THE PULSE OXIMETRY DATA TRANSFER SYSTEM FOR WIRELESS

Baskar.s[1], Suresh kumar.A[2]
Assistant Professor, Electronics and Communication Engineering,
Kongunadu College of Engineering and Technology
Tamil Nadu, India.

Abstract

Blood oxygen content is considered as the 5th vital sign, joining: temperature, respiratory rate, heart rate and blood pressure [3]. The advantage of wireless pulse oximetry is completely non-invasive, wireless hassle free. It can be used to monitor the oxygen saturation of the blood as well as the pulse rate of the patient. it can even send the information. The wireless pulse oximeter is a wireless reflectance pulse oximeter device designed to monitor the blood oxygen content and pulse rate of the patients. Pulse oximetry has become a standard procedure for the measurement of blood-oxygen saturation in the hospital operating room and recovery room. Oximetry shortens the time passed before the detection of hypoxemia, or deficiency of oxygen. This design will provide this information wirelessly giving flexibility to the medical staffs.

Keywords: oximeter, oxygen saturation, wi-fi, oxyhemoglobin, temperature.

I Introduction

As the blood oxygen content is now considered the 5th vital sign joining, temperature, blood pressure and heart beat rate. One of the important benefits of pulse oximetry is that measurements are taken non-invasively through optical measurements. Health care workers will be able to handle the cases easier knowing that if the patient stops breathing or is having trouble breathing at any point, they will come to know from a portable device in front of their table without going near to the patient. And in case of the doctor is not available at the place at the moment or they are in their chamber, they can access the patients data from their chamber with the help of wi-fi technology, thus providing the doctors to give particular instructions to the health workers or nurses.

The Principle of Pulse Oximeter

A pulse oximeter measures and displays the pulse rates and the saturation of hemoglobin in arterial blood. This saturation of hemoglobin is a measure of the average amount of oxygen bound to each hemoglobin molecule[3],[20]. The absorption of visible light by a hemoglobin solution varies with oxygenation. The chemical bounding of the different types of hemoglobin genus changes the physical properties of the hemoglobin. The oxygen chemically combined with hemoglobin inside the red blood cells makes up nearly all of the oxygen present in the blood. Oxygen dissemination, which is often referred to as SaO_2 or SpO_2, is defined as the ratio of oxyhemoglobin (HbO_2) to the total concentration of hemoglobin present in the blood,[1],[2],[11].

$$SaO_2 = \frac{HbO_2}{(HbO_2 + Hb)} \text{ [10].}$$

Ox hemoglobin (HbO_2) and hemoglobin (Hb) have significantly different optical spectra in the wavelength range from 600nm to 1000nm, as shown in Figure 1 (the isobestic point is the wavelength at which the absorption by the two forms of the molecule is the same). The wireless pulse oximeter will measure Arterial SaO_2 and express it as a percentage.[1],[22].

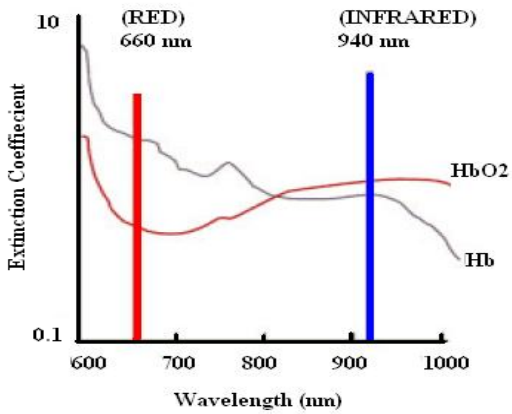

Figure 1: Absorption spectra of Hb and HbO_2 [21].

Under normal physiological condition arterial blood is 97.5% saturated, while venous blood is 75.5% saturated. The difference in absorption spectra of HbO_2 and Hb is used for the measurement of arterial oxygen dissemination because the wavelength range between 600 nm and 1000nm is also the range for which there is a minimum attenuation of light by body tissues. The half power spectral bandwidth of each LED is approximately 20-30nm. The LED's and photodiode chips are to be mounted on divided ceramic substrates. A small amount of clear epoxy resin will be applied over the LED's and photodiode for protection. Recessing and optically protecting the LED's and photodiode inside the sensor will reduce undesired specular light reflection from the surface of the skin and from the direct light path between the LED's and photodiode. The oxygen saturation can then be written in terms of the ratio *R* as follows:[1],[2],[11].

$$S = \frac{a_{r_1} - a_{r_2} R}{(a_{r_1} - a_{o_1}) - (a_{r_2} - a_{o_2}) R}$$

The above equation provides the desired relationship between the experimentally determined ratio *R* and the medically desired oxygen saturation *S.* LEDs are not monochromatic light sources, typically with bandwidths between 20 and 50 nm, and therefore standard molar absorptivities for hemoglobin cannot be used in the above mentioned equation. Also, the simple model presented above is approximately true. For example, the two wavelengths do not necessarily have the exact same path length changes, and second-order scattering effects have been ignored. Consequently the relationship between *S* and *R* is instead determined empirically by fitting the clinical data to a generalized function of the form [19]

$S = (k_1 - k_2 R)/(k_3 - k_4 R)$

An experimental calibration for *R* versus *S* is shown in Figure 2, together with the curve that standard molar absorptivities would predict. In this way, the measurement of the ratio of the fractional changes present in signal intensity of the two LED's is used along with the empirically determined calibration equation to obtain a beat-by-beat measurement of the arterial oxygen saturation in a perfused tissue - continuously, noninvasively, and to an accuracy of a few percent [1],[12].

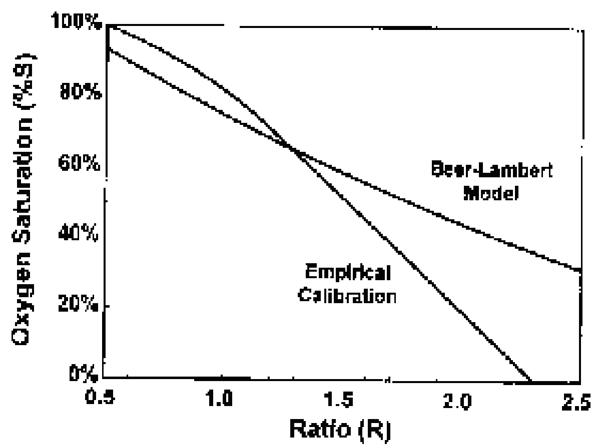

Figure 2: Relationship between the measured ratio of fractional changes in light intensity at two wavelengths, *R,* and the oxygen saturation *S.[1],[13,[21].*

The Design of the pulse oximetry instrumentation

A block diagram of the circuit for a pulse oximeter is shown in Figure 2 and design layout for our proposed wireless pulse oximeter in Figure 3. The main sections of this block diagram are described below.

II Pulse Oximetry Design:

Everyone's oxygen saturation fluctuates, especially when changing activities throughout the day. To determine your normal oxygen range, simply check your oxygen saturation 4 times a day for 5 days using your personal Nonin GO_2 brand fingertip oximeter [22]. Record each measurement in the activity log and be sure to also record what you were doing prior to checking.

Oxygen saturation measures how much oxygen the blood is carrying compared with its full capacity.

- An SpO_2 of greater than 95% is generally considered to be normal.
- An SpO_2 of 92% or less (at sea level) suggests hypoxemia.

In a patient with acute respiratory illness (e.g., influenza) or breathing difficulty (e.g., an asthma attack), an SpO_2 of 92% or less may indicate a need for oxygen supplementation.
In a patient with stable chronic disease (e.g., COPD), an SpO_2 of 92% or less should prompt referral for further investigation of the need for long-term oxygen therapy [4],[12],[13].

Pulse oximetry can be a useful aid in decision-making, but is not a substitute for a clinical assessment nor sufficient for diagnosis by itself. Arterial blood gas measurements, obtained by arterial puncture, remain the gold standard for measurement of oxygen saturation.

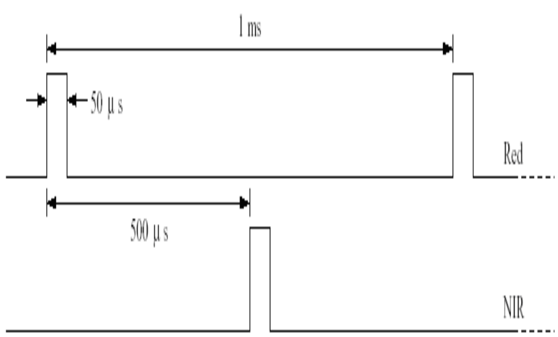

Figure 3: Switching of Power Supply to Light Sources

Power Supply Mode:
The Switching Power Supply most comprehensive programs for standard DC/DC converters, provides you with a diverse selection of package configurations, input and output voltage options, protections and special features. We offer single and dual output, isolated and non-isolated DC-DC power module from 1 to 150 watts in different footprints including SIP, DIP, SMT, 1x1, 2x2, and also DIN Rail mount and Chassis Mount options. Mornsun DC/DC converters are ideal for industrial control, communications industry, electric power system, rail transportation, intelligent building, automotive electronics, etc.

A switched-mode power supply (switching-mode power supply, switch-mode power supply, switched power supply, SMPS, or switcher) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power) to DC loads, such as a personal computer, while converting voltage and current characteristics.
Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy [6]. Ideally, a switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time. In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight.

Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight are required. They are, however, more complicated; their switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor.

As a result of improvements in power semiconductors, moderate frequency switching supplies can now provide the hundreds of amps typically required by accelerators with zero-to-peak noise in the kHz region ~0.06% in current or voltage mode. Modeling was undertaken using a finite electromagnetic program to determine if eddy currents induced in the solid steel of CEBAF magnets and small supplemental additions would bring the error fields down to the 5ppm level needed for beam quality [6]. The expected maximum field of the magnet under consideration is 0.85T and the

DC current required to produce that field is used in the calculations. An additional 0.1% current ripple is added to the DC current at discrete frequencies 360 Hz, 720 Hz or 7200 Hz. Over the region of the pole within 0.5% of the central integrated BdL the resulting AC field changes can be reduced to less than 1% of the 0.1% input ripple for all frequencies, and a sixth of that at 7200 Hz. Doubling the current, providing 1.5T central field, yielded the same fractional reduction in ripple at the beam for the cases checked. For light sources with aluminum vacuum vessels and full energy linac injection, the combination of solid core dipoles and switching power supplies may result in significant cost saving

In order to detect and isolate the signals in which we were interested we chose to use an INA121 instrumentation amplifier from Burr-Brown. This amplifier took as input from the sensor. The signal can be amplified by the INA121 in order to produce an output for our signal transmission. Any voltage that appeared on sensors would not amplified by the INA121, which had a CMRR of 106 dB at 1000 gain. In this manner, ambient noise can be removed from our signal. A schematic of this portion of the circuit follows:[14].

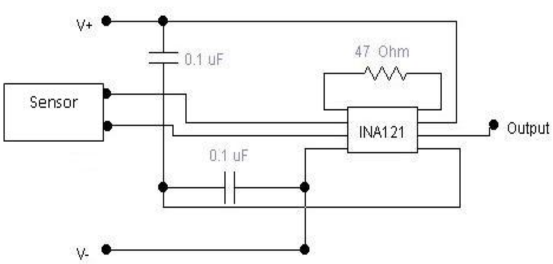

Figure 4: Schematic circuit diagram of Signal Processing.[22].

III Wireless Communication

A schematic representation of how the information collected is sent from the sensor to the monitor can be seen in Figure 5 below. [14]. This shows how data from the sensor is sent to a modulator inside the unit on transmitter which then sends the modulated signal to the RF amplifier and eventually to the antenna which in turn sends the data as an RF signal. This RF signal is then received by the receiver device represented below (Figure 5). [9].

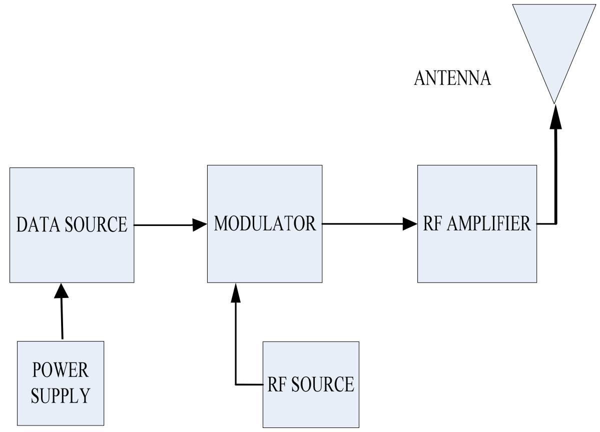

Figure 5: Schematic Diagram of the Wireless Data Transmitter Device

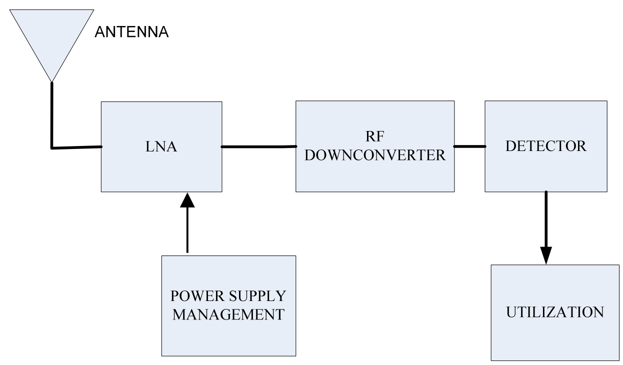

Figure 6: Schematic Diagram of the Wireless Data Receiver Device

For wireless data communication we have two options. The first option is using Wi.232 module kit. This module combines data transceiver and a high-performance protocol controller to create a complete embedded wireless communications link in an IC like package.[14],[15]. The module can be placed into sleep mode through the command mode. In sleep mode, the RF section is completely shutdown, and the protocol processor is in an idle state. Once the module has been placed in the sleep mode, it can be woken by either cycling power, which will lose all volatile settings, or by sending a power-up sequence through the serial port. The power up sequence is a combination of four 0xFF bytes sent back-to-back at the data rate the module is configured at. This will help save battery power so that the wireless pulse oximeter will be able to run for as long as possible. However it must be noted that when the device is in sleep mode it will not be able to receive data. The Wi.232DTS is a very flexible device because of its configurable properties, but it is important that the devices are configured in the same way will not be able to communicate. Every Wi.232 module has read-only internal registers that contain calibration data and a 48-bit MAC address that can be used for other higher level communications than are needed for this application at this time. This MAC address can be read through the command interface.

Due to the high cost of the module as our budget might not support, we have to try for a substitute one. For this we came up with the second option.

Here in the second option we are planning to use the FM transmitter and receiver module kit. As the signals are sent through RF only, so after setting to a proper frequency we could use this module kit. Till date we are working on this project so we came up of till here[7]. The schematic circuit diagram of both the transmitter and receiver is shown in the figure below. Since the signal has been amplified, we can transmit over the FM band. To transmit the signal, a BA1404 FM transmitter can be used.[8],[19],[20]. A schematic of this portion of the circuit follows:

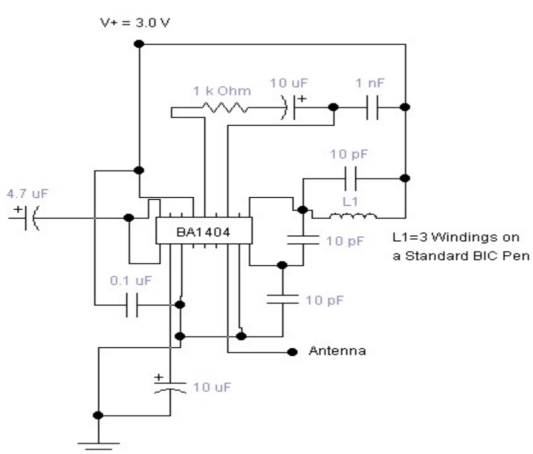

Figure 7: Schematic of transmitter circuit.

For receiver the tuning is done via the variable capacitor C with numbers written on its button.[20].

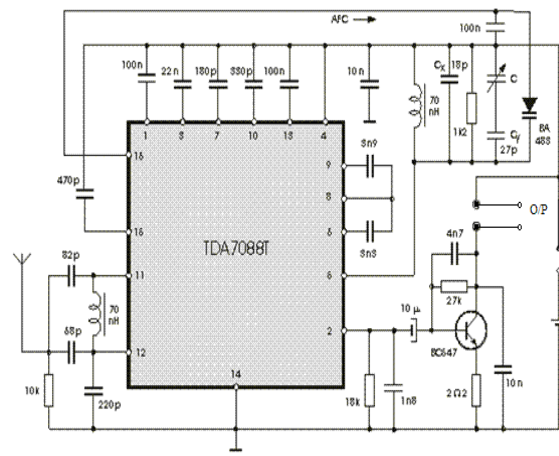

Figure 8: Schematic of receiver circuit.

IV Conclusion

The wireless pulse oximeter is a wireless solution for medical healthcare which will allow monitoring the patients pulse rate and blooding oxygen content. This design will provide this information wirelessly giving flexibility to the medical staffs. The product displays information in a straightforward manner to ease interpretation of the information by the users. In addition to this, it will help the physicians/doctors from the other room to access the patient information from their chamber itself. If further improved, the technique can be used for building wireless sensors used in medical purposes.

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