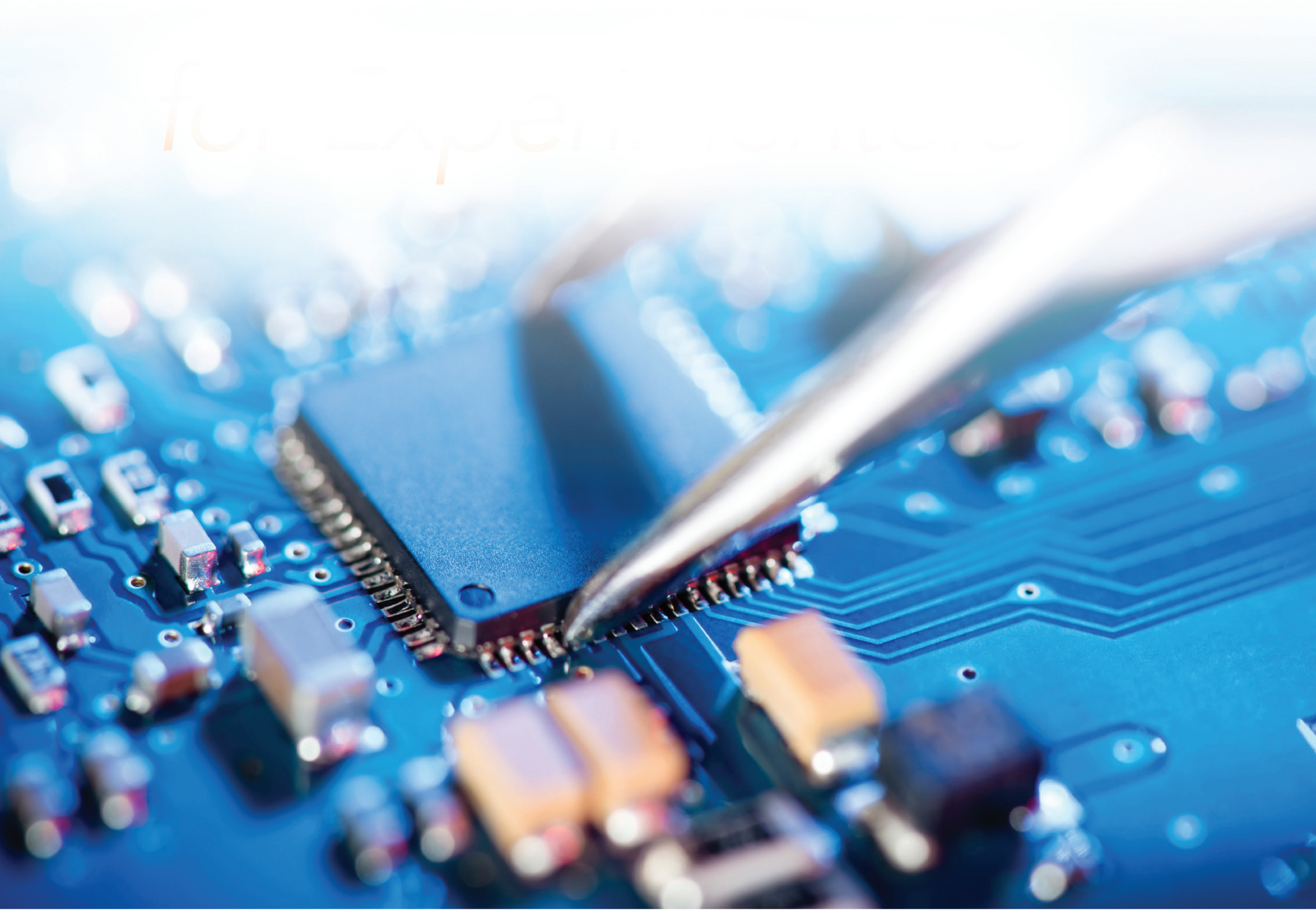
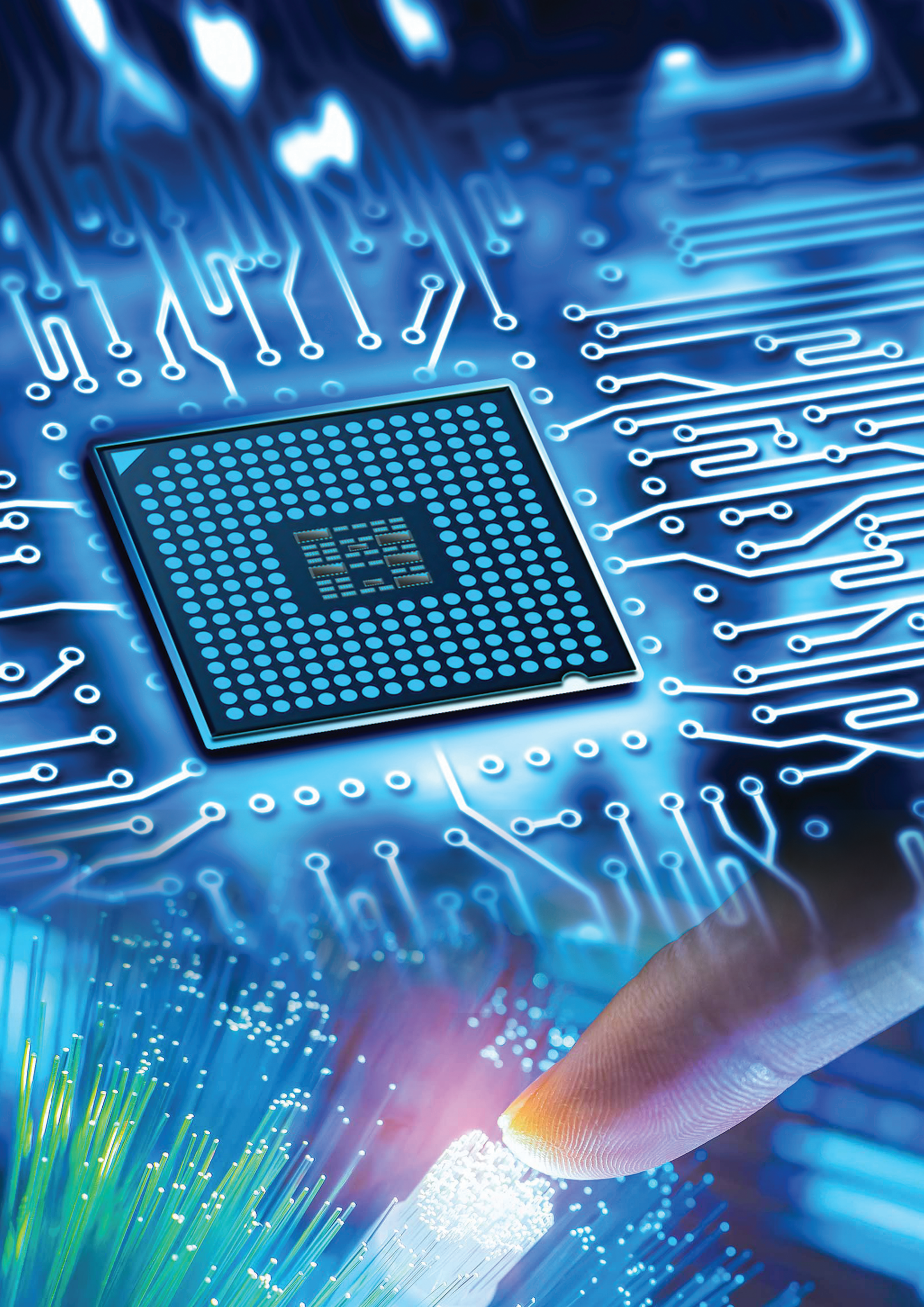
VOLUME - IV

ELECTRONICS



by Olatus Systems Private Limited



Contents

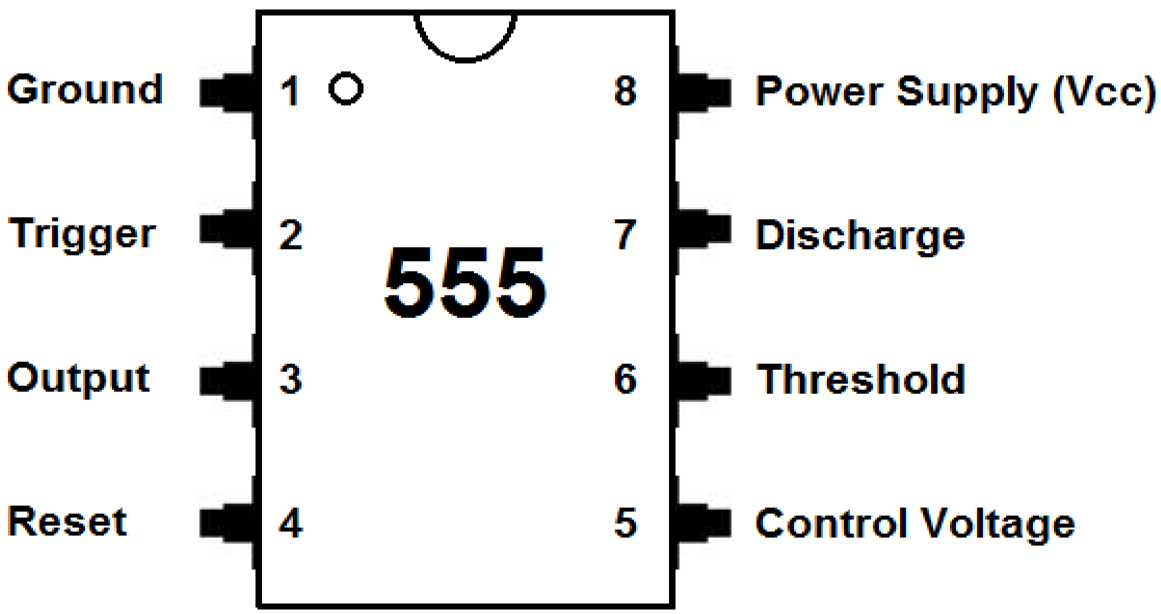
4.5 16 Segment Display

CHAPTER 1: 555 TIMER IC

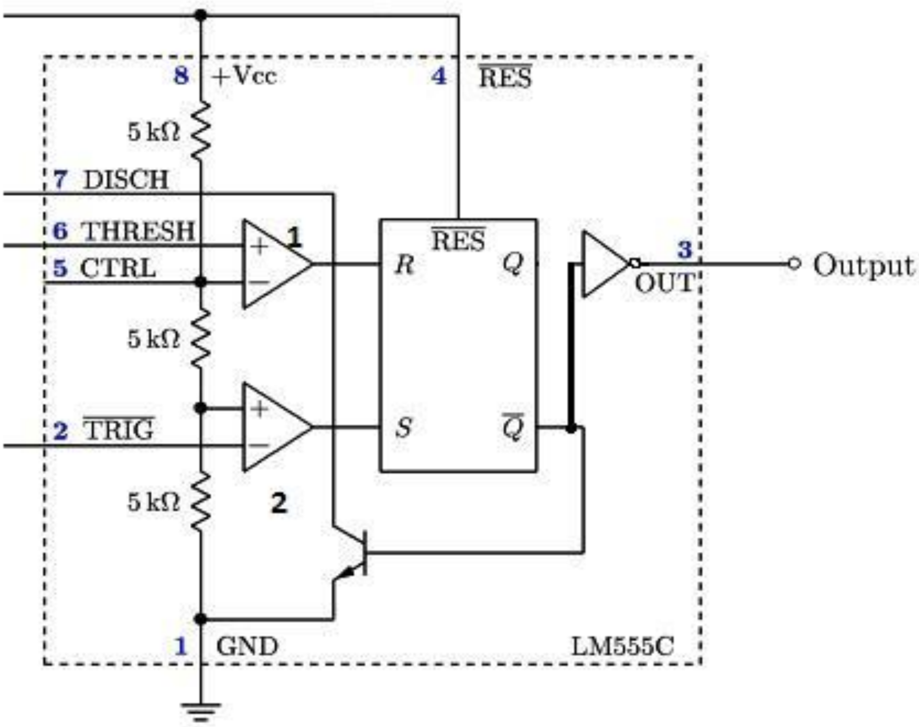
IC 555 timer is a well-known component in the electronic circles but what is not known to most of the people is the internal circuitry of the IC and the function of various pins present there in the IC. Let me tell you a fact about why 555 timer is called so, the timer got its name from the three 5 kilo-ohm resistor in series employed in the internal circuit of the IC.

IC 555 timer is a one of the most widely used IC in electronics and is used in various electronic circuits for its robust and stable properties. It works as square-wave form generator with duty cycle varying from 50% to 100%, Oscillator and can also provide time delay in circuits. The 555 timer got its name from the three 5k ohm resistor connected in a voltage-divider pattern which is shown in the figure below. A simplified diagram of the internal circuit is given below for better understanding as the full internal circuit consists of over more than 16 resistors, 20 transistors, 2 diodes, a flip-flop and many other circuit components.

The 555 timer comes as 8 pin DIP (Dual In-line Package) device. There is also a 556 dual version of 555 timer which consists of two complete 555 timers in 14 DIP and a 558 quadruple timer which is consisting of four 555 timer in one IC and is available as a 16 pin DIP in the market.



CIRCUIT DESCRIPTION



BASICS CONCEPTS

- Comparator: The Comparator are the basic electronic component which compares the two input voltages i.e. between the inverting (-) and the non-inverting (+) input and if the non-inverting input is more than the inverting input then the output of the comparator is high. Also the input resistance of an ideal comparator is infinite.
- Voltage Divider: As we know that the input resistance of the comparators is infinite hence the input voltage is divided equally between the three resistors. The value being $V_{in}/3$ across each resistor.
- Flip/Flop: Flip/Flop is a memory element of Digital-electronics. The output (Q) of the flip/flop is 'high' if the input at 'S' terminal is 'high' and 'R' is at 'Low' and the output (Q) is 'low' when the input at 'S' is 'low' and at 'R' is high.

FUNCTIONS OF DIFFERENT PINS

GROUND: This pin is used to provide a zero voltage rail to the Integrated circuit to divide the supply potential between the three resistors shown in the diagram.

TRIGGER: As we can see that the voltage at the non-inverting end of the comparator is $V_{in}/3$, so if the trigger input is used to set the output of the F/F to 'high' state by applying a voltage equal to or less than $V_{in}/3$ or any negative pulse, as the voltage at the non-inverting end of the comparator is $V_{in}/3$.

OUTPUT: It is the output pin of the IC, connected to the Q' (Q-bar) of the F/F with an inverter in between as show in the figure.

RESET: This pin is used to reset the output of the F/F regardless of the initial condition of the F/F and also it is an active low Pin so it connected to 'high' state to avoid any noise interference, unless a reset operation is required.

CONTROL VOLTAGE: As we can see that the pin 5 is connected to the inverting input having a voltage level of (2/3) V_{in}. It is used to override the inverting voltage to change the width of the output signal irrespective of the RC timing network.

THRESHOLD: The pin is connected to the non-inverting input of the first comparator. The output of the comparator will be high when the threshold voltage will be more than (2/3) V_{in} thus resetting the output (Q) of the F/F from 'high' to 'low'.

DISCHARGE: This pin is used to discharge the timing capacitors (capacitors involved in the external circuit to make the IC behave as a square wave generator) to ground when the output of Pin 3 is switched to 'low'.

SUPPLY: This pin is used to provide the IC with the supply voltage for the functioning and carrying of the different operations to be fulfilled with the 555 timer.

USES

The IC 55 timer is used in many circuits, for example One-shot pulse generator in Monostable mode as an Oscillator in Astable Mode or in Bistable mode to produce a flip/flop type action. It is also used in many types of other circuit for achievement of various purposes for instance Pulse Amplitude Modulation (PAM), Pulse Width Modulation (PWM) etc.

IC555 OPERATING MODES:

IC555 has three different operating modes. These operating modes actually correspond to three different multivibrator configurations.

1. ASTABLE MODE – it is also known as *self-triggering* or *free running* mode. It has no stable state. It has two quasi stable states that automatically changes from one to another. It changes from high to low state and low to high state without any trigger input after pre determine time. This mode is used to generate square wave oscillations, clock pulse, PWM wave etc.

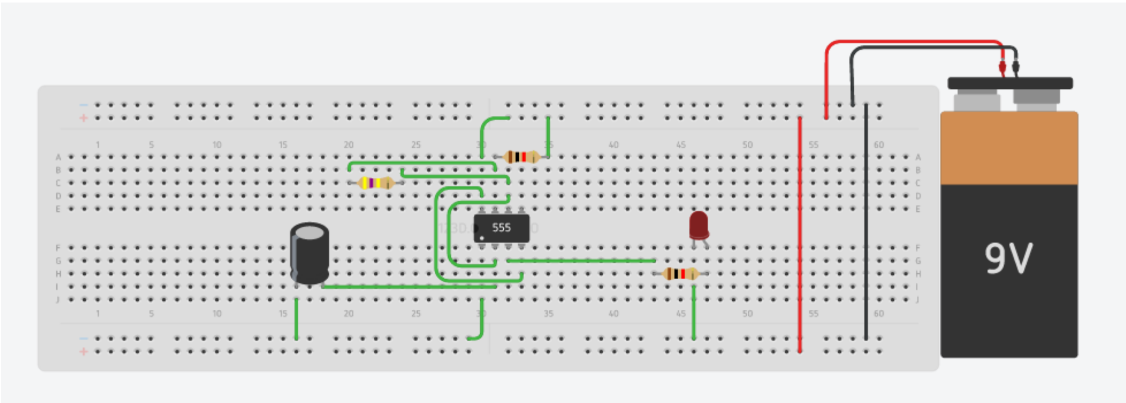
2. MONOSTABLE MODE – it is also known as *single shot* mode. It has one stable state and one quasi stable state. It jumps into quasi stable state from stable state when trigger input is applied and comes back to stable state after pre determine time automatically. It is used in generating pulses, time delay etc.

3. BISTABLE MODE– it is also known as *flip-flop* mode. It has both stable states. Two different trigger inputs are applied to change the state from high to low and low to high. It is used in automatic switching applications, to generate pulse of variable time etc.

ACTIVITY

Make a LED flasher circuit using 555 timer IC.

Circuit Diagram



Material Required

Name	Quantity
9V Battery	1
NE555 Timer IC	1
LED	1
Breadboard	1
Resistance	3
Capacitors	1

Instructions

- Gather all the components from the list.
- Assemble all the components except the battery according to the circuit diagram shown above.
- Now connect the battery to the circuit.

CHAPTER 2: LIGHT DEPENDANT RESISTOR (LDR)

INTRODUCTION TO LDR

A Light Dependent Resistor (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, photo conductive cells or simply photocells. They are made up of semiconductor materials having high resistance. There are many different symbols used to indicate a LDR, one of the most commonly used symbol is shown in the figure below. The arrow indicates light falling on it.

WORKING OF LDR

A light dependent resistor works on the principle of photo conductivity.

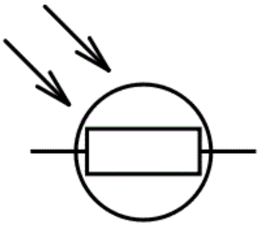
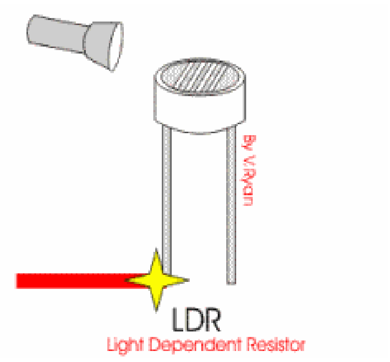
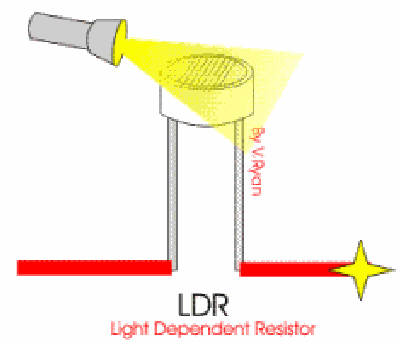


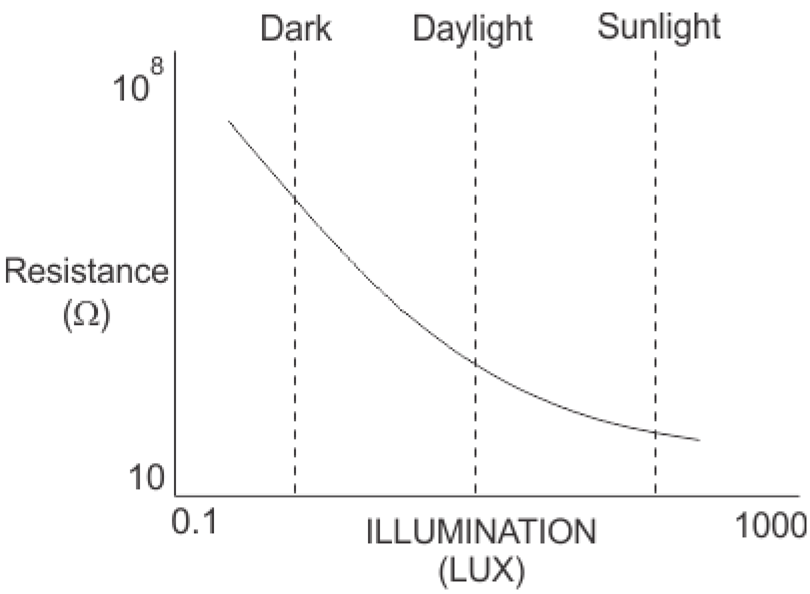
Photo conductivity is an optical phenomenon in which the materials conductivity is increased when light is absorbed by the material. When light falls i.e. when the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence when light having enough energy strikes on the device, more and more electrons are excited to the conduction band which results in large number of charge carriers. The result of this process is more and more current starts flowing through the device when the circuit is closed and hence it is said that the resistance of the device has been decreased.





CHARACTERSTIC OF LDR

LDR's are light dependent devices whose resistance is decreased when light falls on them and that is increased in the dark. When a light dependent resistor is kept in dark, its resistance is very high. This resistance is called as dark resistance. It can be as high as 10^{12} Ω and if the device is allowed to absorb light its resistance will be decreased drastically. If a constant voltage is applied to it and intensity of light is increased the current starts increasing. Figure below shows resistance vs. illumination curve for a particular LDR.



Photocells or LDR's are non linear devices. There sensitivity varies with the wavelength of light incident on them. Some photocells might not at all response to a certain range of wavelengths. Based on the material used different cells have different spectral response curves.

When light is incident on a photocell it usually takes about 8 to 12 ms for the change in resistance to take place, while it takes one or more seconds for the resistance to rise back again to its initial value after removal of light. This phenomenon is called as resistance recovery rate. This property is used in audio compressors. Also, LDR's are less sensitive than photo diodes and photo transistor. (A photo diode and a photocell (LDR) are not the same, a photo-diode is a p-n junction semiconductor device that converts light to electricity, whereas a photocell is a passive device, there is no p-n junction in this nor it "converts" light to electricity).

TYPES OF LDR

Based on the materials used they are classified as:

1. Intrinsic photo resistors (Un-doped semiconductor): These are made of pure semiconductor materials such as silicon or germanium. Electrons get excited from valance band to conduction band when photons of enough energy fall on it and number charge carriers is increased.

2. Extrinsic photo resistors: These are semiconductor materials doped with impurities which are called as dopants. Theses dopants create new energy bands above the valence band which are filled with electrons. Hence this reduces the band gap and less energy is required in exciting them. Extrinsic photo resistors are generally used for long wavelengths.

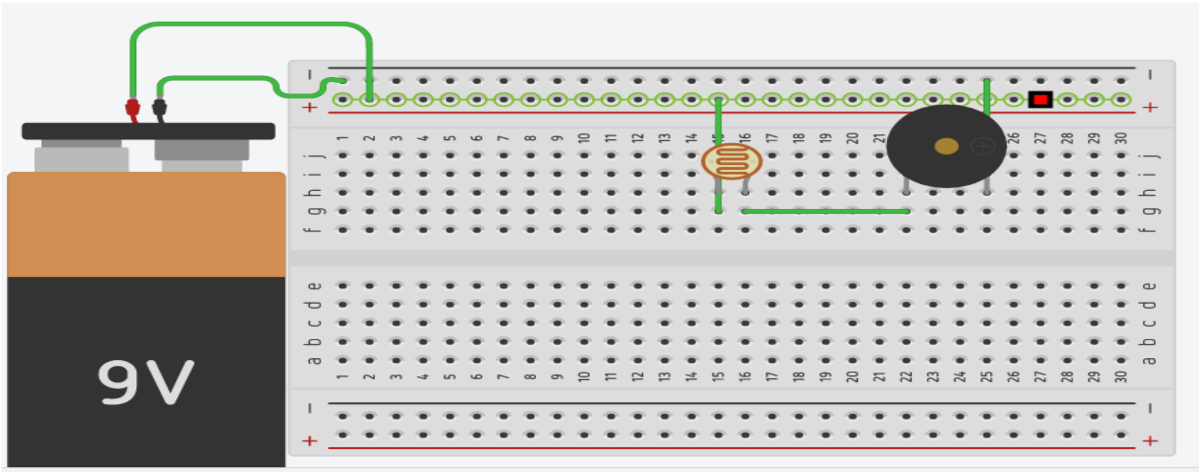
APPLICATIONS OF LDR

LDR’s have low cost and simple structure. They are often used as light sensors. They are used when there is a need to detect absences or presences of light like in a camera light meter. Used in street lamps, alarm clock, burglar alarm circuits, light intensity meters, for counting the packages moving on a conveyor belt, etc.

ACTIVITY

Make a light detecting circuit using LDR.

Circuit diagram



Material Required

Name	Quantity
9V Battery	**1**
Buzzer	**1**
LDR	**1**
Breadboard	**1**

Instructions

- Gather all the components from the list.
- Assemble all the components except the battery according to the circuit diagram shown above.
- Now connect the battery to the circuit.
- Now flash the light and record your observations in the table below.

**Please make a note that you have to be in a relatively darker environment to perform the task. **

Flash Light	Buzzer State
ON	
OFF	

Explain the working of LDR Circuit.

____
____
____
____
____

Now try covering the LDR with different Materials and record the response below

Material	Magnitude of sound by the Buzzer
Transparent	
Translucent	
Opaque	

CHAPTER 3: PIEZOELECTRIC GENERATOR

Students will learn how to build simple piezoelectric generators to power LEDs. To do this, they incorporate into a circuit a piezoelectric element that converts movements they make (mechanical energy) into electrical energy, which is stored in a capacitor (short-term battery). Once enough energy is stored, they flip a switch to light up an LED. Students also learn how much (surprisingly little) energy can be converted using the current state of technology for piezoelectric materials.

ENGINEERING CONNECTION

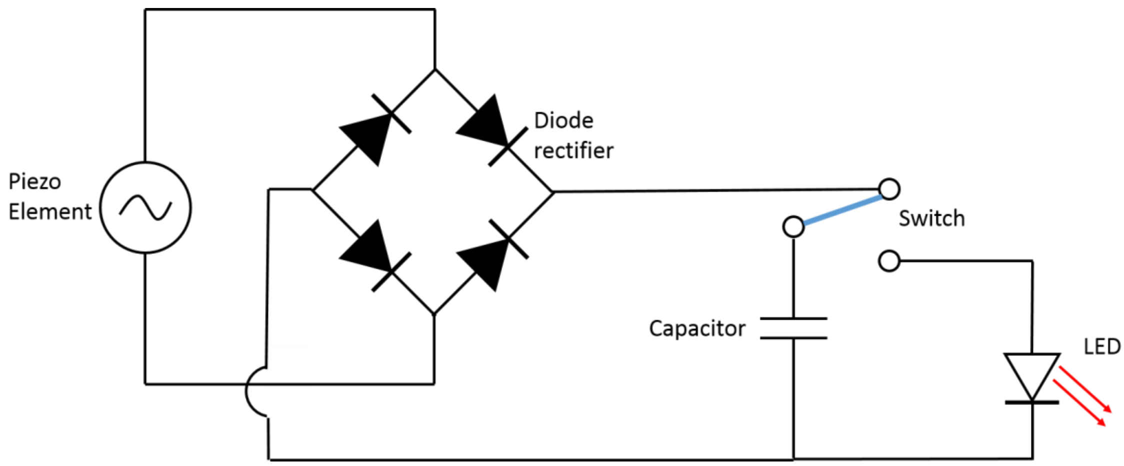
Piezoelectric materials have the unique and useful property of being able to transform mechanical energy into electrical energy, and vice versa. This gives piezoelectric materials a wide range of potential applications from sensors and actuators to artificial muscles. One of the most interesting applications is in the field of energy harvesting, where piezoelectric materials are used to convert mechanical energy that is typically wasted into a source of electrical energy. However, the technology of currently available piezoelectric materials and methods is unable to produce a sufficient amount of energy, so engineers are researching how to improve piezoelectric energy harvesting devices.

MATERIALS LIST

- 1 piezo transducer/piezo element.
- 1 electrolytic capacitor 220 µF or greater (25 to 50 V)
- 1 switch
- 1 LED,
- 1 breadboard
- 2 alligator clips
- 1-3 breadboard jumper wires

EXPLANATION

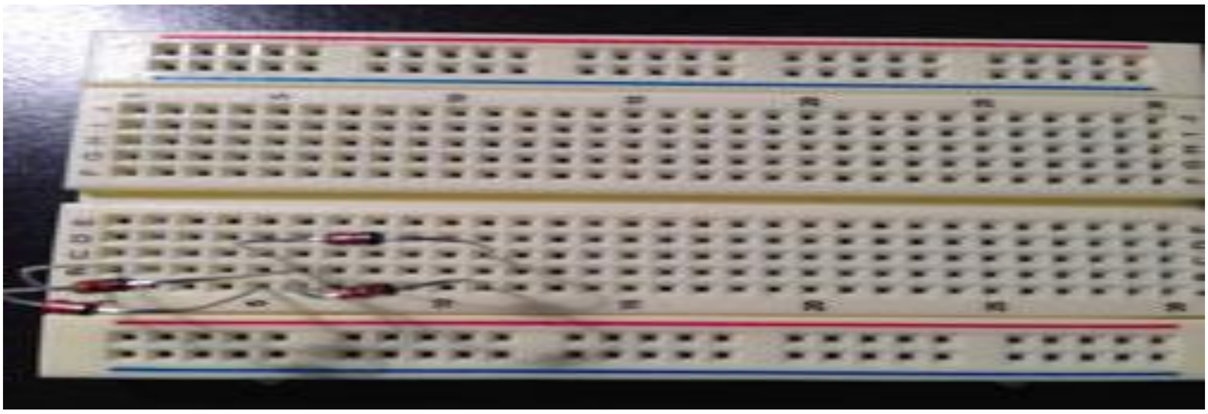
When you were little, did you ever wear shoes that would light up as you walk? Does anyone know how those shoes work? This type of shoe has no batteries, so what is the power source? Piezoelectric materials are placed in the bottoms of the shoes, but they do not store any energy. So from where does the energy come The energy comes from you! Whenever you walk, your movements are mechanical energy and some of that mechanical energy can be converted into electrical energy by piezoelectric materials. In the case of the light-up shoes, that energy is used immediately to light-up some LEDs, which brings up an idea: What are the possibilities for storing that energy to use whenever we please?



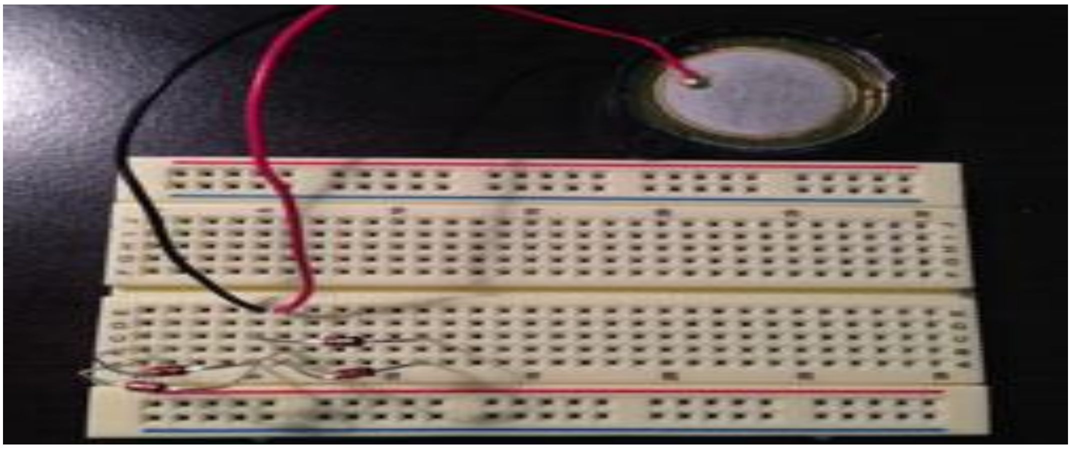
- **<u>Make a diode rectifier bridge on the breadboard</u>**

Diodes permit current to flow in only one direction. Doing this converts the AC voltage generated by the piezo element into a DC voltage, which can be used by the capacitor and the LED. The diodes are marked to show which way the current will flow. The RadioShack diodes have a black stripe that marks the back end of the diode, which is the convention for any 1N4148 type diode.

- On the breadboard, insert diodes into sockets 1A, 1B, 5C and 6A, facing the same direction with the black stripes up.
- Take the diode from 1A and insert the other end into socket 5A, the diode from 1B to 6B, the diode from 5C to 11C, and 6A to 11A.
- Make sure no diode leads are touching, which would cause a short circuit.

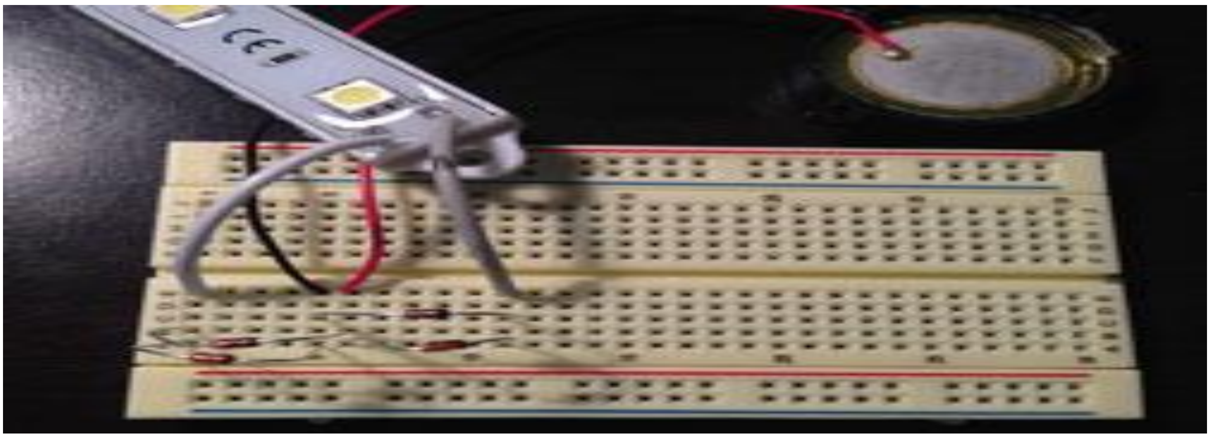


- **<u>Connect the piezo element to the breadboard</u>** (
  To do this, insert the black lead into socket 5E and the red lead into socket 6E. For testing, the piezo element is connected to the diode bridge input and the LED bar to the output.



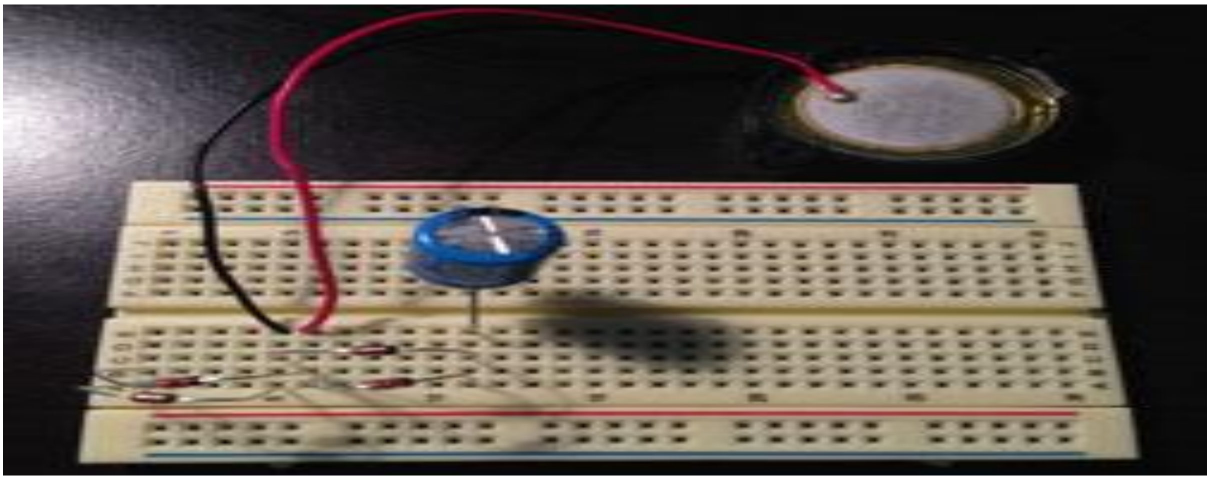
- **<u>Test the circuit by hooking up the LED</u>**
  At this point, we can test the circuit by inserting the LED leads into sockets. using simple LEDs, the positive side is the longer lead, and negative side is the shorter lead; for these LEDs, dimming or turning off the classroom lights helps to make them more visible.

  - Put the positive lead into socket 11E and the negative lead into 1E.
  - Once the LED is hooked up to the breadboard, tap the piezo element; expect the LED to light up briefly, confirming that the circuit works.
  - If the LED does not light up check, the direction of the diodes and the LED to make sure they are not backwards.
  - For the simple LEDs, it is best to look at the very top of the bulb to see if it is lighting up or not.
  - Once the circuit has been tested to make sure it works, remove the LED from the breadboard.



1. **<u>Hook up the capacitor</u>**

Electrolytic capacitors also have positive and negative leads, so direction matters. Again, the longer lead is positive, and the shorter lead is negative. Insert the positive (longer) lead into socket 11E and the negative (shorter) lead into socket 11H.

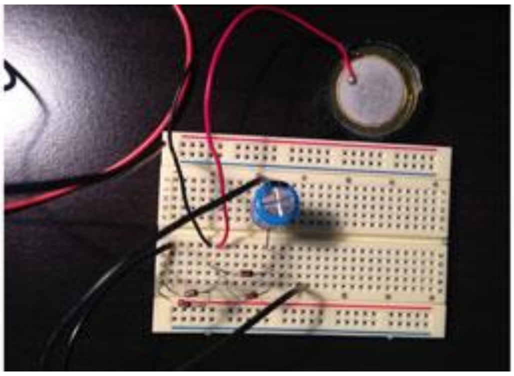


Hook <u>up the switch</u> This is typically the most confusing step. If using the RadioShack switch, a toggle switch, notice that it has three wires coming from it. Hook up this switch by following these steps:

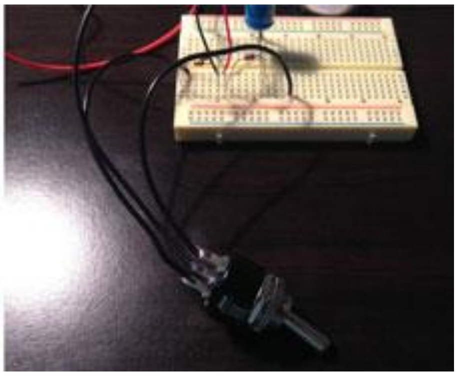
- Insert the middle wire into socket 11J.
- Insert the two remaining wires into sockets 1E and 15E; it does not matter which wire goes to which socket, since it only affects the switch direction.
- Insert a breadboard jumper wire from socket 11B to socket 20E.

- This should be correct, but may need some adjustment as the circuit has not been tested with this switch.

A

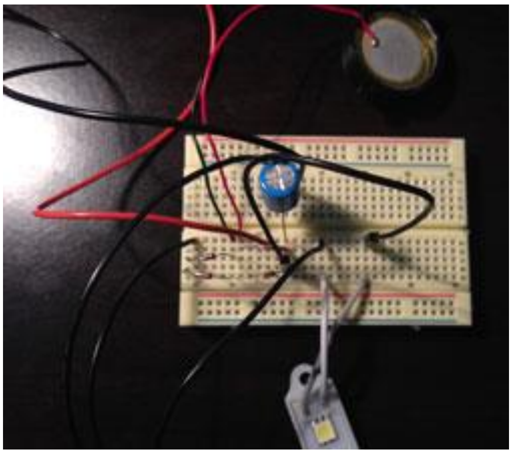


B



2. **Connect the LED**

Connect the positive (longer) lead from the LED (or LED bar) to socket 20A and the negative (shorter) lead to 15A. This completes the circuit!



3. **Hook up alligator clips to measure energy in the capacitor**.

- Insert one exposed wire into socket 11D and clip to the positive (red) lead on the multimeter.
- Insert the other exposed end into socket 11I and clip to the negative (black) lead on the multimeter.

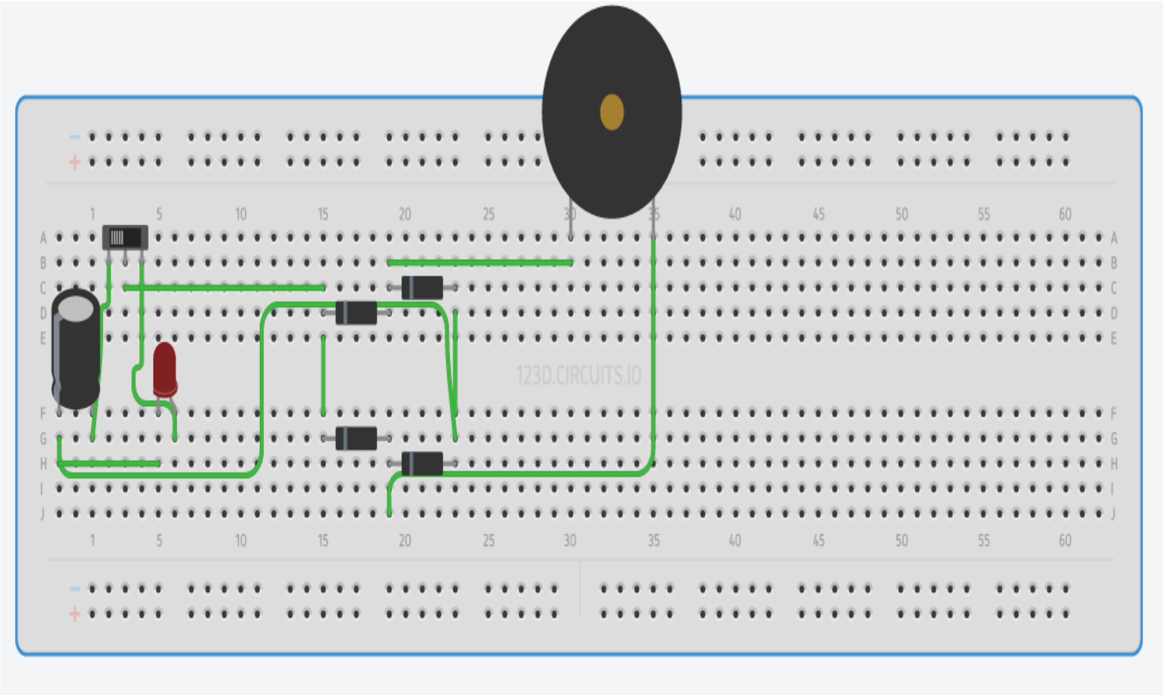
4. **Test the circuit.**

   Turn the multimeter to the 20V DC setting and start tapping on the piezo element. Expect to see the voltage across the capacitor increasing, which indicates that it is storing energy. If not, try flipping the switch to the opposite position. Once the capacitor has stored sufficient voltage, flip the switch and the LED should come on briefly. Note: The required voltage across the capacitor will vary, depending on the exact capacitor and LED used. As an example, using a 220 µF 35V capacitor and the LED light bar, required about 8.5V across the capacitor, while the standard single LED only required about 3V.

Activity

Make a circuit using piezoelectric to generate electricity.

Circuit Diagram



Material Required

Breadboard	**1**
LED	**1**
Piezo	**1**
Diode	**4**
Capacitor	**1**
Switch	**1**

Instructions

- Gather all the components from the list.
- Assemble all the components according to the circuit diagram shown above.
- Now start tapping the Piezo gently and gradually increase the force of tapping.
- Record your observation in the table below.

Observation

Force of Tapping	Intensity of LED
No Tapping	
Gentle Tapping	
Vigorous Tapping	

1. What kind of energy conversion is taking place in the circuit?

1. Electrical to Mechanical
2. Mechanical to Electrical
3. Thermal to Electrical
4. Sound to Electrical

2. What is the role of capacitor in the circuit?

____
____
____
____

3. How much energy does your generator store per tap.

1. Voltage measured before tap (**V_1**): ________
2. Voltage measured after a single tap(**V_2**): _____________
3. Energy stored per tap:____________

CHAPTER 4: RGB LEDs

An RGB LED is a combination of 3 LEDs in just one package:

1x Red LED

1x Green LED

1x Blue LED

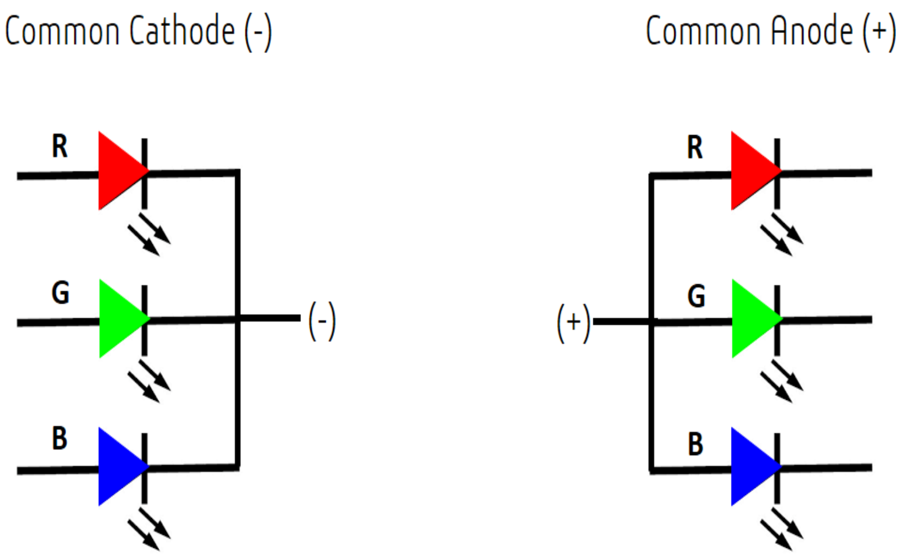
The light that the RGB LED produces is made combining these three LED colors. An RGB LED looks like this:

TWO TYPES OF RGB LEDs

There are common anode RGB LEDs and common cathode RGB LEDs.

As you can see, the 3 LEDs can share the cathode or the anode. This results in an RGB LED that has 4 pins, one for each LED, and one common cathode or one common anode.

The common anode RGB LED is the most popular type.



How to create different color?

You can create one of those three colors – red, green or blue – by activating just one LED.

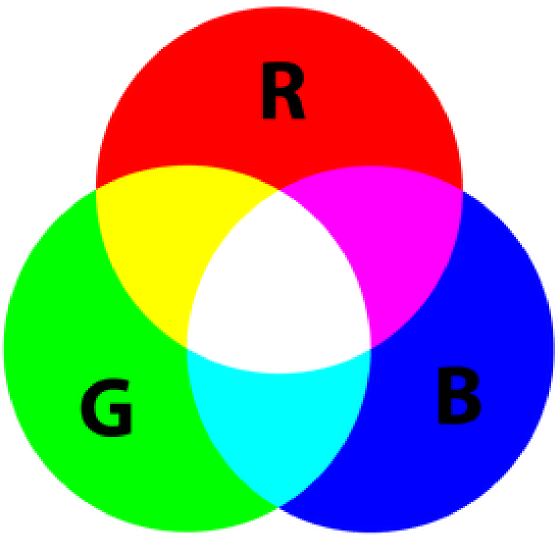
For example, if you want to produce blue, you activate the blue LED and turn off the other two.

MIXING COLORS

To form a color with RGB, three light beams (one red, one green and one blue) must be superimposed (for example by emission from a black screen or by reflection from a white screen). Each of the three beams is called a *component* of that color, and each of them can have an arbitrary intensity, from fully off to fully on, in the mixture.

The RGB color model is *additive* in the sense that the three light beams are added together, and their light spectra add, wavelength for wavelength, to make the final color's spectrum. Zero intensity for each component gives the darkest color (no light, considered the *black*), and full intensity of each gives a white; the *quality* of this white depends on the nature of the primary light sources, but if they are properly balanced, the result is a neutral white matching the system's white point. When the intensities for all the components are the same, the result is a shade of gray, darker or lighter depending on the intensity. When the intensities are different, the result is a colorized hue, more or less saturated depending on the difference of the strongest and weakest of the intensities of the primary colors employed.

When one of the components has the strongest intensity, the colour is a hue near this primary color (reddish, greenish or bluish), and when two components have the same strongest intensity, then the color is a hue of a secondary color (a shade of cyan, magenta or yellow). A secondary color is formed by the sum of two primary colors of equal intensity: cyan is green+blue, magenta is red+blue, and yellow is red+green. Every secondary color is the *complement* of one primary color; when a primary and its complementary secondary color are added together, the result is cyan complements red, magenta complements green, and yellow complements blue.

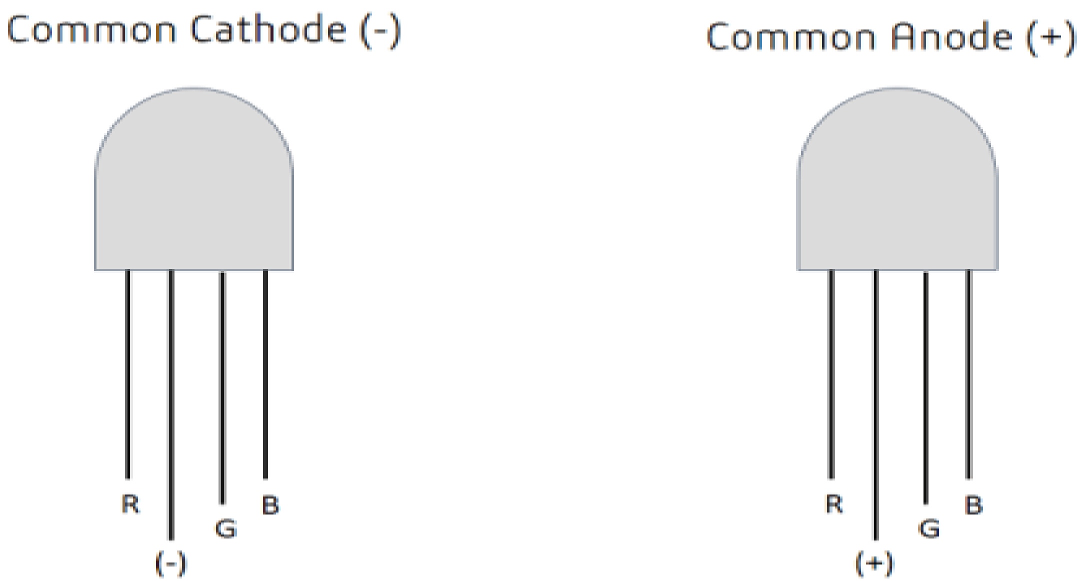


RGB COLOR CHART

RGB LED PINS

RGB LEDs have 4 pins which can be distinguished by their length. The longest one is the ground (-) or voltage (+) depending if it is a common cathode or common anode LED, respectively.

The other three legs correspond to red, green, and blue, as you can see in the figure below:



How do RGB LEDs work?

A colour changing LED isn't one LED in a package but three LEDs along with a small computer to drive them. The LED is made up of red, green and blue LEDs each of which can be controlled by a microcontroller. Since the two legs on the LED that supply the power are connected to the microcontroller and not the LED elements a current limit resistor is not required.

If the red LED is turned on then the output from the colour changing LED is red. When the blue LED is turned on it is blue, if both the blue and red LEDs are turned on then the colour changing LED is a shade of purple (called magenta). Similarly combining red with green gives yellow and blue & green gives cyan.

Although the colour changing LED uses the six colours mentioned above, it slowly changes from one to another. This is still done using the three, basic, red, green & blue elements. If the red LED is combined with the blue LED, but the blue LED is only driven at 50% of its normal brightness then a colour half way between red and magenta is generated.

Whilst the red LED is left turned on, if the blue LED is slowly taken from 0% brightness to 100% brightness then the colour will gradually change from red to magenta.

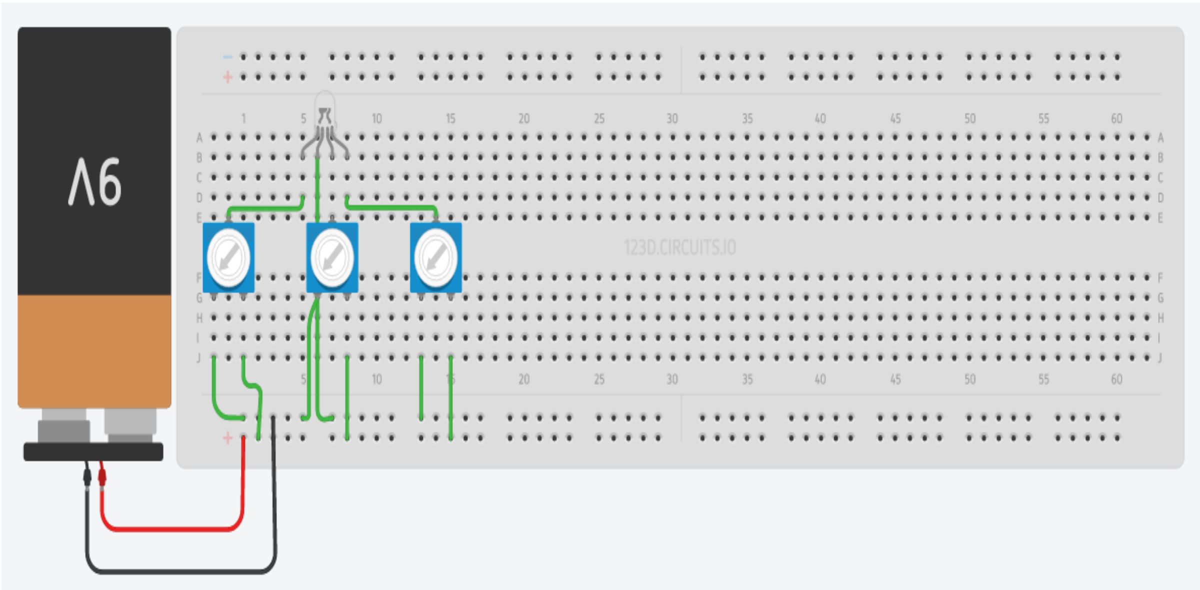
If a standard LED is turned on and off very quickly, say 100 times every second then as far as the human eye is concerned it looks like it is constantly on. If the amount of time the LED is on for is the same as the time it is off for then it will be on for 50% of the time and 50% of its full brightness.

This same method can be done with the three LED elements inside the colour changing LED. This means it is possible to combine any amount of the red, green and blue to give the desired colour. Looking once again at the change from red to magenta, if the blue LED starts mainly turned off, goes to being on and off in even amounts and then to mainly being on.

Activity

Make a circuit to make different colors using a RGB LED.

Circuit Diagram



Material Required

Name	Quantity
9V Battery	1
Potentiometer	3
LED	1
Breadboard	1

Instructions

- Gather all the components from the list.
- Assemble all the components except the battery according to the circuit diagram shown above.
- Now connect the battery to the circuit.
- Now try different potentiometer settings to produce different colors
- Record your observations in the table below.

Observation table

Position of Potentiometer			Color of light emitted by LED
POT 1	POT 2	POT 3	
Extreme Left	Extreme Left	Extreme Left	
Extreme Left	Extreme Left	Extreme Right	
Extreme Left	Extreme Right	Extreme Left	
Extreme Left	Extreme Right	Extreme Right	
Extreme Right	Extreme Left	Extreme Left	
Extreme Right	Extreme Left	Extreme Right	
Extreme Right	Extreme Right	Extreme Left	
Extreme Right	Extreme Right	Extreme Right	

Why do we need extra resistance in the circuit in spite of the fact that potentiometer itself is a resistor?

____

____

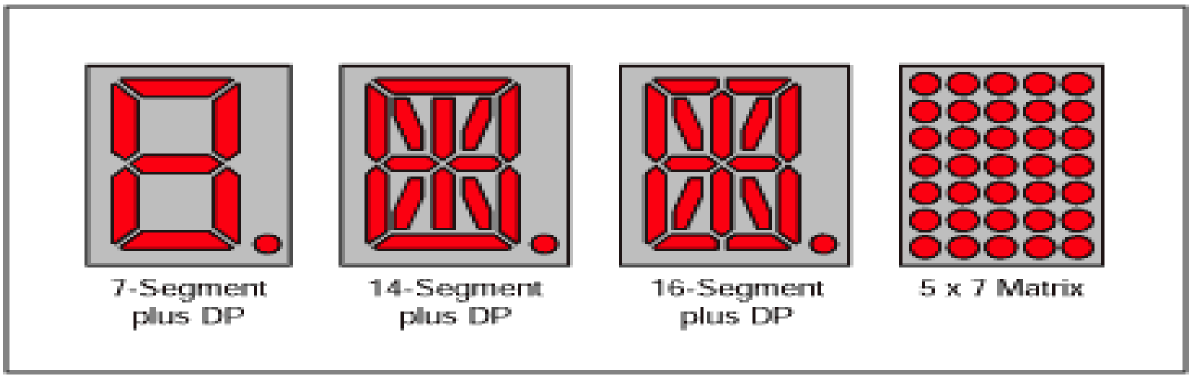
____

____

____

CHAPTER 5: SIXTEEN SEGMENT DISPLAY

A **sixteen-segment display (SISD)** is a type of display based on 16 segments that can be turned on or off according to the graphic pattern to be produced. It is an extension of the more common seven-segment display, adding four diagonal and two vertical segments and splitting the three horizontal segments in half. Other variants include the fourteen-segment display which does not split the top or bottom horizontal segments, and the twenty two-segment display that allows lower-case characters with descenders.

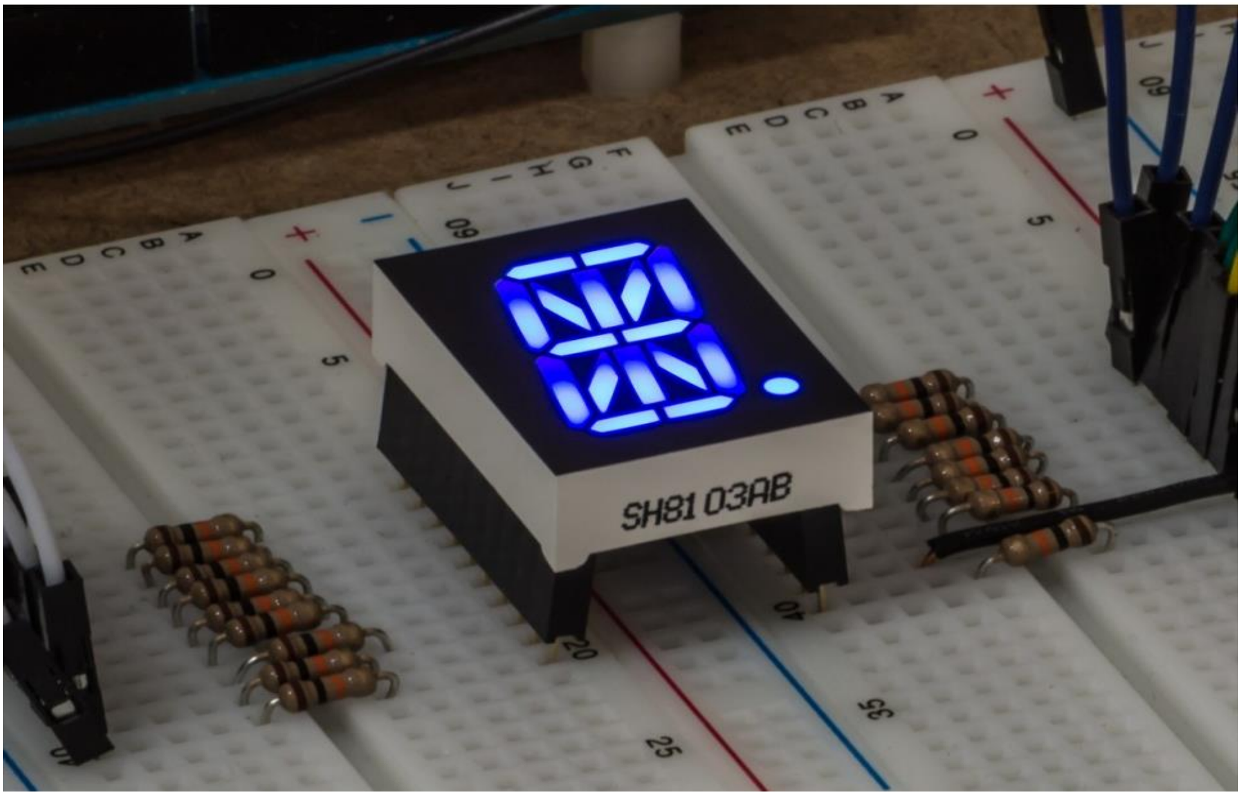


HISTORY

Sixteen-segment displays were originally designed to show alphanumeric characters (Latin letters and Arabic digits). Later they were used to display Thai numerals and Persian characters. Non-electronic displays using this pattern existed as early as 1902.

Before the advent of inexpensive dot-matrix displays, sixteen and fourteen-segment displays were some of the options available for producing alphanumeric characters on calculators and other embedded systems. Sixteen-segment displays may be based on one of several technologies, the three most common optoelectronics types being LED, LCD and VFD. The LED variant is typically manufactured in single or dual character packages, to be combined as needed into text line displays of a suitable length for the application in question.

As with seven and fourteen-segment displays, a decimal point and/or comma may be present as an additional segment, or pair of segments; the comma (used for triple-digit groupings or as a decimal separator in many regions) is commonly formed by combining the decimal point with a closely 'attached' leftwards-descending arc-shaped segment. This way, a point or comma may be displayed between character positions instead of occupying a whole position by itself, which would be the case if employing the bottom middle vertical segment as a point and the bottom left diagonal segment as a comma. Such displays were very common on pinball machines for displaying the score and other information, before the widespread use of dot-matrix display panels.



APPLICATIONS

Multiple-segment display devices use fewer elements than a full dot-matrix display, and may produce a better character appearance where the segments are shaped appropriately. This can reduce the number of driver components and power consumption.

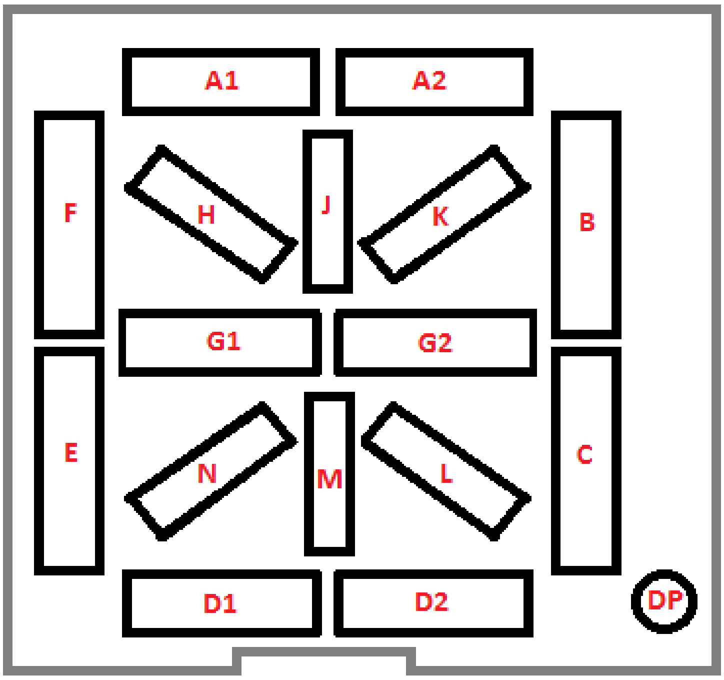
Fourteen-segment gas-plasma displays were used in pinball machines from 1986 through 1991 with an additional comma and period part making for a total of 16 segments.

Sixteen-segment displays were used to produce alphanumeric characters on calculators and other embedded systems. Applications today include displays fitted to telephone Caller ID units, gymnasium equipment, VCRs, car stereos, microwave ovens, slot machines, and DVD players.

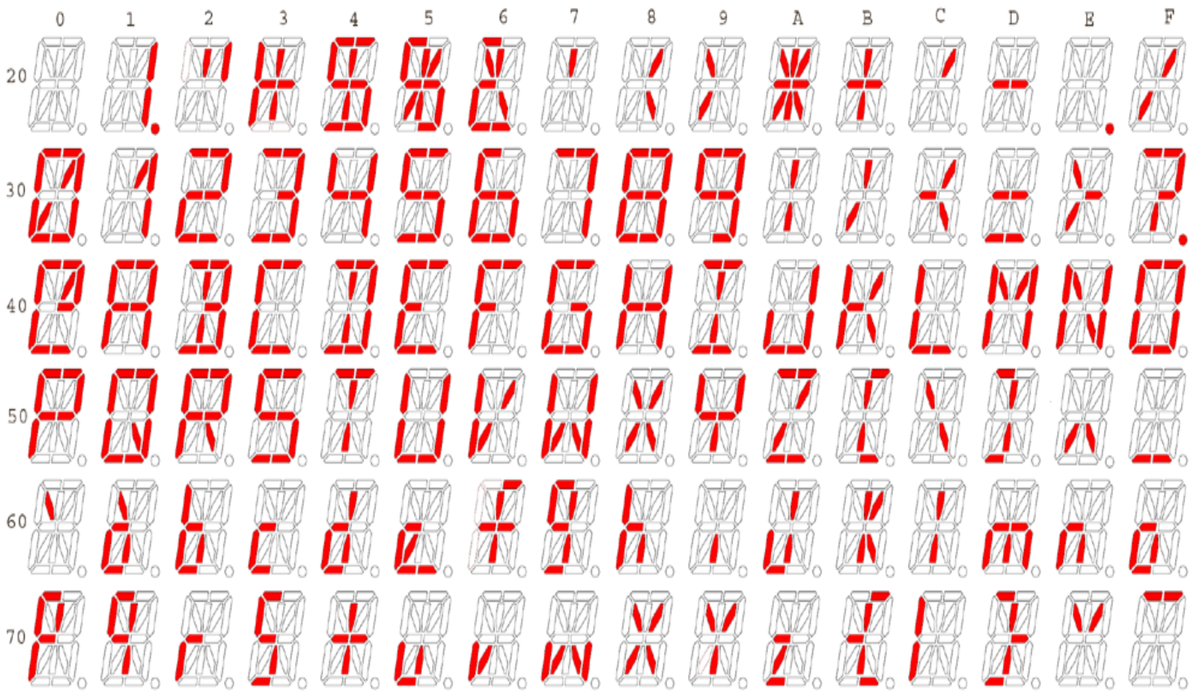
- Display characters and text
- Show numeric status
- Display time and digital combination

PIN CONFIGURATION

Segment	Pin
A1	1
A2	2
J	3
H	4
F	5
E	6
N	7
D1	8
D2	9



Pin	Segment
18	+V
17	K
16	B
15	G2
14	G1
13	C
12	L
11	M
10	DP



CHARACTER CHART FOR A 16 SEGMENT DISPLAY

SPECIFICATIONS

- Colour: Red, Green, Blue, Yellow, White, Orange
- Common Pin: Common Anode
- Current - Test: 20mA
- Digit/Alpha Size: 0.80" (20.32mm)
- Display Type: 16-Segment, Alphanumeric
- Number of Characters: 1
- Packaging: Tube
- Power Dissipation (Max): 75mW
- Size / Dimension: 1.091" H x 0.787" W x 0.335" D (27.70mm x 20.00mm x 8.50mm)
- Voltage - Forward (Vf) (Typ):1.85V
- Wavelength - Peak: 660nm

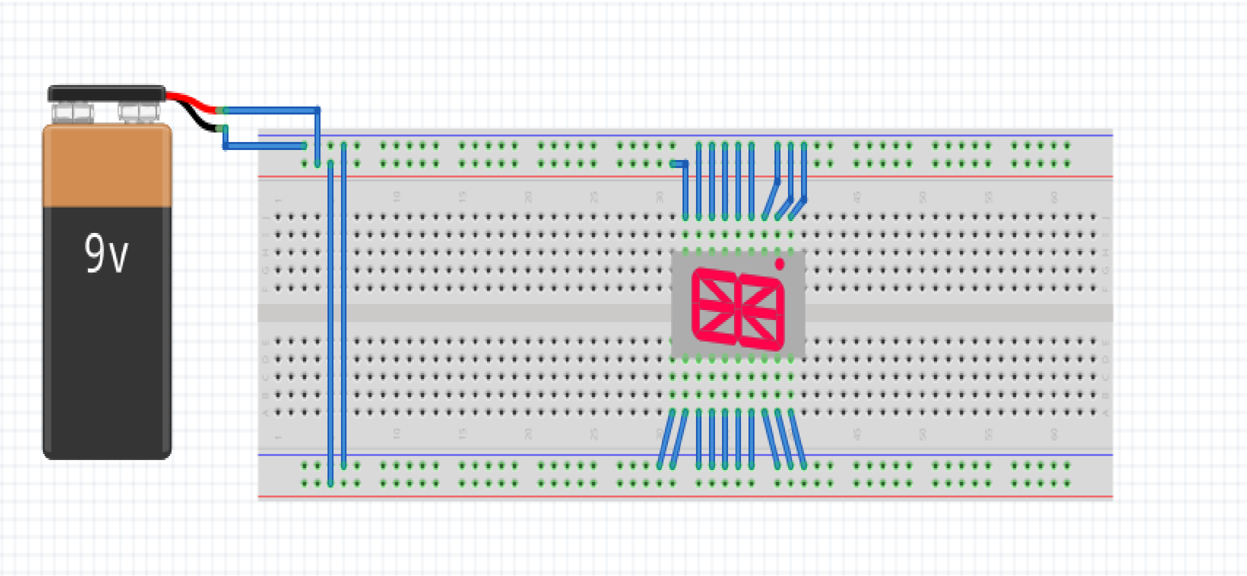
FEATURES

- 0.8-inch character height
- Low current operation
- High contrast light output
- Easy mounting on PC boards or sockets
- Grey face
- White segment

ACTIVITY

Display a number on seven segment display

Circuit Diagram



Material Required

Name	Quantity
9V Battery	1
Sixteen Segment Display	1
Breadboard	1

Instructions

For displaying alphabet A

- Gather all the components from the list.

- Assemble all the components except the battery according to the circuit diagram shown above.
- Now connect the battery to the circuit.
- Record your observations in table below.

Observations

Pin connected	A
A1	
A2	
B	
C	
D1	
D2	
E	
F	
G1	
G2	
H	
J	
K	
L	
M	
N	
DP	

Now try displaying different numbers and alphabets and record your observations in table below.

Pin connected	Number/Alphabet	Number/Alphabet	Number/Alphabet
A1			
A2			
B			
C			
D1			
D2			
E			
F			
G1			
G2			
H			
J			
K			
L			
M			
N			
DP