MICROCONTROLLER BASED PHYSIOLOGICAL MONITORING SYSTEM WITH GSM TECHNOLOGY

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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I am dedicating this project to my Parents, my brother and sisters.

ABSTRACT

In this modern era of technologies, it is essential to have monitoring systems especially for security or heath purposes. Many hospitals are lacking in real time patient monitoring systems and they check physiological parameters manually using various instruments. Therefore monitoring these parameters becomes a tedious process and could lead to death.

In this thesis we designed and simulated a system which can help with real time monitoring in multiple patients (ten patients). This system can monitor several physiological parameters at a time including pulse rate, body temperature, glucose level, hemoglobin level and patient state index continuously. Remotely monitoring a patient encouraged by many doctors in their too much busy schedule. Therefore, to avoid over loading a doctor, he/she should be provided with the latest readings of his/her patients. Only abnormality is reported to the doctor and if no report is received, normality is assumed. Efficient monitoring requires live comparison of the values reported and stored in memory. For the sake of facilitation, the system is capable of monitoring multiple patients at one instant and measuring five vital signs for better diagnosis. All information is transfered to the micro-controller. This microcontroller board analyses data and if any abnormality is observed, it sends warning and emergency messages to a doctor. The reporting process is made through GSM technology via SMS service and the values transmitted are also shown at the very place where patient is kept. Doctor can analyse all the patients' statuses inside and outside the hospital.

Keywords: GSM modem, microcontroller, physiological parameters, wireless system

ÖZET

Bu tezde gerçek zamanlı olarak hasta (on hasta) izleme sistemi tasarlanmıştır. Bu sistemde fizyolojik parametreler olan nabız, vücut ısısı, glükoz seviyesi, hemoglobin seviyesi ve hasta stabilizasyonu gözlemlenmektedir. Doktorun yoğunluğunu azaltmak için hastanın son bilgileri doktora sunulur. Hastada normalin dışında bir gelişme olduğunda doktorla iletişime geçilir. Aksi takdirde hastanın durumu iyi demektir. Sistem hafızadaki ve anlık verileri kıyaslayarak verimli bir gözetim elde edebilir. Kullanıcının işini kolaylaştırmak için birden fazla hastanın bilgileri ekranda gösterilebilir. Bütün bilgiler mikrodenetleyiciye yollanır. Mikrodenetleyici bigileri analiz edip anormal bir durum olduğunda doktora uyarı ve acil mesajı yollar. Uyarı doktora SMS olarak yollanır. Bu sayede doktor hastane içerisinde ve dışında hastayı kontrol edip gözlemleyebilir.

Anahtar sözcükler: Mikrodenetleyiciye, fizyolojik parametreler, glükoz seviyesi, hasta stabilizasyonu

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ABBREVIATIONS

CGM:	Continuously Glucose Monitoring
BPM:	Beats Per Minute
CO2:	Carbon dioxide
g/dl:	Grams per deciliters
EEG:	Electroencephalography
PSI:	Patient’s State Index
MCU:	Microcontroller unit
ROM:	Read Only Memory
RAM:	Random Access Memory
EEPROM:	Electrical Erasable Programming ROM
CPU:	Central Processing Unit
CU:	Control Unit
ALU:	Arithmetic Logic Unit
UART:	Universal Asynchronous Receiver / Transmitter
WDT:	Watch dog timer
PWM:	Pulse-width modulation
GPRS:	General Packet radio service
LCD:	Liquid crystal display
R/W:	Read/Write
ER:	Emergency room
ICU:	Intensive care unit

CHAPTER ONE
INTRODUCTION

1.1 Overview

A monitoring system is a system where by one can observe and assess how something relates and reacts to a specific subject. Patient monitoring system is a technique which enables repeated or constant observation and measurement of physiological vital parameter of a patient for the purpose of guiding clinical decisions which includes when to make beneficial surgery and assessment of these interventions.

1.2 Introduction

A remote patient monitoring system might become necessary to monitor critical physiological parameters of patients such as body temperature, heart rate, glucose level, and hemoglobin level and patient state index.

In this thesis, a system has been designed for wireless monitoring of patients so that a doctor can analyze patients in an intensive care unit (ICU) remotely by keeping a close eye on his/her various important health physiological parameters. Five vital physiological parameters (Heart rate, body temperature, glucose level, hemoglobin level, patient state index) for multiple patients are taken into consideration. All values are measured with a fix time interval and saved in the memory. If all values are within the limits then the system measures all physiological parameters continuously and displays them on the LCD. If any crosses the limit, then the system switches to warning/emergency and sends the patient's condition to the doctor.

In the patient monitoring system, all the simulations have been done with the Proteus software. This is a virtual simulation software which enables designer to design a flexible and reliable prototype. With the extensive component libraries, compatibility, different formats and reliability, the said tool is better option for design of VLSI system. It provides so many impressive features like simulation run time environment, measuring real time voltage, current, frequency and waveforms at desired nodes or loops of circuit simulations.

Along with the simulation software, the programming code requires to be tested in any simulation software that will tell the programmer that code is running according to intention. Therefore, in the thesis, Keil Micro Vision is used for testing of code. It has some comparable and salient features like selection of so many programming IC’s, loading of programming through a single click, adjusting flexibility of frequency parameters and importing and exporting files in so many formats.

Chapter 2 explains system parameters which could be used to measure physiological parameters of the patients.

Chapter 3 describes fundamental components in detail, explaining how each component works

Chapter 4 explains the designed and simulation of this system and analyzes it with different test cases.

Chapter 5 summarizes the conclusions obtained from the suggested analysis.

1.3 Literature Background

Nowadays, in most hospital’s Intensive care units, all patients need continuous monitoring of important physiological parameters like heart rate, body temperature, glucose level, hemoglobin level, patient state index. When any parameter crosses the safe range, a nurse inspecting the patient manually pages the doctor. Thus, doctors may suffer from burn out due to manual monitoring of the patients.

To prevent all of the above problems we designed a wireless portable which is an easy to operate microcontroller based physiological monitoring system between a doctor and the patient that reduces the doctor's load and the patient risks. With this design doctor's can assess patient’s health condition anywhere with GSM technology. Sensors are used to measure all physiological vital parameters [6].

There are many wireless standards that can be used for wireless monitoring such as Bluetooth, Zigbee, wireless LAN and GSM [1, 2, 3]. Bluetooth is low cost wireless solution for short range but it has limitations like more software overload and it can serve less number of users due to its network technology named pico net[1]. Zigbee is also a low cost, low power wireless solution but has limitations on data rate and uses heavy software protocol [1, 2]. Wireless LAN is very good for sharing data but it is not suitable for wireless sensors because of use of heavy, expensive equipment and more power consumption [1].

Several wireless monitoring systems have been presented in the literature [1, 2, 3]. Most recent progress in a patient monitoring system is that it uses sensors to monitor different physiological parameters and if a parameter is approaching some critical limit, warning or emergency message is sent to a doctor. Additionally continuous monitoring report can also be saved to a central storage unit [2, 3]. It uses two modules, one on the patient's side and the other on doctors. Patients module with the patient consists of sensors attached to a microcontroller that collects the patient's information and transmits the data. The module on the doctor's side will receive the patient information and decode it, so he/she can be observe and monitor many patients at the same time. During monitoring, if any physiological parameter goes of the scale , an audio alarm is generated and if a doctor is not around an alert message is sent to him/her through a GSM module attached with the receiver unit [2].

When Patient Monitoring System is started it shows a message on LCD that system is measuring heart Rate, hemoglobin, body temperature, Patient state index and glucose level. After taking the specified values from different sensors, the values are then stored in the system for further processing. The system does the same after pre-defined time interval and keeps track of values taken from ten patients. Now, parallel with this, system also compares that values to the two threshold levels (i.e. Warning and Emergency) with the range specified for normal operation. If the values are lying in the normal range after compared from the range values, all the 5 vital signs of 10 patients will be directly stored to the memory location written in coding of microcontroller. This will be happening until some outstanding value (abnormality case) that is not lying in the normal range is recorded. If so happens, then system will display that abnormal values to the LCD and it will also send a warning message to the doctor’s contact through GSM along with the warning and message content having that outstanding value. If any value from above mentioned values for one cycle is reported as greater than the warning threshold, then system will display that abnormal values to the LCD and GSM module will send an emergency situation message to the doctor’s contact saved in microcontroller’s memory. After sending whether the warning message or emergency message, the system will continue to take readings from the sensors and compare the values. This process will be cyclic so, that the live data may be interpreted for further processing. It can be seen from the flow diagram that system is doing parallel processing in order to achieve accuracy. While sending a warning message to the doctor, it might happen that values may go at such level where emergency should be displayed. The system will be taking the values at that instant and will be comparing as well. Therefore, better sophistication of the system, it is required that no value will be misinterpreted or left unattended. Great care has been taken while analyzing the process flow as depicted in the flow diagram (Figure 1.1).

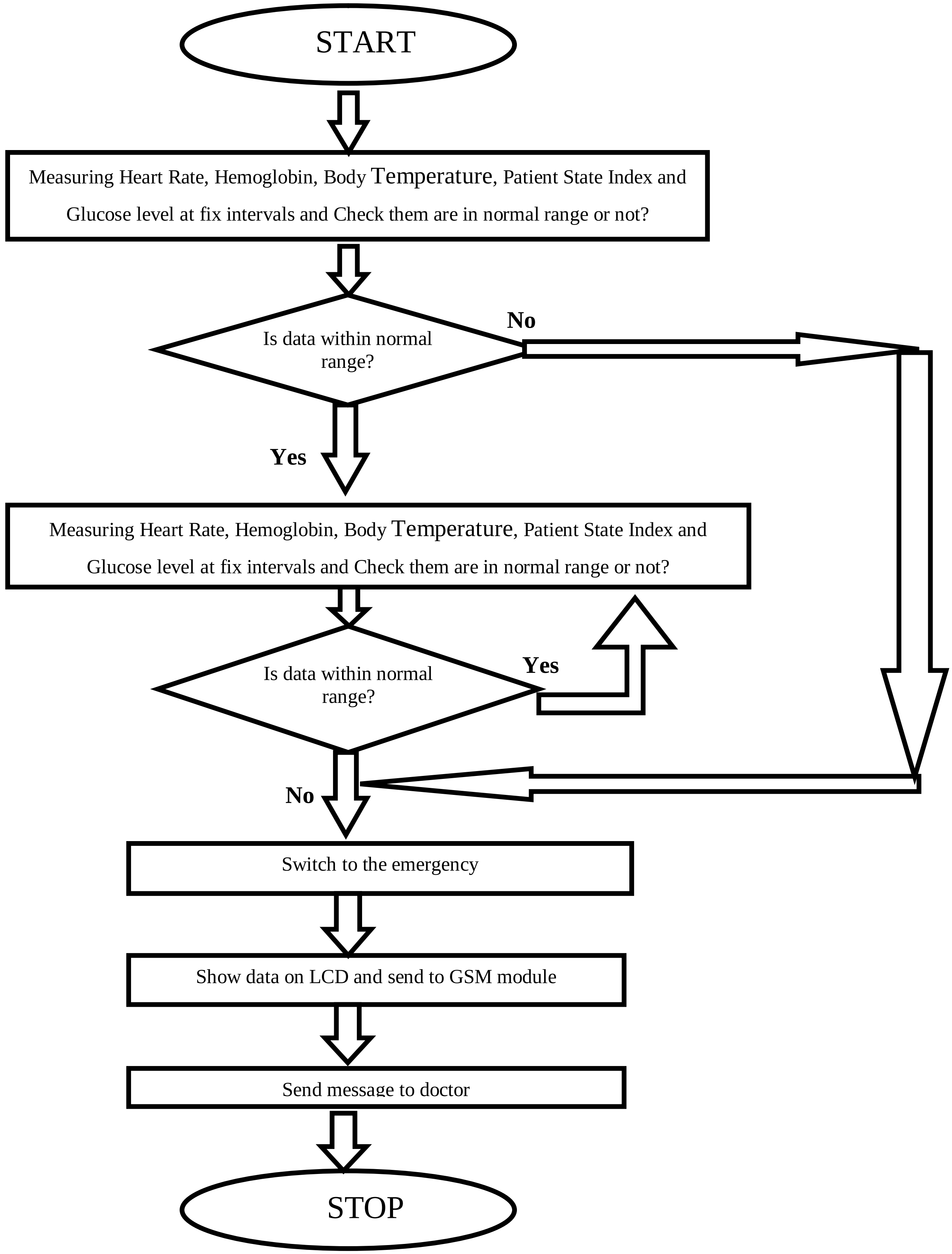


Figure 1.1: Flow chart of patient monitoring system

1.4 Summary

In this chapter was an introduction of this thesis. we discussed why we need this type of microcontroller based physiological monitoring system with the increase of emergency in hosipital. Our research contribution has been explained to improve this system and get better results.

CHAPTER TWO
PHYSIOLOGICAL PARAMETERS

2.1 Overview

In this chapter, we are going to briefly describe the paramedical components that need evaluation.

2.2 Heart Rate

Pulse rate is a speed of heart which can be measured by the number of heart beats per time of unit. It generally indicates the beats per minute (bpm) [7]. pulse rate will vary because human needs to absorb oxygen and discharge carbon dioxide. Both of them will changes physical exercise, sleeping, sickness condition and due to drugs. There are several ways in which the pulse rate can increase or decrease from the normal range. The normal value of pulse rate is between 60 to100 (bpm). If the value of pulse rate is going below 60 (bpm) it means we are in a bradycardia. This is a major problem for the heart would not be able to pump blood to some parts or all parts of human body. When the heart beat is quicker, than the normal heart rate it is called tachycardia. A normal adult heart beats is between 60 to 100 (bpm) [8].

In tachycardia when the heart beat is above 100 bpm the heart will then be working very fast the heart beat would have to be handled by electrical signals.

2.2.1 Heart Rate Measurement Techniques

We can measure the heart rate by finding the pulse of the heart. Heart rate pulse is founded at any point on the human body. The two most commonly spots used to take a pulse are at the radial artery (wrist) and the carotid artery (neck). These two methods are most probable and much reliable method to measure the heart rate in any emergency situations. When we measure the heart rate with radial artery, then we put the index and second fingers of one hand on inside the wrist of the other hand, place our fingers under the base of the other hand’s thumb to get the radial pulse. The easiest way to find a pulse is with carotid artery: with carotid artery (neck) locate both index fingers of one hand on the side of the neck near the windpipe.

In this thesis we will explain a microcontroller based heart rate measurement technique which uses optical sensors to measure the changing in blood level at fingertip with each heart beat. Heart beat sensor has been made to provide digital output [9]. This digital output will be connected to microcontroller to measure the pulse rate in beats per minute. It works on the principle of light modulation by flow of blood through finger each and every pulse.These devices contain an infrared transmitter (LED) and an infrared sensor photo-transistor. The infrared diode transmits an infrared emission towards the fingertip and the photodiode detects the light which is reflected back. The strength of emission light depends on by the blood level in the fingertip. Each pulse rate a bit changes the amount of reflected infrared light |that could be detected from the photodiode. Using a suitable signaling situation, this change in the amplitude of the reflected light may is changed to a pulse. These pulses is usually measured by the microcontroller to discover or find out the pulse rate, after that signal amplified and filtered suitable signal that is fed into a microcontroller for evaluation the pulse rate values and display. The microcontroller measures the number of pulses over a fixed time interval and shows on LCD as shown in Figure 2.1 and Figure 2.2 [10].

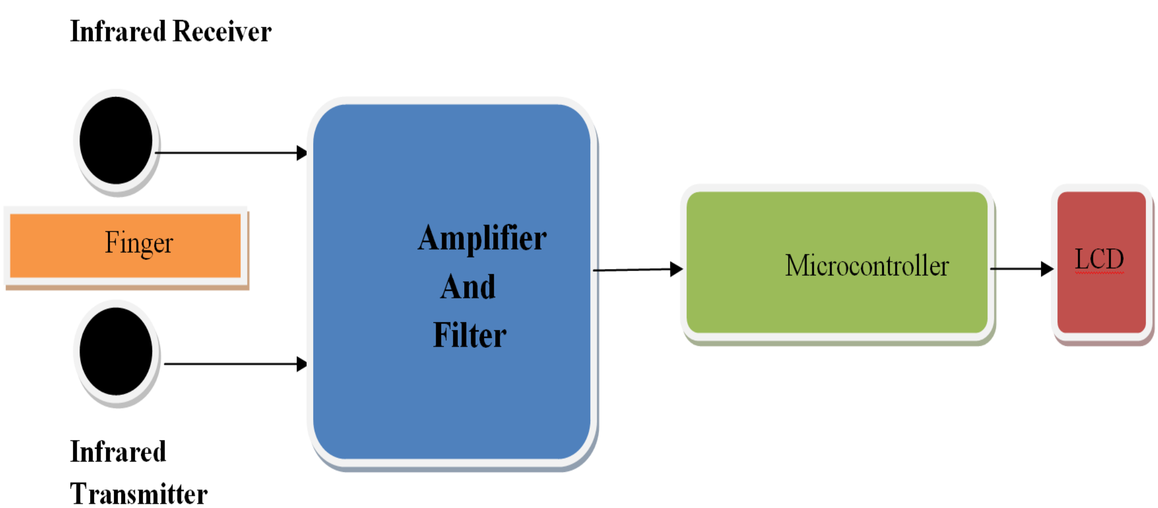


Figure 2.1: Transmitter and receiver for finger tip sensor

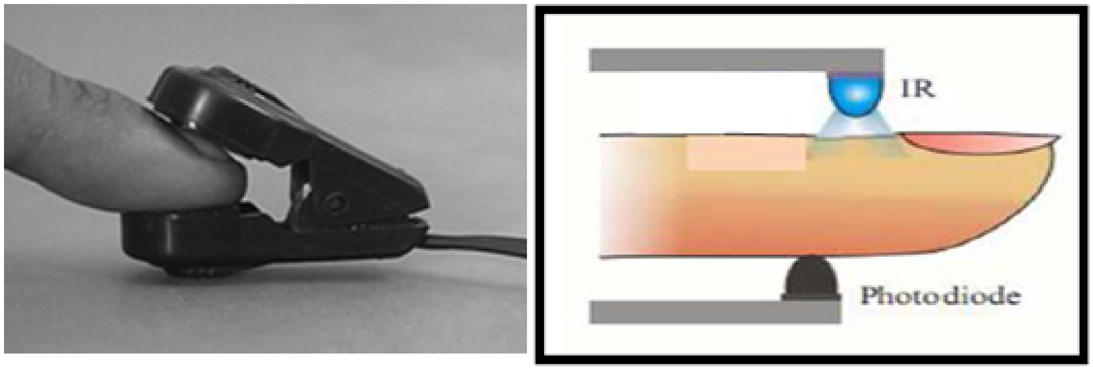


Figure 2.2: Photo diode [9]

2.3 Continuous Glucose Monitoring (CGM)

Continuous glucose monitoring helps people which diabetes to control and prevent its related problems. For continuous glucose monitoring system, patients can make decisions about food and physical activities. The most common methods are by picking a figure tip with a device to get a blood sample. The glucose meter will then glucose level measure. With this the continuous system that is introduced can then be used as an aid for treatment of diabetes. Patients can use, every day a little wearable tool, for the continuous glucose monitoring. This will determine the required level of insulin and it also minimizes the risks of hypoglycaemic.

Figure 2.3: Glucose monitoring device [4]

There are many benefits of performing continuous glucose monitoring. The glucose levels are not always constant this means it keeps on changing during work, patient is exercise eating food etc. Finger prick is one method to measure glucose level. If we do finger stick test routinely, this only provides brief picture relative to the blood sugar level. Ideally to get an accurate reading of general glucose levels one would record data in short intervals of 1 and 5 minutes. This is not realistic using the finger test method. Continuous glucose monitoring (CGM) utilizes a small device injected under the skin to evaluate blood sugar. The device is constantly in place for few days to a week, and then need to be changed. A transmitter transmits data relating to blood sugar levels by using radio waves from the chip of the device [25]. The patient must has to check glucose levels using a glucose meter to program the devices, because at this time approved CGM products quite a bit less accurate and reliable as normal blood glucose meters. Patient must ensure blood sugar levels using a meter before make a modification in treatment. CGM techniques are more costly as compared to regular glucose monitoring system. Continuous glucose monitoring (CGM) devices made by abbott dexcom are approved by the U.S. Food and Drug Administration. This device gives real time measurements of blood sugar levels, showing result in 1 and 5 minute interval [12].

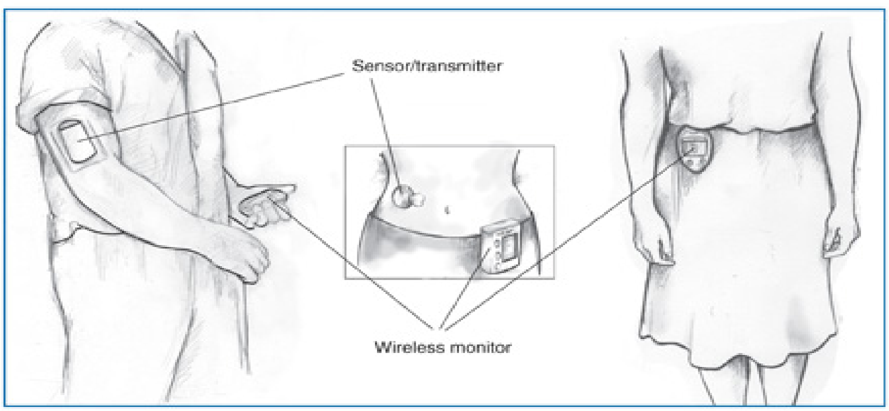


Figure 2.4: Wireless glucose monitor device [4]

It produces actual-meter dimensions, regarding sugar levels, together with blood sugar levels. Users can download information from the equipment to some computer system, for tracking patterns and styles; can display trend charts which the patient can keep track of, from the display screen on the device (Figure 2.5).

Figure 2.5: Dexcom sensor [37]

2.4 Body Temperature

With LM35 (Figure 2.6) it is possible to measure temperature more accurately as compared to using a thermometer. The LM35 sensor circuitry is sealed and never subject to oxidation. LM35 produces a large amount of output voltage as compare to thermocouples. The voltage of LM35 does not need to be amplified. The LM35 are accurate integrated-circuit temperature sensors, [29] the output voltage of LM35 is linearly proportional to the Celsius temperature. The LM35 provides the advantage over linear temperature sensors calibrated in ° Kelvin, because the user is not really necessary to subtract a huge constant voltage from its output to get easy centigrade scaling. The high-precision type of the LM35 does not need any kind of external calibration to provide standard accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. The LM35 low output impedance, linear output, as well as accurate inherent calibration make interfacing to read-out or control circuitry particularly easy and also can used with single power supplies [30].

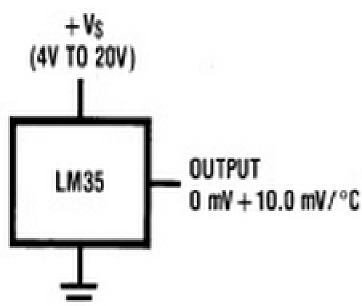


Figure 2.6: LM35 sensor [31]

Probably the majority of micro power circuits, the LM35 have a limited capability to drive heavy capacitive loads. LM35 has ability to work itself on 50 pf without having safety measures. In case if the loads are expected, it is possible to insulate the load with a resistor shows in (Figure 2.7) as well as we can enhance the threshold of capacitance using a series R-C circuit through output to ground which is also showin Figure 2.8

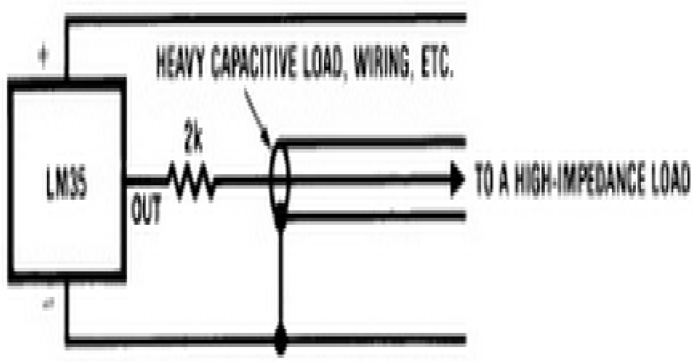


Figure 2.7: LM35 isolate from capacitive load [31]

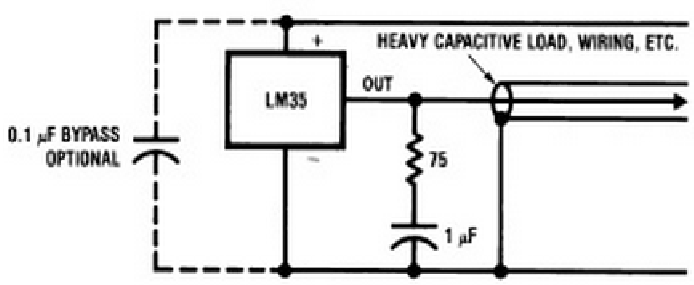


Figure 2.8: LM35 with R-C [31]

LM35 could be used such as other integrated-circuit temperature sensors. It is usually fixed to a surface; its temperature will be within about 0.01˚C of the surface temperature [31]. The air temperature are depends on a surface temperature. If the surface temperature high and low the air temperature behaves likes same it should be high or low. The LM35 will probably die between the surface and air temperature. It is extremely true that with plastic package of TO-92 copper leads carry heat into the device with the principle of the thermal path (Figure 2.9). It is temperature could be closer to the air temperature rather than to the surface temperature.

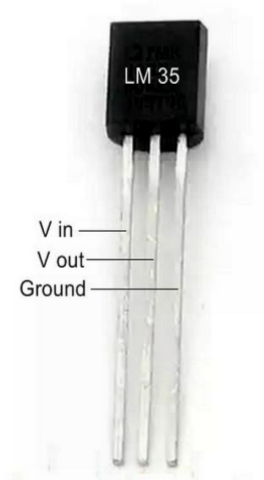


Figure 2.9: TO-92

The most effective way to achieve this is usually to cover these wires using a bead of epoxy that can ensure that the leads and wiring are all at the same.

2.5 MASIMO

It is an international medical company which builds and manufactures modern non-invasive monitoring system, such as medical devices and a variety of sensors. MASIMO is an award winning and vital medical technology company. which provides patient more care reduce and patient risk in emergency and ICU.

MASIMO'S Radical-7 Pulse CO-OXIMETRY device can measure these parameters continuously (Figure 2.10).

- Pulse Rate (BPM)
- Functional Oxygen Saturation
- Perfusion Index
- Total Hemoglobin
- Oxygen Content
- Methemoglobin

All these vital parameters above can be measured by one disposable sensor. There is one more sensor with this device that can measure three different parameters:

- Brain level (BL)
- End-Tidal Carbon Dioxide

- Regional Oximetry

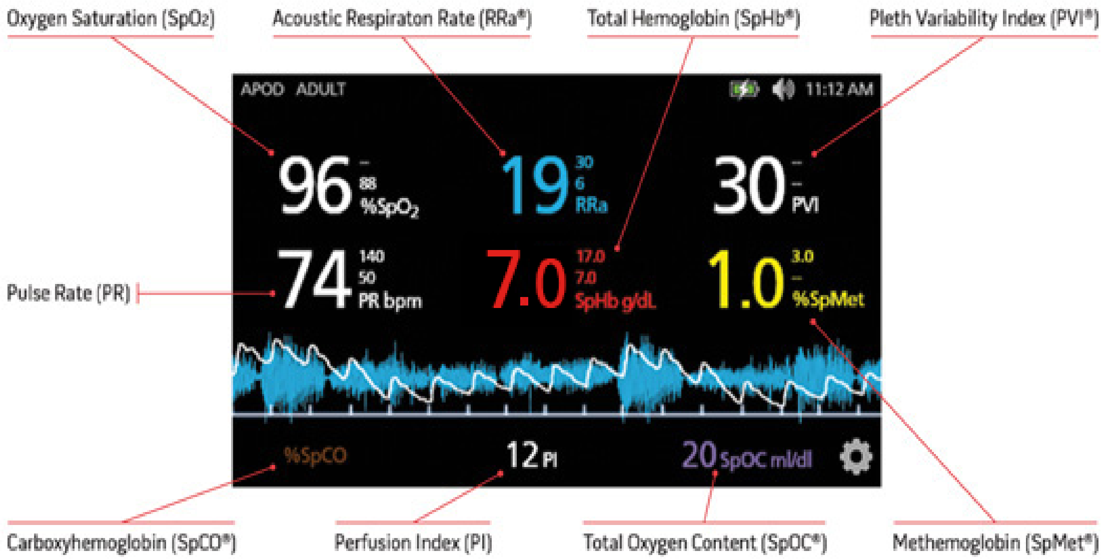


Figure 2.10: Multiple vital physiological parameters [4]

2.6 Top Features of Masimo's Radical-7 Pulse

2.6.1 Displayed Parameters

We are able to change easily displayed parameters having a quick touch. Doctor's are able to move the vital parameter the display and then there is no way of losing the record of any vital values (Figure 2.11).

Figure 2.11: Display parameters [4]

2.6.2 Analyze Patient Trends

This feature provides the capability to check more parameters by using a very quick touch (Figure 2.12). Doctor can move and expand parameters for real time evaluation [15].

Figure 2.12: Analyze patient trends [4]

2.6.3 Normal View

This feature provides a continuous monitoring using a normal view we can monitor multiple parameters shows the normal view output result of multiple parameters values (Figure 2.13).

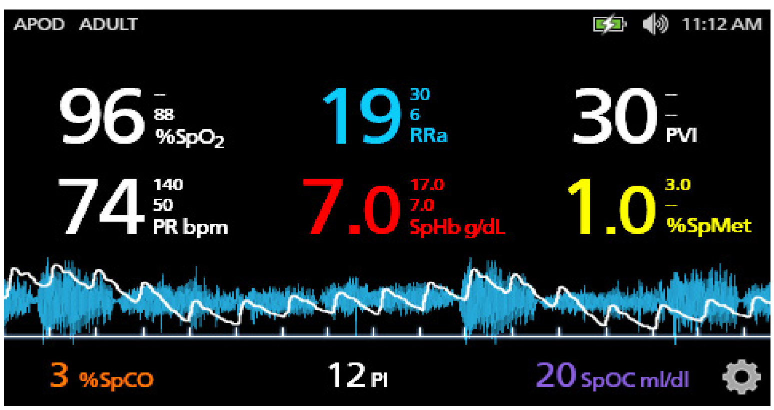


Figure 2.13: Normal view [4]

2.6.4 Trend View

The trend feature provides one-touch accessibility to essential parameter trending information to immediately examine a patient's condition and illness intensity (Figure 2.14).

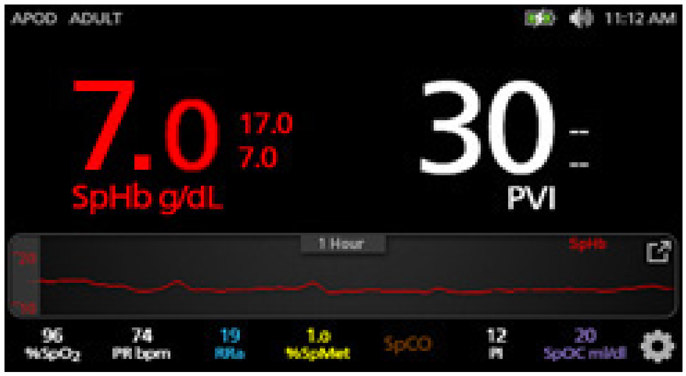


Figure 2.14: Trend view [4]

2.7 Hemoglobin Level

Hemoglobin is a sophisticated protein. This is obtained in red blood cells which containing the iron molecule. The main functionality of hemoglobin is usually to carry oxygen in the lungs towards the body tissues, and to exchange the oxygen for carbon dioxide (co_2), and after carry the carbon monoxide back to the lungs, where it is exchanged for oxygen. The iron molecule in hemoglobin helps maintain the normal shape of red blood cells.

The name is derived from the combination of two words hemo and globin, the hemo is the first part which contains iron atoms that can hold oxygen with iron and second part is globin which produces the protein.

Oxygen is one of the most important elements necessary to maintain human life. If a sufficient supply of oxygen is not circulated during the entire body to essential organs and tissues, brain damage organ failure and death can happen [4].

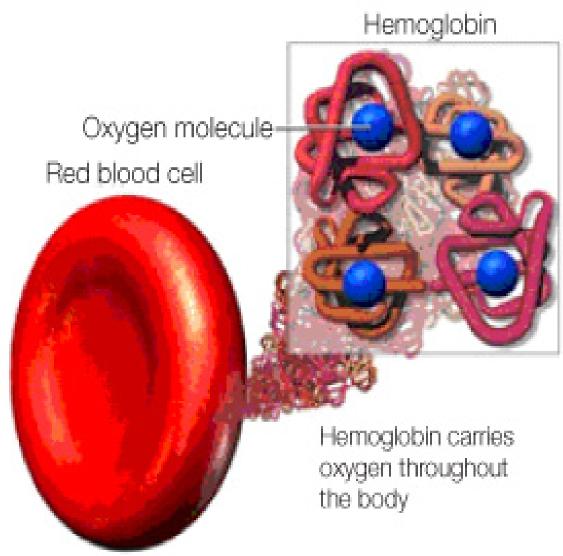


Figure 2.15: Hemoglobin [4]

2.7.1 Functions of Blood in Hemoglobin

Hemoglobin contains in the red blood cells which provide blood it quality color. It acts to hurdle oxygen on the lung towards the tissues we can measure the power of hemoglobin by using diluted blood with suitable solution and measure in the electronic instrument that needs to know the amount is absorbed when it is passed via the solution. This condition is called anemia (anemia, means less than normal levels of red blood cells in a person blood). The term is derived from the Greek term anemia, meaning lack of blood quantity. The body of human normally carries 6 liter of blood. A human blood performs several functions carries O_2 the function which from lung to tissues and tissues to lungs performed by the red cells, carries waste elements from tissues to organ an also maintains the PH of body with the buffer system [23].

2.8 Normal range of hemoglobin

The normal hemoglobin level is indicated as a quantity of or level of hemoglobin in grams per deciliters of complete blood. The standard ranges for normal hemoglobin are based upon the age starting in adolescence and the gender of the person. The normal range of hemoglobin is show in table.

Table 2.1: Normal range values of hemoglobin for different age

1-2 (months)	10.0 to 18.0 g/dl
2-6 (months)	9.5 to 14.0 g/dl
0.5 to 2 (years)	10.5 to 13.5 g/dl
6-12 (years)	13.5 to 15.5 g/dl
12-18 (years)	13.0 to 16.0 g/dl
>18 (years)	13.6 to 17.7 g/dl

2.8.1 Low Level Hemoglobin

Low level hemoglobin is called, anima or a low red blood count. Less than normal quantity of red cells is called anima and hemoglobin demonstrates this number. Few reasons for anima are.

- Waste or lose of blood during upsetting injuries, bleeding
- Health deficiency means iron vitamin B 12 and vitamin BC
- Bone narrow problems
- It also happens by failure of kidneys

2.8.2 High Level Hemoglobin

High hemoglobin levels means that measured hemoglobin levels are above the top of the limits of normal for the age and sex of the person. As an example, a 19 year old who has a detected hemoglobin level of above 17.7 g/dl would have a high hemoglobin level. Several reasons for high hemoglobin levels are listed below:

- Advance lung diseases, one of them is Emphysema
- A disease inside the bone marrow and abuse from the drug
- Hemoglobin is high by chemically raising red blood cells
- Living at a high altitude
- Cancer
- Smoking

- Blood doping

2.9 Bleeding Detection

The majority of injuries are caused by avoidance. It really needs to identify the patient has experience to major bleeding to avoid it and enhance the patient care and also helps the clinical inside and outside the operating room which can monitor and detect the bleeding. It affects nearly 35% of patients in surgery, for patient that is late in detection of bleeding. Will increase risks and costs. Lab test give a late result by inserting a painful needle in a patients body is time consuming. Here are some benefits of this sensor; we can continuously measure hemoglobin with spot checking. We don't need to insert a needle and very fast result in short time. It is user friendly and also helps the hospital staff to measure the hemoglobin increase efficiently. I t will also reduce the risk of accidental needle stick... Patients can get results very rapidly without having to wait for lab result. It is more benefitial for patients to have communication with their doctors [20].

2.10 Hemoglobin Measured

Over 500 thousand Hemoglobin tests, detecting popular blood stream disorders, like anemia are performed on a yearly basis. It is the most frequent technically coherent blood test out. With this very first, brand new, discovery of technology "MASIMO is non-invasive and continual total hemoglobin keeping track of technology makes it possible for hemoglobin examination without a hurtful needle stick. Red blood examination increases the risk and cost to all hospitals. Lots of transfusions are considered unnecessary; it is impotent to reduce these transfusions (Figure 2.16). This product has developed non-invasive and continues hemoglobin monitoring that helps hospital optimized transfusions decision by giving real time trending in hemoglobin and also provides helps to reduce the blood transfusions with low and high loss surgery [4].

Figure 2.16: Hemoglobin measuring meter [4]

2.11 Patient State Index Monitor

2.11.1 Electroencephalography (EEG)

EEG is a test which can observe electrical activity in our brain, using very tiny metal discs which are attached to your head. The human brain cell communicates by using electrical impulses. This is also works whilst the patient is a sleep, as the brain is active. EEG is main diagnosis test for epilepsy [33, 17]. There are many kinds of brain waves which show the brain activity.

alpha waves are a type of brain wave working frequently between 8-12c/s. This wave exists only in present working condition. When the patients eyes are usually closed. When we are physically alert and when you eyes are open, alpha waves disappears. beta waves frequency is 13-30 c/c. beta rays are found when you take high doses of specific medicine i-e benzodiazepines. The third one is delta wave which works under three cycles per second. It is usually found when a child is in a sleeping condition. The last one is theta wave. It has frequency between 4-7c/s but it works same as delta waves. The only difference is in frequency.

2.11.2 Normal EEG

In patients that are awake EEG generally indicates the alpha and beta rays with normal EEG. The results of both sides of the brain show patterns of electrical activity. During the EEG test one light used which is called flashing light is widely used for the test of brain. This can have a quick feed back or response after every flash, only when waves are in normal conditions [32].

2.11.3 Abnormal EEG Waves

When the brain shows different electrical waves at both sides it means EEG is not in normal condition. It displays unexpected bursts of electrical activity in the brain. These situations cause brain tumor, accidental injury, heart attacks. In abnormal condition EEG provides mostly delta and of theta waves, these results will determines brain illness and brain injury [33]. When EEG displays strait lines which means that brain function has stopped due to insufficient oxygen. Flow of blood inside the brain. This can happen when patient is in comma.

2.11.4 Patient state index Monitoring

Brain monitoring is used to enhance the patient's care and reduce the risk of death when the patient is under the anesthesia (anesthesia, which is a temporary state consisting of unconsciousness, loss of memory, lack of pain, and muscle relaxation).

Brain monitoring increases the usage and accessibility of advanced nervous monitoring technology in hospitals. It additionally represents a vital development for the practice of anesthesia. EEG data provides details about both sides of the brain to help quick detection of asymmetrical activity.

2.11.5 Patient's State Index

Patient's State Index (PSI) is a way of measuring brain activity that shows the patient's present level of anesthesia and gives additional information to improve anesthesia control and accomplish electric assessment. It also provides a cost effective solution that can help obtain targeted sedation during all phases of anesthesia inside ICU.

2.11.6 Patient state index guidelines

Brain monitoring function uses this monitoring device. It helps the anesthesia provider, transmits required level of sedation. It works on a sophisticated algorithm to determine the patient state index value by measuring anesthetic depth. The patient state index corresponds to a patient's current level of anesthesia along a scale of zero to hundred, where a hundred s being fully awake. Guidelines for interpreting the entire range of values are presented below. We can see patient's brain condition by reading the PSI range. Which shows the patient condition in the diagram

(2.17) 25-50 value is range of optimal hypnotic state for normal anesthesia? In color diagram numeric patient state index value is shown that is color code for the fast and immediate response of the patient [21].

Real-time, four channels EEG which show the information like a wave from design a density spectral array allow very easy and quick confirmation of PSI value. There are many advantage of PSI. The PSI technique gives very fast assessment as well as provides the color coded and numerical value which clearly indicate the amount of anesthesia. It also provides very early result using density, spectral array and also easy to interpret high definable graphic of hemispheric activity.

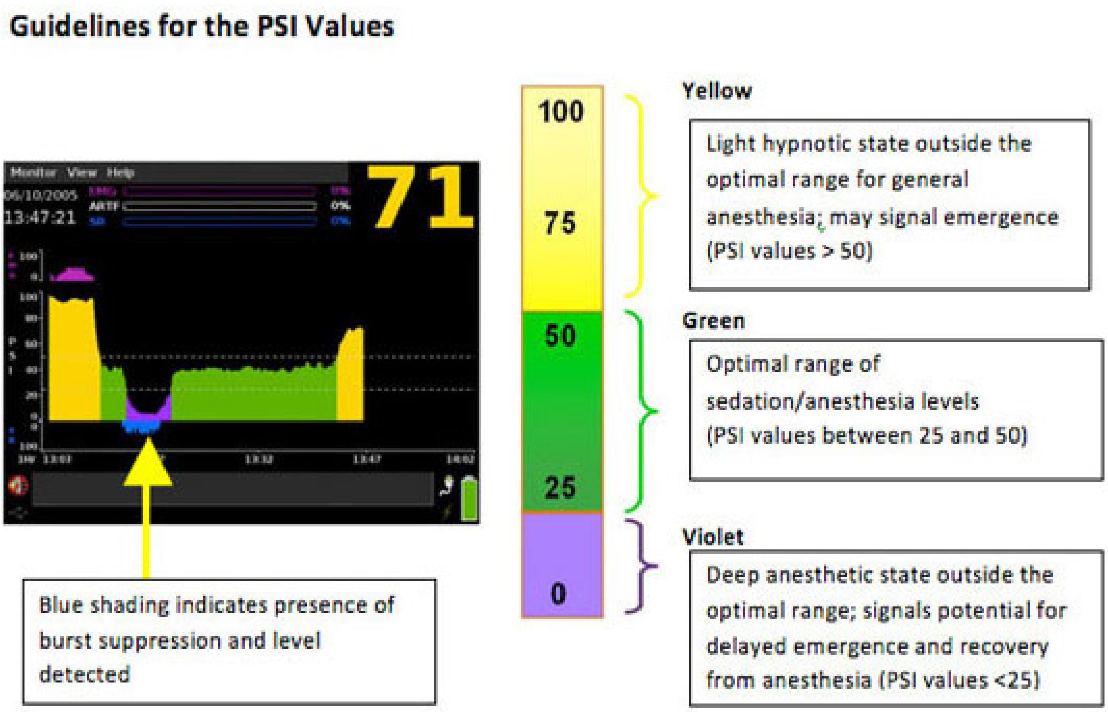


Figure 2.17: Patient state index guidelines [18]

Figure 2.18: EEG four channel [18]

2.12 Sensor Application

For patient's health care and to improve the result, in this case we use a sensor which can make the application easy to use and enhance the quality of data. We can collect higher levels of data which receive good quality EEG signals using this sensor as well as being easy to apply. [22]

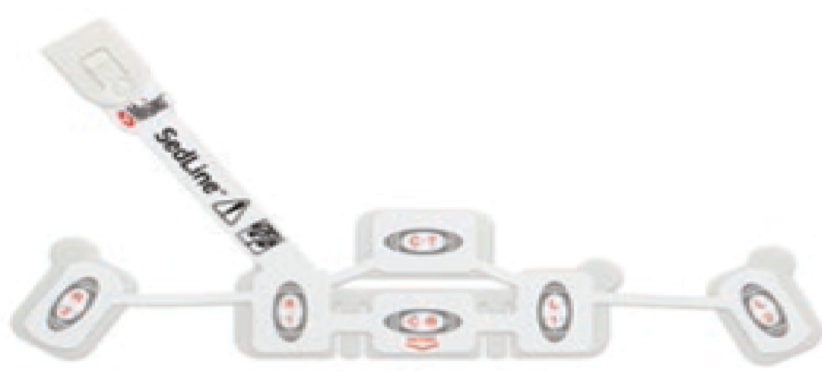


Figure 2.19: Patient state index monitor sensor [18]

2.13Summary

In this chapter was explained five vital parameters sensor device which measured the patient vital physiological parametres, like as Heart Rate, Body Temperature, Glucose level, Hemoglobin and patient state index.

CHAPTER THREE
FUNDAMENTAL COMPONENTS

3.1 Overview

In this chapter, we are going to briefly describe the fundamental components that need for simulation.

3.2 Microcontroller

Microcontroller unit (MCU) is a single chip which contains the processor, volatile and non-volatile memory also called RAM and ROM, input output unit and a clock also known as computer chip. Billions of microcontrollers are embedded annually in a variety of products from toys to appliances to automobiles. Microcontroller is a very compact microcomputer built to control the operation of embedded in office working machines, complicated medical devices, mobile radio transmitters, home appliances, toys, robots and many other application things. A microcontroller has a processor (CPU), memory, RAM, ROM and peripherals [24].

Furthermore, advanced microcontroller can perform vital functions in systems like aircraft, spacecraft etc. In medical technology a microcontroller can regulate the function of an artificial heart, kidney, body organs, and also artificial limbs. Figure 3.1 shows the basic block diagram of a microcontroller.

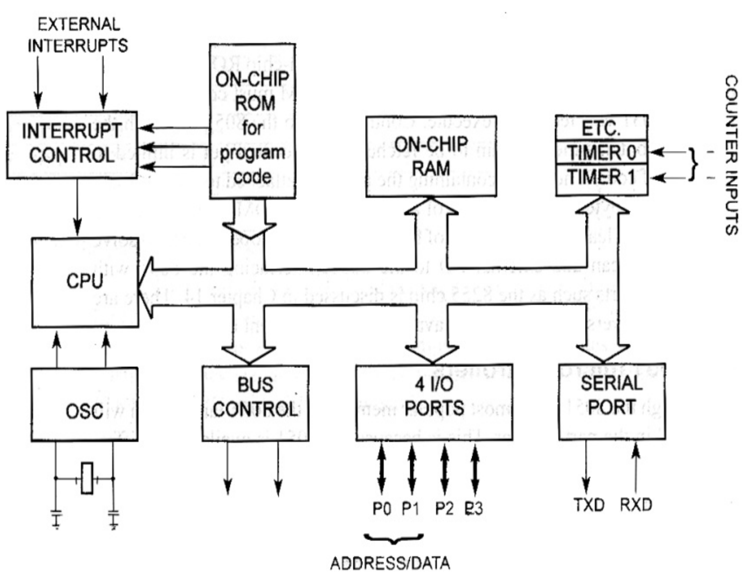


Figure 3.1: Basic block diagram of microcontroller

3.3 Components of a Microcontroller

The components of a microcontroller are discussed in the following sections.

3.3.1 Read Only Memory

ROM is utilized to store the executed data permanently. ROM is usually integrated in the microcontroller or additionally added as an external chip. A microcontroller will be less costly and the program is usually longer if Read Only Memory is designed for the external chip. ROM used internally is smaller but much expensive.

3.3.2 Random Access Memory

RAM is usually a volatile memory that can be used to store the data temporary. Data which is stored in the memory will be cleared if the power supply is off.

3.3.3 Electrical Erasable Programming ROM (EEPROM)

This is a special type of memory which is not available in all microcontrollers. EEPROM is a type of PROM which can be used to remove the data with an electrical charge. Like other types of PROM, EEPROM stores the data if the power supply is turned off. It works more slowly as compared to the RAM.

3.3.4 Program Counter

Program counter is an engine running the program and points to the memory address that contains the next instructions to execute. The value of the counter is increased by 1 after each instruction executed, so that the program can execute only one instruction at a time.

3.3.5 Central Processing Unit (CPU)

The Central Processing Unit (CPU) is responsible for interpreting and executing most of the commands from the computer's hardware and software. The CPU could be considered the "brains" of the computer. In the CPU, the primary components are the ALU (Arithmetic Logic Unit) that performs mathematical, logical, and decision operations and the The CU (control unit) ,which extracts instructions from memory and decodes and executes them, calling on the ALU when necessary.

3.3.6 Input/Output Ports

These are used for making the microcontroller practical which is important to communicate the computer peripheral. Every microcontroller has several registers called ports attached to the microcontroller pins. A port that allows improving operation using the user requirement.

3.3.7 Oscillators

Pulses generated with oscillators enable harmonical function of circuits in a microcomputer. An oscillator is always designed to use quartz crystal for frequency stabilizing. Additionally it can be run without elements for frequency stabilizing like (RC-oscillators). It is very important to say that program instruction will not be executed at the rate imposed with the oscillator but many time slower.

3.3.8 Timers

A timer is the method by which the microcontroller measures the passing of time such as for a clock, a pause/wait command, timer interrupts etc.

3.3.9 Serial Communication

A serial connection in a microcontroller is useful for communication. With serial communication we can use it to program the controller from a computer, use it to output data from your controller to your computer.

3.3.10 USART

The UART (Universal Asynchronous Receiver / Transmitter) is very useful in a microcontroller for communicating the serial data to a computer. USART converts incoming parallel data to serial data.

3.3.11 Watch dog timer (WDT)

Watch dog timer is an electronic timer that is used to detect and recover if something goes wrong with an electronic system and the system does not recover on its own.

3.3.12 Pulse-width modulation (PWM)

This is a modulation technique that is employed in communications systems to encode the amplitude of a signal into the width of the pulse. The main use of PWM is to control the power supplied to the electronic devices.

3.4 PIC-18F4520 Micro-controller

It has an extended structure depending on the PIC-18F4520 that provides. The latest features, such as extended instruction set, power management's modes, very fast speed, and increased USART. It also provides computational performance at less cost and enhances the flash program memory [27].

3.4.1 Top Feature of PIC-18F4520

This microcontroller enhances the program memory and data EEPROMS which are performing huge number of erase/write cycles which are approximately 100,000 to program memory and for EEPROMS it is 1,000,000. With a PIC microcontroller, this could be to write a program memory spaces under interval control. PIC-18F45320 microcontroller extended the instructions set and added new instructions and an indexed mode. In PWM mode, this provides four modulated outputs for handling half and full bridge drivers. Additional features include auto shutdown for disabling PWM outputs on interrupt and auto restart to reactivate outputs when condition has cleared. It also improves the USART which provides stable operation for application [28].

The PIC-18F4520 microcontroller can work with its CPU core disabled but the peripherals are still active, so the power consumption of the system can be reduced. The power requirements for Timer and the Watchdog Timer are reduced and minimize the power consumption during the code execution. Figure 3.2 show the pin diagram of PIC-18F4520 microcontroller.

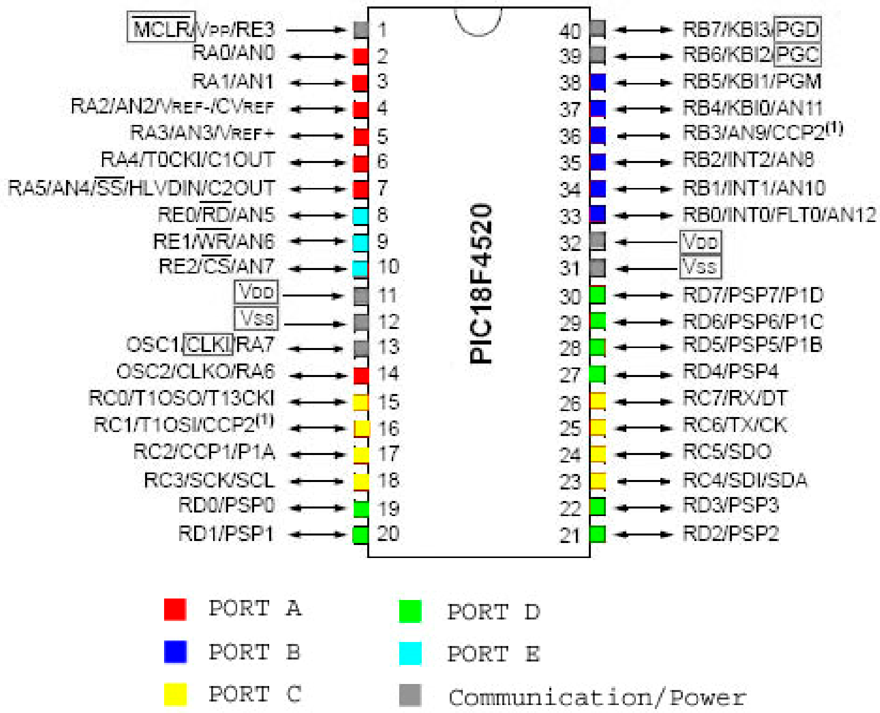


Figure 3.2: Pin diagram of PIC-18F4520 [13]

3.5 GSM Modem

This is a special type of modem that allows a SIM card, and it can works like a cell phone. If a GSM modem is attached to a computer that can be permits the computer to use the GSM modem to connect the mobile network. Even though these types of GSM modems normally helpful to provide mobile internet connectivity and with GSM we can send and receive SMS and MMS message like a cell phone operators.

GSM modem is usually a modem device which can be connecting with a computer with a serial port communication, USB device and the Bluetooth. GSM modem |can be used as a general term to refer any modem in which can be facilitates more than one of the protocols in the GSM, such as 2G and 3G. General packet radio service (GPRS) is usually a packet data service and enhanced Data rate (EDGE) both are use for enhanced the data rate in communication system as well both have very fast speed and designed for the GSM.

GSM modem which can be facilitates like SMS services that can be use to send and receive messages. The cellular operator charges for this message sending and receiving |just as if| |it had been done directly on a cell phone. To execute these tasks, a GSM modem should have facilitates to support an “extended AT command set” the AT command used for sending/receiving SMS messages. Generally a GSM modems is a fast and efficient method of getting started with SMS, due to the fact a special subscription with an SMS service vendor is not necessary

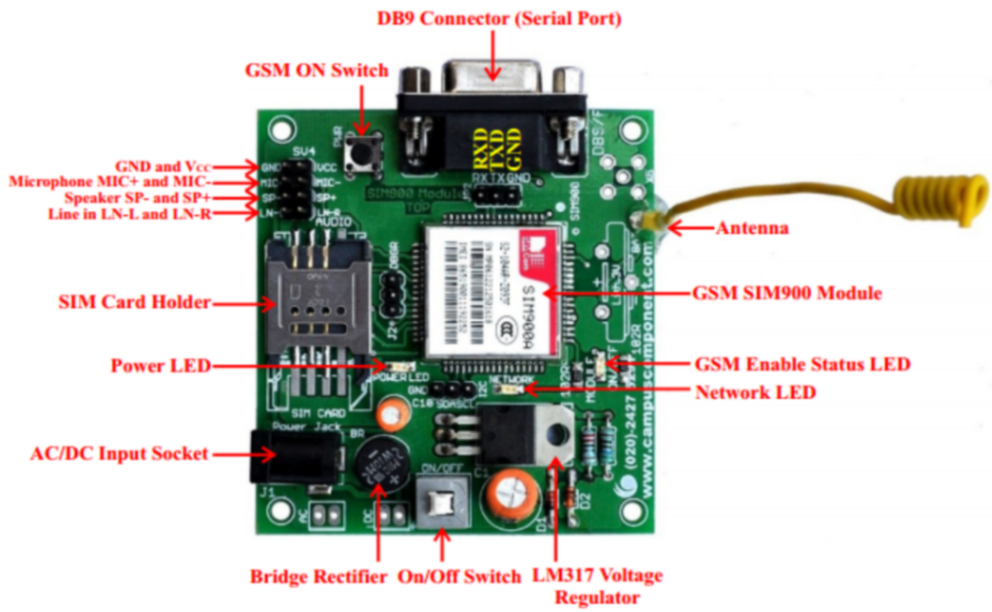


Figure 3.3: GSM modem [19]

3.6 LCD

LCD is a very thin flat display device consisting of a variety of colour pixels arrayed in front of light source. Every pixel has a column of liquid crystal molecules suspended in between two transparent electrodes and couple polarizing filter, the axes of polarity which are perpendicular to each other. Quite a few microcontrollers employ smart liquid crystal display (LCD) to output visible information. LCD features are affordable, user friendly and it is also even possible to make read out pixels display.

This is a standard ASCII group of characters and numerical designs, with an 8 bit data bus the display need a +5V power supply furthermore input output ports for power supply requirement need 4 bit data bus and after 7 additional lines. Data may be put to any location on LCD.

LCD needs three commands line on the microcontroller. The 1st line is an Enable Line which allows using the display via RW and RS line. LCD will be disabled and ignore the signals when the enable line is low from RW or RS and LCD checks the status of the two controller lines and reacts accordingly if line is high, Read/Write(R/W), this line can determine the direction of information between the LCD and microcontroller. Data information writes on LCD when it is Low and we can read data on LCD when it is high. Register selects (RS); by using RS line LCD interprets any type of data on data lines. Instructions written on the LCD are if it is low and character written to the LCD when it is high.

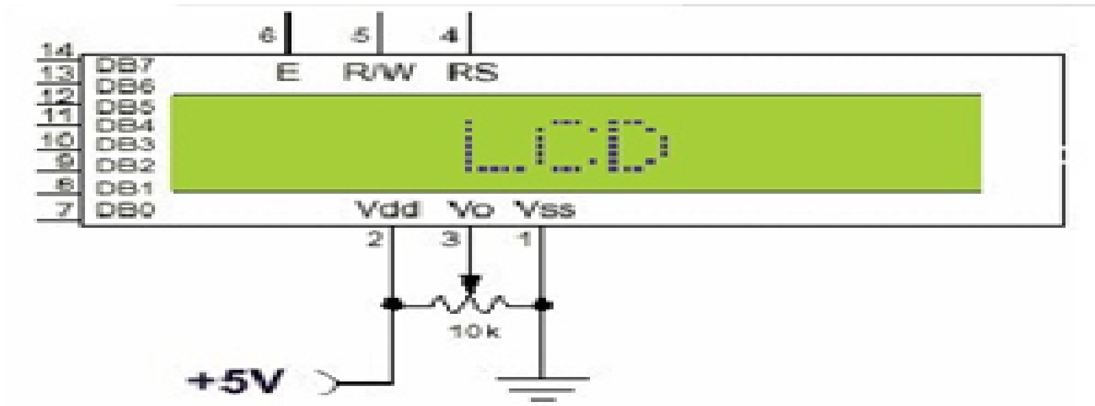


Figure 3.4: LCD [5]

3.7 Voltage Regulator LM7805

LM7805 voltage regulators are designed for a wide range of applications. These applications include on card regulation for elimination of noise and distribution problems associated with single point regulation. Each of these regulators can deliver up to 1.5 A of output current. In addition to being used as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents, and also can be used as the power-pass element in precision regulators.

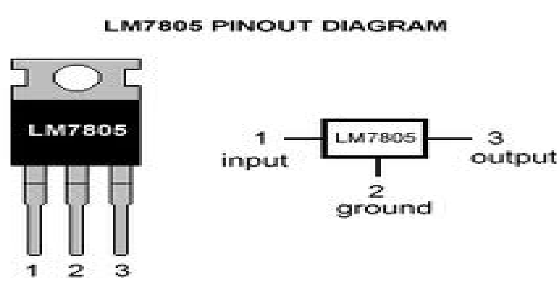


Figure 3.5: Voltage regulator [14]

3.8 Buzzer

A buzzer or beeper is an audio signaling device which may be mechanically, electromechanically and piezoelectric. Typical uses of buzzer include alarm devices, timers and confirmation of user input.

3.9 Serial Port Interface MAX 232

Serial port interface is a parallel interface which sends and receives 8 bits data at the same time over 8 individual wires. This way data will be transferred very quickly, however each cable will be bulkier because of the number of individual wires it contains. Parallel port is generally used to connect a personal computer to a printer. A serial port can send and receive data only 1 bit at a time. Although it takes time to transfer each bite of data, this way only few bites are required, so full duplex communication can be done.

In full duplex communication we can send and receive data at a same time, hence we can send data using three separate wires and receive data on another three wires as well as common signal ground wire [28].

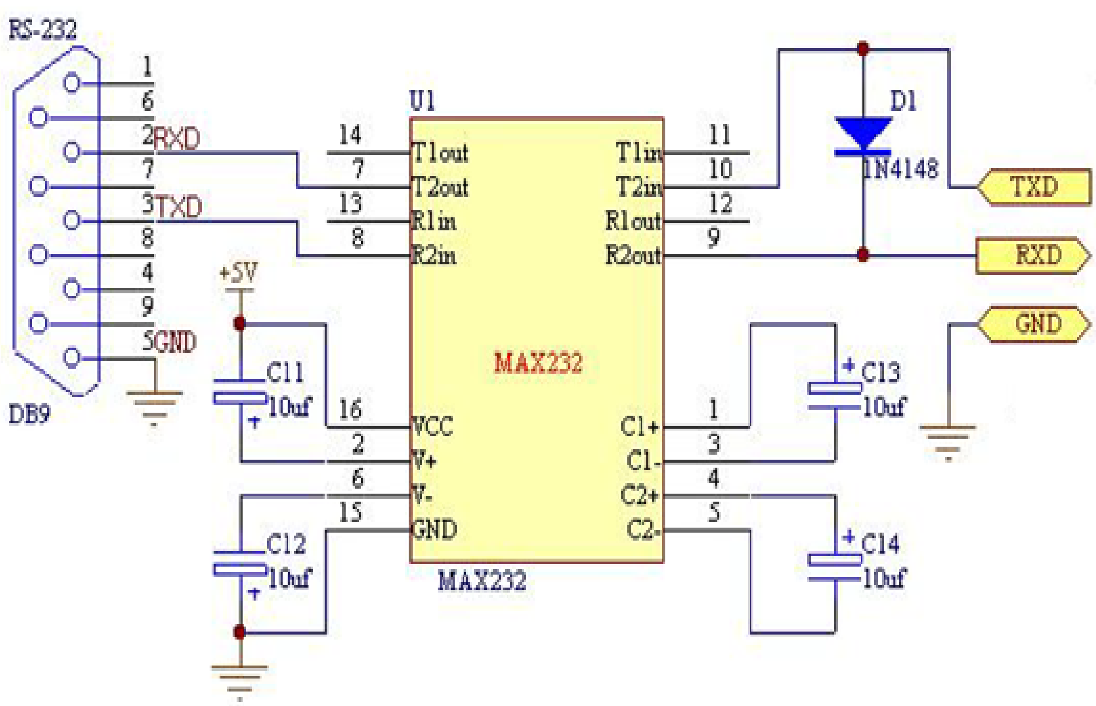


Figure 3.6: Interfacing circuit of serial port [6]

3.10 Summary

This chapter was about hardware components which we really need for simulation. In this chapter we were explained the funtion of each fundamental components that how is works.

CHAPTER FOUR
DESIGN, SIMULATION AND ANALYSIS

4.1 Overview

The goal of this chapter is to describe the design and simulation of a hardware system that can be used to monitor up to 10 patients in a hospital. This system is to check each patient's body temperature, heart rate, hemoglobin level, and patient state index monitor and glucose levels. If the value of any measured physiological parameter crosses a set value, this device can send warning or emergency messages using GSM technology to a remote doctor's mobile in the form of SMS. Measurements are done using multiple devices connected to the patients' body. Then, this information is send to a microcontroller for processing.

4.2 Aim

In emergency cases and risky situations, the doctor's visit to the patient is important and the unavailability of a local doctor may result in death. It is the aim of the system designed here to warn, either locally or remotely, a doctor when a physiological measurement indicates something critical. The system may provide connectivity using GSM technology (SMS to be precise) between the patient and the doctor/paramedical staff for immediate attention.

4.3 Design

Patient monitoring system designed here uses various devices for physiological measurements, such as the measurement of body temperature, heart rate, hemoglobin level, brain level and glucose level, and sends all data to a local microcontroller so that the patient's health could be monitored by a doctor anywhere inside or outside the hospital. This monitoring system may be used for multiple patients in an emergency room (ER) oran intensive care unit (ICU) where multi-patient information is collected from multiple sensors. LM35 sensors may be used for body temperature and MASIMO radical-7 pulse co-oximetry devices may be used for continuous hemoglobin level and brain level. For pulse rate, fingertip sensors and for glucose level, continuous glucose measurement (CGM) devices produced by companies like Abbott and DEXCOM may be used.

4.4 Patient Monitoring System

Block diagram of the patient monitoring system is shown in Figure 4.1. A microcontroller is used to obtain information from multiple devices that values of physiological measurements, which may then be locally displayed on LCD screens, saved or transmitted using GSM technology.

When a patient’s physiological parameter crosses an internally set value, then this device may turn on a buzzer to warn a local doctor of emergency or send a warning message to the doctor’s cell phone. This way, long distance specialist advice could be sought in order to provide enhanced medical facilities to areas that lacks basic infrastructure.

Table 4.1 shows the values of physiological parameters that trigger warning messages or emergency messages.

Table 4.1: Critical values for Measured Physiological Parameters

Physiological Parameters	**Low value**	**High Value**	**Emergency**	**Warning**
Body temperature (^{o}F)	80	120	>120	>110 or <80
Glucose level (mg/dL)	80	120	>120	>110 or <80
Pulse rate (beats/min.)	80	120	>120	>110 or <80
Hemoglobin level (g/dL)	13.8	17.2	>17.2	>15.2or<13.8
Patient state index Monitor	25	100	>100	>75or<25

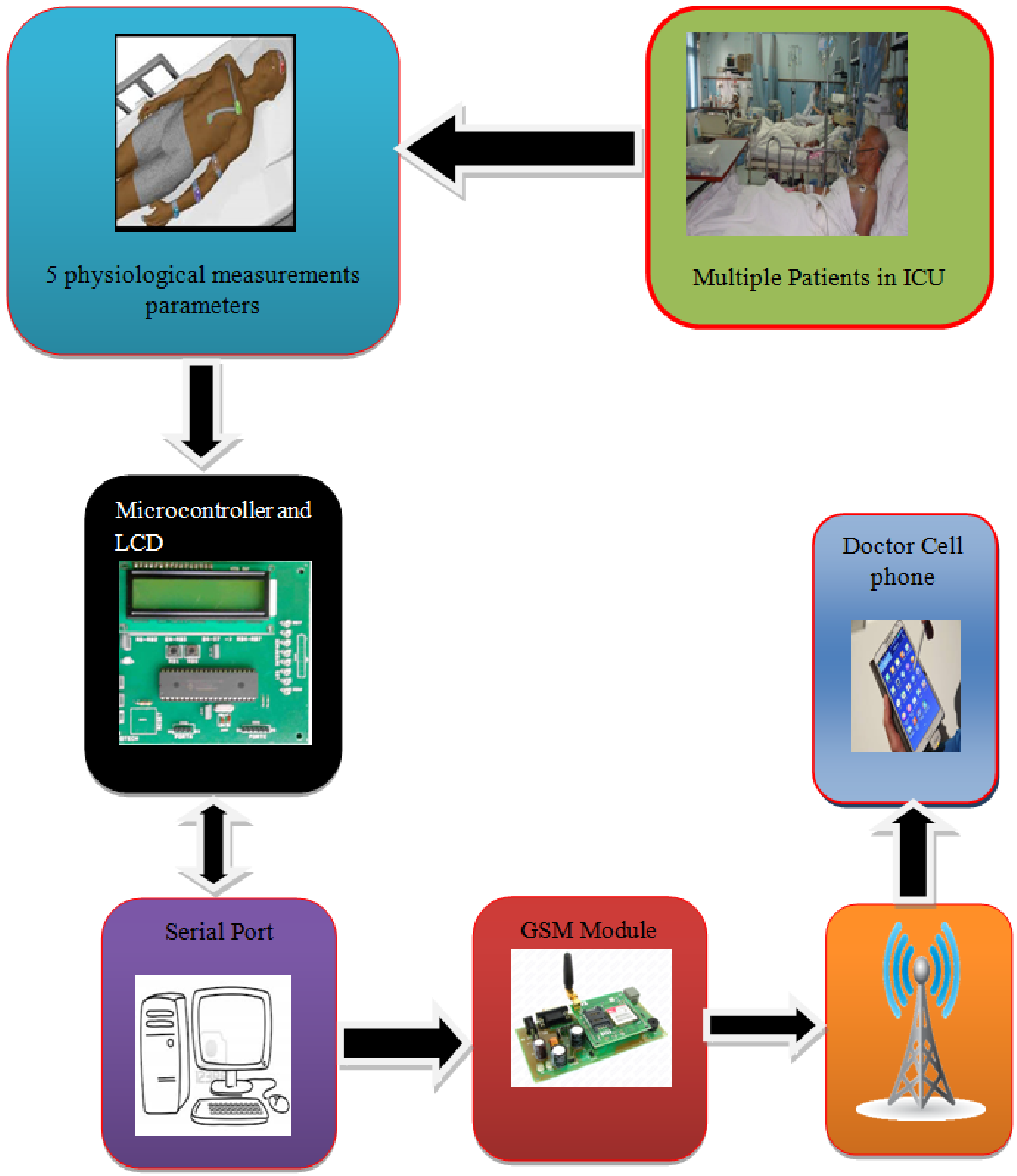


Figure 4.1: Block diagram of patient monitoring systems

4.5 Proteus Simulation Software

It is simulation software for different designs with micro controller. Proteus is very popular because use of all microcontroller inside it. Therefore, it is a very useful tool to evaluate the programs and embedded design for electronics. We can simulate our programming of microcontroller with proteus simulating software. After simulating we are able to make directly PCB design by using this software.

The very important feature regarding Proteus is usually having the ability to simulate the particular discussion between computer and microcontroller with analogue and digital electronics connected with this. Although, the Proteus has special capacity to operate a real time simulation regarding and determined to microcontroller methods. Proteus is a tangible which can do a large amount of simulation with single face function. The Proteus comes with precise characteristics and research for text messaging. This is very beneficial to be considered debugging help allowing for this designer to find out the problems in the software application as well as hardware is much quicker when compared with others.

Figure 4.2(A) and figure 4.2(B) shows the circuit diagram of the monitoring system. This system can be divided into three main units:

- Patient Monitoring Unit
- Local Observation Unit
- Remote Transmission Unit

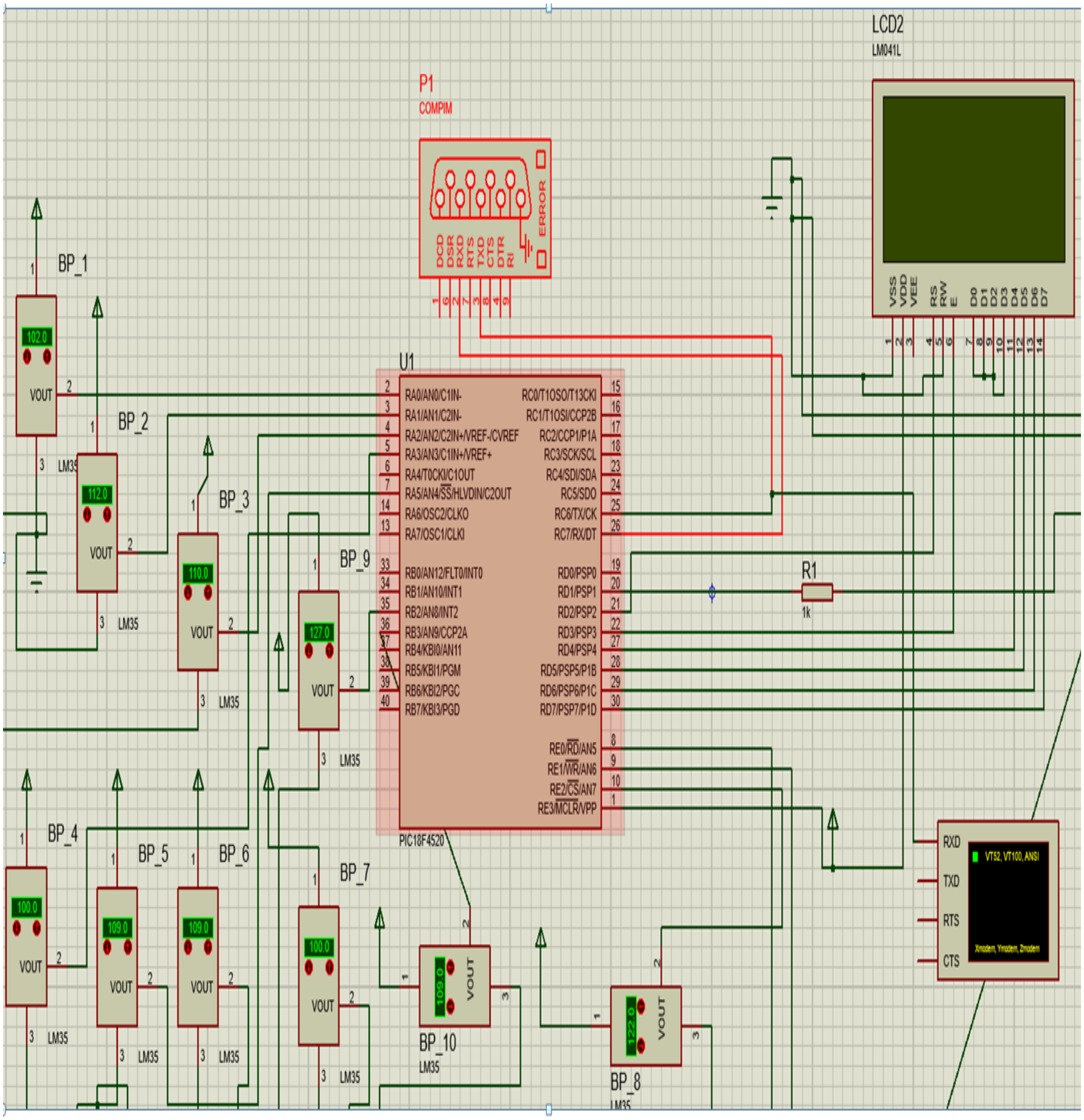


Figure 4.2 a: Circuit diagram of patient monitoring system

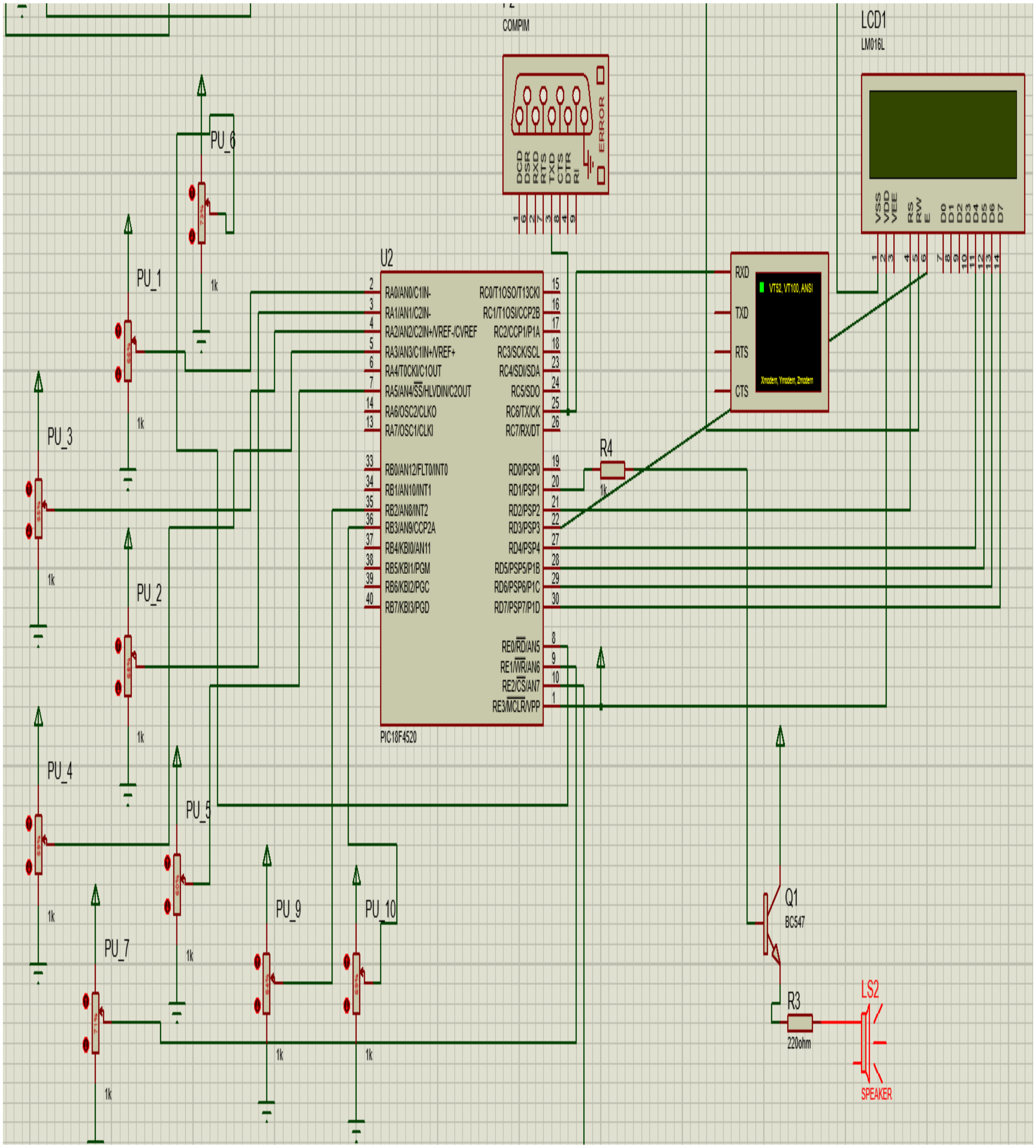


Figure 4.2 b: Circuit diagram of patient monitoring system

4.6 Patient Monitoring Unit

Figure 4.3 shows the block diagram of part of the system that contains five devices for measuring the body temperature, pulse rate, hemoglobin level, brain level and glucose level of the patient. All devices are connected to the patient's body. The microcontroller acquires the measured information, processes and sends it to the main unit.

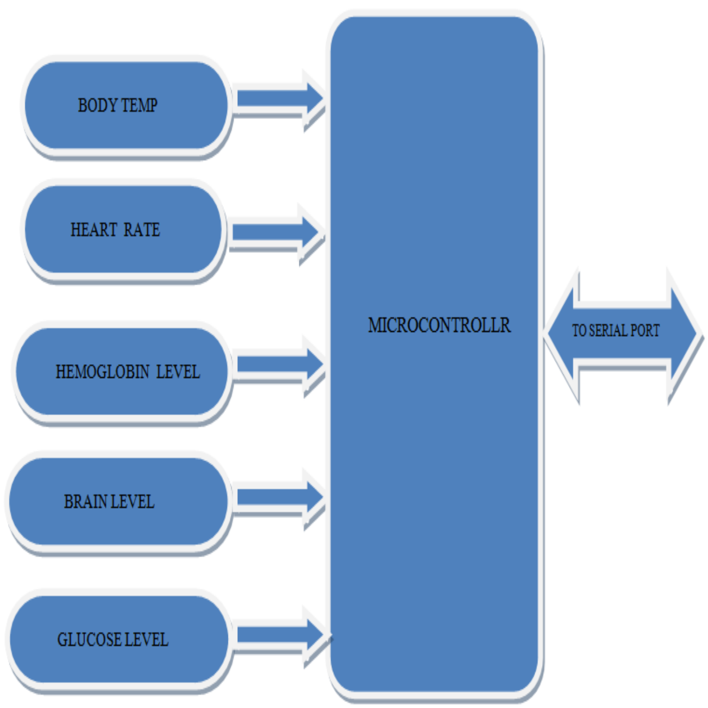


Figure 4.3: Block diagram showing physiological signs being sent to a microcontroller

4.6.1 Body Temperature Measurement

This body temperature sensor shows in Figure 4.4, which is usually called an analog temperature sensor, offers a voltage output which changes linearly relative to the temperature of the body. When the temperature increases its mean voltage also increases. Increasing and decreasing the voltage temperature will generate an analog signal which is directly proportional to the temperature.

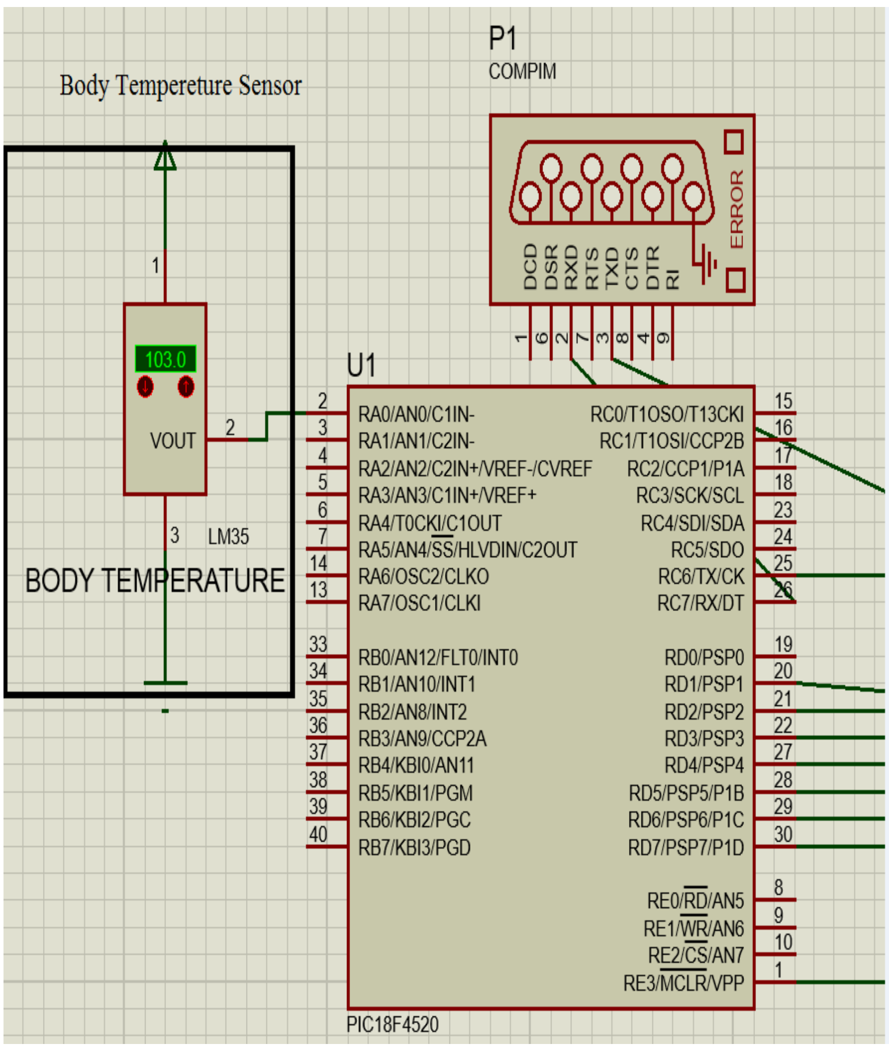


Figure 4.4: Body temperature sensor

4.6.2 Pulse Rate Measurement

The heart rate sensor contains a light emitting diode (LED) and a light detection resistor (LDR) parallel to each other. The patient just needs to put his/her finger in between them to measure the heart rate.

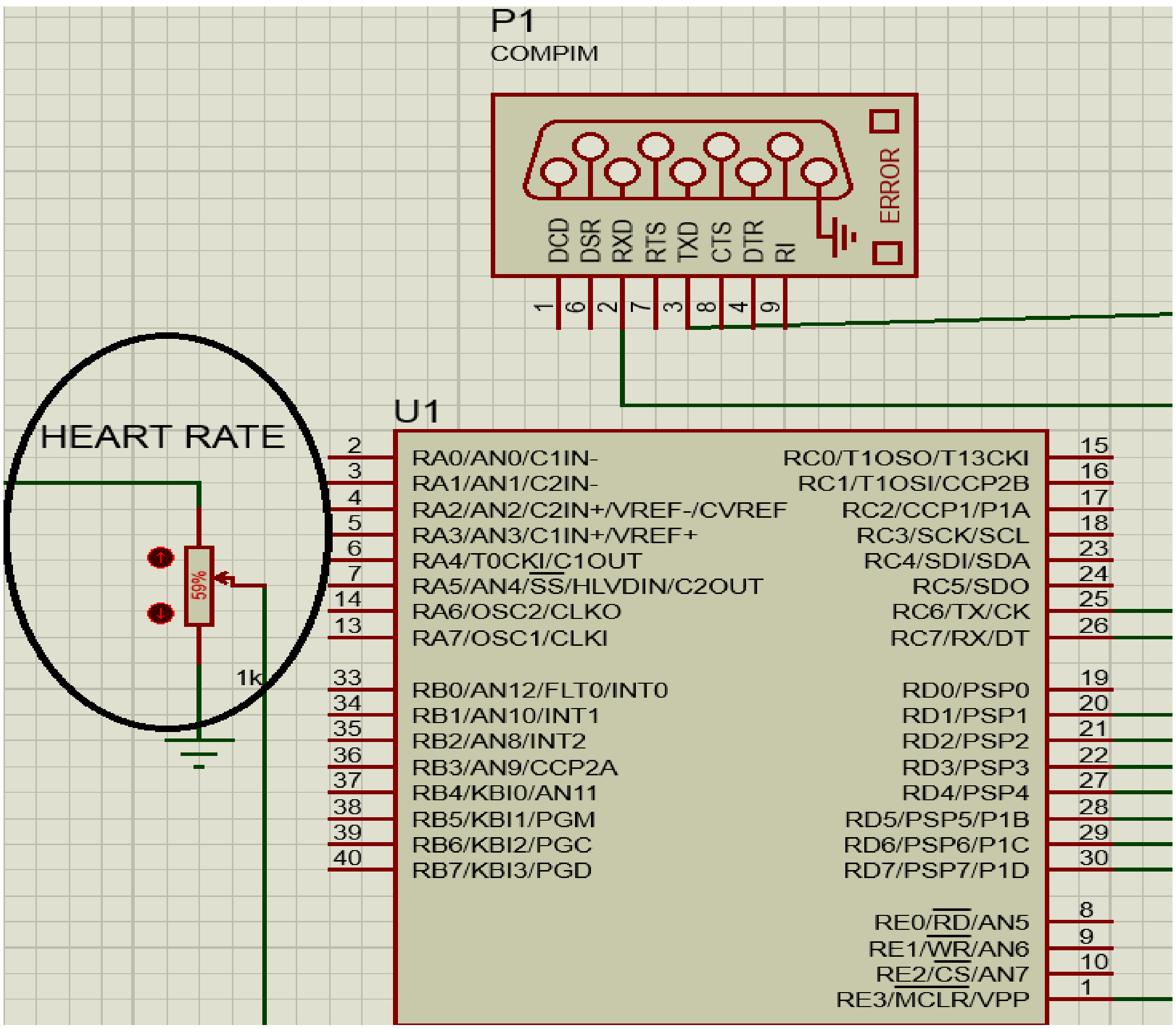


Figure 4.5 Pulse rate sensor

4.6.3 Continuous Glucose Monitoring (CGM)

A very small sensor is inserted into the patient's skin to test the glucose level. Measured values are then sent to the microcontroller through serial port.

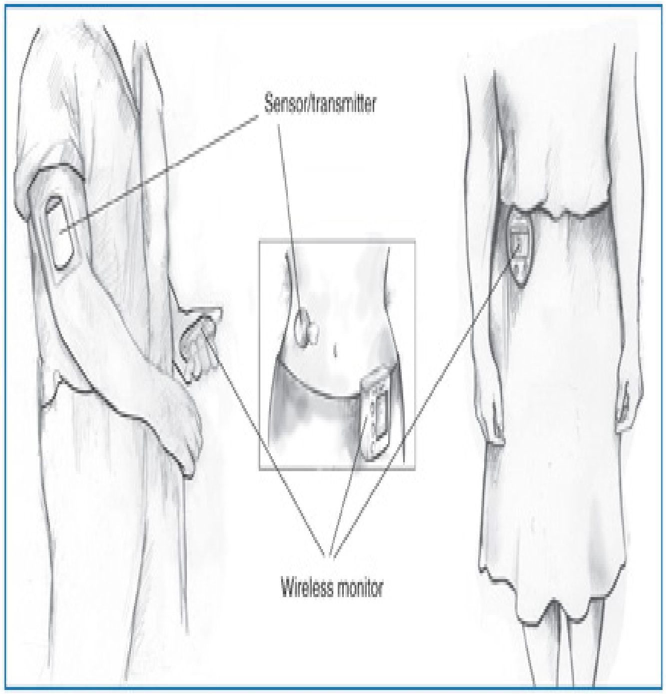


Figure 4.6: Wireless glucose monitor device

4.6.4 Hemoglobin Level Measurement

Radical-7 co-oximetry sensor may be used to measure the hemoglobin level of the patient. Data is then sent to the microcontroller through serial port.

Figure 4.7: Hemoglobin measuring sensor

4.6.5 Patient state index Monitor

It is used to enhance the patient's care and reduce the risk of death when the patient is under the anesthesia (anesthesia, is a temporary state consisting of unconsciousness, loss of memory, lack of pain, and muscle relaxation). A sensor is attached to the patient's brain which measures the patient brain status all these values are sent to the microcontroller through serial port.

Figure 4.8: Patient state index monitor sensor

4.7 Local Observation Unit

Figure 4.9 shows the local observation unit which contains a microcontroller, a serial port, an LCD, and an alarm.

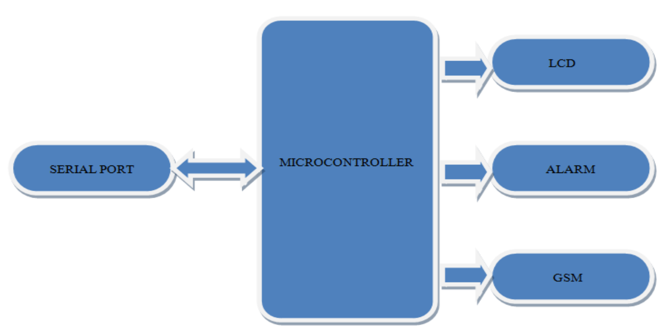


Figure 4.9: Block diagram showing physiological measurements being displayed, saved or used for local warning

4.7.1 Microcontroller

PIC-18F4520 microcontroller is a vital part of the main unit. PIC-18F4520 microcontroller processes the measured data at fixed time intervals and sends the results to LCD, GSM transmitter or buzzer alarm [34].

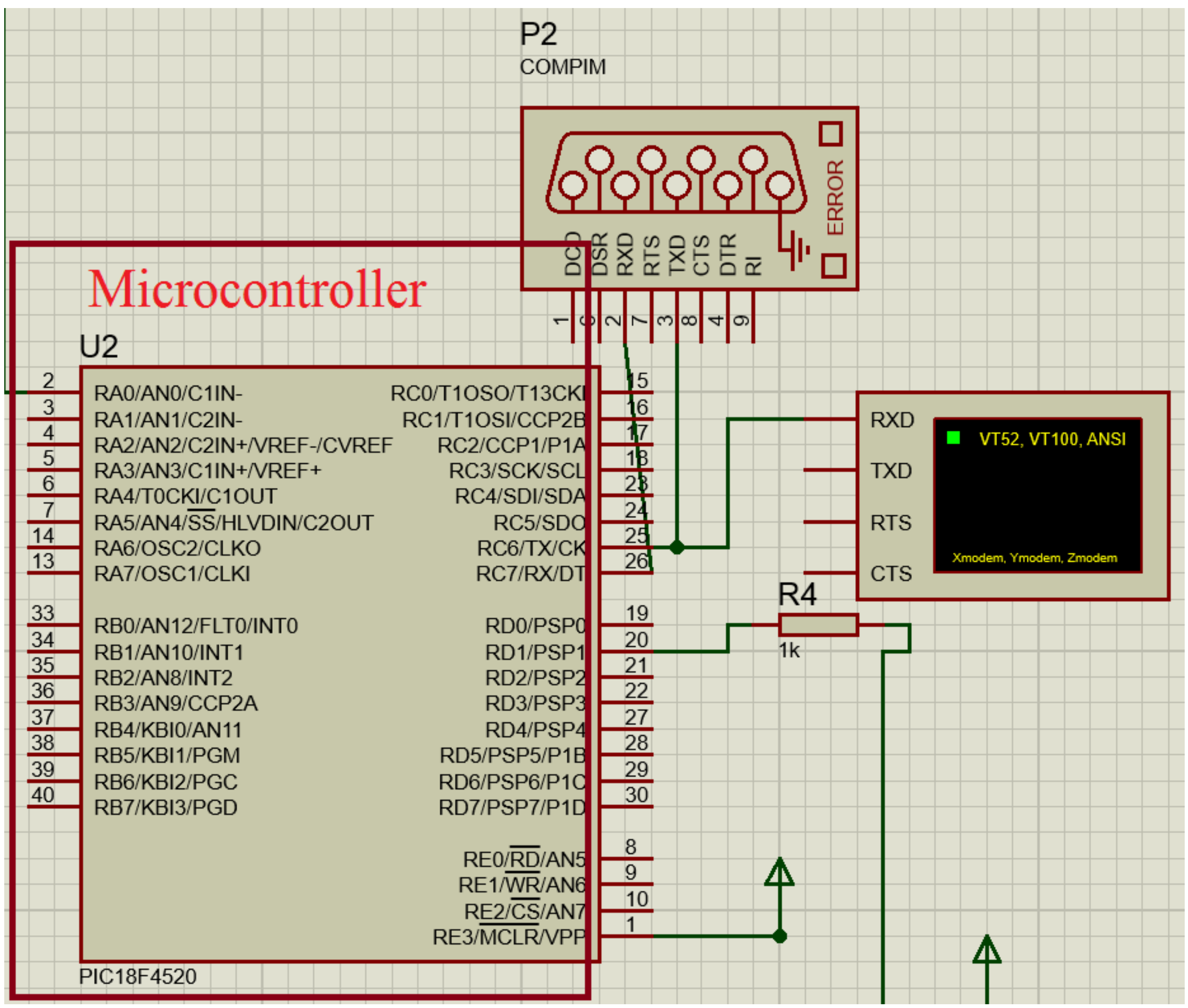


Figure 4.10: PIC-18F4520

4.7.2 Display unit

LCD is a 14 or 16 pin display unit which shows the measured information. 16 pin LCD is much better than 14 pin as it contains extra functions and better features capabilities [34].

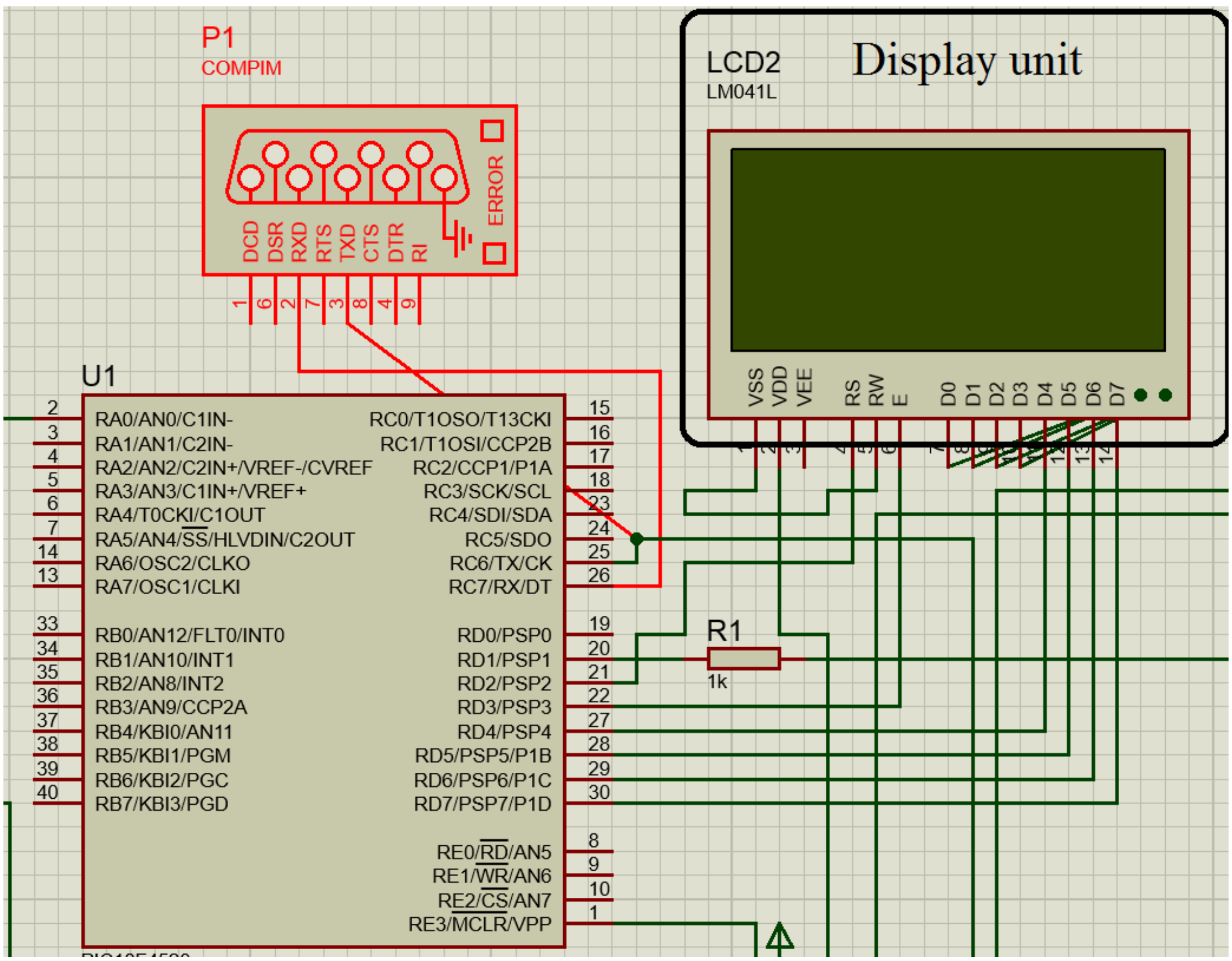


Figure 4.11: LCD (Display unit)

4.7.3 Buzzer Alarm

A buzzer or beeper is an audio signaling device which may be mechanical, electro mechanical and piezoelectric. Typical uses of buzzer include alarm devices, timers and confirmation of user input.

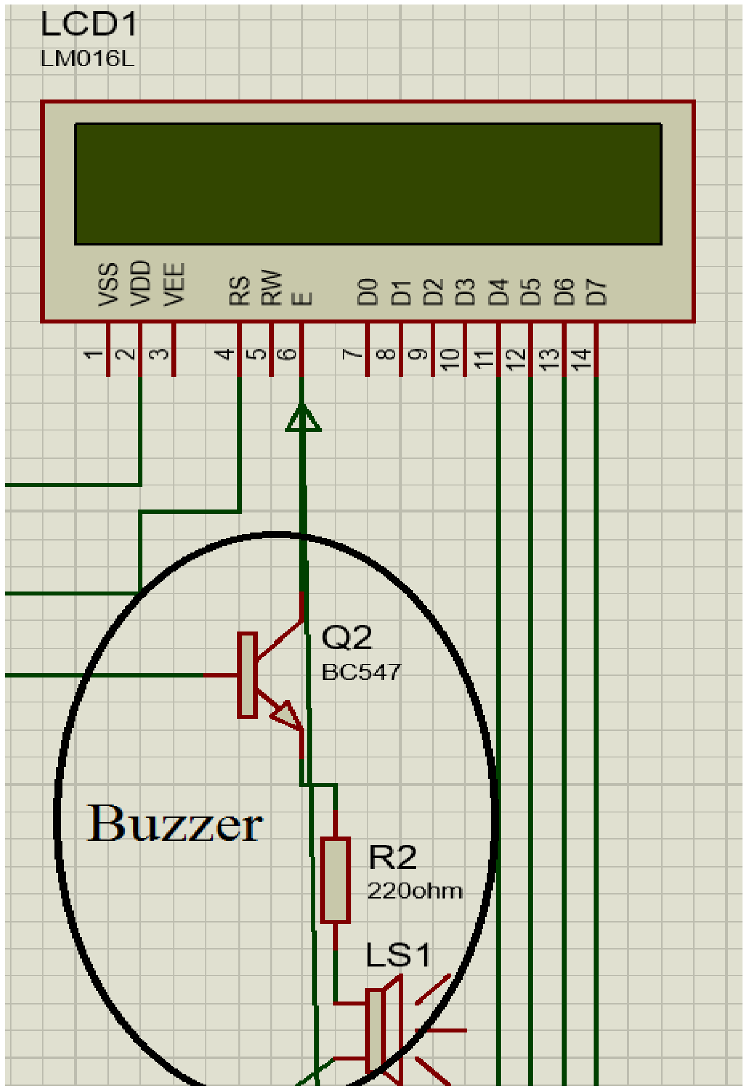


Figure 4.12: Buzzer alarm

4.7.4 Serial Port connector

Various devices collect data from sensors and want to transmit it to a different unit, just like a pc, for further processing. Serial communication is used to send data to and from the microcontroller. Serial communication in PIC-18F4520 microcontroller explains the interfacing of the microcontroller with a computer via RS232 interface. With PIC-18F4520 microcontroller has an inbuilt UART to carry out serial data. The communication within PIC-18F4520 is done in the actual asynchronous method. A serial port, like other Computer ports, is a physical user interface to establish data transfer between computer and an external hardware.

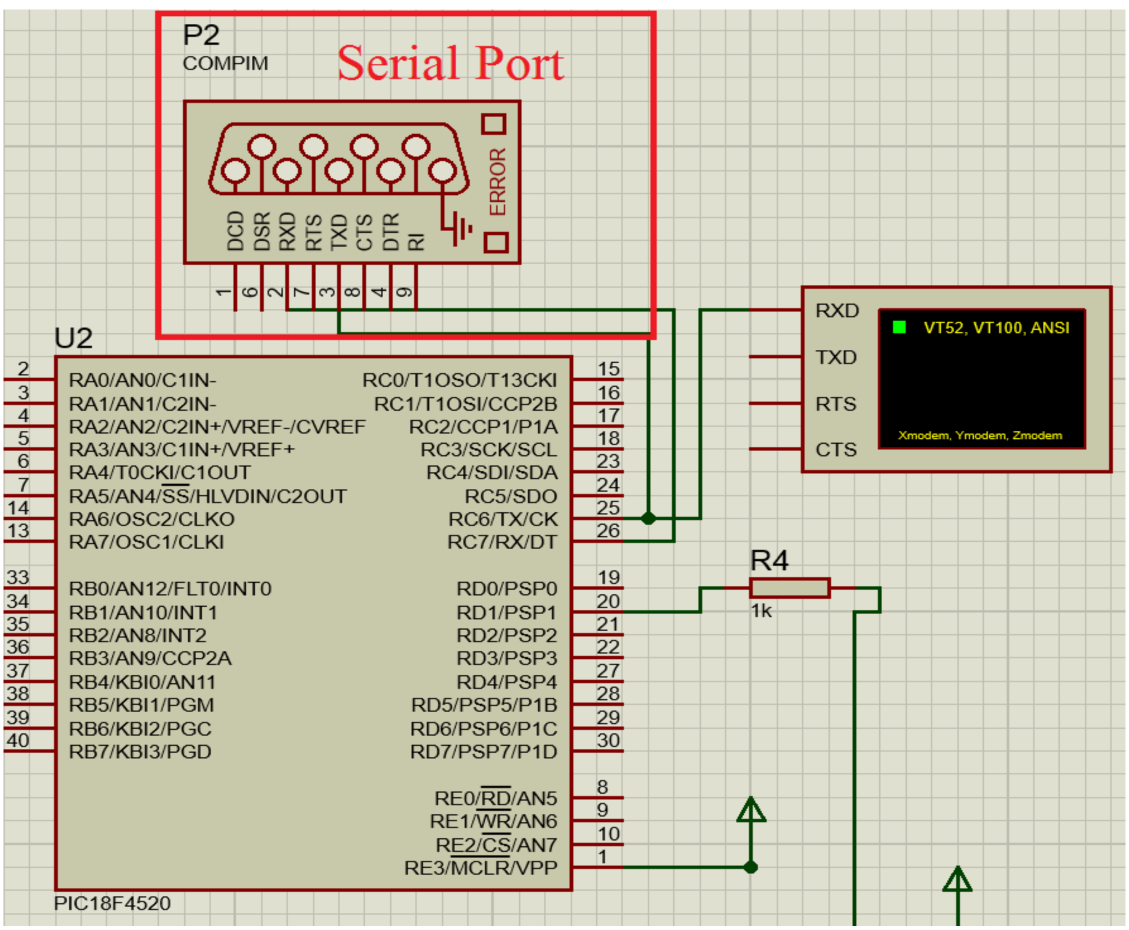


Figure 4.13: Serial port connector

4.8 Remote Transmission Unit

The third part of this system is the remote transmission unit where a doctor can observe the patient’s condition via SMS. This way the doctor will have relevant and up-to-date information about the patient's health and can instruct paramedical staff further action.

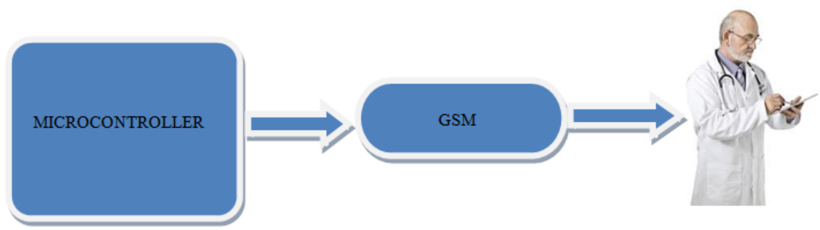


Figure 4.14: Block diagram showing messages being sent to doctor’s mobile

4.8.1 GSM Transmitter

A GSM transmitter is used as a wireless communication tool between the doctor and the patients. After processing, microcontroller sends all data to GSM transmitter for transmission to the doctor’s mobile in the form of SMS.

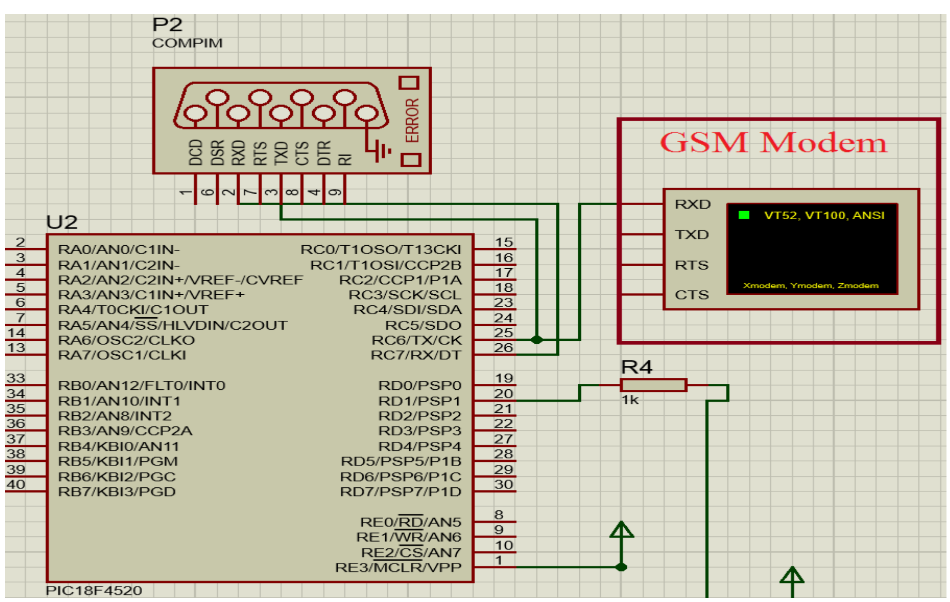


Figure 4.15: GSM Modem connect with microcontroller and serial port

4.9 Simulation and Analysis of 10 Patients Monitoring

The following sections analyze five different cases where warning and emergency messages are displayed and transmitted during continuous monitoring of patients. Messages are sent to the phone number displayed on the virtual terminal boxes.

Designed circuit includes two LCDs. LCD2 on the left is for glucose, hemoglobin, patient state index and body temperature measurements and the other is for pulse rate measurements (Figure 4.6).

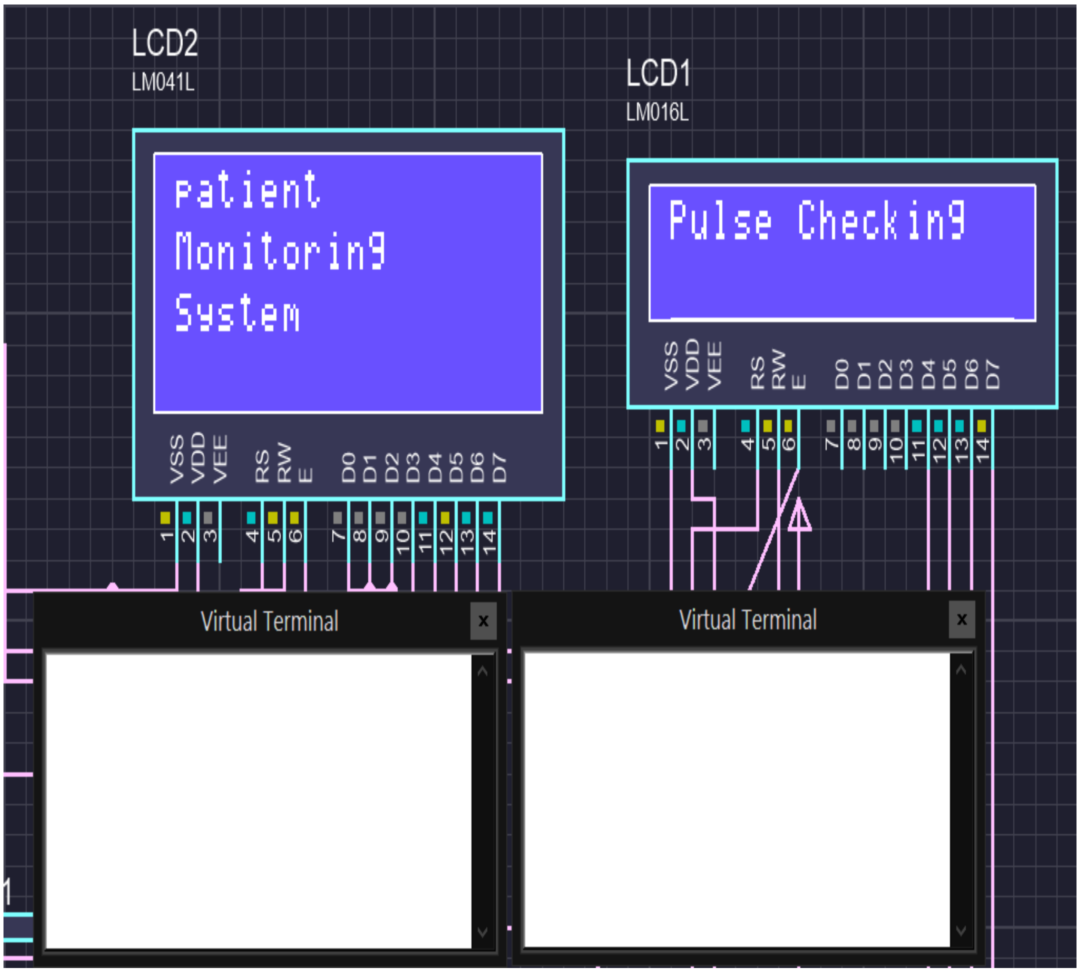


Figure 4.14: System LCD displays

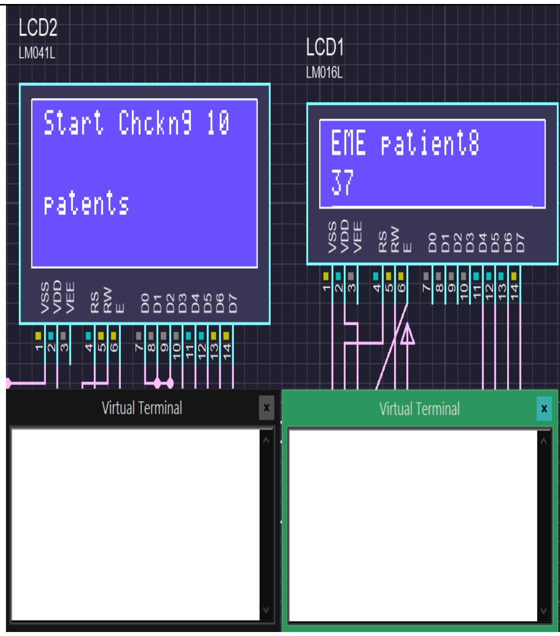
4.10 Results

Case 1:

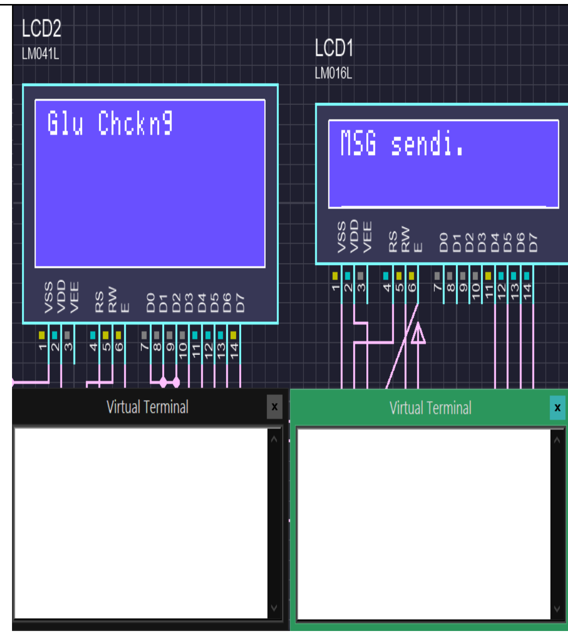
Pulse Rate Emergency and Glucose Level Warning

Figure 4.17 shows the case when pulse rate emergency and glucose level warning occur for patient's no. 8 and 2, respectively. The following is a description of what each LCD monitor is displaying:

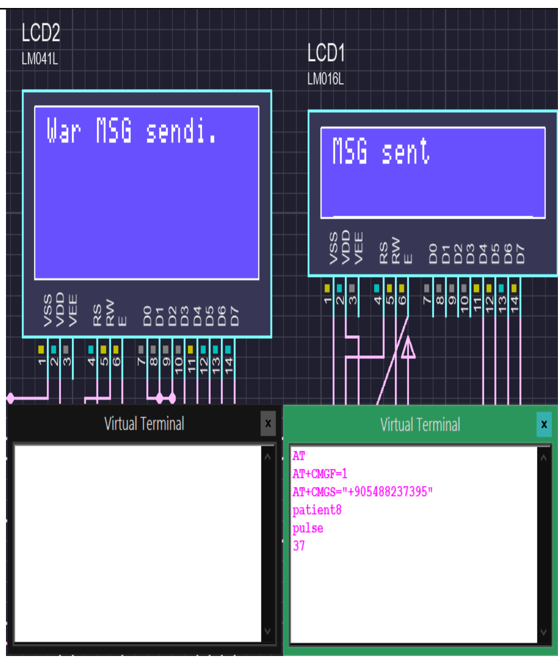
- System started to monitor 10 patients for glucose, haemoglobin, brain level and body temperature (Figure 4.17a, LCD2).
- Emergency message on LCD1 (Figure 4.17a) as patient no. 8 has very low pulse rate (37 beats/min) compare to values predefined in Table 4.1.
- System is monitoring glucose levels (Figure 4.17b, LCD2).
- System is about to send a warning message to a doctor for low pulse rate of patient no. 8 (Figure 4.17b, LCD1).
- Warning message is being sent to the doctor as the system finds out that patient no. 2 has high glucose level (118 mg/dL) (Figure 4.17c, LCD2).
- System completes sending the warning message for patient no. 8. (Figure 4.17c, LCD1).
- System completes sending the warning message for patient no. 2. (Figure 4.17d, LCD2).
- LCD1 shows a normal pulse rate (98 beats/min) for patient no.1 (Figure 4.17d).



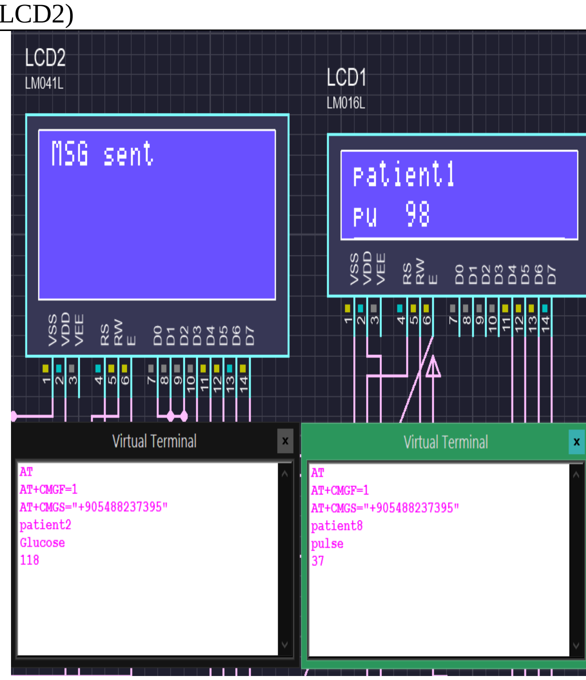
(a) Pulse rate emergency (37 beats/min.) for patient no. 8 (LCD1)



(b) Emergency message being sent for patient no 8 (LCD1) and glucose monitoring for another patient (LCD2)



(c) Glucose warning being sent for patient no. 2 (LCD2) and low pulse rate emergency message sent for patient no.8 (LCD1)



(d) Glucose warning message sent for patient no.2(LCD2) Normal pulse rate (98 beats/min.) for patient no. 1(LCD1)

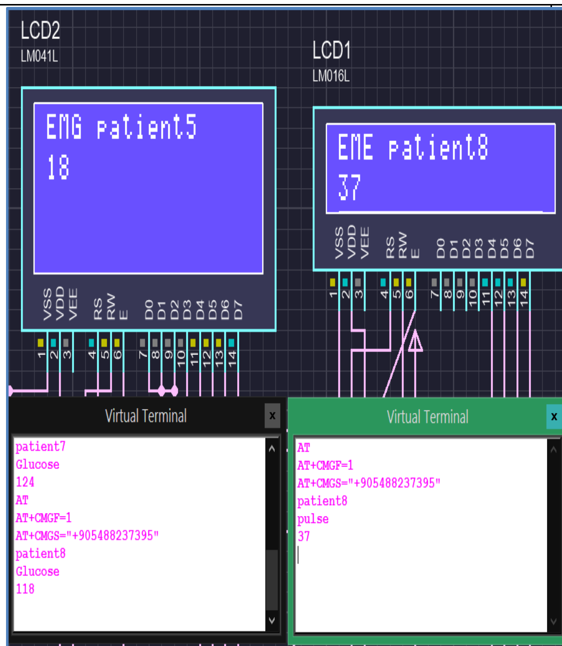
Figure 4.17: Messages being sent due to low pulse rate and high glucose level

Case 2:

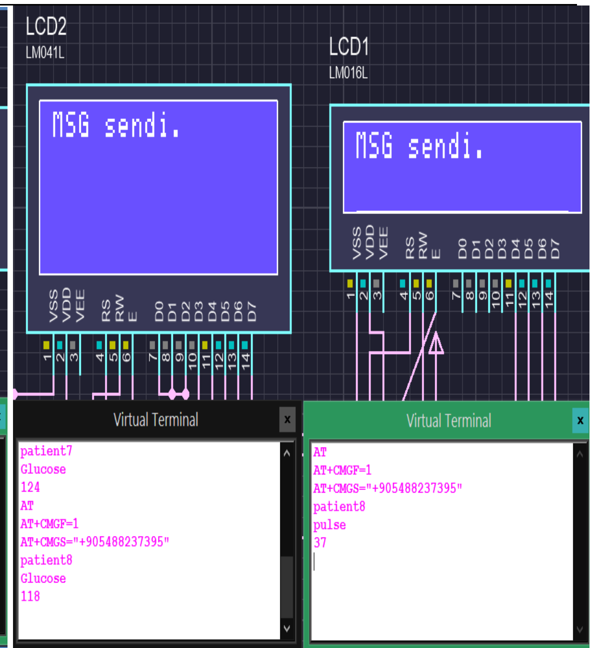
Hemoglobin level and pulse rate emergencies

Figure 4.18 shows the case when hemoglobin level and pulse rate emergencies occur for patient's no. 5 and 8, respectively.

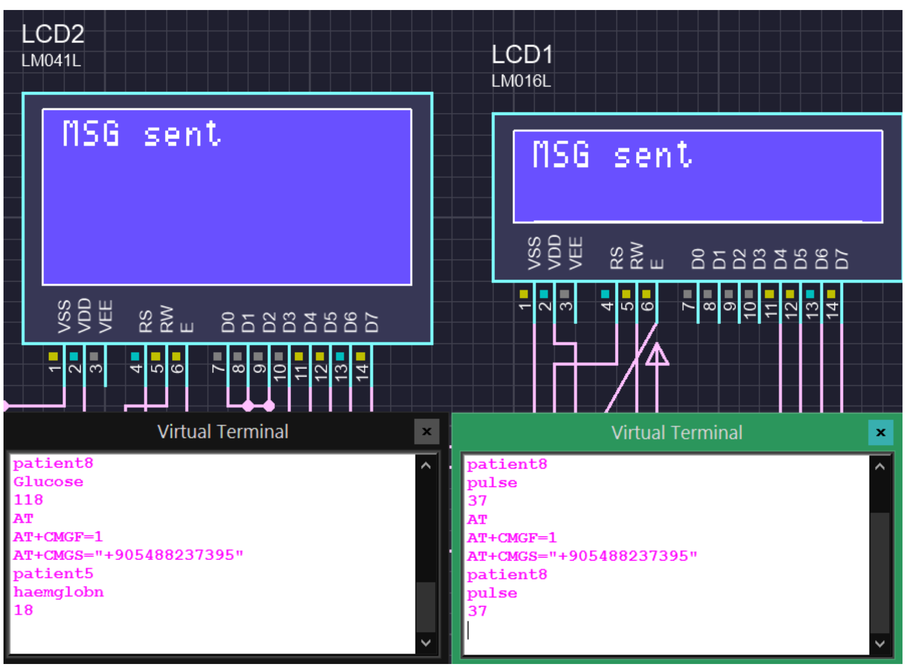
- Emergency message on LCD2 (Figure 4.18a) patient no. 5 has high haemoglobin level (18g/dL).
- Emergency message on LCD1 (Figure 4.18a) as patient no. 8 has low pulse rate (37 beats/min).
- System is about to send emergency messages to a doctor regarding patients no. 5 and 8 (Figure 4.18b, LCD1 and LCD2)
- System completes sending emergency messages for these patients (Figure 4.18c, both LCDs).



(a) Hemoglobin emergency (18 g/dL) for patient no. 5 (LCD2). Pulse rate emergency (37 beats/min) for patient no.8 (LCD1)



(b) Emergency messages being sent for patient no.5 for high hemoglobin level (LCD2) and patient no.8 for low pulse rate (LCD1)



(c) Both emergency messages sent (LCDs 1 and 2)

Figure 4.18: Emergency messages for high hemoglobin and low heart rate

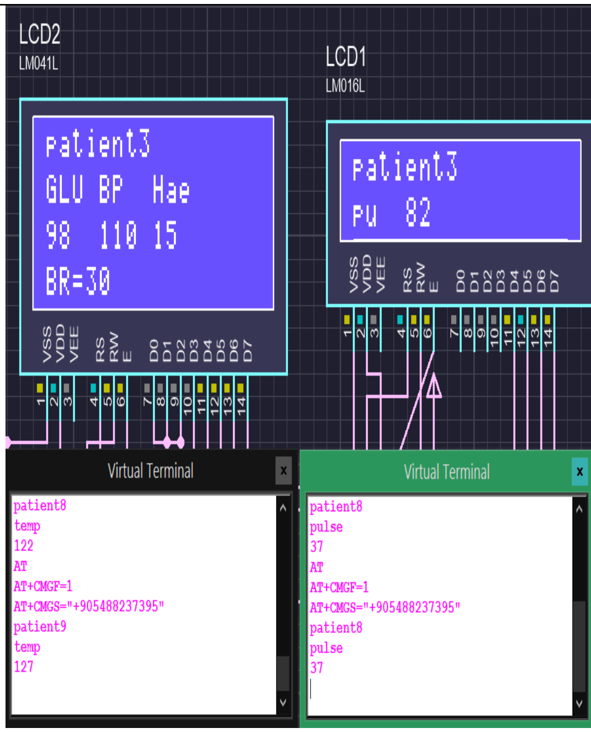
Case 3:

Multiple patients monitoring

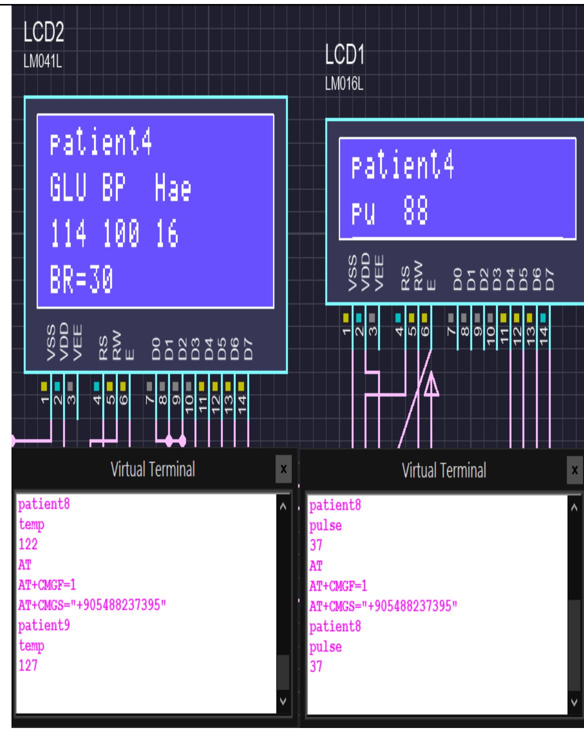
Figure 4.19 shows continuous monitoring of multiple patient physiological parameters. The following is a description of what each LCD monitor is displaying:

- Physiological parameters for patient no. 3 (Figure 4.19a, both LCDs):
    - Pulse rate 82 (beats/min)
    - Glucose level 98 (mg/dL)
    - Body temperature 110 (oF)
    - Hemoglobin level 15 (g/dL)
    - Brain level (30)
- Physiological parameters for patient no. 4 (Figure 4.19b, both LCDs):
    - Pulse rate 88 (beats/min)
    - Glucose level 114 (mg/dL)
    - Body temperature 100 (oF)
    - Hemoglobin level 16 (g/dL)
    - Brain level (30)
- Physiological parameters for patient no. 5 (Figure 4.19c, both LCDs):
    - Pulse rate 90 (beats/min)
    - Glucose level 99 (mg/dL)
    - Body temperature 109 (oF)
    - Hemoglobin level 18 (g/dL)
    - Brain level (15)
- Physiological parameters for patient no. 6 (Figure 4.19d, both LCDs):
    - Pulse rate 109 (beats/min)
    - Glucose level 100 (mg/dL)
    - Body temperature 109 (oF)
    - Hemoglobin level 16 (g/dL)
    - Brain level (80)

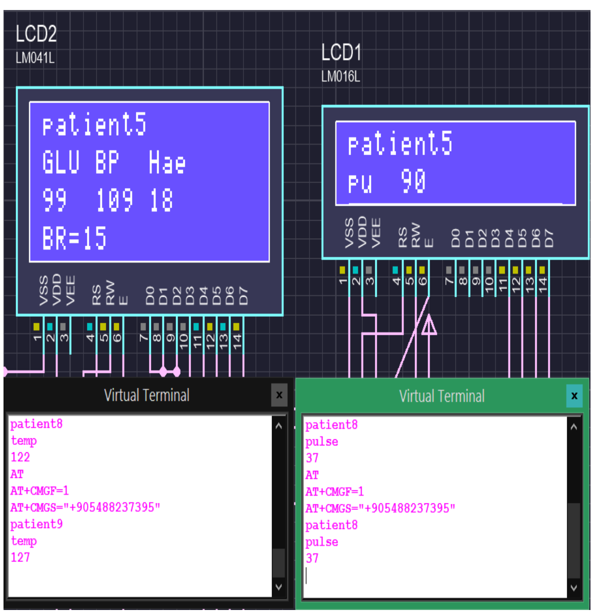
For all these cases, no emergency or warning messages are displayed as all physiological parameter values are within the predefined range.



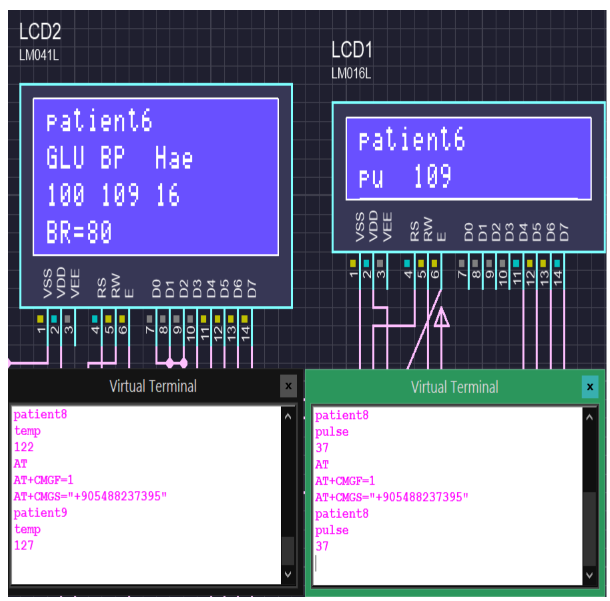
(a) Continuous physiological parameter monitoring for patient no.3



(b) Continuous physiological parameter monitoring for patient no.4



(c) Continuous physiological parameter monitoring for patient no.5



(d) Continuous physiological parameter monitoring for patient no.6

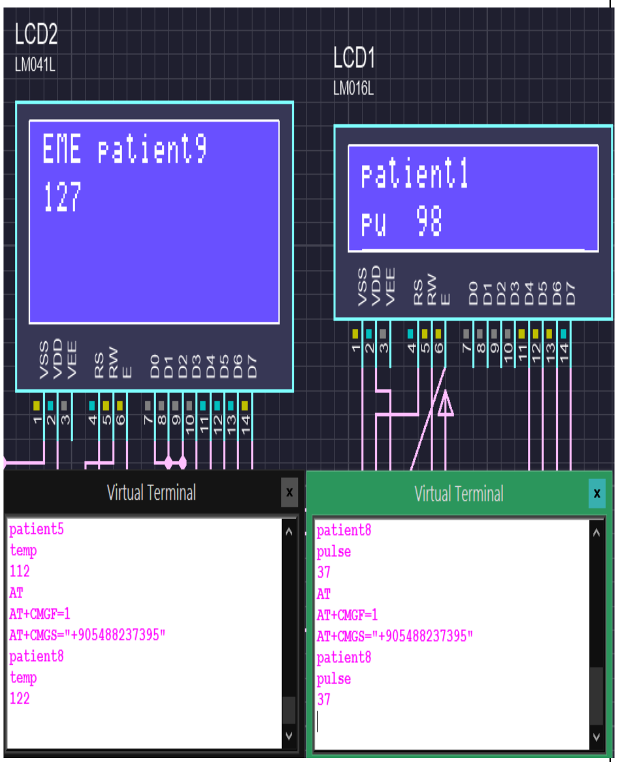
Figure 4.19: Multiple patient information evaluation

Case 4:

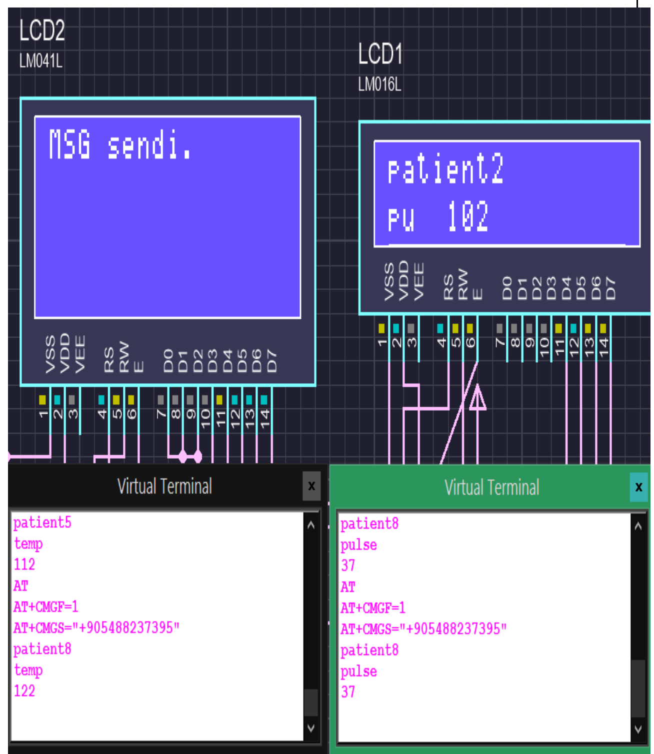
High body temperature emergency for patient no.9

Figure 4.20 shows the case when high body temperature emergency occurs for patient no. 9. The following is a description of what each LCD monitor is displaying:

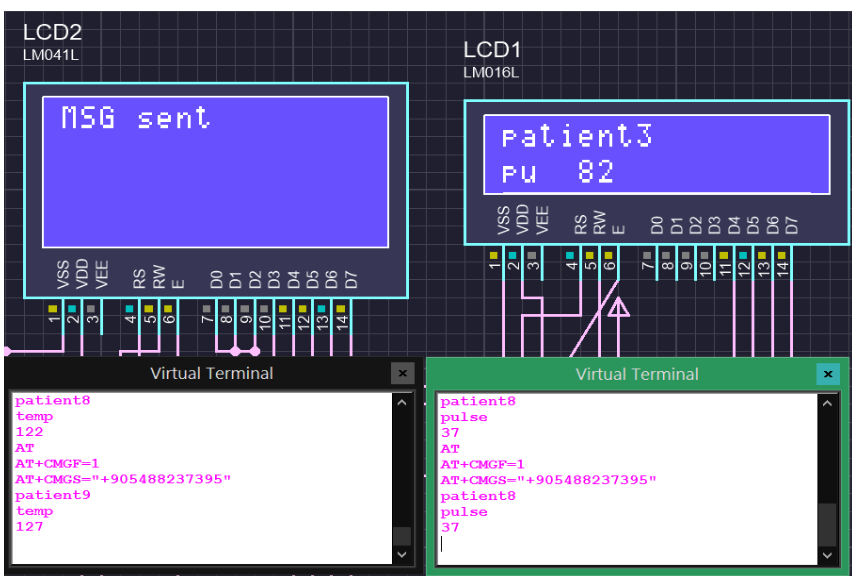
- Emergency for patient no. 9. Very high body temperature (127 ^{o}F) (Figure 4.20a, LCD2).
- Patient no. 1 is being monitored. His/her pulse rate is normal at 98 beats/min. (Figure 4.20a, LCD1)
- System is sending an emergency message for patient no. 9 (Figure 4.20b, LCD2).
- Pulse rate of patient no. 2 is being monitored. It is 102 beats/min. (Figure 4.20b, LCD1)
- Emergency message is sent to a doctor for patient no. 9 (Figure 4.20c, LCD2).
- Patient no. 3 is being monitored. His/her pulse rate is 82 beats/min. (Figure 4.20b, LCD1)



(a) Emergency message for patient no.9 due to high temperature (127 ^{o}F) on LCD2. Normal pulse rate (98 beats/min.) for patient no. 1.



(b) Emergency message being sent for patient no. 9 (LCD2).Monitoring the pulse rate of patient no.2(102 beats/min)



(c) Emergency message sent (LCD2). System is monitoring pulse rate of patient no. 3 (LCD1)

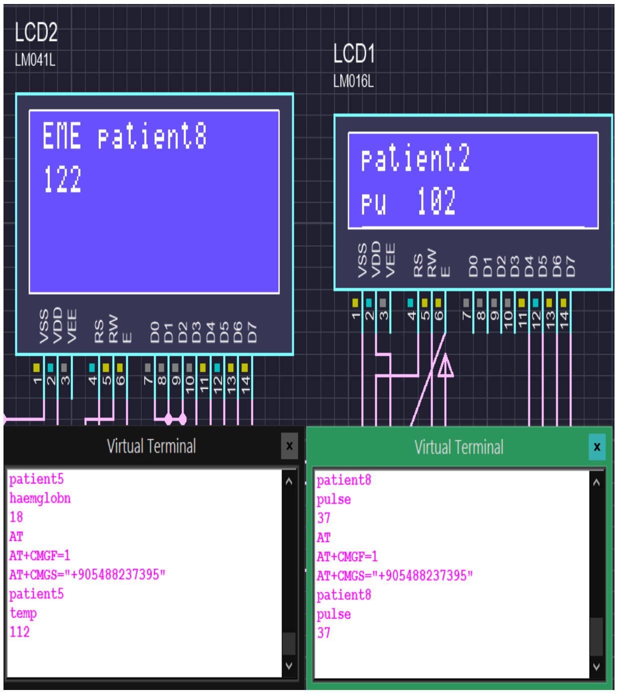
Figure 4.20: High temperature emergencies for patient no.9

Case 5:

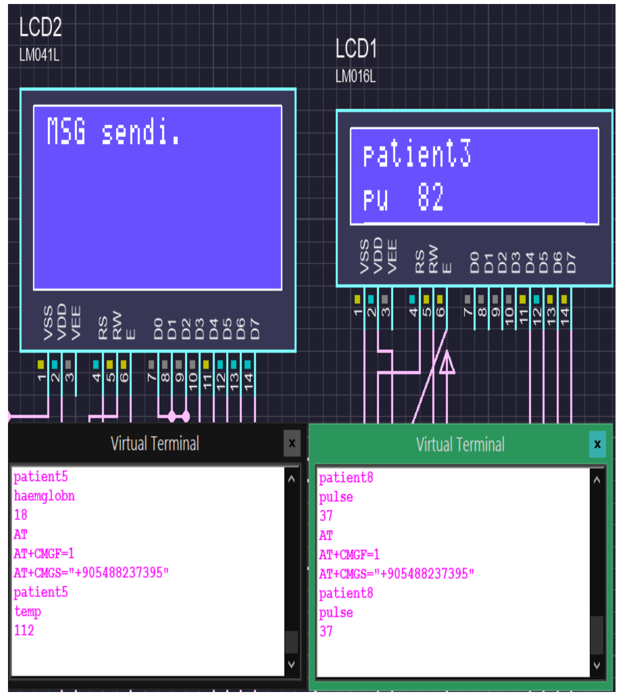
High temperature emergency for patient no.8

In this case, a doctor is being warned as patient no. 8 has high temperature (Figure 4.21). The following is a description of what each LCD monitor is displaying:

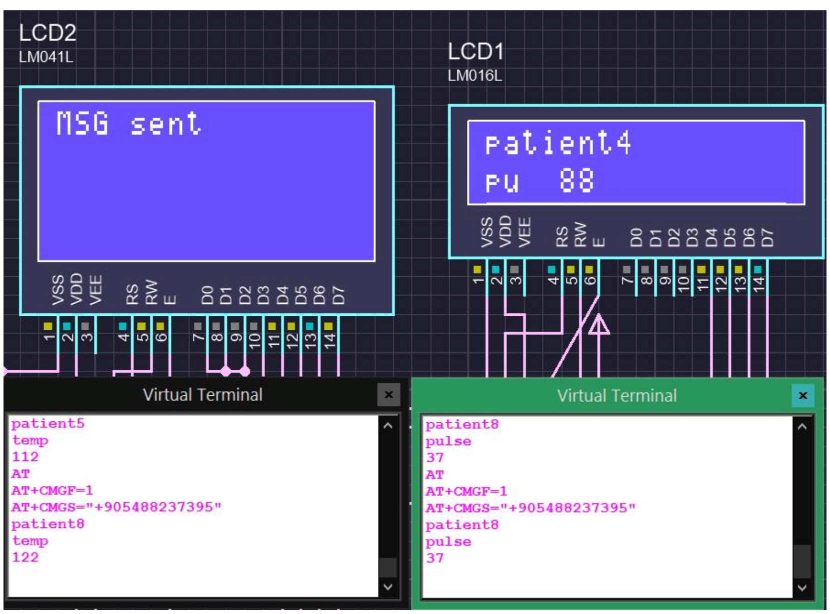
- Patient no. 8 has a high temperature at 122 ^{o}F (Figure 4.21a, LCD2).
- Patient no. 2 has a pulse rate of 102 beats/min. (Figure 4.21a, LCD1).
- System is sending an emergency message for patient no. 8 (Figure 4.21b, LCD2).
- Patient no. 3 has a pulse rate of 82 beats/min. (Figure 4.21b, LCD1).
- System finished sending the message for patient no. 9 (Figure 4.21c, LCD2).
- Patient no. 4 has a pulse rate of 88 beats/min. (Figure 4.21c, LCD1).



(a) High temperature emergency (122 ^{o}F) for patient no.8 on LCD2. LCD 1 shows a normal pulse rate for patient no.2 (102 beats/min.)



(b) Emergency message being sent for patient no. 8 (LCD2). Monitoring the pulse rate for patient no.3(82 beats/min)



(c) Emergency message sent (LCD2). System is monitoring pulse rate of patient no. 4 (LCD1)

Figure 4.21: High temperature emergency for patient no.8

4.11 Discussion and Comparision

The monitoring of the patient’s vital signs is carried out by manually practiced since so many years. But due to the congestion and advent of new technology appealed to have such type of monitoring system that will not require a dedicated paramedical staff member for the job. So basic motivation was taken from the remote patient monitoring system with earlier communication channel devices like infrared and Bluetooth. In these types of monitoring systems, the receiving node should be placed near vicinity of the patient and some has to take values from hub or server system. So the problem persisted for bounding someone to be limited at hospital vicinity. With the arrival of GSM (Global system for Mobile) technology, the said problem is addressed as the values or readings are directly transmitted to the receiver far away from the sender’s location. So the word “remotely” was given actual meaning in this regards.

The problem in that type of the system arises when there is some exceptional situation arises. The receiver node (doctor) will be always receiving too many messages even if the patient is under normal conditions and there is no need for those values. So, one advancement in my proposed method is that it is not always sending each value to doctor or whoever is attending. There are two thresholds values for intimation to doctor about abnormality. One is Warning Message that contains those values of abnormality for which doctor should give attention. The other is Emergency Message that contains those values that must be seen by doctor or should be addressed at immediate basis.

The systems developed before that are capable for transmitting the values taken directly from the sensors over GSM Module but through my proposed method, the values coming from the sensors and the measuring device (MASIMO) which is connect to the patient's and this device can measure multiple vital parameters and the output of the device will be directly fed to the PC and then microcontroller get all information via serial port, it is being compared with the average values stored in the system’s database.

The database is developed through normal tendency of the values of vital signs. Then after the values are compared, decisions are made under programming code whether the value should be treated as normal value, Emergency or Warning. The values are being stored as well as fed to the microcontroller. Microcontroller will take values from PC and Sensors directly connected to it. So storing and analyzing is done in parallel. Earlier systems are only capable for monitoring basic vital signs like temperature and heart beat rate but my proposed system will monitor five vital signs Heart Rate, Hemoglobin level, Body Temperature, Patient state index and Glucose level.

The earlier systems are only measuring the vital signs of just one patient at one time but my proposed system will take ten patients in parallel and will compare and analyze 50 values at one instant. So in this respect, more sophistication and better applicability is achieved through availability of more clients and quick response if any abnormality occurs. The reliability is ensured by the prominent and well known simulation software like Keil® and Proteus Micro vision ® so that ease of use and efficient modification can be adopted through inherited features of the software. Expansion in design or flexibility in design can be achieved by using common type of algorithms and programming language as well as fully-featured software.

The proposed system has been design showed results in different case.

Case 1:

Pulse Rate Emergency and Glucose Level Warning

Figure 4.17 shows the case when pulse rate emergency and glucose level warning occur for patient's no. 8 and 2, respectively.

Case 2:

Hemoglobin level and pulse rate emergencies

Figure 4.18 shows the case when hemoglobin level and pulse rate emergencies occur for patient's no. 5 and 8, respectively.

Case 3:

Multiple patients monitoring

Figure 4.19 shows continuous monitoring of multiple patient physiological parameters. The following is a description of what each LCD monitor is displaying.

Case 4:

High body temperature emergency for patient no.9

Figure 4.20 shows the case when high body temperature emergency occurs for patient no. 9.

Case 5:

High temperature emergency for patient no.8

In this case, a doctor is being warned as patient no. 8 has high temperature (Figure 4.21). The following is a description of what each LCD monitor is displaying:

4.12 Summary

In this chapter we discussed about the design and simulation of a hardware system that can be used to monitor up to ten patients . Patient monitoring system designed here uses various devices for physiological measurements, such as the measurement of body temperature, heart rate, hemoglobin level, patient state index and glucose level, and sends all data to a local microcontroller. Few different cases have been discussed to see different output results.

CHAPTER FIVE
CONCLUSIONS AND FUTURE WORKS

This thesis designs and simulates a patient monitoring system that can be connected to various physiological measuring instruments in order to analyze the results and alert local or remote medical staff whenever a critical measurement is taken. Local alert is carried out using a buzzer alarm, whereas a remote doctor is cautioned with an SMS sent to his/her mobile using GSM technology. The system is to take inputs from medical devices measuring patient body temperature, related to the readings is displayed on two different LCDs.heart rate, hemoglobin level, brain level and glucose levels, and a microcontroller is used to analyse the results. Any information Simulations are carried out in order to observe how this system reacts to critical measurements of patient pulse rate, glucose level, hemoglobin level and body temperature. It can be seen from these simulations that the patient monitoring system is able to easily detect whenever any physiological parameter goes out of a predefined range and warn related local or remote staff for proper and timely care. This can be done for one as well as multiple patients.

Remote monitoring capability of this system is especially useful as it provides the following advantages: (a) reduces the cost of hiring staff (b) reduces the cost of needing to expand hospital space in order to care for more patients (c) multiple patients can be monitored at the same time (d) patients can get help at home (e) effective for those who need constant monitoring such as elderly or people who are disabled (f) emergency patients can be given priority over chronic patients.

Future work includes enhancing the present system in order to analyze additional physiological parameters and care for more patients. On top of data transmission, voice or video transmission capability may also be added so that the patient may give remote medical staff a better description of what is actually wrong.

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