

# CAPACITANCE SUBSTITUTION BOX

MODEL CS-440 / K-38



7 56619 00130 2



Assembly and Instruction Manual

**Elenco™ Electronics, Inc.**

The Capacitance Substitution Box is a convenient instrument in determining the desired capacitance values in circuits under design or test. The values selected for your capacitance substitution box were determined to be the most commonly used in modern solid-state circuits. The values are from 100pF to .1 $\mu$ F in 24 steps.

## PARTS LIST

If you are a student, and any parts are missing or damaged, please see instructor or bookstore.

If you purchased this capacitance box kit from a distributor, catalog, etc., please contact Elenco™ Electronics (address/phone/e-mail is at the back of this manual) for additional assistance, if needed.

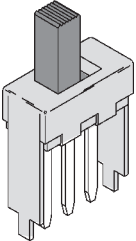
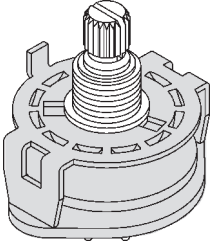


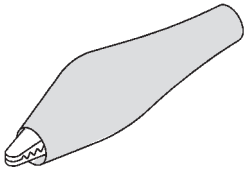

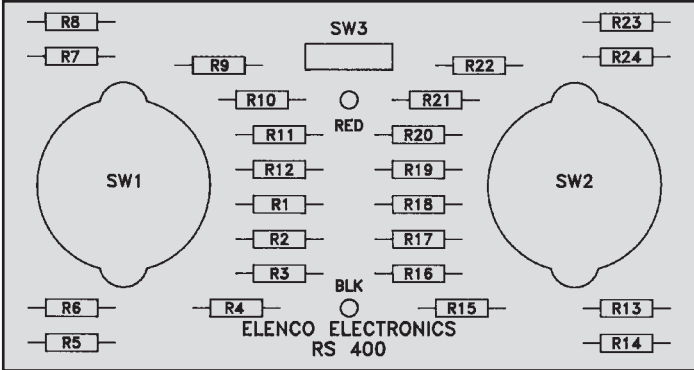
### CAPACITORS

Qty.	Symbol	Description	Part #
<input type="checkbox"/> 1	R1	100pF (101) 50V.....	221017
<input type="checkbox"/> 1	R2	150pF (151) 50V.....	221510
<input type="checkbox"/> 1	R3	220pF (221) 50V.....	222210
<input type="checkbox"/> 1	R4	330pF (331) 50V.....	223317
<input type="checkbox"/> 1	R5	470pF (471) 50V.....	224717
<input type="checkbox"/> 1	R6	560pF (561) 50V.....	225610
<input type="checkbox"/> 1	R7	680pF (681) 50V.....	226880
<input type="checkbox"/> 1	R8	820pF (821) 50V.....	228210
<input type="checkbox"/> 1	R9	1000pF (102) 50V.....	231035
<input type="checkbox"/> 1	R10	1500pF (152) 50V.....	231516
<input type="checkbox"/> 1	R11	2200pF (222) 50V.....	232216
<input type="checkbox"/> 1	R12	3300pF (332) 50V.....	233310
<input type="checkbox"/> 1	R13	.0047 $\mu$ F (472) 50V.....	234710
<input type="checkbox"/> 1	R14	.0056 $\mu$ F (562) 100V.....	235618
<input type="checkbox"/> 1	R15	.0068 $\mu$ F (682) 50V.....	236810
<input type="checkbox"/> 1	R16	.0082 $\mu$ F (822) 100V.....	238218
<input type="checkbox"/> 1	R17	.01 $\mu$ F (103) 100V.....	241017
<input type="checkbox"/> 1	R18	.015 $\mu$ F (153) 100V.....	241517
<input type="checkbox"/> 1	R19	.022 $\mu$ F (223) 100V.....	242217
<input type="checkbox"/> 1	R20	.033 $\mu$ F (333) 100V.....	243317
<input type="checkbox"/> 1	R21	.047 $\mu$ F (473) 100V.....	244717
<input type="checkbox"/> 1	R22	.056 $\mu$ F (563) 100V.....	245618
<input type="checkbox"/> 1	R23	.068 $\mu$ F (683) 100V.....	246818
<input type="checkbox"/> 1	R24	.1 $\mu$ F (104) 100V.....	251017

### MISCELLANEOUS

Qty.	Description	Part #
<input type="checkbox"/> 1	PC Board .....	517007
<input type="checkbox"/> 1	PC Mount Switch .....	541103
<input type="checkbox"/> 2	12 Position Switch .....	542013
<input type="checkbox"/> 2	Knob .....	622009
<input type="checkbox"/> 1	Case w/ Cover and Screws .....	62CS440
<input type="checkbox"/> 2	Nut 9mm .....	644102
<input type="checkbox"/> 2	Washer 9mm x 15mm .....	645103
<input type="checkbox"/> 1	Alligator Clip Black .....	680001
<input type="checkbox"/> 1	Alligator Clip Red .....	680002
<input type="checkbox"/> 12"	Wire Black Stranded .....	814210
<input type="checkbox"/> 12"	Wire Red Stranded .....	814215
<input type="checkbox"/> 1	Solder Tube .....	9ST4

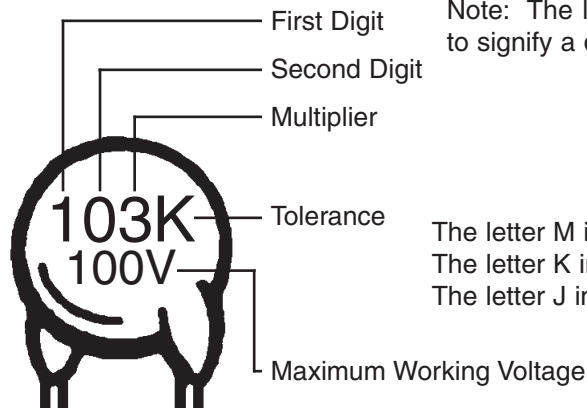
# PARTS IDENTIFICATION

<b>Switch PC Mount</b> 	<b>Switch 12 Position</b> 	<b>9mm Nut</b> 	<b>Washer</b> 	<b>Alligator Clip</b> 
<b>Capacitor</b> 				
<b>PC Board</b> 				

# IDENTIFYING CAPACITOR VALUES

Capacitors will be identified by their capacitance value in pF (picofarads), nF (nanofarads), or  $\mu\text{F}$  (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.

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 letter M indicates a tolerance of  $\pm 20\%$   
 The letter K indicates a tolerance of  $\pm 10\%$   
 The letter J indicates a tolerance of  $\pm 5\%$

The value is  $10 \times 1,000 = 10,000\text{pF}$  or  $.01\mu\text{F}$  100V

# METRIC UNITS AND CONVERSIONS

Abbreviation	Means	Multiply Unit By	Or
p	Pico	.000000000001	$10^{-12}$
n	nano	.000000001	$10^{-9}$
$\mu$	micro	.000001	$10^{-6}$
m	milli	.001	$10^{-3}$
-	unit	1	$10^0$
k	kilo	1,000	$10^3$
M	mega	1,000,000	$10^6$

1. 1,000 pico units = 1 nano unit
2. 1,000 nano units = 1 micro unit
3. 1,000 micro units = 1 milli unit
4. 1,000 milli units = 1 unit
5. 1,000 units = 1 kilo unit
6. 1,000 kilo units = 1 mega unit

# CONSTRUCTION

## Introduction

The most important factor in assembling your CS-440 Capacitance Substitution Box 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.**

## Safety Procedures

- Wear eye protection when soldering.
- Locate soldering iron in an area where you do not have to go around it or reach over it.
- **Do not hold solder in your mouth.** Solder contains lead and is a toxic substance. Wash your hands thoroughly after handling solder.
- Be sure that there is adequate ventilation present.

## 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.

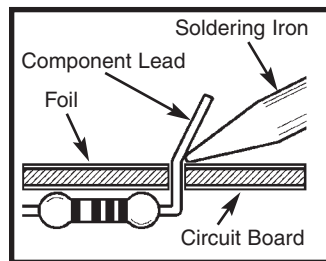
**Use only rosin core solder of 63/37 alloy.**

**DO NOT USE ACID CORE SOLDER!**

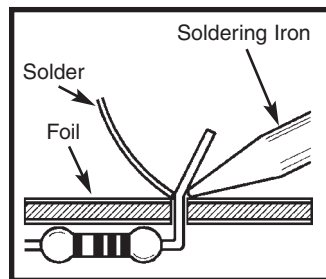
## What Good Soldering Looks Like

A good solder connection should be bright, shiny, smooth, and uniformly flowed over all surfaces.

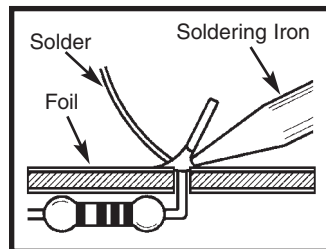
1. Solder all components from the copper foil side only. Push the soldering iron tip against both the lead and the circuit board foil.



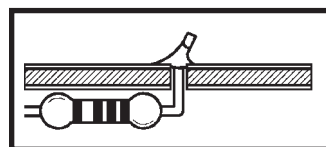
2. Apply a small amount of solder to the iron tip. This allows the heat to leave the iron and onto the foil. Immediately apply solder to the opposite side of the connection, away from the iron. Allow the heated component and the circuit foil to melt the solder.



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.

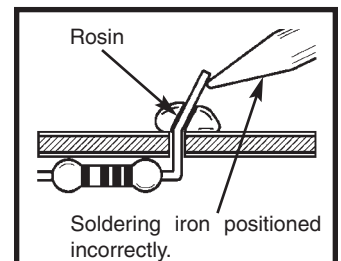


4. Here is what a good solder connection looks like.

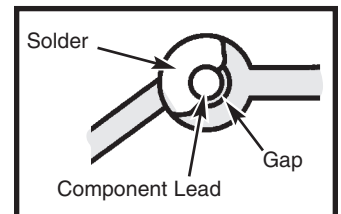


## Types of Poor Soldering Connections

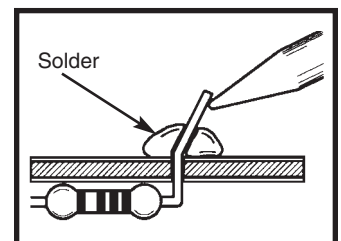
1. **Insufficient heat** - the solder will not flow onto the lead as shown.



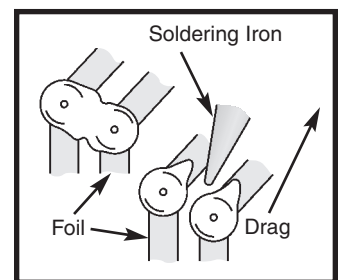
2. **Insufficient solder** - let the solder flow over the connection until it is covered. Use just enough solder to cover the connection.



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

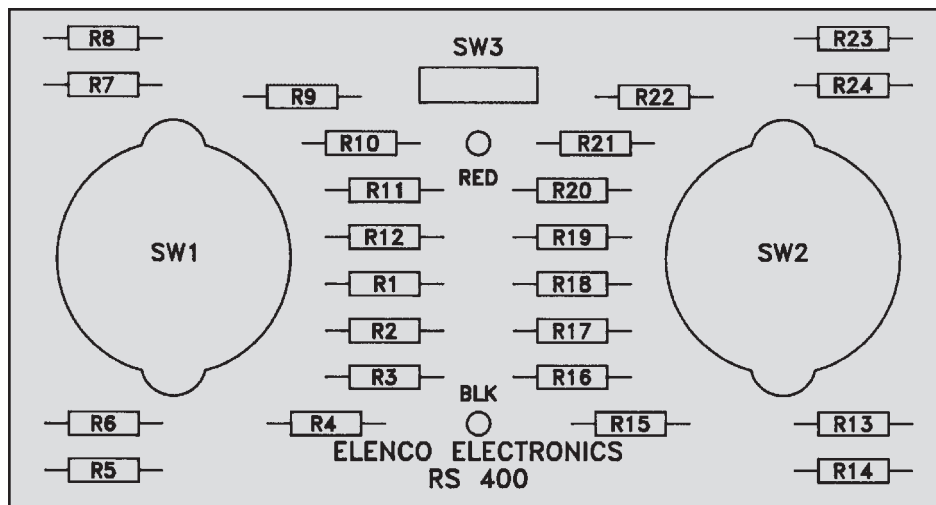
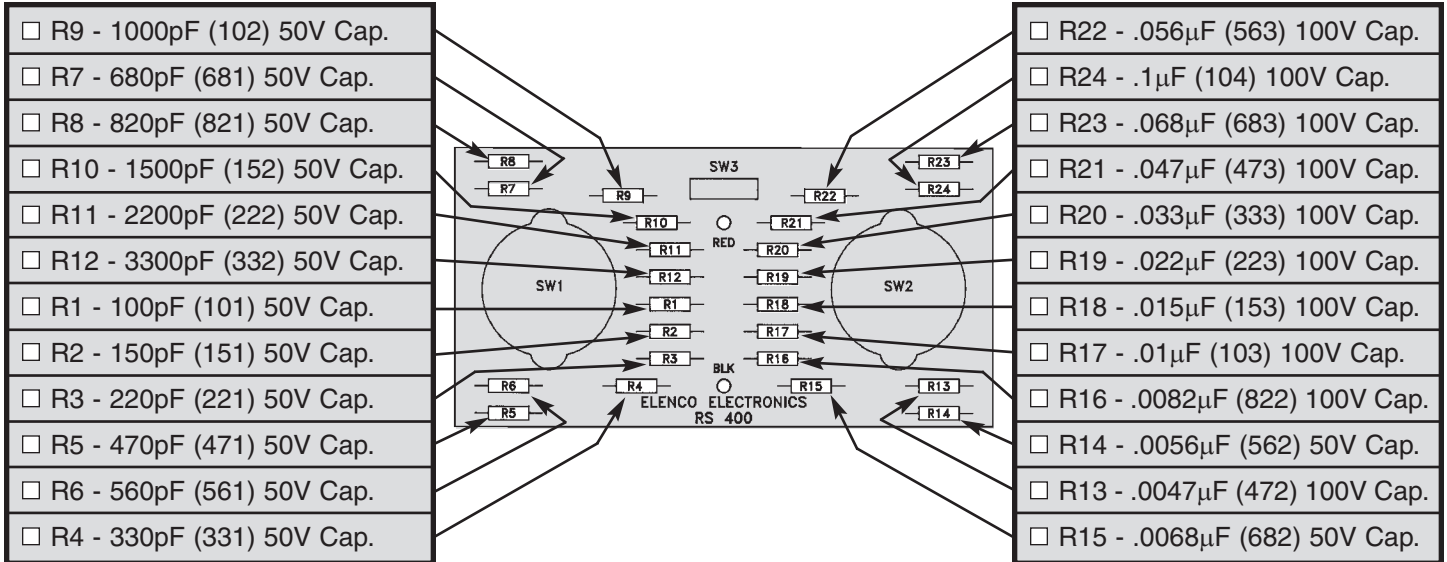


4. **Solder bridges** - occur when solder runs between circuit paths and creates a short circuit. This is usually caused by using too much solder. To correct this, simply drag your soldering iron across the solder bridge as shown.



# ASSEMBLY INSTRUCTIONS

Begin the PC board assembly with the 100pF capacitor placed in position R1. Be sure to identify the correct value. Bend the leads to fit. Place the capacitor into the PC board with the leads coming out on the copper foil side. Solder into place and clip off the excess leads.

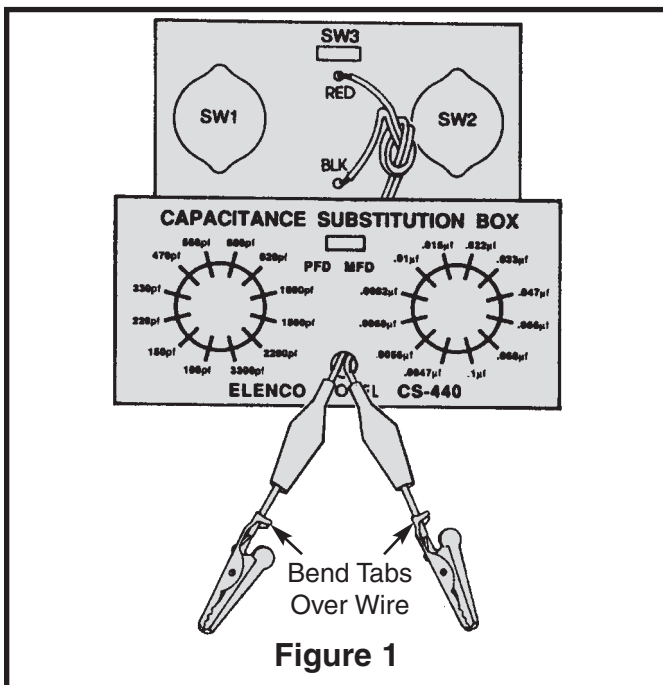


- SW3 - PC Mount Switch

Mount SW3 in the place shown on the PC board. Solder into place.

- Red Test Lead
- Black Test Lead

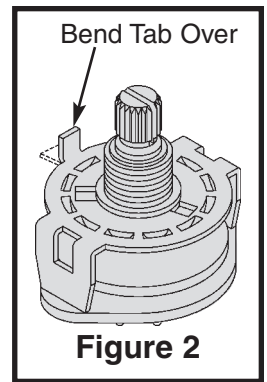
Cut off 1 1/2" of wire off of both the red and black wires (SAVE them for later use). Strip 1/4" of insulation off both ends of the 10 1/2" red and black wires and insert them into the holes as marked on the PC board. Solder into place. Tie a knot with both wires 1 1/2" from the surface of the PC board as shown in Figure 1. Pull the wires through the hole in the cover. Slide the alligator boots onto the wires. Solder the wires to the alligator clips. Then, slide the boots onto the clips.



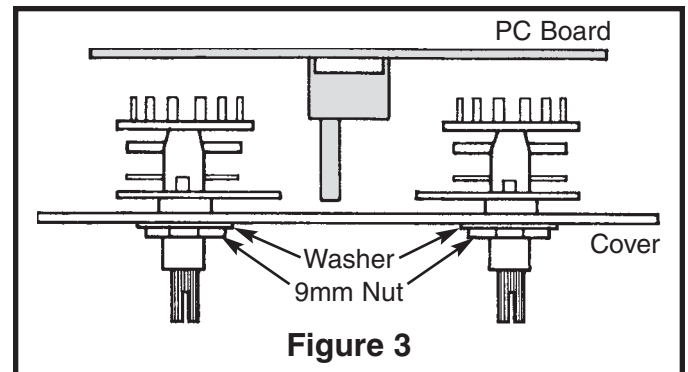
**Figure 1**

- SW1
- SW2

Bend the tab on the switches down (see Figure 2). Attach the two switches loosely to the front panel with the 9mm nuts and washers. Line up the holes of the PC board with the switch lugs, as shown in Figure 3. Be sure that the board lays flat, then solder the lugs into place. Tighten down the 9mm nuts.



**Figure 2**



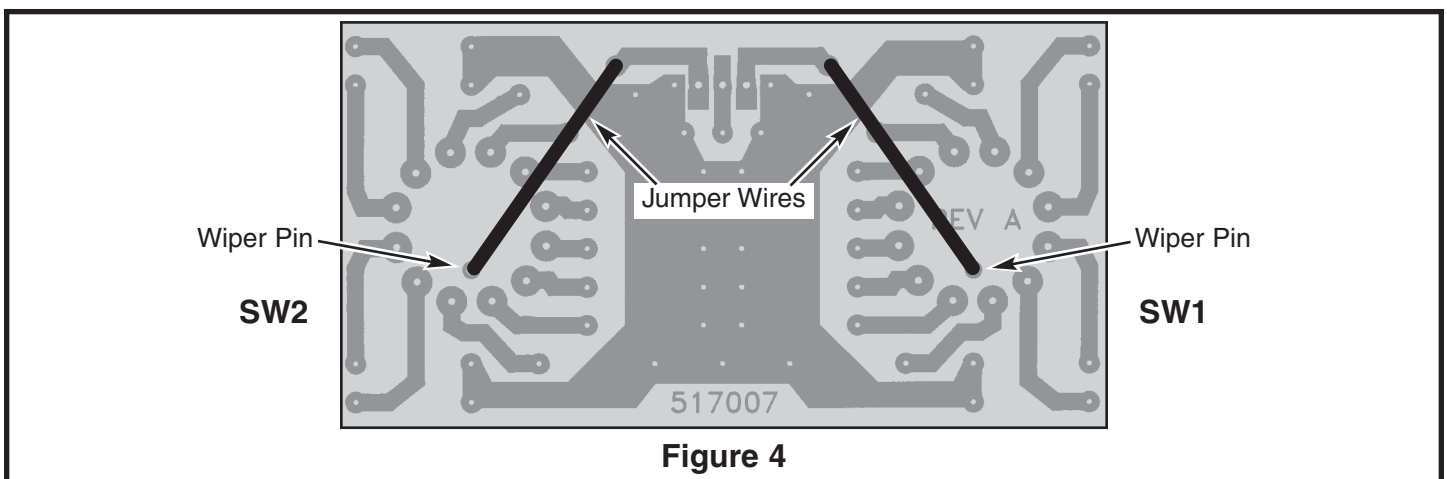
**Figure 3**

- Jumper wire from SW1
- Jumper wire from SW2

Strip 1/4" of insulation off of both ends of the 1 1/2" red and black wires. Solder one end of the wire to the wiper pin on the 12 position switches and the other to the pad without a hole, as shown in Figure 4.

- Installation of Knobs if Capacitance Meter is Available

Place the knobs loosely on the switch posts. Push the slide switch to the PFD position. Connect a capacitance meter to the output. Line up the pointer of the knob with the value shown on your meter, then push the knob onto the shaft. Push the slide switch to the MFD position and repeat the same procedure.



**Figure 4**

□ Installation of Knobs without Capacitance Meter

If a capacitance meter is not available, turn both switches so that the wiper contact is in the position shown in Figure 5. Start with switch SW1, follow the copper run on the PC board from the lug in contact with the wiper to the 680pF (R7) capacitor, to be sure that the switch is set in the proper position. Align the knob on the SW1 (PFD) switch to the 680pF position, push the knob onto the shaft. Follow the same procedure for switch SW2 (MFD), except follow the copper run to the .0047μF (R13) capacitor. Align the knob on the SW2 (MFD) switch to the .0047μF position.

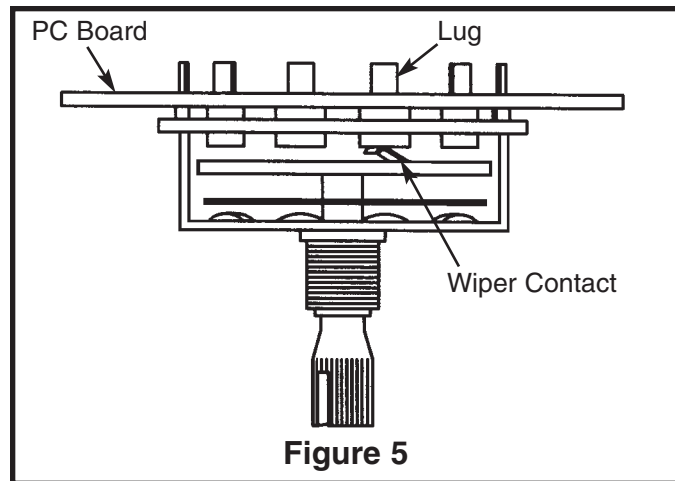


Figure 5

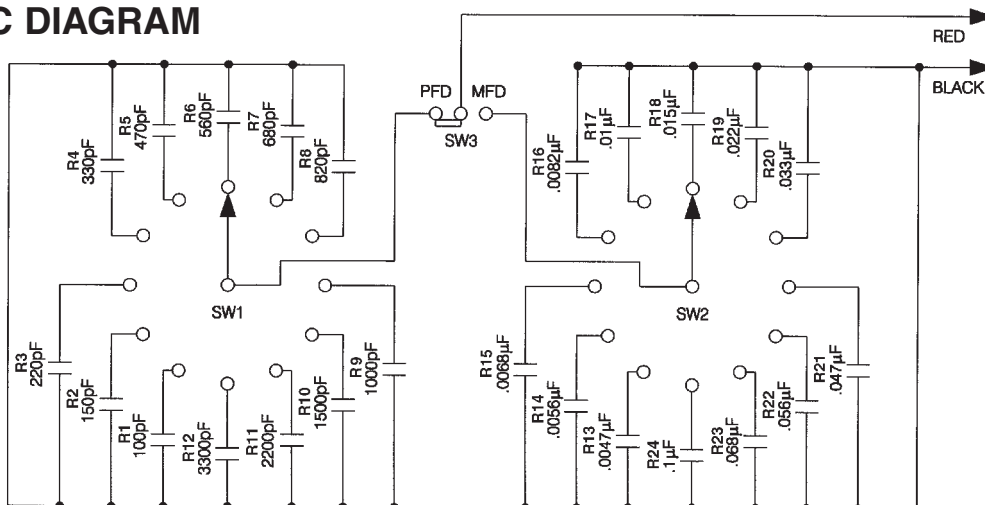
## TESTING THE CIRCUIT

SW1 PFD POSITION	
Value Position	Meter Reading
100pF	
150pF	
220pF	
330pF	
470pF	
560pF	
680pF	
820pF	
1000pF	
1500pF	
2200pF	
3300pF	

SW2 MFD POSITION	
Value Position	Meter Reading
.0047μF	
.0056μF	
.0068μF	
.0082μF	
.01μF	
.015μF	
.022μF	
.033μF	
.047μF	
.056μF	
.068μF	
.1μF	

**Note:** Capacitors being tested have a 10% tolerance. Because of lead capacitance from the alligator clips to the PC board, all values will read 30pF ±10pF above the actual capacitance value.

## SCHEMATIC DIAGRAM



**T**  **USA**  
**Equipment**  
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