Series and Parallel Circuits

Objectives: To study current flow in series and parallel circuits.

Equipment: Light board, power supply*.

Discussion

This procedure is designed to give you practice in constructing series and parallel circuits and to enhance your understanding how current flows in electrical circuits. The apparatus used is a combination of three light bulbs mounted on a board with various switches for connecting the bulbs in series combinations, parallel combinations, and series-parallel combinations. Figure 1 is a schematic diagram of the light board.

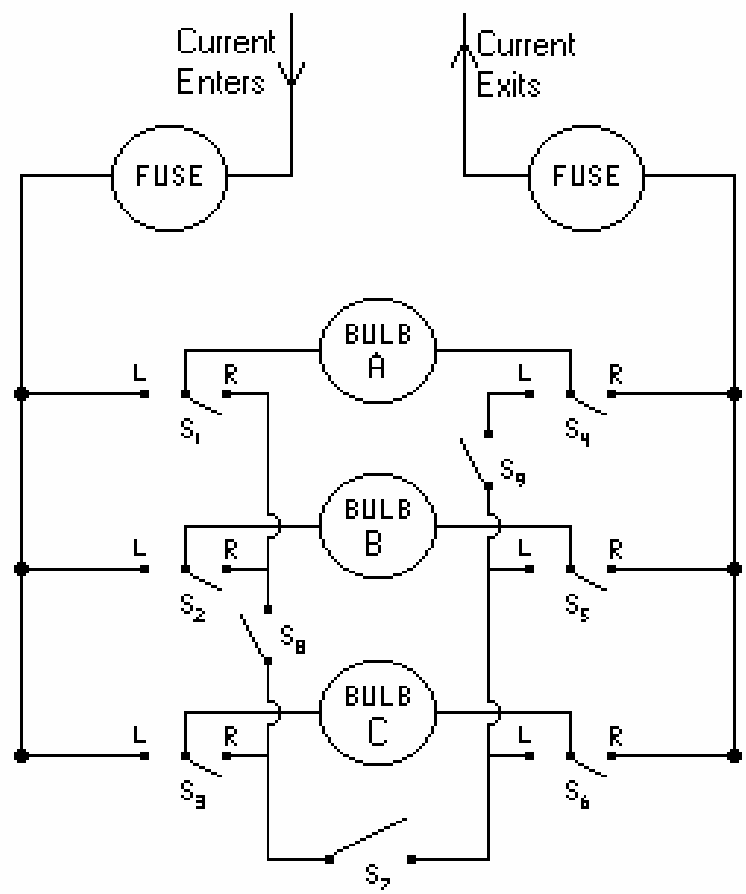

Figure 1. Diagram of Series and Parallel Circuit Board.

There are nine switches S_1, S_2, S_3, ..., S_9, on the board. Six of them (S_1 through S_6) are SPDT (single pole, double throw) switches which have three positions: open, closed to the right, or closed to the left. The other three switches (S_7, S_8, and S_9) are SPST (single pole, single throw) switches which have only two positions, open or closed.

Figure 2 shows the circuits that you are to construct by the proper positioning of the switches on the board. Note that the current must flow through the bulbs A, B, C in the indicated order. Even though the first 6 circuits are all series circuits, they will all have different switch settings. For each of these circuits, you should:

1. Use Ohm's Law ($V = IR$), and your knowledge of the behavior of resistors in series and parallel to predict the relative amount of current that will flow through each bulb when that circuit is energized. Assume that all of the bulbs have the same resistance. Recall:

Resistors in parallel: $\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{R_{eq}}$ Resistors in series: $R_1 + R_2 + R_3 = R_{eq}$

2. Predict the relative brightness each bulb will have, recognizing that the brightness of any bulb increases as the current increases.

3. Consider Figure 1 (or the circuit board itself) and trace out the path the current must follow to produce the desired effect.

4. Close the switches to the positions required to produce the current path you have traced and record the setting of each switch. If the setting of any switch (such as S7, S8, or S9) is irrelevant, list it as O/C (either open or closed).

5. Energize* the board and observe the behavior of the bulbs to make sure that you have actually achieved the desired circuit.

6. Record the information in your lab notebook.

* Your lab may be equipped with either stand alone power supplies for the circuit boards or PC driven power supplies. For the latter observe the following general directions (your TA will assist you with these):

- Open the 213/214 folder on the Windows desktop
- Open the Pasco Data Manager Program
- Set the Power Amplifier voltage to 10 Volts
- Turn on the Power Amplifier

At any point during this exercise, you must be prepared to respond to questions from the instructor requiring you to:

- Trace out the path the current is following around the board.
- Explain why any given bulb has the relative brightness that is observed.
- Explain why it is necessary to have any one the 9 switches in the position that you have set it.
- Predict what would happen if the instructor should reposition any one of the 9 switches.
- Predict what would happen if the instructor should disconnect any one of the three bulbs.

Circuits to be formed:

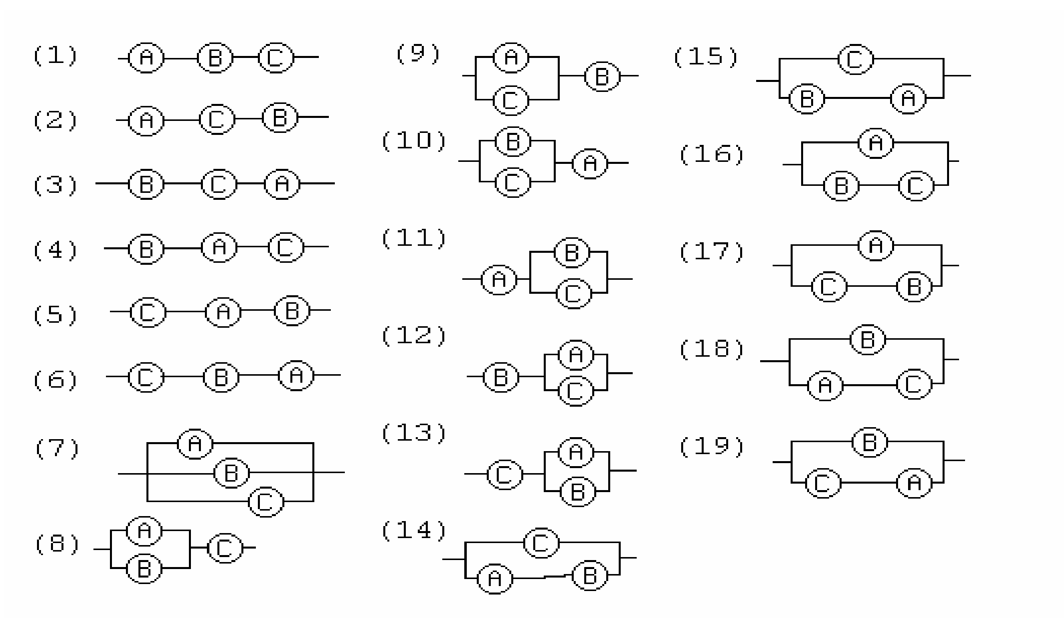

Figure 2.

Questions

1. Explain the behavior of voltage and current across resistors in parallel branches of a circuit. What causes the bulbs in parallel to display increased brightness?
2. Explain the behavior of voltage and current across resistors in series. What causes bulbs in series to display decreased brightness?
3. Draw schematic diagrams of SPST and SPDT switches. How do these work?
4. Why are light bulbs very dim for certain circuit arrangements and very bright for others?
5. Which quantity appears to be conserved and which quantity appears to be "used up" in all of the circuits (current, voltage)?

A frequent situation audio engineers encounter when working with smaller sound systems is the use of many loudspeakers in an attempt to increase the size (loudness) of a system with additional speakers, which are relatively inexpensive, instead of additional power amplifiers which are very expensive (about a dollar per watt for professional power amplifiers).

A loudspeaker is a load in a circuit just like the light bulbs you studied in this procedure. When loudspeakers are connected together the connections are always parallel. Any network of loudspeakers is, therefore, just like a series of light bulbs connected in parallel in the circuits you just examined. Recall the behavior of light bulbs in parallel in this circuit and answer the following questions.

6. What is the likely result of connecting many loudspeakers to the same channel (circuit) of an audio power amplifier?
7. Audio power amplifiers supply constant voltage with a varying current up to a finite amount - in essence as much voltage as needed but with limited current. What do you suppose is the effect of attempting to increase power to a series of loudspeakers in parallel?
8. Based on your newly acquired knowledge of parallel circuits and power supplies, when loudspeakers fail what do you think is the most common mode of failure: overpowering or underpowering? Can underpowering cause a loudspeaker to "burn out"?

In every residence there exists a device known as a breaker box (or a fuse box in older homes). Most devices plugged into wall outlets are connected in parallel with other devices on the same circuit. Based on this, what do you think is the function of a circuit breaker? What is the wisdom of using Waber (multiple outlet) strips to plug in several appliances to the same circuit?