DESIGN OF GSM BASED HOME AUTOMATION CONTROL

A Project Report Submitted to the
Department of Electrical and Electronics Engineering
In Partial Fulfillment of the Requirement for the Degree of
Bachelor of Science in
Electrical and Electronics Engineering

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Dedicated To…

My beloved PARENTS
&
All of my TEACHERS

APPROVAL

This Project titled “Design Of GSM Based home Automation Control” submitted by Istiak Ahmed Chowdhury And Tahera Rahman to the Department of Electrical and Electronics Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. Electrical and Electronics Engineering and approved as to its style and contents. The presentation has been held on

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DECLARATION

We hereby declare that, this thesis has been done by us under the supervision of Mr. Md. Dara Abdus Satter Assistant Professor Department of Electrical and Engineering Daffodil International University. We also declare that neither this Project nor any part of this Project has been submitted elsewhere for award of any degree or diploma.

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Authors

Abstract

With the advancement in technology, the number of electronic devices in our day-to-day lives has increased to make life simpler. So a necessity to construct a Universal Remote System that will easily control all these devices from a distance will not only reduce the complexity of handling the number of devices simultaneously, but also save power.

This paper presents a successfully developed hardware of a Universal Remote Control System using DTMF (Dual- Tone Multi-Frequency) tones as the control signals. The uniqueness of DTMF is that it is simple to generate and noise- immune. This system was also implemented using GSM links besides the wired channel, the main advantage of it being that it helps in controlling devices located at any part of the world or at any place like hazardous plants, where the presence of a human could prove dangerous. So there are a number of practical applications associated with this system. It is simple, economical, easy to use and could be further upgraded by adding a password-protection to it. Through this, only selected people can access control on the devices. A voice-controlled command could be embedded to make the system more flexible.

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1 Introduction

1.1 General Information

This modern era, life without Electronics is unimaginable. With the progressive increase in the number of electronic gadgets, it has become essential to design a remote control system that can control a number of them at the same time. A remote control system now finds a large number of crucial applications like controlling of artificial satellites, manufacture of products by machines or in the control of chemical reactions in hazardous plants from a distance.

For the design of a remote control system that will control the switching of multiple electronic devices at the same time, DTMF (Dual-Tone Multi-Frequency) tones have been used. The main reason for the use of DTMF is that one can control a maximum of twelve (if 3x4 type DTMF keypad is used) to sixteen (if 4x4 keypad is used) devices simultaneously by means of a single remote system.

The aim of the proposed system is to develop a cost effective solution that will provide controlling of home appliances remotely and enable home security against intrusion in the absence of homeowner. The system provides availability due to development of a low cost system. The home appliances control system with an affordable cost was thought to be built that should be mobile providing remote access to the appliances and allowing home security. Though devices connected as home and office appliances consume electrical power. These devices should be controlled as well as turn on/off if required. Most of the times it is done by manually. Now it is a necessity to control devices more effectively and efficiently at anytime from anywhere.

In this system, we are going to develop a cellular phone based home/office appliance. This system is designed for controlling arbitrary devices, it includes a cell phone (not included with the system kit, end user has to connect his/her cell phone to the system) which is connect to the system via head set. To active the cellular phone unit on the system a call is to be made and as the call is answered, in response the user would enter a two/three digit password to access the system to control devices. As the caller press the specific password, it results in turning ON or OFF specific device. The device switching is achieved by Relays. Security preserved because these dedicated passwords owned and known by selected persons only. For instance, our system contains an alarm unit giving the user a remote on/off mechanism, which is capable of informing up to five different numbers over telephony network about the nature of the event. The underlying principle mainly relies up on the ability of DTMF (Double Tune Multi Frequency) 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. In detail, a DTMF generator generates two frequencies corresponding to a number or code in the number pad which will be transmitted through the communication networks, constituting the transmitter section which is simply equivalent to a mobile set.

1.2 History

Home automation has been a feature of science fiction writing for many years, but has only become practical since the early 20th Century following the widespread introduction of electricity into the home, and the rapid advancement of information technology. Early remote control devices began to emerge in the late 1800s. For example, Nikola Tesla patented an idea for the remote control of vessels and vehicles in 1898.

The emergence of electrical home appliances began between 1915 and 1920; the decline in domestic servants meant that households needed cheap, mechanical replacements. Domestic electricity supply, however, was still in its infancy — meaning this luxury was afforded only the more affluent households.

Ideas similar to modern home automation systems originated during the World's Fairs of the 1930s. Fairs in Chicago (1934), New York (1939) and (1964–65), depicted electrified and automated homes. In 1966 Jim Sutherland, an engineer working for Westinghouse Electric, developed a home automation system called "ECHO IV"; this was a private project and never commercialized. The first "wired homes" were built by American hobbyists during the 1960s, but were limited by the technology of the times. The term "smart house" was first coined by the American Association of House builders in 1984.

With the invention of the microcontroller, the cost of electronic control fell rapidly. Remote and intelligent control technologies were adopted by the building services industry and appliance manufacturers.

By the end of the 1990s, "domotics" was commonly used to describe any system in which informatics and telematics were combined to support activities in the home. The phrase is a portmanteau word formed from domus (Latin, meaning house) and informatics, and refers to the application of computer and robot technologies to domestic appliances.

Despite interest in home automation, by the end of the 1990s there was not a widespread uptake, with such systems still considered the domain of hobbyists or the rich. The lack of a single, simplified, protocol and high cost of entry has put off consumers.

While there is still much room for growth, according to ABI Research, 1.5 million home automation systems were installed in the US in 2012, and a sharp uptake could see shipments topping over 8 million in 2017

1.3 TELEPHONE TECHNOLOGY

The world right from the era of Adam & eve has been looking for one way or the other to find comfort. Therefore, the introduction of modern day communication has boosted this comfort to a meaningful extent. The importance of communication in this present day life style can not be over-emphasized. This led to the discovery of post office, telegraphy, finally telephone and of late Internet communication. One of the issues of telephone as a means of communication which this work is all about is made up of two types which are the land line and the Global system of Mobile communication (GSM). The word telephone is made up of two Greek words which are tele- which means “far” and phone- which means “sound”. More emphasis will be based on Global System of Mobile Communication (GSM) because that is what we are using as our means of communication with the household system.

1.4 BACKGROUND OF STUDY

This project attempts to design, construct and use a very compact Dual Tone Multi-Frequency (DTMF) based decoder, macro controller system which organizes the switching from the decode and power switching device for controlling both household (domestic) and industrial classified equipment.

The DTMF decoder and the switching circuit is designed to permit a digital signal processing device control high power external loads by issuing commands encoded as audio DTMF signals. The DTMF decode and the switching circuit receives those commands and control’s the connected loads accordingly. The micro-controller directs the overall operation of the DTMF decoder to perform the actual DTMF audio tone pair decoding. When a valid tone pair is detected by the DTMF decoder, an interrupt is signaled the tone pair code from the decoder and places the symbol in an internal quell for further processing. The decoder is capable of detecting DTMF tone pairs over a wide range of amplitude. Among other applications, the project as described above can be applied in the voice/speaker recognition algorithm which has its primary functions as the ability to recognize the designated keypad tones and consequently term on or off an appliance when detected. With this system, home appliances can be controlled from any place in the world by making use of available network on mobile phone. Digital input/output pins are sometimes available but the ability to easily control a number of electrical loads totaling several hundred watts does not really exist. Yet digital signal processing control of significant electrical loads can add depth and interest to many students’ projects. This project attempts to design, construct and use a very compact dual tone multi-frequency (DTMF) based decoder, microcontroller system which organizes the switching from the decoder and power switching device in controlling both household(domestic) and industrially classified equipment. The DTMF decoder and switching circuit is designed to permit a digital signal processing device control high power external loads by issuing commands encoded as audio DTMF signals. The DTMF decoder and switching circuit receives those commands and controls the connected loads accordingly.

1.5 PROJECT OBJECTIVES

This project is aimed at effectively using public or mobile phone from any collation of existing network to safely control electricity operated household equipment. In addition the system to implement on this project will have pin-check algorithm in order to enlarge salinity tone pair code from the decoder and places the symbol in an internal queue for further processing. The decoder is capable of detecting DTMF tone pairs over a wide range of amplitudes. Amongst other applications, the project as described above can be applied in the voice/ speaker recognition algorithm which has as its primary function the ability to recognize the designated keypad tones and consequently turn on or off an appliance when detected. This simple circuit can control up to three appliances without modifications. The DTMF remote controlled system is a compact and rugged remote control unit, designed for interface with a standard cellular mobile telephone handset. It plugs into the "hands free" adaptor socket on the telephone handset, and operates by receiving DTMF tones from the phone audio output. It is mains powered by electricity, and provides three contact closures capable of switching mains voltages. By setting the handset to auto-answer, remote control is possible at any location with cellular coverage, and from any telephone in the world with tone-dialing capability.

1.6 Scope Of Study

The DTMF remote controlled system is a compact and rugged remote control unit designed for interface with a standard cellular mobile telephone handset. It plugs into the hands free adaptor socket on the telephone handset and operates by receiving DTMF tone from the phone audio output. Its mains is powered by electricity and provides three contacts closure capable of switching mains voltage. By setting the handset to auto-answer, remote control is possible at any vocations with network coverage.

2 Project Discussion

2.1 Use Home Automation to Turn Any House into a Smart Home

The fast pace and ever growing possibilities of today's and tomorrow's technology are exciting. New products are available almost daily to fill our homes full of hi-tech solutions that make our lives more automated, convenient and energy efficient. Smart home is here to help you choose the right devices from our vast range of home automation products that fit your lifestyle. We offer everything for the do-it-yourselfer, putting remote control of your home in the palm of your hand.

Control lighting and appliances throughout your home remotely from a smartphone. You can dim lights while watching a movie or having dinner, or schedule lights to turn on and off while you are on vacation. Stay green and save energy by checking to see if any lights were left on, or turn off anything that is plugged in. Consider using a programmable thermostat to increase energy management and reduce your utility bill by regulating thermostat use and temperatures based on your family's schedule.

Home automation also includes the safety of your family. Smart home offers a complete line of traditional security and surveillance systems to protect your home. We even have the latest biometric (fingerprint) door locks, communicating smoke and carbon monoxide detectors, and wireless sensors to ensure that everyone is protected from dangers inside and outside your home.

Smart home doesn't want you to forget about having some fun too! We have portable speakers for your smartphone or tablet, outdoor products for your yard or patio, accessories for your car and garage, a selection of smart products for kids and everything your need for pet care and pest control.

When it comes to smart home automation, Smart home has you covered.

2.2 Block Diagram

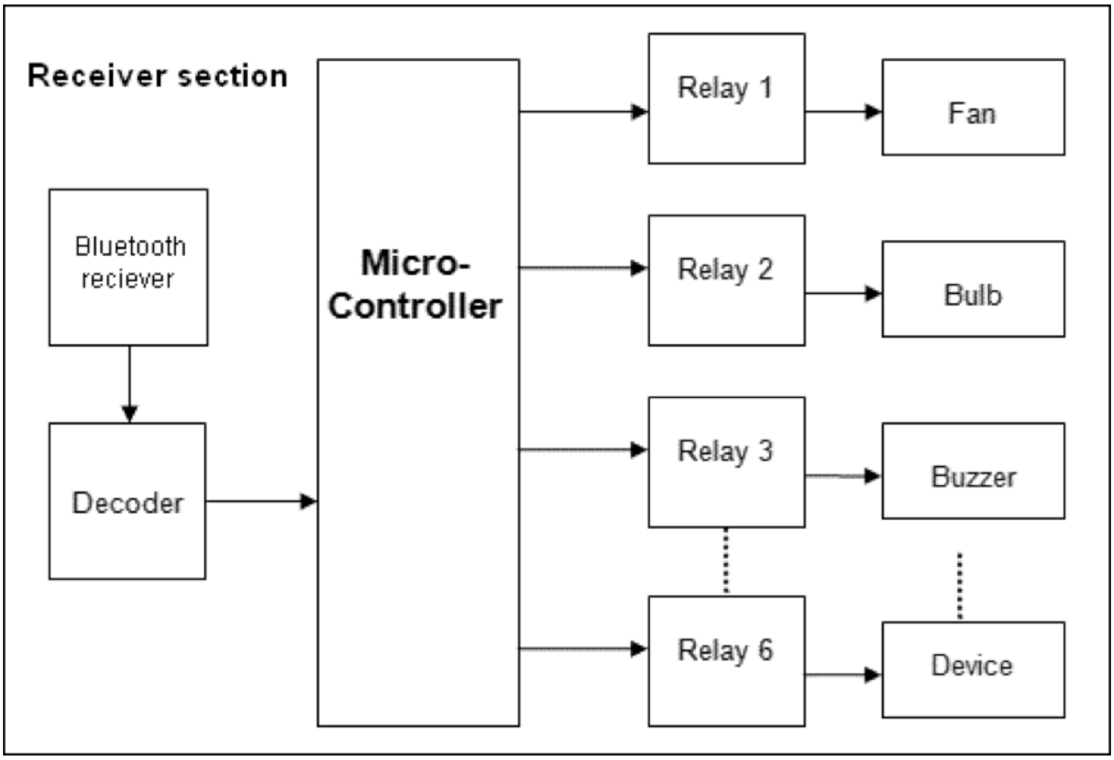

Fig 1: Block Diagram of Home Auto Motion Control circuit

2.3 Working Procedure:

- The project uses M-8870 DTMF decoder IC which decodes tone generated by the keypad of cell phone.
- When we press keys in our cell Phone when call is in progress, the other person will hear some tones with respect to keys pressed. These tones are based on the DTMF technology.
- Data is transmitted in terms of pair of tones. The receiver detects the valid frequency pair and gives the appropriate BCD code as the output of the DTMF decoder IC.
- DTMF signal can be tapped directly from the microphone pin of cell phone device.
- Cut the microphone wire and we will see 4 wires. Among these wires we need only 2 wires Ground and Right

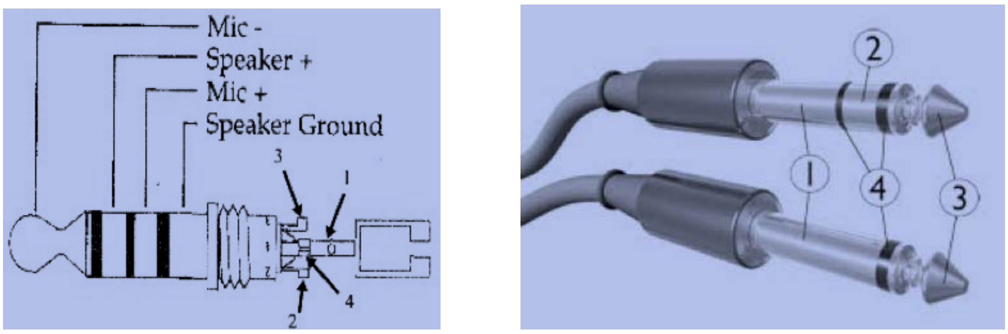

Fig 2: Microphone Wire

- Take the right wire and connect it as input to the decoder circuit. Ground of jack should be connected to common ground of our circuit.
- The signals from the microphone wire are processed by the DTMF decoder IC which generates the equivalent binary sequence as a parallel output as Q1, Q2, Q3, and Q4.
- IC7805 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, 2, 3, 4, 5, 6, 7, 8, 9 and 0 keys, the DTMF decoder IC generates a high pulse which acts as a clock and sets the output to high.
- The output 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
-

In this Project mobile Keypad Tones Working When press :

- Press “1” Output Port “1” is ON
- Press “2” Output Port “1” is OFF
- Press “3” Output Port “2” is ON
- Press “4” Output Port “2” is OFF
- Press “5” Output Port “3” is ON
- Press “6” Output Port “3” is OFF
- Press “7” Output Port “4” is ON
- Press “8” Output Port “4” is OFF
- Press “9” Output Port “ALL” is ON
- Press “0” Output Port “ALL” is OFF

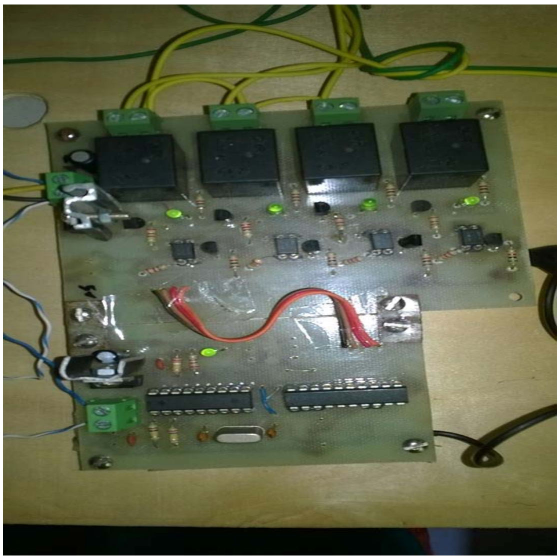

Fig 3 : Project Circuit Diagram

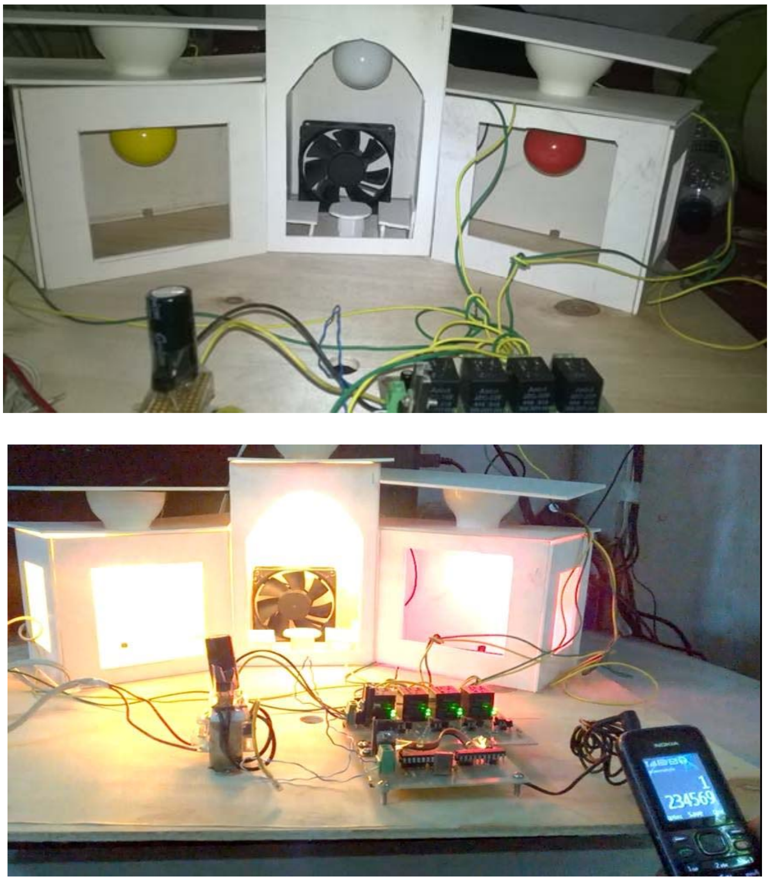

Fig 4 : Final Testing Of Project

2.4 Circuit Diagram

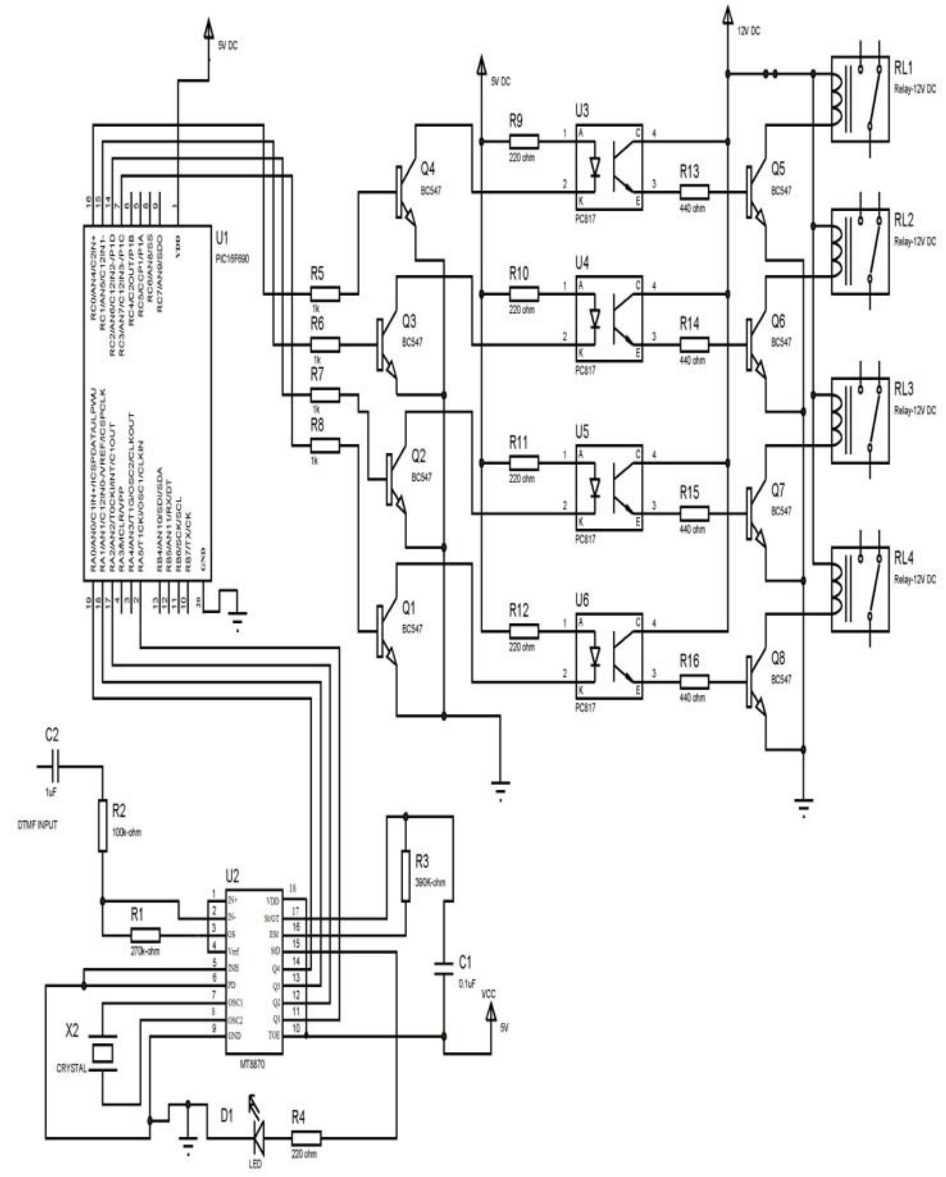

Fig 3: Circuit diagram of Home Automation Control

2.5 Equipment Uses The Circuit

No	Equipment	Quantity
1.	**PIC16f690 microcontroller**	**1**
2.	**MT8870DE DTMF Decoder**	**1**
3.	**Relay 12vdc**	**4**
4.	**Voltage regulating IC (7805, 7812)**	**1+1**
5.	**Opt coupler PC817**	**1**
7.	**Capacitor (10mF-50v,22mF-50v,220mF-200v,22pF, 0.1mF)**	**1+1+1+1+1**
8.	**Resistance (220ohm, 1k, 470k, 390k, 100k)**	**12+4+1+1+1+1**
9.	**LED 3mm**	**5**
10.	**Cristal Oscillator 3.51 MHz**	**1**
11.	**Transistor BC547**	**8**
12.	**Connector (Two Terminal)**	**6**
13.	**PCB**	
14.	**Transformer 24v, 600mA**	**1**

Table 1: Equipment use in the circuit

2.6 DTMF Low and High frequency tones and decoded output

Button	Low DTMF frequency (Hz)	High DTMF frequency (Hz)	Binary coded output			
			Q1	Q2	Q3	Q4
1	697	1209	0	0	0	1
2	697	1336	0	0	1	0
3	697	1477	0	0	1	1
4	770	1209	0	1	0	0
5	770	1336	0	1	0	1
6	770	1477	0	1	1	0
7	852	1209	0	1	1	1
8	852	1336	1	0	0	0
9	852	1477	1	0	0	1
0	941	1336	1	0	1	0
*	941	1209	1	0	1	1
#	941	1477	1	1	0	0

Table 2 : DTMF High And Low Frequency tone

3 Component Description

3.1 DTMF: MT8870DE decoder IC

This DTMF (Dual Tone Multi Frequency) decoder circuit identifies the dial tone from the telephone line and decodes the key pressed on the remote telephone. Here for the detection of DTMF signaling, we are using the IC MT8870DE which is a touch tone decoder IC. It decodes the input DTMF to 5 digital outputs.

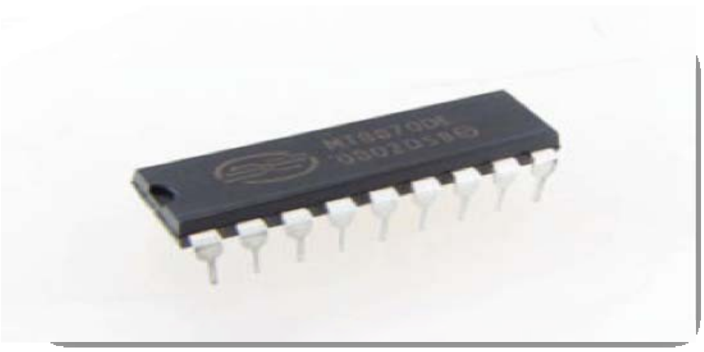

Fig 4: MT-8870DE DTMF decoder IC

The M-8870 DTMF (Dual Tone Multi Frequency) decoder IC uses a digital counting technique to determine the frequencies of the limited tones and to verify that they correspond to standard DTMF frequencies. The DTMF tone is a form of one way communication between the dialer and the telephone exchange. The whole communication consists of the touch tone initiator and the tone decoder or detector. The decoded bits can be interfaced to a computer or microcontroller for further application.

As technology established, pulse or dial tone technique were invented for telephone communication switching. It employs electronics and computers to support switching operations. DTMF is the ultimate technique used in any of the Mobile, Telephone communication systems.

3.1.1 BASIC PRINCIPLES OF DTMF

DTMF as stated is the short form of "Dual-Tone Multi- Frequency" and it is a method of designating digits with tone- frequencies that will be transmitted via an analog communication channel or network like a telephone line. It was developed by Western Electric and introduced by AT&T in 1963. During its development, unique individual frequency filters were chosen carefully so that the tones could easily travel via the telephone lines (the maximum guaranteed bandwidth for a standard telephone line extends from around 300 Hz to 3.5 kHz). DTMF was not intended for data transfer, rather for control signals only. With a standard DTMF encoder/decoder, it is possible to signal at a rate of around 10 tones/signals per second.

The DTMF keypad is laid out in a 4x4 matrix, with two frequencies (each row representing a low frequency and each column representing a high frequency) played simultaneously by a standard home phone/fax or mobile phone. Each key on the telephone's keypad has a unique frequency assigned to it. Pressing a single key (such as '1') will send a sinusoidal tone for each of the two frequencies (697 Hz and 1209 Hz). The multiple tones are the reason for calling the system as multiple-frequency. This prevents the misinterpretation of the harmonics and hence, it is immune to noise. These tone are then decoded by the switching center to determine which key was pressed. When any key is pressed on the DTMF keypad, the circuit plays the corresponding DTMF tone. A typical DTMF keypad is illustrated in the table below

1	**2**	**3**	**A**	**697**
4	5	6	B	770
7	8	9	C	852
*****	0	#	D	941
1209	1336	1477	1633	Frequencies (in Hz)

Table 3: DTMF High and Low Frequency Tones

3.1.2 The operation of DTMF method are as follows

- Caller generates a dial tone consisting of two frequencies. It is transmitted via the telephone line (communication media).
- Telephone exchange consists of a DTMF decoder, which decodes the frequencies in to digital code. These codes are the address of destination subscriber.

3.1.3 Uses of other pins:

- The entire process from frequency detection to latching of the data, is controlled by steering control circuit consisting of St/GT, Est pins, resistor (390kΩ) and a capacitor (0.1µF).
- 5th Pin, INH is an active high pin, inhibits detection of A, B, C, D tones of character.
- 6th Pin, PWDN is an (active high), inhibits the working of oscillator thus stops the working of our circuit.

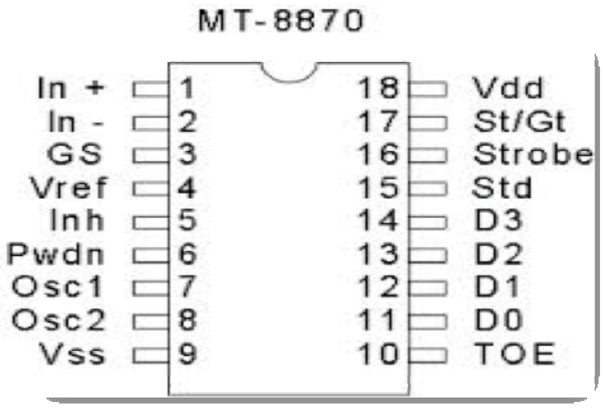

Fig 5 : MT-8870DE DTMF decoder IC Pin diagram

- The 10th pin 10; TOE is the output enable pin which is active high logic and enables the latching of the data on the data pins Q0, Q1, Q2, and Q3.

- 15th Pin StD is the Data valid pin, turn out to be high on detection of valid DTMF tone or else it remains low.
- Pins 7 (OS1) and 8 (OS2) are used to connect crystal oscillator. An oscillator of frequency 3.579545 MHz is used here.

3.2 Transformer

A transformer is an electrical device that transfers energy between two circuits through electromagnetic induction. A transformer may be used as a safe and efficient voltage converter to change the AC voltage at its input to a higher or lower voltage at its output without changing the frequency. Other uses include current conversion, isolation with or without changing voltage and impedance conversion.

A transformer most commonly consists of two windings of wire that are wound around a common core to provide tight electromagnetic coupling between the windings. The core material is often a laminated iron core. The coil that receives the electrical input energy is referred to as the primary winding, the output coil is the secondary winding.

Fig 6: Transformer

An alternating electric current flowing through the primary winding (coil) of a transformer generates a varying electromagnetic field in its surroundings which induces a varying magnetic flux in the core of the transformer. The varying electromagnetic field in the vicinity of the secondary winding induces an electromotive force in the secondary winding, which appears as a voltage across the output terminals. If a load is connected across the secondary winding, a current flows through the secondary winding drawing power from the primary winding and its power source.

Various specific electrical application designs require a variety of transformer types. Although they all share the basic characteristic transformer principles, they are customize in construction or electrical properties for certain installation requirements or circuit conditions.

- Autotransformer: Transformer in which part of the winding is common to both primary and secondary circuits.[83]
- Capacitor voltage transformer: Transformer in which capacitor divider is used to reduce high voltage before application to the primary winding.
- Distribution transformer, power transformer: International standards make a distinction in terms of distribution transformers being used to distribute energy from transmission lines and networks for local consumption and power transformers being used to transfer electric energy between the generator and distribution primary circuits.[83][84][j]
- Phase angle regulating transformer: A specialised transformer used to control the flow of real power on three-phase electricity transmission networks.
- Scott-T transformer: Transformer used for phase transformation from three-phase to two-phase and vice versa.[83]
- Polyphase transformer: Any transformer with more than one phase.
- Grounding transformer: Transformer used for grounding three-phase circuits to create a neutral in a three wire system, using a wye-delta transformer,[80][85] or more commonly, a zigzag grounding winding.[80][82][83]
- Leakage transformer: Transformer that has loosely coupled windings.
- Resonant transformer: Transformer that uses resonance to generate a high secondary voltage.
- Audio transformer: Transformer used in audio equipment.
- Output transformer: Transformer used to match the output of a valve amplifier to its load.
- Instrument transformer: Potential or current transformer used to accurately and safely represent voltage, current or phase position of high voltage or high power circuits.

3.2.1 Basic Principal

The operation of a transformer is based on two principles of the laws of electromagnetic induction: An electric current through a conductor, produces a magnetic field surrounding the conductor, and a changing magnetic field in the vicinity of a conductor induces a voltage across the ends of that conductor.

The magnetic field excited in the primary coil gives rise to self-induction as well as mutual induction between coils. This self-induction counters the excited field to such a degree that the resulting current through the primary winding is very small when the secondary winding is not connected to a load.

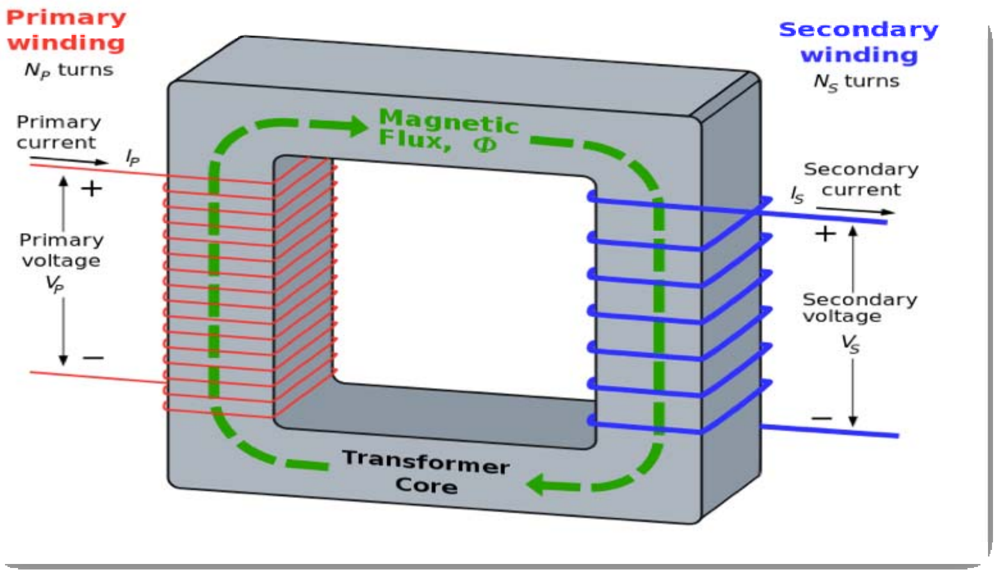

Fig 7: Basic Diagram of a transformer

The physical principles of the inductive behavior of the transformer are most readily understood and formalized when making some assumptions to construct a simple model which is called the ideal transformer. This model differs from real transformers by assuming that the transformer is perfectly constructed and by neglecting that electrical or magnetic losses occur in the materials used to construct the device.

3.2.2 Ideal transformer

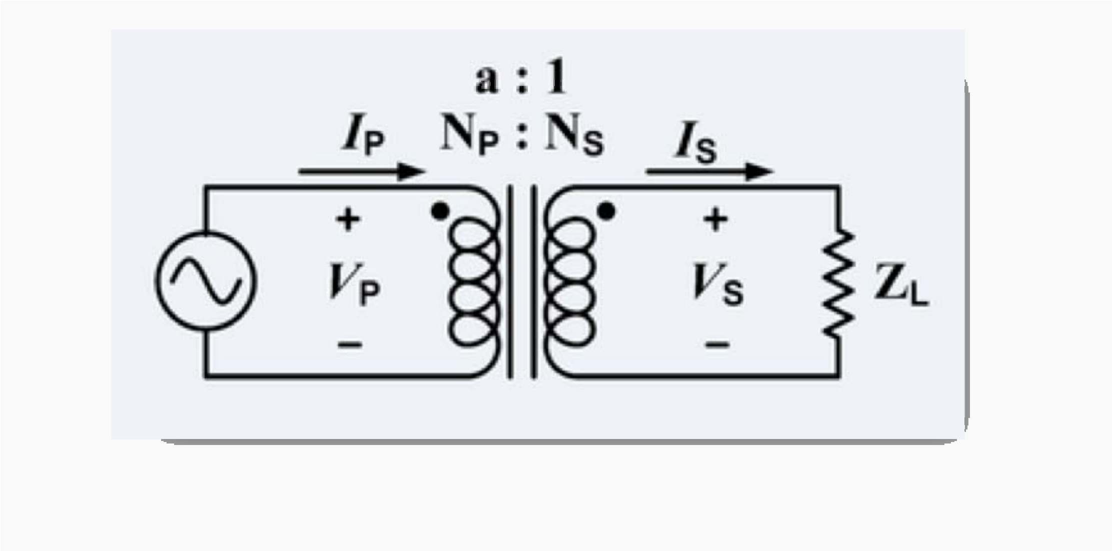

Fig 8: Ideal Transformer

- The windings of the transformer have no resistance. Thus, there is no copper loss in the winding, and hence no voltage drop.
- Flux is confined within the magnetic core. Therefore, it is the same flux that links the input and output windings.
- Permeability of the core is infinitely high which implies that net mmf (amp-turns) must be zero (otherwise there would be infinite flux) hence $I_P N_P - I_S N_S = 0$.
- The transformer core does not suffer magnetic hysteresis or eddy currents, which cause inductive loss.

If the secondary winding of an ideal transformer has no load, no current flows in the primary winding.

The circuit diagram (right) shows the conventions used for an ideal, i.e. lossless and perfectly coupled transformer having primary and secondary windings with N_P and N_S turns, respectively.

The ideal transformer induces secondary voltage V_S as a proportion of the primary voltage V_P and respective winding turns as given by the equation

$$\mathbf{Vp/Vs = Np/Ns = a}$$

where,

a is the winding turns ratio, the value of these ratios being respectively higher and lower than unity for step-down and step-up transformers,[4][5][a][b]

V_P designates source impressed voltage,

V_S designates output voltage, and,

According to this formalism, when the number of turns in the primary coil is greater than the number of turns in the secondary coil, the secondary voltage is smaller than the primary voltage. On the other hand, when the number of turns in the primary coil is less than the number of turns in the secondary, the secondary voltage is greater than the primary voltage.

Any load impedance Z_L connected to the ideal transformer's secondary winding allows energy to flow without loss from primary to secondary circuits. The resulting input and output apparent power are equal as given by the equation.

$$I_pV_p = I_sV_s$$

Combining the two equations yields the following ideal transformer identity

$$V_p/V_s = I_p/I_s = 1.$$

3.3 Light Emitting Diode (LED)

A light-emitting diode (LED) is a two-lead semiconductor light source that resembles a basic pn-junction diode, except that an LED also emits light.[7] When an LED's anode lead has a voltage that is more positive than its cathode lead by at least the LED's forward voltage drop, current flows. Electrons are able to recombine with holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor.

An LED is often small in area (less than 1 mm^2), and integrated optical components may be used to shape its radiation pattern

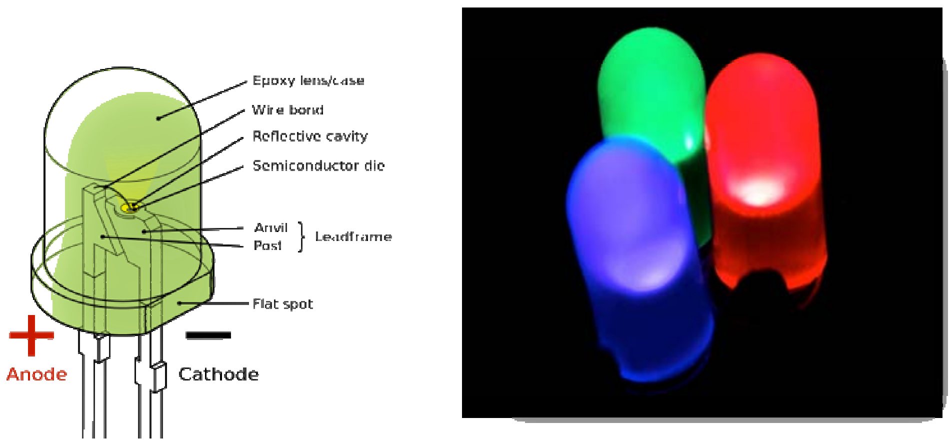

Fig 9: Light Emitting diode (LED)

3.4 Voltage Regulating IC

The 78xx (sometimes L78xx, LM78xx, MC78xx...) is a family of self-contained fixed linear voltage regulator integrated circuits. The 78xx family is commonly used in electronic circuits requiring a regulated power supply due to their ease-of-use and low cost. For ICs within the family, the xx is replaced with two digits, indicating the output voltage (for example, the 7805 has a 5 volt output, while the 7812 produces 12 volts). The 78xx lines are positive voltage regulators: they produce a voltage that is positive relative to a common ground. There is a related line of 79xx devices which are complementary negative voltage regulators. 78xx and 79xx ICs can be used in combination to provide positive and negative supply voltages in the same circuit.

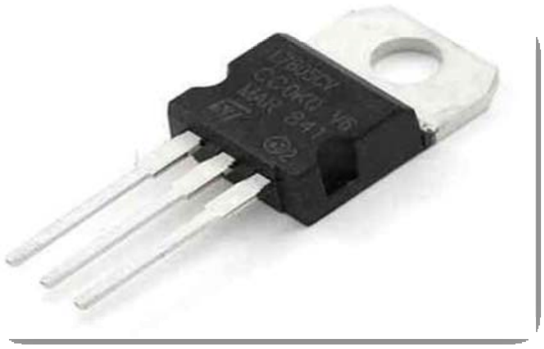

Fig 10: Voltage Regulating IC

78xx ICs have three terminals and are commonly found in the TO220 form factor, although smaller surface-mount and larger TO3packages are available. These devices support an input voltage anywhere from a few volts over the intended output voltage, up to a maximum of 35 to 40 volts depending on the make, and typically provide 1 or 1.5 amperes of current (though smaller or larger packages may have a lower or higher current rating).

Part Number	Output Voltage (V)
7805	+5
7812	+12

Table 4 : Output Voltage of Voltage Regulated IC

3.4.1 Advantage

- 78xx series ICs do not require additional components to provide a constant, regulated source of power, making them easy to use, as well as economical and efficient uses of space. Other voltage regulators may require additional components to set the output voltage level, or to assist in the regulation process. Some other designs (such as a switched-mode power supply) may need substantial engineering expertise to implement.
- 78xx series ICs have built-in protection against a circuit drawing too much power. They have protection against overheating and short-circuits, making them quite robust in most applications. In some cases, the current-limiting features of the 78xx devices can provide protection not only for the 78xx itself, but also for other parts of the circuit.

3.4.2 Disadvantages

- The input voltage must always be higher than the output voltage by some minimum amount (typically 2.5 volts). This can make these devices unsuitable for powering some devices from certain types of power sources (for example, powering a circuit that requires 5 volts using 6-volt batteries will not work using a 7805).
- As they are based on a linear regulator design, the input current required is always the same as the output current. As the input voltage must always be higher than the output voltage, this means that the total power (voltage multiplied by current) going into the 78xx will be more than the output power provided. The extra input power is dissipated as heat. This means both that for some applications an adequate heat sink must be provided, and also that a (often substantial) portion of the input power is wasted during the process, rendering them less efficient than some other types of power supplies. When the input voltage is significantly higher than the regulated output voltage (for example, powering a 7805 using a 24 volt power source), this inefficiency can be a significant issue.

3.5 Capacitor

A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to store energy electrostatically in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors (plates) separated by a dielectric (i.e., insulator). The conductors can be thin films of metal, aluminum foil or disks, etc. The 'non-conducting' dielectric acts to increase the capacitor's charge capacity. A dielectric can be glass, ceramic, plastic film, air, paper, mica, etc. Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, a capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

Fig 11: capacitor

When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge (+Q) to collect on one plate and negative charge (-Q) to collect on the other plate. If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor. However, if an accelerating or alternating voltage is applied across the leads of the capacitor, a displacement current can flow.

An ideal capacitor is characterized by a single constant value for its capacitance. Capacitance is expressed as the ratio of the electric charge (Q) on each conductor to the potential difference (V) between him or her. The SI unit of capacitance is the farad (F), which is equal to one coulomb per volt (1 C/V). Typical capacitance values range from about 1 pF (10^{-12} F) to about 1 mF (10^{-3} F).

The capacitance is greater when there is a narrower separation between conductors and when the conductors have a larger surface area. In practice, the dielectric between the plates passes a small amount of leakage current and also has an electric field strength limit, known as the breakdown voltage. The conductors and leads introduce an undesired inductance and resistance.

Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass. In analog filter networks, they smooth the output of power supplies. In resonant circuits they tune radios to particular frequencies. In electric power transmission systems they stabilize voltage and power flow.

3.6 Resistor

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. Resistors act to reduce current flow, and, at the same time, act to lower voltage levels within circuits. Resistors may have fixed resistances or variable resistances, such as those found

Fig 12: Resistor

in thermistors, varistors, trimmers, photo resistors, humistors and potentiometers.

The current through a resistor is in direct proportion to the voltage across the resistor's terminals. This relationship is represented by Ohm's law:

$$I = \frac{V}{R}$$

where I is the current through the conductor in units of amperes, V is the potential difference measured across the conductor in units of volts, and R is the resistance of the conductor in units of ohms (symbol: Ω)

Resistors are common elements of electrical networks and electronic circuits and are ubiquitous in electronic equipment. Practical resistors can be composed of various compounds and films, as well as resistance wires (wire made of a high-resistivity alloy, such as nickel-chrome). Resistors are also implemented within integrated circuits, particularly analog devices, and can also be integrated into hybrid and printed circuits

3.6.1 Theory of operation

The behavior of an ideal resistor is dictated by the relationship specified by Ohm's law:

$$V = I.R$$

Ohm's law states that the voltage (V) across a resistor is proportional to the current (I), where the constant of proportionality is the resistance (R).

Equivalently, Ohm's law can be stated:

$$I = V/R$$

This formulation states that the current (I) is proportional to the voltage (V) and inversely proportional to the resistance (R). This is directly used in practical computations. For example, if a 300 ohm resistor is attached across the terminals of a 12 volt battery, then a current of

12 / 300 = 0.04 amperes flows through that resistor.

3.7 Microcontroller PIC16f690

A Microcontroller is a computer – on a – chip, some school of thought called it a single – chip computer. Micro suggests that the device is small, and controller tells you that the device might be used to control objects, processes or events. Another term to describe a microcontroller is an embedded controller because the microcontroller and its support circuits are often built in to, or embedded in the device they control. Microcontrollers can be found in all kinds of devices these days. Any device that measures, stores, controls, calculates or display information in most cases comprises of a microcontroller.

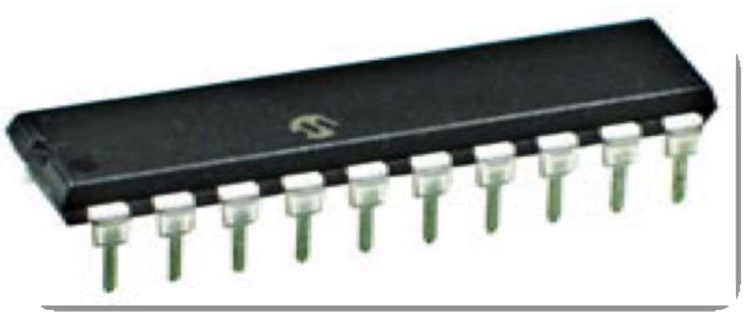

Fig13 : PIC16f690 Micro-controller

3.7.1 Features

- 20-pin Microcontroller with A/D
- Flash Program Memory: 4096 bytes
- EEPROM Data Memory: 256 bytes
- SRAM Data Memory: 256 bytes
- I/O Pins: 18
- A/D Converter: 10-bit Twelve Channel
- Timers: Two 8-bit / One 16-bit
- Enhanced PWM: 10-bit up to 4 Outputs
- SSP: SPI and I²C Support
- EUSART: With RS-485, RS-232 and Lin 2.0 Support
- Internal Oscillator: 8MHz

3.8 Relay 12vdc

A solid-state relay (SSR) is an electronic switching device that switches states when an external voltage is applied along its n-type and p-type junctions. SSR has a small control signal that controls a larger load current or voltage. It consists of a sensor which responds to an appropriate input (control signal), a solid-state electronic switching device which switches power to the load circuitry, and some coupling mechanism to enable the control signal to activate this switch without mechanical parts. The relay may be designed to switch either AC or DC to the load. It serves the same function as an electromechanical relay, but has no moving parts.

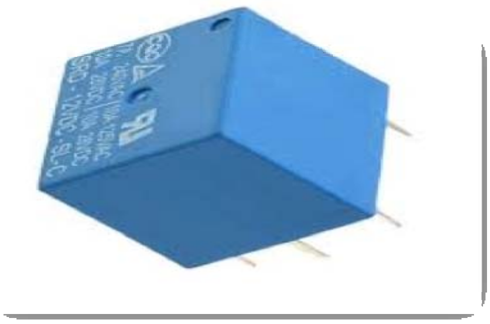

Fig14: Relay 12vdc

3.8.1 Operation

A SSR based on a single MOSFET, or multiple MOSFETs in a paralleled array, works well for DC loads.

MOSFETs have an inherent substrate diode that conducts in the reverse direction, so a single MOSFET cannot block current in both directions. For AC (bi-directional) operation two MOSFETs are arranged back-to-back with their source pins tied together. Their drain pins are connected to either side of the output. The substrate diodes are alternately reverse biased to block current when the relay is off. When the relay is on, the common source is always riding on the instantaneous signal level and both gates are biased positive relative to the source by the photo-diode.

It is common to provide access to the common source so that multiple MOSFETs can be wired in parallel if switching a DC load. Usually a network is provided to speed the turn-off of the MOSFET when the control input is removed.

One significant advantage of a solid-state SCR or TRIAC relay over an electromechanical device is its natural tendency to open the AC circuit only at a point of zero load current. Because SCR's and TRIAC's are thyristors, their inherent hysteresis maintains circuit continuity after the LED is de-energized until the AC current falls below a threshold value (the holding current). In practical terms what this means is the circuit will never be interrupted in the middle of a sine wave peak. Such untimely interruptions in a circuit containing substantial inductance would normally produce large voltage spikes due to the sudden magnetic field collapse around the inductance. This will not happen in a circuit broken by an SCR or TRIAC. This feature is called zero-crossover switching.

3.8.2 Advantages over mechanical relays

Most of the relative advantages of solid state and electromechanical relays are common to all solid-state as against electromechanical devices.

- SSRs are faster than electromechanical relays; their switching time is dependent on the time needed to power the LED on and off, of the order of microseconds to milliseconds
- Increased lifetime, particularly if activated many times, as there are no moving parts to wear and no contacts to pit or build up carbon
- Output resistance remains constant regardless of amount of use
- Clean, bounce-less operation
- No sparking, allowing use in explosive environments where it is critical that no spark is generated during switching
- Totally silent operation.

3.8.3 Disadvantages

Voltage/current characteristic of semiconductor rather than mechanical contacts:

- When closed, higher resistance (generating heat), and increased electrical noise
- When open, lower resistance, and reverse leakage current (typically µA range)
- Some types have polarity-sensitive output circuits. Electromechanical relays are not affected by polarity.
- Possibility of spurious switching due to voltage transients (due to much faster switching than mechanical relay)
- Isolated bias supply required for gate charge circuit.

3.9 Cristal Oscillator 3.51 MHz

A crystal oscillator is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a very precise frequency. This frequency is commonly used to keep track of time (as in quartz wristwatches), to provide a stable clock signal for digital integrated circuits, and to stabilize frequencies for radio transmitters and receivers. The most common type of piezoelectric resonator used is the quartz crystal, so oscillator circuits incorporating them became known as crystal oscillators, but other piezoelectric materials including polycrystalline ceramics are used in similar circuits.

Quartz crystals are manufactured for frequencies from a few tens of kilohertz to hundreds of megahertz. More than two billion crystals are manufactured annually. Most are used for consumer devices such as wristwatches, clocks, radios, computers, and cellphones. Quartz crystals are also found inside test and measurement equipment, such as counters, signal generators, and oscilloscopes.

Fig 15: Cristal Oscillator 3.51 MHz

3.9.1 Operation

A crystal is a solid in which the constituent atoms, molecules, or ions are packed in a regularly ordered, repeating pattern extending in all three spatial dimensions.

Almost any object made of an elastic material could be used like a crystal, with appropriate transducers, since all objects have natural resonant frequencies of vibration. For example, steel is very elastic and has a high speed of sound. It was often used in mechanical filters before quartz. The resonant frequency depends on size, shape, elasticity, and the speed of sound in the material. High-frequency crystals are typically cut in the shape of a simple, rectangular plate. Low-frequency crystals, such as those used in digital watches, are typically cut in the shape of a tuning fork. For applications not needing very precise timing, a low-cost ceramic resonator is often used in place of a quartz crystal.

When a crystal of quartz is properly cut and mounted, it can be made to distort in an electric field by applying a voltage to an electrode near or on the crystal. This property is known as electrostriction or inverse piezoelectricity. When the field is removed, the quartz will generate an electric field as it returns to its previous shape, and this can generate a voltage. The result is that a quartz crystal behaves like a circuit composed of an inductor, capacitor and resistor, with a precise resonant frequency. (See RLC circuit.)

Quartz has the further advantage that its elastic constants and its size change in such a way that the frequency dependence on temperature can be very low. The specific characteristics will depend on the mode of vibration and the angle at which the quartz is cut (relative to its crystallographic axes).[10] Therefore, the resonant frequency of the plate, which depends on its size, will not change much, either. This means that a quartz clock, filter or oscillator will remain accurate. For critical applications the quartz oscillator is mounted in a temperature-controlled container, called a crystal oven, and can also be mounted on shock absorbers to prevent perturbation by external mechanical vibrations.

3.9.2 Commonly used crystal frequencies

Crystals can be manufactured for oscillation over a wide range of frequencies, from a few kilohertz up to several hundred megahertz. Many applications call for a crystal oscillator frequency conveniently related to some other desired frequency, so hundreds of standard crystal frequencies are made in large quantities and stocked by electronics distributors. For example, many (non-television) applications use 3.579545 MHz crystals since they are made in large quantities for NTSC color television receivers. Using frequency dividers, frequency multipliers and phase locked loop circuits, it is practical to derive a wide range of frequencies from one reference frequency.

3.10 Transistor BC547

A BC547 transistor is a negative-positive-negative (NPN) transistor that is used for many purposes. Together with other electronic components, such as resistors, coils, and capacitors, it can be used as the active component for switches and amplifiers. Like all other NPN transistors, this type has an emitter terminal, a base or control terminal, and a collector terminal. In a typical configuration, the current flowing from the base to the emitter controls the collector current. A short vertical line, which is the base, can indicate the transistor schematic for an NPN transistor, and the emitter, which is a diagonal line connecting to the base, is an arrowhead pointing away from the base.

There are various types of transistors, and the BC547 is a bipolar junction transistor (BJT). There are also transistors that have one junction, such as the junction field-effect transistor, or no junctions at all, such as the metal oxide field-effect transistor (MOSFET). During the design and manufacture of transistors, the characteristics can be predefined and achieved. The negative (N)-type material inside an NPN transistor has an excess of electrons, while the positive (P)-type material has a lack of electrons, both due to a contamination process called doping.

The BC547 transistor comes in one package. When several are placed in a single package, it is usually referred to as a transistor array. Arrays are commonly used in digital switching. Eight transistors may be placed in one package to make layout much easier.

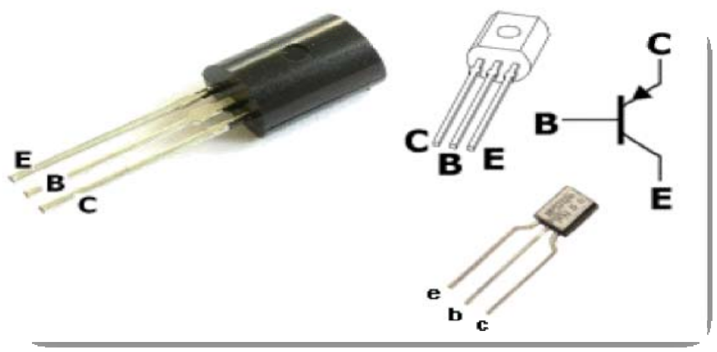

Fig 16: Transistor BC547

To make use of a transistor as an audio preamplifier, a direct current (DC) source is needed, such as a 12-volt (V) power supply. In a common emitter configuration, the negative side of the power supply is alternating current (AC)-coupled to the emitter via a capacitor. There is also a small resistance connecting the power supply to the emitter. The power supply is then connected to the collector via a resistor, which may be referred to as a limiting resistor. When the collector-to-emitter current flows, there will be a voltage drop in the limiting resistor, and in the idle state, the collector voltage is typically 6 V.

Transistor circuit design requires a thorough understanding of current-voltage ratings of various components, such as transistors and resistors. One goal is to keep the components from burning up, while another is to make the circuit work. Saving electricity is also important, such as in the case of battery-operated device.

3.11 Connector

- Electrical connector, a device for joining electrical circuits together
- Audio and video connector, electrical connectors (or optical connectors) for carrying audio signal and video signal, of either analog or digital format
- Gender of connectors and fasteners
- Power connector, devices that allow electrically operated equipment to be connected to the primary alternating current (AC) power supply in a building
- RF connector, an electrical connector designed to work at radio frequencies in the multi-megahertz range
- MIL-STD-1553, a military standard published by the United States Department of Defense that defines the mechanical, electrical, and functional characteristics of a serial data bus

Fig 17: Connector

- Circular connector
- Cigar lighter receptacle
- Blind mate connector, one in which the mating action happens where you can't see or feel it to ensure that it is correctly aligned. They have self-aligning features which allows a small misalignment when mating
- Board–to–board connector, used for connecting printed circuit boards
- Connector (computer science), a pointer or link between two data structures
- Java EE Connector Architecture, a Java-based technology solution for connecting application servers and Enterprise information system

3.12 Opt-Coupler PC817:

An opt-coupler, also called opt-isolator, is an electronic component that transfers an electrical signal or voltage from one part of a circuit to another, or from one circuit to another, while electrically isolating the two circuits from each other. It consists of an infrared emitting LED chip that is optically in-line with a light-sensitive silicon semiconductor chip, all enclosed in the same package. The silicon chip could be in the form of a photo diode, photo transistor, photo Darlington, or photo SCR.

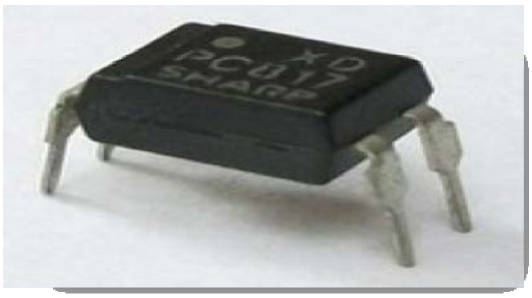

Fig 18: Opt-Coupler PC817

3.12.1 Opt-coupler FUNCTIONS

- To isolate one section of a circuit from another, each section having different signal voltage levels to ensure compatibility between them.

- To prevent electrical noise or other voltage transients that may exist in a section of a circuit from interfering with another section when both sections have a common circuit reference. Noise or voltage transients can be caused by a poor printed circuit board layout.

4 TESTING

4.1 TESTING

Testing is one of the important stages in the development of any new product or repair of existing ones. Because it is very difficult to trace a fault in a finished work, especially when the work to be tested is too complex. For the purpose of this project, two stages of testing are involved

i. Pre-implementation testing

ii. Post-implementation testing.

4.1.1 PRE-IMPLEMENTATION TESTING

It is carried out on the components before they are soldered to the vero-board. This is to ensure that each component is in good working condition before they are finally soldered to the board. The components used in this design are grouped into two.
- Discrete components e.g. resistors, light emitting diodes, capacitors, transistors. Etc.
- Integrated circuit components. The discrete components are tested with a millimeter by switching the meter to the required value and range corresponding to each discrete component to check for continuity.

4.1.2 POST-IMPLEMENTATION TESTING

After implementing the circuit on a project board, the different sections of the complete system were tested to ensure that they were in good operating condition. The continuity test carried out is to ensure that the circuit or components are properly linked together. This test was carried out before power was supplied to the circuit. Finally, after troubleshooting has been done on the whole circuit, power was supplied to the circuit. Visual troubleshooting was also carried out at this stage to ensure that the components do not burn out. Different load was added or connected to the power outlet ranging from 25 watts to 200 watts of power to check if the circuit can carry it without any effect to the circuit. After all the test and observations as explained above, the project was now certified ready for packaging.

4.2 Result

The results obtained during the construction states after necessary troubleshooting were satisfactory. The system was able to respond to its operation on the following electrical and electronic system such as televisions, radio, CD players, electric fan, electric bulb etc. .the decoding of the tones sent by the mobile phone to the DTMF decoder and the sending of this tones to the microcontroller works effectively. Also, the microcontroller functions according to the program used for the software design implementation. It is worth mentioning how fascinating it is to see a designed project working satisfactorily.

5 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Designing and implementation of a multichannel telephone based remote control system was of a truth a fascinating task to undergo .The climax of the whole process was to see that the hardware and software implementation are working as desired after several process of trial and adjustment. This project has given us a great deal of insight into the field of communication and control engineering. The theories of communication which we have being learning from our Subject was made more practicable .The ability to be able to effect control over your systems (electrical appliances, laboratory equipment, house hold appliance etc.) from far distance and in some cases from anther country is of immense importance in control engineering regarding your field or your level of education. Besides the issue of control, the basics of communication (i.e. Global system of Mobile Communication (GSM) was made more clearer because the processes the call goes through from the dialing of the number using the 4×4 standard key to the processes of decoding the number by the Dual Tone Multi-frequency Decoder (DTMF) was also made very clear.

5.2 RECOMMENDATION

This control system is recommended for every homes, offices, laboratories, hospitals and industries to aid those working or living in those places when it comes to controlling their appliances, equipment. This control system has to be perceived by the society and the world at large as a necessary and vital technological upgrade While working on this design, at some point in time we were carried away by the fact that our project is working as desired but on further thinking, we thought about the fact that our control system should working independently on its own when it comes to the power supply unit, that the system get its power from the public power supply system which is well known that it is not stable, so on this note , we will advice any further work on this control system to have its power supply independent on its own or better still use rechargeable batteries or solar if possible.

Appendix

PIC16f690 Micro-controller

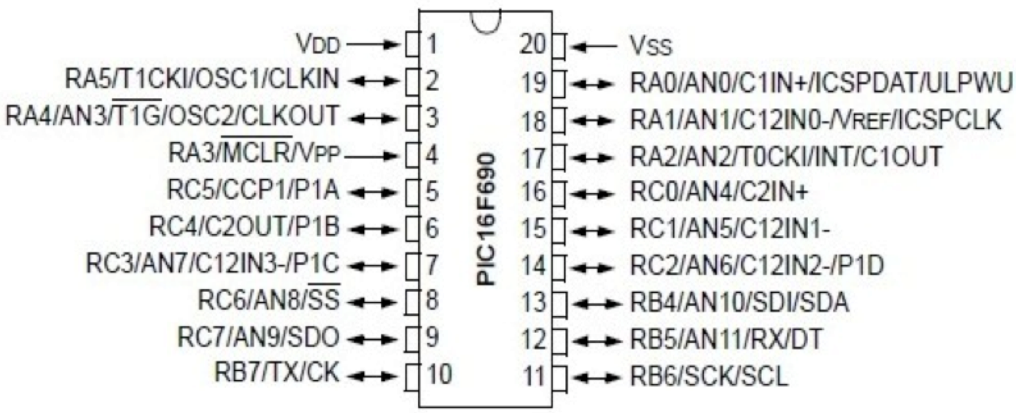

Fig19: PIC16f690 Micro-Controller Pin diagram

Table Of Micro-controller Pin Output :

Name	Function	Input Type	Output Type	Description
RA0/AN0/C1IN+/ICSPDAT/ ULPWU	RA0	TTL	—	General purpose I/O. Individually controlled interrupt-on- change. Individually enabled pull-up.
	AN0	AN	—	A/D Channel 0 input.
	C1IN+	AN	—	Comparator 1 positive input.
	ICSPDAT	TTL	CMOS	ICSP Data I/O.
	ULPWU	AN	—	Ultra Low-Power Wake-up input.
RA1/AN1/C12IN-/VREF/ICSPCLK	RA1	TTL	CMOS	General purpose I/O. Individually controlled interrupt-on- change. Individually enabled pull-up.
	AN1	AN	—	A/D Channel 1 input.
	C12IN-	AN	—	Comparator 1 or 2 negative input.
	VREF	AN	—	External Voltage Reference for A/D.
	ICSPCLK	ST	—	ICSPTM clock.
RA2/AN2/T0CKI/INT/C1OUT	RA2	ST	CMOS	General purpose I/O. Individually controlled interrupt-on- change. Individually enabled pull-up.
	AN2	AN	—	A/D Channel 2 input.
	T0CKI	ST	—	Timer0 clock input.
	INT	ST	—	External Interrupt.
	C1OUT	—	CMOS	Comparator 1 output.
RA3/MCLR/VPP	RA3	TTL	—	General purpose input. Individually controlled interrupt-on- change.
	MCLR	ST	—	Master Clear with internal pull-up.
	VPP	HV	—	Programming voltage.
	AN3	AN	—	A/D Channel 3 input.
	T1G	ST	—	Timer1 gate input.
	OSC2	—	XTAL	Crystal/Resonator.

	CLKOUT	—	CMOS	FOSC/4 output.
RA5/T1CKI/OSC1/CLKIN	RA5	TTL	CMOS	General purpose I/O. Individually controlled interrupt-on- change. Individually enabled pull-up.
	T1CKI	ST	—	Timer1 clock input.
	OSC1	XTAL	—	Crystal/Resonator.
	CLKIN	ST	—	External clock input/RC oscillator connection.
RB4/AN10/SDI/SDA	RB4	TTL	CMOS	General purpose I/O. Individually controlled interrupt-on- change. Individually enabled pull-up.
	AN10	AN	—	A/D Channel 10 input.
	SDI	ST	—	SPI data input.
	SDA	ST	OD	I2C data input/output.
RB5/AN11/RX/DT	RB5	TTL	CMOS	General purpose I/O. Individually controlled interrupt-on- change. Individually enabled pull-up.
	AN11	AN	—	A/D Channel 11 input.
	RX	ST	—	EUSART asynchronous input.
	DT	ST	CMOS	EUSART synchronous data.
RB6/SCK/SCL	RB6	TTL	CMOS	General purpose I/O. Individually controlled interrupt-on- change. Individually enabled pull-up.
	SCK	ST	CMOS	SPITM clock.
	SCL	ST	OD	I2CTM clock.
RB7/TX/CK	RB7	TTL	CMOS	General purpose I/O. Individually controlled interrupt-on- change. Individually enabled pull-up.
	TX	—	CMOS	EUSART asynchronous output.
	CK	ST	CMOS	EUSART synchronous clock.
RC0/AN4/C2IN+	RC0	ST	CMOS	General purpose I/O.
	AN4	AN	—	A/D Channel 4 input.
	C2IN+	AN	—	Comparator 2 positive input.

RC1/AN5/C12IN-	RC1	ST	CMOS	General purpose I/O.
	AN5	AN	—	A/D Channel 5 input.
	C12IN-	AN	—	Comparator 1 or 2 negative input.
RC2/AN6/P1D	RC2	ST	CMOS	General purpose I/O.
	AN6	AN	—	A/D Channel 6 input.
	P1D	—	CMOS	PWM output.
RC3/AN7/P1C	RC3	ST	CMOS	General purpose I/O.
	AN7	AN	—	A/D Channel 7 input.
	P1C	—	CMOS	PWM output.
RC4/C2OUT/P1B	RC4	ST	CMOS	General purpose I/O.
	C2OUT	—	CMOS	Comparator 2 output.
	P1B	—	CMOS	PWM output.
RC5/CCP1/P1A	RC5	ST	CMOS	General purpose I/O.
	CCP1	ST	CMOS	Capture/Compare input.
	P1A	ST	CMOS	PWM output.
RC6/AN8/SS	RC6	ST	CMOS	General purpose I/O.
	AN8	AN	—	A/D Channel 8 input.
	SS	ST	—	Slave Select input.
RC7/AN9/SDO	RC7	ST	CMOS	General purpose I/O.
	AN9	AN	—	A/D Channel 9 input.
	SDO	—	CMOS	SPI data output.
VSS	VSS	Power	—	Ground reference.
VDD	VDD	Power	—	Positive supply.

Table 5: PIC16f690 Micro-controller Pin Description

Programming Uses the Micro-controller

```
#include<pic.h>

#define _XTAL_FREQ 4000000

__CONFIG(INTIO & WDTDIS & PWRTEN & MCLREN & UNPROTECT & UNPROTECT & BORDIS & IESODIS & FCMDIS);

void main()

{

	TRISA0=1;	// input

	TRISA1=1;	// input

	TRISA2=1;	// input

	TRISA5=1;	// input

	TRISC=0;	// output

	PORTC=0;

	PORTA=0;

	ANSEL=0;		//All Digital Pin

	ANSELH=0;

	while(1)

	{

		if(RA0==0&&RA1==0&&RA2==0&&RA5==1)

		{

		RC0=1;

		}

		if(RA0==0&&RA1==0&&RA2==1&&RA5==0)

	{

		RC0=0;

		}

		if(RA0==0&&RA1==0&&RA2==1&&RA5==1)

		{

		RC1=1;

		}

		if(RA0==0&&RA1==1&&RA2==0&&RA5==0)
		{
		RC1=0;
```

```
}
if(RA0==0&&RA1==1&&RA2==0&&RA5==1)
{
RC2=1;
}
if(RA0==0&&RA1==1&&RA2==1&&RA5==0)
{
RC2=0;
}
if(RA0==0&&RA1==1&&RA2==1&&RA5==1)
{
RC3=1;
}
if(RA0==1&&RA1==0&&RA2==0&&RA5==0)
{
RC3=0;
}
if(RA0==1&&RA1==0&&RA2==0&&RA5==1)
{
RC0=1;
RC1=1;
RC2=1;
RC3=1;
}
if(RA0==1&&RA1==0&&RA2==1&&RA5==0)
{
RC0=0;
RC1=0;
RC2=0;
RC3=0;
}
}
}
```

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