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MEMS Based Wireless Health Monitoring System

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Abstract

The design and development of a microchip wireless physiological parameter monitoring device is the system used to monitor various parameters such as human body temperature, body position and ECG recording of the patient. The design is also a proposed optimized wireless ECG monitoring system with consideration of various factors from ECG in medical practice. Wireless sensor network model includes IEEE 802.15.4 transceiver node that supports the high bandwidth requirement and contention free multiple access at hospital environment. This system is built up of electronic device which is worn on wrist and leg by a patient. Measuring vital signs with the help of several sensors, the patient is wirelessly monitored within hospital or home and sends the patient's details in the encrypted form to the receiver unit. The receiver unit receives the data and decrypts it to the doctors PC/Laptop.

Keyword- Body temperature measurement, Wireless Sensor Network (WSN), ECG, IEEE 802.15.4, e-healthcare.

Introduction

In this world wireless technology place a vital role in engineering, medical electronics and defence community. The average life span of human beings are reduced, this results in a need of medical care which is costlier for long-term monitoring and long waiting lists for consultations. Many elderly and chronic patients have to be monitored continuously and provided with immediate medical aid and attention when the patient in emergency. A system in this paper is to monitor the overall health of welfare facility residents with accurate, flexible, comfortable, reliable, and low-cost, who need constant care. This system has been designed with a host computer, microcontroller, wireless sensors network and MI-WI technique.

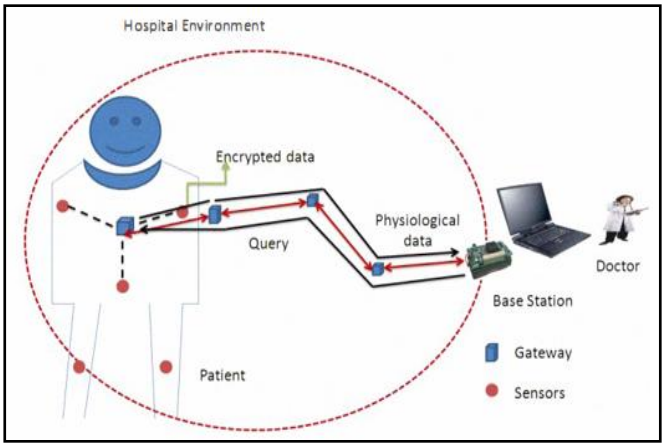

Fig.1 General Model for e-Healthcare monitoring

The system consists of MEMS accelerometer with three axes, a ARM Cortex M3 and Wireless Medical Sensor Network (WSN). It records ECG, temperature, posture of the patient and indicates for 24 hours. Electrocardiogram (ECG) is the most widely used vital signal for monitoring and diagnosis of cardiac status as well as overall health condition. Hence, it is present in most of e-Healthcare monitoring system. But, it is responsible for high bandwidth requirements in compare to other signal such as temperature, heart rate, different gas saturation in blood etc. These data are sent out to the wireless repeater by the transceiver for present and future clarification.

Proposed Model

The project is a priority based monitoring system for the patients for their quick remedy. In existing method ARM processor is used. ARM processor does not have inbuilt ADC, I2C and it has a lot of limitations in embedded field. To overcome these drawbacks ARM Cortex M3 processor is used in this design which is inbuilt with ADC, I2C and high level integrations with low power consumption.

System Description

This system consists of two sections, one is transmitter section and another is receiver section.

i. ***Transmitter Section***

The block diagram of the transmitter section shown in fig.2. The transmitter section consists of the following functional blocks like

a. ECG analog front end board,
b. Medical sensor acquisition mode (Micro controller),
c. MEMS accelerometer,
d. Body temperature sensor,
e. ARM M3cortex and
f. MI-WI wireless protocol.

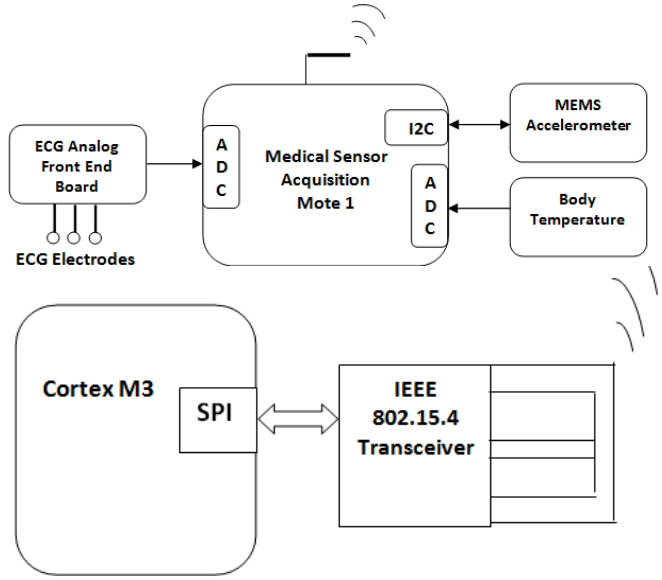

Fig.2 Block of Transmitter section

a. ***ECG analog front end board***

ECG analog front end board consists of bio signal amplifier, electrodes, filter, and buffer. Three electrodes are connecting to the bio signal amplifier. These electrodes are traditionally located on arms and legs, and it is easy to position the electrodes and links are called leads. A lead, records the electrical signals of the heart from a particular combination of recording electrodes. This leads are placed at specific points on the patient's body. Any one of the lead design can be used to give input to the bio signal amplifier. An electrocardiogram (ECG) is obtained by measuring an electrical potential between the various points of the body using a bio signal amplifier. The Bio signal Amplifier is an essential signal-conditioning element designed particularly for electro physiological applications, to establish bio signal data acquisition and real time analysis. The electrical signal measured from the surface has amplitude between 10-5mV and bandwidth from 0.5-150 Hz.

b. ***ECG in Medical practice***

Analysis of different characteristics of ECG waves such as P, Q, R, S, T and U yield some insight on cardiac status. Different ECG indices or parameter are inferred from characteristic ECG waves based on their amplitude, sequence, time-interval between them, temporal dynamic and rhythm. Energy of these characteristics ECG mainly concentrated at below 40Hz frequency. Therefore, sampling rate of 100 Hz is sufficient to calculate most indices or parameters from ECG. Some indices such as Ventricular Late Potential (VLP) and micro T-wave alternant require high resolution ECG.

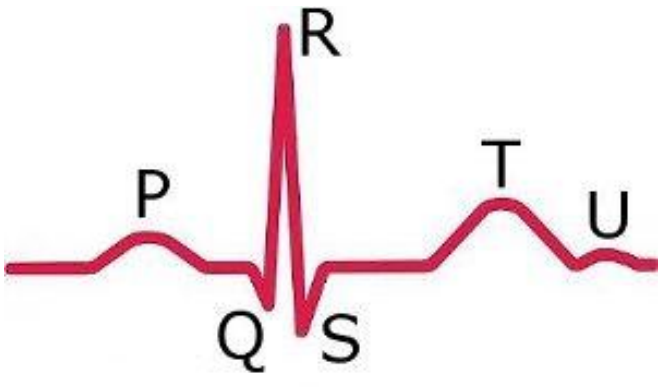

Fig.3 ECG Wave signal

c. ***Medical Sensor Acquisition***

This medical sensor acquisition mote block is the heart of the project. It consists of ADC, I2C, processor and many important ports. The LPC1313 is the microcontroller used which is inbuilt with ARM Cortex-M3 used for embedded applications featuring a high level of integration and low power consumption. The ARM Cortex-M3 is a next generation core that offers system enhancements such as enhanced debug features and a higher level of support block integration.

The LPC 1313 operate at CPU frequencies of up to 72 MHz. The ARM Cortex-M3 CPU incorporates a 3-stage pipeline and uses Harvard architecture with separate local instruction and data buses as well as a third bus for peripherals. The ARM Cortex-M3 CPU also includes an internal pre fetch unit that supports speculative branching. The peripheral complement of the LPC1313 includes up to 32 kB of flash memory, up to 8 kB of data memory, one Fast-mode Plus I2C-bus interface, one UART, four general purpose timers, and up to 42 general purpose I/O pins.

d. ***MEMS accelerometer***

The MEMS 3-axis accelerometer consisting of an accumulation at the centre of the sensor's chip, which is balanced by 4Beams doped with Piezo resistive material. When the sensor is subjected to acceleration in any direction, the movement of the accumulation causes the 4 Beams to deform and so modify the resistance in the piezo material. This enables the sensor to sense the acceleration motion.

e. ***Body temperature sensor***

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in ^{o}C).

Formulas:

Celsius to Fahrenheit	(°C × $^{9}/_{5}$) + 32 = °F
Fahrenheit to Celsius	(°F-32) x $^{5}/_{9}$ = °C

TABLE.1 Normal Values for health

Health Parameter	***Range-Normal Values***
Blood Pressure	<140/90 mm Hg
Body Temperature	36.5-37.5°C (approximate 97-99F°)
Heart Rate (HR) or Pulse	60-80 beats/min

f. ***MIWI Wireless Protocol***

The Microchip MiWi. P2P Wireless protocol is a deviation of IEEE 802.15.4, using Microchip MRF24J40MA 2.4 GHz transceiver and any Microchip 8, 16 or 32-bit microcontroller with a Inter Integrated Circuit (I2C). The protocol provides reliable undeviating wireless communication via an easy-to-use programming interface. It has a wealthy feature set that can be compiled in and out of the stack to meet a wide range of user needs, while minimizing the stack footprint. It supports a sleeping element at the end of the communication. This system Enables Energy Detect (ED) scanning to operate on the least-noisy channel. It provides active scan for detecting existing links and Supports all of the security modes defined in IEEE 802.15.4.

ii. ***Receiver Section***

The block of receiver section is shown in fig.4. The receiver section consists of:

1. LCD display,
2. Base station mode inbuilt with UART& I2C and
3. Doctor's pc/laptop.

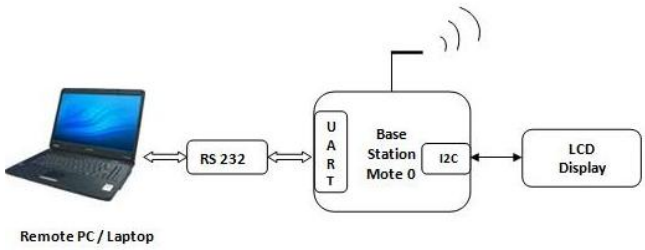

Fig. 4 Block of receiver section

The detail description of the receivers section is given below

a. ***LCD Display***

The PCD8544 is a low power CMOS LCD controller/driver, designed to make a graphic display of 48 rows and 84 columns. The essential functions for the display are provided in a single chip, with on-chip generation of LCD supply and bias voltages, resulting in a minimum of external components and low power consumption. The PCD 8544 interfaces to microcontrollers throughout a serial bus interface. LCD Display is linking to the Base station mote through an I2C bus. Base station mote having one more ARM cortex-M3 processor.

b. ***Remote PC/Laptop***

Remote pc/laptop is connected to the base station mote through UART. Remote pc is used to monitor the heart beat rate and ECG of the patient. In UART connection RS 232 cable is used to transfer the data.

Hardware Description

Medical acquisition mote consists of ECG analog front end board, MEMS accelerometer, body temperature sensor. ECG analog front end board having three electrodes. It is connected to transmitter section through ADC. The 9V input supply is given to the ECG analog front end board. MEMS accelerometer is connected to transmitter section through I2C bus. Body temperature sensor is connected to the ADC. Transmitter section having an inbuilt of ADC and I2C. A MIWI protocol transmitter is connecting to the medical acquisition mote.

The 18V supply is given to the medical acquisition mote. Base station mote was fixed to the Microcontroller LPC1313 which has a transreceiver Wireless function. LCD display is connecting to base station mote through I2C. PC is connected to the base station mote through UART. A MI-WI protocol receiver section is inbuilt to the base station mote.

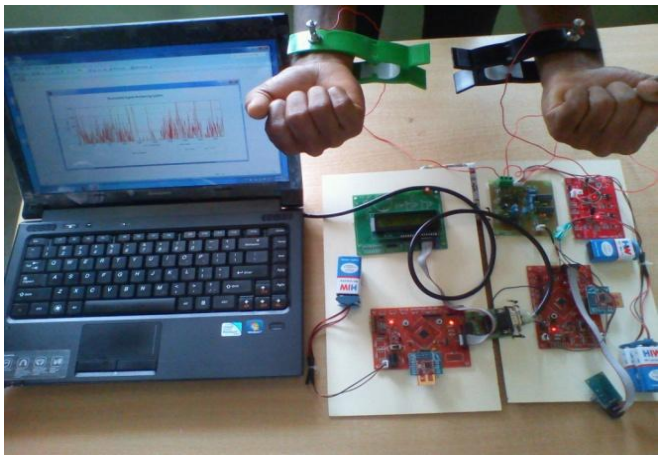

Fig. 5 Working condition of Healthcare monitoring System

Results and Discussion

The output data are displayed on LCD screen and Laptop. LCD displays the result of body position and body temperature. The encrypted and decrypted output data are displayed in laptop / PC as shown in the above figures.

Fig. 6 shows the output of encrypted heart rate data and Fig. 7 shows output data of decrypted heart rate data which is received in a secured form to the doctor.

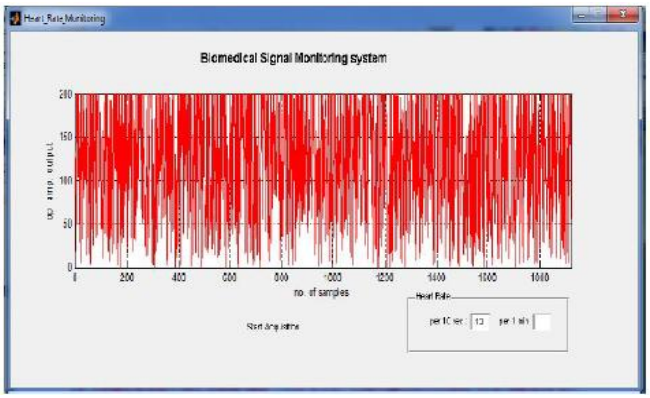

Fig. 6 Encrypted output data

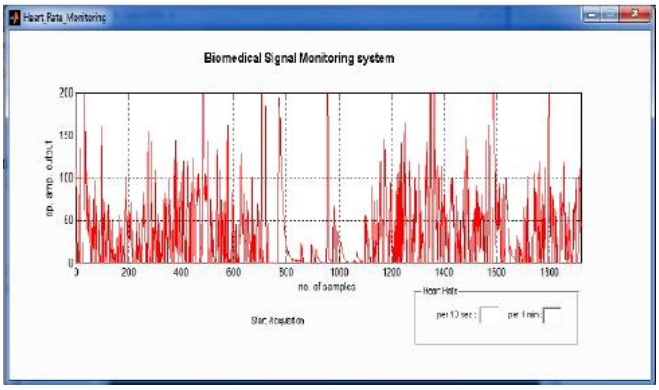

Fig.7 Decrypted output data

Conclusion

This proposed system is used to monitor many physiological parameters and the output data are displayed through LCD display and laptop. This can be used to record events for disease like cardiac arrest can be used widely in hospital and defence forces m. This system provides a secure data transmission of signal by using WI FI. The main advantage of the proposed system is decreasing the intervention time to the patient in an emergency situation.

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