DTMF based Home Automation System

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Abstract:
This paper presents the design of home automation system using dual tone multiple frequency based home automation system. Today’s demand for better home security systems has drifted over to a need for home automation. Not only does a home need to be secure but home appliances need a more refined control system. Home appliances should not be limited to only local control. There needs to be a simple and elegant way to avoid this type of situation and allow people the freedom of having complete control of their house from anywhere. The main objective of this DTMF based home automation system is to develop an embedded system which can control remote appliances remotely by using telephone line.

Keywords: Appliances, DTMF decoder, Home Automation, Microcontroller, Mobile phone.

1. INTRODUCTION
Automation is a technique, method, or system of operating or controlling a process by electronic devices with reducing human involvement to a minimum. The fundamental of building an automation system for an office or home is increasing day-by-day with numerous benefits. Industrialist and researchers are working to build efficient and affordability automatic systems to monitor and control different machines like lights, fans, AC based on the requirement. Automation makes not only an efficient but also an economical use of the electricity and water and reduces much of the wastage [1]. People use different types of communication in control applications to control home appliances, industrial appliances, and other type of automation. There are two types of communication i.e. generally use - one is wired and other one is wireless. In wireless communication we transmits signal wirelessly, like using radio frequency (RF) and in wired communication in which we uses wires like copper wire. In this paper “DTMF Based Home Automation System” we are going to control our home appliances wirelessly. To control any electrical appliances using mobile phone without using a microcontroller. This circuit makes use of DTMF (Dual Tone Multi Frequency) technique. Dual-tone multiple-frequency signaling (DTMF) is an in-band telecommunication signaling system using the voice frequency band over telephone lines between telephone equipment and other communications devices and switching centers. DTMF system also known as touch-tone system. The touch-tone system using a telephone keypad gradually replaced the use of rotary dial and has become the industry standard for landline and mobile service. Other multi-frequency systems are used for internal signaling within the telephone network. As register signaling is used in DTMF phones here tones rather than make/break pulse are used for dialing and each dialed digit is uniquely represented by a pair of sine waves tones. These tones (one from low group and another from high group) are sent to the exchange when a digit is dialed by pushing the key, these tone lies within the speech band of 300 to 3400 Hz and are chosen so as to minimize the possibility of any valid frequency pair existing in normal speech simultaneously. A valid DTMF signal is the sum of two tones, one from a lower group (697-940 Hz) and the other from a higher group (1209-1663 Hz). The DTMF signal contains only one component from each of the high and low group. This significantly simplifies decoding because the composite DTMF signal may be separated with band pass filters into single frequency component each of which may be handled individually. The underlying principle mainly relies upon the ability of DTMF ICs to generate DTMF corresponding to a number or code in the number pad and to detect the same number or code from its corresponding DTMF decoder [2]. DTMF is acronym for Dual Tone Multi Frequency. When you make call for customer care, they will ask you to press 1, 2 or any other number. When you press a number from your mobile, one particular action is happening. All this is because of DTMF. When a button is pressed in your mobile keypad, it will generate a tone of two frequencies. These tones are called row and column frequencies. Generally, row frequencies are low frequencies and column frequencies are high frequencies. These frequencies for DTMF are chosen in such a way that they don’t have harmonic relation with the others, so that they will not produce same tones. The column frequencies are slightly louder than the row frequencies to compensate for the high-frequency roll off of voice audio system. The application of this project is to switch on and off home appliances by a cell phone. It helps in effective control of home appliances and increases power efficiency. It increases appliances lifetime and also power efficiency. DTMF tones are mainly use in terrestrial stations for turning on and shutting off remote transmitter. It is mainly use in telephone stations for detection of called and dialed numbers. It also helps us to reduce electrical power wastage.

1.1 Components of Home Automation System
The home automation system includes main components which are [3]:

- **User interface:** As a monitor, computer, or Phone, for example, that can give orders to control System.

- **Mode of transmission:** Wired connections (example Ethernet) or Wireless (radio waves, infrared, Bluetooth, GSM) etc.

- **Central Controller:** It is hardware interface that
communicates with user interface by controlling domestic services

- **Electronic devices**: A lamp, an AC or a heater, which is compatible with the transmission mode, and connected to the Central control system.

1.2 **Features of Home Automation System**

In recent years, wireless systems like Remote Control have become more popular in home networking. Also in automation systems, the uses of wireless technologies provide several advantages that could not be achieved with the use of a wired network only [4]:

- **Reduced Installation costs**: Installation costs are significantly reduced since no cabling is necessary.

- **Internet Connectivity**: Control devices from anywhere in the world with use mobile phones to control smart home.

- **Scalable and Expandable**: With the Compare of Wireless network is especially useful when, due to New or changed requirements, an extension of the network is necessary.

- **Security**: Easily add devices to create an integrated smart home security system and built-in security ensures integrity of smart home.

II. **RELATED WORK**

The concept of home automation has been around since the late 1970s. But with the advancement of technology and services, people's expectations of what a home should do or how the services should be provided and accessed at home has changed a lot during the course of time, and so has the idea of home automation systems. If we look at different home automation systems over time, they have always tried to provide efficient, convenient, and safe ways for home inhabitants to access their homes. Irrespective of the change in user expectations, advancement of technology, or change of time, the role of a home automation system has remained the same. From an engineering point of view, a home can be broken down into the “Six S’s” as specified by Brand [1] and given in Figure 1 below, along with who has access to each “S”.

![Figure 1. “Six S’s” as specified by Brand [1].](http://ijesc.org/)

The work of John J. Greichen [8] discussed some of the early challenges faced by home automation systems. These include high manufacturing costs, high development costs, high installation costs, additional service and support costs, lack of home automation standards, consumer unfamiliarity with technology, and complex user interfaces. With the advancement of time, we saw a rapid development in technology and processing power which leads to a considerable reduction in device cost and size. All of these factors have contributed to the popularity of electronic devices today, so people are no longer confused or unsure about the use of computer, mobiles, or tablets. Moreover, a lot of home automation protocols, communication and interface standards like X10 [9], ZigBee [10], LonTalk [11], and CEBus [12] were defined overtime. All these factors contributed to addressing the challenges and concerns of early home automation systems, which lead to the popularity and wide acceptance of automated homes. The study done by A.J. Brush et al. [13] discusses the main stumbling blocks in modern home automation systems: the high overall cost of the system, inflexibility due to integration of different devices into the home automation system, lack of reliable devices at home, complex user interfaces, and reliance on skilled consultants. All these factors lead to poor manageability and lack of convincing security. Smart homes of today consist of a plethora of devices like multiple cameras, microphones, different sensors, actuators, device controllers, and home databases, which can be remotely accessed for user convenience. These devices, along with the home database, have a variety of personal information regarding a home's inhabitants, like healthcare information, financial information, videos, pictures, live video feeds from home, daily habits or routines, favorite music, movies, and sometimes even a personal diary. In some rare cases, inhabitants may use implanted medical devices, which need to be remotely accessed by hospitals or medical professionals, which can be done through the home network. Different devices used, bring different security vulnerabilities to the smart home, so, if or when these modern homes are compromised, they present a greater threat to the privacy and physical wellbeing of the home’s inhabitants than ever before. A lot of research has gone into automating the home [14] [15], making it accessible via the Internet [16] or mobile phones [17] [18], saving energy.
[19], technology assisted living for senior citizens [20], and security. Existing research only addresses and proposes defenses against normal intrusion attempts at home, and doesn’t consider the risk of intrusion from sophisticated or tech-savvy criminals.

III. DESIGN AND WORKING

3.1 DTMF Decoder

Dual Tone Multi Frequency (DTMF) that is paired with a wireless module to provide seamless wireless control over many devices in a house. Dual-tone-multi-frequency (DTMF, also known as touch-tone) are the audible sounds you hear when you press keys on your phone. The tone generator (top) uses the 5589 chip and a DIP switch. You can actually hear the tones through the speaker. The bottom circuit uses the 8870 to decode a tone and display its associated number on the 7-segment LED. Touch-tone is familiar to many (telephone), it is a mature technology, and readily available with off-the-shelf, single-chip, low-cost components. For these reasons DTMF is often used in remote control applications that typically use telephones (e.g. accessing your messages from an answering machine, retrieving your account balance info from your bank's database).

Figure 2. DTMF Decoder

3.2 DTMF Controlled Home Automation System Circuit Diagram:

The main principle of this circuit is to control appliances like light and fan using DTMF technology. DTMF encoder is present in your mobile and decoder is HT9107B IC. Mobile jack is connected at 1nf capacitor. Mobile jack consists of two wires (Red and black). Red wire is connected to the decoder IC and Black is grounded. When a button is pressed from mobile it generates a tone which is decoded by the decoder IC and it is sent to ATmega8 controller. Controller then checks for input and it produces the output according to the code written to it. When the DTMF controlled home appliances circuit is powered, then the controller continuously checks the inputs. When 1 is pressed from the DTMF or mobile keypad, the decoder IC decodes the tone and generates 1 (0001), which is given to the ATmega8 microcontroller, which in turn generates high output at the pin PD0 and this is connected to a relay. Here, the relay is used to switching the circuit and thus light is turned on. If the received output is 2, then the light will be switched off. In the same way, if the received input is 3, then the light will be switched ON and if it is 4, the fan will be off.

3.3 Dual Tone Multiple Frequency Keypad

The DTMF keypad is laid out in a 4x4 matrix, with each row representing a low frequency, and each column representing a high frequency. Pressing a single key (such as ‘1’) will send a
sinusoidal tone of superimposition of two frequencies (697 and 1209 hertz (Hz)). The original keypads had levers inside, so each button activated two contacts. The multiple tones are the reason for calling the system multi frequency. These tones are then decoded by the switching center to determine which key was pressed. Present-day uses of the A, B, C and D signals on telephone networks are few, and are exclusive to network control. For example, the A key is used on some networks to cycle through different carriers at will. The A, B, C and D tones are used in radio phone patch and repeater operations to allow, among other uses, control of the repeater while connected to an active phone line. The *, #, A, B, C and D keys are still widely used worldwide by amateur radio operators and commercial two-way radio systems for equipment control, repeater control, remote-base operations and some telephone communications systems. But nowadays in mobile handsets the A,B,C,D keys are not used usually [22].

![Figure 4. DTMF Keypad](image)

The DTMF low and high frequencies tone and decoded output are shown in TABLE 1 [22].

<table>
<thead>
<tr>
<th>Button</th>
<th>Low DTMF Frequency (Hz)</th>
<th>High DTMF Frequency (Hz)</th>
<th>Binary Output</th>
<th>Coded</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>697</td>
<td>1209</td>
<td>0 0 0 1</td>
<td>Q1</td>
</tr>
<tr>
<td>2</td>
<td>697</td>
<td>1336</td>
<td>0 0 1 0</td>
<td>Q2</td>
</tr>
<tr>
<td>3</td>
<td>697</td>
<td>1477</td>
<td>0 0 1 1</td>
<td>Q3</td>
</tr>
<tr>
<td>4</td>
<td>770</td>
<td>1209</td>
<td>0 1 0 0</td>
<td>Q4</td>
</tr>
<tr>
<td>5</td>
<td>770</td>
<td>1336</td>
<td>0 1 0 1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>770</td>
<td>1477</td>
<td>0 1 1 0</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>852</td>
<td>1209</td>
<td>0 1 1 1</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>852</td>
<td>1336</td>
<td>1 0 0 0</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>852</td>
<td>1477</td>
<td>1 0 0 1</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>941</td>
<td>1209</td>
<td>1 0 1 0</td>
<td></td>
</tr>
<tr>
<td>*</td>
<td>941</td>
<td>1336</td>
<td>1 0 1 1</td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>941</td>
<td>1477</td>
<td>1 1 0 0</td>
<td></td>
</tr>
</tbody>
</table>

The output Q4 from the DTMF decoder IC is fed to the clock input of IC 7474 d flip flop which acts as a buffer to the output from M8870 DTMF decoder IC.

IC7474 is configured as Toggling mode that is if it gets a clock pulse the output of this IC (Pin 5) sets to high and further clock pulse reset back the IC. (The outputs toggle whenever a key is pressed). When we press and release any of the keys among 1, 3, 5, 7, 9 and * keys, the DTMF decoder IC generates a high pulse which acts as a clock to our flip flop and sets the output flip flop to high. The output of flip flop is connected to the relay driver circuit via 100Ω resistor; this output energizes the relay coil through BC547 transistor and turns ON the bulb that connected at the normally open terminal of relay circuit.

IV. CONCLUSION

It will encourage us to consider bringing Home Automation into our own lives. The plugs in devices make an easy entry point to working with the technology. The received tone is processed with the help of DTMF decoder. The DTMF decoder then transmits the signal to the microcontroller to operate the relay. It provides the advantage of robust control, working range as large as the coverage area of the service provider. In this way, we have developed this which is capable of receiving & decoding the commands and control signals from the distant areas and can work according to our instructions. This home appliances control or home automation project also uses the same DTMF decoder circuit section with little modifications to control home and office electrical appliances. Just connect your cell phone headset (headphone) jack to the mobile phone and then mobile will control electrical appliances and electrical equipment through the DTMF key pad of your cell phone.

V. REFERENCES

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