BASIC CIRCUIT ANALYSIS AND TROUBLESHOOTING

Troubleshooting is the systematic process of recognizing the symptoms of a problem, identifying the possible cause, and locating the failed component or conductor in the circuit. To be proficient at troubleshooting, the technician must understand how the circuit operates and know how to properly use the test equipment.

There are many ways in which a system can fail and to cover all of the possibilities is beyond the scope of this text. However, there are some basic concepts that will enable the technician to handle many of the common faults encountered in the aircraft.

Before starting a discussion on basic circuits and troubleshooting, the following definitions are given.

- *Short circuit*—an unintentional low resistance path between two components in a circuit or between a component/conductor and ground. It usually creates high current flow, which will burn out or cause damage to the circuit conductor or components.
- *Open circuit*—a circuit that is not a complete or continuous path. An open circuit represents an infinitely large resistance. Switches are common devices used to open and close a circuit. Sometimes a circuit will open due to a component failure, such as a light bulb or a burned out resistor.
- *Continuity*—the state of being continuous, uninterrupted or connected together; the opposite of a circuit that is not broken or does not have an open.
- *Discontinuity*—the opposite of continuity, indicating that a circuit is broken or not continuous.

VOLTAGE MEASUREMENT

Voltage is measured across a component with a voltmeter or the voltmeter position on a multimeter. Usually, there is a DC and an AC selection on the meter. Before the meter is used for measurements, make sure that the meter is selected for the correct type of voltage. When placing the probes across a component to take a measurement, take care to ensure that the polarity is correct. [**Figure 3-117**] Standard practice is for the red meter lead to be installed in the positive (+) jack and the black meter lead to be installed in the negative meter jack (–). Then when placing the probes across or in parallel with a component to measure the voltage, the leads should match the polarity of the component. The red lead shall be on the positive side of the component and the black on the negative side, which will prevent damage to the meter or incorrect readings.

All meters have some resistance and will shunt some of the current. This has the effect of changing the characteristic of the circuit because of this change in current. This is typically more of a concern with older analog type meters. If there are any questions about the magnitude of the voltage across a component, then the meter should be set to measure on the highest voltage range. This will prevent the meter from "pegging" and possible damage. The range should then be selected to low values until the measured voltage is read at the mid-scale deflection. Readings taken at mid-scale are the most accurate.

CURRENT MEASUREMENT

Current is measured with the ammeter connected in the current path by opening or breaking the circuit and inserting the meter in series as shown in **Figure 3-118**. Standard practice is for the red meter lead to be installed in the positive (+) jack and the black meter lead to be installed in the negative meter jack (–). The positive side of the meter is connected towards the positive voltage source. Ideally, the meter should not alter the current nor influence the circuit and the measurements. However, the meter does have some effect because of its internal resistance that is connected with the rest of the circuit in series. The resistance is rather small and for most practical purposes, this can be neglected.

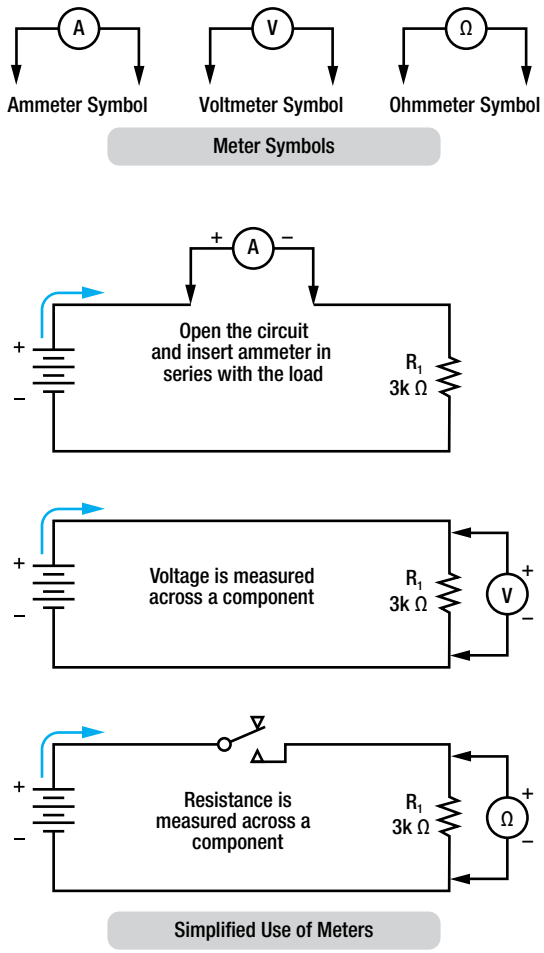

Figure 3-117. Current measurement.

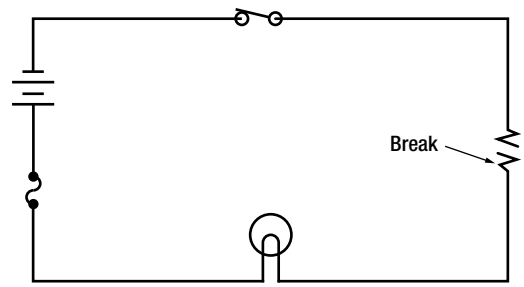

Figure 3-118. An open circuit.

1. In the circuit shown in **Figure 3-134**, an open has occurred in the series portion of the circuit. When the open occurs anywhere in the series portion of a series-parallel circuit, current flow in the entire circuit will stop. In this case, the circuit will not function, and the lamp, L_1, will not be lit.
2. If the open occurs in the parallel portion of a series-parallel circuit, as shown in **Figure 3-135**, part of the circuit will continue to function. In this case, the lamp will continue to burn, but its brightness will diminish, since the total resistance of the circuit has increased and the total current has decreased.
3. If the open occurs in the branch containing the lamp, [**Figure 3-136**] the circuit will continue to function with increased resistance and decreased current, but the lamp will not light.

TRACING OPENS WITH THE VOLTMETER

To explain how the voltmeter and ohmmeter can be utilized to troubleshoot series-parallel circuits, the circuit shown in **Figure 3-137** has been labeled at various points. A point-to-point description is listed with expected results:

1. By connecting a voltmeter between points A and D, the battery and switch can be checked for opens.
2. By connecting the voltmeter between points A and B, the voltage drop across R_1 can be checked. This voltage drop is a portion of the applied voltage.
3. If R_1 is open, the reading between B and D will be zero.
4. By connecting a voltmeter between A and E, the continuity of the conductor between the positive terminal of the battery and point E, as well as the fuse, can be checked. If the conductor or fuse is open, the voltmeter will read zero.
5. If the lamp is burning, it is obvious that no open exists in the branch containing the lamp, and the voltmeter could be used to detect an open in the branch containing R_2 by removing lamp, L_1, from the circuit.

Troubleshooting the series portion of a series-parallel circuit presents no difficulties, but in the parallel portion of the circuit, misleading readings can be obtained.

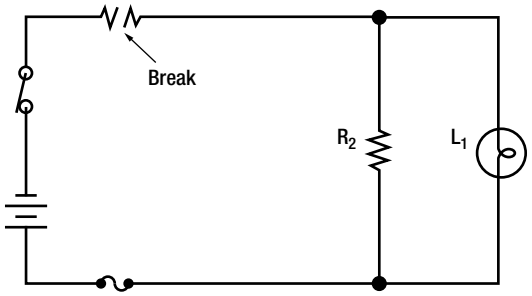

Figure 3-134. An open in the series portion of a series-parallel circuit.

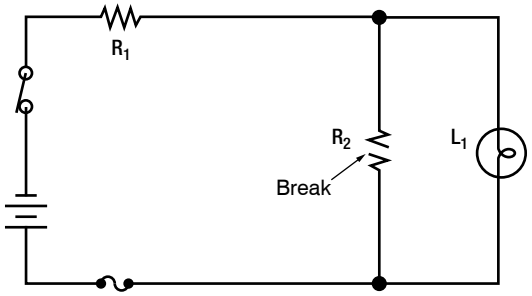

Figure 3-135. An open in the parallel portion of a series-parallel circuit.

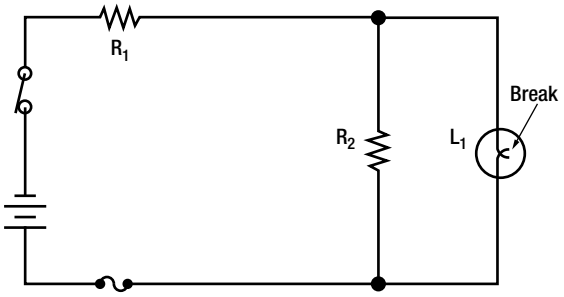

Figure 3-136. An open lamp in a series-parallel circuit.

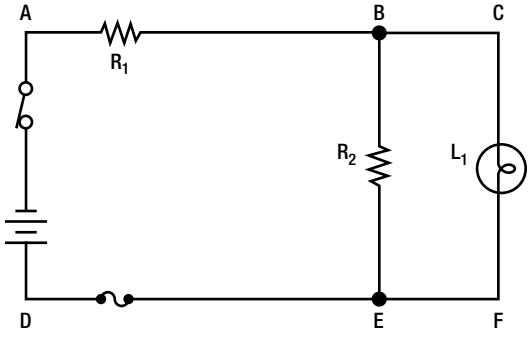

Figure 3-137. Using the voltmeter to troubleshoot a series-parallel circuit.