

Faculty of Information Technology

IN -1900 – ICT Project

Automatic Pipe Cutting Machine

Group No: 39

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1. Introduction

There are different types of machines used in construction sites for different purposes. Complex machinery and new techniques are continuously being developed for cost-effective manufacturing. Simultaneously, care should be taken to ensure that quality and accuracy have not been compromised. Machines have become an intrinsic component of human beings in the age of automation. The utilization of an automation machine demonstrates that it has a higher production rate than a manual machine. Today, automation has made a significant impact on the industrial manufacturing process, allowing for the production of identical and accurate products while reducing human involvement.

A pipe cutting machine is one of the essential machines that is used in mass manufacturing. New machinery and processes are constantly being developed to create various items at lower costs while maintaining excellent quality. For cutting PVC pipes, metal pipes and box bars there exist separate machines which are manual or semi-automatic. But there is an industrial deficit for a fully automatic machine that can reduce human participation to boost productivity and accuracy.

2. Literature Survey

Jeet Machine Tools Construction [5] has developed a Pipe Cutter Machine to cut metal pipes. They have developed semi-automatic systems to make their machinery more efficient and productive. This machine can cut and separate metals that are tough to cut by hand.

But in this machine, there is no automatic method to lower the blade to the cutting point. It requires manpower to direct the cutting arm to its intended location. Because of this manual part, it is not possible to carry out the cutting without an operator. It is a limitation of this machine.



Figure 2.1-Pipe cutter machine



Figure 2.2-Manual Cutting

Sohit Engineering Works [4] has manufactured a semi-automatic pipe cutting machine named “Sohit 385 Automatic Pipe Cutting Machine” which is more suitable for medium-scale industries. For reducing human effort, there is an automatic clamping and cutting process in this machine that helps to save 70% manpower. Since there is no automatic length measuring method is used in this machine, the operator must align the pipe to the cutting point according to his requirement. This machine weighs about 425kg and that causes less portability.



Figure 2.3-Sohit 385 Automatic Pipe Cutting Machine

3. Aim & Objectives

3.1 Aim:

Design and develop a fully automatic pipe cutting machine to measure and cut PVC pipes, steel pipes and box bars.

3.2 Objectives:

- To measure and cut pipes automatically according to the different measurements.
- To cut pipes of different materials by using one machine.
- To reduce manpower by limiting human intervention only to place the pipe on the machine.
- To increase the safety level of the operator by reducing human involvement.

4. Analysis and Design

4.1 Block Diagram

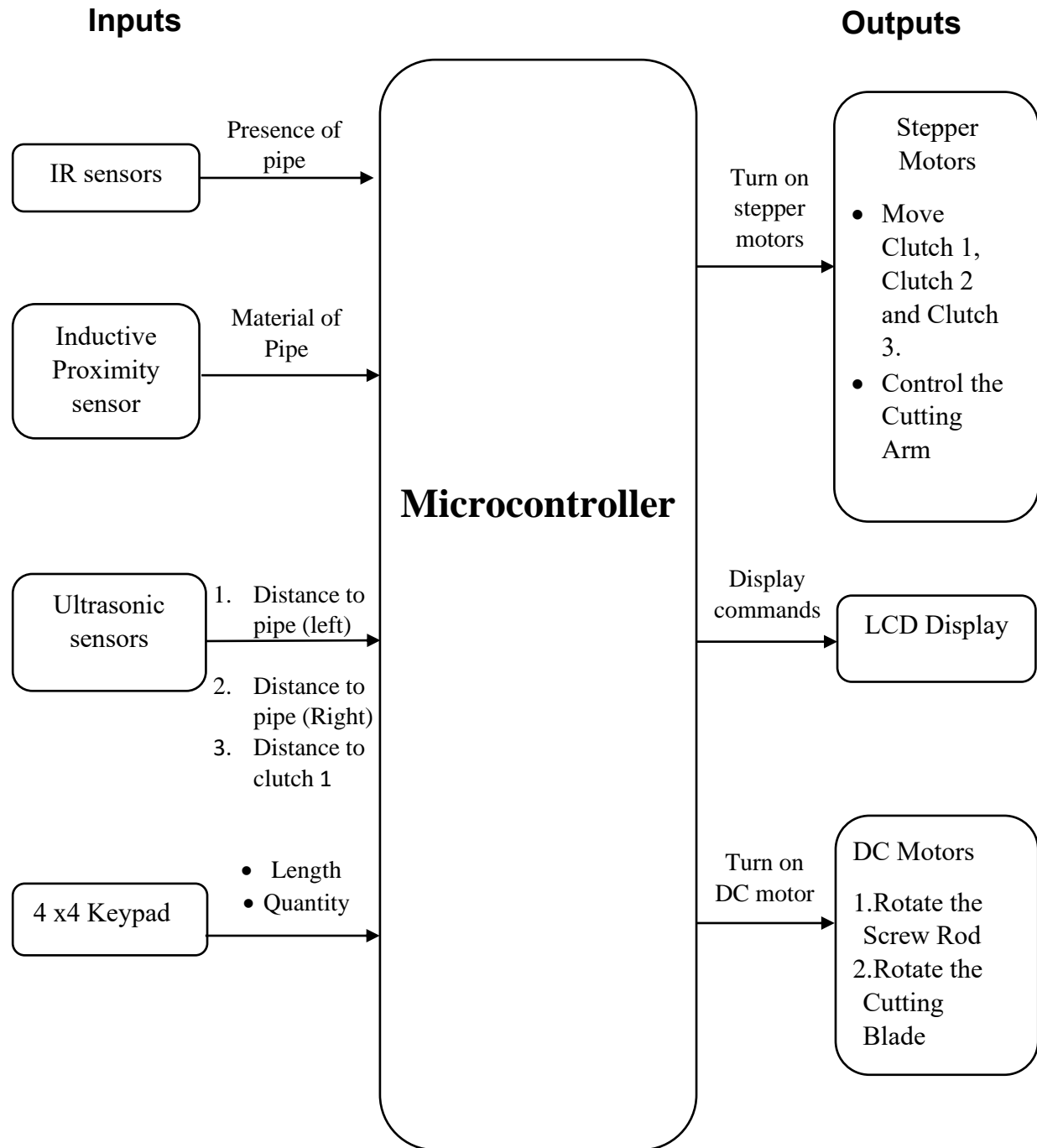


Figure 4.1-Block diagram

4.2 3D Diagram

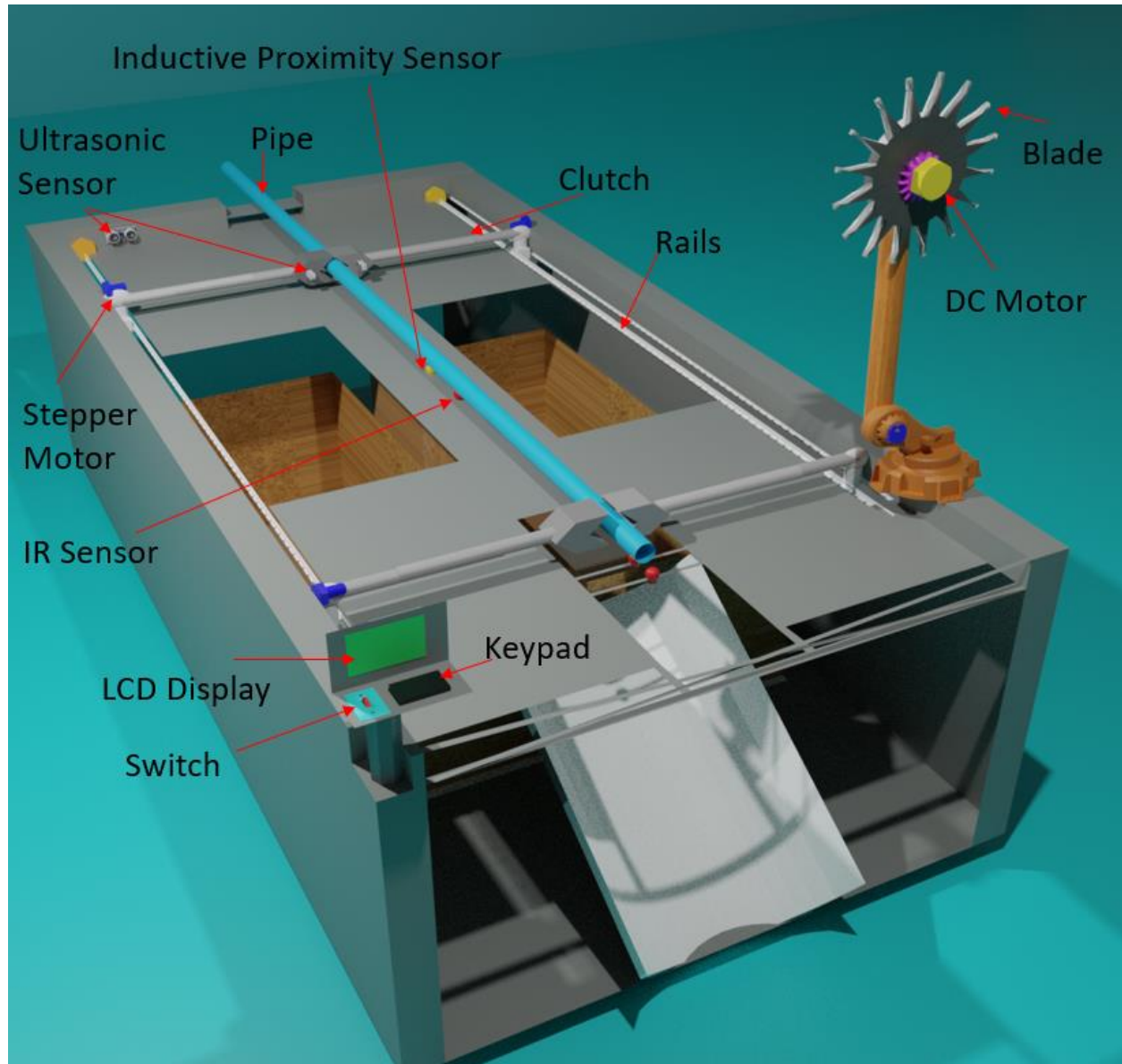


Figure 4.2-3D Model of the machine

4.3 Schematic Diagram

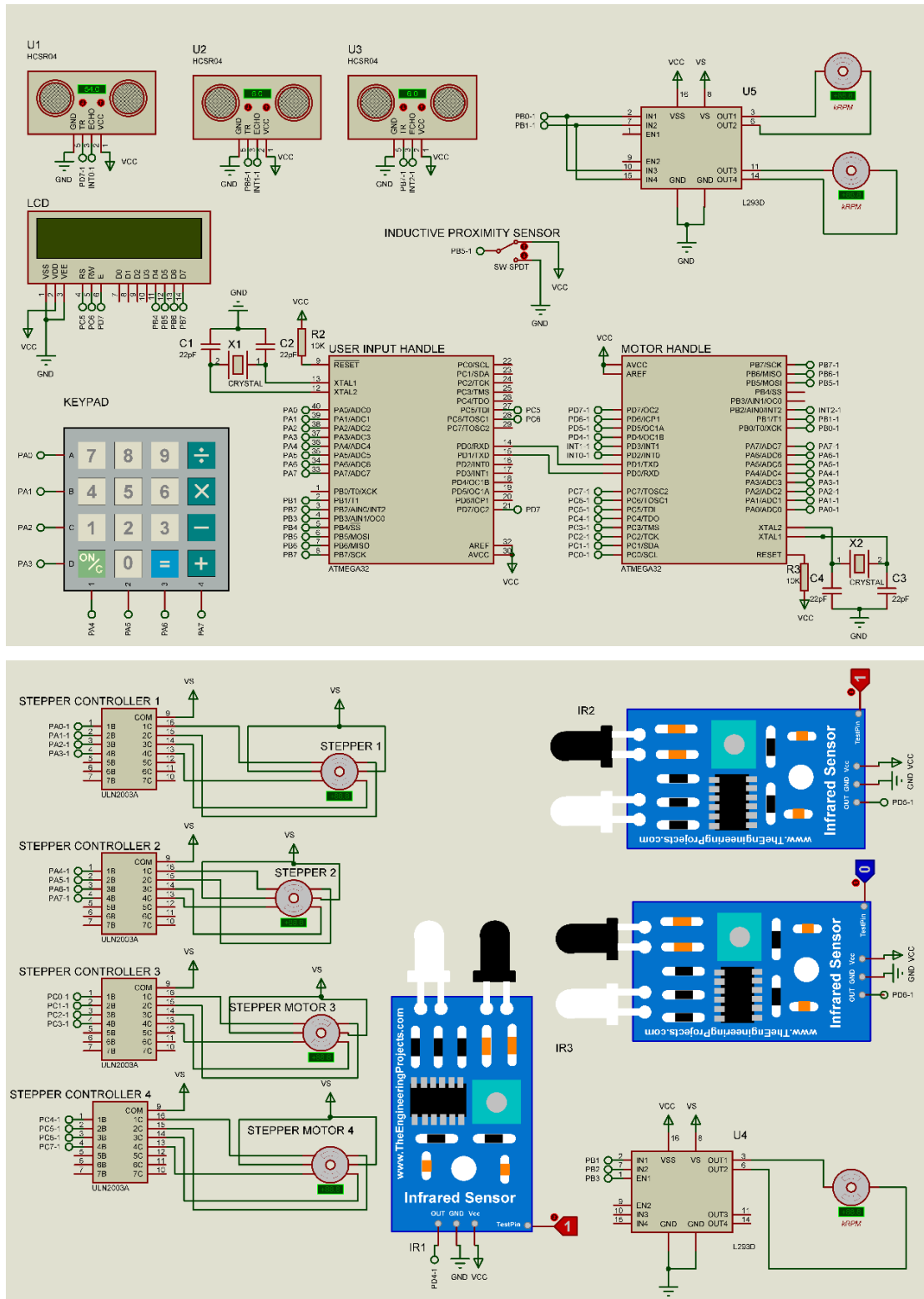


Figure 4.3-Schematic diagram of the machine

4.4 PCB Design

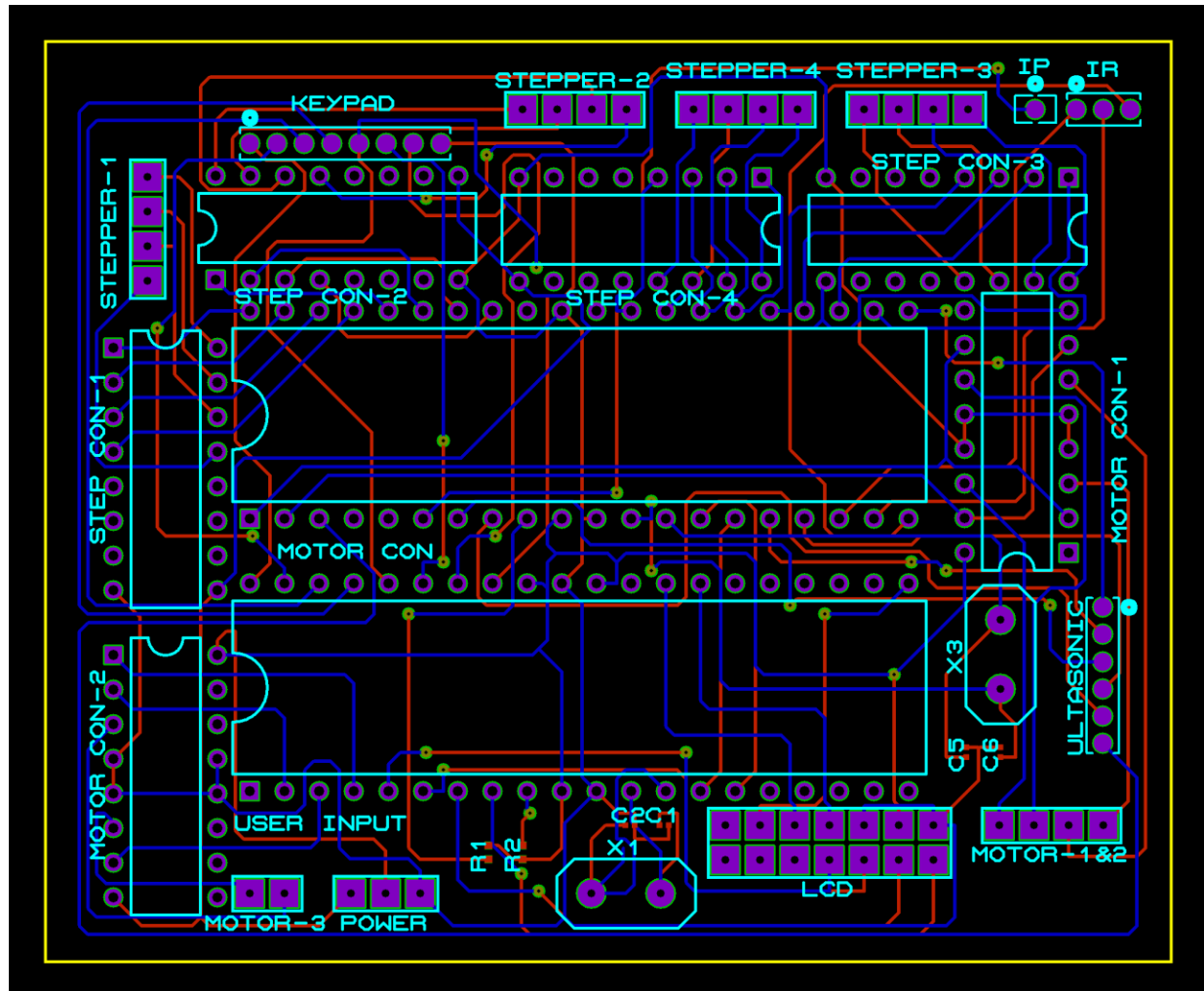


Figure 4.4-PCB design of the machine

5. Testing and Implementation

According to need of our machine, we have used two microcontrollers to interface all the sensors and motors. Also, we have initialized them as ‘User input controller’ and ‘Motor controller’.

Then we have developed the code for the machine by connecting these microcontrollers in USART communication and included header and c files for all the sensors, LCD, keypad, and motors. Both codes built successfully.

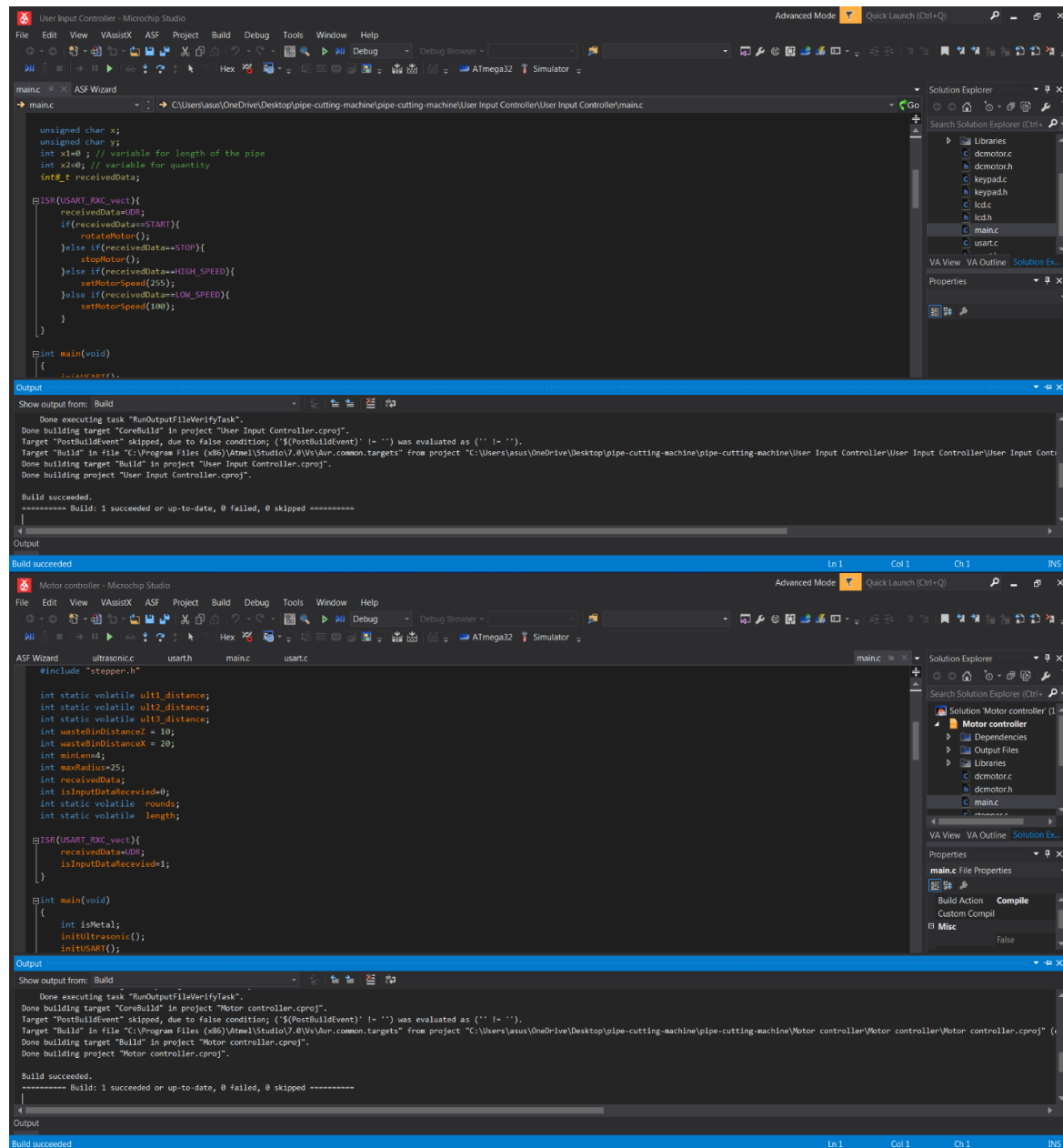


Figure 5.1- Microchip studio code file

Then we have simulated the code with schematic diagram which we have designed with proteus software. After that we tested functioning of each sub process of the machine.

5.1 Entering user inputs

At the beginning, machine must capture needed length and quantity entered by the user.

Result:

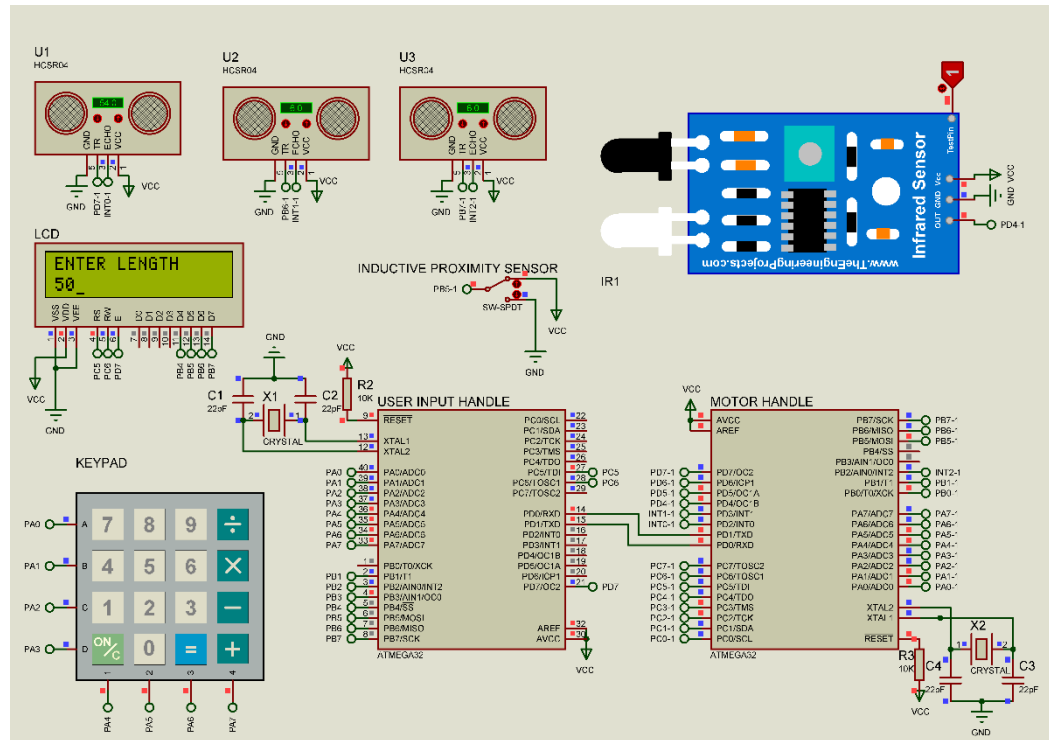


Figure 5.2 – Functioning of keypad and lcd

5.2 Detecting and identifying the material

After that, the machine will detect the presence of the pipe by the IR sensor and will identify the material of the pipe by the Inductive Proximity sensor.

- Both positive signals by IR sensor and Inductive proximity sensor can be considered as ‘metal object detected’. Which means it is a metal pipe.
- Positive signal by IR sensor and negative signal by Inductive proximity sensor can be considered as ‘nonmetal object detected’. Which means it is a PVC pipe.

As it is in simulation mode, we have hard coded inputs of the sensors and got the out as below.

Result:

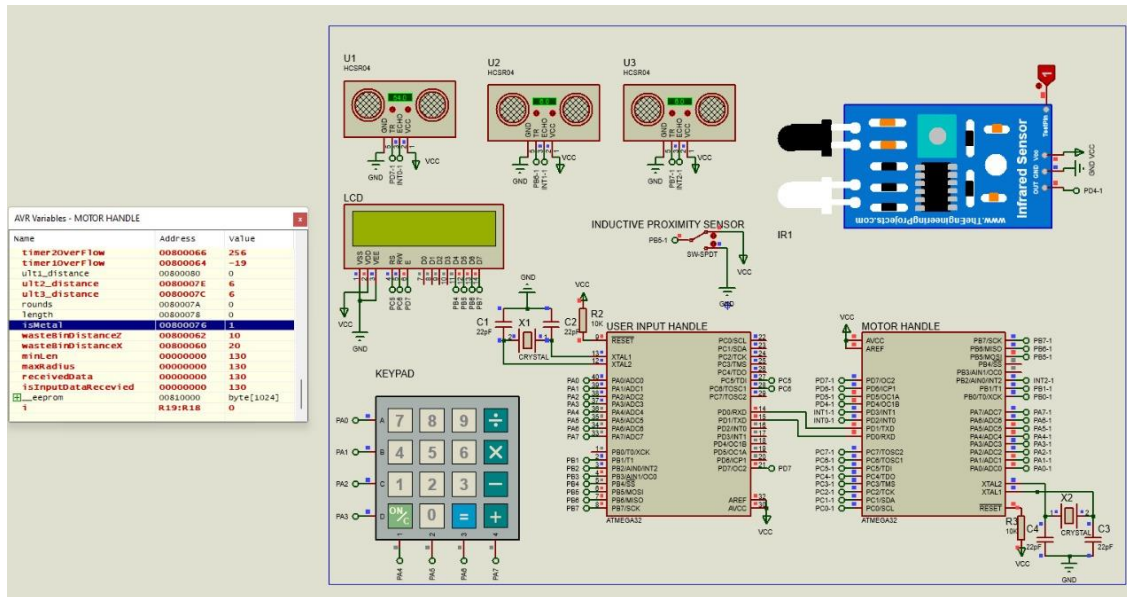


Figure 5.3- identifying the material of pipe

5.3 Tightening Process

After detecting and identifying the pipe, clutches will automatically come forward and the pipe will be tightened. So, stepper motor 1,2 & 3 must rotate accordingly.

Result:

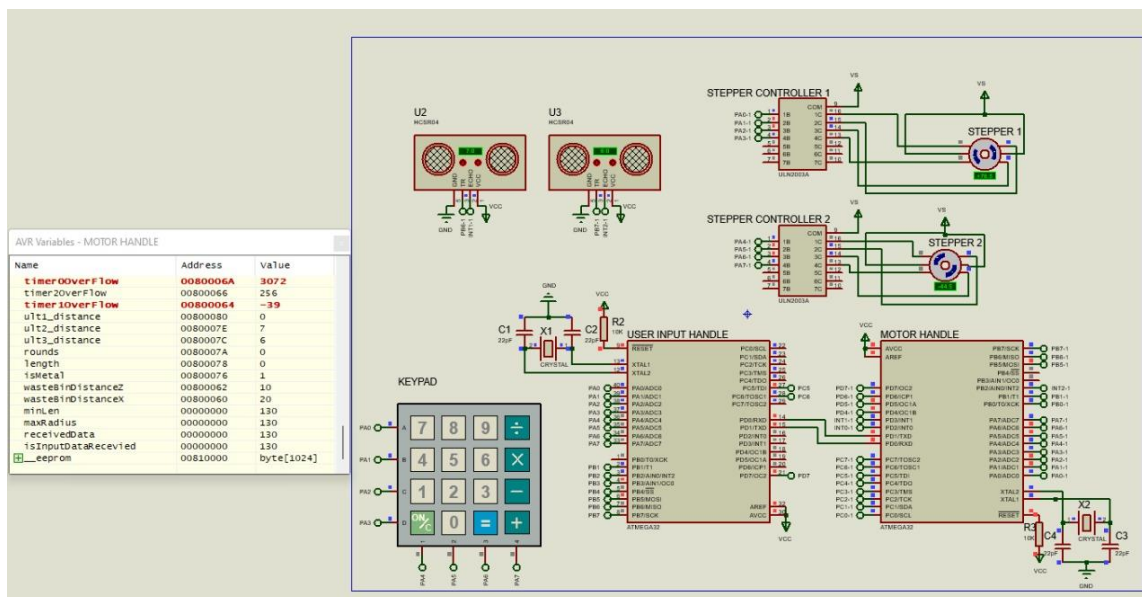


Figure 5.4-tighning the pipe

5.4 Aligning Process

Two IR sensors will be used for this process. When one IR sensor is giving a positive signal and next IR sensor is giving a negative signal, it can be considered as an aligned position. So, microcontroller has to check the inputs of these sensors continuously and rotate the DC motors of rail system.

Result:

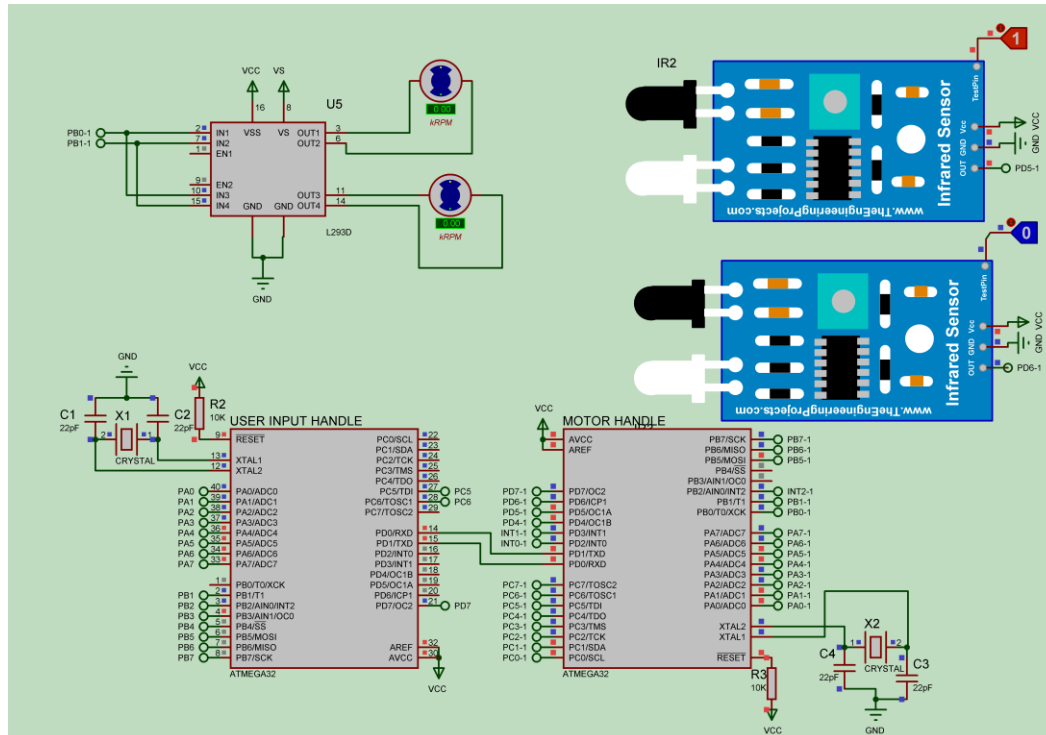


Figure 5.5-Aligning process

5.5 Length Measuring Process

After aligning, the measuring process will be started by the machine. Another Ultra-sonic sensor will be used here. The pipe will be moved forward by the clutches which are connected to the rail system. The ultrasonic sensor will measure the distance to clutch 1. Clutches 1 & 2 will move forward and backward, and it will bring the pipe forward until the given length is satisfied.

So, this time micro controller has to check the inputs of ultrasonic sensor 1 and rotate the DC motors

Result:

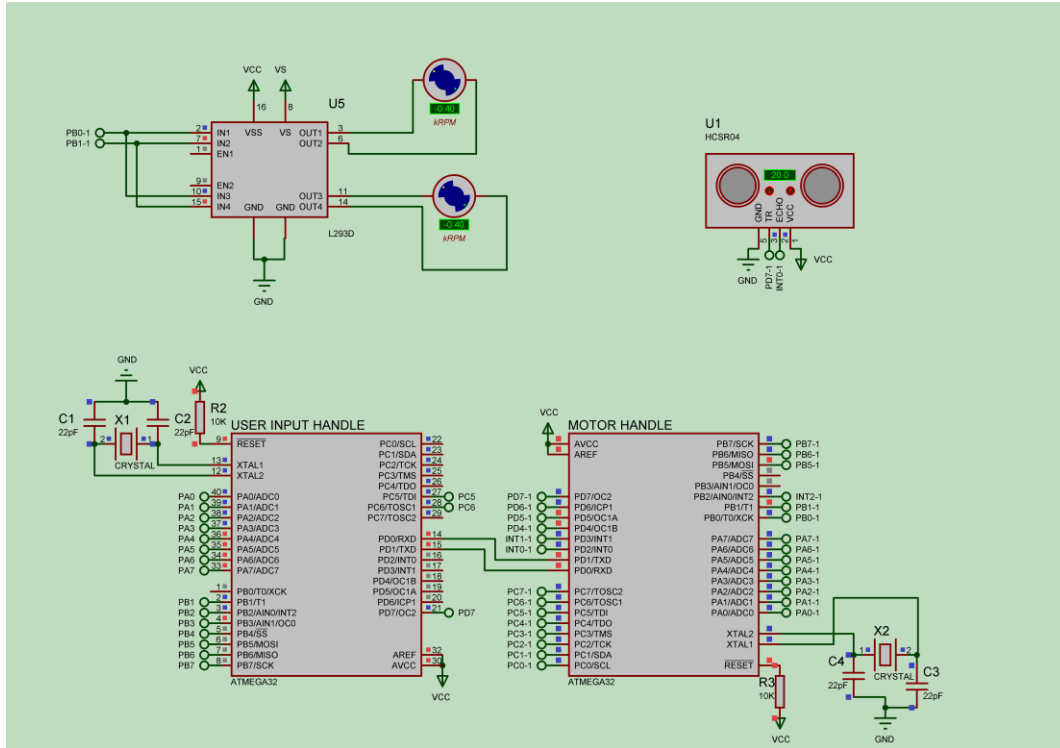


Figure 5.6- length measuring process

5.6 Cutting Process

After identifying the cutting point of the pipe, the cutting process will be started. Here the cutting arm, which is controlled by the stepper motor, will come down and cutting blade will start rotating and cutting the pipe.

So, the stepper motor and DC motor of cutting arm must rotate.

Result:

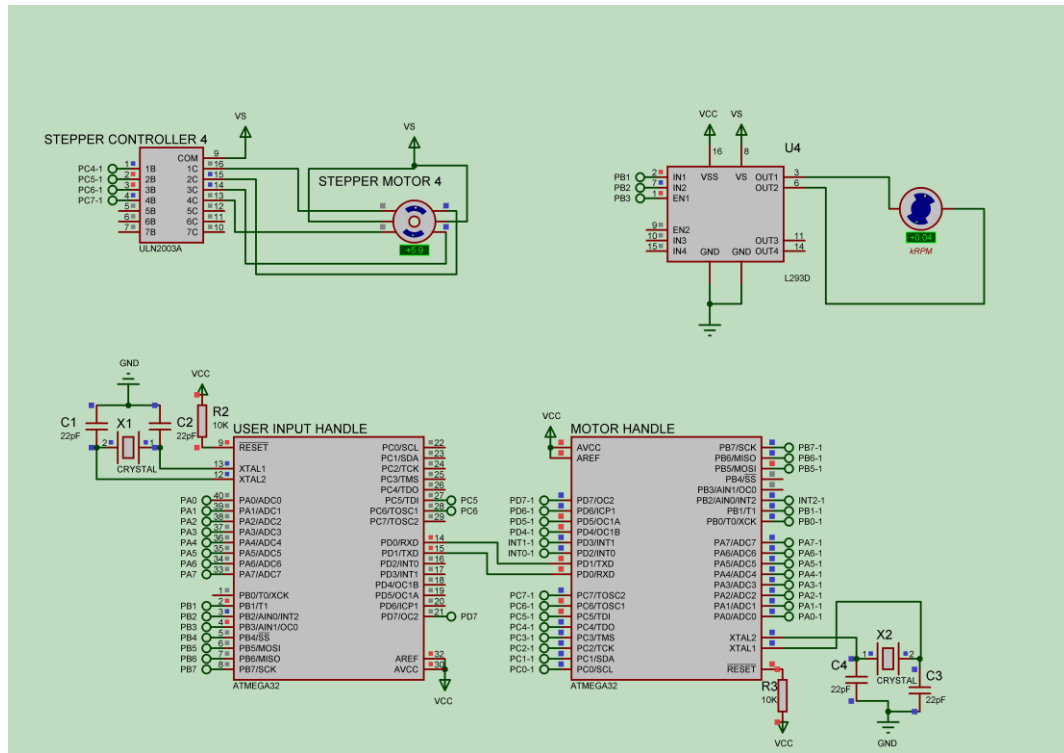


Figure 5.7-pipe cutting process

5.7 Wastage Separating and Collecting Process

At the end of the cutting process, the remaining piece of pipe will be kept between clutch 3 and clutch 4. If the length of this piece is less than 10cm, the machine will consider it as a wastage. IR sensor will be used to identify this. If the remaining piece is identified as a waste, it will be grabbed by clutch 1 and clutch 2 and will be released to the relevant bin. There are two bins placed inside the machine for this purpose.

First, DC motors of rail system must rotate anticlock wise and the stepper motors of clutches must rotate.

Result:

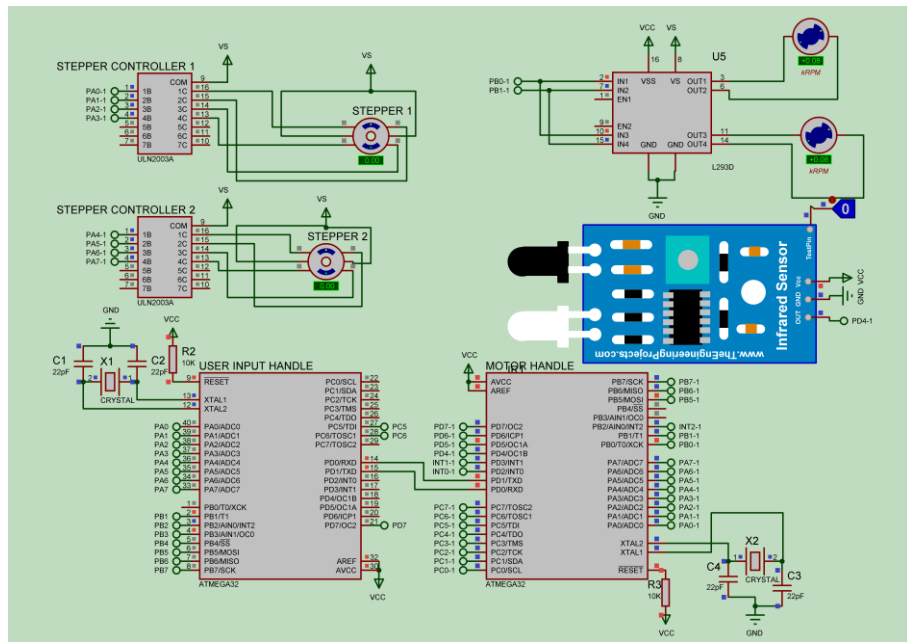


Figure 5.8-remaining piece identified as wastage and separated

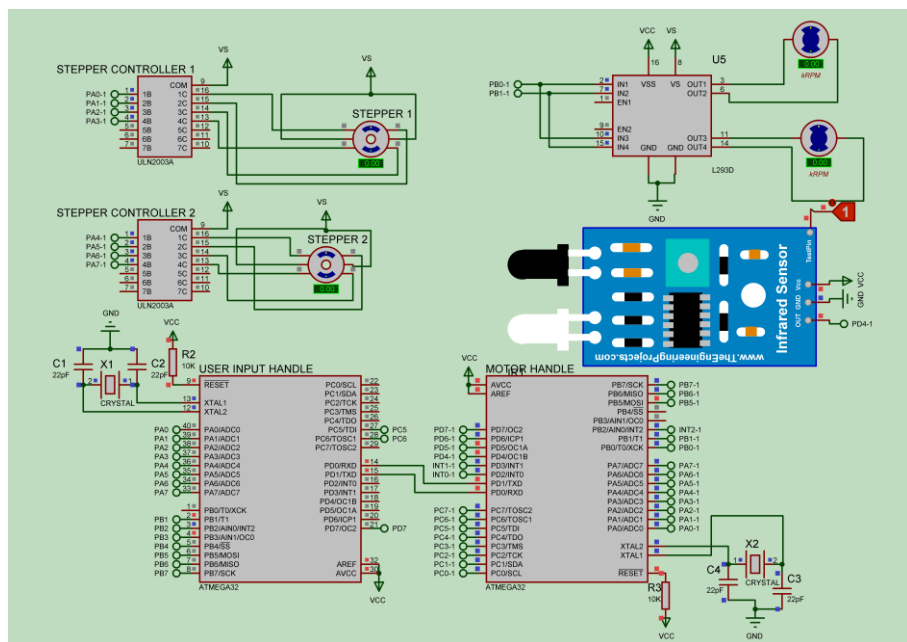


Figure 5.9-remaining piece is not identified as wastage

6. Cost Estimation

Figure 6.1-Cost Estimation

Components	Units	Unit Price	Price
Microcontroller	2	Rs: 550.00	Rs: 1100.00
IR Sensor	3	Rs: 120.00	Rs: 360.00
Inductive Proximity Sensor	1	Rs: 550.00	Rs: 550.00
Ultrasonic Sensor	3	Rs: 400.00	Rs: 1200.00
Keypad	1	Rs: 160.00	Rs: 160.00
LCD	1	Rs: 800.00	Rs: 800.00
Stepper Motor	4	Rs: 3200.00	Rs:12800.00
DC Motor	3	Rs: 950.00	Rs: 2850.00
Grinding Disc	1	Rs: 2000.00	Rs: 2000.00
Drivers A4988 (Stepper motors)	4	Rs: 460.00	Rs: 1840.00
Drivers L1293 (DC motor)	3	Rs: 400.00	Rs: 1200.00
Other expenses			Rs: 5000.00
Total			Rs:29860.00

10. References

1. Components101. 2021. *16x2 LCD Module*. [online] Available at: <<https://components101.com/displays/16x2-lcd-pinout-datasheet>>
2. Cuidevices.com. 2021. [online] Available at: <<https://www.cuidevices.com/product/resource/nema17-amt112s.pdf>>
3. Electronicwings.com. 2021. *ElectronicWings - Hardware Developers Community*. [online] Available at: <<https://www.electronicwings.com/>>
4. indiamart.com. 2021. *Sohit 385 Semi-Automatic Pipe Cutting Machine*. [online] Available at: <<https://www.indiamart.com/proddetail/sohit-385-semi-automatic-pipe-cutting-machine-21986504233.html>>
5. indiamart.com. 2021. *Pipe Cutter Machine*. [online] Available at: <<https://www.indiamart.com/proddetail/pipe-cutter-machine-15005718191.html>>
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10. Youtu.be. 2021. [online] Available at: <<https://youtu.be/w7keb73nNok>>

Individual Contribution to the Project

Name of the Student – P.K.D.P.Chathurangi (204027A)

Responsible Components: 1). Ultrasonic Sensors

2). Stepper Motors

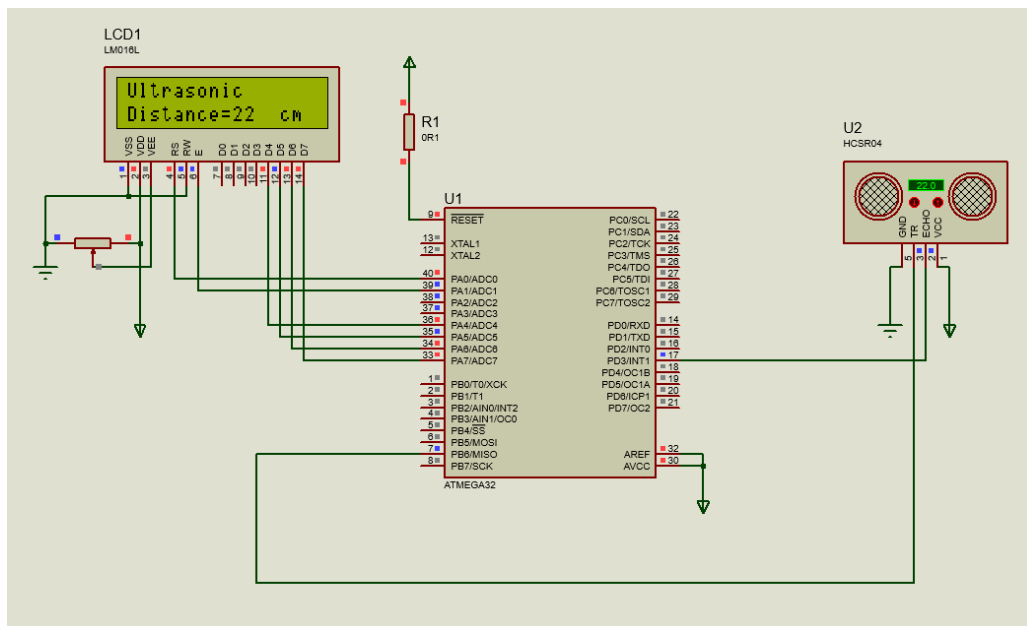
1). Ultrasonic sensor

Ultrasonic sensor is the first component that I am responsible for in our project. We have used two ultrasonic sensors in this machine for tightening process. That are placed in both clutch 1 and clutch 2 to identify the distance to the pipe each side.

Specifications:

- Maximum current: 15mA
- Maximum voltage: 5V
- Range : 2cm-400cm
- Measuring angle : 15 degrees

Schematic diagram for ultrasonic sensor:



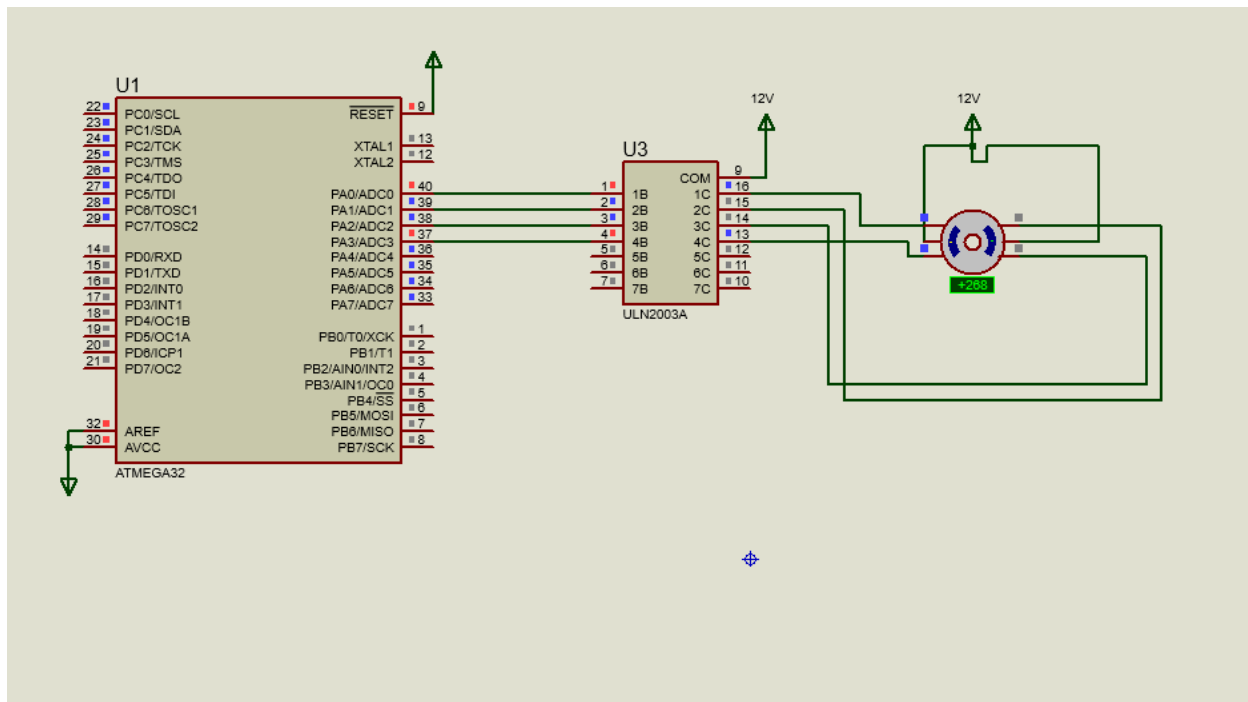
2). Stepper Motor

My second component is Stepper Motor. There are four clutches which are used in the tightening process, and I am responsible for clutch 1 and clutch 2. Here I have used two stepper motors in clutch 1 and clutch 2.

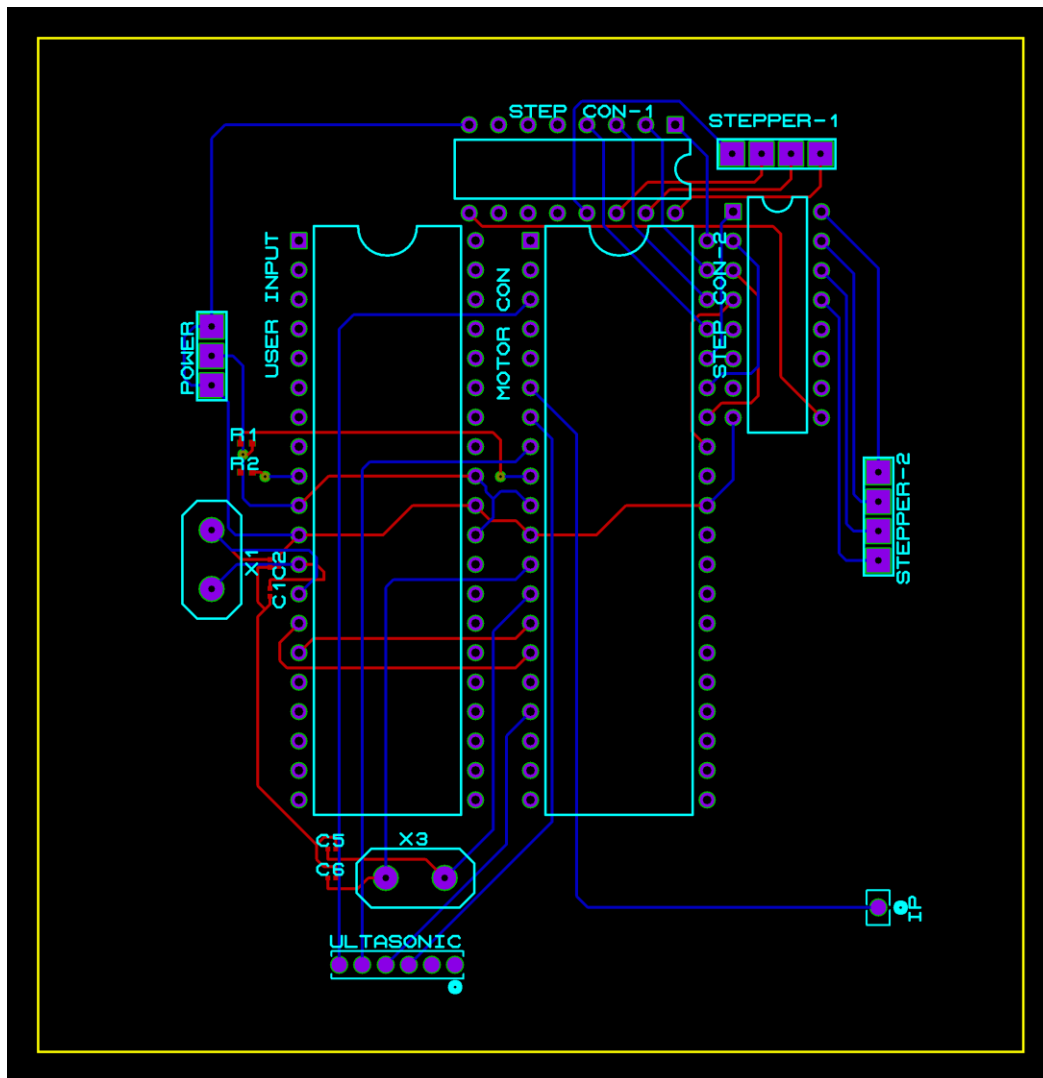
Specifications:

- Maximum current: 1.5A-1.7A
- Maximum voltage: 12 VDC
- Step Angle : 1.8 degree
- Unipolar

Schematic diagram for Stepper Motor:



PCB for above components:



Name of the Student: P.H.A.E.Madhubhashini (204117B)

Responsible Components: 1). 4 x 4 Keypad

2). IR Sensor

3). Power Supply Unit

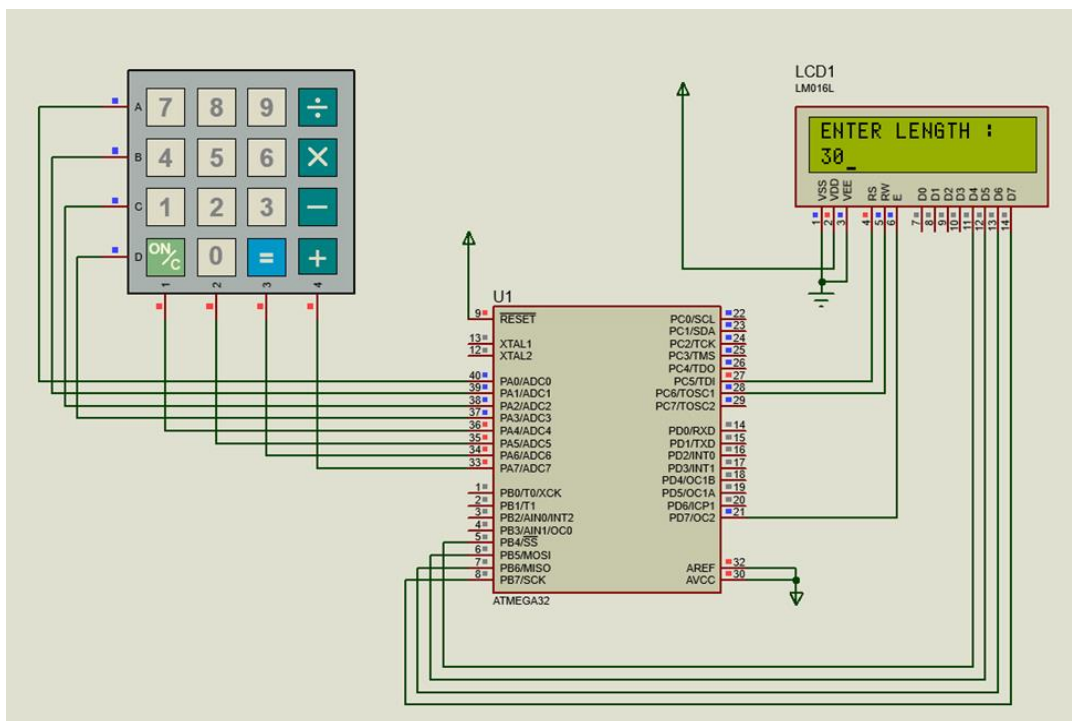
1). 4 x4 Keypad

Keypad is the first component that I am responsible in our project. We have used keypad module in this machine to get two inputs from the user. They are required length of the pipe and the required quantity.

Specifications:

- Maximum current : 30 mA
- Maximum voltage : 24 VDC
- Operating temperature : 0 - 50 °C

Schematic Diagram (Circuit)



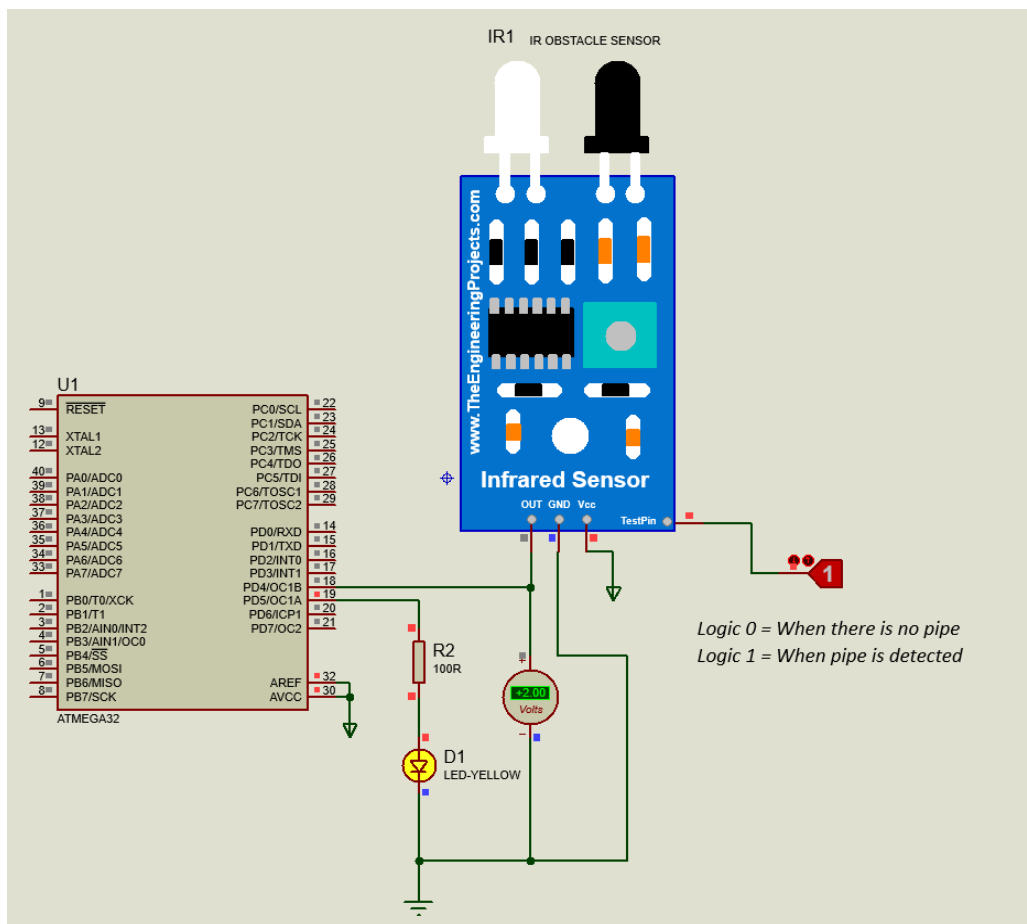
2). IR Sensor

My next component is IR sensor. We have used this IR sensor in two different stages of this machine. IN the Identification process, this IR sensor is used to detect the presence of the pipe and at the final stage which is wastage separating and collecting process we have used this same IR sensor to identify the wastage.

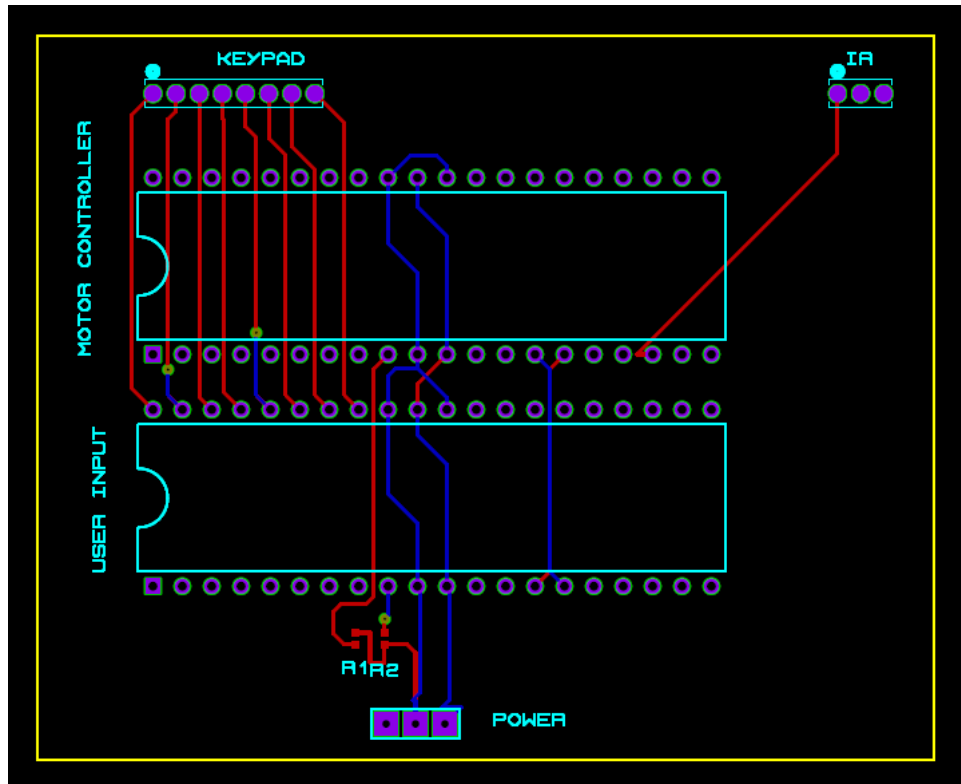
Specifications:

- Supply current : 20 mA
- Operating voltage : 5 VDC
- Range : up to 20 cm

Schematic Diagram (Circuit)



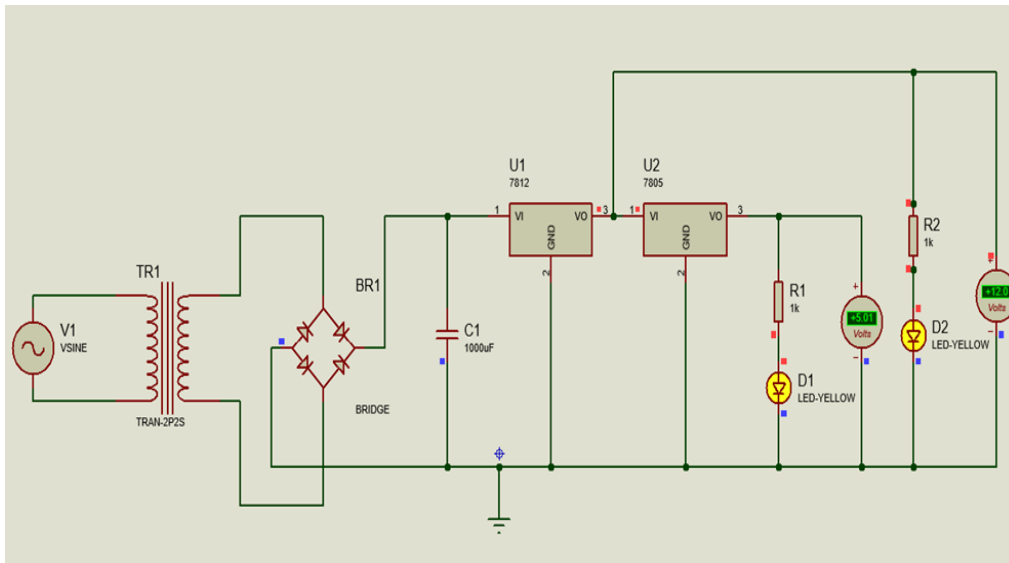
PCB Design (Keypad + IR sensor)



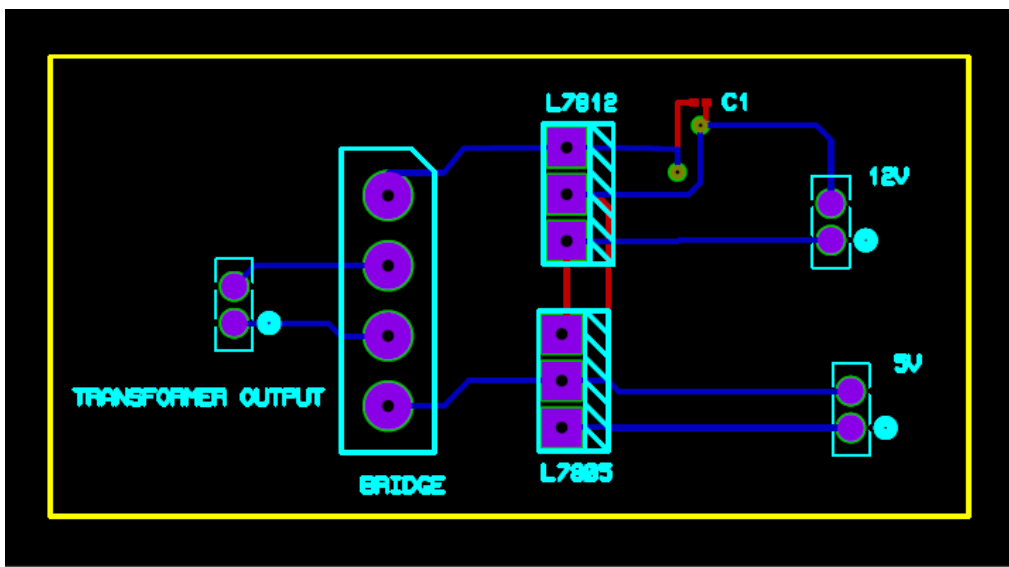
3). Power Supply Unit

Designing a power supply unit for our machine is my next responsibility. Since we have used several sensors and different types of motors for this machine we have to convert 230 VAC domestic power supply to various DC values such as 5VDC and 12VDC according to their need. I have used a step-down transformer, bridge, capacitors and regulators to design the power supply circuit and the whole process happens in the circuit is known as “Full Rectification”.

Schematic Diagram



PCB Design



Name of the Student: D.S.Rathnasinghe (204178K)

Responsible Components: 1). DC Motor

2). IR Sensor

Others: 3). USART Communication

1). DC Motor

DC motor is the first component which I am responsible in our project. We have used this DC motor in the rail system of our machine.

Technique: we have designed a rail system by using two dc motors at both sides of machine.

Specifications

- Maximum current: 1.5A
- Maximum voltage: 20 VDC
- Motor Type :775
- No Load Speed : 12,000 RPM @ 12V.

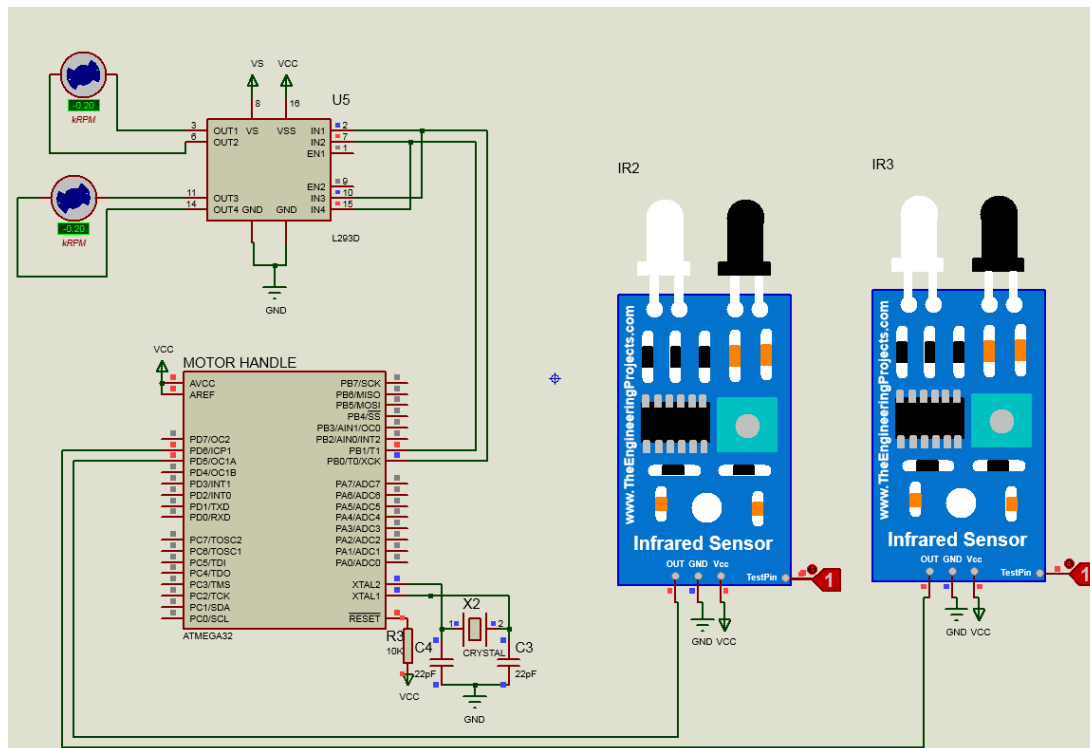
2). IR sensor

My second component is IR Sensor which is used for aligning process. Here we are using two IR sensors to get the align the pipe edge to the cutting point.

Specifications:

- Maximum current: 20 mA
- Maximum voltage: 5 VDC

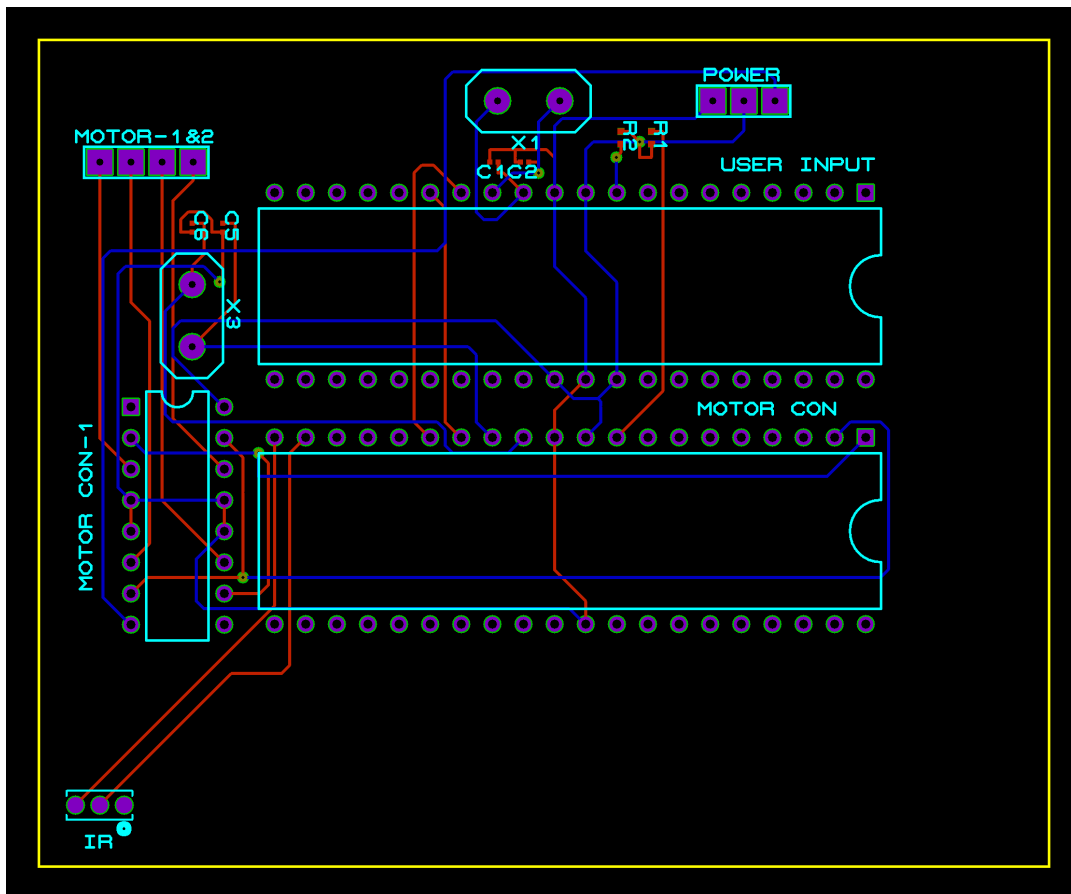
Schematic diagram for above components:



3). USART Communication

As we are using two microcontrollers it is necessary to build a communication between them. we have used USART communication for that. I have developed the code to satisfy our requirement here.

PCB design for the above components:



Name of the Student: J.D.A. Shalinda (204200A)

Responsible Components: 1). Stepper Motor (For Cutting Arm)
2). DC Motor (For Cutting Blade)
3). Inductive Proximity Sensor

1). Stepper Motor: NEMA 17

Stepper Motor is the first component which I am responsible in our project. We have used this stepper motor in our machine to move the cutting arm up and down at the cutting point.

Specifications:

- Maximum voltage: 12 VDC
- Maximum current: 1.5A-1.7A
- Step angle: 1.8° degree
- Holding torque: 3.2 kg - cm
- Unipolar

2). DC Motor

My second component is DC motor which is placed at the upper part of the cutting arm. We have used this DC motor to control the rotation of the cutting blade.

Specifications:

- Maximum current: 1.5A
- Maximum voltage: 20VDC
- No load speed: 12 000 RPM @12V
- Stall torque: 79Ncm @14.4 V

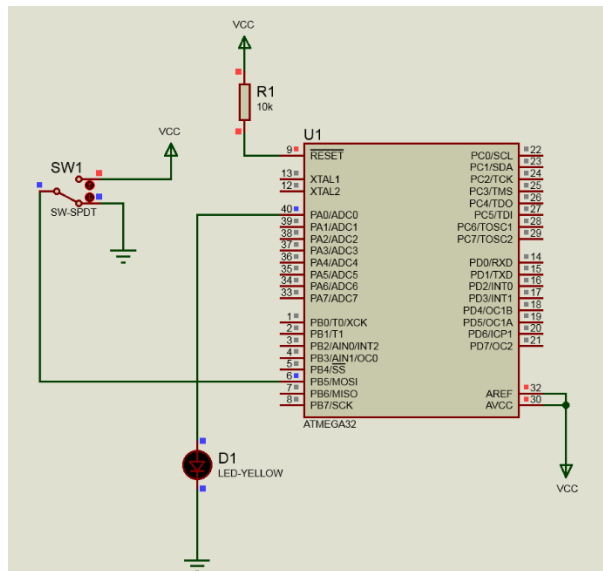
3). Inductive Proximity sensor

Inductive Proximity sensor is my next component and we have used it in the detecting and identification process to identify the material of the pipe. If the material of the pipe is metal, then its output becomes high and set a higher speed to the DC motor and if the material of the pipe is non-metal (PVC) its output becomes low and sets a lower speed to the DC motor.

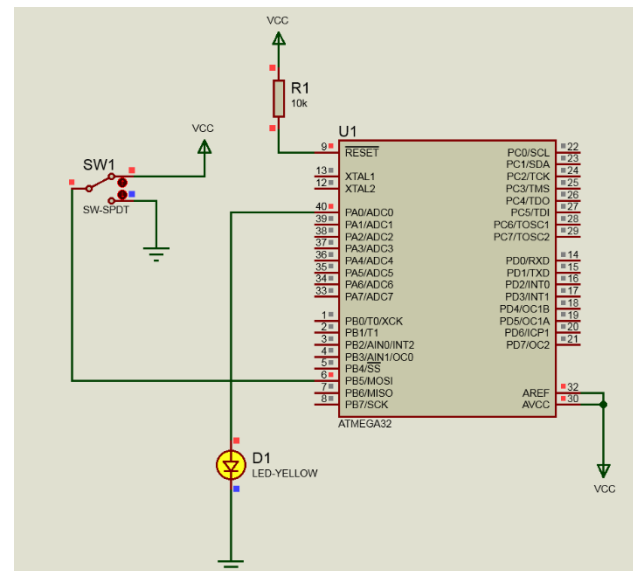
Specifications:

- Maximum voltage: 30VDC
- Maximum current: 200 mA
- Output type: PNP
- Temperature: -25.....70 °c

Schematic diagram for Inductive Proximity sensor:

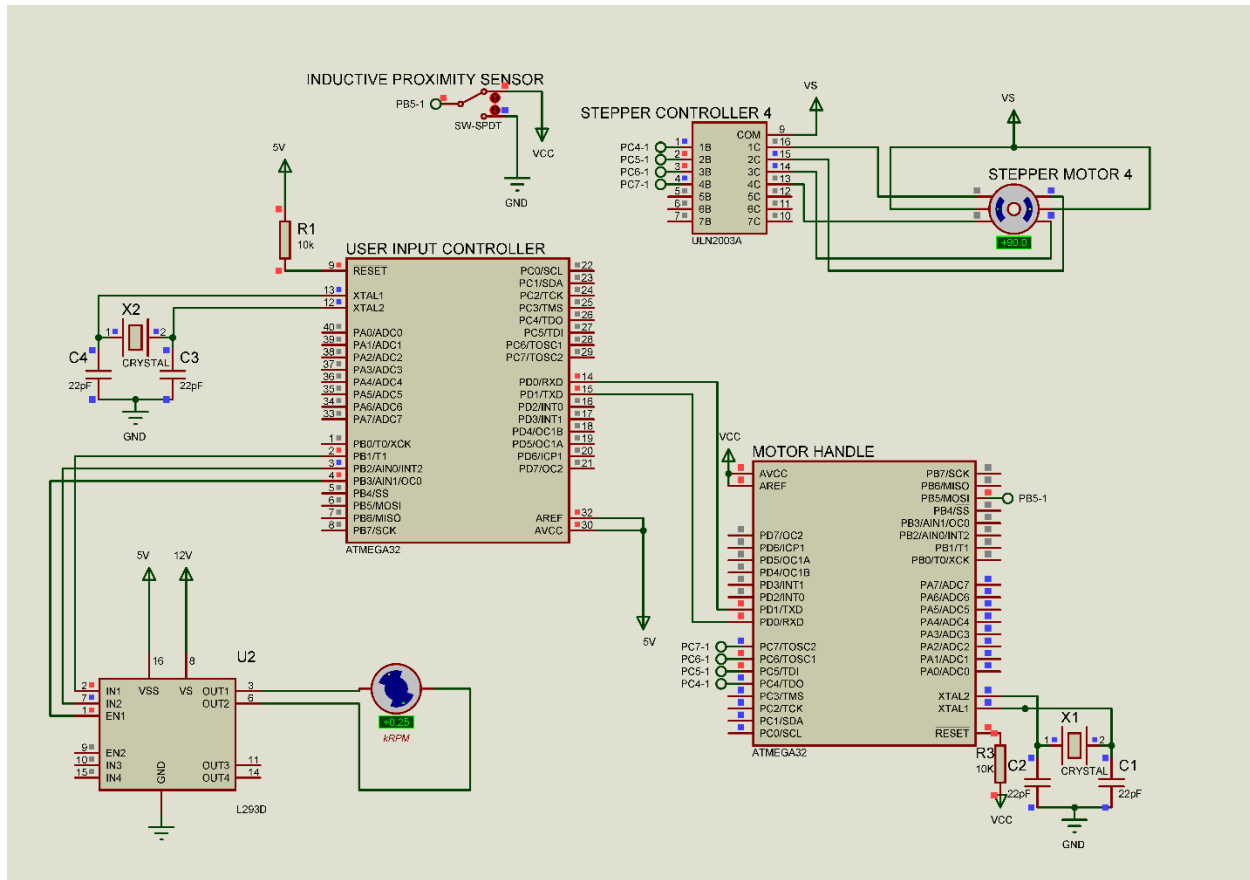


For PVC Pipe

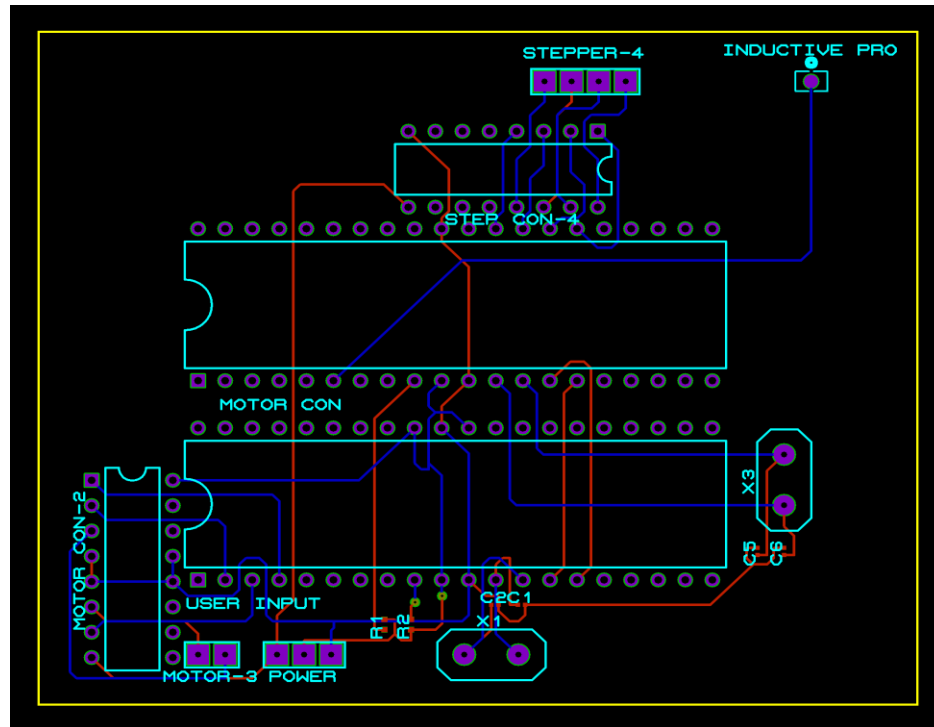


For Metal Pipe

Schematic Diagram For all Components :



PCB design for above components:



Name of the Student: K.M.Tharangana (204215A)

Responsible Components: 1). 16x2 LCD Display

2). Ultrasonic Sensor

3). Stepper Motor

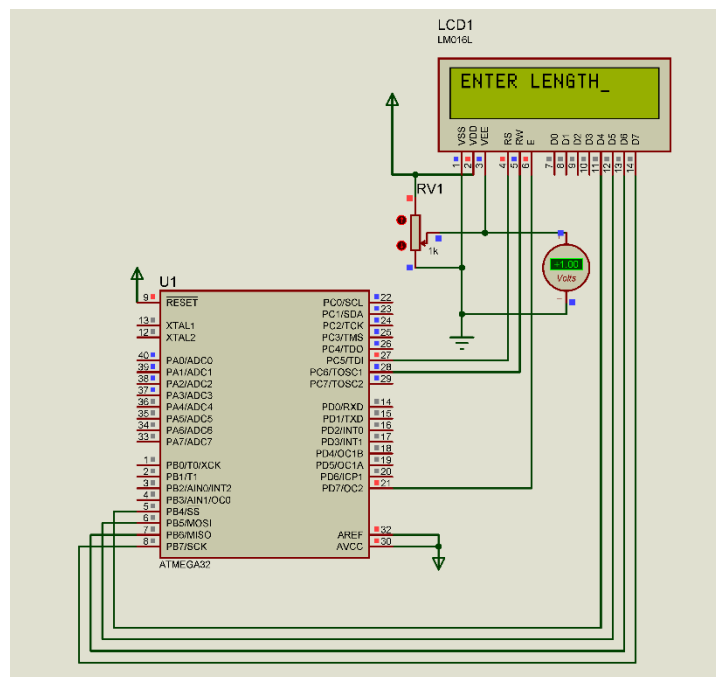
1). LCD Display

16 x2 LCD Display is the first component that I am responsible in our project. This has been used to display commands to the user. It directs the user to enter the needed pipe length and amount.

Specifications:

- Current range : 1.5 - 2.5 mA
- Voltage range : 4.8 - 5.3 VDC
- Operating temperature: 0 - 50 °C

Schematic diagram for LCD Display:



2.Ultrasonic sensor – HCSR04 module

Ultrasonic sensor is the second component of our project for which I am accountable. This sensor is used in the pipe length measurement procedure. We're looking at the distance between clutch 1 and one of the machine's edges. (It gives the pipe length which went ahead in an indirect way) When the specified length is reached, the sensor will interrupt to the microcontroller.

Specifications:

- Maximum current: 15mA
- Maximum voltage: 5 VDC
- Range : 2cm-400cm
- Measuring angle : 15 degrees

3). Stepper Motor – Nema17

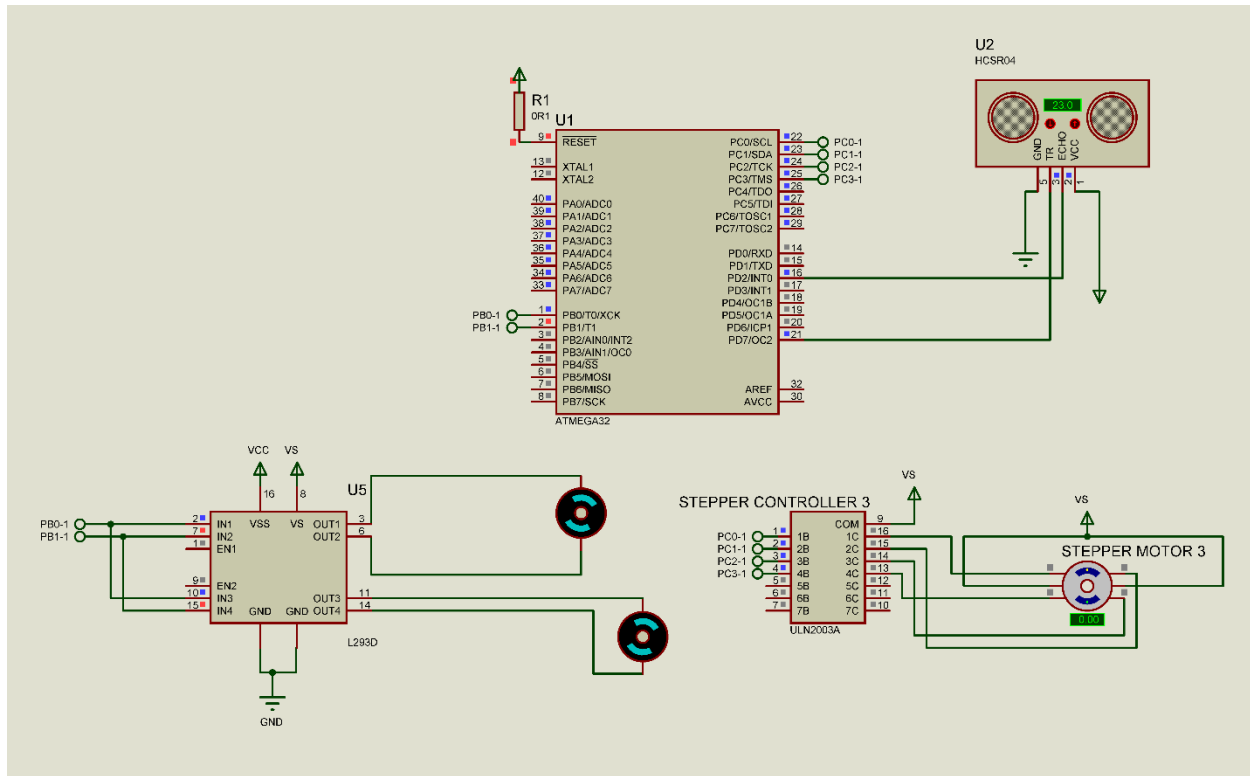
Stepper motor is the next component which I am responsible in our project. We have used this stepper motor in clutch 3 and it will be used in tightening process. This motor takes distance to the pipe as an input and rotate accordingly.

Technique: The stepper motor is used to rotate a screw rod. The clutch will slide in or out with the screw rod due to the internal structure's design.

Specifications:

- Current range: 1.5A-1.7A
- Maximum voltage: 12 VDC
- Step angle: 1.8° degree
- Holding torque: 3.2 kg - cm
- Unipolar

Schematic diagram:



PCB design for above components:

