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A Portable and Low Cost Solution for EMG using ZigBee,GPRS and Internet to Biomedical applications

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***Abstract*- This paper presents a prototype of an acquisition board of electromyographic signals (EMG); an embedded portable, wireless and low cost solution. The system is composed of an EMG acquisition board, Zigbee modules and a device named GPRSx. After acquiring the EMG signal, it is sent through ZigBee wireless technology to GPRSx device. The GPRSx device sends the EMG signal to a server on the Internet by using GPRS wireless technology. Thus, the EMG signal is displayed in a graph on a remote computer. The results are very promising and may serve as a reference in studies for the biomedical area.**

Keywords— EMG; portable; wireless; low cost;ZigBee;GPRS.

I. Introduction

The Electromyography can be characterized as a technique for monitoring the electrical activity of excitable membranes, representing the measurement of action potentials from the sarcolemma, which means the effect of the change of voltage with time. The electromyographic signal (EMG) is the algebraic sum of all signals detected in a certain area and it can be affected by muscular properties, anatomy and physiology. [1].

As far as healthcare of citizens is concerned, various equipment and systems has being developed so as to enable the advancement, comfort and improvements in diagnosis, care and therapies. Additionally, in order to tackle specific problems related to this area, intensive interactions between engineers and health professionals has been performed to take care of these issues. As a consequence and especially in the electromyography, there are works that suggest some devices for acquiring and processing of EMG signals. [2], [3], [4].

In terms of gait analysis, several clinics are treating and studying people with difficulty walking by using devices and sensors with many cables connected to the patient. This provides a discomfort and impairs the person's gait analysis, because he/she cannot perform a natural walking. Thus, the use of a portable device capable of acquire and monitor EMG signals or other biological signals (in a comfortable way for the patient) is an issue that should be investigated.

Furthermore, it should be emphasized that portable devices can provide a reduction in the cost of examinations due to its characteristic of mobility.

In this context, this work turns towards to develop a low-cost device, lightweight, portable and easy to use, which acquires and transmits EMG signals by a wireless system to the Internet. In this way, such signals can be analyzed by an expert or can be stored and viewed later. The proposed instrument may have applicability in hospitals, clinics or in patients' homes who (for some reason) cannot go to a medical center. Additionally, it should be noted that some commercial equipment available have a considerable weight, have a high cost, large size and the majority need a connection via USB or TCP / IP network for analysis of the obtained signals.

This work uses the GPRSx device: an embedded solution for integrating heterogeneous wireless communications standards such as ZigBee/IEEE 802.15.4, GSM/GPRS/IEEE 802.20 and Wi-Fi/IEEE 802.11 [5]. The operation of the system proposed in this paper consists in: obtaining electromyographic signal through acquisition board of EMG signals, sending signals by the ZigBee module to the GPRSx device and, data transmission by GPRSx using the GPRS technology of mobile telephony as shown in Figure 1.

In order to give the general view of the work, this paper is organized as follows: Section II presents the materials and methods adopted and Section III presents the results, Section IV shows the conclusion of the proposed work.

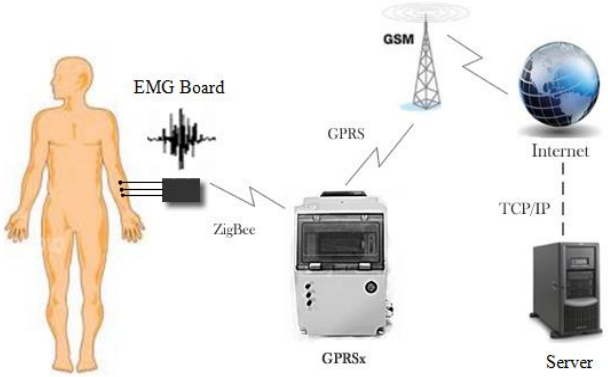

Figure 1. The proposed System Architecture.

II. MATERIALS AND METHODS

The EMG acquisition board is constituted by stages shown in the block diagram presented in Figure 2. The stages are: signal acquisition through electrodes, amplification, filtering, offset circuit, analog/digital conversion (A/D) and data transmission by the ZigBee module.

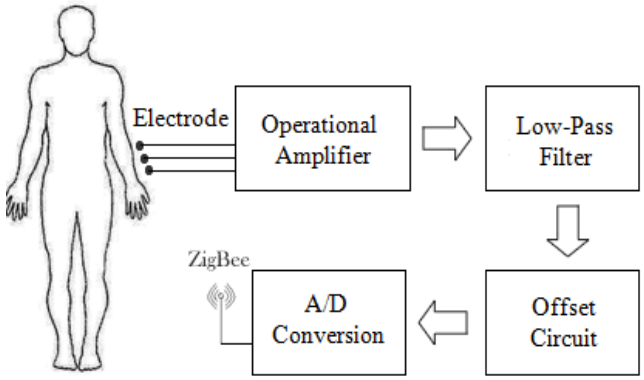

Figure 2. Block diagram of the EMG acquisition board.

The first stage consists of acquiring the electromyographic signal. Although the biopotentials measurements can be made with different kinds of electrodes, in this work, it was used the surface electrodes. The function of these electrodes is coupling the ionic potential generated within the body to the plate (main part of electrodes).

Due to the low amplitude of the EMG signals (approximately 100 µV to 100 mV) during acquisition, it is necessary to amplify the signal. In signal amplification the integrated circuit AD 625 was used in order to amplify and treat the electrical signals obtained. As most of the EMG signals are in the range of microvolts (µV), it was used the operational amplifier AD 625 with a gain of 1000 times.

For the next step, it was developed a low-pass filter with a cutoff frequency around of 500 Hz. It used a Butterworth filter of 4th order, because it is most commonly used to attenuate specific frequency variations of this signal.

An offset circuit was used to adjust the signal to the conversion process. In stage of A/D conversion, it was used a microcontroller dsPIC30F3014 from *microchip* because it is a compact size device that has a capacity of high speed A/D conversion as well as it has low cost.

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For the transmission of the EMG signal, it was used two kind of wireless technologies of communications: ZigBee and GPRS/GSM. Such use of ZigBee module is due to the standard is widely used in wireless sensor networks, in addition to its low cost and inherent characteristics that enable the transmission of data for analysis at a computer.

The GPRSx forwards the data received from ZigBee to a remote server using the Internet through GPRS mobile telephony. Figure 3 shows the circuit schematic and Figure 4 shows the EMG acquisition board already developed in a printed circuit board with electronic components.

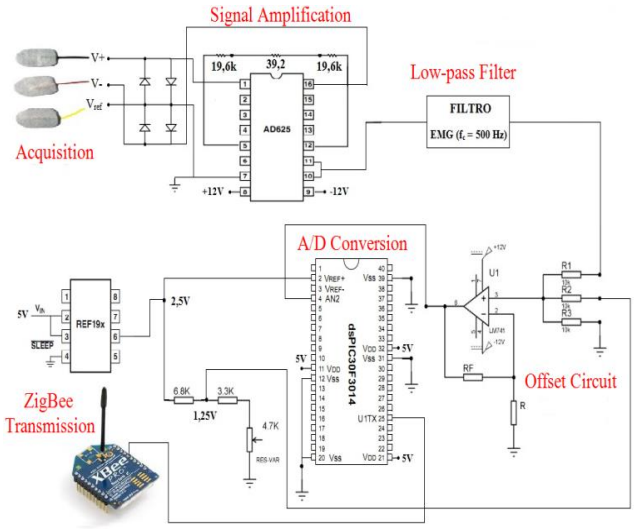

Figure 3. Circuit Schematic

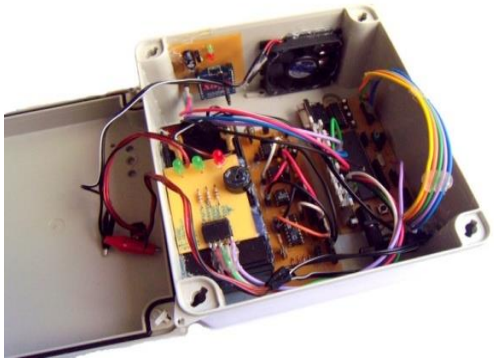

Figure 4. Portable acquisition board of EMG signals.

In order to become the patient information available at distance, it was built the EMG software. Its function is to receive the data from the EMG signal via socket (Internet), storing the data and simultaneously displaying them on a graph. The data can be stored and displayed anytime. Figure 5 shows the software interface and the graphic of the EMG signal acquired.

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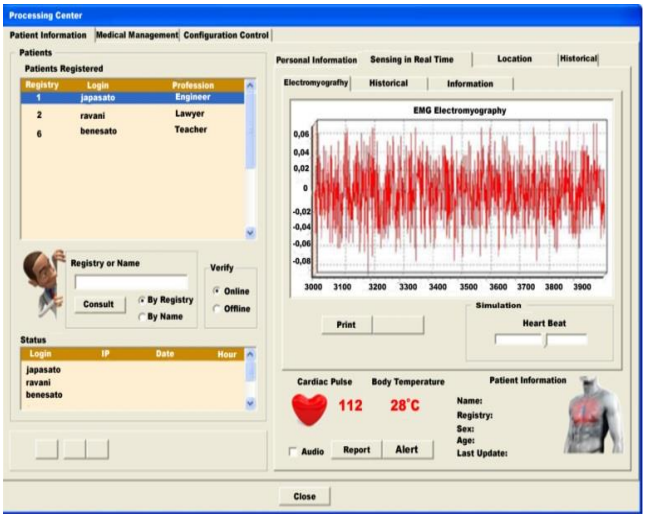

Figure 5. EMG *Software*.

III. RESULTS

Tests were performed to show the functionality and applicability of the proposed work. To check the operation of hardware for EMG signals it was used the ST2354 electronic module from *ScienTech*. The electronics module from *ScienTech* is a trade device used to simulate and acquire EMG signals. The signals were also obtained from surface electrodes using a real situation.

In capturing EMG signals, it was used the ST2354 electronic module from *ScienTech* to simulate an EMG signal. This signal was sent by the hardware and the result can be seen in Figures 7 and 8, which show the simulated signal seen on the oscilloscope and the signal received by the hardware.

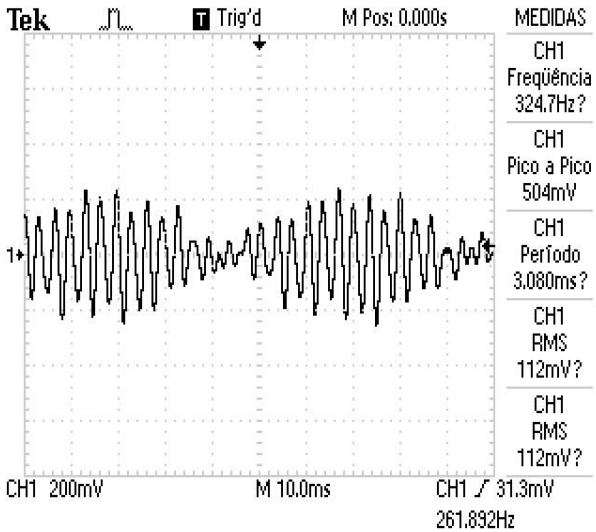

Figure 8. Simulated signal seen on the oscilloscope.

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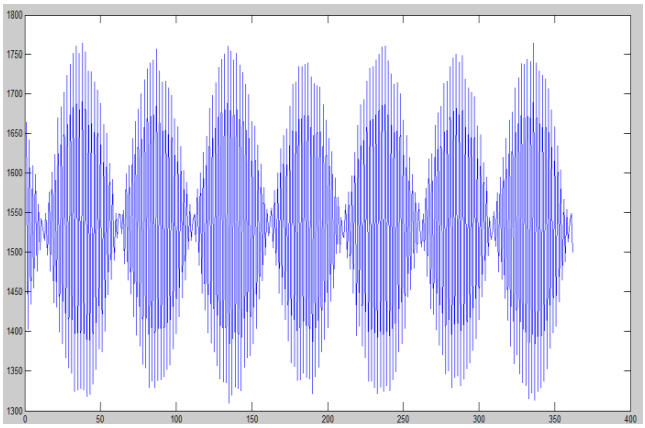

Figure 9. Signal received by the hardware.

Afterwards, a capture of EMG signal via surface electrodes was performed, as shown in Figure 10. After, the EMG signal was sent to the module GPRSx. The GPRSx module has the function of sending the EMG signal to a server on the Internet using GPRS technology. Thus, the EMG signal is shown graphically on a computer (as shown in figure 5).

Figure 10. EMG signal of an effort arm muscle.

Some tests were conducted to acquire data from both simulated signals (through a module ST2354 from ScienTech) and real signals (via electrodes). Those tests showed that the signals captured are compatible with the EMG signals in the literature [6] with respect to its waveform and spectral content. Tests for the solution used for acquisition and transmission of data collected in the system to a remote server via ZigBee /GPRSx has allowed the signal transmition in a range of 41 meters in places totally closed.

IV. CONCLUSION

This paper presented a low-cost solution for acquisition, wireless transmission and signal monitoring of electromyography (EMG).

Functionally, the EMG acquisition board was presented a stable operation during the tests. In these tests, the system proved to be effective for the proposal: acquisition of EMG signals (amplification, filtering, A/D conversion) and wireless transmission of obtained data.

To improve the prototype, it is carried out studies in order to modify the signal acquisition module so as to acquire signals of electrocardiogram (ECG), electroencephalography (EEG) and EMG. Consequently, the next stage of work should include also the more specific tests for the acquisition of EMG, ECG and EEG with the monitoring of medical professionals, aiming at the construction of a final device to be capable of using in academic scenario.

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