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MANUAL of Operating & Maintenance Procedures for

Digital Multimeter

Model 3500

DATA PRECISION

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MANUAL
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Digital Multimeter

Model 3500

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Model 3500 Digital Multimeter

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Chapter 1

INTRODUCTION

The Model 3500 is a 5-1/2 digit wide-range digital multimeter, using improved second-generation features of the innovative Tri-Phasic™ design first introduced by Data Precision in the Series 2500 Multimeters. The Model 3500 DMM provides a choice of either completely autoranging voltage measurements from 1 microvolt to 1 kilovolt and resistance down to a resolution of 1 milliohm, or direct manual range control.

The instrument features:

Tri-Phasic™ A/D Conversion,
Iso Polar™ Reference Generation, and
Ratiohmic™ Resistance Measurements

1.1 TRI-PHASIC A/D CONVERSION CYCLE

The Tri-Phasic technique dramatically reduces three of the four major sources of error in conventional DVM circuits; zero offset and offset drift; resistance tolerance and drift; and ramp-time-constant tolerance and drift. In the first phase of operation, automatic zero-setting occurs. . . automatically updating an error-integrator/memory circuit, every conversion cycle. In the second phase, the analog input is integrated in a differential integrator, one input of which is the stored error, eliminating the offset and drift components from the integrated output. The time constant of the integrator is not an accuracy-determining factor; indeed, NO COMPONENT OR PARAMETER IS ACCURACY-DETERMINING, EXCEPT THE REFERENCE VOLTAGE STANDARD (and the range-divider resistor ratios, used only on the higher ranges). Finally, in the third phase, the conversion to digital format occurs, returning the integrator to its original zero-state, through the original time constant.

1.2 ISOPOLAR REFERENCING

Isopolar® Referencing for ultimate standardization at low cost. The Isopolar® reference circuit (U.S. patent #3750146) achieves an order-of-magnitude improvement over the conventional zener-diode/inverting-amplifier reference schemes used in most high-performance DMM's. Only ONE zener element is used, regardless of the polarity of the measured voltage. . . a premium-grade, cycle-aged, ultra-stabilized component. It is driven from a highly regulated current source, and housed in a thermally regulated oven. The zener voltage is REACTIVELY coupled to the A/D converter, and isolated from the power-line and digital return grounds, thus preserving the guarded/isolated characteristics of the analog "front-end". Because there is no polarity-inverter error, tracking uncertainty is eliminated. The resultant temperature stability is better than 1PPM/°C, and the ultimate stability fully supports the 6-month rated calibration interval.

1.3 RATIOHMIC RESISTANCE MEASUREMENT

Data Precision pioneered the use of a new approach to resistance measurement (patent applied for), in which the unknown is made part of a RATIO SET, and the excitation of the unknown is a SELF-DETERMINED fraction of the reference standard, simply and passively derived. In this new Ratiohmic approach, reference drift does not affect accuracy, and the instrument combines the inherent accuracy of the ratio set with ultra-high sensitivity.

In addition, the Model 3500 DMM incorporates many high performance capabilities that enhance its usefulness in a wide range of measurement applications. These include:

1.4 INHERENT NOISE REJECTION

In addition to a broadband power-line filter, the Model 3500 design provides exceptionally effective normal-mode rejection inherent in the integrator design. All noise components at frequencies that are integral multiples of 10Hz (i.e., 10Hz, 20Hz, 30Hz, 40Hz. . .etc.) are averaged to zero in the signal integration phase of the tri-phasic conversion. The normal mode rejection is 80dB at 50Hz.

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1.5 ULTRAGUARDING

All of the front-end and analog circuits in a Model 3500 are grouped on a compact, electrostatically guarded sector of the main circuit card. This sector contains its own power-supply and regulator supply, which are powered by an isolated, electrostatically guarded winding on the main power transformer, which is TRIPLE-shielded. Input, logic, control, and output interfaces are all effectively isolated. . . .many by pulse-transformer coupling.

1.6 DIGITAL INTERFACES

Control and state signals in the Model 3500 are brought to rear-panel connectors, for use in automated control, test, and computing systems applications. Latched BCD data are brought out through standard DTL/TTL interface circuits, and are valid up to the next updating conversion. This permits asynchronous printing, recording, and/or display. These outputs are completely isolated from signal ground, to prevent analog/digital interaction.

RANGE CONTROLS are brought out for remote command, by computer or programmer logic levels, or by remote manual switches. TRIGGER CONTROLS are brought-out, for both remote triggering, and remote trigger inhibiting.

FUNCTIONAL CHARACTERISTICS

1.7 CONVERSION RATE

The longest conversion required is 250 milliseconds. The reading rate when externally triggered may be any rate up to 4 per second. The internally triggered conversion rate is set at 3.3 per second.

1.8 RANGING AND OVERRANGE

The Model 3500 provides both automatic ranging and local or remote manual ranging. Local ranging is by push-button selection. A full 20% overrange, at full accuracy, is provided on all ranges below 1000V.

1.9 INPUT CHARACTERISTICS

In the voltage modes, the input is a true-differential-floating circuit: HIGH/LOW/GUARD. In the ohms mode, a true 4-wire connection is provided: Five standard front-panel binding posts are provided as input connectors for all modes. (Rear-panel input-connector option is described below).

1.10 RATIO MODE (FRONT PANEL)

The 3-wire format of the Model 3500 in ratio mode establishes a correct sense of the ratio and eliminates a ground-loop error path. Ratio polarities are direct-reading. In this mode, the external reference voltage (1 to 11V "source" positive with respect to "sink") is applied to the REFERENCE binding posts, and the input voltage is applied to the HI and LO front panel inputs.

1.11 EXTERNALLY TRIGGERED MODE

In the External Trigger mode, a positive pulse having a duration> 1μsec and <100 millisec, and an amplitude between +2.4V and +5.5V applied to the rear-panel trigger-input terminal, will initiate a single conversion cycle. The resultant reading will be stored and displayed until a new trigger pulse has been received, and a new conversion has been accomplished. . . .or until the instrument has been returned to the automatic-triggering mode. Maximum trigger rate, 4 per second for 120% full-scale conversion.

1.12 DISPLAY

1/2" high 7 segment planar premium longlife glow-tube indicators provide numerical display and a polarity symbol, plus overrange indication and automatically positioned decimal point. On manually selected ranges, blinking occurs when the selected range is exceeded. In automatic ranging mode, the meter will automatically select the correct range. Display storage is provided until a new reading (conversion) has been accomplished. . . .therefore, the display is steady except for instantaneous transitions to new readings.

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STANDARD OPTIONS

OPTION A3: INPUT CABLE. 60" 3-wire cable assembly extends input connections to point of measurement.

OPTION A4: REAR-PANEL INPUT CONNECTOR. Miniature 5-pin connector duplicates front-panel input terminals. Furnished with mating plug.

OPTION A5: RACK-MOUNTING KIT. Specify left or right for DVM. Converts unit to standard 19" x 3 1/2" EIA rack-panel mountings.

OPTION A5/1: DUAL RACK MOUNT. For two Model 3500's or for one Model 3500 and another half-rack instrument.

OPTION A6: MATING CONNECTOR FOR BCD OUTPUT

OPTION A7: CURRENT SHUNT SET. 1mA to 1000mA, AC & DC

Accuracy*: 1mA, 10mA Ranges: $\pm$0.1% rdg.
100mA, 1000mA Ranges: $\pm$ 0.15% rdg.

Temperature Coefficient*: 1mA, 10mA Ranges: ±0.01%rdg./°C
100mA amd 1000mA Ranges: ±0.02% rdg./°C

*In addition to the basic specifications of the Model 3500.

Dimensions: 3" high, 5 1/4" wide, and 3" deep.

SCOPE OF INSTRUCTION MANUAL FOR MODEL 3500

This Instruction Manual for Model 3500 DMM contains the general description, principles of operation, operating and maintenance procedures, reference schematics, and parts lists.

The Terms "TRI-PHASIC", "ISOPOLAR", and "RATIOHMIC" are registered trademarks of Data Precision Corporation, and are used to describe proprietary circuits, for which patent applications have been made, or patents have been granted.

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DMM MODEL 3500 SPECIFICATIONS

DC VOLTS

NOMINAL RANGE	OVERRANGE	RESOLUTION	IMPEDANCE	MAXIMUM VOLTAGE
± .100000	± .119999	1μV	>1,000 megohms	± 1000V
± 1.00000	± 1.19999	10μV	>1,000 megohms	± 1000V
± 10.0000	± 11.9999	100μV	>1,000 megohms	± 1000V
± 100.000	± 119.999	1mV	10 megohms	± 1000V
± 1000.00	± 1000.00	10mV	10 megohms	± 1000V

ACCURACY

4 upper ranges, including overrange

24 hours, 23°C ± 1°C — ± 0.004% rdg. ±0.001% f.s. ± 1 l.s.d.

6 months, 23°C ± 5°C — ± 0.007% rdg. ±0.001% f.s. ± 1 l.s.d.

lowest range:

24 hours, 23°C ± 1°C — ± 0.005% rdg. ± 0.003% f.s. ± 1 l.s.d.

6 months, 23°C ± 5°C — ± 0.008% rdg. ± 0.003% f.s. ± 1 l.s.d.

VOLTAGE COEFFICIENT (Generally applicable only on highest range)

Add ± 0.00001% rdg./Volt

TEMPERATURE COEFFICIENT (0°C to 50°C)

4 upper ranges: (± 0.001% rdg. ± 0.0002% f.s.)/°C

lowest range: (± 0.001% rdg. ± 0.0005% f.s.)/°C

COMMON-MODE REJECTION RATIOS (minimum):

at DC, 160dB with 1000 Ohm source-impedance unbalance

at 60Hz, 120dB with 1000 Ohm source-impedance unbalance

COMMON-MODE VOLTAGE: 400V DC (or Peak AC) maximum.

NORMAL-MODE REJECTION RATIO: 80dB at 50Hz and every 10Hz increment thereafter

AC VOLTS

NOMINAL RANGE	OVERRANGE	RESOLUTION
.100000	.119999	1μV
1.00000	1.19999	10μV
10.0000	11.9999	100μV
100.000	119.999	1mV
1000.00*	1000.00*	10mV

*See maximum voltage limitation, below

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INPUT IMPEDANCE (all ranges): 1 megohm in parallel with 100pF or less.

SENSING & CALIBRATION: True-Average sensing calibrated in RMS of sinewave.

ACCURACY (6 months, $23^{\circ}C \pm 5^{\circ}C$):

	FOUR UPPER RANGES	.1V RANGE
at 30 Hz	± 1% rdg. ± 0.02% f.s.	± 1% rdg. ± 0.1% f.s.
50Hz - 1kHz	± 0.05% rdg. ± 0.02% f.s.	± 0.05% rdg. ± 0.1% f.s.
10kHz	± 0.2% rdg. ± 0.02% f.s.	± 0.2% rdg. ± 0.1% f.s.
100kHz	± 1% rdg. ± 0.05% f.s.	± 1% rdg. ± 0.5% f.s.

TEMPERATURE COEFFICIENT ($0^{\circ}C$ to $50^{\circ}C$, all ranges):

Four Upper Ranges:

30Hz - 1kHz	(± 0.005% rdg. ± 0.002% f.s.)/$^{\circ}C$
1kHz - 10kHz	(± (0.005 x freq. in kHz) % rdg. ± 0.002% f.s.)/$^{\circ}C$
10kHz - 100kHz	(± 0.05% rdg. ± 0.002% f.s.)/$^{\circ}C$

0.1V Range:

30Hz - 1kHz	(± 0.005% rdg. ± 0.02% f.s.)/$^{\circ}C$
1kHz - 10kHz	(± (0.005 x freq. in kHz) % rdg. ± 0.02% f.s.)/$^{\circ}C$
10kHz - 100kHz	(± 0.05% rdg. ± 0.02% f.s.)/$^{\circ}C$

MAXIMUM INPUT VOLTAGE (sinewave RMS):

30Hz to 10kHz: 700V

above 10kHz: Decreases linearly to 100V at 100kHz

SETTLING TIME (to settle within ± 0.05% of final reading for a full-scale step input): 2.5 seconds

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OHMS

NOMINAL RANGE	OVERRANGE	RESOLUTION	MAX. TEST CURRENT
.100000kΩ	.119999kΩ	1 milliohm	1mA
1.00000kΩ	1.19999kΩ	10 milliohms	1mA
10.0000kΩ	11.9999kΩ	100 milliohms	100μA
100.000kΩ	119.999kΩ	1 Ohm	10μA
1000.00kΩ	1199.99kΩ	10 Ohms	1μA
10000.0kΩ	11999.9kΩ	100 Ohms	0.1μA

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CONFIGURATION: True four-wire.

MAXIMUM OPEN CIRCUIT VOLTAGE: 6.2 Volts.

ACCURACY (6 months, $23^{\circ}C \pm 5^{\circ}C$):

.1kΩ range	± 0.008% rdg. ± 0.003% f.s. ± 1 l.s.d.
1kΩ/10kΩ/100kΩ ranges	± 0.007% rdg. ± 0.001% f.s. ± 1 l.s.d.
1000kΩ range	± 0.02% rdg. ± 0.002% f.s. ± 1 l.s.d.
10,000kΩ range	± 0.2% rdg. ± 0.01% f.s. ± 1 l.s.d.

TEMPERATURE COEFFICIENT ($0^{\circ}C$ to $50^{\circ}C$):

.1kΩ range	(± 0.001% rdg. ± 0.001% f.s.)/°C
1kΩ/10kΩ/100kΩ ranges	(± 0.001% rdg. ± 0.0004% f.s.)/°C
1 megΩ range	(± 0.005% rdg. ± 0.0004% f.s.)/°C
10 megΩ range	(± 0.02% rdg. ± 0.005% f.s.)/°C

SETTLING TIME (to settle to within ± 0.01% of final reading): in seconds for any resistance = 0.1 +0.3 x resistance in megohms.

Max. Input Voltage: ± 150V peak, or 115V AC (RMS)

DC RATIO

SELECTED RANGE	NOMINAL RANGE	OVERRANGE	ACTUAL DISPLAY*
.1	± .0100000:1	± .0119999:1	± .119999
1	± .100000:1	± .119999:1	± 1.19999
10	± 1.00000:1	± 1.19999:1	± 11.9999
100	± 10.0000:1	± 11.9999:1	± 119.999
1000	± 100.000:1	± 119.999:1	± 1199.99

*Displayed Ratio is 10 time true ratio

ACCURACY:

Upper Ranges, 24 hours, $23^{\circ} \pm 1^{\circ}C$:

$$(\pm 0.004\%\ \text{rdg.} \pm 0.001\%\ \text{f.s.} \pm 1\ \text{l.s.d.}) \times \frac{10}{\text{Actual Ref. Voltage}}$$

Lowest Range, 24 hours, $23^{\circ} \pm 1^{\circ}C$:

$$(\pm 0.005\%\ \text{rdg.} \pm 0.004\%\ \text{f.s.} \pm 1\ \text{l.s.d.}) \times \frac{10}{\text{Actual Ref. Voltage}}$$

Upper Ranges, 6 months, $23^{\circ}C \pm 5^{\circ}C$:

$$(\pm 0.008\%\ \text{rdg.} \pm 0.001\%\ \text{f.s.} \pm 1\ \text{l.s.d.}) \times \frac{10}{\text{Actual Ref. Voltage}}$$

Lowest Range, 6 months, $23^{\circ}C \pm 5^{\circ}C$:

$$(\pm 0.008\%\ \text{rdg.} \pm 0.003\%\ \text{f.s.} \pm 1\ \text{l.s.d.}) \times \frac{10}{\text{Actual Ref. Voltage}}$$

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TEMPERATURE COEFFICENT (0^{o}C to 50^{o}C, all ranges):

Upper Ranges: $(\pm 0.001\%$ rdg. $\pm 0.0002\%$ f.s.$)\times\frac{10}{\text{Actual Ref. Voltage}}/^{o}C$

Lowest Range: $(\pm 0.001\%$ rdg. $\pm 0.001\%$ f.s.$)\times\frac{10}{\text{Actual Ref. Voltage}}/^{o}C$

VOLTAGE COEFFICIENT OF RATIO: $\pm$ 0.00001% rdg/Volt

VOLTAGE RANGE: Input Signal: 0 to $\pm$ 1000V
Reference Signal: +1V to +11V

REFERENCE INPUT IMPEDANCE: 100k

COMMON-MODE REJECTION RATIO: Same as DC Volts

NORMAL MODE REJECTION RATIO: Same as DC Volts

INTERFACE AND APPLICATION SPECIFICATIONS

SIGNAL INTERFACES

DATA OUTPUTS (DTL/TTL compatible) BCD 1-2-4-8 coded, positive true.

Logic ONE: > +2.4V
Logic ZERO< +0.4V sink for 4mA
Polarity output, One = Positive polarity

STATE OUTPUTS (DTL/TTL compatible)

Range in use = ZERO:< +0.4 sink for 4mA
Inactive ranges = ONE: >+2.4V
End of Conversion is transition from ZERO to ONE.

CONTROL INPUTS.

RANGE: Each range is selected by the grounding of the appropriate line, through switch contacts or grounded transistor.

EXTERNAL TRIGGER:

Positive pulse 2.4 volts with a pulse width of >1μsec., and <100 msec will initiate a read command. The command will cause the instrument to perform one measurement. The reading will remain in the memory until a new external trigger pulse is initiated.

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TRIGGER INHIBIT INPUT (Applying logic "0" inhibits conversion in all trigger modes):

Logic "1" >+2.4V

Logic "0" <+0.4V sink for 4mA

INPUT POWER: 105V-125V AC (or 210-250V AC) 47-63 Hz, less than 12 Watts. Line-voltage range is selected by rear panel switch.

ENVIRONMENT

TEMPERATURE RANGES: Operating, $0^{\circ}C$ to $+50^{\circ}C$
Storage, $-25^{\circ}C$ to $+80^{\circ}C$

HUMIDITY: 95% RH max, $0^{\circ}C$ to $40^{\circ}C$
80% RH max, $+40^{\circ}C$ to $+50^{\circ}C$

OVERALL DIMENSIONS: 3 1/2" high, 8 1/2" wide, and 12" deep, including panel controls and connectors.

WEIGHT: 8 pounds net, 14 pounds packed for domestic shipment.

STAND: Adjustable, removable, tilt-up stand provided for best viewing in bench use.

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Chapter 2

OPERATION

2.1 UNPACKING

The Model 3500 digital multimeter is shipped in a protective packing case containing the following items:

One digital multimeter, with line cord (3-wire) attached

One instruction manual,

One certificate of traceability to NBS Standards,

One warranty card, and

One copy of the test and inspection data for the instrument.

If the carton showed signs of rough handling or damage, inspect the multimeter carefully and report the damage to the shipping company immediately. Fill out the warranty card as directed and return it to the factory.

2.2 OPERATING CONTROLS AND INDICATORS

The front panel controls and indicators are identified in Figure 2-1, and their functions are described in Table 2-1. The rear panel controls are identified in Figure 2-2, and are described in Table 2-2.

2.3 POWER CONNECTIONS

Model 3500 DMM is shipped with the power switch preset for the AC voltage source anticipated in the user area and the setting is recorded on the Test Data Sheet forwarded with the instrument. (In the United States this is 115V.) The AC source selection switch, S201, is located on the rear panel of the DMM, and its setting may be changed, if necessary. Use a small-blade screw driver to set S201 to the proper value as stamped on switch.

2.4 GUARD CONNECTIONS

Instrument construction provides a GUARD circuit connected to the internal shield surrounding the analog and A/D sections of the instrument and isolated from any analog input or external ground. Prior to any measurement, a proper GUARD connection must be made in order to bring the internal shield as close as possible to the voltage potential of the low side of the input circuit. The low side of the input is separated from internal grounds and is brought out as a front panel connection where it may be connected as required.

The GUARD connection should be made to minimize the common mode currents through the voltage measuring circuit, and it should be connected to the low side as close to the voltage source as possible. If it is not feasible to connect at the source, make the connection between GUARD and the low side of the input at the DMM front panel.

2.5 RANGING

a. Manual Ranging

The DMM is a direct reading instrument in any voltage or resistance range setting, and displays ten times the actual when making Ratio measurement. When any one of the fixed ranges is chosen, the display will automatically indicate correct polarity of high input terminal referred to low (in DC), and will read the input voltage to 5 1/2 significant figures (up to 119999). An out-of-range input signal will result in two effects simultaneously - -

1. A 120000 reading on the display (and decimal point).
2. A blinking "1" in the most significant digit.

When the DMM is switched to the correct range, the reading will be steady at less than 120000.

Zero's in the most significant digits indicate that the full scale range may be decreased. Full resolution capability of the instrument is being used when the reading is between 010000 and 119999, 10% to 120% of full scale, with proper decimal point location.

b. Auto Ranging

When AUTO is selected at the front panel, the meter automatically settles at that range where the reading is

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Table 2-1

FRONT PANEL CONTROLS AND INDICATORS

NOTE

Complete operating instructions follow the description of controls and indicators.

Fig. Ref.	Control/ Indicator	Description	Function
1.	POWER	Push-push switch	Applies power to the DMM from connected source.
2.	DC	Push switch	Selects DC voltage measurement mode of DMM operation. Is interlocked with other mode selectors; is pushed out when other mode is selected.
3.	AC	Push switch	Selects AC voltage measurement mode of DMM action. Is interlocked with other modes so that it is pushed out upon selection of another mode.
4.	kΩ	Push switch	Selects resistance measurement mode of DMM operation. Is interlocked with other modes so that it is pushed out upon selection of another mode.
5.	Vx	Two 5-way binding posts	Connection for input voltage, AC or DC, or resistance.
6.	Rx	Two 5-way binding posts	Current source and sink terminals for resistance connection. Connection for voltage ratio reference Input.
7.	GUARD	One 5-way binding post	External connection to guard shield.
8.	DISPLAY	7-segment planar indicators	Displays digital readout for a maximum of 120000. Decimal point is selected automatically and indicates value of a direct reading. Sign is displayed automatically when in DC measurement mode.
9.	RANGE .1 1 10 100 1K 10K	Push switch for manual range selection	Selects value of full scale range to be used by DMM in measuring input. Is interlocked so that only one may be in at a time. 10K for use with KΩ function only.
10.	AUTO	Push switch for automatic range selection	Initiates DMM operation to locate range for which the input signal will be measured between 10% and 120% of full scale.
11.	RATIO	Push switch	Selects RATIO measurement mode of DMM operation. It is not interlocked with other modes and must be depressed to release. Used in conjunction with DC button for DC/DC RATIO or AC button for AC/DC RATIO.

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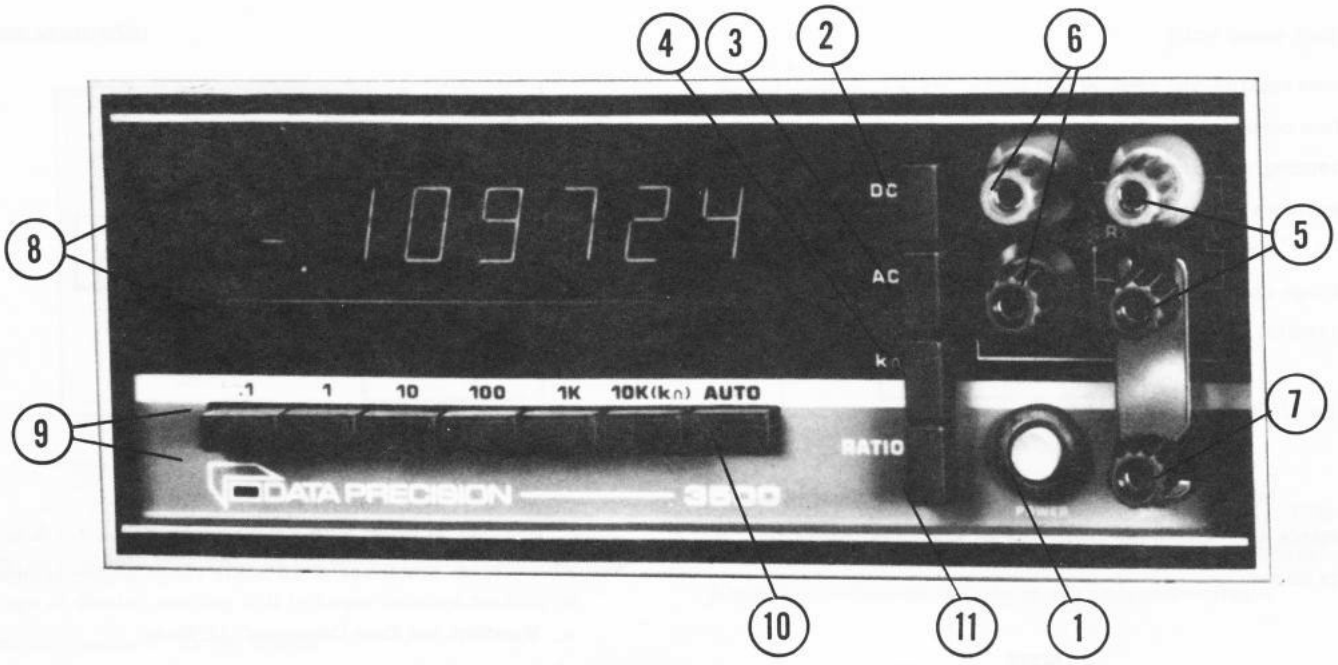


Figure 2-1 Model 3500 Front Panel Controls and Indicators

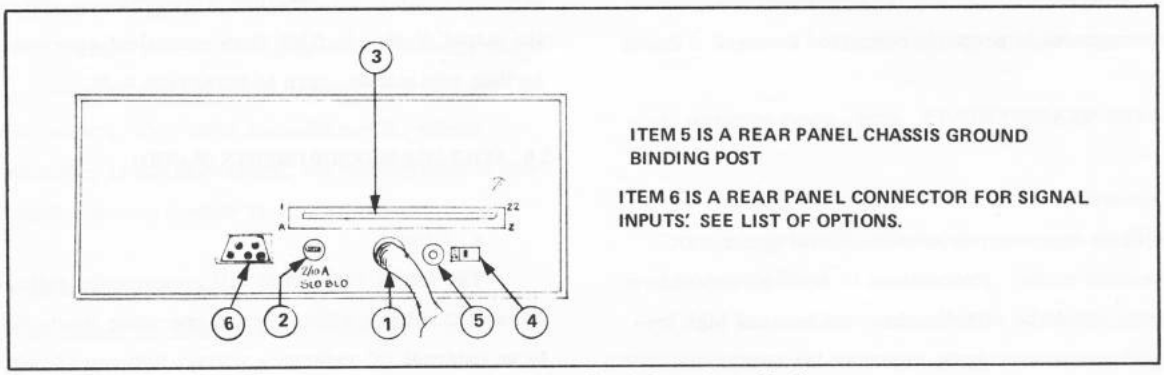


Figure 2-2 Model 3500 Rear Panel Controls and Indicators

Table 2-2

REAR PANEL CONTROLS AND INDICATORS

Fig. Ref.	Control/ Indicator	Description	Function
1.	POWER CORD	3-conductor cord	Connects source power to instrument.
2.	FUSE	Receptacle and holder	For a 2/10 amp slow-blow line fuse.
3.	REMOTE	PC Connector	Provides digital output of measured value, indicates selected range of operation, and provides input for remote control of range and remote triggering of DMM operations. (See Table 2-3).
4.	LINE VOLTAGE SWITCH	115/230V switch	Connects proper transformer voltage taps so that Series 2000 will work in user area.

between 10% and 120% of full scale. This is accomplished in a sequence of conversions, after each of which the range sensing circuit performs a decision-function analysis and switches the range scale until the correct one is chosen.

Decimal point indications on the display follows each range change to update the display for direct reading results.

2.6 ZEROING

In all modes of operation, Model 3500 DMM instruments self-adjust for zero, and no zero-adjustment is required.

NOTE

If no input is connected to the instrument and a sensitive range is selected, spurious readings may appear because of the high impedance input. These are of no consequence and do not indicate any incorrect performance when the instrument is properly connected for use.

2.7 VOLTAGE MEASUREMENTS

a. General

The same procedure is used in AC voltage and DC voltage measurements. Precautions to avoid pickup and stray signals should be strictly observed because high frequency spurious inputs may be mistaken for acceptable signals in the AC measuring mode. Refer to paragraph 2.4 for information on GUARD connection. If possible, enclose both input leads in a shield and connect the shield to GUARD at the instrument end, and to the low side of signal at the source end.

b. Procedure

(See paragraph 2.8 for Ratio.)

1. Select appropriate voltage measurement mode, AC or DC.

2. Connect input circuit to Vx (Figure 2-3). (Link A and B may be left in place).

3. Make appropriate GUARD connections.

4. a) If using Manual Ranging (paragraph 2.5 a.), select most sensitive range that does not cause DMM to indicate an overrange condition. This will utilize full 5 digits of DMM resolution capability.

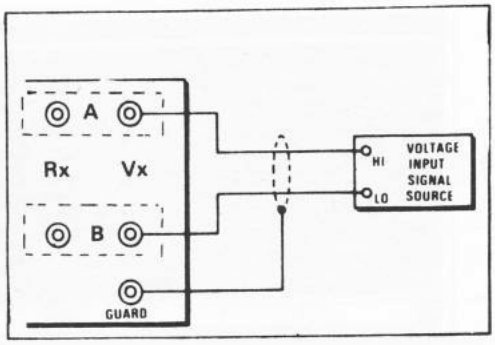


Figure 2-3. Voltage Measurement Connections

b) If using Auto Ranging (paragraph 2.5 b.), wait until display stabilizes at on-scale range before reading.

c. Waveform and Error Comments - AC Mode

In measuring input AC voltages, the DMM circuitry blocks any incoming DC, and the instrument operates within specification accuracy for any superimposed DC voltage up to 500 volts. The DMM measures the average value of one-half cycle of the resulting AC waveform, and calibrates the output display in RMS of an equivalent sine wave. (For further explanation, turn to paragraph 4.3)

2.8 VOLTAGE MEASUREMENTS (RATIO)

a. General

The Model 3500 DMM will measure the ratio of any AC or DC voltage within normal operating limits referenced to an external DC reference voltage between +1 volt and +11 volts. The displayed ratio value will be 10 times the true ratio.

b. Procedure

1. Press RATIO push button at Front Panel (Figure 2-1).

2. Select appropriate AC or DC mode.

3. Select appropriate manual range or auto range.

4. Install links as shown in Figure 2-4. (Link B may be omitted.)

5. Connect voltage input signal to the front panel Vx connectors as in Figure 2-4.

6. Connect the reference voltage input signal to the front panel Rx connectors as shown in Figure 2-4.

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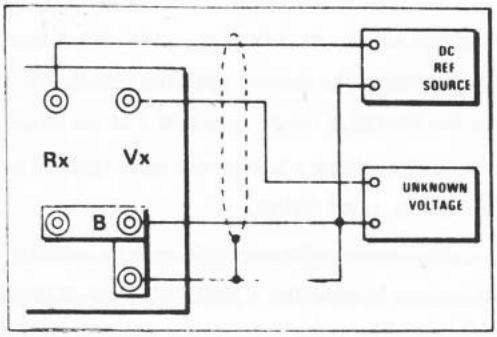


Figure 2-4. DMM Connections for RATIO Measurement

7. Read output after display is stable. Divide by 10 to obtain true ratio of unknown to known reference. Sign of display reading will indicate relative polarity of applied voltages for DC inputs.

2.9 RESISTANCE MEASUREMENT

a. General

The Model 3500 DMM measures any resistor between .119999 kΩ full scale and 11.9999 megohms full scale and offers full four-wire measurement capability to achieve the specified accuracy. For rapid measurements, where extreme accuracy is not necessary, the convenience of two-wire resistance measurements is also afforded.

b. Four-Wire Measurements

1. Select kΩ measurement mode.

2. Connect the Vx terminals to inner connection points, A, of the unknown resistor as shown in Figure 2-5.

3. Connect the current source and sink to the outer connection points, B, of the unknown resistor as shown in Figure 2-5.

4. Connect guard to the low side (current sink) of the circuit as shown in Figure 2-5.

5. Select appropriate autorange of manual range switch for expected resistance. Note that highest range of 10K kilohms = 10 megohms is available in resistance measurement mode.

6. Observe display. As soon as decimal point location is stable, a correct reading may be made. An over range condition will result in a blinking indication as in voltage measurements (see paragraph 2.5a).

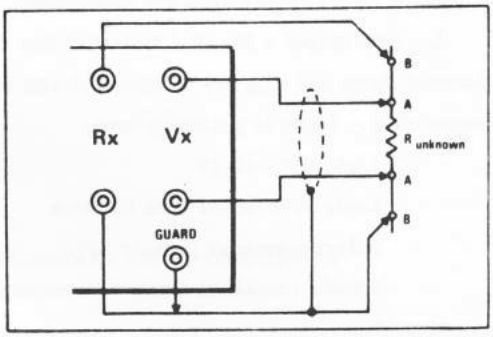


Figure 2-5. Four-Wire Resistance Measurement

7. When measuring high resistance values, it is desirable to shield the resistor through to the connections A and B to reduce the effects of any spurious voltage.

c. Two-Wire Measurements

When making two-wire resistance measurements, connect the unknown resistance and the current source and sink to the connection points as shown in Figure 2-6. Perform the measurement as in steps 4. through 7. in paragraph 2.9a above. (Links must be connected as shown.)

2.10 REMOTE OPERATION

a. Set-Up

To obtain remote control and to transmit data from Model 3500 DMM - -

1. Prepare a cable with 44-pin connector VIKING 2VK22D/1-3 or equivalent, and cabled as shown in Table 2-3.

2. Remove protective covering from the PC Board connector at Rear Panel and connect cabled connector.

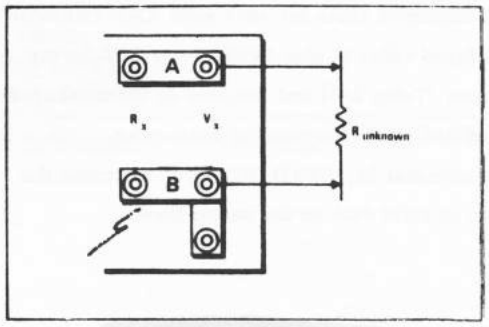


Figure 2-6 Two-Wire Resistance Measurement

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b. Output Signals Specifications and Applications

1. Data Output - Parallel format of five binary-coded decimal digits and sign are transmitted with DTL/T^2L compatibility. Logic is positively true:

Logic "1" > +2.4V

Logic "0" < +0.4V sink for 4mA

Polarity positive is logic "1".

Signals remain as latched on output lines between conversions.

2. Range scale in use is indicated by logic "0". Inactive ranges are logic "1"'s.

(Decimal point is determined and indicated by range in use.)

3. Completion of the conversion (EOC) is indicated by an internal control signal, and is followed immediately by the update of the Display. The availability of updated data is indicated by the READOUT signal on connector tab 14. Valid data outputs are available after the rising edge of the READOUT waveform.

4. Overload - A zero logic level on this line indicates the input of a signal more than 120% of the selected full scale range, necessitating a range change. This output thus serves to indicate existence of incorrect data on the output lines and may be used to inhibit input of incorrect data to receiving printers, computers, etc. It also transmits a short negative pulse at EOC.

c. Remote Control

1. Conversion - In order to exercise a remote control of the conversion, two signals are required: ENABLE, a low level on terminal J to inhibit the internal triggering, and EXT. TRIGGER, a 2.4V positive pulse between 1μsec and 100 milliseconds wide applied to terminal 21. The Model 3500 DMM will make one conversion and hold the displayed value for each such EXT TRIGGER pulse. The displayed value is also available in BCD format on the output lines (Table 2-3) and remains at the measured value until modified by the succeeding conversion. The A high level on terminal 14, READ OUTPUT, indicates the existence of valid data on the output lines.

2. Hold - The measured value may be retained on the display (and in BCD format on the output lines) while on internal trigger, by merely applying a logic "0" (low level) on the ENABLE input, terminal J of the rear panel connector, and applying a low level signal (ground or logic) to connector tab 21 (EXT TRIG).

3. Range - Range scale may be selected from a remote source by applying a logic "0" level at the designated terminal shown in Table 2-3. If the range scale is not externally selected, the appearance of a low level on these terminals indicates the range scale for the measurement value in BCD format on data output lines. Make sure all Range buttons are out.

Table 2-3

REMOTE CONTROL/OUTPUT CABLE			
A	Ground	1	Ground
B	$\overline{10^1}$	2	8
C	8,000	3	4
D	4,000	4	2
E	2,000	5	1
F	1,000	6	$\overline{10^4}$
H	$\overline{10^0}$	7	80
J	Enable	8	40
K	NC	9	20
L	NC	10	10
M	NC	11	$\overline{10^3}$
N	800	12	NC
P	400	13	NC
R	200	14	Read Output
S	100	15	80,000
T	$\overline{10^2}$	16	40,000
U	NC	17	20,000
V	NC	18	10,000
W	NC	19	100,000
X	$\overline{10^{-1}}$	20	+
Y	$\overline{\text{Overload}}$	21	Ext. Trig.
Z	Ground	22	Ground

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Chapter 3

CALIBRATION

Data Precision Model 3500 Digital Multimeter is extremely precise and stable. The 6-month accuracy should last for longer than the specified period. It is advisable to check the instrument periodically. When doing so, follow all procedures carefully and observe all precautions.

3.1 CALIBRATION VERIFICATION

Data Precision Corporation recommends establishing and maintaining a performance history log. Transfer the certified factory performance test data as the initial entry. In order to have a locally available test performance for comparison, it is suggested that the instrument be tested against an available standard as soon as it is unpacked and the test results be recorded at that time. The instrument should be checked thereafter at least every six months.

3.2 PRELIMINARY SET UP CONDITIONS

a. Establish a solid ground connection from the case to the power source ground. If the third wire of the three-wire power cord does not carry through to main power ground, ground the meter case with a clip lead attachment.

b. Accuracy of standards used to calibrate the multimeter should be verified before recalibrating the instrument. Errors of standards should be no worse than 20% of the tolerances specified for the multimeter.

3.3 CALIBRATING EQUIPMENT

The following equipment is recommended for use when called out in the calibration procedure. Substitute units may be employed provided they meet the accuracy characteristics specified below.

Feature Under Test	Standard Type Model No.	Accuracy Requirements
DC Volts Measurement	COHU/Model 355	10V range ± .001% rdg +2μV 100V range ± .001% rdg +20μV 1000V range ± .001% rdg +40μV 1000V range ± .001% rdg +40μV
AC volts	HP/Model 745A and 746A	1mV to 100V: 50Hz-20kHz ± .02% rdg ± .002% range ± 10μV 20Hz-100kHz ± .05% rdg ± .005% range ± 50μV 100V to 1000V: 50Hz-20kHz ± .04% rdg 20Hz-50kHz ± .08% rdg
Resistance	JULIE NB-102-100Ω (.001%) JULIE/DMR-105A (.001%) JULIE/NB-106-1M (.0015%) JULIE/NB-107-10M (.003%)	1 kilohm to 10 megohm ± .001% in decades

Table of Recommended Calibrating Equipment

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3.4 ACCESS TO CALIBRATION ADJUSTMENTS

All calibration adjustments are accessible after the top cover has been removed (see Figure 3-1). The actual calibration potentiometers are mounted on the circuit board, but may be reached through an opening provided in the guard shield. A summary table of the Calibration Procedure is located on the inside top cover of the instrument.

CAUTION

Do not remove the Guard during Calibration Process.

3.5 CALIBRATING SEQUENCE

Perform the calibration in the following sequence of measurement modes:

1. DC Voltage Measurement Mode
2. Resistance Measurement Mode
3. AC Voltage Measurement Mode
4. Ratio Measurement Mode.

3.6 DC VOLTAGE MEASUREMENT MODE

Depress "ON" switch; wait one hour for calibration.

a. Zero Adjust: R300, R45, R46

1. Select DC Volts Mode
2. Select .1V Full Scale
3. Connect shorting bar across input, Vx
4. Adjust R300 for ± 0.00000 display value
5. Set range to 10V Full Scale
6. Connect 10-megohm (approx) resistance across input Vx
7. Adjust R45 for ± 0.00000 display value
8. Connect shorting bar across input Vx
9. Adjust R46 for ± 0.00000 display value
10. Repeat steps 6 through 9 as necessary.

b. Balance Adjust: R83

1. Set Range to 1V Full Scale
2. Apply 1V (approx) to input Vx
3. Read display, Record.

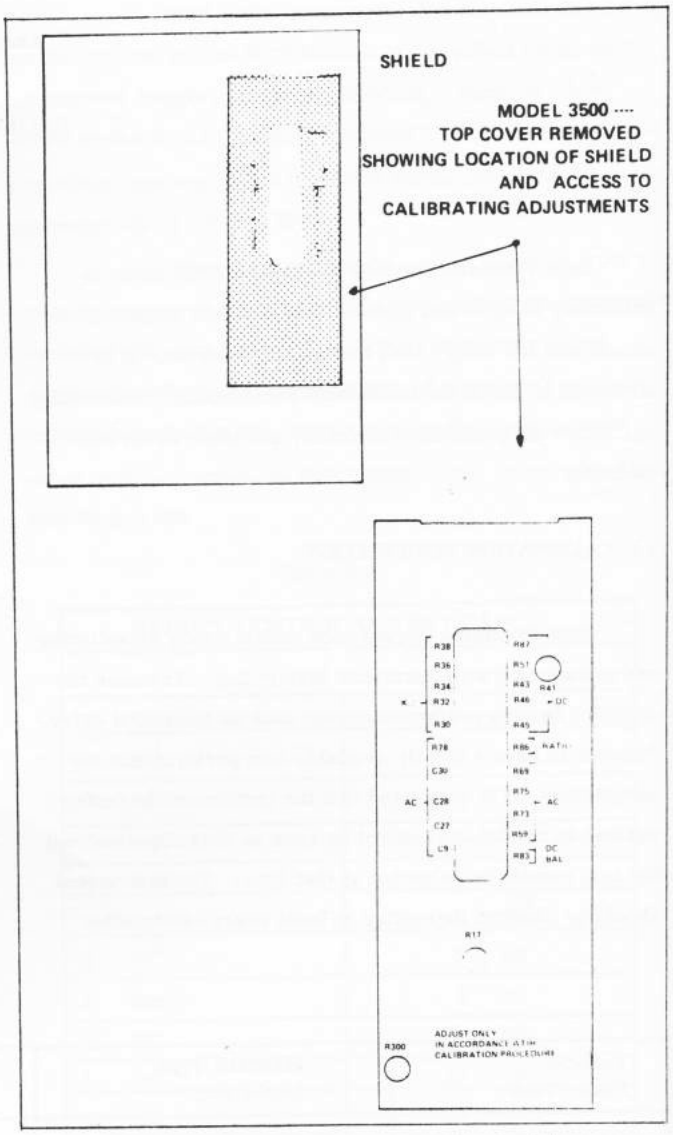


Figure 3-1 Location and Identification of Calibrating Adjustments

4. Reverse input polarity. Record
5. Adjust R83 until values of step step 3. and 4. are exactly same on display
6. Repeat steps 3 through 5 as necessary.

c. Reading Adjustments

For each full scale range, apply positive full scale voltage and adjust the appropriate potentiometer for full scale value on the display.

Set F.S. Range to	Adjust	For reading of
1) 1-Volt Range	R87	+1.00000
2) .1-Volt Range	R17	+.100000
3) 10-Volt Range	R51	+10.0000
4) 100-Volt Range	R43	+100.000

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3.7 RESISTANCE MEASUREMENT MODE

Turn unit "ON". Depress KΩ mode switch.

NOTE

Calibration is accomplished using the 4-wire resistance set-up (Figure 2-5). Adjust until display reads known value of resistor.

Set F.S. Range to	Range Switch	Connect R Value of ohms	Adjust	For Reading of
1 k ohm	1	1.00000 k	R30	1.00000
10 k ohm	10	10.0000 k	R32	10.0000
100 k ohm	100	100.000 k	R34	100.000
1,000 k ohm	1k	1.00000 M	R38	1000.00*
10k k ohm	10k	10.000 M	R36	10000.0*

*Noise may obliterate last decade.

3.8 AC VOLTAGE MEASUREMENT MODE

NOTE

Connect LO voltage input to Guard. Check signal source to assure that it is free of harmonics.

a. Select AC-Volt Mode

b. Zero Adjust: R59

1. Select 100V full scale range
2. Connect shorting bar across Vx
3. Adjust R59 for display reading of 000.000

c. Low Frequency Full Scale Adjustments

At a frequency of appriximately 100 Hz, apply the designated voltage to terminals Vx, and adjust the appropriate calibrating potentiometer for the indicated display reading.

Set F.S. Range to	Apply VRMS to Vx	Adjust	For Reading of
1	1.00000	R69	1.0000
10	10.0000	R73	10.000
100	100.000	R75	100.00
1K	500.00	R78	0500.0

d. High Requency Full Scale Adjustments

Change frequency of signal generator to approximately 50 kHz, apply the designated voltage to terminals Vx, and adjust the designated calibrating adjustment for the designated display reading. Use insulated H. F. type tweeking tool.

Set F.S. Range to	Apply VRMS to Vx	Adjust	For Reading of
1K	0200.00	C9	0200.0
100	100.000	C30	100.00
10	10.0000	C28	10.000
1	1.00000	C27	1.0000

3.9 RATIO DC VOLTAGE MEASUREMENT MODE

a. Select DC voltage and push the RATIO button at the front panel.

b. Apply full scale (+10V DC) simultaneously to the Vx input and to the Rx input in parallel to front panel.

c. Adjust calibrating potentiometer R86 for a reading of +10.0000.

3.10 POST-CALIBRATION

As calibration is completed, enter data below and initial. Turn off power. Reassemble unit by replacing cover.

DATE	CALIBRATION RECORD

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Chapter 4

PRINCIPLES OF OPERATION

4.1 GENERAL

The principles of operation of Model 3500 DMM are presented in two main subdivisions. Initially, in paragraph 4.1 through 4.6, the functional performance of each of the major subsystems is presented in brief. This is intended to provide an understanding of the general function of the unit: of how the different types of input signals are processed through to the display in the various modes of operation. The remainder of Section 4 contains detailed circuit explanations. Such material is useful for further study and understanding of the instrument operation and for detailed corrective maintenance, but may be omitted until needed without detracting from the effective use of the Model 3500 DMM.

4.2 SYSTEM BLOCK DIAGRAM

In its simplest form, the DMM is represented by the Block Diagram of Figure 4-1. The system consists of an input Signal Conditioning block, followed by the TRI-PHASIC™ Analog to Digital (A/D) Converter block, whose decoded outputs are driving signals for the Timing and Display block. The Timing & Control block and two Power Supply blocks complete the unit.

The major blocks in Figure 4-1 physically comprise the following:

Analog Block Diagram
(Figure 4-2)
Digital Block Diagram
(Figure 4-3),

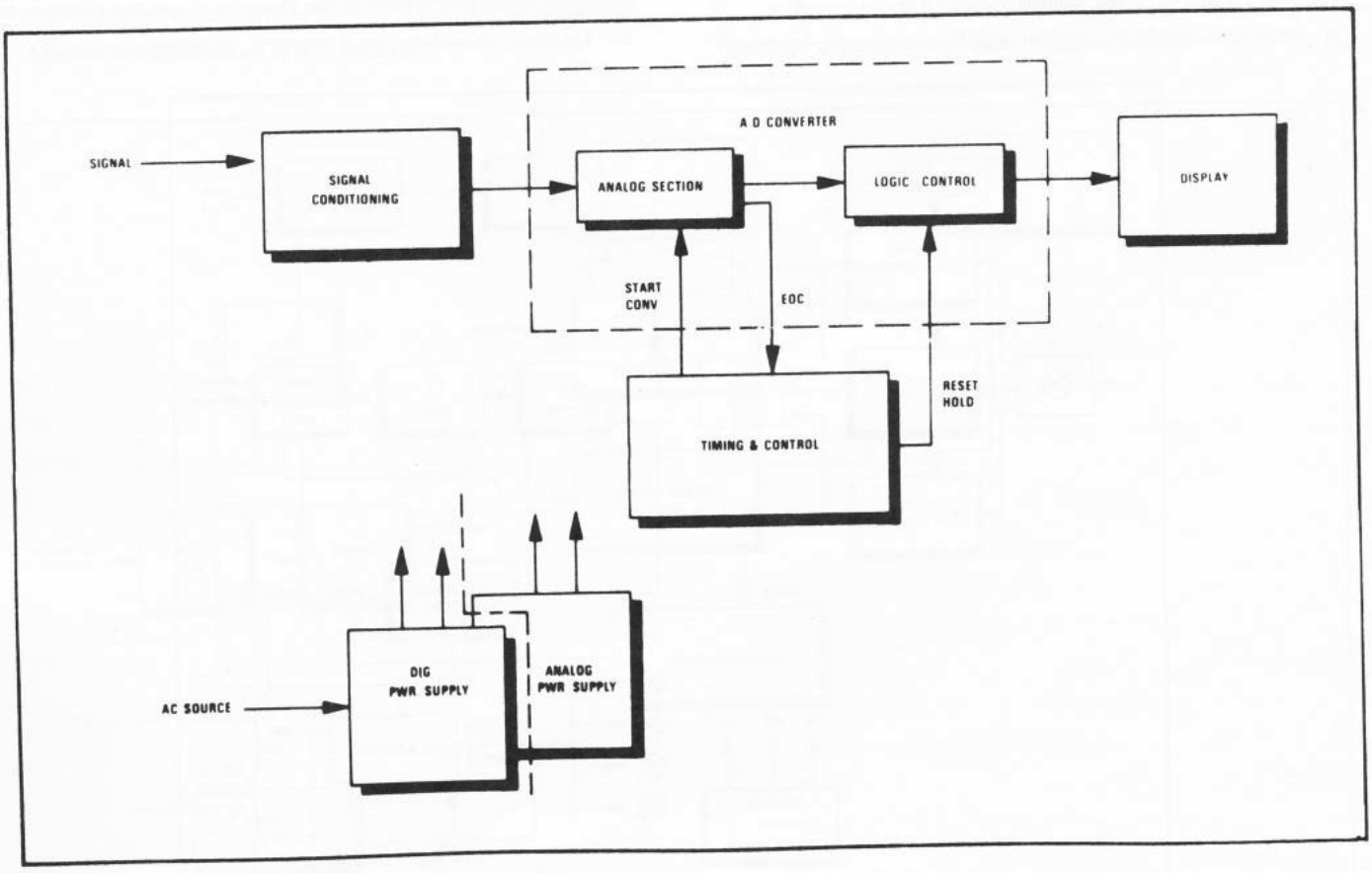


Figure 4-1. Simplified Block Diagram

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The analog portion of the TRI-PHASIC A/D converter accomplishes the conversion in the three phases of (1) self zeroing, (2) unknown integration, and (3) reference integration, the latter two compensated by the stored value of compensating offset.

In the Analog Block Diagram (Figure 4-2), one of the three signal conditioning blocks (for Resistance, DC Volts, and AC Volts measurements) is connected via a switching network as the input to the A/D preamplifier. The preamplifier output is intergrated and then processed by the high gain amplifier. The high gain amplifier outputs: (1) drive the sign indicator at the end of phase 2 to obtain the switching control signals that select the appropriate polarity of the ISOPOLAR™ reference voltage to be applied (via the switching network) to the A/D preamplifier in phase 3 and at the same time drive the Display to indicate sign, and (2) indicate end of phase 3. The high gain amplifier in phase 1 also drives the self zeroing circuitry to develop the offset signal to be applied during the phases 2 and 3 as an input to the A/D preamplifier. Logic and Control circuitry in the Analog Block Diagram receive transformer-coupled "trigger" and "start-phase 3" pulses from the digital blocks to initiate phase 2 and phase 3 converter action, respectively, in each conversion cycle and develop end of conversion pulses to be transmitted via transformer coupling to the digital blocks to end phase 3. An isolated and triple-shielded Analog Power Supply furnishing ± 15V and -5V completes the DMM Analog Block section.

In the Digital Block Diagram (Figure 4-3), the Trigger block generates a control pulse (from its own internal timing circuitry or from external command) as the "start convert" command to the Enable FF. If not blocked by the External Enable signal, the Enable FF gate permits the Crystal Clock pulses to drive the Decade Counter Chain block to start phase 2 operation. At 100,000 counts (end of phase 2) a carry pulse (10^5 CARRY) is transmitted to the Analog Block to start phase 3, while the decade chain continues its counting. When an EOC pulse is received from the Analog Block, the digital control block applies a stop command to the Enable FF stopping the count. At the same time, the Control block generates a transfer command to enable the transfer from the Counter to the Latches, Decoders, and Drivers, updating the display.

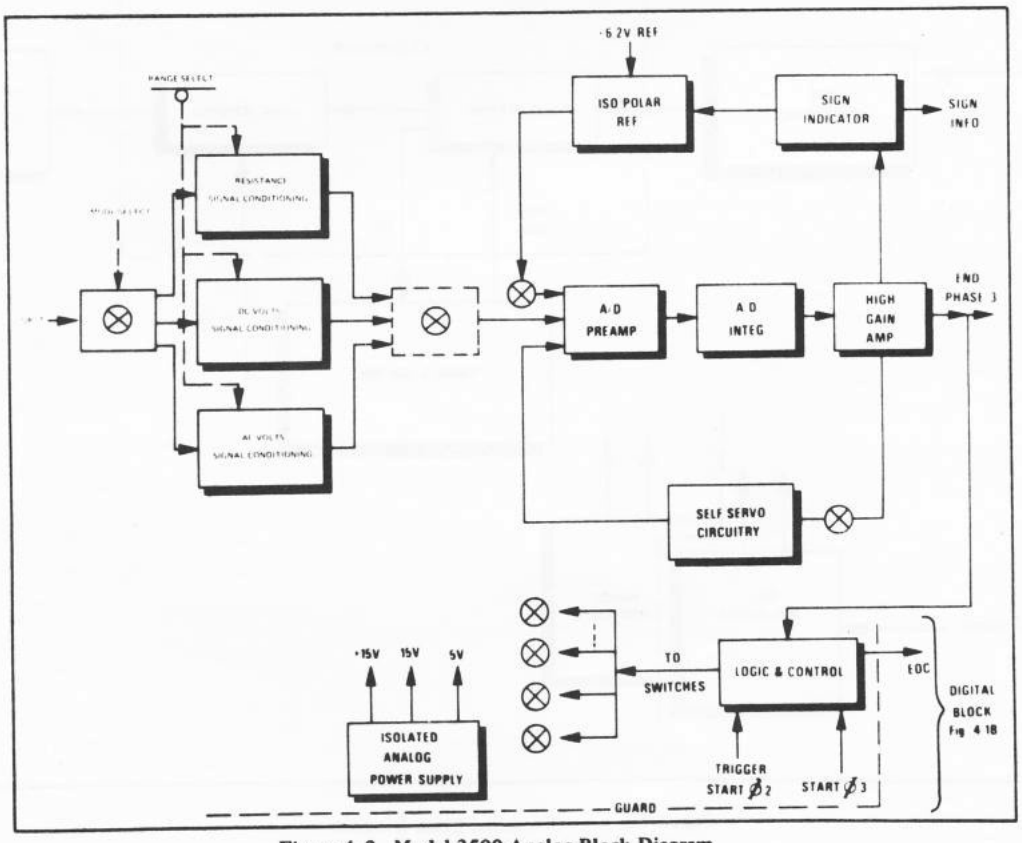


Figure 4-2 Model 3500 Analog Block Diagram

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The updated count (at end of conversion) is held in the Latch and the Display until the next update and is also available as BCD output from the Latch block for remote data output applications.

The Range Select block is driven by one of three sources: manual range selection, remote range selection, or (when in auto range) a command developed when the range of a particular conversion results in a phase 3 count of less than 10,000 or more than 119,999.

Paragraphs that follow now trace the signal through the functional blocks of Figures 4-1, 4-2, and 4-3.

4.3 SIGNAL CONDITIONING BLOCK (Figure 4-2)

An input signal to be measured is introduced into the Signal Conditioning block where it is attenuated according to the range scale chosen, so that a normalized full scale value of ± 1.0 volts DC is delivered to the A/D Converter lock. Overrange capability of 120% of full scale is obtained by accurate operation of the Signal Conditioning block to an output value of ± 1.2 volts.

Signal Conditioning of DC voltage inputs from ± 1V to ± 1000V full scale is accomplished by inserting appropriate attenuating factors for the selected full scale range. Signal conditioning in the 0.1V full scale range is accomplished in the A/D Converter block.

For AC voltage inputs, the Signal Conditioning block rectifies and filters the input signal so that the output, a DC signal, represents the average value of the sine wave multiplied by the conversion factor of 2.22 to yield the RMS equivalent (Figure 4-4).

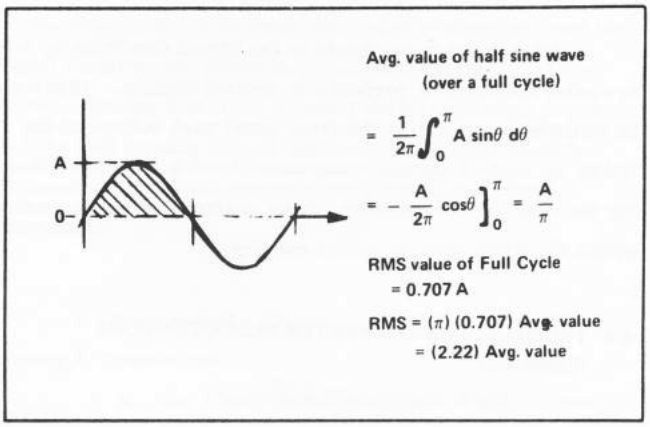


Figure 4-4 Derivation of RMS to AVERAGE Relationship

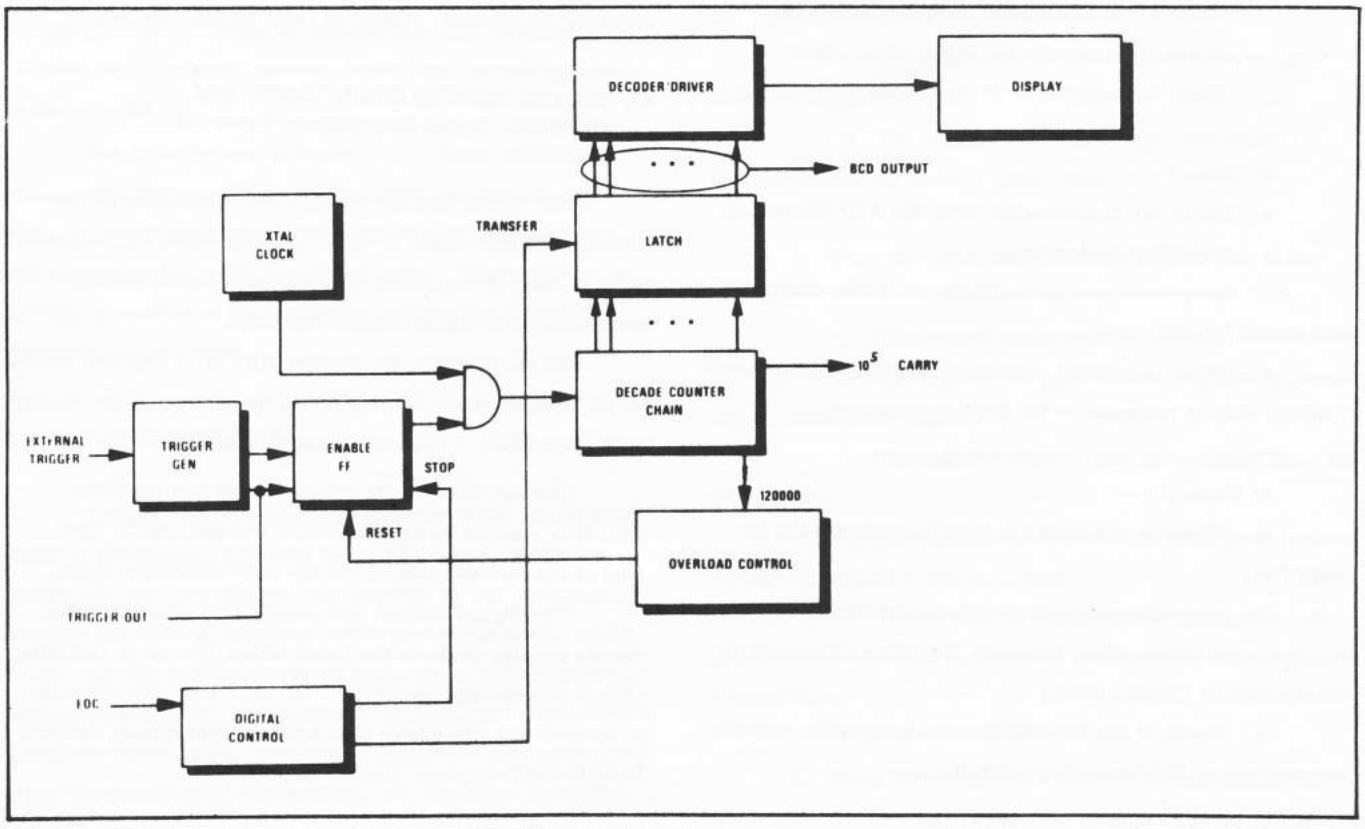


Figure 4-3. Digital Block Diagram

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