A

Mini Project Report

On

Pulse Oximeter

At

Pranveer Singh Institute of Technology Kanpur

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In

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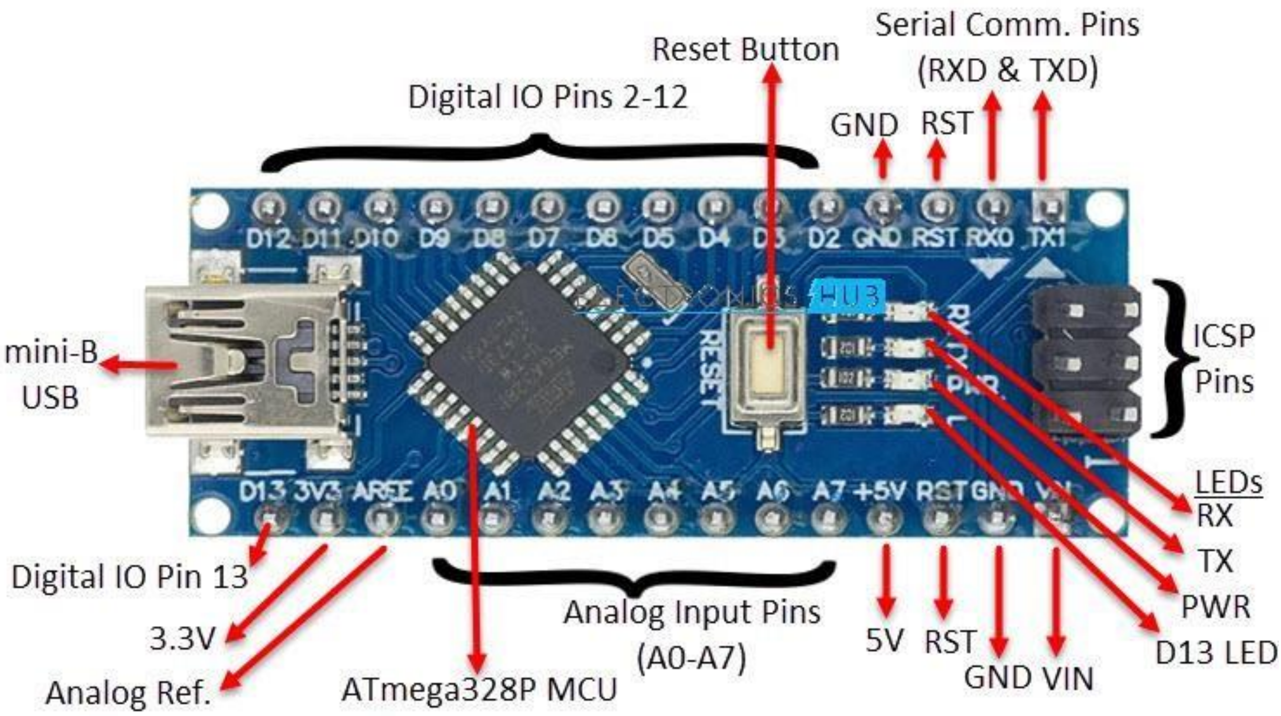
Chapter: - Introduction

The current technologically advanced and lame life style of the modern world has been witnessing the increasing case of heart and related diseases around the globe, it becomes very important to keep track of the day to day functioning of the vital organs of the body which are in one or other way highly dependent on the too major factors as such- the Blood Oxygen levels and the Heart Rate as it determines how well the body is functioning under the given and varying physical and environmental changes. It is vital to both for a healthy person and becomes more crucial for the monitoring of the patient's wellbeing. The minimum oxygen saturation point in blood of every person is more than or equal to 95%. i.e., SPO2>=95% if by chance it is below the threshold point it may cause stain in heart, liver and lungs. It will adversely affect the basic regular functioning of the body and at the same time the regular monitoring of heart rate and blood oxygen levels will enable precise understanding of the patient health. However, some conventional methods are still being used to measure the cardiac values which are less accurate and take expert mechanical knowledge of the instrument to observe the readings which in turns cost loss of valuable time for the critical patients. The conventional devices are still prevalent in the remote locations of the hinterlands which reduces the access of better healthcare services for the marginal and the poor which becomes a major factor for the multidimensional inequality and hinders the human development objectives. Modern advanced technological applications are producing the required medical instruments to accurately measure the vital activity with least latency and the highest accuracy. Pulse oximeter is such a device which is used to measure the heart rate and oxygen saturation of the patient. Oxygen saturation (SPO2) is a measure of oxygen saturated haemoglobin present in the blood. During Covid 19 pandemic the high demand of medical devices with lack of availability due to supply side restraints, created the market volatility increasing the prices to unfordable and inflated levels. This clearly shows the vulnerability of the general population in accessing better healthcare and proper treatment in absence of affordable medical devices. The project tries to design a model to achieve this objective of an affordable and reliable medical device, which will measure the blood oxygen level as SPO2 of the user along with heart rate as BPM with subsequent displays on OLED respectively.

Chapter: -2 Components

1- Arduino nano

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.x). It has more or less the same functionality of the Arduino Duemilanove, but in a different package. It lacks only a DC power jack, and works with a Mini-B USB cable instead of a standard one.



As Arduino Nano is also based on ATmega328P Microcontroller, the technical specifications are similar to that of UNO. But none the less, let me give you a brief overview about some important specifications

MCU	ATmega328P
Architecture	AVR
Operating Voltage	5V
Input Voltage	7V – 12V
Clock Speed	16 MHz
Flash Memory	32 KB (2 KB of this used by bootloader)
SRAM	2 KB
EEPROM	1 KB
Digital IO Pins	22 (of which 6 can produce PWM)
Analog Input Pins	8

2: MAX30100(Pulse and Heart-Rate Sensor)

The sensor is integrated pulse oximetry and heart-rate monitor sensor solution. It combines two LED’s, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse and heartrate signals. It operates from 1.8V and 3.3V power supplies and can be powered down through software with negligible standby current, permitting the power supply to remain connected at all times.

Features: -

1. Consumes very low power (operates from 1.8V and 3.3V)

2. Ultra-Low Shutdown Current (0.7µA, type)
3. Fast Data Output Capability
4. Interface Type: I2C

Working of MAX30100 Pulse Oximeter and Heart-Rate Sensor-
The device has two LEDs, one emitting red light, another emitting infrared light. For pulse rate, only infrared light is needed. Both red light and infrared light are used to measure oxygen levels in the blood.

When the heart pumps blood, there is an increase in oxygenated blood as a result of having more blood. As the heart relaxes, the volume of oxygenated blood also decreases. By knowing the time between the increase and decrease of oxygenated blood, the pulse rate is determined.

It turns out, oxygenated blood absorbs more infrared light and passes more red light while deoxygenated blood absorbs red light and passes more infrared light. This is the main function of the MAX30100: it reads the absorption levels for both light sources and stores them in a buffer that can be read via I2C communication protocol.

Number	Pins	Definition of Pins
1	VIN	Power Input 1.8V - 5.5V
2	SCL	IIC-SCL
3	SDA	IIC-SDA
4	INT	MAX30100 INT
5	IRD	MAX30100 IR_DRV
6	RD	MAX30100 R_DRV
7	GND	Ground

3: OLED Display (128×64)

OLED's are the future of displays, as they possess some of the greatest advantages over both conventional display technologies of LCD's and LED's.

The most attractive thing about using the OLED displays is that they do not need a back-light like conventional LCD/LED screens. The organic material itself has a property known as Electroluminescence (EL), which causes the material to "glow" when stimulated by a current or an electric field. Best energy saving displays ever!!!

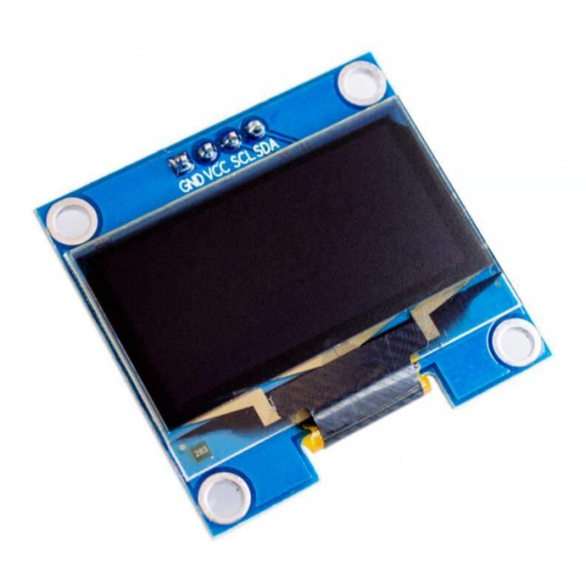
This 0.96″ OLED Display Module offers 128×64-pixel resolution. They are featuring much less thickness than LCD displays with good brightness and also produce better and true colours.

This OLED Display Module is very compact and will add a great ever user interface experience to your Arduino project. The connection of this display with Arduino is made through the I2C (also called as IIC) serial or SPI interface.

The 0.96″ OLED Display Module produces blue text on black background with very good contrast when supplied with DC 2.8V supply. The OLED Display Modules also offers a very wide viewing angle of about greater than 160°.

Features: -

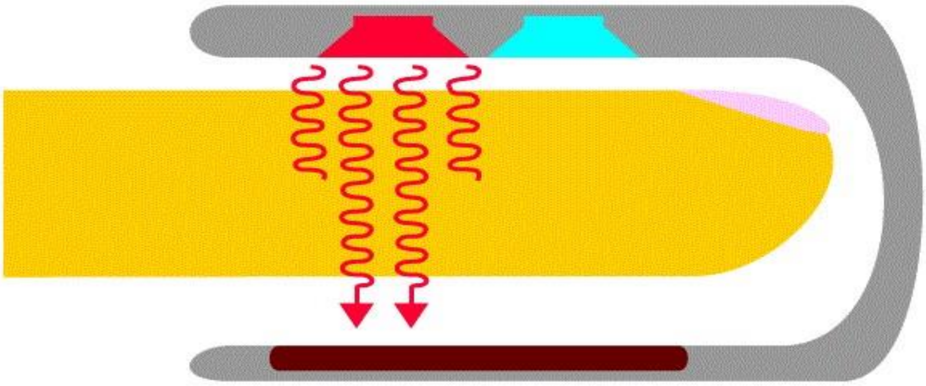
1. No need of the backlight
2. The display is self-illuminating
3. Power requirement is low
4. They are offering the large viewing angle
5. Full Compatible with Arduino
6. Factory configured for SPI protocol (can easily change to IIC)
7. Better performance characteristics than traditional LCD and LED displays.
8. Only Need 2 I/O Port Control



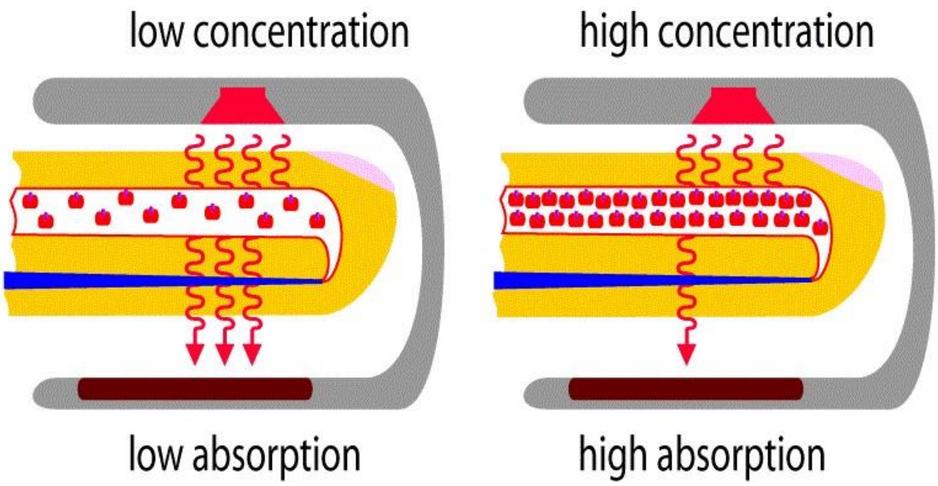
Chapter: -3 Working

How does Pulse Oximeter Works?

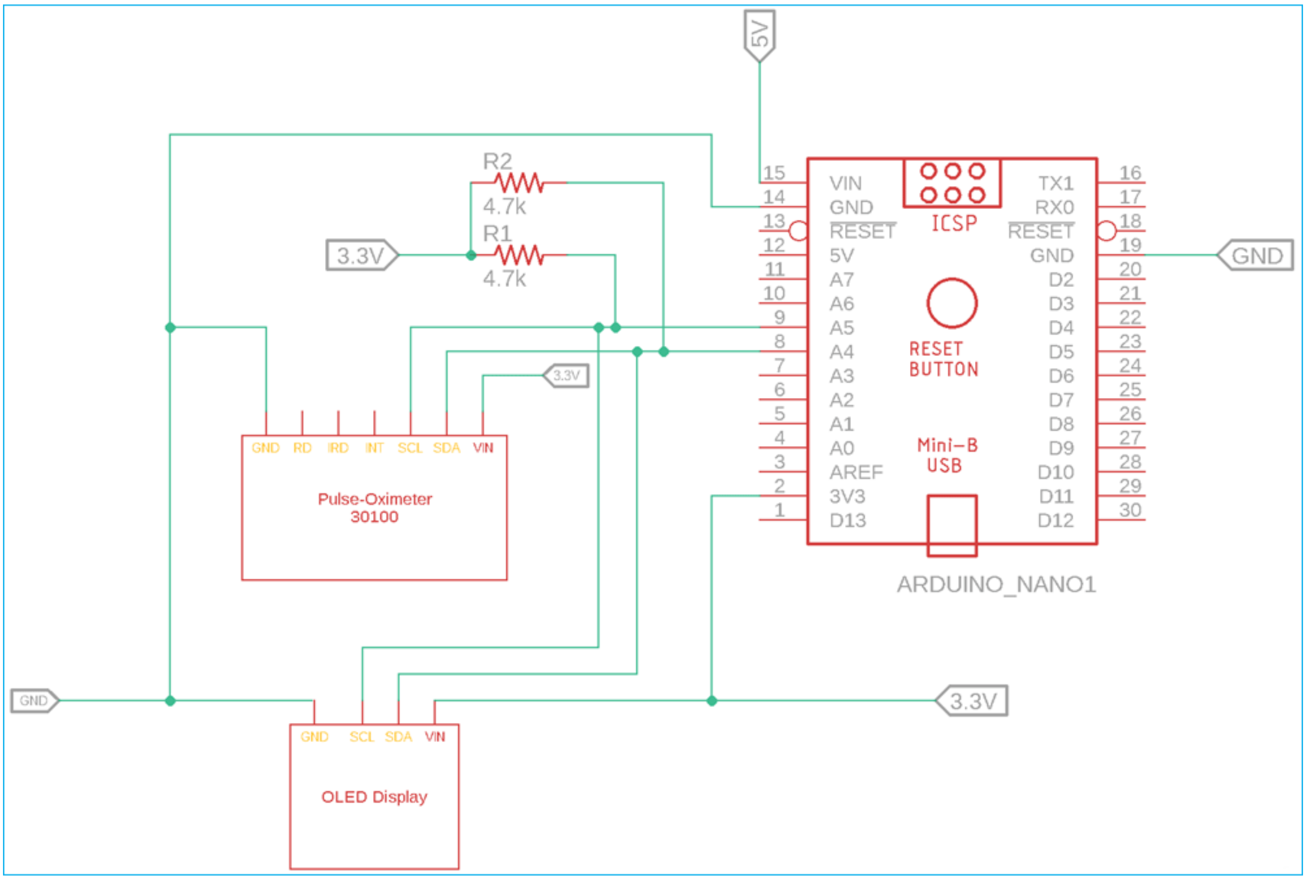
Oxygen enters the lungs and then is passed on into blood. The blood carries oxygen to the various organs in our body. The main way oxygen is carried in our blood is by means of haemoglobin**.** During a pulse oximetry reading, a small clamp-like device is placed on a finger, earlobe, or toe.



Small beams of light pass through the blood in the finger, measuring the amount of oxygen. It does this by measuring changes in light absorption in oxygenated or deoxygenated blood**.**



Schematic of Pulse Oximeter Circuit-



Code Explanation: -

This code uses many libraries and all are important. The libraries are MAX30100 Pulse oximeter sensor library, Wire. h for the I2C, **Adafruit_GFX.h** for showing animation on the display, **Adafruit_SSD1306.h** for the display driver, and Fonts/FreeSerif9pt7b.h for the front.

Those libraries are included at the beginning of the code.

```
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
#include <Fonts/FreeSerif9pt7b.h>
```

Next, two definitions are **ENABLE_MAX30100** which is used for setting the MAX30100 enable bit as 1. Next, the **SCREEN_WIDTH** and **SCREEN_HEIGHT**. This has to be the exact value of the OLED Display resolution.

```
#define ENABLE_MAX30100 1
#define SCREEN_WIDTH 128 // OLED display width, in pixels
```

```
#define SCREEN_HEIGHT 32 //64 // OLED display height, in pixels
```

A callback function is defined when the pulse is detected by the sensor which is available as the function given.

```
void onBeatDetected()
{
  Serial.println("Beat!");   heart_beat(&xPos);
}
```

In the application setup following things are done:

1. Activating the display driver on the I2C line
2. Clearing the display, setting the text size, text color, and setting up the cursor position
3. Printing the Pulse Oximeter
4. Setting up the Heartbeat animation location
5. Initializing the MAX30100
6. Setting up the cursor position for the heartbeat and spo2 information.

Activating the display driver on the I2C line:

```
// SSD1306_SWITCHCAPVCC = generate display voltage from 3.3V internally
if (!display.begin(SSD1306_SWITCHCAPVCC, SCREEN_ADDRESS)) {
Serial.println(F("SSD1306 allocation failed"));     for (;;); // Don't proceed,
loop forever
  }
```

Clearing the display, setting the text size, text colour, and setting up the cursor position:

```
  display.clearDisplay();
display.setTextSize(1);
display.setTextColor(WHITE);
display.setCursor(20, 18);
```

Printing the Pulse Oximeter Text on the OLED Display:

```
display.print("Pulse OxiMeter");
```

Setting up the Heartbeat animation location:

```
int temp1 = 0;   int
temp2 = 40;   int
temp3 = 80;
heart_beat(&temp1);
heart_beat(&temp2);
heart_beat(&temp3);
xPos = 0;
```

Initializing the MAX30100:

```
#if ENABLE_MAX30100
  // Initialize the PulseOximeter instance
  // Failures are generally due to an improper I2C wiring, missing power supply
  // or wrong target chip
if (!pox.begin()) {
    Serial.println("FAILED");
    for (;;);
  } else {
    Serial.println("SUCCESS");
  }
```

Setting up the MAX30100 LED Current and registering the beat detection callback function:

```
pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);
  // Register a callback for the beat detection
pox.setOnBeatDetectedCallback(onBeatDetected);
```

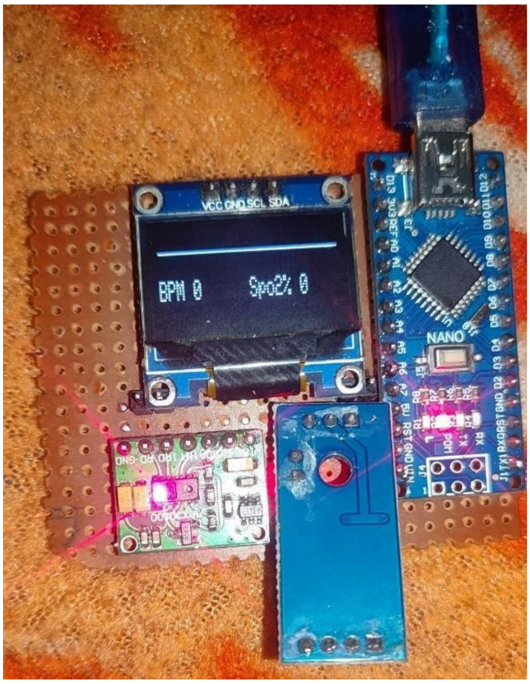
Get BPM and SPO2 Value by Calling two Functions:

By calling this function on the loop section, we can get the updated value from the sensor.

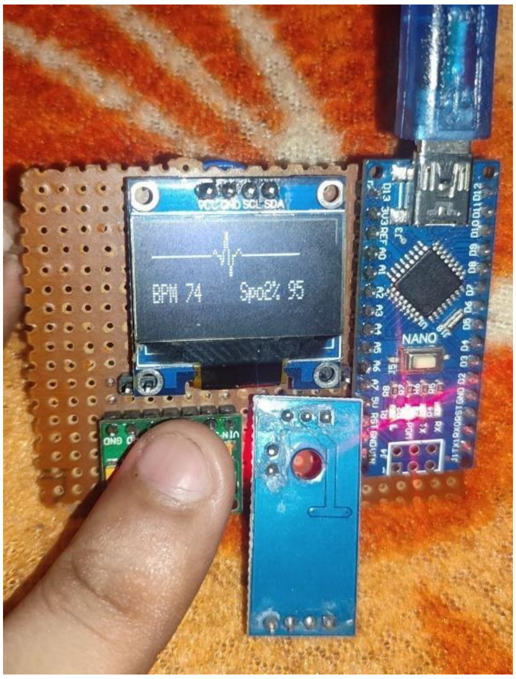
pox.getHeartRate(); and *pox.getSpO2();*

Arduino Based Pulse Oximeter Circuit Testing

The circuit is made in a small compact board. The data is perfectly displayed on the display. Without any data, the screen looks like this.



As we can see in the below image, the SPO2 level is showing 95% and the heartbeat is showing 74 bits per minute when measured and the animation is also changed.



Chapter: -3 Conclusion and Future Scope

Pulse oximetry is truly vital to medical care, but this prominence carries a responsibility. Too often, pulse oximetry readings are misinterpreted or are erroneous for various reasons (see sidebar). The tendency to accept the percentage at face value is high. Many expensive probes continue to be discarded prematurely as defective. Direct patient interventions can also occur based on erroneous results; worse, patients can be inappropriately monitored, giving caregivers a false sense of security. Pulse oximetry has come a long way since its inception in the early 1800s and with future technology, pulse oximeters will continue to improve patient care more effectively and efficiently.

such work that focuses on obtaining accurate pulse-oximetry readings in low perfusion states and during movement is now in progress, as are efforts to miniaturize pulse oximeters and adapt them for wireless data transmission. To that end, one of the strongest and most innovative technologies supporting pulse-oximetry accuracy is signal extraction.

The major difference between conventional pulse-oximetry technology and signal extraction is the concept of physical separation of arterial signals and venous signals. In conventional pulse oximetry, the measured values are assumed to be arterial.

In conventional pulse oximetry, red and infrared wavelengths of light are used to measure arterial blood's oxygen saturation by analyzing the resulting red-infrared ratio. This ratio is, in turn, calibrated to produce a reading of the percentage of oxygen saturation. In order to maintain accuracy, however, a steady-state environment and strong signal distinction are required. Movement affects the reading obtained; in addition, anything that would affect signal strength (such as fluctuating perfusion or poor emitter-to-detector alignment) can also cause erroneous or unstable results.

These artifacts, taken together, constitute the noise component of the signal-to-noise ratio. Signal extraction begins with the knowledge that, during patient motion, the low-pressure venous system is more susceptible to perfusion changes (due to compression and deformity of the vascular bed) than the arterial system. Hence, the venous system is a significant source of noise in the measured signal.

Through the use of an adaptive noise canceller, this venous noise can be filtered out, leaving, in effect, a stronger arterial signal. This allows accurate calculation of optical density ratios. The result is a more accurate and stable oxygen saturation value.

Chapter:4-Refercences

1 L. M. Schnapp, “Pulse Oximetry: Uses and Abuses,” Chest, 1990, volume 98, pgs 1244-1250.

2 N. Netzer, “Overnight Pulse Oximetry for Sleep-Disordered Breathing in Adults: A Review,” Chest, 2001, volume 120

3 C. Zamarron, “Utility of Oxygen Saturation and Heart Rate Spectral Analysis Obtained from Pulse Oximetric Recording in the Diagnosis of Sleep Apnea Syndrome,” Chest, 2003, volume 123, pgs 1567-1576.

4. J. G. Webster, et al, Design of Pulse Oximeters, Series in Medical Physics and Biomedical Engineering. Boca Raton: CRC Press, 1997. 25 Yitzhak Mendelson, “Pulse Oximetry”, in Wiley Encyclopedia of Biomedical Engineering, John Wiley & Sons, Inc, 2006.