Department of
Electrical & Electronics Engineering

Abdullah Gul University

EE 3002

PROJECT REPORT

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I. INTRODUCTION

Intelligent technologies become a big part of daily life especially in recent decades. These kinds of technologies are occurred by lots of sub professional disciples and areas. One of the areas is Embedded Systems. Robots, machines, industrial systems etc. technologies are being developed mostly in Embedded Systems. In this project, a line follower robot system was designed, developed and tested with using STM32F103C8T6 microcontroller. Components, circuit diagram, flowchart, program algorithm and test results were explained in the next parts.

II. DESIGNING OF THE SYSTEM

The system was designed with using STM32F103C8T6 microcontroller board, QTR-8RC reflectance sensor array, L298N motor driver, DC motors, 7V-8V power source, plastic and carton physical materials. Brief and important points of these components were explained in this part.

1. STM32F103C8T6 Microcontroller Card

A development card using STM32F103C8T6 microcontroller was used to control the system. The causes of preference of this board can be ordered such as including STM32F103C8T6 microcontroller which was seen in the courses, small size, highly good achieving STM32's pins with board pins, enough number of ADCs, low power consumption, large scale of open sources on the internet. Also, the usage of the card was asked by the department.

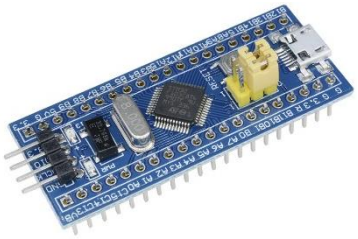

Figure 1 STM32F103

2. QTR-8RC Reflectance Sensor

To detect the line, QTR-8RC reflectance sensor array was used. It includes eight independent reflectance sensors on it to get a more accurate detection. Detection is done by these eight IR emitter and receiver pairs [1].

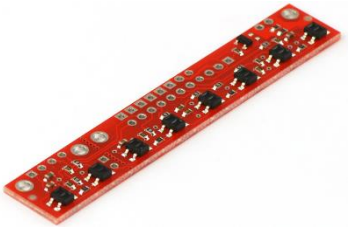

Figure 2 QTR-8RC

3. L298N Motor Driver

Despite the fact that the system contains two DC motor and the power of them cannot provide by STM32 board, L298N motor driver was used to driving motor in wished direction and needed speed. The L298N is one of most common DC motor drivers for robotic applications.

Figure 3 Motor Driver

4. DC Motors

To move the line follower robot, 2 twin DC motor were used.

Figure 4 DC Motors

5. Power Source

To provide enough voltage and ampere to the robot 7V-8V power sources were preferred.

Figure 5 Li-ion Battery

III. METHODS

1. General Flowchart

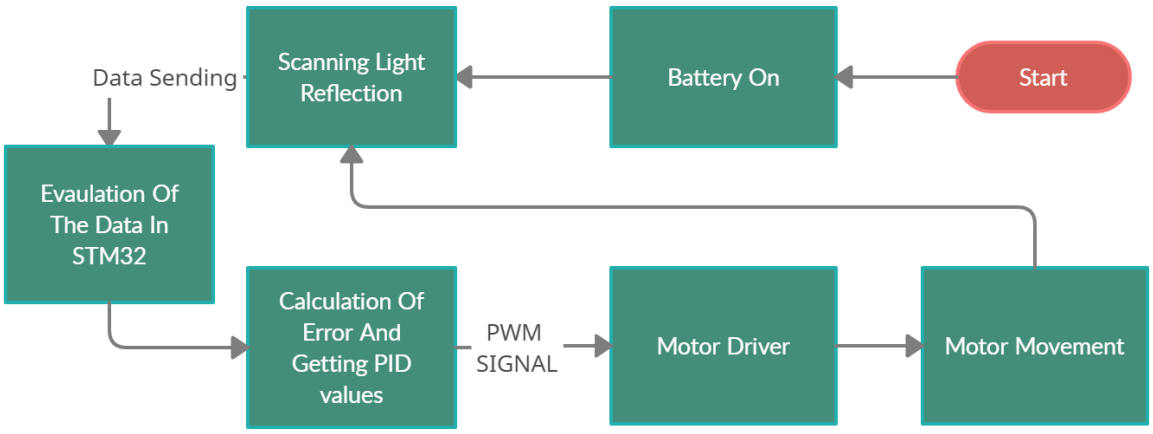

Figure 6 Flowchart of the Project

After the robot is powered up and the code is loaded, the robot starts working. First, it starts to read data thanks to the QTR-8RC sensor. The data received according to the black or white colors on the track are sent to the PID controller. With the PID algorithm, errors are calculated and the speed given to the wheels of the robot is determined accordingly.

2. Circuit Schematics

The circuit diagram was prepared in Proteus. 8 pins are used for the QTR-8RC sensor to read data of each led individually and VCC pin of the sensor is connected to the 3.3V port of TM32 and the ground of the sensor is connected to the common ground to protect voltage difference of sensor with others circuit elements.

As shown in Figure 7, for the L298n motor driver, pins of DC motors and + and - poles of battery are connected to the driver. In addition, enable pins and 5V pin are connected to STM32 and input pins are connected to STM32.

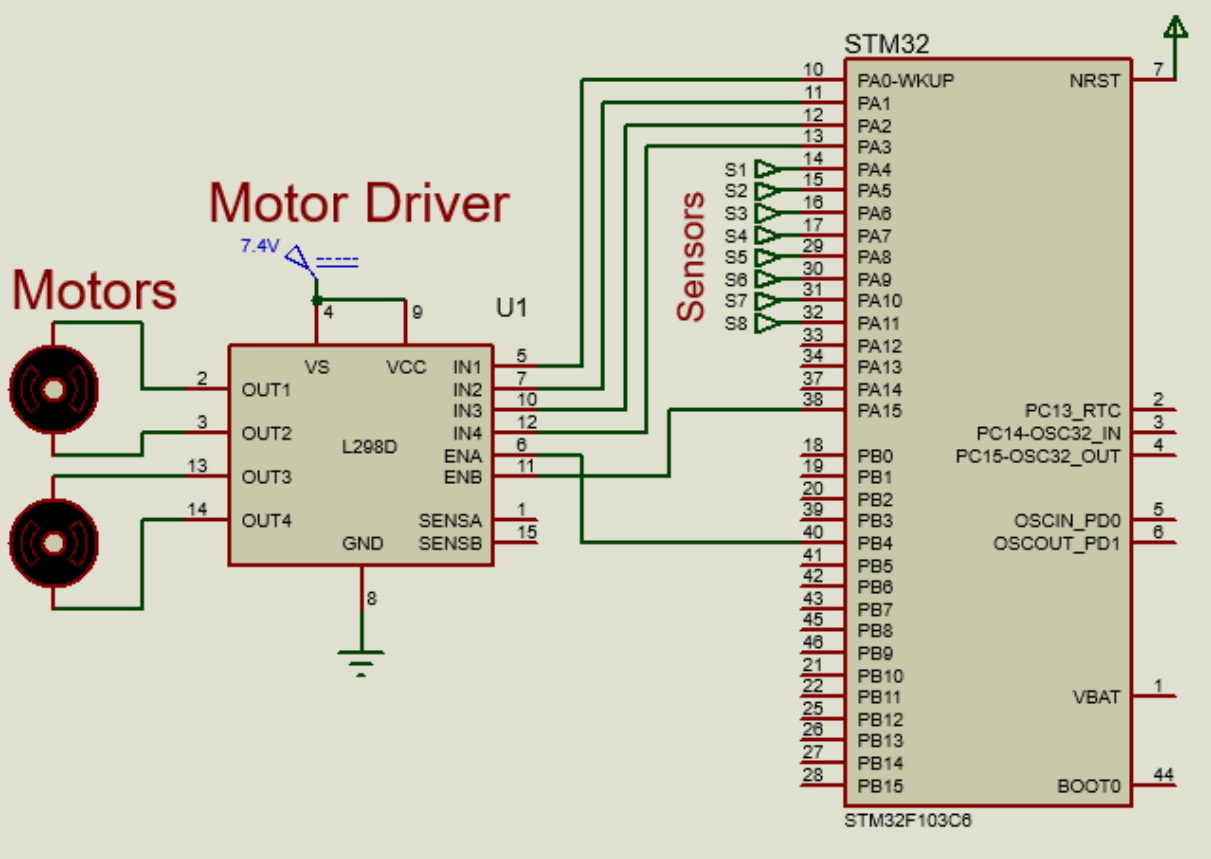

Figure 7 Circuit Schematics

3. Program Algorithm Flowchart

Here, the timer clock is determined as 16 MHz, prescaler 79, and period 99. When the PWM formula is applied, the speed was calculated as 2kHz. However, the full speed of the robot was not used for the stable operation of the robot. It has been used in a duty cycle range of 40-60.

As shown in Figure 8, the robot tries stay on the line with maximum speed and accuracy. When a sensor gives detection of black color output, PID mechanism starts working and calculate PID value according to P (error, proportion) value. PID value is occurred by P, I and D terms. According to which number of sensor give detection output, an error is occurred due to some certain error values. These error values are varying between -5 and +5 and most sided sensors give most high absolute error value.

For PID control values, the Proportional (Kp) value was given 9, the Integral (Ki) value was 0, and the Derivative (Kd) value was given 30. These values are given according to the tests performed by giving many different PID control gain values to the robot. As a result of these tests, the values stated above were given.

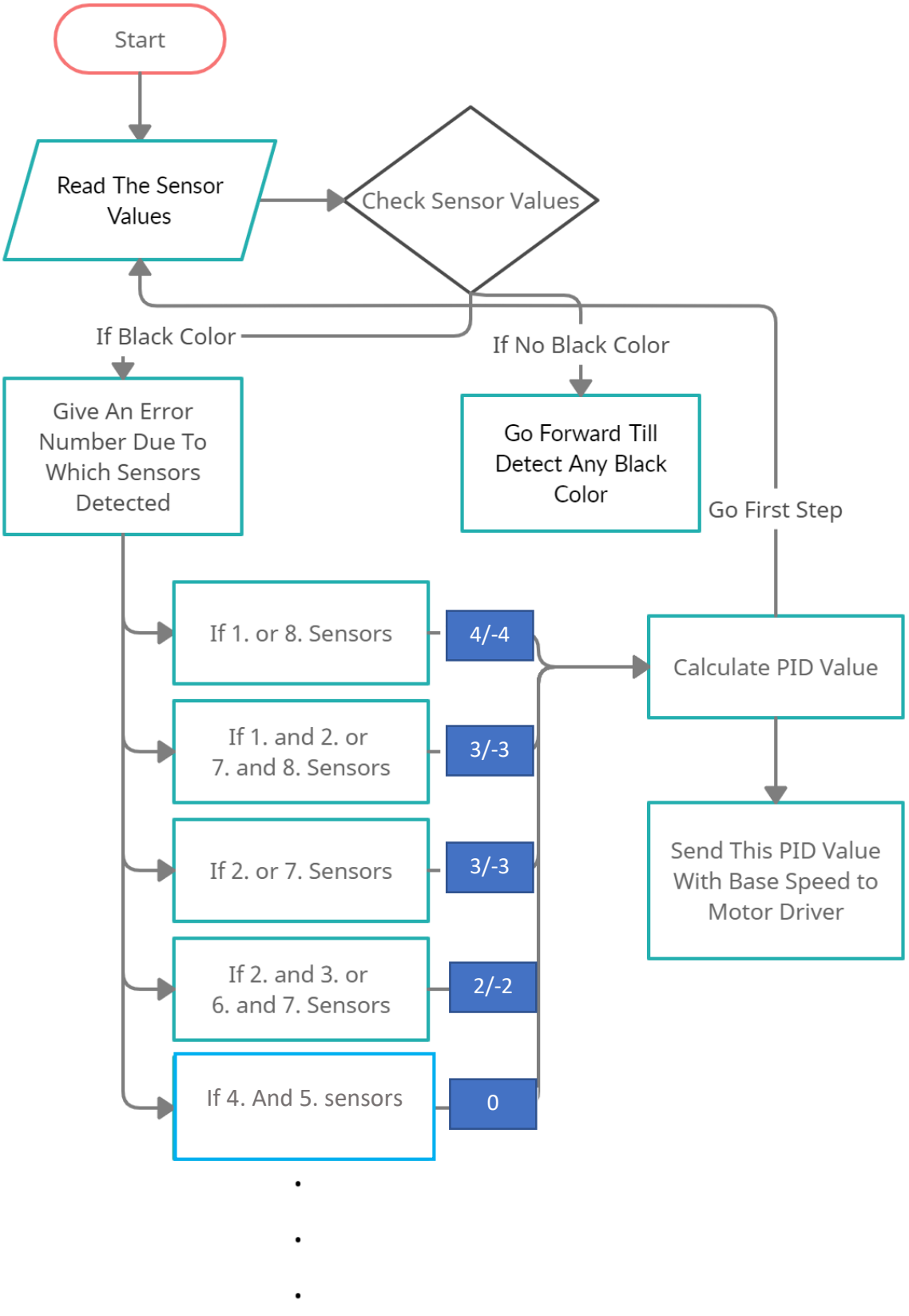

Figure 8 Program Algorithm

Group Members Responsibility and Contribution

In this project, since we are in different cities due to the pandemic process, we both did the necessary things in almost all steps and then we tried to combine the things we need to do by comparing the work we did. For this reason, we preferred to complete this project by doing all the steps together instead of making a division of labor. Although we did the things to be done together in many steps, we shared the tasks in some steps. The sensor reading part was done by M. Hasan Aydoğdu. PID algorithm was made by A.Yasir Cilvez. In the remaining steps, weekly work done by both group members was combined with the weekly regular Zoom meetings.

A.Yasir Cilvez

- Deciding on the materials to be used
- Designing the robot
- C-based code works
- PID Algorithm
- Preparing the track where the robot will work
- Testing

M.Hasan Aydoğdu

- Deciding on the materials to be used
- Designing robot
- Reading data from QTR-8RC
- Stm32 code work
- Working algorithm of the robot
- Preparing the track where the robot will work
- Testing

Challenging Parts

We had many difficulties in this project as we were at our own home and could not access the labs in the school.

- When we got the materials we used for the robot, we saw that some of these materials had to be soldered. Although soldering is not a difficult thing under normal conditions, we had difficulties in soldering because the soldering machines in our house are old and of poor quality. Although we soldered some of the materials ourselves, some parts were helped by the TV service staff.

- Another part we have difficulty in this project is battery selection. At the beginning of the project, we were considering using 9V alkaline batteries. But later, as a result of our research and talking with other friends, we learned that 9V batteries can cause us problems. For this reason, we decided to use a Li-ion battery. However, we were a bit late in testing, as the orders took some time to arrive.

- Another challenge we face in this project is adding the sensor to the robot and creating the runway. The sensor we use must be 3 mm above the floor by default. For this reason, adding the sensor to the robot was a bit inconvenient and sometimes caused the robot to work inconsistently. We also had some problems with the sensor's data reading since we used cardboard while building the track. Here we were able to fix the sensor at a height of 3mm after long efforts and run the robot on a wooden floor instead of cardboard.

How to Improve the Current Design Performance If You Have Time/Resources?

Arduino Nano can be used instead of STM32 to finish the project more easily. Because the QTR-8RC sensor we used does not have a library in STM32. On the Arduino, it is a great convenience to have the sensor's library.

In order to make the project more complex, we would like to design our own line follower design. We would like to design a robot with our own designed circuits and PCB designs. Thus, we gain more experience and knowledge.

A lighter and more efficient robot kit and a more powerful motor can be used to design a faster robot in terms of the speed of the robot. Because when it comes to the speed of the robot, the weight of the robot, the quality of its wheels and the engine are of great importance. Also here we would pay attention to the easy placement of the sensor in the robot kit. For this, we would try to get a robot kit that contains a partition for the QTR-8RC sensor.

We could not do enough research on the battery because our time was limited in this project. If we had enough time, we would do detailed research to find the most efficient battery.