

Multi-Parameter Monitoring Data Acquisition System for SpO₂ Signals

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ABSTRACT: In this paper we have designed the Multi-Parameter Monitoring (MPM) data acquisition system to acquire the real time SpO₂ (Peripheral Oxygen Saturation) signals from the SpO₂ sensor probe. The main aim of the MPM is to monitor multiple parameters such as SpO₂, ECG, blood pressure and body temperature. The Multi-Parameter Monitoring board filters and amplifies the signal acquired from the SpO₂ sensor probe. Further the acquired signal is digitized using Analog to Digital Converter and plotted using MATLAB software. The microcontroller used for converting analog to digital converter is Silicon Labs C8051F380. The signal obtained in MATLAB is further processed to find the oxygen saturation value.

KEYWORDS: SpO₂, Multi-Parameter Monitoring, MATLAB, Silicon Labs C8051F380.

I. INTRODUCTION

Scope of the project is to build the SpO₂ data acquisition device that acquires the SpO₂ signal from the patient using SpO₂ probe. SpO₂ probe used in the project is Nellcor DS-100A as shown in figure 2. It consists of red and infrared light emitting diodes of wavelength 660nm and 940nm and a photodetector. The DB-9 connections of the sensor are shown in figure 3. Deoxyhemoglobin and Oxyhemoglobin absorbs different wavelengths. Deoxyhemoglobin has a more absorption at 660 nm and Oxyhemoglobin has a more absorption at 940 nm as shown in figure 1. Part of the light emitted by the light emitted diodes will be absorbed by the finger and the remaining unabsorbed light reaches the photodetector. The output from the photodetector is acquired using MPM. The signal which is acquired has to be filtered, amplified and digitized. MPM board will filter and amplify the acquired signal. C8051F380 microcontroller is programmed to acquire data from the MPM board and convert to digital using the 10 bit ADC present in the microcontroller. The digitized data is stored in the text file. This stored data is used by the SpO₂ signal processing system to process the data to display and also to determine the oxygen saturation value.

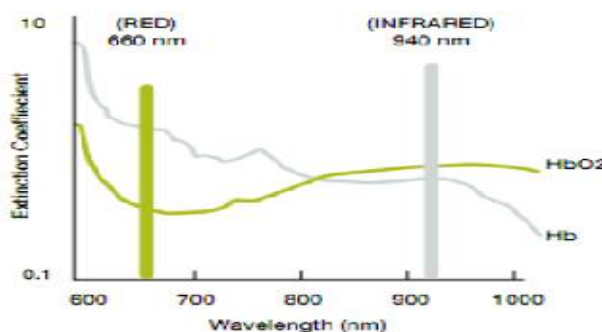


Figure 1: Hemoglobin Light Absorption Graph

II. RELATED WORK

Pulse Oximeter based on compressed sensing approach, samples the photodetector output in order to save the sensor Power [1]. Pulse oximeter for measuring arterial oxygen saturation based on Fuzzy Logic [2]. Low cost pulse pulse oximeter for remote patient monitoring which is useful for new born infants during surgery and to determine hypoxia [3]. Pulse oximetry system with an energy efficient transimpedance amplifier [4]. Wireless low power pulse oximetry system for patient telemonitoring [5]. Pulse rate and SpO₂ measurement using Lab View software [6].

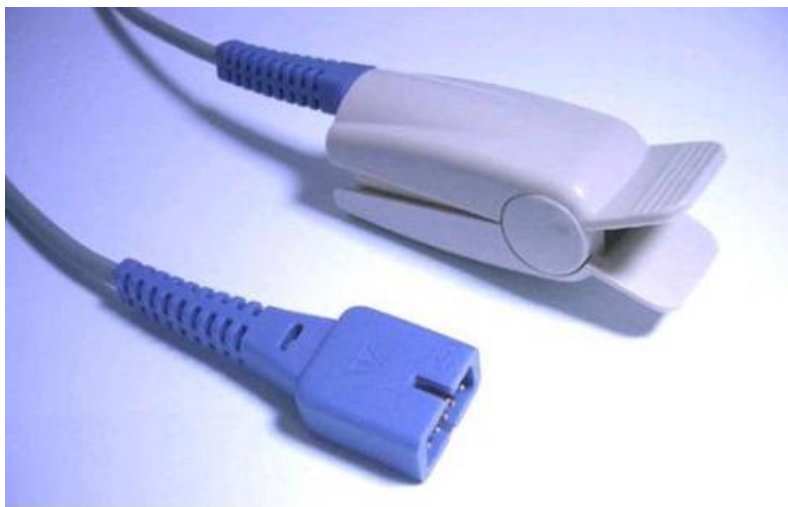


Figure 2: Nellcor DS-100A Pulse Oximeter Finger Probe [3]

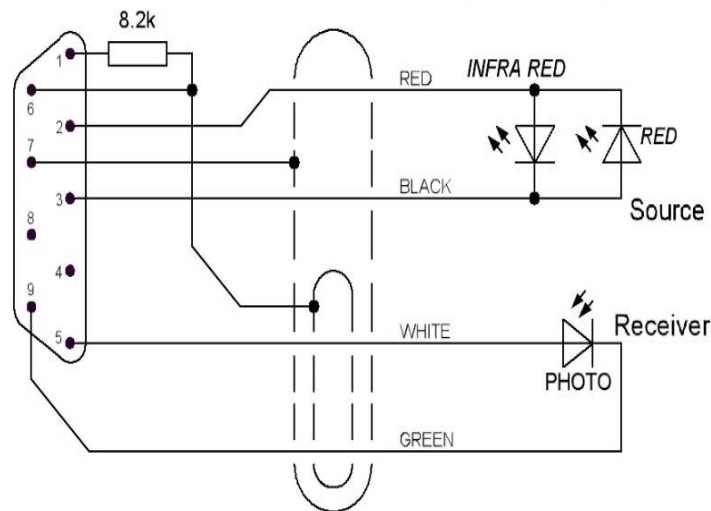


Figure 3: DB-9 connections of the sensor [4]

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Special Issue 9, May 2016

III. METHODOLOGY

SpO₂ sensor probe is placed on the patient's finger, light from red and Infrared LEDs on the sensor travels through the finger and the light which is not absorbed by the LED reaches the photo-detector. The output from the photodetector is a voltage signal has to be filtered and amplified. So the signal is passed to the Multi Parameter Monitoring (MPM) system, where it is filtered and amplified. At this stage, most of the noise from the signal is removed. The output from the MPM is shown in figure 5. The signal is also amplified in order to be detected easily by the ADC. The signal which is filtered signal is sent to an ADC channel of the C8051F380 Microcontroller. The digitized signal is processed in MATLAB. The functional block diagram is shown in figure 4.

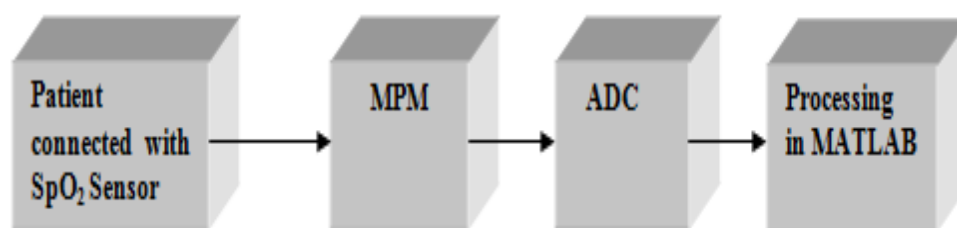


Figure 4: Functional Block Diagram

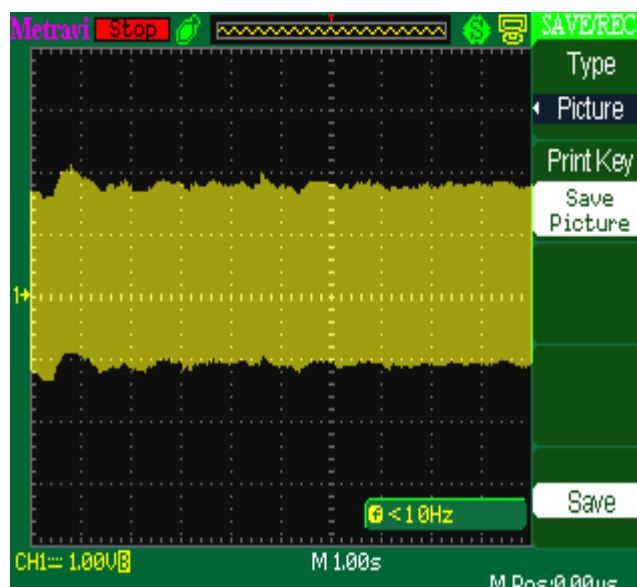


Figure 5: Output of MPM observed on DSO

The MPM board is designed using IC OPA4330. IC OPA4330 has four built in operational amplifiers. The MPM board is used to acquire three lead ECG signal, stethoscope signal and SpO₂. The low level signals are acquired, amplified and band pass filtered for their respective frequencies using the MPM board. The filtered and amplified signals are passed to the C8051F380 microcontroller. The C8051F380 is an 8 bit Silicon Labs low cost microcontroller. The

International Journal of Innovative Research in Science, Engineering and Technology

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MPM board consists of five OPA4330. Of the five OPA4330's present on the MPM board, three OPA4330's are used to process the ECG signal and the other two are used to process the stethoscope signal and SpO₂ respectively. SpO₂ IC operates at a frequency range from 0.5 Hz to 5 Hz. Figure 6 shows the image of the MPM board.



Figure 6: MPM Board

IV. C8051F380 MICROCONTROLLER

C8051F380 board is the customized board of C8051 microcontroller. C8051F380 device is fully integrated mixed-signal System on Chip (SoC) microcontroller unit. The output from the MPM board is fed to the microcontroller which is programmed to convert the analog data into digital data using Successive Approximation Register method (SAR). The output from the analog to digital converter has to be displayed in MATLAB. This can be done by acquiring the information from ADC unit of the microcontroller and storing it in text file. Text file is read from the serial port as shown in figure 8. The information from the microcontroller is transmitted through serial communication using the UART. Debug adapter connected to target board is shown in figure 7.



Figure 7: Experimental set-up showing connection of Debug adapter to Target board

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Vol. 5, Special Issue 9, May 2016

The status of serial port is continuously monitored. Whenever the serial port is open the information coming through the serial port will be read. If the serial port is not open then the status of serial port will be monitored. The information that is read from the serial port is written onto a text file. The content of text file is loaded to the MATLAB workspace. Then the output values are displayed in a graphical form as shown in figure 9.

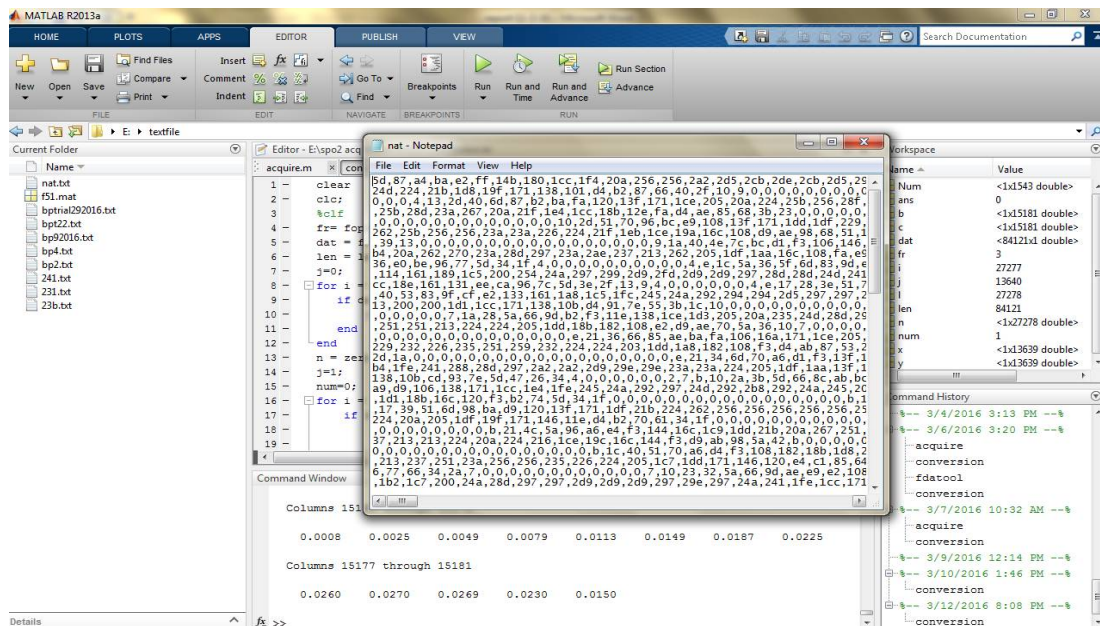


Figure 8: Text file read from the serial port

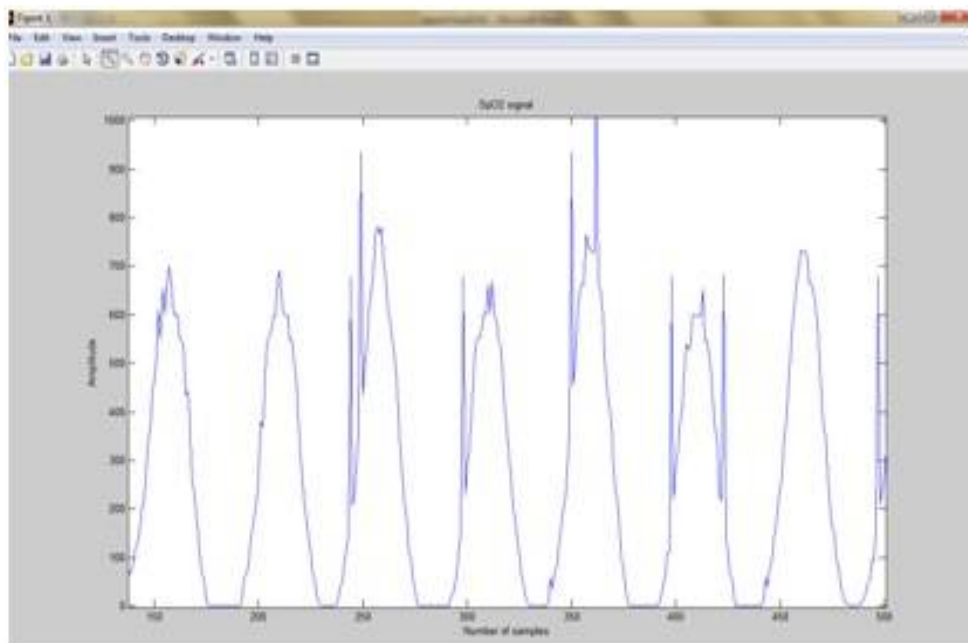


Figure 9: SpO₂ signal Acquired in MATLAB

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Vol. 5, Special Issue 9, May 2016

V. CONCLUSION AND FUTURE WORK

The analog output obtained from the MPM is fed to the microcontroller for ADC conversion. Silicon Labs C8051F380 microcontroller is used to convert the analog values from the MPM to digital output. Digital output is transmitted to the computer through serial port communication using UART and observed on the HyperTerminal. The HyperTerminal output voltages are acquired and displayed using MATLAB. In future the acquired signal has to be processed using peak detection algorithm to find the AC and DC component of red and infrared signal to calculate the SpO₂ value.

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