DIGITAL MULTIMETER KIT

MODEL M-1005K

Assembly and Instruction Manual

Elenco Electronics, Inc.

 REV-J Revised 2000 753042

PARTS LIST

Contact Elenco Electronics (address/phone/e-mail is at the back of this manual) if any parts are missing or damaged. **DO NOT** contact your place of purchase as they will not be able to help you.

RESISTORS

QTY	SYMBOL	VALUE	COLOR CODE	PART #
☐ 1	R0	.01Ω	Shunt Wire	100160
☐ 1	R8	.99Ω .5% 1/4W	black-white-white-silver-green	109950
☐ 1	R7	9Ω .5% 1/4W	white-black-black-silver-green	119000
☐ 1	R9	10Ω 5% 1/4W	brown-black-black-gold	121000
☐ 2	R10, R*	100Ω 5% 1/4W	brown-black-brown-gold	131000
☐ 1	R6	100Ω .5% 1/4W	brown-black-black-black-green	131050
☐ 1	R5	900Ω .5% 1/4W	white-black-black-black-green	139050
☐ 1	R13	900Ω 1% 1/4W	white-black-black-black-brown	139030
☐ 1	R18	2kΩ PTC1		142069
☐ 1	R11	9kΩ 1% 1/4W	white-black-black-brown-brown	149030
☐ 1	R4	9kΩ .5% 1/4W	white-black-black-brown-green	149050
☐ 1	R12	20kΩ 1% 1/4W	red-black-black-red-brown	152030
☐ 1	R3	90kΩ .5% 1/4W	white-black-black-red-green	159050
☐ 2	R16, R26	100kΩ 5% 1/4W	brown-black-yellow-gold	161000
☐ 3	R2A, R2B, R2C	117kΩ 1% 1/4W	brown-brown-violet-orange-brown	161130
☐ 1	R15	180kΩ 5% 1/4W	brown-gray-yellow-gold	161800
☐ 2	R21, R22	220kΩ 5% 1/4W	red-red-yellow-gold	162200
☐ 2	R1A, R1B	274kΩ 1% 1/4W	red-violet-yellow-orange-brown	162730
☐ 1	R14	300kΩ 5% 1/4W	orange-black-yellow-gold	163000
☐ 1	R25	470kΩ 5% 1/4W	yellow-violet-yellow-gold	164700
☐ 1	R23	510kΩ 5% 1/4W	green-brown-yellow-gold	165100
☐ 1	R24	820kΩ 5% 1/4W	gray-red-yellow-gold	168200
☐ 1	R17	1.2MΩ 5% 1/4W	brown-red-green-gold	171200
☐ 2	R19, R20	2.2MΩ 5% 1/4W	red-red-green-gold	172200
☐ 1	VR1	200Ω (201) potentiometer		191310

Note: Your kit may contain a resistor with a better tolerance.

CAPACITORS

QTY	SYMBOL	VALUE	DESCRIPTION	PART #
☐ 1	C1	100pF (101)	Disc	221017
☐ 4	C2, C3, C4, C6	.1μF (104)	Mylar Small	251018
☐ 1	C5	.1μF (104/100n)	Mylar Large	251019

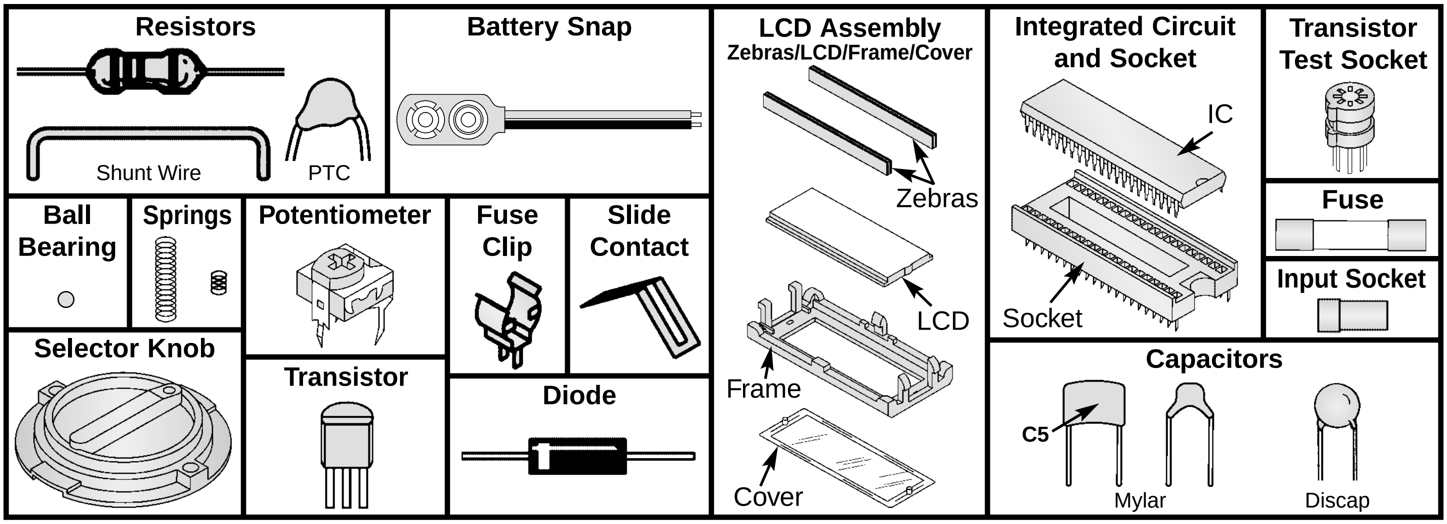
SEMICONDUCTORS

QTY	SYMBOL	VALUE	DESCRIPTION	PART #
☐ 1	D1	1N4007	Diode	314007
☐ 1	IC1	7106	IC 40-Pin	337106
☐ 1	Q1	9013	Transistor	339013
☐ 1	Q2	9014	Transistor	339014

MISCELLANEOUS

QTY	DESCRIPTION	PART #	QTY	DESCRIPTION	PART #
☐ 2	Zebra	500003H	☐ 1	Socket Transistor	664007
☐ 1	PC Board	516100H	☐ 1	Socket 40-pin	664040
☐ 1	Fuse .25A 250V	533003	☐ 3	Input Socket	664101H
☐ 1	Battery 9V	590009	☐ 2	Ball Bearing	666400E
☐ 1	Battery Snap	590098	☐ 6	Slide Contact	680013E
☐ 1	LCD	621016H	☐ 2	Spring 1/4" (Selector Knob)	680014E
☐ 1	Selector Knob	622100H	☐ 1	Spring 1/2" (Shield)	680015E
☐ 1	Case Top (Black)	623110H	☐ 1	Label Shield	723007H
☐ 1	Case Bottom (Black)	623208H	☐ 1	Label Front	724007H
☐ 1	LCD Cover	621040H	☐ 1	Manual Assembly	753042
☐ 1	LCD Frame	629008H	☐ 1	Grease	790004
☐ 2	Screw 2.3mm x 6mm	643439E	☐ 1	Solder Tube	9ST4
☐ 2	Screw 2.3mm x 10mm	643447E	☐ 1	Test Lead Set	RWTL1000B
☐ 2	Fuse Clip	663100E			

PARTS IDENTIFICATION



IDENTIFYING RESISTOR VALUES

Use the following information as a guide in properly identifying the value of resistors.

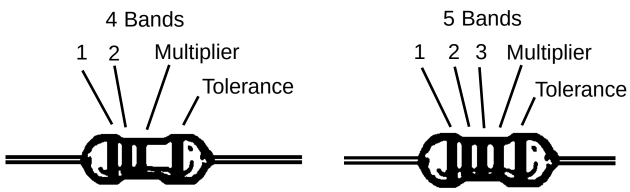
BAND 1 1st Digit	
Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

BAND 2 2nd Digit	
Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

BAND 3 (If Used)	
Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

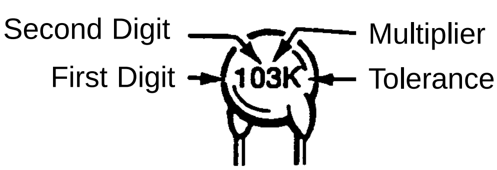
Multiplier	
Color	Multiplier
Black	1
Brown	10
Red	100
Orange	1,000
Yellow	10,000
Green	100,000
Blue	1,000,000
Silver	0.01
Gold	0.1

Resistance Tolerance	
Color	Tolerance
Silver	±10%
Gold	±5%
Brown	±1%
Red	±2%
Orange	±3%
Green	±.5%
Blue	±.25%
Violet	±.1%



IDENTIFYING CAPACITOR VALUES

Capacitors will be identified by their capacitance value in pF (picofarads) or µF (microfarads). Most capacitors will have their actual value printed on them. Some capacitors may have their value printed in the following manner.



Multiplier	For the No.	0	1	2	3	4	5	8	9
	Multiply By	1	10	100	1k	10k	100k	.01	0.1

Note: The letter "R" may be used at times to signify a decimal point; as in 3R3 = 3.3

The above value is 10 x 1,000 = 10,000pF or .01µF
The letter K indicates a tolerance of ±10%
The letter J indicates a tolerance of ±5%

CONSTRUCTION

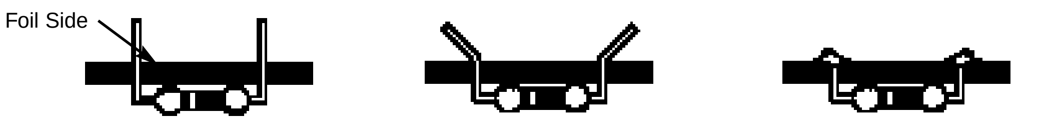
Introduction

Assembly of your M-1005K Digital Multimeter Kit will prove to be an exciting project and give you much satisfaction and personal achievement. If you have experience in soldering and wiring techniques, then you should have no problem with the assembly of this kit. Care must be given to identifying the proper components and in good soldering habits. Above all, take your time and follow these easy step-by-step instructions. Remember, "An ounce of prevention is worth a pound of cure". Avoid making mistakes and no problems will occur.

CAUTION: WEAR SAFETY GLASSES WHEN ASSEMBLING THIS KIT.

Assemble Components

In all of the following assembly steps, the components must be installed on the top side of the PC board unless otherwise indicated. The top legend shows where each component goes. The leads pass through the corresponding holes and the board is turned to solder the component leads on the foil side. Solder immediately unless the pad is adjacent to another hole which will interfere with the placement of the other component. Cut excessive leads with a diagonal cutter. Then, place a check mark in the box provided next to each step to indicate that the step is completed. Be sure to save the extra leads for use as jumper wires if needed.



Mount Part — Bend Leads to Hold Part — Solder and Cut Off Leads

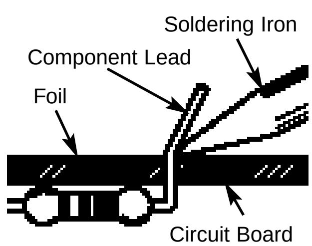
☑ Rx - 100Ω 5% 1/4W Resistor (brown-black-brown-gold)

Soldering

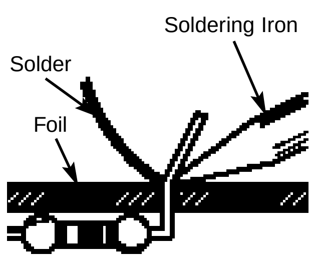
The most important factor in assembling your digital multimeter is good soldering techniques. Using the proper soldering iron is of prime importance. A small pencil type soldering iron of 25 - 40 watts is recommended. **The tip of the iron must be kept clean at all times and well tinned.** Many areas on the PC board are close together and care must be given not to form solder shorts. Size and care of the tip will eliminate problems.

For a good soldering job, the areas being soldered must be heated sufficiently so that the solder flows freely. Apply the solder simultaneously to the component lead and the component pad on the PC board so that good solder flow will occur. Be sure that the lead extends through the solder smoothly indicating a good solder joint. **Use only rosin core solder of 60/40 alloy.**
DO NOT USE ACID CORE SOLDER! Do not blob the solder over the lead because this can result in a cold solder joint.

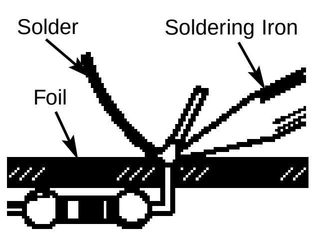
1. Solder all components from the copper foil side only. Push the soldering iron tip against both the lead and the circuit board foil.



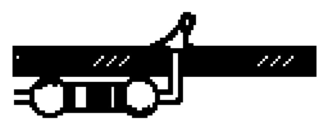
2. First apply a small amount of solder to the iron tip. This allows the heat to leave the iron and onto the foil. Immediately apply solder to the opposite side of the connection, away from the iron. Allow the heated component and the circuit foil to melt the solder.



3. Allow the solder to flow around the connection. Then, remove the solder and the iron and let the connection cool. The solder should have flowed smoothly and not lump around the wire lead.



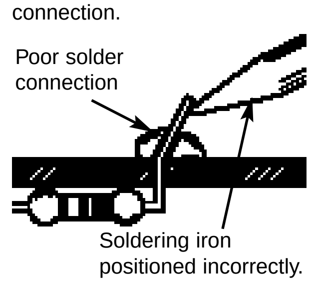
4. Here is what a good solder connection looks like. Cut off excess leads.



Example 1

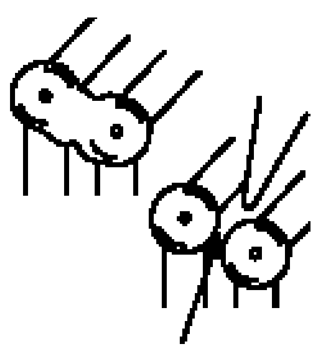
Poor solder connections occur when the lead is not heated sufficiently. The solder will not flow onto the lead as shown. To correct. reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection.

Solder does not flow onto the lead. A hard rosin bead surrounds and insulates the connection.



Example 2

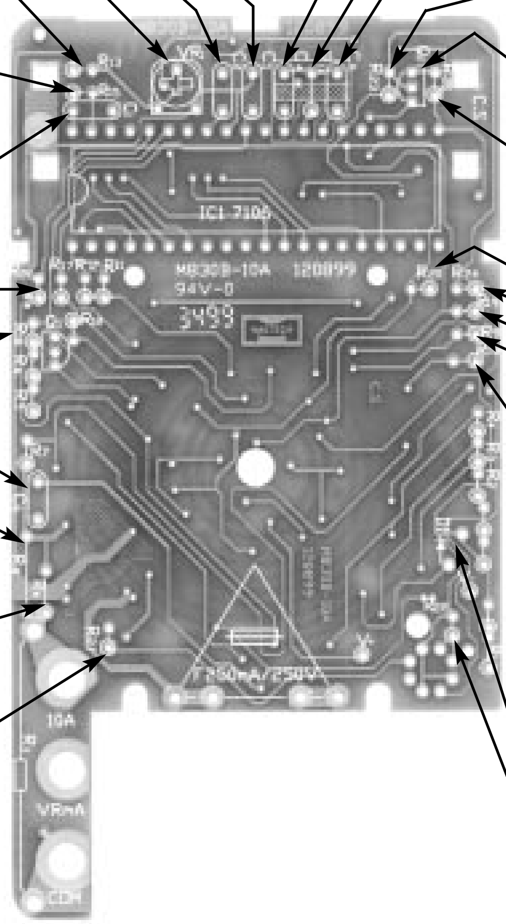
A solder bridge occurs when solder runs between circuit paths and creates a short circuit. This is usually caused by using too much solder. To correct this, simply drag your soldering iron across the solder bridge as shown.



ASSEMBLY INSTRUCTIONS

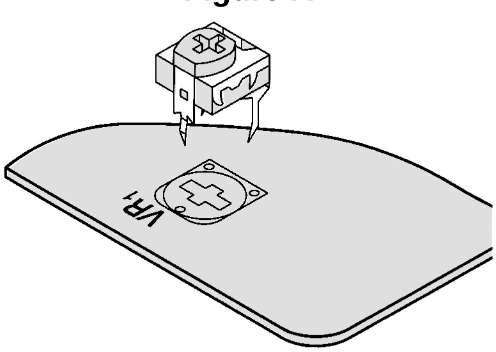
Identify and install the following parts as shown in Figure 4-1. After soldering each part, mark a check in the box provided. Be sure that solder has not bridged to an adjacent pad.

- ☐ C3 - .1µF (104) Mylar Small
- ☐ C2 - .1µF (104) Mylar Small
- ☐ VR1 - 200Ω (201) Potentiometer (see Figure A)
- ☐ R13 - 900Ω 1% 1/4W Resistor (white-black-black-black-brown) (see Figure B)
- ☐ R15 - 180kΩ 5% 1/4W Resistor (brown-gray-yellow-gold) (see Figure B)
- ☐ C1 - 100pF (101) Discap
- ☐ R26 - 100kΩ 5% 1/4W Resistor (brown-black-yellow-gold) (see Figure B)
- ☐ R16 - 100kΩ 5% 1/4W Resistor (brown-black-yellow-gold) (see Figure B)
- ☐ C6 - .1µF (104) Mylar Small
- ☐ R8 - .99Ω .5% 1/4W Resistor (black-white-white-silver-green) (Standard Location)
- ☐ R* - 100Ω 5% 1/4W Resistor (brown-black-brown-gold) (see Figure B)
- ☐ R21 - 220kΩ 5% 1/4W Resistor (red-red-yellow-gold) (see Figure B)



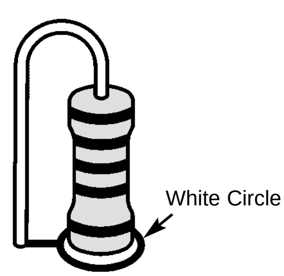
- ☐ C4 - .1µF (104) Mylar Small
- ☐ R14 - 300kΩ 5% 1/4W Resistor (orange-black-yellow-gold) (see Figure B)
- ☐ C5 - .1µF (104) Mylar Large
- ☐ R23 - 510kΩ 5% 1/4W Resistor (green-brown-yellow-gold) (see Figure B)
- ☐ Q2 - 9014 Transistor (see Figure C)
- ☐ R25 - 470kΩ 5% 1/4W Resistor (yellow-violet-yellow-gold) (see Figure B)
- ☐ R20 - 2.2MΩ 5% 1/4W Resistor (red-red-green-gold) (see Figure B)
- ☐ R24 - 820kΩ 5% 1/4W Resistor (gray-red-yellow-gold) (see Figure B)
- ☐ R19 - 2.2MΩ 5% 1/4W Resistor (red-red-green-gold) (see Figure B)
- ☐ R9 - 10Ω 5% 1/4W Resistor (brown-black-black-gold) (see Figure B)
- ☐ R18 - 2kΩ PTC1
- ☐ D1 - 1N4007 Diode (see Figure E)
- ☐ R22 - 220kΩ 5% 1/4W Resistor (red-red-yellow-gold) (see Figure B)

Figure A



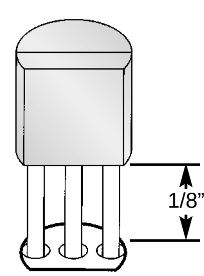
Mount the potentiometer to the PC board as shown.

Figure B



Stand resistor on end as shown with the body inside the white circle

Figure C



Mount the transistor with the flat side in the same direction marked on the PC board.

ASSEMBLY INSTRUCTIONS

Identify and install the following parts as shown in Figure 4-2. After soldering each part, mark a check in the box provided. Be sure that solder has not bridged to an adjacent pad.

- ☐ IC - Socket 40-pin
- ☐ IC - 7106 (see Figure D)

- ☐ R11 - 9kΩ 1% 1/4W Resistor (white-black-black-brown-brown) (see Figure B)

- ☐ R12 - 20kΩ 1% 1/4W Resistor (red-black-black-red-brown) (see Figure B)

- ☐ R17 - 1.2MΩ 5% 1/4W Resistor (brown-red-green-gold) (see Figure B)

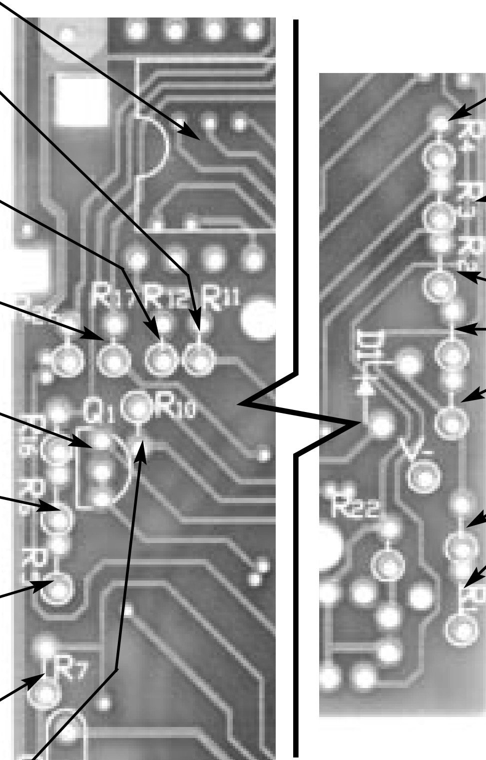
- ☐ Q1 - 9013 Transistor (see Figure C)

- ☐ R6 - 100Ω .5% 1/4W Resistor (brown-black-black-black-green) (see Figure B)

- ☐ R5 - 900Ω .5% 1/4W Resistor (white-black-black-black-green) (see Figure B)

- ☐ R7 - 9Ω .5% 1/4W Resistor (white-black-black-silver-green) (see Figure B)

- ☐ R10 - 100Ω 5% 1/4W Resistor (brown-black-brown-gold) (see Figure B)



- ☐ R4 - 9kΩ .5% 1/4W Resistor (white-black-black-brown-green) (see Figure B)

- ☐ R3 - 90kΩ .5% 1/4W Resistor (white-black-black-red-green) (see Figure B)

- ☐ R2A - 117kΩ 1% 1/4W Resistor
- ☐ R2B - 117kΩ 1% 1/4W Resistor
- ☐ R2C - 117kΩ 1% 1/4W Resistor (brown-brown-violet-orange-brown) (see Figure B)

- ☐ R1A - 274kΩ 1% 1/4W Resistor
- ☐ R1B - 274kΩ 1% 1/4W Resistor (red-violet-yellow-orange-brown) (see Figure B)

*** Note:**

- R1A and R1B are not marked on the board.
- R2A, R2B, and R2C are not marked on the board.

Figure 4-2

Figure D

Align the socket notch (if any) with the notch marked on the PC board. Solder the socket to the PC board. Insert the IC into the socket with the notch as shown below. **Note: If the IC is already inserted into the socket, do not attempt to pull it out, as this will damage the IC and socket. Instead, solder the socket to the PC board with the IC in it.**

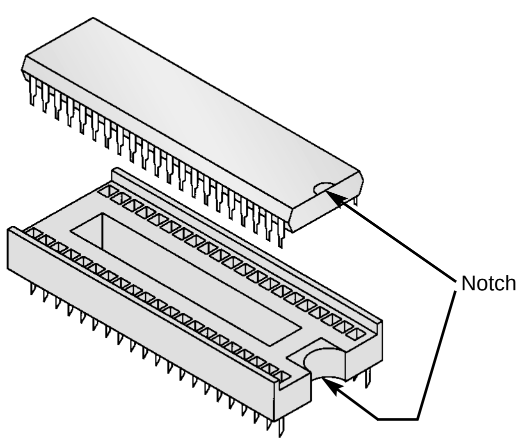
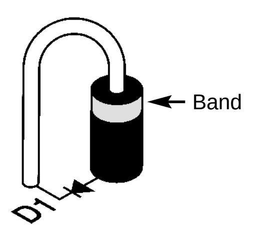


Figure E

Stand diode on end. Mount with band as shown on the top legend.



Install the following parts. Then, place a check mark in the box provided.

☐ Solder the 1/2 inch spring to the PC board as shown in Figure 4-3. This spring will contact the metal shield on the case bottom when the bottom is installed.

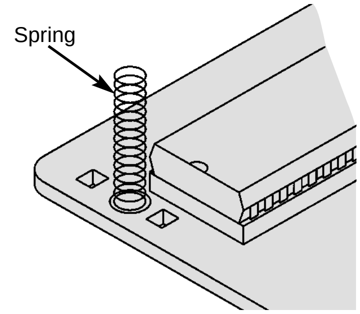


Figure 4-3

☐ Insert the narrow end of the three input sockets into the PC board from the component side, as shown in Figure 4-4. Solder the sockets to the PC board on the components side only. The solder should extend completely around the socket (see Figure 4-4).

☐ Insert the shunt wire (R0) into the PC board holes from the component side as shown in Figure 4-4. Adjust the wire so that it sticks out the other (solder) side of the PC board 3/16 of an inch. Solder the wire to the PC board on the component side only.

☐ Be sure that the 8 pin transistor socket will slide easily through its hole in the top case from either direction. If it does not, carefully slide it through the hole several times in each direction to remove any burrs. Do not push on the socket leads or they may be damaged.
Insert the socket into the PC board holes from the solder side as shown in Figure 4-4. Be sure that the tab lines up with the hole as shown in the figure. Solder the socket to the PC board on the component side of the PC board as shown in the figure and cut off excess leads.

☐ Feed the battery snap wires up through the hole in the PC board from the solder side as shown in Figure 4-4. Insert the red wire into the hole marked (V**+**) and black wire into hole marked (V--) as shown. Solder the wires to the PC board.

☐ Insert the two fuse clips into the PC board holes as shown in Figure 4-4. Be sure that the tabs are on the outside as shown in the figure. Solder the clips to the PC board.

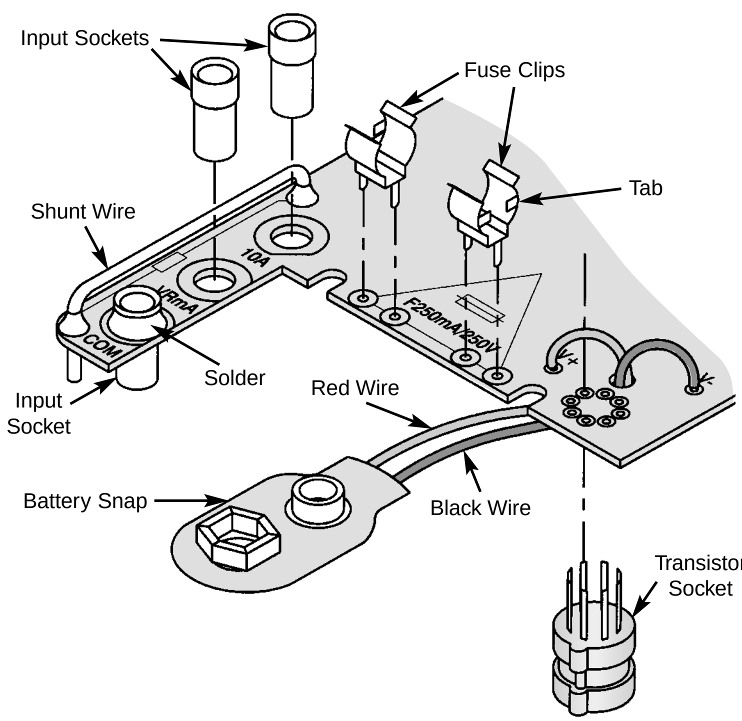
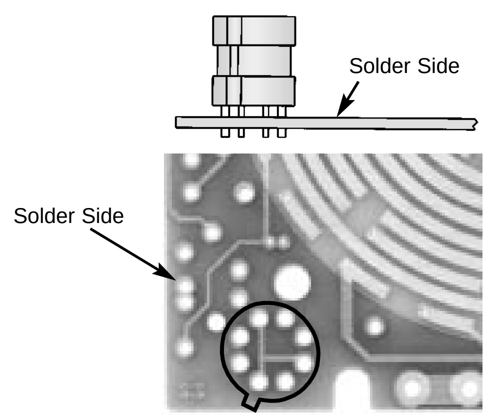
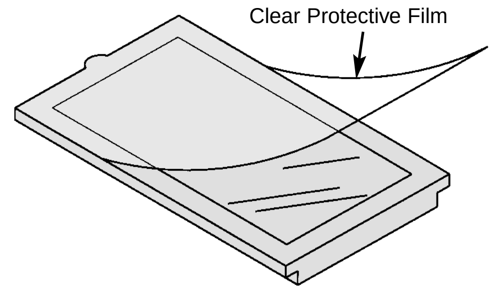


Figure 4-4



Close-up view of the transistor socket and PC board.

☐ Remove the clear protective film from the front of the LCD (**Note:** DO NOT remove the silver backing). Place the LCD and zebras in the LCD frame as shown in Figure 4-5. Be sure that the LCD tab is in the same direction as shown in the figure. Insert the square pins of the LCD frame into the PC board holes, from the solder side, and snap the frame into place on the PC board.



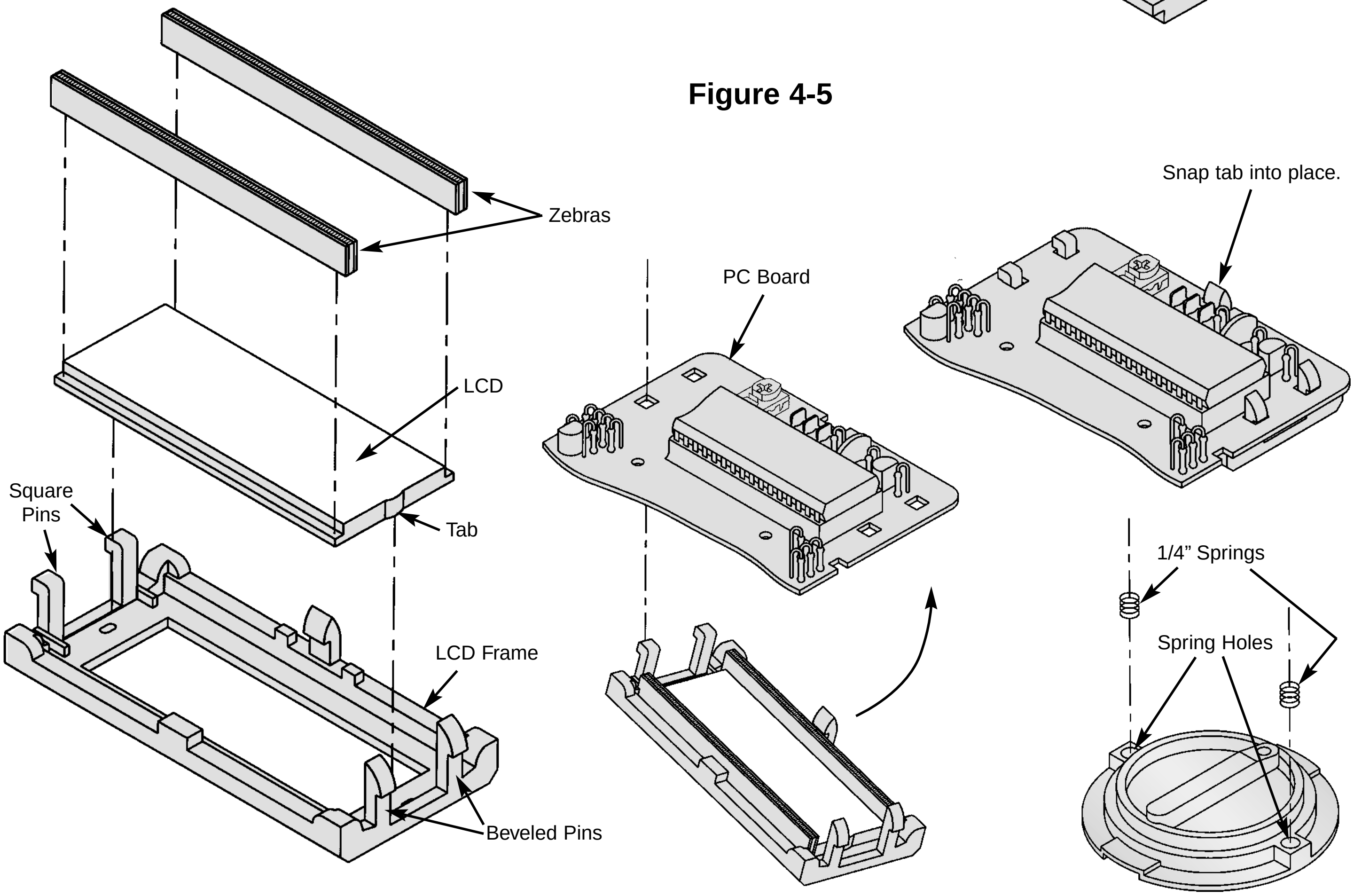


Figure 4-5

Figure 4-6

☐ Cut open the plastic envelope containing the grease and put a small amount of grease in each spring hole of the selector knob as shown in Figure 4-6. Then, insert a 1/4” spring into each hole as shown in the figure.

☐ Put the bearings into two opposite indents in the case top as shown in Figure 4-7.

☐ Place the six slide contactors on the selector knobs as shown in Figure 4-7.

☐ Place the selector knob into the case top so that the springs fit over the bearings as shown in Figure 4-7.

☐ Place the LCD cover into the case as shown in Figure 4-7.

☐ Place the PC board over the selector knob. Be sure that the 8-pin socket slides into its hole. Then fasten the PC board with two 6mm screws as shown in Figure 4-7.

☐ Insert the .25A, 250V fuse into the fuse clips. Your fuse may be unmarked.

☐ Peel the backing off of the shield label and place it in the inside of the bottom case as shown.

☐ Peel the backing off of the front label and place it on the case top.

☐ Connect a 9V battery to the battery snap.

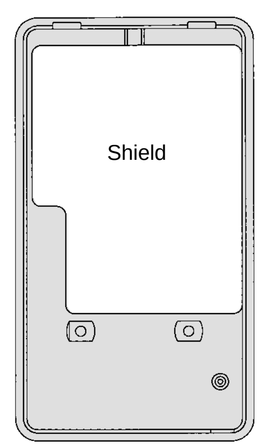
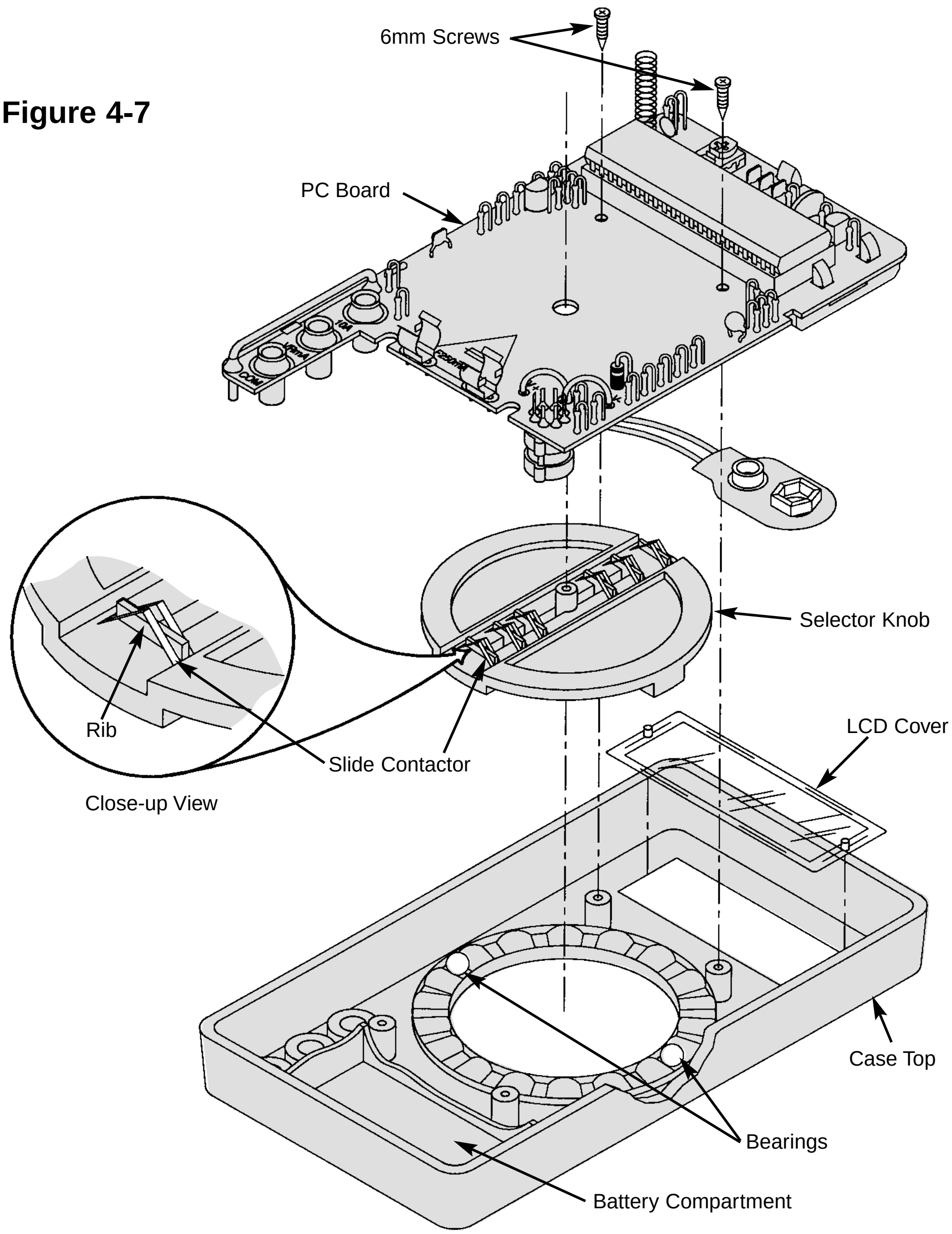


Figure 4-7



TESTING, CALIBRATION, AND TROUBLESHOOTING

TESTING OF LCD

With no test leads connected to the meter, move the selector switch around the dial. You should obtain the following readings. A (--) sign may also be present or blinking.

1) DCV Range:	200m	0 0.0
	2000m	0 0 0
	20	0.0 0
	200	0 0.0
	1000	0 0 0
2) ACV Range:	200	0 0.0
	750	0 0 0
3) DCA,10A Ranges:	200µ	0 0.0
	2000µ	0 0 0
	20m	0.0 0
	200m	0 0.0
	10A	0.0 0

4) Ohms, Diode and h_{FE} Ranges: B indicates blank.

200	1 B B.B
2000	1 B B B
20k	1 B.B B
200k	1 B B.B
2000k	1 B B B
Diode (—▶|—)	1 B B B
h_{FE}	0 0 0

If any of these tests fail:

a) Check that the battery is good.
b) Check that IC1 is installed according to Figure 4-2 of the assembly instructions. Check for bent pins that do not extend into the IC socket. Check for good contact between the leads of the IC and the pins of the socket.
c) Check the values of resistors R14, R15, R19, R20, R23 - R25.
d) Check the values of capacitors C1 - C5.
e) Check that Q2 is installed according to Figure 4-1 of the assembly instructions.
f) Check the PC board for solder bridges and bad solder connections.
g) Check that the slide contactors are seated correctly.
h) Check that the LCD and zebras are seated correctly.

CALIBRATION

Refer to the METER OPERATION section for test lead connections and measurement procedure.

A/D CONVERTER CALIBRATION

Turn the range selector switch to the 20V position and connect the test leads. Using another meter of known accuracy, measure a DC voltage of less than 20 volts (such as a 9V battery). Calibrate the kit meter by measuring the same voltage and adjusting VR1 until the kit meter reads the same as the accurate meter (do not use the kit meter to measure its own battery). When the two meters agree, the kit meter is calibrated. Turn the knob to the OFF position and remove the voltage source.

SHUNT WIRE CALIBRATION

To calibrate the shunt wire, you will need a 5 amp current source such as a 5V power supply and a 1 ohm, 25 watt resistor. If a 5 amp source is not available, you can use a lower current (2 amps). If no supply is available, it is not important to do this test. Set the range switch to the 10A position and connect the test leads as shown in Figure 5-1. If the meter reads higher than 5A, resolder the shunt wire so that there is less wire between the 10A DC and COM sockets.
If the meter reads low, resolder the shunt wire so that there is more wire between the sockets.

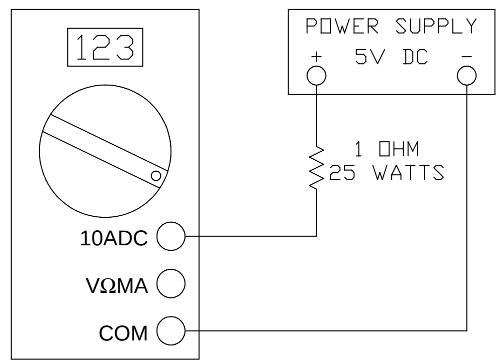


Figure 5-1

If the calibration fails:

a) Check the PC board for solder bridges and bad solder connections.
b) Check that Q1 is installed according to Figure 4-2 of the assembly instructions.
c) Check the values of resistor R10 - R13, R26, and potentiometer VR1.

DC VOLTS TEST

1) If you have a variable power supply, set the supply to about the midpoint of each of the DCV ranges and compare the kit meter reading to a meter known accuracy.

2) If you do not have a variable power supply, make the following two tests:
   a) Set the range switch to 2000mV and measure the voltage across the 100 ohm resistor of Figure 5-2A. You should get about 820mV. Compare the reading to a meter of known accuracy.

   b) Set the range switch to 200mV and measure the voltage across the 100 ohm resistor of Figure 5-2B. You should get about 90mV. Compare the reading to a meter of known accuracy.

If any of these tests fail:

a) Recheck the meter calibration.
b) Check the value and the soldering of resistors R1-R6, R16.

Figure 5-2A

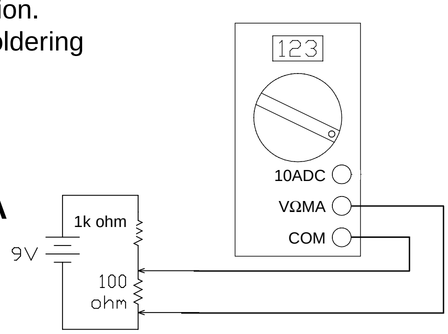
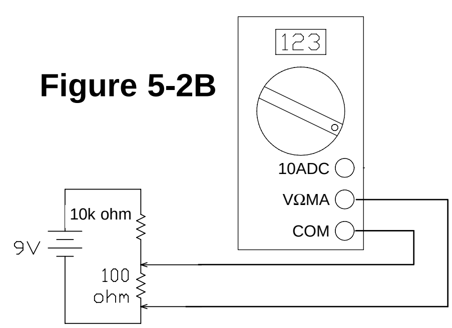


Figure 5-2B



AC VOLTS TEST

To test the ACV ranges, we will need a source of AC voltage. The AC power line is the most convenient.

CAUTION: Be very careful when working with 120VAC. Be sure that the range switch is in the 200 or 750VAC position before connecting the test leads to 120VAC.

1) Set the range to 200VAC and measure the AC power line. The voltage should be about 120VAC. Compare the reading to a meter of known accuracy.
2) Set the range to 750VAC and measure the AC power line. The voltage should be about 120VAC. Compare the reading to a meter of known accuracy.

If either if the above tests fail:

a) Check the values and the soldering of resistors R1 - R6, R16.
b) Check that diode D1 is mounted as shown in the assembly instructions.

DC AMPS TEST

1) Set the range switch to 200µA and connect the meter as in Figure 5-3. With R_A equal to 100kΩ the current should be about 90µA. Compare the reading to a known accurate meter.
2) Set the range switch and R_A as in the following table. Read the currents shown and compare to a known accurate meter.

RANGE SWITCH	R_A	CURRENT (approx.)
2000µA	10kΩ	900µA
20mA	1kΩ	9mA
200mA	470Ω	19mA

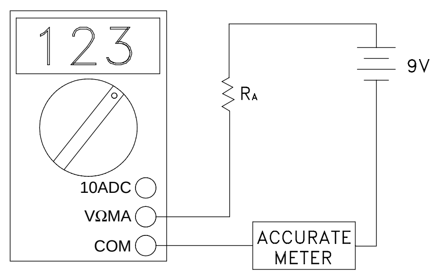


Figure 5-3

If any of the above tests fail:
a) Check the fuse.
b) Check the value and soldering of resistors R7, R8, and R*.

RESISTANCE/DIODE TEST

1) Measure a resistor of about half of the full scale value of each resistance range. Compare the kit meter readings to those from a meter of known accuracy.
2) Measure the voltage drop of a good silicon diode. You should read about 700mV. Power diodes and the base to emitter junction of power transistors may read less.

If any of these tests fail:
a) Check the values and the soldering of resistors R1 - R6, and R18.
b) Check that transistor Q1 is mounted as shown in the assembly instructions.

h_{FE}

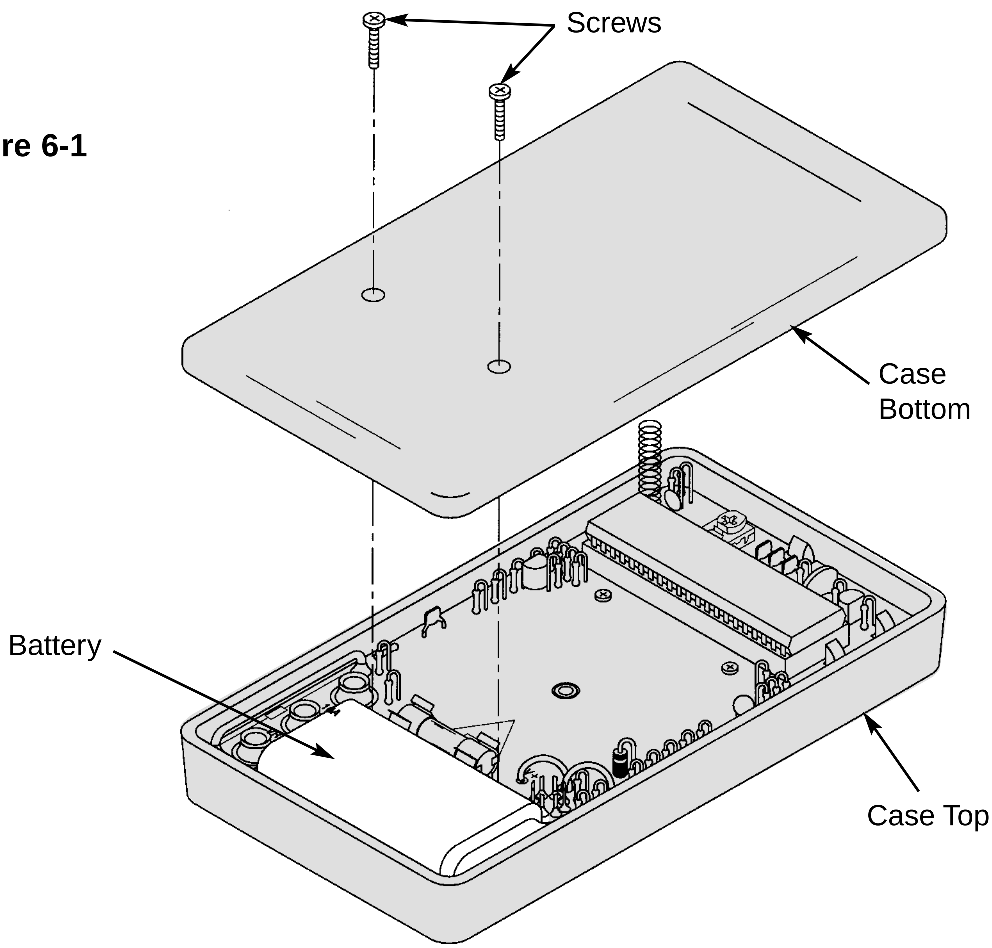
1) Set the range switch to h_{FE} and insert a small transistor into the appropriate NPN or PNP holes in the transistor socket.
2) Read the h_{FE} of the transistor. The h_{FE} of transistors varies over a wide range, but you will probably get a reading between 100 and 300.

If this check fails:
a) Check that the transistor socket is aligned according to Figure 4-4.
b) Check the value and soldering of resistors R9, R21, and R22

FINAL ASSEMBLY

☐ Snap the case bottom onto the case top and fasten with the two 10mm screws as shown in Figure 6-1.

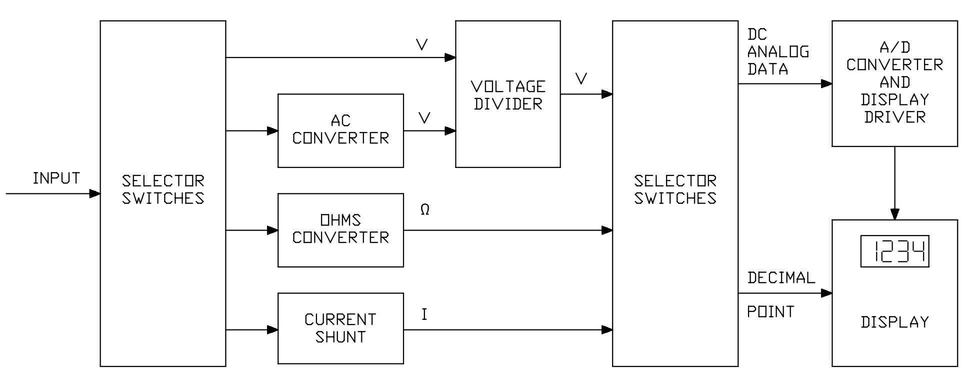
Figure 6-1



THEORY OF OPERATION

A block diagram of the M-1005K is shown in Figure 7-1. Operation centers around a custom LSI chip. This chip contains a dual slope A/D (analog to digital) converter, display latches, seven segment decoder and display drivers. A block diagram of the IC functions is shown in Figure 7-2. The input voltage or current signals are conditioned by the selector switches to produce an output DC voltage with a magnitude between 0 and 199mV. If the input signal is 100VDC, it is reduced to 100mVDC by selecting a 1000:1 divider. Should the input be 100VAC, it is first rectified and then divided down to 100mVDC. If current is to be read, it is converted to a DC voltage by internal shunt resistors.

Figure 7-1



For resistance measurements, an internal voltage source drives the test resistor in series with a known resistor. The ratio of the test resistor voltage to the known resistor voltage is used to determine the value of the test resistor.

The input of the 7106 IC is fed to an A/D converter. Here the DC voltage is changed to a digital format. The resulting signals are processed in the decoders to light the appropriate LCD segments.

Timing for the overall operation of the A/D converter is derived from an external oscillator whose frequency is selected to be 25kHz. In the IC, this frequency is divided by four before it clocks the decade counters. It is then further divided to form the three convert-cycles phases. The final readout is clocked at about two readings per second.

The digitized measurements are presented to the display as four decoded digits (seven segments) plus polarity. The decimal point position on the display is determined by the selector switch setting.

A/D CONVERTER

A simplified circuit diagram of the analog portion of the A/D converter is shown in Figure 7-3. Each of the switches shown represent analog gates which are operated by the digital section of the A/D converter. The basic timing for switch operation is keyed by the external oscillator. The conversion process is continuously repeated. A complete cycle is shown in Figure 7-3.

Any given measurement cycle performed by the A/D converter can be divided into three consecutive time periods, autozero (AZ), integrate (INTEG) and read. A counter determines the length of the time periods. The integrate period is fixed at 1000 clock pulses. The read period is a variable time that is proportional to the unknown input voltage. It can vary from zero counts for zero input voltage to 2000 counts for a full scale input voltage. The autozero period varies from 1000 to 3000 counts. For an input voltage less than full scale autozero gets the unused portion of the read period. The value of the voltage is determined by counting the number of clock pulses that occur during the read period.

During autozero a ground reference is applied as an input to the A/D converter. Under ideal conditions, the output of the comparator would also go to zero. However, input-offset-voltage errors accumulate in the amplifier loop and appear at the comparator output as an error voltage. This error is impressed across the AZ capacitor where it is stored for the remainder of the measurement cycle. The stored level is used to provide offset voltage correction during the integrate and read periods.

The integrate period begins at the end of the autozero period. As the period begins, the AZ switch opens and the INTEG switch closes. This applies the unknown input voltage to the input of the A/D converter. The voltage is buffered and passed on to the integrator to determine the charge rate (slope) on the INTEG capacitor At the end of the fixed integrate period, the capacitor is charged to a level proportional to the unknown input voltage. During the read period, this voltage is translated to a digital indication by discharging the capacitor at a fixed rate and counting the number of clock pulses that occur before it returns to the original autozero level.

As the read period begins, the INTEG switch opens and the read switch closes. This applies a known reference voltage to the input to the A/D converter. The polarity of this voltage is automatically selected to be opposite that of the unknown input voltage, thus causing the INTEG capacitor to discharge at a fixed rate (slope). This rate is determined by the known reference voltage. When the charge is equal to the initial starting point (autozero level), the read period is ended. Since the discharge slope is fixed during the read period, the time required for discharge is proportional to the unknown input voltage. Specifically, the digital reading displayed is 1000 (V_{IN} / V_{REF}).

The autozero period and thus a new measurement cycle begins at the end of the read period. At the same time the counter is released for operation by transferring its contents (the previous measurement value) to a series of latches. This stored data is then decoded and buffered before being used to drive the LCD display.

Figure 7-2
7106 IC Functions

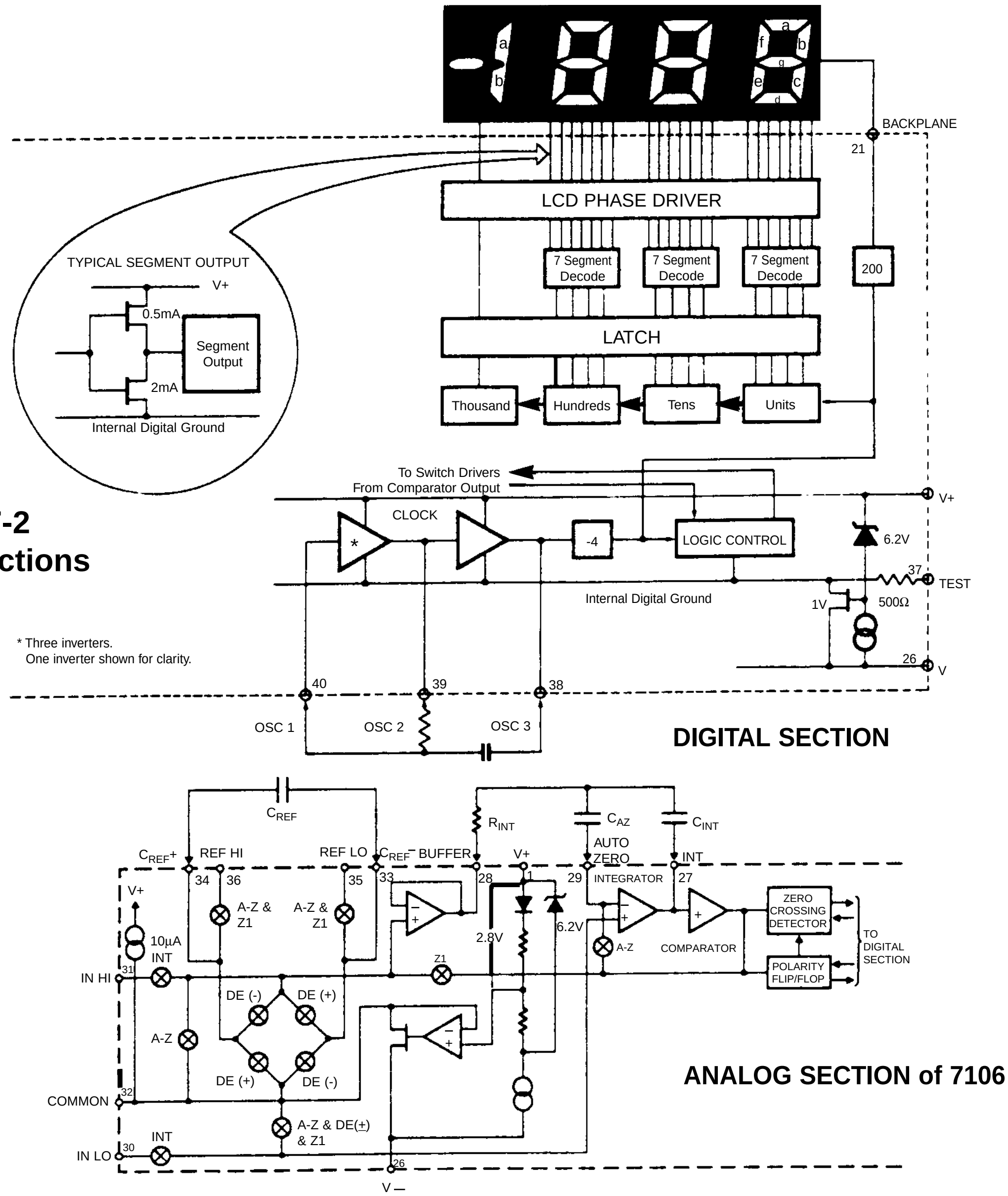
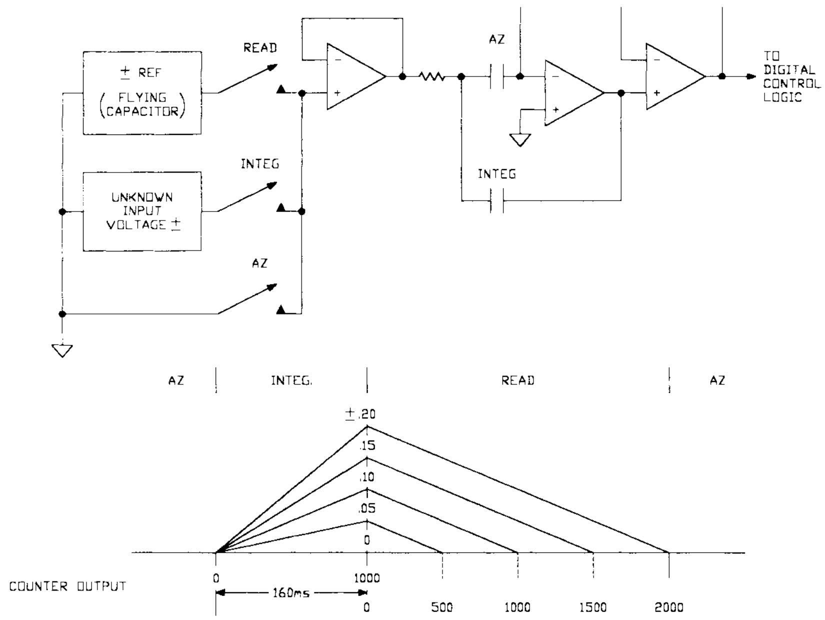


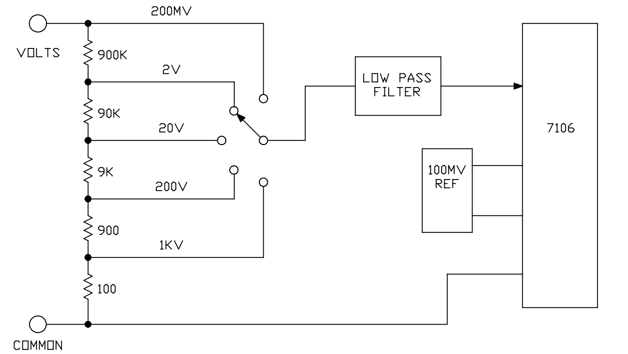
Figure 7-3



DUAL SLOPE A/D CONVERTER

DC VOLTAGE MEASUREMENT

Figure 7-4 shows a simplified diagram of the DC voltage measurement function. The input voltage divider resistors add up to 1 megaohm. Each step down divides the voltage by a factor of ten. The divider output must be within the range -0.199 to +0.199 volts or the overload indicator will function. The overload indication consists of a 1 in the most significant digit and blanks in the remaining digits.

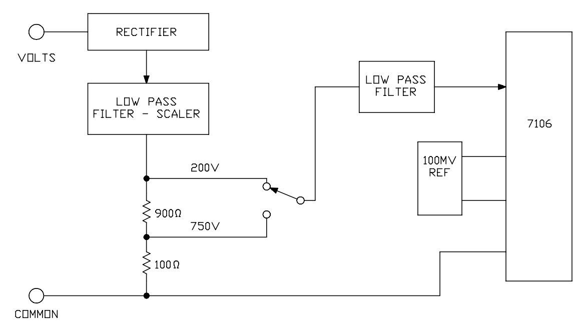


SIMPLIFIED DC VOLTAGE MEASUREMENT DIAGRAM

Figure 7-4

AC VOLTAGE MEASUREMENT

Figure 7-5 shows a simplified diagram of the AC voltage measurement function. The AC voltage is first rectified and passed through a low pass filter to smooth out the waveform. A scaler reduces the voltage to the DC value required to give the correct RMS reading.

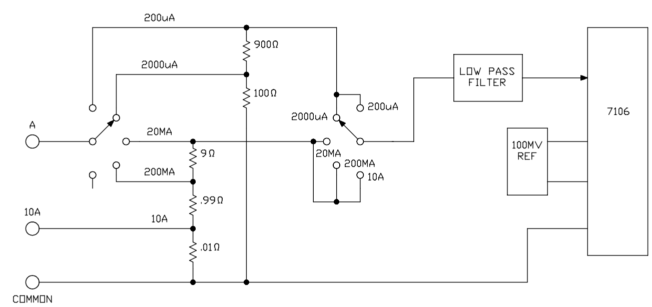


SIMPLIFIED AC VOLTAGE MEASUREMENT DIAGRAM

Figure 7-5

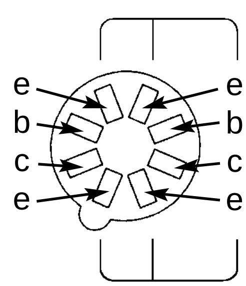
CURRENT MEASUREMENT

Figure 7-6 shows a simplified diagram of the current measurement function. Internal shunt resistors convert the current to between -0.199 to +0.199 volts which is then processed in the 7106 IC to light the appropriate LCD segments. When current in the range of 10A is to be read, it is fed to the 10A input and does not pass through the selector switch.



SIMPLIFIED DC AMPS MEASUREMENT DIAGRAM

Figure 7-6

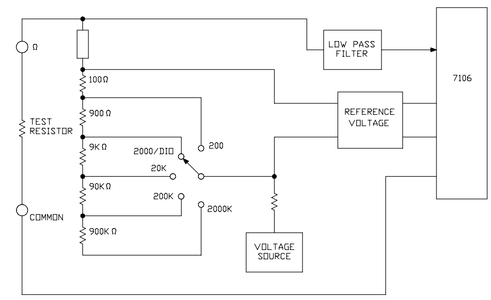


NPN PNP

RESISTANCE MEASUREMENT

Figure 7-7 shows a simplified diagram of the resistance measurement function. A simple series circuit is formed by the voltage source, a reference resistor from the voltage divider (selected by the selector switches), and the test (unknown) resistor. The ratio of the two resistors is equal to the ratio of their respective voltage drops. Therefore, since the value of one resistor is known, the value of the second can be determined by using the voltage drop across the known resistor as a reference. This determination is made directly by the A/D converter.

Overall operation of the A/D converter during a resistance measurement is basically as described earlier with one exception. The reference voltage present during a voltage measurement is replaced by the voltage drop across the reference resistor. This allows the voltage across the unknown resistor to be read during the read period.



SIMPLIFIED RESISTANCE MEASUREMENT DIAGRAM

Figure 7-7

h_{FE} MEASUREMENT

Figure 7-8 shows a simplified diagram of the h_{FE} measurement function. Internal circuits in the 7106 IC maintain the COMMON line at 2.8 volts below V+. When a PNP transistor is plugged into the transistor socket, base to emitter current flows through resistor R21. The voltage drop in resistor R10 due to the collector current is fed to the 7106 and indicates the h_{FE} of the transistor. For an NPN transistor, the emitter current through R10 indicates the h_{FE} of the transistor.

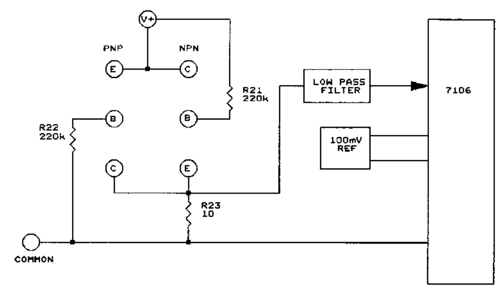


Figure 7-8

SPECIFICATIONS

GENERAL

DISPLAY	3 1/2 digit LCD, with polarity
OVERRANGE INDICATION	3 least significant digits blanked.
MAXIMUM COMMON MODE VOLTAGE	500V peak.
STORAGE ENVIRONMENT	-15°C to 50°C.
TEMPERATURE COEFFICIENT	(0°C to 18°C and 28°C to 50°C) less than 0.1 x applicable accuracy specification per °C.
POWER	9V alkaline or carbon zinc battery.
DIMENSIONS	128 x 75 x 24mm.

DC VOLTAGE

RANGE	RESOLUTION	ACCURACY
200mV	0.1mV	±0.5% rdg ± 2d
2000mV	1mV	±0.5% rdg ± 2d
20V	10mV	±0.5% rdg ± 2d
200V	100mV	±0.5% rdg ± 2d
1000V	1V	±0.5% rdg ± 2d

MAXIMUM ALLOWABLE INPUT 1000VDC or peak AC.
INPUT IMPEDANCE 1MΩ.

DC CURRENT

RANGE	RESOLUTION	ACCURACY
200µA	0.1µA	±1% rdg ± 2d
2000µA	1µA	±1% rdg ± 2d
20mA	10µA	±1% rdg ± 2d
200mA	100µA	±1.2% rdg ± 2d
10A	10mA	±2% rdg ± 3d

OVERLOAD PROTECTION .25A/250V fuse (mA input only).

AC VOLTAGE

RANGE	RESOLUTION	ACCURACY
200V	100mV	±1.2% rdg ± 10d
750V	1V	±1.2% rdg ± 10d

MAXIMUM ALLOWABLE INPUT 750Vrms.
FREQUENCY 45 - 450Hz.

RESISTANCE

RANGE	RESOLUTION	ACCURACY
200Ω	0.1Ω	±0.8% rdg ± 2d
2000Ω	1Ω	±0.8% rdg ± 2d
20kΩ	10Ω	±0.8% rdg ± 2d
200kΩ	100Ω	±0.8% rdg ± 2d
2000kΩ	1kΩ	±1% rdg ± 2d

MAXIMUM OPEN CIRCUIT VOLTAGE 2.8V.

DIODE CHECK

RANGE	RESOLUTION	MAX TEST CURRENT	MAX OPEN CIRCUIT VOLTAGE
DIODE	1mV	1.4mA	2.8V

TRANSISTOR h_{FE} TEST

RANGE	TEST RANGE	TEST CURRENT	TEST VOLTAGE
NPN/PNP	0 - 1000	Ib = 10µA	Vce 3V

METER OPERATION
PRECAUTIONS AND PREPARATIONS FOR MEASUREMENT

1) Be sure the battery is connected to the battery snap and correctly placed in the battery compartment.
2) Before connecting the test leads to the circuit, be sure the range switch is set to the correct position.
3) Be sure that the test leads are connected to the correct meter terminals before connecting them to the circuit.
4) Before changing the range switch, remove one of the test leads from the circuit.
5) Operate the instrument only in temperatures between 0 and 50°C and in less than 80% RH.
6) Pay careful attention to the maximum rated voltage of each range and terminal.
7) When finished making measurements, set the switch to OFF. Remove the battery when the instrument will not be used for a long period of time.
8) Do not use or store the instrument in direct sunlight or at high temperature or humidity.

VOLTAGE MEASUREMENTS

1) Connect the black test lead to the "COM" terminal.
2) Connect the red test lead to the "VΩMA" terminal.
3) Set the range switch to the desired "V⎓ " or "V~" position. If the magnitude of the voltage is not known, set the switch to the highest range.
4) Connect the leads across the points to be measured and read the display. If the range switch is too high, reduce it until a satisfactory reading is obtained.

DCA MEASUREMENTS
HIGH CURRENTS (200mA to 10A)

1) Connect the black test lead to the "COM" terminal.
2) Connect the red test lead to the 10ADC terminal.
3) Set the range switch to the 10A⎓ position.
4) Open the circuit to be measured and connect the leads in series with the load to be measured.
5) Read the display. If the display read less than 200mA, follow the low current procedure below.
6) Turn off all of the power to the circuit being tested and discharge all of the capacitors before disconnecting the test leads.

LOW CURRENTS (less than 200mA)

7) Connect the black test lead to the "COM" terminal.
8) Connect the red test lead to the VΩMA terminal.
9) Set the range switch to the desired A⎓ position. If the magnitude of the current is not known, set the switch to the highest position.
10) Open the circuit to be measured and connect the leads in series with the load to be measured.
11) Read the display. If the range switch is too high, reduce it until a satisfactory reading is obtained.
12) Turn off all power to the circuit being tested and discharge all capacitors before disconnecting the test leads.

RESISTANCE MEASUREMENTS

1) Connect the black test lead to the “COM” terminal.
2) Connect the red test lead to the “VΩMA” terminal.
3) Set the range switch to the desired “Ω” position.
4) If the resistance being measured is connected to a circuit, turn off the power to the circuit being tested and discharge all of the capacitors.
5) Connect the leads across the resistor to be measured and read the display. When measuring high resistance, be sure not to contact adjacent points even if insulated. Some insulators have relatively low resistance and will cause the measured resistance to be lower than the actual resistance.

DIODE CHECK

1) Connect the black test lead to the “COM” terminal.
2) Connect the red test lead to the “VΩMA” terminal.
3) If the diode being measured is connected to a circuit, turn off all power to the circuit and discharge all capacitors.
4) Set the range switch to “▶|”.

Forward Voltage Check

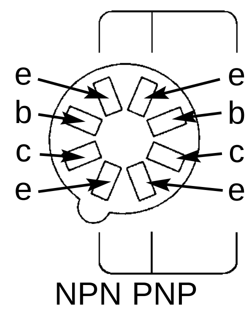
5) Connect the red lead to the anode and the black lead to the cathode of the diode. Normally the forward voltage drop of a good silicon diode reads between 450 and 900mV.

Reverse Voltage Check

6) Reverse the leads to the diode. If the diode is good, an overrange indication is given (a 1 in the most significant digit and blanks in the remaining digits). If the diode is bad, “000” or some other value is displayed.

h_{FE} MEASUREMENTS

1) Set the range switch to h_{FE} and insert the test transistor into the appropriate NPN or PNP holes in the transistor socket.
2) Read the h_{FE} of the transistor.



BATTERY & FUSE REPLACEMENT

If “ ” appears on the display, it indicates that the battery should be replaced.
To replace battery and fuse (250mA/250V), remove the 2 screws in the bottom of the case.
Simply remove the old fuse/battery and replace with a new fuse/battery.

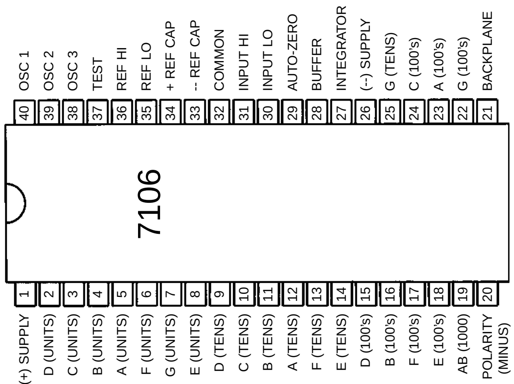
QUIZ

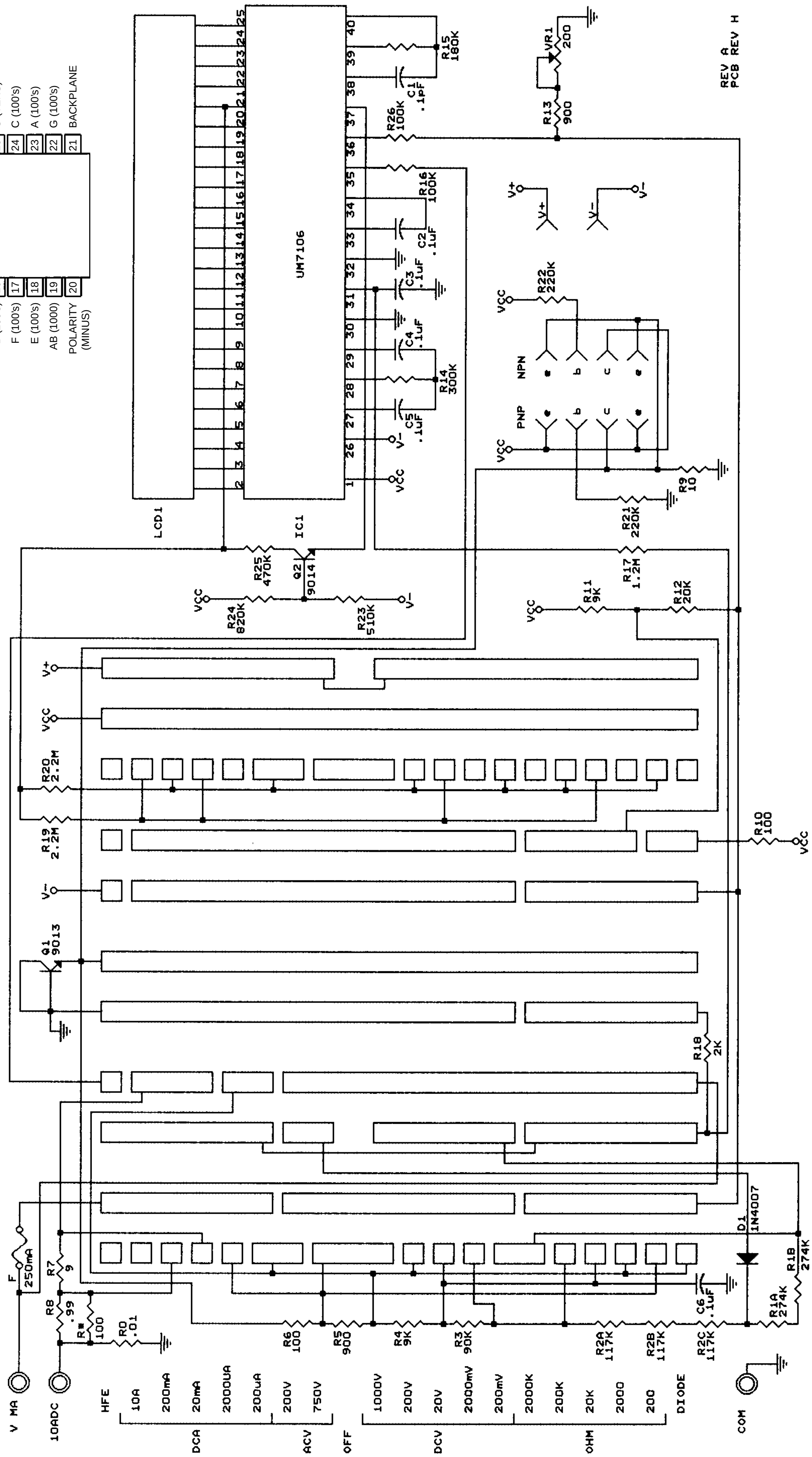
1. The function of the A/D converter is to . . .
   A) convert digital to analog.
   B) divide the analog signal by 2.
   C) convert analog to digital.
   D) convert AC to DC.
2. The divider used for DC voltage measurements is a . . .
   A) divide by 20.
   B) capacitance divider.
   C) divide by 5.
   D) resistor divider.
3. When the AC voltage is measured, it is first . . .
   A) divided by 2.
   B) rectified.
   C) divided by 100.
   D) sent to a high pass filter.
4. When measuring current, the shunt resistors convert the current to . . .
   A) -0.199 to +0.199 volts.
   B) -1.199 to +1.199 volts.
   C) -0.099 to +0.099 volts.
   D) -199 to +199 volts.
5. The DC voltage divider resistors add up to . . .
   A) 100Ω.
   B) 1000Ω.
   C) 100kΩ.
   D) 1MΩ.

Answers: 1. C, 2. D, 3. B, 4. A, 5. D, 6. A, 7. B, 8. C, 9. B, 10. B

6. Resistance measurements are made by . . .
   A) comparing voltage drops in the unknown resistor and a reference resistor.
   B) measuring the current in the unknown resistor.
   C) measuring the current in the reference resistor.
   D) equalizing the voltage drops in the unknown and the reference resistors.
7. The measurement cycle performed by the A/D converter can be divided into time periods known as . . .
   A) long and short.
   B) autozero, integrate and read.
   C) zero, read and interphase.
   D) convert, integrate and display.
8. A resistor with the band colors green-black-green-brown-green is . . .
   A) 50.5kΩ ±5%.
   B) 5.15kΩ ±10%.
   C) 5.05kΩ ±.5%.
   D) 5.05kΩ ±1%.
9. The M-1005K has . . .
   A) A 3 digit display.
   B) A 3 1/2 digit display.
   C) A 4 1/2 digit display.
   D) None of the above.
10. When measuring 450mA, the meter leads should be connected to . . .
    A) COM and VΩmA.
    B) COM and 10A.
    C) 10A and VΩmA.
    D) COM and Building GND.

SCHEMATIC DIAGRAM





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