DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING FEDERAL UNIVERSITY, OYE EKITI,

DESIGN AND CONSTRUCTION OF A MICROCONTROLLLER BASED REMOTE CONTROLLER FOR FAN AND LIGHTING SYSTEM WITH LCD INDIATOR

BY

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A PROJECT PRESENTED TO THE DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING, FEDERAL UNIVERSITY, OYE EKITI, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR DEGREE IN ELECTRICAL AND ELECTRONICS ENGINEERING (B.ENG)

SEPTEMBER, 2016

DECLARATION

I declare that this project was carried out by me under the supervision of Dr. O. Akinsanmi of the Department of Electrical and Electronics Engineering, Federal University, Oye Ekiti, as part of the requirement for the award of Bachelor Degree of Electrical and Electronics Engineering. Sources of Information are specifically acknowledged by means of reference. I solemnly declare that this work has not been submitted elsewhere for the award of any Degree.

.... 26/10/16

Signature Date

CERTIFICATION

This is to certify that this project work has been read and found worthy of approval, having met the requirement of the department Of Electrical and Electronics, Federal University, Oye Ekiti, for the award of Bachelor of Electrical Engineering (B. Eng) degree.

.... 28/10/2016 ....

Dr. O. Akinsanmi

(Project Supervisor)

Date

.... 28/10/2016 ....

Dr. O. Akinsanmi

(Head of Department)

Date

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External Supervisor

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Date

DEDICATION

This project is dedicated to God Almighty for His mercy, grace and guidance over me.

ACKNOWLEDGEMENT

With Sincerity, I acknowledge God Almighty for seeing me through my period of study in FUOYE. It has been by his grace and mercy.

I am deeply grateful to Dr. A.O Akinsanmi, my supervisor for his assistance and fatherly advice towards the success of this project.

I whole heartedly appreciate my Parents and Siblings, Pastor and Mrs. Bomodeoku, Ifedolapo Bomodeoku, Olamide Bomodeoku, and Oladipupo Bomodeoku. I say thanks for being there for me financially at all times, you are the best family members in the world. I love you all. My gratitude also goes to all lecturers in the Department.

I would like to appreciate all the members of staff in the department of Electrical and Electronics Engineering for their moral and technical support. I say God bless you.

ABSTRACT

This report presents a design and implementation of a microcontroller based remote controller for fan and lighting system with LCD indicator. It enables the user to switch ON and OFF the fan and lighting system from approximately 6 meters. The entire system is based on microcontroller that makes the control system smarter and easy to modify. The system ranges from a power supply unit to the control unit and the display unit which indicates when the system is turned ON or OFF. In this project, the loads applied include a 20W bulb and a 30W fan. The system was tested repeatedly and it worked well. This project finds its application in the switching on/off of both bulbs and fan which can be found at homes, offices, industries, schools, etc.

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ABBREVIATIONS

LCD ....Liquid Crystal Display

PIC ....Peripheral Interface Controller

EEPROM ....Erasable Electrical Programming Read Only Memory

RAM...Read Access Memory

RISC ....Reduced Instruction Set Computer

GPR...,,,...............................General Purpose Register

SFR..,,,...............................Special Function Registers

AC..Alternating current

DC ....Direct Current

IC...Integrated Circuit

NPN...Negative Positive Negative

PNP...,,,,................Positive Negative Positive

CMOS ....Complementary Metal Oxide Semiconductor

TTL...Transistor-Transistor Logic

FPGA ....Field-Programmable Gate Array

CRT... Cathode Ray Tube

FSR .... Feedback Shift Register

CHAPTER ONE

GENERAL INTRODUCTION

1.1 PREAMBLE

The need for a remote control system that can control domestic appliances and various lighting points has often been a concern for users. At times users find it inconvenient and time consuming to go around turning their appliances on or off each time there is power outage or each time they are leaving the house for work. It has also often led to damage of appliances due to the fact that an appliance was not turned off before leaving the house.

Remote control facilitates the operation of fan regulators around the home or office from a distance. It provides a system that is simple to understand and operate, a system that would be cheap and affordable, a reliable and easy to maintain system of remote control and durable system irrespective of usage. It adds more comfort to everyday living by removing the inconvenience of having to move around to operate a fan regulator and lighting systems. The solution seeks to develop a system that is cost effective while not undermining the need for efficient working.

The Objective of putting up this project, therefore, is to design an equipment that can facilitate a convenient and easy way of controlling our fan and lighting points, without always going to the appliances physically by ourselves.

1.2 PROJECT MOTIVATION

The ease of putting our fans and lighting points on or off has made it necessary to develop this system in order to control our fans and lighting points from a central point using a remote control.

1.3 AIM & OBJECTIVES

The aim of this project is to design, construct and implement a modest model of a remote control for fan and lighting system.

The objectives for this project include:

- To design an equipment that can facilitate a convenient and easy way of controlling our fan and lighting points.
- To understand the hypothesis involved in how the remote control system works.

1.4 BLOCK DIAGRAM OF PROJECT

The approach used in this work is the modular approach where the overall design was broken into functional block diagrams, where each block in the diagram represents a section of the circuit that carries out a specific function. The system was subdivided into two sections, the transmitting and the receiving section. The transmitting section was designed using 3 functional blocks, as shown in the block diagram Figure.1.1, while the receiving section was designed using 7 functional blocks, as shown in block diagram Figure.1.2.

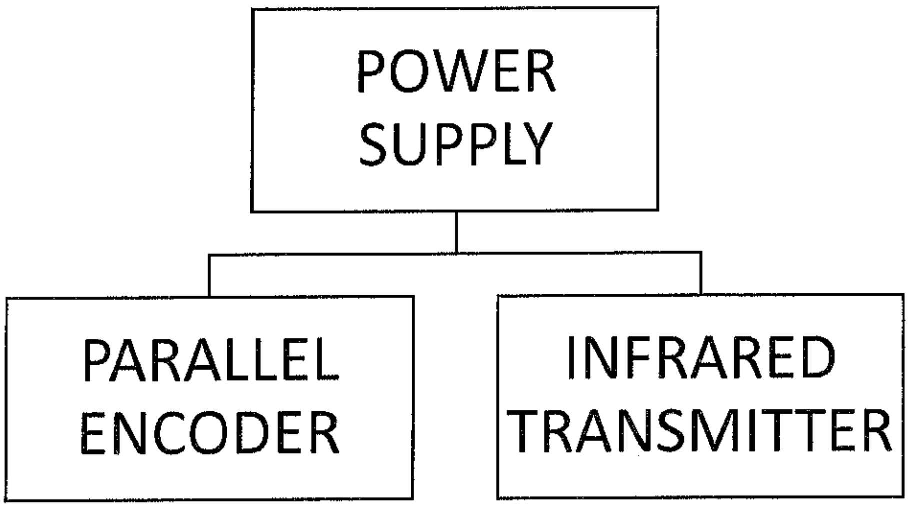


Figure.1.1 Transmitter

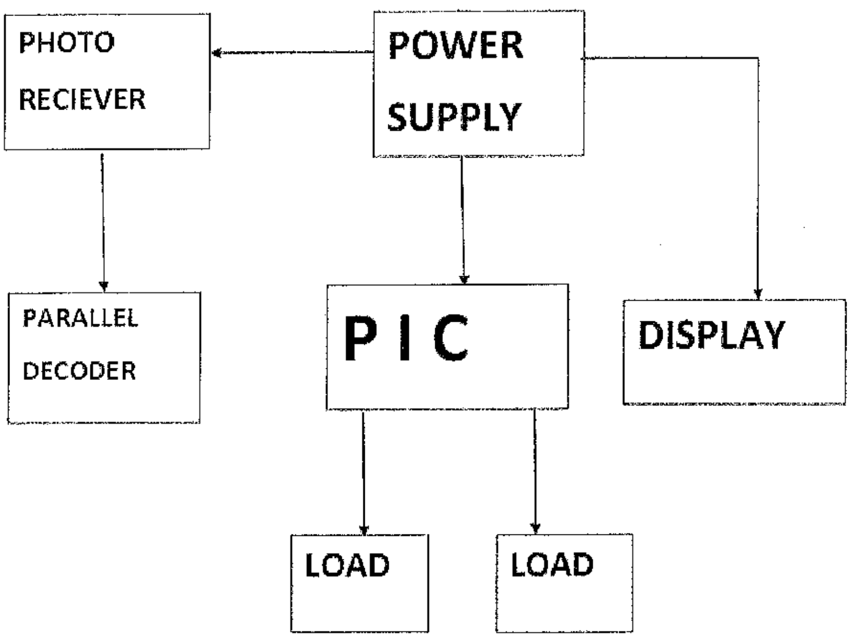


Figure.1.2 Receiver

1.5 REPORT OUTLINE

Chapter two comprises of the source of the materials used in designing and writing the project report, data analysis; the components and devices used in the course of designing this project will be analysis to know their basic means of operation and how they will help in putting up this design.

Chapter three is centered on the hardware components used and their physical realization on the overall circuitry and software design which consist of the various stages of development.

Chapter four talks about the construction of the project and also the final testing of the whole work.

Chapter five states the significance of this project, its advantages, limitations and recommendations for further work.

CHAPTER TWO

THEORETICAL BACKGROUND

2.1 INTRODUCTION

The primary objective of this chapter is to give sufficient insight on the theory and principles upon which the components used in this project are based. This involves the essential description of the PIC16F84A microcontroller which comes from the PIC family.

2.2 LITERATURE REVIEW

The first remote intended to control a television was developed by Zenith Radio Corporation in the early 1950's and made use of wire to connect to the television set. [1] The remote was unofficially called "Lazy Bones", a wire was used to connect to the television set. The Flashmatic also required that the remote control be pointed accurately at the receiver. In 1956 Robert Adler developed "Zenith Space Command", a wireless remote which was mechanical and used ultrasound to change the channel and volume.

Most modern remote control systems for appliances use infrared diode to emit a beam of light that reaches the device or equipment.

Enormous advances have been made in the design and construction of remote controls for fan and lightening systems and some other house hold appliances. Various works have also been carried out in the use of microcontrollers to design circuits.

In [2], designed a remote controlled fan regulator. His design did not include the use of a microcontroller, this made his design cumbersome.

In [3], also designed and constructed a remote controlled fan regulator.

Microcontroller based designs of remote controls includes the work of [4], where remote control signal decoder for home application was implemented. The limitation that faced by this work is the inability to know when the decoder was in the ON/OFF state.

2.3 PIC16F84A MICROCONTROLLER

PIC16F84 belongs to a class of 8-bit microcontrollers of Reduced Instruction Set Computer (RISC) architecture. PIC16F84A belongs to the mid-range family of the PIC microcontroller devices, the program memory contains 1K words, which translates to 1024 instructions, and since each 14-bit program memory word is the same width as each device instruction. The data memory (RAM) contains 68 bytes. DATA EEPROM is 64 bytes. There are also 13 I/O pins that are user-configured on a pin-to-pin basis. Some pins are multiplexed with other device function. These functions include:

i. External interrupt

ii. Change on PORT B interrupt

iii. Timer 0 clock input

Figure.2.1 shows the pin configuration of the PIC16F84A, for further explanation on each pin description, see Appendix A. [5]

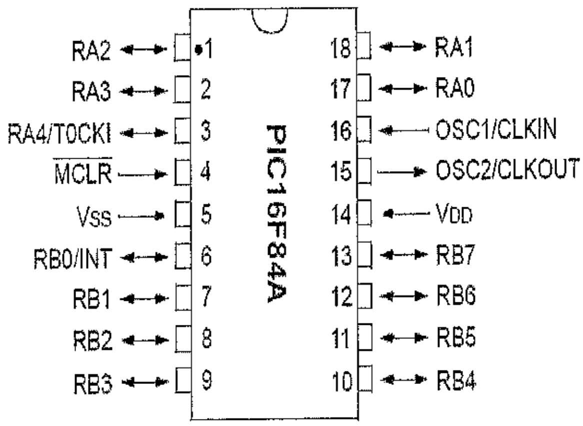


Figure 2.1: Pin configuration of PIC16F84A [5]

Figure 2.2 shows the block diagram of the PIC16F84A. The program memory contains 1K words, which translates to 1024 instructions, since each 14-bits program memory word is the same width as each device instruction. The data memory (RAM) contains 68 bytes. Data EEPROM is 64 bytes. [6]

There are also 13 I/O pins that are user-configured on a pin-to-pin basis. Some pins are multiplexed with other device functions. These functions include:

- External interrupt
- Change on PORTB interrupt
- Timer0 clock input

Table A details the pinout of the device with descriptions and details for each pin.

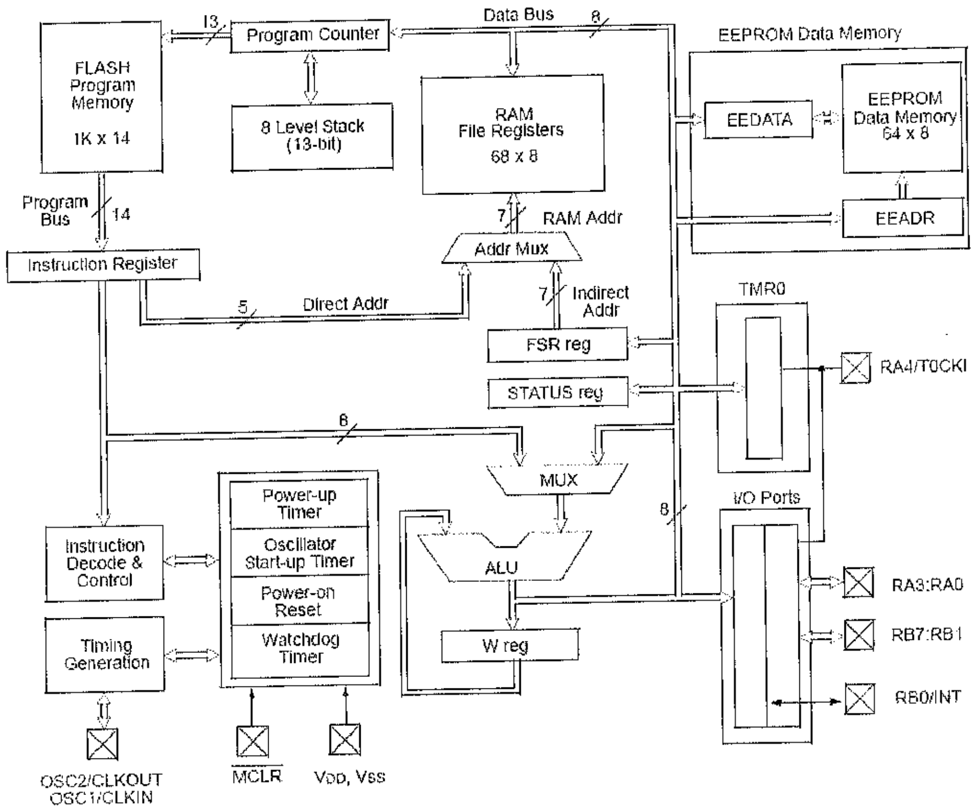


Figure 2.2: Block diagram if PIC16F84A [6]

2.4 LCD 16×2 DESCRIPTION AND PIN DIAGRAM

A liquid crystal display (LCD) is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals (LCs). LCs do not emit light directly. They are used in a wide range of applications, including computer monitors, television, instrument panels, aircraft cockpit display, signage, etc. They are common in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephone. LCDs have displaced cathode ray tube (CRT) displays in most applications. They are usually more compact, lightweight, portable, less expensive, more reliable, and easier on the eye. They are available in a wider range of screen size than CRT and plasma displays, and since they do not use phosphors, they cannot suffer image burn-in.

LCDs are more energy efficient and offer safer disposal than CRTs. Its low electrical power consumption enables it to be used in battery-powered electronics equipment. It is an electronically-modulated optical device made up of any number of pixels filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in colour or monochrome. The earliest discovery leading to the development of LCD technology, the discovery of liquid crystals, dates from 1888. [6] By 2008, worldwide sales of television with LCD screens had surpassed the sale of CRT units.

A 16×2 LCD means it can display 16 characters per line and there are 2 such lines. In this project, the LCD displays when the decoder is in either the ON or OFF state. This LCD has two registers. Figure 2.3 shows a visual display of the LCD. [2] Table 2.1 below shows the pin description of the LCD 16×2.

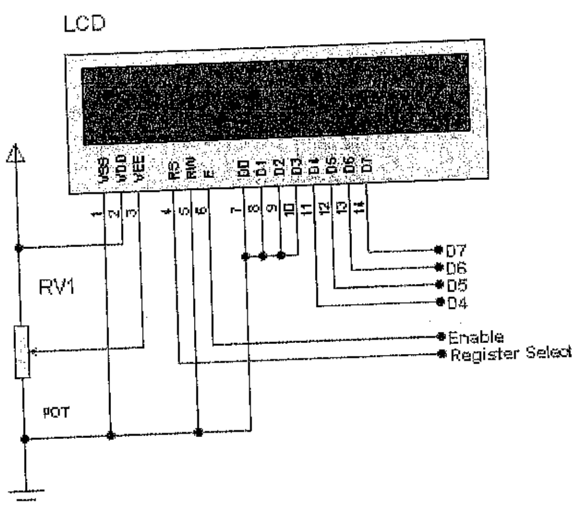


Figure 2.3 LCD

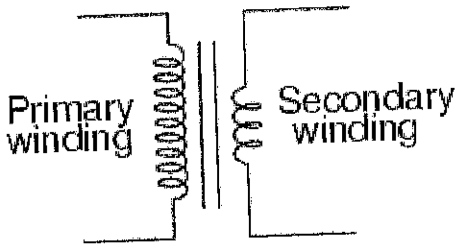
Table 2.1: Pin description of LCD

Pin	Symbols	Description	
1	VSS	Ground	0v
2	VCC	Main power supply	+5v
3	VEE	Power supply to control contrast	Contrast adjustment by providing a variable resistor through VCC RS=0 to select command register
4	RS	Register select	RS=1 to select data register
5	R/W	Read/write	R/W=0 to write to the register R/W=1 to read from the register
6	EN	Enable	A high to low pulse (minimum

			450ns wide) is given when data is sent to data pins
7	DB0	To display letters or numbers, their ASCII codes are sent to data pins (with RS=1). Also instruction command codes are sent to these pins.	8-bit data pins
8	DB1		
9	DB2		
10	DB3		
11	DB4		
12	DB5		
13	DB6		
14	DB7		
15	Led+	Backlight VCC	+5v
16	Led-	Backlight ground	0v

2.5 TRANSFORMERS

A transformer is a device consisting of two closely coupled coils (called primary and secondary). An ac voltage applied to the primary appears across the secondary, with a voltage multiplication proportional to the turns ratio of the transformer and a current multiplication inversely proportional to the turns ratio. Figures 2.4 shows the circuit symbol for a laminated-core transformer (the kind used in this design- 50Hz ac power conversion).



Figures 2.4. Circuit symbol of a Transformer

Transformers are quite efficient (output power is very nearly equal to input power); thus, a step-up transformer gives higher voltage at lower current. A transformer of turns ratio n increases the impedance by n^2. There is very little primary current if the secondary is unloaded.

Transformers serve two important functions in electronic devices:

They change the ac line voltage to a useful (usually lower) value that can be used by the circuit, and they "isolate" the electronic device from actual connection to the power line, because the windings of a transformer are electrically insulated from each other.

Power transformers (meant for use from the 220V power line) come in an enormous variety of secondary voltages and currents: output as low as 1 volt or so up to thousand volts, current ratings from a few milliamps to hundreds of amps.

2.6 TRANSISTOR

Transistors can be regarded as a type of switch, as can many electronic components. They are used in a variety of circuits and you will find that it is rare that a circuit built in a school Technology Department does not contain at least one transistor. They are central to electronics and there are two main types; NPN and PNP. Most circuits (e.g. this project design) tend to use NPN. There are hundreds of transistors which work at different voltages but all of them fall into these two categories. [7]

There are two types of standard transistors, NPN and PNP, with different circuit symbols. The letters refer to the layers of semiconductor material used to make the transistor. Figure 2.5 shows the circuit symbol of a NPN and PNP transistor.

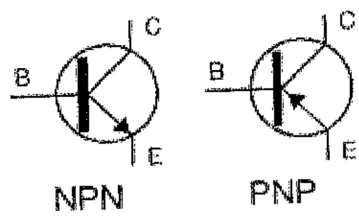


Figure 2.5: Transistor circuit symbols

The leads are labeled base (B), collector (C) and emitter (E).

An NPN transistor 2N222 is required to supply the required current to drive the circuit.

2.7 RELAYS

A relay is a switch worked by an electromagnet. It is useful if we want a small current in one circuit to control another circuit containing a device such as a lamp or electric motor which requires large current, or if we wish several different switch contacts to be operated simultaneously.

The structure of a relay and its symbol are shown in Figure. 2.7 and Figure. 2.8 respectively. When the controlling current flows through the coil, the soft iron core is magnetized and attracts the L-shaped soft iron armature. This rock on its pivot and opens, closes or changes over, the electrical contacts in the circuit being controlled it closes the contacts. The current needed to operate a relay is called the *pull-in* current and the *dropout* current is the current in the coil when the relay just stops working.

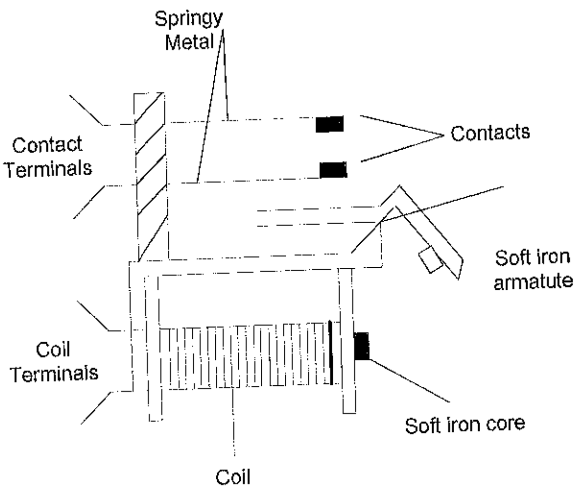


Figure. 2.6: Structure of a relay

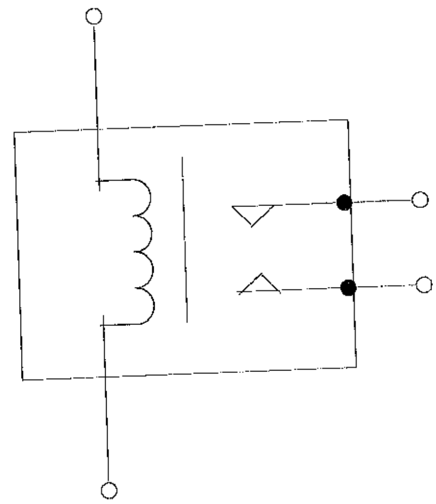


Figure. 2.7: Symbol of a relay

2.8 INFRA RED TRANSMITTERS AND RECIEVERS

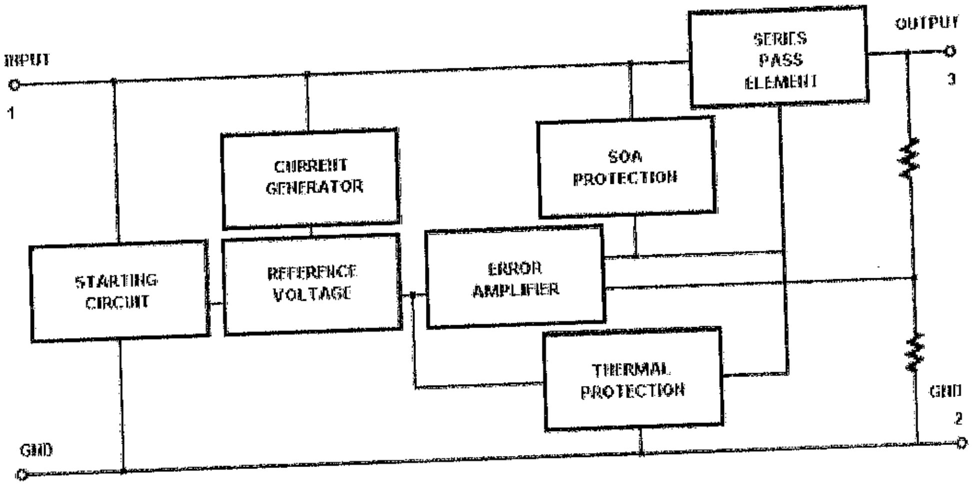
Infrared (IR) radiation is electromagnetic radiation of a wavelength longer than that of visible light, but shorter than that of radio waves. The name means "below red" (from the Latin *infra*, "below"), red being the color of visible light of longest wavelength. Infrared radiation spans three orders of magnitude and has wavelengths between approximately 750 nm and 1 mm. Infra-red light is just below the red portion of the visible spectrum, and so is invisible to the human eye. Infrared transmitters are the devices that transmit signals through Infrared and these signals are received by Infrared receivers. Infrared receivers are signal sensors which are capable of receiving infrared rays and is able to transform this rays to an intended function.

2.9 VOLTAGE REGULATOR

A Voltage Regulator (also called a "regulator") has only three legs and appears to be a comparatively simple device but it is actually a very complex integrated circuit. A regulator converts varying input voltage and produces a constant "regulated" output voltage. Voltage regulators are available in a variety of outputs, typically 5 volts, 9 volts and 12 volts. The last two digits in the name indicate the output voltage. The "LM78XX" series of voltage regulators are designed for positive input.

Table 2.2: Voltage regulators and their voltages

Name	**Voltage**
LM7805	+ 5 volts
LM7809	+ 9 volts
LM7812	+ 12 volts
LM7905	- 5 volts
LM7909	- 9 volts
LM7912	- 12 volts



Figures 2.8: Block diagram of internal configuration of LM 7805 Voltage regulator

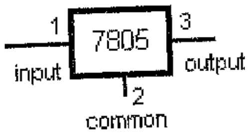


Figure 2.9: Circuit symbol of a typical Voltage Regulator

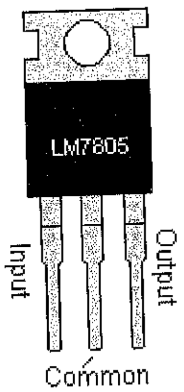


Figure 2.10: Physical appearance of a typical 5V Voltage Regulator

CHAPTER THREE

SOFTWARE AND HARDWARE DESIGN

3.1 INTRODUCTION

In this Chapter, the steps taken to design the component used is discussed. In addition, the software that will control the hardware aspects of the embedded application written in assembly language using the PIC instructions is also presented. The hardware design involves the integration of selected and designed sub-units together with analysis and calculations made at various stages of the design; all these are presented in this chapter.

3.2 CIRCUIT DIAGRAM

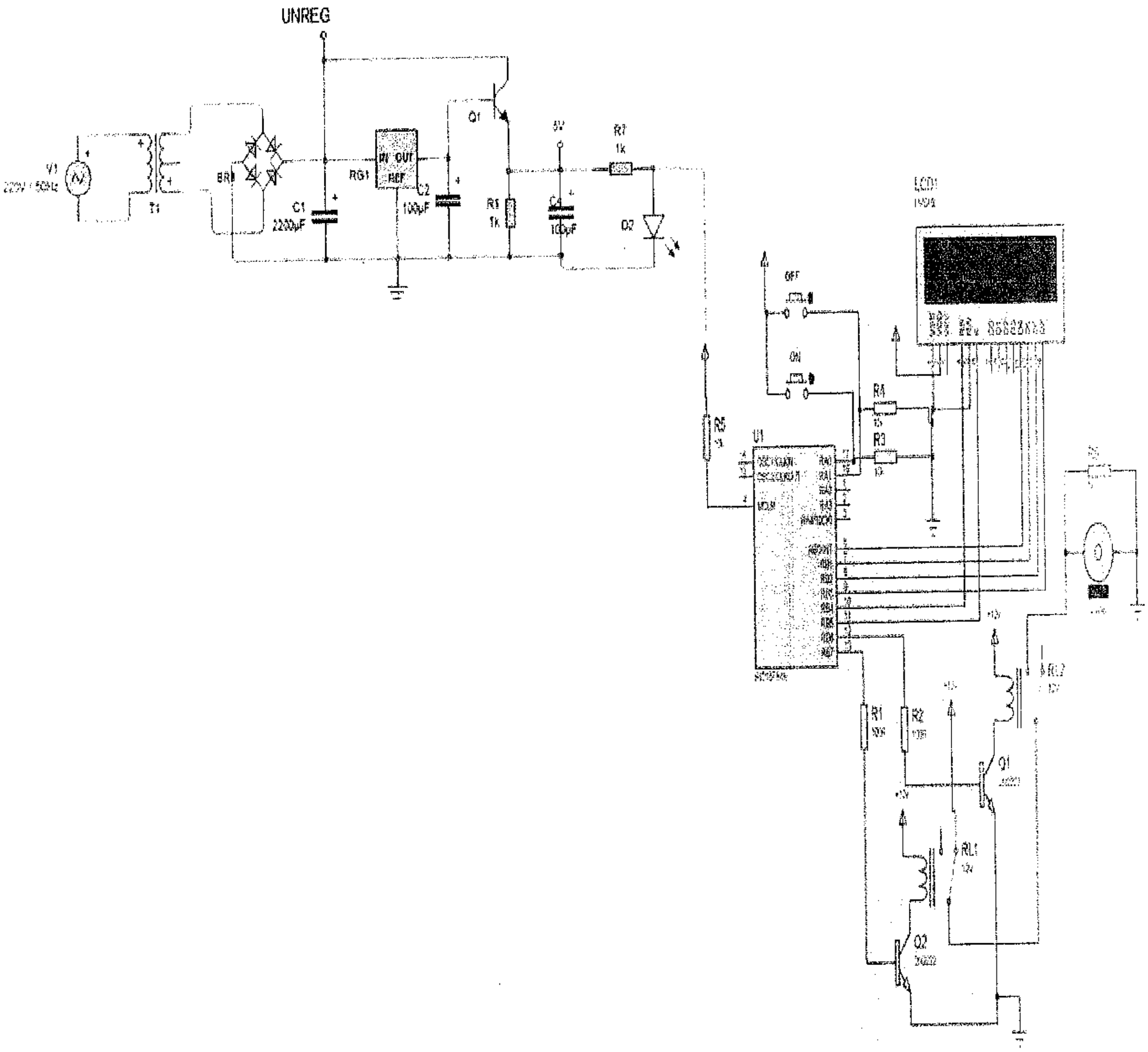


Figure 3.1: Circuit Diagram

3.3 PRINCIPLE OF OPERATION

Figure 3.1 shows the circuit diagram. The 220 V from AC mains is stepped down to 12V and Regulated by IC7805, capacitor and Diodes to 5V. This filtered 5V is used for providing supply to the entire circuit. Any button of remote control can be used to turn ON and OFF the attached load which is the fan and lighting system. The remote control produces infrared rays which is received by the TSOP infrared receives module. The TSOP used here is TSOP 1738. It is capable for receiving signals up to 38 KHZ, the remote control range is approximately 6 meters.

The infrared rays are received by the TSOP sensor and its output is given as a trigger to the microcontroller through a LED and Resistor R3 and R4. The microcontroller triggers the relays which switches the loads ON and OFF.

3.3.1 BASIC POWER SUPPLY DESIGN

Let start with the power supply design. Basically, it employs a 5V regulated power supply that powers the microcontroller which needs nothing but a 5V and the NPN transistors used. A 12V supply is also used in the design which is meant to power a 12V relay.

There are many types of power supply. Most are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. A power supply can by broken down into a series of blocks, each of which performs a particular function.

For example a 5V regulated supply:

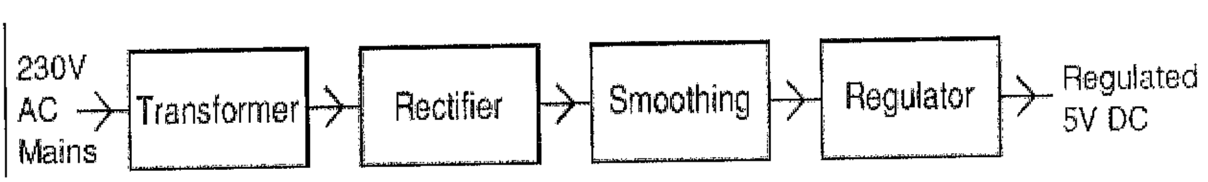


Figure 3.2: Block diagram of power supply

Each of the blocks is described in more detail below:

- Transformer - steps down high voltage AC mains to low voltage AC.
- Rectifier - converts AC to DC, but the DC output is varying.
- Smoothing - smooth the DC from varying greatly to a small ripple.
- Regulator - eliminates ripple by setting DC output to a fixed voltage.

The complete circuit diagram for the supply unit is shown below,

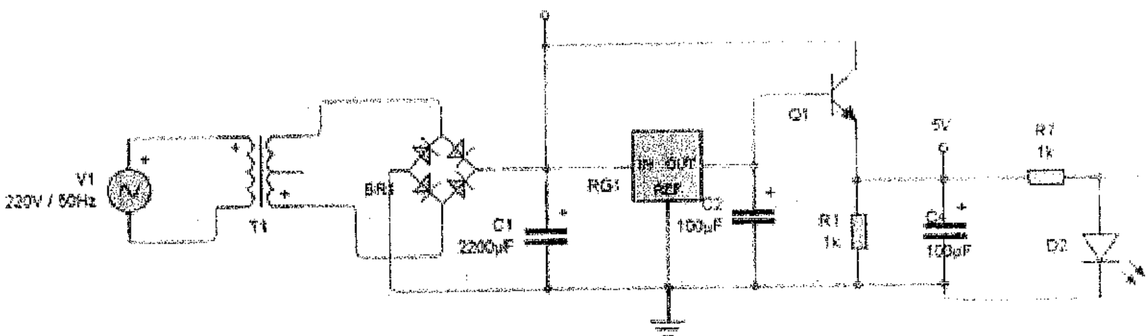


Figure. 3.3: Power supply stage

3.4 MICROCONTROLLER SELECTION

This is the first aspect of the hardware design. This depends on the application and amount of memory required that determines the type of microcontroller used. In this case the PIC16F84A is preferred for this particular application because of its low power consumption, flexibility, reprogrammable flash memory and high speed technology makes it suitable as a control module for the intended application.

3.5 MPLAB AND PICKIT

MPLAB is a proprietary freeware integrated development environment for the development of embedded applications on PIC and dsPIC microcontrollers. [7]

MPLAB IDE is a software program that runs on your PC to provide a development environment for your embedded system design. MPLAB was used to performs the following functions:

i. Compile and assemble the software using a language tool to convert the code into machine code for the PIC device. This machine code eventually became firmware, the code programmed into the microcontroller.
ii. Do the high level design
iii. Knowing which peripherals and pins control the hardware, write the software. Use either assembly language, which is directly translatable into machine code, or using a compiler that allows a more natural language for creating programs. With these language tools I was able to write and edit code that is more or less.
iv. Test your code.
v. "Burn" the code into a microcontroller and verified that it executed correctly in the finished application.

The PIC kit microcontroller programmer is a low cost development programmer. PIC kit is a family of programmers for PIC microcontrollers made by Microchip Technology. They are used to program and debug microcontrollers, as well as program EEPROM. Some models also feature logic analyzer and serial communications (UART) tool. [6]

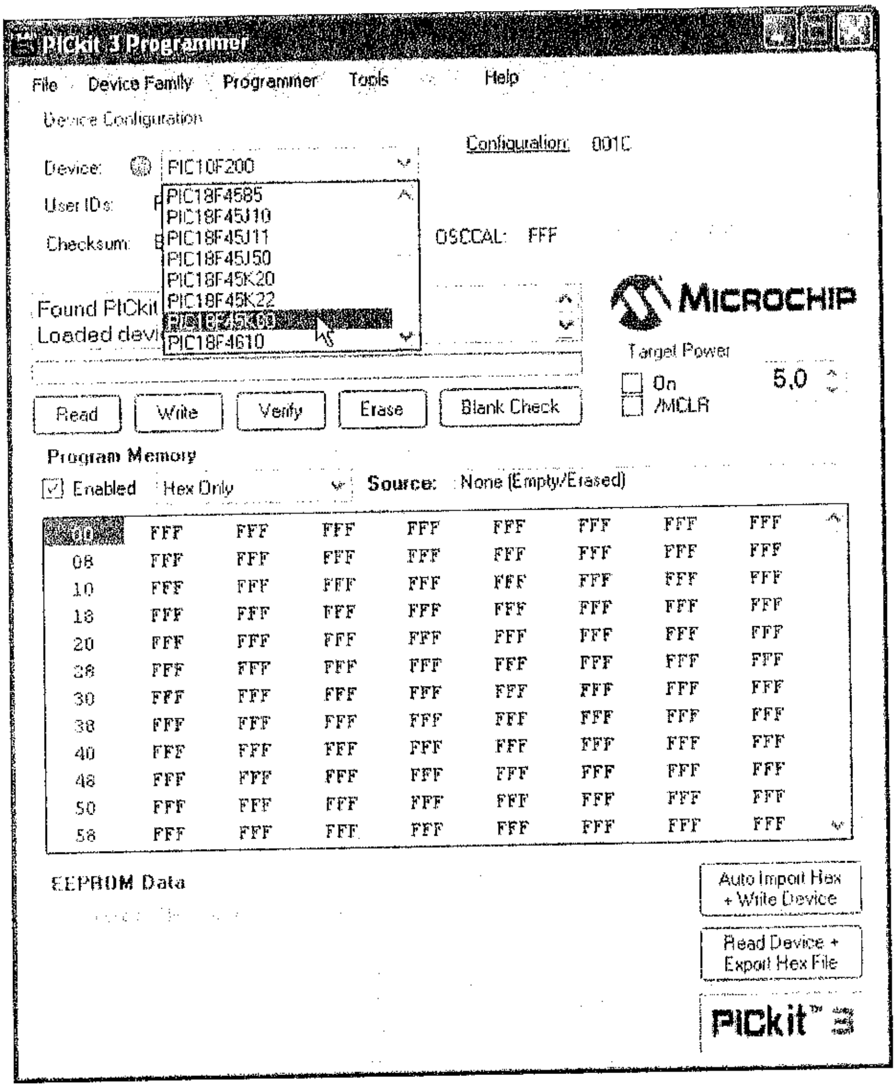


Figure 3.4 PICkit Programming Software

Resistors: To calculate the resistor using ohm's law:

V = I.R 3.1

Vcc = (Current through R5). R_5 .... 3.2

Rearranging the above equation to solve for the resistor:

$$R5 = \frac{Vcc}{Current\ through\ R5} = \frac{5v}{0.0005A} = 10kohms \quad \text{..............................} 3.3$$

To calculate the required base Resistor to be connected to the Transistor:

$$R_B = \frac{Vcc - V_{BE}}{I_B} \quad \text{..............................} 3.4$$

Vcc = 5V

V_{BE} = 0.6

I_B = 50mA

$$R_B = \frac{5-0.6}{50mA} = 88\ ohms. \quad \text{..............................} 3.5$$

Therefore, that is the minimum R_B to be connected to the base of the transistor, for this project 100Ω is used to provide the need base current.

R1 = 100 Ω, R2 = 100 Ω, R3 = 10kΩ, R4 = 10kΩ, R5 = 10kΩ

CHAPTER FOUR

CONSTRUCTION AND TESTING

4.1 INTRODUCTION

In this chapter, the practical actualization of the project specification, where the construction, simulation and actual testing of the system are illustrated.

4.2 CONSTRUCTION

The entire circuit was first constructed temporarily on a bread board and after loading the program source code on the microcontroller to confirm that its operation was according to the design specification and necessary adjustment were made wherever they were required.

The circuoit was then transferred to a vero board and firmly fixed on the vero board by soldering. The LCD was also attached to the circuit.

4.3 CASING

The circuit was housed in a rectangular box, which served as protection as well as for mechanical support. The case has a dimension of 15cm by 11cm with a toggle switch connected to the side of the case. The LCD was also placed on top of the case.

4.4 TESTING

Testing is a vital process in the development and realization of any design, be it hardware based, software based or both. The various components and their circuitry has to be tested to ensure that all the components on board are certified okay and in good working condition. The components that did not give the required output specification where isolated and troubleshooted to determine the nature and cause of the component failure through careful analysis, that is examination of the working principles of the component(s).

Here also during the testing analysis, modularization and Interface design were also tested. Each module in case of the software were tested to know whether it performs the functions assigned to it and also to know whether each of the module can interact as Required by transferring and returning data in form of a signal.

4.4.1 Test Plan

The test plan specifies the steps taken in checking and testing each of the module that constitute the whole system design. The essence of this is to check for the functionality of the system in question for optimal performance.

The complete circuit was build and tested for a period of time and it worked according to specification.

When the circuit was switched on, the LCD was initialized, then after 5 seconds the remote control was used to switch on and off both the fan and the lighting system.

Table 4.1: Tested loads

NAME	POWER RATING (W)
BULB	20
BULB	100
FAN	30
FAN	280

The circuit was repeatedly tested and found efficient and reliable.

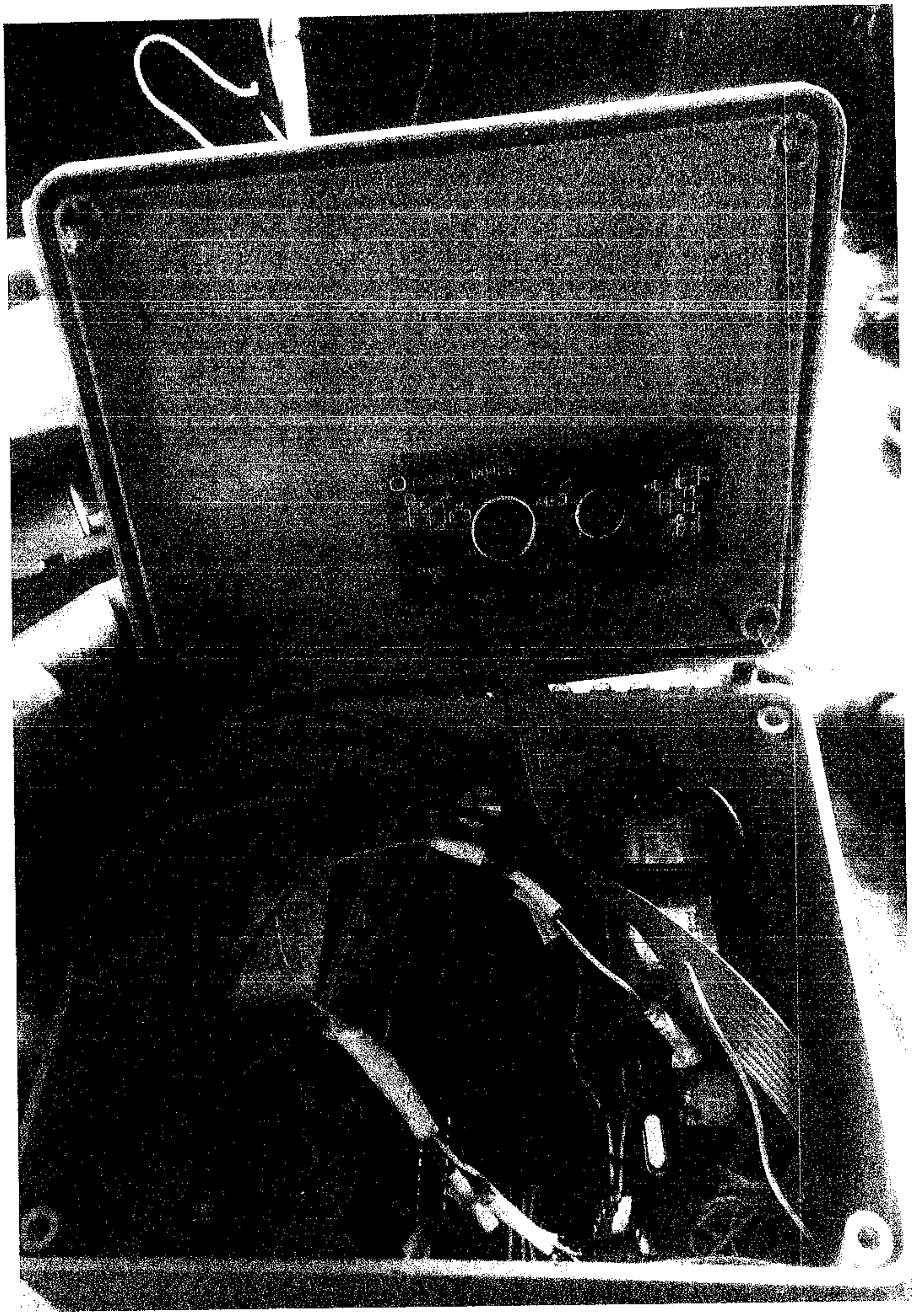


Figure 4.1 Internal View of Finished Project

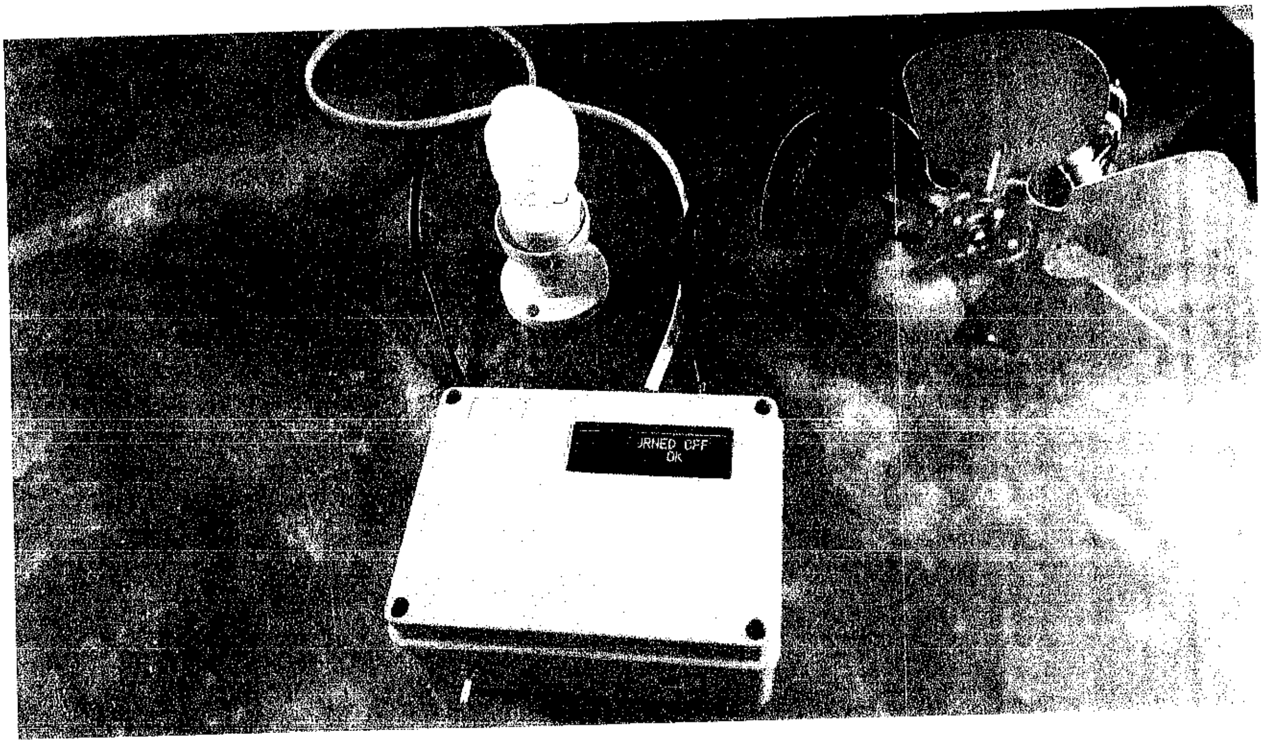


Figure 4.2 Snapshot of the project when turned OFF.

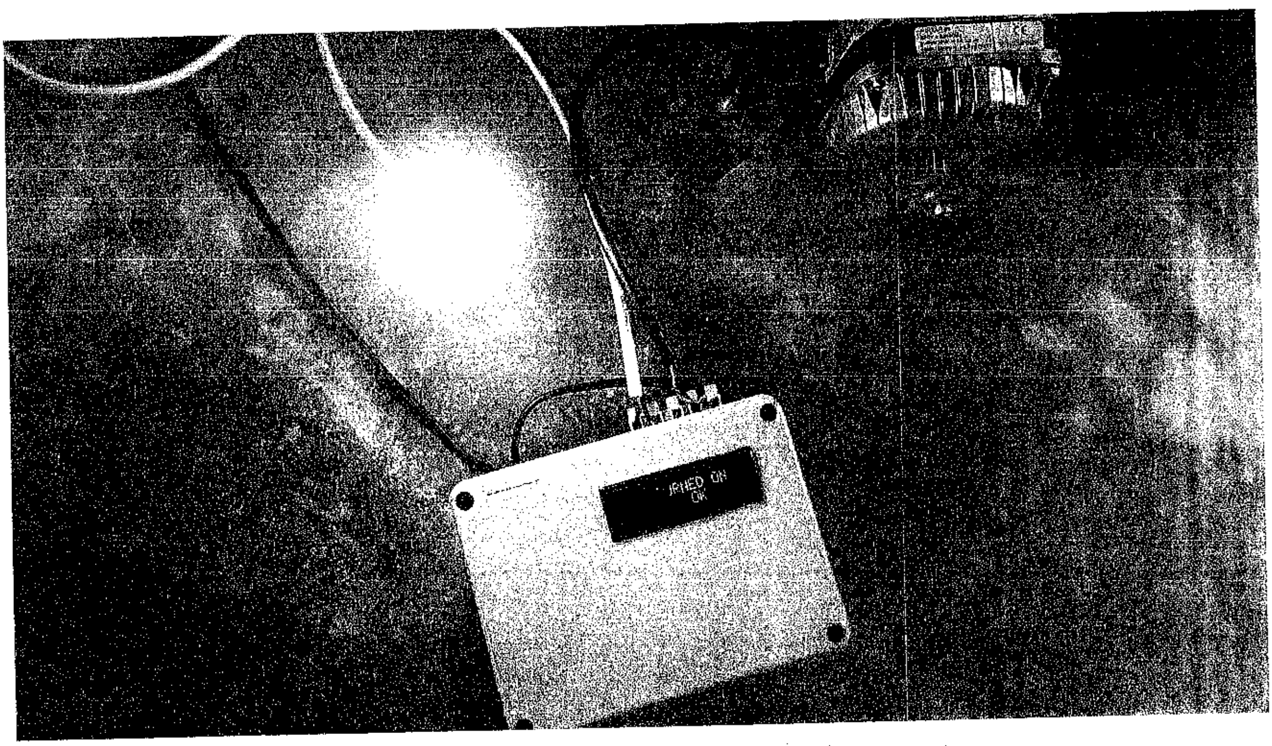


Figure 4.3 Snapshot of the project when turned ON.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

In the design and implementation of this project "design and construction of a microcontroller based remote control for fan and lighting system, the PIC16F84A microcontroller is programmed to coordinate the whole function of the design from the input when the button is pressed to the processing and sending of signals to the receiver sensor from where this signals are processed appropriately and transferred to the relay which are connected to outputs inform of our domestic appliances, lighting points, etc. This project is designed so as to be able to control our domestic appliances using a central remote control.

5.2 PROBLEMS ENCOUNTERED

In the course of the design and implementation of this project, some problems were encountered. They are -

- Low finance during Implementation.
- Difficulty when writing programs, debugging and interfacing
- Component Failures
- Short Circuitry
- Inadequate and epileptic power supply.

The aforementioned problems were however overcomed during the design processes and implementation of this project.

5.3 RECOMMENDATION

This project is a viable one in the sense that it will go a long way in making it more convenient for users to easily control their appliances, lighting points and fans from a central point in their home using a remote control. Because of its importance as a household need, efforts must be geared towards designing a viable project like this one. I strongly recommend that the department should see this project as a priceless possession and should endeavor to provide financial assistance and more research works relating to this project to support and encourage students embarking on this type of project so as to be used not only in homes but also in offices, schools etc.

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APPENDIX A

Table A: Pin Description of PIC16F84A

Pin Name	DIP No.	SOIC No.	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	16	16	I	ST/CMOS [3]	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	15	15	O	—	Oscillator crystal output. Connects to crystal or resonator in crystal oscillator mode. In RC mode, OSC2 pin outputs CLKOUT which has 1/4 the frequency of OSC1, and denotes the instruction cycle rate
MCLR	4	4	I/P	ST	Master clear (reset) input/programming voltage input. This pin is an active low reset to the device.
					PORTA is a bi-directional I/O port.
RA0	17	17	I/O	TTL	
RA1	18	18	I/O	TTL	
RA2	1	1	I/O	TTL	
RA3	2	2	I/O	TTL	
RA4/T0CKI	3	3	I/O	ST	Can also be selected to be the clock input to the TMR0 timer/counter. Output is open drain type.
					PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	6	6	I/O	TTL/ST [1]	RB0/INT can also be selected as an external interrupt pin.
RB1	7	7	I/O	TTL	
RB2	8	8	I/O	TTL	
RB3	9	9	I/O	TTL	
RB4	10	10	I/O	TTL	Interrupt on change pin.
RB5	11	11	I/O	TTL	Interrupt on change pin.
RB6	12	12	I/O	TTL/ST [2]	Interrupt on change pin. Serial programming clock.
RB7	13	13	I/O	TTL/ST [2]	Interrupt on change pin. Serial programming data.
Vss	5	5	P	—	Ground reference for logic and I/O pins.
VDD	14	14	P	—	Positive supply for logic and I/O pins.

Legend: I = input O = output I/O = Input/Output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in serial programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

APPENDIX B

COST OF COMPONENTS

S/N	COMPONENT	QUANTITY	UNIT PRICE (N)	TOTAL AMOUNT
1	PIC 16F84A	1	2,000	2,000
2	RELAYS	2	200	400
3	BREADBOARD	1	800	800
4	CASING	1	1400	1400
5	7806 VOLTAGE REGULATOR	1	250	250
6	VERO BOARD	1	250	250
7	TOGGLE SWITCHE	1	150	150
8	TRANSISTOR 2N222	2	150	300
9	LCD 16×2	1	2000	2000
10	INFRARED RECEIVER	1	200	200
11	RESISTORS	6	10	60
12	FAN	1	1400	1400
13	BULB	1	250	250
14	MISCELLANEOUS			3000
	TOTAL			12460

APPENDIX C

COMPLETE ASSEMBLE CODE

```
;========== Assembler Code

                    ""

Reg_003         EQU         H'0003'
Reg_005         EQU         H'0005'
Reg_006         EQU         H'0006'
Reg_00C         EQU         H'000C'
Reg_00D         EQU         H'000D'
Reg_00E         EQU         H'000E'
Reg_00F         EQU         H'000F'
Reg_012         EQU         H'0012'
Reg_013         EQU         H'0013'
Reg_01E         EQU         H'001E'


        ORG         H'00000'
        CLRF        Reg_01E
        GOTO        Label_00017


Label_00001
```

```
MOVWF        Reg_013
BCF     Reg_006,5
BCF     Reg_006,4
BCF     Reg_006,4
BSF     Reg_003,5
BCF     Reg_006,5
BCF     Reg_006,4
BCF     Reg_006,4
MOVLW        H'00F0'
ANDWF        Reg_006,1
BCF     Reg_003,5
MOVF    Reg_013,0
BTFSC        Reg_01E,1
GOTO    Label_00003
MOVLW        H'003A'
MOVWF        Reg_00D
MOVLW        H'00FC'
CALL    Label_00011
MOVLW        H'0033'
MOVWF        Reg_012
CALL    Label_00006
MOVLW        H'0010'
MOVWF        Reg_00D
```

```
        MOVLW       H'0068'
        CALL        Label_00011
        CALL        Label_00006
        MOVLW       H'0064'
        CALL        Label_00010
        CALL        Label_00006
        MOVLW       H'0022'
        MOVWF       Reg_012
        CALL        Label_00006
        MOVLW       H'0028'
        CALL        Label_00002
        MOVLW       H'000C'
        CALL        Label_00002
        MOVLW       H'0001'
        CALL        Label_00002
        MOVLW       H'0006'
        CALL        Label_00002
        BSF         Reg_01E,1
        MOVF        Reg_013,0
        GOTO        Label_00003

Label_00002

        BSF         Reg_01E,0
```

```
Label_00003

        MOVWF       Reg_012
        BTFSS       Reg_01E,0
        GOTO        Label_00004
        BCF         Reg_006,4
        SUBLW       H'0003'
        BTFSS       Reg_003,0
        GOTO        Label_00005
        CALL        Label_00005
        MOVLW       H'0007'
        MOVWF       Reg_00D
        MOVLW       H'00D0'
        CALL        Label_00011
        BSF         Reg_003,0
        RETURN

Label_00004

        BSF         Reg_01E,0
        SUBLW       H'00FE'
        BTFSC       Reg_003,2
        GOTO        Label_00016
```

```
        BSF     Reg_006,4

Label_00005
        SWAPF   Reg_012,1
        BTFSS   Reg_01E,0

Label_00006
        BCF     Reg_01E,0
        BSF     Reg_006,5
        MOVLW   H'00F0'
        ANDWF   Reg_006,1
        MOVF    Reg_012,0
        ANDLW   H'000F'
        IORWF   Reg_006,1
        BCF     Reg_006,5
        SWAPF   Reg_012,1
        BTFSC   Reg_01E,0
        GOTO    Label_00006
        MOVLW   H'0032'
        CALL    Label_00010
        BSF     Reg_003,0
        RETURN
```

```
Label_00007
        CLRF    Reg_00F

Label_00008
        MOVWF       Reg_00E

Label_00009
        MOVLW       H'00FF'
        ADDWF       Reg_00E,1
        BTFSS   Reg_003,0
        ADDWF       Reg_00F,1
        BTFSS   Reg_003,0
        GOTO    Label_00016
        MOVLW       H'0003'
        MOVWF       Reg_00D
        MOVLW       H'00DF'
        CALL    Label_00011
        GOTO    Label_00009

Label_00010
        CLRF    Reg_00D
```

```
Label_00011
        ADDLW       H'00E8'
        MOVWF       Reg_00C
        COMF        Reg_00D,1
        MOVLW       H'00FC'
        BTFSS       Reg_003,0
        GOTO        Label_00013

Label_00012
        ADDWF       Reg_00C,1
        BTFSC       Reg_003,0
        GOTO        Label_00012

Label_00013
        ADDWF       Reg_00C,1
        CLRWDT
        INCFSZ      Reg_00D,1
        GOTO        Label_00012
        BTFSC       Reg_00C,0
        GOTO        Label_00014

Label_00014
        BTFSS       Reg_00C,1
```

```
        GOTO    Label_00015
        NOP
        GOTO    Label_00015
Label_00015
        RETURN


Label_00016
        BCF     Reg_003,7
        BCF     Reg_003,6
        BCF     Reg_003,5
        CLRWDT
        RETURN

Label_00017
        SLEEP
        GOTO    Label_00021

        ORG     H'02007'
        DE      11,01
        END
```