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JUDUL: **AUTOMATIC AIR CONDITIONER CONTROL SYSTEM**

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SUPERVISOR'S DECLARATION

"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (electronics)"

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AUTOMATIC AIR CONDITIONAL CONTROL SYSTEM

MOHD NOR IDRUS BIN MAT SHARIFF

A thesis submitted
in fulfillment of the requirements for the award of the degree of
Bachelor of Electrical and Electronic Engineering (Electronics)

Faculty of Electrical & Electronics Engineering
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Date : 12 NOVEMBER 2008

To my beloved mother and father

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ABSTRACT

An air conditioner is an appliance, system, or mechanism designed to extract heat from an area using a refrigeration cycle. In construction, a complete system of heating, ventilation, and air conditioning is referred to as HVAC. Its purpose, in the home or in the car, is to provide comfort during hot days and nights. There are certain problems happen when user uses the air conditioner. The conventional air conditional uses more energy, need to pay more bills and waste the energy. This project mainly concern to use PIC to control NPN power transistor further drive air conditional and LEDs on. This situation happen when the sensor detected certain temperature and the movement. The value of environment temperature will display on a LCD screen. When sensor did not detect the movement and environment temperature is below the setting point so the air conditioner will off automatically.

ABSTRAK

Penghawa dingin merupakan suatu alat atau mesin yang telah di cipta untuk melakukan proses penyejatan haba dari persekitaran menggunakan proses penyejukan. Dalam suatu proses pemanas yang sempurna, pengudaraan dan keadaan udara merujuk kepada HVAC. Penghawa dingin selalunya digunakan di rumah atau di dalam kereta. Penghawa dingin memberi keselesaan kepada pengguna dalam cuaca panas dan di waktu malam. Terdapat beberapa masalah yang timbul kesan daripada penggunaan penghawa dingin.Antara masalah tersebut ialah menggunakan tenaga yang banyak untuk beroperasi, perlu membayar bil elektrik yang mahal dan membazir tenaga elektrik. Projek ini menggunakan PIC yang akan mengawal tenaga NPN transistor dan seterusnya menggerakan penghawa dingin dan LED menyala. Keadaan ini berlaku bila sensor mengesan perubahan suhu persekitaran dan pergerakan yang berlaku. Nilai perubahan suhu akan terpapar pada LCD skrin. Bila sensor tidak mengesan pergerakkan dan suhu persekitaran berada pada bawah suhu kawalan maka penghawa dingin akan terpadam secara automatik.

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LIST OF ABREVIATIONS

A/C	Ampere/Current
ACL	Access Control List
A/D	Analog/Digital
ADC	Analog Digital Converter
AM	Ante Meridiem
BP	Back Propagation
BTU	British thermal unit
C	Celsius
CPU	Central Processing Unit
DAS	Data Analysis System
DC	Direct Current
DLC	Data Length Code
DP	Dynamic Programming
DSM	Demand Side Management
EEM	Electrical Energy Management
EMS	Environmental Management System
GND	Ground
HVAC	Heating, Ventilating, and Air Conditioning
LCD	Liquid crystal display
LED	Light Emitting Diode
MEPS	Malaysian Electronic Payment System
MIMO	Multi Input Multi Output
MV	Mega Watt
NPN	Not Pointing in
OOP	Object Oriented Program
PIC	Programmable Interface Control

PM	Post meridiem
PNN	Probabilistic Neural Network
RAM	Random Access Memory
R&D	Research and development
SEER	Seasonal Energy Efficiency Ratio
TPC	Transaction Processing Performance Council
VFC	Variable Frequency Control
VR	Voltage Resistor

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CHAPTER 1

INTRODUCTION

1.1 Overview

An air conditioner is an appliance, system, or mechanism designed to extract heat from an area using a refrigeration cycle. In construction, a complete system of heating, ventilation, and air conditioning is referred to as HVAC. Its purpose, in the home or in the car, is to provide comfort during hot days and nights. Thermostats control the operation of HVAC systems, turning on the heating or cooling systems to bring the building to the set temperature.

Typically the heating and cooling systems have separate control systems so that the temperature is only controlled "one-way”. In winter, a building that is too hot will not be cooled by the thermostat. Thermostats may also be incorporated into facility energy management systems in which the power utility customer may control the overall energy expenditure. In addition, a growing number of power utilities have made available a device which, when professionally installed, will control or limit the power to an HVAC system during peak use times in order to avoid necessitating the use of rolling blackouts.

In a thermodynamically closed system, any energy input into the system that is being maintained at a set temperature (which is a standard mode of operation for modern air conditioners) requires that the energy removal rate from the air conditioner increase. This increase has the effect that for each unit of energy input into the system requires the air conditioner to remove that energy. In order to do that the air conditioner must increase its consumption by the inverse of its efficiency times the input unit of energy. So I can state here that Air conditional use more energy than other electrical equipment.

For residential homes, some countries set minimum requirements for energy efficiency. In the United States, the efficiency of air conditioners is often (but not always) rated by the Seasonal Energy Efficiency Ratio (SEER). The higher the SEER rating, the more energy efficient is the air conditioner. The SEER rating is the BTU of cooling output during its normal annual usage divided by the total electric energy input in watt-hours (W·h) during the same period. So when we use the air conditioner, we need to pay more bills.

The use of electric/compressive air conditioning puts a major demand on the nation's electrical power grid in warm weather, when most units are operating under heavy load. During peak demand, additional power plants must often be brought online, usually natural gas fired plants because of their rapid startup. So when the user uses the air conditioner, some time they don’t realize that they have waste lot of energy every day.

For the user that uses the air conditioner, there is a certain way to save some energy. The savings can be significant when set the thermostat at 1°C or higher (Cooling model) / 2°C or lower (Heating model). For each degree that raises the thermostat setting, reduce seasonal cooling costs by 10%. They also can use a ceiling fan or portable fan to supplement the air conditioning. A fan can make feel a few degrees cooler so can set the thermostat a few degrees higher and save on cooling costs. User also must make sure the air conditioner is not blocked. A free flowing air conditioner operates most efficiently. Filters should be checked every 2 weeks. Dirty filters may reduce cooling and heating efficiency and when air conditioning is on, keep doors and windows closed. Turn off kitchen or bathroom exhaust fans when the air conditioning is operating.

1.2 Objective Research

The main objective of this project is to design and develop a device that it can display the environment temperature value on LCD screen and it can Able to switch on/off air conditioner automatically based on movement detection and environment temperature

1.3 Project Scope

This project is focused to design and build the prototype of automatic air conditional control system that would be a starting point to build the realistic automatic air conditional control system. Therefore, this prototype will cover the scope as followed.

(i) Based on air conditioner.

1.4 Problem Statement

In this project, there are several problems when user uses the air conditioner. The problem they have face is air conditioner use lot of energy compare to other electrical item. The air conditioner also wastes the energy when there is no user in the room when the air conditioner is on. Lastly the problem they face is they need to pay more bills.

1.5 Thesis Organization

This thesis consists of five chapters. This chapter discuss about overview of project, objective research, project scope, problem statement and thesis organization. Chapter 2 contains a detailed description of automatic air conditional control system. It will explain about the concept of automatic air conditional control system, the application of this system and the involved component in this project.

Chapter 3 includes the project methodology. It will explain how the project is organized and the flow of process in completing this project. Also in this topic discusses the methodology of the system, circuit design, software design and the hardware design. Chapter 4 will be discussing about the result obtained in this project and a discussion about the result. Finally, the conclusions for this project are presented in chapter 5. This chapter also discusses about the recommendation for the project and for the future development.

CHAPTER 2

LITERATURE REVIEW

2.1 Energy Efficiency

In early 1997, the energy research group of University Technology Malaysia initiated a research on the feasibility of standardization and appliance labeling program in Malaysia. Currently, no regulation has been imposed on the manufacturer to produce an energy efficient appliance. However the government through the Department of Electricity and Gas supply Malaysia has planned to enforce minimum energy performance standards (MEPS) for some domestic electric appliance. Appliance standards are a set of procedure and regulations which prescribe the energy performance of manufactured products, sometimes prohibiting the manufacture of products less energy efficient than the minimum standards. [1]

2.1.1 Room Air Conditioner

Malaysia, like many other developing countries with hot and humid climates, has been experiencing dramatic growth in the number and use of room air conditioners. As the economy recovers and income level rise, more consumers will seek air conditioning. Since there is potential of substantial energy saving in the domestic room air conditioning sector, the establishment of energy efficiency standard for room air conditioner has been giving priority. [2]

2.1.2 Minimum Efficiency

In order to achieve the minimum efficiency standard, the manufacturers may have to modify their current designs. This may lead to changes in room air conditioner's attributes such as price increment and energy saving. These changes will affect room air conditioner purchases especially for lower income people. So, in order to ensure the success of energy efficiency standards and labeling program, a detailed consumer analysis of room air conditioner market should be carried out, refer to figure 2.1, 2.2 and 2.3. [3]

Room Air Conditioner 1

Unit Price: RM 1500
Energy Saving: RM 100
Brand: Acson
Warranty: 1 year
Quiet operation: Yes

Certainly would would Not purchase — Certainly purchase

0 1 2 3 4 5 6 7 8 9 10

Figure 2.1: Example of a product profile

Category (n=127)		Respondents %
Gender	Male	58.2
	Female	41.8
Age	≤30	34.8
	31-50	52.3
	>50	12.9
Education	Primary	29.4
	PMR/SPM	54.1
	Dip/Degree	16.5
Income	<RM1000	11.2
	RM1k-3k	66.1
	>RM3000	22.7

Figure 2.2: Background characteristic of respondents

Attribute/Level	Utility	Relative importance (%)
Price		35.42
1. RM1300	1.7322	
2. RM1500	-0.1966	
3. RM1700	-1.5444	
Energy Saving		23.00
1.RM0	-1.3222	
2.RM100	0.4111	
3.RM200	1.5667	
Brand		20.07
1.National	0.3333	
2.Acson	0.0000	
3.York	-0.3333	
Warranty		12.23
1.1 year	-0.6667	
2.2 years	0.1445	
3.3 years	0.7222	
Quiet operation		9.28
1.Yes	0.7778	
2. No	-0.7778	

Figure 2.3: Result of conjoint analysis

2.2 Power Consumption

According to the annual report of load growth which has published by TPC shows that the total percentages of power consumption in the island approximately hold on 65% between industrial and commercial customer, but the downcast efficiency of energy is a pending problem, especially these representative high power consumption industries. They need to exert in the aspect of energy saving continuously [4].

2.2.1 Quality of Production

The quality of production is critically requested; the electric energy management has become a concerned issue in customer-side [5]. How to utilize the energy saving system (controller) to aid TPC to execute various load management schemes and the ACL dispatch strategies, such as Demand control, cycling control and timer control schemes to solve shortages in electricity supply during summer season is a very popular study issue [6].The proposes is to apply an optimization mathematical approach based on DP algorithm to find the optimum load control model.

To apply Intel 16-bit microprocessor technique to develop the load controller which is simultaneously provided with demand control, cycling control and timer control schemes. To develop multi-objective function based optimum load strategy to aid customers to avoid violating of demand contract, and to save energy consumption cost [7]. Finally, the proposed system also can increase competitiveness of local production relatively; on the other hand, it can also promote local technologies to enhance the R&D level [8].

2.3 Load Management

This paper is to investigate the potential of air conditioning load management by solving the temperature sensitivity of load demand for various customer classes. The load survey system has been applied to record the power consumption of sampling customers in Taiwan Power Company (Tai power) for 4 years. The effect of the temperature change to the customer power consumption is determined by executing the statistic polynomial regression on the load survey results.

The increase of system power demand for each 1 C temperature rise is then derived by integrating the load change of all customer classes. To verify the accuracy of the simulation, the actual system power demand collected by Tai power EMS system is applied to find the system load response to the temperature change. It is found that the proposed methodology does provide an effective tool for the utility company to identify the customer classes with good potential for air conditioner load management. Based on this study, the load management programs of cooling energy storage system and direct cycling control of air conditioners (A/C) are promoted by Tai power for the commercial and residential customers respectively.

2.3.1 Economic

With the economic development in Taiwan, Tai power has experienced the dramatic increase of system peak demand during recent years due to the usage of air conditioners in various customer classes. The system peak demand has reached 23 830MWin 1998 and the annual growth rate of peak demand is 7.2% [9]. It is found that the system peak demand has doubled its magnitude over the past 10 years and the spinning reserve has dropped below the proper value for system reliable operation.

2.3.2 Industrial Customers

Although various interruptible load control programs [10] have been performed in Tai power by offering incentive to the industrial customers with voluntary load reduction, the service curtailment has to be applied when one of the large generation units in Tai power trips. It has become a critical issue for Tai power to reduce the peak demand by considering more effective load management strategies. However, with more and more air conditioners used in the commercial, office and residential sections, the air conditioner loading has contributed 35% of the total system peak demand.

The annual load growth by air conditioners is 353MWand it is increased by 15% every year. With such a high percentage of air conditioner loading, the system load demand of Tai power is increased by 490 MW when the temperature rises by 1 C. The duty cycling control test of A/C units has been performed by many utilities [11] to evaluate the power reduction and the impact on lifetime of A/C equipments.

To demonstrate the load management, the direct load control of A/C units has also been included in the Tai power DAS project [12]. To enhance the load management programs, the temperature sensitivity analysis of load demand for each customer class has to be performed to identify the potential of peak demand reduction by the proper design of air conditioning load management.

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2.3.3 Power Consumption

The stratified sampling methodology [13] is used to determine the proper customer size for the installation of intelligent meters so that the simulation results can effectively represent the temperature sensitivity of power consumption for each customer class. The power consumption of the test customers during each 15 minutes interval is recorded and the sequential file of the customer power demand is created. The polynomial regression analysis of the power consumption with respect to the temperature is performed to solve the hourly temperature sensitivity of the customer power consumption.

The temperature sensitivity of the actual system demand is then solved by regression analysis to verify the previous integrated system power changes due to temperature rise. After identifying the customer classes with high temperature sensitivity, the field investigation of load composition with air conditioners can be conducted and the potential of system peak demand reduction can be estimated. By considering the avoided cost of generation capacity reduction by the air conditioning load management, the incentive can be designed to promote the load management programs of cooling energy storage system for the large commercial and office customers with central air conditioners. The cycling control of window type air conditioners can also be applied to the small commercial and residential customers. Refer to figure 2.4, 2.5, 2.6 and 2.7.

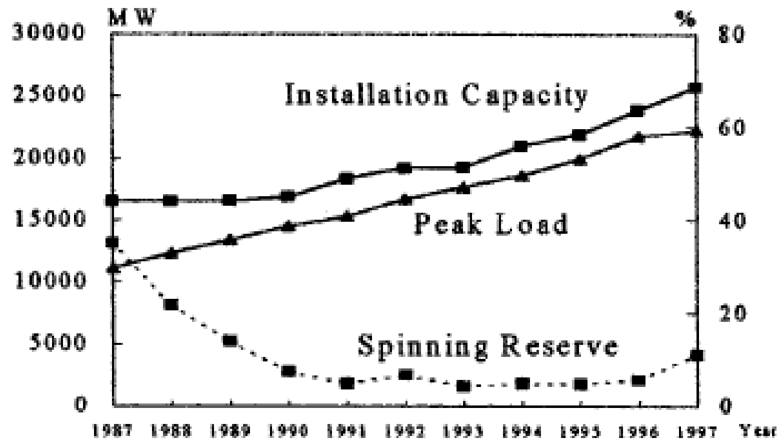


Figure 2.4: the installation capacity, peak load and spinning reserve of Tai power.

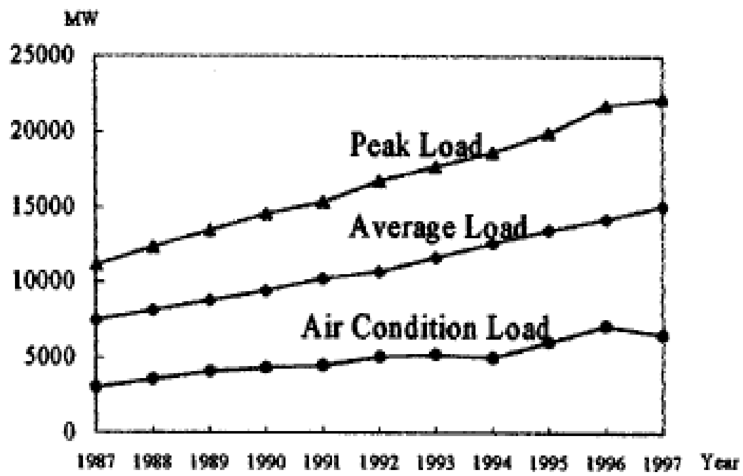


Figure 2.5 the system peak load, average load and air conditioning load of Tai power.

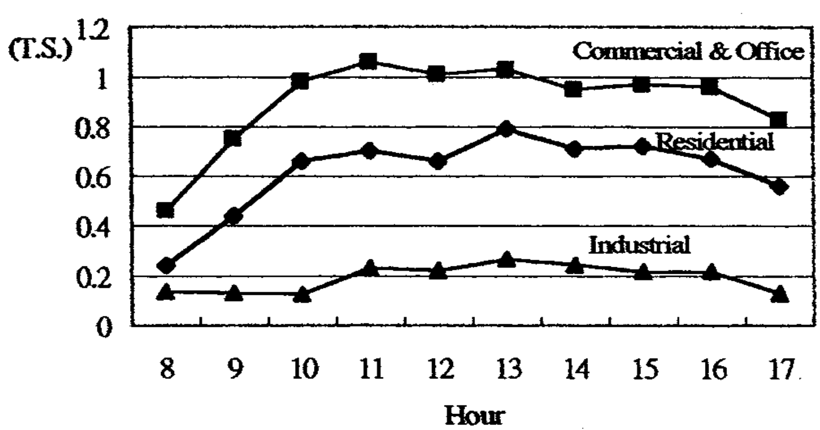


Figure 2.6: Temperature sensitivity of various customer classes.

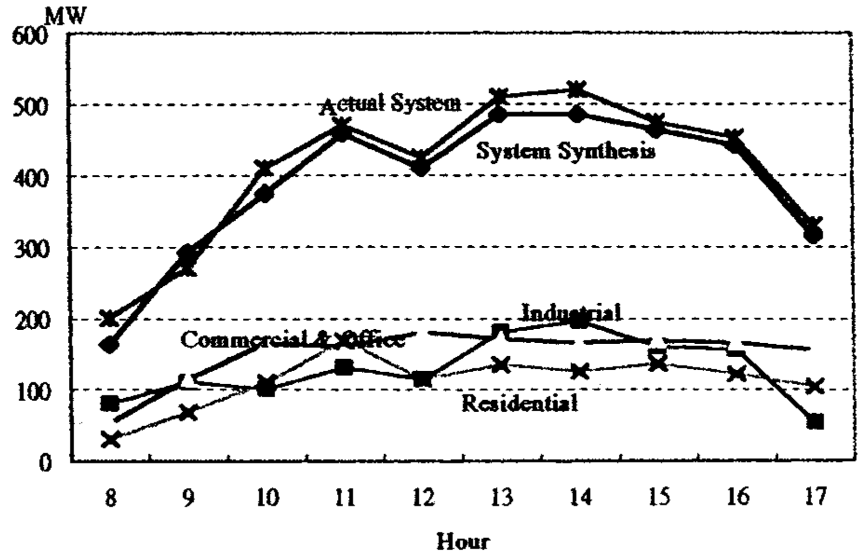


Figure 2.7: the power consumption increases due to 1 C temperature rise in Tai power system.

2.4 Room Air Conditioner

Electrical home appliances go electronic rapidly these days. The needs for a room air-conditioner to be met by electronic control techniques; seeds. The needs include power saving, comfortableness, low noise, improved function, operation ability, and reliability. With the conventional mechanical control system, it is difficult to improve the comfortableness and operation ability, and therefore, emphasis has been laid mainly on improvement of power consumption and noise characteristics.

In contrast to this, an electronic control introduced to a room air conditioner can easily realize the following advantages: comfortableness due to finer then no static setting, operation ability through feather touch operation and remote control, and reliability by a motor lock protection circuit. To get the maximum effect from a room air-conditioner equipped with an electronic control, the authors gave much thought to optimum daily and yearly room air conditioner operating patterns. With them, overcooling and overheating can be prevented, leading to simultaneous realization of power saving and healthy comfortableness. Such control is beyond the reach of the mechanical system, and this is an area where microprocessor control is most effective.

2.4.1 Comfortableness

Temperature, humidity, clothes, activity, wind velocity, and radiation heat (for example, direct sunlight to human body) are closely related to the comfortableness. However, inputting all of these factors to a room air-conditioner as control commands is not practical due to sensory difference of each individual. Since humidity, wind velocity and radiation heat are considered comparatively less variant in a room, these factors have been excluded from the investigation this time.

The comfortable temperature slightly differs with seasons, or depending on the outside temperature, as follows: [14] 21-27^{0}C in summer and 19- 25°C in winter, if relative humidity is 50%. Therefore, the comfortable temperature range is rather wide. The center temperature in the thermostatic control differential is set at 26.5^{0}C in summer and at 20.5^{0}C in winter. To be specific, if the room temperature is 26.5^{0}C or above when the air-conditioner is turned on, it begins to cool, but if the room temperature is 20.5^{0}C or below, it begins to heat the room, and if the room temperature is somewhere between 20.5 and 26.5^{0}C, it functions as a dehumidifier or circulating fan.

2.4.2 Comfortable Temperature

Let's consider the comfortable temperature during a sleep. Since human activity is low while sleeping, it is desirable that the thermostat be set rather high to compensate for the lowered activity level. If the setting were the same as that for daytime, overcooling would result, adversely affecting the health of those who are sleeping, especially children. If a man is assumed to be sitting in a chair quietly, his activity level is 50 kcal/m2 hr and it falls to 35 kcal/m2 hr when he sleeps. To compensate for this loss, the temperature must be raised by 1.75^0C, and to protect children from a chill or cold caught in sleep, the temperature is further raised by approximately 1.3^0C.

2.4.3 Control Characteristics

From the foregoing consideration the optimum operating controls characteristics. The upper curve is first explained here. The sleep timer is installed; until its set time the air-conditioner has been operated to maintain 26.5^0C and thereafter the thermostatic setting is raised by 3^0C. When the temperature drops by 1.5^0C at night even after the cooling cycle stops, the control decides that the outside is cooler and causes the air-conditioner to stop. In the winter heating cycle, the room temperature is maintained at 20.5^0C until time t1 and thereafter it is lowered by 5.5^0C.

When the temperature rises by 1.5^0C toward dawn after the heating cycle stops, the control decides that the outside is warmer and causes the air-conditioner to stop. In this manner, cooling, heating and dehumidifying cycles are automatically switched. This prevents overcooling and overheating, or establishes a healthy, comfortable environment throughout the year. Provide that the relative difference is maintained between the cooling and heating cycles, refer to figure 2.8, 2.9 and 2.10.

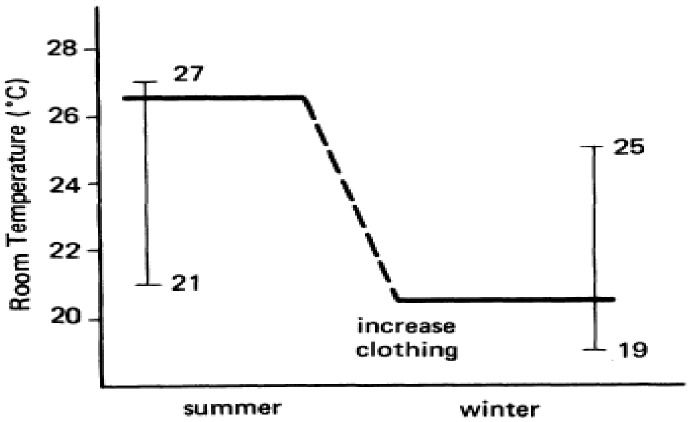


Figure 2.8: Comfortable Temperature in summer and winter

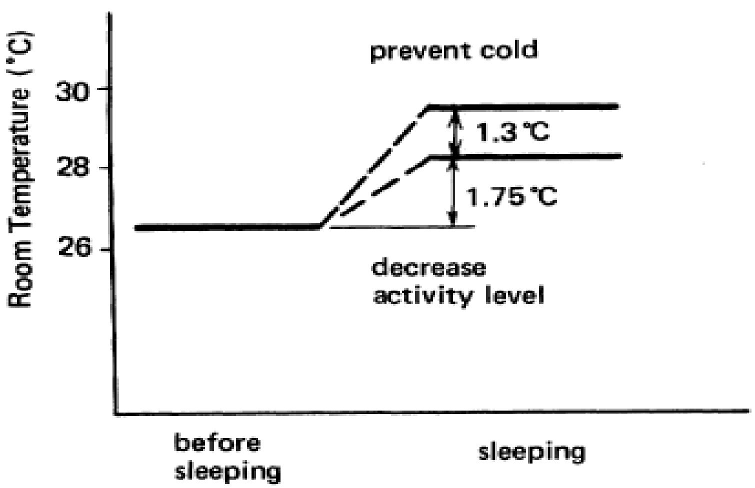


Figure 2.9: Comfortable Temperature in sleeping "summer"

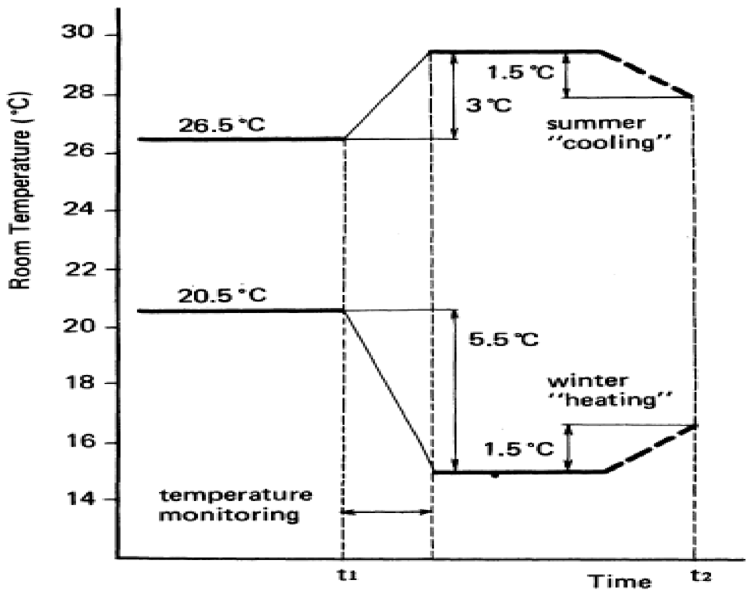


Figure 2.10: Optimum Characteristics of Temperature Control

2.5 Load Control

Population growth along with technological growth force the utility companies to continue struggling to meet the ever increasing need for electricity. With the majority of residents conforming to the 8 AM-5 PM work schedule, the utility companies experience overwhelming demand peaks associated with a large amount of power being consumed at the same time. Complementing this effect are periods of low demand.

Although over a period of time, the average amount of power consumed by a community may be easily generated by a utility, that utility still has to provide enough generation to meet its highest power demand peak. As this trend continues, utility companies may inevitably adopt a real-time-pricing strategy, where customers will pay more for the electric power they use during high demand periods and less during low demand periods. It is in the best interest of the utility companies as well as the consumer to try to reduce these high peak demand periods and level out their power demand profiles as much as possible

2.5.1 Peak Demands

While reducing their peak demands, however, utilities will also need to compete for new customers and keep current customers satisfied with their performance and services. With the upcoming utility deregulation, customer satisfaction is crucial. Thus, in such a business environment, any attempt to reduce the peak load of the system requires the full support of customers. Any control scheme should consider an adequate representation of the customers' specifications and preferences.

If a particular customer's comfort is not kept in mind during the implementation of a control strategy, his or her tolerance level will decrease. Effectively, the customer's willingness to participate in any peak reduction plan also decreases [15]**.** Not only will unsatisfied customers fail to participate in a DLC program, they may likely choose to purchase their power from another utility which is more supporting of the customers' desires and preferences in the deregulated energy market [16].

2.5.2 Peak Reduction

Traditionally, one way that the objective of a peak reduction plan has been accomplished is by controlling residential electric water heaters and air conditioners. The electric water heaters and air conditioners account for the largest contributors to the total power consumption of a residence.

Furthermore, due to their energy storage capabilities, water heaters and air conditioners are the ideal candidates for customer or utility demand-side management (DSM) programs to shift part of the utility power demand from peak periods to off-peak periods [17]. Such DSM strategies could be effective in utility peak load shaving and valley filling, and therefore increasing the utility load factor. For this and other similar reasons, electric water heaters and air conditioners have been the focus of many load analysis and demand-side management studies, i.e. [18].

2.5.3 Parameters

Two parameters are used to quantify the preferences of each individual customer in controlling their air conditioner. The first value is the ambient criterion, or a measure of the internal building temperature that a customer prefers. In this work, the ambient criterion is divided into two parameters: the actual temperature and the preferred temperature of the customer.

With the available technology, it is feasible for a utility to monitor and report the internal temperature of a building. The monitoring could either be conducted using a separate sensor or possibly read from the thermostat of the building. The second parameter is the comfort criteria. This is a measure of the range of temperatures that a customer can tolerate. This gives the utility the possible advantage of longer off-times and the customer the satisfaction of being comfortable during the cycling period. By modeling these two parameters the customer will have a direct voice in the DLC program.

2.5.4 Parameters

Along with the above two parameters chosen to model the customer preferences, two more are determined to accurately model the thermal losses of a building. The two parameters that have the most impact are the size of the building, and the overall insulation rating of the building.

In [19], the insulation rating is related to the age of the house. This assumption might have been valid 15-20 years ago, but it is not valid today. This is because due to the increasing cost of new housing, many of the older homes that are in use have been remodeled and reinsulated so they would no longer fit into this assumption. In this paper the units for the domains of the thermal loss parameters are chosen to be square feet and average BTU loss per square foot.

2.5.5 Fuzzy System

Therefore the fuzzy system will have 5 inputs: preferred temperature, ambient temperature, building size, insulation rating, and comfort level, and one output: time. In order to simply the fuzzy logic process, the fuzzy logic model was determined as follows: The model was divided into two, two input fuzzy controllers and one three-input fuzzy controller.

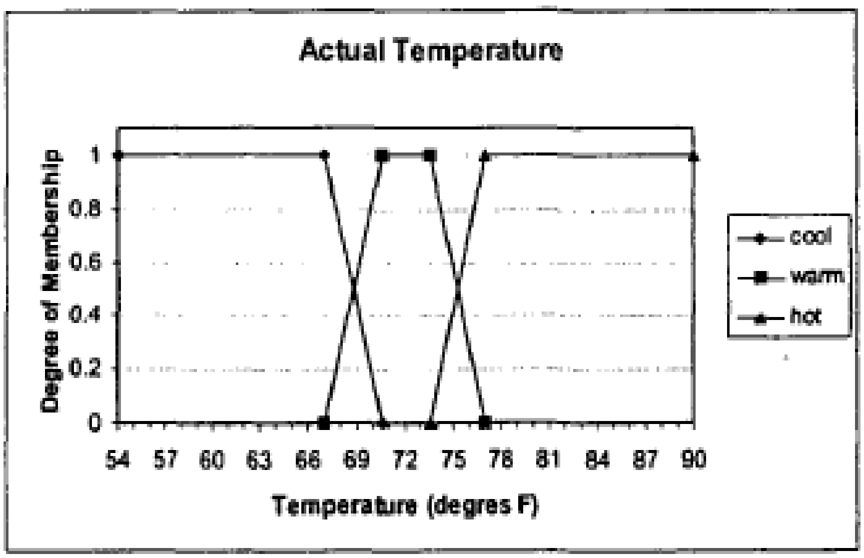
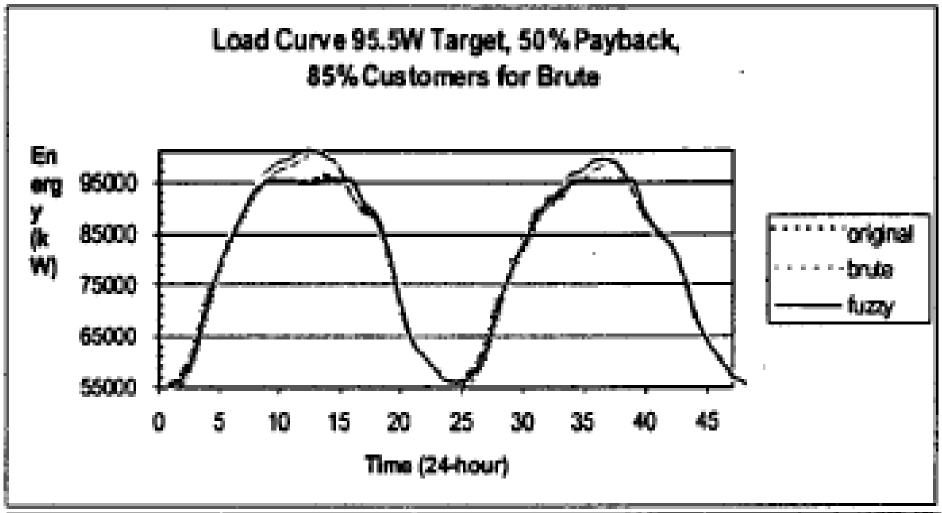


Figure 2.11: Membership function Actual temperature in a building.



Method	Peak Load (kW)	Average Load (kW)	Load Factor	Load Factor Improvement (%)	Load/Hour for disconnection @ 87.5 F	Total Load (MW)	Load Saved (MW)
None	10052.2	80097	0.797	N/A	N/A	3844.66	N/A
Brute Force	95248	79602	0.827	3.0	7909	3820.90	23.76
Fuzzy Logic	95346	79619	0.832	3.5	8110	3821.71	22.95

Figure 2.12: Resulting air conditioner load curves

2.6 The Electricity Savings

In Taiwan, the capacity of air-conditioners is occupied over 50% all energy consumption. The system peak load has increased at an annual rate of 10% due to the rapid increase of air-conditioning apparatus. In order to shift the system peak load, many control strategies have been developed in the past [20].

Some strategies can supply a good tool for load management; it may be influenced peoples' comfortable sensations. "Comfortable sensations" is defined that it will be produce the acceptable thermal environment to 80% or more of the occupants within a space. It will play an important role for performing the control of air-conditioners in future [21]. The thermal control of air-conditions is required for maintaining comfort and saving energy. It is recommended that electric utilities or users use this technology as a demand side management strategy for reducing energy consumption.

2.6.1 Thermodynamics

The first law of thermodynamics states that the amount of energy in any thermodynamic system is constant. The heat-balanced model is taken from the indoor environment due to the use of air-conditioners. The microclimate change including temperature and humidity immediately affects the energy exchange. When the temperature/humidity of the body is greater than that of its surroundings, it will be operated to keep the comfortable environment. Either cooling or humidifying process must be dissipated the electrical energy. To effectively reduce the electrical energy dissipated, a tool with PNN is proposed for reaching the goal

2.6.2 Application

In recent years, many successful applications on air-conditioner load control [22] have been reported to evaluate the power reduction. The ON/OFF operation of air-conditioners will impact on lifetime of equipments and it will produce the huge starting current. Some techniques [23], such as variable frequency control (VFC) of air-conditioners have been developed to reach the saving energy. Although the effect of saving energy by VFC is obvious in industrial applications, it is worthwhile to pay attention to the peoples' comfortable sensation.

The use of Back-Propagation(BP) network, which was proposed for reaching thermal comfort and saving energy of HVAC, was time consuming and very slow without guaranteed global minimum. Probabilistic neural network (PNN) [24] was thus studied and proposed in this paper. PNN lies in its ability to model a multi-input/multi-output (MIMO) system without making complex dependency assumptions among inputs and outputs. It is easy to avoid the model's becoming "black box" due to the large scale of network caused by a number of input variables.

The advantages of PNN include very fast learning and recalling process, no iteration for weight regulations in learning process, no pre-decision for the number of hidden layers and the number of hidden nodes in each layer, and adaptability for architecture changes.

2.6.3 Electrical Energy Management

This paper presents an effective tool for Electrical Energy Management (EEM) of PNN. An analysis conducts a practical air-conditioner with the electromagnetic valves and a variable speed compressor. PNN performance, which acquires information of EEM from the field test, is analyzed with the room temperature, room humidity, saturated vapor pressure, and air vapor pressure. By using the training data, PNN can automatically carry out the compressor operating frequency and the status of electromagnetic valves to obtain a suitable operation point without affecting the comfort of the users. Through analyzing and comparing the power consumption of the air-conditioners, the effectiveness of proposed method can be examined.

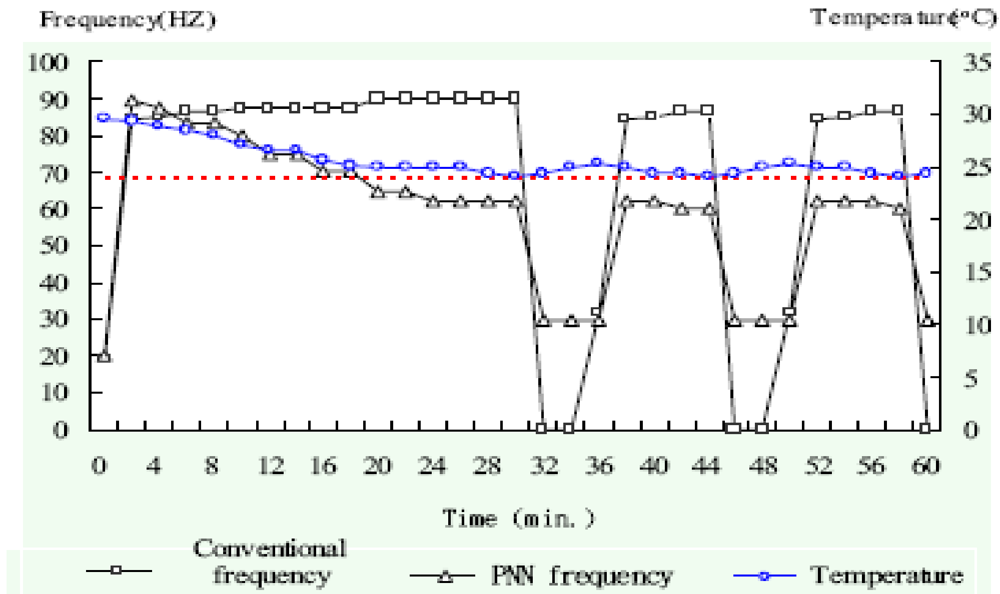


Figure 2.13: The operation frequency of compressor for conventional air-conditioners and PNN controlled air-conditioners

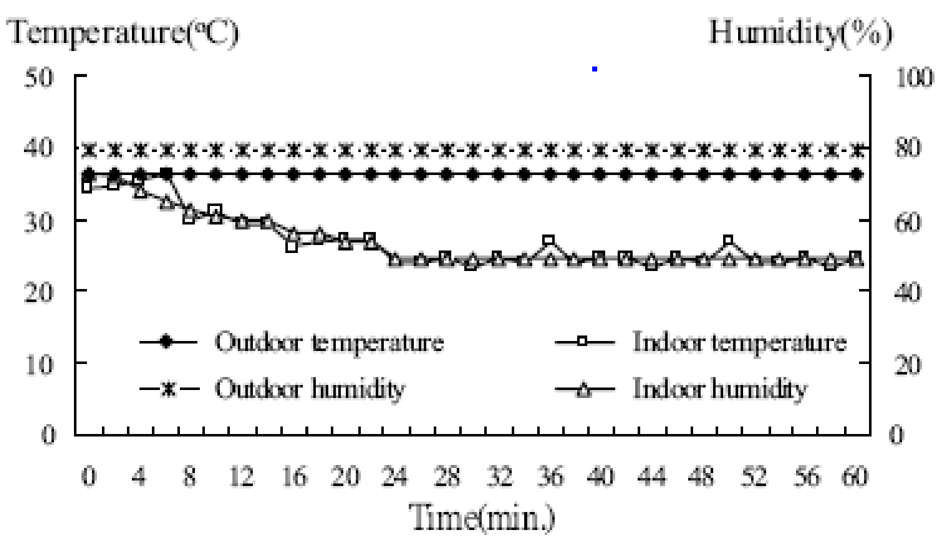


Figure 2.14: The thermal comfortable control

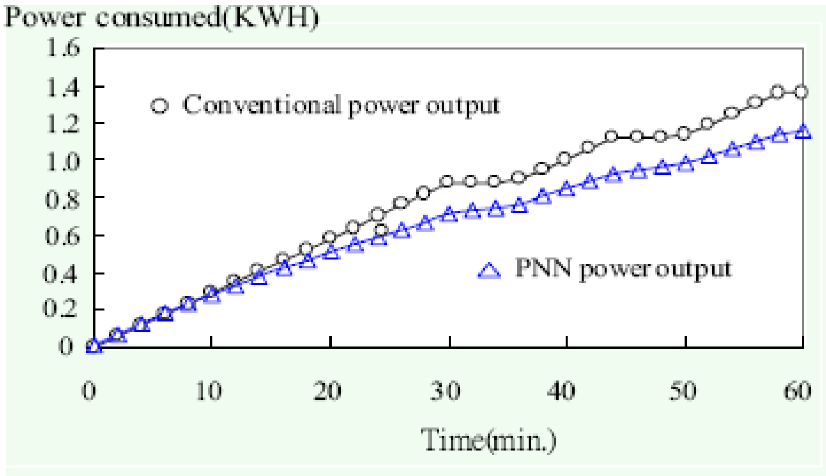


Figure 2.15: The power consumed of conventional air-conditioners and PNN controlled air-conditioners

2.7 PIC Microcontroller

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1640 [25] originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "Programmable Interface Controller"[26], but shortly thereafter was renamed "Programmable Intelligent Computer"[27]PICs are popular with developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability. Microchip recently announced the shipment of its five billionth PIC processor

2.7.1 Characteristic

The PIC architecture is distinctively minimalist. It is characterized by the following features that is separate code and data spaces (Harvard architecture), a small number of fixed length instructions, most instructions are single cycle execution (4 clock cycles), with single delay cycles upon branches and skips, a single accumulator (W), the use of which (as source operand) is implied (ie is not encoded in the op-code), All RAM locations function as registers as both source and/or destination of math and other functions,[1] a hardware stack for storing return addresses, a fairly small amount of addressable data space (typically 256 bytes), extended through banking, data space mapped CPU, port, and peripheral registers and the program counter is also mapped into the data space and writable (this is used to implement indirect jumps)

2.7.2 Limitation

Unlike most other CPUs, there is no distinction between "memory" and "register" space because the RAM serves the job of both memory and registers, and the RAM is usually just referred to as the register file or simply as the registers.
The PIC architectures have several limitations that is only a single accumulator, a small instruction set, Operations and registers are not orthogonal; some instructions can address RAM and/or immediate constants, while others can only use the accumulator, Memory must be directly referenced in arithmetic and logic operations, Register-bank switching is required to access the entire RAM of many devices, making position-independent code complex and inefficient and Conditional skip instructions are used instead of conditional branch instructions (as most other architectures use)

2.8 Advantages of C++

C++ is a programming language which derives from C; the name (C++) means increased C. It is merely an "extension" to C. The advantages of C++ compared to other programming languages are efficiency - C++ is very fast, powerful, and small in size, portability - code written in C++ can be ported to many different operating systems and/or platforms with little or no change, OOP - Object Oriented Programming; C++ is an excellent object oriented programming language, OOP allows re-usability and ease of use, distribution and is much more efficient than structured coding and modular - each source file needs to be compiled only once and if you make a change in one file out of the 100+ files in your project, only that file is compiled and then linked to the rest of the project.[28][29]

2.9 Passive Infra-Red

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. The product 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

2.9.1 The Operation

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.

2.9.2 Calibration

The PIR Sensor requires a 'warm-up' time in order to function properly. This is due to the settling time involved in 'learning' its environment. This could be anywhere from 10-60 seconds. During this time there should be as little motion as possible in the sensors field of view. There is a variable resistor (Delay Time) on the PIR sensor to control the 'ON' delay time for the sensor. Turning the variable resistor clockwise will give longer 'ON' delay time while turning anticlockwise with reduce the 'ON' delay time.

2.9.3 Sensitivity

The PIR Sensor has a range of approximately 5 meters. The PIR sensor can sense object up to 120° within 1 meter range. The sensitivity can vary with environmental conditions. The sensor is designed to adjust to slowly changing conditions that would happen normally as the day progresses and the environmental conditions change, but responds by making its output high when sudden changes occur, such as when there is motion.

CHAPTER 3

HARDWARE AND SOFTWARE DEVELOPMENT

3.1 Introduction

This project will use PIC to control NPN power transistor further drive air conditional and LEDs on. Situation happens when the sensors detect certain environment temperature and the movement. The value of environment temperature will display on LCD screen. When sensor did not detect the movement and environment temperature is below the setting temperature so the air conditioner will off automatically.

To develop this project, there are two main parts. Those parts are:
Hardware Design and Software Design

System overview

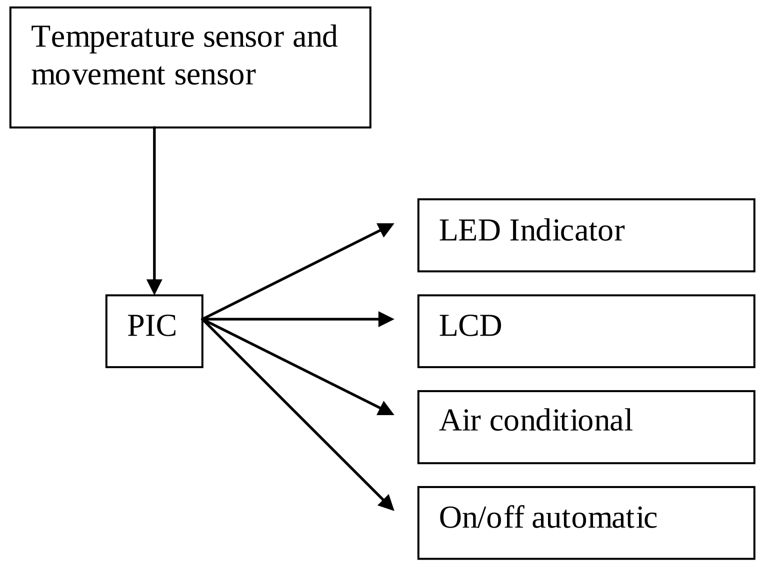


Figure 3.1: hardware overview

Flow chart

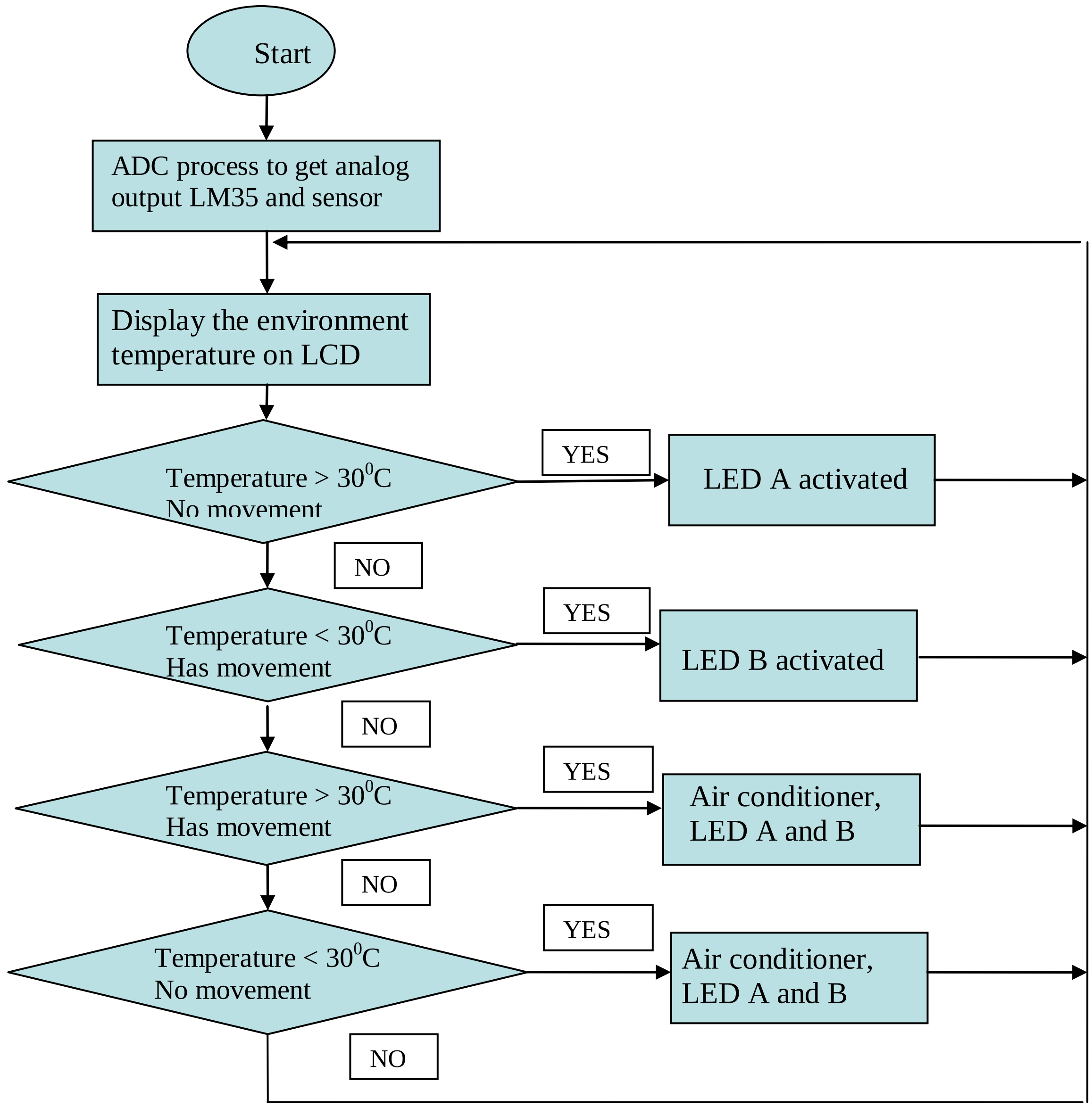


Figure 3.2: software overview

3.2 Hardware Design

Use software MPLAB for design the circuit. This software use for simulation the circuit before applies to the board. Use PIC 16F876A, Temperature Sensor LM35DZ, Passive Infra-Red and DC Brushless Cooling Fan for air conditional model. Refer to appendix.

3.2.1 Power Transistor

BD135 is used for controlling the DC brushless fan with sufficient current. Figure 15 shows the pin diagram of BD135.

3.2.2 Temperature Sensor

In this project, LM35s are used for sense the environment temperature. Vs of the LM35s are given 5V and the Vout pins are connected to AN0 and AN1 (PIC16F876A) separately.

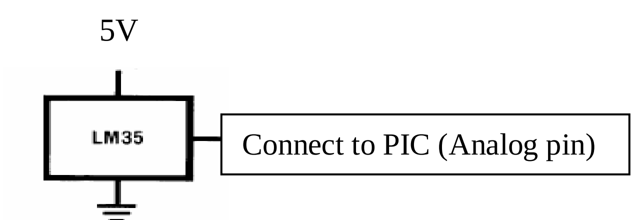


Figure3.2: Temperature sensor

Since the sensor gain (average slope) of the LM35 is $10 mV/{^o}C$ and ADC has 10 bit (210 ≈1000), so pin 5 (Vref) from PIC16F876A must be given for 1V by using the voltage divider concept. For preventing the offset, voltage for pin 5 (Vref) should be adjustable (using rheostat).

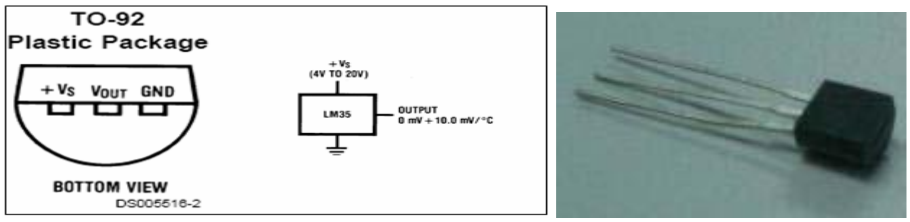


Figure 3.4: Temperature sensor

3.2.3 PIC 16F876A

This powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC® architecture into an 28-pin package and is upwards compatible with the PIC16C5X, PIC12CXXX and PIC16C7X devices. The PIC16F876A features:

• 256 bytes of EEPROM data memory
• Self programming
• An ICD
• 2 Comparators
• 5 channels of 10-bit Analog-to-Digital (A/D) converter
• 2 capture/compare/PWM functions
• the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I^2C™) bus
• A Universal Asynchronous Receiver Transmitter (UART)

All of these features make it ideal for more advanced level A/D applications in automotive, industrial, appliances and consumer applications.

3.2.4 Interface PIC16F876A With Temperature Sensor

Signal pin (Vout) from LM35 can be connected to either one of analog input pin (AN0-AN4) except AN3 (pin 5) but make sure the ADC configuration is correct according to the Figure (appendix B). In fact, pin 5 (Vref+) from PIC should be given for 1V but it may has offset, so a variable resistor (VR1) was installed for voltage adjusting. For more stability, user is recommended add a capacitor (104) between the analog signal and GND for every analog input such as signal from LM35 and variable resistor (VR1).

3.2.5 Interface PIC16F876A With LCD

The 16 header pin should be soldered to the LCD first, refer to figure 3 and 4 at appendix C. The following table shows the LCD (2X16 character) connection:

Pin	Name	Pin function	Connection
1	VSS	Ground	GND
2	VCC	Positive supply for LCD	5V
3	VEE	Contrast adjust	Connected to a preset for contrast adjusting
4	RS	Select register, select instruction or data register	RA2
5	R/W	Select read or write	GND
6	E	Start data read or write	RA5
7	DB0	Data bus pin	RC0
8	DB1	Data bus pin	RC1
9	DB2	Data bus pin	RC2
10	DB3	Data bus pin	RC3
11	DB4	Data bus pin	RC4
12	DB5	Data bus pin	RC5
13	DB6	Data bus pin	RC6
14	DB7	Data bus pin	RC7
15	LED+	Backlight positive input	5V
16	LED-	Backlight negative input	GND

Table 3.1: the LCD (2X16 character) connection

3.2.6 Power Supply for Circuit

For this project, the voltage range of power source could be given for this circuit board between 7V and 15V. Higher input voltage will produce more heat at LM7805 voltage regulator. Typical voltage is 12V. Anyhow, LM7805 will still generate some heat at 12V. There are two type of power connector on the circuit board, DC plug ‘Adaptor’ is for AC-DC adaptor and 2510-02 ‘Power’ is for battery source. Normally AC to DC adaptor can be plugged to ‘Adaptor’ type connector. LM7805 (1A maximum) will regulate the given voltage to 5V (Vcc) for supplying to the PIC16F876A and pull-up the push button (input). The purpose of using diode (D1) is for circuit protection in case the polarity of the power source is incorrect. Capacitor (C5) and capacitor (C1) is use to stabilize the voltage input and output of the LM7805. Capacitor (C2) is used for reducing the instability of PIC and green LED (small) as power indicator. Refer to figure at appendix B.

3.2.7 ICSP for Programming PIC Microcontroller

In Circuit Serial Programming (ICSP) is used for loading program in this project. ICSP gives a convenience way to load program into PIC microcontroller without removing the PIC from the circuit board. So pin 1 (Vpp), pin 27 (PGC) and pin 28 (PGD) from PIC should be connected to USB in Circuit Programmer through the external cable. Besides, GND from the circuit board also should be connected with GND and pin 24 (PGM) should be pulled to GND through a 10K resistor as shown in Figure (appendix).User can also choose other type of PIC programmer to load the program. Since the ICSP is used, three I/O pins (RB3, RB6 and RB7) cannot be used as input again but it still can be used for output. Refer to figure at appendix B.

3.2.8 Push Button as Input for PIC Microcontroller

One I/O pin is needed for one push button as input for PIC microcontroller. The connection of the push button to the I/O pin is shown in Figure (appendix). The I/O pin should be pull up to 5V using a resistor (with value range 1K- 10K) and this configuration will result an active-low input. When the button is being pressed, reading of I/O pin will be in logic 0, while when the button is not pressed, reading of that I/O pin will be logic 1. Refer to figure at appendix B.

3.2.9 LED as Output for PIC Microcontroller

One I/O pin is needed for one LED as output for PIC microcontroller. The connection for a LED to I/O pin is shown in Figure (appendix). The function of R8 is to protect the LED from over current that will burn the LED. When the output is in logic 1, the LED will ON, while when the output is in logic 0, the LED will OFF. Refer to figure 3 and 4 at appendix B.

3.2.10 Interface PIC16F876A with DC Brushless Fan

Since the current of I/O pin from PIC is limited to drive a DC Brushless Fan (0.12A), so Power Transistor (BD135) is required for giving current to it sufficiently.

The maximum collector current, Ic of BD135 is 1.5A, which means the DC Brushless Fan greater than 1.5A cannot be driven. Refer to figure at appendix B.

3.2.11 PIR (Passive Infra-Red) Sensor

3.2.11.1 Pin Definitions and Ratings

Pin	Name	Function
-	GND	Connects to Ground
OUT	Output	Connects to an I/O pin set to INPUT mode (or transistor/MOSFET)
+	Vcc	Connects to Vcc (+5V to + 20V) @ ~100uA

Table 3.2: Pin Definitions and Ratings

3.2.11.3 Recommended Operating Condition

Parameter	Symbol	Rating	Unit
Operating power supply	Vcc	+4.5V - +5.5V	V
Operating Temperature	T	-15°C - +70°C	°C

Table 3.3: Recommended Operating Condition

3.2.11.4 Connecting and Testing

Connect the 3-pin header to your circuit so that the minus (-) pin connects to ground, the plus (+) pin connects to Vcc and the OUT pin connects to your microcontroller's I/O pin. One easy way to do this would be to use a standard servo/LCD extension cable. The unit output is high whenever there is motion detected. Please refer Appendix A for example application of PIR sensor.

3.2.12 Getting Start

Once user has the hardware set, soldering process can be started now. Solder the electronic components one by one according the symbols and the component value and polarity is correctly soldered.

Step for soldering 2510 connector:

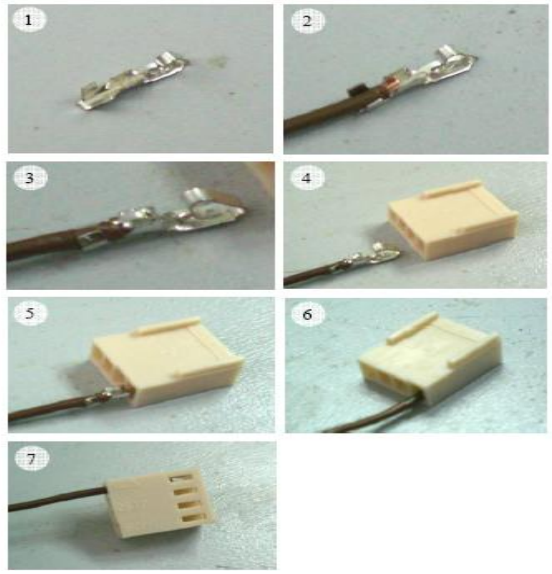


Figure 3.5: Step for soldering 2510 connector

For this project, temperature sensors (LM35) and cooling fans are connected to the circuit board through some wires and connectors. The length of the wires is various depend on the distance of a certain area where would be measured. Each polarity should be correctly connected. Differentiate the types of the connector and use 2510 connector for LM35 and 2532 connector for cooling fan.

After soldering process is finished, plug in the PIC16F876A to the 28 pins IC socket in proper side. After the installation complete, open the project file provided using MPLAB IDE. Plug in the power supply and connect the programmer connector to the circuit board to reprogram the PIC. The slide switch is ON. After modification, build the project and load the hex file into the PIC microcontroller using USB in Circuit Programmer.

User can choose either adaptor or battery to provide the power for the circuit board but make sure the given voltage is between 7V and 15V.When the power is provided, the LED will turn on. First, adjust the ‘Contrast’ VR2 for desired brightness of

LCD Display. Voltage of pin 5 (Vref+) from PIC should adjusted to 1V by rotating the ‘Offset’ VR1 and using a Multi-meters.

3.3 Software Design

3.3.1 Analog to Digital Converter (A/D) Module

The Analog-to-Digital (A/D) Converter module has five inputs for PIC16F876A. The conversion of an analog input signal results in a corresponding 10-bit digital number. The A/D module has high and low voltage reference input that is software selectable to some combination of VDD, VSS, RA2 or RA3. The A/D module has four registers. These registers are:

- A/D Result High Register (ADRESH)
- A/D Result Low Register (ADRESL)
- A/D Control Register 0 (ADCON0)
- A/D Control Register 1 (ADCON1)

The ADCON0 register, shown in Figure 6 (appendix C), controls the operation of the A/D module. Clock conversion Fosc/64 has been selected. Only two channels (AN0 &AN1) are used for two temperature sensors separately. ADCON0 should be 0b10000001 for channel 0 and 0b10001001 for channel 1. The ADCON1 register shown in Figure 7 (appendix C) configures the functions of the port pins. In this project, ADCON1 was set to 0b11000011. Right justified result format was selected (ADFM=1) as shown in Figure 6 (appendix C). The port pins can be configured as analog inputs (RA3 can also be the voltage reference) or as digital I/O. 4 Least Significant bits for ADCON1 were set to 0011, so that the AN0 pin and AN1 pin are configured as analog input but AN3 is set for Vref as shown in Figure 7 (appendixC). The ADRESH: ADRESL registers contain the 10-bit result of the A/D conversion. When the A/D conversion is complete, the result is loaded into this A/D Result register pair, the GO/DONE bit (ADCON0<2>) is cleared and the A/D interrupt flag bit ADIF is set. After the A/D module has been configured as desired, the selected channel must be acquired before the conversion is started. The analog input channels must have their corresponding TRIS bits selected as inputs.

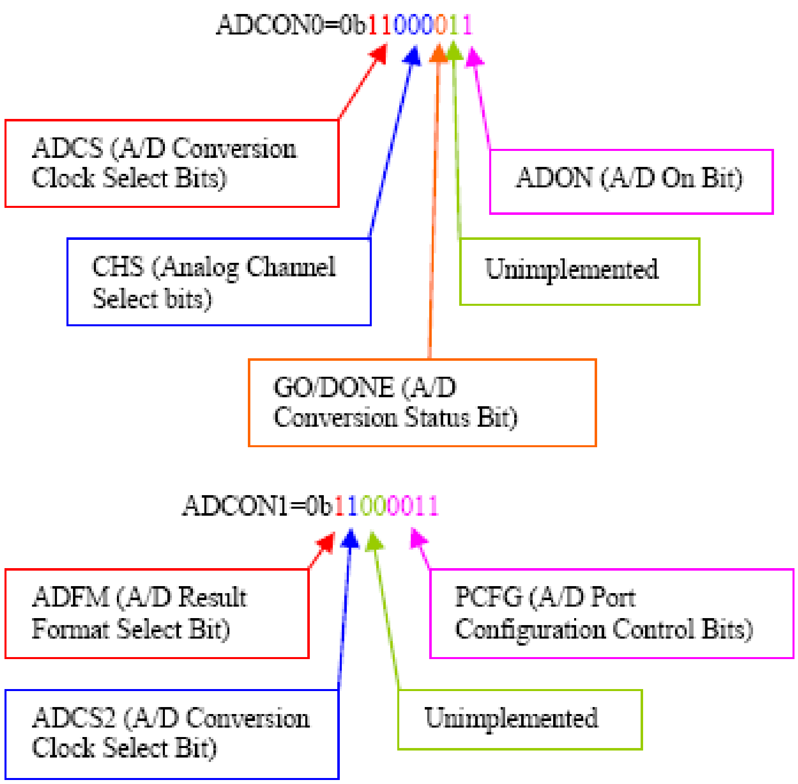


Figure 3.6: Analog-to-Digital (A/D) Converter module

The ADRESH: ADRESL register pair is the location where the 10-bit A/D result is loaded at the completion of the A/D conversion. This register pair is 16 bits wide. The A/D module gives the flexibility to left or right justify the 10-bit result in the 16-bit result register. The A/D Format Select bit (ADFM) controls this justification.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter consists of the discussion about the operation of hardware with the result of simulation is used in programming and implemented to the hardware. All the method to get the results is in below.

1. Sensor detect the environment temperature and display on LCD
2. When temperature is > 30^0C and sensor did not detect the movement, LED A Will activated.
3. When temperature is < 30^0C and sensor detect the movement, LED B will activated.
4. When temperature is > 30^0C and sensor detect the movement, air conditioner, LEDA and LED B will activated.
5. When temperature is < 30^0C and sensor did not detect the movement, air conditioner, LED A and LED B will deactivate.

4.2 Sensor Movement Result

The movement sensor is the main part to achieve the scope. The right movement and position can be reached depend on the movement from user. In this result, it will explain about mode and position that movement sensor need to be operate.

Position	Mode	Description
H	Retrigger	Output remains HIGH when sensor is retrigger repeatedly. Output is LOW when idle (not triggered).
L	Normal	Output goes HIGH then LOW when triggered. Continuous motion result in repeated HIGH/LOW pulses. Output is LOW when idle.

Table 4.1 position and mode of sensor

4.3 Initial Sensor Result

Figure 4.1 shows the position at initial location. Based on program, initial location will be reference point before the air conditioner is on. At the initial position LED, LCD and sensor will not function and in condition OFF.

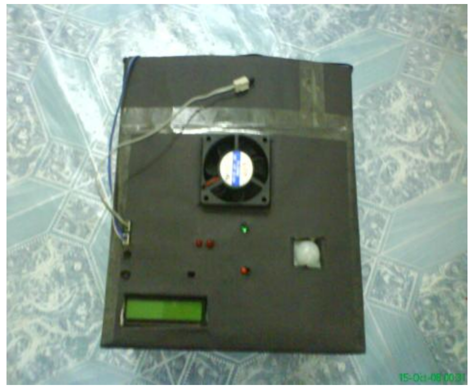


Figure 4.1: Initial location

4.4 Final Sensor Result

Figure 4.2 shows the position at final when sensor movement detects the movement from user and LED will on. Based on program, the movement sensor will detect the movement after the switch is on. At this position LED and LCD will ON. Sensor movement and sensor environment temperature will function and detect the motion and environment temperature. When the condition is satisfied, that mean the environment temperature is above 30 ^{0}C and there is a motion so the fan will run. When there is no motion and the environment temperature is above 30 ^{0}C so the fan will OFF automatically.

Figure 4.2: Detect movement and environment Temperature

4.5 Data Analysis

This project was conduct and testing by using MPLAB circuit design. Firstly the circuit is design based on the hardware. When the circuit is complete design, testing the circuit and interfaces the circuit with the LCD, PIR sensor, LM35 sensor and LED. After the circuit was testing, implement the circuit to the board based on the circuit that has been design.

4.6 Discussion of the project

This project cannot produce the correct output because there is some problem on hardware. The problems are based on sensors that detect the environment temperature and the movement from user. The movement sensor cannot function very well because of the length of sensor that cannot detect the length of motion from user. While the temperature sensor cannot produce the right value because of the environment temperature that always changes.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From this project, we can know Human factors play an important role in energy wastage and the result should show how the air conditioner will be able to switch on/off automatically based on movement detection and environment temperature. As a conclusion, I have gained the knowledge about a PIC. I also practice what I have learned in class and I get new experience. I also know the relationship between hardware and program, also how it is function. In addition, this task, indirectly make me more creative and confidence while entering job field in the future. Beside that, I can know to edit, assemble and execute program into the system. From this experiment, I also expose to design hardware and software of the PIC.

During hardware design, it is important to fully understand each connection made so that the hardware will be functioning and it will be a lot more easily to troubleshoot the design if there is any error. It order to be functional in this hardware design, the project must also be included with the usage of a address decoder as the PIC can only handle one device at a time.

5.2 Future Recommendation

It is recommended that the future development should be increase the output of the design. For example use the timer to set the time for on and off the air conditioner but it will increase the cost and component used. For future development, hardware design should create creatively with innovative effort so that the future user can use the air conditioner that totally easy and comfortable to the user.

5.3 Costing & Commercialization

4.2 List of component and the price

No	Component	Specification	Price / unit	Quantity	Price
1	PCB header	40 ways	RM0.80	10	RM8.00
2	IC base	20pin	RM0.60	2	RM1.20
3	IC base	28pin	RM0.20	2	RM0.40
4	Crystal		RM1.20	1	RM1.20
5	Wire wrap		RM15.00	1	RM15.00
6	Strip board	10’’x4’’	RM5.00	1	RM5.00
7	MAX 233		RM9.50	1	RM9.50
8	PIC6F766A		RM10.50	1	RM10.50
9	Rainbow cable	3 ways 20cm	RM3.30	1	RM3.30
10	Heat sink		RM0.90	1	RM0.90
11	Voltage regulator	LM7805	RM1.00	1	RM1.00
12	Reset switch	Push button	RM0.50	1	RM0.50
13	Resistor	10 M ohm	RM0.06	2	RM0.12
14	Resistor	10K ohm	RM0.06	2	RM0.12
15	Resistor	4.7K ohm	RM0.06	1	RM0.06
16	Resistor	1K ohm	RM0.06	8	RM0.46
17	Resistor	220 ohm	RM0.06	4	RM0.24
18	Capacitor	4.7uF	RM0.07	5	RM0.35
19	Capacitor	1uF	RM0.07	2	RM0.14
20	Capacitor	100uF	RM0.10	2	RM0.20

21	Ceramic cap	30pF	RM0.10	2	RM0.20
22	Ceramic cap	104F	RM0.10	2	RM0.20
23	E-cap	10uF25V	RM0.07	1	RM0.07
24	Temperature sensor	LM35DZ	RM4.00	2	RM8.00
25	LCD screen	2x16	RM30.00	1	RM30.00
26	Connector	2510-02	RM0.20	2	RM0.40
27	Connector	2510-03	RM0.20	2	RM0.40
28	Connector	2600-03	RM0.20	4	RM0.80
29	Connector	2532-02	RM0.20	2	RM0.40
30	LED green	3mm	RM0.15	2	RM0.30
31	LED red	5mm	RM0.15	2	RM0.30
32	Wire(red)	Single core	RM1.00	1m	RM1.00
33	Wire(yellow)	Single core	RM1.00	1m	RM1.00
34	Wire(blue)	Single core	RM1.00	1m	RM1.00
35	DB9	Male and female	RM1.30	1	RM1.30
36	Transistor	BD135	RM2.50	2	RM2.50
37	Slide switch		RM0.55	1	RM0.55
38	DC plug	Adaptor socket	RM3.50	1	RM3.50
39	Diode	1N4007	RM0.20	1	RM0.20
40	Diode	1N4148	RM0.10	1	RM0.10
41	Box header	10pin	RM1.80	1	RM1.80
42	Screw and nuts	3mm	RM0.20	4	RM0.80
43	PIR sensor		RM38.00	1	RM38.00
TOTAL OF PRICE					**RM149.41**

For this project, the total cost is RM149.41. This project can be commercialized because nowadays people in this world use air conditioner in their house and car. But there is a problem when they use the air conditioner. The problem they have is the air conditioner uses more energy, so this make their bill of electricity will increase. Some time the air conditioner is on and there is no user, so this will cause the waste of energy. To improve of the use for the user, this project will help and settle the problem that they face. So this project is very useful for the user.

The advantage of this project is to user is they just need to on the switch. The sensor that has in this product will function and detect the environment temperature and movement of the user. If the condition for this product is available so the air conditioner will function. When there is no user so the air conditioner will off automatically. This advantage will cause the user to buy this product because it can save the money for user to pay the high of bill and the waste of the energy that they face.

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APPENDIX A

SOFTWARE DEVELOPMENT

PIC PROGRAMMING

Program

1) Develop the program and debugging the program

LCD setting

```
void send_config(unsigned char data)
{
   RS=0;
  lcd=data;
  delay(500);
  e_pulse();
}
void e_pulse(void)
{
  E=1;
  delay(500);
  E=0;
  delay(500);
}
void send_char(unsigned char data)
{
   RS=1;
  lcd=data;
  delay(500);
  e_pulse();
}
void lcd_goto(unsigned char data)
{
   if(data<16)
  {
```

```
        send_config(0x80+data);
    }
    else
    {
        data=data-20;
       send_config(0xc0+data);
    }
}
void lcd_clr(void)
{
    RS=0;
     send_config(0x01);
    delay(600);
}
void dis_num(unsigned long data)
{
    unsigned char hundred_thousand;
    unsigned char ten_thousand;
    unsigned char thousand;
    unsigned char hundred;
    unsigned char tenth;

    hundred_thousand = data/100000;
    data = data % 100000;
    ten_thousand = data/10000;
    data = data % 10000;
    thousand = data / 1000;
    data = data % 1000;
    hundred = data / 100;
    data = data % 100;
    tenth = data / 10;
```

```
data = data % 10;

if(hundred_thousand>0)
{
   send_char(hundred_thousand + 0x30);   //0x30 added to become ASCII code
   send_char(ten_thousand + 0x30);
   send_char(thousand + 0x30);
   send_char(hundred + 0x30);
   send_char(tenth + 0x30);
   send_char(data + 0x30);
}
else if(ten_thousand>0)
{
   send_char(ten_thousand + 0x30);   //0x30 added to become ASCII code
   send_char(thousand + 0x30);
   send_char(hundred + 0x30);
   send_char(tenth + 0x30);
   send_char(data + 0x30);
}
else if(thousand>0)
{
    send_char(thousand + 0x30);   //0x30 added to become ASCII code
   send_char(hundred + 0x30);
   send_char(tenth + 0x30);
   send_char(data + 0x30);
}
else if(hundred>0)
{
    send_char(hundred + 0x30);   //0x30 added to become ASCII code
   send_char(tenth + 0x30);
   send_char(data + 0x30);
```

```
  }
  else if(tenth>0)
   {
     send_char(tenth + 0x30);   //0x30 added to become ASCII code
     send_char(data + 0x30);
  }
  else send_char(data + 0x30);   //0x30 added to become ASCII code
}
void increment(unsigned long data)
{
  unsigned short j;
  for(j=10;j>0;j--)
  {   lcd_goto(32);
     data=data+1;
     dis_num(data);
     delay(10000);
  }
}
```

<u>Subroutine ADC</u>

```
void read_adc(void)
{
  unsigned short i;
  unsigned long result_temp=0;
  for(i=2000;i>0;i-=1);      //looping 2000 times for getting average value
  {
     ADGO = 1;               //ADGO is the bit 2 of the ADCON0 register
     while(ADGO==1);            //ADC start, ADGO=0 after finish ADC progress
     result=ADRESH;
     result=result<<8;         //shift to left for 8 bit
     result=result|ADRESL;      //10 bit result from ADC
```

```
    result_temp+=result;
  }
  result = result_temp/2000;      //getting average value
}
unsigned short read_temp(void)
{
  unsigned short temp;
  temp=result;
  return temp;
}
```

Subroutine DELAY

```
void delay(unsigned short i)
{
  for(;i>0;i--);
}
```

MAIN PROGRAM

```
unsigned short result;
unsigned short temp,tempA,moveB;
void main(void)
{
  ADRESH=0;              //clear A/D result
  ADRESL=0;              //clear A/D result

  //setting ADCON1 Register
  ADCON1=0b11000101;        // A/D result right justified,
                            // configure RA2 and RA5 as digital I/O
  TRISA=0b11011011;        //configure PORTA I/O direction
  TRISB=0b00000000;        //configure PORTB as output
```

```
TRISC=0b00000000;        //configure PORTC as output

PORTA=0;
PORTB=0;
status=0;
while(1)
{
  send_config(0b00000001);     //clear display at lcd
  send_config(0b00000010);     //Lcd Return to home
  send_config(0b00000110);     //entry mode-cursor increase 1
  send_config(0b00001100);     //diplay on, cursor off and cursor blink off
  send_config(0b00111000);     //function set
  lcd_goto(0);                 //cursor start from beginning

//display character on LCD
  send_char(' ');
  send_char('T');
  send_char('E');
  send_char('M');
  send_char('P');
  send_char('.');
  send_char('A');
  send_char('=');
  lcd_goto(20);           //cursor go to 2nd line of the LCD

  //display character on LCD
  send_char(' ');
  send_char('M');
  send_char('O');
  send_char('V');
  send_char('E');
```

```
send_char('.');
send_char('B');
send_char('=');
while(1)              //infinity loop
{



//sensor A
ADCON0=CHANNEL1;          //CHANNEL1=0b10001001
lcd_goto(8);
read_adc();
temp=read_temp();
dis_num(temp/10);
send_char('.');
dis_num(temp%10);
send_char(0b11011111);
send_char('C');
send_char(' ');
send_char(' ');
tempA=temp;

//sensor B
ADCON0=CHANNEL0;          //CHANNEL0=0b10000001
lcd_goto(28);
read_adc();
 {
```

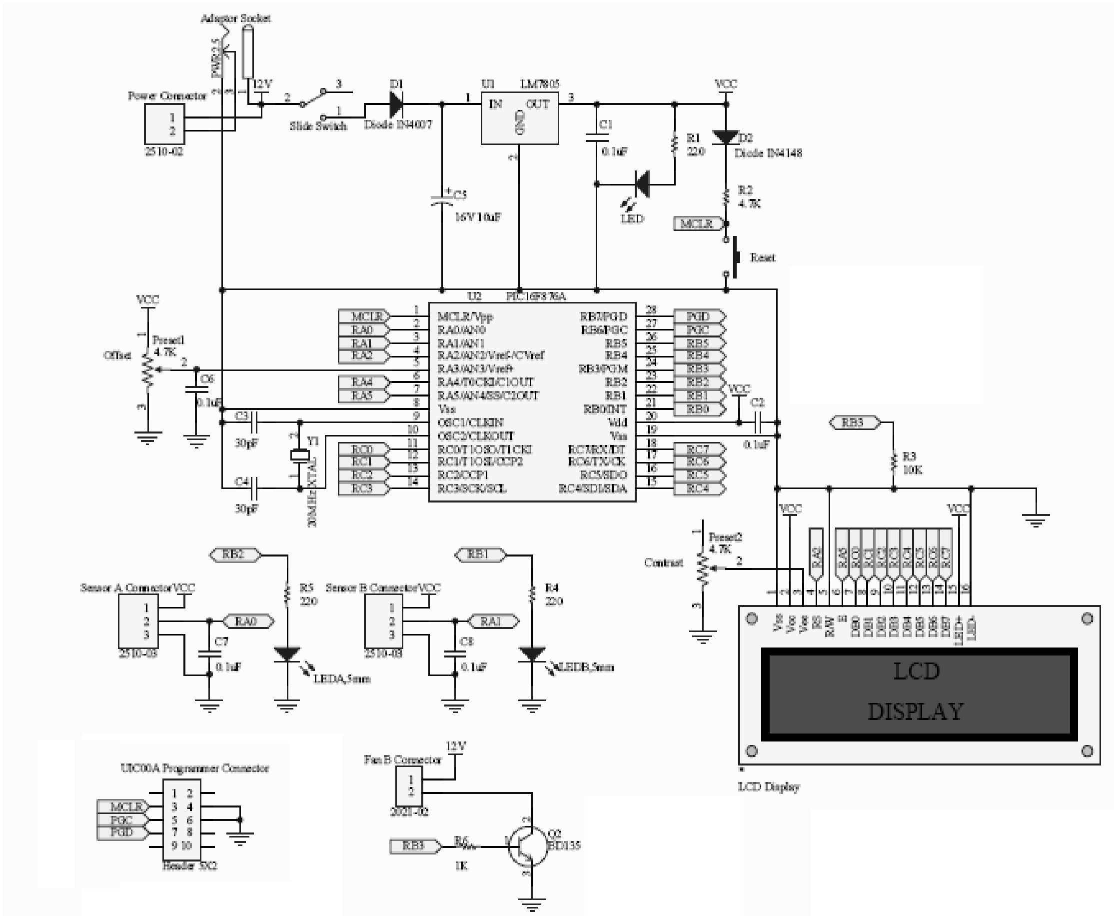
```
//scan input
if(CHANNEL0==1)    //Motion detected

send_char(0b11011111);
send_char('Y');
send_char('E');
send_char('S');
send_char(' ');
send_char(' ');

if(CHANNEL0==0)
send_char(0b11011111);
send_char('N');
send_char('O');
send_char(' ');
send_char(' ');

moveB=temp;

  if((tempA>400)&&(CHANNEL0==0))
                              //   *****************************************
    {                         //   *   LED A activated only for    *
      ledA=1;                 //   *   temperature A greater than 40'C      *
      ledB=0;                 //   *   and move B is no   *
      fanA=1;                 //   *****************************************
    }

  else if((CHANNEL0==1)&&(tempA<400))
                              //   *****************************************
    {                         //   *   LED B activated only for    *
      ledA=0;                 //   *   temperature A less than 40'C and   *
```

```
            ledB=1;                 //  *  move B is yes      *
            fanA=0;                 //  ****************************************
          }

        else if((CHANNEL0==1)&&(tempA>400))
                                    //
********************************************
          {                         //  *  All LED A & LED B, Fan A      *
            ledB=1;                 //  *  activated for temperature A greater than 40'C  *
            ledA=1;                 //  *  and move B is yes           *
            fanA=1;
                                    //  *************************************
          }


        else if((CHANNEL0==0)&&(tempA<400))
                                    //  *************************************
          {                         //  *  All LED A & LED B, Fan A      *
            ledB=0;                 //  *  disactivated for temperature A less than 40'C  *
            ledA=0;                 //  *  and move B is no            *
            fanA=0;                 //  *************************************



          }

      delay(2000);
      }
    }
}
```

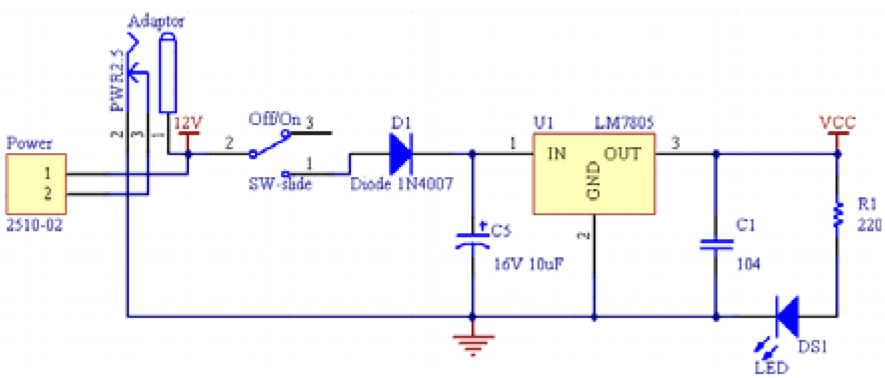
APPENDIX B

PIC MICROCONTROLLER CIRCUIT

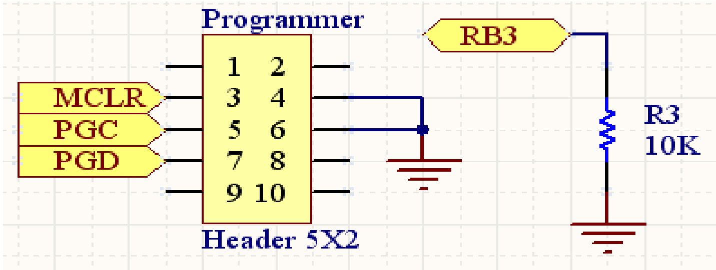
Circuit diagram



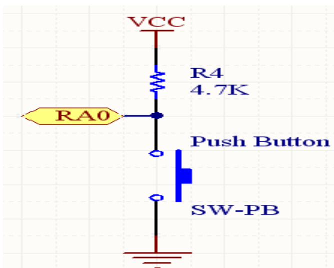
Power Supply for Circuit



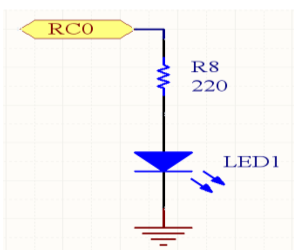
ICSP for Programming PIC Microcontroller Circuit



Push Button as Input for PIC Microcontroller Circuit



LED as Output for PIC microcontroller Circuit



APPENDIX C

FIGURES

Power Transistor (BD135) pin

PINNING

PIN	DESCRIPTION
1	emitter
2	collector, connected to metal part of mounting surface
3	base

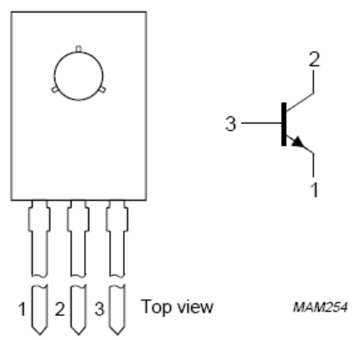


Fig.1 Simplified outline (TO-126; SOT32) and symbol.

Figure 1

PIC16F876A (Microcontroller) pin

28-Pin PDIP, SOIC, SSOP

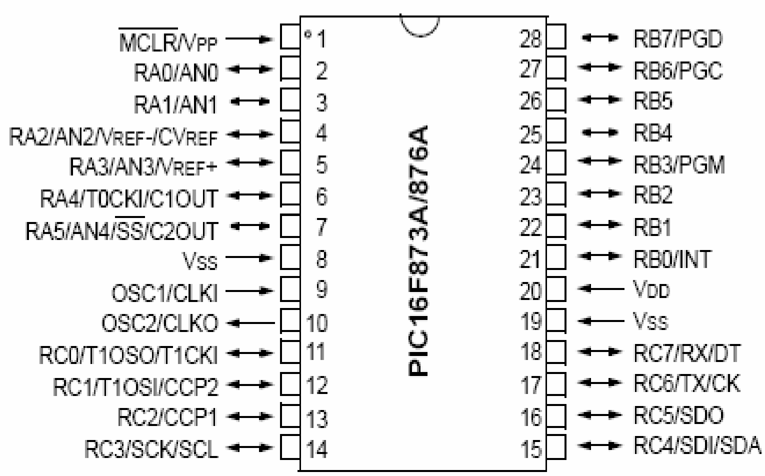


Figure 2 shows the pin diagram for PIC16F876A.

Figure 3

Figure 4 shows the schematic of the LCD display.

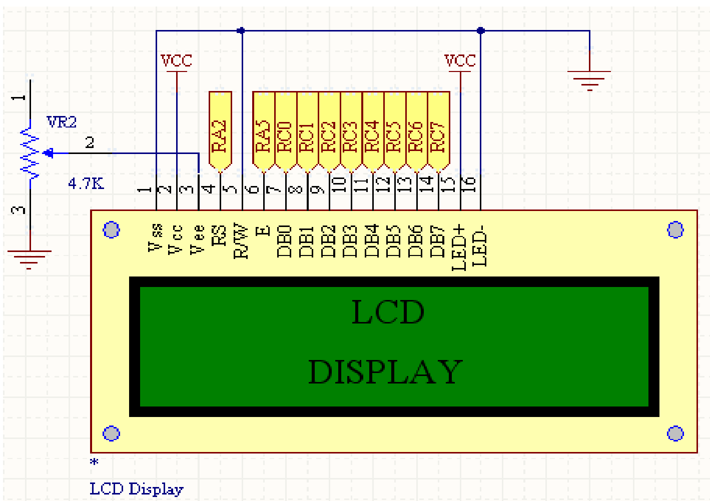


Figure 4

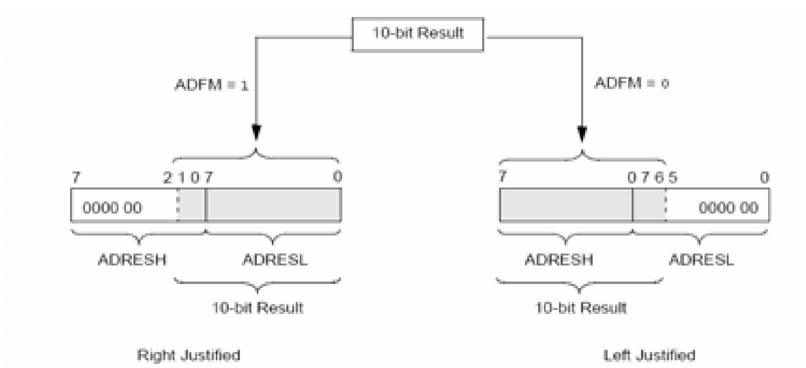


Figure 5

Table of Controls the operation of the A/D module.

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0
ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/$\overline{\text{DONE}}$	—	ADON
bit 7							bit 0

bit 7-6 **ADCS1:ADCS0:** A/D Conversion Clock Select bits (ADCON0 bits in **bold**)

ADCON1 <ADCS2>	ADCON0 <ADCS1:ADCS0>	Clock Conversion
0	00	Fosc/2
0	01	Fosc/8
0	10	Fosc/32
0	11	FRC (clock derived from the internal A/D RC oscillator)
1	00	Fosc/4
1	01	Fosc/16
1	10	Fosc/64
1	11	FRC (clock derived from the internal A/D RC oscillator)

bit 5-3 **CHS2:CHS0:** Analog Channel Select bits

000 = Channel 0 (AN0)
001 = Channel 1 (AN1)
010 = Channel 2 (AN2)
011 = Channel 3 (AN3)
100 = Channel 4 (AN4)
101 = Channel 5 (AN5)
110 = Channel 6 (AN6)
111 = Channel 7 (AN7)

Note: The PIC16F873A/876A devices only implement A/D channels 0 through 4; the unimplemented selections are reserved. Do not select any unimplemented channels with these devices.

bit 2 **GO/$\overline{\text{DONE}}$:** A/D Conversion Status bit

When ADON = 1:
1 = A/D conversion in progress (setting this bit starts the A/D conversion which is automatically cleared by hardware when the A/D conversion is complete)
0 = A/D conversion not in progress

bit 1 **Unimplemented:** Read as '0'

bit 0 **ADON:** A/D On bit

1 = A/D converter module is powered up
0 = A/D converter module is shut-off and consumes no operating current

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
- n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

Figure 6

Table of the functions of the port pins

R/W-0	R/W-0	U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0
ADFM	ADCS2	—	—	PCFG3	PCFG2	PCFG1	PCFG0
bit 7							bit 0

bit 7 **ADFM:** A/D Result Format Select bit

1 = Right justified. Six (6) Most Significant bits of ADRESH are read as '0'.
0 = Left justified. Six (6) Least Significant bits of ADRESL are read as '0'.

bit 6 **ADCS2:** A/D Conversion Clock Select bit (ADCON1 bits in shaded area and in **bold**)

ADCON1 <ADCS2>	ADCON0 <ADCS1:ADCS0>	Clock Conversion
0	00	FOSC/2
0	01	FOSC/8
0	10	FOSC/32
0	11	FRC (clock derived from the internal A/D RC oscillator)
1	00	FOSC/4
1	01	FOSC/16
1	10	FOSC/64
1	11	FRC (clock derived from the internal A/D RC oscillator)

bit 5-4 **Unimplemented:** Read as '0'

bit 3-0 **PCFG3:PCFG0:** A/D Port Configuration Control bits

PCFG <3:0>	AN7	AN6	AN5	AN4	AN3	AN2	AN1	AN0	VREF+	VREF-	C/R
0000	A	A	A	A	A	A	A	A	VDD	VSS	8/0
0001	A	A	A	A	VREF+	A	A	A	AN3	VSS	7/1
0010	D	D	D	A	A	A	A	A	VDD	VSS	5/0
0011	D	D	D	A	VREF+	A	A	A	AN3	VSS	4/1
0100	D	D	D	D	A	D	A	A	VDD	VSS	3/0
0101	D	D	D	D	VREF+	D	A	A	AN3	VSS	2/1
011x	D	D	D	D	D	D	D	D	—	—	0/0
1000	A	A	A	A	VREF+	VREF-	A	A	AN3	AN2	6/2
1001	D	D	A	A	A	A	A	A	VDD	VSS	6/0
1010	D	D	A	A	VREF+	A	A	A	AN3	VSS	5/1
1011	D	D	A	A	VREF+	VREF-	A	A	AN3	AN2	4/2
1100	D	D	D	A	VREF+	VREF-	A	A	AN3	AN2	3/2
1101	D	D	D	D	VREF+	VREF-	A	A	AN3	AN2	2/2
1110	D	D	D	D	D	D	D	A	VDD	VSS	1/0
1111	D	D	D	D	VREF+	VREF-	D	A	AN3	AN2	1/2

A = Analog input D = Digital I/O
C/R = # of analog input channels/# of A/D voltage references

Legend:

R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
- n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

Figure 7

AC to DC adaptor:

Figure 8

9V battery connector:

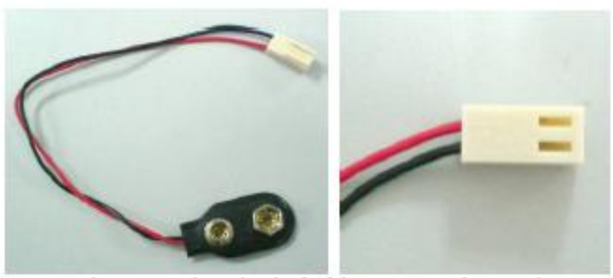


Figure 9

Connection to the PCB board:

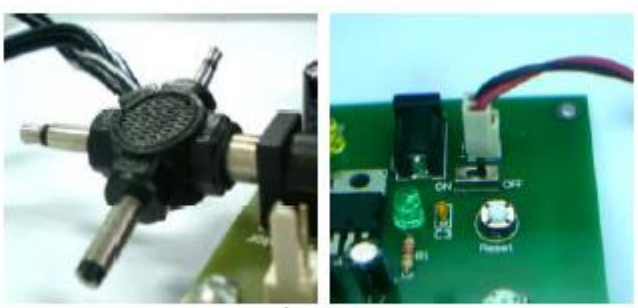


Figure 10

PIR (Passive Infra-Red) Sensor

Figure 11

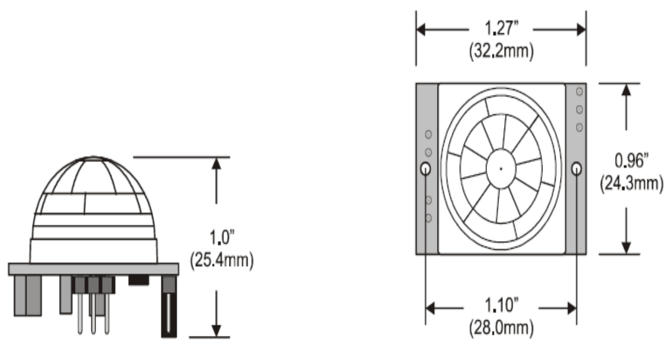


Figure 12

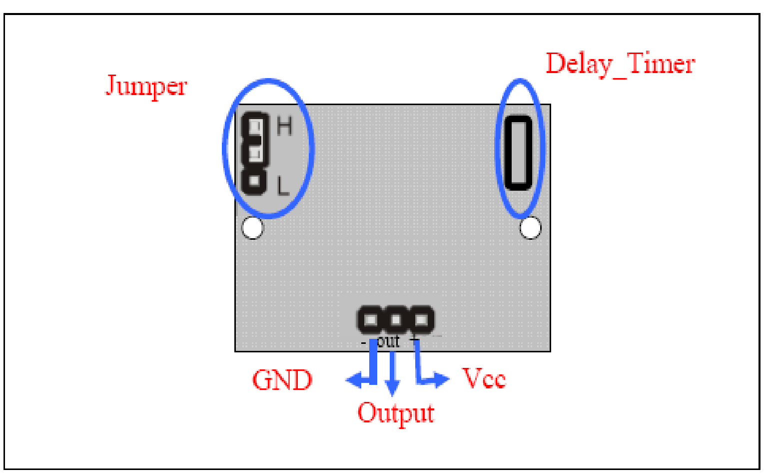


Figure 13

APPENDIX D

DATA SHEET

NPN power transistors BD135; BD137; BD139

FEATURES

- High current (max. 1.5 A)
- Low voltage (max. 80 V).

APPLICATIONS

- Driver stages in hi-fi amplifiers and television circuits.

DESCRIPTION

NPN power transistor in a TO-126; SOT32 plastic package. PNP complements: BD136, BD138 and BD140.

PINNING

PIN	DESCRIPTION
1	emitter
2	collector, connected to metal part of mounting surface
3	base

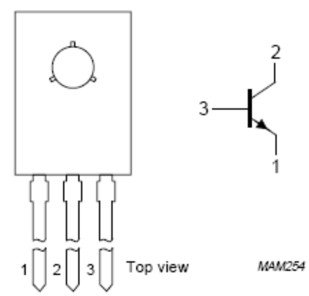


Fig.1 Simplified outline (TO-126; SOT32) and symbol.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BD135		–	45	V
	BD137		–	60	V
	BD139		–	100	V
V_{CEO}	collector-emitter voltage	open base			
	BD135		–	45	V
	BD137		–	60	V
	BD139		–	80	V
V_{EBO}	emitter-base voltage	open collector	–	5	V
I_C	collector current (DC)		–	1.5	A
I_{CM}	peak collector current		–	2	A
I_{BM}	peak base current		–	1	A
P_{tot}	total power dissipation	$T_{mb} \leq 70$ °C	–	8	W
T_{stg}	storage temperature		–65	+150	°C
T_j	junction temperature		–	150	°C
T_{amb}	operating ambient temperature		–65	+150	°C

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
$R_{th\ j\text{-}a}$	thermal resistance from junction to ambient	note 1	100	K/W
$R_{th\ j\text{-}mb}$	thermal resistance from junction to mounting base		10	K/W

Note

1. Refer to TO-126; SOT32 standard mounting conditions.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
I_{CBO}	collector cut-off current	$I_E = 0$; $V_{CB} = 30$ V	–	–	100	nA
		$I_E = 0$; $V_{CB} = 30$ V; $T_j = 125$ °C	–	–	10	μA
I_{EBO}	emitter cut-off current	$I_C = 0$; $V_{EB} = 5$ V	–	–	100	nA
h_{FE}	DC current gain	$V_{CE} = 2$ V; (see Fig.2)				
		$I_C = 5$ mA	40	–	–	
		$I_C = 150$ mA	63	–	250	
		$I_C = 500$ mA	25	–	–	
	DC current gain	$I_C = 150$ mA; $V_{CE} = 2$ V; (see Fig.2)				
	BD135-10; BD137-10; BD139-10		63	–	160	
	BD135-16; BD137-16; BD139-16		100	–	250	
V_{CEsat}	collector-emitter saturation voltage	$I_C = 500$ mA; $I_B = 50$ mA	–	–	0.5	V
V_{BE}	base-emitter voltage	$I_C = 500$ mA; $V_{CE} = 2$ V	–	–	1	V
f_T	transition frequency	$I_C = 50$ mA; $V_{CE} = 5$ V; f = 100 MHz	–	190	–	MHz
$\frac{h_{FE1}}{h_{FE2}}$	DC current gain ratio of the complementary pairs	$\lvert I_C \rvert = 150$ mA; $\lvert V_{CE} \rvert = 2$ V	–	1.3	1.6	

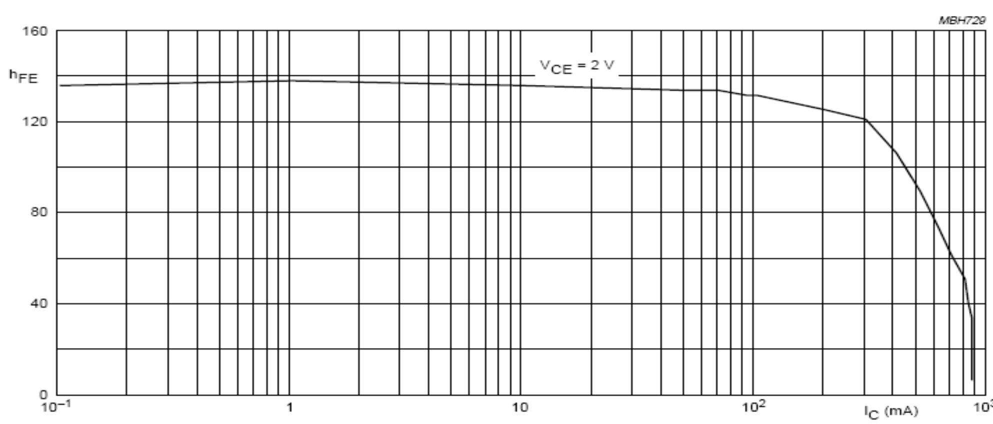


Fig.2 DC current gain; typical values.

National Semiconductor

November 2000

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

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

Typical Applications

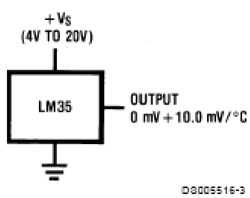
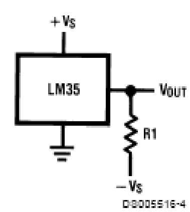


FIGURE 1. Basic Centigrade Temperature Sensor (+2˚C to +150˚C)

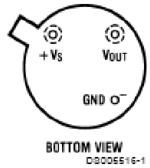


Choose $R_1 = -V_S/50\ \mu A$
V_{OUT}=+1,500 mV at +150˚C
= +250 mV at +25˚C
= −550 mV at −55˚C

FIGURE 2. Full-Range Centigrade Temperature Sensor

Connection Diagrams

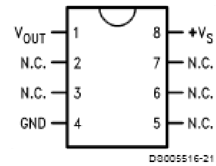
TO-46
Metal Can Package*



*Case is connected to negative pin (GND)

Order Number LM35H, LM35AH, LM35CH, LM35CAH or LM35DH
See NS Package Number H03H

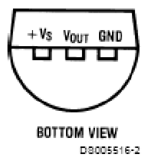
SO-8
Small Outline Molded Package



N.C. = No Connection

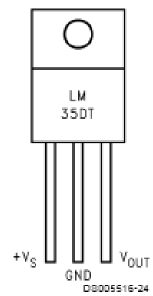
Top View
Order Number LM35DM
See NS Package Number M08A

TO-92
Plastic Package



Order Number LM35CZ, LM35CAZ or LM35DZ
See NS Package Number Z03A

TO-220
Plastic Package*



*Tab is connected to the negative pin (GND).

Note: The LM35DT pinout is different than the discontinued LM35DP.

Order Number LM35DT
See NS Package Number TA03F

Absolute Maximum Ratings (Note 10)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Supply Voltage	+35V to −0.2V
Output Voltage	+6V to −1.0V
Output Current	10 mA
Storage Temp.;	
TO-46 Package,	−60°C to +180°C
TO-92 Package,	−60°C to +150°C
SO-8 Package,	−65°C to +150°C
TO-220 Package,	−65°C to +150°C
Lead Temp.:	
TO-46 Package, (Soldering, 10 seconds)	300°C
TO-92 and TO-220 Package, (Soldering, 10 seconds)	260°C
SO Package (Note 12)	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C
ESD Susceptibility (Note 11)	2500V
Specified Operating Temperature Range: T_{MIN} to T_{MAX} (Note 2)	
LM35, LM35A	−55°C to +150°C
LM35C, LM35CA	−40°C to +110°C
LM35D	0°C to +100°C

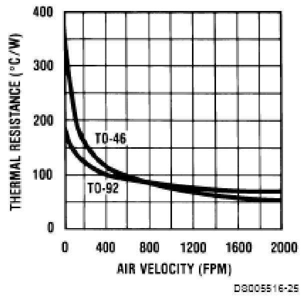
Electrical Characteristics

(Notes 1, 6)

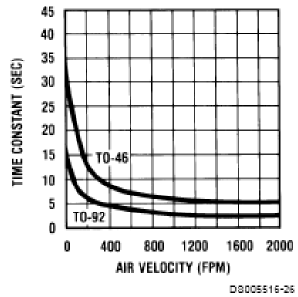
Parameter	Conditions	LM35A			LM35CA			Units
		Typical	Tested Limit (Note 4)	Design Limit (Note 5)	Typical	Tested Limit (Note 4)	Design Limit (Note 5)	(Max.)
Accuracy (Note 7)	T_A=+25°C	±0.2	±0.5		±0.2	±0.5		°C
	T_A=−10°C	±0.3			±0.3		±1.0	°C
	T_A=T_{MAX}	±0.4	±1.0		±0.4	±1.0		°C
	T_A=T_{MIN}	±0.4	±1.0		±0.4		±1.5	°C
Nonlinearity (Note 8)	T_{MIN}≤T_A≤T_{MAX}	**±0.18**		**±0.35**	**±0.15**		**±0.3**	°C
Sensor Gain (Average Slope)	T_{MIN}≤T_A≤T_{MAX}	**+10.0**	**+9.9, +10.1**		**+10.0**		**+9.9, +10.1**	mV/°C
Load Regulation (Note 3) 0≤I_L≤1 mA	T_A=+25°C	±0.4	±1.0		±0.4	±1.0		mV/mA
	T_{MIN}≤T_A≤T_{MAX}	**±0.5**		**±3.0**	**±0.5**		**±3.0**	mV/mA
Line Regulation (Note 3)	T_A=+25°C	±0.01	±0.05		±0.01	±0.05		mV/V
	4V≤V_S≤30V	**±0.02**		**±0.1**	**±0.02**		**±0.1**	mV/V
Quiescent Current (Note 9)	V_S=+5V, +25°C	56	67		56	67		μA
	V_S=+5V	**105**		**131**	**91**		**114**	μA
	V_S=+30V, +25°C	56.2	68		56.2	68		μA
	V_S=+30V	**105.5**		**133**	**91.5**		**116**	μA
Change of Quiescent Current (Note 3)	4V≤V_S≤30V, +25°C	0.2	1.0		0.2	1.0		μA
	4V≤V_S≤30V	**0.5**		**2.0**	**0.5**		**2.0**	μA
Temperature Coefficient of Quiescent Current		**+0.39**		**+0.5**	**+0.39**		**+0.5**	μA/°C
Minimum Temperature for Rated Accuracy	In circuit of *Figure 1*, I_L=0	+1.5		+2.0	+1.5		+2.0	°C
Long Term Stability	T_J=T_{MAX}, for 1000 hours	±0.08			±0.08			°C

Typical Performance Characteristics

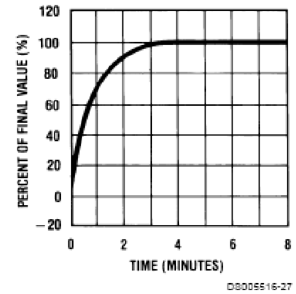
Thermal Resistance Junction to Air



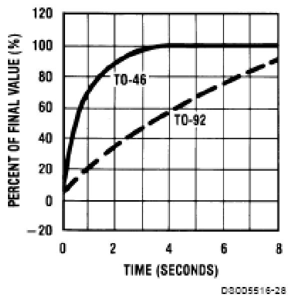
Thermal Time Constant



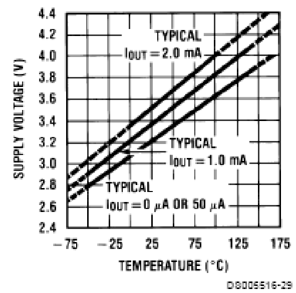
Thermal Response in Still Air



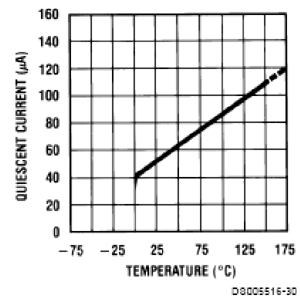
Thermal Response in Stirred Oil Bath



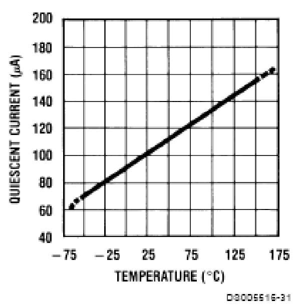
Minimum Supply Voltage vs. Temperature



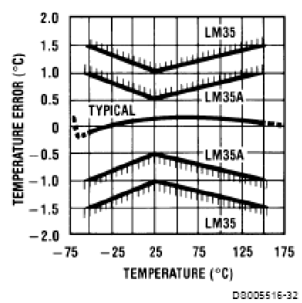
Quiescent Current vs. Temperature (In Circuit of *Figure 1*.)



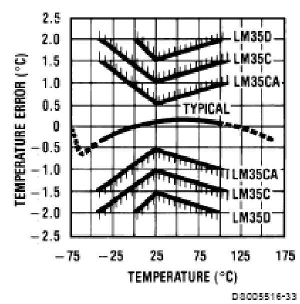
Quiescent Current vs. Temperature (In Circuit of *Figure 2*.)



Accuracy vs. Temperature (Guaranteed)

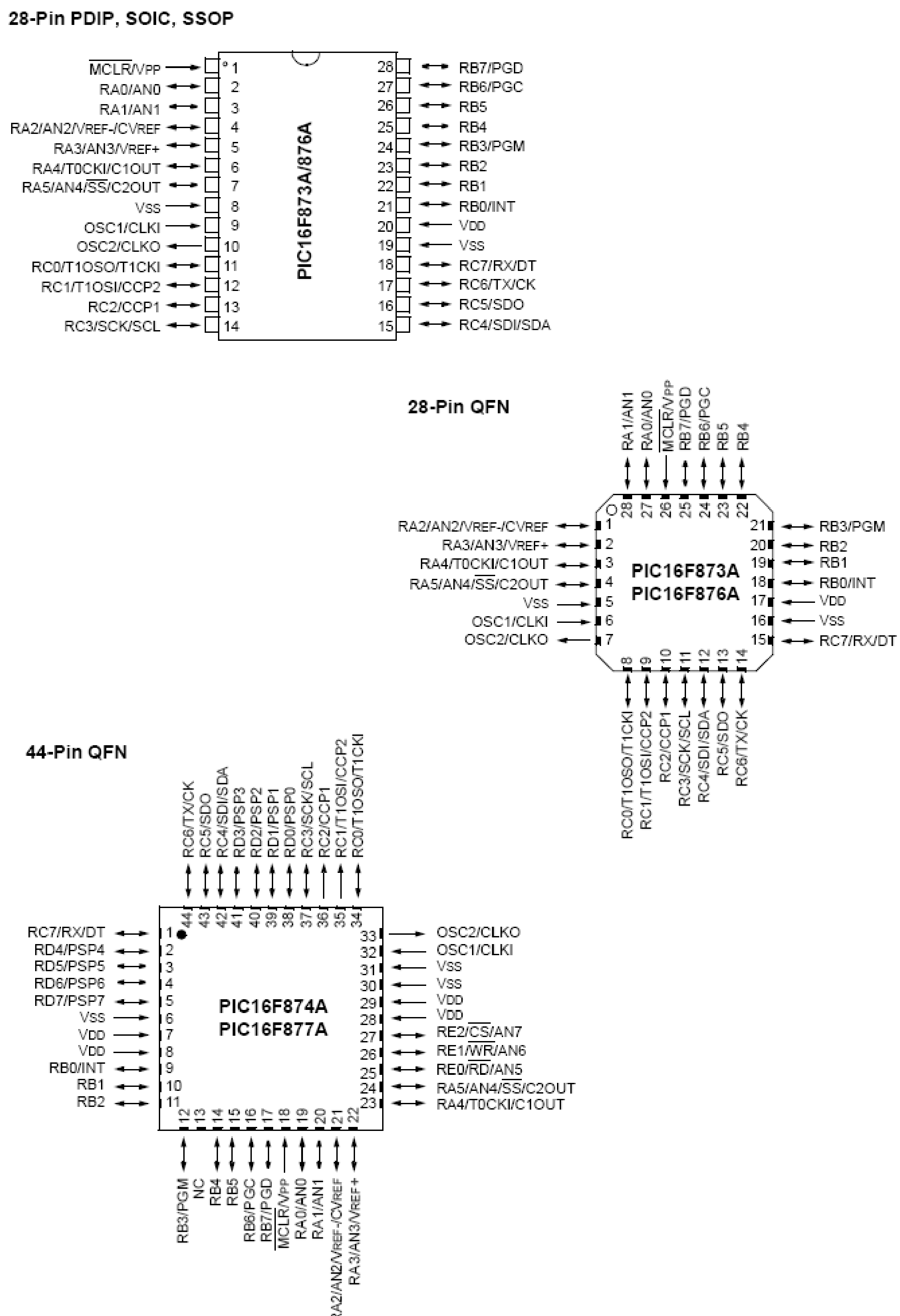


Accuracy vs. Temperature (Guaranteed)



PIC16F87XA

Pin Diagrams



PIC16F87XA

1.0 DEVICE OVERVIEW

This document contains device specific information about the following devices:

- PIC16F873A
- PIC16F874A
- PIC16F876A
- PIC16F877A

PIC16F873A/876A devices are available only in 28-pin packages, while PIC16F874A/877A devices are available in 40-pin and 44-pin packages. All devices in the PIC16F87XA family share common architecture with the following differences:

- The PIC16F873A and PIC16F874A have one-half of the total on-chip memory of the PIC16F876A and PIC16F877A
- The 28-pin devices have three I/O ports, while the 40/44-pin devices have five
- The 28-pin devices have fourteen interrupts, while the 40/44-pin devices have fifteen
- The 28-pin devices have five A/D input channels, while the 40/44-pin devices have eight
- The Parallel Slave Port is implemented only on the 40/44-pin devices

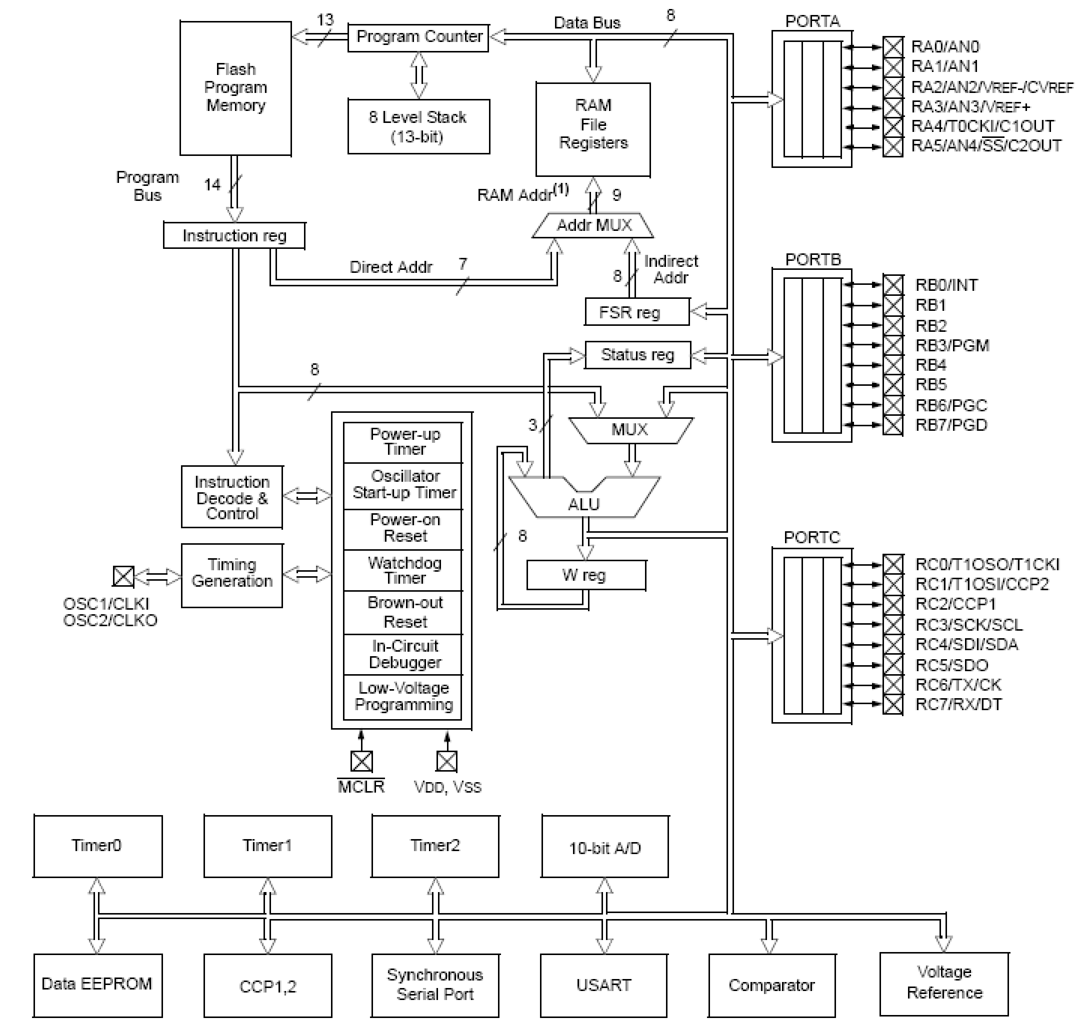
The available features are summarized in Table 1-1. Block diagrams of the PIC16F873A/876A and PIC16F874A/877A devices are provided in Figure 1-1 and Figure 1-2, respectively. The pinouts for these device families are listed in Table 1-2 and Table 1-3.

Additional information may be found in the PICmicro® Mid-Range Reference Manual (DS33023), which may be obtained from your local Microchip Sales Representative or downloaded from the Microchip web site. The Reference Manual should be considered a complementary document to this data sheet and is highly recommended reading for a better understanding of the device architecture and operation of the peripheral modules.

TABLE 1-1: PIC16F87XA DEVICE FEATURES

Key Features	PIC16F873A	PIC16F874A	PIC16F876A	PIC16F877A
Operating Frequency	DC – 20 MHz	DC – 20 MHz	DC – 20 MHz	DC – 20 MHz
Resets (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
Flash Program Memory (14-bit words)	4K	4K	8K	8K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory (bytes)	128	128	256	256
Interrupts	14	15	14	15
I/O Ports	Ports A, B, C	Ports A, B, C, D, E	Ports A, B, C	Ports A, B, C, D, E
Timers	3	3	3	3
Capture/Compare/PWM modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	—	PSP	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Analog Comparators	2	2	2	2
Instruction Set	35 Instructions	35 Instructions	35 Instructions	35 Instructions
Packages	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN

FIGURE 1-1: PIC16F873A/876A BLOCK DIAGRAM



Device	Program Flash	Data Memory	Data EEPROM
PIC16F873A	4K words	192 Bytes	128 Bytes
PIC16F876A	8K words	368 Bytes	256 Bytes

Note 1: Higher order bits are from the Status register.

2.0 MEMORY ORGANIZATION

There are three memory blocks in each of the PIC16F87XA devices. The program memory and data memory have separate buses so that concurrent access can occur and is detailed in this section. The EEPROM data memory block is detailed in **Section 3.0 "Data EEPROM and Flash Program Memory"**.

Additional information on device memory may be found in the PICmicro® Mid-Range MCU Family Reference Manual (DS33023).

2.1 Program Memory Organization

The PIC16F87XA devices have a 13-bit program counter capable of addressing an 8K word x 14 bit program memory space. The PIC16F876A/877A devices have 8K words x 14 bits of Flash program memory, while PIC16F873A/874A devices have 4K words x 14 bits. Accessing a location above the physically implemented address will cause a wraparound.

The Reset vector is at 0000h and the interrupt vector is at 0004h.

FIGURE 2-1: PIC16F876A/877A PROGRAM MEMORY MAP AND STACK

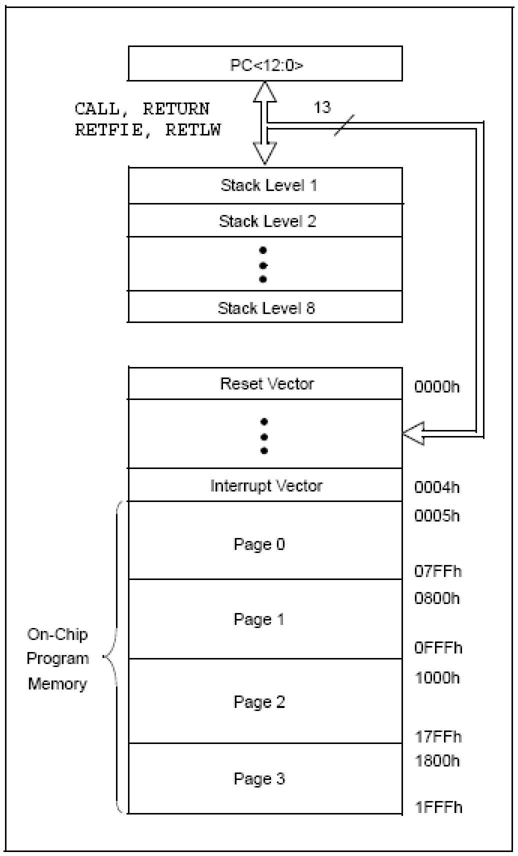


FIGURE 2-2: PIC16F873A/874A PROGRAM MEMORY MAP AND STACK