TECHNOCRATS ROBOTICS

VACATION TASKS

SET-5

Operations of various modules

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Tanush Biju

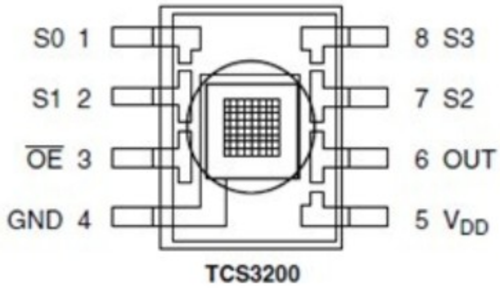
TCS3200 Color Sensor

TCS-3200 is a complete color detector, including a TAOS TCS3200 RGB sensor chip and 4 white LED's. The TCS3200 can detect and measure a nearly limitless range of visible colors. Applications include test strip reading, sorting by color, ambient light sensing and calibration, and color matching, to name just a few.

The TCS3200 GBB Color Sensor For Arduino has an array of photo detectors, each with either a red, green, or blue filter, or no filter (clear). The filters of each color are distributed evenly throughout the array to eliminate location bias among the colors. Internal to the device is an oscillator which produces a square-wave output whose frequency is proportional to the intensity of the chosen color.

Specifications

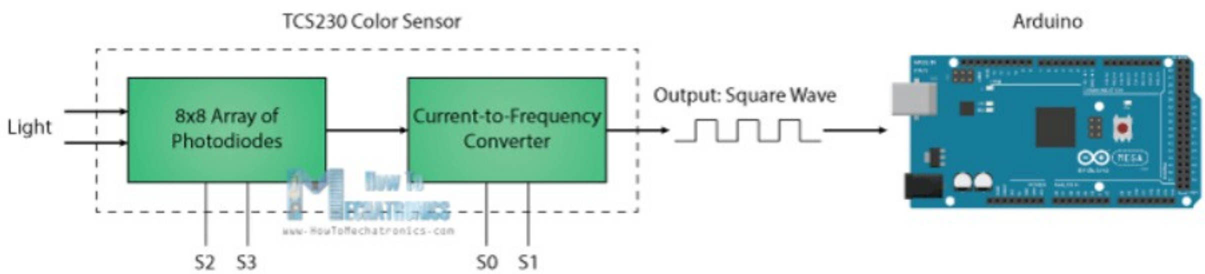
- Single-Supply Operation (2.7V to 5.5V)
- High-Resolution Conversion of Light Intensity to Frequency
- Programmable Color and Full-Scale Output Frequency
- Power Down Feature
- Communicates Directly to Microcontroller
- S0~S1: Output frequency scaling selection inputs
- S2~S3: Photodiode type selection inputs
- OUT Pin: Output frequency
- OE Pin: Output frequency enable pin (active low), can be impending when using
- Support LED lamp light supplement control
- Size: 28.4x28.4mm
- VDD-Supply voltage
- GND-Power supply ground



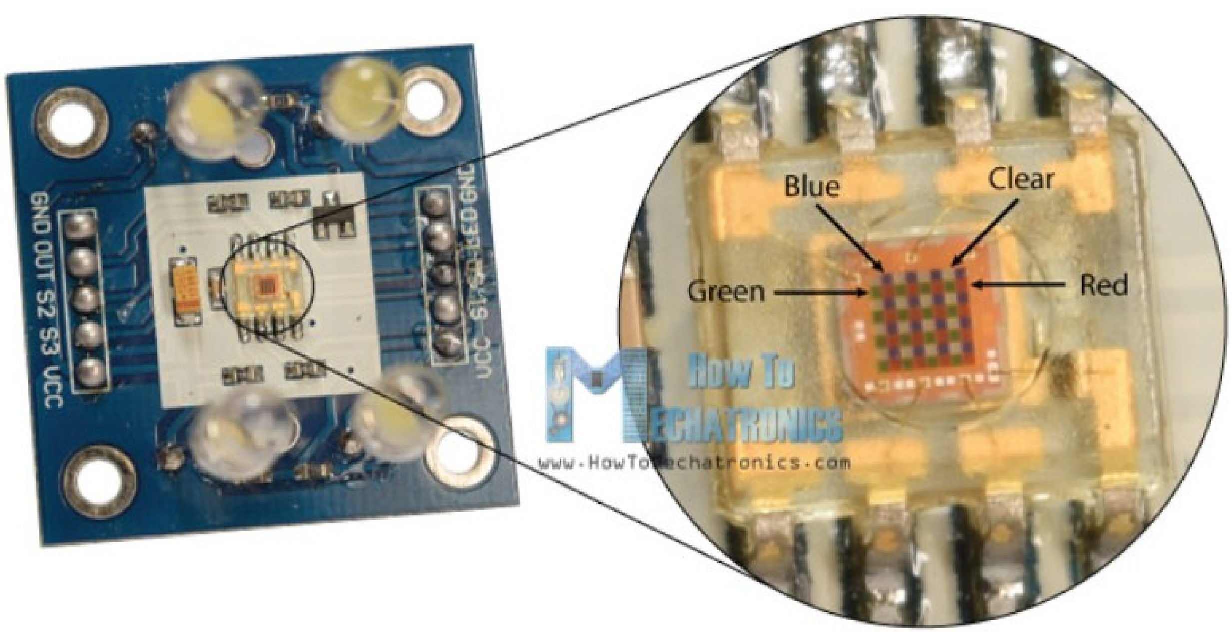
Pin Name	I/O	DESCRIPTION
GND(4)		Power supply ground. All voltages are referenced to GND
OE(3)	I	Enable for fo (active low).
OUT	O	Output frequency (fo).
S0,S1（1,2）	I	Output frequency scaling selection inputs.
S2,S3（7,8）	I	Photodiode type selection inputs
VDD（5）		Supply voltage

Working

The TCS230 senses color light with the help of an 8 x 8 array of photodiodes. Then using a Current-to-Frequency Converter the readings from the photodiodes are converted into a square wave with a frequency directly proportional to the light intensity. Finally, using the Arduino Board we can read the square wave output and get the results for the color.



If we take a closer look at the sensor we can see how it detects various colors. The photodiodes have three different color filters. Sixteen of them have red filters, another 16 have green filters, another 16 have blue filters and the other 16 photodiodes are clear with no filters.



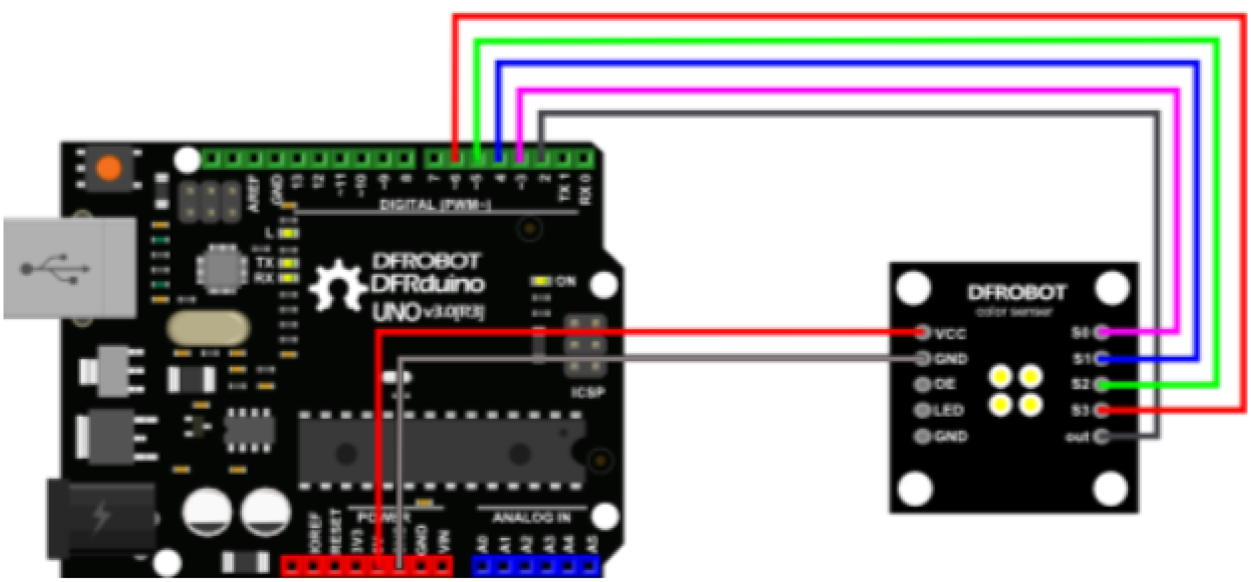
Each 16 photodiodes are connected in parallel, so using the two control pins S2 and S3 we can select which of them will be read. So for example, if we want to detect red color, we can just use the 16 red filtered photodiodes by setting the two pins to low logic level according to the table.

S0	*S1*	*Output Frequency Scaling*
L	L	Power down
L	H	2%
H	L	20%
H	H	100%

S2	*S3*	*Photodiode Type*
L	L	Red
L	H	Blue
H	L	Clear (no filter)
H	H	Green

The sensor has two more control pins, S0 and S1 which are used for scaling the output frequency. The frequency can be scaled to three different preset values of 100 %, 20 % or 2%. This frequency-scaling function allows the output of the sensor to be optimized for various frequency counters or microcontrollers.

Connection Diagram



Wiring instructions	
VCC——5V	GND——GND
S0——D3	S1——D4
S2——D5	S3——D6
OUT——D2	

Hardware and Software Required

- Colour Sensor TCS3200 Module
- Arduino Uno
- Arduino IDE(1.0.6V)

Hardware Connections

The color sensor should be connected to Arduino Uno as follows:

- VCC to 5V
- GND to GND
- S0 to digital pin 8
- S1 to digital pin 9
- S2 to digital pin 12
- S3 to digital pin 11
- OUT to digital pin 10

In addition to this, connect red, green and blue led to digital pin 2,3 and 4 of Arduino Uno board.

Program for Colour Sensor TCS3200

After the connections are made, upload the problem given below. Now place red colour which means any object red in color in front of the colour sensor and as a result the red led will glow as soon as it senses the red colour. Likewise repeat the same to detect the green and blue colour.

```
const int s0 = 8;
const int s1 = 9;
const int s2 = 12;
const int s3 = 11;
const int out = 10;
// LED pins connected to Arduino
int redLed = 2;
int greenLed = 3;
int blueLed = 4;
// Variables
int red = 0;
int green = 0;
int blue = 0;
void setup()
{
 Serial.begin(9600);
 pinMode(s0, OUTPUT);
 pinMode(s1, OUTPUT);
 pinMode(s2, OUTPUT);
 pinMode(s3, OUTPUT);
 pinMode(out, INPUT);
```

```
 pinMode(redLed, OUTPUT);
 pinMode(greenLed, OUTPUT);
 pinMode(blueLed, OUTPUT);
 digitalWrite(s0, HIGH);
 digitalWrite(s1, HIGH);
}
void loop()
{
 color();
 Serial.print("R Intensity:");
 Serial.print(red, DEC);
 Serial.print(" G Intensity: ");
 Serial.print(green, DEC);
 Serial.print(" B Intensity : ");
 Serial.print(blue, DEC);
 //Serial.println();
 if (red < blue && red < green && red < 20)
 {
  Serial.println(" - (Red Color)");
  digitalWrite(redLed, HIGH); // Turn RED LED ON
  digitalWrite(greenLed, LOW);
  digitalWrite(blueLed, LOW);
 }
  else if (blue < red && blue < green)
 {
  Serial.println(" - (Blue Color)");
  digitalWrite(redLed, LOW);
  digitalWrite(greenLed, LOW);
  digitalWrite(blueLed, HIGH); // Turn BLUE LED ON
 }
  else if (green < red && green < blue)
 {
  Serial.println(" - (Green Color)");
  digitalWrite(redLed, LOW);
  digitalWrite(greenLed, HIGH); // Turn GREEN LED ON
  digitalWrite(blueLed, LOW);
 }
 else{
 Serial.println();
 }
 delay(300);
 digitalWrite(redLed, LOW);
 digitalWrite(greenLed, LOW);
 digitalWrite(blueLed, LOW);
}
void color()
{
 digitalWrite(s2, LOW);
 digitalWrite(s3, LOW);
```

```
 //count OUT, pRed, RED
 red = pulseIn(out, digitalRead(out) == HIGH ? LOW : HIGH);
 digitalWrite(s3, HIGH);
 //count OUT, pBLUE, BLUE
 blue = pulseIn(out, digitalRead(out) == HIGH ? LOW : HIGH);
 digitalWrite(s2, HIGH);
 //count OUT, pGreen, GREEN
 green = pulseIn(out, digitalRead(out) == HIGH ? LOW : HIGH);
}
```

MPU6050 Sensor

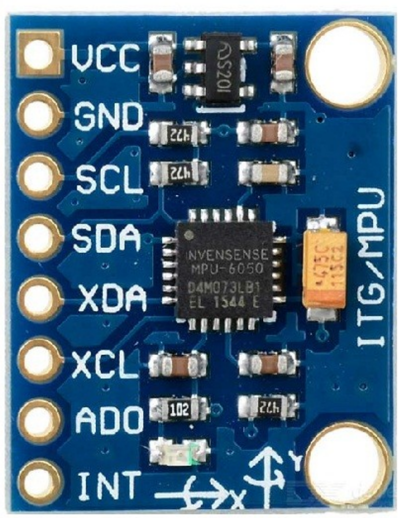
MPU-6050 is an IMU Sensor that contains a MEMS (Microelectromechanical System) Accelerometer and MEMS Gyroscope on a single chip.

Here, IMU Sensor, where IMU stands for Inertial Measurement Unit, is a device that measures the specific force using Accelerometer, angular rate using Gyroscope and magnetic field using Magnetometers.

IMU Sensors are used in self-balancing robots, aircrafts, mobile phones, tablets, spacecraft, satellites, drones, UAVs (unmanned aerial vehicles) etc. for guidance, position detection, orientation detection, motion tracking and flight control.

The two common IMUs are ADXL 335 Accelerometer and MPU-6050. The ADXL 335 contains a 3-axis Accelerometer.

In case of MPU-6050, it is a six-axis motion tracking device that combines a 3-axis Accelerometer and a 3-axis Gyroscope on a single chip.



The MPU-6050 is a six-axis motion tracking device developed by InvenSense. The main features of the MPU6050 device are mentioned below.

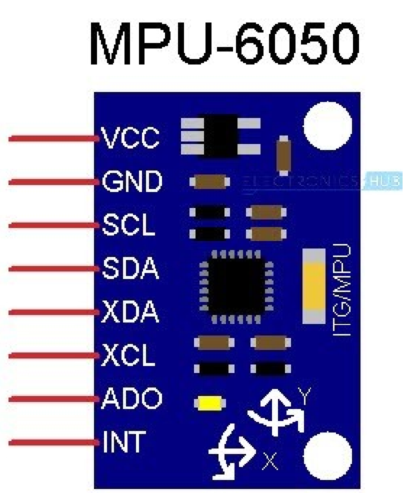
- Three – axis Accelerometer
- Three – axis Gyroscope
- Digital Output Temperature Sensor
- Six 16-bit ADC (three for Accelerometer and three for Gyro)
- Integrated Digital Motion Processor (DMP)
- 1024B FIFO Buffer

The six-axis MPU-6050 is some time called as a 6 DoF (six Degrees of Freedom) device, as it provides six output values (three from Accelerometer and three from Gyro). The MPU-6050 can communicate using I2C Protocol.

Digital Motion Processor or the DMP is an embedded processor that can reduce the computational load from the host processor, like an Arduino, by acquiring and processing data from Accelerometer, Gyroscope and an external Magnetometer.

Interfacing MPU6050 with Arduino

As mentioned earlier, the MPU6050 supports only I2C Communication and hence, it must be connected only to the I2C Pins of the Arduino. The I2C pins of Arduino are multiplexed with the analog input pins A4 and A5 i.e. A4 is SDA and A5 is SCL.



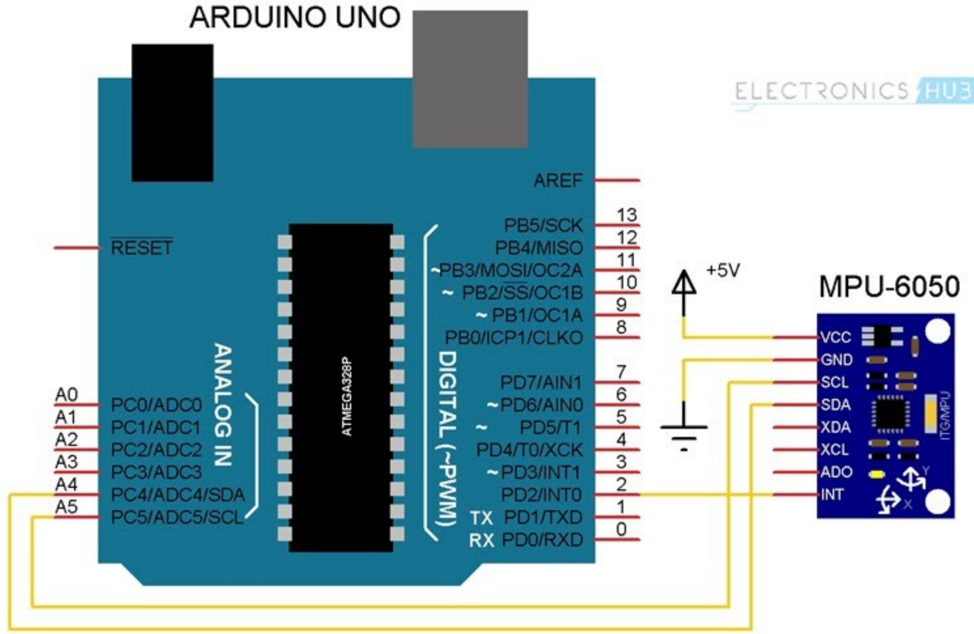
Circuit Diagram

The following image shows the circuit diagram for interfacing MPU6050 with Arduino UNO. As mentioned earlier, the interface between MPU6050 and Arduino must be implemented using I2C Protocol.

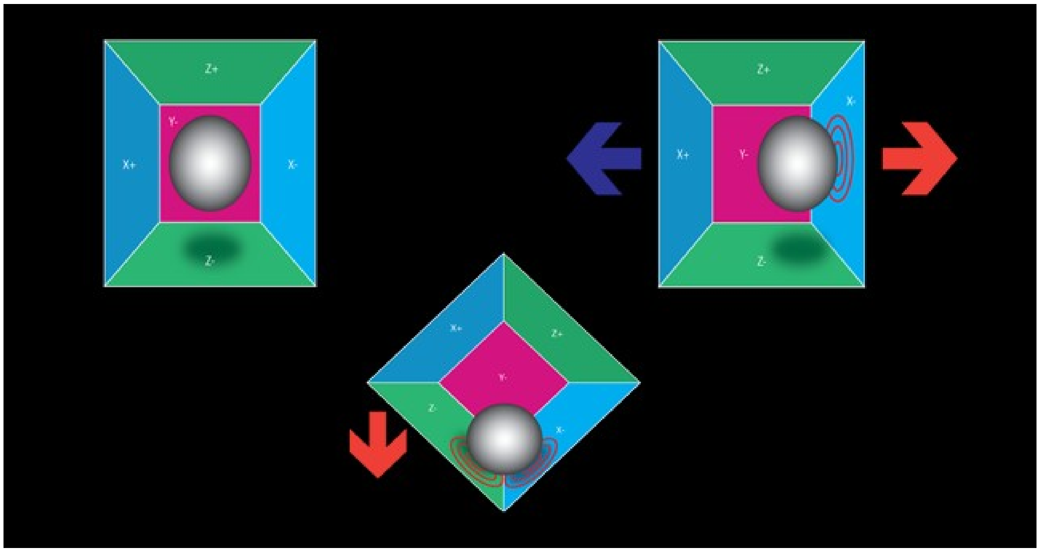
Hence, the SCL Pin of the Arduino (A5) is connected to the SCL Pin of the MPU6050. Similarly, the SDA Pin of the Arduino (A4) is connected to the SDA Pin of the MPU6050 board.

Additionally, we will be using the Interrupt feature of the MPU6050 to indicate (or interrupt) Arduino when the 1024 Byte FIFO buffer is full. So, connect the INT pin of the MPU6050 to the external interrupt 0 (INT0) pin of Arduino UNO i.e. Pin 2.

NOTE: In I2C Communication, the MPU-6050 always acts as a slave.

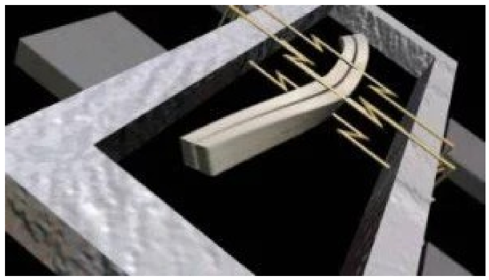


Working of Accelerometer



An accelerometer works on the principle of the piezoelectric effect. Imagine a cuboidal box with a small ball inside it, like in the picture above. The walls of this box are made with piezoelectric crystals. Whenever you tilt the box, the ball is forced to move in the direction of the inclination due to gravity. The wall that the ball collides with creates tiny piezoelectric currents. There are three pairs of opposite walls in a cuboid. Each pair corresponds to an axis in 3D space: X, Y, and Z axes. Depending on the current produced from the piezoelectric walls, we can determine the direction of inclination and its magnitude.

Working of Gyroscope



Gyroscopes work on the principle of Coriolis acceleration. Imagine that there is a fork-like structure that is in a constant back-and-forth motion. It is held in place using piezoelectric crystals. Whenever you try to tilt this arrangement, the crystals experience a force in the direction of inclination. This is caused as a result of the inertia of the moving fork. The crystals thus produce a current in consensus with the piezoelectric effect, and this current is amplified. The values are then refined by the host microcontroller.

HC-05 Module

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication. This serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature).

The Bluetooth module HC-05 is a MASTER/SLAVE module. By default the factory setting is SLAVE. The Role of the module (Master or Slave) can be configured only by AT COMMANDS. The slave modules cannot initiate a connection to another Bluetooth device, but can accept connections. Master module can initiate a connection to other devices.

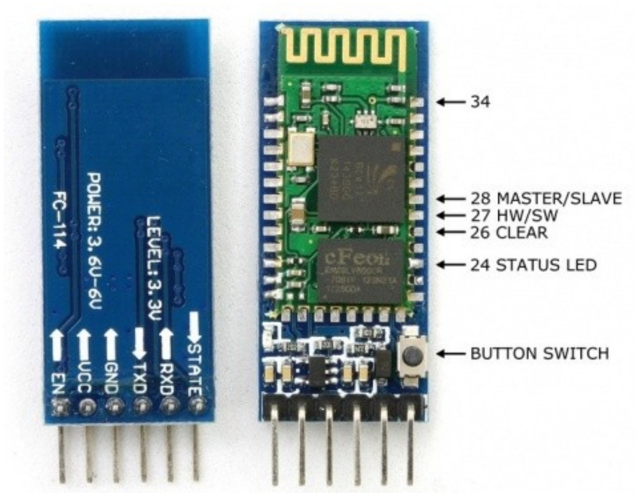
Hardware Features

- Typical -80dBm sensitivity.
- Up to +4dBm RF transmit power.
- 3.3 to 5 V I/O.
- PIO(Programmable Input/Output) control.
- UART interface with programmable baud rate.
- With integrated antenna.
- With edge connector.

Software Features

- Slave default Baud rate: 9600, Data bits:8, Stop bit:1,Parity: No parity.
- Auto-connect to the last device on power as default.
- Permit pairing device to connect as default.
- Auto-pairing PINCODE:”1234” as default

Pin Description



The HC-05 Bluetooth Module has 6 pins. They are as follows:

ENABLE:
When enable is pulled LOW, the module is disabled which means the module will not turn on and it fails to communicate. When enable is left open or connected to 3.3V, the module is enabled i.e the module remains on and communication also takes place.
Vcc:
Supply Voltage 3.3V to 5V

GND:
Ground pin

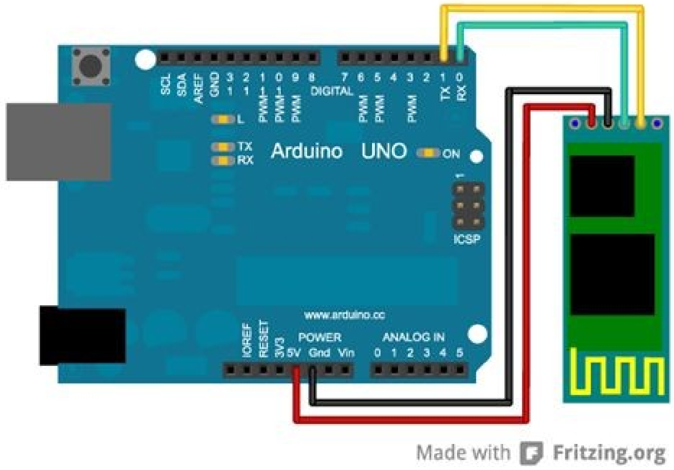
TXD & RXD:
These two pins acts as a UART interface for communication

STATE:
It acts as a status indicator. When the module is not connected to / paired with any other Bluetooth device, signal goes Low. At this low state, the led flashes continuously which denotes that the module is not paired with other device. When this module is connected to/paired with any other Bluetooth device, the signal goes High. At this high state, the led blinks with a constant delay say for example 2s delay which indicates that the module is paired.

BUTTON SWITCH:
This is used to switch the module into AT command mode. To enable AT command mode, press the button switch for a second. With the help of AT commands, the user can change the parameters of this module but only when the module is not paired with any other BT device. If the module is connected to any other Bluetooth device, it starts to communicate with that device and fails to work in AT command mode.

Hardware Connections

As we know that Vcc and Gnd of the module goes to Vcc and Gnd of Arduino. The TXD pin goes to RXD pin of Arduino and RXD pin goes to TXD pin of Arduino i.e(digital pin 0 and 1).The user can use the on board Led. But here, Led is connected to digital pin 12 externally for betterment of the process.

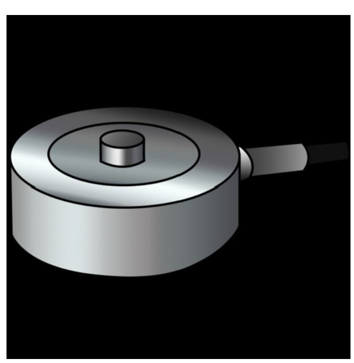


Load Cell

A load cell is a sensor or a transducer that converts a load or force acting on it into an electronic signal. This electronic signal can be a voltage change, current change or frequency change depending on the type of load cell and circuitry used. There are many different kinds of load cells. We offer resistive load cells and capacitive load cells.

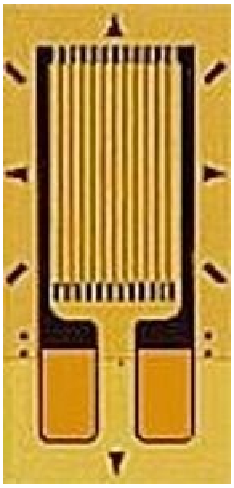
Resistive load cells work on the principle of piezo-resistivity. When a load/force/stress is applied to the sensor, it changes its resistance. This change in resistance leads to a change in output voltage when an input voltage is applied.

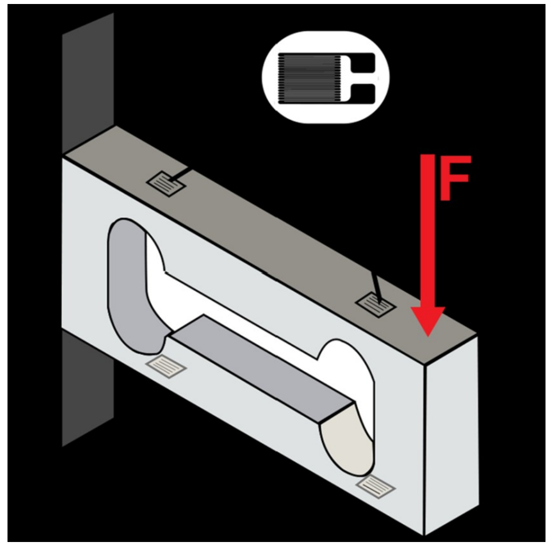
Capacitive load cells work on the principle of change of capacitance which is the ability of a system to hold a certain amount of charge when a voltage is applied to it. For common parallel plate capacitors, the capacitance is directly proportional to the amount of overlap of the plates and the dielectric between the plates and inversely proportional to the gap between the plates.



Resistive Load Cells

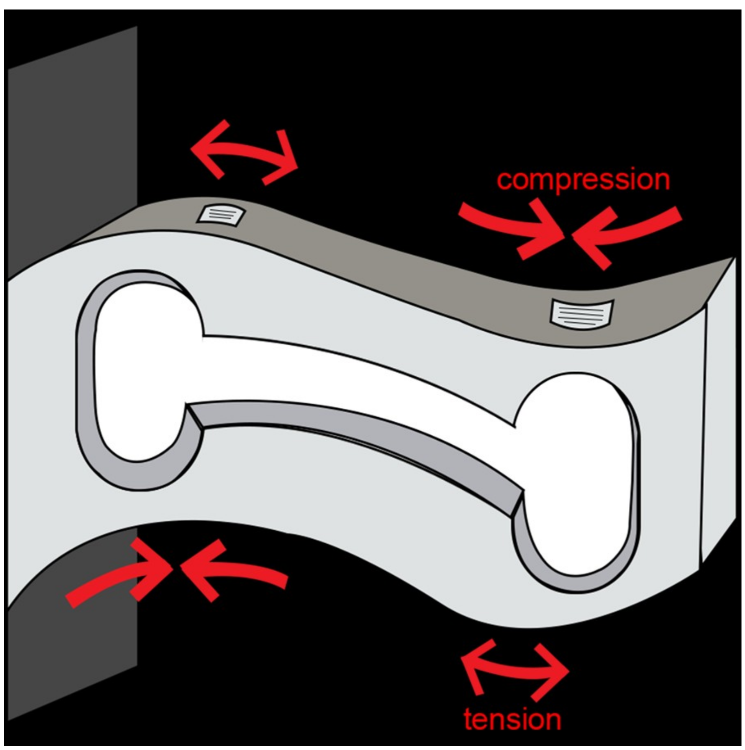
A load cell is made by using an elastic member (with very highly repeatable deflection pattern) to which a number of strain gauges are attached.



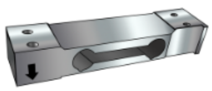
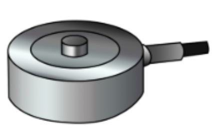
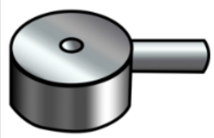


there are a total of four strain gauges that are bonded to the upper and lower surfaces of the load cell.

When the load is applied to the body of a resistive load cell as shown above, the elastic member, deflects as shown and creates a strain at those locations due to the stress applied. As a result, two of the strain gauges are in compression, whereas the other two are in tension.



Types of Resistive Load Cells

Single Point Load Cells	Button Load Cells	S-Beam Load Cells	Miniature Load Cells	Through Hole Load Cells	Pancake Load Cells
					
Generally used to build scales and in applications where space is not limited. They offer excellent off-center loading compensation.	Ideal for measuring compression forces that are applied axially. They are compact and easy to use.	Ideal for tension (pull) or Universal (push and pull) force measurement applications	Smallest miniature load cells we offer for compression force measurements only. Ideal for cramped locations.	Rugged, industrial load cells for compression and/or tension force measurements. Has a through hole with threads to attach accessories	High Capacity load cells with capacities up to 100K lbs for compression and/or tension load cell measurements.
RAPG:(100 g, 300 g, 500g, 1 kg, 2 kg, 3 kg)	RSB2:(25 kg, 50 kg, 100 kg, 250 kg, 500 kg, 1000 kg)	RAS1:(25 lb, 50 lb, 100 lb, 250 lb, 500 lb, 1000 lb, 2500 lb, 5000 lb, 10K lb, 20K lb, 40K lb)	RSB5:(5 lb, 10 lb, 50 lb)	RSB6:(250 kg, 500 kg, 1000 kg, 2.5K kg, 5K kg)	RAL1:(5K lb, 10K lb, 25K lb, 50K l, 100K lb)
RSP1:(3 kg, 5 kg, 10 kg, 20 kg, 50 kg, 150 kg)	RSB1:(2000 kg, 5000 kg)	RES2:(5 kg, 10 kg, 50 kg)	REB5: (2 kg, 10 kg, 100 kg)		

Design and function of a load cell

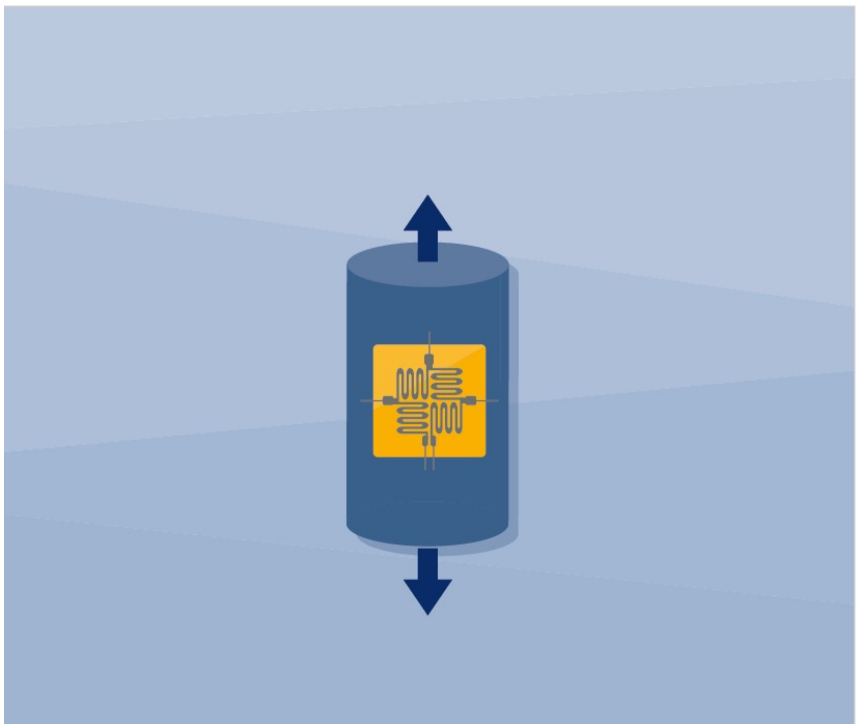
Load cells are used to measure weight. Of course they are usually not immediately recognizable, because they are hidden in the inner workings of instruments.

Load cells generally consist of a spring element on which strain gauges have been placed. The spring element is usually made of steel or aluminum. That means it is very sturdy, but also minimally elastic. As the name "spring element" suggests, the steel is slightly deformed under load, but then returns to its starting position, responding elastically to every load. These extremely small changes can be acquired with strain gauges. Then finally the deformation of the strain gauge is interpreted by analysis electronics to determine the weight.

To understand this last point, let us consider strain gauges in more detail: They are electrical conductors firmly attached to a film in a meandering pattern. When this film is pulled, it – and the conductors – get longer. When it is contracted, it gets shorter. This causes the resistance in the electrical conductors to change. The strain can be determined on this basis, as resistance increases with strain and diminishes with contraction.

The strain gauges are firmly attached to the spring element, and therefore undergo the same movements it does. These strain gauges are arranged in what is called a bridge circuit, or more precisely a Wheatstone bridge circuit. This means that four SGs are connected "in a ring" and the measuring grid of the force being measured is aligned accordingly.

If an object is placed on the load cell or suspended from it, the object's weight can be determined. The intended load for a load cell is always aligned in the direction of the center of the earth, in other words in the direction of gravity. Only that force component of the load should be acquired. That is not the case for force sensors, which are similar in design, and are also frequently specified as "load cells": They are usually designed to acquire loads that occur in all directions. The direction of the earth's gravitational force is not relevant to how they are installed.



Environmental effects on load cells

One special feature of load cells is that the environment in which they are used plays a decisive role – in a number of ways.

Ambient temperatures

Every material changes with temperature, expanding in response to heat and contracting in response to cold. Of course the same applies to load cells and their strain gauges. This also changes the electrical resistance of the conductor. Yet load cells must measure the correct weight everywhere in the world, regardless of the ambient temperature. To achieve this, a sophisticated temperature compensation mechanism is built into every HBM load cell.

Load cells must be able to withstand various effects. "Consider a truck scale: These scales are exposed to the elements: rain, dirt or heat – they have to be able to withstand outdoor ambient conditions. And we are talking world-wide: A truck scale in Siberia, for example, is exposed to different effects than one in South Africa. But they do have one thing in common:

They must be designed for environments with severe weather and must therefore be correspondingly rugged," says Stefan Schmidt.

Application of force in other directions ("parasitic forces")

Depending on the technical environment in which a load cell is installed – for example in a system for weighing containers or in a weighing cell under a conveyor belt – other loads in addition to the weight may occur. "Parasitic forces" are forces acting on the load cell not only in the desired principal direction, but also from the side, from below or in some other way. The load cell was not developed for this purpose and the measurement results may be inaccurate or simply wrong. Care must therefore be taken during installation to ensure that there are no parasitic forces, or as few as possible. HBM load cell fittings and weighing modules help users minimize these parasitic forces and achieve precise measurement results.

Sharp IR Sensor

Sharp infrared detectors and rangers boast a small package, very low power consumption and a variety of output options. In order to maximize each sensor's potential, it is important to understand how these types of IR sensors work, their effective ranges, and how to interface to them.

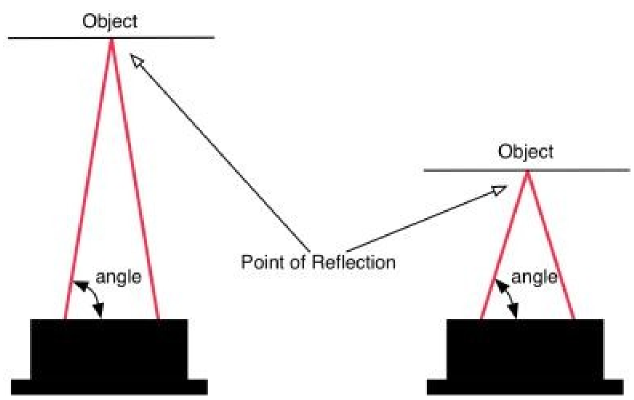
IR Sensors work by using a specific light sensor to detect a select light wavelength in the Infra-Red (IR) spectrum. By using an LED which produces light at the same wavelength as what the sensor is looking for, you can look at the intensity of the received light. When an object is close to the sensor, the light from the LED bounces off the object and into the light sensor. This results in a large jump in the intensity, which we already know can be detected using a threshold.

Since the sensor works by looking for reflected light, it is possible to have a sensor that can return the value of the reflected light. This type of sensor can then be used to measure how "bright" the object is. This is useful for tasks like line tracking.

THEORY OF OPERATION

There are two major types of Sharp's infrared (IR) sensors based on their output: analog rangers and digital detectors. Analog ranges provide information about the distance to an object in the ranger's view. Digital detectors provide a digital (high or low) indication of an object at or closer than a predefined distance.

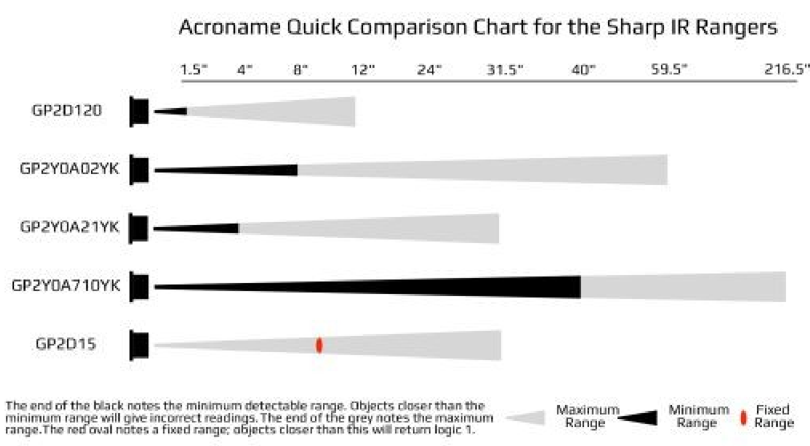
These rangers all use triangulation and a small linear CCD array to compute the distance and/or presence of objects in the field of view. In order to triangulate, a pulse of IR light is emitted by the emitter. The light travels out into the field of view and either hits an object or just keeps on going. In the case of no object, the light is never reflected, and the reading shows no object. If the light reflects off an object, it returns to the detector and creates a triangle between the point of reflection, the emitter and the detector.



The incident angle of the reflected light varies based on the distance to the object. The receiver portion of the IR rangers is a precision lens that transmits reflected light onto various portions of the enclosed linear CCD array based on the incident angle of the reflected light. The CCD array can then determine the incident angle, and thus calculate the distance to the object. This method of ranging is very immune to interference from ambient light and offers indifference to the color of the object being detected.

SHARP IR RANGE COMPARISON

The table below characterizes each sensor by minimum and maximum ranges, as well as whether the sensor returns a varying distance value or a digital detection signal:



MODEL	OUTPUT	MIN. RANGE	MAX RANGE
GP2D120/GP2Y0A41	Analog	1.5"	11.8"
GP2Y0A02	Analog	8"	59"
GP2Y0A21	Analog	4"	30"
GP2Y0A710	Analog	36"	216"
GP2D15	Digital	9.5"	

The GP2Y0A710 ('0A710'), GP2D120, GP2Y0A41, GP2Y0A21 ('0A21'), and GP2Y0A02 ('0A02') sensors offer true ranging information in the form of an analog output. The GP2D15, by contrast, provide a single digital value based on whether an object is present in it's range or not. None of the detectors require an external clock or signal. Instead, they fire continuously, requiring around 25mA of continuous current.