1. INTRODUCTION

1.1 INTRODUCTION TO THE PROJECT

The mobile phone is one of the greatest inventions of the 20^{th} century. It started off as a very plain communication tool but over the years as technology advanced the features provided by the then so simple mobile proliferated. It has now embodied itself in every man's pocket. So much so that it is giving its big brother the PC a run for its money. Having said so, people at large still are in the dark about the computing power of such a small embedded device. Hence we have decided to utilize the power lying dormant in our pockets i.e. our cell phone.

The aim of this project is to demonstrate that the control can be achieved with a normal mobile phone. This means that any house with a mobile can enjoy the benefits of an automated home without the high end maintenance and demanding technical proficiency.

Here we are using a mobile phone as a media, which serves main part of this system. The "Home Automation Control System Using DTMF the project is a secure DTMF control system for intelligent houses.

With this implemented system, it is possible to safely control electricity operated domestic devices.

1.2 HOME AUTOMATION

What is Home Automation?

Home automation is the residential extension of "building automation". It is automation of the home, housework or household activity. Home automation may include centralized control of lighting, heating, ventilation and air conditioning, appliances, and other systems, to provide improved convenience, comfort, energy efficiency and security. Home automation for the elderly and disabled can provide increased quality of life for persons who might otherwise require caregivers or institutional care.

A home automation system integrates electrical devices in a house with each other. The techniques employed in home automation include those in building automation as well as the control of domestic activities, such as home entertainment systems, houseplant and yard watering, pet feeding, changing the ambiance "scenes" for different events (such as dinners or parties). Through the integration of information technologies with the home environment, systems and appliances are able to communicate in an integrated manner which results in convenience, energy efficiency, and safety benefits. Typically, a new home is outfitted for home automation during construction, due to the accessibility of the walls, outlets, and storage rooms, and the ability to make design changes specifically to accommodate certain technologies.

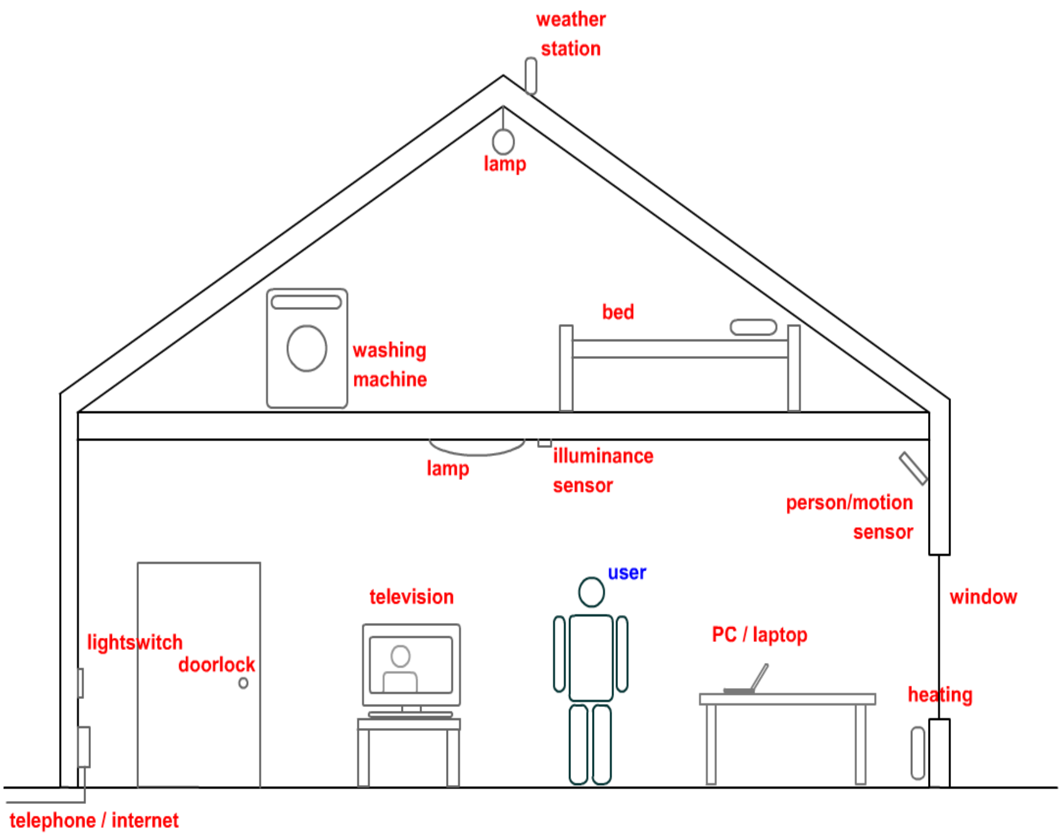

Fig 1.1 Home Automation

1.3 NEED OF THE PROJECT

How this project is different from other home automation control system?

Controlling device using switches are common. From a few decades controlling devices using remote control switches like infrared remote control switch, wireless remote control switches, light activated switches are becoming popular. But these technologies have their own limitations Here we are using a mobile as a media, which serves main part of this system. The "Home Automation Control System Using DTMF Telephone Line" project is a secure DTMF control system for intelligence houses.With this implemented system, it is possible to safely control electricity operated domestic devices.

1.4 Report Organization

The organization of this dissertation report is as follows:

Chapter 2: Literature Survey

This chapter gives the detailed review of literature, i.e. the methods which can be used for home automation. Problems faced are also explained. It also mentions the disadvantages of existing technology and the approach used in this project is also highlighted. It also gives a detailed explanation of all the main components used in our project.

Chapter 3: Problem Formulation

The project is aimed at controlling all appliances at home via a remote terminal using the mobile phone. To develop a program to transmit the DTMF code using a mobile phone, receiving the code on a device and decoding the DTMF tone, giving decoded data to microcontroller to control appliances, developing a circuitry to control appliances using relays.

Chapter 4: PCB Making

This chapter gives theoretical information about PCB making, procedure and various other steps involved in making a printed circuit board.

Chapter 5: Software Implementation

This chapter provides our code written for the arduino board. It also gives an example of writing a simple android application.

Chapter 6: Proposed Problem Solution

This chapter provides the steps to achieve home automation using DTMF which overcomes the problems stated in chapter 3. These techniques will prove to yield better results.

References

The source of all technical work is mentioned explicitly in this part.

2. Literature Survey

2.1 Introduction

In this chapter we deal with various research works which has been done regarding home automation. Controlling device using switches are common. From a few decades controlling devices using remote control switches like infrared remote control switch, wireless remote control switches, light activated switches are becoming popular. But these technologies have their own limitations. Laser beams are harmful to mankind.

Some technologies like IR remote control are used for short distance applications. In such case if we have system which does not require any radiations or which is not harmful, long remote control switch!! Yes here is the solution. Here we are introducing such a system which does not require any radiations, any laser beam which has no limitation of range, we mean it can be used from any distance from meters to thousands of kilometers using a simple mobile phone.

2.2 Existing Technologies

2.2.1 Remote Controlling using Mobile Telephony[1]

Bluetooth Based Solution: Bluetooth wireless technology stands in the way of traditional short-range wired communications technology connecting portable and/or fixed devices while maintaining high levels of security. It obsoletes wires between your workstation, mouse, laptop computer, music head-phones etc. The key features of Bluetooth technology are robustness, low power yet low cost. The Bluetooth specification sets the standard for a wide range of devices to connect and communicate with each other. A fundamental strength of Bluetooth wireless technology is the ability to simultaneously handle both data and voice transmissions, making it most feasible for handheld devices.

Advantages of using bluetooth

1. Bluetooth offers a global standard for connecting a wide range of devices with
different services..

2. Bluetooth is available at most of the handheld devices like cell phones, music players and cameras all conforming to the defined standard. To use the bluetooth with computer, one need not think about overheads like internet and web servers.
3. The technology is very easy to use. The devices generally come with built-in software support for Bluetooth operations and these are most commonly used applications for handheld devices.

Disadvantages of using Bluetooth

1. One of the major limitations of Bluetooth technology is the short range of operations. So the system is unable to cope with mobility.
2. Bluetooth is not fully developed and integrated into all the products involved. We have to still wait for it to get fully evolved.

2.2.2 Attention (AT) Command Based Solution [2]

Wherever AT commands provide the computer with the most flexible way to control and explore the services and resources of a mobile. AT commands enable one to send and receive SMS from the computer and also it lets the computer to browse the mobiles resources like memory and phone book and so on. ‘AT’ stands for ’Attention’ command. GSM mobile phones are equipped with built in GSM Modems which responds to the commands issued as an SMS by the connected computer. AT commands create a logical bidirectional communication between computer and mobile phone.

Advantages of using AT Command

1. The communication is solely implemented using SMS protocol which is available at most of the places.
2. It doesn’t rely on the internet and web servers, which cuts down the overhead and the cost of the communication.
3. From the programming point of view, all the efforts are rendered for the

computer and not the mobile, which makes the total implementation a relatively simple task.

4. There is no binding about the physical connection link that is used between the computers and mobile, which makes it more versatile and interoperable with data cables, Bluetooth and infrared.

Disadvantages of using AT Commands

1. AT command is somewhat device dependent. So, to permit devices from multiple vendors and multiple models, it may be necessary to alter the commands accordingly.

2. It is desired for a bidirectional communication that the communication can start from any of the two ends. But here the communication always starts with the command from the computer’s end.

3. ANALYSIS AND DESIGN

3.1 Introduction

This part consists of problem formulation & its preferred solution. It includes requirements of project & significance of individual element. It also consists of why we are going for particular element & what its advantage over other element. It also includes detail structure of project & its analysis for desired output.

3.2Problem Formulation

Home automation is one of the most common and versatile way of controlling home appliances. Home automation includes applications for the protection and comfort of occupants. They are used to manually, remotely or automatically manage numerous components and elements of your home. The major advantages include systems can irrigate your landscaping or secure a pool or spa. They can also control home audio systems and notify you via the house speakers when an incident is taking place. You can save energy and money by hooking the heating and cooling unit into your system.

3.3. Problem Solution

3.3.1 Block Diagram [3]

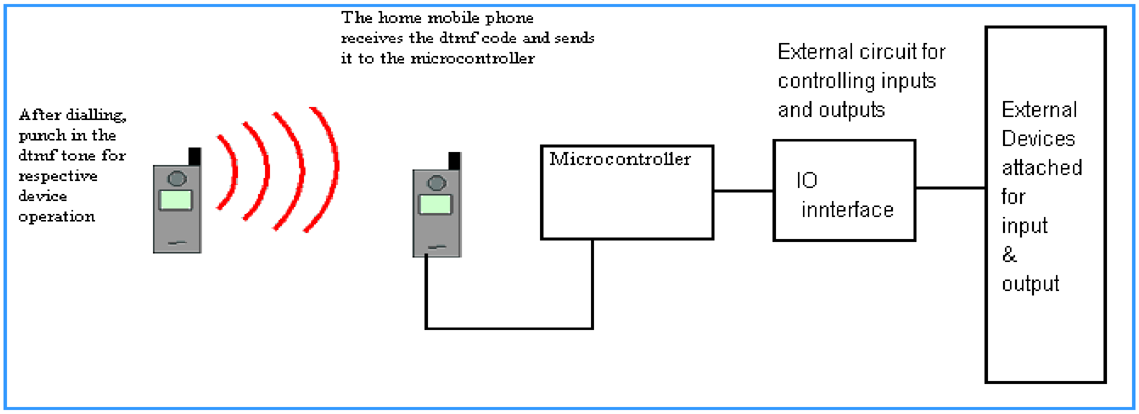

Fig. 3.1 Block Diagram of the Solution

3.3.2 Solution Description

1. Developing an Android application for the user mobile phone
2. Receiving respective DTMF tones on the home phone.
3. Decoding the tones using DTMF decoder IC MT8870.
4. Giving decoded data to the controller.
5. Using the received data to control appliances at home using relays.

3.4 ATmega 328 Architecture [4]

The AVR architecture was conceived by two students at the Norwegian Institute of Technology (NTH) Alf-Egil Bogen and Vegard Wollan. The original AVR MCU was developed at a local ASIC house in Trondheim, Norway called Nordic VLSI at the time, now Nordic Semiconductor, where Bogen and Wollan were working as students. It was known as a μRISC (Micro RISC) and was available as silicon IP/building block from Nordic VLSI. The designers worked closely with compiler writers at IAR Systems to ensure that the instruction set provided for more efficient compilation of high-level languages. Atmel says that the name AVR is not an acronym and does not stand for anything in particular. The creators of the AVR give no definitive answer as to what the term "AVR" stands for. However, it is commonly accepted that AVR stands for **A**lf (Egil Bogen) and **V**egard (Wollan)'s **R**isc processor.

The high-performance, low-power Atmel 8-bit AVR RISC-based microcontroller combines 128KB of programmable flash memory, 4KB SRAM, a 4KB EEPROM, an 8-channel 10-bit A/D converter, and a JTAG interface for on-chip debugging. The device supports throughput of 16 MIPS at 16 MHz and operates between 4.5-5.5 volts. By executing instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

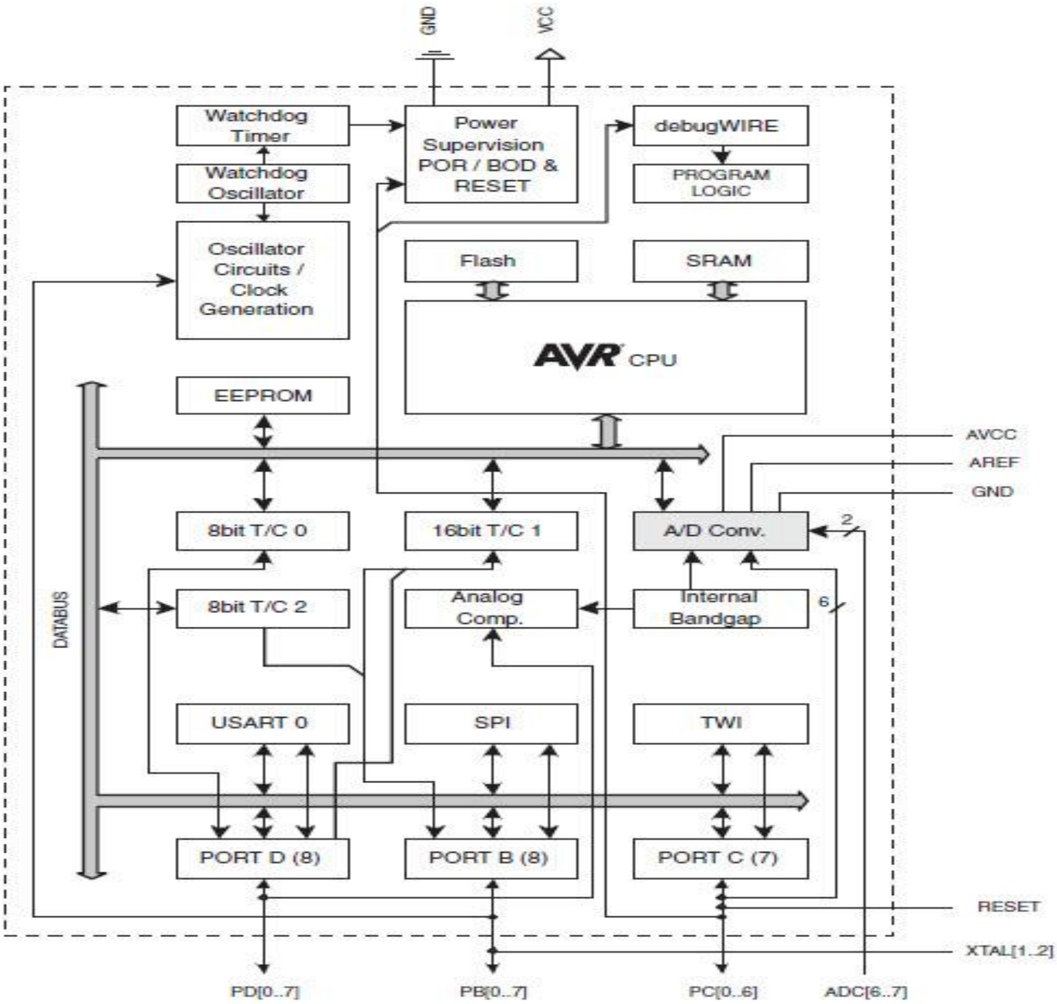

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Fig. 3.2 ATmega 328 Architecture

3.5 Arduino [5]

3.5.1 Introduction

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments.

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the arduino programming language (based on wiring) and the arduino development environment (based on processing). arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing, MaxMSP).

The boards can be built by hand or purchased preassembled; the software can be downloaded for free. The hardware reference designs (CAD files) are available under an open-source license, you are free to adapt them to your needs.

3.5.2 Why Arduino?

There are many other microcontrollers and microcontroller platforms available for physical computing. All of these tools take the messy details of microcontroller programming and wrap it up in an easy-to-use package. Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems:

- Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms.
- Cross-platform - The Arduino software runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.
- Simple, clear programming environment - The arduino programming environment is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well.
- Open source and extensible software- The arduino software and is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from arduino to the AVR C programming language on which it's based.
- Open source and extensible hardware - The arduino is based on Atmel's ATMEGA8 and ATMEGA328 microcontrollers. Relatively inexperienced users can build the breadboard version of the module in order to understand how it works and thus save money.

3.6 Dual Tone Multi Frequency (DTMF)[6][7]

3.6.1 What is DTMF?

As we know the telephone was invented in mid-nineteenth century by Alexander Graham Bell. Since the of its invention the telephone as well as the dialling systems used has been the subject of constant innovation. However, the long-term weakness of pulse dialling used in the Bell telephone system was recognized only in the 1950s and a framework for the development of a more advanced dialling system was set in place.

The system that evolved is known as the tone dialling or DTMF system. DTMF is the acronym for dual tone multi-frequency. The DTMF system makes use of tones instead of pulses. As the name suggests, in the DTMF system, each dialled digit is represented by a unique pair of sine wave tones which is sent to the exchange as each digit is dialled .The sine wave tone pair determines which has been dialled. We use a 12-key keyboard, having a 3x4 matrix arrangement of keys. The keys for digits 0-9 and symbols *&# are arranged on the keypad in 4 row – 3 columns matrix. Each row and column has a unique tone frequency. When key corresponding to a digit is pressed, the tones for its rows and column are transmitted. Thus for each digit dialled, we shall have unique row-column, frequency-combination.

E.g. : When you press a button in the set keypad, a connection is made that generates a resultant signal of two tones at the same time.This two tones are taken from a row frequency and a column frequency. The resultant frequency signal is called a “Dual Tone Multiple Frequency “. These tones are identical and unique. A DTMF signal is the algebraic sum of two different audio frequencies, and can be expressed as follows:
f(t)=A0sin(2*?*fa*t)+B0sin(2*?*fb*t)+…---> (1)
Where fa and fb are two different audio frequencies with A and B as their peak amplitude and f as the resultant DTMF signal. fa belongs to the low frequency group and fb belongs to the high frequency group.

3.6.2 Description of DTMF decoder

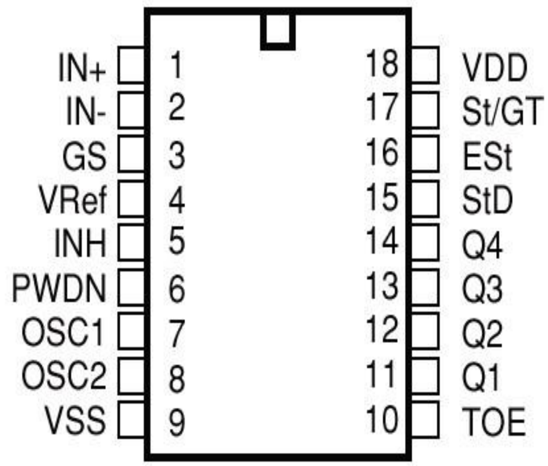


Fig 3.3 IC MT 8870

The MT8870C/MT8870 is a complete DTMF receiver integrating both the band split filter section uses switched capacitor techniques for a high and low group filters; the decoder uses digital counting techniques to detect and decode all 16 DTMF tone appears into a 4-bit code. External components count is minimized by on chip provision of a different input amplifier, clock oscillator and latched three state bus interfaces. The one common element and the most important of all phone connection is the voice. The bandwidth necessary for legible voice communication is in the range of 300 to 3000hz.The twisted pair of copper wires would be able to carry audio tones as long as they fell into the current bandwidth.

The modern tone dialling phone today uses these seven tones with all 12 combinations for 0-9, the asterisk * and pound sign #.thus the name Dual-Tone-Multiple Frequency(DTMF) was coined.

The phone company added an eight tone. These eight tones were grouped with four low frequency tones and four high frequency tones

This four-by-four array produced 16 different combinations as shown in the table below.

DTMF	1209 HZ	1336 HZ	1447 HZ	1663 HZ
697 HZ	1	2	3	A
770 HZ	4	5	6	B
852 HZ	7	8	9	C
941 HZ	*	0	#	D

Table 3.1 DTMF combinations

As an example when pressing the number 5 on a keypad, the single low frequency tone of 770 Hz (shown in the first column)is combined with the single high frequency tone of 1336 Hz (shown in the top row) and is transmitted over the audio carrier. Electronically generating these tones was the easy part; accurately detecting them was much harder.

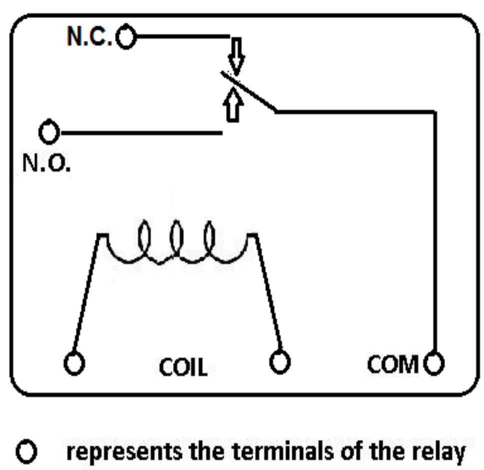
3.6.3 Features of IC MT8870:

- Low power consumption
- Adjustable Acquisition and release times
- Central Office Quality and Performance
- Power-down and Inhibit Modes
- Inexpensive 3.58 MHz Time Base
- Single 5 volt Power supply
- Dial Tone suppression.

3.7 RELAYS

3.7.1 Introduction to relays [8]

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and most have double throw (changeover) switch contacts. Relays allow one circuit to switch a second circuit which can be completely separate from the first.



For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits, the link is magnetic and mechanical.

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. The maximum output current for the popular 555 timer IC is 200mA so these devices can supply relay coils directly without amplification. Relays are usually SPDT or DPDT but they can have many more sets of switch contacts, for example relays with 4 sets of changeover contacts are readily available.

The relay's switch connections are usually labeled COM, NC and NO:

- **COM** = Common, always connect to this, it is the moving part of the switch.
- **NC** = Normally Closed, COM is connected to this when the relay coil is **off**.
- **NO** = Normally Open, COM is connected to this when the relay coil is **on**.

3.7.2 Selecting a Relay

We need to consider several features when choosing a relay:

1. **Physical size and pin arrangement** : If you are choosing a relay for an existing PCB you will need to ensure that its dimensions and pin arrangement are suitable. You should find this information in the supplier's catalogue.
2. **Coil voltage**: The relay's coil voltage rating and resistance must suit the circuit powering the relay coil. Many relays have a coil rated for a 12V supply but 5V and 24V relays are also readily available. Some relays operate perfectly well with a supply voltage which is a little lower than their rated value.
3. **Coil resistance:** The circuit must be able to supply the current required by the relay coil. Ohm's law is used to calculate the current:

Coil current=(supply voltage/ coil resistance).

4. **Switch ratings (voltage and current):** The relay's switch contacts must be suitable for the circuit they are to control. You will need to check the voltage and current ratings. Note that the voltage rating is usually higher for AC, for example: "5A at 24V DC or 125V AC".
5. **Switch contact arrangement (SPDT, DPDT etc):**Most relays are SPDT or DPDT which are often described as "single pole changeover" (SPCO) or "double pole changeover" (DPCO).

3.7.3 Advantages of relays:

- Relays can switch **AC and DC**, transistors can only switch DC.
- Relays can switch **higher voltages** than standard transistors.
- Relays are often a better choice for switching **large currents** (> 5A).
- Relays can switch **many contacts** at once.

3.8 ANDROID [9]

3.8.1 What is Android?

Android is a software stack for mobile devices that includes an operating system, middleware and key applications. Android is a Linux-based mobile OS such as smartphones and tablet computers. It is developed by the Open Handset Alliance led by Google.

Google purchased the initial developer of the software, Android Inc., in 2005. The unveiling of the Android distribution in 2007 was announced with the founding of the Open Handset Alliance, a consortium of x86hardware, software, and telecommunication companies devoted to advancing open standards for mobile devices. Google releases the Android code as open-source, under the Apache License. The Android Open Source Project (AOSP) is tasked with the maintenance and further development of Android.

Android has a large community of developers writing applications that extend the functionality of the devices. Developers write primarily in a customized version of Java. Apps can be downloaded from third-party sites or through online stores such as Google Play(formerly *Android Market*), the app store run by Google.

3.8.2 Android Architecture [10]

Applications: Android will ship with a set of core applications including an email client, SMS program, calendar, maps, browser, contacts, and others. All applications are written using the Java programming language.

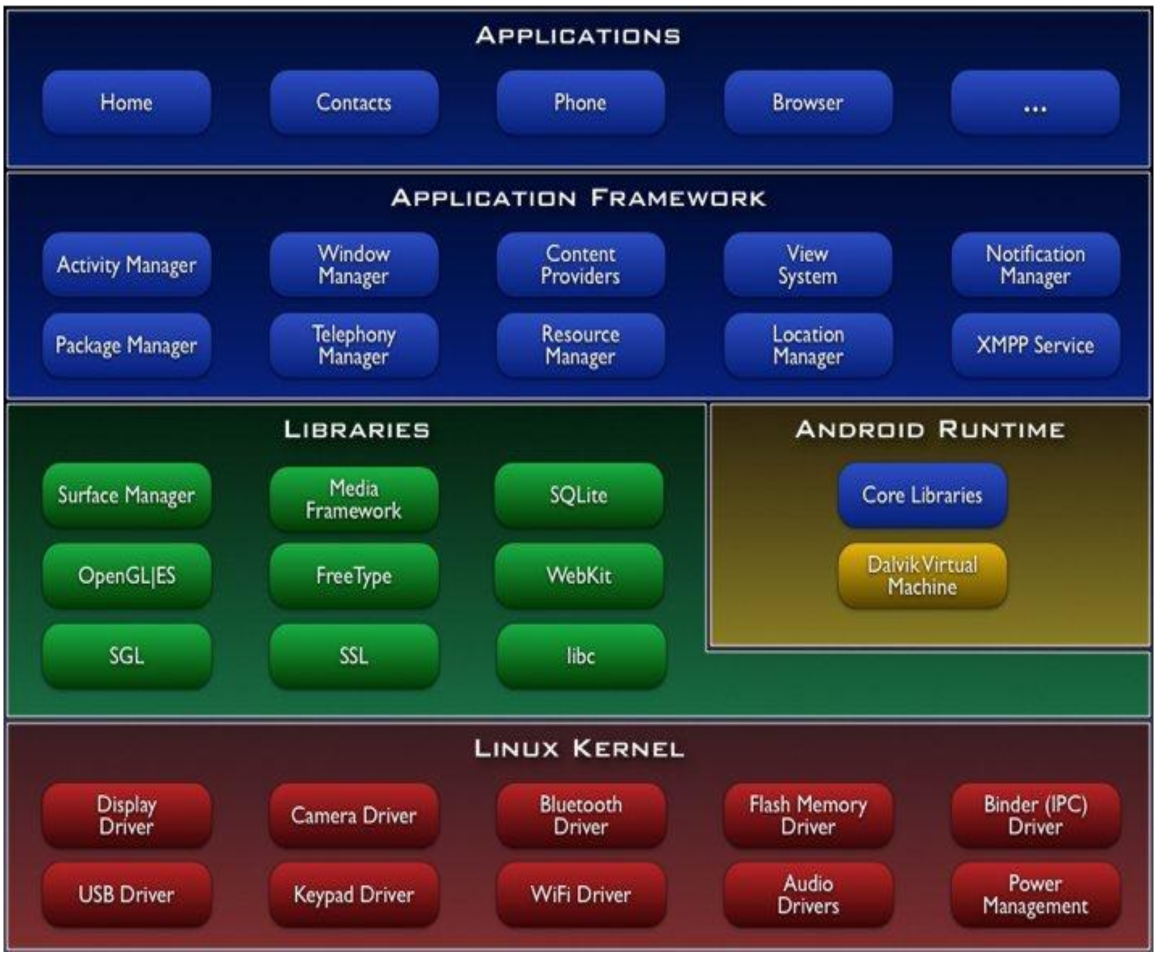


Fig. 3.5 Android Architecture

Linux Kernel: Android relies on Linux version 2.6 for core system services such as security, memory management, process management, network stack, and driver model. The kernel also acts as an abstraction layer between the hardware and the rest of the software stack.

Application Framework: By providing an open development platform, Android offers developers the ability to build extremely rich and innovative applications. Developers are free to take advantage of the device hardware, access location information, run background services, set alarms, add notifications to the status bar, and much, much more. The application architecture is designed to simplify the reuse of components; any application can publish its capabilities and any other application may then make use of those capabilities (subject to security constraints enforced by the framework). Underlying all applications is a set of services and systems, including:

- A rich and extensible set of Views that can be used to build an application, including lists, grids, text boxes, buttons, and even an embeddable web browser.
- Content Providers that enable applications to access data from other applications (such as Contacts), or to share their own data.
- A Resource Manager, providing access to non-code resources such as localized strings, graphics, and layout files.
- A Notification Manager that enables all applications to display custom alerts in the status bar.
- An Activity Manager that manages the lifecycle of applications and provides a common navigation back stack.

Libraries: Android includes a set of C/C++ libraries used by various components of the Android system. These capabilities are exposed to developers through the Android application framework. Some of the core libraries are listed below:

- **System C library** - a BSD-derived implementation of the standard C system library (libc), tuned for embedded Linux-based devices
- **Media Libraries** - based on Packet Video's OpenCORE; the libraries support playback and recording of many popular audio and video formats, as well as static image files, including MPEG4, H.264, MP3, AAC, AMR, JPG, and PNG

- **Surface Manager** - manages access to the display subsystem and seamlessly composites 2D and 3D graphic layers from multiple applications
- **LibWebCore** - a modern web browser engine which powers both the Android browser and an embeddable web view
- **SGL** - the underlying 2D graphics engine
- **3D libraries** - an implementation based on OpenGL ES 1.0 APIs; the libraries use either hardware 3D acceleration (where available) or the included, highly optimized 3D software rasterizer
- **SQLite** - a powerful and lightweight relational database engine available to all applications.

Android Runtime: Android includes a set of core libraries that provides most of the functionality available in the core libraries of the Java programming language. Every Android application runs in its own process, with its own instance of the Dalvik virtual machine. Dalvik has been written so that a device can run multiple VMs efficiently. The Dalvik VM executes files in the Dalvik Executable (.dex) format which is optimized for minimal memory footprint. The VM is register-based, and runs classes compiled by a Java language compiler that have been transformed into the .dex format by the included "dx" tool.

4. PCB MAKING

4.1 INTRODUCTION TO PCB MAKING [11]

A printed circuit board, or PCB, is used to mechanically support and electrically connect electronic components using conductive pathways, tracks or signal traces etched from copper sheets laminated onto a non-conductive substrate. It is also referred to as printed wiring board (PWB) or etched wiring board.

A PCB populated with electronic components is a printed circuit assembly (PCA), also known as a printed circuit board assembly or PCB Assembly (PCBA). Printed circuit boards are used in virtually all but the simplest commercially produced electronic devices.

Alternatives to PCBs include wire wrap and point-to-point construction. PCBs are often less expensive and more reliable than these alternatives, though they require more layout effort and higher initial cost. PCBs are much cheaper and faster for high-volume production since production and soldering of PCBs can be done by automated equipment. Much of the electronics industry's PCB design, assembly, and quality control needs are set by standards that are published by the IPC organization.

4.2 PCB DESIGNING

PCB Wizard was used to design the PCB boards.

4.3 PROCEDURE FOR MAKING A PCB

The PCB is made by the following procedure

- Cut the board
- Print the mask pattern
- Etching
- Drilling
- Apply the solder-resist(optional).
- Soldering.

- Cut the board: The PCB must be cut according to the size of the circuit to make. Also, it is mainly related with the size of the equipment to incorporate the PCB into. When cutting the positive exposure printed board, the attention is necessary. The sensitizer which reacts to the ultraviolet rays is painted to the positive exposure printed board. Because it is, it is necessary to cut in the place which isn't exposed to the ultraviolet rays when cutting the board. Cover the paper to the thing except the cut part, and it stops with the cellophane tape and cut it.

- Print the mask pattern : Print the mask pattern using the fluorescence light. Set the clamp equipment which set the printed board, the mask under the fluorescence light. The ultraviolet rays in the sun are very strong and in the case in the daytime, the exposure completes as much as the 2 minutes. The ultraviolet rays of the fluorescence light are weak. About 20 minutes are necessary to expose. When the exposing time is short, the long development time is necessary.

- Etching: Etching done with ferric chloride, ammonium persulfate, or sometimes hydrochloric acid. For PTH (plated-through holes), additional steps of electro less deposition are done after the holes are drilled, then copper is electroplated to build up the thickness, the boards are screened, and plated with tin/lead. The tin/lead becomes the resist leaving the bare copper to be etched away. The simplest method, used for small-scale production and often by hobbyists, is immersion etching, in which the board is submerged in etching solution such as ferric chloride.

- Drilling: Holes through a PCB are typically drilled with small-diameter drill bits made of solid coated tungsten carbide. Coated tungsten carbide is recommended since many board materials are very abrasive and drilling must be high RPM and high feed to be cost effective. Drill bits must also remain sharp so as not to mar or tear the traces. The drilling is performed by automated drilling machines with placement controlled by a drill tape or drill file.

- Apply the solder- resist(optional): Areas that should not be soldered may be covered with a polymer solder resist (solder mask) coating. The solder resist prevents solder from bridging between conductors and creating short circuits. Solder resist also provides some protection from the environment. Solder resist is typically 20–30 micro meters thick.

- Soldering : Mount the parts and assemble the circuit into the complete PCB. Soldering the parts to the PCB while seeing parts mounting drawing. To be careful at this time is to install from the part with the height which is as short as possible. When having put the parts with the tall earlier, it becomes difficult to install the part with the short. The following order is proper. Jumpers →Resistors →Diode →Ceramic capacitors →ICs →Crystal oscillator (Xtal) → Transistor →Electrolytic capacitors →Transformers for the use of high frequency → Relays.

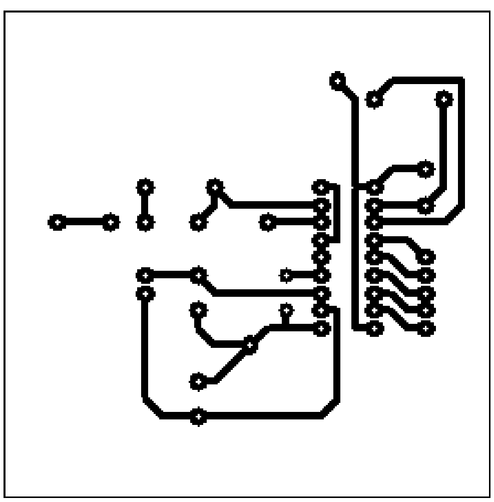


fig4.1. PCB Layout

5. SOFTWARE IMPLEMENTATION

5.1 Arduino Code:

```
int pin = 13;
boolean first = true;
volatile int state = LOW;
int result;
boolean value[4];
long values[5];
long mapvalues[5];
void setup()
{
pinMode(pin, OUTPUT);
attachInterrupt(0, blink, FALLING);
Serial.begin(9600);
pinMode(9, INPUT);
pinMode(10, INPUT);
pinMode(11, INPUT);
pinMode(12, INPUT);
pinMode(4, OUTPUT);
pinMode(5, OUTPUT);
pinMode(6, OUTPUT);
pinMode(7, OUTPUT);
pinMode(8, OUTPUT);
digitalWrite(4,HIGH);
digitalWrite(5,HIGH);
digitalWrite(6,HIGH);
digitalWrite(7,HIGH);
digitalWrite(8,HIGH);
}
```

```
void loop()
{
digitalWrite(pin, HIGH);
Serial.println("In Loop");
delay(175);
}
void blink()
{
state = !state;
Serial.println("Interrupt");
values[0]= analogRead(0);
values[1]= analogRead(1);
values[2]= analogRead(2);
values[3]= analogRead(3);
digitalWrite(pin, LOW);
detachInterrupt(0);
attachInterrupt(1, blinking, FALLING);
}
void blinking()
{
long ddout=analogRead(0);
int dout= map(ddout,0,1023,0,5);
for(int i=0; i<=3; i++)
{
mapvalues[i] = map(values[i], 0, 1023, 0, 5);
if(mapvalues[i]>=2)
{
value[i]=1;
}
else
```

```
{
value[i]=0;
}}
result =
(int(value[0])+ (2*int(value[1]))+(4*int(value[2]))+(8*int(value[3])) );
Serial.println(result);
if(dout >=2)
{
Serial.println("Second Read HIGH");
digitalWrite(pin, HIGH);
digitalWrite(result, HIGH);
}
else
{
Serial.println("Second Read LOW");
digitalWrite(pin, HIGH);
digitalWrite(result, LOW);
}
detachInterrupt(1);
attachInterrupt(0, blink, FALLING);
}
```

5.2 Writing a simple program in Android:[13]

HelloAndroid .java file

```
package com.example.helloandroid;
import android.app.Activity;
import android.os.Bundle;
import android.widget.TextView;

public class HelloAndroid extends Activity {
   /** Called when the activity is first created. */
   @Override
   public void onCreate(Bundle savedInstanceState) {
       super.onCreate(savedInstanceState);
       TextView tv = new TextView(this);
       tv.setText("Hello, Android");
       setContentView(tv);
  }}
```

AndroidMainifest.xml file

```
<?xml version="1.0" encoding="utf-8"?>
<TextViewxmlns:android="http://schemas.android.com/apk/res/android"
  android:id="@+id/textview"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  android:text="@string/hello"/>
```

R.java File

```
package com.example.helloandroid;

publicfinalclass R {
```

```
    publicstaticfinalclass attr {
    }
    publicstaticfinalclass drawable {
        publicstaticfinalint icon=0x7f020000;
    }
    publicstaticfinalclass id {
        publicstaticfinalint textview=0x7f050000;
    }
    publicstaticfinalclass layout {
        publicstaticfinalint main=0x7f030000;
    }
    publicstaticfinalclassstring{
        publicstaticfinalint app_name=0x7f040001;
        publicstaticfinalint hello=0x7f040000;
    }
}
```

OUTPUT

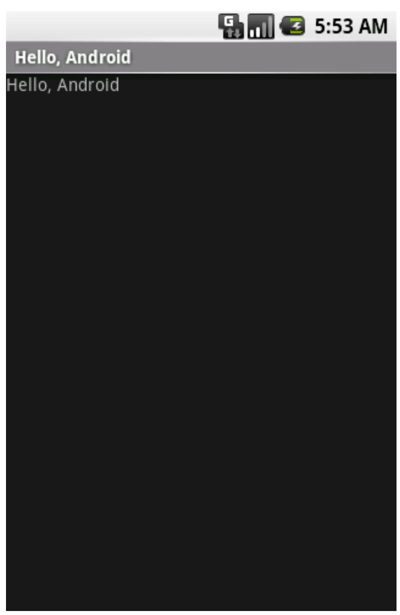


Fig 4.1 Output Hello World

5.3 Home Automation Application Screenshot

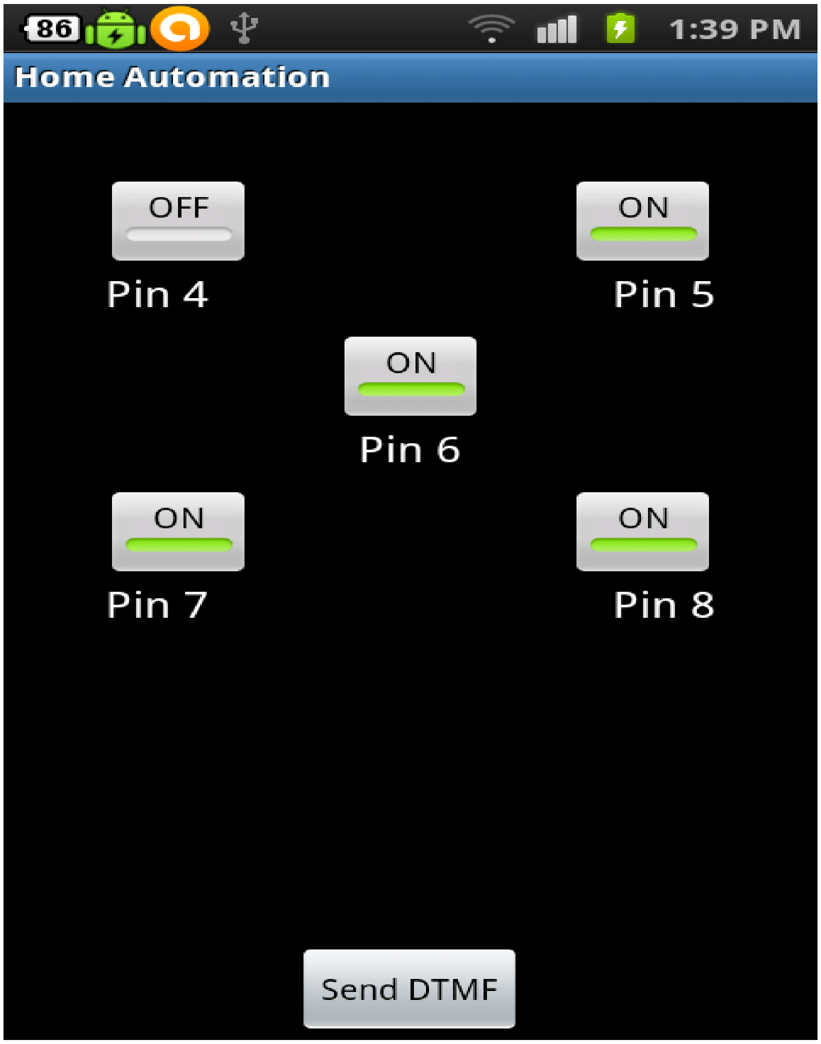


Fig 4.2 Home Automation Mobile Application

6. SUMMARY AND CONCLUSION

We have developed an application in Android which helps us to send a DTMF tone for a selected operation to be performed, to any mobile phone which is placed at the residence or location where the appliance is to be controlled. The DTMF tone is transmitted using a call. At the receiver, a mobile phone receives the call as an auto answer, and the tone is available on the output audio port. The audio output is connected to the DTMF Decoder IC which is MT8870. This decoder IC decodes the tone and outputs binary information on the 4 digital output pins and also sets the interrupt pin to logic high when the output latch is updated. The microcontroller is programmed to read the decoded data and switch the respective appliance on or off according to the received data. The microcontroller gives the signal to the relay circuitry which controls the appliance at the mains level.

Applications

1. Navigation in remote and inaccessible areas
2. For lighting control
3. Lighting control techniques can be used for switching on/off of the electrical bulbs around the home.
4. Lighting control techniques can be used for switching on/off of the electrical bulbs/tube lights of the whole building.

7. References

[1] [2] http://www.sersc.org/journals/IJSH/vol2_no3_2008/IJSH-Vol.2-No.3%20-%203.pdf

Block Diagram

[3] http://1.bp.blogspot.com/-yFGShdTmgbo/TisI7-ksLEI/AAAAAAAADG4/aRyCz18Qggo/s1600/mobile%2Bphone%2Binterfacing%2Bwith%2Bmicrocontroller%2B8051.gif

Atmega328 datasheet

[4]http://atmel.com/dyn/resources/prod_documents/8271S.pdf

Arduino

[5] http://arduino.cc/en/Guide/Introduction

DTMF

[6]http://www.genave.com/dtmf.htm

[7]http://nemesis.lonestar.org/reference/telecom/signaling/dtmf.html

MT8870C/MT8870 datasheet

Relays

[8] http://www.kpsec.freeuk.com/components/relay.htm

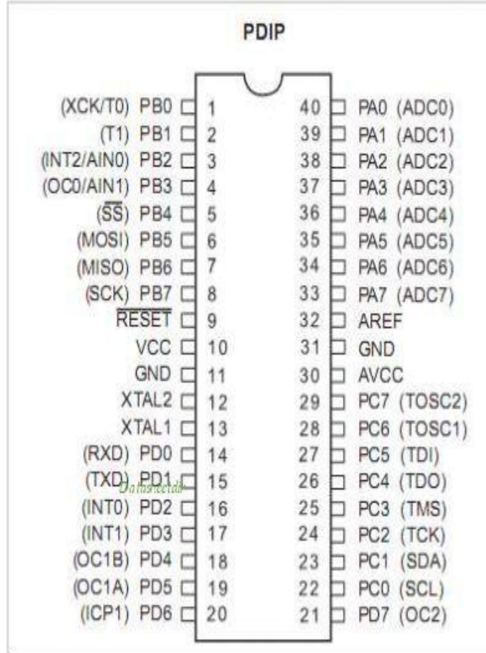
Android

[9] http://en.wikipedia.org/wiki/Android_%28operating_system%29

[10] http://developer.android.com/guide/basics/what-is-android.html

Appendix

1. Pin Description of ATmega 328



VCC: Digital supply voltage

GND: Ground

XTAL1: Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

XTAL2: Output from the inverting Oscillator amplifier.

RESET: Reset Input A low level in this pin for longer than the minimum pulse length will generate a reset, even if the clock is not.

Port A (PA7-PA0): Port A serves as the analog input to the A/D converter. Alternatively Port A serves as an 8-bit bidirectional I/O port. Port pins can provide internal pull up- resistors (selected for each bit). The port A output buffers have symmetrical drive characteristics with both high sink and source capability. When pins PA0 and PA7 are used as inputs and are externally pulled low, they will source current if the external pulls up resistors are activated. The Port A pins are tri- when a reset condition becomes active, even if the clock is not running.

Port (PB7-PB0) : Port B is an 8 bi-directional I/O port. Port B also serves the functions of various special features of the ATmega 32 which includes SPI, Timers and Counters, Analog comparators and USART.

PORT C (PC7-PC0): Port C is an 8-bit bi-directional I/O port. If the JTAG interface is enabled, the pull-up resistors on pins PCS (TDI), PC2 (TMS)will be activated even if a reset occurs. The D0 pin is tri-stated unless TAP states that shift out data are entered. Port C also serves the function of the JTAG interface and other special features of the ATmega32 as Timers, Oscillators and Serial communication.

Port D(PD7-PD)0): Port D is an 8-bit bi-directional I/O Port identical to Port A. Port D also solves the function of various special features of the ATmega 328 as external Interrupts, Timers, Counters and USART Rxd and Txd

AVCC: AVCC is the supply voltage pin for Port A and A/D convert. It should be externally, even if the ADC is not used. If the ADC is used it should be connected to VCC through a low pass filter.

AREF: AREF is the analog reference pin for A/D converter.

CMOS Integrated DTMF Receiver

Features

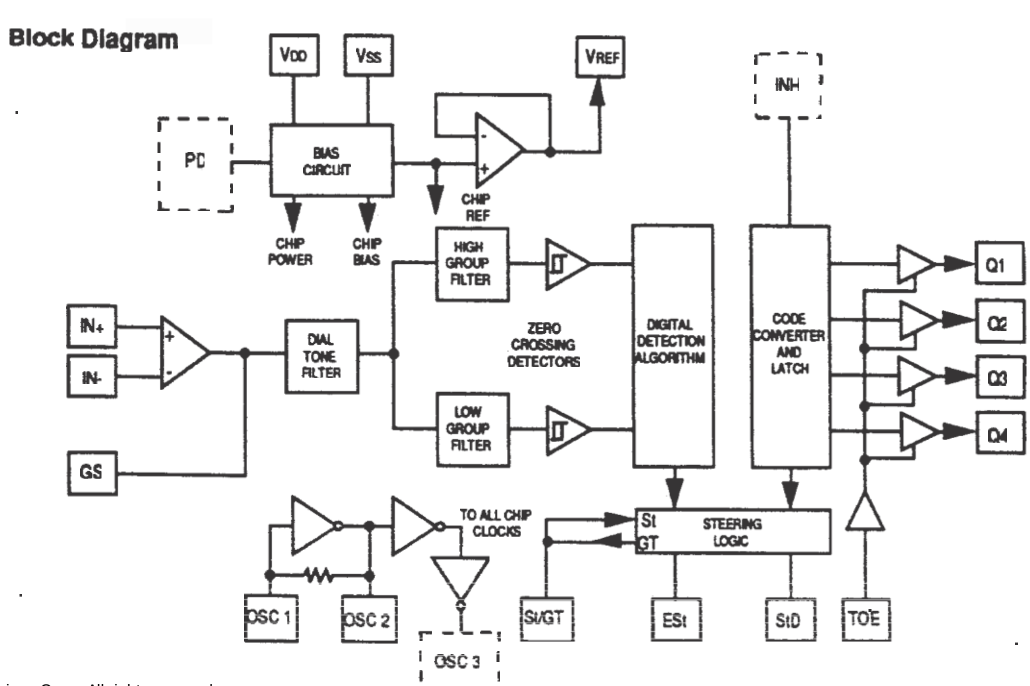
- Full DTMF receiver
- Less than 35mW power consumption
- Industrial temperature range
- Uses quartz crystal or ceramic resonators
- Adjustable acquisition and release times
- 18-pin DIP, 18-pin DIP EIAJ, 18-pin SOIC, 20-pin PLCC
- **CM8870C**
  - — Power down mode
  - — Inhibit mode
  - — Buffered OSC3 output (PLCC package only)
- CM8870C is fully compatible with CM8870 for 18-pin devices by grounding pins 5 and 6

Applications

- PABX
- Central office
- Mobile radio
- Remote control
- Remote data entry
- Call limiting
- Telephone answering systems
- Paging systems

Product Description

The CAMD CM8870/70C provides full DTMF receiver capability by integrating both the bandsplit filter and digital decoder functions into a single 18-pin DIP, SOIC, or 20-pin PLCC package. The CM8870/70C is manufactured using state-of-the-art CMOS process technology for low power consumption (35mW, max.) and precise data handling. The filter section uses a switched capacitor technique for both high and low group filters and dial tone rejection. The CM8870/70C decoder uses digital counting techniques for the detection and decoding of all 16 DTMF tone pairs into a 4-bit code. This DTMF receiver minimizes external component count by providing an on-chip differential input amplifier, clock generator, and a latched three-state interface bus. The on-chip clock generator requires only a low cost TV crystal or ceramic resonator as an external component.



Absolute Maximum Ratings: (Note 1)

ABSOLUTE MAXIMUM RATINGS		
Parameter	**Symbol**	**Value**
Power Supply Voltage (V_{DD}-V_{SS})	V_{DD}	6.0V Max
Voltage on any Pin	Vdc	V_{SS}-0.3V to V_{DD}+0.3V
Current on any Pin	I_{DD}	10mA Max
Operating Temperature	T_A	-40°C to +85°C
Storage Temperature	T_S	-65°C to +150°C

This device contains input protection against damage due to high static voltages or electric fields; however, precautions should be taken to avoid application of voltages higher than the maximum rating.

Notes:

1. Exceeding these ratings may cause permanent damage, functional operation under these conditions is not implied.

DC Characteristics: All voltages referenced to V_{SS}, V_{DD} = 5.0V ± 5%, T_A = -40°C to +85°C unless otherwise noted.

DC CHARACTERISTICS							
Parameter		**Symbol**	**Min**	**Typ**	**Max**	**Units**	**Test Conditions**
Operating Supply Voltage		V_{DD}	4.75		5.25	V	
Operating Supply Current		I_{DD}		3.0	7.0	mA	
Standby Supply Current		I_{DDQ}			25	µA	PD=V_{DD}
Power Consumption		P_O		15	35	mW	f=3.579 MHz; V_{DD}=5.0V
Low Level Input Voltage		V_{IL}			1.5	V	V_{DD}=5.0V
High Level Input Voltage		V_{IH}	3.5			V	V_{DD}=5.0V
Input Leakage Current		I_{IH}/L_{IL}		0.1		µA	$V_{IN} = V_{SS} = V_{DD}$ (Note 1)
Pull Up (Source) Current on TOE		I_{so}		6.5	20	µA	TOE=0V, V_{DD}=5.0V
Input Impedance, (IN+, IN-)		R_{IN}	8	10		MΩ	@ 1KHz
Steering Threshold Voltage		V_{Tst}	2.2		2.5	V	V_{DD} = 5.0V
Low Level Output Voltage		V_{OL}			0.03	V	V_{DD} = 5.0V, No Load
High Level Output Voltage		V_{OH}	4.97			V	V_{DD} = 5.0V, No Load
Output Low (Sink) Current		I_{OL}	1.0	2.5		mA	V_{OUT} = 0.4V
Output High (Source) Current		I_{OH}	0.4	0.8		mA	V_{OUT} = 4.6V
Output Voltage	V_{REF}	V_{REF}	2.4		2.7	V	V_{DD} = 5.0V, No Load
Output Resistance	V_{REF}	R_{OR}		10		KΩ	

Operating Characteristics: All voltages referenced to V_{SS}, V_{DD} = 5.0V ± 5%, T_A = -40°C to +85°C unless otherwise noted.

Gain Setting Amplifier

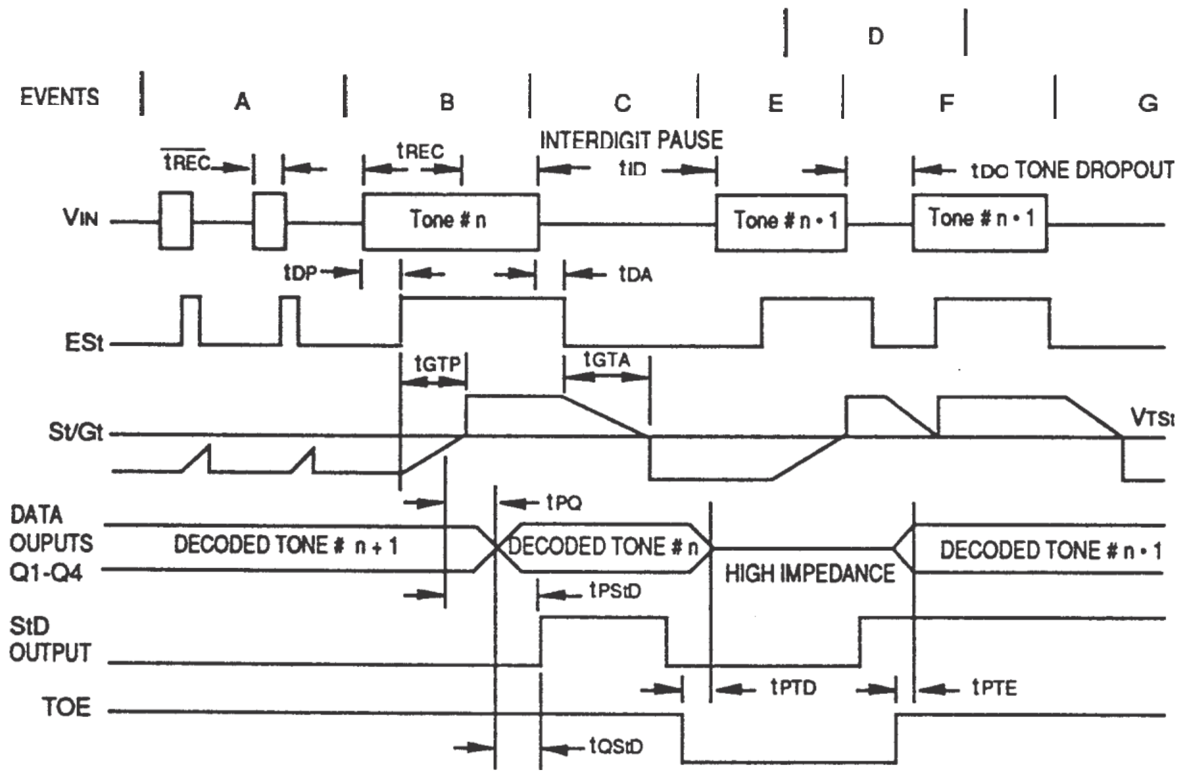
OPERATING CHARACTERISTICS						
Parameter	**Symbol**	**Min**	**Typ**	**Max**	**Units**	**Test Conditions**
Input Leakage Current	I_{IN}			±100	nA	$V_{SS} < V_{IN} < V_{DD}$
Input Resistance	R_{IN}	10			MΩ	
Input Offset Voltage	V_{OS}			±25	mV	
Power Supply Rejection	PSRR	50			dB	1KHz (Note 12)
Common Mode Rejection	CMRR	40			dB	-3.0V < VI_N < 3.0V
DC Open Loop Voltage Gain	A_{VOL}	32			dB	
Open Loop Unity Gain Bandwidth	fc	0.3			MHz	
Output Voltage Swing	V_O	4.0			V_{P-P}	$R_L \geq$ 100KW to V_{SS}
Maximum Capacitive Load (GS)	C_L			100	pF	
Maximum Resistive Load (GS)	R_L			50	KΩ	
Common Mode Range (No Load)	Vcm	2.5			V_{P-P}	No Load

AC Characteristics: All voltages referenced to V_{SS}, V_{DD}=5.0V ±5%, T_A=-40°C to +85°C, f_{CLK}=3.579545 MHz using test circuit (Fig. 1) unless otherwise noted.

AC CHARACTERISTICS							
Parameter		**Symbol**	**Min**	**Typ**	**Max**	**Units**	**Notes**
Valid Input Signal Levels (each tone of composite signal)			-29		+1	dBm	1,2,3,4,5,8
			27.5		869	mV_{RMS}	
Positive Twist Accept					10	dB	2,3,4,8
Negative Twist Accept					10	dB	
Freq. Deviation Accept Limit					1.5%±2Hz	Nom.	2,3,5,8,10
Freq. Deviation Reject Limit			±3.5%			Nom.	2,3,5
Third Tone Tolerance				-16		dB	2,3,4,5,8,9,13,14
Noise Tolerance				-12		dB	2,3,4,5,6,8,9
Dial Tone Tolerance				+22		dB	2,3,4,5,7,8,9
Tone Present Detection Time		t_{DP}	5	8	14	mS	Refer to Timing Diagram
Tone Absent Detection Time		t_{DA}	0.5	3	8.5	mS	
Min Tone Duration Accept		t_{REC}			40	mS	(User Adjustable) Times shown are obtained with circuit in Fig. 1)
Max Tone Duration Reject		t_{REC}	20			mS	
Min. Interdigit Pause Accept		t_{ID}			40	mS	
Max. Interdigit Pause Reject		t_{DO}	20			µS	
Propagation Delay (St to Q)		t_{PQ}		6	11	µS	TOE = V_{DD}
Propagation Delay (St to StD)		$t_{PS}t_D$		9	16	µS	
Output Data Set Up (Q to StD)		$t_{QS}t_D$		3.4		µS	
Propagation Delay (TOE to Q)	Enable	t_{PTE}		50		nS	R_L = 10KΩ C_L = 50pF
	Disable	t_{PTD}		300		nS	
Crystal/Clock Frequency		f_{CLK}	3.5759	3.5795	3.5831	MHz	
Clock Output (OSC 2)	Capacitive Load	C_{LO}			30	pF	

Notes:
1. dBm = decibels above or below a reference power of 1 mW into a 600 ohm load.
2. Digit sequence consists of all 16 DTMF tones.
3. Tone duration = 40mS. Tone pause = 40 mS.
4. Nominal DTMF frequencies are used.
5. Both tones in the composite signal have an equal amplitude.
6. Bandwidth limited (0 to 3 KHz) Gaussian Noise.
7. The precise dial tone frequencies are (350 Hz and 440 Hz) ±2%.
8. For an error rate of better than 1 in 10,000
9. Referenced to lowest level frequency component in DTMF signal.
10. Minimum signal acceptance level is measured with specified maximum frequency deviation.
11. Input pins defined as IN+, IN-, and TOE.
12. External voltage source used to bias V_{REF}.
13. This parameter also applies to a third tone injected onto the power supply.
14. Referenced to Figure 1. Input DTMF tone level at -28 dBm.

Timing Diagram



Explanation of Events

A) Tone bursts detected, tone duration invalid, outputs not updated.
B) Tone #n detected, tone duration valid, tone decoded and latched in outputs.
C) End of tone #n detected, tone absent duration valid, outputs remain latched until next valid tone.
D) Outputs switched to high impedance state.
E) Tone #n + 1 detected, tone duration valid, tone decoded and latched in outputs (currently high impedance).
F) Acceptable dropout of tone #n + 1, tone absent duration invalid, outputs remain latched.
G) End of tone #n + 1 detected, tone absent duration valid, outputs remain latched until next valid tone.

Explanation of Symbols

V_{IN} DTMF composite input signal.
ESt Early Steering Output. Indicates detection of valid tone frequencies.
St/GT Steering input/guard time output. Drives external RC timing circuit.
Q1-Q4 4-bit decoded tone output.
StD Delayed Steering Output. Indicates that valid frequencies have been present/absent for the required guard time, thus constituting a valid signal.
TOE Tone Output Enable (input). A low level shifts Q1-Q4 to its high impedance state.
t_{REC} Maximum DTMF signal duration not detected as valid.
t_{REC} Minimum DTMF signal duration required for valid recognition.
t_{ID} Minimum time between valid DTMF signals.
t_{DO} Maximum allowable drop-out during valid DTMF signal.
t_{DP} Time to detect the presence of valid DTMF signals.
t_{DA} Time to detect the absence of valid DTMF signals.
t_{GTP} Guard time, tone present.
t_{GTA} Guard time, tone absent.

Functional Description

The CAMD CM8870/70C DTMF Integrated Receiver provides the design engineer with not only low power consumption, but high performance in a small 18-pin DIP, SOIC, or 20-pin PLCC package configuration. The CM8870/70C's internal architecture consists of a bandsplit filter section which separates the high and low tones of the received pair, followed by a digital decode (counting) section which verifies both the frequency and duration of the received tones before passing the resultant 4-bit code to the output bus.

Filter Section

Separation of the low-group and high-group tones is achieved by applying the dual-tone signal to the inputs of two 9th-order switched capacitor bandpass filters. The bandwidths of these filters correspond to the bands enclosing the low-group and high-group tones (See Figure 3). The filter section also incorporates notches at 350 Hz and 440 Hz which provides excellent dial tone rejection. Each filter output is followed by a single order switched capacitor section which smooths the signals prior to limiting. Signal limiting is performed by high-gain comparators. These comparators are provided with a hysteresis to prevent detection of unwanted low-level signals and noise. The outputs of the comparators provide full-rail logic swings at the frequencies of the incoming tones.

Decoder Section

The CM8870/70C decoder uses a digital counting technique to determine the frequencies of the limited tones and to verify that these tones correspond to standard DTMF frequencies. A complex averaging algorithm is used to protect against tone simulation by extraneous signals (such as voice) while providing tolerance to small frequency variations. The averaging algorithm has been developed to ensure an optimum combination of immunity to "talk-off" and tolerance to the presence of interfering signals (third tones) and noise. When the detector recognizes the simultaneous presence of two valid tones (known as "signal condition"), it raises the "Early Steering" flag (ESt). Any subsequent loss of signal condition will cause ESt to fall.

Steering Circuit

Before the registration of a decoded tone pair, the receiver checks for a valid signal duration (referred to as "character-recognition-condition"). This check is performed by an external RC time constant driven by E_{St}. A logic high on ESt causes V_C (See Figure 4) to rise as the capacitor discharges. Providing signal condition is maintained (ESt remains high) for the validation period (t_{GTP}), V_C reaches the threshold (V_{TSI}) of the steering logic to register the tone pair, thus latching its corresponding 4-bit code (See Figure 2) into the output latch. At this point, the GT output is activated and drives VC to V_{DD}. GT continues to drive high as long as ESt remains high, signaling that a received tone pair has been registered. The contents of the output latch are made available on the 4-bit output bus by raising the three-state control input (TOE) to a logic high. The steering circuit works in reverse to validate the interdigit pause between signals. Thus, as well as rejecting signals too short to be considered valid, the receiver will tolerate signal interruptions (drop outs) too short to be considered a valid pause. This capability together with the capability of selecting the steering time constants externally, allows the designer to tailor performance to meet a wide variety of system requirements.

Guard Time Adjustment

In situations which do not require independent selection of receive and pause, the simple steering circuit of Figure 4 is applicable. Component values are chosen according to the following formula:

$t_{REC} = t_{DP} + t_{GTP}$

t_{GTP} » 0.67 RC

The value of t_{DP} is a parameter of the device and t_{REC} is the minimum signal duration to be recognized by the receiver. A value for C of 0.1 uF is recommended for most applications, leaving R to be selected by the designer. For example, a suitable value of R for a t_{REC} of 40 milliseconds would be 300K. A typical circuit using this steering configuration is shown in Figure 1. The timing requirements for most telecommunication applications are satisfied with this circuit. Different steering arrangements may be used to select independently the guardtimes for tone-present (t_{GTP}) and tone absent (t_{GTA}). This may be necessary to meet system specifications which place both accept and reject limits on both tone duration and interdigit pause.

Guard time adjustment also allows the designer to tailor system parameters such as talk-off and noise immunity. Increasing t_{REC} improves talk-off performance, since it reduces the probability that tones simulated by speech will maintain signal condition for long enough to be registered. On the other hand, a relatively short t_{REC} with a long t_{DO} would be appropriate for extremely noisy environments where fast acquisition time and immunity to drop-outs would be requirements. Design information for guard time adjustment is shown in Figure 5.

Input Configuration

The input arrangement of the CM8870/70C provides a differential input operational amplifier as well as a bias source (V_{REF}) which is used to bias the inputs at mid-rail.

Provision is made for connection of a feedback resistor to the op-amp output (GS) for adjustment of gain.

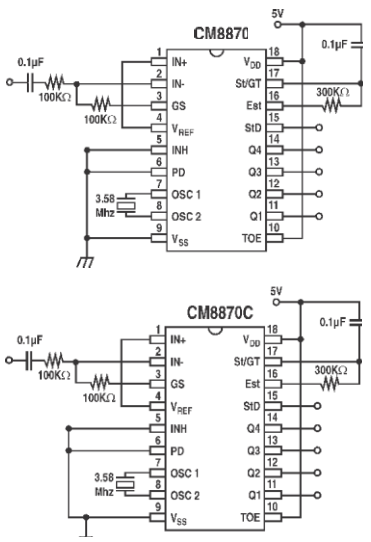
In a single-ended configuration, the input pins are connected as shown in Figure 1, with the op-amp connected for unity gain and VREF biasing the input at ½ V_{DD}. Figure 6 shows the differential configuration, which permits the adjustment of gain with the feedback resistor R5.

Clock Circuit

The internal clock circuit is completed with the addition of a standard television color burst crystal or ceramic resonator having a resonant frequency of 3.579545 MHz. The CM8870C in a PLCC package has a buffered oscillator output (OSC3) that can be used to drive clock inputs of other devices such as a microprocessor or other CM887X's as shown in Figure 7. Multiple CM8870/70Cs can be connected as shown in figure 8 such that only one crystal or resonator is required.

Pin Function Table

PIN FUNCTION		
Name	**Description**	
IN+	Non-inverting Input	Connection to the front-end differential amplifier
IN-	Inverting Input	
GS	Gain Select	Gives access to output of front-end differential amplifier for connection of feedback resistor.
V_{REF}	Reference voltage output (nominally $V_{DD}/2$). May be used to bias the inputs at mid-rail.	
INH	Inhibits detection of tones represents keys A, B, C, and D	
OSC3	Digital buffered oscillator output.	
PD	Power Down	Logic high powers down the device and inhibits the oscillator.
OSC1	Clock Input	3.579545 MHz crystal connected between these pins completes internal oscillator.
OSC2	Clock Output	
V_{SS}	Negative power supply (normally connected to OV).	
TOE	Three-state output enable (input). Logic high enables the outputs Q_1-Q_4. Internal pull-up.	
Q_1 Q_2 Q_3 Q_4	Three-state outputs. When enabled by TOE, provides the code corresponding to the last valid tone pair received. (See Fig. 2).	
StD	Delayed steering output. Presents a logic high when a received tone pair has been registered and the output latch is updated. Returns to logic low when the voltage on St/GT falls below V_{TSt}.	
ESt	Early steering output. Presents a logic high immediately when the digital algorithm detects a recognizable tone pair (signal condition). Any momentary loss of signal condition will cause ESt to retum to a logic low.	
St/Gt	Steering input/guard time output (bidirectional). A voltage greater than V_{TSt} detected a St causes the device to register the detected tone pair. The GT output acts to reset the external steering time constant, and its state is a function of ESt and the voltage on St. (See Fig. 2)	
V_{DD}	Positive power supply.	
IC	Internal Connection.	Must be tied to V_{SS} (for 8870 configuration only)



All resistors are ±1%tolerance.
All capacitors are ±5% tolerance.

F_{LOW}	F_{HIGH}	KEY	TOW	Q_4	Q_3	Q_2	Q_1
697	1209	1	H	0	0	0	1
697	1336	2	H	0	0	1	0
697	1477	3	H	0	0	1	1
770	1209	4	H	0	1	0	0
770	1336	5	H	0	1	0	1
770	1477	6	H	0	1	1	0
852	1209	7	H	0	1	1	1
852	1336	8	H	1	0	0	0
852	1477	9	H	1	0	0	1
941	1209	0	H	1	0	1	0
941	1336	·	H	1	0	1	1
941	1477	#	H	1	1	0	0
697	1633	A	H	1	1	0	1
770	1633	B	H	1	1	1	0
852	1633	C	H	1	1	1	1
941	1633	D	H	0	0	0	0
-	-	ANY	L	Z	Z	Z	Z
L = logic Low, H = Logic High, Z = High Impedance							