UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS◆

JUDUL: **MULTI-PATIENT MONITORING SYSTEM USING A RELIABLE WIRELESS SENSOR PROTOCOL**

SESI PENGAJIAN: **2009/2010**

Saya **KOH KIM HO (861021-02-5659)**
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MULTI-PATIENT MONITORING SYSTEM USING A RELIABLE WIRELESS SENSOR PROTOCOL

KOH KIM HO

This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering (Hons.) (Electronics)

Faculty of Electrical & Electronics Engineering
Universiti Malaysia Pahang

NOVEMBER, 2009

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

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To my beloved parent, sister and brother

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ABSTRACT

Patient monitoring system is a monitoring system for providing continuous health monitoring of a patient. The aim is to collect and store important parameters of patient during critical period. In addition, it also helps to improve patient care and make early detection of medical emergencies. Previous monitoring systems are using wired system which can be seen right next to the patient. Now with wireless, nurses can monitor patients in distance. Next, too much of wire will easily cause accident. In addition, patient movements will also be limited. Therefore, wireless eliminates unsightly cables and patients can freely move around. Besides, wired system will cause the transmission delay problem. But, with wireless technology, the delay problem will be reduced.

ABSTRAK

Sistem pemantau pesakit merupakan satu sistem yang dapat menantau kesihatan pasakit secara berterusan. Tujuannya adalah untuk mengutip dan menyimpan parameter yang penting dari pesakit pada tempoh genting. Selain itu, sistem ini membantu untuk meningkatkan kebajikan pesakit dan membuat pengesanan awal terhadap kecemasan perubatan. Sistem pemantau terdahulu menggunakan sistem pendawaian yang hanya dapat dipantau bersebelahan dengan pesakit sahaja. Dengan mempunyai teknologi *wireless*, jururawat dapat memantau pesakit pada jarak jauh. Seterusnya, kemalangan senang berlaku jika terdapat kabel yang banyak. Tambahan lagi, pergerakan pesakit juga terhad. Oleh sebab itu, *wireless* mengingkirkan dawai supaya pesakit boleh bergerak sesuka hati. Selain itu, sistem kabel mengakibatkan masalah penangguhan penghantaran data. Akan tetapi, teknologi *wireless* dapat menguragkan masalah ini.

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LIST OF SYMBOLS

GUI	Graphical User Interface
PC	Personal Computer
V	Volt
DC	Direct Current
MHz	Mega Hertz
EIA	Electronics Industries Association
ADC	Analog to Digital Converter
TE	Transmission Enable
VT	Valid Transmission
USB	Universal Serial Bus
cc	Clock Cycle
°C	Degree Celsius
RF	Radio Frequency
GND	Ground
Vcc	5V DC
EEPROM	Electrically Erasable Programmable Read-Only Memory
FM	Frequency Modulation
LED	Light Emitting Diode
bps	Bit per Seconds
ASCII	American Standard Code for Information Interchange
GSM	Global System for Mobile communication
GPS	Global Positioning System

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Multi Patient Monitoring System is a wireless based biomedical monitoring system. Wireless technology is now widely used in communication area to facilitate information transfer and exchange. This wireless technology is applied in Multi Patient Monitoring System in order to eliminate the use of cables, which provide enormous for patients. Multi Patient Monitoring System can be applied in a variety of health care scenarios such as paramedic, diagnostic, surgical, and post-operative phases.

In order to that, a sensor is required to acquire medical parameter from patient. Recently, biomedical sensors are introduced in digital world. Digital sensor has advantages over analog sensor such as greater accuracy and resolution. In addition, the digital sensor requires minimum reading time compared to its compatriot. Moreover, digital signal has greater noise immunity. In fact, the chance for data loss and data error will be greatly reduced. Nowadays, biomedical sensors are increasingly used in monitor biological parameters for patient and detect abnormal biological changes.

But the system needs a brain for signal processing. Hence, a reliable microcontroller is implemented in this project. Embedded controller technology has continuously improved in functionality, performance and power consumption. Microcontroller is now integrated with some extra component to increase the functionality and execute at high frequency to improve the system performance. The power consumption are greatly reduced in order to increase the time of operation when operate with battery.

Besides, sophisticated software for user interface is important. Graphical User Interface (GUI) is a type of user interface application that allows people easily to interact without typing complex command. GUI provides graphical icons and visual indicators for the users easier to learn and use. In addition, GUI has the capability of multitasking which can perform several tasks simultaneously. This advantage, undoubtedly increase the efficiency of the monitoring system tremendously.

1.2 Project Objective and Scope

The objective of this project is to develop a Multi-Patient Monitoring System. This system capable of monitoring several parameters of each patient and send these data to central unit so that these parameters can be displayed and stored on the main station. These parameters are continuous monitored and updated in defined function or interval set by the system.

In order to provide a simple, high performance and stand alone system, wireless technology is explored in the design and allows patients to move freely without any cable attach to his body. This obviously offers versatility and flexibility to the system.

In order to achieve the project objective, the scope of project are summarise as follow:

- Microcontroller system to control the operation of control centre and patient remotes
- Radio frequency transceiver system to transmit and receive data using radio wave
- Sensory module to acquire medical parameter from patient
- GUI to display and update the status of patient continuously

1.3 Thesis outline

The thesis is orderly organized into 6 chapters and they are outlined as below:

Chapter 1 introduces various technologies that invent recently. It also outlines objective and scope of this project.

Chapter 2 describes the architecture and basic operation of the project. It gives a brief review of microcontroller system board architecture, wireless communication module, sensor module and serial communication module.

Chapter 3 provides description and discussion on the design of the hardware of each module in the systems. The module consists of microcontroller board, sensor, encoder and decoder, transceiver and serial communication.

Chapter 4 indicates the development of the software of each module and system operation as well as GUI development. This chapter also includes the flowchart of each module.

Chapter 5 presents various testing and results that are conducted to each module. This chapter also includes the complete circuit diagram and programming.

Lastly, Chapter 6 summarise the overall conclusion for this thesis and a few suggestion and recommendation for future development.

CHAPTER 2

SYSTEM ARCHITECTURE AND OPERATION

2.1 Introduction

A basic block diagram of Multi-Patient Monitoring system is shown in Figure 2.1 where temperature of both patients is monitored at control centre. Medical temperature sensor is implemented in both patient modules. The sensors read current body temperature of each patient and display on PC using GUI. The temperature reading will be updated every minute and logged into database.

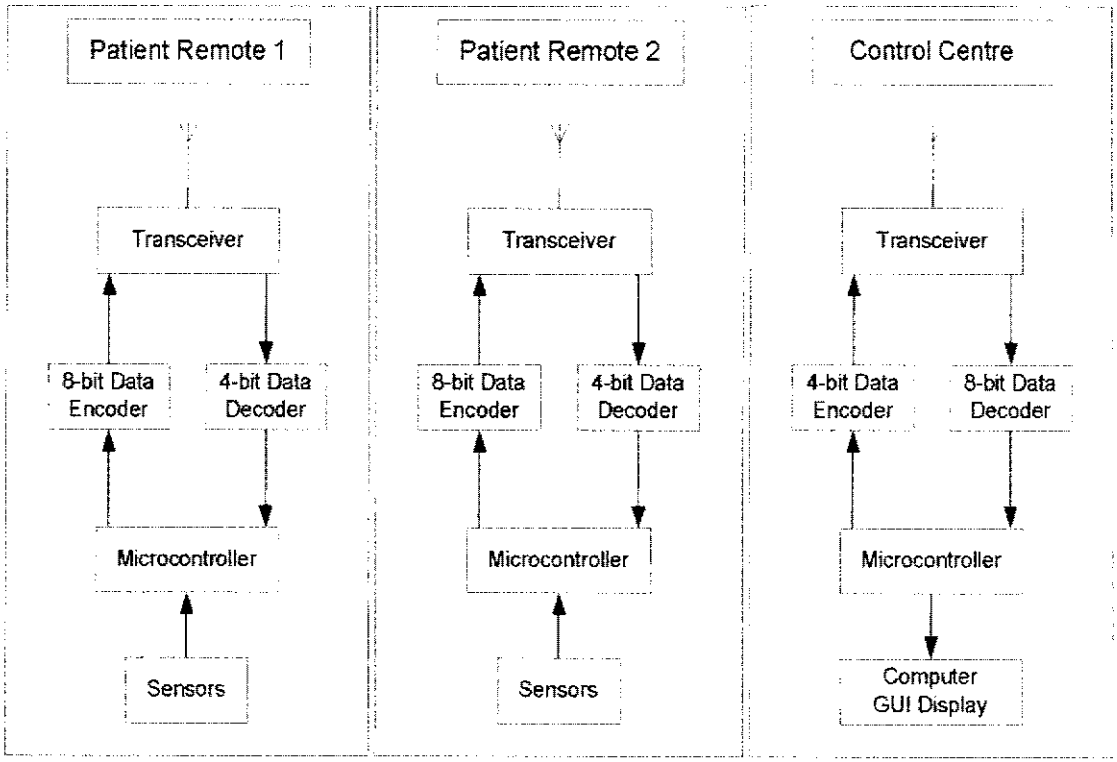

Figure 2.1: Block Diagram of Remote Multi-Patient Monitoring System

2.2 Microcontroller System Board Module

Microcontroller is the brain of the system. Microcontroller MC68HC11A1 is chosen to implement in this project due to its high performance, high speed, low power consumption, various function and features. Furthermore, MC68HC11A1 is operating in bootstrap mode because it does not require extra input and output ports. Bootstrap mode allows the programs to be loaded into internal EEPROM. The block diagram of system board as shown in Figure 2.2 consists of power circuit, reset circuit, clock circuit and EIA232 module. Power circuit is needed to provide constant and stable 5V DC voltage to the system while reset circuit is used to initialize the microcontroller process into its normal operation. Clock circuit is required to supply constant 2 MHz clock speed. EIA232 module is important to communicate serially between microcontroller and computer.

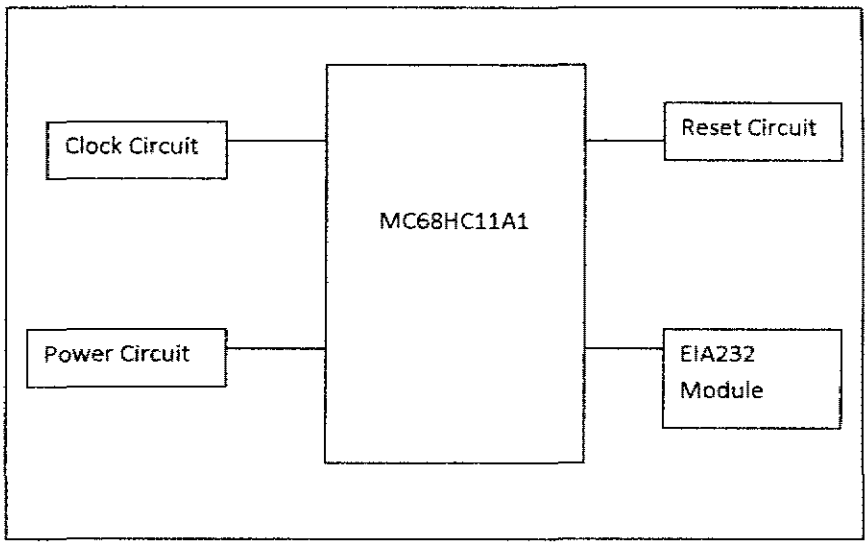

Figure 2.2: Block Diagram of Microcontroller Board Module

2.3 Sensor Module

TSic 301 as indicated in Figure 2.3 is used in this project to read the body temperature of patient. It is an integrated circuit sensor that can be used to measure temperature with an electrical output which is proportional to the temperature in degree Celsius. The output of this sensor is measured in analog voltage. The output of TSic 301 is then amplified by scale of 5 and connected to the internal ADC of microcontroller.

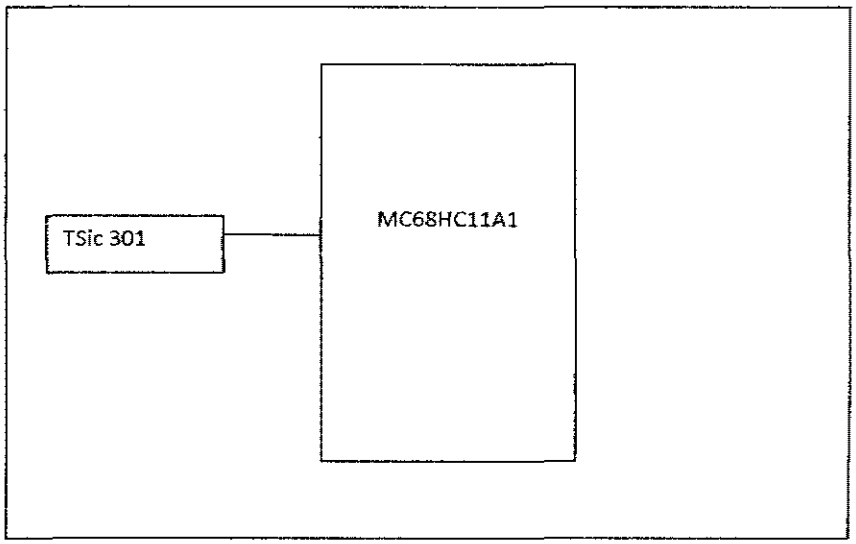

Figure 2.3: Block Diagram of Sensor Module

2.4 Wireless Communication Module

A basic block diagram of wireless communication module is shown in Figure 2.4. The transceivers that operate at 433 MHz is chosen as the medium of transferring data. Transceiver transfer data using Amplitude Shift Keying (ASK) modulation technique.

Data encoder read parallel data from microcontroller and manipulates it into serial format before transmits using transceiver. At the other side, the data decoder will receive the signal from transceiver. Data decoder then decodes the serial data and regenerates the original data in the parallel form.

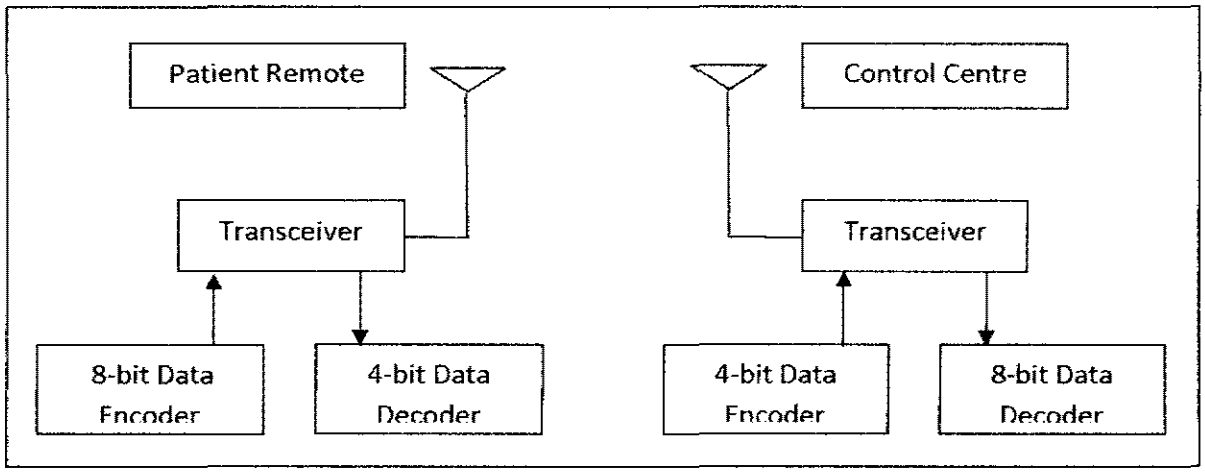

Figure 2.4: Block Diagram of Wireless Communication Module

2.4.1 Encoder and Decoder Module

Data encoder is used to change a parallel data into serial data. The data may serve any of a number of purposes such as compressing information for transmission or storage, encrypting or adding redundancies to the input code, or translating from one code to another. Data encoder that implemented in this project is HT640 and HT12E. HT640 is capable to encode 18 bits of information which consists of 10 address bits and 8 data bits. While HT12E is capable to encode 12 bits of information which consists of 8 address bits and 4 data bits. The application flexibility of this encoder is enhanced by the capability to select a TE trigger type.

Data decoder is a device which does the reverse of encoder. It is undoing the encoding to reproduce information. HT648 and HT12D are chosen as the data decoder in this project. HT648 is paired with the HT640 encoder. This decoder is capable of decoding 18 bits of information that consists of 10 bits of address and 8 bits of data. HT12E is paired with the HT12E encoder. This decoder is capable of decoding 12 bits of information that consists of 8 bits of address and 4 bits of data. Decoder receives serial data from that series of encoder and compares the serial input data twice continuously with its local address. The input data codes are decoded and transferred to output pins if no errors codes are encountered. At the same time, valid transmission (VT) is trigger high.

2.4.2 Transceiver Module

Transceiver is an electronic device which has the function of transmit and receive data. Transceiver propagates an electromagnetic signal with the aid of an antenna. Transceiver modulates the incoming signal information onto carrier frequency before it is transmitted. On other hand, transceiver demodulates the incoming signal information together with carrier frequency at receiver end. Transceiver used in this project is known as RTX MID 5V. It is able to transmit analogue or digital data over 200 metres. It is chosen because of its small size and the capability to transmit in high data rates. This type of transceiver is operated in frequency of 433MHz.

2.5 Serial Communication Module

There are several ways to communicate with PC such as using parallel port, serial port or Universal Serial Bus (USB). For this system, serial port is chosen to communicate with computer. In order to communicate via serial port, EIA232 module is required. EIA232 module is a standard protocol for transferring data via serial communication.

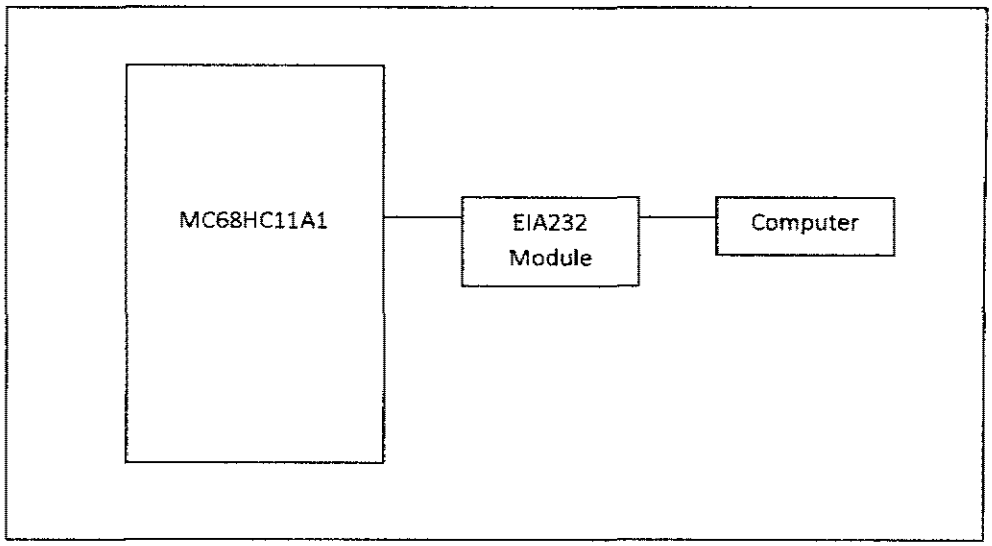

Figure 2.5: Block Diagram of Serial Communication Module

CHAPTER 3

HARDWARE DESIGN

3.1 Introduction

The hardware design consists of microcontroller board module, wireless communication module, encoder and decoder module, sensor module, and serial communication. The system board is designed to operate in Bootstrap Mode due to size and cost.

3.2 Microcontroller System Board Module

The microcontroller MC68HC11A1 is operating in Bootstrap mode. Hence, both MODA and MODB pins are grounded as shown in Figure 3.1. Microcontroller Board Module consists of power circuit, reset circuit, clock circuit, and EIA232 module. They are very important to support the basic operation of microcontroller.

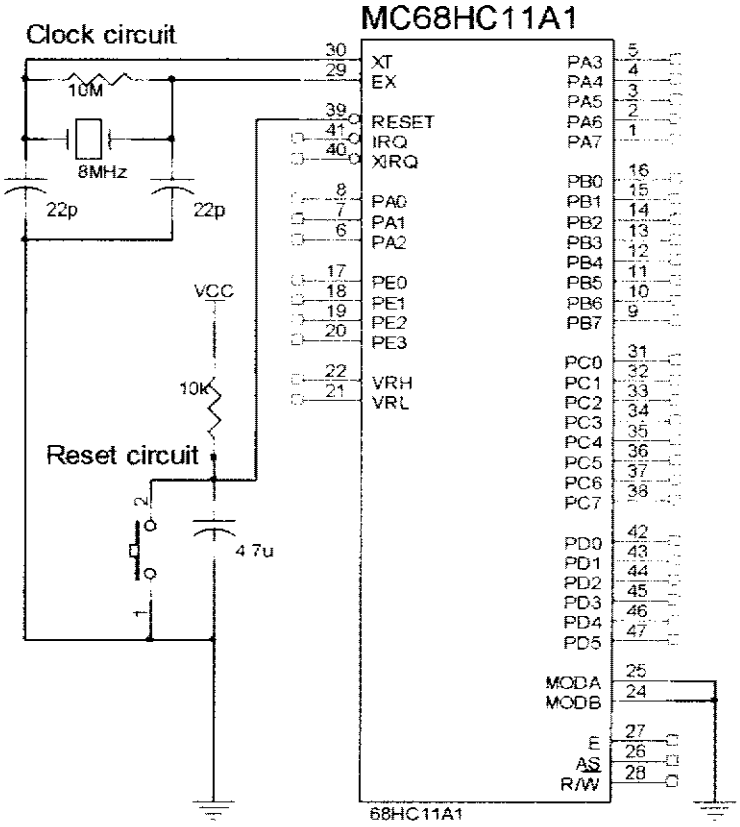

Figure 3.1: Microcontroller System Board Circuit

3.2.1 Power Circuit

A regulator is needed to provide a constant and stable 5V DC. Electronic devices are sensitive to the supply voltage especially microcontroller. Any unstable voltage supply can easily cause damage the electronics component. In this project, voltage regulator LM7805 is used to regulate 5V DC voltage. Figure 3.2 shows the schematic diagram for power circuit.

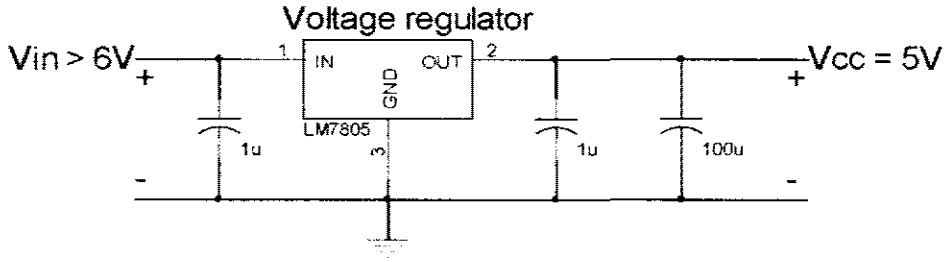

Figure 3.2: Power Circuit

3.2.2 Clock Circuit

Crystal oscillator provide stable and constant clock signal at high frequency. In this project, an 8 MHz crystal is used to produce 2 MHz output clock cycle. The clock circuit is connected to the pin XTAL and EXTAL at the microcontroller. Figure 3.3 shows the schematic diagram of clock circuit.

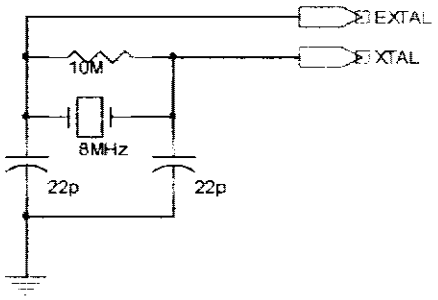

Figure 3.3 Clock Circuit

3.2.3 Reset Circuit

Reset circuit is used to reset the microcontroller process. The reset process occur by simply pressing the push button and this will causes the signal to be pulled low, thus forcing a reset on microcontroller. For microcontroller 6811, the reset operation must be longer than 6 clock cycle (cc) so that the system can distinguish from internal reset. Hence, the value of resistor and capacitor must be chosen properly so that the reset circuit can produce output greater than 6cc. The reset circuit is shown in Figure 3.4.

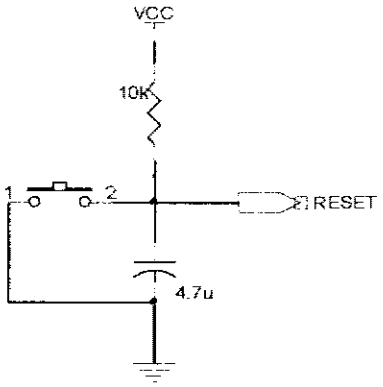

Figure 3.4: Reset Circuit

3.2.4 EIA 232 Module

MAX233 is connected to system to allow the microcontroller to communicate with computer through serial port. MAX233 is used to connect between computer and microcontroller to load program into EEPROM of microcontroller. Figure 3.5 shows the schematic diagram of EIA232 module.

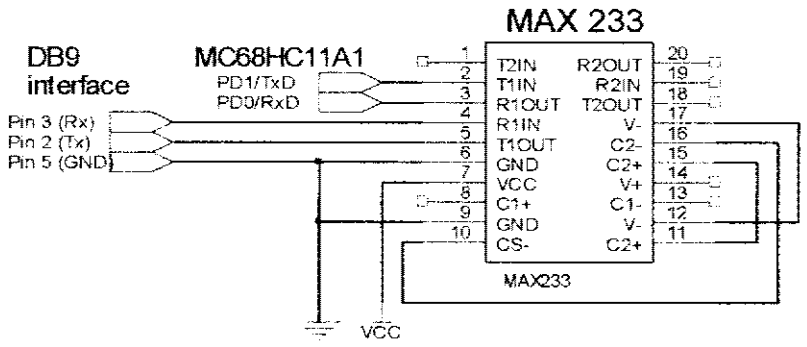

Figure 3.5: EIA232 Circuit

3.3 Sensor Module

TSic 301 plays an important role for temperature measuring in this project. The output voltage of TSic 301 is linearly proportional to the Celsius (Centigrade) temperature. TSic 301 provides typical accuracies of ± 0.3°C at room temperature and having resolution of 0.1°C. In this project, TSic 301 senses current body temperature of patient and send the analog information to microcontroller through port E. Analog to digital converter (ADC) in port E will converts the analog signal into digital signal. Figure 3.6 indicates the schematic diagram of temperature sensor circuit.

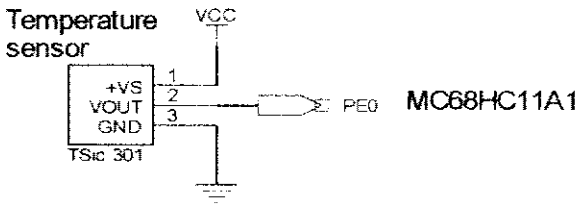

Figure 3.6: TSic 301 Circuit

3.4 Encoder and Decoder Module

One of the disadvantages of using RF system is it exposed to all users that use the same frequency. In order to ensure only the intended receiver receives the signal, the encoder and decoder pair are used. In addition, the module is also used to convert the parallel signal to serial signal.

3.4.1 Encoder

Various type of encoder is available in the market. However, HOLTEK product of HT640 and HT12E are chosen due to cost, performance, power consumption and easy to use.

3.4.1.1 Encoder HT640

Encoder HT640 is able to operate in 2.4V to 12V voltage range. Encoder HT640 consumes low power and is applicable for remote control system applications. In this case, the programmable address or data are transmitted together with the header bits via an RF transmission medium upon receipt of a trigger signal on the TE line. When the transmission enable line (TE) is pulled high, the encoder begins a three-word transmission cycle. As long as the TE line is pulled high, this cycle will repeat itself. The encoder output will completes its final cycle once TE falls low. The encoder scans and transmits the status of the 18 bits of address or data serially in the order A0 and A9 as well as D0 to D7 when a transmission enable signal is applied Figure 3.7 represents the schematic diagram of encoder HT640 circuit.

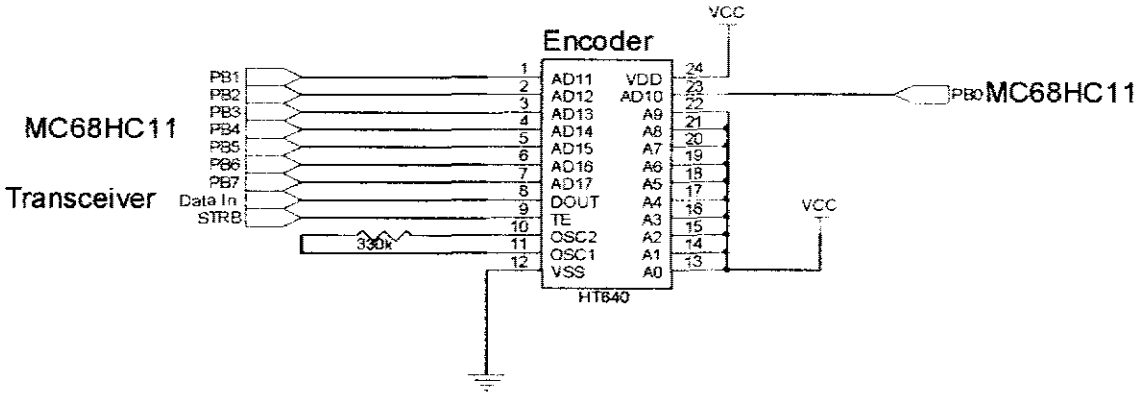

Figure 3.7: Encoder HT640 Circuit

3.4.1.2 Encoder HT12E

Encoder HT12E is able to operate in 2.4V to 12V voltage range. In this case, the programmable address or data are transmitted together with the header bits via an RF transmission medium upon receipt of a trigger signal on the TE line. When the TE is pulled low, the encoder begins a four-word transmission cycle. As long as the TE line is pulled low, this cycle will repeat itself. The encoder output will completes its final cycle once TE falls low. The encoder scans and transmits the status of the 12 bits of address or data serially in the order A0 and A7 as well as D0 to D3 when a transmission enable signal is applied Figure 3.8 represents the schematic diagram of encoder HT12E circuit.

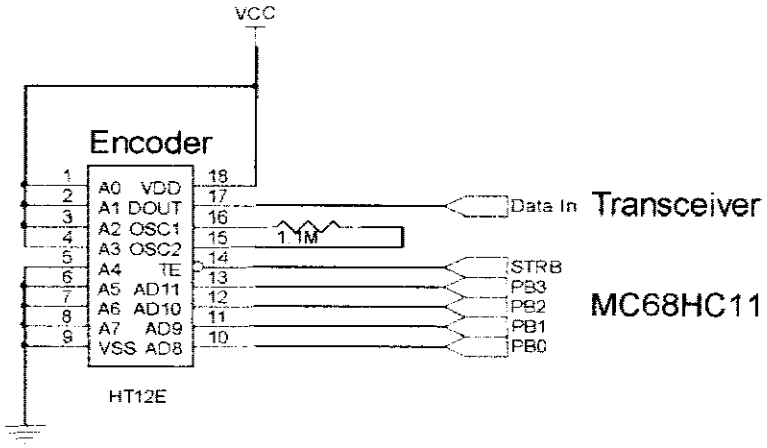

Figure 3.8: Encoder HT12E Circuit

3.4.2 Decoder

Decoder like encoder, HOLTEK product is used in this case is HT648 and HT12D.

3.4.2.1 Decoder HT648

HT648 decoder is paired with HT640 encoder in this project. Thus, it is capable to receive serial address and data from the encoder that are transmitted by a carrier using an RF transmission medium. Then, it compares the serial input data twice continuously with its local address. The input data codes are decoded if no errors or unmatched codes are encountered. Then, the data are transferred to the output pins. At the same time, VT pin goes high to indicates a valid transmission and vice versa. As HT640, the decoder is capable of decoding 18 bits of information that consists of 10 bits of address and 8 bits of data. For this project, the pins A0 to A7 of decoder are connected to Vcc and pins A8 to A9 are controlled by microcontroller to match the address from encoder. Figure 3.9 represents the schematic diagram of decoder circuit.

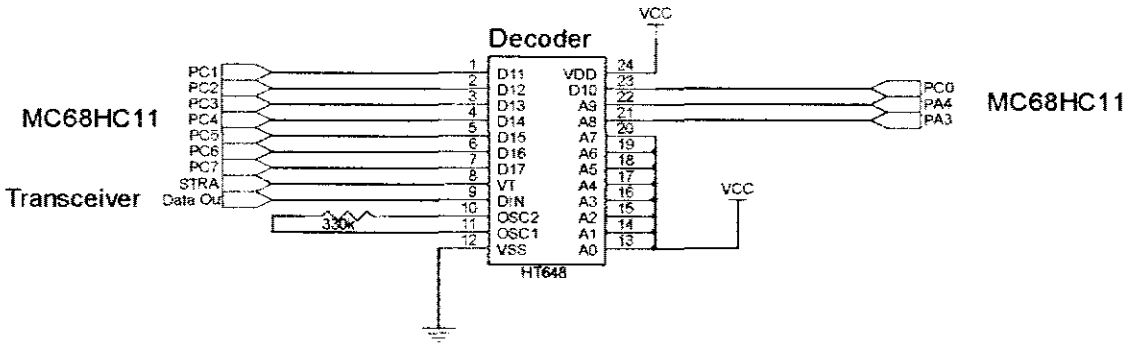

Figure 3.9: Decoder HT648 Circuit

3.4.2.2 Decoder HT12D

HT12D decoder is paired with HT12E encoder in this project. HT12D received the incoming data and compares the serial input data twice continuously with its local address. The input data codes are decoded if no errors or unmatched codes are encountered. Then, the data are transferred to the output pins. At the same time, VT pin goes high to indicates a valid transmission and vice versa. As HT12E, the decoder is capable of decoding 12 bits of information that consists of 8 bits of address and 4 bits of data. For this project, pins A0 to A3 of decoder are connected to Vcc and pins A4 to A7 of decoder are connected to GND to match the address from encoder. Figure 3.10 represents the schematic diagram of decoder circuit.

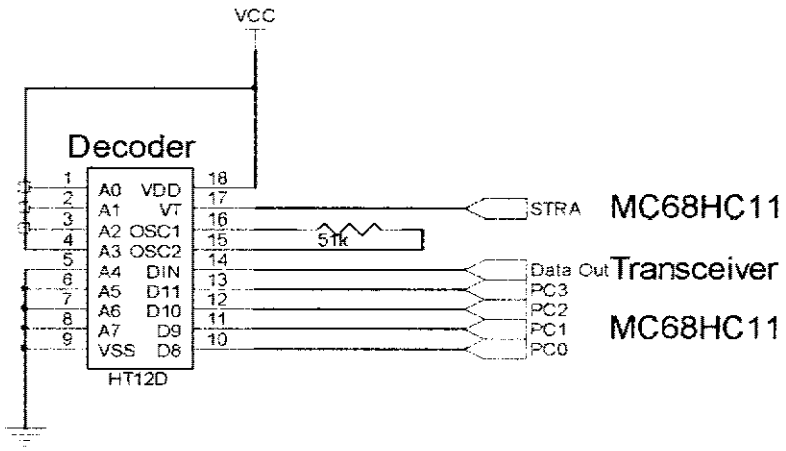

Figure 3.10: Decoder HT12E Circuit

3.5 Transceiver Module

In order to transmit a signal through radio wave, a pair of transceiver are used at both ends. Transceiver RTX MID 5V shown in Figure 3.11 is capable to transmit and received analogue or digital data over 200 metres. The features of this transceiver include small in size and high data rates. Pin 1 of transceiver is connected to antenna. Pin 2 and pin 7 of transceiver are grounded. 5V is supplied to pin 10 of transceiver. Pin 4 can accept serial data from encoder and ready to transmit. While, pin 9 lead the serial data that received to the decoder. The pin 5 is used to select transceiver to transmit or receive data. If pin 5 triggers high, transceiver will transmit the data and vice versa. Pin 6 is used to enable and disable the action of transmit or receive data. If pin 6 triggers high, the transceiver will perform transmit or receive action and vice versa. The antenna is located directly out the top of the system in order to reach the maximum transmission range.

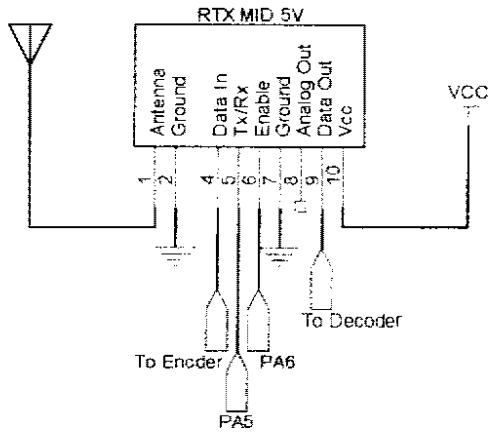

Figure 3.11: Transceiver Circuit

3.6 Serial Communication Module

In this project, microcontroller has to send data to computer and display the data on GUI. Since serial communication is selected to communicate with computer, EIA232 module is required. EIA232 module is a standard protocol for data transferring via serial communication. MAX 233 is used to achieve the standard of EIA232. A basic circuit of MAX 233 is shown in Figure 3.5. MAX 233 is connected to pin TxD and RxD of microcontroller to enable data to be transmitted serially for a longer distance.

CHAPTER 4

SOFTWARE DEVELOPMENT

4.1 Introduction

Two difference programming language is applied in this project which are assembly language and high level language. Microcontroller MC68HC11 is programmed using assembly language due to the efficiency of the system as limited internal memory is awardable to store the program. On other hand, high level language is applied in developing GUI due to the complexity of program flow for analysis and logging the data.

4.2 Assembly Language

For microcontroller MC68HC11A1, the program is written in assembly language and is assembled by using AS11 assembler as shown in Figure 4.1. The object code (S19 file) is generated from the assembler. This object code is then downloaded into internal EEPROM of microcontroller via Serial Communication Port (COM1 to COM4). Then, machine code is downloaded through this interface by using communication software, which is WP11 as shown in Figure 4.2.

There are few steps that must be followed by user before the program can be downloaded into microcontroller. Firstly, hardware must be initialized by clicking the 'Initialize Device' button. Then, the reset button is pressed on the hardware in order to terminate all the running system. This is followed by a simple clicking on 'Erase EEPROM' button. Since, the EEPROM is empty and it is ready for downloading the program. Finally, the 'Program EEPROM' button is used to download program into microcontroller. When downloading process is completed, TxD and RxD lines must be shorted to ensure the proper operation of the system.

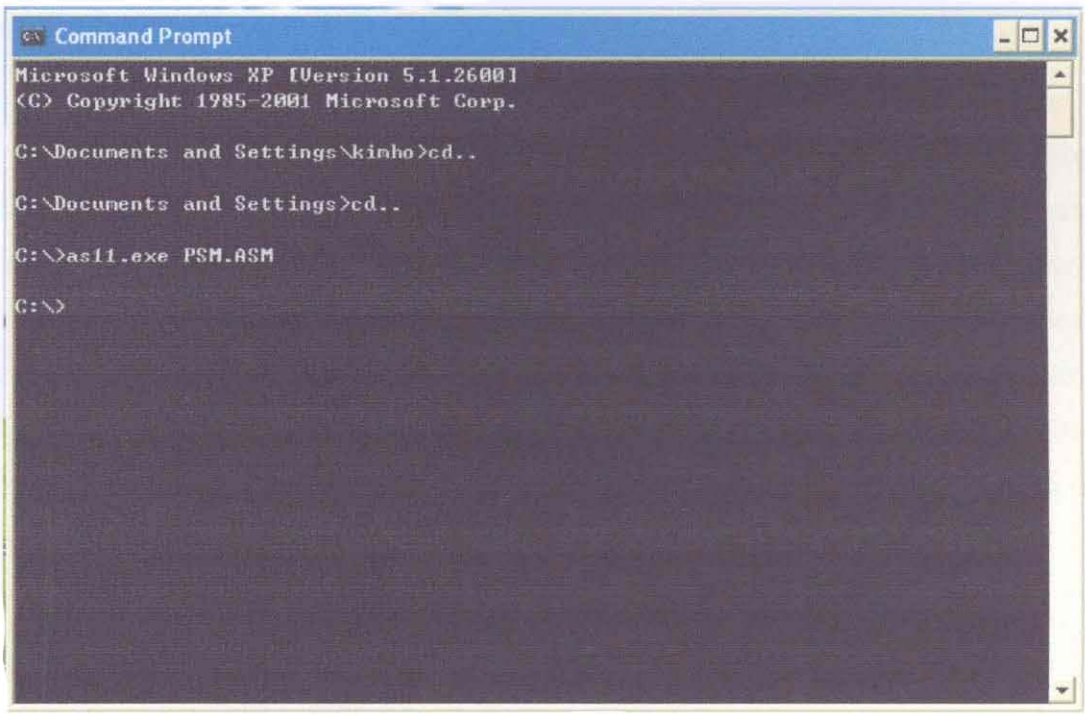

Figure 4.1: AS11 Assembler

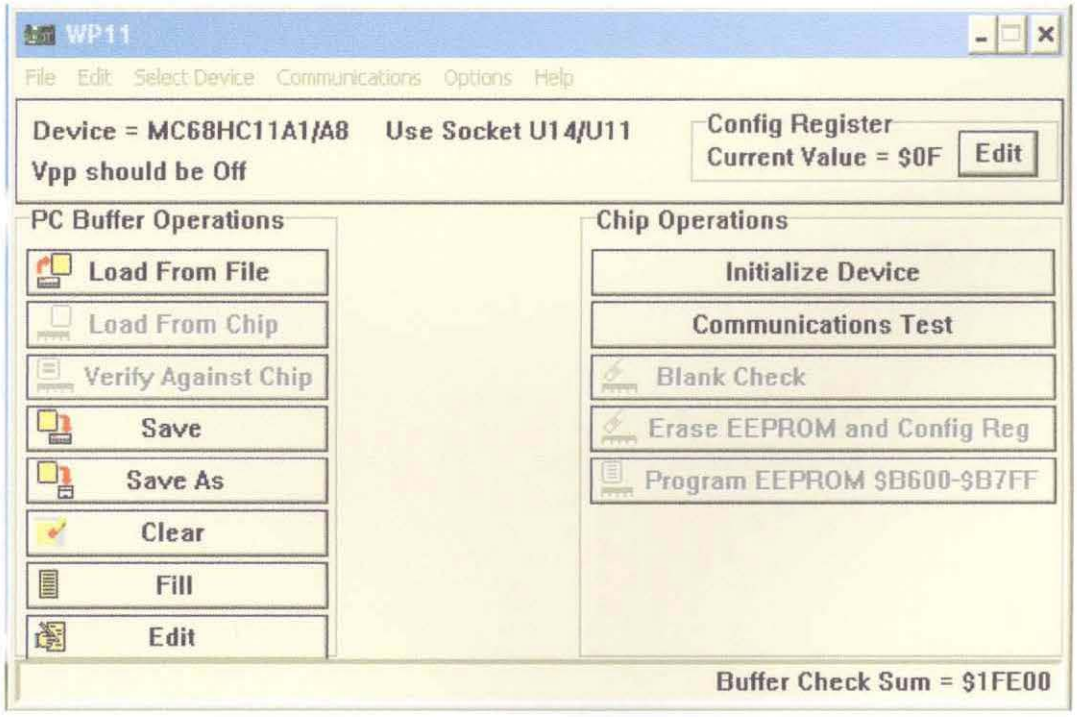

Figure 4.2: WP11 Communication Software

4.2.1 Patient Remote Software Development

Once the system is powered up, patient body temperature is sensed by temperature sensor (TSic 301). The reading is then amplified by scale of 5 and sent to microcontroller for manipulation purpose. Temperature reading then is converted to digital form by using internal Analog-to-Digital Converter (ADC). These conversions cause the reading of temperature represented in 8-bit binary forms. Then, the reading is encoded into serial data using encoder and transmit the data using transceiver. Figure 4.3 shows the simple flow chart to indicate the operation of both patient located distances away from central unit.

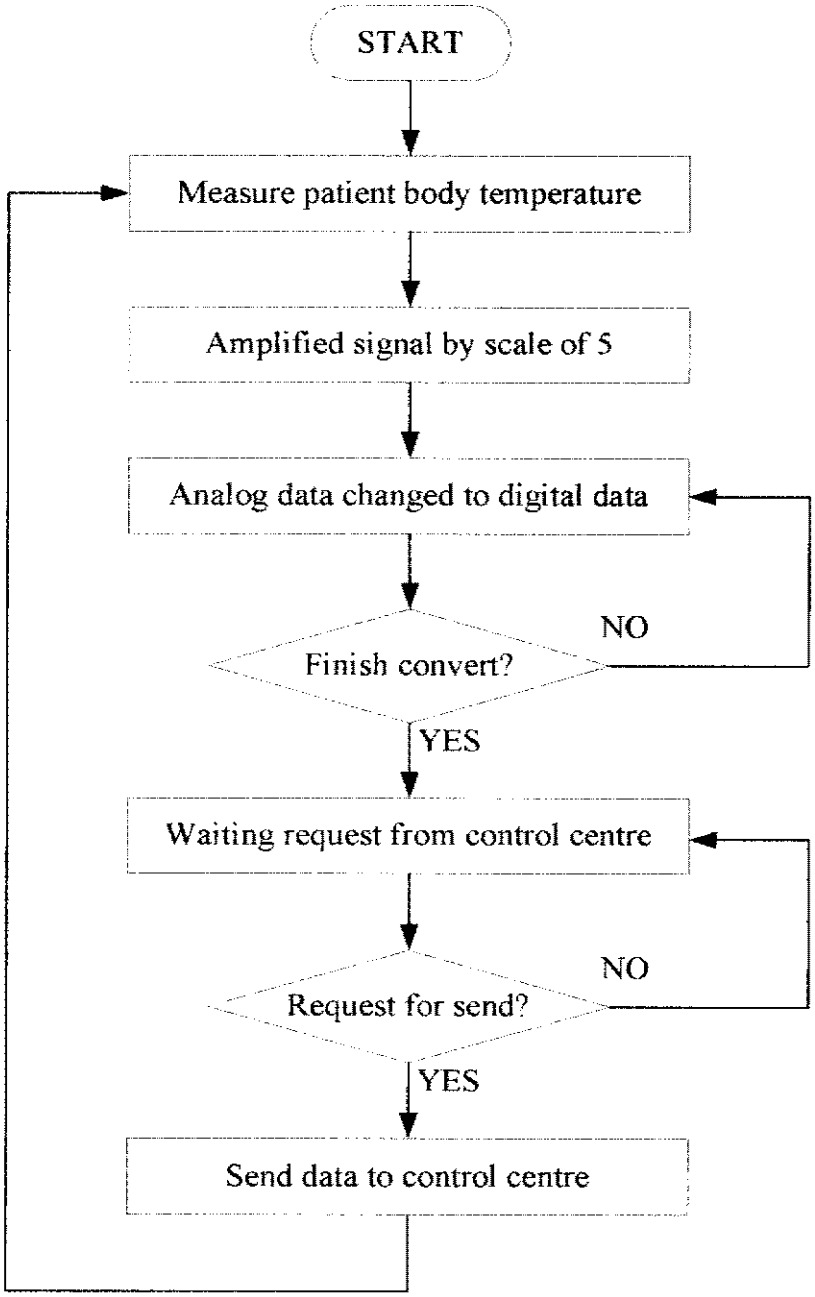

Figure 4.3: Flow Chart of Patient Remote

4.2.2 Control Centre Software Development

In control centre, microcontroller is initially requests data from sub system in patient remote 1. After received the data from sub system, the data are and examined to ensure they are free of error. Once the data are identified, the data are decoded by decoder. Then, similar process is repeated to the other patient remote 2 sub system. After both data are successfully received, the data are manipulated and send to computer via serial communication. Figure 4.5 is a simple flow chart indicates the operation of control room.

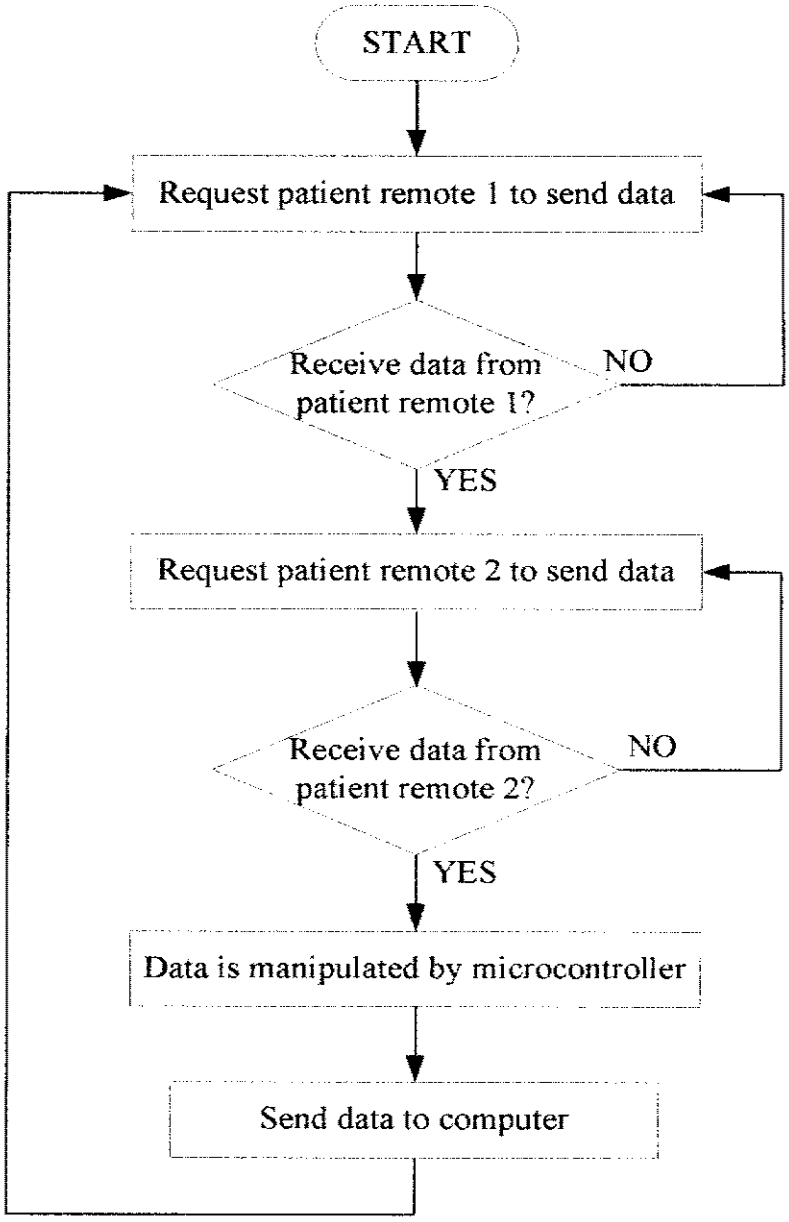

Figure 4.4: Flow Chart of Control Centre

4.3 High Level Language

High level programming language is a user friendly programming language. This language is easy to learn because the programming statement is similar with English statement. In fact, user can easily understand the programming language.

4.3.1 GUI Software Development

In this project, GUI is developed using Microsoft Visual Basic 6.0. The GUI consists of two pages which is Form 1 and Form 2. Form 1 will be shown when the program is launched as shown in Figure 4.5. Form 1 is used to select the COM port. The program will automatically search the available COM port. The flow chart of Form 1 is shown in Figure 4.6.

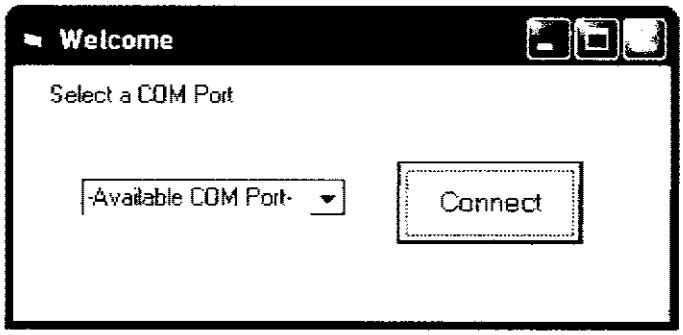

Figure 4.5: Form 1

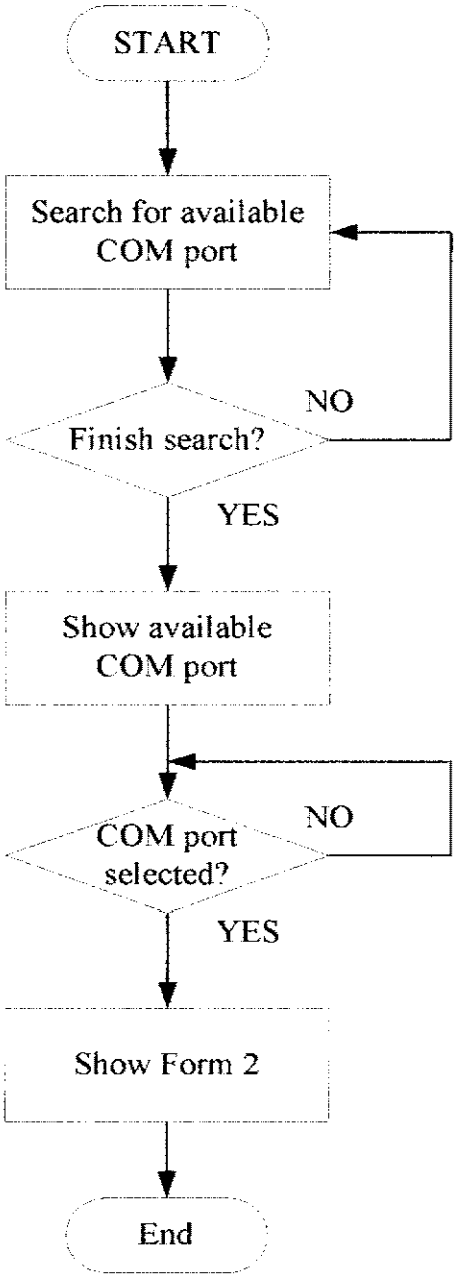

Figure 4.6: Flow Chart of Form1

After select the proper COM port, Form 2 will pop up as shown in Figure 4.7. At this moment, the process of monitoring begins when the 'START' button is clicked. The system reads the data from microcontroller and converts it into actual temperature reading. This temperature reading is displayed and updated on text and graph. At the same time, the temperature reading is logged once every minute together with the date and time. All the reading will be logged into Microsoft Excel Application. A new Microsoft Excel file will be created every time the application is launched. In addition, the user is allowed to enter or change the patient name. The name of patient also will be stored. The flow chart of Form 2 is shown in Figure 4.8.

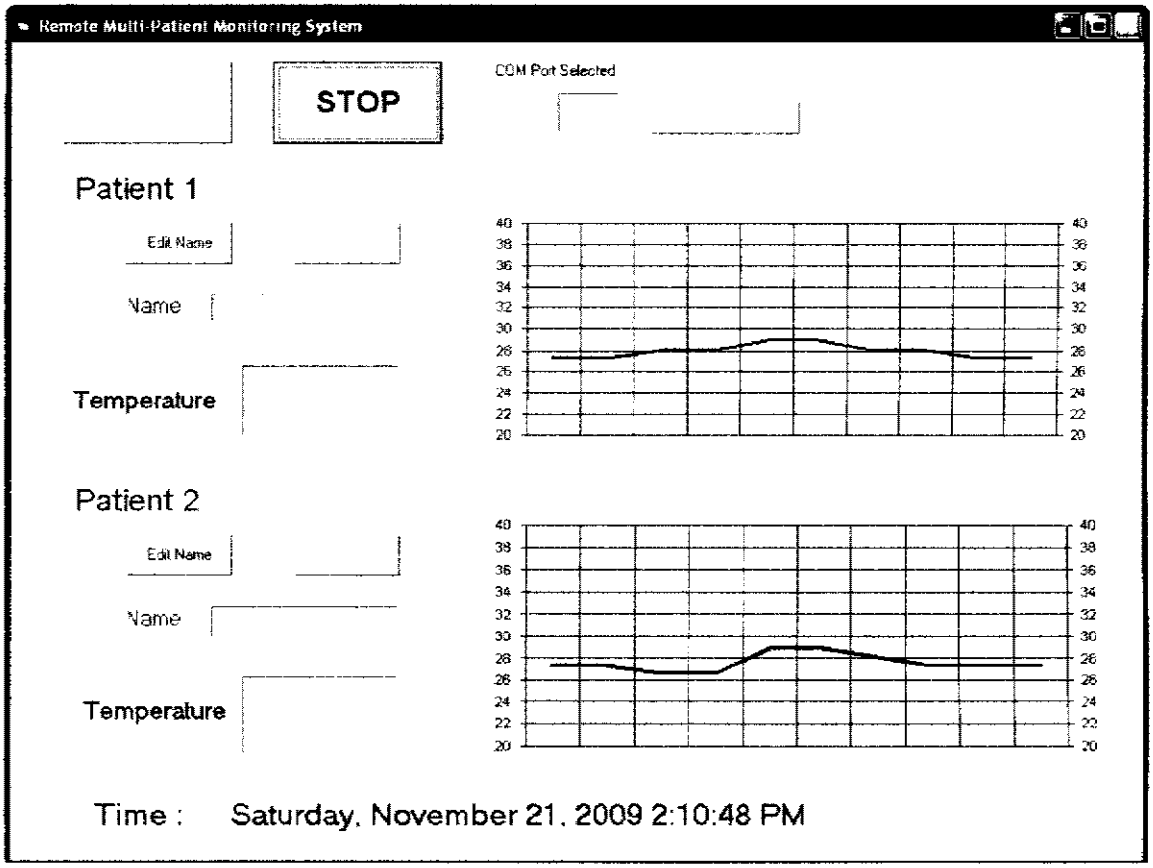

Figure 4.7: Form 2

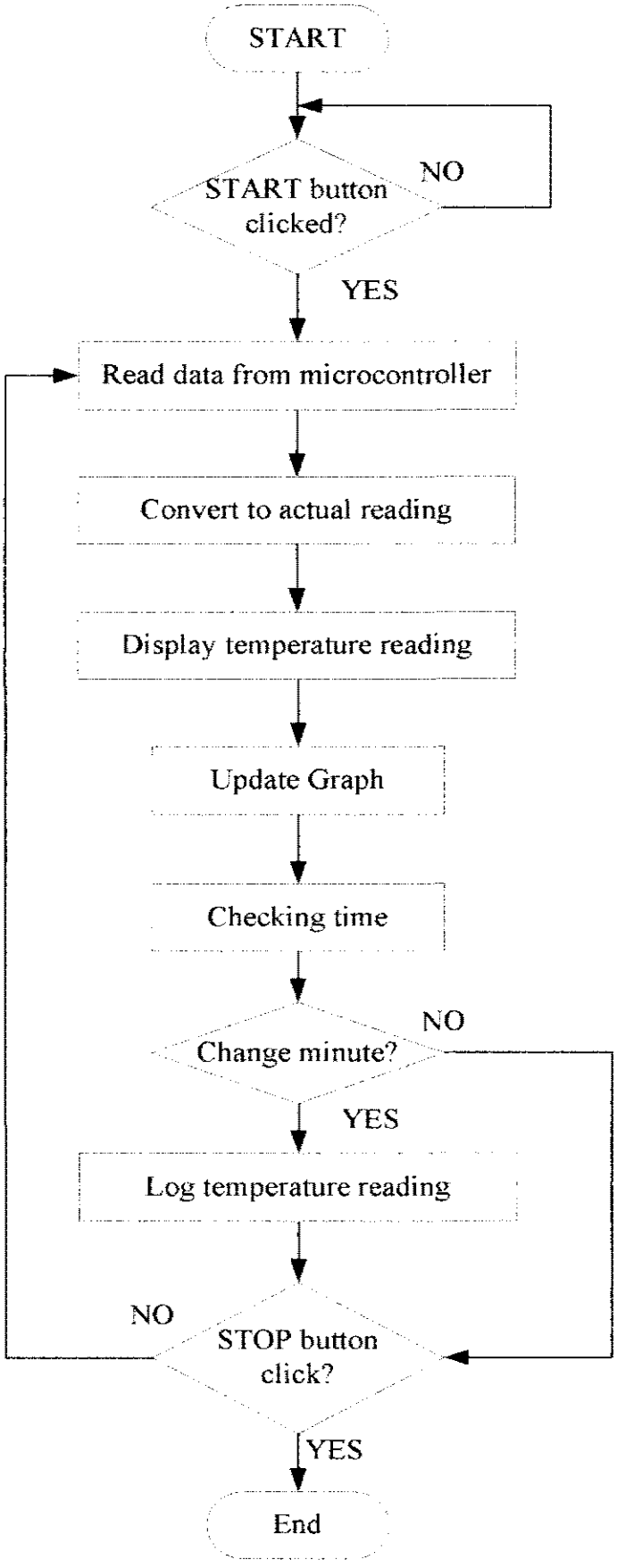

Figure 4.8: Flow Chart of Form 2

CHAPTER 5

TESTING AND EVALUATING RESULT

5.1 Introduction

Several testing have been performed during the development of this system. The approach taken in executing the various tests is discussed in this chapter.

In developing Remote Multi-Patient Monitoring System, various tests are conducted. The tests are sensory module testing, wireless communication testing as well as serial communication testing. Finally, each module is integrated into a single system to produce a fully functioning Remote Multi-Patient Monitoring System.

5.2 Microcontroller System Board Testing

Microcontroller MC68HC11A1 system board is shown in Figure 5.1. A simple program as shown in Figure 5.2 is executed by microcontroller. As the result, a simple alternate light glowing is produced. This verifies that microcontroller system is functioning successfully.

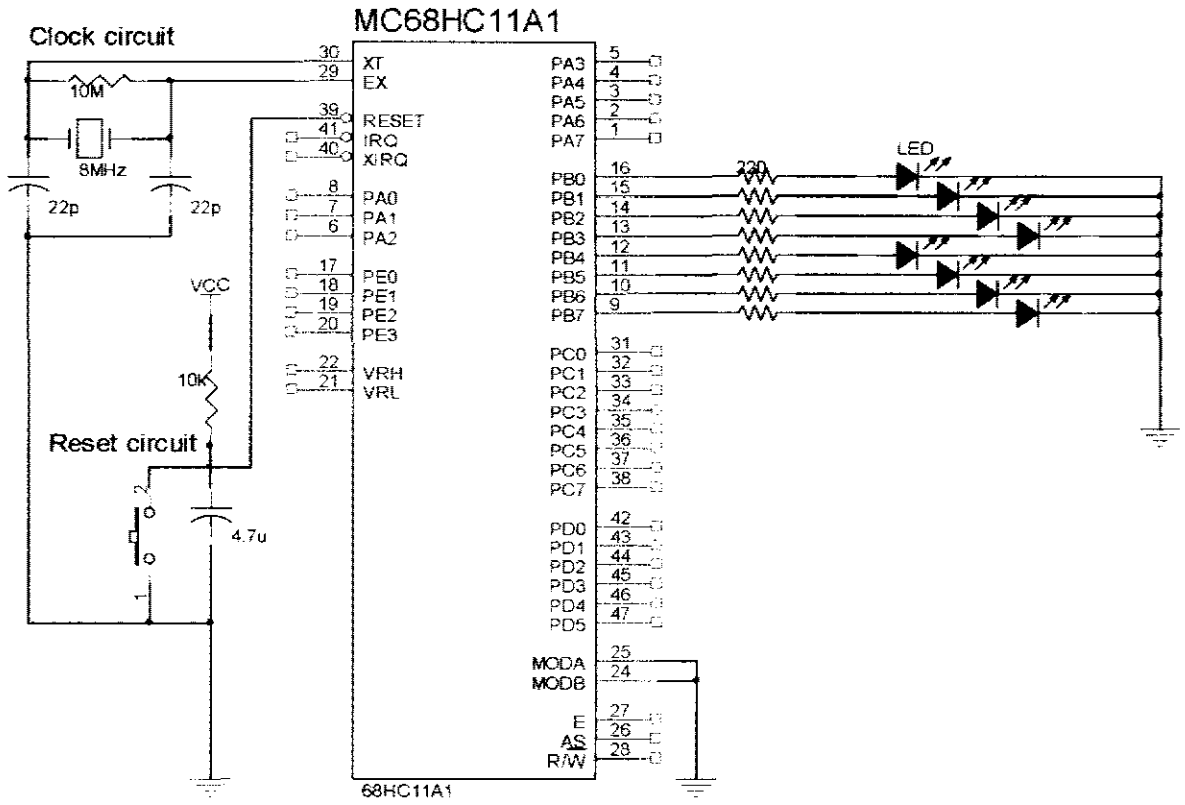

Figure 5.1: Microcontroller System Board Testing Circuit

Microcontroller System Board Testing Program

```
REGS        EQU         $1000
PORTB       EQU         $4

            ORG         $B600
            LDX         #REGS
            LDS         #$FF

*********MAIN PROGRAM FOR DANCING LIGHT****************

            LDAA        #$F0
AGAIN       STAA        PORTB,X
            JSR         DELAY
            COMA
            BRA         AGAIN

*********SUBROUTINE FOR DELAY*****************************

DELAY       LDY         #$08FF
LOOP        LDAB        #$FF
LOOP2       DECB
            BNE         LOOP2
            DEY
            BNE         LOOP
            RTS

            END
```

Figure 5.2: Microcontroller System Board Testing Program

5.3 Sensor Module Testing

A simple manual test is performed on temperature sensor (TSic 301) based on datasheet as provide in Appendix D. Initially, output voltage of TSic 301 is measured at room temperature by using digital multimeter. The output voltage of the temperature sensor is approximately 0.375V at 25°C. Then, the sensor is placed near a lit candle which is 60°C. There is a great increase in voltage to 0.55 Volts when measured by multimeter. This shows that output voltage of the sensor is linearly proportional to the Celsius temperature.

The output of TSic 301 is analog voltage. Hence, the voltage must be converted to digital form in order to manipulate by microcontroller. One of the features of MC68HC11A1 is internal ADC. The internal ADC in microcontroller will convert the analog voltage into 8-bit digital data. However the output voltage needs to be amplified by scale of 5 using an operational amplifier to optimize the resolution.

5.4 Wireless Communication Testing

The wireless communication test is conducted in two stages. The first stage is transmission of data using the encoder and decoder via a wire as transmission medium. The second stage is replacing the wire with a FM transceiver.

5.4.1 8-bit Data Encoder and Decoder Circuit Testing

Both encoder HT640 and decoder HT648 are tested in pair as shown in Figure 5.3. D_{out} of encoder HT640 is directly connected to D_{in} of decoder HT648 using a wire. The inputs of encoder, D0 to D7 are connected to push buttons whereas the addresses of encoder, A0 to A9 are connected to ground. On other hand, D0 to D7 of the decoder are connected to LED and the address of decoder, A0 to A9 are connected to ground. Hence, the address of encoder and decoder are similar. When, TE is triggered high, the output of LED will represents the similar value of the input of encoder. If different addresses are applied, the output of the decoder would not update with the data sent by the encoder. In fact, the decoder will keep the previous data. These results verify the specification given by the manufacturer.

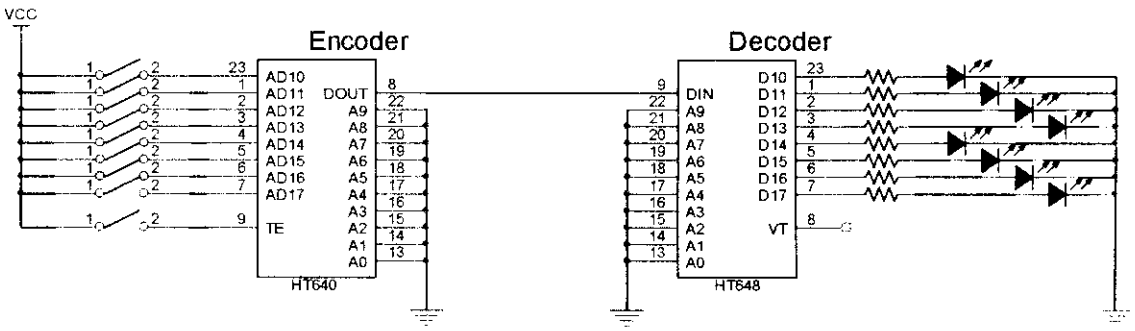

Figure 5.3: 8-bit Encoder and Decoder Circuit Testing

5.4.2 4-bit Data Encoder and Decoder Circuit Testing

Both encoder HT12E and decoder HT12D are tested in pair as shown in Figure 5.4. D_{out} of encoder HT12E is directly connected to D_{in} of decoder HT12D using a wire. The inputs of encoder, D0 to D3 are connected to push buttons whereas the addresses of encoder, A0 to A7 are connected to ground. On other hand, D0 to D3 of the decoder are connected to LED and the address of decoder, A0 to A7 are connected to ground. Hence, the address of encoder and decoder are similar. When, TE is pulled low, the output of LED will represents the similar value of the input of encoder. If different addresses are applied, the output of the decoder would not update with the data sent by the encoder. In fact, the decoder will keep the previous data. These results verify the specification given by the manufacturer.

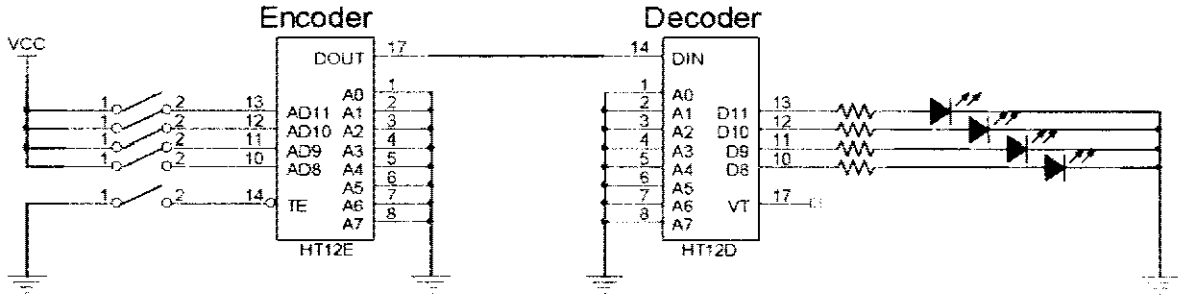

Figure 5.4: 4-bit Encoder and Decoder Circuit Testing

5.4.3 Transceiver Testing

A pair of transceiver is used to replace the wire as shown in Figure 5.5. The transceiver will act as a transmitter when the Tx/$\overline{Rx}$ pin triggers high. On other hand, the transceiver will act as a receiver when the Tx/$\overline{Rx}$ pin pulls low. In order to transmit and receive data, the Enable pin must be triggered high. By now, the setting of transceiver is completed. The output LED represents the similar value of the input of encoder. The antenna is added to amplify the transmission power in order to achieve longer transmission distance.

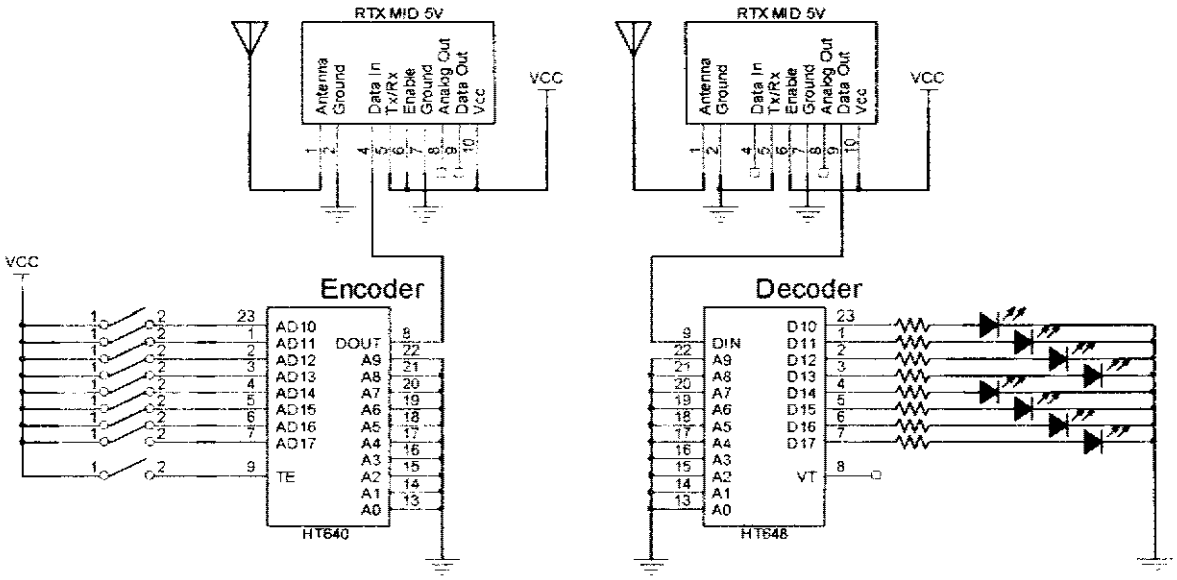

Figure 5.5: Transceiver Circuit Testing

5.5 Serial Communication Testing

Circuit of EIA 232 module is designed in order to communicate with computer via serial communication. The circuit of EIA 232 module is shown in Figure 5.6. Few parameter need to be initialized before the data can send to computer. For this system the parameter settings are:

- Baud rate of 9600 bps
- Data bit is set to 8 bits
- Stop bit is set to 1 bit
- No parity bit selected

For testing purpose, Hyper Terminal is chosen to communicate with microcontroller. A simple program for testing the serial communication module is shown in Figure 5.7. The result display on Hyper Terminal is shown in Figure 5.8.

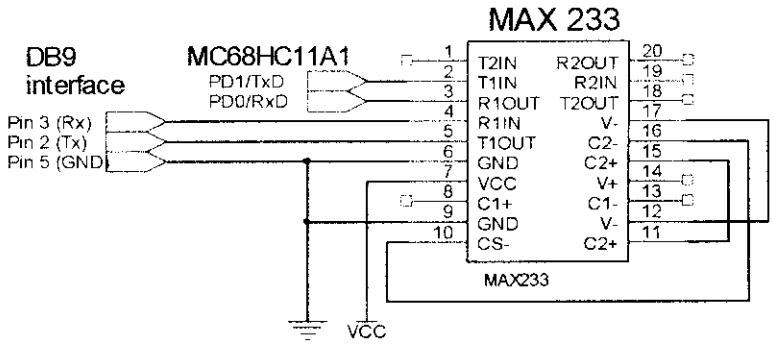

Figure 5.6: Circuit of EIA 232 Module

Serial Communication Testing Program

```
REGS        EQU         $1000
PORTB       EQU         $4
BAUD        EQU         $2B
SCCR1       EQU         $2C
SCCR2       EQU         $2D
SCSR        EQU         $2E
SCDR        EQU         $2F

            ORG         $B600
            LDX         #REGS
            LDS         #$FF

*********INITIALIZE SCI**************************************

            CLR         SCCR1,X             ;Initialize SCI
            BSET        SCCR2,X     $0C
            LDAA        #$30
            STAA        BAUD,X              ;Baud rate = 9600 bps

*********SEND DATA TO COMPUTER*****************************

            LDAA        #$67                ;ASCII "g"
SEND        BRCLR       SCSR,X  $80     SEND
            STAA        SCDR,X
            BRA         SEND

            END
```

Figure 5.7: Serial Communication Testing Program

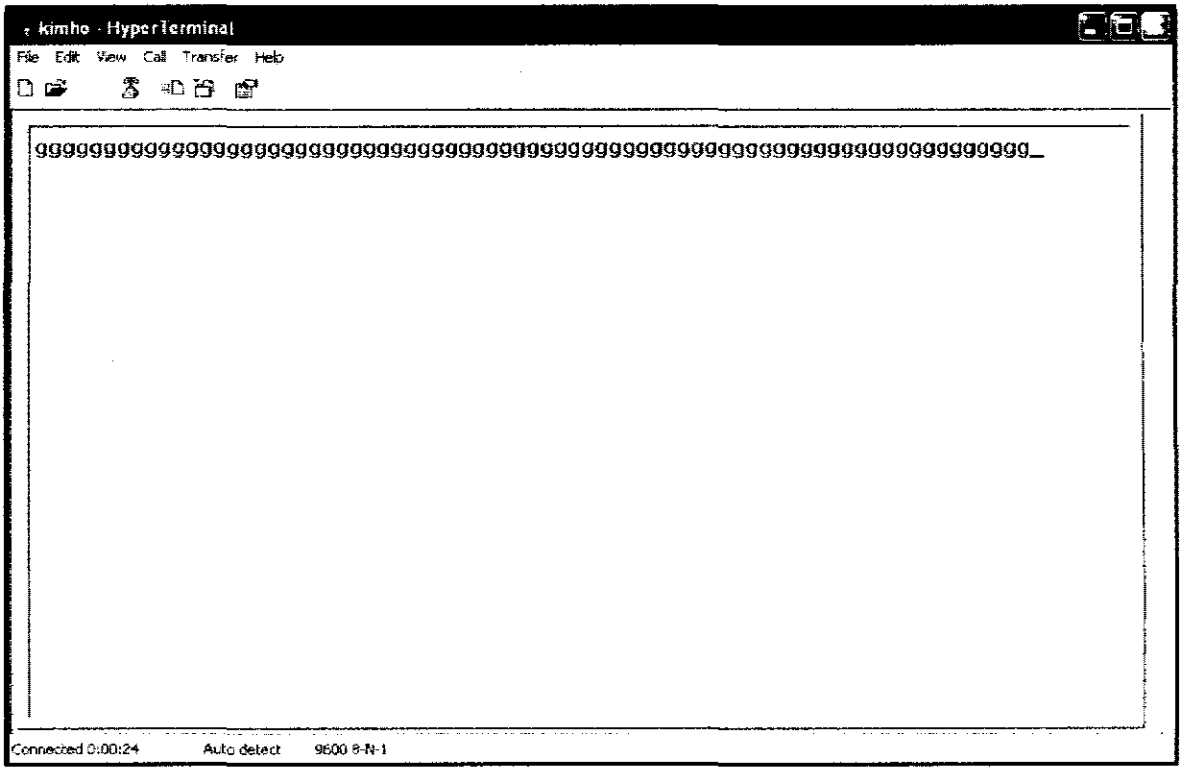

Figure 5.8: Result Display on Hyper Terminal

5.6 Integrated System Testing

The hardware is set up based on the circuits as shown in Figure 5.9, Figure 5.10 and Figure 5.11. The data from each patient in remote location send to control centre through transceiver. This data are then transfer to computer via serial communication. The GUI is continuously display the temperature reading as shown in Figure 5.12. Figure 5.13 shows the data are stored according to the preset time interval. The complete program shown in Appendix A is executed for microcontroller. The complete source code shown in Appendix B is executed for GUI.

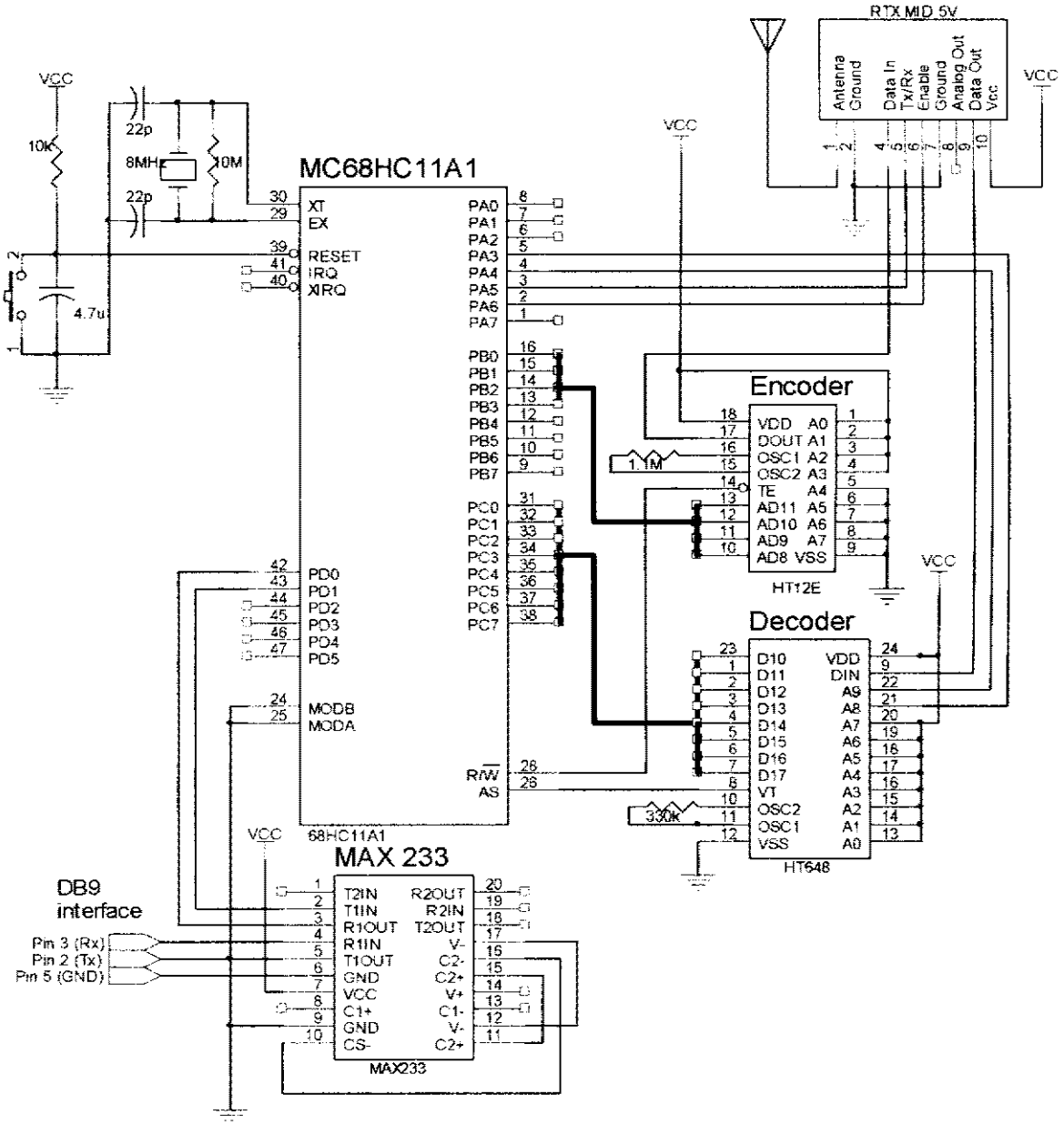

Figure 5.9: Circuit of Control Centre

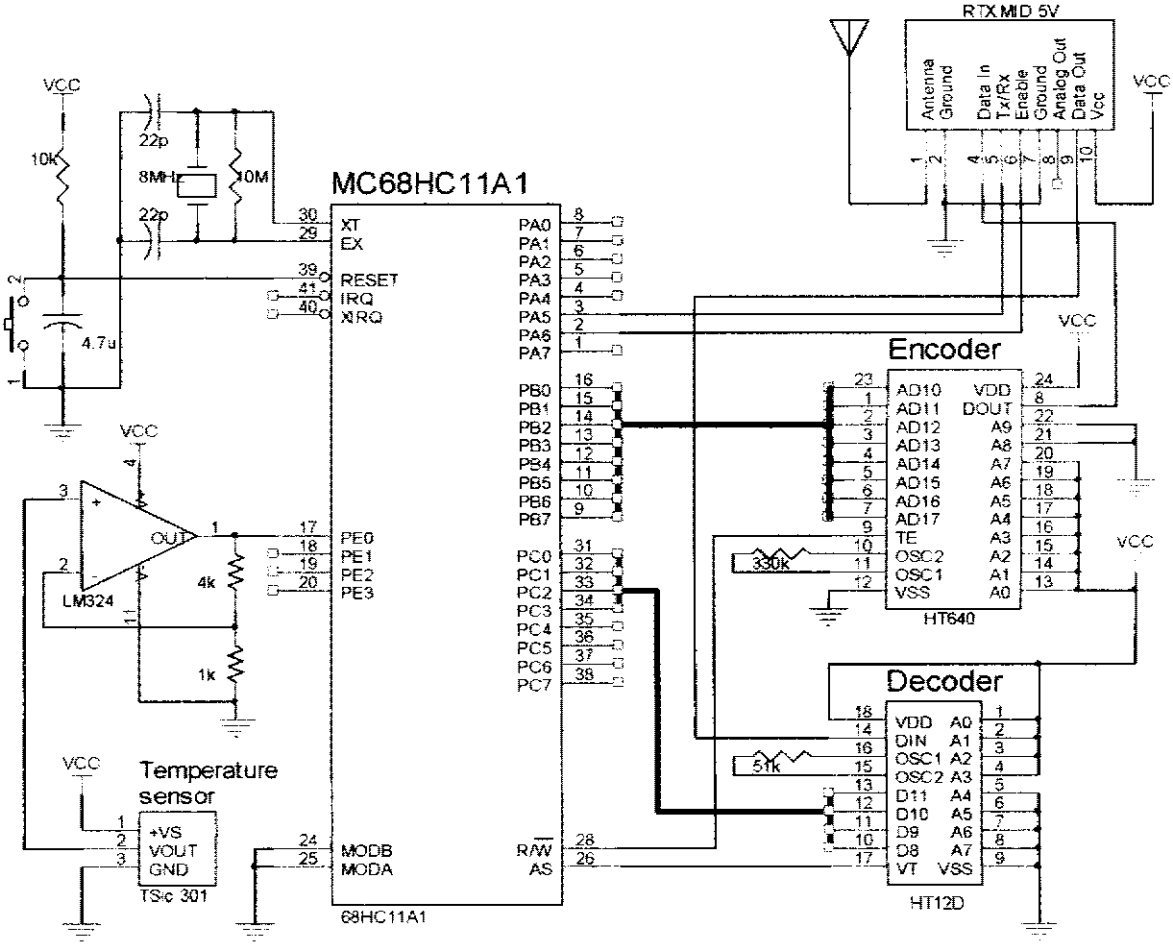

Figure 5.10: Circuit of Patient Remote 1

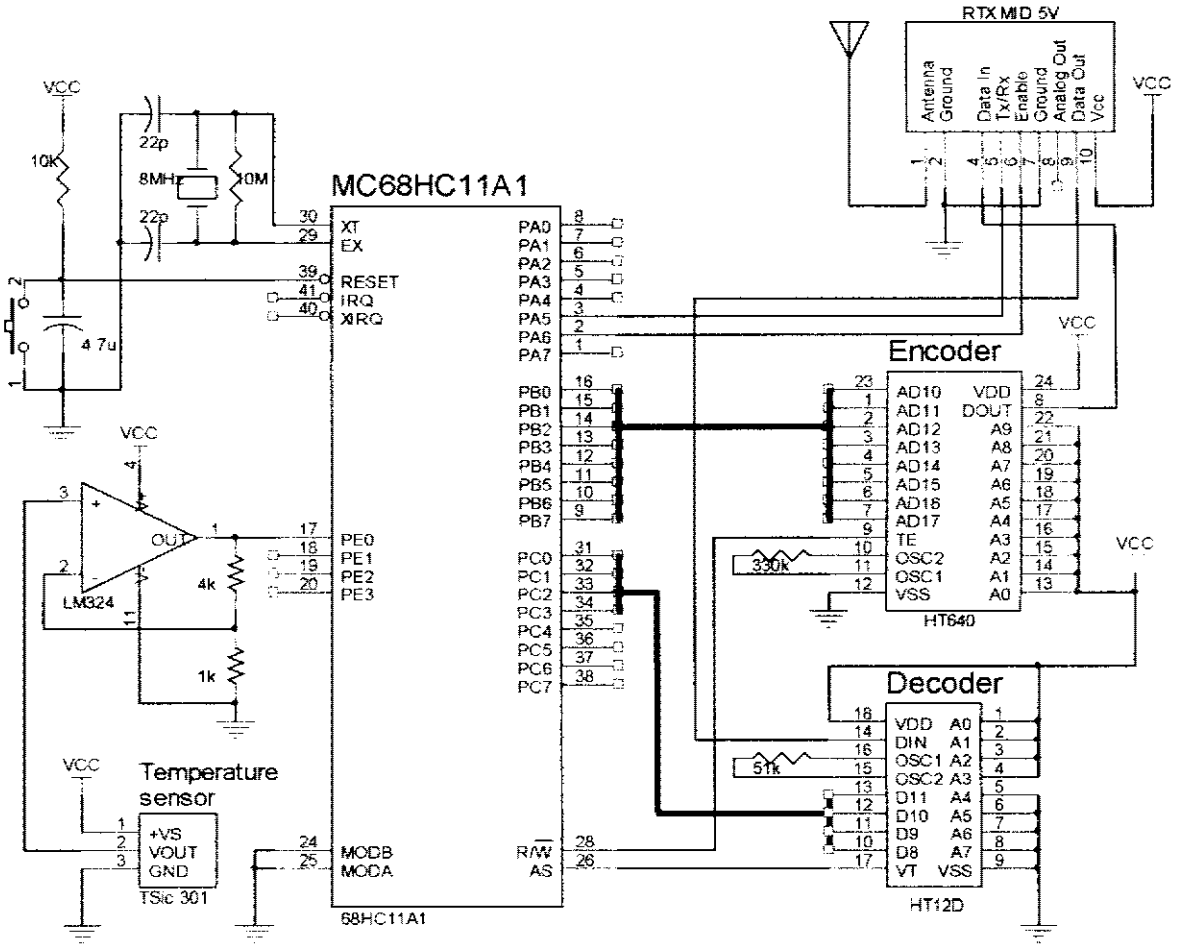

Figure 5.11: Circuit of Patient Remote 2

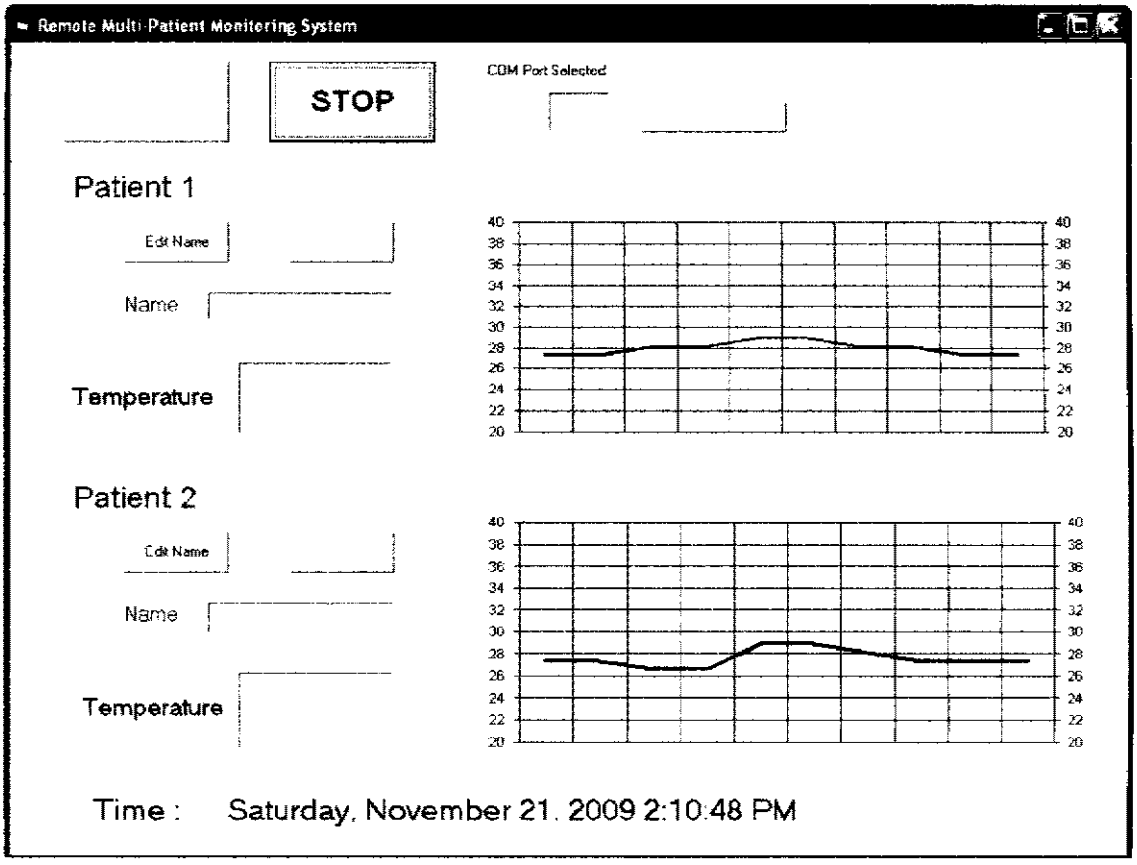

Figure 5.12: GUI Main Form

	A	B	C
1	**Date & Time**	**Patient 1**	**Patient 2**
2	Saturday, November 21, 2009 2:01:00 PM	26.6	26.6
3	Saturday, November 21, 2009 2:02:00 PM	27.3	27.3
4	Saturday, November 21, 2009 2:03:00 PM	35.2	28.9
5	Saturday, November 21, 2009 2:04:00 PM	29.7	28.1
6	Saturday, November 21, 2009 2:05:00 PM	36.7	29.7
7	Saturday, November 21, 2009 2:06:00 PM	35.2	30.5
8	Saturday, November 21, 2009 2:07:00 PM	29.7	27.3
9	Saturday, November 21, 2009 2:08:00 PM	27.3	27.3
10	Saturday, November 21, 2009 2:09:00 PM	28.1	26.6
11	Saturday, November 21, 2009 2:10:00 PM	28.1	28.1
12	Saturday, November 21, 2009 2:11:00 PM	27.3	27.3
13	Saturday, November 21, 2009 2:12:00 PM	26.6	26.6
14	Saturday, November 21, 2009 2:12:54 PM	26.6	26.6

Figure 5.13: Example of Data Base

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The project has accomplished the main objective where the Multi-Patient Monitoring System is successfully developed. The project consists of three parts; two patients remote and one control centre.

The patient remote module is capable to measure patient parameter and transfer this data wirelessly to control centre module. This data is then displayed at computer and stored according the interval set by the system.

6.2 Recommendation

This project has successfully demonstrated a Multi-Patient Monitoring system. Future work on this project may include:

- The system can acquire more parameter on patient include blood pressure, heart beat, and others.

- The system can perform more analysis on the data such as predict the future trend of state of illness or even predict the probability of pathology change.

- Improve the transmission quality by introduce the ZigBee technology. This technology offer noise immune and long range coverage.

- Integrate with GSM or GPS system to allow the status of parameter can be informed to related parties.

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9. Visual Basic 6 (VB6)
http://www.vb6.us/

APPENDIX A

Complete Program for Multi-Patient Monitoring System

Control Centre

```
            ORG     $B600

REGS        EQU     $1000
PORTA       EQU     0
PORTB       EQU     4
PORTC       EQU     3
PORTD       EQU     8
PORTE       EQU     10
PIOC        EQU     2
PORTCL      EQU     5
DDRC        EQU     7
DDRD        EQU     9
PACTL       EQU     $26
BAUD        EQU     $2B
SCCR1       EQU     $2C
SCCR2       EQU     $2D
SCSR        EQU     $2E
SCDR        EQU     $2F

START2      LDS     #$C0                    ;Initialize Stack Pointer
            LDX     #REGS
            CLR     DDRC,X                  ;PortC = Input
            BSET    PACTL,X     $80         ;PA7 = Output
            CLR     PORTB,X
            BCLR    PORTA,X     $78
            CLR     SCCR1,X                 ;Initialize SCI
            BSET    SCCR2,X     $0C
            LDAA    #$30
            STAA    BAUD,X                  ;Baud rate = 9600
            JSR     DELAY500
            BCLR    PIOC,X      $01         ;Invert STRB
            JSR     DELAY500

*********Get Data From Patient Remote 1*************
            BCLR    PORTA,X     $40         ;Enable=False
            JSR     DELAY500
            BSET    PORTA,X     $20         ;Select Tx
            BCLR    PORTA,X     $80         ;Request R1
            JSR     DELAY500
            BSET    PORTA,X     $40         ;Enable=True
            LDY     #$FFFF
            LDAB    #$02                    ;Request R1 to send data
AGAIN2      STAB    PORTB,X
            DEY
            BNE     AGAIN2
            BCLR    PORTA,X     $40         ;Enable=False
            JSR     DELAY500
            BCLR    PORTA,X     $20         ;Select Rx
            BCLR    PORTA,X     $18         ;Address of R1
            JSR     DELAY500
            BSET    PORTA,X     $40         ;Enable=True
            JSR     DELAY500
            LDAB    #$12
            CLRA
            BCLR    PIOC,X      $80
NEXT2       DECB
            BEQ     ERROR2
```

```
        LDY     #$FFFF
SCAN2   DEY
        BEQ     NEXT2
        BRCLR   PIOC,X      $80     SCAN2
        JSR     DELAY500
        LDAA    PORTCL,X
        JSR     SEND2
        BCLR    PORTA,X     $40     ;Enable=False
        JSR     DELAY
        BRA     START1
ERROR2  LDAA    #$00
        JSR     SEND2
        BRA     START1

SEND2   PSHA
        LDAA    #$01
        JSR     DELAY500
SC1     BRCLR   SCSR,X      $80     SC1
        STAA    SCDR,X
        PULA
        JSR     DELAY500
SC2     BRCLR   SCSR,X      $80     SC2
        STAA    SCDR,X
        RTS

*********Get Data From Patient Remote 2**************
START1  BCLR    PORTA,X     $40     ;Enable=False
        JSR     DELAY500
        BSET    PORTA,X     $20     ;Select Tx
        BSET    PORTA,X     $80     ;Request R2
        JSR     DELAY500
        BSET    PORTA,X     $40     ;Enable=True
        LDY     #$FFFF
        LDAA    #$04                ;Request R2 to send data
AGAIN1  STAA    PORTB,X
        DEY
        BNE     AGAIN1
        BCLR    PORTA,X     $40     ;Enable=False
        JSR     DELAY500
        BCLR    PORTA,X     $20     ;Select Rx
        BSET    PORTA,X     $18     ;Address of R2
        JSR     DELAY500
        BSET    PORTA,X     $40     ;Enable=True
        JSR     DELAY500
        LDAA    #$12
        CLRB
        BCLR    PIOC,X      $80
NEXT1   DECA
        BEQ     ERROR1
        LDY     #$FFFF
SCAN1   DEY
        BEQ     NEXT1
        BRCLR   PIOC,X      $80     SCAN1
        JSR     DELAY500
        LDAB    PORTCL,X
        JSR     SEND1
        BCLR    PORTA,X     $40     ;Enable=False
        JSR     DELAY
        JMP     START2
ERROR1  LDAB    #$00
```

```
            JSR         SEND1
            JMP         START2

SEND1       PSHB
            LDAB        #$02
            JSR         DELAY500
SC3         BRCLR       SCSR,X      $80     SC3
            STAB        SCDR,X
            PULB
            JSR         DELAY500
SC4         BRCLR       SCSR.X      $80     SC4
            STAB        SCDR.X
            RTS

*********Subroutine Of Delay*************
DELAY500    PSHY
            LDY         #$03FF
LOOP1       DEY
            BNE         LOOP1
            PULY
            RTS

DELAY       PSHY
            PSHB
            LDAB        #$20
LOOP4       LDY         #$FFFF
LOOP3       DEY
            BNE         LOOP3
            DECB
            BNE         LOOP4
            PULB
            PULY
            RTS

            END
```

Patient Remote 1

```
        ORG     $B600

REGS    EQU     $1000
PORTA   EQU     0
PORTB   EQU     4
PORTC   EQU     3
PORTD   EQU     8
PORTE   EQU     10
PIOC    EQU     2
PORTCL  EQU     5
DDRC    EQU     7
DDRD    EQU     9
OPTION  EQU     $39
ADCTL   EQU     $30
ADR1    EQU     $31
ADR2    EQU     $32
ADR3    EQU     $33
ADR4    EQU     $34

        LDS     #$C0                    ;Initialize Stack Pointer
        LDX     #REGS
        LDAA    #$FF
        STAA    DDRD,X                  ;PortD = Output
        CLR     PORTD,X

        BSET    OPTION,X $80            ;Initialize ADC
        BCLR    OPTION,X $40
        JSR     DELAY100

START   LDAA    #$30                    ;SCAN = 1 , MULT = 1
        STAA    ADCTL,X
        BCLR    PORTD,X  $02            ;Enable=False
SCAN    BRCLR   ADCTL,X  $80    SCAN    ;Read CCF
        LDAA    ADR1,X
        JSR     DELAY64
        BCLR    PORTD,X  $01            ;Select Rx
        BSET    PORTD,X  $02            ;Enable=True
AGAIN   LDAB    PORTCL,X
SCAN2   BRCLR   PIOC,X   $80    SCAN2
        LDAB    PORTCL,X
        ORAB    #$F0
        CMPB    #$F1
        BNE     AGAIN

        BCLR    PORTD,X  $02            ;Enable=False
        BSET    PORTD,X  $01            ;Select Tx
        BSET    PORTD,X  $02            ;Enable=True
        JSR     DELAY
        STAA    PORTB,X                 ;Send data to encoder
        JSR     DELAY
        BCLR    PORTD,X  $02            ;Enable=False
        BRA     START

DELAY64 LDAB    #26
LOOP1   DECB
        BNE     LOOP1
        RTS
```

```
DELAY   LDY     #$00FF
LOOP2   DEY
        BNE     LOOP2
        RTS

DELAY100        LDAB    #$FF
LOOP3   DECB
        BNE     LOOP3
        RTS

        END
```

Patient Remote 2

```
        ORG     $B600

REGS    EQU     $1000
PORTA   EQU     0
PORTB   EQU     4
PORTC   EQU     3
PORTD   EQU     8
PORTE   EQU     10
PIOC    EQU     2
PORTCL  EQU     5
DDRC    EQU     7
DDRD    EQU     9
OPTION  EQU     $39
ADCTL   EQU     $30
ADR1    EQU     $31
ADR2    EQU     $32
ADR3    EQU     $33
ADR4    EQU     $34

        LDS     #$C0                    ;Initialize Stack Pointer
        LDX     #REGS
        BCLR    PORTA,X $28

        BSET    OPTION,X $80            ;Initialize ADC
        BCLR    OPTION,X $40
        JSR     DELAY100

START   LDAA    #$30                    ;SCAN = 1 , MULT = 1
        STAA    ADCTL,X
        BCLR    PORTA,X $20             ;Enable=False
SCAN    BRCLR   ADCTL,X $80     SCAN    ;Read CCF
        LDAA    ADR1,X
        JSR     DELAY64
        BCLR    PORTA,X $08             ;Select Rx
        BSET    PORTA,X $20             ;Enable=True
AGAIN   LDAB    PORTCL,X
SCAN2   BRCLR   PIOC,X  $80     SCAN2
        LDAB    PORTCL,X
        ORAB    #$F0
        CMPB    #$F4
        BNE     AGAIN

        BCLR    PORTA,X $20             ;Enable=False
        BSET    PORTA,X $08             ;Select Tx
        BSET    PORTA,X $20             ;Enable=True
        JSR     DELAY
        STAA    PORTB,X                 ;Send data to encoder
        JSR     DELAY
        BCLR    PORTA,X $20             ;Enable=False
        BRA     START

DELAY64 LDAB    #26
LOOP1   DECB
        BNE     LOOP1
        RTS

DELAY   LDY     #$000F
```

```
LOOP2   DEY
        BNE     LOOP2
        RTS

DELAY100        LDAB    #$FF
LOOP3   DECB
        BNE     LOOP3
        RTS

        END
```

APPENDIX B

Microsoft Visual Basic 6.0

Source Code

FORM 1

```
Public PortNumber As Integer

Function IsComPortAvailable(ByVal PortNum As Integer) As Boolean
   Dim fnum As Integer
   On Error Resume Next
    fnum = FreeFile
    Open "COM" & CStr(PortNum) For Binary Shared As #fnum
    If Err = 0 Then
      Close #fnum
      IsComPortAvailable = True
   End If
 End Function

Private Sub Command1_Click()
If Combo1.Text = "-Available COM Port-" Then
MsgBox "Please Select a COM Port"
Else
PortNumber = Combo1.Text
Form2.Show
'Me.Hide
Unload Form1
Set Form1 = Nothing
End If
 End Sub

Private Sub Form_Load()
Dim i As Integer
For i = 1 To 9
If IsComPortAvailable(i) Then
Combo1.AddItem i
End If
Next
End Sub
```

FORM 2

```
Public PortNumber As Integer
Public vStopLoop As Boolean

Dim ExcelApp As Excel.Application
Dim ExcelWorkbook As Excel.Workbook
Dim ExcelSheet As Excel.Worksheet

Dim FileName As String
Dim MyYear As String
Dim MyMonth As String
Dim MyDay As String
Dim MyHour As String
Dim MyMinute As String
Dim MyExtension As String
Dim MyFileName As String
Dim FileCheck As String

Dim gdataA(1 To 10, 2) As Variant
Dim gdataB(1 To 10, 2) As Variant
Dim gdataI(1 To 10, 2) As Variant
Dim g As Integer

Private Sub LoadData()

Dim fnum As Integer
Dim txt As String
Dim i As Integer

   For i = 0 To 1
      Text1(i).Text = ""
   Next i

   ' Open the configuration file
   On Error GoTo NoFile
   fnum = FreeFile
   Open App.Path & "\config.dat" For Input As fnum

   ' Get the text boxes
   Input #fnum, txt
   Text1(0).Text = txt
   Input #fnum, txt
   Text1(1).Text = txt

   ' Close the file
   Close fnum

NoFile:

End Sub

Private Sub SaveData()

Dim fnum As Integer
Dim txt As String
Dim i As Integer

   ' Open the configuration file
```

```
    On Error GoTo NoFile
    fnum = FreeFile
    Open App.Path & "\config.dat" For Output As fnum
    ' Save the text boxes
    Write #fnum, Text1(0).Text
    Write #fnum, Text1(1).Text
    ' Close the file
    Close fnum

NoFile:

End Sub

Private Sub Command1_Click()

vStopLoop = True

' Open COM port
If MSComm1.PortOpen = False Then
    MSComm1.PortOpen = True
Else
End If

Command1.Enabled = False
Command2.Enabled = True
Command3.Enabled = True
Command5.Enabled = True
Command6.Enabled = False
Command4.Enabled = False
Command7.Enabled = False
Frame1.Enabled = True
Frame2.Enabled = True
Text1(0).Enabled = False
Text1(1).Enabled = False
Text3.Enabled = False
Text4.Enabled = False

Dim Data1 As String
Dim Data2 As String
Dim Data3 As String
Dim Data4 As String
Dim Data5 As String
Dim Data6 As String
Dim Data7 As String
Dim Data8 As String
Dim Row As Integer

Row = 2

Do
    Do
        Do
            DoEvents
        Loop Until MSComm1.InBufferCount > 0 Or Second(Now) = 0 Or vStopLoop = False

        If Second(Now) = 0 Or vStopLoop = False Then
        Else

            If MSComm1.PortOpen = True Then
                Data7 = MSComm1.Input
```

```
   Data8 = Asc(Data7)
Else
End If

Select Case Data8

Case 1

   Do
      DoEvents
   Loop Until MSComm1.InBufferCount > 0 Or Second(Now) = 0 Or vStopLoop = False

   If Second(Now) = 0 Or vStopLoop = False Then
   Else

      If MSComm1.PortOpen = True Then
         Data1 = MSComm1.Input
         Data2 = Asc(Data1)

         If Data2 = "0" Or Data2 = "1" Or Data2 = "2" Then
            Data3 = Text3.Text
         Else
            Data3 = (Data2 * 200 / 256) - 50 'TSic 301
         End If

      Else
      End If

      Data3 = Format(Data3, "#0.0")
      Text3.Text = Data3

      ' Plot graph
      For g = 1 To 9
         gdataA(g, 2) = gdataA(g + 1, 2)
      Next g
      gdataA(10, 2) = Text3.Text
      MSChart1.ChartData = gdataA

   End If

Case 2

   Do
      DoEvents
   Loop Until MSComm1.InBufferCount > 0 Or Second(Now) = 0 Or vStopLoop = False

   If Second(Now) = 0 Or vStopLoop = False Then
   Else

      If MSComm1.PortOpen = True Then
         Data4 = MSComm1.Input
         Data5 = Asc(Data4)

         If Data5 = "0" Or Data5 = "1" Or Data5 = "2" Then
            Data6 = Text4.Text
         Else
            Data6 = (Data5 * 200 / 256) - 50 'TSic 301
         End If

      Else
```

```
                End If

                Data6 = Format(Data6, "#0.0")
                Text4.Text = Data6

                ' Plot graph
                For g = 1 To 9
                   gdataB(g, 2) = gdataB(g + 1, 2)
                Next g
                gdataB(10, 2) = Text4.Text
                MSChart2.ChartData = gdataB

             End If

          Case Else
          End Select

       End If

    Loop Until Second(Now) = 0 Or vStopLoop = False

    ' logged data into Microsoft Excel
    ExcelSheet.Cells(Row, 1) = Format(Date, "Long Date") & " " & Format(Time(), "Long Time")
    ExcelSheet.Cells(Row, 2) = Text3.Text
    ExcelSheet.Cells(Row, 3) = Text4.Text

    Row = Row + 1

    Do
       DoEvents
    Loop Until Second(Now) > 0 Or vStopLoop = False

Loop Until vStopLoop = False

End Sub

Private Sub Command2_Click()

vStopLoop = False

' Close COM port
If MSComm1.PortOpen = True Then
   MSComm1.PortOpen = False
Else
End If

Frame1.Enabled = False
Frame2.Enabled = False
Command2.Enabled = False
Command1.Enabled = True
Command7.Enabled = True
Command3.Enabled = True
Command5.Enabled = True
Command4.Enabled = False
Command6.Enabled = False

' Save the data for next time
   SaveData

End Sub
```

```
Private Sub Command3_Click()

Command3.Enabled = False
Command4.Enabled = True
Text1(0).Enabled = True

End Sub

Private Sub Command4_Click()

Command3.Enabled = True
Command4.Enabled = False
Text1(0).Enabled = False

' Save the data for next time.
   SaveData

End Sub

Private Sub Command5_Click()

Command5.Enabled = False
Command6.Enabled = True
Text1(1).Enabled = True

End Sub

Private Sub Command6_Click()

Command5.Enabled = True
Command6.Enabled = False
Text1(1).Enabled = False

' Save the data for next time
   SaveData

End Sub

Private Sub Command7_Click()

If MSComm1.PortOpen = True Then
   MSComm1.PortOpen = False
Else
End If

' Save the data for next time
SaveData

Unload Form2
Set Form2 = Nothing
Form1.Show

End Sub

Private Sub Form_Load()

Dim PortNum As Integer

vStopLoop = True
```

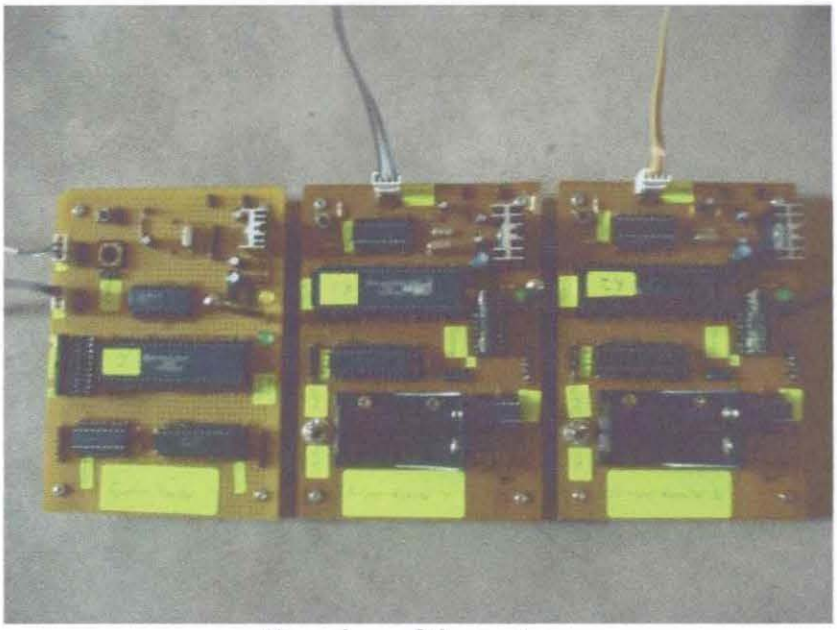
```
PortNum = Form1.PortNumber
Text2.Text = PortNum

' COM port setting
With MSComm1
   .CommPort = PortNum
   .Settings = "9600,N,8,1"
End With

' Close COM port
If MSComm1.PortOpen = True Then
   MSComm1.PortOpen = False
Else
End If

' Load the data from last time
   LoadData

Frame1.Enabled = False
Frame2.Enabled = False
Command2.Enabled = False
Text2.Enabled = False
MSChart1.Enabled = False
MSChart2.Enabled = False
' Initialize Graph
For g = 1 To 10
   gdata1(g, 2) = ""
Next g
MSChart1.ChartData = gdata1
MSChart2.ChartData = gdata1

'get year
MyYear = Year(Now)

'get month
MyMonth = Month(Now)

'get year
MyDay = Day(Now)

'get hour
MyHour = Hour(Now)

'get minute
MyMinute = Minute(Now)

'working directory
Mydirectory = App.Path + "\DATA_BASE\"
   If Dir(Mydirectory) = "" Then
      MkDir Mydirectory
   End If

FileName = MyYear + "_" + MyMonth + "_" + MyDay + "_" + MyHour + "_" + MyMinute

'Excels extension
MyExtension = ".xlsx"

'complete path and file name
MyFileName = Mydirectory + FileName + MyExtension
```

```
On Error Resume Next

'create Excel object
Set ExcelApp = CreateObject("Excel.Application")

'if file exists, place file name in FileCheck
FileCheck = Dir$(MyFileName)
  If FileCheck = FileName + MyExtension Then
    'Workbook exists, open it
    Set ExcelWorkbook = ExcelApp.Workbooks.Open(MyFileName)
    Set ExcelSheet = ExcelWorkbook.Worksheets(1)
  Else
    'Workbook doesn't exist, create new workbook
    Set ExcelWorkbook = ExcelApp.Workbooks.Add
    Set ExcelSheet = ExcelWorkbook.Worksheets(1)

    ExcelSheet.Cells(1, 1) = "Date & Time"
    ExcelSheet.Cells(1, 2) = "Patient 1"
    ExcelSheet.Cells(1, 3) = "Patient 2"

    ExcelApp.Range("A1:C1").Select
    ExcelApp.Selection.Font.Bold = True

    ExcelApp.Columns("A:A").ColumnWidth = 40
    ExcelApp.Columns("B:B").ColumnWidth = 20
    ExcelApp.Columns("C:C").ColumnWidth = 20
  End If

End Sub

Private Sub Form_Unload(Cancel As Integer)

vStopLoop = False

' Close COM port
If MSComm1.PortOpen = True Then
    MSComm1.PortOpen = False
Else
End If

' Save the data for next time
    SaveData

     If FileCheck = FileName + MyExtension Then
       'Save existing workbook
       ExcelWorkbook.Save
    Else
       'Save new workbook
       ExcelWorkbook.SaveAs MyFileName
    End If

       'Close Excel
       ExcelWorkbook.Close savechanges:=False
       ExcelApp.Quit
       Set ExcelApp = Nothing
       Set ExcelWorkbook = Nothing
       Set ExcelSheet = Nothing

End Sub
```

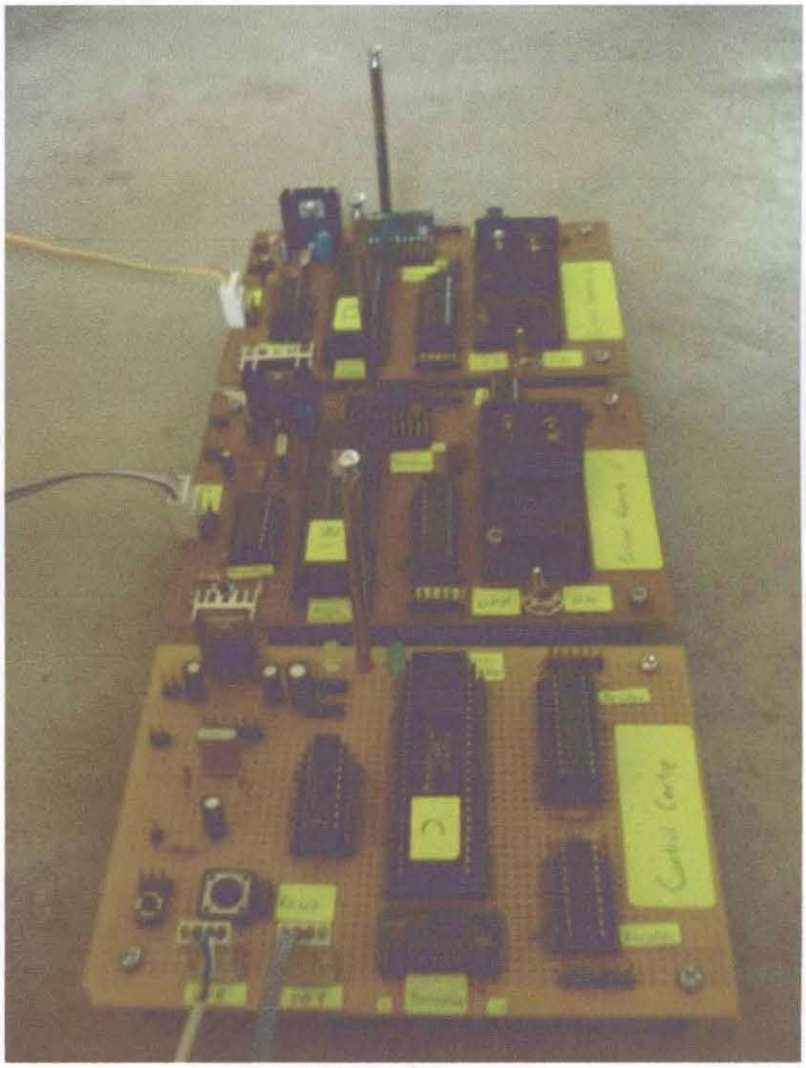
```
Private Sub Timer1_Timer()

Label5.Caption = Format(Date, "Long Date") & " " & Format(Time(), "Long Time")

End Sub
```

APPENDIX C

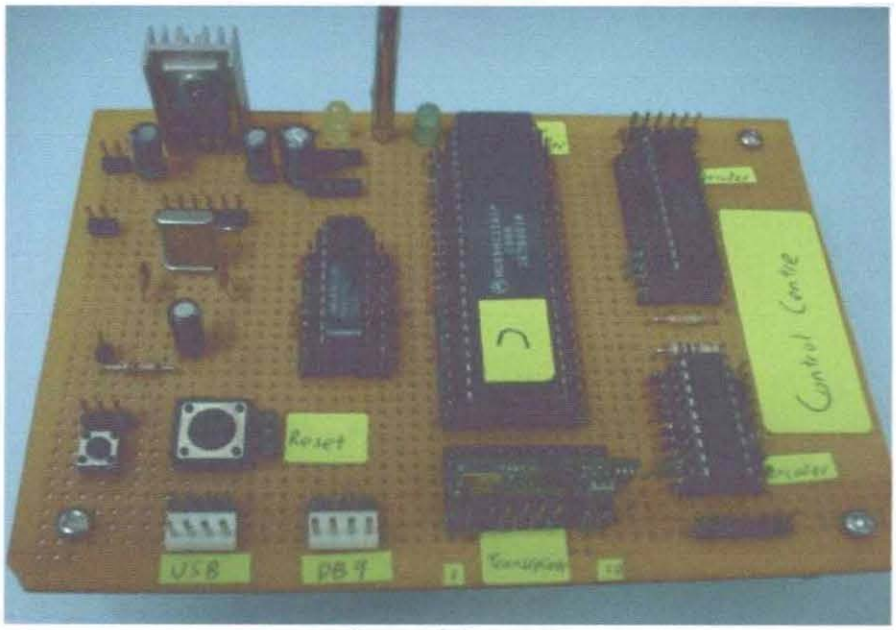
Hardware Photo Gallery



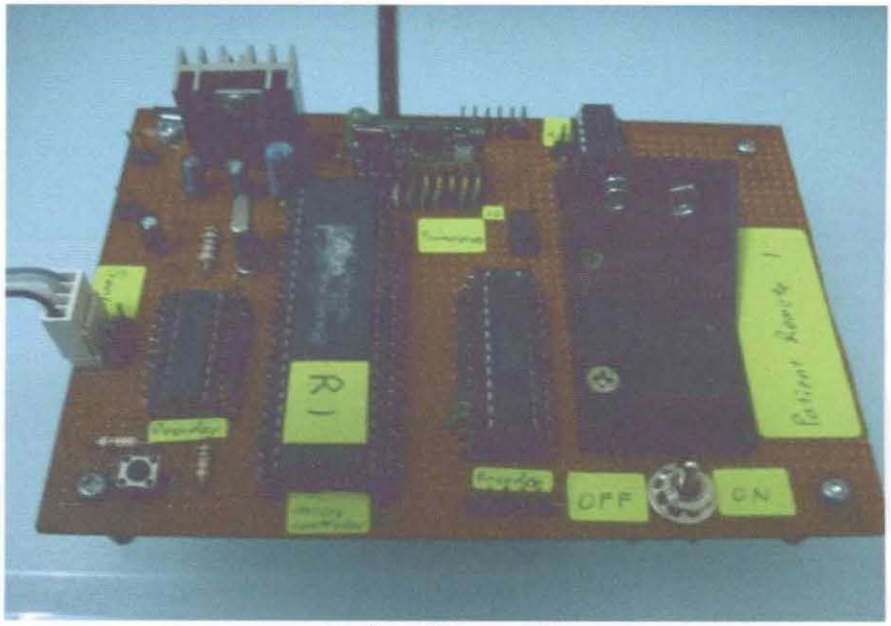
Top view of the system



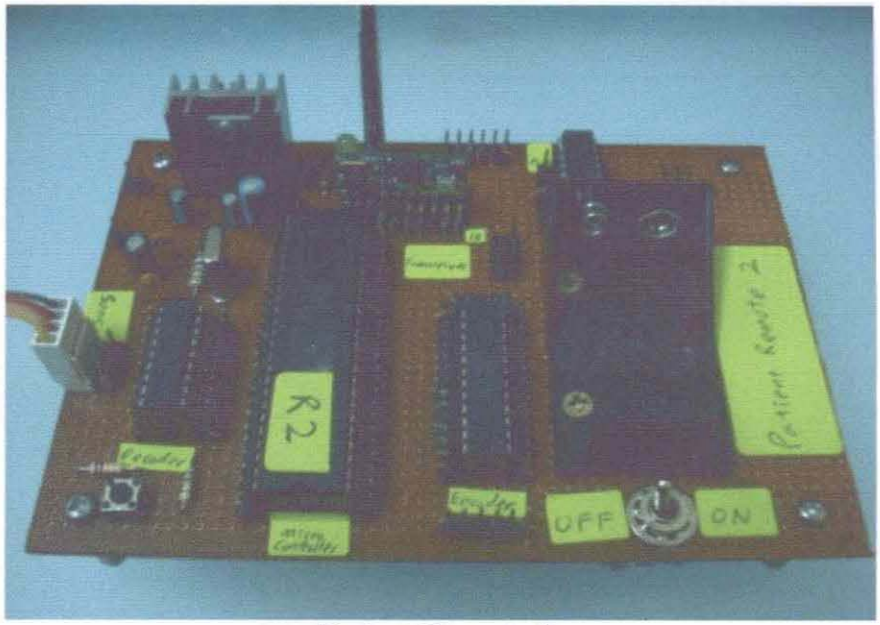
Front view of the system



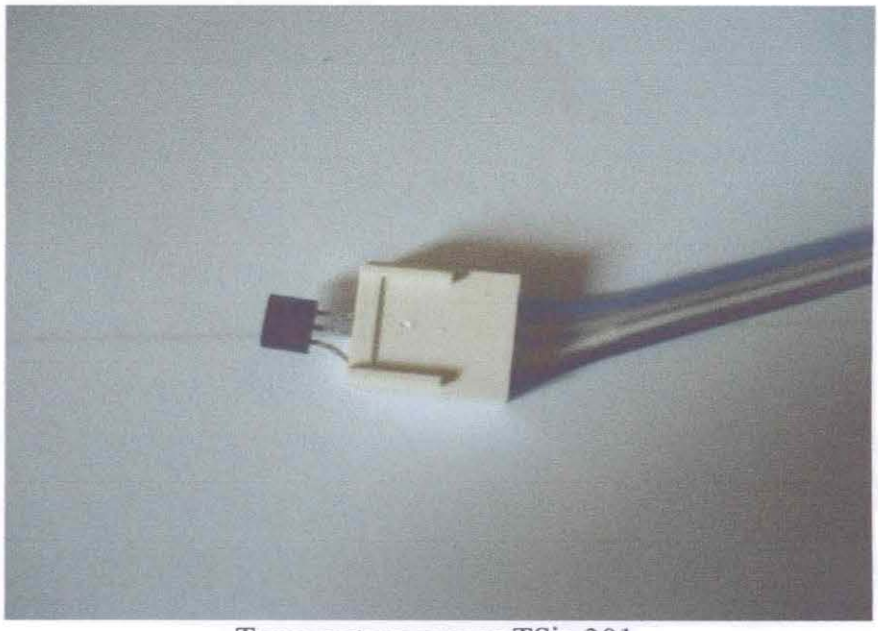
Control Centre



Patient Remote 1



Patient Remote 2



Temperature sensor TSic 301

APPENDIX D

Data Sheets

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

Order this document
by MC68HC11A8TS/D

MC68HC11A8
MC68HC11A1
MC68HC11A0

Technical Summary
8-Bit Microcontrollers

1 Introduction

The MC68HC11A8, MC68HC11A1, and MC68HC11A0 high-performance microcontroller units (MCUs) are based on the M68HC11 Family. These high speed, low power consumption chips have multiplexed buses and a fully static design. The chips can operate at frequencies from 3 MHz to dc. The three MCUs are created from the same masks; the only differences are the value stored in the CONFIG register and whether or not the ROM or EEPROM is tested and guaranteed.

For detailed information about specific characteristics of these MCUs, refer to the *M68HC11 Reference Manual* (M68HC11RM/AD).

1.1 Features

- M68HC11 CPU
- Power Saving STOP and WAIT Modes
- 8 Kbytes ROM
- 512 Bytes of On-Chip EEPROM
- 256 Bytes of On-Chip RAM (All Saved During Standby)
- 16-Bit Timer System
  - 3 Input Capture Channels
  - 5 Output Compare Channels
- 8-Bit Pulse Accumulator
- Real-Time Interrupt Circuit
- Computer Operating Properly (COP) Watchdog System
- Synchronous Serial Peripheral Interface (SPI)
- Asynchronous Nonreturn to Zero (NRZ) Serial Communications Interface (SCI)
- 8-Channel, 8-Bit Analog-to-Digital (A/D) Converter
- 38 General-Purpose Input/Output (I/O) Pins
  - 16 Bidirectional I/O Pins
  - 11 Input-Only Pins and 12 Output-Only Pins (Eight Output-Only Pins in 48-Pin Package)
- Available in 48-Pin Dual In-Line Package (DIP) or 52-Pin Plastic Leaded Chip Carrier (PLCC)

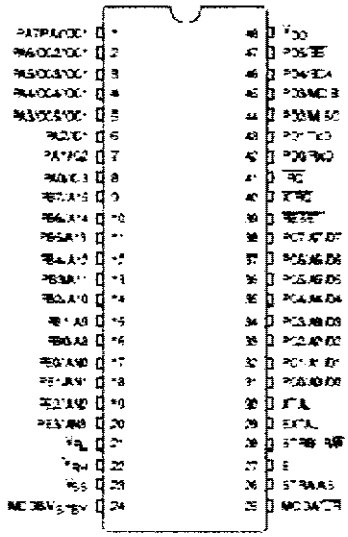


Figure 3 48-Pin DIP Pin Assignments

2 Operating Modes and Memory Maps

In single-chip operating mode, the MC68HC11A8 is a monolithic microcontroller without external address or data buses.

In expanded multiplexed operating mode, the MCU can access a 64 Kbyte address space. The space includes the same on-chip memory addresses used for single-chip mode plus external peripheral and memory devices. The expansion bus is made up of ports B and C and control signals AS and R/W. The address, R/W, and AS signals are active and valid for all bus cycles including accesses to internal memory locations. The following figure illustrates a recommended method of demultiplexing low-order addresses from data at port C.

Data Sheet Preliminary
Rapid Response, Low-Cost Temperature Sensor IC

ZMD

TSic™101/106/201/206/301/306/506

Brief Description

The TSic™ temperature sensor IC family are fully tested and calibrated sensors with absolute measurement accuracy on delivery, no further calibration needed.
The TSic™ combines outstanding accuracy with long term stability, yet it is very simple to use.
The TSic™ series is specifically designed for high performance, cost-effective solutions for sensing temperature in building automation, automotive, industrial, office automation, white goods and low-power/mobile applications.
TSic™ employs a high precision bandgap reference with PTAT output; a low-power, precision ADC; and an on-chip DSP core with EEPROM to precisely calibrate the output temperature signal.
The TSic™ series includes ICs with two linear analog signal output options, such as standard 0-1Vout (Supply voltage (V+) = 3.0V to 5.5V) or ratiometric (10-90% of supply voltage); or the digital serial output signal for interfacing with microcontrollers.
Standard TSic™ devices are available with digital (ZacWire, TSic™x06) or analogue (0-1V, TSic™x01) output signal.

Features

- Low cost, precision temperature sensor
- Analog 0 to 1 Volt signal output[1)]
- Resolution: 0.1°C(0.034°C TSic™506)
- Single-wire 11-bit digital serial signal output[2)]
- Communication range > 10 meters[2)]
- Accuracy: up to ±0.1°C over span of 40°C
- Wide measurement range:
  -50 to +150 °C (TSic™ 10x/20x/30x)
  -10 to +60 °C (TSic™ 506)
- Signal read-out every 0.1s (other rates available on request)
- Supply Voltage 3.0V to 5.5V; high accuracy operation in range 4.5V to 5.5V[1)]
- Package: 8-pin SOP, 3-pin TO-92, Die on Wafer
- Low quiescent current to minimize self-heating and power consumption (45µA typ.)
- System-on-chip based on advanced mixed-signal CMOS technology integrating precision temperature sensing bandgap reference with proportional-to-absolute-temperature (PTAT) output, digital signal processor (DSP) core, and electrically erasable memory (EEPROM)

Benefits

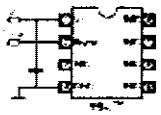
- Several accuracy classes available with 100% upward compatibility
- No calibration by customer needed; absolute calibration specified
- Simple to integrate, reducing cost and time for application-development
- Fast data measurement – optimal for temperature control
- Packages for standard SMD, THT or application specific assembly
- Very low power consumption – ideal for mobile and standard applications
- Field reconfiguration/recalibration option available (high volume customers only)

Available Support

For TSic™ evaluation ZMD provides a special Evaluation Tool. *(Ordering Code: TSic Lab Kit.)*
Further application support is available through the hotline:

email: tsic@zmd.de
Phone: +49 351 6822-631

TSic™101/106/201/206/301/306/506 Overview



1) For TSic™ with analog output only: TSic™101/201/301
2) For TSic™ with digital output only: TSic™106/206/306/506

3 Output Examples for TSic™101/106/201/206/301/306/506

Table 3-1 Output Examples for TSic™101/106/201/206/301/306/506

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-50	-58	0.000	0x000	-
-10	14	0.200	0x199	0x000
3	37	0.250	0x200	0x154
25	77	0.375	0x2FF	0x3FF
63	145	0.550	0x465	0x7FF
125	257	0.875	0xBFE	-
150	302	1.000	0xFFF	-

1. Temperature Measurement Range -50...150°C (-58...302°F) Wide Range Device
2. Temperature Measurement Range -10...60°C (14...140°F) [illegible]
3. Temperature = [illegible]
4. Temperature = [illegible]

4 Lifetime for TSic™101/106/201/206/301/306/506 Devices

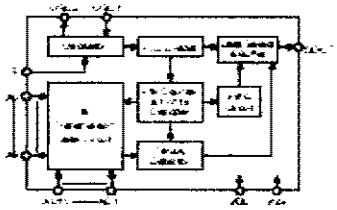
Table 4-1 Output Examples for TSic™101/106/201/206/301/306/506

[illegible]	[illegible]
140°C...150°C	min. 1500h
125°C...140°C	min. 3000h

Block Diagram

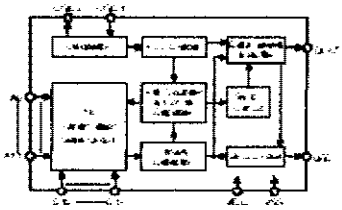
TE trigger

HT600/HT640/HT680



DATA trigger

HT640/HT640/HT680

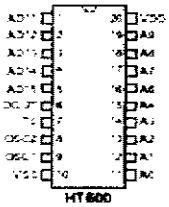


Note: The address/data pins are available in various combinations.

Pin Assignment

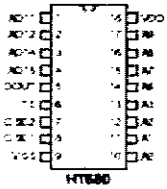
TE trigger type

9-Address
5-Address/Data



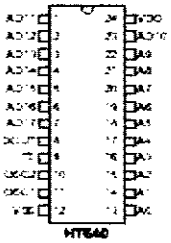
HT600
– 20 DIP/SOP

8-Address
4-Address/Data



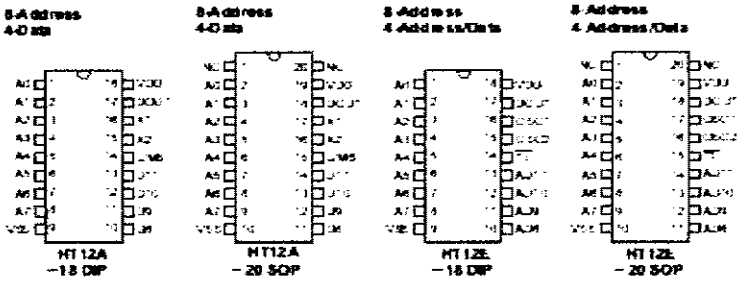
HT680
– 18 DIP/SOP

10-Address
8-Address/Data



HT640
– 24 SOP/SDIP

Pin Assignment



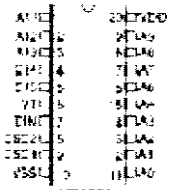
Pin Description

Pin Name	I/O	Internal Connection	Description
A0~A7	I	CMOS IN Pull-high (HT12A)	Input pins for address A0~A7 setting These pins can be externally set to VSS or left open
		NMOS TRANSMISSION GATE PROTECTION DIODE (HT12E)	
AD8~AD11	I	NMOS TRANSMISSION GATE PROTECTION DIODE (HT12E)	Input pins for address/data AD8~AD11 setting These pins can be externally set to VSS or left open
D8~D11	I	CMOS IN Pull-high	Input pins for data D8~D11 setting and transmission enable, active low These pins should be externally set to VSS or left open (see Note)
DOUT	O	CMOS OUT	Encoder data serial transmission output
LMB	I	CMOS IN Pull-high	Latch/Momentary transmission format selection pin Latch: Floating or VDD Momentary: VSS

Package Information

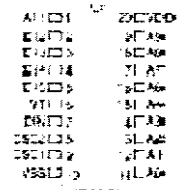
Latch series

12-Address 2-Data



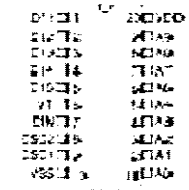
HT602L
– 20 DIP/SOP

10-Address 4-Data



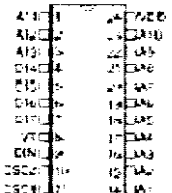
HT604L
– 20 DIP/SOP

8-Address 5-Data



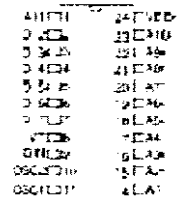
HT605L
– 20 DIP/SOP

14-Address 4-Data



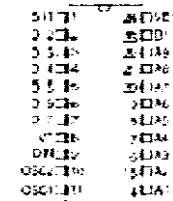
HT644L
– 24 SOP/SDIP

12-Address 6-Data



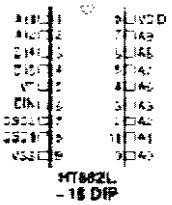
HT646L
– 24 SOP/SDIP

10-Address 8-Data



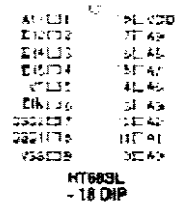
HT648L
– 24 SOP/SDIP

10-Address 2-Data



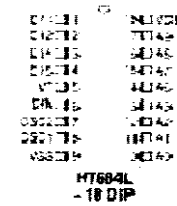
HT682L
– 18 DIP

9-Address 3-Data



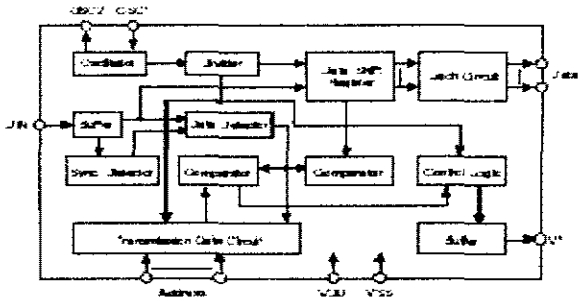
HT683L
– 18 DIP

8-Address 4-Data



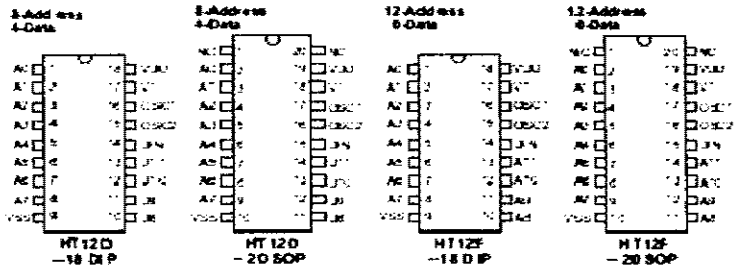
HT684L
– 18 DIP

Block Diagram



Note: The address/data pins are available in various combinations (see the address/data table).

Pin Assignment



Mini ASK Data Transceivers

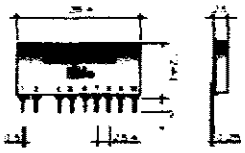
RTX MID 3V

P.N. 6502010336

RTX MID 5V

P.N. 6502010446

Dimensions



Descrizione

Ricetrasmettitore ASK miniaturizzato con alta sensibilità e la possibilità di configurazione in basso consumo. Ideale per applicazioni radio bidirezionali che richiedono spazi ristretti e una lunga durata della batteria. Conforme alle Normative Europee.

Component Side

Description

Mini ASK transceiver module with high sensitivity and power-down functionality. Ideal for a 2-way radio system needing to save space and battery life. In compliance with European Normative.

Pin Out

1) A
2) Ground
3) Data
4) VCC
5) RSSI
6) RF out
7) Ground
8) Antenna Out
9) Data Out
10) VCC

TECHNICAL SPECIFICATION

Alimentazione	Power Supply	2.1	3	3.5	Vdc
Alimentazione	Power Supply	4.5	5	5.5	Vdc
Corrente assorbita TX ON	Supply Current TX ON		15	20	mA
Corrente assorbita RX ON	Supply Current RX ON		4.5	6.5	mA
Corrente assorbita ENABLE OFF	Supply Current ENABLE OFF			1	µA
Frequenza di ricezione	Reception frequency		433.92*		MHz
Sensibilità RF	RF Sensitivity		106		dBm
Potenza TX	TX Power	8	10		dBm
Impedenza di antenna	Antenna impedance		50		ohm
Tempo di commutazione	Switch time			500	µS
Temperatura di lavoro	Operating temperature range	-20		+85	°C

* 433.42 - 434.42 MHz available on demand

A.R.E. S.r.l. - Via [illegible] - 40033 [illegible] (BO) Italy - Phone +39-0546-048128 - Fax +39-0546-54666
E-mail: [illegible]