

# EEG Virtual Acquisition Chain User Guide

## *Introduction*

The Electroencephalograph (EEG) Virtual Acquisition Chain is a software tool that simulates the behavior of a real EEG acquisition chain. It is aimed at helping students to view an acquisition chain globally in an intuitive way. More precisely, it allows the student to:

- understand the main principles of EEG data acquisition;
- build an EEG acquisition chain with a set of modules;
- replace a module with another;
- visualize the signal at any point of the chain;
- observe the impact of any parameter change on the signal.

Electroencephalography is a medical diagnosis technique. The process consists of measuring the biopotentials produced by the upper layers of the brain at various standardized and spatially distributed locations on the skull, as shown in Figure 1.



*Fig 1: The EEG.*

This technique includes:

- the collection of the biopotentials by the electrodes,
- the signal transmission to the electroencephalograph,
- the signal conditioning by the electroencephalograph,
- the signal processing.

The obtained recording, called an electroencephalogram, shows the topography of the electric activity at the surface of the brain. On this signal, there are various important paroxysms related to the EEG: spikes, spikes-and-waves, and fast waves. One of the most important patterns to detect is the spike, which is why we decided to include a spike detection algorithm on the EEG signal recorded by the chain. Other patterns are, however, just as much interesting to detect, like the crisis.

This manual is aimed at giving information about how to use the EEG Virtual Acquisition Chain.

### Downloading the EEG Virtual Acquisition Chain

The EEG Virtual Acquisition Chain can be downloaded at:  
<http://beams.ulb.ac.be/beams/research/all/virtualchain.html>.

LabVIEW (version 7 or later) must be installed to start the EEG Virtual Acquisition Chain. To acquire LabVIEW, please visit [www.ni.com/labview/](http://www.ni.com/labview/).

### EEG Virtual Acquisition Chain organization

The EEG Virtual Acquisition Chain responds to a three level formalism. It permits a clear and modular representation:

- Level 3 is the module assembly layer, corresponding to the hardware chain set-up, that provides the direct representation of the real hardware chain.
- Level 2 is the experimentation layer that evaluates the signal quality at each modules output.
- Level 1 is the module layer that defines the module behavior. The operations at level 1 consist of modeling the behavior for a module.

The EEG Virtual Acquisition Chain starts at Level 3. The primary module is “EEG VIRTUAL CHAIN LEVEL 3.vi” and is the only one belonging to Level 3. Click on the file to launch LabVIEW and load the VI. Then press Ctrl + E to see the chain implementation (see Figure 2).

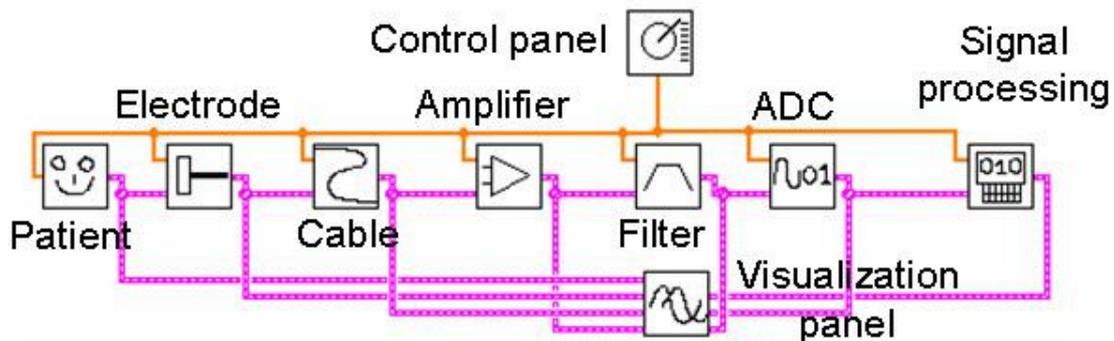


Fig. 2: Level 3 acquisition chain.

Level 3 is comprised of Level 2 modules representing the different stages of the chain, in addition to the signal that is running through the chain (see Figure 3).

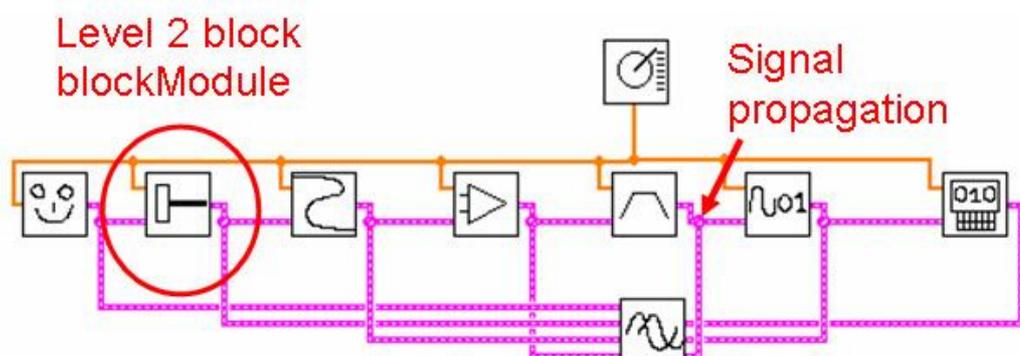


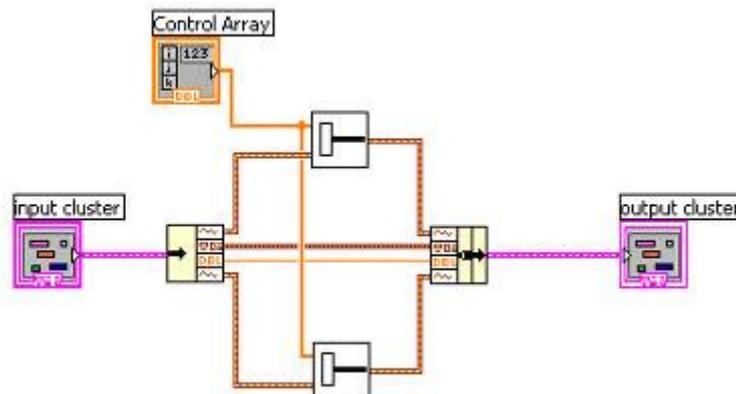
Fig. 3: Level 3 acquisition chain.

The chain is comprised of:

- the patient/EEG signal generator, realizing the role of the source;
- the electrode, realizing the role of a transducer (transforming ionic current in the patient's scalp to electric current);
- the cable, transmitting the signal to the rest of the acquisition chain (often subject to ambient 50Hz hum);
- the amplifier;
- the filter;
- the sample and hold and the ADC;
- the computer which processes the signal. The signal processing selected is aimed at revealing the intrinsic characteristic of the spikes, making them clearly appear from the background EEG.

Two additional modules are present. On top of the chain stands the control panel where all the chain characteristics can be adjusted. On the bottom stands the visualization panel where the signal can be followed on the chain. Those two modules are described later in this manual.

Each Level 2 module can be accessed by clicking on it. Clicking on a module and then pressing Ctrl + E leads to an implementation similar to the acquisition chain shown in Figure 4.



*Fig. 4: Level 2 acquisition chain.*

The signal running through Level 3 is actually comprised of two signals in Level 2 modules. This is because each Level 2 module compares two signals at each point of the chain: one corresponds to the ideal signal (the one that is generated by an ideal chain) and the second correspond to the non-ideal signal (the one that is generated by a chain with imperfection modeled). This is illustrated on Figure 5.

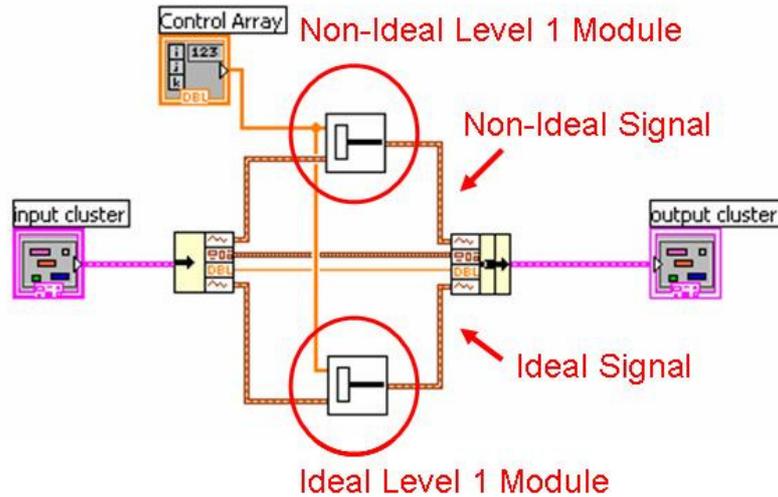


Fig. 5: Level 2 acquisition chain.

This way, two complete acquisition chains are actually modeled (one ideal and the other non-ideal) and the signals of those two chains are compared at each Level 2 module. Other comparisons could have been made, including but not limited to local comparison, signal quality measurement comparison, and noise measurement module.

On the top left of the figure stands the Control Array that is connected to the Control Panel, which allows for the adjustment of the characteristics for the Level 1 modules.

Each Level 1 module can be accessed by clicking on it. Clicking on a module and then pressing Ctrl + E leads to an implementation like the one of Figure 6.

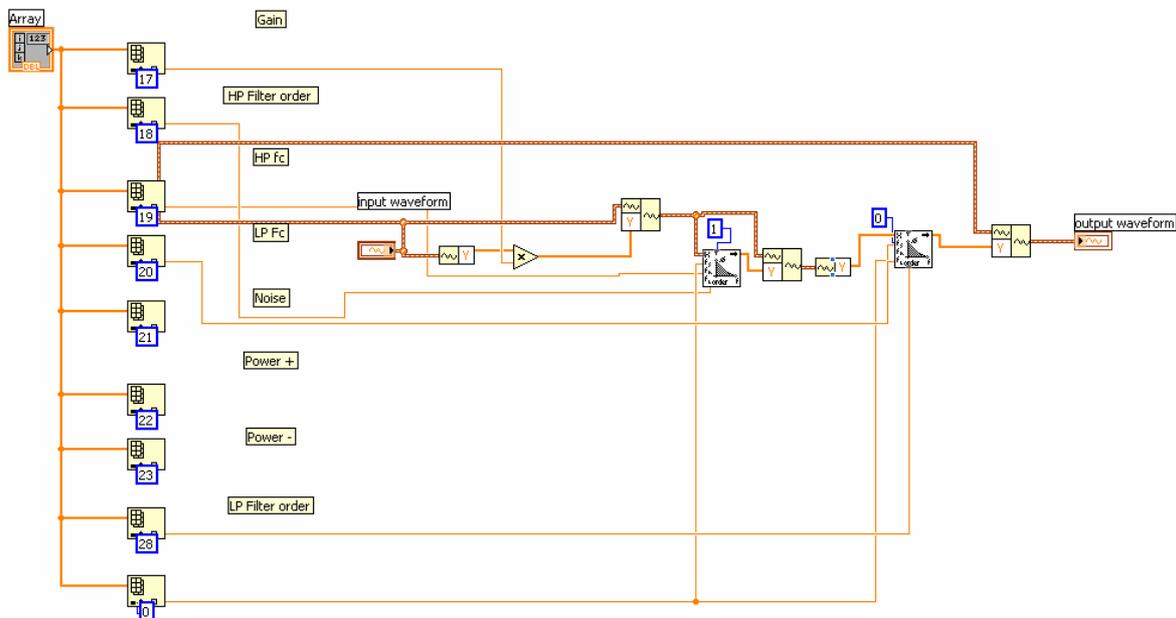


Fig. 6: Level 1 acquisition chain.

The behavior of the chain is modeled at Level 1.

### Starting the EEG Virtual Acquisition Chain

To start the chain, go to the Level 3 module and click on the ‘running continuously’ button.

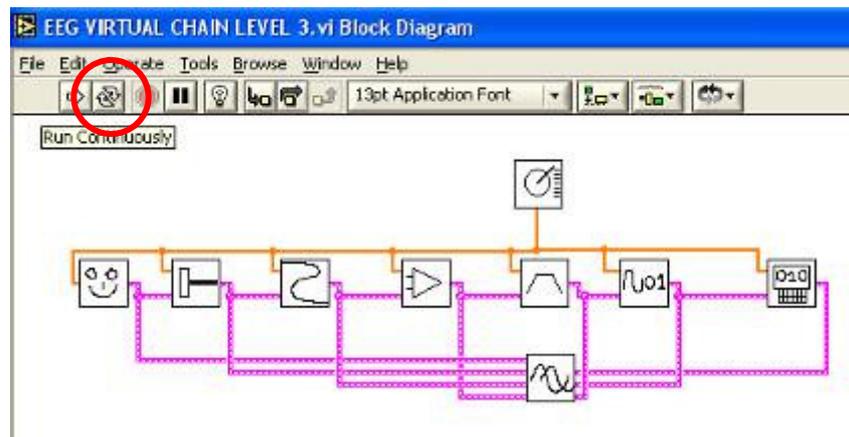


Fig. 7: Starting the acquisition chain.

Now, that the chain is running, the user can follow the signal anywhere on the chain by clicking on the different wires of the modules. There is a more convenient way to control and visualize the whole chain at once: using the control panel and the visualization panel. This will be explained in the two next paragraphs.

### Following the signal through the chain

The signal can be followed thanks to the visualization panel (see Figure 8).

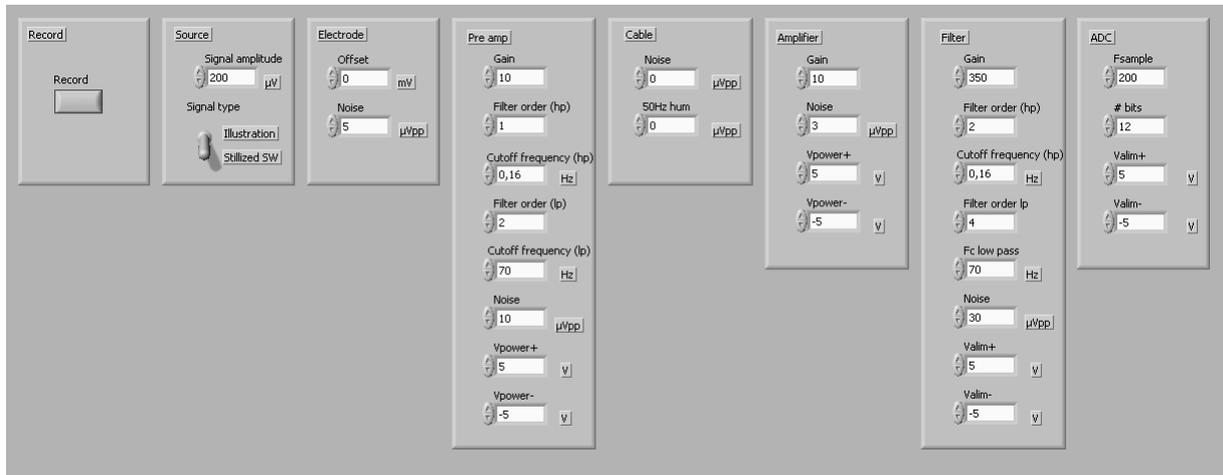


Fig.8: Visualization panel.

On the bottom of the screen, the ideal signal and the non-ideal modules are present on two plots. On the top right of the screen, the main signal quality indicators (like the standard deviation of the noise or the SNR of the signal) are displayed. On the top left of the screen, the acquisition chain stage to be visualized can be selected.

### ***Changing the characteristics of the chain***

The chain characteristics can be changed thanks to the control panel (see Figure 9).



*Fig.9: Control panel*

The first frame is the 'record' frame, where it is possible to record the signal. When the button is pushed, two files are added in the main folder: IdealSig.txt and NonIdealSig.txt (respectively the recording of the ideal and non-ideal signals), which are sampled at 1 kHz.

The second frame is the 'source' frame. On the top, the signal amplitude can be adjusted. On the bottom, the signal type can be chosen. The first choice is an illustration of a real EEG signal recording. The second one is train of stylized spike-and-wave (a typical pattern in EEG).

The next six frames correspond to the chain modules. In each frame, some imperfections or specifications can be adjusted.

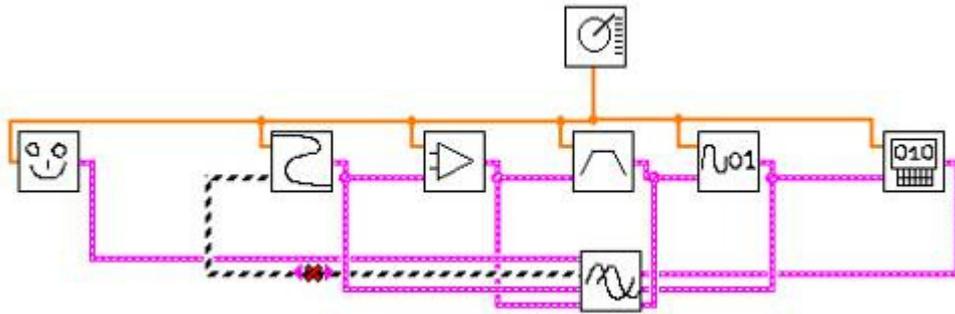
The pre-amp module, however, is an optional module and is not included in the default chain. The following paragraph describes how to replace the traditional electrode module by the active electrode module which combines the electrode and the pre amp.

### ***Changing a module of the chain***

Each module can be replaced by another, which allows comparing the difference in signal quality that this change produces.

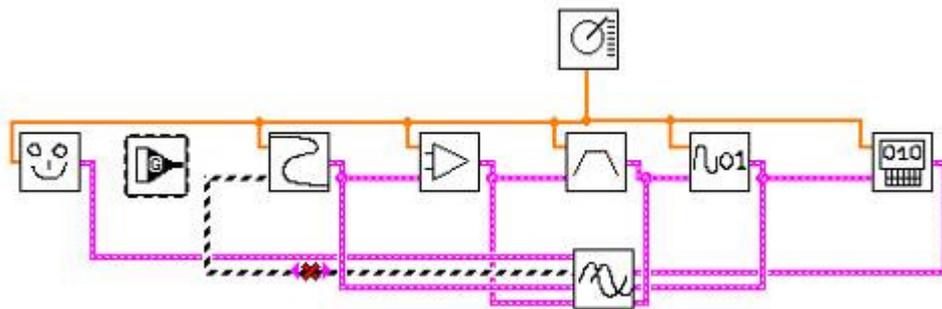
In this paragraph, the example chosen is the use of the active electrode that can replace the traditional passive electrode. The active electrode minimizes the electrode impedance and increases the power of the signal before it passes through the leads, thereby improving the signal quality of the EEG chain.

To delete the electrode module, go to Level 3 module, click on the electrode module and then press delete. The chain should now look similar to Figure 10.



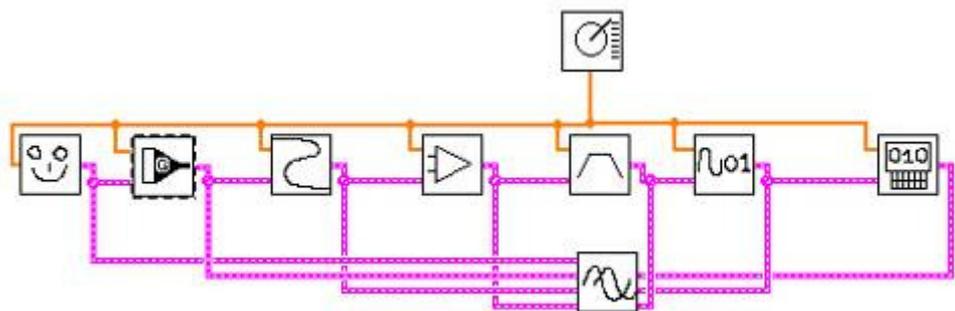
*Fig.10: Changing a module*

Now, click on the “Active Electrode Level 2.vi” icon and drag and drop the symbol on the top left of the screen to the acquisition chain. It should now look like this:



*Fig.11: Changing a module*

By placing the mouse on the symbol, the three terminals appear. Click on each of them to connect them to their corresponding signal inputs/outputs (see Figure 12).



*Fig.12: Changing a module*

The chain is now fitted with active electrodes. Click on the ‘running continuously’ button and compare the changes in the signal quality with the previous chain.