instrument to the RS-232 menu. (if installed)	see table 3-5	n/a
LINE FREQ	Select line frequency.	50Hz, 60Hz	60 Hz
INSTRCAL	Access instrument calibration settings. For service only.	n/a	n/a

1) Either IEEE-488 or RS-232 interface installed, not both.

3-20. IEEE Menu. The IEEE submenu is used to configure the Model 9230 for communications over the GPIB. An example of the menu is shown in Figure 3-10 and the description of the commands, parameters and factory defaults is given in Table 3-4. This menu will appear only if the standard IEEE-488 interface is installed.

3-21. RS-232 Menu. The RS-232 menu is used to configure the Model 9230 for serial communications over the RS-232 bus. An example of the submenu is shown in Figure 3-11 and an explanation of the commands, parameters and factory defaults is given in Table 3-5. This menu will appear only if the optional RS-232 interface is installed.

R	T	N															√	^
A	D	D	R	E	S	S						1	5					
E	M	U	L	A	T	I	O	N				N	O	N	E			
E	O	S		L	S	T	N					L	F					
E	O	S		T	A	L	K	E	R			C	R	L	F			
E	O	I										O	F	F				
S	R	Q		M	A	S	K					0						

Figure 3-10. IEEE Menu Display

TABLE 3-4. IEEE MENU FUNCTIONS <MENU> <SETUP> <IEEE>

Function	Description	Parameters	Default
RTN	Returns the instrument to the previous menu.	n/a	n/a
ADDRESS	GPIB address assigned to the instrument.	0 to 30	n/a
EMULATION		n/a	n/a
EOS LSTN	End of string indicator for received messages.	LF, CR, CRLF, NONE Where: LF = Line Feed CR = Carriage Return CRLF = Carriage Return and Line Feed	LF
EOS TALKER	End of string character sent with transmitted messages.	LF, CR, CRLF, NONE	CRLF
EOI	Enables/disables the end or identify hardware control line.	ON, OFF	OFF
SRQ MASK	Service request interrupt mask. See Table 4-7 for bit descriptions.	00 to 255 Where: 255 enables all interrupts	0

R	T	N				<											✓	^
B	A	U	D		R	A	T	E							9	6	0	0
D	A	T	A		B	I	T	S							8			
S	T	O	P	S		B	I	T	S						1			
P	A	R	I	T	Y										N	O	N	E
E	O	S			L	I	S	T	E	N	E	R			L	F		
E	O	S			T	A	L	K	E	R					C	R	L	F
S	R	Q			M	A	S	K							0			

Figure 3-11. RS-232 Menu Display

TABLE 3-5. RS-232 MENU FUNCTIONS <MENU> <SETUP> <RS-232>

Function	Description	Parameters	Default
RTN	Returns the instrument to the previous menu.	n/a	n/a
BAUDRATE	Rate at which data is transferred over the bus.	300,1200,2400,9600 19200	9600
DATABITS	Number of data bits in a message.	7,8	8
STOPBITS	Number of stop bits in a message.	1,2	1
PARITY	Parity bit mode in a message.	ODD,EVEN,NONE	NONE
EOS	End of string indicator for received messages.	LF,CR,CRLF,NONE	LF
LISTENER		Where: LF = Line Feed CR = Carriage Return CRLF = Carriage Return & Line Feed	
EOSTALKER	End of string character sent with transmitted messages.	LF,CR,CRLF,NONE	CRLF
SRQMASK	Service request interrupt mask. See Table 4-7 for bit descriptions.	0 to 255 Where: 255 enables all interrupts	0

3-22. Diagnostics Menu. The Model 9230 can be directed to perform self-tests from the diagnostics menu. The Diagnostics menu is shown in Figure 3-12 and a description of each command is given in Table 3-6.

3-23. SENSOR KEY.

3-24. Pressing the <Sensor> key brings the instrument to the Sensor menu and facilitates viewing and editing of the power sensor's parameters. An access code is required to enter the editing mode (refer to Table 3-7). A sample display of the Sensor menu is shown in Figure 3-13.

3-25. The instrument is capable of using sensor calibration data from either the sensor data adapters or from any one of four internal tables. The sensor calibration data contained within the sensor data adapter is only accessible to the installed channel. For example, Channel 1 can use the sensor calibration data from any of the internal tables or the sensor data adapter 1. Similarly, Channel 2 can use the sensor calibration data from any of the internal tables or the sensor data adapter 2.

R	T	N				<												
S	E	L	F	T	E	S	T					<						
S	W	I	T	C	H	E	S											
R	E	C	O	R	D	E	R											

Figure 3-12. Diagnostics Menu Display

TABLE 3-6. DIAGNOSTICS MENU FUNCTIONS <MENU> <DIAGNOSTICS>

Command	Description	Parameters	Default
RTN	Returns the instrument to the previous menu.	n/a	n/a
SELFTEST	Instructs the instrument to perform internal diagnostics and the display test results.	n/a	n/a
SWITCHES	Interactive test to verify proper operation of the front panel switches. <MENU> escapes.	n/a	n/a
RECORDER	The recorder output DAC is exercised through its full range from 0 to 10 V.D.C. in 1V steps continuously until the <Menu> key is depressed.	n/a	n/a

							C	H	1						C	H	2		
S	E	R	#		>	5	0	1	4	0				4	2	9	1	0	
E	D	I	T		D	A	T	A			5	0	1	4	0				

Figure 3-13. Sensor Display Menu

Section III Operation

3-26. Referring to Figure 3-13, the cursor can be positioned to three fields. The two fields below the 'CH1' and 'CH2' indicate the serial number of the sensor whose calibration data is selected for channels 1 and 2 respectively. The instrument uses this data for the linearity and high frequency correction data and automatically applies the correction to the measured value.

3-27. To change the current selection for channel 1, use the arrow keys to move to the SER# command line and position the cursor below the 'CH1' field. Press the <Enter> key and use the <Up Arrow> and <Down Arrow> keys to scroll through the parameter list. The parameter list typically consists of serial numbers for each power sensor. Scroll through the list until the desired serial number is displayed and press <Enter> to accept. Move the cursor below the 'CH2' field and follow the same procedure used to change the table for channel 2.

3-28. The instrument detects the presence of the sensor data adapter and automatically down-loads the sensor calibration data. This occurs when the power to the unit is first applied or after plugging the sensor data adapter into the instrument. The power sensor and corresponding sensor data adapter have matching serial numbers for maintaining them as a matched pair.

3-29. The parameter list will show TBLn (where n = 1, 2, 3, 4) when a serial number has not been entered for the

corresponding internal table. For example, TBL3 will be displayed if the serial number has not been previously entered for internal table 3. In addition, the parameter list will show ADPTn (where n = 1, 2) if a serial number has not been entered for the table contained within the sensor data adapter. For example, ADPT2 is displayed when the serial number has not been previously entered for sensor data adapter 2.

3-30. To edit the sensor calibration data, use the <Down Arrow> key to move the cursor to the EDIT DATA function and press <Enter>. Use the <Up Arrow> and <Down Arrow> keys to scroll through the list of serial numbers, adapter numbers and table numbers to locate the desired data for editing. Press <Enter>. A message will request the ACCESS CODE. Enter the ACCESS CODE as described in Table 3-7.

3-31. Edit Data Menu. An example of the Edit Data Menu is shown in Figure 3-14. Table 3-8 contains a description of the functions and associated parameters.

3-32. Linearity Factors. Eight upscale and downscale linearity factors are assigned to each RF Voltage Probe sensor. These values are unique to each sensor and are the result of a calibration procedure. RF Voltage Probes which are purchased with a Model 9230 or with a Data Adapter will have

TABLE 3-7. EDIT DATA ACCESS CODE

The access code to enter the Edit Data menu is as follows:
Press the front panel switches in the following order:
<FREQ> <AVG> <AVG> <FREQ> <Sensor> <Enter>

R	T	N															∇	^
M	O	D	E	L							9	5	2	0	0	1		
S	E	R	I	A	L		#				>	4	2	9	1	0		
D	A	T	E								0	7	/	2	9	/	9	6
U	P	S	C	A	L	E					0	:	4	0	6	5		
D	O	W	N	S	C	A	L	E			0	:	0	0	0	0		
M	I	D	S	C	A	L	E				0	:	0	0	0	0		

Figure 3-14. Edit Data Menu Display

the linearity factors installed in the adapter at the factory. For probes purchased separately or for older probes undergoing calibration, the data is supplied in printed form. For existing printed linearity data which has only seven sets of factors, enter the data for range 6 into both range 6 and 7 of the 9230. In most cases this will not degrade accuracy.

3-33. The linearity factors can be edited by moving the cursor to UPSCALE, DOWNSCALE or MIDSCALE and pressing <Enter>. Press the <Up Arrow> and <Down Arrow> keys to scroll through the 8 values. To edit a value, use the <Right Arrow> and <Left Arrow> keys to position the underline cursor under a digit to be modified and use the <Up Arrow> and <Down Arrow> keys to increment/decrement the digit. Continue with each digit to be modified. If there are no changes to the other seven factors in the group, press <ENTER> to exit the group. Otherwise, move the cursor back to the entry number column on the left and continue editing. When the entire group of 8 factors is correct, press <ENTER>. Continue until all three groups of 8 are correct.

3-34. Saving the edited values. Editing the sensor data linearity

and other values in the menu does not automatically write the changes into the data adapter or tables. When exiting the menu either by use of the RTN function or by pressing another top level key, a confirmation message will appear, "CONFIRM SAVE" NO/YES. The default answer is NO. To cause the edited data to be written into the adapter or table, the "YES" answer must be selected and <ENTER> pressed. Any other action will cause the edit to be discarded and the data in the adapter or table will remain unchanged.

3-35. FREQ Key. The FREQ is not currently used for RF Voltmeter operation. The parameters which appear in the menu are not active.

3-36. AVG Key.

3-37. The averaging time may be adjusted to optimize measurement speed and display stability. Averaging time, in seconds, can be adjusted in 0.05 increments to a maximum of 20.00 seconds.

3-38. To adjust the averaging time, press the <AVG> key and the instrument will display the screen as shown in

TABLE 3-8. EDIT DATA MENU FUNCTIONS
<SENSOR> <V> <ENTER> [SELECT S/N or TBL n] <ENTER> [ACCESS CODE]

Function	Description	Parameters	Default
RTN	Returns the instrument to the previous menu	n/a	n/a
MODEL	Power sensor model number	0 to 99999	0
SER#	Power sensor serial number	0 to 99999	0
DATE	Calibration date	MM/DD/YY Where: MM = 01 to 12 DD = 01 to 31 YY = 00 to 99	01/01/01
UPSCALE	Upscale linearity factors	Range: Factor [0 to 7]: [0 to 9999]	5000
DOWNSCALE	Downscale linearity factors	Range : Factor [0 to 7]: [-999 to 999]	0
MIDSCALE	Midscale linearity factors	Range: Factor [0 to 7]: [-999 to 999]	0

Figure 3-15. Position the cursor under the desired channel heading and press the <Enter> key. Use the arrow keys to set the desired value and then press <Enter> to accept. Entering 00.00 selects the auto filtering Mode. This menu can be accessed to show the filter setting in the auto mode.

3-39. ZERO Key. Press the <ZERO> key to select CH1 or CH2 for zeroing. Zeroing must always be performed when the instrument is turned ON, preferably after a warm-up period of 5 to 15 minutes and when a sensor is changed. Periodic zeroing is required when low level voltages are measured. For critical applications perform a zero before each measurement. For measurements above 30 mV, intervals of several hours are practical provided the thermal environment is stable.

The instrument calculates and stores zero corrections for each hardware range and applies the corrections to subsequent measurements. The zero corrections are lost when the power is turned OFF.

The RF Probe sensor must be disconnected from all signal sources while the zeroing procedure takes place. In noisy RF environments, place a 50 Ohm termination on the probe during zeroing.

3-40. REF LEVEL Key.

3-41. Press the <REF Level> key to enter a value or to use

the current channel measurement for the reference level. The measurement units will automatically change to dBr for subsequent measurements. An example of the instrument's display is shown in Figure 3-17.

3-42. To set a reference level, depress the <REF Level> key to display the REFERENCE LEVEL sub-menu. Move the cursor to the reference value for the appropriate channel. (Channel 1 is default.) Depress the <Enter> key to initiate the editing process. Use the arrow keys to edit the reference value in dBm. Once the desired value has been selected, depress the <Enter> key to leave the editing function. To use this value as the reference, depress the <Down Arrow> key to MODE, depress the <Enter> key for mode selection and using the <Up> or <Down Arrow> keys, select SET. Depressing the <Enter> key will place the appropriate channel to the "dBr" mode of operation using the set value as the reference.

The instrument can also load the current measured value as the reference level. To do this, depress the <REF Level> key to display the REFERENCE LEVEL sub-menu. Navigate the cursor using the arrow keys to the MODE selection of the desired channel. Depress the <Enter> key for mode selection and using the <Up> or <Down Arrow> keys, select LOAD. Depressing the <Enter> key will place the appropriate channel to the dBr mode of operation using the measured value as the reference level.

To turn off relative measurements, select OFF as the MODE.

To turn off relative measurements, select OFF as the MODE.

T	I	M	E														
					C	H	1						C	H	2		
S	E	C		>	1	0	.	5	0				0	0	.	8	0
S	A	M	P	S			2		1	0						1	6

Figure 3-15. Averaging Time Display

											C	H	1		C	H	2
Z	E	R	O									>					

Figure 3-16. Zero and Calibration Display

R	E	F	E	R	E	N	C	E		L	E	V	E	L				
					C	H	1						C	H	2			
d	B	m			+	0	0	.	0	0			+	2	5	.	0	0
M	O	D	E		L	O	A	D					S	E	T			

Figure 3-17. Reference Level Display

TABLE 3-9. REFERENCE LEVEL MENU FUNCTIONS

Function	Description	Parameters	Default
dB	Reference level value in Preset mode.	-99.99 to 99.99 dB	0
MODE	Reference level mode. "LOAD" makes the current channel measurement as the reference level. The Set mode is used to select the entered reference level. The Off mode disables the reference level adjustment.	LOAD, SET, OFF	OFF

SECTION IV APPLICATION NOTES

4-1. ZEROING THE INSTRUMENT.

For greatest accuracy, especially on the more sensitive ranges, the instrument must be zeroed. To eliminate the need for tedious and often inaccurate manual zeroing, the instrument incorporates an automatic zeroing capability. When automatic zeroing is initiated, the microprocessor reads, averages and stores zero corrections for each measurement range of the instrument and applies the proper zero correction for the range in use for all subsequent measurements. Zero corrections are most important on the more sensitive ranges of the instrument. During instrument warm-up periods and during use in environments with varying ambient temperatures, the instrument should be zeroed frequently if measurements are being made on the lower ranges. To zero the instrument, proceed as follows:



Never press the ZERO key with a signal applied to the probe. To do so will result in erroneous zero corrections and inaccurate subsequent measurements. If the input exceeds normal zero offsets, an error message will be displayed when automatic zeroing is initiated; remove the input signal and rezero the instrument.

1. Remove All Input Signal to the Probe. This can be done by unscrewing the probe tip until the tip just breaks contact with the internal connection, leaving the metal shell engaged with the probe body threads. Alternatively, the probe tip can be removed and a Model 952002 50 Ω adapter connected in its place.

2. Press the ZERO key. The automatic zeroing cycle takes approximately 9 seconds; the microprocessor computes and stores zero corrections during this period. When zeroing is complete, the instrument display typically shows -99.99 in all dB modes, indicating input underrange. In the mV mode, the underrange indication does not appear; the instrument display shows the "zero condition". This is composed of residual noise and offsets and, ideally, should show + and - excursions of similar amplitude less than 100 μ V.

4-2. MAKING MEASUREMENTS. Once the instrument has been programmed and zeroed, it is ready for voltage or dB level measurements. Merely connect the probe to the source whose voltage or dB level is to be measured; the measured level will be displayed directly.

4-3. OVERLOAD LIMITS.

1. The Model 952001B RF Probe supplied with the

instrument is overload protected to 10 volts AC and 200 volts DC. Exceeding these limits may result in permanent damage.

2. The Model 952002 50 Ω BNC Adapter supplied with the instrument should not be subjected to continuous overload of more than 10 volts (DC + RMS AC) in order to avoid excessive heating of the terminating resistor.

3. Where voltages above the specified overload limits are likely to be encountered, use the Model 952005 100:1 Voltage Divider. Maximum rating of the voltage divider is 1000 volts (DC + peak AC).

4-4. The terminated Model 952009 RF Probe should not be subjected to continuous overload of more than 4 volts (DC + rms AC) in order to avoid excessive heating of the terminating resistor. Exceeding these limits may result in permanent damage.

4-5. CONNECTION RECOMMENDATIONS.

1. The Model 952001B probe is equipped with a detachable tip and ground lead. For measurement of signals below approximately 100 MHz, this tip provides a convenient means for making both signal and ground connections.

2. For frequencies above 100 MHz, the probe tip should not be used because the series impedances of the connection will affect the voltage level at the probe and cause an error in measurement. For high impedance voltage measurements, connection should be made directly to the center contact of the RF probe, with the ground connection kept as short as possible. For matched impedance measurements, one of the various terminated adapters, tee adapter or Model 952009 Probe should be used. Refer to Figure 4-1.

4-6. LOW LEVEL MEASUREMENTS. The instrument will provide reliable, repeatable measurements of signal levels as low as 200 microvolts. Useful indications extend down to 50 μ V. Zeroing of the instrument is essential when using the lower ranges in order to achieve the specified accuracy. Zeroing is also strongly recommended for all ranges up to 30 millivolts. Refer to paragraph 4-1 for the zeroing procedure.

4-7. TEMPERATURE EFFECTS.

1. The accuracy specifications for the instrument apply over a temperature range of 0°C to 50°C. Outside these limits, operation of the instrument is possible, but appreciable inaccuracies can be expected; however, no permanent change in probe characteristics will result from any reasonably high or low temperature exposure.

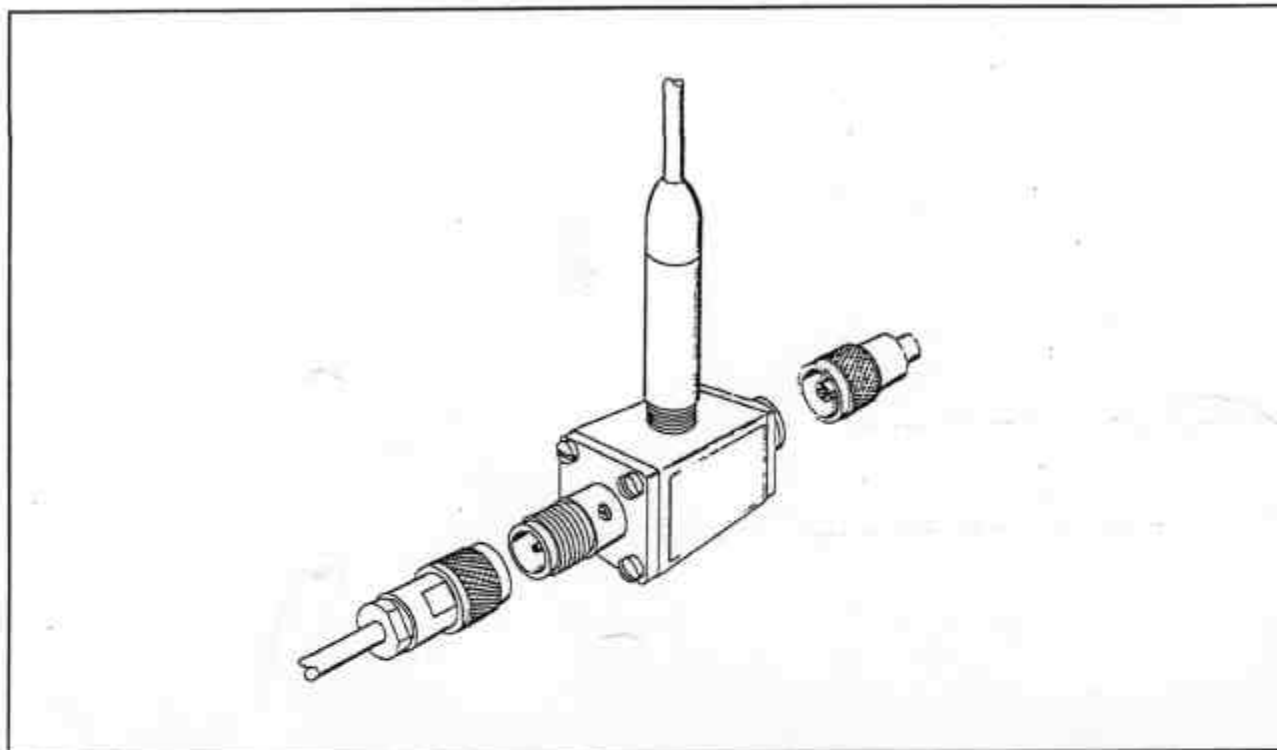
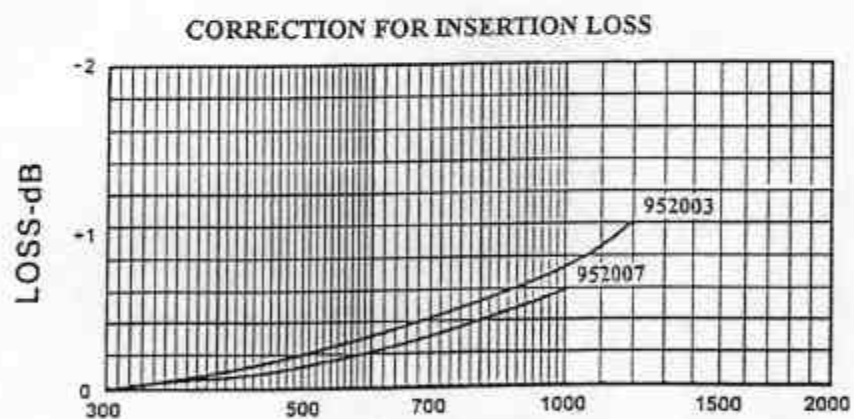


Figure 4-1. Attachment of Model 952003 to (Type N) Tee Adapter to Model 952001B Probe and Model 952014 50 Ohm Termination



NOTES

Attenuation shown is between the input and output ports of the tee. The instrument measures the input voltage of the tee.

Subtract the correction from the value indicated on the instrument if the output voltage of the tee is to be measured.

Do not use the correction if terminated measurements are required
(Model 91-15A termination installed on the output port).

Figure 4-2. Correction Curves for Model 952003 and 952007 (Type N) Tee Adapters

2. It should be noted that inaccuracies of measurement resulting from temperature effects may occur when measuring with the probe in the vicinity of heat sources such as resistors, heat sinks and so forth.

3. When making low level measurements (below approximately 2 millivolts), it is important to make sure that the probe has attained a uniform temperature throughout its body. A temperature gradient between the inside and outside of the probe can generate a small thermal voltage that may add to the DC output of the detector diodes.

4-8. HUM, NOISE AND SPURIOUS PICKUP. When measuring low level signals, precautions should always be taken to avoid the possibility of measurement errors resulting from hum, noise or stray RF pickup. Although all low frequency hum and noise are attenuated at the input, unwanted high level signals could still possibly cause error. In some cases it may be necessary to provide extra shielding around the probe connection to reduce stray pickup. Some typical sources of spurious radiation are dielectric heating units, diathermic machines and transmitters.

4-9. RECORDER OUTPUT. The DC output provided at the rear panel RECORDER connector may be used to drive an XY recorder for swept measurements, or a strip chart recorder for monitoring applications. Refer to Section 2, paragraph 2-7.

4-10. CORRECTION CURVE for MODEL 952003 50 Ohm Type N Tee Adapter. When using the optional Model 952003 Tee Adapter, the input voltage to the adapter is indicated directly on the instrument. To obtain the correct output voltage from the adapter, subtract the correction shown in Figure 4-2 from the input voltage, in dB, indicated on the instrument. Corrections are not required if the Model 952003 is terminated with 50 Ω .

4-11. CORRECTION CURVE for MODEL 952007 75 Ohm Type N Tee Adapter. When using the optional Model 952007 Tee Adapter, the input voltage to the adapter is indicated directly on the instrument. To obtain the correct output voltage from the adapter, subtract the correction shown in Figure 4-2 from the input voltage, in dB, indicated on the instrument. Corrections are not required if the Model 952007 is terminated with 75 Ω .

4-12. RF Power Measurements. The Z_0 function in the CHANNELS sub-menu enables the user to set a characteristic impedance to be used for power calculations. The default value is 50 ohms; however, values from 5 to 2500 ohms may be used. This value is used only in association with the dBm and dBW units. The power level is calculated using the expression:

$$P = V^2 / Z_0 \quad \text{where } V \text{ is in volts}$$

Z_0 is in ohms

P is in watts

For dBm units, the result is the ratio in decibels of the calculated power to 1 milliwatt (0 dBm = 1 milliwatt). For dBW units, the result is the ratio in decibels of the calculated power to 1 watt (0 dBW = 1 watt). This capability is useful for determining the power dissipated in a non-standard load impedance or in a load which is not part of a coaxial transmission line. The accuracy of this method depends upon the ability to measure the effective voltage across the load. The RF Probe enables the user to reach components mounted on circuit boards.

4-13. REMOTE (GPIB) OPERATION.

4-14. Introduction. If the Model 9230 is equipped with the IEEE-488 interface, the instrument can be operated remotely through an IEEE-488 interface. The IEEE-488 is a hardware standard which describes the communication and handshaking across the 8-bit parallel bus between a bus controller and up to 15 instruments.

4-15. The Model 9230 IEEE-488 capabilities are as follows:

C0	NO CONTROLLER	Capability
SH1	SOURCE HANDSHAKE	Complete capability
AH1	ACCEPTOR HANDSHAKE	Complete capability
RL1	REMOTE LOCAL	Complete capability
DC1	DEVICE CLEAR	Complete capability
DT1	DEVICE TRIGGER	Complete capability
RL1	REMOTE LOCAL	Complete capability
DC1	DEVICE CLEAR	Complete capability
DT1	DEVICE TRIGGER	Complete capability
PP0	PARALLEL POLL	No capability
TE0	EXTENDED TALKER	No capability
T6	BASIC TALKER	Complete capability except for talker only
LE0	EXTENDED LISTENER	No capability
L4	BASIC LISTENER	Complete capability except for listener only
DMA		Not supported

4-16. Local Operation. This is the front panel operation of the instrument. The instrument initializes to the local mode on bus power on, and the remote mode becomes active only when the instrument is remote addressed by the bus controller. Once in the remote mode, the instrument can be returned to the local mode in any of three ways: by a GTL (go to local) command from the bus controller, by turning off power to the instrument, or by pressing the front panel <Menu> key. The third method can be disabled by a local lockout (LLO) command issued by the bus controller.

4-17. Remote Operation. In the remote mode, all front panel key closures are ignored except for the <Menu> key (which may also be disabled by a LLO command from the bus controller). When the instrument is in the remote mode, the front panel REM annunciator is activated.

4-18. Bus Address. The IEEE-488 listen/talk address (MLTA) of the instrument can only be altered from the MENU-Setup-IEEE menu. Refer to paragraph 3-20.

4-19. Terminating Characters. To inform the instrument that a message has been completed, the bus controller must end all messages with a terminating character or EOI control signal. The Model 9230 can be programmed for several combinations of terminating characters as required by the controller employed. Selection of terminating characters is accomplished via the MENU-Setup-IEEE menu. There the instrument can be programmed for individual end of string characters in both listener and talker modes as well as independently enabling the end or initiate control signal.

4-20. Listen Operation. The instrument may be addressed as a listener without regard for remote or local mode. When the listener state is set by the bus controller, the instrument will receive bytes over the bus and place them in its input buffer. For listen operation, the input buffer is 150 characters long. Only one message can be entered into the input buffer at a time. A second message cannot be sent until the instrument has processed the previous message.

4-21. Talk Operation. When the instrument is requested to talk, the instrument response will depend on how it has been set up. The setup is either through talk modes or talk array commands. Talk modes are associated with making measurements; talk array commands are associated with the downloading of calibration data and instrument states. Refer to paragraph 4-30 for setup of the talk mode.

4-22. Only one instrument at a time can be addressed to talk, but many instruments can be addressed to listen simultaneously. When the Model 9230 is in the talk mode, the front panel TLK annunciator is illuminated. The format for each talk message is different and is explained in the paragraphs that follow.

4-23. IEEE-488 Command Support. The Model 9230 supports the following standard IEEE-488 commands:

a. Interface Clear Command. The interface clear (IFC) command forces all devices on the bus to clear their interfaces, and the bus to an initialized state, clearing the error condition. This command can only be issued by the bus controller in charge. The Model 9230 responds by clearing the interface.

b. Device Clear. For this instrument, the device clear (DCL) command operates the same way as the IFC command described above.

c. Group Execute Trigger. The group execute trigger (GET) command allows the bus controller to issue a trigger to all instruments on the bus simultaneously. The Model 9230 will save the current reading at the time of the GET command and return it at the time of the next talk message mode. This is in essence a bus latch. The instrument must be set to one of its trigger modes. See paragraph 4-56.

d. SRQ. The service request (SRQ) allows an instrument to inform the bus controller that some special event has occurred. The instrument then expects the bus controller to perform a serial poll to determine what event has occurred. Events that generate service requests include instrument error, measurement error, measurement is ready, and zeroing or calibration is completed. When the instrument SRQ is active, the front panel SRQ annunciator is illuminated.

e. Serial Poll. The serial poll (SP) command on the bus allows the bus controller to check the SRQ status byte of each instrument to determine which instrument is requesting service. The byte returned by the Model 9230 is composed of multiple bits that represent different status and error conditions. These conditions are individually maskable, as shown in Table 4-7.

f. Parallel Poll. The parallel poll (PP) command is not supported.

4-24. Number Formatting. Number formatting is shown for each of the commands in the paragraphs that follow, but general rules are as follows:

- a. Fixed or floating formats are accepted.
- b. The optional + or - may precede the mantissa and/or the exponent.
- c. An optional decimal point may appear at any position within the mantissa. A decimal point in the exponent is ignored.
- d. The optional "E" for exponent may be upper or lower case.
- e. All ASCII characters below and including ";" (3Bh) are considered command delimiters. The ASCII characters " " (20h), ",", " " (2Ch), ":", " " (3Bh), and "." (3Ah) are considered numeric delimiters.

4-25. String Format. String formatting is as follows:

- a. The programming sequence is in natural order, that is, a function mnemonic is sent first, followed by the argument value (parameter), if applicable.
- b. The data strings sent to the instrument are not case sensitive. This means lower case and upper case are the same.
- c. Spurious numbers occurring in the listen string are ignored.
- d. All array modes have formatted data or ASCII strings. See paragraph 4-43.

4-26. Listen Parameter Commands. Listen parameter commands are listed in Table 4-1. These are commands, received by the instrument, that expect one numerical value to follow for setting a particular operating condition. Except as noted in the table, these commands correspond to specific front panel commands. Key commands correspond to single

keystrokes; non-key commands are submodes or menu types of data entry.

4-27. The numeric value (parameter) can be sent in the next listen string if the listen parameter command was the last value of the previous string. If, for any reason, a command is sent without a parameter following the command, the CL command can be used to clear the active command, or a new command can be used. The parameter number listed in Table 4-1 is the number returned when the talk parameter mode (talk mode 6) is exercised.

4-28. Listen Action Commands. Listen action commands are listed in Table 4-2. These commands initiate an action without any parameters being sent.

4-29. Listen Array Commands. Listen array commands listed in Table 4-3 transfer arrays of data (more than one parameter) to the instrument. Sensor data and DC calibra-

TABLE 4-1. LISTEN PARAMETER COMMANDS

Mnemonic	Function and Limits	Description	Parameter No.
CH#	Channel select # 1, 2	Sets channel	12,N
FL#	Filter time select # 0 to 20.00 in 0.05 steps	Corresponds to AVG-Sec data entry (AUTO FILTER MODE when set to 0) (see FA command)	3,N
LH#	High limit select # -99.99 to 99.99 in 0.01 steps (or 0 to 99999 in Watts mode)	Corresponds to Menu -Channels-Hi Lmt data entry	14,N
LL#	Low limit select # -99.99 to 99.99 to 0.01 steps (or 0 to 99999 in Watts mode)	Corresponds to Menu-Channels-Lo Lmt data entry	15, N
LM#	Alarm select # 0 disable # 1 enable	Corresponds to Menu-Channels-Alarm command	17, N
RS#	Range select # 0 to 7	Corresponds to Menu-Channels-Range selection	5, N (-1 = RA)*
SM#	SRQ Mask # 0 - 255	Corresponds to the Menu-Setup-IEEE-SRQ Mask data entry	11, N
SR#	Set dBr reference # -99.99 to 99.99 in 0.01 steps	Corresponds to REF Level-dB data entry with Mode=Set	6,N
Z0	#5 - 2500 ohms	Impedance for power calculation	19,N
SS#	Sensor data source # 1 - 6 Where: # 1 - 4 are internal tables # 5 is the sensor data adapter for channel 1 # 6 is the sensor data adapter for channel 2	Corresponds to Sensor-Ser# selection. Use CH# to select channel before using SS#. (Selection of an invalid table may cause malfunction.)	1,N
TM#	Talk Mode # 0 to 6	Sets talk mode for IEEE-488 bus operation.	8,N

tion data are typical data. The data array is formatted as in paragraph 4-93. The actual amount of data depends on the specific command being used. Listen array commands are only operable over the bus, and have no application from the front panel.

4-30. Talk Modes. When the Model 9230 is requested to talk, it responds according to how it has been set up. The talk setup is either through talk array commands or talk modes. Talk modes are associated with making measurements; talk array commands are associated with downloading of calibration data and instrument states. The talk modes are described in the following paragraphs.

4-31. The Model 9230 supports eight talk modes of operation, as listed in Table 4-5. Once the talk mode has been set, the bus controller need only tell the Model 9230 to talk and it will respond according to the talk mode.

4-32. Talk modes 0 through 6 can be set directly by use of the talk mode (TM) command. For these modes, the instrument will remain in the selected mode until the talk mode is changed or until a talk array command is received. Talk mode 7 is a temporary talk mode that is automatically enabled in response to a talk array command. This mode cannot be set by the bus controller directly. This temporary talk mode is disabled when the talk array operation is complete.

4-33. The default condition for the talk mode is 0. The talk modes are described individually in paragraphs 4-77 through 4-86.

4-34. Talk Mode 0 (Talk Measurement Floating Point). The talk mode 0 format is as follows:

#1,#2

where:

- #1 is the error flag (1 = error, data invalid).
- #2 is the measurement in floating point notation in the units selected (dBV, dBmV, dBW, dBm or dBr). In volts mode, the unit is fixed at mV.

Examples:

- 0,1.5E3 - No error, voltage is 1.5 volts.
- 1,0 - Under range error at <100 μ V.
- 0,98.9 - No error, power is 98.9 millivolts.

4-35. Talk Mode 1 (Talk Measurement with Units). The format for talk mode 1 is as follows:

#1,\$1

where:

- #1 is the error flag (1 = error).

\$1 is the measurement. The format is fixed point followed immediately by a string that indicates the unit of measurement. Possible units are mV, dBV, dBmV, dBW, %, dBm. If needed, the string can be parsed externally into a number and a three character message.

Examples:

- 0,0.00dBV - No error at 0.00 dBV
- 1,0dBV - Under range error at dBV
- 0,98.9mV - No error at 98.9 millivolts

4-36. Talk Mode 2 (Talk Error). The talk mode 2 format is as follows:

#1,#2,#3

where:

- #1 is the instrument error number. A 0 will always be reported in this position.
- #2 is the measurement error, from 0 to 99. A 0 indicates no error. Refer to Table 4-6 for error messages.
- #3 is the channel reporting errors. A 1 is reported for channel 1 and a 2 is reported for channel 2.

Execution of this talk mode automatically clears the measurement error after it has been reported. If more than one error occurs, the instrument will indicate the first one that occurred.

Examples:

- 0,0,1 - No error is reported for channel 1
- 0,3,2 - Measurement level is under range for channel 2

4-37. Talk Mode 3 (Talk Both Channels). The talk mode 3 format is as follows:

#1, #2, #3, #4

where:

- #1 is the error flag for channel 1
(1 = error, data invalid)
- #2 is the measurement in floating point notation in the units selected.
- #3 is the error flag for channel 2 (1 = error, data invalid)
- #4 is the measurement in floating point notation in the units selected.

TABLE 4-2. LISTEN ACTION COMMANDS

Mnem- onic	Function	Description	Menum- onic	Function	Description
CL	Clear	Clears error number and error	MS	Measure Settled	Sets settled measurement mode
DB	dBm select	Corresponds to Menu--Channel-Units-dBm selection	TF	Trigger Filtered	Selects filtered trigger mode
DF	Display off	Turns off instrument display	TFD	Trigger Fast Dual	Selects fast dual channels trigger mode
DN	Display on	Turns on instrument display	TFS	Trigger Fast Single	Selects fast single channel (CH1 only) trigger mode
DR	dBr select	Corresponds to REF-Level-Mode equal to SET using the previous reference level	TN	Trigger Normal	Selects normal trigger mode
FA	Auto filter	Sets instrument to auto filter	TR	Bus trigger	Bus trigger command
LR	Load Reference	Loads the current measurement as the reference level. Corresponds to REF Level-Mode equal to LOAD.	TS	Trigger Settled	Selects settled trigger mode
MF	Measure Filtered	Sets filtered measurement Mode	ZR	Instrument zero	Corresponds to Zero/CAL-ZERO selection
MFD	Measure Fast Dual	Sets fast dual channels measurement mode	?ID	Talk instrument ID	Calls up instrument identification
MFS	Measure Fast Single	Sets fast single channel (CH1 only) measurement mode	*IDN?	Talk instrument ID	Calls up instrument identification
MN	Measure Normal (free run)	Sets normal free run measurement mode			

4-38. Talk Mode 4 (Talk with Channel Status). The format for talk mode 4 is as follows:

#1,#2,#3,#4,#5,#6,#7

where:

- #1 is always 1 in the 9230
- #2 is always 1 in the 9230
- #3 is the measurement units that the channel is set;
 - 2 - mV
 - 3 - dBr, %
 - 4 - -dBmV
 - 5 - -dBV, dBm
 - 6 - -dBW
- #4 indicates the trigger mode of operation;
 - 0 Measure Normal (also known as free-run)
 - 1 Measure Filtered
 - 2 Measure Settled
 - 3 Trigger Normal
 - 4 Trigger Filtered
 - 5 Trigger Settled
 - 6 Reserved
 - 7 Measured Fast Single
 - 8 Measured Fast Dual
 - 9 Reserved
 - 10 Trigger Fast Single
 - 11 Trigger Fast Dual
- #5 is always 0 in the 9230
- #6 is always 0 in the 9230
- #7 is the software version number.

4-39. Talk Mode 5 (Talk Instrument Status). Not used for 9230.

#1,#2,#3,#4

Always returns 0,1,00

4-40. Talk Mode 6 (Talk Parameter). The format for talk mode 6 is as follows:

#1,#2

where:

- #1 is the active parameter number (0 = no parameter selected).
- #2 is the active parameter value, for example

“frequency”. The units are defaulted.

4-41. This command returns two numbers which describe the current “opened” or selected parameter in the instrument and its value. For example, the frequency to which the instrument is set can be read over the bus. To read a parameter, it must be “opened” first as described in paragraph 4-85. A parameter in the Model 9230 is defined as a front panel or bus command that allows or requires a numerical value to be entered into it. The parameters and parameter numbers are listed in Table 4-1. The data sent over the bus is the same as the data that would appear on the instrument’s displays when the parameter is selected.

4-42. To use this talk mode, the instrument is first placed in talk mode 6 and a parameter is then opened (made active) by sending the bus command. No numeric value should follow and the clear command should not be used. Then, while the parameter is active, a talk command is issued to the instrument and the data for that parameter is sent out on the bus. A parameter can be deactivated by simply entering a number or sending another command.

Examples:

0,0 No parameter is active and the second value should be ignored

14,-3.00 The High Limit Value is currently set to -3.00 dB.

5,1 Range 1 is set.

4-43. Talk Mode 7 (Talk Array). Each of the different talk array commands has a different format. (Refer to the applicable section of paragraph 4-75.) This talk mode is not directly settable by the bus controller; it is set automatically by execution of one of the talk array commands. Talk mode 7 builds a data string in the talk buffer for a one time transmission. It is used to send an array of numerical data or a string of character data, such as sensor and/or calibration data. Once executed, this mode is automatically cleared to its previously selected value or default condition.

4-44. Talk Mode (TM) Command. The talk mode command is used to change to a selected talk mode. The range of data for this command is from 0 to 6. Talk mode 7 can only be set indirectly by execution of a talk array command. The talk mode command is classified as a listen parameter command.

Example:

TM1 - Set talk mode 1 which is talk measurement with units.

4-45. VSO Command. The VSO command is used to request sensor data from the Model 9230. The data is read from the active sensor data adapter or table and formatted

as described below. Before using the VSO command, select the channel using the CH command. If the sensor data source desired is not selected, select it using the SS command. The data string returned is made up of the

Model_number, Serial_number,
U0,...,U7,D0,...,D7,M0,...,M7

Sensor Model number in the form 95XXXX where XXXX is 4 digits which complete the RF Probe model number, e.g. 952001.

Sensor Serial number between 0 and 99999, e.g. 309321.

U0-U7 Upscale calibration factors, 1000 to 9000.

D0-D7 Downscale calibration factors, -999 to +999.

M0-M7 Midscale calibration factors, -999 to 999.

4-46. VSI Command. The VSI command is used to send sensor data to the Model 9230. If valid data is received it will be loaded into the active sensor data adapter or data table. Before using the VSO command, select the channel using the CH command. If the sensor data destination desired is not selected, select it using the SS command. The data string format is identical to that for the VSO command.

VSI Model_number,Serial_number,U0,...,U7,D0,...,D7,
M0,...M7

Example:

VSI952001,23456,5011,5026,4998,5001,5030,5066,5500,6000,0,0,
-11,21,19,-1,0,0,44,21,-21,5,0,0,9,-8

The model number must be valid and the number of entries must be correct or the data will be discarded. Always use the VSO command to read back the data and verify successful operation.

4-47. DF Command. This command blanks the front panel display for secure ATE applications and speeds up operations by reducing the number of tasks that have to be performed by the Model 9230. When the display is turned off, the display hardware is still functional, but it is not updated for certain types of information.

4-48. DN Command. This command enables the front panel display, complementing the DF command.

4-49. SM (SRQ Mask) Command. This command is used to set the SRQ mask which selectively enables service requests generated by the Model 9230. The range of numeric entry is from 0 to 255. The SRQ mask is logically ANDed with the SRQ sources to determine if an SRQ should be generated. The SRQ bit map is shown in Table 4-7. For more information on SRQ and the related serial poll, refer to paragraph 4-23.

Examples:

SM 0 - Disable all service requests

SM 2 - Enable SRQ only on measurement errors

SM 8 - Enable service request only when a zeroing operation is complete

4-50. MEASURED AND TRIGGERED OPERATION AND SETTLED READING.

4-51. General. Five measurement modes and five triggered modes are available over the bus. They are:

- a. Measure Normal (also known as free-run)
- b. Measure Filtered
- c. Measure Settled
- d. Measure Fast Single Channel
- e. Measure Fast Dual Channels
- f. Trigger Normal
- g. Trigger Filtered
- h. Trigger Settled
- i. Trigger Fast Single Channel
- j. Trigger Fast Dual Channels

The instrument must be in remote bus operation to invoke these modes of operation. When in local operation, only measure normal is available. The five measurement modes are each self triggering (free running) while the triggered modes require a bus trigger command. The operation of each mode is modified by filter selection and range selection. See paragraphs 4-16 and 4-18. The modes are described below.

4-52. Measure Normal (MN). This is the mode to which the instrument initializes at power up when the local

TABLE 4-5. TALK MODES

Talk Mode	Description
0	Talk measurement floating point
1	Talk measurement with units
2	Talk error
3	Talk both channels
4	Talk channel status
5	Talk instrument status
6	Talk parameter
7	Talk array (Indirect only)

command is issued in bus operation or when returning from a calibration mode.

4-53. Measure Filtered (MF). In this mode, the front panel display is self triggered and continuously updated. In response to a step change in power of approximately 0.02 dB or an internal range change, the front panel displays the " - - -" (dashes) message until the digital filter time constant has elapsed. This mode guarantees that the reading is filtered by holding off the display of partially filtered readings.

4-54. Measure Settled (MS). In the MS mode, the front panel display is self-triggered and continuously updated. In response to a step change in power or an internal range change, the front panel displays the " _ _ _" (dashes) message until the settled condition occurs. The minimum time for a settled reading is twice the selected filter time constant. The maximum time is unlimited, because the settled condition may never occur for noisy signals or constantly varying signals. This mode should not be used in a data acquisition system because the unsettled condition may holdoff the GPIB indefinitely.

4-55. Measure Fast Single (MFS). The measure fast single channel mode of operation provides the instrument's fastest measurement response when addressed to talk over the IEEE bus. Measurements at a rate of 240 readings per second can be obtained (see Figure 4-11). This mode only applies to channel 1 and will disable channel 2 when executed. The fast hardware filter for channel 1 is employed.

4-56. Measure Fast Dual (MFD). The measure fast dual channel mode of operation provides the instrument's fastest measurement response for both channels when addressed to talk over the IEEE bus. Measurements at a rate of 120 readings per second for each channel can be obtained. In this mode, the fast hardware filters for channel 1 and channel 2 are employed.

4-57. Trigger Normal (TN). In this mode, the front panel displays the -TRIG- message until the 9230 is triggered by a bus command. The instrument continuously measures power as in the measure normal mode but does not display the reading. When triggered, the instrument captures the most recent measurement and displays the reading until another trigger command changes the display. This mode provides a quick response to trigger and the capability to hold a reading until required. However, the user is required to assure stability of the reading at the time of trigger.

4-58. Trigger Filtered (TF). When entering this mode, the front panel displays the "-TRIG-" message. When a bus trigger command is received, the instrument begins the measure filtered mode. The 9230 displays the "-TRIG-" message until the digital filter time constant has elapsed. The instrument displays and holds the filtered reading

until another bus trigger command is received. In this mode, the digital filter guarantees a filtered reading upon trigger and the capability to hold a reading until required.

4-59. Trigger Settled (TS). When this mode is entered the front panel displays the "-TRIG-" message. The measure settled mode begins when a bus trigger command (GET) is received. The "-TRIG-" message will continue to be displayed until the settled condition occurs. The minimum time for a settled reading is twice the selected filter time constant. The maximum time is unlimited, because the settled condition may never occur for noisy signals or constantly varying signals. In a data acquisition system this mode should be used only in connection with a bus service request ((SRQ) to signal the controller when the measurement is complete. This allows the user's program to limit the time allowed for settling and take appropriate action if it is not achieved. Otherwise, an unsettled condition may hold off the GPIB indefinitely.

4-60. Trigger Fast Single (TFS). When the TFS command is executed, the front panel displays the "-TRIG-" message. Once a bus trigger command is received, the instrument begins the fast single channel measurement mode of operation. The "-TRIG-" message is displayed until the completion of the measurement. Triggered response times of 5 ms may be obtained (see Figure 4-11). This mode only applies to channel 1 and will disable channel 2 when executed. The fast hardware filter for channel 1 is employed.

4-61. Trigger Fast Dual (TFD). When the TFD command is executed, the front panel displays the "-TRIG-" message. Once a bus trigger command is received, the instrument begins the fast single channel measurement mode of operation. The "-TRIG-" message is displayed until the completion of the measurement. Triggered response times of 10 ms may be obtained. In this mode, the fast hardware filters for channel 1 and channel 2 are employed.

4-62. IEEE PROGRAMMING EXAMPLES.

4-63. REMOTE OPERATION, RS-232 INTERFACE.

4-64. General. RS-232 interface is available for the Model 9230 in lieu of the IEEE-488. The command set and data transfer protocol are nearly identical to those for the GPIB option. The Menu-SETUP-RS-232 is used to configure the RS-232 interface to comply with the terminal in use. Setting the end-of-string character and SRQ Mask is accomplished by using the EOS Talker/Listener and SRQ Mask commands respectively.

4-65. Entering the Remote Mode. The Model 9230 enters the remote mode when the ASCII "SI" character (hexadecimal 0F/CTRL O) is received. In the remote state, the front panel keyboard is disabled, except for the

<Menu> key which serves as the return to local function. The display will show the REM indicator on the last line and enable the TLK, LSN and SRQ as appropriate.

NOTE

Do not confuse the ASCII control characters "SI" and "SO" with the Sensor command strings SI and S 0 . The former are non-printing control codes, the latter 2 character literal strings.

4-66. Returning to Local Mode. The instrument will return to the local state when;

- a. The <Menu> key is pressed.
- b. The ASCII "SO" character (hexadecimal 0E/CTRL N) is received.

NOTE

The instrument must be placed in the remote state for it to respond to data messages. It is not possible to store data in the local state for execution in the remote state.

4-67. Talk Operations. The Model 9230 can be requested to talk in two ways. The "??" mnemonic is available for requesting data via the RS-232 port. Immediately after receiving this mnemonic, the instrument responds by transmitting data based on the current talk mode. For example, the following interactive sequence causes the Model 9230 to transmit the measurement with the associated units:

<u>Terminal Sends</u>	<u>Model 9230 Response</u>
O (CTRL O/hexadecimal 0F)	REM annunciator illuminates, indicating remote operation.
DB TM1 ??<ENTER>	Set measurement to dBm, set the talk mode to 1 (talk measurement with units), talk. 0,-3.00 dBm - No error at -3 dBm

NOTE

<ENTER> means transmit end-of-string as defined via the Menu-SETUP-RS 232-EOS Listener parameter (typically CR).

4-68. Additionally, the ASCII "DC2" character (hexadecimal 12/CTRL R) will cause the instrument to immediately transmit data based on the current talk mode. Continuing the above example:

<u>Terminal Sends</u>	<u>Model 9230 Response</u>
TM0 <ENTER>	Set the talk mode to send Floating Point Measurements.
R (CTRL R/hexadecimal 12)	Talk the error flag and the measurement in floating point notation. 0,-3.00 - no error, power is -3 dBm

4-69. The rules for number and data strings are the same as for the IEEE-488 interface. Number formats are free form and data strings are case insensitive.

TABLE 4-6. ERROR MESSAGES

Error Message Code	Description
0	No Errors
1	Number entry out of range for parameter set.
2	Unused
3	-LO- indication on display. Is caused by a. Power level below amount allowed in dBm display during autorange b. Power level below amount allowed for range set in watts or dBm display.
4	-HI- indication on display. Is caused by a. Power level above amount allowed in dBm display during autorange. b. Power level above amount allowed for range set in watts or dBm display.
5	Occurs when input channel attempts to autorange below the range 0. Caused by incorrect zeroing of channel or a sensor which is damaged or not connected.
6	Unable to zero instrument because power is applied to the sensor, the sensor is damaged, or the sensor is not connected.
7 thru 24	Unused
25 thru 29	Unused
30	The message string has exceeded 150 characters. All commands sent are ignored.
31	The command string sent has not been recognized by the instrument. If more than one command has been sent, the commands occurring before the unrecognized command have been executed, while subsequent commands will be ignored.
32 thru 39	Unused

TABLE 4-7. SRQ MASK BITS

Bit	Description
0	Set bit indicates LO LIMIT alarm in CH1
1	Set bit indicates that a measurement error has occurred
2	Set bit indicates that either a Trigger Filtered or Trigger Settled measurement is ready
3	Set bit indicates that a Zeroing command is complete
4	Set bit indicates HI LIMIT alarm in CH1
5	Set bit indicates LO LIMIT alarm in CH2
6	Set bit indicates that an SRQ is active; this is a summary bit used in serial poll, not a masked bit
7	Set bit indicates HI LIMIT alarm in CH2

TABLE 4-8. BOONTON 9230 GPIB COMMANDS

Code	Description	Comments
AM	Measure CH1 - CH2	(dBmodes <=-99.99)
AR	Measure CH1/CH2	
BD	Measure CH2-CH1	(dB modes <=-99.99)
BR	Measure CH2/CH1	
CH	Channel select	1 - 2
CL	Clear	
DB	dBm select	
DF	Display off	
DN	Display on	
DR	dBr select	
DU	Display user message	(Use DN to cancel)
FA	Auto filter	
FL	Filter time select	0 to 20.00 in 0.05 steps
?ID	Talk instrument ID	
*IDN?	Talk instrument ID	
LH	High limit	-99.99 to 99.99 in 0.01 steps
LL	Low limit	-99.99 to 99.99 in 0.01 steps
LM0	Disable limits checking function	
LM1	Enable limits checking function	
LR	Load reference	
PK0	Disable peak readout.	
PK1	Peak sinewave voltage	(x.1414 or +3dB)
VOLT	Volts units select	(μ V, mV)
MF	Measure filtered	
MFD	Measure Fast Dual Channels	(9232 only)
MFS	Measure fast single channel	
MN	Measure normal, free run	
MS	Measure settled	
PW	Watts select	
RA	Autorange	
RB	Recorder bottom	
RC	Recall instrument configuration	1 - 4
RE	Resolution - select bus number decimal places	1 - 3

TABLE 4-8. BOONTON 9230 GPIB COMMANDS (CONT.)

Code	Description	Comments
RN	Recorder normal	
RS	Range select	0 - 07
RT	Recorder top (use RN to cancel)	
VSI	Send linearity data to instrument	
SM	Service request (SRQ) mask	0 - 255
VSO	Get linearity data from instrument	
SR	Set dBr reference	-99.99 to 99.99 in 0.01 steps
SS	Sensor select	1 - 6
ST	Store instrument configuration	1 - 4
TF	Trigger filtered	
TFD	Trigger fast dual channels	(9232 Only)
TFS	Trigger fast single channel	
TN	Trigger normal	
TM	Talk mode	0 - 6
TR	Bus trigger	
TS	Trigger settled	
ZR	Instrument zero	
Z0	Set characteristic impedance	5-2500
XT0	X100 Divider not used	
XT1	x100 divider installed	