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Remote-control of multi appliances based latching circuit and DTMF

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ABSTRACT

There are multiple technologies used to remotely control electric appliances like Wi-Fi, Bluetooth, global system for mobile (GSM), and dual-tone multi-frequency (DTMF), but these technologies contain limitations, whether by coverage distance or by the number of devices that are controlled remotely. In this paper, these restrictions were overcome with the use of DTMF and digital latching devices, which doubles the number of remote-controlled electrical appliances compared to other research using the same intended technology DTMF. Using the proposed mechanism in this paper enables the users to effectively control several electric remote devices equal to the standard number of mobile keypad buttons, so in this way, can control 12 devices. This is via the mobile phone by sending commands in the form of analog tones through calling to auto-answer remote control panel phone (RCPP). An interesting feature of this research, each keypad key of the owner mobile (OM) using to control one remote electric device to switch it ON or OFF, so that the first pressing will cause to switch it ON and the second pressing caused to switching it OFF. This method is used instead of using two keypad keys, one for ON and the other for OFF. The proposed idea working is the same as manually switching but here remotely and electronically. This feature is achieved by using a D-latch digital circuit. The work is implemented and tested by using Proteus simulation program.

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1. INTRODUCTION

Controlling home appliances remotely is one of the important applications required today. To achieve this, the first thing that a researcher or thinker thinks about is taking advantage of the technologies that exist in the country and one of these is the mobile networks whose existence has become part of the lives of the people that cannot be dispensed with, in addition to the presence of their infrastructure and its coverage everywhere. Using mobile phones to turn on/off appliances is one of the effective solutions used for different places such as homes, offices, institutions, factories, banks, and others, especially in large sites that contain few operators compared to a large number of devices, or in other words to reduce the number of operators in large sites.

Using android mobile and microcontrollers with wireless techniques as remote control tools for home appliances control, but this system has a working limitation in the range of response that is limited from 10 to 100 m, this is because using 2.4 GHz Bluetooth technique [1]. A modern method for controlling home appliances, using the smart home system, based on the Internet of things and four types of sensors,

namely temperature, PIR, ultrasonic, and smoke gas sensors for intrusion detection and automatic environmental control [2], [3].

Design and implementation of home automation system based on DTMF, the system allow the user to control 5 different electric appliances anywhere and anytime [4]. Implement effective automation-based DTMF technology to overcome the drawback of using Bluetooth and Wi-Fi which are limited in range restrictions. Two keypad phone numbers are used to control one device, and as a result, this model also contains limiters, which are control a small number of electrical devices, i.e. as much as half the number of the phone's keypad numbers [5].

Depending on the availability of mobile services, including the use of the technique of pressing the mobile phone key during a call for the purpose of generating DTMF tone signals, and using these signals for the purposes of controlling home appliances from remote places [6]–[8]. Live video and audio monitor tools by using smartphones and internet service for the child or aged person depend on the DTMF technique with microcontroller type Atmega2560 [9]. Multiple sensors fire extinguisher robot can be remote control its operations in different modes based on DTMF, Bluetooth, global system for mobile (GSM), and Global positioning system (GPS) technologies. Temperature, flame, and smoke sensors have been used to detection of fire and the robot activity can be controlled by either DTMF or smartphone [10].

By using a mobile phone as a modem for controlling four home appliances has been designed and developed, the programmable interface controller (PIC) is used for the purpose of the control the switching of the output [11]. A home automation base on ZigBee and Arduino which is integrated through a home gateway with an android application output a system for remote control of indoor and outdoor appliances, a study of using these concepts in home automation, determining their activities and the feasibility of using them [12].

Today it is one of the most general remote control applications based on DTMF technology along with mobile network and GSM and after it was merged with the Arduino control board which forms a leap in the field of remote control applications in various fields [13]–[19]. Server independent systems used to control remote selected appliances depend on using the internet of things. The device can be controlled for this research started from industrial machine to consumer goods, the connectivity module using Arduino Uno microcontroller and ESP8266-01 [20]. The use of advanced microcomputers in smart control and remote monitoring applications to control and manage various systems using wireless and wired technologies, including, for example, electrical appliances, whether in homes, departments, or institutions, among others. The use of microcomputers of all kinds provides a suitable environment for carrying out remote control operations through ease of interfacing and compatibility with other devices used for this purpose [21].

In this work, remote control of electric appliances by using DTMF techniques interfacing with latch circuits is presented. This is via making a call by the owner mobile phone by sending commands in the form of analog tones through calling to auto-answer remote control panel phone (RCPP). Then the owner must click various keys to control various devices so that each key is used for on/off one device. This is done in such a way that using the first press of the key to turn ON the remote device and the second presses to switch it at OFF state. This process occurs using D-latch digital circuit.

2. PROPOSED DESIGN OUTLINE

The proposed wireless remote-control design is developed to control remote electric devices from any place regardless of time and space. The system is operated based on DTMF technology. In this technology, for the purpose of achieving control of electrical appliances wirelessly and remotely, cellular communication networks, two mobile phones, and other components are used for this purpose.

Figure 1 shows the block diagram of the proposed system. The system is divided into three parts denoted as, digital parts which are included buffer, 4-bits comparator integrated circuits (ICs), and latches ICs. The power parts which are consist of an upper limit of normal (ULN) 2003 driver, power supply unit, relays, and electric devices. Then, the third part is the tone generation, transmitting, receiving, and decoding (TGTRD) which are included tone decoder CM 8870 IC, RCPP, OM, and GSM network devices.

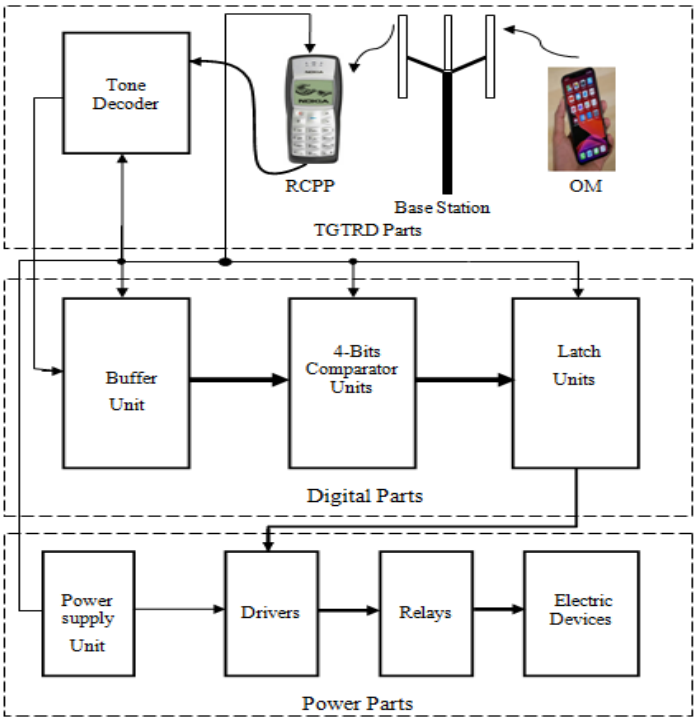

Figure 1. Proposed system block diagram

3. DTMF CONCEPTS

DTMF is a method used in mobile and landline phones for signal tone generation. The generated tones occur when any button is pressed on a keypad of the phone through making a call so that any pressing key will generate a separate signal tone matched with the pressed number. There are 12 standard signal tones. Ten represent the numbers from zero to nine, one asterisk (*) and one hashtag (#). The general mobile phone uses 12 keys [22], [23]. Figure 2, shows the standard phone keys with equivalent tone frequencies.

Each keypad number tone is formed by adding two frequencies, the low frequency (row line) and high frequency (column line) [24]. In other words, the output resultant tone is a convolution of low and high frequencies. Each of these tones can be expressed mathematically as (1):

$$f(t) = A_H \sin(2\pi f_H t) + A_L \sin(2\pi f_L t) \quad (1)$$

Where A_H, A_L are the amplitude of each frequency and f_H, f_L are the high and low frequencies [25]. DTMF tone frequencies have properties that can be summarized as:

- The difference between any two frequencies does not equal any of the other frequencies.
- No frequency is an integer multiple of another.
- The sum of any two frequencies does not equal any of the other sums of frequencies.

Table 1 shows all possibilities for generation tone signal frequencies of a keypad cell phone.

Table 1. Standard keypad phone frequencies

Keypad number	Low frequency (Hz)	High frequency (Hz)	Tone frequency (Hz)
1	697	1209	1906
2	697	1336	2033
3	697	1477	2174
4	770	1209	1979
5	770	1336	2106
6	770	1477	2247
7	852	1209	2061
8	852	1336	2188
9	852	1477	2329
*	941	1209	2150
0	941	1336	2277
#	941	1477	2418

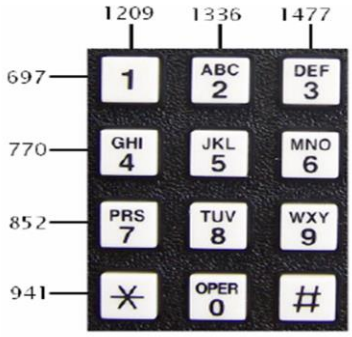

Figure 2. Standard 12 keys of cell phone keypad with frequencies Hz

4. DETAILS PROPOSED SYSTEM COMPONENTS

4.1. Power parts

The power part consists of a power supply, driver, relays, and electric devices. The power supply unit as shown in Figure 3, is responsible for generating all required voltages in the design. Main input 220 VAC power given to step down transformer (220 to 12) VAC, then it is rectified using bridge rectifier (D1 D4) IN4007 and regulated by capacitor C1 470 µF 25V. The output of the bridge rectifier is connected to two fixed regulators. First, the 12V regulator is denoted as 7812 to supply the relays and drivers. Second, the 5V regulator is denoted as 7805 to supply all system digital ICs. The resistance R1 330 Ω and red-LED D1 are used as an indicator. The ULN2003 driver IC is an array of Darlington transistors. This IC is used for interfacing with relays because of its high current and high voltage, it can carry a load of 500 ma, 50 v output.

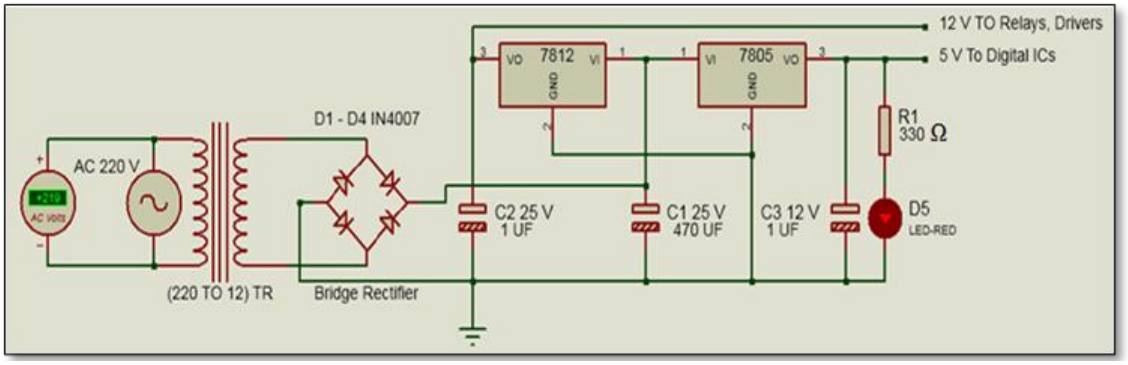

Figure 3. Power supply unit circuit diagram

4.2. Digital parts

This part consists of buffer ICs type 74LS244, this circuit is used for the purpose of protecting the tone decoder from high load and for distribution of the binary tones to comparators. 4-bits comparator 74LS85, this device has two groups of entrances denoted as Group A and Group B. Group A connected to buffered binary tones, Group B connected to fixed values so that each pin can either be connected to VCC or GND matched with phone keypad key. Each comparator compares the two input groups and output logic high at pin (QA=B), these are used for ignition latch circuit that represents d-type flip-flop connected as D-latch circuit.

4.3. TGTRD parts

This part included OM, RCPP, and tone decoder. For OM, because it's used for tone generation, the keypad key sound must be activated at a maximum sound value. In the far place, RCPP is used as a receiver so the auto-answer service must be activated and the speaker volume level increases to the highest value. The CM8870 IC represents a tone decoder that performs the function of changing the received tone from the RCPP audio jack to 4-bit binary tones. This device requires a crystal oscillator, so the 3.597 MHz crystal oscillator is used.

5. DESCRIPTION OF THE FUNCTIONS OF THE PROPOSED SYSTEM

DTMF technique is used to identify which key is pressed in the keypad of OM during the call. The keypad represents a password entry device. Pressing any individual key in OM phone through the call will generate a unique tone matched with the pressed key which sends to RCPP. The RCPP receives the transmitted DTMF signals from OM, then connected to tone decoder IC CM8870 through headphone jack wires for the purpose of filtering, analyzing, and converting them from analog tone to 4-bits digital tone which is denoted by Q1, Q2, Q3, and Q4.

The 4-bits digital tones are connected to inputs of buffer IC type 74LS244. The output of this buffer is connected to twelve of 4-bits digital comparator IC (74LS85). Each comparator has two groups of 4-bits of inputs, denoted as group A and group B. group A inputs of all comparators connected to four outputs of the buffered circuit. While each bit of group B of individual comparator connected to VCC or GND matched with keypad key, so that for the first comparator group B must be connected to match with one key i.e., for group A tones equal to (Q4Q3Q2Q1=0001), therefore group B must be connected to GND VCC. And group B of the second comparator matched with pressing two keys, i.e., for group A tones equal to (Q1Q2Q3Q4=0010), therefore group B must be connected to VCC GND and so on for the other ten comparators. Table 2 summarized all probability of tone generating for all keypad keys and the equivalent status of group A and group B.

The digital comparator has three outputs denoted as (QA<B, QA=B, and QA>B). The output (QA=B) of each comparator is selected for connected to latch circuit in order to enable it for the first pressing key and disable it for the second pressing the same keypad key. The output of each latch circuit connected to an input of ULN2003 driver which leads to connect load relay that used to drive different kinds of electrical devices.

Table 2. All cases of tone generating

Keypad key	Binary tones group A	State of group B
1	0001	gnd gnd gnd vcc
2	0010	gnd gnd vcc gnd
3	0011	gnd gnd gnd vcc
4	0100	gnd gnd vcc gnd
5	0101	gnd gnd gnd vcc
6	0110	gnd gnd vcc gnd
7	0111	gnd gnd gnd vcc
8	1000	gnd gnd vcc gnd
9	1001	gnd gnd gnd vcc
*	1010	gnd gnd vcc gnd
0	1011	gnd gnd gnd vcc
#	1100	gnd gnd vcc gnd

6. SYSTEM IMPLEMENTATION AND SIMULATION

The proposed design consists of twelve stages, in addition to tone decoder and buffers. Each stage matches with one keypad key to control one electric device. Figure 4 explain in detail one stage circuit components but in this stage for the purpose of the simulation, the four-logic state device is used instead of CM8870 decoder and this stage may repeat 12 times to cover all system design by only changing the group A and group B. Figure 5 shows the first four stages circuit diagram of the real system circuit.

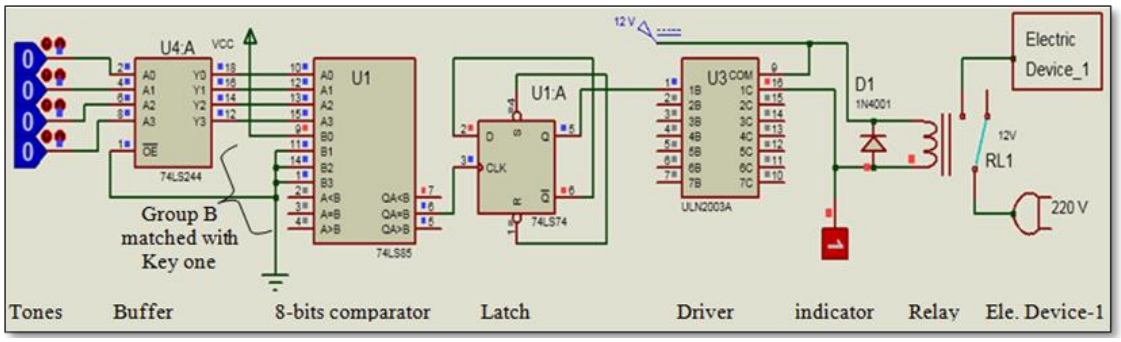

Figure 4. One stage circuit diagram

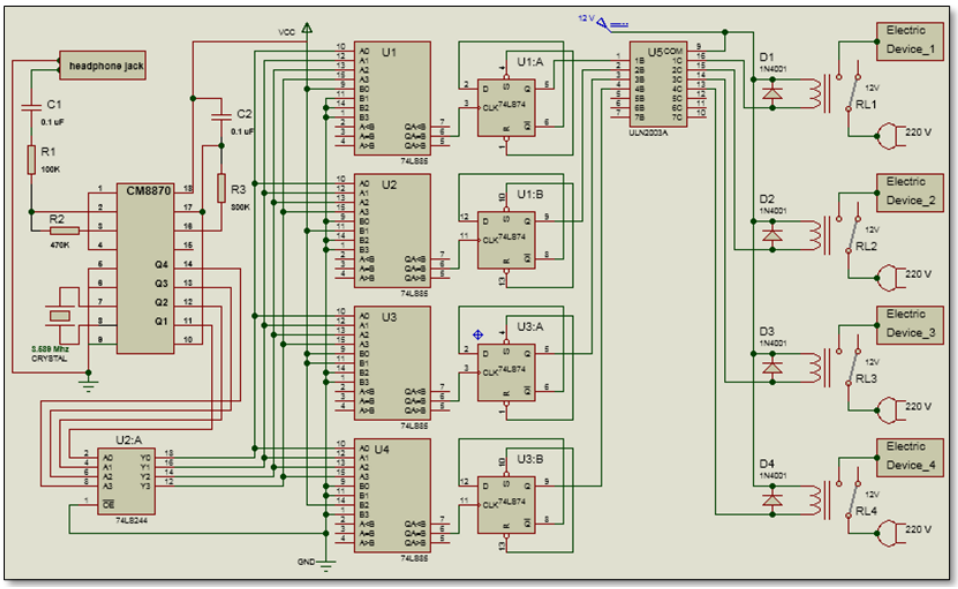

Figure 5. Four stages of the real proposed circuit diagram

7. TESTS AND RESULTS

Before implementing and testing the hardware design with physical components. An appropriate simulation program should be used to implement and tested the operation of the design, ascertain it, and address defects. A Proteus schematic program was chosen for this purpose as a result of its uses in the wide fields of simulated analog and digital components, programmable components like microcontrollers, components with specific communication protocols, all kinds of electronic, and electromechanical components and systems [26].

For the purpose to achieve optimal simulation to check all the circuit component working properly, a four-logic state is used instead of CM8870 IC and one logic probe is used at the output of each stage as the indicator. In order to check each stage individually and within the group, two tests are chosen.

7.1. First test

This test provides the ability to fully check all parts of a circuit, by sequentially pressing the twelve mobile keypad keys. Four logic state devices are used instead of CM8870 to simulate four digital tones. Each key is responsible for turning on and off one electric device labeled (electric device_1 to electric device _12) so that the first press of the key leads to on the device and the second press of the same key leads to turn off it. This test also ensures that there are no conflicts or overlaps between the components of the total circuit. This test can be applied to all twelve devices, but for the purpose of abbreviation, one device is selected as an example, which is device_4. For control of electric device_4, first press keypad key number 4 switched it at ON state, then second pressed the same number for switched it OFF. This test is shown in Figure 6 for ON state and Figure 7 for OFF state.

7.2. Second test

To check the operation of all stages by using a single circuit with a four logic state used to simulate four digital tones this is for group A and changing group B for matched with the inputs binary tone and see the results in the form of switched ON and OFF. The electrical appliances are represented by a 220 volts lamp which is fed from an alternating voltage source through a load relay.

To achieve the second test, the circuit shown in Figure 8 is used to simulate the implementation of all stages working, so that to test each stage only the group B selector has been to change corresponds the binary tone input according to the case detailed in Figure.

7.3. Testing the operation of electric device_1

To switch ON/OFF the first device denoted by electric device_1, who used a lamp instead of him. Keypad key 1 must press for the first time to switch ON and the second time to switch it OFF. This is done by changing Group B to match with binary tone inputs (Q4, Q3, Q2, Q1=0001). The result for first pressed key 1 is shown in Figure 9 for ON state and second pressed key 1 is shown in Figure 10 for OFF state.

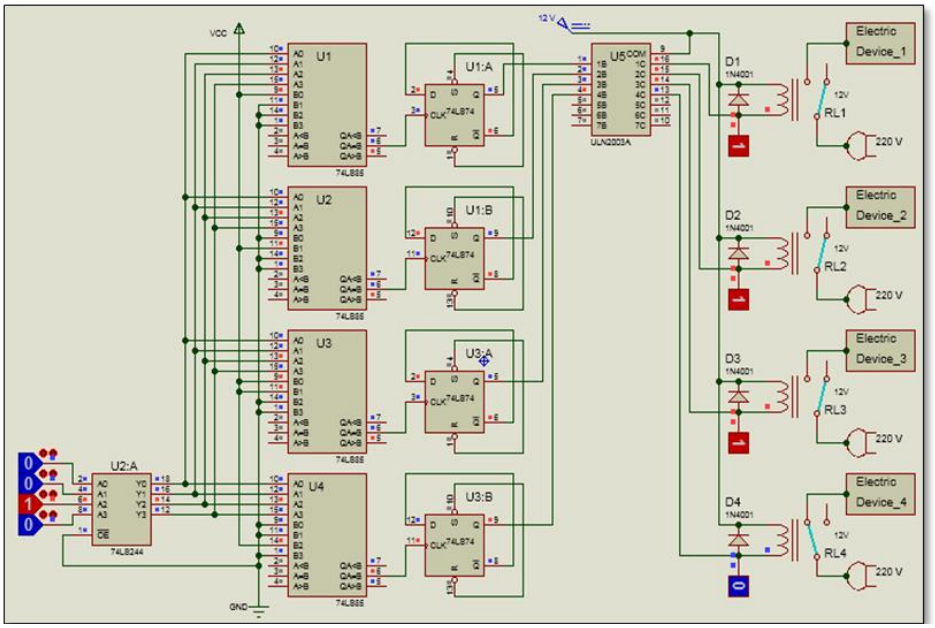

Figure 6. Switch ON electric device_4 for first pressed key 4

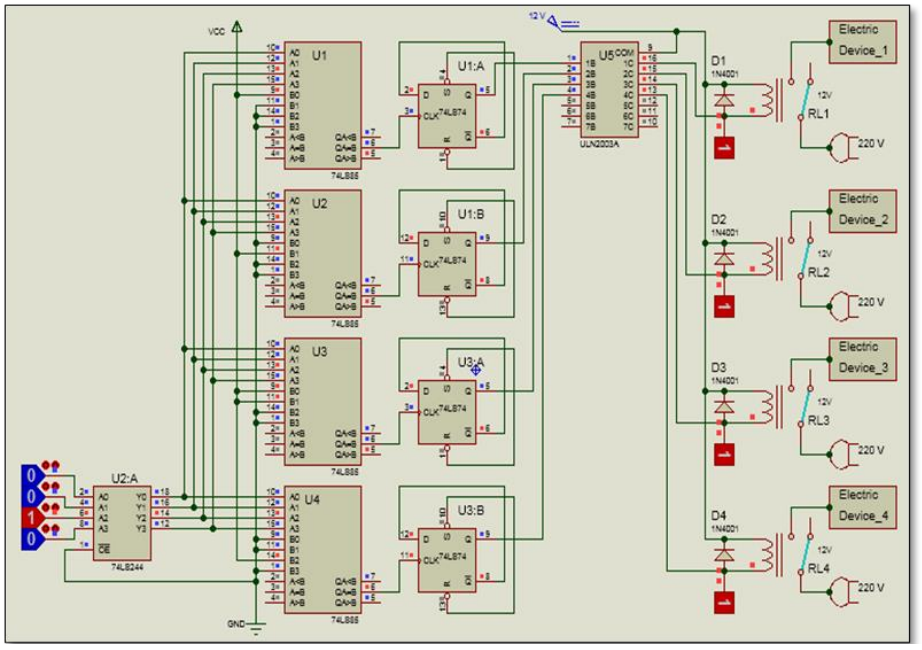

Figure 7. Switch OFF electric device_4 for second pressed key 4

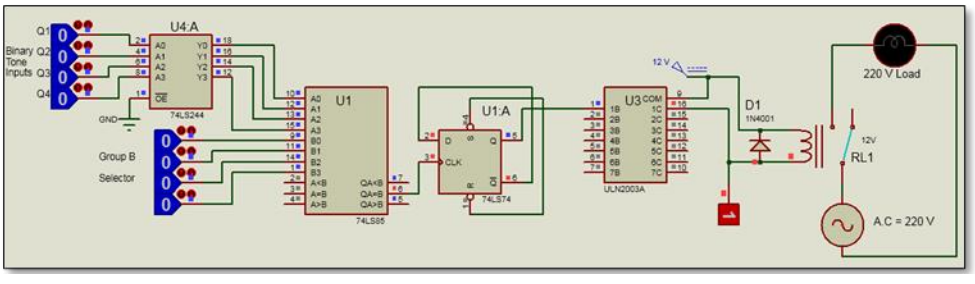

Figure 8. Simulator single stage circuit diagram

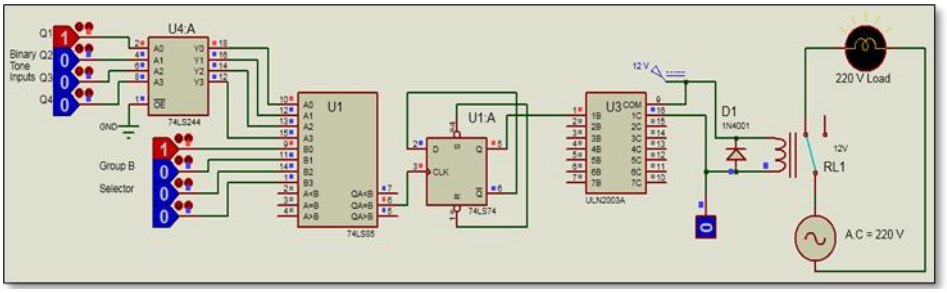

Figure 9. First press key 1 for ON the electric device_1(Ele.dev.1=on)

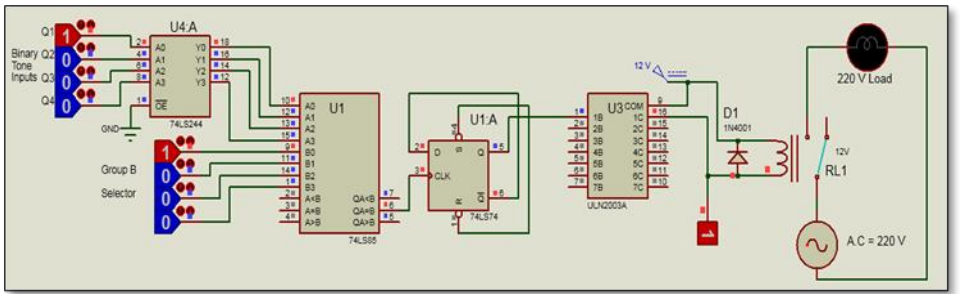

Figure 10. Second press key 1 for OFF the electric device_1(Ele.dev.1=off)

In the same way, it is possible to simulate the operation and test of 12 electrical devices through the pressing of OM keypad keys to obtain the result shown in Table 3.

Table 3. Required actions of electric devices control

Key number	First pressed	Second pressed	Binary tones Q4Q3 Q2 Q1	Electric load device action
1	Ok		0001	Ele.dev.1=on
1		Ok	0001	Ele.dev.1=off
2	Ok		0010	Ele.dev.2=off
2		Ok	0010	Ele.dev.2=on
3	Ok		0011	Ele.dev.3=on
3		Ok	0011	Ele.dev.3=off
4	Ok		0100	Ele.dev.4=on
4		Ok	0100	Ele.dev.4=off
5	Ok		0101	Ele.dev.5=on
5		Ok	0101	Ele.dev.5=off
6	Ok		0110	Ele.dev.6=on
6		Ok	0110	Ele.dev.6=off
7	Ok		0111	Ele.dev.7=on
7		Ok	0111	Ele.dev.7=off
8	Ok		1000	Ele.dev.8=on
8		Ok	1000	Ele.dev.8=off
9	Ok		1001	Ele.dev.9=on
9		Ok	1001	Ele.dev.9=off
*	Ok		1010	Ele.dev.10=on
*		Ok	1010	Ele.dev.10=off
0	Ok		1011	Ele.dev.11=on
0		Ok	1011	Ele.dev.11=off
#	Ok		1100	Ele.dev.12=on
#		Ok	1100	Ele.dev.12=off

8. CONCLUSION

In recent years, the dependence on remote control over electrical appliances has increased, by depending on various technologies, such as GSM, DTMF, Wi-Fi, IoT, and others. The remote control is an excellent way to control electrical appliances such as water pumps, lamps, TV, cooling devices, heating appliances, and so on. The use of such technology is a solution and is very beneficial for people with

disabilities or the elderly or in large places such as departments, institutions, factories, and so on or for the purpose of reducing the expenses of electrical energy consumption, especially in the periods when the home or institution is free of people. In this research, a DTMF technology was chosen, due to the availability of GSM infrastructure and ease of use in addition to it is not limited in place and time. This research provided the ability to control 12 electrical devices remotely and wirelessly from anywhere in the world using the mobile phone and prevents unauthorized access to these appliances. An interesting and important feature of this design is the use of the same keypad number to switch ON and OFF the same remote electrical device. This feature is not present in other research, so it has become possible to control multiple numbers of devices using the standard mobile keypad, by relying on a D-type latching digital circuit that changes the state with every pressure the same key.

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