

RadioShack®

Electronics Learning Lab

Instruction and Reference Manual

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Introduction

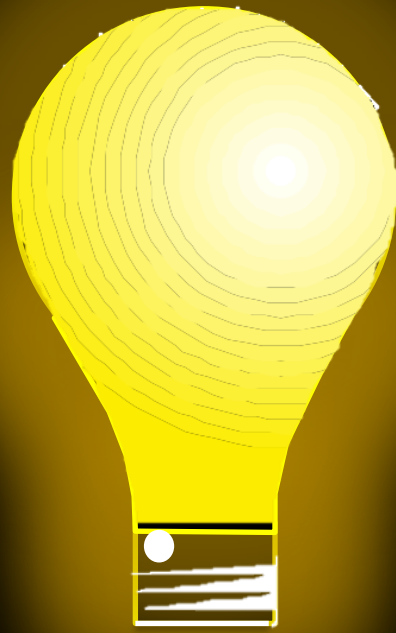
At the University of North Texas, the Electrical Engineering department's goal for the EENG 1910 Project I course is to teach students about learning, responsibilities, and professionalism. Projects given in the EENG 1910 Project I class incorporate the department's goals while also providing exposure to the basic elements of Electrical Engineering. The exposure to Electrical Engineering occurs during the projects given throughout the course that require the use of the RadioShack Electronics Learning Lab. However, the RadioShack Electronics Learning Lab is not designed to be used by beginners.

The RadioShack Electronics Learning Lab comes with two workbooks that contain circuits a student can build with the components provided in the kit. Each circuit in the workbook is accompanied with written instructions, diagrams, and tips for building the circuit. The Learning Lab supplies the components needed to build the circuits inside of the workbooks, and additional components will be supplied by an instructor.

This manual has been created to help students learn about the RadioShack Electronics Learning Lab and the basics of Electrical Engineering. This manual covers information on components available to students in the EENG 1910 Project I class. Information on other subjects, such as voltage, current, and the mathematics of Electrical Engineering will be discussed in class. This manual will provide students in the EENG 1910 Project I class using the RadioShack Electronics Learning Lab with the information to

- read and understand diagrams provided
- learn the uses of components and devices given
- handle the Learning Lab independently

Chapter One

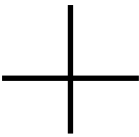
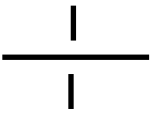
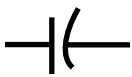
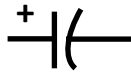




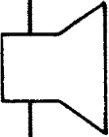
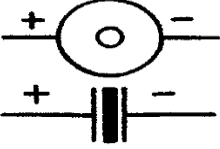

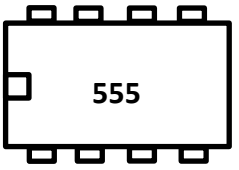



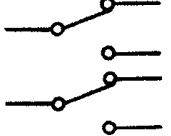


Diagrams

Diagrams

Reading Symbols

A workbook is provided with every RadioShack Electronics Sensor Lab. The workbook is a compilation of many projects that can be done with the materials provided in the kit. Each project in the workbook has a set of written instructions. Each project also comes with a diagram of the circuit to be made for those that want less guidance. The diagram symbols that you will need to know are shown below. Additional information about major components will be given later.

			
Connected Wires	Unconnected Wires	Ceramic Capacitor	Electrolytic Capacitor
			
Positive Voltage Connection	Ground	Resistor	Potentiometer
			
Magnetic Speaker	Buzzer	Light-Emitting Diode	Integrated Circuit
			
Photo-resistor	Pushbutton Switch	SPDT Switch	DPDT Switch

On diagrams, you may find that some symbols will be labeled with a letter and a number. For instance, you will find that resistors will be labeled R1, R2, R3, etc. and capacitors labeled C1, C2, C3, etc. This is done to allow communication about a circuit to be simpler. You may call the elements by their labeled name, instead of referring to them by their value.

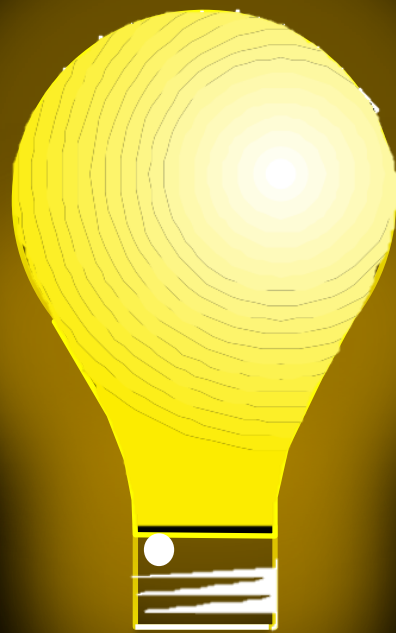
Tips for Recreating the Circuit



CAUTION: Before creating any circuit, turn off the power switch.

1. Always gather the components needed for the circuit before you start recreating the circuit. This will help prevent you from pausing during your work to search for a component.
2. Don't rush. Take time to observe the diagrams and read the information given. You will make less mistakes if you take your time.
3. Always start a circuit by connecting and wiring the IC, if it has one.
4. If the IC has a pin that isn't connected to anything, then connect it to Ground. Remember that all pins of an IC must be connected to something.
5. Always work on one part of a circuit at a time. This will help once your circuits become larger.
6. Do not move on to another part of the circuit until the section you are working on is complete. This will help to prevent you from forgetting to complete a part of the circuit.
7. Connect resistors before connecting capacitors. Resistors and capacitors tend to be placed close together. Resistors are harder to place in breadboards than capacitors, so it's best to connect resistors first.

Chapter Two



INTEGRATED CIRCUITS

Integrated Circuits (ICs)

Purpose

Integrated Circuits, also known as ICs, are small pre-made electronic circuits. Some versions of ICs that you may know consist of memory chips, microprocessors found in computers, and amplifiers. ICs are meant to help make circuits compact and cheaper. They are cheaper because less material is needed to build an IC than to build the circuit that they contain in a life-sized model. Additionally, ICs have a high performance level because of the close proximity of the components. Since the components are close together, less power is needed and the components are able to interact with one another better.

Every IC has pins that enable it to be installed into a Breadboard. These pins have different functions and are used to connect different parts of a circuit to the IC. Every IC will have a notch on it that represents where pin 1 is.

Features of an IC

On the flat side of an IC, there will always be a notch or a circle present. This notch is called the index marker. The index marker identifies the top part of the IC and pin 1.

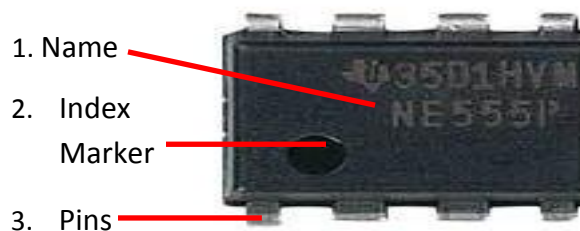


Figure 2.1: The 555 IC

1. **Name:** The name will identify what type of IC you are using and will always be accompanied by the manufacturing number.
2. **Index Marker:** This index marker identifies the top part of the IC. The marker will also indicate which pin is pin 1.
3. **Pins:** Use these pins to install an IC into a breadboard.

How to Install an IC

1. Push the power switch to off.
2. Find the index marker on the IC.
3. Hold the IC between your pointer finger and thumb, with the index marker of the IC closest to your pointer finger.
4. Gently insert the tips of the pins of the IC into the desired connection points on the breadboard.
5. Once the IC is in the desired spot, use your pointer finger to push down on the IC. The IC should be flat on the Breadboard.

How to Remove an IC

To remove an IC, you will need the IC remover, seen in Figure 2.2 below. There is an IC remover provided in every RadioShack Electronics Learning Lab.



Figure 2.2: IC Remover

1. Push the power switch to off.
2. Hold the IC remover provided in your kit. You should be able to squeeze the IC remover easily.
3. Insert 1 of the metal grips of the IC remover under the IC you want to remove.
4. Insert the other metal grip of the IC remover to the opposite side of the IC you want to remove.
5. While squeezing the IC remover, gently pull the IC remover up until the IC “legs” are fully out of the Breadboard.

The Basic 555

The 555 IC is one of the most used ICs. The 555, also known as the 555 timer and the NE555, has the ability to act as a timer, a pulse generator, and an oscillator, meaning the 555 can output a signal that is similar to a sine wave.

You will be using the 555 IC in many of your circuits, so it's vital that you become familiar with how the IC functions.

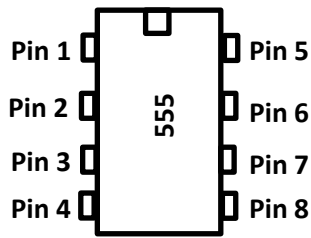


Figure 2.3: Pins of the 555 IC

1. **Pin 1:** Always connect this pin to Ground. Pin 1 will always act as a stabilizer for this IC.
2. **Pin 2:** This pin is also known as the trigger. The trigger will activate the 555 IC when current is pushed into it.
3. **Pin 3:** This pin is the output. If an LED is connected to the output pin, then it will turn on once the 555 IC is activated.
4. **Pin 4:** This pin is the reset pin. When pin 4 is activated by a low amount of voltage, the 555 IC will restart. The function of this pin is similar to the reset button on timers in that the device is ready to be used again right after the reset is activated.
5. **Pin 5:** This pin is often connected to Ground in circuits where the 555 IC is the only IC present. Also known as the control pin, pin 5 has the ability to decrease the amount of fluctuation of incoming voltage when connected to a capacitor.
6. **Pin 6:** When the 555 IC is used as a timer and pin 6 and pin 7 and both used, pin 6 monitors how much voltage is being stored inside of the capacitor pin 7 uses. Once the voltage being stored reaches a certain point, pin 6 will end the timing cycle.
7. **Pin 7:** This pin works similarly to pin 5. However, instead of decreasing fluctuation by leveling out the voltage like pin 5, pin 7 sends the overflow of voltage to a capacitor, which then sends the voltage to Ground, where the voltage is redistributed throughout the console of the Learning Lab.
8. **Pin 8:** This pin must always be connected to a power supply. The 555 can take a minimum of 4.5 volts, and a maximum of 15 volts.

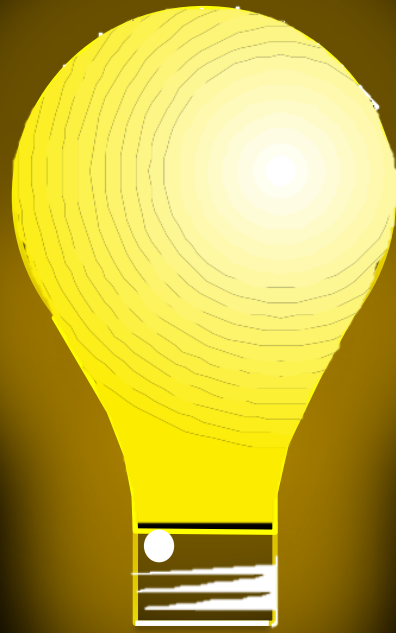
Applications

Since 555 ICs are able to create and send off pulses, they are commonly used in alarms and sirens that are in buildings and emergency vehicles. Many simple music-making machines also have the 555 IC inside of them.

All ICs have a different purpose and function and can be found in the average household. For instance, microwaves have LED displays that are controlled by a 4511 IC that was built to translate binary input, also known as the language of computers, into signals that an LED display could accept.

Information on additional ICs will be provided in future courses.

Chapter Three



Resistors & Potentiometers

Resistors and Potentiometers

Function

The purpose of resistors is to resist the flow of electricity. Resistors are often used to prevent damage to LEDs and speakers by reducing the current that flows into them.

Potentiometers are adjustable resistors. Potentiometers look like dials that you can move until you have the desired resistance. Since potentiometers can be adjusted while a circuit is working, they are often used in amplifiers.

Series v. Parallel

In circuits, resistors can be placed in either series or parallel.

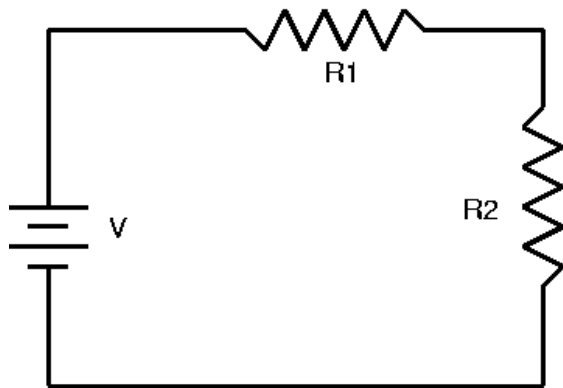


Figure 3.1: Resistors in Series

The circuit in Figure 3.1 has resistors that are in series with one another. By definition, resistors are in series when they are arranged in a chain. In other words, the current flowing has only one path that it can take.

The circuit below (Figure 3.2), however, has resistors that are in parallel with one another. When this happens, the current flowing through the circuit is split up temporarily in order to flow through the branches of the parallel circuit. To be in parallel properly, the two branches must combine and become one.

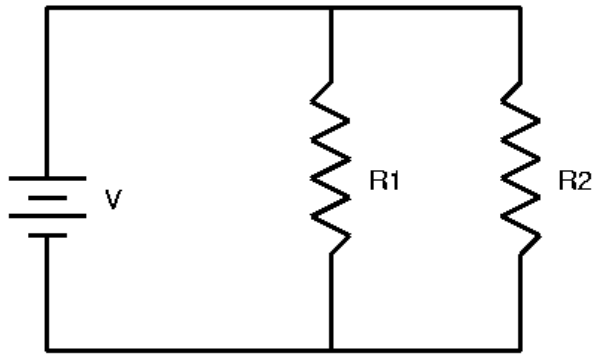


Figure 3.2: Resistors in Parallel

Seeing resistors in series is much more common than seeing resistors in parallel. However, don't underestimate the power of parallel resistors, especially if you have a limited supply of resistors. Resistors are only available in standard values. Once you begin creating bigger projects, you may find that you need a resistor that you don't have, or isn't made. When you don't have the single resistor you need, then that is the when you use resistors in parallel as the equation for total resistance is different.

Below (Figure 3.3) is a table showing some of the characteristics of resistors in series and in parallel. More information about series and parallel will be given in future courses.

Resistors in Series	Resistors in Parallel
Voltage = Current \times Total Resistance	Voltage = Current \times Total Resistance
Total Resistance = $R1 + R2 + \dots$	Total Resistance = $\frac{(R1 \times R2)}{R1+R2}$
Current is the same for each resistor.	Voltage is the same for each resistor.
If a resistor in series burns out, the circuit will not be complete and will not operate.	If a resistor burns out, the circuit will continue to operate.

Figure 3.3: Series v. Parallel

How to Calculate the Resistance of a Resistor with Four Bands

The bands you see on resistors are used to calculate resistance. Use Figure 3.4 and Figure 3.5 to help you calculate the resistance of a resistor with four bands.

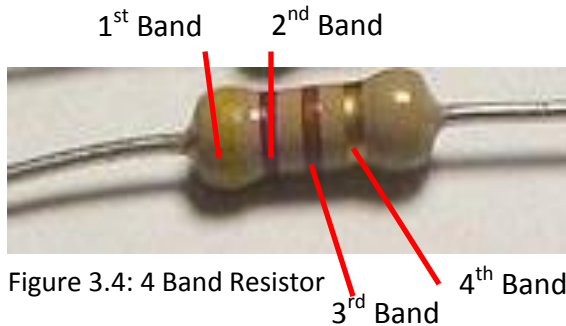


Figure 3.4: 4 Band Resistor

Color	1st Band	2nd Band	Multiplier	Tolerance
Black	0	0	1 Ω	
Brown	1	1	10 Ω	$\pm 1\%$
Red	2	2	100 Ω	$\pm 2\%$
Orange	3	3	1K Ω	
Yellow	4	4	10K Ω	
Green	5	5	100K Ω	
Blue	6	6	1M Ω	
Violet	7	7	10M Ω	
Grey	8	8	100M Ω	
White	9	9	--	
Gold			.1	$\pm 5\%$
Silver			.01	$\pm 10\%$

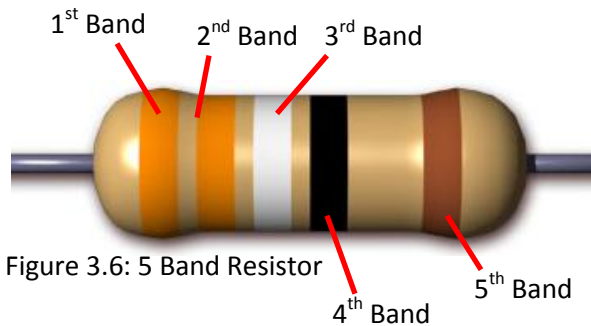
Figure 3.5: Resistor Color Code Chart for 4 Bands

1. Select a 4-banded resistor you want to find the resistance of.
2. Look at the 1st band. Find the color of this band in Figure 3.3 and take note of the number that is designated to it in the 1st Band column.
3. Look at the 2nd band. Find the color of the band in the chart above and take note of the number that is designated to it in the 2nd Band column.
4. Combine the two numbers obtained from steps 2 and 3. For instance, if your first number was a 2 and your second number was a 6, then your new number is now 26.
5. Look at the 3rd Band. Find the color of the band in the chart above under the column labeled 'multiplier.'

6. Multiply the number obtained from Step 5 to the number you determined in Step 4. This new number is the resistance of your resistor, measured in ohms (Ω).
7. The color of the 4th band represents the tolerance, or the amount of error that can be present in the resistor. For this course, you do not need to factor the tolerance into the resistance.

How to Calculate the Resistance of a Resistor with Five Bands

Use Figure 3.6 and Figure 3.7 to help you calculate the resistance of a resistor with five bands.



Color	1st Band	2nd Band	3rd Band	Multiplier	Tolerance
Black	0	0	0	1 Ω	
Brown	1	1	1	10 Ω	$\pm 1\%$
Red	2	2	2	100 Ω	$\pm 2\%$
Orange	3	3	3	1K Ω	
Yellow	4	4	4	10K Ω	
Green	5	5	5	100K Ω	
Blue	6	6	6	1M Ω	
Violet	7	7	7	10M Ω	
Grey	8	8	8	100M Ω	
White	9	9	9	--	
Gold				.1	$\pm 5\%$
Silver				.01	$\pm 10\%$

Figure 3.7: Resistor Color Code Chart for 5 Bands

1. Select a 5-banded resistor you want to find the resistance of.
2. Look at the 1st band. Find the color of this band in Figure 3.7 under the column labeled '1st Band' and take note of the number that is designated to it.
3. Look at the 2nd band. Find the color of the band in Figure 3.7 under the column labeled '2nd Band' and take note of the number that is designated to it.
4. Look at the 3rd band. Find the color of the band in Figure 3.7 under the column labeled '3rd Band' and take note of the number that is designated to it.
5. Combine the three numbers obtained from steps 2, 3, and 4. For instance, if your first number was a 2, your second number was a 6, and your third number is a 0, then your new number is now 260.
6. Look at the 4th Band. Find the color of the band in Figure 3.7 under the column labeled 'multiplier.'
7. Multiply the number obtained from Step 6 to the number you determined in Step 5. This new number is the resistance of your resistor, measured in ohms (Ω).
8. The color of the 5th band represents the tolerance, or the amount of error that can be present in the resistor. For this course, you do not need to factor the tolerance into the resistance.

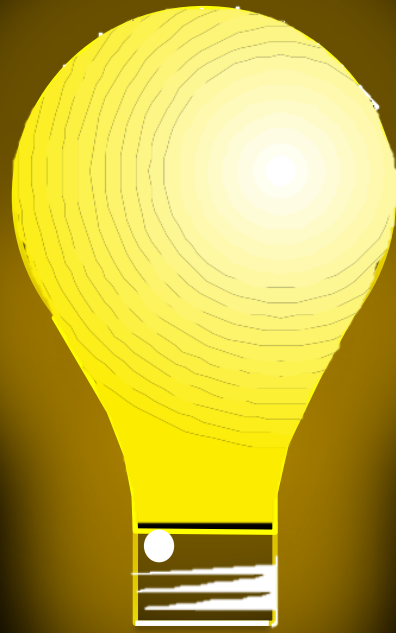
Applications

You see resistors in use every day. One of the simplest examples where resistors are being used is light bulbs. The voltage that comes from the wall sockets in homes is about 110 volts. Most light bulbs require less than that, and are thus built with resistors inside of them to help bring down incoming voltage.

Light bulbs are also a good example of devices with resistors in series. Take Christmas tree lights, for example. If one light bulb in the string of lights burns out, then all of the light bulbs turn off as well.

For a good example of a device in your home that uses resistors in parallel, consider a circuit breaker. If you were to plug in a microwave, a coffee machine, and a lamp, the voltage given to the devices by the circuit breaker would be the same. Though all three devices are using the same power source, the devices do not rely on each other. Unplugging one device would not affect the others.

Chapter Four



Capacitors

Capacitors

Function

Capacitors have the ability to store an electrical charge. Due to this, they are often used to calm a fluctuating signal and to help a circuit run smoothly.

All capacitors have their capacitance measured in farads. Most capacitors only have the ability to hold a few millionths of a farad, so you will often find capacitance labeled as μF , where F stands for farad, and μ stands for micro, which stands for one millionth.

Electrolytic v. Ceramic



Figure 4.1: Ceramic Capacitor



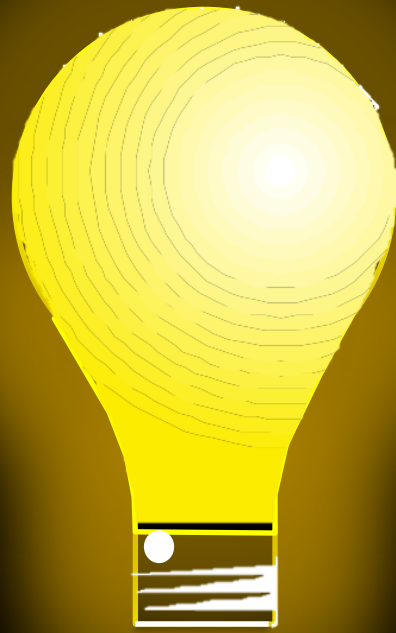
Figure 4.2: Electrolytic Capacitor

Characteristics of Capacitors are shown below in Figure 4.3.

Electrolytic Capacitor	Ceramic Capacitor
Large capacity	Small capacity
Commonly used with power related devices	Commonly used with frequencies
Has a short life span	Has a long life span
Outputs large amounts of current	Outputs small amounts of current

Figure 4.3: Electrolytic Capacitor v. Ceramic Capacitor

Chapter Five



Indicators

Indicators

Indicators such as speakers and Light-Emitting Diodes (LEDs) are used to provide verbal and visual feedback from a circuit. Some circuits use indicators as a way to test a circuit that doesn't have an obvious output. Other circuits use indicators to their full potential by utilizing them in ways that are more extensive than just testing. As speakers will be discussed in class, only information on LEDs is provided below.

Light-Emitting Diodes

LEDs emit light when current is applied to them. Some LEDs emit near-infrared waves. Due to these two qualities, LEDs are often used in communication devices, remote controls, and connections between computers.

In the RadioShack Electronics Learning Lab, there are a total of 19 LEDs provided. 10 of these LEDs are built into the console. 7 of the LEDs create the 7-segment LED display. The last 2 are kept separate from the console and can be used in the breadboard.

The loose LEDs have 2 legs. The shorter leg is called the cathode, and the longer leg is called the anode. However, since the legs will bend after multiple uses, most manufacturers of LEDs will make LEDs that have a flat side. This flat side will tell you which leg is the cathode.



CAUTION: Do not connect an LED incorrectly as you can burn-out the LED.

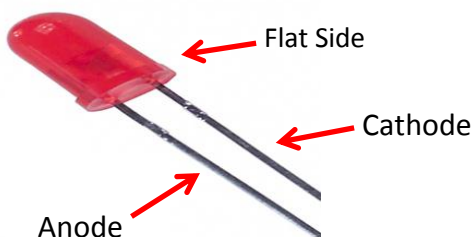
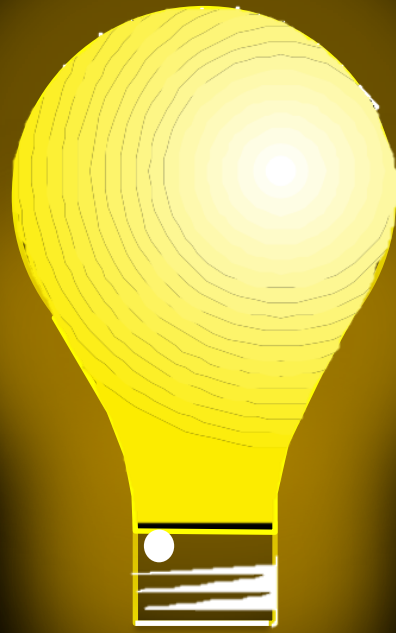


Figure 5.1: Red LED

Chapter Six



Troubleshooting

Troubleshooting

If your circuit does not work the first time you turn the power switch on, then follow the steps below before asking your instructor for help:



CAUTION: Before troubleshooting your circuit, turn off the power switch.

1. Check your batteries. The batteries may be installed incorrectly or may be dead.
2. Make sure all wires and pins are fully inserted into the breadboard.
3. Make sure that your components have been installed correctly. The pins of ICs and Diodes must be installed in the breadboard in a specific position. Additionally, each pin of an IC must have a connection to a part in the circuit.
4. Check your components. Make sure that you are using the correct parts by checking the names of your components, the colors of your resistors, and the capacitance of your capacitors.
5. If you are using elements that are built into the console, such as the potentiometers and the LEDs, then configure your circuit to use different components. For instance, use resistors in place of potentiometers and the loose LEDs in place of the LEDs in the console.
6. If none of the previous steps have solved the issue, then rebuild the circuit.

If your circuit doesn't work after completing the steps above, then ask your instructor for help. It is possible that a component has burnt out and no longer works.

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