



Neuroelectrics User Manual  
– Part III NIC2 –

CAUTION: INVESTIGATIONAL DEVICE  
Limited by United States law to investigational use.



Europe Office  
Avinguda Tibidabo, 47 bis  
08035 Barcelona, Spain  
Tel. +34 93 254 03 66  
Fax. +34 93 212 64 45

US Office  
210 Broadway, Suite 201  
Cambridge, MA 02139, USA  
Tel. +1 617 682 0770

Email: [info@neuroelectronics.com](mailto:info@neuroelectronics.com)

[www.neuroelectronics.com](http://www.neuroelectronics.com)

Copyright© by Neuroelectronics®. All rights reserved.



Manufacturer:

Neuroelectrics Barcelona SLU  
Avinguda Tibidabo 47, bis  
08035 Barcelona  
Spain  
Telephone: + 34 93 254 03 66



Manual Update:

Version: 1.5

Date: 2018.26.10



Software version:

NIC2 v2.0.10

# About the NIC User Manual

The NIC User Manual is Part III of the Neuroelectrics User Manual.

The Neuroelectrics User Manual includes three parts:

- ▶ Part I: Enobio User Manual or Starstim User Manual
- ▶ Part II: Electrode User Manual
- ▶ Part III: NIC User Manual

Before you use the Enobio or Starstim system, read the three parts of the Neuroelectrics User Manual. The NIC User Manual does not negate the need of reading the Enobio/Starstim and Electrode parts.

The PDF version of all parts of the Neuroelectrics User Manual can be found under the Manual section of Neuroelectrics webpage:

[www.neuroelectrics.com/documentation](http://www.neuroelectrics.com/documentation)

# Change Record

Issue	Date	Changes made
1.0	2016.10.04	First version of the manual for NIC2 (v2.0.2)
1.1	2016.11.08	NIC2.0.3 update
1.2	2016.12.05	NIC2.0.4 update
1.3	2017.02.28	NIC2.0.5 update
1.4	2017.07.25	NIC2.0.6 update
1.5	2018.03.01	NIC2.0.9 update
1.6	2018.26.10	NIC2.0.10 update

# Table of Contents

About the NIC User Manual .....	4	V. EEG Experiments .....	37
Change Record .....	5	V.1 EEG Protocol .....	38
I. Introduction .....	8	V.2 EEG Monitoring .....	40
I.1 System Requirements .....	9	V.3 EEG Signal Quality .....	42
I.2 Installation .....	10	V.4 EEG Analysis .....	44
I.3 NIC2: Home Pane .....	12	V.5 Holter Mode .....	46
II. My Devices .....	14	VI. Stimulation Experiments .....	47
III. Protocols .....	16	VI.1 Stimulation Protocols .....	48
III.1 Protocol Design .....	18	Bipolar montages .....	49
III.2 Protocol Summary .....	20	Multi-polar Montages tDCS .....	51
III.3 Protocol Settings .....	22	Complex waveforms: tDCS, tACS & tRNS .....	53
III.4 Stim Preview .....	24	Custom waveforms .....	55
IV. Liveview .....	26	VI.2 Impedance Check .....	56
IV.1 Liveview Plots .....	28	VI.3 Dosage of the stimulation .....	57
IV.2 Liveview Design .....	32	VI.4 Blind modes .....	58
IV.3 Custom Liveview .....	34	Active Stimulation and Sham Profiles .....	59
		VII. NIC File Formats .....	60
		VIII. NUBE: EEG Cloud .....	62
		XI. Offline Mode .....	64



# I. Introduction

NIC stands for Neuroelectrics Instrument Controller. NIC is the application that allows a computer to interact with Neuroelectrics' devices. NIC is prepared for both wired and wireless connections to control the devices.

NIC allows EEG data to be streamed and analyzed in real-time with both Enobio and Starstim devices. It provides a secure way to define the stimulation parameters for Starstim units. NIC is a powerful platform that is equipped with basic and advanced modes to design and monitor any experiment involving electroencephalography (EEG) and/or non invasive brain stimulation with transcranial current stimulation (tCS).

NIC2 corresponds to the second version of the former NIC. NIC2 has a completely new interface that provides a unique experience to both clinicians and researchers in Neuroscience departments. The new graphical user interface (GUI) simplifies the interaction with the advanced technology embedded in Neuroelectrics devices.



Enobio 8



Starstim 32

## I.1

# System Requirements

---

NIC2 is only compatible with Neuroelectrics devices. NIC2 must be used to control your device. In case you need your device to interact with a third-party software, contact Neuroelectrics support team for assistance.

The following devices are compatible with NIC2:

- ▶ Enobio (8/20/32) \*
- ▶ Enobio (8/20/32) 5G
- ▶ Starstim 8 \*
- ▶ Starstim 8 5G
- ▶ Starstim tCS \*
- ▶ Starstim 20
- ▶ Starstim 32

\* Former versions of these devices (shipped until October 2014; with firmware < 1251) are not compatible with NIC2. Contact our sales team if you need an upgrade of your system to benefit from NIC2 features.

The computer used to install NIC2 needs to have the following system requirements (minimum):

- ▶ Operative systems compatible:
  - Windows (Vista / 7 / 8 /10)
  - Mac OS X (> Snow Leopard)
- ▶ Processor: 1.6 GHz
- ▶ RAM: 2 GB
- ▶ Interface: USB, or WiFi
- ▶ Screen resolution: 1280 x 768

## I.2

# Installation

---

### Installation files

The latest version of NIC2 can be downloaded from the Software section of Neuroelectrics® website:

[www.neuroelectrics.com/downloads/](http://www.neuroelectrics.com/downloads/)

Alternatively, the installation files can also be found in the USB stick included in the package wherein the device was shipped.

To install NIC2, first choose the installation file according to the operating system of the computer where the software is intended to run. For Windows computers choose the \*.exe file and follow the installation instructions; for MAC OS X choose the \*.zip file and unzip it.

### In Mac OS X

The installation in computers running Mac OS X is simple and straightforward. Double click on the unzipped NIC2 application file and follow the installation instructions. The installation should not take longer than a few minutes.

The user might need to first allow the computer to install programs from unidentified developers. For that, go to System Preferences / Security & Privacy and choose Anywhere in the Allow apps downloaded from. Administrator credentials are required to modify these settings.

The WiFi™dongle provided with the system is not compatible with Mac OS X system. Do not use the WiFi™dongle with a computer running Mac OS X.

---

## In Windows

If using the cable connection option, a few steps are needed to install the USB drivers in Windows, before using NIC2. After installing NIC2, follow the instructions below:

In Windows 7, with the device switched on and connected via cable, go to the Control Panel definitions and select Device Manager. Right-click on CDC Virtual COM and choose Update Driver Software. Select the driver location as: C:\Program Files\NeuroElectrics\NIC2\usbdriver. After this, you may launch NIC2 and proceed as described in the next page.

In Windows 8, with the device switched on and connected via cable, go to C:\Program Files\NeuroElectrics\NIC2\usbdriverwin8. Execute and install the driver driver-atmel-bundle-7.0.888. After this, you may launch NIC2 and proceed as described in the next page.

In Windows 10 there is no need to install any drivers. NIC2 will be ready to use as soon as the installation is completed.

For wireless connections with Windows systems, it is recommended to use the – WiFi™ – dongle provided with the system.

## I.3

# NIC2: Home Pane

---

NIC2 displays the **HOME** pane when launched.

In NIC2 window, the left-side bar is always visible and it contains the Neuroelectrics® icon, the unlocked NIC2 panes and the version of NIC2 installed.

- 1 By clicking and dragging the Neuroelectrics® icon, NIC2 window can be moved.
- 2 The Pane bar shows all the active panes.
- 3 The bottom left corner indicates the installed version of NIC2. Make sure you have the latest version installed to get the best of your device. The latest NIC2 version is available on the download section of Neuroelectrics website:

[www.neuroelectrics.com/downloads/](http://www.neuroelectrics.com/downloads/)

- 4 **Connection Type.** The first thing to do after launching NIC2 is to choose the type of connection to interact with the device. NIC2 is prepared to interact with Neuroelectrics® devices that use WiFi™ and/or USB. Select the type of connection compatible with your device.

Alternatively, it is possible to proceed without connecting to any device by either clicking on the Protocol editor command or the Offline mode one. In the first case, NIC2 will allow protocols to be created based on the features of the last device paired with NIC2. In the second case, NIC2 will allow loading previously recorded files to check the EEG signals within.

Read the **My DEVICES** chapter (pp. 14-15) to learn on how to establish the connection between NIC2 and your device.

- 5 **News.** The latest news shown on Neuroelectrics® website are also displayed in NIC2. Make sure that the computer has Internet connection to have the news updated.

# NIC2 Home Pane

The image shows the NIC2 Home Pane interface with five numbered callouts:

- 1**: Points to the top header bar containing the **NE®** logo.
- 2**: Points to the top navigation bar containing a Wi-Fi icon.
- 3**: Points to the bottom status bar containing the version number **v2.0.10**.
- 4**: Points to the central content area which includes:
  - A circular logo with the **NE®** symbol.
  - The text: "Make sure that the device is ON".
  - Three orange buttons: **USE USB DEVICES**, **USE WI-FI DEVICES**, and **USE BT DEVICES**.
  - Text below the buttons: "Or start *Protocol editor*" and "Or start *Offline mode*".
- 5**: Points to a right-hand sidebar containing a network diagram background and three news items:
  - EGLAB\_NE Plugin hotfix**  
Wed, 27 Jun 2018
  - Ana Maiques has done a Podcast interview for FutureTech**  
Wed, 23 May 2018
  - New hotfixes have been released for NIC 2.09!**  
Tue, 08 May 2018

# II. My Devices

After selecting the type of connection, you are directed to the **My Devices** section. The general settings can be defined before pairing the device with NIC2.

- 1 Click on the **SCAN FOR DEVICES** button to command NIC to search for devices. NIC only finds devices that are switched on and using the connection type selected in the **HOME** pane.
- 2 Select your device from the list of devices detected. The available wireless devices indicate the corresponding MAC address. When connected, NIC2 detects the type of device, the firmware version and the battery percentage level.
- 3 You may lock/unlock TCP connections to and from NIC (p.45), activate double blind mode (p. 57), connect to NUBE EEG cloud (pp. 61-64), enable the synchronizer, or invert the polarity of the EEG signal for visualization.
- 4 Activate the line noise filter to remove main line artifacts from the EEG data. Choose the 50 Hz option in Europe, and the 60 Hz filter for North America. Both options affect the data visualization. If the **ENABLE AT RECORDING** button is active, the filtering is also applied to the recorded data.
- 5 Choose the frequencies of the visualization filter, to be applied only for EEG visualization.

- 6 For stimulation, choose the type of **Impedance Check** (p. 55) between DC (default) and AC modes.
- 7 For advanced stimulation protocols, it is possible to load a custom waveform (pp. 53-54).
- 8 Finally, click on the **USE THIS DEVICE** button to connect NIC2 with the device when all the previous settings are defined. When paired, the button will be replaced by the **DISCONNECT** button.

When a device is successfully connected, the type of device, the firmware version and the battery level become visible. A successful connection also lights up the LED of the device icon on the lateral pane bar. Each color of the LED has a different meaning related to the battery level:

- ▶ **grey**: device not connected
  - ▶ **red**: [0 - 33] %
  - ▶ **orange**: [33 - 66] %
  - ▶ **green**: [66 - 100] %
- 9 After defining the general settings and connecting to the device, proceed to the **PROTOCOL** pane.

# My Devices

1 SCAN FOR DEVICES

2 My devices  
NE-Wif(00-07-80-0D:71:68)  
SS8 Fw v4.0.13 Battery 87%

3 Settings

4 TCP Connection  
Double blind  
Save recordings to NUBE  
Enable Synchronizer  
Invert polarity

5 Line Noise Filter  
50Hz 60Hz None  
Enable at recording

6 Default visualisation filter (Hz)  
2,0 to 40,0  
Enable visualisation filter

7 Manual Check Impedances  
DC AC

8 C:/ Waveform

9 DISCONNECT

Warning:

The synchronizer should be enabled during experiments when the timing synchronization of the device with the computer and/or other external devices is required (e.g. Event-related potentials – ERPs).

When enabled, the application will perform two synchronisation processes: the first is very short and is carried out before a protocol is loaded. The second is performed afterward, while the EEG is received. It prevents starting a recording until synchronisation accuracy between the Necbox and NIC2 is accurate enough. This procedure may take a few minutes (1-3 min).

# III. Protocols

With NIC2, all the experiments are managed with the protocol structure. Each protocol corresponds to one experiment, and each experiment may contain one or more steps.

Within the **PROTOCOL** pane, all the parameters regarding the experiment can be defined. Three types of experiments can be created: EEG monitoring experiments; stimulation-only experiments, or hybrid experiments that include both EEG & stimulation.

Enobio devices only allow for EEG protocols. Starstim tCS devices only allow for stimulation protocols. Starstim 8/20/32 allow for all types of protocols (EEG-only, tCS-only and combined EEG & tCS).

- 1 **Protocol List.** When NIC2 is launched for the first time, there are no protocols listed. If NIC2 has been used before, it may contain previous protocols that were saved. By clicking on a specific protocol, NIC2 displays the protocol summary in **Protocol Workspace** on the right side of the page.
- 2 **Add New Protocol.** To create a new protocol, click on the **ADD NEW PROTOCOL** button. Consult the **Protocol Design** subchapter (pp. 18-19) to read the protocol creation instructions.
- 3 **Import Protocols.** NIC2 allows protocols to be imported. If a protocol is imported, any protocol with the same name will be overwritten. NIC2 is not compatible with protocols/templates created with former NIC.
- 4 **Protocol Workspace.** The Protocol Workspace is used for:
  - ▶ Protocol Design (pp. 18-19)
  - ▶ Protocol Summary (pp. 20-21)
  - ▶ Stim Preview (pp. 24-25)

# Protocols

The interface displays a list of protocols in the sidebar and a network graph in the main area.

Protocol Name	Steps in Protocol	Duration
PROTOCOL A	1 steps in Protocol	01:00
PROTOCOL B	2 steps in Protocol	02:10
PROTOCOL C	3 steps in Protocol	03:10
PROTOCOL D	5 steps in Protocol	05:12
PROTOCOL E	1 steps in Protocol	01:00

Buttons: **ADD NEW PROTOCOL** (2), **IMPORT...** (3)

Network Graph (4): A complex network diagram with nodes of varying sizes and connecting lines.

Version: v2.0.10

### III.1

## Protocol Design

---

Follow the next steps to create a new protocol from scratch:

- 1 **Protocol Name.** Start by defining the protocol name, the name should be unique. This is a case sensitive field.
- 2 **Step List.** Define the name and the duration of each step of the protocol. Multi-step protocols can be created, but the mount must be the same for all the steps of the same protocol, regardless of the function set to each channel. Steps can be copied and re-ordered using the dedicated buttons.
- 3 **Template & Mount.** With 8-channel devices, the template option is set to **User defined**. For 20-/32-channel devices, choose between **User defined** and **Standard mount**. The former option allows any of the 76 scalp map positions (or EOG1, EOG2, ECG and EXT) to be assigned to the channels of the device; whilst the latter locks the positions to the predefined mount of the system.

4 **Head Diagram.** The diagram shows a subset of the 10-10 EEG coordinate system. The color code identifies the channels and their function/status:

- ▶ **green:** positions available with the current template/mount.
- ▶ **blue:** channels assigned to stimulation during the current step.
- ▶ **purple:** channels assigned to EEG during the current step.
- ▶ **circled green:** available positions that are assigned to EEG and/or Stimulation in other steps of the same protocol.
- ▶ **white:** positions unavailable in the standard mount templates.

5 **Design.** The design area allows the user to build the electrode montage. To assign the EEG or Stimulation function to a specific channel, first click on the corresponding **EEG** or **STIMULATION** button, then click on the desired scalp position and drag it from the **Head Diagram** to the workspace on the right. Alternatively, double click on the desired position, and choose between EEG and Stim functions.

6 **Cancel, Finish & Save.** These buttons allow the user to save the last modifications of the protocol and leave the editing area, or cancel and leave without applying the last changes.

# New Protocol

**1** NE®

**2** PROTOCOLS

PROTOCOL A  
1 steps in Protocol 01:00

PROTOCOL B  
2 steps in Protocol 02:10

**PROTOCOL C**  
3 steps in Protocol 03:10

PROTOCOL D  
5 steps in Protocol 05:12

PROTOCOL E  
1 steps in Protocol 01:00

ADD NEW PROTOCOL

IMPORT ...

**3**

**Step 1**  
EEG Pre-Stim 01:00

**Step 2**  
EEG & tDCS

EEG  
1 EEG Channels

EEG  
4 EEG Channels

STIM  
2 STIM Channels

**4**

Mount  
8 Mount

EEG Stimulation

EDIT SETTINGS EXPORT

**5**

03:10

**Step 3**  
EEG Post-Stim 01:00

EEG  
3 EEG Channels

Dosage of protocol: 71.5 mC  
Dosage of step: 71.5 mC

STIM PREVIEW LOAD PROTOCOL

**6**

- ▶ To introduce Resting steps between steps of the same protocol, add a new step, with name and duration defined, and set no channels for EEG/tCS.

## III.2

# Protocol Summary

---

Within the **PROTOCOL** pane, it is possible to have the general information about each protocol.

**1 Protocol List.** The number of steps and the total duration of each protocol is shown for all the protocols in the list. Select the protocol in which you are interested. On the right side of the window, the **Protocol Workspace** will display the summary of the selected protocol.

When a protocol is selected, the copy icon becomes visible. By clicking on it, a new protocol is added to the list, identical to the original protocol and with “\_Copy” appended to the name.

**2 Protocol Sequence.** This section summarizes the selected protocol and briefly describes each of its steps. The top bar displays the duration of the entire protocol, and the table below contains basic data of each step: name, duration, number of EEG channels, and number of stimulation (STIM) channels. The mount diagram below refers to the step selected.

**3 Mount.** The mount diagram identifies the 10-10 position coordinate of the EEG and STIM channels used for the pre-selected step of the protocol. If no step is selected, the Mount refers to the first step of the protocol. The user is also informed about the stimulation dosage of each step and of the total protocol. More information about the dosage can be found on page 56.

**4 Action Buttons.** Three actions can be performed regarding the selected protocol:

- ▶ **EDIT:** redirects the user to the **Protocol Design** (pp. 18-19) so the protocol can be modified.
- ▶ **SETTINGS:** general settings regarding the file format, markers and data streaming can be defined (pp. 22-23).
- ▶ **EXPORT:** the user may export the protocol data to a \*.txt file.

**5 Stim Preview and Load Protocol**

- ▶ **Stim Preview** (pp. 24-25)
- ▶ **Load Protocol** (pp. 26-27).

# Protocol Summary

**NE® Protocols**

**PROTOCOL A**  
1 steps in Protocol 01:00

**PROTOCOL B**  
2 steps in Protocol 02:10

**PROTOCOL C**  
3 steps in Protocol 03:10

**PROTOCOL D**  
5 steps in Protocol 05:12

**PROTOCOL E**  
1 steps in Protocol 01:00

**ADD NEW PROTOCOL**

**IMPORT ...**

Step 1	Step 2	Step 3
EEG Pre-Stim 01:00	EEG & tDCS 01:10	EEG Post-Stim 01:00
EEG 1 EEG Channels	EEG 4 EEG Channels STIM 2 STIM Channels	EEG 3 EEG Channels

**Mount**  
8 Mount

Dosage of protocol: 71.5 mC  
Dosage of step: 71.5 mC

Legend: EEG (purple dot), Stimulation (blue dot)

Toolbar: EDIT, SETTINGS, EXPORT, STIM PREVIEW, **LOAD PROTOCOL**

Callouts: 1 (Protocols list), 2 (Step summary table), 3 (Mount diagram), 4 (Toolbar), 5 (LOAD PROTOCOL button)

### III.3

## Protocol Settings

---

The protocol settings are defined for all protocols and they are applied to all their steps.

1 File formats & Directory. NIC2 allows five types of file to be saved.:

- ▶ \*.nedf : binary file with an \*.xml header
- ▶ \*.easy : ASCII file saved during EEG recording.
- ▶ \*.edf : The EDF extension stands for the European Data Format (EDF). The EDF+ is the standard binary file format for EEG data.
- ▶ \*.sdeeg : binary EEG file stored in the SD card during offline recording.

The user may choose which file types to be recorded. More information about the NIC files can be found on pages 59-60. Then they should specify the path in the directory where those files should be saved.

**Warning:** The \*.nedf file format has 24-bit resolution, while the \*.edf format has 16-bit resolution. The DC component is filtered when \*.edf files are created.

2 Markers. Up to 9 markers can be assigned to the keys 1 to 9 of the keyboard. When those keys are pressed during the experiment, the marker number is added to the corresponding sample.

3 Data streaming. NIC2 allows data to be streamed and receive markers from third party software applications running on the same network by using Lab Streaming Layer (LSL) connections.

# Protocol Settings

1

**File formats**

.nedf  .easy  SD File  .EDF+

Output Directory C:/Users/Neuroelectrics/Documents/NIC/

2

**Key Markers**

Key 1 Eyes open (EO)	Key 6
Key 2 Eyes closed (EC)	Key 7
Key 3 Blinking	Key 8
Key 4	Key 9
Key 5	

3

**LSL Server**

Outlet for Lab Streaming Layer NIC

Markers Lab Streaming Layer 1 Presentation

Markers Lab Streaming Layer 2 ExternalMarker

OK

## III.4

# Stim Preview

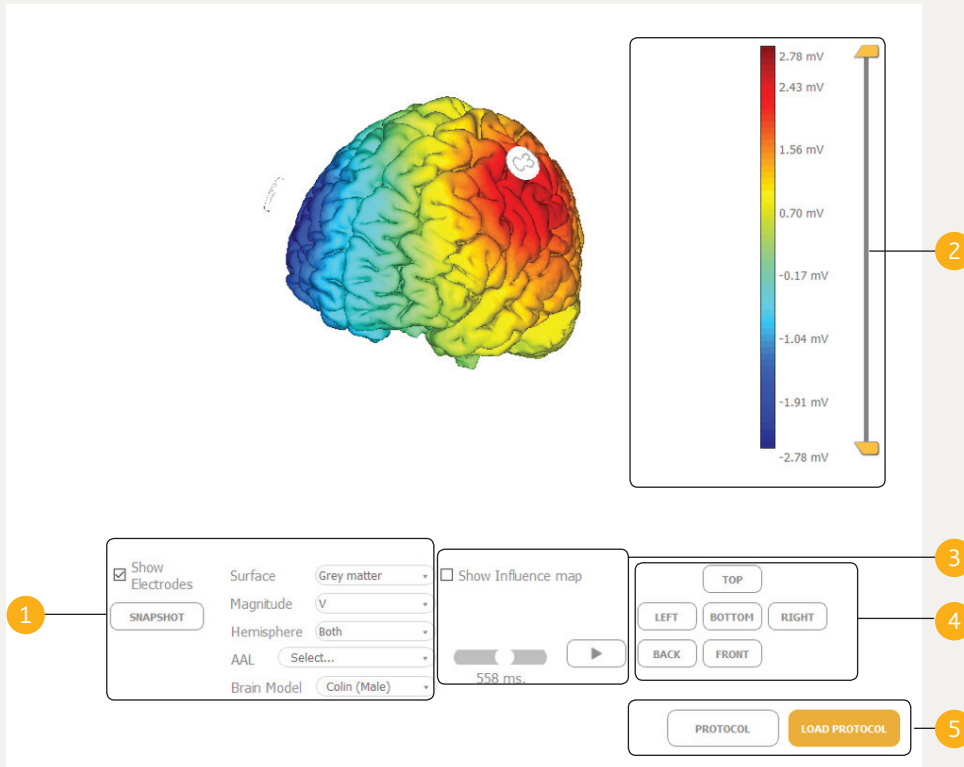
---

The **STIM PREVIEW** pane is only available for Starstim devices. In Stim Preview, the electric field generated in the brain, that results from the stimulation montage of each step of a stimulation protocol, is displayed in a 3D standardized model.

It is recommended to use the Stim Preview visualization as a confirmation step before loading a stimulation protocol.

- 1 Interact with the 3D model and choose what to be displayed:
  - ▶ White and grey matter options
  - ▶ Electric potential  $V$ , electrical field magnitude  $\|E\|$ , and its normal  $E_n$  and tangential  $E_t$  components
  - ▶ Left, right or both hemispheres
  - ▶ Automated anatomical labeling (ALL) regions
  - ▶ Show electrodes used for stimulation
  - ▶ Male or female brain model
  - ▶ Snapshot the 3D model
- 2 The upper and lower limits of the color map can be changed on the vertical scale.
- 3 For tACS protocols, it is possible to visualize the variations of the electric field over time. Press the **PLAY** button to see the oscillatory effects. Additionally, it is possible to visualize the influence map of tACS montages, which identifies the areas of the cortex that are the most/less affected by tACS overtime.
- 4 The six buttons allow the user to display the brain surface according to any of the six orthogonal views.
- 5 Go back to the protocol summary, or load the protocol.

# Electric Field Visualization



# IV. Liveview

When a protocol is loaded, the **LIVEVIEW** panes are unlocked. To load a protocol, click on the **LOAD PROTOCOL** button, available within the **Protocol Summary** and the **Stim Preview** sections.

- 1 **Liveview Home.** The Liveview Home is the NIC2 pane that must be used to control both EEG and tCS experiments. This pane cannot be customized.
- 2 **Liveview Customization.** NIC2 allows users to create Liveview panes according to their preferences. The Liveview Customization pane is the NIC2 section where the user can select and combine different tools to analyse EEG data in real-time.
- 3 **Customized Liveviews.** After creating a customized Liveview, the user can load it. The user can load up to 4 customized Liveviews simultaneously. The loaded customized Liveviews are added to the Pane bar on the left of the NIC2 window. At anytime, the user can remove (i.e. unload) a customized Liveview. Click on the cross on the superior right corner of the Liveview icon to close it.

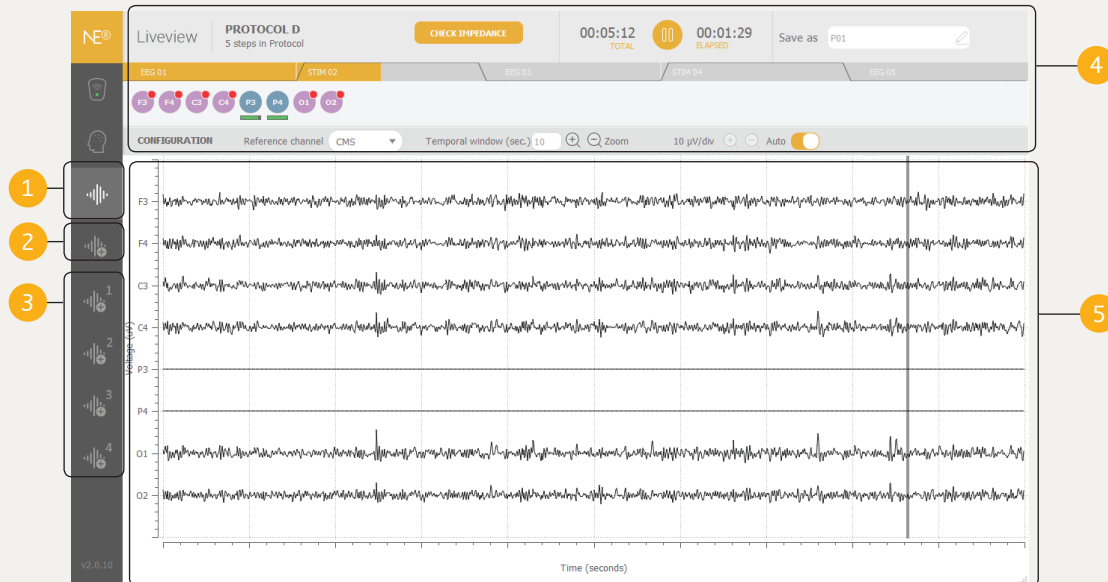
4 **Monitoring bar.** The top monitoring bar is common to all Liveview panes, and it contains the basic commands:

- ▶ Protocol name and total number of steps
- ▶ Impedance Check (p. 55)
- ▶ Timing info and Play/Pause/Quit button (p. 27)
- ▶ Set ID of the saved files.
- ▶ Progress bar with step identification and stimulation profiles.
- ▶ Channel bar with signal quality (EEG channels, p. 42-43) and impedance (STIM channels, p. 55) values.
- ▶ Configuration bar – choose the reference channel for visualization, and adjust the voltage ( $\mu\text{V}$ ) and time (s) scales. The voltage scale can be set to Auto so it adjusts to the amplitude of the signals.

5 **Main EEG Plot.** The multi-channel signal is plotted for all the positions defined in the mount template in the **Protocol Design** pane. Stimulation channels typically display a flat line. To add/remove channels to/from the Main EEG Plot, click on the circle label on the Channel Bar.

# Liveview Home

- ▶ Click on the Play/Pause button to start or stop the protocol (EEG or Stimulation) at any time.
- ▶ Click the Play/Pause button to pause the protocol.
- ▶ Click and hold the Play/Pause button for 3 seconds to stop and re-start the protocol from 0.



## IV.1

# Liveview Plots

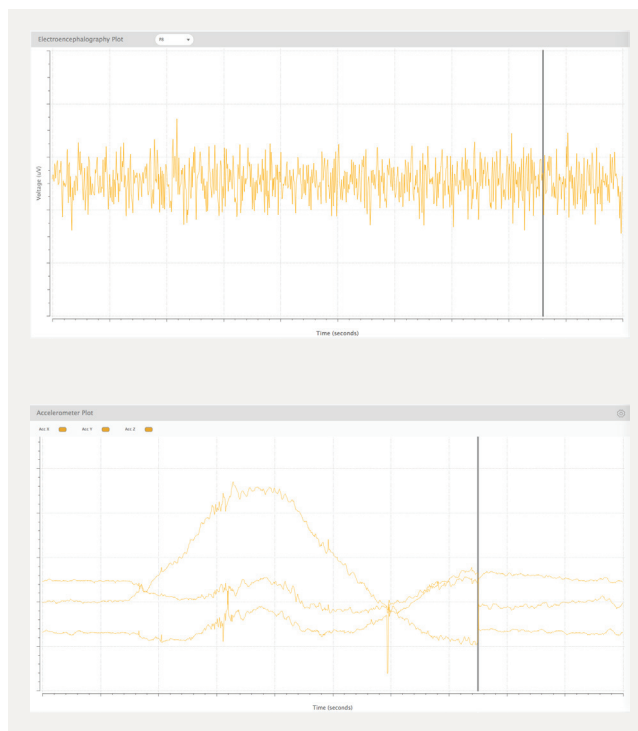
The customizable Liveview panes allow the user to combine different types of EEG analysis plots. There are seven Liveview plots in NIC2 that can be used for real-time EEG monitoring. Below, you may find a description of each plot type.

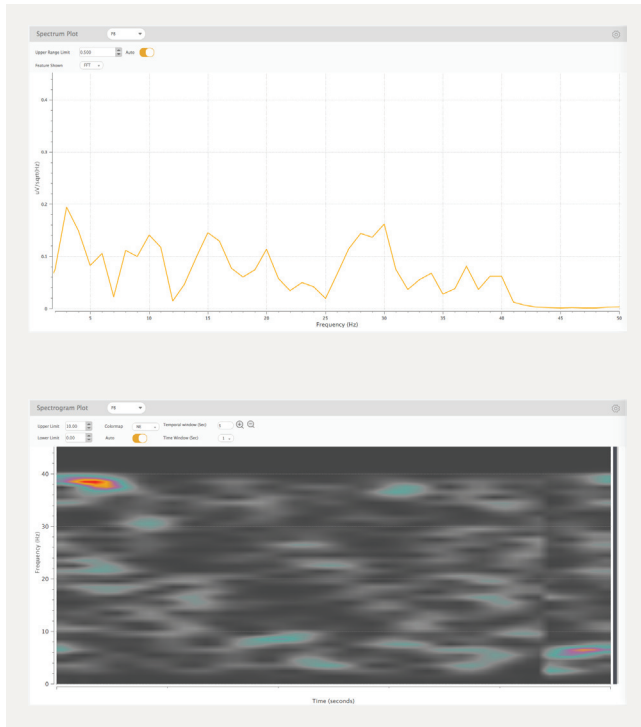
### EEG Plot

Choose one EEG channel to be plotted. Any channel can be selected from the list of channels selected for EEG in the protocol in use.

### Accelerometer

The 3-axis accelerometric data can be displayed in real time. By clicking on the gear symbol (upper right corner), it is possible to choose which accelerometric components (x, y, z) to be visualized.





## Spectrum

This window displays the Fast Fourier Transform (FFT) or the Power Spectrum Density (PSD) of the selected channel. The upper range limit (vertical scale) can be set to auto or defined by the user. Click on the gear symbol on the top-right corner to modify such parameters.

## Spectrogram

The power spectrogram displays the online frequency contents of the signal of a specific EEG channel over time. The temporal window (horizontal scale), time window (used to compute the signal spectrum to be plotted), the colormap, and the spectrum limits maybe adjusted. Click on the gear symbol on the top-right corner to modify such parameters.

## IV.1

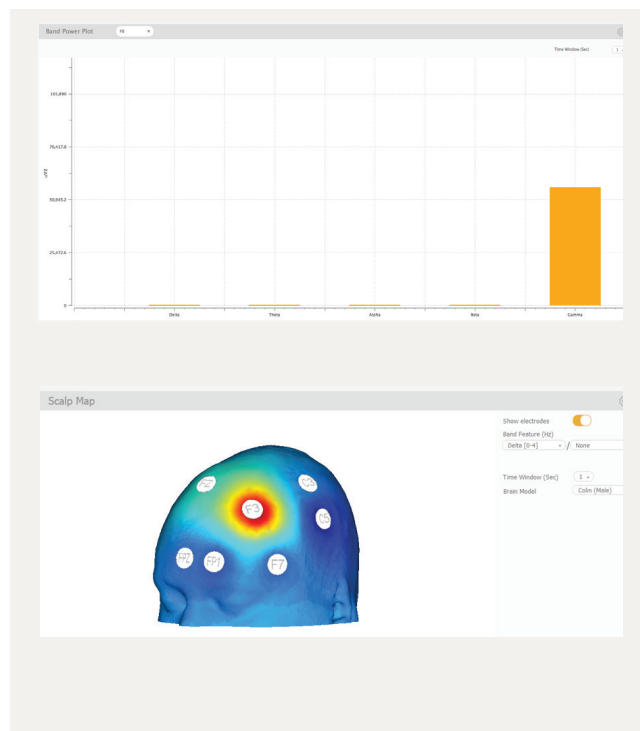
# Liveview Plots

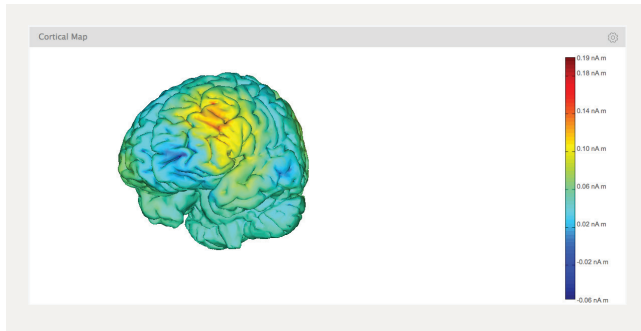
### Band Power

The power of the different EEG bands (Delta, Theta, Alpha, Beta, Gamma) can be computed in real-time for any specific channel. It is possible to adjust the time window (1, 2 or 4 seconds) used to compute band power values. Click on the gear symbol on the top-right corner to modify such parameters.

### Scalp Map

The scalp map displays a color code to spatially represent the power distribution  $\mu V^2$  for the band, or band ratio, selected. The electrodes can be made visible or not. Male or female brain model can be selected. Click on the gear symbol on the top-right corner to modify such parameters.





## Cortical Map

The cortical map uses backward problem solving to compute the density of electric dipoles (nA m) on the brain surface. This source localization tool allows active brain areas to be identified, on both white and grey matter surfaces, based on the electric potential values measured by the scalp sensors. This is only available for devices with 20 and 32 channels using the standard mount.

## IV.2

# Liveview Design

---

The Liveview Customization pane allows the user to create and customize new Liveviews. The Liveview plots are organized in grids, and NIC2 allows groups up to 5 rows and 2 columns – a total of 10 plots. To create a new Liveview, follow the steps:

- 1 Click on the **ADD NEW ANALYSIS TEMPLATE** button.
- 2 Define the name of your new Liveview. The name should be unique.
- 3 Click on **ADD NEW ANALYSIS PLOT**.
- 4 Choose, from the drop-down list, the type of EEG Analysis Plot to add to the view:
  - ▶ EEG Plot
  - ▶ Accelerometer (Acc) Plot
  - ▶ Spectrum
  - ▶ Spectrogram
  - ▶ Band Power
  - ▶ Scalp Map
  - ▶ Cortical Map

5 Click on the plus sign to add a second column in the corresponding row. The plus sign is located on the right side of the plot slot. A second drop-down menu will appear. Repeat steps 3-5 to add more rows to the customized Liveview.

6 To remove any plot from the grid, click on the cross sign located on the top left corner of each slot.

7 Click on the **FINISH & SAVE** button when the new Liveview is complete. Alternatively, you may proceed without saving the changes applied to the Liveview by clicking on the **CANCEL** button.

When the Liveview is saved, it is automatically loaded. When returning to the Liveview Design, the edit option allows the user to modify the Liveview grid structure and plots of the customized Liveviews. The **LOAD** button directs the user to the Customized Liveview pane. NIC2 is capable of loading up to 4 customized Liveviews simultaneously.

# Liveview Design

The screenshot displays the NE Liveview software interface. At the top, the header includes the NE logo, the title 'Liveview', and 'Protocol C' with '5 steps in Protocol'. A 'CHECK IMPEDANCE' button is visible, along with a timer showing '00:05:12 TOTAL' and '00:00:00 ELAPSED'. A 'Save as' field contains 'P01'. Below the header, a row of EEG channels is shown, including EEG 01, EEG 03, and EEG 05, with individual channel labels like P8, T8, CPG, FCG, F8, F4, C4, P4, AF4, Fp2, Fp1, AF3, Fz, FCz, Cz, CPz, PO3, O1, Oz, O2, PO4, Fz, CP1, FCL, P3, C3, F3, F7, FC3, CP5, T7, P7. A 'CONFIGURATION' section shows 'Reference channel' set to 'CMS'. The main area is titled 'Liveview Panel Configuration' and contains a list of analysis plots: 'My Liveview 01' (2 Analysis Plots) and 'My Liveview 02'. A '+ ADD NEW ANALYSIS TEMPLATE' button is located below the list. The right side of the configuration panel shows a preview of an analysis plot with 'EEG Plot' and 'Spectrogram' dropdowns, a 'Band Power' dropdown, and an 'ADD NEW ANALYSIS PLOT' button. At the bottom, there are 'CANCEL' and 'FINISH and SAVE' buttons. Numbered callouts (1-7) point to various UI elements: 1 points to the '+ ADD NEW ANALYSIS TEMPLATE' button; 2 points to the vertical sidebar on the left; 3 points to the 'ADD NEW ANALYSIS PLOT' button; 4 points to the 'Band Power' dropdown; 5 points to the '+' button in the plot preview; 6 points to the 'Spectrogram' dropdown; and 7 points to the 'FINISH and SAVE' button.

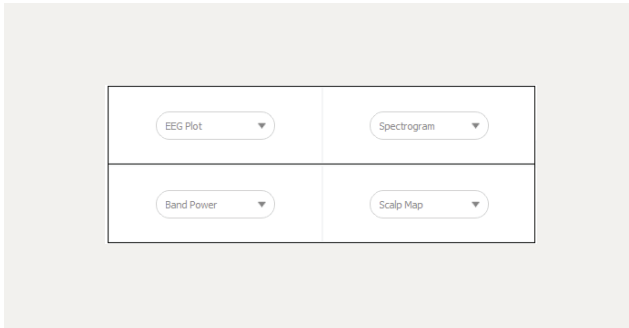
## IV.3

# Custom Liveview

---

When a new Liveview is loaded, all the plots are generated and plotted in NIC2 window.

The example given on page 35 corresponds to a Liveview created with the following grid structure (2 x 2).



The Liveview plots can be further adjusted:

- 1 To modify the height of the rows, drag vertically the horizontal border between them.
- 2 To adjust the column width of slots of the same row, drag the vertical border between both columns.
- 3 For the EEG, Spectrum, Spectrogram, and Band Power plots, the user can choose the channel, from the used mount, to reference the EEG data being plotted. The reference for the Cortical Map plot is Cz and can not be modified.
- 4 Each plot allows the user to define specific configurations. For instance, the Scalp Map plot allows the option to show/hide the electrodes from the model, and also to plot a band ratio instead of a standard brainwave band. It is up to the user to set those parameters.

# Customized Liveview





# V.EEG Experiments

## V.1

# EEG Protocol

---

An EEG protocol is typically one-step protocol. Preparing the EEG protocol is a simple process. Follow the steps below based on the example shown on pages 18-19.

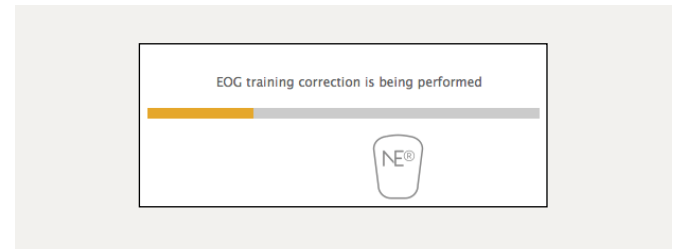
- 1 Name the Protocol (e.g. EEG Protocol)
- 2 Optionally, name the protocol step (e.g. EEG01).
- 3 Define the duration of the EEG recording (e.g. 10 min). Note that wireless Enobio systems have a limited battery duration. Make sure the battery is charged before loading long protocols.
- 4 Define the template mount. Place the cursor above the available positions (green) and drag them to the EEG workspace. Make sure the selected positions become purple.
- 5 Optionally, define the EOG Training settings (i.e. EOG channels and EOG Training duration)
- 6 Save the protocol and, then, load it.

Note: The stimulation related parameters (i.e. ramp-up/down times, Sham activation, and dosage information) are not visible when using Enobio. When using a Starstim 8/20/32 for an EEG-only protocol, those fields should not be used, because they will have no effect.

## EOG Correction

The EOG correction feature allows artifacts, associated to the eye movement, to be removed from the EEG signal. The EOG correction requires one or two channels to be assigned to the EOG function. Those channels should be associated to adhesive electrodes placed near the eye to better detect the ocular movements.

To activate the EOG correction, first assign one or two channels of the mount to the EOG labels shown on the Head Diagram. Select the duration of the EOG training which corresponds to the time period during which the EOG channels learn the signals associated to the movement of the eyes. When the EEG protocol starts, the EOG training will start and, when finished, the EEG recording begins. EOG correction will be applied only during visualization.



# EEG Protocol

The interface is divided into several sections:

- 1** (Top Left): **NE®** logo and **New Protocol** header.
- 2** (Middle Left): **Steps** section containing a list with one item: **1 EEG 01**.
- 3** (Middle Left): **Step total duration** set to **00:10:00**.
- 4** (Top Right): **Design** section with tabs for **EEG** and **Stimulation**. The **EEG** tab is active, showing a grid of channels: **Ch 1** to **Ch 8**, with **EOG1** and **EOG2** also listed.
- 5** (Bottom Right): **EOG Correction** toggle (checked) and **EOG Training Duration (sec)** set to **60**.
- 6** (Bottom Center): **FINISH and SAVE** button.

**Template** section (Center):

- Dropdown menu: **User defined**
- Diagram of a human head with electrode positions. Green circles represent EEG electrodes, and blue circles represent Stimulation electrodes.
- Legend: **● EEG** (green), **● Stimulation** (blue)
- Text: **Dosage of protocol: 0.0 mC**, **Dosage of step: 0.0 mC**

## V.2

# EEG Monitoring

---

When an EEG protocol is loaded and the Play button is pressed, the recording starts. If EOG training is activated, the EOG training window will pop-up before the recording starts. During the EEG monitoring, pay attention to the filters, the reference system, and the plot scales. Make use of the Liveview panes (pp. 26-35) for real-time EEG analysis and visualization.

### Data Filtering

NIC2 allows EEG data to be filtered. The 50 Hz (Europe) and the 60 Hz (US) filters can be enabled/disabled in the **My DEVICES** pane (pp. 14-15). Both line noise filters are applied for the visualization and they can be optionally applied for the recorded data.

Additionally, the user may define a visualization filter (pp. 14-15). These filters are applied to the EEG plots in NIC2, but they do not affect the data recorded. A possible band-pass filter can be 2 Hz - 40 Hz, since it removes the offset of the channels and line noise.

### EEG Reference

During the monitoring, the operator may select the reference channel. By default, all channels are plotted in reference to the CMS channel. Optionally, the signals can be also referenced to the average of all EEG channels. Bipolar and banana referencing options are available for 20-/32-channel systems using the standard mount template.

**Warning:** Note that the chosen reference is only for visualization purposes. All the recorded EEG data is referenced to the CMS channel.

### Time & Voltage scales

Both time and voltage scales can be adjusted. The standard time scale is set to 10 seconds, whilst the voltage scale is initially set to Auto. Use a vertical scale  $< 100 \mu\text{V}$ , to be able to properly visualize the EEG signals and their quality.

# EEG Monitoring



## V.3 EEG Signal Quality

---

In NIC2, the quality of the EEG signals is assessed via the quality index (QI). The QI is computed every 2 seconds, and it depends on four parameters as described by Equation 1:

- ▶ Line Noise: power ( $\mu V^2$ ) of the signal in the standard line noise frequency band (EU:  $50 \pm 1$  Hz; US:  $60 \pm 1$  Hz).
- ▶ Main noise: signal power of the standard EEG band (1–40Hz)
- ▶ Offset: mean value of the waveform
- ▶ Drift: the drift is measured but not included in the QI computation because it has a high inter-subject variability. A high drift does not imply bad signal.

During EEG monitoring, place the cursor above the superscripted quality circles, to see the values of drift, offset, main noise, line noise and QI. The parameter in bold is the one affecting the signal the most.

The quality indicator is meant to be used as a guidance, 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 proceed with the experiment. If the indicator becomes red at some point, there is no need to immediately stop recording.

Each EEG channel displays a color code based on its QI:

- ▶ green (QI: 0.0 - 0.5)
- ▶ orange (QI: 0.5 - 0.8)
- ▶ red (QI: 0.8 - 1.0)

First visually inspect the signal and wait until it becomes orange or green again. Read the Electrode manual to learn how to improve the signal quality. The signal quality depends on the type of EEG electrode and on the CMS reference channel. If that does not happen, several reasons may explain that:

Examples of EEG signals

Page 43 contains examples of EEG signals:

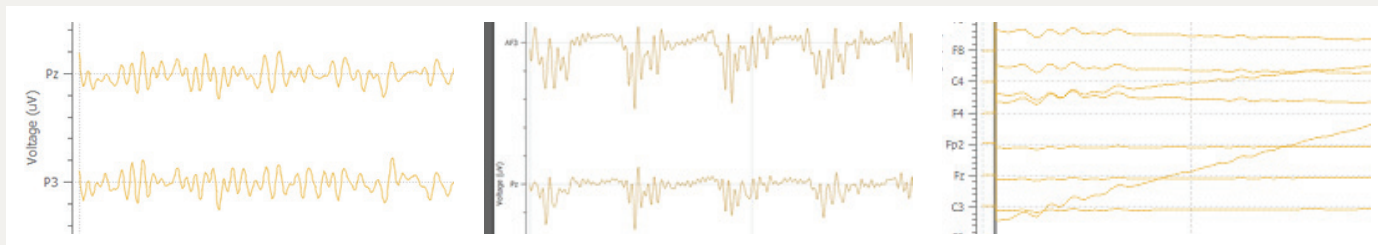
- ▶ Normal EEG signal.
- ▶ Signal with artifacts derived from repetitive chewing movements.
- ▶ Multichannel EEG with one signal with high drift.

Equation 1:

$$QI(t) = \tanh \left( \sqrt{\left( \frac{Offset(t)}{WeightOffset} \right)^2 + \left( \frac{MainNoise(t)}{WeightMainNoise} \right)^2 + \left( \frac{LineNoise(t)}{WeightLineNoise} \right)^2} \right)$$

- ▶ WeightOffset = 280 mV
- ▶ WeightLineNoise = 100  $\mu$ V
- ▶ WeightMainNoise = 250  $\mu$ V

**Warning:** The quality index (QI) is not an Impedance Check measurement. The Impedance Check feature is available, only for stimulation channels.



Normal EEG signal

Signal with chewing artifacts

Signal with drift

## V.4

# EEG Analysis

---

NIC2 allows real-time data analysis via Liveview panes (pp. 26-35). Nevertheless, the processed data is not stored, only displayed. Neuroelectrics® provides two options for post-processing: NUBE&Cirrus service and TCP/LSL streams. The former offers automatic EEG reports, while the latter makes EEG data available for advanced processing with third-party applications.

Neuroelectrics® also provides a plugin to allow EEG data from NIC2 to be imported into the EEGLAB MATLAB (MathWorks®) toolbox ([www.sccn.ucsd.edu/eeglab/](http://www.sccn.ucsd.edu/eeglab/)).

### Data streaming

EEG data can be read and processed with third-party softwares, such as MathWorks® MATLAB. Both Lab Streaming Layer (LSL) and Transmission Control Protocol (TCP) options are available in NIC2. To activate the LSL and/or TCP streams, go to the Protocol Settings (pp. 22-23).

To activate the LSL go to the Protocol Settings (pp 22-23) and provide a name for the LSL Outlet. NIC2 will use this name to provide 4 different outlets: provided\_name-EEG, provided\_name-Accelerometer, provided\_name-Quality, provided\_name-Markers. A third-party application can connect to them to

receive information regarding EEG streaming, accelerometer, quality and markers data respectively.

To activate the connection through TCP go to the My Device Settings (pp 14-15) and activate the TCP Server option. Click on the gear symbol to modify parameters such as:

- 1 The network adapter where the server will be listening
- 2 Activate/deactivate server for raw EEG data
- 3 Inclusion of received marker on the raw EEG data server
- 4 Activate/deactivate server for EEG power in bands data
- 5 Definition of a custom band to be sent on the EEG power in bands server
- 6 Inclusion of timestamps
- 7 Option to send the information in ASCII format rather than binary
- 8 Option to make NIC2 wait for incoming connections (default) or to actively initiate a connection to the provided IP addresses to send data

### TCP connection settings

Adapters Available

TCP Connection for EEG data   :

Include markers

TCP Connection for EEG bands   :

Custom Band

Include timestamps

Send data in ASCII

Wait for connections  Initiate the connections

1

2

3

4

5

6

7

8

## V.5

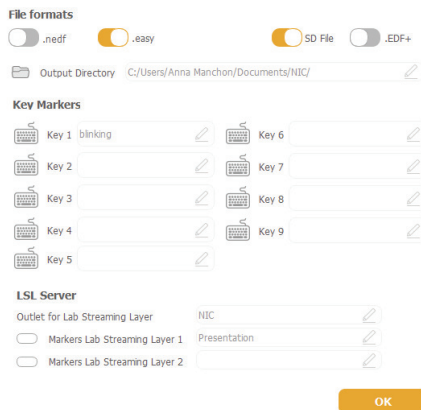
# Holter Mode

NIC allows Enobio devices to enter in Holter Mode. The data will be stored in the SD card inserted into the Enobio amplifier so the EEG system is completely wireless and wearable. Check your firmware version to make sure it is supported for this function.

How to enter Holter Mode:

- 1 Insert the SD card in the SD card slot (Enobio lateral side) and configure the desired protocol with the total duration the recording shall last.
- 2 Enable the SD Card file (Go to Protocol Settings page 23 and check the picture on the right.)
- 3 Load the protocol and press the start button for EEG acquisition. Note that message with the exact amount of free space in the SD card that is needed to carry out the recording will appear. If there is no such free space, the device will rapidly blink for a few seconds indicating that the recording could not be started in the SD card. The same behaviour occurs when the SD card is not present.
- 4 Once the recording has started, close NIC2. Here, NIC2 asks for permission to enter in Holter Mode so press Yes.
- 5 The data recorded is stored for the time the protocol has been configured in NIC2. Note that the device will blink while the

recording in the SD card is happening and that will get back to the idle state when it stops recording.



Technical Specifications:

For optimal performance, fast micro SDHC (Micro Secure Digital High-Capacity) cards are recommended (UHS-I or higher, Class 10.)

As a recommendation, the SD card should not be protected against writing. The battery level is read every 5 minutes and it records data to SD Card every 10 minutes

# VI. Stimulation Experiments

**Warning:** During stimulation with Starstim, NIC2 needs to maintain continuous communication with the device. If communication is lost, the stimulation is automatically aborted.

## VI.1

# Stimulation Protocols (1/4)

---

Many types of tCS studies can count on NIC2 to be implemented. NIC2 allows for bipolar anodal/cathodal montages, multi-electrode templates, and even combined EEG&tCS protocols. In addition NIC2 includes three types of tCS:

- ▶ transcranial Direct Current Stimulation (tDCS)
- ▶ transcranial Alternate Current Stimulation (tACS)
- ▶ transcranial Random Noise Stimulation (tRNS)

Due to the complexity that stimulation protocols can reach in NIC2, it is highly important that one understands how to implement such protocols.

NIC2 protocols for stimulation can be created in **Basic** or **Advanced** modes. The former allows only one channel for stimulation and one or multiple return channels; whilst the latter allows for multiple stimulation channels and only one return. In addition, the advanced mode allows the user to combine tDCS, tACS and tRNS for each channel, independently.

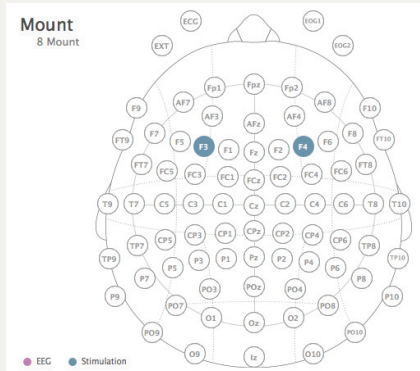
Depending on the complexity of the protocol to be created, the user should choose the most appropriate mode.

## Bipolar Montages

The Basic mode is suitable for simple bipolar montages. To create an anodal tDCS protocol, go to the Protocol Design section in NIC2 and follow the steps below. An example of a Bipolar Montage tDCS can be found on p.48:

- 1 Select Stimulation under the Design workspace.
- 2 Select the Basic mode, and choose tDCS.
- 3 Define the anode
  - ▶ Drag the channel position F3 from the Head Diagram to the Design/Stimulation workspace.
  - ▶ Choose the Stimulation function for this channel, and select Anodal.
  - ▶ Type the desired current amplitude, 1000  $\mu\text{A}$  (= 1mA).
- 4 Define the cathode
  - ▶ Drag the channel position F4 from the Head Diagram to the Design/Stimulation workspace.
  - ▶ Choose the Return function for this channel, and type the return percentage, 100%.

# Bipolar Montage tDCS, 1mA



Design

EEG | Stimulation

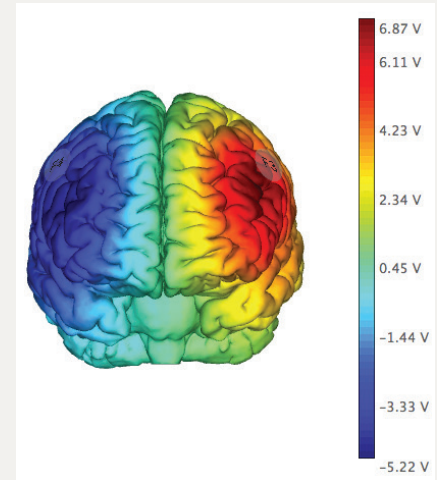
tDCS | Basic | Advanced

Channel 1: Stimulation (F3) | X

Channel 2: Return (F4) | X

tDCS: Amp (µA) 1000

Stimulation Return Percentage (%) 100



The stimulation protocol will use the positions located at F3 and F4 as indicated in the mount diagram.

F3 channel is defined as anode, with a current intensity of 1mA. The total amount of current (100%) will return at F4 (cathode).

Stim Preview confirms that the chosen montage will target the desired brain area, with anode over F3 and cathode over F4.

## VI.1

# Stimulation Protocols (2/4)

---

### High-definition Montages

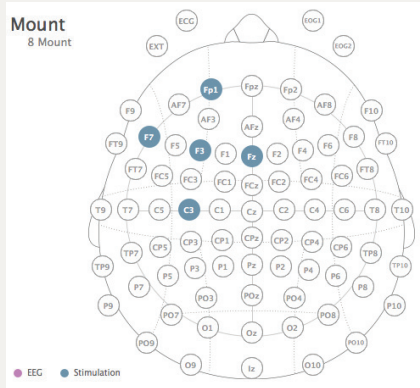
The Basic mode is also suitable to create high-definition tDCS montages. The term high-definition tDCS—or multi-polar tDCS— describes the concept of having a central electrode over the target area, and a set of return electrodes arranged in a ring around the central electrode.

Neuroelectronics® Starstim products are suitable for multi-polar tDCS montages. The multi-polar montages can be formed with the conventional ring of 4 cathodes or with more than 4 return channels to minimize the current under the cathodes.

To create a multi-polar tDCS protocol, with a ring of 4 return channels as illustrated with the images on the right, follow the steps below, in the Protocol Design section:

- 1 Select Stimulation under the Design workspace.
- 2 Select the Basic mode, and choose tDCS.
- 3 Define the Anode
  - ▶ Drag the channel position F3 from the Head Diagram to the Design/Stimulation workspace.
  - ▶ Choose the Stimulation function for this channel, and select Anodal.
  - ▶ Type the desired current amplitude, 1000  $\mu\text{A}$  (= 1mA).
- 4 Define the ring of cathodes
  - ▶ Drag the channel positions that form the ring – Fp1, F7, Fz and C3 – from the Head Diagram to the Design/Stimulation workspace.
  - ▶ Choose the Return function for this channel, and type the return percentage of 25% for each of the four channels.

# Multi-polar Montage tDCS, 1mA



### Design

EEG | Stimulation

tDCS | Basic | Advanced

F3 Channel 1 | Stimulation | x

Anodal | Cathodal

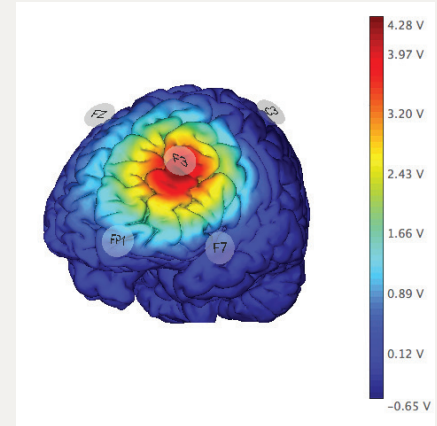
tDCS: Amp (µA) 1000

Fp1 Channel 2 | Return | x

F7 Channel 3 | Return | x

Stimulation Return Percentage (%) 25

Stimulation Return Percentage (%) 25



The stimulation protocol will use the main location F3, with 4 channels around the positions located at F3 and F4 as indicated in the mount diagram.

F3 channel is defined as anode, and four cathodes (Fp1, F7, Fz and C3) are used to disperse the return current effects.

Stim Preview confirms that the chosen montage will target the desired brain area, with anode over F3, without the reverse effect on the counter side.

## VI.1

### Stimulation Protocols (3/4)

---

Complex waveforms: tDCS, tACS & tRNS

NIC2 can combine tDCS, tACS and tRNS in order to produce more complex waveforms that result from the linear combination of those. In the Advanced mode, more than one channel can be used for stimulation and their currents can be independently defined.

The stimulation current per channel can be defined as a linear combination of tDCS, tACS and tRNS. The following five parameters can be independently chosen for each channel:

- 1 DC amplitude:  $\text{Amp}_{\text{tDCS}}$  ( $\mu\text{A}$ )
- 2 AC amplitude:  $\text{Amp}_{\text{tACS}}$  ( $\mu\text{A}$ )
- 3 AC frequency:  $F_{\text{tACS}}$  (Hz)
- 4 AC phase:  $P_{\text{tACS}}$  ( $^\circ$ )
- 5 Random noise amplitude:  $\text{Amp}_{\text{tRNS}}$  ( $\mu\text{A}$ )

**Warning:** Note that the currents of all stimulation channels should add zero. Alternatively, one, and only one, of the channels can be defined as return. The current in the return channel is set through the current conservation law.

In Design/Stimulation workspace, the stimulation parameters can be defined as it follows:

- ▶ Click on the `STIMULATION` button.
- ▶ Select the Advanced mode.
- ▶ Click on and drag the desired channel to the white area below.
- ▶ Insert the desired values of the stimulation parameters for the corresponding channel.

The injected current ( $I_{\text{NIC}}(t)$ ,  $\mu\text{A}$ ) in the corresponding electrode position is given by Equation 2, where  $t$  is the time in seconds and RNS is white noise with an unitary variance Gaussian distribution.

- 6 The RNS waveform can be filtered using low, band or high pass filters. The cut-off frequencies can be defined by the user.

# tDCS, tACS & tRNS

Channel 1 Stimulation

tDCS: Amp (μA) 0

tACS: Amp (μA) 500 f (Hz) 50 P (°) 180

tRNS: STD σ 0 p-p (μA): 0

Equation 2:

$$I_{NIC}(t) = Amp_{tDCS} + Amp_{tACS} * \sin(2\pi * F_{tACS} * t + P_{tACS}) + Amp_{tRNS} * RNS(t) \text{ (}\mu\text{A)}$$

**Warning:** Regardless of the values assigned, the current at any electrode never exceeds the maximum value allowed by the device at any given time. The maximum value is either 2 mA or 4 mA, depending on the version of the Starstim. Starstim limits the maximum injected current per channel and per system at any time instant.

Design

EEG Stimulation

Basic Advanced

Channel 1 Stimulation

tDCS: Amp (μA) 0 f (Hz) 50 P (°) 180

tACS: Amp (μA) 500 f (Hz) 50 P (°) 180

tRNS: STD σ 0 p-p (μA): 0

Channel 2 Stimulation

tDCS: Amp (μA) 0 f (Hz) 50 P (°) 0

tACS: Amp (μA) 500 f (Hz) 50 P (°) 0

tRNS: STD σ 0 p-p (μA): 0

Waveform: None Single Loop

tRNS Filtering: None Low Band High

## VI.1

# Stimulation Protocols (4/4)

---

### Custom Waveforms

With NIC2, it is possible to customize waveforms that, due to their complexity, can not be created using a linear combination of tDCS, tACS and/or tRNS (eg. rectangular waveform). Follow the steps below to customize the stimulation waveforms for Starstim:

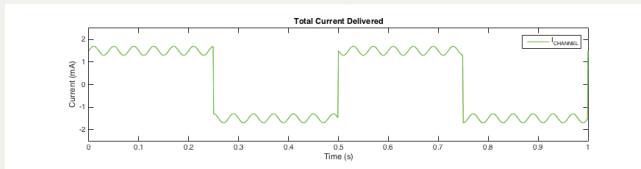
- 1 Create a text file (\*.txt) that contains the samples of the stimulation waveforms that correspond to the multi-channel stimulation. The file should contain the following specifications:
  - ▶ The number of columns should correspond to the number of stimulation channels used in the protocol.
  - ▶ Each row corresponds to a multi-channel sample with a millisecond resolution (e.g. 1 second waveform requires a file with 1000 rows).
  - ▶ The stimulation values are defined in micro-ampere ( $\mu\text{A}$ )
  - ▶ For each row, the values must add zero in order to respect the current conservation law at any time instant.
- 2 In the **My DEVICES** pane (pp. 14-15) load the text file previously created. NIC2 will show an error message in case there is a problem with the file structure.
- 3 When creating the stimulation protocol, make sure that all the stimulation steps use the same number of stimulation channels, which equals to the number of columns of the loaded

text file.

- 4 The user has the option to apply the custom waveform once (single) or repeated times (loop) during the total duration of the stimulation step.

**Warning:** The custom waveform feature is only available with the following devices: Starstim 8 5G and Starstim R20/32. To be compatible, Starstim 8 5G must have a firmware version equal or superior to 4016, and Starstim R20/32 must have a firmware version equal or superior to 3028.

# Custom Waveforms



**Warning:** Regardless of the values assigned, the current at any electrode never exceeds the maximum value allowed by the device at any given time, that is 2 mA. Starstim limits the maximum injected current per channel and per system at any time instant.

Design

EEG Stimulation

tDCS Basic Advanced

Channel 3 Stimulation X

Anodal Cathodal

tDCS: Amp ( $\mu$ A) 0

Channel 7 Return X

Stimulation Return Percentage (%) 100

Waveform None Single Loop

fc1 (Hz) 0 trNS Filtering

fc2 (Hz) 0 None Low Band High

## VI.2

# Impedance Check

---

The impedance of the stimulation channels can be measured by NIC2. This feature is available for Starstim devices, but not for Enobio devices.

The `IMPEDANCE CHECK` button is used to measure the impedance of the channels used for stimulation, including the return channel. The Impedance Check should be performed before launching any protocol with stimulation.

For each channel, the Impedance Check is computed via Ohm's law. NIC2 allows for two types of impedance check: with alternate current (AC) and with direct current (DC).

With the AC option, an alternating current of 300  $\mu\text{A}$  amplitude and 30 Hz frequency is injected and the resulting voltage values are measured. The DC impedance is measured using a 300  $\mu\text{A}$  constant current. Both methods measure the impedance values during 5 seconds per pair of channels.

The impedance bar appears below the icons of the stimulation channels and its color depends on the obtained value:

▶ **green**: [0 - 10]  $\text{k}\Omega$

▶ **orange**: [10 - 15]  $\text{k}\Omega$

▶ **red**: [15 - 20]  $\text{k}\Omega$

In the LiveView panes, by placing the cursor above the bar, a rectangle appears showing the actual impedance value. Those values are automatically saved on a text file too.

During a stimulation protocol, the impedance is monitored every second. At any instant, if the impedance exceeds 20  $\text{k}\Omega$  in any stimulation electrode, the stimulation protocol aborts to protect the subject from the high voltages generated.

### How to improve the contact impedance

There are several ways to decrease the impedance of the stimulation electrodes and improve the contact with the scalp:

(a) part the hair underneath the electrode (b) clear the visible scalp using a cotton swab (c) add more conductive liquid between the electrode and the scalp.

## VI.3

# Dosage of the Stimulation

---

The stimulation dosage is defined as the amount of charge received by the subject during a tCS session.

For each stimulation protocol, NIC2 computes the total dosage of the protocol, and the dosage of the each protocol step.

The dosage is calculated using the equation:

Equation 4:

$$Dose = \frac{1}{2} \sum_{n=1}^N \int_0^T |I_n(t)| dt$$

N = total number of stimulation channels

## VI.4

# Blind Modes

---

NIC2 is prepared to conduct single and double blind stimulation experiments. In both scenarios, the Sham mode is needed to control the placebo effect of the stimulation.

### Single Blind: Sham

Conducting a Sham session implies that the subject undergoing the stimulation experiment should not be aware if a real tCS protocol is being applied or if he/she is being submitted to a fake tCS protocol. The Sham protocol should therefore be designed to provide the same sensation as a real stimulation without its effects. Sensations similar to those in tCS are created by generating currents at the start and at the end of the stimulation, although it is possible to disable the sensations at the end of the session by activating the Single Ramp option.

To enable the Sham mode, activate the Sham slider when defining the name and duration of the stimulation step. After activating the Sham, set the duration of the Sham ramp. In this situation the current will increase and decrease at the beginning and at the end of the corresponding active stimulation experiment.

To disable the ramp-up/down at the end of the experiment, activate the Single Ramp slider.

### Double blind

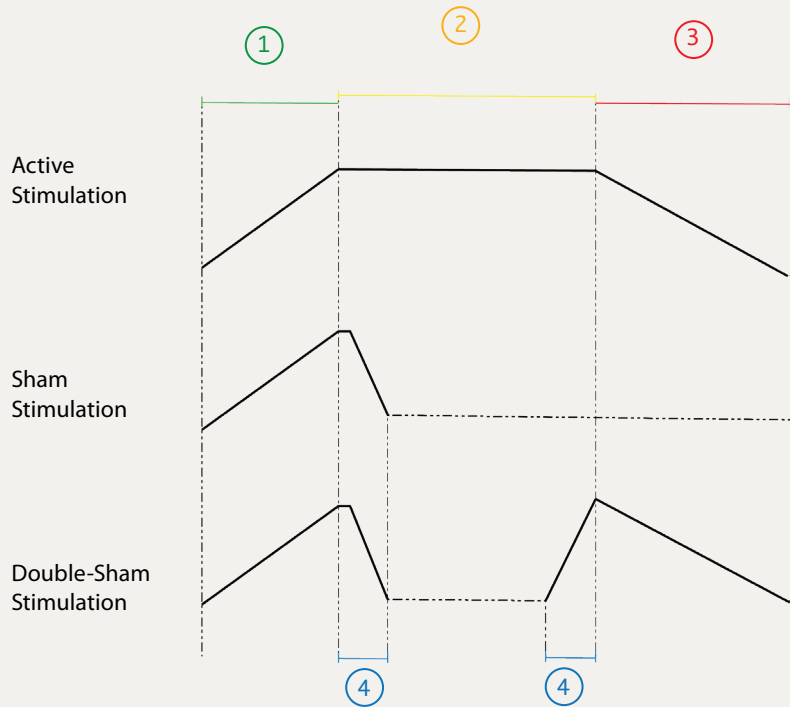
Before explaining how to activate the double blind mode, one needs to define the concept of administrator and operator. The administrator is the person who creates and manages the protocols. The operator only runs the experiments, and is not informed about which protocols refer to active stimulation and which protocols are in the Sham mode.

The protocols should be given a generic name (e.g. Protocol A1, Step A.1). The administrator should also prepare a list that assigns a protocol to the corresponding subject.

The double blind mode is activated in NIC2 in the **My DEVICES** pane (pp. 14-15). NIC2 requests a password to activate the double blind mode. The administrator should activate the double blind mode, and the operator should not have access to the password. When the double-blind mode is activated, non-essential information is hidden.

Contact Neuroelectronics® in case you forget your password.

# Active Stimulation and Sham Profiles



### New Protocol

Bipolar tDCS

#### Steps

1 STIM 01

Step total duration 00:20:00

Ramp-up 5 Ramp-down 5 Sham

+ ADD NEW STEP

1. Stimulation Ramp-up
2. Stimulation Duration
3. Stimulation Ramp-down
4. Fade-out/in Ramp



---

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

Additionally, NIC2 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. NIC2 produces the EDF+ files (extension of EDF) which is the standard binary file format for EEG data. The binary \*.nedf files are proprietary NIC files with an xml header, while the binary \*.sdeeg file format is used when offline recording is used in a SD memory card.

# VIII. NUBE: EEG Cloud

---

NIC2 has been designed to allow the access to **NUBE**. Neuroelectrics® Nube is a cloud service that helps researchers to manage all the EEG experiments. NUBE cloud is bundled with Neuroelectrics® Cirrus service which generates automatic EEG reports.

Both NUBE & Cirrus are services that require customer subscription. Contact Neuroelectrics® to be eligible for a free-trial.

In case you already have a NUBE account, follow the next steps to use the service via NIC2:

- 1 To unlock **NUBE** pane, go to **My DEVICES** and activate the Save recordings to Nube option. The NUBE cloud icon will immediately appear on the Pane bar.
- 2 To connect to NUBE, introduce the login credentials (ID & Password). Make sure you have Internet connection.
- 3 Select the file to be uploaded to NUBE. Only \*.NEDF files are allowed in NUBE. Make sure you have the \*.NEDF format option active in the **Protocol Settings** (pp. 22-23).
- 4 The three fields –Subject, Experiment and Take – need to be defined before uploading files to the cloud. Prepare NUBE before uploading EEG files.
- 5 To access to NUBE Settings, click on the **RECORDING SETTINGS** button.

Choose the correct parameters (e.g. eyes open/close, electrical ground location, etc.) and register the name of the operator. If the Autoupload button is active, the files added to the upload list will be automatically uploaded to NUBE.

6 After choosing the file and defining the NUBE parameters and settings, press the **ADD TO UPLOADS** button. The selected file should now be visible in the **Upload List**.

7 The Upload List keeps tracking the uploading status of all the files selected to be uploaded.

# NUBE Cloud

The screenshot displays the NUBE Cloud user interface. On the left is a vertical sidebar with a dark grey background and an orange top section containing the 'NE®' logo. The main content area is light grey and contains several sections: a 'NUBE' header with 'Researcher ID' and a password field; a 'File to Upload' section with a text input and folder icon; a 'Subject' section with dropdown menus for 'Subject', 'Experiment', and 'Take'; a 'File upload Progress' table; a 'NUBE Settings' dialog box; and a bottom bar with 'DISCONNECT', 'RECORDING SETTINGS', 'File Upload Status', and 'ADD TO UPLOADS' buttons. Seven orange callout boxes with numbers 1 through 7 point to specific elements: 1 (cloud icon), 2 (DISCONNECT button), 3 (NUBE header), 4 (File to Upload input), 5 (Experiment dropdown), 6 (RECORDING SETTINGS button), and 7 (File upload Progress table and ADD TO UPLOADS button).

**1** Cloud icon in the sidebar

**2** DISCONNECT button

**3** NUBE header

**4** File to Upload input field

**5** Experiment dropdown menu

**6** RECORDING SETTINGS button

**7** File upload Progress table and ADD TO UPLOADS button

**File upload Progress**

	Progress	Take	Filename
1			

**NUBE Settings**

Recording Date: 28-09-2016  
Recording Length: 00:01:00  
Eyes: Open  
Electrical Ground: EEG Position  
Experiment Type: Visual ERP  
Recording Operator: [input field]  
Comments: [input field]  
Autoload:  **OK**

# XI. Offline Mode

NIC2 can read files with distinct formats to inspect their EEG signals.

The Offline Mode can be accessed from the Home Pane by clicking on the Offline mode command. Files with \*.easy, \*.nedf, \*.info and \*.sdeeg formats can be loaded. Once the file is fully read by NIC2 the EEG signals are presented in the Liveview Home pane. In Offline mode this pane is slightly changed.

1 Click on the **Offline Mode** button. A box will appear to load a new file. Make sure to select a file from your Directory.

2 Use Play/Pause and forwards/backwards button to inspect the EEG signals.

3 Drag and drop the time line bars to rapidly move to an exact time in the file

4 When the file contains markers, it is possible to select any type and navigate to where they are with the double-arrow buttons.

5 Click on the Export File button to convert the current loaded file to a different format (\*.easy, \*.nedf, \*.edf) by clicking on the **Export File** button.

6 By clicking on the Create Report button, it is possible to generate a

post-processing report on the current loaded data. A dialog will be open where the post-processing parameters can be adjusted as well as the data starting and finishing time.

7 Access to Custom views (p28-35) is also available in Offline mode.

1



# Offline Mode

NE®

Liveview

Offline Protocol  
1 steps in Protocol

LOAD FILE

00:03:00 TOTAL

00:01:01 ELAPSED

EXPORT FILE

CREATE REPORT

20161118121841\_SS32\_validation\_test19\_eyes closed.ea

STEPNAME

Fp1 Fp2 AF3 AF4 F7 F3 Fz F4 F8 FC5 FC1 FC2 FC6 T7 C3 Cz C4 T8 CP5 CP1 CP2 CP6 P7 P3 Pz P4 P8 PO3 PO4 O1 O2 O2

CONFIGURATION

Reference channel CMS

Temporal window (sec.) 10

Zoom

100 µV/div

Auto

Markers

Voltage (µV)

Time (seconds)

v2.0.18

# Offline Mode

**Export Settings**

Recording Date	19/09/2018 12:52
Recording Length	00:03:00
File Format	<input type="text" value=".edf"/>
Voltage units	uV
Sampling rate (S/s)	500
Filtering	HP:0.1Hz

