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Rapid Prototyping of Pulse Oximeter using ARDUINO

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Abstract-Optical Pulse Oximetry is feasibly the greatest advance in patient monitoring. Pulse Oximetry enables oxygenation, an important physiological variable that is not properly detected by clinical means, to be monitored continuously and easily [1]. Hypoxemia is commonly found in all aspects of medical practice and is a major cause of organ abnormality and death. It should be widely available in market and used routinely in clinical practice both in primary care and in hospital [2].

This paper will design a non-invasive Arduino based optical pulse oximeter. The pulse oximeter consists of a sensor and an Arduino microcontroller. In it photo transistor sensor is used for the pulse wave's detection, and the Arduino microcontroller is used to analyze the pulse wave to calculate the oxygen saturation (SaO_2). The results are displayed on a light emitter diode. This paper designs a reflectance pulse oximeter sensor that includes two light emitting diodes (LEDs), in which one in the visible red spectrum (660nm) and the other in the infrared spectrum (890nm) [12] [13].

The oxygen saturation is calculated by the help of intensity from each frequency of light after it reflects through the body tissue. The pulse oximeter uses the ARDUINO as microcontroller, which has ultra-low power capability, so the system's power consumption is very low [3].

Keywords-Pulse Oximeter, Arduino Microcontroller, Hemoglobin, Oxygen Saturation

1. INTRODUCTION

Oxygen gas is necessary for living as well as human life. It 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 measured by measuring the amount of oxygen in blood, as a percentage of the maximum capacity [4].

Pulse oximeter has become a standard procedure for the measurement of blood-oxygen saturation in the hospital operating room and recovery room [14]. Oximeter shortens the time passed before the detection of hypoxemia or deficiency of oxygen. These hypoxemic events have been documented in the critically ill during invasive or diagnostic procedures and during movement from one location to another. Significant hypoxemic events are also common during cardiac catheterization or inserting a catheter into a chamber or vessel of a patient's heart. Pulse oximeter also provides an early warning of oxygen ventilator malfunction. Finally pulse oximeter provides an important function in the intensive care unit, as an early warning system for patient emergencies [5].

In addition, many screening devices for sleep apnea use pulse oximeter as its most important parameter. By recording oxygen saturation and pulse readings during sleep, pulse oximeter can be an effective and low-cost screening tool that may be used away from the hospital. With the information being easily analyzed and viewed on a computer, it can be a worthwhile, objective view [6] [7].

2. RING SENSOR

The finger sensor part consists of the photo transistor and the LEDs. Fig. 2.1 shows the prototype developed for finger sensing.

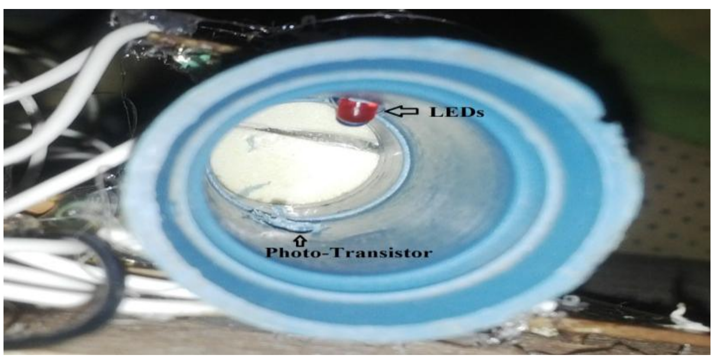

Fig. 2.1 Finger Sensor Prototype

2.1 Red LED

The red LED, in particular, has strict requirements. due to its position on the light extinction curve, unpredictability in the LED wavelength can alter the accuracy of the final SPO_2 calculation. For this reason, having a narrow bandwidth, or spectral line half-width, is necessary [8]. Having a wavelength of 660nm is important, because most of the research has been done with this wavelength, as it is easy to work with. The deviation from the 660nm wavelength can be accounted for with a wavelength coding resistor. For the sake of simplifying the project, this was not implemented. The maximum pulsed current is crucial, as it is necessary to pulse the LED brightly in order to obtain a quality signal. The angle of the light beam is also a consideration, as a wide angle can waste energy. Any light not received by the light detector is wasted light. Size and mounting ability is also an issue. Too large an LED would not easily fit in a compact sensor. For these reasons, the LTL-4266N red LED was chosen [9].

2.2 Infrared LED

The IR LED has lesser requirements. Due to its position on the light extinction curve, wavelength accuracy is not a prime concern. Like the red LED, maximum current, beam angle, and size are key criteria. The LTE-4206 was chosen for these reasons [9].

2.3 Photo-Transistor

The light sensor has to be responsive to both wavelengths of light. One of the most important parameters of interest is the rise and fall time. The faster the times, the lower the duty cycle can be for pulsing the LEDs. In this design, an integrated photo-detector and op-amp pair were chosen for simplicity of design, fast rise and fall times, and a wide spectrum response. The OPT 101 was chosen [11].

RESULT ANALYSIS

Table 1 shows the combined analysis of heart rate and oxygen saturation of both devices. Fig. a shows the graphical representation of these experimental data. Here both oxygen saturation and heart rate measured at same time from both devices. After comparing these values, there will be some difference between the measured values from both devices. These differences occur due to hand movement and small portion of ac signal representing the arterial pulse. To remove these errors, ring sensor and combination of low pass filter, notch filter and high pass filter are used in proposed device.

Table 1 Output Comparison of Proposed Device and Existing Device

S. No.	Person	Spo2		Heart Rate	
		Proposed Device	Existing Device	Proposed Device	Existing Device
1	1	99	97	85	77
2	2	99	99	89	73
3	3	99	92	94	103
4	4	99	96	78	85
5	5	97	88	95	96
6	6	98	99	93	100
7	7	98	99	99	95
8	8	98	95	79	87
9	9	99	93	88	88
10	10	99	99	80	75

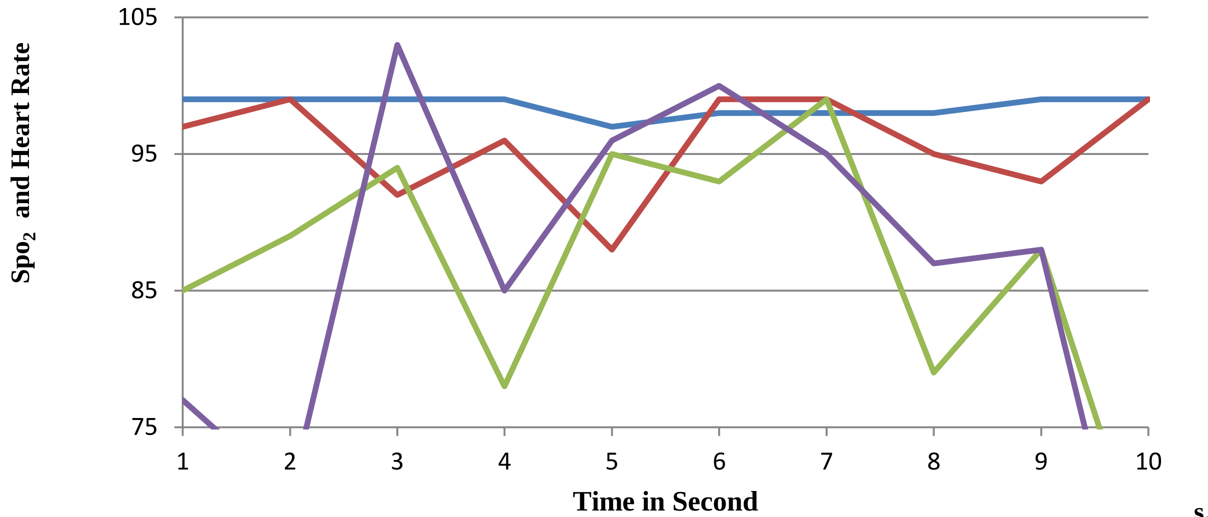

Fig. a Graph between Times v Spo_2/Heart Rate

COST COMPARISON

Table 2 Cost Comparison of Different Pulse Oximeter

S. No.	Device Name	Cost (Rs.)	Remark
1	Scure FTP 601 Pulse Oximeter	1249	It is used for only Spo_2 measurement
2	Surgi4 Fingertip Pulse Oximeter	1999	No visual alarm and Spo_2 range is 70% to 99%
3	Choicemeed Pulse Oximeter	2999	No visual alarm and Ideal for only adults.
4	Operon io_2 Pulse Oximeter	2999	No visual alarm and Ideal for only adults.
5	Dr Morepen PO-04	3499	No visual alarm
6	Nidek 6500 Pulse Oximeter	4500	No visual alarm and Ideal for only adults.
7	Proposed Device	1328	Visual alarm, ideal for both adult and child, Work both ac and dc power supply

Table 2 shows the cost comparison of proposed device and some existing devices, which are mostly used for measurement of oxygen saturation. The estimated cost of proposed device is 1328 rupees, which is less as compare to other existing pulse oximeters.

Proposed device provide more accurate and less errored information as compare to existing device as well as some advantages are also provided by proposed device as compare to other pulse oximeters. These advantages are briefly discussed in table 3.

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Table 3 Comparisons of Proposed Device and Existing Device

S. No.	Parameter	Remark
1	Output	In normal condition output of both devices are same but if there will be any movement present in hand then the output of suggested device is better as compared to other device.
2	Monitoring	Less monitoring required in suggested device because below set point alarm goes on.
3	Movement Effect	In suggested device the shape of finger sensor is ring shaped so there will be less distortion of signal due to hand movement. Hence the output is more accurate.
4	Time Efficient	Very simple and time efficient process to change device parameter for newly born child or an adult person.
5	Cost	Cost of suggested device is less as compared to existing one.
6	Power Supply	Proposed device work on both power supply while others are works on only one i.e. either ac or dc.

CONCLUSION

Initially the main objective of the project was to develop a portable Pulse Oximeter unit that receives data from a probe and processes it in order to return the values of heart rate and oxygen saturation in blood, thus allowing a continuous monitoring of these parameters. As already mentioned in this thesis, the project gained new guidelines and thus the main objectives become the development of an oximeter probe whose data is acquired by Arduino module, which communicate with a platform that would have implemented algorithms in order to perform the signal processing.

At this moment, it is available an efficient probe prototype constituted by economic components which is sensitive to the changes of light that occurs during the arterial pulse. Different measuring conditions such as a situation of physical activity are also detected by the oximeter probe. The oximeter probe developed is able to acquire biological signals to determine the heart rate and Sp02.

The functional modules i.e. LED driving circuit, that allow the LED driver and switching and the detection of light are also designed, developed and tested. The results show that these circuits are efficient, but still needed several improvements.

The Arduino is ready to acquire data from the probe but it is necessary to adjust acquisition frequency. This module communicates via USB with the processing platform, whose the firmware to board initialization and communications protocols was already developed and operational.

The signal processing algorithms were developed in C. They have the ability to apply a filter to the signal in order to reduce noise and then apply a criterion of detection that allows the separation of the spectra, the detection of peaks and thus determine the values of heart rate.

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