A

Capstone Project Report

On

"LANE DETECTION AND OBSTACLE DETECTION FOR AUTOMATED GUIDED VEHICLE"

Submitted

in partial fulfillment of the requirements for the degree of

Bachelor of Technology

in

Electronics and Telecommunication Engineering

By

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(An autonomous Institute, Affiliated to Shivaji University)

2022-2023

CERTIFICATE

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Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, Affiliated with Shivaji University)

2022-2023

This is to certify that, we below-mentioned list of students, have completed the dissertation work and submitted the dissertation report on, "**Lane Detection and Obstacle Detection for Automated Guided Vehicle**". For the partial fulfillment of the requirement for the degree of Bachelor of Technology in Electronics and Telecommunication Engineering as per the rules and regulations for the academic year 2022-2023 at Rajarambapu Institute of Technology, Rajaramnagar.

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DECLARATION BY STUDENTS

We hereby declare that the project entitled "**Lane Detection and Obstacle Detection for Automated Guided Vehicle**" was carried out and written by us under the guidance of Prof. R. J. Patil, Assistant Professor, Department of Electronics and Telecommunication Engineering, Rajarambapu Institute of Technology, Rajaramnagar. This work has not previously formed the basis for the award of any degree, diploma, or certificate, nor has it been submitted elsewhere for the award of any degree or diploma.

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DECLARATION BY GUIDE

It is certified that the work contained in the project report titled "**Lane Detection and Obstacle Detection for Automated Guided Vehicle**" by the above-mentioned students has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

Signature of Project Guide

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ABSTRACT

Automated Guided Vehicles (AGV) are load carriers that are capable of driving autonomously around distribution centres, manufacturing facilities, and warehouses with no driver on board. Because of its importance, the concept of autonomous vehicles has drawn wide attention. AGV systems are widely used for jobs that would usually be handled by conveyor systems, forklifts, or manual carts, such as repetitively moving large loads of materials of all kinds. Automated guided vehicles are used in industries like food, automotive, packaging, paper, and printing. The analysis in this report presents the design of the human-machine interface for an automated guided vehicle and the lane and obstacle detection for an automated guided vehicle. Automated systems will be able to detect the distance and angle of objects present within the lane of the vehicle for effective classification and decision-making to assist the vehicle. The aim of the project is to develop an automated guided vehicle for transportation on college campuses.

Keywords: automated guided vehicles, object detection, line detection.

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CHAPTER 1

INTRODUCTION

1.1 Project Management:

Let us consider a bus capable of transporting any material or people automatically and driving better than any driver. Consider a vehicle that takes you to your desired destination. Automated Guided Vehicles are used for tasks that are typically be handled by forklifts, conveyor systems, manual carts, etc.

Fig 1.1 - Self Driving Car

Automated Guided Vehicles (AGV) load carriers or transports that travel autonomously throughout distribution centre, or manufacturing facility without an on-board operator or driver. Autonomous vehicles neither drink alcohol nor take drugs, they are never tired or sick, they never lose their concentration or talk on phone call, they know how to drive from the first moment and don't need to learn. On the other hand, they will drive much more smoothly, pollute less, and if they have an accident, they will ask for help autonomously.

Autonomous vehicles require a variety of sensors, such as cameras, GPS, ultrasonic sensors, and so on. The camera detects the lane and guides the vehicle to reach its desired location. AGVs are used in a variety of applications and are often used for transporting raw materials such as metal, plastic, rubber, paper, etc. For example, AGVs can transport raw materials from receiving to the warehouse or deliver materials directly to production lines.

1.2 Project Objective:

AGV can consistently deliver the raw materials needed without human intervention, ensuring that production lines always have the materials they need without interruption. The objectives of this module are:

1. To develop an automated guided vehicle for transportation on a college campus
2. Detect the lane using white line detection and image processing.
3. The task is real-time lane detection in a video.
4. To develop an algorithm to detect the distance and angle of objects present within the lane of the vehicle for effective classification and decision-making to assist vehicles
5. Predict their likely motions.
6. Improving safety
7. Design should be adaptable.

1.3 Project Scope:

This project works on effective obstacle avoidance. It minimises the accidents. This project can be used in many areas such as robotics, security applications, surveillance, mines, the food industry, and authentication, where aim is to detect objects and control overall systems mechanism.

. **Fig 1.2 - Lane Detection**

1.4 Introduction to project:

AGV (Automated Guided Vehicle) is type of mobile robot that is used to transport materials within a facility or warehouse. AGVs are equipped with sensors and navigation systems that allow them to follow a predetermined path or track, and they can be programmed to stop at designated locations to pick up or drop off materials. AGVs are typically used in manufacturing and logistics environments to improve efficiency, reduce labour costs, and increase safety by automating the movement of materials.

There are several types of AGVs, including track-guided AGVs, which follow a physical track or wire embedded in the floor, laser-guided AGVs, which use lasers to navigate, and vision-guided AGVs, which use computer vision to navigate. AGVs can be customized to meet the specific needs of a facility or application, and they can be integrated with other automation systems, such as material handling equipment and warehouse management systems

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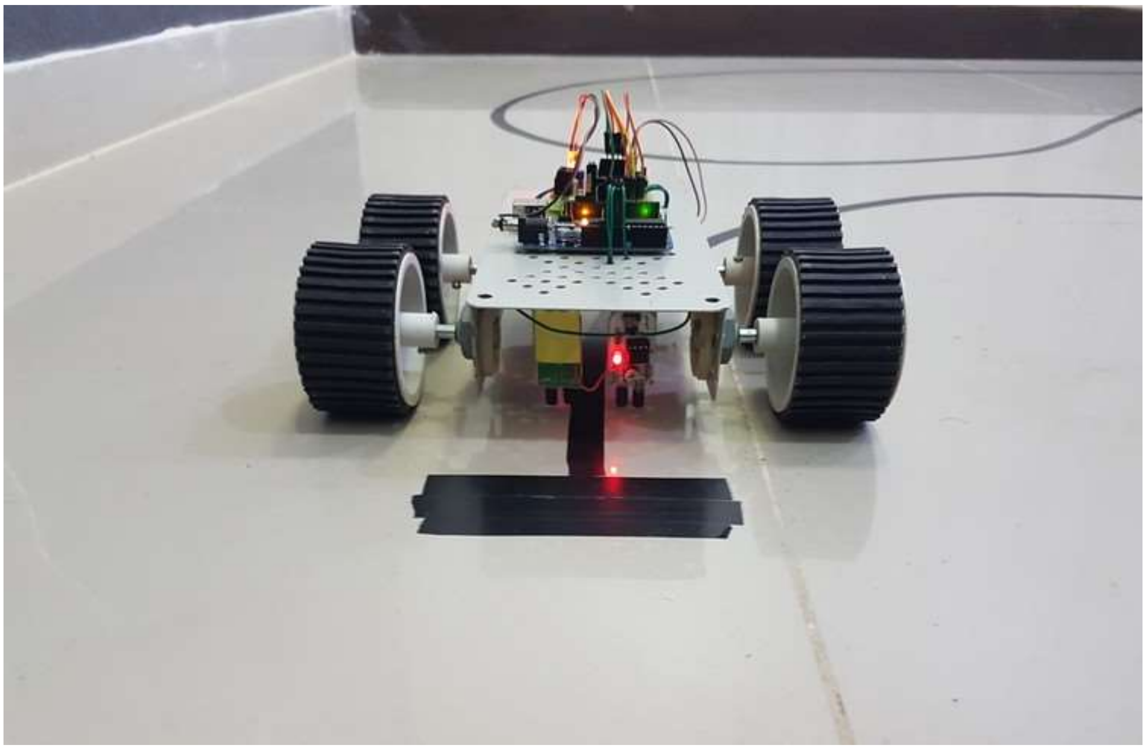

Fig 1.3 - Line Detection

1.5 Block Diagram and Description of Project

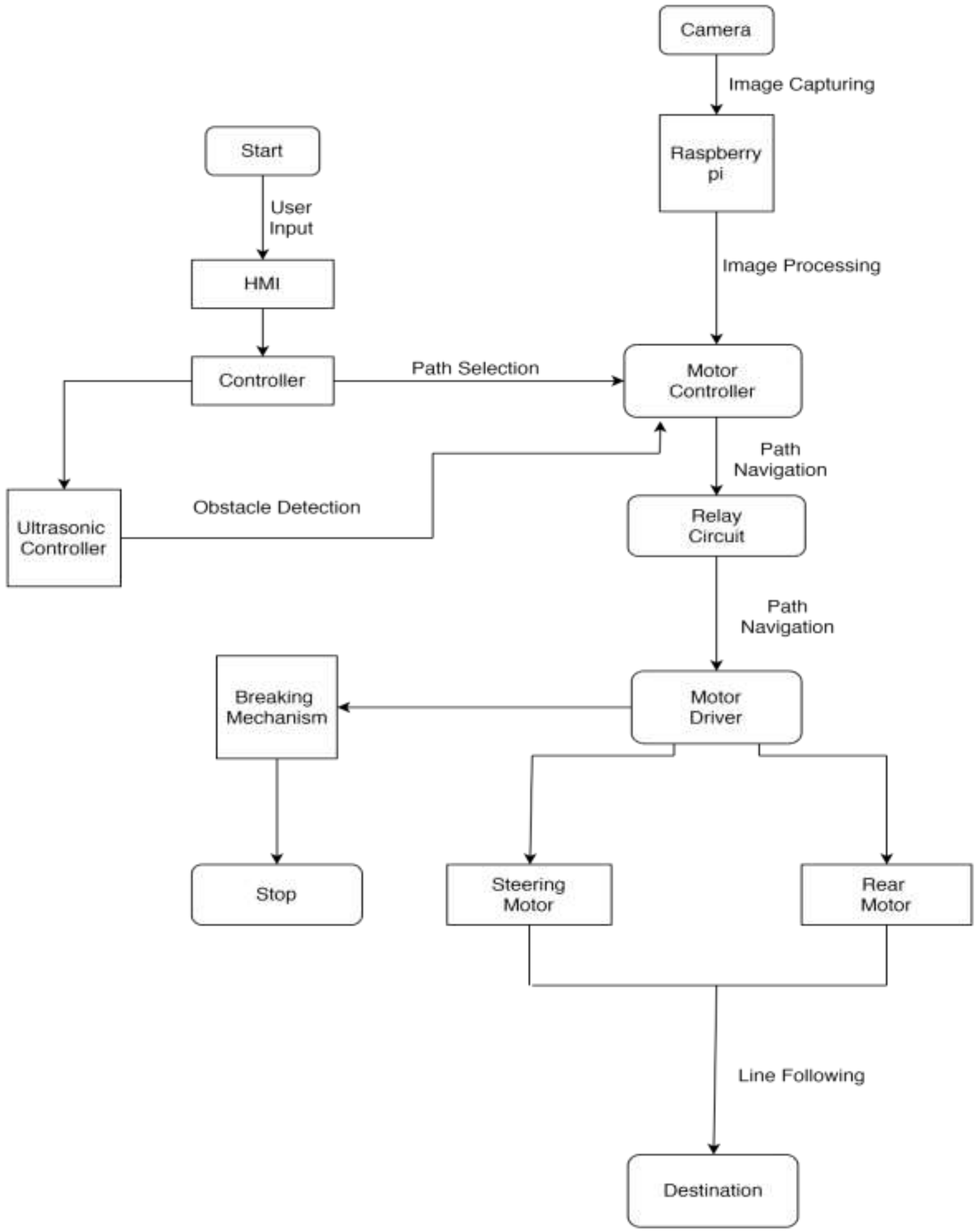

Fig. 1.4 Block Diagram of Project

Process Followed:

1. HMI Interface
   In this unit, the user can choose the destination from different destinations displayed on the display of the car.

2. Path selection and the path navigation
   In this unit, according to the vehicle the user has chosen, the shortest path to the destination is determined. Then it detects the white line and follows the lane. If the car detects the obstacles, then it waits until the obstacle passes.

1.6 Project Features:

1. It minimizes accidental problems.
2. Minimize human efforts.
3. Effective decision making capacity.
4. Good project accuracy.
5. Lane-keeping assist.
6. Automated Vehicle Guidance system.

CHAPTER 2

LITERATURE SURVEY

2.1 Design and Methodology Review:

Automated guided vehicle (AGV) is mobile robot that follows a predetermined path or set of instructions to transport materials within a facility. AGVs are commonly used in manufacturing and logistics environments to move materials from one place to other, such as from a storage area to a production line or from a loading dock to a warehouse.

There are several different types of AGVs, including laser-guided, vision-guided, and magnetically guided AGVs. The specific design and methodology of an AGV depends on the type of guidance system being used. Vision-guided AGVs use cameras and computer vision algorithms to navigate their environment. This type of AGV is typically used in environments where the path may change or be less predictable, such as in a warehouse.

Overall, the design and methodology of AGVs is focused on automating the transportation of materials within a facility to improve efficiency, reduce costs, and improve safety.

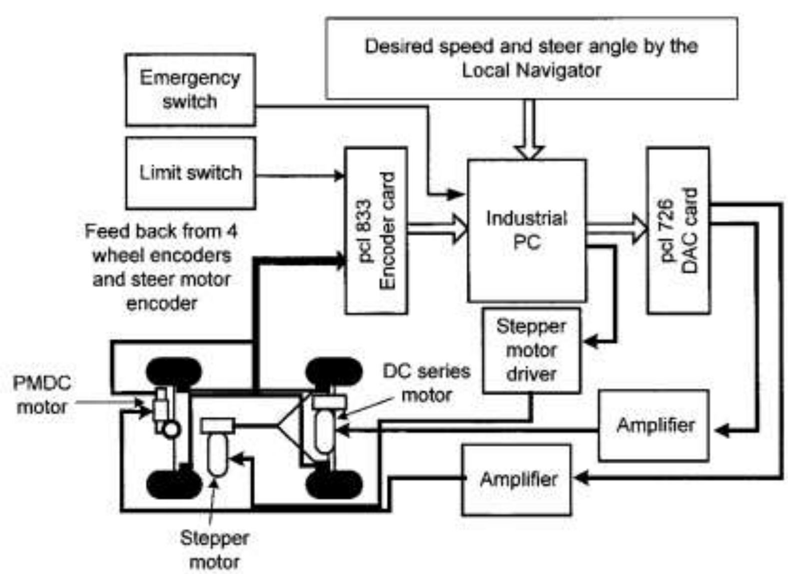

Fig 2.1 Experimental System

2.2 Fuzzy Speed and Steering Control

The development of techniques for lateral and longitudinal control of vehicles has become an important and active research topic in emerging markets for advanced autonomous guided vehicles (AGVs) and mobile robots.

In fuzzy speed & steering control, the fuzzy logic controller receives input from sensors and other sources, such as the vehicle's speed, the angle of the steering wheel, and the position of the vehicle on the road. The controller then processes this input using fuzzy rules, which are defined by the designer to describe the desired behaviour of the system. The output of the fuzzy logic controller is then used to control the speed and steering of the vehicle.

Conclusion of Fuzzy Speed and Steering Control

Fuzzy speed and steering control also has some limitations. For example, it may not be as precise as other control techniques, and the results may be sensitive to the choice of fuzzy rules and other design parameters. Additionally, fuzzy control may not be suitable for high-speed or highly dynamic systems that require fast and accurate control.

Overall, fuzzy speed and steering control can be a useful tool for controlling the motion of vehicles in a variety of applications, but it is important to carefully consider its limitations and potential trade-offs when deciding whether to use it..

2.3 Research on Intelligent AGV Control System

There has been a significant amount of research done on intelligent AGV and control systems in recent years, focused on improving the efficiency and flexibility of AGVs, as well as increasing their safety and reliability. Some areas of research include:

1 .Navigation and localization: Researchers are developing advanced algorithms and technologies to improve the accuracy and reliability of AGV localization and navigation, allowing the AGVs to navigate through complex and changing environments.

2. Cooperation and coordination: Researchers are studying ways to improve the coordination and cooperation between AGVs and other systems, such as conveyor belts and robots, to improve the overall efficiency of material handling systems.

3. Machine learning and artificial intelligence: Researchers are using machine learning and artificial intelligence techniques to develop intelligent AGV control systems that can adapt to changing environments and learn from past experiences to improve performance.

4. Human-machine interaction: Researchers are studying ways to improve the interaction between humans and AGVs, such as developing intuitive interfaces and improving the safety of AGV operation.

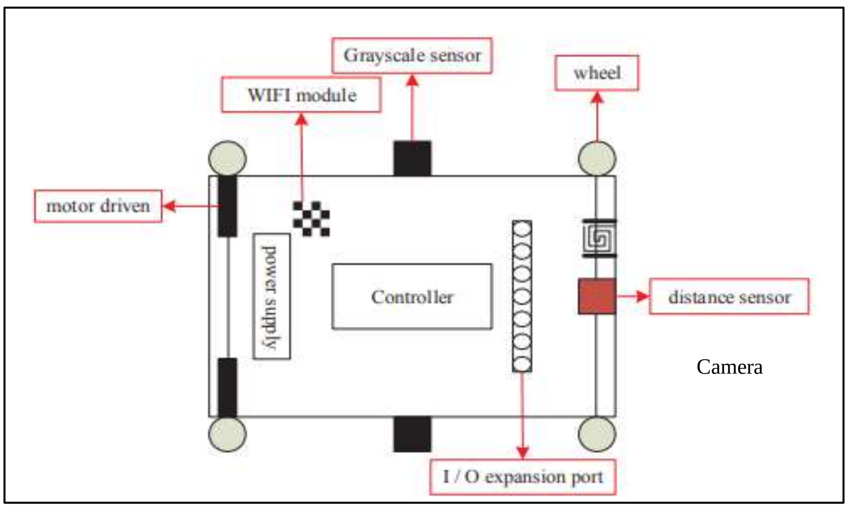

Fig 2.2 - Body Structure

2.4 Summary of AGV Path Planning

Path planning for AGVs involves designing and optimizing the routes that AGVs will follow to transport materials within a facility. This process typically involves defining the starting and ending locations of each AGV trip, as well as any intermediate stops or transfer points along the way.

There are several factors that can influence the design of AGV paths, including the layout of the facility, the types of materials being transported, the volume of material being moved, and any constraints or restrictions on the movement of the AGVs.

AGV path planning can have significant impact on efficiency and effectiveness of the material handling in a facility. Careful planning can help to minimize travel time, reduce the number of AGVs needed, and reduce the risk of collisions or other accidents. In addition, AGV path planning can be used to optimize the utilization of AGVs, ensuring that they are used efficiently and effectively to meet the needs of the facility.

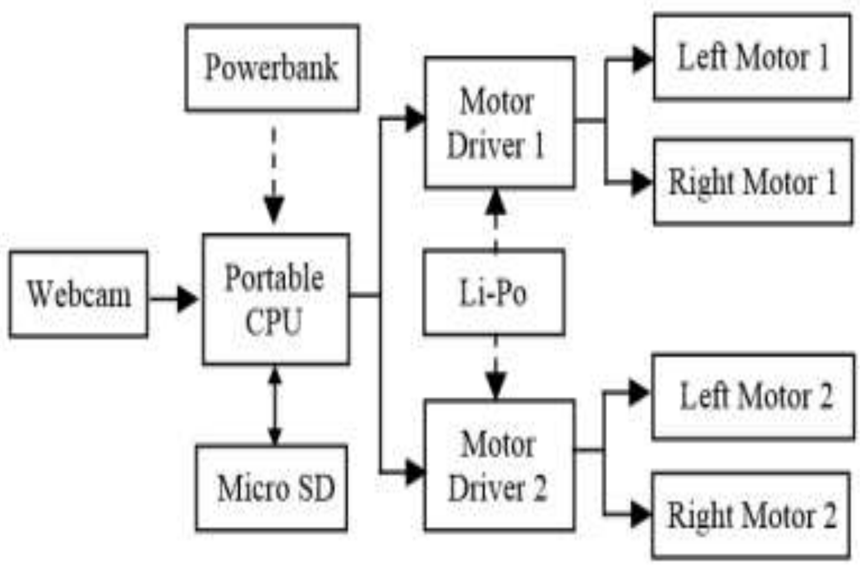

Fig 2.3 - Hardware Block Diagram

CHAPTER 3

PROJECT REQUIREMENTS

3.1 Hardware Selection

3.1.1 Arduino Uno and ATMega328P:

Fig 3.1 - Arduino Uno

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega 328P microcontroller. In our project we use ATMega328P as a controller. Arduino UNO is a low-cost, flexible easy for using programmable open-source microcontroller board that can be integrated into a variety of electronic projects. The ATMega328P is a microcontroller that is used in a wide range of electronic devices. It is part of the ATMega family of microcontrollers from Atmel (now owned by Microchip Technology). The ATMega328P has a number of features that make it well-suited for a variety of applications.

In AGV, ATMega328P is used as a controller in control circuits such as motor control circuit, nextion control circuit and ultrasonic control circuit. It takes inputs from the sensor, nextion display and camera. Output signals are given to control circuits.

3.1.2 Raspberry Pi 4 Model B:

Fig 3.2 - Raspberry Pi 4 Model B

We use Raspberry Pi Model B for Image Processing. The output of Raspberry pi is transferred to motor controller by UART communication protocol. The data signal is generated in motor controller, and then transferred to the Relay Circuit. According to switching of relay, the movement is created in rear motors and vehicle moves. Also with the help of steering mechanism, vehicle can move in direction having turns.

In AGV output of nextion display and camera is given to Raspberry Pi which does image processing, sences HMI and sends signal high to controller . The output of Raspberry Pi is given to controller to take further actions.

3.1.3 Camera:

Fig 3.3 - 60 fps webcam

The camera with gimbal is used for image capturing. Cameras are often used in AGVs (automated guided vehicles) as part of the guidance system to navigate the vehicle along a predetermined path. In particular, vision-guided AGVs use cameras and computer vision algorithms to navigate their environment. These AGVs are typically used in environments where the path may change or be less predictable, such as in a warehouse.

In AGV, camera captures the real time image of white line and gives output to Raspberry Pi for image processing.

3.1.4 Ultrasonic Sensor:

Fig 3.4 - Waterproof Ultrasonic Sensor

An ultrasonic sensor is a device that makes use of high-frequency sound waves to measure distance and detect objects. It consists of a transmitter that sends out ultrasonic waves and a receiver that listens for the waves to be reflected back. By measuring time it takes for the waves to return, the sensor can determine distance to an object or surface.

Ultrasonic sensors are commonly used in a variety of applications, including distance measurement, object detection, and level sensing. They are often preferred over other types of sensors because they are non-contact, meaning they can measure distance without physically touching the object being measured. This makes them well-suited for use in dirty or hazardous environments.. The formula used for the calculation of distance is:

$$\mathbf{D = (T*C)/2}$$

where,

D = Distance

T = Time

C = Speed of the sound

In AGV, ultrasonic sensors detect obstacle and give the output to controller, due to which accidents are avoided.

3.1.5 Nextion Display:

Fig 3.5 - Nextion Display

Nextion is the brand of human machine interface Human Machine Interface (HMI) display modules which are commonly used in a variety of applications, including industrial control, home automation, and robotics. These displays are designed to be easy to use and integrate into a wide range of systems, and they are available in a range of sizes and resolutions to meet different needs.

Nextion displays typically consist of a display screen, a microcontroller, and a set of input/output (I/O) interfaces. The microcontroller is responsible for controlling the display and processing user input, while the I/O interfaces allow the display to communicate with other devices in the system. Nextion displays are typically programmed using a proprietary programming language called Nextion Editor, which allows users to create custom user interfaces and interact with the display.

Nextion displays are widely used in AGVs (automated guided vehicles) to provide a user interface for controlling and monitoring the vehicle. They can be used to display information about the vehicle's status, such as its current location and battery level, as well as to provide controls for manually directing the vehicle or changing its behaviour.

In AGV, nextion display is used as HMI to select the destination and navigate the vehicle. Output of nextion display is given to Raspberry Pi for navigation.

3.1.6 Drivers:

Fig 3.6 - Motor Driver

A motor driver is a device that is used to control the movement of an electric motor. It receives input signals from a controller and converts them into appropriate voltage and current levels to drive the motor. Motor drivers are commonly used in variety of applications which include robotics, automation, and transportation.

There are several types of motor drivers, including brushed DC motor drivers, brushless DC motor drivers, and stepper motor drivers. Each type of motor driver is designed to work with a specific type of electric motor and is optimized for different applications

In AGV, actual motor drivers are not used but the logic in motor drivers i.e. H bridge logic is used. An H-bridge is a type of electronic circuit that allows a voltage to be applied across a load in either direction. It is called an H-bridge because the circuit diagram resembles the letter H. An H-bridge can be used to control the speed and direction of a motor, or to control the direction of current in a load. An H-bridge consists of four switches (either transistors or mechanical relays) arranged in a way that allows them to be controlled such that current can flow through the load in either direction.

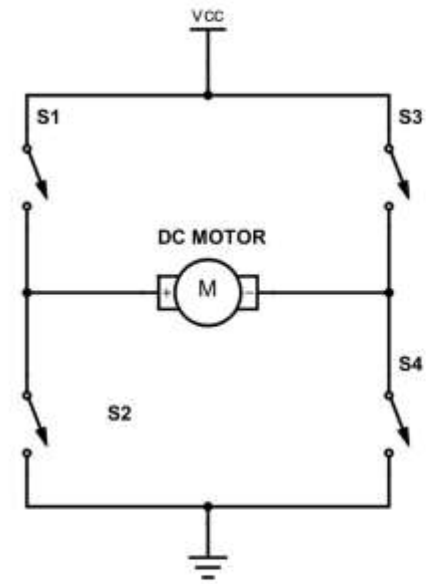

Fig. 3.7 H Bridge

H Bridge works using 4 switches. Here in figure let’s say 4 switches are S1, S2, S3, S4. When supply is provided, for rotation in clockwise direction, switches S1 and S4 are closed and polarity of motor at A and B is ‘+’ and ‘–’ respectively.

When supply is provided, for rotation in anticlockwise direction, switches S3 and S2 are closed and polarity of motor at A and B is ‘-’ and ‘+’ respectively.

3.1.7 FRC Connector:

Fig 3.8 - FRC connectors

FRC is also known as "multi-wire planar cables" as they are type of cables formed by joining insulated wires in a flat plane, forming a ribbon shape. They are ribbon cables that have many conducting wires running parallel on the same flat plane.

FRC stands for "Flexible Robotic Cable." It is a type of cable that is used in robotics and automation applications, where flexibility and durability are important requirements. FRC cables are typically made of a combination of copper wire and a flexible outer jacket, and they are designed to withstand the high flexing and bending that is often encountered in these types of applications.

In AGV, 2 FRC are used for data transmission between motor controller circuit and relay circuit. Here the FRC used is 10 pin FRC. Out of 10 pins, 2 pins are used as Vcc and GND. Remaining 8 pins are used as signal pins.

3.1.8 Relay:

Fig 3.9 - Relay

A relay is an electrically operated switch that can be used to control an electrical circuit. It consists of a coil of wire that, when energized, creates a magnetic field that attracts a metal armature to close a set of contacts. These contacts can then be used to complete or break an electrical circuit, allowing electricity to flow to a device or cutting power to a device. Relays can be used in a variety of applications, such as controlling lights, starting motors, and activating alarms.

When the relay is de-energized, a spring returns the armature to its original position, and the contacts open, breaking the circuit. The relay can be controlled by an electronic circuit, such as a microcontroller or a transistor, which energizes the coil by applying a voltage to it.

3.2. Software Used:

3.2.1. Proteus Software:

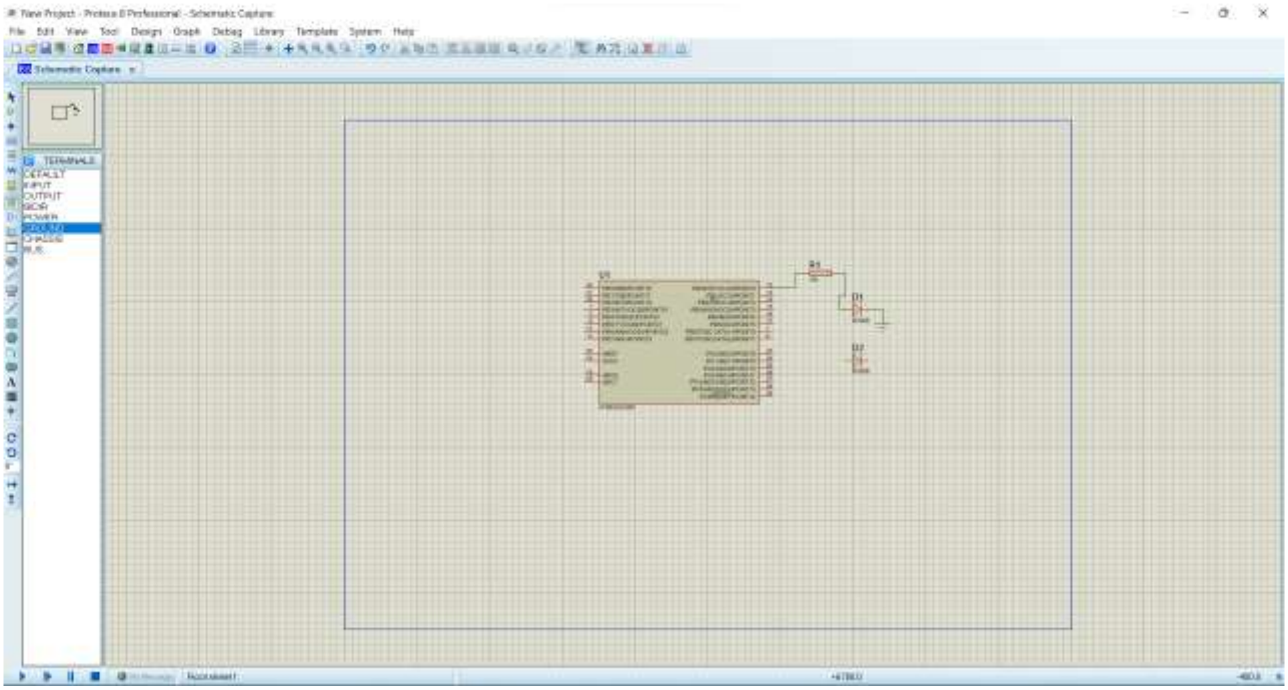

Fig 3.10 - Proteus Software

Proteus is a software suite for designing and simulating electronic circuits. It is developed by Lab centre Electronics and is widely used in the field of electronics engineering for prototyping, testing, and verifying electronic circuits.

Proteus is widely used in education and industry to design and prototype a wide range of electronic circuits, including microcontroller-based systems, embedded systems, and IoT devices. It is a powerful and versatile tool that offers a wide range of features and capabilities to help users design, test, and verify their circuits.

Proteus ARES: This is a schematic capture and PCB layout tool that is used to design printed circuit boards (PCBs). It includes a variety of design tools and features, such as auto routing and 3D visualization, to help users create high-quality PCBs.

In AGV, Proteus software is used to design schematic circuit and PCB layout for PCB designing. Also Dip Trace software can be used for the same.

3.2.2. Nextion Editor:

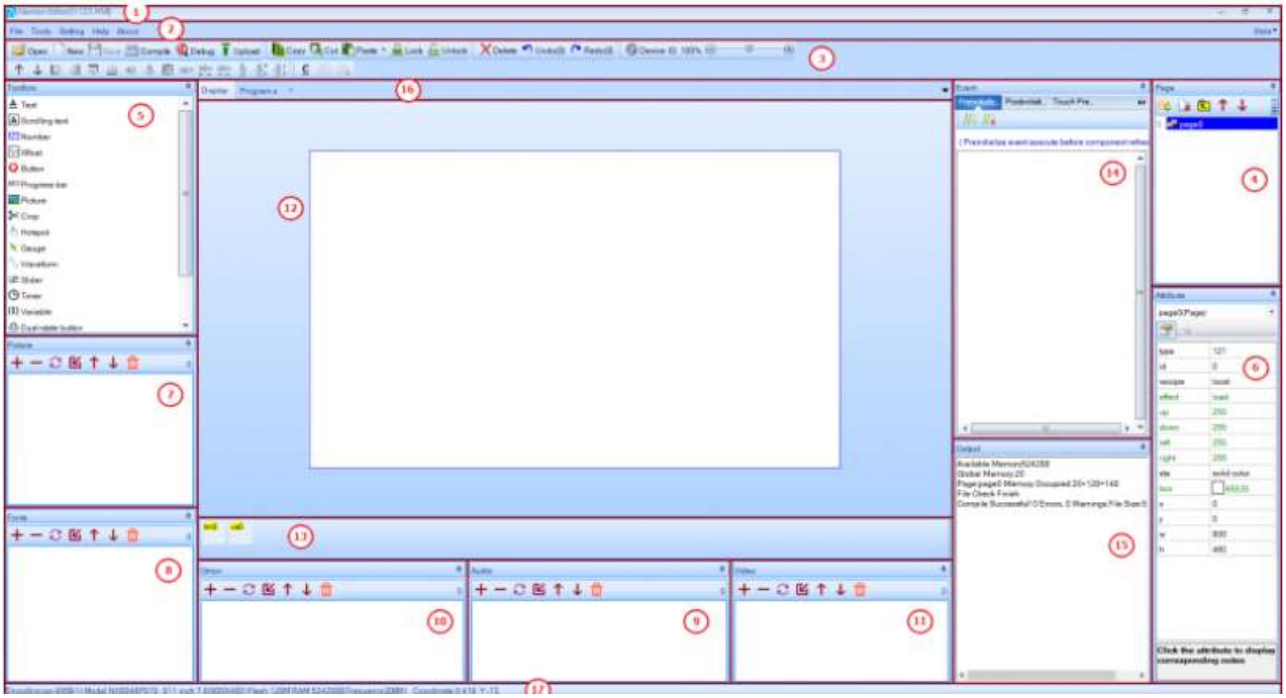

Fig 3.11 - Nextion Editor

Nextion Editor is a software tool that is used to design graphical user interfaces (GUIs) for Nextion HMI displays. Nextion Editor allows users to create custom GUIs by dragging and dropping UI elements (buttons, text boxes, sliders) onto design canvas. It also provides a number of pre-designed templates. Once the GUI has been designed, it can be uploaded to the Nextion display using a USB connection. The display will then be able to display the GUI and respond to user input in real-time.

In AGV, Nextion Editor is used as HMI guide to provide interface for user to select particular destination. Using Nextion Editor we design the output screen to be displayed on nextion display.

3.2.3. Arduino IDE:

Fig 3.12 - Arduino IDE

The Arduino Integrated Development Environment- or Arduino Software(IDE)- contains a textbook editor for writing law, a communication area, a textbook press, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino tackle to upload programs and communicate with them. fresh commands are set up within the five menus train, Edit, Sketch, Tools, Help. The menus are environment sensitive, which means only those particulars applicable to the work presently being carried out are available

In AGV, Arduino IDE is used for programming of different controller circuits.

3.3. Protocols

3.3.1. Inter Integrated Circuit (I2C):

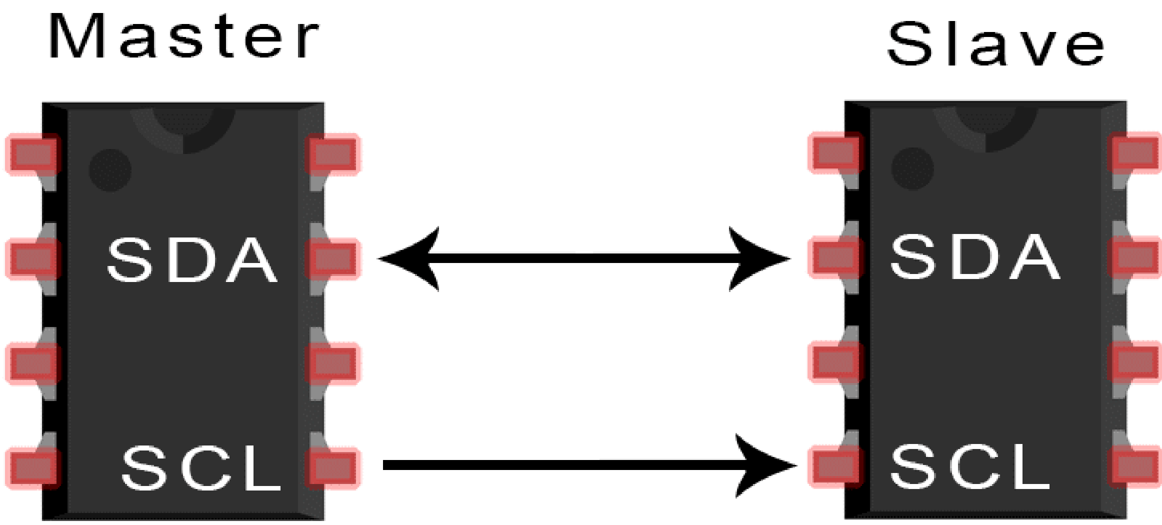

Fig 3.13 - I2C Communication

I2C (Inter-Integrated Circuit) is a type of serial communication protocol that is used to connect devices within a system. It allows multiple devices to communicate with each other and with a central controller using just two wires: a clock wire and a data wire. It is synchronous and timer signal is controlled by the master.

3.3.2 Universal Asynchronous Receiver-Transmitter (UART):

UART (Universal Asynchronous Receiver/Transmitter) is a type of serial communication protocol that allows devices to transmit and receive data. It is commonly used to connect devices that communicate with each other through a serial interface, such as microcontrollers and computers.

In UART communication, data is transmitted and received as a series of individual bits, rather than in parallel. Each bit is transmitted one at a time over a single wire (or a pair of wires, in the case of full-duplex communication).

UART communication requires two wires: a transmit (TX) wire and a receive (RX) wire. The transmitting device sends data over the TX wire, and the receiving device receives the data over the RX wire.

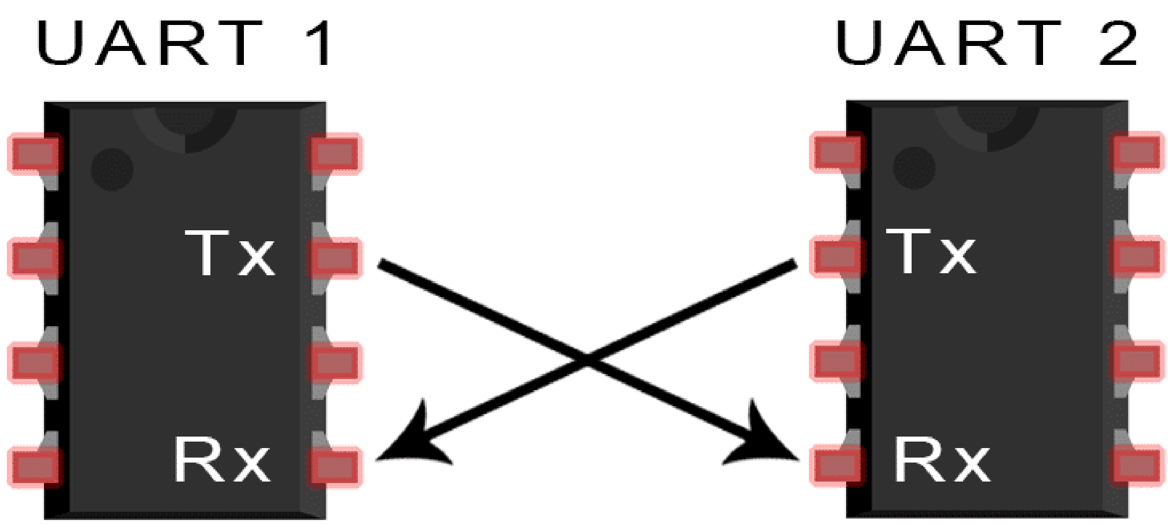

Fig 3.14 - UART Communication

3.3.3. Serial Communication:

A serial communication protocol is a set of rules for transmitting data one bit at a time over a communication channel or computer bus. One represents a sense HIGH, or 5 volts, and zero represents a sense LOW, or 0 volts. The transmission modes are classified as simplex, half- duplex, and full- duplex. There will be a source(sender) and a destination(receiver) for each transmission mode. Universal Serial Bus (USB), I2C, Serial peripheral interface, wire are commonly used serial communication protocols.

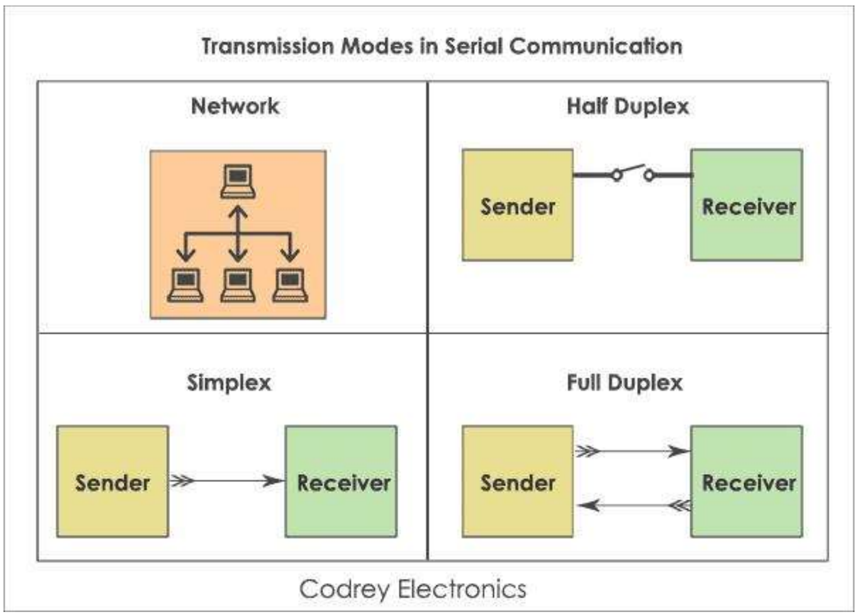

Fig 3.15 - Transmission modes in serial communication

CHAPTER 4

PROJECT DESIGN FLOW

4.1 Block Diagram of Project Design Flow:

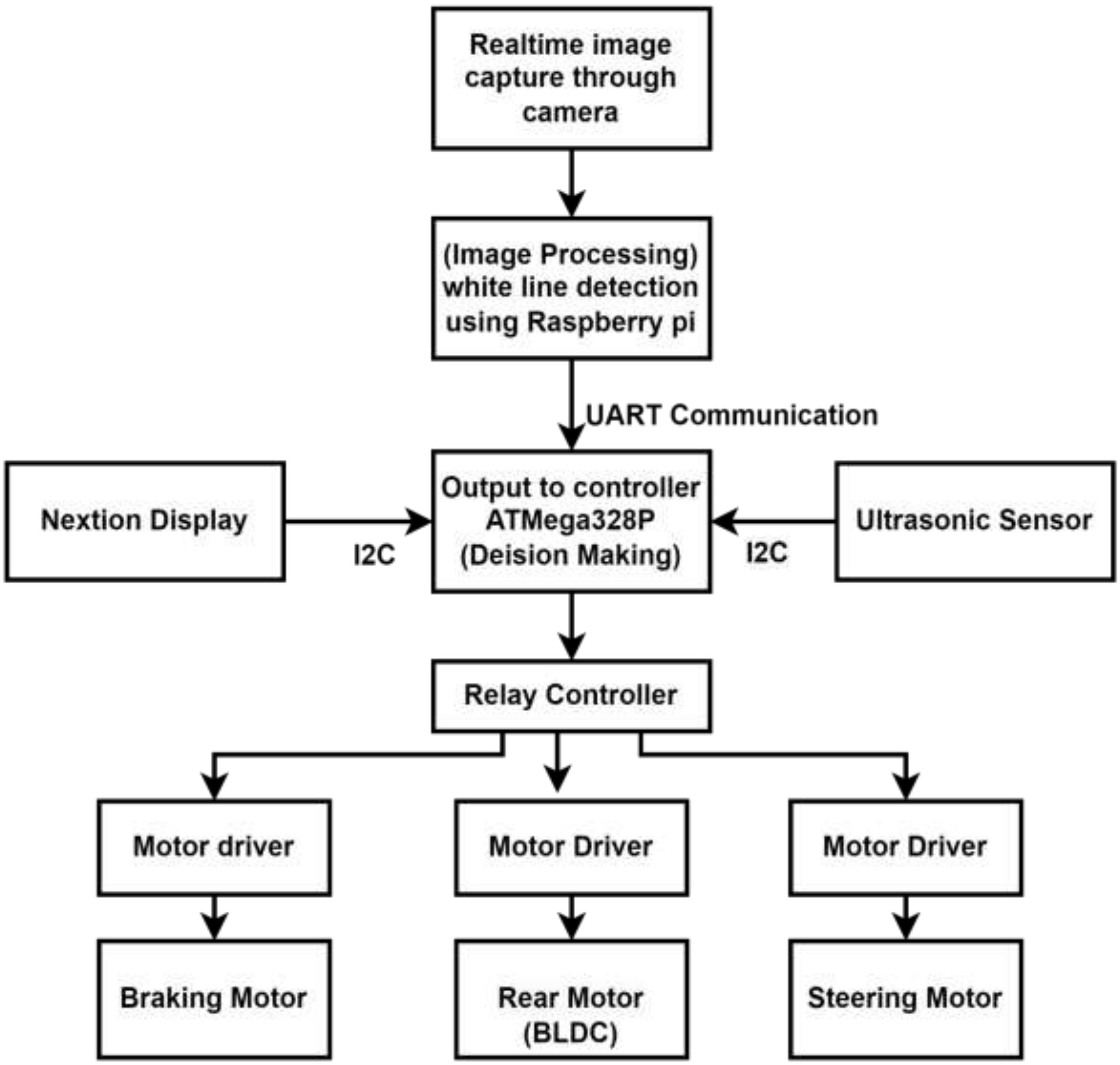

Fig 4.1 - Block Diagram of Project Flow

4.1.1 Design Flow Description:

The project flow is as shown in above block diagram. The flow consists of several steps as -

Step 1 - Real-time image capturing is done through the camera. The captured image as output of camera is then sent as an input to Raspberry pi.

Step 2 - Raspberry pi holds that image and image processing is done. During the image processing, white line on the road surface is detected and used further.

Step 3 - The output of Raspberry pi is then sent to controller. For communication of Raspberry pi with controller, UART protocol is used. Using UART, serial communication is done.

Step 4 - Nextion display is used for Human Machine Interface (HMI). The output of HMI is bought to controller (ATMega328P). For communication of Nextion with controller I2C protocol is used

Step 5 - Ultrasonic sensors detect obstacles in between the path of navigation at a particular distance from the vehicle. For communication with controller (ATMega328P), I2C is used.

All the inputs to controller are analysed and decision is made for particular action/movement.

Step 6 – The decision made by controller is the output of ATMega328P, which is given to Relay controller. Relay controller acts as switching circuit and switches between points of motor driver. Motor driver controls three actions of vehicle.

Step 7 – 1. When path is being navigated, if any obstacle is detected at specified distance then braking motor comes into action and vehicle is instructed to stop.

2. When path is being navigated, if no any obstacle is detected then the rear motors (BLDC) stay in action and motor stays in movement.

3. When path is being navigated, if no any obstacle is detected and turn is introduced then steering motor comes into action along with rear motors and turn is completed.

4.2 Block Diagram of Motor Controller:

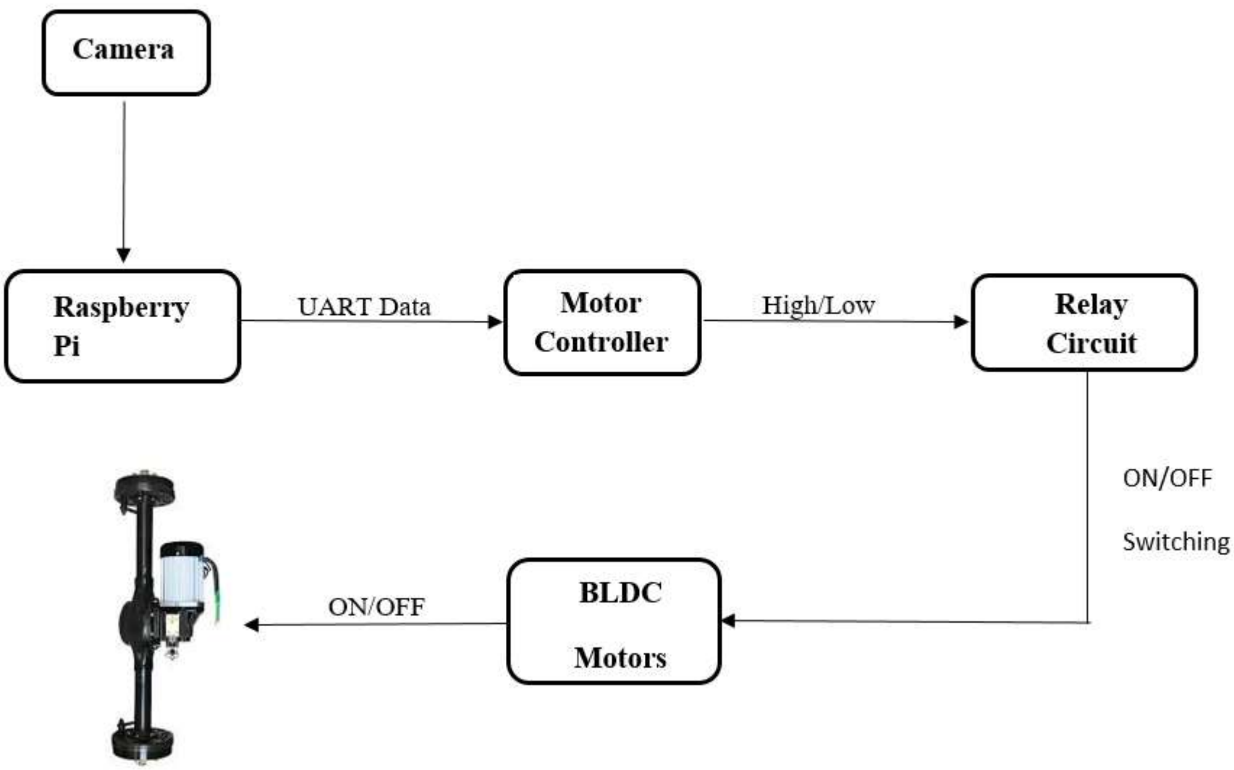

Fig 4.2 - Block Diagram of Internal Motor Controller

Motor controllers are the devices that regulate operation of an electric motor. Raspberry pi is used to send the data to microcontroller.

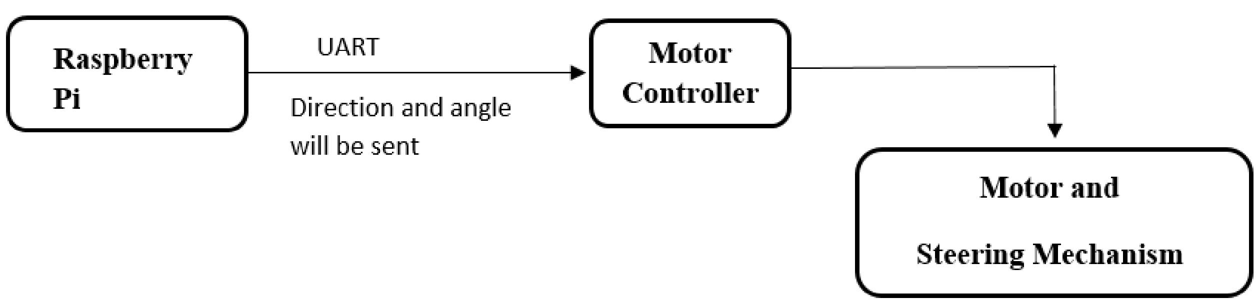

Fig 4.3 – Motor Controller

4.2.1 Motor Controller Operation Flow:

The working of motor controller is as shown in above block diagram. The flow consists of several steps as -

Step 1 – Here we are using 60 fps webcam for capturing images that will detect line. Once the image is captured, it is transferred to Raspberry pi for processing.

Step 2 - Raspberry pi holds that image and image processing is done. During the image processing, white line on the road surface is detected and used further.

Step 3 - The processed data i.e. image is transferred using UART protocol to the motor controller. Motor controller accepts the data and accordingly makes the decision.

Step 4 – Once the decision is made by motor controller, it is transferred to relay circuit using FRC cables. Relay circuit controls the voltage and current by switching the relay ON/OFF. Motor controller sends HIGH/LOW signals to Relay Circuit.

Step 5 – The output of relay is in form of switching and it switches between ON/OFF. This output is then given to BLDC motors, where it turns ON/OFF accordingly and motors are in movement.

4.3 Block Diagram of Power supply

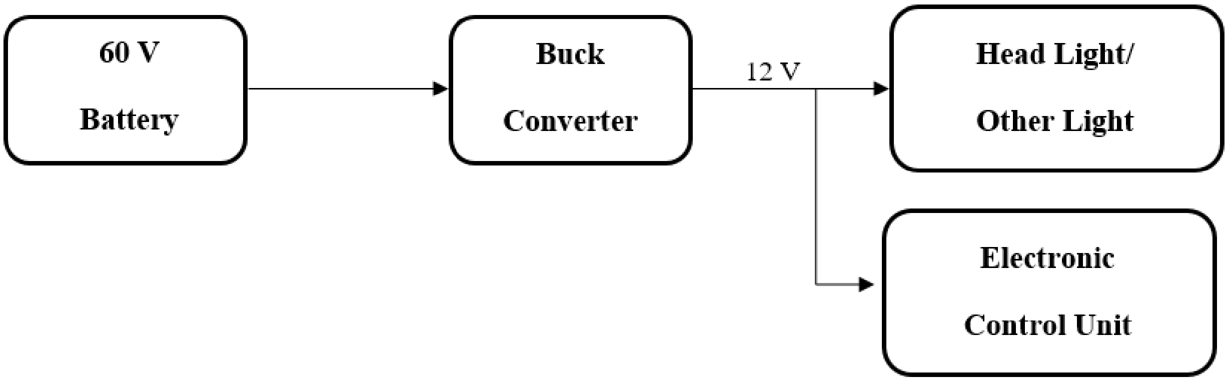

Fig 4.4 - Block Diagram of Power Supply

4.3.1 Power supply Operation Flow:

To provide power supply to the system we are using 60V battery. But for internal systems, we need 12V supply. So, for converting 60V into 12V, we are using a buck converter. The buck converter is DC-DC converter that is found easily and converts high voltage to low voltage efficiently. The buck converter has property of efficient power conversion and also extends battery life and reduces the heat.

Step 1 – A battery of 60V is connected to buck converter. Input for buck converter is 60V and it will result into 12V.

Step 2 – Buck converter converts the 60V into 12V with help of the circuit that consists the MOSFET DIODE, CAPACITOR of appropriate ratings.

Step 3 – The resultant 12V is used for various systems like Electronic Control Unit, Relay Circuits etc.

4.4 Block Diagram of Ultrasonic Sensor

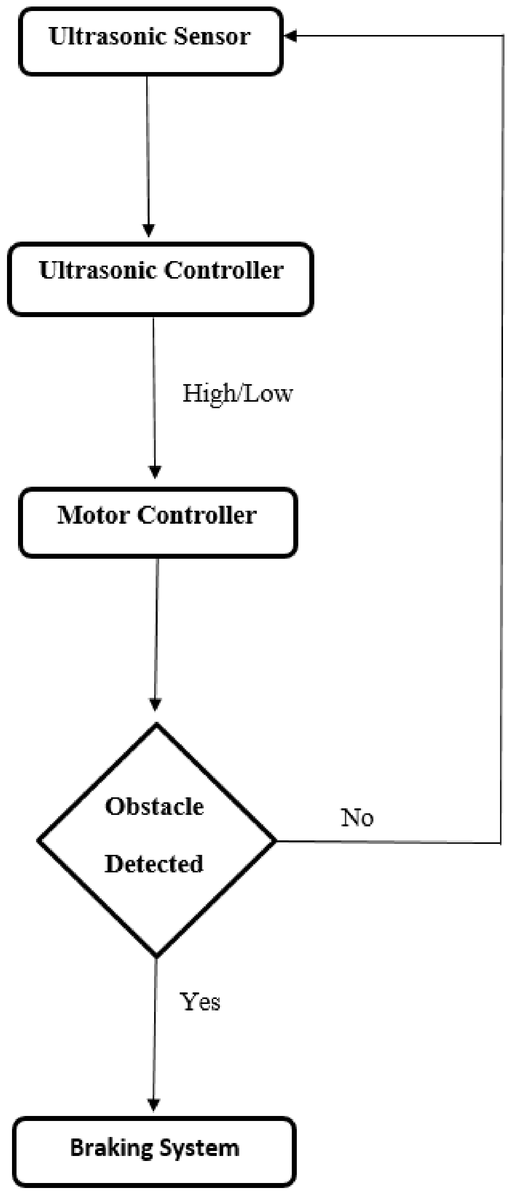

Fig 4.5 - Block Diagram of Ultrasonic Controller

4.4.1 Ultrasonic Sensor Operation Flow:

The working of ultrasonic sensor is as follows -

Step 1 - Waterproof ultrasonic sensor is used for obstacle detection. Ultrasonic sensor senses the obstacle blocking the path that is to be navigated. Ultrasonic wave is generated by ultrasonic sensor and then obstacle is detected by converting reflected sound into electric signal.

Step 2 - The electrical signal generated by sensor is then given to ultrasonic sensor controller. The output of ultrasonic sensor is transferred to motor controller through ultrasonic sensor controller.

Step 3 – The signal received by motor controller is in form of HIGH/LOW. If the ultrasonic sensor sends the HIGH signal then we say that obstacle is detected and if it sends LOW signal then obstacle is not detected.

Step 4 – When obstacle is detected, motor controller activates the braking system and due to braking mechanism, the vehicle stops until obstacle is cleared from path.

Step 5 – If obstacle is not detected then motor controller will activate rear motors and the vehicle will keep moving. The loop will continue until the obstacle is detected or destination is reached.

4.5 Block of Nextion Controller:

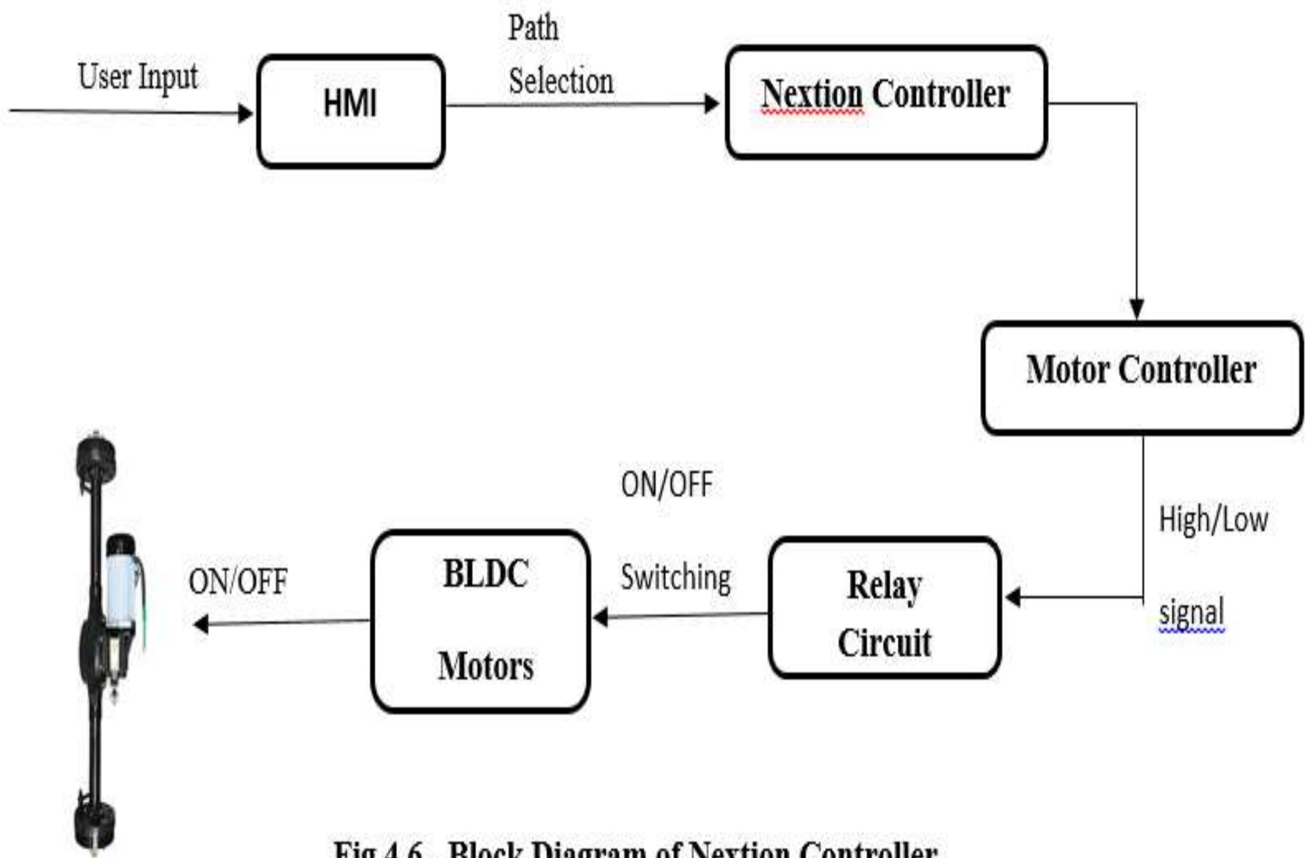

Fig 4.6 - Block Diagram of Nextion Controller

4.5.1 Nextion Controller Operation Flow:

User is provided with HMI and for this purpose Nextion Display is used. The working of nextion display is as shown in above block diagram. The flow consists of several steps as

Step 1 – User is provided with HMI, where he/she needs to select a destination.

Step 2 – HMI will consist of data of map to several destinations. Once the destination is selected the signal of that particular path will be sent to nextion controller.

Step 3 – Through motor controller, path is navigated as per the user input and destination selected. HIGH/LOW signal is sent to relay circuit.

Step 4 – Relay circuit being a switching circuit, controls the voltage by switching the relay ON/OFF. When motor controller sends the signal HIGH, the relay circuit turns ON and for LOW it remains OFF.

Step 5 – Once relay does switching, BLDC motors receives the signal and it controls the motion. For HIGH signal, motor turns ON and for LOW it remains OFF.

CHAPTER 5

Design and Development of System

5.1 Introduction:

The section on system design and development describes the outline of proposed work, block diagram of the system, the working and selection of components, and the design of the circuit. The support of the online community and its factors is one of the reasons for selecting the hardware of the system based on software and open-source hardware.

The system consists of different stages such as

1. HMI Interface
2. Line detection
3. Detection of obstacles

HMI Interface

The HMI interface is an interface that allows humans and machines to interact with each other. There are different types of HMIs present in market, but we are using Nextion Display due to its specifications and its Nextion Editor. Suppose you get into an automatic car or truck, and you don't have any options to select where you want to go. In this scenario, the HMI interface comes into play. In this project, the Nextion Intelligent NX8048P070-011C-Y 7.0″ HMI capacitive touch display is used. Whenever we start the car, it will give us options for destinations.

Fig 5.1 - Block Diagram of HMI

The first user gives input to the Nextion Display. According to what the user has selected, HMI takes the input and gives its output to the central processing unit. According to what the user has selected, HMI gives information to the controller about where the user wants to reach in the string. And then the CPU gives further instructions to the next units, which are the USB camera, steering control module, drive controller module, and obstacle detection module. Here are some pictures of the HMI interface

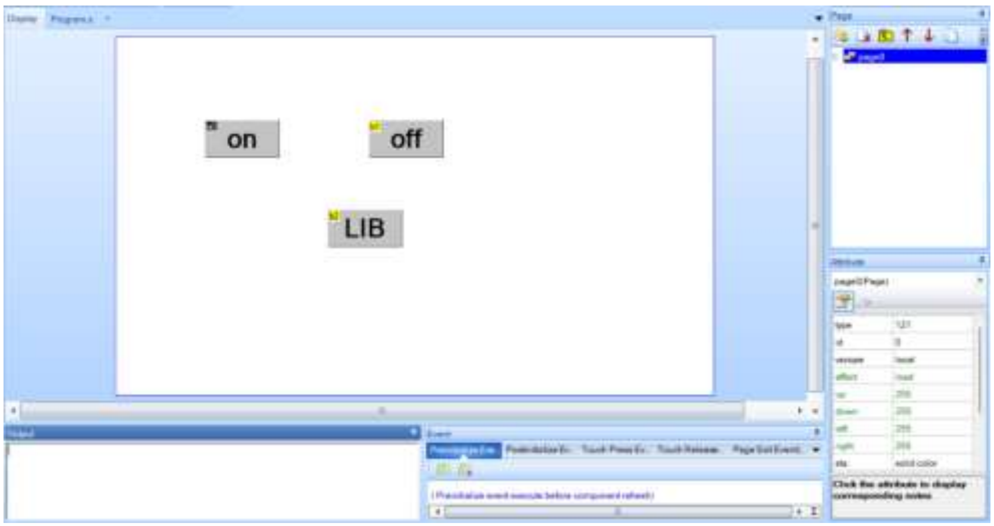

Fig 5.2 - Input Screen of HMI

Fig 5.3 - Output Screen of HMI

Detection of line:

In this project, the main controller used is the Raspberry Pi, which processes the input signal generated by the camera and provides an output signal to control the actuator, which is nothing but a motor. The camera's input signal takes the form of an image or live recorded video. With the help of Python and the Raspberry Pi, this signal is processed to detect white lines present on the lane. As video is nothing but millions of frames, these frames are extracted from the video, and various image processing techniques are applied to these frames to detect white lines present on the lane. After detection, an output signal is generated in the form of a 3-bit binary. These bits are provided as a controlling signal to control the motor and for decision-making.

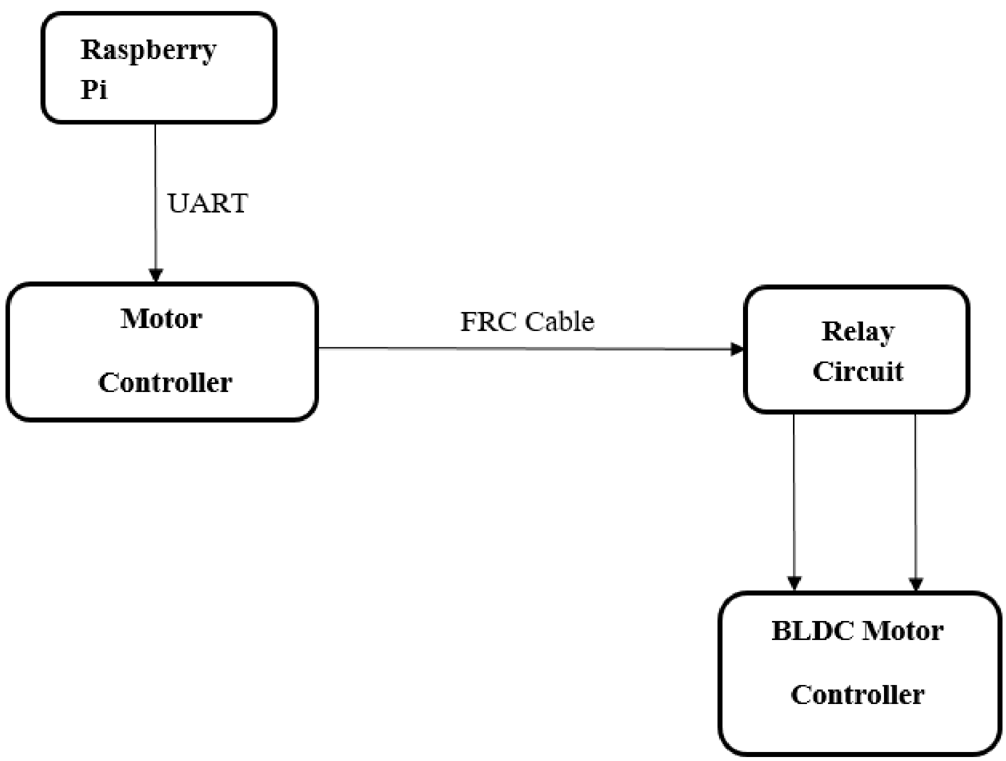

Fig 5.4 - Block Diagram of Line Detection

Detection of Obstacles:

The ultrasonic sensor transmits sound and then receives sound reflected from an object. When ultrasonic sound is incident on an object, diffused reflection of energy takes place over a wide solid angle, which might be as high as 180 degrees. So, some bit of the incident energy is reflected back to transducer in form of echoes. If the object is truly close to the sensor, the sound swells return quickly, but if the object is far from sensor, the sound take longer to return. Whenever the ultrasonic sensor detects an object or obstacle in the path of the vehicle, it gives a signal to the controller, and the controller gives a signal to the motor controller, and brake is applied.

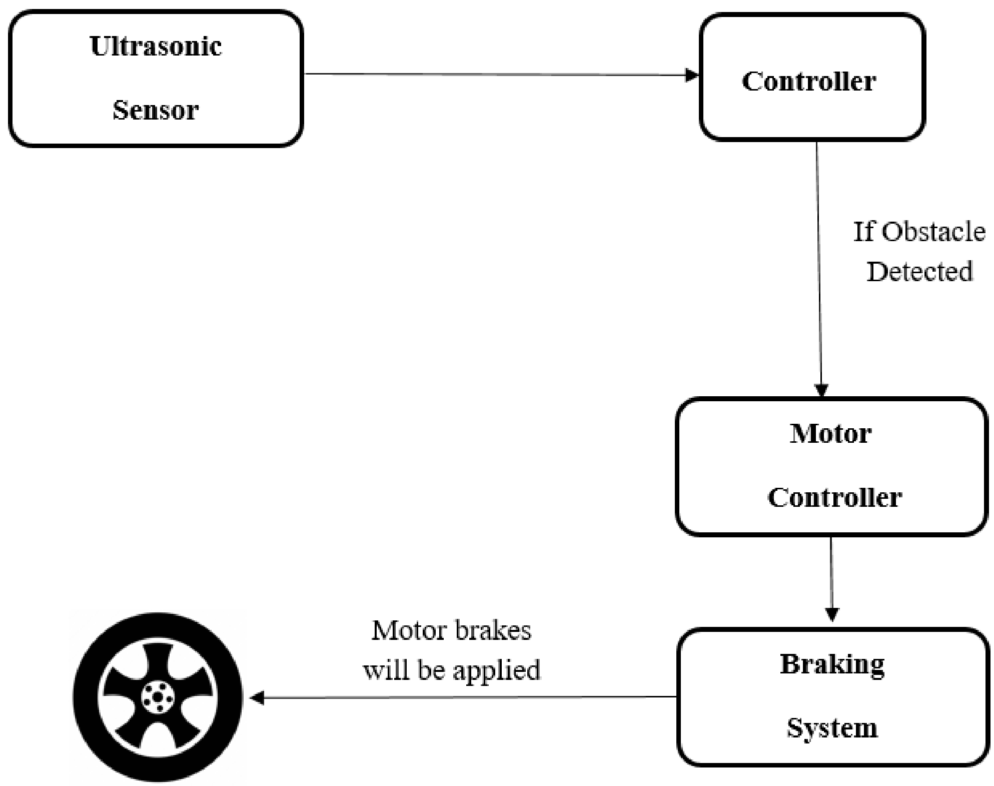

Figure 5.5: Block Diagram of Obstacle Detection

5.2 Outline of Project:

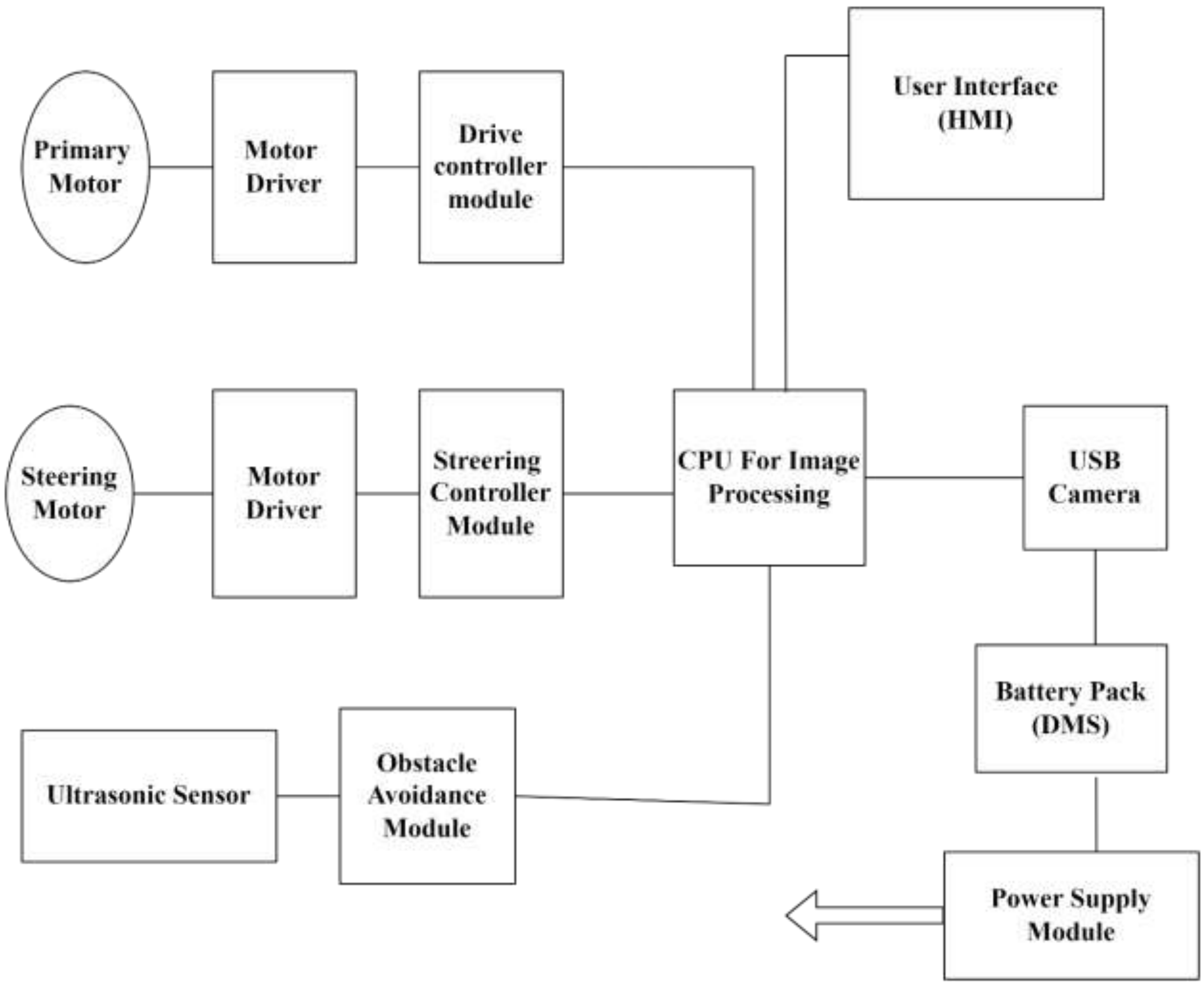

Fig 5.6 - Block Diagram of Project

Raspberry pi acts as a central processing unit for AGV project. Total 4 modules viz. Driver controller module, steering controller module, obstacle avoidance module and user interface module are interfaced with raspberry pi.

Step1 - User will give input through HMI by selecting a particular destination. The Signal HIGH is sent to CPU from HMI.

Step 2- The signal will be then sent to driver controller module which will then come in action and move forward.

Step3 - Once the signal High is received then USB Camera turns ON and captures the images. These images are then sent to CPU.

Step4- Those images are then processed and white line is detected by Raspberry pi.

Step5 - While following a path, whenever a curve is found, steering motors come in action and motor driver of steering controller defines a certain angle for curve.

Step6 - While following the path, Ultrasonic sensors are also active. If any obstacle is detected in between the path, then ultrasonic sensor module sends the signal High to CPU and CPU commands the Driver module too stop. Hence vehicle stops its movement.

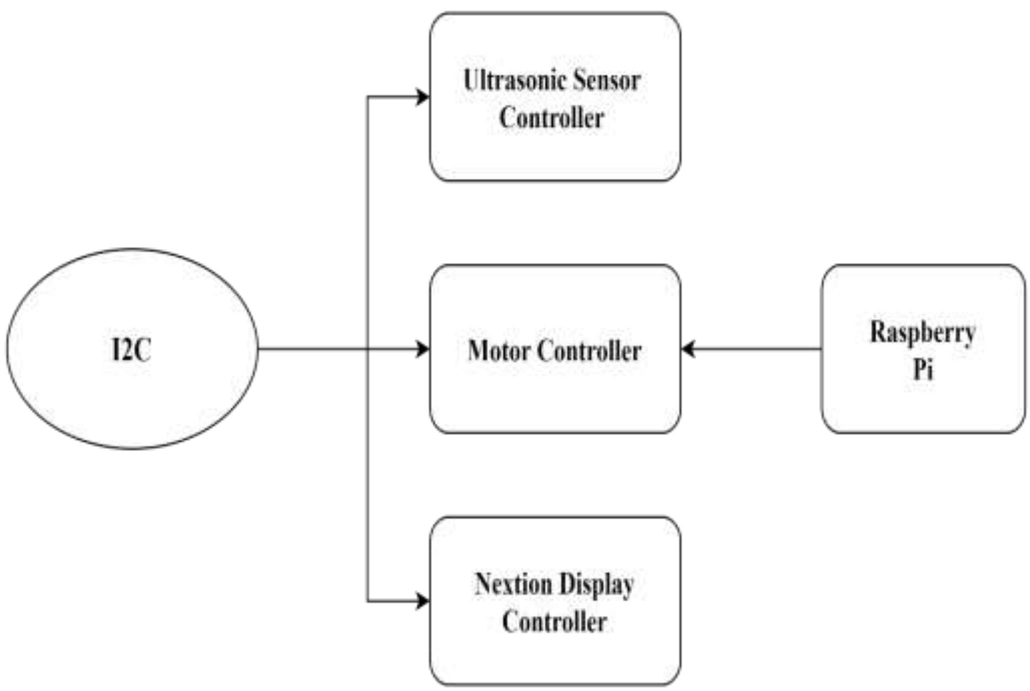

Fig 5.7 - Block Diagram of Communication

Prototype Image:

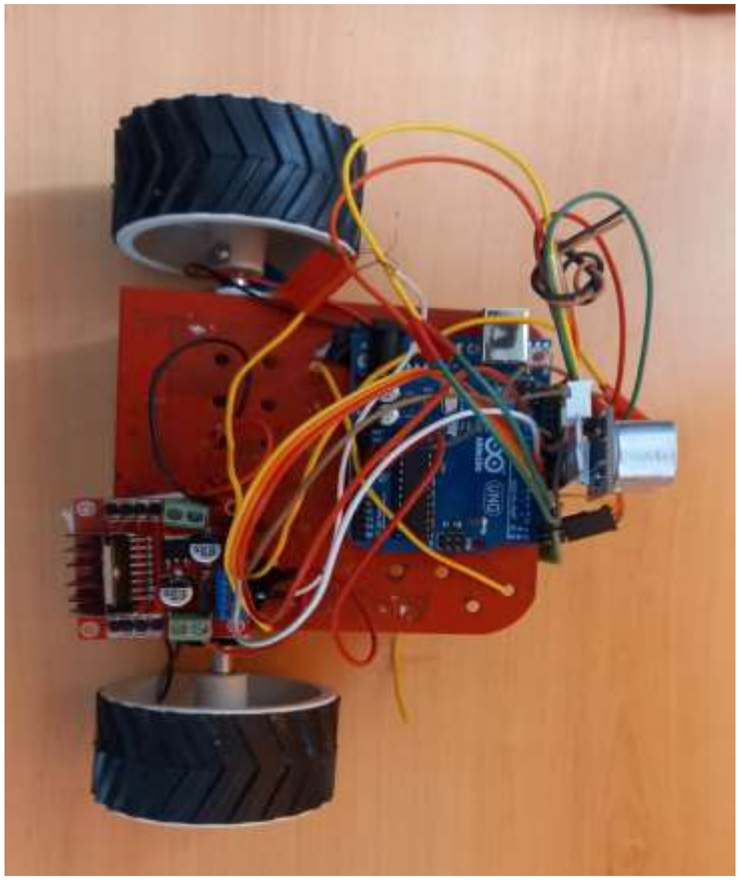

Fig 5.8 - Prototype Testing Module

Prototype Testing Video

The following QR code consists of a video that demonstrates testing of project prototype.

5.3 Design and development of PCB:

5.3.1 Motor Controller (using ATMega328P):

This PCB was designed for the interfacing of the AtMega328p and crystal oscillator. The purpose of this PCB was for testing.

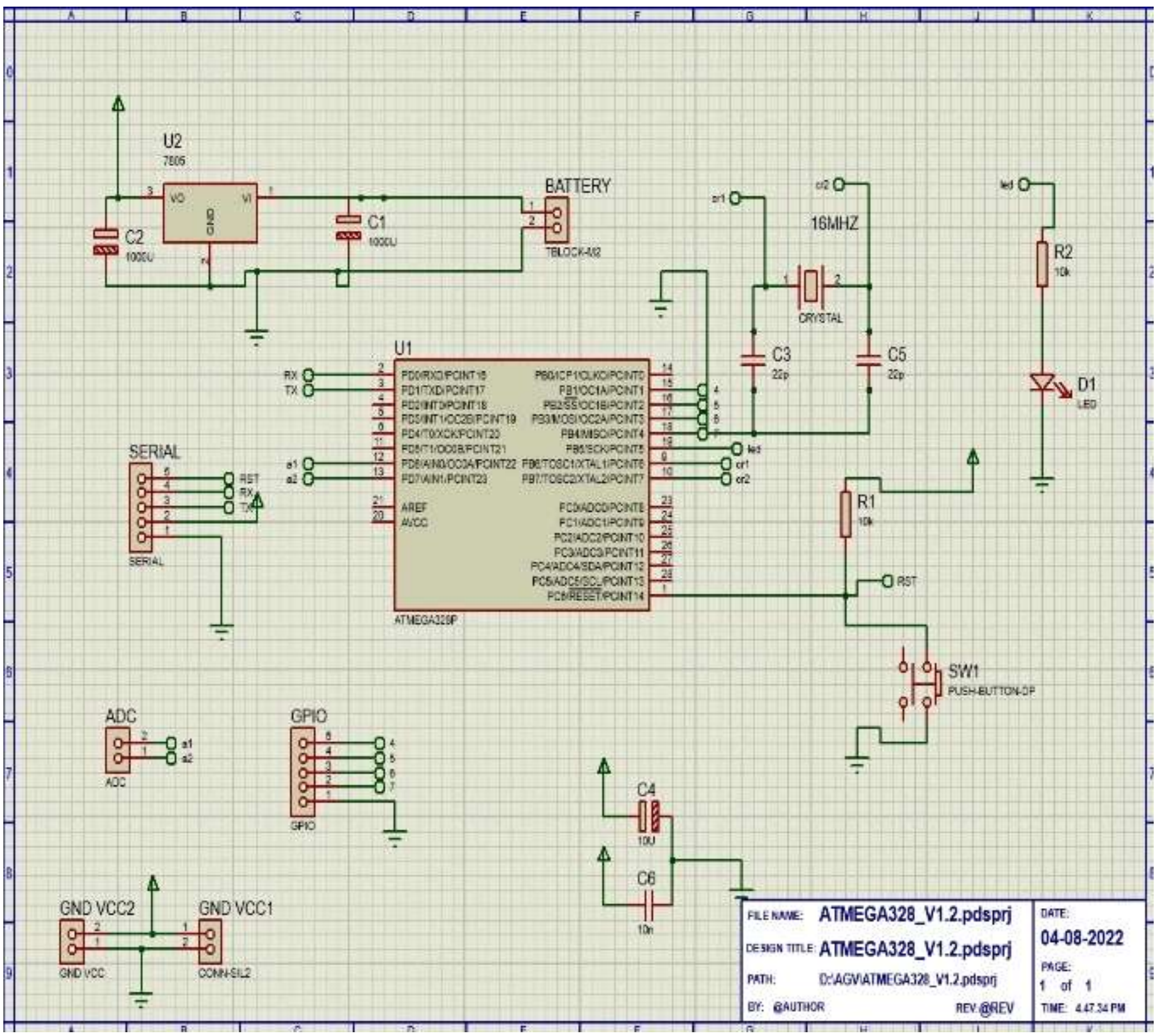

Fig 5.9 - Schematic of Motor controller Iteration-1 (Done for practice)

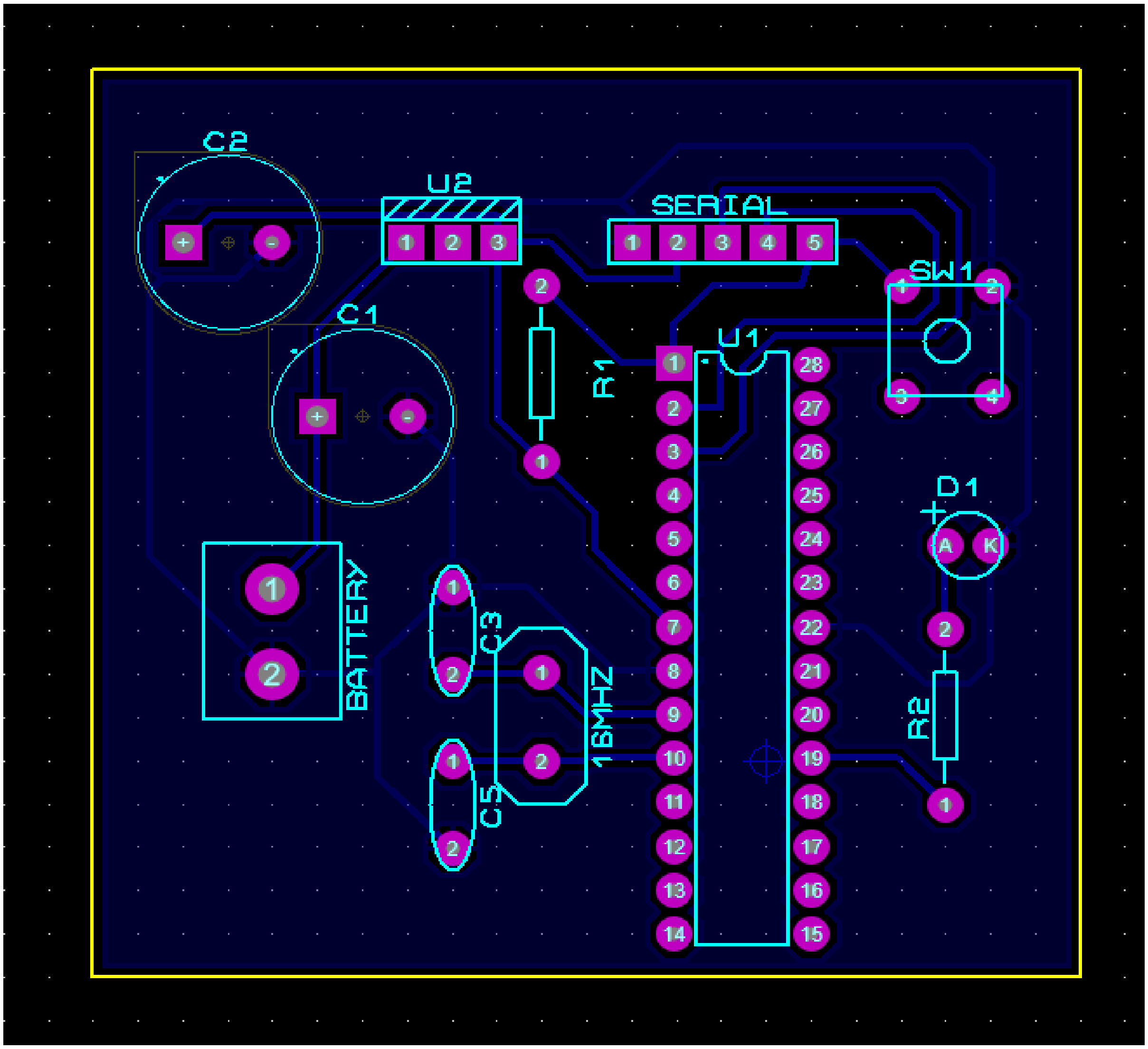

Fig 5.10 - PCB Layout of Motor controller Iteration-1

Arduino PCB Proteus File

The following QR code consists of a Proteus File that includes Schematic and PCB Layout of Arduino

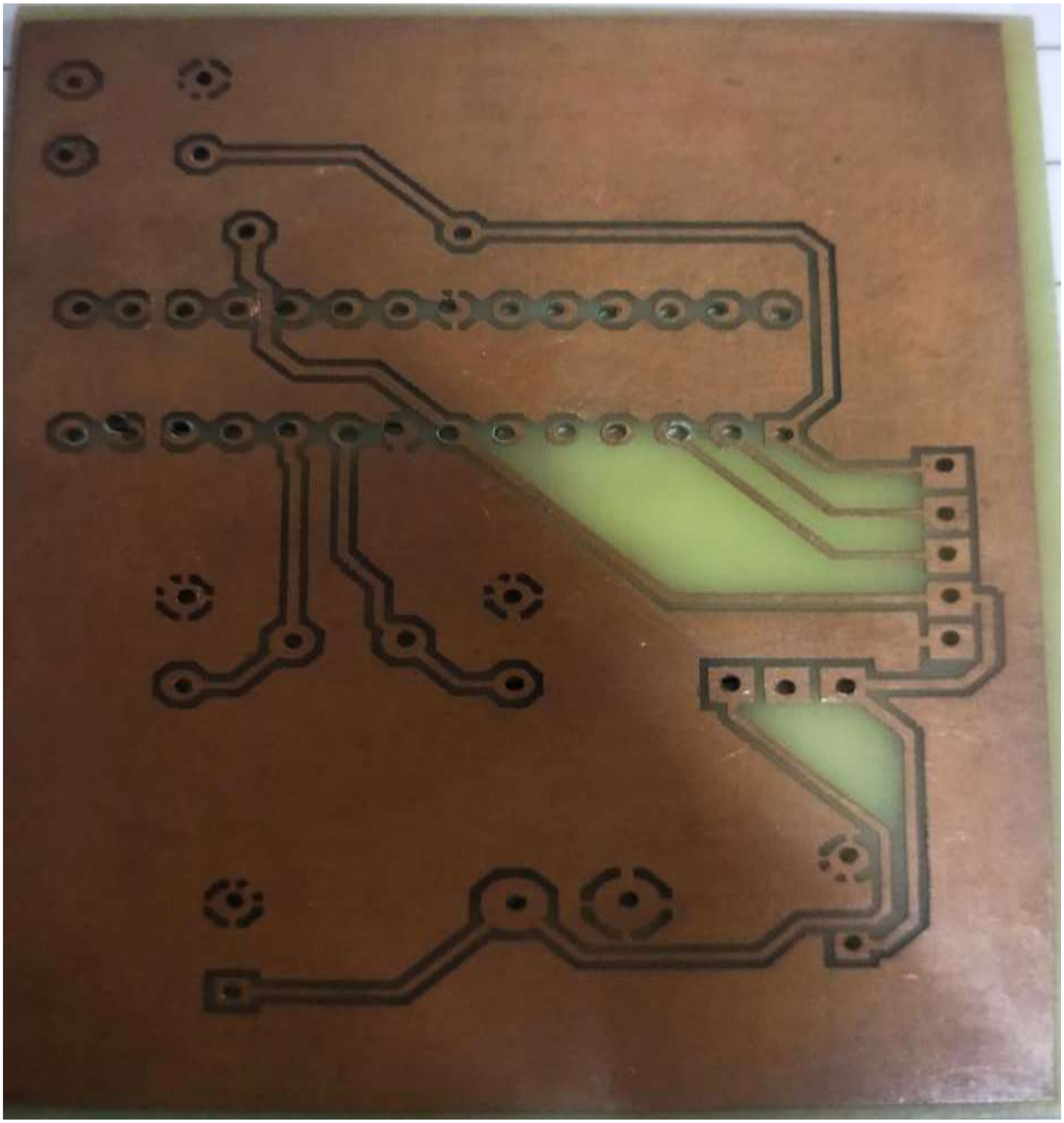

Fig 5.11 – PCB Of Motor controller Iteration 1 (Before mounting components)

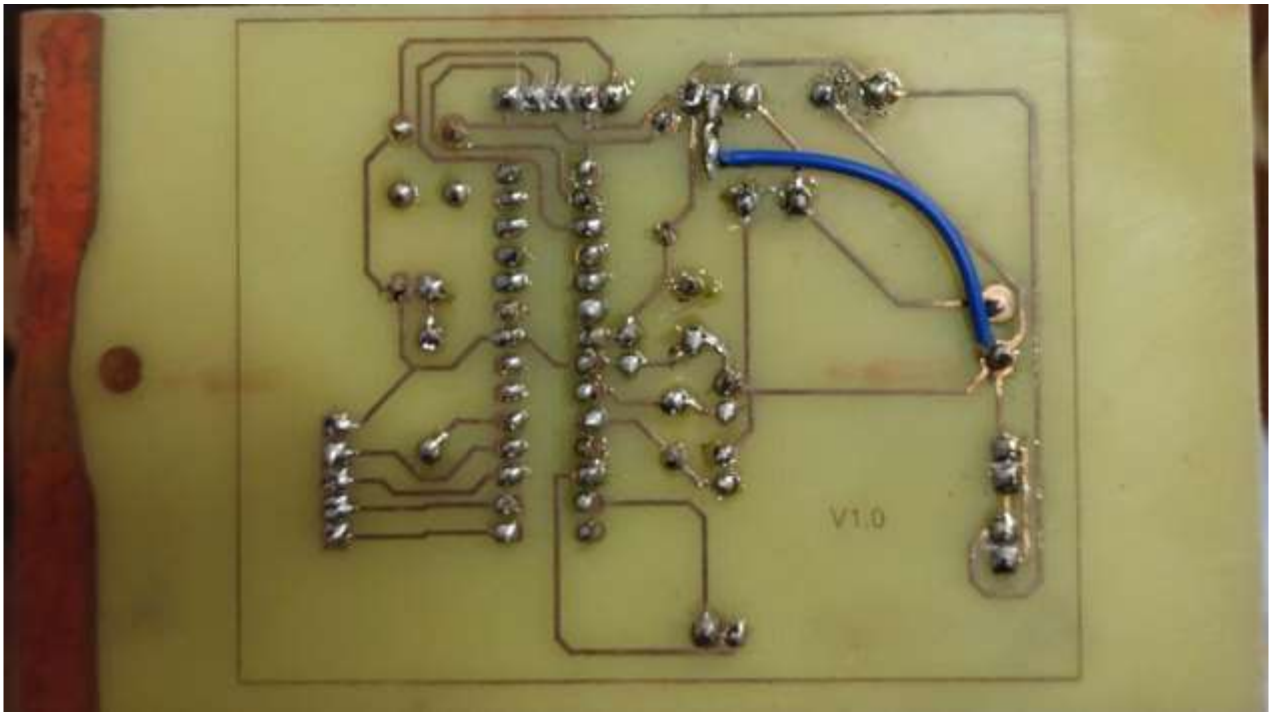

Fig 5.12 – PCB of Motor controller Iteration 1 (After mounting components)

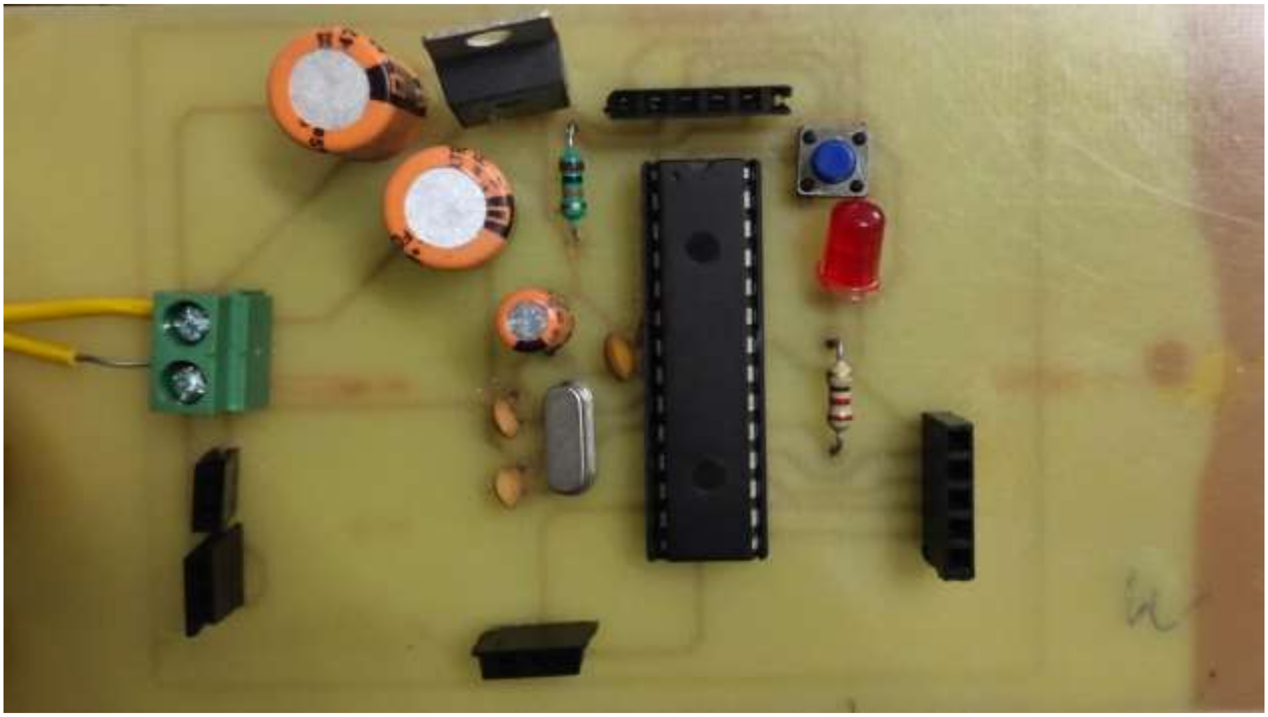

Fig 5.13: PCB after mounting component Iteration 1 (After mounting components)

5.3.2 Motor Controller Circuit (using ATMega328P):

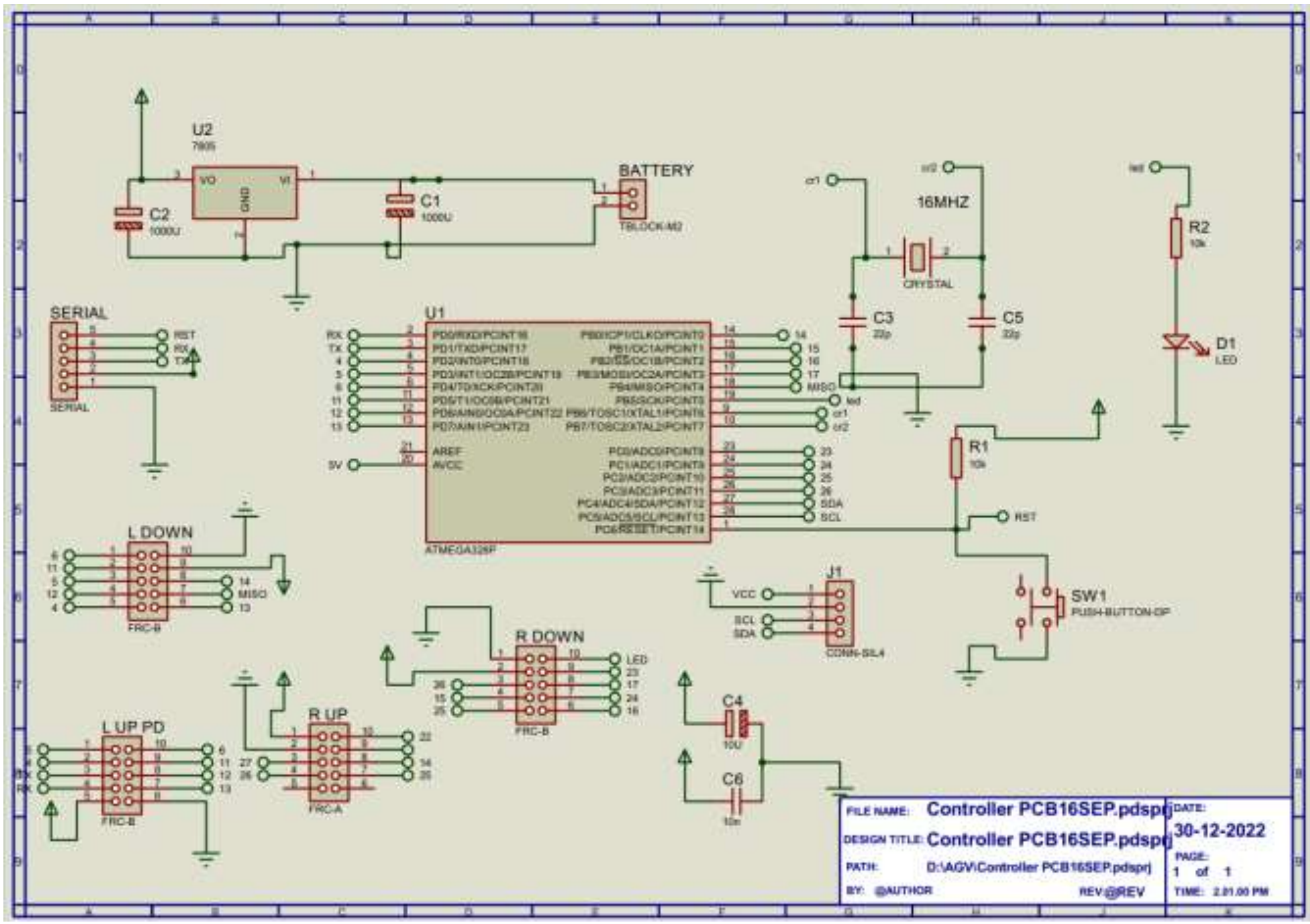

Fig 5.14: Schematic of Motor Controller Circuit (using ATMega328P) Iteration-2

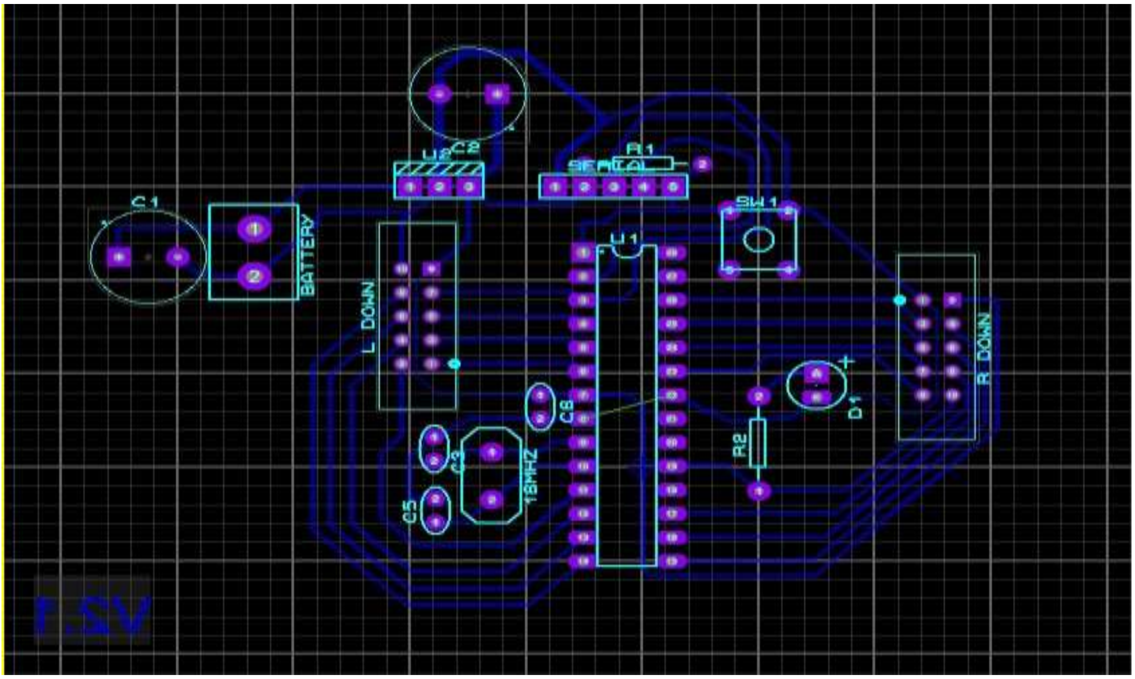

Fig 5.15 - PCB Layout of Motor controller Iteration-2

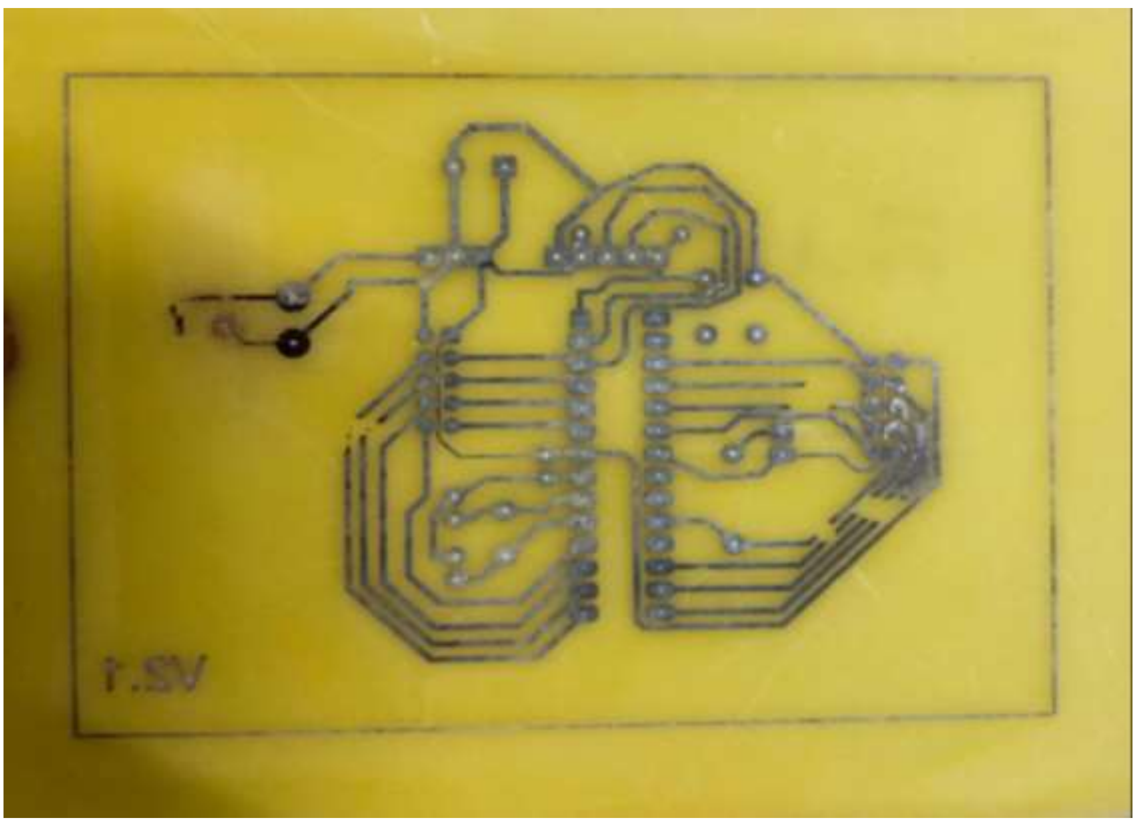

Fig 5.16 - PCB of Motor controller Iteration 2 (Before mounting components)

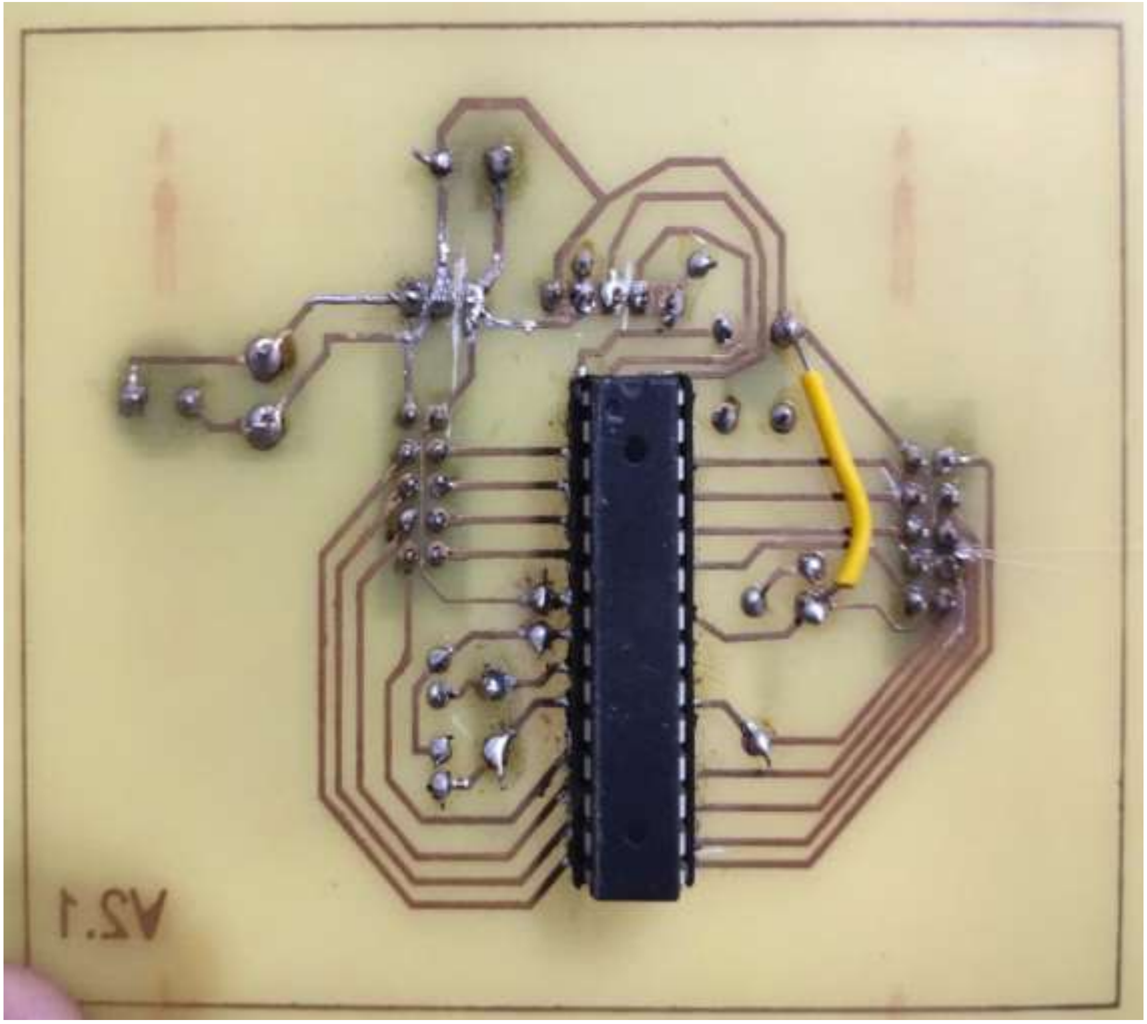

Fig 5.17 - PCB of Motor controller Iteration 2 (After mounting components)

ATMEGA Controller PCB Proteus File

The following QR code consists of a Proteus File that includes Schematic and PCB Layout of ATMega328P Controller.

ATMEGA Controller Testing Video

The following QR code consists of a video that includes testing of ATMega328P Controller.

5.3.3 Relay Circuit:

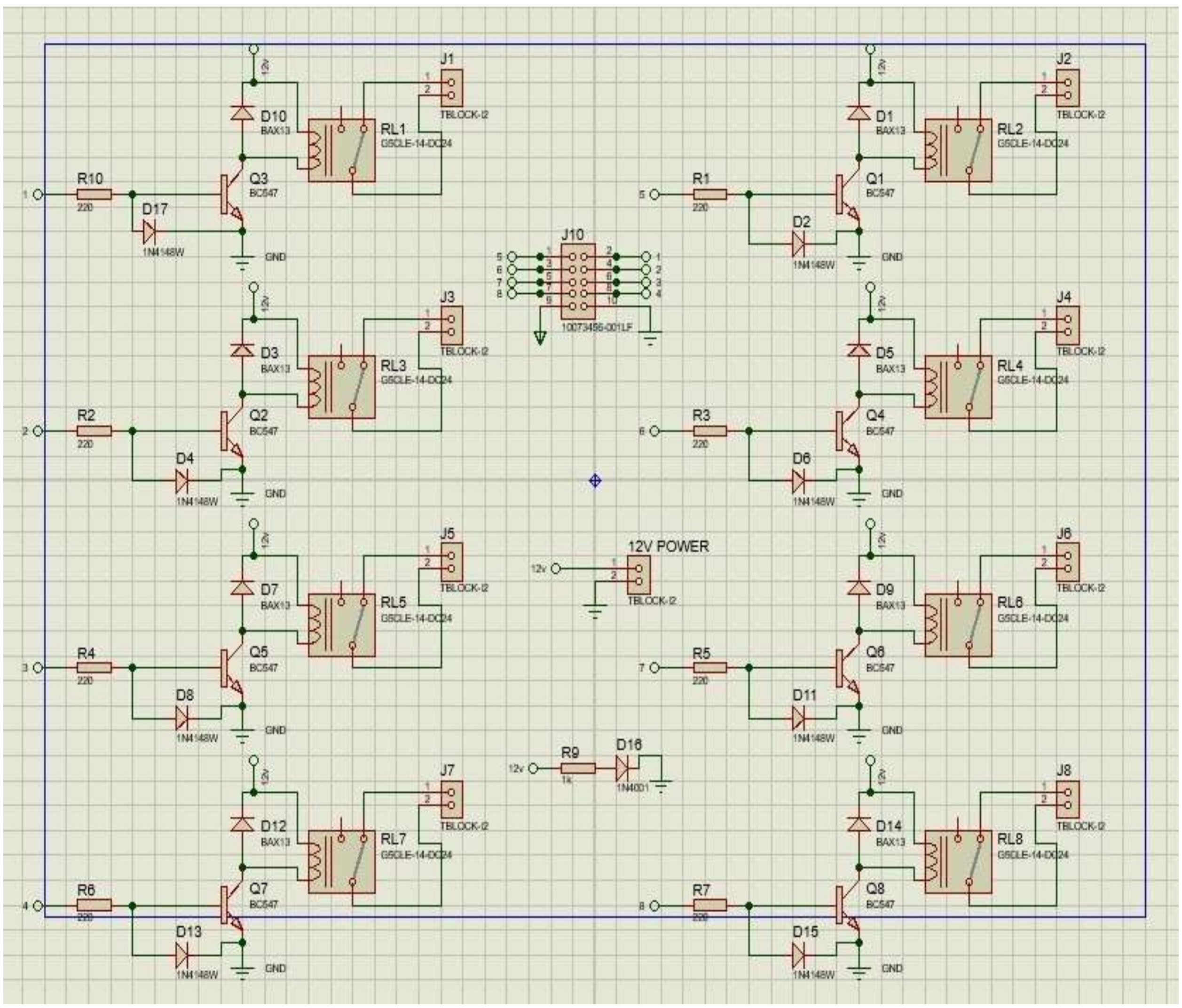

Fig 5.18 - Schematic of Relay Circuit

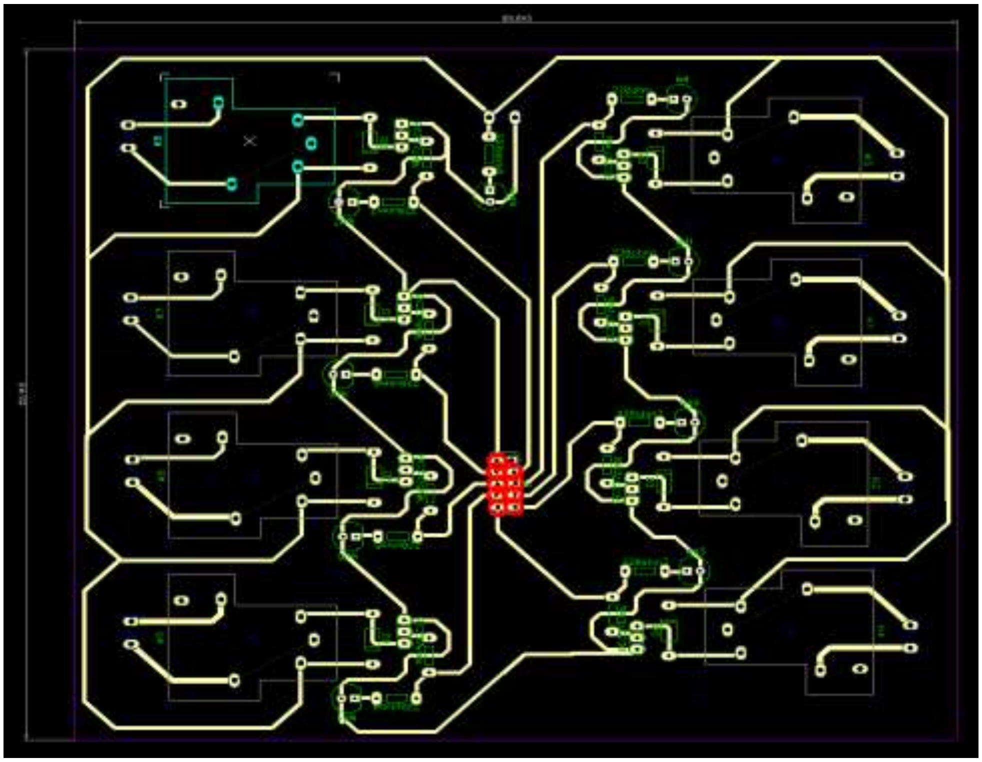

Fig 5.19 - PCB Layout of Relay Circuit

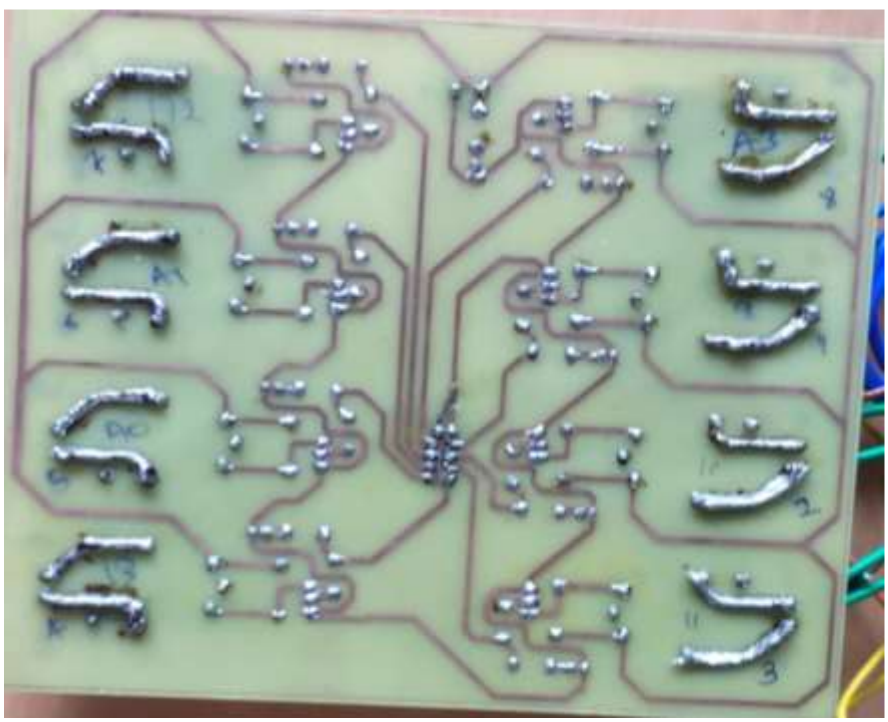

Fig 5.20 – Relay circuit PCB soldering (Trace width is increased as more current passes through it)

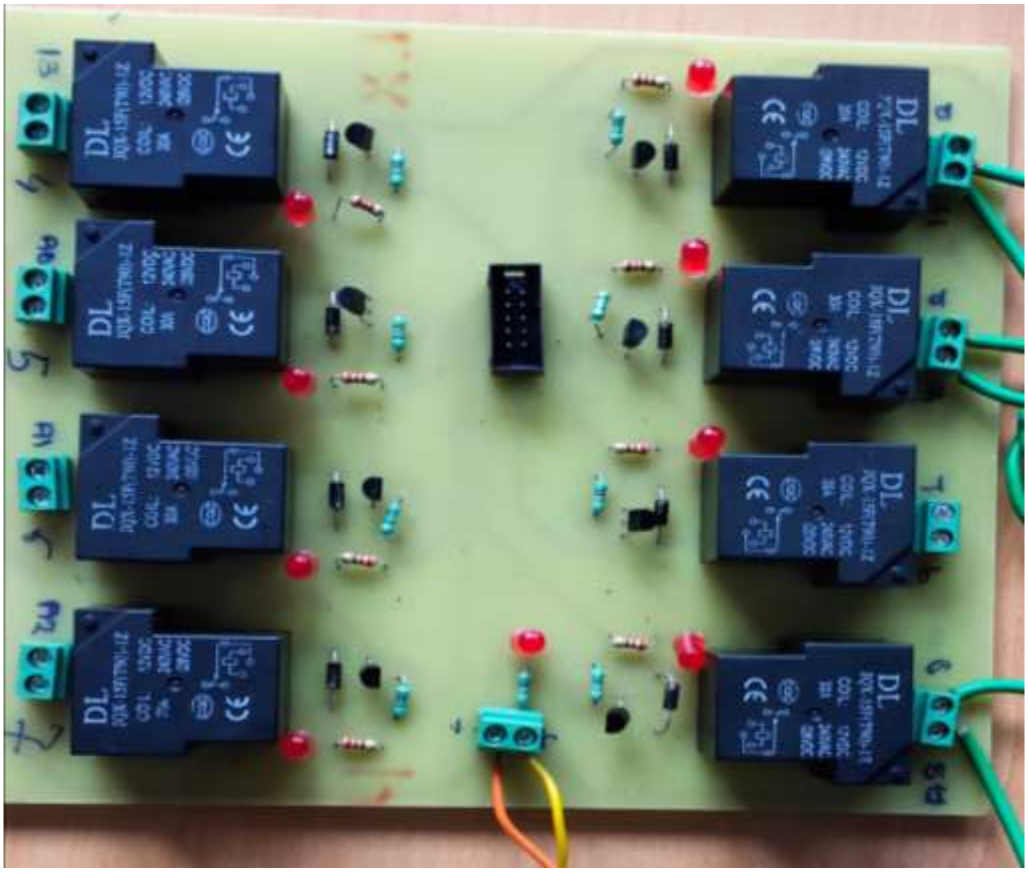

Fig 5.21 - Relay PCB after Mounting Components

Relay PCB Diptrace File

The following QR code consists of a Diptrace File that includes Schematic & PCB Layout of the Relay Circuit.

Relay PCB Testing Video

The following QR code consists of a video that includes testing of Relay Circuit PCB.

5.3.4 Ultrasonic Circuit:

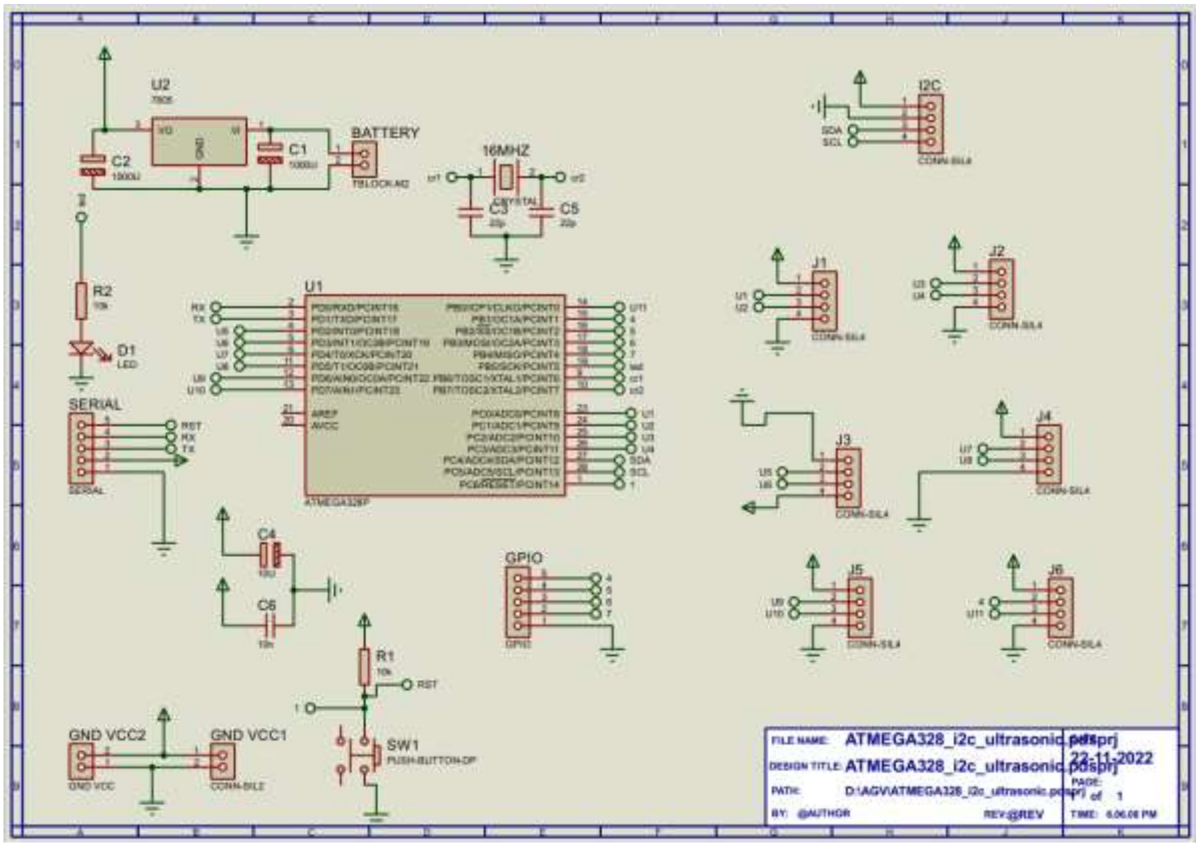

Fig 5.22 - Schematic of Ultrasonic control circuit

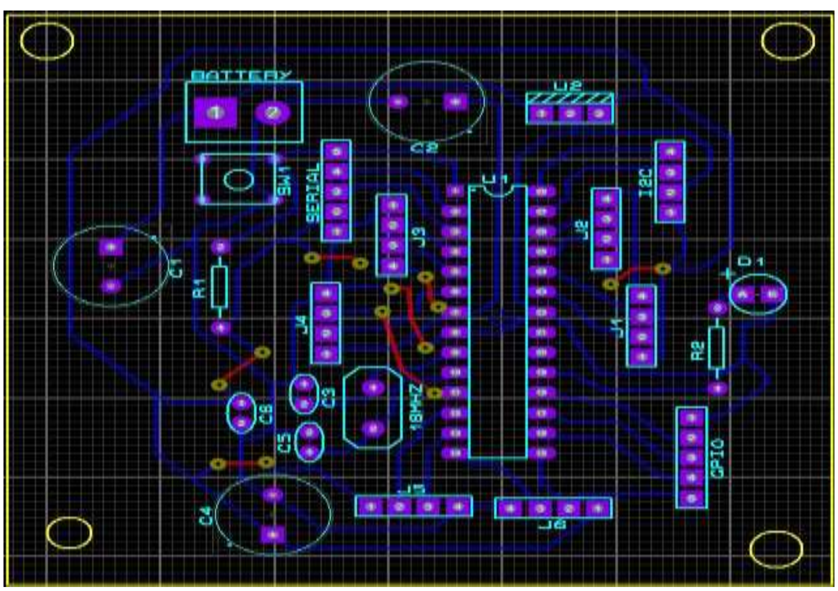

Fig 5.23 - PCB Layout of Ultrasonic control circuit

Fig 5.24 – Ultrasonic PCB after Mounting Components

Ultrasonic PCB Proteus File

The following QR code consists of a Proteus File that includes Schematic and PCB Layout of Ultrasonic Controller Circuit.

5.3.5 Nextion Circuit:

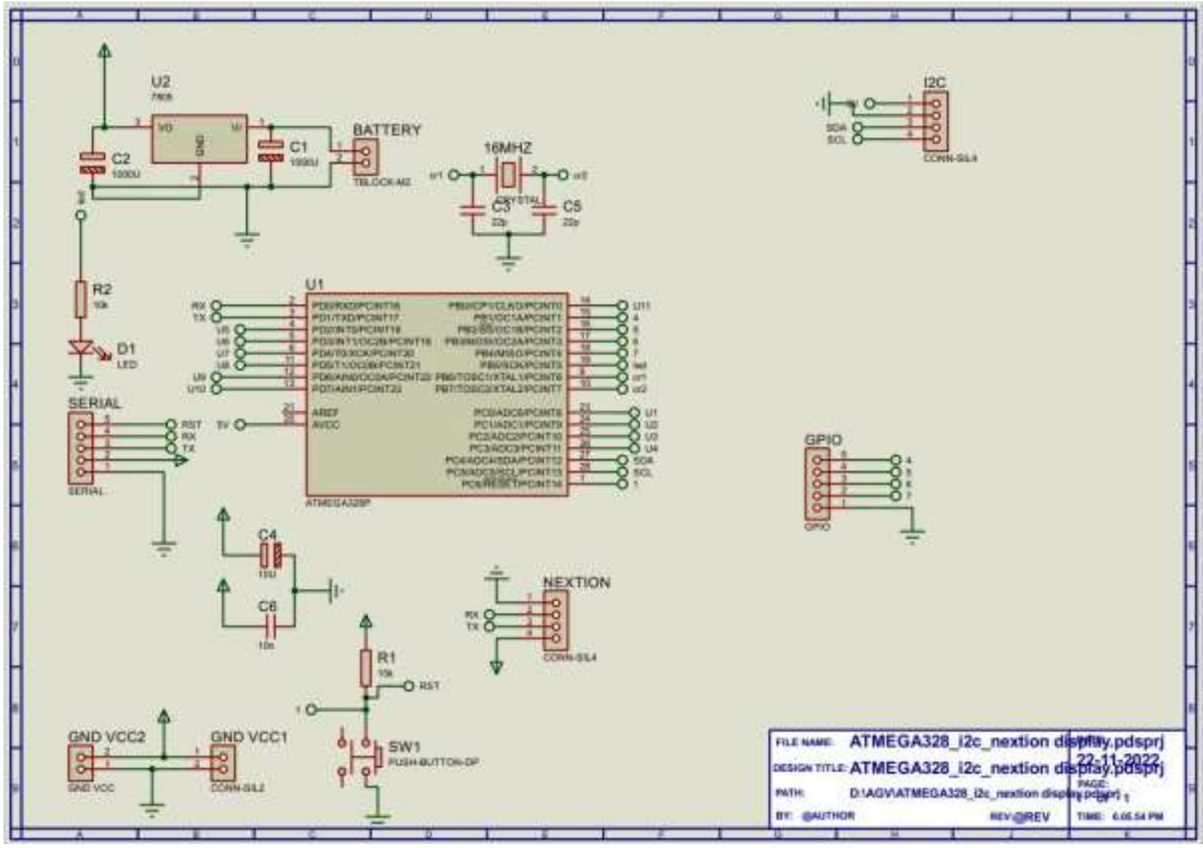

Fig 5.25 - Schematic of Nextion Display

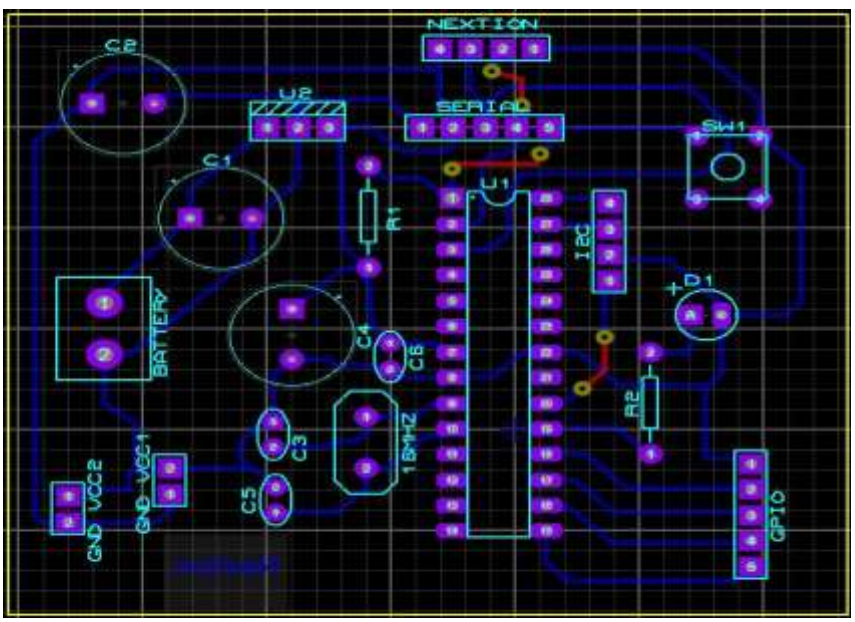

Fig 5.26 - PCB Layout of Nextion Display

Fig 5.27 – Nextion PCB after Mounting Components

Nextion Display PCB Proteus File

The following QR code consists of a Proteus File that includes Schematic and PCB Layout of Nextion Display Controller Circuit.

Nextion Display testing Video

The following QR code consists of a video that includes testing of PCB of Nextion Display Controller Circuit.

CHAPTER 6

Results and Discussion

"Automated Guided Vehicle" works on two principles, white line detection and obstacle detection. This is achieved by image processing and ultrasonic sensing respectively and the motor is controlled accordingly.

For this 4 circuits were designed, ultrasonic control circuit for obstacle detection, nextion circuit to select the destination and navigate through the path, motor control circuit and relay circuit for switching.

Initially, Line following was done with the help of IR sensors just to test on prototype.. Later on image processing was done and commands like start, stop, forward, right, left, etc. were given to the controller. The testing was done on prototype at first. It was difficult to take sharp turns when IR sensors were used. This constraints were removed after image processing was done and it could take sharp zigzag turns along with 90 degree turns.

Also for relay circuit, 7amp relays were used at first. But as these relays were falling short of power, 7amp relays were replaced by 30amp relays. Initially the prototype was getting jerk while turning due to continuous commands. Use of steering control mechanism minimized this constra

Steering mechanism testing Video

Zigzag Line / 90degree turn testing Video

Clockwise motor rotation testing video

Anti-Clockwise motor rotation testing video

CHAPTER 7

Conclusion and Future Scope

Automated guided vehicles (AGVs) are robotic vehicles that are used to transport materials within a facility, such as a warehouse or manufacturing plant. They are typically programmed to follow a predetermined path, using sensors and other guidance technologies to navigate through the facility.

There are many potential future developments for AGVs that could enhance their capabilities and expand their use in a variety of applications. Some possible areas of focus for future AGV development include:

- Improved navigation and guidance technologies: AGVs rely on various guidance technologies to navigate through facilities, including laser guidance, magnetic tape, and vision-based systems. In the future, there may be improvements in these technologies to make AGVs more accurate and efficient in their movements.
- Enhanced flexibility and adaptability: AGVs are typically designed to perform specific tasks within a defined environment. In the future, AGVs may be developed with more flexibility and adaptability, allowing them to perform a wider range of tasks and to operate in more diverse environments.
- Greater integration with other automation technologies: AGVs may be integrated with other automation technologies, such as robots and conveyor systems, to create more comprehensive and efficient material handling solutions.
- Increased use of AGVs in various industries: AGVs are already used in variety of industries which include manufacturing, logistics, and healthcare. In the future, AGVs may be adopted by an even wider range of industries, including construction, agriculture, and retail.
- Development of AGVs with specialized capabilities: AGVs may be developed with specialized capabilities to perform tasks that require specific skills or expertise. For example, AGVs could be equipped with sensors and manipulators to perform tasks such as quality inspection or assembly

APPENDIX A

Specifications

Hardware:

1. **ATMEGA328P:**

- ATMega328P Processor
- Memory AVR CPU at up to 16 MHz
  1. 32KB Flash
  2. 2KB SRAM
  3. 1KB EEPROM 8 34 65 19
- Security
  1. Power on Reset (POR)
  2. Brown out Detection (BOD)
- Peripherals
  1. 2x 8-bit Timer/Counter with a dedicated period register and compare channels
  2. 1x 16-bit Timer/Counter with a dedicated period register, input capture, and compare channels
  3. 1x USART with fractional baud rate generator and start-of-frame detection 1x controller/peripheral Serial Peripheral Interface (SPI)
  4. 1x Dual mode controller/peripheral I2C
  5. 1x Analog Comparator (AC) with a scalable reference input Watchdog Timer with a separate on-chip oscillator
  6. Six PWM channels
  7. Interrupt and wake up on pin change
  8. ATMega16U2 Processor 8-bit AVR® RISC-based microcontroller
- Memory
  1. 16 KB ISP Flash
  2. 512B EEPROM
  3. 512B SRAM

• Power

1. 2.7-5.5 volts

Digital Pin:

Arduino Uno contains 14 digital pins (0–13). These pins serve as digital input/output pins. The built-in LED is connected to PIN 13. A PWM signal can be carried on six pins. Each pin can provide or sink a maximum of 40 mA. But the recommended current is 20 mA. 40 64 40 20

Analog Pin:

There are six analogue pins (A0-A5) on it. These pins utilise the ADC. These pins serve as analogue input but can also function as digital input or output. These pins are used to connect sensors. Power LED: Power LED indicates that the Arduino board receiving power.

Power DC Jack:

It is also called Barrel Jack. It is used as a power connector. The barrel jack is usually connected to a wall adapter. The board can be powered by 5–20 volts, but the regulators might overheat, and below 7 volts, they might not suffice.

Tx / Rx LED:

These LEDs indicate the communication between the Arduino and the rompu. The Tx LED indicates that the signal is being transmitted, whereas the R LED indicates that the signal is being received.

USB JACK:

It is used to connect the computer to the Arduino and also used to upload sketches to Arduino and for communication with computers. Reset Button It is used to reload the entire code. It does not clear the Arduino's memory.

2. Raspberry Pi4 Model B:

- Model-Raspberry Pi 4 Model-B
- Processor- Broadcom BCM2711, quad-core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
- RAM Memory - 4 GB LPDDR4 SDRAM
- Connectivity
  1. 2 × USB 2.0 Ports
  2. 2 × USB 3.0 Ports
  3. 2.4 GHz and 5.0 GHz IEEE 802.11b/g/n/ac wireless LAN, BLE Gigabit Ethernet, Bluetooth 5.0
- Operating Power
  1. 5 Volt 3 Ampere DC via GPIO Header
  2. 5 Volt 3 Ampere DC via USB Type-C Connector
  3. Power Over Ethernet (PoE)–Enabled (requires separate PoE HAT)
- GPIO- (Fully backward compatible with previous boards)
- Multimedia
  1. H.264 (1080p60 decode, 1080p30 encode)
  2. H.265 (4Kp60 decode)
  3. OpenGL ES, 3.0 Graphics
- Video and Sound
  1. 2 × micro-HDMI ports (up to 4Kp60 supported)
  2. 2-Lane MIPI CSI Camera a Port
  3. 2-Lane MIPI DSI Display Port 4
  4. Pole Stereo Audio and Composite Video Port
- Clock Speed- 1.5 GHz
- Micro-SD Card Slot- Yes (FAT32 format), support maximum 32G Micro SD Card Memory Features
- Operating Temperature Range 1. 0ºC to 50ºC

3. Camera:

- Display Technology – LCD
- Optical Sensor Resolution – 1080 MP
- Focal Length – 7 mm
- Type – 60 fps
- Camera Angle – 100 degree
- Focal Length – 70 mm to infinity

4. Ultrasonic Sensor:

- Integrated with a wire-enclosed waterproof probe, suitable for wet and harsh measurement occasions
- Small and simple to use
- Operating Voltage: 5 V
- Sonar Sensing Range: 25-450 cm
- 450 cm maximum sensing range
- Frequency: 40 kHz

5. Nextion Display:

- Nextion Display Type: Intelligent Series
- Nexiton Model: NX8048P070-011C-Y (7.0-inch resistive touchscreen with enclosure)
- Built-in RTC support (battery type: CR1220)
- Operating Voltage:5V-6.5V
- Operating Current: 530 mA (VCC = +5 volts, 100% brightness).

6. Motor Driver:

- The L293D is a 16-pin motor driver IC that can control a set of two DC motors simultaneously in any direction.

- The L293D is designed to provide bidirectional drive currents of up to 600 mA (per channel) at voltages from 4.5 V to 36 V (at pin 8!).

- You can use it to control small dc motors - toy motors. Sometimes it can be extremely hot.

7. FRC:

- High flexibility: FRC cables are designed to bend and flex easily, which makes them well-suited for use in applications where there is a lot of movement.
- Durability: FRC cables are typically made with a durable outer jacket that is resistant to wear and tear, and they are designed to withstand high levels of flexing and bending.
- Resistance to temperature extremes: FRC cables are typically designed to operate in a wide range of temperatures, which makes them well-suited for use in outdoor or industrial environments.
- Low voltage drop: FRC cables are designed to have a low voltage drop, which means that they are able to transmit power efficiently over long distances.
- FRC cables are commonly used in robotics, automation, and other applications where flexibility, durability, and reliability are important considerations.

8. Relay:

- Contacts: The contacts of a relay are the electrical switch that opens and closes to complete or break an electrical circuit..
- Contact rating: The contact rating of a relay is the maximum amount of current that the contacts can safely carry. This is an important factor to consider when selecting a relay for a particular application, as the contacts must be able to handle the current flowing through the circuit.
- Coil voltage: The coil voltage of a relay is the voltage required to energize the coil and close the contacts. This voltage can be either AC or DC.
- Operating time: The operating time of a relay is the amount of time it takes for the contacts to close after the coil is energized.
- Insulation rating: The insulation rating of a relay is a measure of the relay's ability to withstand electrical shock.

- Environmental factors: Some relays are designed for use in specific environments, such as high temperatures, high humidity, or harsh industrial environments. It is important to consider the environmental factors when selecting a relay for a particular application

9. Proteus:

- Circuit design
- Microcontroller simulation
- Virtual instrumentation
- 3D modeling
- Automatic routing
- Collaboration tools
- Comprehensive library

10. Nextion Editor:

- Drag-and-drop design
- Templates and libraries
- Code generation
- Animation support.
- Multi-language support
- Virtual display

11. Arduino IDE:

- Code editor
- Library manager
- Serial monitor
- Code examples:
- Board and port selection
- Automatic code formatting
- **Compiler**

12. I2C communication protocol:

- Multi-master capability: I2C allows multiple devices to act as masters, which means that they can initiate communication with other devices on the bus.
- Addressing: Each device on the I2C bus has a unique address, which allows the master to communicate with specific devices.
- Speed: I2C supports a range of speeds, from standard-mode (100 kHz) to high-speed mode (400 kHz).
- Low pin count: I2C requires only two wires (clock and data) to communicate, which makes it well-suited for applications where pin count is a concern.
- I2C is widely used in a variety of applications where there are multiple devices to communicate with each other, but where the number of available pins is limited.

13. UART communication protocol:

- Asynchronous transmission: UART allows devices to transmit and receive data asynchronously, which means that the transmit and receive clocks are not synchronized.
- Full-duplex communication: UART supports full-duplex communication, which means that devices can transmit and receive data simultaneously.
- Error detection: UART includes built-in error detection mechanisms, such as parity bits and checksums, which can be used to detect transmission errors.
- UART is widely used in a variety of applications, including microcontroller-based systems, computer peripherals, and industrial control systems.

14. Serial Communication:

- Asynchrony: Serial communication can be either asynchronous or synchronous.
- Full-duplex: Serial communication can be full-duplex, which means that data can be transmitted and received simultaneously which is faster communication.
- Error checking: Most serial communication protocols include some form of error checking, such as checksum or cyclic redundancy check (CRC), to ensure that the data being transmitted is accurate.
- Flow control: Flow control is used to prevent the sender from transmitting data faster than the receiver can process it.
- Data rates: Serial communication protocols typically support a range of data rates, allowing for flexibility in the speed of communication.
- Distance: Serial communication can be used over relatively long distances, depending on the specific protocol and the quality of the communication channel.