SERIES CIRCUITS TROUBLESHOOTING

During previous lessons you have studied the theory of operation of the series circuit. Unfortunately electrical and electronic circuits never operate correctly all the time and it is your job as a technician to determine why a circuit is not operating correctly. By applying the basic rules of troubleshooting and some particular methods you will learn in this lesson, locating malfunctions will become easier.

Four basic principles must be recognized and learned in the approach to troubleshooting; VISUALIZE, SECTIONALIZE, LOCALIZE AND ISOLATE.

FIRST, let's look at the process of visualization. Visualization, looking, requires that we develop a keen sense of perception. Look for visual indications of trouble spots.

EXAMPLES:

Lights that do not light.
Fuses that may be blown.
Interlocking safety switches not closed.
Power supply controls tampered with.
Broken circuit interconnecting wires.
Broken or cracked printed circuit (PC) boards.
Solder joints that are loose or appear to have cold joints.
Components that are discolored or distorted from normal configuration, (swollen, cracked, broken).
With the power disconnected, components may be touched (if safety permits) to detect heat.
Most components have a smell characteristic, such as a burned resistor.
Vacuum tube problems can be spotted sometimes by lack of a glowing filament, or improper seating in the socket.

NOTE: A good technician, like a good medical doctor, must learn to recognize that there is something wrong and judicially relate this to where the wrong is located. The question should be asked by good technicians, what are the symptoms? A symptom, then may be defined as those recognizable conditions that are not normal.

After the look, feel and smell tests are completed you are ready for the next step.

SECOND, let's begin by trying to SECTIONALIZE the malfunction into a particular section of the circuit. You must remember that all circuits can be reduced to the power supply and one series equivalent resistor. From this we can determine if there is a change in the resistance of the circuit and which way it changed.

EXAMPLE: Increased current means decreased resistance, therefore a component is shorted. Decreased current means the resistance has increased, therefore a component is open.

NOTE: Simple series, parallel, and series-parallel circuits would be hard to SECTIONALIZE because they are the section.

THIRD, this brings us to the place where we can LOCALIZE the malfunctioning component. Voltage measurements will be the next check because the next step up from a simple series circuit would be a more complex series circuit involving two or more components. Measure the voltage drops across each component. If you measure zero volts across a component, that component is shorted or has zero resistance. If you measure the supply voltage across a component, that component is open or had infinite resistance.

FOURTH, this brings us to the time to ISOLATE the malfunctioning component. Turn the power off, ISOLATE the components and make resistance checks to pin point the malfunctioning component.

To be able to understand electrical or electronic circuits, one must be able to understand SHORTS AND OPENS. To understand shorts and opens, one must come to grips with some terminology which will explain or clarify the meaning of SHORT and OPEN.

CONDUCTOR:

A conductor may be explained as a material that will carry a current. MOST METALS have the capability of carrying current.

NON-CONDUCTOR OR INSULATOR:

An insulator is understood to be a material that will not carry current.

CONTINUITY:

Continuity can be expressed as shown in FIGURE 3.

WATER flowing from point A to point B in a pipe is said to be connected if the water is moved from A to B. Cut the pipe and

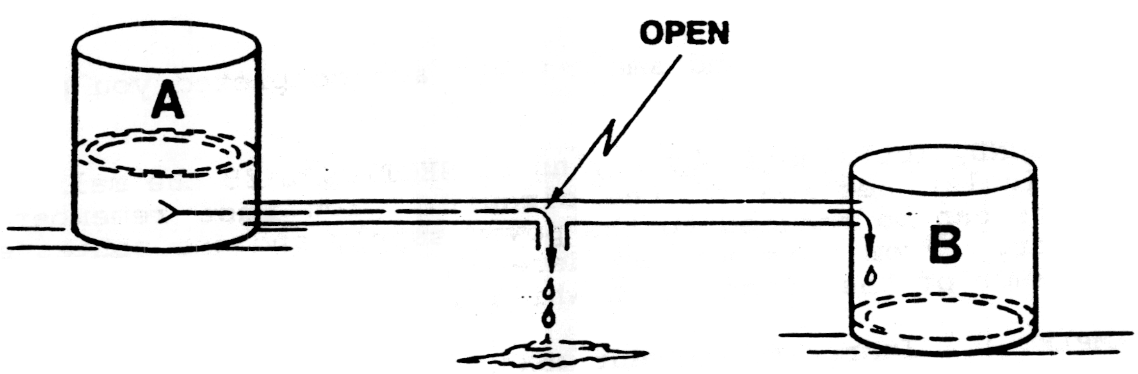

FIGURE 3 (SLIDE EP12AL-S03)

the water will not be present at point B. Current flowing through a conductor from point A to point B is said to be connected if the current is moved from A to B. Cut the conductor and the current will not be present at point B, thus there is no continuity. Continuity can be defined as a path for continuous current flow. Continuity can be expressed in another term:

AVAILABILITY:

How much water would be available at point B if the pipe were connected normally? All of it.
How much would be available if the pipe had holes in it? Some of it.

How much would be available if the pipe were reduced in size? Some of it. How much would be available if the pipe were cut? None of it. How much current would be available at point B if the conductor were connected normally? All of it.

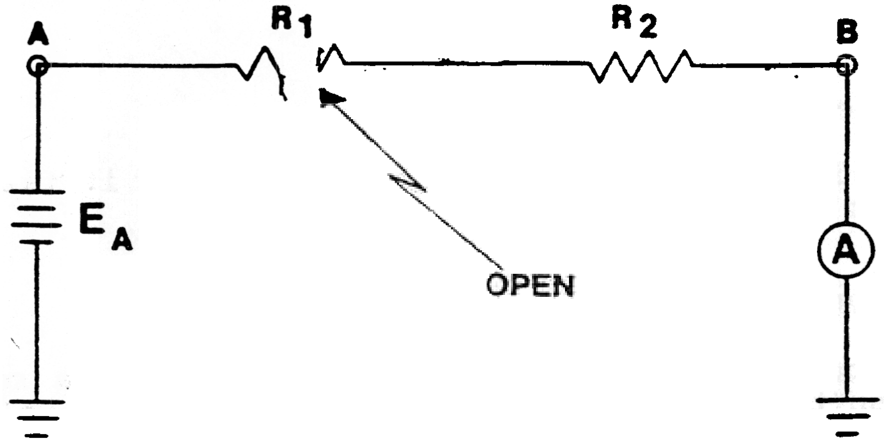

FIGURE 4 (SLIDE EP12AL-S04

How much current would be available if resistor R1 was burned open in FIGURE 4? None of it. Continuity makes the current and voltage available to be used at point B. No continuity makes it unavailable to be used at point B.

Current, like most natural phenomena will follow the path of least resistance. Water always flows down hill. Current will always flow through the path of least resistance. If current has the choice of a conductor or an insulator, it would flow through the conductor as shown in FIGURE 5.

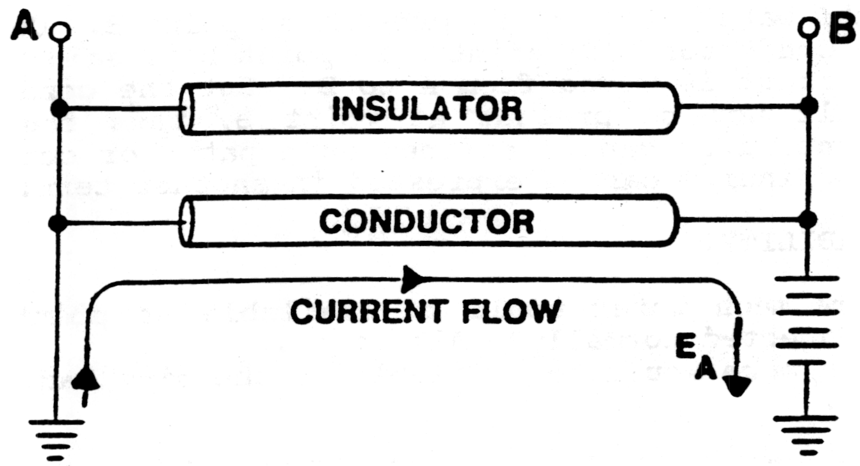

FIGURE 5 (SLIDE EP12AL-S05)

Use of current and voltage to do work depends on its availability at the work place - thus the conductors must be able carry the voltage and current to that point. If the conductor is to carry the current, any impairment of this ability will render it inadequate. This brings us to another term:

MALFUNCTION.

A device is considered malfunctioned when it fails to perform (work) as it normally should.

EXAMPLE:

If you turn a switch to the ON position in a room and the light doesn't illuminate, something, obviously, has malfunctioned in the circuit. In this case the most likely assumption would be that the bulb is burned out.

Electronic and electrical devices have malfunctioning characteristics which fall into one of two categories:

FIRST, some devices burn open and the circuit is broken, preventing current from flowing. This is called an OPEN CIRCUIT.

SECOND, some devices become shorted, that is, fused or melted together forming a short circuit, allowing a great increase in current flow.

SERIES CIRCUITS TROUBLESHOOTING

WHAT IS A SHORT CIRCUIT?

A short circuit has zero ohm.

A short circuit will drop zero volts.

A short circuit does not oppose current flow.

A short circuit has continuity.

WHAT IS AN OPEN CIRCUIT?

An open circuit has infinite ohms.

An open circuit will drop the applied voltage.

An open circuit has no continuity.

You have learned that in order for current to flow from A to B the conductor must have continuity. The conductors that make current available, from A to B, must be the path of least resistance. This circuit can be controlled by having a switch to make (SHORT) or break (OPEN) the circuit. We close the switch making a path for current to flow to the light. We open the switch breaking the path for current to flow.

During this lesson you will learn to locate MALFUNCTIONS in series circuits using resistors.

During the previous lessons you have learned the theory of operation of series circuits. Unfortunately electronic circuits never operate correctly all the time and it is your job as a technician to determine why a circuit is not operating correctly. This procedures is known as TROUBLESHOOTING. By applying the basic troubleshooting rules and methods that you will learn in this lesson, locating MALFUNCTIONS will be much easier.

FIRST, let's begin by looking at the SYMPTOMS. A good technician like a good medical doctor must be able to recognize the symptoms of the trouble. Thus, we can define symptoms: As those recognizable conditions that are not normal for the circuit, VISUALLY AND ELECTRICALLY.

SERIES CIRCUITS TROUBLESHOOTING

STEP #1.

VISUAL OR PHYSICAL;

Would be to look for trouble using sight, smell, touch

Hot or warm resistors usually indicate trouble. You will soon learn to recognize the characteristic smell of burning or hot resistors.

2. Look for blackened or discolored resistors.

3 Are there any broken circuits, that is, loose solder joints, broken printed circuit (PC) boards, or pads?

4 Are all switches in the proper operating positions?

5. Is proper power applied?

6 Are all indicator lights and meters giving normal indications?

STEP #2.

ELECTRICAL:

Would be to set up a chart for normal conditions;

1. Record calculated and measured resistor value then calculate and measure R_T.

2 Record measured applied voltage E_A.

3. Record calculated and recorded total current, I_T.

4. Record calculated and recorded voltage drops for each resistor.

NOTE: Remember that "Calculate" means that you "OHMS LAW" using resistor color code calculations. When doing this remember that resistors have a tolerance. Alway use "Measured" values taken with a DMM, because a 10 ohm resistor by color code may measure 9.87 ohms with a DMM and still fall in tolerance.

NEXT, measure and record the actual values of:

1. Resistance-Remember to turn power off and ISOLATE.

2. Current-Remember to measure current, you must break the circuit and insert the ammeter in series with the circuit observing proper POLARITY.

NOTE: A good technician will know what to expect from his circuits under normal conditions and will be able to quickly recognize changes from normal.

Now that you understand that any change from normal operating conditions are symptoms of a malfunction, you are ready to practice recognizing these symptoms.

Let's observe a symptom.

SYMPTOM: The total current, I_T, has increased in the series circuit

1. From Ohm's Law you have been taught that current is inversely proportional to resistance if the voltage remains the same. If current INCREASES and resistance DECREASES then a resistor has to be shorted or read zero ohm's.

2. From Ohm's Law you can determine what the voltage drop would be across a short or zero resistance, E=IR. $E=I_T x0=0V$

   If you measure the voltage drops across each resistor, you will find that the shorted resistor will have a zero volt drop across it and the good resistors voltage drops will increase and total the applied voltage.

4. This will be confirmed by ISOLATING and measuring the resistance of the suspected resistor, to find its resistance to be zero ohms.

SECOND, let's look at another SYMPTOM: Total current, I_T, is zero amperes in the series circuit.

1. From Ohm's Law you have learned that current and resistance are inversely related. If total current goes down to zero this would mean that total resistance would go up to infinity (open resistor).

2. What would happen to the voltage drop across the open resistor? The open resistor will drop the applied voltage. To verify the resistor is open turn off the power; isolate, and ohm out the resistor with a DMM.

In FIGURE 6, we have a simple series circuit containing R_1; R_2; R_3 and switch S_1, used to break the circuit.

Question: How many paths for current flow are there in the circuit?

ANSWER: One.

It is true then, since there is only one path for current flow, the current will be the same at all points in the circuit? Yes. If the ammeter is connected in series with the circuit.

If switch S_1, is open, the current meter can be connected to T_{P5} and T_{P6} observing polarity. The current meter is now in series with the circuit (it becomes like one of the resistors), thus all of the current flows through the meter.

NOTE: The current in any circuit can <u>only</u> be measured in <u>series</u> with that circuit. Serious damage to the meter, the circuit or the power source can occur if it is not connected in series.

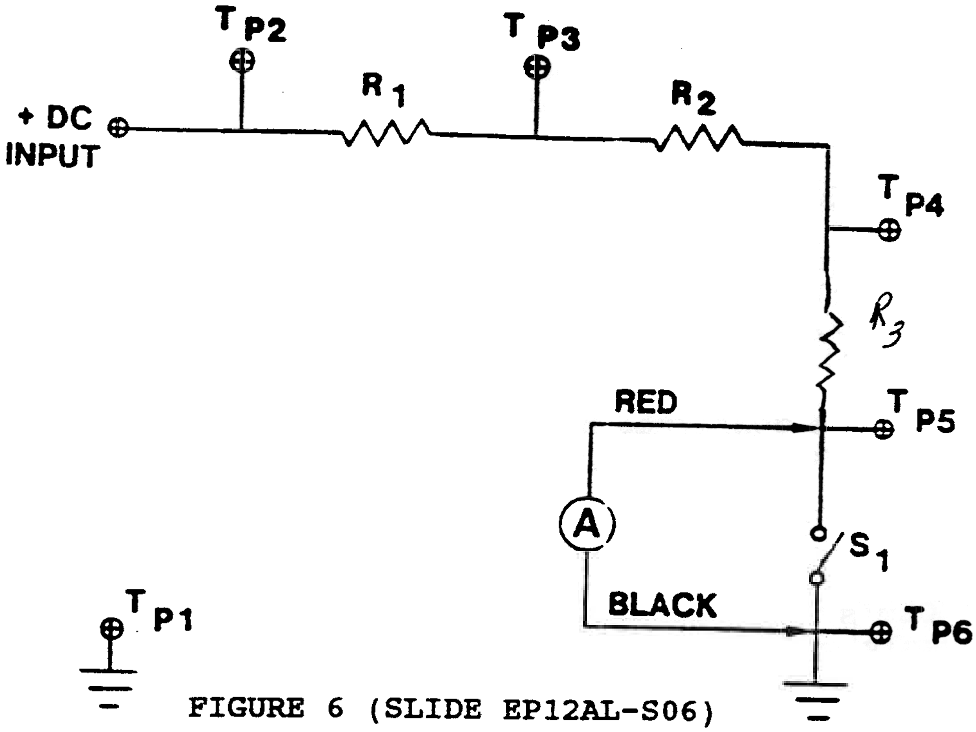

FIGURE 6 (SLIDE EP12AL-S06)

If the circuit is normal, there will be a given amount of current.

If any part of the circuit is open there will be zero current flowing in the circuit.

If one of the resistors, R_1 or R_2, is shorted, the current will increase. By ohm's Law;

$$I = \frac{E}{R}$$

From FIGURE 6, it may be shown that by adjusting the multimeter to read DC voltage while connected to T_{P5} and T_{P6}, with S_1 open, the applied voltage will be read on the multimeter. The circuit is now open.

SERIES CIRCUITS TROUBLESHOOTING

If a series circuit is open, zero current will flow.

Zero voltage will be dropped across R_1 or R_2, because there is zero current with S1 open. By Ohm's Law:

$$I_T\ R_1$$

$$0 \times R_1$$

$$0V$$

$$E_{R2} = I_T\ R_2$$

$$E_{R2} = 0 \times R_2$$

$$E_{R2} = 0V$$

If there is no voltage dropped across R_1 or R_2, all of the applied voltage must be dropped across the open switch.

If S_1 is closed and current flows, the circuit is normal

If R_1 has a short circuit across it, the current will increase and the applied voltage will be dropped across R_2. By Kirchhoff's Law:

$$E_A = E_{R1} + E_{R2} \text{ and } E_{R1} = I_T\ R_1,$$

$$E_A = 0 + E_{R2}, \qquad E_{R1} = 0 \times R_1,$$

$$E_A = E_{R2}, \qquad E_{R1} = 0V,$$