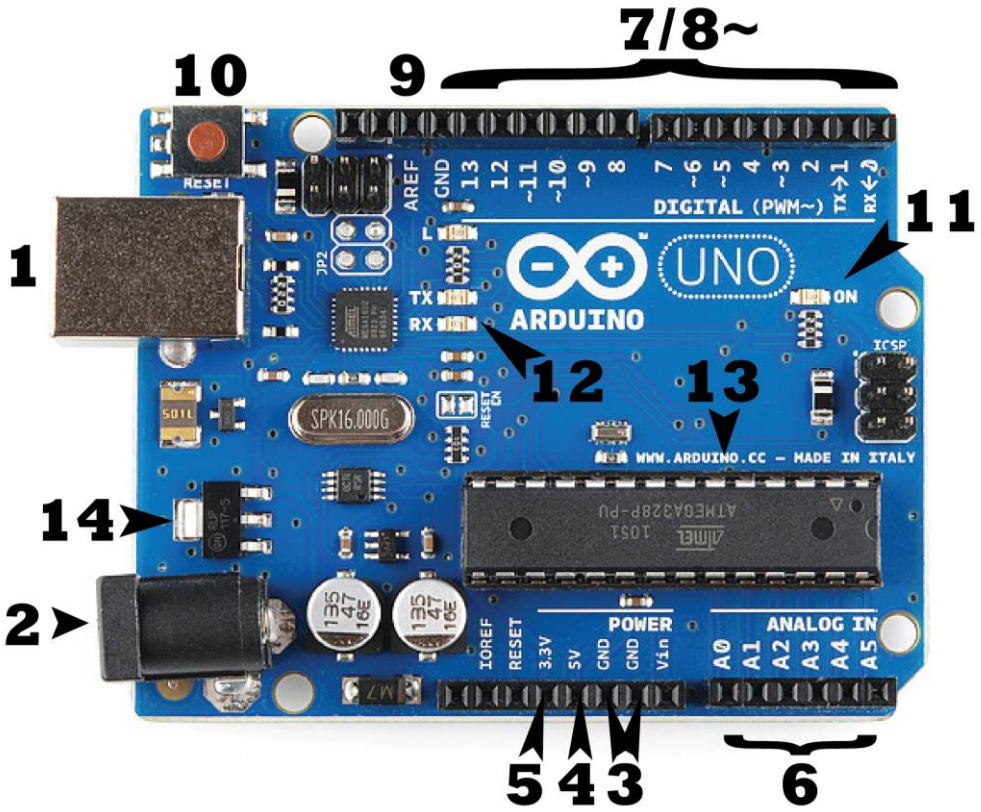
Experiment No. 1

Objective: Introduction to Arduino platform, introduction to various sensors and actuators & its application

Theory:

Arduino is an open-source prototyping platform in electronics based on easy-to-use hardware and software. Arduino is a microcontroller based prototyping board which can be used in developing digital devices that can read inputs like finger on a button, touch on a screen, light on a sensor etc. and turning it in to output like switching on an LED, rotating a motor, playing songs through a speaker etc.

The Arduino board can be programmed to do anything by simply programming the microcontroller on board using a set of instructions for which, the Arduino board consists of a USB plug to communicate with your computer and a bunch of connection sockets that can be wired to external devices like motors, LEDs etc.



Power (USB / Barrel Jack)

Every Arduino board needs a way to be connected to a power source. The Arduino UNO can be powered from a USB cable coming from your computer or a wall power supply that is terminated in a barrel jack. Here, USB connection is labeled (1) and the barrel jack is labeled (2). USB connection is helps to load code onto your Arduino board. NOTE: The recommended voltage for most Arduino models is between 6 and 12 Volts.

Pins (5V, 3.3V, GND, Analog, Digital, PWM, AREF)

Pins on Arduino are places where we connect wires to construct a circuit using black plastic 'headers' that allows to plug a wire right into the board. The Arduino has several different kinds of pins, each of which is labeled on the board and used for different functions.

- GND (3): Short for 'Ground'. There are several GND pins on the Arduino, any of which can be used to ground your circuit.

- 5V (4) & 3.3V (5): As you might guess, the 5V pin supplies 5 volts of power, and the 3.3V pin supplies 3.3 volts of power.
- Analog (6): The area of pins under the 'Analog In' label (A0 through A5 on the UNO) are Analog In pins. These pins can read the signal from an analog sensor (like a temperature sensor) and convert it into a digital value that we can read.
- Digital (7): Across from the analog pins are the digital pins (0 through 13 on the UNO). These pins can be used for both digital input (like telling if a button is pushed) and digital output (like powering an LED).
- PWM (8): Notice tilde (~) symbol, next to some digital pins (3, 5, 6, 9, 10, and 11 on the UNO). These pins act as normal digital pins, but can also be used for something called Pulse-Width Modulation (PWM).
- AREF (9): Stands for Analog Reference. Most of the time you can leave this pin alone. It is sometimes used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins.

Reset Button
the Arduino has a reset button (10). Pushing it will temporarily connect the reset pin to ground and restart any code that is loaded on the Arduino.
Power LED Indicator
Tiny LED next to word 'ON' (11). This LED lights up whenever we plug Arduino into a power source. If this light doesn't turn on, there's a good chance something is wrong. Time to re-check your circuit!
TX RX LEDs
TX is short for transmit, RX is short for receive (used for serial communication).

Main IC
It is the brains of our Arduino. Main IC on Arduino is slightly different from board type, but is usually from the ATmega line of IC's from the ATMEL company.

Voltage Regulator
Voltage regulator (14) controls amount of voltage that is let into the Arduino board. It will turn away an extra voltage that might harm the circuit.

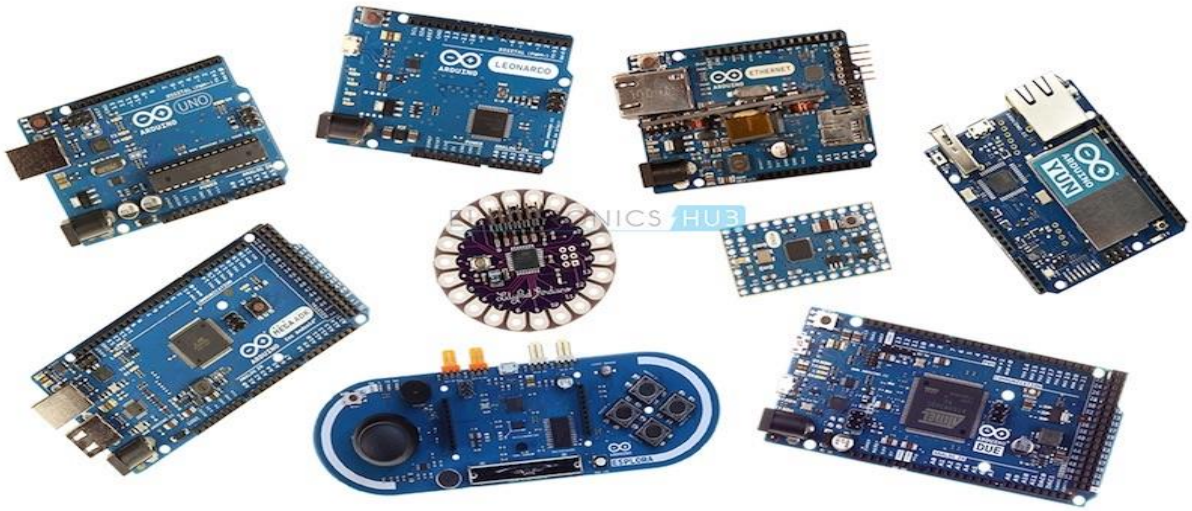
Arduino Programming Language

The Arduino Programming Language is basically a framework built on top of C++. It’s not a real programming language.
A program written in the Arduino Programming Language is called **sketch**. A sketch is normally saved with the .ino extension (from Arduino).
The main difference from “normal” C or C++ is that you wrap all your code into 2 main functions.
One is called **setup(),** the other is called **loop().** The first is called once, when program starts, the second is repeatedly called while your program is running.
We don’t have a main() function like you are used to in C/C++ as the entry point for a program. Once you compile your sketch, the IDE will make sure the end result is a correct C++ program and will basically add the missing glue by pre-processing it.

Types of Arduino Boards

There are many types of Arduino boards available in the market which can be programmed using the Arduino IDE. The reasons for different types of boards are different power supply requirements, connectivity options, their applications etc.

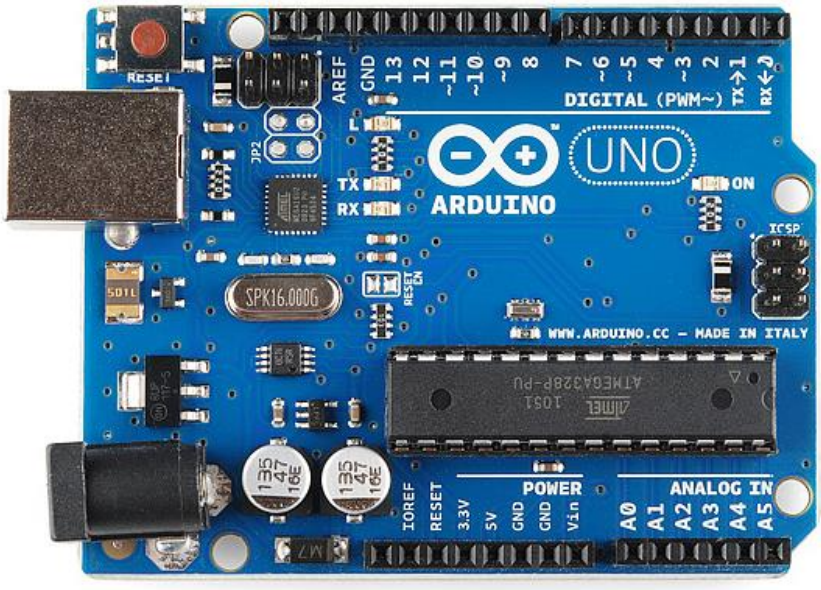
Arduino boards are available in different sizes, form factors, different no. of I/O pins etc. Some of the commonly known and frequently used Arduino boards are Arduino UNO, Arduino Mega, Arduino Nano, Arduino Micro and Arduino Lilypad.



There are add-on modules called Arduino Shields which can be used to extend the functionalities of the Arduino boards. Some of the commonly used shields are Arduino Proto shield, Arduino WiFi Shield and Arduino Yun Shield.

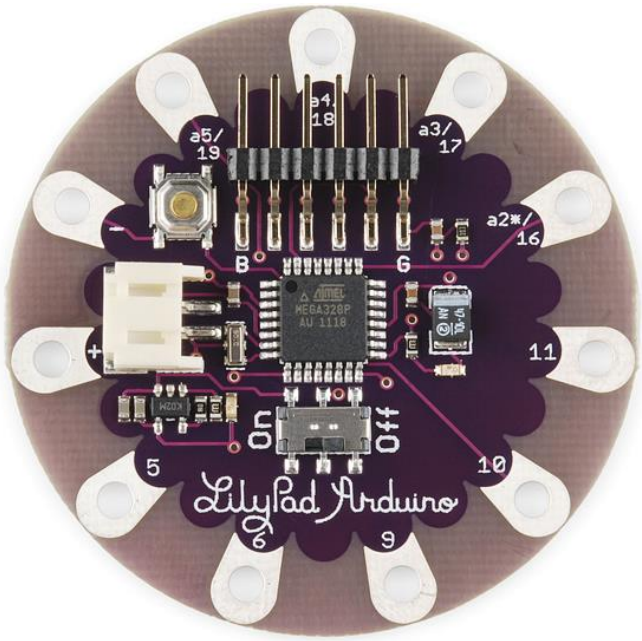
Arduino Uno (R3)

The Uno is a huge option for your initial Arduino. It consists of 14-digital I/O pins, where 6-pins can be used as PWM (pulse width modulation outputs), 6-analog inputs, a reset button, a power jack, a USB connection and more. It includes everything required to hold up the microcontroller; simply attach it to a PC with the help of a USB cable and give the supply to get started with a AC-to-DC adapter or battery.



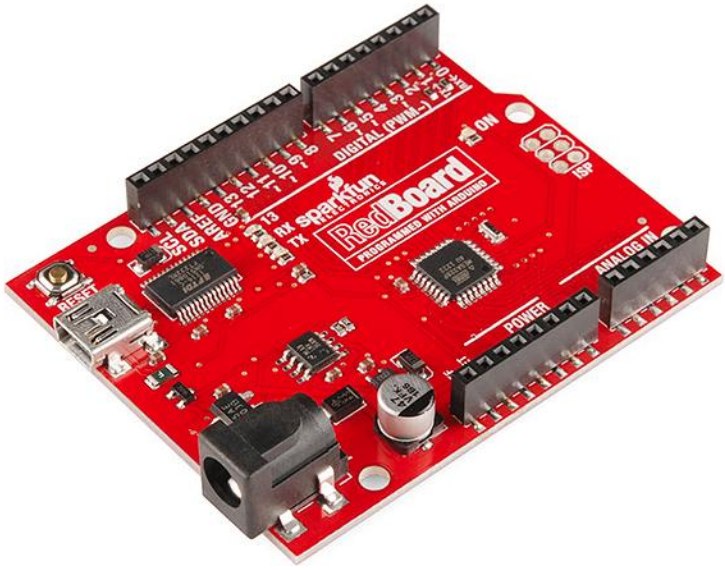
LilyPad Arduino Board

The Lily Pad Arduino board is a wearable e-textile technology expanded by Leah "Buechley"and considerately designed by "Leah and SparkFun". Each board was imaginatively designed with huge connecting pads & a smooth back to let them to be sewn into clothing using conductive thread. This Arduino also comprises of I/O, power, and also sensor boards which are built especially for e-textiles. These are even washable!



RedBoard Arduino Board

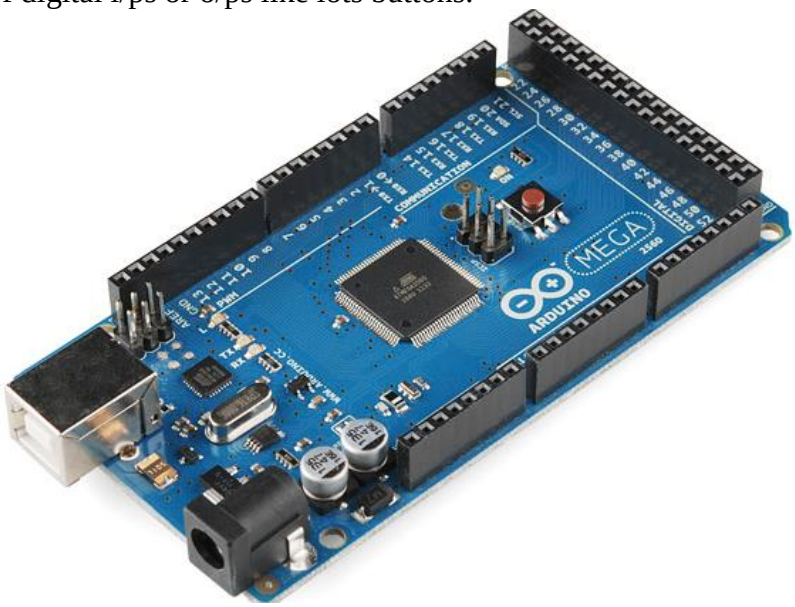
The RedBoard aAduino board can be programmed using a Mini-B USB cable using the Arduino IDE. It will work on Windows 8 without having to modify your security settings.It is more constant due to the USB or FTDI chip we used and also it is entirely flat on the back. Creating it is very simple to utilize in the project design. Just plug the board, select the menu option to choose an Arduino UNO and you are ready to upload the program. You can control the RedBoard over USB cable using the barrel jack.



Arduino Mega (R3) Board

The Arduino Mega is similar to the UNO's big brother. It includes lots of digital I/O pins (from that, 14-pins can be used as PWM o/ps), 6-analog inputs, a reset button, a power jack, a USB connection and a reset button. It includes everything required to hold up the microcontroller; simply attach it to a PC with the help of a USB cable and give the supply to get started with a AC-to-DC adapter or

battery.The huge number of pins make this Arduino board very helpful for designing the projects that need a bunch of digital i/ps or o/ps like lots buttons.



Arduino Leonardo Board

The first development board of an Arduino is the Leonardo board. This board uses one microcontroller along with the USB. That means, it can be very simple and cheap also. Because this board handles USB directly, program libraries are obtainable which let the Arduino board to follow a keyboard of the computer, mouse, etc.

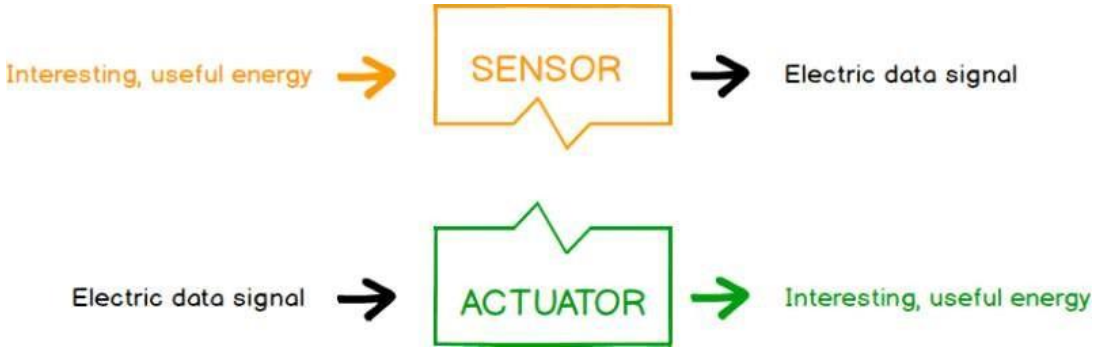
Introduction to Sensors and Actuators:

Sensors and actuators are two critical components of every closed loop control system. Such a system is also called a mechatronics system. Mechatronics system consists of a sensing unit, a controller, and an actuating unit. Sensing unit consist of additional components such as filters, amplifiers, modulators, and other signal conditioners. Controller accepts information from sensing

unit, makes decisions based on control algorithm, and outputs commands to actuating unit. Actuating unit consists of an actuator and optionally a power supply and a coupling mechanism.

What is a Sensors?

A **Sensor** is a converter that measures a physical quantity and converts it into a signal which can be read by an observer or by an (today mostly electronic) instrument.



SENSORS

We frequently use different types of sensors in several electrical and electronic applications, which are classified as chemical, pressure, temperature, position, force, proximity, thermal, presence, flow, optical, automotive, sound, speed, magnetic, electric, heat, fiber-optic sensors, analog and digital sensors. A sensor can be defined as an appliance that detects changes in physical or electrical or other quantities and by this means, generally, produces an electrical or optical signal output as an acknowledgement of the change in that specific quantity.

What is an Actuator:

An **Actuator** is a type of motor for moving or controlling a mechanism or system. It is operated by a source of energy, typically electric current, hydraulic fluid pressure, or pneumatic pressure, and converts that energy into motion. An actuator is the mechanism by which a control system acts upon an environment.

Actuators are devices which drive a machine (robot) including its grippers. Muscles of a human arm and hand. While human arm provides motion, hand is used for object manipulation. So, actuators in robots (machine) provides motion while grippers manipulates objects. An actuator system comprises of several subsystems, namely,

(i) Power supply; (ii) Power amplifier;
(iii) Servomotor; (iv) Transmission system.

<u>Different Types of Sensors</u>

The following is a list of different types of sensors that are commonly used in various applications. All these sensors are used for measuring one of the physical properties like Temperature, Resistance, Capacitance, Conduction, Heat Transfer etc.

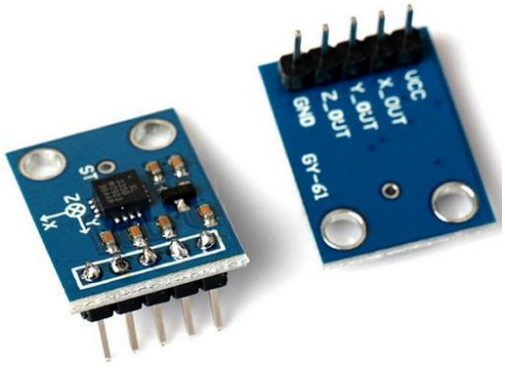
1. Temperature Sensor
2. Proximity Sensor
3. Accelerometer
4. IR Sensor (Infrared Sensor)
5. Pressure Sensor
6. Light Sensor
7. Ultrasonic Sensor
8. Smoke, Gas and Alcohol Sensor
9. Touch Sensor

10. Color Sensor
11. Humidity Sensor
12. Position Sensor
13. Magnetic Sensor (Hall Effect Sensor)
14. Microphone (Sound Sensor)
15. Tilt Sensor
16. Flow and Level Sensor
17. PIR Sensor
18. Touch Sensor
19. Strain and Weight Sensor

ANALOG SENSORS

1. **Accelerometers**

   Analog sensors that detect changes in position, velocity, orientation, shock, vibration, and tilt by sensing motion are called as accelerometers. These analog accelerometers are again classified into different types based on the variety of configurations and sensitivities.

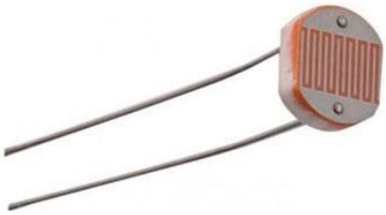


These accelerometers are available as analog and digital sensors, based on the output signal. Analog accelerometer produces a constant variable voltage based on the amount of acceleration applied to the accelerometer.

- Small board size - Just 28mm X 23mm
- Simple 5 pin interface (VCC, GND, Xout, Yout, Zout, Self Test)
- Needs no external components
- Easy to mount on General purpose PCB, Breadboards and special PCBs
- Low Current Consumption: 500 µA
- Low Voltage Operation: 5V
- High Sensitivity for small movements
- Fast Turn On Time
- Integral Signal Conditioning with Low Pass Filter
- Robust Design, High Shocks Survivability

2. Light Sensors

Analog sensors that are used for detecting the amount of light striking the sensors are called as light sensors. These analog light sensors are again classified into various types such as photo-resistor, Cadmium Sulfide (CdS), and, photocell.



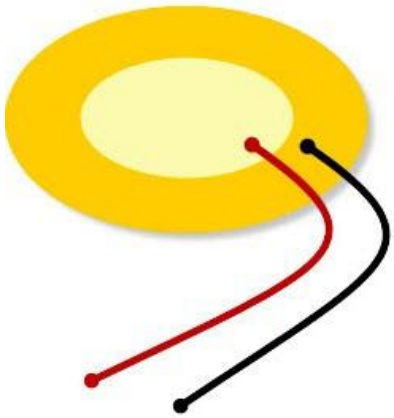
Light dependent resistor (LDR) can be used as analog light sensor which can be used to switch on and off loads automatically based on the day light incident on the LDR. The resistance of the LDR increases with decrease in light and decreases with increase in light.

3. Sound Sensors

Analog sensors that are used to sense sound level are called as sound sensors. These analog sound sensors translate the amplitude of the acoustic volume of the sound into an electrical voltage for sensing sound level. This process requires somecircuitry, and utilizes microcontroller along with a microphone for creating an analog output signal.

4. Pressure Sensor

The analog sensors that are used to measure the amount of pressure applied to a sensor are called as analog pressure sensors. Pressure sensor will produce an analog output signal that is proportional to the amount of applied pressure. These piezoelectric sensors are one type of pressure sensors that can produce an analog output voltage signal proportional to the pressure applied to the piezoelectric sensor.

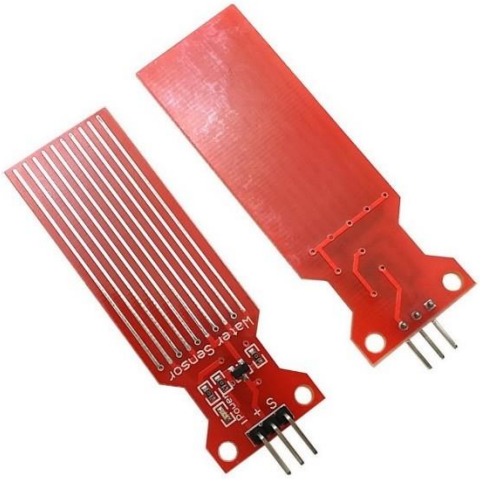


5. Analog Temperature sensor

Temperature sensors are widely available as both digital and analog sensors. Typically used analog temperature sensors are thermistors. There are different types of thermistors that are used for different applications. Thermistor is a thermally sensitive resistor that is used for detecting changes in temperature. If the temperature increases, then the electrical resistance of thermistor increases. Similarly, if temperature decreases, then the resistance decreases. It is used in various temperature sensor applications.

6. Water Level Sensor

Water Sensor water level sensor is an easy-to-use, cost-effective high level/drop recognition sensor, which is obtained by having a series of parallel wires exposed traces measured droplets/water volume to determine the water level. Easy to complete water to analog signal conversion and output analog values can be directly read Arduino development board to achieve the level alarm effect.

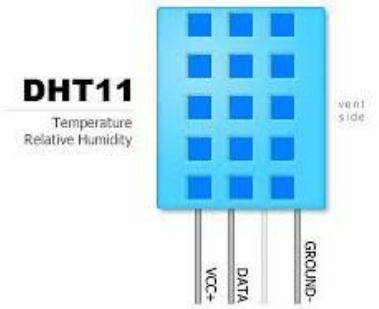


DIGITAL SENSORS:

Electronic sensors or electrochemical sensors in which data conversion and data transmission takes place digitally are called as digital sensors. These digital sensors are replacing analog sensors as they can overcome the drawbacks of analog sensors. The digital sensor consists of majorly three components: senor, cable, and transmitter. In digital sensors, the signal measured is directly converted into digital signal output inside the digital sensor itself. And this digital signal is transmitted through cable digitally. There are different types of digital sensors that overcome disadvantages of analog sensors.

1. Digital Temperature and Humidity Sensor

DHT11 and DHT22 digital temperature sensor available for measurement of temperature and humidity



DHT11 sensor includes a resistive-type humidity measurement component, an NTC temperature measurement component and a high- performance 8-bit microcontroller inside, and provides calibrated digital signal output. It has high reliability and excellent long-term stability

DHT22 includes a capacitive sensor wet component and a high-precision temperature measurement device, and connected with a high-performance 8-bit microcontroller. The sensor has excellent quality, fast response, strong anti-jamming capability, and high cost. Standard single-bus interface, system integration quick and easy. Small size, low power consumption, signal transmission distance up to 20 meters, making it the best choice of all kinds of applications and even the most demanding applications. DHT22 has higher precision and can replace the expensive imported SHT10 temperature and humidity sensor.

DHT22 pins	
1	VCC
2	DATA
3	NC
4	GND

2. Ultrasonic Sensor

Ultrasonic sensor distance measuring module is stable, measure the distance accurately. The sensor with High precision, blind spots (3cm) super close. Its provides a full set of ranging process

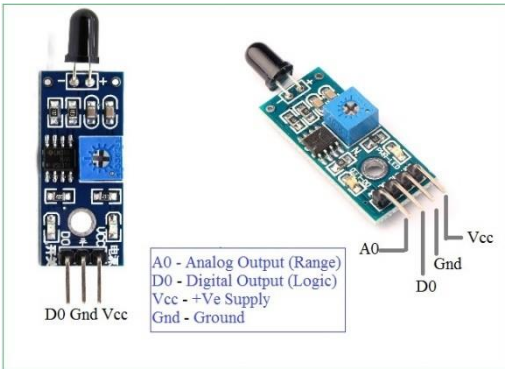
3. IR Sensor (Obstacle sensor)

IR Obstacle Sensor consists of a TSOP as a receiver and IR LED as a transmitter. TSOP as a receiver provides flexibility of sensing light.The sensor is perfectly suited for Detecting obstacle within line of sight. Interface with any device compatible with Digital Signal.

- Obstacle Avoider or Obstacle sensor for robots and electronics with range between 3cms to 7cms
- 0.1th inch (2.54 mm) with Breadboard compatiblity
- Obstacle sensing LED and Power LED
- Arduino, AVR, PIC and other microcontroller Compatible
- A compact form on a tiny board

4. Flame Sensor

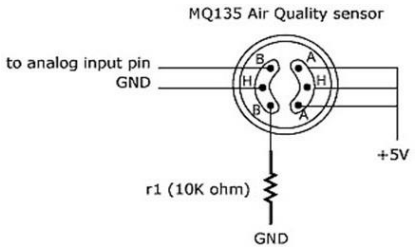
Flame Detection Sensor Module is sensitive to the flame, but also can ordinary light. Usually used as a flame Detects a flame or a light source of a wavelength in the range of 760nm Flame detection distance, lighter flame test can be triggered within 0.8m, if the intensity of flame is high , the detection distance will be increased.



5. Gas Sensor

It is a hazardous gas detection apparatus for the family, the environment, suitable for ammonia, aromatic compounds, Sulphur, benzene vapors, smoke and other gases harmful gas detection, gas-sensitive element test.

Air quality sensor is for detecting a wide range of gases, including NH3, NOx, alcohol, benzene, smoke and CO2. Ideal for use in office or factory with simple drive and monitoring circuit.



- Dual signal output (analog output, and TTL level output)
- TTL output valid signal is low
- Analog output with increasing concentration, the higher the concentration, the higher the voltage
- Sulphide, benzene, smoke and other harmful gases with high sensitivity

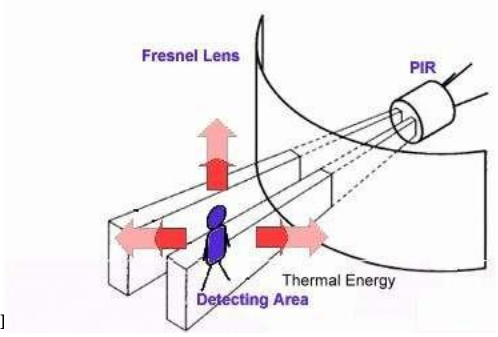
- Has a long life and reliable stability
- Rapid response recovery characteristics

6. Line Tracker Sensor

Line Tracker sensor consists of 3 IR transmitter and IR receiver pairs. This tracker sensor is typically used for robots in line following task. It can be used for either dark or bright line following. The tracker sensor have 3 digital outputs to user indicating the existence of the line. Every sensor is provided with its own LEDs as indication of line detection

7. PIR Motion sensor

The Passive Infrared Sensor (PIR) sensor module is used for motion detection. It can be used as motion detector for security systems or robotics. It works on 5V DC and gives TTL output which can be directly given to microcontroller or to relay through a transistor.It consists of pyroelectric sensor and Fresnel lens that detects motion by measuring change in the infrared levels emitted by the objects. It can detect motion up to 20ft. This module is very sensitive to change in infrared levels subjected by human movement.



- Supply: 5V DC
- Detection range: 6meters
- Output: 3.3V
- Adjustable sensitivity levels (High or Low)
- Settling time: 60 seconds
- Size: Length 32mm, Width 24mm, Height 26m

ACTUATORS

1. Relay

Relay provides an electrical connection between two or more points in response to the application of a control signal. Relays are basically electrically operated switches that come in many shapes, sizes and power ratings suitable for all types of applications. Relays can also have single or multiple contacts within a single package

2. DC Motor

A DC motor (Direct Current motor) is the most common type of motor. DC motors normally have just two leads, one positive and one negative. If you connect these two leads directly to a battery, the motor will rotate. If you switch the leads, the motor will rotate in the opposite direction.

3. Servo Motor

A Servo Motor is a small device that has an output shaft. This shaft can be positioned to specific angular positions by sending the servo a coded signal. If the coded signal exists on the input line, the servo will maintain the angular position of the shaft. If the coded signal changes, the angular position of the shaft changes. In practice, servos are used in radio-controlled airplanes to position control surfaces like the elevators and rudders. They are also used in radio-controlled cars, puppets, and of course, robots.

A standard servo such as the Futaba S-148 has 42 oz/inches of torque, which is strong for its size. It also draws power proportional to the mechanical load. A lightly loaded servo, therefore, does not consume much energy.

4. Stepper Motor

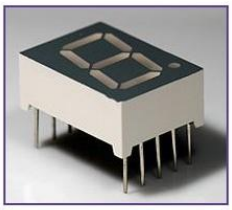
A Stepper Motor or a step motor is a brushless, synchronous motor, which divides a full rotation into several steps. Unlike a brushless DC motor, which rotates continuously when a fixed DC voltage is applied to it, a step motor rotates in discrete step angles.

The Stepper Motors therefore are manufactured with steps per revolution of 12, 24, 72, 144, 180, and 200, resulting in stepping angles of 30, 15, 5, 2.5, 2, and 1.8 degrees per step. The stepper motor can be controlled with or without feedback.

Imagine a motor on an RC airplane. The motor spins very fast in one direction or another. You can vary the speed with the amount of power given to the motor, but you cannot tell the propeller to stop at a specific position.
Now imagine a printer. There are lots of moving parts inside a printer, including motors.

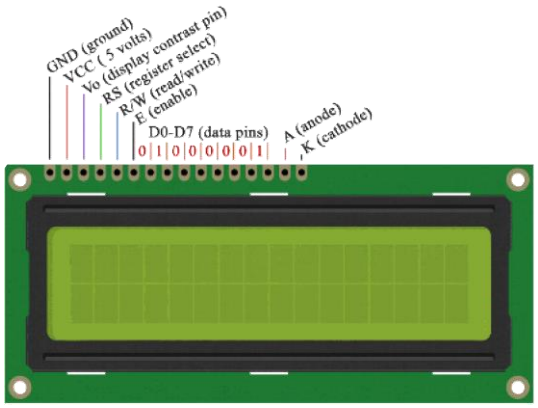
5. Seven Segment Display

The seven segments display a very simple device. It is a combination of 8 LEDs (the decimal point -DP- is the 8th), which can be arranged so that different combinations can be used to make numerical digits.



Segments Inputs							7 Segment Display Output
a	b	c	d	e	f	g	
0	0	0	0	0	0	1	0
1	0	0	1	1	1	1	1
0	0	1	0	0	1	0	2
0	0	0	0	1	1	0	3
1	0	0	1	1	0	0	4
0	1	0	0	1	0	0	5
0	1	0	0	0	0	0	6
0	0	0	1	1	1	1	7
0	0	0	0	0	0	0	8
0	0	0	0	1	1	0	9

6. LCD Display



An LCD is an electronic display module which uses liquid crystal to produce a visible image. The 16×2 LCD display is a very basic module commonly used in DIYs and circuits. The 16×2 translates display 16 characters Per line in 2 such lines. In this LCD each character is displayed in a 5×7 pixel matrix