A COLOR - CODED BRACELET MODELLING SYSTEM TO MEASURE HEART RATE PRESSURE AND DRUG LEVEL FOR SPORTS APPLICATION

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Abstract

This paper presents a current invention for monitoring the athletes' heart rate. A bracelet with 3 LED's is designed as a wrist heart rate monitor. In the sports field, the Bracelet is used to find the heart rate (because the range of heart rate should be compatible with the exercise done by an athlete to get an optimum exercise) and also to find people who take drugs .The heart beat sensor in the bracelet is used to find the heart beat level, pressure sensor is to check the blood pressure level and drug detection sensor is to detect drug consumption. The sensor output is processed by the controller and received by the receiver through Zigbee. The processing software is a user friendly, and it provides data acquisition, monitoring and recording. And hence the software displays the heartbeat, pressure and the intake of drug level. This will be very helpful for athletes and coaches to monitor the fitness level of athletes and regulate their exercise training regime in a more effective and safer manner.

1. INTRODUCTION

Nowadays, the use of a heart rate monitor is very common and not merely used at the hospitals as a monitoring system for patients. Generally, heart rate monitor was used by a person who cares about their heart to ensure that they have a normal heart rate. The early detection of the abnormal heart rate can help to prevent from the serious disease. In the sport field, the heart rate monitor is needed to determine the range of heart rate. This range of heart rate should be compatible with the exercise done by an athlete to get an optimum exercise to prevent from serious injury. Such digital display of target heart rate did not provide for ease of reading the display under the most conditions of use, particularly when the user is exercising vigorously [1, 4]. This paper proposed an innovation to respond to this problem by providing a novel wearable biomedical signal sensor device for monitoring heartbeat conditions at home easily, which displays the heart rate by glowing of 3 different LEDS and enabling a user to tell at a brief glance, whether they are exercising at a suitable intensity and the coach to identify the sports person who have in taken drug or alcohol. The proposed innovation will be programmed to automatically suggest the user about their health conditions. The work will be focused for sport training application [2]. This Prototyping can monitor appropriate heart rate while performing an exercise by sending feedback to the user via the specific color (LED) and to the coach via the wireless protocol. The Zigbee wireless protocol is chosen as a transmission medium because it provides a small volume, high expansion, low power consumption, stylization and two-way transmission [3] compared to Bluetooth [5].

In this research work, we developed a group of sensors for measuring heart beat rate, pressure level and drug level with real-time monitoring system based on Zigbee wireless network. The heart beat data measured by the sensor is processed by the ADC in the microcontroller that data was read every second and stored on microcontroller. The data from microcontroller unit was sent to base node via Zigbee wireless network and stored on data-logging PC. Microcontroller hardware and Zigbee module are packed in suitable case and can be worn on the sports person's wrist.

The physiological parameters that are monitored with the proposed wearable bracelet are electrocardiogram (ECG), heart rate (HR) derived from ECG signals by determining the R–R intervals, body temperature, respiratory rate, and three axis movement (acceleration and position) of the subject measured using an accelerometer. In order to design and construct the signal acquisition circuits efficiently and simply, modular design concept is adopted in this research. Three basic high quality and flexible modules for signal conditioning are designed and assembled together for satisfying each

sensor. Human biomedical parameters can be registered and analyzed continuously during homework activities.

The rest of the paper is organized as followed. Section 2 describes about the proposed system's hardware design. Section 3 describes about the data transmission based on Zigbee wireless sensor network. In section 4, the software design of proposed system is explained and the last section is about the conclusion.

2. HARDWARE DESIGN

The heart rate monitoring bracelet model mainly consists of two subsystems: first, a wearable data acquisition hardware, where the sensors for acquiring the biomedical parameters are integrated and transmitted to the receiver through Zigbee, and secondly, a remote monitoring station placed separately.This system as a whole is used in sports application.

The hardware design mainly consists of three sensors namely: Drug detection Sensor, Heartbeat Sensor, Pressure Sensor. These sensors are connected to the microcontroller. This microcontroller is further connected to three different color LED's. The transmission medium used here is zigbee wireless protocol [Fig 1]

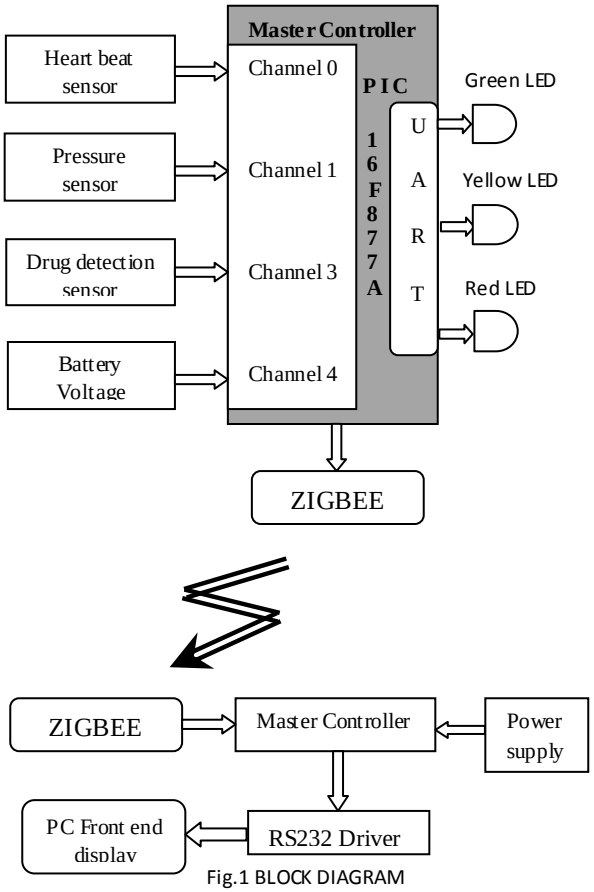


Fig.1 BLOCK DIAGRAM

A. Transmitter Module

i. Heart Beat Sensor

There are three sensors used in the transmitter module. They are the, Heartbeat Sensor, Pressure Sensor and Drug detection Sensor. The heart beat sensor used here is 1157 Heart beat sensor. This sensor is designed to give digital output of heart beat when a finger is placed on it. When the heart beat detector is working, the beat LED flashes in unison with each heartbeat. This digital output can be connected to microcontroller directly to measure the Beats per Minute (BPM) rate. It works on the principle of Light modulation by blood flow through finger at each pulse.

The pin details are the following: PIN1-power supply positive input, PIN2- active high output and PIN3- power supply ground [Fig 2]. Specifications are Operating Voltage is +5V DC regulated, Operating Current is 100 mA , Output data Level is 5V TTL level , Heart Beat detection is indicated by LED and Output High Pulse Light source used is 660nm Super Red.

Fig.2 HEART BEAT SENSOR

ii. Pressure Sensor

High blood pressure, also known as hypertension, occurs when the force (or pressure) of blood against your artery walls is too great, causing excessive strain on your blood vessels. This condition is dangerous because its damaging effects accrue over time and may not become apparent until an individual's blood pressure is shockingly high. This is why hypertension is sometimes known as a "silent killer."

The sensor can be used to detect pressure in a range of situations from air pressure in tyres to blood pressure. The capacitance-type pressure sensor is generally characterized by high sensitivity and low current consumption and this product also minimizes the influence of temperature changes on pressure detection. Due to the ability of the ceramic packaging to withstand a wide range of temperatures, it can even be used in the volatile automotive environment. The sensor detects air, blood and other pressures by means of changes in

capacitance. Pressure is detected when pressure changes cause the membrane on the moveable electrodes known as a 'diaphragm' to flex, the capacitance between the fixed electrodes changes and the degree of this change is converted into an electrical signal. A person's blood pressure is usually expressed in terms of the systolic pressure over diastolic pressure and is measured in millimetres of mercury (mmHg)

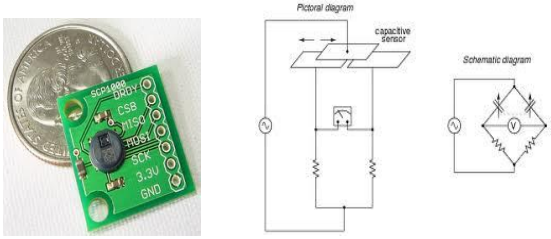


Fig.3 PRESSURE SENSOR

iii. Drug Detection Sensor

The drug detection sensor used here is Gas sensor MQ-303A. It is a tin di -oxide semiconductor gas sensor which has a high sensitivity to alcohol with quick response speed. This model is suitable for alcohol detection such as portable drug detection or breath alcohol checker. The pin details are the following: PIN1-power supply positive input, PIN2- active high output and PIN3- power supply ground [Fig 4]. Specifications are Operating voltage is dc voltage less than 6V, resistance is 4.5Ω ± 0.5Ω, current is less than 13mA , Power dissipation is less than 10mW.

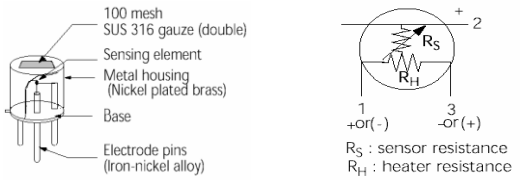


Fig.4 DRUG DETECTION SENSOR

The change of the sensor resistance (R_S) is obtained as the change of the output voltage across the fixed or variable resistor (R_L). In order to obtain the best performance and specified characteristics, the values of the heater voltage (V_H) circuit voltage (V_C) and load resistance (R_L) must be within the range of values given in the standard operating conditions shown in the Specification table on the next page. Generally, the sensor enters into normal working conditions after several minutes' preheating, If you connect the sensor heater with a high voltage 2.2 ± 0.20V for 5-10 sec before normal testing , the sensor shall stabilize and enter into normal working conditions quickly.

B. DATA PROCESSING

The microcontroller used here is PIC16f877a .It is a 40 pin microcontroller with 5 I\O ports, 10 bit ADC up to 8 channels, three 16 bit timers and 2 comparators. Operating speed: DC 20 MHz clock input DC – 200 ns per instruction cycle. It has 8K x 14 words of Flash Program Memory, 368 x 8 bytes of Data Memory (RAM) and 256 x 8 bytes of EEPROM. 5 volt dc supply is given to the heart beat sensor, pressure sensor, drug detection sensor. Primarily the heart beat sensor's output is given to the PIC16F877A .This microcontroller has built-in analogue to digital converter (ADC) and RS-232 serial communication interface. The flash program memory allows in-circuit reprogramming of the firmware. Although the ADC has a 10-bit These heart beat signals are in turn converted from analog to digital form in this built in ADC. Then this converted output is temporarily stored in RAM memory of PIC16F877A.After a small delay of 3ns the pressure sensor output is given to the microcontroller where these pressure signals are in turn converted from analog to digital form. Then this converted output is temporarily stored in RAM memory of PIC16F877A. Again After a small delay of 3ns drug detection sensor output is given to the microcontroller where these signals are in turn converted to digital form. Then this converted output is temporarily stored in RAM memory of PIC16F877A .
The heart rate is calculated using the equation as followed

BPM (Beats Per Minute) = 60 \ period (second) (1)

Normally with the help of the Age Prediction formula (2) and (3) the individual's heart rate is determined. Initially, microcontroller will calculate the heart rate maximum (HR max) and then determine the target heart rate zone desired by user. This HR max value is obtained by inserting the user age and gender information. The formula used to calculate the HR max is presented in equation (1) and (2) respectively for male and female.

Male: HR max = 206.9 - (0.67 x age) ……. (2)

Female: HR max = 212.9 - (0.67 x age)…… (3)

Then, the following equation is used to calculate the target heart rate (THR) zone.

THR = HR max x % intensity (4)

After this Target heart rate value is found based on the Age Prediction formula (2) and (3) prediction

equations then the heart rate and the pressure rate for each second of an individual is found. The calculated Target heart rate and the measured heart rate are compared. Then the heart rate for that second is found to be normal, low or high in the PIC16F877A microcontroller. If the heartbeat value is normal when compared to the target heart rate then the Yellow LED glows in the transmitter section, in the wearable bracelet. And if the heartbeat value is low when compared to the target heart rate then the Green LED glows. And if the heartbeat value is high when compared to the target heart rate then the Red LED glows. By this range of heart rate, it should be compatible with the exercise done by an athlete to get an optimum exercise to prevent from serious injury.

C. Receiver Module

MCU receives the sensor's data in area via the Zigbee network, which Zigbee base node module was set in coordinator node. The data from every node are stored in the memory of MCU and subsequently transferred to a computer by UART every second. Data from the base node are sent to a computer using USB to serial converter. To add more end nodes into this network, the new nodes will send a request to the router or base node and wait for a reply. A PC is working as a data logger in this network because a large number of spatial and temporal data can be stored for further analysis by user. The user can also access current heartbeat data from a base-PC computer.

3. DATA TRANSMISSION

A. Zigbee Wireless Module

Various wireless network technologies have been used in health monitoring system. This system is based on Zigbee wireless standard. Zigbee is famous for low cost, low power consumption and flexible network topology. All wireless sensor hardware operates upon a short-range communication between 40 to 120 meters. The ZigBee based on IEEE 802.15.4 standard, defines the characteristics of the physical and the medium access control (MAC) layer for the low power of personal area network (PAN). The three frequencies was support by ZigBee physical layer: 2.4 GHz ISM band (worldwide), 915 MHz ISM band (America), and 868 MHz band (Europe). In this work, we used ZigBee module from Max stream which provides 16 of personal area network ID (PAN ID) and used frequency of 2.4 GHz. This Max stream's ZigBee module.

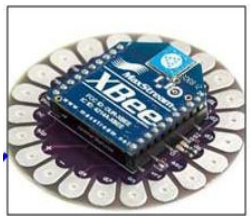


Fig.5 Zigbee Module with Microcontroller module

Since communication of the micro-controller and PC with the Zigbee transceivers is transparent byte-oriented data stream, data is packetized before being sent to the RF module for wireless transmission and de-packetized after receiving them from the transceivers. Each packet consists of eight bytes. The first byte is a header and the following seven bytes are data. To distinguish the header from the following data, the most significant bit of the header is set to one. The first most significant bits of the following seven data bytes are shifted to the seven unused bits of the header. Then they are cleared as zeros. At the receiver side, a header can be detected when the most significant bit of the received byte is one. Following the header are the seven data bytes which can be recovered easily by shifting the seven bits from the header back to the most significant bits of the seven data bytes.

The transceiver's interface is RS-232 style with standard CMOS signal levels, which makes the electronic integration with the micro-controller and PC much easier through UART. Hence the heartbeat, pressure level and the intake of drug is acknowledged from PC which can be seen by the coach during sports activities.

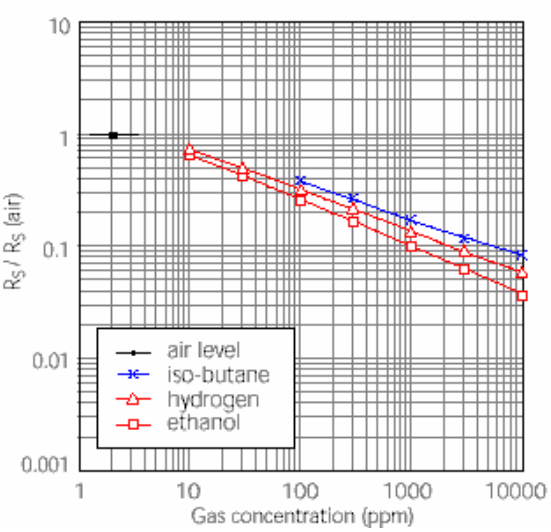
OBSERVATION

Led Color	Target zone	Training Recommended
Yellow	Normal(72 BPM)	Fit person, maintain the activity level.
Green	Low(60-70 BPM)	Unfit person, increase the activity level.
Red	High(>72 BPM)	Indicates the person is in abnormal state, recovery and cool down exercises should be done

TABLE I
Different Color of LED Based On Heart Rate Zone

Led Color	Pressure level	systolic (mmHg)	diastolic (mmHg)
Yellow	Normal	90 - 130	60 – 80
Green	Low	< 90	< 60
Red	High	>140	> 90

TABLE I
Different Color of LED Based On Blood Pressure level



Sensitivity of Alcohol sensor

4. SOFTWARE DESIGN

The software can be separated into two parts: the firmware running in the micro-controller on the front end analogue circuit board and the application program running on PC.

A. Firmware Design

The program embedded on the microcontroller is written in Embedded C. The program contains the following:

- Conversion of analogue signals (heartbeat, pressure rate,drug level) to digital values.
- Heartbeat detection. Target Heart rate and Maximum Heart rate calculation.
- Analyzing whether the Heart rate is normal, low or high.
- Indication of the respective LED's according to the Heart rate at that instant.
- Packetization of the collected data and the transmission of them through the serial communication interface.
- Reception, interpretation and execution of commands from the serial communication interface.

B. Application Program Design

On the computer side, all sampled physiological data are displayed and saved to a file on hard disk of PC in real-time. The application program running on PC is written in Microsoft Visual C++ for Windows. The program contains the following: the main part handles the data collection. It collects the data received by RS232 serial communication port from one of the Zigbee transceivers connected to it. The received data is stored in a data buffer and a data buffer block. Then that data is obtained from the data buffer and displays them on the PC screen. There are two data buffer blocks used alternatively. When one of them is full, the saving thread will be created to save it to a file on the hard disk. The program has been running on a computer without losing any data.

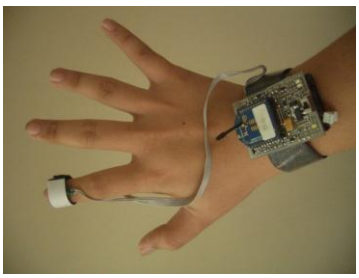


Fig. 6 Model of Wearable Heart Rate Monitor with a Pulse Oximeter

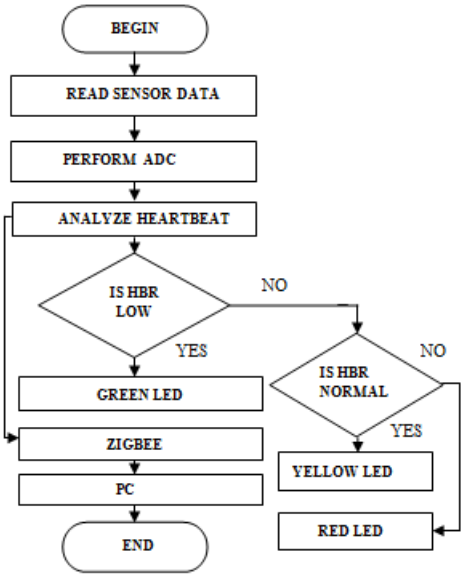


Fig.7 FLOWCHART

5. CONCLUSION

The portable color coded bracelet modeling system is Designed as a wearable bracelet which is non-invasive, lightweight and easily worn so that the athlete feel comfortable and will not impede their activities. This device also gives an advantage to coach to easily get the information about athlete heart rate, blood pressure and the in-taken drug level by only monitoring the LED indicator on bracelet wearing by athletes

Future works will be focused on reducing the size of LED strips/bracelet to be worn as a wrist band and can be designed for low cost with less power consumption so can be comfortably used in daily life.

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