WIRELESS INTERFACE FOR SENSORS IN SMART TEXTILES

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Abstract: This paper describes a smart suit with sensors and electronics for monitoring patients at hydrotherapy sessions in swimming-pools. The smart suit allows the monitoring of the heart rate, patient posture and activity level. The sensors input are converted in a PWM using a V-F converter. A robust, low-voltage (3.0 V) and low-power electronic wireless CMOS RF interface was implemented at 433 MHz using ASK modulation.

Keywords: Interface and system issues, RF CMOS transceiver, smart textiles.

INTRODUCTION

An emerging new field of research is the smart textiles. The smart textiles have not only the wearable capabilities but also have local monitoring and computation, as well as wireless communication capabilities. The sensors and a simple computational element are embedded in smart textiles with the goal of gathering sensitivity sensitive information [1].
The concept of wireless smart suit for hydrotherapy sessions allows the monitoring of individual biometric data, such as heart rate, movement and temperature of the patient body and swimming-pool water temperature. The smart suit will be lightweight, machine washable, comfortable, easy-to-use shirt with embedded sensors. The sensitive information is able to monitoring vital statistics and sending them remotely for further processing. Therefore, a small-size, robust, low-cost and low-power electronic microsystem embedded in the cloth is a promising approach.
The information data from the electronics microsystems network must be sent by radio signal as Bluetooth or any IEEE 802.11 standard to PC or PDAs or by a dedicated CMOS RF transceiver.

DESIGN

The monitoring electrodes, the sensors and the electronics are sewed in the textile material (e.g. neoprene, usually used in diving suits) achieving a good skin contact. The sensors are plugged into the suit around patient's chest and abdomen, which allows to measure the heart rate, movement and temperature of the patient body and swimming-pool water temperature. Thus, a single-channel measures heart rate; a 2-axis accelerometer senses patient posture and activity level; and a network of CMOS temperature sensors distributed in the suit is used for monitoring the body and water temperature. The microsystem has the look and feel of typical garments (Fig. 1) and can be tossed into the washing machine [2].
A RF transceiver operating at 433 MHz, with ASK modulation, was fabricated in 0.7 µm CMOS process (with 2 metals and 1 polysilicon layer) (Fig. 2). The radio signals are sent through a commercial half-wave dipole wire antenna, mounted on the cap. A 3 V battery is required for the transceiver.
A block-diagram of the transceiver is depicted in Fig. 3. The 433 MHz carrier frequency is generated by a phase-looked-loop (PLL) in transmitter section. The reference signal of the PLL is generated by a crystal oscillator working at 13.86 MHz. The sensors input are connected to a voltage-frequency converter (V-F converter) in order to achieve a digital PWM. This digital signal is modulated at ASK and is further amplified by a switched class E power amplifier.
The receiver (used for configuration and calibration of the sensors) was implemented with super-regenerative architecture [3]. As depicted on Fig. 3, the receiver includes an oscillator, two buffers, a quenching amplifier and an envelope detector as demodulator. The quenching network supervises the super-regeneration phenomena and the output of the receiver is transmitted through a bit stream.

EXPERIMENTAL RESULTS

The measurement of the water and body patient temperatures is shown in Fig. 4. It was

used a thermistor as temperature sensor. The input is connected a V-F converter.

CONCLUSIONS

A wireless smart suit, containing sensors and electronics for monitoring patients at hydrotherapy sessions in swimming-pools was designed. The smart suit allows the monitoring of the heart rate, patient posture and activity level. The sensors input are converted in a PWM using a V-F converter. A robust, low-voltage (3.0 V) and low-power electronic wireless CMOS RF interface was implemented at 433 MHz using ASK modulation.
This smart suit can be a powerful tool, helping health professionals with rapid, accurate and sophisticated diagnostic in free-living patients, when are doing hydrotherapy sessions in swimming-pools.
Additional analysis in the future may include respiration rate, blood oxygen saturation and a complete electrocardiogram (ECG) diagnostic.

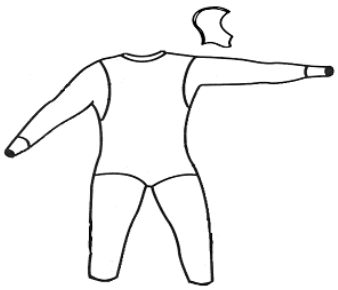

Fig.1. An artist impression of the smart suit.

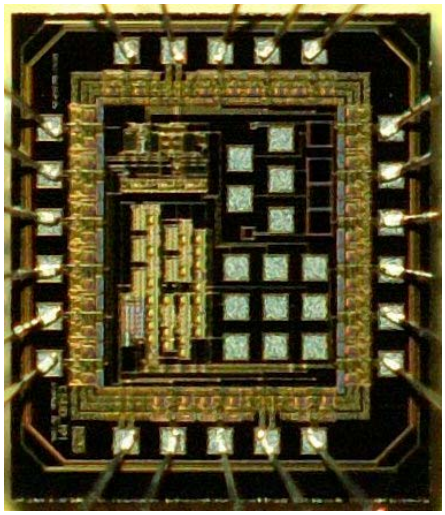

Fig. 2. RF CMOS transceiver at 433 MHz (1.6 mm×1.5 mm size dimensions) fabricated in CMOS 0.7 μm.

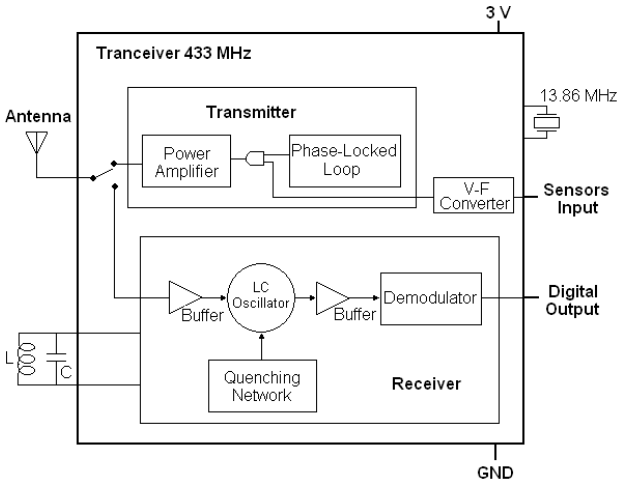

Fig. 3. 433 MHz RF CMOS transceiver block-diagram.

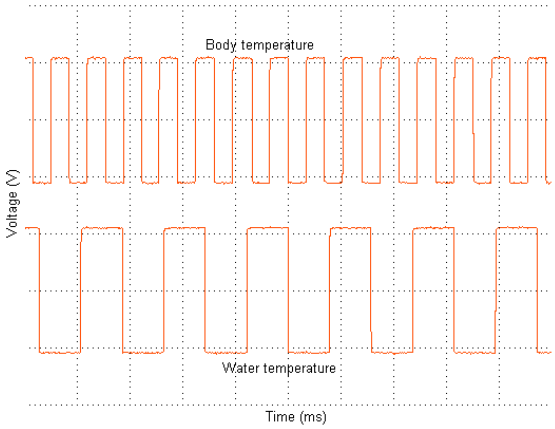

Fig. 4. The water (2 kHz@22 ºC) and body patient (10 kHz@36 ºC) temperatures.

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