ENERGY EFFICIENT AUTONOMOUS FIELD VEHICLE FOR COMPLETE COVERAGE

A PROJECT REPORT

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BONA FIDE CERTIFICATE

Certified that this project work titled **" ENERGY EFFICIENT AUTONOMOUS FIELD VEHICLE FOR COMPLETE COVERAGE "** is the bona fide work of Mr. LOGANATHAN .M (12MES09) , who carried out the research under my supervision. Certified further, that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other students.

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First I would like to express my hearty thanks to the Trust and Management for giving me an opportunity to exhibit my talents.

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ABSTRACT

Nowadays, service vehicles are being implemented for various functionalities such as tour guidance vehicles [1] & vehicles for search and rescue, vacuum cleaners [3], tractors, automotive painting etc. To make these vehicles autonomous, the amount of human control and interference is to be reduced significantly. Normally, the cost of agricultural materials and systems cannot be controlled; however it should be taken into consideration during the system design. Power consumption is also another major factor to be taken into account. This paper presents a system model that aims to reduce the power consumption of the farming vehicle and to implement complete coverage of agricultural field. This type of system would gain scope for huge precision farming applications such as harvesting, seeding, spraying, applying fertilizers, tillage, and the like.

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LIST OF ABBREVIATIONS

TxD	- Transmitter
RxD	- Receiver
GPS	- Global Positioning System

CHAPTER-I

LITERATURE REVIEW

1.1 LITERATURE REVIEW:

Local Path Planning for Off-Road Autonomous Driving With Avoidance of Static Obstacles

Authors **:** Keonyup Chu, Minchae Lee ; Myoungho Sunwoo

Publications : Intelligent Transportation Systems, IEEE Transactions on (Volume:13 , Issue: 4), Dec. 2012

Summary **:**

In this paper, a real-time path-planning algorithm that provides an optimal path for off-road autonomous driving with static obstacles avoidance is presented. The proposed planning algorithm computes a path based on a set of predefined waypoints. The predefined waypoints provide the base frame of a curvilinear coordinate system to generate path candidates for autonomous vehicle path planning. Each candidate is converted to a Cartesian coordinate system and evaluated using obstacle data. To select the optimal path, the priority of each path is determined by considering the path safety cost, path smoothness, and path consistency. The proposed path-planning algorithms were applied to the autonomous vehicle A1, which won the 2010 Autonomous Vehicle Competition organized by the Hyundai-Kia Automotive Group in Korea.

A Two-level Path Planning Method for On-road Autonomous Driving

Authors **:** Liang Ma, Jing Yang, Meng Zhang

Publications **:** Intelligent System Design and Engineering Application (ISDEA), 2012 Second International Conference on, Jan. 2012

Summary **:**

Here present a real-time path planning method for on-road autonomous driving. This method utilizes a two-level hierarchy consisting of on-road behavior planning and online path generating to achieve feasible paths for autonomous vehicle in dynamic on-road environment which is characterized by lots of structured information and flat terrain. An on-road behavior planning technique is used to transform the uncertain path planning problem into several determined sub-ones. Then, the online path planning algorithm is applied to solve these sub-problems. This method contains three major components: anytime behavioral replanning, online path planning and mitigation strategy for time lag due to an agent system with asynchronous multi-sensor. We evaluate the proposed method on the KUAFU-1, an autonomous vehicle prototype modified by ourselves. Experimental results show that the proposed method can successfully provide real-time feasible paths in various on-road traffic sceneries.

Design of intelligent mobile vehicle system and its global optimal path planning

Authors **:** Xiaoyong Ye, Yong Lei, Haijun Hou

Publications **:** Industrial Technology, 2008. ICIT 2008. IEEE International Conference , April 2008

Summary **:**

The intelligent mobile vehicle (IMV) is designed on embedded system with ARM9 and Windows CE.NET embedded operation system (EOS). It is a completely autonomous mobile vehicle system with hardware executive mechanics and corresponding intelligent path planning algorithm. The goal for the IMV is to run from the start point to the end point along the shortest path in any random scene autonomously. There are three problems needed to be solved to fulfill the goal: acquire the scene information, quickly plan out the global shortest path and track the optimal path. The global scene information is got through camera on top, then processed and transmitted to the IMV by radio and the global optimal path is planned out based on improved ant colony algorithm. The IMV tracks the optimal path by controlling the driver wheels with two DC motors based on fuzzy control method. Many sensors also

must be equipped to assist tracking the shortest path. All the algorithms are realized with C++ under Windows CE.NET. The experiments show that the IMV system has a good performance in planning and tracking the global optimal path autonomously.

Study of technology on path planning for mobile robots

Authors **:** Li Guangshun, Shi Hongbo

Publications **:** Control and Decision Conference, 2008. CCDC 2008, July 2008

Summary **:**

The research of intelligent robot technology is the hot topic recently. Intelligent robot path planning technology is one of the important domains in intelligent robot technologies psila research. The paper mainly includes global path planning and local path planning. The classification and present situation of mobile robot is summarized. In addition, the advantages and disadvantages of these algorithms are pointed out, and also some algorithms is improved. At last, the trend of mobile robot path planning is described.

A fast path planning by path graph optimization

Authors **:** Joo Young Hwang ,Korea Adv. Inst. of Sci. & Technol., South Korea Jun Song Kim ; Sang Seok Lim ; Kyu Ho Park

Publications **:** Systems, Man and Cybernetics, Part A: Systems and Humans, IEEE Transactions on (Volume:33 , Issue: 1), Jan. 2003

Summary **:**

A fast path planning method by optimization of a path graph for both efficiency and accuracy is proposed. A conventional quadtree-based path planning approach is simple, robust, and efficient. However, it has two limitations. We propose a path graph optimization technique employing a compact mesh representation. A world space is triangulated into a base mesh and the base mesh is simplified to a compact mesh. The compact mesh representation is object-dependent; the positions of vertexes of the mesh are optimized according to the curvatures of the obstacles. The compact mesh represents the obstacles as accurately as the quadtree even though using much fewer vertexes than the quadtree. The compact mesh distributes vertexes in a free space in a balanced way by ensuring that the lengths of edges are below an edge length threshold. An optimized path graph is extracted from the compact mesh. An iterative vertex pushing method is proposed to include important obstacle boundary edges in the path graph. Dijkstra's shortest path searching algorithm is used to search the shortest path in the path graph. Experimental results show that the path planning using the optimized path graph is an order of magnitude faster than the quadtree approach while the length of the path generated by the proposed method is almost the same as that of the path generated by the quadtree.

Path planning problems and solutions

Authors **:** Goldman, J.A. Syst. Concepts Section, Wright Res. & Dev. Center, Wright-Patterson AFB, OH, USA

Publications **:** Aerospace and Electronics Conference, 1994. NAECON 1994., Proceedings of the IEEE 1994 National, May 1994

Summary **:**

Path planning has been a topic of research in many areas including robotics and navigation. The purpose of this paper is to explore the problems of three-dimensional path planning in the context of a point-like airplane traveling to avoid circular danger regions. We will explore two distinct problems. The first problem is how to plan a path when the locations of all the dangers are known. The solution to this problem gives the plane an optimal path to follow before it even leaves the ground. We will refer to this as the global path planning case. In the second problem, the locations of the dangers are not known in advance. Instead, the locations of the danger points are known to the plane when they are within a sensor range, the plane changes its path when

it senses the danger areas. We will refer to the second problem as the dynamic path planning case. Both of these cases will be subject to turning constraints. For the global path planning case, the problem can be solved with Collins decomposition. The dynamic path planning case, however, is still open ended. This paper outlines several approaches and their pitfalls concluding with sub goal avoidance as a solution for particular classes of reconnaissance scenarios.

1.2 PROBLEM STATEMENT:

- Service vehicles are being implemented for various functionalities such as tour guidance vehicles [1] & vehicles for search and rescue, vacuum cleaners [3], tractors, automotive painting etc.
- To make these vehicles autonomous, the amount of human control and interference is to be reduced significantly.
- Normally, the cost of agricultural materials and systems cannot be controlled; however it should be taken into consideration during the system design.
- Power consumption is also another major factor to be taken into account.

1.3 METHODOLOGY OF SOLVING THE PROBLEM:

- Follows GEOMETRY METHOD.
- Plans path on the fly.
- Appropriate operational modes can be chosen– either **energy conservation** or **time saver mode**.
- Uses GPS for field and obstacle manipulation.
- Requires no prior learning.
- Wall following technique employed to overcome the obstacle.
- Assumption–- field features to be convex polygons

CHAPTER-II

INTRODUCTION

2.1 INTRODUCTION:

Robots to be designed for agricultural techniques must replace human operators and must be built using limited set of tools. A completely autonomous robot must be capable of understanding its environment, work for unlimited time without any intervention, adapt to environmental changes and must also provide human safety. Autonomous path and motion planning being one of the fields with wider scope, lots of research works are been undertaken in it. A number of complete coverage path planning methodologies have been implemented for agricultural farms [8][9][11], in which path planning and obstacle avoidance are of significant importance in these aforementioned systems. In this paper the following features are considered

- Path planning
- Complete coverage
- Obstacle Avoidance
- Power Optimization

EXISTING METHODOLOGIES

Several systems were implemented using advanced AI (Artificial Intelligence) and fuzzy logic such as Neural network approach [1], swarm intelligence [6] with biological system inspirations [4][11]. Though nearly 100% optimality can be achieved using such techniques, the main drawback of the aforementioned techniques is that those require a learning phase which incurs additional cost to the system design process.

In case of large field of about acres and hectares, learning cost grows much worse. Hence the main objective of vehicle design is to develop a geometric approach that computes path on the fly without prior learning. Even Image processing techniques (Vision-based navigation systems)[10] are being used for covering larger terrains. Owing to poor performance of image processing with changing environmental conditions, it cannot be considered as better choice for such vehicles. But a system as the one proposed here is capable of achieving the objective, irrespective of the day/night time, poor visibility due to climatic conditions.

2.2 SYSTEM COMPONENTS AND WORK FLOW:

2.2.1 System work flow:

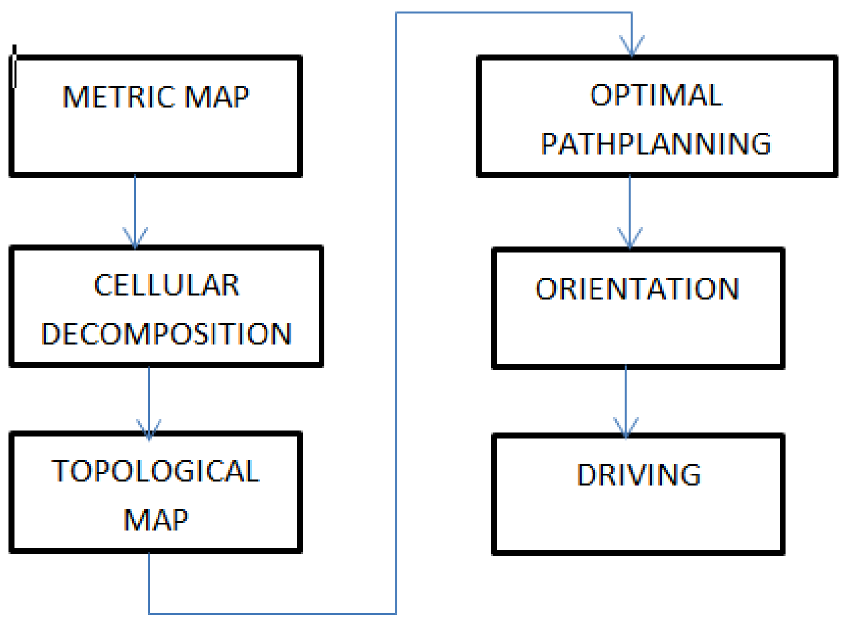


Fig. 2.1System workflow

2.2.2 USER INERFACE UNIT

The user interface unit consists of a matrix keypad, Liquid crystal Display and a buzzer. The dimensions of the agricultural field are usually provided to the system by means of the keypad. The input would be the length and breadth of the field.

The LCD is used for notifying messages to the user. The messages include

- Notification about completion of harvest process
- Errors, if any, occurring in system
- The field information while feeding the input to the system

The buzzer is used to warn user about battery power down.

2.2.3 HARVERSTER UNIT

The harvester unit comprises of the actuators for carrying out cutting process. The blade suitable for the crop should be fixed up for harvesting mechanism. For current system implementation, only the cutter is been considered. The provisions for additional mechanism such as seedling, application of fertilizers, etc. can also be included for future enhancements.

2.2.4 ROBOT MOVEMENT CONTROL UNIT

As per input fed to the system, the path traversal is computed and the controller instructs the robotic wheel movement. The drivers associated with the robot wheel are used to co-ordinate the wheel movement. IR sensors are used to identify wheel movement and the sensor data are fed as input to the controller to perform further system operations. The movement of the robot as per the applied input is verified and also the turns made during traversal are also been monitored.

2.2.5 COMMUNICATION UNIT

The information about system functioning such as errors occurred in the system, battery power drain, completion of harvester process, etc. are sent to user mobile with the help of GSM. The system could also be stopped by sending sms from user mobile. Level converter MAX232 is used for interfacing GSM modem with the system controller.

The sending SMS through GSM modem when interfaced with microcontroller or PC is much simpler as compared with sending SMS through Modem in PDU Mode. Text message may be sent through the modem by interfacing only three signals of the serial interface of modem with microcontroller i.e.,TxD,RxD and GND.In this scheme RTS and CTS signals of serial port interface of GSM Modem are connected with each other. The transmit signal of serial port of microcontroller is connected with transmit signal (TxD) of the serial interface of GSM Modem while receive signal of microcontroller serial port is connected with receive signal (RxD) of serial interface of GSM Modem.

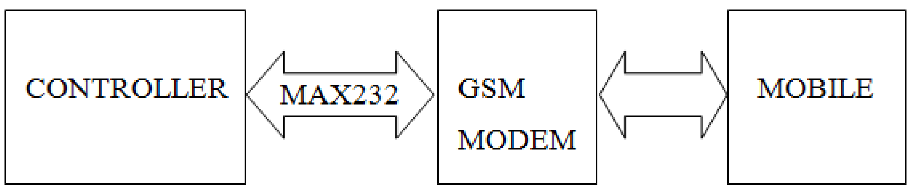


Fig. 2.2 Communication unit

2.2.6 BATTERY LEVEL MONITORING UNIT

The system is battery powered and if battery power drains during system execution, the battery level monitoring unit is used to notify user about power drain. The signal from this unit enables buzzer as a warning to user. Battery powered robot systems perform very sophisticated tasks making higher demands on the limited power supply. Operation breakdowns can only be avoided with an adequate knowledge of the available energy and a proper battery management.

2.3 WORKING DESCRIPTION:

2.3.1 PATH PLANNING

It is the process of finding an optimal path that covers the entire field and such that it minimizes certain costs, especially in case of an agricultural environment. Basically farming costs depends on time and area coverage. Hence finding the shortest path computation is concerned with the optimality to be obtained. In this model two phases are involved in path planning process, namely

- Offline or global planning
- Online or local planning

OFFLINE PLANNING

The offline planning or global planning refers to computation of optimal path without taking the obstacles into consideration. In this model, the fields dimensions are fed into the system as the set of co-ordinates those describe the boundaries of the filed. From these co-ordinates, the boundary edges of the field are calculated using interpolation methods such as trapezoidal co-ordinate transformation and inverse transformations.

ONLINE PLANNING

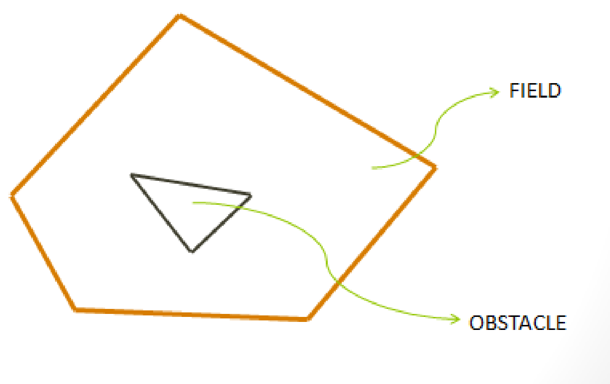
This refers to planning of path dynamically when the systems traverse through the field. Wall following technique can be considered for obstacle avoidance. Finding obstacles along the path can be carried out with the help of combination of sensors. However, sensing pits in fields is not considered in this model. Different types of sensors can be used for various features of the fields and type of application to be carried out.

The metric map is the world file where the co-ordinates can be located either using global map service or by entering the latitude, longitude co-ordinates obtained using the GPS receivers placed at requires field boundaries. The cellular decomposition is used for transforming the metric map into topological map.

The topological map takes the form of graph which consists of cells, making it suitable for computation. Localization and orientation of vehicle is achieved with the help of Differential Global Positioning System (GPS) that achieves accuracy with error percent lesser than 1%. The global path planning is completed once the topological map is constructed.

After finding the optimal path and direction, the vehicle has to orient itself in the particular direction with the help of used Navigation system, say, GPS. Finally the vehicle is driven with the instructions by the controller node.

2.3.2 CELLULAR DECOMPOSITION AND OPTIMIZATION



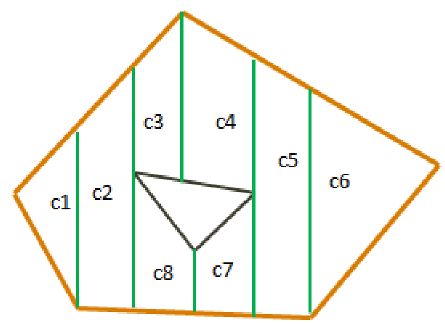


Fig. 2.3 A field with an obstacle **Fig 2.4 Cellular decomposition**

For regular shaped fields such as square or rectangular fields, the optimization can be achieved in a simpler way. For example, the path of traversal can be planned parallel to the longest edge of its boundary as shown in the following figure.

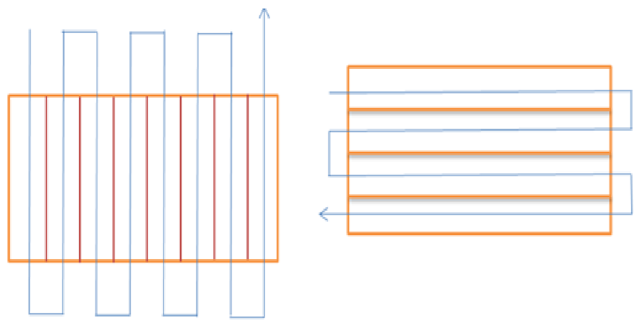


Fig.2.5 Routing parallel to shorter edge(a) and longer edge(b)

For irregular shaped fields some advanced methods should be used. One of such algorithm is the “divide and merge” method. The following are the steps involved in the algorithm execution.

- Division of field in to several cells
- Finding optimal path for each individual cell
- Merging all the cells with a global optimal path.

The cellular decomposition can be done using either exact cellular decomposition or combining it with boustrophedon passes. This is used to decompose the fields into trapezoidal cells using plane sweeping.

The trapezoidal cells are analyzed for the optimal path and start direction. This is similar to the method defined for regular shaped fields. During the final stage, all the cells are merged with several constraints. One of the conditions for merging is that when two adjacent cells have same path direction and there occurs a chance for smooth transition between those cells, they can be merged into a single cell.

2.3.3 OBSTACLE AVOIDANCE

Obstacle avoidance is of greater complexity for implementation. Normally the obstacles can be detected using a wide range of sensors [5]. For example, the Infrared and ultrasonic sensors can be used to identify static sensors. Image processing can be used. In case of harvesting application still more complex sensory system has to be implemented. This is because the image processing subsystem must be efficient and faster enough to identify obstacles as the vehicle moves towards it, however, the distance between the system and the obstacle cannot be interpreted [2][7].

Ultrasonic sensors can be used in such a case but the obstacles cannot be perceived properly, that is the system will not be able to analyze whether the confronted object is an obstacle or a crop plant. In such a case a complex design must be implemented to differentiate between the field objects. The positioning of sensors also depends upon the height of crop plants, and similar characteristics. The pits or wells are still difficult to identify in a farm field. For simpler implementations these features are not considered in this system definition. A simpler sensory system with 3 or 4 ultrasonic sensors are used in this model.

So far, the considerations were made for static obstacles that take the structure of convex polygon. During routing of the vehicle, dynamic obstacles such as animals, etc., can also be faced. In case of an obstacle being identified, wall following technique can be undertaken. That is, the vehicle is made to traverse along the contour of the obstacle. When the obstacle is dynamic, the vehicle is instructed to pause for specific time period and then to resume work once the path is free from it [9].

2.3.4 POWER OPTIMIZATION

The energy cost of robotic vehicle is highly associated with the number of turns the vehicle takes during its traversal. The controversial characteristic of time and energy considerations is that only either of the two can be achieved at a time. More the number of turns, lesser the routing time but higher the cost incurred with respect to power consumption. Therefore the number of turns can be reduced. Energy utilized during a turn is significantly more when compared to a straight pass. In a single Boustrophedon pass, two turns are involved (1 right and 1 left turn) .In such cases, the wall following passes can be implemented as follows

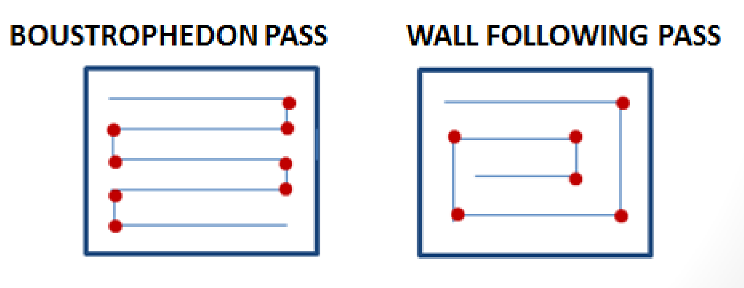


Fig.2.7 Comparison of methods

With addition to this, the vehicle can be provided with solar cells, for improving power saving and proper utilization of solar power. The power optimality also depends on the path planning algorithm used. The path with the minimal turning parameters would consume the least energy. The path planning suitable for coverage time reduction is depicted. The path planning meant for energy conservation. The main difference between the two is that the amount of turning parameters is reduced in the second method

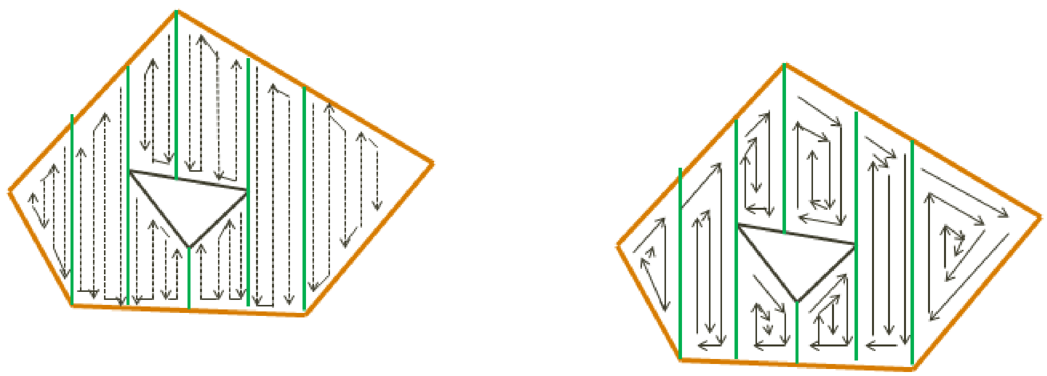


Fig 2.8 Path planning for(a) time saver mode (b)power saver mode.

CHAPTER-III

HARDWARE DESCRIPTION

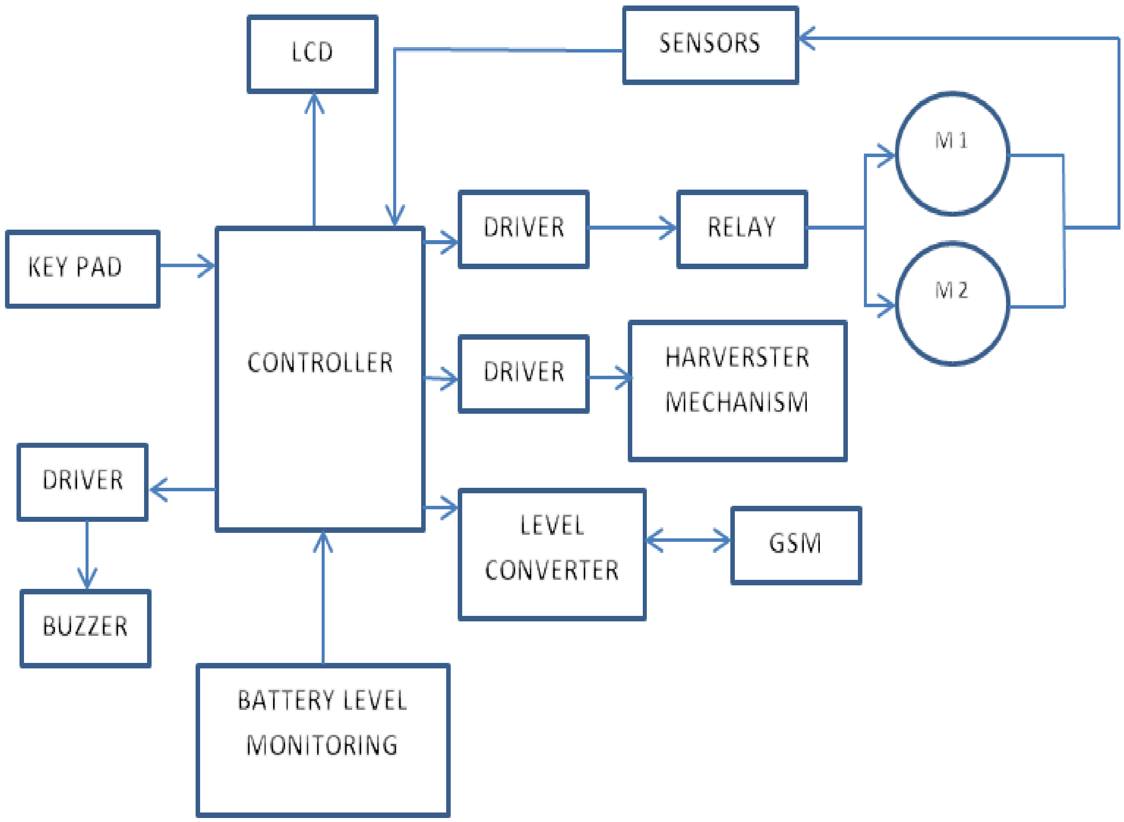


Fig. 3.1 System components

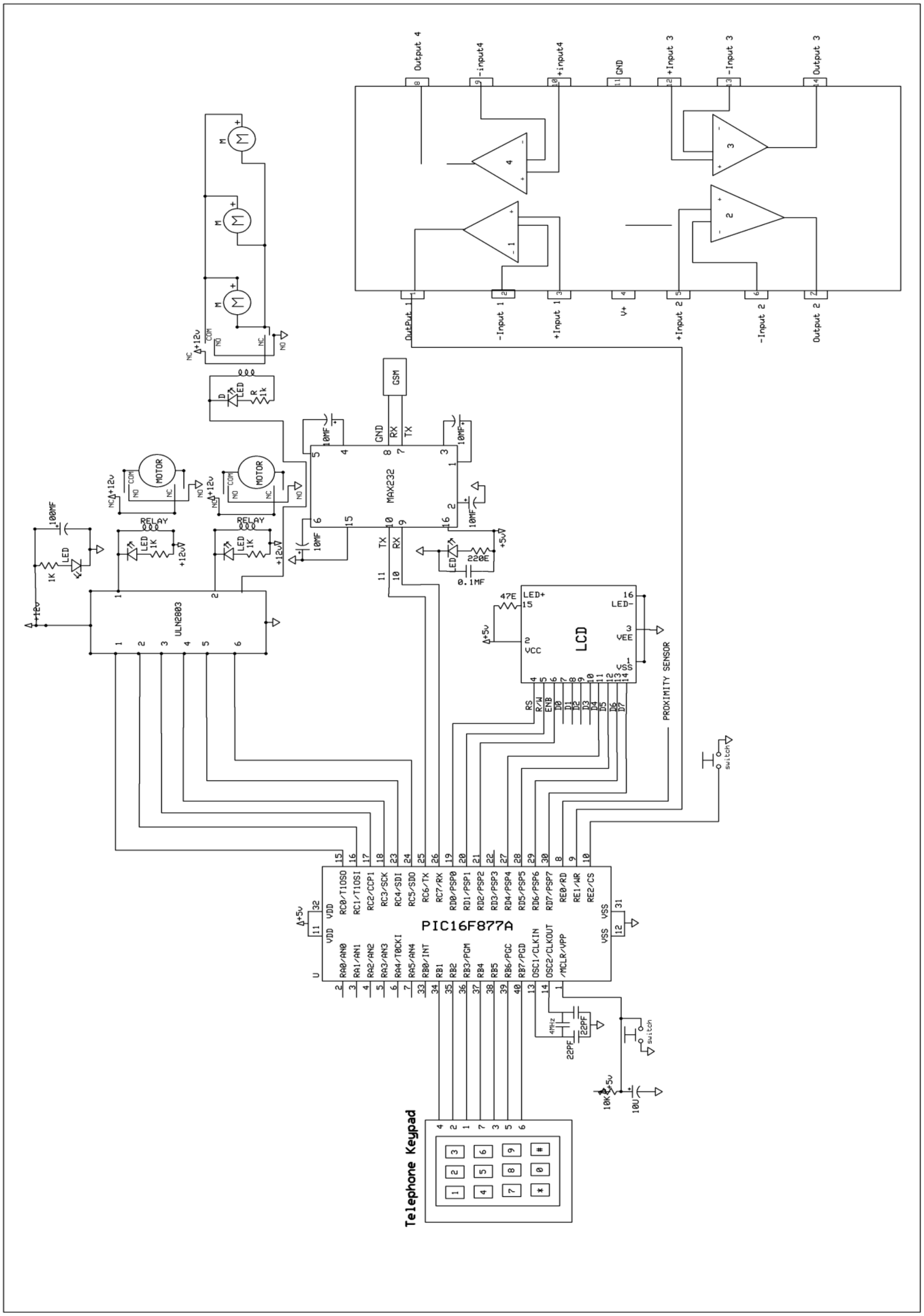


Fig. 3.2 Pin Schematic diagram

3.1 SENSORS:

A sensor is a device which measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. Monitoring and controlling of robotic wheel movement is of significance in the system. This is because the system should be made capable of identifying malfunctioning of motors those drive the robotic wheel. The sensor used in this system is Infra-Red Sensor.

3.1.1 INFRA-RED SENSOR

Infrared imaging is used extensively for military and civilian purposes. Military applications include target acquisition, surveillance, night vision, homing and tracking. Non-military uses include thermal efficiency analysis, remote temperature sensing, short-ranged wireless communication, spectroscopy, and weather forecasting. Infrared astronomy uses sensor-equipped telescopes to penetrate dusty regions of space, such as molecular clouds; detect cool objects such as planets, and to view highly red-shifted objects from the early days of the universe.

3.1.1.1 Features of the IR sensor:

1. Infrared radiation (IR) is electromagnetic radiation with a wavelength between 0.7 and 300 micrometers, which equates to a frequency range between approximately 1 and 430 THz.
2. Its wavelength is longer (and the frequency lower) than that of visible light, but the wavelength is shorter (and the frequency higher) than that of terahertz radiation microwaves.

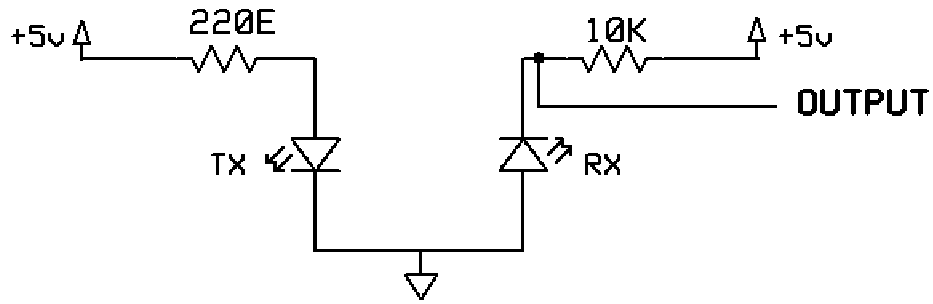


Fig. 3.1.1 IR sensor

The schematic is divided into 2 parts the **sender** and the **receiver**. **The sender** is composed of an IR LED (D2) in series with a 470 Ohm resistor, yielding a forward current of 7.5 mA. **The receiver** part is more complicated, the 2 resistors R5 and R6 form a voltage divider which provides 2.5V at the anode of the IR LED (here, this led will be used as a sensor). When IR light falls on the LED (D1), the voltage drop increases, the cathode's voltage of D1 may go as low as 1.4V or more, depending on the light intensity. This voltage drop can be detected using an Op-Amp (operational Amplifier **LM358**). You will have to adjust the variable resistor (POT.) R8 so the voltage at the positive input of the Op-Amp (pin No. 5) would be somewhere near 1.6 Volt. if you understand the functioning of Op-Amps, you will notice that the output will go High when the volt at the cathode of D1 drops under 1.6. So the output will be High when IR light is detected, which is the purpose of the receiver.

3.2 USER INTERFACES:

3.2.1. BUZZER

A buzzer or beeper is a signaling device, usually electronic, typically used in automobiles, household appliances such as a microwave oven, or game shows. It most commonly consists of a number of switches or sensors connected to a control unit that determines if and which button was pushed or a preset time has lapsed, and usually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound. Initially this device was based on an electromechanical system which was identical to an electric bell without the metal gong (which makes the ringing noise). Often these units were anchored to a wall or ceiling and used the ceiling or wall as a sounding board. Another implementation with some AC-connected devices was to implement a circuit to make the AC current into a noise loud enough to drive a loudspeaker and hook this circuit up to a cheap 8-ohm speaker. Nowadays, it is more popular to use a ceramic-based piezoelectric sounder like a Sonalert which makes a high-pitched tone. Usually these were hooked up to "driver" circuits which varied the pitch of the sound or pulsed the sound on and off.

The word "buzzer" comes from the rasping noise that buzzers made when they were electromechanical devices, operated from stepped-down AC line voltage at 50 or 60 cycles. Other sounds commonly used to indicate that a button has been pressed are a ring or a beep.

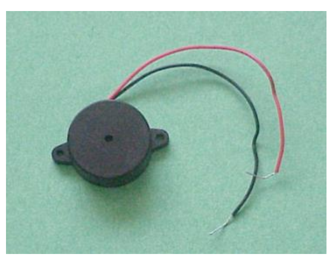


Fig. 3.2.1 Buzzer

3.2.2 KEYPAD

Keypads are a part of HMI or Human Machine Interface and play really important role in a small embedded system where human interaction or human input is needed. Matrix keypads are well known for their simple architecture and ease of interfacing with any microcontroller. The 4x4 Keypad is a general purpose 16 button (4x4) matrix keypad. It comes ready to work, simply peel-off the adhesive backing, stick it to your surface and plug it in. Its 76mm x 102 mm and has an extra-long flex cable lead length of 72mm. Available in black only.

Fig. 3.2.2 Matrix keypad

This keypad provides a visually appealing way to get numeric data to your control system. The board is a series of pushbutton switches that provide structured input for measuring user input. Output pins are 1-7, where pin 1 corresponds to the pin closest to the * key.

3.2.3 LIQUID CRYSTAL DISPLAY

A liquid crystal display (LCD) is an electronically-modulated optical device shaped into a thin, flat panel made up of any number of color or monochrome pixels filled with liquid crystals and arrayed in front of a light source (backlight) or reflector. It is often utilized in battery-powered electronic devices because it uses very small amounts of electric power. LCD has material, which continues the properties of both liquids and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered from similar to a crystal.

LCD consists of two glass panels, with the liquid crystal materials sandwiched in between them. The inner surface of the glass plates is coated with transparent electrodes which define in between the electrodes and the crystal, which makes the liquid crystal molecules to maintain a defined orientation angle. When a potential is applied across the cell, charge carriers flowing through the liquid will disrupt the molecular alignment and produce turbulence.

When the liquid is not activated, it is transparent. When the liquid is activated the molecular turbulence causes light to be scattered in all directions and the cell appears to be bright. Thus the required message is displayed. When the LCD is in the off state, two polarizer's and the liquid crystal rotate the light rays, such that they come out of the LCD without any orientation, and hence the LCD appears transparent.

Fig. 3.2.3 Liquid Crystal Display

3.3 ACTUATORS AND DRIVERS:

3.3.1 RELAYS

A relay is an **electrically operated switch**. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and most have **double throw** (**changeover**) switch contacts as shown in the diagram. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. The maximum output current for the popular 555 timer IC is 200mA so these devices can supply relay coils directly without amplification.

Fig. 3.3.1 Relay

Relays are usually SPDT or DPDT but they can have many more sets of switch contacts, for example relays with 4 sets of changeover contacts are readily available. The coil will be obvious and it may be connected either way round. Relay coils produce brief high voltage 'spikes' when they are switched off and this can destroy transistors and ICs in the circuit. To prevent damage you must connect a protection diode across the relay coil.

The relay's switch connections are usually labeled COM, NC and NO:

- **COM** = Common, always connect to this, it is the moving part of the switch.
- **NC** = Normally Closed, COM is connected to this when the relay coil is **off**.
- **NO** = Normally Open, COM is connected to this when the relay coil is **on**.
- Connect to COM and NO if you want the switched circuit to be **on when the relay coil is on**.
- Connect to COM and NC if you want the switched circuit to be **on when the relay coil is off**.

3.3.2 DC MOTOR

DC motors are part of the electric motors using DC power as energy source. These devices transform electrical energy into mechanical energy. The basic principle of DC motors is same as electric motors in general, the magnetic interaction between the rotor and the stator that will generate spin.

Simple motor has six parts:

1. Armature or rotor
2. Commutator
3. Brushes
4. Axle
5. Field magnet
6. DC power supply of some sort

3.3.2.1 Working Principle of DC motor

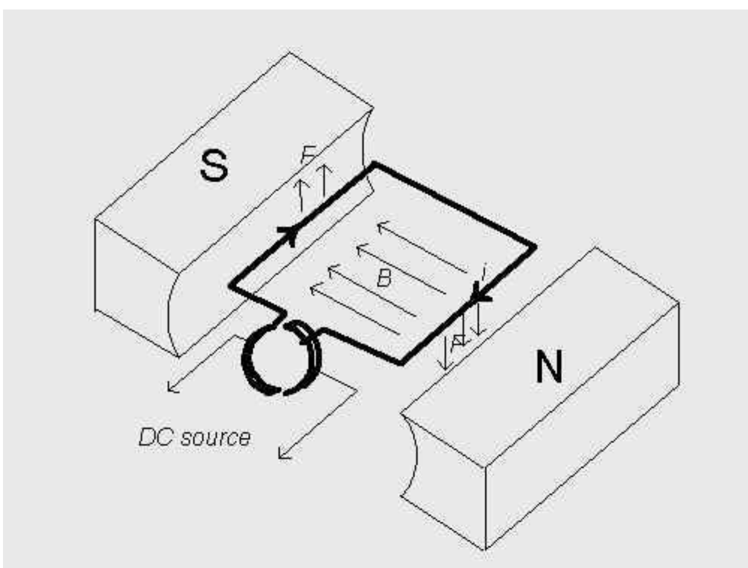


Fig. 3.3.2 DC Motor

When DC electric current flowing in the coil in accordance with the direction of the arrow, while the direction of the magnetic field B is from north to south pole, the coil will be driven by the force F in the direction as shown in Figure 1. This condition occurs continuously so will result in rotation on the axis of the coil. The direction of the electric current in the coil is fixed, because of the split ring on the end of the coil.

The major classes of DC motors are

- Shunt wound.
- Series wound.
- Compound wound.
- Separately excited.

These types of motors differ only in the connection of the field circuits. The armatures, commutators, and so forth are nearly identical with each other and with those of the generators. All four major classes of motors are widely used. This is in contrast to the generators, in which the compound wound type is used for nearly all general power applications.

3.3.3 RELAY DRIVER

A relay is an electro-magnetic switch which is useful if you want to use a low voltage circuit to switch on and off a light bulb (or anything else) connected to the 220v mains supply. The diagram below shows a typical relay (with "normally-open" contacts).

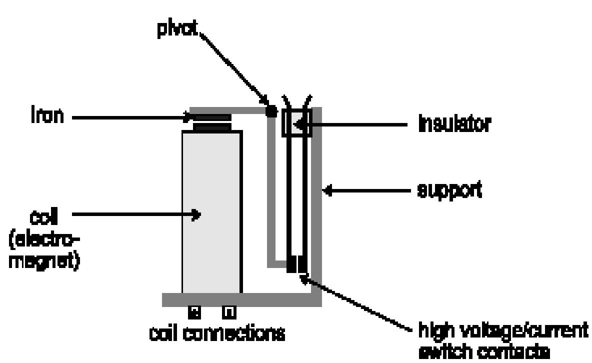


Fig. 3.3.3 Relay driver

The current needed to operate the relay coil is more than can be supplied by most chips (op. amps etc), so a transistor is usually needed.

3.3.3.1Driver using IC ULN 2803:

A ULN2803 is an Integrated Circuit (IC) chip with a High Voltage/High Current Darlington Transistor Array. It allows you to interface TTL signals with higher voltage/current loads. In English, the chip takes low level signals (TLL, CMOS, PMOS, NMOS - which operate at low voltages and low currents) and acts as a relay of sorts itself, switching on or off a higher level signal on the opposite side.

A TTL signal operates from 0-5V, with everything between 0.0 and 0.8V considered "low" or off, and 2.2 to 5.0V being considered "high" or on. The maximum power available on a TTL signal depends on the type, but generally does not exceed 25mW (~5mA @ 5V), so it is not useful for providing power to something like a relay coil. Computers and other electronic devices frequently generate TTL signals. On the output side the ULN2803 is generally rated at 50V/500mA, so if can operate small loads directly. Alternatively, it is frequently used to power the coil of one or more relays, which in turn allow even higher voltages/currents to be controlled by the low level signal. In electrical terms, the ULN2803 uses the low level (TTL) signal to switch on/turn off the higher voltage/current signal on the output side.

The ULN2803 comes in an 18-pin IC configuration and includes eight (8) transistors. Pins 1-8 receive the low level signals; pin 9 is grounded (for the low level signal reference). Pin 10 is the common on the high side and would generally be connected to the positive of the voltage you are applying to the relay coil. Pins 11-18 are the outputs (Pin 1 drives Pin 18, Pin 2 drives 17, etc.).

The ULN2803 is a small integrated circuit that contains 8 transistor driver channels. Each channel has an input to a resistor connected to the base of a transistor and a 1 amp open collector output capable of handling up to about 30volts .Each of the collectors has a reverse biased diode connected to a common Vcc pin that provides inductive spike protection. Typical uses are for micro-processor interfaces to relays, lamps, solenoids and small motors. A 2803 with a set of relays is a simple and effective way of switching mains voltages for example. They are used less commonly today but were once an almost universal means of interfacing processors to power devices.

3.3.3.2Driver Features

1. TTL, DTL, PMOS, or CMOS Compatible Inputs
2. Output Current to 500 mA
3. Output Voltage to 95 V
4. Transient-Protected Outputs
5. Dual In-Line Package or Wide-Body Small-Outline Package

3.4 GSM:

GSM, which stands for *G*lobal *S*ystem for *M*obile communications, reigns as the world's most widely used cell phone technology. Cell phones use a cell phone service carrier's GSM network by searching for cell phone towers in the nearby area. The origins of GSM can be traced back to 1982 when the Groupie Special Mobile (GSM) was created by the European Conference of Postal and Telecommunications Administrations (CEPT) for the purpose of designing a pan-European mobile technology.

It is approximated that 80 percent of the world uses GSM technology when placing wireless calls, according to the GSM Association (GSMA), which represents the interests of the worldwide mobile communications industry. This amounts to nearly 3 billion global people. GSM uses digital technology and is a second-generation (2G) cell phone system. GSM, which predates CDMA, is especially strong in Europe. EDGE is faster than GSM and was built upon GSM.

GSM carrier frequencies

- GSM networks operate in a number of different carrier frequency ranges (separated into GSM frequency ranges for 2G and UMTS frequency bands for 3G), with most 2G GSM networks operating in the 900 MHz or 1800 MHz bands.

Where these bands were already allocated, the 850 MHz and 1900 MHz bands were used instead (for example in Canada and the United States). In rare cases the 400 and 450 MHz frequency bands are assigned in some countries because they were previously used for first-generation systems.

- Most 3G networks in Europe operate in the 2100 MHz frequency band.
- Regardless of the frequency selected by an operator, it is divided into timeslots for individual phones to use. This allows eight full-rate or sixteen half-rate speech channels per radio frequency. These eight radio timeslots (or eight burst periods) are grouped into a TDMA frame. Half rate channels use alternate frames in the same timeslot. The channel data rate for all 8 channels is 270.833 kbit/s, and the frame duration is 4.615 ms.
- The transmission power in the handset is limited to a maximum of 2 watts in GSM850/900 and 1 watt in GSM1800/1900.
- A GSM modem is a wireless modem that works with a GSM wireless network. A wireless modem behaves like a dial-up modem. The main difference between them is that a dial-up modem sends and receives data through a fixed telephone line while a wireless modem sends and receives data through radio waves.
- A GSM modem can be an external device or a PC Card / PCMCIA Card. Typically, an external GSM modem is connected to a computer through a serial cable or a USB cable. A GSM modem in the form of a PC Card / PCMCIA Card is designed for use with a laptop computer. It should be inserted into one of the PC Card / PCMCIA Card slots of a laptop computer.
- A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. From the mobile operator perspective, a GSM modem looks just like a mobile phone.
- A GSM modem can be a dedicated modem device with a serial, USB or Bluetooth connection, or it may be a mobile phone that provides GSM modem capabilities.
- The term GSM modem is used as a generic term to refer to any modem that supports one or more of the protocols in the GSM evolutionary family, including

the 2.5G technologies GPRS and EDGE, as well as the 3G technologies WCDMA, UMTS, HSDPA and HSUPA.

- A GSM modem exposes an interface that allows applications such as Now SMS to send and receive messages over the modem interface. The mobile operator charges for this message sending and receiving as if it was performed directly on a mobile phone. To perform these tasks, a GSM modem must support an "extended AT command set" for sending/receiving SMS messages, as defined in the ETSI GSM 07.05 and 3GPP TS 27.005 specifications.
- GSM modems can be a quick and efficient way to get started with SMS, because a special subscription to an SMS service provider is not required. The mobile operator charges for this message sending and receiving as if it was performed directly on a mobile phone. In most parts of the world, GSM modems are a cost effective solution for receiving SMS messages, because the sender is paying for the message delivery.

3.5 LEVEL CONVERTER MAX232:

The **MAX232** is an integrated circuit that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals.

The drivers provide RS-232 voltage level outputs (approx. ± 7.5 V) from a single + 5 V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing RS-232 in devices that otherwise do not need any voltages outside the 0 V to + 5 V range, as power supply design does not need to be made more complicated just for driving the RS-232 in this case.

The receivers reduce RS-232 inputs (which may be as high as ± 25 V), to standard 5 V TTL levels. These receivers have a typical threshold of 1.3 V, and a typical hysteresis of 0.5 V. The later MAX232A is backwards compatible with the original

MAX232 but may operate at higher baud rates and can use smaller external capacitors – 0.1 μF in place of the 1.0 μF capacitors used with the original device.

When a MAX232 IC receives a TTL level to convert, it changes a TTL Logic 0 to between +3 and +15V, and changes TTL Logic 1 to between -3 to -15V, and vice versa for converting from RS232 to TTL. The RS232 Data Transmission voltages at a certain logic state are opposite from the RS232 Control Line voltages at the same logic state.

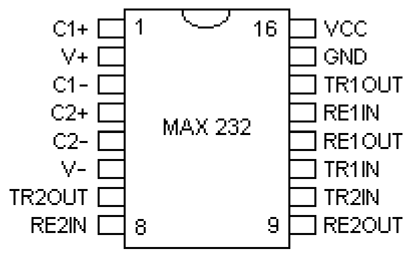


Fig. 3.5.1 MAX232 Pin Configuration

3.6 BATTERY CELLS:

Battery Cells are the most basic individual component of a battery. They consist of a container in which the electrolyte and the lead plates can interact. Each lead-acid cell fluctuates in voltage from about 2.12 Volts when full to about 1.75 volts when empty. Note the small voltage difference between a full and an empty cell (another advantage of lead-acid batteries over rival chemistries).

A lead-acid battery is an electrical storage device that uses a reversible chemical reaction to store energy. It uses a combination of lead plates or grids and an electrolyte consisting of a diluted sulphuric acid to convert electrical energy into potential chemical energy and back again. The electrolyte of lead-acid batteries is hazardous to your health and may produce burns and other permanent damage if you come into contact with it.

3.7 PIC MICROCONTROLLER

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1640, originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "**Programmable Interface Controller**".

PICs are popular with both industrial developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability.

Core architecture

The PIC architecture is characterized by the following features:

- Separate code and data spaces (Harvard architecture) for devices other than PIC32, which has a Von Neumann architecture.
- A small number of fixed length instructions
- Most instructions are single cycle execution (2 clock cycles), with one delay cycle on branches and skips
- One accumulator (W0), the use of which (as source operand) is implied (i.e. is not encoded in the opcode)
- All RAM locations function as registers as both source and/or destination of math and other functions.
- A hardware stack for storing return addresses
- A fairly small amount of addressable data space (typically 256 bytes), extended through banking
- Data space mapped CPU, port, and peripheral registers
- The program counter is also mapped into the data space and writable (this is used to implement indirect jumps).

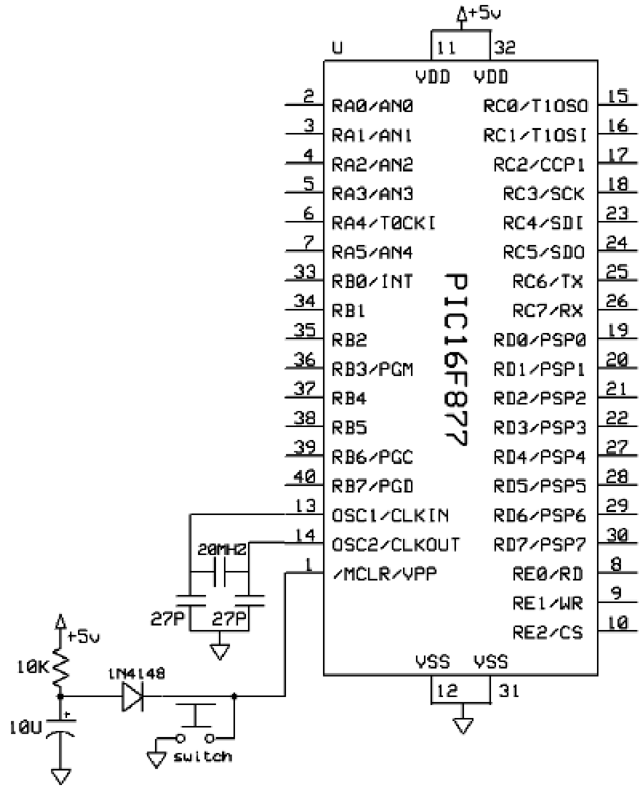


Fig. 3.7.1 PIC16F877 Pin Configuration

CHAPTER-IV

SOFTWARE DESCRIPTION

4.1 MPLAB IDE:

Integrated Development Environment (IDE) is a free, integrated toolset for the development of embedded applications on Microchip's PIC and dsPIC microcontrollers.

MPLAB IDE v8:

The current version of MPLAB IDE is version 8.90 is used. It is a 32-bit application on Microsoft Windows and includes several free software components for application development, hardware emulation and debugging. MPLAB IDE also serves as a single, unified graphical user interface for additional Microchip and third-party software and hardware development tools.

Both Assembly and C programming languages can be used with MPLAB IDE v8. Others may be supported through the use of third-party programs. MPLAB IDE v8 does not support Linux, UNIX or Macintosh operating systems.

CHAPTER-V

RESULTS

5.1 SIMULATION RESULTS:

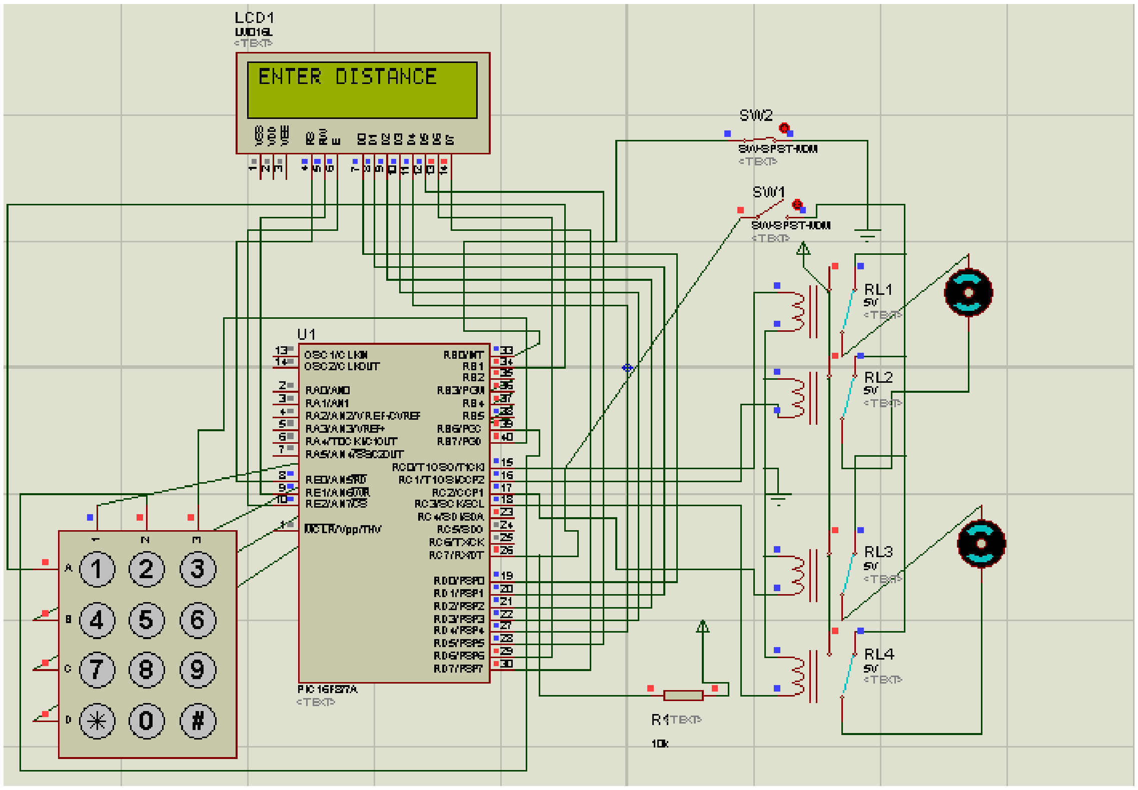


Fig. 5.1 Start up

This fig shows the simulation of start-up phase of the vehicle. Here the vehicle is ready to input values from user using LCD and keypad.

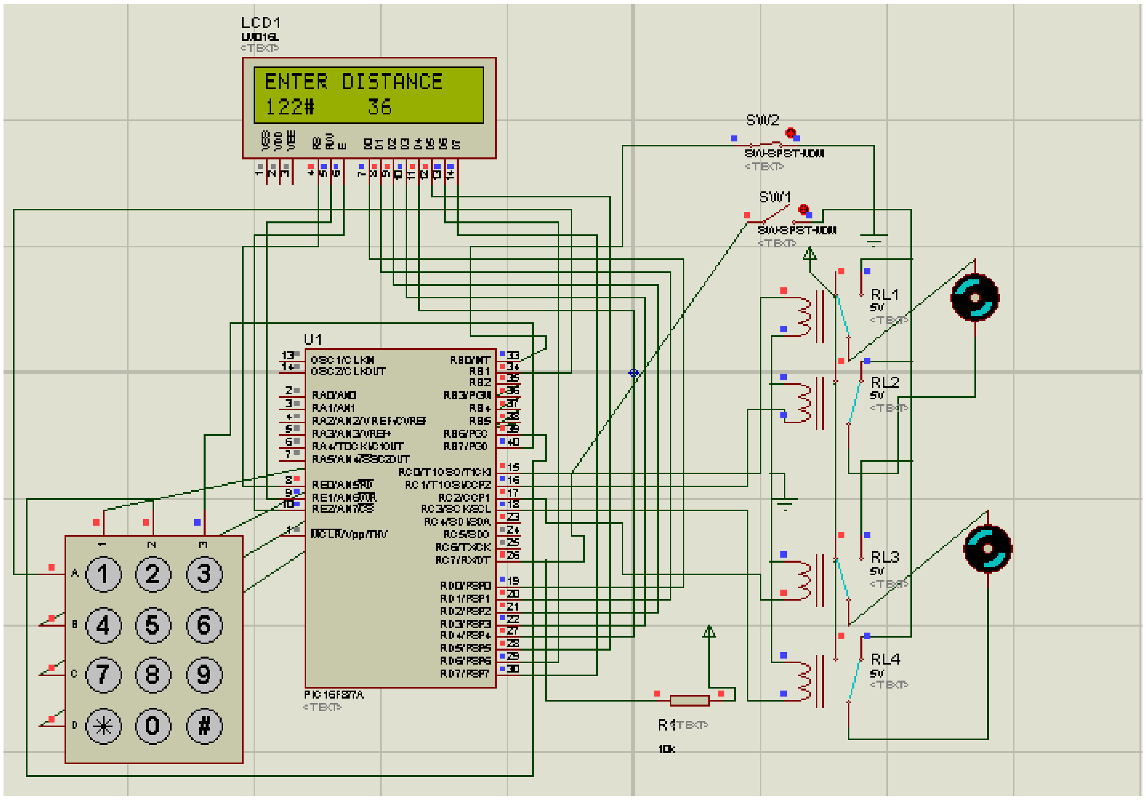


Fig. 5.2 During traversal

This is the simulation result for user input. The input is fed in the format of DDD* where D represents a digit. The nearer value represents the total count, which on system execution gets decremented such that it drains to 0 on traversal completion. The first 2 digits correspond to the length of traversal and 3rd digit corresponds to the vehicle turn parameter.

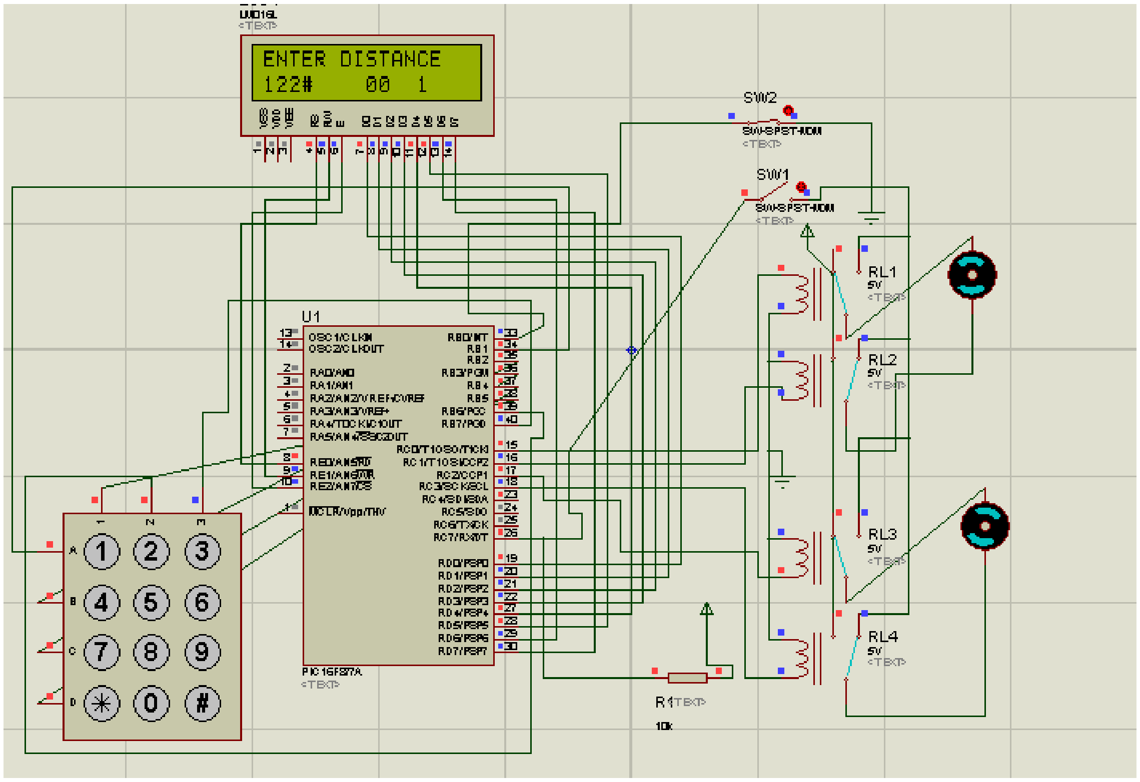


Fig. 5.3 Traversal completion

This is the simulation result for completion of traversal. Here the total count becomes 0.

5.2 HARDWARE RESULTS

Fig. 5.4(a) User Interface

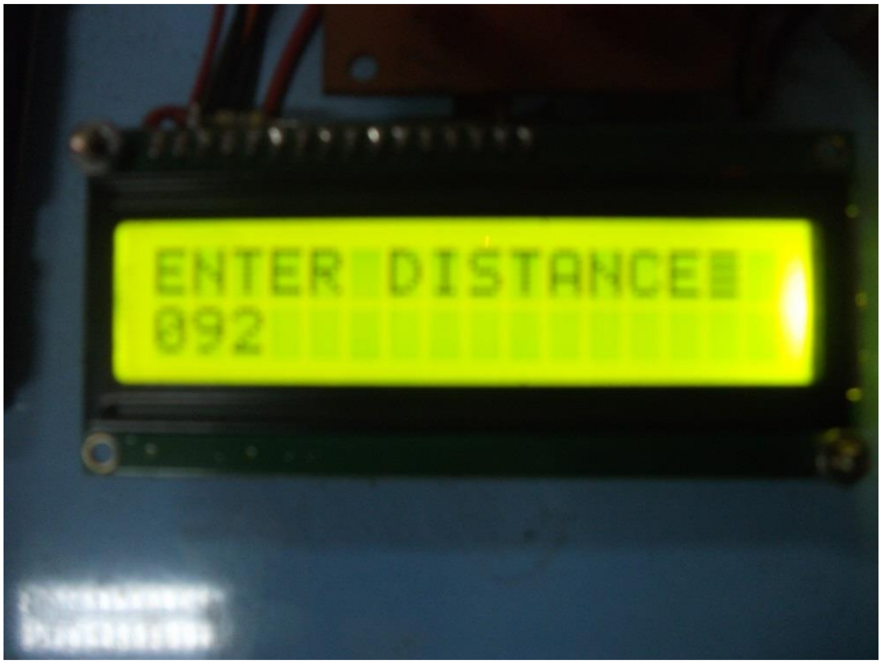


Fig. 5.4(b) User Interface- input format

This fig corresponds to the user interface unit for feeding input to the system. The input format is similar to the one described in the simulation.

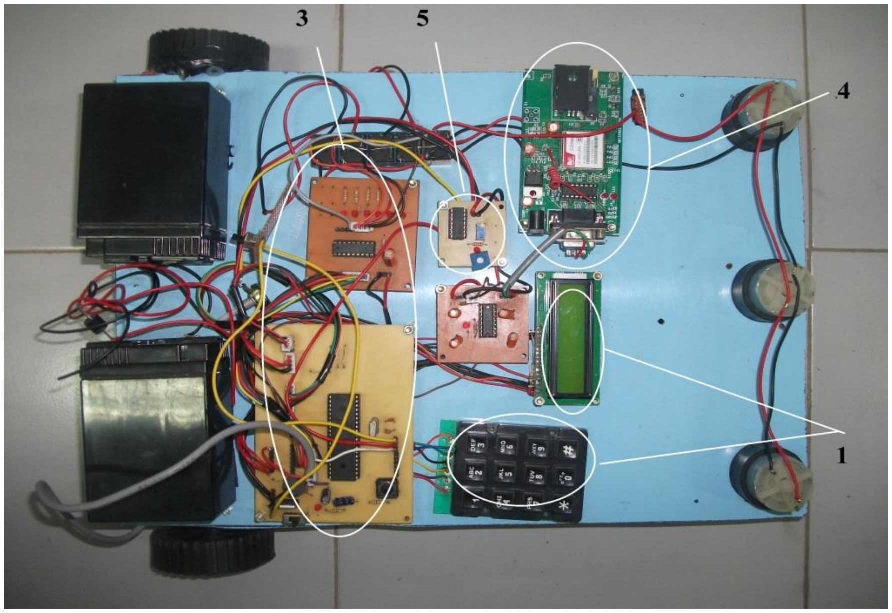


Fig. 5.5 Hardware module

The aforementioned fig shows the system units 1.User- Interface unit, 3. Robot Movement control unit, 4. Communication unit, 5. Battery level monitoring unit. The harvesting unit of the system is shown in the fig below. 3 blades driven by dc motors constitute the harvester unit.

Fig. 5.6 Harvesting unit

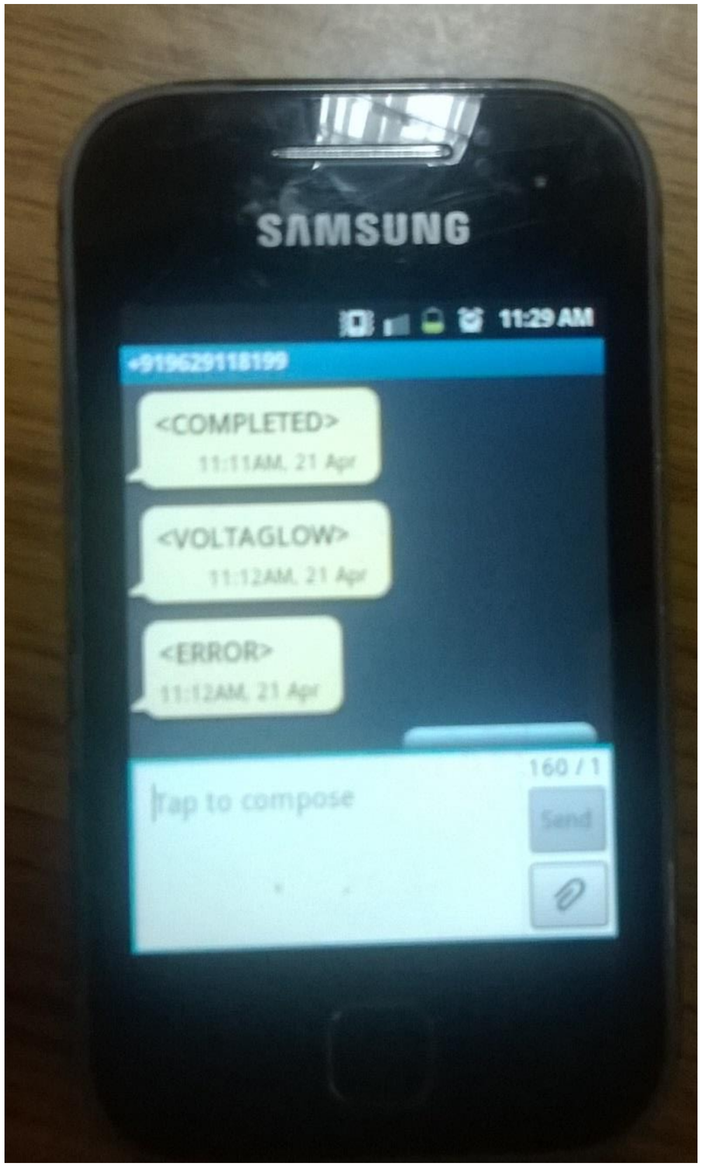


Fig. 5.7 On completion of traversal

The screenshot for traversal completion is shown in this fig. On completion, an "<COMPLETED>" sms is sent via GSM to the user mobile and is depicted above. . For current implementation, a switch is been introduced to control error occurrence. On occurrence of an error, a "<ERROR>" sms is sent via GSM to the user mobile and is depicted above. The battery monitoring unit, on low voltage, notifies the user with a "<LOWVOLTAGE>" sms, as shown above.

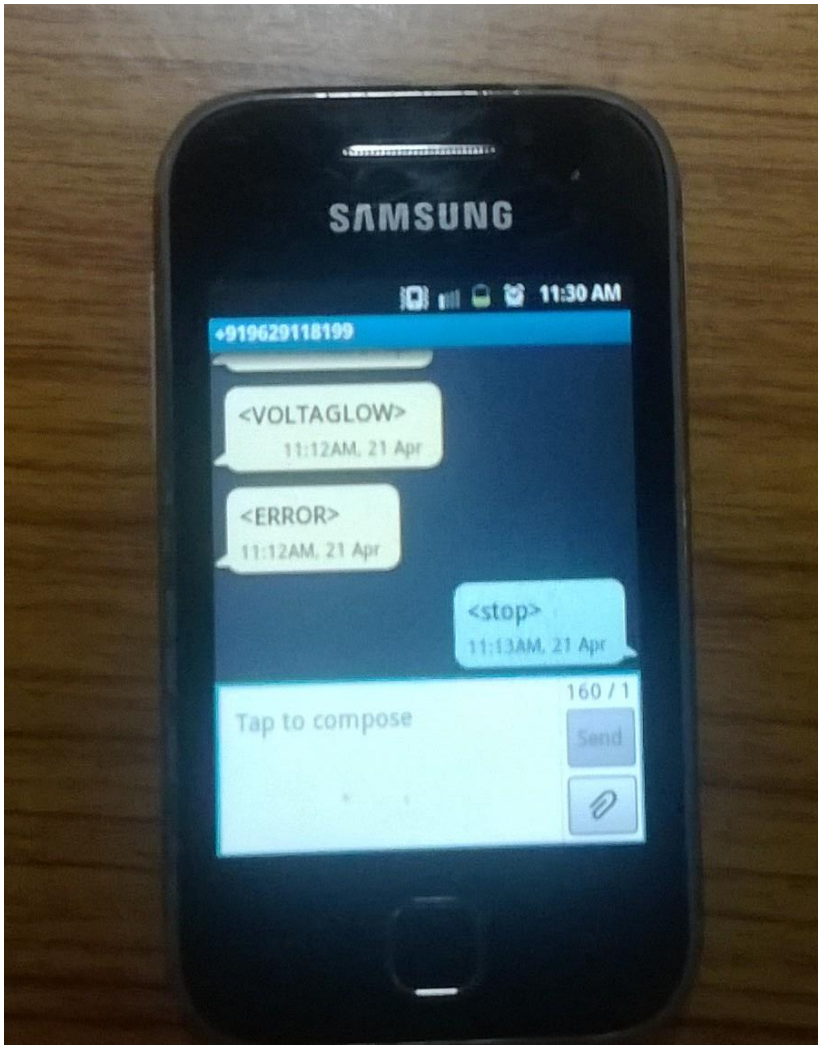


Fig. 5.8 Vehicle -emergency cease

In order to stop vehicle forcibly, a “<STOP>” sms can be sent from the user mobile as shown above.

CHAPTER-VI

CONCLUSION

6.1 CONCLUSION:

The autonomous agricultural system model with optimal path planning with obstacle avoidance was proposed. The power optimization was implemented with the help of an efficient path planning methodology. The GPS enabled system with self-navigation and orientation was defined. The power consumption can be minimized to maximum level of possibility.

6.2 FUTURE ENHANCEMENTS:

- System is to be enhanced for usage in fields with obstacles of any shapes.
- Dynamic obstacles must be identified and overcome.
- Solar power can also be made use of, as a further better energy conservation methodology.
- System is currently defined for static obstacles.
- Further improvisations can be made to differentiate obstacles and to identify their characteristics.

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LIST OF PUBLICATIONS

1. N. Prakash, M. Loganathan, "**Energy Efficient Autonomous Field Vehicle for Complete Coverage",** International Journal of Engineering Research and Technology. Vol. 3 - Issue 1 (January - 2014)

2. N. Prakash, M. Loganathan, "**Energy Efficient Autonomous Field Vehicle for Complete Coverage"**, International Conference on Renewable Energy Utilization (ICREU 2014) at CIT, Coimbatore.