Development of a Pulse Oximeter Using MSP430 Microcontroller

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***Abstract*—In this paper,we propose and demonstrate the design of a Pulse Oximeter using MSP430FG439 Microcontroller.The Oxygen Saturation and Heart Rate are the two important key parameters for health monitoring of a patients.The proposed system consists of spo₂ Sensor,MSP430FG439 Pulse Oximeter board With LCD Display,PC.The oxygen saturation is calculated by measuring the ratio between the intensities of two different lights.The heart rate is calculated by measuring the elapsed time between the peaks of IR signal.The measured parameters are then transferred to a PC via Zigbee Module and displayed on lcd.**

Keyword-Pulse Oximeter,Heart Rate,SpO_2,MSP430FG439 Pulse Oximeter board,LCD Display,Zigbee Module.

I. INTRODUCTION

Health Monitoring becomes a hot topic today.The very important parameters for health monitoring are Oxygen Saturation and Heart rate.The pulse oximeter is a non-invasive medical device used for measuring Oxygen Saturation and Heart rate.Change in intensity of light transmitted through tissue due to arterial blood pulse can be measured as a voltage signal called the photoplethysmography(PPG).The developed real time pulse oximeter monitoring system consists of pair of LEDs,one in the visible red spectrum (660 nm) and the other in the infrared spectrum(940 nm). There are two methods of sending light,they are transmission and the reflectance. In the transmission method, the emitter and the photo detector are opposite of each other with the finger in-between. The light can then pass through the finger. In the reflectance method, the emitter and photodetector are next to each other on top of the measuring site.The light bounces from the emitter to the detector across the site.

The Pulse Oximeter is recommended for the patients in the hospital.It is less expensive compared to other health monitoring devices.It is very widely used for new born infants in the hospital.It is used as an important care tool for monitoring patients.Remote monitoring of patients is also possible,hence Pulse Oximeters are very widely used nowadays.

II. PULSE OXIMETER

Pulse Oximeter is a non-invasive medical device used for measuring Oxygen Saturation and Heart Rate of a patient.The pulse Oximeter consists of pair of LEDs,red and infra-red of two different wavelengths(660 nm and 940 nm) connected back to back and the other side it has a photo-detector.By placing the finger in between ,the Ratio(R) between the intensities of two different lights are measured.

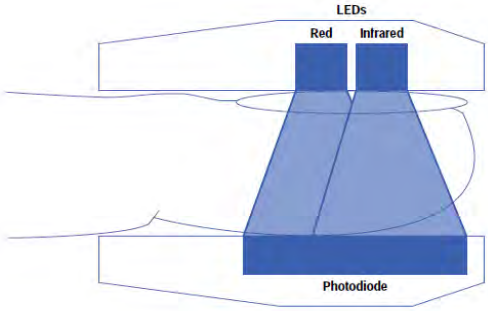

Figure 1.SpO_2 Sensor

There are a DC and an AC component in the measurements. It is assumed that the DC component is a result of the absorption by the body tissue and veins. The AC component is the result of the absorption by the arteries.The transmission of light through the tissue can be calculated using Eq.(1)

$$Iout = Iin \times e^{-A} \quad (1)$$

The Ratio(R) can be calculated using Eq.(2)

$$R = \frac{\log\left(\frac{\text{Rrms}}{\text{Rdc}}\right)}{\log\left(\frac{IRrms}{IRdc}\right)} \quad (2)$$

SpO2 is defined as the ratio of the level oxygenated Hemoglobin over the total Hemoglobin level(oxygenated and depleted).

$$oxygen\ saturation = \frac{HbO_2}{total\ haemoglobin} \quad (3)$$

The nomal person SpO_2 reading must be in the range of 95-100. The heart rate is determined by measuring the elapsed time between peaks of the IR signal.The heart rate is then calculated using the equation as followed Eq. (4):

$$Heart\ rate = 60/periods(seconds) \quad (4)$$

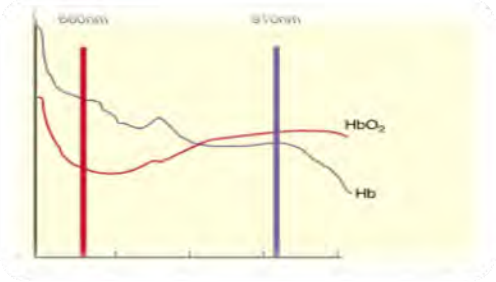

Figure 2. Absorption of Oxygenated and Non-oxygenated Haemoglobin at Different Wavelengths.

The heart beat is measured by counting the number of samples. A sensor is placed on a thin part of the patient's body, usually a fingertip or earlobe, or in the case of an infant, across a foot, and a light containing both red and infrared wavelengths is passed from one side to the other.Thus by using a single medical device we can measure both Oxygen saturation and Heart Rate of a human.

III. SYSTEM OVERVIEW

The developed pulse oximeter consists of pulse oximeter MSP430FG439 board connected to a MSP-FET430UIF JTAG Debugger.The debugger is powered by connecting into USB port.

A.Pulse Oximeter MSP430FG439 board:

The Pulse Oximeter MSP430FG439 board consists of H-bridge circuit,JTAG connector,MSP430FG439 Microcontroller.The MSP430 Microcontroller is an ultra low power microcontroller,it is very widely used in Pulse Oximeter applications.It is an 80 pin Microcontroller consists of in built op-amps ,DAC,ADC,SBLCDA4 LCD display.It is a custom LCD used for this application.The MSP430FG43x series are microcontroller configurations with two 16-bit timers, a high performance 12-bit A/D converter, dual 12-bit D/A converter, three configurable operational amplifiers, one universal synchronous/asynchronous communication interface (USART), DMA, 48 I/O pins, and a liquid crystal display (LCD) driver.

B.FET430UIF Debugger:

The MSP-FET430U80 is a powerful flash emulation tool used to download a program to the microcontroller unit via JTAG.It includes a USB debugging interface (MSP-FET430UIF) used to program and debug the MSP430 in-system through the JTAG interface or the pin saving Spy Bi-Wire (2-wire JTAG) protocol. The flash memory can be erased and programmed in seconds.The debugging tool interfaces the MSP430 to the IAR OR Code Composer Studio environment.

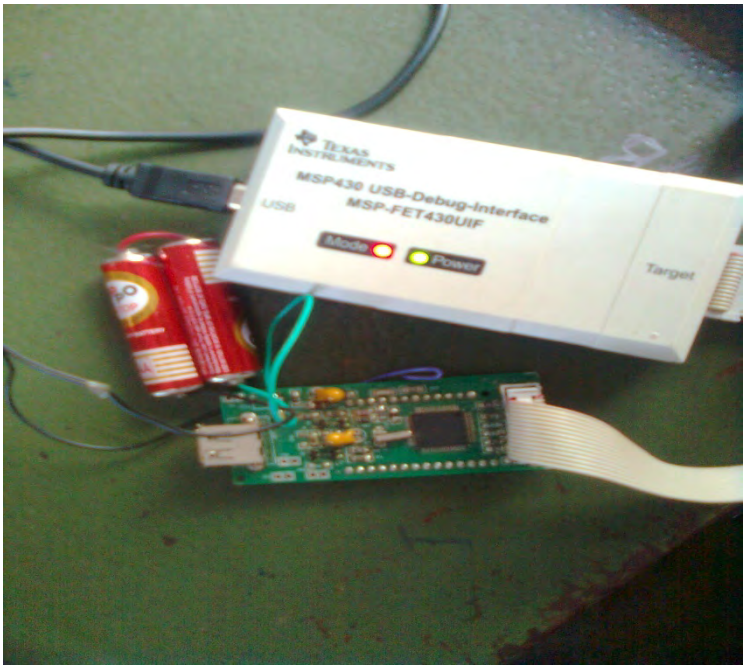

Figure 3..Hardware Setup

IV. DESIGN AND IMPLEMENTATION

The pulse oximeter design consists of 2 sections:

A.Transmitter section

B.Receiver section

A.Transmitter Section

The transmitter section consists of 3 blocks

1) Sensor module
2) Data processing module
3) Zigbee module

1)Sensor module:

The sensor module consists of SpO2 sensor.The SpO2 sensor consists of two led and photodiode facing to a patient fingertip. The bio-physical signal is captured at the level of a segment of the body (the forefinger or the earlobe) through the use of the pair LED-photodiode with 660 nm(red) and 940 nm(infrared).The photo detector detects the light signal and converts it into electrical signal.The resulted signal is processed through levels of conversion, amplification, and filtration.

2)Data processing module:

The data processing module contains a MSP430FG439 pulse oximeter board used for processing the bio physical signal to calculate oxygen saturation and heart rate.The incoming bio-physical signals are amplified by using internal op-amps.The ADC12 produce the sample outputs of the amplified signal.Then the samples are correctly sequenced and Microcontroller unit seperates the infra-red and red components.By measuring the intensities between infra-red AC,DC components and red AC,DC components,the ratio(R) has been calculated.

3)zigbee module transmitter:

The zigbee module transmitter transmits the processed data to the PC via zigbee module receiver and ATmega Microcontroller.

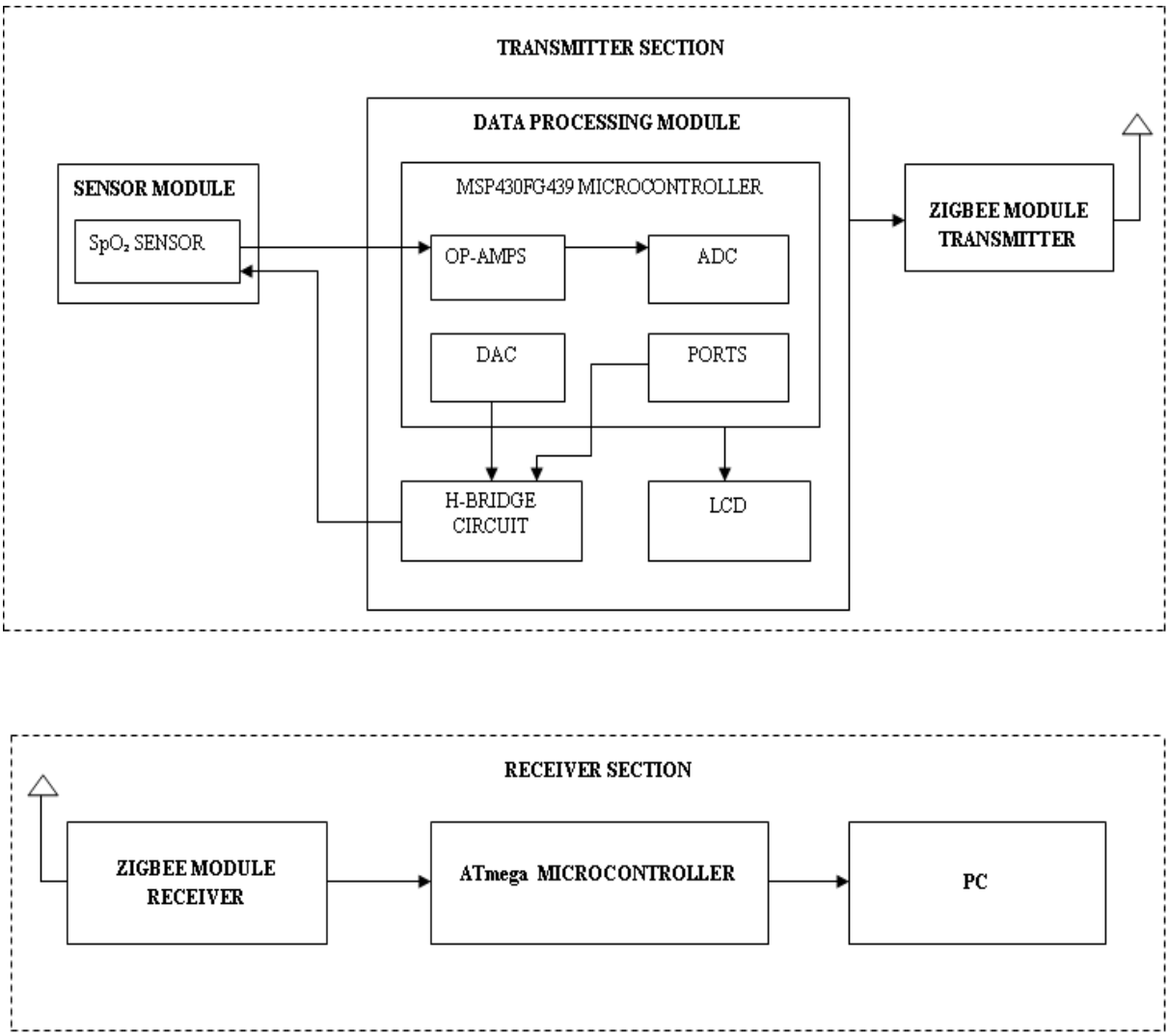

Figure 4.block diagram

B.Receiver section

The receiver section consists of

1)zigbee module receiver
2)ATmega Microcontroller
3)PC

1)zigbee module receiver:
The zigbee module receiver receives the data and send that to ATmega microcontroller.

2)ATmega microcontroller:
The ATmega microcontroller is used for storing the data before sending to a PC.

3)PC:
The results are displayed on a PC.

Thus the transmitter and receiver sections of a experimental set up are discussed.

V. RESULTS

The heart rate and oxygen saturation are calculated using MSP430 microcontroller and the results are displayed on a lcd.

Figure 5. Results Displayed on LCD

VI. CONCLUSION

The MSP430FG439 Microcontroller is used in order to reduce the power consumption.Thus the heart rate and oxygen saturation is calculated using an ultra low power microcontroller.The main advantage is pulse oximeter MSP430FG439 board consist of in built driver circuit for driving LEDs.

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