Assembling and Using your

CONAR

Frequency Counter

Model 202

Excerpted from NRI Booklet #6TT
Digital Techniques, Modulation,
and Frequency Measurement
ADVANCED ELECTRONICS
TRAINING KIT LESSON 256

QUALITY EQUIPMENT BUILT ON A HALF CENTURY OF SERVICE IN ELECTRONICS

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CONAR INSTRUMENTS DIVISION OF NATIONAL RADIO INSTITUTE, WASHINGTON, D.C. 20016

NATIONAL RADIO INSTITUTE, WASHINGTON, D.C. 20016

1978 EDITION

SPECIAL INSTRUCTIONS

MODEL 202 FREQUENCY COUNTER

Two types of LED displays are used in the Model 202 Frequency Counter. One type of display uses a single decimal point, and all readings are made in kilohertz. The other type of display uses two decimal points so that readings may be made in either kilohertz or megahertz.

Example: One decimal point display

Display		*Reading*
1234.56	=	1234.56 kilohertz

Example: Two decimal point display

Display		*Reading*
1.234.56	=	1234.56 kilohertz
	=	1.23456 megahertz

SPECIAL INSTRUCTIONS

CRYSTAL CR30 MARKING

You may find that crystal CR30 is marked incorrectly as 6.5546 MHz. The manufacturer made this error during the marking process. The actual value of the crystal is 6.5536 MHz and can be used in this instrument.

*39-SI-284

Assembling the Frequency Counter: Stage 1

Temporarily set aside the Discovery Lab and your experimental parts. At this time you will partially assemble the digital frequency counter. Then you will perform Experiment 9 using the partially assembled frequency counter. After completing Experiment 9 you will finish the assembly of the frequency counter, test its operation, and use the completed instrument to perform Experiment 10.

You will first assemble the circuit board for the frequency counter. You will need the following parts from bag 3B-6TT:

Part No.	Quan.	Description	Price Each
CN191	1	22 pf NP0 disc capacitor	.15
CN235	1	10 pf NP0 disc capacitor	.15
CN261	1	1 μf tantalum capacitor	.74
CN269	2	0.012 μf mylar capacitors	.25
HA902	8′	Thin solder	.45
WR914	2′	Bare wire	.06

You will also need the following part that is *not* in a bag:

Part No.	Quan.	Description	Price Each
EC69	1	Frequency counter circuit board	5.25

Be sure to use the solder supplied with the parts to perform the wiring on the circuit board. This is a special thin solder that is best to use when working on crowded circuit boards.

The first stage of the circuit board assembly is shown in Fig. 1. Install and solder the parts as indicated in this figure. Use the bare wire supplied for the jumpers shown, and be sure to save the leftover wire as it will be needed later. When you get to an assembly step that is shaded in, stop and solder the parts just installed, and clip off any excess lead lengths from the foil side of the circuit board. Be very careful in your soldering not to allow solder to flow from one conductor to another. If you *do* make a solder bridge, stop and heat the solder splash with your iron to allow the solder to flow onto your iron tip, thus removing the solder from the board.

When you have completed the assembly steps shown in Fig. 1, go on to the next assembly stage.

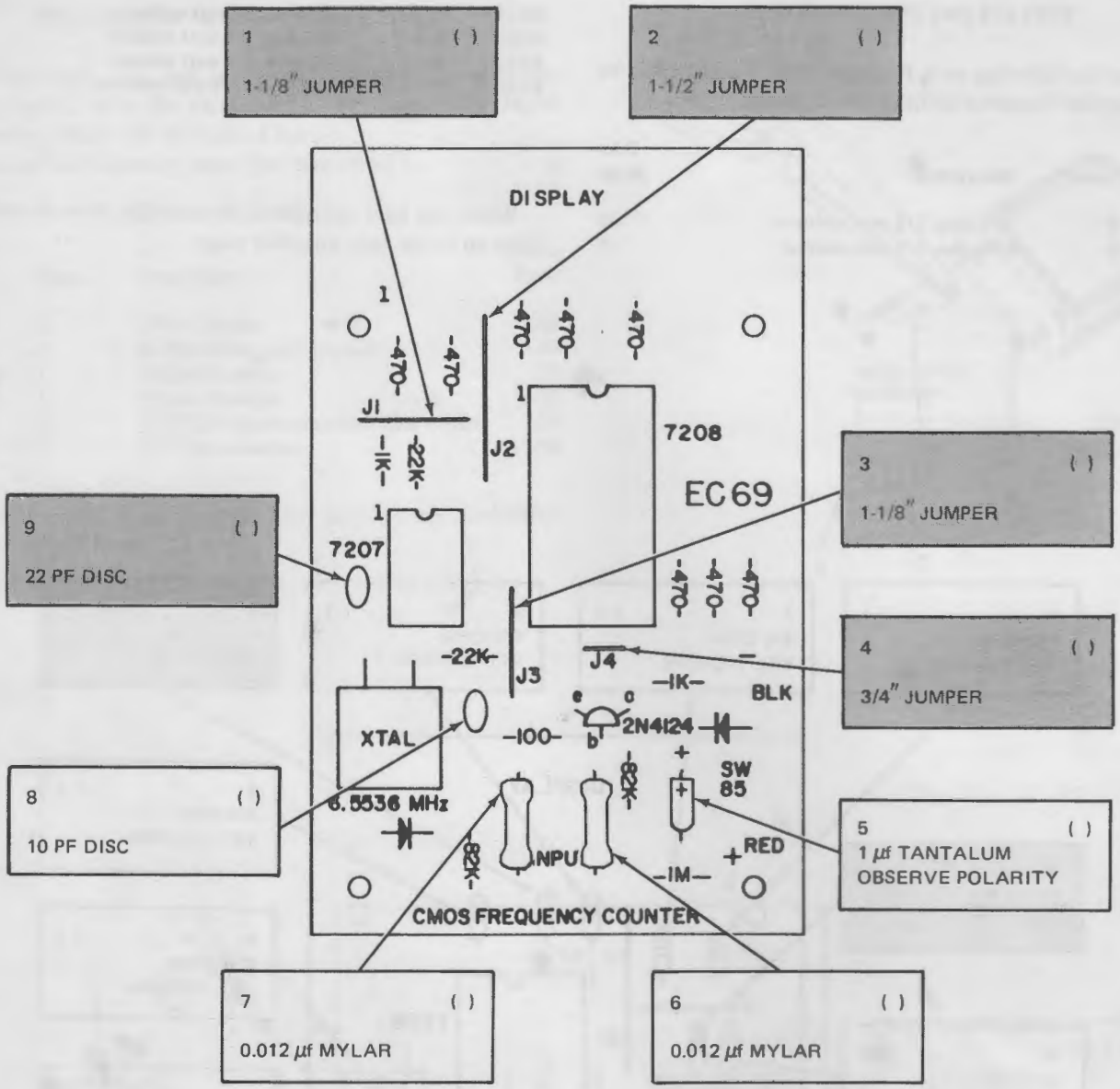


Fig. 1. Installing the jumpers and capacitors.

INSTALLING THE RESISTORS

Remove the following parts from bag 3B-6TT and install the resistors on the frequency counter circuit board:

Part No.	Quan.	Description	Price Each
RE167	8	470 ohm, 1/4 watt resistors	.15
RE192	1	100 ohm, 1/4 watt resistor	.15
RE194	2	1k-ohm, 1/4 watt resistors	.15
RE197	2	22k-ohm, 1/4 watt resistors	.15
RE199	2	82k-ohm, 1/4 watt resistors	.25
RE201	1	1 megohm, 1/4 watt resistors	.15

When you have completed the assembly steps shown in Fig. 2, go on to the next assembly stage.

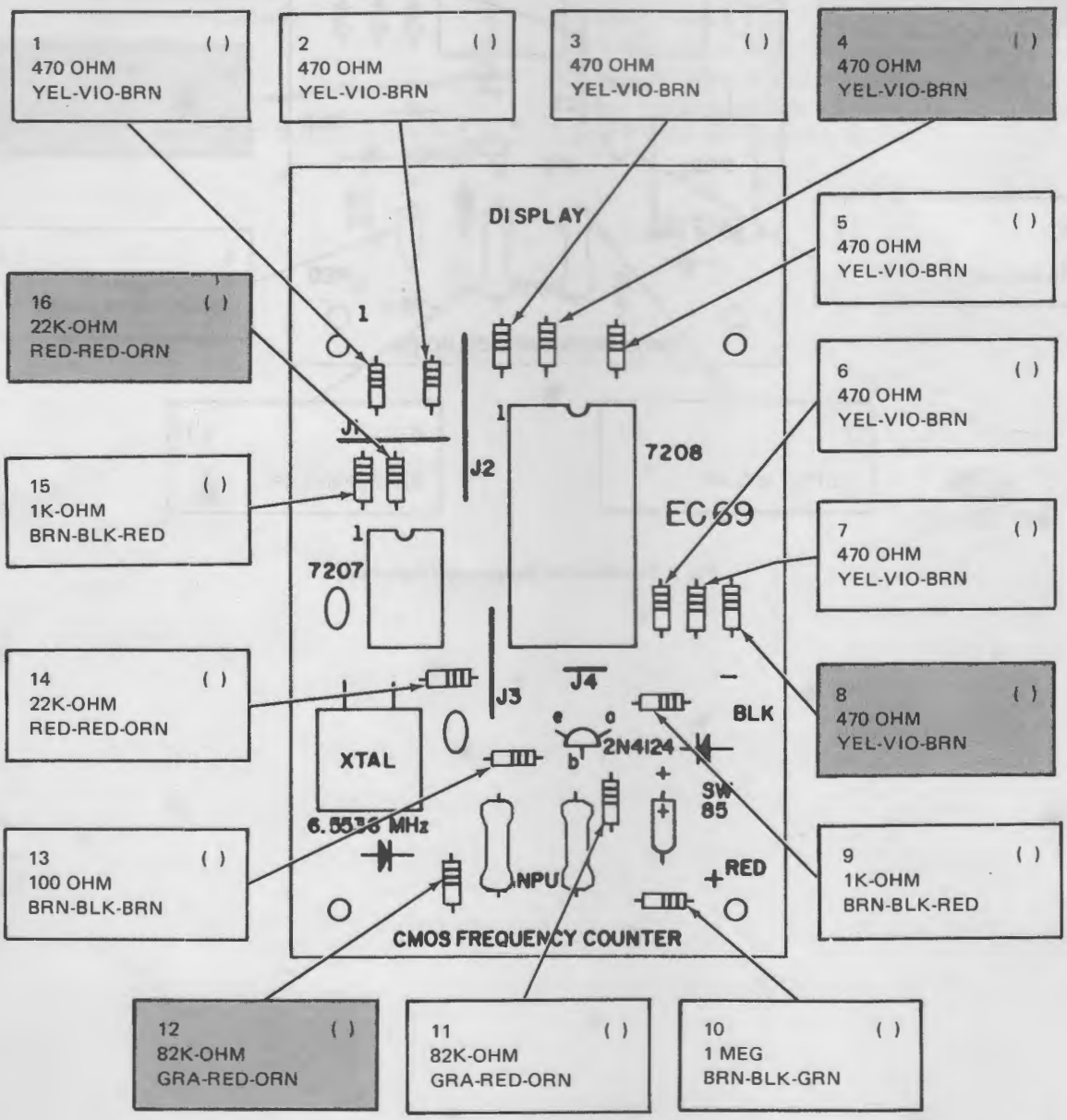


Fig. 2. Installing the resistors.

INSTALLING THE REMAINING PARTS

In this stage, you will install the remaining parts on the circuit board, with the exception of the display and input connector, which will be installed later.

Remove the following parts from bag 3B-6TT:

Part No.	Quan.	Description	Price Each
CR23	2	1N914 diodes	.40
CR30	1	6.5536 MHz quartz crystal	5.25
SO84	1	14-pin IC socket	.75
SO103	1	28-pin IC socket	1.25
SW85	1	DPDT PC-mount miniature slide switch	.30
TS43	1	2N4124 transistor	.45

Refer to Fig. 3 and install these parts on the frequency counter circuit board.

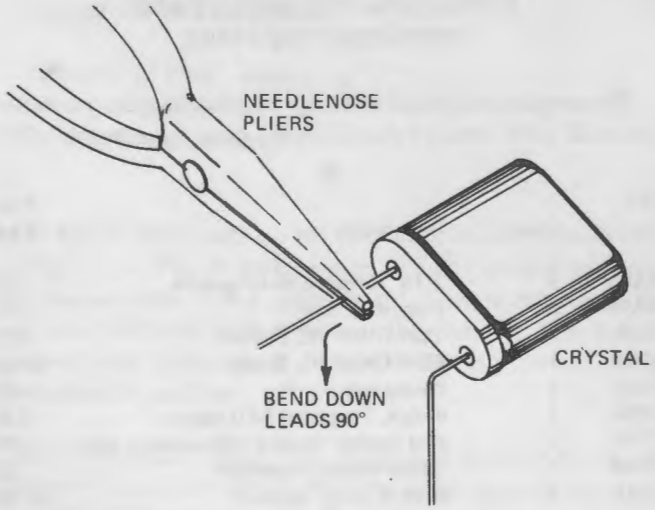


Fig. 3. Detail A.

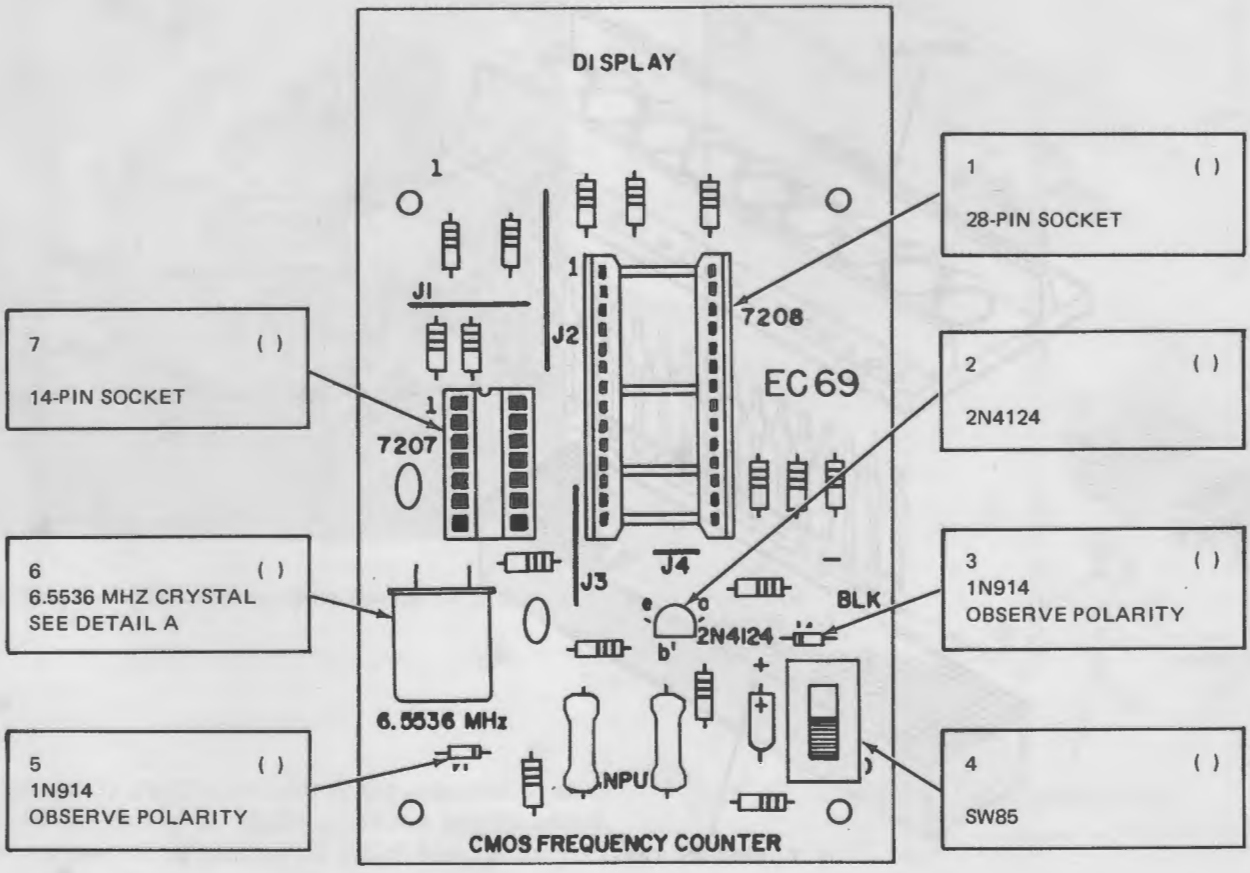


Fig. 3. Installing the remaining parts.

INSTALLING THE DISPLAY AND PREPARING THE PANEL

To complete the initial assembly of your frequency counter, you will need some of the following parts from bag 1C-6TT:

Part No.	Quan.	Description	Price Each
HA85	4	7/16″ threaded metal spacers	.10
HA904	2″	Foamstick tape	.05
IG68	1	7207 CMOS IC, 14-pin	5.75
IG69	1	7208 CMOS IC, 28-pin	22.50
JA10	1	Phono jack	.50
LP25	1	6-digit, 7-segment LED display	7.25
MS90	1	Red display window with masking tape	.30
MS60	1	18-pin display connector	.25
SC41	4	6-32 X 3/16″ screws	12/.25
SC86	4	6-32 X 3/8″ black nylon screws	12/.40
WA14	1	3/8″ flat control washer	12/.15
WA25	1	3/8″ control lockwasher	6/.15
WA26	8	No. 6 lockwasher	12/.15

In addition, you will need the following part that is *not* in a bag:

Part No.	Quan.	Description	Price Each
PA63	1	Front panel	2.85

You will not need all of the parts in bag 1C-6TT, so be sure to return those parts that you don't use to the bag. They will be used when you perform the final assembly after Experiment 9.

(1) Locate the 18-pin display connector (MS60) and examine it closely. You will notice that the pins are held between two carrier strips which have a series of holes punched in them. You will note further that there is a thick part on each pin near one end of the pin. Grasp the perforated carrier strip nearest the end of the pin that has the thick part with a pair of longnose pliers as shown in Fig. 4. While holding the pins in one hand, carefully break off the carrier strip nearest the thick part of the pins ..... ( )

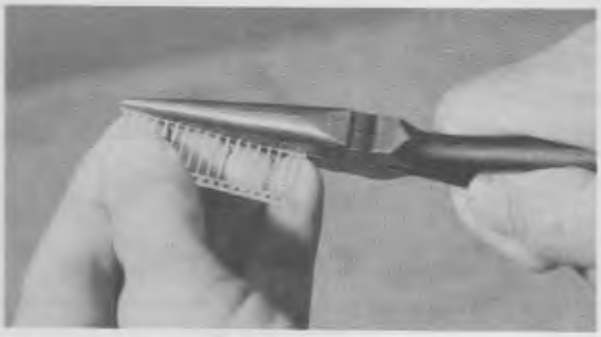


Fig. 4. Preparing the display connector.

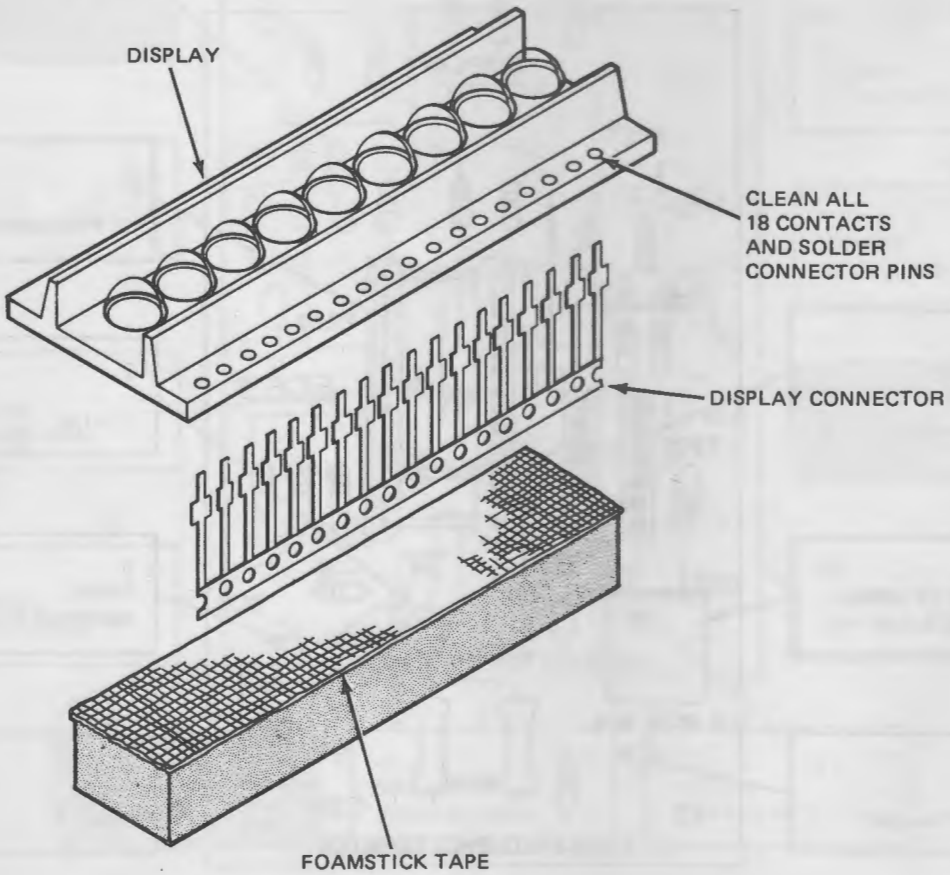


Fig. 5. Preassembling the display.

(2) Locate the six-digit, seven-segment display. Notice that there are 18 holes in the small circuit board on which the display is mounted, and that there is a gold plating around each of the holes. Clean the plated area on the side of the circuit board on which the display is mounted by rubbing with a soft pencil eraser. The metal should be bright and shiny when it is properly cleaned ..... ( )

(3) Now refer to Fig. 5 and insert the 18 pins of the 18-pin connector into the display circuit board. Making sure that the pins are at right angles to the circuit board, solder all 18 pins to the display ..... ( )

(4) Locate the length of foamstick tape and remove the paper backing from the adhesive side of the tape and install the tape just behind the 18-pin connector as shown in Fig. 5. Cut off any excess tape from the end of the display ..... ( )

(5) Finally, grasp the remaining carrier at the end of the 18 pins with your longnose pliers and break the carrier off, leaving the pins separated ..... ( )

Locate the assembled frequency counter circuit board. You will now "exercise" the pins of the 28-pin IC socket using the 18 pins of the display connector. This will make it much easier for you to install the 28-pin IC in the socket later.

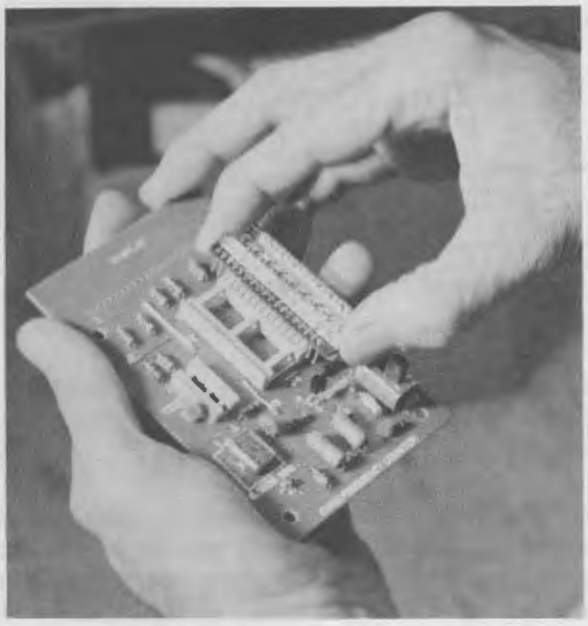


Fig. 6. Using the display connector pins to exercise the 28-pin socket.

(6) There are 14 pins on each side of the connector, so when you insert the pins of the display connector into the socket, four of the pins will *not* go into the socket. Insert and remove the display connector from the IC socket as shown in Fig. 6. Do this several times on each side of the socket ..... ( )

Locate the following parts:

4 6-32 X 3/16" screws
4 7/16" spacers
8 No. 6 lockwashers

(7) Install these parts on the frequency counter circuit board as shown in Fig. 7, making sure that the spacers are on the component side of the circuit board. Tighten the screws fully as you hold the spacers with your pliers. Be sure that the screws and lockwashers do not make any circuit bridges between foil sections ..... ( )

(8) Temporarily install the display as shown, but do *not* attempt to solder the display connector pins to the circuit board yet. Set the assembly aside while you prepare the front panel ..... ( )

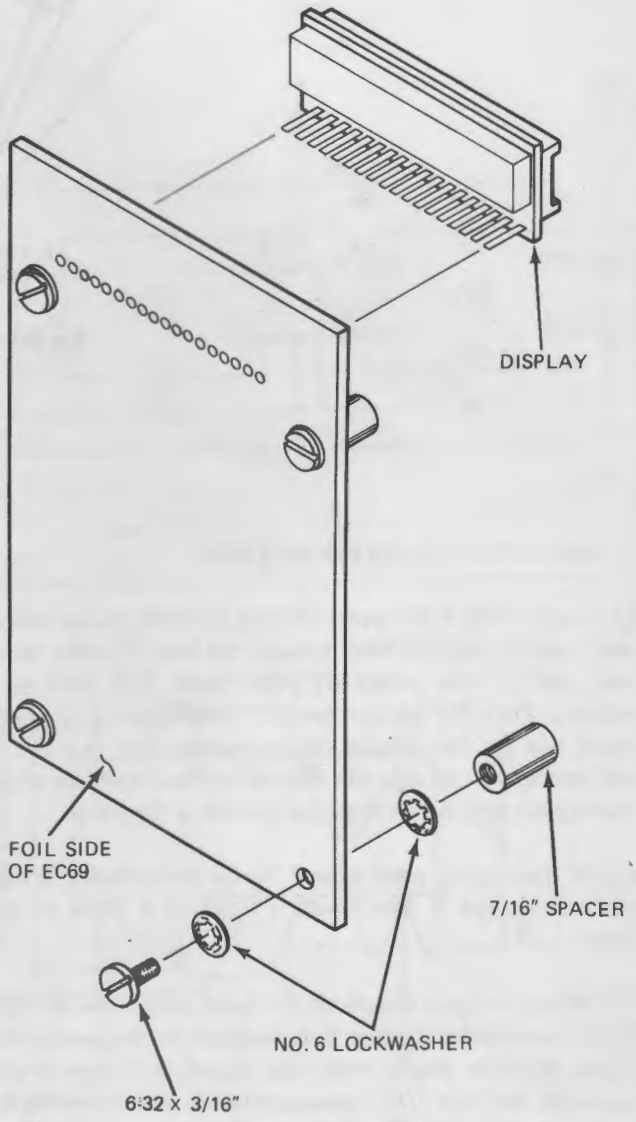


Fig. 7. Installing the display and spacers on EC69.

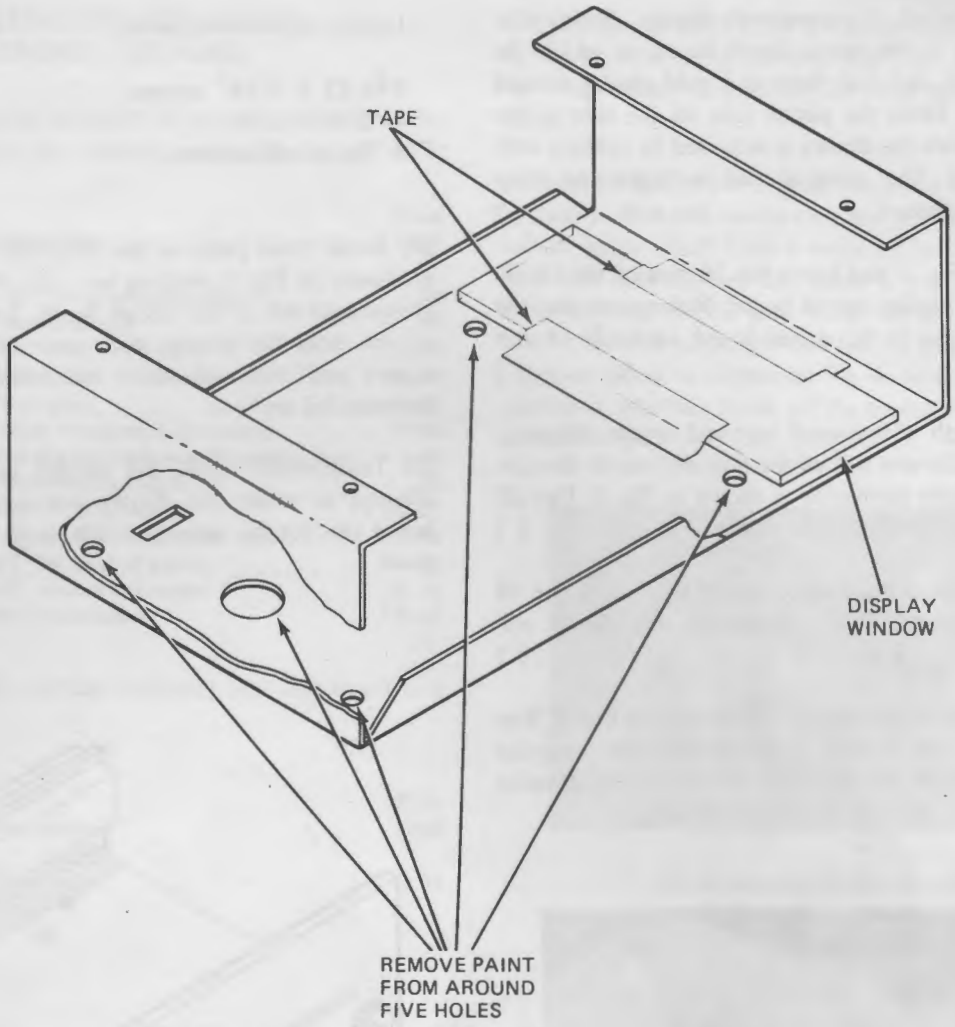


Fig. 8. Preparing the front panel.

Refer to Fig. 8 for the following steps:

(1) Locate the front panel (PA63) and the display window with masking tape (MS90). Remove the tape from the window and peel off the protective paper from both sides of the window. Place the window over the rectangular opening in the panel and cut two lengths of the masking tape to a size that will enable you to tape the window in place as shown without making the tape visible from the outside of the panel .... ( )

(2) If there is any paint around the five holes shown in Fig. 8, carefully scrape it away with a knife or a piece of sandpaper ..... ( )

(3) When you have completed the front panel, take the circuit board assembly and place it in position in the inside of the panel. Hold the display with your fingers so it stays in place, and align the four 7/16" spacers with the four mounting holes in the front panel. The display will rest against the display window, and the foamstick tape will compress slightly as you hold the circuit board in place. The knob of the slide switch should pass through the small rectangular opening in the front panel ..... ( )

(4) While holding the circuit board in place, secure the assembly to the panel temporarily with the four black nylon screws through the four holes in the front panel. When the screws are tight and all four spacers are tight against the inside of the front panel, solder the pins of the display connector to the pads on the circuit board ..... ( )

(5) After you have soldered the 18 pins, remove the four black nylon screws and the circuit board from the front panel ..... ( )

Set the panel assembly aside and put the leftover parts (including the four black nylon screws) back in bag 1C-6TT. You will use these parts later when you finish the assembly of the frequency counter. You are now ready to perform Experiment 9.

Assembling the Frequency Counter: Stage 2

Locate bag 1C-6TT that you have already opened, and remove the two IC's. Install the 14-pin IC (7207) in the proper socket on the frequency counter. Make sure the notch in the end of the IC is pointing *toward* the display. Now install the 28-pin IC (7208) in the other socket, making sure the notch is again pointing toward the display. Do *not* press the IC in its center to fit the pins into the socket. Instead, press evenly along both sides of the IC, directly above the pins, to fully seat the IC in the socket. You could easily crack the ceramic case of the IC if you apply pressure to the center of the IC.

When you have installed the two IC's, locate the remaining parts from bag 1C-6TT, as well as the bare wire left over from the assembly of the circuit board. Refer to Fig. 9 for the following steps:

(1) Cut a 3″ length of bare wire and wrap this lead once around the threaded part of the phono connector. Put the 3/8″ control lockwasher over the end of the connector and insert the connector in the 3/8″ hole from the inside of the frequency counter panel. The bare wire should be oriented toward the large bend in the panel toward the bottom . . . ( )

(2) Place the 3/8″ flat washer over the phono connector and secure the connector to the panel with the control nut . . . ( )

(3) Cut a 2″ length of bare wire and solder one end to the center terminal of the phono jack . . . . . ( )

Now reinstall the frequency counter circuit board on the inside of the front panel. The 2″ wire from the center of the phono connector must pass through the hole marked INPUT between the two capacitors on the circuit board, and the 3″ ground wire should come past the end of the circuit board.

With the circuit board in the correct position and the two bare wires correctly placed, secure the circuit board to the front panel with the four black nylon screws. Do not overtighten.

Now solder the input lead to the foil pad and clip off the excess lead length. Take the 3″ ground wire and bend it down so that it rests on the foil at the very end of the circuit board. Solder the ground wire to the ground foil of the circuit board.

For the next assembly steps, you will need the parts in bag 1D-6TT:

Part No.	Quan.	Description	Price Each
BA5	4	Penlight cells	.25
CL19	2	Penlight cell holders	.50
HA24	4	Rubber feet	4/.25
NU5	4	4-40 nuts	12/.25
SC6	4	4-40 X 1/4″ screws	12/.25
SC58	4	6-32 X 3/8″ thread cutting screws	12/.25
WA26	4	No. 6 lockwashers	12/.25
WR922	1′	Black stranded wire	.05
WR923	1′	Red stranded wire	.05

You will also need the following part which is not in a bag:

Part No.	Quan.	Description	Price Each
CB26	1	Cabinet	1.25

Refer to Fig. 10 and prepare both the penlight cell holders as indicated in the following steps:

(1) Bend all four solder lugs of both holders down at an angle of 90° . . . . . ( )

(2) Solder a short length of bare wire between two adjacent terminals of both holders . . . . . ( )

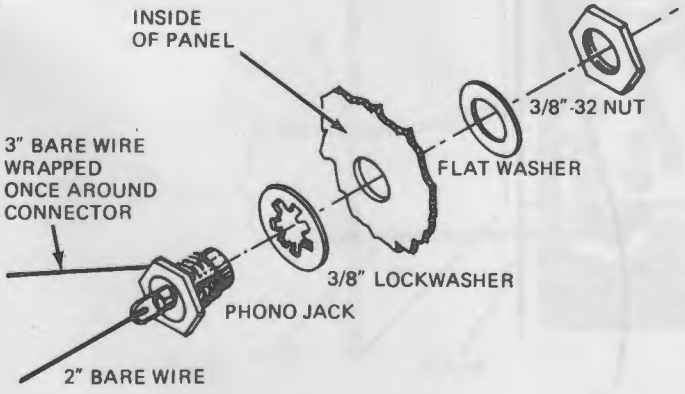


Fig. 9. Installing and wiring the phono jack.

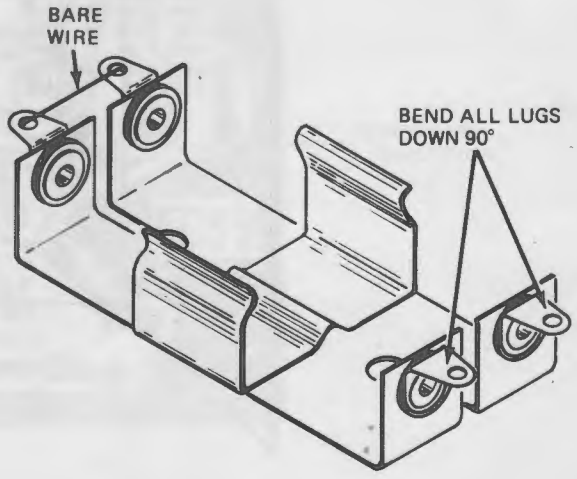


Fig. 10. Preparing the battery holders.

Refer to Fig. 11 for the next steps:

(1) Install the two cell holders on the inside of the cabinet in the positions shown. Use two 4-40 screws, No. 6 lockwashers, and 4-40 nuts to secure each holder ..... ( )

(2) Wire together the two cell holders using a 1" length of bare wire. Solder both connections ..... ( )

(3) Cut the red stranded wire to a length of 7" and strip 1/4" of insulation from each end. Twist the strands tightly together and lightly tin the bare ends with solder ..... ( )

(4) In a similar manner, prepare a 9" length of black stranded wire ..... ( )

(5) Solder the red and black leads to the cell holders as shown. Dress the wires toward one end of the cabinet ... ( )

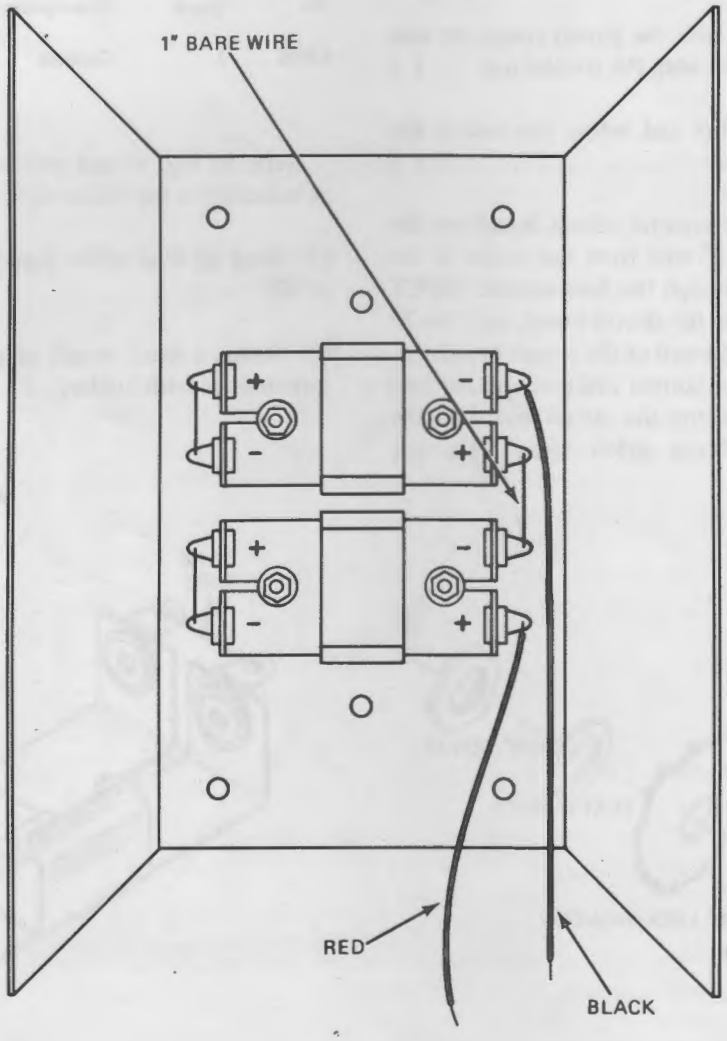


Fig. 11. Preparing the cabinet.

Refer to Fig. 12 for the following steps:

(1) Make sure the switch on the front panel of the frequency counter is in the OFF (down) position, then solder the red and black wires from the cell holders to the points labeled RED and BLK on the circuit board. Solder both connections . . ( )

(2) Solder a piece of bare wire in the place indicated as a temporary test connection for the completed frequency counter . . . . . ( )

Locate the four penlight cells and install them in the two cell holders with the polarity shown in Fig. 11. The flat end of the cell is the negative end. With the four cells installed, turn the frequency counter over so that you can see the display on the front panel. Turn the power switch on.

The display should light, and you should see 0001.60 indicated by the display. If you do *not* see this number on the display, turn off the power immediately. Check your wiring of the cell holders carefully and make sure the four penlight cells are connected properly in series. Use your tvom to check the voltage between the red and black wires. You should measure at least 6.0 volts dc with the red lead positive. If you get this reading and still do not get the proper display, carefully check to see that the temporary jumper (Fig. 12) is properly installed with no solder bridges.

Next be sure that there are no solder shorts or unsoldered connections on the circuit board. Be very sure that both IC's are properly installed. If you still are unable to get the correct display, write your instructor for further help.

Now, with the proper display shown on the frequency counter display, you are ready to complete the assembly of the counter. Turn the power off and remove the temporary connection from the foil side of the circuit board.

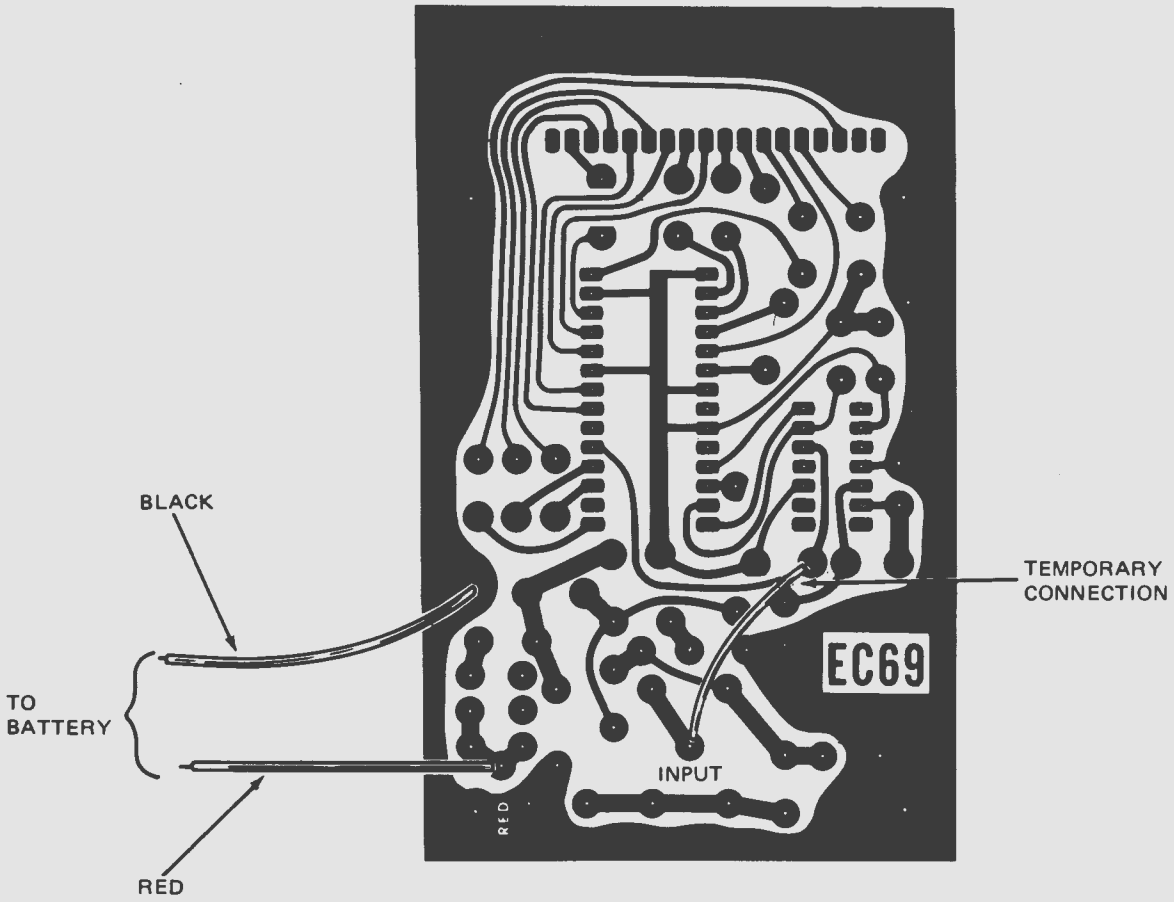


Fig. 12. Connecting the battery and installing the temporary test connection.

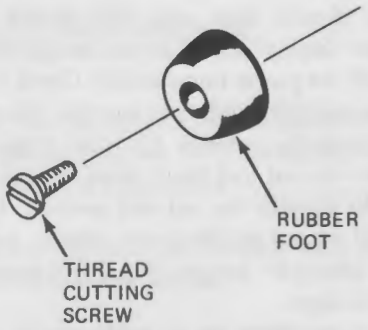


Fig. 13. Push the thread-cutting screw into the recess of the rubber foot.

Locate the four rubber feet and the four 6-32 X 3/8" thread cutting screws. Push one screw fully into the recess of each rubber foot as shown in Fig. 13. Now put the cabinet in place over the rear of the front panel, being careful not to pinch the red and black battery leads. The four holes in the back of the cabinet should line up with the four mating holes in the lips of the front panel. Secure the cabinet to the panel with the four prepared rubber feet/screw combinations. Do not overtighten the screws or you will strip the threads in the panel.

Set the completed frequency counter aside while you prepare the coax input cable.

Locate bag 1E-6TT and remove the following parts:

Part No.	Quan.	Description	Price Each
CA911	3′	RG58 coaxial cable	.45
CL8	2	Alligator clips	.15
HA72	1	Black alligator clip boot	.06
HA73	1	Red alligator clip boot	.06
IN902	5″	Shrinkable tubing, large ID	.15
PL16	1	Phono plug	.25

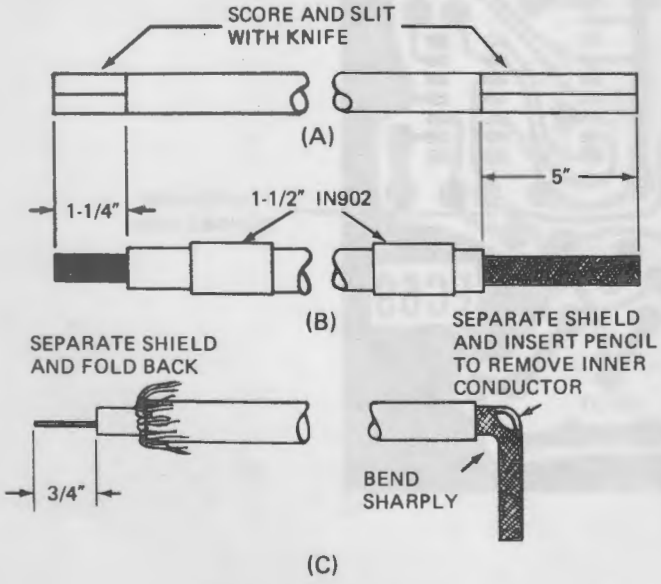


Fig. 14. Preparing the cable.

Refer to Fig. 14 for the following steps:

(1) Remove 1-1/4" of the outer covering from one end of the length of coaxial cable, and 5" from the other end. Score around the outside of the cable and run a slit all the way to the end with a knife, being careful not to cut the shield braid beneath the outer covering ..... ( )

(2) Cut two 1-1/2" lengths of the shrinkable tubing from the 5" length supplied and slip both lengths onto the coaxial cable. Save the remaining 2" length for use later in Experiment 10 ..... ( )

(3) At the end of the cable from which you removed 5" of the outer covering, bend the cable sharply and separate the strands of the shield braid at the outer part of the bend. Insert a pencil or other pointed object under the braid and pull out the inner conductor from the shield braid ..... ( )

(4) At the other end of the cable, separate the strands of the shield braid so that all strands are free and separate. Fold these strands back over the outer covering, and remove 3/4" of insulation from the inner conductor ..... ( )

(5) Twist the strands of the inner conductor tightly together and lightly tin them with your soldering iron ..... ( )

Refer to Fig. 15 for the following steps:

(1) Insert the end of the cable you just prepared into the opening of the phono plug, as far as it will go. Brush the strands of the shield braid forward over the outside of the phono plug ..... ( )

(2) Take a 3" length of bare wire and wrap it snugly around the shield wires on the outside of the phono plug. If any strands of the shield braid extend past the wire wrap, trim them off with a pair of cutters or scissors. Solder the wire to the braid and the phono plug ..... ( )

(3) Apply your soldering iron to the side of the tip of the phono plug to heat it thoroughly. Feed solder down into the end of the plug to solder the lead to the center pin ..... ( )

(4) Clip off any excess lead length protruding from the center pin ..... ( )

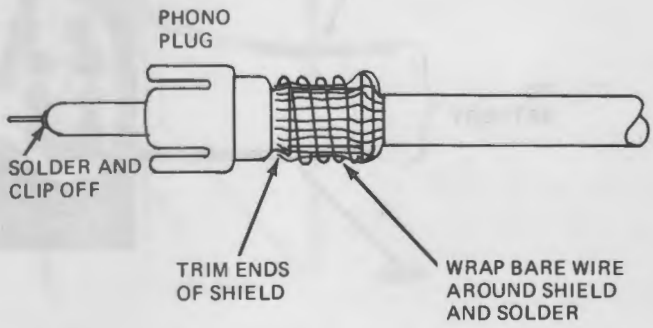


Fig. 15. Installing the phono plug.

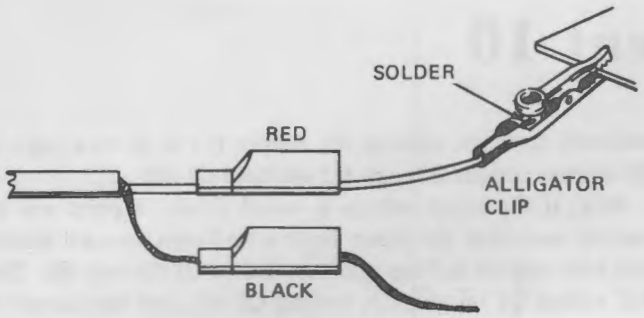


Fig. 16. Installing the alligator clips and boots.

Refer to Fig. 16 for the following steps:

(1) Slide the red alligator clip boot onto the center conductor at the other end of the coaxial cable ..... ( )

(2) Remove 1/4" of insulation from the end of the center conductor, and tightly twist the strands together. Lightly tin the strands with your soldering iron ..... ( )

(3) Clip one of the alligator clips onto the edge of a book or some other object to hold it steady, and insert the end of the center conductor into the solder loop of the clip. Solder the connection securely ..... ( )

(4) Slide the red alligator clip boot down over the alligator clip after you remove it from the book or other object ... ( )

(5) Slide the black alligator clip boot over the shield braid, and in a manner similar to that used in Steps 3 and 4 above, complete the installation of the second alligator clip on the shield braid ..... ( )

Refer to Fig. 17 for the following steps:

(1) Slide one of the 1-1/2" lengths of shrinkable tubing down the cable to the point where the two leads with the alligator clips emerge from the cable. Center the tubing over the point as shown, and slowly heat the tubing with a match or other heat source to shrink the tubing onto the cable ..... ( )

(2) Slide the other piece of shrinkable tubing down the cable and over the entire phono plug assembly. Heat this tubing also until it shrinks tightly down over the phono plug. If any part of the tubing extends past the end of the plug, trim the protruding part off with a razor blade or sharp knife .... ( )

This completes the assembly of your frequency counter.

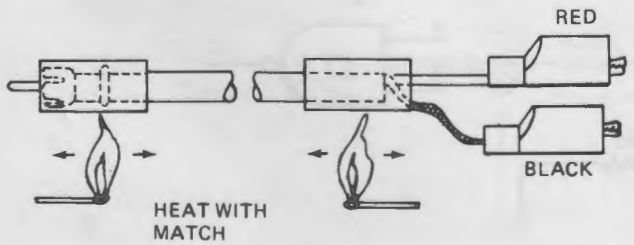


Fig. 17. Shrinking the tubing onto the cable.

USING THE FREQUENCY COUNTER

The frequency counter you have just completed is capable of measuring frequencies in the range of 10 Hz to about 3 MHz ±10 Hz, depending upon the condition of the batteries. With fresh batteries, you should easily be able to measure a maximum frequency of 6 MHz, accurate to within 10 Hz.

The display is shown in kilohertz, as indicated on the panel of the meter, and there are six digits present – four to the left of the decimal and two to the right of the decimal. The two digits to the right of the decimal are fractional parts of a kilohertz, representing hundreds of hertz and tens of hertz, going to the right from the decimal. Thus, a reading of 2002.34 (kHz) would be "two thousand two kHz, three hundred forty Hz." You could also read this in MHz as "2.00234 MHz" by mentally moving the decimal point three places to the left.

Your frequency counter has a moderate input impedance of about 50,000 ohms. This means that it can be connected to most low impedance sources without any worry of having the counter "load" the signal source. There may be some slight loading if you attempt to connect the counter to a high impedance source. In most instances, this will have no harmful effects on your frequency measurements.

At most frequencies, it will take a signal level of about 100 millivolts to get an accurate reading on the frequency counter. This is a fairly small signal (0.1 volt), showing that the counter has good sensitivity. The maximum signal that should ever be applied to the input of the counter is 200 volts, combined ac and dc. A larger signal input may damage components in the input circuit. Therefore, be *very* sure never to exceed the input voltage rating of 200 volts. Even with this rating, it is *not* safe to measure the frequency of the ac power line directly. Even though the line voltage is nominally 120 volts, there are often power surges which have spikes of a few microseconds duration that can be in excess of 1000 volts. *This will damage your frequency counter.* If you want to measure the power line frequency, do so at the 6.3 VAC tie point block *only*!

To use the frequency counter to measure frequencies, connect the black alligator clip to the ground circuit of the device under test, and the red alligator clip to the point at which you wish to measure the frequency. Turn the power on and read the frequency. When you have completed the reading, be sure to turn the power off to conserve the penlight cells. Regular zinc-carbon cells should last at least 10 hours if the instrument is left on continuously. Alkaline cells will last much longer. In actual use, the cells will give much longer service than 10 hours if you take the time to turn the instrument off when it is not being used.

As the cells age, their output voltage decreases, and the display will probably appear slightly dimmer than with new cells. At the same time, the instrument will not respond as well to the higher frequency signals. It may not be possible to read frequencies higher than about 1 MHz when the cells are near the end of their life. A sure sign that the cells need to be replaced is that only one of the six digits will light when the instrument is turned on. Of course, if none of the digits lights you should replace the four penlight cells.

Now that you know a little something about your new frequency counter, you will continue with Experiment 10.

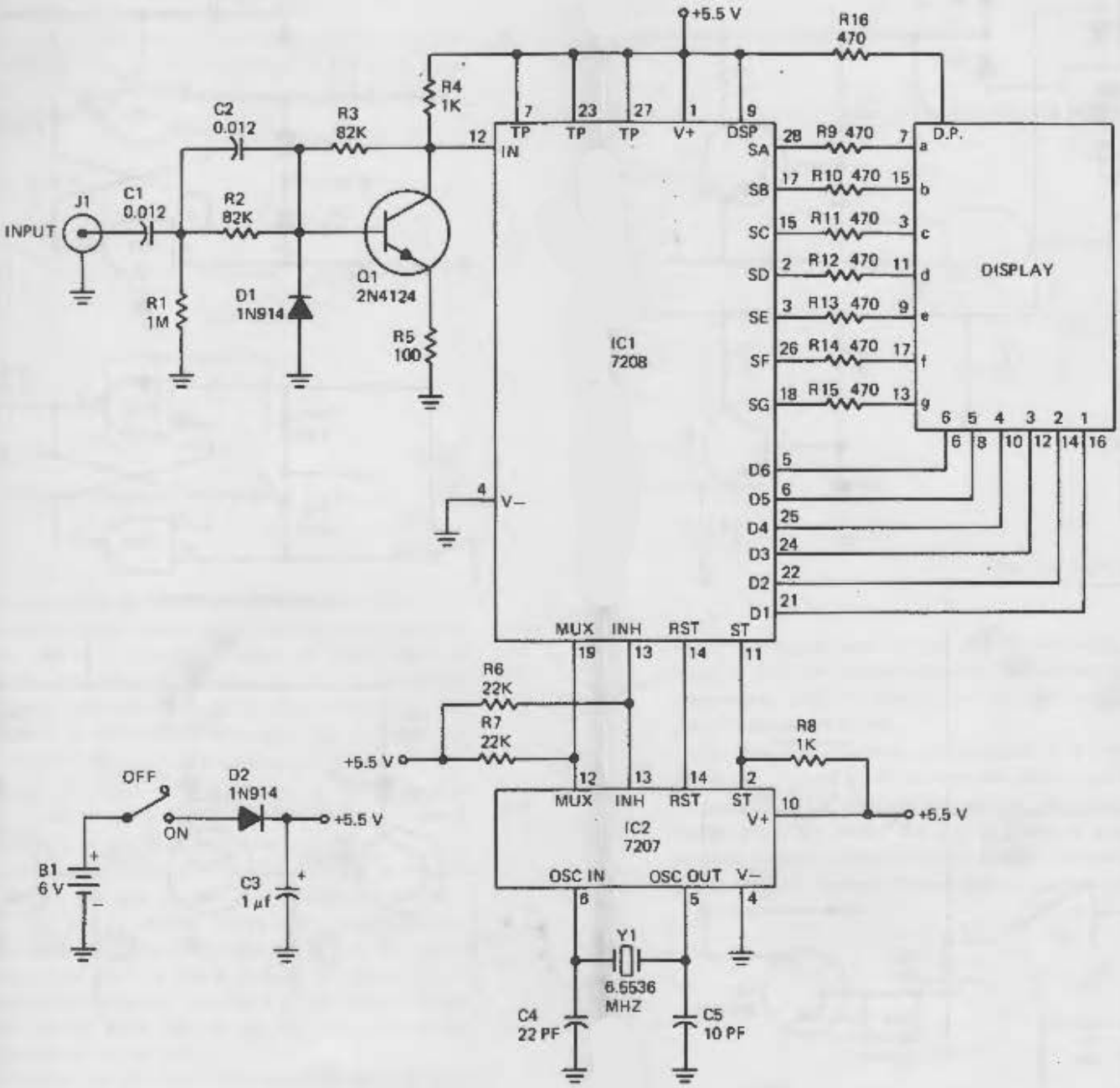


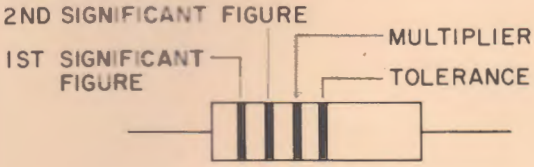
Fig. 19. Schematic of the Model 202 frequency counter.

RESISTOR AND CAPACITOR COLOR CODES

JAN and EIA stand for the two common color codes (Joint Army-Navy and Electronics Industries Association). The two codes are the same except as indicated. We have not indicated temperature coefficients or characteristics of capacitors, because they are not necessary for identifying your parts.

COLOR	SIG. FIG.	MULTIPLIER	RESIS.	TOLERANCE			
				CERAMIC CAPACITORS		MICA CAPACITORS	PAPER
				10 MMF OR LESS	OVER 10 MMF	(As below, or ± 1 mmf, whichever is larger)	CAP
Black	0	1		± 2.0 MMF	± 20%	± 20%	20%
Brown	1	10		± 1.0 MMF	± 1%	± 1%	
Red	2	100			± 2%	± 2%	
Orange	3	1000			± 2.5%	± 2.5%	
Yellow	4	10,000					
Green	5	100,000		± 0.5 MMF	± 5%	± 5% (EIA)	5%
Blue	6	1,000,000					
Violet	7	10,000,000					
Gray	8			± 0.25 MMF			
White	9			± 1.0 MMF	± 10%		10%
Gold		.1	± 5%			5% (JAN)	5%
Silver		.01	± 10%			10%	10%
No color			± 20%				20%

RESISTORS — RESISTANCE GIVEN IN OHMS

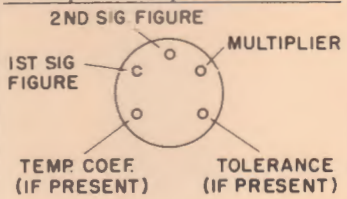


Black body = composition, non-insulated.
Colored body = composition, insulated.
Double width band for 1st sig. figure indicates wire-wound.

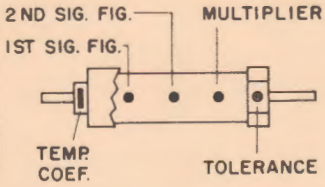
CAPACITORS — CAPACITY GIVEN IN MMF

CERAMIC

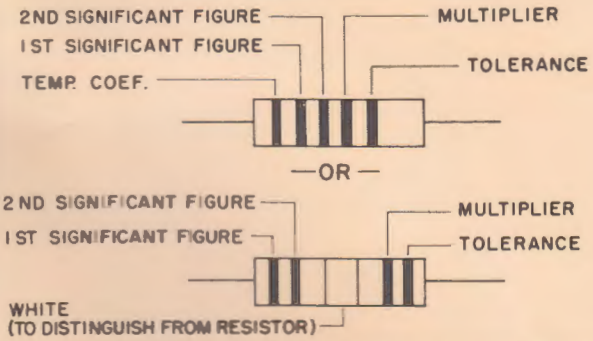
DISCS, BUTTON, OR FEED-THRU



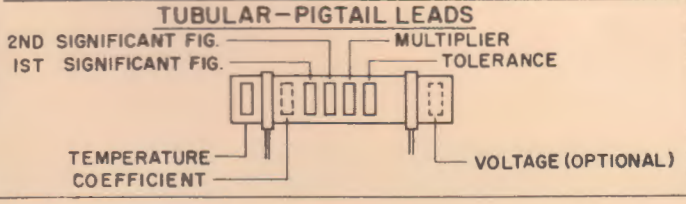
STAND-OFF



TUBULAR—AXIAL LEADS



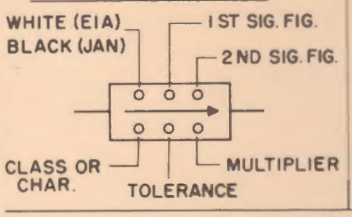
TUBULAR—PIGTAIL LEADS



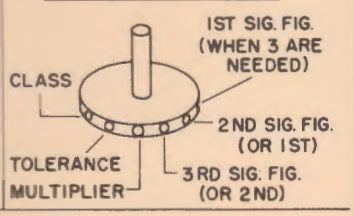
MICA

CLASS OR CHARACTERISTIC REFERS TO Q FACTOR, TEMPERATURE COEFFICIENT, AND PRODUCTION TEST REQUIREMENTS

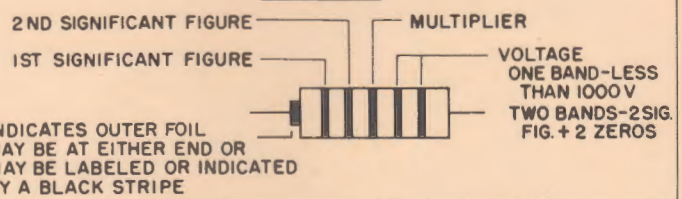
FLAT MOLDED



BUTTON SILVER

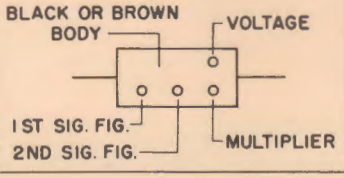


PAPER TUBULAR

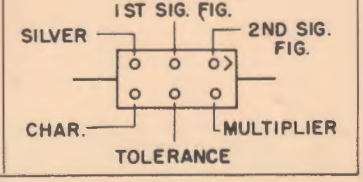


FLAT

EIA CODE



JAN CODE



USE THIS HANDY RULER FOR MEASURING LENGTHS OF WIRE