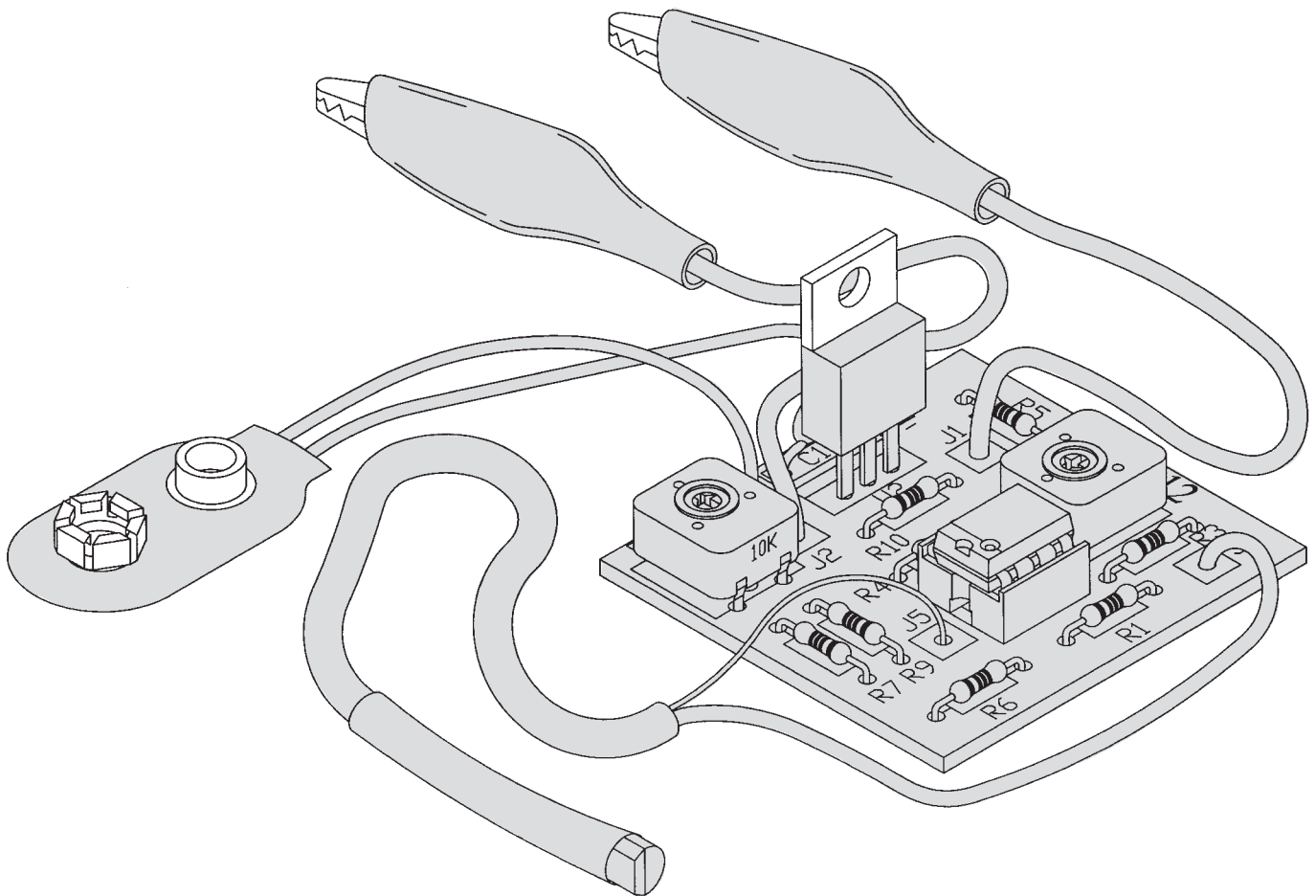


TEMPERATURE ADAPTER KIT

MODEL TA-12/K-40



Assembly and Instruction Manual

Elenco Electronics, Inc.

PARTS LIST

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

If you purchased this temperature adapter 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.

RESISTORS

Qty.	Symbol	Description	Color Code	Part #
<input type="checkbox"/> 2	R5, R6	1k Ω 5% 1/4W	brown-black-red-gold	141000
<input type="checkbox"/> 1	R7	3.3k Ω 5% 1/4W	orange-orange-red-gold	143300
<input type="checkbox"/> 2	R1, R10	3.9k Ω 5% 1/4W	orange-white-red-gold	143900
<input type="checkbox"/> 2	R4, R9	10k Ω 5% 1/4W	brown-black-orange-gold	151000
<input type="checkbox"/> 1	R3	47k Ω 5% 1/4W	yellow-violet-orange-gold	154700
<input type="checkbox"/> 2	R2, R8	10k Ω Trim Pot		191510

CAPACITORS

Qty.	Symbol	Description	Part #
<input type="checkbox"/> 1	C1	.01 μ F, 50V (103)	241031

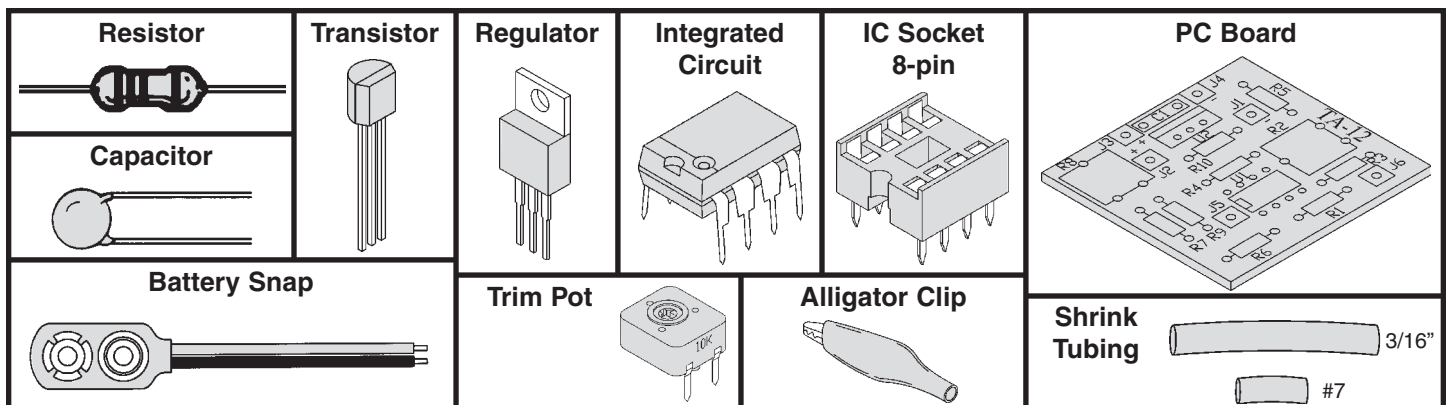
SEMICONDUCTORS

Qty.	Symbol	Description	Part #
<input type="checkbox"/> 1	Q1	2N3904 NPN Transistor	323904
<input type="checkbox"/> 1	U1	LM1458N Op-Amp Integrated Circuit (IC)	331458
<input type="checkbox"/> 1	U2	MC7805 5V Regulator	337805

MISCELLANEOUS

Qty.	Description	Part #
<input type="checkbox"/> 1	PC Board	518040
<input type="checkbox"/> 1	Solder Roll 24"	551124
<input type="checkbox"/> 1	Battery Snap	590098
<input type="checkbox"/> 1	IC Socket 8-pin	664008
<input type="checkbox"/> 1	Alligator Clip Black	680001
<input type="checkbox"/> 1	Alligator Clip Red	680002
<input type="checkbox"/> 1	Solid Black Wire 22ga. 6"	814120
<input type="checkbox"/> 1	Solid Red Wire 22ga. 6"	814220
<input type="checkbox"/> 1	Cable 2 Conductor 24"	876090
<input type="checkbox"/> 1	#7 Shrink Tubing 1/2"	890050
<input type="checkbox"/> 1	3/16" Dia. Shrink Tubing 1 1/2"	890120

PARTS IDENTIFICATION



INTRODUCTION

The TA-12/K-40 Temperature Adapter Kit is used in conjunction with a digital multimeter to read temperature. The Temperature Adapter consists of

three main sections:

- *Voltage Regulator*
- *Temperature Sensor*
- *Op-Amp*

THEORY OF OPERATION

VOLTAGE REGULATOR

The MC7805 (U2) is the voltage regulator which is used to supply a constant voltage of about 5V to the circuit.

TEMPERATURE SENSOR

The Temperature Sensor is an NPN transistor (2N3904). The NPN transistor has three terminals: the *collector*, *base*, and *emitter* as shown in Figure 1. When the collector and base of this transistor are shorted together as shown in Figure 2, they behave exactly like a diode, which is a temperature-sensitive device. At a constant current, the voltage across the base to emitter junction decreases by approximately 1mV for every 1°F increase in temperature.

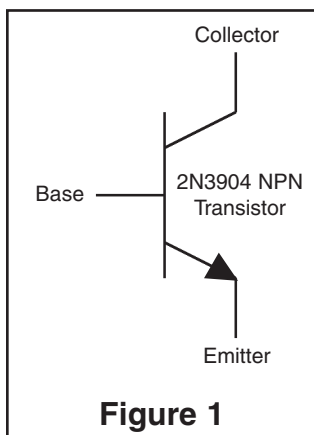


Figure 1

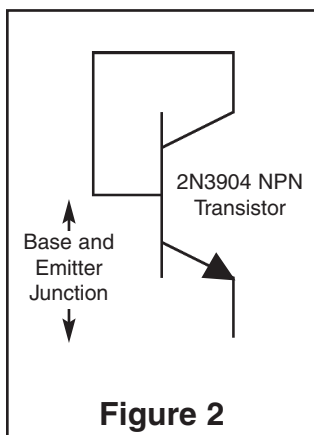


Figure 2

OP-AMP

The op-amp (LM1458) has two input terminals and one output terminal. Figure 3 shows the op-amp symbol. Terminals 1 and 2 are the input terminals, and terminal 3 is the output terminal. Many op-amps use two DC power supplies. The two terminals, 4 and 5, are connected to a positive voltage (V+) and negative voltage (V-), respectively. The TA-12/K-40 uses a single supply with ground tied to the V- input.

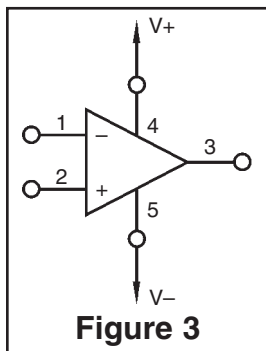


Figure 3

The op-amp senses the difference between the voltage signals applied at its two terminals (that is, the quantity $v_2 - v_1$), multiplies this by the open loop gain A, and causes the resulting voltage $A(v_2 - v_1)$ to appear at output terminal 3 as shown in Figure 4.

In an ideal op-amp, the input impedance is infinite, the output impedance is zero and the open loop gain A is very large and ideally infinite. In practice, the open loop gain is usually greater than 100,000.

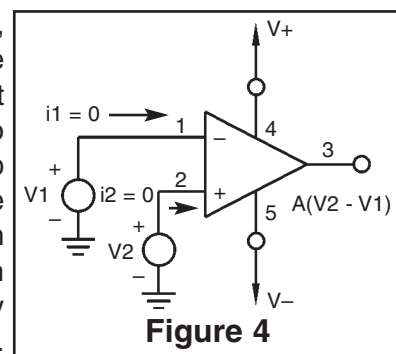


Figure 4

In order to control the gain of our circuit we use feedback to close the loop around the op-amp as shown in Figure 5. This circuit consists of an op-amp and two resistors R1 and R2. Resistor R2 is connected from the output terminal of the op-amp, terminal 3, back to the negative input terminal, terminal 1. We speak of R2 as applying negative feedback; if R2 were connected between terminals 3 and 2, we would call this *positive feedback*. Note that R2 closes the loop from the output terminal back around to the input terminal of the op-amp. In this circuit, the closed loop gain (G) of the op-amp, from the input V_i to the output terminal, depends on the ratio of R2 to R1.

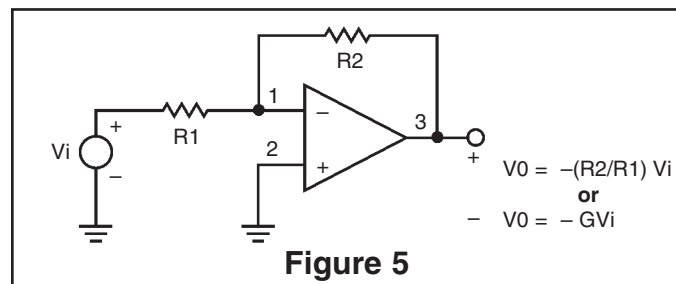


Figure 5

For example, if $R_2 = 100$ and $R_1 = 10$, the gain $G = R_2/R_1 = 100/10 = 10$. Thus, the output voltage V_0 at terminal 3 would be equal to $-10(V_i)$. The (-) sign indicates that the output and input voltages are of opposite polarity.

CONSTRUCTION

Introduction

The most important factor in assembling your TA-12/K-40 Temperature Adapter 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.

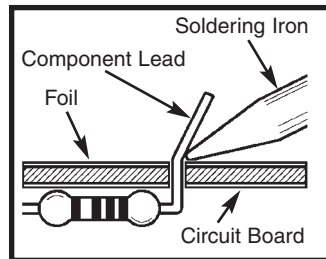
Use only rosin core solder of 63/37 alloy.

DO NOT USE ACID CORE SOLDER!

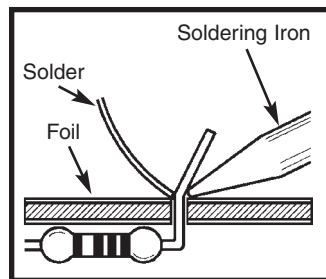
What Good Soldering Looks Like

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

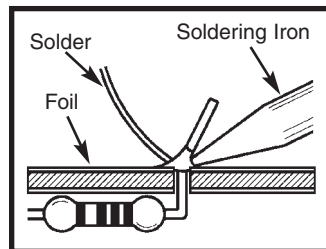
1. Solder all components from the copper foil side only. Push the soldering iron tip against both the lead and the circuit board foil.



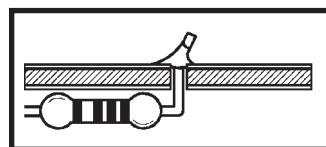
2. Apply a small amount of solder to the iron tip. This allows the heat to leave the iron and onto the foil. Immediately apply solder to the opposite side of the connection, away from the iron. Allow the heated component and the circuit foil to melt the solder.



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.

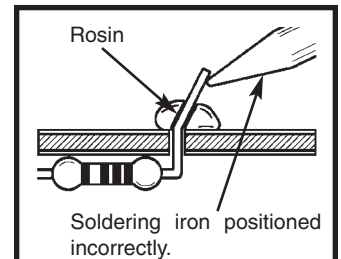


4. Here is what a good solder connection looks like.

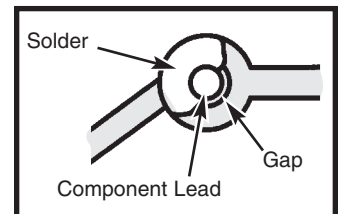


Types of Poor Soldering Connections

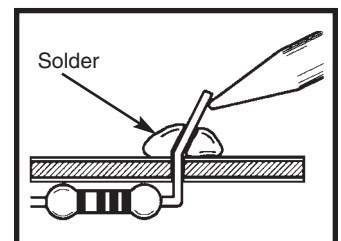
1. **Insufficient heat** - the solder will not flow onto the lead as shown.



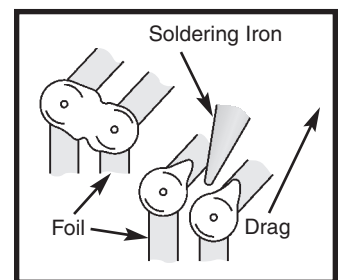
2. **Insufficient solder** - let the solder flow over the connection until it is covered. Use just enough solder to cover the connection.



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.



ASSEMBLE COMPONENTS TO THE PC BOARD

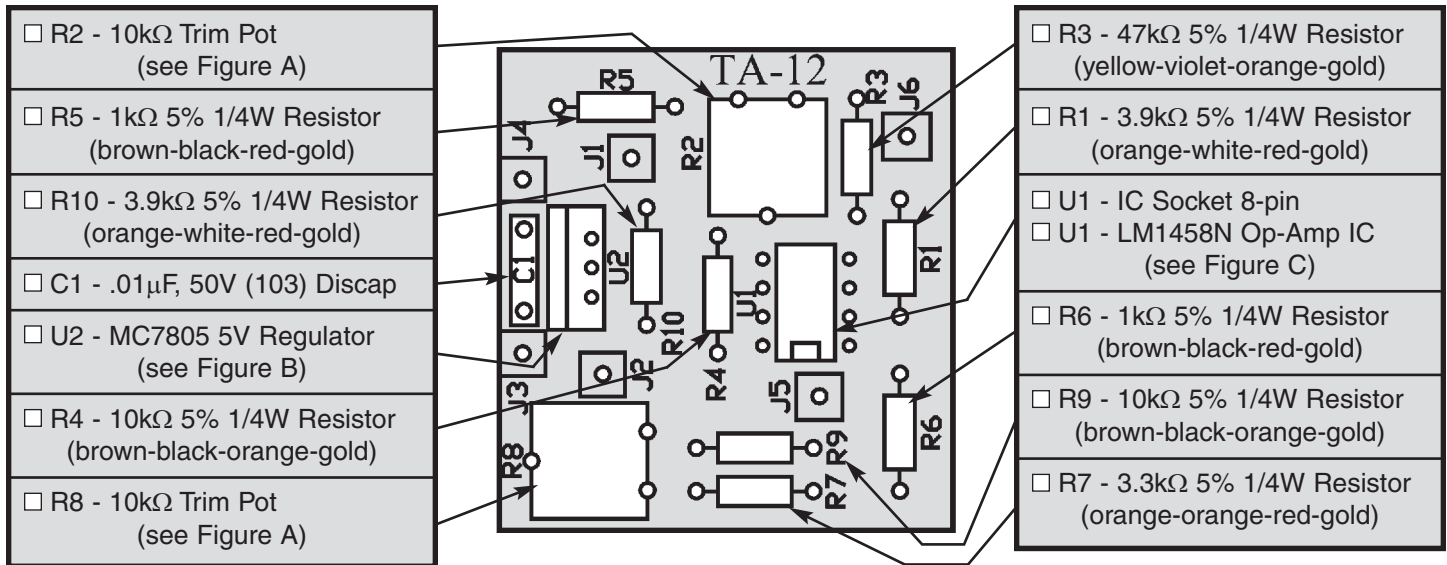


Figure A

Insert the trim pot into the PC board as shown. Solder and cut off excess leads.

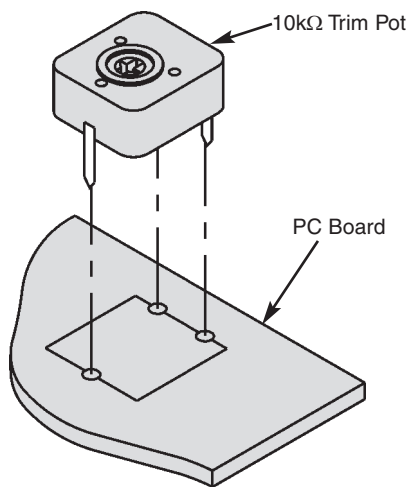


Figure B

Insert the regulator into the PC board in the direction shown. Solder and cut off excess leads.

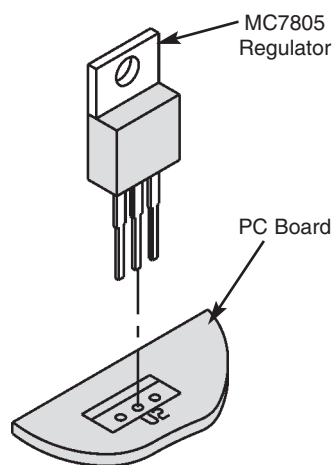
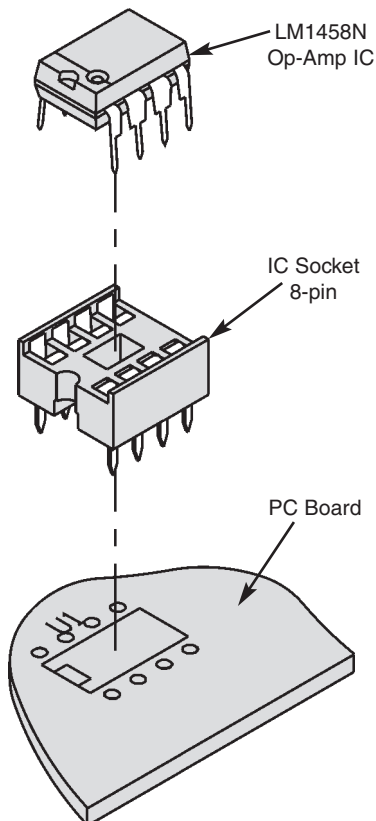


Figure C

Insert the 8-pin IC socket into the PC board in the direction shown. Solder and cut off excess leads. Then, insert the LM1458N op-amp IC into the socket in the same direction shown.



FINAL ASSEMBLY

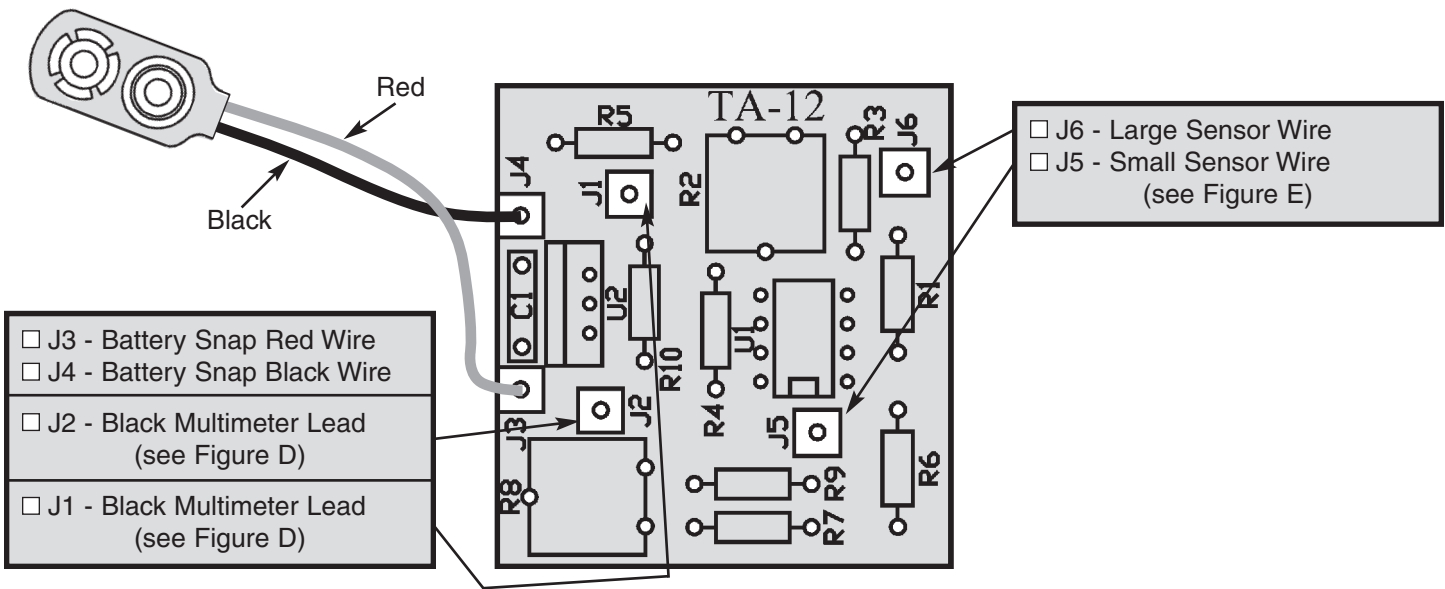


Figure D

Pull the boot off of the alligator clip (to remove boot, clip the alligator clip onto a pencil, then pull off boot). Insert the wire (red wire for red boot, black wire for black boot) into the alligator clip as shown. Crimp the tabs over the wire as shown and solder the wire to the clip. Cut off any excess wire from the solder joint. Slide the boot back onto the alligator clip.

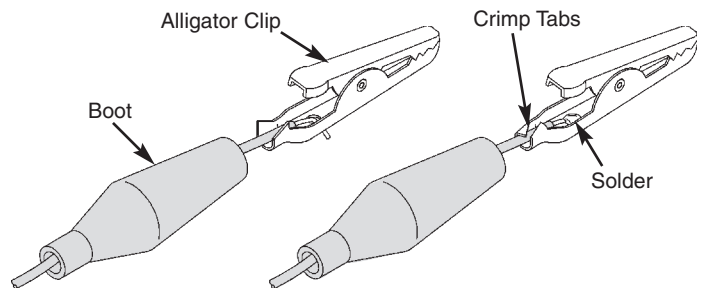


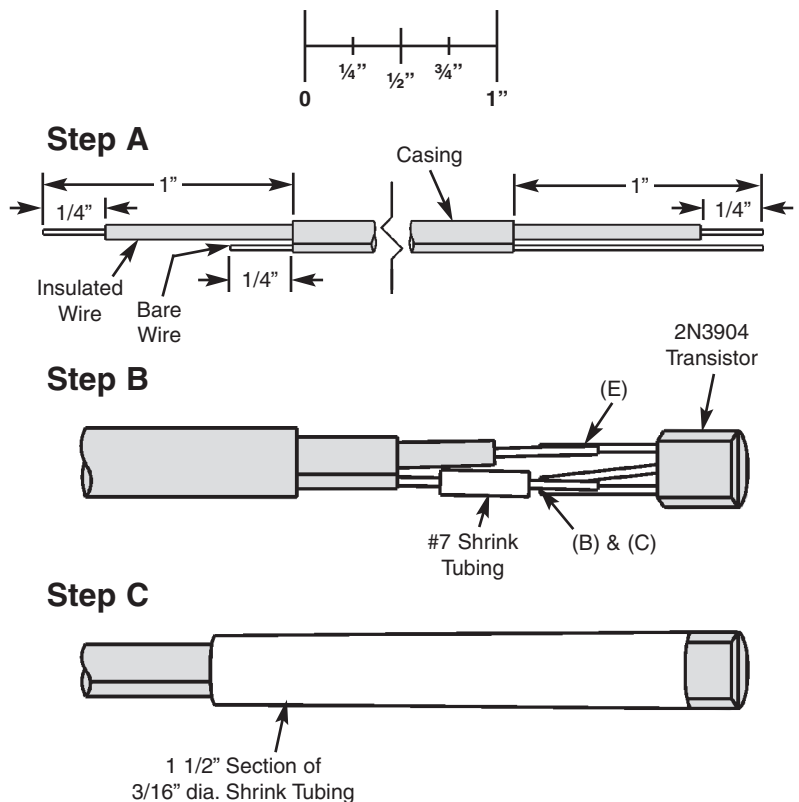
Figure E

Prepare the ends of the 24" cable as shown in Step A to the right. Very carefully strip off 1" of casing on both ends of the cable to expose the two wires inside. Then strip the insulation off of both ends of the insulated wire to expose 1/4" of bare wire. On one end, cut the bare wire so that it is 1/4" long.

Solder the 2N3904 transistor to the end of the cable wire with the 1" bare wire as shown in Step B to the right. Slide the 1/2" section of #7 shrink tubing over the bare wire. Solder the bare wire to the base (B) and collector (C) leads of the transistor. Slide the #7 tubing over the solder joint. Put your hot soldering iron or heat gun close to the tubing (do not touch the tubing). The heat from your iron or heat gun will shrink the tubing into place. Solder the insulated wire to the emitter (E) transistor lead.

Slide the 1 1/2" section of 3/16" shrink tubing over the transistor to cover the exposed wires as shown in Step C to the right. Shrink the tubing in place with your iron or heat gun.

Solder the other end of the cable to the PC board. The insulated wire goes to point J6 and the bare wire to point J5.



CALIBRATION

1. Connect a 9V battery to the battery snap.
2. Connect the positive probe of your digital multimeter to point J1, and the negative probe to GND.
3. Adjust R2 for a reading of about 2.5 to 3V.
4. Then, connect the positive probe of the digital multimeter to J2 and the negative probe to J1.
5. Adjust R8 for the correct temperature reading on the digital multimeter. If you use the 2 volt range, you can read the temperature to one tenth of a degree (that is, if the reading on the digital multimeter shows 0.733, then you should read the temperature as 73.3°F).

COMPONENT CHECK

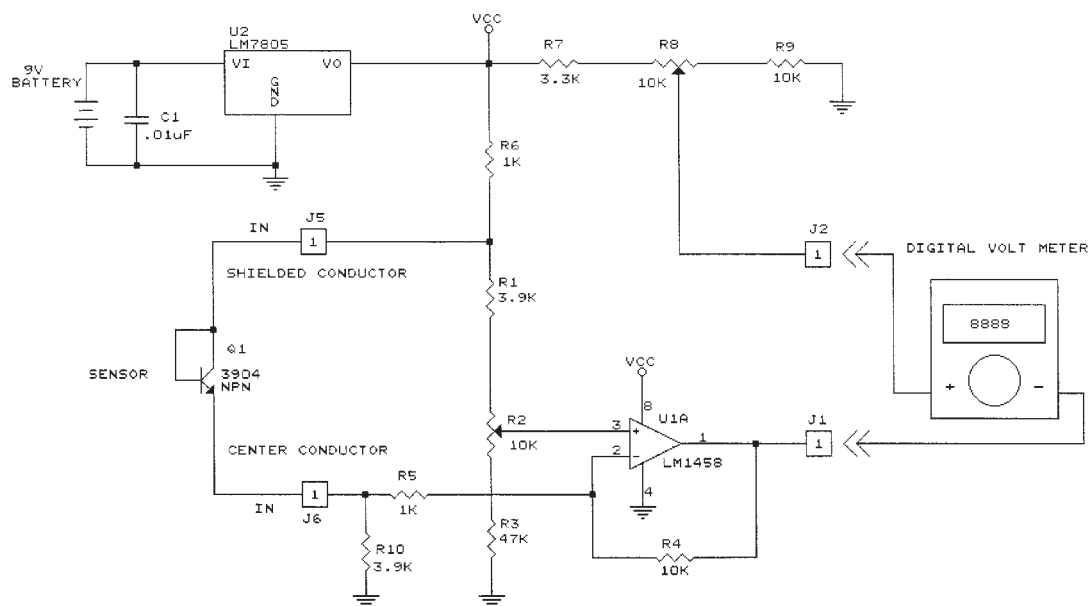
1. Recheck all of the values of the resistors, and make sure that they are placed in their exact location.
2. Be sure that the temperature sensor (2N3904) wire are soldered to their correct positions.
3. Be sure the notch of the op-amp (1458) is installed in the same direction as the marking on the PC board.
4. Be sure the regulator (7805) is mounted as instructed in the manual.

TROUBLESHOOTING

Contact Elenco Electronics if you have any problems. **DO NOT** contact your place of purchase as they will not be able to help you.

1. One of the most frequently occurring problems is poor solder connections. Tug slightly on all parts to make sure that they are indeed soldered.
2. All solder connections should be shiny. Resolder any that are not.
3. Solder should flow into a smooth puddle rather than a round ball. Resolder any connection that has formed into a ball.
4. Have any solder bridges formed? A solder bridge may occur if you accidentally touch an adjacent foil by using too much solder or by dragging the soldering iron across adjacent foils. Break the bridge with your soldering iron.

SCHEMATIC DIAGRAM



QUIZ

Fill in the blanks and check your answers below.

1. The three main sections of the TA-12/K-40 are _____, _____, and _____.
2. The output voltage of the LM7805 regulator is _____ volts.
3. Name the three terminals of the transistor: _____, _____, and _____.
4. The _____ and _____ leads of the transistor are shorted together to make the sensor.
5. At a constant current, the voltage across the base to emitter junction decreases by approximately _____ for every _____ increase in temperature.
6. The op-amp has _____ inputs terminals and _____ output terminal.
7. The TA-12/K-40 circuit uses _____ feedback to control the gain of the op-amp.
8. In the TA-12/K-40 circuit, a _____ supply is used to power the op-amp.
9. In an ideal op-amp, the input impedance is _____, the output impedance is _____ and the open loop gain A is ideally _____.
10. You adjust trim pot _____ for the correct temperature reading on the meter.

Answers: 1. voltage regulator, temperature sensor, op-amp; 2. five; 3. collector, base, emitter; 4. collector, base; 5. 1mV, 1°F; 6. two, one; 7. negative; 8. single; 9. infinite, zero, infinite; 10. R8

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