

# Design of Home Automation System using Dual-Tone Multi-Frequency Technique

Chandan Chaudhary, Alisha Kshetri, Sujay Lal Shrestha, Kamal Chapagain\*

Department of Electrical and Electronics Engineering, Kathmandu University, Dhulikhel, Nepal

\*E-mail: [kamal.chapagain@ku.edu.np](mailto:kamal.chapagain@ku.edu.np)

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## Abstract

With the growth of modern wireless technology and the advancement in the field of automation, a cost-effective home automation system to operate remotely located electrical appliances has been designed. The several technologies to design an automation system are identified and studied in the literature. Dual-tone multi-frequency (DTMF) technology has been identified to develop an automation system that can depict the picture of automation. The technology is identified to help elderly or physically challenged individuals to control the home appliances remotely. Thus, the DTMF automation technology has been implemented in a system. The study also focuses on saving energy by remotely switching the appliances on the state or off state as required. Android-based applications (Apps) has been implemented for simplicity. The app provides a convenient way to switch the appliances and lights on and off as required. This data from the app is further decoded and stored in the flip-flop and is used to trigger the relay through relay drivers. Based on the signal or the touch tones, the appliances are controlled. The system thus designed provides a wide range of coverage as it can be controlled remotely from any corner of the world with the availability of a GSM network.

**Keywords:** Dual Tone Multi-Frequency, Integrated Circuits, Touch Tones, Mobile Apps.

## 1. Introduction:

In the generation of information and technology, home automation systems controlled by cell phones have been rapidly developing in every nooks and corner of the world. Intending to help the physically challenged people, old ones, and save energy, DTMF-based home automation has been designed which is based on the principle of the decoding of the touch-tone or the DTMF tone. Dual-Tone Multi-Frequency (DTMF) is a telecommunication signaling system using the voice-frequency band over telephone equipment and other switching centers. DTMF was first developed by Bell System in the United States and was known by the names Touch-tones [1].

DTMF controller, integrated circuits (ICs), and relays has been used to make a system that successfully controls home appliances remotely as well as manually through the connected mobile phone.

With the advancement of technology, people shift towards being smart and develop better technology for the control of appliances and an easy way of controlling the appliances. Remote control of the appliances has been taken as a challenge to achieve. Physically disabled/challenged people are the ones benefited from such systems.

DTMF tones are simply two frequencies played simultaneously by a mobile phone Each button

press after the phone is called and received sends a pair of tones; one high frequency and other low frequency which can be decoded to control the appliances as required. The frequency pair in the numbers of the dial pad is shown in Table 1 below.

Table 1:DTMF keypad Frequencies

	1209 Hz	1336 Hz	1633 Hz
697 Hz	1	2	3
770 Hz	4	5	6
852 Hz	7	8	9
941 Hz	*	0	#

The major objective of this study was to design and develop a home automation system as an energy-efficient prototype using DTMF technology. The mobile Apps design and integration with the home automation system without the use of a microcontroller provided novelty to the study. Therefore, this product can be suitable for implementation in commercial purposes. We believe that this paper can be picked as one of the best reference papers for graduate or undergraduate researchers who are looking for a similar concept of design in their research works.

## 2. Literature Review:

Bluetooth, Zigbee, and IoT has been widely accepted technology for the application in home automation. Yet there are some drawbacks in the field of area coverage, cost, relevance, and implementation. IoT has been a better option yet inefficiencies-inefficient and plicable in the location which lacks internet. DTMF has been identified as a relevant and efficient way to achieve home automation.

DTMF or touch-tone was primarily used for telephone signaling to the and from local exchange and in today's world of wireless communication. DTMF tones can be transmitted over GSM network and internet and can be decoded for its use in appliances control interacting with the computer system and answering machines as well. In DTMF, the keypad is designed on a 4×4 matrix for the generation of the tones with the help of push buttons. Pressing a button produces a sinusoidal tone from the super-imposition of two frequencies a high frequency and another low frequency. The A, B, C, D tones are used in the

radio phone patch and repeater operations to allow, among other uses, control of the repeater while connected to an active phone line. The DTMF keys are still used by amateur radio operators, and a commercial two-way radisystemsem for equipment control, repeater control, remote base ope, rations and telecommunications.

In literature, different methodologies were studied to design home automation systems. The most promising method DTMF is discussed in [2] where home appliances are controlled using the DTMF system. There are two major types of communication specifically wired and wireless communication. Wired including the joysticks, using PC and RS 232 cable and wireless via microwave and RF communication. DTMF comes to play after the imperfection of propagation delay in the trans receiving of data where the home appliances are controlled using mobile phone signals [2]. The DTMF-based Home Automation is controlled by the mobile touch tone. The DTMF decoder MT8870 is a DTMF decoder as well as a band split filter. The filter section uses the capacitor technique for high and low group filters. The decoder decodes the 16 tone pairs into a 4-bit code using digital counting. The external clock oscillator is 3.579545 MHz which is used to create electrical signals. IC 7805 is a linear voltage regulator which is used to regulate the voltage in the circuit.

Another application of DTMF technology is speed control of AC motor which is discussed in paper [3]. The design provides wireless access to control the speed of the motor from anywhere and display the status of the motor. Designed on the principle of DTMF tone in a motive to support the farmers in the agricultural field with controlling the pumps in fields with large area coverage, the microcontroller-based mobile operated speed controller allows remote access to the control of agricultural pumps as well as other pumps. The GSM-based system allows the control of the pumping sets and monitors the water pump from any place [3]. Industries, houses, agriculture, and offices have also been identified as the prominent field of application. Android passed Home Automation using Bluetooth which is discussed in [4] focuses on utilizing the opportunities of automating the

tasks for a smart home using an android and Bluetooth in the home network. Taking the benefit of huge libraries available in the android system, the product tends to control multiple home appliances in any home environment. In automatic mode, the appliances were controlled on the sense of temperature and the intensity of light, however, were manually operated using an android phone. The short-range control of the Bluetooth technology adds hindrance in the wide range coverage.

With a primary focus to study the conservation of energy in every way possible, the paper [5] provides a comparative study of various techniques to bring about home automation. The GSM-based home automation controls the home via GSM network, internet, and speech transmitting the user commands and processing it via PC. Working via speech, SMS, and transmitting and controlling the system in real-time is performed using JAVA embedded cell phones. However, the GSM-based home automation discussed in [5] lacks to verify the status of the appliances.

The hardware implementation of DTMF for home automation was also observed in [6,22]. The DTMF technology was implemented with AT89C51, which is a low-power, high-performance CMOS eight-bit microcontroller with 8K flash bytes of Flash programmable and read-only memory (PEROM) [6]. The features of password protection, high voltage A.C. application can be observed inintegrated in the system fabricated in the same paper.

The system fabricated in [7] establishes robotwork of robot with the DTMF technology in which any robot can communicate with the other. The DTMF transceiver is integrated with a microcontroller and a mobile phone to establish bidirectional communication. The project focuses on setting up two-way communication using DTMF technology over a large area.

BesiDTMF technology, the Bluetooth technology was designed as a low-cost secured technology in [5]. It used the interface of Arduino, relays, and interactive programs to control the appliances. The system provided smart control short rangences in a short-range. For a wider range of coverage, phone-based home automation is discussed. The system provided a common

framework for home automation with a system controller, house-wide wiring, and a common interface. The system using DTMF technology was able to control appliances over a wide range but provided a limited number of appliances.

In the home automation system, Zigbee-based home automation discussed in [5] presented the use of PIC controllers and voice recognition. The voice signal for the control of the appliances featured with automatic alarm and message to the user on fire and smoke detection added point to this method. The systems using WIFI and Bluetooth for wireless control discussed in [4] provided a transparent network to the user. The user made a layer of web browsers, pocket pc applications, speech-based commands in the Linux platform. With the advantage of interoperability, dynamic discovery of service, and sharing of service, the system provides the use of a smartphone, pc-controlled Arduino board, GUI designed in MATLAB, PC communication to the internet.

Similarlythe , internet of things has been widely observed and adopted technology for home automation. The Wi-Fi based home automation in [8] provides an android app interfaced with the system linked to the internet for operation. Similar automation in [9] presents the implementation of Arduino microcontroller and IP connectivity to form an internet interface using a Wi-Fi module. The interfacing and control relating to web-browser, smart phone, and IR remote module.

IoT has found its way through smart security and smart home automation as mentioned in [10,24], the home control being achieved using the Node MCU module. Raspberry Pi has been implemented to achieve internet interfacing and build home automation [11]. The project in [12] uses an integration of raspberry pi with a smartphone for communication over Wi-Fi and monitor and control the appliances remotely. The appliances control through integration of IoT, cloud computing and rule-based event processing has also been studied for home automation in [13].

DTMF technology has found its scope in military use for remotely controlling of the military vehicle. The technology has been widely used in search and rescue operations,

controlling Unmanned Aerial Vehicles (UAVs), remote-controlled arms, and others. Another prominent application of the technology is in space exploration by controlling the arms and manipulating the payloads and controls [8]. Because of the cost relevance, and wide-area coverage, we have chosen DTMF based home automation as a simple, reliable, cheaper and highly applicable method for controlling the appliances in home.

### 3. Materials and Methods:

DTMF-based Home Automation requires a set of DTMF decoders, demultiplexers, Darlington arrays, and relay boards. The system consists of two mobile phones in the application. One mobile phone is of the user while the other is connected to the control part of the system. The appliances can be controlled by the means of both mobile phones.

The block diagram in Fig. 1 describes the details in two stages, i.e., the input stage and output stage. In the input stage, input is taken from the dial pad and transmitted. In the output stage, the signal is received and output loads are controlled. The detail of the block diagram is presented in simplified form in Fig. 2 as the systematic diagram, and the complete electrical circuit diagram in Fig. 3. The implementation of the circuit diagram and the designed App is captured and presented in Figs. 4, and 5, respectively.

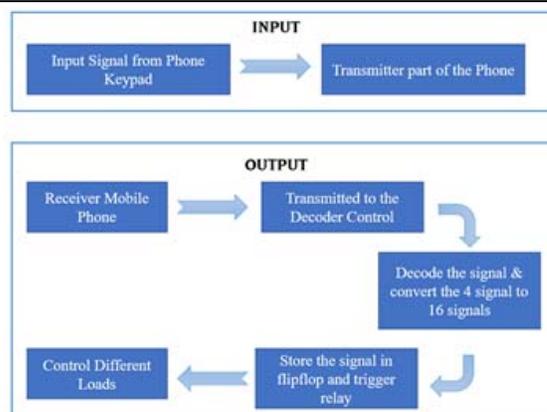


Figure 1: Block Diagram of DTMF based Home Automation

The electrical appliances controlling app has been designed for the controlling of the loads. Individual users can control the appliances by calling to the phone connected to the circuit and dialing the tones from the Dial-pad. The receiver part consists of a DTMF receiver and decoder that receives and decodes the signal from the user and then converts it into a four-bit output. The four-bit output is converted into 16 binary outputs which are individually used to control the appliances of the home. The individual bits of the 16-bit output is used to store in the flip-flop to store the information and then this is used to trigger the relay using relay driver switching the home appliances.

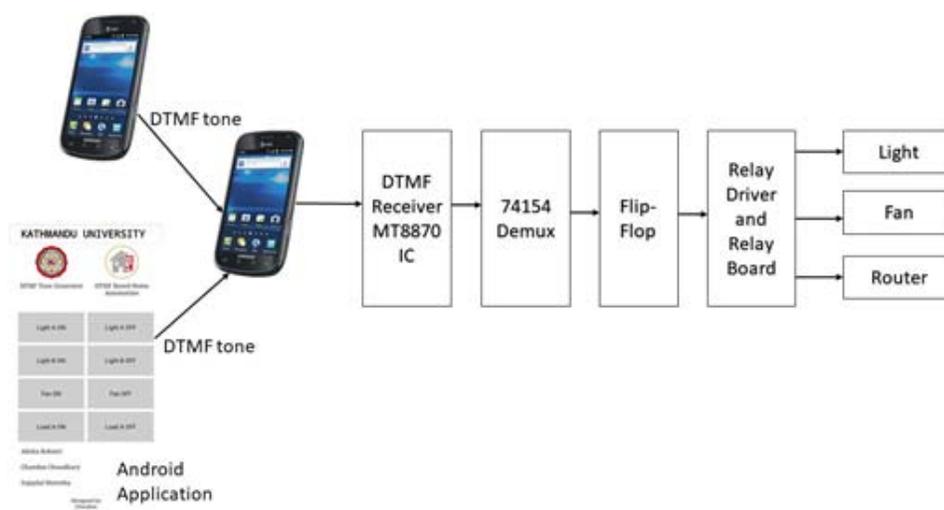


Figure 2: Schematic Diagram of DTMF based Home Automation

The automation system uses a GSM sim card for the operation which is controlled by calling the receiver's mobile phone or manually through the switched app designed. While the manual switch app is used in the mobile phone attached, the appliances can be turned on and off as required. On the other hand, when the mobile in control is

used and the user dials the phone, then the numbers in the Dial-pad are used to turn the appliances on and off. In this case, one number in the Dial-pad as connected in the decoding part is used to switch the load on while the following number is used to switch the load off.

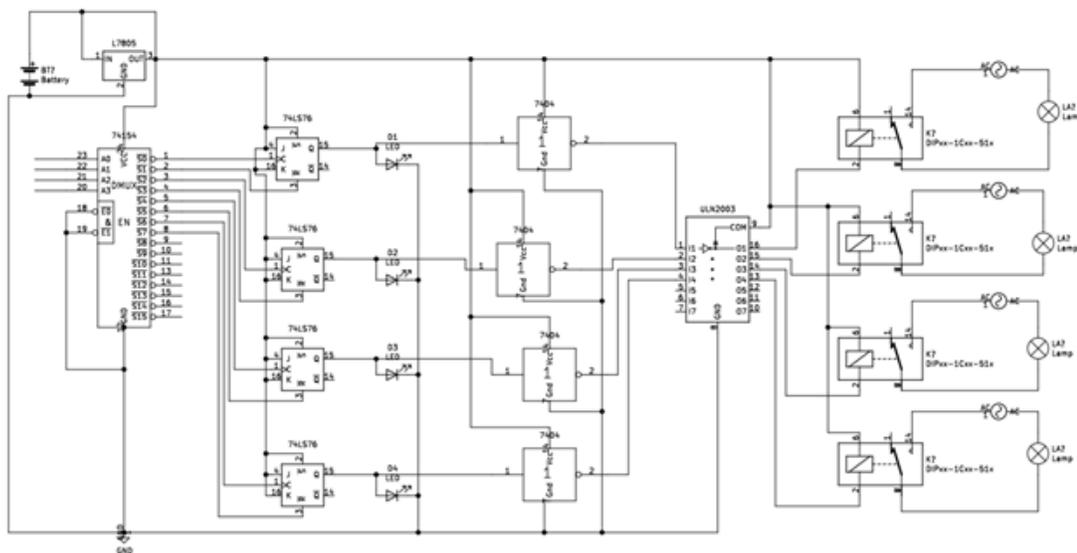


Figure 3: Circuit Diagram

In Fig. 3, we see the four-bit binary coded output of the MT8870 IC as the input of the DEMUX 74154 IC. The individual output of the DEMUX is transmitted to the flip-flop to store the bit information. The stored output is used to light the indicator LED and trigger the relay via relay driver ULN2003. The four lamps as shown has been used for the simulation purpose which can also be seen in the same figure.

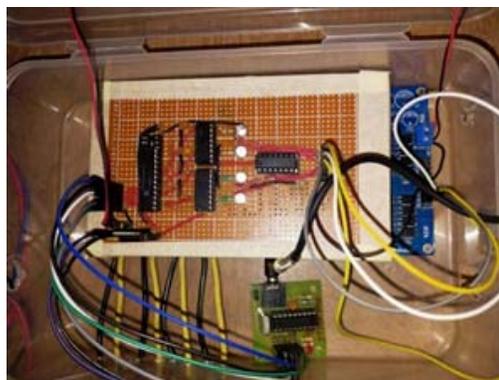


Figure 4: Image of the designed System

From the app designed, when the Light A ON is pressed in the mobile connected to the control, the light is triggered on. Whereas, while pressing the Light A OFF, switches the light off. Similar procedure is valid for other devices. This is the way how this Apps works.

For the wireless GSM medium, the user makes a phone call to the mobile phone connected to the system. The phone is adjusted in auto receive mode. After the phone, the user dials in his mobile, and as per the numbers pressed (like one to trigger the light on, two to trigger the load off), the appliances can be controlled.

#### 4. Result and Discussion:

Successful simulation and testing of the circuit have been completed with the final prototype of the system in Fig. 4. DTMF decoder module has been connected to the circuit and the matrix board is connected to the relay board. From the relay board, the load is controlled. The input is given to the circuit through the auxiliary jack.

Figure 5 presents the screenshot of the app designed. The app is designed from an open-source app design portal MIT app inventor. The

DTMF tones are loaded in the app which is set in the LIGHT A ON, LIGHT A OFF, LIGHT B ON, LIGHT B OFF, FAN ON, FAN OFF, LOAD A ON, and LOAD A OFF as shown in Fig. 5. The tones are generated when the button is pressed and the load is controlled as required.

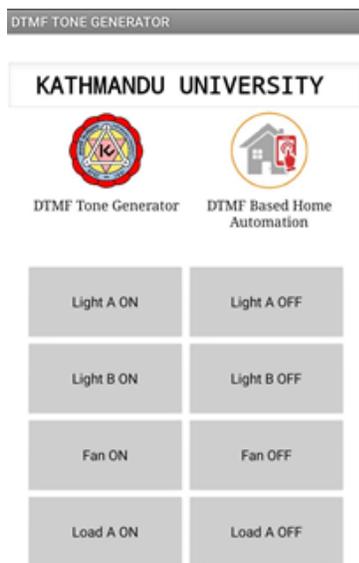


Figure 5: Image of designed

The binary code for the output of the DTMF decoder as pressed by the user is given in the table 2. The binary code 0001 is output when the number 1 is in dial pad or LIGHT A ON in the app is pressed which turned the first light on. Similarly, the binary code 0010 is the output when the number 2 is pressed in the dial pad or LIGHT A OFF is pressed in the app which turned the light off and other codes in the same way as shown in Table 2.

Different devices were controlled through remote by using cell phones in the prototype designed. Front-end operation was found uncomplicated with the development of app. However, the backend operation of activating the control unit by calling the cell phone connected to the system was a challenge. The appliances were also turned on through GSM and turned off through the application design. Numbers 1, 3, 5, and 7 from the dial pad were used to turn the appliances on and the numbers 2, 4, 6, and 8 turns the respective appliances off. The details of operation and action are presented in Table 1

Table 2: Binary code designed for individual load control

DTMF frequency tone	Action performed while pressing keys		Low frequency (Hz)	High frequency (Hz)
Pressed keys	Code	Action		
1	0001	Bulb 1 ON	697	1209
2	0010	Bulb 1 OFF	697	1336
3	0011	Bulb 2 ON	697	1633
4	0100	Bulb 2 OFF	770	1209
5	0101	Charging port ON	770	1336
6	0110	Charging port OFF	770	1633
7	0111	Fan ON	852	1209
8	1000	Fan OFF	852	1336

The superimposition of the two DTMF frequencies when a button was pressed was studied along with the system design. The superimposition of a high frequency 1209 Hz and low-frequency 697 Hz when button 1 was pressed was studied. Similarly, the other frequency pairs as presented in Table 1 were also thoroughly studied. According to the combination of these frequency pairs, the devices to be controlled can be assigned.

The open-source portal MIT app inventor of the Massachusetts Institute of Technology (MIT)

was identified for the design of the android application for the purpose in the project. The app was thus designed for the convenience of the system.

DTMF technology was found to provide a quick response as observed. The fabrication of the system was cheaper, and the system was noticeably reliable and efficient for installation. DTMF technology was found to be appropriate for an average household with 5-6 appliances to be controlled. The system was also found effective as it provided both wired-manual and

remote-wireless methods of operation with low power consumption. The DTMF communication was established without the integration of any microcontroller in the system.

### 5. Conclusion:

Considering the need of the physically challenged and elderly people, DTMF-based home automation has been designed that could be controlled through manual app and remotely through GSM Mobile Network successfully. The system fabricated doesn't use any microcontroller but decoder and integrated circuits which made it cost effective and convenient to implement. The DTMF based home automation designed overcomes the drawbacks of cost inefficiency, and unreliability in the places with internet unavailability. Multiple devices have been controlled in the

system in the experimental phase. The user-friendly mobile application added convenience in the operation of the system. The integration of the relay in the system makes it feasible for integration with high AC voltage. DTMF has been identified as a cheap, reliable and efficient method for establishing a home automation system.

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