International Journal of
Scientific Engineering and Technology Research

ISSN 2319-8885
Vol.03,Issue.10
May-2014,
Pages:2000-2004

www.semargroup.org,
www.ijsetr.com

Design and Development of Microcontroller Based Air Conditioning System

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Abstract: This research paper describes the design and development of air conditioner control card based PIC16F877A microcontroller to get a comfortable thermal feeling for air conditioning system. Various types of air conditioner control cards are available in the markets nowadays but this control card in this system is different depending on microcontroller technology by changing control design and parameters. It is more reliable to use for the consumer. To be controlled based PIC16F877A for air conditioning system is only the temperature to provide more comfortable and conductive environment. The outputs of microcontroller are given commands to drive inputs of ULN 2003A which drives relays for output loads. The control card based on PIC16F877A will be constructed on air conditioning system to control temperature values for heating and cooling process, and speeds for compressor motor and fan. LCD display has been constructed for showing operations of air conditioning system. IC LM35 temperature sensor is used to detect the environment temperature change. In this paper, control card for air conditioner is implemented by Micro C programming language embedded in microcontroller.

Keywords: PIC16F877A, LM35 Temperature Sensor, Air Conditioning System, Micro C Programming Language, LCD Display, ULN 2003A.

I. INTRODUCTION

Nowadays, air conditioners and air conditioning systems are essential in parts of almost institution. Therefore, air conditioners are commonly found in various areas due to the natural demand for thermal comfort. Air conditioning systems are classified into different types of air conditioners for various environmental applications. Air conditioning systems can be modified such as window air conditioner, split air conditioner, packet air conditioner, and central air conditioner. Among them, the most commonly used air conditioning units are split air conditioners. Split air conditioners are perfect for when on room requires cooling or heating for constant climate control. They monitor the room temperature with a sensor on the indoor unit. The split air conditioner comprises of two parts: the outdoor and indoor unit. This paper describes an air conditioning system for indoor and outdoor using the control card for split type air conditioner based on a PIC16F877A microcontroller.

The air conditioning system is to maintain an acceptable comfort level in the various areas needed rather assume a homogeneous environment. The main objective of control systems in buildings for heat, air conditioning and ventilating is to ensure certain indoors climate comfort and minimum energy consumption in [1]. According to thermal comfort theory, the required indoors temperature of a building is not a fixed value in [2]. The necessaries of the temperature are changed depending on situation. In order to maintain indoor temperature within the required temperature range, correct and fast measurement must be combined with heating and cooling process in [3]. In this paper, controller card based split air conditioning system is designed and constructed utilizing a PIC16F877A for all of heating and cooling processes and for home applications. The operation of this control card involves driving of various motor of the outdoor compressor, the refrigerative circulation, ventilation and wind direction adjustment, etc. The control card compiles with the statutory and industry standards for the safety, reliability and performance.

II. WORKING PRINCIPLES OF AIR CONDITIONER

Ambient temperature affects directly working performance of persons. Hot or cold environment do certainly not sustain higher working efficiency and thermal comfort. Outdoor climate may not be convenient for working condition. However, indoor climate can be adjusted according to personal preferences. Generally, air conditioners are used for these purposes. The amount of cooling or heating indoor varies depending on outdoor and indoor temperatures. The cooling and heating can be achieved by an air conditioner. When the air conditioner is on, the compressor operates at a high speed in order to cool, or heat the room quickly. As the room temperature is equal to the reference temperature, the compressor slows down, maintaining a constant temperature and saving energy.

A. Working of Air Conditioner in Cooler Mode

The refrigerant is the R22 liquid which flows through pipes to absorb the extra heat indoors. It then evaporates and is carried out through narrow copper tubes to the outdoor unit as a gas, where the heat is released into the atmosphere. Therefore, the gas becomes a liquid again and flows back to the door unit, where the air is ventilated to carry out the heat from the room. These processes are replaced until the reference temperature is needed.

B. Working of Air Conditioner in Heater Mode

Heat pump air conditioning units additionally allow the circulation described above to be reversed. A heat pump extracts free heat from outdoor air and transfers the heat indoors. Thus, heat pump units eliminate the need for heating system and allow the user to cool and heat with the same unit. In this paper, air conditioning system comprises of five major components. They are evaporator, compressor, condenser, receiver or drier and expansion device. All these components can be controlled by microcontroller by implementing Micro C programming language. The typical operation of air conditioner is shown in Fig. 1.

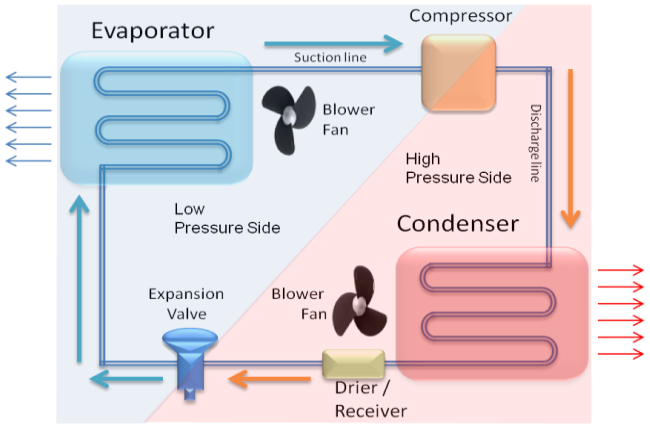

Fig.1. Block diagram based on air conditioning system.

III. HARDWARE DESIGN SCHEME

The whole system for hardware design block diagram is illustrated in Fig. 2. In this paper, the control card for air conditioner is constructed for hardware design based on PIC16F877A. Micro C programming is considered for software implementation. Related to development and innovation in semiconductor technology, PIC16F877A is introduced for both circuit design scheme and software programming to design and build a controlled device. The main proposed control card is fully controlled by the 8 bit microcontroller PIC16F877A which has an 8 Kbytes of ROM for program memory.

The units of the desired hardware which belongs to LCD display with air conditioner based on PIC16F877A microcontroller are stated as below respectively.

- PIC 16F877A microcontroller
- LM35 temperature sensor
- Liquid Crystal Display (LCD)
- Relay Driver Circuit (ULN 2003A)
- And related circuit components

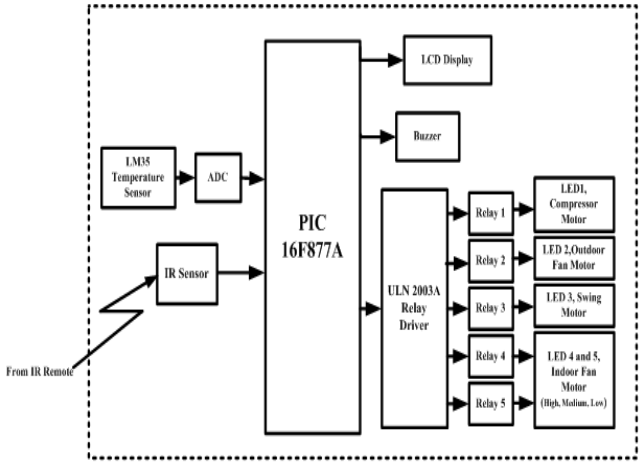

Fig. 2. Block diagram of the system.

The units of the designed and constructed hardware are explained as follows:

A. PIC 16F877A microcontroller

The PIC microcontroller was designed using Harvard Architecture, with separate address spaces for data (SRAM), Program (FLASH, or EPROM) and EEPROM memory, PIC processor with few exception do not allow for direct access to their program memory space. A PIC16F877A microcontroller has 33 Input/output pins, which can be configured in different ways to communicate with many peripheral devices as in [4]. The integrated circuit used in this paper operates at 8MHz clock frequency. As their structure are based on CMOS technology PICs consume very less energy. Pin diagram of microcontroller system is shown in fig. 3.

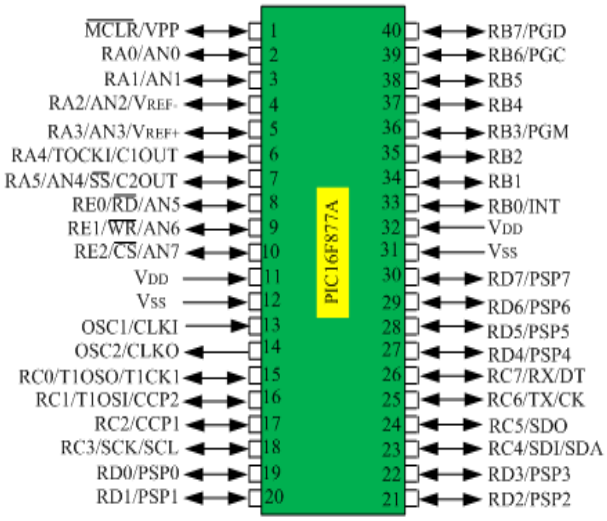

Fig. 3. Pin diagram of microcontroller system.

B. LM35 Temperature Sensor

The LM35 series are precision integrated circuit temperature sensors, whose output voltage is linearly proportional to the Celsius temperature with a gradient of

10mV/°C as in [6].An output voltage proportional to the centigrade temperature can easily obtained using LM 35 which has a temperature range from -55(°C) to +150(°C) in [6]. Connection of LM35 temperature sensor is given in fig.4.

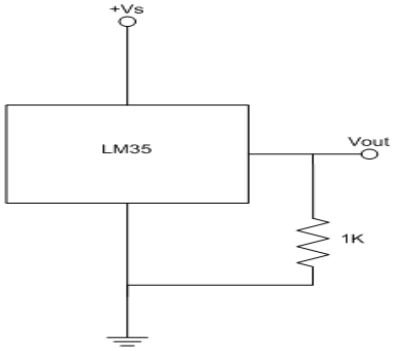

Fig. 4. Connection of LM35 temperature sensor.

C. Liquid Crystal Display (LCD)

Microcontroller controlled LCD are widely used in many application, having replaced most of their LEDs because of their low power consumption and flexible graphics display. This intelligent LCD module can show 160 different characters. The entire system is supplied with a 5V power supply. Data are entered via the data line (D0-D7) in [7] as shown in the following table 1.

D. Relay Driver (ULN2003A)

ULN2003 is a high voltage and high current Darlington arrays IC. It contains seven open collector Darlington pairs with common emitters. Each channel rated at 500mA and can withstand peak currents of 600mA. A Darlington pair is an arrangement of two bipolar transistors. These versatile devices are useful for driving a wide range of loads including solenoids, relays DCmotors, LED displays filament lamps, thermal print heads and high power buffers. The pin connection of ULN 2003A is displayed in fig. 5.

TABLE1: PIN CONNECTION OF LCD

Pin No	Name	Function
1	V_{SS}	Ground
2	V_{DD}	Positive supply
3	V_{EE}	Contract
4	RS	Register select
5	R/W	Read/Write
6	E	Enable
7	D0	Data bit 0
8	D1	Data bit 1
9	D2	Data bit 2
10	D3	Data bit 3
11	D4	Data bit 4
12	D5	Data bit 5
13	D6	Data bit 6
14	D7	Data bit 7

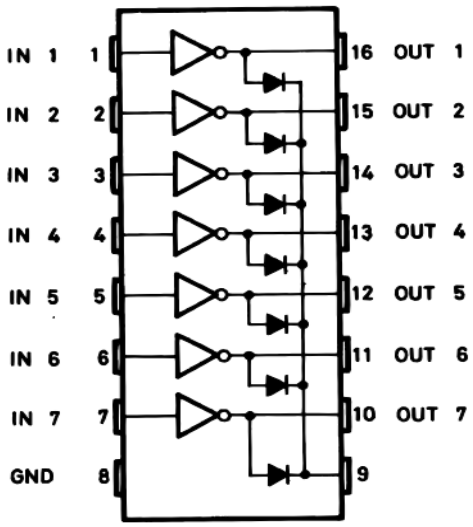

Fig. 5. Connection of ULN2003A.

IV. THE MAIN CONTROL CARD FOR AIR CONDITIONER

In this system, there are two input pins and six control output pins at main controller card shown in fig. 6. Implementation block diagram for the control card is described in Fig. 6. The control card is intended for 1.5 horse power (Hp) for consumer application for air conditioning system. The main component in this control card is PIC16F877A microcontroller. The first input is a LM35

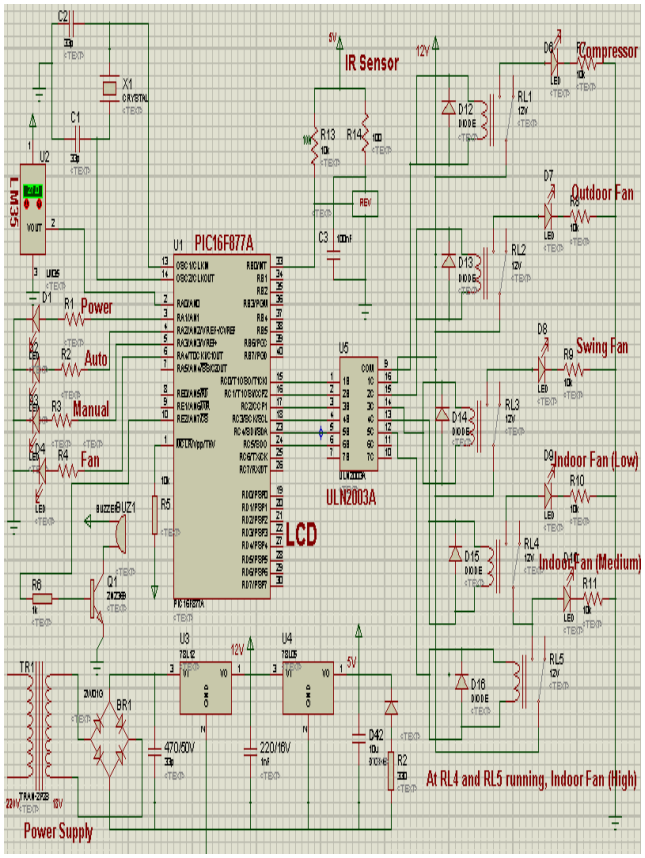

Fig.6. Circuit diagram of air conditioner controller.

temperature sensor. It senses the temperature with the variation of environment and connected to PIN RA0 of the PIC16F877A. The rest pins, PORTA1, PORTA2, PORTA3, and PORTA4 are applied for LEDs display. LEDs respectively on this controller will light on as soon as receiving the signals from IR remote control. The next input pin is given for IR receiver connected to another RB0 pin. The IR receiver in the circuit is TSOP1736**.** It receives the signals from IR transmitter and retrieves the original modulating signal from the 36 kHz carrier. The output will be active low. Output of TSOP1736 will be HIGH when no signals fall on it and the output will be LOW when 36 KHz infrared rays fall on it. This IR receiver sensor decodes the demodulated frame from sensor module to corresponding commands and address data byte.

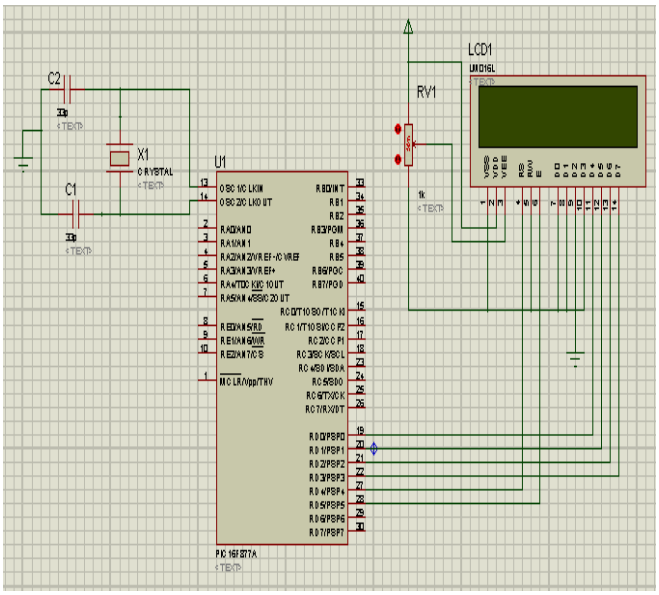

Fig.7. Circuit diagram of air conditioner controller with LCD display.

The control command signal pin from IR is driven to set up running mode, temperature, fan speed and process. Then, the first output is used to control compressor and connected to PINRC0 to drive the circuit. The next pins pair is used for outdoor fan and swing fan connected with PINRC1 and PINRC2. The last three pins are utilized for indoor fan speed in the range of low, medium and high connected to PINRC4, PINRC5 and PINRC6. The control card consists of five relays for connection of output loads. The five relays with 12V are used, that cannot be controlled by the microcontroller directly. In this system, ULN 2003A is used to drive the desired output loads and depends on the output bits of PIC16F877A.The four LEDs on PIC16F877A which indicates power ON/OFF and mode selection from the user preference by IR. LCD module interfaced with microcontroller is used to indicate the operation of control card for air conditioning system. In fig. 7, LCD is connected to RD0, RD1, RD2, RD3, RD4, and RD5 PINs for microcontroller, so the controlling data displays the LCD. E, RS and RW of LCD are used for control purposes. The rest output pins are used for showing status and modes of air conditioner. The system is supplied with a 5 V power supply.

V. FLOWCHART OF CONTROL CARD'S OPERATION

The program flow is started with the initialization of IR control as soon as power on. In this paper, temperature

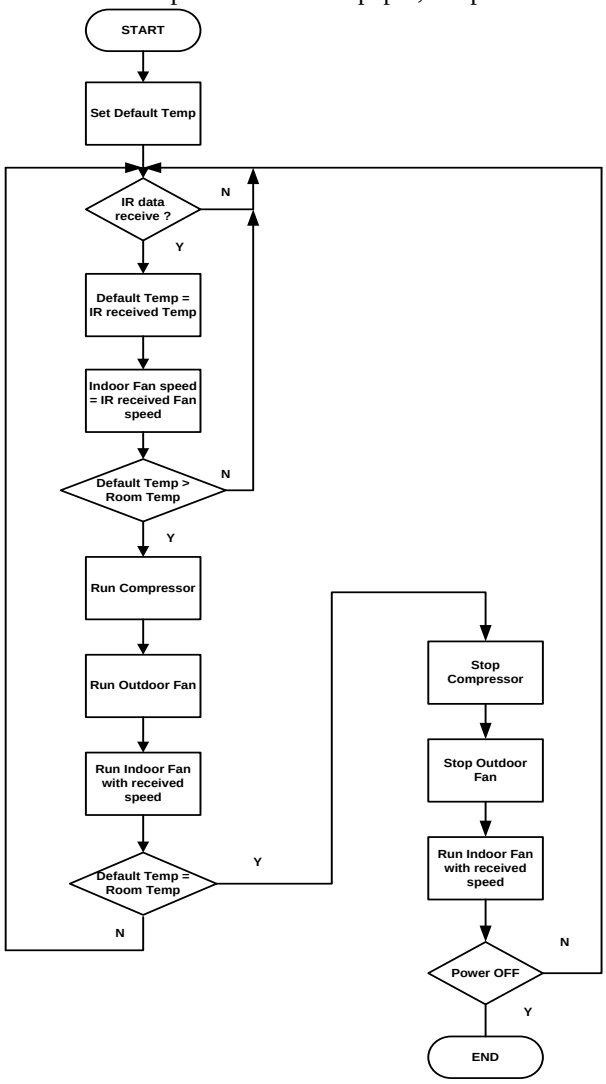

Fig. 8. Flowchart of the control card's operation.

setting in the program allows user to be adjustable in a range of 18°C to 30°C. The default temperature value is compared with IR received temperature value. If default temperature is greater than room temperature or current temperature sensed by LM35 temperature sensor, compressor motor speed, outdoor fan, and indoor fan will start to run. If the default temperature value is equal to room temperature, compressor and outdoor fan speed will stop but indoor fan speed will run with IR receive speed. Fig. 8 shows the flowchart of the operation of the control card based air conditioning system.

VI. EXPERIMENTAL RESULTS OF THE SYSTEM

Construction of hardware system for the control card based on PIC 16F877A microcontroller is shown in Fig. 9. In this circuit, control card is operated at Auto mode by IR and shows the received data on LCD display. In this paper, the control card board can be successfully demonstrated for control applications by using Micro C programming. The

control program embedded in PIC16F877A can be customized as the user desire for the design of control card. By using microcontroller technology, the control card in this paper is more compactible than any other control cards available in the markets because driver circuit board for relays shown in fig. 10 can be changed to get desired high Horse power (Hp) for the industrial air conditioner types.

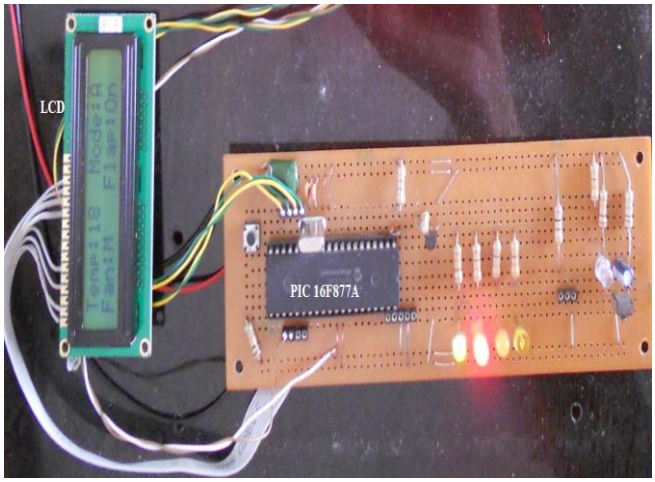

Fig.9. Control card based on PIC 16F877A and LCD display.

Five LEDs on relay board shown in Fig.10 indicates receiving the IR pulses sent from IR remote or thermostat setting. ULN 2003A is a relay driver. Five relays are used for output loads. Relay1, relay2, relay3, relay4 and relay5 are described for five LEDs which indicate control circuit output devices operate. The experimental results of air conditioner control card testing are displayed. Five LEDs on relay board will be activated when temperature reaches a temperature value. Relay1 is used for the compressor motor. Relay2 is referred for outdoor fan and Relay3 is referred to swing fan. Relay4 is intended for indoor fan, Low condition. Relay5 is indicated for fan Medium condition. The state of working both relay4 and relay5 simultaneously shows fan High condition.

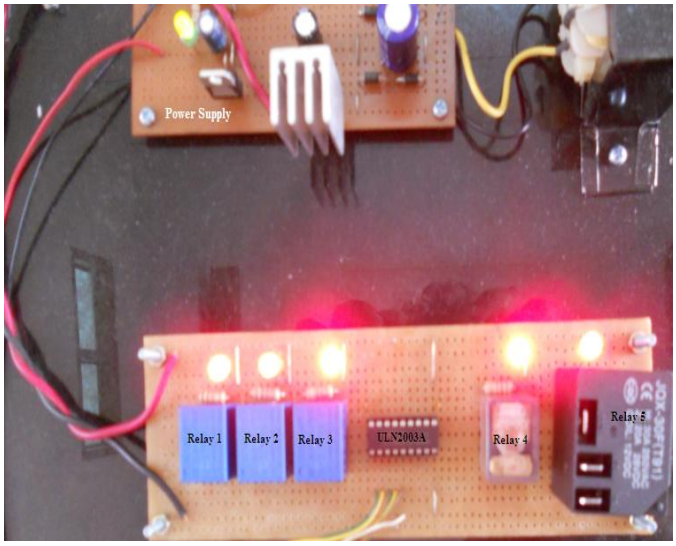

Fig.10. Relay board with ULN2003A.

VII. CONCLUSION

Microcontroller based air conditioner prototype can be widely applied to control different kinds of human appliances and industrial applications. The control card for air conditioning system plays a vital role nowadays because of the global warming. The main control card is mainly constructed by a PIC16F877A microcontroller which reduces the cost, low consumption, easily handling and increases the efficiency. After designing and testing this research, it became pretty obvious that microcontroller is a smart way to do this due to more reliable ready to build. According to the control design and hardware systems, software implementations of the control system are realized.

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