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Electronic Patch Wireless Reflectance Pulse Oximetry for Remote Health Monitoring

S.Venkatesh

Department of ECE, Anna University,Chennai, India

Abstract

This project describes the development of a wireless electronic patch for wearable health monitoring by reflectance pulse oximetry. The Electronic Patch is the health monitoring system which incorporates the biomedical sensors, detectors, communication system, and a battery in a polymer based material that will hold all the components by safely. The Electronic Patch is accompanied with a new optical biomedical sensor for reflectance pulse oximetry so that the Electronic Patch in this case can measure the pulse and the oxygen saturation. Apart from this the body temperature is also measured by using an appropriate miniature temperature sensor which is incorporated in the sensor module. It has the potential for use in combat casualty care, such as for soldier, fireman, remote triage, tunnel, remote mining etc.

Keywords: Electronic Patch, Wireless Reflectance Pulse Oximetry, SpO2, Heart Rate, Body Temperature.

Introduction

The Electronic Patch is a new health monitoring system incorporating biomedical sensors, detectors, communication system, and a battery in a polymer based material that will hold all the components by safely. The Electronic Patch is accompanied with a new optical biomedical sensor for reflectance pulse oximetry so that the Electronic Patch in this case can measure the pulse and the oxygen saturation. Apart from this the body temperature is also measured by using an appropriate miniature temperature sensor which is incorporated in the sensor module. The Electronic Patch has a disposable part of soft adhesive polymer based material and a reusable part of hard polymer which has a long life in a controlled atmosphere and will withstand the electronic components. The reusable part is pasted on to the disposable part when the patch is prepared for use.

Need for the Work

For patients or persons in risky job at the risk of respiratory failure, it is very important to monitor the blood oxygen saturation along with pulse rate of such individuals to ensure proper perfusion of blood in their body. Preferably this information should be received on a continuous basis. These objectives can be reached via the non−invasive method of pulse oximetry. This is currently used in hospital/clinical settings, however uses wires which in effect bound an individual to an area. Also the size of the pulse oximetry is bigger and it will be fixed in the patient finger but in our case the main area of focus is to cover the persons who are working the risky location and it is not possible to wear the sensor in their finger because they may use the finger and hand for the job what they meant for. So, the sensor which we want must be compact in size and it should not affect the job work of the person.

Both military and civilian populations could possibly benefit from this type of sensor. The military could implement this technology for remote monitoring of a soldier’s physiological status during combat situations. Since medics may be a significant distance from a soldier, there is a time delay between the instant a soldier is wounded to immediate notification of the injury. The data from this device could be sent to first responders or hospitals for continuously monitoring the health status of an injured individual. A similar device could be implemented by firefighters, remote triage, tunnel evacuation, remote mining, police, and recreational users. In these situations, remote monitoring could help to detect early signs of health problems, thus enabling preventive actions to take place as soon as injuries occur.

For this purpose we adopt the telemedicine concept to receive the signal from the sensor. Telemedicine is the use of medical information exchanged from one site to another via electronic communications to improve patient’s health status.

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Due to its potential benefits and advances leading to improved electronic and wireless technologies, its use has steadily gained interest in recent years.

Pulse Oximetry

Pulse oximetry is a method for non-invasive measurement of the arterial oxygen saturation (SpO2) and pulse rate. It can be generally performed in either transmission or reflection modes. In general the light is transmitted through the tissue e.g. a finger and in the latter light is backscattered from the tissue. This method realize on difference in the absorption spectra of oxygenated and de-oxygenated hemoglobin. The ratio has a peak at approximately 660 nm and at higher wavelengths the ratio is lower than one. Conventionally two wavelengths at 660 nm (RED) and 940 nm (IR) are used since the absorption ratio is large and small at those wavelengths respectively. This minimizes the uncertainty of the SpO2 measurement. A photoplethysmograms is an optical recording of the cardiovascular cycle. The SpO2 is a function of the measured magnitude at the systolic and diastolic states on the two photoplethysmograms (RED and IR),

$$SpO2=\frac{\ln(REDsystole/REDdiastole)}{\ln(IRdiastole/IRdiastole)}$$

where REDsystole and REDdiastole are the magnitudes of the red light measured at the systolic and diastolic states respectively and likewise for IRsystole and IRdiastole.

A. Reflectance Pulse Oximetry

The concept of reflectance mode is shown in the fig.1, in this type of pulse oximetry the light sources and light detector are placed on the same surface which allow for a smaller solution where light sources and light detector are integrated and therefore can be placed within one patch. The reflectance mode has also less restriction for placement on the body. This is therefore the method to utilize in this project.

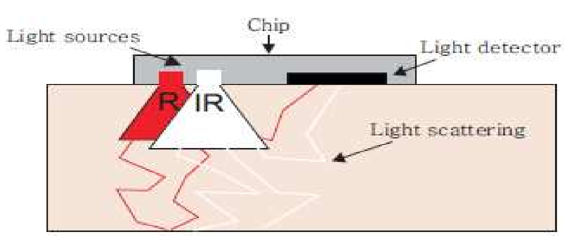

Fig.1.Reflectance Pulse Oximetry

IV SYSTEM ARCHITECTURE

The system architecture of the proposed system is illustrated in fig.2.The system consist of transmitter module and receiver module. The transmitter module is incorporated in the electronic patch and it has a disposable part of soft adhesive polymer and a reusable part of hard polymer. The disposable part contains the battery. The reusable part contains the reflectance pulse oximetry sensor and microelectronics. The reusable part is pasted into the disposable part when the patch is prepared for use.

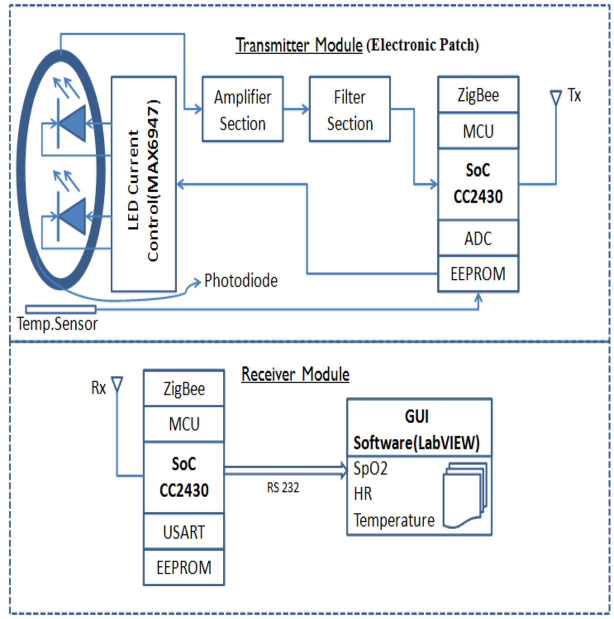

Fig.2. System Architecture

Apart from the pulse oximetry temperature sensor was also incorporated in the electronic patch to measure the body temperature.

System Design

A. Power Supply Module

The input power supply module was described as shown in Fig.3.The input 230 V AC power supply was converted into 12 V AC using step down transformer and it was converted into DC power source by the full way rectifier, then it was filtered by high pass filter as well as low pass filter using and further it was regulated using voltage regulator LM7805C. The 5 V DC was feed to the bio-sensor and microcontroller PIC16F877A.

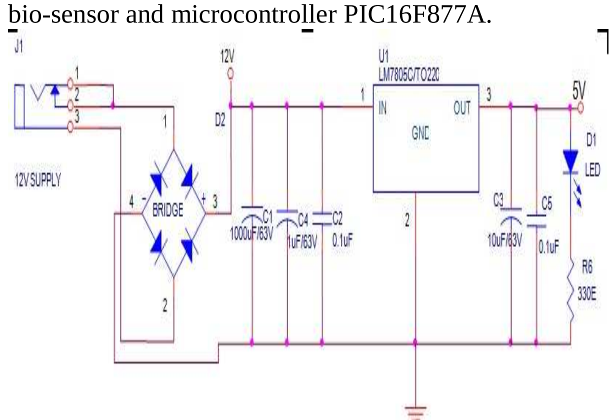

Fig.3.Power Supply Module

B. Sensor modules

The reflectance pulse oximetry and temperature sensor (LM36) and their wiring description corresponding with microcontroller and it were denoted in the Fig.4.

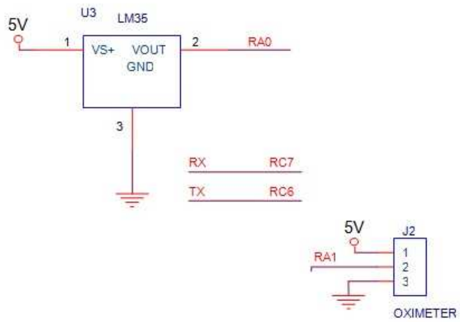

Fig.4.Sensor Modules

C. Microcontroller and Zigbee Communication:

The microcontroller used in this project is PIC16F877A and the pulse oximetry sensor and temperature sensor was connected to the PIC microcontroller as per in the Fig.5.

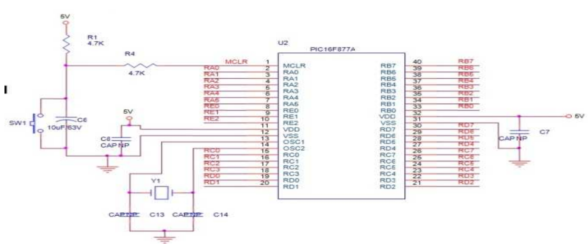

Fig.5.Microcontroller Unit

and the input processing was executed using a appropriate formula and the output ie., SpO2,Heart Rate(HR) and Body Temperature was displayed in the interconnected LED display and the PIC microcontroller can be initiated using a RESET switch when it was required.

The processed inputs were sent to the serial communication unit as shown in the Fig.6. ie., MAX232.In this the output from the microcontroller was received and the data are then fetch to the Zigbee communication unit.

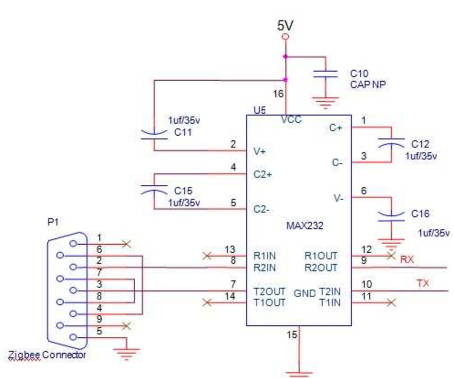

Fig.6.Zigbee Communication

The Zigbee communication was carried out using CC2430 and it transmits the data to the remote location. In the receiver another one setup of Zigbee device is connected to receive the data and the received data has been displayed in the remote display unit.

Results and Discussion

A. Transmitter Module:

The integrated receiver module is made ready and the total system is as shown in the Fig.7.

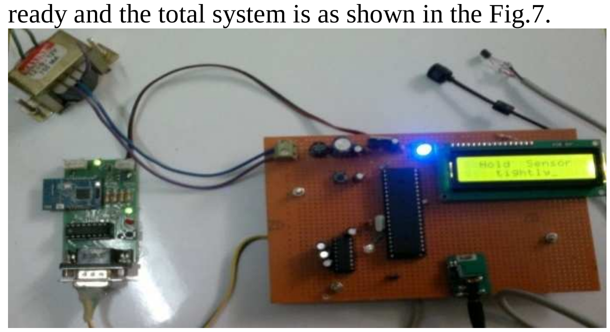

Fig.7.Transmitter Module

In this the power supply module, PIC microcontroller, Input sensor module and integrated display unit is incorporated in the single module. The Zigbee communication is established through the serial bus to the Zigbee communication (*2.4 GHz IEEE 802.15.4 systems)* module.

B. Receiver Module:

The receiver module is as shown in the Fig.8. consist of a Zigbee communication IC with the serial port communication protocol.

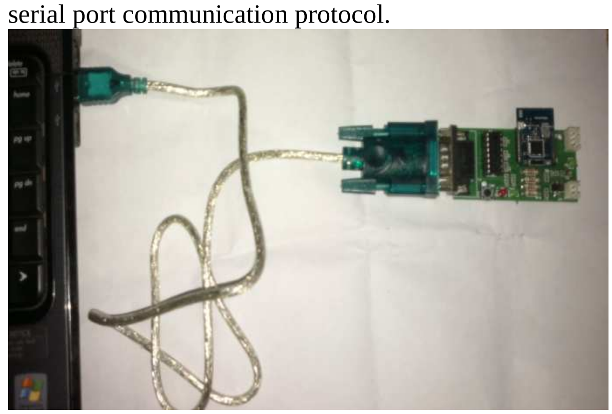

Fig.8.Receiver Module

The receiver module was interconnected the system using serial to USB converter cable and the communication can be established using appropriate driver which was installed in the system.

C. Output:

The communication setup was established by selecting the baud rate, COM port and the parity bit. The display is as shown in the Fig.9.

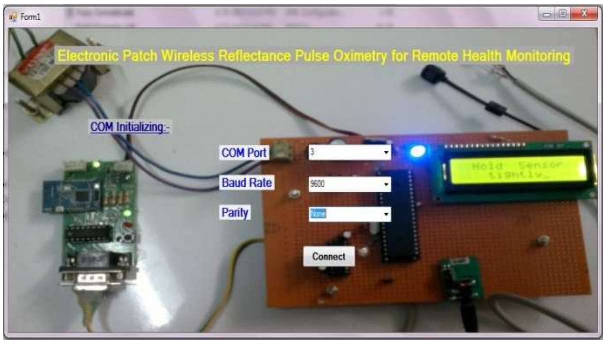

Fig.9.Estabilishing Communication

After establishing the communication the health data (SpO2, HR and Temperature) will start to display in the local display unit as will the transmitter receive the data and it will be display in the remote monitoring system as shown in the Fig.10.

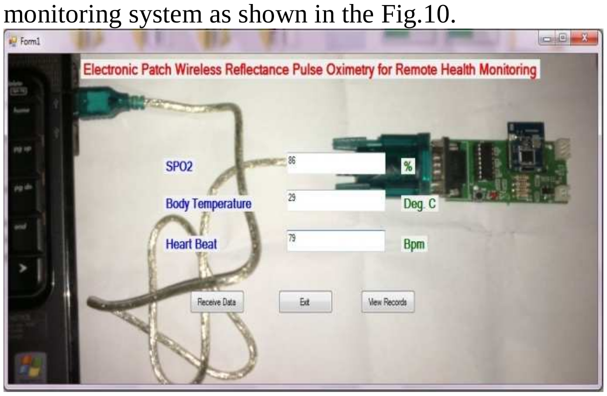

Fig.10.Remote Monitoring Display

The received data is stored in the database as shown in the Fig.11. and it will be further utilized for future clinical evaluation. The data base can be very useful for analyzing the health data during any mishap and with the backup we can monitor as well as analyze the patient or person involved in mining, tunnel work.

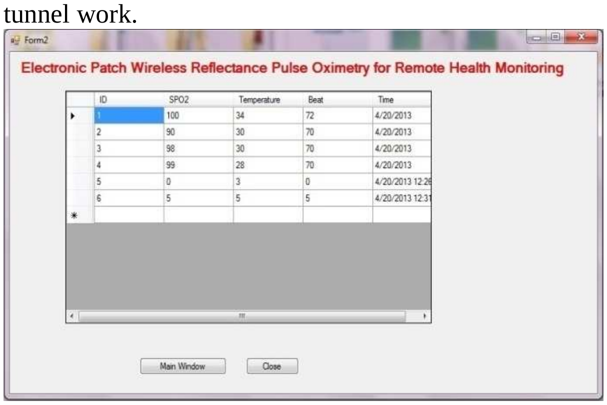

Fig.11.Database

Conclusion and Future Works

This paper has described the development of reflectance pulse oximetry for remote health monitoring. The target people of this project is the field workers involved in mines, tunnel, remote triage etc. and the module will be incorporate in the workers safety helmet.

For this purpose it can be developed based on a small forehead-mounted sensor. The reflectance pulse oximeter should be completely integrated into the miniature electronic patch for optimizing the systems. The next trial is to develop a battery-operated device employs a lightweight optical reflectance sensor and incorporates an annular photodetector to reduce power consumption.

The information could enhance the ability of first responders to extend more effective medical care, thereby saving the lives of critically injured persons.

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