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Developments in Pulse Oximetry and the Proposed Advancements in the Pulse Oximeter

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Abstract:
Knowing exact values of the health parameters like percentage oxygen saturation in blood and Heart Rate in case of medical emergencies like surgery or other emergent situations like Covid-19 is a must for the proper diagnosis followed by the medication. During WW II (World War II) the percentage oxygen was made known through the very crude method since no oximetry technology was available. After around a period of three plus decades, in 1974 for the first time the concept of non-invasive pulse Oximetry came to an existence and since then many technological developments took place and still are going on to make the system even more user friendly, cheaper and more importantly the designing of a biomedical electronic instrument to meet utmost accuracy so as to authenticate by the medical doctors in emergencies. Here in this paper the developmental journey of the pulse oximeter is reviewed and the advancement in the existing pulse oximeter is proposed with added feature of measuring the body temperature along with the percentage oxygen in blood and the heart rate and also to have all these parameters online available in real time through GSM technology, so that the real time monitoring of the patients at remote places possible.

Keywords: Percentage oxygen in blood, Heart Rate, Body Temperature, Covid-19, Non-invasive, Biomedical, GSM Technology

INTRODUCTION:

Though pulse oximeters have proved its importance at all times since its invention; during Covid-19 even a lay man came to know its importance for knowing the percentage of oxygen in blood and the heart rate. The pulse oximeters used in the big hospitals for knowing the percentage oxygen levels and the heart rate are too costly and can't be affordable at the small places while the cheaper pulse oximeters available in the market mainly have accuracy issues and hence the medical doctors never authenticate the readings of such pulse oximeters in emergencies.

Important thing is to have balance between accuracy and the cost, without compromising the accuracy and maintaining the cost reasonable so that even at the small places initial emergent diagnosis followed by primary medication can be done.

Here through this proposed advancements we are looking for the pulse oximeter wherein the three main health related parameters namely Percentage oxygen in blood, heart rate in BPM and the Body temperature will be measured with utmost accuracy keeping in mind the reasonable cost of the pulse oximeter and to have this data online available through the GSM technology on a single SMS where the delay will not be more than 5 to 10 sec.

REVIEW OF DEVELOPMENTAL PROCESS OF PULSE OXIMETER:

In 1942, during World War II according to Millikan, the oxygen saturation of arterial blood was measured continuously in situ with bichromatic photoelectric colorimetry of the intact fully flushed ear where the accuracy was lying within 3% to 8% as determined by gas analysis of arterial blood samples.

As per Millikan's in the design of pulse oximeter; there are 3-forms of oximeter with the similar things namely the design of ear unit, utilization of calibration data, standard filters and the supply voltage to the lamp (± 0.5V) and the difference lies in a method in transforming identical combination of photo-currents into identical saturation readings. [1]

In 1946, as per Comroe and Dripps, the technique used prior to oximeters was to check the sufficiency of oxygenation and was useful when 15% or 2-3 g of the hemoglobin is desaturated and blood hemoglobin concentration is not below normal limits. Oxygen saturation measurement through the color change was developed during 1930's and 1940's and then remain idle for a longer period followed by its use to measure the saturation of drawn blood along with the saturation of patients, employing the new technology called pulse oximetry. [2]

In 1949, Wood and Geraci improve upon Millikan's idea by adding pneumatic cuff to Millikan's ear oximeter, resulting in bloodless oximetry for the first time which has not made any significant change to the accuracy. [3]

In 1964, Robert Shaw devised a self calibrating 8 wavelength ear oximeter. The concept was to solve the simultaneous equations uniquely using one more wavelength than the number of separate forms of hemoglobin needing identification. But because of its large earpiece and great expense, it was seldom used for clinical monitoring. In those times oximeters were used in pulmonary medicine and physiology but were not employed in anesthesiology or critical care as a monitoring device. [4]

This was continued for 20 years till the introduction of Clark's 02 electrodes and then the idea of using pulsatile light variation to measure oxygen saturation was thought by the Japanese physiological Engineer Takuo Aoyagi. [5]

Late in 1970, many groups started working on Aoyagi's idea but sensitivity to motion which was the extremely prominent problem they found. Minolta-Mochida Oximet MET 1471 was the World's first finger measurement type pulse oximeter tested clinically by various Japanese groups [6-9]

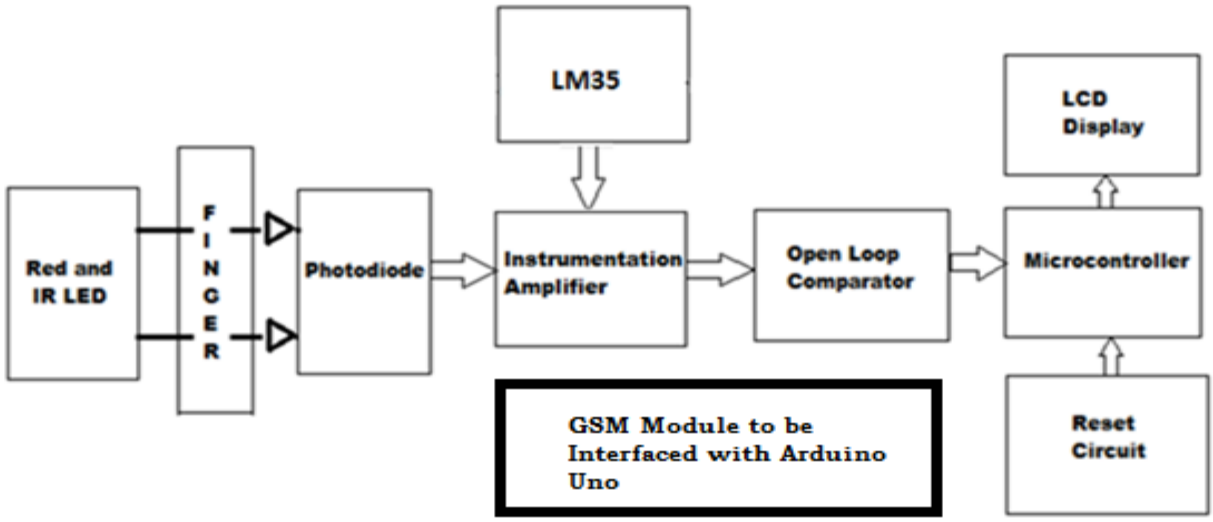
In 1972, Pulsoximetry was developed by the Bioengineers Takuo Aoyagi and Michio Kishi who have used the ratio of Red to Infrared light absorption of pulsating components at the measuring site. Medical Surgeon, Susumu Nakajima and his associate first tested the patient with the device at Sapporo Minami National Sanatorium and reported it in 1975. [5]

In 1980, William New, an Anesthesiologist at Stanford University has rediscovered the clinical utility of noninvasive oximeter in the operating room and realized that a continuous, noninvasive oxygenation monitoring would be useful for anesthesiologists. William New developed and marketed this pulse oximeter to the group. The Nellcor model N100 becomes almost synonymous with the term "pulse oximeter'. [10]

Since then continuous updations in design of pulse oximeters using microprocessors followed by the microcontrollers are going on wherein the data processing and manipulation is done majority by these processors. Initially the microprocessors were used in the designing but due to the limitations associated with these processors they were replaced by the microcontrollers. Still the modifications are going on to meet the accuracy standards with minimum losses as the pulse oximetry deals with the prominent health related parameters. [11]

DESIGN OF PROPOSED CLOUD BASE PULSE OXIMETER:

The proposed pulse oximeter will be a transmittance method based, non invasive device designed using microcontroller, keeping in mind the measurement of percentage oxygen in arterial blood, Heart rate in Beats per minute (bpm) and the body temperature in degree Fahrenheit (°F). The system is facilitated with the online availability of all these parameters related to the patient to the medical doctor or to the close ones through Global System for Mobile communication (GSM). Thus, the designed pulse oximeter is definitely a step ahead than the existing pulse oximeters.



HOW THE PROPOSED CIRCUIT WORKS?

Here the input received is in the form of oscillation of blood sensed through the change in intensities of RED and IR light passing through two LEDs; Red (660 nm) and Infrared (940 nm) with the photo detector (Photodiode here).

Due to transmittance method, Red and IR LED will be on one side and photo detector on other side of a finger. Photo detector is to sense the change in intensities of these two lights and converting them into an equivalent electrical voltage. This voltage comes across instrumentation amplifier and the probe use to calculate the percentage oxygen which digitizes the signal and converts it into a digital form done on the basis of average calculation and finally from the mean value the percentage oxygen saturation is calculated.

Temperature measurement can be done many means like; Thermometer or IR gun but here I'm using button type sensor PT100 which includes LM35 IC. This sensor is in contact with the body and as it senses the temperature, being a thermocouple device its resistance changes equivalently. This change in resistance is then applied to the other instrumentation amplifier and the instrumentation signal converts it into an equivalent electrical signal.

Both the above outputs by two separate instrumentation amplifiers will be applied to an Arduino on separate ports and the complete computational data regarding percentage oxygen in blood , Heart rate in bpm (Which is kept in data sheet basket X) and the data related to the measured temperature (Which is kept in data sheet basket Y) is then applied to the microcontroller for the display purpose which is done through LCD-128H064A providing the address for the respective parameter on the LCD screen.GSM connections also provided to, two serial ports of the microcontroller which provides the facility of making available the online data about the patient with respect to these three parameters. With the free software **Way2SMS** the data can easily be moved between the cloud and the mobile phone.

Using GSM technology here is to make the system useful for the masses and not for the classes, since even in financial year 2020 the percentage of population using smart phones was only 42% and estimated to reach to 51% in the financial year 2025. The system works only on the service **Way2SMS** wherein the 95% of SMSes are delivered in less than 10 seconds with zero tolerance that is the redundancy at every level ensures zero loss of messages resulting in 100% SMS delivery.

CONCLUSION AND FUTURE SCOPE:

From the review it is very clear that the accuracy related to the health related parameters through the various designed pulse oximeters are having the following discrepancies;

The percentage oxygen saturation in the blood didn't go below 0.82%.

The heart rate was not less than ±2 bpm and

The body temperature didn't go below 0.78%

And so far the future scope is concern;

The design should be simple, user friendly and portable

The cost of the designed circuit and the accuracy of the parameters obtained through should have balance amongst them.

Majority, the oximeters are designed to measure percentage oxygen in the blood and the heart rate but the system designed is expected to measure even more health related parameters.

The designed pulse oximeters should be permitted to use in emergent situations by the medical doctors for measuring the various parameters as above.

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