Alexandria Higher Institute of Engineering &Technology (AIET)

Department of (Electronics and communication)

Final Year Project Report

Project Title (Electronic attendance registration system using facial recognition**)**

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A report submitted in part fulfilment of the degree of

BSc in Department of Electronics and Communication

Supervisors: Dr. Ola Hussein & Dr. Amr Yassin

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Declaration

This report has been prepared on the basis of our own project. Where other published and unpublished source materials have been used, these have been acknowledged.

نقر نحن طلاب مشروع (Electronic attendance registration system using facial recognition) الموقعين أدناه أنه تم اتباع قواعد وقوانين الملكية الفكريه

Student Name: **Signature:**

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Date of Submission: (……)

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Abstract

This project aims to provide an easy, reliable and automated way to register the attendance of students so as when the student stands in front of the robot camera, it recognizes his/her face by means of a Convolutional Neural Network that does feature extraction on the face and there's another Convolutional Neural Network that extracts features from each image stored in the database and the system computes the difference between the feature vectors of the student's face and each image in the database, and registers the student whose image has the lowest difference with the test image, this technique is called one shot learning and this connection between the two Convolutional Neural Networks is called the siamese network, there are various ways to obtain the differences between feature vectors, the function used in this project is cosine function, when the system obtains the ID number of the student from the features of his/her face, it automatically registers his/her name, ID number, and time of entrance in a single record in an excel spreadsheet which allows filtering, conditional formatting and efficient query manipulation among the records, the motion of the robot is controlled using various modules such as ultrasonic sensors, Bluetooth and it can be controlled either manually or automatically,it moves by means of servomotors in various directions, the robot consists of multiple degrees of freedom and joints, the robot is totally designed using solidworks tool, it weights around 5 kg, and it's height is about 1-1.2 meters, it's manufactured using PLA plastic material and it's thoroughly designed and its dimensions are calculated precisely, and it takes the human shape…

Project Specification

In the recent spread of the newly present Corona virus and all the huge dangers threating humanity and all the challenges that were faced to prevent the spread of the virus which maybe lethal or could cause life-threatening disease.

We have to -as engineers- contribute in this challenge to prevent the spread of the virus. And from the most dangerous things that helps in the spread of this virus is physical interactions between people and the interactions between their tools or being in close proximity to each other e.g., the process of taking attendance of the lecture attendees and the dangers that this operation presents in spreading the virus.

And given that we are living in this modern age where we face a plethora of technological advancements therefore, we should use this technology in facing this challenge and that's what we have done by using the latest and most advanced technology which is Artificial Intelligence.

In this project we built a robot capable of movement inside the lecture hall to take the attendance of all the students while they are sitting in place with out any input from the student or any physical interaction between the robot and the student. That is what the robot is capable of by using facial recognition on the faces of all the students and taking their attendance and recording it into an excel sheet and sending all the recorded data to the IT section of the educational institute.

Nevertheless, how does this robot perform this process?

To answer this question, we must firstly know what the robot consists of to perform this process, The robot consists of three primary sections and they are, the artificial intelligence section and the database section and the control section which is responsible for the motion of the robot.

Firstly, the artificial intelligence section;

This section is responsible for the process of recognizing the face and this section consists of a group of tools that is required to perform this process, The first thing is a Redragon GW600 camera which takes pictures of the students while they are inside the lecture hall to be sent to the next step which is the detection of faces in the picture to be sent to the neural network to extract the facial features to be compared with the facial features stored in the database that belongs to all the students currently recorded in the group where every faces is recorded with the name of the student and all the information about the students, The Nvidia Jetson Nano is responsible for this process where it contains the processor Quad-Core ARM Cortex-A57 64-bit @ 1.42 GHZ and the graphical processor NVIDIA Maxwell w/ 128 CUDA cores @ 921 MHz and RAM of size 4 GBs which enables the process to be performed quickly. .

This single board computer runs on a distribution of Linux (Ubuntu) and the main program was written in Python which is a very popular language, Python contains a plethora of very powerful and useful libraries for artificial intelligence e.g., Keras, Tensorflow, and sklearn. Which allows us to write code at a very high accuracy.

The Nvidia Jetson Nano is connected to a screen of size 7 inches and a resolution of 1024*600 pixels, also the screen supports touch to show the data during the process and the control of the robot.

Secondly the database system :

The project involves automated creation of excel workbooks and excel sheets and registration of attendance without human intervention, it also involves automated saving and storage of excel files each sheet with its timestamp and each student is registered with accurate timing of his/her entrance, with the option of termination of the student and cancelling his/her attendance registration any time in case of inappropriate behavior, the sheet is created with the name and code of the course attached with the date

Thirdly, Control Section;

This section is responsible for the motion of the robot in the lecture hall and how it moves in its intended path,

The robot contains three modes for motion, the first mode is drawing the path intended for the robot to be used by the robot to move on it by using a line follower sensor and an Arduino.

The second mode is using an ultrasonic sensor for motion by way of avoiding hurdles. The third mode is the control of the robot by using Bluetooth through a mobile application.

Chapter 1: **Introduction**

1.1Project objectives

With the spread of covid 19 around the world, there's a further need for systems and solutions that minimizes the contact between people and objects in order to minimize the infection among them, so this project is a prototype for a contact-less biometric system which works on facial recognition biometric modalit

1.2Project outlines

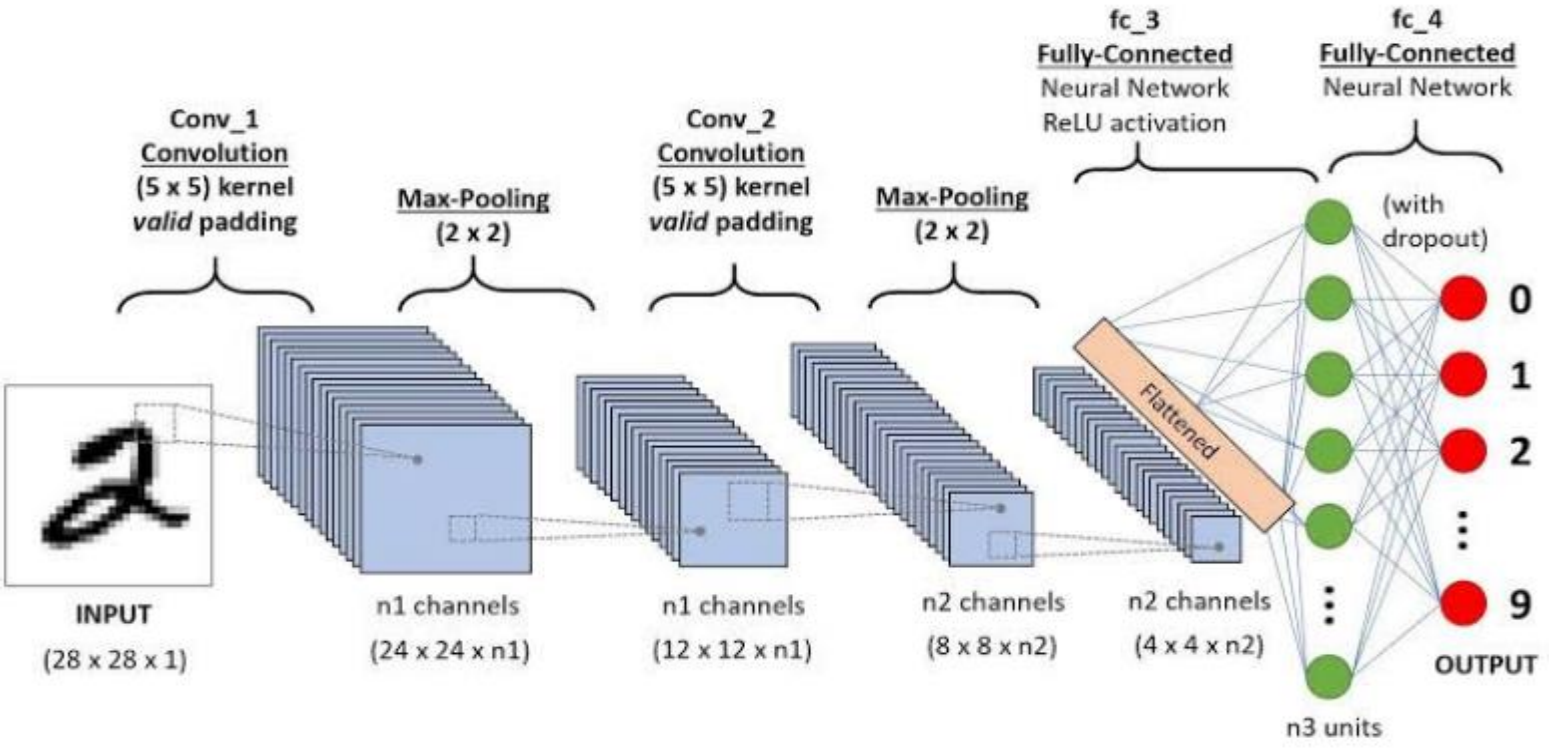
The robot registers the data of each attendee automatically which maintains data integrity and each attendee is registered only by his face sample which maintains data confidentiality against any unauthorized use or manipulation, the facial recognition biometric modality has high collectablility that the process of sample collection is easy, it has high acceptability so it is user friendly, it's non intrusive and it has low circumvention so the face sample is not easy to be imitated so this maintains data accuracy, this project aims to provide an agent based system that is very accurate, has minimal false acceptance rate (Type I error) and minimal false rejection rate (Type II error) , has low prediction processing time and easy to use so that users can feel convenient, the agent also has high motion control capabilities, it can be controlled using Bluetooth module, ultrasonic sensors and line follower system, the motion control is programmed using arduino mega development kit and runs via DC Motors and is supplied with power using Lithium ion batteries via a Battery Management System, the facial recognition part is programmed using Nvidia Jetson Nano development kit and using Python programming language using tools like tensorflow, keras and opencv, and the excel automation is also programmed using python language with the aid of a tool called openpyxl, the robot is designed using solidworks, and it's manufactured with PLA plastic material it weights around 5 kg and its height is about 1-1.2 meters, it uses a high resolution camera and it interfaces the system to the users via a 7 inch screen

Chapter 2: **Artificial intelligence**

2.1 One Shot Learning (Siamese Network)

As we talked about Standard Classification, so we feed the neural network with thousands of instances of each class so it is trained to classify and differentiate between various classes, so as number of instances for each class increases, the cost of the data increases and also the training process consumes so much times, even some neural networks take weeks and months to complete the training process, the standard classification is suitable only for models that classify few numbers of classes, for example binary classification, such as classifying between benign and malignant tumors, classifying between whether a fruit is corrupt or healthy, it's also can be used for multiclassification but with few numbers of classes, such as to detect whether the vehicle is a car, bus or motorcycle, such as to detect the human race, whether African, American, Caucasian, Asian, but let's consider that we have a huge number of classes, for example if we have a government that wants to make a model to detect the information of lost children to return them to their parents so let's consider that the county has a million children under 10 years so logically first, it's not economically feasible to collect thousands of training examples for each of the million children so we will have to collect billions of images, second, in order for the network to be trained on billions of instances it will take so much time to be trained it may take tens or even hundreds of years which is completely unlogical, moreover, everyday the population increases with new children so with each new child that is born, we have to add thousands of images of him to the network then retrain it which is neither cost-efficient nor time-efficient.

Figure 1.



The above image demonstrates the structure of a standard Convolutional Neural Network, which takes the input image, extracts its features and outputs a probability distribution over the labels of possible classes and the class with the highest probability is considered the class which the image belongs to, it does this by applying a group of filters on the image on each layer to convolve the image and reduce its size and also a group of max pooling filters, and at the end of the network it applies a softmax function to generate the probability distribution over the labels of each class, there are also some other functions than softmax such as relu, tanh, etc…, this is done mainly using tensorflow and keras tools.

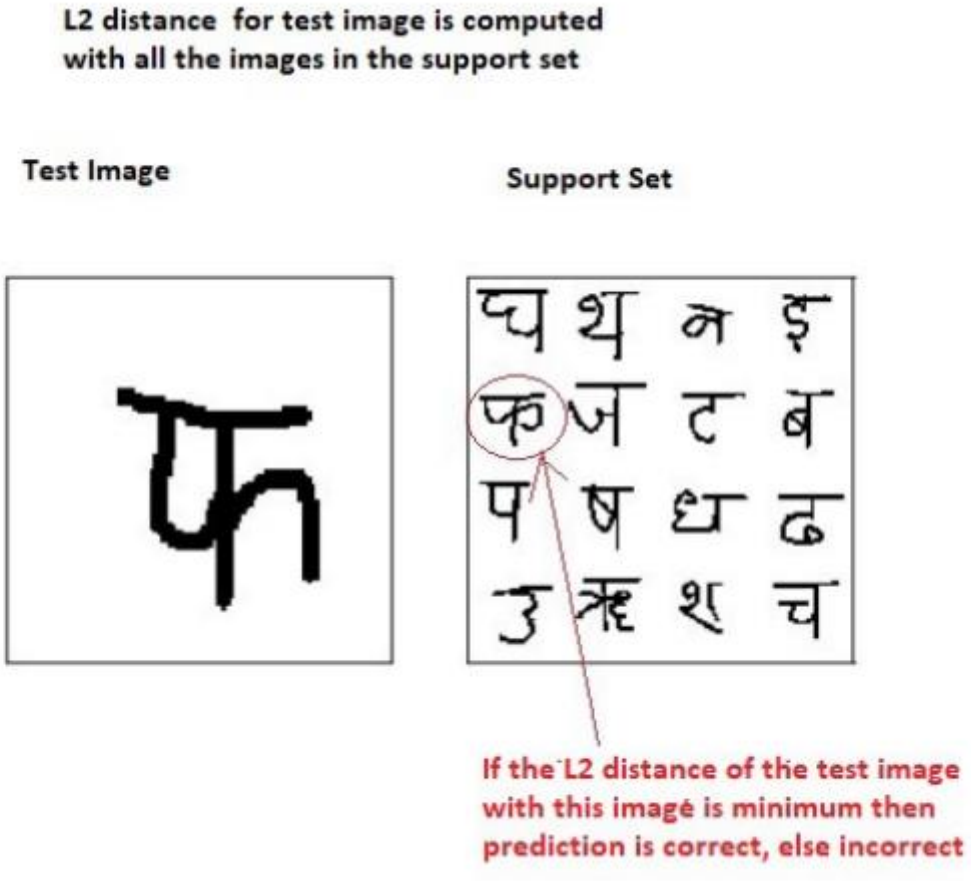
So how to classify images with hundreds or even thousands of classes, we need to have a model that accepts a few numbers of instances for each class, this is done by a technique called One Shot Learning, in which the neural network accepts only one or few instances of each class and trains on them in which we don't have to collect much instances and pay so much money,

and we don't have to train the network on so much training examples so we will not consume so much time, but how this is done?, well, the one shot learning technique is implemented by a special type of Convolutional Neural Network called Siamese Network, the siamese network consists of two Convolutional Neural Networks in which each network is fed with an image, when we want to test an image and determine the class for which the image belongs to, we feed one CNN with the test image that we want to test, and we feed the other network with each image in the training dataset one by one, and in each iteration, the siamese network applies a difference function which outputs a similarity score between the two images, the similarly score lies between 0 and 1,

0 indicates no similarity at all and 1 indicates full similarity, so the siamese neural network does not output a probability distribution over classes, it rather outputs a list of similarity score between the test image and each reference image in the dataset, and the reference image that has the highest similarity score with the test image is considered to be of the same class as the test image.

Model Validation:

To validate the model and test whether it's accurate or not, there are multiple ways to test it, one of the most common ways is called the N-way one shot learning, in which we take a test image and compare it with a group of images, this group is called the support set, and monitor if the model will predict the class correctly, we do this multiple times (trials), the number of trials is denoted by k, let's say that we compare our test image to 25 images 50 times, so N=25, k=50, let's say that the model predicted the correct image from the 25 images 45 times and predicted wrongly 5 times, this means that the model accuracy is 90%, the N-way one shot learning can be implemented by various ways such as calculating the Euclidean Distance between each pair of images.



our project employs the One Shot learning technique, to register the attendance of each student based on face recognition, let's say that the college has 5000 students, it's not economically feasible to collect thousands of images for each one, so we use the one shot learning technique that we've mentioned so during the inference process, each students stands in front of the camera, this biometric modality (facial recognition) has high collectability which means that the process of sample collection is easy, so the model collects the sample of his face when they stand in front of the camera, then compares this sample will all the recorded templates, then registers the student whose image has the highest similarity score with the test image (image of the student in front of the camera), if and only if the highest similarity score is greater than predetermined threshold value, otherwise it will not be able to register the student in the attendance list.

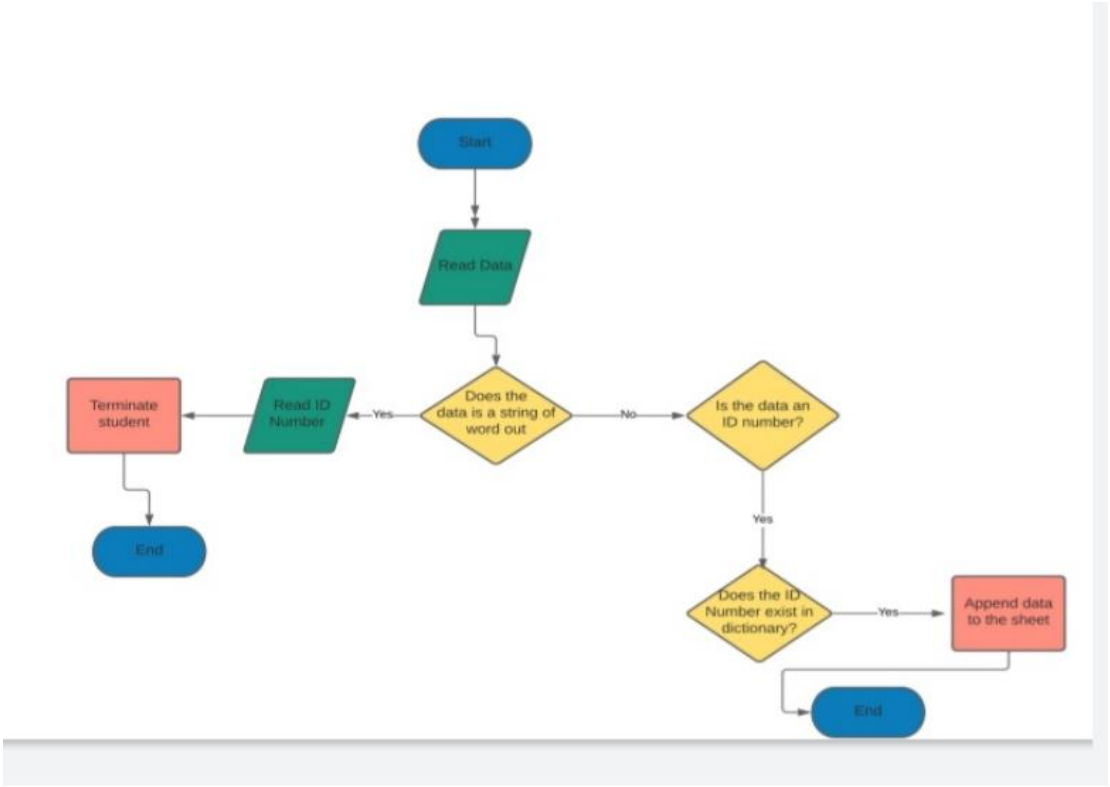
2.2 Excel Automated Attendance registration:

As we mentioned that the facial recognition based system obtains the ID Number of the student when the camera captures his/her face, once the system recognizes the student's ID Number it automatically registers his data in an excel spreadsheet, when the professor or supervisor launches the program it automatically creates a new spreadsheet named with the course title + course code + date, then the students stand in front of the camera progressively and the camera captures their photos, obtains their ID numbers and registers their data in an excel spreadsheet sequentially and in a real time manner, the data that are registered in the excel spreadsheet is the ID Number, student's name, time of entering the lecture hall, and the word attended, all these 4 pieces of information will be stored in 4 fields in a single record for each student respectively, the professor or supervisor can also terminate the student from the lecture hall and cancel his/her attendance, this is done when the professor enters the word "stop" manually and then manually enters the student's ID Number that will be terminated, once the professor does that, the word "attended" in the fourth field in that student's record will be replaced by the word "out".

Note: A record means a single row and a field means a cell that will be filled with information in that row.

These procedures are implemented using python programming language and integrated with the portion of facial recognition, the module used in python to control the registry of the student's data in excel sheets is called openpyxl**,** it automatically creates a sheet on launch of program when the teacher enters his ID Number and course code, there is a data structure in python called dictionary in which data is expressed in the notation of key-value pairs, students' names and ID number are read from the students' list that belongs to the educational organization, and stored in a dictionary in which each student is an item in the dictionary where his/her ID number is the key and the full name is the value, note : the full name is of type 'str' in python which means a string (array of characters) that build up the student's

full name, and the ID number (key) is of type ‘int’ which means an integer value, a function in openpyxl module is called ‘append’, we pass to it one argument which is a list of values, so it adds these values in a single record (row) in the excel sheet, each value in a single field in the record, the values as we mentioned are the name, ID Number, time and the word ‘attended’, the date and time are automatically obtained using the module ‘datetime’, and it includes a function called datetime.now(), which returns the data and time at this exact moment, but we use a slightly different function called strftime which we pass to it some directives to format the date and time in a string so we format it using directives and then append this string to the third field in the record, if the teacher wants to terminate a student from the lecture hall and cancel their registration, we enable this option via a user defined function called terminate, in which the teacher can manually enter the word ‘out’ in the program terminal, and then the program immediately jumps to the function terminate, the function asks the teacher for the ID of the student to be terminated, when the teacher enters it, the program reads the list of ID numbers registered in the sheet till that moment and replaces the word ‘attended’ in the fourth field of that student with the word ‘out’ this indicates to the statistician that assembles the attendance list that this student is terminated, so they can use filtering to filter out the records of the students whose fourth fields have the word ‘out’, instead of manually checking canceled attendees name by name., note : the data that the program reads from the excel sheet is of data type ‘cell’ so it must be casted to int or string in order to have higher manipulation capabilities and to be edited.


Start
Read Data
Does the data is a string of word out
Yes
Read ID Number
Terminate student
End
No
Is the data an ID number?
Yes
Does the ID Number exist in dictionary?
Yes
Append data to the sheet
End

Mechanical section

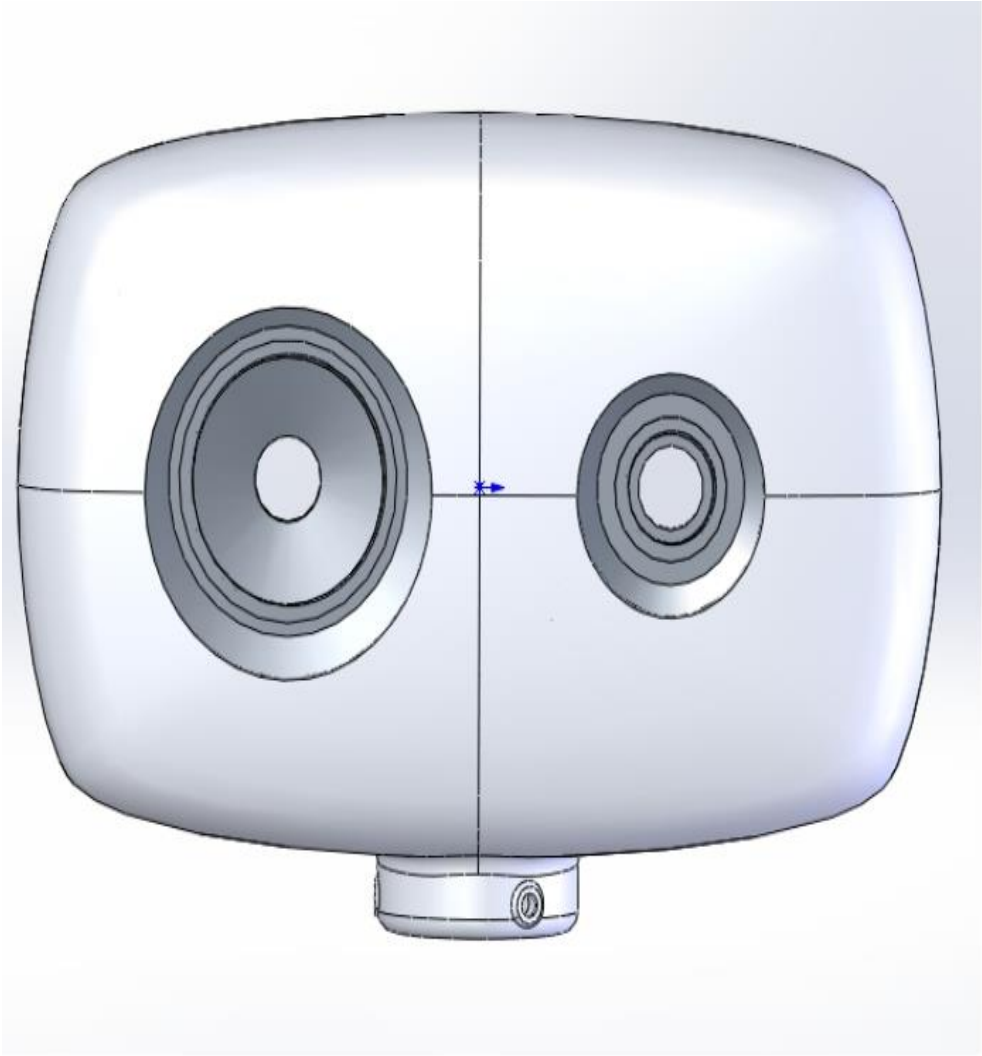
chpter3: **Design**

3.1 introduction

The mechanical engineer, before design can begin, must first know the basic task that the project will undertake to design a robot that fits with this task.

For this project the main task is face recognition. This fundamental thing in design is the location of the cameras.

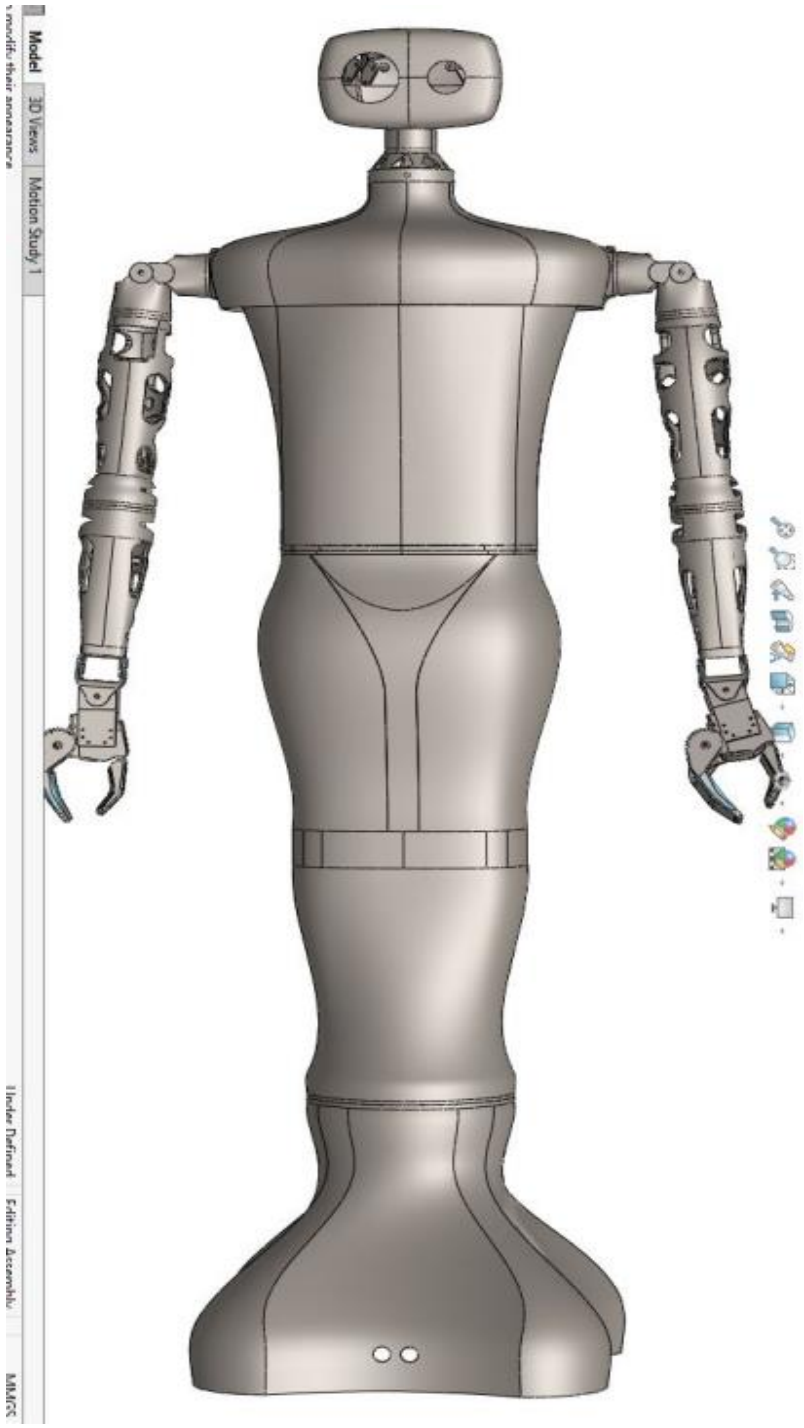
In addition, there is a sub-task, which is to enable the robot to move in the places around it.



Design program:

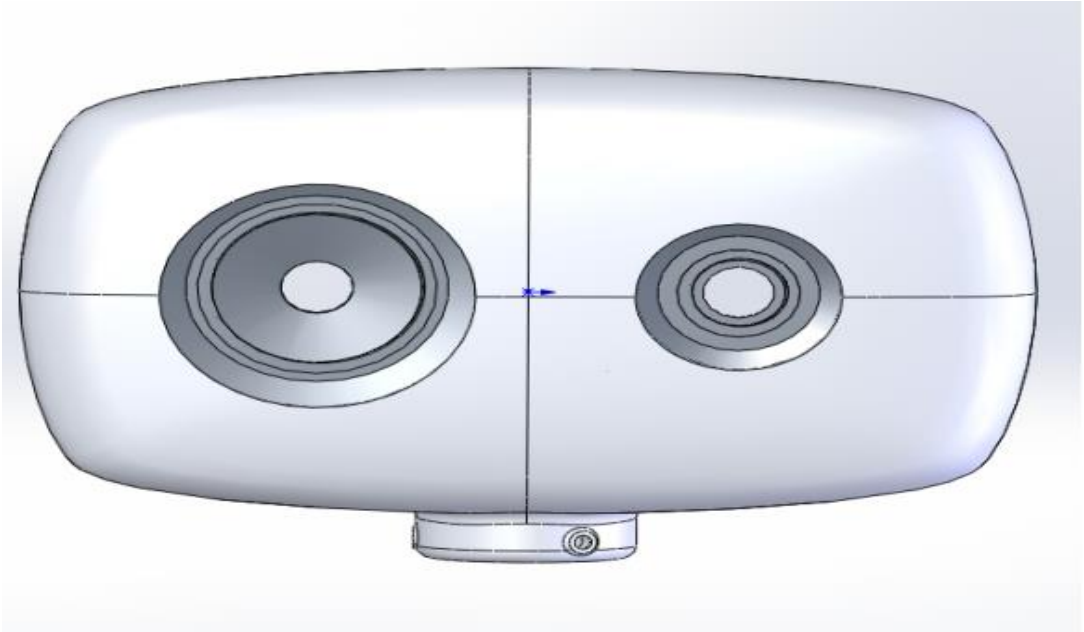
SOLIDWORKS

Assembly:



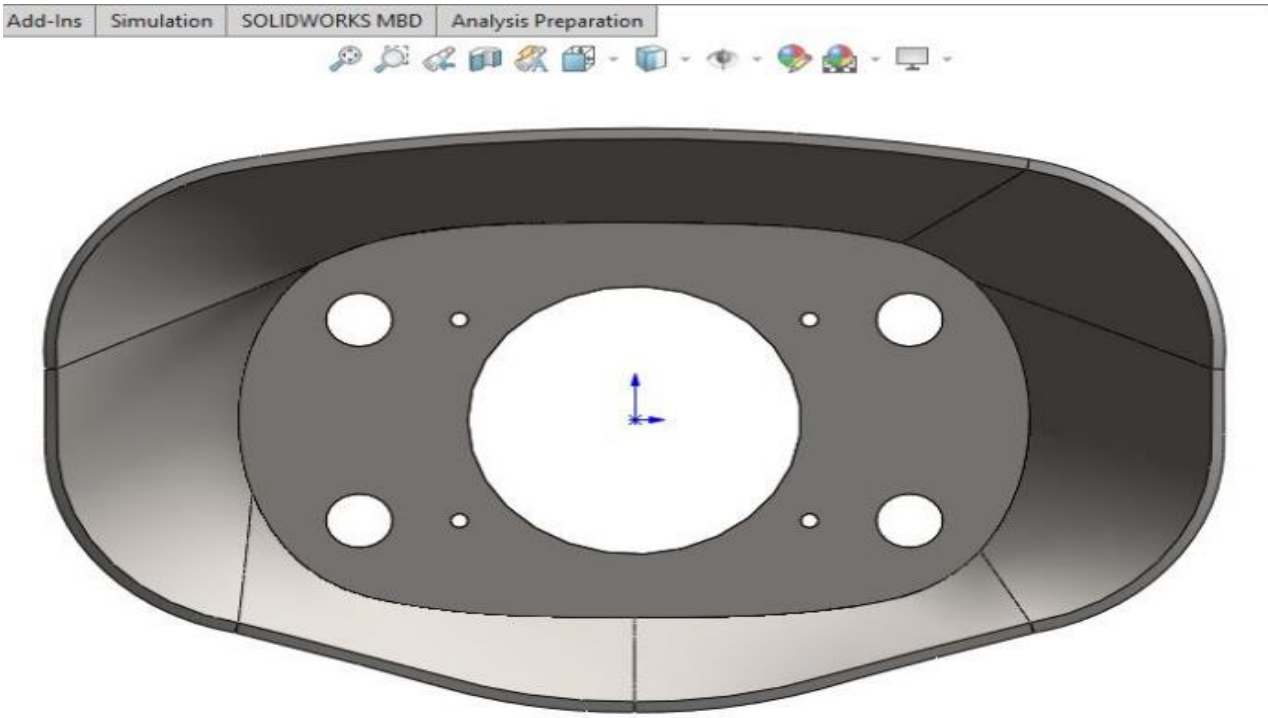
3.2Main parts:

3.2.1. Head

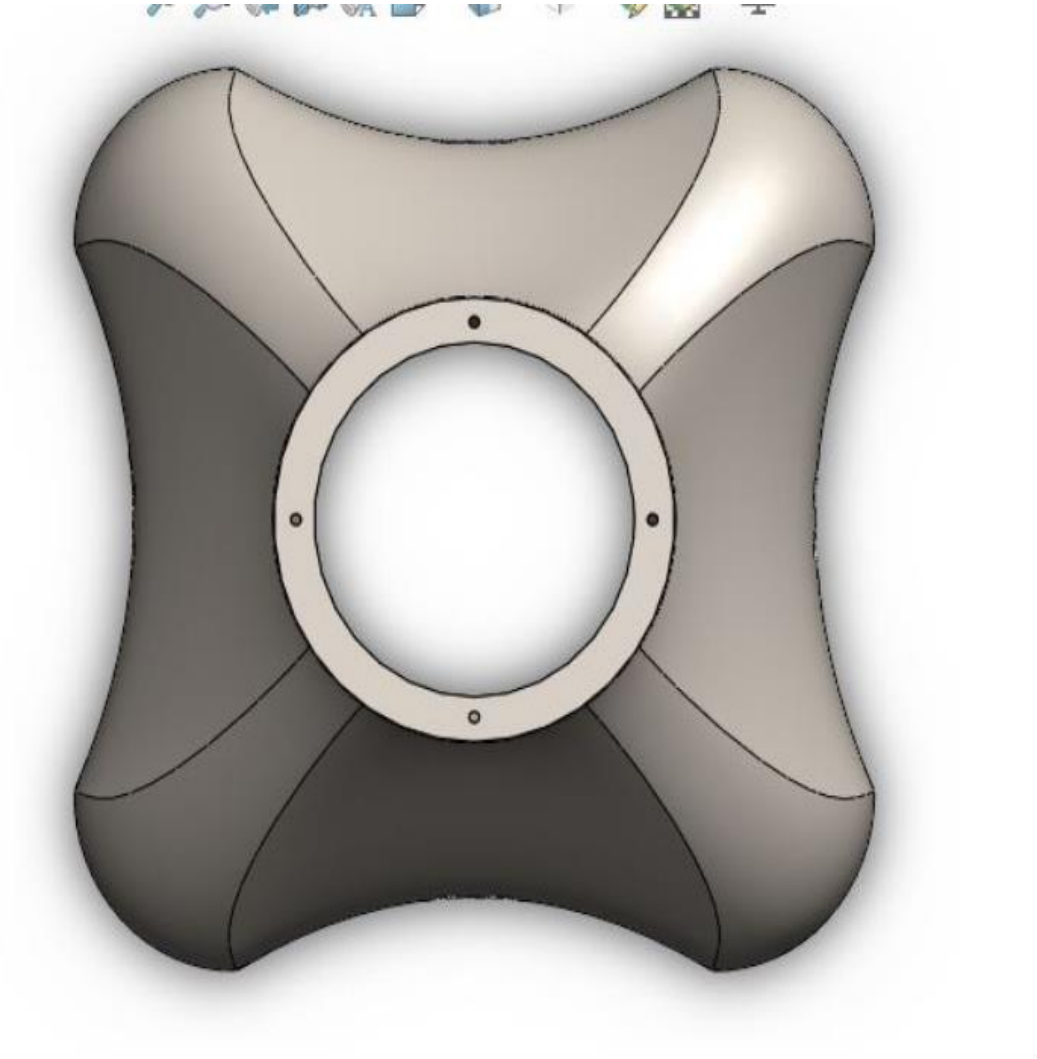


3.2.2. Chest

3.2.3. Shirt:

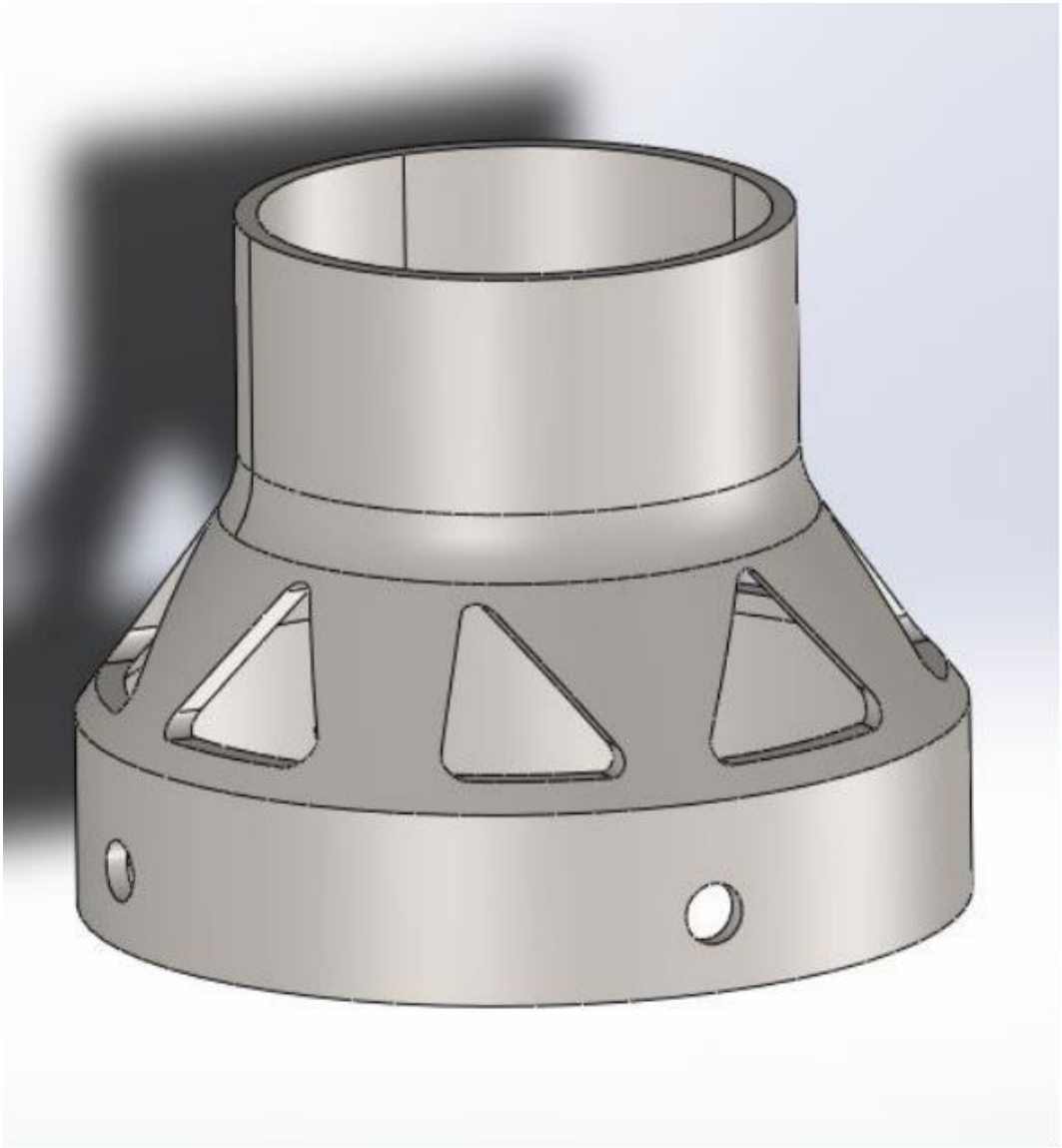


3.2.4.Bottom



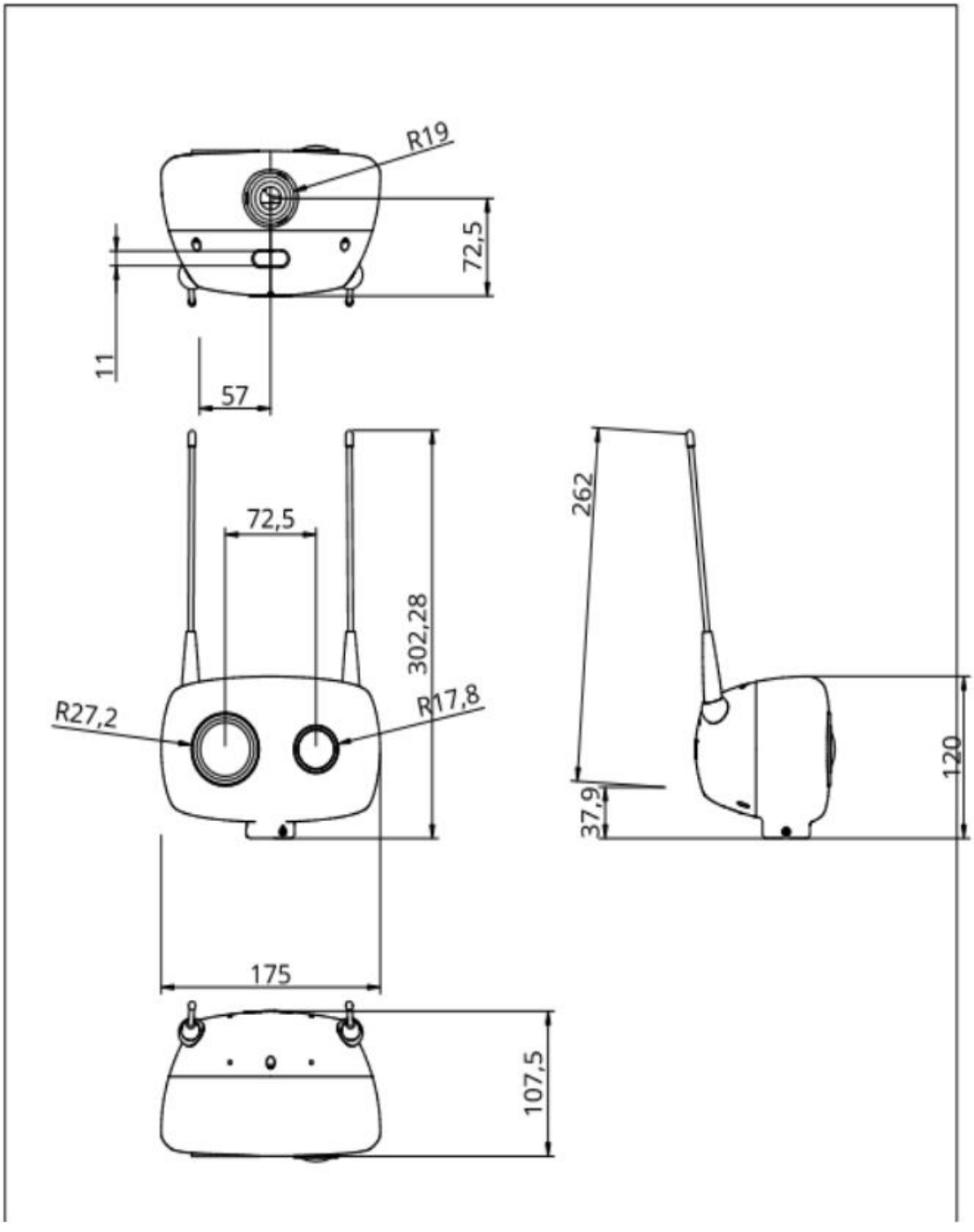
3.2.5. Arm

3.2.6.Neck:

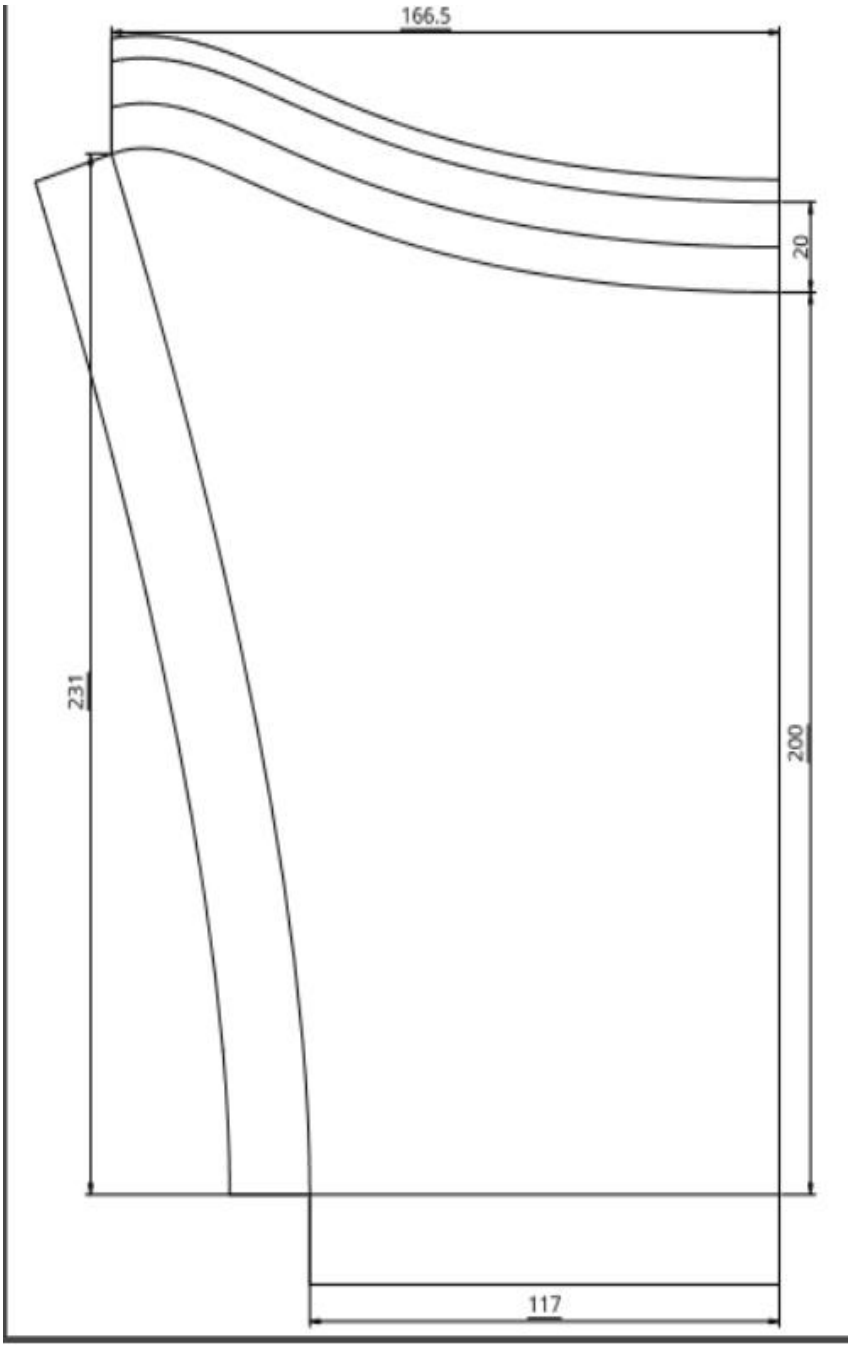


3.3.Drawing sheet:

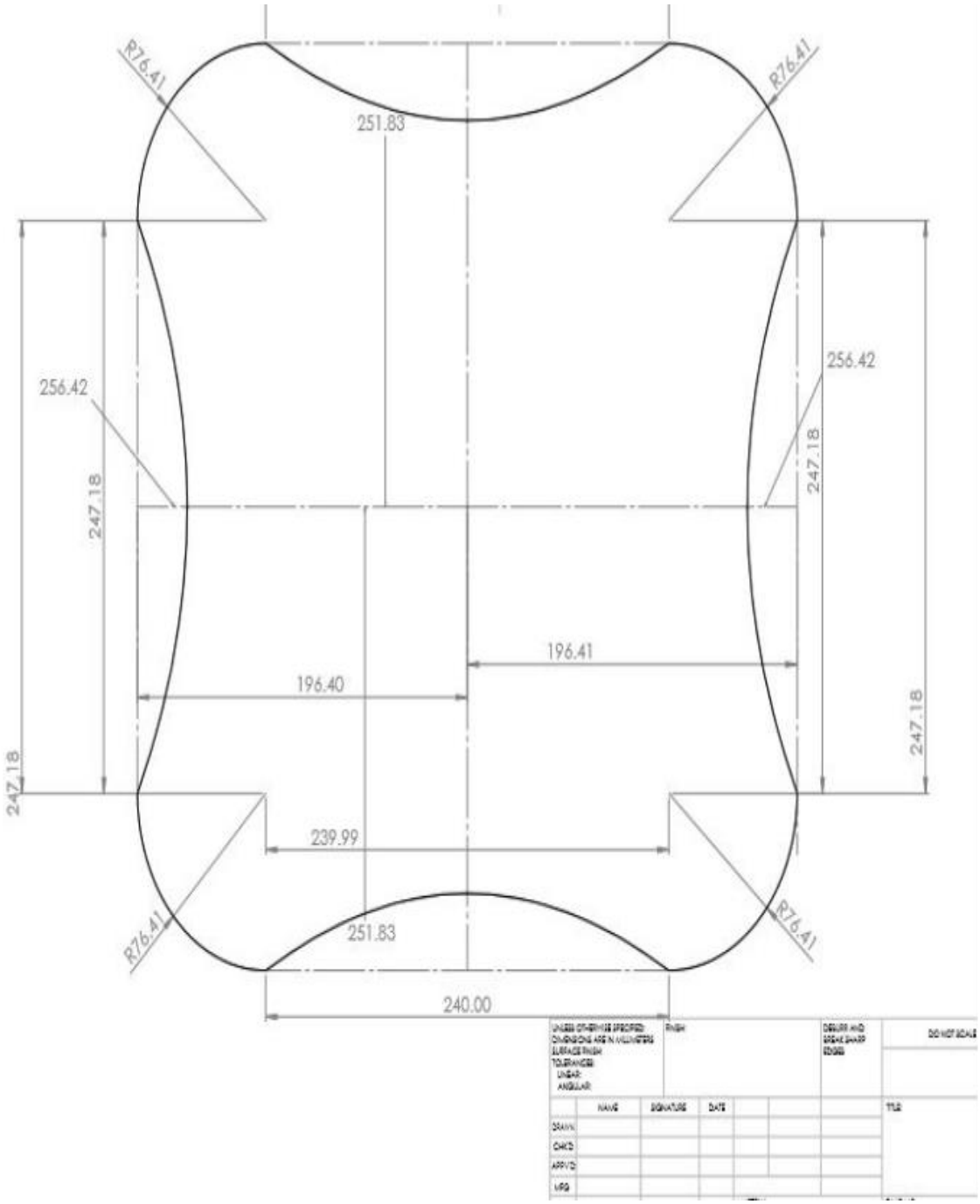
3.3.1 Head drawing:



3.3.2. Shirt drawing:



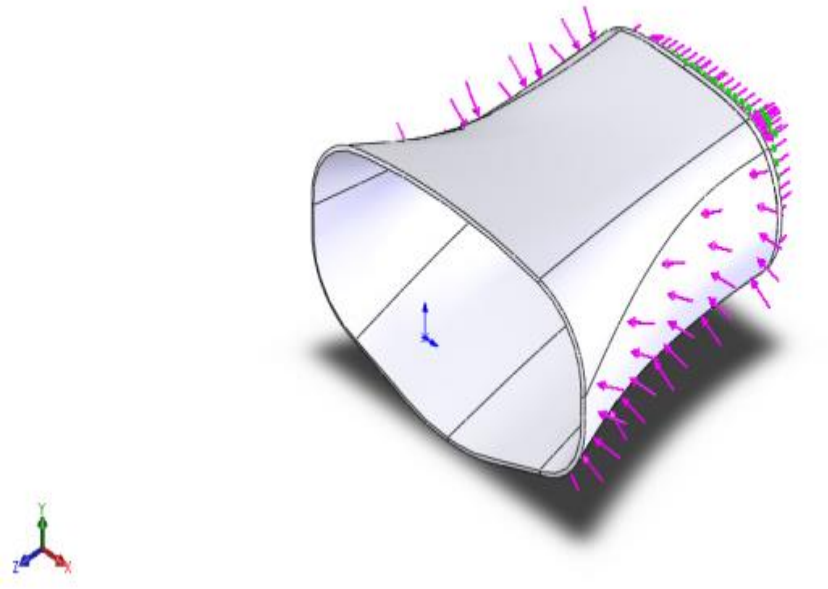
3.3.3. Bottom:


R76.41
R76.41
251.83
256.42
256.42
247.18
247.18
247.18
247.18
196.41
196.40
239.99
R76.41
R76.41
251.83
240.00

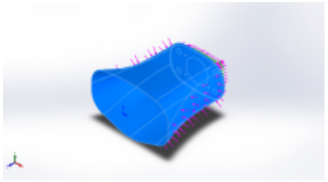
3.4.Stress analysis:

3.4.1.Shirt:

Model Information

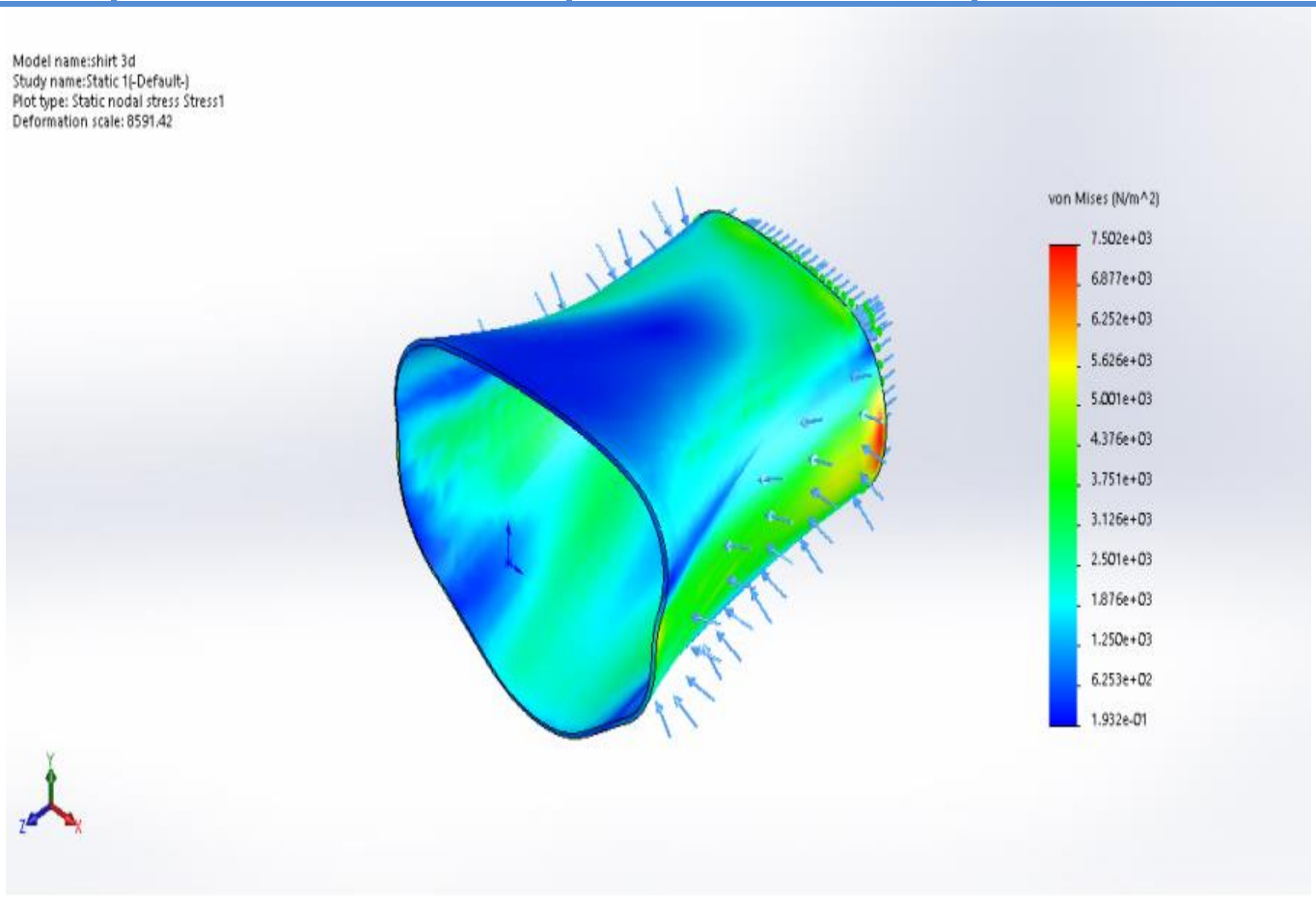


Model name: shirt 3d
Current Configuration: Default

Solid Bodies			
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Cut-Extrude2 	Solid Body	Mass:1.07922 kg Volume:0.001057 m^3 Density:1021.02 kg/m^3 Weight:10.5763 N	E:\المشروع\chest module\shirt 3d.SLDPRT

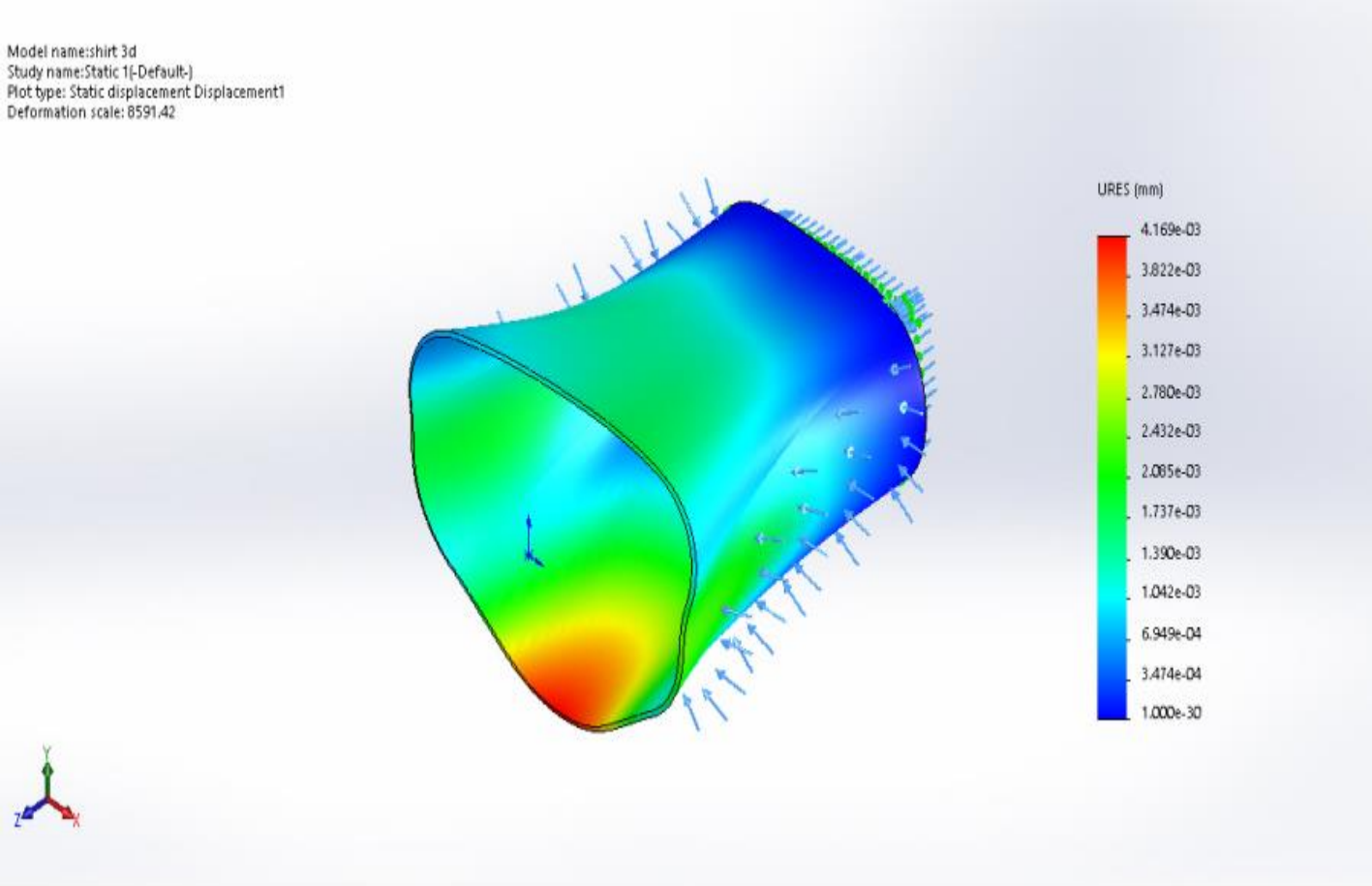
Study result

Name	Type	Min	Max
Stress1	VON: von Mises Stress	1.932e-01 N/m^2 Node: 3809	7.502e+03 N/m^2 Node: 273



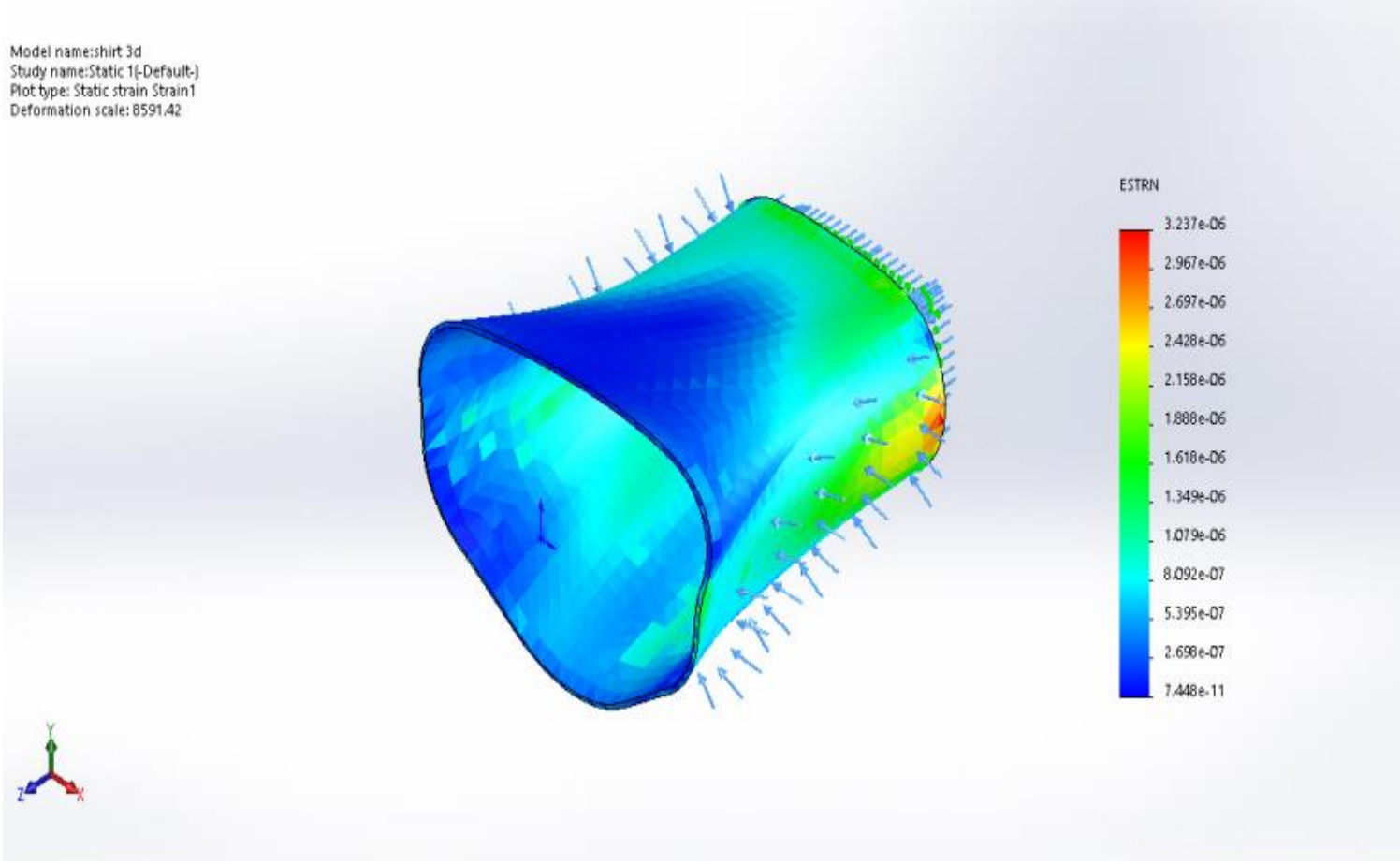
shirt 3d-Static 1-Stress-Stress1

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00 mm Node: 10	4.169e-03 mm Node: 2071



shirt 3d-Static 1-Displacement-Displacement1

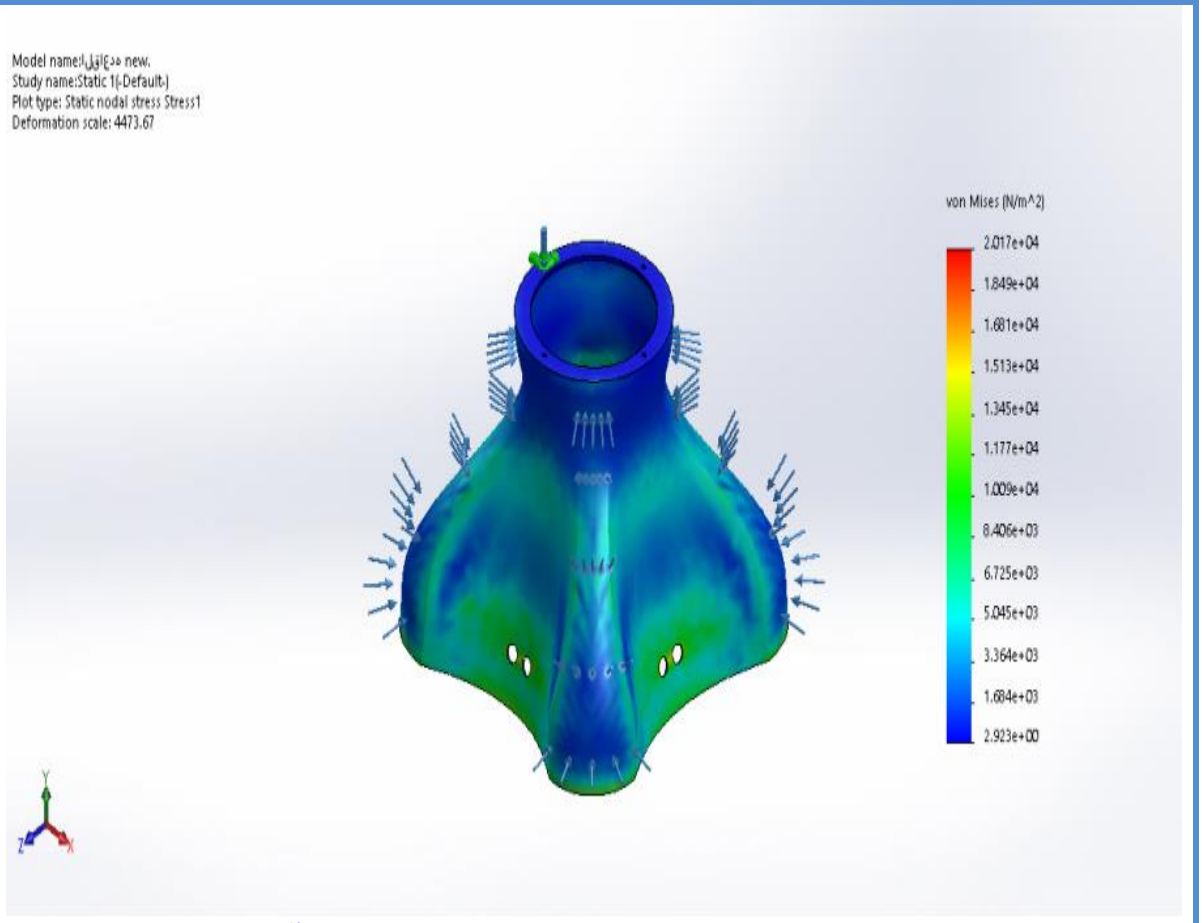
Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	7.448e-11 Element: 4808	3.237e-06 Element: 2598



shirt 3d-Static 1-Strain-Strain1

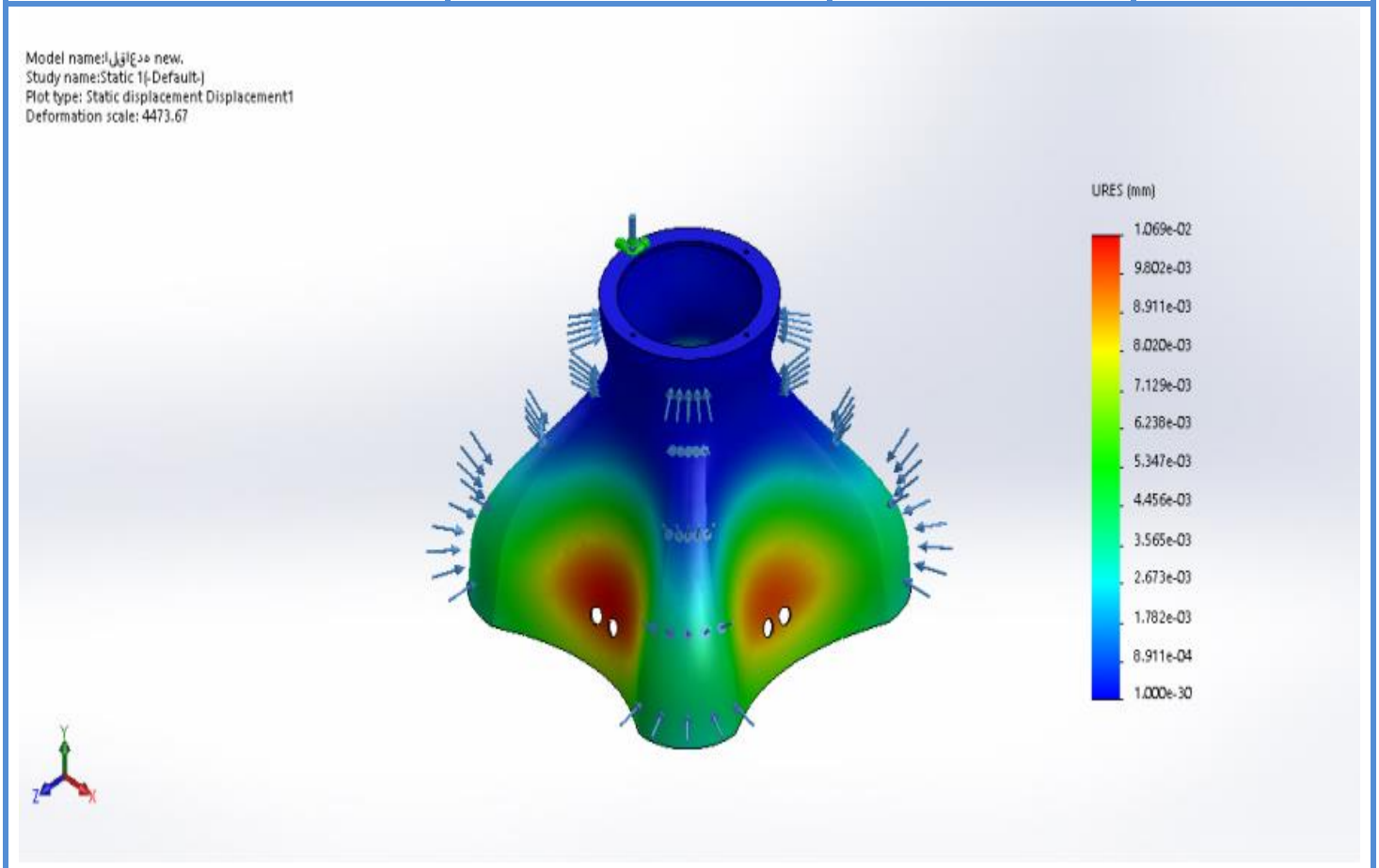
3.4.2Bottom:

Name	Type	Min	Max
Stress1	VON: von Mises Stress	2.923e+00 N/m^2 Node: 5136	2.017e+04 N/m^2 Node: 3429



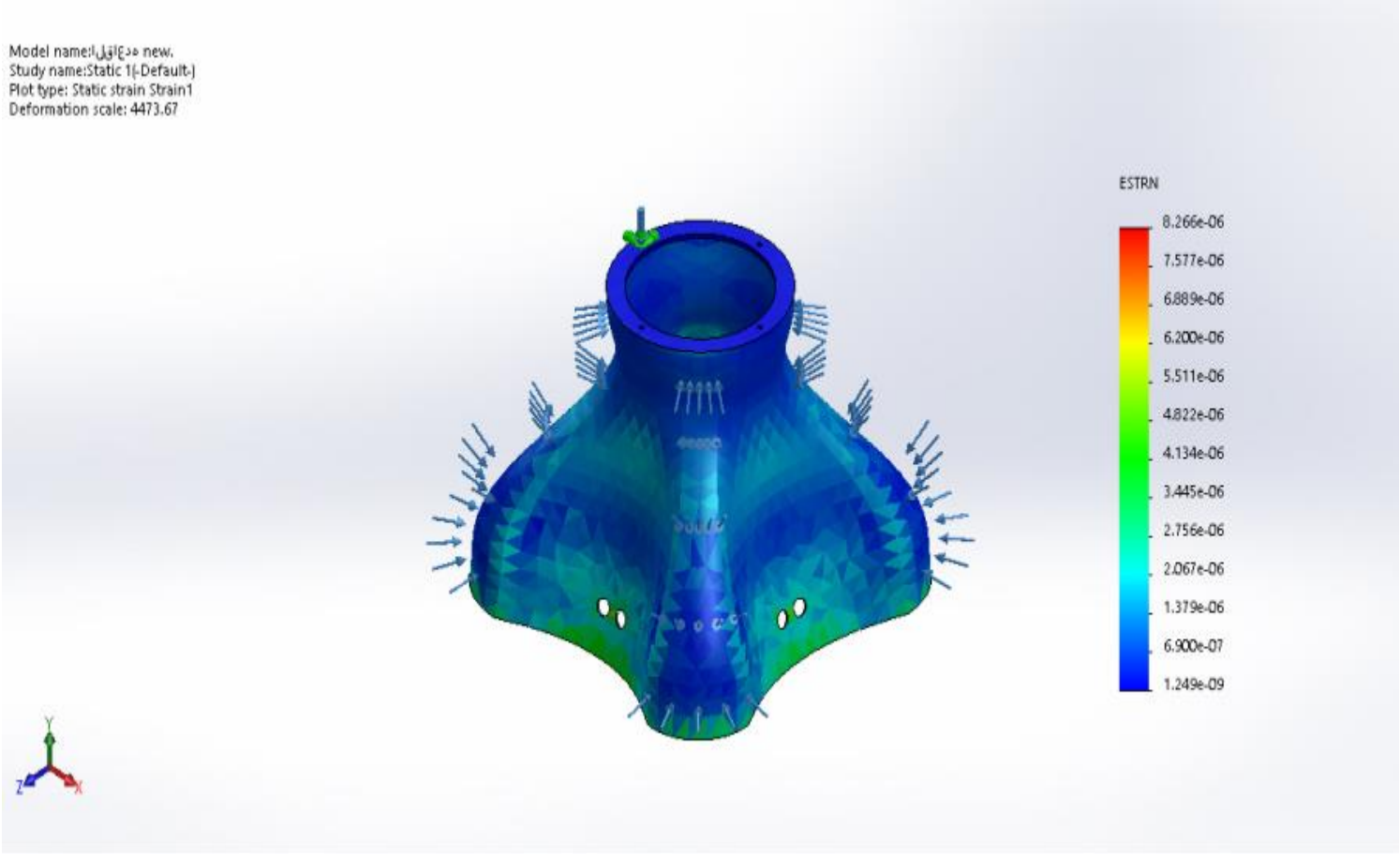
القاعده new.-Static 1-Stress-Stress1

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00 mm Node: 553	1.069e-02 mm Node: 13552



القاعده new.-Static 1-Displacement-Displacement1

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	1.249e-09 Element: 7440	8.266e-06 Element: 10376



القاعده new.-Static 1-Strain-Strain1

chapter 4: Control

4.1Ultrasonic sensor

This is the HC-SR04 ultrasonic distance sensor. This economical sensor provides 2cm to 400cm of non-contact measurement functionality with a ranging accuracy that can reach up to 3mm. Each HC-SR04 module includes an ultrasonic transmitter, a receiver and a control circuit.

There are only four pins that you need to worry about on the HC-SR04: VCC (Power), Trig (Trigger), Echo (Receive), and GND (Ground). You will find this sensor very easy to set up and use for your next range-finding project.

4.1.1 What is an Ultrasonic Sensor?

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves .

An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity. High-frequency sound waves reflect from boundaries to produce distinct echo patterns.

4.1.2 How Ultrasonic Sensors Work?

Ultrasonic sensors work by sending out a sound wave at a frequency above the range of human hearing. The transducer of the sensor acts as a microphone to receive and send the ultrasonic sound. Our ultrasonic sensors, like many others, use a single transducer to send a pulse and to receive the echo. The sensor determines the distance to a target by measuring time lapses between the sending and receiving of the ultrasonic pulse. .

sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. Ultrasonic waves travel faster than the speed of audible sound (i.e. the sound that humans can hear). Ultrasonic sensors have two main components: the transmitter (which emits the sound using piezoelectric crystals) and the receiver (which encounters the sound after it has travelled to and from the target). .

In order to calculate the distance between the sensor and the object, the sensor measures the time it takes between the emission of the sound by the transmitter to its contact with the receiver. The formula for this calculation is **D = ½ T x C** (where D is the distance, T is the time, and C is the speed of sound ~ 343 meters/second .

working principle of this module is simple. It sends an ultrasonic pulse out at **40kHz** which travels through the air and if there is an obstacle or object, it will bounce back to the sensor by calculating the travel time and the speed of sound, the distance can be calculated .

.Ultrasonic sensors are a great solution for the detection of clear objects. For liquid level measurement, applications that use infrared sensors, for instance, struggle with this particular use case because of target translucence. .

forpresence detection, ultrasonic sensors detect objects regardless of the color, surface, or material (unless the material is very soft like wool, as it would absorb sound.) To detect transparent and other items where optical technologies may fail, ultrasonic sensors are a reliable choice.

4.1.3 How are Ultrasonic Sensors used?

Our ultrasonic distance, level, and proximity sensors are commonly used with microcontroller platforms like Raspberry Pi, ARM, PIC, Arduino, Beagle Board, and more .

Ultrasonic sensors transmit sound waves toward a target and will determine its distance by measuring the time it took for the reflected waves to return to the receiver. .

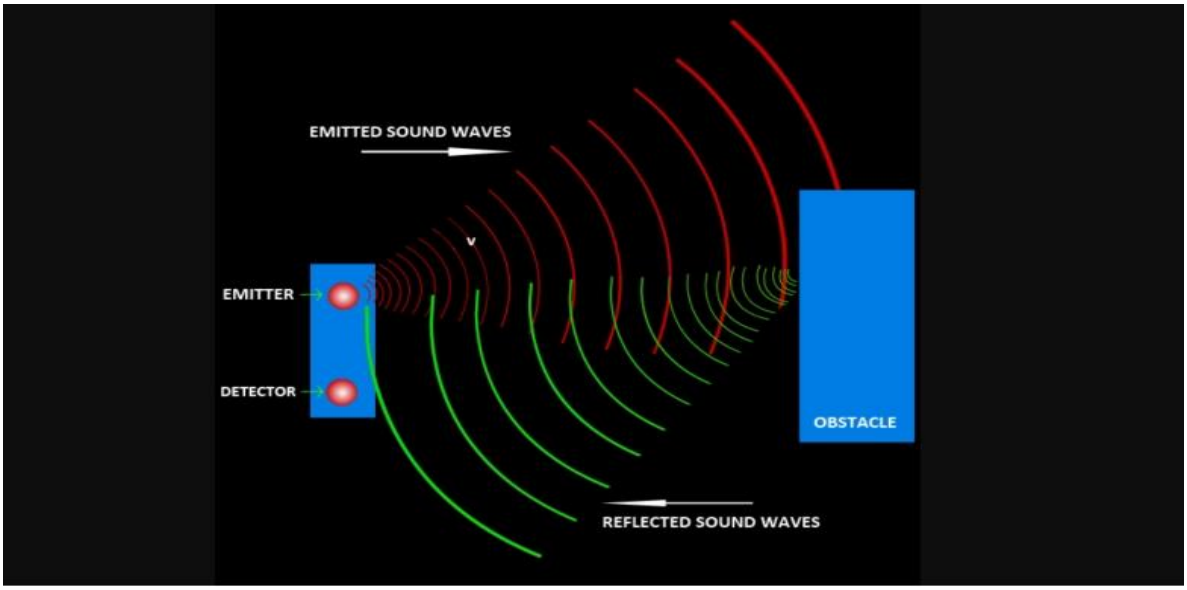
This sensor is an electronic device that will measure the distance of a target by transmitting ultrasonic sound waves, and then will convert the reflected sound into an electrical signal .

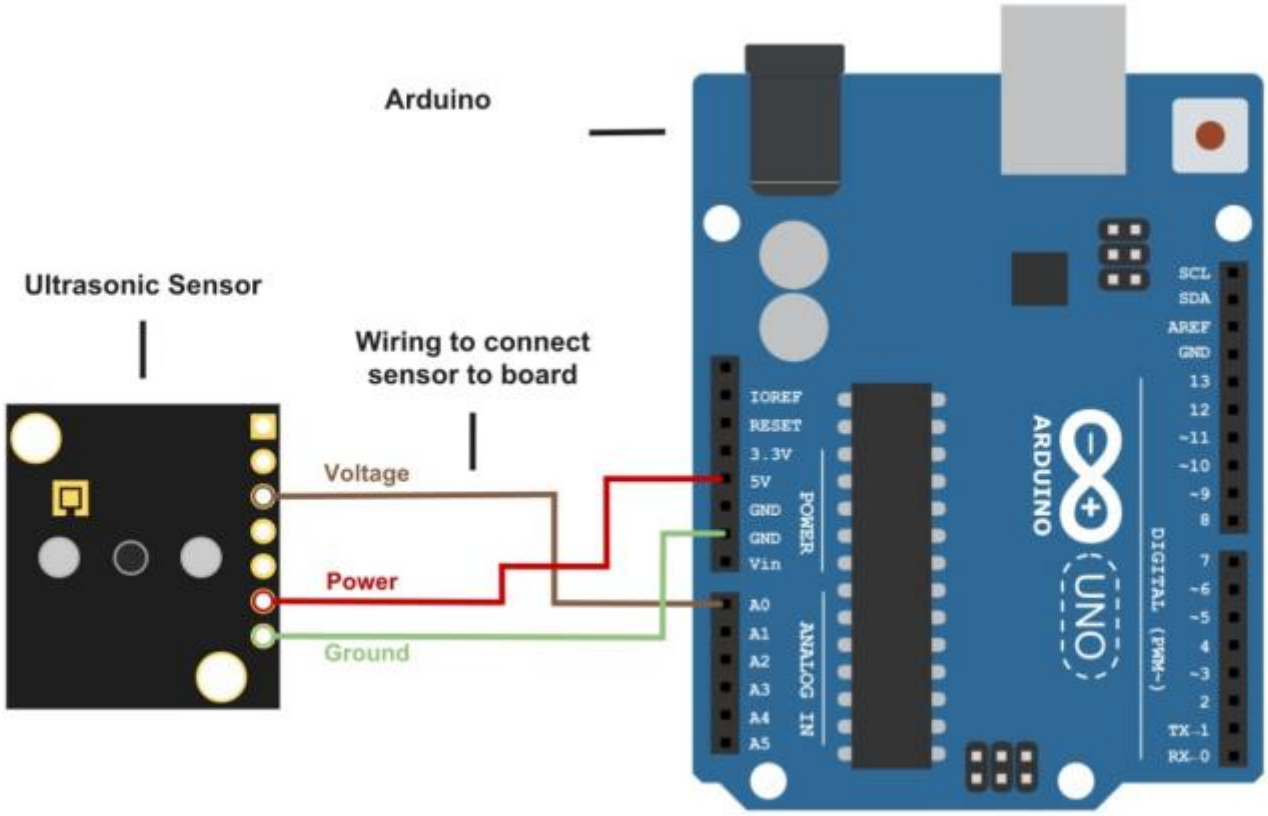
Our sensors are often used as proximity

sensors . .

Ultrasonic sensors are also used in obstacle avoidance systems, as well as inmanufacturing.

Our ShortRange sensors offer the opportunity for closer range detection where you may need a sensor that ranges objects as close to 2cm . These are also built with very low power requirements in mind, as well as environments where noise rejection is necessary.





When Not To Use an Ultrasonic Sensor

In some cases, the target object is so small that the reflected ultrasonic signal is insufficient for detection, and the distance cannot be measured correctly.

Using Ultrasonic Sensor in Project

1. HOOK UP CONTROLLER

We used an Arduino

2. INSTALL SOFTWARE

Install Arduino Sketch coding software onto your PC. This is where you type the code you want to compile and send to the Arduino board.

3. SET UP YOUR SENSOR WITH ARDUINO

Plug your Arduino into the USB cable and into your computer. Once you upload Arduino, you can then compile and activate the code.

4. COMPILE AND RUN CODE

The code below will allow you to read distance in centimeters. Compile and run this code to obtain real-time distance measurements to the closest object.

4.1.4 Why use an Ultrasonic Sensor?

Ultrasound is reliable in any lighting environment and can be used inside or outside. Ultrasonic sensors can handle collision avoidance for a robot, and being moved often, as long as it isn't .
too fast
Ultrasonics are so widely used, they can be reliably implemented in grain bin sensing applications, water level sensing, drone applications and sensing cars at your local drive-thru restaurant or bank. Ultrasonic rangefinders are commonly used as devices to detect a collision.

Ultrasonic Sensors are best used in the non-contact detection of:

- Presence
- Level
- Position
- Distance

Ultrasonics are Independent of:

- Light
- Smoke
- Dust

- Color
- Material (except for soft surfaces, i.e. wool, because the surface absorbs the ultrasonic sound wave and doesn't reflect sound.)

Ultrasonic sensors are superior to infrared sensors because they aren't affected by smoke or black materials, however, soft materials which don't reflect the sonar (ultrasonic) waves very well may cause issues. It's not a perfect system, but it's good and reliable.

4.2 Line Follower sensor

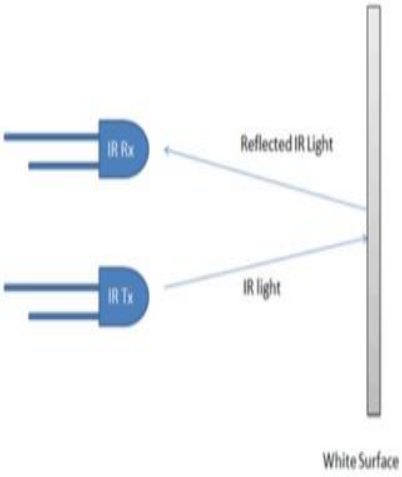
Line follower Robot is a very simple robot that follows a line, either a black line or a white line. These type of robots are very simple to build and is often the first choice for beginners who are getting started with robotics. Basically, there are two types of line follower robots: one is a black line follower which follows the black line and the second is a white line follower which follows the white line. Line follower actually senses the line and follows it. Though the idea sounds simple, with a little more development, robots similar to this are practically used in many applications like factory floor management robots or warehouse robots.

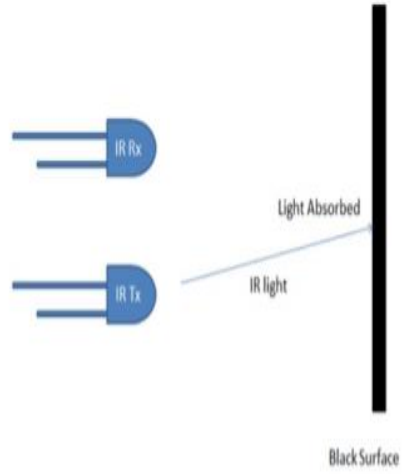
4.2.1 What is an line follower Sensor?

A line follower consists of an infrared light sensor and an infrared LED. It works by illuminating a surface with infrared light; the sensor then picks up the reflected infrared radiation and, based on its intensity, determines the reflectivity of the surface in question. Light-colored surfaces will reflect more light than dark surfaces, resulting in their appearing brighter to the sensor. This allows the sensor to detect a dark line on a pale surface, or a pale line on a dark surface. You can use a line follower to help your robot navigate along a marked path, or in any other application involving discerning the boundary between two high-contrast surfaces. A typical application uses three line follower sensors

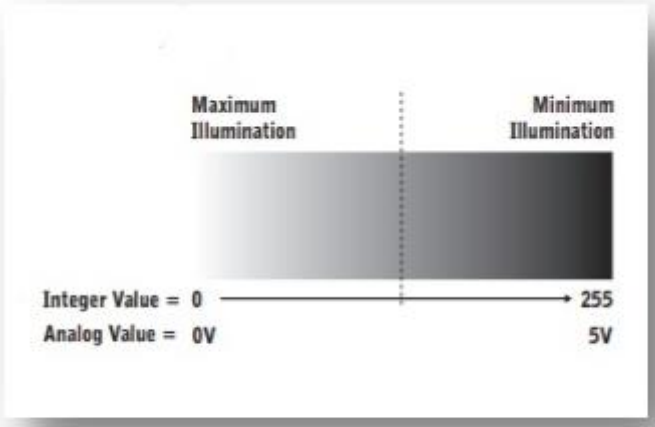
4.2.2 How line follower Sensors Work?

The concept of working of line follower is related to light. We use here the behavior of light at the black and white surfaces. When light falls on a white surface it is almost fully reflected and in the case of a black surface light is completely absorbed. This behavior of light is used in building a line follower robot.

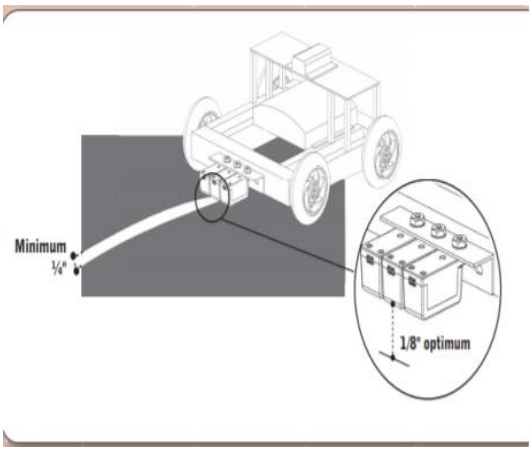

IR Rx
Reflected IR Light
IR Tx
IR light
White Surface


IR Rx
Light Absorbed
IR Tx
IR light
Black Surface

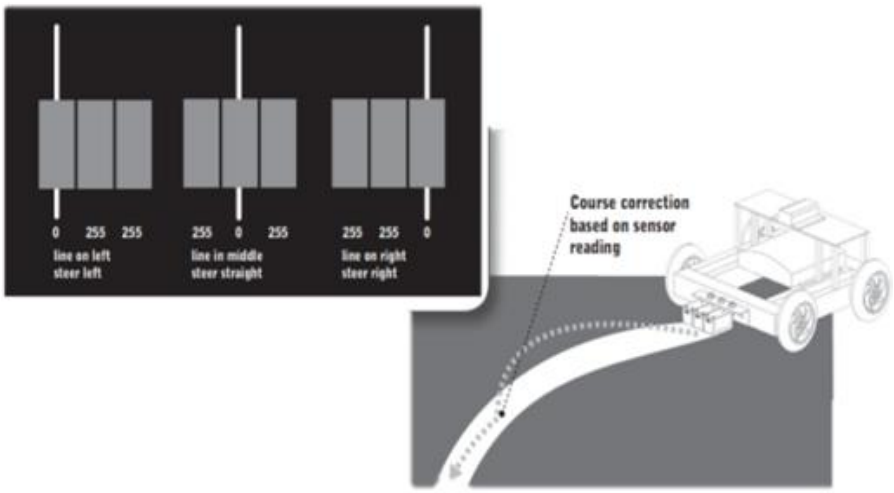
In this Arduino based line follower robot, we have used IR Transmitters and IR receivers also called photodiodes. They are used for sending and receiving light. IR transmits infrared lights. When infrared rays falls on the white surface, it's reflected back and caught by photodiodes which generate some voltage changes. When IR light falls on a black surface, light is absorbed by the black surface and no rays are reflected back, thus photo diode does not receive any light or rays. Here in this Arduino line follower robot when the sensor senses white surface then Arduino gets 1 as input and when senses black line Arduino gets 0 as input.



This is an analog sensor, meaning that its output covers a range of values (in this case, from zero to five volts) rather than being only high (five volts) or low (zero volts), as is the case for a digital sensor. This range of output from zero to five volts is sent to the microcontroller, which reads it as a range of integer values from 0 to 255.



For this particular sensor, sensor output will be low (around 0) when the infrared light bounces back to the detector – in other words, when the surface is pale or highly reflective – and high (around 255) when the light is absorbed and does not bounce back we can then set a threshold value in our code to act as a trigger for behaviors. From this basic premise, we can build more complicated behaviors.

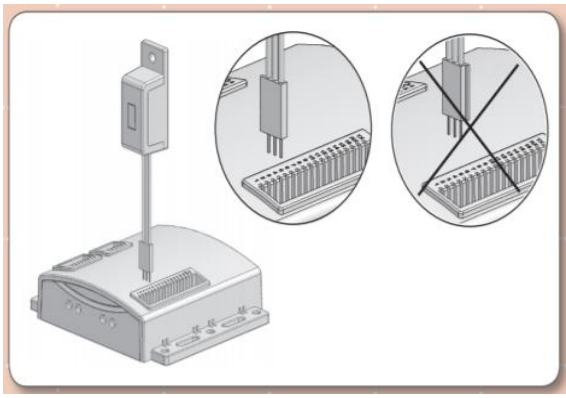


For example, if you have three line sensors on the front of your robot then you can program your robot to follow a white line on a black surface. LineFollower_Middle should always see white, and the other two LineFollower_Left and LineFollower_Right — should always see black. If LineFollower_Left starts seeing white, then your robot needs to steer back to the left. If LineFollower_Right starts seeing white, then your robot needs to steer back to the right

The optimal range for the line follower is approximately 0.02 to 0.25 inch. The minimum line width it can detect is 0.25"

Sensor output will be low (0V) when the infrared light bounces back to the detector – in other words, when the surface is pale or highly reflective – and high (+5V) when the light is absorbed and does not bounce back.

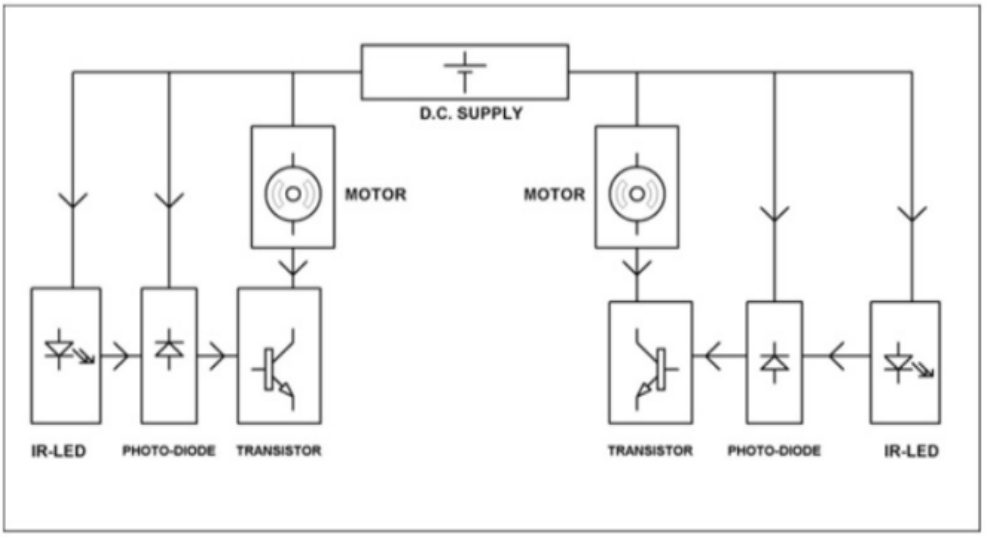
HELPFUL HINT: Because the line follower uses an infrared LED to illuminate its target and an infrared sensor to detect the reflected light, it will actually work in low-light conditions or even in the dark! However, this also means that it can easily become saturated — in other words, everything will look white to it, like an over-exposed photograph — in environments where there is a lot of infrared radiation. You'll find environments like this in competition settings where tungsten lights are used for illumination. To avoid saturating the infrared sensor, consider mounting it underneath the robot or adding a cardboard shield to block ambient radiation.



Reading data from the line follower: Reprogramming your microcontroller to read the sensor Start by plugging your line follower into any port in the Analog/Digital bank on the Vex Microcontroller. Note that the connector is mechanically keyed to fit into the microcontroller ports in a specific orientation. Plugging it in backwards could result in damage to your sensorIn order for your robot to be able to read the sensor, you will have to reprogram the microcontroller.

4.2.3How are linefollower Sensors used?

2 Ways of controlling a line Follower Robot



Block diagram of control system

Without using Microcontrollers

It consists of an IR-LED and Photodiode arrangement for each motor which is controlled by the switching on and off of the .
transistor. .
The IR LED on getting proper biasing emits Infra red light. This IR light is reflected in case of a white surface and the reflected IR light is incident on the photodiode. The resistance of the photodiode decreases, which leads to an increase in current through it and thus the voltage drop across it. The photodiode is connected to the base of the transistor and as a result of

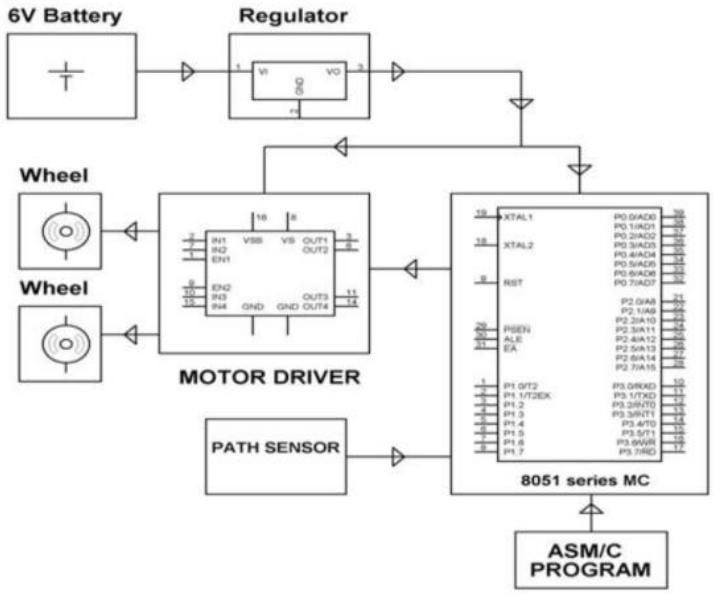
increased voltage across the photodiode, the transistor starts conducting and thus the motor connected to the collector of the transistor gets enough supply to start rotating. In case of a black color on the path encountered by one of the sensor arrangement, the IR light is not reflected and the photodiode offers more resistance, causing the transistor to stop conduction and eventually the motor stops rotating.

Thus the whole system can be controlled using a simple LED-Photodiode-Transistor arrangement

With using Microcontrollers

Working principle:

The line fallowing robot is one of the self-operating robots. That detects and fallows a line drawn on the area. The line is indicated by white line on a block surface or block line on a white surface. This system must be sense by the line. This application is depends upon the sensors. Here we are using two sensors for path detection purpose. That is proximity sensor and IR sensor. The proximity sensor used for path detection and IR sensor used for obstacle detection. These sensors mounted at front end of the robot. The microcontroller is an intelligent device the whole circuit is controlled by the microcontroller.



Block Diagram of Line Following Robotic Vehicle with Microcontroller

Circuit Explanation

The whole **Arduino line follower robot** can be divided into 3 sections: sensor section, a control section, and driver section.

Sensor section:

This section contains IR diodes, potentiometer, Comparator (Op-Amp) and LED's. The potentiometer is used for setting reference voltage at comparator's one terminal and IR sensors are used to sense the line and provide a change in voltage at the comparator's second terminal. Then the comparator compares both voltages and generates a digital signal at the output. Here in this **line follower circuit,** we have used two comparators for two sensors. LM 358 is used as a comparator. LM358 has inbuilt two low noise Op-amps.

Control Section:

Arduino Pro Mini is used for controlling the whole the process of the line follower robot. The outputs of comparators are connected to digital pin numbers 2 and 3 of Arduino. Arduino read these signals and send commands to driver circuit to driveline follower.

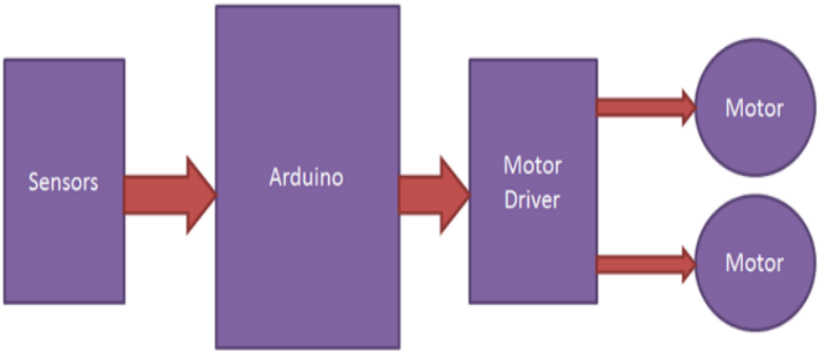
Driver section:

The driver section consists of motor driver and two DC motors. The motor driver is used for driving motors because Arduino does not supply enough voltage and current to the motor. So we add a motor driver circuit to get enough voltage and current for the motor. Arduino sends commands to this motor driver and then it drives motors.

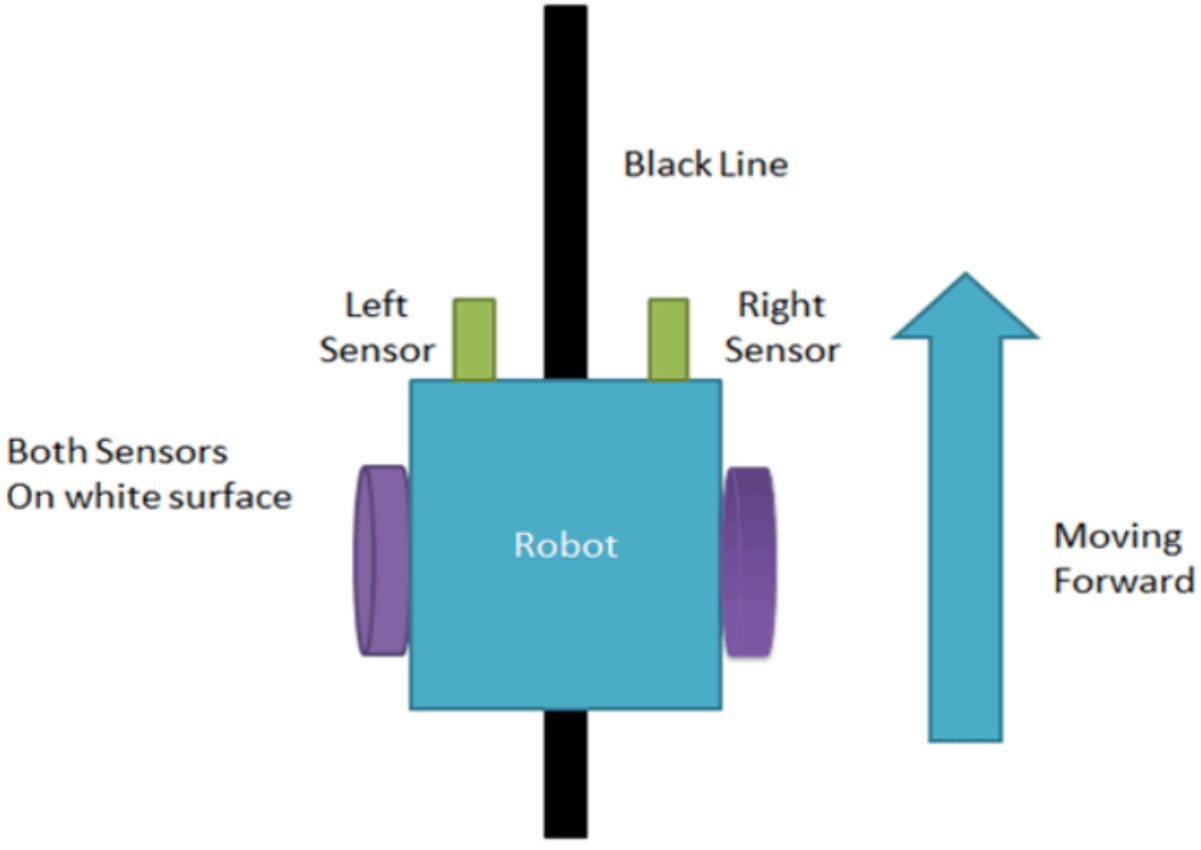
Working of Line Follower Robot using Arduino

Building a **Line follower robot using Arduino** is interesting. The line follower robot senses a black line by using a sensor and then sends the

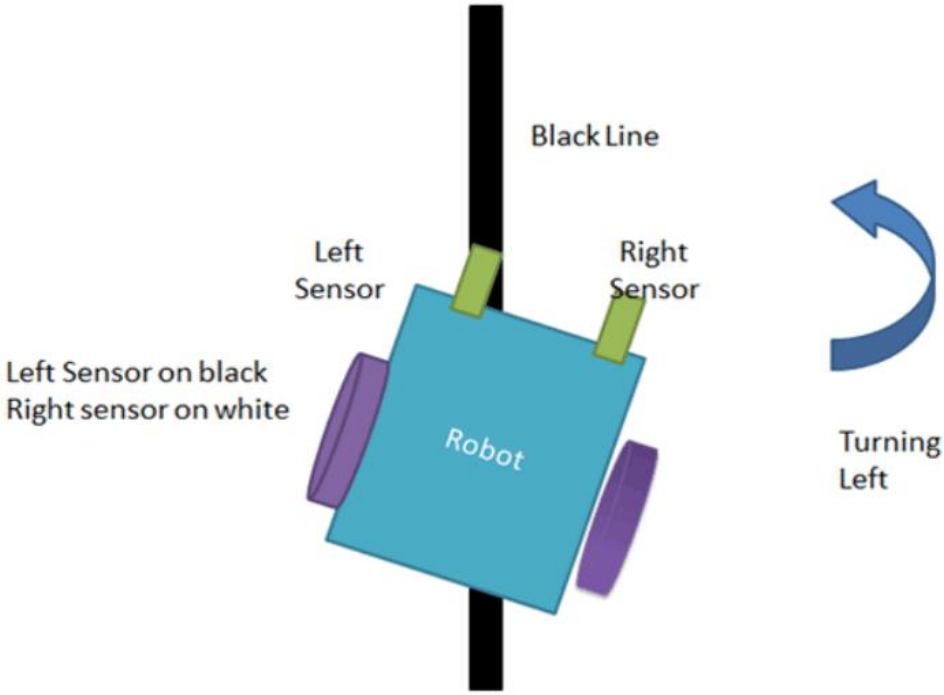
signal to Arduino. Then Arduino drives the motor according to sensors' output.



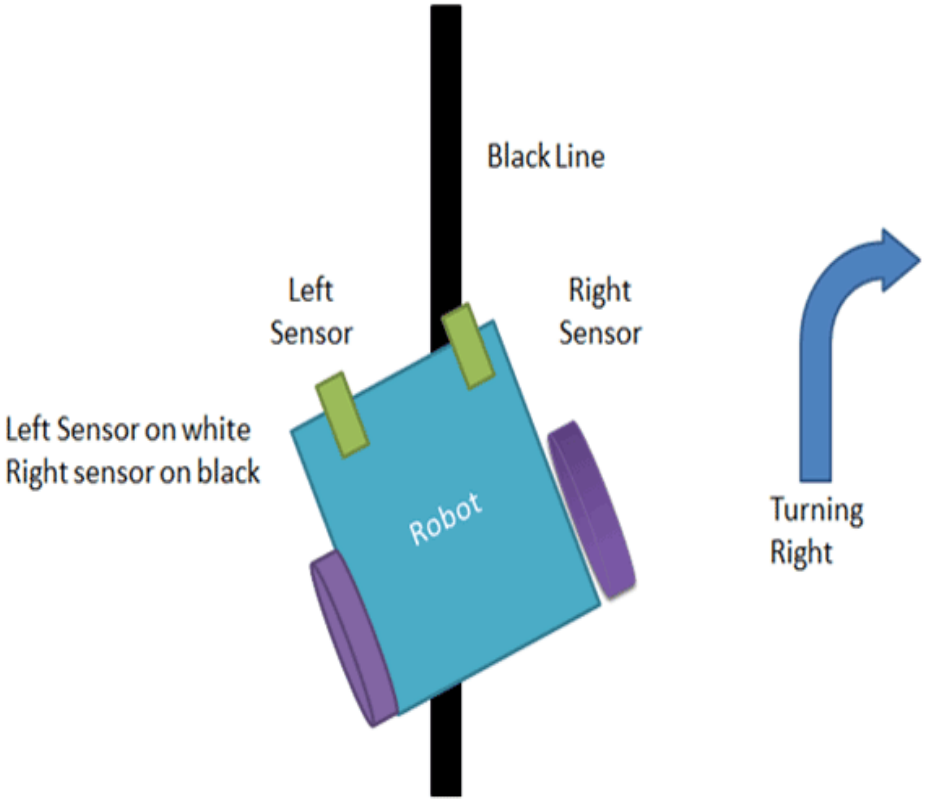
Here in this project, we are using two IR sensor modules namely the left sensor and the right sensor. When both left and right sensor senses white then the robot moves forward.



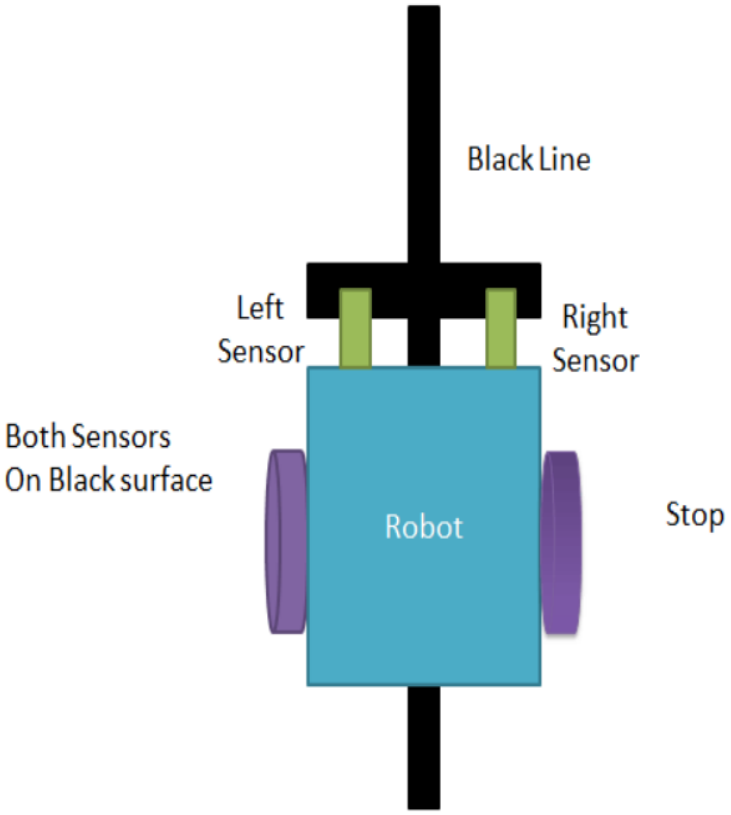
If the left sensor comes on a black line then the robot turn the left side.



If the right sensor sense black line then robot turn right side until both sensors comes at the white surface. When the white surface comes robot starts moving on forward again.



If both sensors come on the black line, the robot stops.



Different types of line controlled robotic vehicles:

There are two types of line controlled robotic vehicles

- Mobile based line controlled robotic vehicle
- RF based line controlled robotic vehicle

Applications of line follower robot:

- **Industrial Applications**: These robots can be used as automated equipment carriers in industries replacing traditional conveyer belts.
- **Automobile applications**: These robots can also be used as automatic cars running on roads with embedded magnets.
- **Domestic applications**: These can also be used at homes for domestic purposes like floor cleaning etc.
- **Guidance applications**: These can be used in public places like shopping malls, museums etc to provide path guidance.

Advantages:

- Robot movement is automatic
- It is used for long distance applications
- Simplicity of building
- Fit and forget system
- Used in home, industrial automations etc.

Specifications

• Interface type : 05V Analog x3

• Operating voltage : 5V (Nominal)

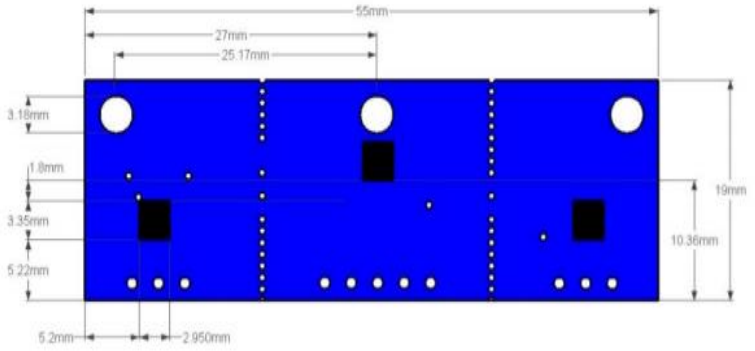
• Supply current : 75 mA for the entire module

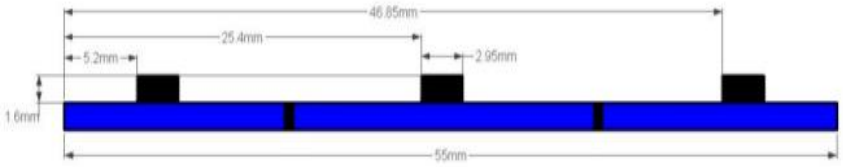
• Sensing range : 3mm (0.125") to ~6mm (0.25")

• Pin definition : Out 1 (Right sensor), Out 2 (Left Sensor), Out 3 (Middle Sensor) • Optimal sensing distance: 3mm (0.125")

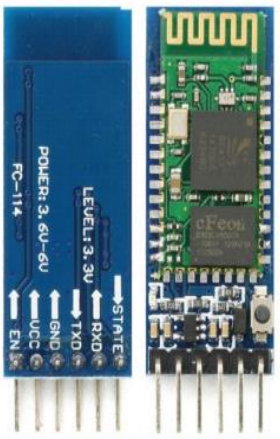
• Optimal line thickness: black electric tape is ideal (≈17mm)

Dimensions


55mm
27mm
25.17mm
3.18mm
1.8mm
3.35mm
5.22mm
19mm
10.36mm
5.2mm
2.950mm


46.85mm
25.4mm
5.2mm
2.95mm
1.6mm
55mm

4.3.Bluetooth module hc-05



HC-05 Bluetooth Module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Its communication is via serial communication which makes an easy way to interface with controller or PC. HC-05 Bluetooth module provides switching mode between master and slave mode which means it able to use neither receiving nor transmitting data.

4.3.1What is bluetooth Module HC-05?

HC-05 is a Bluetooth module which is designed for wireless comunication. This module can be used in a master or slave configuration It is used for many applications like wireless headset, game controllers, wireless mouse, wireless keyboard and many more consumer applications It has range up to <100m which depends upon transmitter and receiver, atmosphere, geographic & urban conditions It is IEEE 802.15.1 standardized protocol, through which one can build wireless Personal Area Network (PAN). It uses frequency-hopping spread spectrum (FHSS) radio technology to send data over air It uses serial communication to communicate with devices. It communicates with microcontroller using serial port (USART).

4.3.2.Circuit Schematics

Here’s how we need to connect the module to the Arduino Board.

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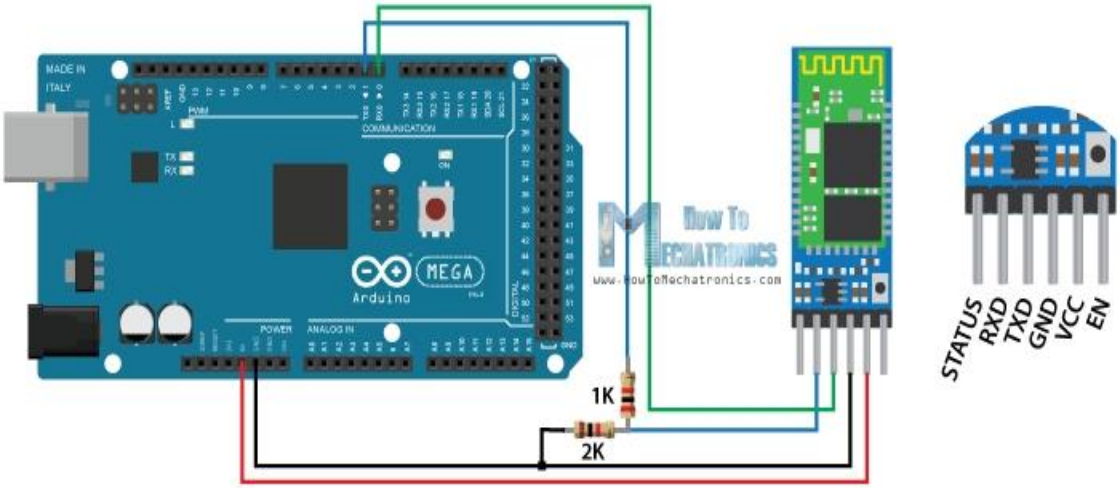
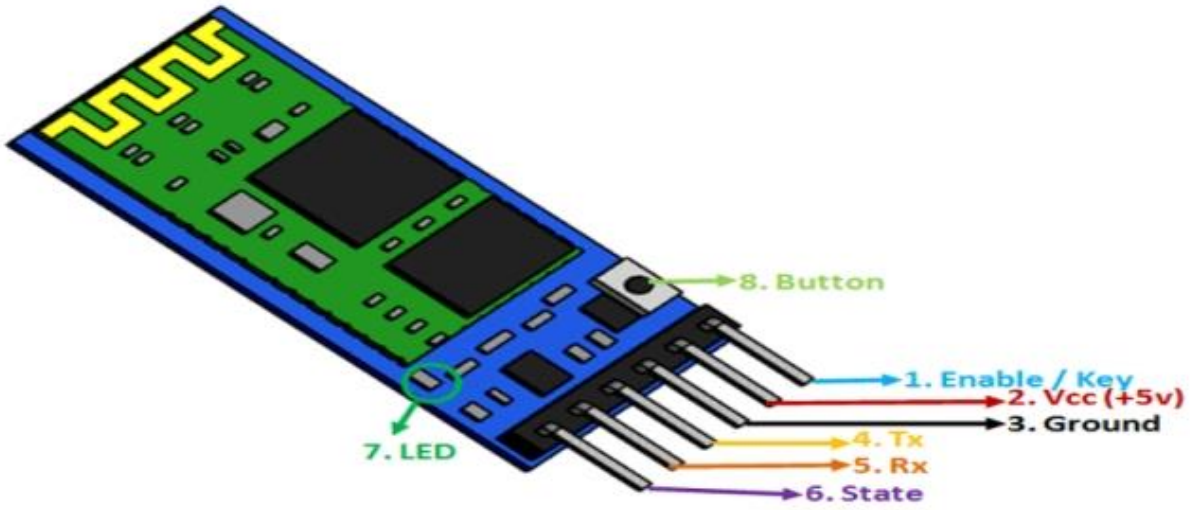


The particular module that we have can be powered from 3.6 to 6 volts, because it comes on breakout board which contains a voltage regulator. However, the logic voltage level of the data pins is 3.3V. So, the line between the Arduino TX (Transmit Pin, which has 5V output) and the Bluetooth module RX (Receive Pin, which supports only 3.3V) needs to be connected through a voltage divider in order not to burn the module. On the other hand, the line between the Bluetooth module TX pin and the Arduino RX pin can be connected directly because the 3.3V signal from the Bluetooth module is enough to be accepted as a high logic at the Arduino Board.



4.3.3Pin Configuration

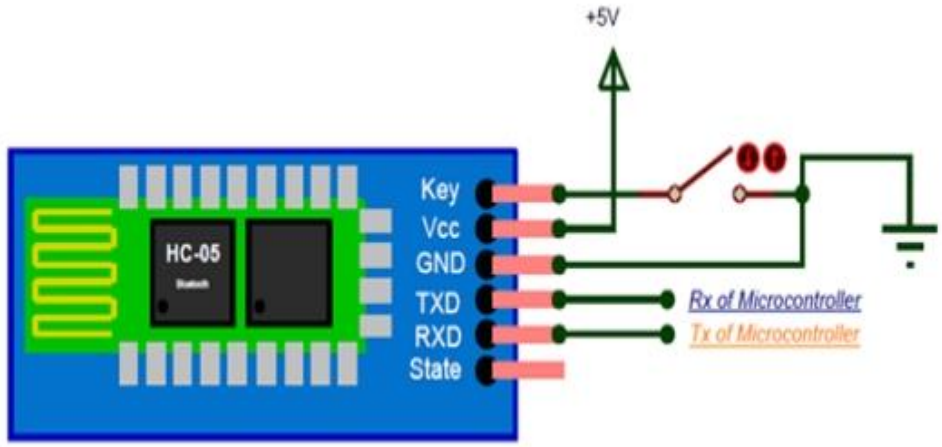
Pin Number	Pin Name	Description
1	Enable / Key	This pin is used to toggle between Data Mode (set low) and AT command mode (set high). By default it is in Data mode
2	Vcc	Powers the module. Connect to +5V Supply voltage
3	Ground	Ground pin of module, connect to system ground.
4	TX – Transmitter	Transmits Serial Data. Everything received via Bluetooth will be given out by this pin as serial data.
5	RX – Receiver	Receive Serial Data. Every serial data given to this pin will be broadcasted via Bluetooth
6	State	The state pin is connected to on board LED, it can be used as a feedback to check if Bluetooth is working properly.
7	LED	Indicates the status of Module Blink once in 2 sec: Module has entered Command Mode Repeated Blinking: Waiting for connection in Data Mode Blink twice in 1 sec: Connection successful in Data Mode
8	Button	Used to control the Key/Enable pin to toggle between Data and command Mode

4.3.4.How to Use the HC-05 Bluetooth module?

The HC-05 has two operating modes, one is the Data mode in which it can send and receive data from other Bluetooth devices and the other is the AT Command mode where the default device settings can be changed.

We can operate the device in either of these two modes by using the key pin as explained in the pin description.

It is very easy to pair the HC-05 module with microcontrollers because it operates using the Serial Port Protocol (SPP). Simply power the module with +5V and connect the Rx pin of the module to the Tx of MCU and Tx pin of module to Rx of MCU as shown in the figure below



During power up the key pin can be grounded to enter into Command mode, if left free it will by default enter into the data mode. As soon as the module is powered you should be able to discover the Bluetooth device as “HC-05” then connect with it using the default password 1234 and start communicating with it. The name password and other default parameters can be changed

4.3.5.How Bluetooth Module Interfacing with Microcontrollers?

In communication, the Bluetooth wireless technology has become very popular and it is one of the fastest growing fields in the wireless technology. Hence it is important to learn how the **HC 05 Bluetooth module** interfacing with the microcontroller. Nowadays, demands of mobile phones and personal communication the bandwidth are easy and convenient to use. The Bluetooth technology manages the communication channel of the wireless part. The Bluetooth modules can transmit and receives the data wirelessly by using two devices. The Bluetooth module can receive and transmits the data from a host system with the help of the **host controller interface** (HCI). The UART & USB are the most popular host controller interfaces and in this article, we have discussed the UART. By using the UART connections, the Bluetooth module can be integrated and it gives the best possible solutions for the Bluetooth embedded systems.

4.3.6.Classification of the Bluetooth Module

There are three different types of Bluetooth module which are classified and described below

Class 1: The output range of Class 1 Bluetooth module is about the 100 mW. The distance between the two Bluetooth module devices is about the 100 meters.

Class 2: The output range of this Bluetooth module is about the 2.5 mW and the distance of two Bluetooth devices are about the 10 meters.

Class 3: The output range of this type Bluetooth module is 1mW and the distance is about the 10 centimeters of two Bluetooth devices.

The Bluetooth module requires a communication protocol to interface with the other devices. In this article we are discussing the Bluetooth module is interfaced with the microcontroller and pic microcontroller. The microcontroller can communicate with the Bluetooth devices with the

following wired communications to receive and send the information to other Bluetooth devices.

- UART
- SPI
- USB

We can use any one of the above three wired communication for the interfacing to a microcontroller with the Bluetooth module. There are many Bluetooth modules which are available in the market. The Bluetooth modules are following. In this article, we will discuss two modules which are HC 05 Bluetooth Module and RN-42.

- HC-04
- HC-05
- RN-41
- RN-42
- AUBTM
- BLUESMIRF

4.3.7.HC-05 Bluetooth Module Connection with Android

Ever wanted to control your Mechanical Bots with an Android Phone or design the robots with custom remote, here in this tutorial we will learn about a Bluetooth Module HC-05 used for the above mentioned and many other cases. Here we will be understanding the connection and working of a HC-05 module and also its interfacing with custom android app.Basics

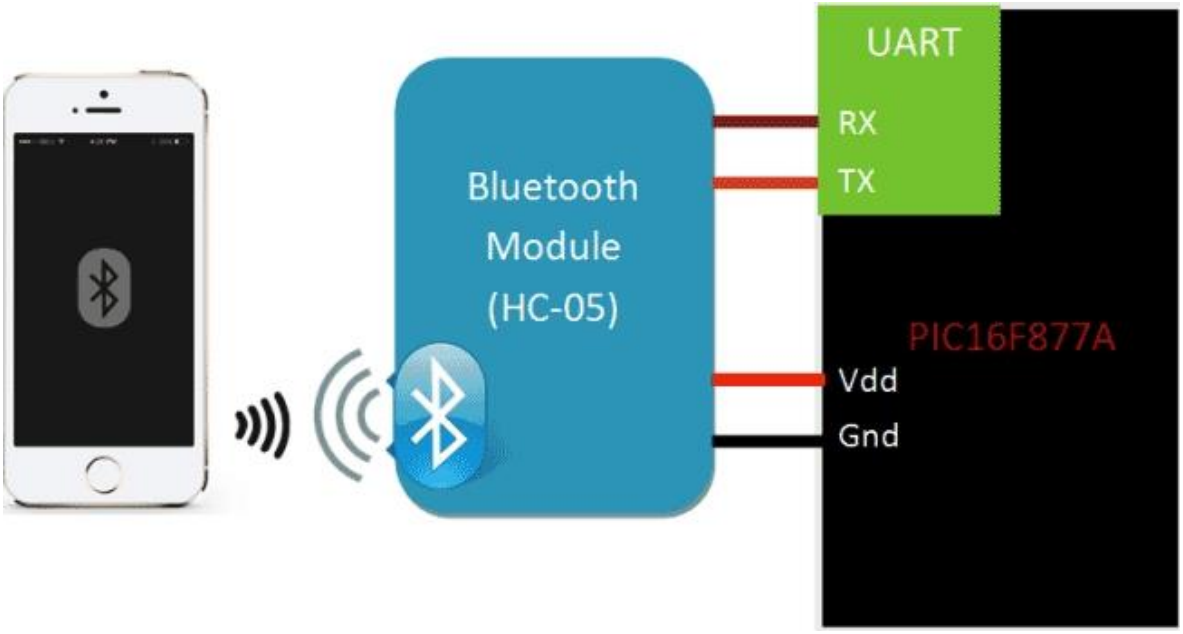
Wireless communication is swiftly replacing the wired connection when it comes to electronics and communication. Designed to replace cable connections HC-05 uses serial communication to communicate with the electronics. Usually, it is used to connect small devices like mobile phones using a short-range wireless connection to exchange files. It uses the 2.45GHz frequency band. The transfer rate of the data can vary up to 1Mbps and is in range of 10 meters.

The HC-05 module can be operated within 4-6V of power supply. It supports baud rate of 9600, 19200, 38400, 57600, etc. Most importantly it can be operated in Master-Slave mode which means it will neither send or receive data from external sources.

How to make out PIC projects wireless by interfacing a Bluetooth Module (HC-05):

Here, we have used the popular Bluetooth module HC-05. Using this module we can receive and send information wirelessly from our PIC MCU to a mobile application or a computer. Communication between PIC and HC-06 is established using the USART module present in the PIC Microcontroller. We again operate on the same Asynchronous 8-bit mode, but this time we will modify our code a bit so that it works with the Bluetooth module. Hence learning UART tutorial beforehand is an added advantage for this project.

The basic block diagram for the setup is shown below.



Requirements:

Hardware:

PIC16F877A Perf Board

HC-05 or HC-06 Bluetooth Module

Computer (for programming)

Mobile Phone

PICkit 3 Programmer

Software:

MPLABX

Bluetooth Terminal (Mobile Application)

Bluetooth can operate in the following two modes:

1. Command Mode
2. Operating Mode

In ***Command Mode*** we will be able to configure the Bluetooth properties like the name of the Bluetooth signal, its password, the operating baud rate etc. The ***Operating Mode*** is the one in which we will be able to send and receive data between the PIC Microcontroller and the Bluetooth module. Hence in this tutorial we will be toying only with the Operating Mode. The Command mode will be left to the default settings. The Device name will be HC-05 and the password will be 0000 or 1234 and most importantly the default baud rate for all Bluetooth modules will be 9600.

SendingdatatoArduinoVia Bluetooth

. .

HC05 module has an internal 3.3v regulator and that is why you can connect it to 5v voltage. But we strongly recommend 3.3V voltage, since the logic of HC05 serial communication pins is 3.3V. Supplying 5V to the module can cause damage to the module .

In order to prevent the module from damages and make it work properly, you should use a resistance division circuit (5v to 3.3v) between arduino TX pin and module RX pin .

When master and slave are connected, blue and red LEDs on the board blink every 2seconds. If they aren't connected, only blue one blinks every 2 seconds.

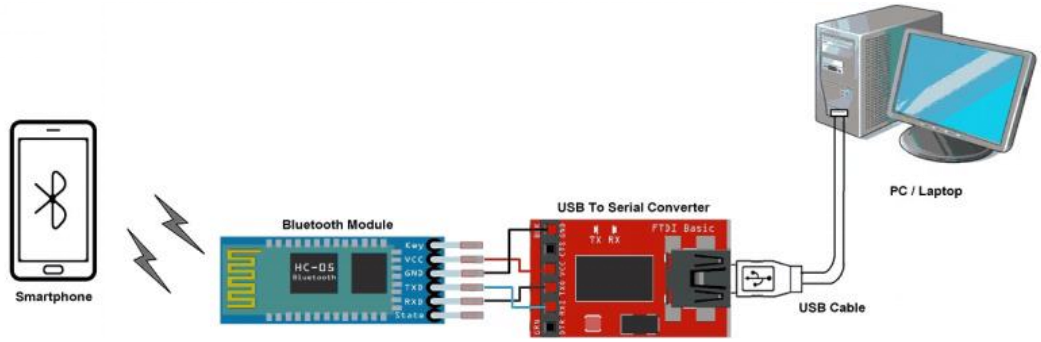
Bluetooth communication between Devices

E.g. Send data from Smartphone terminal to HC-05 Bluetooth module and see this data on PC serial terminal and vice . versa

. .

To communicate smartphone with HC-05 Bluetooth module, smartphone requires Bluetooth terminal application for transmitting and receiving data. You can find Bluetooth terminal applications for android and windows in respectiveapp

store.



Bluetooth Module Serial Interface

So, when we want to communicate through smartphone with HC-05 Bluetooth module, connect this HC-05 module to the PC via serial to USB converter.

Before establishing communication between two Bluetooth devices, 1st we need to pair HC-05 module to smartphone for communication.

Pair HC-05 and smartphone:

1. Search for new Bluetooth device from your phone. You will find Bluetooth device with “HC-05” name.
2. Click on connect/pair device option; default pin for HC-05 is 1234 or 0000.

After pairing two Bluetooth devices, open terminal software (e.g. Teraterm, Realterm etc.) in PC, and select the port where we have connected USB to serial module. Also select default baud rate of 9600 bps.

In smart phone, open Bluetooth terminal application and connect to paired device HC-05.

It is simple to communicate, we just have to type in the Bluetooth terminal application of smartphone. Characters will get sent wirelessly to Bluetooth module HC-05. HC-05 will automatically transmit it serially to the PC, which will appear on terminal. Same way we can send data from PC to smartphone.

After completing hardware and source code installation on Arduino UNO, the next step is setting up PC site. In order to communicate with Arduino UNO, a Bluetooth device is needed as well on PC site. We recommend using USB plug in Bluetooth device in PC site. See below diagram for data transfer between Arduino UNO and PC via Bluetooth devices

4.3.8.Advantages of Bluetooth Module

- When we are traveling with the laptop and with the other wireless devices we don’t need to carry the connection cables.
- The cost of the Bluetooth is not an expensive.
- The Bluetooth modules are standardized protocol because they can connect with the same Bluetooth as well as with the different Bluetooth projects model.
- The Bluetooth module can connect automatically with another Bluetooth device at a range of 30 feet.
- There is a low energy consumption in the Bluetooth devices in generally we can see in the mobile phones.

4.3.9.Applications of Bluetooth Module

- 1.Wireless communication between two microcontrollers
- 2. Communicate with Laptop, Desktops and mobile phones
- 3. Data Logging application
- 4. Consumer applications
- 5. Wireless Robots
- 6. Home Automation

4.4.The lithium-ion battery

4.4.1.Is Lithium-ion the Ideal Battery?

For many years, nickel-cadmium had been the only suitable battery for portable equipment from wireless communications to mobile computing. Nickel-metal-hydride and lithium-ion emerged In the early 1990s, fighting nose-to-nose to gain customer's acceptance. Today, lithium-ion is the fastest growing and most promising battery chemistry. .

Pioneer work with the lithium battery began in 1912 under G.N. Lewis but it was not until the early 1970s when the first non-rechargeable lithium batteries became commercially available. lithium is the lightest of all metals, has the greatest electrochemical potential and provides the largest energy density for weight Attempts to develop rechargeable lithium batteries failed due to safety problems. Because of the inherent instability of lithium metal, especially during charging, research shifted to a non-metallic lithium battery using lithium ions. Although slightly lower in energy density than lithium metal, lithium-ion is safe, provided certain precautions are met when charging and discharging. In 1991, the Sony Corporation commercialized the first lithium-ion battery. Other manufacturers followed suit .

The energy density of lithium-ion is typically twice that of the standard nickel-cadmium. There is potential for higher energy densities. The load characteristics are reasonably good and behave similarly to nickel-cadmium in terms of discharge. The high cell voltage of 3.6 volts allows battery pack designs with only one cell. Most of today's mobile phones run on a single cell. A nickel-based pack would require three 1.2-volt cells connected in series.Lithium-ion is a low maintenance battery, an advantage that most other chemistries cannot claim. There is no memory and no scheduled cycling is required to prolong the battery's life. In addition, the self-

discharge is less than half compared to nickel-cadmium, making lithium-ion well suited for modern fuel gauge applications. lithium-ion cells cause little harm when disposed Despite its overall advantages, lithium-ion has its drawbacks. It is fragile and requires a protection circuit to maintain safe operation. Built into each pack, the protection circuit limits the peak voltage of each cell during charge and prevents the cell voltage from dropping too low on discharge. In addition, the cell temperature is monitored to prevent temperature extremes. The maximum charge and discharge current on most packs are is limited to between 1C and 2C. With these precautions in place, the possibility of metallic lithium plating occurring due to overcharge is virtually eliminated Aging is a concern with most lithium-ion batteries and many manufacturers remain silent about this issue. Some capacity deterioration is noticeable after one year, whether the battery is in use or not. The battery frequently fails after two or three years. It should be noted that other chemistries also have age-related degenerative effects. This is especially true for nickel-metal-hydride if exposed to high ambient temperatures. At the same time, lithium-ion packs are known to have served for five years in some applications. Manufacturers are constantly improving lithium-ion. New and enhanced chemical combinations are introduced every six months or so. With such rapid progress, it is difficult to assess how well the revised battery will age. Storage in a cool place slows the aging process of lithium-ion (and other chemistries). Manufacturers recommend storage temperatures of 15°C (59°F). In addition, the battery should be partially charged during storage. The manufacturer recommends a 40% charge.The most economical lithium-ion battery in terms of cost-to-energy ratio is the cylindrical 18650 (size is 18mm x 65.2mm). This cell is used for mobile computing and other applications that do not demand ultra-thin geometry. If a slim pack is required, the prismatic lithium-ion cell is the best choice. These cells come at a higher cost in terms of stored energy.

4.4.2.Advantages

- High energy density - potential for yet higher capacities.
- Does not need prolonged priming when new. One regular charge is all that's needed.
- Relatively low self-discharge - self-discharge is less than half that of nickel-based batteries.
- Low Maintenance - no periodic discharge is needed; there is no memory.
- Specialty cells can provide very high current to applications such as power tools

4.4.3.Limitations

- Requires protection circuit to maintain voltage and current within safe limits.
- Subject to aging, even if not in use - storage in a cool place at 40% charge reduces the aging effect.
- Transportation restrictions - shipment of larger quantities may be subject to regulatory control. This restriction does not apply to personal carry-on batteries.
- Expensive to manufacture - about 40 percent higher in cost than nickel-cadmium.
- Not fully mature - metals and chemicals are changing on a continuing basis.

4.4.4.Applications

- Portable Electronics
- Electric Vehicle
- Solar powered device
- Power wall
- Power banks
- Laptop Batteries

lithium ion battery

18650

Product Name:	Tenergy Lithium Ion 18650 Cell	
Product Number:	30003	
Battery Model:	18650 2200mAh	
Battery Chemistry:	Lithium Ion Rechargeable	
Dimension:	Max Diameter (φ): 18.3mm	
	Max Height (H): 65.0mm	

Scope

The specification describes the technology parameters and testing standard for the lithium ion rechargeable cell.

Basic characteristics

Capacity	Nominal Capacity : 2200mAh (0.2C_A Discharge)
	Minimum Capacity: 2100mAh (0.2C_A Discharge)
Nominal Voltage	3.7V
Internal impedance	≤ 80mΩ(with PTC)
Discharge Cut-off Voltage	3.0V
Max Charge Voltage	4.20± 0.02 V
Standard Charge Current	0.5C_A
Rapid Charge Current	1C_A
Standard Discharge Current	0.5C_A
Rapid Discharge Current	1C_A

Max Discharge Current	2.0 C_A	
Weight	45±1g	
Max. Dimension	Diameter(φ):	18.3mm
	Height (H):	65.0mm
Operating Temperature	Charge	0 0 45℃
	Discharge	-20 0 60℃
Storage Temperature	Within 1 month	-5 0 35℃
	Within 6 months	0 0 35℃

Standard Conditions for Test

Unless specified, all tests should be conducted within one month after the delivery under the following conditions: Ambient Temperature: 25±5 ; Relative Humidity: 65±20%

Standard Charge:	Constant Current and Constant Voltage (CC/CV)Current = 1100mA End-up Voltage = 4.2 V End Current = 22mA
Standard Discharge:	Constant Current (CC)Curre nt = 1100mA End Voltage = 3.0V

Electrical Performances

Item	Test procedure	Requirements
Nominal Voltage	The average value of the working voltage in the whole discharge progress.	3.7V
Discharge Performance	The discharge capacity of the cell, which ismeasured at $1C_5A$ (or 0.5CA) current discharge to 3.0V within 1 hour after completely charge.	≥57(or 120)min
Capacity Retention	After 28 days storage at 25±5℃ after completed charge, the residual capacity isabove 90%.	Capacity≥1980mAh
Cycle Life	After 300 cycles in 100% DOD charge and discharge at 0.5CA current, the residual discharge capacity is above 60% of nominalcapacity.	≥300 cycles
Storage	(Within 3 months after manufactured) after standard charged 40-50% capacity and stored at ambient temperature 25±5℃ 、 65±20%RH for 12 months, thestorage expiry and the cell completely charged, the cell is discharged at 0.2 CA current discharge to 3.0V.	Discharge time≥4h

safety Performances

Short Circuit	The cell is to be short-circuited by connecting the positive and negative terminals of the celldirectly with copper wire with a resistance less than 0.05Ω.	No fire, no explosion.
Impact Test	Impacting of a cell on a hard surface following a hammer of 10 kilograms free fall from 1m height.	No fire, no explosion.

5.2.3 Overcharge(3C/10 V)	The cell that connect with the thermocouple isput in the fume hood, the positive and negative terminals are connected by a permanent constant electrical source, regulate current to 3 CA and voltage to 10 V. Then charge the cell until voltage is 10 V, current about 0A. Monitor the temperature change of cell when the temperature of cell is about lower 10℃than peak value, the test is over.	No fire, no explosion.
5.2.4 Thermal shock	After standard charging, heat cell to 150±2℃at rate of 5±2℃/min and keep 10minutes.	No fire, no explosion.

Environmental tests

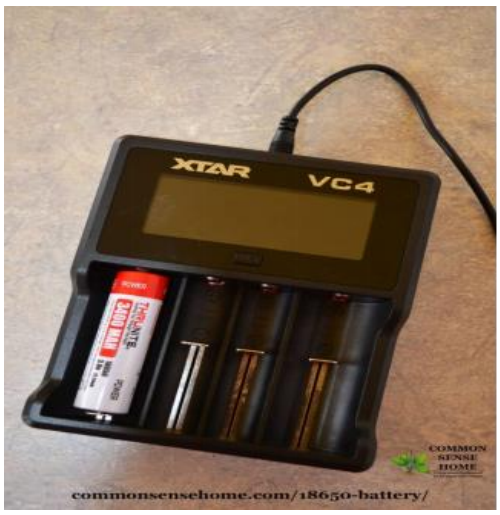
High temperatureperf ormance	The fully charged cell is put in the surrou ndings of 55±2℃for 2 hours, and th enit is discharged to the 2.75V at 1C A current rate.	Capacity≥2160mAh
Low temperatureperforma nce	The charged cell is put 16-24 hours at - 20±2℃and then discharge to 2.75V at 0.2 CAcurrent rate.	Capacity≥1680mAh
Vibration Test	After standard charging, the cell is fixe d on theplatform and be subjected to vi brate on following frequency 10055Hz and amplitude vibration for 30 minutes with direction of X, Y. Vibration Frequ ency: 10030Hz, vibration amplitude 0.3 8mm. Vibration Frequency: 30055Hz, vibration amplitude 0.19mm	
Drop Test	The cell is to be dropped from a heig ht of 1mto hard board in X 、 Y 、 Z directions for twice respectively. Then discharge the cell at 1CA current rate to 3.0V, and undertake more than three circles of standard charge and discharge at 1CA current rate.	No fire, no explosion.

18650 BATTERY CHARGER

18650 batteries are rechargeable, so you will need a good charger. We use two different 18650 chargers.

The best 18650 battery charger is the **Nitecore i4** because it can charge pretty much anything.

Specifically, it supports: lithium ion 26650, 22650, 21700, 18650, 17670, 18490, 17500, 18350, 16340 (the 16340 is also known as RCR123), 14500, 10440 and Ni-MH and Ni-Cd AA, AAA, AAAA, C rechargeable batteries. This is our favorite charger for the 18650s



Our runner up is the **XTAR VC4 Charger**. It is a USB powered 18650 charger. It charges the batteries with any USB power source. This unit is dependent on the power source

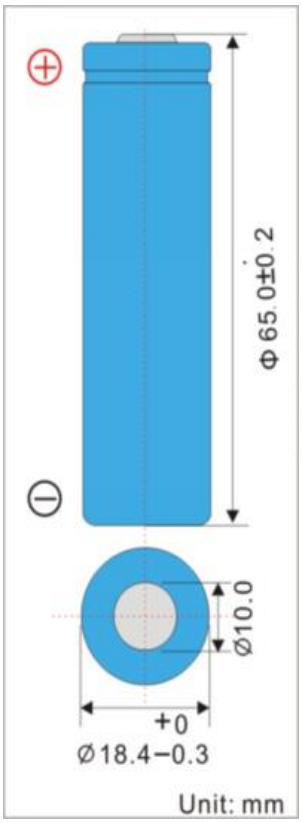
It has an LCD display for charging status.

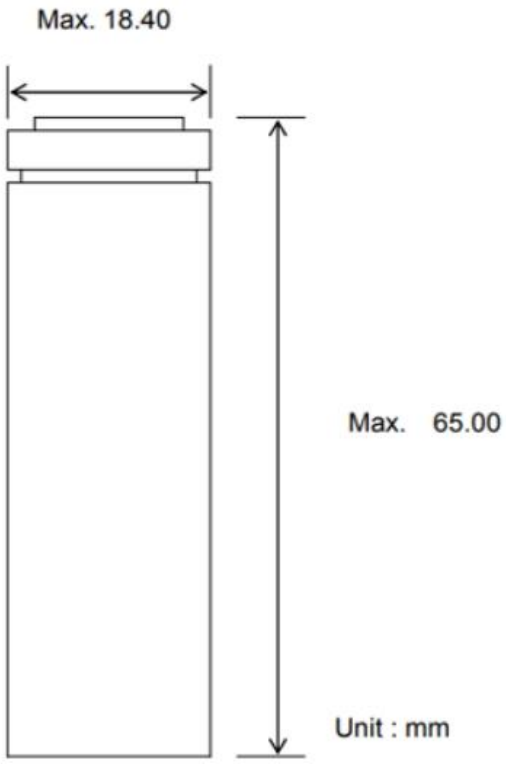
A 2amp interface yields slower charge speeds. Even the 5amp is slow because it charges at .5 amps. We have used the XTAR with a **Nektek solar panel** that has a 2amp USB interface and it has consistently worked.

Packing

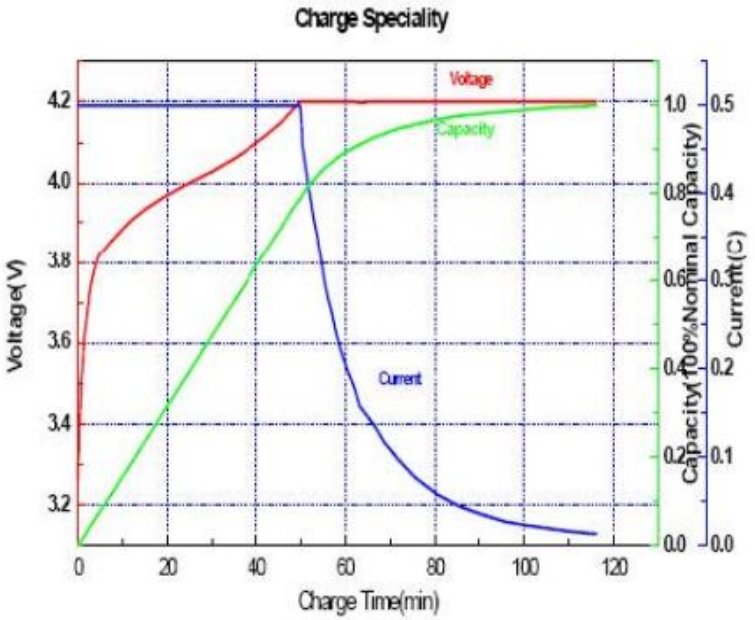
Keep the cells at the half-fully charged state before packing.

Dimension and Performance

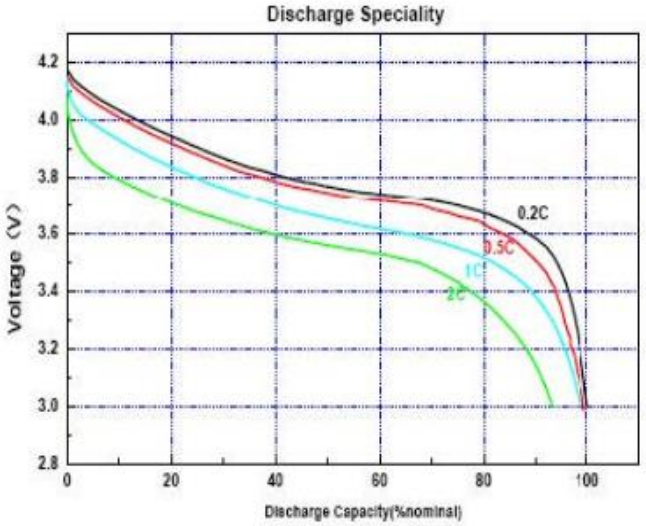




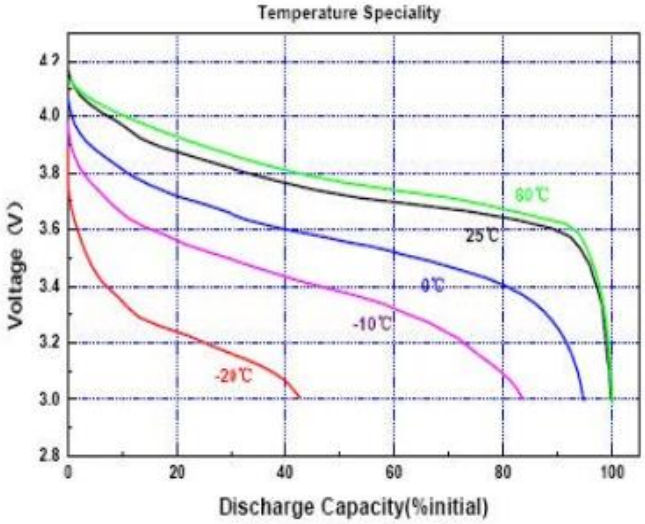
Performance Curve



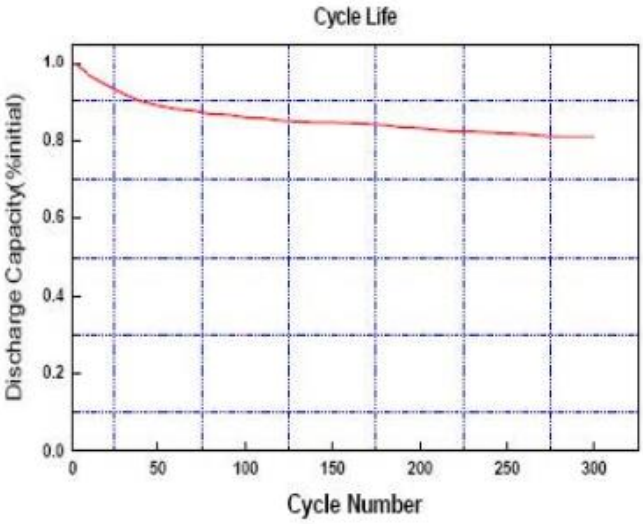
Charge: CC/CV 0.5CmA, 4.2V, 20mA cut off at RT.



Charge: CC/CV 0.5CmA, 4.2V, 20mA cut off at RT
Discharge: 3.0V cut off at RT.



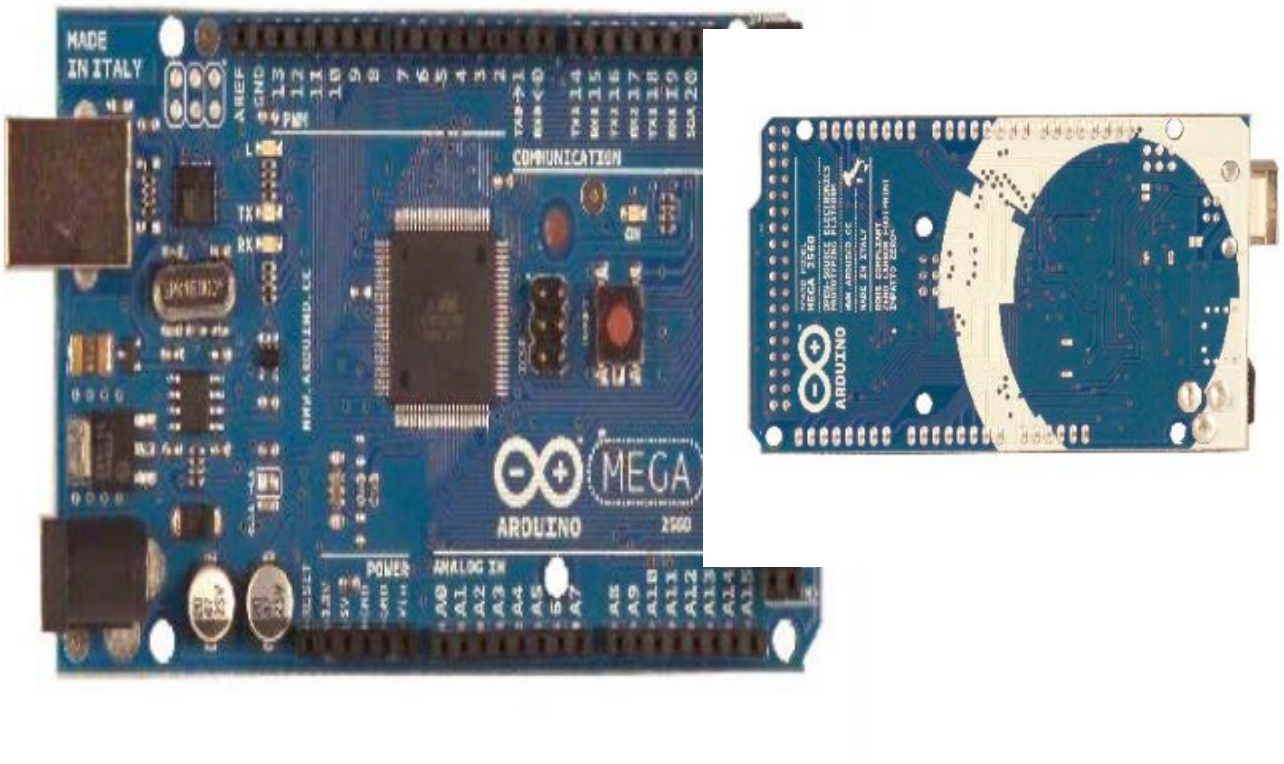
Charge: CC/CV 0.5CmA, 4.2V, 20mA cut off
Discharge: 3.0V cut off



Charge: CC/CV 0.5CmA, 4.2V, 20mA cut off at RT
Discharge: CC 0.5CmA, 3.0 V cut off at RT.

Note:
CC represent constant current
CV represent constant voltage
1C represent multiple current
RT represent room temperature

4.5.Arduino Mega 2560



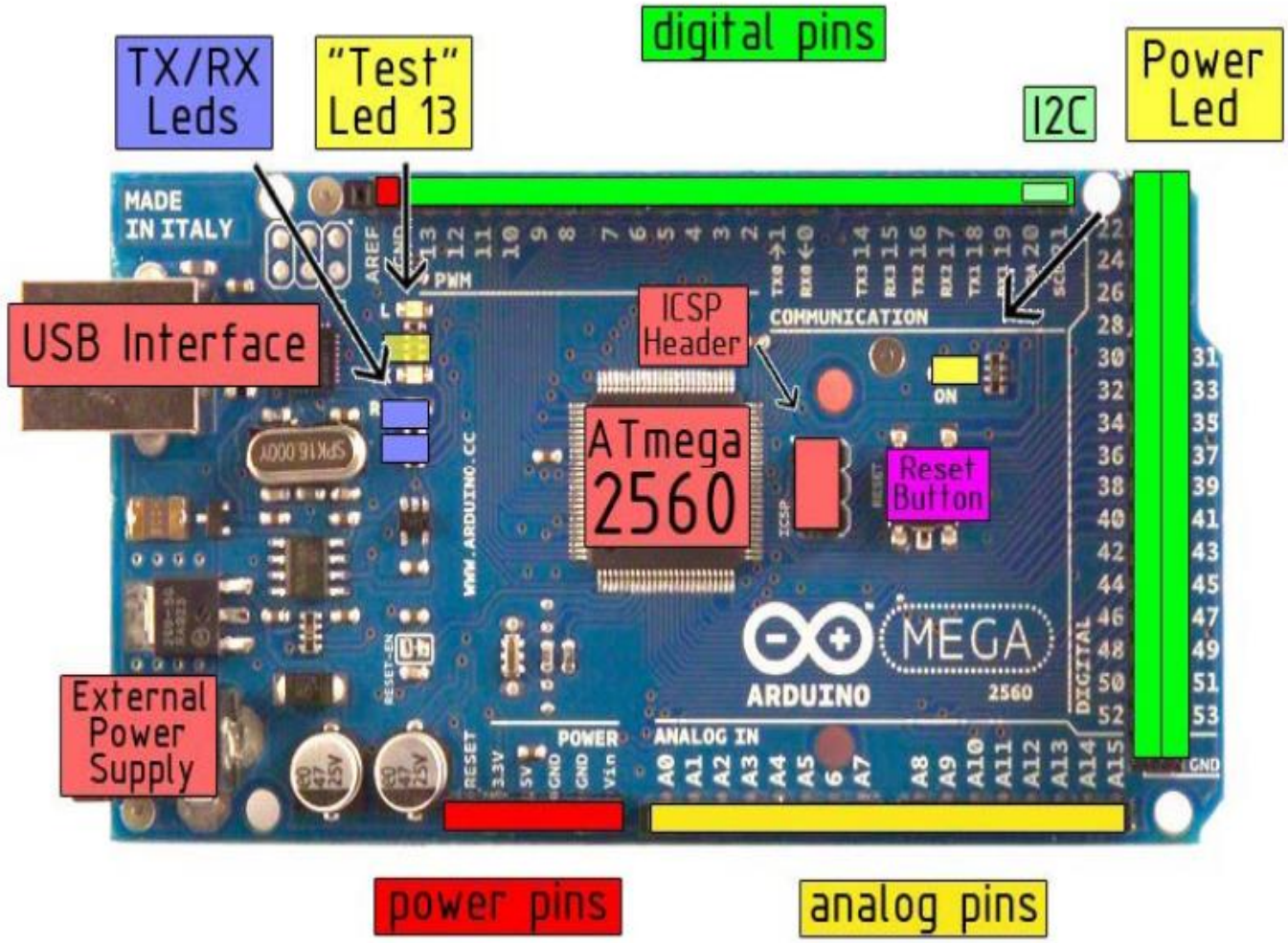
4.5.1.Overview

- The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 (datasheet).
- It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.
- It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a ACto- DC adapter or battery to get started.
- The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila.

4.5.2.Summary

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 14 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

4.5.3.The board



Power

- The Arduino Mega can be powered via the USB connection or with an external power supply. The power source is selected automatically.
- External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.
- The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage

regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

- The Mega2560 differs from all preceding boards in that it does not use the FTDI USB-toserial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

The power pins are as follows:

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

- **5V.** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.

- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

- **GND.** Ground pins.

Memory

The ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the bootloader), 8 KB of SRAM and 4 KB of EEPROM.

Input and Output

Each of the 54 digital pins on the Mega can be used as an input or output, using pinMode() , digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have **specialized functions:**

- **Serial: 0 (RX) and 1 (TX); Serial 1: 19 (RX) and 18 (TX); Serial 2: 17 (RX) and 16 (TX); Serial 3: 15 (RX) and 14 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. Pins 0 and 1 are also connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- **External Interrupts: 2 (interrupt 0), 3 (interrupt 1), 18 (interrupt 5), 19 (interrupt 4), 20 (interrupt 3), and 21 (interrupt 2).** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- **PWM: 0 to 13.** Provide 8-bit PWM output with the analogWrite() function.
- **SPI: 50 (MISO), 51 (MOSI), 52 (SCK), 53 (SS).** These pins support SPI communication using the SPI library. The SPI pins are also broken out on the ICSP header, which is physically compatible with the Uno, Duemilanove and Diecimila.
- **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.
- **I2C: 20 (SDA) and 21 (SCL).** Support I2C (TWI) communication using the Wire library (documentation on the Wiring website). Note that these pins are not in the same location as the I2C pins on the Duemilanove or Diecimila.

The Mega2560 has 16 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground

to 5 volts, though is it possible to change the upper end of their range using the AREF pin and analogReference() function.

There are a couple of other pins on the board:

- **AREF.** Reference voltage for the analog inputs. Used with analogReference().
- **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

Communication

The Arduino Mega2560 has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega2560 provides four hardware UARTs

for TTL (5V) serial communication. An ATmega8U2 on the board channels one of these over USB and provides a virtual com port to software on the computer (Windows machines

will need a .inf file, but OSX and Linux machines will recognize the board as a COM port automatically. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the ATmega8U2 chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows for serial communication on any of the Mega2560's digital pins.

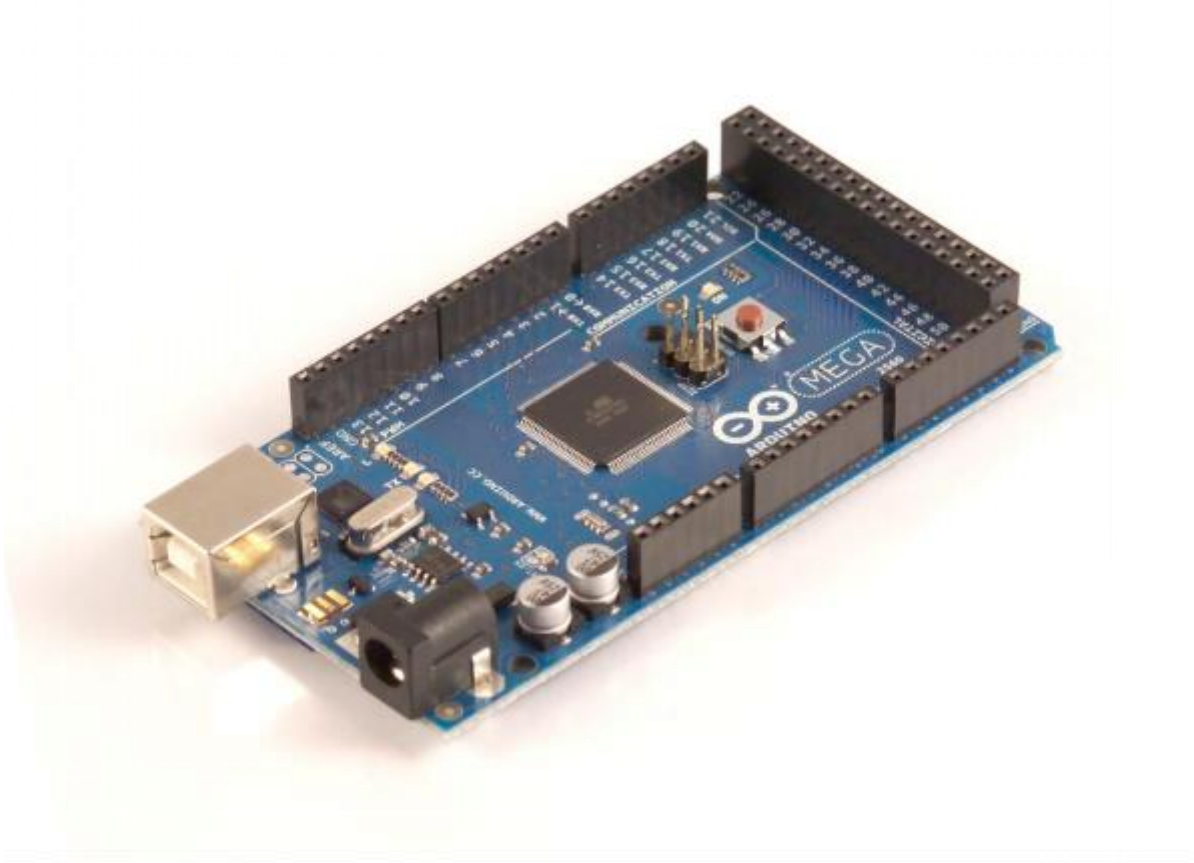
The ATmega2560 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation on the Wiring website for details. For SPI communication, use the SPI library.

4.5.4.Programming

The Arduino Mega can be programmed with the Arduino software (download). For details, see the reference and tutorials.

The ATmega2560 on the Arduino Mega comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

You can also bypass the bootloader and program the microcontroller through the ICSP (In- Circuit Serial Programming) header; see these instructions for details.



Automatic (Software) Reset

Rather then requiring a physical press of the reset button before an upload, the Arduino Mega2560 is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2 is connected to the reset line of the ATmega2560 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Mega2560 is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via

USB). For the following half-second or so, the bootloader is running on the Mega2560. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code),

it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

The Mega2560 contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may

also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

4.5.5.USB Overcurrent Protection

The Arduino Mega2560 has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

4.5.6.Physical Characteristics and Shield Compatibility

The maximum length and width of the Mega2560 PCB are 4 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Three screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.
The Mega2560 is designed to be compatible with most shields designed for the Uno, Diecimila or Duemilanove. Digital pins 0 to 13 (and the adjacent AREF and GND pins), analog inputs 0 to 5, the power header, and ICSP header are all in equivalent locations. Further the main UART (serial port) is located on the same pins (0 and 1), as are external interrupts 0 and 1 (pins 2 and 3 respectively). SPI is available through the ICSP header on
both the Mega2560 and Duemilanove / Diecimila.

How To Use Arduino

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, MaxMSP).

4.6.DC Motors

DC Motors

DC
DC MOTOR

Output Shaft Type
- **D** : D-Cut Type Shaft
- **K** : Key Type Shaft
- **G** : Shaft for General Type Gearhead
- **P** : Shaft for Powerful Type Gearhead
- **W** : Shaft for Worm Solid Type Gearhead

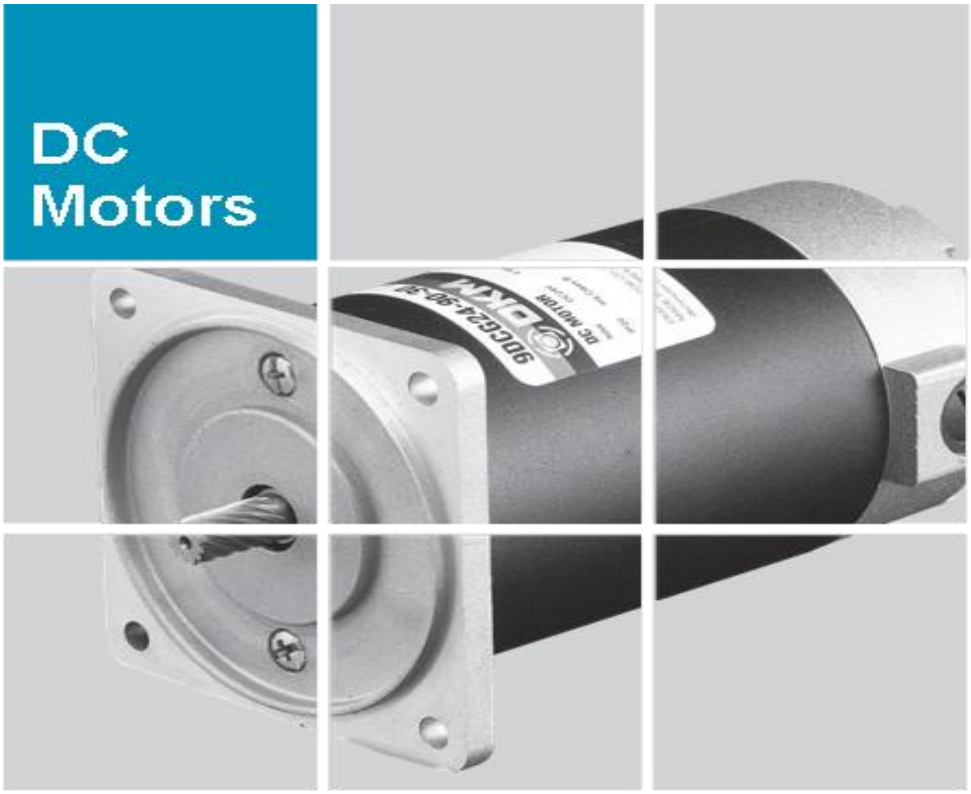
9 DC G 12 – 25 – 30

Motor Frame Size
- **6** : □60mm sq. (2.36 in.sq.)
- **8** : □80mm sq. (3.15 in.sq.)
- **9** : □90mm sq. (3.54 in.sq.)

DC Voltage
- **12** : DC 12V
- **24** : DC 24V
- **90** : DC 90V

Output
- **15** : 15W
- **25** : 25W
- **40** : 40W
- **60** : 60W
- **90** : 90W
- **120** : 120W

r/min
- **30** : 3000r/min



4.6.1Why choose a D.C. motor ?

Many applications call for a high start-up torque. The D.C. motor, by its very nature, has a high torque vs. falling speed characteristic and this enables it to deal with high starting torques and to absorb sudden rises in load easily. The speed of the motor adjusts to the load. Furthermore, the D.C. motor is an ideal way of achieving the miniaturisation designers are constantly seeking because the efficiency it gives is high compared with other designs.

4.6.2Design of D.C. motors

- **Safety**

  no ground connection

  ■ so-called «principal insulation» motors (single insulation)

  ■ protection index : IP00 to IP40

  ■ insulation classes : A to F

- **Electromagnetic compatibility (EMC)**

  D.C. motors and geared motors are considered as components meant for integration into other equipment and therefore fall outside its field of

  application. However, these products are designed in compliance with

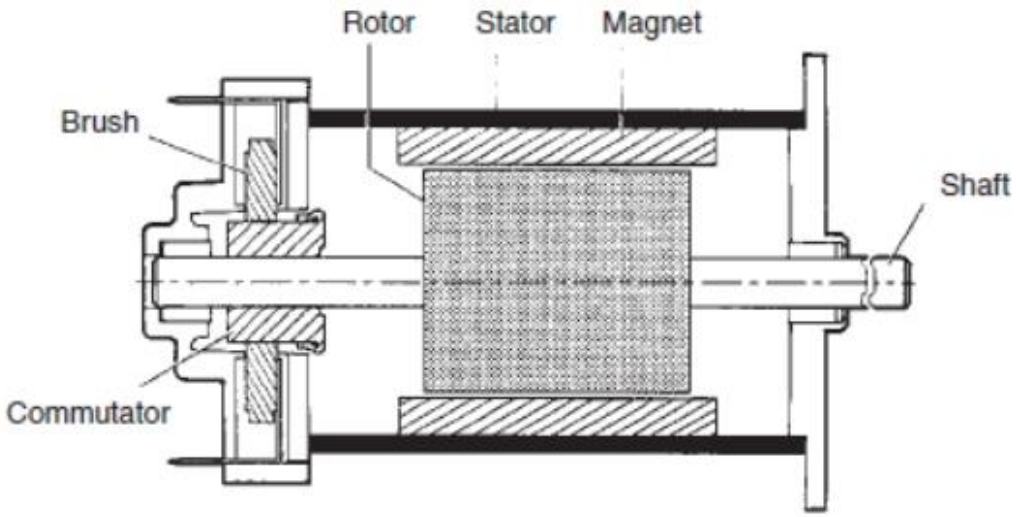
  EMC characteristics and consequently can be incorporated in equipment

  having to comply with the EMC directive.

4.6.3.Definition of the D.C. motor

This motor follows linear laws of operation and because of this it is easier to fully exploit its characteristics compared to synchronous or asynchronous motors.

4.6.4.Composition of a D.C. motor

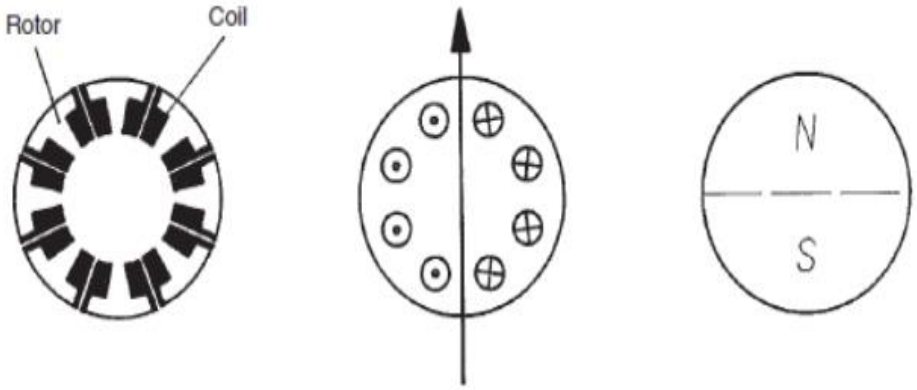


The stator is formed by a metal carcass and one or more magnets that create a permanent magnetic field inside the stator. At the rear of the stator are the brush mountings and the brush gear which provide electrical contact with the rotor.

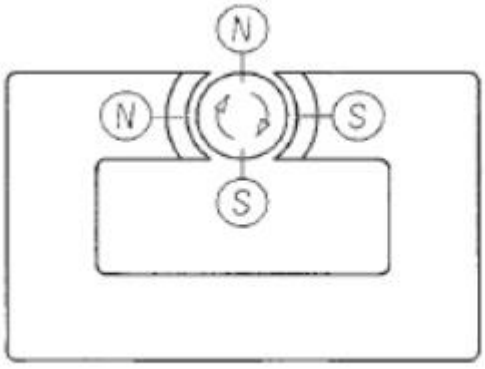
The rotor is itself formed by a metal carcass carrying coils which are interconnected at the commutator at the rear of the rotor. The commutator and brush assembly then select the coil through which the electric current passes in the opposite direction.

4.6.5.Principle of operation

Whatever the complexity of the rotor coil windings, once they are energised, they may be represented in the form of a ferromagnetic cylinder with a solenoid wrapped around it. The wire of the solenoid is in practice the wire bundle located in each groove of the rotor. The rotor, when energised, then acts as an electromagnet, the magnetic field following the axis separating the wires of the solenoid in the direction of the current which flows through .
them.



The motor, therefore, consists of fixed permanent magnets (the stator) a moving magnet (the rotor) and a metal carcas to concentrate the flux (the motor body).



By the attraction of opposite poles and repulsion of like poles, a torque then acts on the rotor and makes it turn. This torque is at a maximum when the axis between the poles of the rotor is perpendicular to the axis of the poles of the stator.

As soon the rotor begins to turn, the fixed brushes make and break contact with the rotating commutator segments in turn.

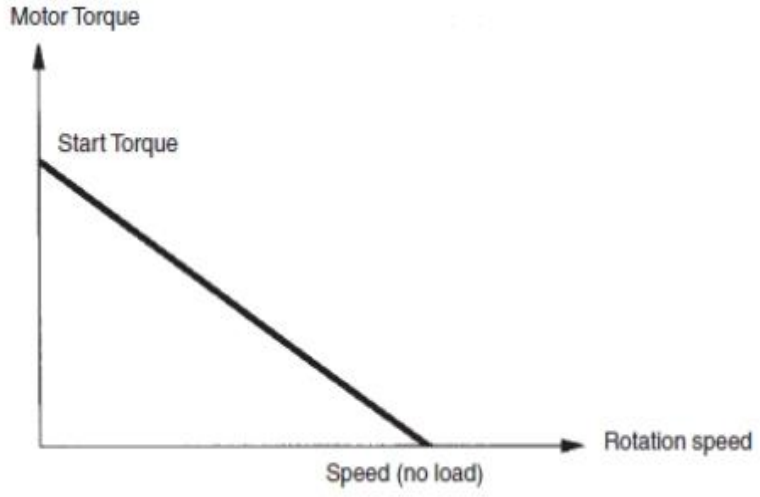
The rotor coils are then energised and de-energised in such a way that as the rotor turns, the axis of a new pole of the rotor is always perpendicular to that of the stator. Because of the way the commutator is arranged, the rotor is in constant motion, no matter what its position. Fluctuation of the resultant torque is reduced by increasing the number of commutator segments, thereby giving smoother rotation.

By reversing the power supply to the motor, the current in the rotor coils, and therefore the north and south poles, is reversed. The torque which acts on the rotor is thus reversed and the motor changes its direction of rotation. By its very nature, the D.C. motor is a motor with a reversible direction of rotation.

4.6.6.Torque and speed of rotation

The torque generated by the motor, and its speed of rotation, are dependent on each other.

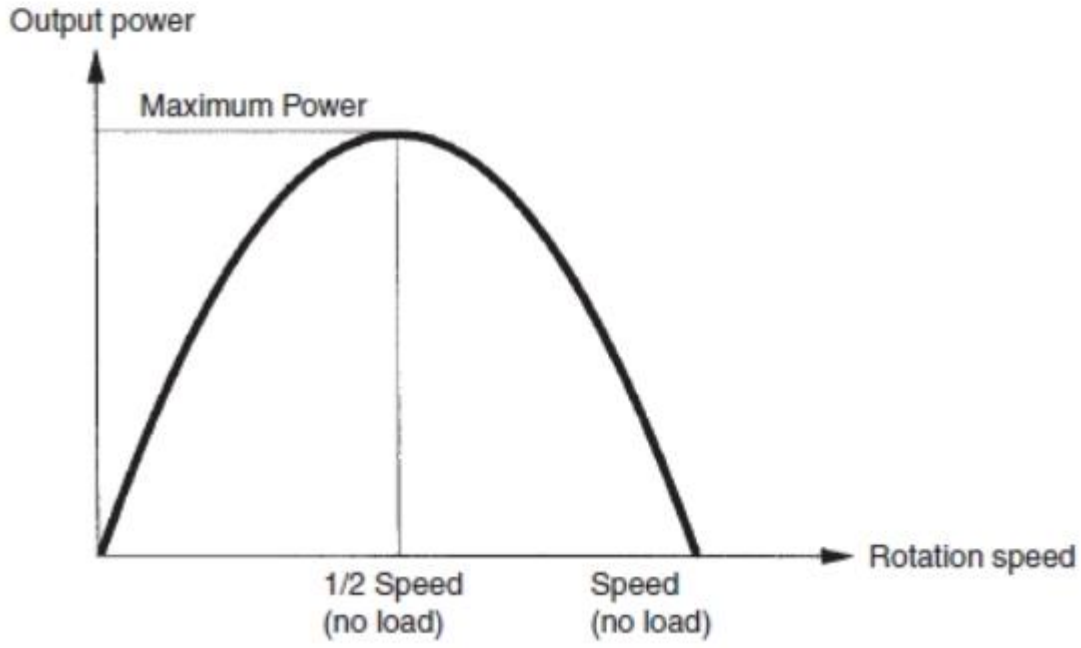
This is a basic characteristic of the motor ; it is a linear relationship and is used to calculate the no-load speed and the start-up torque of the motor.



The curve for the output power of the motor is deduced from the graph of torque versus speed.

$$Pu\ (W) = \frac{2\pi}{60} \times C\ (N.m) \times N\ (rpm)$$

Output power	Motor torque	Speed of rotation



The torque vs. speed and output power curves depend on the supply voltage to the motor.

The supply voltage to the motor assumes continuous running of the motor at an ambient temperature of 20°C in nominal operational conditions.

It is possible to supply the motor with a different voltage (normally between -50% and + 100% of the recommended supply voltage). If a lower voltage is used compared to the recommended supply the motor will be less powerful.

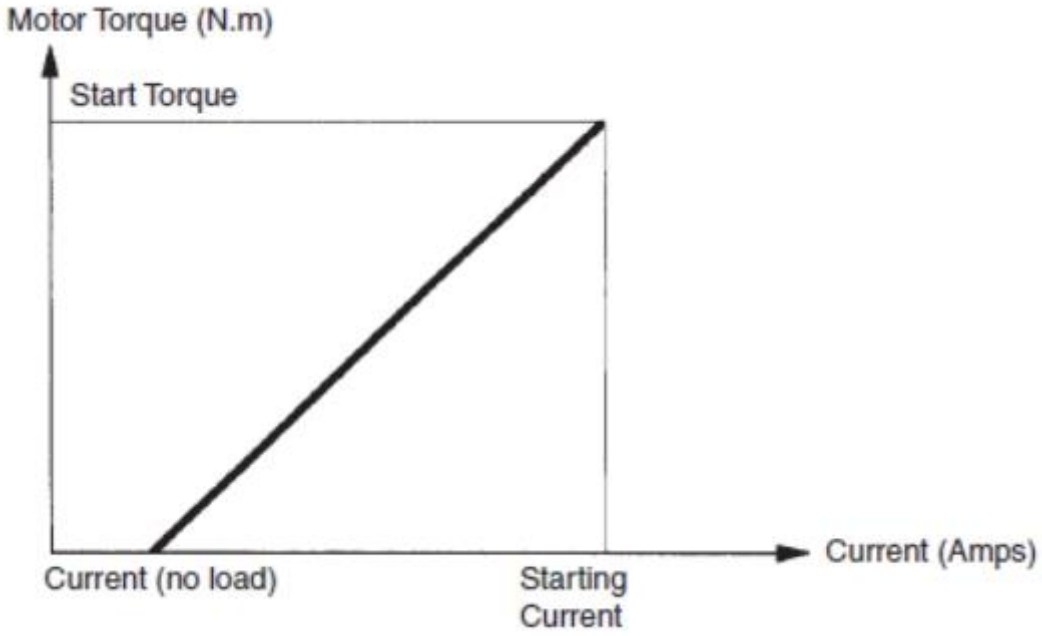
If a higher voltage is used, the motor will have a higher output power but will run hotter (intermittent operation is recommended).

For variations in supply voltage between approximately - 25% to + 50%, the new torque vs. speed graph will remain parallel to the previous one. Its start-up torque and no-load speed will vary by the same percentage (n%) as

the variation in supply voltage. The maximum output power is multiplied by (1 + n%)2.

4.6.7.Torque and supply current

This is the second important characteristic of a D.C. motor. It is linear and is used to calculate the no-load current and the current with the rotor stationary (start-up current).



The graph for this relationship does not vary with the supply voltage of the motor. The end of the curve is extended in accordance with the torque and the start-up current.

The gradient of this curve is called the «torque constant» of the motor.

$$Kc = \frac{Cd}{Id - Io}$$

This torque constant is such that :

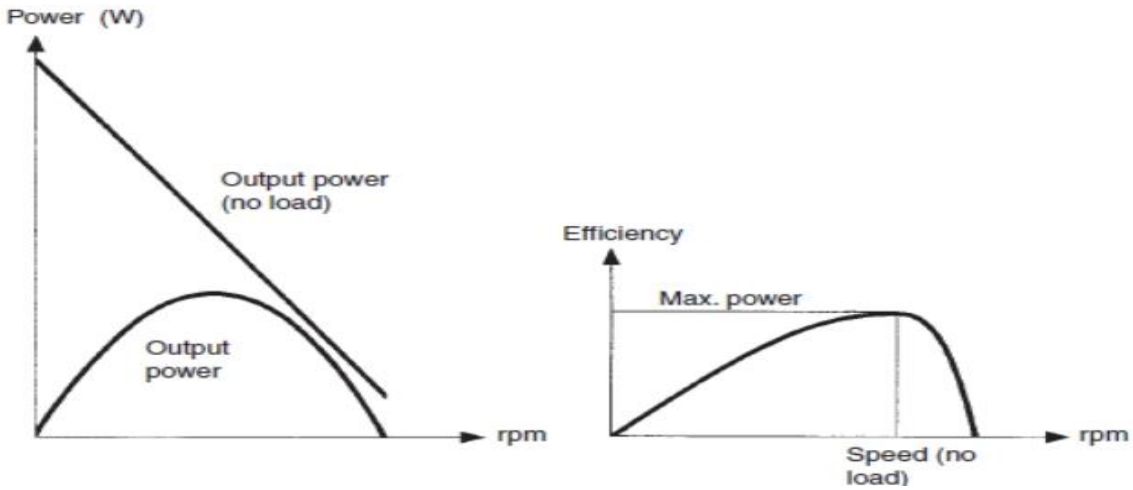
$$C = Kc\ (I - Io)$$

The «rotational friction torque» is Kc Io.
The torque is therefore expressed as follows :

$$C = Kc\ I - Cf \quad \text{with} \quad Cf = Kc\ Io$$

Kc = Torque constant (Nm/A)
C = Torque (Nm)
Cd = Start-up Torque (Nm)
Cf = Rotational friction torque (Nm)
I = Current (A)
Io = No-load current (A)
Id = Start-up current (A)

The graph of torque vs. current and torque vs. speed is used to determine the absorbed power as a function of the speed of rotation of the motor.



4.6.8.Efficiency

The efficiency of a motor is equal to the mechanical output power that it can deliver, divided by the power which it absorbs.

The output power and the absorbed power vary in relation to the speed of rotation, therefore the efficiency is also a function of the speed of the motor. Maximum efficiency is obtained with a given rotational speed greater than 50% of no-load speed.

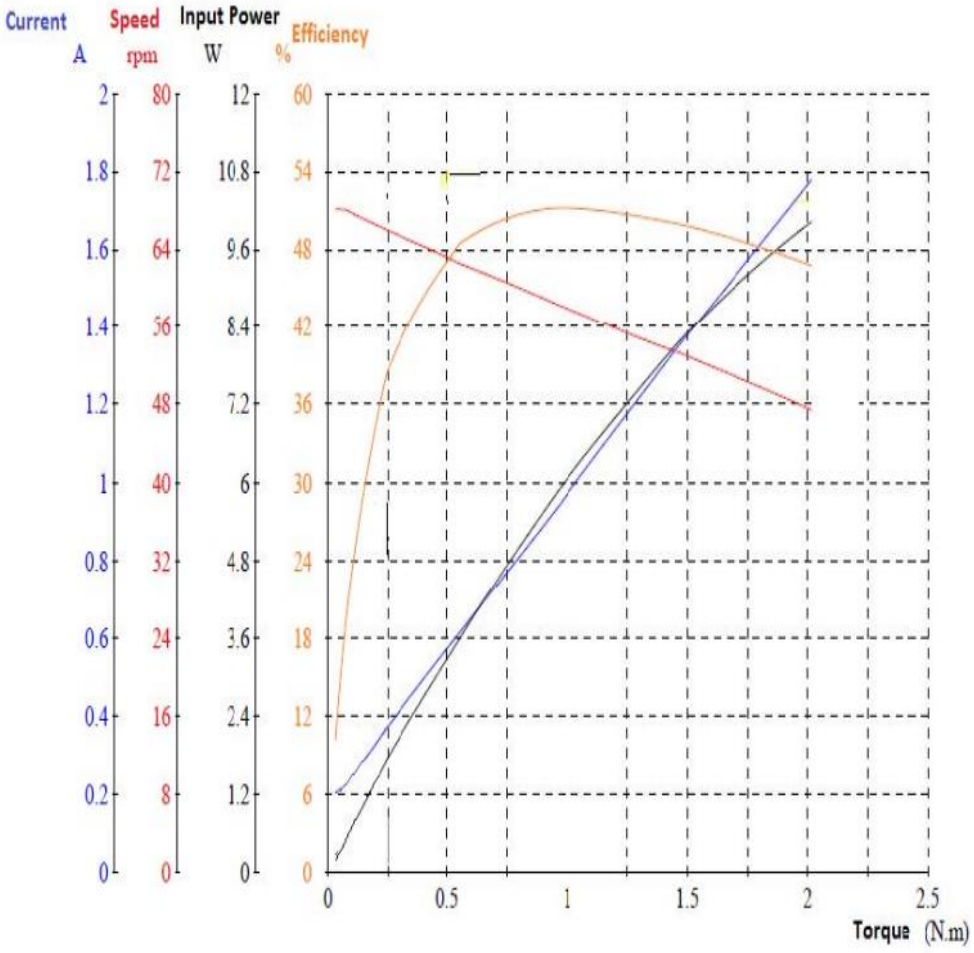
4.6.9.Temperature rise

The temperature rise of a motor is due to the difference between the absorbed power and the output power of the motor. This difference is the power loss.

Temperature rise is also related to the fact that power loss, in the form of heat from the motor, is not rapidly absorbed by the ambient air (thermal resistance). The thermal resistance of the motor can be greatly reduced by ventilation.

DC motor 12V 70 RPM

Feature Points	Voltage(V)	Current(A)	Input power(W)	Torque (N.m)	Speed(RPM)	Output Power(W)	Efficiency (%)	Time(s)
No Load	12.16	0.208	2.525	0.036	68.0	0.257	10.2	0.000
Eff. max	12.12	1.073	13.01	1.120	56.8	6.655	51.2	40.16
P_{out} max	12.07	1.776	21.43	2.016	47.5	10.03	46.8	55.21
Torque max	12.07	1.776	21.43	2.016	47.5	10.03	46.8	55.21



Chapter:5 Conclusions and Recommendations for Future Work

This project aims to provide an easy, reliable and automated way to register the attendance of students so as when the student stands in front of the robot camera, it recognizes his/her face by means of a Convolutional Neural Network that does feature extraction on the face and there's another Convolutional Neural Network that extracts features from each image stored in the database and the system computes the difference between the feature vectors of the student's face and each image in the database, and registers the student whose image has the lowest difference with the test image, this technique is called one shot learning and this connection between the two Convolutional Neural Networks is called the siamese network, there are various ways to obtain the differences between feature vectors, the function used in this project is cosine function

The robot registers the data of each attendee automatically which maintains data integrity and each attendee is registered only by his face sample which maintains data confidentiality against any unauthorized use or manipulation, the facial recognition biometric modality has high collect ablility that the process of sample collection is easy, it has high acceptability so it is user friendly, it's nonintrusive and it has low circumvention so the face sample is not easy to be imitated so this maintains data accuracy, this project aims to provide an agent based system that is very accurate, has minimal false acceptance rate (Type I error) and minimal false rejection rate (Type II error) , has low prediction processing time and easy to use so that users can feel convenient, the agent also has high motion control capabilities, it can be controlled using Bluetooth module, ultrasonic sensors and line follower system, the motion control is programmed using arduino mega development kit and runs via DC Motors

During this project, we learned many areas of engineering to build a robot. We were evolved in mechatronics, which involves three types of tasks: electronic, mechanical and computer engineering. Using the mechanical

aspect of engineering we constructed the Square Bot, using VEX parts and components. We designed a four-wheel robot with an arm to perform tasks. Also, we used the electrical engineering to construct Infrared Receiver Board that go into the vex controller. We used soldering equipment to solder the appropriate components and connection for the infrared board. While working on electric aspect of the project, we started soldering non-polar component like resistor, connectors first and did the non-polar part like LED and capacitor. Furthermore, we used many aspects of computer engineering interchangeably to program the robot so that it can perform the task successfully. The programming part was little tricky and needed many trials to check the best performance of the robot. We also used ultrasonic sensor

Aiming to the problem of time-consuming and low precision of the traditional tooth arrangement methods, a conception of a professional and miniature Cartesian coordinate type robot with Screw arrangement was put forward in this project work with Embedded System based Control of the drive system. have built the whole three-dimensional model of Cartesian coordinate type robot with screw rod and linear guideways after functional analysis of every function module of Cartesian Coordinate robot. !he kinematics simulation analysis of robot model using ia Composer is performed, and the results indicates that it .

is feasible and practical to realise the scheme design and structural design of Cartesian coordinate tooth-arrangement robot. this project work presents methods for modeling and controlling Cartesian Coordinate robots, with the goal of simultaneously achieving to structural design and fast and accurate positioning. Several joint position control model matching controllers are designed. the embedded system based control provides nearly optimal settling times with reduced structural vibration and this project work describes the integrating the two different fields of &robotics and Embedded Systems as one aspect and the development of Cartesian Coordinate robotic system. !his robotic System design can work as small modular workgroups in the industrial house. the design, development and testing of this project proved to be very challenging. aspecific set of uirements strove to produce a final product which was accurate, effective no

more complete than necessary. the primary objective of designing, developing and interfacing both the Cartesian Coordinate robot with embedded systems proved to be the most challenging, as did not have prior experience in Embedded Systems the design process is relatively straightforward. the reach at platform level is consider ably more than that at ground level the reach stays essentially constant within a broad range of operation of the Cartesian Coordinate robot

Bibliography

	Andrew, S., and Paul, H. 2018. "Trust in Artificial Intelligence. Transform Your Business with Confidence." (https://home.kpmg/content/dam/kpmg/uk/pdf/2018/06/trust_in_artificial_intelligence.pdf, accessed January 1, 2019).
	AWS. 2018. "What Is Artificial Intelligence? Machine Learning and Deep Learning." (https://aws.amazon.com/machine-learning/what-is-ai/, accessed January 1, 2019).
	Bernard, J.-G., and Gallupe, R. B. 2013. "IT Industry Analysts: A Review and Two Research Agendas.," CAIS (33), p. 16.
	Ramya, A., and Kannathal, A. 2018. "Artificial Intelligence and Robotics Process Information." (https://www.infosys.com/industries/financial-services/insights/Documents/robotics-processautomation-cards.pdf).
	Samiee, S. 1984. "Transnational Data Flow Constraints: A New Challenge for Multinational Corporations," Journal of International Business Studies (15:1), Springer, pp. 141–150.
	Bantz, C.R., 1995. Social dimensions of software development. In: J.A. Anderson, ed. Annual review of software management and development. Newbury Park, CA: Sage, 502–510.

	Crandall, J.W., and Goodrich, M.A. (2003). Measuring the intelligence of a robot and its interface. In Proceedings of PerMIS ’03, September 16-18, Washington, DC.
	AI Based Robot Safe Learning and Control Xuefeng Zhou, Zhihao Xu, Shuai Li
	Singer, P. W. (2009, February 11). Military robots and the laws of war. https://www.brookings.edu/articles/military-robots-and-the-laws-of-war/
	Intelligent Control, 2005. Proceedings of the 2005 IEEE International Symposium on, Mediterrean Conference on Control and Automation
	G. Oriolo, A. Luca and M. Vandittelli, ”WMR Control Via Dynamic Feedback Linearization: Design, Implementation, and Experimental Validation,” IEEE Transactions on Control Systems Technology, vol. 10, no. 6, pp. 835-852, 2002.
	M. Lepetic, G. Klan ˇ car, I. ˇ Skrjanc, D. Matko and B. Poto ˇ cnik, ˇ ”Time optimal planning considering acceleration limits,” Robotics and Autonomous Systems,vol. 45, pp. 199-210, 2003.

Appendix

- Python
- Opencv
- Tensorflow
- Keras
- openpyxl
- solidworks
- Arduino
- c programming