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Wireless Wearable Pulse Oximeter Sensor

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Abstract

This project aim is designing a wireless wearable plus oximeter. There is two units: the first one to measure, calculate, and transmit the heart rate and the oxygenation (sensor unit). The second unit contains the receiver and PC to receive the data and display it in the PC using graphical user interface (PC unit). The design is unobtrusive, comfortable for long-term wear, portable, low power consumption, and remote monitoring. There are many people who will benefit from the ability to have a constant with a plus oximeter that does not interfere with their daily activities. Similar products are expensive and offer fewer options.

The sensor unit consists of a soft silicon, preprocessing circuit, processing unit, and transmitter circuit. The soft silicon houses the LEDs (light-emitting diode) and photodiode necessary for obtaining plus oximeter data, preprocessing circuit for converting the current to voltage and filtering the signal, processing unit to calculate the heart rate and the oxygenation, and transmitter circuit to transmit the data using radio frequency to the second unit.

The PC unit consists of an RF receiver, microcontroller unit, USB to UART, and PC. The RF receiver receives the data from the transmitter in waveform, the microcontroller unit obtains the data from the signal, the USB to UART converts the data from serial to UART, and contacts the receiver circuit with PC and PC using for display the data using GUI.
المستخلص

لا سلكي يمكن ارتداءه مكون من وحدتان (plus oximeter) الهدف من هذا المشروع هو تصميم دائرة الأولى لقياس وحساب وارسال معدل نبضات القلب والوحدة الثانية تحتوي على مستقبل والكمبيوتر الشخصي لاستقبال البيانات المرسلة وعرضها علي الكمبيوتر الشخصي باستخدام نافذة عرض البيانات.

هذا التصميم خفيف ومريح ويمكن ارتدائه لفترات طويلة. الطاقة المستهلكة منخفضة، ولها خاصية المراقبة عن بعد. هناك العديد من الأشخاص الذين يمكنهم أن يستفيدون منه لأن قابلية القياس بصورة مستمرة كما أنه لا يتفاعل مع نشاطاتهم اليومية. المنتجات المشابهة تكون مرتفعة الثمن ولها عدد قليل من الخيارات.

تتكون وحدة القياس من حساس، دائرة للمعالج المبديء، ووحدة المعالجة، دائرة الارسال. يتكون الحساس من 2LED وثنائي ضوئي لاستقبال الضوء وإعطاء إشارة في شكل تيار.

دائرة المعالجة المبديء تقوم بتحويل النيازك الي جهد ومن ثم تعمل على تنقية الإشارة. كما تقوم وحدة المعالجة بحساب نبضات القلب ونسبة الأكسجين في الدم وارسالها باستخدام موجات الراديو.

اما الوحدة الثانية فتكون من الكمبيوتر الشخصي يحتوي علي مستقبل موجات الراديو والتحكم (US to UART) مستقبل موجات الراديو يقوم باستقبال الإشارة في شكل موجات ووحدة التحكم تحافظ علي شكل الإشارة وربط دائرة الاستقبال بالكمبيوتر الشخصي الذي يستخدم للمعالجة للبيانات عن طريق نافذة عرض البيانات.
Table of Contents

dedication ......................................................... I
Acknowledgements ................................................... II
Abstract ............................................................. III
المستخلص ............................................................ IV
Table of contents .................................................. V
List of figures ...................................................... VIII
List of tables ....................................................... XI

Chapter one : Introduction

1.1 Introduction ................................................... 1
1.2 Problem statement ............................................. 2
1.3 Objectives of the project ...................................... 2
1.4 research methodology ........................................ 3
1.5 scope of the study ............................................. 5
1.6 research organization ......................................... 5

Chapter two : Literature review

2.1 Introduction ................................................... 7
2.2 Medical sensor networking ................................... 7
2.3 Portable systems ............................................. 9
Chapter three: General hardware
3.1 Introduction .................................................. 14
3.2 Pulse oximeter sensor ...................................... 14
3.3 Wireless transmission methods ......................... 16
3.4 General component ....................................... 20
3.5 amplifier ...................................................... 20
3.6 signal processing unit .................................... 23
3.7 voltage regulator .......................................... 27
3.8 H-bridge .................................................... 28
3.9 summary ..................................................... 30

Chapter four: Circuit design
4.1 Introduction .................................................. 31
4.2 Simulation ................................................... 31
4.3 Hardware implementation ............................... 35
4.4 summary ..................................................... 46

Chapter five: Software
5.1 Introduction .................................................. 47
5.2 Microcontroller programming .................................... 47
5.3 Graphical user interface ......................................... 49
5.4 Summary .................................................................. 50

Chapter six: Result and discussion

6.1 Introduction .......................................................... 51
6.2 Circuit design ...................................................... 51
6.3 Signal .................................................................. 52
6.4 Overall performance ............................................ 55
6.5 Summary .............................................................. 55

Chapter seven: Conclusion and Recommendations

7.1 Conclusion .......................................................... 56
7.2 Recommendations ............................................... 57

References ............................................................... 58

List of figures

Figure (1.1): research methodology ................................. 4
Figure (3.1): blood stream diagram……………………………………15
Figure (3.2): photo detector in the sensor……………………………………15
Figure (3.3): the AC and DC component ........................................16
Figure( 3.4): circuit diagram symbol of the OP-Amp………………..22
Figure (3.5): OP-Amp chip……………………………………23
Figure (3.6): PIC microchip microcontroller ………………….………..24
Figure (3.7): Atmel AVR microcontroller ………………….………..26
Figure (3.8): arduino single board microcontroller……………….27
Figure (3.9): voltage regulator …………………………………………28
Figure (3.10):78xx family voltage regulator ……………………28
Figure (3.11):H-bridge ………………………………………………….29
Figure (3.12): switching element of H-bridge ........29
Figure (4.1): The simulation in general ……………………………..31
Figure (4.2): LED driver ………………………………………………32
Figure (4.3): The preprocessing circuit ………………………………33
Figure (4.4): The connection of the OP-amps ………………….35
Figure (4.5): Nellcor DS-100 pulse oximeter sensor………………..36
Figure (4.6): Pin-out figure of the Nellcor DS-100 pulse oximeter sensor .37
Figure (4.7): SN741. 741 Operational Amplifier ………………….38
Figure (4.8): L293D is a similar motor driver …………..……………38
Figure (4.9): Atmel Atmega 32 microcontroller .......................... 39
Figure (4.10): The RF Transmitter ........................................... 40
Figure (4.11): The RF receiver ................................................. 40
Figure (4.12): UC00A (USB to UART Converter) ....................... 41
Figure (4.13): the Voltage Regulator- 7805 ............................... 41
Figure (4.14): The output from the current to voltage converter after connected to the sensor ......................................................... 42
Figure (4.15): The high pass filter output signal ............................ 42
Figure (4.16): The low pass filter and amplifier output signal ........... 43
Figure (4.17): The circuit connected together ............................... 43
Figure (4.18): The top layer of the final circuit ............................. 44
Figure (4.19): The bottom layer of the final circuit ...................... 45
Figure (4.20): final circuit ......................................................... 45
Figure (4.21): the receiver circuit ............................................. 46
Figure (5.1): micro C program ..................................................... 48
Figure (5.2): GUI by LABVEIW appearance .............................. 50
Figure (6.1): circuit design ....................................................... 52
Figure (6.2): Signal that has two information ............................. 52
Figure (6.3): The bandwidth became large when the whole light passes to the photodiode ......................................................... 53
Figure (6.4): When there is some light absorbed with putting the finger in sensor

Figure (6.5): Error in signals when transmitted with high value of bandwidth

List of tables

Table (6.1): SPO2 values according to finger size
1.1 Introduction:

Oximetry is the measurement of transmitted light through a translucent measuring site to determine a patient's oxygen status noninvasively. Oximetry measurements can be traced to the early 1930's when German investigators used spectrophotometers (instruments that measure different wavelengths and intensities of light) to research light transmission through human skin. In 1934, one investigator reported measuring oxygen saturation in blood flowing through closed vessels in animals [1, 2].

In 1939, German researchers reported use of an "ear oxygen meter" that used red and infrared light to compensate for changes in tissue thickness, blood content, light intensities and other variables. However, it was not until World War II that interest in oximetry took hold [1].

Today there are many manufacturers of pulse oximeters. All offer a variety of different oximeter boxes with SpO2 (oxyhemoglobin) and pulse rate readings, waveform displays, alarms, etc. While the boxes and the displays may differ, they use a similar method of measuring oxyhemoglobin saturation by two wavelengths of light in the red and infrared range. But while the two-wavelength method is used to start the SpO2 measurement process, the way the signals are processed after that point, play a major role on how accurate the readings will be, especially through motion and low perfusion [1].

During the late 1990's and into the next decade, 'new generation' pulse oximeters have been introduced that have elevated the accuracy of pulse oximeter readings significantly [1].
Wireless technologies used in medical field prevent patient comfort and good quality medical service. Pulse oximetry is one of the important medical tests that can use this technologies in observation of patient continuously [1, 2].

1.2 Problem statement

Previously, there have been a number of medical systems for specialized occupations. These previous systems suffer from a number of serious drawbacks, for example:

1. Small in size.
2. Low cost.
3. High accuracy.
4. Provide continuous patient monitoring at home/hospital.
5. Enables the patient’s mobility.

Tremendous methods and techniques have been introduced to improve and overcome these drawbacks such as:

1. Using rechargeable batteries.
2. Wireless communication links.

1.3 Objectives of the project

The main objectives of the current project is to design, prototype, and test a wireless pulse oximeter system that perform the followings

1. Continuous patient monitoring
2. Home monitoring for chronic and elderly patient
3. Small in size
4. Low cost
5. High accuracy
1.4 **Research Methodology:**

The goals of this research are mainly achieved by dividing the process of investigations into three stages. The first stage concerns with the Design the circuit. The second stage clarify the process of connecting the hardware component of the device as well as testing the device after each stage of connection. At the end comes the third stage that explains the process of programming as well as testing the overall performance of the device. All these steps are described in figure (1.1) as the methodology of the research.
Literature Review

Design the circuit

Purchase and connect the hardware components

Test the hardware component after connection

Desired Results

Programming

Test the overall device performance

Desired Results

Finalize the project
1.5 **Scope of the Study**

In this research, an effort has been made to study and investigate the possibilities designing and fabricating a wearable wireless Pulse Oximeter system. The major scopes of this research are detailed as follows:

i. Study and understand the usage of pulse oximeter sensor and their possibilities of replacing rigid pulse oximeter by a wireless wearable pulse oximeter.

ii. Conduct simulation and experiments techniques to investigate, examine and categorize each component required and necessary for designing the wearable wireless system.

iii. Evaluate and compare measured results and consequences of the wearable pulse oximeter system with simulated results.

iv. Finalize the designs, compile reports, and produce regional/international conferences and journal papers.

1.6 **Research Organization**

The thesis consists of seven chapters. The current chapter discusses the problem definition, justification for carrying out the research, and objectives. The chapter is introduced with the vision of the emerging technology between pulse oximeter concept and wearable systems, followed by applications of wireless wearable pulse oximeter system.

Chapter 2 reviews some of the previous researches on wearable systems considering non wireless pulse oximeter systems as well as other wireless wearable devices. The research also discusses several pulse oximeter devices proposed previously based on different designs and variable types of components.
Perceptions, principles and requirements of pulse oximeter system intended for wearable applications are introduced in Chapter 3. The applications of wireless wearable pulse oximeter system, as well as important design considerations related to wearable systems designs are also discussed.

Chapter 4 presents the Circuit design of the research with brief fundamental concepts related to pulse oximeter system designs.

In Chapter 5, the software procedures where the microcontroller is programmed along with the options available for the purpose were discussed. Also the graphical user interface that had been chosen to work with and display the SPO2 and heart rate values in a PC after the transmission process will also be discussed.

Chapter 6 discusses and presents results obtained by the design, where results achieved in this project and some troubles that have been in the research path. The chapter discusses the device final design that have been tested to indicate the final results achieved as well as the efficiency of the device.

The conclusions are stated in Chapter 7 together with the findings summary of the research and suggestions for other areas of additional researc