DECLARATION

We are the student of VIII semester B.E studying in the Department of Electrical and Electronics Engineering. Proudhadevaraya Institute of Technology, Hosapete. Hereby declare that the Project Phase-2 entitled **“MASTER SLAVE CONFIGURATION OF ROBOTIC ARM”** has been carried out under the supervision of **Prof. S.G. BASAVARAJU, Assistant Professor, Dept of EEE, PDIT,** and submitted in partial fulfillment of the requirements for the award of degree in **Bachelor of Engineering in Electrical and Electronics Engineering of Visvesvaraya Technological University, Belagavi** during academic year **2021-2022**.

PLACE:

DATE:

ARAVINDA LAKAMAPURMATH (3PG18EE003)

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ABSTRACT

In the past two decades the industrial works are found to be implemented through robots. The industrial robots are designed to eliminate error and intervention of human. The pick and place robot is designed to perform pick and place operation. The literature survey suggest that the pick and place robot is used in various fields such as packaging, inspection of jobs and also for military purposes for defusing bombs. The project deals with designing and analysing the structure of robotic arm with different materials. It will pick and place an object from source to destination safely. The soft catching gripper used in the arm will not apply any extra pressure on the objects. The robot is controlled using android based smart phones or PC through Bluetooth. The robotic arm has 4-DOF. It has additional features such as mechanical gripper and pneumatic gripper for versatility while using.

Index Terms - 4-DOF Robotic Arm for Pick and Place Operation

Keywords: robotic arm; path record and play; pick and place operation

CHAPTER 1

INTRODUCTION

A robotic arm has a mechanical structure that alters its form using a group of electric motors that behave like servo motors, pneumatic, or hydraulic actuators. They are usually programmable, with similar functions to a human arm; the arm may be the sum total of the mechanism or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement. The links of the manipulator can be considered to form a kinematic chain. The terminus of the kinematic chain of the manipulator is called the end effector and it is analogous to the human hand. Many elements of robots are built with inspiration from the nature. Construction of the manipulator as the arm of the robot is based on human arm. The robot has the ability to manipulate objects such as pick and place operations. They attempt to reproduce movement similar to a human arm. Robots are generally used to perform operations that are risky, hazardous and troublesome tasks. They are used for different operations such as material handling, assembly, arc welding, resistance welding and machine tool load and unload functions, painting, spraying, etc.

CHAPTER 2

LITERATURE SURVEY

[1] Development of Robotic Arm Using Arduino UNO by 1 Priyambada Mishra,2Riki Patel, 2Trushit Upadhyaya, 2Arpan Desai.

In this paper, they have used 4 servo motors to make joints of the robotic arm and the movement will be controlled with the help of potentiometer. The controller used is Arduino UNO. The analogue input signals of the Arduino's is given to the Potentiometer. The arm has been built by the Cardboard and individual parts are attached to the respective servo motors. The arm is specifically created to pick and place light weight objects. So low torque servos, with a rotation of 0 to 180 degrees have been used. Programming is done using Arduino 1.6.10. Thus the paper basically focuses on creating a robotic arm with non useful materials and its application on small purposes.

[2] Design of Robotic Arm with Gripper and End effector for spot welding' by Puran Singh, Anil Kumar, Mahesh Vashishth.

According to the paper the robotic arm consists of 2 degrees of freedom is being made for the purpose of spot welding, gripper will be used in the arm. The end effector consists of an arrangement of spur gears and threaded shafts along with an AC motor. Aims considered while building the robotic arm are

1.To have a rigid structure.

2.Movement of parts to defined angles.

3.To attain consumption of power at optimum level.

4.To perform spot welding operation with the help of end effectors. The material used for manufacturing the bottom of robotic arm was plywood which has the dimensions as follows

Length-48 cm,

Breadth-28 cm,

Thickness-2 cm.

Arm manipulator will be made up of plastic and has the following description-

● Weight= (30)2=60 g for big arm and (10)2=20 g for small arm.

● Length=25 cm for big arm and 5cm for small arm.

At the assembly point of wrist and end effector, 2 end effectors are used, in which one end effector is fixed and the other is movable, the end effector assembly has meshing of spur gears and worm gears which are connected to a 9 V stepper motor. The stepper motor has a step angle of 1.8 degrees and a speed of 100rpm. Force calculation on joints is done. This design of the robotic arm has two d.o.f. which performs the function of lifting, and for each linkage the center of mass was acting at the half of the length. Since there are many possible configurations for the robotic arm, the maximum degrees of rotation of each joint is 180 degrees. All the locations of the End Effector to which it can reach so that the workspace required can be calculated. This type of technology which is used in robotic arms can help in doing spot welding operation more efficiently. The material handling was carried out easily by picking and placing of the desired object. We can change the variation in the robot arm structure and their angle of movement.

[3] Review on Object-Moving Robot Arm basedon Color By Areepen Sengsalonga, Nuryono Satya Widodo

The objective of this finding is to make a manipulator which can sort objects on basis of color using specific motors and photodiode sensors programmed with an Arduino Mega series microcontroller. The light photodiode sensor can identify RGB colors. In this system the output of Arduino Mega 2560 is displayed on a LCD screen which is an indication of the observed color. The first step of object moving process is by distinguishing the RGB color. The gripper of robotic arm will move to pick objects based on color, depending on the color input given by the light photodiode sensor. Arduino Mega 2560 is a microcontroller that uses ATmega2560 which is installed in robotic arm having 54 digital i/o ports segregated into different types.

iv) Modeling and Simulation of Robotic Arm Movement using Soft Computing by V. K. Banga, Jasjit Kaur, R. Kumar, Y. Singh.

In this research paper the authors successfully built a 4 degrees of freedom robotic arm using soft computing. They have formulated ways for controlled movement of robotic arm and planning of trajectory with the help of Genetic Algorithms (GAs) and fuzzy logic (FL). As optimal movement is critical for efficient autonomous robots. This architecture is used to limit the issues related to the motion, friction and the settling time of different components in robotic arm. Genetic optimization is used to find the finest joint angles for this four d-o-f robotic system. This type of optimization replaces the long process of trial and error in search of better combination of joint angles, which are valid as per inverse kinematics for robotic arm movement. These logic models (Fuzzy logic) have been developed for the joint movement, friction and least settling time attributes as the fuzzy logic input.

[4] Design Analysis of a Remote Controlled “Pick and Place” Robotic Arm

By B.O. Omijeh In this paper, the design of a Remote-Controlled Robotic Arm has been completed. A prototype was built and confirmed functional. This system would make it easier for man to unrivalled the risk of handling suspicious objects which could be hazardous in its present environment and workplace. Complex and complicated duties would be achieved faster and more accurately with this design.

CHAPTER 3

OBJECTIVES

The main objectives of this project are: -

- To design a robotic arm and analyse its structure with different materials (stainless steel and aluminium alloy).
- To control the displacement of the robotic arm with servo motors so that the arm can be used to pick and place the elements from any source to destination.
- To control the displacement and movement of robotic arm using Bluetooth control from smart phone or Pc.
- To implement a robotic arm with six degrees of freedom.

3.1 DOF ROBOTIC ARM

3.1.1. DEGREE OF FREEDOM” (DOF) MEAN EXACTLY

Surely, one of the first questions for those new to robotics or mechanics is: What does “Degree of Freedom” mean? The DOF of a mechanical system is a specific mode in which said system can move; that is, a rotational or a translational movement. In the case of robot arms, rotational and translational movements are produced by revolute and prismatic joints, respectively. Most types of robot arms have only revolute joints, materialized with servos. To find out how many degrees of freedom a robot arm has, it is enough to just count the number of servos since each servo provides one DOF (of rotational movement).

So, Number of servos = Number of DOF. Easy!

3.1.2 PARTS OF A SIX DOF ROBOT ARM

Why exactly 4 DOF? Because four DOF is the minimum that an arm needs to be able to reach to any point within a specific volume of space from every possible angle with its end effector (claw, manipulator, hand, etc.). Many industrial and hobbyist robot arms have four DOF.

A robot arm can be compared with a human arm, which has at least four DOF. As observed in Figure 1, the robot arm also has a shoulder, elbow, wrist, and “hand” (end effector). Note that the shoulder and the wrist of the robot arm have two DOF each, as there are two perpendicular servos whose axes intersect in the joint.

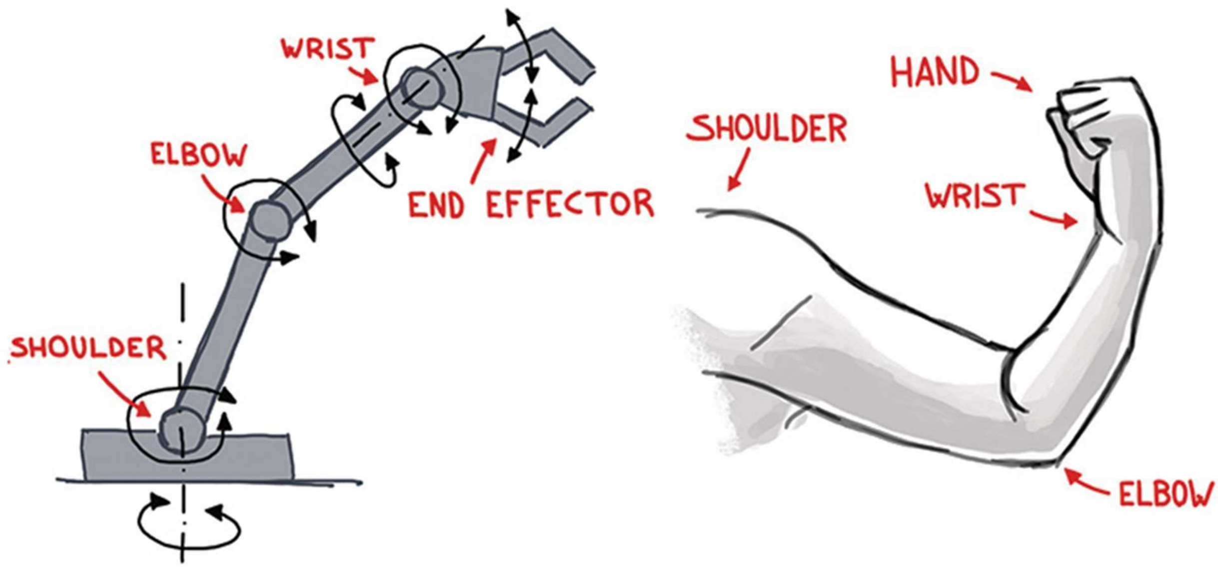


FIG 3.1. Comparison of robot arm and human arm.

3.1.3 HOW TO CALCULATE MOTION: FORWARD AND INVERSE KINEMATICS

Let's see how a robot arm can be controlled. There are two approaches to this:

- Forward kinematics: The end effector space coordinates and orientation (from now on "pose") are calculated considering a given set of joint angles.
- Inverse kinematics: The joint angles are calculated considering a given end effector pose.

It is clear that in most cases, we will need to bring the end effector to a specific pose and therefore calculate the necessary joint angles, which means that we will have to deal with inverse kinematics! Inverse kinematics is rather complicated compared with forward kinematics, and there are different approaches to solve this problem:

- Algebraic solution: Very complicated equations in matrix form are needed.
- Numerical solution: Provides an initial guess of the joint angles and performs iterations to minimize the error.
- Geometric solution: Uses trigonometry based on the robot arm geometry.

Although the geometric solution may get very complicated for complex arms, a simplified model was my choice, as it was the easiest method to implement in the Arduino code. (More details on this will follow in the second article.)

CHAPTER 4

METHODOLOGY

4.1 HOW MY ROBOT ARM WORKS

The possibilities of controlling the robot arm from a PC/Raspberry Pi through the serial port (USB) are almost infinite: MATLAB or C++, Processing, Robot Operating System (ROS), Arduino IDE (integrated development environment; serial monitor), etc. The controller also interfaces with an Android/iOS device (tablet, smartphone) through Bluetooth, and can be controlled manually using a "control box" with rotating knobs as well.

An important upgrade that I plan for the future (as previously mentioned) is the addition of robotic vision with a webcam mounted on the end effector and connected to a PC/Arduino nano. This way, the robot could recognize different types of objects (by colour and/or size) and grab them.

4.1.1 CONSTRUCTION OF THE ROBOT ARM

The robot arm is divided into three main elements:

- Robot arm body
- Hardware (electronic controller)
- Software

In the following sections, I will go through each of these parts.

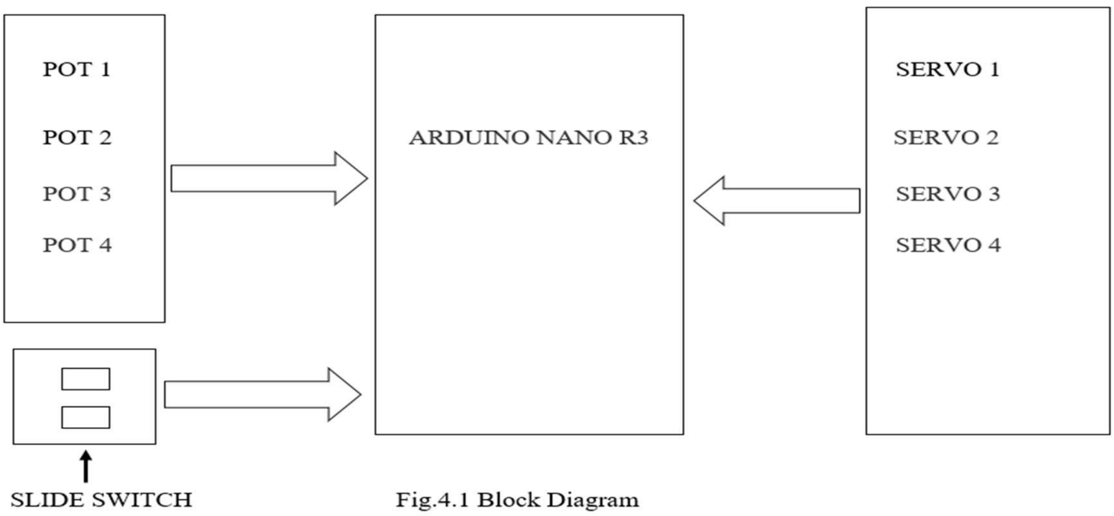


Fig.4.1 Block Diagram

4.1. construction of the robot arm body

To build the robot arm body (see **Figure 4.2**), I purchased some servos on eBay that already included aluminium brackets so that it would be easier to connect the servos to each other, as well as to other elements of the robot arm (see **Figure 4.3** for the aluminium brackets I made).

Fig 4.2. Robot arm body.

These servos rotate up to 180 degrees and their maximum torque is 15 kg, which is more than enough.

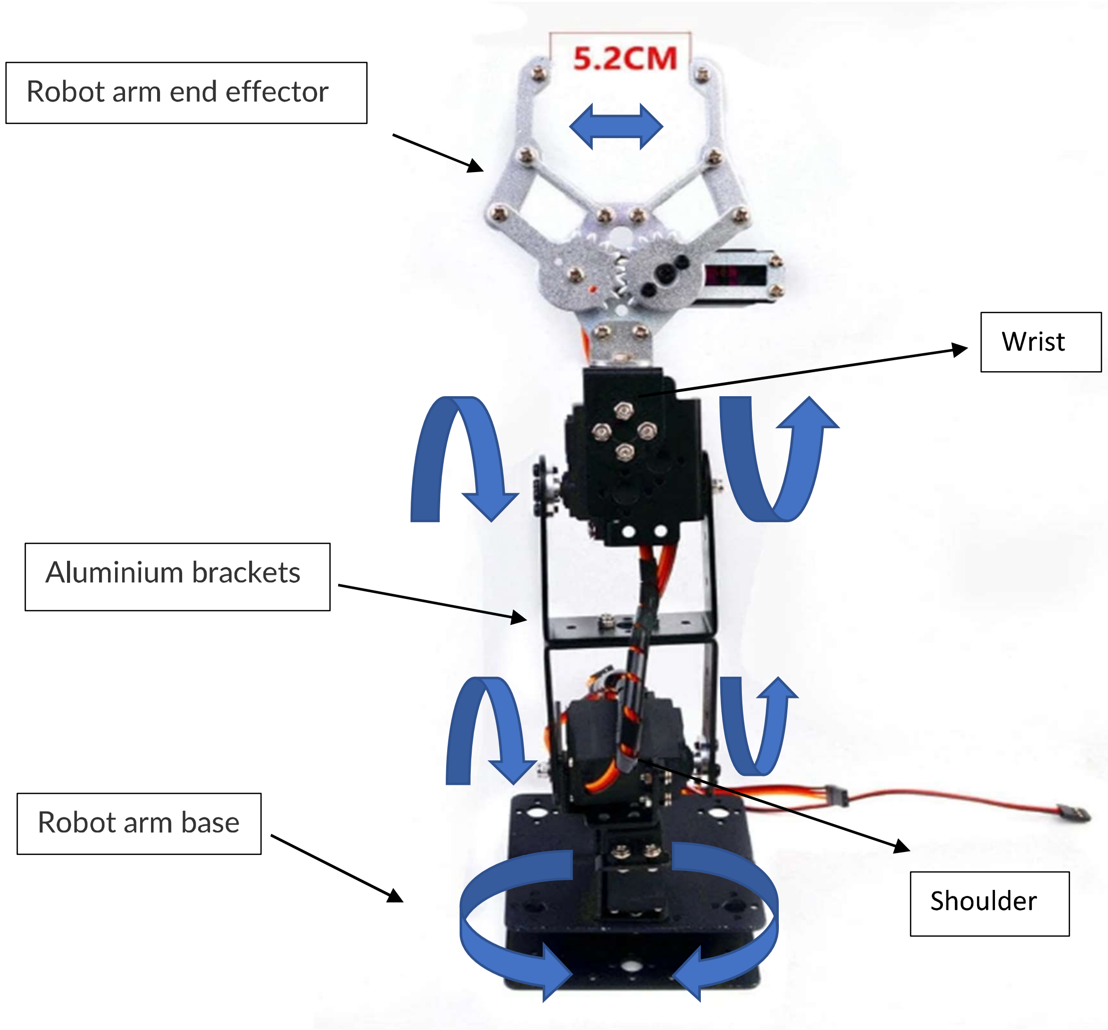


Fig.4.3 Robot arm body Made with Aluminium

This servo is not very strong, but for now it has done the job and its height is minimal, so the rotating base is kept as low as possible (for the overall center of gravity to be kept in a low position). For the base and end effector, I used servos that can also rotate up to 180 degrees. Otherwise, the robot arm movements would be very limited.

The two main challenges that I faced while building the arm body were the design of the base and the end effector. In order for the base to be able to rotate around the vertical axis and be stable enough to stand the whole weight of the arm, I used four small wheels that I found in a DIY store (yes, the kind used for wardrobe doors!). Below the horizontal plate, there’s a micro servo fixed with brackets to the main base (Figures 4.4 and 4.5).

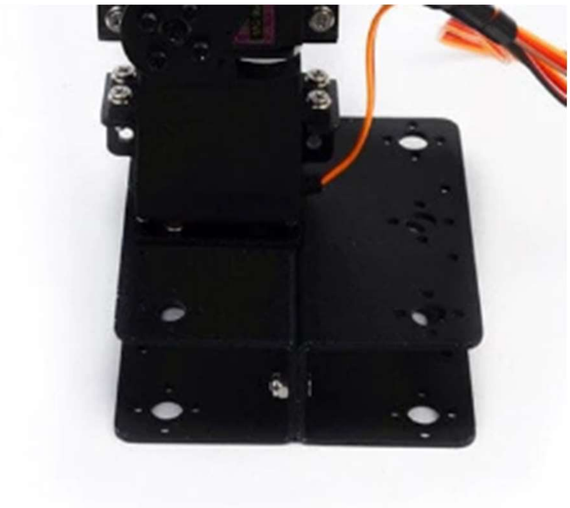


Fig.4.4 base of robotic arm

Fig.4.5 Robot arm end effector.

The end effector is rotated by another micro servo. As I couldn't find a simple way of adding a gear mechanism to control the two "fingers" of the end effector with a single servo, I decided to use two micro servos for controlling the two fingers.

4.1.3 CONTROLLER BOARD PARTS LIST: -

- DC jack adapter
- 2x1 SPDT slide switch
- 2x 10 µF capacitors
- 5V Voltage regulator
- 6V Voltage regulator
- Eight-pin male connector plug
- 8x Female pin header (1x6)
- 8x Male pin header (1x6)
- Atmel ATmega328 chip (DIP28). If it does not have the Arduino bootloader installed, you will need to install it.
- 4x1 Servo motors
- 4x1 Potentiometers

4.2 HARDWARE COMPONENTS: -

4.2.1 SERVO MOTORS: -

Fig.4.6. Servo motor

The simplicity of a servo is among the features that make them so reliable. The heart of a servo is a small direct current (DC) motor, similar to what you might find in a toy. These motors run on electricity from a battery and spin at high **RPM** (rotations per minute) but put out very low **torque** (a twisting force used to do work—you apply torque when you open a jar). An arrangement of gears takes the high speed of the motor and slows it down while at the same time increasing the torque (Basic law of physics: work = force x distance.)

A tiny electric motor does not have much torque, but it can spin really fast (small force, big distance). The gear design inside the servo case converts the output to a much slower rotation speed but with more torque (big force, little distance).

The amount of actual work is the same, just more useful. Gears in an inexpensive servo motor are generally made of plastic to keep it lighter and less costly. On a servo designed to provide more torque for heavier work, the gears are made of metal and are harder to damage. EZ-Robot servos use metal gears to prolong Usability and servo life.

Within a servo, a positional sensor on the final gear is connected to a small circuit board. This sensor tells the circuit board how far the servo output shaft has rotated. The electronics on the circuit board decode the signals to determine how far the user wants the servo to rotate. It then compares the desired position to the actual position and decides which direction to rotate the shaft so it gets to the desired position.

4.2.2 POTENTIOMETER: -

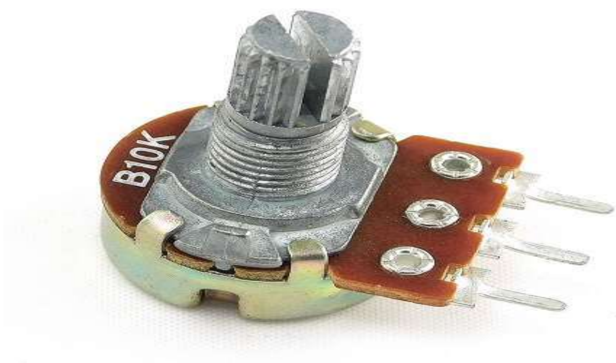


Fig.4.7. Potentiometer

Potentiometers are electronic components. They can work as a voltage divider to help you obtain an adjustable output voltage at the wiper (or slider) from a fixed input voltage that's applied throughout the two terminal ends of the potentiometer. Their sliding contact or wiper moves to provide a uniform resistance. The input voltage in potentiometers is applied across the resistor's length. The voltage drop that happens between the fixed and sliding contact shows the output voltage. This is shown in the picture below

Potentiometers have different applications. The most popular one is in audio systems for adjusting volume. Televisions and computers also benefit from potentiometers. They are used in both these devices for changing the picture brightness. There are also other applications such as measuring a battery cell's internal resistance, comparing the EMF between a standard cell and a battery cell, measuring the voltage across a circuit's single branch.

They are used in different industries for different applications but the ones mentioned above are the most popular applications. You can use them as a calibration component, control input, and even position measurement. A rotary potentiometer (and sometimes a slide pot) are both used in audio control systems for changing the volume and the loudness, frequency attenuation, and many other audio signals' characteristics.

They can also help in a servomechanism to create closed-loop control with the help of position feedback devices. The angle and speed in DC Motor are measured with the help of this motion control method.

Another application of potentiometers is for computational purposes. Potentiometers that have high precision are used in analog computers for scaling intermediate results by demanded constant factors. They can also be used for setting the initial conditions that need calculation.

4.2.3 Slide Switch: -

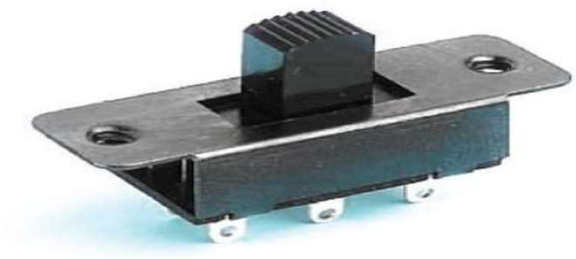


Fig.4.8 DPST Slide Switch

Slide switches are mechanical switches defined by their method of Operation. In this switch there is a slider that moves(slides) from position to position linearly making it easy to ON/OFF circuit or as selector switch with a fingertip easily. Slide switch has a rectangle casing with a bar handle which slides from one position to another changing its state. It can handle between a 1/10th of an amp to several amps of current, and up to about 200 volts, which depends on the size of the switch. It has 0.1" spacing making it easy to mount on the pcb and making it advantageous over toggle switch.

4.2.4 Arduino Nano: -

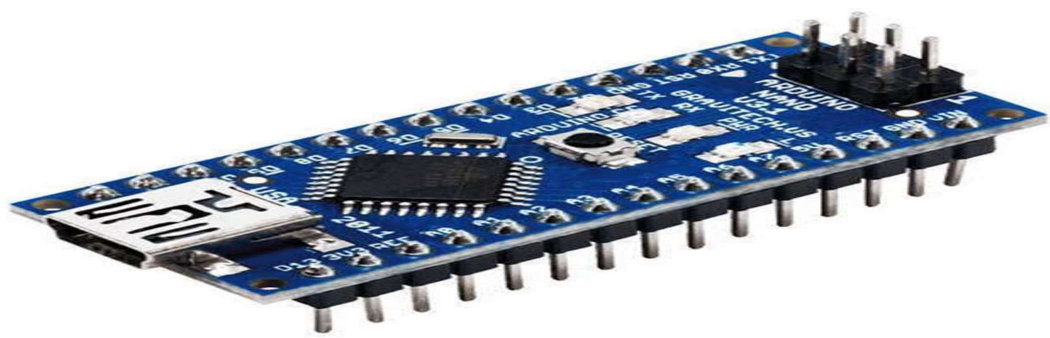


Fig 4.9 Arduino nano module

Arduino is an Integrated Development Environment based upon Processing. It has made very easy several things namely these are embedded system, physical computing, robotics, automation and other electronics-based things.

Every Arduino has the same functionality and the same features except the number of pins and size. Arduino Nano is a small chip board based on ATmega 328p/Atmega 168. The Arduino comes for the following operating systems. You may go for any of these.

Windows

Linux

Mac O

CHAPTER 5

EXPERIMENTATION

5.1 WORKING PROCEDURE: -

1. First of all, set all the servo in order to make the Robotic Arm.
2. Now fix all the 4 potentiometers in the base of the robotic arm.

Fig 5.1 Potentiometer

3. Now connect all the VCC pin of the potentiometer, to make a common Vcc for all the servo.

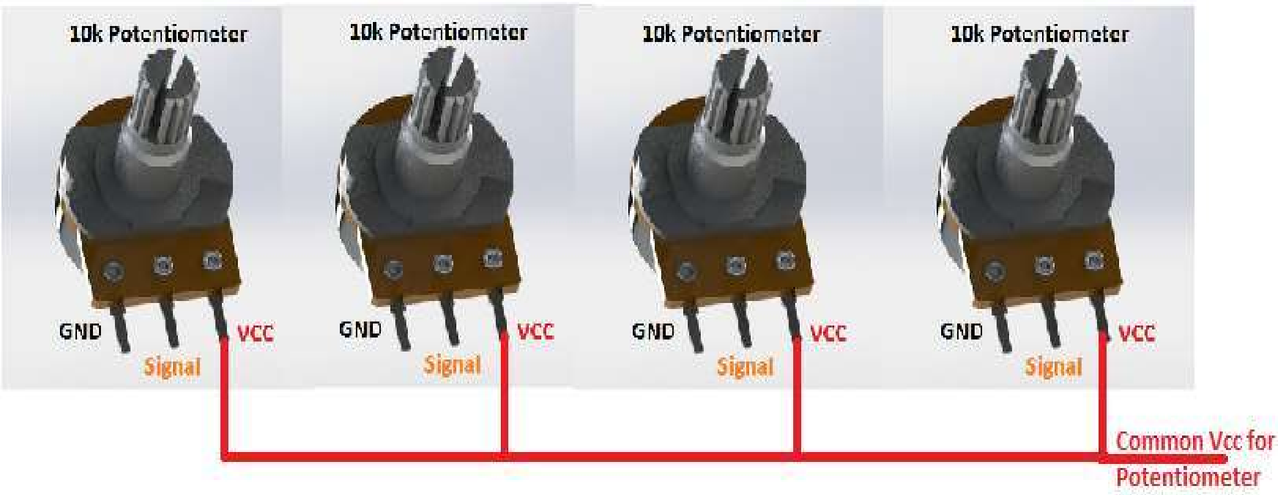


Fig.5.2 VCC connection of potentiometer

4. Similarly, connect all the GND of the potentiometer to make a common GND for it.

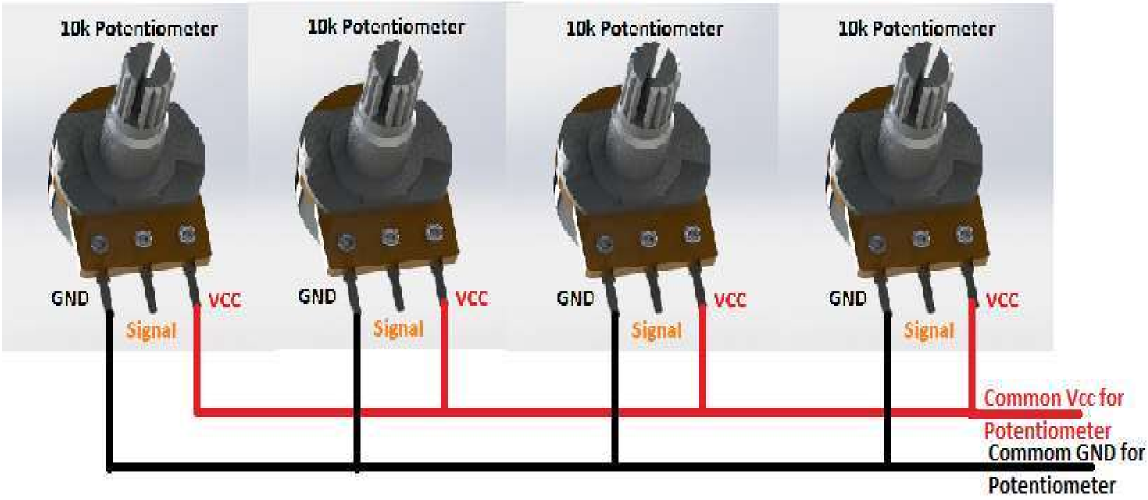


Fig. 5.3 GND VCC connection of potentiometer

5. Now connect 4 wires to the signal pin of the potentiometer.

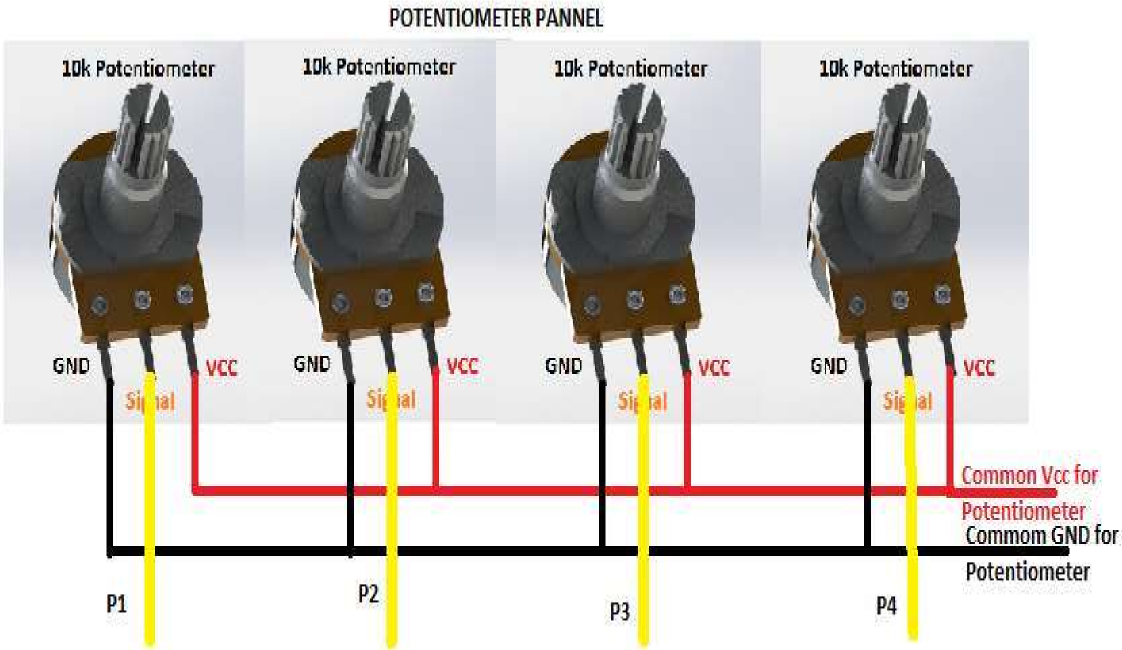


Fig.5.4 GND VCC Signal connection of potentiometer

6. Now let's have a look on the pin configuration of the servo.

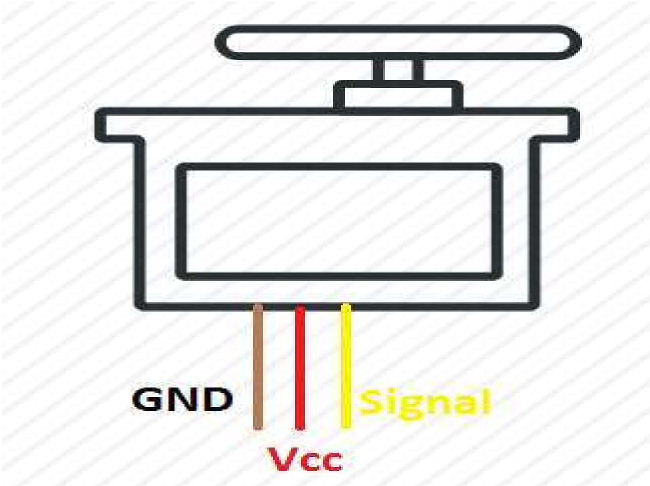


Fig.5.5 Servo motor

7. Now connect all the Vcc pin of the servos to make a common Vcc for the servos, similarly do that for the GND of the servos.

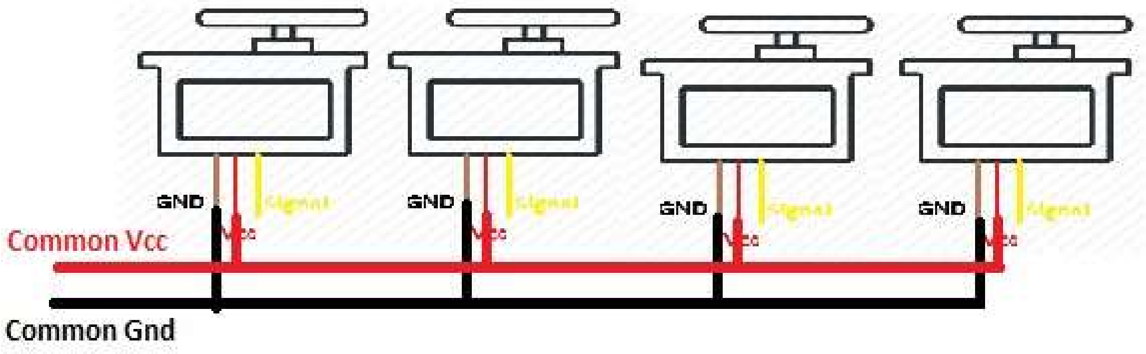


Fig.5.6 Servo motor VCC and Gnd connection

8. Now connect 4 wires to the 4 signal pins of the servos.

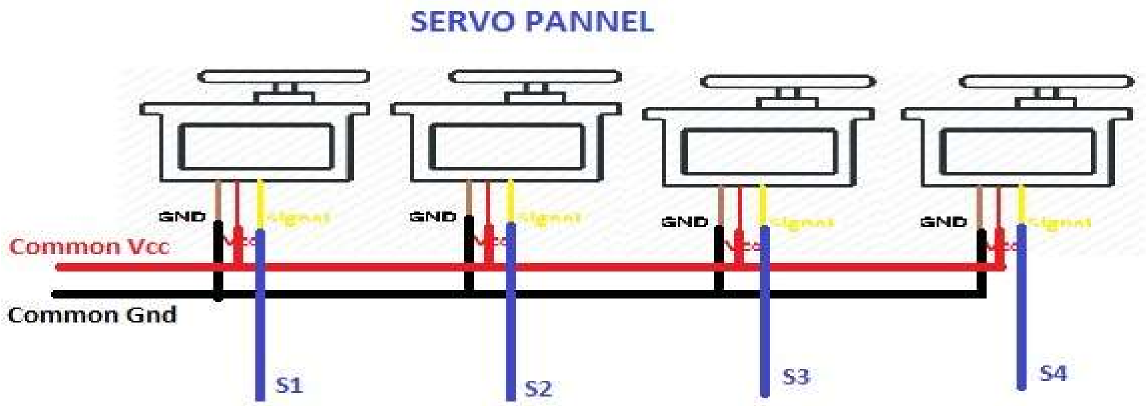


Fig.5.7 VCC GND Signal connection of Servo motor

9. Now connect two slider switches as connected in the diagram below

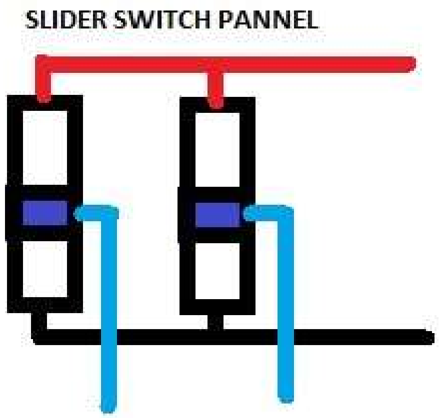


Fig.5.8 Slide switch

10. Now connect the VCC, GND of both Potentiometer strip and slider switch panel to make common Vcc, GND for both of them.

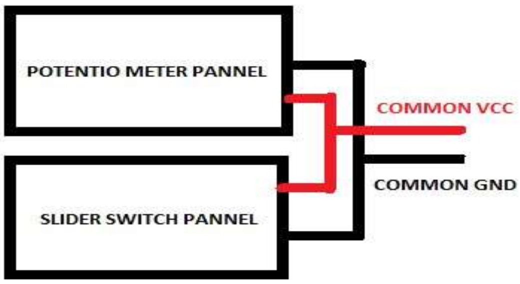


Fig.5.9 Potentiometers common connection

11. Now make an additional wire from the GND of the servos, and connect that to the GND of the Arduino Uno.
12. Connect Servos to one 5v charger and the Arduino to another 5v charger to avoid the Servo Jitter Problem.
13. Now connect the Servo Signal Pins as follows:
14. Servo1 Signal pin --> Pin 8 of Arduino
15. Servo2 Signal pin --> Pin 9 of Arduino
16. Servo3 Signal pin -->Pin 10 of Arduino
17. Servo4 Signal pin -->Pin 11 of Arduino

Now connect the Signal pin coming from the Potentiometer Strip to the Arduino as follows: -

18. Potentiometer1, p1-->A0 of Arduino.
19. Potentiometer2, p2-->A1 of Arduino.
20. Potentiometer3, p3-->A2 of arduino.
21. Potentiometer4, p4-->A3 of arduino.
22. Now connect the pins coming out from both the slider switch to A4, A5 of the Arduino Nano.

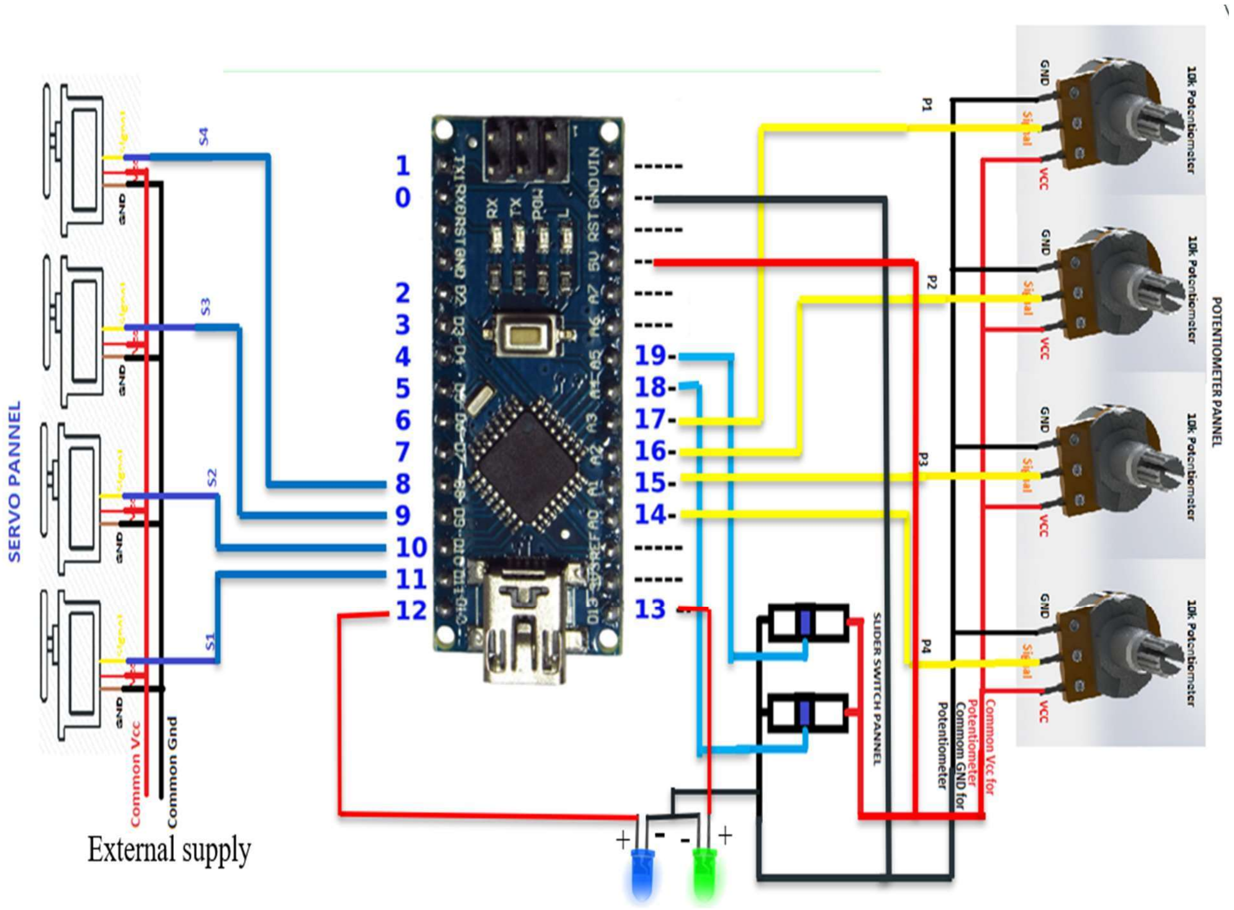


Fig.5.1.1 Complete connection of the system

5.2 CODING OF ARDUINO NANO: -

1. After downloading Arduino Nano – Driver Software, extract the zip folder and run the application file.

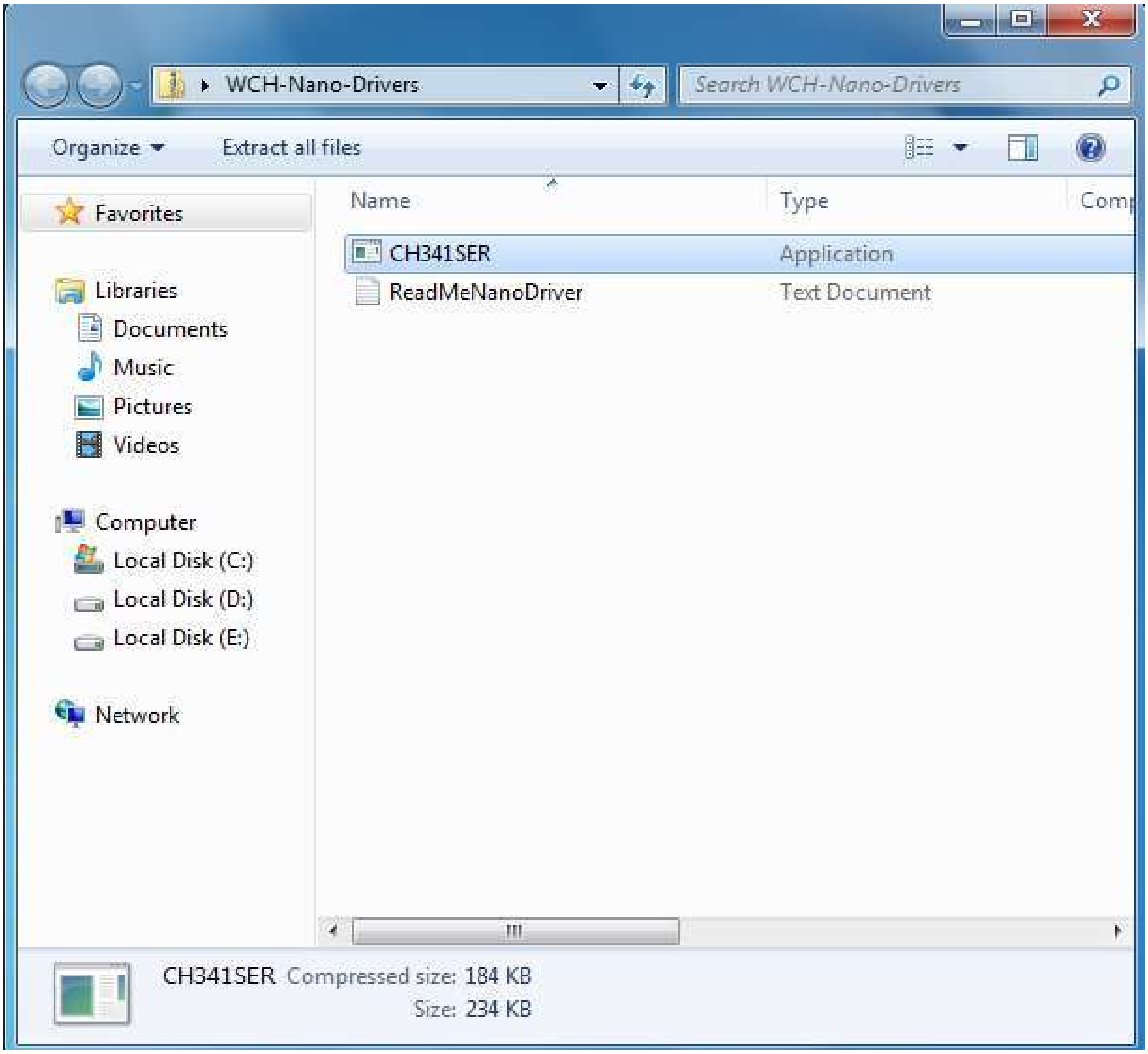
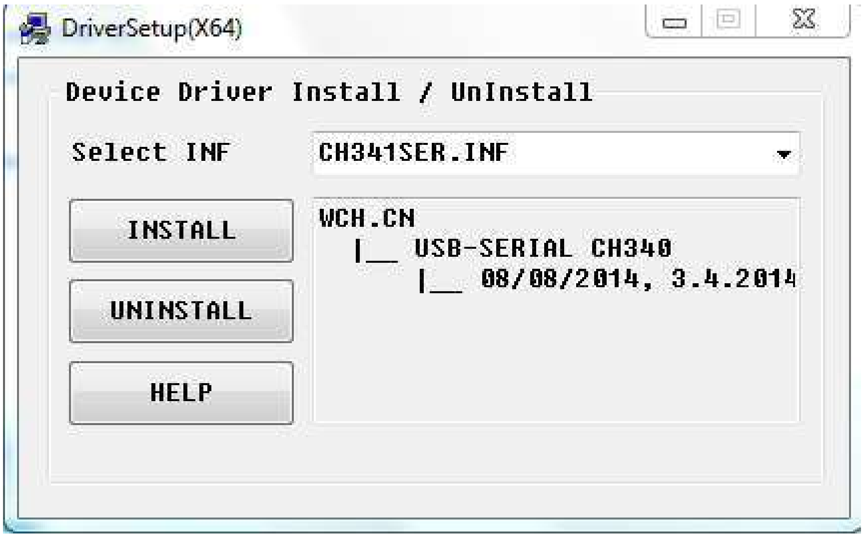


Fig.5.2.1 Zip file

2. Click on the run button.

3. Follow the installing steps, then click on the install button.



4. The pop-up window of successful installation will appear on the screen after installation.
5. Right click on the computer icon on the desktop. Select properties and find 'Device Manager >> Ports (COM & LPT) >> USB-SERIAL CH340 Port (COM13)'. This COM PORT will be required later in this tutorial.

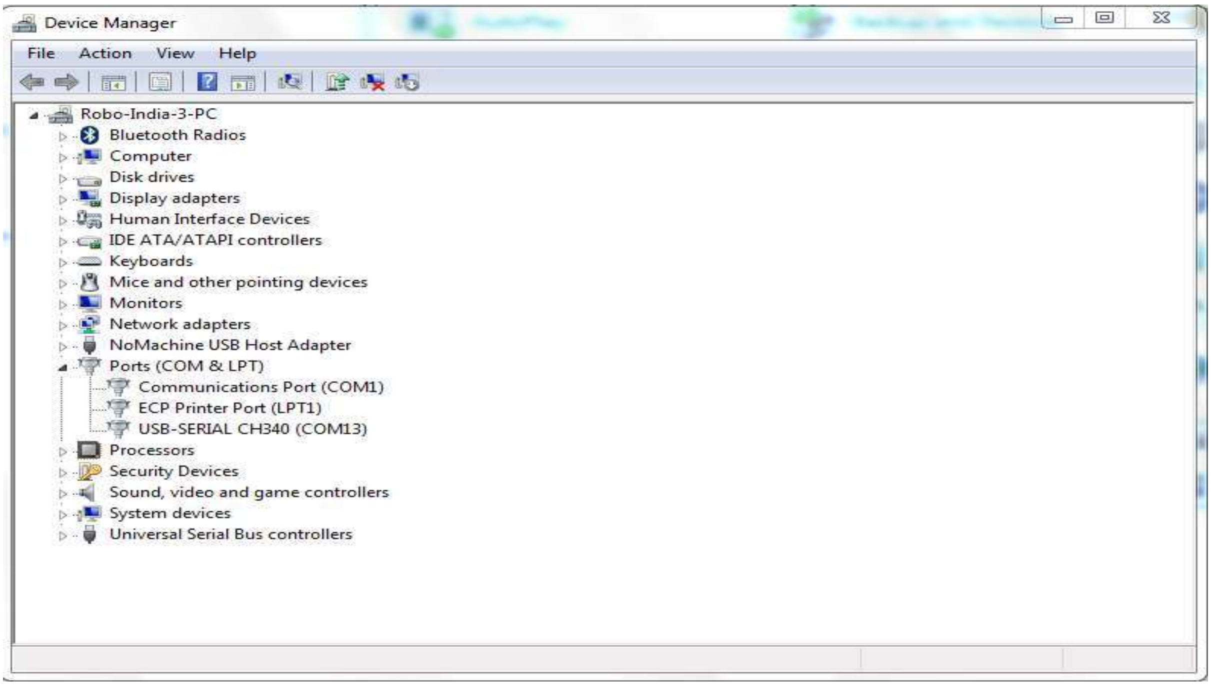


Fig.5.2.2 Device Manager

5.2.1 ARDUINO SOFTWARE INTRODUCTION:

Some general Understanding:

1. Code we write in Arduino is known as **SKETCH**.
2. Compilation of the code is known as **VERIFY**.
3. Transfer of the code from computer to Arduino board is known as **UPLOAD**.
4. If you directly hit **UPLOAD** button of Arduino software, the software will first VERIFY the code and then will transfer that code to Arduino Board.

4.1 After installation of drivers open Arduino Software. It looks like the following screenshot.

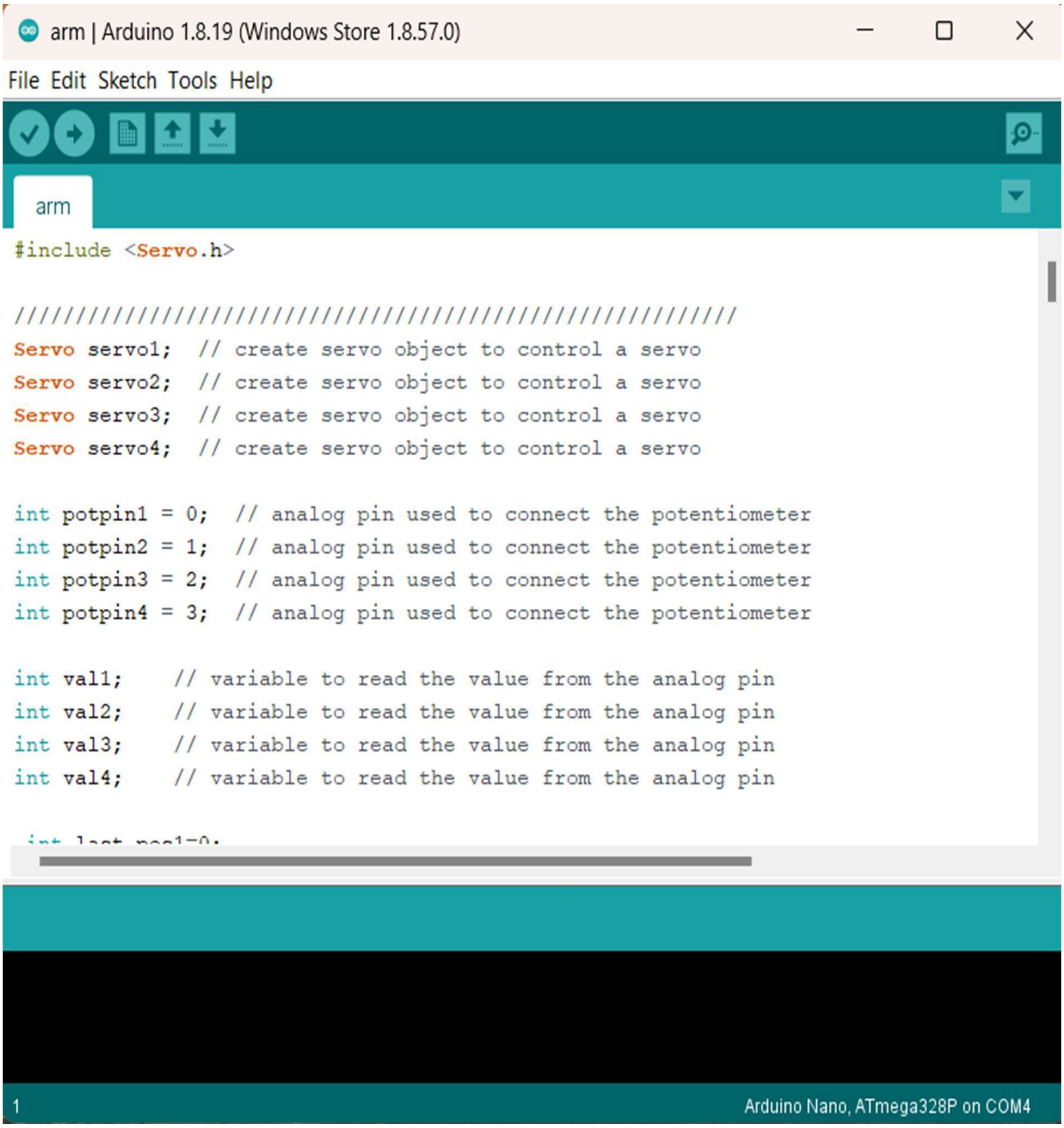


Fig.5.2.3 Code

5.2.2 BUTTONS OF ARDUINO SOFTWARE

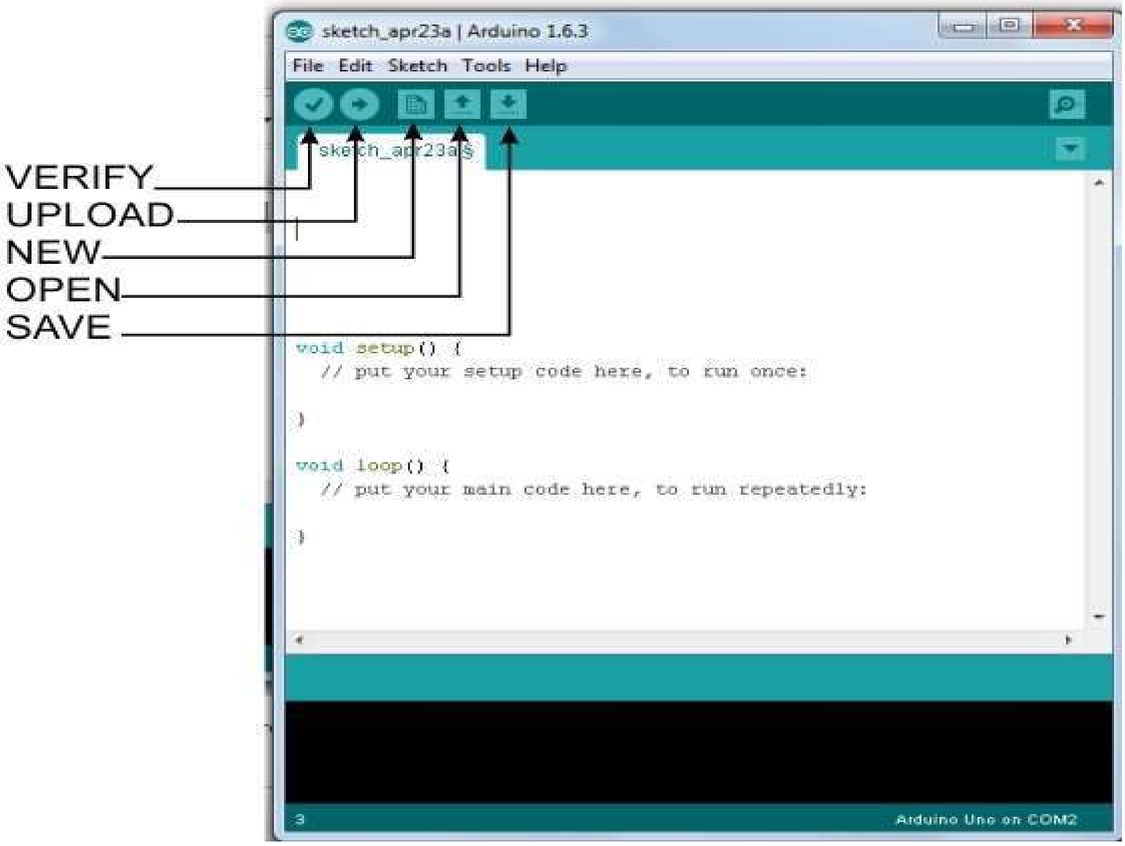


Fig.5.2.4 Software futures

Until You Save Your Project, it displays its name as sketch date. Default folder to save Arduino code(sketch) is My Documents/Arduino or similar location for Mac OS and Linux. Arduino saves each code in a folder extension of code is. ino. By default, it creates a folder and, in that folder, create a file with the extension we have seen. It is to be noted that name of the folder and containing file should be same (If you want to rename the sketch then change name of both).

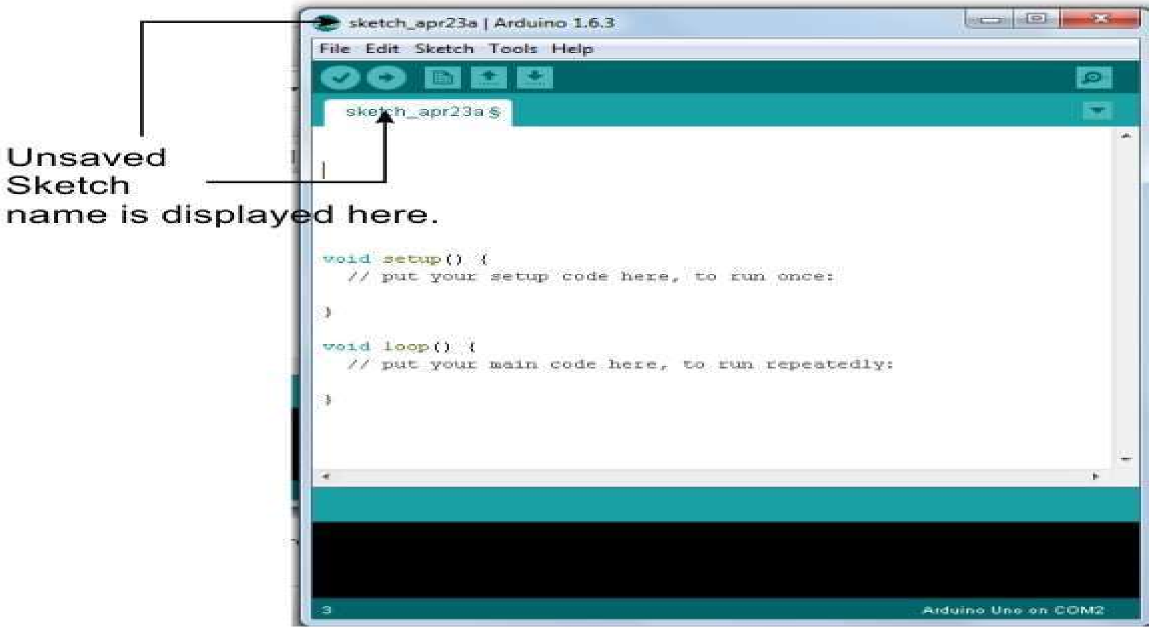


Fig.5.2.5 Software futures

5.2.3 SELECTION OF BOARD: Select the Arduino Nano Board you are having from the available list

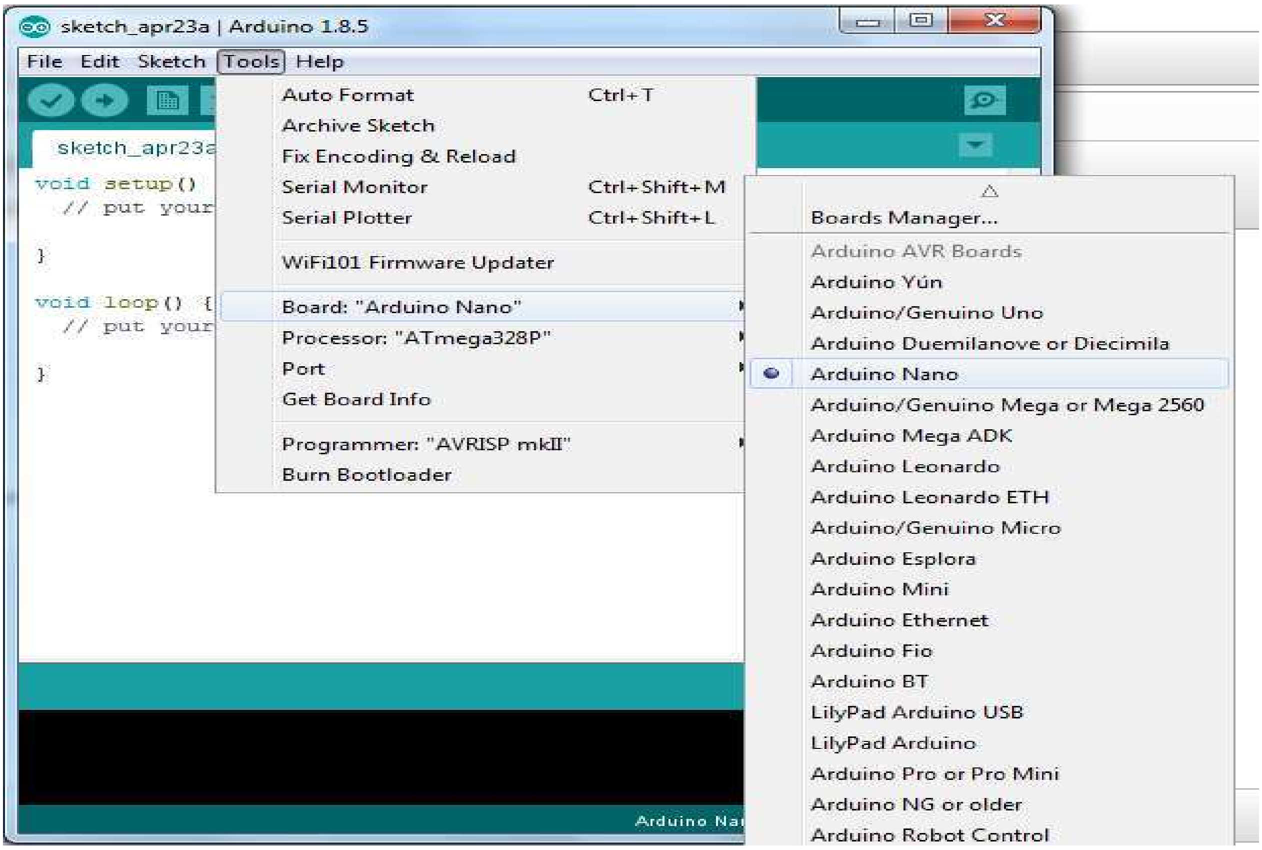


Fig.5.2.6 Selection of board

5.2.6 SELECTION OF PORT:

The port number you wrote is to be selected here i.e COM Port 4 (The Board should be attached to computer).

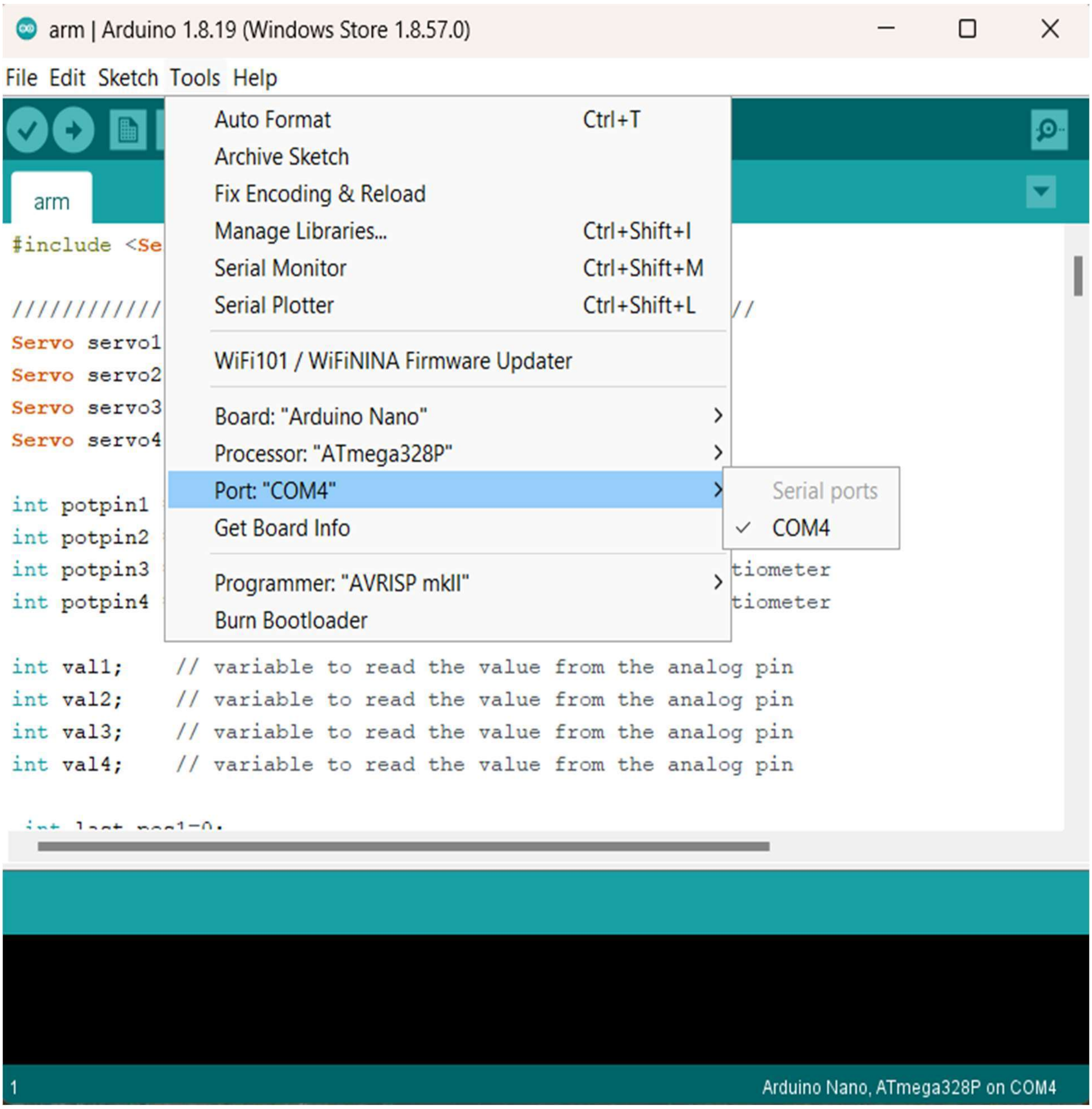


Fig.5.2.7 Selection Ports

Once you have written your code save it and press UPLOAD button.

CHAPTER 6

WORKING

6.1 EXPERIMENTAL WORKING: -

Mechanical parts mounting: -

- The Aluminum metal parts are assembled together with the servo motors and assembly of the robot arm.
- The robot arm moves by 4 axes and performs this movement with 4 MG996R Servo Motors. After drawing the parts on SolidWorks and making the necessary parts, the design of the mechanical part is started and the robot arm is made of a stationary lower body and movable upper body.
- There is one servo motor in the stationary lower part of the robot arm and this robot is called Arm base

Fig6.1 parts of the arms

- The 1st axis provides rotation of the robot arm to the right or left.
- There are 2 servo motors in the moving upper body part. Since these servo motors must operate parallel to each other, both start and end positions are set simultaneously.
- These two servo motors are named as 2nd axis and 3rd axis respectively.
- The tasks of 2nd and 3rd axes are to move the robot arm up and down. Mounting of servo motors in 1st and 2nd and 3rd axes is given in Fig 8.

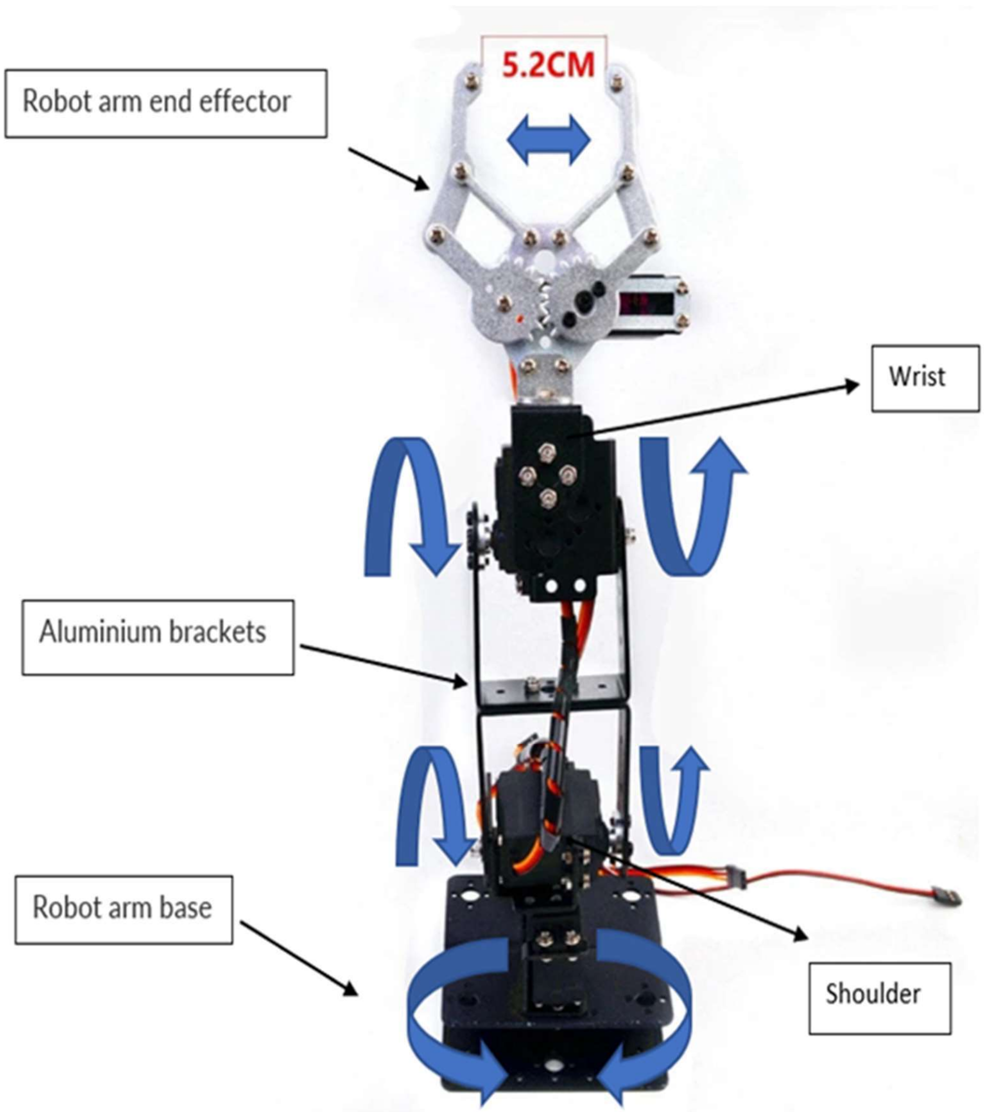


Fig.6.2 Master Slave Robotic Arm

6.1.1 WORKING: -

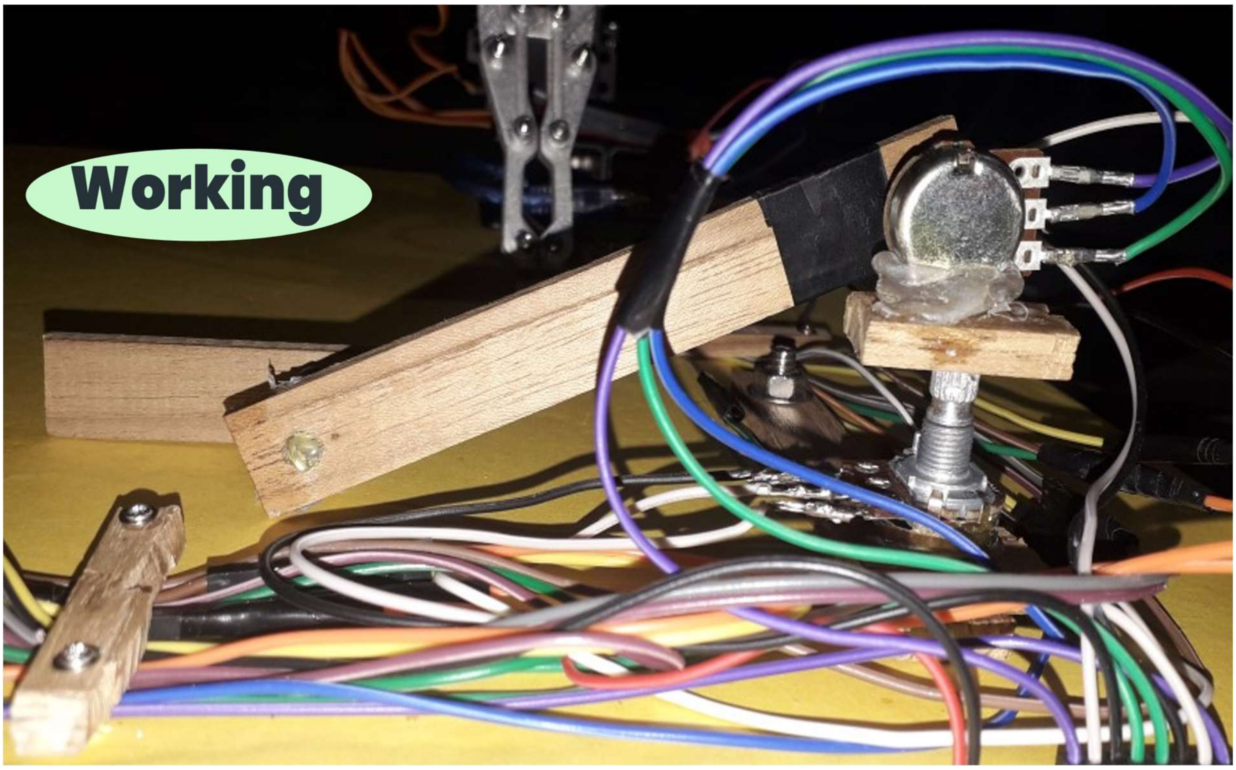


Fig 6.3. Working module

Stage: - 1

- By turning on the power of Arduino nano, potentiometers get the power through 5v pin.
- The servos which are attached to the external supply and signal wire is connected with respect to the PWM pins of Arduino Nano.

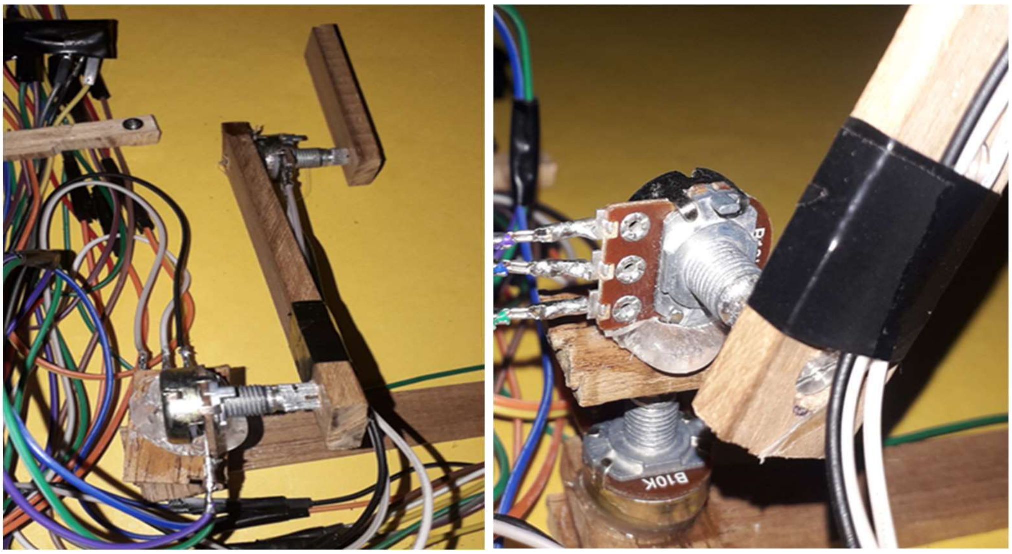


Fig.6.4 Potentiometer connection

Stage: - 2

- Now when the potentiometers rotated the change in the position of potentiometer will be sent to Arduino.
- Arduino will now command the servos exactly in the same angle or degree which is followed with respect to potentiometer.
- called MASTER.

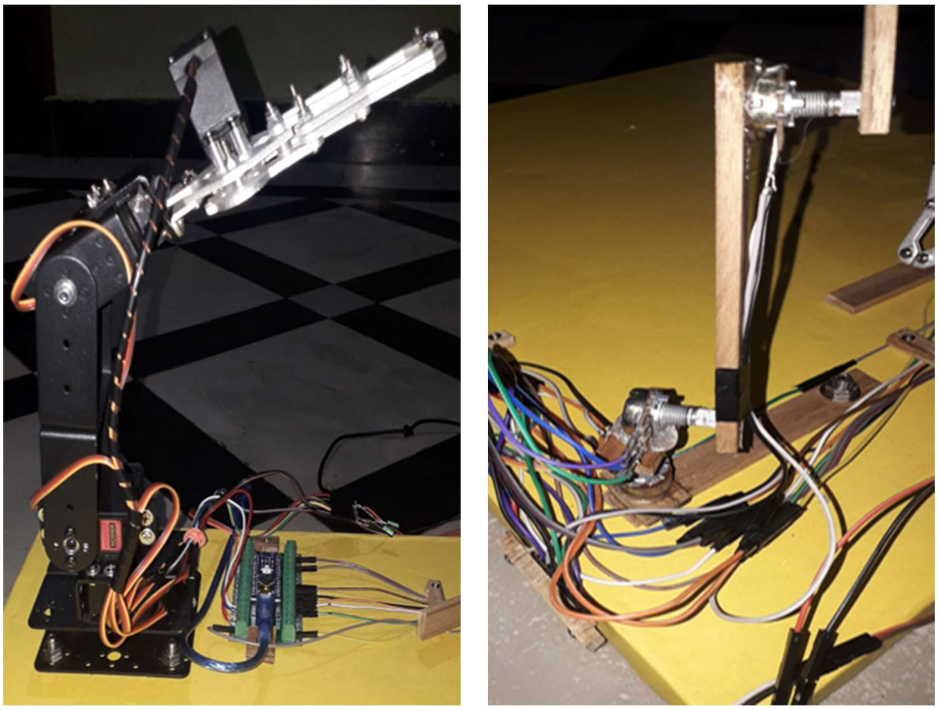


Fig. 6.5 Master & Slave

Stage: - 3

- The servo motors which are powered by external source and also connected capacitor to maintain the fluctuating current due to load.
- Since we have 4 DOF Arm, All the 4 arm are built similar to the potentiometer slave arm.

Stage: - 4

- Now one of the most important Future of this project is to record every single position made by the potentiometer, we use two slide switches for that.
- Switch 1 which is connected to pin 4 of the Arduino nano is to record the positions.
- Switch 2 Which is connected to pin 5 of the Arduino nano is to play.

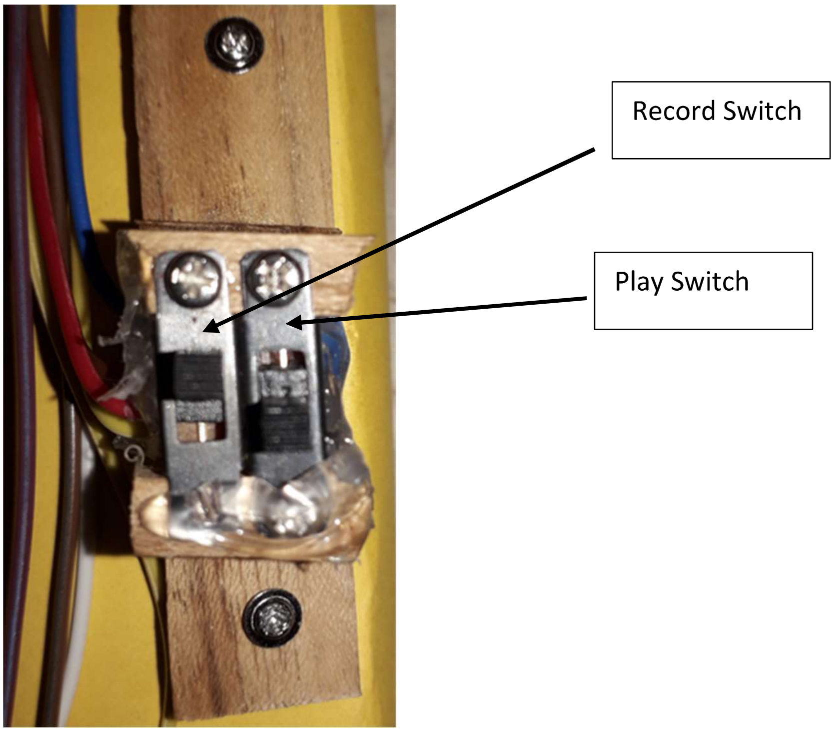


Fig6.6 Slide Switch connection

CHAPTER 7

RESULTS AND CONCLUSION

7.1 TEST AND RESULTS

Experimental studies are within themselves; the method followed in the project, robot arm control system and programming. In the method and robot arm control system part of the project, the basic commands are explained after the basic information is given and the robot can perform the required tasks. In the program section, there is the software information required for the movement of the robot. The RECORD and PLAY part of the program is given in Appendix to the project to make the project more regular.

7.2 CONCLUSION

Robotic arms, many areas are developable. many tasks are made easier and the resulting error level has been reduced to a minimum. infecting the patient in the medical sector is minimized, while the human errors are minimized during the surgical intervention. Despite the fact that the robotic arm made by this project is of prototype quality, it has a quality that can be improved for more robotic systems. Besides these, robotic arm sector, which is open to development, will keep its importance in the future. The purpose of the project is to provide control of 4 axes moving robot arm design and this robot arm with a PLAY and RECORD Future which will make the new way in the automation. During the process of making and developing the project, a lot of theoretical knowledge has been transferred to the practice and it has been ensured that it is suitable for the purpose of the project

7.3 FUTURE WORK

- To build a system that would be capable of controlling the robotic arm remotely.
- By using the users own arm movement to control the robot. To make the usage more intuitive, a simple hectic feedback system will be implemented.