UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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DEVELOPMENT OF ROOM TEMPERATURE MONITORING SYSTEM

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Industrial Electronic) (Hons.)

by

TAN KAI YIH
B071310892
911214-12-5237

FACULTY OF ENGINEERING TECHNOLOGY

2016

ABSTRACT

Nowadays, in industrial and commercial, there are a lot of equipment, component, and others need monitor in a specific range of temperature in order to prevent breakdown, damage and so on. A room temperature monitoring system was created with temperature sensor, GSM and others important component which controlled by a PIC microcontroller. The temperature sensor use to read the temperature in a room. The temperature will compare to the temperature range which can be adjust manually. If the temperature is out of range, the GSM module will send an alert message to the user. The range of temperature, average temperature and the readings of each sensor are display on the LCD. So, the user can easily to know which sensor is out of range and the current range from the display on LCD.

CHAPTER 1
INTRODUCTION

1.0 Introduction

In this introduction chapter, detailed explanation of room temperature monitoring system used in frozen food industries and in healthcare specifically blood ban in hospitals. The room temperature monitoring system is widely used to monitor the room temperature. This system is very important for various industry and hospital used in a storage room. This is because there are several device, equipment, item, machine and component are sensitive to the temperature.

1.1 Background

The developed system is a temperature monitoring system which inform the user of the room's temperature at several points. This will inform the user of average temperature at specific areas across the room. This project consist of temperature sensor to monitor the temperature in the room. This sensor is control by a microcontroller so the sensor will pass on the data to the microcontroller. There are temperature set limit which can be set manually by the switch. When the temperature reach the lower limit or upper limit, the system will send a text immediately to alert the user by using GSM system. The temperature set limit and current temperature detect by the sensor will display in LCD.

1.2 Problem Statement

Room temperature monitoring is used in various applications such as a room for storage. For example blood bank and Vaccine storage are very sensitive to the temperature changes. Even a few degrees too hot, blood and vaccine will be spoiled. Blood donated to the blood bank, for instance, goes through several processes and storage rooms. Blood constitutes of cells and plasma. Through centrifugation blood can be fractioned into cells and plasma. Red blood cells carries the oxygen, white blood cells is part of the body's immune system and the platelets contributes to blood clotting. While plasma is the liquid medium that the cells contains in. The complete and unseparated blood must be stored between 1 and 6 degrees Celsius. Plasma needs an environment at or below -18 degrees C. Platelets is stored at 20-24 degrees, and must be kept at constant temperature. Therefore, temperature monitoring system is needed to monitor the temperature in a blood bank to ensure the blood quality. This monitoring system will allow continuous temperature monitor instead of having periodically check the room temperature. This is one of many examples of why a room temperature monitoring system is imperative.

1.3 Objective

To overcome the problem stated above, few objective are stated in order to achieve the purpose of the project. The main objective for this project:

1. To study available room temperature monitoring systems based on temperature sensor.
2. To develop a room temperature monitoring system using microcontroller and several sensors in order to increase coverage.
3. To implement a more accurate room temperature monitoring system due to its sensor's coverage.

1.4 Scope of the Project

This project involves several work scope in order to achieve the stated objectives. This project is focus on the study of the type of sensor for the room temperature monitoring system. This project also focused on a developing algorithm for PIC16F877A microcontroller that is able to read the sensors reading, display the real and averaged values of the temperature on LCD. Lastly, this project also cover in produce a prototype for room temperature monitoring system with GSM module which sends real time values of the monitored room.

1.5 Thesis Outline

This part will stated the structure of the report. The structure and layout of the thesis is as below:

Chapter 1 – Introduction: This chapter gives a short introduction on the project which consists of background, problem statement, objective, and scope of the project.
Chapter 2 – Literature review: This chapter discuss briefly about the previous studies and theory which related with this project.
Chapter 3 – Methodology - All of the procedures and steps to achieve the project will be discussed in this chapter.

1.6 Conclusion

The short briefing of this project had been discussed in this chapter. The studies about room temperature monitoring which is literature review will be discussed in Chapter 2.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

In this chapter, the relevant topics and a guide for studies about temperature monitoring will be reviewed and discussed. The main source in the thesis guide is from reference book, research journal, and online conference article. This section will include the study about temperature sensor, microcontroller, temperature monitoring and other related components.

2.1 Blood Bank Room Temperature

Blood Banks have specific environmental requirements for maintaining compliance for their blood storage. In the blood bank, each component of blood has a specific temperature range that cannot be exceeded, so the first point is that each part of a blood donation will need to be stored in separate areas. The complete and unseparated blood must be stored between 1 and 6 degrees Celsius. Plasma needs an environment at or below -18 degrees Celsius and platelets can be stored at 20-24 degrees (Jeffrey, 2015).

2.2 Temperature Sensor

Temperature sensors is a device that use to measure the amount of heat energy or even coldness and allowing the detection of any physical change to that temperature producing either an analogue or digital output (Electronics-tutorials, 2016). There are

many type of temperature sensor. Such as ICs sensor, thermostat, thermocouple, RTD and thermistor. There are two basic physical types of temperature sensor which is contact type and non-contact type. The contact type of temperature sensor are required to be in physical contact with the object which need to be sensed and use conduction to monitor the change is temperature. However, the non-contact type of temperature sensor use convection and radiation to monitor the change in temperature.

2.2.1 ICs Sensor

An IC Temperature Sensor is a two terminal integrated circuit temperature transducer that produces an output current is directly proportional to the temperature. The sensor has a low thermal mass and a fast response time. The most common temperature range of this sensor is 55 to 150°C (-58 to 302°F) which will produce 10mV per degree. The output of this sensor can either be analog or digital. The measurement range of IC temperature sensors is small if compared to other type of temperature sensor such as thermocouples and RTDs. However, this sensor have several advantages which is small size if compare to others, more accurate, and inexpensive. Typically, IC temperature sensors has an accuracy within ±1°C at room temperature and the accuracy error increases exponentially at hot and cold temperature extremes. Figure 2.1 shows the several type of ICs temperature sensor.

Figure 2.1: Several types of ICs temperature sensor

There are many type of ICs temperature sensor such as LM35, TMP 36, and AD590. Each of the ICs temperature sensor have their own features and application. Table 2.1 shows the type of ICs temperature sensor with the features and application. Table 2.2 shows the application of LM35 and TMP 35.

Table 2.1: Type of ICs temperature sensor with the features and application.

Features	LM35	TMP36	AD590
Calibrated	Celsius	Celsius	Celsius
Accuracy	±0.5°C	±2°C	±0.5°C
Range	−55 ˚C to +150 ℃	−40°C to +125°C	-55°C to +150°C
Power supply	4 V to 30 V	2.7 V to 5.5 V	4 V to 30 V
Linearity	±0.25°C	±0.5°C	±0.3°C
Scale factor	+ 10.0 mV/ ℃	10 mV/°C	1 µA/K

Table 2.2: Application of LM35 and TMP 35

LM35	TMP36
- Power supplies - HVAC - Battery management - Appliance	- Environmental control systems - Thermal protection - Industrial process control - Power system monitors

2.2.2 Thermostat

The thermostat temperature sensor is a contact type electro-mechanical temperature sensor. This sensor basically will consists of two different type of metals. For example nickel, copper, tungsten or aluminium etc. The thermostat consists of two thermally different type of metals. Both of the metals is stick together. There are one contact apply at the end of metal which connect the

electrical connection to the metal strip. The contact are closed and it will pass the current through the thermostat when the metal is cold. However, one of the metal will expend more than other when it is cold. Therefore, the bonded bi-metallic strip will bends up (or down) and stop the current pass through thermostat by opening the contacts. Figure 2.2 shows the basic concept of thermostat.

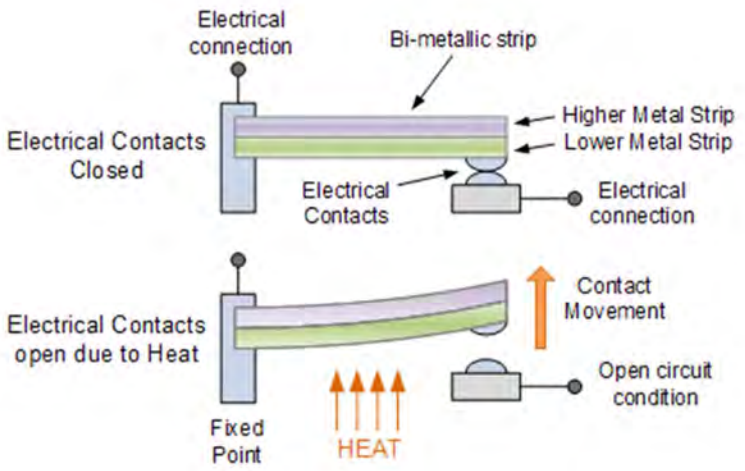


Figure 2.2: The basic concept of thermostat.

There are two main types of bi-metallic strips based mainly upon their movement when subjected to temperature changes. There are the “snap-action” types and the slower “creep-action” types. The “snap-action” types of bi-metallic strips that produce an instantaneous “ON/OFF” or “OFF/ON” type action on the electrical contacts at a set temperature point. This type of thermostat are widely use in our home to controlling the temperature of set point. Such as ovens, irons, immersion hot water tanks and domestic heating system. The “creep-action” types of thermostat gradually change their position as the temperature changes. Creeper types generally consist of a bi-metallic coil or spiral that slowly unwinds or coils-up as the temperature changes. Since the strip in this type of thermostat is longer and thinner, this make them become ideal for use in temperature gauges and dials. Besides that, creeper type bi

metallic strips also more sensitive to temperature changes than the “snap-action” types (Electronics-tutorials, 2016).

2.2.3 Thermistor

A thermistor is a type of temperature sensor which consist of sensitive resistor in which resistance change with temperature. There are two types of thermistors which are positive temperature coefficient (PTC) thermistors and negative temperature coefficient (NTC) thermistors. The temperature is inversely proportional to value of resistor. For example the application of NTC thermistors, in which when the value of resistance decreases, it will follow by the increase in temperature. By referring to this principle, thermistor is calculated temperature by measuring the value of resistance (Cypress, 2015).
A common temperature sensor is a Thermistor. This temperature sensor is a resistor which changes resistance with temperature. The most widely used in thermistors are Negative Temperature Coefficient (NTC). This define as the temperature will increase when the resistance is decrease (Wavelength Electronics, 2016).

The advantages of thermistors is it has a very high sensitivity to changes in temperature (having a thermal response of up to -100Ω/°C at 25°C), fast response time and low cost. The main drawback of thermistors is that the change in resistance with temperature is highly non-linear at temperatures below 0°C and greater than 70°C.

Thermistor is a semiconductor correspond of metallic oxides and not pure metal, their resistance decrease curvilinealy, rather than increase, with temperature. For small range, the output from the sensor can be linearized with appropriate circuitry, and many thermistors are supplied in this form. Thermistor same as RTD, which require a power supply and instruments capable of measuring change in resistance or a voltage drop across the unit. However, the different to RTD is the change in thermistor resistance with temperature is large so that sensitivity over narrow temperature ranges is improved (Hicklenton and Royal, n.d.).

2.2.4 Resistance Temperature Detector

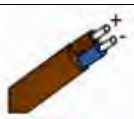
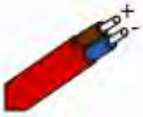
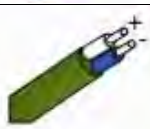
The Resistance Temperature Detector (RTD) is a type of electrical resistance temperature sensor. This temperature sensors made from high-purity conducting metals such as platinum, copper or nickel, it is similar to the thermistor. Resistive temperature detectors have positive temperature coefficients which can measure the temperature more accuracy than thermistor. However, RTD has a poor thermal sensitivity than thermistor which it only produce a very small output change in a change of temperature. For example, it only produce 1Ω per ^{o}C. The temperature are passive resistive devices and by allowing a constant current pass through the temperature sensor. Than the temperature sensor will produce an output voltage which will increase linearly with the temperature. The operating range of RTD is between -200 to +600^{o}C and from 20Ω to 340Ω. For example, the base resistance of RTD is 100Ω at 0^{o}C. So, when the temperature is 100 ^{o}C, the resistance will equal to 140Ω (Electronics-tutorials, 2016). The resistance temperature detector (RTD) consist of resistance of certain metals changes with temperature. They are very stable and resistant of environmental degradation. Although their large size makes them unsuitable for plant tissue temperature measurements, they are well suited to the continuous measurement of air temperature, provided normal precaution are taken to shield the sensor from lamp radiation. The accuracy of RTD is similar to that of thermocouple, measurements accurate to within 0.1^{o}C are possible. Measurements instruments used with RTD must be capable of measuring the resistance of the sensor as a small current is supplied, usually from a DC source in the circuit. Because changes in the electrical resistance of metal caused by fluctuation in temperature are extremely small, special circuitry and sensitive equipment are necessary (Hicklenton and Royal, n.d.).

2.2.5 Thermocouple

The thermocouple temperature is use for measurements over a wide range of temperatures. The operating principal of a thermocouple is fused

together the junction of the two different type of metals such as iron and constantan. This fusion will produces a “thermo-electric” effect. This effect will produce a constant potential difference which is only a few millivolts (mV) between them. The different of the voltage between the two junctions is called the “Seebeck effect”. This effect is a temperature gradient which will generated along the conducting wires producing an EMF. The function of the temperature changes is the output voltage from a thermocouple (Electronics-tutorials, 2016). Figure 2.3 shows the basic concept of thermocouples. The different type of material in the junction will produce a different range of temperature can be measure. The range of thermocouples can be lower as -200^{o}C and up to +1250^{o}C. There are large choice of type of junction and temperature range. Table 2.3 shows the color code for standard thermocouples.

Table 2.3: The type and color code for standard thermocouples.

Code type	Conductor (+/-)	Sensitivity	Color
E	Nickel chromium / constantan	-200 to 900^{o}C	
J	Iron / constantan	0 to 750^{o}C	
K	Nickel chromium / Nickel aluminium	-200 to 1250^{o}C	
N	Nicrosil / Nisil	0 to 1250^{o}C	
T	Copper / constantan	-200 to 350^{o}C	
U	Copper / copper Nickel compensating for “S” and “R”	0 to 1450^{o}C	

Thermocouple consists of a pair of dissimilar metallic conductors joined to form two junction in a simple circuit. An electromotive force,

proportional to the temperature different between the junctions will flow spontaneously in the circuit. If one junction is held at a known temperature and an instrument capable of measuring the emf flow is included in the circuit, then the temperature of the unknown junction can be calculated. The accuracy of these devices may be 0.1^{o}C if reasonable precautions are taken. There are two common type of thermocouple which are type "T" and type "K". Type "T" thermocouple has excellent corrosion resistance and a nearly linear response over the 0 to +50ºC temperature range. However, the type "K" thermocouple have a similar response and are preferred for reason discussed at the end of this section. Thermocouple are relatively inexpensive and easy to construct. Two-conductor wire is readily available and can be soldered to form the measurement junction, but welding is preferred, especially with thin wire thermocouples, to reduce measurement error (Hicklenton and Royal, n.d.).

2.3 Temperature Monitoring

Temperature monitoring are needed in any situation, as long as the situation require a set temperature to be maintain. Usually this situation is the object which required to be heated or cooled and to remain at the set temperature no matter the changing of environment around it. Temperature monitoring are widely used in the manufacturing industries such as textile mill, pharmaceutical industry, and oil refinery industry. All of this kind of industrial are requires temperature monitoring. The temperature monitoring system has one reference temperature called set point or set temperature that is the desired temperature range that must be maintained. This temperature monitoring are used to monitor temperature of process or plant or any material in a range. This reference temperature can be always adjustable according to requirements. The system will tries to monitor the temperature set by sensing the current temperature and compare it with the set temperature. When the temperature sense by sensor deviates from the set temperature, the monitoring system will generates an output signal to the user (Bhatt, 2012).

2.3.1 Temperature Control with Digital Sensor

The temperature control system use a digital temperature sensor as the transducer to control the temperature in medical applications or industries. The advantages of this system is more accurate than the thermostat system. This control system will provide the temperature information and it will display it on 7 segment display. The lamp will turn ON which function as the heater when the temperature exceeds lower limit of the set point. This control system consists of four nos. of seven-segment display. All of the 7 segment display is connect directly to the microcontroller. This type of microcontroller in this project is 8051 family. This system only consists of a digital temperature sensor which connect directly to the microcontroller to read the temperature conditions. To adjusting the temperature range settings, this control system use four push button which two for lower limit and the other two was use to upper limit. Microcontroller read the temperature information through a digital temperature sensor continuously and displays it on 7 segment display. The microcontroller will switches off the lamp, when the temperature exceeds the upper limit set point. When the temperature falls to the lower limit of set point, the heater will turn on automatically (Edgefx Technologies Pvt Ltd, 2012).

2.3.2 Temperature Control with Thermistor

The project is a system of temperature control by using a thermistor. It is more suitable to maintain a constant temperature of an enclosed area. This project consists of lamp, transformer, op-amp, thermistor, and rectifier. The lamp will function as a heater to increase temperature. Whenever the temperature reach the lower limit, a lamp (indicating a cooler) is switched on to increase the temperature and bring the temperature to normal value. This system does not require anyone to monitor the temperature in person because this system is monitor by comparator which will switching ON or OFF the lamp automatically. When the temperature going out of range, the negative co-efficient thermistor is used along with an operational amplifier to actuate the

relay. Since thermistor is cheap, so it is often used compare to other temperature sensors.

However, the resistance-versus-temperature characteristics are highly nonlinear. It also need correction for applications that require a linear response. The change of temperature will send the input parameters to the op-amp. After that, the op-amp will send an output which will energize the relay and it will switch ON or OFF the lamp automatically. Figure 2.3 shows the block diagram of temperature control with thermistor.

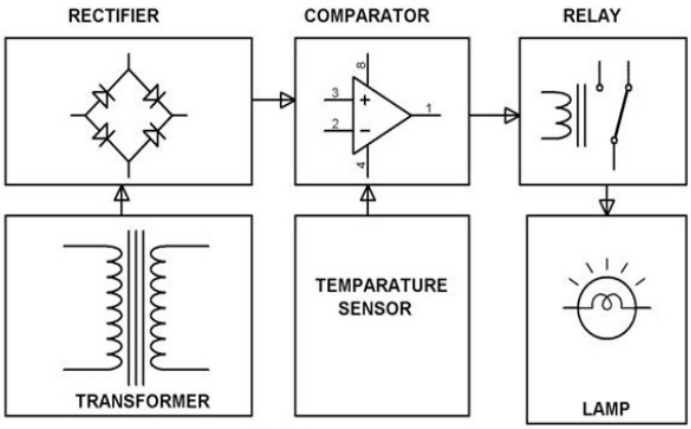


Figure 2.3: Block diagram of temperature control with thermistor.

2.3.3 Room Temperature Monitoring System Based on Microcontroller.

This monitoring system is to monitoring server room temperature. The main component of the system is temperature sensor, microcontroller and GSM modem. The temperature sensor use in this system is LM35. This sensor will read the current temperature and send the analog output to microcontroller. The microcontroller had been use in this system is AVR ATmega8535, which will function as a brain of this system. The GSM modem is used to send a text message immediately to warn the administrator. The server room temperature will be display on liquid crystal display (LCD).

This system will have the specification as follows, when the room temperature is above threshold (28°C), the system will raise an alarm and send a text immediately to warm the administrator. Besides that, the message will only sent to the registered phone number where the number had been record in the system. For example the server administrator phone number. Next, this system are able to receive text message from administrator. After that, it will automatically send back the report about sensor status and current room temperature to the administrator. This system are also able to equip with relay board to control electronic equipment. Lastly. The administrator are able to send the text message to control electronic equipment connected to the relay board and get its status either ON or OFF (Wellem, 2012). Figure 2.4 show the block diagram of room temperature monitoring system based on microcontroller.

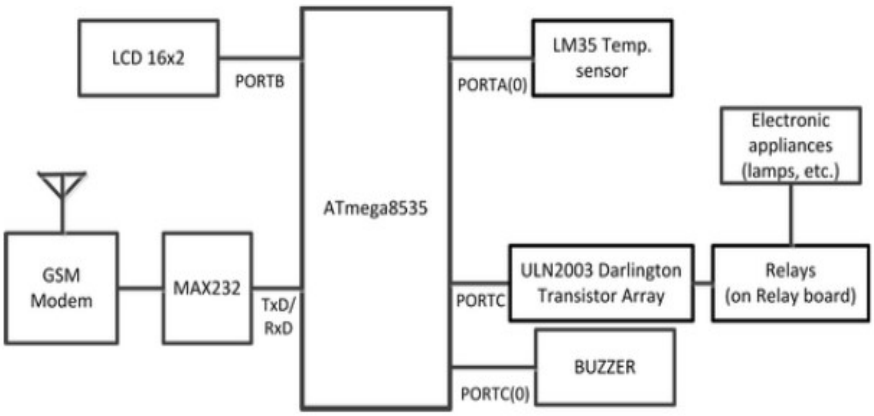


Figure 2.4: Block diagram of room temperature monitoring system based on microcontroller.

2.3.4 Web Based Temperature Monitoring System.

This research is to implement a prototype product that used to monitor the room temperature continuously. By using this system, user may monitor the data anytime and anywhere through internet. The hardware part use in this

system is ATmega88 microcontroller, LM 35 temperature sensor, USB RS232 connection cable, and basic electronic circuit. The software part use in this system is Bascom software, Visual Basic 6.0 and Active Server Pages (ASP).

The temperature sensor will read the temperature ambient and send analog output to microcontroller. After that, microcontroller will convert the analog input to digital output and send to computer. So that the computer is easy to understand the value. The application to capture and display the temperature is built by using Visual Basic 6.0 software. Next, all the data will be stored into MS Access database. The ASP scripting language is used to publish the detected temperature in the web browser. Therefore, the user can be monitor the temperature through internet. This research is ready to launch in real system implementation (Kassim et al., 2011).

2.4 Microcontroller

A microcontroller is a small computer on a single unit chip. Its required external support chip to operation. Such as a processor core, memory, and programmable input/output peripherals. A microcontroller are processor chip that generally have memory, input ports, and output ports within the chip itself. Therefore, they can also be called single chip computer, computer-on-a-chip, or system on a chip. Microcontroller are used in machine control; application, where there is no need to change the program (Kumar et al., 2010). A microcontroller function as a small and low-cost computer for the purpose of dealing with specific tasks, such as displaying information in a microwave LED or receiving information from a television's remote control. Microcontrollers are usually used in the products which require a degree of control to be exerted by the user.

The major different between microcontroller and microprocessor is that microcontroller are comparatively faster because of reduced external memory accessing. Besides that, there still have others advantages of microcontroller compare to microprocessor. First, the price of microcontroller is much cheaper than microcontroller. This is due to the hardware and replace cost of microprocessor are ten

time expensive than microprocessor. Next, the microcontroller need a less power to operated. This is because microcontroller are mode generally mode from complementary metal oxide semiconductor (CMOS). In addition, microcontroller is all in one device. Which comprises of CPU, RAM, ROM, and i/o port (EngineersGarage, 2012).

2.4.1 PIC16F877A

The PIC microcontroller PIC16f877a is widely used in the industry. The coding or programming of this controller is easy to design and there are many references of this controller coding. The major advantages of this controller is that it use FLASH memory technology. So, it can be write-erase as many times as possible(Bilial, 2015). This microcontroller is using the combination of Havard architecture and Reduce Instruction Set Computing architecture. The controller features is 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions. The PIC 16F877A have of 40 pin and there are 33 pins for input and output. Each of the pin have their own function. Figure 2.5 shows the name and number of pin for microcontroller PIC16F.

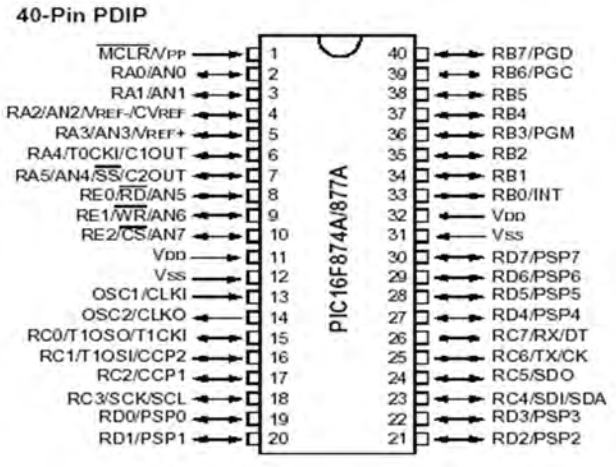


Figure 2.5: Number and name of pin for microcontroller PIC16F877A.

The PIC16F877A is a 40-pin chip. In this 40 pin, it consists of V_{DD}, V_{SS} , oscillator, and port A, B, C, D. The power supply $+V_{CC}$ and V_{SS} takes two pins and the built-in clock oscillator requires two pins for connecting the crystal. Figure 2.4 shows the pin diagram of PIC16F877A.

Table 2.4: The input & output pin of PIC 16F877A.

Type	Pin	Name of pin	Function
PORT A	2-7	RA0 – RA5	Port A is an 8-bit wide, bidirectional port. All Port A pins act as digital inputs/outputs. Five of them can also be analog inputs.
PORT B	33-40	RB0 –RB7	Port B is an 8-bit wide, bidirectional port. This pins act as analog inputs or digital inputs/outputs.
PORT C	15-18& 23-26	RC0 – RC7	Port C is an 8-bit wide, bidirectional port. Register configures the appropriate port pin as an input.
PORT D	19-22& 27-30	RD0 – RD7	Port D is an 8-bit wide, bidirectional port. Can configures the appropriate port pin as input.
PORT E	8-10	RE0 – RE2	Port E is a 4-bit wide, bidirectional port. Similar to Ports A and B, three pins can be configured as analog inputs in this case.
Oscillator	13&14	Osc1&2	This pin is connected to the crystal oscillator.
Power	11&32 12&31	V_{SS} & V_{DD}	The pin Vss is connected to the supply voltage. However, the pin $V_{DD}$is connected to ground.

2.4.2 Intel 8051

The 8051 microcontroller is the product from Intel. Intel Corporation has many microcontroller in both 8-bits and 16 bits configuration. The 8051 provides Boolean processing, six interrupt capabilities, and an 8-bit CPU for control application. The 8051 is the 8-bit microcontroller, the data bus within and outside the chip is eight bits wide. The address bus of the 8051 is 16 bits wide. So it can address 64 KB memory (N. senthil kumar, M.saravanan 2010).

The 8051 is a 40-pin chip. The power supply $+V_{CC}$ and V_{SS} takes two pins and the built-in clock oscillator requires two pins for connecting the crystal. Figure 2.6 shows the pin diagram of 8051.

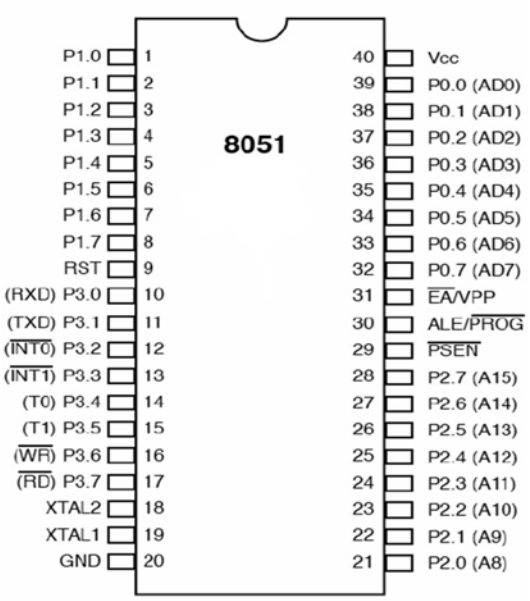


Figure 2.6: The input and output pin diagram of 8051.

The 8051 has 32 I/O pins configured as four 8-bit parallel port (P0, P1, P2 and P3). All four ports are bidirectional. Each pin will be configured as input or output. All port-pins are multiplexed except the pins of port 1. It is important to note that many pins 8051 are used for more than one function. The alternative functions of each pins in 8051are shows in table 2.5.

Table 2.5: The number and function of each pin in Intel 8051(A.P.Godse, 2007).

Port	Pin Number	Function
Port 0	Pins 32-39	This port can be use as I/O pins. The output drives and input buffers of port 0 are used to access external memory.
Port 1	Pins 1-8	This port can be used only as I/O pins.
Port 2	Pins 21-28	This port used as an I/O port. The output drives of port 2 are used to access external memory.
Port 3	Pins 10-17	All port pins of port 3 are multifunctional. They have special functions which including two external interrupt, two counter input, two special data lines and two timing control strobes.
V_{CC} & V_{SS}	Pins 40 & 20	The +5 V is connected to this pin with rated power supply current of 125mA.
XTAL 1 & XTAL 2	Pins 18-19	For generating an internal clock signal, the signal external oscillator is connected at these two pins.
ALE	Pin 30	To demultiplex the line AD_0 to AD_7 and for obtaining lower half of an address.
RST	Pin 9	This pin is use to reset 8051.
$\overline{PSEN}$	Pin 29	It is the active low output control signal used to activate the enable signal of the external ROM/EPROM.

2.4.3 Comparison of PIC16F877A and Intel 8051 Microcontroller.

Every microcontroller have their own features. By studying the feature of microcontroller, we can choose the best microcontroller which is most suitable to our requirement. Table 2.6 shows the difference between PIC16F877A and Intel 8051 microcontroller.

Table 2.6: The different between PIC16F877A and Intel 8051 microcontroller.

Features	**PIC16F877A**	**Intel 8051**
Program memory	8 KBytes	4 KBytes
RAM	368 Bytes	128 Bytes
Clock	20MHz	12MHz
Architecture	Havard	Von-Neuman
Interrupts source	15	5
Port number	5	4
Timer	3	2

Beside the features of the microcontroller, PIC16F877A and Intel 8051 also use the different type of instruction set. PIC16F877A use Reduce Instruction Set Computing architecture (RISC). However, Intel 8051 using Complex Instruction Set Computing architecture (CISC). Table 2.7 shows the comparison between both instruction set (Osborn, 2010).

Table 2.7: The comparison between CISC and RISC instruction set.

CISC	**RISC**
- Many instruction set.	- Few instruction.
- Variable length instruction words.	- Fixed length instruction words.
- Many addressing mode.	- Few addressing mode.
- Memory-based data operation.	- Register-based data operations.
- Assembly language driven.	- High-level language driven.

2.5 Global System for Mobile Communication (GSM).

GSM stand for global system for mobile communication. GSM is protocols for second generation (2G) digital cellular networks which used by mobile phones. It is a standard developed by the European Telecommunications Standards Institute (ETSI).

This GSM was developed to replace the first generation analog cellular network. The first generation cellular network is a half-duplex voice telephony. However, the second generation cellular is a full duplex voice telephony (Jivani, 2014). A GSM modem act like a mobile phone, it is a typical type of modem which able to accepts a SIM card, and operates over a subscription to a mobile user. The GSM modem just looks like a mobile phone, it can transmit and receive data to and from user. So, this modem can be used for sending and receiving SMS and MMS messages. With the GSM modem, the computer is able to communicate over the mobile network through this GSM modem (Now Wireless, 2016) . Figure 2.7 shows the overview of SIM 900A GSM module.

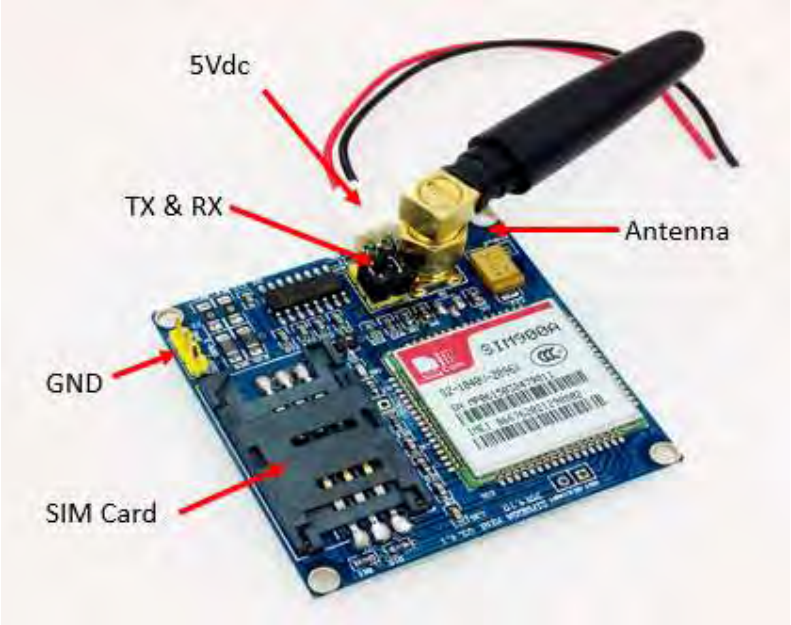


Figure 2.7: Overview of SIM 900A GSM module.

2.6 Current Available of Commercial Product

In this part, the commercial product of temperature monitoring system will be discussed. There are several commercial product of room temperature monitoring system that are availability in market. The Temperature@lert and ITwatchdogs

Company have provide temperature monitoring system product. Room temperature monitoring system is commonly used in various application. This system product also have a wide availability. One of the system is product by Temperature@lert. Temperature@lert provide two types of room temperature monitoring system which are Wifi Edition and Cellular Edition Temperature Monitoring System. Both of the devices are high-performance devices which monitors the surrounding temperature in server room, refrigerator, lab, commercial property, or any other location. When the temperature out of range, alerts message or notification will send through email and telephone. The only different between this two types of monitoring system is Cellular Edition easy to install without any network setup but sim card and data plan is needed. This Cellular Edition is more expensive than Wifi Edition. However, Wifi Edition requires AC power and a connection to internet network (Temperature@lert, 2016). Figure 2.8 shows the Wifi Edition module. Figure 2.9 shows the Cellular Edition module.

Figure 2.8: Wifi Edition module

Figure 2.9: Cellular Edition module.