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DESIGN AND FABRICATION OF GSM BASED ROBOT

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Abstract*-Robotics has revolutionized the field of science 'As Knowledge is power'. Its application can be beneficial or detrimental in the entire field like Science, Engineering, Communication, Control, Wireless etc. This paper summarizes a study conducted to examine the feasibility of implementing Global System for Mobile Communications (GSM), using Duel Tone Multi-Frequency (DTMF) as an alternative means of communication to Radio Frequency (RF) to control a robot. With advantages of simplicity and audibility, the goal is to move a robot viewing by video calling features and control the movement using DTMF technology via GSM network. In the present design, we are using GSM to control the robot from any other mobile phone. The paper deals with design and experimentation, which can be useful for the people who are working in research laboratory, industry & education in the field of Robotics Control for vehicle, fountain sprayer and spying purpose in the enemy area.*

Keywords: Robot, GSM, DTMF, Wireless, Spy

1. INTRODUCTION

The objective is to develop a wheeled robot. The robot will work as an "Unmanned Human Vehicle". It will play an important role both for the people and industries involved in development of new technologies.

The "Design and Fabrication of GSM based Robot" project entails the design and construction of a remotely controlled mobile robot, in which latest telecommunication technology such as DTMF (Dual Tone Multi- Frequency) is implemented. The aim is to summarize a study conducted to examine the feasibility of implementing GSM (Global System for Mobile Communications), using Multi-Frequency (DTMF) and Video calling as an alternative mean of communication to Radio Frequency (RF) to control a robot. Figure 1 illustrates the final project.

Fig.1: Final Project

1.1 Problem Statement

(1) The first sub problem is to establish (produce) a conceptual design and then develop a detailed design of each of the different constituents of the system.

(2) The second sub problem is to develop and build all the components of the robot and finally integrate.

(3) The third sub problem is to test the operation of the built model and assess its performance and limitations.

1.2 Hypothesis

(1) The implementation of a fast remote control can be achieved by connecting the robot to a GSM network.

(2) All units, mainly electronics, and mechanical will be integrated such that a coherent operation may result.

(3) The final model will be robust and able to execute commands and perform the requested task immediately after reception of instruction.

1.3 Delimitations

This work was limited to the design and construction of the robot. It mainly focuses on the following aspects:

- Mobility
- GSM system
- DTMF system
- Video calling features
- Voice recording

The study will not consider the following aspects:

- Artificial Intelligence for autonomous operation
- Sending and receiving SMS/MMS messages
- Take pictures and send them as MMS messages
- Construction of the outer shell of the robot

1.4 Assumptions

(1) It is assumed that the mobile GSM network operator will provide a proper and reliable service all the time.

(2) It is assumed that the circuit to be incorporated inside the robot will not be sensitive to vibrations and shocks.

(3) It is assumed that the person interacting with the robot has a basic knowledge of the implemented functions.

2. LITERATURE REVIEW

The desire of making life better and easier is part of human nature. Building a system or a machine that could do things without human intervention was and is still very fascinating. The first robotic companies and research groups were formed in the 60's. Since then, robotics has evolved significantly and today we find robots almost everywhere in our everyday lives.

2.1 GSM

GSM is a standard for digital mobile telephony developed in Europe to substitute the existing analog mobile telephony technology. GSM stand for Global System for Mobile Communication and gained worldwide popularity. GSM offers three categories of services. The first category is related to the transportation of data to or from an ISDN terminal. The second category is referred to as Tele-services (includes services such as telephony and SMS). The third category is referred to as supplementary service (includes services such as caller identification, call forwarding) [1, 3].

2.2 DTMF

DTMF signaling is used for telecommunication signaling over analog telephone lines in the voice-frequency band between telephone handsets and other communications devices and the switching center. A valid DTMF signal is the sum of two tones, one from a low group (697-941Hz) and one from a high group (1209-1633Hz) with each group containing four individual tones. The tone frequencies were carefully chosen such that their inter modulation products result in minimal signaling impairment. It allows for 16 unique combinations. Ten of these codes represent the numerals zero through nine, the remaining six (*,#,A,B,C,D) being reserved for special signaling [2, 4].

Table1: Keypad Dial Tone Frequency Table

	1209 Hz	1336 Hz	1477 Hz	1633 Hz
697 Hz	1	2	4	A
770 Hz	4	5	6	B
852 Hz	7	8	9	C
941 Hz	*	0	#	D

The applications for DTMF signaling are tremendous and due to innovative technological advances its use is increasingly widespread. The applications are limited only by one's imagination.

2.3 Robotics

Asimov introduced the term "Robotics" which he first used in his book "Runaround" in 1942. But Asimov's most important contribution to the history of the robot is the creation of his three laws of robotics (Dowling, 1996) [5]:

- A robot may not injure a human being, or, through inaction, allow a human to come to harm.
- A robot must obey the orders given to it by human beings except where such orders would conflict with the first law.
- A robot must protect its own existence as long as such protection does not conflict with the first or second law.

Asimov later added a "zeroth law" to the list, which is stated as follow:

- A robot may not injure humanity, or, through inaction, allow humanity to come to harm.

2.3.1 Robot Design

Generally, the design of a robot requires a main control unit, sensors, input and output interfaces, response units, and a power supply.

The mainframe: It is the mechanical housing and the supporting framework for the machine.

Internal power supply: This is the source of electrical power. It directly supplies all internal electrical circuits and external response mechanisms.

External power supply: This is used to recharge the batteries and provide electrical power for testing.

The internal response mechanisms: These are devices that response relevant to machine's internal operation.

The external response mechanisms: These are devices such as motors and loudspeakers that provide the means for making responses with external environment.

3. SYSTEM DESIGN AND IMPLEMENTATION

A robot is a mechatronics system, which is made not only of mechanical and electronic components, but also of built-in software constituents for controlling them. Designing such a system requires multidisciplinary expertise since the disciplines involved span from electronics, sensor technology, programming, control engineering, mechanical design, materials and manufacturing. This project was no exception to the rule. Looking at the robot and the functions to be implemented as a complete system, the design of it was done in two phases. The first one was to draw a conceptual design of the system and the second one was the detailed design.

3.1 Conceptual Design

The shape of the machine was not of the utmost importance but rather the robot had to be able to move forward, backward, turn left and right, and execute commands originating from a mobile phone.

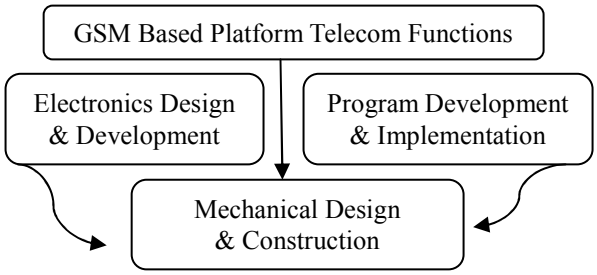


Fig. 2: System Design Approach

Generally, a three wheels system is more stable than a 2 wheels system, but four wheels are more stable for most of the ordinary terrains. So the design of GSM based Robot is based on a four wheel configuration. In order to simplify the control and the steering of the system, two of the wheels are driven by motors and the other two are castor wheels for increased stability. This GSM Robot needs an integrated circuit to manage and control the whole system. A mobile phone has to be incorporated in the robot. This is implemented by using a DTMF IC MT8870 and using a microcontroller (PIC16F84A) in system, making it enough intelligent to make the necessary decisions on basic and regular tasks.

3.2 Detailed Design

Detailed design of GSM based robot is divided in 5 subsystems: Telecommunication, Electronics, Motion control, Programming and Mechanical.

3.2.1 Telecommunication

The telecommunication part of the system consisted in the implementation of the remote control function using DTMF technology via GSM network. PIC16F84A is the brain of the whole system, so the PIC inside the robot has to be able to connect to the GSM network so that it can be reached by using a remote mobile with a known number. To establish a communication a mobile phone is one option which is easy to use in such an incorporating device that can link the robot's brain to the mobile network. It is flexible due to the fact that various kind of mobile phone is available in market. Therefore in this project, the mobile phone was found to be the best option. A wired headphone is used to connect the mobile phone with the DTMF IC CM8870.

3.2.2 Electronics

The robots being an electromechanical system, there are a number of electronic circuits design and used in this project. The most important circuits developed are the DTMF circuit, PIC circuit, the motor control circuit.

3.2.2.1 Microcontroller Circuit

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Microcontrollers are used in automatically controlled products and devices. Here PIC16F84A is used.

The words in the microcontroller are programmed in the sequence as the work so that when the microcontroller reads the input from the DTMF IC MT8870, it is able to identify the word that has been said. The microcontroller will then transmit the desired commends to the motor control circuit.

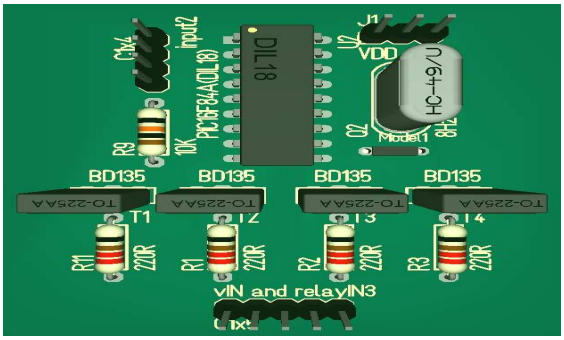


Fig. 3: PIC16F84A Circuit

3.2.2.2 Motor Control Circuit

It refers to the electronic interface between the central control board and the actual motors. This can be achieved using BJT or FET transistors in a half bridge configuration, or by using half bridge IC's such as LD293. But in this project, due to the estimated weight of the robot and therefore the expected current, the option selected was the use of relays in the circuit.

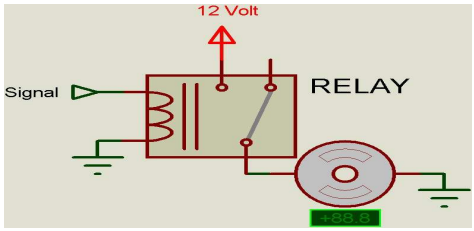


Fig. 4: Motor Control Circuit

3.2.2.3 DTMF Circuit

The purpose of this circuit is to provide the robot with some senses. GSM Robot being a remote controlled mobile robot, it needs "commands" to follow the instructions, providing it with a mean of mobile frequency.

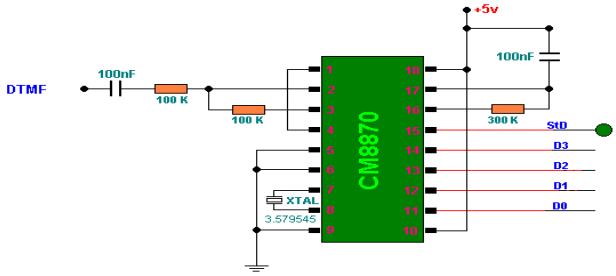


Fig. 5: DTMF Receiver Circuit

Many types of DTMF IC are available for mobile frequency detection applications, in this project CM8870 were the best option because in this specific case they work better than the others and are available in market. The CM8870 decoder uses digital counting techniques for the detection and decoding of all 16 DTMF tone pairs into a 4-bit code.

Table 2: Functional Decode Table

Key Tone	Output Logic			
	Q4	Q3	Q2	Q1
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	1	0	1	0
*	1	0	1	1
#	1	1	0	0

3.2.3 Mechanical

The robot needed a body of some shape in order to be useful especially for doing its job. Due to the scope of the work and the time allocated, it was found necessary to focus more on the implementation of the GSM functions to be implemented, so on the mechanical side, the idea was to build a basic frame on which the various electronics circuits and other equipments could be supported and carried. The height of the robot 12cm; the shape is like a rectangle. This frame can serve for experimental purposes, and later can be improved for future versions of the robot.

The main frame has four portions. The left/right portion is 48 x 10 cm^2 and the front/back portion is 35 x 7 cm^2.

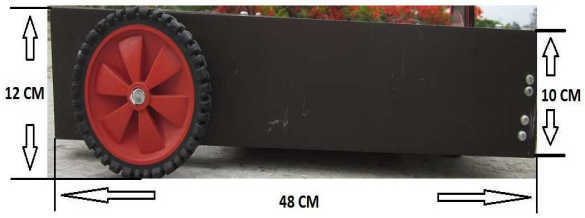


Fig. 6: Left/Right View

Fig. 7: Front View

The frame is a structure with two wheels on the rear-left and rear-right sides and two smaller wheels at the bottom-front.

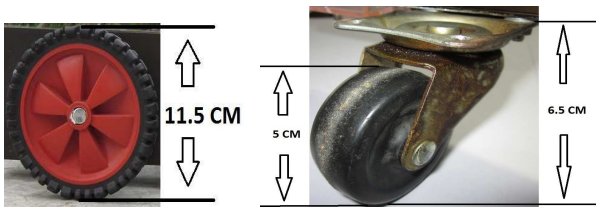


Fig. 8: Wheel

The big wheels on the sides are 11.5cm diameter, and the small wheels at the bottom are 5cm diameter.

The structure has plywood in upper and lower portion to support to the main frame. It is also used as a base to provide space to store the equipments like battery, circuit board.

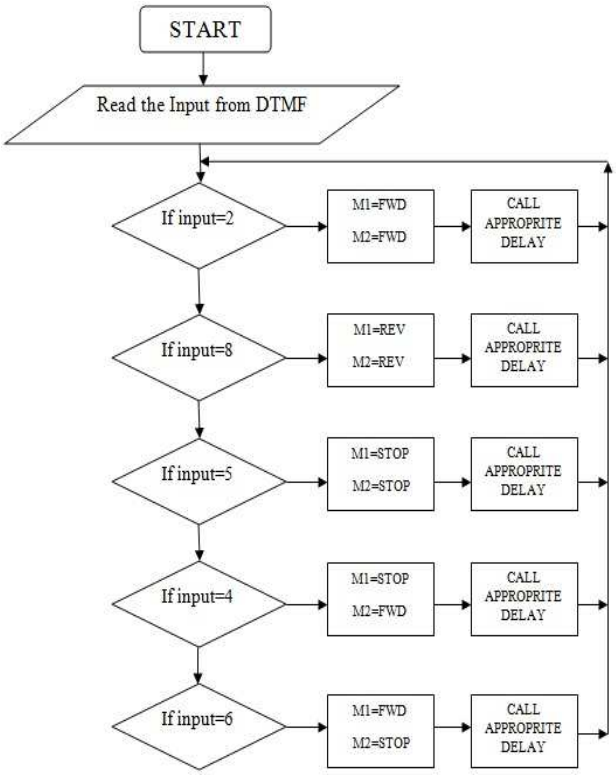
3.2.4 Programming and Software

The implementation of the GSM based Robot required some programming. C programming that developed on mikroC (a window based C compiler for Microchip PIC microcontrollers) is the main brain of the system, which manages the all tasks to be carried out by the robot. Most of the control is done by the PIC16F84A, which is the central processing unit of this robot.

To complete the project it required some software, used for simulation, for programming, to control response mechanisms (motors), for circuit making, and to burn hex file in PIC. They are

- Proteus
- Target 3001! V15
- IC-Prog 1.05A
- mikroC, mikroElektronika C compiler

3.2.5 Flowchart



4. TEST AND RESULT

Integration is one of the most interesting and difficult parts of any project, in the sense that it reveals a lot of crucial issues and sensitive aspects necessary for the operation of the system. The design resulted in a number of processes.

4.1 Complete System Integration

All the different board was combined as planned for system integration. The circuit integration was done in two bread board. The last phase of integration was to integrate the electronic assembly and the other devices that constitute the robot such as the batteries and the mobile phone into the mechanical body to support it.

Fig. 9: Complete System Integration

4.2 Final Design

Fig. 10: Left/Right Side View

Fig. 11: Front View

Fig. 12: Back View

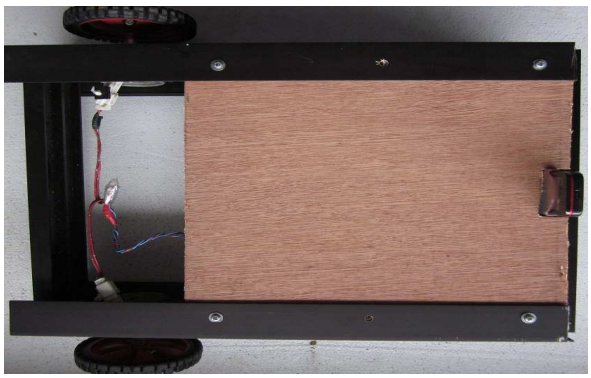


Fig. 13: Top View

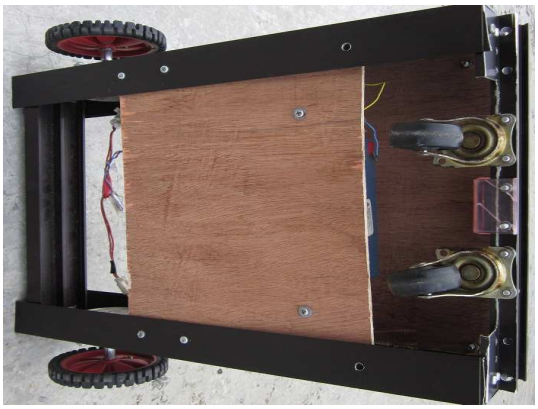


Fig. 14: Bottom View

4.3 Performance

The aim of this project was to design and build a GSM Robot, and the main output of this project is an unmanned human vehicle referred to here as GSM based Robot. Some important tools and some aspects of the performance of the robot were presented.

Table 3: Performance Table

Functions	Features	Performance
Motion	Forward	√
	Backward	√
	Turn right	√
	Turn left	√
GSM Control	By Mobile	√
Picture	take by Bluetooth device (PC)	√
Video	take by Bluetooth device (PC)	√
Bluetooth	Data transfer	√
DTMF Signal	Receiving	√
Battery Life	12V 7AMPH	√
Wiper Motor	Torque & Speed	√
Structural Material (Aluminum)	Strength, Light Weight	√
Flexibility	Assembly	√
Design		√
Sensibility		√

5. CONCLUSION

Designing a GSM mobile robot to be used as an "unmanned human vehicle" and assessing its performance was the main objective of this project. In this section all the conclusions drawn from the design and implementation of systems are described.

5.1 Design Conclusions

The design of GSM Robot is based on the concept developed during the early stage of the project, inspired by both the nature and the goal of the project. The design concept of is consisted by two different section brought together, mainly the electronic section and the mechanical section.

The electronic section of the system is consisted by meaning of the system controls only some devices like motors while others like DTMF circuit are quite independent and communicates between the mobile phone and PIC circuit for frequency based data transfer. The connection has also been taken care of in order to keep the interior clear and presentable.

The mechanical design is adapted to facilitate mobility of the robot. It is a simple design made where two motors are mounted and all the necessary equipments like battery, circuit are placed. The frame is made by aluminum. The frame has four portions. The four portions can be assembled together and dismantled with relative ease. The motors and the wheels can also be dismantled further by separating from the aluminum frame and therefore the whole system is flexible. All these aspects make the system easy to understand, use and maintain.

5.2 Performance Conclusions

GSM Robot performs a number of communication and mechanical functions. Mobility is one of the most important requirements of the project, and GSM Robot does move forward, backward and turn left as well as right at the operator's command. The performance as far as the motion is concerned is satisfactory. The electronics and mechanics used to implement motion are also satisfactory.

The concept of controlling the robot with a mobile phone has also been implemented with great success. Though the reliability of the use of a mobile phone as a remote control depends on mainly on GSM network, but no failure was observed during the test period. The complete system is working properly. The Robot responds to all the implemented commands given by the PIC and performing all the commands perfectly.

6. REFERENCES

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