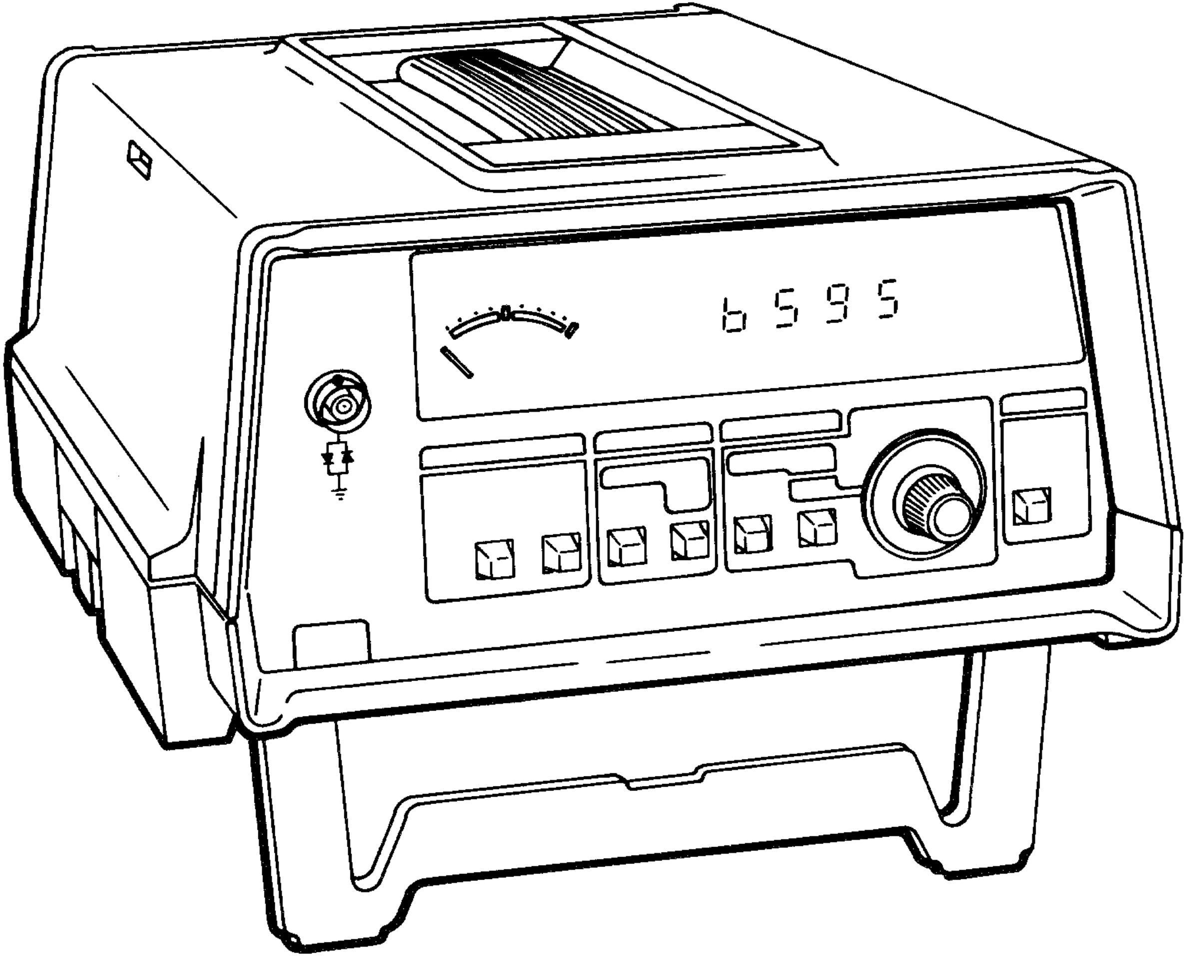
THIS MANUAL HAS BEEN CORRECTED PER CHANGE/ERRATA
INFO. ISSUE NO. 3 9/80

8922A

True RMS Voltmeter

Instruction Manual

FLUKE ®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Introduction & Specifications

1-1. INTRODUCTION

1-2. The Model 8922A is a Digital True RMS Voltmeter, capable of accurately measuring the true rms value of nonsinusoidal signals containing AC or AC + DC components. The instrument has a frequency range of 10 Hz to 11 MHz with a full-scale crest factor of seven, and is capable of displaying measurements in either volts or dB units.

1-3. Selecting the VOLTS position on the dB/VOLTs switch enables the volts display mode and two applicable front panel annunciators (V, mV). In this mode, the instrument displays up to a 3½ digit figure to indicate the true rms value of any AC or AC + DC input signal whose amplitude is between 180 μV and 700V rms (1000V peak).

1-4. The dB display mode (logarithmic) is enabled when dB is selected on the front panel dB/VOLTS display switch. In this mode, the instrument displays up to a 4½ digit dBm value of the input signal referenced to one-of-twelve manually selected impedances (50 to 1200 ohms). The dB display mode also uses two annunciators -- dB and RELATIVE REFERENCE -- and to establish the instrument's operating status. The RELATIVE REFERENCE annunciator lights whenever the REL switch is depressed to indicate that any further dB measurements will be referenced to the voltage present at the time the switch was pressed. An UNCAL annunciator lights with both display modes when internal protection circuits are energized. When AUTO is selected on the AUTO/HOLD switch (the out position) the autorange mode selects one-of-seven input ranges to optimize the display resolution.

1-5. Complementing the instrument's high digital resolution is an analog panel meter for use in applications that require peaking or nulling. This meter does not have calibration markings since it is intended for peaking and nulling indications only.

1-6. Note that the 8922A accomodates floating measurements up to approximately 0.6V peak with respect to earth ground. Isolation of 0.6V peak will accomodate the few hundred millivolts of typical common mode voltage. Full operator protection is maintained since -- under fault conditions -- the diode isolation circuitry conducts to insure that the common mode voltage is never greater than one diode drop.

1-7. Several options and accessories are available for use with the 8922A. The options and accessories are listed and described in Table 1-1. They may be ordered for factory or field installation. Detailed information concerning each option and accessory is given is Section 6 of this manual.

Table 1-1. 8922A Options and Accessories

MODEL NO.	DESCRIPTION
OPTIONS	
8922A-003	Counter Output
8922A-004	Logarithmic Analog Output
8922A-521	DMM Digital Interface
8922A-529	DMM-IEEE-488 Interface
ACCESSORIES	
Y2014	Rack Mounting Kit (single unit)
Y2015	Rack Mounting Kit (double unit)
Y2020	Panel Mount (DIN size)

1-8. The PTI (Portable Test Instrument) case is a family of injection molded, plastic instrument packages of various sizes which may be stacked vertically and latched together to form portable test stations. When instruments are stacked the weight of the stack should be limited to 40 pounds total, and the instrument drawing the most power should be on the top. Stacked instruments have a horizontal air space between them to reduce heat conduction between instruments.

1-9. SPECIFICATIONS

1-10. Detailed specifications for the Model 8922A True RMS Voltmeter are given in Table 1-2. Specifications for the Model 8922A options are given in Table 1-3.

Table 1-2. Specifications

ELECTRICAL (Basic)

The electrical specifications given assume an operating temperature of 23°C ±5°C, relative humidity up to 80% and a minimum 90 day calibration cycle.

FUNCTIONS:	AC true rms, AC + DC true rms (with 2 Hz damping for improved low frequency performance).
DISPLAYS:	Digital Display, Panel selectable for volts or dB. Analog peaking/nulling meter.
RANGING:	Autoranging, HOLD to defeat Autoranging, STEP-UP for manual up-ranging. Ranges up at 2000 counts. Ranges down at 180 counts.
LOW PASS FILTER:	200 kHz Low Pass Filter.
MAXIMUM INPUT:	700V rms or 1000V peak, not to exceed 1 X 10^8 volts-Hz product on any range.
RESPONSE TYPE:	True rms thermal converter will accept: sine, complex, pulse, or random waveforms.
RESPONSE TIME:	
AC:	1.6 seconds typically to rated accuracy within a range, composed of 1 second settling time and 0.6 seconds macimum digitizing time.
AC + DC:	7 seconds maximum to rated accuracy within a range, composed of 5 seconds settling time and 2 seconds maximum digitizing time.
INPUT IMPEDANCE:	2 mV to 700V range = 10 MΩ/shunted by <30 pF.
CREST FACTOR:	7 at full-scale, increasing proportionately as percent of scale decreases. See the Crest Factor portion of the Input Signal Considerations in Section 2.
FREQUENCY RANGE:	2 mV – 20V range = 2 Hz to 11 MHz 200V – 700V range = 2 Hz to 1 MHz

ELECTRICAL (VOLTS Display Mode)

RANGES:	2 mV, 20 mV, 200 mV, 2V, 20V, 200V, and 700V.
RESOLUTION:	0.05% of range. (3½ digits).

ELECTRICAL (dB Display Mode)

dB RANGE:	In the autorange mode the instrument appears as though it has a single range spanning 132 dB. Transients will appear in the readout as the transition through which the analog voltage range points occur.
dB RANGE REFERENCES:	
dBm REFERENCES:	Twelve manually selectable impedances with which to reference a 0 dBm, 1mW signal level. Impedances are 50, 75, 93, 110, 124, 135, 150, 300, 600, 900, 1000 and 1200 ohms.
RELATIVE dB REFERENCE:	A voltage present when this switch is depressed to its REL position is held as 0 dB reference for all other voltages.
dB RESOLUTION:	0.01 dB (4½ digits).
ACCURACY:	The accuracy specifications given below apply to the volts and dB display modes at 9% to 100% of full-scale, 23°C ±5°C, 90 day. For 6 month specifications, multiply all values by 1.5.

8922A Voltmeter Specifications 23°C ±5°C, 90 Days

INPUT VOLTAGE	RANGE	AC ACCURACY % OF VOLTAGE READING OR ±dB 2 Hz – 10 Hz	10 Hz – 20 Hz	20 Hz – 50 Hz	50 Hz – 10 kHz	10 kHz – 200 kHz	200 kHz – 1 MHz	1 MHz – 2 MHz	2 MHz – 11 MHz
		FILTER IN				FILTER OUT			
180-700V 18.0-199.9V	700V 200V	Damping* (3% or 0.35 dB)	5% or 0.5 dB Damping* (1% or 0.15 dB)	1% or 0.15 dB	0.5% or 0.1 dB		0.7% or 0.15 dB	Not Specified	
1.80-19.99V .180-1.999V 18.0-199.9 mV	20V 2V 200 mV							3% or 0.35 dB	5% or 0.5 dB
1.80-19.99 mV	20 mV		5% or 0.5 dB Damping* (2% or 0.25 dB)	2% or 0.25 dB	1% or 0.15 dB		2% or 0.25 dB		
.180-1.999 mV	2 mV	Damping* (5% or 0.5 dB)	5% or 0.5 dB	3% or 0.35 dB	2% or 0.25 dB	4% or 0.4 dB			

AC + DC ACCURACY
(USE 50 Hz - 10 kHz SPEC FOR DC ONLY)

ADD TO AC SPECIFICATION: ±10 Digits or 0.5 dB Above 2 mV.
±100 Digits or 5 dB Below 2 mV.

*Valid When AC + DC (Damping) is Selected and Input is AC Only.

Below 2 mV add: $\frac{5}{\text{mV Input}}$ digits or $\frac{0.05}{(\text{mV Input})^2}$ dB

TEMPERATURE COEFFICIENTS at 0°C to 18°C, 28°C to 50°C (32 to 64.4°F, 82.4 to 122°F)

FUNCTION

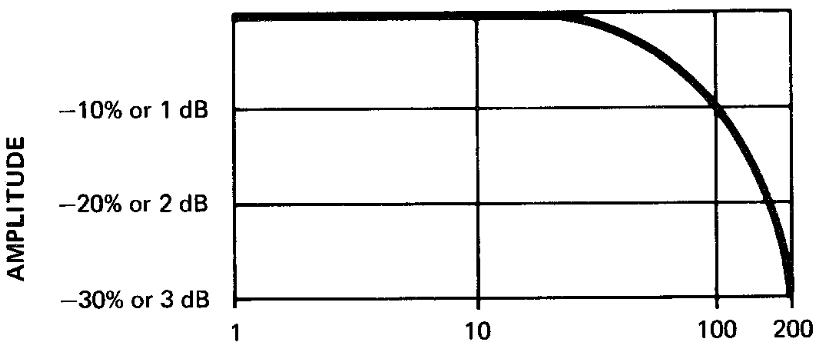
AC

2 Hz	1 MHz	11 MHz
0.07%/°C or 0.006 dB/°C	0.1%/°C or 0.01 dB/°C	

AC + DC

INPUT	ABOVE 2 mV	BELOW 2 mV
AC + DC	±(2 digits/°C or 0.1 dB/°C)	±(20 digits/°C or 1.0 dB/°C)
AC	Same as AC Function	$+ \frac{2 \text{ digits}}{\text{mV input}}$ /°C or $+ \frac{2 \text{ digits}}{(\text{mV input})^2}$ /°C

LOW PASS FILTER RESPONSE (Typical)



GENERAL

INPUT: Isolated BNC input floating up to .6V peak.

DISPLAYS: 5 (0.3" high) digit, 7-segment LED's with automatic decimal point location and mV, V, dB, RELATIVE REFERENCE, and UNCAL annunciators. The display also incorporates an uncalibrated analog meter for nulling and peaking.

AUTORANGING RATE:

VOLTS: AC 700 ms max/range change; 2.2 sec max for 6 range changes.
AC + DC 2.5 sec ac max/range change; 10 sec max for 6 range changes.

dB: AC 950 ms max/range change; 2.9 sec max for 6 range changes.
AC + DC 3.5 sec max/range change; 13 sec max for 6 range changes.

READING RATE: AC 2.5 readings per second.
AC + DC 1 reading per second.

OVERRANGE INDICATION: Flashes maximum allowed reading for that range.

UNDERRANGE INDICATION: Flashes decimal point, but continues to display the reading.

GENERAL (cont):

UNCAL INDICATION:	Illuminates to indicate crest factor is exceeded.
MAXIMUM COMMON MODE: VOLTAGE:	400 mV rms or 600 mV peak, diode clamped.
INPUT COMMON MODE: REJECTION:	> 80 dB @ 50 or 60 Hz (with 100 ohms in either lead).
LINEAR ANALOG OUTPUT:	Each range provides a linear output with 2V dc equal to 2000 counts on the readout, ±1.0% of reading relative to display; essentially 0 ohm output resistance into a > 10 kΩ load; non-isolated with output common the same as input common.
STORAGE TEMPERATURE:	−40°C to +75°C.
OPERATING TEMPERATURE:	0°C to 50°C.
HUMIDITY RANGE:	80% RH.
MTBF:	Greater than 10.000 hours.
POWER:	100V ac ±10%, 120V ac ±10%, 220V ac ±10%, or 240V ac ±10% to 250V ac max. selected by internal switches, 45 to 440 Hz, 10 W max.
DIMENSIONS:	32.7 cm (12.9 in.) L X 20.3 cm (8.0 in.) W X 10.8 cm (4.3 in.) H.
WEIGHT:	2.47 kg (5 lb. 7 oz.).
PROTECTION CLASS	CLASS 1 (IEC 348

OPTION –003, COUNTER OUTPUT OPTION

OUTPUT VOLTAGE:	100 mV peak square wave.
OUTPUT IMPEDANCE:	50 ohms.
MAXIMUM ISOLATED LEVEL:	Maintains instrument isolation with respect to earth ground.

OPTION –004, LOGARITHMIC ANALOG OUTPUT OPTION

OUTPUT VOLTAGE DC:	200 μV rms input = 0 dB, 0V dc out. 700V rms input = 131 dB, 13.1V dc out. i.e., 100 mV = 1 dB. Non-isolated, output common is the same as input common.
LINEARITY:	Within each range: ±0.35 dB. Over all seven ranges: ±2 dB.
OUTPUT IMPEDANCE:	1 kΩ.

OPTION –521 DMM DIGITAL INTERFACE

DESCRIPTION:	Serial BCD output of all digits and annunciators.
OPTICAL ISOLATION:	Transfer reliable up to 500V ac rms common mode from dc to 440 Hz.
OPERATING POWER:	From DMM +5V and GND From external device +5V at less than 10 mA and GND.

OPTION –529 DMM-IEEE-488 INTERFACE

DESCRIPTION:	Option for interfacing the 8922A to IEEE 488-1978. Package consists of one pcb mounted in the 8922A, one pcb mounted in the 1120A Translator and one interconnect cable. The 1120A must be used to interface to the IEEE 488 General Purpose Bus.
FUNCTION:	Talker.
IEEE REPERTOIRE	SH1, AH1, T3, TE3.

Operating Instructions

2-1. INTRODUCTION

2-2. The information we have presented in this section is intended to familiarize you with the capabilities and limitations of the Model 8922A. We have included instructions for the installation and operation of your 8922A as well as a brief description and identification of each control and indicator on the instrument.

2-3. SHIPPING INFORMATION

2-4. The Model 8922A is packaged and shipped in a protective container. When you receive the equipment, make a thorough inspection for any possible shipping damage. If your 8922A was damaged in shipment contact your nearest John Fluke Service Center immediately. A list of these service centers may be found in Section 7.

2-5. If reshipment of the instrument is necessary, use the original container. If the original container is not available, a new one may be obtained from the John Fluke Mfg. Co., Inc. Please indicate the instrument's model number (8922A) when requesting a new shipping container.

2-6. INSTALLATION

2-7. The 8922A is designed for bench-top use, for installation in a standard 19-inch equipment rack, or for panel mounting into any DIN size opening. Available rack mounting kits are listed in Table 1-2. In bench-top environments the 8922A may be stacked with other Fluke products that use the PTI case. To connect two or more PTI cases, pull the side connectors out, place one case squarely on top of another and press in on the side connectors of the top case until they seat firmly into the slots on the case below. See Figure 2-1.

CAUTION

Before you attempt to lift a series of stacked instruments, check each unit to ensure that its case connectors are properly mated and latched to the next lower instrument.

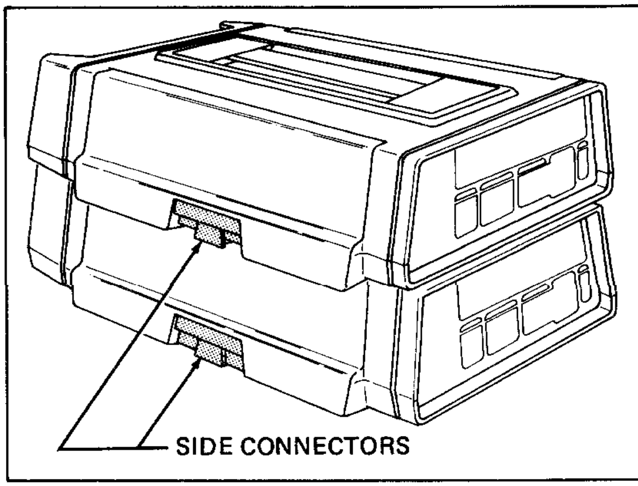


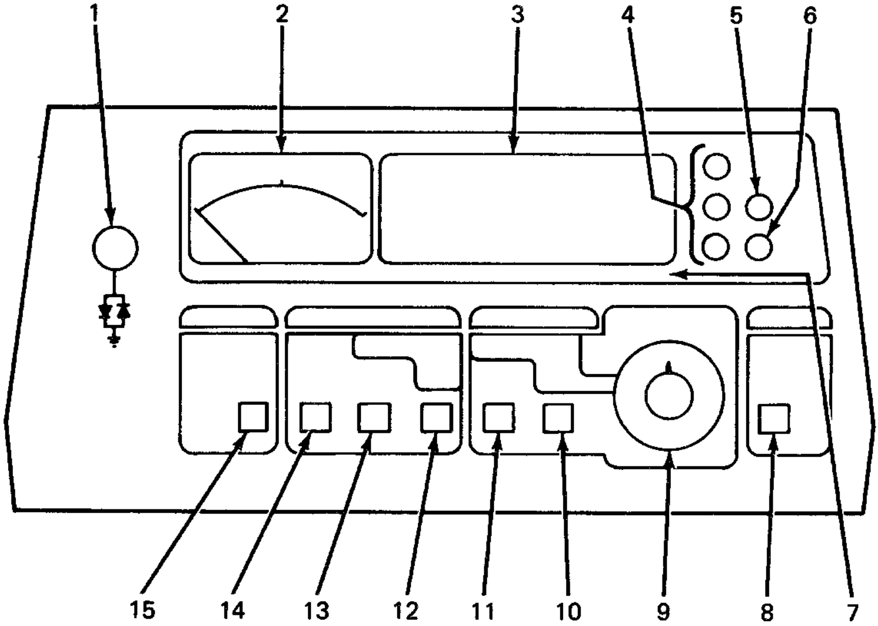
Figure 2-1. PTI Connection

2-8. INPUT POWER

2-9. The 8922A can be operated from one of several line voltages: 120, 100, 220, or 240V. Refer to the procedure in Section 4 to alter the line power configuration of the instrument. We recommend that this procedure be performed by qualified personnel only.

2-10. CONTROLS AND INDICATORS

2-11. The 8922A controls, indicators, and connectors are shown in Figure 2-2 and described in Table 2-1. Locate each feature on your DMM as you read the description.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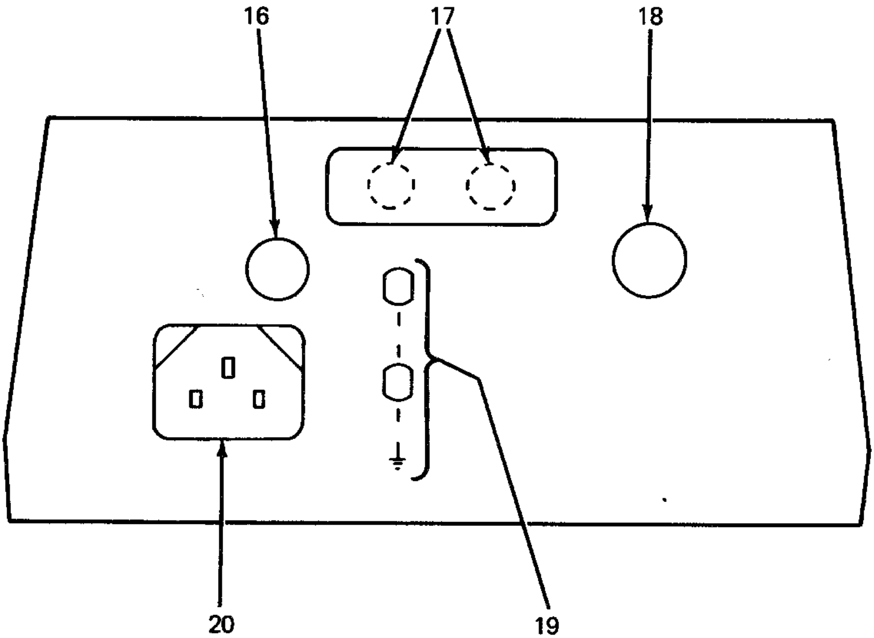
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REF NO.	NAME	FUNCTION
1	INPUT	A BNC input connector. The low side is isolated from power ground through a pair of parallel diodes.
2	Analog Panel Meter	Uncalibrated panel meter provides analog tracking of input level; useful for peaking and nulling indications.
3	Digital Display	LED display provides a direct readout of the input signal level; includes decimal point and polarity.
4	Annuniciators	LED's that light to indicate the selected measurement function V (volts), mV (millivolts) or dB (decibels).
5	UNCAL	An LED that light to indicate that the instrument's internal protection circuitry is energized, see Crest Factor, under operating instructions.
6	RELATIVE REFERENCE	An LED that lights to indicate that the voltmeter is in the dB display mode and using a relative voltage reference.
7	2/20/200/700	Indicate DMM range by decimal point locations.
8	POWER Switch	A push-push switch used to turn the instrument ON (in) and OFF (out).
9	dBm REFERENCE	Rotary switch used to manually select 1-of-12 reference impedances when the dBm and dB display modes are selected.
10	REL/dBm	A push-push switch used to select either the relative dB or the dBm display mode. When REL is depressed, the existing input level is used to establish a 0 dB reference. Subsequent level changes at the input are displayed in dB and referenced to the operator established 0 dB level. When dBm is selected, measurements are displayed in terms of dBm and the dBm REFERENCE setting.
11	dB/VOLTS	A push-push switch used to select either the voltage (out) or dB (in) display mode.
12	STEP UP	A momentary pushbutton switch used to incrementally step the voltmeter to its higher range. This switch is enabled only when the HOLD RANGE mode is selected.
13	HOLD/AUTO	A push-push switch used to select the manual (HOLD) or autorange (AUTO) mode. Selecting HOLD (in) enables manual upranging with the STEP UP switch. Selecting AUTO (out) enables the unit to autorange.
14	FILTER	A push-push switch which, when depressed, engages a single pole filter to reject unwanted high frequency signals. See the Specifications table for effect on accuracy.
15	AC/AC + DC (damping)	A push-push switch used to include (in) or delete (out) dc components as part of the input signal level. When AC + DC is selected (in) damping increases which extends low frequency operation down to 2 Hz. Reading and ranging rates are slower.
16	F1	Line fuse, MDL 1/8A slo-blo.(5 x 20 mm, 1/8A, slow acting for metric.)

REF. NO.	NAME	FUNCTION
17	DIGITAL OUTPUT/ LOG-ANALOG OUTPUT	An output port reserved for use with the Logarithmic Output Option-004-521 Option, or the -529 IEEE Interface Option, see Section 6 for details.
18	COUNTER OUTPUT	An output port reserved for use with the Counter Output Option -003. See Section 6 for details.
19	Linear Analog	A pair of banana jacks for output accessing the dc linear analog output voltage. This voltage is proportional to the V rms input and is linearly scaled; 2V dc out equals a 2000 count readout. The scale repeats for each range.
20	Input Power Connector	A 3-prong line power connector for connecting the unit to line power.

2-12. OPERATING NOTES

2-13. The following paragraphs describe various conditions which you should be aware of before attempting to operate the 8922A.

2-14. Fuse Replacement

2-15. The Model 8922A is fuse protected from the power line. You can access the fuse by pressing and turning (CCW) the fuse cap located on the rear panel. When replacement is necessary use an MDL type 1/8 amp slo-blo fuse for all voltage configurations. (For metric fuse, use 1/8A, slow acting, 5 x 20 mm glass tube type.)

2-16. Display Indications

2-17. In addition to the standard digital readout, we have equipped the front panel display with a series of unique visual indicators. These include an overrange/overload indication, an underrange indication, and an analog meter. They function automatically to help you make error free measurements.

2-18. For example, when an input signal level exceeds the display limit for the selected range an overrange will occur. The display digits flash while the overrange is present. Selecting a higher range will eliminate the overrange condition.

2-19. Measurement accuracy is uncertain when the higher voltage ranges are used to measure low level signals. To alert you to this condition, the decimal point will flash when the input is too low for the selected range (less than 180 digits). You may eliminate this underrange indication by manually selecting a lower range or selecting autorange.

2-20. The uncalibrated analog panel meter complements the digital display by linearly tracking the input signal level. It provides a 0-to-100%-of-scale indication for the selected range. This feature will aid you in detecting the peak and null points of inputs having varying levels.

2-21. Measurement Connections

2-22. COAX OR OPEN LEADS

2-23. We recommend that shielded or coax leads be used at the input for low level or high frequency measurements. Open leads (unshielded) may pick up interference from other sources causing errors at low levels. You may reduce high frequency errors by minimizing inductance and capacitance between the source and the 8922A input connector.

2-24. SAFETY CONSIDERATIONS

2-25. Under normal operating conditions, the 8922A will not present a potential electrical shock hazard to the operator. However, careless use of input-lead connectors and/or adapters may create a shock hazard.

2-26. The low input on the 8922A is connected to power ground through a pair of diodes (see front panel connector). These diodes allow the low input terminal to float up to 400 mV rms. Their function is twofold; they provide isolation between input low and power ground, and they protect the operator from the possibility of hazardous voltages existing on the exposed low input connector.

2-27. At first glance, 400 mV of isolation does not appear significant. However, in most cases it provides enough isolation to prevent ground loop currents and, therefore, measurement errors due to ground loops.

2-28. When you connect the low input of the 8922A to a potential greater than 400 mV above power ground, the diode pair conducts and effectively clamps the input common mode voltage.

WARNING

TO AVOID ELECTRICAL SHOCK HAZARD DO NOT REMOVE OR OTHERWISE DEFEAT THE INPUT DIODE PAIR.

2-29. Under no circumstances should you attempt to defeat the function of the diodes. Specifically, the diodes should not be removed, the ground return on the power cord should not be floated, and an isolation transformer should not be used to power the 8922A. If the diodes are defeated, a shock hazard will exist at the low input connector when the low input lead is floated above 30 volts.

2-30. IMPEDANCE MATCHING

2-31. Two types of ac voltage measurements are typically made; those involving matched impedance systems and those where voltmeter loading is minimized (high impedance measurements) and no impedance matching occurs.

2-32. When matched impedance systems are measured, the input cable should be terminated as close as possible to the 8922A input, thereby minimizing input capacitance and enhancing accuracy at high frequencies. This is accomplished by including the meter as an integral part of the circuit as shown in Figure 2-3A. Notice that the integrity of the 50Ω system is maintained by using a 50Ω broadband matching power splitter. An alternate solution is shown in Figure 2-3B. In this case, the source is alternately connected to the 8922A and the test circuit. This allows the source to be adjusted to a known level before being connected to the test circuit. Since both the meter and the test circuit are 50Ω loads the circuit integrity is maintained. In either method, the accuracy will be determined in part by the accuracy of the source impedance and the accuracy of the termination.

2-33. High impedance measurements are based on the assumption that the voltmeter's fixed 10 MΩ input resistance and low input capacitance will not appreciably load or otherwise affect the circuit being measured. If the measurement frequency is low, this assumption holds true.

2-34. COMMON MODE VOLTAGE MEASUREMENTS

2-35. The 8922A will accomodate common mode voltages as high as 600 mV peak, usually enough to eliminate ground loops in the power connections. Higher common mode voltages will be clamped to 600 mV up to a 25 amp maximum load capability.

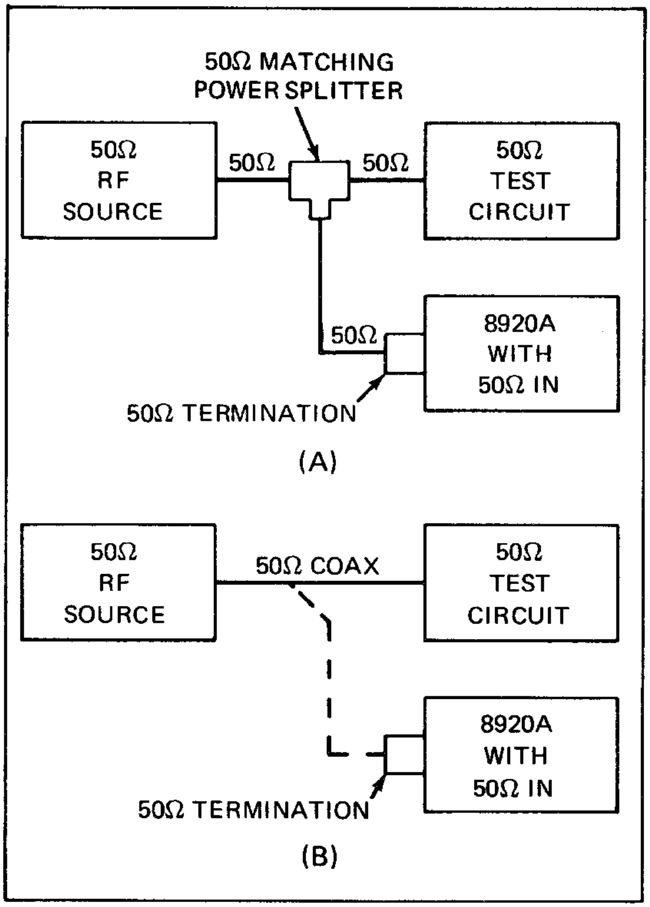


Figure 2-3. Matched Impedance Measurement Techniques

2-36. Input Signal Considerations

2-37. The 8922A is a true rms voltmeter, and as such, is subject to input conditions not encountered with the ordinary average-reading ac voltmeter. Of these, the two most important are crest factor and input coupling.

2-38. CREST FACTOR

2-39. Crest factor is the ratio of the peak voltage to the rms voltage with the dc component removed. Above 10 Hz, the crest factor is limited by the dynamic range of the amplifiers. Crest factor capability in this frequency range will be at least 7 for full-scale inputs and will increase proportionally as the input goes down-scale. Use the following formula to calculate the crest factor of signals less than full-scale:

$$\text{Crest Factor} = \frac{7\ (\text{Range})}{\text{Input Level}}$$

For example, given the DMM is at the 20V range with a 10V input:

$$\text{Crest Factor} = \frac{\geq (20V)}{10V} = \frac{140V}{10V} = 14$$

2-40 Below 10 Hz, crest factor is limited by the time required for the internal rms sensor protection circuit to energize and limit the sensor temperture. Typical low frequency crest factor limitation is shown in Figure 2-4. When the protection circuit does not energize, the UNCAL annunciator will light indicating that the protection circuit is introducing measurement errors. When this occurs, manually selecting a higher range may produce a better measurement.

2-41. INPUT COUPLING, AC/DC

2-42. The 8922A is equipped with a FUNCTION switch which allows you to select either AC or AC + DC coupling. When the switch is out, AC coupling is selected. In this function the dc component is removed from the input signal and is not measured or displayed. Depressing the FUNCTION switch selects AC + DC coupling. This function allows the 8922A to measure and display the true rms value for the total input signal; ac components and dc components. You should always consider the dc component when power dissipation is being determined. This function also increases the damping which is required for good performance below 10 Hz. This additional damping may also aid in the measurement of higher frequency signals when the level of the signal fluctuates.

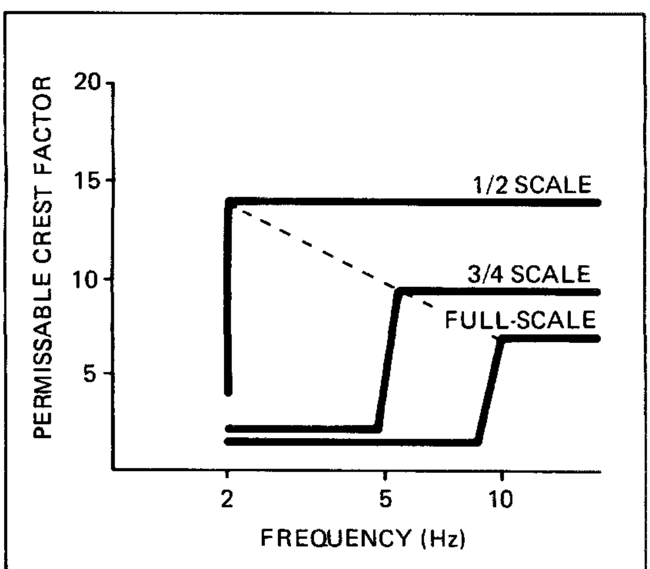


Figure 2-4. Typical 8922A Crest Factor Limitation

2-43. Range Selection

2-44. Seven voltage ranges, and what appears to be a single dB range spanning 132 dB are provided in the instrument. Range selection is normally accomplished automatically. Override switches, however, allow you to interrupt the autorange function and manually increment the range.

2-45. The autorange function optimizes the display reading for a given input. Each reading is displayed complete with decimal point and units' annunciator. The individual ranges are directly defined for the operator by labeled decimal points. Underrange (flashing decimal point) and overrange (flashing digits) indications are provided to indicate when a range change is necessary.

2-46. AUTORANGE

2-47. The proper measurement range is automatically selected when the HOLD/AUTO switch is in the AUTO (out) position. Both decimal point and units' annunciator change automatically with range.

2-48. MANUAL

2-49. Manual range determination is accomplished by selecting a range using the autorange mode and then depressing the HOLD/AUTO switch. The meter will stay in that range regardless of input level changes. If the range becomes invalid for a given input level, an overrange or underrange indication will flash. If an underrange is indicated, select autorange (AUTO). After the proper range is selected, press HOLD. For overrange conditions, momentarily press the STEP UP switch once for each desired range increment. Holding the switch in will increment the meter to the 700V range. Select autorange (AUTO) to downrange.

2-50. Voltage Display Mode

2-51. The 8922A will display a voltage input in one-of-two measurement units; volts or dB. To display the input voltage in units of volts, you must set the dB/VOLTS switch to VOLTS. The instrument will now display all input in units of volts or millivolts, as indicated by the front panel annunciators (V), (mV).

2-52. Two points of interest about the volts display mode are as follows: one, if the input is completely unknown, allow the autoranging circuit to select the appropriate range. Two, the selection of the volts display mode will not affect any previous reference established in the dB display mode (see following paragraphs for additional information about establishing a dB reference).

2-53. dB Display Mode

2-54. When the instrument is in its dB display mode, all voltage inputs are referenced to a selected level, and displayed as deviations (in dB) above or below that level. If you wish to display the input voltage in dB units, set the dB/VOLTS switch to dB. The instrument's front panel dB annunciator will now light, indicating to you that the display is presenting a measurement in dB units.

2-55. The instrument references all inputs to a selected level. Before a meaningful measurement in dB units can be made, the desired reference level (0 dB) must be established. See RELATIVE REFERENCE Selection and dBm REFERENCE.

2-56. dBm Measurements

2-57. Measurements made to a fixed 1 milliwatt reference are defined as dBm. The 1 milliwatt reference is generally assumed, as indicated by m. However, the system impedance must be specified for a particular measurement. Once the impedance is selected, the instrument will display its measurements in dBm.

2-58. The 8922A is equipped with a rotary switch called dBm REFERENCE (Ω). By setting the switch to 1-of-12 possible standard reference impedances (50Ω, 75Ω, 93Ω, 110Ω, 124Ω, 135Ω, 150Ω, 300Ω, 600Ω, 900Ω, 1000Ω, and 1200Ω) you establish that impedance as a reference. When the system impedance and the reference are the same, the display is in terms of dBm.

NOTE

If the 1000 ohm reference impedance is selected ("dBV" on the rotary switch), the 0 dB point will correspond to 1V.

2-59. dBm REFERENCE SELECTION

2-60. Use the following procedure to select a reference impedance and enable the dBm display mode:

1. Depress the dB/VOLTS switch (in).

2. Release the REL/dBm switch (out).

3. Set the dBm REFERENCE (Ω) switch to correspond with the system impedance.

NOTE

The dBm REFERENCE switch does not affect the fixed 10 MΩ input impedance of the 8922A. All impedance matching terminations must be added externally by the operator.

2-61. Relative Measurements (REL)

2-62. This feature allows you to make any voltage input a "0 dB point" to which all other voltage inputs may be referenced. For measurements at a single test point, press the dB switch, then the REL switch and watch the dB change as you make adjustments or circuit changes.

2-63. A typical application for the dB measurement mode is shown in Figure 2-5. The relative reference (0 dB) has been established at TP2. Subsequent dB measurements at TP1, TP3, TP4, and TP5 are displayed (in dB) as shown.

2-64. RELATIVE REFERENCE SELECTION

2-65. Use the following procedure to enable the relative (REL) display mode and select a relative (0 dB) reference.

1. Connect the reference source to the 8922A input terminals. If desired, measure and adjust the reference supply voltage level.

2. Select the autorange mode (AUTO).

3. Release the REL/dBm switch (out).

4. Depress the dB/VOLTS switch (in).

5. With the reference level still connected to the input terminals, depress the REL switch. The display should now read 0 dB and the RELATIVE REFERENCE annunciator should be lit.

2-66. OTHER dBm REFERENCES

2-67. When a dBm reference, other than those given on the dBm REFERENCE switch is required, use the following procedure to establish the reference:

1. Define the reference impedance (R) and calculate V using the following formula:

$$V = 0.001 \times R$$

2. Apply an adjustable voltage source to the 8922A input and set the dB/VOLTS switch to the VOLTS position. Adjust the voltage source for a display reading equal to the calculated value of V.

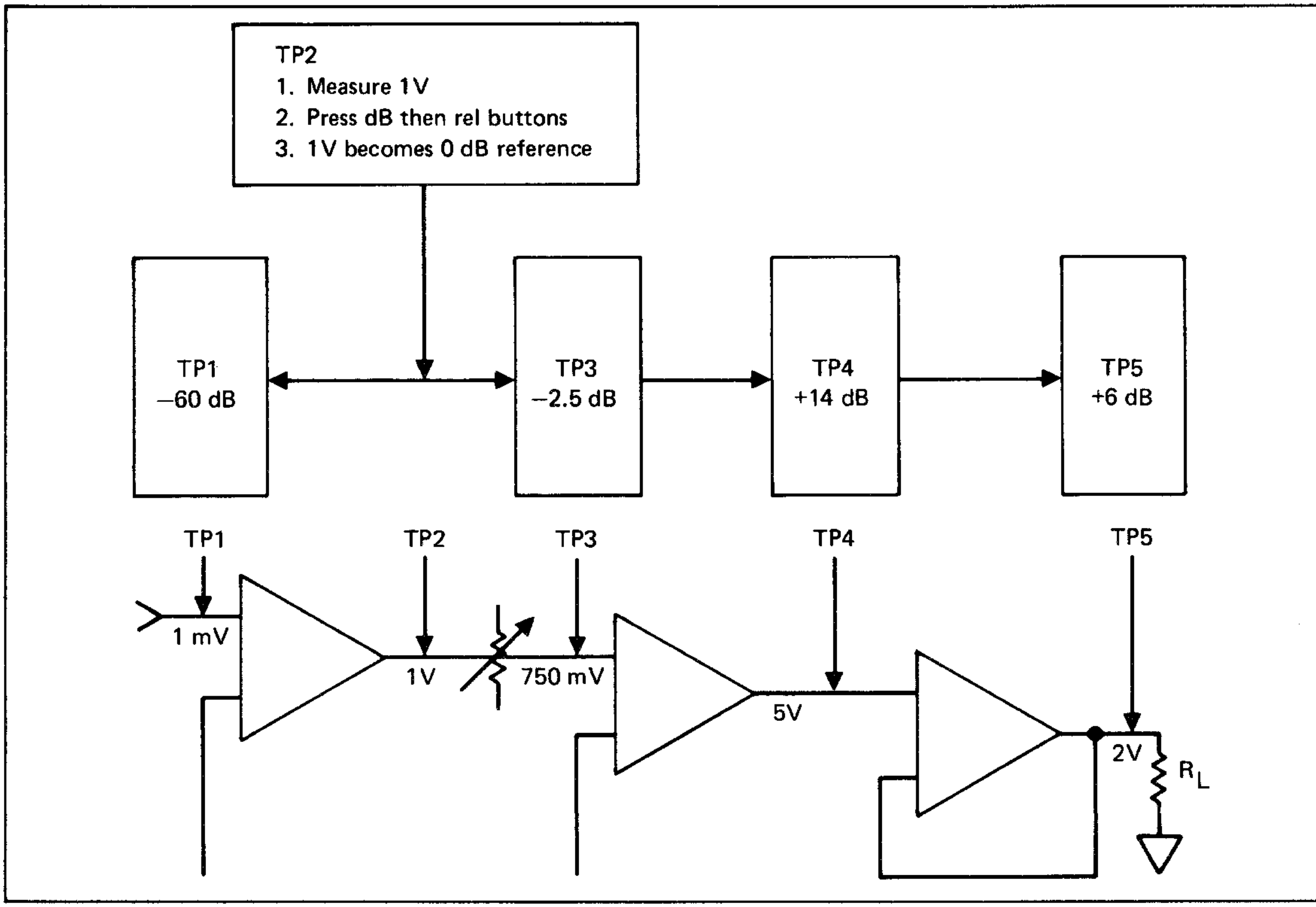


Figure 2-5. Typical Relative dB Measurements

3. Depress the dB/VOLTS switch (in).

4. Depress the REL/dBm switch (in). This establishes the voltage (V) as the 0 dB reference level. Therefore, subsequent dB measurements will be equivalent to dBm measurements as long as the system impedance R is maintained.

NOTE

This reference will hold as long as the REL/dBm switch is at the in position and the instrument is energized.

2-68. Linear Analog Output

2-69. A pair of banana jacks on the rear panel of the 8922A provides access to a linear dc analog output signal. This signal is proportional to the applied input signal and is linearly scaled; a 2V dc output is equal to 2000 counts on the display. Output accuracy is ±1% relative to the front panel reading. The output signal is buffered, and is suitable for driving an external analog meter, recorder, plotter, scope, etc.

2-70. OPERATION

2-71. With reference to the preceding paragraphs, use the following procedure to turn-on and operate the Model 8922A (refer to Section 6 for option and accessory information):

1. Connect the 8922A to line power.

2. Set the front panel POWER switch to ON (in). The front panel display should light.

3. Select the appropriate input leads and connect them to the meter's input terminals. Add terminations as close as possible to the input connector, if impedance matching is required.

4. Select input coupling by setting the FUNCTION switch to AC (out) or AC + DC (in), as desired.

5. Select the desired range. Use automatic or manual method, as desired.

6. Set the DISPLAY switches to select the desired measurement mode: volts, dB, or dBm. If dB is selected, establish a 0 dB reference.

7. Observing safety considerations, connect the test leads to the measurement points. The results are displayed on the 8922A readout.

Theory of Operation

3-1. INTRODUCTION

3-2. The information in this section describes the theory of operation for the 8922A True RMS Voltmeter. The theory has been divided into two major headings; overall functional description and detailed block diagram description. To gain maximum benefit from this section, we recommend that you read each paragraph in the order presented while referring to the associated figure or the appropriate schematic in Section 8.

3-3. OVERALL FUNCTIONAL DESCRIPTION

3-4. As you can see in Figure 3-1, the circuitry of the 8922A can be divided into two sections; analog and digital. An overall functional description of these two sections is presented in the following paragraphs.

3-5. Analog Circuitry

3-6. The analog section comprises the largest portion of the 8922A circuitry. As shown in Figure 3-1, this section is broken down into the following areas: the signal conditioner, the rms converter and the power supply.

3-7. Referring to Figure 3-2, you can see that the signal being measured by the 8922A can be coupled to the signal conditioner in one of two ways (AC or AC + DC). When you place the FUNCTION switch on the front panel to the AC position all input signals are capacitively coupled; when the AC + DC position is selected the input signal is dc, or directly coupled. This feature contributes to the measurement accuracy when dc components are present in the input signal.

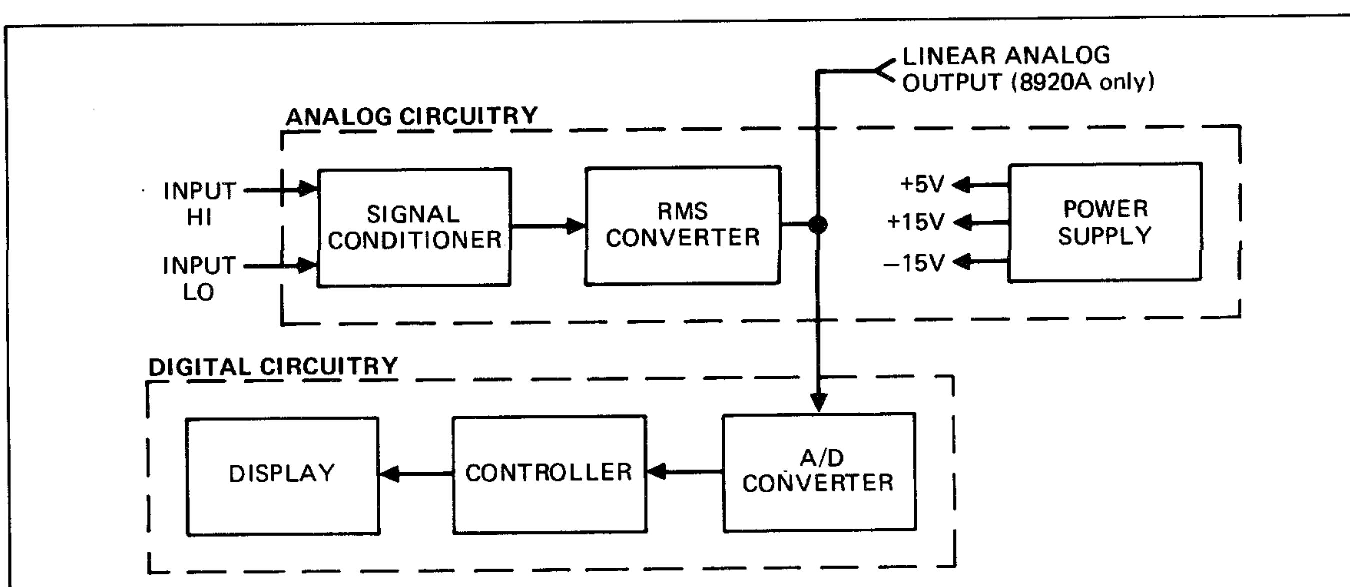


Figure 3-1. Overall Block Diagram

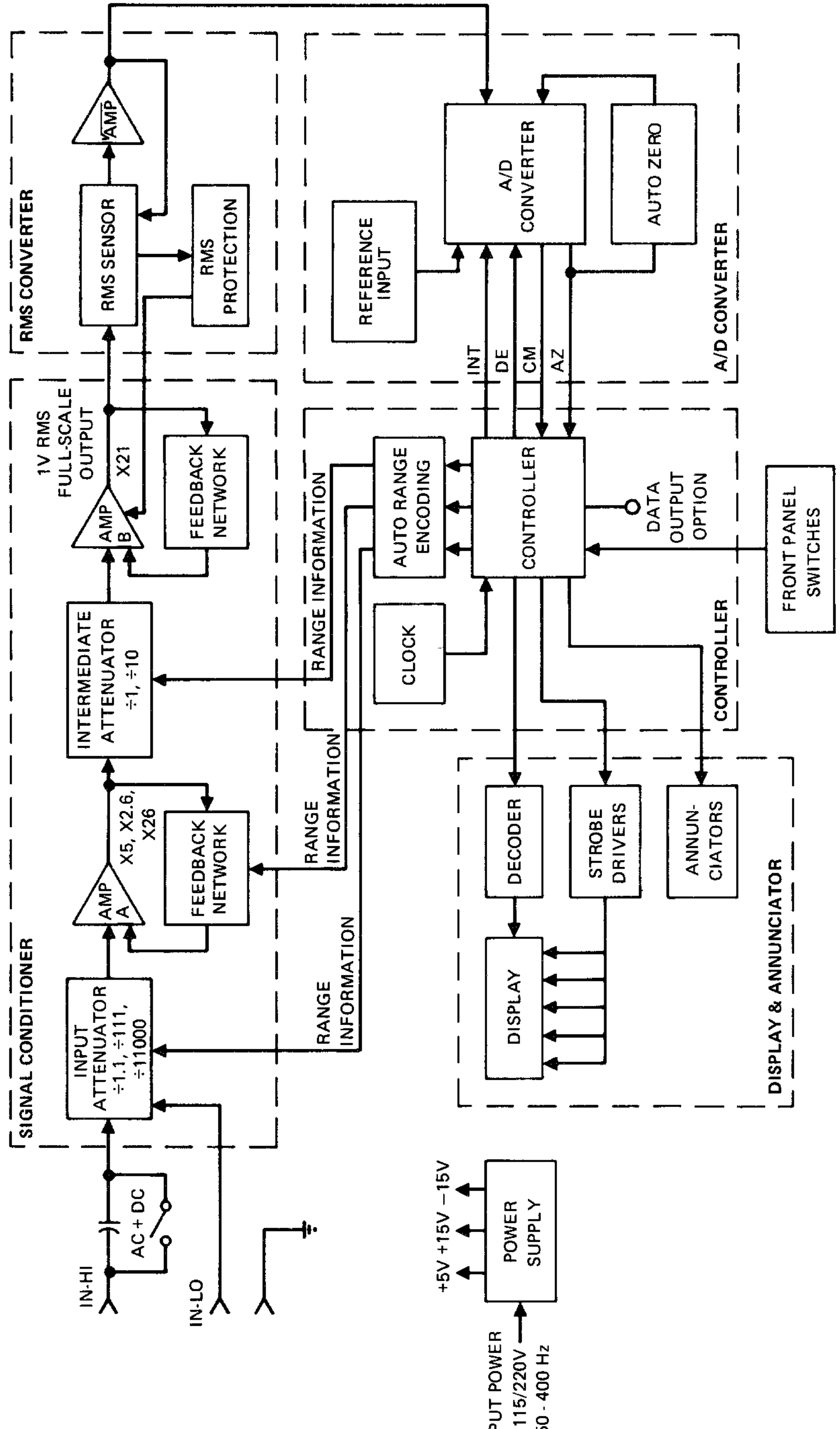


Figure 3-2. Detailed Block Diagram

3-8. The signal conditioner insures that the varying levels of instrument input voltages are properly scaled before being applied to the rms converter. The rms converter works on a thermal sensing principle. Basically, it operates by balancing the heating power of a dc feedback signal to the heating power of the ac input signal. When the two are equal, the circuit is in equilibrium and the dc output voltage applied to the A/D converter is directly representative of the true rms value of the ac input signal. The dc output of the rms converter is also applied to the LINEAR ANALOG OUTPUT terminals on the rear panel of the 8922A, as well as the analog meter on the front panel of the 8922A.

3-9. The last analog circuit we discuss in this section is the power supply. This circuit provides three regulated power supplies (+5V, +15V and -15V) to operate the instrument.

3-10. Digital Circuitry

3-11. The digital circuitry comprises the A/D converter, the controller, and the display. Together these circuits develop a digital representation of the rms value of the input signal, produce the commands that set the range and function of the instrument, and finally display the input value.

3-12. The dc output of the rms converter is translated to a digital representation by the A/D converter. The digital representation is processed by the controller to obtain a bcd output which is proportional to the selected display mode (VOLTS, dB, dBm, REL). The BCD output is decoded and applied to the display.

3-13. DETAILED BLOCK DIAGRAM DESCRIPTION

3-14. In the following paragraphs we discuss, in detail, the individual functions within the major areas of circuitry in the 8922A. Each major circuit area is detailed in Figure 3-2. The description for each circuit is keyed to a separate block diagram, or to the schematics in Section 8.

3-15. Signal Conditioner

3-16. The signal conditioner utilizes an input attenuator, two amplifiers (Amp A and B) and the intermediate attenuator. As shown in Figure 3-3, these circuits are used to scale the varying voltage levels applied to the instrument so that the input to the rms converter is always between 0.09V rms and 1V rms. The diagram in Figure 3-3, illustrates the configuration of the circuitry within the signal conditioner. The controller, through a range decoder network, issues commands which select the appropriate division factor in the attenuators and the correct multiplication factor for amplifier A. Table 3-1, lists each operating range and the corresponding division and multiplication factors for the attenuators and amplifier (note that amplifier B has a fixed gain of X21).

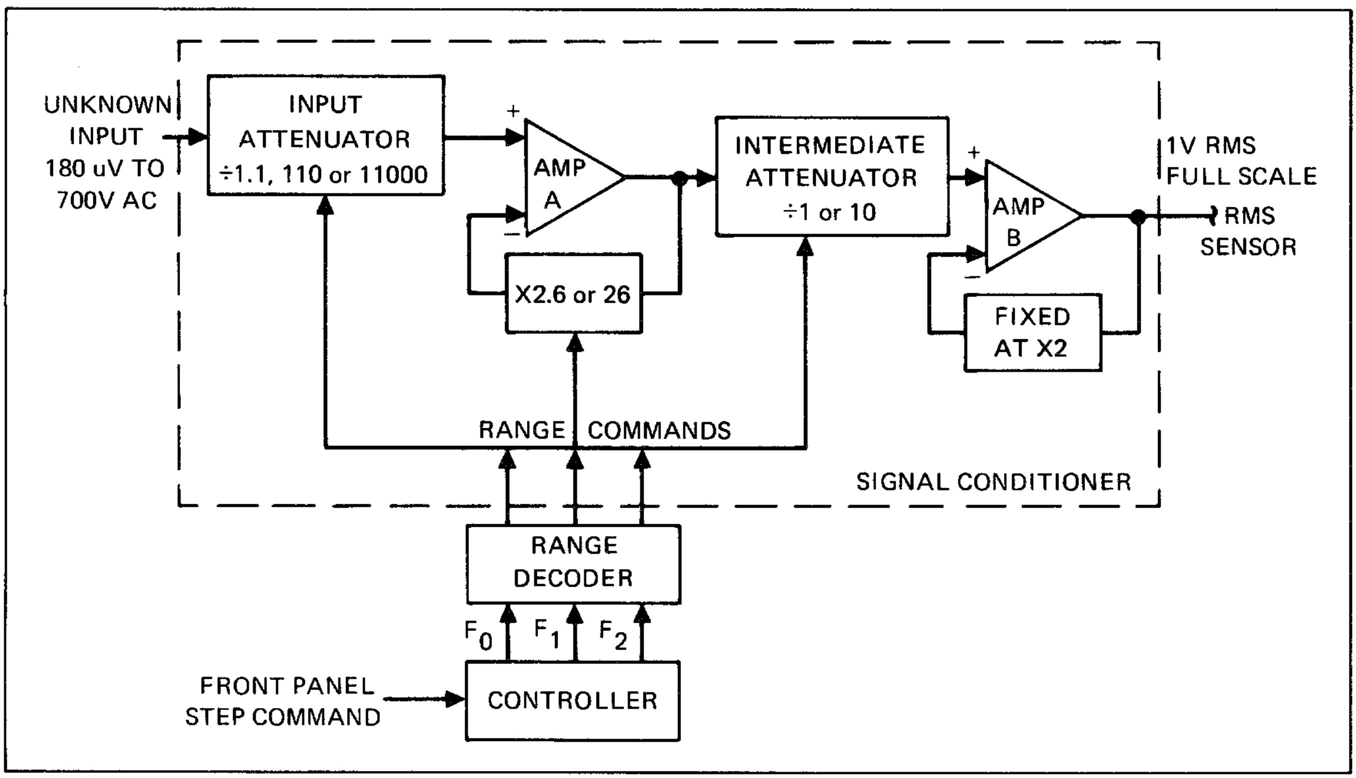


Figure 3-3. Signal Conditioner

Table 3-1. Signal Conditioner Gain Configuration

RANGE	INPUT ATTENUATOR	AMP A	INTERMEDIATE ATTENUATOR	*CONDUCTING COMPONENTS
2 mV	÷1.1	X26	÷1	K1, Q6, Q28, Q32
20 mV	÷1.1	X2.6	÷1	K1, Q6, Q29, Q32, Q57
200 mV	÷1.1	X2.6	÷10	K1, Q6, Q29, Q31, Q57
2V	÷110	X2.6	÷1	K2, Q3, Q5, Q29, Q32, Q57
20V	÷110	X2.6	÷10	K2, Q3, Q5, Q29, Q31, Q57
200V	÷11,000	X2.6	÷1	K2, Q4, Q5, Q29, Q32, Q57
700V	÷11,000	X2.6	÷10	K2, Q4, Q5, Q29, Q31, Q57

*Refer to the schematics in Section 8.

The last column lists the component's FETs and relays, that conduct to establish gain configuration of the circuits (see the schematics for details on components).

3-17. RMS Converter

3-18. The 8922A uses a thermal rms converter circuit which supplies a dc output voltage proportional to the rms value of the ac input. The thermal sensor is a pair of resistor-transistor elements thermally isolated from each other and the case (see Figure 3-4). The ac input signal (Vac from amp B) produces a temperature change in the rms sensor's input resistor which is sensed by the associated transistor and causes a voltage change at the negative input of the integrator. Feedback, through the square root amplifier, provides a dc voltage to the rms sensor's output resistor so that a similar temperature rise occurs in the output resistor. The sensor gain is not constant with changes in input amplitude. These changes in gain are compensated for by the square root amplifier to maintain a constant response time for level changes.

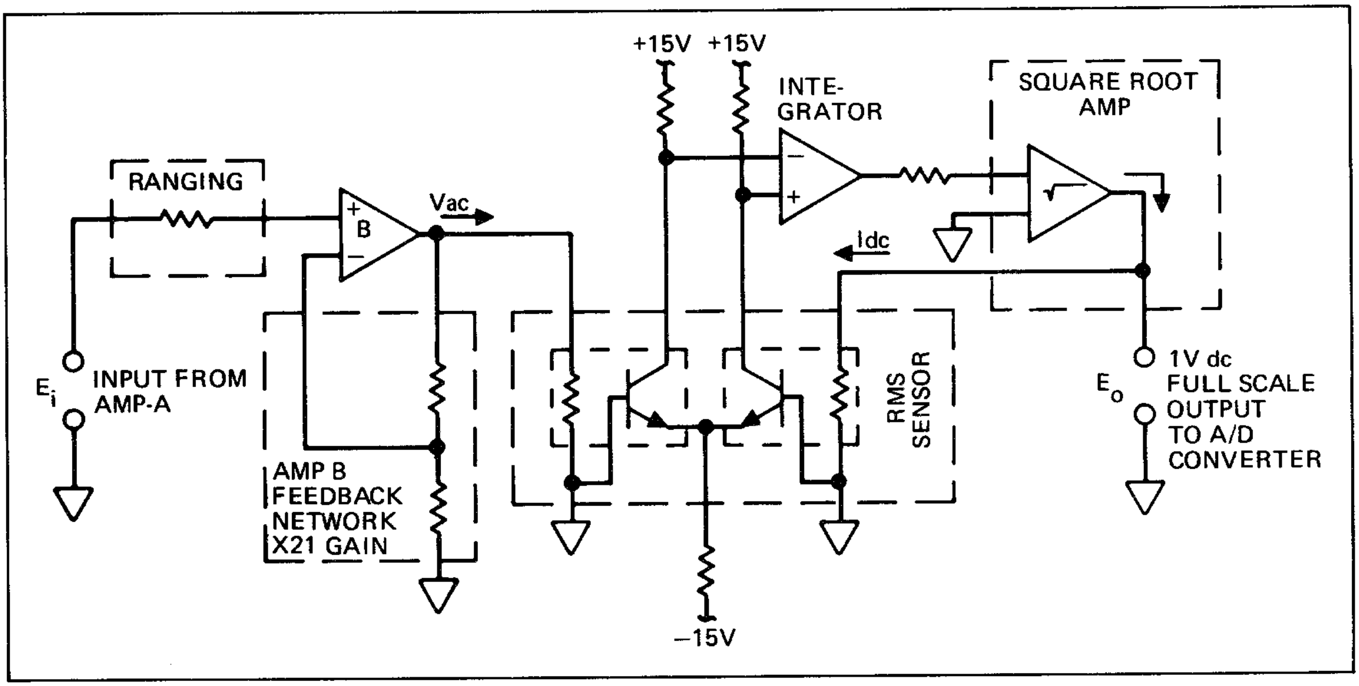


Figure 3-4. RMS Converter

3-19. The rms sensor is susceptible to damage from overvoltage inputs. During an overload condition, the protection circuit will clamp the output of Amplifier B to prevent damage to the sensor. Overload conditions would result during turn on, turn off, or any time the rms value of the applied input exceeds the operating range of the sensor.

3-20. A/D Converter

3-21. A dual-slope integration A/D conversion technique is used in the Model 8922A. This method applies the unknown voltage to a capacitor and allows the capacitor to charge for a specific time interval. At the end of this interval, the unknown voltage is removed (the charge on the capacitor at this time will be proportional to the level of the unknown voltage). Then a known voltage of opposite polarity is applied to the capacitor, and clock pulses are counted while the capacitor discharges. When the capacitor has reached its original charge point, the number of clock pulses counted is a digital construct of the analog voltage input to the A/D converter.

3-22. For the following discussion refer to Figure 3-5, the A/D Converter Simplified Schematic and Timing Diagram, and Figure 3-6, Controller Timing (A/D Converter).

3-23. At the beginning of the measurement cycle, INT goes high and the dc output of the rms sensor is applied to the A/D integrator for 100 msec. Capacitor, C203, charges up from the auto zero level at a rate proportional to the applied input voltage and the comparator's output, CM, is driven low. At the end of the 100 msec integrate period, DE (–) goes high, applying the reference voltage to the integrator. The integrator then discharges at a rate which is constant for all on scale inputs and the controller begins counting clock pulses. When C203 has discharged to the auto zero level, CM will go high, the controller will stop counting and the reading is displayed. This starts the auto zero period which allows the A/D converter circuitry to settle before the next cycle begins. If CM has not occurred before the end of the 200 msec maximum DE (–) period, the input will have exceeded the present range. In this case, the DE period will continue until either CM or the end of the 100 msec AZ1 occurs. When the AC + DC function is selected, all timing increase approximately 2.5 times.

3-24. Controller

3-25. The controller is a custom LSI that controls autoranging, the A/D converter, the display, and annunciators. In addition, the Controller can count in a non-linear (dB) scale and display its count in dB units. A summarized description of each input and output pin used on the controller is give in Table 3-2 and shown in Figure 3-7.

3-26. AUTORANGING

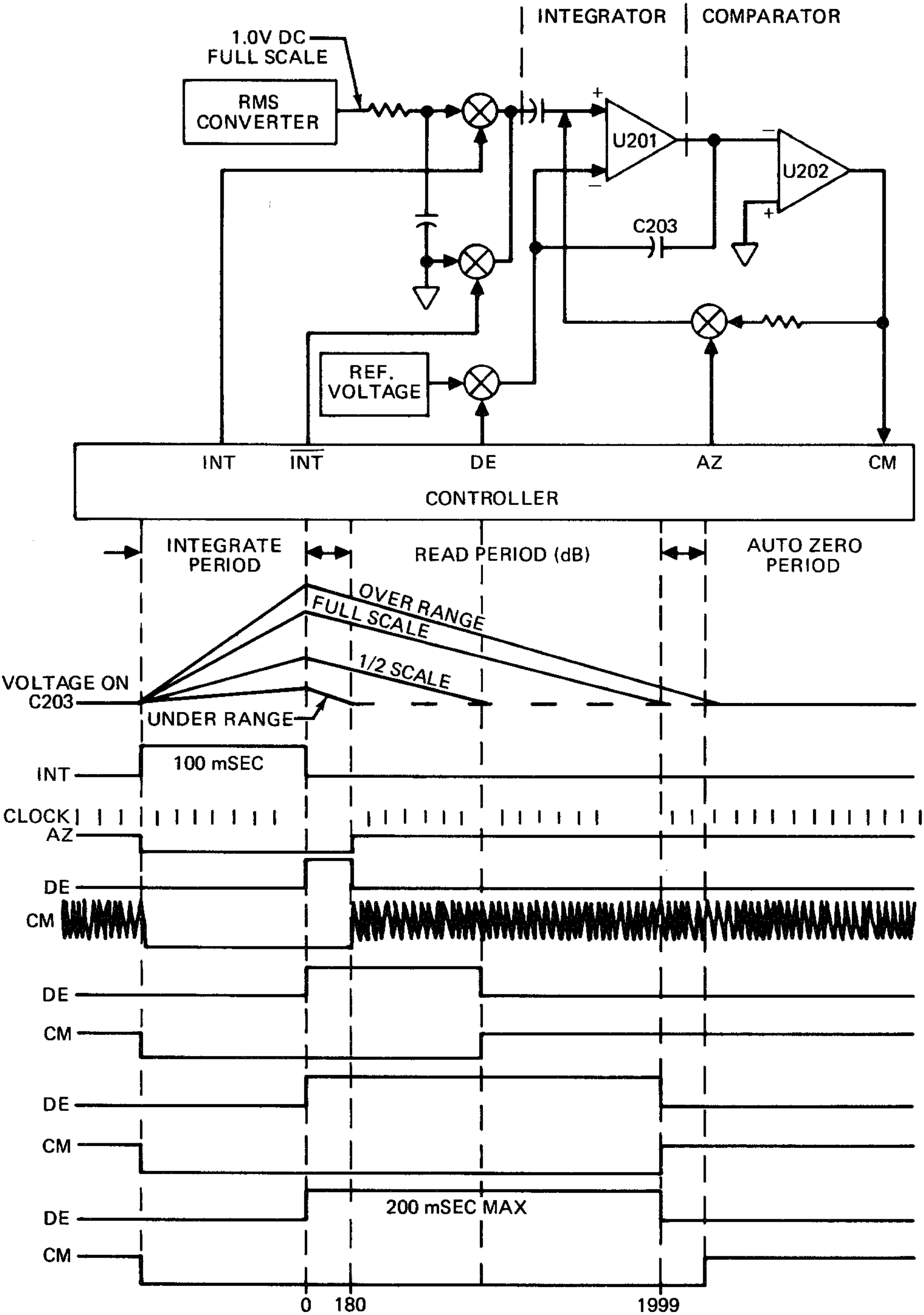
3-27. Autoranging is the automatic selection of the instrument's range by the controller. With the low range enabled, the instrument may range through seven voltage ranges from 2 mV to 700V rms. Autoranging also applies in the dB modes but gives the effect of a single range spanning 132 dB. By coding the logic levels on the three lines, F0, F1, and F2, the controller selects a range (see Table 3-3, Output Range Codes) by setting up the circuit conditions of the input and intermediate attenuators and amplifier A that are necessary for signal conditioning in that range. (See Table 3-1, Signal Conditioner Gain Configuration.) If the controller senses that the input is above or below the selected range (see Table 3-4, Over/Underload Conditions), it shifts up or down one range (depending upon the direction sensed) and halves its cycle time. The controller blanks the display and determines whether the input to the instrument is now in range or if a further change in range is necessary. When the proper range is found, display blanking is removed and the cycle time returns to normal. Use of the HOLD RANGE control will command the Controller to remain at the present range (see Table 3-5, Input Range Codes) via command input line D, E, and F. A signal from the STEP UP RANGE control will increment the instrument one range.

3-28. COMPUTATIONS

3-29. The controller is able to count (compute) in two modes, linear or non-linear. The following paragraphs will explain how the controller obtains its linear (volts) or non-linear (dB) readings.

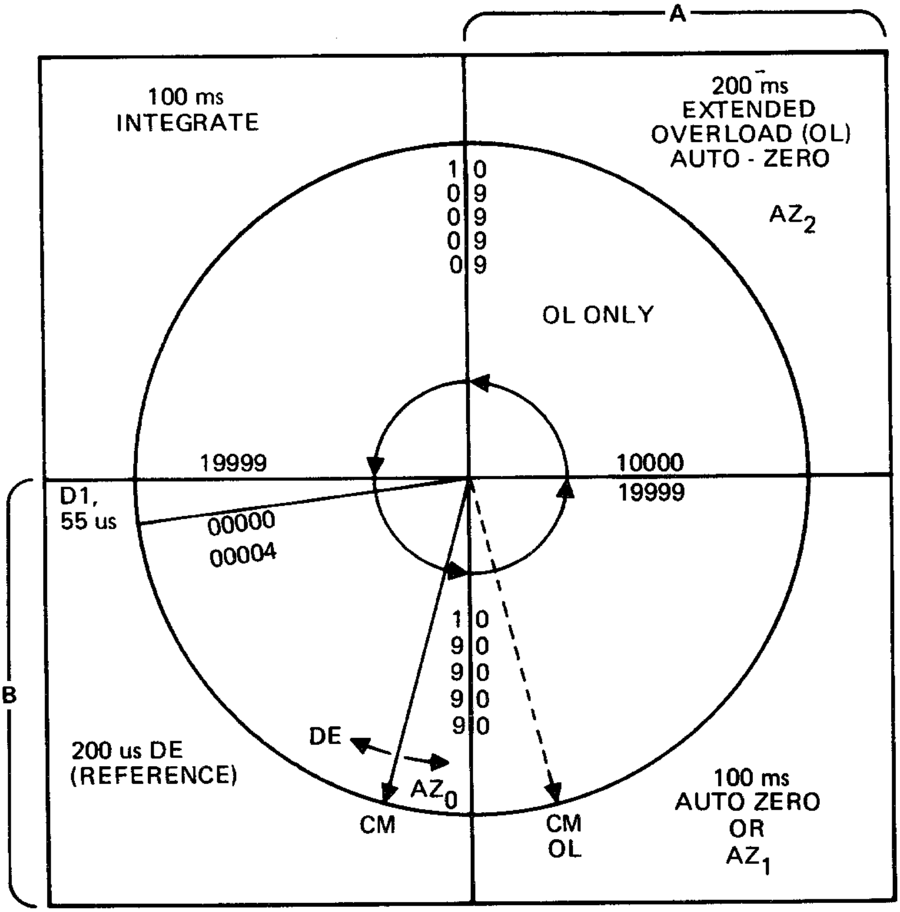
3-30. Voltage Computations

3-31. To make a voltage measurement the controller must linearly count clock pulses for a time determined by the A/D converter. Referring to Figure 3-7, you can see that when the dB/VOLTS switch is placed in its up (out) position the rate multiplier (RM) will be shunted and the main counter will count the number of clock pulses exactly as they occur (linear). As soon as the integrator in the A/D converter reaches the auto-zero point, CM will go high, commanding the main counter to stop counting and start shifting its count to the data latches. A count of clock pulses, in BCD format, that is proportional to the true rms value of the signal being measured. The BCD data is then shifted out of the controller, to a seven-segment decoder on four lines: W, X, Y and Z.



For AC + DC (damping) Function, times increase by 2.5.

Figure 3-5. A/D Converter Simplified Schematic and Timing



NOTE:
If AC + DC (damping) is selected, all times increase by 2.5.

Figure 3-6. Controller Timing (A/D Converter)

Table 3-2. Controller Summary

INPUT/ OUTPUT	PIN #	PIN NAME	PIN DESCRIPTION
Input	1	V_{SS}	+5V supply
Input	2	CM	Compare signal from A/D Converter.
Input	3	CL_1	External Oscillator input.
Input	4	CL_2	400 kHz crystal input for internal oscillator.
Output	5	$\overline{RG}$	Negative going pulse in the middle of each strobe. Insures strobed data for DOU is valid.
Output	6-10, 12-14	ST_0-ST_7	Eight strobes that indicate which LED is to be enabled and accept the data on lines W, X, Y and Z.
Input	11	RD	Impedance reference selection line, in dB.
Output	15-17	F_0-F_2	Encoded range lines, F_0 = MSB, F_2 = LSB, code equals range # + 1, voltage swings from; −15 to 0V.
Input	18	β	Strobe input on this pin determines the lower range limit.
Input	19	α	Strobe input on this pin determines the upper range limit.
Output	20	DP	Enables display decimal point.
Input	21	V_{DD}	Ground, 0V supply.

Table 3-2. Controller Summary (cont)

INPUT/ OUTPUT	PIN #	PIN NAME	PIN DESCRIPTION
Output	22	BZ	Indicates new data is ready for DOU, occurs after CM, one strobe raster long.
Input	23-25	F, E & D	Enables controller ranging, see Table 3-5.
Output	26-29	W, X, Y & Z	BCD data, W = MSB, Z = LSB, TTL compatible.
Output	30	$\overline{BLK}$	Drives blanking input on display decoder driver, TTL compatible.
Input	31	$\overline{K}$	700V range overload enable.
Input	32	V_{GG}	−15V supply.
Input	33	$\overline{J}$	Enables 3½ or 4½ digit display in linear mode and determines (in combination with RD) the fixed reference in dB mode.
Input	34	T_1	Test (not used).
Input	35	dB	Enables dB display mode.
Output	36	$\overline{INT}$	Enables not integrate period of A/D Converter.
Output	37	INT	Enables integrate period of A/D Converter.
Output	38	AZ	Enables auto zero period of A/D Converter.
Output	39	DE (−R)	Enables integrate reference period for positive input of A/D Converter.
Output	40	DE (+R)	Enables integrate reference period for negative input of A/D Converter (not used).

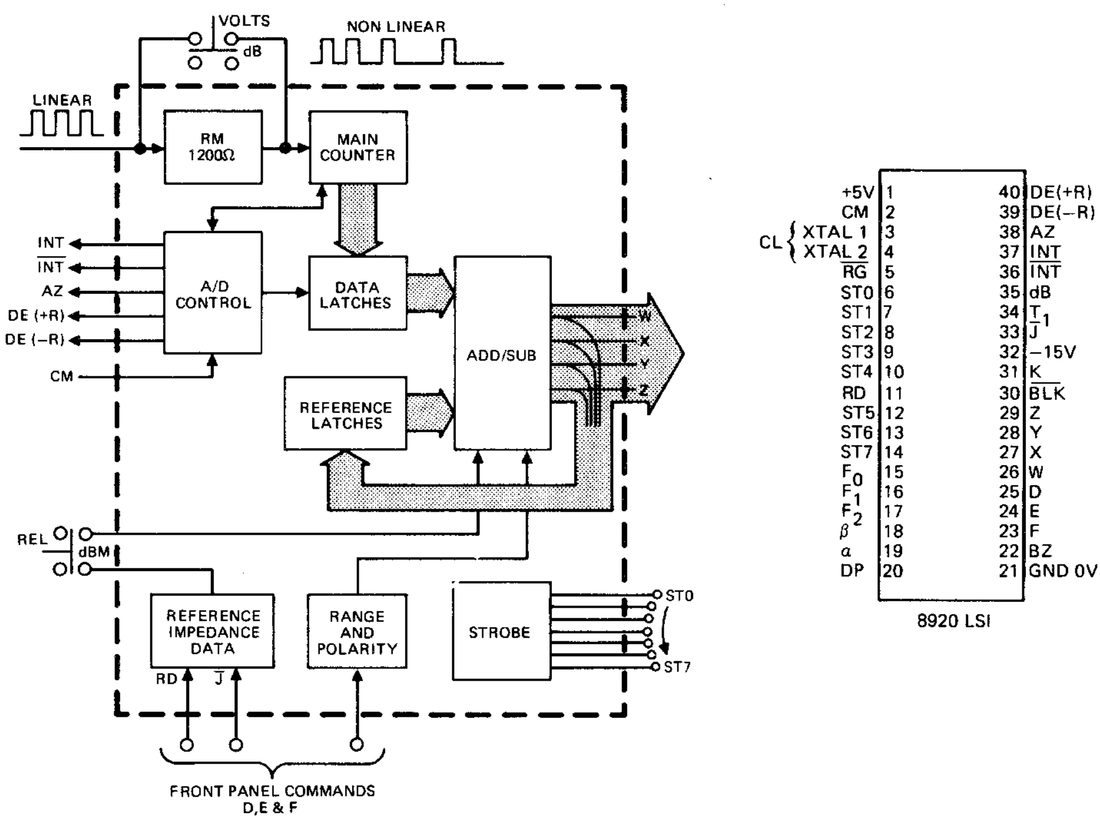


Figure 3-7. Controller Functions

Table 3-3. Output Range Codes

RANGE	DATA LINES		
	F_0	F_1	F_2
2 mV	0	0	1
20 mV	0	1	0
200 mV	0	1	1
2V	1	0	0
20V	1	0	1
200V	1	1	0
700V	1	1	1

Table 3-4. Over/Underload Conditions

	LINEAR	dB*
Overload:	>1999 β	25.30 (20V range)
except for 700 700V range:	>700 α	56.10
Underload:	<180	4.30 (20V range)
minimum input for accurate dB conversion	132	1.60 (20V range)

*dB calculations are based on a 1200 ohm reference impedance and 20V range. The calculation is then corrected for the proper range and the selected impedance by the addition of the appropriate constant, which may be calculated from the following equation:

$20 \log \sqrt{1.2} - 20 \log \sqrt{0.001R} + N\ (20).$

Where N = number of ranges above or below the 20V range, i.e., 2 mV range N = X4

Table 3-5. Input Range Codes

COMMAND LINES			8922A CONTROLLER FUNCTION
D	E	F	
0	0	1	Auto range fast range cycle
1	0	0	Hold present range (overridden by α & β)
1	1	0	Range up at CM time (overridden α & β)

3-32. dB Computations

3-33. If the dB/VOLTS switch is in the dB position, a non-linear count of the clock pulses is enabled. The binary rate multiplier (RM) passes only a fraction of the clock pulses on to the controller's main counter (see the illustrated input to the main counter on Figure 3-7). This count approximates the logarithmic curve of the dB scale and, like the VOLTS mode, is stored in the data latches.

3-34. dBm Reference

3-35. Don't let the m confuse you, it simply means that the power level, as measured in "dB Computations", is referenced to 1 mW. In other words, when the instrument reads 0 dB the system being measured will be dissipating 1 mW of power. The following will explain how the controller obtains a measurement of power referenced to 1 mW (dBm).

3-36. In order for the controller to obtain a measurement in dBm, the appropriate reference impedance must be used. A 1200 ohm reference impedance is assumed by the RM. Therefore, if any other reference is desired an appropriate constant must be added or subtracted from the count. The dBm REFERENCE rotary switch connects one of the eight strobes to RD and J. The controller responds by sending the appropriate constant to its ADD/SUB.

3-37. Referring to Figure 3-7, let's assume that a 600 ohm reference impedance is selected and the instrument has previously made a relative measurement. Strobe zero will be applied to RD until the REL/dBm switch is placed in its dBm position. At this time strobe 4 (corresponding to 600 ohms) is applied to RD and causes the controller to select the 600 ohm reference impedance data. This data along with the range and polarity data is then shifted to the ADD/SUB where it is combined with the count referenced to 1200 ohms. The resultant value is now equivalent to a dBm reading referenced to 600 ohms. The range and polarity data is held in the reference latches until RD or J detect a strobe change or unless the instrument is turned off. (Switching to the VOLTS mode will not cause the data in the reference latches to be lost.)

3-38. Relative (REL) Reference

3-39. Relative reference measurements allow any voltage input to become the 0 dB point to which all subsequent voltage inputs are referenced. The controller makes a relative reference computation much the same way it made a dBm computation. However, in the REL mode, 0 dB no longer refers exclusively to 1 mW. The following explains how the controller makes a relative reference measurement.

3-40. Referring the Figure 3-7, you can see that upon selection of the REL mode, the reference impedance data line will be disabled. However, to make a relative reference measurement the controller must use an initial reading, and to obtain an initial reading it must use a reference impedance. Therefore, before the REL mode can be selected the controller must be allowed to make at least one complete measurement while in the dBm mode. Once the measurement has been completed the REL mode may be selected. The reading will now be fed back to the reference latches and held. The controller will subtract the reading in the reference latches from all subsequent readings. Note that if the instrument is ranged up/down, 20 dB will be added to or subtracted from the reading held in the reference latches. The reading held in the reference latches, however, will be lost any time the instrument is turned off or if the REL switch is released.

3-41. Display and Annunciators

3-42. The computed value of the input to the instrument is transmitted serially as four-bit BCD characters on the W, X, Y, and Z data lines from the controller to the seven-segment-decoder, see Figure 3-8, Display and Annunciators. The output of the seven-segment-decoder drives the Display Data Bus, which is common to the inputs of all five of the display LEDs. Strobe pulses from the controller determine which display LED is enabled to accept the data on the Display Data Bus. ST4 through ST7 strobes the seven-segment LEDs from LSD to MSD, respectively. ST0 gates the ±1 digit. If the volts display mode is selected, 3½ digits will be enabled resulting in a resolution of 0.05%. If the dB display mode is selected, 4½ digits will be enabled and the resolution will be 0.01 dB. The decimal point is enabled separately by the DP line from the controller.

3-43. the annunciators, excepting the UNCAL, are strobed on by ST0 which is routed through two circuits. One path is completed when the dB/VOLTS switch is in the dB position. The dB annunciator DS309 is enabled. If the REL/dBm control is in the REL position, RELATIVE REFERENCE annunciator, DS308, will also be enabled. If the dB/VOLTS switch is in the VOLTS position, ST0 is routed through another path and either the V annunciator, DS307, or the mV annunciator, DS306, is enabled depending upon the current range of the instrument.

3-44. Power Supply

3-45. The power supply section on the Main PCB provides the instrument with operating voltages of +15V, -15V, and +5V.

3-46. Line voltage (100V, 120V, 220V or 240V, as selected by switches S209 and S210) is connected to the primary of the main power transformer, T200 via POWER switch, S208, and fuse, F1. the secondary of T200 contains two windings. One winding drives the +5V power supply, the other drives the ±15V power supply.

3-47 In the +5V power supply, power from the secondary winding is full-wave rectified by CR205, filtered by C211, and regulated by VR203.

3-48. In the ±15V power supply, power from the secondary winding is full-wave rectified by CR204, filtered by C209 and C210, and regulated to +15V by VR202. The -15V is regulated by U211 and Q207.

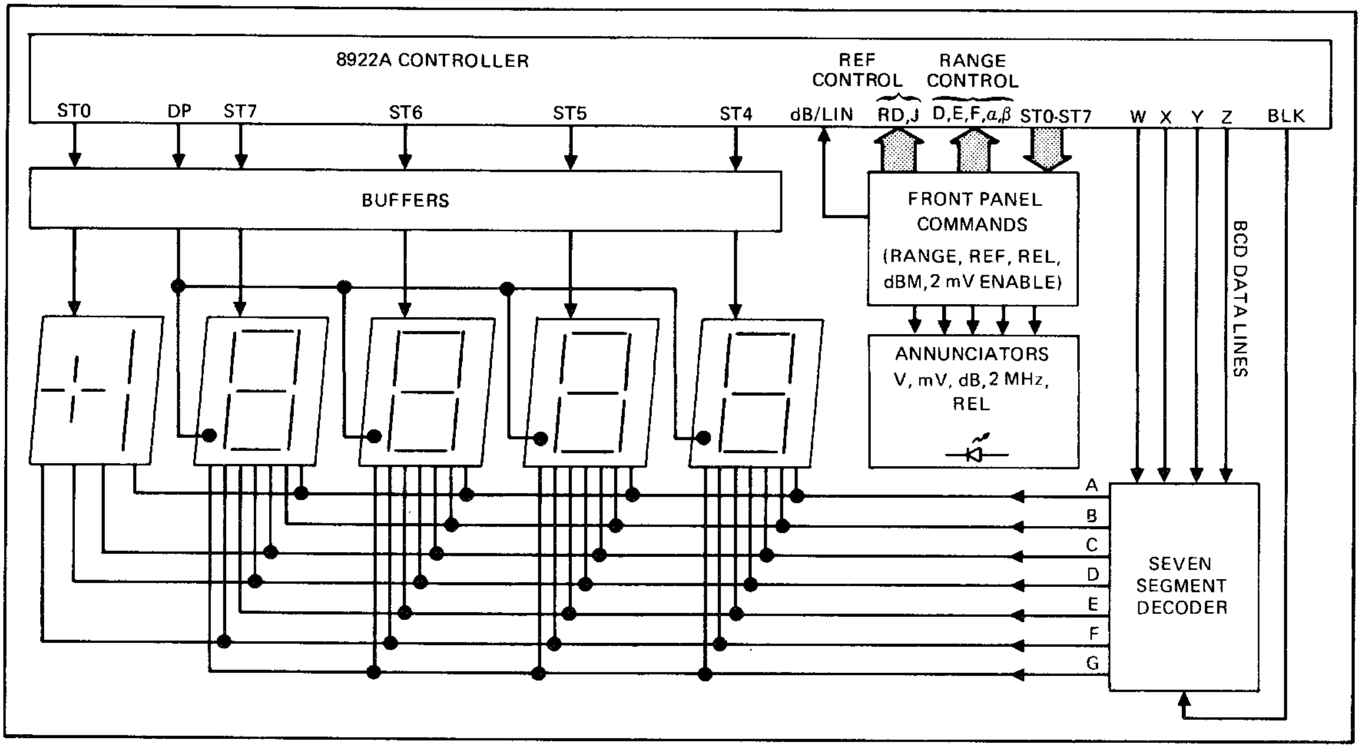


Figure 3-8. Display and Annunciators