Remote Patient Monitoring System Using Pulse Oximeter

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Abstract— A remote patient monitoring system is implemented which is used for real time monitoring of various heath parameters of a remotely based patient. Oxygen saturation and body temperature are the two parameters calculated and transmitted via a server to a remote client. A ZigBee module is used for enabling mobility of the monitored patient. Graphical display of the health parameters is made available on the server via Visual Basic software. The components used in this project are MSP430FG437 processer, pulse oximeter, LM35 sensor and ZigBee transreceiver module. The aim of this project is to extend healthcare to places other than hospitals.

Index Terms—MSP430, Visual Basic, ZigBee,SpO2, LM35 Sensor, Pulse Oximeter Sesor, HbO2

1 INTRODUCTION

In the recent decades, heath related issues are becoming more and more important. In conventional health monitoring systems, mobility of patient is hindered. Also, emergency cannot be handled immediately. Solution to this is real time data monitoring. The remote health care is a useful solution to achieve continuous monitoring of patients effectively [1]. Oxygen gas is integral for countless biological processes. The transport of oxygen throughout the human body is performed by the circulatory system, and more specifically, hemoglobin in red blood cells. Critical medical information can be obtained by measuring the amount of oxygen in blood, as a percentage of the maximum capacity. Pulse oximeter is a medical instrument that is used to measure amount of oxygen in the blood [2]. Pulse oximetry shortens the time passed before the detection of hypoxemia i.e. Deficiency of oxygen which has been documented in the critically ill people during invasive or diagnostic procedures. Wireless pulse oximetry adds many advantages to the traditional wired units. They are more convenient for the patient to use and dont need to be reconnected each time the patient is moved. Also, body temperature is an early indicator of a patients deteriorating health. If body temperature rises above a critical value, it could be fatal.

In my project, LM35 is used to measure body temperature. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 does not require any external calibration or trimming to provide typical accuracies of 1/4 deg Cel at room temperature and 3/4 deg Cel over a full -55 to +150C temperature range.

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The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 uA from its supply, it has very low self-heating, less than 0.1 deg Cel in still air. The formula for ca lculating temperature is:

$$\text{Temp in}^{\circ}\text{C} = \frac{\text{Vout (inmV)}}{10}$$

The pulse oximeter probe includes two light emitting diodes (LEDs), one in the visible red spectrum (660 nm) and the other in the infrared spectrum (940 nm) [3]. Here, the emitters and photo detector are opposite of each other with the measuring site in-between. The light can then pass through the site. The light bounces from the emitter to the detector across the site. Figure 1 shows that at the tip of finger, there are con stant light absorbers always present. They are skin, tissue, venous blood, and the arterial blood [4].

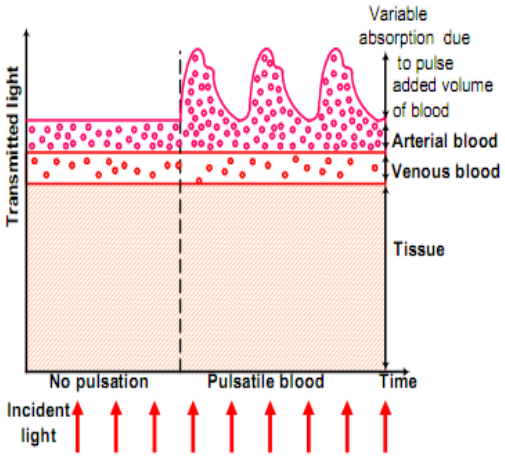

Figure 1. Pulsatile and non-pulsatile Blood

However, with each heart beat the heart contracts and there is a surge of arterial blood, which momentarily increases arterial blood volume across the measuring site. This results in more light absorption during the surge. If light signals received at the photo detector are looked at as a waveform, there should be peaks with each heartbeat and troughs between heartbeats. If the light absorption at the trough (which should include all the constant absorbers) is subtracted from the light absorption at the peak then, in theory, the resultants are the absorption characteristics due to added volume of blood only; which is arterial. A small portion of AC pulses is also detected which is around 1% of the signal which represents the AC in the arterial blood. An intermediate value, known as the Normalized R ratio [5], is calculated using these signals. Using R, we can calculate SpO2 value using the formula [6]:

$$Sp\ O2 = 110 - 25 * R$$

The MSP430 incorporates a 16-bit RISC CPU, peripherals, and a flexible clock system that interconnect using a von- Neumann common memory address bus (MAB) and memory data bus (MDB). Partnering a modern CPU with modular memory-mapped analog and digital peripherals, the MSP430 offers solutions for demanding mixed-signal applications.

2 PROPOSED SYSTEM

2.1 Transmitter Section

All The two main sensors are pulse oximeter and LM35. The pulse oximeter measures arterial oxygen saturation inside the human body.

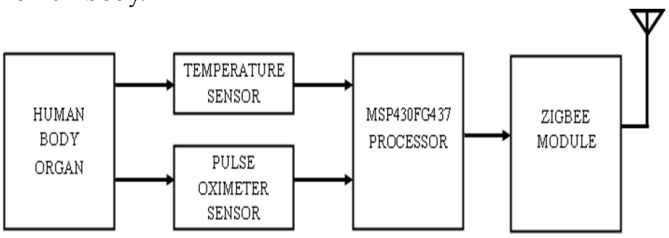

Figure 2 Block Diagram of Transmitter

LM35 senses the temperature of the human body. The output of the sensors is given to the signal conditioning circuit. The signal conditioning circuit then converts the output of the sensors into a suitable form so that it can be given to the microcontroller.The microcontroller MSP430FG437 then converts the input into digital form. It also computes SPO2 and body temperature. It then gives the output via UART to ZigBee module which transmits the data to a server computer.

2.2 Receiver Section

The transmitted data is received wirelessly using another ZigBee transceiver which is connected to the server computer. An application is developed in Visual Basic and it is run on the server computer. This application opens the virtual serial port and accepts the SpO2 and temperature values. These values

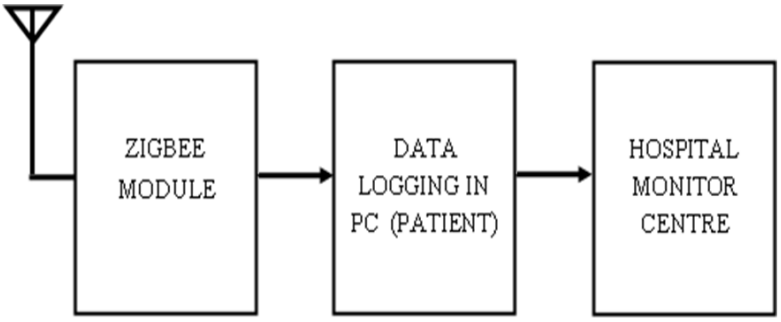

Figure 3 Block Diagram of Receiver

are graphically displayed as and when received. The computer at the hospital acts as the client and establishes the connection with the server computer via internet. The client requests for data transmission. Upon receiving the request from the client, the Visual Basic application on the server sends the SpO2 and Temperature values. This transfer of data is achieved using winsock control in Visual Basic.

3 RESULTS

Figure 4 shows the complete MSP430FG437 board along- with pulse oximeter probe and LM35 temperature sensor. The LCD displays the value of the room temperature and SpO2 value in deg Cel and % respectively.

Figure 4 Board showing parameter values

Initially, when the MSP430FG437 board is turned ON, it goes into wait mode and waits for request from server computer to start measuring body temperature or SpO2 value. The server computer is turned ON and it listens for any request from any remote client computer. The remote client computer connects to the server computer via TCP/IP after entering the IP address of the server computer. After establishing the connection, the remote client requests the server computer for temperature and SpO2 value by entering t and s respectively. The server computer then requests the portable MSP430 board to send the corresponding values via ZigBee. The MSP430FG437 board then measures and computes body temperature or SpO2 value of a patient and transmits it to the server computer via ZigBee module. The server computer then displays it on a text box and also plots it on a graph. This value is also transmitted to the remote client through Internet. Figure 5 shows the VB application running on the server. The application displays the values of temperature and SpO2 and graphically plots them.

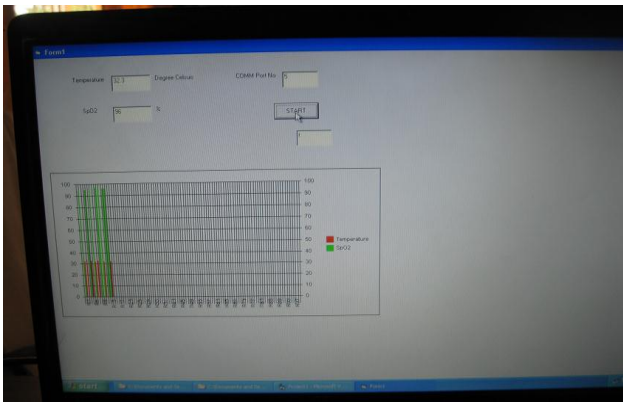

Figure 5 VB Application at Doctor

The acceptable value of SpO2 lies between 95% to 99% for healthy individual [7]. We took SpO2 values of a number of individuals and found them in the acceptable range. Repeated readings from the same individual resulted in same SpO2 values. Also, we took readings of room temperature as well as body temperature of various individuals and found them to be satisfactory. Similar to SpO2 repeated measurements from the same person resulted in same values indicating high precision. For body temperature measurement, fingers are held in contact with the LM35 sensor and the temperature of the sensor noticeably rises. The other key areas for body temperature measurement are back of the ear lobe, under the arms and tip of the tongue. Figure 6 shows the VB application at the client side. The application displays and logs the incoming parameter values in real time.

Figure 6 VB Application at Patient

4 Conclusion

I have successfully implemented Remote Patient Monitoring System. The use of MSP430FG437 processor enables low power consumption and longer battery life because of its power saving modes and low standby current. The use of ZigBee as wireless technology has enabled low power consumption and secured transmission as Zigbee uses DSSS technology. ZigBee enables mobility to patients. The measured parameters can be accessed using internet as the system is network enabled. This feature allows real time continuous patient monitoring by a medical expert from anywhere in the world and handle emergencies.

5 Future Scope

In future, heart rate and respiration rate [8] can also be measured by pulse oximeter along with SpO2 providing further functionality to the project. Also,different sensors like blood pressure sensor and ECG sensor can be added to measure other parameters as well. Further, by integrating GSM with our project, we can send notification messages to a medical expert helping in immediate alert in case of emergencies. Provision of information regarding prescription and reminder for medicine intake can also be included.

REFERENCES

1] Ashwin K. Whitchurch, Jose K. Abraham, and Vijay K. Varadan, Design and Development of a Wireless Remote Point-of-Care Patient Monitoring System, 2007 IEEE Region 5 Technical Conference, April 20-21.

[2] Ho Sung Lee, Seung Hun Park, and Eung Je Woo, Remote Patient Mo nitoring Service through World-Wide Web, 19th International Conference - IEEE/EMBS Oct. 30 - Nov. 2, 1997 Chicago, IL. USA.

[3] Dong Ik Shin, Soo Jin Huh and Pil June Pak, Patient Monitoring System using Sensor Network Based on the ZigBee Radio, 6th International Special Topic Conference on ITAB, 2007.

[4] Vincent Chan and Steve Underwood, A Single-Chip Pulsoximeter De ign Using the MSP430, Application Report - SLAA274A November 2005 Revised June 2010.

[5] Yuanlong Liu and Reza Sahandi, Zigbee Network for Remote Patient Monitoring on General Hospital Wards, 978-1-4244-4221-8/09 2009 IEEE.

[6] Guowei Di, Xiaoying Tang and Weifeng Liu, A Reectance Pulse Oxime-ter Design Using the MSP430OF149, 2007 IEEE/ICME Inter-national Conference on Complex Medical Engineering.

[7] Joseph Bailey, Michael Fecteau and Noah L. Pendleton, Wireless Pulse Oximeter, Major Qualifying Project Report, April 24, 2008.

[8] Alessandro Canu and Massimiliano Canu, Respiration Rate Calcula-tion Using Low Power DSP Processor and SpO2 sensor, 978-1-4244-9338 8/11/2011 IEEE