Handbook of Electronics

Produced by: Electronics Club

eclub.iitk@gmail.com

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SECTION 1

Basics

1.1 Bouncing

1.1.1 What is Bouncing ?

Bouncing is a phenomenon that occurs whenever a switch is pressed. Whenever a switch is pressed two metal contacts touch each other. Due to physical limitations, these two metal contact have a small amount of space in which they can move freely. When the two contacts touch each other, the contacts don't stop moving and bounce apart, and touch once again. This may occur multiple times in a single press.
The time between each bounce varies a lot but is usually in the range of 10s of microseconds. This is not a issue in everyday circuit as it is too fast for humans to perceive. However, in Electronics, we regularly encounter circuits that work much faster than the bounce time. This result in a single press being register as multiple presses.

1.1.2 Debouncing

Since bouncing is a phenomenon that occurs in each and every switch, we cannot remove it. We need to account for it while designing the circuit. Bouncing can be compensated by two methods.

- Hardware Debouncing
  You can debounce a switch just using a Resistor and Capacitor. The output of the switch should be connected to a RC low-pass filer before being connected to the circuit.

- Software Debouncing
  Software debouncing works a little differently. Whenever you detect a switch begin pressed, you start a timer for a set duration and ignore the switch's state for that duration.

1.2 Pull Up and Pull Down Resistors

When working with digital circuits, one needs to make sure that every input is clearly defined in the form of a particular value : either HIGH or LOW. If the inputs of the digital circuit are not within the range of values by which they can be clearly separated as HIGH or LOW triggers, then it may lead to the sensing of a false trigger or self bias that will lead to the circuit not working properly.

For example, consider the digital circuit on the left. The two switches, a and b, represent

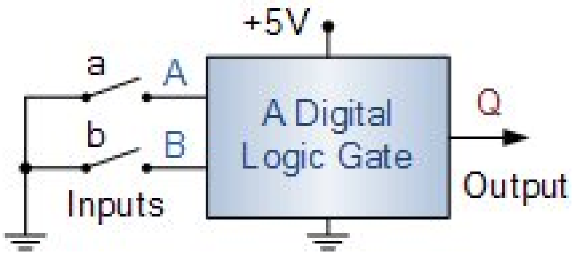


Figure 1: Example

the inputs to a generic logic gate. When switch a is closed (ON), input A is connected to ground, (0v) or logic level 0 (LOW) and likewise, when switch b is closed (ON), input B is also connected to ground, logic level 0 (LOW) and this is the correct condition we require. However, when switch a is opened (OFF), what will be the value of the voltage applied to input A, HIGH or LOW?

We assume it will be +5V (HIGH) as switch a is open-circuited and therefore input A is not shorted to ground, but this may not be the case. As the input is now effectively unconnected from either a defined HIGH or LOW condition, it has the potential to **float** about between 0V and +5V (Vcc) allowing the input to selfâĂŞbias at any voltage level whether that represents a HIGH or a LOW condition. This may lead to an open(HIGH) switch to be assessed as a closed(LOW) switch that may lead to a change in the output that is obtained at the logic output (Q).

Then to prevent accidental switching of digital circuits, any unconnected inputs called **floating inputs** should be tied to a logic 1 or logic 0 as appropriate for the circuit. We can easily do this by using what are commonly called Pull-up Resistors and Pull-down Resistors to give the input pin a defined default state, even if the switch is open, closed or there is nothing is connected to it.

1.2.1 Pull Up Resistor Application

By using these two pull-up resistors, one for each input, when switch A or B is open (OFF), the input is effectively connected to the +5V supply rail via the pull-up resistor. The result is that as there is very little input current into the input of the logic gate, very little voltage is dropped across the pull-up resistor so nearly all the +5V supply voltage is applied to the input pin creating a HIGH, logic 1 condition.

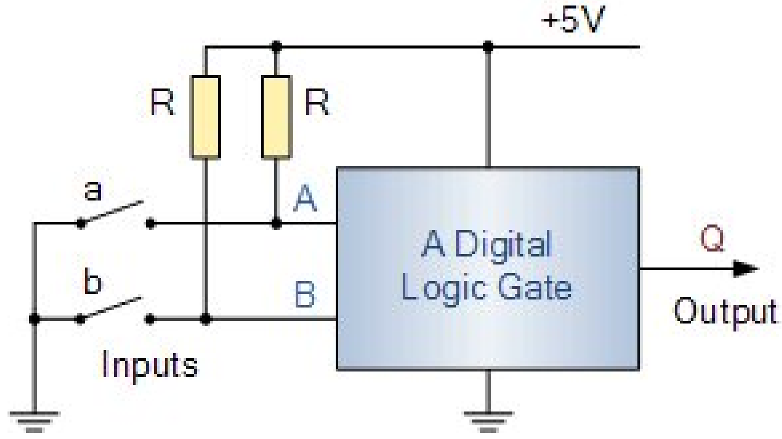


Figure 2: Application of pull-up

When switches A, or B are closed, (OFF) the input is shorted to ground (LOW) creating a logic 0 condition as before at the input.We are not shorting out the supply rail as the pull-up resistor only passes a small current (as determined by Ohms law) through the closed switch to ground.If we do not use a resistor then a high value of current will pass through the circuit and that could damage the electronic devices involved in the circuit.

By using a pull-up resistor in this way, the input always has a default logic state, either 1 or 0, high or low, depending on the position of the switch, thus achieving the proper output function of the gate at Q and therefore preventing the input from floating about or self-biasing giving us exactly the switching condition we require.

1.2.2 Pull Down Resistor

A Pull-down resistor works in the same way as the previous pull-up resistor, except this time the logic gates input is tied to ground, logic level 0 (LOW) or it may go HIGH by the operation of a mechanical switch. This pull-down resistor configuration is particularly useful for digital circuits like latches, counters and flip-flops that require a positive one-shot trigger when a switch is momentarily closed to cause a state change.

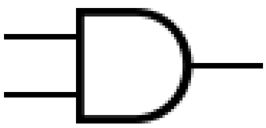
1.3 Logic Gates

1.3.1 What are Logic Gates?

Logic gates are the basic building blocks of any digital circuit. They are electronic circuits which have one or more inputs and only one output which relates to the input signals based on a certain logic.

There are three basic logic gates:

- AND Gate

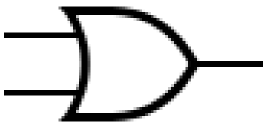


(a) AND Gate Symbol

Inputs		Output
A	B	AB
0	0	0
0	1	0
1	0	0
1	1	1

(b) AND Gate Truth Table

- OR Gate

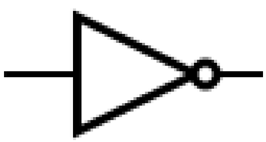


(a) OR Gate Symbol

Inputs		Output
A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	1

(b) OR Gate Truth Table

- NOT Gate

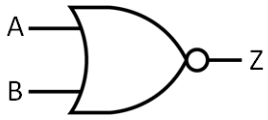


(a) NOT Gate Symbol

Inputs	Output
A	B
0	1
1	0

(b) NOT Gate Truth Table

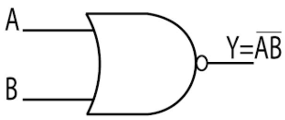
- NOR Gate



(a) NOR Gate Symbol

Inputs		Outputs
X	Y	Z
0	0	1
0	1	0
1	0	0
1	1	0

(b) NOR Gate Truth Table

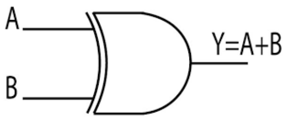


(a) NAND Gate Symbol

Inputs		Outputs
X	Y	Z
0	0	1
0	1	1
1	0	1
1	1	0

(b) NAND Gate Truth Table

- NAND Gate
- Ex-OR Gate



(a) Ex-OR Gate Symbol

Inputs		Outputs
X	Y	Z
0	0	0
0	1	1
1	0	1
1	1	0

(b) Ex-OR Gate Truth Table

- Ex-NOR Gate

The NAND (NOT-AND) and NOR (NOT-OR) gates are considered universal gates and can be used to make any other logic gate.

SECTION

2 Digital Systems

2.1 What are Digital Systems?

Digital Systems are designed to store, process, and communicate information in digital form. They are found in a wide range of applications, including process control, communication systems, digital instruments, and consumer products.These systems store data in a discrete way.
The simplest form of digital system is binary, with exactly two distinct values for inputs and outputs. Binary digital sys-tems form the basis of just about all hardware systems in existence today.

2.2 Advantages of Digital Systems

The critical advantage of digital systems is their inherent ability to deal with electrical signals that have been degraded by transmission through circuits. Because of the discrete nature of the outputs, a slight variation in an input is translated into one of the correct output values. In analog circuits, a slight error at the input generates an error at the output. If analog circuits are wired together in series, the output of one feeding the input of the next, each stage adds its own small error. The sum of the errors over several stages becomes overwhelming. Digital components are considerably more accurate and reliable.

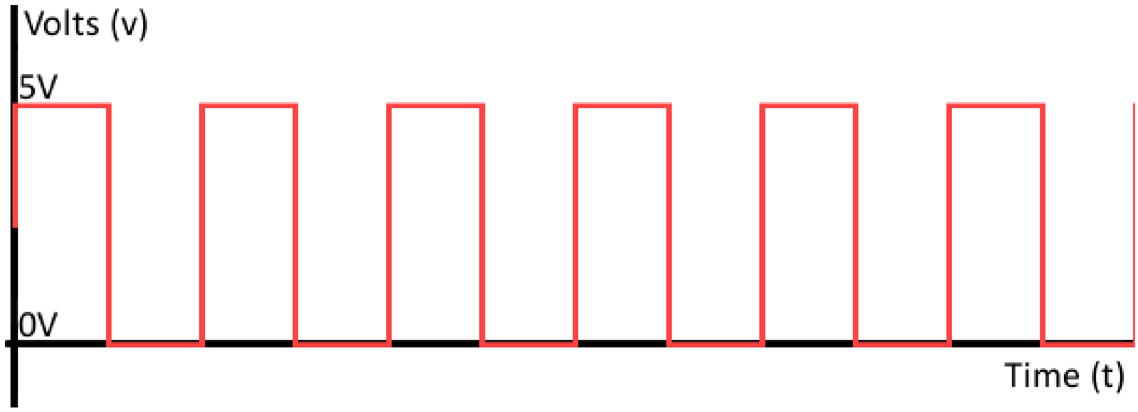


Figure 10: Waveform of Digital Signals

2.3 Number Systems

In digital electronics, the number system is used for representing the information. The number system has different bases and the most common of them are the decimal, binary, octal, and hexadecimal. The base or radix of the number system is the total number of the digit used in the number system. Suppose if the number system representing the digit from 0 to 9 then the base of the system is the 10.
Types of Number System:

- Decimal Number System : The number system is having digit 0, 1, 2, 3, 4, 5, 6, 7, 8, 9; this number system is known as a decimal number system because total ten digits are involved.The base of the decimal number system is 10.

- Binary Number System : The modern computers do not process decimal number; they work with another number system known as a binary number system which uses only two digits 0 and1.The base of binary number system is 2 because it has only two digit 0 and 1.The digital electronic equipments are works on the binary number system and hence the decimal number system is converted into binary system.

- Octal Number System : The base of a number system is equal to the number of digits used, i.e., for decimal number system the base is ten while for the binary system the base is two. The octal system has the base of eight as it uses eight digits 0, 1, 2, 3, 4, 5, 6, 7.

- Hexadecimal Number System : These numbers are used extensively in microprocessor work.The hexadecimal number system has a base of 16, and hence it consists of the following sixteen number of digits.

  0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F.

  The size of the hexadecimal is much shorter than the binary number which makes them easy to write and remember.

2.4 Applications

The most common applications of Digital Systems are the following:

- Digital Indicators.
- Internet based communication.
- Satellite Navigation.
- Digital Transmission.
- Image processing for pattern recognition, robotic vision and image enhancement.
- Data Compression
- Speech Processing

SECTION 3

Integrated Circuits

3.1 555 IC

The 555 timer IC is an integrated circuit used in a variety of timer, pulse generation, and oscillator applications. The 555 can be used to provide time delays, as an oscillator, and as a flip-flop element. The 555 timer Ic has so many applications that it has become an industry standard.This IC is having 8 pins.The pin connections of IC 555 are shown below:

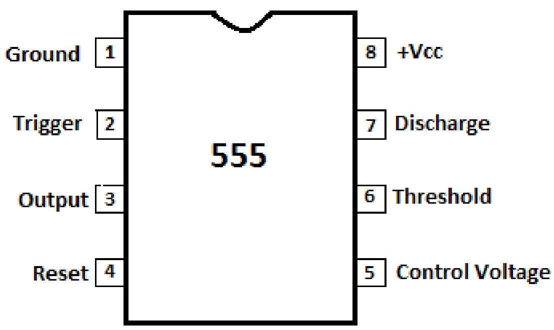


Figure 11: Pin connections of IC 555

3.1.1 Block Diagram

IC 555 is a 8 pin IC. It consists of potential divider, two comaparators formed by using opamps , RS flip flop and a discharge transistor. The supply voltage required is between 4.5 and 16 V.

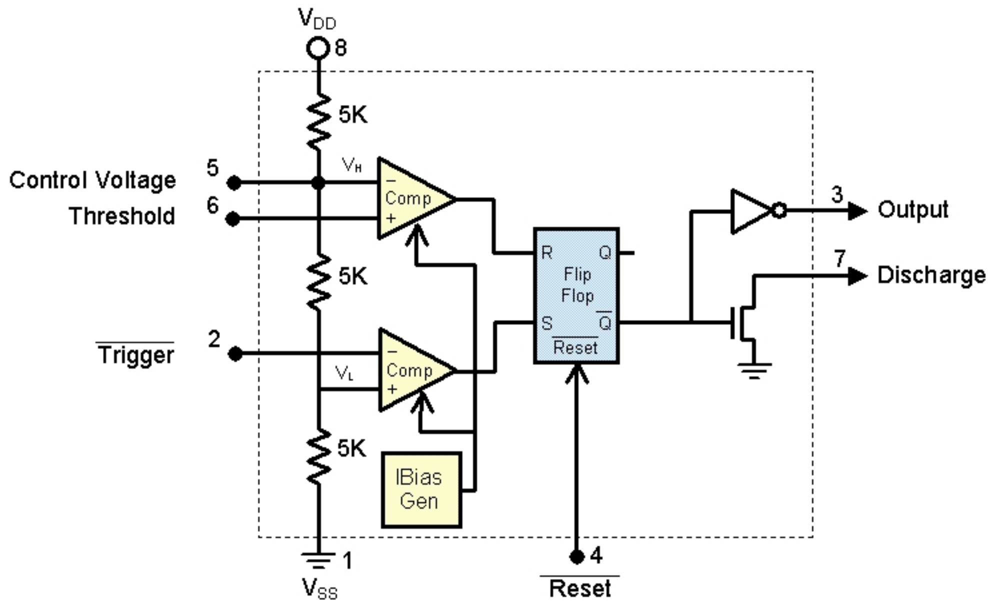


Figure 12: Block diagram of IC 555

The inverting input of the lower comparator is called as Trigger(pin 2). The upper comparator has two inputs. The threshold input is at pin 6 and control input is at pin 5.The Q output of RS Flip flop is given to the base of transistor. The collector of this discharge transistor is connected to to pin 7.At pin 3 complementary output of flip flop $\overline{Q}$ is obtained. When pin 4 is grounded,it prevents the device from working.this is called inhibiting.Mostly external reset is not used and pin 4 is connected directly to supply voltage.Pin 1 is the chip ground and pin 8 is the supply pin.

3.1.2 Applications

1. Monostable multivibrator
2. Astable multivibrator
3. Bistable multivibrator
4. Voltage controlled oscillator
5. Used in Circuit of PPM, PAM, FSK.
6. Ramp generator

3.1.3 Sample circuits

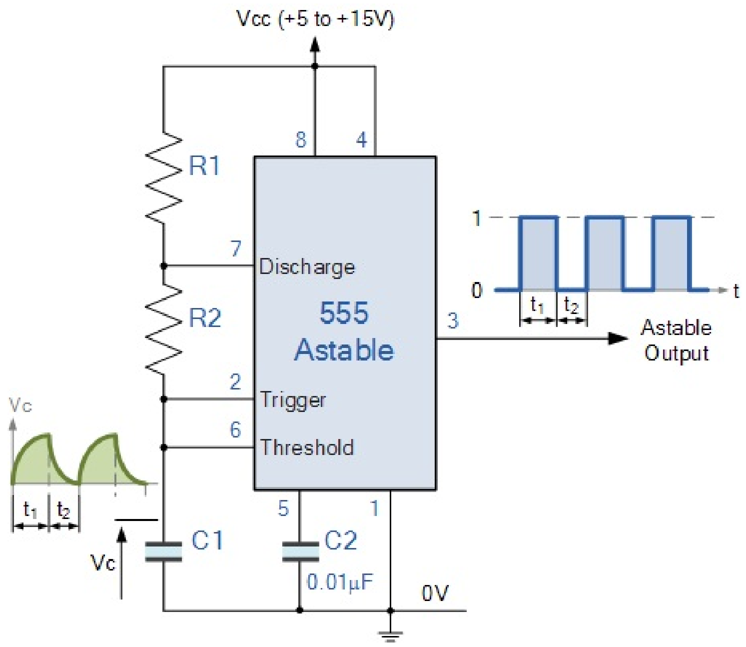


Figure 13: IC 555 as Astable multivibrator

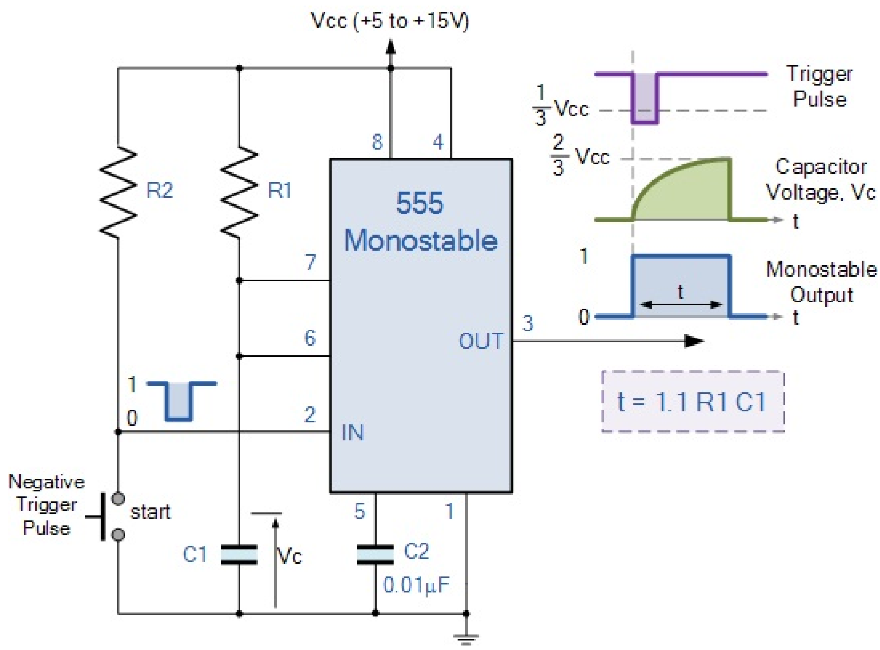


Figure 14: IC 555 as monostable multivibrator

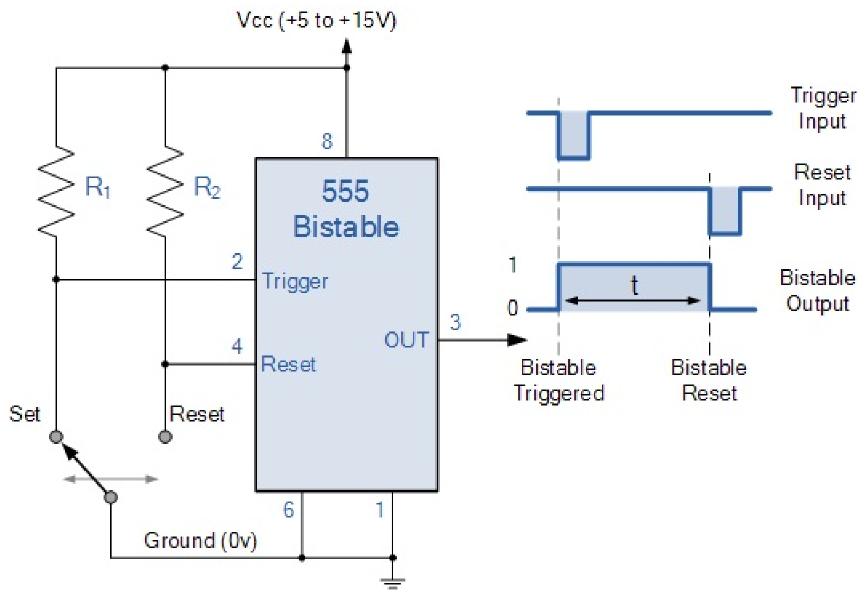


Figure 15: IC 555 as Bistable multivibrator

3.2 4029 IC

One of the most common requirements in digital equipment is counting. And the most common counting requirement has to do with time. From a basic digital clock (which is incorporated into most digitally-controlled appliances) to interval timers and event counters, the need for counting circuits is very great. The 4029 IC is a presettable up/-down counter which counts in either binary or decade mode depending on the voltage level applied at binary/decade input whenever a signal is recieved at the CLOCK.

3.2.1 Functioning of 4029

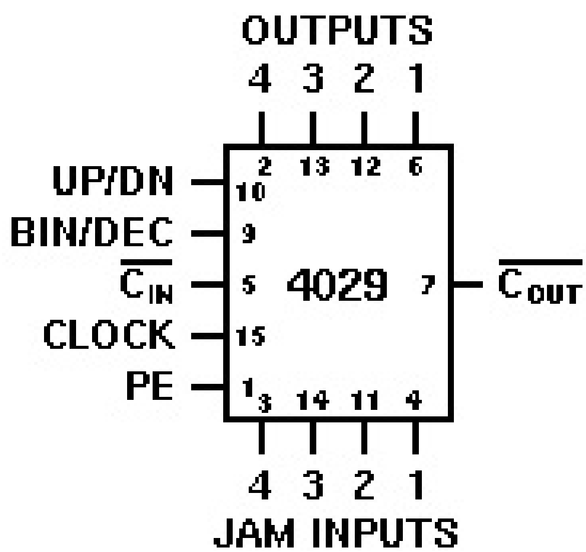


Figure 16: Functional Diagram of IC 4029

The internal schematic diagram of the 4029 is quite complex, as it involves a gating structure that will allow counting either up or down, in binary or decimal, and with parallel inputs to preset a count. However, we can't reach the internal circuitry in any case, so the functional diagram to the right is far more useful for our purposes.

Most of the designations are straightforward and intuitive. The up/dn input, for example, tells the counter to count up if it is a logic 1, or down when it is logic 0. In the same way, a logic 1 to the bin/dec input causes the counter to operate in binary mode, while a logic 0 switches it to decimal (sometimes called decade) mode. If CIN is logic 1, the counter won't count at all. When CIN goes to logic 0, the counter operates normally. The pe input is the preset enable line. When this line is logic 0, the counter operates normally. However, when pe becomes logic 1, the logic signals present on the four jam input lines get copied directly to the four bits of the counter, overriding any prior count. These inputs are not always used, and many applications ignore them.

3.2.2 Multiple 4029

If multiple 4029s are cascaded for a larger count, all up/dn pins are connected together and driven from a common signal, as are all bin/dec lines. The CIN and COUT lines form the means of cascading counters and still keeping a fully synchronous count. If CIN is logic 1, the counter won't count at all. When CIN goes to logic 0, the counter operates normally. Then, when the counter reaches its terminal count (9, 15, or 0 depending on the states of up/dn and bin/dec), COUT goes to logic 0. This is connected to the CIN line of the next IC to allow the next higher order of magnitude to count once. Then COUT goes to logic 1 again. The first counter IC in the set, representing the least significant digit, has its CIN line grounded to logic 0 so it will always count.

The clock input, like up/dn and bin/dec, is fed to all 4029s in an extended counter circuit. This is the signal that represents whatever is to be counted. Any 4029 that is enabled by having its CIN line at logic 0 will change state to the next count when the clock rises from logic 0 to logic 1. Any changes to the CIN and COUT lines will occur just after that rising edge, and so will be ready for the next clock pulse.

3.3 7447 IC

74LS47 is a BCD to 7-segment decoder/driver IC. It accepts a binary coded decimal as input and converts it into a pattern to drive a seven-segment for displaying digits 0 to 9. Binary coded decimal (BCD) is an encoding in which each digit of a number is represented by its own binary sequence (usually of four bits).

3.3.1 Description

74LS47 IC accepts four lines of BCD (8421) input data and generates their complements internally. The data is decoded with seven AND/OR gates to drive indicator LEDs of the seven segment directly.

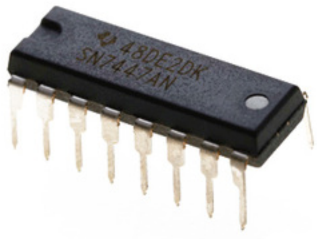


Figure 17: 7447IC

3.3.2 Pin Diagram

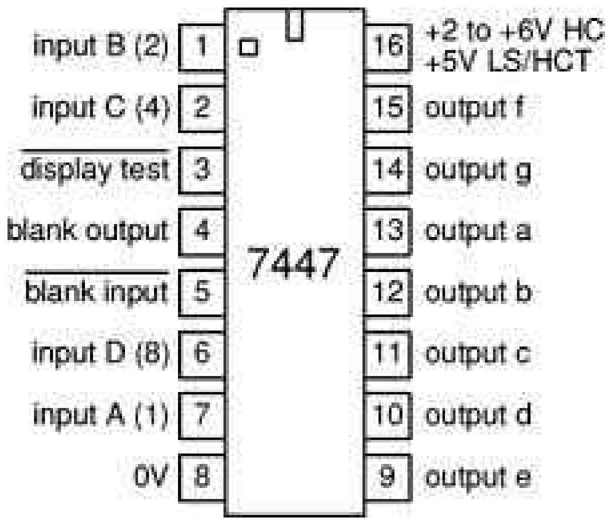


Figure 18: Pinout

3.3.3 Connection

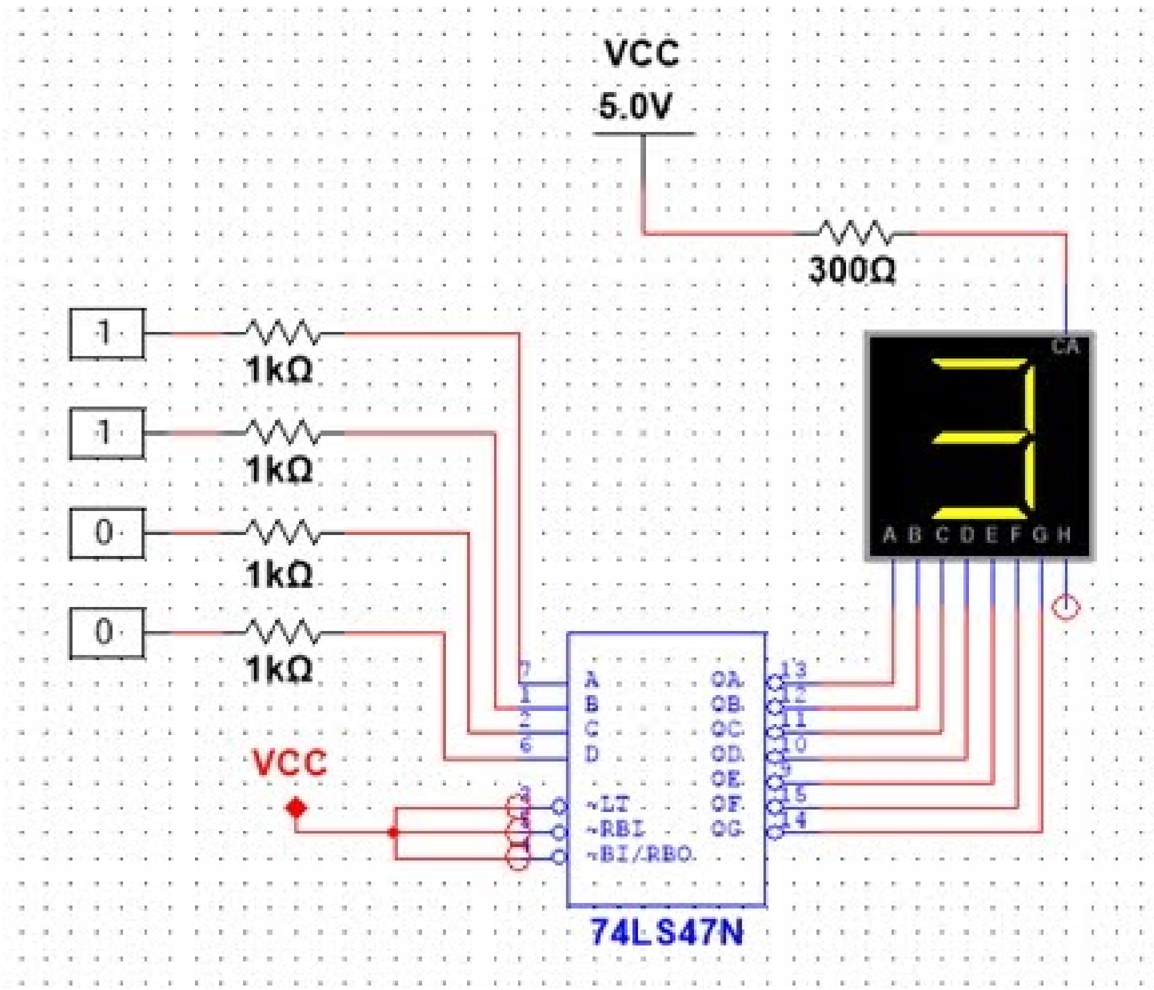


Figure 19: Connecting 7447 IC to Seven Segment Display

3.4 7805 IC

A voltage regulator IC maintains the output voltage at a constant value. 7805 IC, a member of 78xx series of fixed linear voltage regulators is a popular voltage regulator integrated circuit (IC).

3.4.1 7805 IC Rating

- Input voltage range: 7V- 35V
- Current rating of IC = 1A
- Output voltage range: VMax=5.2V ,VMin=4.8

3.4.2 Pin Diagram of 7805 IC

- Pin 1 is the **INPUT** Pin. A positive unregulated voltage is given as input to this pin.
- Pin 2 is the **GROUND** Pin. It is common to both Input and Output.

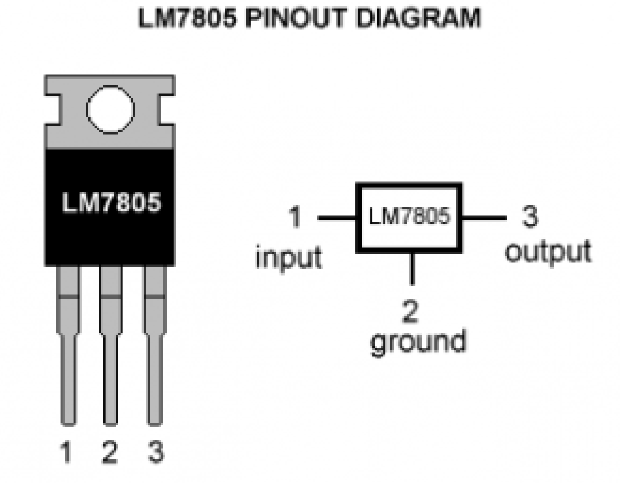


Figure 20: Pinout Diagram of 7805 IC

- Pin 3 is the **OUTPUT** Pin. The output regulated 5V is taken at this pin of the IC.

As you may have noticed, there is a significant difference between the input voltage the output voltage of the voltage regulator. This difference between the input and output voltage is released as heat. So to disipate the heat and protect the instrument from malfunctioning, we have 2 options. Either design your circuit so that the input voltage going into the regulator is limited to 2-3 volts above the output regulated voltage or place an appropriate heat sink, that can efficiently dissipate heat.

3.4.3 Applications of 7805 IC

- Fixed-Output Regulator
- Positive Regulator in Negative Configuration
- Adjustable Output Regulator
- Current Regulator
- Adjustable DC Voltage Regulator
- Regulated Dual-Supply
- Output Polarity-Reversal-Protection Circuit
- Reverse bias projection Circuit

3.5 Multiplexer

A multiplexer (or mux) is a device that selects one of several digital input signals and directs it to a single output. A multiplexer of 2n inputs has n select lines, which are used to select which input line to send to the output. A multiplexer is also called a data selector. Multiplexers are capable of handling both analog and digital applications. In analog applications, multiplexers are made up of of relays and transistor switches, whereas in digital applications, the multiplexers are built from standard logic gates. When the multiplexer is used for digital applications, it is called a digital multiplexer. Multiplexers are classified into four types:

1.2-1 multiplexer (1select line)

2.4-1 multiplexer (2 select lines)

3.8-1 multiplexer(3 select lines)

4.16-1 multiplexer (4 select lines)

3.6 De-multiplexers

A Demultiplexer is a data distributor read as DEMUX. It is quite opposite to multiplexer or MUX. It is a process of taking information from one input and transmitting over one of many outputs. This article explains different types of Demultiplexers.

DEMUX are used to implement general-purpose logic systems. A demultiplexer takes one single input data line and distributes it to any one of a number of individual output lines one at a time. Demultiplexing is the process of converting a signal containing multiple analog or digital signals backs into the original and separate signals. The information regarding the pins is as follows :

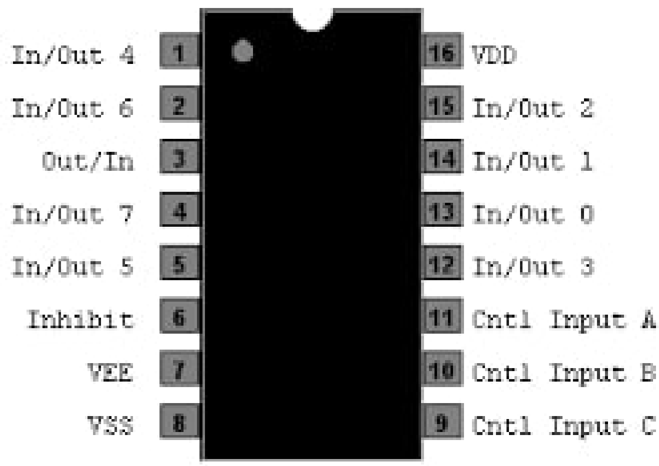


Figure 21: Demux IC CD-4051

- IN/OUT : These are the output pins that are used to transfer the single input into different channels
- A,B,C : These are the select pins. The input to these pins is binary, and that when converted to decimal tells us which output pin is the input signal directed to.

- Inhibit : This pin has to be kept low so that the IC functions properly.
- VSS,VEE : Ground
- VCC/VDD : Power Input (5V)

4

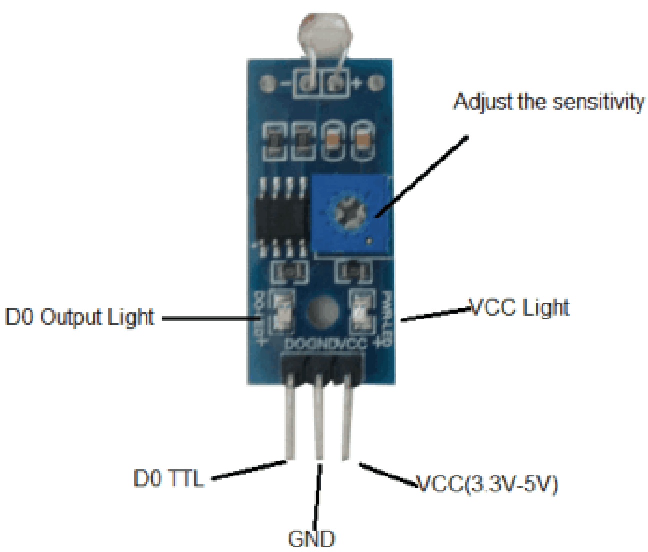
SECTION

Detectors

4.1 SN Light Mod (Photosensitive Resistor Module)

4.1.1 Introduction

SN-LIGHT-MOD is a photosensitive resistor module, suitable to detect environmental light intensity and ambient brightness. This has many applications, and therefore deserves a seperate sub section of its own. Its sensitivity can be tuned with an on board potentiometer, where turning it clockwise will increase the sensitivity and increase the detection range.



4.1.2 Features

- Comes with a high-quality light dependent resistor (LDR).
- Equipped with an on-board potentiometer to adjust light brightness threshold.
- Digital output
- OperTo introduce the basic steps on how to use SN-LIGHT-MOD with Arduino UNO to detect the light brightness in the environment and decide to switch OFF or ON light.ating Voltage is 3.3-5 V

4.1.3 Application

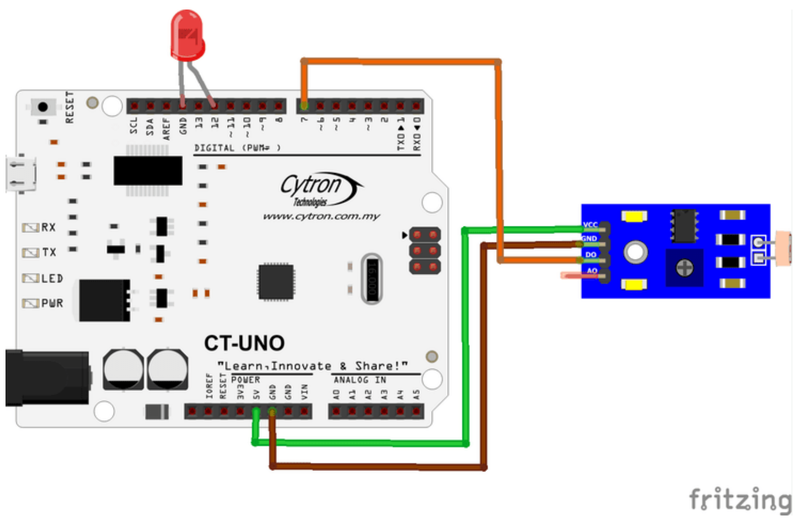
Objective

To introduce the basic steps on how to use SN-LIGHT-MOD with Arduino UNO to detect the light brightness in the environment and decide to switch OFF or ON light.

Hardware Requirements

- Arduino UNO
- Light Sensor Module
- USB Cable
- Jumper Cables
- LED

Setup



Software Requirements

Arduino IDE

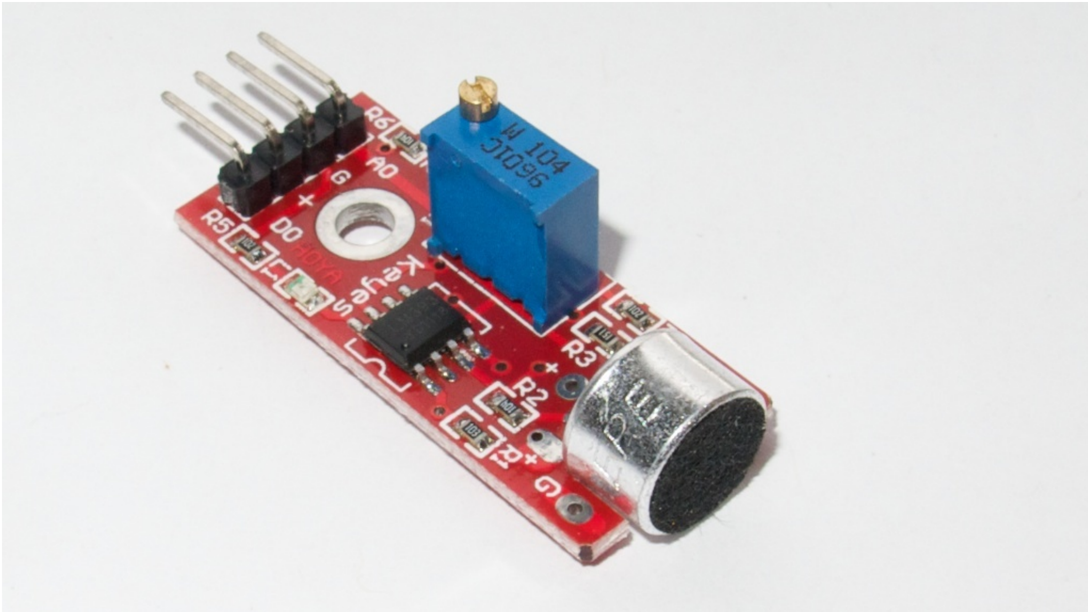
Sample Code

```
int ldrPin = 7;
int ledPin= 12;
int val = 0;
void setup() {
  pinMode(ldrPin, INPUT);
  pinMode(ledPin, OUTPUT);
  Serial.begin(9600);
}

void loop() {
  int val = digitalRead(ldrPin);
  Serial.println(val);

  if(val == HIGH ){
    digitalWrite(ledPin, HIGH);
    Serial.println("LED ON");
  }
  else{
    digitalWrite(ledPin, LOW);
    Serial.println("LED OFF");
  }
}
```

4.2 Microphone(small pressure sensor)

4.2.1 Introduction

The microphone sound sensor, as the name says, detects sound. It gives a measurement of how loud a sound is.
There are a wide variety of these sensors. It is most commonly used with arduino.



sensor.jpg sensor.jpg

4.2.2 Pin Wiring

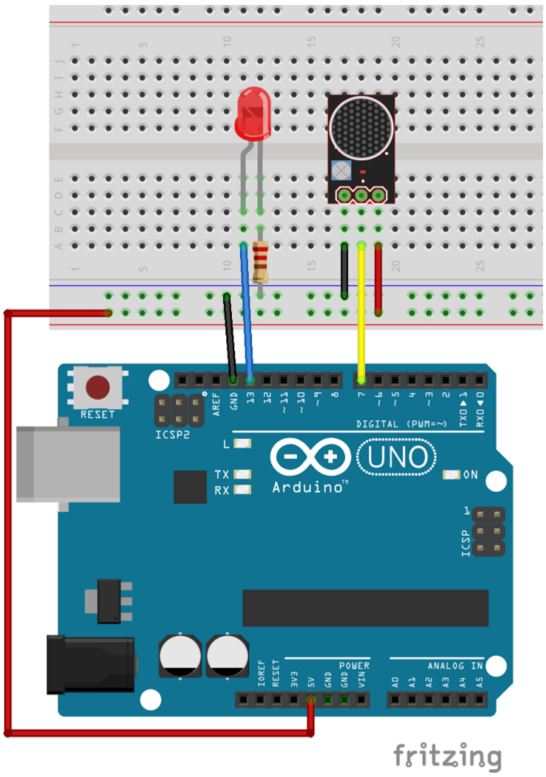
A0- Analog pins
D0- Digital pins
GND- GND
VCC- 5V

4.2.3 Application

Objective
In this example, a microphone sensor will detect the sound intensity of your surroundings and will light up an LED if the sound intensity is above a certain threshold.
Hardware Required

- 1x Microphone sound sensor
- Arduino UNO âĂŞ read Best Arduino Starter Kits
- 1x Breadboard
- 1x LED
- 1x 220 Ohm resistor wires

Setup



setup.png setup.png

Software Required

Aurduino IDE

Sample Code

```
int ledPin=13;
int sensorPin=7;
boolean val =0;

void setup(){
  pinMode(ledPin, OUTPUT);
  pinMode(sensorPin, INPUT);
  Serial.begin (9600);
}

void loop (){
  val =digitalRead(sensorPin);
  Serial.println (val);
  // when the sensor detects a signal above the threshold value, LED flashes
  if (val==HIGH) {
    digitalWrite(ledPin, HIGH);
  }
  else {
    digitalWrite(ledPin, LOW);
  }
}
```

SECTION

5 Amplifiers

5.1 Operational Amplifier(Op-amp)

5.1.1 Introduction

An operational amplifier is basically a high gain,direct coupled amplifier. It has two inputs and an one output, but generally it is operated in single ended input-single ended output mode. The differential amplifier forms the first stage of an op-amp. Opamp can perform several arithmetic operations like addition, subtraction, differentiation, integration,comparison, analog to digital conversion etc. Opamp are used is analog computers.

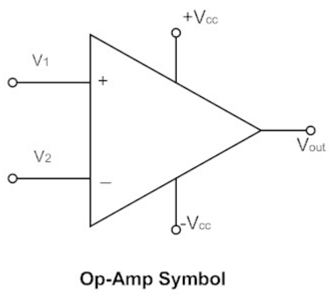


Figure 22: schematic symbol of Op-amp

IC 741 is widely used Op-amp. In this IC when input is zero, the output can be adjusted to zero by varying the 10K potentiometer between offset null terminal.

5.1.2 Block diagram and inputs

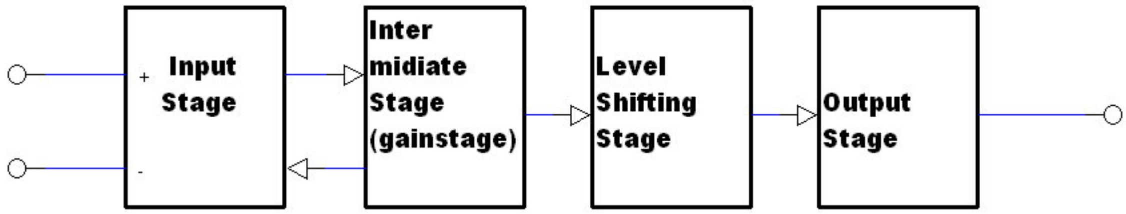


Figure 23: Block diagram of Opamp

An opamp has two input terminals:
1. Non-inverting input: output signal is in phase with input signal, denoted by (+).
2. Inverting input: output signal is out of phase with input signal, denoted by (-).

5.1.3 Non-inverting Opamp

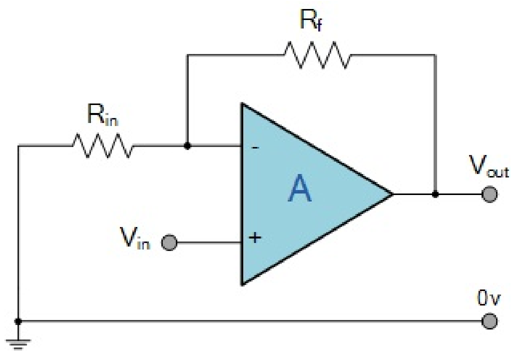


Figure 24: Non-inverting Opamp

The input signal is applied to the non-inverting input of an amplifier and a fraction of output voltage is then supplied and fedback to the inverting input. output voltage=Vo = Vi(1 + Rf/Ri). output signal is in phase with input signal

5.1.4 Inverting Opamp

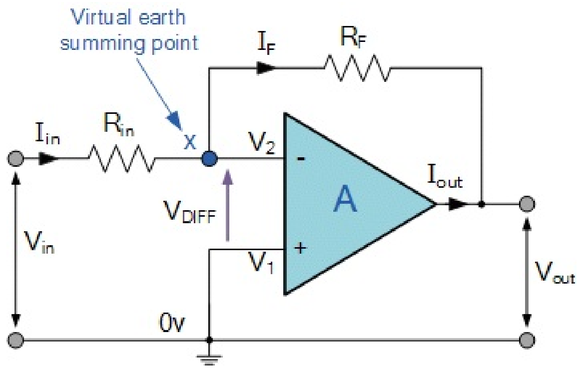


Figure 25: Inverting Opamp

In inverting opamp input signal is applied to the inverting input terminal through input resistor Ri. Output voltage = Vo = -(Rf/Ri).Vi. Output signal is 180 degree out of phase with input signal.

5.1.5 Opamp as buffer

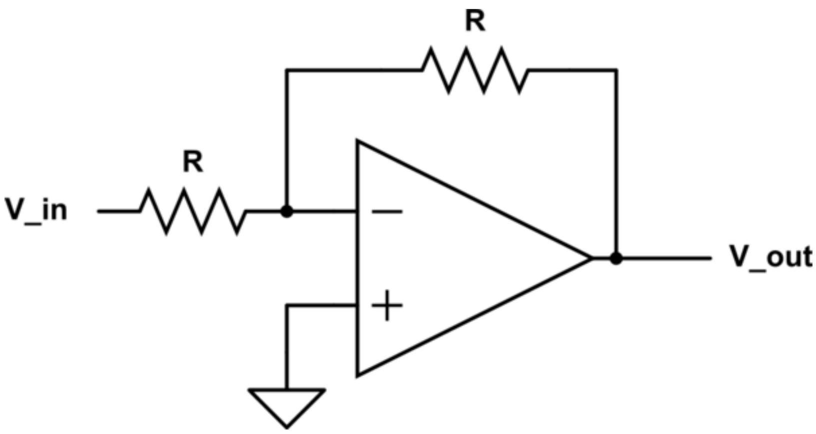


Figure 26: Opamp as buffer

A buffer amplifier is a stage that isolates the preceding stage from the following stage. As gain of this amp is 1, it is called 'Unity gain voltage follower'. Output signal is in phase with input signal.

5.1.6 Opamp as Comparator

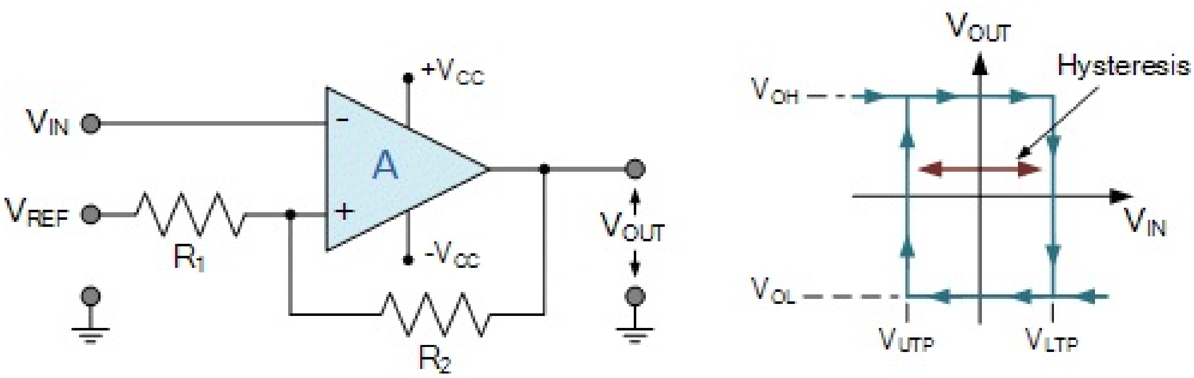


Figure 27: Opamp as Comparator

The output of opamp will retain in a state until the inpur exceeds the reference voltage for that state. In short it is used when we want to compare two voltage levels.

6

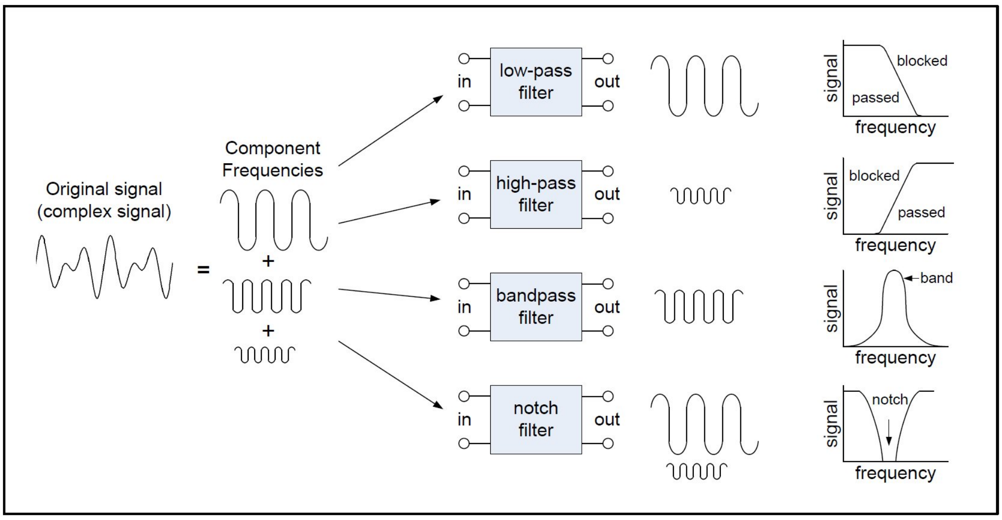
SECTION

Active and Passive Filters

The filter is a circuit which changes amplitude and phase of the input signal and produces output accordingly. It filters or eliminates some frequencies and passes some frequencies. Hence it provides different attenuation to different frequencies. Based on components used in the construction of the filter there are two types of filters i.e active filter and passive filter.

Four major types of Filters

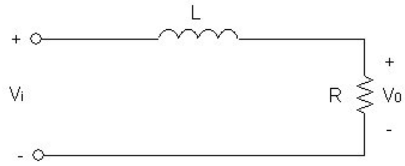
The four primary types of filters include the low-pass filter, the high-pass filter, the band-pass filter, and the notch filter (or the band-reject or band-stop filter). Note: A notch filter is a bandstop filter with a narrow bandstop bandwidth. Notch filters are used to attenuate a narrow range of frequencies.



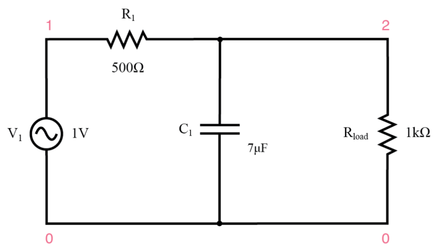
6.1 Low Pass Filter

Allows low-frequency signals and difficult passage to high-frequency signals.

- Inductive Low-Pass Filter



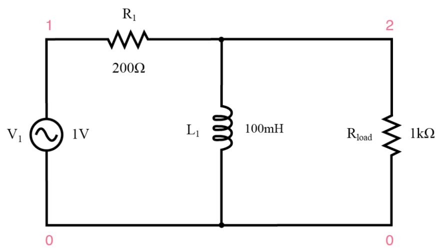
- Capacitive Low-Pass Filter



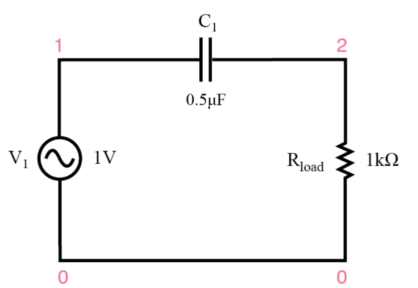
6.2 High Pass Filter

Offers easy passage of a high-frequency signal and difficult passage to a low-frequency signal.

- Inductive High Pass Filter

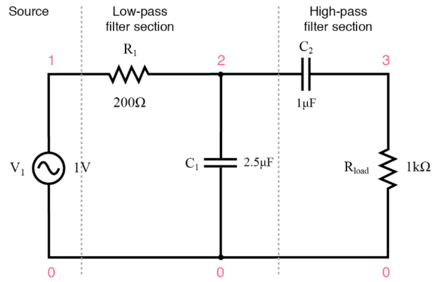


- Capacitive High Pass Filter



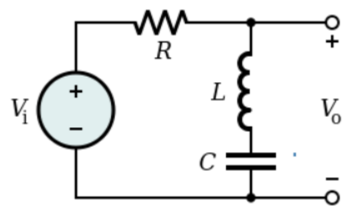
6.3 Band Pass Filter

Combining the properties of low-pass and high-pass into a single filter creates a Band Pass Filter.



6.4 Band Stop Filter

This kind of filter passes all frequencies above and below a particular range set by the component values.

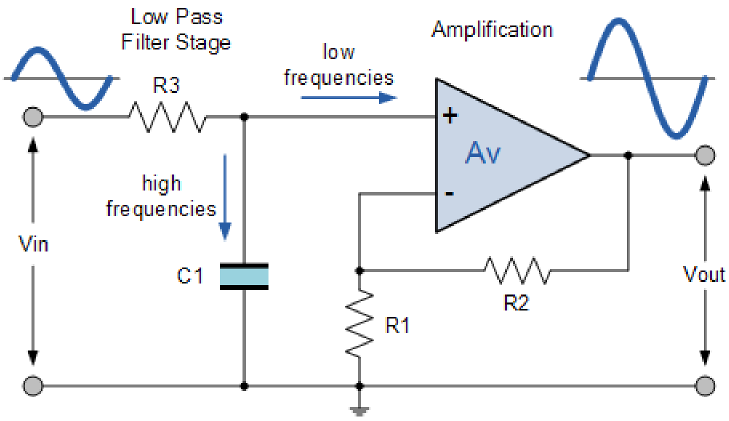


6.5 Active Filter:

This filter type uses active components such as OP-AMP (i.e. operational amplifier) in addition to Resistors (R) and Capacitors (C) in the construction of the filter. Hence it is known as active filter.

Advantages

- No resonance issues.
- It can eliminate any harmonics
- Used for voltage regulation
- Used for reactive power compensation
- It provides reliable operation

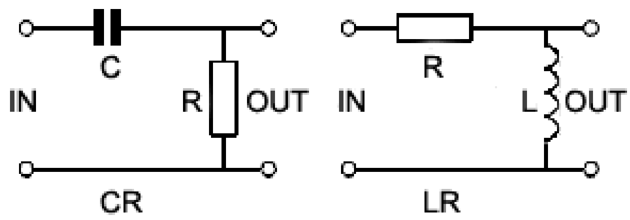


6.6 Passive Filter

This filter type uses passive components such as resistors (R), coils or inductors (L) and condenser or capacitors (C) in the construction of filter. Hence it is known as passive filter.

Advantages

- Cheap
- Reliable
- Easy Design
- High Efficiency



Applications

- Radio communications: Filters enable radio receivers to only "see" the desired signal while rejecting all other signals (assuming that the other signals have different frequency content).
- DC power supplies: Filters are used to eliminate undesired high frequencies (i.e., noise) that are present on AC input lines. Additionally, filters are used on a power supply's output to reduce ripple.
- Analog-to-digital conversion: Filters are placed in front of an ADC input to minimize aliasing.

7

SECTION

Battery and Power Supply

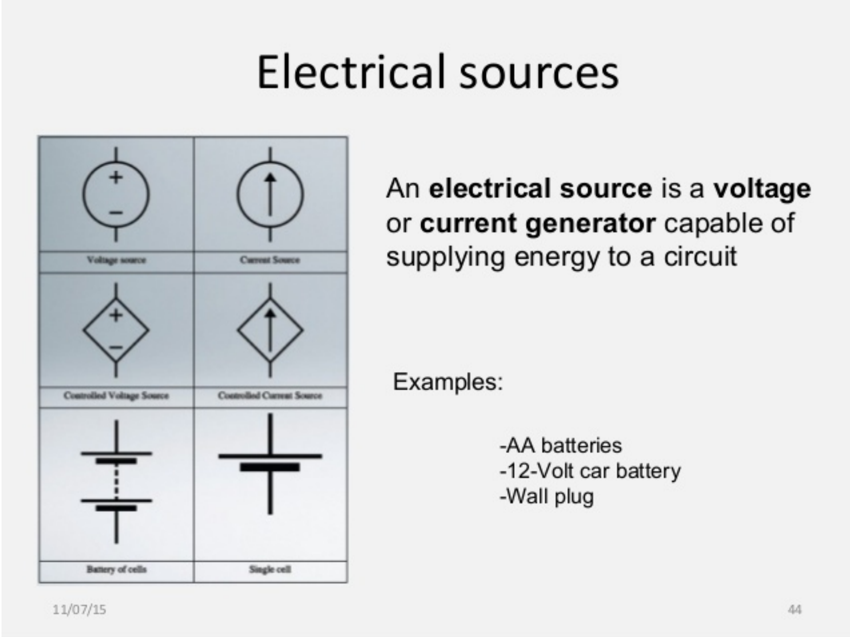
7.1 Electrical Sources

Electrical sources, both as a voltage source or a current source can be classed as being either independent (ideal) or dependent, (controlled) that is whose value depends upon a voltage or current elsewhere within the circuit, which itself can be either constant or time-varying.

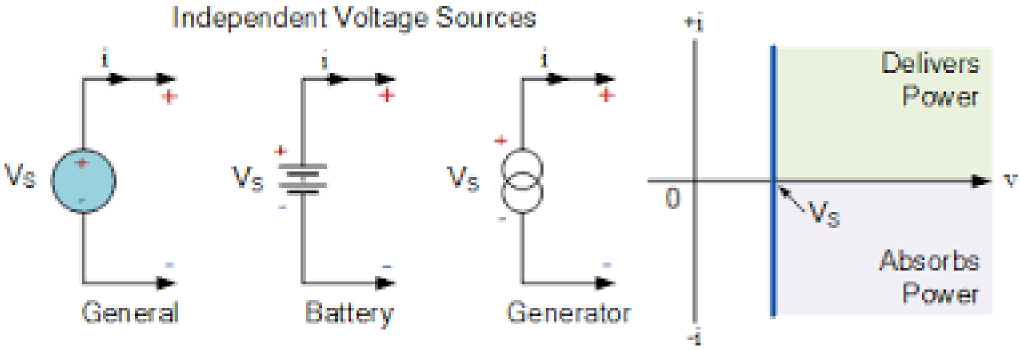
When dealing with circuit laws and analysis, electrical sources are often viewed as being âĂIJidealâĂİ, that is the source is ideal because it could theoretically deliver an infinite amount of energy without loss thereby having characteristics represented by a straight line. However, in real or practical sources there is always a resistance either connected in parallel for a current source, or series for a voltage source associated with the source affecting its output.

7.2 The Voltage Supply

A voltage source, such as a battery or generator, provides a potential difference (voltage) between two points within an electrical circuit allowing current to flowing around it. Remember that voltage can exist without current. A battery is the most common voltage source for a circuit with the voltage that appears across the positive and negative terminals of the source being called the terminal voltage.



Ideal Voltage Source

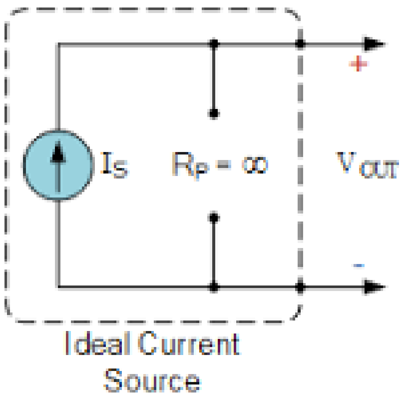


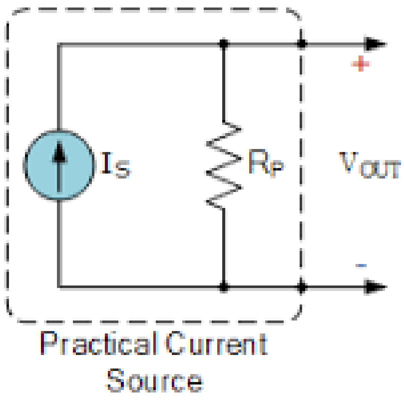
An ideal voltage source is defined as a two terminal active element that is capable of supplying and maintaining the same voltage, (v) across its terminals regardless of the current, (i) flowing through it. In other words, an ideal voltage source will supply a constant voltage at all times regardless of the value of the current being supplied producing an I-V characteristic represented by a straight line.

Then an ideal voltage source is known as an Independent Voltage Source as its voltage does not depend on either the value of the current flowing through the source or its direction but is determined solely by the value of the source alone. So for example, an automobile battery has a 12V terminal voltage that remains constant as long as the current through it does not become to high, delivering power to the car in one direction and absorbing power in the other direction as it charges.

On the other hand, a Dependent Voltage Source or controlled voltage source, provides a voltage supply whose magnitude depends on either the voltage across or current flowing through some other circuit element. A dependent voltage source is indicated with a diamond shape and are used as equivalent electrical sources for many electronic devices, such as transistors and operational amplifiers.

Practical Voltage Supply



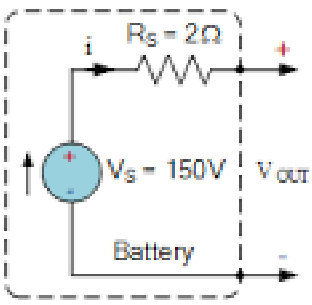


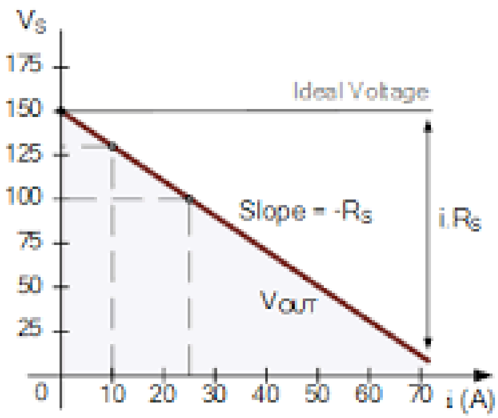
We have seen that an ideal voltage source can provide a voltage supply that is independent of the current flowing through it, that is, it maintains the same voltage value always. This idea may work well for circuit analysis techniques, but in the real world voltage sources behave a little differently as for a practical voltage source, its terminal voltage will actually decrease with an increase in load current.

As the terminal voltage of an ideal voltage source does not vary with increases in the load current, this implies that an ideal voltage source has zero internal resistance, RS = 0. In other words, it is a resistorless voltage source. In reality all voltage sources have a very small internal resistance which reduces their terminal voltage as they supply higher load currents.

For non-ideal or practical voltage sources such as batteries, their internal resistance (RS) produces the same effect as a resistance connected in series with an ideal voltage source as these two series connected elements carry the same current as shown.

7.3 Battery I-V Characteristics



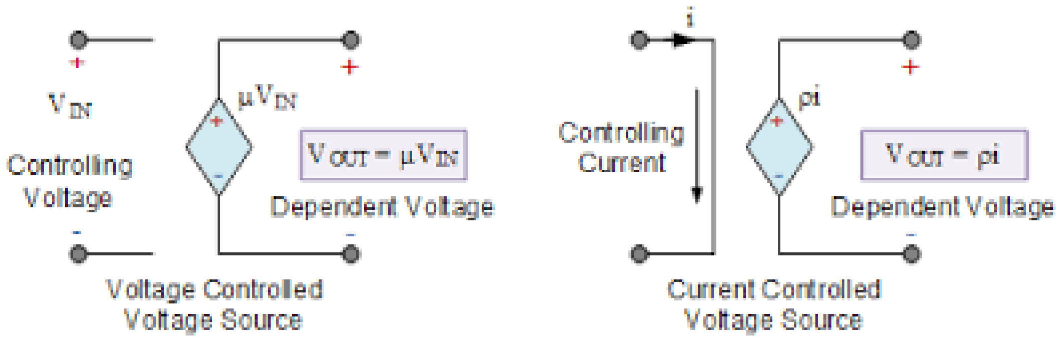


Dependent Voltage Source

Unlike an ideal voltage source which produces a constant voltage across its terminals regardless of what is connected to it, a controlled or dependent voltage source changes its terminal voltage depending upon the voltage across, or the current through, some other element connected to the circuit, and as such it is sometimes difficult to specify the value of a dependent voltage source, unless you know the actual value of the voltage or current on which it depends.

Dependent voltage sources behave similar to the electrical sources we have looked at so far, both practical and ideal (independent) the difference this time is that a dependent voltage source can be controlled by an input current or voltage. A voltage source that depends on a voltage input is generally referred to as a Voltage Controlled Voltage Source or VCVS. A voltage source that depends on a current input is referred too as a Current Controlled Voltage Source or CCVS.

Ideal dependent sources are commonly used in the analysing the input/output characteristics or the gain of circuit elements such as operational amplifiers, transistors and integrated circuits. Generally, an ideal voltage dependent source, either voltage or current controlled is designated by a diamond-shaped symbol as shown.



SECTION 8

Sensors

8.1 IR Sensor

An infrared sensor is an electronic instrument that is used to sense certain characteristics of its surroundings. It does this by either emitting or detecting infrared radiation. Infrared sensors are also capable of measuring the heat being emitted by an object and detecting motion.

Infrared technology is found not just in industry, but also in every-day life. Televisions, for example, use an infrared detector to interpret the signals sent from a remote control. Passive Infrared sensors are used for motion detection systems, and LDR sensors are used for outdoor lighting systems. The key benefits of infrared sensors include their low power requirements, their simple circuitry and their portable features.

8.1.1 Infrared Raditaiton Theory

Infrared waves are not visible to the human eye. In the electromagnetic spectrum, infrared radiation can be found between the visible and microwave regions. The infrared waves typically have wavelengths between 0.75 and 1000Âţm.

The infrared spectrum can be split into near IR, mid IR and far IR. The wavelength region from 0.75 to 3Âţm is known as the near infrared region. The region between 3 and 6Âţm is known as the mid-infrared region, and infrared radiation which has a wavelength greater higher than 6Âţm is known as far infrared.

8.1.2 Types of Infrared Sensors

Infrared sensors can be active or passive and they can be split into two main types:

- **Thermal infrared sensors** âĂŞ use infrared energy as heat. Their photo sensitivity is independent of the wavelength being detected. Thermal detectors do not require cooling but do have slow response times and low detection capabilities. Read more about Thermal Infrared Sensors here.
- **Quantum infrared sensors** âĂŞ provide higher detection performance and faster response speed. Their photo sensitivity is dependent on wavelength. Quantum detectors have to be cooled in order to obtain accurate measurements.

8.1.3 Theory Behind Working of IR sensors

The physics behind infrared sensors is governed by three laws:

Planckś radiation law: Every object at a temperature T not equal to 0 K emits radiation

Stephan Boltzmann Law: The total energy emitted at all wavelengths by a black body is related to the absolute temperature

Weinś Displacement Law: Objects of different temperature emit spectra that peak at different wavelengths All objects which have a temperature greater than absolute zero (0 Kelvin) posses thermal energy and are sources of infrared radiation as a result.

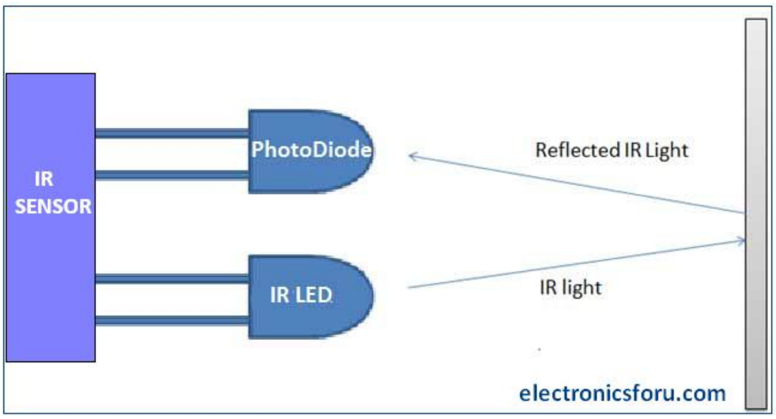
Sources of infrared radiation include blackbody radiators, tungsten lamps and silicon carbide. Infrared sensors typically use infrared lasers and LEDs with specific infrared wavelengths as sources.

A transmission medium is required for infrared transmission, which can be comprised of either a vacuum, the atmosphere or an optical fiber.

Optical components such as optical lenses made from quartz, CaF2, Ge and Si, polyethylene Fresnel lenses and Al or Au mirrors are used to converge or focus the infrared radiation. In order to limit spectral response, band-pass filters can be used.

Next, infrared detectors are used to detect the radiation which has been focused. The output from the detector is usually very small and hence pre-amplifiers coupled with circuitry are required to further process the received signals.

8.1.4 Working Principle

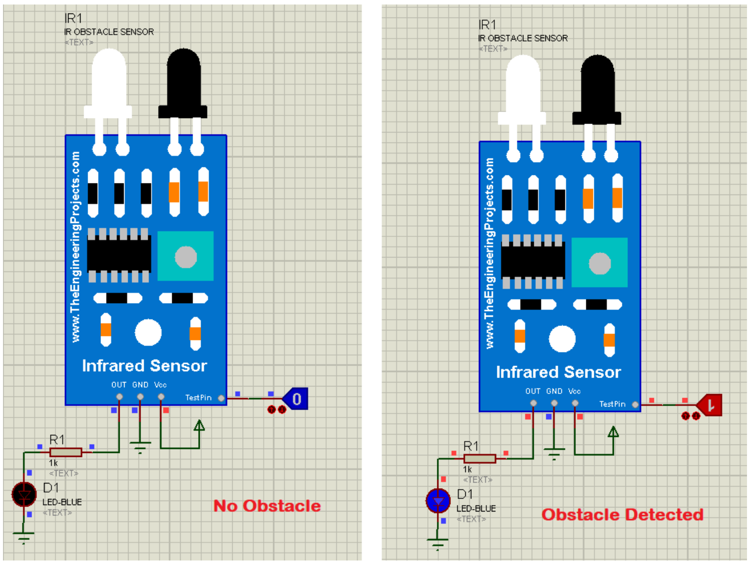


An IR sensor consists of two parts, the emitter circuit and the receiver circuit. This is collectively known as a photo-coupler or an optocoupler.

The emitter is an IR LED and the detector is an IR photodiode. The IR phototdiode is sensitive to the IR light emitted by an IR LED. The photo-diodeâĂŹs resistance and output voltage change in proportion to the IR light received. This is the underlying working principle of the IR sensor.

The type of incidence can be direct incidence or indirect incidence. In direct incidence, the IR LED is placed in front of a photodiode with no obstacle in between. In indirect incidence, both the diodes are placed side by side with an opaque object in front of the sensor. The light from the IR LED hits the opaque surface and reflects back to the photodiode.

8.1.5 Applications



Proximity Sensors

Proximity sensors employ reflective indirect incidence principle. The photodiode receives the radiation emitted by the IR LED once reflected back by the object. Closer the object, higher will be the intensity of the incident radiation on the photodiode. This intensity is converted to voltage to determine the distance. Proximity sensors find use in touchscreen phones, among other devices. The display is disabled during calls, so that even if the cheek makes contact with the touchscreen, there is no effect.

Line Follower Robots

In line following robots, IR sensors detect the color of the surface underneath it and send a signal to the microcontroller or the main circuit which then takes decisions according to the algorithm set by the creator of the bot. Line followers employ reflective or non-reflective indirect incidence. The IR is reflected back to the module from the white surface around the black line. But IR radiation is absorbed completely by black color. There is no reflection of the IR radiation going back to the sensor module in black color.

Item Counter

Item counter is implemented on the basis of direct incidence of radiation on the photodiode. Whenever an item obstructs the invisible line of IR radiation, the value of a stored variable in a computer/microcontroller is incremented. This is indicated by LEDs, seven segment displays and LCDs. Monitoring systems of large factories use these counters for counting products on conveyor belts.

8.1.6 Other Applications

- Infrared Tracking
- Object Detection
- Art History and Restoration
- Hyperspectral Imaging
- Climatology
- Meterology