DESIGN AND CONSTRUCTION OF A GSM BASED HOME APPLIANCE CONTROL SYSTEM

BY

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DEDICATION

This work is dedicated to God Almighty, and to my parents, Mr. and Mrs. E.O. Olawepo

DECLARATION

I, Olawepo Taye Peter, declare that this work was done by me under the supervision of Mr. Nwozor Obinna, and has never been presented elsewhere for the award of a degree. I hereby relinquish the copyright to the Federal University of Technology, Minna.

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ABSTRACT

This project presents a new method which enables users to control their home appliances and systems from remote using a cell phone based interface. It is designed to make home automation easy to control when a user is not at home. To access the control unit, the user should send an authentication code (DTMF) along with the required action to the home control system via Global System for Mobile communication (GSM). This authentication code is such that can be changed from time to time if the need arises. Upon being properly authenticated, the cell phone-based interface at home (control unit) would relay the commands to a microcontroller that would perform the required function/action, and return a function completion confirmation that would be sent to the source of the original command (user's cell phone) in the form of a beep (twice); and if for whatever reason, the action is not executed, a confirmation is also sent to the user in the form of a single beep. The system is wireless therefore more adaptable and cost-effective.

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CHAPTER ONE

INTRODUCTION

The concept of "automation" has existed for many years. It began with a student who connected two electric wires to the hands of an alarm clock to close a circuit of a battery and light bulb. Later, companies developed automated systems of their own to control alarms, sensors, actuators and video cameras. As an answer to the increasing effect of the information technology, people's expectations in their life fields are developing. People want their houses to make their lives easier, answer their necessities, and offer more safety, more comfortable and more economical life. The adaptation of control systems used in industry field to life field created home technology concept. The system design is a form of the home technology according to personal necessities and wishes. This form of automation using the GSM is referred to as Home Appliance Control System (HACS).

A strong reason why HACS are becoming popular is because there are plenty of attractive features that can easily lure companies to enter quickly this emerging market, also they represent a great research opportunity in creating new fields in engineering, architecture and computing **[1]**. However, these new technologies are still in their early stages with a lack of robust standards and system compatibility. Another problem is that these systems are not always fully accepted by final users, especially the old and disabled – arguably the ones that need them most. It is the goal of researchers to find out how to introduce home automation into our lives so as to affect us positively.

The home appliance control system is a form of home control which employs various means of remote access to appliances, such as the internet, bluetooth, infrared, and so on. In the case of this project, it employs the use of one of the features of the GSM technology, i.e. dialling. Imagine the possibility of building or designing a home system to suite one's own very need, thereby making life very attractive and comfortable. For instance, this project looks into the design of a system that can help control an appliance in the home, say air-conditioner, from anywhere outside the home.

1.1 AIMS OF THE PROJECT

The aim of this project work is to present a cost effective solution that will provide controlling of home appliances remotely, thereby adding greater flexibility to switching functions. In addition there was a need to automate home so that user can take advantage of the technological advancement in such a way that best suites him.

The main objective of the project is to implement the design of a home appliance control systems (HACS) that will be controlled using the GSM technology. It serves so many purpose, some of which are listed below.

First, it helps combat the problem of personal dissatisfaction and discomfort. This is such that the user on a sunny day is able to switch on the airconditioner while still a long way off, to cool the home before getting there, to ensure that as soon as he enters, he is very much relaxed and satisfied with the cool atmosphere, making him comfortable and enabling him to quickly settle in to do some other things.

Secondly, the issue of fire accident and electric shock is to a large extent prevented. In the case of fire, it affords the user the opportunity to switch off the appliance when he forgets to do so before leaving home, thus, preventing the appliance from overheating due to overly long working hours which could lead to a fire outbreak. At times, electric faults could arise in home, and the easiest way to detect this is by possible shock from the appliances, especially when there is current leakage. With this system, one does not manually need to frequently switch on/off the appliances, and thus reducing the risk of being electrocuted.

Also, it reduces the stress of going to the access point of the appliance always, to be able to control such appliance. Then, the lesser the frequency of the manual operation and physical contact with the device, the longer its lifespan.

1.2 OBJECTIVES

The objectives are as follows;

1. To build a control system that can be used to control home appliances using the dialing feature of GSM technology.
2. To analyze and develop the instruction codes utilized by the interface to interact with the device using a high-level programming language.
3. To connect the phone with a microcontroller and programming it with necessary condition.

1.3 METHODOLOGY

The system is made up of both the hardware and software(microcontroller program) subsystems. The circuit was implemented with the help of of some major components like the ac mains supply, rectifier, microcontroller, modem(GSM phone), voltage comparator, DTMF Decoder IC, external memory, relay, and transistor.

The whole circuit connection was done on a veroboard. The power supply is built with the help of a cable which carries the mains supply of 230V, which is stepped down to 12V by a 230-12V transformer. This output voltage is then rectified by a bridge rectifier, made up of four IN4001 diodes, connected to the transformer output terminal; and also filtered by a filter capacitor connected to clear ripples present, and further regulated by a voltage regulator IC(LM7805).

The preset buttons and the LEDs were also connected to the microcontroller which gives the signal for indication by the LEDs and works on the command from the buttons.

The microcontroller, voltage comparator, DTMF Decoder IC, external memory and some other components were then mounted on the board and their pins connected with the help of the IC sockets; and the transistor and relay connected to dedicated pins of the microcontroller to perform the switching operation as shown in the circuit diagram.

Also, the GSM phone is connected to the circuit with the help of a headset which serves as an interface for the system.

Both the software and hardware components were then integrated to produce a wholly functional system with the various components and the whole system tested to evaluate its functionality and workability. After all the steps listed above steps have been carried out, the system would be implemented.

1.4 SCOPE OF THE PROJECT

The scope of this project covers largely the remote accessibility and management of various and as much home appliances and/or devices such as heater, light, air conditioner, microwave, television, and so on. The system has as the control unit, the AT89S52 microcontroller produced by ATMEL Corporation. This project is limited in scope to the control of an appliance, an airconditioner in the home. The system allows for the provision of security such that it will take no action against the instructions received from unauthorized number. The required task is performed only when the pre-configured number instructs the system. The ease of deployment is due to wireless mode of communication. GSM technology provides the benefit that the system is accessible in remote areas as well.

CHAPTER TWO

LITERATURE REVIEW

Home control system provides an increased control of household appliances and features in residential dwellings, particularly through electronic means that allow for things impracticable, overly expensive or simply not possible in recent past decade **[2]**. It refers to industrial uses of similar technology, particularly the automatic or semi-automatic control of lighting, doors and windows, heating, ventilation and air conditioning, and security and surveillance systems.

With the invention of the electronic microcontroller and the widespread deployment of digital communication technology, the cost of electronic control fell rapidly and reliability improved. Remote and intelligent control technologies were adopted by the building services industry and appliance manufacturers worldwide, as they offer the end user easily accessible and/or greater control of their products.

The internet at some later time was also employed in switching, especially remotely. Due to the problem of uneasy access to the internet in some places, the use of GSM which is readily available to almost anyone is now the order of the day, and is employed in switching processes like in home appliances.

Remote controlling through GSM is employed today for various functions such as monitoring and controlling of home appliances and security systems. It is therefore possible to remotely access and manage home appliances from anywhere, either close or far-off using GSM.

2.1 HISTORICAL BACKGROUND

One of the earliest examples of remote control was developed and patented in 1898 by Nikola Tesla, a system for controlling moving vessels and vehicles. In 1898, he demonstrated a radio-controlled boat which he called "teleautomaton" [3].

In 1903, Leonardo Torres Quevedo presented the Telekino at the Paris Academy of Science, which consisted of a robot that executed commands transmitted by electromagnetic waves. It constituted the world's first apparatus for radio control and was a pioneer in the field of remote control. In 1906, Torres successfully demonstrated the invention in the port of Bilbao, guiding a boat from the shore. Later, he would try to apply the Telekino to projectiles and torpedoes, but had to abandon the project for lack of financing.

The first machines to be operated by remote control were used mainly for military purposes. A Radio-controlled motorboat, developed by the German Navy, was used to crash enemy ships in WWI and was worked intensively during the Second World War, one result of this being the German Wasserfall missile.

By the late 1930s, several radio manufacturers offered remote controls for some of their higher-end models. Most of these were connected to the set being controlled by wires, but the Philco Mystery Control (1939) was a battery-operated low-frequency radio transmitter, thus making it the first wireless remote control for a consumer electronics device.

Zenith Radio Corporation developed the first remote intended to control a television in 1950. The remote, called "Lazy Bones", was connected to the television by a wire. A wireless remote control, the "Flashmatic", was developed in 1955, it worked by shining a beam of light onto a photoelectric cell, but the cell did not distinguish between light from the remote and light from other sources. The Flashmatic also had to be pointed very precisely at the receiver in order to work.

The early teletext sets were controlled using wired remote to select pages, but its continuous use made it necessary for teletext to quickly provide a wireless remote. By 1978, a remote which could control more functions was prototyped after talks between some television manufacturers and BBC engineers. ITT was one of the companies, which later gave its name to be ITT protocol of infrared communication.

In 1980, CL-9 was established by Steve Wozniak of Apple, to manufacture a remote control that could operate multiple electronic devices. The CORE unit (Controller of Remote Equipment) was introduced in 1987 with the advantage that it could "learn" remote signals from different devices. It had the ability to perform specific or multiple functions at various times with its built-in clock. It was the first remote control that could be linked to a computer and loaded with updated software code as needed, but was much too cumbersome for the average user to program [4].

In the late 2000s-early 2010s, a number of smartphone and portable media player platforms were provided with installable software applications which allow for the remote controlling of media centres and media players on home theater PCs and general-purpose personal computers over Wi-Fi, such as iTunes Remote on iOS. In comparison to the user interfaces of physically buttoned dedicated remote control devices, the user interfaces of these remote control applications are designed to take advantage of the dynamic graphics offered by usually touchscreened handheld devices, making for larger virtual buttons and virtual keyboards **[5]**.

2.2 THEORETICAL BACKGROUND

GSM based Home Appliance Control System uses GSM network technology for multiple access and control of home appliances. In this system we developed the overall method in a way that the targeted device can be controlled by sending DTMF [6] (dual tone multi frequency) from the user's mobile.

There is a control unit/module which is able to connect to the cellular network automatically, to receive DTMF [7] and to decode for password identification and instructions which is sent to the microcontroller. The microcontroller [8] within the control unit will issue the command to the electrical appliances through a simple control circuit.

Here, a cell phone is connected in the control unit via headset, such that when a call is made the cell phone in the control unit is auto answered. Then password is being inputted. These DTMF is decoded with the help of a dedicated decoder IC, CM8870. Then a decoded output will be sent to the microcontroller, to issue the desired command to control devices connected to it. Device switching is performed by relay.

2.2.1 DTMF Generation and Decoding

DTMF is short for Dual Tone Multi frequency, and is used by touch-tone telephones. DTMF assigns a specific frequency (consisting of two separate tones) to each key so that it can easily be identified by a microprocessor.

DTMF generation is a composite audio signal of two tones between the frequency of 697Hz and 1633Hz [9]. The DTMF keypad is arranged such that each row will have its own unique tone frequency and also each column will have its own unique tone. The tone frequencies were selected such that harmonics and intermodulation products will not cause an unreliable signal. Each tone must fall within the proper bandpass before a valid decoding will take place. If one tone falls outside the bandpass spectrum, the decoder will become unreliable or not operate at all.

The purpose of DTMF decoding is to detect sinusoidal signals in the presence of noise. In many cases, the DTMF decoder IC interfaces with a microcontroller. Here it is logical that the microcontroller should not be used to decode the sinusoids, because the typical microcontroller based decoder requires an A/D converter. In addition, the signal processing associated with the decoding is usually beyond the scope of the microcontroller's capabilities. So the designer is forced to use the dedicated IC or upgrade the microcontroller to perhaps a more costly digital signal processor [10].

2.2.2 Description of Components.

i. Transistor

A transistor is a device that consists of three regions namely collector, emitter and base of semiconductor material. There are two basic forms of transistor, the bipolar family and the field-effect family, and both appear in ICs.

Considering the bipolar transistor, of which there are two types, n-p-n and p-n-p electrically they differ only in terms of current direction and voltage polarity. Figure 2.3 shown below (a) illustrates the idealized structure of an n-p-n transistor, and diagram (b) implies that it corresponds to a pair of diodes with three leads. This representation does not convey sufficient information about the actual operation of the transistor, but it does make the point that the flow of conventional current (positive to negative) is easy from the base to the emitter, since it passes through a forward-biased diode, but difficult from the collector to the base, because flow is prevented by a reverse biased diode. Figure 2.3(c) gives the standard symbol for the n-p-n transistor, and diagram (d) defines the direction of current flow and the voltage polarities observed when the device is in operation. Finally, diagram (e) shows that for the p-n-p transistor, all these directions are reversed and the polarities are inverted. For a transistor, there is a main current flow between the collector and the emitter, and a very much smaller current flow between the base and the emitter. So, the following relations may be written:

$$I_E = I_C + I_B$$

(Note that the arrow on the transistor symbol defines the emitter and the direction of current flow out for the n-p-n device, and in for the p-n-p.) Also

$$I_C / I_B = h_{FE}$$

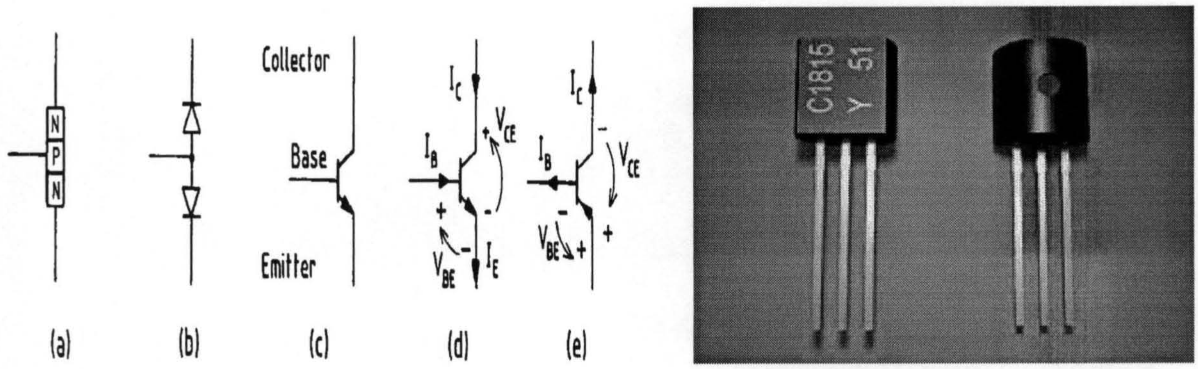


Figure 2.1: The bipolar transistor. (a) To (d) n-p-n transistor; (e) p-n-p transistor; & pictorial diagram

ii. Resistor

A resistor is a very simple but basic electronic component designed to do exactly what the Ohms law is about, produce a voltage drop between its terminals (commonly just two). Resistors are used as parts in electronic circuits they are extremely common in most electronic designs and circuits resistors can be made of various compounds and films, as well as wire as you can imagine there are many categories of resistors in the market depending on your needs such as carbon film resistors, metal film resistors, variable resistors (potentiometer), power resistors, wire wound resistors etc. When you want to use resistors in a circuit you need to know the primary characteristics which are their resistance (Ohms) and the power (Watt) they can dissipate.

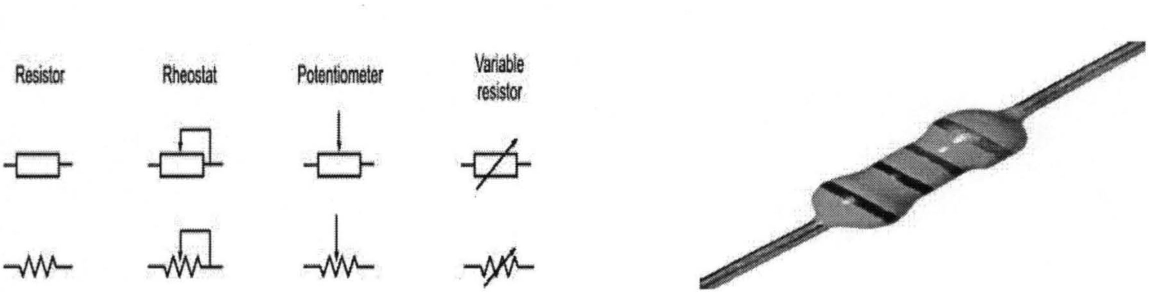


Figure 2.2: Electrical Symbols of Different Kinds of Resistor & Pictorial Diagram

iii. Capacitor

A capacitor or condenser is a passive electronic component consisting of a pair of conductors separated by a dielectric. When a voltage potential difference exists between the conductors, an electric field is present in the dielectric this field stores energy and produces a mechanical force between the plates. The effect is greatest between wide, flat, parallel, narrowly separated conductors. An ideal capacitor is characterized by a single constant value capacitance which is measured in farads. This is the ratio of the electric charge on each conductor to the potential difference between them. In practice, the dielectric between plates passes a small amount of leakage current the conductors and leads introduce an equivalent series resistance and the dielectric has an electric field strength limit resulting in a breakdown voltage.

Capacitors are widely used in electronic circuits to block the flow of direct current while allowing alternating current to pass, to filter out interference, to smooth the output of power supplies, and for many other purposes. They are used in resonant circuits in radio frequency equipment to select particular frequencies from a signal with many frequencies.

And also there are different type of capacitors namely mica, ceramics, tantalum, electrolytic, polyester, polystyrene and variable capacitors, some are polarized and some non-polarized.

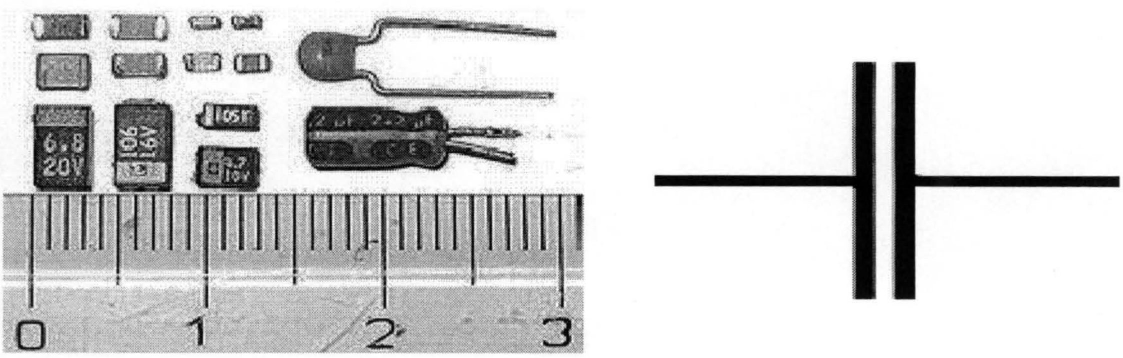


Figure 2.3: Different Type of Capacitors & the Symbol.

iv. Light Emitting Diode

This is a semiconductor device that converts electrical energy efficiently into visible light by electro-luminescence at a forward-biased p-n junction and it is also known as solid state lamp, such a junction may be produced with p-type and n-type compounds of gallium arsenide.

LEDs in transparent cases are used in displays and indicators while infrared emitting LEDs are used; in remote controls and optical communication systems. The symbol for an LED is shown in figure 2.6 below with two arrows indicating emitted light.

Fig. 2.4 Symbolic & Pictorial Diagram of an LED

v. Relay

A relay is used to isolate one electrical circuit from another. It allows a low current control circuit to make or break an electrically isolated high current circuit path. In this project, it acts as a switch between the microcontroller and a device. The relay is used as the electromechanical device. Designs of time-delay relays use electronic circuits with resistor-capacitor (RC) networks to generate a time delay, and then energize a normal (instantaneous) electromechanical relay coil with the electronic circuit's output. The electronic-timer relays are more versatile than the older, mechanical models, and are less prone to failure. Many models provide advanced timer features such as "one-shot" (one measured output pulse for every transition of the input from de-energized to energized), "recycle"(repeated on/o output cycles for as long as the input connection is energized) and "watchdog" (changes state if the input signal does not repeatedly cycle on and on).

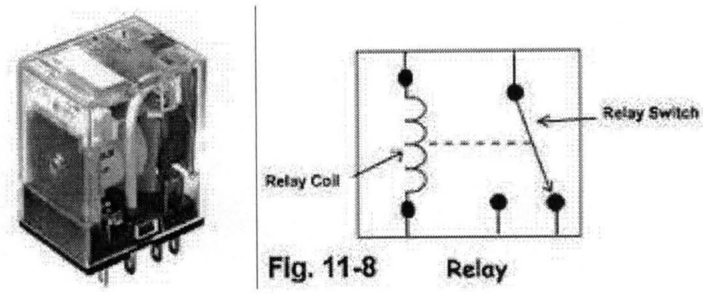


Fig 2.5: Relay Diagram & Symbol

vi. Crystal Oscillator

This is an electronic component that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with the required frequency. This frequency is used for keeping track of time, in order to provide a stable clock signal for the microcontroller.

Fig 2.6: Crystal Oscillator Diagram & Symbol

vii. Transformer

Transformer is an inductively coupled circuit used for transmitting alternating current energy. It consists of a primary winding, one or more secondary winding and a soft iron magnetic core. When an alternative current passes through the primary winding, electromagnetic field is produced and when these field lines are couple to the secondary winding an AC voltage is induced in the secondary. This induced voltage is a function of the turn's ration, defined as the ratio of the secondary to the primary. The induced voltage is directly proportional to the number of the turn in each winding, frequency of the AC supply and the magnetic flux linking the windings.

- Transformer Voltage Relationship

Since the mutual flux in the core of any transformer interlinks the turns of primary and secondary windings, any change in flux result to production of induced e.m.f. or voltage in secondary winding. In assumption that the secondary winding has half turns of the primary winding then, the total secondary voltage will be half of the induced impressed primary voltage. Also, when the secondary winding is twice the primary windings the total induced secondary voltage will be twice of impressed primary voltage.

It can be concluded that the induced voltage in the winding is always directly proportional to the number of turns in the winding i.e.

$$E_p/E_s = N_p/N_s$$

Where, N_p = Number of primary turns

N_s = Number of secondary turns

E_p = Primary voltage

E_s = Secondary voltage

- Transformer Current Relationship

The modern transformer is highly efficient device; in fact, some large iron core transformers have an efficient exceeding 99%. This means that almost all the power taken out of the transformer is being put into it. For analytical purposes, we may assume that the transformer has an efficiency of 100%. If the efficiency is 100%, then the primary and secondary power factors are equal. Power input to the transformer is given by EpIp x Power factor (p.f). Since input and output power are equal.

$$E_p \times I_p \times PF = E_s \times I_s \times PF$$

$$\frac{Ep \times P.F}{Es \times P.F} = \frac{Is}{Is}$$

Where, Ep = primary voltage

Es = secondary voltage

Ip = primary current

Is = secondary current

viii. Buzzer (Beeper)

This is a transducer which converts electrical energy to sound. It is an electronic signalling device consisting of a number of switches connected to the micro-controller, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound. This will be used to sound an alarm if a person enters a wrong password or when there is a bad voltage condition.

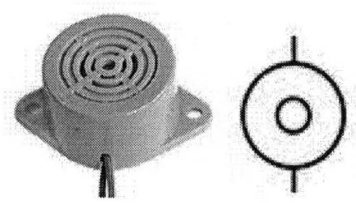


Fig 2.7: Buzzer Diagram & Symbol

2.3 GSM REMOTE CONTROL

The Global System for Mobile Communications (GSM) is a digital standard wireless technology; GSM is the most widely used wireless technology in the world today with over 2 billion customers globally, which represents 72% of all wireless customers. GSM has a high presence among users (almost everybody has a mobile) raising the probability of the remote controlled HACS to be accessible, furthermore by programming the GSM modem using specific commands, it provides another security layer (modem will respond only to specific mobiles) and certain robustness. Afterwards user is able to activate/deactivate some automated devices required to solve the issue either by dials or messaging. In another case, using a web interface, in any case the user will have always two possible accesses in case that one fails. Normally the probability of accessing the GSM network will be higher than accessing the internet.

2.4 RELATED AND PREVIOUS RESEARCH / PROJECTS

Several research works have been carried out on the HACS, some of which are designed taking different factors into consideration based on the problem statement of the designer, some of which are related to this project.

Delgado et al (2006) consider the problems with the implementation of home automation systems. Furthermore the possible solutions are devised through various network technologies as shown in figure 2.1. Several issues affecting home automation systems such as lack of robustness, remote controlling issues, compatibility issue and acceptability among the old and disabled people are discussed. In their paper, further consideration were given to the factors the designer must consider in designing the home automation systems for the categories of people mentioned so that they can feel the importance of the system to them [2]. The remote controlling issues identified are;

- Interoperability
- Scalability
- Security
- Limited services
- Usability
- Existence of multiple standard

Interoperability refers to the capability of devices of different types and from different manufacturers to communicate and cooperate. Scalability refers primarily to scalability in terms of geographical distance and location independence. In the context of offering remote access as a service, scalability in terms of capacity would also be an issue. Security is probably the most important issue among them and the hardest to deal with regarding the media used in wireless communications. Limited Service is due to bandwidth limitations of wireless networks as compared with other wired technologies which utilize almost all the available bandwidth.

Ciubotaru-Petrescu et al (2006) present a design and implementation of SMS based control for monitoring systems. The design has three modules involving sensing unit for monitoring the complex application, a processing unit that is microcontroller and a communication module that uses GPRS modem or cell phone via serial port RS-232. The SMS is used for status reporting such as power failure [11].

In their paper, Conte and Scaradozzi (2003) view home automation systems as M2M short for machine-to-machine, man-to-machine or mobile-to-machine and it is estimated to get an exponential growth in the coming years. M2M enables the flow of data between machines and machines and ultimately machines and people. Regardless of the type of machine or data, information usually flows from a machine over a network, and then through a gateway to a system where it can be processed and analyzed. In other words, M2M allows a machine or device to transmit or receive its data remotely over a network [12].

Furthermore, Alkar and Buhur (2005) propose an Internet Based Wireless Home Automation System for Multifunctional Devices. This paper proposes a low cost and flexible web-based solution but this system has some limitations such as the range and power failure [13]. Murthy (2008) explores primary health-care (PHC) management for the rural population. A solution proposes the use of the mobile web-technologies providing the PHC services to the rural population. The system involves the use of SMS and cell phone technology for information management, transactional exchange and personal communication [14].

Jawarkar et al (2008) propose remote monitoring through mobile phone involving the use of spoken commands. The spoken commands are generated and sent in the form of text SMS to the control system and then the microcontroller on the basis of SMS takes a decision of a particular task. A system is developed to remotely monitor process through spoken commands using mobile. Mel cepstrum features are extracted from spoken words. Learning Vector Quantization Neural Network is used for recognition of various words used in the command. The accuracy of spoken commands is about 98%. A text message is generated and sent to control system mobile in form of SMS. On receipt of SMS, control system mobile informs micro-controller based card, which performs specified task. The system alerts user in case of occurrence of any abnormal conditions like power failure, loss of control, etc [15].

Potamitis et al (2003) suggest the use of speech to interact remotely with the home appliances to perform a particular action on behalf of the user. The approach is inclined for people with disability to perform real-life operations at home by directing appliances through speech. Voice separation strategy is selected to take appropriate decision by speech recognition [16].

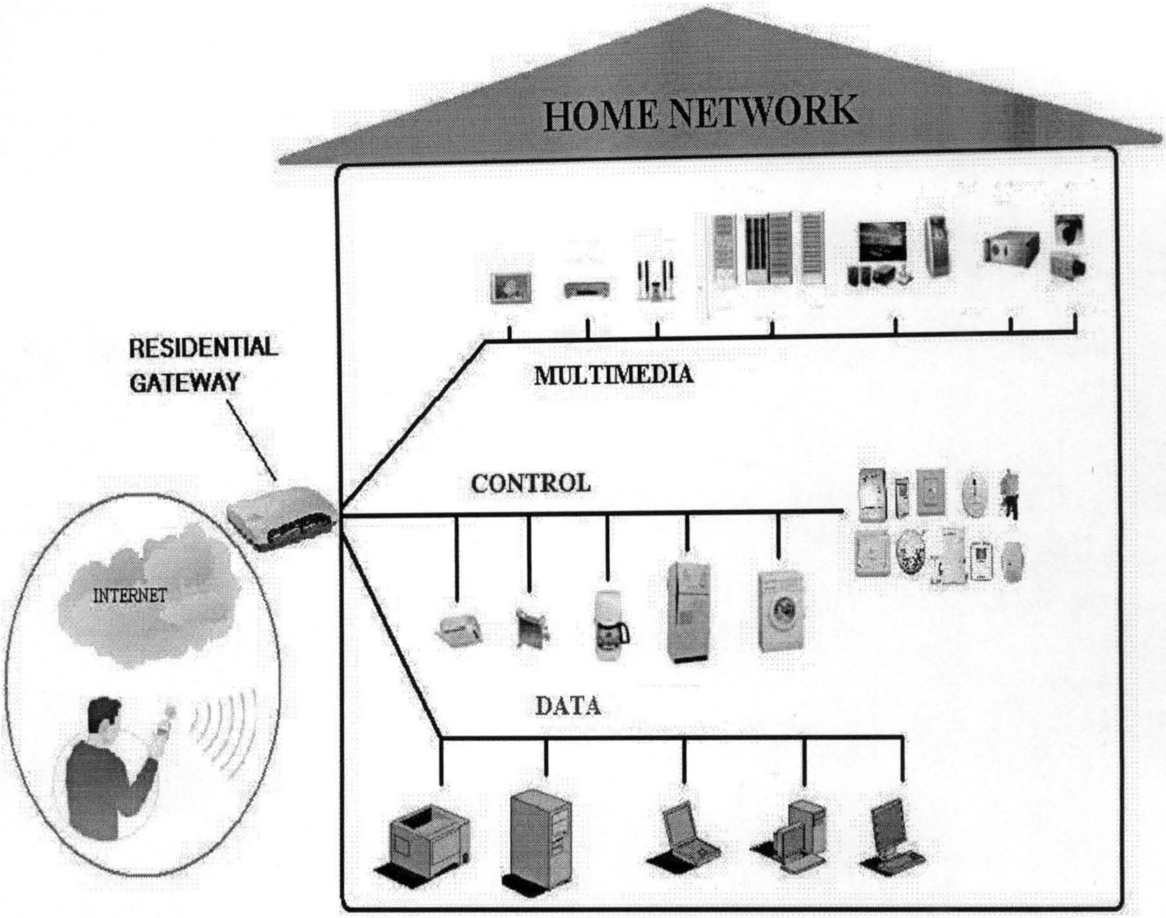


Figure 2.8: HACS with different Network Topologies

2.5 LIMITATIONS

1. It was discovered that the device will have limited use in areas that experience poor network and will not function in areas where it is not readily available.
2. The mobile phone to be used for connection to the programmed system must have been configured with the required instruction sequence.
3. Only devices with electrical controlling input ports will be possible targets for controlling.

CHAPTER THREE

DESIGN AND IMPLEMENTATION

This chapter consists of the procedures, techniques and methods used in carrying out the set objectives of the project. The aim of the project is to design and implement a Home Appliance Control System using GSM in which appliances such as bulbs, fans, electric cooker etc can be controlled through the means of communication between the phone and controller. Both the phone and microcontrollers have their importance in the realization of the project aim. The microcontroller and the phone to be used have their limitations. Microcontrollers are very good at communicating with smaller electronics devices.

3.1 DESIGN CONCEPT

This project is a Home Appliance Control System using GSM in which the programmable ATMEL microcontroller is utilized. This chapter gives a breakdown of the steps that were taken in order to achieve the highlighted objectives in chapter one and also a detailed description of the components and peripherals that were used in the design. A block diagram of the overall system design is shown in figure 3.1. The implementation of the project will involve two major sections which are:

i. The hardware module

ii. The software module.

The hardware module discusses the physical components that are involved in this design and its implementation, while the software module discusses the programme codes used in the design of the project.

3.2 HARDWARE MODULE

The hardware module comprises of the physical part of the design which can be seen. The hardware components contained in this project are listed below.

- A GSM Phone
- ATMEL microcontroller (AT89S52)
- DTMF Decoder IC (CM8870)
- Transformer (Step down 220/240-12v)
- Bridge Rectifier
- Capacitors
- 5volt Regulator (7805)
- Light Emitting Diode (LED)
- Transistor Switching Unit
- Crystal Oscillator (12MHz)
- Relays
- Transistors
- Comparators

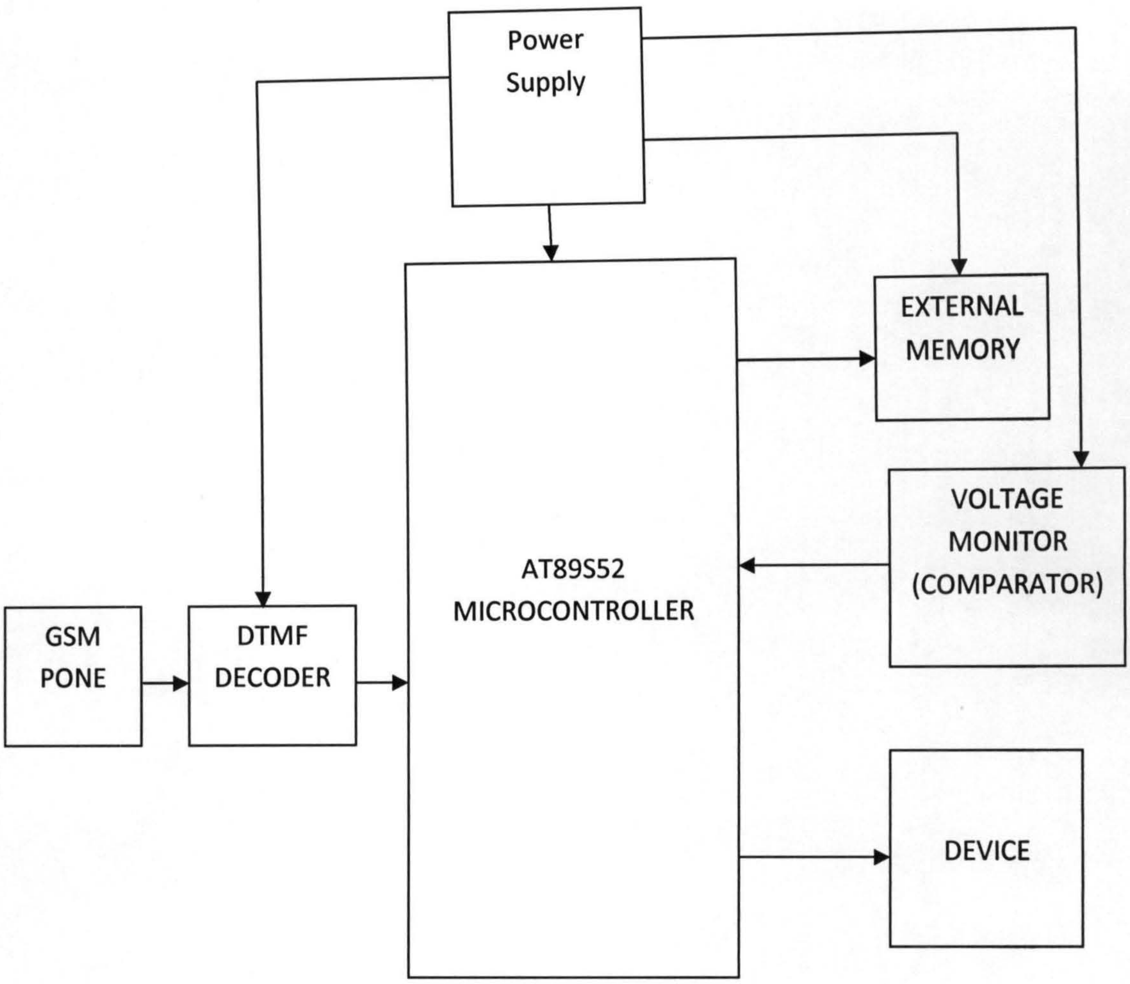


Figure 3.1: Block Diagram of the Home Appliance Control System

3.2.1 THE GSM PHONE

The GSM Modem is the link between the remote user and the entire device (therefore the home appliance). It provides a remote access to the appliance using the GSM as the medium in that it allows the possibility of sending command to the microcontroller. The GSM modem could be a modem that connects to the microcontroller or it could be a GSM mobile phone with the appropriate cable and software driver to connect to the microcontroller but either way, the work of the GSM modem is to allow for remote access control.

Figure 3.2: A GSM Phone

3.2.2 EXTERNAL CLOCK UNIT

The overall speed of the microcontroller operation is entirely dependent on the clock frequency, the higher the speed of the crystal oscillator, the faster the processing of data by the ATMEL. This is made up of a crystal oscillator with its end pin connected with OSC1 and OSC2 pins on the microcontroller and a pair of 22pF capacitors connected in parallel and its other end connected to ground. They ensure frequency stability of the generated pulse. Also, the overall power consumption of the microcontroller has a strong dependence on clock frequency, with high speed operation being much more power dependent than slow speed. Every microcontroller has a specified range for its clock.

3.2.3 THE POWER SUPPLY UNIT

The ATMEL system hardware components and relays are powered from a +5V dc and +12V dc fixed, regulated power supply. The power supply unit consists of the following components:

- 220/12V ac step down transformer
- Full wave bridge rectifier
- 7805 +5V dc regulator

- Electrolytic capacitor

From the ac mains supply, 220V gets to the transformer. This voltage being too high to power our device will need to be stepped down in order to give the right voltage required for powering the device without damaging any of the components. The 220V is stepped down to 12V and the bridge rectifier rectifies the ac to dc as shown in figure 3.3. Rectification is necessary for the purpose of converting AC to DC in order to supply power to the electronic apparatus. The rectifier converts alternating voltage into a pulsating but non alternating waveform and the capacitor smoothes out the pulsations, while the capacitors are responsible for filtering any ac trace coming out of the rectifying stage before it gets to the input of the regulator.

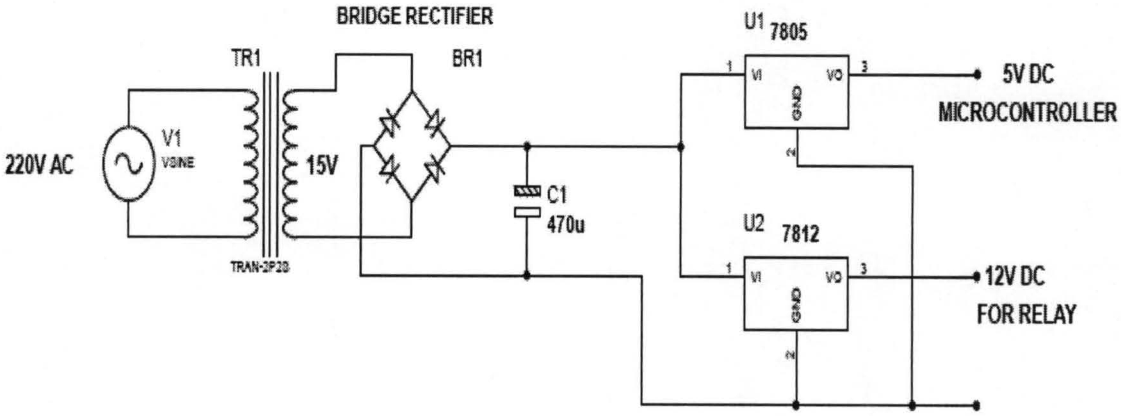


Figure 3.3: The Power Supply Circuit

There is a regulator in the circuit for regulating and maintaining a stable dc output. The regulator used is the 7805 model which provides +5V regulated dc for the transmitter and receiver module; while the +12V dc from the rectifier is used for energizing the relay.

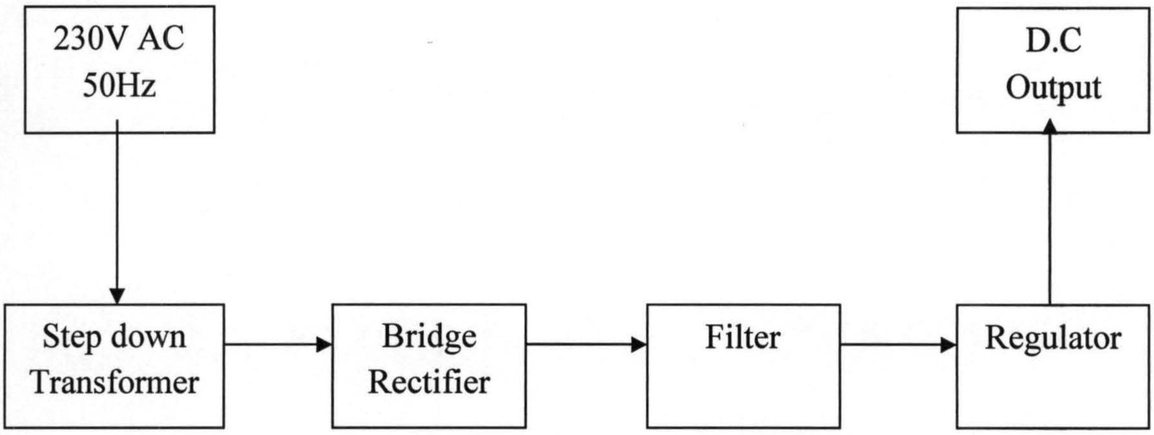


Fig 3.4: Power Supply Diagram

i. Transformer:

Usually, DC voltages are required to operate various electronic equipment and these voltages are 5V, 9V or 12V. But these voltages cannot be obtained directly. Thus the a.c input available at the mains supply i.e., 220V is to be stepped down to the required voltage level. This is done by a transformer. Thus, a step down transformer is employed to decrease the voltage to a required level.

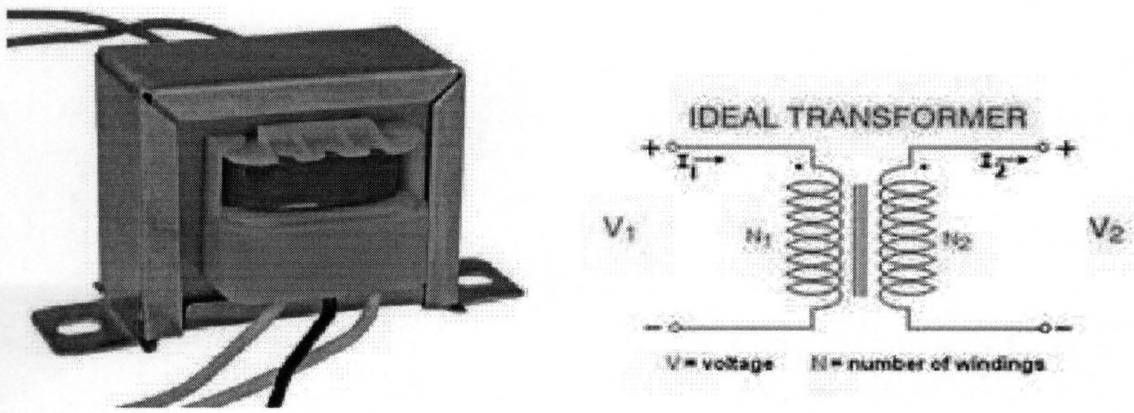


Fig 3.5: Transformer

ii. Rectifier:

The output from the transformer is fed to the rectifier. It converts A.C. into pulsating D.C. The rectifier may be a half wave or a full wave rectifier. In this project, a bridge rectifier is used because of its merits like good stability and full wave rectification.

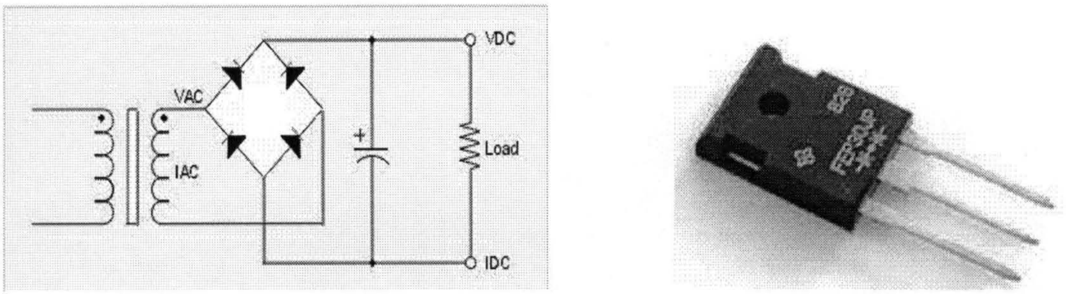
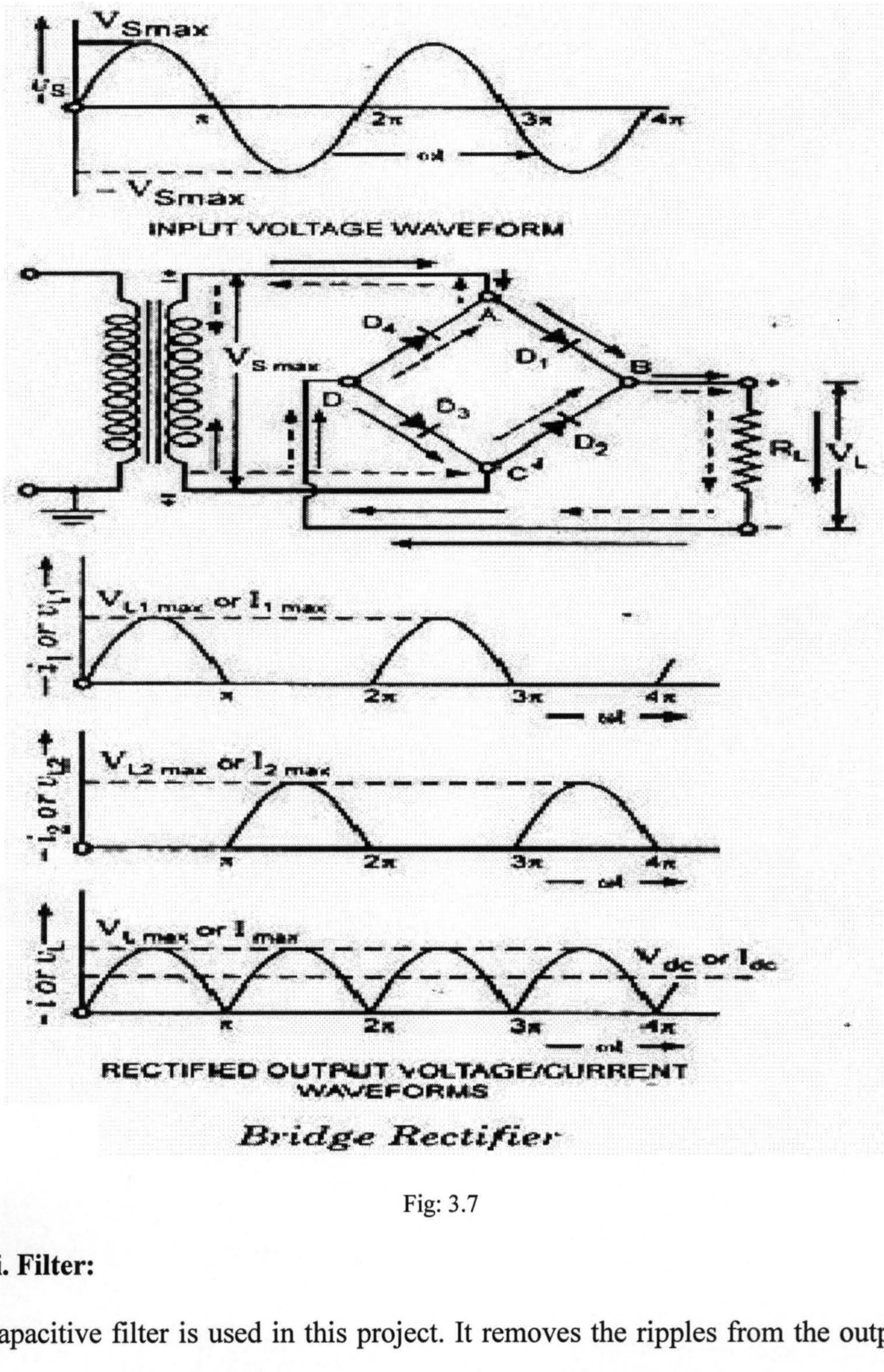


Fig 3.6: Bridge Rectifier

The bridge rectifier is a circuit, which converts an ac voltage to dc voltage using both half cycles of the input ac voltage. The Bridge rectifier circuit is shown in the figure above. The circuit has four diodes connected to form a bridge. The ac input voltage is applied to the diagonally opposite ends of the bridge. The load resistance is connected between the other two ends of the bridge.

For the positive half cycle of the input ac voltage, diodes D1 and D3 conduct, whereas diodes D2 and D4 remain in the OFF state. The conducting diodes will be in series with the load resistance RL and hence the load current flows through RL.

For the negative half cycle of the input ac voltage, diodes D2 and D4 conduct whereas, D1 and D3 remain OFF. The conducting diodes D2 and D4 will be in series with the load resistance RL and hence the current flows through RL in the same direction as in the previous half cycle. Thus a bi-directional wave is converted into a unidirectional wave.



Bridge Rectifier

Fig: 3.7

iii. Filter:

Capacitive filter is used in this project. It removes the ripples from the output of the rectifier and smoothens the D.C. Output received from this filter is constant until the mains voltage and the load is maintained constant. However, if either of the two is varied, D.C. voltage received at this point changes. Therefore a regulator is applied at the output stage.

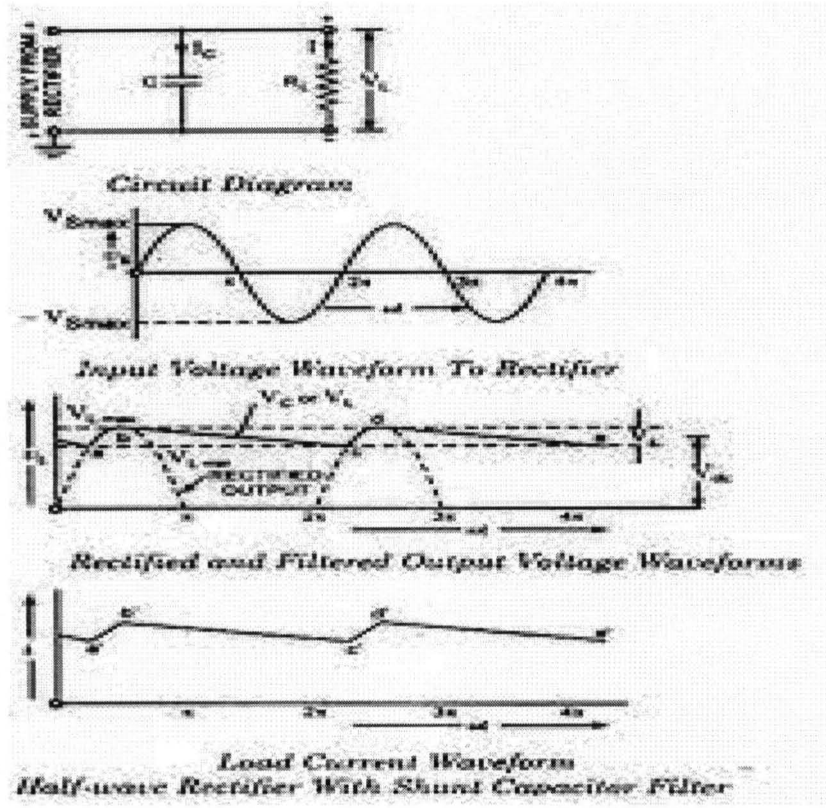


Fig: 3.8 Output Waveform of Capacitor Filtration

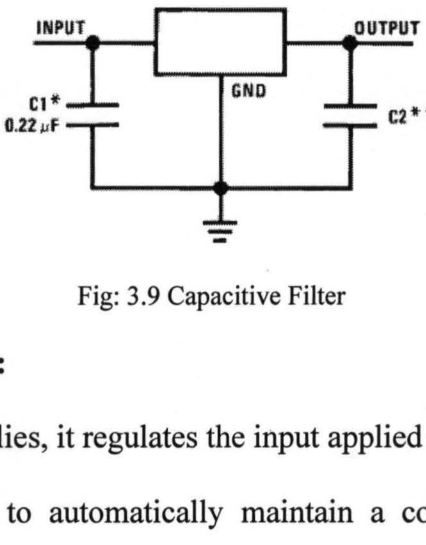


Fig: 3.9 Capacitive Filter

iv. Voltage Regulator:

As the name itself implies, it regulates the input applied to it. A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. In this project, power supply of 5V and 12V are required. In order to obtain these voltage levels, 7805 and 7812 voltage regulators are to be used. The first number 78 represents positive supply and the numbers 05, 12 represent the required output voltage levels. The L78xx series of three terminal positive regulators is available in TO-220, TO-220FP, TO-3, D2PAK and

DPAK packages and several fixed output voltages, making it useful in a wide range of applications.

These regulators can provide local on-card regulation, eliminating the distribution problems associated with single point regulation.

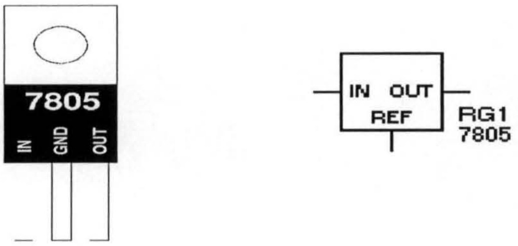


Fig: 3.10 Voltage Regulator

Each type employs internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltage and currents.

3.2.4 THE CONTROL UNIT

This consists of the microcontroller and the memory IC. The microcontroller computes the incoming decoded binary number from the decoder IC and compares it with the saved binary number in the memory IC originally saved as the password. If the saved binary is equal to the incoming decoder binary number, the relay is triggered through a switching transistor, and also triggers a buzzer to make a single beep which serves as feedback to the user as a confirmation; else if the decoded input binary number is not equal to the saved password, it beeps twice, also sending a feedback to user indicating an error password.

The Control Unit also consists of three manual preset buttons which are used to stop the timer, trigger the circuit, and OFF the load.

LEDs were also connected to the control unit to show the various states of operation.

LED 1: glows while timing

2: glows while load is ON

3.2.5 THE COMPARATOR/VOLTAGE MONITOR UNIT

An LM358 dual operational amplifier IC configured as comparator in window comparative mode was used to achieve the voltage comparison. A preset voltage value was applied to the non-inverting input of the first unit and also to the inverting input of the second unit. A variable resistor of 10kΩ was connected to the inverting input of the first unit and also to the non-inverting input of the second unit. This was used to achieve precision of the minimum and maximum input voltage from the mains.

If the input voltage falls below the minimum or goes above the maximum preset value of the operational amplifier at the comparator unit, the operational amplifier goes high and switches individual N-P-N transistor which sends a signal to the controller to determine which state is outside precision, thereby indicating on the LED 3 and 4. The controller then switches off the load and triggers an alarm until the input voltage becomes normal again.

3.2.6 DTMF DECODER IC

DTMF simply means Dual Tone Modulation Frequency. A DTMF IC (CM8870) was configured with a gain of 10 to achieve the DTMF output. As the input tone is fed from the GSM phone, the DTMF IC decodes the binary input and gives out a corresponding binary output which compared with the internally saved binary number i.e. password.

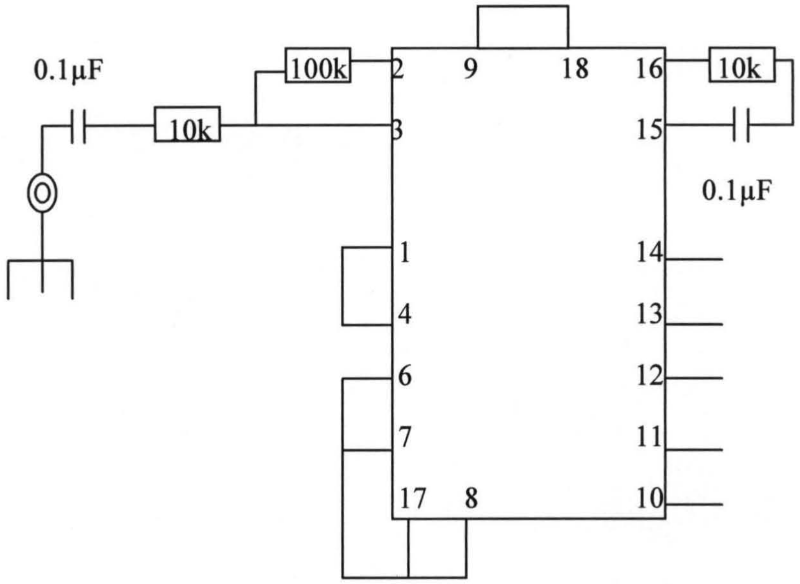


Figure 3.11: DTMF Decoder IC (CM8870)

3.2.7 THE RELAY SWITCHING UNIT

The inability of transistors to switch AC or high voltages such as mains electricity, makes them a bad choice for switching large currents (> 5A). In these cases a relay will be needed, hence the need for the relay switching unit. A relay was used to perform electrical switching through the switching transistor. An electromechanical relay is opened or closed by energizing an electromagnet to either attract or repel a metal contact on a movable strip of metal. Since a relay is able to control an output circuit of higher power than the input circuit, it can be considered to be, in a broad sense, a form of an electrical amplifier. They are compatible with digital circuitry and have a wide variety of uses with such circuits. A relay makes use of a solenoid to allow switching.

3.2.8 THE AT89C52 MICROCONTROLLER

This is the type of computer that is designed into a product, in order to provide its control. It is quite hidden from view, such that the user often doesn't know it's even there. This sort of product is called an embedded system. These little computers are generally called microcontrollers. The microcontroller unit can be regarded as the brain of the design, as it will be programmed to perform the switching operations.

A microcontroller is an embedded solution of the general purpose computer. Like the general purpose computer, the microcontroller contains the basic units used for input, control, processing and output of data which include: the central processing unit (CPU), the arithmetic and logic unit (ALU), control units and the input/output ports. Unlike the general purpose computer, the microcontroller is used for single control applications and can be re-programmed to suit whatever application needs to be addressed. A microcontroller is a single chip that contains the processor (the CPU), non-volatile memory for the program (ROM or flash), volatile memory for input and output (RAM), a clock and an I/O control unit.

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density non-volatile memory technology and is compatible with the industry-standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller, which provides a highly flexible and cost-effective solution to many, embedded control applications. The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, it is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next interrupt

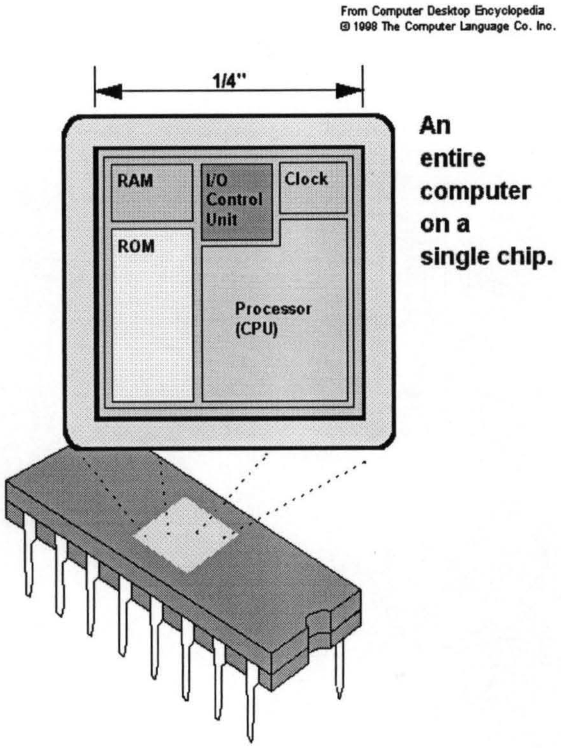


Figure 3.12: Diagram of the Microcontroller

The hardware is driven by a set of program instructions, or software. Once familiar with hardware and software, the user can then apply the microcontroller to the problems easily.

The pin diagram of the 8051 shows all of the input/output pins unique to microcontrollers:

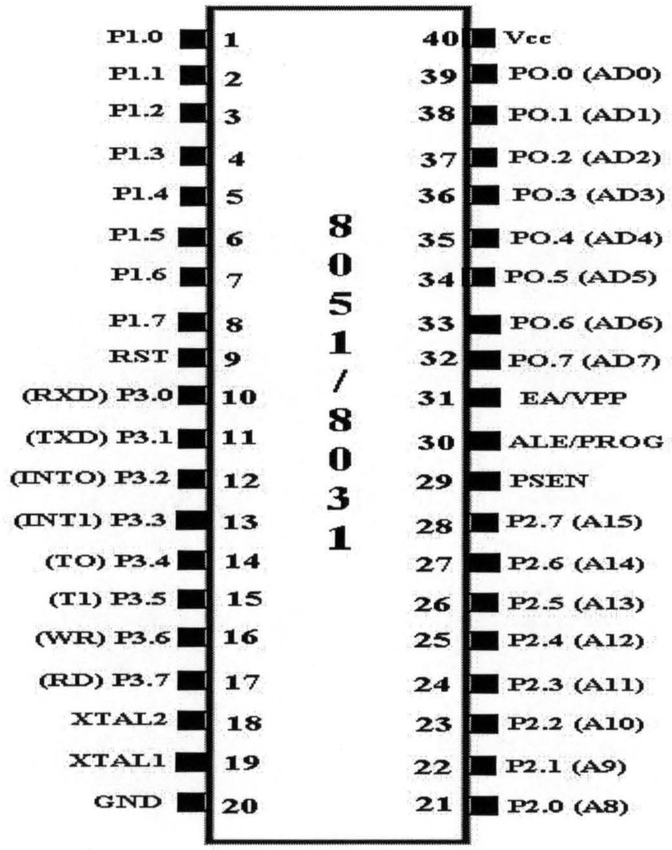


Figure 3.13: Diagram of the Dual in-line package (DIP) microcontroller pins

The following are some of the capabilities of 8051 microcontroller.

- ✓ Internal ROM and RAM
- ✓ I/O ports with programmable pins
- ✓ Timers and counters
- ✓ Serial data communication

The 8051 architecture consists of these specific features:

- 16 bit PC &data pointer (DPTR)
- 8 bit program status word (PSW)
- 8 bit stack pointer (SP)
- Internal ROM 4k

- Internal RAM of 128 bytes.
- 4 register banks, each containing 8 registers
- 80 bits of general purpose data memory
- 32 input/output pins arranged as four 8 bit ports: P0-P3
- Two 16 bit timer/counters: T0-T1
- Two external and three internal interrupt sources Oscillator and clock circuits.

3.3 THE SOFTWARE MODULE

The microcontroller is nothing without the software. To accomplish any task on an ATMEL, there must be a set of explicit instructions. A collection of such instructions is called a program. The software module constitutes the discussion of the intangible components involved in this project design. It involves a brief description of the programming language used, the keil μ-vision3.0 simulator, the integration of the hardware and software modules and other techniques that will be used for achieving the design.

Now, it is possible but very tasking to give the computer information and instructions using long strings of 1's and 0's. This process would be very time consuming and prone to error. To resolve these problems, several languages have been developed in which to write programs. These Languages help the programmer by making the job of programming a computer faster, more efficient, and more reliable. Programming languages also increase the portability, readability and modifiability of programs.

After a program is compiled it must be tested using a simulator or an emulator. A simulator is a software program which allows a developer to run a program designed for one type of machine (the target machine) on another (the development machine). The simulator simulates the running conditions of the target machine on the development machine. Using a simulator you can step through your code while the program is running. After testing, the developer uses a special machine called a programmer to imprint the translated program into the memory of the microcontroller.

3.3.1 Keil µ-Vision3.0

The keil µ-vision3.0 provides you with software development tools for all 8051 based microcontrollers. With the Keil tools, you can generate embedded applications for virtually every 8051 derivative. The supported microcontrollers are listed in the µ-vision

3.3.2 Program Code

Below is the program code which was burnt into the microcontroller to run the project. It's written in C-Language

```
#include <reg51.h>
//#define debug
#include <intrins.h>
#define xtal 12000000UL
#define tone_port P1
#define tone_in 0x01
#define tone_3 0x02
#define tone_2 0x04
#define tone_1 0x08
#define tone_0 0x10
void write_timeout(void)
{
        delay_ms(11);
}
void delay_ms(unsigned int ms)
{
        ms*=4;
        TR0=0;
```

```
        TL0=-timebase;
        TR0=1;
        while(ms)
        {
                TF0=0;
                while(!TF0);
                ms--;
        }
        TR0=0;
}
void serialize(unsigned char c,unsigned char reg_select)
{
        unsigned char z;
        lcd_load=0;
        lcd_clock=0;
        lcd_en=0;
        for(z=0;z<8;z++)
        {
                lcd_out=!(c&0x80);
                lcd_clock=1;
                lcd_clock=0;
                c<<=1;
        }
        lcd_rs=reg_select;
        lcd_load=1;
        lcd_load=0;
        lcd_en=1;
        lcd_en=0;
}
```

```
void lcd_data(unsigned char c)
{
        serialize(c,1);
        delay_ms(2);
}
void lcd_cmd(unsigned char c)
{
        serialize(c,0);
        delay_ms(2);
}
void lcd_clear(void)
{
        lcd_cmd(0x01);
}
void lcd(char code *ptr)
{
        while(*ptr)lcd_data(*ptr++);
}
void check_hv(void)
 {
 if(!hi_v)
 hi_led=0;
 low_led=1;
 }
void init_lcd(void)
{
        code unsigned char lcd_table[]={0x38,0x38,0x38,0x0c,0x01,0x06,0x00};
        unsigned char code *s=lcd_table;
        delay_ms(50);
```

```
	while(*s)
	{
		lcd_cmd(*s++);
		delay_ms(20);
	}
}
void dly(void)                                                          //
{
	_nop_();
	_nop_();
	_nop_();
	_nop_();
	_nop_();
	_nop_();
}
void i2c_start(void)
{
	sda=1;
	scl=1;
	dly();
	sda=0;
	dly();
	scl=0;
	dly();
}
void i2c_stop(void)
{
	sda=0;
	dly();
```

```
	scl=1;
	dly();
	sda=1;
}
void no_ack(void)                                   //
{
	sda=1;
	_nop_();
	scl=1;
	_nop_();
	scl=0;
}
unsigned char write_byte(unsigned char p)          //
{
	unsigned char d;
	for(d=0;d<8;d++)
	{
		sda=p&0x80;
		_nop_();
		scl=1;
		dly();
		scl=0;
		dly();
		p<<=1;
	}
	sda=1;
	_nop_();
	scl=1;
	_nop_();
```

```
	p=sda;
	scl=0;
	return p;
}
unsigned char read_byte(void)
{
	unsigned char x,c;
	c=0x00;
	sda=1;
	for(x=0;x<8;x++)
	{
		c<<=1;
		scl=1;
		dly();
		c|=sda;
		scl=0;
		dly();
	}
	return c;
}
unsigned char write(unsigned char address,unsigned char *s,unsigned char cnt)
{
	unsigned char t=0;
	while(cnt--)
	{
		i2c_start();
		t=write_byte(slave_address|write_flag);
		t|=write_byte(address++);
		t|=write_byte(*s++);
```

```
            if(t){i2c_stop();return 1;};
            i2c_stop();
            write_timeout();
        }
        return 0;
}
unsigned char read(unsigned char address,unsigned char *s,unsigned char cnt)
{
        unsigned char t=0;
        while(cnt--)
        {
            i2c_start();
            t=write_byte(slave_address|write_flag);
            t|=write_byte(address++);
            i2c_start();
            t|=write_byte(slave_address|read_flag);
            if(t){i2c_stop();return 1;}
            *s++=read_byte();
            no_ack();
            i2c_stop();
        }
        return 0;
}
unsigned char read_dtmf(void)
{
        unsigned char c=0,dta;
            if(tone_port&tone_in)                    //if STD high grab data
        {
            dta=tone_port;
```

```
		if(dta&tone_0)c|=0x01;
		if(dta&tone_1)c|=0x02;
		if(dta&tone_2)c|=0x04;
		if(dta&tone_3)c|=0x08;
		while(tone_port&tone_in);	//wait until STD deasserted
		return table[c];
	}
	return 0;
}
unsigned char get_dtmf(void)
{
	unsigned char *ptr=buffer;
	unsigned char x=0;
	unsigned char c;
	while(1)
	{
		start_timeout();
		while((!(c=read_dtmf()))&&(!timeout));
		if(timeout)
		{
			stop_timeout();
			return 0;
		}
		if(c)
		{
			stop_timeout();
			if(c==cmd_stop)return x;
			*ptr=c;
			ptr++; x++;
```

```
                    #ifdef debug
                    lcd_data(c);
                    #endif
                    if(x>max_cmd)return 0;
            }
        }
}
void init_irq(void)
{
        ET1=1;
}
void init_timer(void)
{
        TCON=0x00;
        TMOD=0x22;
        TH0=-timebase;
        TL0=-timebase;
        TH1=-timebase;
        TL1=-timebase;
}
unsigned char reset_pin(void)
 {
        unsigned char buff[4];
        buff[0]='1'; buff[1]='2';
        buff[2]='3'; buff[3]='4';
        return(store_pin(buff));
}
void show_loading(void)
{
```

```
        lcd_clear();
        lcd("loading...");
        delay_ms(1000);
}
void show_pin(void)
{
        unsigned char buff[4];
        read(pin_address_start,buff,pin_length_size);
        lcd_clear();
        lcd("PIN: ");
        lcd_data(buff[0x00]);
        lcd_data(buff[0x01]);
        lcd_data(buff[0x02]);
        lcd_data(buff[0x03]);
        delay_ms(1000);
}
unsigned char sys_init(void)
{
        unsigned char z=0;
        IE=0x00;
        relay_dx=1;
        tone_off();
        init_irq();
        init_timer();
        EA=1;
        if(!reset)z=reset_pin();
        #ifdef debug
        init_lcd();
        show_loading();
```

```
        show_pin();
        #endif
        return z;
}
void beep_error(void)
{
        unsigned char z=3;
        tone_dx=0;
        while(z--)
        {
                delay_ms(500);
                tone_dx=!tone_dx;
        }
        tone_dx=1;
}
void tone_on(void)
{
        tone_dx=0;
}
void tone_off(void)
{
        tone_dx=1;
}
void send_error(void)
{
        tone_on();
        delay_ms(900);
        tone_off();
}
```

```
void send_ok(void)
{
	tone_on();
	delay_ms(700);
	tone_off();
	delay_ms(500);
	tone_on();
	delay_ms(700);
	tone_off();
}
void gain_access(void)
{
	relay_dx=0;
	delay_ms(50000);
	relay_dx=1;
}
unsigned char compare_pin(unsigned char *ptr)
{
	unsigned char s[10],x;
	if(read(pin_address_start,s,pin_length_size))return 1;
	for(x=0;x<pin_length_size;x++)
	{
		if(s[x]!=*ptr)return 1; ptr++;
	}
	return 0;
}
unsigned char store_pin(unsigned char *ptr)
{
	return(!(write(pin_address_start,ptr,pin_length_size)));
```

```
}
unsigned char  decode_dtmf(unsigned char c)
{
	if((compare_pin(buffer+pin_start)))return 0;
	switch(c)
	{
		case access_ctrl:		gain_access();
							return 1;
		case pin_change:		return(store_pin(buffer+pin2_start));
		default:			return 0;
	}
}
void main(void)
{
	unsigned char c;
	if(sys_init())beep_error();
	#ifdef debug
	while(1)
	{
		lcd_clear();
		lcd_cmd(0x80);
		while(!tone_in);
		if(!(c=get_dtmf()))
		{
			lcd_clear();
			lcd("command error!");
			delay_ms(1000);
		}
		else
```

```
			{
				if(decode_dtmf(c))
				{
					lcd_clear();
					lcd("cmd exec ok!");
					delay_ms(1000);
				}
				else{
					lcd_clear();
					lcd("cmd exec error!");
					delay_ms(1000);
					}
			}
		}
		#endif
		#ifndef debug
		while(1)
		{
//		check_hv();
//		check_lv();
			while(!(tone_port&tone_in));
			if(!(c=get_dtmf()))send_error();
			else{
					if(!(c=decode_dtmf(c)))send_error();
					else send_ok();
				}
		}
		#endif
}
```

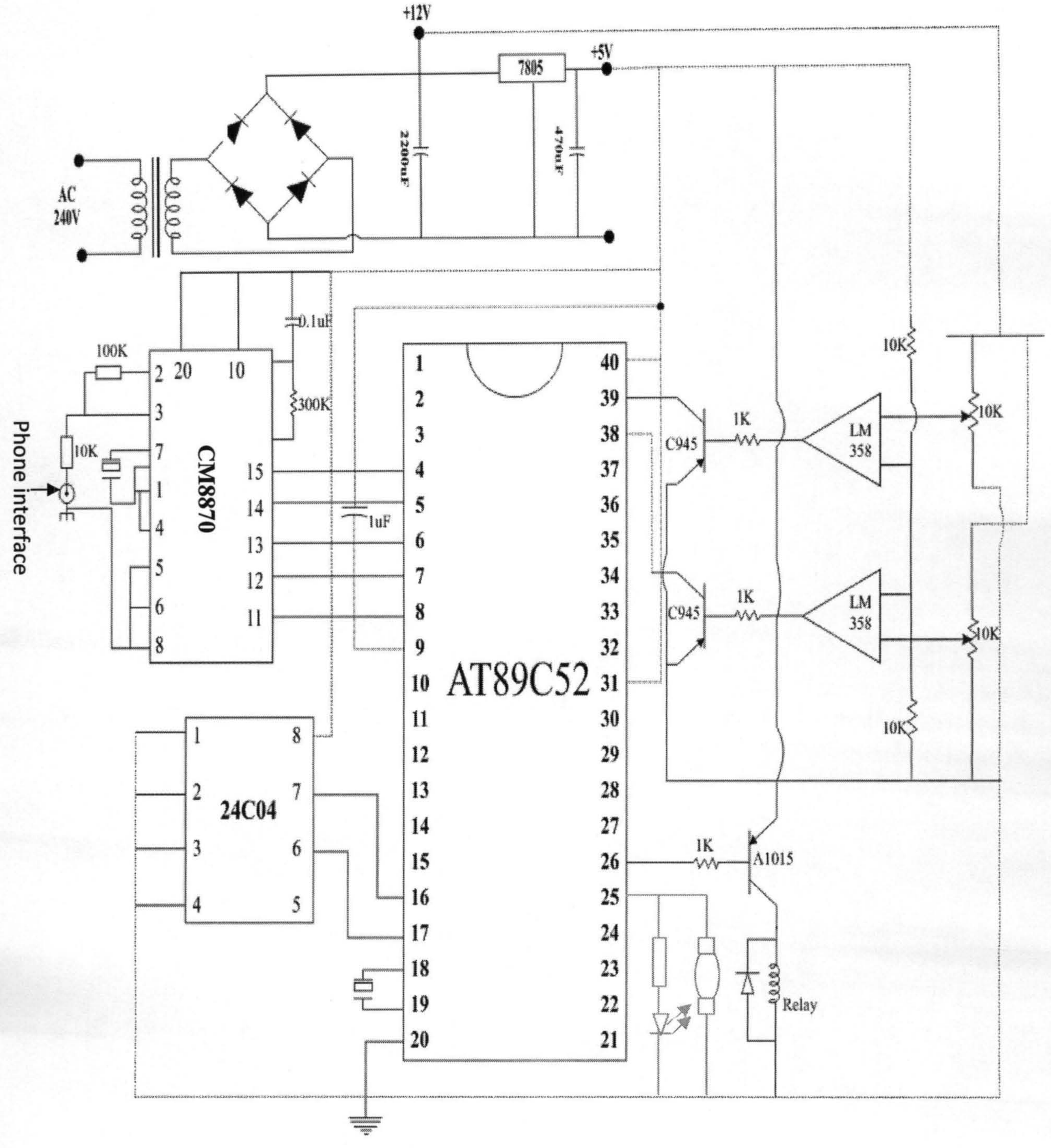


Figure 3.14: Complete Circuit Diagram of Home Appliance Control System

CHAPTER FOUR

TESTS AND RESULTS

4.1 TESTS

On completion of circuit construction, tests were carried out to ensure full functionality of the circuit. Tests were carried out on both the hardware and the software.

4.1.1 Hardware testing

Hardware testing is basically a test of all physical components in the circuit. To ensure circuit functionality, each component was tested separately and the connection between components. Some of the tests carried out under hardware include

- Continuity Test: This is the testing of all physical connections or paths and polarity linking the different circuit components used. This was done to ensure that the circuit was realized as it is in the diagram.
- Short Circuit Test: The polarity of supply was tested all across the circuit before power on to avoid damage to the circuit due to short circuit current.
- Partial Contact Test: This was done to ensure that all components were firmly placed on board, so that errors that may arise due to partial contact were avoided.

4.1.2 Software Testing

To avoid malfunction of the circuit due software errors, the software was also tested. The test carried out on software was basically running the software on the microcontroller after each segment is written. Errors detected were immediately corrected and the process

4.2 TESTING OF THE POWER SUPPLY STAGE

The power supply unit of the system consist of +5V and +12V supplies. The test performed on the power supply unit is taken to ensure that the correct voltages are realized at the output of the power supply unit. The test was conducted in the following ways;

- The power supply unit was constructed on the veroboard using physical components
- The outputs of the power supply unit were then measured and found to be +5V from the output of the LM7805 and the +12V from the output of the transformer.

4.3 TESTING OF THE SWITCHING CIRCUIT

The switching circuit was then tested for proper operation through the following means;

- Construction of the switching circuit on the veroboard with physical components
- By bypassing the microcontroller and supplying the switching circuit directly from the 5V and 12V power supply, the switching devices (relays) were manually tested
- The response of the switching circuit and controlled devices were observed and found to work fine as connected and disconnected.

4.4 ATMEL WORKING CONDITION TEST

The microcontroller was connected to the power supply according to the connection directions specified in its datasheet. With a very simple LED-blinking code in the ATMEL and LEDs connected to the port B pins through current limiting resistors, the ATMEL port B was verified to be working as the LEDs blink as expected.

The following code was used to test the microcontroller for the LED blinking project;

Program LED_Blinking

Main:

TRISB = 0 ‘PORTB is output

PORTB = %11111111 ‘Turn ON diode on PORTB

```
Delay_ms(1000)            'wait for one second
PORTB = %00000000         'turn OFF diode on PORTB
Delay_ms(1000)            'wait for 1second
Goto main                 'endless loop
end
```

The UART terminal of the ATMEL was tested by burning the complete project codes to it, but without the phone connected. By programming design, the microcontroller is meant to continuously monitor the line, hence its TXD (pin 25) should stay high as long as data is not ready (phone is not connected). The voltage on this pin was measured to ground and found to be 5V as expected. The voltage on the RXD (pin 26) was also measured to the ground and found to be 0V as expected.

4.5 SYSTEM PERFORMANCE

The step by step performance of the home appliance control system is listed below;

i) The module is powered through the mains 220V power supply

ii) The phone was then connected to the HACS module and the system was powered through the mains supply.

iii) The phone dials up to show that a connection has been established between it and the microcontroller.

iv) The program code will periodically check and read any received command from the HACS module.

v) The microcontroller acts on the command received and consequently delete such from the phone memory so as to guard against congestion of memory.

vi) A set of correct and incorrect passwords when sent to the microcontroller and the response observed for each of the inputted passwords, it was observed that the microcontroller grants access to all the right passwords.

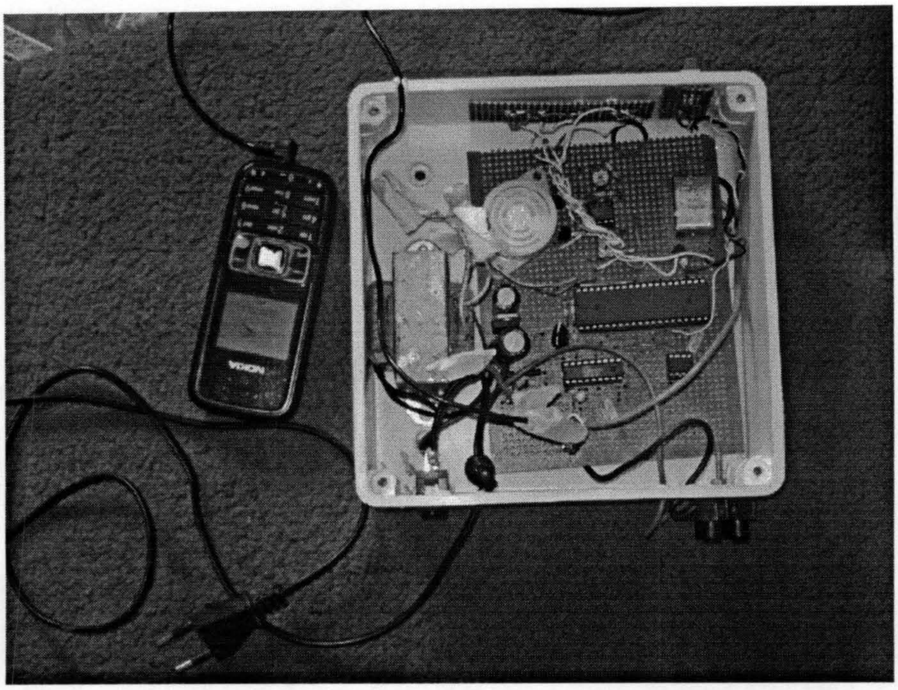


Figure 4.1: Pictorial Diagram of Internal Circuitry

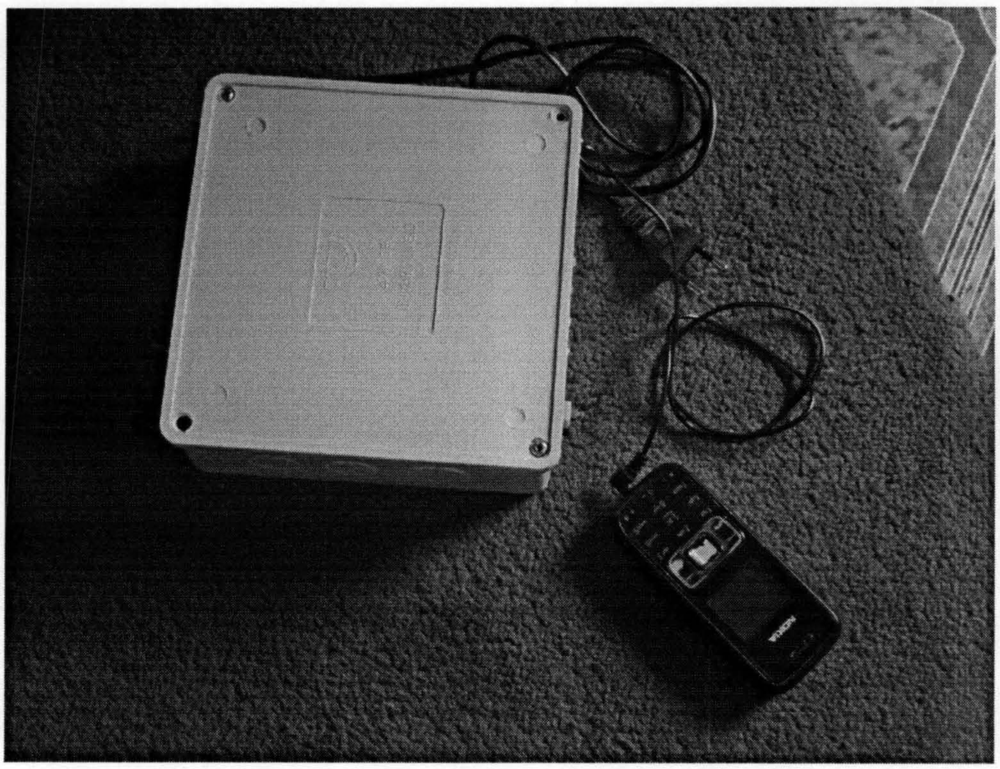


Figure 4.2: Pictorial Diagram of Coupled Circuit

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

A low cost, secure, ubiquitously accessible, remotely controlled solution for appliance control has been introduced. This project has achieved the target to control home appliances remotely using the GSM-based system satisfying user needs and requirements. GSM technology capable solution has proved to be controlled remotely, provide home security and is cost-effective as compared to the previously existing systems. Hence we can conclude that the required goals and objectives of HACS have been achieved.

The basic level of home appliance control and remote monitoring has been implemented. The system is extensible and more levels can be further developed using automatic motion/glass breaking detectors so the solution can be integrated with these and other detection systems. In case of remote monitoring other appliances can also be monitored such that sensors can also be applied that can detect gas, smoke or fire in case of emergency the system will automatically generate signals.

5.2 RECOMMENDATIONS

In agreement with Potamitis et al (2003) that the most likely way of interfacing with devices in the future will be IP; since it is more flexible, scalable and compatible. The biggest issue will be probably to make it usable and accessible to all kinds of users. Since this is a new field of investigation, the results of the project are likely to be worthy of further analysis. The completion of a whole cycle of control between a remote device and the entire building, and not just appliances will be critical for the success of the research; once control is achieved a meticulous study about how users and the system interact has to be done.

Also a provision can be made for the alternative power to cater for the limitation posed by the erratic power supply.

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