# Mixed Signal Interface Chip for Wearable Healthcare System

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## ABSTRACT

Smart sensors, which are created by combining sensing materials with integrated circuitry are being considered for several biomedical application such as a glucose level ,temperature ,Ecg ,etc. Practical usability of the majority of current wearable body sensor systems for multiple parameter physiological signal acquisition is limited by the multiple physical connections between sensors and the data-acquisition modules. In order to improve the user comfort and enable the use of these types of systems on active mobile subjects, a wireless body sensor system that incorporates multiple sensors on a single node is proposed [10]. The system must be suitable for longer-term monitoring of the subjects, such as continuous wear and autonomous operation up to several days without replacement of the power source. Thus power consumption is a major challenge in these applications.

The sensing and read-out of the signals may draw a significant part of the power budget in today's sensor nodes in WBAN, especially when the number of signals or channels is increasing. Thus, reducing the power required for signal extraction is an important challenge. Many system-on-chip (SoC) solutions have been presented for multiparameter sensor systems, but these do not offer application engineers the freedom of tailoring modules in their system to suit their specific application.

**Keywords:** sensors,WBSN,health care .

## 1. INTRODUCTION

Recently, the Wireless Body Sensor Network (WBSN) system has been a popular topic for researchers. Typical WBSN applications include the medical and health applications such as vital signs monitoring, fitness and medical care [1][2][3][4]. Such a network consists of a moderate quantity of low-power, resource-constrained miniature devices (called the sensor nodes) placed in, on or around the body which are usually wirelessly controlled by a portable central control device (called the base station by some researchers).

Fig. 1 shows some typical applications in WBSN. In these applications, rather than the peer-to-peer self-organized network topologies, the single-hop star network topology and the master-slave protocol are commonly adopted to lower the system complexity and power consumption as well [1], [4]. A typical WBSN is usually composed of a portable device which serves as the master node for central around, on, or inside the human bodies that act as the slave nodes. Compared to the master node, the slave nodes have more stringent constraints in terms of power consumption and size limitation. And this work mainly focuses on the slave sensor nodes in the WBSNs.control, and a number of miniaturized sensor nodes placed

Typical WBSN slave sensor nodes can be used for biomedical information acquisition, signal preprocessing, data storage, and wireless transmission (sometimes direct transmission without any preprocessing). This type of slave sensor node is called the sensing node. In addition, the function of sensor nodes can be expanded to medical treatments, such as drug delivery and nerve stimulating [5], and this type of slave sensor node is called the stimulating node. One difference between the two types of nodes is that the functions of a sensing node are usually periodically performed, while the functions of a stimulating node can be either periodical or event driven.

A study has been made on these two types of WBSN nodes, and a network protocol has been proposed and implemented which meets the requirements of both, targeting the power-efficient

operations. Specifically, the implemented ASIC has two standby modes. In the active standby mode, only an ultra-lowpower (ULP) timer with a low-frequency clock generator is active, and it periodically power ups the sensor node. In the passive standby mode, the whole sensor node is power silent, and a secondary passive RF receiver works as the supervisor circuit.

The specifically designed passive RF receiver can harvest energy from the RF signals in the space (transmitted by the master node which is not power critical), and hence, the passive standby mode consumes zero power ideally. The active standby mode can be used for the sensing and stimulating nodes. As a contrast, the passive standby mode can find its perfect use for the stimulating nodes, since the event-driven stimulating nodes can be woken up on demand without any response latency, while consuming zero power.

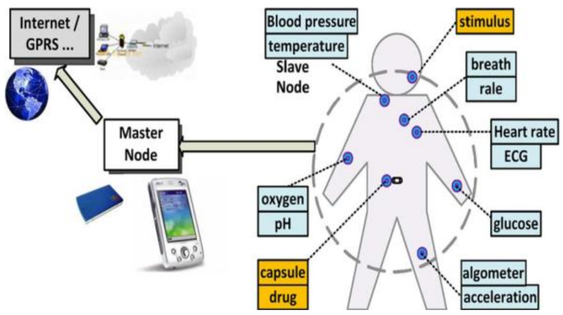


Fig 1.1 System diagram of typical WBSN applications

## II Wearable Healthcaresystem Applications

There is a wide range of applications for Wearable Healthcare system in supporting medical and healthcare services. By attaching Wearable devices to patients, vital or healthcare data can be automatically collected, which is then forwarded to a nurse centre for patient state monitoring. The Benefit of this scenario is that it can reduce the working load of nurses and result in increased efficiency on patient management.

A reasonable range between these sensors with a receiver carried by the person is set in advance. When the person forgets his belongings and leaves them over the pre-set range, warning signal is generated automatically. Furthermore, in advanced applications, cameras can be attached to a people with visual disability. Pictures taken by cameras are sent to a receiver carried by the people, where they are converted to audio signal to provide guidance to the people. The similar principle can be used for assisting people with speech disability. Here, sensors to catch finger and hand movements are used. The obtained information caught by sensors is converted into speech.

## 3.ARCHITECTURE

Wireless Sensor Network (WSN) 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, and tracking one or more subjects of interest. The BSN node is designed based on the Texas Instrument (TI) MSP430F149 microcontroller. The MSP430 processor is a 16-bit ultra low power RISC processor with 60KB flash memory, 2 KB RAM and 12-bit ADC. The ultra low power processor can operate at minimum of 1.8V, and requires only 3mW at active mode and 15µW at sleep mode, which is much less than the Atmel processor. In addition, it provides a wide range of interconnection functions, such as 12-bit ADCs and serial programming interface.

For wireless communication, the Chipcon CC2420, is used in the BSN node. The CC2420 has a maximum throughput of 250kpbs with a range of over 50m. In addition, it has a built-in the AES-128 (Advanced Encryption Standard) hardware encryption/decryption and the IEEE 802.15.4 MAC (Medium Access Control) functions. With the built-in buffers and MAC, the CC2420 can act as a coprocessor to handle all the packet communications, and which significantly reduce the computational demands on the microcontroller.

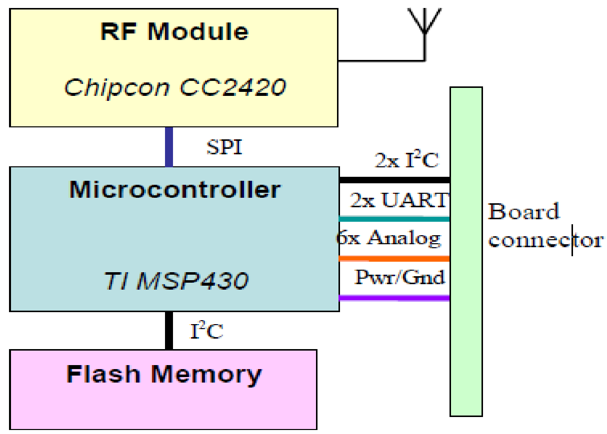


Figure 2 BSN node architecture

dynamic reprogramming of the BSN node, 512KB of serial flash memory is incorporated in the BSN node. With the 512KB of memory, almost 1.5hour of ECG (100Hz) data can be stored without any compression. By applying the DPCM and LZW in series, ECG data can be compressed down to 11% of its original size, which means that the memory may be able to hold up to 13 hours of ECG data [8].

Stackable design is adopted in the BSN node, where different sensor boards can be stacked on top of the BSN node. By using the 20-pins connector, various digital and analogue interfaces are provided, which includes two $I^2C$ buses, two UART interfaces, six analogue channels, power and ground signals. In addition to providing sensor interface, the board connector is also used for programming the BSN node where separate a USB programmer is designed for programming the node.

In terms of software, the BSN node is designed to run TinyOS by U.C. Berkeley, which is a small, open source and energy efficient sensor board operating system. It provides a set of modular software building blocks, of which designers can choose the components they require. The size of these files is typically as small as 200 bytes and thus the overall size is kept to a minimum. The operating system manages both the hardware and the wireless network—taking sensor measurements, making routing decisions, and controlling power dissipation.

By using the ultra low power TI microcontroller, the BSN node requires only 0.01mA in active mode and 1.3mA when performing computational intensive calculation like a FFT. With a size of 26mm, the BSN node is ideal for developing wireless biosensors. In addition, the stackable design of the BSN node and the available interface channels ease the integration of different sensors with the BSN node. Together with TinyOS, the BSN node can significantly cut the development cycle for wireless biosensor development.

## 4.MULTISENSOR INTERFACING:

Depending on the application and the operation of the sensor nodes in WBSN, the components of the sensor nodes varies accordingly. There are several sensor nodes, which typically comprises of a wireless transceiver, a processing unit and different types of physiological sensors like electrocardiogram (ECG) sensor, electromyography (EMG) sensor, electroencephalography (EEG) sensor, blood pressure sensor, tilt sensor, breathing sensor, movement sensor, thermometer, etc, deployed on the human being [24].

In most clinical and research settings, parameters, such as ECG, heart-rate, cardiac vibration, blood oxygen level, blood pressure, respiration, body temperature, body movement, among many others, are commonly obtained through multiple independent bench instruments. When simultaneous and synchronous recording is necessary, a separate signal-acquisition instrument is often utilized to record the multiple signals. The large size and large number of instruments required for multiparameter physiology analysis often renders mobile and continuous monitoring on active subjects impossible. To address this challenge, for multiparameter body activity and vitals monitoring, a small, lightweight, thin, flexible, one piece, wireless multisensor node is used [10].

## 5 MULTISENSOR INTERFACING MODULE DESIGN CHALLENGES:

(A) **Energy efficiency (low power consumption):** The total energy consumption of sensor needs to be drastically reduced to allow energy autonomy. The sensing and read-out of the signals may draw a significant part of the power budget in today's sensor nodes in WBAN, especially when the number of signals or channels is increasing. Thus, reducing the power required for signal extraction is an important challenge here [4].

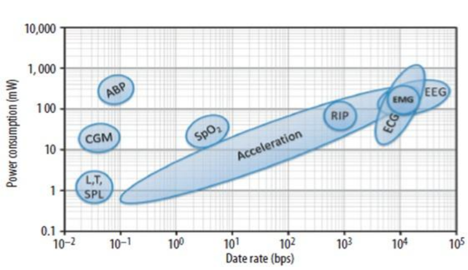


**Figure 3 - Average power consumption of continuous ambulatory monitoring applications**

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Commercial sensors exhibit a wide range of power supply requirements, calibration parameters, output interfaces, and data rates. Figure 3 shows the power consumption and data rate across a sampling of commercial systems for continuous, ambulatory monitoring. These differences suggest the need to support multiple applications in a narrow range of data rates (such as combining ECG, EEG, and EMG on a single node) or to support a single application across a wide range of data rates, such as acceleration.

### (B) **Size**:

To achieve social acceptance, WBSN nodes must be extremely non-invasive, and a WBSN must have fewer and smaller nodes The overall size and weight of sensor nodes should be tailored to the human body. This requires new integration and packaging technologies

### (C) **Reliability :**

The acquisition of bio-potential signals, namely EEG, ECG, EMG and EOG signals, presents an interesting challenge as the signal amplitudes are in the µV range. Various noise sources, such as electrode offset voltage and interference from power-lines, requires high-performance readout circuit design that is capable of rejecting such aggressors while amplifying the weak bio-potential signals. Since sensors are deployed for physiological data monitoring, they need to have a very low failure rate. Thus improvement of reliability requires minimizing not only wireless communication errors but also sensing and read-out errors [4].

### (D) **Intelligence**:

The intelligence should be added to sensor signal conditioning and processing so that it is capable of efficiently transferring captured signal data or extracted parameters continuously or on an event-triggered basis. Intelligence could also be introduced at the MAC protocol and wireless communication level.

### (E) **Sensor positioning:**

For distinguishing motions, an accelerometer/gyroscope array with tens of sensors can be deployed. This raises questions for positioning and noise reduction techniques. Proper positioning reduces the number of accelerometers/gyroscopes needed and the resulting data rate. Decreasing the number of sensors reduces the motion detection signal-to -noise ratio due to lower redundancy, thus requiring the sensors to be deployed at the planned locations with higher accuracy.ECG/EMG/EEG sensors measure potential differences across electrodes attached to corresponding parts of the body.

# 6.CONCLUSION

A prototype WBSN system was built to verify the design. The measurement results show
that prototype WBSN with the designed ASIC can operate efficiently as expected. In addition to the work-on-demand capability, the special passive standby mode offered by this design shows great advantage in terms of the standby power for the
sensor nodes in the WBSN for medical applications.

key issues in WSBN / WSN, and the application specific requirements have been discussed. And then a sensor node architecture with a hybrid of active / passive RF transceivers is proposed. Adopting the passive RF, the "real-time" demand in the medical care purpose can be satisfied with no extra energy induced in the sensor nodes, solving

the problems that tradeoff occurs between low-power and "real-time" wakeup in WBSN. It is especially suitable for long-term standby stimulus (or drug delivery) sensor node in the medical application

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