I-CUBEX

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BioVolt User Guide

Warning

The BioVolt sensor is to be used only with extreme caution according to the instructions below. It is intended for research purposes only and not intended for any medical purposes whatsoever.

1. The BioVolt sensor must only be plugged into a battery powered, wireless I-CubeX digitizer (eg. the Wi-microDig or Wi-miniDig) manufactured by Infusion Systems and not any other digitizer.
2. The BioVolt sensor must only be connected as shown in the diagram on the wireless digitizer.
3. The wireless digitizer used with the BioVolt sensor must only be powered by a common 9V battery as used in consumer goods or an I-CubeX BatteryPack.
4. Only I-CubeX sensors may be connected to the wireless digitizer that is used for interfacing the BioVolt.
5. When using the BioVolt sensor, I-CubeX products may not be connected in any way to the electrical power grid or any other high voltage source.

Any violation of these instructions nullifies any warranty (express or implied) and nullifies any liability or culpability (express or implied) of Infusion Systems Ltd.. Any violation of these instructions can result in electrocution, severe injury, or even death.

Using the sensor with the Wi-microSystem not only ensures electrically safe operation but also enables you to use the sensor without being tethered to your computer or MIDI device.

Introduction

The BioVolt headband is a sophisticated bioelectric signal acquisition device that is designed to capture three types of signals:

- Brainwave **EEG**
- Eye motion **EOG**
- Muscle **EMG**

BioVolt converts these signals into a form usable by a computer for interactive applications.

The **EEG** is an AC signal that is generated by brain activity and is captured by sensors on the scalp, forehead, or mastoid (behind the ear) areas. The following trace shows a burst of 10Hz alpha wave activity that is generated by a few seconds of eye closure. Alpha usually appears in the EEG as a sinusoidal burst with a center frequency at about 10 Hz, and at much greater amplitude than the continuous background beta wave activity. Alpha is one of the brain wave frequencies that can be generated intentionally and is therefore useful for interactive biocontroller applications.
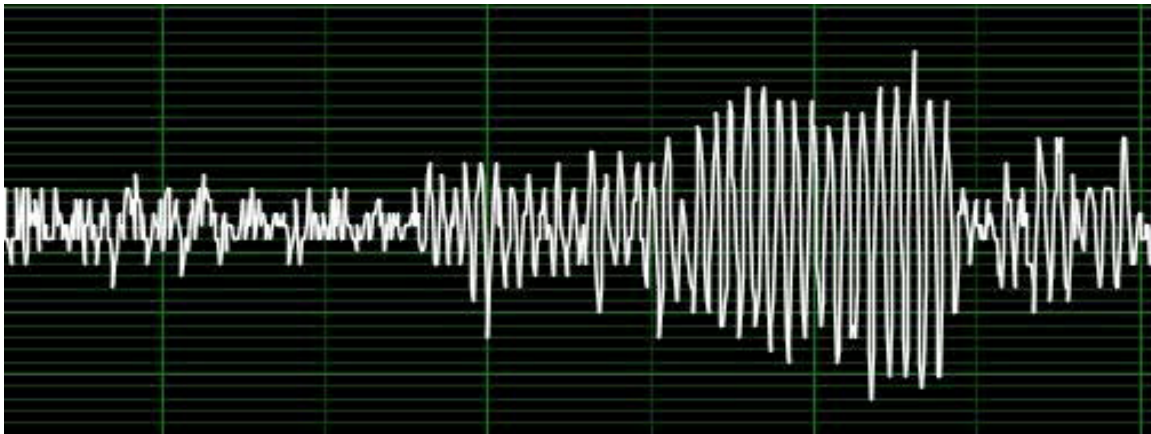
The **EOG** is a DC signal that is generated by the eye and changes polarity with the direction of eye motion. The trace below shows the EOG signals generated as a result of horizontal eye movements: left, center, right, center, left, center, etc. Notice how the polarity of the deflection changes direction with left and right glance. BioVolt makes EOG available for biocontroller MIDI applications such as panning the auditorium sound from side to side simply by shifting your gaze.
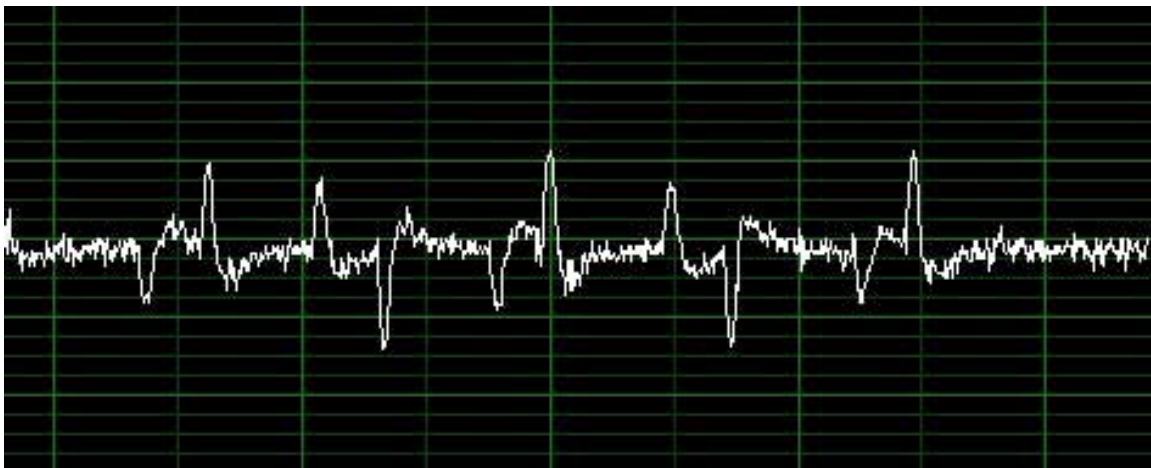
The **EMG** is an AC signal that is generated as a result of muscle contraction. The figure below shows the actual EMG signal generated from the BioVolt (worn on your forehead) when the user does a brief jaw clench. This EMG, generated by the temporalis muscles, produces a large signal from the forehead sensors of the BioVolt. Like the BioFlex, the BioVolt EMG can be used for a variety of interactive applications.
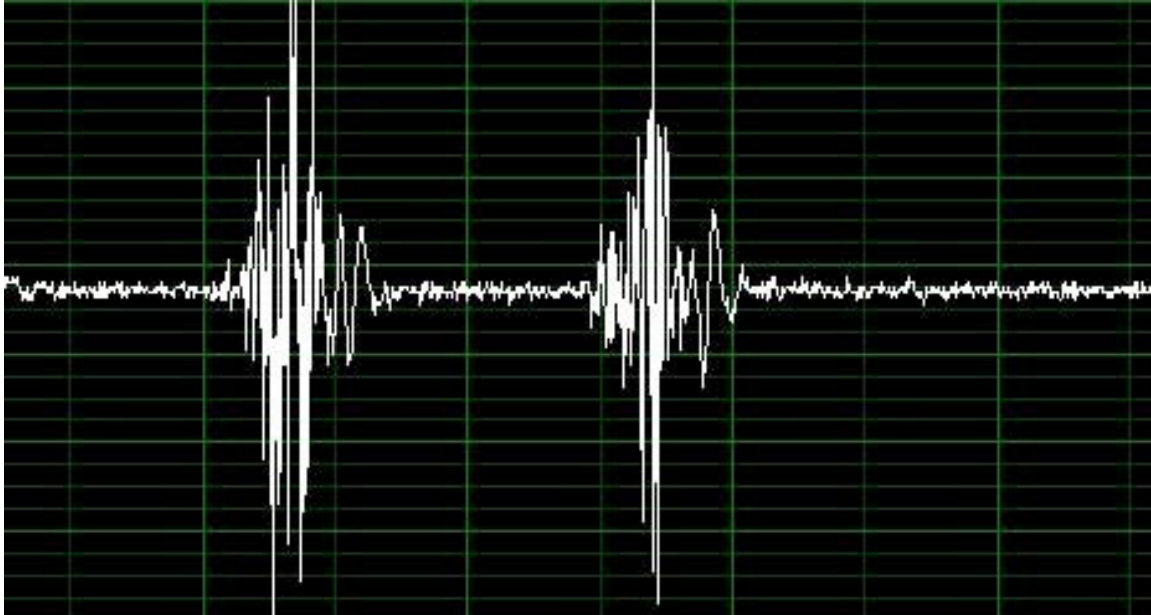
BioVolt set-up

The BioVolt headband is designed to hold the blue sensor module in place on the forehead. You can also rotate the headband to place the sensors on the back or side of the head. The sensor module has 3 gold sensor contacts that are designed to capture EEG, EOG, and EMG – and each of these signals requires slightly different use of the headband.

Sensor contact adjustment – The gold sensor contacts work for most people with simple skin contact. Your skin should be clean and free of oily substances such as suntan lotion. Some users have very dry skin and this can make it difficult for the sensor contacts to capture a good signal. Users with very dry skin will get better BioVolt operation by putting a little tap water on the skin where you will wear the unit, dry off the excess water and then apply the sensor band.

The band includes a 1 meter cable with a connector that plugs into the Wi-microDig unit. This allows the Wi-microDig unit to be worn at a distance from the band (e.g. on the belt) and allows freedom of motion.

BioVolt use

The band has a Velcro strips on both ends that allow for adjusting the fit of the band around the head. The easiest way to put on the headband is to hold the band so that you are looking at the 3 gold sensor contacts. Then bring the band up to your forehead and position the center electrode above your nose. Then wrap the band around your head and secure the Velcro ends together.

<u>BioVolt Max patch</u>

To start enjoying your BioVolt - position the band as shown in this photo. Check to be sure that all 3 sensor contacts are making good contact on your forehead. Each head has slightly different contours and you may have to move the band up or down on your forehead to get 3 good contacts.

Assuming that you have already verified that your Wi-microDig is functioning with an input device using the I-CubeX Editor, now:

- launch the BioVolt Max patch
- plug your BioVolt into the Wi-microDig
- connect the Wi-microDig battery
- note that the red pilot light is lit

With the BioVolt screen in view, first establish a connection with the Wi-microDig. Next, verify that the "min" and "max" sliders on the left of the screen are set to 0 and 511 respectively.
To activate the patch, click on the On/Off box at the upper left. Sometimes it is necessary to toggle between Reset and On/Off in order to start the program.
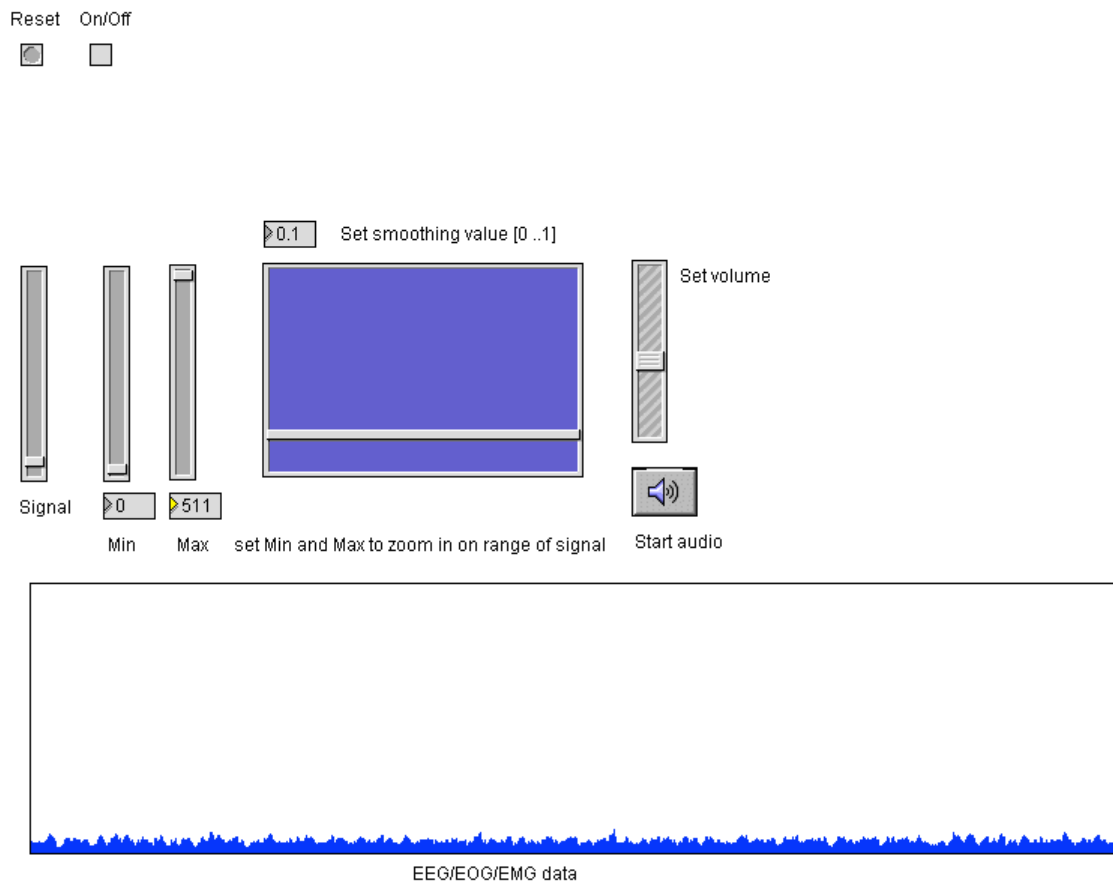
Once the program is running, you will see the data trace scrolling across the "EEG/EOG/EMG data" window.
If your BioVolt is making good contact with the skin, the trace will look like the figure above with low baseline activity. This trace is actually showing the continuous "background" brainwave activity – known as beta activity.

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If your BioVolt is not fitted properly and one of the sensor contacts is not touching the skin, you will see high baseline activity scrolling across the window. If this happens you need to adjust the BioVolt to make sure that all sensor contacts touch the skin.
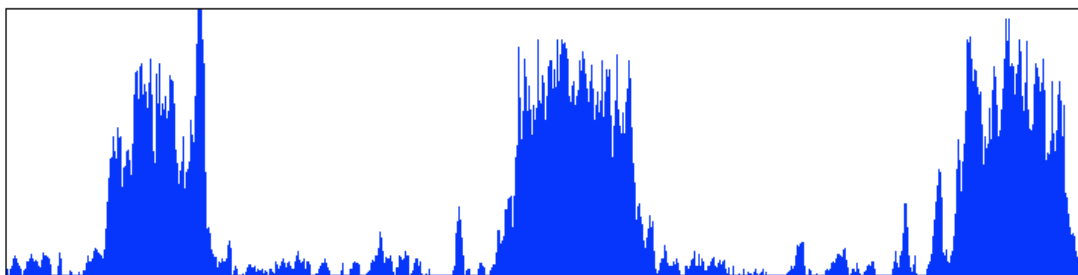
BioVolt EMG

Now that you are running with a good low noise baseline with your BioVolt, try lightly clenching your jaw muscles by squeezing your teeth together. Each time you make the jaw "gesture" the display will create a "mountain" trace. This is the EMG signal generated by the temporalis muscles located on the sides of your head. This trace looks quite different than the raw data trace shown at the beginning of this document – because it is a summation or envelope display that is showing the total energy from EMG data. In the screen shown below, the min and max sliders have been adjusted to lower the baseline and raise the peak amplitude, so that the EMG signal fills the display window. Try adjusting the min and max sliders yourself to see the effect on the data display.

BioVolt EOG

Now that you are familiar with the BioVolt EMG, you can modify the display to view other types of data as well. To view the eye motion EOG signal set the min at 30 and the max at 300. You may want to adjust these values a bit, but this is a good starting place for looking at EOG. As we saw from the EOG raw data trace at the beginning of this document, left and right eye movements produce deflections of opposite polarity. The trace below shows example EOG data with the summation display. Notice that left and right eye glances do not produce the same signal. Depending on the placement of the BioVolt headband, the left and right signals may not be symmetrical.

This is a good time to experiment with the MIDI audio. The MIDI algorithm included in this patch maps signal amplitude to note number. Click on the "Start audio" button and you can listen to your eye movements. This is a great feature, since you cannot look at the screen while you are scanning your vision from side to side. Note that your right eye glance sounds different than your left glance. There is more to glance and visual object tracking than meets the eye (excuse the pun), and you can learn a lot about your own eye movements by listening to them.
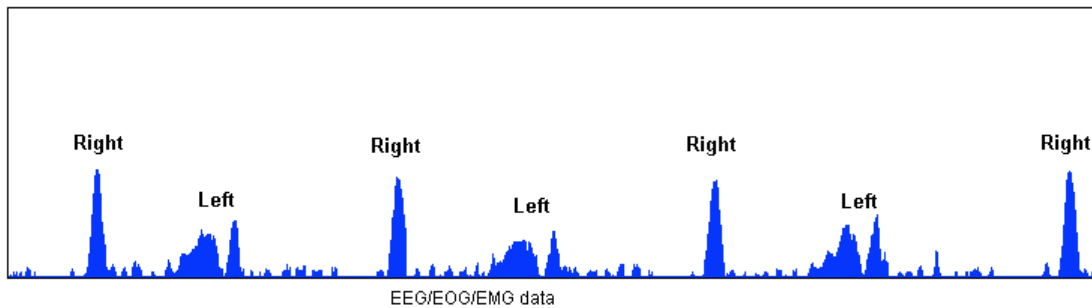
BioVolt EEG

In order to see an EEG signal that is controllable we need to make a headband adjustment. The big alpha signal burst that is shown in the first figure of this document was made with the BioVolt sensors placed on the *back* of the head. For most users the alpha response is not visible using forehead sensors. Alpha is mostly generated from the back of the brain and the forehead is too far away to pick up a good signal. So go ahead and position the BioVolt so that all 3 sensors are on the back of your head. You can loosen the Velcro and just rotate the band 180 degrees and then tighten the Velcro strips on your forehead.

Now you need to get the hair wet between each sensor contact and the scalp. The best way to do this is to put some tap water in a small squeeze bottle and drip a small amount of water into the hair under each sensor contact. Also, maybe get a friend to do this for you – they can see the back of your head better than you can. Don't use too much water – you do not want the sensors to short together – that will eliminate the input signal.

Once the BioVolt is in place and your sensors are moistened, start your BioVolt patch and check to see that you have a good low noise baseline as shown below. If you have a lot of noise on your display it means that one or more of your sensors are not getting signal through the hair.
By the way if you have little or no hair you'll have no problem getting a good signal.
The other display condition that you may encounter is a flat line – no signal at all. This means you have used too much water and the sensor contacts are shorted together. In this case, you need to remove the BioVolt, dry your hair, and start over.

OK, time to see some alpha. Most people generate alpha waves in response to darkness. The easiest way to get a darkness response is with eye closure.

EEG/EOG/EMG data
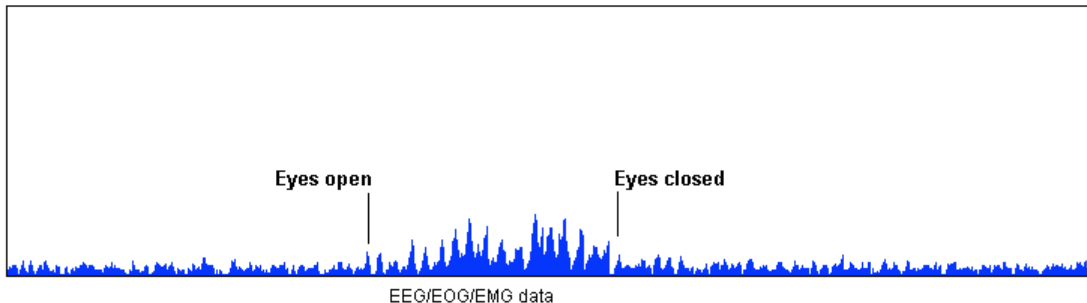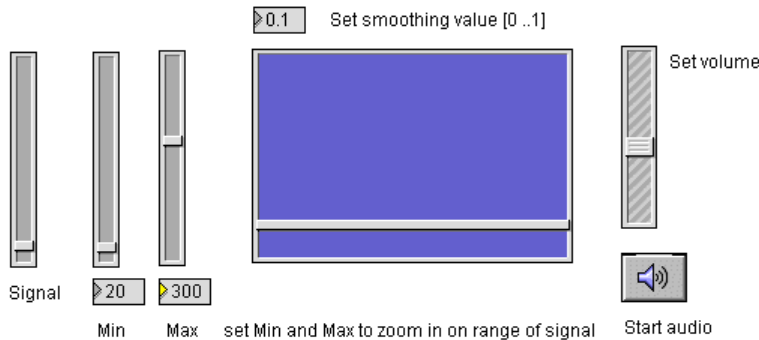
With your min and max sliders set at 20 and 300 respectively, you should be able to see your alpha response pop up above the background beta wave activity – as shown in the example screen above. Everyone has a different alpha response. Some people have a very large amplitude response – like the one shown at the beginning of this document. Other people have a very small amplitude response. The above data display is only showing signal amplitude. In the next version of the BioVolt Max patch we will include an alpha detector that operates in the frequency domain. That version will detect alpha activity even at low amplitude.

The following screen shows other examples of alpha activity. Notice that the amplitude changes during the course of eye closure. You can see that alpha comes in bursts – it is not a continuous brain wave state.

This is a good time to activate your audio patch. Click on the "Start audio" button and listen to your alpha activity come and go with your eyes closed.

Enjoy.

Reset   On/Off

> 0.1   Set smoothing value [0 ..1]

Set volume

Signal   > 20   > 300

Min   Max   set Min and Max to zoom in on range of signal   Start audio

Eyes open   Eyes closed   Eyes open   Eyes closed

EEG/EOG/EMG data