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Bio-Processing Using MSP430 Low Power Embedded Systems

Silambarasan. T, P. Sethupriyan

Professor, Department of Electronics and Tele-Communication Engineering, Bharath University, Chennai, Tamil Nadu, India

Assistant Professor, Bharath University, Chennai, Tamil Nadu, India

ABSTRACT: MSP 430, a 16 bit processor is an emerging signal processing tool that enables low power embedded systems for measuring signals such as electrocardiogram (ECG), electrooculogram (EOG) and electromyogram (EMG) biosignals. The major advantage of using this processor is a portable and compact device which works at extra low power consumption.Consequently, it can be applied to biosignal acquisition systems to reduce the data rate to realize ultra-low-power performance. This application is compared to conventional and adaptive measurement techniques and several system-level design considerations are presented in this paper.This technique of using MSP 430 ensures the elimination of mobile radiations from smart phones which has been implemented in the existing system. Also for better performance and faster transmission of data, WIMAX transmitter and receiver are used for sending continuous data to the health care provider. The major advantage of using this WIMAX technology ensures the transmission of transmitting from single station to multiple receiver sections.

KEYWORDS: ECG , EOG, EMG, MSP430, WIMAX

I. INTRODUCTION

Wearable and wireless body-area networks (BAN) are revolutionizing healthcare. A BAN typically integrates multiple motion, inertial,andbiosignal sensors with ultra-low power radios. Real-time biomedical data is communicated to a BAN personal base station (e.g., a smartphone or personal computer) and then to a healthcare provider via the Internet.

Increased energy efficiency is essential to the mass deployment of such feature-rich personal health-monitoring systems. Most of the power in a biosignal sensor is dissipated when the RF power amplifier (PA) transmits data to the personal base station.

For example, the PA in a BAN transmitter developed for theMedical Implant Communication Services (MICS) standard consumes 66.5 of the total power of 90. Thus, it is desirable to decrease the amount of data to be transmitted and reduce the duty cycle of the transmitter to increase the efficiency. Compressed sensing (CS) does this. Specifically, the application of CS before the transmission of typical biosignals achieves compression of the data with a proportionate savings in energy.

CS has been used previously to reduce noise and artifacts in ECG signals. Compressed sensing or compressive sampling is a data acquisition approach that requires only a few incoherent measurements to compress signals that are sparse in some domain.

For example, a typical ECG signal that comprises a high activity complex followed by a low activity region between complexes is sparse in the time domain whereas EMG signals typically are sparse in the time and/or frequency domains. In either case, CS compresses input samples into output values. Simulation studies show that compression factors are possible for ECG and EMG signals. Hence, it is possible to reduce the duty cycle and the corresponding energy consumption of a BAN transmitter by the same factor. In one possible embodiment of a CS CODEC, the transmitter receives the biosignal from a low-noise amplifier. In figure 1.1 has shows the function of sensors communicating and transferring the compressed signal.

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The analog front-end (AFE) compresses the -sample analog input vector, into an -sample analog output vector.Consequently, the ADC and RF PA can operate with a smalle duty cycle. The receiver, which may reside in a smartphone, uses basis functions along with optimization techniques to recover the original signal.

Compressed sensing (CS) is an emerging signal processing paradigm that enables sub-Nyquist processing of sparse signals such as electrocardiogram (ECG) and electromyogram (EMG) biosignals. Consequently, it can be applied to biosignal acquisition systems to reduce the data rate to realize ultra-low-power performance. CS is compared to conventional and adaptive sampling techniques and several system-level design considerations are presented for CS acquisition systems including sparsity and compression limits, thresholding techniques, encoder bit-precision requirements, and signal recovery algorithms. Simulation studies show that compression factors greater than 16X are achievable.

II. SYSTEM DESCRIPTOR

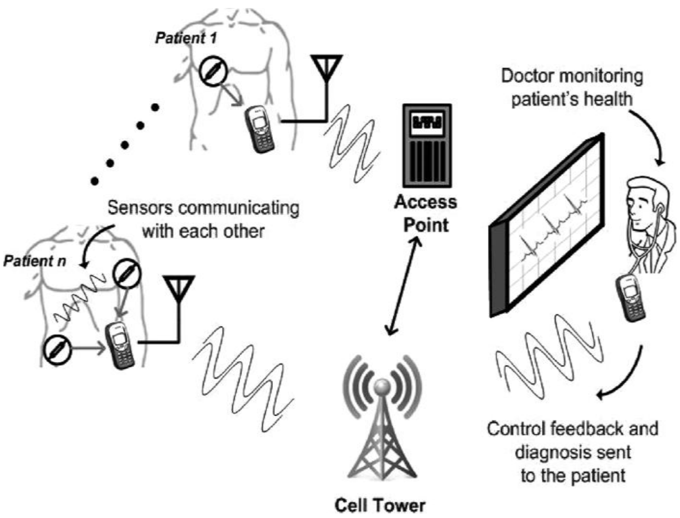

Figure. 1. Biosignal sensors communicate with a smartphone in a BAN to access a healthcare professional via the Internet.

In this system, MSP 430, a 16 bit processor is used to measure the bio signals such as ECG, EMG, EOG from human body. Initially, the bio signals are sensed using AgCl electrodes and sent to the processor kit using bio signal sensors. Then after processing the analog signals to digital signals from the processor , it is then sent to the WIMAX transmitter. Finally, the data are sent to the health care provider using WIMAX receiver. This ensures the low power embedded systems under low cost.

Figure 1 represents the functions of MSP430 processor and WIMAX standard. For remote monitoring of vital signs to fulfil its promise, it is extremely important to maintain the clinical integrity of the signals. This requires vital signs from the sensors to be free of sensing and motion artifacts wireless modems to provide a reliable communication link; and the wearable, wireless sensors to be extremely power efficient, so that they can be made small and long lasting.

In wireless networks, packet losses occur due to many reasons including excessive path loss, interference from other wireless systems, handoffs, congestion, system loading, etc. In the context of BANs, most of the emerging radios operate in the 2.4 GHz Industrial, Scientific and Medical (ISM) bands.

There could be a lot of competing traffic from WiFi, Bluetooth, Zigbee, etc. in this band, resulting in unacceptable packet loss rate. In some recent studies, packet losses as high as 50% were observed due to interference and congestion in clinical applications on networks designed for non-healthcare applications.

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A. Introduction of ECG measurement system

The ECG system comprises four stages, each stage is as following:

1. The first stage is a transducer—AgCl electrode, which convert ECG into electrical voltage. The voltage is in the range of 1 mV ~ 5 mV.
2. The second stage is an instrumentation amplifier (Analog Device, AD624), which has a very high CMRR (90dB) and high gain (1000), with power supply +9V and -9V.
3. We use an opto-coupler (NEC PS2506) to isolate the In-Amp and output.
4. After the opto-coupler is a bandpass filter of 0.04 Hz to 150 Hz filter. It's implemented by cascading a low-pass filter and a high pass filter.

B. ECG Signal

The basic structure of the heart is shown on Figure 2. Measuring at different region of the heart will retrieve different biopotential. And, so that it will generate different ECG waveforms. The ECG generated by each cardiac cycle is summarized.

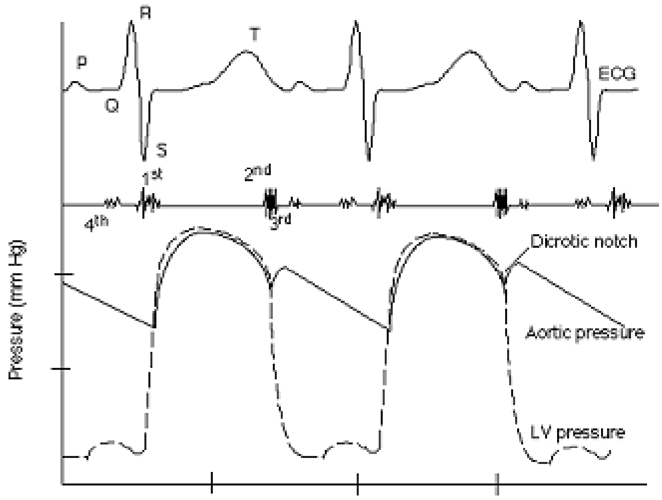

Figure 2.The ECG cardiac cycle.

The ECG is converted into electrical voltage by electrodes. A typical surface electrode used for ECG recording is made of Ag/AgCl, as shown on Figure 2. The disposable electrodes are attached to the patients' skin and can be easily removed. Cardiac rhythm analysis may be accomplished informally via cardiac monitoring and more diagnostically via a 12-lead electrocardiogram (ECG).Cardiac monitoring can depict the electrical impulse flow between two leads at one time, while a 12-lead ECG can provide information about the electrical impulse flow from 12 different views of the heart.The cardiac mechanism of ECG is shown on Figure 2. In the top figure, the electrocardiogram (ECG) initiates the cardiac cycle. The cardiac sounds are also shown.

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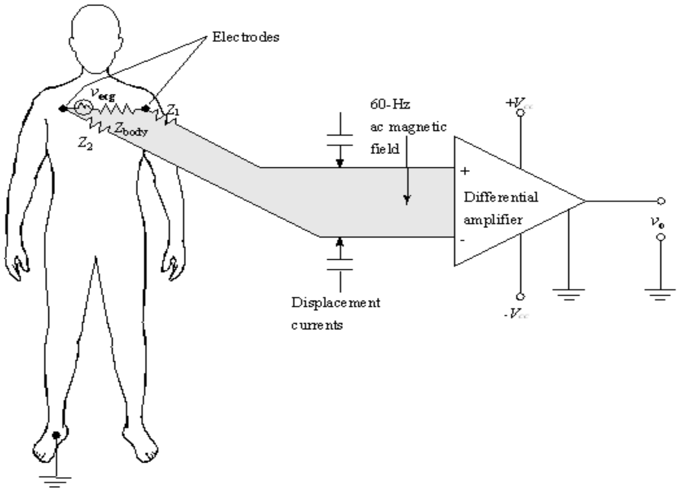

Figure 3. Simplified ECG recording system

Once the electrodes convert the ECG into electrical voltage, these voltage can be fed into an instrumentation amplifier, and then be processed.

Measuring the ECG by connecting two electrodes on the right and left chest respectively. The body should be connected to ground of the circuits, so that we connect the leg to the ground. If the body is not grounded, no signal would be obtained. Figure 3 has simplified ECG recording system.

C. Bandpass filter

In general, components of the signal of interest will reside in the 0.67 to 40-Hz bandwidth for standard ECGs and up to 300 Hz to 1 kHz for pacemaker detection. We take the suggestion by the book of John Webster to have the bandpass filter the frequency range of 0.04 Hz ~ 150 Hz. The filter is implemented by cascading a low-pass filter and a high-pass filter. The data of low-pass and high-pass filter are implemented by simple RC components.

III. METHODOLOGY

As portability becomes a growing trend in medical products, manufacturers are seeking technologies that reduce the design complexity and time in developing the finished product. In most of these medical equipments, the actual physiological signals are analog and require signal conditioning techniques, such as amplification and filtering, before they can be measured, monitored, or displayed. The MSP430 microcontroller MCU offers a platform of ultra-low-power processors with the high integration of the complete signal chain that is required for applications such as personal blood pressure monitors, spirometers, pulsoximeters, and heart rate monitors.The WIMAX standard for speed and secure transmition and receiving function.

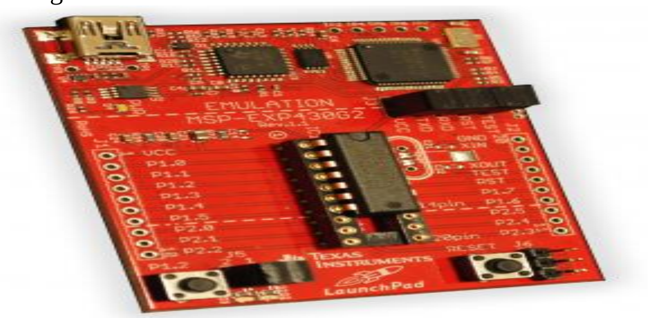

Figure 4.MSP 430 Processor Overview

A. WIMAX Standard

WiMax (Worldwide Inter-operability for Microwave access) is a wireless standard that will make Wi-Fi look mini. It is 30 times faster than third-generation mobile technology and 100 times faster than Wi-Fi. WiMax is a technology to

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provide last-mile connectivity to the user, from the junction box to the subscriber's home. The last mile link will enable solution providers to develop more efficient solutions to sell it at the bottom of the pyramid.

The operating frequency for WiMax is 2Ghz to 66Ghz that covers an area of 48km with data transfer rates as high as 70Mbps. However, this frequency range in India is currently being used by defenceorganisations. For practical purposes India will have a licensed spectrum of 2.2Ghz to 3.5Ghz with 4-10 Mbps of throughput.

WiMAX can provide at-home or mobile Internet access across whole cities or countries. In many cases this has resulted in competition in markets which typically only had access been through an existing incumbent DSL (or similar) operator.

Additionally, given the relatively low costs associated with the deployment of a WiMAX network (in comparison with 3G, HSDPA, xDSL, HFC or FTTx), it is now economically viable to provide last-mile broadband Internet access in remote locations. WiMax and Wi-Fi both have similar underlying technologies. But WiMax scores over Wi-Fi on security and area coverage. While Wi-Fi is wireless LAN, WiMax is a wireless wide area network.Wi-Fi has a range of 91m and can provide wireless access to a coffee shop, home or one floor of an office building.

WiMax has a range of up to 30-50 km and can provide wireless connections to an entire city. WiMax transmits signals that are encrypted and since they travel in registered bandwidth (unlike Wi-Fi) the possibility of signal-overlapping is marginal. WiMax provides connectivity that travels with you wherever you go. Due to the freedom and convenience to move anywhere and stay connected, WiMax may play a major role in bridging the urban-rural digital divide.

C. Scope and challenges

Until now rural India remains largely untouched by any new communication technology and it's not profitable for SPs or even feasible to surmount the geographical hurdles and lay cables in villages. Wimax will make it easier for service providers to reach these remote areas.But biggest challenge for Wimax is the allocation of spectrum. Obtaining the right spectrum to enable the telcos to provide services will play a key role.There are other challenges to mass adoption. The requirements and conditions in rural and urban areas vary but connectivity is mostly based on copper. Some SPs have experimented by laying optic fiber to connect areas in major cities and using Wi-Fi to connect to the consumer. But laying cables in the remotest and farthest points is not possible and wireless can be a solution to bridge the digital divide.However, for mass adoption of the technology it is important to provide low-cost devices, network and subscriptions along with bandwidth, services and content. The telecos are intend to provide affordable connections and service.

IV. SIMULATION RESULTS

Sensing ECG signals using AgCl electrodes from the human body are done. The received signals are then transmitted to MSP 430 which is a 16 bit processor to measure the signal. Band pass filter is used in this processor which reduces the noise rate.Then the compressed signal is transimitted using Wimax transmitter and the data has been received by the health care monitor using Wimax receiver.

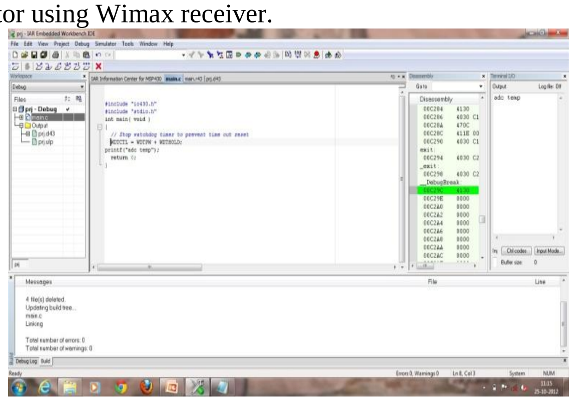

Fig.5. Temperature Sensing Using MSP 430 Processor

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IV. CONCLUSION

Several design considerations for ECG biosignals are presented using MSP 430 processor which enables low power embedded systems under low cost. Experimental results show the difference in performance by using clinical ECG systems and this embedded system for ECG bio-signals. Also by using this WIMAX standard helps in faster transmission of data while comparing to the existing systems.

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