WIRELESS TEMPERATURE MONITORING SYSTEM

By

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FINAL PROJECT REPORT

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CERTIFICATION OF APPROVAL

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Approved:

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UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

December 2008

CERTIFICATION OF ORIGINALITY

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

Khairun Nadiah Bt Mohd Yusof

ABSTRACT

This report is discussed about the basic understanding and the progressing of work for the chosen topic, ***"Wireless Temperature Monitoring System"***. The objective of this project is to design the wireless monitoring system to monitor temperature in health care industry by using temperature sensor. This project is helping to solve problem that current system unable to deal with. In health care industry, temperature plays a big role to ensure product such as blood, medicine and clinical samples in good condition. However, by keeping manual logs for every store's temperature is really a tedious work. It requires a lot of time and workers to continuously check the temperature of every room that store the items. Thus, this device is really useful to reduce workload and time consumption. The temperature data will be sending wirelessly to the respective staff for any action. In addition, using wireless is more practical instead of running wires or cabling system in such application because the wireless system can be implemented in a big area and it is lower in cost. The challenges in this project are to select the suitable signal to be use in transmission and reception the data and also to design the most favorable alert system. The methodology used in this project includes constructing a simple circuit of transmitter and receiver and troubleshooting will be done to ensure the circuit is working. Then, the programming will also be involved upon the completion of this project. Improvement and adjusting of this system will be done after the simple circuit demonstrates the expected output. The expected outcome from this project is to be able to demonstrate the wireless monitoring system that will be able to send the gathered data from the sensor to receiver and display the data at the base station.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Wireless temperature monitoring system has been under rapid development during recent years. Wireless temperature monitoring system is developed to solve problem that traditional system unable to deal with. Obviously, wireless temperature monitoring system is more beneficial compared to wiring system in term of cost.

The word "*monitoring*" implies to the surveillance of temperature in order to ensure the desire temperature is maintained. This wireless temperature monitoring system has been applied to many industries which are including health care industry. Wireless temperature monitoring system is the best solution for alerting staff of temperature reading for important health care items and products.

In hospitals, there are many departments need to use wireless temperature monitoring system such as clinical lab, blood bank, pharmaceutical and research lab. This system is set to show the reading of current temperature at rooms that store the health care items. Basically using this system a quick action can be taken if temperature exceeds or goes below the specification limit of products' temperature.

This application helps to enhance regulatory compliance, improve processes, increase safety and enhance patient care [1]. It reduces time consumption and cost of labor since this system can be installed in such wide area and no need to keep manual logs of temperature reading. Staff can stop from wasting their time with manual logs and more focus on patient care.

1.2 Problem Statement

By keeping manual logs of temperature data for important items at hospitals is really a tedious work. It requires a lot of time and workers to continuously check the temperature of every room that store the items. Products of health care such as blood, medicine and clinical samples are really important to keep at the right temperature. By adopting wireless temperature monitoring system in such place will reduce workload and product loss. In addition, using wireless is more practical instead of running wires or cabling system in such application because the wireless system can be implemented in a big area and it is lower in cost in order to build and maintain the system.

1.3 Objective and Scope of Study

The main objective of this project is to build wireless monitoring system to monitor temperature in health care industry by using temperature sensor.

The scopes of project are:

- To assemble sensor and wireless module to be wireless monitoring system.
- The parameter measure was based on simulated temperature.
- Wireless module works within limited range. (~1 meter)

CHAPTER 2

LITERATURE REVIEW

2.1 Temperature

Temperature can be defined in several ways, many of which are not completely accurate. One definition of temperature is that it is a measure of the average translational kinetic energy associated with the disordered microscopic motion of atoms and molecules [2]. Basically, heat will flow from a high temperature to a lower temperature area to achieve thermal equilibrium. Temperatures are measured in one of the three standard temperature scales: Celsius, Kelvin and Fahrenheit.

2.1.1 Temperature Scales

The Celsius, Kelvin, and Fahrenheit temperature scales are shown in relation to the phase change temperatures of water. The Kelvin scale is called absolute temperature and the Kelvin is the SI unit for temperature.

Boiling point of water at atmospheric pressure:

$$373.15\,K = 100\ ^{\circ}\mathrm{C} = 212^{\circ}\mathrm{F} \qquad (1)$$

Freezing point of water:

$$273.15\,K = 0^{\circ}\mathrm{C} = 32^{\circ}\mathrm{F} \qquad (2)$$

From (1) and (2), relationship between Celsius, Kelvin, and Fahrenheit temperature scales can be shown as formula below:

$$T_K = T_C + 273.15 \qquad (4)$$

$$T_C = \frac{5}{9}(T_F - 32) \qquad (5)$$

$$T_F = \frac{9}{5}T_C + 32 \qquad (6)$$

2.2 Current Method of Water Quality Monitoring System

Operationally, data acquisition consists of sample collection and laboratory analysis. Laboratory analysis is a complex activity because it involves the analysis for many water quality variables with several alternatives procedure [3].

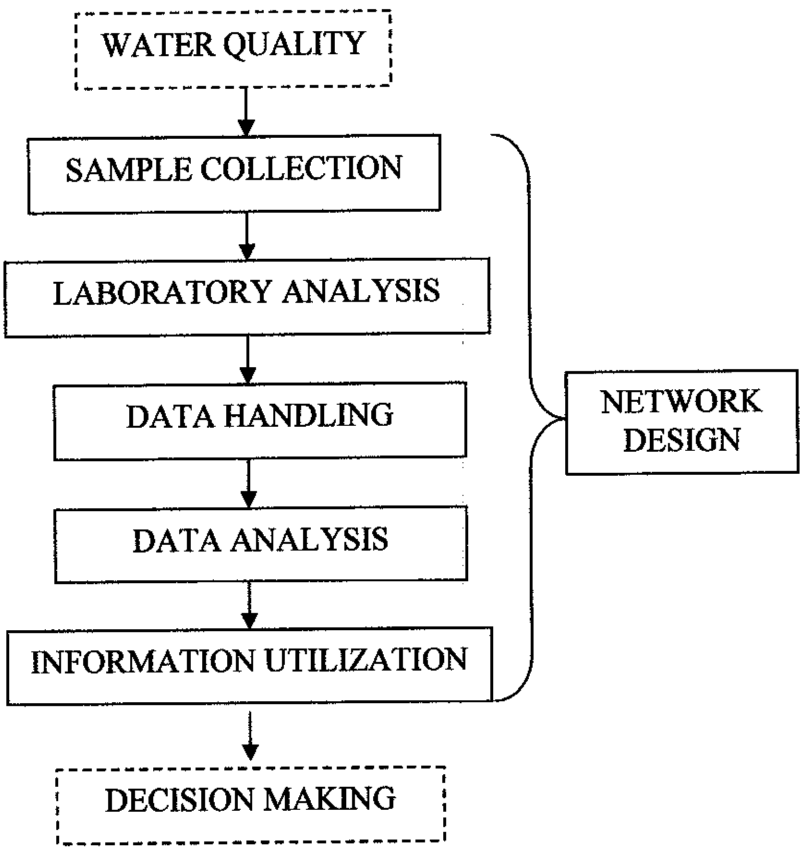

Figure 1: Flow of collecting data

2.3 Wireless System

In wireless systems, the electromagnetic waves are used instead of using wire or cable to build connection between two equipments such as a mobile station and a based station. There are many types of wireless signals which are including Bluetooth, optical, *radio frequency* (RF) and infrared communications systems. The present practicable limits of *radio frequency* (RF) are roughly 10 kHz to 100 GHz [4]. Wireless systems at present commonly operate in hundreds MHz or a few GHz frequency.

2.3.1 Bluetooth

Bluetooth wireless technology is a simple two-way wireless (radio) protocol that allows different electronic instruments to talk to each other without using cables or *infrared* (IR) [5]. *Bluetooth* is commonly used for low-cost, low-power, short-range radio links between mobile PCs, PDAs, mobile phones, and electronic instruments.

In order to operate the system using *Bluetooth*, it needs 2.4 GHz radio spectrum. This technology could be divided into three different classes. In these three classes, there are different in usage of power output and also the different of communication ranges. The three classes are stated as below:

Class 1: 100 meters

Class 2: 10 meters

Class 3: 1 meter

Advantages	Disadvantages
o Lower power o Simple connectivity o Easy interface with other telemetry modems o Industry/international standard communications o No communications cost	o Communication range considerations o Designed for only short-range communications o Potential USB Adapter Conflicts o Radio repeaters under development

Comparing the performance of Bluetooth with IR input device, it seems Bluetooth is much better. However it hard to implement and its cost is very high compared with IR. Thus, the low cost wireless signal and also have good performances are needed. For this purpose, using RF module is proposed and implemented.

2.3.2 Radio Frequency

A *Radio Frequency (RF) signal is* divided into several ranges or bands. Any RF signal has a *wavelength* (distance) that is inversely proportional to the *frequency.* As known, the formula for speed of light is:

$$c = f\lambda \qquad \text{where } c = 3 \times 10^8 \qquad (7)$$

In the atmosphere or in outerspace, if f is the frequency in Megahertz and the wavelength in meters then,

$$\lambda = 300 / f \qquad (8)$$

From equation (8), at 9 kHz, the free-space wavelength is approximately 33 kilometers (km) or 21 miles (mi). The relation between the frequencies ranges and the wavelength is shown in Table 1 below [6].

Table 1: The Frequencies range, f versus the Wavelength, λ

Designation	**Abbreviation**	**Frequencies**	**Free-space Wavelengths**
Very Low Frequency	VLF	9 kHz – 30 kHz	33 km – 10 km
Low Frequency	LF	30 kHz – 300 kHz	10 km – 1 km
Medium Frequency	MF	300 kHz – 3 MHz	1 km – 100 m
High Frequency	HF	3 MHz – 30 MHz	100 m – 10 m
Very High Frequency	VHF	30 MHz – 300 MHz	10 m – 1 m
Ultra High Frequency	UHF	3 MHz – 30 MHz	1 m – 100 mm
Super High Frequency	SHF	3 MHz – 30 MHz	100 mm – 10 mm
Extremely High Frequency	EHF	3 MHz – 30 MHz	10 mm – 1 mm

Radio frequency (RF) is an alternative way to send signals between users to electronics devices or to send signals between two devices. This technology can eliminate some problems that occur when using the other types of communication signals. By using RF signals the signals could be sends over greater distance and from its specification, it also can be even go through walls in order to reach the other devices. RF module is a low cost and it also has good performance.

RF transmitter is capable to transmit signal up to 100 meters range around the open area. The factors that can affect the effective distance are the antenna design, working environment and supply voltage. This RF receiver can detect any signal from any compatible RF transmitter.

2.4 Cost Effectiveness Estimation (Example of Wireless System)

There is a cost comparison between a wired system design with in-plenum wiring and wireless design. The cumulative wiring distance for all temperature sensors are about 3000 feet with the majority of loose in-plenum wiring. Assumed there are 18 cable for sensors connections at an approximately cost of $0.07/ft and labor cost of $1.53 per linear foot of wiring. The cost comparison is shown in Table 2-2 below.

Table 2: Cost Comparison between Wired and Wireless Design for In Building Temperature Sensors [7].

	QTY	**Wired Design**		**Wireless Design**	
		Cost per Unit	Total Cost	Cost per Unit	Total Cost
Temperature Sensor	30	$60	$1800	$70	$2 100
Wiring	3000 ft	$1.6 per linear ft	$4 800		
Wireless network gear					$1 650
RF surveying	4 hours			$100	$400
Wireless network conf.	4 hours			$100	$400
Total Cost			**$6 600**		**$4 550**

The wireless temperature system for this application is about 30% less expensive than wired solution. Given the layout of the building in Figure 2-2, the majority of the cost of wired temperature sensor solution, 72% is attributed to the wiring. If the wiring system is implemented for older building, the estimated cost might be higher because of the installation could damage for instance, asbestos ceiling or wall.

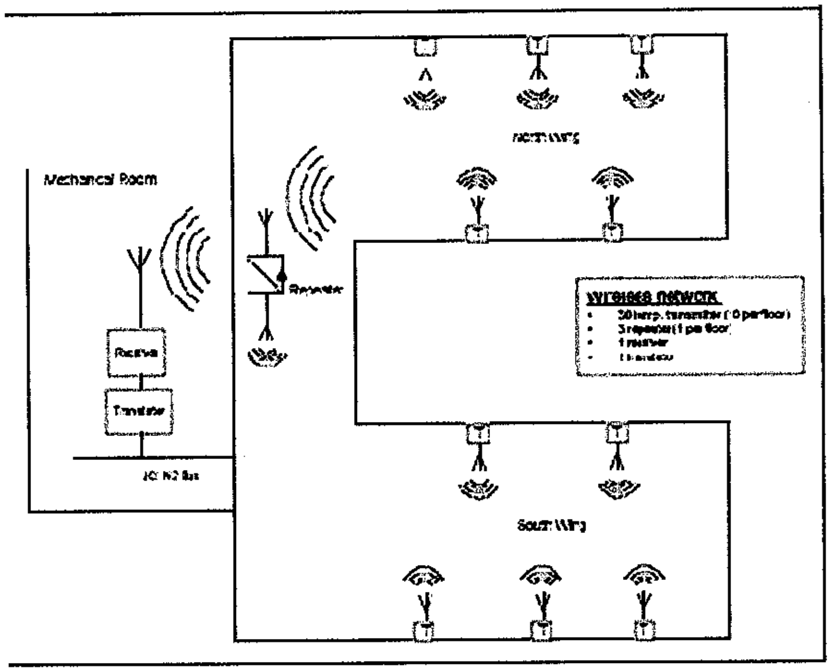

Figure 2: Layout of Wireless Sensor Network.

CHAPTER 3

METHODOLOGY

3.1 Procedure Identification

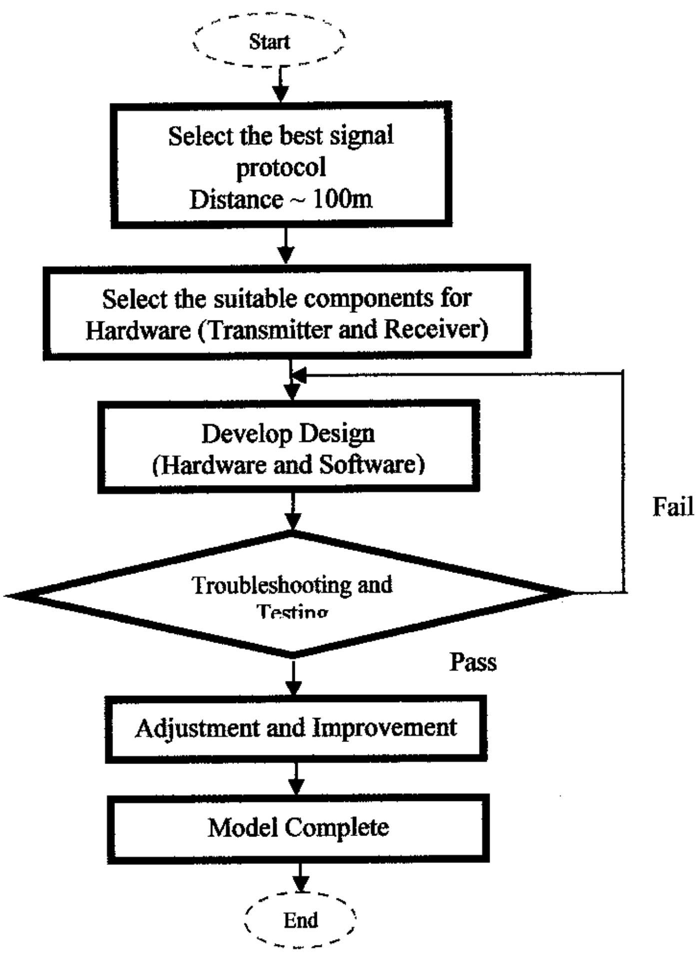

Figure 3: Flowchart of Project Methodology

From Figure 3, the flowchart shows the procedure to achieve the completion of the model. The constructions of the model are carried out stage by stage. From the beginning of the design, performance for the system must be set as goals for completing the model. The several criteria should be put in goals such as effectiveness, efficiency and cost of the final product.

3.2 System Overview

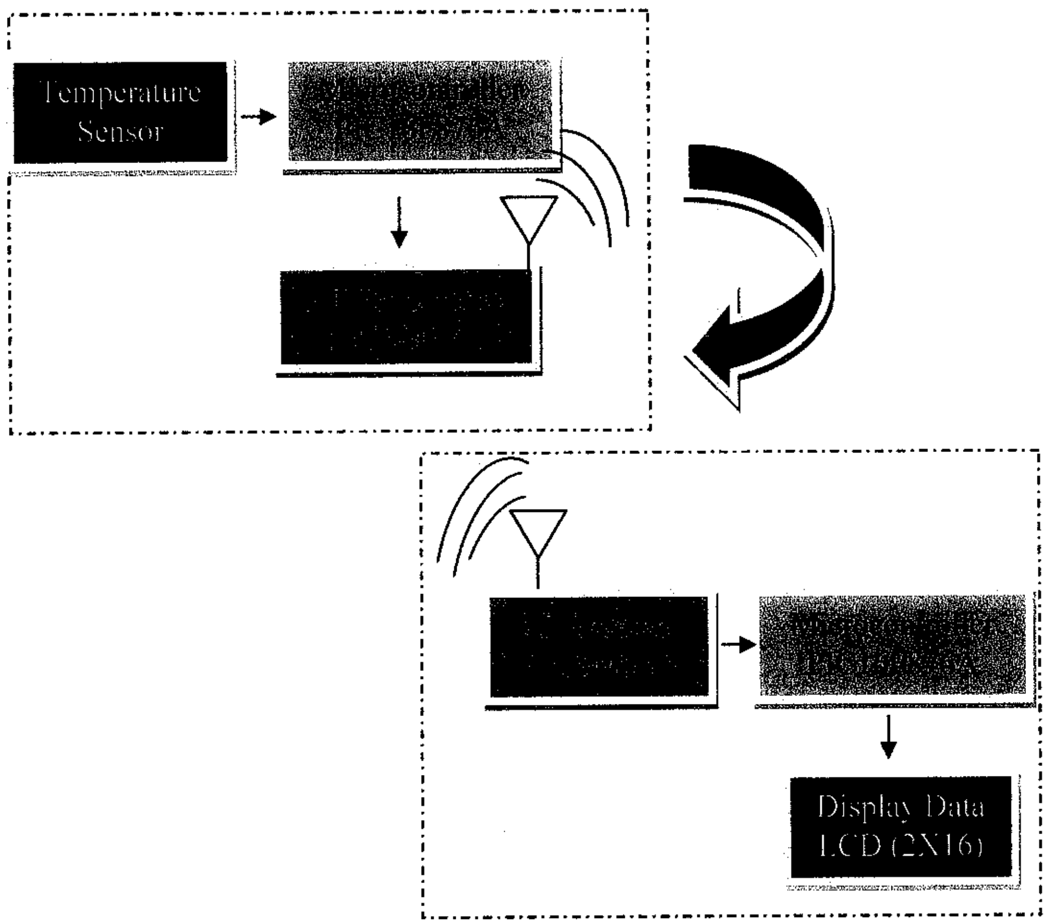

Figure 4: Block Diagram of the Wireless Temperature Monitoring System

From Figure 4, the basic idea to design the wireless water quality monitoring system consists of two distinct components: 1) the *transmitter* which is included the sensor 2) *receiver* which is included the LCD.

The function of this system is to read temperature sensor and display the reading on the LCD. This project will use two PIC16F876A to control RF module. Since transmission and reception using RF module is in digital data, PIC16F876A is also used to convert the analog input to digital input.

3.3 Transmission and Reception Data

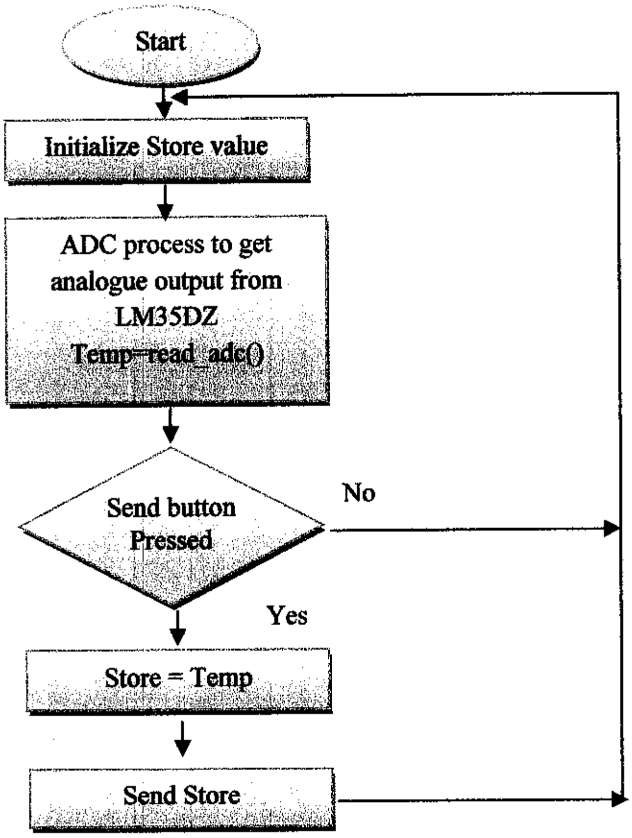

Figure 5: Flowchart of transmission data

As mentioned at system overview part, the important components are included transmitter and sensor devices. From Figure 5, the system starts when the transmitter circuit is activated. Subsequently temperature sensor read temperature value and then store to microcontroller which is PIC16F876A. Next, if send button is pressed the new temperature value will send to receiver device.

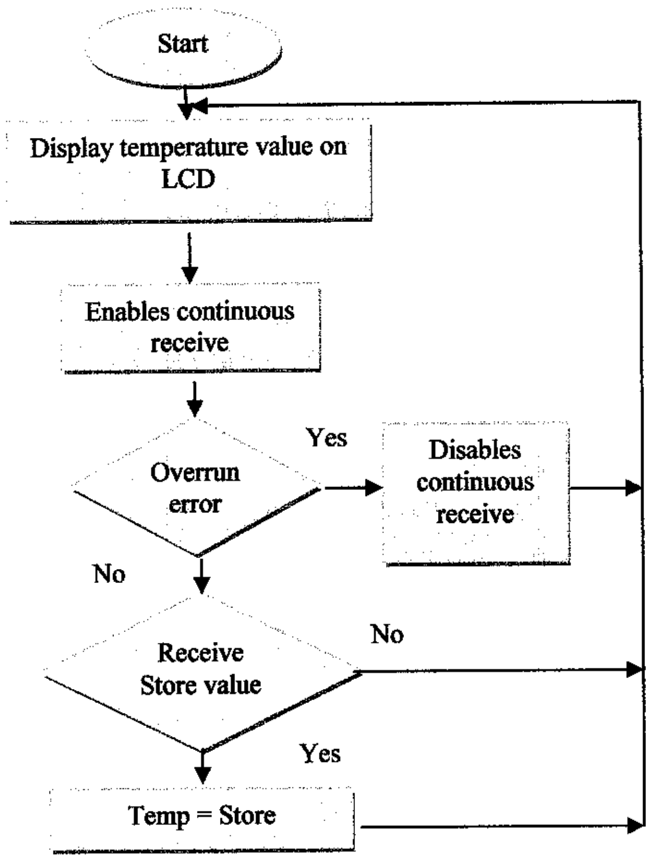

Figure 6: Flowchart of reception data

From Figure 6, at receiver part LCD will display the initial value of temperature. It also enables continuous receive the transmit signal from the transmitter device. If no error in receiving continuous data, microcontroller will check the receive data. If the data is the Store value from transmission part, the new reading of temperature value will store in microcontroller. After that, LCD will display the new reading of temperature value.

3.4 Tools

3.4.1 Hardware

This project will require following hardware:

- 1 x RF Module Set (Transmitter and Receiver)
- 2 x Printed Circuit Board
- 2 x PIC16F876A
- LCD display JHD162A (2x16 characters)
- Temperature Sensor
- Other related electronic components

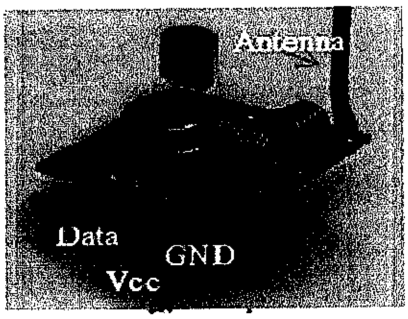

Figure 7: RF transmitter (315 MHz)

Table 3: Specification of the RF transmitter (315 MHz)

Operating Voltage	2.5 to 12 V
Operating Current	4ma @ 5V, 15mA @ 9V
Quiescent Current	10μA
Operating Temperature	-10°C - 60°C
Modulation	ASK
Max. Data Rate	9.6K
Data Input	TTL
RF Power	20mW@5V

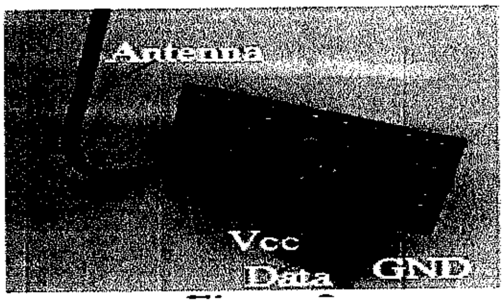

Figure 8: RF receiver (315 MHz)

Table 4: Specification of the RF receiver (315 MHz)

Operating Voltage	4.5 to 5.5 V
Operating Current	4ma @ 5V
Operating Temperature	-10°C - 60°C
Sensitivity	-105dBm
Max. Data Rate	4.8K
Data Input	TTL

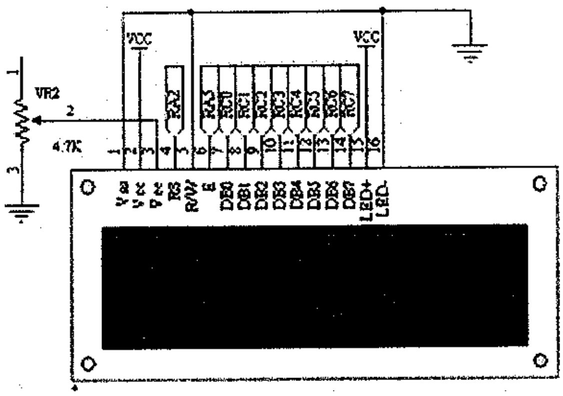

Figure 9: LCD (2x16 characters)

Figure 9 shows the schematic of LCD display. Refer to datasheet of JHD162A the 16 pins of LCD display needs to place in right position. The following Table 5 shows the LCD connection (Refer datasheet).

Table 5: LCD connection

Pin	Name	Pin Function
1	VSS	GND
2	VCC	Positive supply for LCD
3	VEE	Contrast adjust
4	RS	Select register, select instruction or data registration
5	R/W	Select data read or write
6	E	Start data read or write
7	DB0	Data bus pin
8	DB1	Data bus pin
9	DB2	Data bus pin
10	DB3	Data bus pin
11	DB4	Data bus pin
12	DB5	Data bus pin
13	DB6	Data bus pin
14	DB7	Data bus pin
15	LED+	Backlight positive input
16	LED-	Backlight negative input

3.4.2 Software

- PICC Lite ANSI C Compiler
- EAGLE Layout Editor
- PIC Simulator IDE
- PICkit 2
- PCW C compiler
- MPLAB

CHAPTER 4

RESULT AND DISCUSSION

4.1 Wireless system versus Wired System

From the research, it is really obvious that wireless system can increase the amount of process information that can be economically collected for both monitoring and control purposes. Moreover, temperature sensor has also been cost effective but if the sensor is implemented using wire system it will be uneconomic due to both the direct and indirect cost of wiring.

The implementation of wireless system towards health care industry really gives big impact to allow process of collection data more efficient and not longer wasting time. From Table 6, the advantages of wireless system compare to wire system can be shown:

Table 6: Advantages of wireless system compare to wired system

Wireless System	Wired System
Low power consumption	High power consumption
Implement in wide area	Limitation of area
Easy to install	Difficult to install
Lower in cost – installation / maintenance	Higher in cost – installation / maintenance

4.2 UART Communication

The Universal Asynchronous Receiver/Transmitter (UART) controller is the key component of the serial communications subsystem of a computer. The UART takes bytes of data and transmits the individual bits in a sequential fashion. At the destination, a second UART reassembles the bits into complete bytes. Serial transmission is commonly used with modems and for non networked communication between computers, terminals and other devices.

There are two primary forms of serial transmission: Synchronous and Asynchronous. Depending on the modes that are supported by the hardware, the name of the communication subsystem will usually include "a" if it supports Asynchronous communications, and a "s" if it supports Synchronous communications.

- UART : Universal Asynchronous Receiver/Transmitter
- USART : Universal Synchronous-Asynchronous Receiver/Transmitter

```
void uart_send(unsigned char data)
{
        while(TXIF==0);                    //only send the new data after
        TXREG=data;                                //the previous data finish sent
}
```

This project uses the UART communication to sending data among the 2 PIC microcontrollers. Actually, the data pin from transmitter and receiver is connected together but the task of the RF module is to change the wired to wireless. However, UART only can send 8 bit data at one time which is 0-255 in decimal, 0-FF in hex and 00000000-11111111 in binary.

4.3 Analogue Input

```
//configure ADC
ADCON0=0b10000001;          //enable ADC converter module
ADCON1=0b01000100;          //configure ADC and ANx pin
```

4.3.1 ADCON0

In this project, author is using analogue input which is determined by temperature sensor. For **ADCON0**, it is split into four different parts.

First part: It consists of the highest 2 bits: **ADCSI** and **ADCS0**. These bits set the clock frequency that will be used for the analogue to digital conversion and there are divided down from the system clock. From Table 7, as transmitter part is using a 20MHz clock, so it is decided to use Fosc/32.

Table 7: A/D Conversion Clock Select bits

ADCS1	**ADCS0**	**A/D Conversion Clock Select bits**	**Max. Clock Freq.**
0	0	Fosc/2	1.25MHz
0	1	Fosc/8	5MHz
1	0	FOsc/32	20MHz
1	1	Frc (Internal A2D RC Osc.)	Typ. 4uS

Second part: It consists of the next 3 bits: **CHS2, CHS1** and **CHS0**. These are the channel select bits, and they will set which input pin is routed to the analogue to digital converter. As in this project using PIC16F876A, only five pins (AN0-AN4) are available on it. Table 8 shows the available option for selecting the channel bit:

Table 8: Channel Select Bit

CHS2	CHS1	CHS0	Channel	Pin
0	0	0	Channel0	RA0/AN0
0	0	1	Channel1	RA1/AN1
0	1	0	Channel2	RA2/AN2
0	1	1	Channel3	RA3/AN3
1	0	0	Channel4	RA5/AN4
1	0	1	Channel5	RE0/AN5
1	1	0	Channel6	RE1/AN6
1	1	1	Channel7	RE2/AN7

Third part: This part consists of single bit which is the second lowest bit, bit 2, **GO/DONE**. This bit has two functions. Firstly by setting the bit it initiates the start of analogue to digital conversion. Secondly the bit is cleared when the conversion is completed.

Fourth part: Another single bit at bit 0, ADON. This simply turns the Analogue to Digital ON or OFF. When the bit set, it will indicate ON and with the bit cleared it is OFF. It saves the power consumption.

So for this application the data required in ADCON0 is binary '10000001' to read from AN0, and binary '10001001' to read from AN1. Bit 1 is not used, and can be either '0' or '1'. The result of the setting can be shown as below:

Table 9: Data in ADCON

Bits required in ADCON0.								
Input	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
AN0	1	0	0	0	0	0	-	1
AN1	1	0	0	0	1	0	-	1

4.3.2 ADCON1

When writing a programming that involves analogue reading, one more thing needs to be concern is **ADCON1** which is split into two sections.

First part: This part consists of a single bit, **ADFM**. As the **Result Format Selection Bit**, it will select if the output is Right Justified (bit set) or Left Justified (bit cleared). The advantage of using this makes it very easy to use as an 8 bit converter instead of ten bits. The author can get 8 bits result by clearing this bit and reading **ADRESH**. Moreover, it needs to ignore the two least significant bits in **ADRESL** for achieving the result.

Second Part: **PCFG3-0** are probably the most complicated part of setting the A2D section, they set a lot of different options, and also limit which pins can be analogue, and which can be digital:

Table 10: Setting for **PCFG3-PCFG0**

PCFG3: PCFG0	**AN7 RE2**	**AN6 RE1**	**AN5 RE0**	**AN4 RA5**	**AN3 RA3**	**AN2 RA2**	**AN1 RA1**	**AN0 RA0**	**Vref+**	**Vref-**
0000	A	A	A	A	A	A	A	A	Vdd	Vss
0001	A	A	A	A	Vref+	A	A	A	RA3	Vss
0010	D	D	D	A	A	A	A	A	Vdd	Vss
0011	D	D	D	A	Vref+	A	A	A	RA3	Vss
0100	D	D	D	D	A	D	A	A	Vdd	Vss
0101	D	D	D	D	Vref+	D	A	A	RA3	Vss
0110	D	D	D	D	D	D	D	D	Vdd	Vss
0111	D	D	D	D	D	D	D	D	Vdd	Vss
1000	A	A	A	A	Vref+	Vref-	A	A	RA3	RA2
1001	D	D	A	A	A	A	A	A	Vdd	Vss
1010	D	D	A	A	Vref+	A	A	A	RA3	Vss
1011	D	D	A	A	Vref+	Vref-	A	A	RA3	RA2
1100	D	D	D	A	Vref+	Vref-	A	A	RA3	RA2
1101	D	D	D	D	Vref+	Vref-	A	A	RA3	RA2
1110	D	D	D	D	D	D	D	A	Vdd	Vss
1111	D	D	D	D	Vref+	Vref-	D	A	RA3	RA2

From the Table 10, the setting can be easier if splitting down them into four steps:

1. Setting a pin to be an analogue input.
2. Setting a pin to be a digital input.
3. Setting the positive reference for the converter (Vref+).
4. Setting the negative reference for the converter (Vref-).

After going through all steps, all possibilities which are not used in the setting will be eliminated. This brings down to the only option that meets all the requirement of setting. So the value will be used to write to **PCFG3-PCFG0** as shown below.

Table 11: Data in ADCON1

Bits required in ADCON1.								
Name	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
ADCON1	1	-	-	-	0	1	0	1

Programming for analogue inputs is quite difficult if there is only a little bit of understandable towards input command for PIC16F876A. The microcontroller is trying to convert actual value from the temperature sensor to be decimal data which is limited to 0-255 decimal for sending the data to receiver.

4.4 Results

Before the whole system can be done, the constructing of the wireless temperature monitoring system is divided into two parts:

- Developing the wireless system without temperature sensor
- Developing the temperature monitoring system using wire system

4.4.1 Developing the Wireless System

As mentioned before, this system is excluded of temperature sensor. At transmitter part, four push buttons have been assigned as "Increase", "Decrease" "Send" and "RESET" button. Only one push button is used at receiver part and it has been assigned as "RESET" button. Both transmitter and receiver parts use 7-segment to display the result of the transmission and reception data.

Action	Expected Result
Push the sliding switch - Transmitter device - Receiver device	The Green/Red Led lights up. • These Green/Red led indicates that the connection of the power supply is correct. • Both devices are activated at this moment. 7-segment shows initial value = 0.
Pressing the "Increase" button	Increasing of number at 7-segment. • When this button keeps pressing, the value will change by +1.
Pressing the "Decrease" button	Decreasing of number at 7-segment. • When this button keeps pressing, the value will change by -1.
Pressing the "Send" button	7-segment at receiver device will show the same number as at transmitter device. • At this moment, it shows that the transmission and reception process is successful. • The desired data has been received at receiver part.
Pressing the "RESET" button	Number at 7-segment is back to initial number which is 0.

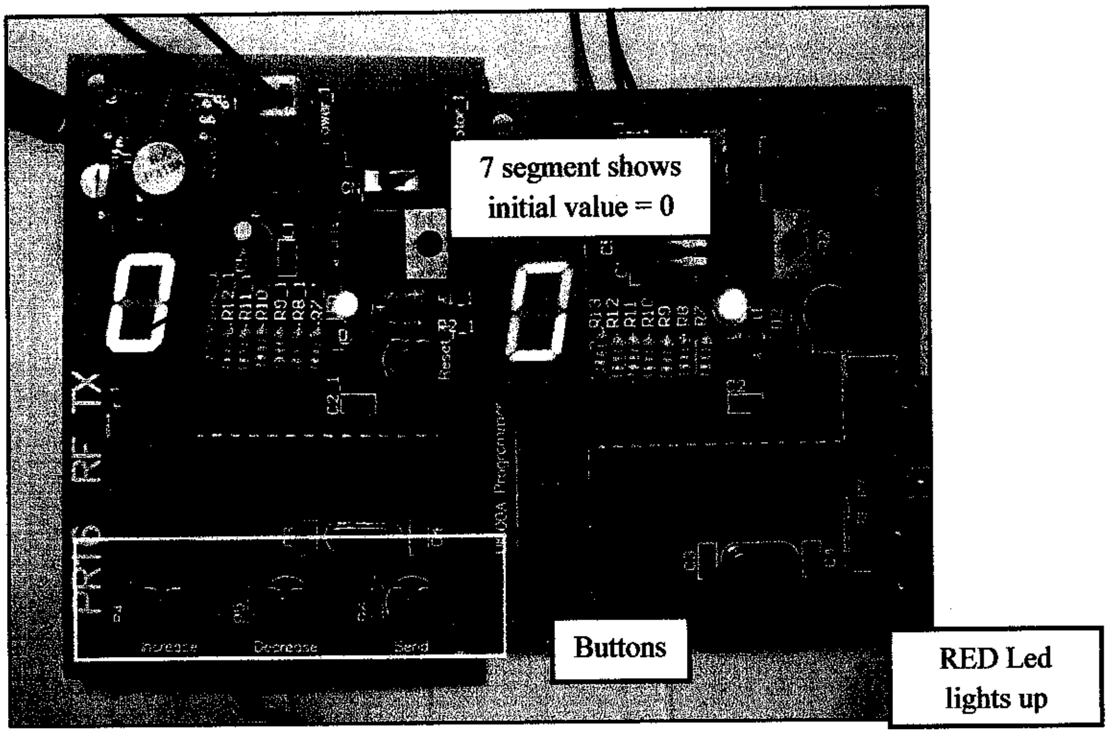

Figure 10: Push the sliding switch

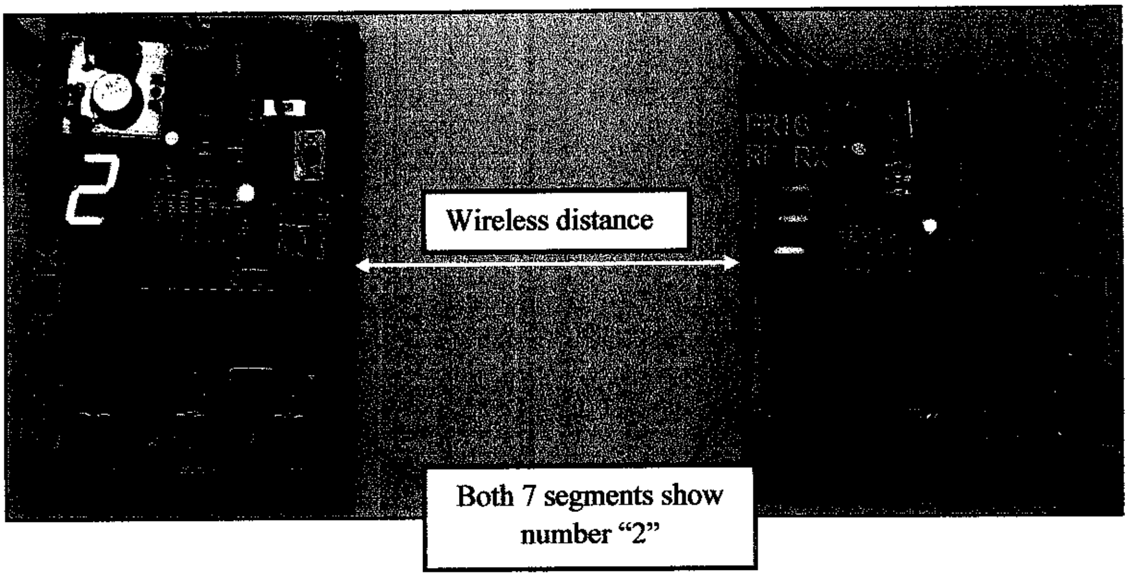

Figure 11: Press the "Send" button

Both of Figure 10 and Figure 11 show the output which is performed accordingly expectation after some action has been taken. In this case, author has pressed "Increase" button twice and send the data to receiver then 7 segment displays number "2".

4.4.2 Developing the Temperature Monitoring System

For this part, the important components are temperature sensor (LM35DZ) and LCD display (2x16). Moreover, two variable resistors have been used to control voltage value and name them as "Contrast" and "Offset". Expected result for this part is when circuit has been activated then temperature sensor will start to sense the temperature reading. After that, the value will be displayed at LCD.

Action	Expected Result
Push the sliding switch	The Green Led lights up. • This green led indicates that the connection of the power supply is correct and circuit has been activated. LCD displays the initial value of temperature reading.
Adjust the "Contrast"	It will change the brightness of LCD display. • Adjusting of the variable resistor will allow a certain value of voltage to go through LCD. • It is important to have this component so that the output will be displayed clearly at LCD.
Adjust the "Offset"	Ambient temperature will change. • Voltage of pin 5 (Vref+) from PIC should adjusted to 1V by rotating the "Offset" and by using multimeter to ensure the value of voltage. • This is done for preventing offset since the sensor gain of the LM35DZ is 10mV/°C.
Give additional heat to temperature sensor - Solder - Hair dryer - Hot water	Temperature reading will increase.

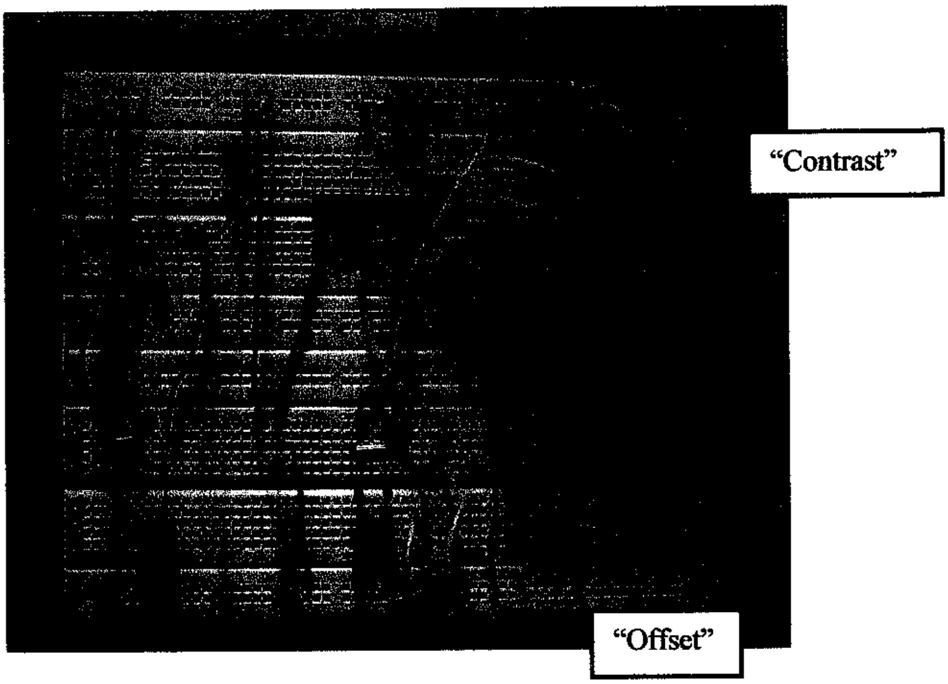

Figure 12: Circuit is in "*deactivation*" mode

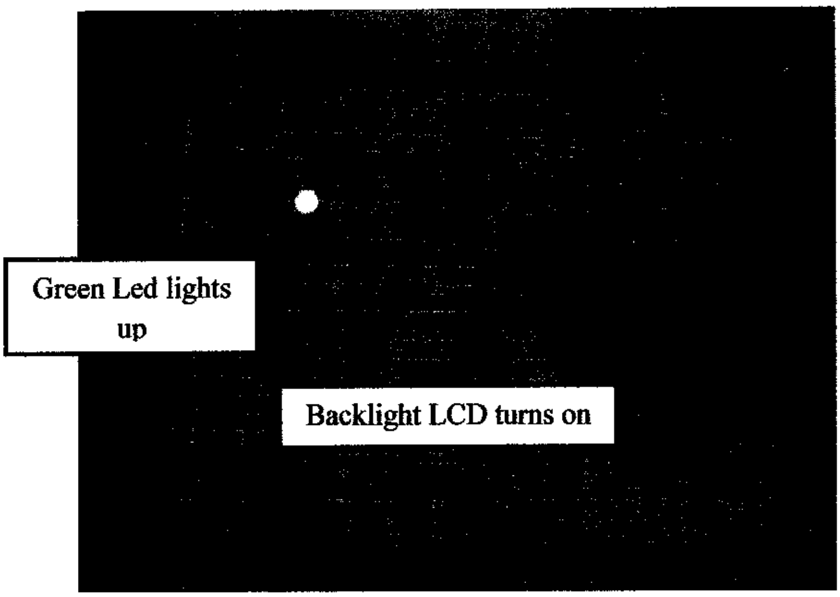

Figure 13: Push the sliding switch

For this part, it seems that after pushing the sliding switch the Green led and backlight LCD turn on. However, nothing is shown at LCD screen. Further investigation on this part is needed to attempt this problem.

4.4.3 The Overall System

As both of parts have shown the expected output, thus constructing the whole system will able to be done. In the whole system, push button for "Increase" and "Decrease" button no longer need to be used. Thus, data from temperature sensor will be directed to be used as transmission data. The basic idea for the whole system is just extract from both parts. Constructing the whole system can be easier if the second part of the system shows the expected output. This is because converting the analogue output to digital is tedious work indeed. As in *Analogue Input* section, the bits need to be selected accordingly as its specification.

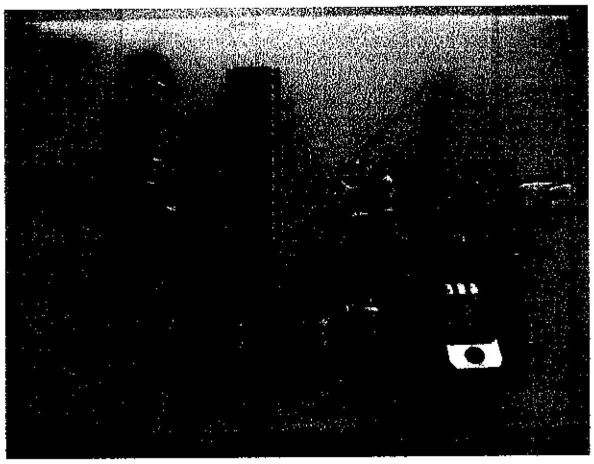

Figure 14: Transmitter and Temperature sensor part

Figure 15: Receiver and LCD display part

4.5 Engineering Analysis

4.5.1 Voltage of LM7805

Both of transmitter and receiver circuit using two PIC16F876A as microcontroller. The voltage range of power source could be given for this circuit is between 7V and 15V because of most of components are low power consumption. Higher input voltage will produce more heat at LM7805 voltage regulator. LM7805 (1A minimum) will regulate the given voltage to 5V (Vcc) for supplying power to the PIC16F876A and pull up the push button.

At troubleshooting stage, the desired outputs for transmission and reception parts are not shown. By using a multimeter, the author identifies that one component of the circuits does not function accordingly as its specification. As mentioned, LM7805 will regulate the given voltage 5V for supplying power to the PIC16F876A, however it shows 7V after measuring the voltage of LM7805. Because of that, it is assumed that the connection of the component is not right. After doing some modification, the component is placed correctly and both circuits are functioning well. From Figure 16, there are two capacitor used to stabilize the voltage input and output of the LM7850.

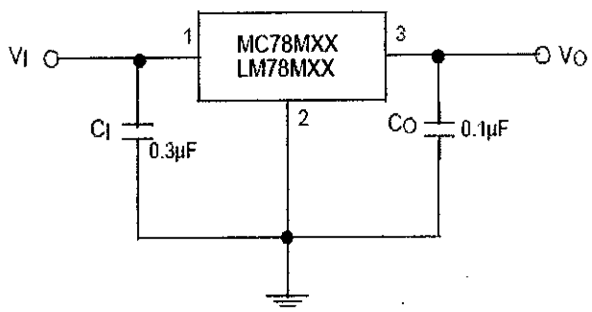

Figure 16: Voltage Regulator

4.5.2 Antenna Design (315 MHz)

From the specification of the RF transmitter module (315 MHz), it is supposedly can transmit signal up to 100m (Appendix). However, the author finds that the transmitter only can transmit the data less than 1m. Because of that, the author reviews back the specification for both transmitter and receiver. Finally the author discovers that, the design for the antenna does not meet its specification. The antenna should be design using any soft or hard wire. Then referring to the specification, the length of wire for antenna (315 MHz) should be 24 cm and if a soft wire is used, it must be fully extended. Besides the antenna design, working environment and supply voltage will seriously impact the effective distance. From Figure 17, the hole with ANT label, should be soldered with correct antenna length which is 24 cm for 315MHz of RF module.

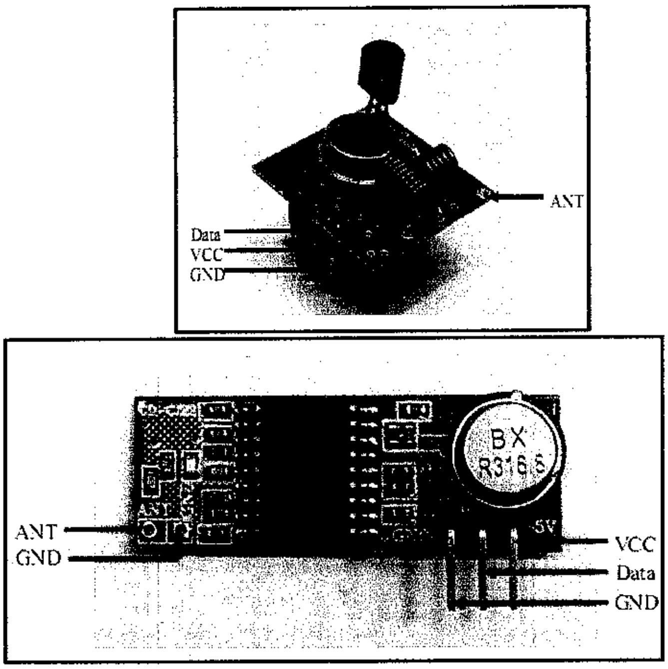

Figure 17: RF module

4.5.3 Temperature Sensor – LM35DZ

In this project, LM35DZ is used for sensing the temperature. Basically, LM35DZ is one of LM35 series which are precision integrated-circuit temperature sensors. For LM35 series, output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. Other types of LM35 are LM35C, LM35CA, and LM35D. They are different in term of packaging.

Features:

- Calibrated directly in ° Celsius (Centigrade)
- Linear + 10.0 mV/°C scale factor
- 0.5°C accuracy guarantee able (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 ±1⁄4°C typical
- Low impedance output, 0.1 Ω for 1 mA load

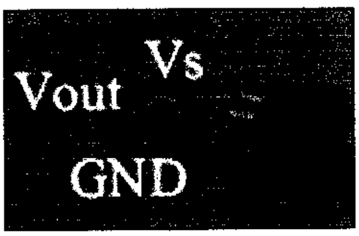

Figure 18: LM35DZ

4.5.4 Printed Circuit Board (PCB)

For this system, the author is needed to design printed circuit board (PCB) as it has been compulsory. By using Eagle Layout software, schematics for overall system had been done. Then using the same software the author convert the schematics to be board printed.

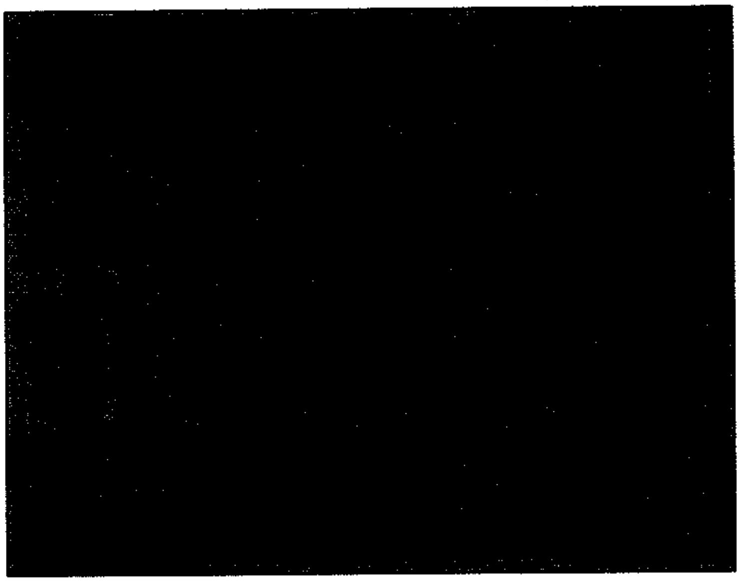

Figure 19: Transmitter part

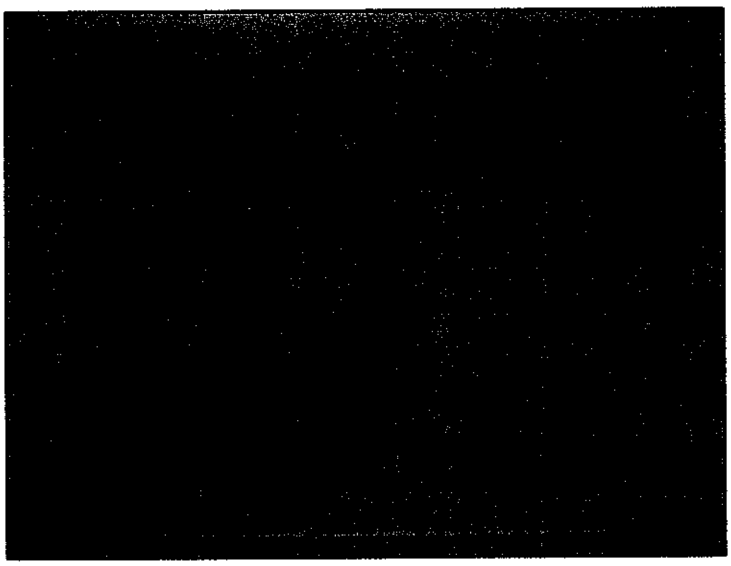

Figure 20: Receiver part

There are some advantages of using PCB:

Easy to duplicate	• Many sheets of the same circuits can be made with the same quality.
Reliable	• Give better reliability for a long life cycle.
Compactly made	• The small wiring can be made using the print technique.

However, using PCB also give an disadvantages to the circuit. This is because all components need to be soldered. When any component has been soldered in wrong place, hence author will be responsible to disolder back the components. The fatal error might be occurred if process of disolder is not done carefully. From Figure 21, it shows that the printed route is missing. Then the author uses wire to make connection between two pins.

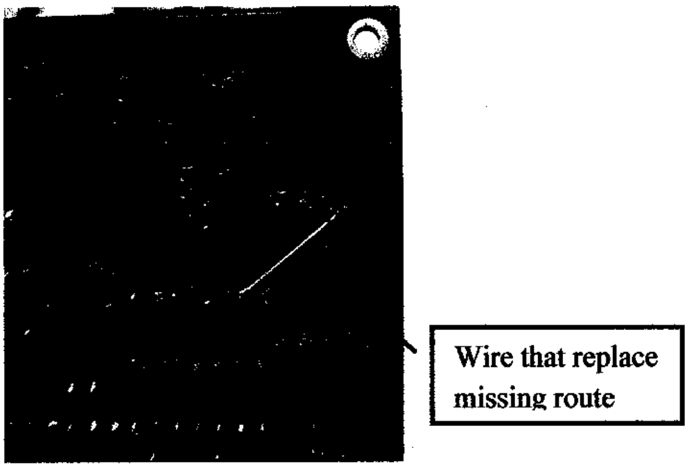

Figure 21: Replace route with additional wiring on the board

As LCD display also built on PCB, it might be damaged while the process of soldering the pin header on it.

4.6 Simulation

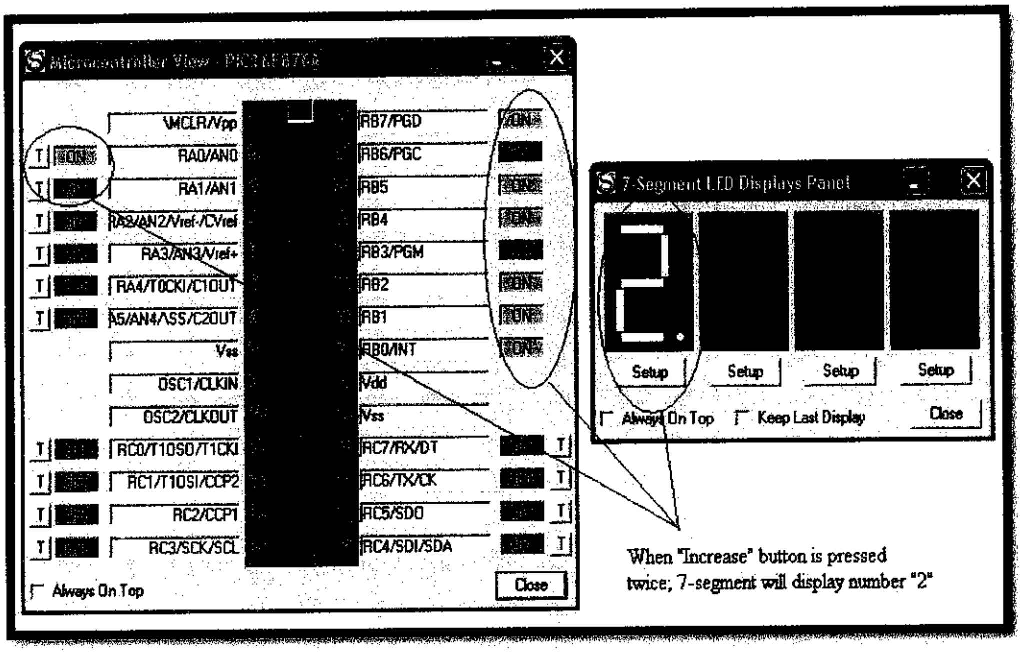

Figure 22: Simulation of Transmitter device

PIC Simulator IDE can simulate any programming (hex file) before implementing them on hardware. Figure 22 shows one example of simulation for programming on transmitter at section 4.5.1. In this case, RA0 has been assigned as "Increase" button. While "Increase" button is pressed twice, 7-segment will display number "2". From microcontroller view, we can see bit at RB7, RB5, RB4, RB2, RB1, and RB0 are ON which is equal 0b10110111 (equivalent 2 in decimal).

4.7 Cost Analysis

Table 12 below shows the cost analysis for important components only for the whole system. Basically if wired system is implemented, it is obvious that the total cost become higher as wiring cost will be included. The cost of wiring should be taken as how far the distance of wireless system can achieve. Thus, the distance of wired system should be same as the distance of wireless system.

Table 12: Cost Analysis for the whole system

No.	Item	Price per unit	Quantity	Price
1	RF Transmitter (315Mhz)	RM 20.00	1	RM 20.00
2	RF Receiver (315Mhz)	RM 30.00	1	RM 30.00
3	PIC16F876A	RM 25.00	2	RM 25.00
4	Temperature Sensor (LM35DZ)	RM 8.00	2	RM 16.00
5	LCD display (2x16)	RM 35.00	1	RM 35.00
Total Cost				RM 126.00

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

As conclusion, confidently "***Wireless Temperature Monitoring System***" is able to provide an easy and effective way to observe health care items' temperature. It will be able to be a substitute system rather than keeping manual logs which is indeed impractical nowadays. A low power wireless sensor network implementation is really viable instead of using cabling system in such of application. The cost will reduce up to 30% and the system is really easy to maintain while using the wireless system. Hence, the objective of the project has been met.

5.2 RECOMMENDATION

The mechanism of the system still needs a lot of improvements and further evaluation to make it marketable and more attractive to users. The project has to be improved and reinforced in a more proper manner and robust design.

As suggestion, further research on health care items need to be continued. For this project, measurement is done on simulated temperature without applying to actual temperature of rooms that store the items. Additionally, in future this project can be improved by adding a system that can automatically operate if any temperature reading of health care items goes beyond its limitation.

REFERENCES

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[3] Qizheng (2005). RF System Design of Transceiver for Wireless Communications.

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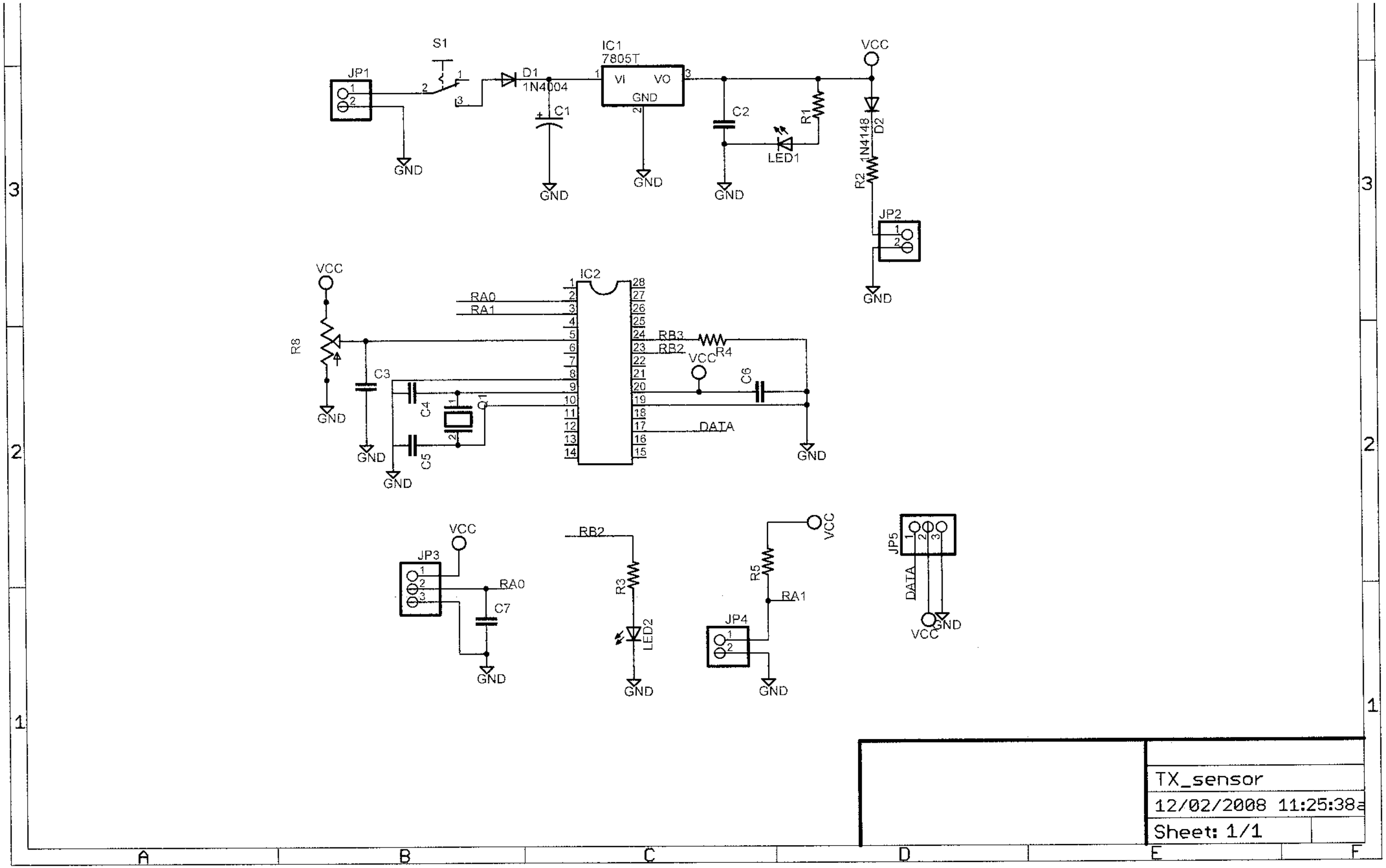
[7] F.L.Lewis (2004). Wireless Sensors Networks.

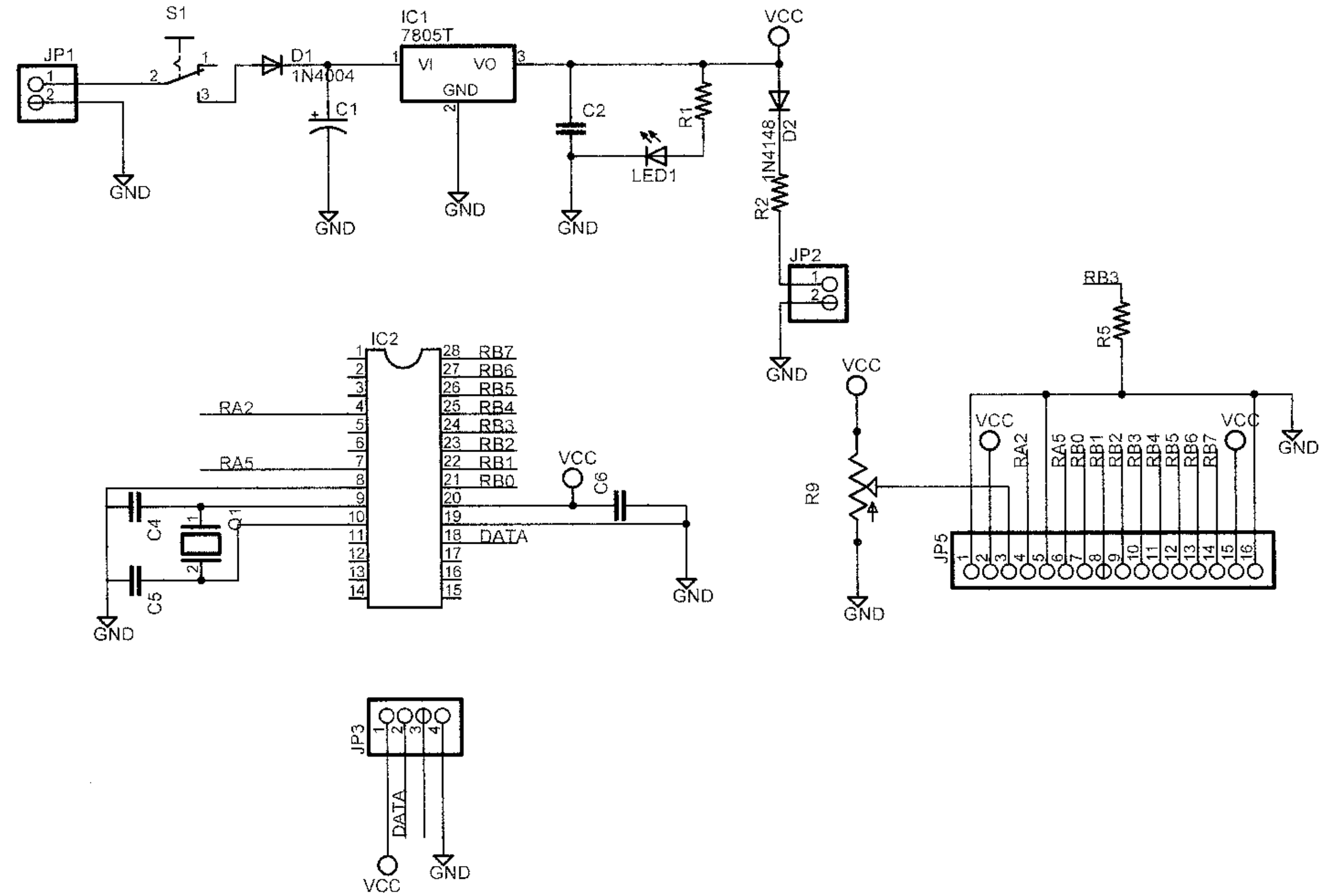
[8] William Stallings (2007).*Data and Computer Communications*, pp. 92.

[9] http://www.bsbwireless.com/FAQ.html

APPENDIX A

(Schematics)

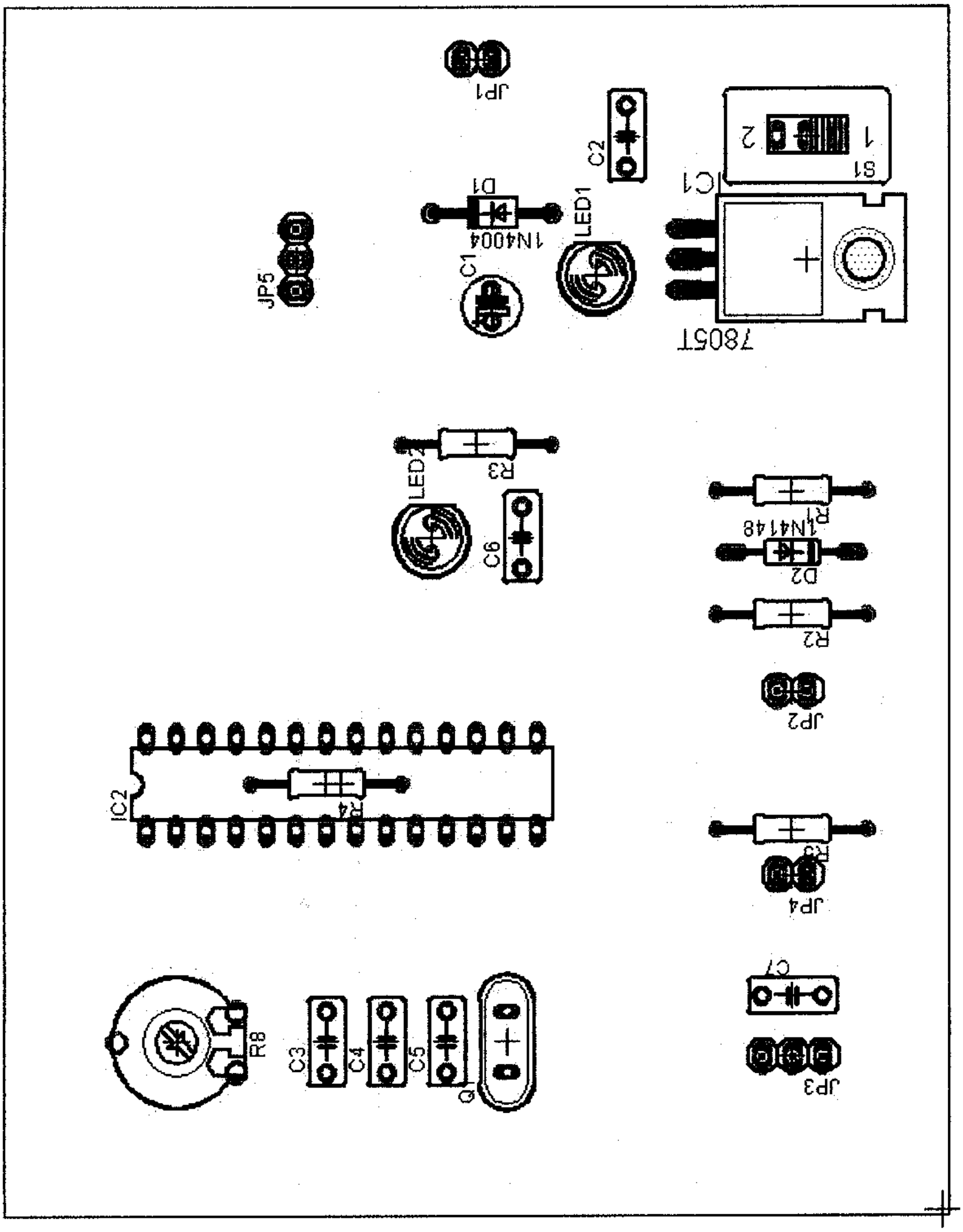

S1
JP1
D1
1N4004
C1
IC1
7805T
VI
VO
GND
C2
R1
LED1
VCC
D2
1N4148
R2
JP2
GND
IC2
RA0
RA1
R8
C3
C4
C5
Q1
RB3
RB2
R4
C6
DATA
JP3
C7
R3
LED2
R5
JP4
JP5
TX_sensor
12/02/2008 11:25:38a
Sheet: 1/1

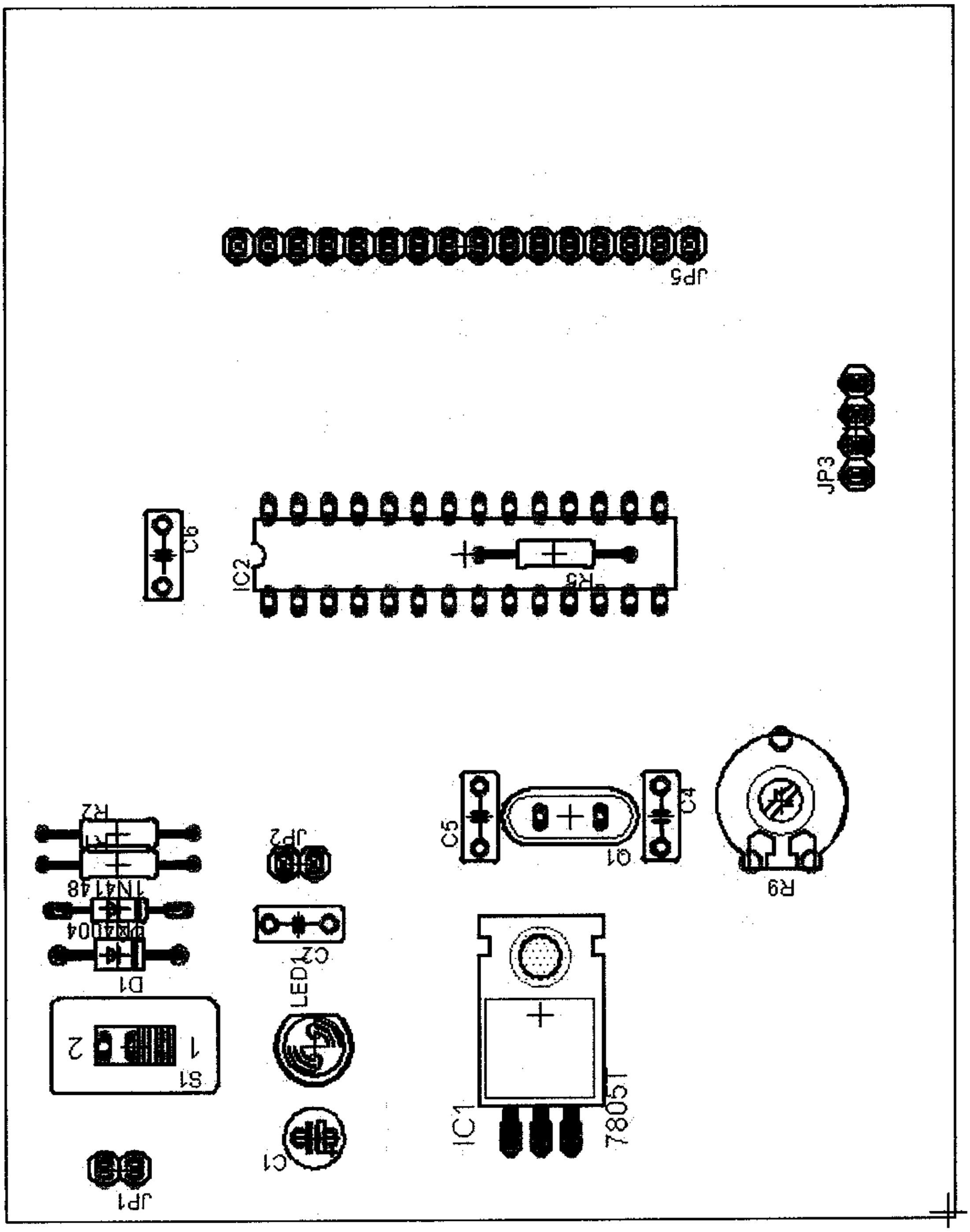


RX_LCD
12/02/2008 11:35:12a
Sheet: 1/1

APPENDIX B

(Printed Circuit Board)


JP1
C2
S1
IC1
D1
1N4004
LED1
C1
JP5
7805T
R3
LED2
C6
R1
1N4148
D2
R2
JP2
IC2
R4
JP4
C7
JP3
R8
C3
C4
C5
Q1


JP5
JP3
IC2
C6
R5
C5
C4
Q1
R9
JP2
R2
1N4148
4004
C2
LED1
D1
1
2
S1
IC1
7805T
C1
JP1

APPENDIX C

(Coding)

Appendix C: Transmitter & Sensor Part

```
#include <pic.h>                                        //include PIC microcontroller library

__CONFIG ( UNPROTECT & LVPDIS & HS );                   //disable code protect, disable low voltage programming, set
clock = 20 MHz

#define         send_button             RA2             //set pin A2 as button to change temperature

void uart_send(unsigned char data);         //prototype function 'uart_send'
unsigned char read_ad (void);               //prototype function 'read_ad


void main(void)
{
        unsigned char temp,store;               //declare a temporary variable for reading ADC

        ADCON0=0b10000001;                              //enable ADC converter module
        ADCON1=0b10001110;                              //1 = Right justified. 6 Most Significant bits of ADRESH are
read as '0'. 000 = don't care
                                                                        //1110 = only pin RA0 is
analog
        TRISA = 0xff;                                   //configure PORTA input
        TRISB = 0x00;                                   //configure PORTB as output

        BRGH = 0;                                               //baud rate low speed option
        SPBRG = 255;                                    //set boud rate to 1200bps for 20Mhz crystal
        TX9 = 0;                                                //8-bit transmission
        TXEN = 1;                                               //enable transmission
        SYNC = 0;                                               //asynchronous
        SPEN = 1;                                       //enable serial port

        temp=0;                                                 //declare initial temp as 0

        while(1)                                                //infinity loop
        {

                uart_send(store);                       //continuous send data
                temp=read_ad();                         //read channel 0 (RA0 value)

                 if(send_button==0)             //if send button is presssed "active low"
                store=temp;                                     //save current temperature value

                uart_send(store);                       //continuous send data

        }                                                               //end of endless loop
}                                                                       //end of main function


void uart_send(unsigned char data)
{
        while(TXIF==0);                                 //only send the new data after the previous data finish
sent
        TXREG=data;                                     //transmit given data
}

unsigned char read_ad(void)                     //function read analog input according to the given channel
{
        unsigned char result;                   //declare a variable call result
        ADGO=1;                                         //start ADC convertion
        while(ADGO);                                    //wait for ADC convertion to complete
        result=ADRESH;                                  //read the result
        return result;                                  //return the result
}
```

Appendix C: Receiver Part & LCD display

```
//================include==============================
#include<pic.h>

//================configuration========================
__CONFIG (0x3F32);

//================define IO port=======================
#define   lcd      PORTB
#define   RS       RA2
#define   E        RA5
#define   CHANNEL0  0b10000001  // AN0
#define   led      RB2

//================FUNCTION PTOTOTYPE===================
void e_pulse(void);
void delay(unsigned short i);
void send_char(unsigned char data);
void send_config(unsigned char data);
void lcd_goto(unsigned char data);
void lcd_clr(void);
void dis_num(unsigned long data);
void increment(unsigned long data);
void read_adc(void);
unsigned short read_temp(void);
unsigned char uart_rec(void);

//================MAIN=================================
unsigned short result;
unsigned short temp;

void main(void)
{

        //setup USART
        BRGH = 0;                                   //baud rate low speed option
        SPBRG = 255;                    //set boud rate to 1200bps for 20Mhz crystal
        SPEN = 1;                       //enable serial port
        RX9 = 0;                        //8-bit reception
        CREN = 1;                                   //enable reception

  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;

  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

    temp=0

    while(1)            //infinity loop
    {


            CREN=1;                                                         //enable continuos receive
            if(OERR==0) temp=uart_rec();            //receive sata if overrun error free
            else CREN=0;                                            //if overrun error, disable continuos receive


            lcd_goto(8);
            dis_num(temp/10);
            send_char('.');
            dis_num(temp%10);
            send_char(0b11011111);
            send_char('C');
            send_char(' ');
            send_char(' ');

            if((temp>0)&&(temp<1000))
        {
          led=1;
        }


    delay(2000);

    }

  }

}


//========================subroutine 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);
  }

}

//==================subroutine ADC=======================

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--);
}

//          functions
//=========================================================================================
unsigned char uart_rec(void)       //receive uart value
{
          unsigned char rec_data;
          while(RCIF==0);                               //wait for data
          rec_data = RCREG;
          return rec_data;                          //return the received data
}
```

APPENDIX D

(Datasheet)

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

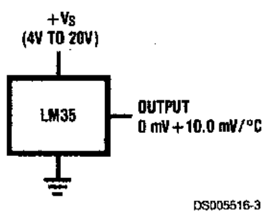
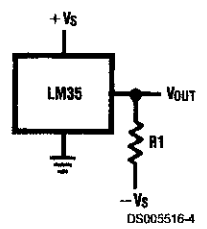


FIGURE 1. Basic Centigrade Temperature Sensor (+2°C to +150°C)



Choose $R_1 = -V_S/50\ \mu A$

V_{OUT} = +1,500 mV at +150°C

= +250 mV at +25°C

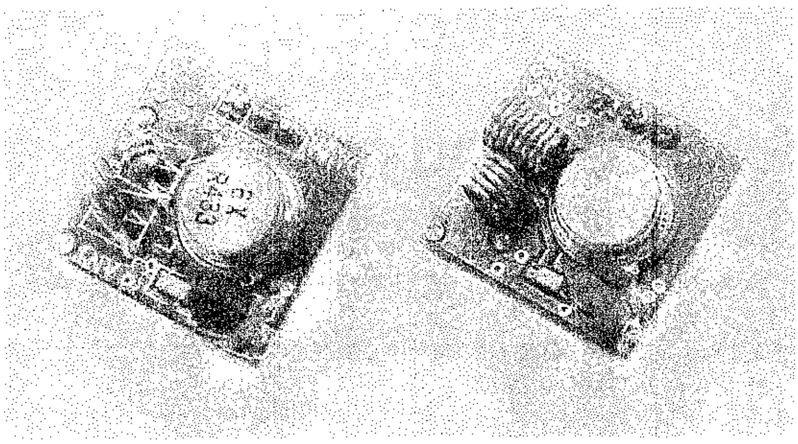
= −550 mV at −55°C

FIGURE 2. Full-Range Centigrade Temperature Sensor

 DS005516

Cytron
Technologies

RF-TX-315
RF-TX-433
RF Transmitter Module



User's Manual

V1.0

June 2008

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1. INTRODUCTION AND OVERVIEW

These RF Transmitter Modules are very small in dimension and have a wide operating voltage range (3V-12V). The low cost RF Transmitter can be used to transmit signal up to 100 meters (the antenna design, working environment and supply voltage will seriously impact the effective distance). It is good for short distance, battery power device development. Cytron Technologies provides 2 types of RF Transmitter Modules at either 315MHz or 433MHz for user:

Product Code	Description
RF_TX_315	RF Transmitter 315MHz
RF_TX_433	RF Transmitter 433MHz

The application includes:

- Industrial remote control, telemetry and remote sensing.
- Alarm systems and wireless transmission for various types of low-rate digital signal.
- Remote control for various types of household appliances and electronics projects.

2. PRODUCT SPECIFICATION

2.1 The Specifications of RF Transmitter Module

Except for the frequency and antenna length, RF_TX_315 and RF_TX_433 share the same product specifications as shown in table below:

No.	Specifications	RF Transmitter Module
1.	Operating Voltage	3V to 12 V
2.	Operating Current	Max ≤ 40mA (12V), Min ≤ 9mA (3V)
3.	Oscillator	SAW (Surface Acoustic Wave) oscillator
4.	Frequency	315MHz~433.92MHz
5.	Frequency error	±150kHz(max)
6.	Modulation	ASK/OOK
7.	Transfer Rate	≤10Kbps
8.	Transmitting power	25mW (315MHz@12V)
9.	Antenna Length	24cm (315MHz), 18cm (433.92MHz)

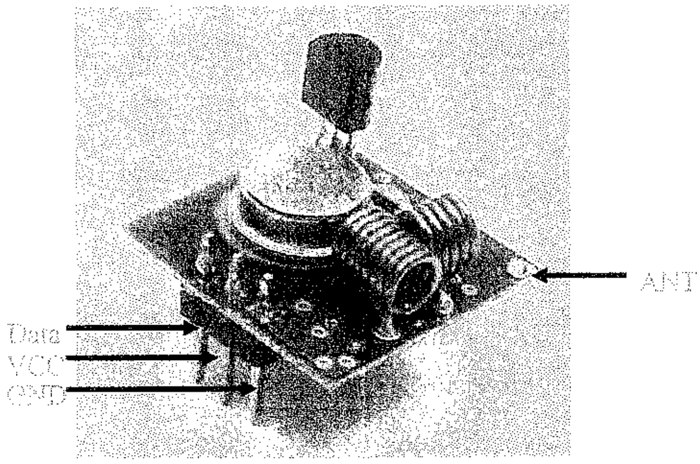
2.2 Antenna

1. User may use any soft or hard wire (likes Drawbars antenna) as antenna. The frequency is determined by the length of antenna, **please select the correct length with refer to specification of RF Transmitter above** (Section 2.1, No. 9). If a soft wire is used, please make sure it is fully extended.

2. If the transmitter module is molded in a metal casing, please use an external antenna. For better result, use A 50 Ohm coaxial cable can be used as antenna to the module.

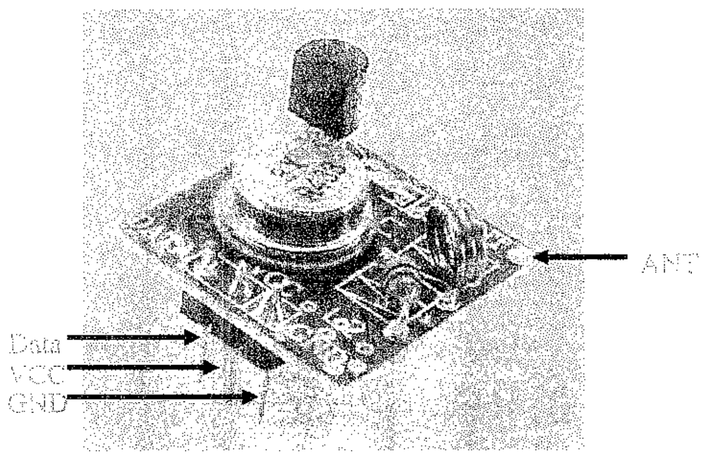
3. PRODUCT LAYOUT

3.1 RF_TX_315MHz



Label	Description
Data	The Data pin of the transmitter.
VCC	The power supply to the transmitter.
GND	The Ground of the transmitter.
ANT	The hole to solder and connect antenna. (Please select the correct antenna length, which is 24cm)

3.1 RF_TX_433MHz



Label	Description
Data	The Data pin of the transmitter.
VCC	The power supply to the transmitter.
GND	The Ground of the transmitter.
ANT	The hole to solder and connect antenna. (Please select the correct antenna length, which is 18cm)

4. GETTING STARTED

Solder the antenna to the RF Transmitter module; **please select the correct length with refer to specification of RF transmitter at Section 2.1, No. 9.** Connect the 3-pin header to your circuit so that the GND pin connects to ground of the circuit board, the VCC pin connects to VCC of the circuit board and the Data pin connects to your microcontroller's I/O pin. Please refer Cytron product, Sending Data using RF Module (Product code: PR16) for example application of RF transmitter module. The details description and schematics of PR16 can be downloaded from http://www.cytron.com.my/PR16.asp .

Note: The RF transmitter module should be use in pair with RF receiver module.

5. WARRANTY

- Product warranty is valid for 6 months.
- Warranty only applies to manufacturing defect.
- Damage caused by mis-use is not covered under warranty.
- Warranty does not cover freight cost for both ways.

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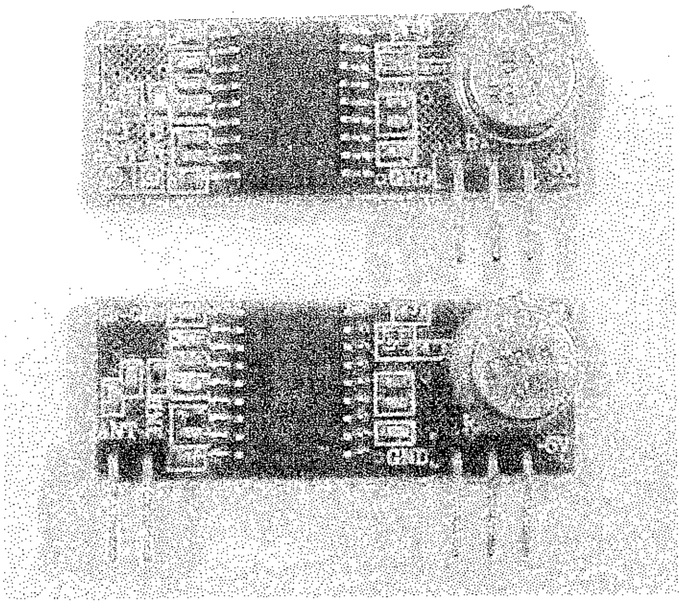
RF-RX-315
RF-RX-433
RF Receiver Module



User's Manual

V1.0

June 2008

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1. INTRODUCTION AND OVERVIEW

These RF receiver modules are very small in dimension. The low cost RF Receiver can be used to receive RF signal from transmitter at the specific frequency which determined by the product specifications. Super regeneration design ensure sensitive to weak signal. Cytron Technologies provides 2 types of RF Receiver Modules at either 315MHz or 433MHz for user:

Product Code	Description
RF_RX_315	RF Receiver 315MHz
RF_RX_433	RF Receiver 433MHz

The application includes:

- Industrial remote control, telemetry and remote sensing.
- Alarm systems and wireless reception for various types of low-rate digital signal.
- Remote control for various types of household appliances and electronics projects.

2. PRODUCT SPECIFICATION

2.1 The Specifications of RF Receiver

Except for the frequency and antenna length, RF_RX_315 and RF_RX_433 share the same product specifications as shown in table below:

No.	Specifications	RF Receiver
1.	Operating Voltage	5.0V ± 0.5V
2.	Operating Current	≤5.5mA @5.0V
3.	Operating Principle	Monolithic super heterodyne receiving
4.	Modulation	OOK/ASK
5.	Frequency	315MHz, 433.92MHz
6.	Bandwidth	2MHz
7.	Sensitivity	-100dBm
8.	Rate	<9.6Kbps (315MHz @-95dBm)
9.	Data Output	TTL
10.	Antenna Length	24cm (315MHz), 18cm (433.92MHz)

2.2 Antenna

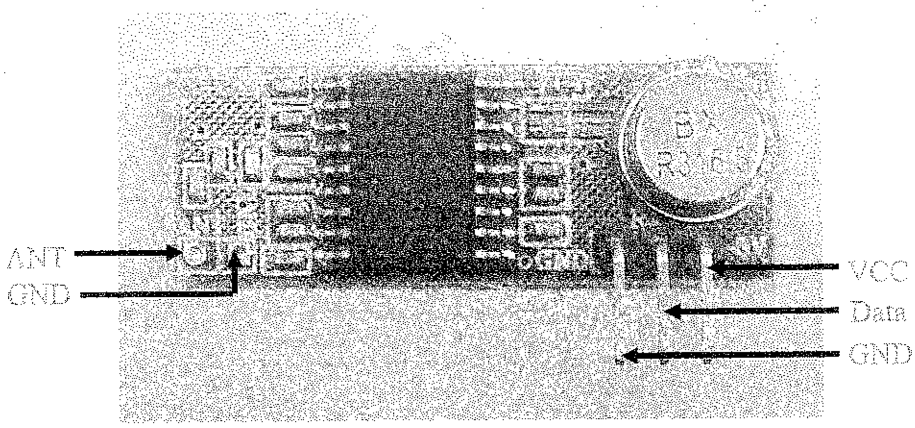
1. User may use any soft or hard wire (likes Drawbars antenna) as antenna. If the soft wire is used, do make sure it is fully extended. The distance of reception will be influence by the length of antenna; **please select the correct length with refer to specifications of RF Receiver above.** (Section 2.1, No. 10). Please keep the RF Receiver Module away from metal objects.

2.3 Important Notes

1. If the module is used with microcontroller, the clock frequency should be under 4MHz. Please try to keep a distance between oscillator and the RF Receiver module to avoid the disturbance from oscillator.
2. The voltage supply need to stable and the ripple voltage need to be as low as possible, multi-level filtering are needed. (For example, add ferrite bead, inductor and capacitor.)

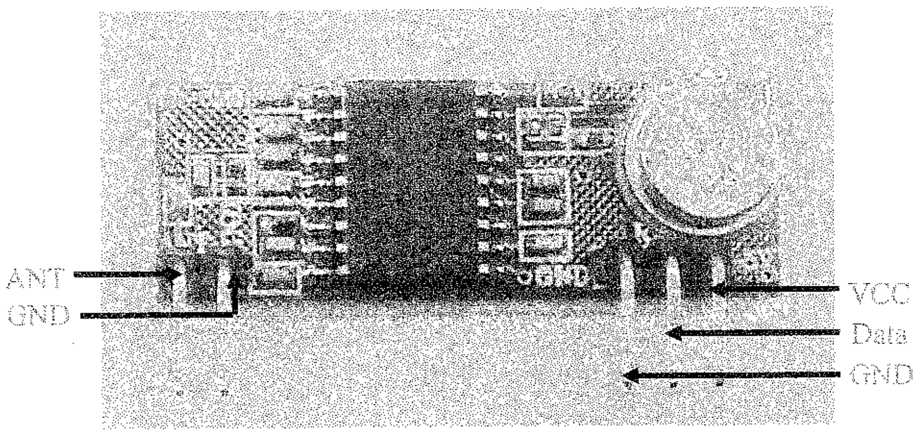
3. PRODUCT LAYOUT

3.1 RF_RX_315MHz



Label	Description
ANT	The hole to solder and connect antenna. (Please select the correct antenna length, which is 24cm)
VCC	The power supply (5V) to the receiver.
GND	The Ground of the receiver. (The 2 GND are internally connected each other.)
Data	The Data pin of the receiver.

3.1 RF_RX_433MHz



Label	Description
ANT	The pin to connect antenna. (Please select the correct antenna length, which is 18cm)
VCC	The power supply (5V) to the receiver.
GND	The Ground of the receiver. (The 2 GND are internally connected each other.)
Data	The Data pin of the receiver.

4. GETTING STARTED

Solder or connect the antenna to the RF Receiver Module, **please select the correct length with refer to specification of RF receiver at Section 2.1, No. 10.** There are 2 GND on the module which are internally connected each other. Connect the 3-pin header to your circuit so that the GND pin connects to ground of the circuit board, the VCC pin connects to VCC of the circuit board and the Data pin connects to your microcontroller's I/O pin. Please refer Cytron product, Sending data using RF module (Product code: PR16) for example application of RF Receiver. The details description and schematics of PR16 can be downloaded from http://www.cytron.com.my/PR16.asp

Note: The RF receiver module should be use in pair with RF transmitter module.

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- Product warranty is valid for 6 months.
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