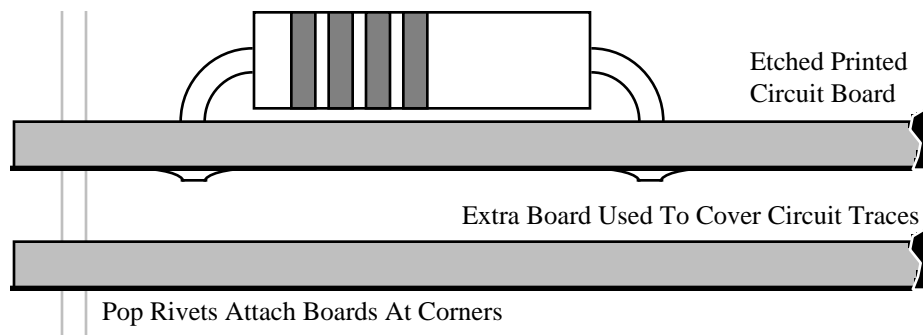


# Printed Circuit Board Construction Guide for the Troubleshooting Experiments

- The printed board layouts, are printed full size within this guide.
- Printed circuit boards used for the troubleshooting experiments are constructed on normal single-sided copper clad boards.
- The normal problem associated with creating troubleshooting boards for student use is hiding the circuit faults so that the student must isolate the component fault with measurement techniques, rather than just observing the fault. The methods presented here will make the faults invisible to the student.
- Circuit boards are constructed as shown in Figure 1, with the components mounted on the upper board, which is the actual etched printed circuit board. The trace side of the board is hidden from student view by the lower board. The lower board can be made from unetched single-sided copper clad board as is used for the upper board, or any other similar opaque fibre board. The boards are pop-riveted together.



**Figure 1. Board Construction**

- Most types of copper clad board are suitable for the etched board, however those with high transparency are preferred since they allow the student to see a general outline of the circuit board traces while not allowing a view of how the actual faults are created.
- Short circuited resistors are simulated by soldering a piece of fine wire across the resistor terminals on the foil side of the board. The short circuit is obviously not visible from the foil side since the opaque board totally blocks the view. From the component side of the board, even with very translucent board material, the view of the trace is sufficiently blurred that the short circuit will not be visible.

- Open circuited resistors are created by cutting carbon film resistors which have the resistive layer close to the outer surface of the resistor. The resistor is easily cut using a Dremel<sup>®</sup> Moto-Tool<sup>®</sup> with Cutting Wheel # 409. This thin emery wheel will cut a small fine slot along the longitudinal axis of the resistor, as shown in Figure 2. The resistor is then mounted flush with the circuit board, with the slot on the side directly against the board. The cut in the resistor will not be visible even if closely inspected.



**Figure 2. Making an Open Resistor**

- Open circuit board traces can be created using the tool described above to cut a thin break in the trace itself.
- Power supply connections to the troubleshooting boards can be made by using a variety of connectors attached or soldered to the board. One suggestion that works well is to use “J Pins,” manufactured by Vector Products (device # K32/C). These are generally available through any electronic component supplier. Normal banana to alligator test leads will easily clip on to these pins. Another suggestion is to just clip the power supply test leads directly onto the resistor leads nearest the power supply terminals.
- The printed circuit board positives provided are “minimum-etch” layouts, requiring a minimum of copper to be etched and therefore allowing the etchant solution to last longer.
- It is a good idea to use 1 watt or 2 watt resistors for these boards for three reasons: the color codes are larger and thus easier for beginning students to read, the boards will be stronger and will thus last longer, and the resistors will stay in place and hide the faults better. Students will poke at 1/4 watt resistors and easily damage them.

## Circuit Boards for “troubleshooting DC Circuits” Experiment

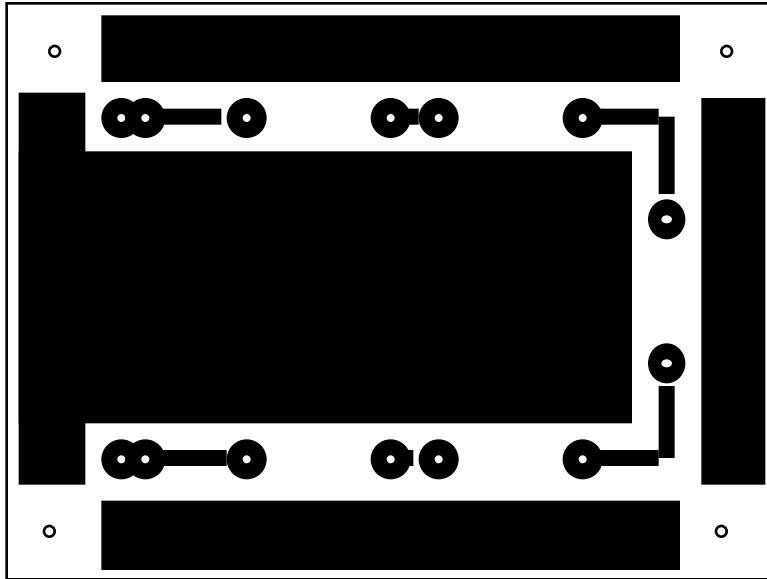
- This lab experiment requires two printed circuit boards, one a series circuit, the other a parallel circuit.
- Each circuit has five resistors, with values as given in the actual lab experiment.

### Series Board

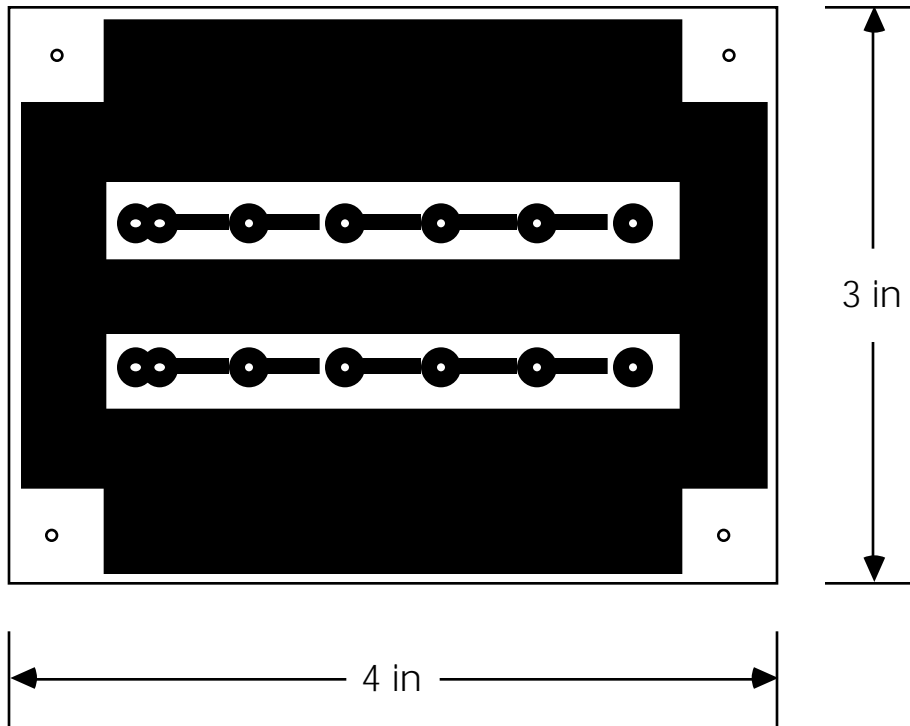
- The suggested faults for this board would be: R1 open, R1 shorted, R2 open, R2 shorted, R3 open, R3 shorted, R4 open, R4 shorted, R5 open, R5 shorted, open trace between R1 and R2, open trace between R2 and R3, open trace between R3 and R4, and an open trace between R4 and R5. The answer manual will have answers for the faults listed above.
- There are 14 possible faults listed above. For a class of 20 students, it would be best to build 28 boards, or two complete sets of 14 faults. This would allow enough extra boards so that students are not kept waiting for others to finish with a particular board. It is recommended that there be only one fault per board.
- Figure 1 on the following page is the full size series printed circuit board positive for this Experiment.

### Parallel Board

- The suggested faults for this board would be: R1 open, R2 open, R3 open, R4 open, R5 open, open trace between the tops of R1 and R2, open trace between the tops of R2 and R3, open trace between the tops of R3 and R4, open trace between the tops of R4 and R5, open trace between the bottoms of R1 and R2, open trace between the bottoms of R2 and R3, open trace between the bottoms of R3 and R4, and an open trace between the bottoms of R4 and R5. The answer manual will have answers for the faults listed above.
- There are 13 possible faults listed above. For a class of 20 students, it would be best to build 26 boards, or two complete sets of 13 faults. This would allow enough extra boards so that students are not kept waiting for others to finish with a particular board. It is recommended that there be only one fault per board.
- Figure 2 on the following page is the full size parallel printed circuit board positive for this Experiment.



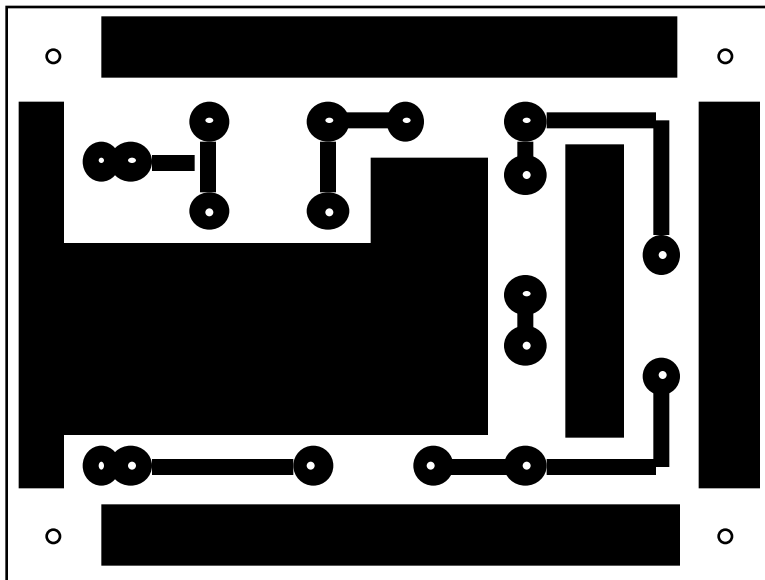
**Figure 1. Series DC Troubleshooting Board Positive**



**Figure 2. Parallel DC Troubleshooting Board Positive**

## Circuit Boards for “troubleshooting Series-Parallel Circuits” Experiment

- This lab experiment requires one printed circuit board, a series-parallel circuit.
- The circuit has seven resistors, with values as given in the actual lab experiment.
- The suggested faults for this board would be: R2 open, Open trace above R7, R5 shorted, R1 or R2 shorted, Open trace between R5 and R6, R7 open, R6 open, R4 shorted, Open trace above right side of R2, R3 shorted. The answer manual will have answers for the faults listed above.
- There are 10 possible faults listed above. For a class of 20 students, it would be best to build 30 boards, or three complete sets of 10 faults. This would allow enough extra boards so that students are not kept waiting for others to finish with a particular board. It is recommended that there be only one fault per board.
- Figure 3 is the full size series printed circuit board positive for this Experiment.



**Figure 3. Series-Parallel DC Troubleshooting Board Positive**