# Wireless Body Area Network for Multi-channel EMG Recording

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## Abstract

Portable biomedical instrumentation has become an important part of diagnostic and treatment instrumentation, including telemedicine-applications. The goal of this study is to develop a lightweight, low powered system used to collect bioelectric signals from multiple channels over Bluetooth, creating a wireless Body Area Network (BAN). As a case study, we present the development of real-time portable EMG amplifiers. BT-enabled EMG amplifiers attached to different areas of the body are sending signals wirelessly to the central station to be displayed on a PC. The differential EMG amplifier feature high CMMR and make use of ultra low power hardware and single power supply producing the desired amplification. Precise profiling of the power consumption of different hardware subsystems is particularly crucial for battery powered systems, since the battery requires a large portion of overall size and weight of the system. This new system will enable us to remove artefact prone cabling during real pain research experiments and during physical exercises.

## 1 Introduction

Wearable health monitoring systems are novel information processing devices to support early detection of abnormal conditions and prevention of their serious consequences. Many patients can benefit from continuous monitoring as a part of a diagnostic procedure. One important limitation of the existing systems for continuous monitoring is unwieldy wires between sensors and a processing unit. These wires may limit the patient's activity and level of comfort and thus negatively influence the measured results. The challenging task for this work is to develop a wireless reliable and secure communication setup with remote Bluetooth devices.

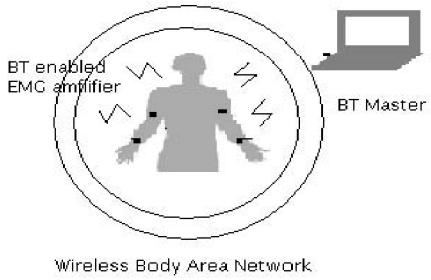


**Fig. 1 Wireless Body Area Network of 4 EMG amplifiers and BT enabled communication**

A Bluetooth based WBAN is presented that can include a number of bioelectric (here EMG) sensors. Information of several sensors can be combined to be used in pain research experiments [7]. Our EMG sensors typically generate analog signals that are interfaced to Bluetooth wireless network that provide secure communication capabilities. The EMG sensors should satisfy the following requirements. 1) Minimal weight 2) ultra low power operation to permit prolonged continuous monitoring 3) compact design. Multiple EMG sensors (slave) share a single wireless network node (master) through serial interfaces using RFCOMM layer in Bluetooth. (see **Fig.1**)

## 2 Methods And Material

### 2.1 Input Stage

The user physiological state is monitored using a bioamplifier implemented by an instrumentation amplifier with a single conditioning circuit. The circuit makes use of single supply (3.3V and GND) instrumentation amplifier INA326 that features very high CMMR (>100) as well as ultra low power hardware (CMOS inputs). The INA326 uses internal circuit topology that provides true rail-to-rail input.

### 2.2 Amplifier Design

The frequency of interest in EMG signals lies between 10Hz and 340Hz.The first stage of filtering process is

designed for 2nd order high pass Bessel filter that uses multiple feedback topology with an amplification of "40dB". This filter is used primarily to remove any DC offset from the signal but is also used to remove low frequency signals that are associated with movement of the patient (movement artefact). The high pass filter is set to lower cut-off frequency at 10 Hz. 2nd order low pass Bessel filter that uses multiple feedback topology is set to 340Hz with an amplification of "40dB". In order to avoid aliasing effect, a 8th order Bessel low pass filter is set to comply with the maximum sampling rate offered by A/D converter of BluesenseAD.

### 2.3 Bluetooth Module

BluesenseAD is an OEM Bluetooth class-2 module by Corscience GmbH & Co. KG (Erlangen) that is used to simply integrate Bluetooth communication in medical measuring system. The essential parts of BluesenseAD are 12-bit A/D converter, micro-controller and Bluetooth module. The Bluetooth module consists of a 2.4 GHz transceiver and a baseband controller processing the protocol stack. The Bluetooth module is controlled by the micro-controller through Bluetooth serial port profile (SPP), which establishes the connection to a Bluetooth monitor in order to allow data transmission over the emulated serial port. SPP enables all power saving modes that have been defined by Bluetooth Special Interest Group (SIG).

### 2.4 Final Design

Bluetooth enabled EMG amplifiers (slave) attached by triode (self adhesive electrode) to different parts of the body sending signals wirelessly to the central station bluetooth USB dongle (master). The master in a Bluetooth network is the node that initiates connection inquiry. Our master Bluetooth is attached to the USB port at the PC and is able to create virtual serial ports corresponding to that of EMG amplifiers used. So

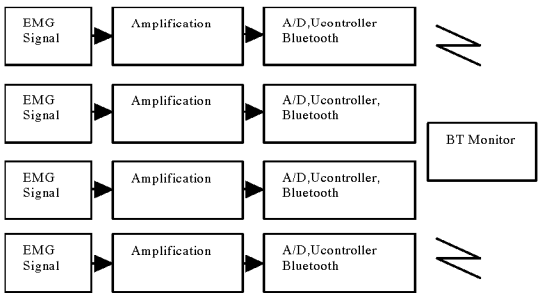


**Fig. 2 Final Design**

4 virtual serial ports are created at the PC end and wireless communication will be held on those virtual serial ports. (See **Fig.2**)

## 3 Results

We introduce a WBAN for EMG sensors. The system performs real-time acquisition of sensor data from different areas of the body thus providing guidance and feedback to the user.

## 4 Conclusion

A wireless body area network (WBAN) of EMG sensors is presented with the potential to provide a better and less expensive way of continuous multi-channel monitoring. This may provide benefits to the patients, physicians and society through continuous monitoring which in turn may improve quality of life and provide patient with an increased level of confidence. In addition, remote monitoring will allow patients to engage in normal activities of daily life rather than staying at home or close to specialized medical services.

## 5 Literature


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