DIGITAL MULTIMETER KIT

MODEL M-1008K

7 56619 00936 0

HV 100.8

DCV
600
200
20
2000m
200m
2000k
Ω 200k
20k
2000
200

OFF

600
200
ACV
DCA
200u
2000u
20m
200m
10 A
hFE

E E
B   B
C   C
E E
NPN PNP

CE

10ADC
10A max
UNFUSED

VΩmA
600VAC
600VDC
200mA max

COM
500V max
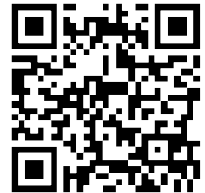
ELENCO®
M-1008K

Assembly and Instruction Manual

ELENCO®

PARTS LIST

If you are a student, and any parts are missing or damaged, please see instructor or bookstore. If you purchased this meter kit from a distributor, catalog, etc., please contact ELENCO® (address/phone/e-mail is at the back of this manual) for additional assistance, if needed.

RESISTORS (Parts mounted on card)

Qty.	Symbol	Value	Color Code	Part #
❒ 1	R7	0.99Ω 0.5% 1/4W	black-white-white silver-green	109950
❒ 1	R8	9Ω 0.5% 1/4W	white-black-black-silver-green	119050
❒ 1	R19	10Ω 1% 1/4W	brown-black-black-gold-brown	121030
❒ 1	R18	100Ω 1% 1/4W	brown-black-black-black-brown	131030
❒ 1	R1	100Ω 0.5% 1/4W	brown-black-black-black-green	131050
❒ 1	R23	470Ω 1% 1/4W	yellow-violet-black-black-brown	134730
❒ 1	R12	900Ω 1% 1/4W	white-black-black-black-brown	139030
❒ 1	R2	900Ω 0.5% 1/4W	white-black-black-black-green	139050
❒ 1	R9	1.5kΩ	PTC Resistor	141569
❒ 3	R22,26,27	47kΩ 1% 1/4W	yellow-violet-black-red-brown	144730
❒ 1	R10	9kΩ 1% 1/4W	white-black-black-brown-brown	149030
❒ 1	R3	9kΩ 0.5% 1/4W	white-black-black-brown-green	149050
❒ 1	R11	20.5kΩ 1% 1/4W	red-black-green-red-brown	152130
❒ 1	R4	90kΩ 0.5% 1/4W	white-black-black-red-green	159050
❒ 2	R14,17	100kΩ 1% 1/4W	brown-black-black-orange-brown	160030
❒ 6	R16,20,21,25,28,29	220kΩ 1% 1/4W	red-red-black-orange-brown	162230
❒ 1	R5	352kΩ 0.5% 1/4W	orange-green-red-orange-green	163550
❒ 1	R6	548kΩ 0.5% 1/4W	green-yellow-gray-orange-green	165450
❒ 1	R15,24,30,31,32	1MΩ 1% 1/4W	brown-black-black-yellow-brown	171030

Resistors tolerance may be lower than listed
These parts are not mounted on card:

Qty.	Symbol	Value		Part #
❒ 1	R13	0.01Ω	Shunt wire	100165
❒ 1	VR1	200Ω (201)	Potentiometer	191300

CAPACITORS

Qty.	Symbol	Value	Description	Part #
❒ 1	C6	100pF (101)	Disc	221017
❒ 1	C7	220pF (221)	Disc	222210
❒ 3	C3, C4, C5	0.1μF (104)	Mylar (small)	251017S
❒ 1	C2	0.22μF (224)	Mylar (large)	251017L
❒ 1	C1	2.2μF 50V	Electrolytic	262247

SEMICONDUCTORS

Qty.	Symbol	Value	Description	Part #
❒ 1	D1,D2,D3	1N4007	Diode (mounted on resistor card)	314007
❒ 1	Q1	2SA9013	Transistor	329013
❒ 1	Q2	2SA9015	Transistor	329015

MISCELLANEOUS

Qty.	Description	Part #	Qty.	Description	Part #
❒ 1	Liquid crystal display (LCD)	351117	❒ 2	Fuse holder clips	663100
❒ 1	Zebra 7.5 x 40mm	500008	❒ 1	Transistor socket	664007
❒ 1	PC board, ICs installed	516110	❒ 3	Input socket	664105
❒ 1	Fuse 200mA, 250V 5 x 20mm	530020	❒ 2	Ball bearing	666400
❒ 1	Battery 9V	590009	❒ 6	Slide contact	680013
❒ 1	Battery snap	590098	❒ 2	Spring 2.7 x 4mm (selector knob)	680014
❒ 1	Buzzer with wires	595208	❒ 1	Spring 3.2 x11mm	680015
❒ 1	Selector knob	622107	❒ 1	Label shield	750010
❒ 1	Case top	623080	❒ 1	Label meter	724010
❒ 1	Case bottom	623080	❒ 1	Grease	790004
❒ 1	Zebra frame	629018	❒ 1	Lead-free solder	9LF99
❒ 5	Screw 2.0mm x 6mm (PC Board)	643439	❒ 1	Test lead set	9TL1008
❒ 2	Screw 2.0mm x 10mm (Case)	643447			

PARTS IDENTIFICATION

RESISTORS

Shunt wire

Carbon film   Potentiometer

CAPACITORS

C2

Mylar   Disc   Electrolytic

SEMICONDUCTORS

Diode

Transistor

Liquid crystal display (LCD)

Zebra frame

Selector knob

Zebra

Fuse holder clip

Transistor socket

MISCELLANEOUS

Battery snap

Buzzer with wires

Input socket

2.0mm x 6mm   2.0mm x 10mm

Screws

Slide contact   Springs

PC board with ICs installed

Ball bearing   Fuse
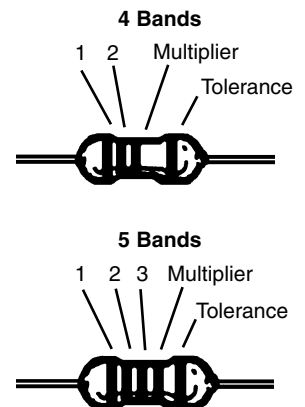
IDENTIFYING RESISTOR VALUES

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

BAND 1 1st Digit		BAND 2 2nd Digit		BAND 3 (If Used)		Multiplier		Resistance Tolerance	
Color	Digit	Color	Digit	Color	Digit	Color	Multiplier	Color	Tolerance
Black	0	Black	0	Black	0	Black	1	Silver	±10%
Brown	1	Brown	1	Brown	1	Brown	10	Gold	±5%
Red	2	Red	2	Red	2	Red	100	Brown	±1%
Orange	3	Orange	3	Orange	3	Orange	1,000	Red	±2%
Yellow	4	Yellow	4	Yellow	4	Yellow	10,000	Orange	±3%
Green	5	Green	5	Green	5	Green	100,000	Green	±.5%
Blue	6	Blue	6	Blue	6	Blue	1,000,000	Blue	±.25%
Violet	7	Violet	7	Violet	7	Silver	0.01	Violet	±.1%
Gray	8	Gray	8	Gray	8	Gold	0.1		
White	9	White	9	White	9				

4 Bands

1 2   Multiplier
Tolerance

5 Bands

1 2 3   Multiplier
Tolerance

IDENTIFYING CAPACITOR VALUES

Capacitors will be identified by their capacitance value in pF (picofarads), nF (nanofarads), or μF (microfarads). Most capacitors will have their actual value printed on them. Some capacitors may have their value printed in the following manner. The maximum operating voltage may also be printed on the capacitor.

Second digit ——— Multiplier

First digit ——— 103K Tolerance*
100V

Maximum working voltage
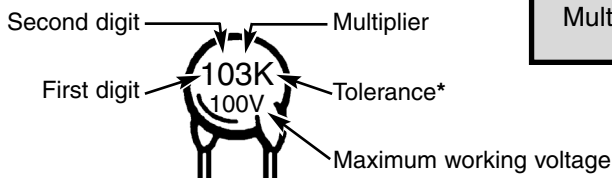
The value is 10 x 1,000 = 10,000pF or .01μF 100V

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

Electrolytic capacitors have a positive and a negative electrode. The negative lead is indicated on the packaging by a stripe with minus signs and possibly arrowheads.

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

* The letter M indicates a tolerance of ±20%
The letter K indicates a tolerance of ±10%
The letter J indicates a tolerance of ±5%

Warning:

If the capacitor is connected with incorrect polarity, it may heat up and either leak, or cause the capacitor to explode.

Polarity marking

(−)

(+)

CONSTRUCTION

Introduction
The most important factor in assembling your M-1008K Digital Multimeter Kit 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.**

Solder
For many years leaded solder was the most common type of solder used by the electronics industry, but it is now being replaced by lead-free solder for health reasons. This kit contains lead-free solder, which contains 99.3% tin, 0.7% copper, and has a rosin-flux core.

Lead-free solder is different from lead solder: It has a higher melting point (about 440°F, compared to about 360°F for lead solder), so you need higher temperature for the solder to flow properly. Recommended tip temperature is 700°F-800°F; higher temperatures improve solder flow but accelerate tip decay. An increase in soldering time may be required to achieve good results. Soldering iron tips wear out faster since lead-free solders are more corrosive and the higher soldering temperatures accelerate corrosion, so proper tip care is important. The solder joint finish will look slightly duller with lead-free solders.

Use these procedures to increase the life of your soldering iron tip when using lead-free solder:

- Keep the iron tinned at all times.
- Use the largest tip possible for best heat transfer.
- Turn off iron when not in use or reduce temperature setting when using a soldering station.

- Tips should be cleaned frequently to remove oxidation before it becomes impossible to remove. Use Dry Tip Cleaner (Elenco® #SH-1025) or Tip Cleaner (Elenco® #TTC1).
- DO NOT use a sponge, this worsens tip life because the temperature shocks accelerate corroding of the tip. If you insist on using a sponge, use distilled water (tap water has impurities that accelerate corroding).

Safety Procedures
- **Always wear safety glasses or safety goggles to protect your eyes when working with tools or soldering iron, and during all phases of testing.**
- Be sure there is **adequate ventilation** when soldering.
- Locate soldering iron in an area where you do not have to go around it or reach over it. Keep it in a safe area away from the reach of children.
- **Do not hold solder in your mouth.** Solder is a toxic substance. Wash hands thoroughly after handling solder.

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 in the board and are soldered on the foil side. **Use only rosin core solder.**
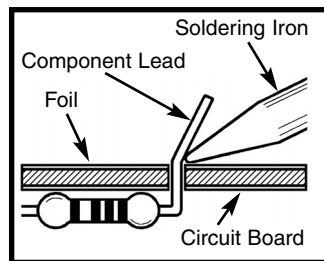
DO NOT USE ACID CORE SOLDER!

What Good Soldering Looks Like
A good solder connection should be bright, shiny, smooth, and uniformly flowed over all surfaces.

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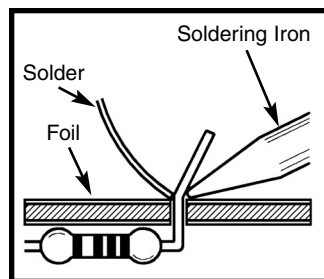
3. Allow the solder to flow around the connection. Then, remove the solder and the iron and let the connection cool. The solder should have flowed smoothly and not lump around the wire lead.
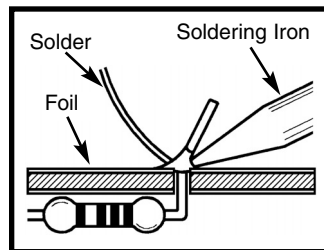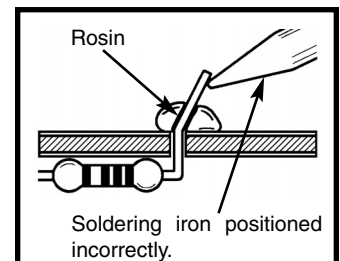

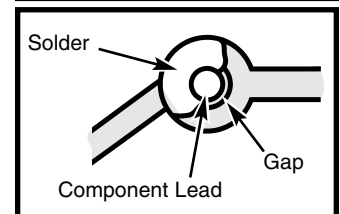4. Here is what a good solder connection looks like.
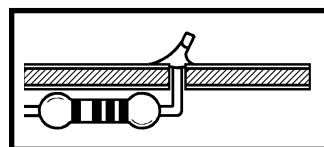
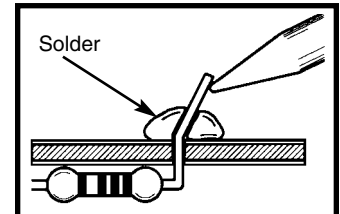## Types of Poor Soldering Connections

1. **Insufficient heat** - the solder will not flow onto the lead as shown.


2. **Insufficient solder** - let the solder flow over the connection until it is covered. Use just enough solder to cover the connection.

3. **Excessive solder** - could make connections that you did not intend to between adjacent foil areas or terminals.

4. **Solder bridges** - occur 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.
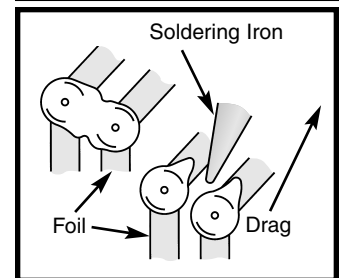
ASSEMBLY INSTRUCTIONS

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

NOTE: The 7106 IC1 is already installed on the PC board. This type of installation is called C.O.B. (chip on board). The LM358 U2 IC is also mounted and uses a surface mount package.

☐ R14 - 100kΩ 1% 1/4W Resistor
(brown-black-black-orange-brown)
(see Figure A)

☐ C2 - 0.22µF (224) Mylar cap.

☐ C3 - 0.1µF (104) Mylar cap.

☐ R32 - 1MΩ 1% 1/4W Resistor
☐ R30 - 1MΩ 1% 1/4W Resistor
☐ R31 - 1MΩ 1% 1/4W Resistor
☐ R15 - 1MΩ 1% 1/4W Resistor
(brown-black-black-yellow-brown)
(see Figure A)

☐ R16 - 220kΩ 1% 1/4W Resistor
(red-red-black-orange-brown)
(see Figure A)

☐ R18 - 100Ω 1% 1/4W Resistor
(brown-black-black-black-brown)
(see Figure A)

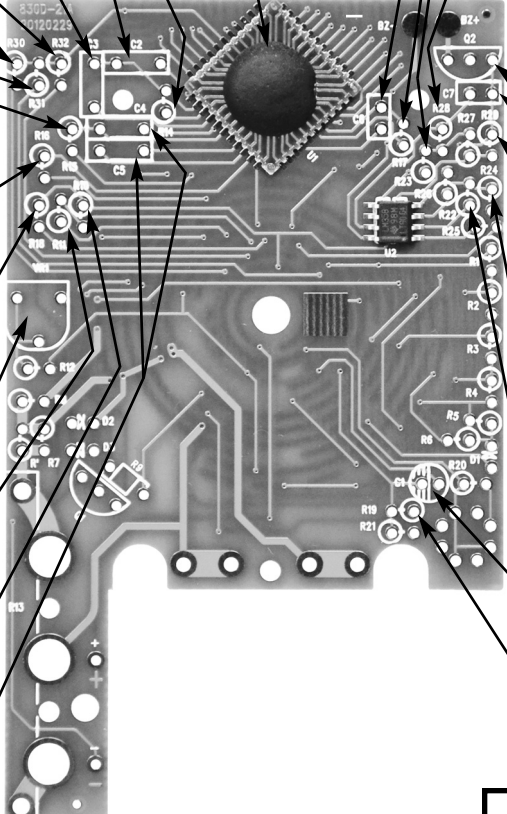☐ VR1 - 200Ω (201) Potentiometer
(see Figure B)

☐ R11 - 20.5kΩ 1% 1/4W Resistor
(red-black-green-red-brown)
(see Figure A)

☐ R10 - 9kΩ 1% 1/4W Resistor
(white-black-black-brown-brown)
(see Figure A)

☐ C4 - 0.1µF (104) Mylar cap.
☐ C5 - 0.1µF (104) Mylar cap.

☐ C6 - 100pF (101) Discap

☐ R17 - 100kΩ 1% 1/4W Resistor
(brown-black-black-orange-brown)
(see Figure A)

☐ R23 - 470Ω 1% 1/4W Resistor
(yellow-violet-black-black-brown)
(see Figure A)

☐ R28 - 220kΩ 1% 1/4W Resistor
(red-red-black-orange-brown)
(see Figure A)

☐ Q2 - 2SA9015 Transistor
(see Figure C)

☐ C7 - 220pF (221) Discap

☐ R29 - 220kΩ 1% 1/4W Resistor
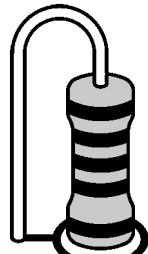(red-red-black-orange-brown)
(see Figure A)

☐ R24 - 1MΩ 1% 1/4W Resistor
(brown-black-black-yellow-brown)
(see Figure A)

☐ R22 - 47kΩ 1% 1/4W Resistor
(yellow-violet-black-red-brown)
(see Figure A)
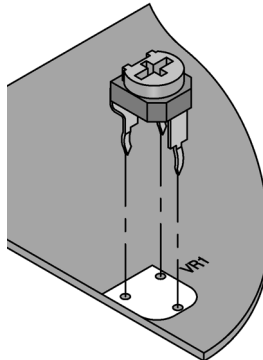
☐ C1 - 2.2µF 50V Electrolytic cap.
(see Figure D)

☐ R19 - 10Ω 1% 1/4W Resistor
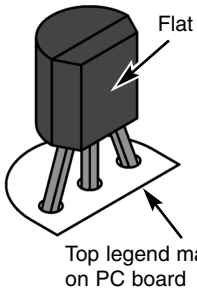(brown-black-black-gold-brown)
(see Figure A)

Figure A

Stand resistor on end as shown. Solder and cut off the excess leads.
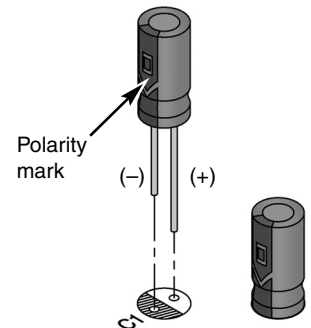
Figure B

Mount the potentiometer to the PC board as shown.

Figure C

Flat

Top legend marking on PC board

Mount the transistor with the flat side in the same direction as the marking on the PC board as shown.

Figure D
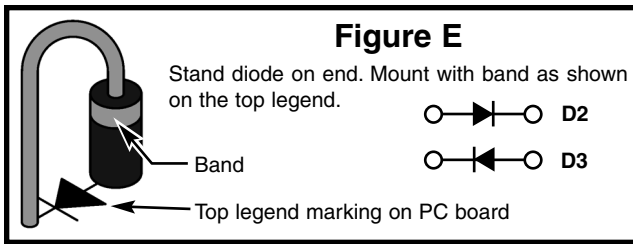
Polarity mark

(–) (+)

Be sure that the negative (short) lead is in the correct hole on the PC board.

Warning:
If the capacitor is connected with incorrect polarity, it may heat up and either leak, or cause the capacitor to explode.

ASSEMBLY INSTRUCTIONS

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

Figure E

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

○——▶|——○ **D2**

——— Band

○——|◀——○ **D3**

——— Top legend marking on PC board

☐ D3 - 1N4007 Diode
☐ D2 - 1N4007 Diode
      (see Figure E)

☐ R12 - 900Ω 1% 1/4W Resistor
(white-black-black-black-brown)
(see Figure A)

☐ R8 - 9Ω 0.5% 1/4W Resistor
(white-black-black-silver-green)
(see Figure A)

☐ R7 - 0.99Ω 0.5% 1/4W Resistor
(black-white-white-silver-green)
(see Figure A)

☐ Q1 - 2SA9013 Transistor
(see Figure C)

☐ R9 - 1.5kΩ PTC Resistor

☐ R6 - 548kΩ 0.5% 1/4W Resistor
(green-yellow-gray-orange-green)
(see Figure A)

☐ R21 - 220kΩ 1% 1/4W Resistor
(red-red-black-orange-brown)
(see Figure A)
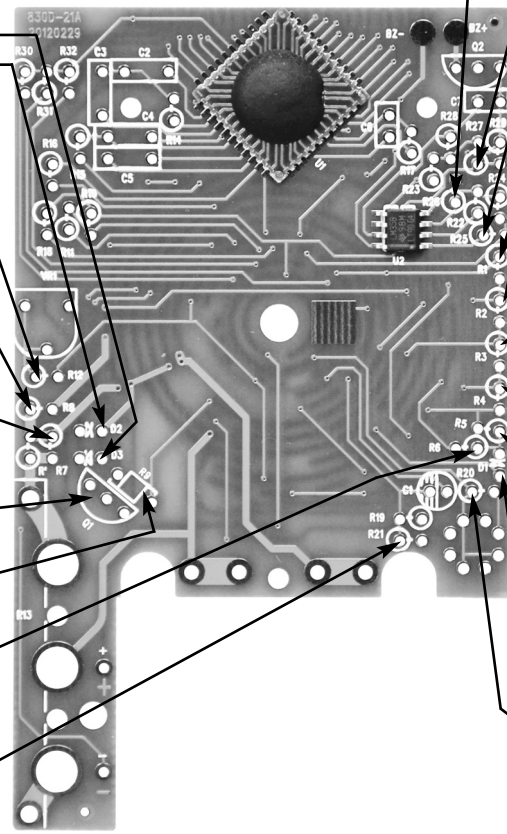
☐ R26 - 47kΩ 1% 1/4W Resistor
☐ R27 - 47kΩ 1% 1/4W Resistor
(yellow-violet-black-red-brown)
(see Figure A)

☐ R25 - 220kΩ 1% 1/4W Resistor
(red-red-black-orange-brown)
(see Figure A)

☐ R1 - 100Ω 0.5% 1/4W Resistor
(brown-black-black-black-green)
(see Figure A)

☐ R2 - 900Ω 0.5% 1/4W Resistor
(white-black-black-black-green)
(see Figure A)

☐ R3 - 9kΩ 0.5% 1/4W Resistor
(white-black-black-brown-green)
(see Figure A)

☐ R4 - 90kΩ 0.5% 1/4W Resistor
(white-black-black-red-green)
(see Figure A)

☐ R5 - 352kΩ 0.5% 1/4W Resistor
(orange-green-red-orange-green)
(see Figure A)

☐ D1 - 1N4007 Diode
      (see Figure E)   **D1**

☐ R20 - 220kΩ 1% 1/4W Resistor
(red-red-black-orange-brown)
(see Figure A)

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

❒ Insert the narrow end of the three input sockets into the PC board from the top legend, as shown in Figure F. Solder the sockets to the PC board on the top legend only. The solder should extend completely around the socket (see Figure F).

❒ Insert the shunt wire (R13) into the PC board holes from the component side as shown in Figure F. Solder the wire to the PC board on the component side only.

❒ Insert the 8-pin transistor socket into the PC board holes from the solder side as shown in Figure F. 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.

❒ Insert the two fuse clips into the PC board holes on the component side as shown in Figure F. Solder the clips to the PC board.

❒ Solder the 11mm spring to the solder pad on the top legend side of the PC board as shown in Figure G.

❑ Feed the battery snap wires up through the holes in the PC board from the solder side as shown in Figure F. Insert the red wire into the hole marked (**+**) and black wire into hole marked (**–**) as shown. Solder the wires to the PC board.

❑ Peel the backing off the foam tape on the buzzer and attach it to the PC board as shown in Figure H.

❑ Solder the red wire to the BZ+ pad and black wire to the BZ– pad as shown in Figure H.

❑ Remove the clear protective film from the front of the LCD as shown in Figure I.
(**Note:** DO NOT remove the white backing on the other side of the LCD).

❑ Insert the LCD into the frame (the tab on the LCD must be in the same direction shown in Figure J).

❑ Insert the zebra frame as shown in Figure K.

❑ Place the zebra onto the grooved surface of the LCD as shown in Figure K.

❑ 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 L. Then, insert a 4mm spring into each hole as shown in the figure.
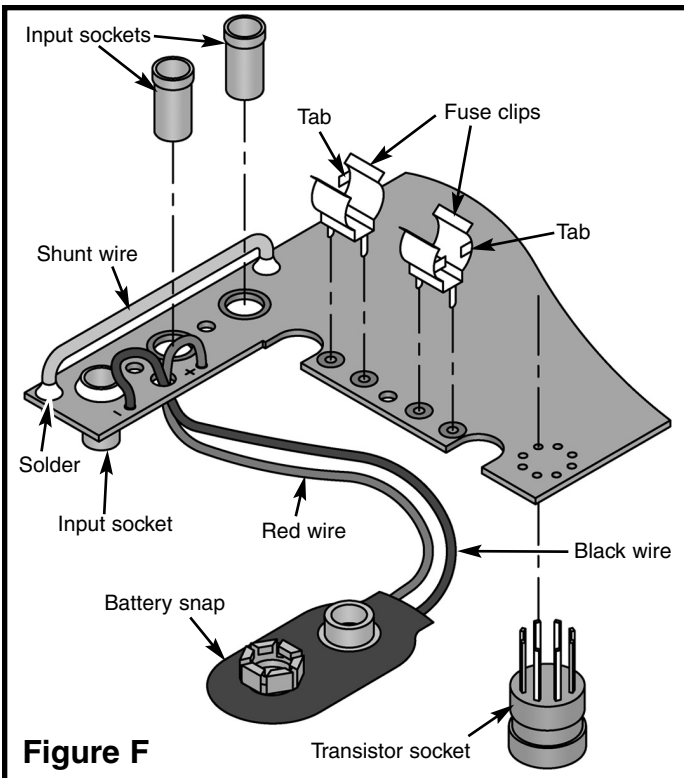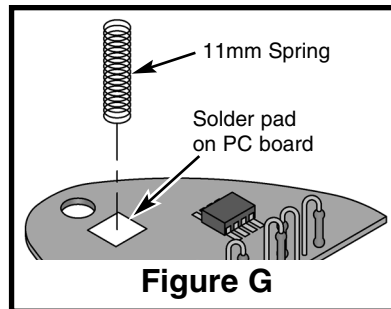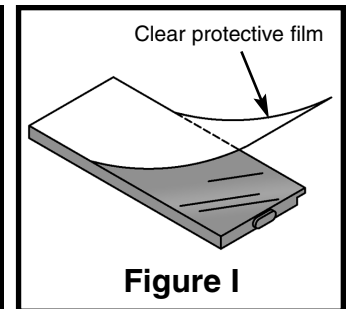

Figure F

Input sockets
Tab
Fuse clips
Tab
Shunt wire
Solder
Input socket
Red wire
Black wire
Battery snap
Transistor socket

Figure G

11mm Spring
Solder pad on PC board

Figure I

Clear protective film

Figure H

Black wire (BZ–)
Buzzer
Red wire (BZ+)

Figure J

LCD
Tab
Mounting tab

Figure K

Zebra
Zebra frame
Mounting tabs
LCD
Mounting tabs

Figure L

4mm Springs
Spring holes
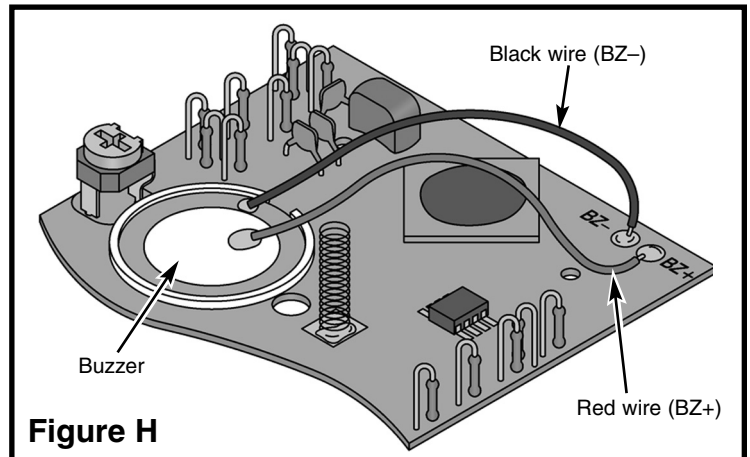
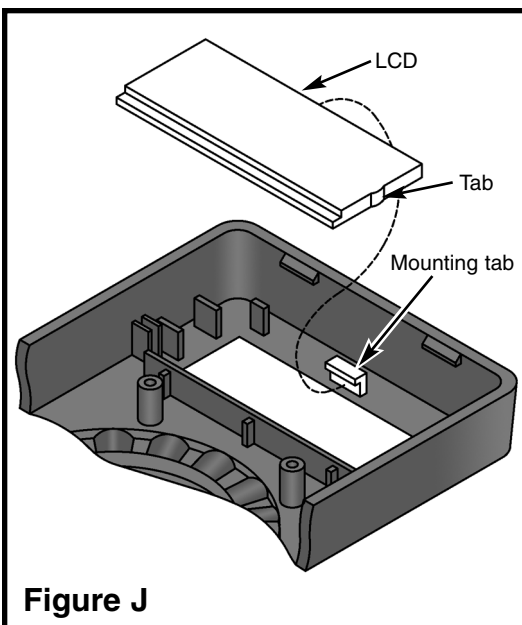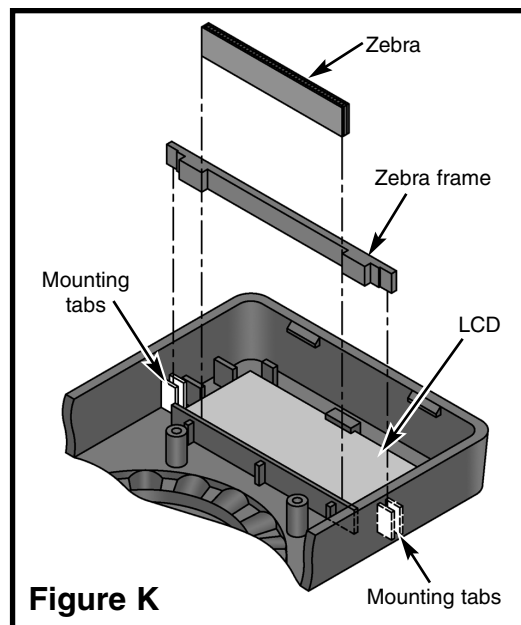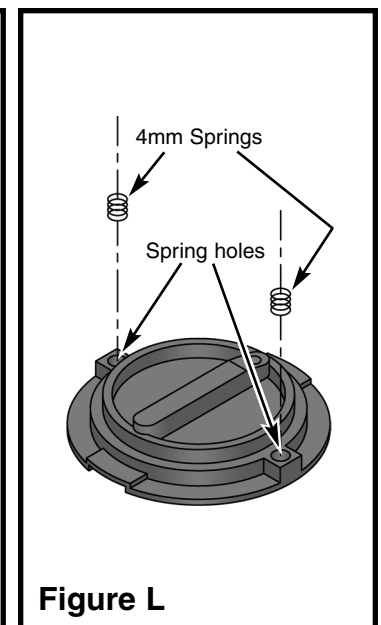- ❏ Put the ball bearings into two opposite indents in the case top as shown in Figure M.
- ❏ Place the six slide contacts on the selector knobs as shown.
- ❏ Place the selector knob into the case top so that the springs fit over the ball bearings as shown.
- ❏ Place the PC board over the selector knob. Be sure that the 8-pin socket slides into its hole. Then fasten the PC board with five 6mm screws as shown.
- ❏ Insert the 200mA, 250V fuse into the fuse clips.
- ❏ Peel the backing off of the front label and place it on the case top.
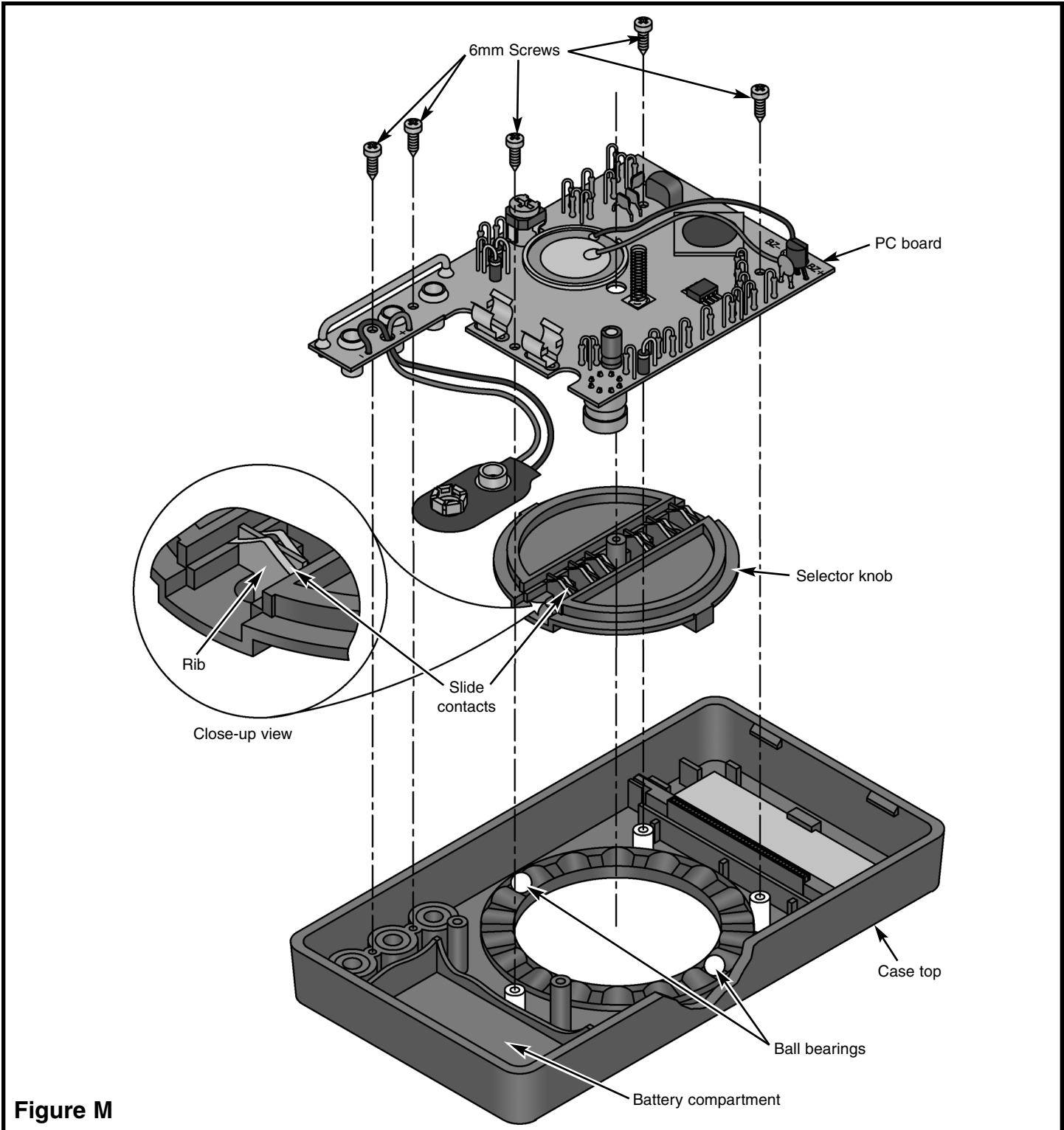- ❏ Connect a 9V battery to the battery snap.

6mm Screws

PC board

Selector knob

Rib

Slide contacts

Close-up view

Case top

Ball bearings

Battery compartment

Figure M

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) ACV Range: 600   HV 0 0 0
                      200   0 0.0

2) DCA,10A Ranges:
200μ	0 0.0
2,000μ	0 0 0
20m	0.0 0
200m	0 0.0
10A	0.0 0

3) Ohms, Diode and h$_{FE}$ Ranges: B indicates blank.

h$_{FE}$	0 0 0
Diode "→▶—⊢—" "•)) "	1 B B B
200	1 B B.B
200	1 B B.B
2,000	1 B B B
20k	1 B.B B
200k	1 B B.B
2,000k	1 B B B

4) DCV Range:
200m	0 0.0
2,000m	0 0 0
20	0.0 0
200	0 0.0
600 HV	0 0 0

If any of these tests fail:

a) Check that the battery is good.

b) Check the values of resistors R14 - R17, R30 - R32.

c) Check the values of capacitors C1 - C6.

d) Check the PC board for solder bridges and bad solder connections.

e) Check that the slide contacts are seated correctly.

f) 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 to the VΩmA and COM sockets. 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 1A current source such as a 5V power supply and a 5Ω, 5W resistor. 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 N. If the meter reads higher than 1A, 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.
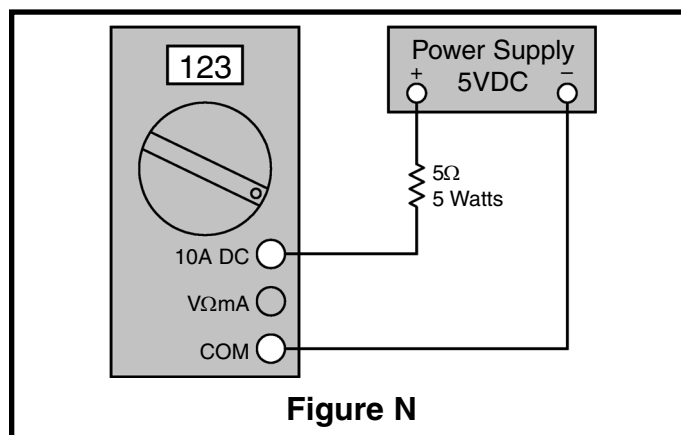

Figure N

If the calibration fails:

a) Check the PC board for solder bridges and bad solder connections.

b) Check the value of resistors R10 - R12 and VR1.

Attach the bottom case without screws.

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 2V and measure the voltage across the 100Ω resistor of Figure O. 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 100Ω resistor of Figure P. 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.

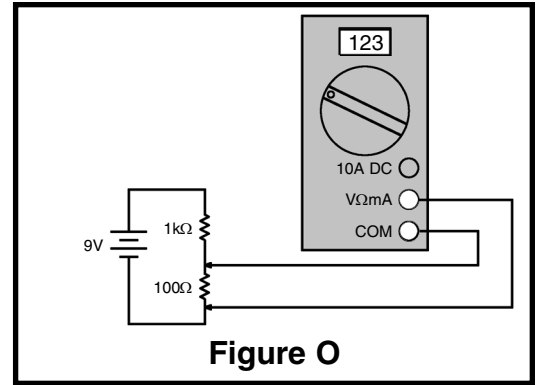b) Check the value and the soldering of resistors R1 - R6, R10 - R12, R14 - R17, VR1, and capacitor C4.
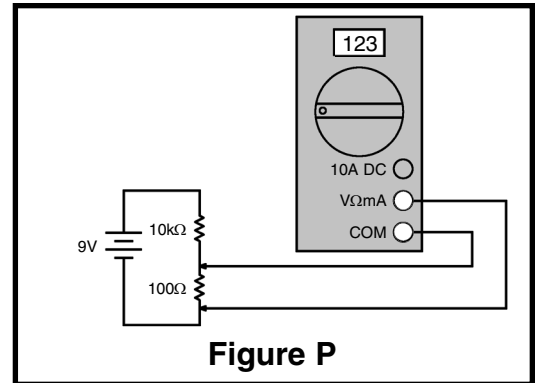

Figure O

Figure P

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 600VAC 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 600VAC 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 D1,R1-6 and R19.

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 Q. With RA equal to 100kΩ the current should be about 90μA. Compare the reading to a known accurate meter.

2) Set the range switch and RA as in the following table. Read the currents shown and compare to a known accurate meter.

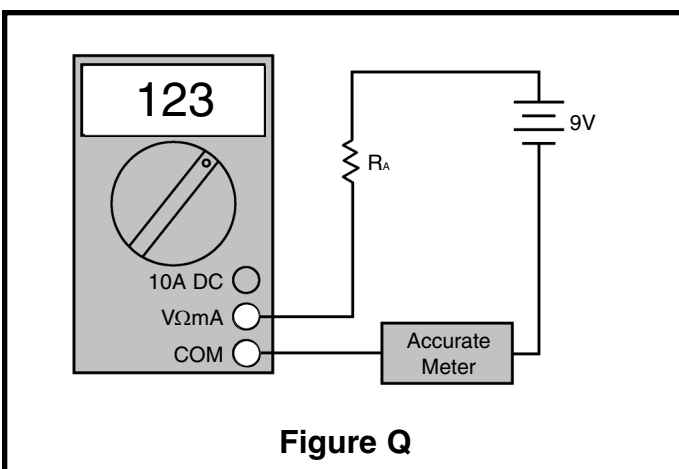| Range Switch	R_A	Current (approx.)
2mA	10kΩ	900μA
20mA	1kΩ	9mA
200mA	470Ω	19mA

If any of the above tests fail:

a) Check the fuse.

b) Check the value and soldering of resistors R7, R8,R13,D2 and D3.

Figure Q

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 PTC, R1-6, R9, and R16.

h_{FE} TEST

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 the value and soldering of resistors R19-21.

CONTINUITY TEST

1) Set the range switch to the "•)) " position.

2) Touch the tips together and all zeros displays as the buzzer sounds.

If this check fails:

   a) Check the value and soldering of resistors R22-29, Q2, C7, and buzzer.

FINAL ASSEMBLY

❏ Peel the backing off of the shield label and stick it onto the case bottom in the location shown in Figure Ra.

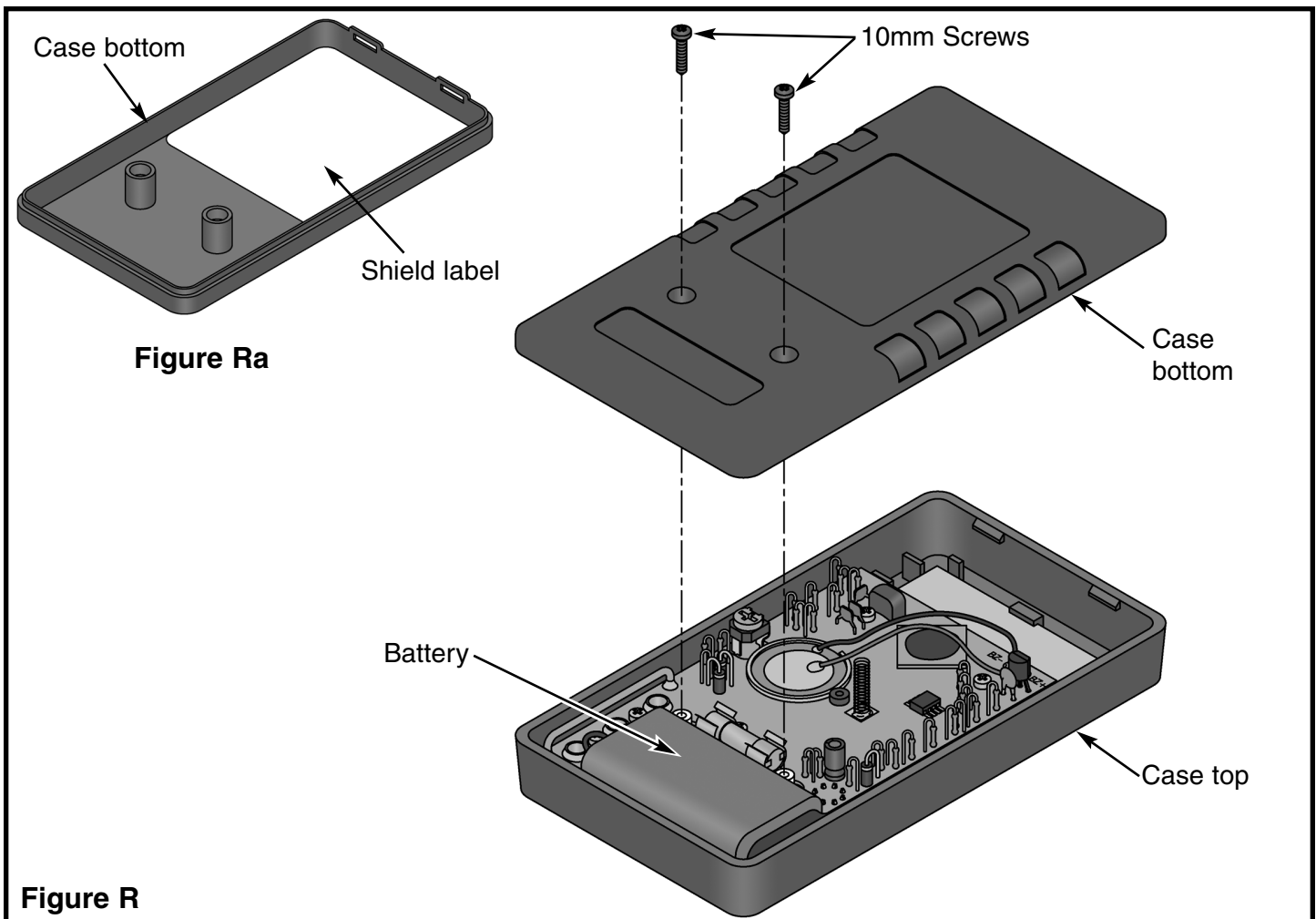❏ Snap the case bottom onto the case top and fasten with the two 10mm screws as shown in Figure R.

Case bottom

Shield label

Figure Ra

10mm Screws

Case bottom

Battery

Case top

Figure R

THEORY OF OPERATION

A block diagram of the M-1008K is shown in Figure 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 1. 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 1
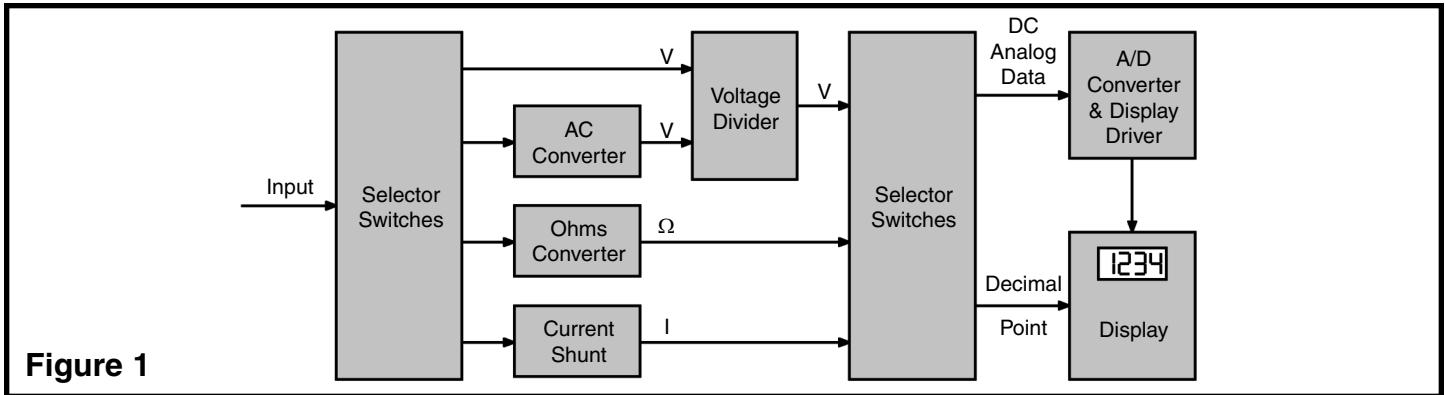
For resistance measurements, an internal voltage source drives the test resistor in series with a known resistor. The ratio of the test resistor voltage to the known resistor voltage is used to determine the value of the test resistor.

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 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 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 1,000 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 2,000 counts for a full scale input voltage. The autozero period varies from 1,000 to 3,000 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.
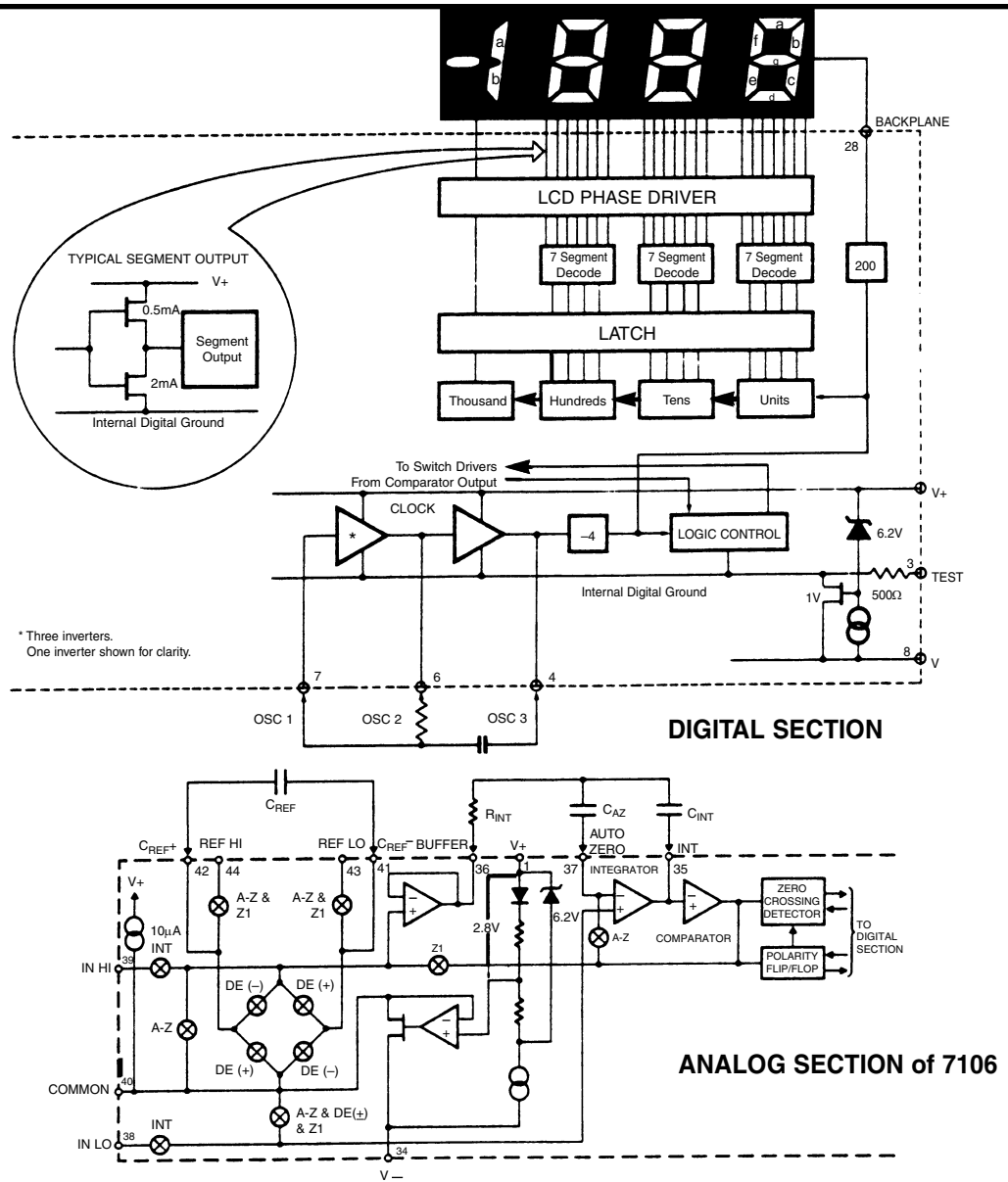
Figure 2
7106 IC Functions

TYPICAL SEGMENT OUTPUT

LCD PHASE DRIVER

7 Segment Decode

LATCH

Thousand | Hundreds | Tens | Units

To Switch Drivers
From Comparator Output

CLOCK

LOGIC CONTROL

* Three inverters.
  One inverter shown for clarity.

OSC 1   OSC 2   OSC 3

DIGITAL SECTION

ANALOG SECTION of 7106

Figure 3

DUAL SLOPE A/D CONVERTER

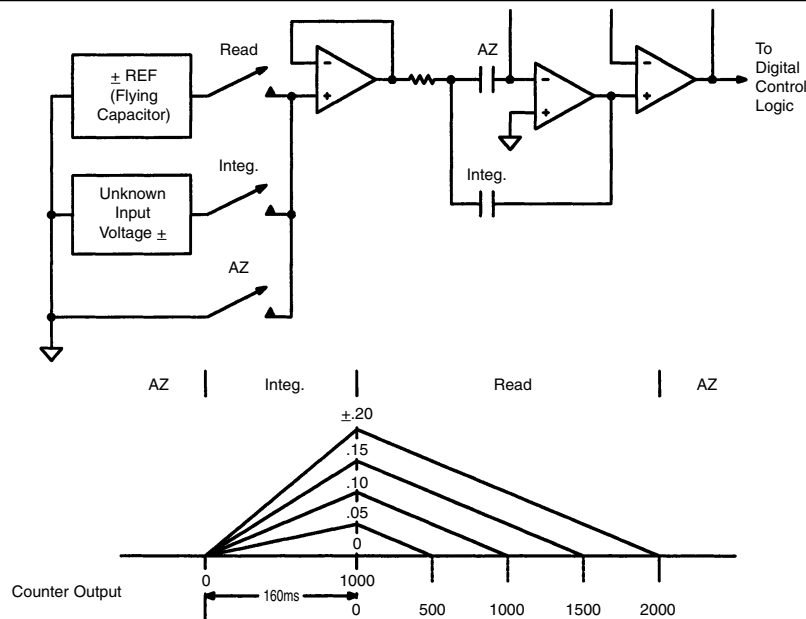## DC VOTAGE MEASUREMENT

Figure 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.
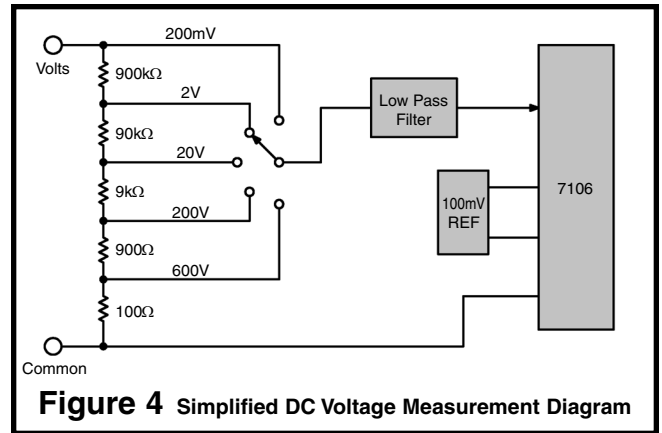
Figure 4 Simplified DC Voltage Measurement Diagram

AC VOLTAGE MEASUREMENT

Figure 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.
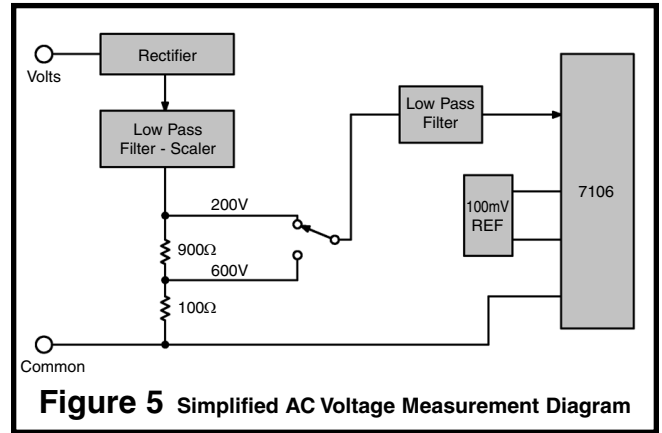
Figure 5 Simplified AC Voltage Measurement Diagram

CURRENT MEASUREMENT

Figure 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.
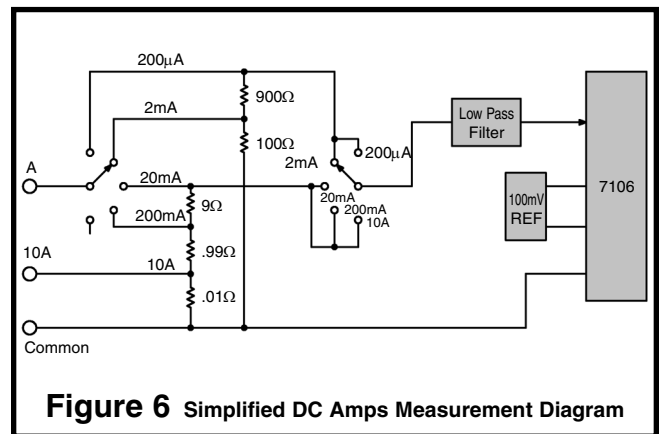
Figure 6 Simplified DC Amps Measurement Diagram

RESISTANCE MEASUREMENT

Figure 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.
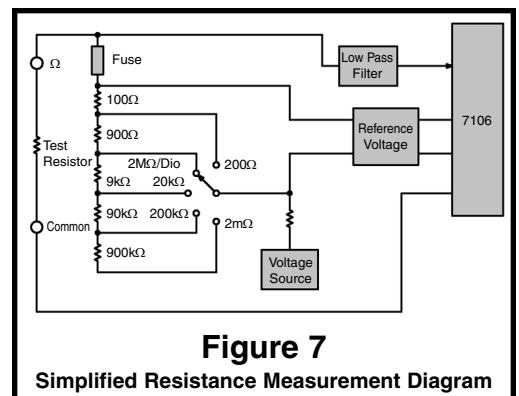
Figure 7
Simplified Resistance Measurement Diagram

-14-

CONTINUITY MEASUREMENT

Figure 8 shows a diagram of the continuity measurement function. The circuit uses two op-amps and a piezoelectric buzzer. When the leads are connected across a circuit and the resistance less than 20Ω the circuit oscillates and the buzzer sounds.
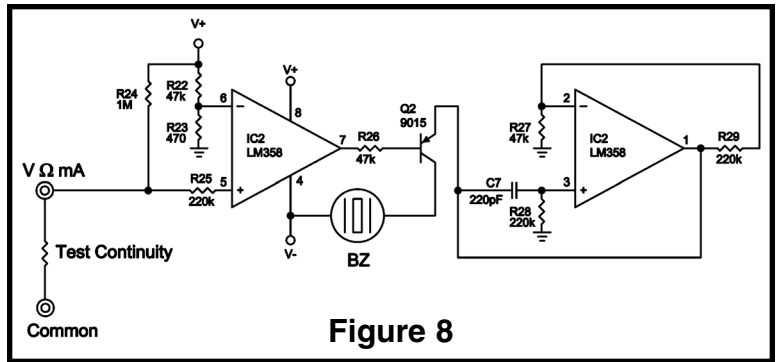

Figure 8

h$_{FE}$ MEASUREMENT

Figure 9 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 R1. The voltage drop in resistor R1 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 R2 indicates the h$_{FE}$ of the transistor.
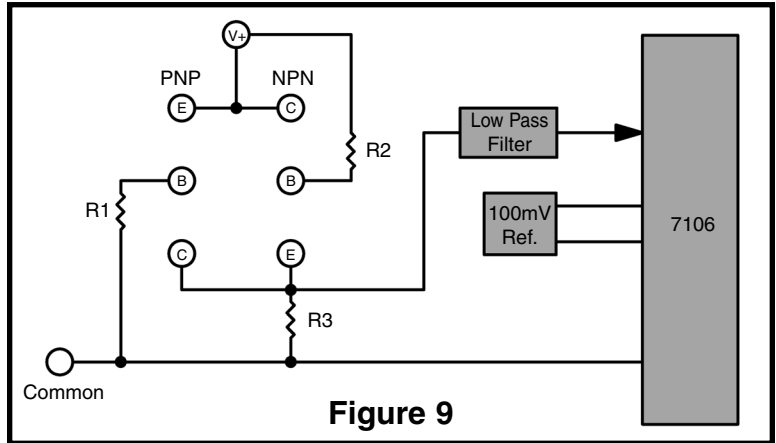

Figure 9

SPECIFICATIONS

GENERAL

DISPLAY	3 1/2 digit LCD, with polarity
OVERRANGE INDICATION	3 least significant digits blanked.
MAXIMUM VOLTAGE BETWEEN	
TERMINALS AND EARTH GROUND	CAT II 600V
STORAGE ENVIRONMENT	−10°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.
FUSE	200mA/250V
DIMENSIONS	126 x 70 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
600V	1V	±0.5% rdg ± 2d

MAXIMUM ALLOWABLE INPUT	250V rms for 200mV, 600VDC or rms AC for other ranges.
INPUT IMPEDANCE	1MΩ.

DC CURRENT

RANGE	RESOLUTION	ACCURACY
200µA	0.1µA	±1.8% rdg ± 2d
2000µA	1µA	±1.8% rdg ± 2d
20mA	10µA	±1.8% rdg ± 2d
200mA	100µA	±2.5% rdg ± 2d
10A	10mA	±3% rdg ± 3d

OVERLOAD PROTECTION	200mA/250V fuse (µA,mA input only). 10A not fused (15 seconds only)

AC VOLTAGE

RANGE	RESOLUTION	ACCURACY
200V	100mV	±2% rdg ± 10d
600V	1V	±2% rdg ± 10d

MAXIMUM ALLOWABLE INPUT	600VDC or rms AC.
FREQUENCY	45 - 450Hz.

RESISTANCE

RANGE	RESOLUTION	ACCURACY
200Ω	0.1Ω	±1% rdg ± 10d
2000Ω	1Ω	±1% rdg ± 10d
20kΩ	10Ω	±1% rdg ± 10d
200kΩ	100Ω	±1% rdg ± 10d
2000kΩ	1kΩ	±1% rdg ± 4d
MAXIMUM OPEN CIRCUIT VOLTAGE		3.2V.
MAXIMUM ALLOWABLE INPUT		250V rms AC

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

CONTINUITY TEST

Audible Indication: Less than 20Ω approx.

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 "DCV" or "ACV" 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 DCA 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.

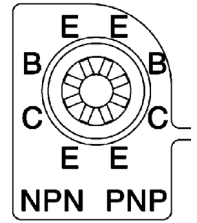4) Set the range switch to "▶▐".

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.

CONTINUITY CHECK

1) Set the range switch to the "•))" position.

2) Touch the tips across two points and if the resistance is less than 20Ω the buzzer will sound.

BATTERY & FUSE REPLACEMENT

If " ⊡ " appears on the display, it indicates that the battery should be replaced.

To replace battery and fuse (200mA/250V), remove the 2 screws in the bottom of the case. Simply remove the old fuse/battery and replace with a new fuse/battery. Fuse 200mA # 530020.

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.

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-1008K has . . .
   ❏ A) a 3 digit display.
   ❏ B) a 3½ digit display.
   ❏ C) a 4½ 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

M1008K
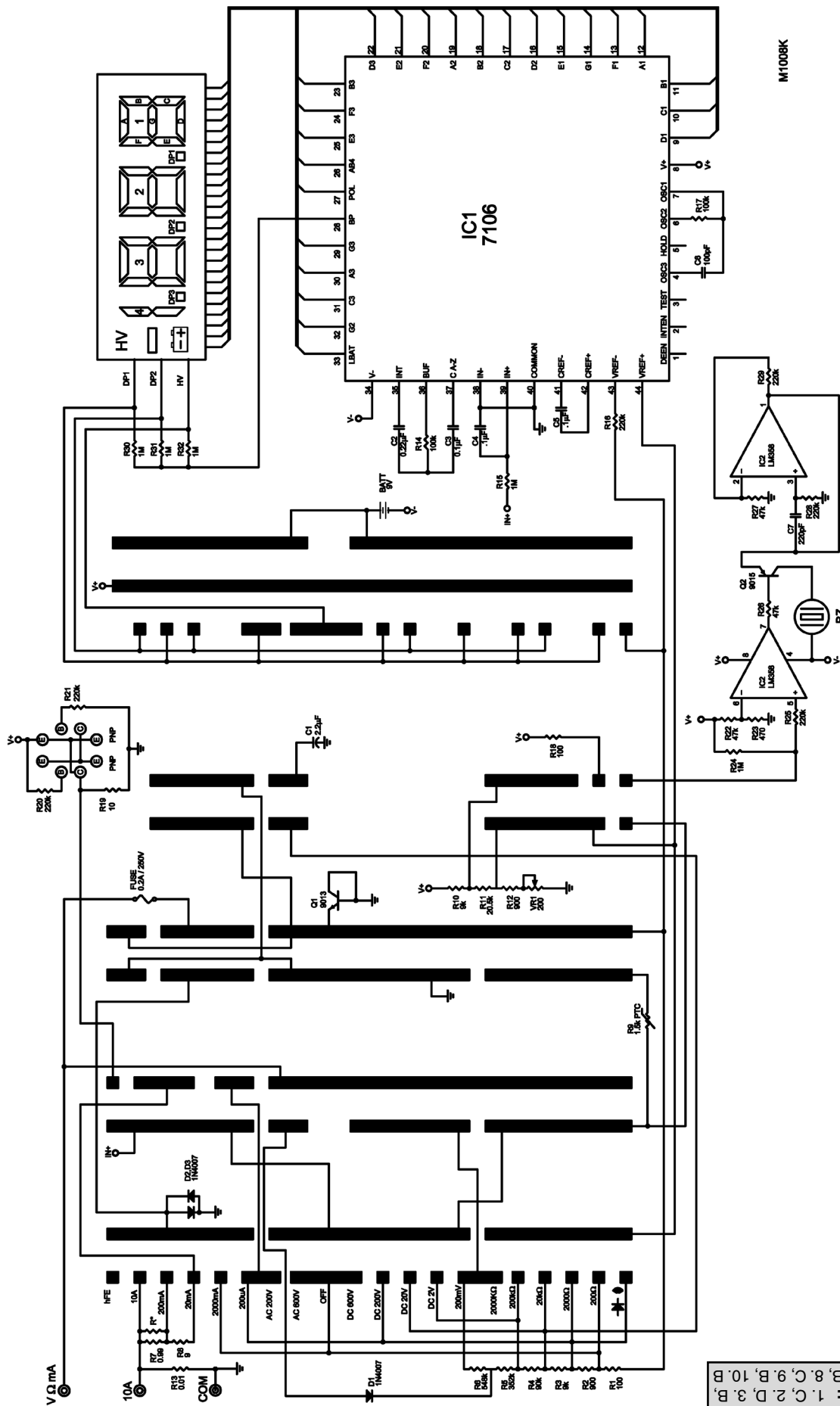
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e-mail: elenco@elenco.com

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