Design of Obstacle Avoidance and Waypoint Navigation using Global position sensor/ Ultrasonic sensor

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Abstract: *The objective of the research work to focus on a path planning aims to plan the route of an Unmanned Vehicle (UV) using Global Positioning System (GPS), and the most suitable path is selected avoiding the obstacles along the desired path. The coordinates of the starting point and destination are fed through programming. In addition, an obstacle avoidance algorithm is used and waypoints are given using the AVR Programming. Waypoint Navigation System for the Unmanned Ground Vehicle is use with GPS avoiding the obstacles in its path. The Waypoint Navigation System is the planning of the path of an object so that the path goes through some specified coordinates or benchmarks to the final destination thus avoiding any obstacles. The technology used to accomplish the aim includes Global Positioning System (GPS), Ultrasonic Sonic sensors and Micro-controller for programming. GPS will be the guiding medium from source to destination and two Ultrasonic Sensors will be used. These types of vehicles are used for many purposes and have been used by United States of America for Military and Defense purposes. In advanced cases, an Unmanned Aerial Vehicle may also be developed using these algorithms.*

Key Words: *Unmanned Vehicle, Obstacle Avoidance, Global Positioning System, Navigation*

1. INTRODUCTION

Unmanned ground vehicles have gained a lot of importance in modern times due to their various advantages such as eliminating the possibility of losing vehicles, cargo or their human operator. These types of vehicles have found recent application in Iraq where America is used this technology to secure its cargo.

Such ground and air vehicles can be used in agriculture, for the recovery of soldiers or civilians during natural disasters, for site inspection and construction activities, but can also be used in the army for espionage and combat [1], [2]. Therefore, the concept of obstacle avoidance has been taken into consideration and also we will try to implement certain boundary constraint that is to say that the vehicle should not go beyond certain specified boundaries and if it reaches that point then it should change its path at the limiting points.

Our objective was for the vehicle to cover a track length of 250 miles of sand dunes covered deserts within the time span of 10 hours, [3]. To avoiding the obstacles in its path,

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which are either stationary or moving. There are three categories of sensors that were employed on the vehicle are:

(1) Position and orientation sensors,

(2) Finding the location through GPS,

(3) Obstacle detection sensors.

The position of the vehicle was determined by the use of GPS for the low accuracy while the inertial sensors like Accelerometers, gyroscopes and magnetometers were used for higher accuracy by the method of dead reasoning, [4].

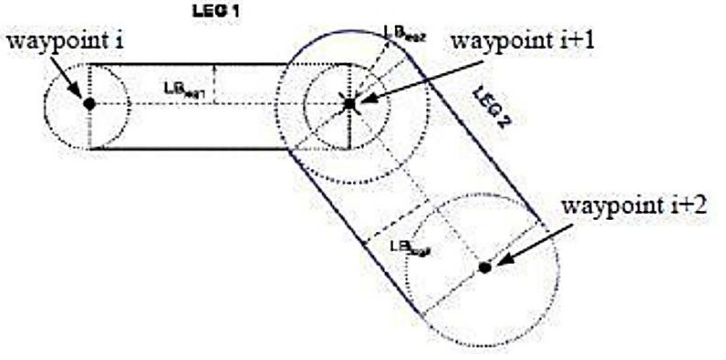

Fig. 1: Waypoint selection

Obstacle Detection method uses the high accuracy sensors like LIDAR or Laser Rays while due to the cost and complex operation we are using the ultrasonic sensors for the obstacle avoidance.

2. LITERATURE REVIEW

The purpose of this project is to use the GPS to navigate an unmanned vehicle. In the following discussion, we are going to describe how GPS navigation is applied to unmanned ground vehicles, and then to test the accuracy of the navigation.

In the end, the experiment will reveal the practical performance and limitation of the navigation [5].

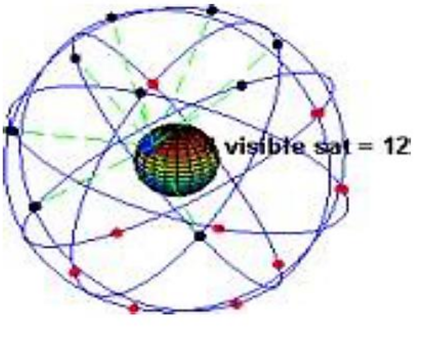

Fig. 2: GPS Satellite and constellation

The collected information about the ultrasonic sensors functioning will be explained through figures 3 [6].

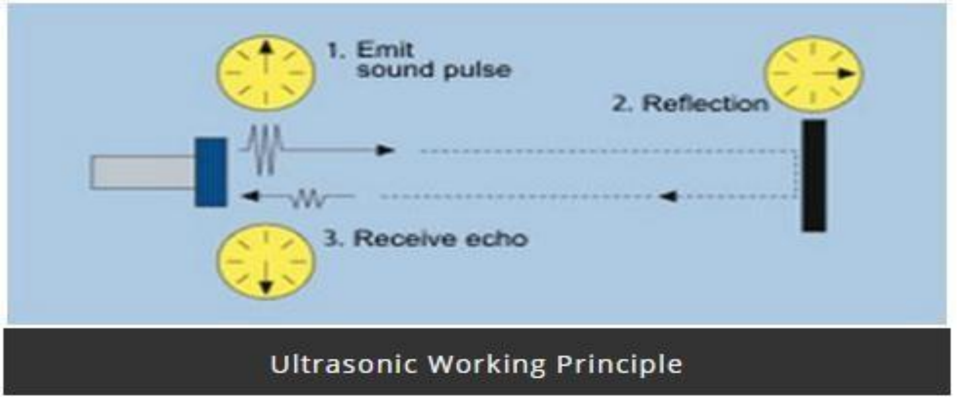

Fig. 3: Ultra sonic Working

In addition, we went through many research papers, which provided us the pros and cons of using different methods that helped us in choosing the right approach for our project [7].

The main tasks of our project were:

1. UV travel waypoint A to waypoint B
2. Develop the Obstacle avoidance algorithms

The following algorithm played a great role in deciding our algorithms and the use of sensors for our project. In addition, we got significant knowledge about the waypoint navigation system [8].

The block diagram for the operation is shown in fig. 4.

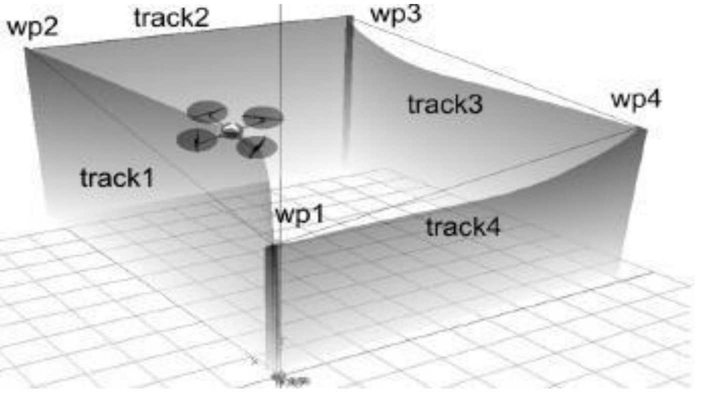

Fig. 4: Different waypoint of quadrotor

First, we went through the research paper GPS-based Position Control and Waypoint Navigation System for Quadcopters that gave us significant ideas regarding the waypoint navigation for our unmanned ground vehicle. The following figure illustrates it properly. This figure (4) properly shows through simulation how the quad rotor follows various waypoints while completing its path [9].

3. METHODOLOGY

A. Selection of the platform

For this experiment, an assembled DC motor car was chosen to be the platform of the unmanned ground vehicle.

The features of the model are cost-effective, convenient to obtain and easy to remodel. For finding the location with the help if GPS system.

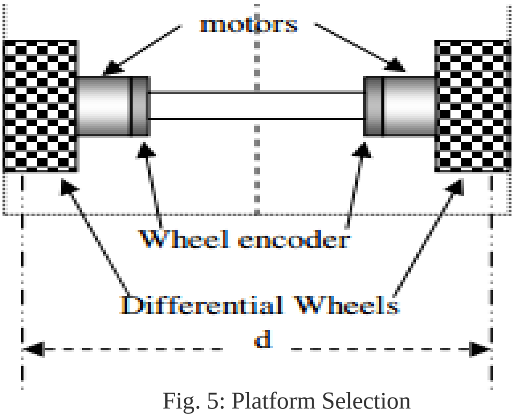

Fig. 5: Platform Selection

The car model needs to be remodeled. Then, a GPS could be able to be added on the platform for the navigation function.

In this research work considered the DC motor and GPS for giving the coordinates, we will use a GPS and for giving the waypoints, ATMEGA and AVR-STUDIO programming [11].

B. Interfacing of GPS unit with ultrasonic sensors

The project will work in sequence with the interfacing of GPS unit with ultrasonic sensors. The UGV will work on the principle of mutual working of GPS with obstacle avoidance. Firstly, the GPS will acquire the coordinates and check if the source and destination are not the same.

During the time of programming the destination of the GPS setup will be set for go while the GPS initial source remains the same.

For long distances of more than 20m there will be much of effective changes in the GPS coordinates but the time taken will be long enough due to the small wheel diameter and sizing of UGV. So, the concern will be on using sensitive GPS system while using bigger battery at the same time [12].

The project also involves obstacle avoidance for which ultrasonic sensors have been chosen due to their high effectivity in day time as well as in night time. But there can be problems in traffic in metropolitan cities. [Refer Appendix A].

C. Waypoint Navigation

Obstacle avoidance operation depends on the threshold voltage of the sensors. The system is fitted with two ultrasonic sensors inclines at an angle to vertical, so that they may also get some data out of the side wall of bot.

For UGV to change its due course of travel, the voltage in either of them must be higher than the threshold voltage and the other must be lower than if both are raised; the robot will move back and try to move in either directions in less time from the ultrasonic sensor [13]; the robot will move back and try to move in direction less time than the ultrasonic sensor

Basically the methodology is divided into three sections:

1) Waypoint Navigation
2) Obstacle Avoidance using Ultrasonic Sensor
3) Interfacing of GPS with AVR.

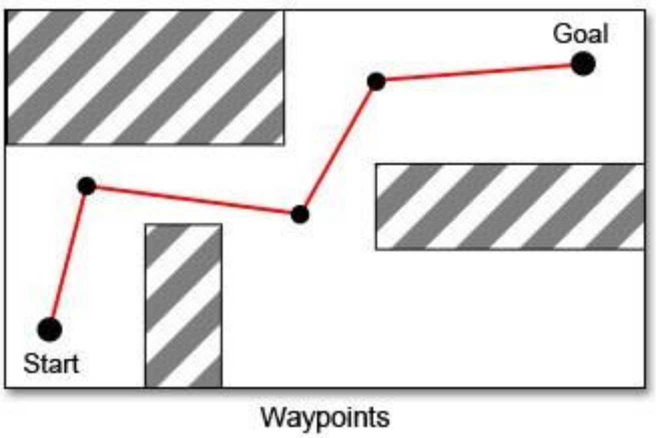

Fig. 6: Path planning

The above figure shows different waypoints which is taken by the vehicle avoiding the obstacles in its path and reaching the final destination.

D. Interfacing of GPS with AVR

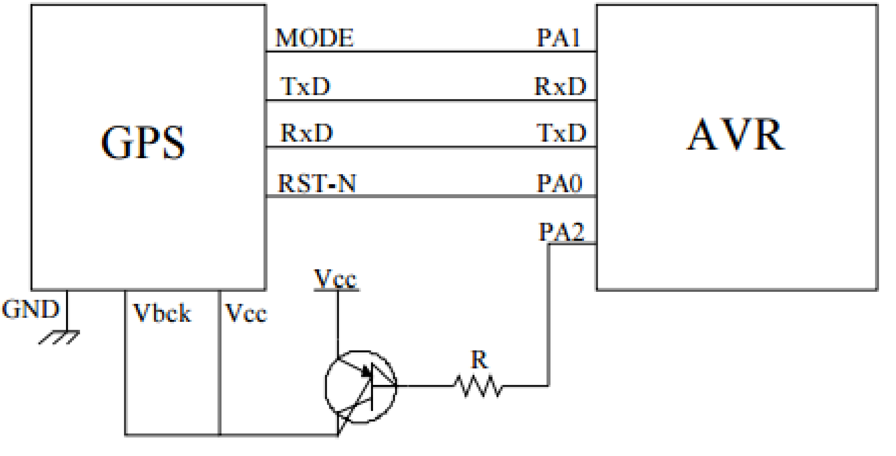

Fig. 7: Control process of AVR to GPS

The control process of AVR to GPS

As shown in figure 8, first set power-on for GPS by clear bit PA2.

After, 300ms set bit PA0 for reset GPS.

Send control command GPS receiver parameters such as:

Setup Full-time operation mode (10000001),

Setup Periodical Output Data (10001111),

Wait for interrupt receiver complete.

Used USART interrupt receive data from GPS then move data into SRAM by assembly program. SRAM address has 400 spaces begin from 0x0060 to 0x045F if writing data into SRAM are full (0x045F) the assembly program will return to write next data into 0x0060 until 0x045F then repeat again [14].

Obstacle Avoidance using Ultrasonic Sensors

The working of the sensors is shown below.

Table 1: Sensors Characteristics

S. No.	Left sensor	Right sensor	Action
1	Low	Low	Move straight
2	High	Low	Move right
3	Low	High	Move Left
4	High	High	Move Back

The Turning of the motor cart is required to change the course of UGV and hence we will need to master the movement of motors and know how to change the direction of motors when required; this problem is solved by giving differential voltage to the motors i.e. by changing the polarity of the motors, the direction of motors are reversed and for stopping them both poles are either high or low depending upon the need. The working algorithm for the project is given in term of flow chart. For the course of obstacle avoidance by the ultrasonic sensors the flow chart diagram is represented as given below for the loop formation. The given flow diagram will be repeated for all the waypoints and stops [15].

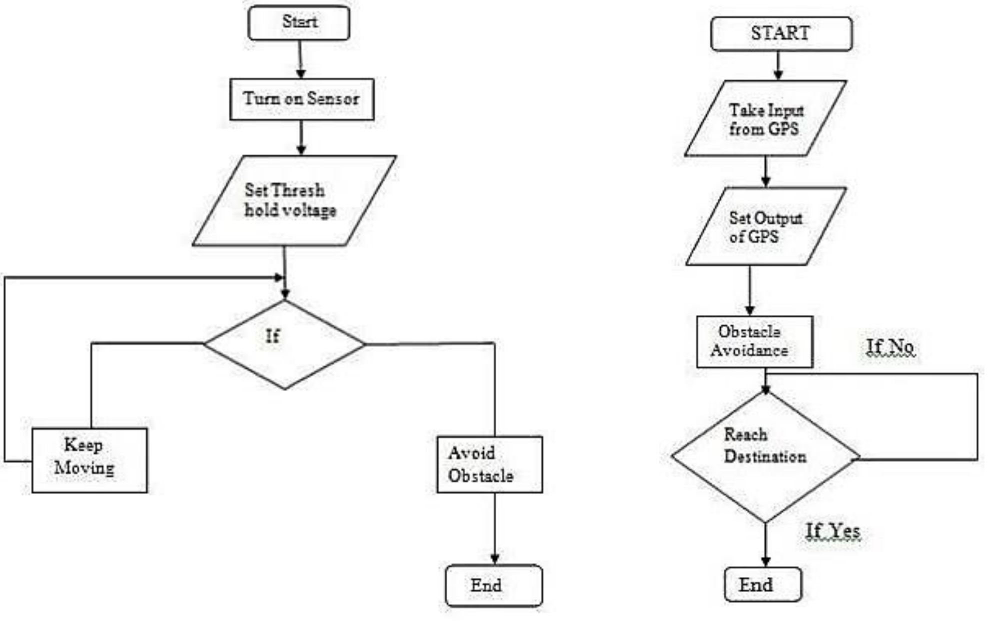

Fig. 8: (a) Complete path of UG (b) Obstacle avoidance

Hardware Required

- GPS- Module Kit V1.0 model RM0035
- DC Motor
- ATMEGA 16 Development Board
- Ultrasonic Sensors- DYP-ME007 V2- Range of 0.02 ~ 5.00m - calculated by

Table 2: Specifications of GPS chosen are

General Characteristics	
Type	GSM/RFID
Voltage (Output)	3.3 Volts
Product ID	RM0035

Dimension	(3.14*0.90) inch
Operating Current	20mA
Interface	Fully Duplex UART (Tx & Rx)
Communication Module	Serial

- distance by 340m/ sec- accuracy 1cm

Fig. 9: GPS Module

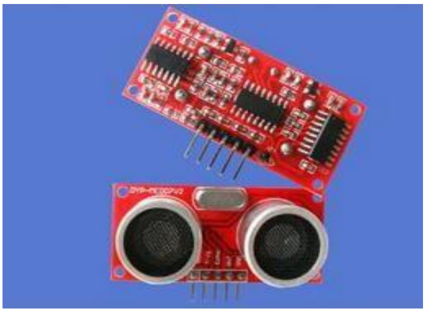

Fig. 10: Ultrasonic Sensor

4. RESULTS

Errors in Global position system (GPS)

The following plot shows the GPS error when we keep it at a particular place for a long time. In the following curve we have taken the co-ordinates of the Aerospace department.
Also some other errors are shown in the following figure 11 as given below:

Ranging errors

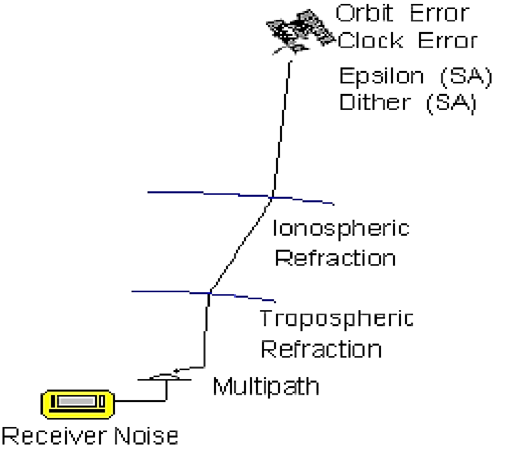

Fig. 11: Ranging Errors in GPS

We kept our GPS there for about half an hour and readings were taken after every thirty seconds. The fluctuations in the readings were observed and therefore a graph is plotted as change in the latitude and longitude is plotted.
The GPS errors are plotted in this curve for the different values of longitudes and latitudes given by GPS on LCD for a specified time and taking the 100 readings for a span of 1 week.
The interpreted result is the plot of readings taken within the span.

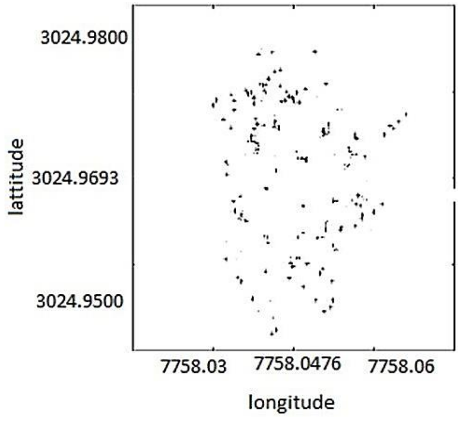

Fig. 12: Longitude Vs. Latitude error

- Coordinates of places where the video has taken are shown below in tabular form.

Table 3: Waypoints

Point name	Longitude	Latitude
Start	077°00’44.3”	30°19’39.8”
Point B	077°00’44.3”	30°19’40.0”
Destination	077°00’44.4”	30°19’40.0”

Ultrasonic sensor

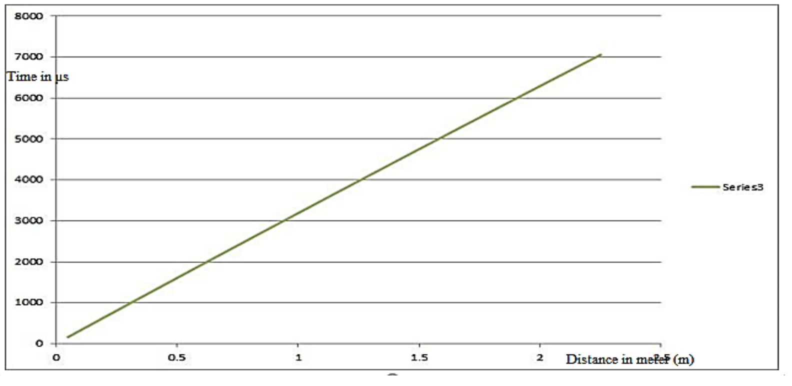

Fig. 13: Distance Vs. Time

The following graph is plotted between the response time and the distance shown by ultrasonic sensor. By this graph we can estimate the velocity of sound. It also shows the estimated time response for the ultrasonic sensor.

This graph can be used to improvise upon the type of sensor used for the obstacle avoidance purpose.

For this curve slope comes out to be 321m/s. Delay in circuit response may be the reason. This last plot shows the obstacle avoidance mechanism when we move from our source to destination.

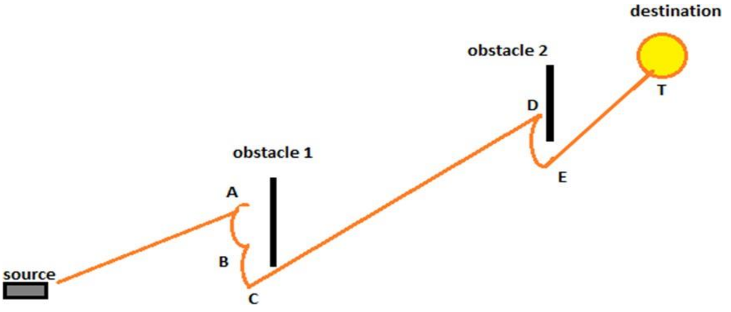

Fig. 14: Vehicle avoiding obstacle

Through this plot we see that when our vehicle starts from the source and senses an obstacle it takes a right turn and again move forward. Same process happens throughout the course of the vehicle until it reaches the final destination.

5. CONCLUSIONS

By using the curve from ultrasonic sensors, the process involves the Waypoint Navigation System is planning of the path of an object that the path goes through some specified coordinates or benchmarks to the final destination thus avoiding any obstacles. GPS is guiding medium from source to destination and two Ultrasonic Sensors with a known distance. Experiment is performed and results were plotted in a curve shown above.
For this curve slope comes out to be 321m/s. Delay in circuit response may be the reason.

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Annexure A

Atmega 8 Development Board

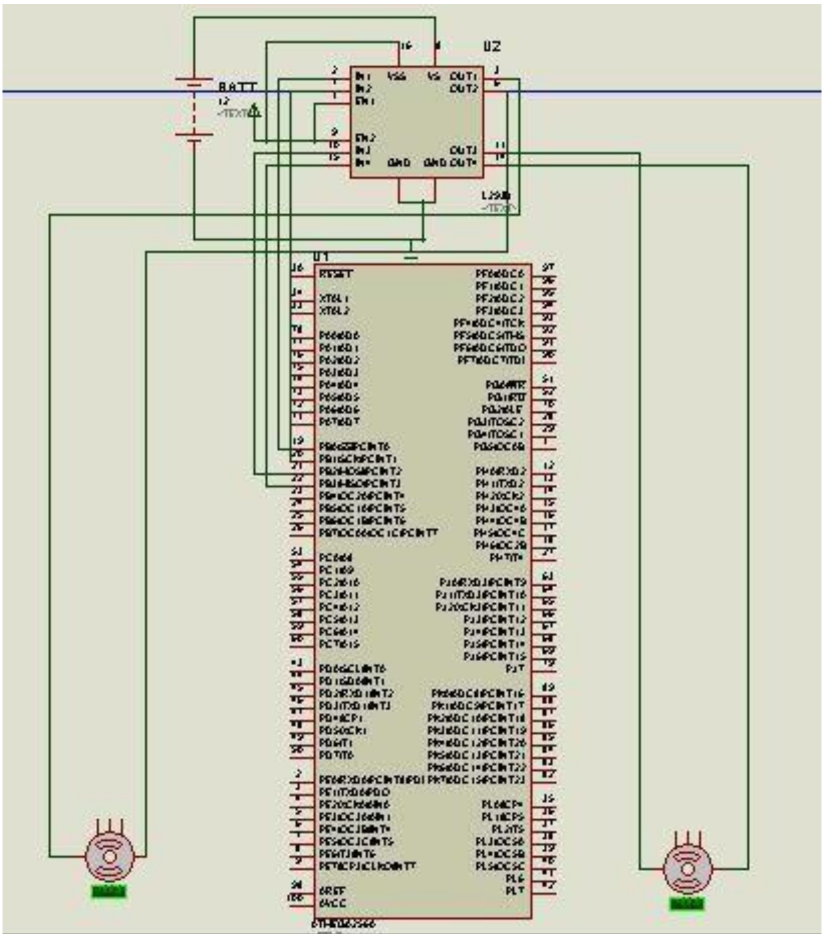

Fig. 15: Proteus circuit diagram