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About the NIC User Manual

The NIC User Manual belongs to the Part III of the Neuroelectrics User Manual v2.0.

Before you first use the Starstim system, you should read the three parts of the Neuroelectrics User Manual. The Starstim User Manual does not discard the need of reading the Electrode and NIC parts.

The Neuroelectrics User Manual v2.0 includes three parts:
- **Part I**: Enobio User Manual or Starstim User Manual
- **Part II**: Electrode User Manual
- **Part III**: NIC User Manual

The PDF version of all parts of the Neuroelectrics User Manual can be found under the Documentation section of Neuroelectrics webpage:
www.neuroelectrics.com/documentation
## Change of Record

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<th>Author</th>
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<td>1.0</td>
<td>14/02/2012</td>
<td>First version</td>
<td>Guillem Mitjà</td>
</tr>
<tr>
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<td>18/02/2016</td>
<td>Neuroelectrics User Manual divided in three parts: (1) Enobio / Starstim, (2) Electrode and (3) NIC.</td>
<td>Miguel Mendes</td>
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I. What is NIC?

NIC stands for Neuroelectrics Instrument Controller. NIC is the software required to pair with the Neuroelectrics devices, like Enobio and Starstim. It has a user-friendly interface packed full of features.

**NIC is a platform full of capabilities:**
- Control Neuroelectrics devices via Bluetooth®
- Manage and record EEG sessions
- Stream data over the network
- Receive network triggers
- Visualize EEG features online: raw or filtered data and spectral power scalp maps
- Set up and launch multi-electrode stimulation protocols
- Visualize the electric field on the cerebral cortex that results from the stimulation currents

**System Requirements:**
- OS compatibility: Windows (Vista / 7 / 8 /10) and Mac OS X (Snow Leopard or above)
- Processor: 1.3 GHz (minimum)
- RAM: 2 GB (minimum)
- Bluetooth®: 3.0 or 2.1
II. How to get started

II.1 Install NIC

NIC software installer file can be found on the USB stick included with Enobio and Starstim packages. Alternatively, the latest version of the software may be downloaded directly from the Downloads section on the Neuroelectrics webpage: http://www.neuroelectrics.com/downloads.

You should choose the installer file according to the operating system, Windows or MAC OS X, of the computer where the software is intended to run.

To install NIC, you just need to run the installer file. The installation should not take longer than one minute.
II.2 Launch NIC

When NIC is launched for the first time, you are automatically asked to select the Neuroelectrics device you want NIC to pair with. At this step, you should first switch on the necbox using its power switch, and then make sure that the Bluetooth® port of the computer is switched on, too. Afterwards, press the Scan button to search for devices, select your device from the list of devices and press the Select device button. Now NIC is ready to be used!

For further information on how to pair your device with NIC, read pages 12-13.

II.3 General Principles

- NIC can communicate with different Neuroelectrics devices. Its appearance is automatically modified according to the device it pairs with.
- NIC has been designed to provide online information on EEG. EEG data may be filtered for visualization purposes, but it is saved in raw format. Exceptionally, filtered data may be saved if the line noise filter is applied.
- Software LED’s display either orange or grey colors; on and off positions, respectively.
- NIC buttons can be either dark grey or light grey. When the button has been clicked on, it is dark grey.
- During stimulation with Starstim (tCS), NIC needs to maintain continuous bluetooth communication with the device. If communication is lost, the stimulation is automatically aborted.
- When EEG has been recorded during tDCS, the EEG data is affected by an offset, but no extra noise is added. The EEG amplifiers do not saturate due to the 24-bit digitization.
- NIC is constantly evolving and new features will be added in the next versions.
II.4
Graphical User Interface

NIC is a platform with a structured user interface (UI), which is divided in tabs and panes:

- Tabs are displayed on the horizontal top navigation bar (e.g. EEG Setup, EEG Analysis, Stimulation, Settings)
- Panes appear on the vertical left navigation bar

NIC displays more or less tabs according to the type of device that is paired with, and the available panes differ from tab to tab. NIC platform has the following user interface elements that are common among all or most tabs:

1. Navigation Tabs
2. Navigations Panes
3. Device identifier: Enobio or Starstim.
4. Bluetooth LED: off when device is not paired; blinking when the connection is unstable, on when paired.
5. Battery level indicator: indicates the percentage of battery charged (with a built-in "reserve" margin).
6. Signal monitoring pane: can be turn on-off to track the streamed EEG signals
7. Signal recording pane: displays elapsed and remaining time
8. TCP/IP streaming pane: shows the server address and connected clients.

9. NIC platform allows the user to define visualization filters. As the name suggests, the filters are only used for visualisation purposes, the recorded data will remain raw, unless the line noise filter is activated.

These filters allow the user to visualise each one of the bands or to customize one specific visualisation band.

Warning: Enobio and Starstim sample EEG signal at 500 SPS. In order to visualize the signals properly, the signal is filtered at high frequencies depending on the screen resolution and the temporal window selected. This can reduce the amplitude of the visualization of the high frequency signals.
NIC Graphical User Interface (GUI)
When launched, NIC always tries to pair with the last device it was paired with. To pair with another device, you should go to the **Settings / Bluetooth** pane, and follow the next steps:

1. Switch the necbox device and the Bluetooth® port of the computer on.
2. Press the **Scan** button and wait until your device identification appears on NIC. Make sure that you select the correct device by confirming its unique MAC address. The MAC address can be found on the upper label of the necbox. Once NIC displays your device identification, double click on it, or select it and press the **Select device** button.
3. NIC GUI will reconfigure according to the type of device. The Bluetooth® LED will become steady and orange, and you will see the battery percentage of the device. After a few synchronizing seconds, the device will be ready to be used!

This process is only needed once. NIC will automatically pair with your device, unless you use more than one Neuroelectrics device with the same computer.

When paired with Enobio 20 or Enobio 32, NIC shows an additional button, identified as **Use as Enobio 8**. When selecting this option the Enobio must be use with the 10 electrode cable NE017, and the 8 electrode positions may be freely chosen.

III. Pair NIC with your device
Tab: Settings  /  Pane: Bluetooth

**Bluetooth Devices:**
- NE-ENOBIOS (00:07:80:31:D0:78)
- NE-ENOBIOS32 (00:07:80:31:D0:73)
- NE-ENOBIOS20 (00:07:80:31:D0:7C)
- NE-ENOBIOS8 (00:07:80:31:D0:78)

**Options:**
- Select device
- Scan

**Battery:** 34%

**Signal Monitoring:** OFF

**Record:**
- Elapsed Time: 00:00:00
- Remaining Time: 00:00:00
- Record ID: Patient01_Test01
- File:

**TCP Server:**
- Server: 192.168.11.113:1234
- Clients:
IV. EEG Monitoring

In the EEG Setup / Time Domain pane, you may start monitoring EEG and customize the visualization window. Check page 36 to obtain further information about the recorded EEG files.

1 Choose the reference channel for visualization. For instance, if channel Fz is selected, its data will be subtracted from the data of all channels, including Fz (which will become zero). Note that the recorded data is always referenced to the CMS channel, as displayed when “None” is selected, independently on the reference channel chosen.

2 Data is plotted with the Neuroelectrics’ orange color for all the EEG channels used. The position of the channels of Enobio 8 can be freely chosen on the Placement pane, while the position list is pre-defined for Enobio 20 and Enobio 32. If stimulation is taking place, purple is used for the stimulation channels which are conventionally set to zero.

3 It is possible to visualize the 3-axial accelerometer data (mm/s²). To activate this, go to the Advanced / Settings tab.

4 Select the temporal visualization window span using the zoom-in/out buttons. The horizontal time scale is changed accordingly.

5 To define the Voltage vertical scale, unclick the Auto option and use the zoom-in and zoom-out buttons. If the Auto option is selected, the scale adjusts along the time, according to the voltage amplitude of the channels.

6 Each EEG channel has a button and a quality indicator LED. By clicking on the button, you disable the channel, which will stop being plotted. Click on the button again, to enable it again. By placing the cursor above the LED, the signal quality parameters are displayed, and, in bold, the parameter that affects the signal quality the most is identified. For further information about the signal quality, read page 16.
Tab: EEG Setup / Pane: Time Domain
Before recording any EEG data, the quality of the monitored signal should be checked to ensure the correct recording. The quality signal comprises four parameters: drift, offset, line noise (EU: 50±1 Hz; US: 60±1 Hz) and main noise. During EEG monitoring, the channels become green (0.0 - 0.5), orange (0.5 - 0.8) or red (0.8 - 1.0), according to the value of the quality indicator.

The quality indicator is meant to be used as a guidance, so it does not need to be taken very strictly; visual inspection of the EEG signal is equally important. If the signal looks good and the quality indicator is orange/green, you may move forward with the experiment. If the indicator becomes red at some point, there is no need to immediately stop recording.

**How to improve the signal quality**

First visually inspect the signal and wait until it becomes orange or green again. If that does not happen, several reasons may explain that:

(a) the electrode gel is not enough, (b) the reference electrodes are not properly placed, or (c) the electrode has reached the end of its lifetime. Sometimes, the reason is external, like the strong line noise, but it does not mean that the EEG recording is really bad.

**Warning:** The signal quality indicator is not an impedance check. The impedance check feature is not available for Enobio, only with Starstim.

**Electrode replacement**

The EEG establishes a good redox reaction on the contact surface between the electrode and the scalp. The signal recorded might have a large DC drift, which should be avoided because it affects the results.

If the signal quality shows an increased drift or noise, the electrode might be at the end of its life and needing to be replaced. The picture on the right shows the signal acquired using a noisy electrode.
IV.2
Electrode Placement & Quality Indicator

1 With Enobio 8, the channels can be assigned to any position of the headcap, and a default montage can be defined. You should confirm and change the position of the electrodes, as well as the corresponding channels.

On the other side, if you are using Enobio 20 or Enobio 32, the 20 or 32 electrode positions and corresponding channels, are predefined and it is not possible to change them in NIC. Obviously, you are free to use the channels with positions that are not in the predefined position list, but you should bear that in mind when analyzing your data.

Enobio 20/32 Channels & Positions

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>1 P7</td>
<td>9 T8</td>
<td>17 Fp1</td>
<td>25 CP6</td>
</tr>
<tr>
<td>2 P4</td>
<td>10 F8</td>
<td>18 T7</td>
<td>26 CP2</td>
</tr>
<tr>
<td>3 Cz</td>
<td>11 C4</td>
<td>19 F7</td>
<td>27 CP1</td>
</tr>
<tr>
<td>4 Pz</td>
<td>12 F4</td>
<td>20 EXT</td>
<td>28 CP5</td>
</tr>
<tr>
<td>5 P3</td>
<td>13 Fp2</td>
<td>21 PO4</td>
<td>29 FC1</td>
</tr>
<tr>
<td>6 P8</td>
<td>14 Fz</td>
<td>22 FC6</td>
<td>30 FC5</td>
</tr>
<tr>
<td>7 O1</td>
<td>15 C3</td>
<td>23 FC2</td>
<td>31 AF3</td>
</tr>
<tr>
<td>8 O2</td>
<td>16 F3</td>
<td>24 AF4</td>
<td>32 PO3</td>
</tr>
</tbody>
</table>

2 Within the Placement pane, by placing the cursor above any used position, you may also check the quality parameters of each signal. The three possible colors are green, orange or red, corresponding to the values of the quality indicator as explained in page 16.
Tab: EEG Setup / Pane: Placement

* The EEG Setup / Placement pane is available only with Enobio

Drift: -0.358 uV/s
Offset: -0.2 mV
Line noise level: 19.9 uV
Main noise level: 14.5 uV
Quality value: 0.20

Set as Default
IV.3
EEG Settings

The **Settings** pane allows you to modify a few parameters regarding the way the files with the recorded EEG data are saved. In this pane it is also possible to define up to 9 markers that can be used to tag and identify time instants when some specific event has occurred. Finally, you can set the layer names related to the LSL connection.

1. Choose the file format of the EEG recorded data. It may be recorded as an internal NIC file format (*.nedf), as a binary file (*.edf) or as a plain text file (*.easy). Read pages 38-40 for further information on NIC file formats. If you intend to do an offline EEG recording, select the **record in SD card** option and insert a microSD card on the corresponding slot. In this case, after the EEG recording session has started, NIC may be switched off.

2. Choose the ID of the file and the directory where it should be saved. The file name will contain the time stamp when the recording starts and the file ID. If you do not define the **Duration of recording**, then the EEG recording will continue until you press the **Stop** button in the **Time Domain** pane.

3. The markers are an optional feature provided by NIC. You can assign the 1 to 9 keyboard keys to specific actions. During the recording, each time an action occurs, you press the corresponding key. The markers information is also stored in the saved file.

4. This option allows you to include the markers information within the TCP streaming (page 41).

5. Here you can name the LSL streaming layers to receive triggers from a ERP software or to stream markers to another NIC. The LSL connection LED becomes **orange** when the outlet is connected and **green** when the trigger is received (pages 42-43).
In the EEG Analysis tab, you may find a variety of tools that allow the online visualization of the data that is being recorded. Similarly to the EEG Setup tab, the visualization filters can be defined and the temporal scales can be modified. Additionally, the Fast Fourier Transform (FFT) or the Power Spectral Density (PSD) computing, need a predefined time window duration (1, 2 or 4 seconds) that can be chosen by the user. Note that the channel data displayed in this tab is always referenced to the channel chosen as the reference in the EEG Setup/Time Domain pane.

**Spectrum Pane**

1. It is possible to visualize the FFT or the PSD spectrum of a specific channel, simultaneously with the voltage signal.

**Spectrogram Pane**

2. The power spectrogram displays the online frequency contents of the signal as a function of time. The colormap may be defined by the user.

**Features Pane**

3. This pane allows the user to analyse the data according to the common EEG bands. The power of each of the five bands is displayed, and the power evolution over time of the chosen bar as well. The user can also analyze the data using a customized band, or even observe ratios between different bands.

**Scalp Map Pane**

4. The power of the chosen band is displayed in real-time and in the corresponding position of the scalp. Use the cursor to change the head model position and click on it to make it stop spinning.
Tab: EEG Analysis

1. Spectrum pane
   - Spectrum Analysis Configuration
   - Channel: P1
   - Frequency (Hz)
   - Time (Sec)

2. Spectrogram pane
   - Spectrogram Configuration
   - Channel: C3
   - Frequency (Hz)
   - Time (Sec)

3. Features pane
   - Band Power Features Configuration
   - Channel: P1
   - Delta (0-4)
   - Time (Sec)

4. Scalp Map pane
   - Scalp Map Configuration
   - Band Feature (Hz): Delta [0-4]
   - Time Window (Sec)
V.1
For Experts

**PSD Calculation**
Data is stored in a one second FIFO buffer for a given electrodes selected by the user. Every 100 ms the FFT is computed over this buffer. The FFT is calculated unilaterally over fixed or floating point temporal windows. The buffered signal is detrended and multiplied by a Hamming window prior the FFT. To calculate the PSD, the complex power of two of the fourier coefficients is computed and each one is divided by the buffer length.

**PSD Representation**
The spectrogram delivers every 0.1 seconds the PSD coefficients of the last temporal window evaluated. The 1-second window with 0.9-second overlap is used to compute the FFT delivering its coefficients with a resolution of 1 Hz.

The PSD representation graph plots the average of the coefficients obtained over the last N seconds defined by the user (N = 1, 2, or 4). Everytime a new PSD calculation arrives (10 times per second), the graph is updated. The average of the coefficients, corresponding for the frequencies ranging from 0 to 50 Hz over the last N seconds, is calculated and plotted in the PSD representation graph.

**Visualization Filters**
The filters used are finite impulse response filters (FIR) order 500 (1 second) and the minimum bandpass allowed is 3 Hz. Both low and band pass FIR filters have been implemented. FIR filters need more coefficients than infinite response filters (IIR) and, therefore they introduce more delay, but they have been chosen because: (a) they do not introduce phase distortion or delay, (b) they are always stable at any band, (c) they introduce a fixed delay of 0.5 second which is acceptable, and (d) for the minimum bandwidth allowed, 3 Hz, the filter selectivity and attenuation in the band pass has been proven to be very accurate.
VI. Stimulation

The Stimulation tab appears on NIC only when NIC has been paired with Starstim or Starstim tCS devices. In this tab, you can configure the tDCS, tACS, tRNS session, or any linear combination of these three types of stimulation. Optionally, you may also set the Sham (single blind) mode.

The stimulation with Starstim is carried out in three steps. First, you decide the stimulation settings in the Configure pane. Then, you should confirm the electrode montage and electrode contact impedance in the Mount pane. Finally, you launch the stimulation session in the Launch pane.

It is possible to load a stimulation template. It consists of a group of settings that includes the electrode montage, the function and current at each electrode, and the duration of the stimulation session. In the Configure pane you may import and modify a template.

Additionally, you need to specify ramp up and ramp down times, as well as Pre and Pos-stimulation EEG recording times. EEG data may be collected before, during and after stimulation. During the stimulation, only the electrodes not used for stimulation can be used for EEG recording. The EEG features are not available for Starstim tCS.

In the basic configuration, it is not possible to select more than one stimulation electrode. If that is needed, the advanced configuration should be activated. The advanced protocol allows you to define the parameters of the tACS for each electrode independently.

Warning: Starstim limits to 2 mA the current (anodal or cathodal) at any single electrode, and to 4 mA by all the electrodes, at anytime. Starstim will disconnect if impedance is too high at any electrode. Starstim will disconnect if it has lost communication with NIC. NIC requires you to set a stimulation duration, which cannot exceed 1 hour, and it will shut off on completion. These constraints may be altered in the future, as the knowledge regarding tCS grows.
VI.1
Basic Configuration

1. Select a stimulation template of your choice. If you want to use one template that is not on the list you can import a new one as long as it is in the ASCII file format. Alternatively, you may create a new template and save it in the ASCII file format as well.

2. Choose the stimulation type among tDCS, tACS or tRNS. Unlock Edit template, to set your own stimulation parameters. Sham mode (single blind) can be optionally activated.

3. For each channel (up to 8) you can select the scalp position and the type. The electrodes can be used for stimulation (anodal: inject current; or cathodal), for return or even for EEG recording. The stimulation parameters (amplitude, offset and frequency) available depend on the type of the stimulation selected. One return electrode needs to be selected at least, and all the return percentage values should add 100 %. Only one stimulation electrode is possible in the basic mode. For more complex stimulations, press the Advanced Config button (page 29).

4. Define the duration of the ramp up/down times, and of the EEG recording (for all electrodes) before and after the stimulation.

5. You can decide to apply a low/band/high pass filter to the signal when using tRNS. In this situation, you can choose the lower and/or upper cut-off frequencies of the filter.

6. If you choose to save a report, a file is generated. The file will contain the configuration of the stimulation and the electric fields that result from the stimulation.

7. You can choose the duration of the stimulation session (max: 1 hour). The duration time excludes the ramp up/down times.
VI.2 Advanced Configuration

When you switch from basic to advanced configuration, NIC translates the parameters you have already set to the advanced mode. However, this feature does not work when you switch from advanced to basic, in that situation the information is lost.

The advanced mode lets you define the stimulation current per channel as a linear combination of tDCS, tACS and tRNS. For each channel, you may choose the values to be assigned for the following five parameters:

- DC amplitude (Atdcs, µA)
- AC amplitude (Atacs, µA)
- AC frequency (Ftacs, Hz)
- AC phase (Ptacs, °)
- Random noise amplitude (Atrns, µA)

The injected current (I(t), µA) in the corresponding electrode is given by Equation 1, where \( t \) is the time in seconds and RNS is white noise with a unitary variance Gaussian distribution.

\[
I(t) = A_{t\text{dcs}} + A_{t\text{acs}} \sin(2\pi F_{t\text{acs}} t + P_{t\text{acs}}) + A_{t\text{rns}} RNS(t) \quad (\mu A)
\]

Warning: Regardless of the values assigned, the current at any electrode never exceeds 2 mA at any given time.

Warning: For simplicity, the current in the return electrode is set through the current conservation law. Only one electrode can be used as return electrode in the advanced mode.
VI.3 Electrode Montage

In the Mount pane, you can check the electrode montage by confirming the position and the function of each electrode. At this step, it is important that you make sure that the 8 channels of the electrode cable are connected to the electrodes inserted in the corresponding positions of the electrode cap. On the scalp map diagram, the electrode positions are colored according to the function of the corresponding electrode: purple (stimulation), blue (return), or grey (EEG recording). See the example below that refers to the electrode montage shown on the picture of the next page.

Additionally, you should check the impedance of the electrodes used for stimulation and return. The stimulation and return electrodes can be either Sponstim or Pistim (read the Electrode User Manual). Press the Start Impedance Check button and wait for completion. The impedance bars will become green, orange or red. The longer the bar, the higher the impedance is. The three colors correspond to the following impedance intervals:

- **green**: [0 - 10] kΩ
- **orange**: [10 - 15] kΩ
- **red**: [15 - 20] kΩ

If the impedance bar is red, the stimulation should not be launched and you should check the following steps:

- Confirm the reference CMS & DRL channels are properly placed either on the mastoid (Sticktrodes) or on the ear lobe (Earclip).
- Confirm if the electrode-scalp contact is ok (move the hair apart)
- Inject more saline solution (Sponstim) or electrode gel (Pistim) as described in the Electrode User Manual.

<table>
<thead>
<tr>
<th>Function</th>
<th>Position (Channel)</th>
<th>Color</th>
<th>Impedance Check (I.C.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stimulation</td>
<td>Fp1 (1)</td>
<td>purple</td>
<td>yes</td>
</tr>
<tr>
<td>Return</td>
<td>Cz (2) &amp; C4 (3)</td>
<td>blue</td>
<td>yes</td>
</tr>
<tr>
<td>EEG Recording</td>
<td>Fp2 (4) &amp; F3 (5)</td>
<td>grey</td>
<td>no</td>
</tr>
</tbody>
</table>
Tab: Stimulation  /  Pane: Mount
VI.4
Launch Stimulation

In the Launch pane, you monitor the progress of the stimulation while the electrode impedance is continuously checked.

1. The plot displays the EEG (blue) and Stimulation (purple) parts of the session as the time goes on. The grey vertical bar indicates instant where the session is. Between the EEG and Stimulation, it is possible to visualize the ramp up and down times when the stimulation current increases and decreases respectively.

2. The impedance of the stimulation and return electrodes is continuously checked during the whole stimulation session. This way it is possible to know if there is any problem with the electrodes.

3. Press the Launch button to initiate the stimulation session. If for any reason you need to stop immediately the stimulation, press the Abort button and the predefined ramping down will start. Afterwards, if you want, you may resume the session in the same instant where it was stopped by clicking on the Resume button. If the stimulation aborted due to an excessively high electrode impedance or due to communication problems between NIC and Starstim, you may also resume the session after solving the problem.
Tab: Stimulation / Pane: Launch

Stimulating

Stimulation Session: Stimulation tDcs Anodal 500µA Fp1/Cz/C4

Elapsed Time: 00:04:43
Remaining Time: 00:13:17

Electrode Status:

- Impedance
  - 1: 3.2
  - 2: 4.1
  - 3: 4.1

- Current (µA)
  - 1: 244
  - 2: -376
  - 3: -373

- Voltage (V)
  - 1: 2.2
  - 2: 4.1
  - 3: 4.1

Launch | Abort | Resume
VI.5 Electric Field Visualization

In the **Stim View** tab, you may visualize the parameters of the electric field that results from the stimulation montage chosen.

1. These commands allow you to modify the visualization settings. First, you can choose to display the white or grey matter. Secondly, you select the magnitude between voltage and electrical field (magnitude $|E|$, normal $E_n$ or tangential $E_t$ components). The normal component is perpendicular to the brain surface. Finally, you can also choose only one brain hemisphere to be shown, and the automated anatomical labeling (ALL) region to be highlighted. Optionally you may visualise the Influence Map which is particularly interesting in tACS applications.

2. Here it is possible to show or hide the electrode positions used for the predefined montage, take a snapshot of the electrical field magnitude or voltage color maps, and show the information regarding the stimulation protocol used.

3. The upper and lower limits of the color map can be changed on the vertical scale.

4. The six buttons allow the user to display the grey or white matter surfaces according to any of the six orthogonal views.
Tab: Stim View

1. Show Electrodes
2. SnapShot
3. Show Influence map
4. Front, Right, Bottom, Left, Back, Top
VII. General Settings

**Bluetooth Pane**

1. NIC highlights the type and the MAC address of the last device that it was paired with. Below, it lists the devices that have been previously paired with NIC or that have been detected when NIC searches for devices.

2. The Select button is used to choose a device, previously selected from the list, to be paired with NIC. The Scan button is used to order NIC to search for more devices via Bluetooth®.

3. When pairing with Enobio 20 or Enobio 32, NIC also displays the Use as Enobio 8 button. This way the device is used with 8 channels that can be freely placed in any position of the cap.

**Advanced Pane**

4. This feature allows the visualization of the EEG signal with an inversion of the voltage values.

5. Choose the order (alphabetical or nasion-to-inion) according to which the positions are listed when assigning the respective channel (only for Enobio 8, Starstim and Starstim tCS).

6. The low and high frequency limits of the Default Visualization Filter shown in the EEG Setup and EEG Analysis tabs can be set here. As the name suggests, this filter only works for visualization purposes; the data is saved raw (or line-noise-filtered).

7. The line noise filter (Europe: 50 Hz; US: 60 Hz) can be enabled for visualization and for recorded data.

8. The accelerometer data can also be set to appear along with the EEG channels on the Time Domain pane, and it can be optionally recorded as well. The three components, \((a_x, a_y, a_z)\), correspond to the directions shown on the diagram next page.

9. With Enobio 8, the EOG correction requires one or two channels to be previously assigned to EOG1 and EOG2 positions EEG Setup/Placement tab. With Enobio 20 and Enobio 32, Fp1 and Fp2 positions are automatically assigned to EOG1 and EOG2. To activate, the EEG monitoring needs to be first turned on. Once enabled, the EOG calibration starts and it lasts the number of seconds defined by the user.

10. When the double blind mode is activated, NIC asks for a password which locks the protocol information to the user. Read pages 45-47 to know more about double blind mode.
Tab: Settings

Bluetooth Pane

Advanced Pane

1. Bluetooth Pane
2. Select device
3. Use as Enbio 8
4. Invert Polarity
5. Electrode Listing
6. Default Visualization Filter (Hz)
7. Line noise filter
8. Accelerometer
9. EOG Correction
10. Double-blind Mode
VIII. NIC file formats

NIC works with files with distinct file formats.

When recording EEG, two ASCII files are created with the *.info and *.easy file extensions. The former corresponds to a text file that contains the metadata of the corresponding recording. Information, like the EEG sampling rate, the percentage of packet loss, the channel-position list, are written on this file, as well as any additional comment that the user included in the dialogue box at the end of the recording.

The latter is also a text file containing the data itself which is organized as it follows:

1. The first 8 (20 or 32) columns correspond to the voltage signal, in nanoVolts (nV), of the EEG channels. If stimulation has been simultaneously used, the stimulation channels will display, by convention, the value -1.

2. Optionally, the three following columns will display the acceleration ($a_x$, $a_y$, $a_z$) in millimeters per second squared (mm/s$^2$). To activate this feature, go to the Settings / Advanced pane.

3. The next column corresponds to the markers column and it displays mostly zeros. The numbered flags (1 to 9) are registered when the corresponding keys are pressed. The number 255 identifies the samples when data loss occurred.

4. The last column contains the Unix Time Stamp, in milliseconds (ms), for each sample. This time unit refers to the number of milliseconds since January 1, 1970.
This is an example on how to read data from an *.easy file generated during the EEG recording with Enobio 8. The file should be placed in the MATLAB working directory and its name may be changed as desired.

```matlab
% Load the *.easy file
data = load('20150915150342_enobiodata.easy') ;

% Define the time axis
time = data(:, end) ;  % milliseconds Unix Time
time = time - time(1) ;  % set clock to zero (first sample)
time = time / 1000 ;  % change time units to seconds

% Define data (Enobio 8)
EEG = data(:, 1:8) ;  % Voltage in nanoVolts (nV)
ACC = data(:, 9:11) ;  % Accelerometer (mm/s²)
Markers = data(:, 12) ;  % Markers info

% Example: plot 8 channels in μV
figure(1);
plot(time , EEG(:, :) / 1e3 ) ;  % divide time by one thousand to go to μV
xlabel('Time from start (s)') ; ylabel('Voltage (μV)') ; title('EEG Data: 8 channels') ;
legend({'Ch1','Ch2','Ch3','Ch4','Ch5','Ch6','Ch7','Ch8'}) ;
ylim([-200 200]) ;  % fix the voltage scale (y-axis) limits to ± 200μV
```
When stimulation is performed, an optional ASCII file, with the extension *.stim, can be saved. Similarly to the *.easy file, this type of file contains one column per each channel, and an extra ninth column with the Unix Time Stamp. Each stimulation channel will display the current injected (μA) by the device at each millisecond (1000 SPS). If there is simultaneous EEG, then the EEG channels will display, by convention, the value -1.

The ASCII files (*info, *.easy and *.stim) can be opened with, for instance, Notepad (Windows) or TextEdit (MAC OS).

Additionally, NIC also works with binary files: *.edf, *.nedf and *.sdeeg.

The *.edf extension stands for the European Data Format (EDF) which is a binary file format commonly used to exchange and store multichannel data from physiological signals. NIC produces the EDF+ files (extension of EDF) which is the standard binary file format for EEG data. The binary *.nedf files are internal NIC files with an *.xml header, while the binary *.sdeeg file format is used when offline recording is used in a SD memory card.

NIC Offline software is capable of reading the binary files, as well as the *.easy files.

NIC Offline can also convert different file formats as it follows:

- *.nedf --> *.easy or *.edf
- *.sdeeg --> *.easy
- *.easy --> *.nedf or *.edf

NIC Offline can be downloaded for free from Downloads section of Neuroelectrics webpage: www.neuroelectrics.com/downloads
IX. TCP/IP Interface

TCP (Transmission Control Protocol) is a connection-oriented protocol for transferring data reliably in either direction between a pair of users. NIC platform is capable of streaming the EEG data to any other application in the same network via TCP/IP, and it can also send or receive triggers from up to five clients simultaneously.

The NIC Server address is displayed on the TCP Server section on the right bottom corner of the NIC window. Below the address, you may find the list of Clients that are connected to NIC by TCP. The clients are identified by the IP address of the computer where the secondary software applications are running. The TCP/IP streamed data may include only the EEG channels or also the markers information. This option is enable/disabled on the Settings/Advanced pane.

Below it is an example on how to, first establish a TCP connection between NIC and MATLAB and, then send a trigger, with the value 25, from MATLAB to NIC. The MATLAB Instrument Control Toolbox is required.

```matlab
% Create TCP/IP connection object, specifying the IP (default home IP:127.0.0.1) and Port number indicated in NIC.
connectionObject = tcpip('192.168.11.113', '1234');

fopen(connectionObject); % Open connection
fprintf(connectionObject, '<trigger>25</trigger>'); % Sending Trigger with the value 25
fclose(connectionObject); delete(connectionObject); % Disconnect and clean up the server connection
```
The Lab Streaming Layer (LSL) is a standard library used to send TCP/IP data, including timing information in such a way that clock synchronization among different devices is possible. NIC is equipped with LSL features that allow data streaming and markers input. Therefore, NIC LSL features allow Enobio and Starstim to be used in ERP experiments which always require a precise time synchronization so markers can be received with a sub-sample accuracy.
**X.1 Data Streaming**

To send data to another application, NIC requires the name of the Outlet layer to be defined (EEG Setup / Settings pane). The name is, by default, NIC, but the outlet layer can be renamed. Below find an example of the LSL streamed data being imported in MATLAB.

**X.2 Receiving Markers**

NIC is capable of receiving markers simultaneously from two distinct applications via LSL. The name of each layer should be defined on the EEG Setup / Settings pane. The received markers will be registered in the *.easy file along with the EEG data.

NIC requires the data format for the markers to be streamed must follow the following configuration:

- **Name:** NIC
- **Type:** Markers
- **Channel count:** 1
- **Nominal sample rate:** n/a (0)
- **Channel format:** int_32
- **Unique source ID:** Enobio/Starstim MAC address

```matlab
lib = lsl_loadlib(); % Initiate library
result = {}; % Initiate library
while isempty(result)
    result = lsl_resolvebyprop(lib,'type','EEG'); % New marker info
end
inlet = lsl_onlet(result{1}); % create a new inlet
while true
    [vec, ts] = inlet.pull_sample(); % register received data
end

lib = lsl_loadlib(); % Initiate library
info = lsl_streaminfo(lib,'MyMarkerStream','Markers',1,0,'cf_int32', 'myuniquesourceid2343'); % New marker info
outlet = lsl_outlet(info); % Opening outlet

lib = lsl_loadlib(); % Initiate library
result = {} ; % Initiate library
while isempty(result)
    result = lsl_resolvebyprop(lib,'type','EEG') ;
end
inlet = lsl_onlet(result{1}); % create a new inlet
while true
    [vec, ts] = inlet.pull_sample(); % register received data
    outlet.push_sample(mrk); % note that the string is wrapped into a cell-array
end
```
XI. Sham mode

Whether you are doing a double or single blind experiment, stimulation sham mode is needed to control for placebo effects. A sham session is designed to feel as a real stimulation session without its effects. Sensations similar to those in tCS are created by generating currents only at the start and the end of the session.

1. The sham mode can be enabled at the **Stimulation / Configure** pane. When the **Sham** mode is activated, you need to select the duration (in seconds) of the **Sham ramp** time.

![Sham mode interface](image)

![Sham stimulation profile](image)
XII. Double Blind mode

**Administrator**

The administrator is the person who can create and manage the protocols. In a double blind study, the administrator creates a series of protocol templates for stimulation and gives them generic names (e.g. Protocol 1) that do not provide montage related information. For instance, two protocols may refer to stimulation sessions with different parameters, while a third protocol corresponds to the Sham stimulation. The administrator should also prepare a list for the operator assigning a protocol to each subject and session (e.g. Subject01_Session01).

**Operator**

The operator is responsible for selecting the appropriate template for the session/subject (from a list or from the template names if they contain relevant information), setting up the electrodes according to the montage, checking impedances, launching it and annotating the session as needed. During the stimulation session, the operator will have no access to protocol data (currents, Sham settings, EEG traces, etc.) and thus remain effectively blinded.
Once the templates have been defined, the administrator can activate the double blind mode using the button in the **Settings / Advanced** pane. When activating the double blind mode, a window pops-up and requests a password. The administrator should insert a password of his choice to initiate the operator blind mode. The same password will be needed to unlock the double blind mode.

When the double-blind mode is activated, non-essential information is hidden in NIC interface from the operator. The operator can select the stimulation protocol from the list of templates, without knowing the stimulation parameters. Contact Neuroelectrics in case you forget your password.