DESIGN AND IMPLEMENTATION OF MICROCONTROLLER BASED AUTOMATIC FAN SPEED REGULATOR USING MOBILE PHONE

1PRINCE NONSO NWANKWO, 2MARY. N. ORJI

1Department of Computer Engineering; Federal Polytechnic, Oko (Anambra State, Nigeria)
2Department of Computer Science; Federal Polytechnic, Oko (Anambra State, Nigeria)

E-mail: 1princetechfoundation@yahoo.com, 2basorji@yahoo.com

Abstract- Past few years; home automation, remote control and monitoring systems have witnessed a rapid growth as a result of advancements in technology. As the world is becoming more technologically advanced, home and industrial automations are becoming more popular. Today, almost all the available Fans (standing and ceiling) are controlled manually by voltage regulators which have different stages of speed. This type of control is an uphill task for the physically challenged persons and the aged ones due to movement constraints. Sometimes; we are victims of electric shocks from our electric Fan when we try to regulate them, due to leakage currents from the electric switches/regulator. This paper presents the overall cost-effective “Microcontroller Based Automatic Fan Speed Regulator Using Mobile Phone”. The aim of the project is to develop a system which uses DTMF technology available in our mobile phones and Bluetooth module to remotely regulate the speed of a standing Fan. This project is a means of exposing another vital application of the mobile phone other than its primary purposes of making/receiving calls, sending messages, and browsing the internet. The designed project is restricted to the control of a standing Fan with three speed levels (speed 1, speed 2, and speed 3). The designed system has a Bluetooth interface. The range of the Bluetooth is 10 meters, thus; the user can be able to regulate the Fan speed within a distance of 10 meters. The system makes use of three (3) relays, representing the three speed levels of the Fan. Each relay is controlling a particular speed level. The relays are interfaced to the microcontroller via BC337 (NPN) transistors which acts as a buffer. When a key is pressed on the mobile phone, the tone of that particular key is coupled to the DTMF decoder via the Bluetooth module. The DTMF decoder chip (MT8870) decodes the frequency of the key, and generate the corresponding 4-bit code at the output (Q1- Q4); which are interfaced to the microcontroller for further processing and control. The microcontroller regulates the Fan speed by energizing or de-energizing the corresponding relay. We have discussed about hardware requirement, Software requirement, block diagram, flow chart, and the operation of the system. A satisfactory result based on the design specifications was achieved after construction. Therefore an indigenous low cost control system has been developed which can be used in real life application.

Keyword- Dual Tone Multi-Frequency (DTMF), Global for System Mobile Communication (GSM), Bluetooth Module, Microcontroller, Relay, Seven Segment Display.

I. INTRODUCTION

Home automation using GSM technology is increasingly becoming an easy and comfortable way of control to the populace. The technology is exposing different applications of the mobile phone other than its primary purposes of making/receiving calls, sending text massages, and browsing the internet by more than 95% of its users. Almost all the available Fans today are controlled manually by voltage regulators or control knob which has different stages of speed. After a person falls asleep, the metabolic rate of one’s body decreases, and one is expected to wake up from time to time to adjust the speed of the Fan. Many people have died as a result of this, and the physically challenged persons and aged ones are affected the most; because of the inconveniences and movement constraints associated with changing the Fan speed level or switching it OFF manually when the room temperature changes [1]. The importance of the designed project most especially to the physically challenged persons and the aged ones cannot be over-emphasized, as it enables them to automatically change the Fan speed or switch it OFF remotely from the comfort of their wheelchair or bed without relying on their relatives, which may not be around to manually regulate the Fan speed when the need arise. The distinct characteristic of automatic control system is that it eliminates or reduces the human operator. In this project, we designed and implemented a cost effective GSM Fan speed regulator using mobile phone. Dual Tone Multi-Frequency (DTMF) are generated from the keypad of the mobile cell phone of the user to remotely regulate the speed of a standing Fan having three different speed levels, and also to switch it OFF. The project uses DTMF technology available in our mobile phones to achieve its aim and objectives.

1.2 Background

In this paper, we presented a cost effective automatic Fan speed regulator using mobile phone. Integrated DTMF receivers (MT8870) decode the tones and send the corresponding 4-bit code to the microcontroller for further processing and control. The system has a Bluetooth attached to it to wirelessly receive the tone of the key pressed on the mobile phone of the user. The Bluetooth operates within a distance of 10 metres, thus; overcoming the limited range of infrared to offer the physically challenged persons and aged ones better, reliable, efficient and effective means of regulating their Fan speed
speed. The system has three relays which represents the three speed levels of the Fan. Anytime the microcontroller decodes the key pressed on the mobile phone, it carries out the necessary decoding, comparing and switching of the relay (via a transistor) based on the code programmed into its memory. The designed system allows a greater degree of freedom to an individual in regulating Fan speed. The system will also go a long way in helping the physically challenged persons and the aged ones in remotely regulating their Fan speed rather than relying on their relatives.

1.3. Aim and Objectives
The aim of the project is to design an embedded system that can control Fan speed with three (3) different speed levels by pressing the corresponding key on the user mobile phone using DTMF technology.

The objectives of project:

1. To design a system which aimed at effectively using mobile phone (DTMF) to regulate the speed of a standing Fan having three (3) speed levels.
2. To design a system that helps the physically challenged persons and the aged ones remotely regulates Fan Speed instead of relying on their relatives.
3. To implement a cost effective control system that will provide regulating of Fan speed remotely within a distance of 10 meters.
4. To design an embedded system that will eliminate electric shocks from our electric Fans when we try to change their speed/switch them OFF; due to leakage currents from the regulator or the control knob.
5. To Design an automatic control system that can display the Fan speed at any particular point in time.

1.4: Motivation
1. To expose another vital application of the mobile phone other than its primary purposes of making/receiving calls, sending text messages, and browsing the internet.
2. To explore and analyse the importance of adopting mobile phone and DTMF technology in controlling of physical processes.
3. To explore and expand the capability and the compatibility of the mobile phone, microcontroller, Bluetooth module and the DTMF decoder.
4. To demonstrate how to interface the DTMF decoder chip (MT8870) and the microcontroller in controlling of physical processes.
5. To demonstrate the need and importance of adopting GSM technology in home automation, and hazardous industrial control.

1.5. Scope of Work
The project is restricted to the control of Fan speed with three (3) speed levels. If additional two relays are connected to the system; it can be used to regulate the speed of a Ceiling Fan; which normally have five (5) different speed levels.

II. SYSTEM IMPLEMENTATION

The Bluetooth technology is the gift for the modern home automation which operates over 2.4GHz frequency. Bluetooth technology can link electronic devices within a range of 10m to 100m at the speed of up to 3 Mbps depending on the Bluetooth device [2]. The designed project uses DTMF technology, microcontroller, Bluetooth module, and other active/passive electronic components to remotely regulate the speed of a standing Fan with three (3) different speed levels.

A block diagram of the system was first developed, to have a better understanding of the overall functionality of the system. Fig. 1 below shows the complete block diagram of the automatic Fan speed regulator using mobile phone. The design comprises of different modules interfaced with the AT89c52 microcontroller to achieve the desired system. The main units of the project include:

- The Magnetic Isolation Unit.
- The DTMF Decoder Unit.
- The Relays Driver Unit.
- The Regulated Power Supply Unit.
- The Microcontroller Unit.
- The Seven Segment Display Unit.

![Fig. 1. Block Diagram of the Automatic Fan Speed Regulator](image)

2.1. The Magnetic isolation unit

The Magnetic isolation unit is a 12v, 500mA set-up transformer, clearly shown in fig. 2 below. It is used to provide electrical isolation between DTMF decoder and Bluetooth module. The transformer isolates the system ground and Bluetooth module. Therefore, the DTMF decoder integrated circuit is not affected by noise. The signal from the Bluetooth module is weak, therefore needs to be amplified. The magnetic isolation unit is also used to boast the electrical signal from the Bluetooth module before it
is fed as an input to the DTMF decoder for further processing. The primary side of the transformer is connected to the input of the DTMF decoder, while the secondary side is connected to the Bluetooth module via an earpiece wire. Therefore, the magnetic isolation unit is used to couple the signal from the Bluetooth module to the DTMF decoder.

2.2. The DTMF Decoder Unit
This circuit decodes the keypad pressed on the mobile phone via the Bluetooth module. The dial tone you hear when you press any key in your mobile phone is called Dual Tone Multi-Frequency, DTMF in short. The name was given because the tone is actually made up of two distinct frequency tones (high and low), hence the name dual tone [3]. The DTMF decode chip (MT8870) is used to decode any number pressed on the mobile phone. The binary equivalent of the decoded number is sent to the microcontroller for further processing and control. The possible 16 tones in your mobile phone are shown in fig. 3 below, while the possible 12 tones available on phone keypad are shown in fig. 4. Table 1 below shows the DTMF low and high frequency tones and decoded output. Fig. 5 shows the Pin-out configuration of the MT8870 DTMF Decoder.

<table>
<thead>
<tr>
<th>Button</th>
<th>Low DTMF frequency (Hz)</th>
<th>High DTMF frequency (Hz)</th>
<th>Binary coded output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>697</td>
<td>1209</td>
<td>0 0 0 1</td>
</tr>
<tr>
<td>2</td>
<td>697</td>
<td>1336</td>
<td>0 0 1 0</td>
</tr>
<tr>
<td>3</td>
<td>697</td>
<td>1477</td>
<td>0 0 1 1</td>
</tr>
<tr>
<td>4</td>
<td>770</td>
<td>1209</td>
<td>0 1 0 0</td>
</tr>
<tr>
<td>5</td>
<td>770</td>
<td>1336</td>
<td>0 1 0 1</td>
</tr>
<tr>
<td>6</td>
<td>770</td>
<td>1477</td>
<td>0 1 1 0</td>
</tr>
<tr>
<td>7</td>
<td>852</td>
<td>1209</td>
<td>0 1 1 1</td>
</tr>
<tr>
<td>8</td>
<td>852</td>
<td>1336</td>
<td>1 0 0 0</td>
</tr>
<tr>
<td>9</td>
<td>852</td>
<td>1477</td>
<td>1 0 1 0</td>
</tr>
<tr>
<td>*</td>
<td>941</td>
<td>1209</td>
<td>1 0 1 1</td>
</tr>
<tr>
<td>#</td>
<td>941</td>
<td>1477</td>
<td>1 1 0 0</td>
</tr>
</tbody>
</table>

Each key pressed on the keypad generates two tones of particular frequencies, so a voice or a random signal cannot mimic DTMF signaling tones. One tone is generated from a High DTMF frequency group of tones and the other from Low DTMF frequency group [4].

2.3. The Relays Driver Unit
The relays driver unit consists of three transistors and three relays for controlling the Fan speed levels. Each relay is responsible for a particular speed. The relays are interfaced with the microcontroller via the transistors. Fig. 6 below shows how the microcontroller is interfaced with the relays via the transistors. The relays are connected to the control knob of the Fan (internally), to automatically regulate the Fan speed instead of controlling it manually. The microcontroller use Setb and Clr commands to energize and de-energize the relays. The diodes connected across the relays are called “flywheel
diodes”. They are used for blocking back voltage produced during the switching operation of the relays.

Fig. 6. Microcontroller to transistors and relays interface

2.4. The Regulated Power Supply Unit

The regulated power supply is used to provide the power requirements of the system. Electronic components require a steady DC power supply, thus; a regulated power supply unit was built to this effect. A regulated power supply converts Alternating Current (AC) to a constant Direct Current (DC). A regulated power supply is used to ensure that the output remains constant even if the input changes [5]. A regulated DC power supply is also known as a linear power supply; it is an embedded circuit and consists of various blocks. Fig. 7 below shows the complete power supply circuit of the designed system.

Fig. 7. Regulated Power Supply Circuit (5vDc)

2.5. The Microcontroller Unit

The AT89c52 comes from the popular 8051 family of Atmel Microcontrollers. It is an 8-bit CMOS microcontroller with 8K as Flash memory and 256 bytes of RAM. It has 32 I/O pins comprising of three 16-bit timers, external interrupts, full-duplex serial port, on-chip oscillator and clock circuitry [6]. The CPU of the AT89c52 microcontroller comprises of the Arithmetic and Logic Unit (ALU), the Registers, and the Control unit. The function of the ALU is to perform all the arithmetic and logic expressions from or within the CPU. The register part of the CPU is a temporary memory unit. The Control unit is the most complex part of the CPU. It receives the binary number signifying the instruction about to be carried out, decodes the instruction, and carries it out according to the steps required [7]. The pin configuration of the AT89c52 is shown in Fig. 8 below.

Fig. 8. The Pin Configuration of the AT89c52

2.6. The Seven Segment Display Unit

The seven segment display unit consists of four -in-one 7-segment display and four Bc337 (NPN) transistors. The transistors are used as buffer, to boost the signal from the microcontroller to the desired level required to drive/light the 7-segment display. The type of 7-segment used in this project is the common anode type. The cathodes of the 7-segment display are directly connected to port 2 of the microcontroller, while the anode (positive terminal) of each segment is connected to the microcontroller via a transistor. The 7-segment display screen and the microcontroller interface are shown in fig. 9 below.

Fig. 9. Microcontroller and 7-segment Display Interface
III. SYSTEM FLOW-CHART AND PRINCIPLE OF OPERATION

3.1. System Flow-chart
The Flow Chart of the Automatic Fan Speed Regulator is shown in fig. 10 below.

A flow chart is a graphical or symbolic representation of a process. Each step in the process is represented by a different symbol and contains a short description of the process step. The flow chart symbols are linked together with arrows showing the process flow direction [8].

3.2. Principle of Operation
The designed project “Automatic Fan Speed Regulator using Mobile Phone” is an embedded system that is capable of controlling/regulating the speed of an electric Fan using mobile phone. The project uses DTMF technology incorporated in our mobile phones to regulate the speed of an electric Fan with three speed levels. The DTMF decoder (MT8870) uses digital counting techniques to detect and decode each tone pairs into a 4-bit code. When a key is pressed on the mobile phone, a tone (electrical signal) is generated which is coupled to the magnetic isolation unit via the Bluetooth module. The magnetic isolation unit which is a step-up transformer boosts the electrical signal and fed as an input to the DTMF decoder. The MT8870 (DTMF decoder) decodes the tone into a 4-bit code, which is sent to the microcontroller for further processing and control actions. The microcontroller performs the necessary control actions based on the 4-bit code received from the output of the DTMF decoder (Q1-Q4) and the code stored into it during programming.

IV. IMPLEMENTATION, TESTING, AND RESULTS
The system design was implemented with assembly language. During individual component testing, pins of soldered segments on the vero-board were checked for dry joints and a multi-meter was used to test for short-circuiting in the connections. 40 pins IC socket and 18 pins IC sockets for the microcontroller and the DTMF decoder respectively, were first soldered permanently on the vero-board so that the microcontroller can be removed and reprogrammed; and also to avoid damaging the integrated circuits during soldering. Continuity test was carried out to ensure that there was no bridging. The next test was to check and confirm proper required voltage at various components.

5v typically was confirmed for the microcontroller and the DTMF decoder. After the implementation of the project, the Bluetooth module was paired with Nokia phone (music express), to establish wireless communication link. The project was tested by sending different commands wirelessly via the mobile phone. The project performed different operations required for regulating/changing the Fan speed.

4.1. Operation Codes of the Designed Project
Table 2 below shows the operation codes of the Automatic Fan Speed Regulator using Mobile Phone. The codes were stored into the microcontroller during system programming. Anytime a key is pressed on the mobile phone, the microcontroller decodes the number with the help of the DTMF decoder and checks the operation codes to ascertain the operation to be performed.

<table>
<thead>
<tr>
<th>Speed 1</th>
<th>Spd 1</th>
<th>2</th>
<th>Go to Speed 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed 2</td>
<td>Spd 2</td>
<td>5</td>
<td>Go to Speed 2</td>
</tr>
<tr>
<td>Speed 3</td>
<td>Spd 3</td>
<td>8</td>
<td>Go to Speed 3</td>
</tr>
<tr>
<td>OFF</td>
<td>OFF</td>
<td>0</td>
<td>Switch Off the Fan</td>
</tr>
</tbody>
</table>

Table 2: Operation codes of the designed project

4.2. Testing and Results
After design and implantation, the project was tested and it works satisfactorily; as it was able to regulate the speed of an electric Fan having three different speed levels; according to operation codes shown in table 2 above. The snap shots of the results obtained during testing of the project are shown in fig. 10 to fig. 14 below.

Fig. 10: Fan - Speed 1 (Spd 1)
V. CONCLUSION

The designed system was able to regulate the speed of an electric Fan having three different speed levels. This was achieved using five main components; AT8952 microcontroller, MT8870 DTMF decoder, Bluetooth module, relays, seven segment display; among other active and passive electronic components.

The designed project overcomes the limited range of infrared, and provides physically challenged persons and aged ones with better ease of regulating speed of their Fans. Indeed, this is a wonderful breakthrough in mobile phone home automation and control system.

REFERENCES


