AUTOMATIC CEILING FAN CONTROLLER BASED ON TEMPERATURE SENSOR AND REACTIVATED SYSTEM

By

Nur Mohd Fadzli Bin Nordzi

Dissertation

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved:

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Mrs Zazilah May
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

December 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Nur Mohd Fadzli Bin Nordzi

ABSTRACT

This study aims to make adjustment or improvement towards common ceiling fan operation that widely use centrifugal switch as a controller. The objective of this project is to create reliable automatic fan controller and human detection system especially for the user. Common technology – ceiling fan operation had been applied especially at home area. This operation had been used by thousand of people like in south East Asia's area to accommodate with too high temperature in a day. This study implements the new way on how people can distract themselves on reducing to too much dependable of centrifugal switch. This project will be applied to system that focuses more on controlling the fan speed and also addition of alarm-detection system for the human/user.

ACKNOWLEDGEMENT

In the name of Allah, The Most Gracious, The Most Grateful

First of all, my utmost thanks to Allah for everything. For the air that I breathe and for the five senses given, I am still alive with which I can see His greatness through His creation. Utmost thanks also given to Him for the honor of being born as a Muslim and for the honor of having faith in Him. With His Greatest power, I have successfully completed this Final Year Project.

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LIST OF ABBREVIATIONS

PIR	Passive Infrared Sensor
LED	Light Emitting Diode Alternating Current
AC	Alternating Current
DC	Direct Current
LM35	Fuzzy Logic Controller
LDR	Light Dependent Resistor
FYP	Final Year Project
IGBT	Insulated Gate Bipolar Transistor
IRCUTP	Information Resource Centre University Technology PETRONAS
MOSFET	Metal Oxide Semiconductor Field-Effect Transistor
PWM	Pulse Width Modulation
UTP	Universiti Teknologi PETRONAS

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Nowadays, there are almost of all the houses in the world especially in Southeast Asia have at least a ceiling fan. It has become very popular among people in recent years. The ceiling fans objectively build to control the room temperature to appropriate condition. There are several advantages of using ceiling fan. For example, people prefer to use ceiling fan instead of using the air conditioner due to it easy to install, cheap in maintenance and also it is really the suitable equipment to control the room temperature in South East Asia area. In fact, the ceiling fan also can be used to blow wind and act as an agent to dry up the clothes.

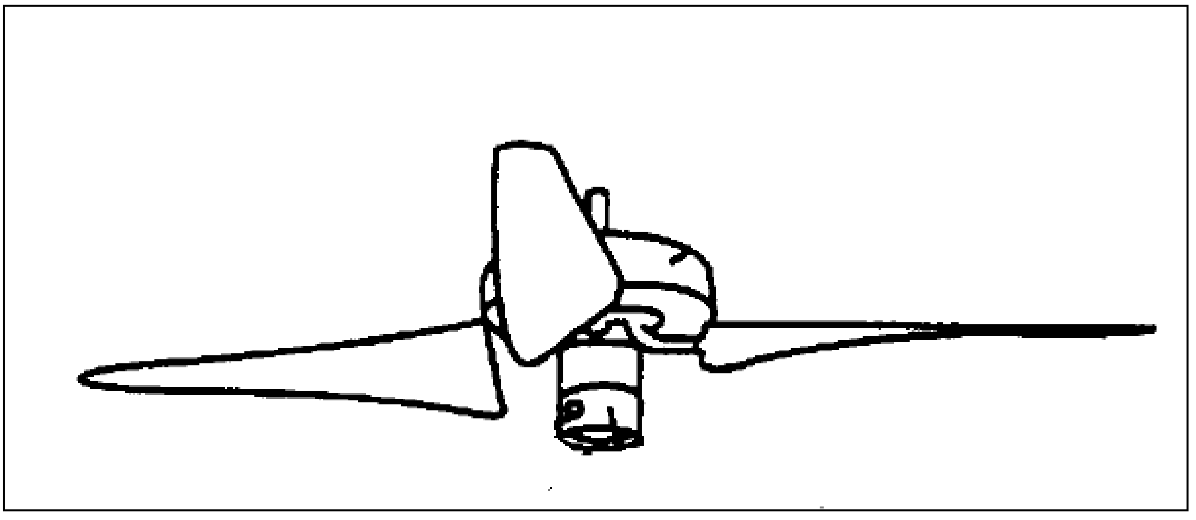
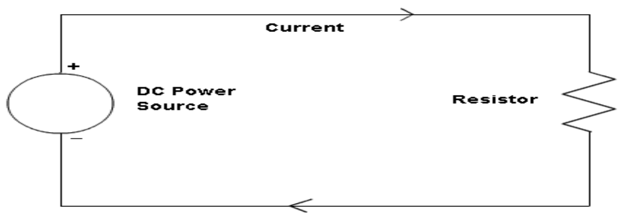


Figure 1 Ceiling fan

1.2 Problem Statement

The basic idea behind the project is to exploit loss electrical energy in fan motor at ceiling fan operation. Losses of electrical energy will develop to much serious problem especially on the safety of the user. So, why the automatic ceiling fan controller must be invented?



P loss=i^2R

Figure 2 Power loss

There are a lot of concerns when dealing with “traditional” ceiling fan especially in the operations of the fans. The real support for this problem is due to the inability of the user to define the most appropriate temperature room. The user cannot sense the room temperature directly by their skin. This process can be beneficial by providing an effective way in controlling ceiling fan mechanism-monitor the room temperature automatically.

Switching problems is also a factor towards ceiling fan operation [9]. For information, ceiling fan operation like on/off or speed change mechanism required switching operation. Problem arrived especially among the new arriving occupants. When new arriving occupants enter to new room and darkened rooms, they have to search for hard to find wall toggle switches to turn on the ceiling fan. Warm or stuffy rooms can be very uncomfortable to newly arriving occupant, who would have to wait for the rooms to cool down and circulate airflow. Further, turning on and off fans in home or building is often so inconvenient the fans are left on.

Another problem is regarding the usage for electricity [9]. This concern happen widely in house area. For example, traditional fans are often left on when occupants leave rooms with overhead ceiling fan. Thus, the fans can consume unnecessary power in unoccupied rooms.

1.3 Objectives and Project Scope

1.3.1 Objectives

1) To build an automatic fan controller based on temperature sensor.
2) To create detection system that aims to detect human's motion appearance
3) To implement a controller based model to count number of persons visiting particular room
4) Keypad controller for user purpose

1.3.2 Project Scope

1) Functionality check on temperature sensor
   - LM35 sensor
   - LCD – to show temperature detected
2) Study on reliable motion sensor for human detection
   - PIR sensor
   - Ultrasonic sensor
3) Study on C programming on how to interface
   - Temperature sensor(AC) with PIC16f877A (DC)
   - PIC16f877A with AC single phase induction motor
4) PIC programming

CHAPTER 2
LITERATURE REVIEW

2.1 PIC16f877A microcontroller chip

Microcontroller chip operate as the main controller for entire system. It will synchronize variety of procedure including detection of temperature via temperature sensor. PIC16f877A is one of the types from PIC16 microcontroller family. This component occupied with a lot of abilities that goes along with this project. It is a high computational performance at a reasonable price. In fact, it is being supported by addition of high endurance and enhanced flash memory. Furthermore, the PIC16F877 introduces design enhancement that capable in making microcontroller a logical device for many high performance application.

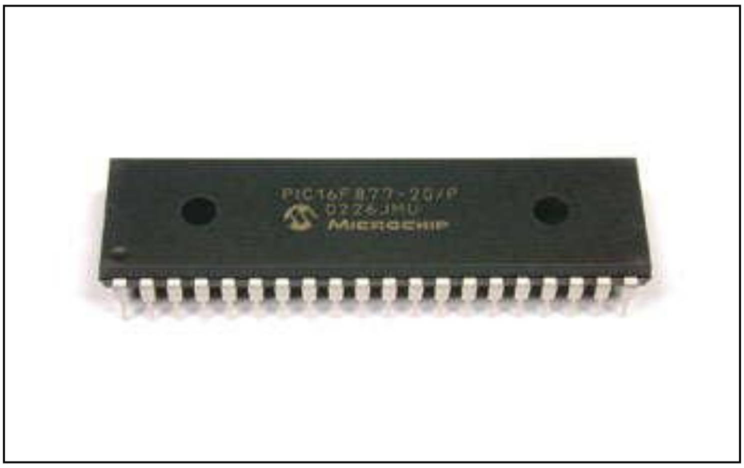


Figure 3 PIC16f877A

It uses new technology that significantly reduces power consumption [3]. It includes:

- Lower consumption in key modules
- Alternate run modes
- Multiple Idle modes

Several advantages using PIC 16F877

- Memory endurance-

The memory is easy-reprogrammable. The memory is rated to last for many thousand of erase/write cycles.

- Self programmability

The device can write to its own program memory spaces under internal software control. Capable to create an application that can update itself in the field [20]

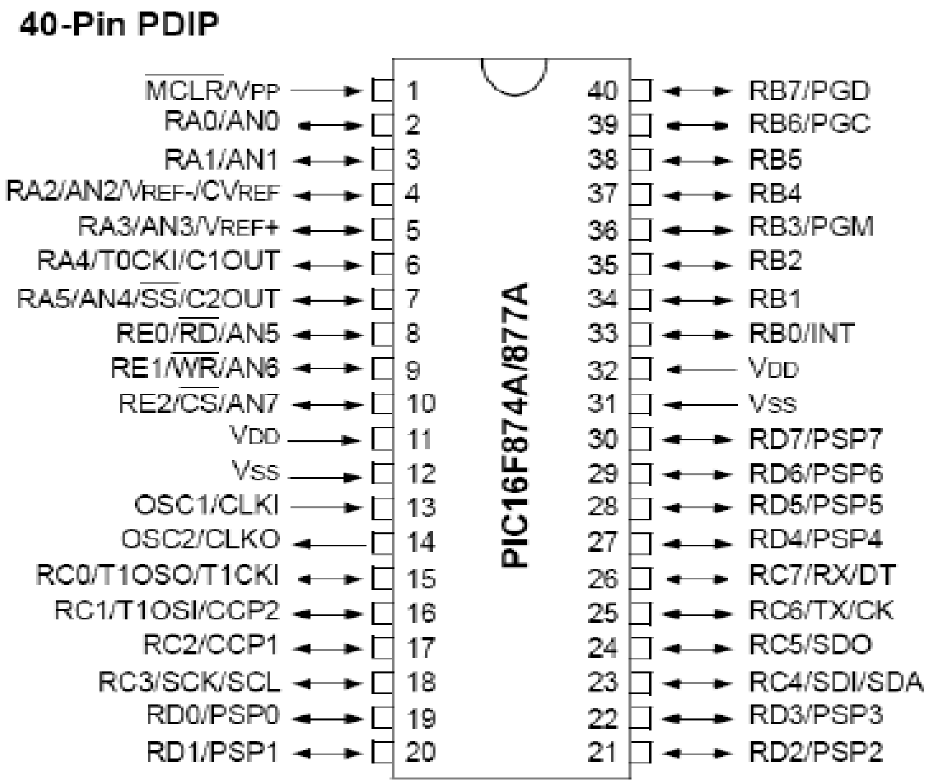


Figure 4 Structure 40 Pin PIC16f877

2.1.1 Influence toward project

This component contain 5 different port which are Port A, B, C, D and E. Port A and C act as the input port while the others port operate as output port

- Port A- Temperature sensor (LM35 sensor)
- Port C- Passive Infrared Sensor (PIR) & Ultrasonic sensor
- Port B- LCD display
- Port D- single phase Ac motor & counter circuit

2.2 Temperature Sensor- LM35 CZ sensor

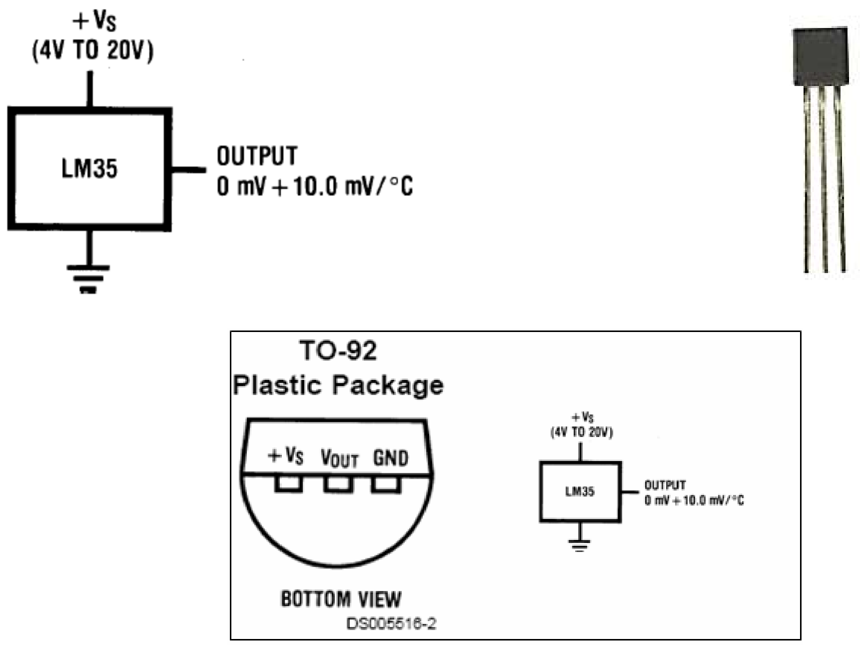


Figure 5 LM35CZ overview

Consider as one of the main elements in this project. After several researches, LM35CZ had been choose - temperature sensor. This component been choose due to their easiness to install, configure and also the cost is cheap. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature [25].Basic operation of this sensor is act as detection of surrounding temperature. It is assumed that 10 Mv correspond to 1 Celsius. This sensor has 3 ports with different function. One of the ports act as input source towards other component (like pic16f877a) while the others act as ground and 5v source. The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling [25].

The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to control circuitry seem to be simple. It can be used with single power supplies, or with plus and minus supplies. It has very low self-heating, less than 0.1°C in still air [6]. The LM35 is rated to operate over a −55° to +150°C temperature range [25].

2.2.1 LM35 ADC calculation

LM35CZ output is an AC source. In this project, the entire process will be using microcontroller chip (PIC 16f877A) whose originally only detect DC input. So, conversion of AC to DC value is essential to ensure appropriate value manage to goes through "analyze part" (Microcontroller chip).

ADC or analog to digital conversion can be done using PIC16f877A since this component consist a component or pin that can do ADC conversion. Port from Pin A0-A5 can be useful for analog to digital conversion. The PIC can contain only 5 Voltage and can produce up to 1024

ADC calculation consists of 2 important steps:

- Calculate the voltage in milivot:

  mv= (adc_out x 5000)/1023

  adc_in =0 → adc_out= 0

  adc_in=5000mv → adc_out=1023 ; yield 5000mv

- Divide output calculated by 10; correspond to LM35 principal is 10 mV/' C : temperature (deg celsius) = mV/10 = ((adc_out x 5000) / 1023)/10 ;

2.3 Motion sensor – Ultrasonic sensor

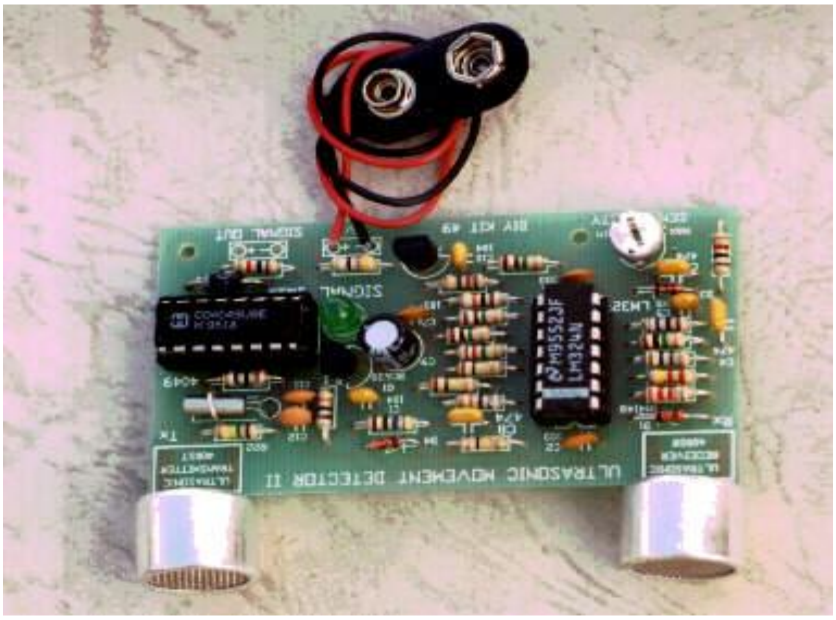


Figure 6 Ultrasonic sensor

This sensitive ultrasonic motion detector circuit uses a quartz crystal to lock the detector frequency for maximum stability and reliability.All components, including the Xtal controlled oscillator, detector circuits and a pair of edge mounted ultrasonic transducers, are mounted on a single board. Only the power supply and Signal Out connections are required.Range detection of motion is up to 4-7m away (figure 7). Sensitivity is adjustable. Red LED 'active' indicator. Signal Output (8.5Vdc) is capable of driving an external relay or other low power circuit. This sensor works perfectly on indoor area [4].

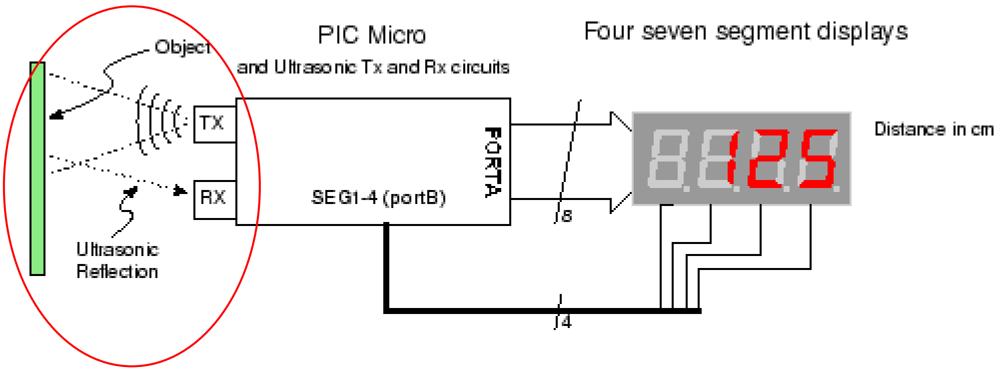


Figure 7 Ultrasonic range detection ((TX= transmitter) && (RX= receiver))

Ultrasonic sensor based from research can be applied using 2 alternative circuits which are:

2.3.1 Option A Basic Transmitter & Receiver (Ultrasonic)

- Transmitter

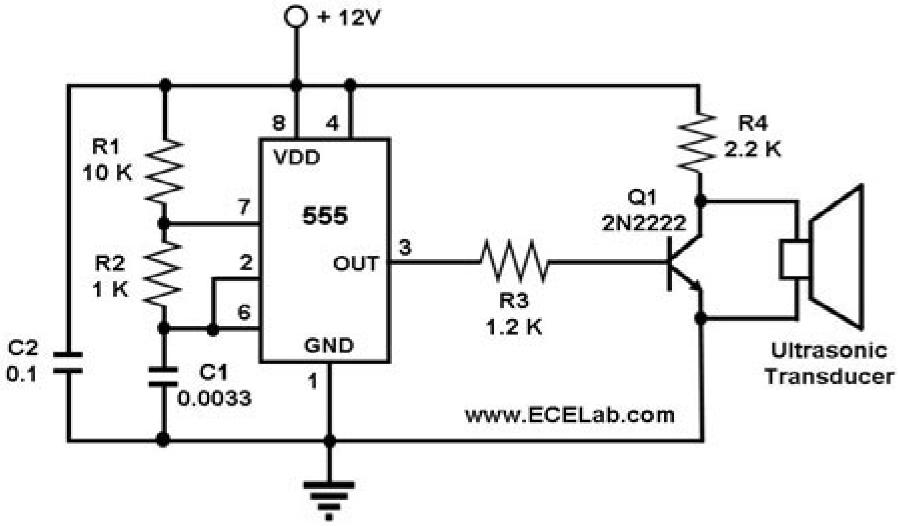


Figure 8 transmitter

The ultrasonic transmitter uses a 555 based astable multivibrator . It oscillates at frequency of 40 to 5o kHz. This circuit is used to transmit ultrasonic waves through air, which are intended to be picked up by a matching ultrasonic receiver. The circuit uses a 555 timer IC configured as an astable multivibrator, i.e., it generates a continuous signal of a set frequency as long as its reset pin (pin 4) is held high. Since the ultrasonic transducer used in this circuit is one designed to vibrate optimally at about 40 kHz, the resistor and capacitor values of the circuit were chosen such that the 555 will output a signal whose frequency is about 40 kHz. This 555 output is amplified by Q1, which drives the ultrasonic transducer. The transducer then vibrates at 40 Khz, generating ultrasonic sound waves of that frequency.If paired with a matching ultrasonic receiver, such a simple transmitter can be used as a proximity sensor, such as one that can help a robot avoid running into walls. If used in that manner, the transmitter and receiver transducers must be positioned such that the receiver will only receive echoes of the transmitted signal and not the transmitted signal itself [27].

- Receiver

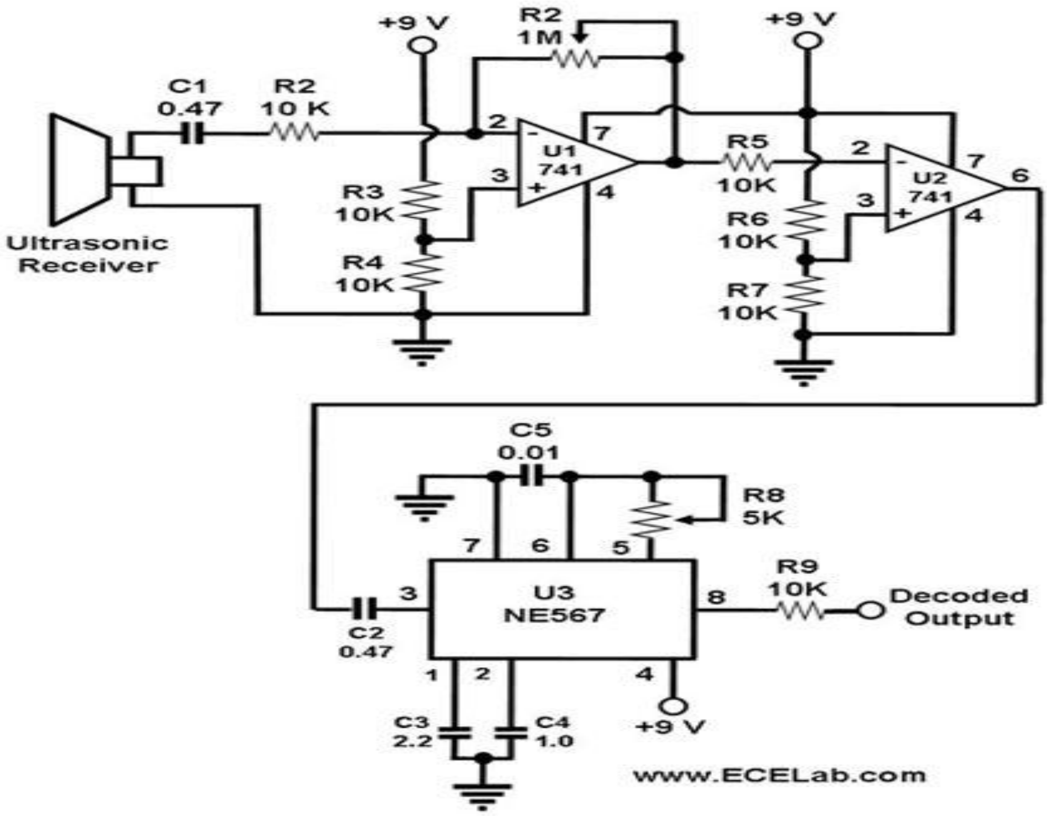


Figure 9 Receiver

The circuit has been design based on the schematic collected on the internet-hobby kit. The modification been made out by implementing the 12 v relay in between the entire sensor and PIC16f877. The circuit works based on the ultrasonic tranduscer when sensing ultrasonic signals. The signal by amplified by selectable transistor. Then the amplified signal are rectified and filtered. The filtered DC voltage is given to invert the pin of op-amp. The non-inverting is connected to variable dc voltage. The output of op-amp is used to bias 2 transistor one component each time. As the second transistor conduct, it will allow current to pass through the modification circuit (relay –transistor implementation). The Common pin of relay been connected toward PIC pin while the NC pin been placed at ground [27].

2.3.2 Option B Transmitter & Receiver (Ultrasonic)

- Transmitter & Receiver

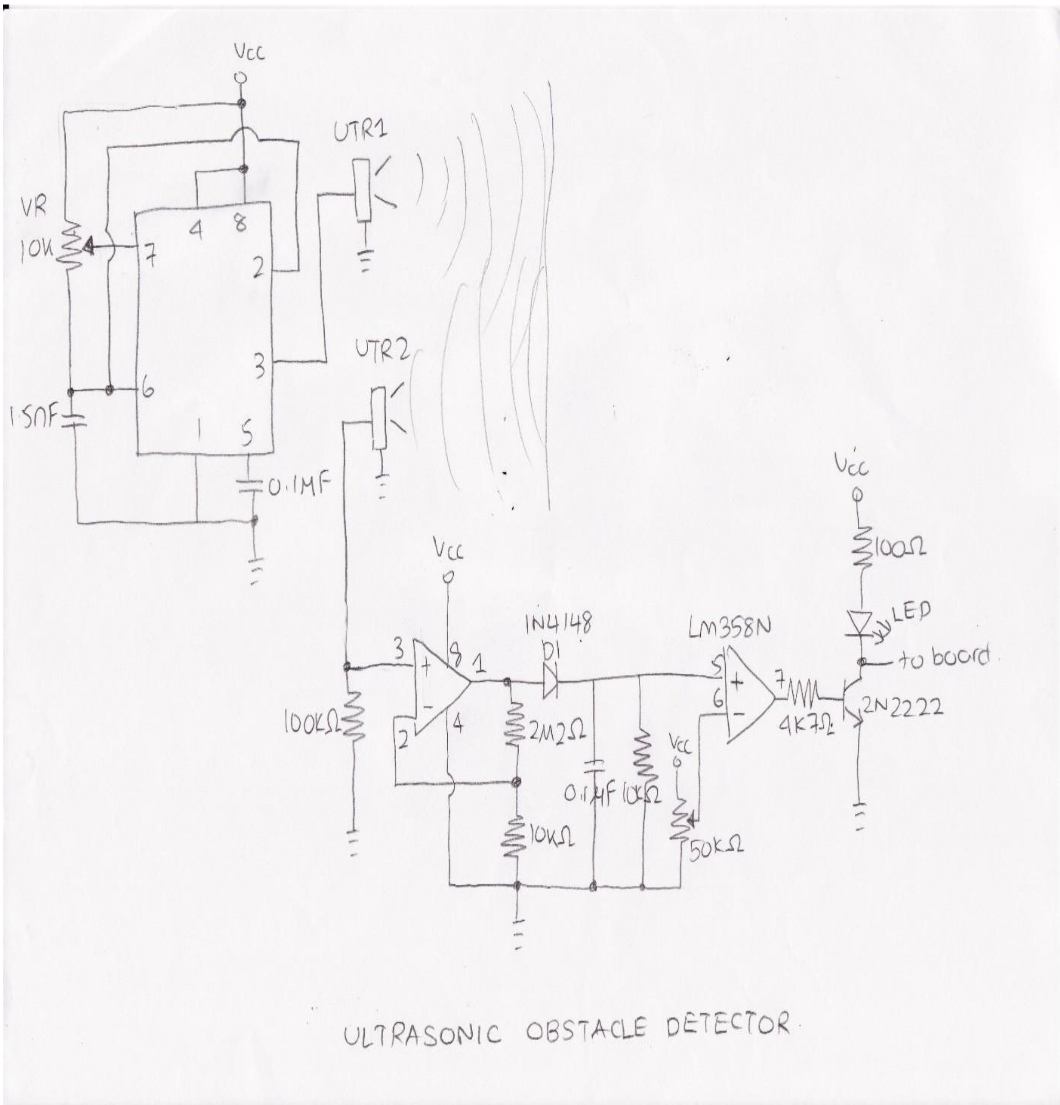


Figure 10 Option B Ultrasonic Sensor

This circuit mainly uses only 5v to operate. The indication of alertness is based on LED condition. The coverage detection is about 1 meter. The detection can be modified via variable resistor uses like:

- 50 K ohm
- 10 K ohm

It triggers any motion including object movement. Above circuit useful in movement detection especially on human [29].

2.4 Passive Infrared sensor (PIR sensor)

Figure 11 PIR sensor

The PIR (Passive Infra-Red) Sensor is a pyroelectric device that detects motion by measuring changes in the infrared levels emitted by surrounding objects. This motion can be detected by checking for a high signal on a single I/O pin [24] . The component features include:

- Single bit output
- Small size makes it easy to conceal
- Compatible with all types of microcontrollers
- 5V till 20V operation with <100uA current draw

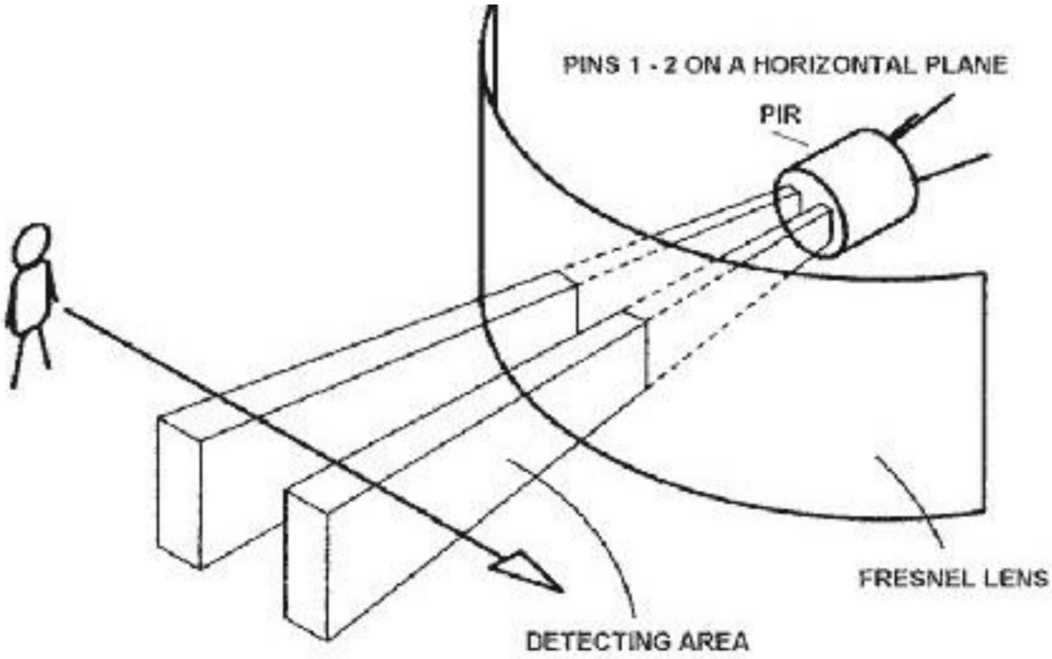


Figure 12 Area Detection

Pyroelectric devices, such as the PIR sensor, have elements made of a crystalline material that generates an electric charge when exposed to infrared radiation. The changes in the amount of infrared striking the element change the voltages generated, which are measured by an on-board amplifier. The device contains a special filter called a Fresnel lens, which focuses the infrared signals onto the element. As the ambient infrared signals change rapidly, the on-board amplifier trips the output to indicate motion [24]. Above shown area of detection of this sensor.

2.5 Relay circuit mechanism

2.5.1 Relay 6v

Figure 13 Relay

A single pole dabble throw (SPDT) relay is connected to output port of the microcontroller through a driver transistor. The relay requires 6 volts at a current of around 10ma, which cannot provide by the microcontroller. So the driver transistor is added. The relay is used to operate the external solenoid forming part of a locking device or for operating any other electrical devices. Normally the relay remains off. As soon as pin of the microcontroller goes high, the relay operates. When the relay operates and releases. Diode the standard diode on a mechanical relay to prevent back EMF from damaging other element when the relay releases [16].

2.5.2 Car relay

Figure 14 Car Relay

For smoothness and high voltage application (12v) car relay also can be used to accommodate with the entire project. The procedure is quite the same with 6 volt relay which consist of diode and switching transistor. The difference is regarding the power supply of the relay. Here, 12V voltage will be used to ensure the relay operates [17].

2.6 Switching / driver transistor

Figure 15 Switching transistor

Transistor switching will placed mainly at the output section of microcontroller. This component be used when interface with component whose voltage exceed 5 volt. As the microcontrollers provide an output voltage (5 volt), this component will allow other element like relay or motor to interacted [27].

2.7 LCD 16x2

Figure 16 LCD 16x2

LCD is one of the main outputs for this project. This component mainly aims to display the temperature detected by the LM35 sensor. LCD 16x12 stands for 16 characters per one line. This means there are total about 32 characters that can be display. In fact, addition of driver LCD (Appendix A) in C programming is essential to allocate the entire pin toward PIC microcontroller chip (much simpler) [14].

2.8 Transformer

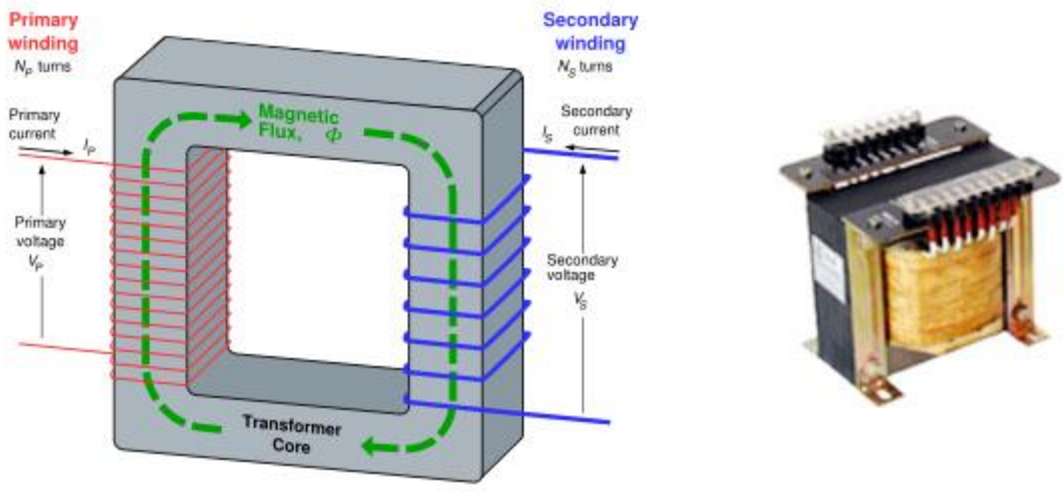


Figure 17 Transformer

A transformer efficiently raises or lowers AC voltages. In this project, transformer step down will be use to step down 240 AC volt from the plug to 12 volts [13]. This approach is essential to avoid any component damage. For example, PIC16f877A can only contain 5 volts value. So the power supply still need to be balanced out to satisfied the requirement of PIC16f877A. Plus, additions of LM7805 are important to reduce the 12 V to 5v. Additional rectifier been needed to convert AC to DC.

240 A

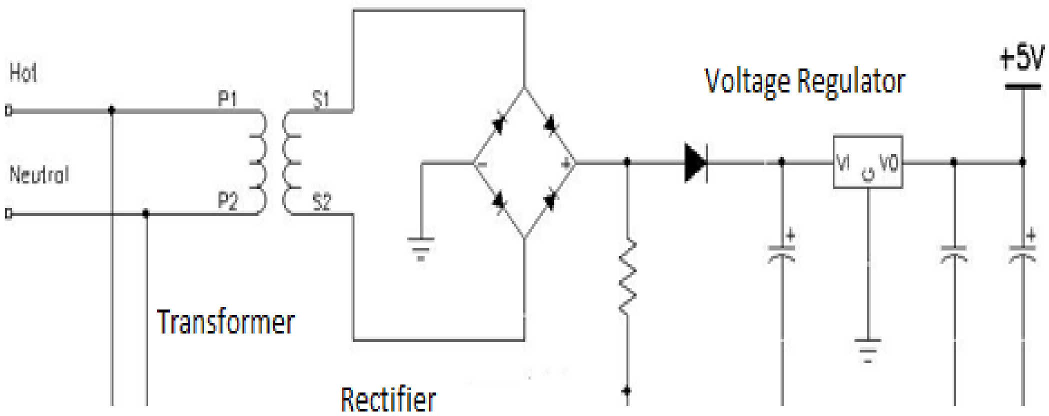


Figure 18 240 Volts AC to 5 Volts DC conversion circuit

2.9 AC motor- single phase induction motor

DC/AC motor acknowledgement

DC motor

Figure 19 DC motor

The DC motor has two basic parts:

- The rotating part that is called the *armature* and the stationary part that includes coils of wire called the *field coils [8]*.
- The stationary part is also called the *stator*.

Figure above shows a picture of a DC fan motor and picture of a typical DC motor. The armature is made of coils of wire wrapped around the core, and the core has an extended shaft that rotates on bearings. The ends of each coil of wire on the armature are terminated at one end of the armature. The termination points are called the *commutator*, and this is where the brushes make electrical contact to bring electrical current from the stationary part to the rotating part of the machine [2].

AC induction motor Single phase

The real ceiling fan circuit basically uses ac induction motor. Compare to the previous motor, this motor tend to be a lot of difficult to interface due to several reason:

- Ac induction only convey AC value- while the output of PIC is only in DC source
- For on/off circuit, implementation of relay can be useful

Basic overview of single phase AC induction motor

AC induction motor in collection –split phase

Figure 20 Typical AC motor

Firing angle control analogy

- ☐ One of it by using phase controller technique. Aim is to control the firing angle of the converter. The higher firing angle being set the speed became much slower[8]

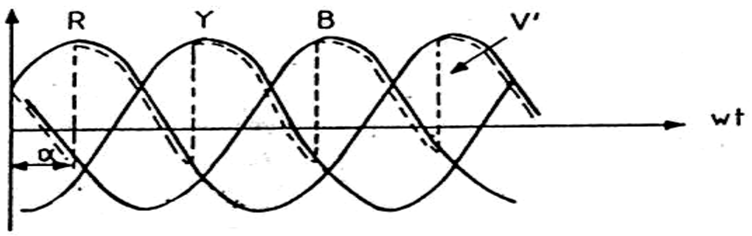


Figure 21 Firing angle analogies

Area of motor ON (a value); the longer a value the speed of the motor become much slower

Sample Phase control technique

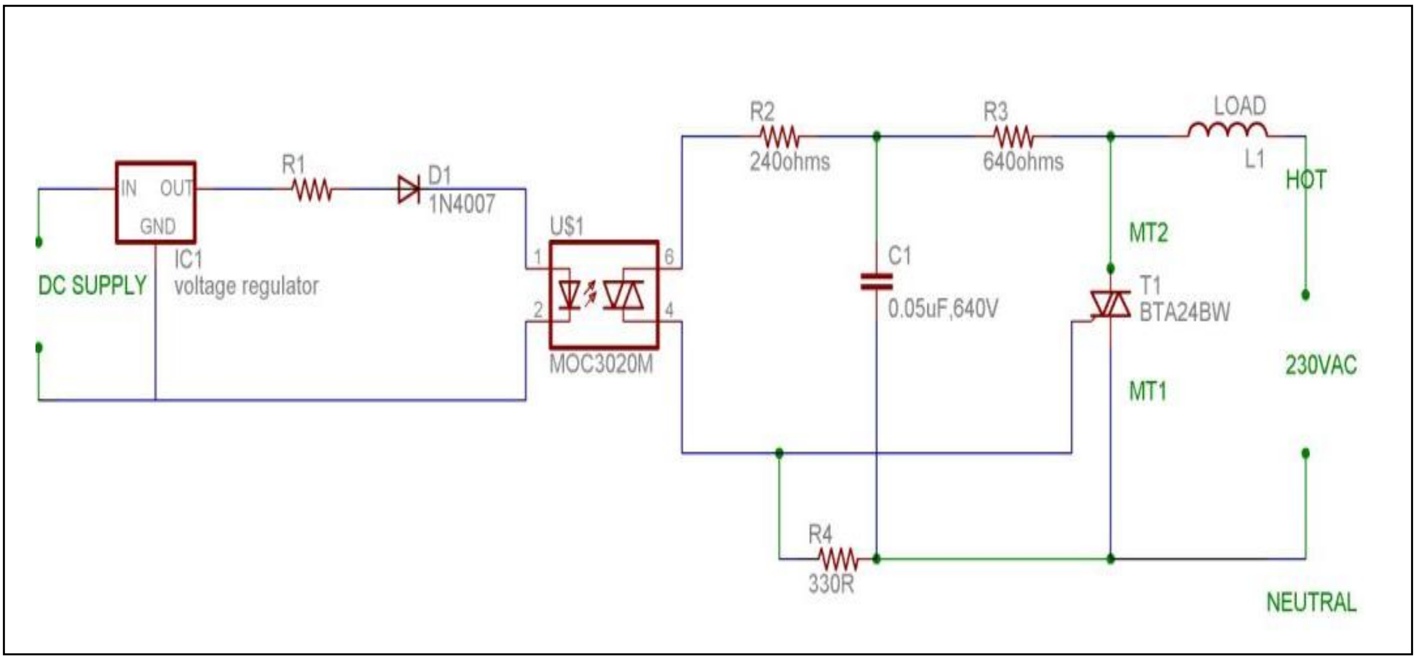


Figure 22 Phase control circuit

For Phase Angle firing Method consist of 2 important steps:

Step 1: zero crossing circuit→ by using opt coupler; detect Volt-Amplitude equal to zero

Step 2: Isolation circuit for firing TRIAC ==> use MOC 303x (with zero crossing) –firing angle control being set up.[8]

2.10 Keypad 4x4

Figure 23 Keypad 4x4

Keypad is added for manual purpose if the user wants to try and error approach toward the system. With Keypad, the user can just easily pressed any desired temperature value that be classified as “interested value”. The resulting value will be joined up with the actual temperature detected (via LM35) for some mathematical operation like subtraction. Resulting margin will lead towards the fan speed. Bigger margin will force the fan run much faster and it will be the same goes with another situation (low margin). Keypad 4x4 consists of 4 rows and 4 columns pin which will be connecting toward the pin of PIC16f877A [30].

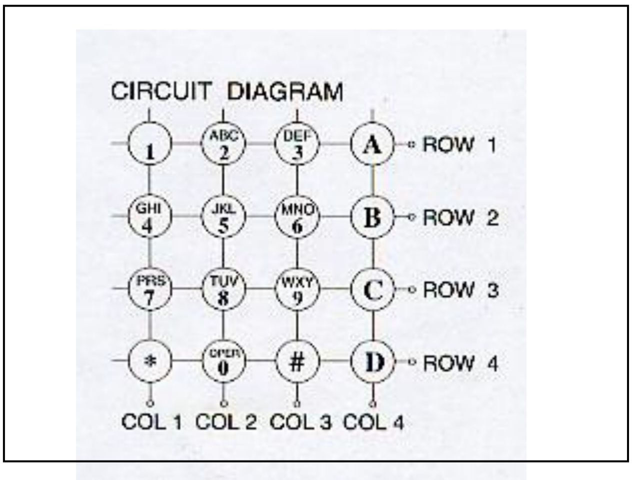


Figure 24 Row and column of Keypad 4x4

2.11 Motor interface via PIC16f877A

For whole semester (both fyp1 and Fyp2) there are several knowledge and research that had been made out especially on interfacing DC or AC motor toward PIC 16f877A.

- FYP1- DC motor
- FYP2- AC motor

2.11.1 DC motor

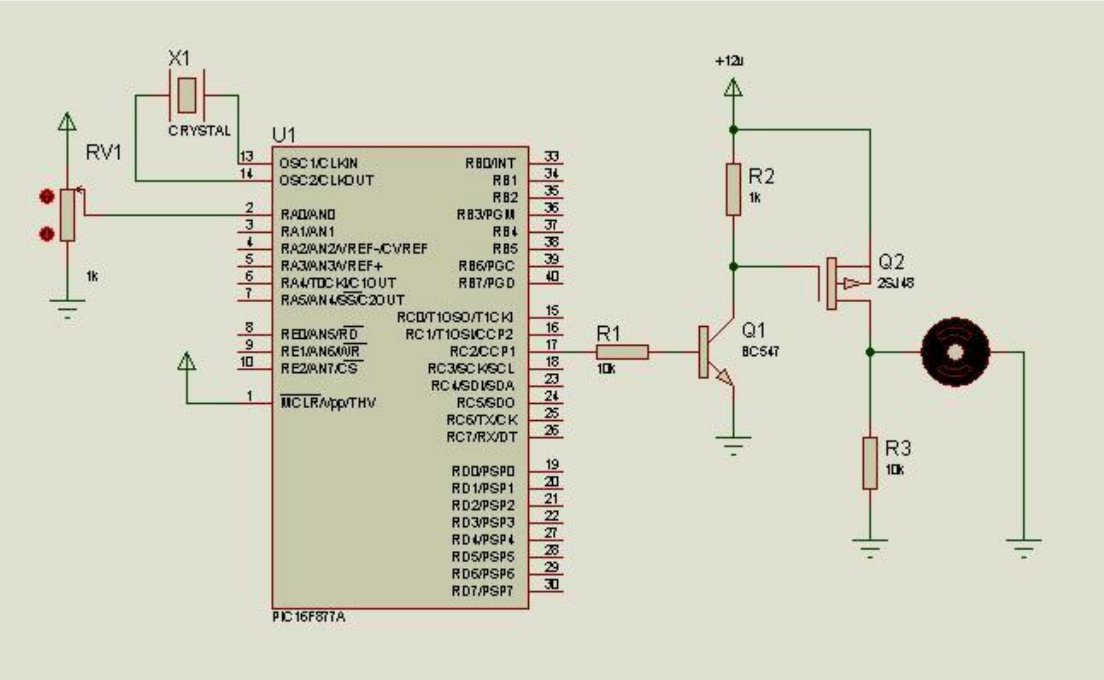


Figure 25 Diagram DC motor connections

For DC motor, it is quite direct connection from PIC16f877A (figure 24) since both are DC source. The fan will operate as the motion being capture by motion sensor.

2.11.2 AC motor

For AC motor, based from study and research had been made out there are 2 ways that can be used:

- Option A – switching transistor + Relay + AC fan (used for this project- due to much cheaper cost)

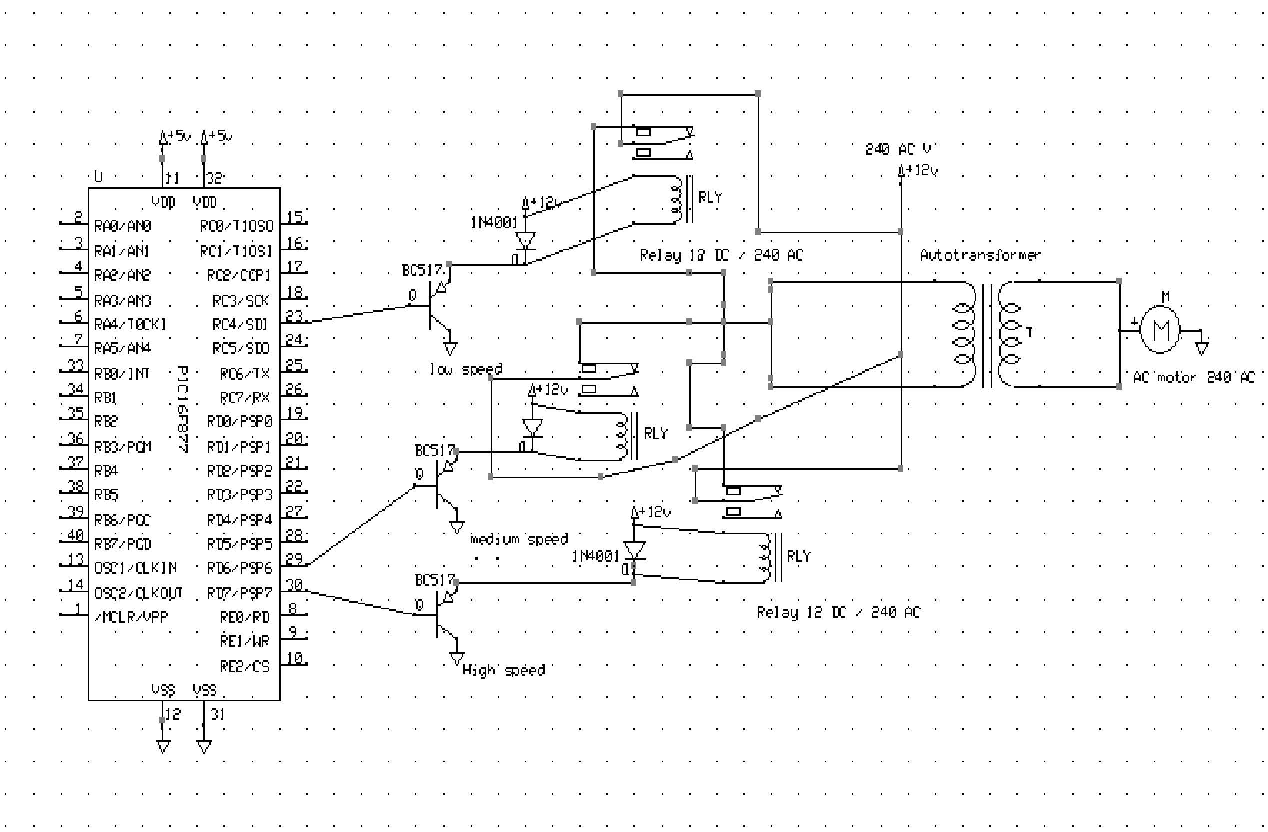


Figure 26 AC motor + BC517 + relay 240 ac rating

One approach that can be made out when interface with AC motor and PIC16f877a is by using relay. Here, (see figure 26) motor that had been equipped with autotransformer (Speed change purpose) can interact with PIC with the help of several components. The component like:

- Transistor switching – BC517 or BC107
- Relay 6V / 240 rating
- Diode 1N4001

- Option B PWM pulse analogies

  - ***PWM Motor speed analogy***

Another ways that can be useful in varying the speed of Motor is by using PWM technique. This technique can provide the system to change the fan speed greater than 3 speeds. The first real deal is on how to interface between the Fan and PIC16f877. Since the Fan is AC single phase induction motor while the PIC is commonly is DC source, so the need for a little bit additional circuit needs to add. From research and observation, this problem can be solved using PWM / complement PWM technique. Since it single phase it required 4 IGBT (figure 28) components to ensure the interaction of PIC and AC motor. Figure 27 explain about on how the connection can be made between PIC and AC motor. This connection will ensure DC output of PIC can be converted into AC output. This output will directly goes toward the fan.

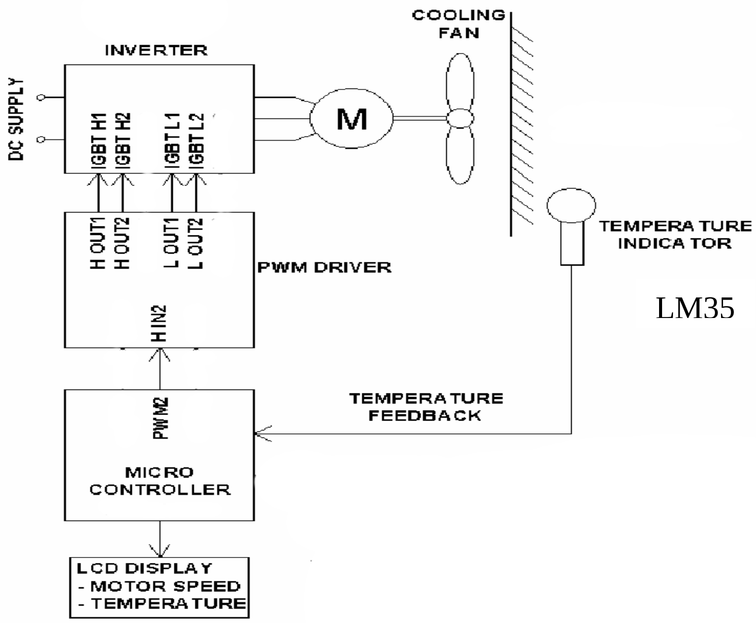


Figure 27 Microcontroller and AC motor

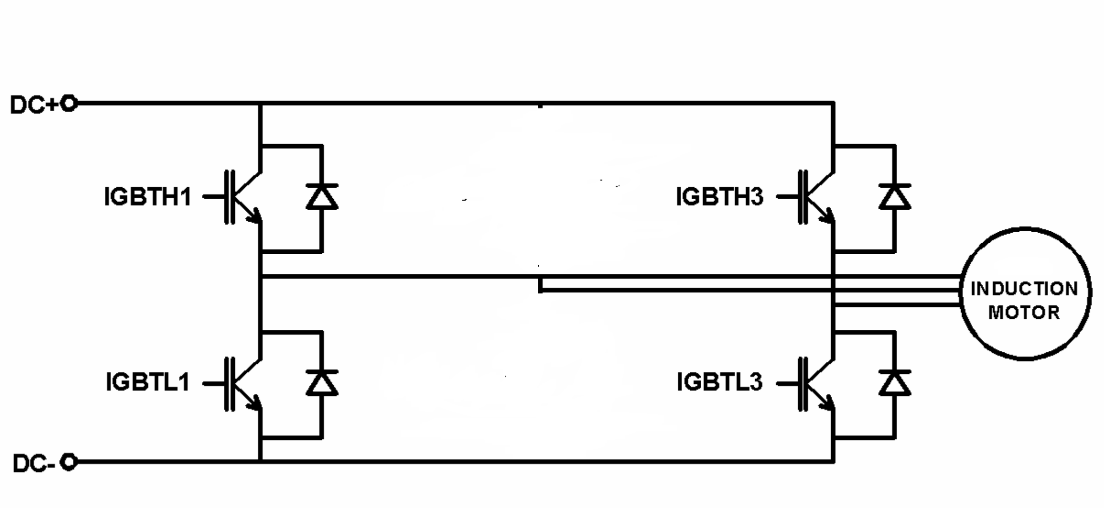


Figure 28 IGBT-AC motor

The mechanism to vary the speed using PWM is actually focused on provides the length of one pulse. The longer one pulse being set, the speed becomes slower. If n speed need to provide, that means, there are 4 different pulses that need to be set. For example, if the desired system wants 4 different fan speeds there are 4 different pulses (in term of length) need to be provided using programming via PIC16f877. Figure 29 here, show on how the length of pulse affect the speed of fan.

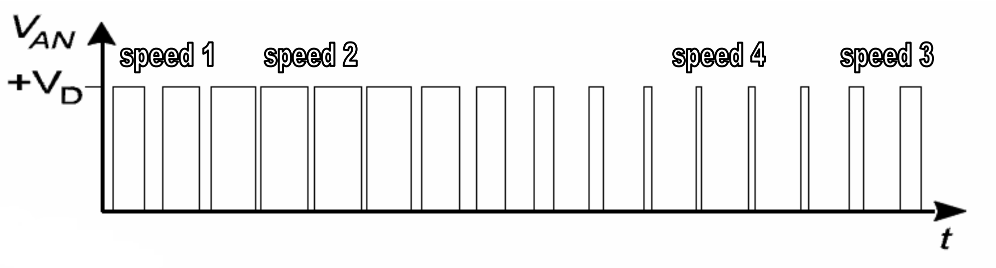


Figure 29 Example Pulse length analogies

Plus, to be more precise, for PWM formulation, especially on setting on the pulse, formula that being used;

setup_timer_2(TMR2_prescaler_value,PR2,1)

The strategy used here is to control the period of each PWM pulse and at the same time maintaining a total of 180 pulses in a complete cycle. When the period of each PWM pulse is reduced, the total time taken to generate 180 pulses is also reduced. Thus the period of one cycle of AC output is reduced and hence a higher output frequency is realized. Reversely, when the period of each pulse is increased, a lower output frequency is generated.

Another important formula inbuilt-in function is the setting of period of PWM pulses;

The PWM period is calculated in

$$\textbf{PWM Period} = \textbf{(PR2+1)} \times 4 \times T_{OSC} \times \textbf{TMR2 prescaler value.}$$

This formula is very useful especially in providing different speed value toward the fan.

CHAPTER 3

METHODOLOGY

3.1 Procedure Identification

For this semester (FYP2), the entire work is basically a follow up toward the previous work that had been done in FYP1. The objective of FYP2 is to create a reliable prototype for ceiling fan operation.

Below is the flow of project for FYP2.

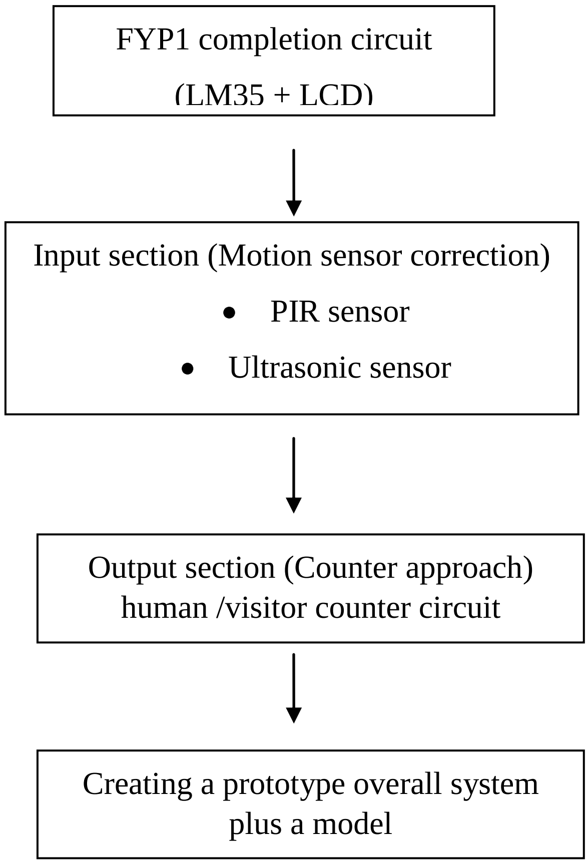


Figure 30 Flow of Project

3.1.1 PIC16f877A programming

In this project, PIC16f877A will be programmed using C language since it quite familiar to use it. Plus, it is easy to make an adjustment if any error occurs. In fabrication process (Programming) there are a lot of procedure need to be create

- ADC conversion toward LM35 sensor
- LCD display (temperature detected)
- Functionality check of motion sensor (PIR sensor) with LED
- Functionality check of motion sensor (ultrasonic) with fan
- Counter approach→ PIR sensor + ultrasonic sensor
- AC single phase induction motor

3.1.2 Programming Protocol @ Procedure

PROTOCOL

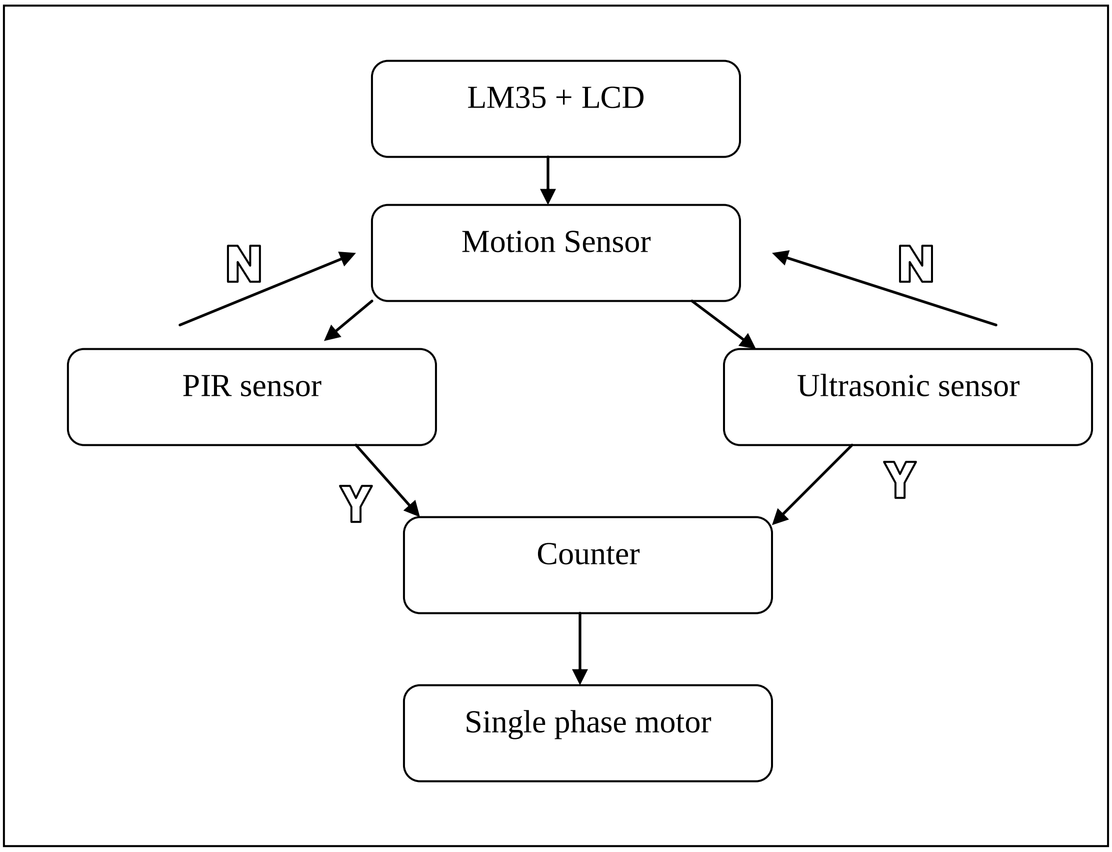


Figure 31 Project Protocol

1) First stage creating a code for LM35 sensor. There are 2 task need to be done which are ADC conversion and LCD display
2) Second stage was proceeding to second sensor which is motion sensor. There are 2 sensor need to code out. Both experiment use LED as output for indication detection exist.
3) Third stage can only been proceed if second stage managed to be accomplished. In this stage, the counter code using PIC16f877 been made out for human detection

All the programming will be using PIC burner and PCW kit 2.9

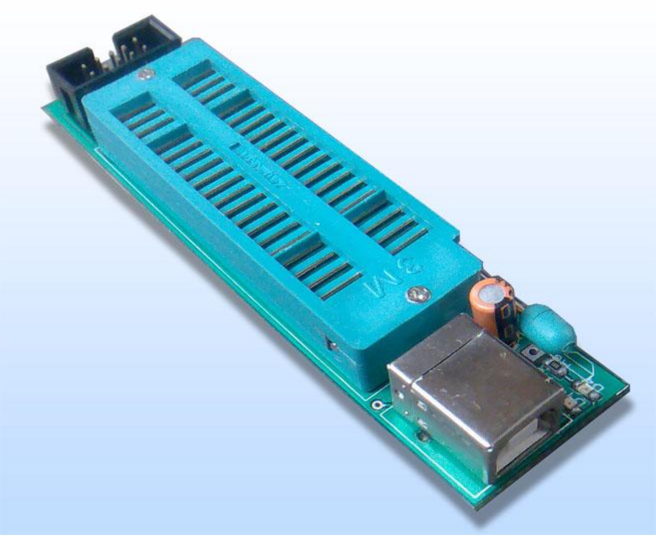


Figure 32 PIC16F877A burner

3.2 LM35 Functionality check

3.2.1 LM35 Functionality

LM35 sensor consists of 3 pin. The second pin connected to the PIN_A1 of PIC since port A can be used for ADC conversion. To make the LM35 sensor operate, 5 volt applied at the first pin of LM35

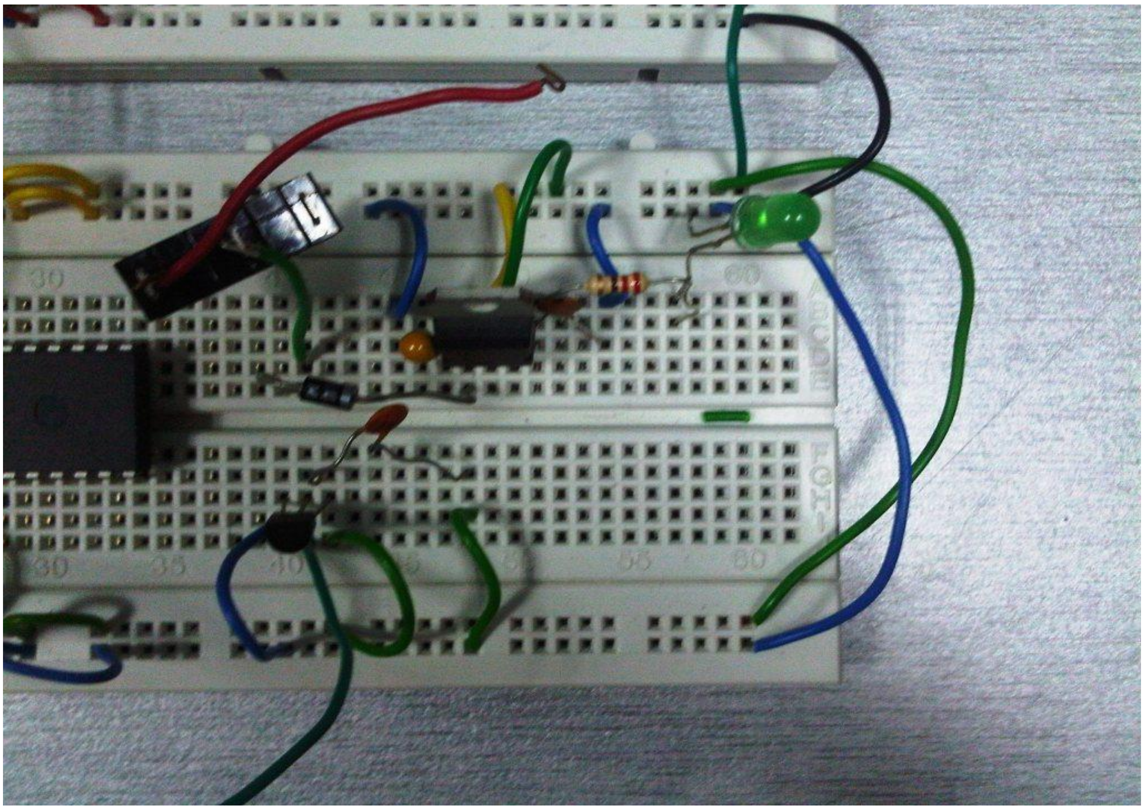


Figure 33 circuit testing LM35

Figure 33 explain about the test – circuit toward LM35 sensor. This sensor consist 3 pin which basically can be stressed like:

Pin 1 – 5 v, Pin 2 – input point, Pin 3- gnd

For function check, using either voltmeter or oscilloscope, one wire of either things (voltmeter (black wire) or oscilloscope) being placed at pin 3, while for others wire (red voltmeter wire or positive supply) goes to second pin of LM35. The result of both experiments can be seen at figure 43 and figure 44.

3.2.2 LCD display detected temperature

LCD 16x2 will be use for temperature display. For LCD connection there are about 10 pin being connected to Microcontroller chip (figure 34). Beside, to accommodate with the need of the 40 pin PIC16f877A, LCD driver being use to simplified the problem. The code of (Appendix B) explain entirely regarding interfacing between LCD and PIC16f877A

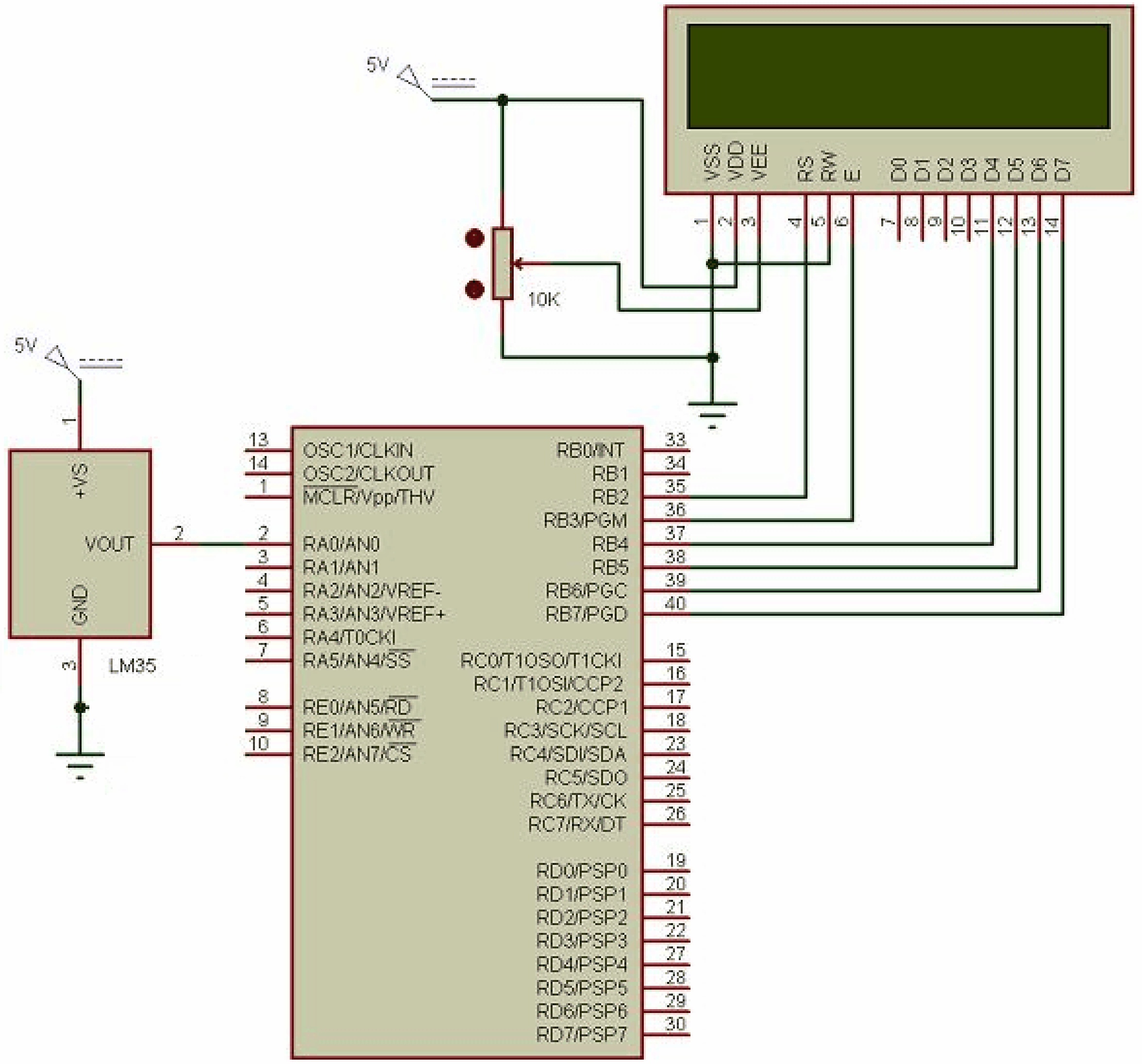


Figure 34 LCD + LM35 + PIC connection

3.3 Motion sensor functionality check

3.3.1 PIR sensor example connection

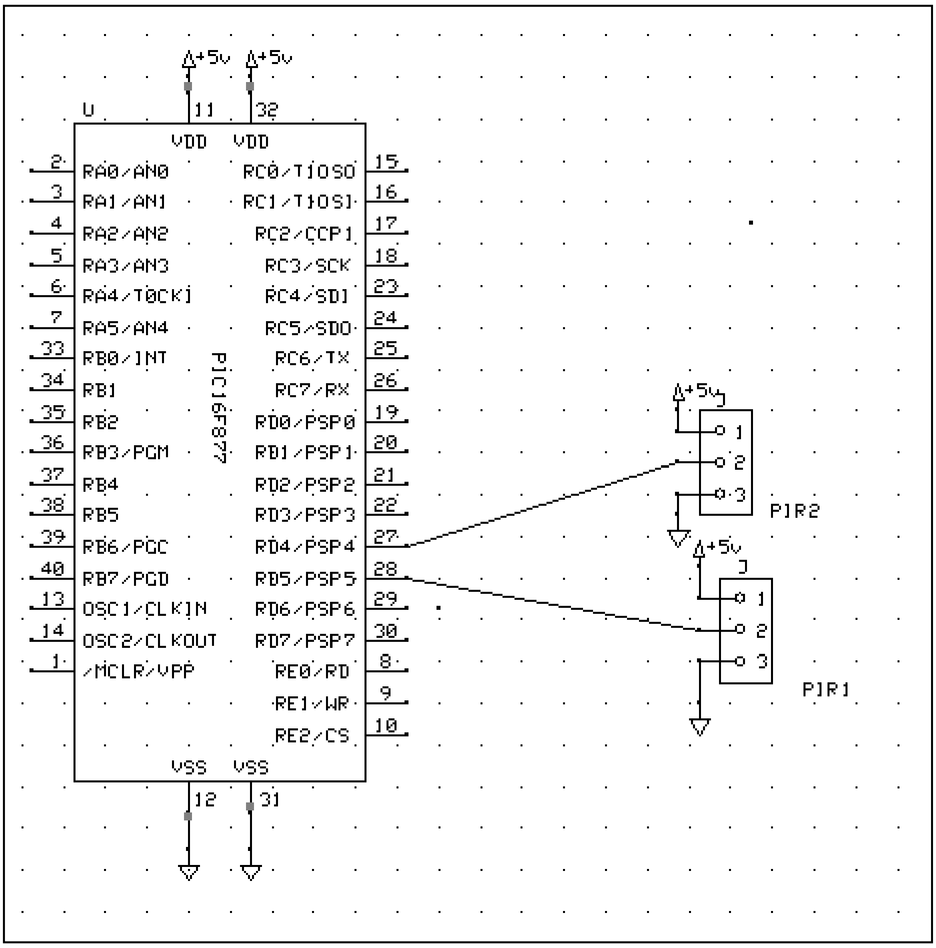


Figure 35 PIR-PIC connections

Table 1 PIR sensor Advantages & Disadvantages

Advantages	**Disadvantages**
Simple interfacing with PIC 16F877A	Detection is too big

For output purpose, either Buzzer or LED can be used. PIR sensor can be directly connected toward PIC16f877A

From observation, the detection of PIR sensor is actually a little bit confusing.

Figure 36 will explain about the length of detection if some motion occurs.

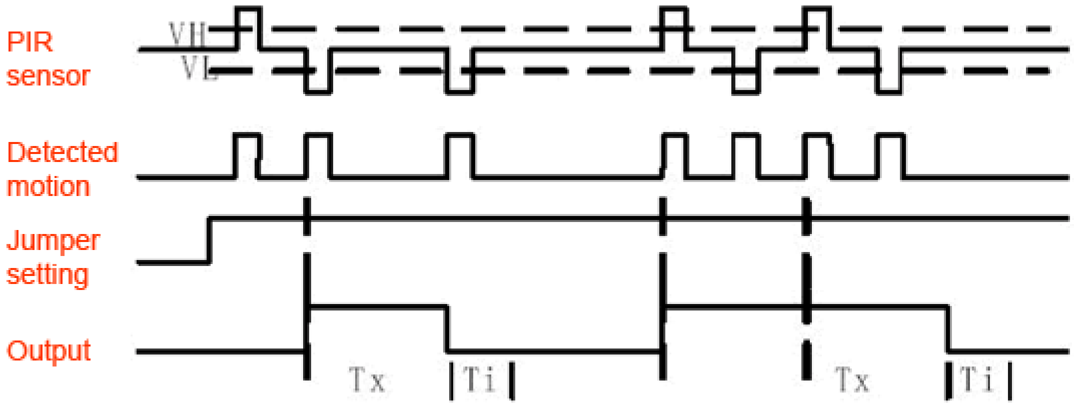


Figure 36 Detection operation

There are two ‘timeouts’ associated with the PIR sensor. One is the “**Tx**” timeout: how long the LED is lit after it detects movement. The second is the “**Ti**” timeout which is how long the LED is guaranteed to be off when there is no movement.

Tx = The time duration during which the output pin (Vo) remains high after triggering.
Ti = During this time period, triggering is inhibited. See timing charts for details.

Tx ≈ 24576 xR10 x C6; **Ti** ≈ 24 x R9 x C7。 (ref to schematic)

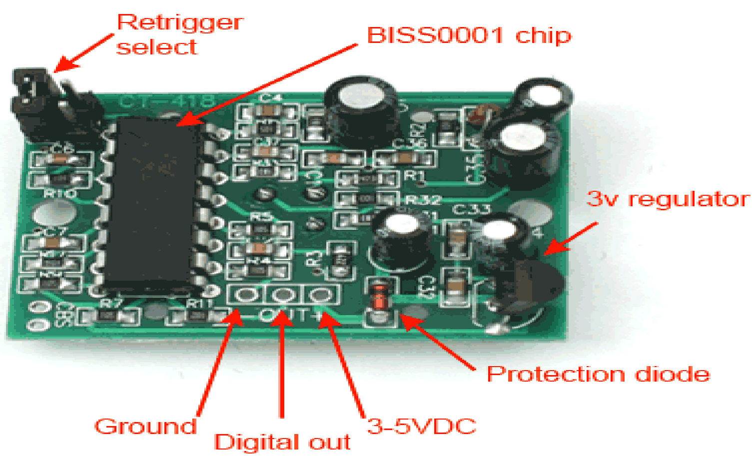


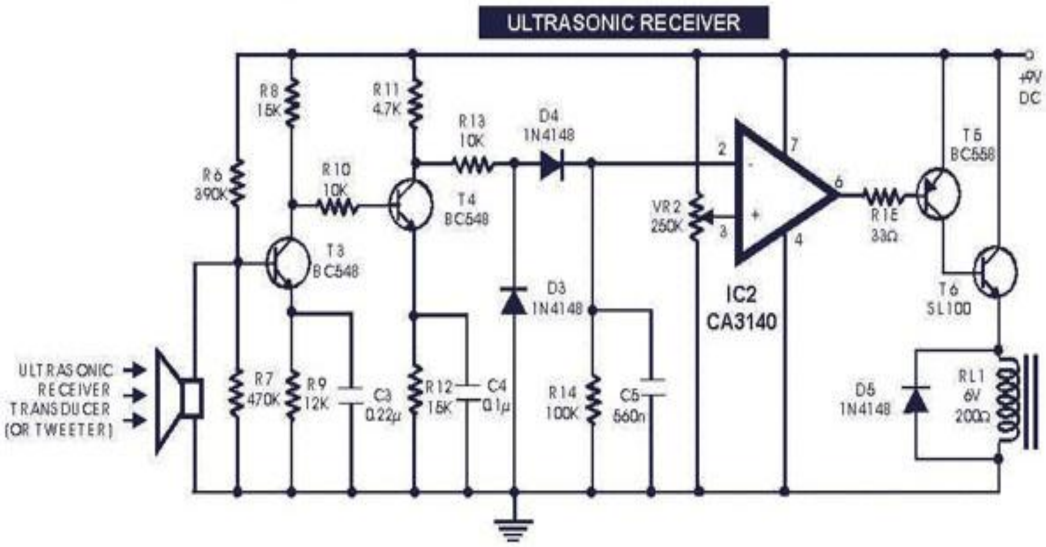
Figure 37 Backside overview of PIR sensor

Figure 37 tells about on where the important pin to interface with PIC16f877A. There are about 3 pin which are Ground, Digital out and 3-5VDC pin.

3.3.2 Ultrasonic sensor

Table 2 Ultrasonic sensor Advantages & Disadvantages

Advantages	**Disadvantages**
Detection one line (accurate detection)	Need to use other component when dealing with PIC



Trigger circuit consist Relay component

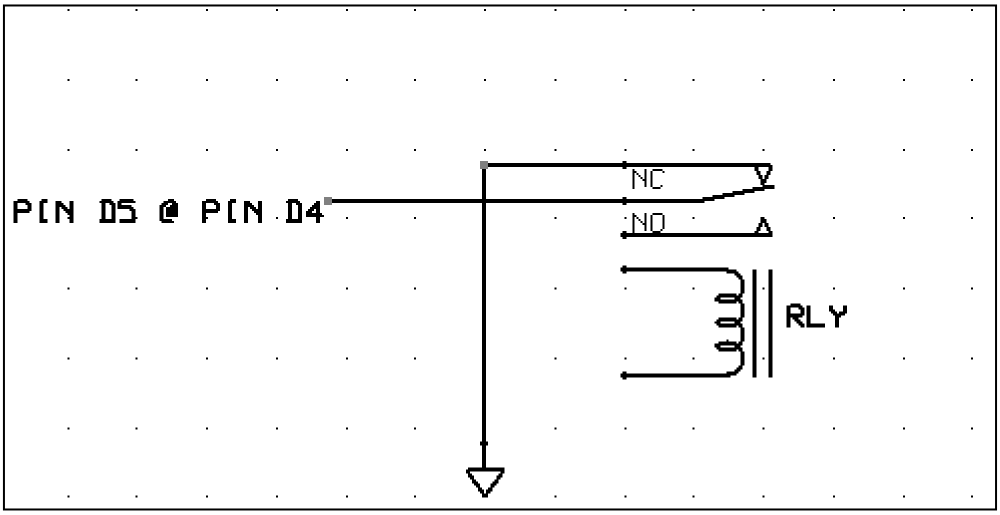
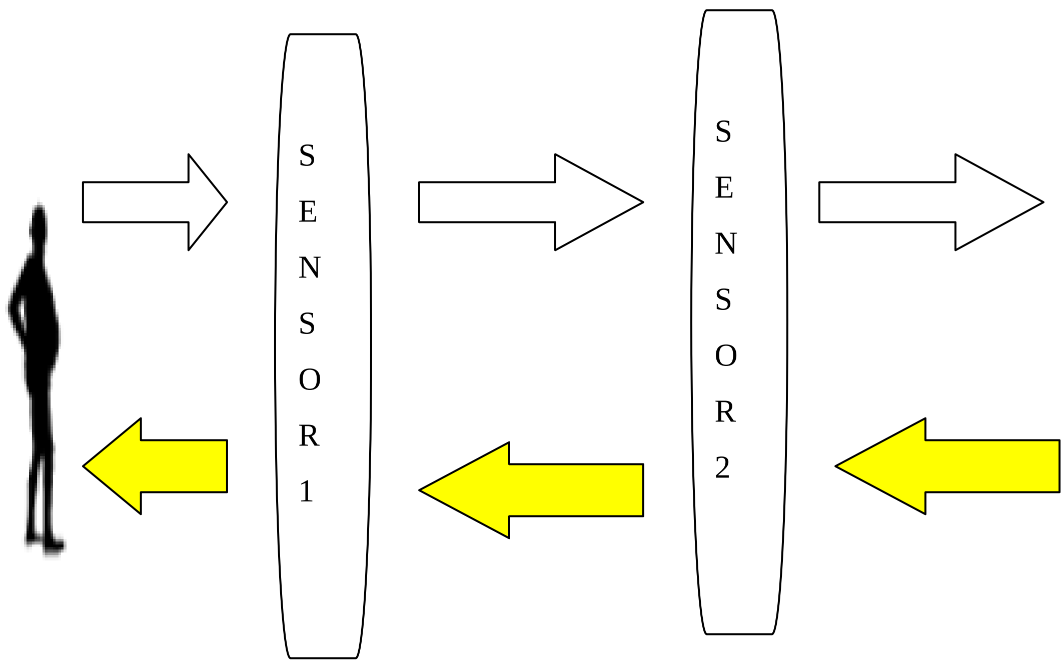


Figure 38 Ultrasonic detection analogy-Modified receiver circuit

Compare to PIR sensor, Ultrasonic Sensor itself contain variety of equipment when to make it operating. In that circuit consist of 12 v relay connection. A little adjustment is made out by using the connection of relay to provide an input toward PIC. Relay consists of 5 pin including common, normally close (NC) and normally open (NO). So for connection, the NC pin of the relay connected at ground source and Common Pin to the one of the pin in PIC16f877 just like PIR sensor. Here, based on the diagram above**;**

the Common pin will connected toward pin D5 or D4 of PIC as an input source. The connection is quite similar with PIR sensor, just additional relay between the sensor and PIC need to be added to ensure it run smoothly.

3.4 Counter – human detection



White arrow- **goes inside direction**

Yellow arrow- **goes outside direction**

Figure 39 Counter analogy

Counter analogy been built to count the number of human that entered the room. The room will add count value if the number entering increasing and will subtract the count if people goes outside. The count will act as the “switch” effect for entire system. If count greater than zero, overall system will operated. Else, if the count equal zero with indicates no ones entering the room; the system will automatically off. The count procedure is written in C code (appendix 4). The resulting output in this case will be using LED. As the Count >0; Led will light on.

For counter purpose, there are 2 sensor will be used which comes from any motion sensor that been explained above. Two sensor been made out to distinguish between people entering and leaving.

- Sensor1(on) → Sensor 2 (on) = count increment
- Sensor 1(on) → Sensor 1 (on) = count reduce

3.5 Interfacing PIC16f877a, AC motor and Relays

One approach that can be made out when interface with AC motor and PIC16f877a is by using relay. Here, (see figure 40) motor that had been equipped with autotransformer (Speed change purpose) can interact with PIC with the help of several components. The component like:

- Transistor switching – BC517 or BC107
- Relay 6V / 240 rating
- Diode 1N4001

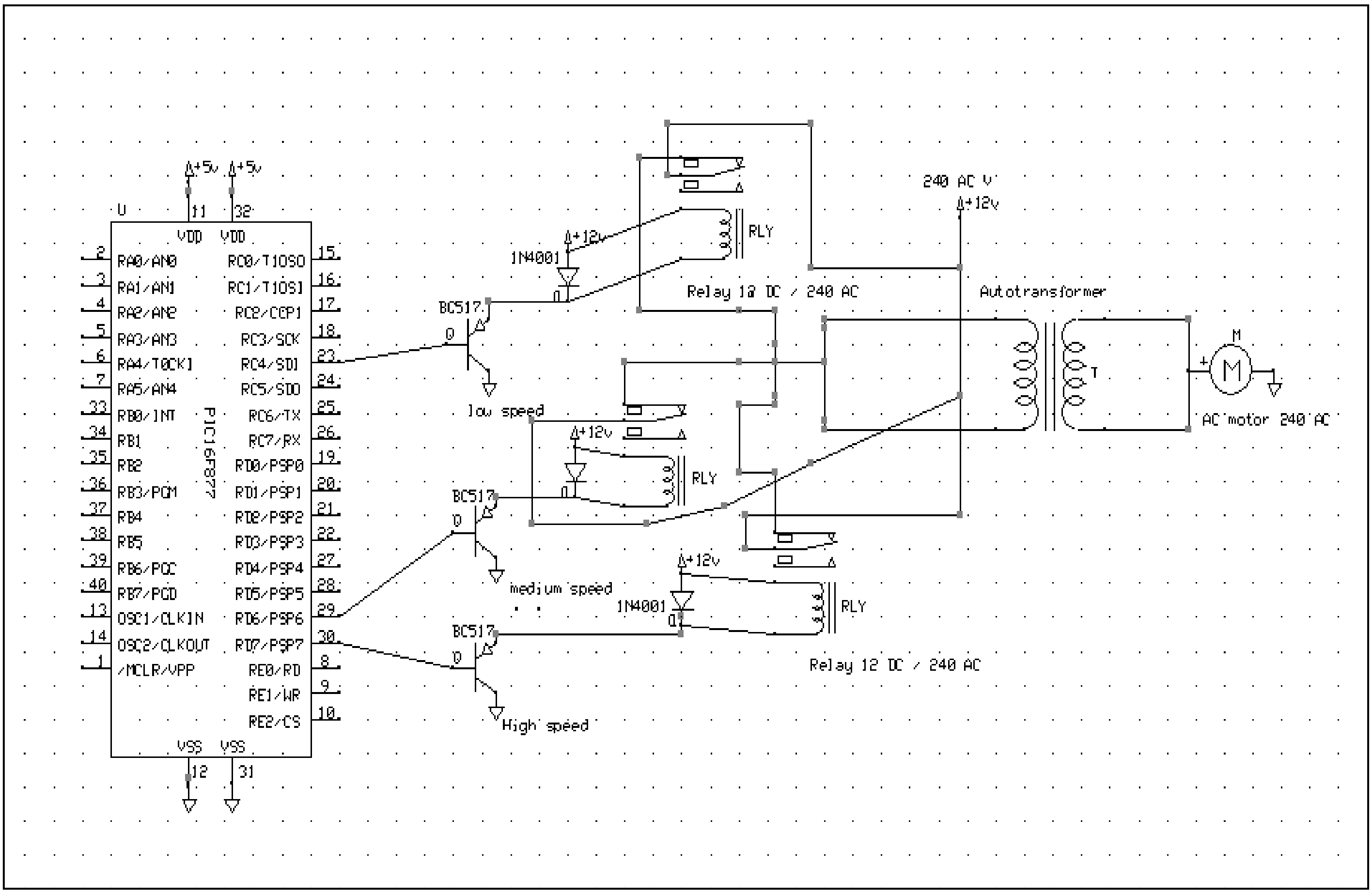


Figure 40 AC motor interfaces PIC16f877A

Diode 1N4001 being placed at each relay coil that been used. This component the relay work in stable condition and also provide smoothness if speed change occur. Here, Transistor – Darlington pair been used as medium between relay, PIC and AC motor. Darlington transistor (BC517) be choose since it provided high collector current that will eventually suitable to make the relay working. Plus, act as protection action for the PIC (memory crashed). Suitable relay need to be used with importantly provide 240 AC rating at the output of relay. Relay either 6 V, 9V or 12 V (SDPT type) can be use in this connection.

3.6 Keypad testing approach

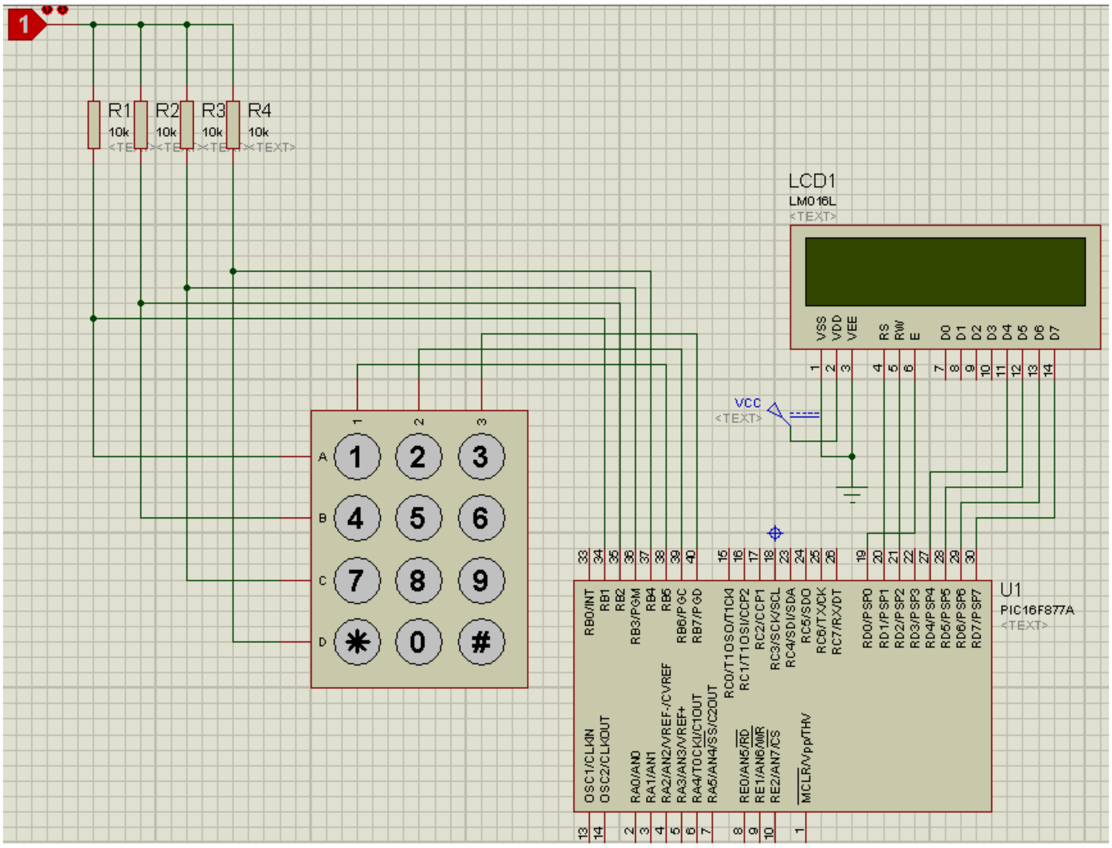


Figure 41 Keypad test

Just like LCD connection, Keypad connections toward PIC contain several pin that need to be connected (figure 41). Here, there are about 8 pin (4 rows, 4 columns) that need to be taken as consideration. The code (Appendix E) that be named as KBD.c is Keypad driver that allow the user to implement the entire pin to any suitable pin in PIC16f877A. In addition, for Rows connection there are 10k ohms resistor that need to be placed on with will be acting as pull-up resistor. The 10k ohms will be directly connected at 5v source at one end and Keypad pin for the other end of the resistor.

3.7 Overall programming flow-chart

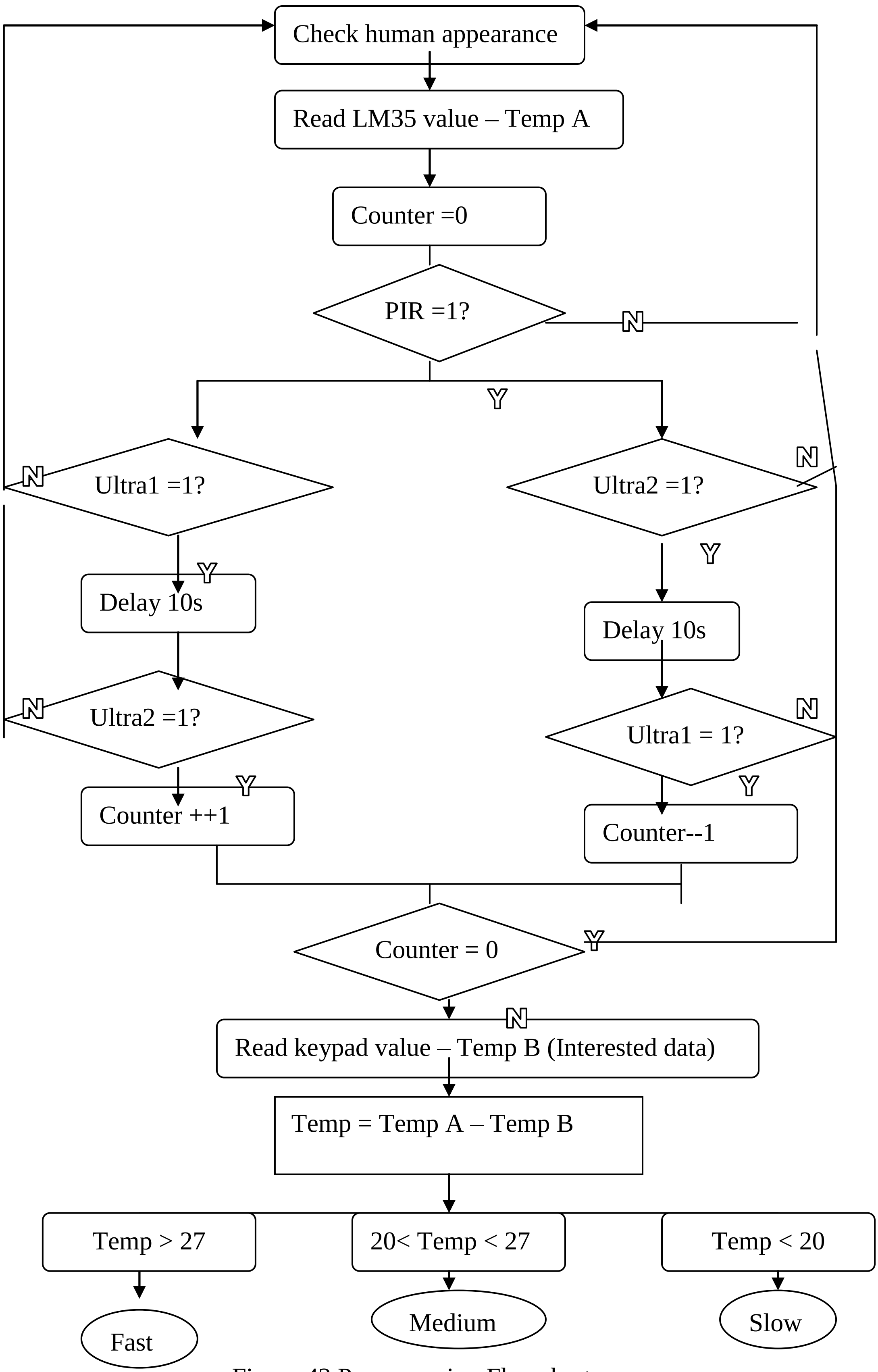


Figure 42 Programming Flowchart

Figure 42 tells about overall flowchart that being programmed using PIC16f877A. It contains overall involvement component in this project like:

- PIR sensor
- Ultrasonic sensor
- AC fan
- LM35 sensor
- Keypad 4x4
- LCD 16x2

CHAPTER 4
RESULT AND DISCUSSION

4.1 Result

The fabrication process managed to work on schedule. Here a list of result:

- LM35
- LCD display
- DC motor
- PIR sensor
- & Ultrasonic Sensor
- Counter approach via LED
- Keypad routine & AC motor

4.1.1 LM35 functionality check

Goes with the principle, 10 mv output value is actually equivalent toward 1 degree. Here, there are 2 sample results for LM35 functionality Check

- LM35 using oscilloscope (figure 43)
- The result is based on Voltage peak to peak that been display in oscilloscope. Yield a reasonable result around 220 mv which equivalent to 22 degree. The reading been taken in air-conditional room (Lab EE).

Result via voltammeter

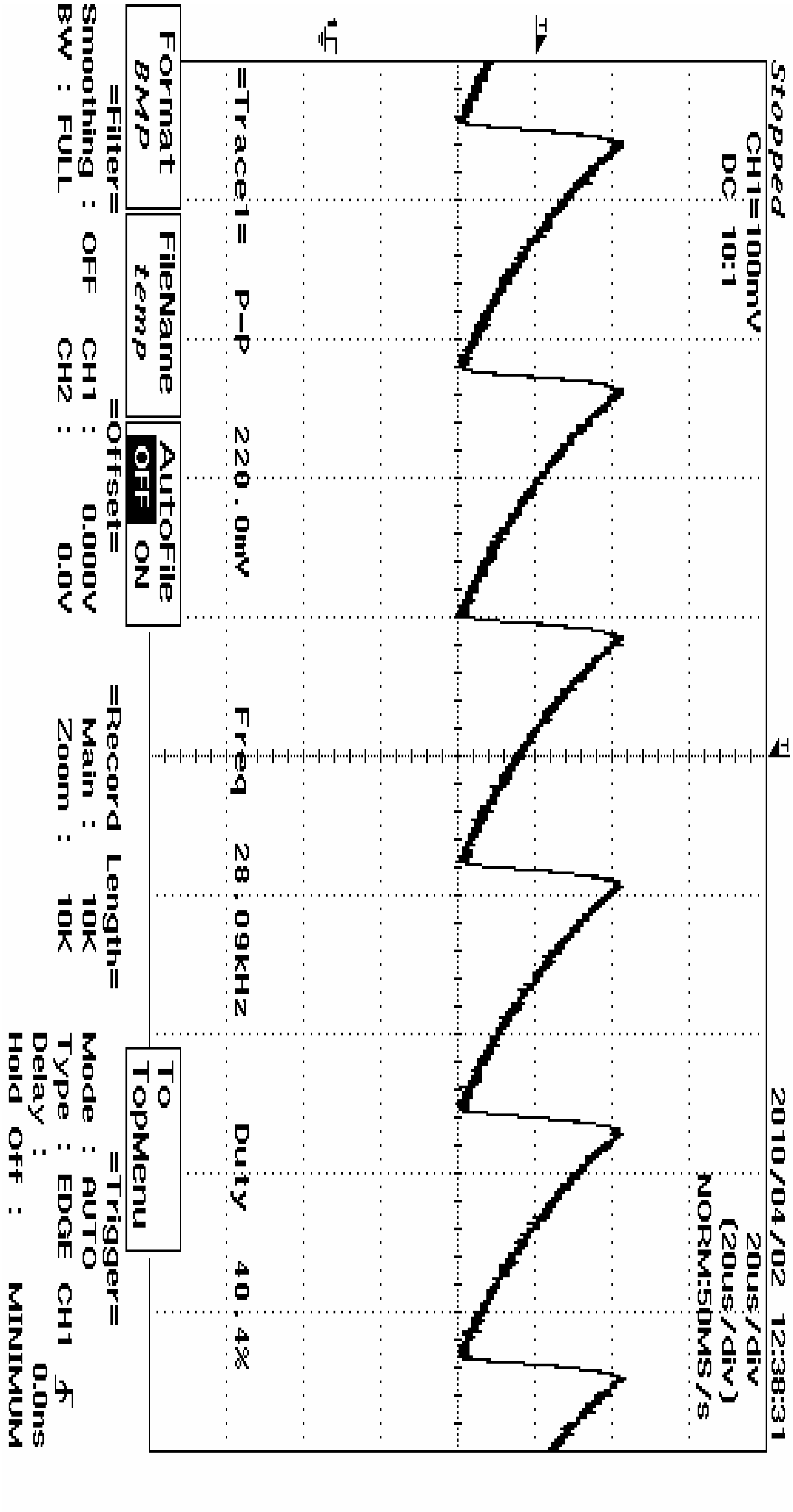


Figure 43 LM35 Oscilloscope result

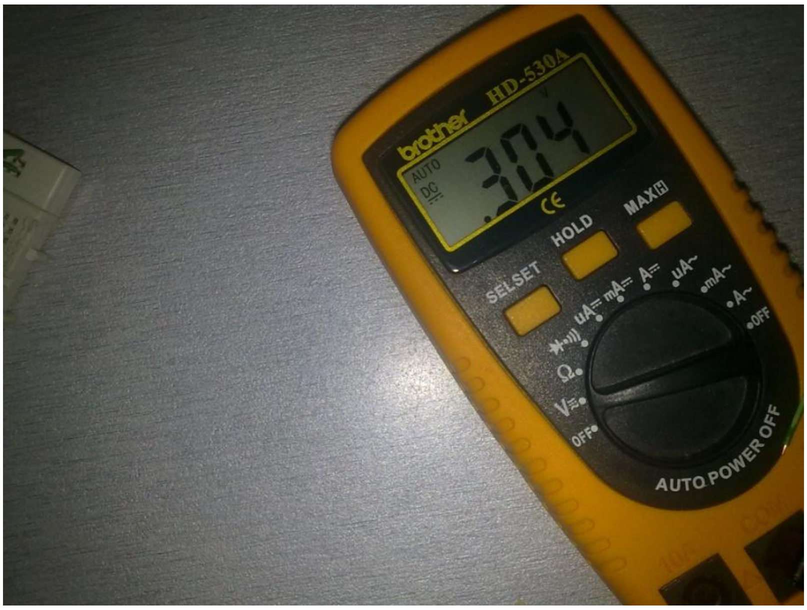


Figure 44 Voltmeter result

Figure 44 show the result of LM35 detection which proving the theory of the sensor which states about 10mv/1 degree. The reading collected around 304mv which equal to 30.4 degree manages to be captured (in a room).

4.1.2 LCD display

LCD component purposely aim to display the detected temperature of LM35. The LCD operate based on the instruction that been programmed in PIC16f877A chip. The code (Appendix D) consist the explanation of usage of LCD driver. Figure 44 show result about LCD result capturing actual temperature using LM35. The connection is quite the same with figure 34.

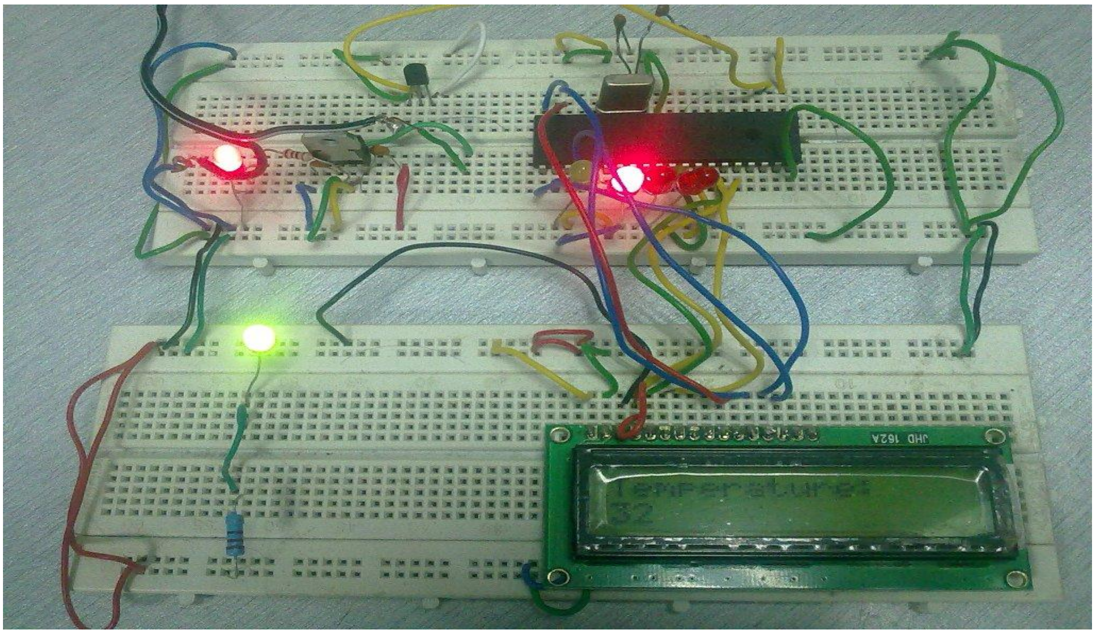


Figure 45 LCD Result

4.1.3 PIR sensor functionality (PIC16f877 + PIR sensor + LED)

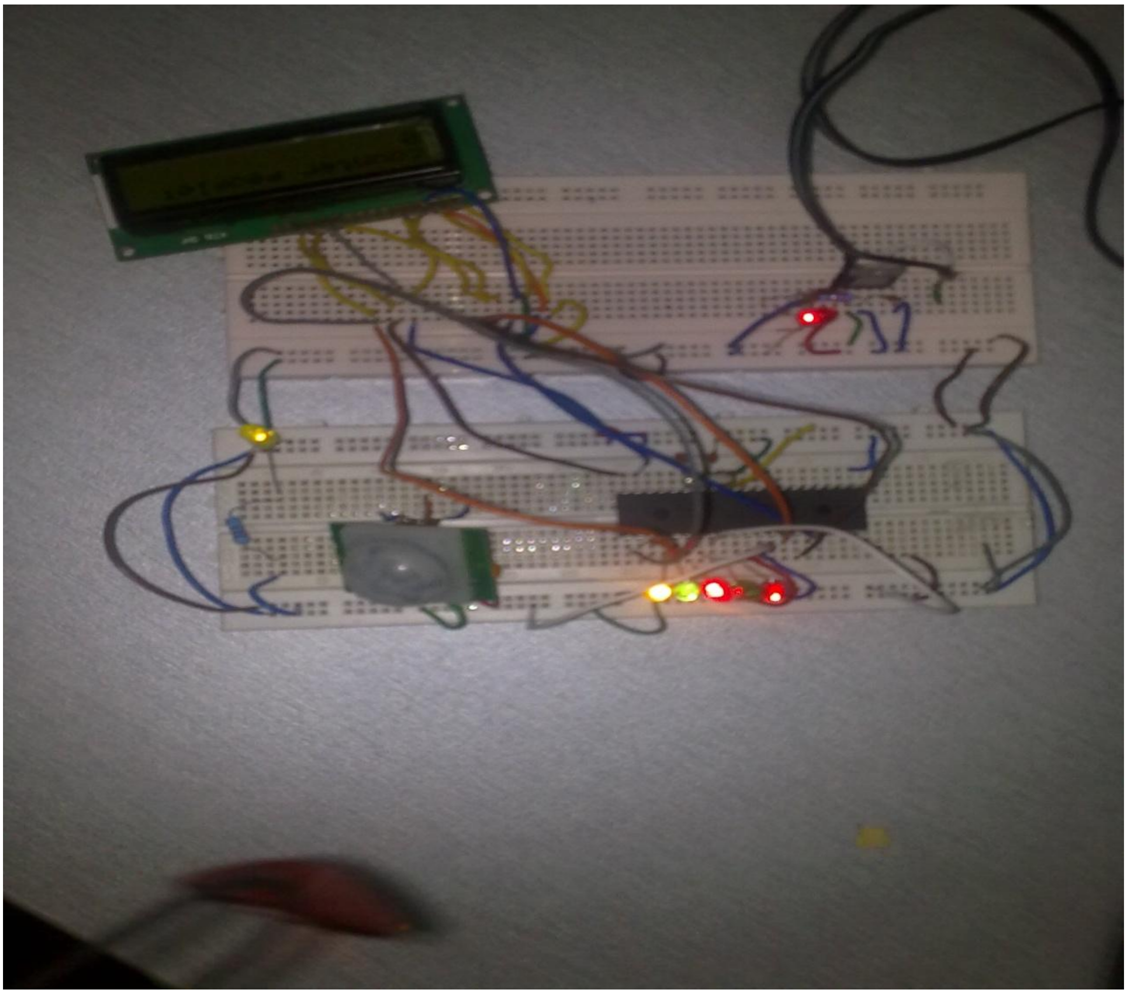


Figure 46 PIR sensors Implementation

The testing approach is made out using PIR sensor as input and LED as output (figure 46). LED being selected as output to avoid any complication when dealing with microcontroller chip. As the motion sensor alert (LED blink) it will make the output or LED at PIN (in PIC) in ‘on’ condition. The connection can be seen from figure 35.

4.1.4 Ultrasonic Sensor functionality check (Sensor + PIC + DC fan)

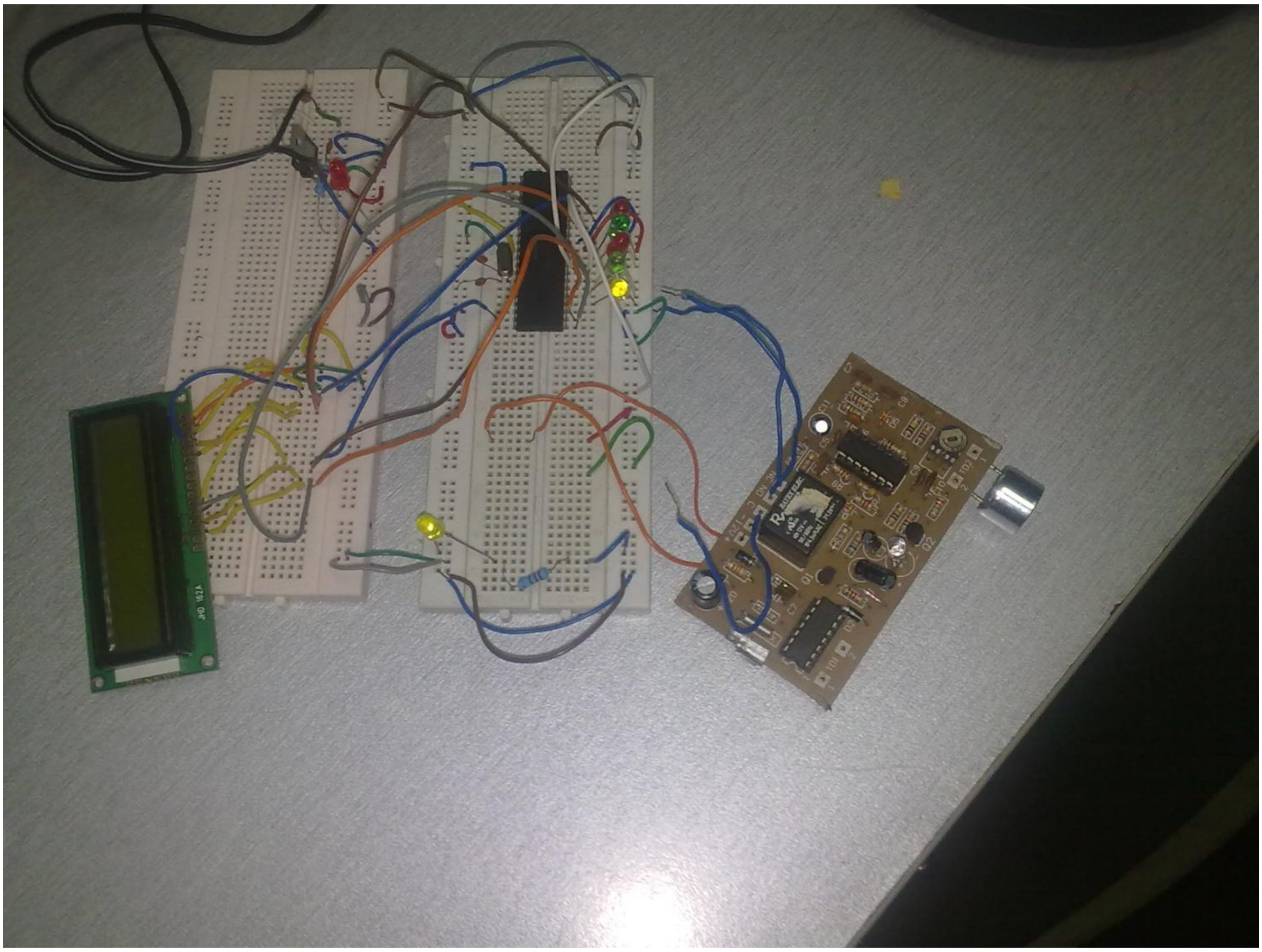
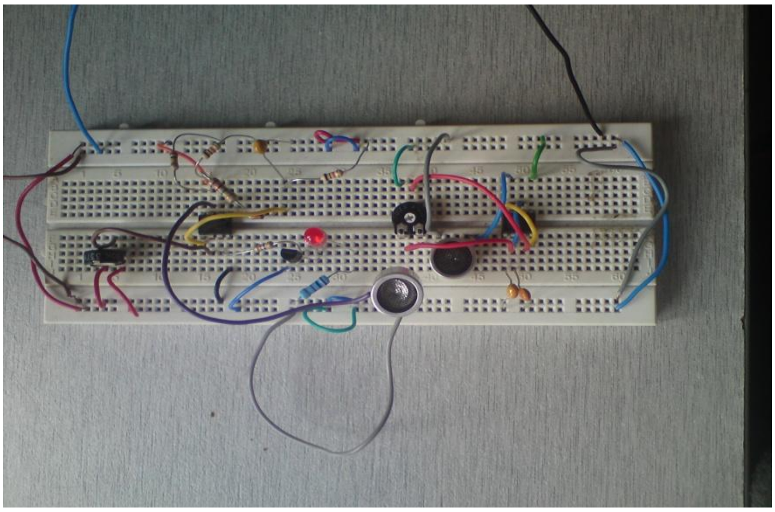


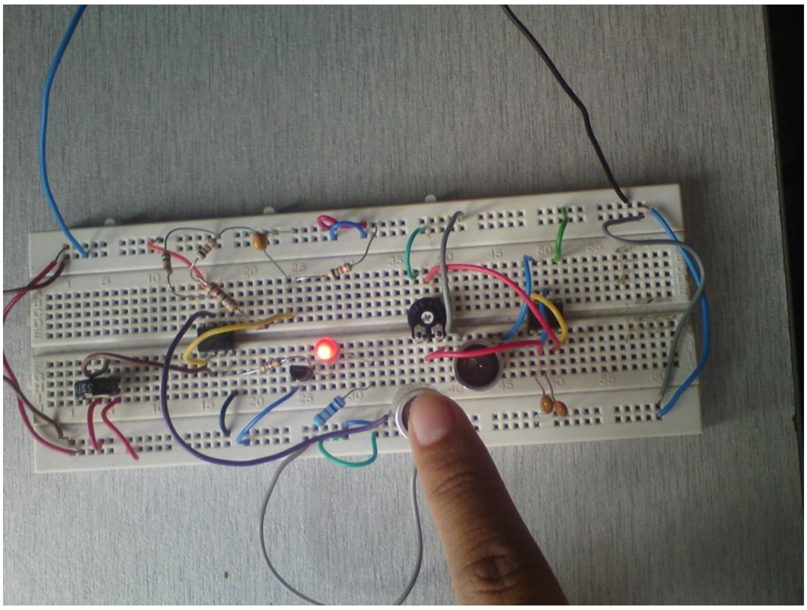
Figure 47 Ultrasonic implementation

The testing approach is made out using ultrasonic sensor as input and LED as output. LED being selected as output to avoid any complication when dealing with microcontroller chip. As the motion sensor alert (LED blink) it will make the output or LED at PIC pins in ‘on’ condition. The connection of the sensor and PIC16f877 can be referred at Appendix G. Figure 38 explains clearly on how both components interact.

Figure 48 explain more about the functionality of this sensor that being test using breadboard. LED will act as indicator that as motion (finger approaching) exists; it will make the LED ON.



No motion (LED off)



Motion exist (LED ON)

Figure 48 Breadboard check on Ultrasonic sensor

4.1.5 Counter approach

The counter approach is the mechanism to count on human that enter the room. The counter circuit will be using 2 sensors as the main input for the system. The system will be placed at the door and also around the room.

Counter Up

Count up as the human enter the room. In the code (Appendix 4) it stated about mechanism where the overall system will be on if count is greater than zero value. This means, whenever human exist in the area, the system will still be operating.

Figure 49 show the counter equal to 1 which indicates one person had entered the room. This condition will allow the fan operation to operate immediately. Next, Figure 50 that there are LED ON to indicate entire sensor is alert that someone enter the room.

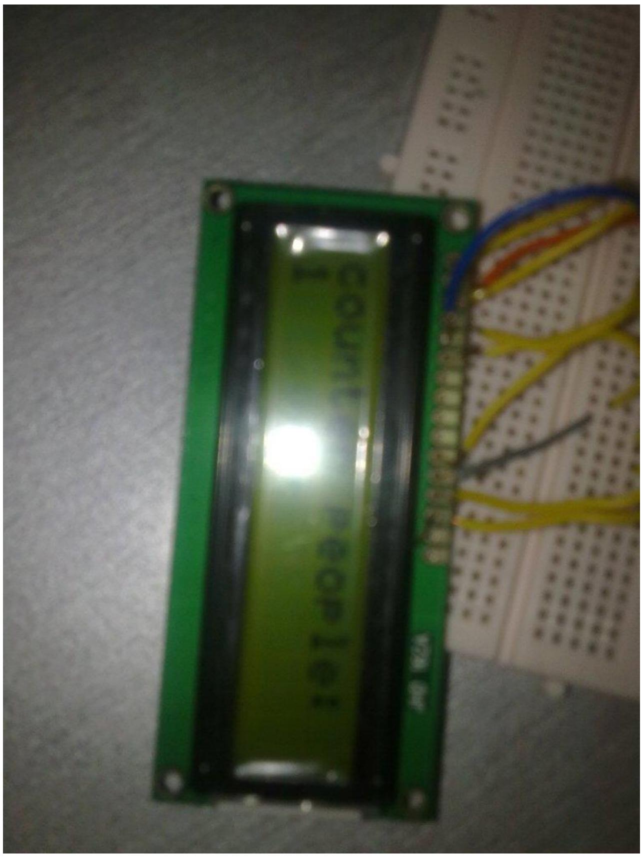


Figure 49 Count UP

LED at PIC pin 'blink'

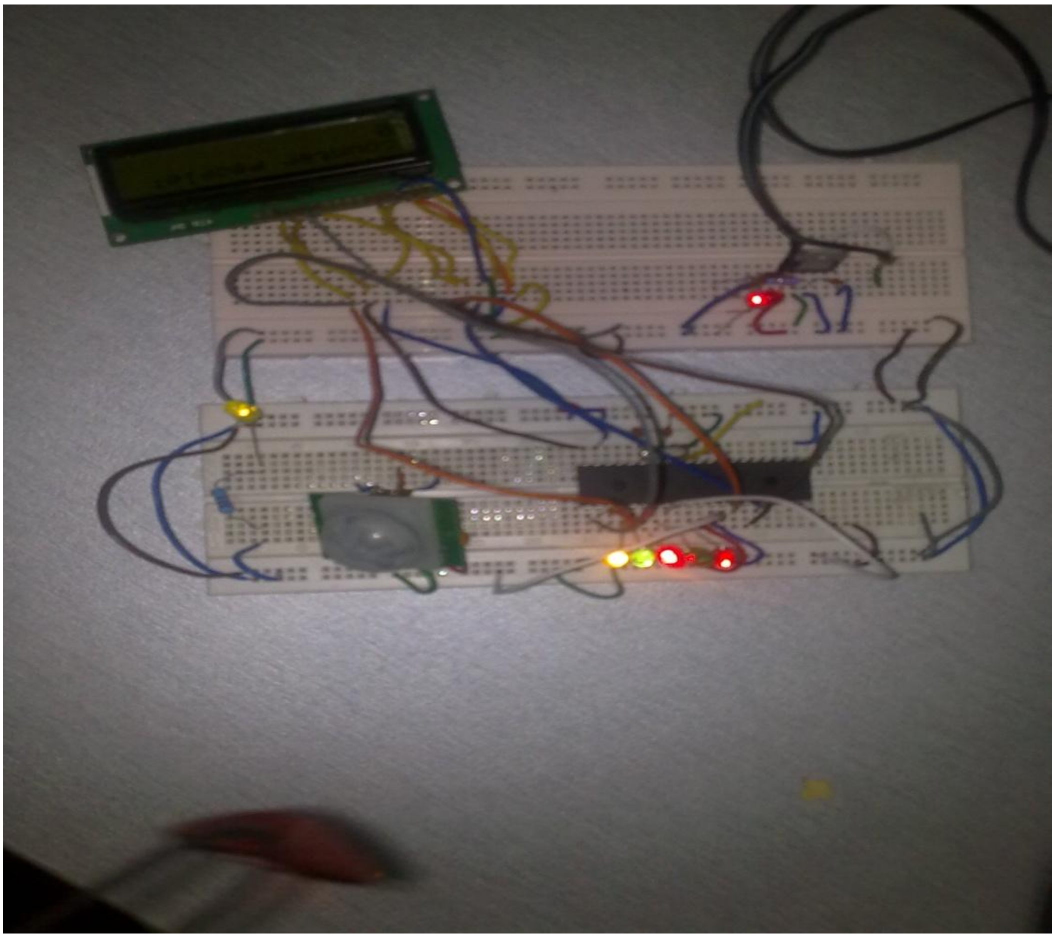


Figure 50 System ON

Counter Down

Figure 51 show about count down operation routine – Counter value equal to zero. Count down or reduce counter approach explain about the condition when the human leaving the room. Just be stated earlier, in Counter mechanism, the system will only off if the count equal to zero.

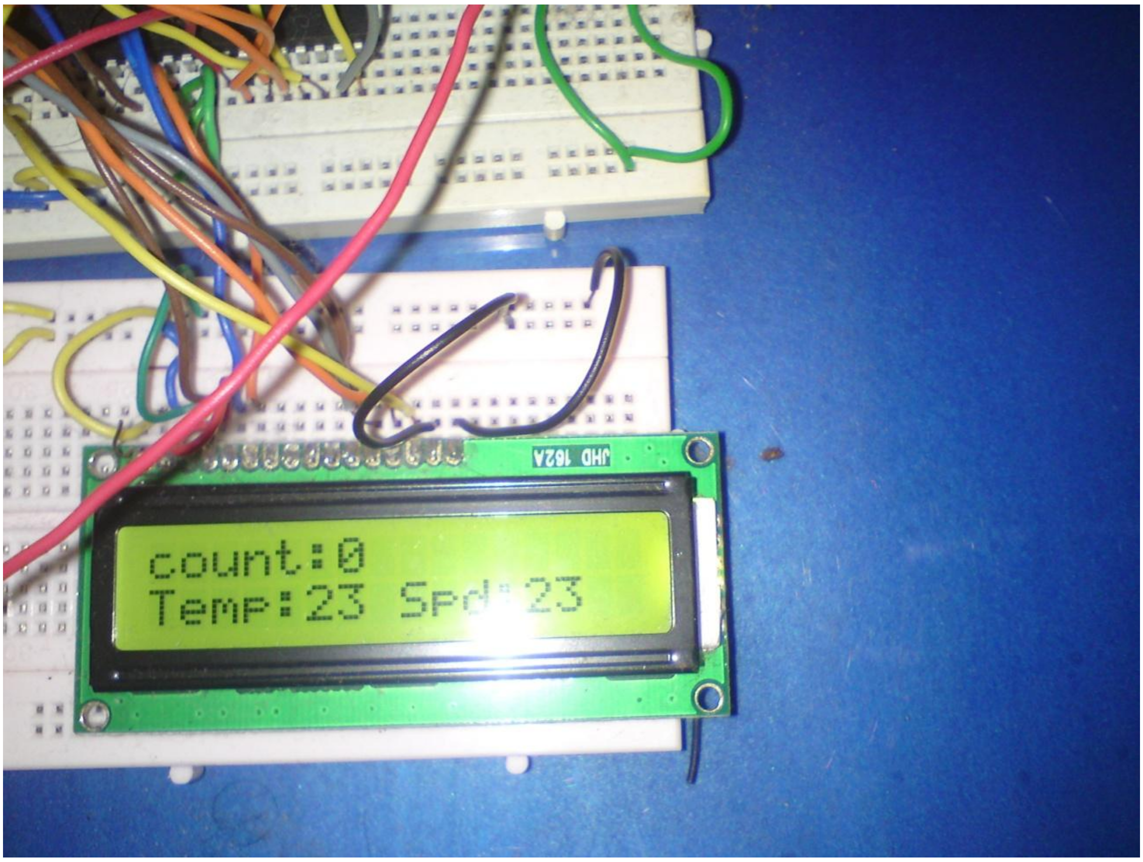


Figure 51 Count Zero

4.1.6 DC Motor application

Testing is made out to justify the capability of DC fan motor toward motion detection. Here, ultrasonic sensor been used as the sensor to control the output of DC fan. The Ultrasonic sensor is connected by using DC fan as an output via 12 relay. Just like the PIR sensor experiment, this picture (Figure 51) also aims to justify the movement detection toward human. As the motion captured by sensor (LED blink) it will provide sufficient current to make the DC fan operate.

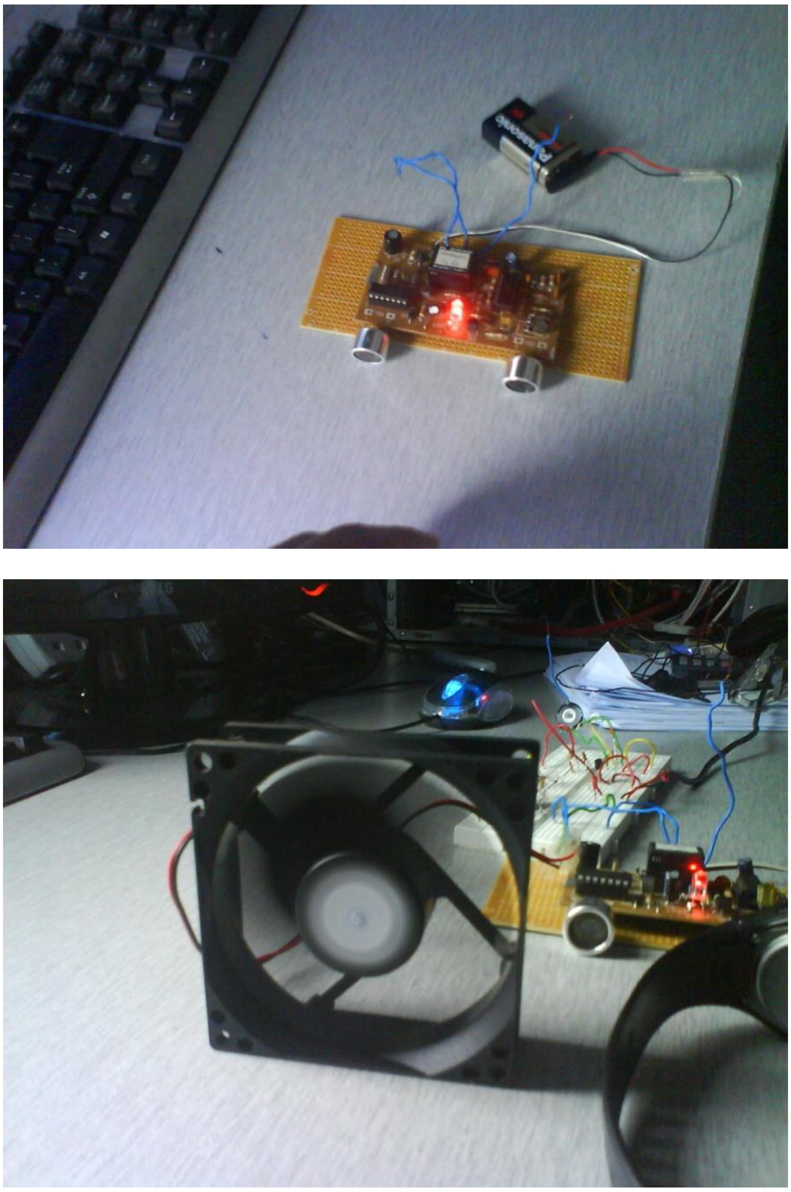


Figure 52 DC fan Experiment

4.1.7 Keypad routine Checking

Figure 52 explain about keypad routine. The systems are occupied with several components such as LCD, PIC16f877 and Keypad 4x4. The result stated that the keypad mechanism working properly (Appendix E). As the user pressed one button like 1 the LCD manage to produce it in the screen. This approach just to show that keypad is function well.

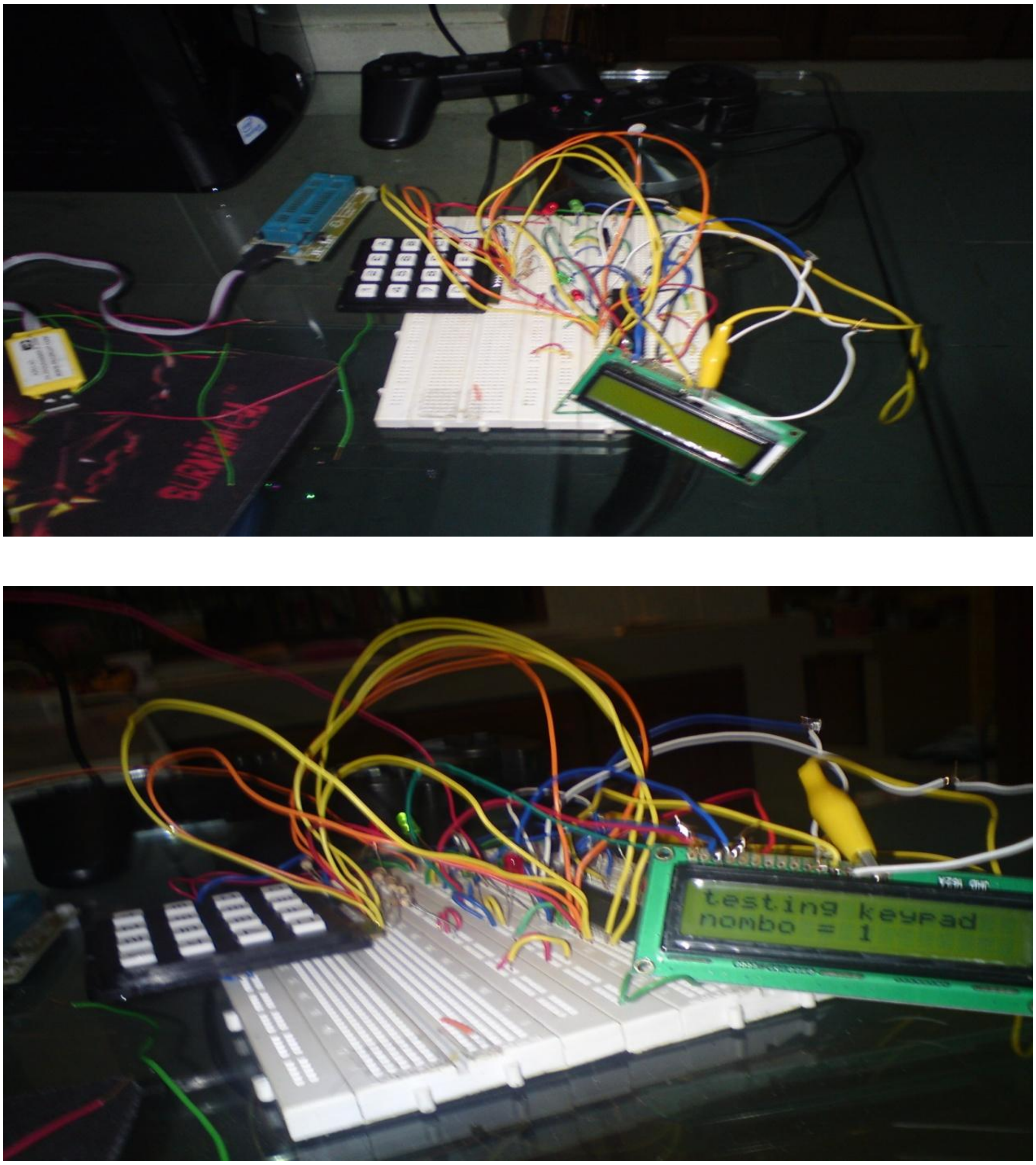


Figure 53 Keypad display

4.1.8 AC motor operation checking operation

Figure 54 and 55 explain about how that AC motor can operate by using PIC16f877A. As shown earlier in the schematic given, the AC motor manages to changes the speed accordingly. For example; at first, the motor only operate if counter >0 and detected temp value

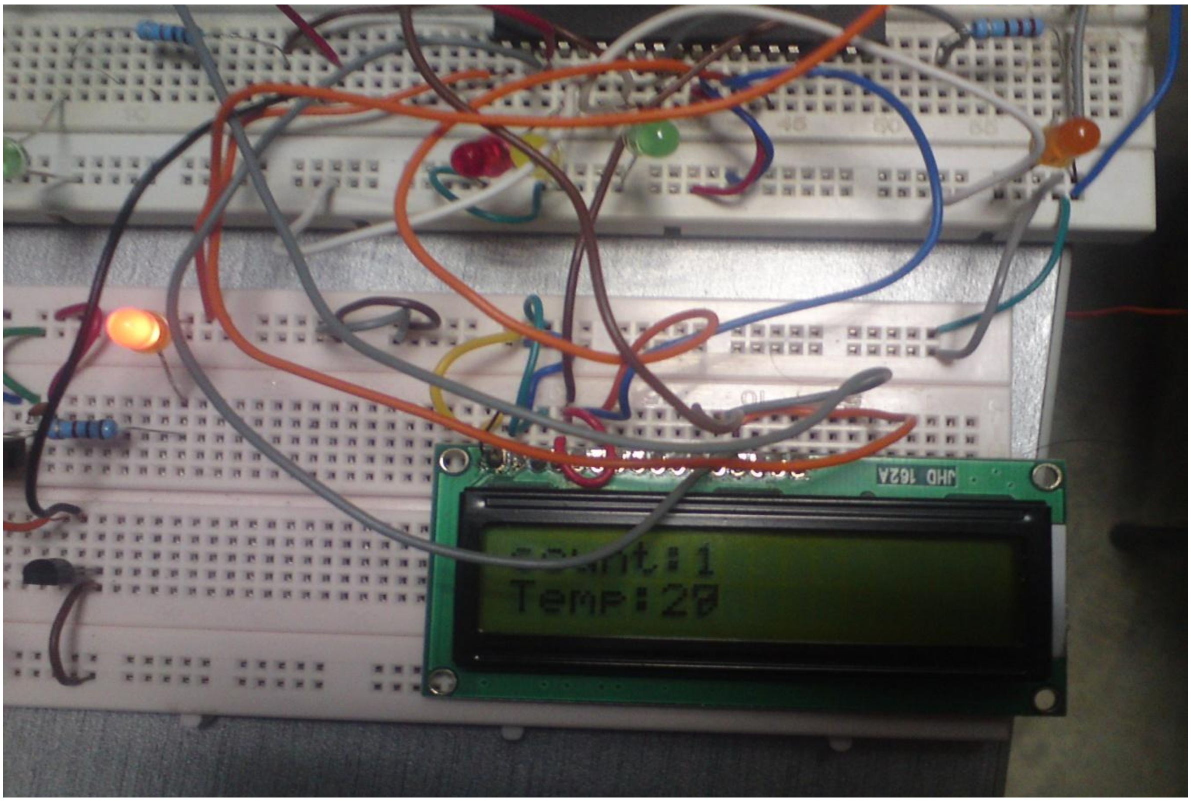


Figure 54 Detected temperature & Counter

Figure 55 Resultant Fan

4.1.9 Overall result – running fan

Motion detected (Both PIR and Ultrasonic)

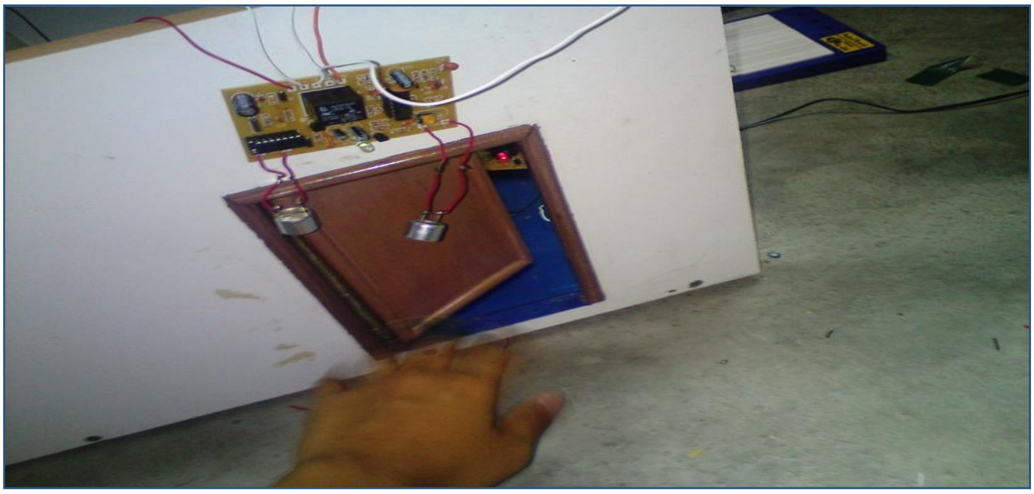


Figure 56 Motion exist

Figure 56 explain about existence of human movement. Here, movement of hand, will alert both sensor (Sensor 1 and 2) that there are motion exist. As a consequence, it will allow other operation to operate;

- Temperature detection
- Fan operation

The sensor section it co-dependent on PIR sensor. If the PIR sensor not alert, the alertness of both Ultrasonic still be in OFF condition. To be more precise, PIR sensor aim to distinguish between human and pet appearance.

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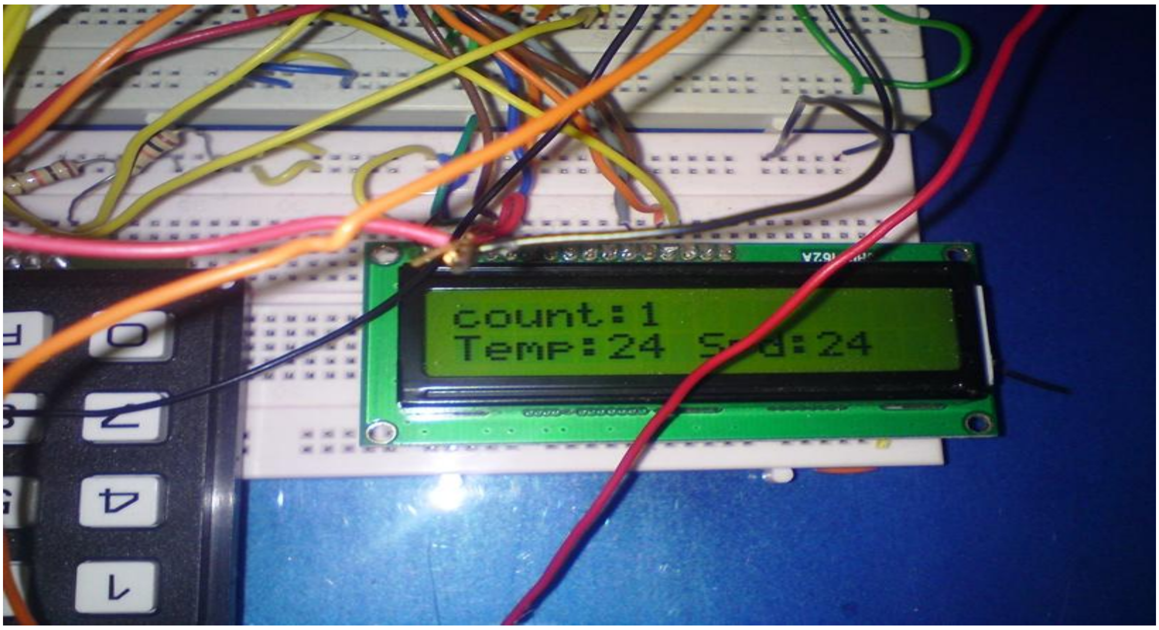


Figure 57 Example of Actual Temperature

Figure 57 is example of situation of LM35 operation and counter operation. If counter value greater than zero, it will allow the entire system to operate. Below, is about actual temperature being detected by LM35 sensor. It will detect the actual temperature and display it in LCD. Meanwhile, Figure 58 is another proves about the alertness of overall sensor. Here, there are 3 LED ON to indicate the entire sensor alert:

- PIR sensor
- Ultra 1
- Ultra 2

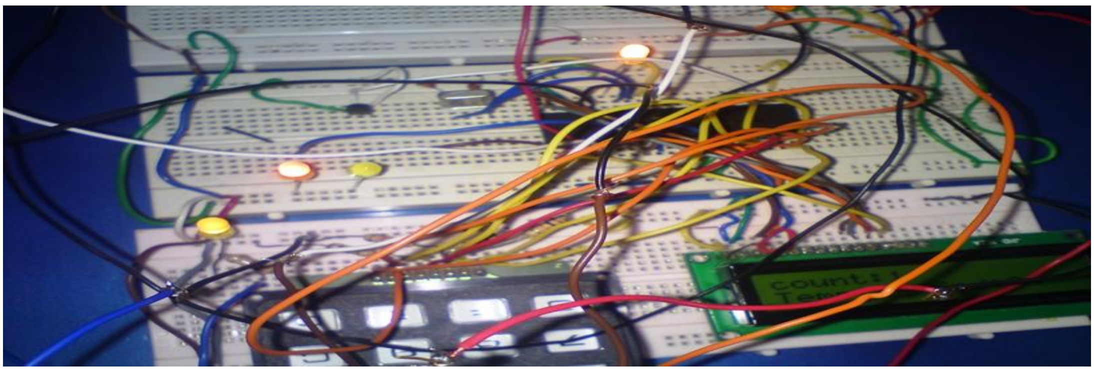


Figure 58 System Operate (2 LED on –indication of sensor)

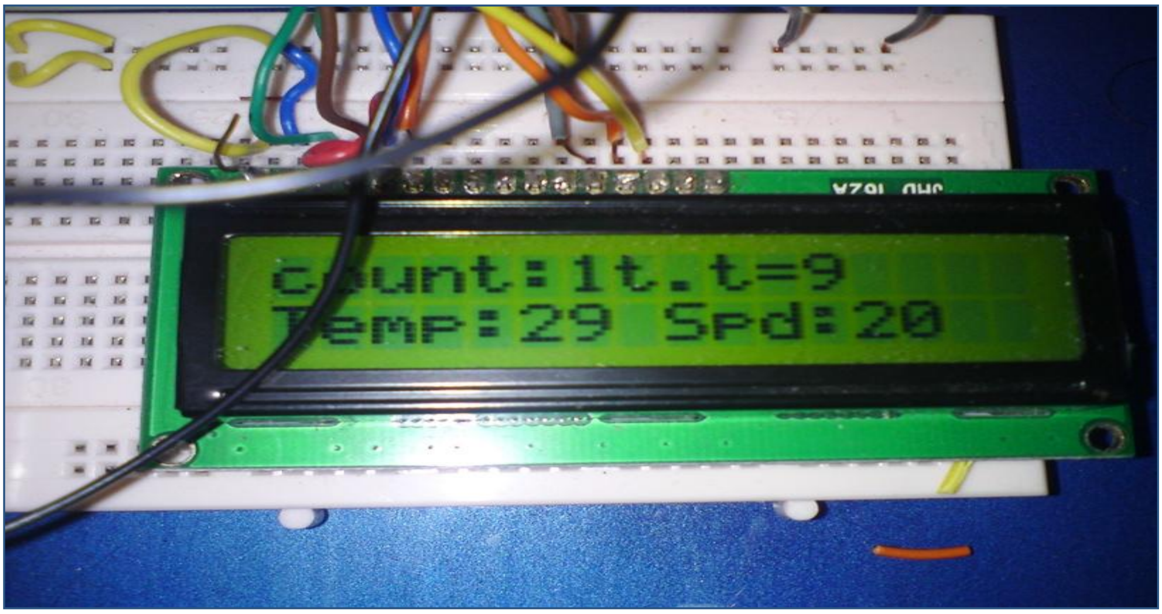


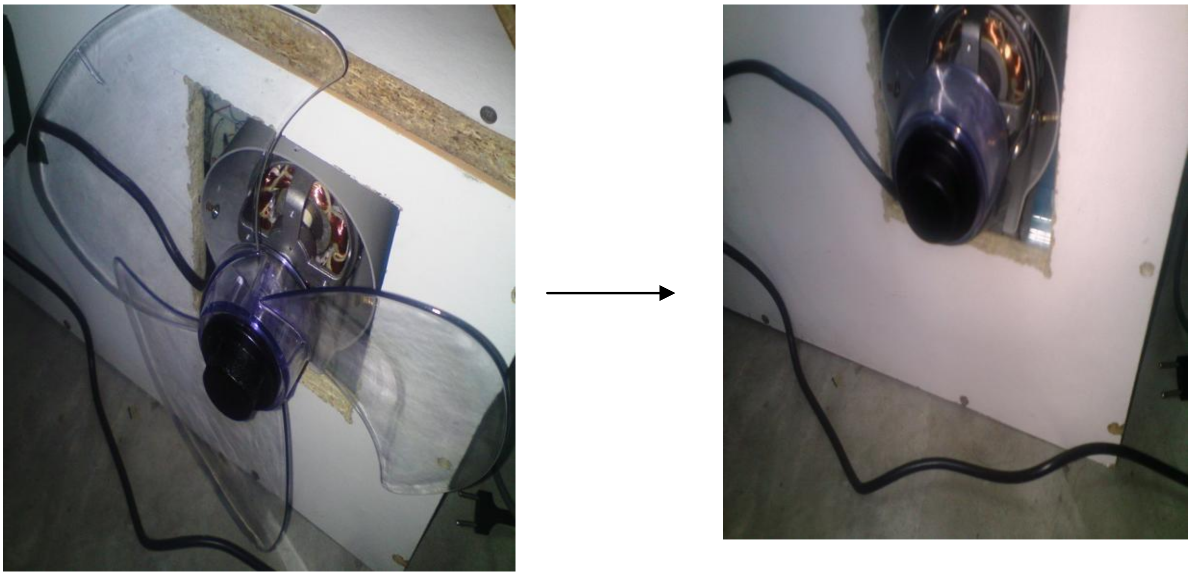
Figure 59 Interested temperatures (“t.t”)

Figure 59 explain about the influence of keypad. To be more precise, it about the value of keypad button being pressed by the user. “t.t” is indication of value being pressed by keypad. This value will be subtracted from actual temp for speed value of Ceiling fan. Here, SPD is equal to 20 degree which equal to medium speed of ac motor.

The Fan speed can be done using PWM technique or relay-BC517 operation. Here, due to limitation budget, “relay- BC517” connection been used for the prototype.

Fan speed being set via C programming:

- Speed >27 = Fast speed
- 20< Speed< 27 = Medium speed
- Speed< 20 = Slow speed



OFF condition   ON condition

Figure 60 Fan running

Figure 60 is resultant output that focuses on the condition of the Fan. Fan ran based on the SPD value being display in LCD. For example, from Figure 49, the Fan runs at medium speed. Meanwhile, Figure 61 is the Prototype Fan-view being placed outside the house due to size of element (size of fan quite bigger compare to size of the house).

Figure 61 Prototype Fan-view

Figure 62 Prototype of overall project

Figure 62 show the actual prototype that consist all the ingredient of this project. The circuit or schematic can be view via Appendix F. The ingredients include:

- PIC16f877
- LM35
- PIR sensor
- 2 Ultrasonic sensor
- LCD
- 4x4 Keypad
- LM35 sensor and other element.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This project needs a very careful study and consistent work. Based from the result, the prototype managed to be finished on time set. There will be many obstacle that need to be handled in accomplished the task. The result proves out the capabilities the entire sensor like LM35 sensor, Ultrasonic sensor and Passive Infrared Sensor (PIR) by using C programming on PIC16f877A. This PIC controlled fan project will be the stepping-stone for the future UTP undergraduates to develop much flexible system. Implementing knowledge gained from classed will be different from knowledge of hand-on experience.

5.2 Recommendation

Recommendation of this project can base on 2 things:

- User friendly features
- Neat design

Weakness of the project, due to limited of time and budget, the speed mechanism of AC motor can be improved by using phase angle technique to provide variety of fan speed needed like greater than 5 speeds.

Detection of animal like cat or dog can be prevent if PIR sensor being used as main sensor (avoid false alarm). However, for ultrasonic motion, it totally detects any motion that appears around the detection area.

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APPENDICES

APPENDIX A
GANTT CHART FYP1

Activities / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Topic selection	■	■												
Preliminary research	■	■												
Submission of Preliminary Report		■												
Study on programming language – PIC 16f877A	■	■	■	■	■	■								
Study on sensor (AC- DC converter) – Temperature & motion			■	■	■	■								
Laboratory test-temperature sensor/ motion sensor					■	■	■	■						
Preparation for Progress Report						■	■							
Submission of Progress Report								■						
Seminar									■					
Study on AC/DC motor (fan)									■	■	■	■		
Implementation test-overall prototype											■	■	■	
Preparation for Interim Report											■	■	■	
Submission of Interim Report												■	■	
Oral presentation														■

APPENDIX B

GANTT CHART FYP2

			JUL	AUGUST				SEPTEMBER			OCTOBER				NOV-DEC				
No.	Task Name	Duration	1	2	3	4	5	6		7	8	9	10	11	12	13	14	15	16-18	20
1	Resolve the problems encountered during FYP 1																			
2	Generate the actual protocol via PIC16f877A								M											
3	Preparation for Progress Report 1								I											
4	Submission of Progress Report 1								D										E	
5	Works on entire sensor including motion and temperature sensor																		X	
6	Works on Fan Mechanism and module prototype								S											
7	Preparation for Progress Report 2								E										A	
9	Submission of Progress Report 2								M										W	
10	Complete all the entire model																		E	
11	Pre-EDX Exhibition (Wednesday Week 11)																			
12	Developed System								B										E	
13	Preparation for the Final Report								R										K	
14	Submission Draft of Final Report								E											
15	Submission Final Report (Soft copy) and Technical Report								A											
16	Oral Presentation (week 18)								K											
17	Submission Final Report (Hard Bound)																			

APPENDIX C
LCD DRIVER CODE

```
// flex_lcd.c
// These pins are for the Microchip PicDem2-Plus board,
// which is what I used to test the driver.  Change these
// pins to fit your own board.

#define LCD_DB4   PIN_D0
#define LCD_DB5   PIN_D1
#define LCD_DB6   PIN_D2
#define LCD_DB7   PIN_D3
#define LCD_E     PIN_B1
#define LCD_RS    PIN_B3
#define LCD_RW    PIN_B2
// If you only want a 6-pin interface to your LCD, then
// connect the R/W pin on the LCD to ground, and comment
// out the following line.
#define USE_LCD_RW   1

//========================================

#define lcd_type 2        // 0=5x7, 1=5x10, 2=2 lines
#define lcd_line_two 0x40 // LCD RAM address for the 2nd line

int8 const LCD_INIT_STRING[4] =
{
 0x20 | (lcd_type << 2), // Func set: 4-bit, 2 lines, 5x8 dots
 0xc,                    // Display on
 1,                      // Clear display
 6                       // Increment cursor
 };

//-------------------------------------
void lcd_send_nibble(int8 nibble)
{
// Note:  !! converts an integer expression
// to a boolean (1 or 0).
 output_bit(LCD_DB4, !!(nibble & 1));
 output_bit(LCD_DB5, !!(nibble & 2));
 output_bit(LCD_DB6, !!(nibble & 4));
 output_bit(LCD_DB7, !!(nibble & 8));
```

```
 delay_cycles(1);
 output_high(LCD_E);
 delay_us(2);
 output_low(LCD_E);
}
//-----------------------------------
// This sub-routine is only called by lcd_read_byte().
// It's not a stand-alone routine.  For example, the
// R/W signal is set high by lcd_read_byte() before
// this routine is called.

#ifdef USE_LCD_RW
int8 lcd_read_nibble(void)
{
int8 retval;
// Create bit variables so that we can easily set
// individual bits in the retval variable.
#bit retval_0 = retval.0
#bit retval_1 = retval.1
#bit retval_2 = retval.2
#bit retval_3 = retval.3
retval = 0;

output_high(LCD_E);
delay_cycles(1);
retval_0 = input(LCD_DB4);
retval_1 = input(LCD_DB5);
retval_2 = input(LCD_DB6);
retval_3 = input(LCD_DB7);
output_low(LCD_E);
return(retval);
}
#endif

//---------------------------------------
// Read a byte from the LCD and return it.

#ifdef USE_LCD_RW
int8 lcd_read_byte(void)
{
int8 low;
int8 high;

output_high(LCD_RW);
delay_cycles(1);
high = lcd_read_nibble();
```

```
low = lcd_read_nibble();
return( (high<<4) | low);
}
#endif
//----------------------------------------
// Send a byte to the LCD.
void lcd_send_byte(int8 address, int8 n)
{
output_low(LCD_RS);
#ifdef USE_LCD_RW
while(bit_test(lcd_read_byte(),7)) ;
#else
delay_us(60);
#endif
if(address)
   output_high(LCD_RS);
else
   output_low(LCD_RS);
 delay_cycles(1);
#ifdef USE_LCD_RW
output_low(LCD_RW);
delay_cycles(1);
#endif
output_low(LCD_E);
lcd_send_nibble(n >> 4);
lcd_send_nibble(n & 0xf);
}

//----------------------------
void lcd_init(void)
{
int8 i;

output_low(LCD_RS);
#ifdef USE_LCD_RW
output_low(LCD_RW);
#endif
output_low(LCD_E);
delay_ms(15);
for(i=0 ;i < 3; i++)
   {
    lcd_send_nibble(0x03);
    delay_ms(5);
   }

lcd_send_nibble(0x02);
```

```
for(i=0; i < sizeof(LCD_INIT_STRING); i++)
  {
   lcd_send_byte(0, LCD_INIT_STRING[i]);

   // If the R/W signal is not used, then
   // the busy bit can't be polled.  One of
   // the init commands takes longer than
   // the hard-coded delay of 60 us, so in
   // that case, lets just do a 5 ms delay
   // after all four of them.
   #ifndef USE_LCD_RW
   delay_ms(5);
   #endif
  }
}

//----------------------------

void lcd_gotoxy(int8 x, int8 y)
{
int8 address;

if(y != 1)
  address = lcd_line_two;
else
  address=0;
address += x-1;
lcd_send_byte(0, 0x80 | address);
}

//-----------------------------
void lcd_putc(char c)
{
 switch(c)
  {
   case '\f':
     lcd_send_byte(0,1);
     delay_ms(2);
     break;
   case '\n':
      lcd_gotoxy(1,2);
      break;
   case '\b':
      lcd_send_byte(0,0x10);
      break;
```

```
    default:
      lcd_send_byte(1,c);
      break;
  }
}

//------------------------------
#ifdef USE_LCD_RW
char lcd_getc(int8 x, int8 y)
{
char value;
lcd_gotoxy(x,y);
// Wait until busy flag is low.
while(bit_test(lcd_read_byte(),7));
output_high(LCD_RS);
value = lcd_read_byte();
output_low(lcd_RS);

return(value);
}
#endif
```

APPENDIX D
CODE

LM35 ADC and LCD display

```
#include <16F877A.H>
#device ADC=10
#fuses HS, NOWDT, NOPROTECT, BROWNOUT, PUT, NOLVP
#use delay(clock = 20000000)
//LCD driver include
#include "E:\note ngaji\FYP\stuff last sem\code\led experiment\brum\Flexlcd2.c"

//========================
#define     LED1    PIN_D7
#define     LED2    PIN_D6
#define     LED3    PIN_D5
#define     LED4    PIN_D4
void main(void)
{
      int16 temp_adc;
      int temp;
       setup_adc(ADC_CLOCK_DIV_8);
       setup_adc_ports(PIN_A1);
       set_adc_channel(1); //read analog input from channel 1
       lcd_init();
        lcd_putc("\fTemperature:\n");
         while(1)
          {
// ADC Conversion & LCD display
           temp_adc = read_adc();
           temp = 5.00*temp_adc*100.00/1023.00;
        lcd_gotoxy(1,2);
           printf(lcd_putc,"%d",temp);
```

APPENDIX E

OVERALL PROGRAMMING CODE

```
Overall programming
#include <16F877A.H>
#device ADC=10
#fuses HS, NOWDT, NOPROTECT, BROWNOUT, PUT, NOLVP
#use delay(clock = 20000000)

#include "C:\Users\deli\Desktop\finale\LCD\Flexlcd2.c"
#include "C:\Users\deli\Desktop\finale\Keypad\kbd.c"
#define  LED1  PIN_C7
#define  LED2  PIN_C6
#define  LED3  PIN_C5
#define  EXIT  PIN_C4
#define  EXIT2 PIN_D4
#define  HERO  PIN_C0
#define toint(c) ((int)((c)-'0'))
//#include "flex_lcd.c"
//#include "KBD.c"
//#include "flex_lcd.c"
//#include "KBD.c"
void main()
{
int16 temp_adc=0,counter1;
int inout_counter=0,pir1,pir2,in,out,pir3;
int tempb,temp,tempA;
char k;
      setup_adc(ADC_CLOCK_DIV_8);
      setup_adc_ports(PIN_A1);
      set_adc_channel(1);
lcd_init();
kbd_init();
while(1){
            pir1=0;
            pir2=0;
            in=0;
            out=0;


            temp_adc = read_adc();
           temp=5.00*temp_adc*100.00/1023.00;
           lcd_gotoxy(1,2);
           printf(lcd_putc,"Temp:%d",temp);
       k=0;
```

```
  tempb=0;
  while (1){
           k=kbd_getc();
           // returns typ 'char'
           if(k!=0)
       {  // I put this '{' and now it is working
            if(k>=48&&k<=57){
              tempb=10*tempb+toint(k);
              lcd_gotoxy(6,1);
              printf(lcd_putc,"int.t=%d",tempb);
           if(tempb>50) // if the desired temp exceed 50..the temperature return to 0 value
           {
             tempb=0; }
           } // end of loop if(k!=0)
      if(k=='D') break;
       }
{      lcd_gotoxy(1,1);
      printf(lcd_putc,"count:%d",inout_counter);
       pir1 = input(PIN_C1);
       pir2 = input(PIN_C2);
       pir3 = input(PIN_C3);
       if (PIR3==1)
{   output_high(HERO);
   //output_high(HERO);
   if(pir1==1)
  {
   output_high(EXIT);
   for(counter1=10000;counter1>0;counter1--)
   {
     pir2 = input(PIN_C2);
     delay_ms(1);
     if(pir2==1)
     in=1;
   }
   if(in==1)
   inout_counter++;
  }
  else if(pir2==1)
  {
   for(counter1=10000;counter1>0;counter1--)
   {
     output_high(EXIT2);
     pir1 = input(PIN_C1);
     delay_ms(1);
     if(pir1==1)
     out=1;
   }
   if(out==1)
   inout_counter--;
```

```
        }
        else
        {
        output_low(HERO);
        }
       }
{
    tempA= temp-tempb;

            if(inout_counter==0)
         {
         //output_high(LED1);   //desired output
         //output_low(LED2);
         //output_low(EXIT);
         //output_low(EXIT2);
         output_low(LED2);
         output_low(LED3);
         output_low(LED1);
        }
    else
        {
          if((tempA >= 27))
          {
          output_high(LED1);
          output_low(LED2);
          output_low(LED3);
          }
          else if ((tempA> 20) && (tempA < 26))
          {
          output_high(LED2);
          output_low(LED1);
          output_low(LED3);
          }

          else
          {
          output_high(LED3);
          output_low(LED1);
          output_low(LED2);
          }
         }
  }
       }

lcd_gotoxy(9,2);
printf(lcd_putc,"Spd:%d",tempA);

}
          }}
```

APPENDIX F
KEYPAD DRIVER CODE

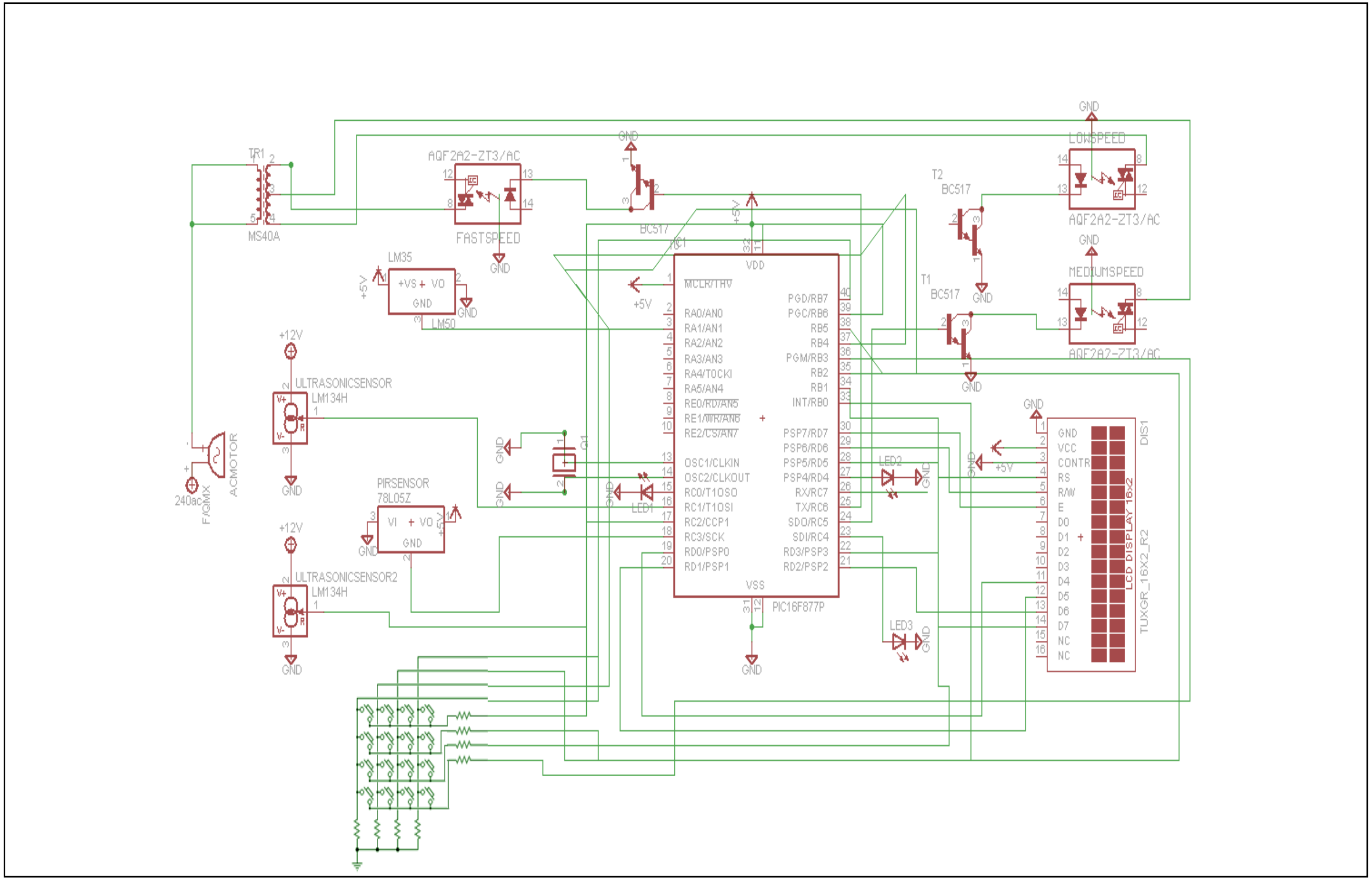
```
#include <16F877A.H>
#fuses HS, NOWDT, NOPROTECT, BROWNOUT, PUT, NOLVP
#use delay(clock = 20000000)

#include "C:\Users\User\Desktop\deli coding\krypad\brum\Flexlcd2.c"
#include "C:\Users\User\Desktop\deli coding\krypad\zoro\kbd.c"

//#include "flex_lcd.c"
//#include "KBD.c"
void main() {
  char k;
  lcd_init();
  kbd_init();
  lcd_gotoxy(1,1);
  printf(lcd_putc,"testing keypad");
  delay_ms(2000);
   while(TRUE)
   {
    k=0;
    while (k==0) { //Loop waiting for the key
      k=kbd_getc();
      delay_ms(1);
    }
    lcd_gotoxy(1,2);
    printf(lcd_putc,"nombo = %c", k);
   }
}

KBD.C
//Keypad connection:
#define row0 PIN_B4
#define row1 PIN_B5
#define row2 PIN_B6
#define row3 PIN_B7
#define col0 PIN_B0
#define col1 PIN_B1
```

```
#define col2 PIN_B2
#define col3 PIN_B3
// Keypad layout:
char const KEYS[4][4] =
{{'1','2','3','A'},
 {'4','5','6','B'},
 {'7','8','9','C'},
 {'*','0','#','D'}};
#define KBD_DEBOUNCE_FACTOR 33 // Set this number to apx n/333 where
// n is the number of times you expect
// to call kbd_getc each second
void kbd_init()
{
//set_tris_b(0xF0);
//output_b(0xF0);
port_b_pullups(true);
}
short int ALL_ROWS (void)
{
if(input (row0) & input (row1) & input (row2) & input (row3))
   return (0);
else
   return (1);
}
char kbd_getc()
{
static byte kbd_call_count;
static short int kbd_down;
static char last_key;
static byte col;
byte kchar;
byte row;
kchar='\0';
if(++kbd_call_count>KBD_DEBOUNCE_FACTOR)
  {
   switch (col)
     {
      case 0:
        output_low(col0);
        output_high(col1);
        output_high(col2);
        output_high(col3);
        break;
         case 1:
        output_high(col0);
        output_low(col1);
```

```
      output_high(col2);
      output_high(col3);
      break;
    case 2:
      output_high(col0);
      output_high(col1);
      output_low(col2);
      output_high(col3);
      break;
    case 3:
      output_high(col0);
      output_high(col1);
      output_high(col2);
      output_low(col3);
      break;
    }
 if(kbd_down)
   {
    if(!ALL_ROWS())
      {
       kbd_down=false;
       kchar=last_key;
       last_key='\0';
      }
   }
 else
   {
    if(ALL_ROWS())
      {
       if(!input (row0))
          row=0;
       else if(!input (row1))
          row=1;
       else if(!input (row2))
          row=2;
       else if(!input (row3))
          row=3;
       last_key =KEYS[row][col];
       kbd_down = true;  }
    else
      { ++col;
       if(col==4)
          col=0;
      } }
 kbd_call_count=0;
}return(kchar);  }
```

APPENDIX G

SCHEMATIC DIAGRAM



APPENDIX H

LM35

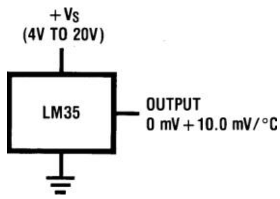
National Semiconductor

LM35 Precision Centigrade Temperature Sensors

LM35 Precision Centigrade Temperature Sensors

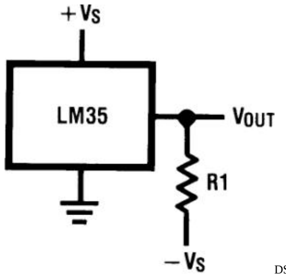
General Description

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ˚ Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±¼˚C at room temperature and ±¾˚C over a full −55 to +150˚C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1˚C in still air. The LM35 is rated to operate over a −55˚ to +150˚C temperature range, while the LM35C is rated for a −40˚ to +110˚C range (−10˚ with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.



Features

n Calibrated directly in ˚ Celsius (Centigrade) n Linear + 10.0 mV/˚C scale factor n 0.5˚C accuracy guaranteeable (at +25˚C) n Rated for full −55˚ to +150˚C range n Suitable for remote applications n Low cost due to wafer-level trimming n Operates from 4 to 30 volts n Less than 60 µA current drain n Low self-heating, 0.08˚C in still air n Nonlinearity only ±¼˚C typical n Low impedance output, 0.1 Ω for 1 mA load



DS005516-4

Typical Applications

Choose $R_1 = -V_S/50\ \mu A$ V_{OUT}=+1,500 mV at +150˚C

DS005516-3

FIGURE 1. Basic Centigrade Temperature Sensor

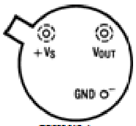
= +250 mV at +25˚C

(+2˚C to +150˚C)

Connection Diagrams

TO-46 SO-8 Metal Can Package

DS005516-2

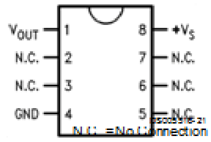


DS005516-1
BOTTOM VIEW

*Case is connected to negative pin (GND)

Order Number LM35H, LM35AH, LM35CH, LM35CAH or LM35DH
See NS Package Number H03H
TO-92
Plastic Package

Package* Small Outline Molded

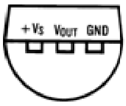


DS005516-21
N.C. = No Connection

Top View
Order Number LM35DM
See NS Package Number M08A
TO-220
Plastic Package*

Order Number LM35CZ, Number Z03A

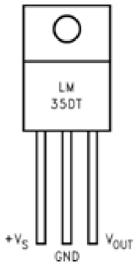
DS005516-24



*Tab is connected to the different than the **LM35DT See NS**

LM35CAZ or LM35DZ See NS Package

negative pin (GND). **Note:** The LM35DT pinout is discontinued LM35DP. **Order Number Package Number TA03F**



APPENDIX I

LCD 16X2

MECHANICAL DATA

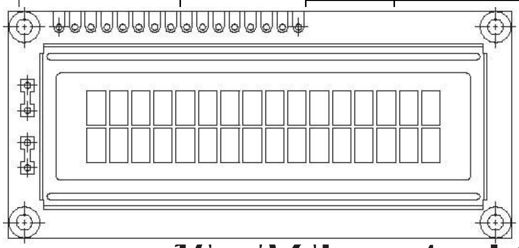
ITEM	STANDARD VALUE	UNIT
Module Dimension	80.0 x 36.0	mm
Viewing Area	66.0 x 16.0	mm
Dot Size	0.56 x 0.66	mm
Character Size	2.96 x 5.56	mm

ABSOLUTE MAXIMUM RATING

ITEM	SYMBOL	STANDARD VALUE	UNIT
		TYP.	

MECHANICAL DATA

ITEM	STANDARD VALUE	UNI'
Module Dimension	80.0 x 36.0	mm
Viewing Area	66.0 x 16.0	mm
Dot Size	0.56 x 0.66	mm



LCD-016M002B

Vishay

16 x 2 Character LCD

FEATURES

- 5 x 8 dots with cursor
- Built-in controller (KS 0066 or Equivalent) • + 5V power supply (Also available for + 3V)
- 1/16 duty cycle
- B/L to be driven by pin 1, pin 2 or pin 15, pin 16 or A.K (LED)
- N.V. optional for + 3V power supply

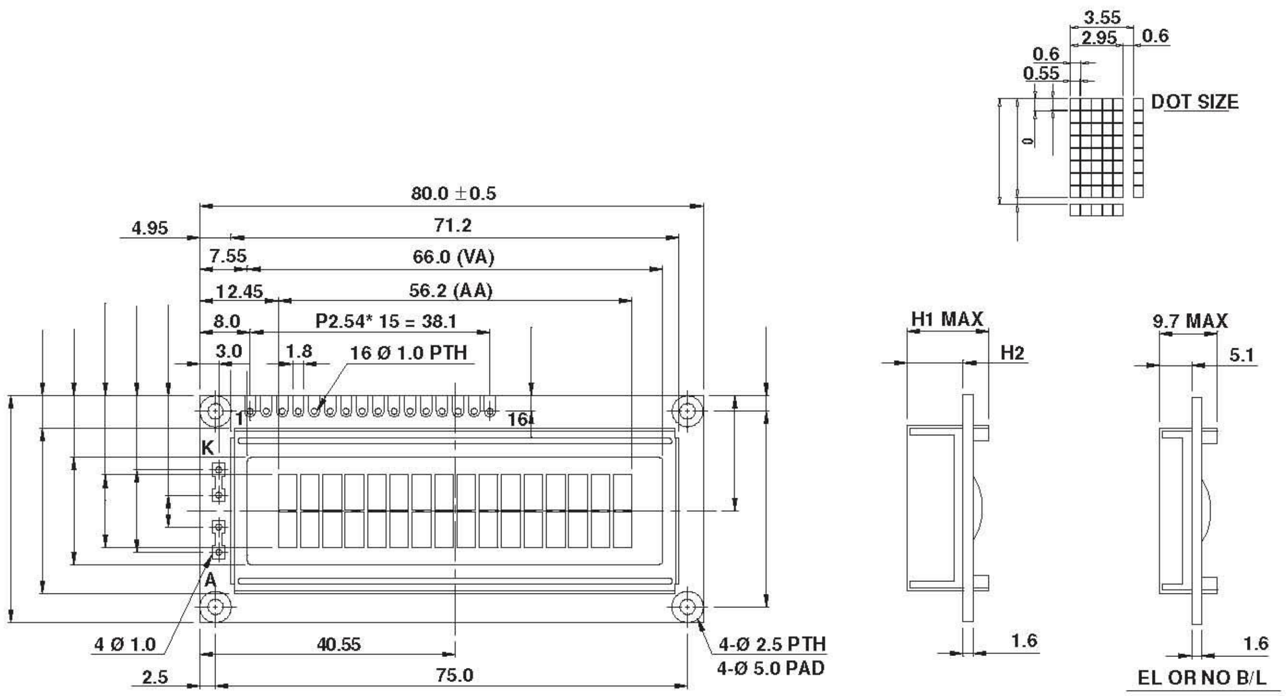
NOTE: VSS = 0 Volt, VDD = 5.0 Volt

LCD-016M002B

16 x 2 Character LCD

PIN NUMBER	SYMBOL	FUNCTION
1	Vss	GND
2	Vdd	+ 3V or + 5V
3	Vo	Contrast Adjustment
4	RS	H/L Register Select Signal
5	R/$\overline{W}$	H/L Read/Write Signal
6	E	H →L Enable Signal
7	DB0	H/L Data Bus Line
8	DB1	H/L Data Bus Line
9	DB2	H/L Data Bus Line
10	DB3	H/L Data Bus Line
11	DB4	H/L Data Bus Line
12	DB5	H/L Data Bus Line
13	DB6	H/L Data Bus Line
14	DB7	H/L Data Bus Line
15	A/Vee	+ 4.2V for LED/Negative Voltage Output
16	K	Power Supply for B/L (OV)

DIMENSIONS in millimeters



LED - H/L B/L		
	HIGH	LOW
H1	13.2	12.1
H2	8.6	7.5

APPENDIX J

KEYPAD 4X4

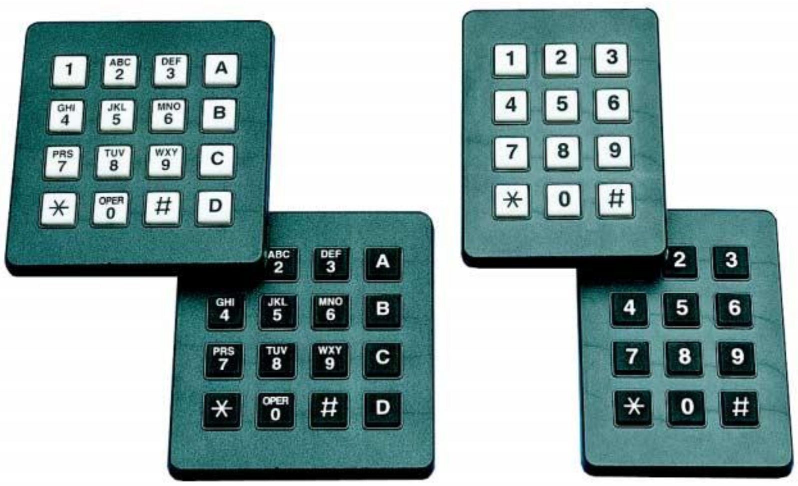
SERIES 96 Conductive Rubber

FEATURES

- Quality, Economical Keyboards
- Easily Customized Legends
- Matrix Circuitry
- Backlit and Shielded Options Available
- Termination Mates With Standard Connectors
- Tactile Feedback to Operator
- 1,000,000 Operations per Button
- Compatible With High Resistance Logic Inputs

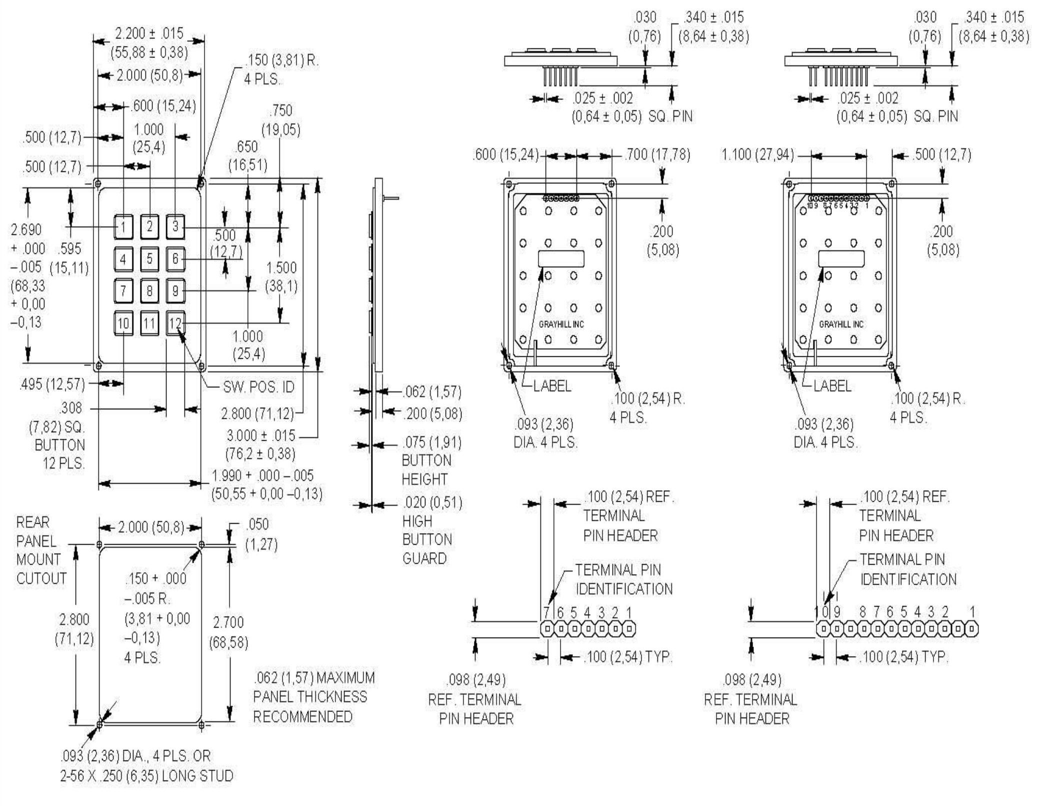
The Series 96 is Grayhill's most economical 3x4 and 4x4 keypad family. The contact system utilizes conductive rubber to mate the appropriate PC board traces. Offered in matrix circuitry, with shielded and backlit options. Built with quality component parts, the Series 96 is subjected to our rigid statistical process control to insure that it meets our reliability standards.

DIMENSIONS In inches (and millimeters)



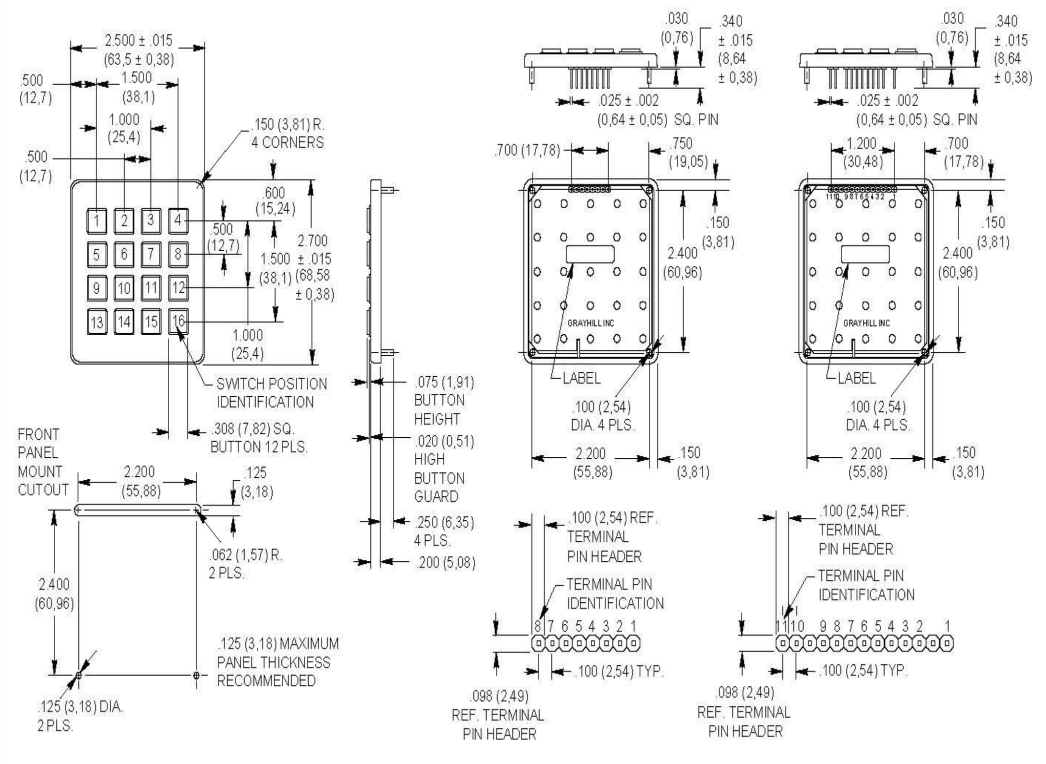
3x4 Rear Mount Keyboard

Standard Versions | Shielded/Backlit Versions



4x4 Front Mount Keyboard

Standard Versions | Shielded/Backlit Versions



APPENDIX K

PIC16F877A

MICROCHIP

PIC16F87XA

28/40/44-Pin Enhanced Flash Microcontrollers

Devices Included in this Data Sheet:

- PIC16F873A
- PIC16F874A
- PIC16F876A
- PIC16F877A

High-Performance RISC CPU:

- Only 35 single-word instructions to learn
- All single-cycle instructions except for program branches, which are two-cycle
- Operating speed: DC – 20 MHz clock input
  DC – 200 ns instruction cycle
- Up to 8K x 14 words of Flash Program Memory, Up to 368 x 8 bytes of Data Memory (RAM), Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to other 28-pin or 40/44-pin PIC16CXXX and PIC16FXXX microcontrollers

Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during Sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max. resolution is 12.5 ns
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is 10-bit
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I²C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) – 8 bits wide with external $\overline{RD}$, $\overline{WR}$ and $\overline{CS}$ controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

Analog Features:

- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference (V_{REF}) module
  - Programmable input multiplexing from device inputs and internal voltage reference
  - Comparator outputs are externally accessible

Special Microcontroller Features:

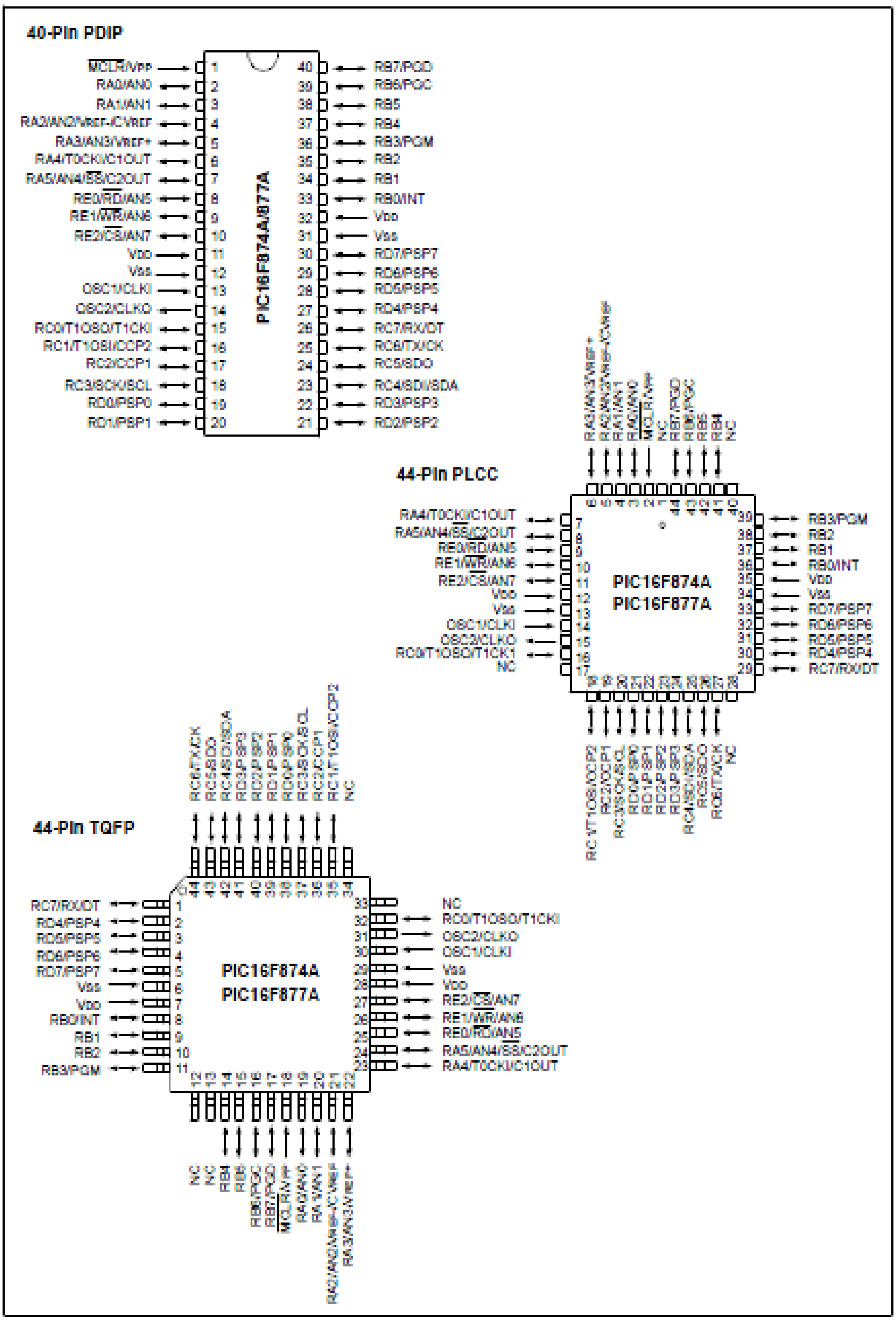
- 100,000 erase/write cycle Enhanced Flash program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Data EEPROM Retention > 40 years
- Self-reprogrammable under software control
- In-Circuit Serial Programming™ (ICSP™) via two pins
- Single-supply 5V In-Circuit Serial Programming
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug (ICD) via two pins

CMOS Technology:

- Low-power, high-speed Flash/EEPROM technology
- Fully static design
- Wide operating voltage range (2.0V to 5.5V)
- Commercial and Industrial temperature ranges
- Low-power consumption

Device	Program Memory		Data SRAM (Bytes)	EEPROM (Bytes)	I/O	10-bit A/D (ch)	CCP (PWM)	MSSP		USART	Timers 8/16-bit	Comparators
	Bytes	# Single Word Instructions						SPI	Master I²C			
PIC16F873A	7.2K	4096	192	128	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F874A	7.2K	4096	192	128	33	8	2	Yes	Yes	Yes	2/1	2
PIC16F876A	14.3K	8192	368	256	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F877A	14.3K	8192	368	256	33	8	2	Yes	Yes	Yes	2/1	2

Pin Diagrams (Continued)



APPENDIX L

RELAY 6V

SONGLE RELAY

松乐继电器 ® SONGLE RELAY	RELAY ISO9002	SRD

1. MAIN FEATURES

- ☐ Switching capacity available by 10A in spite of small size design for highdensity P.C. board mounting technique.
- ☐ UL,CUL,TUV recognized.
- ☐ Selection of plastic material for high temperature and better chemical solution performance.
  - ☐ Sealed types available.
- ☐ Simple relay magnetic circuit to meet low cost of mass production.

2. APPLICATIONS

- ☐ Domestic appliance, office machine, audio, equipment, automobile, etc.
  (Remote control TV receiver, monitor display, audio equipment high rushing current use application.)

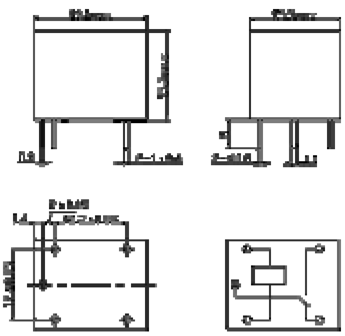
3. ORDERING INFORMATION

SRD	XX VDC	S	L	C
Model of relay	Nominal coil voltage	Structure	Coil	Contact form
SRD	03、05、06、09、12、24、48VDC	S:Sealed type F:Flux free type	L:0.36W D:0.45W	A:1 form A B:1 form B C:1 form C

4. RATING

CCC	FILE NUMBER:CQC03001003729	7A/240VDC
CCC	FILE NUMBER:CQC03001003731	10A/250VDC
UL /CUL	FILE NUMBER: E167996	10A/125VAC 28VDC
TUV	FILE NUMBER: R50056114	10A/250VAC 30VDC

5. DIMENSION(unit:mm) DRILLING(unit:mm) WIRING DIAGRAM



APPENDIX M

BC517

Philips Semiconductors | Product specification

NPN Darlington transistor — BC517

FEATURES

- High current (max. 500 mA)
- Low voltage (max. 30 V)
- Very high DC current gain (min. 30000).

APPLICATIONS

- Where very high amplification is required.

DESCRIPTION

NPN Darlington transistor in a TO-92; SOT54 plastic package. PNP complement: BC516.

PINNING

PIN	DESCRIPTION
1	emitter
2	base
3	collector

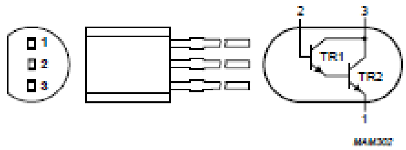


Fig.1 Simplified outline (TO-92; SOT54) and symbol.

ORDERING INFORMATION

TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
BC517	SC-43A	plastic single-ended leaded (through hole) package; 3 leads	SOT54

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter	–	40	V
V_{CES}	collector-emitter voltage	$V_{BE} = 0$ V	–	30	V
V_{EBO}	emitter-base voltage	open collector	–	10	V
I_C	collector current (DC)		–	500	mA
I_{CM}	peak collector current		–	800	mA
I_B	base current (DC)		–	100	mA
P_{tot}	total power dissipation	$T_{amb} \le 25$ °C; note 1	–	625	mW
T_{stg}	storage temperature		–65	+150	°C
T_j	junction temperature		–	150	°C
T_{amb}	ambient temperature		–65	+150	°C

Note

1. Transistor mounted on an FR4 printed-circuit board.