Design and Fabrication of Low Power Sensor Network Platform for Ubiquitous Health Care

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Abstract: Recent advancement in wireless communications and electronics has enabled the development of low power sensor network. Wireless sensor network are often used in remote monitoring control applications, health care, security and environmental monitoring. Wireless sensor networks are an emerging technology consisting of small, low-power, and low-cost devices that integrate limited computation, sensing, and radio communication capabilities. Sensor network platform for health care has been designed, fabricated and tested. This system consists of an embedded micro-controller, Radio Frequency (RF) transceiver, power management, I/O expansion, and serial communication (RS-232). The hardware platform uses Atmel ATmega128L 8-bit ultra low power RISC processor with 128KB flash memory as the program memory and 4KB SRAM as the data memory. The radio transceiver (Chipcon CC1000) operates in the ISM band at 433MHz or 916MHz with a maximum data rate of 76.8kbps. Also, the indoor radio range is approximately 20-30m. When many sensors have to communicate with the controller, standard communication interfaces such as Serial Peripheral Interface (SPI) or Integrated Circuit (I^2C) allow sharing a single communication bus. With its low power, the smallest and low cost design, the wireless sensor network system and wireless sensing electronics to collect health-related information of human vitality and main physiological parameters (ECG, Temperature, Perspiration, Blood Pressure and some more vitality parameters, etc.)

Keywords: Wireless sensor network, sensor platform, low power, health care, radio transceiver

1. INTRODUCTION

Nowadays, a low power sensor network technology is very important in wireless communication technology. Wireless sensor network are often used in remote monitoring control applications, health care, security and environmental monitoring. [1] Wireless sensor networks are an emerging technology consisting of small, low-power [4], and low-cost devices that integrate limited computation, sensing, and radio communication capabilities.

With the maturity of sensing and pervasive computing [3] techniques, extensive research is being carried out in using sensor networks for health care. The concept of ubiquitous health care is to use unobtrusive sensors that are placed around the person's to form a wirelessly connected network. [2]

Figure 1 shows system configuration of Ubiquitous health care. The health parameters of human body were monitored via internet /IEEE 802.11(WLAN) from PC or PDA. The system consists of a sensor node, base-station and display unit from PC or PDA. The sensor node, capable of supporting multiple sensors, in attached to a subject for monitoring health parameters, and the data from the sensor unit is sent to the base-station via a RF transmitter. One of the major design issues addressed for the sensor node was to develop a small size, low power wireless sensor node [6] which can be strapped on the body of the person. The base-station is a stand-alone unit, which is able to receive the data from sensor node using a RF receiver, store it and also transfer it to a mobile unit using Internet/IEEE 802.11(WLAN).

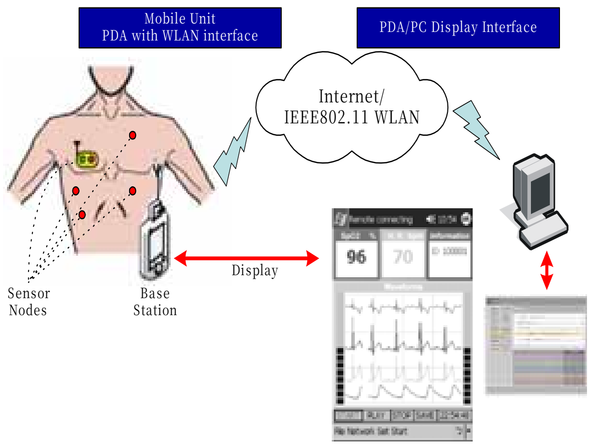


Fig. 1 Ubiquitous health care system for patient monitoring.

In this paper, low power sensor network platform for health care has been designed, fabricated and tested. This platform consists of an embedded micro-controller, Radio Frequency (RF) transceiver, power management, I/O expansion, and serial communication (RS-232).

2. SYSTEM DESIGN

Figure 2 shows the block diagram of the designed sensor network platform, consisting of five major modules: embedded micro-controller, Radio Frequency (RF) transceiver, power management, I/O expansion, and serial communication (RS-232).

The main micro-controller is an Atmel ATmega128L or ATmega128 running at 8MHz and delivering about million instructions per second (MIPS). [5] This 8-bit micro-controller has 128KB flash program memory, 4KB static RAM, 10-bit analog-to-digital converter, four hardware timers, 53 general-purpose I/O lines, two external universal asynchronous receiver transmitter (UART) and one serial peripheral interface (SPI) port. The radio Transceiver module consists of a CC1000 RF wireless transceiver (Chipcon Ltd., Norway), operates in the ISM band at 433MHz or 916MHz with a maximum data rate of 76.8kbps and has three LED's for output. At active mode, the hardware consumes 33mA. In sleep mode, the system draws only 30uA of current, enabling the battery to last for more than a year. Also, the indoor radio range is approximately 20-30m. When many sensors have to communicate with the controller, standard communication interfaces such as Serial Peripheral Interface (SPI) or Integrated Circuit (I^2C) allow sharing a single communication bus. The I/O subsystem interface consists of I/O expansion connector that we designed to interface with a variety of sensing and programming boards.

The expansion connector can also be used to program the device and to communicate with other devices, such as a PC serving as a gateway node. Additionally, it contains a standard UART (RS-232) interface to control or provide data to any UART protocol based device. In power battery part, battery system of the micro-controller (ATmega128L) and radio transceiver requiring 3V. The micro-controller has been optimized for low-power, battery operated systems.

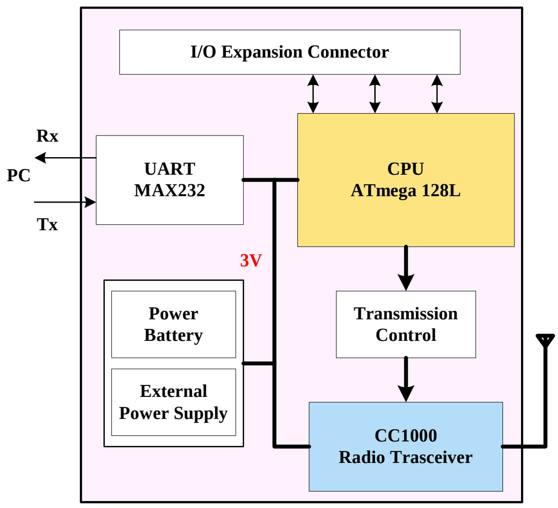
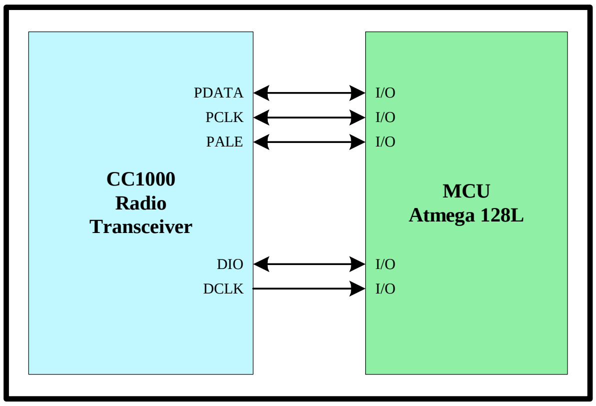
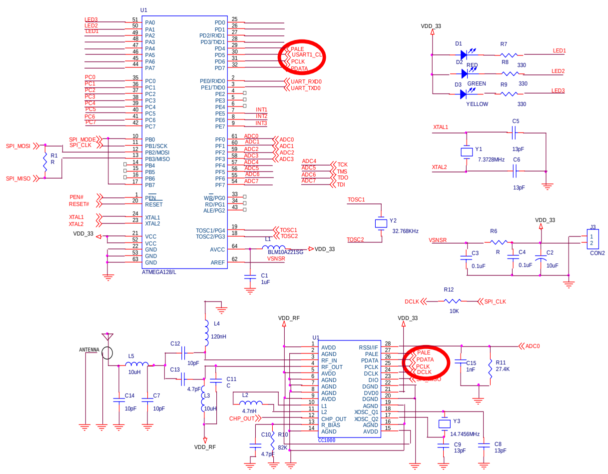


Fig. 2 Block diagram of a fabricated sensor network platform.

Figure 3 (a) shows the CC1000 RF wireless transceiver interfacing with a micro-controller. The schematic of RF transceiver interface as shown in Figure 3 (b). The CC1000 RF wireless transceiver chip is configured using a three-wire bus, comprising of PCLK, PDATA and PALE signals. Data interfacing is done via the DCLK and DIO pins of the microcontroller. The DIO and DCLK pins can be used for connecting the RF transceiver to a UART.



(a)



(b)

Fig. 3 Interface connection between a transceiver and a MCU.
(a) RF transceiver interface with MCU.
(b) The schematic of RF transceiver interface.

3. SYSTEM TEST

Figure 4 shows the fabricated board of wireless transceiver board. As the sensor node is to be carried by the person, the microcontroller used in the setup is about 1.4in ×1.4in in size, and RF Transceiver module is lesser than 1in×1in, resulting in the total size of the board is approximately 2.9in × 2.9in. As a RF transceiver for wireless sensor networking, CC1000 RF wireless transceiver can be used as shown in Figure 2. The commercialized UHF data transceiver module chips (CC1000, Chipcon Ltd,. Norway) were integrated in single chip. In contrast, at optimum input supply voltage, the CC1000 RF wireless transceiver consumes 14.8mA to transmit at 3mW and consumes 5.3mA to have a receive sensitivity of -20dBm.

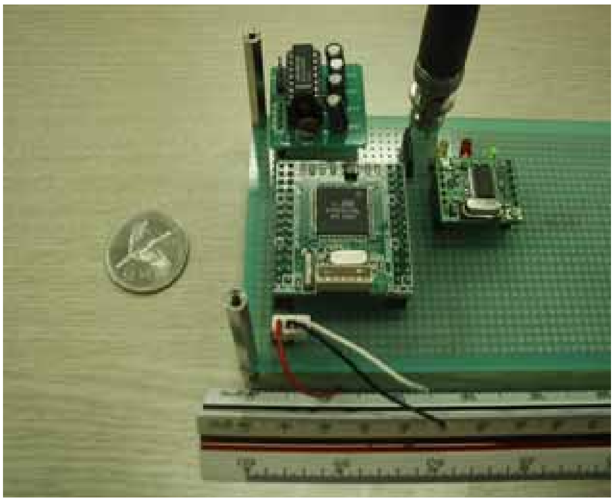


Fig. 4 Fabricated wireless transceiver board.

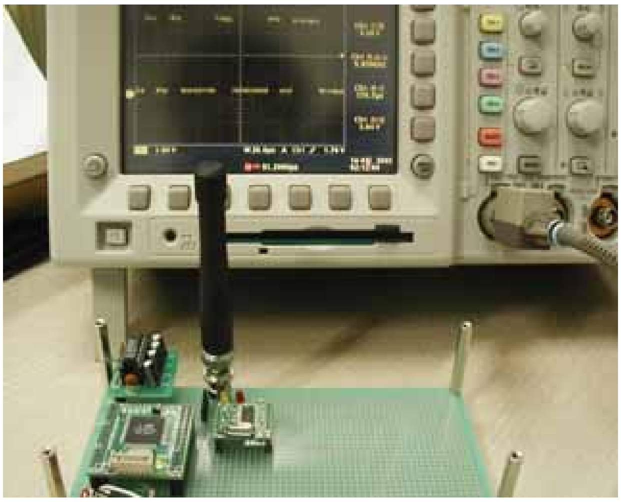


Fig. 5 Test system for the fabricated transceiver board.

When transmitting at the same, the CC1000 RF wireless transceiver consumes 12mA. In practice RF transceiver provides an outdoor, line-of-site communication range of up to 300 feet compared to 900 feet for the RF transceiver. The RF transceiver offer transmission data rates of approximately 76.8Kbps.

Figure 5 shows test system for the fabricated transceiver board for wireless sensor networking. The fabricated board consists of three parts. The First parts consists of a micro-controller, the second part consists of a RF transceiver from control signal of the microcontroller. The third part consists of a UART (RS-232) serial communication to other device. The sensor node was tested successfully to obtain the required RF signal from the micro-controller and RF transmitter. This part of the sensor nodes and base station was able to communicate in the range of 30~100m.

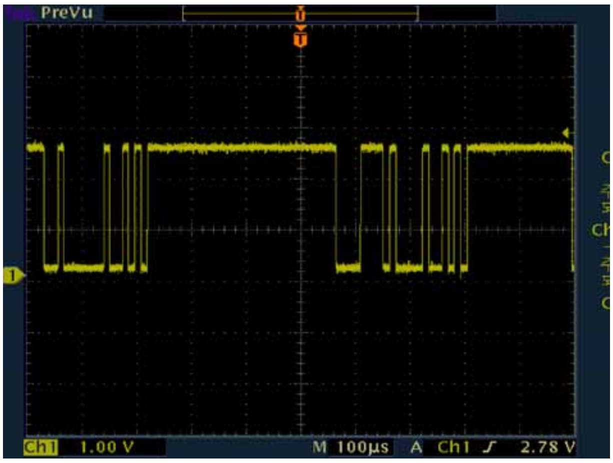


Fig. 6 Data packet of the RF transceiver.

4. EXPERIMENTAL RESULTS

A low power sensor platform and sensor node was designed and fabricated for ubiquitous health care system. A sensor network monitors continuously patients under their natural physiological states. In this paper, we describe wireless sensor network architecture consisted of sensor nodes, RF transceiver. Also, in this paper, sensor network platform for health care has been designed, fabricated and tested. The design of a series of platforms for sensing, processing, communication and power has been described. The First parts consists of a micro-controller, the second part consists of a RF transceiver from control signal of the microcontroller. The third part consists of a UART (RS-232) serial communication to other device. The sensor node was tested successfully to obtain the required RF signal from the microcontroller and RF transmitter. We also optimized the sensor node in the view point of system simplification, small system size, and low operating power.

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