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Implementing Body Sensor Network with Biomedical Signal Processing Through Wireless System

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Abstract

In this paper we describe the design, implementation, verification of a system-on-chip aimed to play the role for a wireless body area sensor network node. We supposed to use mixed signal silicon chip that has most of the attributes required for use in a wearable BSN. We used two types 1) analog based 2) digital based. Analog includes temperature & pH, multiplexing of data, digital includes microcontroller, wireless transmission. The paper ends presenting fully evaluated and tested by connection to external sensors of the implemented system-on-chip.

Keywords: Wireless System.

Introduction

Body Sensor Networks are a specific category of wireless sensor networks intended to operate in a pervasive manner for on-body applications. Much of the theory relating to general wireless sensors relates also to Body Sensor Networks (BNSs) and issues such as power optimization, battery life performance and radio design are key. These issues are examined in the first section of the chapter and key design considerations such as the correlation between Moore's Law (i.e. integration density) and power/battery performance are discussed. In this paper, we describe the development of a wireless biomedical sensor interface system-on-chip (SOC) that aims to combine many of the functions of the BSN Microsystems onto a single substrate. Our design is specified for a biosensor system with up to eight pH and temperature data channels communicating via an encoded wireless interface to a remote base station. The system comprises analog sensor interface circuit, data-conversion circuits, a microcontroller, a data encoder, and a frequency-shift keying (FSK) RF transmitter. Many of the system blocks were imported in an intellectual-property (IP) block form; thus, the design represents the first steps toward a generic BSN-on-chip.

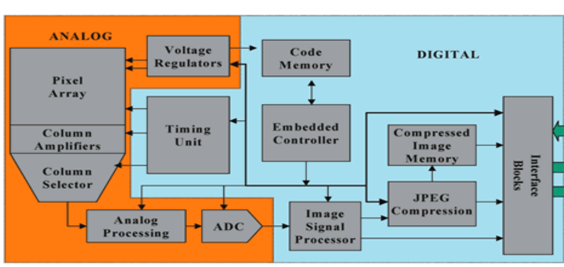

Fig 1.0 Block Diagram of System-on-chip.

Body Sensor Network System – On – Chip

Key to body worn sensors are issues such as usability, durability, robustness, how well the sensor 'fits' in with the application and reliability and security of the data. Sensor networks suffer from the so called 'reliability dilemma' which means that the more reliable and secure you want to make data transmission, the higher the data overhead and consequently the higher the power required. Hence battery life is reduced. These issues are discussed and some of the techniques for overcoming this dilemma are discussed. System-On-Chip developments which promise to significantly advance sensor integration (and reduce cost) and some of the current offerings in this area are presented. Notable research projects in this space are summarized and current research within the EU is also summarized. This document also examines the software aspects of wireless sensor networks and presents a brief history of operating systems development from the original single thread, event-driven Tinos to some of today's multithread systems such as Contac and Mantis. As sensor networks have evolved from the domain of the programmer and scientist to general use, so have the means of developing solutions and rapid prototypes. No longer do users need to be proficient programmers and developers and environments such as Mote view, Lab VIEW and BioMOBIUS™ are CAPSIL Background and Common Clinical Requirements presented as environments that facilitate non programming users to build solutions and rapid prototypes. Barriers to the general adoption of Body Sensor Networks are then discussed. These issues are mirrors of barriers to telehealthcare and telemedicine in general, and include lack of reimbursement policy,

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lack of standards, interoperability issues, privacy and security concerns and broadband proliferation issues. These are presented with suggestions of how government influence may help to remove these barriers. The document finishes with a review of pilot activity and trials that have been carried out both in the domain of telemonitoring i.e. medical monitoring from the home, and also Ambient Assisted Living.

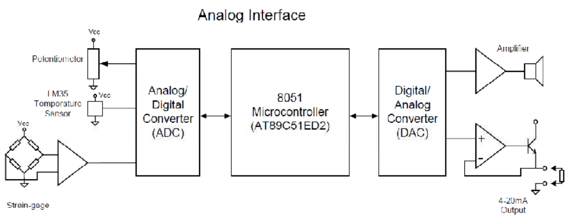

Fig 2.0 Block Diagram of Serial Interface

A Body Sensor Networks Operating Systems

The role of any operating system (OS) is to promote development of reliable application software by providing a convenient and safe abstraction of hardware resources. In PCs and servers, the OS allocates application processing threads to processors, maps virtual addresses to locations in memory while manipulating disks, networks and peripherals on behalf of the application. The operating systems used with wireless sensor network systems tend to be less complex than general-purpose operating systems. This is due to the physical and logical device size and the need to 'load the device' as little as possible (power and load optimization can be achieved.

B Sensor Interface

Micro-controllers are useful to the extent that they communicate with other devices, such as sensors, motors, switches, keypads, displays, memory and even other micro-controllers. Many interface methods have been developed over the years to solve the complex problem of balancing circuit design criteria such as features, cost, size, weight, power consumption, reliability, availability, manufacturability. Many microcontroller designs typically mix multiple interfacing methods. In a very simplistic form, a microcontroller system can be viewed as a system that reads from (monitors) inputs, performs processing and writes to (controls) outputs.

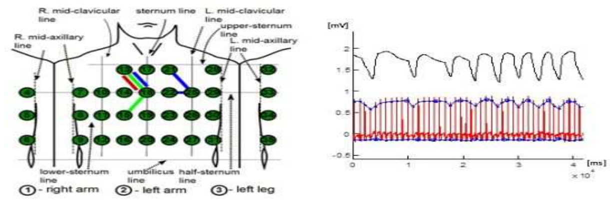

Fig 2.1 Experimental Result

Many sensors, such as thermocouples, generate a relatively small voltage so noise is always an issue. The most common source of noise is the utility power lines (50 Hz or 60 Hz). Typically, the bandwidth for temperature sensors is much lower than 50 or 60 Hz so a simple low-pass filter will work well in many cases. Thermocouples convert temperature to voltage. They rely on See beck effect which states that a junction of different metals will generate a voltage that is proportional to the temperature of the metals. Thermocouples are low cost temperature sensors, they are readily available from multiple sources and they can measure a wide range of temperatures that cannot be measured with semiconductor type temperature sensor. For example, they can be used to measure the temperature of the inside of a ceramics kiln which can reach 1200 Celsius.

Fig 2.0 4channel sensor interface

C. Wireless Interface

The integrated RF section on the SOC could be activated. The amplification stage of the RF session was elaborated to be a near-class-E RF power amplifier that was driven by the encoder's digital output. A two-stage driving amplifier was utilized. The gain budget of this amplifier was carefully asserted to maintain high gain and linearity while limiting the total current. The amount of amplitude and bandwidth extensions was optimized for this design in order to minimize data jitter. In the output stage, the back-termination poly silicon resistors were used to reduce reflections from output ports. A relatively low carrier frequency was selected for the on-chip RF section. This is because, applications, such as the implantable laboratory-in-a-pill in-situ experiments, have confirmed that low-frequency signals are less strongly absorbed and regulatory requirements allocated for 30 MHz The carrier frequency signal was generated directly by using an oscillator with an external SAW resonator, rather than by having a low-frequency oscillator multiplied up to the desired frequency.

Fig 2.1 Wireless interface

Performance of the System

In addition to evaluating each individual block, we have tested the performance of the complete integrated system. A complete functional flow of the SOC, from sensors to a DAQ device, was demonstrated.

A.Power Consumption

A printed-circuit board (PCB) was used for SOC testing. The packaged SOC was plugged into the PCB and powered by two SR44 silver-oxide cells attached using short leads. The battery voltage decreases with use and the average current consumption of the SOC for different battery voltages is measured. The largest power consumption is from the sensor interfaces and RF sections, which are 1.9 mA at 3 V and 1.7 mA at 3 V, respectively. With the on-chip RF section activated, the maximum measured power consumption for new batteries was 18 mW, decaying to 8 mW for batteries approaching the end of their lifetime. No significant perform deteriorations were affected by decreasing battery levels within the battery operation ranges.

Conclusion

We have presented a fully specified and functional biomedical sensor interface system-on-chip to acquire process and communicate sensor data wirelessly. The blocks include analog and digital which have microcontroller, temperature, wireless transmission. We believe that the concept we present here can be greatly developed into range of BSN application.

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