VIRTUAL SIGNAL GENERATOR FOR BIOMEDICAL SIGNALS WITH GUI

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Abstract: This paper describes an implementation method of a virtual signal generator for biomedical signals, the hardware component is a data acquisition board, the software component is made in Matlab environment and includes a graphical user interface (GUI). Using data files, with biomedical signals previous aquiared, it can be generated signals with desired waveforms, by changing parameters values, for research.

Keywords: signal generator, biomedical signals, data acquisition board, data files, graphical user interface.

1. INTRODUCTION

In the last decades electronics and telecommunications knew an unprecedented development which continues more accelerated in present, has appeared measurement instruments, personal computers and has growed impressive their computation power, the consequence is possibility of using algorithms more sophisticated while costs have significant decreases. These elements have became component parts of biomedical signal analysis systems in healthcare applications and have marked profound medical diagnostic techniques base on signal processing (the electroneurogram, the electromyogram, the electrocardiogram, the electroencephalogram, the vibroarthrogram etc) and image processing (digital radiology, computerised tomography, gamma camera, nuclear magnetic resonance imaging, ultrasound imaging (Jennings, 1995)) obtained with the help of sensors and instruments, providing better information about physiological phenomenons and patient state.

Today biomedical signal analysis is made using models (which simulate the behaviour of real systems) for diagnostic improvement, the patiens with severe diseases are monitorized in real time, persons who have disabilities are using electronic assistive devices, developed by studing their needs and are used to improve functional capabilities (Kutz, 2003). The computers allow quantitative and objective analysis of signals, in contrast with a human observer subjectivity, with limited perceptions, different from a person to other, affected by fatigue, attention distraction etc. The interpretation of signals demands experts with very good skills while computer analysis can assures the same accuracy like un expert with considerably experience. On the other hand the development of an algorithm for biomedical signals processing is a complex process and are necessary through knowledges about signals analysis, systems analysis, statisctics and take time to understand the link between physiological phenomenons by study of real cases, because of variability and interdependence between biomedical signals parameters, in addition the used techniques must be adapted in function of analysed signals (Rangayyan, 2002).

The mathematical models allow by changing parameters values analysis and prediction of state operations of real systems. These models are used for development of medical devices, drug, drug therapies and are divided in two types: black box, which disregards internal operations of systems base on input-output characteristics (neural network models, autoregressive models), and building blocks models, obtained by building up from other blocks, whereon the internal subsystems are studied using physical laws. First type are used for systems with internal processes unknown or too complex and the second type is for systems base on understood processes.

2. BIOMEDICAL SIGNALS

The electrocardiograma (ECG) represents electrical activity of heart. The heart is divided in two atria and two ventricles, its operation cycle contains a few stages. Recording of this signal is made using surface electrodes place on limbs or chest, after that the recorded signal can be used to estimate the number of beats per minute. Varied diseases affect the waveshape of signal.

The waveshape of a typical ECG signal is presented in the next figure. The electrical control of heart activity is made with the help of sino-atrial node (SA), which is a natural cardiac pacemaker, during a few consecutive steps: SA initiates contraction of both atrium, consequently P wave begins to take shape, after that the excitation signal is propagated to atrio-ventricular node (AV) with delay, it appears PQ segment and finally reaches the node causing contraction of the ventricles, then appears QRS wave, the final step is relaxation of the ventricles and appearence of T wave.

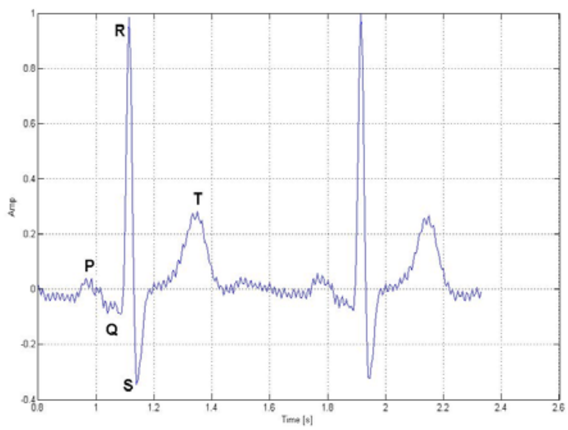


Fig. 1. Waveshape of the ECG signal

The normal heart rate when we are resting is 70 bpm (beats per minute) and it is lower during sleep. A value below 60 bmp for an active person is abnormal, it can be a sign of disease. During intense activities the heart rate can reach 200 bpm.

The electroencephalogram (EEG) describes electrical activity of brain, on its areas are generated electrical signals in function of external stimuli. In this case signal recording is made simultaneous on several channels using surface electrodes place on certain areas of the scalp. The studies of EEG signals show existence of links between characteristics of waveforms and mental and physiological processes, supplementary from spectral analysis was obtained a classification of major brain rhythms after frequency bands: delta (0.5-4 Hz), theta (4-8 Hz), alpha (8-13 Hz) and beta (14-30 Hz). At wake-sleep transition the EEG activity decreases in frequence from beta wave to theta-delta wave. Theta waves appear at the beginning of sleep, while delta waves appear later at deep-sleep stages. Alpha waves appear in the case of creative activities.

Presence of delta or theta waves at a wakeful person is considered abnormal and can indicate a brain injury or tumors.

The vibroarthrogram (VAG) is a record of knee-joint sound when is moving, in the case of degeneration of joint the level of sound is louder. From human body joints the knee-joint is the most afected usually. The VAG signal is complex and its analyses is difficult.

3. GRAPHICAL USER INTERFACE AND EXPERIMENTAL RESULTS

In the figure 1 are presented the elements of graphical user interface, each one has attached a suggestive label. The left part contains two elements for the visualization of output signal wave shape and its spectrum. The rest of the elements are situated in the right side and grant: loading of data file with a recorded biomedical signal, saving a profile file in ASCII format which contains file name and parameters values inserted by keyboard, opening or loading of file, selection of signal type (ecg, eeg1, eeg2, eeg3, eeg4, eeg5, vag1, vag2), inserting the parameters of the selected signal (amplitude, which if it is higher than 10 the signal is normalized, frequency, sampling frequency and visualization of sampling frequency range). The area from right down corner allows the starting/stopping of data acquisition board and the closing of the application.

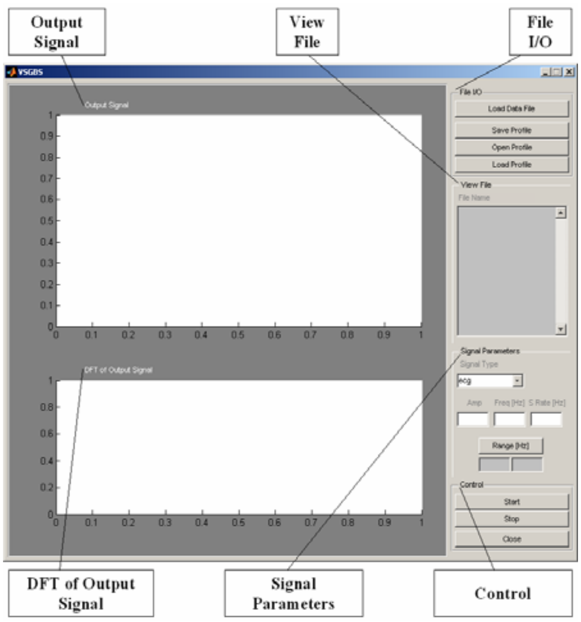


Fig. 2. Elements of graphical user interface

The experiments have been performed using a PC computer with a data acquisition board from National Instruments NI PCI-6110E, NI BNC-2110 adapter, an analogical oscilloscope for visualizing the signals and a BNC cable to link the board output and the oscilloscope input (fig. 3).

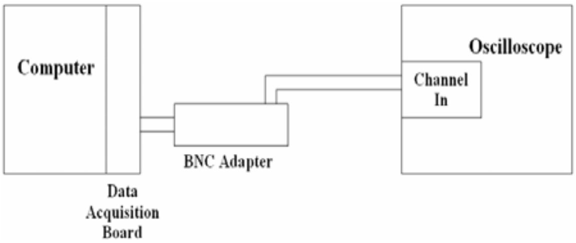
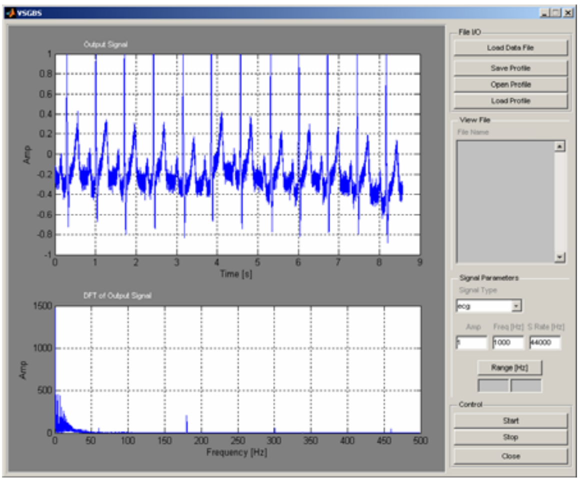


Fig. 3. Connection between computer and oscilloscope

The ECG signal from next figure is obtained after selection of signal type, by using parameters amplitude, frequency, sampling frequency with values 1, 1000, 44000. This signal is characteristic for a intense physical activity. By the decrease or increase of signal frequence it is obtained a bigger or lower heart rate.



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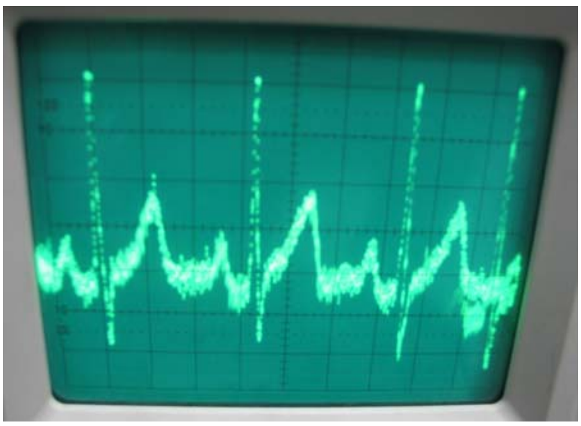
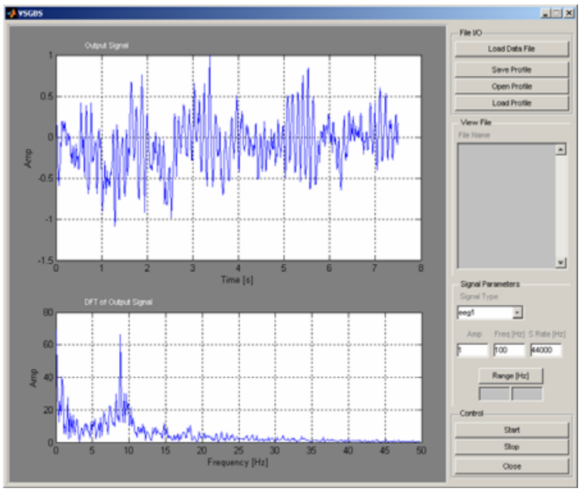


b)

Fig. 4. ECG signal

The EEG signal from figure 5 is obtained using the same values for signal parameters like in the previous case with one exception, the frequence value is 100.



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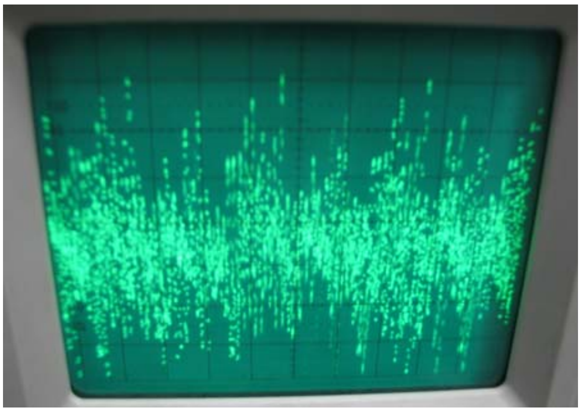
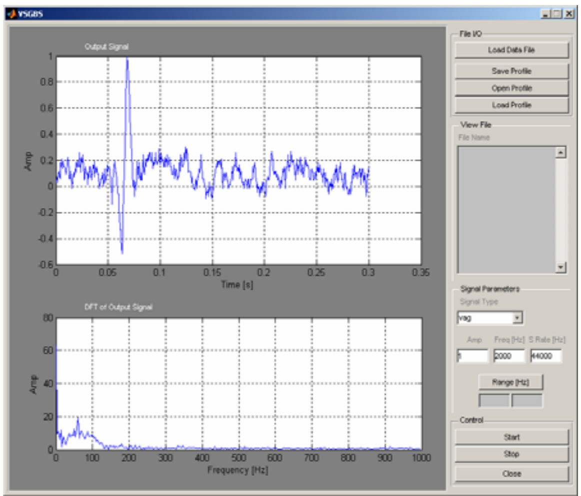


b)

Fig. 5. EEG signal

Further, in order to obtain the VAG signal (fig. 6) the only different parameter value is again for frequency and is 2000.



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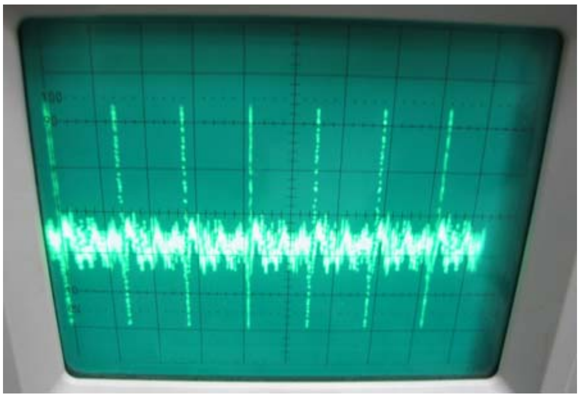

b)

Fig. 6. VAG signal

4. CONCLUSIONS

In Matlab environment using a data acquisition board may be achieved a virtual signal generator for biomedical signals with GUI for their research. The user-friendly interactive GUI allows the easy and quick selecting of the parameters for the desired output signal by the users with a low level of knowledge in the field. This PC-based instrument affords visualization of biomedical signals without the help of specialized medical instruments and is not necessary the patient presence.

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