

# Impact of filtration elements on bioelectrical signal

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**Abstract.** Filtering of the wanted signal from the noise caused by power lines, magnetic pickup, interference from body movement, etc. in the field of medical data processing is a weighty problem of cardiography. To date, different types of digital filters have been used to clear the signal from unnecessary frequency bands. This paper presents the results of the filter simulation in MATLAB package.

## 1. Introduction

Currently, due to the development of microprocessor technology, portable diagnostic devices that can successfully be used in everyday life are invented. The most important tasks are determination of a true diagnosis, detection of pathologies in the early stages of disease and prevention of cardiovascular diseases.

Electrocardiography (ECG) is one of the fundamental methods for the study of the cardiovascular system, which is still the most accessible and popular one for general use.

Recording of high resolution ECG signals with the presence of background interference is the important aspect for studies. The results of these studies will include improved ECG signal. It is necessary to separate some signal components from unnecessary artifacts to facilitate interpretation of the ECG signal.

All recording devices, both analog and digital ones, have properties that make them susceptible to noise. Noise can be random and not coherent, that is not related to the signal itself, or coherent, made by the recording devices and processing algorithms [1].

Noise is random fluctuations of various physical nature notable for complex temporal and spectral structure [2].

Receipt of signal against the background of noise is described as a procedure for signal filtering using the filter; the task in this case is the maximum weakening of noise and interference and minimal distortion of the received signal [3].

Filter (lat. Filtrum 'felt') is notions, devices and mechanisms which extract (or eliminate) some part with preset properties from the initial object [4].

The problem of useful signal extraction against the background of the whole complex of noise and distortion is a major one in the course of modern electrocardiological studies. The presence of artifacts in an electrocardiological signal (ECS) significantly impedes its analysis and identification of diagnostic features. The complexity of this problem solution consists in selection of filtering methods to eliminate certain types of artifacts, as well as the optimization criteria of used algorithms [5].

Standard for cardiographic equipment does not regulate the use of filters for the electrocardiograph, as well as their characteristics in certain models of cardiographs. Many sources contain information on



very strong influence of filtering elements on the ECG signal. Several types of filters that are used for different tasks are applied in modern cardiographs, and each of them can be implemented in several variants. This approach creates a large number of possible combinations of filters. For example:

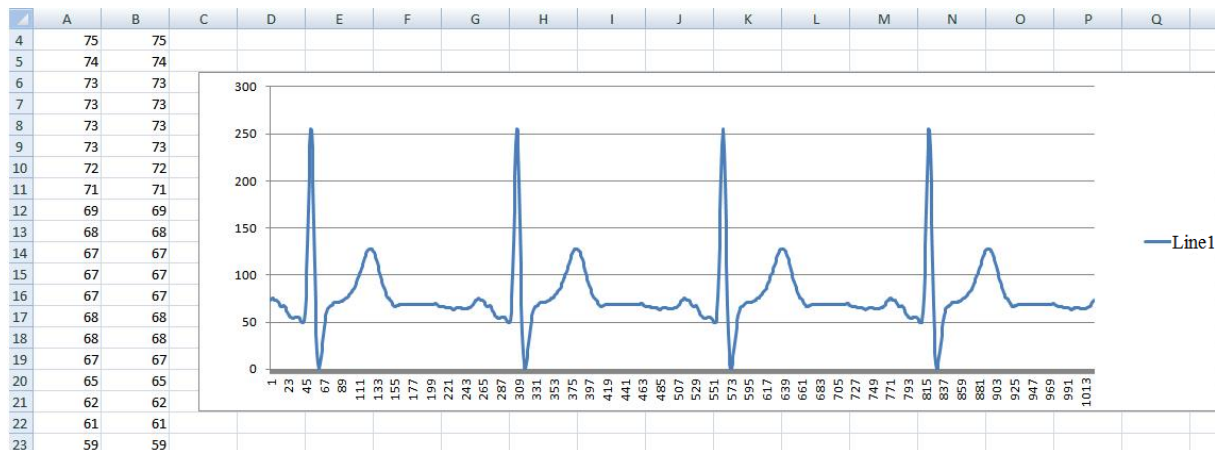
- power-supply noise filter;
- high-pass filter, limiting signal below the cut-off frequency;
- low-pass filter, limiting signal above the cut-off frequency.

Various types of filters are used in various electrocardiographs and, consequently, they will have a different impact on the ECG signal. Exactly various impact of filters on the ECG can explain the difference in the readings of different electrocardiographs. Fairly significant changes may be observed depending on the signal filtering parameters [6, 7].

## 2. Methods and techniques

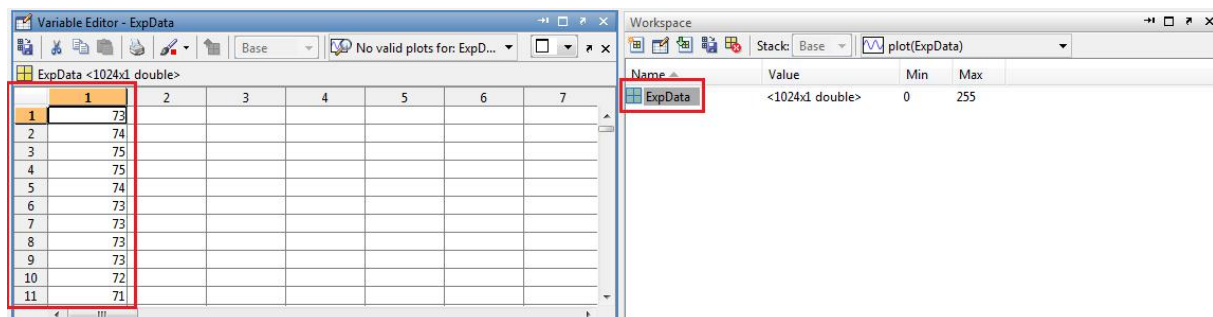
The impact of the filter on the signal was studied; in our case the model of the ECG signal was created. The circuit containing the low-pass filter (LPF) was designed in the MatLab package.

Initially the signal was created in the program for work with electronic worksheets Microsoft Excel. (Figure 1).



**Figure 1.** Fragment and model of the ECG signal in Microsoft Excel.

We faced a task of data export to Matlab. There are several ways, but they all are aimed at transmission of data to Workspace. Figure 2 shows the result of the work of a standard method of data export.

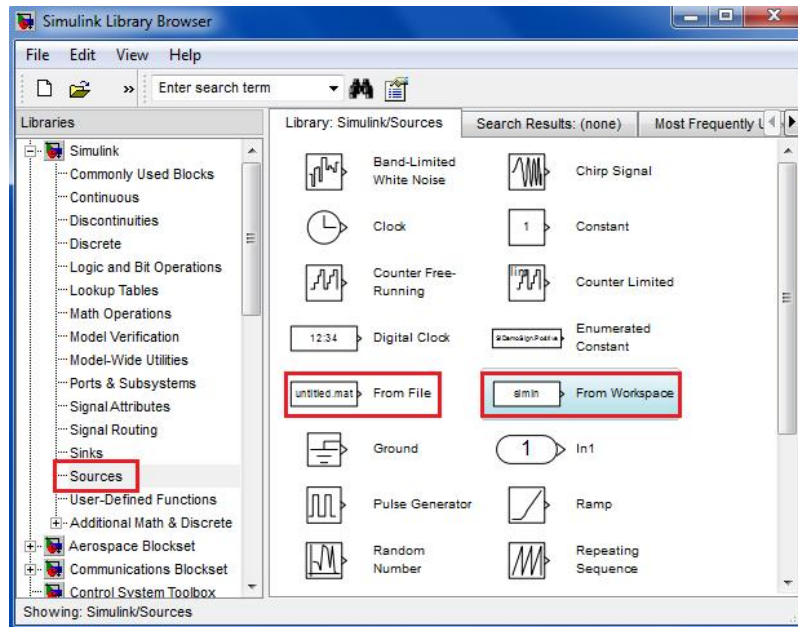


**Figure 2.** Result of data export using a standard method.

The Figure shows that the data are transmitted as a simple array; this is due to the fact that in many cases it is enough for further operations in the command line. But we need to use the exported data in

Simulink, and a simple array will not be enough, due to the fact that the data transmitted from Matlab in Simulink require special formatting.

We use the method implemented via a simin component to transmit data from Matlab to Simulink (Figure 3).



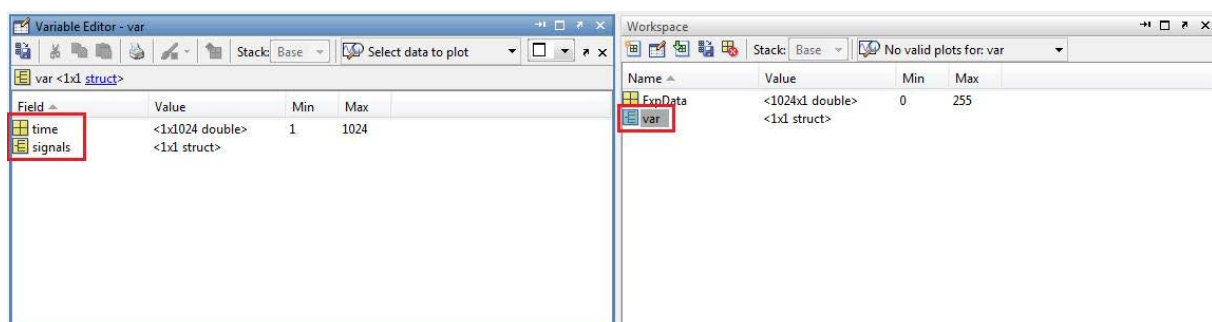
**Figure 3.** Elements for data transmission.

A simin component (From Workspace) receives data from Workspace and transmits them to Simulink. For correct operation of the component it has to receive a number of parameters, but the most important of them is the name of the variable, from which it is necessary to retrieve data, and correct formatting of data in this variable.

It is necessary to execute a number of commands in the command line in order to format the exported data:

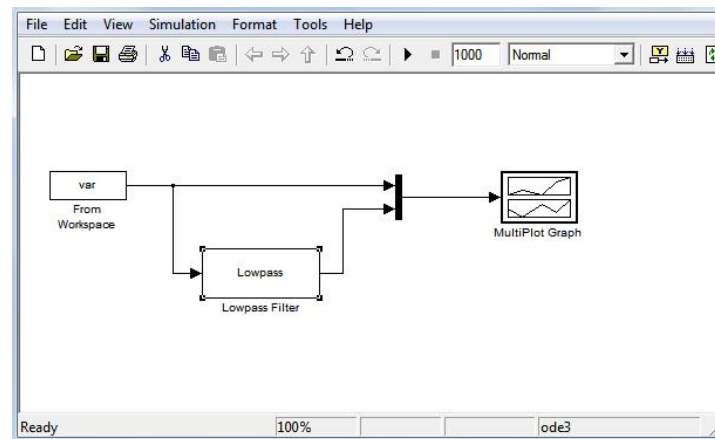
- `var.time=[1:length(ExpData)];`
- `var.signals.values=ExpData;`

The result will represent a structure which complies with the requirements of the simin component (From Workspace) (Figure 4).



**Figure 4.** Structure 'var'.

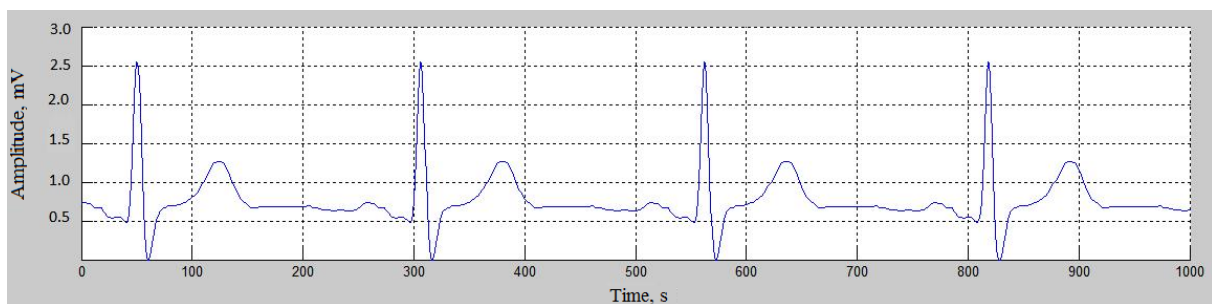
All the necessary work with a signal was made and then it became possible to use it in the Matlab system. A simulated circuit for studying of the impact of filters is shown in Figure 5.



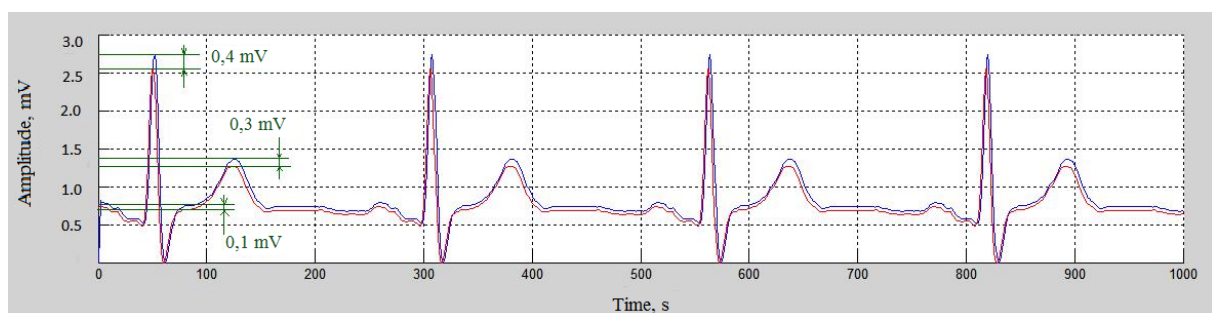
**Figure 5.** Circuit for the studying of the impact of filters.

This circuit contains: a unit (From Workspace), a low-pass filter (Filter Lowpass), multiplex (Mux), a unit (MultiPlot Graph).

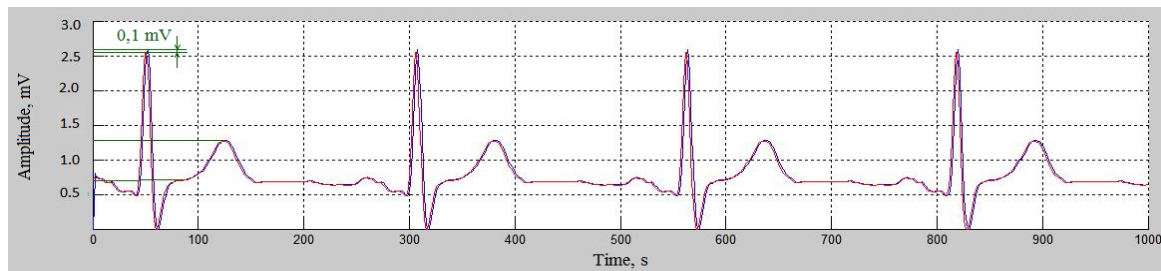
A simulated ECG signal is sent to the circuit input; there is a MultiPlot Graph at the output – this is a unit for graph plotting, which allows for graphical observation of the filter impact on the ECG – signal in the MatLab package [8]. We use multiplex (Mux) in order to combine the graphs of input and output signals for a more convenient analysis. The input signal is represented in Figure 6. The result of the low-pass filter impact is shown in Figure 7–9.



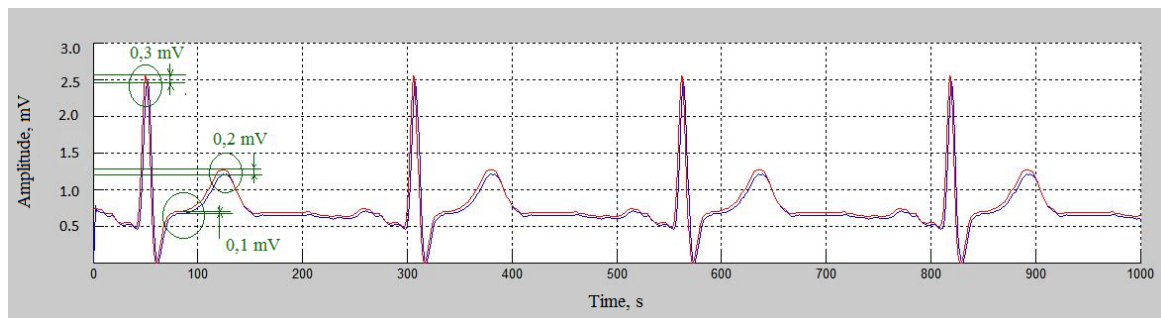
**Figure 6.** Input signal.



**Figure 7.** LPF output signal with cut-off frequency of 40 Hz (Input signal is red, output signal is blue).



**Figure 8.** LPF output signal with cut-off frequency of 100 Hz  
(Input signal is blue, output signal is red).



**Figure 9.** LPF output signal with cut-off frequency of 150 Hz  
(Input signal is blue, output signal is red).

### 3. Conclusion

As a result, we can clearly see how the filters affect the signal. Our findings represent a significant deviation when interpreting the electrocardiogram, which will certainly lead to incorrect diagnosis and consequently increase the risk of harm to human health.

In order to register a high resolution signal undistorted by filters in terms of level, it is necessary to standardize the use of filters in electrocardiographs and to develop electrocardiographic equipment of a new generation.

### 4. Acknowledgement

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