Miniature Portable 3-½ Digit Digital Multimeter

MODEL 175

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Theory of Operation
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Schematics

Frontispiece. Model 175 Digital Multimeter.

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Chapter 1

INTRODUCTION

1.1 GENERAL

a. Data Precision Model 175 3½ digit multimeter (DMM) (frontispiece) is a miniature, rugged, battery-powered (or line-charged battery), portable meter for measuring DC or AC voltages, DC or AC currents, in or out of circuit resistances with 0.05% resolution in 32 ranges with 100% overrange. The Model 175, like its predecessor 4½ digit Model 245, uses the field-proven Tri-Phasic™ analog-to-digital conversion, Isopolar™ reference, and Ratiohmic™ resistance measurement technique. It provides laboratory-grade performance of high accuracy consistent with 3½ digit resolution, stability, and reliability.

b. The Model 175 DMM is complete, including carrying case, wrist strap, test probes, battery pack with rechargeable batteries, charger with integral line cord, and this complete instruction manual. Performance-extending accessories are available and are listed in paragraph 1.4.

1.2 OPERATING & DESIGN FEATURES

a. Model 175DMM is operated simply by selecting the measuring mode with one front-panel rotary switch and an appropriate range with the other. The measured input signal including sign and decimal point is displayed on 7-segment planar LED characters. All measured values are direct reading as determined by the selected function and range. Out-of-range inputs (overload) are indicated by a blanked display (decimal point and polarity sign, if appropriate, remain lighted).

b. A nominal full scale sensitivity of 100mV, 100 ohms, and 100 microamps is available for voltage, resistance, or current measurements, respectively, providing a resolution of 100 microvolts, 100 milliohms, and 100 nanoamperes. Measurements up to 100% overrange may be made on each range scale (except for voltage on the highest range) with the same high accuracy as for in-range measurement on each scale. Model 175 DMM incorporates protection circuitry to permit maximum input signals (within specifications) to be applied indefinitely on any selected range, without damage.

c. A fully-charged battery pack will supply 6 hours of in-specification operation; it can be recharged fully overnight (12 hours). Moreover, the batteries are always being recharged when the battery charger is connected, whether the meter is turned on or off. Power consumption is less than 1 watt when operating the charger, and is 0.6 watts when in battery operation only. Battery drain and parts count are minimized by the use of a proprietary LSI/CMOS chip which performs all the logic functions required by the A/D converter.

1.3 SPECIFICATIONS

1.3.1 DC Volts

Range	Full Scale	Resolution
100mV	± 199.9mV	100μV
1	± 1.999V	1mV
10	± 19.99V	10mV
100	± 199.9V	100mV
1k	± 1000.V	1V

Input Impedance: 10MΩ, all ranges.
Maximum Voltage: 1000V, all ranges.
Accuracy (1 year @ 23°C ±5°C): ±0.1% input ±1 l.s.d.
Temperature Coefficient (0°C to 40°C, all ranges):
± (0.01% input + 0.01% range)/°C.
Common Mode Voltage: 500 VDC (or peak AC) max when connected to AC power line.
1000 VDC (or peak AC) max when on battery operation.
Common Mode Rejection Ratio:
(with 1000 ohm source impedance unbalance)
AC line operation: >140 dB @ dc.
>120 dB @ 50Hz and @ 60Hz
Battery operation: Essentially infinite @ dc
>120 dB @ 50Hz and @ 60Hz
Normal Mode Rejection Ratio: >60 dB @ 50Hz and @ 60 Hz

1.3.2 AC Volts

Range	Full Scale	Resolution
100mV	199.9mV	100μV
1	1.999V	1mV
10	19.99V	10mV
100	199.9V	100mV
500VAC	500.V	1V

Input Impedance: 10MΩ in parallel with 75pF or less.
Sensing and Calibration: Average sensing, calibrated in RMS of sinewave.
Accuracy (1 year, @ 23°C ± 5°C).

Frequency*	Inaccuracy
30Hz	± (1% input + 5 l.s.d.)
50Hz to 500 Hz	± (0.4% input + 2 l.s.d.)
5kHz	± (1.0% input + 2 l.s.d.)
50kHz	± (3.0% input + 2 l.s.d.)

*Interpolate linearly between frequency end points.

Temperature Coefficients (0°C to 40°C, all ranges):

Frequency*	Coefficients
30 Hz to 500 Hz	± (0.02% input + 0.02% range)/°C
5kHz	± (0.1% input + 0.02% range)/°C
50kHz	± (0.15% input + 0.02% range)/°C

*Interpolate linearly between frequency end points.

Maximum input voltage (sinewave)
30Hz to 10kHz: 500 VRMS
>10kHz : Decreasing to 200 VRMS @ 50kHz

Settling Time: 2.5 seconds max.

1.3.3 Resistance

Range	Full Scale	Resolution	Nominal Test Current Hi Excitation	Nominal Test Current Lo Excitation
100Ω	199.9Ω	100mΩ	1mA	1mA
1	1.999k Ω	1Ω	1mA	200μA
10	19.99k Ω	10Ω	200μA	20μA
100	199.9k Ω	100Ω	20μA	2μA
1k	1999.k Ω	1kΩ	2μA	200nA
10MΩ	19.99MΩ	10kΩ	200nA	20nA

Accuracy (1 year @ 23°C ± 5°C):

Range	Inaccuracy Hi Excitation	Inaccuracy Lo Excitation
100Ω	±(0.2% input + 2 l.s.d.) + 100mΩ	±(0.1% input + 1 l.s.d.) + 100mΩ
100k Ω	±(0.1% input + 1 l.s.d.)	±(0.2% input + 2 l.s.d.)
1k	±(0.1% input + 1 l.s.d.)	±(0.3% input + 2 l.s.d.)
10MΩ	±(0.2% input + 1 l.s.d.)	±(1.0% input + 2 l.s.d.)

Temperature Coefficient (0°C to 40°C):

Range	Coefficient Hi Excitation	Coefficient Lo Excitation
100Ω, 1, 10, 100	±(0.01% input + 0.01% range)/°C	±(0.01% input + 0.01% range)/°C
1k	±(0.01% input + 0.01% range)/°C	±(0.02% input + 0.02% range)/°C
10MΩ	±(0.02% input + 0.02% range)/°C	±(0.1% input ±0.1% range)/°C

Maximum Open Circuit Voltage: 2.5 Volts (HiV); 300mV (LoV)
Maximum Input Voltage: 250 VRMS AC or DC

Settling Time:

Range	Time
100Ω, 1, 10, 100, 1k	1 second
10MΩ	4 seconds

1.3.4 DC Current.

Range	Full Scale	Resolution
100μA	±199.9μA	0.1μA
1	±1.999mA	1μA
10	±19.99mA	10μA
100	±199.9mA	100μA
1k	±1999.mA	1mA

Maximum Current: * Limited to 2A by series fuse (250V) located in red probe
Nominal Full Scale Voltage Across Shunts: 100mV
Accuracy (1 year @ 23°C ± 5°C): ±(0.3% input + 1 l.s.d.)
Temperature Coefficient (0°C to 40°C): ±(0.02% input + 0.01% range)/°C

1.3.5 AC Current

Range	Full Scale	Resolution
100μA	199.9μA	0.1 μA
1	1.999mA	1μA
10	19.99mA	10μA
100	199.9mA	100μA
1k	1999.mA	1nA

Maximum Current*: Limited to 2A by series fuse (250V) located in red probe.
* CAUTION: Protection is defeated if fused probe is not used.

Nominal Full Scale Voltage Across Shunts: 100mVRMS
Accuracy (1 year @ 23°C ± 5°/C):

Frequency*	Inaccuracy
30Hz	±(1.5% input + 5 l.s.d.)
50Hz to 10kHz	±(0.75% input + 2 l.s.d.)
50kHz	±(3.0% input + 2 l.s.d.)
	(±5.0% on 100 μA range)

*Interpolate linearly between frequency end points.

Temperature Coefficients (0°C to 40°C):

Frequency*	Coefficient
30Hz to 10kHz	± (0.03% input + 0.02% range)/°C
50kHz	± (0.1% input + 0.02% range)/°C

*Interpolate linearly between frequency end points.

1.3.6 All Measuring Modes.

Reading Rate: 2.5 readings/second
Polarity : Automatic plus (+) or minus (-) displayed for all dc measurements
Overload : Indicated by blanking of all digits; decimal point and polarity (if appropriate) remain lighted.

Power Supply: Battery pack with 4 NiCd batteries (5V). Recharging requires approximately 12 hours. Battery charger operates from 105-125V (47 to 400Hz). Model 175E operates from 220-250V (47 to 400Hz).
Power Consumption: $<$1 watt (0.6w battery operation).
Low Battery Indication: Decimal point blinks @ 2.5/second for approximately 10 minutes before discharge.
Environment:
Temperature Range: Operating, 0°C to 40°C
Storage, -25°C to +50°C
Humidity: 80% RH, 0°C to 40°C, noncondensing
Physical:
Size: 5½" w x 1¾" h x 3½"d.
Weight: 1.1 lb. net; $<$3 lb. packed for shipping.

1.4 Accessories

Name	Data Precision Model No.
Bench Stand	B40
Battery Module (Spare)	C75
Test Leads (Spare) (Set of two)	T4
Charger/Line Cord (105-125V)	L15
Charger/Line Cord (220-250V)	L30
High Voltage Probe (to 40kV)	V40A
Leather Case	WE8
Adaptor, Std. Banana to Mini Banana	MB2
Rack Mount	R35

NOTES

Chapter 2

OPERATION & CALIBRATION

2.1 GENERAL

a. Model 175 3½ digit Multimeter has been shipped with a fully charged battery pack, and should be usable immediately upon opening the box and attaching the probe leads.

b. This chapter contains:

(1) an inventory list of what you should find upon opening your packing carton;

(2) a complete description of the operating controls and indications;

(3) a step-by-step procedure for operating the instrument in any of its 6 measuring modes;

(4) a procedure for determining when to recalibrate the meter; and

(5) application notes to help obtain the measurement accuracies of which the meter is capable.

2.2 UNPACKING & REPACKING

a. Model 175 is shipped in a molded protective fitted container. This manual has been packed in a recess at the top of the outer protective layer, and should be read before attempting to use the meter. When the protective box is opened, you should find the following items inside the flexible fitted carrying case:

(1) Model 175 3½ digit Multimeter with attached wrist strap and battery pack module inserted;

(2) Line cord with attached battery charger unit; (Charger L15 for 105-125V) (Charger L30 for 220-250V);

(3) Two probes (Red probe fused with 2A (250V) fuse);

(4) Certificate of Conformance and copies of authenticated Factory Test Data Sheets;

(5) Warranty Card;

b. Carefully examine these articles, noting especially the matching serial numbers of the instrument and the test data. Inspect the packing case and the instrument for any signs of damage during shipment and report immediately to the carrier. Fill out and return the warranty card to register your instrument and to establish your warrantied service interval.

c. Accessories, such as bench stand, spare charger, spare battery pack, or high voltage probes, may have been ordered. These will be shipped in their own containers.

d. Retain the packing material for reshipment.

e. When shipping Model 175 DMM, place the instrument in its protective carrying case, including test probes and battery charger. Use foam liners and pack in original shipping carton, if available.

If original shipping carton is no longer available, wrap the instrument (in its carrying case as above) with a foam-type insulation or air bubble plastic and pack in a suitable carton. Use sufficient stuffing to keep the unit securely positioned in the carton.

f. If the Model 175 DMM is to be kept stored without use for any appreciable time (6 months or more), the batteries should be recharged every 6 months.

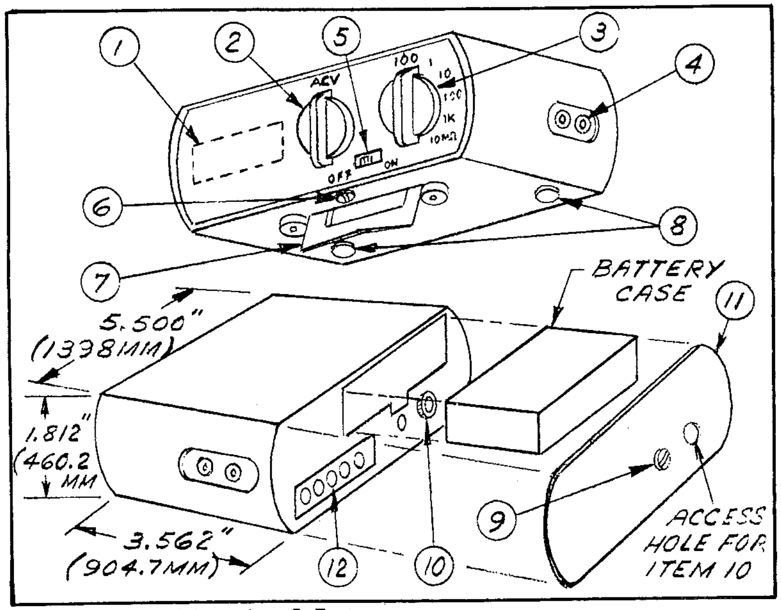


Fig. 2-1. Outline Dimensions & Features.

2.3 KEY POINTS ON YOUR MODEL 175 DMM (FIGURE 2–1)

Fig. Ref.	Item	Functional Description
1.	Display Area	Automatic polarity indication; decimal digits plus overrange "1"; and range-scale selected decimal point display.
2.	Function Switch	Rotary 6-position switch. Selects one of six measuring functions.
3.	Range Switch	Rotary 6-position switch. Selects one of five full scale display values and corresponding decimal points for voltage and current measurements, and one of six full scale values for resistance measurements.
4.	COM, HI	Receptacles for probe leads, common and high.
5.	Power Switch	Two position slide switch (ON–OFF). Applies battery power to multimeter.
6.	Assembly Screw	Slotted screw fastens meter assembly to case.
7.	Flip-Down Tilt Leg	Recessed hinged leg to support meter in tilt position.
8.	Non-skid pads	2 pads to prevent meter from sliding on smooth surfaces.
9.	Screw	Holds rear cover in place.
10.	Charger Input	Receptacle for charger input.
11.	Rear Cover	Removable cover to permit access to calibrating adjustments, and to remove battery.
12.	Adjustments	6 calibrating adjustments.

2.4 OPERATING PROCEDURES

2.4.1 General

Operate your multimeter in the following sequence for most efficient use:

a. If line power is to be used, attach battery charger output to meter at rear panel connector; then plug in battery charger to appropriate AC power line. See power data on charger label. Do not remove battery pack. Battery pack must always be installed for proper operation.

b. Turn the instrument on by selecting the desired measurement function with Function Mode Switch. . .DCV, ACV, etc.

c. Select the appropriate full scale range. . .1K, 100, 10, etc.

d. Connect test leads to meter and apply probes to circuit under test.

e. Read display.

f. Select range for highest resolution capability.

2.4.2 Applying Power

a. The Model 175 3½ digit multimeter may be operated from power supplied by the internal battery module containing four rechargeable NiCd batteries. The batteries will supply up to six hours of in-spec operation when fully charged. Completely discharge the batteries before recharging. Recharging requires approximately 12 hours. The meter may also be operated from AC line power, where available, without disconnecting the batteries. Use the AC charger and integral connecting cable supplied with the instrument. The standard Model 175 is shipped with a charger that operates from 105-125V AC; Model 175E is shipped with a charger intended for 220-250V AC. When the line cord and battery charger are connected, the batteries are always charging, even when power switch is in the off position. A protective circuit prevents overcharging the batteries. For extended field use without access to charging power, an extra battery module is recommended.

b. Low battery voltage is indicated by a blinking decimal point in the display, and approximately 10 minutes of useful battery power remains when the display first starts to blink.

2.4.3 Selecting Measuring Function

The left-hand, six-position rotary Function Switch makes the required internal connections to measure DC volts, AC volts, Kilohms (2.5V max. excitation), Kilohms (300mV max. excitation), DC milliamperes, or AC milliamperes. The switch positions are as shown in Table 2-1.

2.4.4 Selecting Range

The right-hand rotary Range Switch selects the full scale sensitivity of the measurement and simultaneously positions the decimal point for direct reading in the selected units. The switch positions and the full-scale readings are shown in Table 2-2. Note that the 10MΩ position is used only for resistance measurements.

CAUTION

When making voltage measurements, exercise care that the source signal does not include high voltage spikes which could be injurious to personnel or equipment.

2.4.5 Connecting the Inputs

Connect the probes: red probe lead to the HI receptacle and the black probe lead to the COM receptacle of the meter. Measurements made at the sensing ends of the probes will be the value of the HI input with respect to the COM input. If the meter reads +17.72 Volts DC, then the HI (red-lead) terminal is 17.72 Volts more positive than the COM (black-lead) terminal.

Table 2-1 Function Switch Selections

FUNCTION SWITCH POSITION (clockwise from DCV)	PARAMETER MEASURED
DCV	DC voltages up to 1,000 volts.
ACV	Up to 500 VRMS of true-average-calibrated in RMS AC voltage, from 30Hz to 10KHz, decreasing linearly to 200V at 50KHz.
kΩ(HiV) kΩ(LoV)	Resistance up to 20 megohms with maximum open-circuit voltage of 2.5V(HiV) or 300mV (LoV). Able to withstand connected external voltage of 250 VRMS AC or DC.
DCmA	Direct Current in milliamperes, up to 2,000mA, protected by 2-ampere fuse rated at 250V in red input probe.
ACmA	Alternating Current in milliamperes. Up to 2,000mA of true average value calibrated in RMS of equivalent sinewaves, protected by 2-ampere fuse (250V) in red input probe.

2.4.6 Reading the Display

a. DC polarities are automatically indicated on the display, and reflect the polarity of the HI signal with respect to the COM.

b. Overrange values up to 100% above the selected range will be measured and displayed. The maximum indication is 1999 with the appropriate decimal point location. (See exceptions for maximum voltages per specifications.)

Table 2-2 Range Switch Selection

Switch Position Marking (Clockwise from top)	Nominal Range	Overrange Full Scale Value	Units		
			Voltage	Current	Resistance
100(mV,Ω,µA)	100.0	199.9	mV	µA	Ω
1	1.000	1.999	V	mA	kΩ
10	10.00	19.99	V	mA	kΩ
100	100.0	199.9	V	mA	kΩ
1K/500VAC	1000.	(Note 1)	V	mA	kΩ
10MΩ	10.00	19.99	–	–	MΩ

(Note 1): See specification para 1.3 for overrange limits on these scales.

c. Overload measurements of more than 100% above the selected range are indicated by a blanking of all digits, leaving only the polarity of overload and decimal point display lighted. For example, if the applied signal is more than +19.99 volts on the 10 volt full scale range, only the + sign and the decimal point will appear.

d. Values on the display are interpreted directly in engineering units defined by the setting of the function switch and scaled by the setting of the range switch. The table below illustrates the interpretation of various displayed values for appropriate range scales and function modes.

Displayed Value	Function	Range	Interpretation
+1.234	DCV	1	1.234 volts positive DC
123.4	kΩ	100Ω	123.4 ohms
1.234	kΩ	1	1.234 kilohms
12.34	kΩ	10	12.34 kilohms
1234.	kΩ	1K	1,234 kilohms or 1.234 megohms
12.34	kΩ	10MΩ	12.34 megohms
+ .	DCV	10	Input is greater than +20 volts dc
.	kΩ	10MΩ	Input is greater than 20 megohms

2.5 CALIBRATION

a. The Model 175 Digital Multimeter is factory calibrated and burned-in prior to shipment, and is designed to remain in calibration for a minimum of one year before the recalibration procedure should be required. The complete set of factory test data sheets for each instrument are shipped with the meter, and may be referenced to determine the need for calibration.

NO ZERO ADJUSTMENT IS EVER REQUIRED ON ANY MEASUREMENT FUNCTION OR RANGE SCALE AND NONE IS PROVIDED.

b. When calibration is required, test standards of the ranges and accuracies listed below should be used to eliminate any test standard uncertainty.

Parameter	Range	Accuracy Tolerances
DC Voltage	0 to 200.0mV	±0.01%
AC Voltage		
@ 500Hz	0 to 200.0mV RMS	±0.05%
@ 10kHz	0 to 500.0V RMS	±0.10%

c. Calibration Adjustments are accessible through the rear panel, behind the removable cover plate in the lower left corner. Lift out the cover plate by inserting a small tool in the hole and lifting out. The circuit reference designations are stamped on the rear panel for each of the six adjustments.

d. Perform the adjustments in the sequence tabulated below. Apply test input standards of amplitude and frequency as close as possible to the values listed in the table. Adjust the designated control until the display is the input (or the designated reading). If available test standards do not develop the listed values, then the closest value to the specified input should be used and the control adjusted accordingly. It is desirable to use signals at least 50% of the full scale value for the specified range.

Calibration Sequence

Step	Function Select	Range Select	Test Input	Adjust
1.	DCV	100mV	+190.0mV	R10
2.	ACV	100mV	500Hz 190.0mVRMS	R4
3.	ACV	100	5kHz 190.0V	C1
4.	ACV	1000	5kHz 500V	C7
5.	ACV	10	5kHz 19.00V	C3
6.	ACV	1	5kHz 1.900V	C2
7.	Repeat Steps 3–6.			

2.6 APPLICATION NOTES

2.6.1 General

Optimum performance is obtained from your Model 175 by observing a number of precautions in establishing the test measurement conditions. The few hints included in these paragraphs are only indicative of the types of measuring environment problems which may influence the meter performance. It is suggested that the user add his own application aids in the space provided.

2.6.2 Avoiding Ground Loops (Making Grounded Measurements)

If the battery charger/line cord is connected, a potential difference may exist between the "ground" of the power source and the "ground" of the measured circuit. This difference of ground potentials may set up ground-loop currents and affect the measured values although the instrument will reduce their effects significantly (CMRR = 120dB, NMR = 60dB). The ground loop effects can be avoided almost completely by operating the meter on batteries.

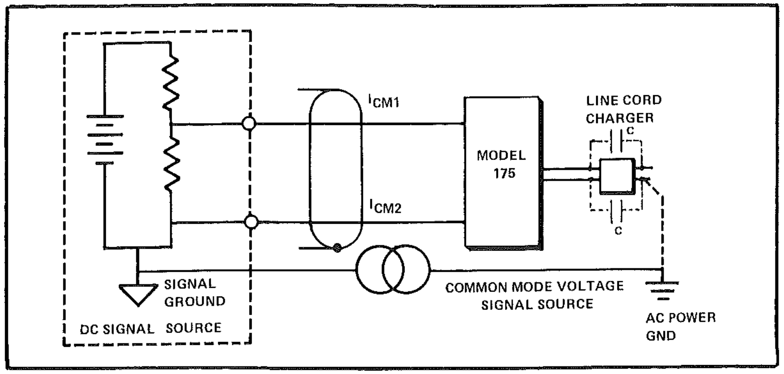


Fig. 2-2. Ground Loop Voltage Generation

2.6.3 Making "Floating" Measurements

In a floating measurement, such as in figure 2-3, it is possible to introduce a common mode voltage by reactive coupling through the AC power line when that source of Model 175 power is connected. As in paragraph 2.6.2, although this effect is small, it may be avoided almost completely by disconnecting the AC power source and reverting automatically to battery power.

2.6.4 Making High Resistance Measurements

a. When making measurements of very high impedance sources, as when required to measure resistance on the 10MΩ range, the input circuit may be susceptible to noise. The effect of voltage-producing noise fields on the probe leads may

be sufficient to introduce significant changes in the least significant digit of the display.

b. Measurement errors may be kept to a minimum under these circumstances by keeping the leads as short as possible (do not use any extensions on the probes), and by twisting the probe leads so as to equalize any field effects on the signal input leads.

NOTE: It is good practice to twist probe leads whenever possible in order to equalize any field effects on the signal input leads.

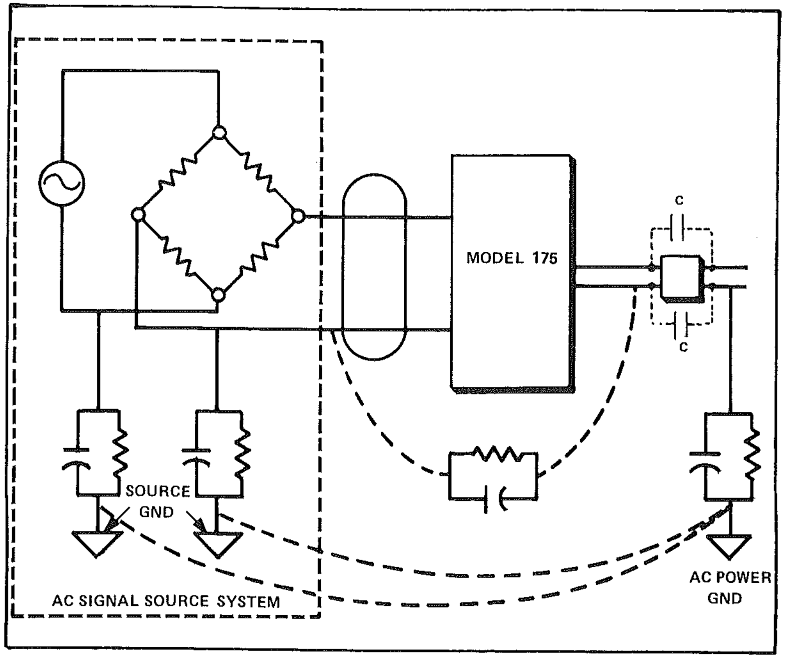


Fig. 2-3. Induced AC Common Mode Voltages

2.6.5 Making Very Low Voltage Measurements

Problems may arise when measuring very low voltages because of the differences in temperature of the probe contact points. Both probes are plated brass, and if the HI probe is in contact with copper in a high ambient temperature (for example, in a computer tape drive mechanism), while the COM probe is grounded at a very much cooler steel cabinet frame, then a difference in emf of several hundred microvolts may result, changing the least significant digit. In order to minimize such errors, connect the probes wherever possible at approximately the same temperature.

2.6.6 Making Complex Waveform AC Measurements

a. The Model 175 is calibrated in equivalent RMS values of a sine wave whose average half-wave rectified value is the value actually measured by the multimeter. Thus, if a non-sinusoidal waveform is applied at the input, the displayed value may be in error, depending upon the extent of the departure of the waveform from a true sinusoid.

b. The Model 175 develops a DC voltage from an AC input by half-wave rectification. The ratio of RMS to average halfwave of a sinewave is 2.2:1 for which the displayed value is calibrated. The corresponding ratios for other sample waveforms are shown in Table 2-4.

2.6.7 Making DCV Measurements in the Presence of AC Interference

Input dc voltages are frequently measured in circuits that inject an ac voltage in series with the unknown dc input signal. These "normal mode" interference signals are rejected by the Model 175 circuitry in accordance with the NMRR specifications in Chapter 1. The extent to which the ac component of the dc signal is attenuated depends upon the frequency of the ac interference. At 50 and 60 Hz, the ac signal amplitude is attenuated by a factor of at least 1000 (60dB).

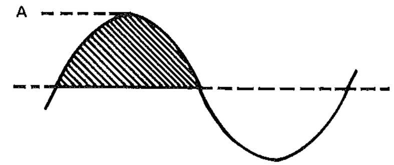
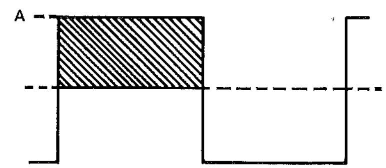
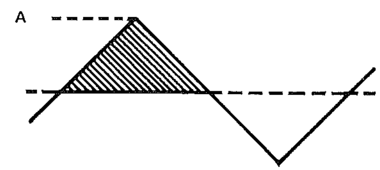
WAVEFORM	Model 175 AVG VALUE	TRUE RMS VALUE	MULTIPLY DISPLAY VALUE BY
	.707A	.707A	1.0
	1.11A	1A	0.909
	.555A	.574A	1.034

Table 2-4 Multiplying Factors for Non-Sinusoidal Waveform Measurements.

NOTES

Chapter 3

PRINCIPLES OF OPERATION

3.1 INTRODUCTION

Model 175 DMM is triggered automatically to initiate a 3-phase measurement cycle. During Phase 1 the meter circuits are automatically servoed to determine the correction for the accumulated zero offsets in the analog integrator loop. In Phase 2 the signal to be measured, which has been conditioned according to the type of signal (AC, DC, Hi or Lo Ohms) and selected range scale, is connected in series with the zero offset correction to the dual slope A/D converter integrator which integrates the conditioned input for a fixed time interval of 100 milliseconds. After the fixed time interval of Phase 2, Phase 3 begins, in which the input signal is disconnected from the A/D converter, and in its place a reference signal of opposite polarity and fixed magnitude is connected in series with the zero offset correction. The integration of the reference signal continues in Phase 3 until this second ramp of the dual ramp A/D converter reduces the voltage on the integrating capacitor to zero. The zero level on the integrating capacitor is sensed and indicates the End of Conversion (EOC) if it occurs in 200 msec or less during Phase 3. If there has not been an EOC signal within 200 msec in Phase 3, the meter interprets this as an overload condition. It quickly ends Phase 3 via a fast time discharge and initiates Phase 1 to restart the conversion cycle. The fast time constant introduced into the capacitor discharge circuit assures that the auto-zeroing integration in Phase 1 will start from zero conditions after an out-of-range input. The overload sense circuit also initiates the development of logic control signals for the overload display.

3.2 OVERALL BLOCK DIAGRAM

As shown in Fig. 3-1, the meter consists of the following major functional sections:

a. Input Signal Conditioners (Excitation, Dividers, Shunts, AC/DC Converter)

b. Tri-Phasic™ Analog-to-Digital Converter.

c. Digital Logic Programmer and Master Timing Oscillator.

d. Isopolar Reference Generator.

e. Display (Decoder and Scanner).

f. Power Supply (Including DC/DC Converter and Reference).

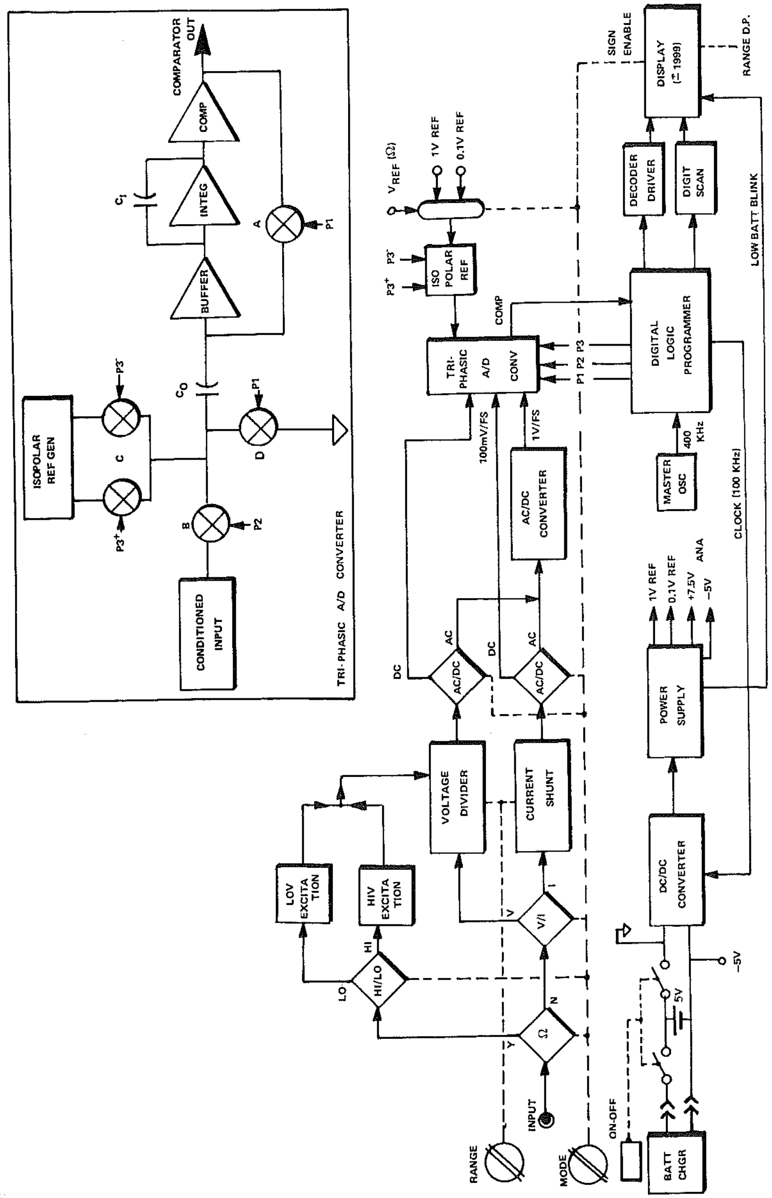


Fig. 3-1. Overall Block Diagram

3.2.1 Input Signal Conditioner

a. The input signal conditioner develops a scaled voltage output in accordance with the selected meter function and selected full-scale range. The signal-conditioned output is 1.0VDC full scale when the unknown input is a full scale ac voltage or current signal or when using Hi excitation for kilohms measurement. It is 0.1VDC full scale when the unknown input is a full scale dc voltage or current signal or when an unknown resistance is driven by the Lo excitation.

b. The input signal conditioner section remains linear for 100% of overrange input signal values and includes protective elements for overload conditions beyond the specified maximum measurable inputs.

3.2.2 A/D Converter

The analog section of the Tri-Phasic Analog-to-Digital Converter includes an input buffer stage, integrator, and comparator, connected as shown in a very simplified schematic of Figure 3-1. They function as follows during the three phases of Tri-Phasic operation.

a. Phase 1

During Phase 1 the analog section automatically zeros the unit to correct for the zero offsets inherent within the analog functioning elements. During this phase, switch A and switch D are closed, removing the conditioned input, and grounding the input to the high input impedance unity gain amplifier. As a result, the closed loop servos the output of the A/D comparator to near-zero. At that time a voltage will have been developed across the memory capacitor, C_O, which balances the sum total of all the individual offsets generated within the loop, and the servo loop "sees" a zero error signal.

b. Phase 2

At the start of Phase 2, switches A and D open, and switch B closes. In the open position of switches A and D, the analog section retains the offset voltage on memory capacitor C_O as a correcting value which will be combined algebraically with the input signals and the values integrated in Phase 2 and Phase 3.

Switch B, which remains closed during Phase 2, connects the input signal conditioner output to the unity gain buffer. The buffer output is integrated for a fixed time of 100 milliseconds as controlled by the digital logic. The voltage developed across the integrating capacitor C_I is therefore proportional to the magnitude of the input signal, and the output of the high-gain comparator amplifier will be at a saturation level of opposite polarity to the conditioned input voltage.

c. Phase 3

At the start of Phase 3, switch B opens, removing the conditioned output signal from the unity gain amplifier. At the same time (start of Phase 3), the polarity sense function of the digital section determines the polarity of the comparator output and transmits a control signal to the Isopolar reference switching network, thereby connecting the correct polarity of the reference voltages through Switch C to the unity gain amplifier for integration during Phase 3. The reference voltage integrated during Phase 3 decreases the voltage across integrating capacitor C_I until the output of the high gain comparator changes polarity. This change in comparator output polarity indicates end of conversion and is sensed in the logic to indicate the end of Phase 3 and the start of Phase 1. The cycle repeats.

If the charge on C_I is not reduced to zero in the time interval allowed for full overrange measurements, the digital control logic initiates the overload actions in the multimeter, as explained later. It should be noted that the zero offset is generated and the storage capacitor charge is updated in each conversion cycle. Also, note that the stored voltage representing the corrected zero is introduced into the analog section for both the unknown integration and the reference integration, thereby removing the zero effects from both the charging and the discharging actions on C_I.

3.2.3. Digital Logic Programmer

a. All of the logic circuitry to develop the phase timing control signals for the A/D converter are incorporated in one CMOS integrated circuit. This component receives the 400 kHz master oscillator pulse chain from which it derives the control signals for the start of Phase 1, the start of Phase 2 (100 milliseconds later) and the start of Phase 3 (100 milliseconds after the start of Phase 2). It also receives the A/D comparator output from which it derives the control signals to select the polarity of the reference for Phase 3 signal integration and the control signal that ends Phase 3.

b. The logic chip also generates the control signal for the fast discharge of the integrating capacitor, if applicable, and the control signals that cause the overload indication in the display.

c. The digitized value of the conditioned multimeter input is time multiplexed in BCD format on four parallel lines to the Decoder Driver, while the corresponding digit address is transmitted to the address scan element.

3.2.4. Decoder/Driver

The digitized value of the conditioned input is converted from the BCD format into 7-segment display code in a CMOS Decoder/Driver. The Decoder/Driver outputs provide adequate current to drive directly the segment of each

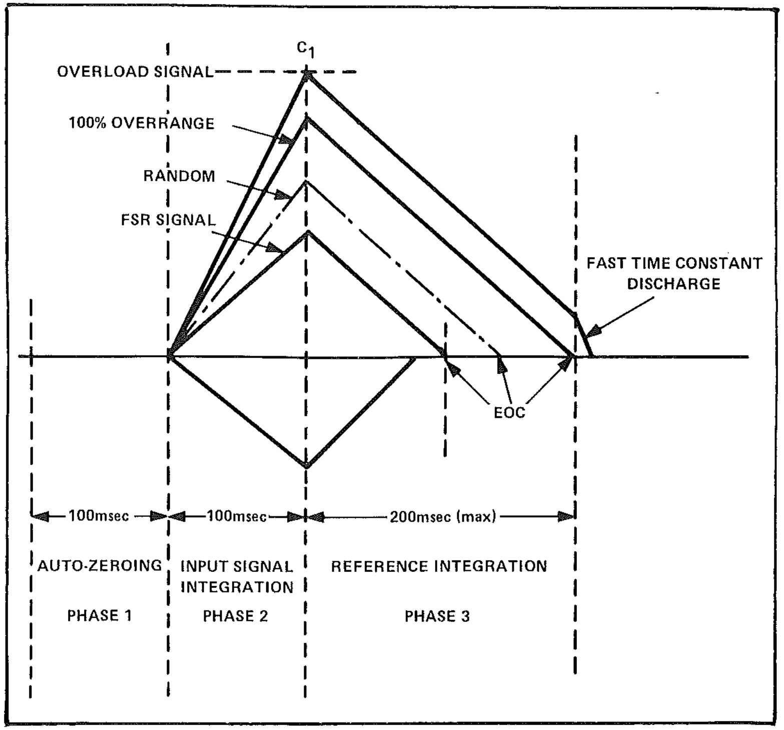


Fig. 3-2. System Timing Waveforms

digit display. The decoder unit also receives the blanking control output from the digital programmer (paragraph 3.2.3) and responds with the blanked display format of an overload indication.

3.2.5 Display

The display consists of three full decades of seven-segment characters, a fourth element which may take a character of "1" or remain blank, and an element for indicating the polarity of the input signal. The decimal point position is controlled directly by the manual range selection, and may be located in any one of four positions.

3.2.6 Reference Generator

The Iso-polar™ reference generator provides a precise 1.0 or 0.1 volt level to be connected to the analog input for Phase 3 operation. The selection of 1.0

or 0.1 voltage level is accomplished by the mode selection. The Iso-polar action obtains positive or negative references with equal magnitudes.

3.2.7 DC/DC Converter & Power Supply

a. Power for the meter is obtained from a 5-volt battery supply which is connected as a negative voltage source. A plug-in battery charger, provided as standard equipment, maintains the 5 volt charge whenever the charger is connected to line power, whether or not the meter is on. The DC/DC converter is connected to the battery supply only when the meter is turned ON, and develops nominal +7.5 volts for the analog circuitry. The –5 volts for the digital logic and for the analog amplifier units are supplied directly by the battery.

b. The reference voltage generator regulates the +7.5 volt output of the DC/DC converter, and develops both the +1 volt and 100mV reference potentials for use in the A/D conversion. The isopolar reference circuitry determines the appropriate polarity of these levels before connection to the A/D converter in Phase 3. The regulation circuitry also monitors the level of the –5V supply and causes the decimal point to blink when a low-battery condition exists.

3.3 INPUT SIGNAL CONDITIONING

3.3.1 Voltage Divider

a. Model 175 DMM scales all ac and dc voltages in a frequency-compensated voltage divider, as shown in the fold-out reference schematic. Parts of the divider are also used as the reference resistance for the Ratiohmic resistance measurement. In voltage measurement operation, the input is scaled to apply 100mV at nominal full scale (199.9mV at 100% overrange) to the input of the A/D or AC/DC converter. The decimal point location automatically tracks the decade selection effected by the range switch.

b. Resistance elements of the divider are contained in a single resistor network, A1, that has been trimmed during manufacture to within 0.1% relative and absolute accuracy. No external resistive trimming is required. Capacitive elements that trim the network for specified frequency response are mounted external to the resistor network. As noted in the reference illustration, C14, C13, and C12 are trimmed by C1, C2 and C3, respectively for the separate decades, while C4 is trimmed by bleeding some current through C7 from the full input via C6. The combination R1 and C10 provides a compensation for the distributed capacitance changes as the switch position is changed.

3.3.2 DCV Signal Conditioning

When the Function Switch is in the DCV position, the output of the voltage divider is connected to the A/D converter during Phase 2 of the 3-phase conversion cycle. Resistor R7 and capacitor C23 form a simple input filter for all dc input signals.

3.3.3 ACV Signal Conditioning (Reference Fold Out)

a. When the Function Switch is in the ACV position, the output of the voltage divider is connected to the AC/DC converter. The AC/DC converter is of the follower type.

b. Transistors Q3 and Q4, preceded by the clamping action of CR6 and CR7, form a high impedance source follower input for the signal from the input attenuator. Amplifier Z1 and its circuitry are connected as a half-wave rectifier with a gain such that an input sinusoid of 100mVRMS will produce a nominal 1 volt dc output of the AC/DC converter. The AC/DC converter is connected through a pair of contacts of the Function Switch to the A/D converter through the same filter action (R7C23) as for dc input signals. Another pair of Function Switch contacts operate in the A/D circuit to control the loop gain of the integrator to correspond to the 1 volt full scale output of the AC/DC converter.

3.3.4 Current Shunt & Current Input Conditioning

a. When in either DCmA or ACmA position, the Function Switch connects the input signal to a decade current shunt (R24 through R28). Shunt values are selected so that full scale output will be 100mV. Diode ring CR1 thru CR4 provide a protection against overload input to keep the shunt voltage outputs within ± 1.5V.

b. When in DCmA position, the Function Switch connects the shunt output to the A/D converter, as for DCV operation.

c. When in ACmA position, the Function Switch connects the shunt output to the AC/DC converter and the AC/DC converter output to the A/D input as for ACV operation.

3.3.5 Resistance Measurement Signal Conditioning

a. In the Data Precision Ratiohmic technique of resistance measurement, the signal conditioning for A/D input is accomplished as part of the same circuit that develops the Isopolar reference input for the A/D during Phase 3. Figure 3-3 is a simplified schematic of the Model 175 instrumentation illustrating the principles of operation.

b. As shown in the illustration, selection of kΩ (LoV) by the Function Switch applies a nominal 250mV as the reference voltage, while selection of kΩ (HiV) applies a nominal 2.5V as V REF. In either mode, the reference voltage is applied across the series-connected unknown resistance and the range-selected precision standard resistance. (The standard resistance is selected from the voltage-divider precision resistor network described previously in paragraph 3.3.1.) The voltages for Phase 2 and Phase 3 are generated by the current, I_S, whose value is determined by the series combination of the two resistances.

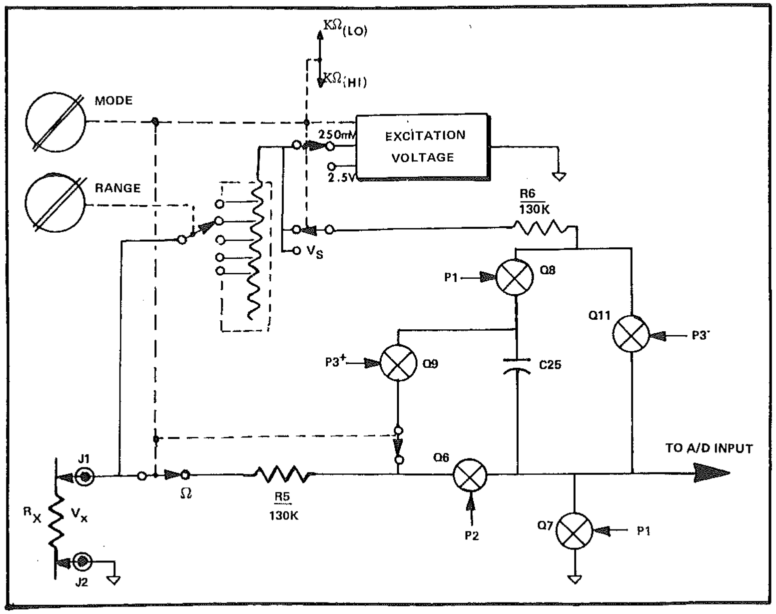


Fig. 3-3. Resistance Measurement Signal Conditioning

c. The voltages connected to the A/D input are controlled by the switch closures of Q6, Q7, Q8, Q9, and Q11. During Phase 1, C25 is charged to the value $V_S + V_X$ by the closing of Q8 and Q7. The input to the A/D is zero because of the closing of Q7. During Phase 2, Q7 and Q8 open, Q6 closes, and the input to the A/D is V_X. During Phase 3, Q6 opens, and Q9 closes connecting the high side of C25 to V_X. The low side of C25 is thus $V_X - (V_X + V_S)$, or $- V_S$, and that value is the input to the A/D. The dual slope integration digitizes the ratio V_X/V_S. But $V_X = I_S \cdot R_X$, and $V_S = I_S \cdot R_S$, so that the measured value is the ratio R_X/R_S, as required.

d. The generation of V_{REF} for resistance excitation is illustrated in the simplified schematic of Figure 3-4. Selection of HiV or LoV mode determines the inverting input to differential amplifier Z6. The non-inverting input is obtained from the regulated +7.5V, and is $\frac{270 \times 10^3}{7.77 \times 10^6}$ (7.5) = 250 millivolts, nominal. For LoV excitation, the V_{REF} is servoed to the nominal 250 millivolts. When in HiV excitation mode, the feedback around Z6 is opened, causing it to saturate to the +7.5 volts of the supply voltage, producing 2.5V max as V_{REF}.

3.4 TRI-PHASIC A/D CONVERTER

a. The fold-out reference schematic identifies the A/D circuitry containing

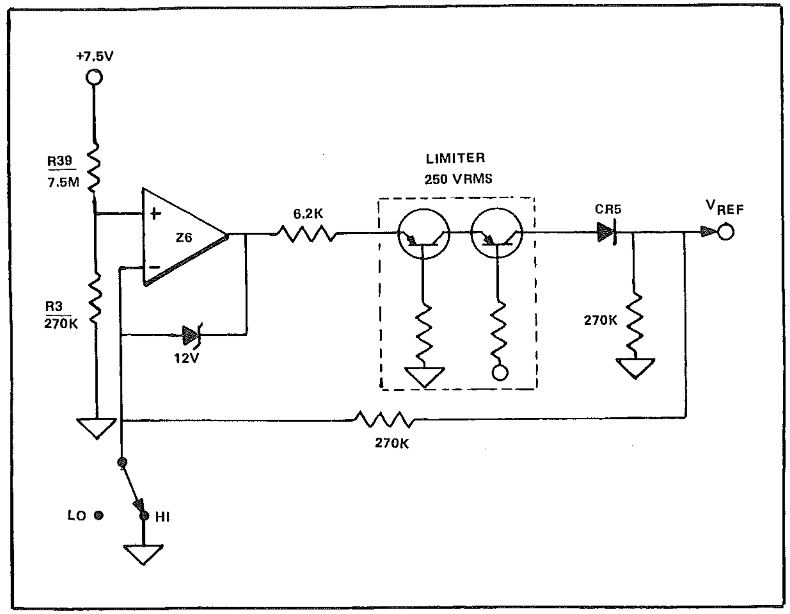


Fig. 3-4. Resistance Voltage Excitation

active elements Q13, Z2A, Z2B, and Z3. Unity gain buffer amplifier Z2A is preceded by the matched high impedance FET pair Q13. Amplifier Z2B is connected as an integrator with integrating capacitor C27, and selectable charging-path-resistor 100K, or the parallel combination of 10K. Amplifier Z3 is connected as a high gain comparator with gain control by R9 and R10.

b. During Phase 1 Q14 is closed, connecting the comparator output to the A/D input, and servoing any non-zero signals generated in the active elements to charge capacitor C26 with a voltage balancing the non-zero effects. If the prior conversion is overload, digital logic programmer Z4 transmits the FC signal to close Q18 and provide a path from comparator output to the integrator capacitor. This action delivers a high level charging current to reduce the remaining voltage on C27 to zero before the start of Phase 2.

c. During Phase 2 Q6 is closed, connecting the conditioned input to the A/D converter. If the conditioning includes the AC/DC converter or the HiV excitation, the input is scaled at 1V for full scale, and the Function Switch selection sets up the 100K resistor in the integrator charging path. If the conditioning is of a dc input signal or by the LoV excitation, then the input is scaled at 100mV for full scale, and the Function Switch selects the 10K resistor combination in the integrator charging path. Thus, the effective integration is the same for all measuring modes. Phase 2 lasts for 100 milliseconds. At the end of Phase 2, the comparator output is sensed by the digital logic Z4, and the appropriate

Phase 3 control signal is generated to select the opposite polarity reference signal for Phase 3 integration. (See para. 3.5 for Isopolar referencing.)

d. During Phase 3 Q6 opens, removing the conditioned signal input, while the closing of Q11 applies a negative reference, or of Q9 applies a positive reference to the A/D converter. The reference magnitude is determined by the Function Switch selection so that 1VDC or 100mVDC are selected, as appropriate. The charging path for C27 remains set up as for Phase 2, and the circuit reduces the voltage on C27 while the digital counter in Z4 digitizes the measured value. Phase 3 lasts until comparator Z3-1 indicates the zero crossing of the C27 voltage by a change in polarity of the Z3-1 output. The comparator output change is sensed in digital logic Z4 and results in the generation of the Phase 1 control signals to start the next conversion.

3.5 ISOPOLAR REFERENCING

a. Figure 3-5 is a simplified schematic of the complete circuit in the fold-out reference. The Function Switch selection applies 100mVDC when selecting DCV or DCmA, or 1VDC when selecting ACV, ACmA.

b. During Phase 1, Q2 and Q7 are closed, charging C25 to the 100mV or 1V reference value. During Phase 3, if a negative reference is required (positive conditioned input) Q9 closes, placing the high side of C25 at ground level. As a result, the negative side of C25 is negative by the magnitude of the voltage on C25. If a positive reference is required (negative conditioned input), then Q11 is closed, connecting the positive reference as input to the A/D converter.

3.6 DIGITAL LOGIC PROGRAMMER & MASTER OSCILLATOR

a. The digital logic programmer circuitry is contained entirely on one CMOS solid state component, Z4. It contains (Fig. 3-6):

3-Decade Counter and the MSD flip-flop
Latching BCD Output Register
Clock Generator
A/D Phase Signal Generator and Fast Charge Control
Polarity and Overload Detection Logic

b. In addition to the phase control signals described earlier, digital logic Z4 outputs the latched register BCD values series by digit, parallel by bit on 4 BCD output lines. The digit address for the BCD data is indicated on a high level on one of 3 parallel lines, while separate output lines indicated the binary value of the MSD (0 or 1), and the polarity (binary + or –). The binary overload condition is also indicated on a separate Z4 output line.

c. The master clock oscillator circuit containing crystal Y1 oscillates at 400 kHz. This frequency is counted down by 40 to obtain a basic counting rate of

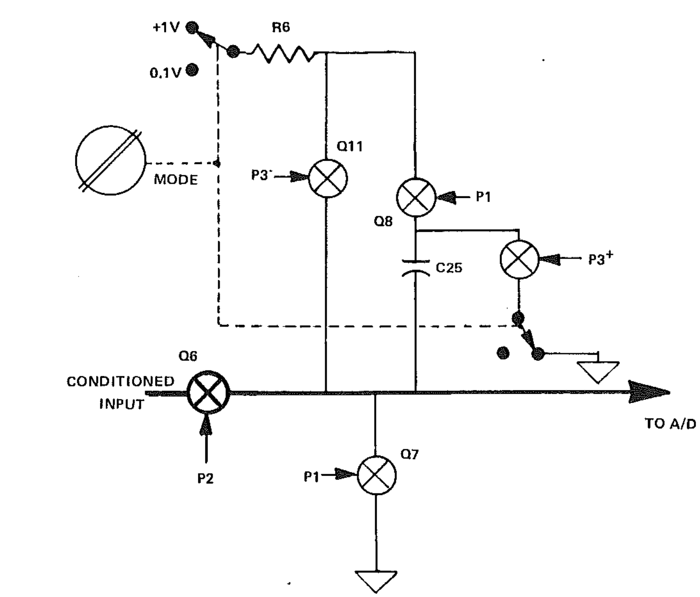


Fig. 3-5. Isopolar Reference Voltage Generation

10kHz so that the carry from the 3-decade counter represents an interval of 100 milliseconds for Phase 1 and Phase 2 timing. An MSD divide-by-two flip flop at the output of the 3-decade counter is used to sense the MSD of 10^4 counts, and, when digitizing an overload input to the A/D, senses 2 X 10^4 from which the blanking control and FC control signals are developed.

d. Decoder/Driver Z5 receives the latched outputs in BCD format time multiplexed on 4 parallel lines successively for each of the three full decades. It converts these to appropriate seven-segment outputs for the LED display digits.

e. Figure 3-7 is a summary of the timing relationships of the waveforms generated in Z4. Conditions for converting an in-range A/D input are shown

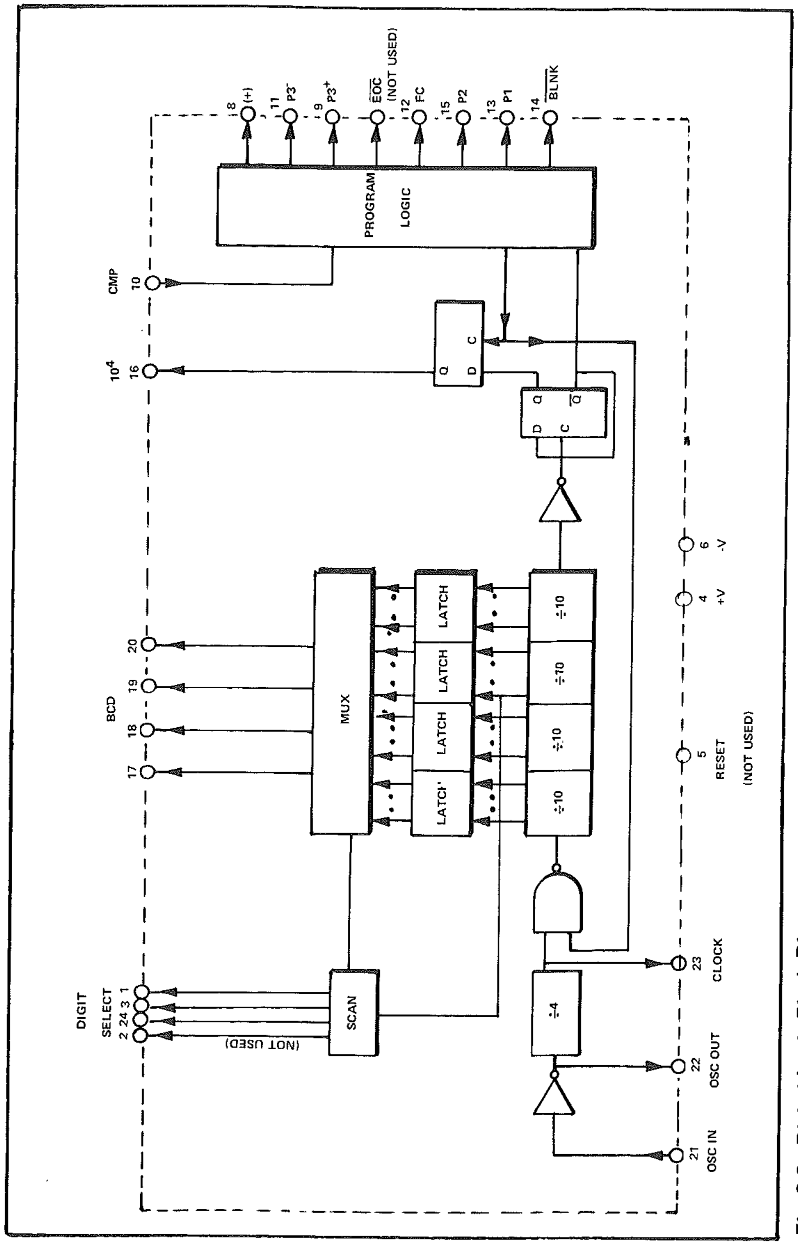


Fig. 3-6. Digital Logic Block Diagram

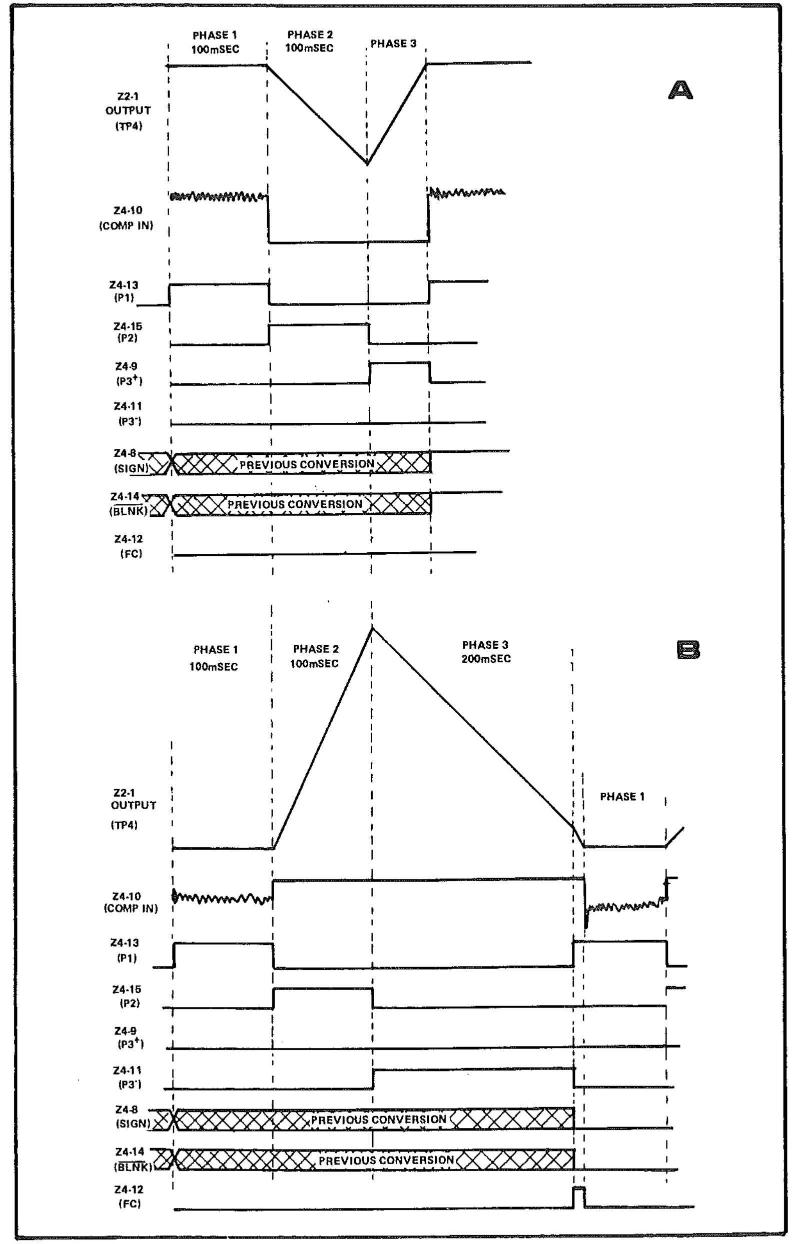


Fig. 3-7. Digital Logic Timing Waveforms

in Fig. 3-7A and for an overload input in Fig. 3-7B. The voltages of the output of the A/D integrator and comparator are reproduced as references for the timing, and note that Figure 3-7A illustrates the conditions for a positive in-range input, while Figure 3-7B assumes a negative overload condition. The SIGN output of Z4 is always produced; whether the polarity is displayed is determined by an enabling signal controlled by the setting of the front-panel Function Switch.

3.7 DISPLAY

The display is assembled on a separate PC card. It contains the four display digits, including sign and decimal points, current limiting resistors for the segment drivers of the three full decades, transistor driver circuits for the most significant "1" (when appropriate), and for the polarity (plus or minus). Digit address enabling signals multiplex the full decade digits DS102, DS103 and DS104; a control signal from the main PC board assembly enables the polarity display when in DCV or DCmA measuring function. Range-selected control signals drive the decimal point in the appropriate decade through limiting resistors.

3.8 DC/DC CONVERTER & POWER SUPPLY

a. The DC/DC Converter is of the switching regulator type, triggered by a 100kHz pulse train from the digital programmer. Transistors Q19 and Q20 switch current through L1 alternately through Q19 and CR11. When Q19 is "OFF", the current in L1 continues to flow through CR11 and charges capacitors C38 and C37, which, with R14 provide a filtering of the

b. Amplifier Z6 and zener reference CR10 are connected in a voltage regulator circuit that results in a regulated +7.5V for the analog circuitry, and from which is derived the analog references of +1V and 100mV for Phase 3 A/D conversion. Five-sixths of the zener reference of 6.4V to the inverting input of Z6 is servoed in Z6 until the same value is input to the non-inverting input to Z6. At equilibrium, the voltage output will be a nominal +7.5V, and will be maintained at that value by the regulator action. This value is sufficient so that adjustment of R10 will result in 100mV reference to appear within the range of R18, and a value of 1 volt to exist within the voltage range across R4 for ac reference.

c. Comparator Z3 senses the low battery condition, and transmits a square-wave control signal through decimal point driver Q16 to cause the blinking decimal point indication of low battery.

Chapter 4

MAINTENANCE

4.1 GENERAL

CAUTION

The Model 175 Multimeter is covered by a one-year warranty and should be referred to the factory for maintenance within the warranty period. Attempts to make any extensive repairs within the warranty period may invalidate the warranty. If repairs are needed after the warranty period, only qualified technicians should attempt to effect such repairs and should use test instruments and standards calibrated within the accuracy and tolerances of the specifications.

4.2 TROUBLE-SHOOTING FLOW CHART

Should the meter performance indicate a possible need for repair, a well-defined strategy should be used to isolate the cause of trouble. This is illustrated in Figure 4-1. It indicates a sequence of steps in terms of standard symbols and defines a program of actions based on a philosophy of positive maintenance. The positive approach isolates to the faulty sections by verifying proper operation of the remaining instrument sections.

4.3 TEST POINTS

The test sequences identified in the chart of Figure 4-1 are described in step-by-step detail in the paragraphs that follow. In performing the tests detailed in these paragraphs, the maintenance technician is directed to make measurements at designated test points which have been placed at significant portions in the circuit. The special test points are identified by TP- and E-reference numbers, and their locations on the printed circuit board are shown in Figure 4-2. Other test points designated in the test procedure paragraphs may be pin terminals of circuit components, and technicians should refer to component data sheets for the pin terminal locations as well as to Figure 4-2. Use caution in attaching test leads to avoid accidental shorting of adjacent components. The use of EZ Mini Hook R, or equivalent is suggested to aid in making good connections.

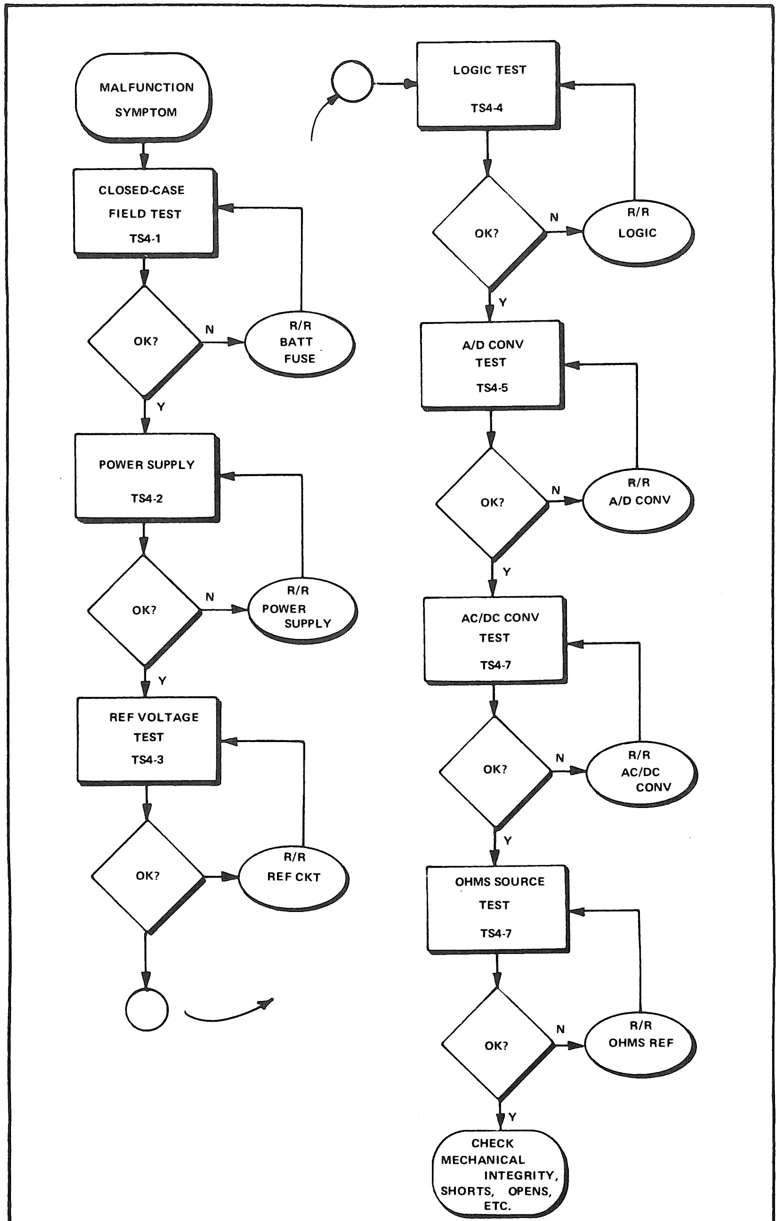


Fig. 4-1. Trouble Shooting Strategy

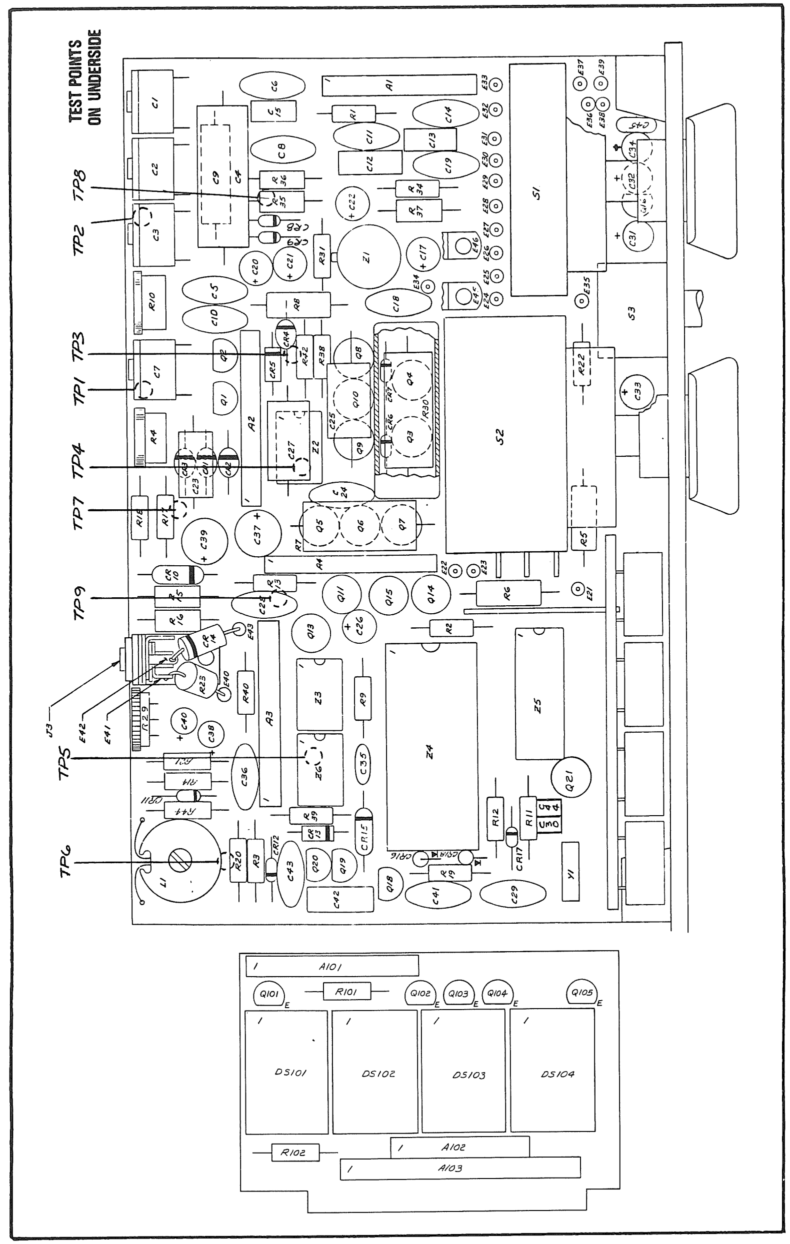


Fig. 4-2. Assembly Parts and Test Points

4.4 CLOSED-METER TESTS (FIELD MAINTENANCE) TS4-1

a, The first test sequence is performed with the "cased" meter. The sequence is fully detailed in the illustration of Figure 4-3.

b. Model 175 DMM may exhibit certain battery performance below rated characteristics that are only temporary operational effects typical of battery usage patterns. Such below-specification performance can be corrected easily and in a minimum of time.

Memory. If the meter is used in a series of repeated partial charge and discharge cycles that use only a small portion of the available battery capacity, the battery will become conditioned to deliver only slightly more than normal end-of-discharge voltage capacity when called on to perform in an extended discharge cycle.

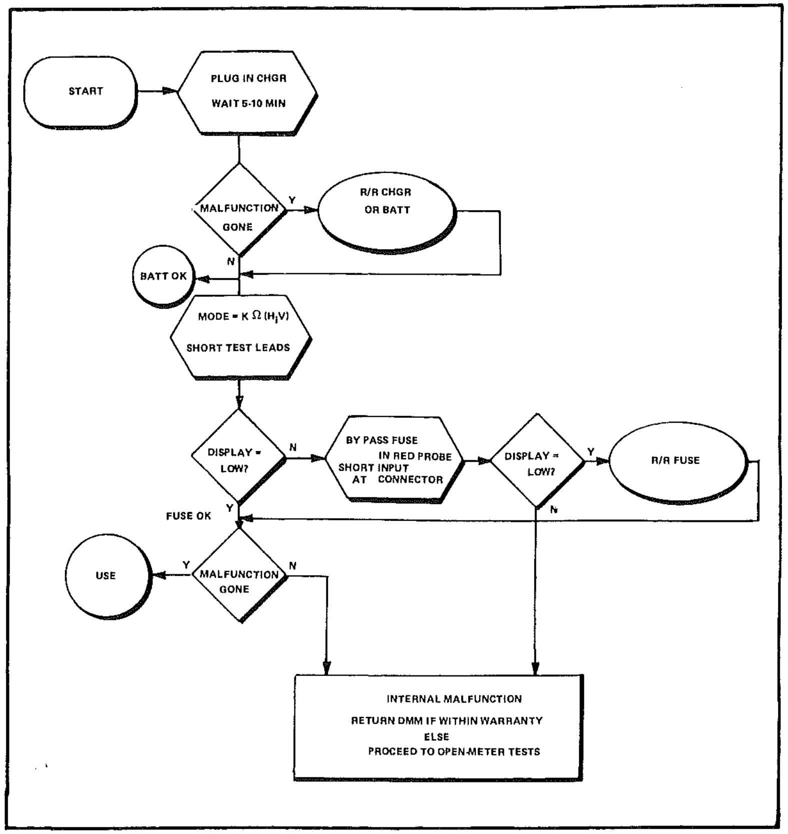


Fig. 4-3. Test TS4-1, Closed Meter Testing

To correct this condition, subject the battery to a deep discharge, and then recharge to full capacity. This will erase the "memory" pattern.

Sustained Overcharge. If the meter is kept on "high voltage charge" for long periods of time without discharge interruptions, the battery may not deliver normal voltage at the end of the first sustained discharge operation thereafter.

To correct, proceed as for the memory effect described above; discharge the battery, then recharge to full capacity.

4.5 OPEN-METER TEST/MAINTENANCE

4.5.1 General

If the multimeter does not perform correctly after the tests of TS4-1 are satisfactorily completed, then it is likely that repairs to an internal assembly are required. The sequence of such tests is indicated in the overall strategy of Figure 4-1, and is identified by a TS number for further reference. Each test sequence paragraph includes the designation of test points, the indications of proper performance, the circuits that are checked when proper performance is observed, and the circuits that should be examined in greater detail when indications of improper performance are recorded. Refer to the fold-out schematic in the back of this manual for complete circuit details, and to Chapter 6 for replacement parts identification.

4.5.2 Removal of Meter Assembly from Case (See Figure 2-1)

a. The meter assembly is contained on one main PC board. To remove this board from the case:

(1.) Remove the battery module;

(2.) Remove the fastening screw from the case underside;

(3.) Carefully withdraw the meter assembly from the case through the front. Place on insulating surface. Major assemblies are pointed out in Figure 4-2.

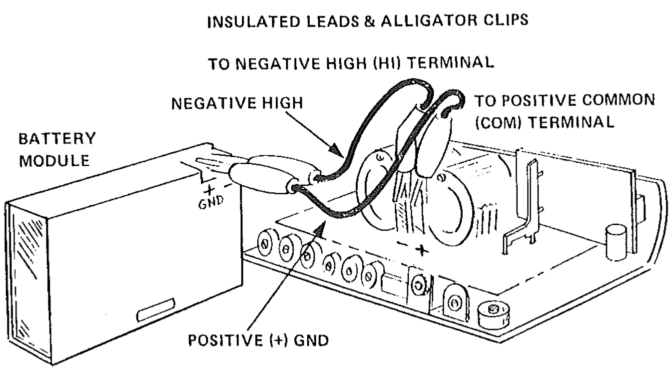
b. To insure specified accuracy, the meter must be recalibrated each time it is removed and replaced in its case. See Chapter 2 for recalibration procedures.

4.5.3 Applying Power to the Meter Assembly

Power for the multimeter may be obtained by connections to the battery pack with jumpers as shown in Figure 4-4. Be sure that a fully charged battery pack is available for these trouble-shooting test sequences. The battery charger may be connected after the battery has been connected to the circuit.

WARNING

Be sure to maintain the proper polarity relationships as shown in Figure 4-4. Improper polarity connection, even if momentary, may result in major component damage. The battery module should be connected before connecting the charger input because the battery acts as a necessary filter for the charger circuit.



WARNING
CROSSED POLARITIES WILL CAUSE IRREPARABLE DAMAGE TO COMPONENTS!!!

Fig. 4-4. Connecting Battery Module to Assembly

4.6 TEST EQUIPMENT

Test instruments and reference standards needed for the trouble shooting analysis should have the following characteristics:

Parameter	Range	Accuracy	Measure/Generate* M/G
DC Voltage	-10V to +10V	±0.1%	M/G
AC Voltage	1 kHz 100 mV 150KHz 1 VRMS 10KHz 200 VRMS 100 VRMS 10 VRMS 1 VRMS	±0.1%	M/G
Timing Waveforms	Oscilloscope 5 MHz BW	± 5%	M
Resistance	0 to 10 MΩ	±0.1%	M/G

*Measure = indicates test instrument. Generate = indicates source instrument.

4.7 POWER SUPPLY TEST TS4-2

a. Select KΩ Mode and 10MΩ Range positions.

b. Check for the indicated voltages at the test points shown below:

Test Points*	Measure Value*
E46	Battery (-5V nom)
TP7	-5V± 0.5V
TP6	7.5V ± 0.5V

*Measurements are made with respect to E45.

c. If all readings are correct the DC/DC converter and regulator are operating satisfactorily. An incorrect reading may result from a short circuit in one of the boards driven by the power supply or by a failure within the DC/DC converter. If TP7 test result is in error, also check ON-OFF switch and R13.

d. Unless a battery is shorted or completely discharged, it is unlikely that the -5V supply will be in error, because it is directly connected to the battery. If the +7.5 supply is out of tolerance, then proceed as in the following paragraphs.

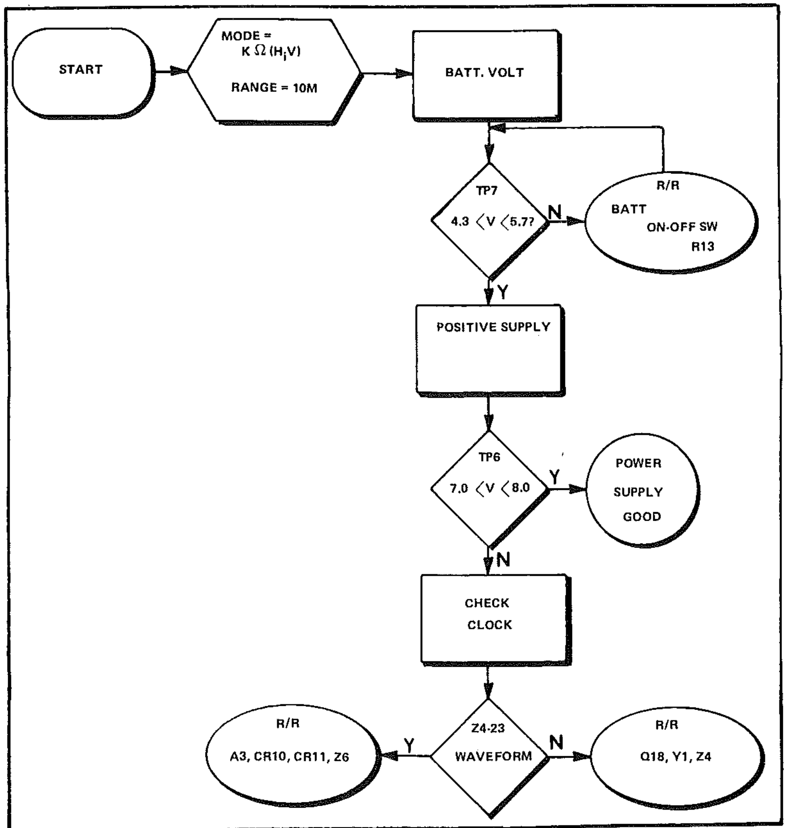
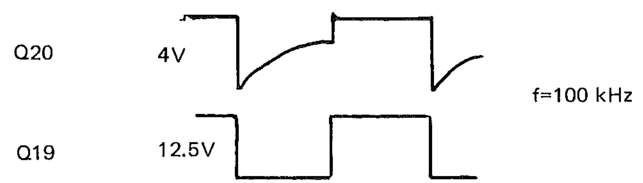


Fig. 4-5. Test TS4-2, Power Supply Trouble Shooting

e. Check waveform at Z4 pin 23. Proper functioning of master oscillator circuit (Y1) and count-down section of Z4 are indicated by observing a 100kHz square wave at amplitude of 4V p-p.

f. Check switching components Q18, Q19, and Q20 for waveforms on Q20 base and Q19 collector.



g. If switching operation is satisfactory, then the regulator amplifier Z6 and associated circuitry should be checked to clear symptom of low voltage at TP6.

4.8 DIGITAL LOGIC TS4-3

All the digital logic functions are essentially implemented in two CMOS chips, Z4 and Z5. The separate and sometimes independent functions performed by these LSI circuits are checked as shown in Figure 4-6. Proceed as shown below. (A simplified block diagram of Z-4 is shown in Figure 3-6.)

4.8.1 Time-Base Generation

Check 100kHz Clock. Waveform at Z4-23 should have 4V p-p amplitude. If not, trace from origin at master timing oscillator and Z4.

4.8.2 Program Logic

a. Connect Z4-10 to Z4-5. Simulates overload input.

b. Observe waveforms at Z4 outputs and compare with those illustrated in Figure 4-7. If satisfactory, then Z4 is functioning properly.

4.8.3 Decoder/Driver Logic

a. Observe display. If indication is of an overload input (blanked digits), then Z5 function is partially checked.

b. Short Z5-4 to ground (Z5-3) and connect Z5-7, Z5-1, Z5-2, and Z5-6 to Z5-5 (–5V). This action simulates a zero value out of the counter of Z4.

c. Observe display. If indication is 000, Z5 is functioning properly.

d. Remove all shorting jumpers.

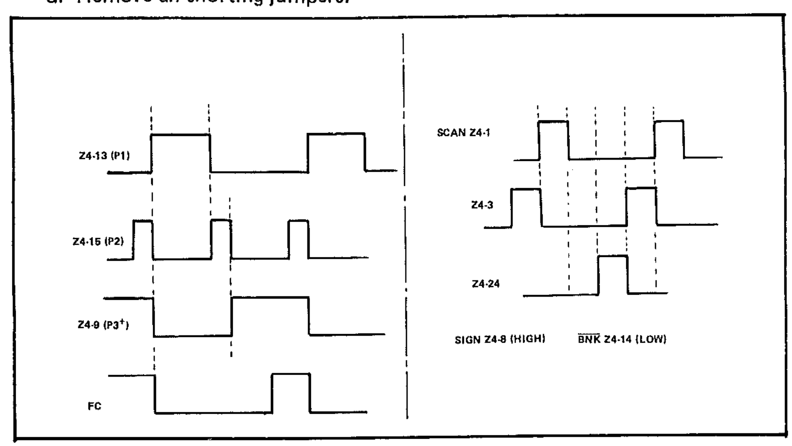


Fig. 4-7. Program Logic Waveforms

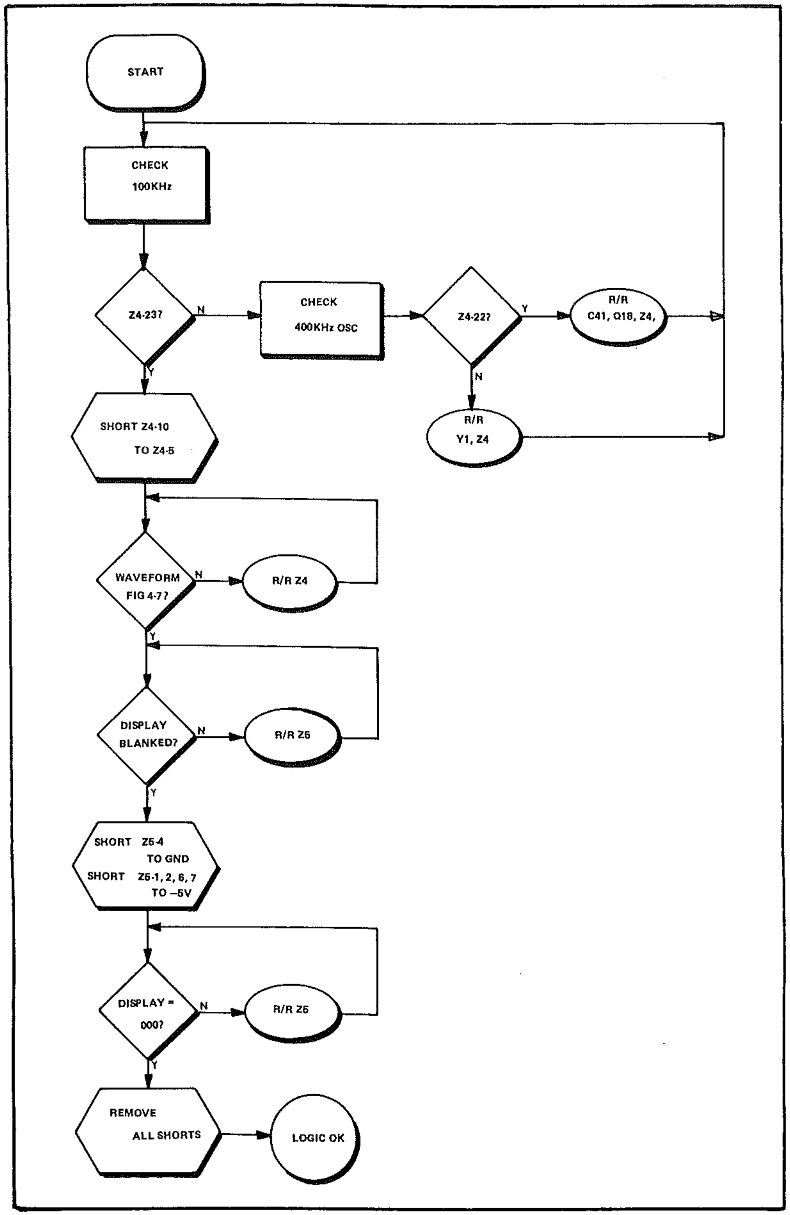


Fig. 4-6. Test TS4-3. Digital Logic Trouble Shooting

4.9 A/D CONVERTER & SIGNAL CONDITIONERS TS 4-4

4.9.1 Analog A/D

a. Select DCV measuring function.

b. Connect Z4-13 to ground E39 and Z4-9, Z4-11, Z4-12, and Z4-15 to Z4-5 (–5V). This places the A/D in Phase 1 auto zero operation.

c. Observe output of comparator Z3-1. Proper functioning of the auto zero loop is indicated by the appearance of noise of about nominal 1V amplitude. If output at Z3-1 is saturated (high or low) then replace Z3.

d. Signal trace through A/D by following the steps shown in Figure 4-8. Remove shorting connections when finished.

4.9.2 AC/DC Signal Conditioner

a. Select ACV function.

b. Apply 100mVRMS @ 1kHz to V_X Hi and V_X COM.

c. Observe waveform at TP8. Round-top "square" waves approximately 3.5V peak-to-peak amplitude at 100kHz indicate proper operation of the AC/DC conditioner circuit.

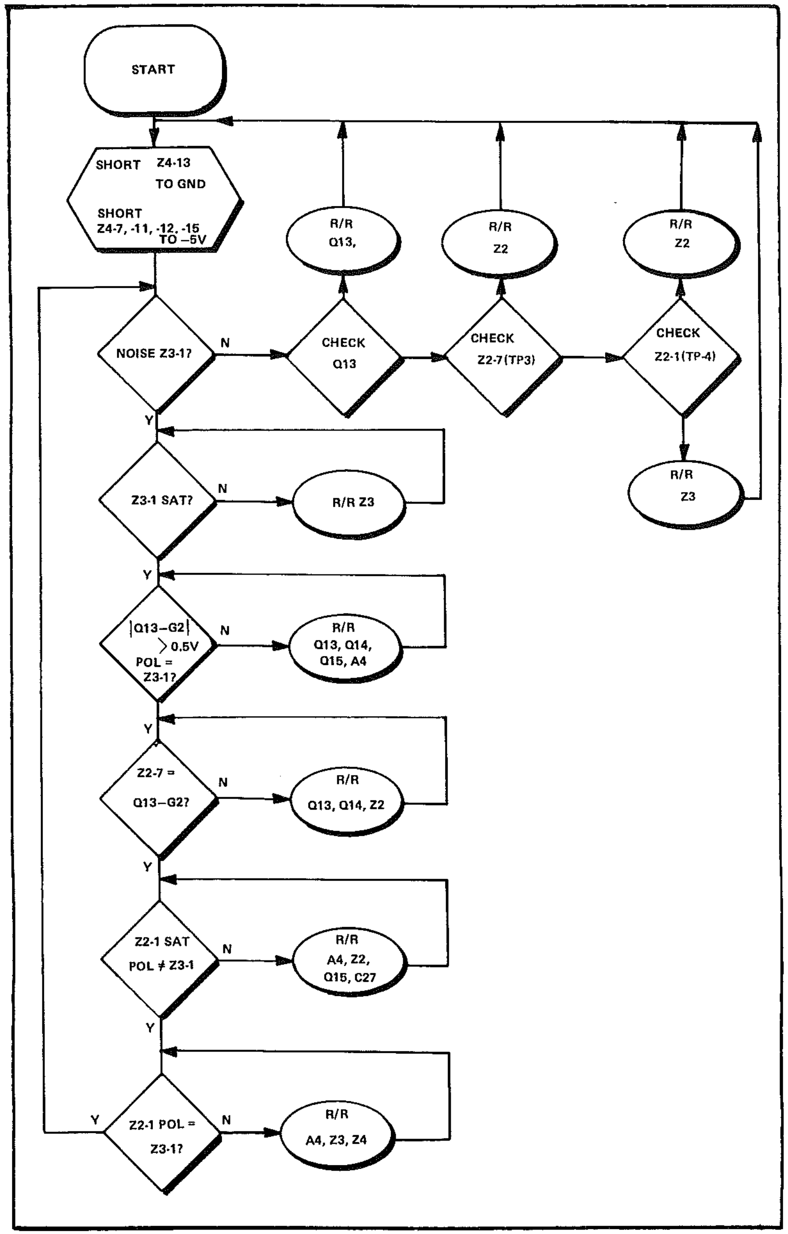


Fig. 4-8. Test TS4-4, Analog A/D Trouble Shooting

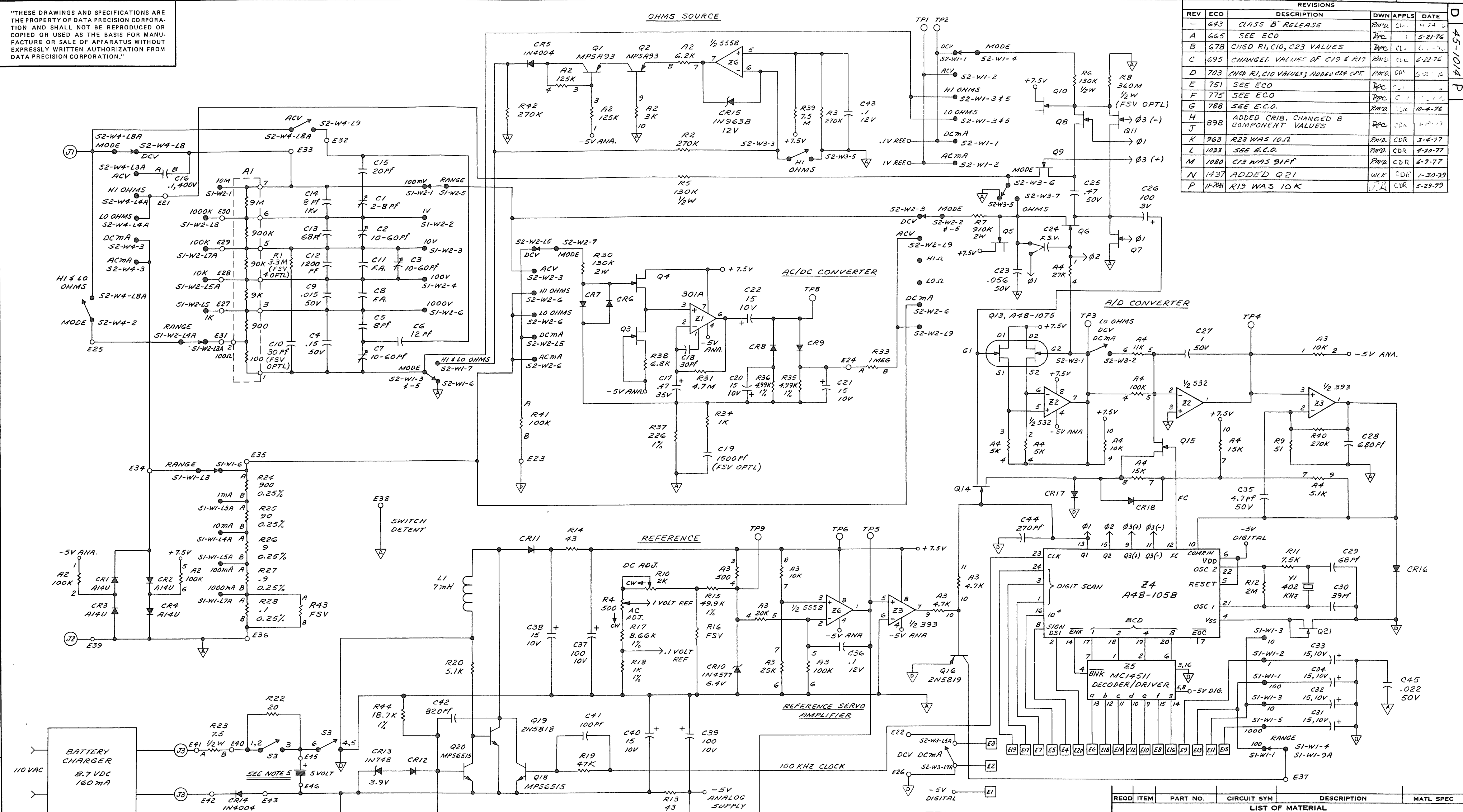
Chapter 5

PARTS LISTS

(Replaceable Parts)

REF. SYMBOL	DESCRIPTION	DATA PREC. PART NO.
A1	RES NETWORK	22-48-1085-01
A2	RES NETWORK	22-48-1071
A3	RES NETWORK	22-48-1072
A4	RES NETWORK	22-48-1073
A101	RES NETWORK	22-48-1077
A102	RES NETWORK	22-48-1078
A103	RES NETWORK	22-48-1079
C1	CAP, TRIM, 2-8 pf	23-810004
C2,3,7	CAP, TRIM, 10-60 pf	23-810003
C4	CAP, P.C., 0.15 μf, 2%, 50V	23-510014
C5	CAP, DISC, 8 pf, NPO	23-111001
C6	CAP, DISC, 12 pf	23-111002
C9	CAP, P.S., 0.015 μf, 2%, 50V	23-550101
C10	CAP, DISC, 30 pf, (FSV OPTL)	23-110012
C12	CAP, MICA, DM15, 1200 pf, 5%	23-311037
C13	CAP, MICA, 68 pf, 5%, DM10	23-310019
C14	CAP, DISC, 8 pf, SEL.	23-111001-A
C19	CAP, Disc, 1200 pf, 10% (FSV OPTL)	23-110054
C15	CAP, MICA, DM10, 20 pf, 5%	23-310003
C16	CAP, MYLAR, 0.1 μf, 20%, 400V	23-240001
C17	CAP, TANT, 0.47 μf, 20%, 35V	23-441051
C18	CAP, DISC, 30 pf	23-110012
C20,21,31,32,33 C34,38,40,22	CAP, TANT, 15 μf, 20%, 10V	23-441003
C23	CAP, P.C., 0.056 μf, 10%, 50V	23-510020
C25	CAP, P.C., 0.47 μf, 10%, 50V	23-510018
C26	CAP, TANT, 100 μf, 20%, 6.3V	23-442051
C27	CAP, P.C., 1 μf, 10%, 50V	23-510001-A
C28	CAP, DISC, 680 pf, 10%	23-110048
C29	CAP, DISC, 68 pf, 10%	23-110019
C30	CAP, CERM, 39 pf, 20%	23-140020
C35	CAP, 4.7 pf, 50V	23-140101
C36,43	CAP, DISC, 0.1 μf, 12V	23-118206
C37,39	CAP, ALUM., 100 μf, 20%, 10V	23-620008
C41	CAP, DISC, 100 pf	23-111072
C42	CAP, MICA, 820 pf, 5%, DM15	23-311034
C44	CAP, CERM, 270 pf, 20%	23-140030
C45	CAP, CERM, 0.022 uf, 10%, 50V	23-140100
CR1,2,3,4	DIODE, A14U, 2.5 AMP, 25 PIV	24-102001
CR5,14	DIODE, IN4004	24-104004
CR6,7,8,9,12,16,17,11,18	DIODE, IN4148	24-110001
CR10	DIODE, REF, IN4577, 6.4V	24-130010
CR13	DIODE, ZENER, IN748	24-120066
CR15	DIODE, IN963B	24-120094
DS101	DISPLAY, OVERFLOW	25-227756
DS102 thru DS104	DISPLAY, 7 SEGMENT	25-227760

L1	INDUCTOR, 7 mH	25-48-1083
Q1,2	TRANS, MPS-A93	24-240A93
Q3,5,8,9,10	FET, YEL/WHT DOT	24-48-1014-09
Q4,6,11,14,15	FET, YEL/GRN DOT	24-48-1014-07
Q7	FET, YEL/BLU DOT	24-48-1014-06
Q13	DUAL FET	24-48-1012
Q16	TRANS, 2N5819	24-245819
Q18,20	TRANS, MPS6515	24-236515
Q19,101 THRU 105	TRANS, 2N5818	24-235818
Q21	TRANSISTOR FET	24-48-1074-01
R1	RES, 3.3 MEG, ¼W, 5% (FSV OPTL)	22-023359
R2,3,40,42	RES, 270K, ¼W, 5%	22-022749
R4	RES, TRIM, 500Ω	22-674501
R5,6	RES, 130K, ½W, 5%	22-031349
R7	RES, 910K, 2W, 5%	22-059149
R8	RES, 360 MEG, ½W, 20% (FSV OPTL)	22-033677
R9	RES, 51Ω, ¼W, 5%	22-025109
R10	RES, TRIM, 2K	22-674202
R11	RES, 7.5K, ¼W, 5%	22-027529
R12	RES, 2 MEG, ¼W, 5%	22-022059
R13,14	RES, 43Ω, ¼W, 5%	22-024309
R15	RES, 49.9K, 1%, RN55C	22-344992
R17	RES, 8.66K, 1%, RN55C	22-348661
R18	RES, 1K, 1%, RN55C	22-341001
R19	RES 47K, ¼W, 5%	22-024739
R101,102	RES, 10K, ¼W, 5%	22-021039
R20	RES, 5.1K, ¼W, 5%	22-025129
R21,44	RES, 18.7K, 1%, RN55D	22-331872
R22	RES, 20Ω, ¼W, 5%	22-022009
R23	RES, 7.5Ω,½W, 5%	22-037R59
R24	RES, 900Ω, 0.25%	22-48-1068-1
R25	RES, 90Ω, 0.25%	22-48-1068-2
R26	RES, 9Ω, 0.25%	22-48-1068-3
R27	RES, 0.9Ω, 0.25%	22-48-1068-4
R28	RES, 0.1Ω, 0.25%	22-48-1068-5
R29	RES, TRIM, 10K	22-674103
R30	RES, 130K, 2W, 5%	22-051349-A
R31	RES, 4.7 MEG, ¼W, 5%	22-024759
R33	RES, 1 MEG, ¼W, 5%	22-021059
R34	RES, 1K, ¼W, 5%	22-021029
R35,36	RES, 4.99K, 1%, RN55C	22-344991
R37	RES, 226Ω, 1%, RN55C	22-342260
R38	RES, 6.8K, ¼W, 5%	22-026829
R39	RES, 7.5 MEG, ¼W, 5%	22-027559
R41	RES, 100K, ¼W, 5%	22-021049
S1	SWITCH, RANGE	PL40-1109
S2	SWITCH, FUNCTION	PL40-1110
S3	SWITCH, DP-DT	25-441005
Y1	RESONATOR, 402KHz, $\pm$2 KHz	25-141000
Z1	I.C., OP. AMP, LM301AH	24-420301
Z2	I.C., DUAL OP. AMP	24-48-1089
Z3	I.C., DUAL COMPARATOR, LM393N	24-400393
Z4	I.C., LSI CMOS A/D LOGIC	24-48-1058
Z5	I.C., DECODER/DRIVER, MC14511CP	24-L14511
Z6	I.C., DUAL OP. AMP, 5558	24-405558



REVISIONS

REV	ECO	DESCRIPTION	DWN	APPLS	DATE
—	643	CLASS "B" RELEASE	P.M'D.	CDR	[illegible]
A	665	SEE ECO	DPC	[illegible]	5-21-76
B	678	CHGD R1, C10, C23 VALUES	DPC	CDR	[illegible]
C	695	CHANGED VALUES OF C19 & R19	P.M'D.	CDR	6-22-76
D	703	CHGD R1, C10 VALUES; ADDED C24 OPT.	P.M'D.	CDR	[illegible]
E	751	SEE ECO	DPC	[illegible]	[illegible]
F	775	SEE ECO	DPC	[illegible]	[illegible]
G	788	SEE E.C.O.	P.M'D.	CDR	10-4-76
H / J	898	ADDED CR18. CHANGED 8 COMPONENT VALUES	DPC	CDR	[illegible]
K	963	R23 WAS 10Ω	P.M'D.	CDR	3-4-77
L	1033	SEE E.C.O.	P.M'D.	CDR	4-20-77
M	1080	C13 WAS 91PF	P.M'D.	CDR	6-9-77
N	1437	ADDED Q21	WLK	CDR	1-30-78
P	11-2081	R19 WAS 10K	[illegible]	CDR	5-29-79

SIZE D 45-1014 REV P

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTORS ARE 1/4W, 5%, C.C., VALUES IN OHMS.
2. ALL 1% RESISTORS ARE TYPE RN55C, FIXED FILM.
3. ALL CAPACITOR VALUES IN MICROFARADS.
4. ALL DIODES ARE 1N4148.
5. INSTRUMENT WILL NOT OPERATE PROPERLY WITHOUT BATTERY.

REQD	ITEM	PART NO.	CIRCUIT SYM	DESCRIPTION	MATL SPEC

LIST OF MATERIAL

NEXT ASSY	USED ON
PL40-1038	175

APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± ~ DECIMALS ± ~ ANGLES ± ~

MATERIAL

FINISH

APPLICABLE SPECIFICATIONS

DRAWN P. McDonough DATE 4-16-76
CHECKED
DESIGNER
ENGINEER ROLLMAN 4-17-76
APPROVED
RELEASED
WEIGHT

DATA PRECISION CORP.
Data Precision Corporation, Wakefield, Mass. 01880

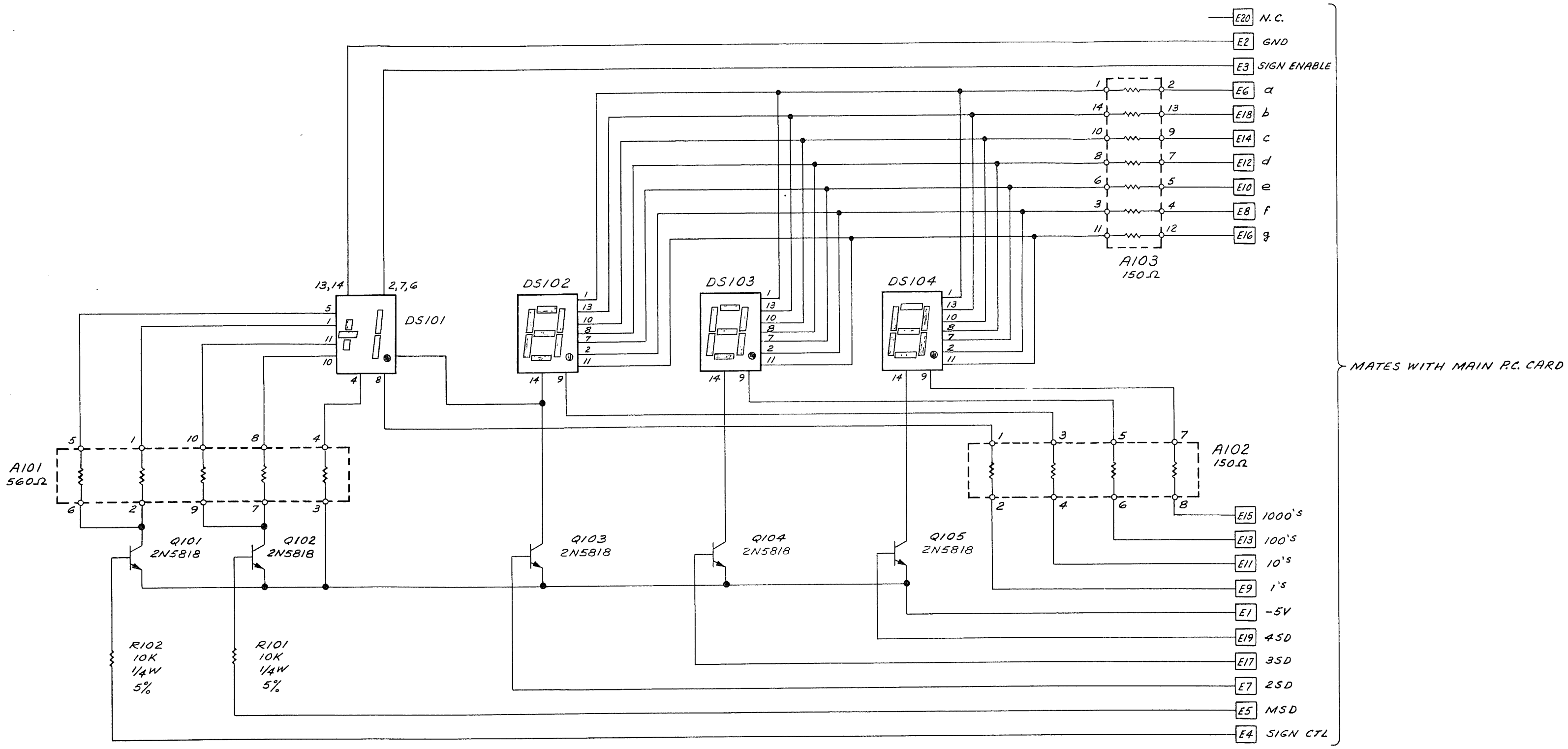
SCHEMATIC
MAIN BOARD
MODEL 175 DMM

CODE IDENT NO. SIZE D 45-1014 REV P

SCALE NONE ACCOUNT NO. SHEET 1 OF 2

REVISIONS					
REV	ECO	DESCRIPTION	DWN	APPLS	DATE

SIZE D 45-1014 REV P



REQD	ITEM	PART NO.	CIRCUIT SYM	DESCRIPTION	MATL SPEC

LIST OF MATERIAL

PL40-1039	175
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± ~ DECIMALS ± ~ ANGLES ± ~

MATERIAL

FINISH

APPLICABLE SPECIFICATIONS

		DATE
DRAWN		
CHECKED	P. McDonough	4-16-76
DESIGNER		
ENGINEER		
APPROVED		
RELEASED		
WEIGHT		

DATA PRECISION CORP.
Data Precision Corporation, Wakefield, Mass. 01880

SCHEMATIC
DISPLAY BOARD
MODEL 175 DMM

CODE IDENT NO. | SIZE D | 45-1014 | REV P

SCALE ~ | ACCOUNT NO. | SHEET 2 OF 2