LiquidCrystal Library

This library allows an Arduino board to control LiquidCrystal displays (LCDs) based on the Hitachi HD44780 (or a compatible) chipset, which is found on most text-based LCDs. The library works with in either 4- or 8-bit mode (i.e. using 4 or 8 data lines in addition to the rs, enable, and, optionally, the rw control lines).

To use this library
`#include <LiquidCrystal.h>`

LiquidCrystal()

Description

Creates a variable of type LiquidCrystal. The display can be controlled using 4 or 8 data lines. If the former, omit the pin numbers for d0 to d3 and leave those lines unconnected. The RW pin can be tied to ground instead of connected to a pin on the Arduino; if so, omit it from this function's parameters.

Syntax

LiquidCrystal(rs, enable, d4, d5, d6, d7)
LiquidCrystal(rs, rw, enable, d4, d5, d6, d7)
LiquidCrystal(rs, enable, d0, d1, d2, d3, d4, d5, d6, d7)
LiquidCrystal(rs, rw, enable, d0, d1, d2, d3, d4, d5, d6, d7)

Parameters

rs: the number of the Arduino pin that is connected to the RS pin on the LCD

rw: the number of the Arduino pin that is connected to the RW pin on the LCD (*optional*)

enable: the number of the Arduino pin that is connected to the enable pin on the LCD

d0, d1, d2, d3, d4, d5, d6, d7: the numbers of the Arduino pins that are connected to the corresponding data pins on the LCD. d0, d1, d2, and d3 are optional; if omitted, the LCD will be controlled using only the four data lines (d4, d5, d6, d7).

begin()

Description

Initializes the interface to the LCD screen, and specifies the dimensions (width and height) of the display. begin() needs to be called before any other LCD library commands.

Syntax

lcd.begin(cols, rows)

Parameters

lcd: a variable of type LiquidCrystal

cols: the number of columns that the display has

rows: the number of rows that the display has

clear()

Description

Clears the LCD screen and positions the cursor in the upper-left corner.

Syntax

lcd.clear()

Parameters

lcd: a variable of type LiquidCrystal

setCursor()

Description

Position the LCD cursor; that is, set the location at which subsequent text written to the LCD will be displayed.

Syntax

lcd.setCursor(col, row)

Parameters

lcd: a variable of type LiquidCrystal

col: the column at which to position the cursor (with 0 being the first column)

row: the row at which to position the cursor (with 0 being the first row)

print()

Description

Prints text to the LCD.

Syntax

lcd.print(data)
lcd.print(data, BASE)

Parameters

lcd: a variable of type LiquidCrystal

data: the data to print (char, byte, int, long, or string)

BASE (optional): the base in which to print numbers: BIN for binary (base 2), DEC for decimal (base 10), OCT for octal (base 8), HEX for hexadecimal (base 16).

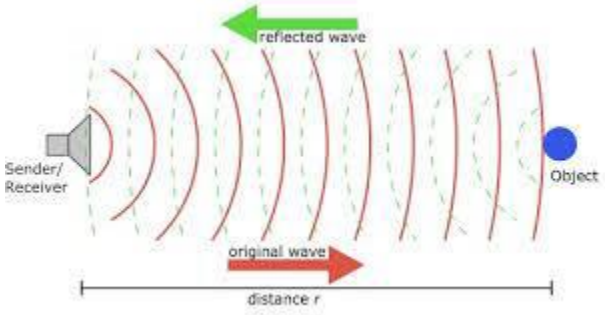
Returns

byte
print() will return the number of bytes written, though reading that number is optional

Ultrasonic Sensor

Technical Specifications

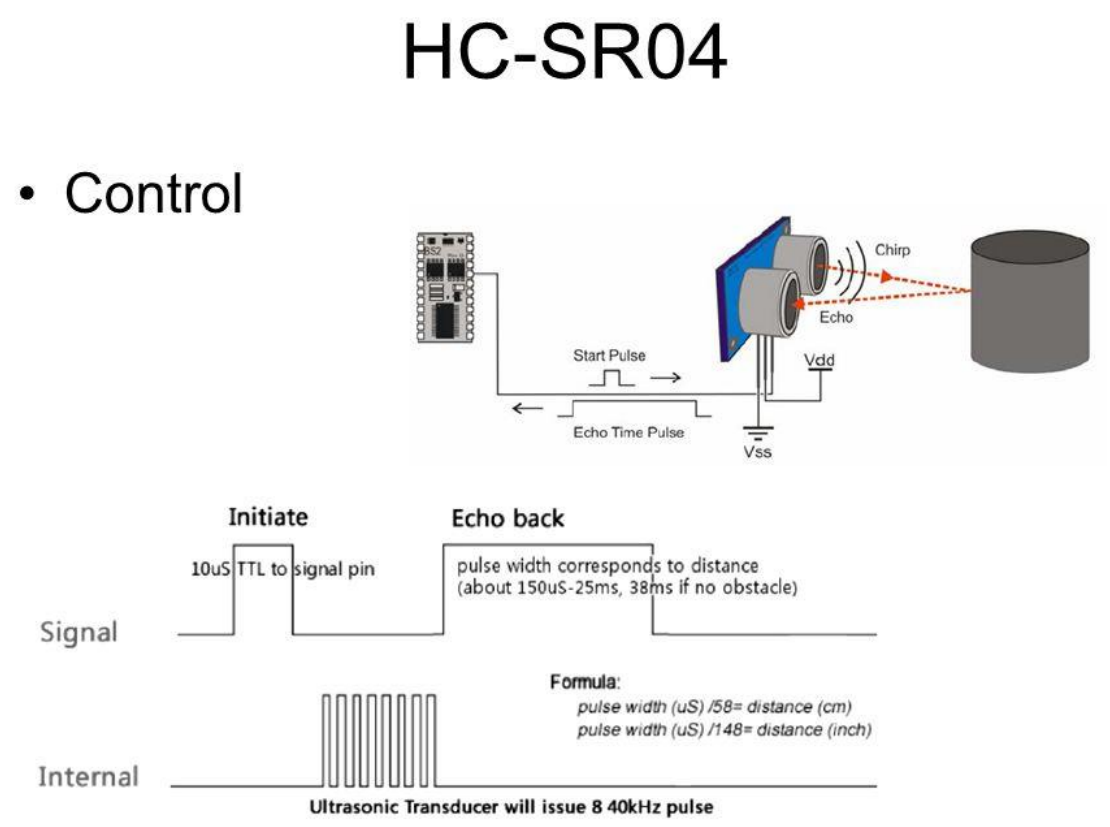
- Power Supply − +5V DC
- Quiescent Current − <2mA
- Working Current − 15mA
- Effectual Angle − <15°
- Ranging Distance − 2cm – 400 cm/1″ – 13ft
- Resolution − 0.3 cm
- Measuring Angle − 30 degree
- The HC-SR04 ultrasonic sensor uses SONAR to determine the distance of an object just like the bats do. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package from 2 cm to 400 cm or 1” to 13 feet.
- The operation is not affected by sunlight or black material, although acoustically, soft materials like cloth can be difficult to detect. It comes complete with ultrasonic transmitter and receiver module.



Working of ultrasonic sensor

1. This sensor uses ultrasonic sound to measure distance just like bats and dolphins do.
2. Ultrasonic sound has such a high pitch that humans cannot hear it.
3. This particular sensor sends out an ultrasonic sound that has a frequency of about 40 kHz.
4. The sensor has two main parts: a transducer that creates an ultrasonic sound and another that listens for its echo.
5. To use this sensor to measure distance, the robot's brain must measure the amount of time it takes for the ultrasonic sound to travel.

6. Sound travels at approximately 340 meters per second. This corresponds to about 29.412µs (microseconds) per centimeter.
7. To measure the distance the sound has travelled we use the formula: Distance = (Time x SpeedOfSound) / 2.
    a. The "2" is in the formula because the sound has to travel back and forth.
    b. First the sound travels away from the sensor, and then it bounces off of a surface and returns back.
    c. The easy way to read the distance as centimeters is to use the formula:
    Centimeters = ((Microseconds / 2) / 29).
    For example, if it takes 100µs (microseconds) for the ultrasonic sound to bounce back, then the distance is ((100 / 2) / 29) centimeters or about 1.7 centimeters.



- **How to use Ultrasonic sensor**
- Connect the VCC and GND pins to a 5V power supply, the trigger input (Trig) pin to a digital output and the echo (Echo) pin to a digital input on your robot's microcontroller.

Pulse the trigger (Trig) pin high for at least 10us (microseconds) and then wait for a high level on the echo (Echo) pin. The amount of time the Echo pin stays high corresponds to the distance that the ultrasonic sound has travelled. The quicker the response, the closer your robot is to an obstacle.

MQ3 Sensor

MQ3 Alcohol Sensor

MQ3 is one of the most commonly used sensors in the MQ sensor series. It is a Metal Oxide Semiconductor (MOS) type of sensor. Metal oxide sensors are also known as Chemiresistors, because sensing is based on the change of resistance of the sensing material when exposed to alcohol. So by placing it in a simple voltage divider network, alcohol concentrations can be detected.

MQ3 alcohol sensor works on 5V DC and draws around 800mW. It can detect Alcohol concentrations anywhere from 25 to 500 ppm.

What is 1 ppm equal to?

When measuring gases, the term concentration is used to describe the amount of gas by volume in the air. The two most common units of measurement are parts-per-million, and percent concentration.

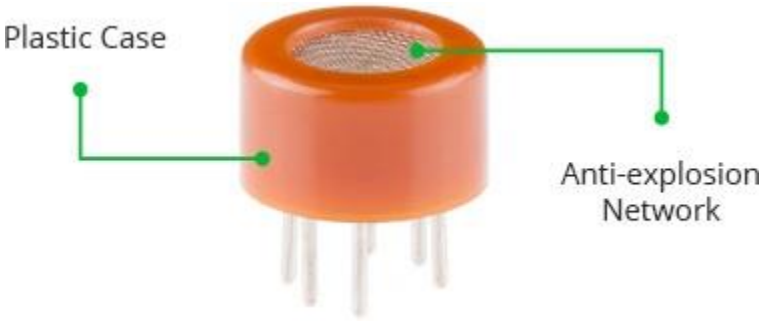
Parts-per-million (abbreviated ppm) is the ratio of one gas to another. For example, 500ppm of alcohol means that if you could count a million gas molecules, 500 of them would be of alcohol and 999500 molecules would be some other gases.

Here are the complete specifications

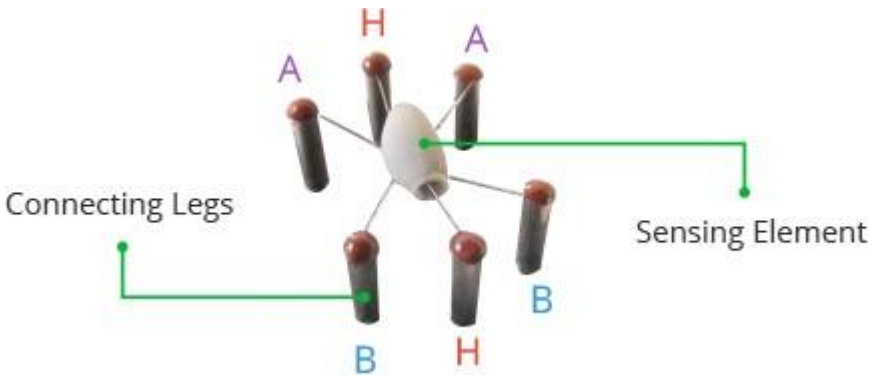
Operating voltage	5V
Load resistance	200 KΩ
Heater resistance	33Ω ± 5%
Heating consumption	<800mw
Sensing Resistance	1 MΩ – 8 MΩ
Concentration Scope	25 – 500 ppm
Preheat Time	Over 24 hour

Internal structure of MQ3 Alcohol Sensor

MQ3 is a heater-driven sensor. That's why it is enclosed in two layers of fine stainless steel mesh called an Anti-explosion network. It ensures that heater element inside the sensor will not cause an explosion, as we are sensing flammable gas (alcohol).

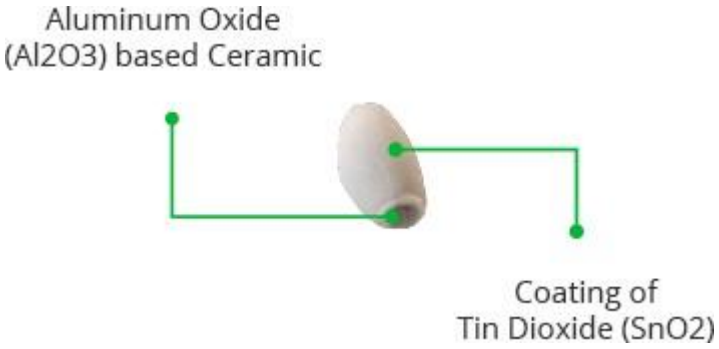


It also provides protection for the sensor and filters out suspended particles so that only gaseous elements are able to pass inside the chamber.

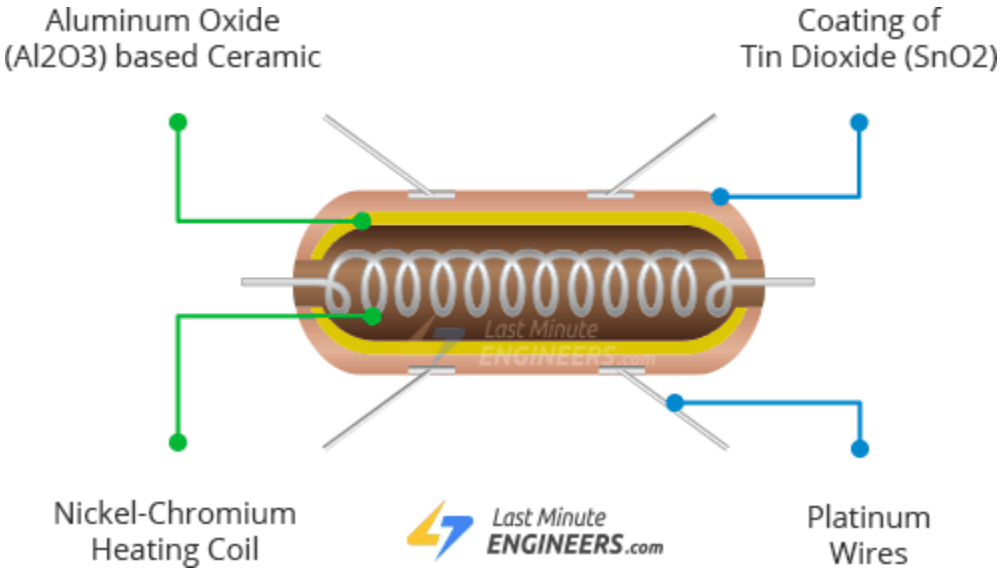


This is what the sensor looks like when outer mesh is removed. The star-shaped structure is formed by the sensing element and six connecting legs that extend beyond the Bakelite base. Out of six, two leads (H) are responsible for heating the sensing element and are connected via a Nickel-Chromium coil (a well known conductive alloy).

The remaining four leads (A & B) responsible for output signals are connected using Platinum Wires. These wires are connected to the body of the sensing element and convey small changes in the current that passes through the sensing element.



The tubular sensing element is made up of Aluminum Oxide (AL2O3) based ceramic and has a coating of Tin Dioxide (SnO2). The Tin Dioxide is the most important material being sensitive towards alcohol. However, the ceramic substrate only increases the heating efficiency and ensures that the sensor area is continuously heated to the working temperature.



So, to summarize, the Nickel-Chromium coil and Aluminum Oxide based ceramic forms a Heating System; while Platinum wires and coating of Tin Dioxide forms a Sensing System.

How MQ3 Alcohol Sensor Works?

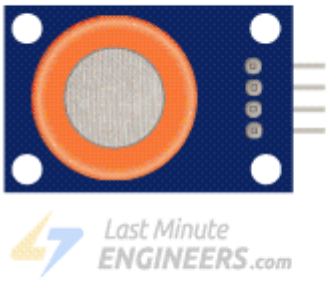
When SnO2 semiconductor layer is heated at high temperature, oxygen is adsorbed on the surface. In clean air, electrons from the conduction band in tin dioxide are attracted to oxygen molecules. This form an electron depletion layer just below the surface of SnO2 particles and forms a potential barrier. As a result, the SnO2 film becomes highly resistive and prevents electric current flow.

In the presence of alcohol, however, the surface density of adsorbed oxygen decreases as it reacts with the alcohols; which lowers the potential barrier. Electrons are then released into the tin dioxide, allowing current to flow freely through the sensor.

MQ3 Alcohol Sensor Module Hardware Overview

Since the MQ3 alcohol sensor is not breadboard compatible, we recommend this handy little breakout board. It's very easy to use and comes with two different outputs. It not only provides a binary indication of the presence of alcohol but also an analog representation of its concentration in air.

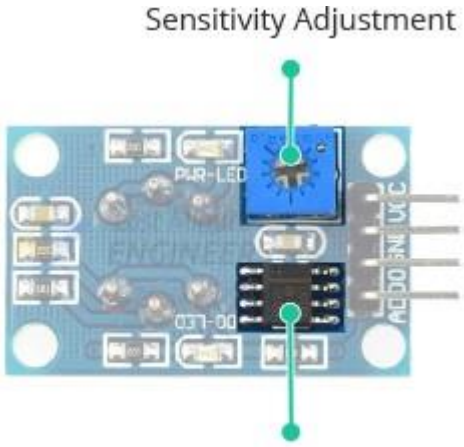
The analog output voltage provided by the sensor (at AO pin) varies in proportion to the alcohol concentration. The higher the alcohol concentration in the air, the higher the output voltage; Whereas lower concentration gives lower output voltage. The following animation shows the relationship between alcohol concentration and output voltage.



Clean Air

Output Voltage

The same analog signal is fed to a LM393 High Precision Comparator to digitize it and is made available at the Digital Output (DO) pin.



The module has a built-in potentiometer for adjusting the sensitivity of the digital output (DO). You can use it to set a threshold; so that when the alcohol concentration exceeds the threshold value, the module will output LOW otherwise HIGH.

This setup is very useful when you want to trigger an action when certain threshold is reached. For example, when the alcohol concentration in the breath exceed a threshold, you can tell if someone is drunk. You got the idea!

How Servo Motors Work

Servo Motors: High in Efficiency and Power

Servo motors have been around for a long time and are utilized in many applications. They are small in size but pack a big punch and are very energy-efficient. These features allow them to be used to operate remote-controlled or radio-controlled toy cars, **robots** and airplanes. Servo motors are also used in industrial applications, robotics, in-line manufacturing, pharmaceutics and food services. But how do the little guys work?

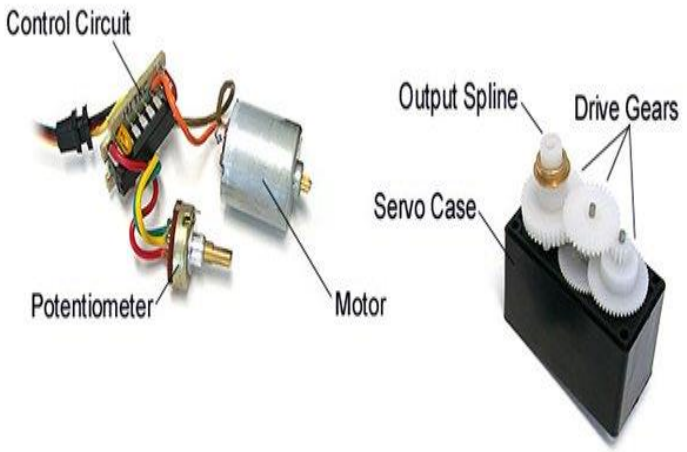
The servo circuitry is built right inside the motor unit and has a positionable shaft, which usually is fitted with a **gear** (as shown below). The motor is controlled with an electric signal which determines the amount of movement of the shaft.

What's inside the servo?

To fully understand how the servo works, you need to take a look under the hood. Inside there is a pretty simple set-up: a small **DC motor**, **potentiometer**, and a control circuit. The motor is attached by gears to the control wheel. As the motor rotates, the potentiometer's resistance changes, so the control circuit can precisely regulate how much movement there is and in which direction.

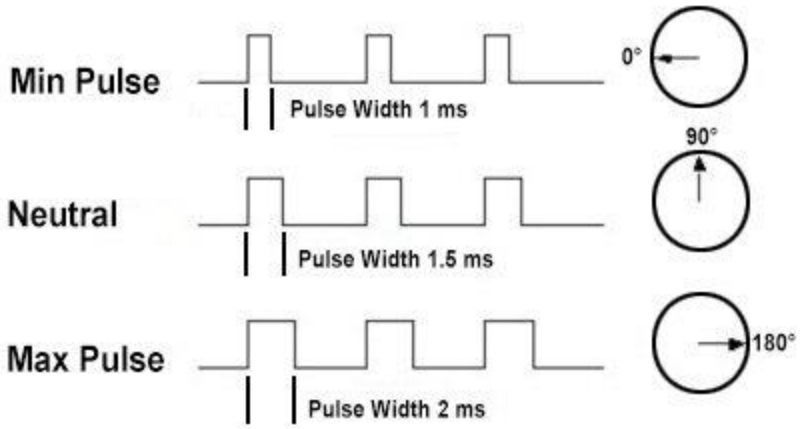
When the shaft of the motor is at the desired position, power supplied to the motor is stopped. If not, the motor is turned in the appropriate direction. The desired position is sent via electrical pulses through the **signal wire**. The motor's speed is proportional to the difference between its actual position and desired position. So if the motor is near the desired position, it will turn slowly, otherwise it will turn fast. This is called **proportional control.** This means the motor will only run as hard as necessary to accomplish the task at hand, a very efficient little guy.

How is the servo controlled?



The guts of a servo motor (L) and an assembled servo (R)

Servos are controlled by sending an electrical pulse of variable width, or **pulse width modulation** (PWM), through the control wire. There is a minimum pulse, a maximum pulse, and a repetition rate. A servo motor can usually only turn 90° in either direction for a total of 180° movement. The motor's neutral position is defined as the position where the servo has the same amount of potential rotation in the both the clockwise or counter-clockwise direction. The PWM sent to the motor determines position of the shaft, and based on the duration of the pulse sent via the control wire; the **rotor** will turn to the desired position. The servo motor expects to see a pulse every 20 milliseconds (ms) and the length of the pulse will determine how far the motor turns. For example, a 1.5ms pulse will make the motor turn to the 90° position. Shorter than 1.5ms moves it in the counter clockwise direction toward the 0° position, and any longer than 1.5ms will turn the servo in a clockwise direction toward the 180° position.



Variable Pulse width control servo position

When these servos are commanded to move, they will move to the position and hold that position. If an external force pushes against the servo while the servo is holding a position, the servo will resist from moving out of that position. The maximum amount of force the servo can exert is called the **torque rating** of the servo. Servos will not hold their position forever though; the position pulse must be repeated to instruct the servo to stay in position.

Types of Servo Motors

There are two types of servo motors - AC and DC. AC servo can handle higher current surges and tend to be used in industrial machinery. DC servos are not designed for high current surges and are usually better suited for smaller applications. Generally speaking, DC motors are less expensive than their AC counterparts. These are also servo motors that have been built specifically for continuous rotation, making it an easy way to get your robot moving. They feature two ball bearings on the output shaft for reduced friction and easy access to the rest-point adjustment potentiometer.

Servo Motor Applications

Servos are used in radio-controlled airplanes to position control surfaces like elevators, rudders, walking a robot, or operating **grippers.** Servo motors are small, have built-in control circuitry and have good power for their size.

In food services and pharmaceuticals, the tools are designed to be used in harsher environments, where the potential for corrosion is high due to being washed at high pressures and temperatures repeatedly to maintain strict hygiene standards. Servos are also used in **in-line manufacturing**, where high repetition yet precise work is necessary.

Of course, you don't have to know how a servo works to use one, but as with most electronics, the more you understand, the more doors open for expanded projects and projects' capabilities.

L293D Motor Driver IC

Features

- Can be used to run Two DC motors with the same IC.
- Speed and Direction control is possible
- Motor voltage Vcc2 (Vs): 4.5V to 36V
- Maximum Peak motor current: 1.2A
- Maximum Continuous Motor Current: 600mA
- Supply Voltage to Vcc1(vss): 4.5V to 7V
- Transition time: 300ns (at 5Vand 24V)
- Automatic Thermal shutdown is available
- Available in 16-pin DIP, TSSOP, SOIC packages

What Is Motor Driver IC?

A motor driver IC is an integrated circuit chip which is usually used to control motors in autonomous robots. Motor driver ICs act as an interface between microprocessors in robots and the motors in the robot. The most commonly used motor driver IC’s are from the L293 series such

as L293D, L293NE, etc. These ICs are designed to control 2 DC motors simultaneously. L293D consist of two H-bridge. H-bridge is the simplest circuit for controlling a low current rated motor. For this tutorial we will be referring the motor driver IC as L293D only. L293D has 16 pins, they are comprised as follows:

Ground	Pins	-	4
Input	Pins	-	4
Output	Pins	-	4
Enable	pins	-	2
Voltage	Pins	-	2

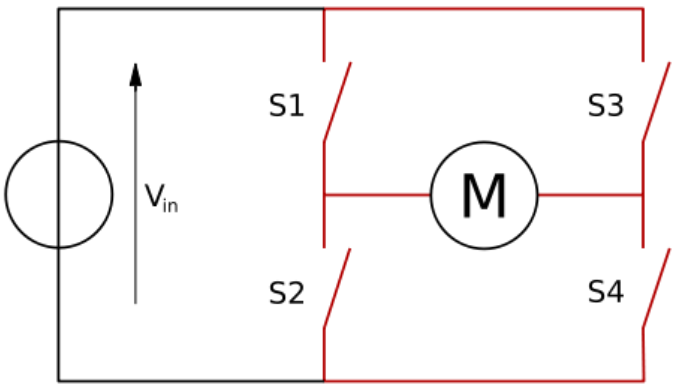
The workings of the individual pins are explained in detail, later in the tutorial.

Why We Need Motor Driver IC?

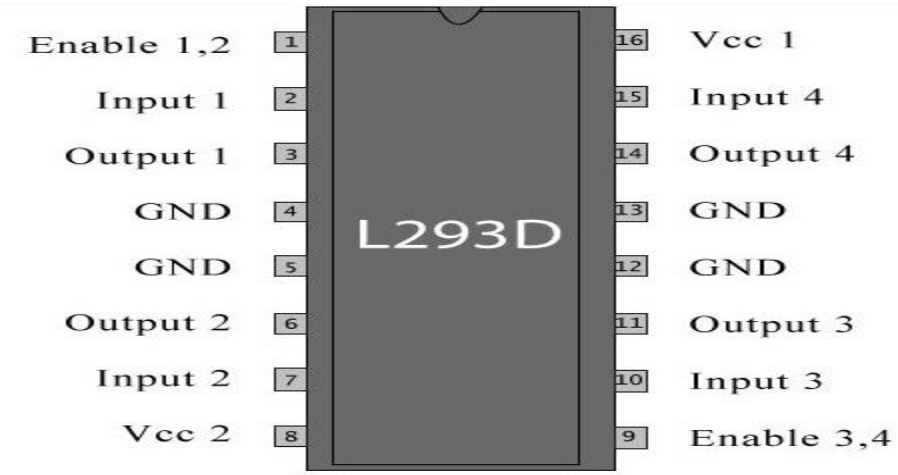
Motor Driver ICs are primarily used in autonomous robotics only. Also most microprocessors operate at low voltages and require a small amount of current to operate while the motors require a relatively higher voltages and current . Thus current cannot be supplied to the motors from the microprocessor. This is the primary need for the motor driver IC.

Working Of A H-bridge

H-bridge is given this name because it can be modelled as four switches on the corners of 'H'. The basic diagram of H-bridge is given below :



In the given diagram, the arrow on the left points to the higher potential side of the input voltage of the circuit. Now if the switches S1 & S4 are kept in a closed position while the switches S2 & S3 are kept in a open position meaning that the circuit gets shorted across the switches S1 & S4. This creates a path for the current to flow, starting from the V input to switch S1 to the motor, then to switch S4 and then the exiting from the circuit. This flow of the current would make the motor turn in one direction. The direction of motion of the motor can be clockwise or anti-clockwise, this is because the rotation of the motor depends upon the connection of the terminals of the motor with the switches.
For simplicity, lets assume that in this condition the motor rotates in a clockwise direction. Now, when S3 and S2 are closed then and S1 and S4 are kept open then the current flows from the other direction and the motor will now definitely rotates in counter-clockwise direction
When S1 and S3 are closed and S2 and S4 are open then the 'STALL' condition will occur(The motor will break).
Stall Condition:
When the motor is applied positive voltage on both sides then the voltage from both the sides brings the motor shaft to a halt
L293D Pin Diagram :



How Motor Driver Operates?

The L293D IC receives signals from the microprocessor and transmits the relative signal to the motors. It has two voltage pins, one of which is used to draw current for the working of the L293D

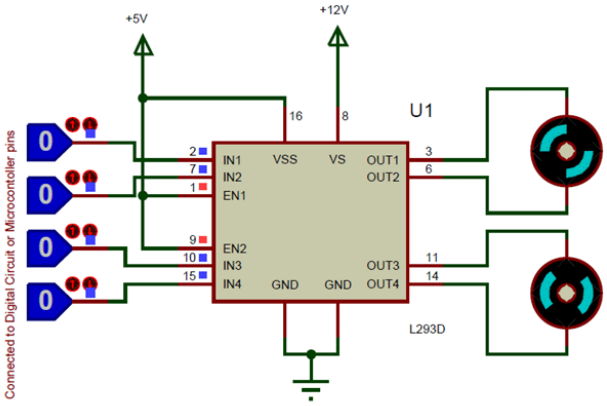
and the other is used to apply voltage to the motors. The L293D switches it output signal according to the input received from the microprocessor.
For Example: If the microprocessor sends a 1(digital high) to the Input Pin of L293D, then the L293D transmits a 1(digital high) to the motor from its Output Pin. An important thing to note is that the L293D simply transmits the signal it receives. It does not change the signal in any case.

L293D And Its Working

The L293D is a 16 pin IC, with eight pins, on each side, dedicated to the controlling of a motor. There are 2 INPUT pins, 2 OUTPUT pins and 1 ENABLE pin for each motor. L293D consist of two H-bridge. H-bridge is the simplest circuit for controlling a low current rated motor. The Theory for working of a H-bridge is given below.

How to use a L293D Motor Driver IC

Using this L293D motor driver IC is very simple. The IC works on the principle of **Half H-Bridge**, let us not go too deep into what H-Bridge means, but for now just know that H bridge is a set up which is used to run motors both in clock wise and anti clockwise direction. As said earlier this IC is capable of running two motors at the any direction at the same time, the circuit to achieve the same is shown below.

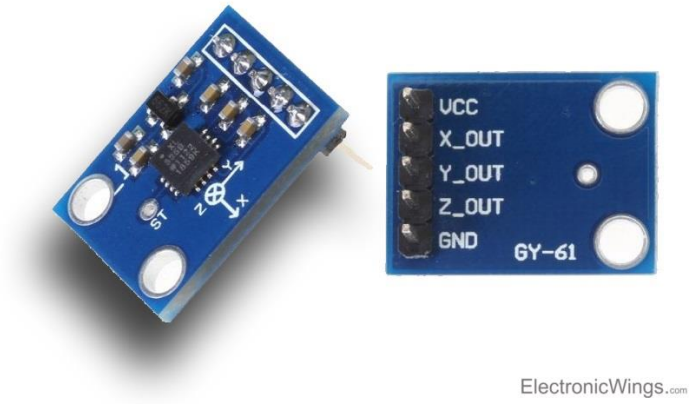


ADXL 335 Accelerometer

ADXL335 Accelerometer Module

Introduction

An accelerometer is an electromechanical device that will measure acceleration force. It shows acceleration, only due to cause of gravity i.e. g force. It measures acceleration in g unit.



ADLX335 Accelerometer

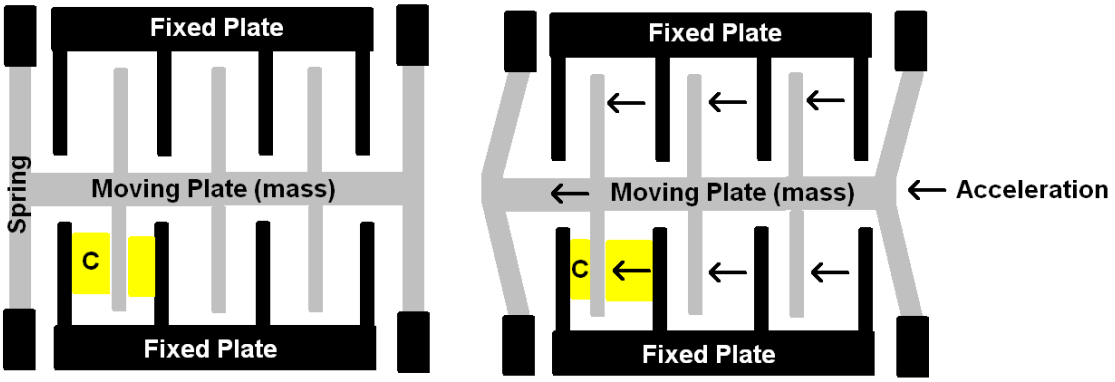
On the earth, 1g means acceleration of 9.8 m/s2 is present. On moon, it is 1/6th of earth and on mars it is 1/3rd of earth.

Accelerometer can be used for tilt-sensing applications as well as dynamic acceleration resulting from motion, shock, or vibration.

ADXL335 module

- The ADXL335 gives complete 3-axis acceleration measurement.
- This module measures acceleration within range ±3 g in the x, y and z axis.
- The output signals of this module are analog voltages that are proportional to the acceleration.
- It contains a polysilicon surface-micro machined sensor and signal conditioning circuitry.

Working Mechanism



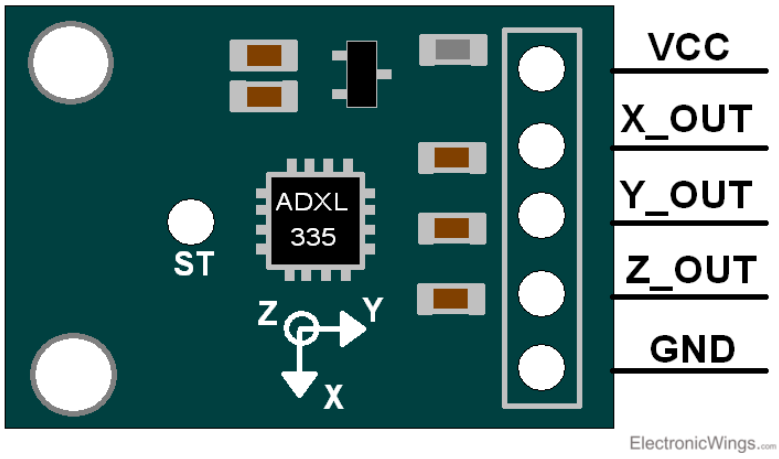
Accelerometer Sensor MEM Mechanism

- As we can see from the above figure, basic structure of accelerometer consists fixed plates and moving plates (mass).

- Acceleration deflects the moving mass and unbalances the differential capacitor which results in a sensor output voltage amplitude which is proportional to the acceleration.

- Phase-sensitive demodulation techniques are then used to determine the magnitude and direction of the acceleration.

Accelerometer ADXL335 Module



VCC: Power supply pin i.e. connect 5V here.

X_OUT: X axis analog output.

Y_OUT: Y axis analog output.

Z_OUT: Z axis analog output.

GND: Ground pin i.e. connect ground here.

ADXL335 accelerometer provides analog voltage at the output X, Y, Z pins; which is proportional to the acceleration in respective directions i.e. X, Y, Z.

Angles using ADXL335

We can calculate angle of inclination or tilt by using X, Y, Z's value. Also, we can calculate Roll, Pitch and Yaw angles with respect to X, Y and Z axis. So first we need to convert 10-bit ADC values into g unit.

As per ADXL335 datasheet maximum voltage level at 0g is 1.65V and sensitivity scale factor of 330mV/g.

Above formula gives us acceleration values in g unit for X, Y and Z axis as,

Axout = (((X axis ADC value * Vref) / 1024) – 1.65) / 0.330

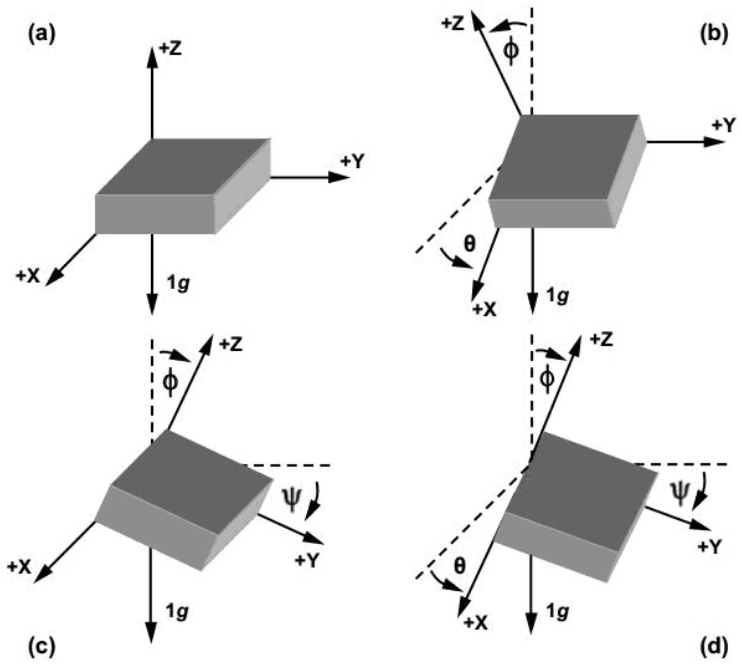
Ayout = (((Y axis ADC value * Vref) / 1024) – 1.65) / 0.330

Azout = (((Z axis ADC value * Vref) / 1024) – 1.65) / 0.330

Note that, practically we get slightly different voltage at 0g. So, put the practical value of voltage at 0g.

Angle of Inclination

- Angle of inclination means by how much angle the device is tilted from its plane of surface.
- Angle of inclination are shown in below figure.
- To calculate angle of inclination of X, Y, Z axis from its reference, we need to use below formulas.



Angle of inclination can be calculated as,

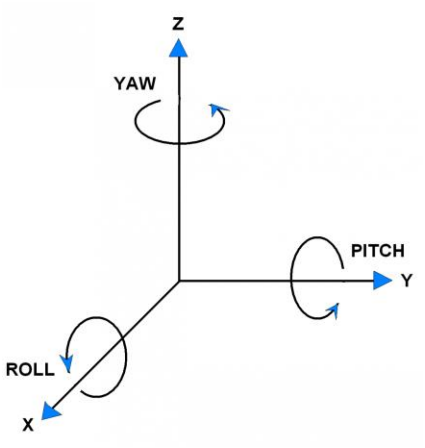
We get these angles in radians. So, multiply these values by (180/π) to get angle in degrees within range of -90° to +90° each axis.

Angle of Rotation

Now let's find a complete angle of rotation (0° to 360°) around X, Y, Z axis, which we can also call as,

- Roll - Angle of rotation along the X axis
- Pitch - Angle of rotation along the Y axis
- Yaw - Angle of rotation along the Z axis

All of them are shown in below conceptual diagram.



These angles are in degrees and can give readings of a complete rotation.

Now let's calculate these angles. As we get Θ, Ψ and Φ in the range of -90° to +90°. Here we need to make these values in the range of -180° to +180° so that we can calculate complete 360° angle of rotation. Let calculate these with arc tangent function which can be expressed as,

$$\operatorname{atan2}(y,x) = \begin{cases} \arctan\left(\frac{y}{x}\right) & \text{if } x > 0, \\ \arctan\left(\frac{y}{x}\right) + \pi & \text{if } x < 0 \text{ and } y \geq 0, \\ \arctan\left(\frac{y}{x}\right) - \pi & \text{if } x < 0 \text{ and } y < 0, \\ +\frac{\pi}{2} & \text{if } x = 0 \text{ and } y > 0, \\ -\frac{\pi}{2} & \text{if } x = 0 \text{ and } y < 0, \\ \text{undefined} & \text{if } x = 0 \text{ and } y = 0. \end{cases}$$

This function will produce the result in the range of -π to π. These values in radians we can convert into degree by multiplying it with (180/π ≈ 57.29577951) factor. So here we get values in -180° to +180°, and we can convert it to complete 0° to 360° by just adding 180° to range.

Hence, we get roll, pitch and yaw angles as,

Roll = (atan2(Ayout, Azout)) *57.29577951+180

Pitch = (atan2(Azout, Axout)) *57.29577951+180

Yaw = (atan2(Axout, Ayout)) *57.29577951+180

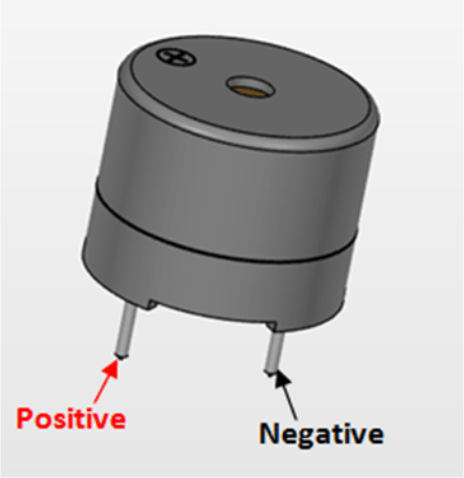
Note that, rotation along X (roll) and Y (pitch) axis will produce change in acceleration but rotation along with Z axis (yaw) will not produce any change in acceleration as it is perpendicular to the plane of surface. Hence using only accelerometer, yaw cannot be calculated.

We can also see this effect on X and Y axis when these axes are made perpendicular with plane of surface.

Here are the complete specifications of ADXL335 Accelerometer IC.

Operating Voltage	1.8V – 3.6V
Operating Current	350μA (typical)
Sensing Range	±3g (Full Scale)
Temperature Range	−40 to +85°C
Sensing axis	3 axis
Sensitivity	270 to 330mV/g (Ratiometric)
Shock Resistance	Up to 10,000g
Dimension	4mm x 4mm x 1.45mm

Buzzer



Buzzer Pin Configuration

Pin Number	Pin Name	Description
1	Positive	Identified by (+) symbol or longer terminal lead. Can be powered by 6V DC
2	Negative	Identified by short terminal lead. Typically connected to the ground of the circuit

Buzzer Features and Specifications

- Rated Voltage: 6V DC
- Operating Voltage: 4-8V DC
- Rated current: <30mA
- Sound Type: Continuous Beep
- Resonant Frequency: ~2300 Hz
- Small and neat sealed package
- Breadboard and Perf board friendly

Equivalents for Passive Buzzer

Piezo Electric buzzer, Speaker, Active Passive Buzzer with Module

How to use a Buzzer

A **buzzer** is a small yet efficient component to add sound features to our project/system. It is very small and compact 2-pin structure hence can be easily used on breadboard, Perf Board and even on PCBs which makes this a widely used component in most electronic applications.

There are two types are buzzers that are commonly available. The one shown here is a simple buzzer which when powered will make a Continuous Beeeeeeppp.... sound, the other type is called a readymade buzzer which will look bulkier than this and will produce a Beep. Beep. Beep. Sound due to the internal oscillating circuit present inside it. But, the one shown here is most widely used because it can be customised with help of other circuits to fit easily in our application.

This buzzer can be used by simply powering it using a DC power supply ranging from 4V to 9V. A simple 9V battery can also be used, but it is recommended to use a regulated +5V or +6V DC supply. The buzzer is normally associated with a switching circuit to turn ON or turn OFF the buzzer at required time and require interval.

Applications of Buzzer

- Alarming Circuits, where the user has to be alarmed about something
- Communication equipments
- Automobile electronics
- Portable equipments, due to its compact size

LED Specifications: light emitting diode parameters

When choosing LEDs it is necessary o understand the datasheet specifications so that the optimum LED part can be chosen for the particular application.

There is a huge variety of different LEDs that are available, each type with its own datasheet and specifications. Everything from the colour to the package, light output to the voltage drop and many more specification parameters.

This page will help unravel the meaning of the major LED datasheet specifications and help bring some clarity to understanding LED specifications.

LED colour

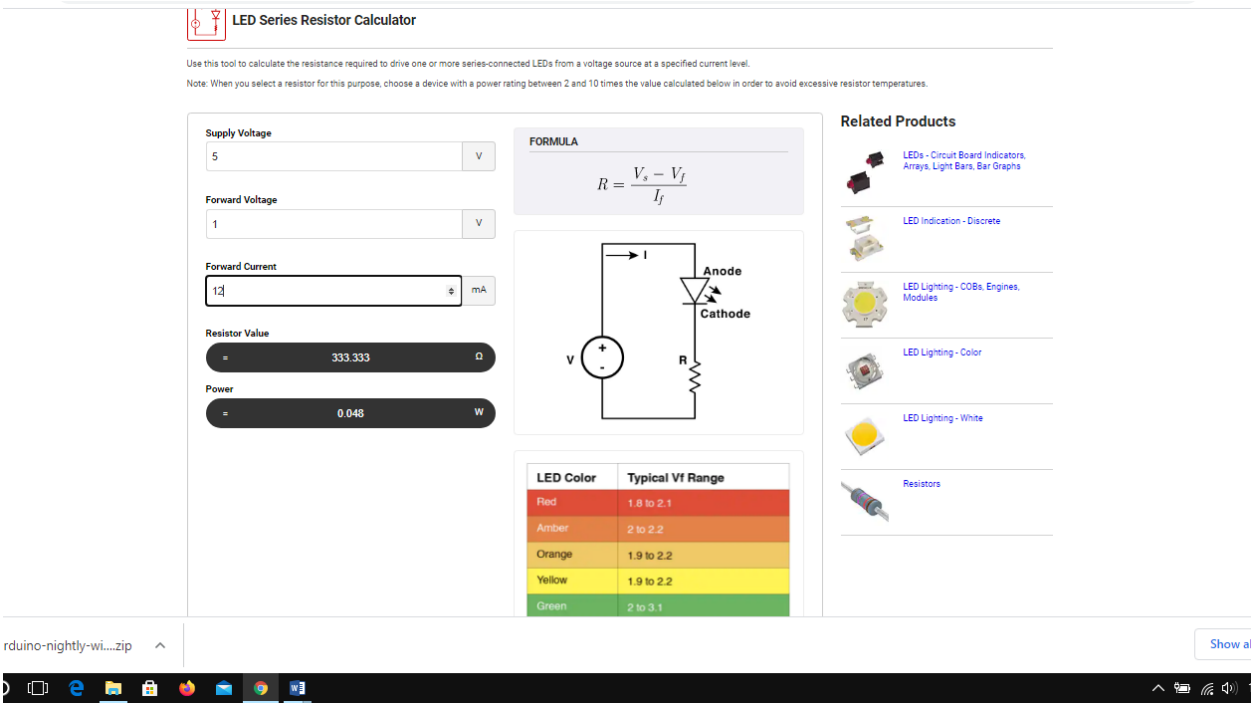
The colour of an LED is obviously of major importance when choosing an LED.

LEDS tend to provide what is effectively a single colour. In fact the light emission extends over a relatively narrow light spectrum.

The colour emitted by an LED is specified in terms of its peak wavelength (lpk) - i.e. the wavelength which has the peak light output. This is measured in nanometers (nm).

The colour of the LED, i.e. the peak wavelength of the emission from the LED governed mainly by the material used for the LED and also by the chip fabrication process. Variations in the process can tailor the peak wavelength variations up to figures of around ±10nm.

When choosing colours within the overall LED specification, it is worth remembering that the human eye is most sensitive to hue or colour variations around the yellow / orange area of the spectrum, i.e. between about 560 to 600 nm. Slight process variations could cause slight colour variations that could be noticeable if orange LEDs are chosen and sit next to each other on a front panel. This may affect the choice of colour, or position of LEDs if this could be a problem.



Arduino
VS
8051 Microcontroller

Comparison Chart

Arduino	8051 Microcontroller
Arduino isn't a microcontroller, it's a system based on an AVR microcontroller with its own IDE.	The 8051 is just a single microcontroller that belongs to the 8-bit family of microcontrollers.
The Arduino Uno has only 32K bytes of flash memory and 2K bytes of SRAM.	The 8051 microcontroller has a total of 128 bytes of RAM and it has no EEPROM.
The Arduino can accept between 6V and 20V (7-12V recommended) via the direct current barrel jack connector or into the Vin pin.	The Intel 8051 operates safely at a voltage between +5 volts to a maximum of 6.6 volts.
Used for home automation systems and IoT applications.	Used in remote controls, power tools, auto engine control systems, appliances, toys, and more.

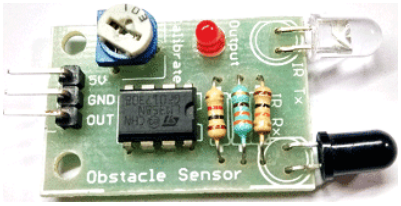
Distinguish between Microprocessor and Microcontroller

S.No	Microprocessor	Microcontroller
1	A microprocessor is a general purpose device which is called a CPU	A microcontroller is a dedicated chip which is also called single chip computer.
2	A microprocessor do not contain onchip I/OPorts, Timers, Memories etc..	A microcontroller includes RAM, ROM, serial and parallel interface, timers, interrupt circuitry (in addition to CPU) in a single chip.
3	Microprocessors are most commonly used as the CPU in microcomputer systems	Microcontrollers are used in small, minimum component designs performing control-oriented applications.
4	Microprocessor instructions are mainly nibble or byte addressable	Microcontroller instructions are both bit addressable as well as byte addressable.
5	Microprocessor instruction sets are mainly intended for catering to large volumes of data.	Microcontrollers have instruction sets catering to the control of inputs and outputs.
6	Microprocessor based system design is complex and expensive	Microcontroller based system design is rather simple and cost effective
7	The Instruction set of microprocessor is complex with large number of instructions.	The instruction set of a Microcontroller is very simple with less number of instructions. For, ex: PIC microcontrollers have only 35 instructions.
8	A microprocessor has zero status flag	A microcontroller has no zero flag.

No.	RISC	CISC
1.	Simple instructions taking one cycle	Complex instructions taking multiple cycles.
2.	Very few instructions refer memory	Most of instructions may refer memory.
3.	Instructions are executed by hardware.	Instructions are executed by microprogram.
4.	Fixed format instructions	Variable format instructions.
5.	Few instructions	Many instructions.
6.	Few addressing mode, and most instructions have register to register addressing mode.	Many addressing modes.
7.	Complexed addressing modes are synthesized in software.	Supports complex addressing modes
8.	Multiple register sets.	Single register set.
9.	Highly pipelined.	Not pipelined or less pipelined.
10.	Complexity is in the compiler	Complexity is in the microprogram
11.	Conditional jump can be based on a bit anywhere in memory.	Conditional jump is usually based on status register bit.

Microcontroller	ATmega328
Clock Speed	16MHz
Operating Voltage	5V
Maximum supply Voltage (not recommended)	20V
Supply Voltage (recommended)	7-12V
Analog Input Pins	6
Digital Input/Output Pins	14
DC Current per Input/Output Pin	40mA
DC Current in 3.3V Pin	50mA
SRAM	2KB
EEPROM	1KB
Flash Memory	32KB of which 0.5KB used by boot loader

IR sensor module



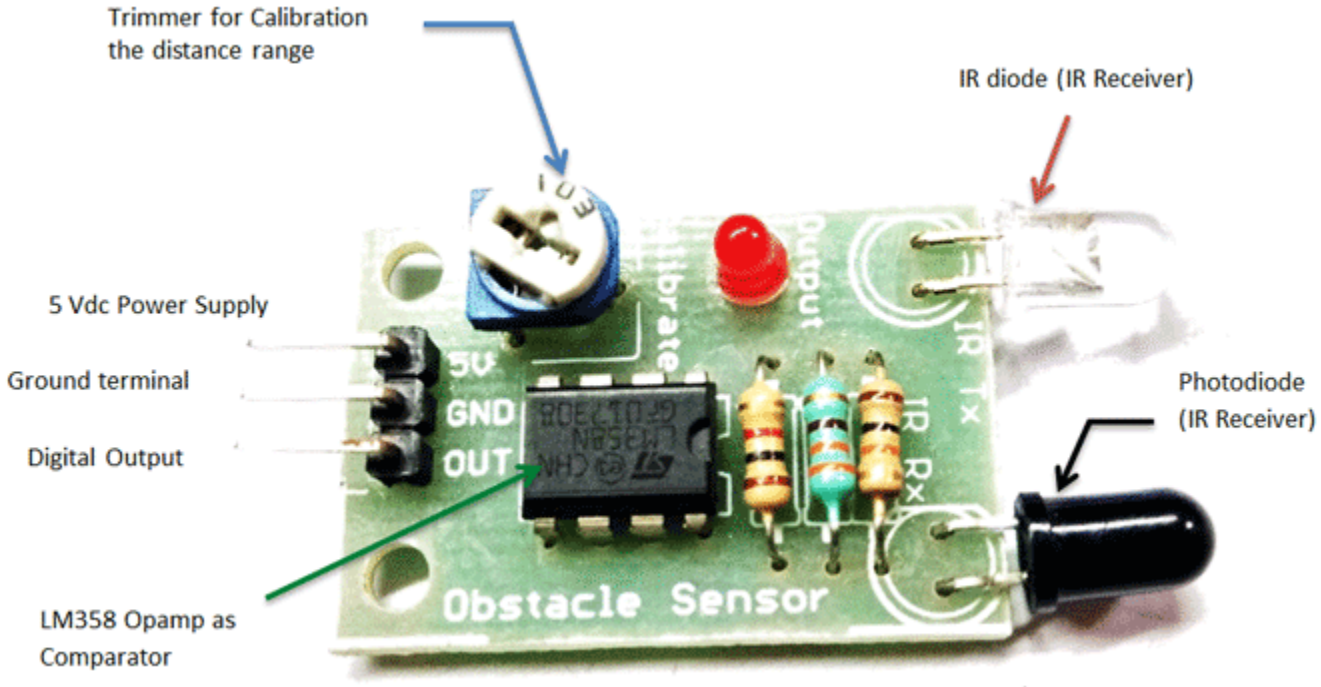
Pin Configuration

Pin Name	Description
VCC	Power Supply Input
GND	Power Supply Ground
OUT	Active High Output

IR Sensor Module Features

- 5VDC Operating voltage
- I/O pins are 5V and 3.3V compliant
- Range: Up to 20cm
- Adjustable Sensing range
- Built-in Ambient Light Sensor
- 20mA supply current
- Mounting hole

Brief about IR Sensor Module



The IR sensor module consists mainly of the IR Transmitter and Receiver, Opamp, Variable Resistor (Trimmer pot), output LED in brief.

IR LED Transmitter

IR LED emits light, in the range of Infrared frequency. IR light is invisible to us as its wavelength (700nm – 1mm) is much higher than the visible light range. IR LEDs have light emitting angle of approx. 20-60 degree and range of approx. few centimeters to several feets, it depends upon the type of IR transmitter and the manufacturer. Some transmitters have the range in kilometers. IR LED white or transparent in colour, so it can give out amount of maximum light.

Photodiode Receiver

Photodiode acts as the IR receiver as its conducts when light falls on it. Photodiode is a semiconductor which has a P-N junction, operated in Reverse Bias, means it start conducting the current in reverse direction when Light falls on it, and the amount of current flow is proportional to the amount of Light. This property makes it useful for IR detection. Photodiode looks like a LED, with a black colour coating on its outer side, Black colour absorbs the highest amount of light.

LM358 Opamp

LM358 is an Operational Amplifier (Op-Amp) is used as voltage comparator in the IR sensor. the comparator will compare the threshold voltage set using the preset (pin2) and the photodiode's series resistor voltage (pin3).

Photodiode's series resistor voltage drop > Threshold voltage = Opamp output is High

Photodiode's series resistor voltage drop < Threshold voltage = Opamp output is Low

When Opamp's output is **high** the LED at the Opamp output terminal **turns ON** (Indicating the detection of Object).

Variable Resistor

The variable resistor used here is a preset. It is used to calibrate the distance range at which object should be detected.

How to Use IR Sensor Module?

The 5 VDC supply input is given to the VCC pin and the supply negative is connected to the GND terminal of the module. When no object is detected within the range of the IR receiver, the output LED remains off.

When a **object is detected** within the range of the IR sensor the LED glows.

Applications

- Obstacle Detection
- Industrial safety devices
- Wheel encoder

GSM Module

SIM900, works on frequencies 850/ 900/ 1800/ 1900 MHz. The Modem is coming with RS232 interface,which allows you connect PC as well as microcontroller with RS232 Chip(MAX232). The baud rate is configurable from 9600-115200 (default baudrate is 9600) through AT command. The GSM/GPRS Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. It is suitable for SMS, Voice as well as DATA transfer application in M2M interface.

The Modem is manufactured with Automatic Pick and place machine with high quality standard.The onboard Low dropout 3A Power supply allows you to connect wide range unregulated power supply . Using this modem,you can make audio calls, SMS, Read SMS, attend the incoming calls and internet etc through simple AT commands.

The SIM900 is a complete Quad-band GSM/GPRS solution in a SMT module which can be embedded in the customer applications. Featuring an industry-

standard interface, the SIM900 delivers GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. With a tiny configuration of 24mm x 24mm x 3 mm, SIM900 can fit almost all the space requirements in your M2M application, especially for slim and compact demand of design.

Note:SIM900 can be used worldwide.GSM-900 Bands and GSM-1800 Bands are used in most parts of the world: Europe, Middle East, Africa,Australia, Oceania (and most of Asia).GSM-850 Bands and GSM-1900 Bands are used in Canada, the United States and many other countries in the Americas.

Features:

- High Quality Product (Not hobby grade)
- Quad-Band GSM/GPRS 850/ 900/ 1800/ 1900 MHz
- RS232 interface for direct communication with computer or MCU kit
- Configurable baud rate
- SMA connector with GSM Antenna.
- SIM Card holder.
- Built in Network Status LED
- Inbuilt Powerful TCP/IP protocol stack for internet data transfer over GPRS.
- Audio interface Connector
- Normal operation temperature: -20 °C to +55 °C
- Input Voltage: 4.5V-12V DC

Specification:

GSM/GPRS Specification	
GSM/GPRS Module	SIM900
Frequency	850MHz/900MHz/1800MHz/1900MHz
Modem Interface	RS232 Serial Interface
Baud Rate(Default factory)	9600bps
Power requirement	4.5V to 12V
Current requirement	<590mA
SIM900 module operating temperature	-40°C to +85°C
Weight	40g

Sim900d is a system on chip(SOC) by **SimCom**. Sim900 can work as gsm and gprs module. It also has Input/Output pins for controlling appliances but they are rarely used. Pre-assembled sim900 gsm boards available in market did not expose its gpio pins. Only the gsm and gprs connection pins are present on board(UART port pins **Tx** and **Rx**).

Sim900d gsm/gprs module works on **AT** command set. Almost every GSM chip by simcom works on **AT** command set. An external microcontroller is required to talk to sim900 gsm module. Sim900 communicates with external controller on **UART** protocol. In uart protocol only two pins are required to talk with external devices **Tx(Transmit)** and **Rx(Receive)**. Both the devices must have one single uart port to talk with each other. Communication speed in uart protocol is termed as **baud rate**. We first have to set the baud rate speed of the modules who are going to communicate on uart protocol. Both the modules must be on the same speed for successful communication.

Arduino has a default uart port on its pins#0 and 1. So arduino can talk to devices which requires uart protocol for communication. Arduino Rx or pin#0 is tied to Tx of sim900 module and arduino Tx or pin#1 is tied with Rx of sim900 module for communication.

Coming to wards 'AT' command set. Their are numerous 'AT' commands if you go through the data sheet of sim900 gsm module. In this tutorial i will explain only the ones which are required to send an sms with gsm sim900 module. If you wan to learn all the commands go through the data

sheet of sim900 module. AT commands which are required to send a text message/sms are listed below. .

Sim900 gsm module 'AT' commands to send an SMS/Text Message

- **AT**
  - ✓ This command sends the status of the GSM. If ready it sends back "ok". If not, it sends back "Error".
- **AT+CMGF=1**
  - ✓ Set Sim900 GSM module in SMS Text Mode.
- **AT+CMGS= "Cell Number"**
  - ✓ Enter the receptionist cell number. **Note: Very Important:** Include the Cell number in double quotes.
- After cell number write your text message. Suppose I want to send **Hello Love**. Final **AT+CMGS= "Cell Number" Hello Love**
- Then press **CTRL+Z** together to send SMS message. Since we are sending message through Arduino code. So, for CTRL+Z key the code is **26**(Decimal) or **0x1A**(Hexadecimal).

sim900 gsm module AT command set to send sms text message

The upper few AT commands are required to send an sms with arduino gsm module. We can skip the first command 'AT', if we are sure that our module is perfectly operational. 'AT' command only checks the status of the gsm module working or not.

GPS Module

GPS (Global Positioning System) module and is used for navigation. The module simply checks its location on earth and provides output data which is longitude and latitude of its position.It is from a family of stand-alone GPS receivers featuring the high performance u-blox 6 positioning engine. These flexible and cost effective receivers offer numerous connectivity options in a miniature (16 x 12.2 x 2.4 mm) package. The compact architecture, power and memory options

make **NEO-6 modules** ideal for **battery operated mobile devices** with very strict cost and space constraints.

Features and Electrical Characteristics

- Standalone GPS receiver
- Anti-jamming technology
- UART Interface at the output pins (Can use SPI ,I2C and USB by soldering pins to the chip core)
- Under 1 second time-to-first-fix for hot and aided starts
- Receiver type: 50 Channels - GPS L1 frequency - SBAS (WAAS, EGNOS, MSAS, GAGAN)
- Time-To-First-fix: For Cold Start 32s, For Warm Start 23s, For Hot Start <1s
- Maximum navigation update rate: 5Hz
- Default baud rate: 9600bps
- EEPROM with battery backup
- Sensitivity: -160dBm
- Supply voltage: 3.6V
- Maximum DC current at any output: 10mA
- Operation limits: Gravity-4g, Altitude-50000m, Velocity-500m/s
- Operating temperature range: -40ºC TO 85°C

Applications

- GPS application
- Smart phone and tablets
- Navigation systems
- Drones
- Hobby projects

How Does GPS Work?

Now that you know the main principles of GPS, you may wish to learn more about the fundamental physics and mathematics behind GPS. Although it is not possible to go into great detail - the entire

system is quite complex and many different aspects must be taken into account - here are some of the underlying facts.

The basic principle inherent in GPS is to determine with the best possible accuracy a point in space, as defined by three coordinates, here geographical latitude and longitude, as well as elevation above sea level. For sailors, the elevation is not relevant!

This is done by means of triangulation, that is measurement of triangles. In practice, this involves determining the distances to at least three GPS satellites from the user's GPS receiver. The positions of the satellites in space are known all the time by means of various observational methods and orbital computational methods.

When one distance is known, the user must be located on the surface of a sphere with the satellite at the centre and with a radius equal to this distance. With two distances, the location must be on a circle that represents the intersection betwen the two spheres. With three distances known, two points are possible of which one will be far out in space and can be eliminated. Thus, the point in space has been determined

The triangulation method

Now that you know the main principles of GPS, you may wish to learn more about the fundamental physics and mathematics behind GPS. Although it is not possible to go into great detail - the entire system is quite complex and many different aspects must be taken into account - here are some of the underlying facts.

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