Development of a Remote Vehicle Control Through Cell Phone Using DTMF

[1]F. T. Oyediji, [2]A. J. Yakubu, and [3]A. O. Aluko
[1,2,3]Department of Computer Engineering, Federal Polytechnic, Ile-Oluji, Nigeria.

E–mails: funsayo2003@yahoo.com; yakubuanakobe@fedpolel.edu.ng;

Abstract
In the past years, the motion of wireless vehicles has been restricted by limited distance of control, line-off site control and interference which is mainly caused by the use of infra-Red and Radio Frequency circuits for the remote control of the vehicle. This project presents a solution to such problem whereby a GSM based remote control system is used to control a vehicle. The design methodology involves four main components, namely: Motor driver, Dual tone multi-Frequency, DC Motor, ATmega328 Microcontroller and Vehicle Chassis. The microcontroller was soldered on a Vero board with some other components like the LM7805, Crystal oscillator, Resistor and capacitor. The output pin of the voltage regulator (LM7805) was connected to microcontroller pin 1 and a 10kilo ohm resistor was connected from the pin 1 to pin 7 of the microcontroller and also the pin 9 and 10 of the Atmega328 microcontroller was connected to a crystal Oscillator and two 22pico farad capacitor that was connected to ground, while the pin 8 was connected to the ground of the LM7805 voltage regulator, The input pin of the regulator was connected to the positive terminal of the battery and the ground was connected to the negative. The DTMF pin D0 to D3 were connected to microcontroller pin 23 to 26 and motor driver pin 6, 18, 13, 14 were connected to Atmega328 pin 4,12,7 and 8 respectively. An AUX wire was connected to the DTMF that helped the receiver phone which was received automatically. The 2, 8, 4, 6 and 5 buttons were pressed on the remote phone to move the vehicle forward, backward, left and right respectively, the performance evaluation of the designed work after series of tests was very satisfactory.

Keyword: *Vehicle Control, Development, Cell Phone Using DTMF*

1. INTRODUCTION

A remote control vehicle can be described as any mobile device that is controlled by a means that does not restrict its motion with an origin external to the device. This is often a radio control device, cable between control and vehicle, or an infrared controller. A remote control vehicle differs from a robot in that the remote control vehicle is always controlled by a human and takes no positive action autonomously. According to [1] the IR system follows the line of sight approach which involves the process of actually pointing the remote at the device being controlled; this makes communication over obstacles and barrier quite impossible. To overcome such problems, a signalling scheme utilizing voice frequency tones is employed. This is known as Dual Tone Multi-Frequency (DTMF), Touch Tone or simply tone dialling. A valid DTMF signal is the sum of two tones, one from a low group (697-941Hz) and the other from a high group (1209- 1633Hz) with each group containing four individual tones [2]. DTMF signalling therefore play an important role in distributed communication systems such as multiuser mobile radio. In this paper, phones making use of the GSM network interfaced directly with the DTMF decoder and the motor driver is used to remotely control an unmanned vehicle thus overcoming the distance barrier problem and communication over obstacles with very minimal or no interference but is solely network dependent. [3] design of unmanned vehicle proposed here make use of microcontroller ATmega328p.The transmitter used is a handheld cell phone.

2 LITERATURE REVIEW

In 1898, Nikola Tesla built the first propeller driven radio controlled boat, which can be regarded as the original prototype of all modern day uninhabited aerial vehicles and precision guided weapons. Records state that it is the first among all remotely controlled vehicles in air, land or sea. It was powered by lead-acid batteries and an electric drive motor. The vessel was designed in such a way that it could be maneuverer alongside a target using instructions received from a wireless remote-control transmitter. Once in its position, a command would be sent to detonate an explosive charge contained within the boat's forward compartment [4].

The weapon's guidance system introduced a secure communications link between the pilot's controller and the surface running torpedo in an effort to assure that control could be maintained even in the presence of electronic counter measures. Wireless controlled unmanned vehicles which are used nowadays typically use radio electronic circuits for motion and control. But radio electronic circuits suffer from the disadvantage of limited working range which results in limited control. As radio electronic circuits' follows LOS (Line of sight) approach, it fails miserably in NLOS (Non-Line of Sight) conditions involving obstacles and barriers. To overcome these, one method was proposed by [1] which typically makes use of the DTMF technology along with a microcontroller based circuit for maneuver and control of these unmanned robotic vehicles.

Ashish and Rashika [2] also proposed the construction of an unmanned vehicle which could be especially used for ground combat using a similar technology. Recently, [5] discussed in detail the method involving the use of a microcontroller by providing the necessary circuit details and the software code. In designed implemented the design of an unmanned vehicle using the same technology as described in the papers mentioned earlier, modified the existing circuit and code has been described with thorough and detailed analysis of the design paradigm which is the best possible explanation to our knowledge till date.

However, upon implementation we also found that the proposed method could also be implemented using a microcontroller, which is one of the key elements in the design of the circuit. [6] employ the use of Bluetooth technology along with a arduino UNO based circuit for control of these unmanned robotic vehicles. Similarly,

Ashish & Rashika [2] also constructed an unmanned vehicle which could be especially used for ground combat using a similar technology. [7] method involving the use of a arduino UNO to construct an unmanned vehicle using microcontroller.

3 METHODOLOGY

This research describes the methodologies used for the design of the hardware and software parts, Software and hardware construction divided into two parts. Flow chart used to illustrate the flow of thesis while block diagram used to scheduling project activities. The main hardware parts are the Dual Tone Multi-frequency and how it is interfaced to the Atmega 328 microcontroller and the GSM interface.

3.1 Hardware System Design

This System consists of mechanical, electrical, and electronic components, which are integrated to complete the system design, as follows:

3.2 Implementation of Hardware Design

Hardware of the system consists of the ATmega328 microcontroller, DTMF module, sensor, Motor Driver IC, GSM phone, Vehicle chassis, DC motor and other components which its design was carried out on the manufactured Vero board mainly surface mounted components, in system programmer and relays to control the appliances [8].

3.3 Hardware Interface Design

In designing this vehicle we interfaced The DTMF module and the microcontroller together ensuring proper connection between them. The DTMF pin DO, D1, D2, and D3 is connected to microcontroller pin 23, 24, 25 and 26. The table below shows the equivalent pin configuration between DTM module and microcontroller.

Table 3.1: Equivalent pin configuration between DTMF module and microcontroller

DTMF Pin Port	Microcontroller Pin Port
D0	23
D1	24
D2	25
D3	26

Likewise in designing this vehicle we interfaced the motor driver and the microcontroller together ensuring proper connection between them. The motor driver pin6, 18, 13, and 14 is connected to microcontroller pin 4, 12, 7 and 8. The table below shows the equivalent pin configuration between motor driver and microcontroller.

Table 3.2: Equivalent pin configuration between microcontroller and motor driver

Microcontroller Pin Port	Motor Driver Pin Port
4	6
12	18
7	13
8	14

3.4 Mode of Operation

For this project we have mainly used two mobile phone, one is receiver's phone while the other one is remote phone. The receiver's phone is been connected to the DTMF Module, using AUX cable the DTMF module is also connected to atmega328 microcontroller via the appropriate pin ports which actually does the whole process. The microcontroller is connected to the motor driver which drives the dc motor in order for the vehicle to move forward, backward, right, left. According to [9] the program on the microcontroller. Now this is how it works. The remote phone is used to call the receiver' phone which is already set in automatic answer, then either key 2, 8, 4, 6 are pressed on the remote phone according to direction we want the vehicle to go, then the DTMF module decodes the tone of the keys and convert it into corresponding BCD codes of 4digit and the signal is sent to Atmega328p microcontroller which will decode the digit and gives respond to the motor driver according to the program [10].

Table 3:3 shows DTMF button arrangement with respect to the BCD Codes.

Input					Output				
Mobile key	DTMF Decoder				Motor				Vehicle movement
	D3	D2	D1	D0	M11	M12	M21	M22	
5	0	1	0	1	0	0	0	0	Stop
4	0	1	0	0	1	0	0	0	Left
6	0	1	1	0	0	0	1	0	Right
2	0	0	1	0	1	0	1	0	Forward
8	1	0	0	0	0	1	0	1	Backward

Table 3.4: Equivalent phone to DTMF button arrangement

Key	Corresponding binary coded decimal (BCD)	Vehicle direction
2	0100	Forward
8	0001	Backward
6	0110	Right
4	0010	Left
5	1010	Stop

3.5 Programming Aspect of the Project

For this project C programing language was used to write the code, and since we are using arduino UNO as the microcontroller, then we use ardiuno compiler. The program is been loaded on the microcontroller using arduino software which we already have the program written on. The basic of the code is to direct the vehicle forward, backward, right or left. This is done by using binary coded decimal (BCD) which deals with 0s and 1s.

3.6 Parameters Used in the Programming Aspect of the Research

(i). C Programming Language

C is general purpose, imperative computer language, supporting structured programming, lexical variable scope and recursion, while a static type system prevents many unintended operations. By design, C provides constructs that map efficiently to typical machine instructions, and therefore it has found lasting use in applications that had formerly been coded in assembly language, including operating systems, as well as various application software for computers ranging from supercomputers to embedded systems [11]

(ii) Binary Coded Decimal (BCD)

In computing and electronic systems, binary-coded decimal (BCD) is a class of binary encodings of decimal numbers where each decimal digit is represented by a fixed number of bits, usually four or eight. Special bit patterns are sometimes used for a sign or for other indications (e.g., error or overflow). In byte-oriented systems (i.e. most modern computers), the term unpacked BCD usually implies a full byte for each digit (often including a sign), whereas packed BCD typically encodes two decimal digits within a single byte by taking advantage of the fact that four bits are enough to represent the range 0 to 9 [12]. The precise 4-bit encoding may vary however, for technical reasons. The ten states representing a BCD decimal digit are sometimes called tetrads (for the nibble typically needed to hold them also known as tetrad) with those don't care-states unused named pseudo-tetrad(e)s (de) or pseudo-decimal digit BCD's main virtue is its more accurate representation and rounding of decimal quantities as well as an ease of conversion into human-readable representations, in comparison to binary positional systems.

3.8 Selection of Materials

The materials that we used for this project were well selected for their efficiency and functionality, the materials includes:

(a) Vehicle Chassis

This is an internal framework of an artificial object, which supports the object in its construction and use, chassis is a vehicle frame, the under part of a motor vehicle, on which the body is mounted; if the running gear such as wheels and transmission, and sometimes even the driver's seat, are included, then the assembly is described as a rolling chassis. It is selected because it is of four wheels which is capable of carrying over all other component incorporated in it [13]. Figure 3.1 shows the diagram of a vehicle chassis

Figure 3.1: Vehicle chassis (Snap Shot)

(b) Microcontroller (ATmega 328p)

ATmega 328p has 1KB Electrically Erasable Programmable Read Only Memory (EEPROM). This property shows if the electric supply supplied to the micro-controller is removed, even then it can store the data and can provide results after providing it with the electric supply. ATmega-328p has 2KB Static Random Access Memory (SRAM). ATmega 328p has several different features which make it the most popular device in today's market [14]. These features consist of advanced RISC architecture, good performance, low power consumption, real timer counter having separate oscillator, 6 PWM pins, programmable Serial USART, programming lock for software security, throughput up to 20 MIPS etc. Which is the reason why it was used in this project ATmega-328p is mostly used in

Arduino. Figure 3.2: shows the diagram of a Microcontroller ATmega 328p (ATmega328 datasheet. Atmel Corporation, 2008.)
Figure 3.2: A Microcontroller AT mega 328p (ATmega328 datasheet. (Atmel Corporation, 2008).

Figure 3.2 A Microcontroller ATmega 328p

(iii) DTMF (Dual Tone Multi-Frequency)

Signalling is used for telecommunication signalling over analogue telephone lines in the voice frequency band between telephone handsets and other communication devices and the switching center. The DTMF system generally uses eight different frequency signals transmitted in pairs to represent sixteen different numbers, symbols and letters. When someone presses any key in the key pad of the handset, a DTMF signal generates unique tone which consists of two different frequencies one of higher frequency range (>1KHz) and lower frequency (1KHz). This was selected because it consumes low power and it is very easy to work with. Figure 3.3: shows the diagram of DTMF [15].

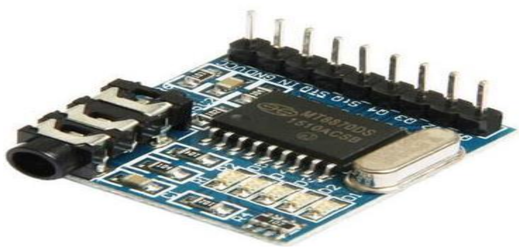


Figure 3.3: Diagram of DTMF module (https://www.google.com)

(d) DC Motor Driver

DC motor is electromechanical device that converts electrical energy into mechanical Energy that can be used to do many works. It can produce mechanical movement to moving the wheels of the robot. DC motor has two wires, we can say they are positive terminal and negative terminal, when these wires are connected with power supply the shaft rotates. We can reverse the direction of the rotation. L293d motor driver is cheap and very safe to use for DC motor control. This L293D is 16bit chip. Chip is design to control four DC motor, there are two inputs and two outputs for each motor. (jadharetal,(2012). Figure 3.4 show the diagram of a Motor Driver [16].

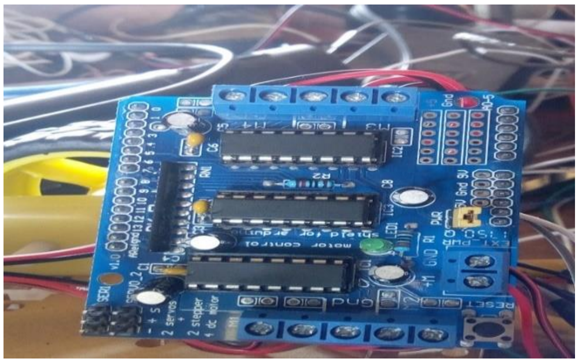


Figure3.4: A Motor Driver (Snap Shot)

(e) DC Motor

A DC motor is any class of rotatory electrical machines that converts direct current I electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electrochemical or electronic; to periodically change the direction of current flow in part of the motor. This type of DC motor is cheap and very efficient in working. Figure3.5 bellow shows the diagram of DC motor [16].

Figure 3.5: A DC motor and it working principle. (Gupta etal,(2013)

(f) Crystal Oscillator

The external clock (EC) mode uses the system clock source configured from external oscillator. The frequency of this clock source is unlimited (0- 16MHz).It used to control the execution speed of the microcontroller (https://www.google.com).Figure 3.6: shows the diagram of Crystal Oscillator.

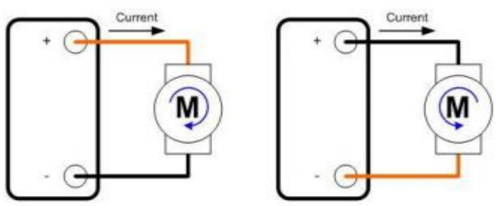


Figure 3.6: External Oscillator (crystal)

(g) Capacitor (22 Pico farads)

A capacitor is a passive two-terminal electrical component that stores potential energy in an electric field. The effect of a capacitor is known as capacitance. While some capacitance exists between any two electrical conductors in proximity in a circuit, a capacitor is a component designed to add capacitance to a circuit.22 Pico farads capacitor is used in this project to store charges for the microcontroller. The figure 3.7 shows the diagram of Capacitor [17].

Figure 3.7: The diagram of Capacitor

(h) Resistor (10k Ohms)

An ohm is the resistance that occurs when a current of one ampere passes through a resistor with a one volt drop across its terminals. The current is proportional to the voltage across the terminal ends. This ratio is represented by Ohm's law. Figure 3.8: shows the diagram of resistor [18].

Figure 3.8: The diagram of resistor

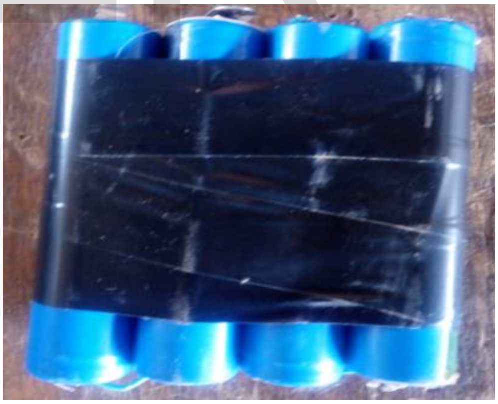
(i) Mobile Phone

A mobile phone is a wireless handheld device that allows users to make and receive calls and to send text messages, among other features. The earliest generation of mobile phones could only make and receive calls. Mobile phone is selected for this project because it is portable and easy to move around with. Figure 3.9 shows the diagram of mobile phone [18].

Figure 3.9: The diagram of a mobile phone

(j) Battery (12V)

This is a unit related to the energy storage capacity of the battery. The rating is defined as the current a lead-acid battery at that temperature can deliver for 30 seconds and maintain at least 1.2 volts per cell (7.2 volts for a 12-volt battery). The type of battery was selected because it can be easily partition to



various section of the circuit [19].

Figure 3.10 Diagram of 12 volt battery

(k) Aux Wire

Auxiliary (AUX) inputs are simple audio connections that look like headphone sockets. Paired with an AUX-IN cable they will allow you to input sound from any media device with a normal headphone socket. They are one of the easiest ways to play music, audiobooks or podcasts in your car. This was selected to help the DTMF collect tone from the receiver'

ISSN 2229-5518

phone. Figure 3.11: shows the diagram of AUX wire [19].

Figure 3.11: AUX wire

(l) Switch

A single throw (ST) switch is a simple on/off switch. When the switch is ON, the two terminals of switch are connected and current flows between them. When the switch is OFF the terminals are not connected, so current does not flow. The switch was selected to help switch the circuit off after the operation of the vehicle so that the battery will not drain off. Figure 3.12: show the diagram of switch.

Figure 3.12: A switch

(m) IC 74HC595 (Shift Register)

Integrated circuit (IC) An integrated circuit (IC), sometimes called a chip or microchip, is a semiconductor wafer on which thousands or millions of tiny resistors, capacitors, and transistors are fabricated. An IC can function as an amplifier, oscillator, timer, counter, computer memory, or microprocessor. Figure 3.13: show the diagram of IC 74HC595 [20].

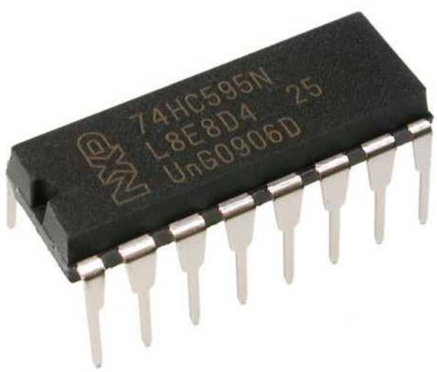


Figure 3.13: IC 74HC595

(n) Voltage Regulator (LM7805)

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. Although the internal construction of the IC is somewhat different from that discrete voltage regulator circuits, the external operation is much the same. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustable set voltage. Voltage regulator (LM7805) is selected because the microcontroller requires 3.3-5volt, therefore the voltage regulator was used to step down the battery to the required volt that the microcontroller can use. Figure 3.14 shows the diagram voltage regulator IC [14].

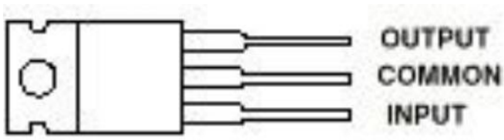


Figure 3.14: A voltage regulator

3.9 Construction Procedure

The procedure is divided into three major sections namely:

(i) Remote section: This section's main component is DTMF. Here we get a tone from our cell phone by using aux wire to DTMF Decoder IC namely MT8870 which decodes the tone into digital signal of 4bit.

(ii) Control Section: Microcontroller is used for controlling the whole process of vehicle. Microcontroller reads commands sent by DTMF Decoder through the aid of microcontroller that already have the codes uploaded on, and compare with define code or pattern. If commands are match Microcontroller sends respective command to driver section. Vero board has a microcontroller socket that the microcontroller can be plugged in.

(iii) Driver section: Driver section consists motor driver and four DC motors. Motor driver is used for driving motors because Microcontroller does not supply enough voltage and current to motor. So we add a motor driver circuit to get enough voltage and current for motor. By collecting commands from Microcontroller, motor driver drives motor according to commands. The diagram below shows procedure sections in block.

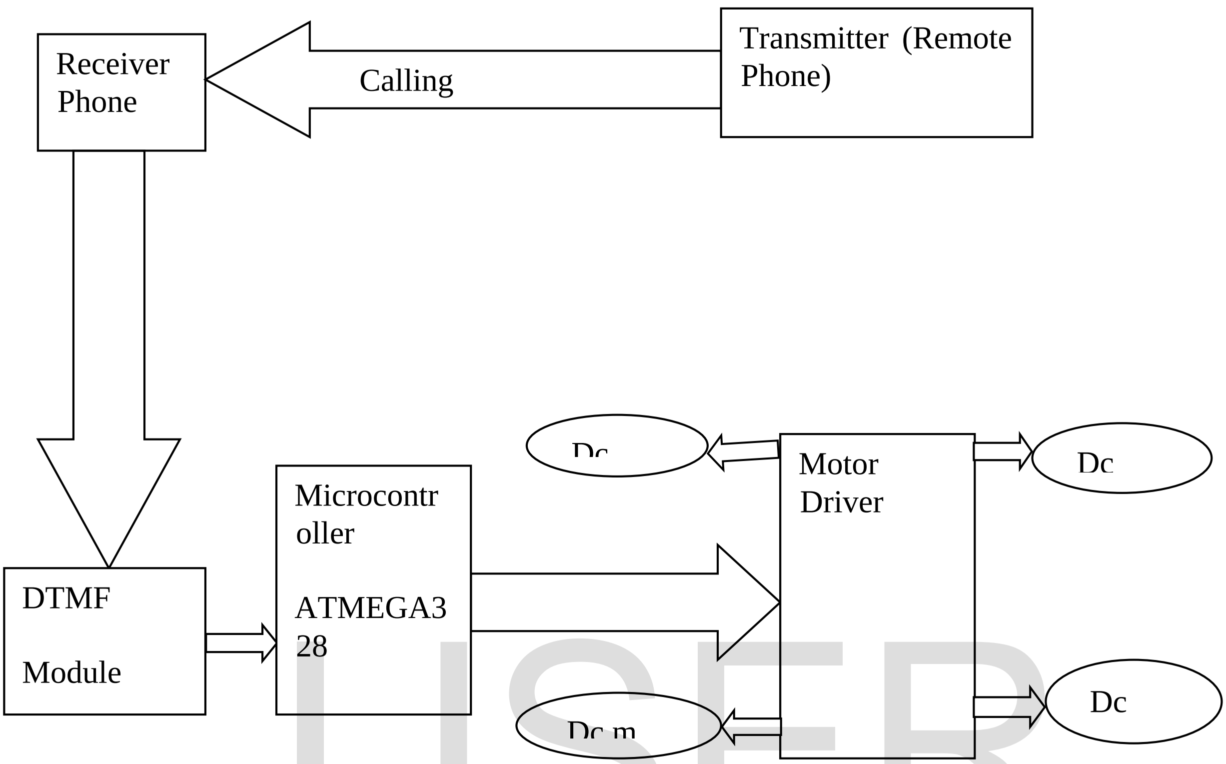


Figure 3.15: block diagram of remote vehicle control

3.9.1 Circuit Explanation of Vehicle Microcontroller

Circuit diagram for Microcontroller based DTMF Controlled vehicle is very similar with our other vehicle like PC controlled vehicle, Line Follower, Gesture Controlled vehicle, etc. One motor driver is connected to Microcontroller for driving vehicle. Motor driver's input pin 6, 18, 13 and 14 is connected at Microcontroller digital pin number 4, 12, 7 and 8 respectively. Here we have used four DC motors to drive vehicle, in which one motor is connected at output pin of motor driver 3 and 6 and another motor is connected at 11 and 14. A 12 volt Battery is also used to power the motor driver for driving motors. A DTMF decoder is attached to this circuit and this decoder is plugged into a mobile phone using an aux wire for receiving command or DTMF Tone. DTMF decoder pin D0-D3 is directly connected with Microcontroller pin number 23,24,25,26. 12 Volt batteries are used to power the circuit in which 7volt is used to power the motors, connected at motor driver IC pin number 8. And another 5 Volt battery is connected to power the remaining circuit

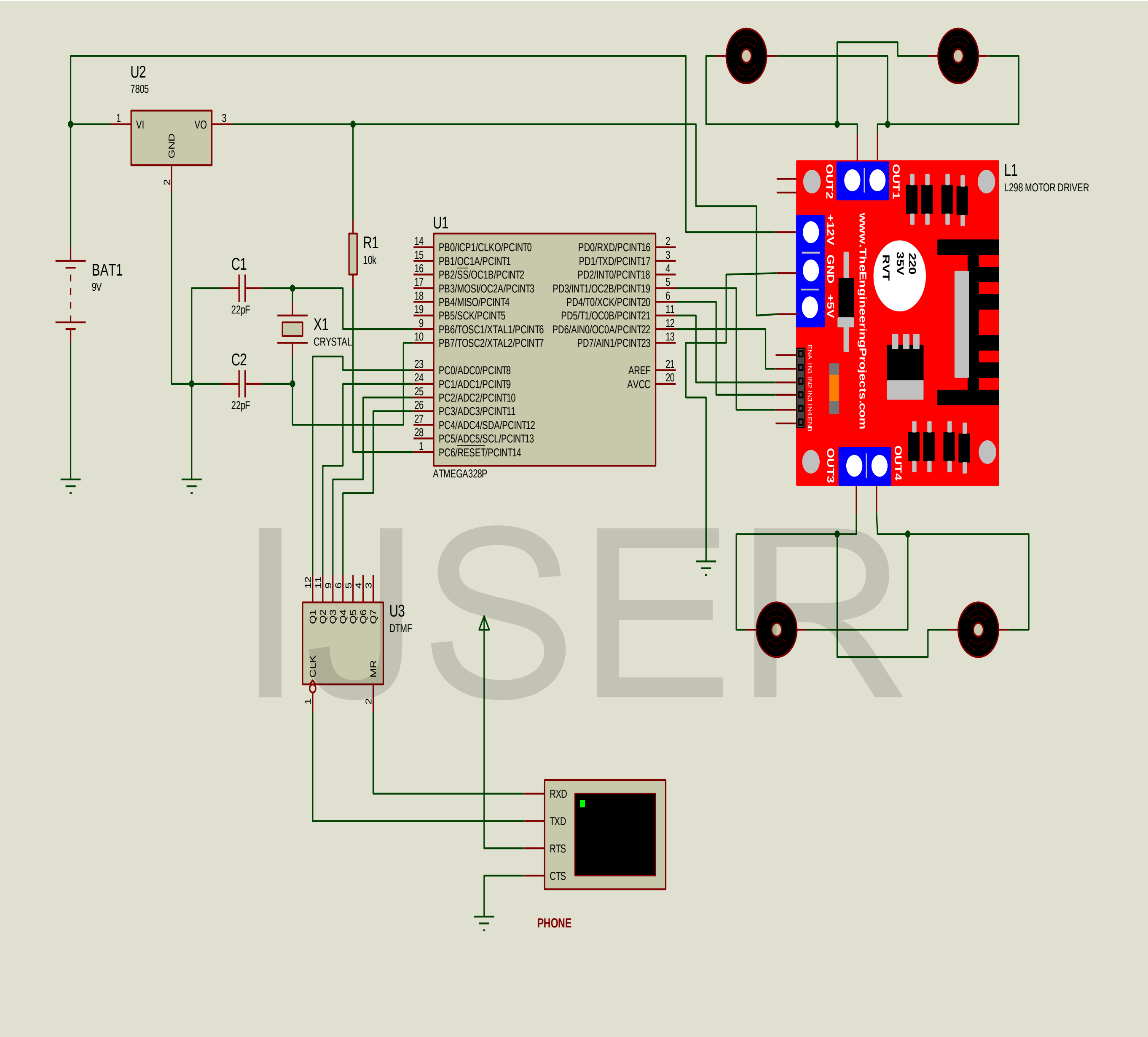


Figure 3.16: Circuit Diagram of remote vehicle control

3.9.3 Explanation of the Flow Chart

All input are read from the Dual Tone Multi-frequency (DTMF). When we press '2' by remote phone, the DTMF convert the key to the corresponding BCD codes according to the program uploaded on the microcontroller and vehicle starts moving forward and moving continues forward until next command comes, The same thing happen When we presses '8' by remote phone, vehicle change his state and start moving in backward direction until other command comes. When we press '4', vehicle get turn left till next command is executed. When we press '6', vehicle turned to right. And for stopping vehicle we pass'5.

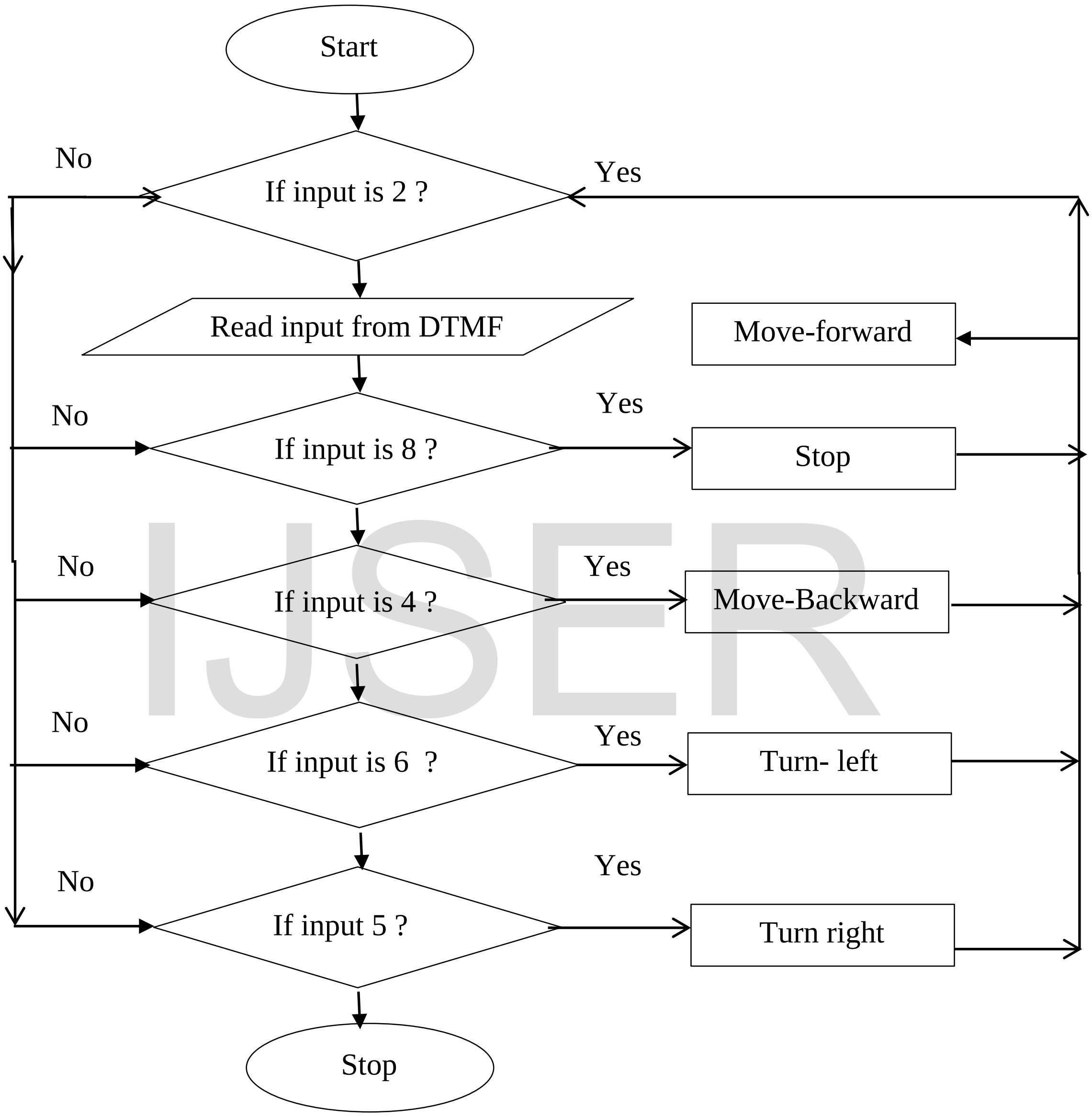


Fig 3.17: Flow Chart of Remote Vehicle Control

4. RESULT AND DISCUSSION

The proper testing of each stage became necessary to enhance proper handshaking of the stages. The testing is categorized into two namely: Software testing and Hardware testing

4.1 Hardware Testing

This can also be subdivided into two; Pre-implementation and Post-implementation

Pre-implementation testing: This was done on the vero board. Only the microcontroller circuit was arranged on the vero board, while other circuit are arrange stage by stage and in accordance with the block diagram. Each stage was tented and the output of each stage was compared with the expected result, any deviation was critically checked and corrected. Figure 4.1: Show the diagram of Vero board testing

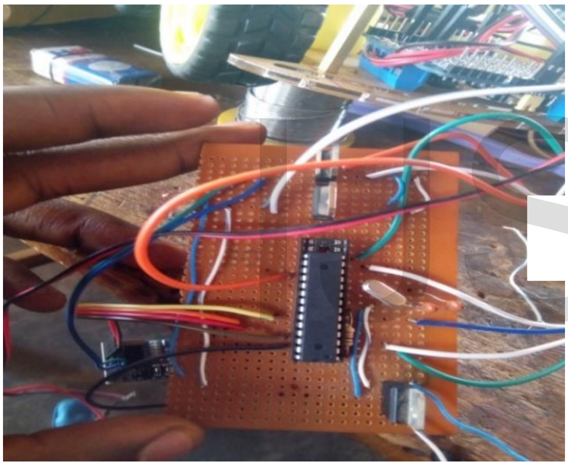


Figure 4.1: Vero board testing

Post-implementation testing: This testing was carried out after the circuit had been arranged and soldered on the Vero-board. This is necessary to check the performance of the circuit and the interaction of each block. The deviations between the expected value and the result were compensated for and the degree of accuracy was noted.

4.2 Software Testing

This testing is carried out by mimicking the component and the devices of the system so as to analyze its performance. It is subdivided into code and hard-wire simulation.

Code simulation: the code for the ATmega328p microcontroller was written in C language, the codes were compiled to hex file using an Arduino interface v1.67 package. The hex file that was burnt on the microcontroller, but for the purpose of testing, the hex file was exported to another software package known as the Proteus simulator. The simulator has a USART (Universal Synchronous/Asynchronous Receiver and Transmitter) to imitate the operation of a mobile phone and DTMF to demonstrate the outputs. This made it possible to monitor the interactions between the mobile phones and the microcontroller. The satisfactory outputs observed through the Movement of the vehicle and the USART gives a confidence that the code is working as expected.

Hardware simulation: The full circuit was drawn on a software package known as Proteus 7 professional. The hex file compiled using Arduino interface v1.67 was imported to the microcontroller and the cooperation of the microcontroller and the other peripheral was monitored.

4.3 Presentation of Result

The physical implementation of the project design confirms its applicability. After the design of the project, the circuit diagram was converted to the working project. The final outcome of this project after completion of all these process would be like as of shown in the figure below. The vehicle is of four-wheel mechanism so that it is stable to carry over all the components. The cell phone is fixed on the top of the vehicle independently and it is capable of interacting with the other phone and moving the car in various directions according to the user control. Figure 4.2: Show the diagram of complete construction

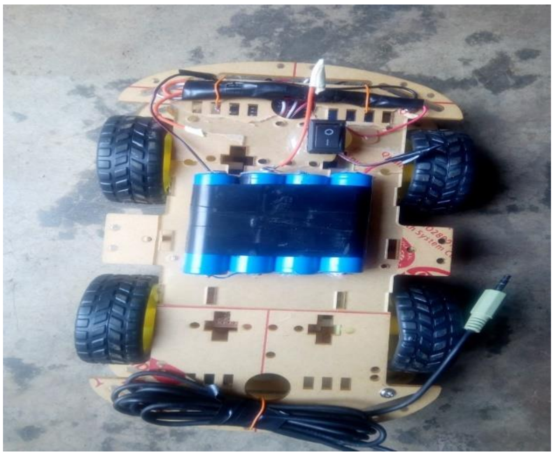


Figure 4.2: Show the diagram of complete construction

4.4 Result Testing

The implementation was done in stages as it was in the block diagram. The AT mega 328p microcontroller was programmed using C language, the microcontroller and its peripheral was assembled on the Vero board

4.5 Discussion of Result

Whenever the phone on the device is called and the command is imputed the DTMF convert the tone produced by the phone to BCD code and the BCD code Is converted to Binary equivalent that the microcontroller understand then the Binary is sent to the motor driver to drive there motor with respective input pressed on the phone. I.e. BCD to binary equivalent.

4.6 Applications of the Research

(i). **Military use:**

Military usage of remotely controlled military vehicles dates back the first half of 20th century. This can be a great asset to save lives of both people along with soldiers in case of terrorist attacks like the one happened in 26 Nov, 2008 in Mumbai, India.

ii. **Search and Rescue:**

Unmanned Aerial Vehicles (UAVs) will likely play an increased role in search and rescue in the United States. Slowly other European countries (even some developing nations) are thinking about making use of these vehicles in case of natural calamities & emergencies.

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The construction of the vehicle remote control was successful. The project exploits the advancement in the technology of communication to provide a comfort for users. Implementing this project in every home, factory implies improving the security of the vehicle. This project design achieved all its targeted aims and accomplished its objectives successfully.

5.2 Recommendation

For the purpose of future researches on this project and a means of improving this project, it is will recommended that the system should have the ability to detect an obstacle through sensor.as well execute some function like raise alarm, initiate an alert to a security services itself. The vehicle source of power can also be improved into a solar powered module and the system could be improved to afford the user ability to add, change and select recipients without the need of a technician or the manufacture

Acknowledgements

Authors hereby acknowledge the Ibrahim M. O. of the Department of Computer Engineering, Federal Polytechnic Ile-Oluji, Nigeria; for his Technical contribution in carried out this research.

References

[1] Awab, F. & Jovita, S. (2010). Cell Phone Operated Robotic Car. *International Journal of Scientific & Engineering Research*, *25*(4), 55-67.

[2] Ashish, H. & Rashika, S. (2012). An unmanned vehicle which can be used especially for ground combat. *International journal for computer telecommunication engineering*, *2*(5), 123-133.

[3] Sabuj, K. & asika, J. (2013). An unmanned vehicle which using microcontroller. *International journal for computer telecommunication engineering*, *1*(2), 78-81.

[4] Das, M. Sanaullah, H. M. G.,Sarower, J. & Hassan, M. M. (2010). Development of a cell phone based remote control system: an effective switching system for controlling home and office appliances. *International Journal of Electrical &Computer Sciences IJECS*, *9*(10), 37-39.

[5] Dharmani, C.C. (2009).Design with microcontrollers: IR Remote Controlled Car (PWM motor control using ATmega8). [Online] Availablefrom:www.dharmanitech.com/2009/01/ir-remotecontrolied-car-pwmmotor.html?m=1. [Accessed 08/01/2017].

[6] Fadnavis, S. A. (2012). Design of GUI Based Wireless Robotic Car. *Research Journal of Engineering Sciences*, 1(2), 26-31.

[7] Gupta, S.S., Arman R. O., Mohammad S.H. & Nahid H.S. (2013). Design & Implementation of Mobile Operated Toy Car by DTMF. *International Journal of Scientific Research Publications*, *3*(1), 201-313.

[8] Haldun, G. & Nihat, T. (2008). A Cellular Phone Based Home/Office Controller &Alarm System.BSC thesis, DaldalGazi University Technical Education Faculty, 06500, Besevler, Ankara, Turkey.

[9] Hachenburg, B., Holm, M. & Smith, J. (1997). Data signaling functions for a cellular mobile telephone system. *IEEE Journal of Trans Vehicular Technology*, 26(1), 82.

[10] adhav, B, Ashish, R, Mahesh, K, & Meenakshi P. (2012). Cell Phone Controlled Ground Combat Vehicle. *International Journal of Computer and Communication Engineering*, *2*(3), 20-37.

[11] Labcenter, E. (2015).Proteus Design Suite Version 8.0". [Online] Available: http://www.labcenter.com.

[12]. Lagura, J. L. R., Pascual, M. C. G., Rabadan, R. J. R.. & Tabac, A. G. (2004).Microcontroller based aid for the blind in reading mobile phone messages using braille system. Undergraduate Thesis.De La Salle University Manila.

[13] Luo, T.M., Chen, C. & Yih C. C. (2000). Intelligent autonomous mobile robot control through the Internet. *IEEE International Symposium ISIE*, *1*(2), 20-30.

[14] Mandakini, H. & Pimple, R.C, (2015). Design and Implementation of Unmanned Ground Vehicle using GSM Network. *International Journal of Current Engineering Technology*, *3*(4), 344-356.

[15] Selman, R. & Paramesran, S. (2007). Comparative Analysis of Methods Used in the Design of DTMF Tone Detectors.*IEEE. International Conference on Telecommunications*, *5*(3), 60-68

[16] Sharma, K., Kumar, J. & Viq, G. (2006). DTMF Based Remote Control System. *IEEE International Conference*, *2*(6), 45.

[17] Banerji, E. & Sourangsu, T. (2013). Design & Implementation of an Unmanned Vehicle using a GSM network with Microcontrollers. *International Journal of Science, Engineering and Technology Research*, *2*(2), 36-39.

[18] Bourdillon, B. (2015). Design analysis of a GSM/RF-based remote controlled robotic car. *International Journal of Computer Engineering and Intelligent Systems*, *6*(1), 67-69.

[19] Binoy, B. N, Abhinav, K. T., Keerthana, A. S.,Rathnaa, B. & Aswathy, S. N. (2010). AGSM-based Versatile Unmanned Ground Vehicle. *IEEE Conference on Emerging Trends in Robotics and Communication Technologies, Chennai, Indi*, *2*(5), 50-57

[20] Cho, j. & Jeon, w. (2008). Remote Robot control System based on DTMF of Mobile Phone. *IEEE International Conference*, *2*(4), 45-47.

APPENDIX 1

ISSN 2229-5518

PROGRAMMING

```
//#define m11 2 //#define m12 3 //#define
m21 4 //#define m22 1
//#define m31 0 //#define m32 6 SSS//#define
m41 7 //#define m42 5
constint D0 = A0, D1 = A1, D2 = A2, D3 =
A3, SQ = A4;
constint LAT = 12, DAT = 8, CLK = 4, OE =
7;
constint PINS[] = {D0, D1, D2, D3, SQ,
LAT, DAT, CLK, OE};
int mode, incoming;
void forward(){
digitalWrite(LAT, 0); digitalWrite(OE, 1);
mode = 1;
shiftOut(DAT, CLK, MSBFIRST,
B10010101);
digitalWrite(LAT, 1); digitalWrite(OE, 0);
Serial.println("Forward");
// digitalWrite(m11, HIGH);
digitalWrite(m12, LOW);//
digitalWrite(m21, HIGH); digitalWrite(m22,
LOW);
// digitalWrite(m31, HIGH);
digitalWrite(m32, LOW);//
digitalWrite(m41, HIGH); digitalWrite(m42,
LOW);
}
void backward(){
digitalWrite(LAT, 0); digitalWrite(OE, 1);
mode = 2;
shiftOut(DAT, CLK, MSBFIRST,
B01101010);
digitalWrite(LAT, 1); digitalWrite(OE, 0);
Serial.println("Backward");
// digitalWrite(m11, LOW);
digitalWrite(m12, HIGH);//
digitalWrite(m21, LOW); digitalWrite(m22,
HIGH);
// digitalWrite(m31, LOW);
digitalWrite(m32, HIGH);//
digitalWrite(m41, LOW); digitalWrite(m42,
HIGH);
}
void left(){
digitalWrite(LAT, 0); digitalWrite(OE, 1);
mode = 3;
shiftOut(DAT, CLK, MSBFIRST,
B00000101);
digitalWrite(LAT, 1); digitalWrite(OE, 0);
Serial.println("Left");
// digitalWrite(m11, HIGH);
digitalWrite(m12, LOW);//
digitalWrite(m21, LOW); digitalWrite(m22,
LOW);
// digitalWrite(m31, HIGH);
digitalWrite(m32, LOW);//
digitalWrite(m41, LOW); digitalWrite(m42,
LOW);
}
void right(){
digitalWrite(LAT, 0); digitalWrite(OE, 1);
mode = 4;
shiftOut(DAT, CLK, MSBFIRST,
B10010000);
digitalWrite(LAT, 1); digitalWrite(OE, 0);
Serial.println("Right");
// digitalWrite(m11, LOW);
digitalWrite(m12, LOW);//
digitalWrite(m21, HIGH); digitalWrite(m22,
LOW);
// digitalWrite(m31, LOW);
digitalWrite(m32, LOW);//
digitalWrite(m41, HIGH); digitalWrite(m42,
LOW);
}
void Stop(){
digitalWrite(LAT, 0); digitalWrite(OE, 1);
mode = 0;
shiftOut(DAT, CLK, MSBFIRST, 0);
digitalWrite(LAT, 1); digitalWrite(OE, 0);
Serial.println("Stop");
}
void setup(){
Serial.begin(9600); Serial.println("Ready..");
for(int x=0; x<=4; x++){
pinMode(PINS[x], 0); pinMode(PINS[x+5],
1);
} Stop();
}
void loop(){
// while(Serial.available()){
//   char inchar = Serial.read();
Serial.println(inchar);
//   if(inchar == 'f') forward();
//   else if(inchar == 'b') backward();
//   else if(inchar == 'l') left();
//   else if(inchar == 'r') right();
//   else if(inchar == 's') Stop();
// }
int temp1=digitalRead(D0); int
temp2=digitalRead(D1);
```

ISSN 2229-5518

```
int temp3=digitalRead(D2);  int
temp4=digitalRead(D3);
if(digitalRead(SQ) && !incoming){
incoming++;
if(temp1==0 && temp2==1 && temp3==0
&& temp4==0 && mode!=1)  forward();
else if(temp1==0 && temp2==0 &&
temp3==1 && temp4==0 && mode!=3)
left();
else if(temp1==0 && temp2==1 &&
temp3==1 && temp4==0 && mode!=4)
right();
else if(temp1==0 && temp2==0 &&
temp3==0 && temp4==1 && mode!=2)
backward();
else if(temp1==1 && temp2==0 &&
temp3==1 && temp4==0 && mode)  Stop();
  else if(!digitalRead(SQ))  incoming = 0;
```