LIGHTING AND FAN CONTROL USING PIC

Najihah Bt. Ahmad Diniah (2003328367)
Faculty of Electrical Engineering,Universiti Teknologi MARA
40450 Shah Alam, Selangor.

Supervisor: Encik Mahmud B. Ibrahim

ABSTRACT - This paper describe the design of automatic control of fan and lighting of a room depending on the occupancy. The light and fan will be 'ON' whenever the room is not empty. It temperature will be controlled to a set temperature when the room is vacant and the system will shut down automatically. Motion sensor, Passive Infrared (PIR), temperature sensor and Peripheral Interface Controller (PIC) are integrated to detect status of the occupancy and the room temperature and then control the room ambient temperature. Successful prototype was designed with combination of hardware and software with the keep of Cadence OrCard and MPLAB IDE respectively.

Keywords: Motion sensor, temperature sensor, PIC.

1.0 INTRODUCTION

1.1 Overview

A smart room system can be defined as a room or working environment equipped with technology to allow for devices and systems to be controlled automatically. Sensors are used to detect and measure environment parameter such as ambient temperature, humidity and brightness. The output of the sensors is then used as an input for a control system.

A motion sensor will be the main sensor where it detects the movement in that room. There are two types of motion sensor, which are area sensor and local sensor. Both sensors will detect the movement within specific area. The difference is that area sensor can detect any movement in large area scope compared to local sensor. Example for area sensor is Passive Infrared (PIR) or pyroelectric, proximity (RF field), microwave or radar and ultrasonic. Example for local sensor is Active Infrared (light beam), visible light beam and laser beam.

For this project, motion sensor type PIR (Passive Infrared) sensor is used. This sensor is simple electronic device which is sensitive to 'heat', or infrared light that is emitted by warm or hot objects like human. Human having a skin temperature in about 93^{O}F or 33.9^{O}C, radiate infrared energy with a wavelength between 9 and 10 micrometers. Therefore, the sensor is typically sensitive in the range of 8 to 12 micrometers [1].

The motion sensor has sort of plastic 'lens' or 'Fresnel' lens as shown in Figure 1 that covers the circuit board and the PIR sensor device. The sensor will be more sensitive to motion of a warm body, horizontally 'across the field of view' because the lens prevents the introduction of dust and insects which could obscure the sensor's field of view.

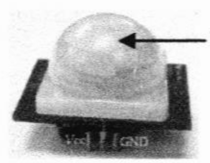


Figure 1.1: Motion sensor with covering plastic lens.

When there is an occupant entering the room, the motion sensor will detect and a fan will turn to 'ON' mode. After that the temperature sensor will sense the temperature of the area at that time. If the temperature sensor detects the temperature to be below 20^{O}C, the fan will be in 'LOW' mode. Between 20^{O}C until 25^{O}C, the fan will be in 'MEDIUM' speed and above 25^{O}C the fan will shift to 'HIGH" speed.

The system will continue within specific of time until there is no occupant in that room, for example setting time in programming about 30 seconds. After 30 seconds the system will stop.

The main controller of the switch system is PIC 16F873 microcontroller. It is because PIC 16F873 *fits perfectly in application ranging from high speed* automotive and appliance motor control to low-power remote sensors, electronic locks, security devices and smart cards. It is also suitable for analog and digital devices. The flash/EEPROM technology makes customization of application programs [2].

There are many types of temperature sensors that will use various technologies and have different shapes. These sensors are used in many fields in the industry *and in household equipment*

Feasible temperature is the most basic parameter for human and all animals and plants. Temperature monitor and control have significant interest in modern life. Unfortunately, the usually used temperature monitoring system has two kinds of shortcoming in current life. One is that it needs a lot of wires to transfer the sensor signal to data acquisition card and the implementation of linking signal wires is very troubling. Also, the cost is high. The other shortcoming is that the signal transferred in wire is analog signal. There will be a log of noise and loss. In order to overcome these shortcomings, a kind of digital 1-Wire bus technology emerges as the times require. Digital 1-Wire bus technology, DS18S20 is implemented by adopting the new device of DALLAS Company [3].

According to this kind of technology, the address *line, data line and control line used the same line.* Hundreds of control and monitor objects could be connected to this line by using 1-Wire bus technology. Analog signals can be digitalized in the checking position through 1-Wire bus protocol and transferred in 1-Wire bus. Therefore, digital signal will transfer in 1-Wire bus [3].

The 1-Wire bus temperature measurement system introduced in this paper is built based on 1-Wire bus technology and its device. The 1-Wire bus monitoring system is connected to PIC. It has the characteristics of high ratio of hardware performance to price, convenient for construction, good anti-jamming performance and simple software development. It is suitable for field monitor at open country, intelligent building and security alarming [3].

1.2 Problem statement

Motion sensor will be more effective when it is placed above 1.8m from the ground. If less than 1.8m, it will be less sensitive because there will be limited angle area from the vertical and horizontal axis. A wide-angle motion sensor detects a nearly 75 percent wider area than standard motion sensors. A wider detection area means more motion can be detected and the light may turn on more often. After the motion sensor is placed at the designation altitude, the light bulb is checked. If the light bulb blinks repetitively then there is a problem in term of the placing of the motion sensor [4].

The motion sensor operating mode must be synchronized with the temperature sensor operating point. Therefore, the temperature need more than 10MHz to operate but at software setting it needs 10.9MHZ due to the tolerance of the components.

1.3 Objective of the project

The main objectives of this project are as follows:

1.3.1 Provide a system which by running it automatically according to a set program.

1.3.2 To design a fan speed controller with implementation of sensors and a microcontroller.

1.3.3 To enable automatic fan speed adjustment based on surrounding temperature in room.

1.4 Scope of work

This project combines the usage of temperature sensors, motion sensor and PIC microcontroller as part of an automated system design. The design of the system consist of three main parts, they are:

i. Software – Main controller that control the fan speed level and light bulb by using programming that
ii. Electronic Circuit – Include all of the electronic parts such as 1-wire digital thermometer (temperature sensor), motion sensor and switching.
iii. The structure – light bulbs and fan.

PIC is used to control the operation of the system. The software used to program the microcontroller is Microchip MPLAB IDE version 8.00 and circuits of the system is using application circuit for temperature sensor control speed of fan and motion sensor control the light bulb.

2.0 METHODOLOGY

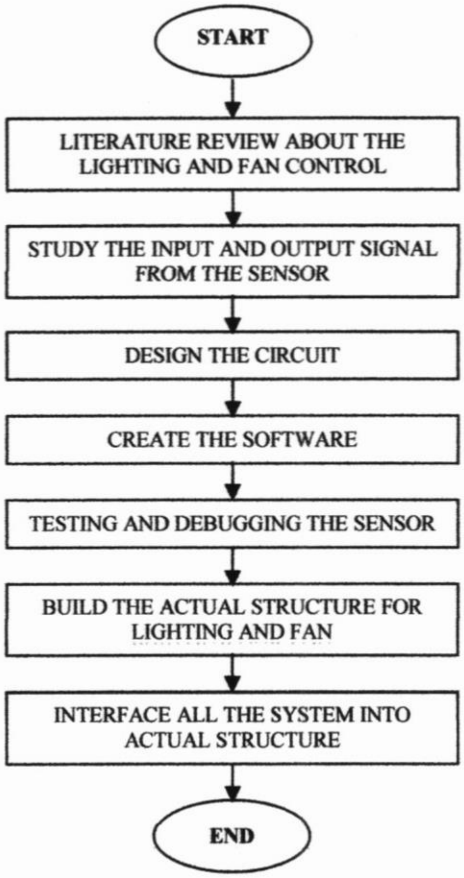


Figure 2.1: The methodology flow diagram

Figure 2.1 shows the design flows of developing the smart room controlled using sensors. Firstly, the literature reviews about the lighting and fan system control using sensors. All information about the motion sensor and temperature sensor was collected and studied the input and output signal from the sensors.

Next step is designing a few suitable circuits. In this project, the motion and temperature sensors are to switch the light and detect ambient temperature respectively. The temperature sensor transmits and receives the signal or well-known as "bidirectional" function.

Relay is used in control the AC power and light bulb and fan speed to ON-OFF condition.

The Peripheral Interface Controller (PIC) 16F873 is a driver circuit for the switching. It is because PIC 16F873 is suitable for analog and digital devices and fits perfectly in application ranging from high speed automotive and appliance motor control to low-power remote sensors, electronic locks, security devices and smart cards.

After the circuits are confirmed function, interfacing with software is done. The complete test on the circuit is done. After the experiment success, the actual size of the circuit is measured and built.
All system is interfaced and the experiments are performed.

2.1 Hardware Design

2.1.1 Motion Sensor

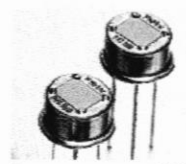


Figure 2.2: Motion sensor or PIR sensor

There are two types of motion sensors which are wireless PIR sensor while another one is using wire to PIC microcontroller. For this project, motion sensor as shown in Figure 2.2 is selected and light bulb represented the output. This sensor measure infrared radiation emanating from objects in the field of view. It only has one output pin and another two pins is connected to 5V and ground separately.

Once power is applied to the PIR, apparent motion is detected when an infrared emitting source with one temperature, such as human body, passes in front of source with another temperature, such as wall. The unit output is high whenever there is motion detected. If the motion continuous, the output remains high. After motion stops, the output remains high for a few second depend on setting delay for 30 seconds. The delay was setting to as low as possible so that the output of the sensor would not remain high for a long time after motion stops.

This motion sensor should be mounted around 1.8 meters above the ground in a location so that a moving object will cut across it's beams and automatically senses motion over a wide area (130°).

2.1.2 Temperature Sensor

Figure 2.3: 1-Wire Digital Thermometer

Figure 2.3 show a 1-Wire Digital Thermometer that called DS18S20 and has 3 pin which are ground (GND), data Input/Output (DQ) and V_{DD}. It has an accuracy of 0.5^{0} degree centigrade and gets its power from serial port.

The DS18S20 is in parasite power mode as shown in Figure 2.4 which is the V_{DD} pin connected to ground [10]. It is because the 1-Wire bus and C_{PP} can provide sufficient current to the DS18S20 for most operations as long as the specified timing and voltage requirements are met as shown in figure 2.5. However, when the DS18S20 is performing temperature conversions or copying data from the scratchpad memory to EEPROM, the operating current can be as high as 1.5mA. This current can cause an unacceptable voltage drop across the weak 1-Wire pull up resistor and more current is supplied by C_{PP}. To assure that the DS18S20 has sufficient supply current, it is necessary to provide a strong pull up on the 1-Wire bus whenever temperature conversions process is done from the scratchpad to EEPROM [10].

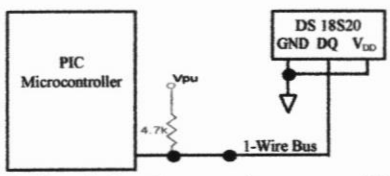


Figure 2.4: Supplying the parasite-powered DS18S20

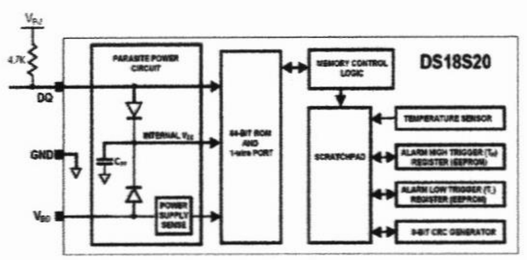


Figure 2.5: DS18S20 Block Diagram

Figure 2.6 show the output from Port C. The Port C consists of light bulb, mode of speed fan, driver relay and relay. The driver relay consists of darlington transistor array that function as switch to control the circuit. Figure 2.7 show the input Port A and Port B which are the Port A is from temperature sensor and Port B is from motion sensor.

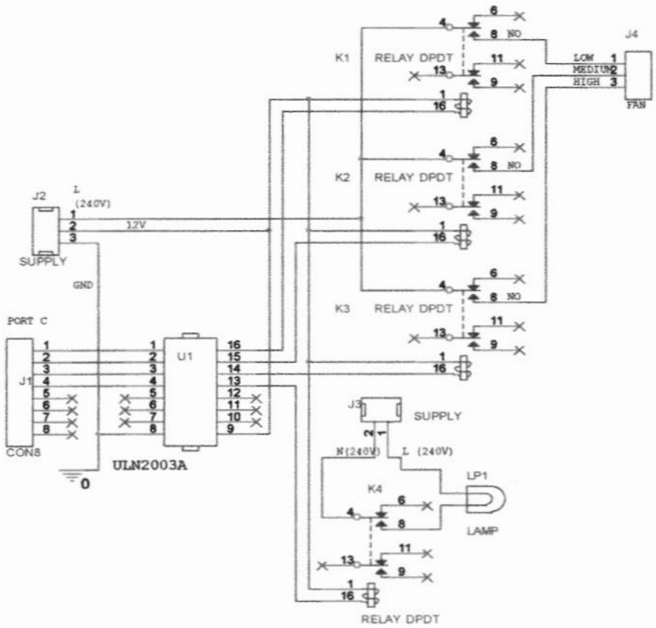


Figure 2.6: Output PORT C (light bulb and fan)

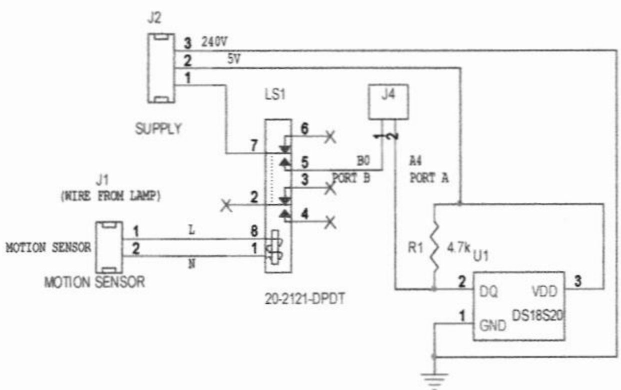


Figure 2.7: Input PORT A (temperature sensor) and PORT B (motion sensor).

2.2 Software Design

The PIC16F873 is used as a microcontroller and the software used is the assembly language. The block diagram in Figure 2.6 and Figure 2.7 are shows about the general activity in motion sensor and temperature sensor.

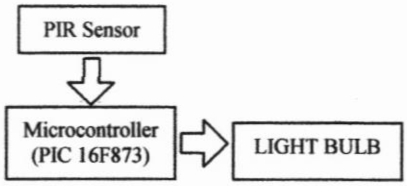


Figure 2.8: Block Diagram of motion sensor system.

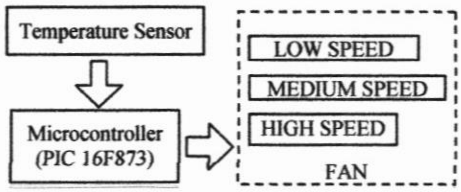


Figure 2.9: Block Diagram of temperature sensor system.

The input and output assignment is listed in the Table 2.1 for this system.

Table 2.1: The I/O assignment on PIC ports

PORTS		I/O	Connection/Description
PORT A	RA0	-	-
	RA1	-	-
	RA2	-	-
	RA3	-	-
	RA4	Input	Temperature sensor
	RA5	-	-
PORT B	RB0	Input	Motion sensor
	RB1	-	-
	RB2	-	-
	RB3	-	-
	RB4		
	RB5	-	-
	RB6	-	-
	RB7	-	-
PORT C	RC0	Output	Speed Fan 1
	RC1	Output	Speed Fan 2
	RC2	Output	Speed Fan 3
	RC3	Output	Bulb/lamp
	RC4	-	-
	RC5	-	-
	RC6	-	-
	RC7	-	-

Oscillator was used for providing a microcontroller with a clock. Clock is needed so that microcontroller could execute a program or program instructions. [2]

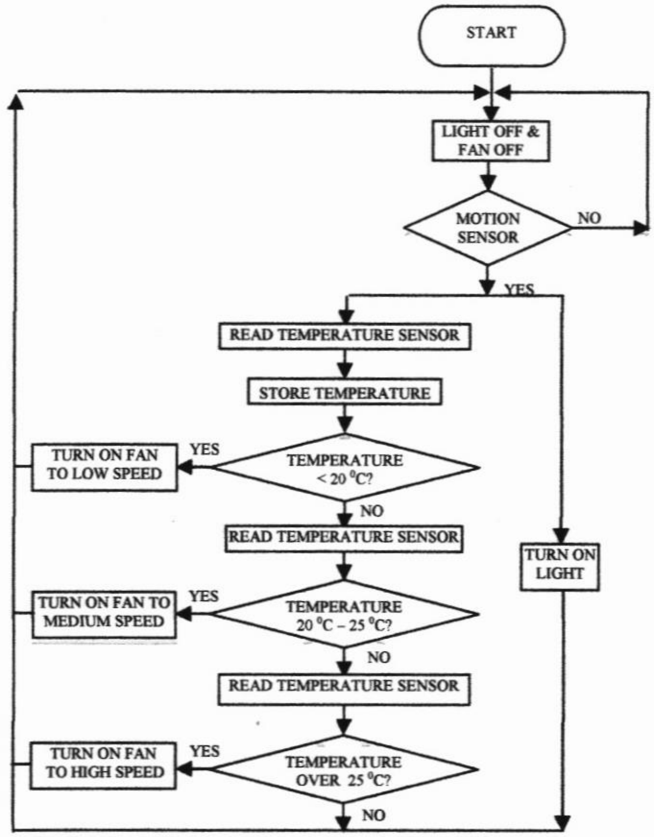


Figure 2.10: Flow chart of the system.

Figure 2.10 show the flow chart of the system. Firstly, the light bulb and fan is in OFF mode. When the motion sensor detect any movement, light bulb will turn ON and the temperature sensor will start read the data from ambient temperature. The data will be read. The data will be read and compare all the time. When the sensor detect the temperature that less than 20°C, the signal will be transmit to the fan in low speed level. While if the temperature increases more than 20°C and not more than 25°C, it will go to medium speed level and if the temperature reaches more than 25°C, the fan will turn to the high speed. During the temperature receive the data, light bulb always ON, because setting time for this motion sensor detect movement to be match with the time for the temperature sensor read the data from DQ and then transmit the signal back to DQ. This is because the temperature sensor functions which that it can read in bidirectional, transmit and receive data.

The motion sensor not only detect movement, at the same time it also sensitive to the heat especially from human body. But the main function is more on detecting the movement of the object nearby. The light bulb and fan will turn OFF when there is no one in the room. This is due to scientific research, human body position that without any disturbance means

that in the comfortable position, at least 30 minutes it will loose.
Therefore, the setting time for the time delay is after *30 minutes and no movement, the light bulb will turn* OFF and the fan also OFF.

For temperature sensor command, firstly it temperature sensor's input must be set at open drain. Port A4 in PIC 16F873 is used because pin RA4 is a Schmitt Trigger input and its open drain has a strong pull up the signal.

It must follow the protocol for accessing the DS18S20 via the 1–Wire port. The steps:

1. Initialization
2. ROM Function Command
3. Memory Function Command
4. Transaction/Data

It is very important to follow this sequence every time the DS18S20 is accessed, as the DS18S20 will not respond if any steps in the sequence are missing or out of order. After issuing either of these read only *memory (ROM) commands, the master must return* to Step 1 in the sequence.

The initialization sequence consists of a reset pulse transmitted by the bus master followed by presence pulse(s) transmitted by the slave(s). The four basic operations of a 1-Wire bus are Reset, Write 1 bit, Write 0 bit, and Read bit. The time it takes to perform one bit of communication is called a time slot in the device datasheets. Byte functions can then be derived from multiple calls to the bit operations. Figure 2.11 illustrates the waveforms graphically. See Table 1 below for a brief description of each operation and a list of the steps necessary to generate it.

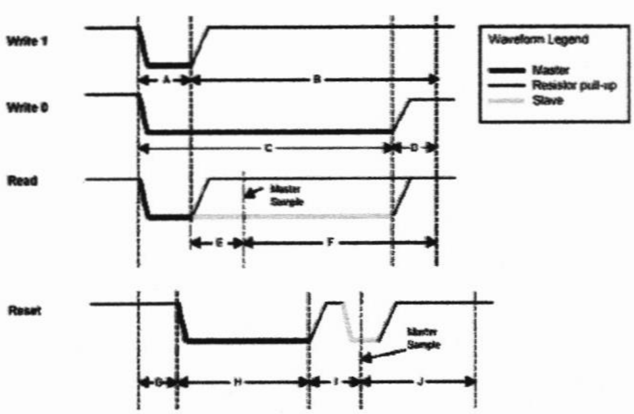


Figure 2.11: Waveforms operation of the DS18S20.

Table 1: Operation of temperature sensor

MASTER MODE	DATA (LSB FIRST)	COMMENTS
TX	RESET	Master issues reset pulse.
TR	Presence	DS18S20 respond with presence pulse.
TX	CCh	Master issues Skip ROM command.
TX	44h	Master issues Convert T command.
TX	DQ line held high by strong pull up	Master applies strong pull up to DQ for the duration of the conversion (t_{conv}).
TX	Reset	Master issues reset pulse.
RX	Presence	DS18S20 responds with presence pulse.
TX	CCh	Master issues Skip ROM command.
TX	BEh	Master issues Read Scratchpad command.
RX	9 data bytes	Master reads entire scratchpad including cyclic redundancy check (CRC). The master then recalculates the CRC of the first eight data bytes from the scratchpad and compares the calculated CRC with the read CRC (byte 9). If they match, the master also calculates the TEMP_READ value and stores the contents of the COUNT REMAIN and COUNT PER ^{o}C registers.
TX	Reset	Master issues reset pulse.
RX	Presence	DS18S20 responds with presence pulse.

3.0 RESULTS AND DISCUSSION

The system is tested under an oscilloscope and the *timing output is measured. Meanwhile, motion sensor* is tested using LED to determine the compatibility between motion sensor circuit and PIC programming.

3.1 Motion Sensor

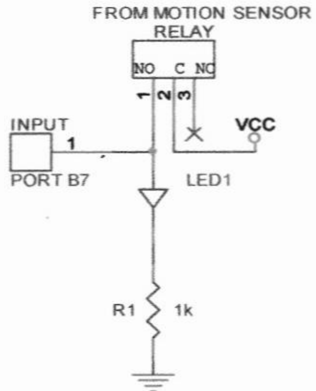


Figure 3.1: Testing and debugging from motion sensor and PIC.

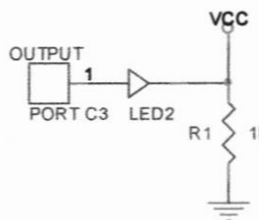


Figure 3.2: Testing and debugging from output motion sensor (light bulb).

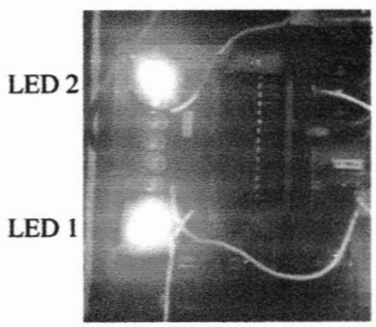


Figure 3.3: Test programming

Figure 3.1 show the PORT B7 is connected to LED 1 to test weather the input signal from motion sensor is transmitted to PIC. PORT C3 is connected to LED 2 to test weather the PORT C3 received a signal from motion sensor as shown in Figure 3.2.

As a result shown in Figure 3.3, LED1 and LED 2 are ON. The LED 1 is ON when the input signal from motion sensor is transmitted to PIC. Meanwhile LED 2 is ON when the PIC is receiving signal from motion sensor. LED 1 will OFF when no signal is received. But LED 2 still ON until 30 second delay. This shows that the motion sensor receive the command from PORT B7 clearly and transmit the output to PORT C3.

3.2 Temperature Sensor

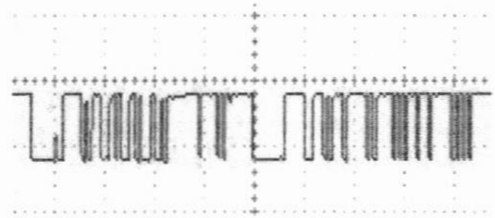


Figure 3.4: Input from temperature sensor (Port A4)

CCh = $_{(LSB)}$ 01010101$_{(MSB)}$ for Master issues Skip ROM command

44h = $_{(LSB)}$ 00100010$_{(MSB)}$ for Master issues Convert T command.

CCH = $_{(LSB)}$ 01010101$_{(MSB)}$ for skip ROM command

BEH= $_{(LSB)}$11010111$_{(MSB)}$ for read scratchpad command.

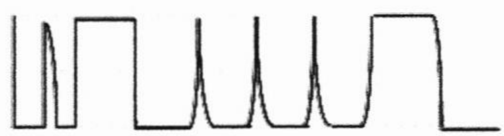


Figure 3.5: Reading in binary: 00100010=24h
24h=36d (Decimal)
1 h=0.5 ^{O}C
36d x 0.5 ^{O}C = 18 ^{O}C

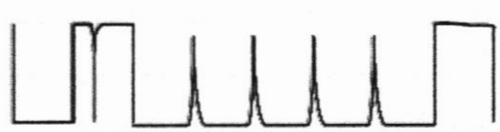


Figure 3.6: Reading in binary: 01000001=28h
28h=40d (Decimal)
1 h=0.5 ^{O}C
40d x 0.5 ^{O}C = 20 ^{O}C

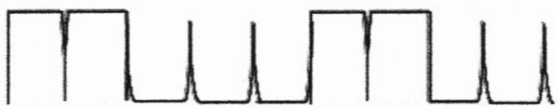


Figure 3.7: Reading in binary: 110001100=32h
32h=50d (Decimal)
1 h=0.5 ^{O}C
50d x 0.5 ^{O}C = 25^{O}C

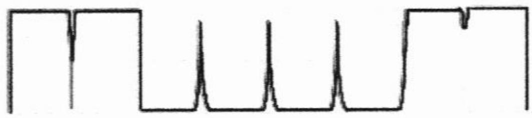


Figure 3.8: Reading in binary: 11000011=3Ch
3Ch=60d (Decimal)
1 h=0.5 ^{O}C
60d x 0.5 ^{O}C = 30^{O}C

Figure 3.4 show initialization of temperature sensor. The waveform from oscilloscope show the initialization of temperature is CCh, 44h, CCh and BEh.

Figure 3.5 to 3.8 shows the output from temperature sensor that range from low speed to high speed of fan.

4.0 CONCLUSION

The project is about designing, constructing, testing and evaluating a light and fan controller using sensor. The system of sensor is design the switch 'ON' and 'OFF' the light and fan by using PIC 16F873 microcontroller. It is expected that design, testing and debugging process such as design corrections are made and testing is done again accordingly.

This project has introduced a smart room system using electronic circuit. It can control both fan and lighting bulb automatically by just a single microcontroller PIC 16F873. The objectives of this project have been achieved.

5.0 FUTURE DEVELOPMENT

For future development, this project can be modified to improve the smart room system. It is propose that the smart room system is designed for limited area which the program is simple.

.

The future development for the smart room system using PIC has prospect to be commercialized. There are plenty of adjustments that could be improved in the system. Basically, this project has an automatically system for fan and lamp that use motion sensor and temperature sensor. For the future development, the smart room system should be upgrade to more sophisticated systems such as it can expand from smart room system to smart home system. Smart home system is wider scope system that can be more systematic.

The security system is whenever motion detected around the perimeter of the house, flood lights will automatically turn on and a buzzer is activated to warn homeowner and to frighten an intruder. And at the same time, a video recorder can be activated. It can also provide safety and security in the event of a fire or other disaster. Lights can automatically go on to illuminate passages to staircases and exits.

Besides that this software also can be upgraded from MPLAB IDE to RABBIT, which is the best software because it is more efficient to use compare to MPLAB.

REFERENCES

[1] www.talkingelectronics.com

[2] Microchip, 2006, PIC16F873 Data Sheet, viewed January 2006, www.microchip.com.

[3] Wang Jingzhuo Gong Chenglong, Department of Electronic Engineering, Huaihai Institute of Technology, Lianyungang 222005 China, IEEE "Research on 1-Wire Bus Temperature Monitoring System"

[4] Version 1.1, Jan 2008, Cytron Technologies Sdn. Bhd. www.cytron.com.my

[5] http://cgfm2.emuviews.com

[6] http://www.delorie.com//djgpp/doc/

[7] I. Akyildiz, W. Su, Y. Sanakarasubramaniam, E. Cayirci. "Wireless Sensor Networks: A Survey." Computer Networks Journal, Vol. 38, No. 4, pp. 393 - 422, 2002.

[8] Savvides, C. Han, M. B. Strivastava. "Dynamic finegrained localization in Ad-Hoc networks of sensors." MOBICOM, pp. 166 - 179, 2001.

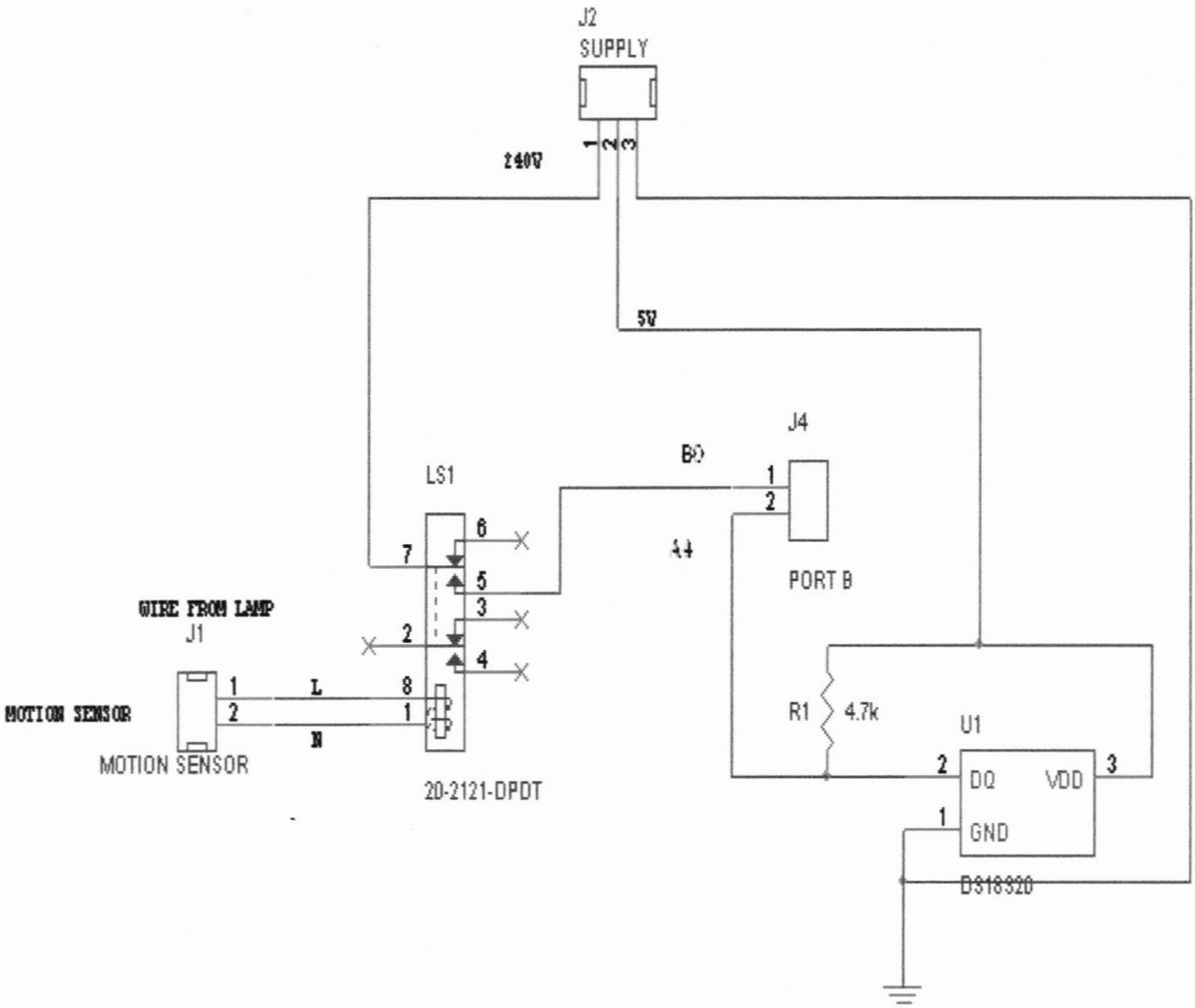
[9] www.DatasheetCatalog.com

[10] www.dalsemi.com

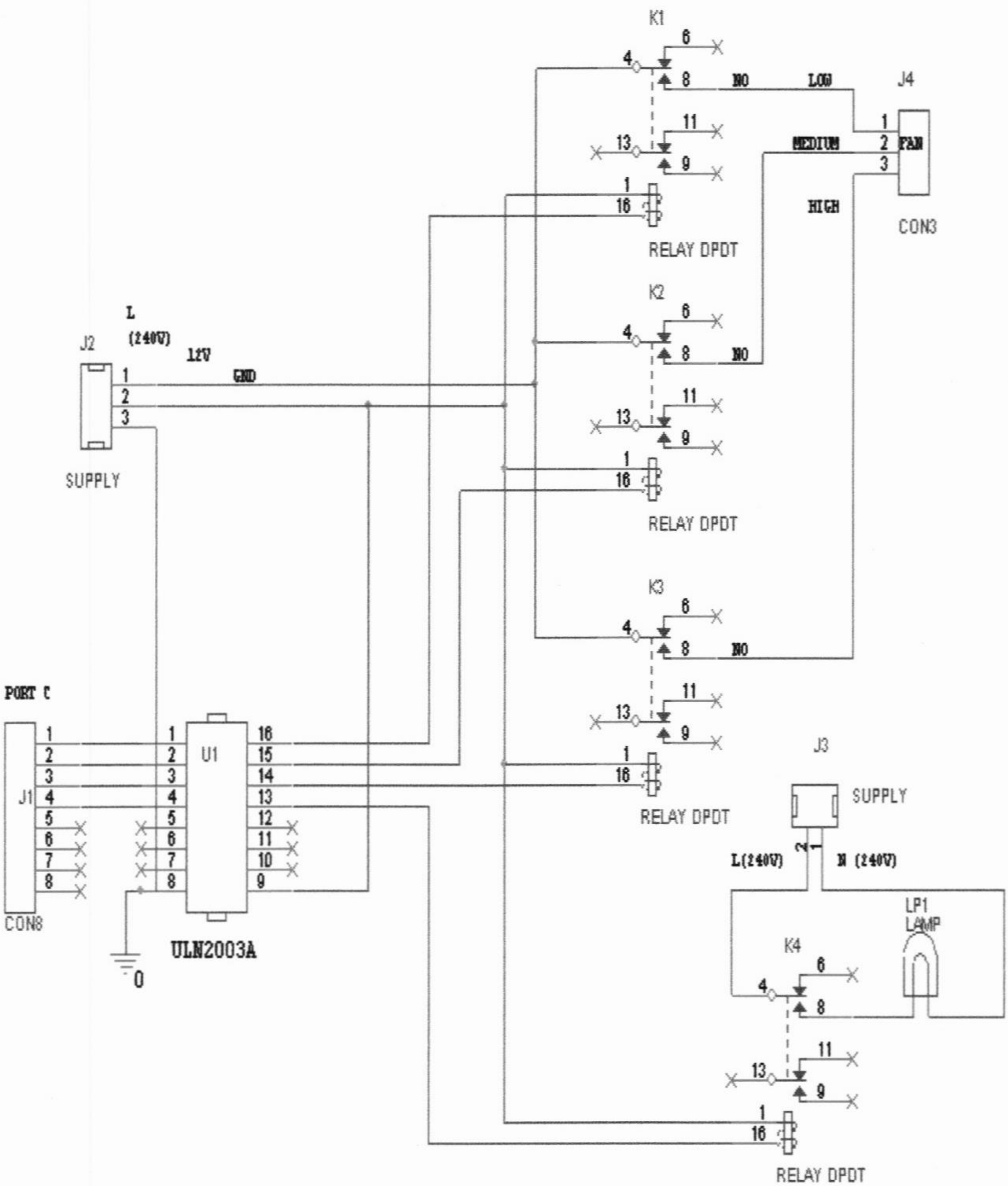
[11] R.H.M. Goossens "Fundamentals of body support The bursa-like interface". Delft University of Technology, Faculty of Industrial Design Engineering, Landbergstraat 15, 2628 CE, Delft, The Netherlands.

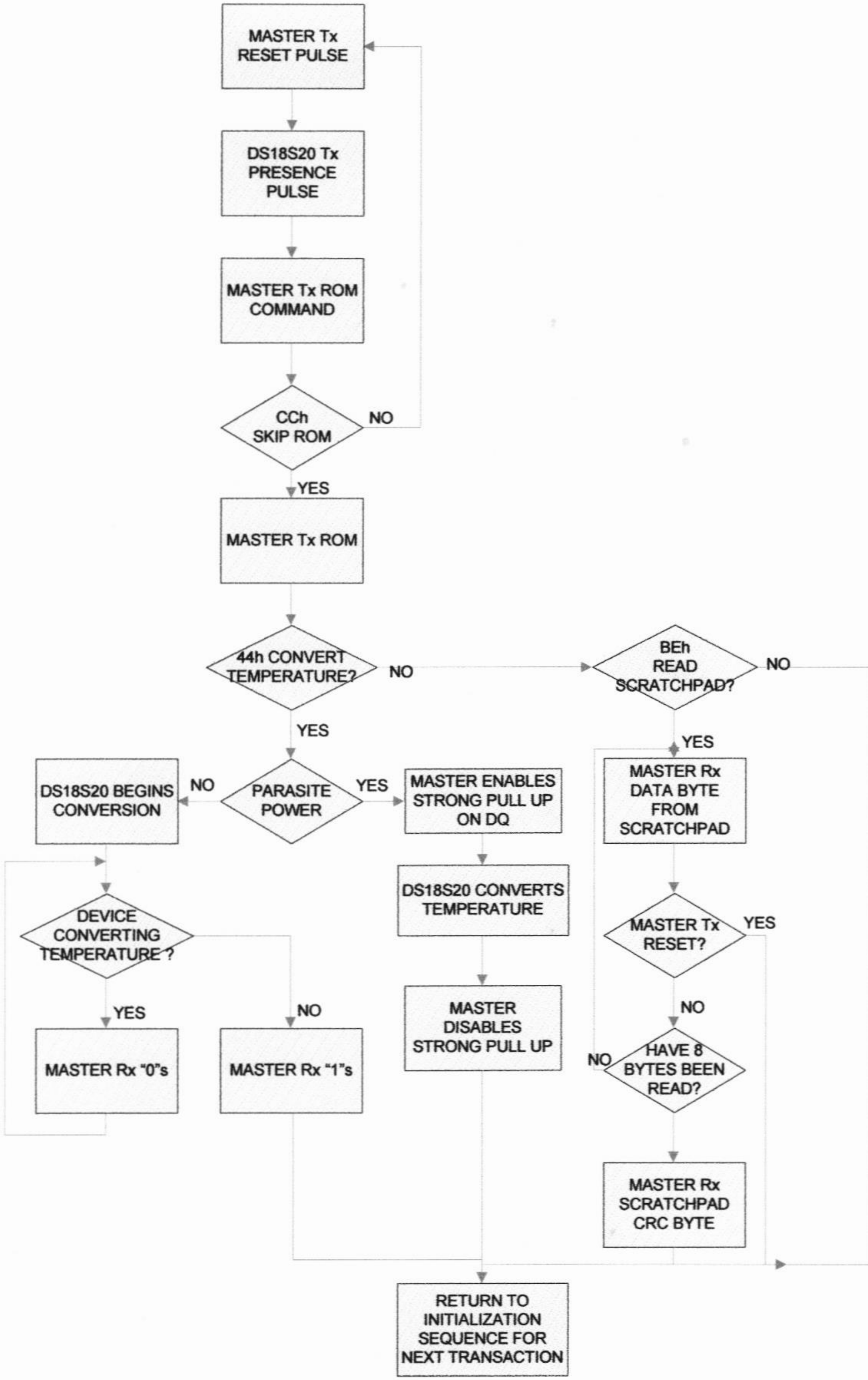
ATTACHMENT

INPUT PORT A AND PORT B



OUTPUT PORT C





SOFTWARE DESIGN: Flow chart of temperature sensor