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A Miniaturized Telemetry Module for Bio-Signal Transmission at Wearable Computing

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Abstract and objective

In order to monitor the variation of body temperature from multi-patient in real-time in the hospital room based on body sensor network (BSN), a miniaturized wireless telemetry module based on PAN was designed and implemented in this paper. The transmitting part of telemetry system consists of a temperature sensor, a miniaturized UHF transmitter with a transmitting antenna, a microprocessor for data encoding, and a battery. The diameter and thickness of implemented transmitter are 20 mm and 3 mm respectively. The receiving part consists of a receiving antenna, a RF receiver, and a processor for data decoding, and the decoded data was transformed to RS232C format to be transferred to computer. From the experimental result in the simulation environment that resembles a hospital room, the implemented telemetry module was verified to operate well with sufficient reliability.

Keywords[1]:
telemedicine, physiologic monitoring, medical electronic

Introduction

The wireless sensor network is becoming a significant enabling technology for a wide variety of applications. The rationale behind the distributed sensor network is for detecting, identifying, localizing, monitoring, or tracking one or more subjects of interest. One of its potential deployments is in the form of body sensor network (BSN) for measuring physiological parameters. The aim of having a ubiquitous monitoring environment for wearable sensors is to provide continuous management of patients under their natural physiological states so that transient but life threatening abnormalities can be detected and predicted.

The wireless telemetry system at the environment of wearable computing system must be small and have sufficient bandwidth for transmission of various biomedical signals. In this paper, a miniaturized telemetry module was designed and implemented based on personal area network, which uses a wireless RF transmission at ultra high frequency.

Methods

The wireless communication system for wearable computing needs miniaturized device size and wide band width that is possible to transmit various bio signals. In this paper, the UHF (ultra high frequency) bio signal telemetry module which based on the PAN (personal area network) is designed and implemented.

The designed system consists of a signal pre-processor which includes an A/D convertor, digital encoder which prevents a noise and divides a communication channel, a RF transmitter, an antenna, and a crystal oscillator. The designed receiving system includes a receiving antenna, a RF amplifier, signal post-processor which consists of the decoder and demodulator, and an interface circuit. The biomedical signal which is divided with each channel and restored to original data, is changed to the RS-232 format and transmitted to the computer.

The μ-processor C8051F330 (Silicon Labs, USA) was used as the pre-processor for A/D converting and encoding of analog data. This μ-processor consists of a 10-bit ADC, several digital I/O ports, and a high speed control core. The control core supports the CPU, flash memory, SRAM, and interrupt controller. The speed of CPU is 25 MIPS at the 25MHz clock, and the power consumption is 6 mA at the range from 2.7 to 3.6 volt.

The biomedical signal pre-processed in analog part is converted to the suitable stream for digital transmission in the digital I/O part, and the transmission rate is controlled by the controller core. All data steam was converted to 100 kbps because the maximum transmission bandwidth of implemented transmitter was 100 kbps.

In this paper, the target signal for wireless transmission was the variation of body temperature. The temperature data are accumulated to the register in the u-controller without a parity and garbage bit. 12 bit temperature data is accumulated to the register during 10 times. It is added to 4 bit address data, so whole stream for transmission at a time is 124 bit. If the various signals or many patients' data

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has to be transmitted simultaneously, each of signals can be distinguished by the address, which can be extended by simple programming. The sleep mode guarantees the lower power consumption of whole system, and this sleep time can be controlled by programming.

The whole data stream is encoded by the Manchester encoding method, which has the clock information, so the synchronization of transmitted data in the receiver is easy to be implemented. The RF transmitter consist of a MAX7044 (Maxim, USA), a crystal oscillator, and some passive elements. The MAX7044, which is a crystal-referenced phase-locked-loop (PLL) VHF/UHF transmitter, is designed to transmit OOK/ASK data in the frequency range from 300 to 450 MHz. The transmitter circuit was consisted to support the transmission rate of 100 kbps, with was designed in considerations of channel extension and increasing resolution. The RF transmission power was set up to minimize and distance guarantee is 5 m radius.

The receiver was designed and implemented using a MAX1473 (Maxim, USA). The minimum sensitivity of receiver was 109.3 dB at the 433.92 MHz. The block diagram of implemented receiver is illustrated in figure 5. The RF signal which is received in the antenna is amplified and controlled by low noise amplifier (LNA) and auto gain control (AGC). The amplified signal is mixed with the signal from the local oscillator. The mixed signal is changed to the digital data by a data slice circuit, and the sliced data is sampled with over sampling method by μ-controller. Then, the μ-controller decodes the Manchester-encoded data and distinguishes it to the address and temperature data. The decoded data is transmitted to PC using the RS-232 cable.

Results

From the designed circuits and algorithms for signal processing, a miniaturized transmitter which can be attached to human skin and a portable receiver was implemented respectively. The whole elements were placed on a top layer because the bottom side of the PCB was stock to the human skin. The diameter and thickness of implemented transmitter was 20 mm and 4 mm respectively. The implemented receiver using a Max1473 chip was illustrated in Figure 7, and the width, height, and thickness was 20 mm, 25 mm, and 12 mm respectively.

The wireless communication experiments were performed using the implemented system in laboratory environment, where has the same conditions as a hospital room. In the experiments, the transmitted temperature signal from the miniaturized transmitter was received in the RF receiver and restored to original data. This data was transmitted to PC using RS-232c interface and displayed on the monitor. The experiments for verification of implemented system were performed as following methods respectively;

(a)Leaving alone the transmitter module for wireless measurement of room temperature.
(b)Gripping the transmitter module on the hand for measurement of hand temperature.
(c)Blowing breath to the transmitter module for measuring the steam of breath.

From all experimental result in the environment that resembles a hospital room, the implemented telemetry system was verified to operate well with sufficient reliability. The system response of temperature variation was in real-time and the displayed waveform reflected well the variation of temperature.

Results

A miniaturized telemetry system that can simultaneously measure the variation of patients' body temperature was designed and implemented. The miniaturized transmitter and receiver were implemented respectively and the stable operation was confirmed from all experiments, which was performed in the environment similar to the hospital room. The implemented telemetry is expected to be useful solution for the ubiquitous technology in the field of non-intrusive measuring from the human body.

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