DESIGN AND CONSTRUCTION OF A MICROCONTROLLER BASED GSM SWITCHING CONTROL SYSTEM

BY

ADAMS, JUSTICE LUCAS
(2003/15289EE)

DEPARTMENT OF ELECTRICAL/COMPUTER ENGINEERING

NOVEMBER, 2008

DESIGN AND CONSTRUCTION OF A MICROCONTROLLER BASED GSM SWITCHING CONTROL SYSTEM

BY:

ADAMS, JUSTICE LUCAS
(2003/15289EE)

A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL/COMPUTER ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE

DEDICATION

This project is dedicated firstly to God, my parents, siblings, my friends and all who have in one way or the other contributed to my academic pursuit may the good lord bless you all abundantly.

DECLARATION

I Adams, Justice Lucas declare that this work was done by me and has never been presented elsewhere for the award of a degree; I also hereby relinquish the copyright to the Federal University of Technology Minna.

Adams Lucas Justice	Mr. Galadima
(Name of student)	(Name of supervisor)
06/11/08 …………………………………	04/11/08 …………………………………
(Signature and date)	(Signature and date)
Engr.Y.A. Adediran	…………………………………
(Name of H.O.D)	(Name of External Examiner)
…………………………………	…………………………………
(Signature and date)	(Signature and date)

ACKNOWLEDGEMENT

I would like to take this time out to extend my sincere gratitude to God, my supervisor, ExxonMobil, ChevronTexaco, and finally to all my friends and family for all their immense contributions towards my academic endeavors in their own special way, love you guys a lot.

ABSTRACT

This project is about taking home automation system to the next level by the use of mobile phones to actually control appliances a great distance away via the mobile network (MTN, ZAIN, and GLO) i.e. provided there is GSM coverage between the operator and the equipment to be controlled. The construction makes use of a micro controller and a digital tone converter which are interfaced to a computer system and a phone, when the phone number of the phone connected to the computer is dialed and is ringing the computer will automatically pick up the phone and by pressing digit keys like 1, 2, 3,*, # etc gives a predetermined command to the computer to control the equipment attached to it (i.e. to turn on or switch off). The system has a feedback to let the person controlling the equipment if the task has been carried out successfully or not.

TABLE OF CONTENTS

Dedication......iv

Declaration......v

Acknowledgement......vi

Abstract......vii

1.0 Chapter One: Introduction......1

1.1 Background......1
1.2 Scope of work......1
1.3 Methodology......1
1.4 Concept of Digital tone multi-frequency......2

2.0 Chapter Two......4

2.1 Literature review......4

2.2 Development of remote control devices......4

3.0 Chapter Three......8

3.1 Design objectives......8

3.2 Design consideration......8

3.3 Design calculations......9
3.3.1 Power supply......9

3.3.2 Drive circuitry......14
3.3.2.1 Differential Input......15

3.3.2.2 Crystal Oscillator......16

3.3.2.3 Steering circuit......17

3.3.2.4 Comparator circuit......18

3.3.2.5 Microcontroller..21

3.4 Working operation of the device..21

3.5 Software design..23

4.0 Chapter Four..26

4.1 Power supply implementation and testing..26

4.2 Main circuitry implementation and testing..26

4.3 Soldering..27

4.4 Casing construction..27

4.4.1 Physical factors..27

4.4.2 Environmental factors..28

4.5 System reliability and maintenance..29

4.6 Applications..30

4.7 Problems encountered..30

5.0 Chapter Five..32

5.1 Summary of work done..32

5.2 Recommendations..32

Reference..33

Appendix..34

List of figures

Fig 3.1 A typical dc power supply block diagram....................................10
Fig 3.2 Voltage output at the transformer, rectifier and filter........................11
Fig 3.3 Load resistance of relays in the circuit...12
Fig 3.4 Load resistance of decoder and microcontroller..............................12
Fig 3.5 A part of the drive circuit comprising of the tone decoder and comparator...14
Fig 3.6 A simplified diagram of the differential input configuration..............15
Fig 3.7 The steering circuit of the decoder...17
Fig 3.8 The voltage divider circuit...19
Fig 3.9 Block diagram description of the cell phone remote control................22
Fig 3.10 A flowchart description of the microcontroller program..................25
Fig 4.1 An Isometric view of the casing..29

List of tables

Table 1.1 DTMF keypad frequencies..2

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND

A new and essential part of household electronics is domestic automation. Attempts are been geared towards achieving this end. This has become inevitable in order to achieve greater control and efficiency. Home automation also reduces the requirement on humans in the control of appliances.

This can be achieved using either Remote means or a nearby means. The method of interest in this work is the Remote Automation means. Methods of remotely accomplishing this vary from voice control over existing voice frequency links, different varieties of radio control, i.e. Bluetooth, Infra-red, SCADA (Supervisory Control And Data Acquisition System) and most importantly the Dual Tone Multi-Frequency (DTMF) via GSM.

1.2 SCOPE OF WORK

This project work covers such areas as itemized below;

- An overview of some remote control means available.
- A description of some essential concepts pivotal to the project realization.
- A description of the components used in the circuit implementation.
- Circuit design, analysis and implementation.
- Software design, analysis and implementation.
- Project packaging.
- Project application, limitations, problems encountered and recommendations.

1.3 METHODOLOGY

The approach used in the actualization of remote control of appliances in this project, is based on Dual Tone Multi-Frequency (DTMF) using the Global System for Mobile communication (GSM). The method employing DTMF signals is a keying system, where DTMF tones are used at the site of automation by an Interface device (Project Work) to power the desired electrical/electronic devices.

1.4 CONCEPT OF DUAL TONE MULTI-FREQUENCY

Dual Tone Multi-frequency (DTMF) signaling is used for telephone signaling over the line in the voice frequency band to the call switching center. DTMF is an example of a Multi-frequency shift keying (MFSK) system. Today, DTMF is used for most call setup to the telephone exchange: at least in developed regions of the world.

The DTMF keypad is laid out in a 4 x 4 matrix with each row representing a low frequency, and each column representing a high frequency. Pressing a single key such as '1' will send a sinusoidal tone of the two frequencies 697 Hz and 1209Hz. These tones are then decoded by the switching center in order to determine which key was pressed [1]. This is done by converting these frequencies into binary code and sent to the computer via the parallel port. When the code gets to the system it is being converted to hexadecimal code which is being used to the write the program for the software.

Table 1.1 DTMF keypad frequencies

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

The tone frequencies, as defined by the precise tone plan, are selected such that harmonics and inter-modulation products will not cause an unreliable signal. No frequency is a multiple of another and the difference between any two frequencies does not equal any of the frequencies and the sum of any two frequencies does not equal any of the frequencies. The frequencies were initially designed with a ratio of 21/19, which is slightly less than a whole tone.

Dual tone Multi-frequency signals are decoded using the Goertzel Algorithm and are also called Multi-frequency Pulsing and multiple frequency signaling.

CHAPTER TWO

2.0 LITERATURE REVIEW

A remote control is an electronic device used for the remote operation of a machine. The term sometimes abbreviated to "remote" and also called a flipper or "clicker" is most commonly used to refer to a remote for television or other consumer electronics such as stereo system and DVD players and to turn on and off a main plug. Remote controls for these devices are usually small handheld objects with an array of buttons for adjusting various settings such as television channel, track number, and volume. In fact, for the majority of modern devices with this kind of control, the remote contains all the function controls while the controlled device itself only has a handful of essential primary controls. Most of these remotes communicate to their respective devices via infra red (IR) signals and a few via radio signals.

2.1 DEVELOPMENT OF REMOTE CONTROL OF APPLIANCES.

One of the earliest examples of remote control was developed in 1893 by Nikola Tesla, and described in his patent, named *Method of and Apparatus for Controlling Mechanism of moving vehicles*. The first remote-controlled model airplane flew in 1932. The use of remote control technology for military purposes was worked intensively during the Second World War. One result of this was the German '*wasserfall*' missile. The first remote intended to control a television was developed by Zenith Radio Corporation in the early 1946. The remote, unofficially called 'Lazy-Bones' used a wire to connect to the television set. To improve the cumbersome setup, a wireless remote control was created in 1955. The remote called *flashmatic,* worked by shining a beam of light into a photoelectric cell. Unfortunately, the cells did not distinguish between light from the remote and light from other sources. The *flashmatic* also required that the remote control be pointed accurately at the receiver.

The invention of the transistor made possible, cheaper electronic remotes that contained a piezoelectric crystal that was fed by an oscillating electric current at a frequency near or above the upper threshold of human hearing. The receiver contained a microphone attached to a circuit that was tuned to the same frequency.

In the early 1980s when semiconductor for emitting and receiving infrared radiation were developed, remote controls gradually switched to that technology which as at 2006 is still widely used. On December 12, 1901, the scientist and Nobel Prize winner ***Guglielmo Marconi*** was able to transmit across the Atlantic Ocean, for the first time in history. One century later, wireless communications are ubiquitous and widespread. Everyone can pick up a cell phone and talk with a friend who's in a different continent. Voice calls are only one of the options of the functionality of a mobile phone; other functions include sending of faxes, exchange of SMS, mails, music and even internet connectivity. No matter the source of the information it can be shrinked to smaller data packets and delivered to a mobile phone.

Coming down to the twenty-first century, we notice great advancement in communication and control of devices such as home automation systems, Bluetooth, Wi-Fi and tracking devices on cars and mobile phones and more recently the control of devices via global system mobile (GSM).

In 2005 a student by the name of Akande Adeleke (99/9312EE) was able to control and monitor devices (e.g. fluorescent light, motor or air conditioner) using mobile phone but via the use of SMS. Two phones were used; one master and the other slave. The slave is interfaced or configured to a tiny planet circuit through a data cable connected to DB9 of the circuit, it uses AT command protocol to communicate with the ATtiny12 (microcontroller), and also transmit and receive SMS to and fro the master phone. The design also consisted of a relay which was connected to the device to be controlled and a detector connected to the device to be monitored. The detector is a transducer to convert the input signal from the device to be monitored into an electrical equivalent signal which was fed back to the microcontroller and appropriate action will then be taken. The project was only limited to turning on and off a device.

In 2007 a student by the name of Yakubu Mohammed (2001/12145EE) also worked on similar project. He was able to achieve control by connecting the device to be controlled to a GSM and interfaced with an Ericsson T105 mobile and a computer to a microcontroller (ATmeg98515). The serial port of the microcontroller was interfaced with the serial port of the phone, while the parallel port of the microcontroller (Port B) was interfaced to the parallel port of the computer. A program which had been developed to send commands to the microcontroller just as the phone does was loaded on the computer. The program on the computer was updated by the microcontroller after a change had been effected on the states of each of the devices connected to the computer, whether it had been implemented by the phone or computer.

The microcontroller was able to access the serial port of the mobile phone via its' AT command instruction set. When the device was powered on, the microcontroller initialized the phone and selects the phone memory as the default storage location in preference to that of the simcard. At periodic intervals the microcontroller accesses the phone for new text messages at the pre-assigned memory location. There are two categories of messages obtainable: a valid message (command) and an invalid message (command). If invalid, it will be deleted from the phone memory, if valid, the microcontroller will check to see what the command it is and then execute it.

Also last year (2007) a student by the name of Ubah T. Ubah (2002/12131EE) designed a similar circuit but using a network or internet to control devices. In his design the various loads will be connected to a terminal through a custom built interface circuitry, which will act as the switching or control device. The computer will use RS-232 interface which is a serial communication port for sending and receiving control states. The computer runs an application which acts as a server software, this software directly communicates with the serial port to send or receive data. Also a web server which will be used to serve the page containing the client or command console will be installed on the system.

The server will be connected to a network where other computers on the network will be able to access the command user interface which will be used to control the devices; both client and server were written in Java. The design was able to control three devices out of which two were static while the other was dynamic; dynamic in the sense that it was able work with varying voltage levels. Controlled devices were interfaced with the host computer using a network or internet. The switching circuitry is made up of an AT89C2051 microcontroller which is used to receive and decode command signals sent from the server computer via its RS-232 interface. The microcontroller is equipped with a full duplex UART or serial port which enables it receive and send serial data. These command signals are byte-wise data and contain bits which indicate whether a particular device is to be switched off or on. A logic 1 turns on the device while a zero (0) turns off the device. The components for switching on and off are triacs and relays.

The design has a short coming of the inability to ascertain the working condition of the controlled appliances and also the inability to add extra appliances.

CHAPTER THREE

3.0 DESIGN AND ANALYSIS

3.1 DESIGN OBJECTIVES

In implementing this project, certain objects were borne in mind. These are outlined below:

1.) The operation of the project should not have any distance limitation (except where is no network coverage).

2.) It should work as a non line of sight (NLOS) device.

3.) It should completely reject any kind of audio noise

4.) It should control multiple appliances with a minimum of three (3).

5.) It should be compatible with a variety of mobile phones.

6.) The circuit should be powered from the mains to reduce the cost of changing batteries in the long run.

7.) It should be able to withstand environmental conditions especially in the tropical region (i.e. Nigeria).

3.2 DESIGN CONSIDERATION

While embarking on the cell phone remote control, a number of factors were considered with obvious emphasis on the following;

1.) **COST**: cost was a major consideration in the choice of components used except where the particular components were cardinal to the realization of the project as in the DTMF decoder.

2.) **AVAILABILITY**: this was given the utmost consideration it deserved. Thus, prior to the final circuit design; a market survey to determine the availability of the various components was carried out.

3.) **MAINTAINABILITY**: to ensure easy maintenance of the project, the modular design philosophy was adopted. The casing was sealed using screws, which could be unscrewed when the need arises.

4.) **AESTHETICS**: beauty and user friendliness was considered in choosing packaging material.

5.) **REL.ABILITY**: to ensure the project worked well; components with proven track record of performance, extreme precision (e.g. the DTMF crystal oscillator has a 99.9999% precision) and casing material that could withstand varying temperature, humidity, vibration and dust were used. In the final analysis, a trade off was made between the factors enumerated above.

3.3 DESIGN CALCULATIONS

3.3.1 POWER SUPPLY

Adequate voltage supply is of paramount importance for the proper functioning of all the components. It is likened to a man drinking water. It is most probable that the man taking in clean water will live long than a man drinking unclean water. With this in mind, we set out to design and realize adequate, stable power supply system.

From the circuit diagram (Appendix III) the voltage requirements from the power supply to the MT8870DE, microcontroller and relays are either +5v or +12v. The current requirements for the components are as outlined below;

1. DTMF decoder (MT8870DE) ----- 9.0mA
2. microcontroller (PIC16f84A) ----28.0mA
3. relay ---30mA each

   (With 5 in parallel gives) ------150.0mA

Total = 187mA

Armed with this knowledge, the following components and values were chosen.

a.) 220/12v, 500mA transformer: this also falls within the 6v – 24v input limit of the 7805 voltage regulator and has a supply current (500mA) greater than the circuit requirement.

b.) 7805 voltage regulator to produce a fixed +5v output.

c.) 100µf and 1000µf capacitors for filtering

d.) A bridge rectifier (W08m)

e.) 500mA fuse

For a better understanding of the power supply circuit, its block diagram is shown below;

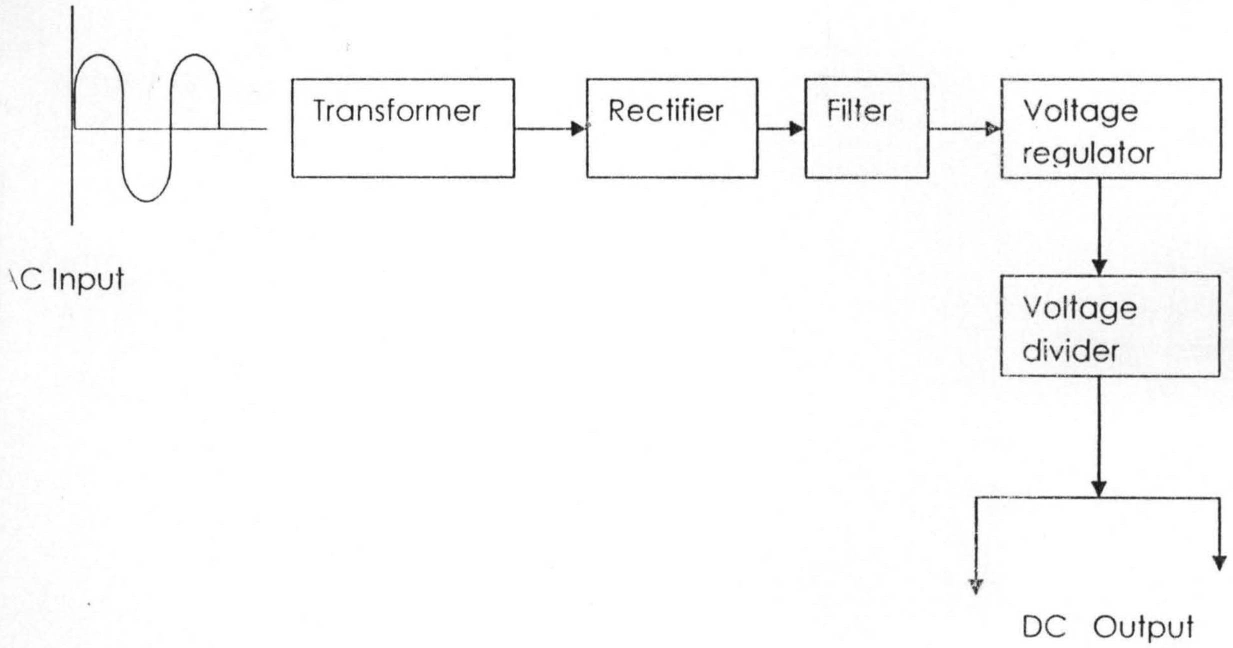
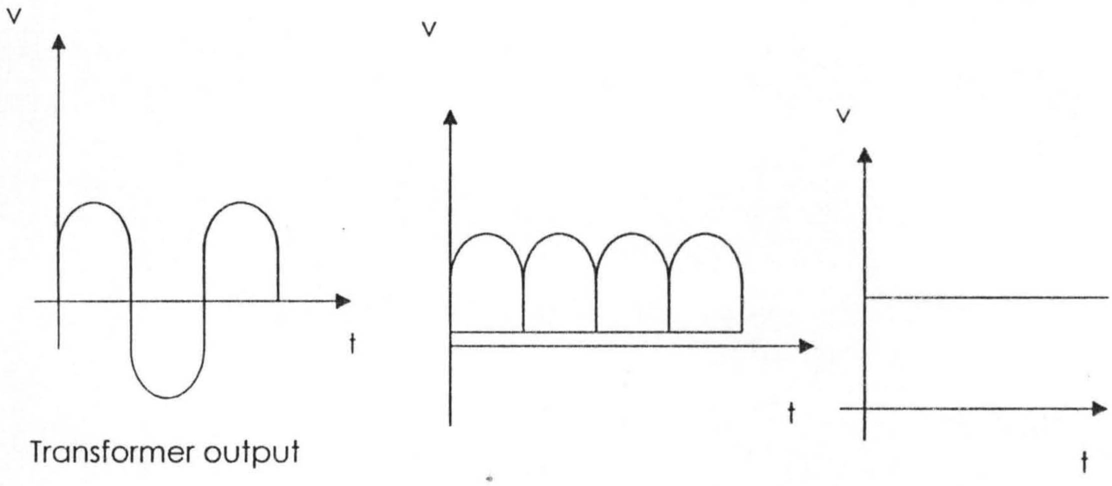


Fig 3.1: A typical dc power supply block diagram.

a) TRANSFORMER: A 220/12V, 500mA transformer was used to step down the A.C. supply voltage to 12v so as to suit the requirement of the solid-state electronic devices and circuits fed by the DC power supply. The transformer has a 500mA fuse connected to it, to prevent damage to circuit due to excessive current from mains supply. The transformer output is fed into the rectifier section.

b) RECTIFIER: the full wave bridge rectifier employs four IN4001 diodes to converts the transformer 12v AC output into pulsating DC voltage as illustrated below;



Rectifier output (near

Filter output

(a) (b) (c)

Fig 3.2: Voltage output at the transformer, rectifier and filter.

Some of the strong selling points of the bridge rectifier are:

i. no centre-tap is required on the transformer
ii. Much smaller transformers are required.
iii. It has lower ripple factor than half wave rectifier.
iv. It has less peak inverse voltage (PIV) rating per diode.

C.) FILTER: The capacitor removes the fluctuations (ripples) present in the output voltage supplied by the rectifier. A Capacitor-filter was preferred to clock filter because it has a higher DC output voltage, lower peak inverse voltage (PIV) requirements for diodes and are smaller weight than inductors and clock filters. Basically, a high capacitance (1000μf,) was used in order to:-

i.) Reduce the time of flow of current pulse through the diode.

ii.) Increase the peak current in the diode.

iii.) Reduce ripple magnitude (ripple factor).

This is illustrated below:-

Output frequency = 2x input frequency ------ equ (3.1)

But, input frequency from the mains = 50Hz.

Thus, output frequency = ripple frequency

$$= 2 \times 50Hz = 100Hz.$$

The resistive load from the DTMF decoder, micro controller and relays connected to the power supply are as shown.

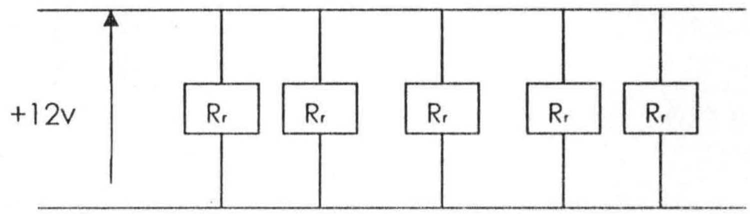


Fig 3.3: load resistance of relays in the circuit

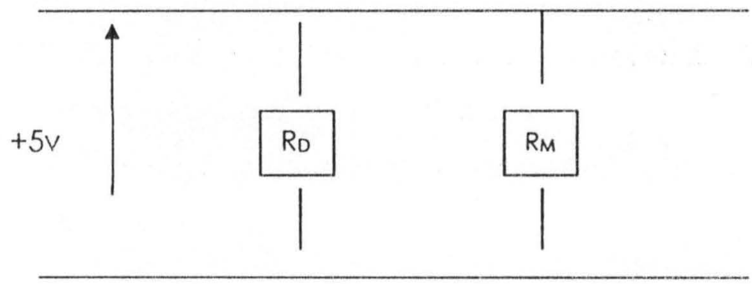


Fig 3.4: load resistance of the decoder and microcontroller

Where R_r, R_D and R_m are the resistances of the relays, decoder and micro controller.

From manufacturers' specifications

$R_r = 400\Omega$

R_D (gain select resistive load) = $50K\Omega$

Current into the microcontroller = I_m = 28mA

Therefore, $R_m = V_{DD}/I_m$ .... equ (3.2)

$= 5x10^3 /28 = 178.6\Omega$

Equivalent relay resistance = R_{rT}

$1/ R_{rT} = {}^1/_{400} + {}^1/_{400} + {}^1/_{400} + {}^1/_{400} = {}^1/_{80}$

$R_{rT} = 80\Omega$

Total equivalent load resistance = R_L

$1/ R_L = 1/RrT + 1/R_D + 1/R_m = 1/80 + 1/50{,}000 + 1/178.6$

$1/R_L = 0.0125 + 0.00002 + 0.005599 = 0.018119$

$R_L = 55.19\Omega$

But ripple factor,

$Y = {}^1/4\sqrt{}(3fCR_L)$ for a full wave rectifier [19]. ----- equ (3.3)

By substituting our parameters, we have

$Y = ¼ \sqrt{3} (100)(1000 x10^{-6}) x 55.19\Omega$

$Y = ¼ \sqrt{3} x 5.510 = 1/38.2368 = 0.026$

This is a very low ripple factor of 2.6%.

d.) REGULATION: A monolithic integrated circuit voltage regulator (7805) was used to keep the terminal input voltage to the voltage sensitive ICs constant even when

i. AC input voltage to the transformer varies

ii. The load varies

A zener diode or a transistor could have been used for this purpose but for simplicity of implementation.

e.) VOLTAGE DIVIDER: Voltage dividing was also an essential part of the supply to provide the +5v and +12v dc needed in the project.

3.3.2 DRIVE CIRCUITRY

The drive circuitry consists of all other parts of the project except the power supply.

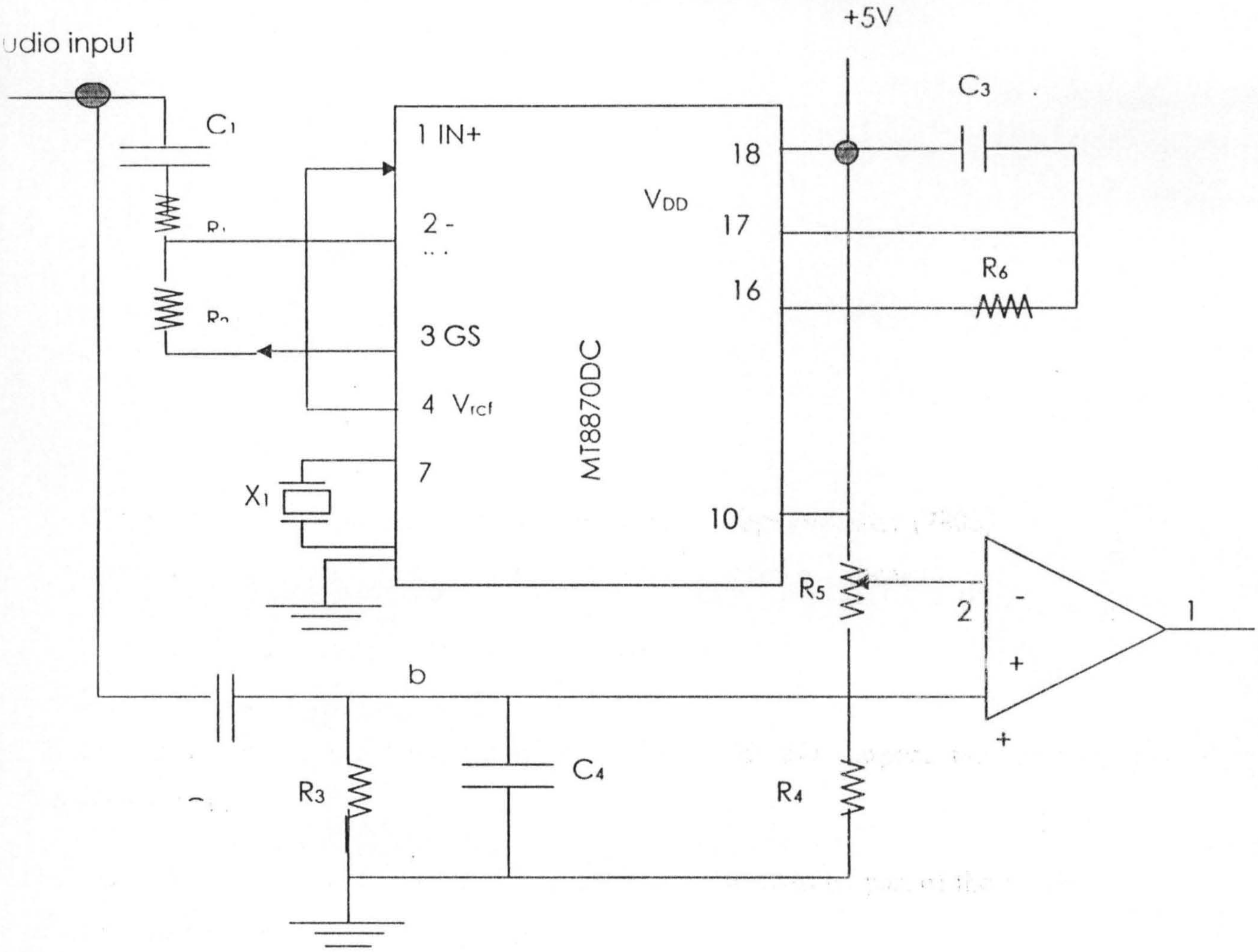


Fig 3.5: A part of drive circuit Comprising the tone decoder and comparator

3.3.2.1 DIFFERENTIAL INPUT

By the manufacturer's specification as explained earlier

$V_{ref} = V_{DD}/2$ ---------------- Equ (3.4)

$= 5/2 = +2.5V$

Thus, +2.5v is fed into the non-inverting input (IN+). Pin 3 of the decoder (Gain select) helps to boost the low audio signal input (300mv – 900mv) to the inverting input (pin 2). This can be understood better by redrawing the circuit as

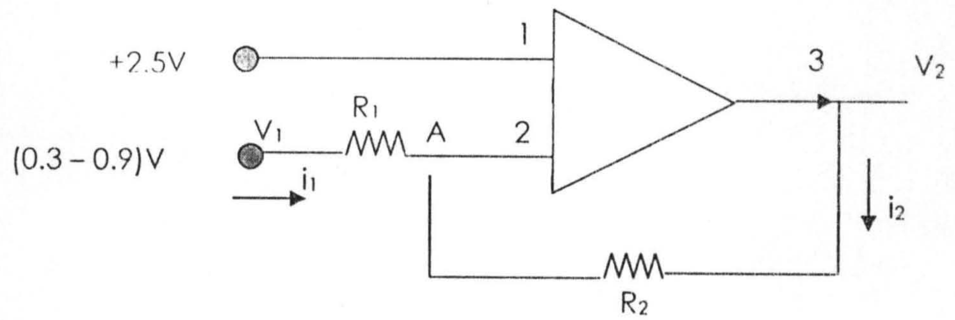


Fig 3.6: A simplified diagram of the differential input configuration.

Since point A is at ground or zero potential

$I_1 + (I_2) = 0$ ---------------------- equ (3.5)

$I_1 = -I_2$

Thus, $V_1/R_1 = -V_2/R_2$ .... equ (3.6)

By re-arranging,

A_v = gain = $V_2/V_1 = -R_2/R_1$ .... equ (3.7)

Thus, we had a choice to vary R_1 and R_2 provided we could obtain a high enough gain to make the differential inputs almost equal.

Accordingly, R_1 and R_2 were chosen as 10k and 100k respectively.

A_v becomes -100/10 = -10.

IN- becomes say 0.3 x -10 = -3v.

C_1 is a filter whose value, 0.1μf, was carefully experimented and chosen to reject any DC (or very low frequency of the ringing signal) component of the audio signal input according to the expression.

$$Xc = 1 \div 2\Pi fc \qquad \text{---------------------- Equ (3.8)}$$

3.3.2.2 CRYSTAL OSCILLATOR

The internal clock circuit of the decoder is completed with the addition of an external 3.579545 MHz crystal with 0.1% tolerance. The tolerance value which is very low must be adhered to during selection for proper functioning of the decoder.

A logic high applied to pin 6 (power down) will power down the device to minimize the power consumption in a standby mode. It stops the oscillator and functions of the filters. So too, logic high input to pin 5 (inhibit mode) will inhibit the detection of tones representing characters A, B, C and D. Since these were not necessary, pins 6 and 5 were left unconnected.

3.3.2.3 STEERING CIRCUIT

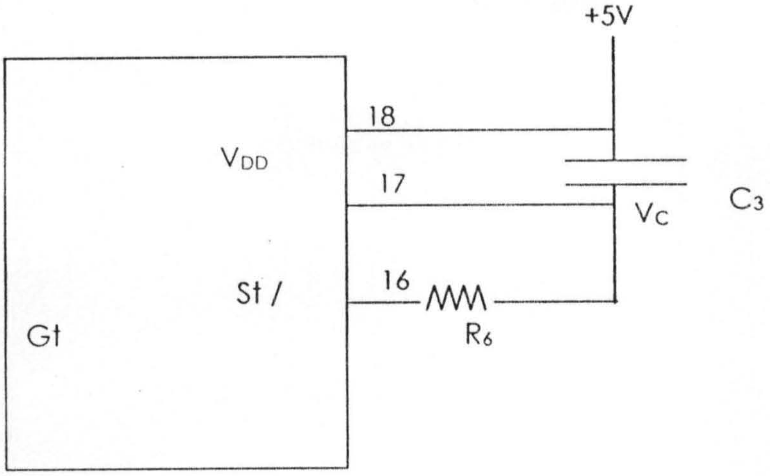


Fig 3.7: The steering circuit of the decoder

The minimum DTMF signal duration required for valid recognition t_{REC} is 40ms.

$t_{REC} = t_{DP} + t_{GTP}$ .... equ (3.9)

If the time to detect the presence of valid DTMF signals, t_{DP} is 14ms (which is within the 5-14ms specified by the manufacturer, then

$t_{REC} = 14ms + t_{GTP}$........................ equ (3.10)

but t_{GTP} = Guide time. tone present is given as RCIn[$V_{DD}/(V_{DD} - V_{Tst})$]................................ equ (3.11)

Where, V_{Tst} = Threshold voltage of v_c shown above in fig 3.7

0.1μf for C_3 is usually recommended for must applications [20]. Thus, the value of R_6 which gave an acceptable value of t_{GTP} was derived as shown below

$$t_{GTP} = RC\ In[V_{DD} \div (V_{DD} - V_{Tst})]$$

$V_{DD} - V_{TsT}$ is taken as approximately IV from experimentation.

Therefore,

$$t_{GTP} = RCIn[V_{DD}]$$

If R = 100k, C = 0.1μf, then

$$t_{GTP} = 0.1 \times 10^{-6}\,(10^5)In[5]$$

$$= 10^{-2}(1.609)$$

$$= 16.1ms$$

Substituting into equation (3.10), gives

$$t_{REC} = 14ms + 16.1ms \qquad = 30.1ms.$$

Since 30.1ms value for t_{REC} is less than the maximum that can be acceptable, our assumed value of R_6 and C_3 are in order.

3.3.2.4 COMPARATOR CIRCUIT

LM358 comparator IC was used because of its high maximum operating temperature (+70^{0}C) and its range of input voltage i.e. -0.3v to +32v [21]. This means that the audio input signal which could range from 0.3v - 0.9v could be effectively compared. A variable resistance of 20k was used. This could be turned to vary the V_{DD} voltage which enters the comparator through pin2.

If the particular phone used has an audio signal of 0.6v, then C_2 and R_3 act as a high pass filter (HPF) which allows the higher frequency ringing signal to pass while rejecting lower noise signals or hum. The series capacitor, C_2 is a coupling capacitor which couples the audio signals to the comparator and simultaneously blocking constant DC voltage. The voltage at point b in fig 3.8 is shown below

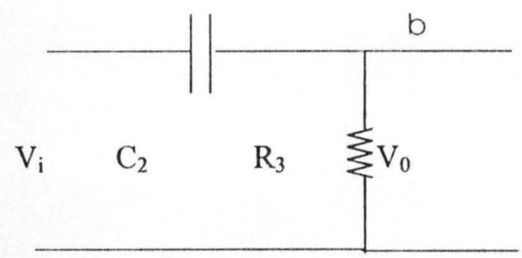


Fig 3.8: The voltage divider circuit

$V_i = IR_T$ --------------------------------- equ (3.12)

$R_T = R - J X_C$ --------------------------- equ (3.13)

$I = V_i \div R_T = Vi \div (R - JX_c)$ .... equ (3.14)

Since $V_0 = iR_3$

$V_O = (V_iR_3 / R) - JX_C$

But V_i ranges from 0.3V to 0.9V

From fig 3.5,

If $V_i = 0.6V$, $C_2 = 122\mu F$ and $R_3 = 10K\Omega$ and $R6 = 0.5K\Omega$, then Xc from equ (3.8) becomes 261Ω and

$V_o = 0.3 \times 10 \times 10^3 \div (10 \times 10^3 - j261)$

$V_o = 3000 \div \sqrt{\{30000^2 + 261^2 [\tan^{-1} (261/30000)]\}}$

$V_o = 6000 \div [30001.14\tan^{-1}(0.0087)]$

$V_o = 3000 \div (30001.14 < 0.5^0)$

$V_o = 30001.14 < 0.5^0$

$V_0 = 0.1999924$

$V_0 \approx 0.2 < -0.5^oV$

Since V_o is within the ± 1.5V to 16V input of the comparator, then our chosen values of C_2 and R_3 are in order. This value of input voltage is passed through C_4 to remove its rippling.

The LM358 input pin 2 has to be near 0.2v for a high at the comparator output. This can be achieved by turning the variable resistor to around 19KΩ as seen in the calculation below;

$V_{DD} = 5v$

Variable Resistance = 20kΩ

Total Resistance in the line = 20.5KΩ

Current to the comparator = 5 / 20500 = 0.244mA

Voltage drop at variable resistor,

$= 20 \times 10^3 \times 0.244 \times 10^{-3} \approx 4.88v.$

This means that the voltage at pin2 of the comparator is = 0.18v which compares well with the 0.1999v at the other input.

For a Nokia phone that has a different audio signal voltage (since Nokia hands free was used). R_5 will have to be retuned for the required differential input to be obtained.

3.3.2.5 MICROCONTROLLER

By the internal design configuration, the microcontroller operates with an external crystal oscillator X_2, in this case a 5.5 MHz crystal, to provide proper timing of the microcontroller operations.

The resistors $R_7 - R_{12}$ were experimented and a suitable value of 4.7k was chosen for them. These enabled keeping the memory clear (MCLR) pin of the micro controller (pin 4) high and trigging of the switching transistors BC945. They also ensure that the maximum load current of the micro controller (28mA) is not exceeded

3.4 WORKING OPERATION OF THE INTERFACE DEVICE

In describing the operation of the project, a block diagram model has been developed. There are different functional modules that are critical to the realization of the cell phone remote control. The first and of course the most vital part is the dual tone multi-frequency (DTMF) decoder. This receives signals from the mobile phones through the phone's audio channels. The tones that are decoded are sent by the mobile phone through any service provider network i.e. MTN, GLOBALCOM, ZAIN, NITEL and M-TEL e.t.c. that has such license and compatibility. The decoder has an in-built intelligent algorithm which enables it to reject noise and stray tones.

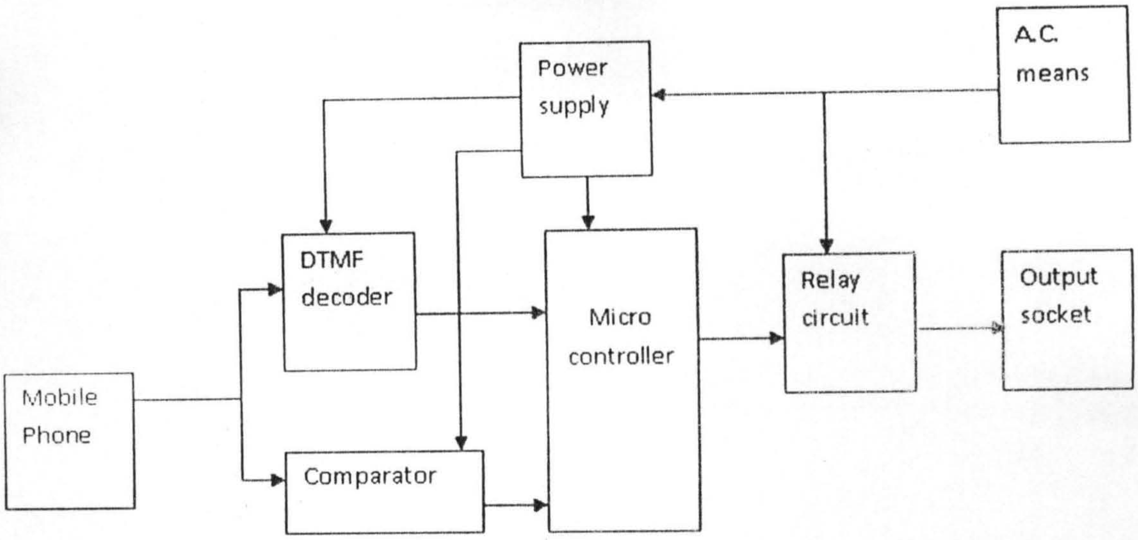


Fig 3.9: Block diagram description of the cell phone remote control

Simultaneously, 0.3 – 0.9V audio output of the phone is fed to a comparator, LM358 and the DTMF decoder. The output of the comparator is sent to the microcontroller. This enables the microcontroller to trigger the relay circuit that automatically accepts the call after a fixed time. These eliminate false calls e.g. flashing. Thus, a high from the comparator means a phone call is in progress while a low indicates that the phone is dormant.

Eventually, when a valid call is detected by the tone decoder, it outputs binary values representing the codes (i.e. numeric or alphanumeric values) sent by the operator. The microcontroller coordinates every signal within the circuitry. The binary signals it receives from the tone decoder are processed and its output are used to trigger the relay circuit according to how it has been programmed. Each of the appliances has its own unique code, programmed into the microcontroller which is used to control them remotely. The binary signals from the decoder are simultaneously fed to the parallel port of the computer which are used to run software.

The relay circuitry contains switching transistors (BC945) and relays that receives signals from the microcontroller. It then switches AC from the mains to the output socket. The transistors aside from been switching devices also boost the signal level into the relays in order for them to be triggered.

The power supply circuit is made up of a step down transformer, a rectifier and a regulator. It delivers regulated DC voltage from the AC mains supply to the tone decoder, micro controller and the comparator.

The output socket consists of sockets used to connect the appliances to the interface device. These are 13-amps sockets. The AC input mains is a regular 220v supply. A two (2) pin plug is used to feed in the 220v supply to the power supply and relays.

3.5 SOFTWARE DESIGN

The construction of this project has two basic parts namely:

- The hardware and
- The software parts

The software requirement is the assembly language hex code necessary to enable the microcontroller to combine the operations of the hardware constituent parts.

The software design was developed using the basic principle of first drawing out the flow chart before writing the source code. The flow chart is shown below and the assembly language source code is shown in the appendix.

The objectives of the software design include;

1.) To ensure that the memory requirement is as low as possible.

2.) To ensure that adequate delay for the proper functioning of the circuitry was incorporated.

3.) To reduce the number of errors to be debugged as much as possible.

4.) To simplify the codes for easy understanding

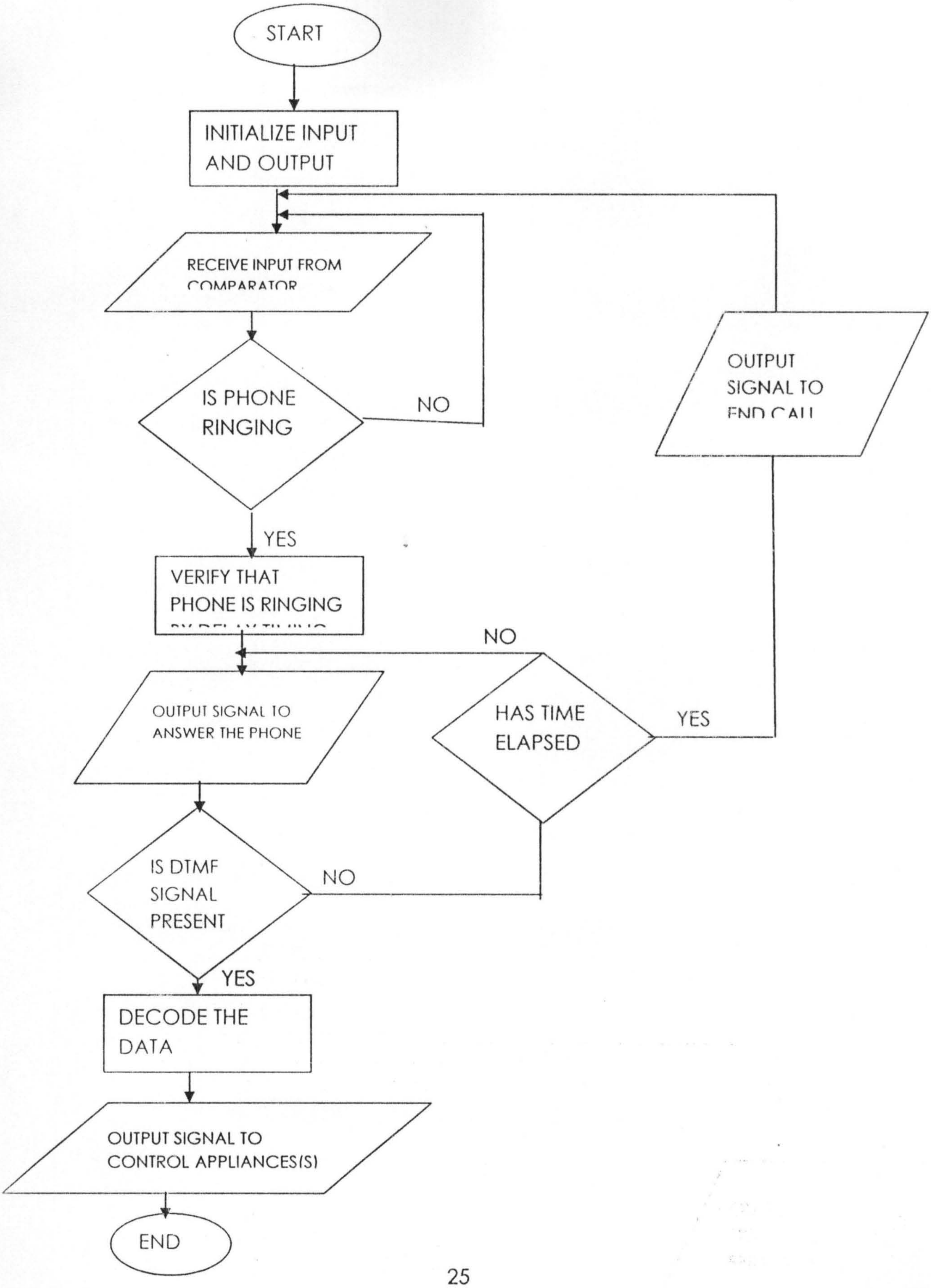
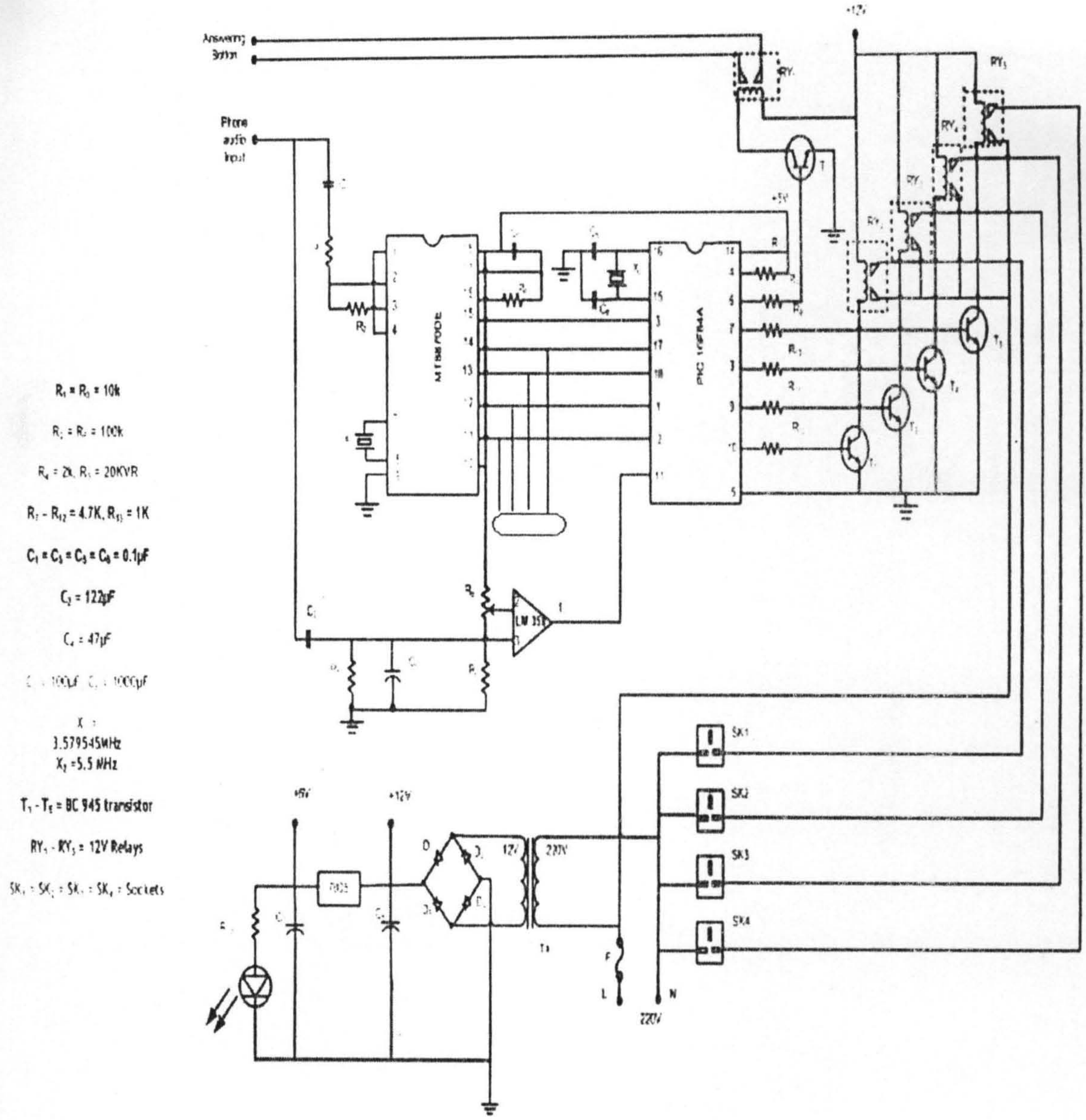


Fig 3.10: A flowchart description of the Micro controller program


Answering Button
Phone audio input
RY₁
RY₂
RY₃
RY₄
RY₅
+12V
+5V
MT8870DE
PIC 16F84A
LM 358
SK1
SK2
SK3
SK4
7805
12V
220V
F
L
N
220V
+5V
+12V
$R_1 = R_3 = 10k$
$R_2 = R_{[illegible]} = 100k$
$R_4 = 2k, R_{[illegible]} = 20KVR$
$R_7 - R_{12} = 4.7K, R_{13} = 1K$
$C_1 = C_3 = C_5 = C_6 = 0.1\mu F$
$C_2 = 122\mu F$
$C_4 = 47\mu F$
[illegible]
$X_1 =$
$3.579545MHz$
$X_2 = 5.5 MHz$
$T_1 - T_5 =$ BC 945 transistor
$RY_1 - RY_5 =$ 12V Relays
$SK_1 = SK_2 = SK_3 = SK_4 =$ Sockets

CHAPTER FOUR

4.0 IMPLEMENTATION AND TESTING

This was a crucial part in the realization of the circuit. Testing of the workability of the project was done in practice on a bread board. This was after the theoretical achievement of the circuit on a work bench. The choice of bread board was for the following reasons;

a.) Easy removal of faulty components

b.) To ensure the whole system worked well

c.) To enhance better planning and space management on the final (Vero) Board.

4.1 POWER SUPPLY IMPLEMENTATION AND TESTING

Sequel to the design of a suitable power supply circuit which has the capacity to deliver a regulated +5v and +12v, the actual implementation was achieved through the steps below;

i.) The components were assembled and tested with a multi-meter to ensure they were in good working condition.

ii.) The board was cleaned to remove dust and oil, in case there were any.

iii.) The position of each component was determined

iv.) The components were carefully soldered to avoid dry joints.

v.) The output of the power supply was tested using a digital multi-meter to confirm it had nearly constant values of +5v and +12v dc.

4.2 MAIN CIRCUITRY IMPLEMENTATION AND TESTING

This was achieved using the same procedure adopted for the power supply. The only difference was that the microcontroller source code was first tested on a microcontroller simulator to verify its correctness.

Again, the outputs of the tone decoder, comparator and microcontroller were all tested to ensure that the correct signals and signal levels where outputted from these components.

4.3 SOLDERING

Components had to be soldered onto the Vero board instead of a printed circuit board. Although, printed circuit board is more reliable and durable (thus it is used for commercial circuits). the Vero board was chosen because it is easy to use.

To ensure good quality soldering, the following precautions were adhered to;

i.) Prior to soldering, the board was cleaned thoroughly to ensure it was free from oil and dust.

ii.) All circuitry and contacts that were not to be soldered were covered with heat resistant materials.

iii.) Care was taken while soldering to avoid damage to components and vero board by using IC sockets and by not applying heat in a localized region.

iv.) After cooling, soldered joints were cleaned and made to have a smooth uniform shiny surface.

4.4 CASING CONSTRUCTION AND ASSEMBLY

The casing was first designed with AutoCAD (any graphic software could be used). This design was then implemented with a cardboard sheet to actually visualize the dimension and shape of the casing.

A plastic casing was used after a number of variables, which broadly fall into two categories, were considered. The categories are;

- Physical factors.
- Environmental factors

4.4.1 PHYSICAL FACTORS

The physical considerations in choosing a plastic casing are;

i.) APPEARANCE: we wanted a final package which is beautiful and physically appealing

ii.) WEIGHT: a casing that should be light weight

4.4.2 ENVIRONMENTAL FACTORS

The environmental factors that also influenced the choice of casing are;

i.) AMBIENT TEMPERATURE: since the device is to be demonstrated in the high tropical area i.e. Minna, the casing should withstand high temperature.

ii.) HUMIDITY: to ensure that the casing does not rust or water does not get into the internal circuitry, the package must be rustproof, resistant and water tight.

iii.) SHOCK AND VIBRATION: due to the adverse effects of shock and vibration, the casing should be spacious, damped and must not be a conductor to prevent shock.

iv.) PESTS AND INSECTS: the casing should be able to withstand the destructive tendencies of pests and insects.

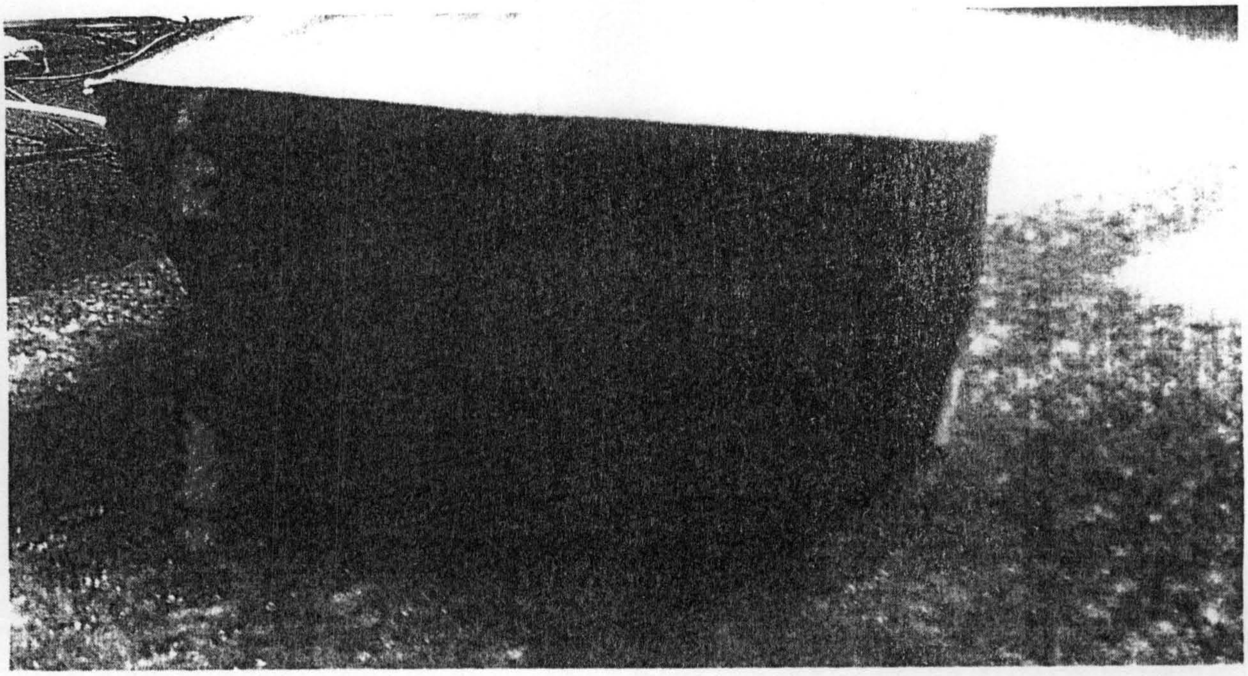


Fig 4.1 casing of the design

4.5 SYSTEM RELIABILITY AND MAINTENANCE

Due to the increasing complexity of modern engineering system, the concept of reliability has become a very important factor in the overall system design. Reliability is important because a designer must design electronic system that will work both in theory and in practice. The general acceptable definition of reliability is that 'Reliability' is the characteristic of systems or components that can be expressed in terms of the probability that it will continue to perform its function over a specific period of time and under specified operating condition [22].

Thus, reliability can be viewed as a measure of successful performance of a system. Reliability which is an inherent characteristic of a system, similar to the system's capacity or power rating, needs to be critically addressed at every stage of the product or system development including design, manufacturing and testing. In the design phase, proper design method relating to the components, material, processes, tolerance and so on, are carefully selected. The objectives at this stage are to ensure that well–established design procedure are applied, known material and processes are used and the areas of uncertainty are highlighted for further actions. When the initial hardware manufacturing are completed, tests are carefully planned, executed and data collected to generate confidence in the design.

Reliability Analysis was not left undone is this design. In fact, right from the beginning of the concept through specifications and design to the implementation of the cell phone remote controller, the system was intended to be reliable. Thus in order to improve reliability, the original complex circuit which included up to seven ICs (DTMF – to – BCD converter, 4-to-16 lines demultiplexer and 5 D flip-flop ICs) was reduced until the present compact design which used only three ICs was arrived at.

4.6 APPLICATIONS

The cell phone remote control is an interesting project which finds a wide range of applications in security and control systems. These include;

a. It could be used in the remote control of industrial and electrical machines without the need to be physically present at the site.
b. It could be used in the remote control of home appliances.
c. It could be used for locking of vehicles in the event of theft.
d. It may be used for opening alternative exit door during emergency situations in big buildings and factories.
e. During burglary actions, it may be used activate security alert systems.

4.7 PROBLEMS ENCOUNTERED

The various difficulties experienced during the construction of the project include

i. The audio signal level of different phones varies considerably. Thus, it was difficult to set the variable resistor, R_5 value to a accommodate a number of mobile phones

ii. The DTMF crystal oscillator, X_1 with a value of 3.579545 MHz was not easy to find especially due to the high precision required.

iii. The DTMF decoder was not readily available in market which posed a lot of delay in the construction.

iv. The erratic nature of power supply posed some difficulties during soldering.

CHAPTER FIVE

5.0 CONCLUSION

5.1 SUMMARY OF WORKDONE:

From the preceding chapters, an attempt to explain the design and implementation of the cell phone remote control has been made. This involves the description of the concept of mobile phone remote control, the dual tone multi-frequency and the various types of remote control systems and the description of the various components used.

The project also involved understanding the objectives, considerations, design calculations used as well as the microcontroller assembly language.

5.2 RECOMMENDATIONS

The aim of the students' project work is to enhance the creativity and understanding of engineering concepts by students. The following recommendations can help in this regards.

i. A USB port can be used to further improvement on the design in other increase the compatibility of the control unit with other systems.

ii. It is recommended that an alternate source of power be used to power the circuit and devices to be controlled to ensure efficient control.

iii. The departments through the university should seek industrial and corporate sponsorship for students' projects and good token awarded for good and quality projects as a way of encouraging younger students.

REFERENCE

1. "LM358 datasheet", available: www.fairchildsemi.com (6/06/2008)
2. Anupam Baid, *Opening up powerful lines of communication*, IEEE potentials, Vol.24, No.5, pp. 41-45, September 2008.
3. Blackburn J.L; *Protective Relaying, Principles and Application*, 2nd ed, 1997
4. Free web encyclopedia on dtmf, available: http://en.wikipedia.org/DTMF (24/09/2008)
5. Harris F.K; *Electrical measurement*, reprint 1975
6. Horowitz P. and Hill W., *The Art of Electronics*, 2nd ed 1995, Cambridge University press, pp.4-5
7. http://electrosofts.com/dtmf/index.html (12/07/2008)
8. http://microchip.com (11/10/2008)
9. http://www. Answer. Com/ topic/ remote control (6/07/2008)
10. http://www.sbproject.com/knowledge/ir/ir.htm (12/08/2008)
11. http://www.scadalink.com/scada.htm (12/09/2008)
12. Karser C.J, *The capacitor Handbook*, 2nd Ed. 1995.
13. Malvino W., *Electronic principles*, 3rd edition, McGraw-Hill, pp.608
14. McGraw-Hill Encyclopedia of science and technology
15. *MT8870D/MT8870D-1 integrated DTMF receiver*, available: www.datasheet.com (15/10/2008)
16. RAO S.S, *Reliability- Based Design*, 1992, McGraw-Hill Inc, pp. 2-3
17. Rockis Gray, *Residential Wiring*, 1978, American Technical publishers Inc., pp. 68-69
18. Say M.G (ed), *Electrical Engineer's Reference Book*, 15th ed, 1993.
19. Singh L.P., *Digital Protection: Protective Relaying from Electromechanical to Microprocessor*
20. Theraja B.A and Theraja A.K; *Electrical engineering technology*, S. chand and company limited, New Delhi, pp.2220
21. Theraja B.L and Theraja A. K; *A textbook of Electrical Technology*, S. chand and company limited, New Delhi, pp.1938
22. William L. Faissler, *An introduction to modern electronics* 2nd edition, John Wiley and Sons Inc., pp.331

APPENDIX

SOURCE CODE

```
******************************************
Dim cnt As Variant
Private Sub answer Timer()
If lab.BackColor = vbGreen Then
lab.BackColor = vbRed
pik.Enabled = True
Else
lab.BackColor = vbGreen
End If
End Sub

Private Sub blink_Timer()
If blina.BackColor = vbGreen Then
blina.BackColor = vbRed
Out (&H378), 1
Else
blina.BackColor = vbGreen
Out (&H378), 0
End If
End Sub

Private Sub blinkb_Timer()
If blinb.BackColor = vbGreen Then
blinb.BackColor = vbRed
Out (&H378), 5
Else
blinb.BackColor = vbGreen
Out (&H378), 0
End If

End Sub

Private Sub Form_Load()
lab.BackColor = vbGreen
cnt = 0
Out (&H378), 0
Out (&H37A), 192 'set CONTROL LINE LOW
End Sub

Private Sub getinput_Timer()
```

```
x = Inp(&H379)

If x = 119 Then
screen.Text = 1
realdata.Text = "0001"
L1.BackColor = vbRed
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen

ElseIf x = 111 Then
screen.Text = 2
realdata.Text = "0010"
L1.BackColor = vbGreen
L2.BackColor = vbRed
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen

ElseIf x = 103 Then
screen.Text = 3
realdata.Text = "0011"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbRed
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen

ElseIf x = 95 Then
screen.Text = 4
realdata.Text = "0100"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbRed
L5.BackColor = vbGreen
```

```
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen
ElseIf x = 87 Then
screen.Text = 5
realdata.Text = "0101"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbRed
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen
ElseIf x = 79 Then
screen.Text = 6
realdata.Text = "0110"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbRed
L7.BackColor = vbGreen
L8.BackColor = vbGreen
ElseIf x = 71 Then
screen.Text = 7
realdata.Text = "0111"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbRed
L8.BackColor = vbGreen
ElseIf x = 63 Then
screen.Text = 8
realdata.Text = "1000"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
```

```
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbRed

ElseIf x = 55 Then
screen.Text = 9
realdata.Text = "1001"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen

ElseIf x = 47 Then
screen.Text = 0
realdata.Text = "1010"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen

ElseIf x = 39 Then
screen.Text = "*"
realdata.Text = "1011"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen
End If

If x = 112 Then
screen.Text = 1
```

```
realdata.Text = "0001"
L1.BackColor = vbRed
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen

ElseIf x = 104 Then
screen.Text = 2
realdata.Text = "0010"
L1.BackColor = vbGreen
L2.BackColor = vbRed
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen

ElseIf x = 96 Then
screen.Text = 3
realdata.Text = "0011"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbRed
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen

ElseIf x = 88 Then
screen.Text = 4
realdata.Text = "0100"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbRed
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen
```

```
ElseIf x = 80 Then
screen.Text = 5
realdata.Text = "0101"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbRed
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen


ElseIf x = 72 Then
screen.Text = 6
realdata.Text = "0110"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbRed
L7.BackColor = vbGreen
L8.BackColor = vbGreen

ElseIf x = 64 Then
screen.Text = 7
realdata.Text = "0111"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbRed
L8.BackColor = vbGreen

ElseIf x = 56 Then
screen.Text = 8
realdata.Text = "1000"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
```

```
L7.BackColor = vbGreen
L8.BackColor = vbRed

ElseIf x = 48 Then
screen.Text = 9
realdata.Text = "1001"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen

ElseIf x = 40 Then
screen.Text = 0
realdata.Text = "1010"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen

ElseIf x = 32 Then
screen.Text = "*"
realdata.Text = "1011"
L1.BackColor = vbGreen
L2.BackColor = vbGreen
L3.BackColor = vbGreen
L4.BackColor = vbGreen
L5.BackColor = vbGreen
L6.BackColor = vbGreen
L7.BackColor = vbGreen
L8.BackColor = vbGreen

End If


End Sub
```

```
Private Sub pik_Timer()
cnt = cnt + 1
If cnt = 1 Or 2 Or 3 Or 4 Or 5 Or 6 Or 7 Or 8 Then
Lab1.BackColor = vbRed
Out (&H37A), 196 'set pin 16 HIGH
sho.Text = cnt
Else
Lab1.BackColor = vbGreen

End If


If cnt = 10 Then
cnt = 0
sho.Text = cnt
Lab1.BackColor = vbGreen
Out (&H37A), 192 'set the CONTROL LINE LOW
pik.Enabled = False
End If
End Sub

Private Sub putout_Timer()
If L1.BackColor = vbRed Then
Out (&H378), 1
MMControl2.Command = "close"
MMControl3.Command = "close"
MMControl4.Command = "close"
MMControl5.Command = "close"
MMControl6.Command = "close"
MMControl1.Command = "open"
MMControl1.Command = "play"

ElseIf L2.BackColor = vbRed Then
Out (&H378), 4
MMControl1.Command = "close"
MMControl3.Command = "close"
MMControl4.Command = "close"
MMControl5.Command = "close"
MMControl6.Command = "close"
MMControl2.Command = "open"
MMControl2.Command = "play"

ElseIf L3.BackColor = vbRed Then
Out (&H378), 5
MMControl1.Command = "close"
MMControl2.Command = "close"
```

```
MMControl4.Command = "close"
MMControl5.Command = "close"
MMControl6.Command = "close"
MMControl3.Command = "open"
MMControl3.Command = "play"

ElseIf L4.BackColor = vbRed Then
blink.Enabled = True
blinkb.Enabled = False
MMControl1.Command = "close"
MMControl2.Command = "close"
MMControl3.Command = "close"
MMControl5.Command = "close"
MMControl6.Command = "close"
MMControl4.Command = "open"
MMControl4.Command = "play"

ElseIf L5.BackColor = vbRed Then
blinkb.Enabled = True
blink.Enabled = False
MMControl1.Command = "close"
MMControl2.Command = "close"
MMControl3.Command = "close"
MMControl4.Command = "close"
MMControl6.Command = "close"
MMControl5.Command = "open"
MMControl5.Command = "play"

ElseIf L1.BackColor = vbGreen Or L2.BackColor = vbGreen Or L3.BackColor = vbGreen Or L4.BackColor = vbGreen Or L5.BackColor = vbGreen Or L6.BackColor = vbGreen Or L7.BackColor = vbGreen Or L8.BackColor = vbGreen Then
Out (&H378), 0
MMControl1.Command = "close"
MMControl2.Command = "close"
MMControl3.Command = "close"
MMControl4.Command = "close"
MMControl5.Command = "close"
MMControl6.Command = "open"
MMControl6.Command = "play"
blina.BackColor = vbGreen
blinb.BackColor = vbGreen
blink.Enabled = False
blinkb.Enabled = False
MMControl1.Command = "close"
MMControl2.Command = "close"
MMControl3.Command = "close"
```

```
MMControl4.Command = "close"
MMControl5.Command = "close"


Else
Out (&H378), 0
blink.Enabled = False
blinkb.Enabled = False
End If
End Sub
```