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# Designing Pulse Oximeter with the Ability of Measuring Temperature and Sending Information

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***Abstract:*** *This paper examined pulse oximetry as a widely used medical tool. The advantages and disadvantages of this method were discussed compared with other methods of oxygen meter. Ultimately, a pulse oximeter prototype have been designed, so that it could measure the body temperature, heart rate, oxygen saturation. In addition, it could send and archive information via WiFi to PCs and smartphones. One of the advantages of this method was that it increased the processing maneuver on the signal, allowing for much more information to be obtained from this signal. Sending patient information to the device was done wirelessly to reduce the side effects of Motion Artifact and the damages to the device due to patient movements. On the other hand, patients` information could be sent to a central server so that nurses and doctors could have access and keep the track of patients` information.*

***Keywords:*** *Pulse Oximetry, Oxygen Meter, Pulse Oximeter, SpO2*

## INTRODUCTION

Oxygen of the blood is in two forms: soluble and attached to hemoglobin. Hemoglobin can be operative or inoperative in terms of oxygen binding and transmition. Operative hemoglobin binds to oxygen and transmits it. It can be accessed as oxyhemoglobin (HbO2), a hemoglobin-bound oxygen, and deoxyhemoglobin, which is a hemoglobin-refined without oxygen binding (Hb). Inoperative Hb is not capable of binding and transferring oxygen, being realized as carboxyhemoglobin and methemoglobin. Carboxy hemoglobin is a Carbon monoxide -bound hemoglobin. Methemoglobin is a hemoglobin as ferric iron + (3Fe). That is, it has an oxidized form of ferrous iron (+29 Fe) carrying oxygen. The relative pressure of the oxygen dissolved in the arterial blood is called PaO2. The percentage of oxygen saturation associated with hemoglobin in the arterial blood is called SaO2. When this value is measured by a pulse oximeter, it is then called SPO2.

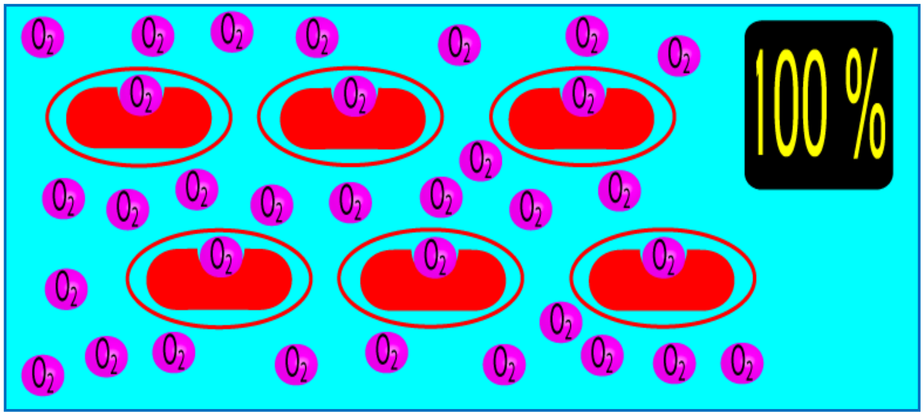



**Figure 1:** SPO2 display at a rate of 100% graphically

**Temperature measurement**

To measure the temperature, the DS18B20 sensor was used, which measured the body temperature. It was advantageous to commonly used thermometers such as digitization, low error, and hygiene. However, mercury thermometers allowed the transmission of bacteria and virus from one person to another. After measuring the temperature on the LCD, it sent the measured value to the smartphone or computer via the Wi-Fi module at the same time.

**Oxygen metric examination and various methods**

To carry out metabolic actions and to maintain life, oxygen must be transferred from the air to the lungs and then into the bloodstream being transported through the bloodstream to the tissues. As a result, knowing the amount of oxygen in the bloodstream is one of the vital parameters in the diagnosis and treatment of many diseases and tissue damages. The respiratory unit in the lungs includes pulmonary bronchiole, alveolar ducts, atria and alveoli. There are about 300 million vents within the two lungs. Each alveoli is 0.2 mm in diameter. The alveolar walls are very thin, and the veins pass through these alveoli along a thin surface. The reason for the release of oxygen or any gas from the membrane is the difference in pressure between the gases on the both sides of the membrane. For example, in the lungs, the exchange time between the alveoli and blood, the relative pressure of the oxygen on the alveolar side (104 mmhg) is greater than the relative pressure of the oxygen in the blood side (40 mmhg). For this reason, oxygen is released from the alveoli into the bloodstream.

Oxygen is always used by tissue cells. As a result, the relative pressure of oxygen in the intercellular space is less than that of the intracranial pressure. In addition, due to the gap between the cells and the capillaries, the intermediate cell gap varied between 5 and 40 mm of mercury; an average of 23mmhg. The amount of pressure required for cell activity was 3 to 1 mmHg. Then, despite a low pressure of 23 mmHg, there was a higher pressure than adequacy, which was a safety factor.

**The effect of hemoglobin on oxygen transfer**

Approximately 97% of the amount of oxygen to the tissues come from its chemical composition with hemoglobin. The remaining 3% is transmitted through its dissolution in plasma water. Oxygen is loosely bound to the hemoglobin and can be reversed; the reaction of which, is equilibrium and reversible.

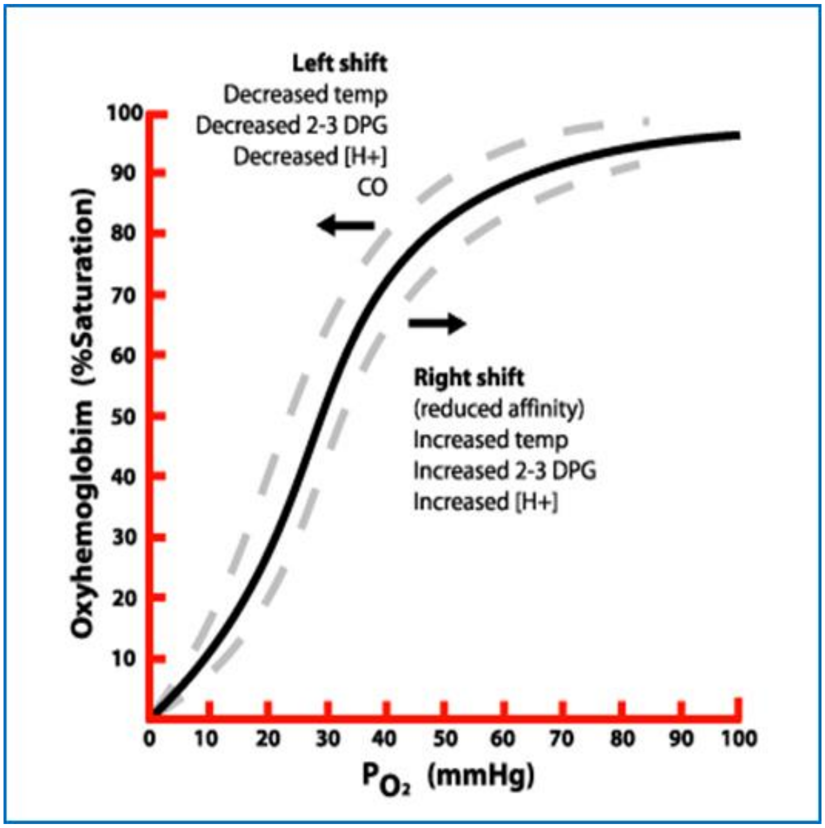



**Figure 2:** Percent oxyhemoglobin to PO2

As can be seen, some factors affect the hemoglobin saturation percentage. Including:
Changes in the concentration of carbon dioxide in the blood
Changes in blood temperature
Change in DPG value
Changes in blood pH

**Pulse oximetry and other methods of measuring blood oxygen**

There are several ways to measure oxygen levels in blood, which can be categorized in general:
Invasive: Invitro method and invasive catheter method
Non-invasive: Pulse Oximetry
Pulse Oximetry consists of the following words:
Puls: Blow, changes in blood arteries with any heart rate
Oxi: Oxygen
Meter: Measuring tool
A pulse oximeter is a device that measures oxygen content as a percentage of hemoglobin molecules being mixed with oxygen, relative to the total amount of hemoglobin molecules. Pulse Oximeters also show heart rates.

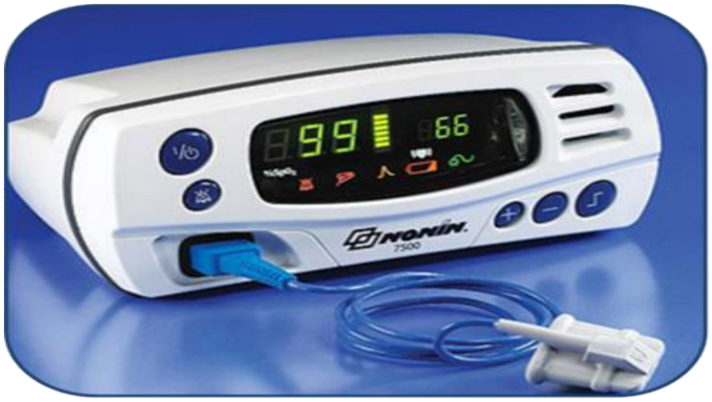


**Figure 3:** A pulse oximeter laboratory

**The operation of the pulse oximeter**

The device consisted of an optical sensor mounted on a pulsed sheath. (Usually on a person's index fingertip), the two LEDs were located as transmitters on one side, which emitted 2 red wavelengths of 660 nm and infrared wavelengths of 930 nm. The red light was absorbed by a hemoglobin (Hb), whose natural color is blue, and the infrared was absorbed by the combined oxygen along with hemoglobin (HbO2). In fact, two types of wavelengths were sent by the two LEDs as transmitters.

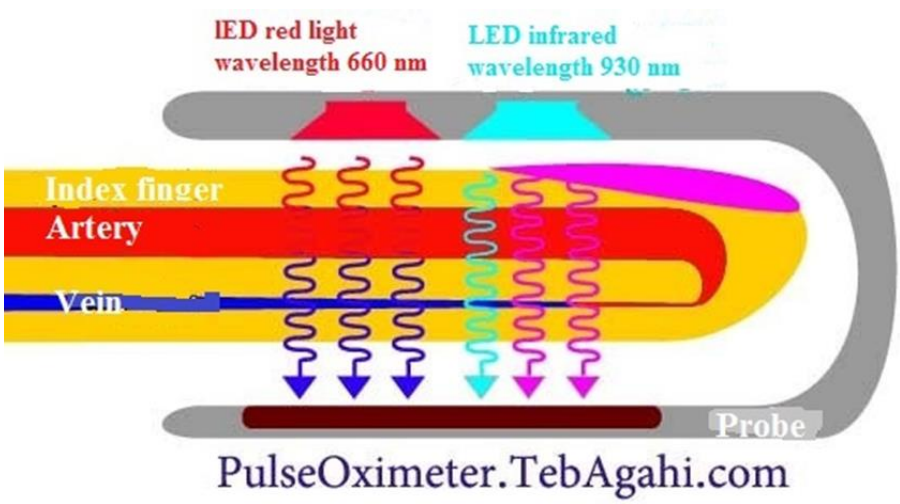



**Figure 4:** The structure of a pulse oximeter probe

On the other side, there was a receiver, a photodiode, which was responsible to detect the light passing through the tissue. This light was converted into an electrical signal by a receiver in terms of the intensity of light. In fact, it was the device's input signal and electronic and microprocessor boards, which were determined by these circuits of oxygen saturation measurements.

SpO2 was equal to Oxyhemoglobin ×100% Maximum hemoglobin value in the range of 4 to 8 hours and heart rate being calculated and displayed according to the pulse rate. To this end, two lights were used, because Hb and HbO2 had a different absorption spectrum at these wavelengths. In the red region, HbO2 absorbed less light than Hb, and in the infrared region, the opposite occurred. Then, the ratio of these absorption values was calibrated relative to the direct measurement of saturated oxygen content in the blood, and then the obtained algorithm was located in the microprocessor being inserted into the pulsar oximeter. When the device was used, a calibrated chart was applied to estimate the amount of oxygen saturated in the blood.

The light absorbed by a non-pulsatile tissue was constant (DC). Non-uniform absorption (AC) was a result of pulsatile flow. The optical sensor produced a voltage corresponding to the light. The alternating part of the received voltage waveform was about 1-5%. The high frequency of the light emitted by the diode caused the amount of adsorption to be calculated repeatedly. This reduced the effects of motion.

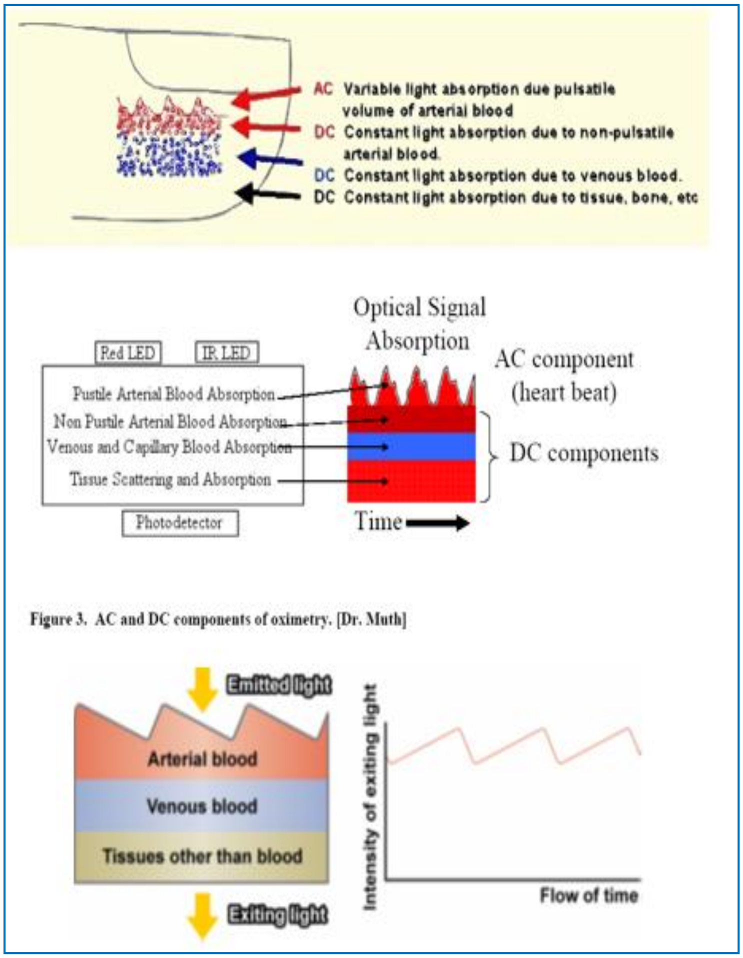



**Figure 5:** How to absorb light in the blood[1]

Places used in adults for pulsed oximetry included fingers, toes, and upper or lower ears, and in infants, hand palms, foot palms, thumbs or hands.

**The operation of the pulse oximeter**

The biggest advantage of an oximeter pulse was attributed to its non-invasiveness. With this method, the permanent measurement of SpO2 was easy and without the need for special clinical conditions. This system did not require daily calibration, and could be realized at small and affordable prices. One of the disadvantages of this system, was its high error rate in lower values of SpO2. The common systems for the SpO2 range were above 60%. Another weakness of the oximeter pulse was the issue of low perfusion, which resulted from a reduction in the bleeding of the desired tissue that weakened the AC signal. This also occurred in open heart surgery, which made practicing the use of pulse oximeter impossible. One of the other disadvantages of this approach was its Motion Artifact sensitivity, such as the increase in ambient light and interactions of electrical equipment, which reduced the satisfaction of the operation of conventional pulse oximeter systems and weakened their accuracy.

Masimo's pulse oximeter has been the first example of a pulse oximeter initiative in the past twenty-five years. Compared with the limitations of conventional methods, Masimo's model had a significant role in increasing safety and reducing the cost of medical care.
Many clinical studies have proven that the use of "MASIMO SET" along with Massimo's sensors reduced the maintenance costs, improved patient retention and increased patient safety. Some of the benefits of MASIMO include:
Ultimate accuracy and low cost
The best pulse oximetry at the time of weak signal amplitude and motion
High quality and precision
High precision during high patient movement, including tremor, stinginess, neonatal Movement and sudden shock
Applicable when moving a patient with a helicopter or an ambulance
Reduced maintenance costs along with reliable monitoring and durable adhesive sensors
Reducing eye injuries and medical errors

**Introduction of different pulse oximeter sections**
A pulse oximeter device is generally composed of the following parts:

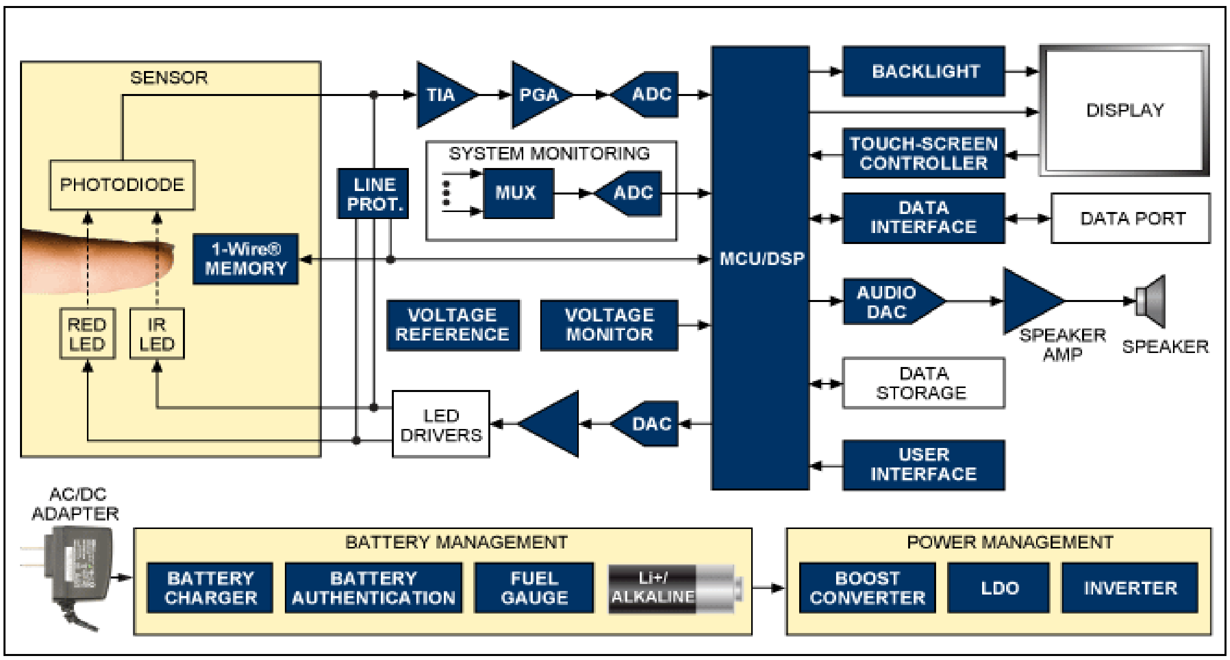


**Figure 6:** Diagram block of a complete laboratory pulse oximeter

The core of the pulse oximeter was a microcontroller processor or a DSP [2]. The LED start command was given to the driver so that once the red LED was lit and the signal was sensed by the photodiode, it was turned off and after a certain period the infrared LED was lit and the signal was received and turned off. This process repeated. Depending on the ambient light and the micro-received signal, the processor controlled the reflected light intensity of LED using a DAC.

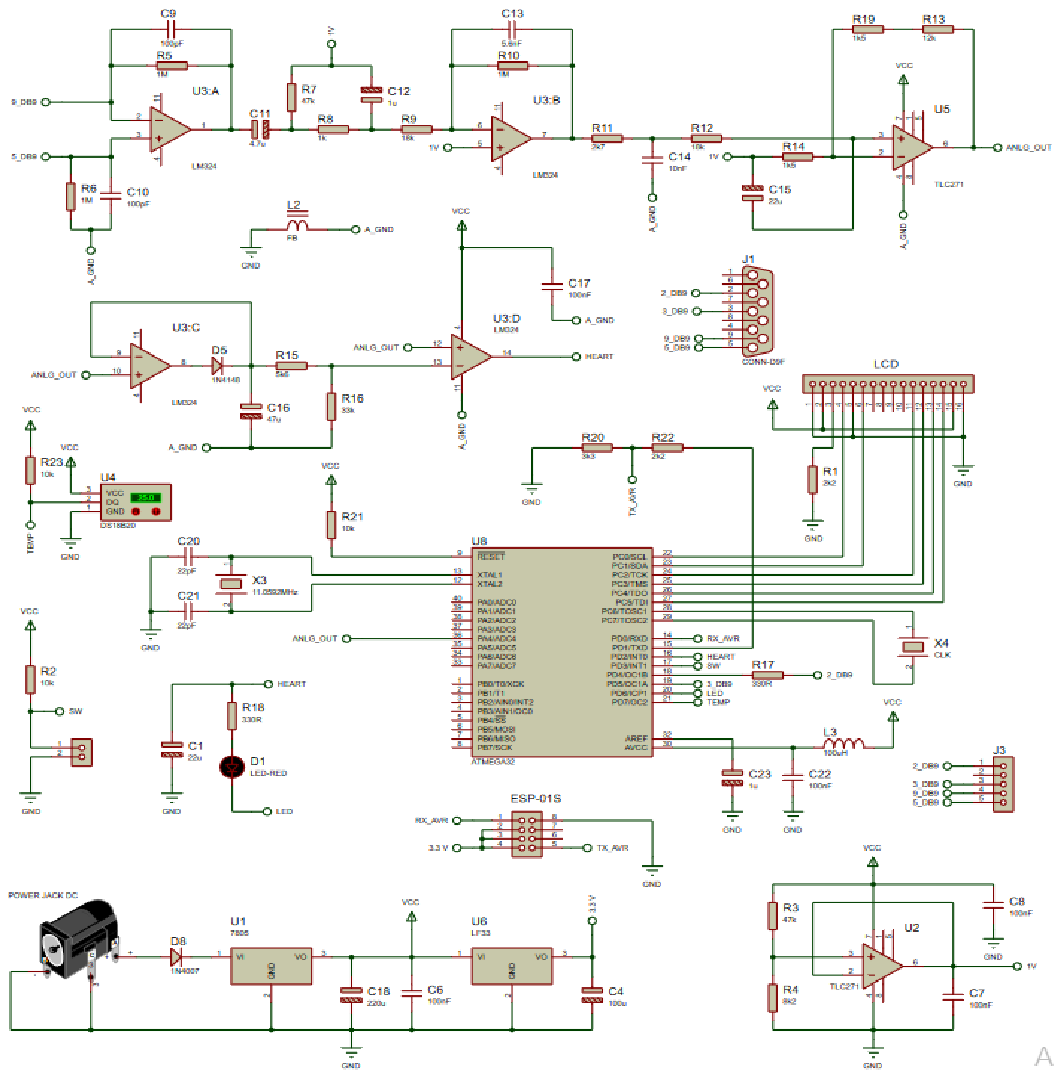


**Figure 7:** Designed Schematic of pulse oximeter

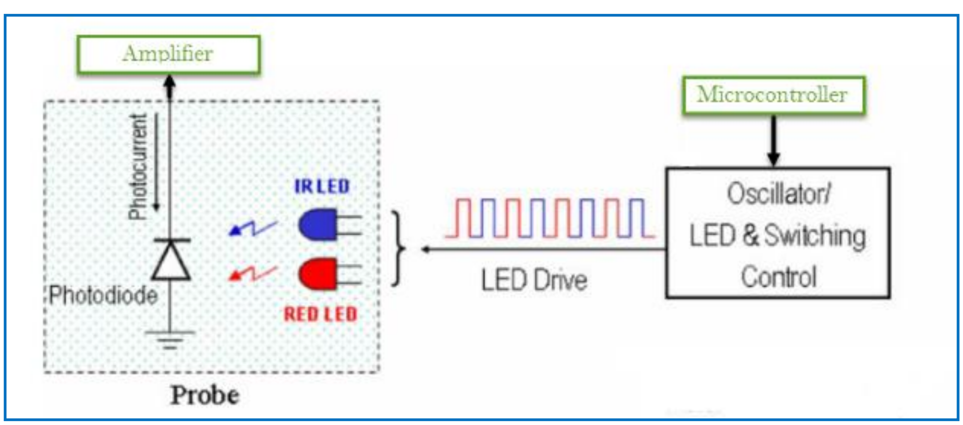
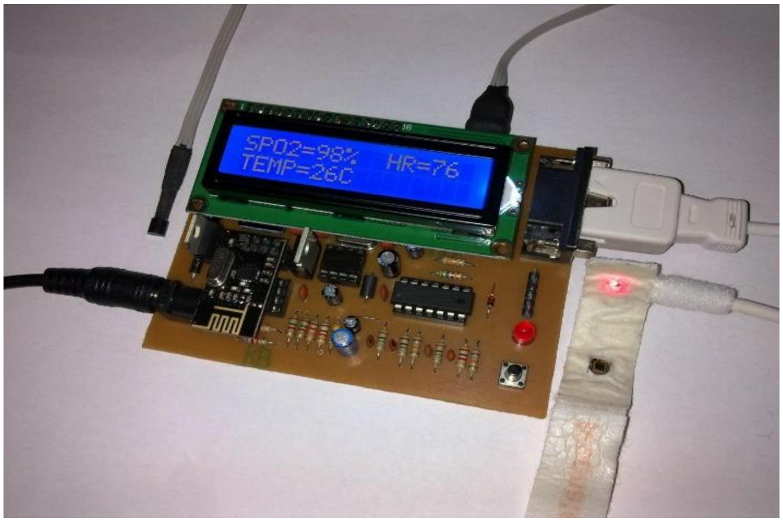



**Figure 8:** Installation of infrared and red diodes in a pulse oximeter

After receiving a photodiode signal, which was usually in the form of a current, it was converted to a voltage and was amplified by multi-stage up-amp. Meanwhile, in these classes noise signals were also filtered out. This signal was given to the digital converter after amplification to the analogue converter. A digital signal could also be transmitted to the computer via an interface, where the SpO2 graph could be seen, and more processing could be done on the received signal. The interface could be either wired or wireless. The power supply also included a battery charging circuit and various energy supply management.




**Fgiure 9:** Final Prpject

**The purpose of the project and implementation method**

In this project, a pulse oximeter was designed using an AVR microcontroller. Moreover, the received signal from the sensor was given using a series of intermediate circuits, including amplifier and filter, to the ADC microcontroller, where the processing took place on the data, and finally the data processed on the LCD was displayed and sent to a smartphone or computer via Wi-Fi.

Pulse oximetry is one of the most widely used medical tools. This project intended to produce an oximeter pulse with other features such as body temperature measurement and Protype heart rate booster, so that whenever it was necessary, it could be enhanced.

In this paper, a pulse oximeter prototype have been designed, such that this pulse oximeter could connect to computers and smart phones, and could monitor information on a computer. Sending information to the computer, it could provide many additional capabilities, such as increased processing maneuvers on the signal, and so much more information could be obtained from the signal.

After connecting the adapter to the circuit, the device displayed the basic information and launched the Wi-Fi module. In this case, the user could see the Wi-Fi PULSE OXIMETER on his/her mobile phone through turning on Wi-Fi on the mobile phone. The user had to connect to the network by selecting this network and entering the 12345678 password and then run the telnet software. Then device's IP and connected port should be entered being linked to the device. In case of successful connection, Connecting ... was displayed on the Android software.

In this case, the user could remove the finger of the device and fix his/her finger so that neither the finger moved inside, nor it was very firm. Then, by pressing the SW button, the temperature was first measured and then the device could take the beat rate in 15 seconds. After a simple calculation, it evaluated data in one minute, then it was time to measure the oxygen saturation. In this case, the terms displayed on the LCD were sent via Wi-Fi to the cell phone and were displayed on the Android software.

## Conclusion

Pulse Oximetery is a potentially life-saving tool, if it is used properly. Health care workers need to be aware of the indications, advantages, and disadvantages of pulse oximetry. More importantly, physicians should be able to interpret the pulse oximetry data. Having provided training and advice, physicians find the pulse oximeter as a valuable monitoring tool. Body temperature was measured in this method, which was advantageous to commonly used thermometers such as digitization, low error, and hygiene. However, mercury thermometers allowed the transmission of bacteria and virus from one person to another. Sending and archiving information via WiFi to PCs and smartphones were advantages in this method. Moreover, it increased the processing maneuver on the signal, which allowed for much more information from this signal. Sending patient information to the device was done wirelessly to reduce the side effects of Motion Artifact and damages to the device, due to patient movements. On the other hand, patient information could be sent to a central server, so that nurses and doctors could have access and keep the track of patient information.

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