g.RECORDER

BIOSIGNAL RECORDING SOFTWARE

USER MANUAL

g.RECORDER

User Manual: g.Recorder
Version: 1.20.03

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g.RECORDER

CONTENTS

1 INTRODUCTION

Welcome to **g.Recorder**!

g.Recorder is a novel, user-friendly software package for the recording of biosignal data such as EEG, ECoG, ECG, EOG, EMG and sensor data. Trigger information and video sequences can also be captured. An easy-to-use replay mode allows for the inspection of data after recording.

g.Recorder has been designed to work with the g.tec biosignal amplifiers g.HIamp and g.USBamp, and with the portable g.Nautilus devices.

g.Recorder offers raw data inspection and also the extraction and presentation of different parameters. These include, but are not limited to, heart rate variability, heart rate, compressed spectral arrays, and cerebral function.

g.Recorder data can be exported seamlessly to g.tec's biosignal analysis software, g.BSanalyze, for in-depth offline evaluation and data processing.

2 RELEASE NOTES

Release notes bring to your attention new features of, and changes to, g.Recorder when upgrading to a newer version.

2.1 NEW FEATURES

- None.

2.2 CHANGES

- Compatibility update of software licensing for g.tec Suite 1.20.05.

2.3 FILES ON YOUR COMPUTER

g.Recorder program files - are stored under (it is assumed that the default path setting is used)

```
C:\Program Files\gtec\gRecorder
```

Help files - are stored under

```
C:\Program Files\gtec\gRecorder\Help
```

Tools - import tool to import HDF5 files to MATLAB stored in

```
C:\Program Files\gtec\gRecorder\MATLAB Tools
```

Montage files – for pre-assembled g.tec caps are stored in

```
C:\Users\<USER NAME>\Documents\gRecorder\Electrode Montages
```

3 RUNNING g.RECORDER IN USER MODE

After finishing the installation, **g.Recorder** can be operated in *User Mode* with the g.tec biosignal amplifiers as described in this chapter.

3.1 RECORDER MAIN WINDOW

By double-clicking on the g.Recorder icon on the desktop g.Recorder is started in User Mode. This mode is the standard mode and typically used to acquire data within a specific study using predefined configurations. Such configurations can be adapted and created by advanced users in the Administrator Mode.

g.Recorder consists of six elements:

- the Status Bar
- the Toolbar
- the Data Viewer
- the Feature Viewer
- the Video Viewer
- the Evoked Potentials Viewer

In the g.Recorder Menu and Toolbar you can select and set different recording parameters, filenames and start/stop the actual measurement, etc.

The Data Viewer window shows the raw biosignal data. Using the menu and toolbar window, the number of channels and the seconds on screen can be adapted, etc. The channel information (number and name) and the channel scaling is displayed on the left side of the window.

Selected parameters, for example, heart rate and cerebral function are displayed in the Feature Viewer window. The parameters are displayed from left to right. On the left side of the window the y-axis scaling as well as the specific feature name are displayed.

In the Video Viewer window the actual video sequence is displayed.

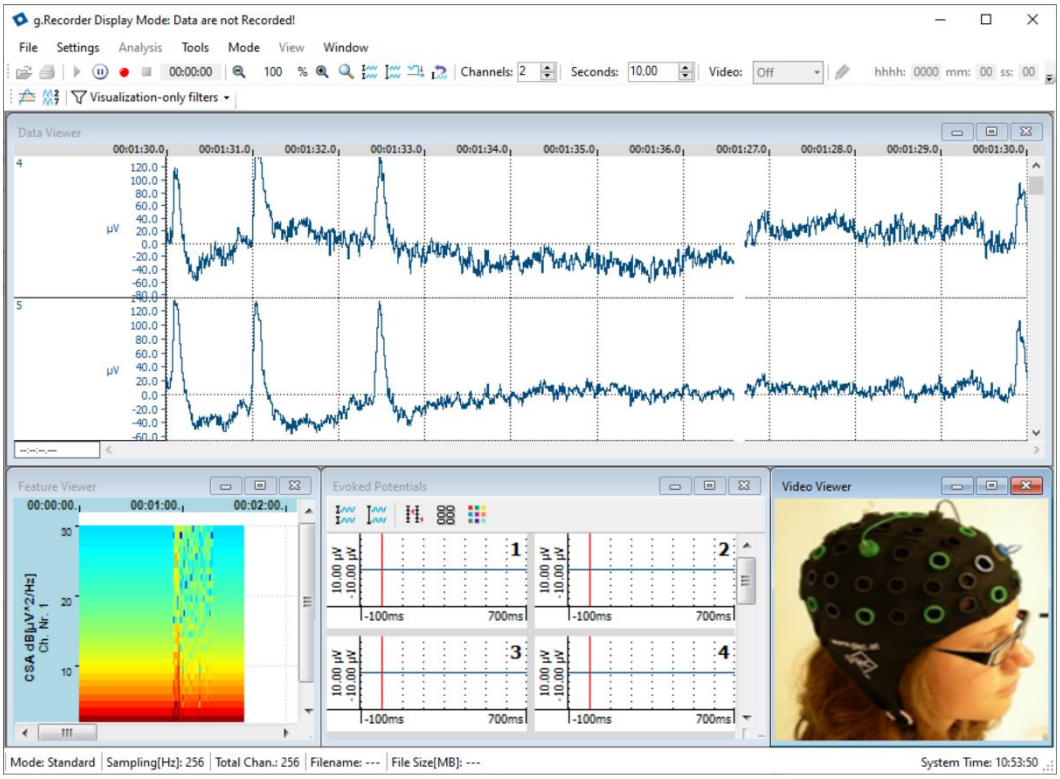
The Evoked Potentials viewer displays calculated evoked potentials for each acquired raw data channel, if configured. Zooming, scrolling and scaling for the evoked potential plots can be adapted directly in this viewer.

The Status bar indicates the actual state of g.Recorder.

You can resize all windows according to your preferences and needs. Individual windows can be hidden to enlarge for example the area of the Feature Viewer.

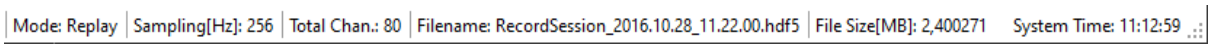
NOTE

The actual layout of the screen and the specific settings are stored to a default configuration file when g.Recorder is closed. This default configuration is used the next time you start g.Recorder. This allows easy continuation of your studies. You can of course load another configuration.



3.2 STATUS BAR

The actual status of g.Recorder is displayed in the Status Bar at the bottom of the main window. The Status Bar shows information that relates to the current recording. The first field shows the current g.Recorder Mode. When data are stored to the hard disk the mode is set to Recording. If data is loaded for off-line visualization it is set to Replay and otherwise to Standard.

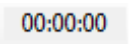
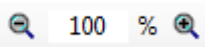


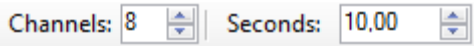
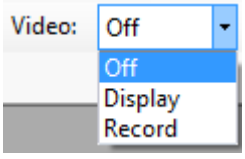
The next fields display information about the:

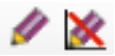
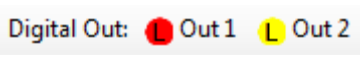
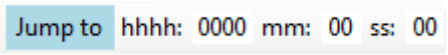
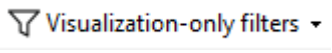
- Sampling frequency per channel in Hertz [Hz],
- Total number of channels,
- selected filename,
- actual file size in megabytes [MB]
- actual system time in the format hh:mm:ss AM/PM.

3.3 TOOLBAR

The **Toolbar** is always shown below the **Menu** and includes functions for file opening, printing, starting and stopping the data acquisition and video capturing, setting markers and navigating to a certain instant in the data.

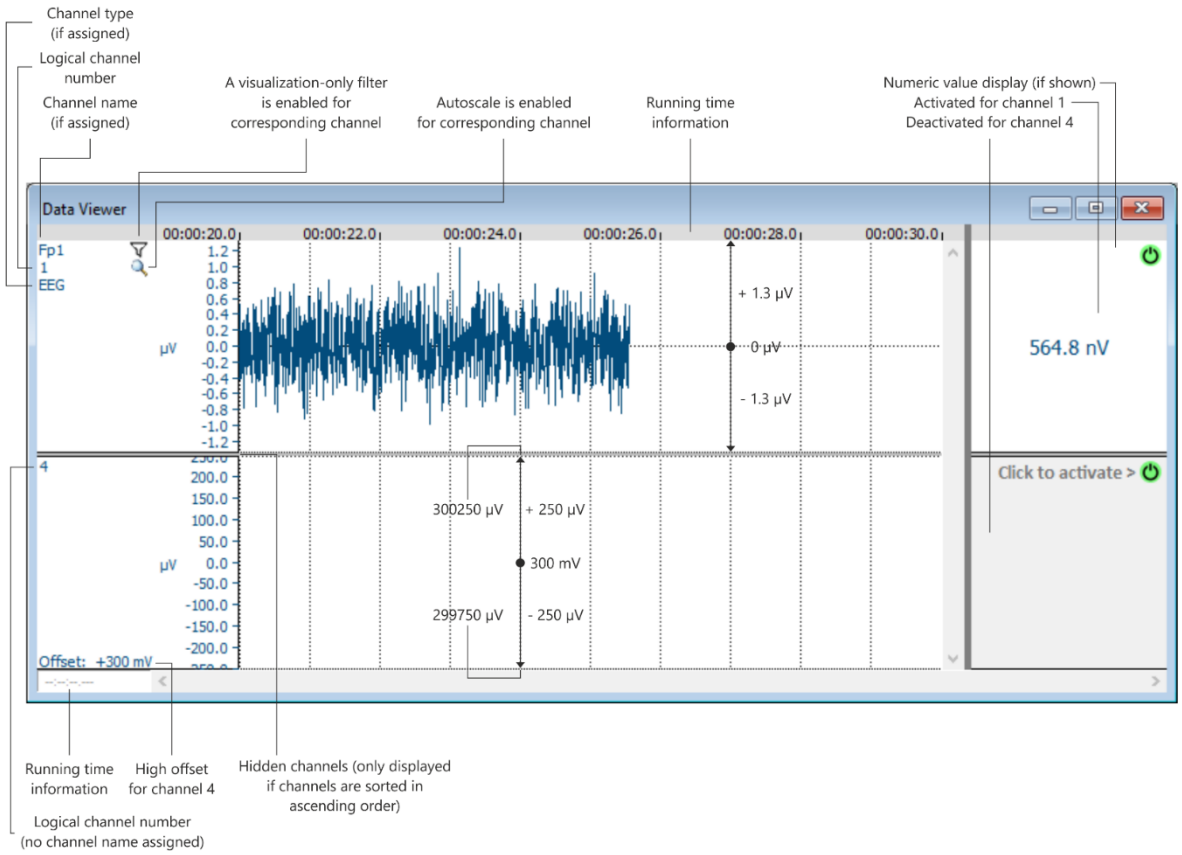
	**Open...** Load an already recorded file for offline replay
	**Print features...** Print selected features
	**Start data viewing** Start displaying data on the screen for visual inspection  **NOTE** No data are stored to disk in this mode
	**Pause data viewing** Pause displaying data in Standard mode. If the pause button is pressed in Recording mode, then only the raw data display in the Data Viewer is stopped. The Video Viewer and the Feature Viewer are still updated in real-time.  **NOTE** All data are still stored to the hard disk if this button is pressed in Recording Mode
	**Record** Start data acquisition to hard disk. Depending on the selected options raw data from the amplifiers, the video and features are saved.  **NOTE** For immediate recordings, no specific filename or subject information must be provided. The filename for the recording will be predefined as a standard file name including the date and system time.
	**Stop** Stop data acquisition
	Actual recording time in the format hh:mm:ss from the beginning of the recording to hard disk
	Zoom out and zoom in into the raw data in the Data Viewer. The percentage can also be inserted directly by typing in the desired zooming level

	**Auto scale** The data in the Data Viewer are scaled to the actual maximal absolute value of the displayed data sequence. If Auto scale is activated, a small icon is displayed in the channel information area on the left side of the Data Viewer window and the data is rescaled for every new page of data.
	**Global maximum auto scale** Auto-scale all channels to the global minimum and maximum value of the displayed data sequence (plus 10%). This scaling is applied only once per click.
	**Individual maximum auto scale** Auto-scale all the channels individually to their minimum and maximum value of the displayed data sequence (plus 10%). This scaling is applied only once per click.
	**Offset auto scale** Auto-scale each channel to its individual offset, preserving its previously configured amplitude range. This scaling is applied only once per click.
	**Show/hide display of numeric signal value** Expands or collapses a panel on the right-hand side in the data viewer which can show the signal's current numeric value for each channel separately.
	**Restore user-defined scaling** Restores the user-defined scaling that was set in the Channel settings dialog before any auto-scale operation was performed.
	**Signal cropping** Enable or disable signal cropping. If signal cropping is enabled, the signal will be cropped at its displayed vertical channel range. If signal cropping is disabled, the data of the displayed channels may overlap the other channels' ranges. Examples are given below. Signal cropping is disabled by default.
	Set the number of channels and the number of seconds to be displayed in the Data Viewer
	**Off**: no video is displayed. **Display**: the video is displayed. **Record**: the video is displayed and recorded (in recording mode).

	Activate/deactivate displaying the marker information on screen.
	Click on the icon to insert a specific marker into the Data Viewer and Feature Viewer. **NOTE** In the Data Viewer the markers are presented as vertical color-coded lines from the top to the bottom of the window including the names of the markers. In the Feature Viewer the marker information is shown as short color-coded line on top of the individual feature.
	Jump to a specific point in time in Replay mode
	**Visualization-only filters** Customizable digital filters can be applied to the analog input channels in the data viewer for visualization purposes only. The filters are not applied to the recorded or analyzed data. To apply filters on recorded and analyzed data, use the configuration dialog of the selected amplifier instead.

3.4 DATA VIEWER

This window displays the raw data acquired with the g.tec amplifiers. Data are displayed in an overwrite mode from left to right. The number of channels displayed on the screen is set via the **Toolbar** to 2. The current time is given above the first displayed channel.



Channel names (e.g. Fp1 for channel 1 in the example above) and channel types (e.g. EEG for channel 1 in the example above) are displayed in addition to the logical channel number only if assigned. The scaling and unit of the channel are displayed directly at the vertical axis. If the offset is too high with respect to the displayed amplitude range, it is indicated separately at the bottom of the channel label. In this case, the offset must be added to the values of the vertical axis in order to retrieve the actual scaling of the axis as illustrated for channel 4 in the example above. Channel names, types, and the minimal and maximal scaling values of each channel can be adapted via the menu Settings/Channels….

The funnel symbol is displayed only if a visualization-only filter is applied to the corresponding channel. The magnifying glass is displayed only if continuous auto-scaling is enabled for the corresponding channel. Visualization-only filters can be configured via the toolbar or the Settings/Visualization-only filters… menu.

If the numeric display is activated (as it is in the example above), a small area at the right hand-side of each channel let allow to display the numeric value and unit of the signal's current value via the channel's on/off button. The numeric display can be activated/deactivated via the toolbar.

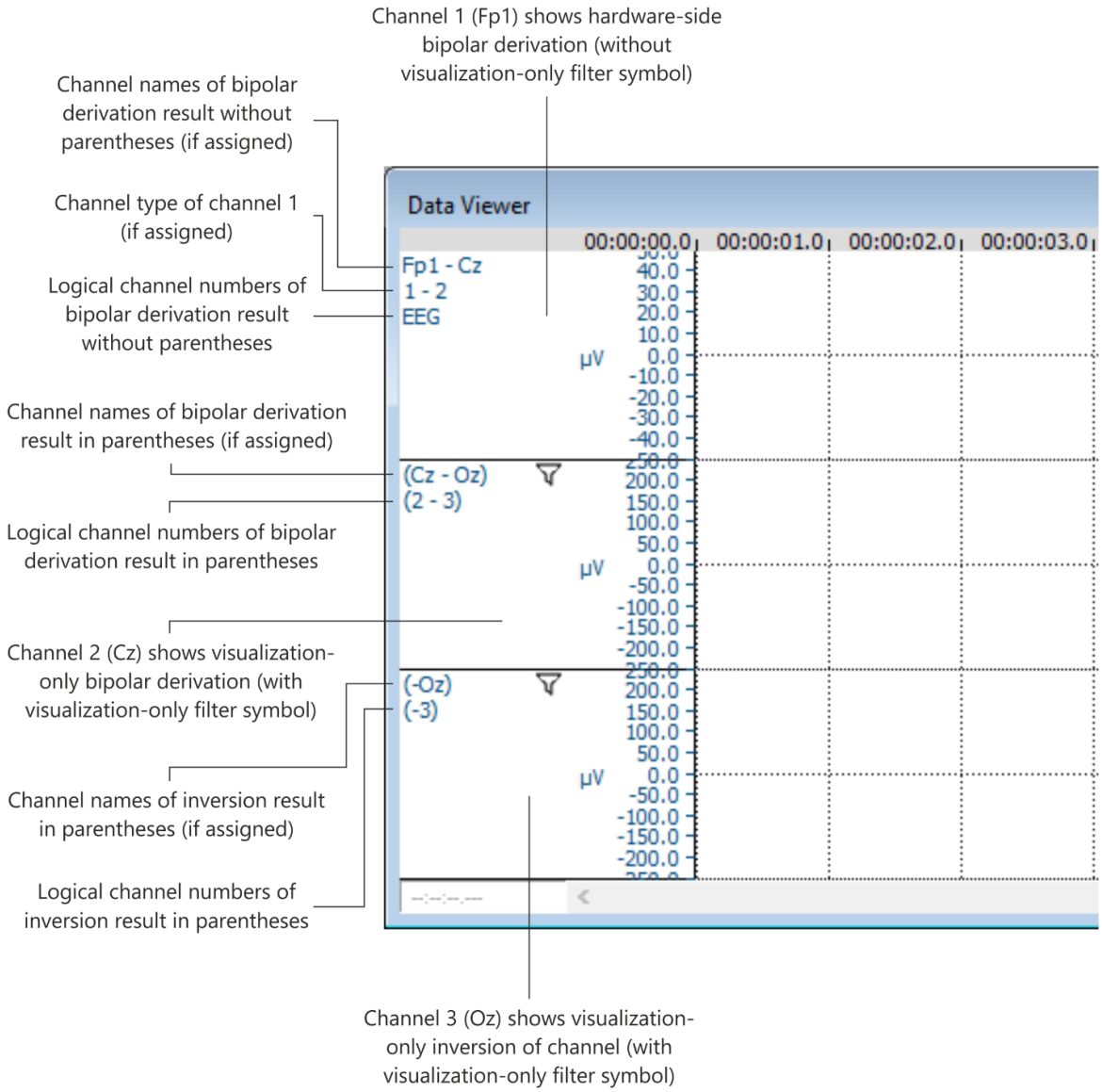
Dragging the vertical axis' ticks with the left mouse button modifies the displayed amplitude offset. Dragging the vertical axis' ticks with the right mouse button modifies the displayed amplitude range. Double-clicking the vertical axis' ticks auto-scales to the best fitting amplitude range and offset for the corresponding channel.

Pressing the up and down arrow keys while the data viewer window has focus decreases/increases the displayed amplitude range for all channels by a certain factor. The left and right arrow keys

decrease/increase the displayed time range. The page up and down arrow keys scroll the displayed channels.

Channels can be selected by clicking the channel label at the left side of the vertical axis' unit. Selected channels can be reordered by dragging and dropping them to a different position. Channel selected for acquisition can also be hidden in the data viewer via the menu Settings/Channels…. Hidden channels are indicated via a small gray bar if they're sorted in ascending order (as indicated for hidden channels 2 and 3 in the example above).

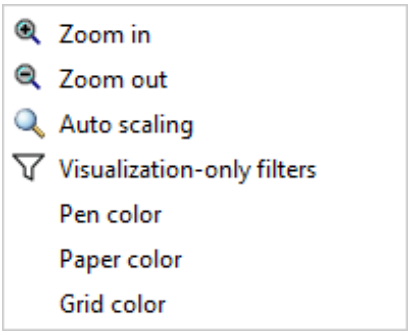
The running time information area displayed bottom-left next to the horizontal scrollbar is only used in review mode and indicates the exact time position of the ruler.



If bipolar derivation is applied for a channel, this is indicated in the channel label as well, showing the result of the bipolar derivation that is displayed at the corresponding channel (e.g. the result of channel 1 (Fp1) minus channel 2 (Cz) at the first channel, and the result of channel 2 (Cz) minus channel 3 (Oz) at the second channel in the example above).

There are two ways on how to configure bipolar derivation: hardware-side via the amplifier configuration (where only filtered data is recorded), and software-side via visualization-only filters (where the filtered signal is only shown in the data viewer, but the raw signal is recorded without filters). Hence, hardware-side and software-side filtering is indicated differently in the channel label. While the result of visualization-only bipolar derivation (e.g. for channel 2-3 (Cz-Oz) in the example above) or single channel inversion (e.g. for channel 3 (-Oz) in the example above) is always enclosed in brackets (also showing the funnel symbol), hardware-side bipolar derivation is not (e.g. for channel 1-2 (Fp2-Cz) in the example above).

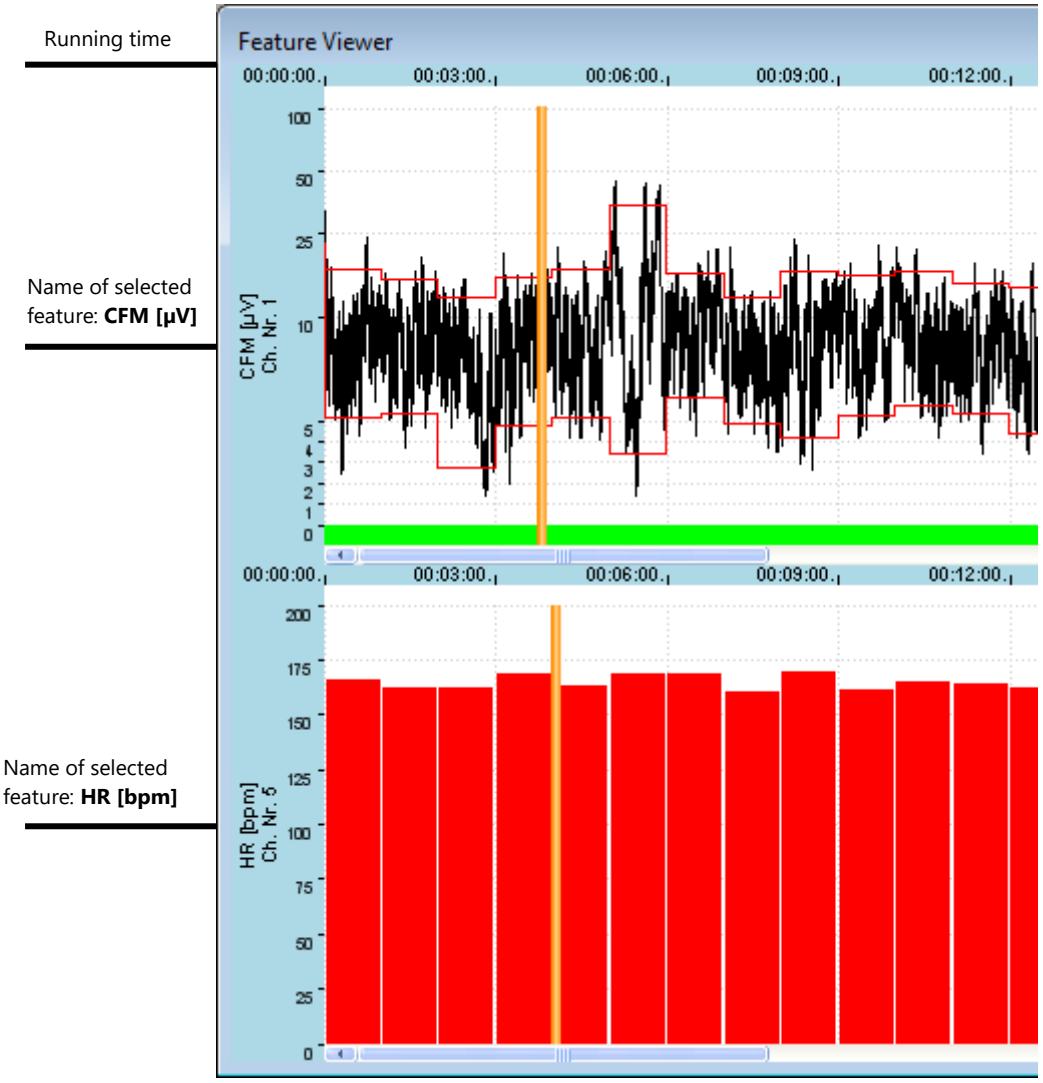
The zooming level of the **Data Viewer** as well as the color for the paper, pen and grid of a specific channel can also be defined via a context menu by clicking the right mouse button in the channel's data area (not the channel axis label) in the **Data Viewer**. Configured visualization-only filters for that channel can be enabled or disabled in addition.



3.5 FEATURE VIEWER

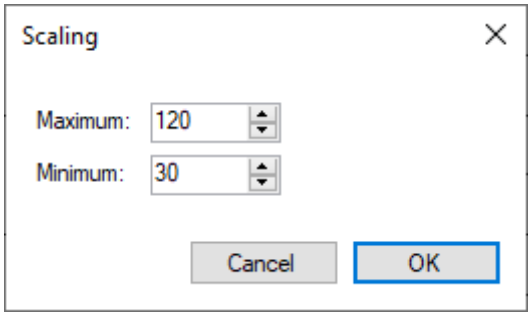
This window displays the parameters extracted from the raw data displayed in the **Data Viewer**. Data are displayed in an overwrite mode from left to right. The features that are computed from the raw data can be defined in the menu **Analysis/Feature definition...**. In this example the feature CFM (cerebral function monitor) is displayed in the upper panel and the feature HR (heart-rate) is displayed in the lower panel.

The actual time is given on top of individual feature panels as the time on screen can vary depending on the specific user settings. The format of the time is hh:mm:ss. The y-axis scaling and units depend on the specific selected feature. The minimal and maximal values can be adapted via the feature specific context menu. The y-scaling for the CFM feature is fixed to 0 and 100 µV. The scaling for the HR feature is set to 0 and 200 beats per minute [bpm].



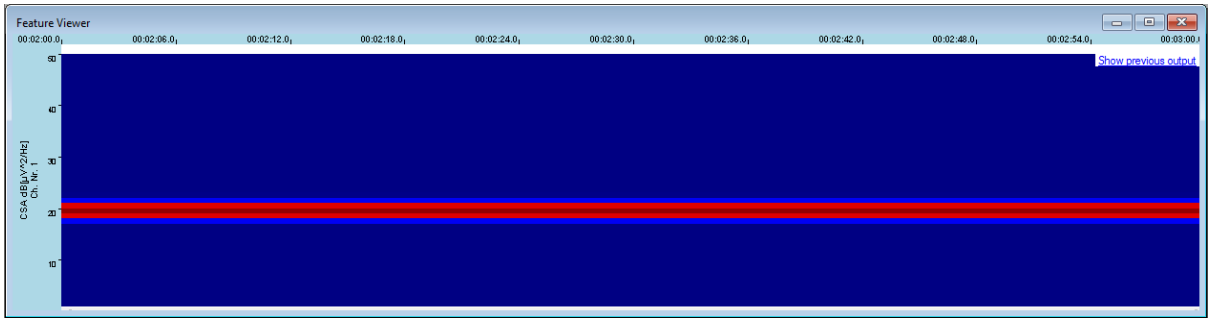
3.5.1 CONTEXT MENU SCALING

The scaling values of the Heart rate feature can be set via a context menu by clicking on the right mouse button in the feature panel.

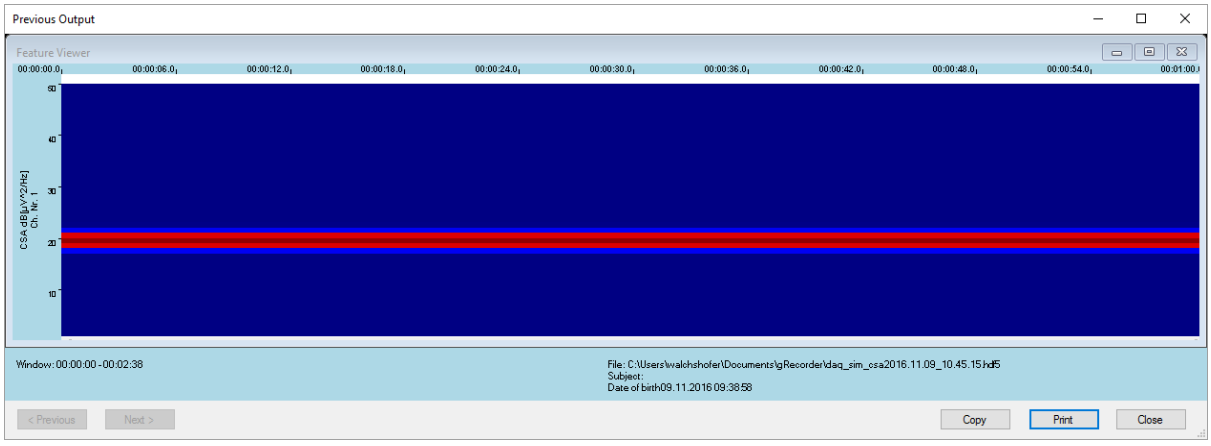


3.5.2 THE FEATURE VIEWER REVIEW MODE DURING DATA ACQUISITION

The Feature Viewer review mode allows for the inspection of previous epochs of feature signals. If the time on screen is elapsed, then a menu entry appears in the upper right corner of the Feature Viewer window.



By clicking on the Show previous output a review panel is displayed.



The **Previous Output** review panel allows the user to scroll trough past feature signals. The upper panel area displays the already recorded features and the lower panel area yields more specific information about the time interval **Window**, the **File** name of the actual recording and **Subject** specific information.

The content of the panel can be copied to the clipboard for further use by clicking the Copy button, or directly printed to the default printer by using the Print button. To close the **Previous Output** window click on **Close**.

NOTE

This review panel is only available during data recording.

3.6 EVOKED POTENTIALS VIEWER

The **Evoked Potentials Viewer** displays averaged data frames for each acquired analog input channel. An evoked potentials plot is created for each acquired analog input channel. The time frame represents a defined time period, consisting of a pre-trigger period, a post-trigger gap and a post trigger period. The viewer displays the trigger's occurrence and an averaged time frame for target and non-target evoked potentials. Significant differences between target and non-target evoked potentials can be calculated and highlighted.

In addition, the number of target/non-target trials contained in the currently displayed average and the number of totally accepted or rejected target/non-target trials are displayed at the bottom of the window. If artifact detection criteria are changed on-the-fly during the measurement, these numbers might not reflect all trials anymore from the current session, depending on the configured settings.

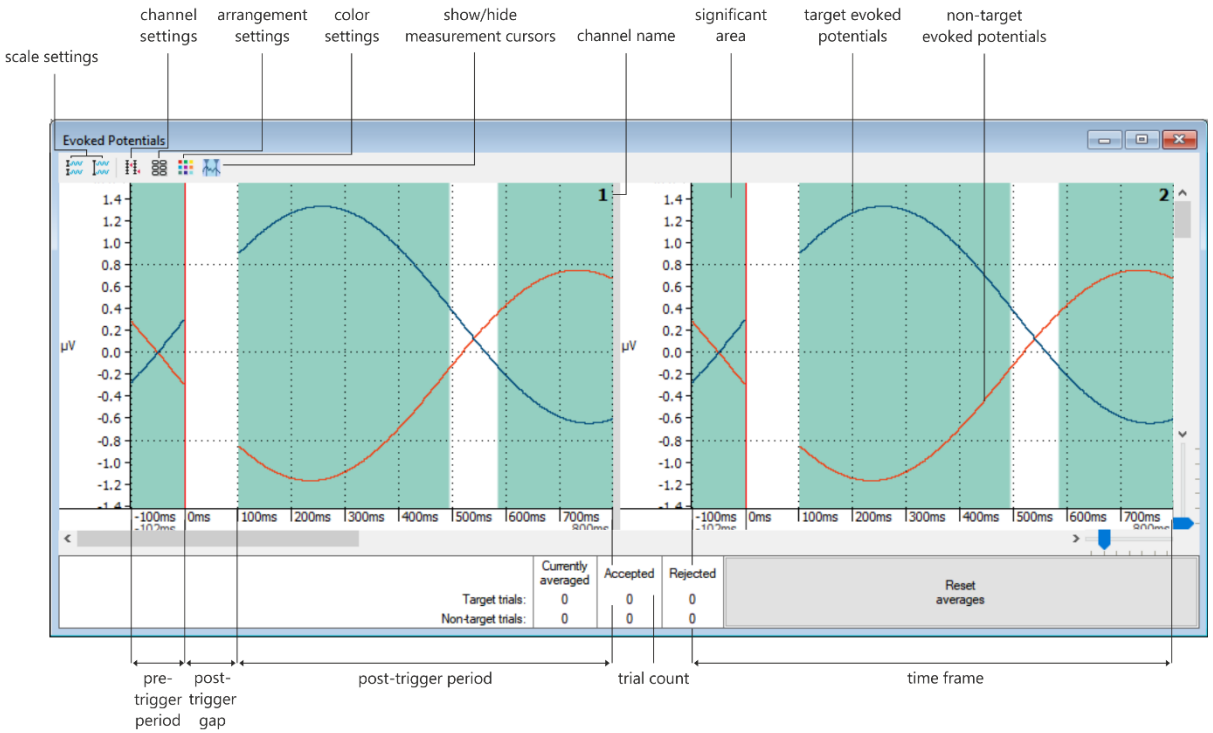
It is possible to configure the **scale settings**, to scale the data to the individual minimum/maximum of each acquired channel or to the global minimum/maximum of all acquired channels. Additionally, pressing the up and down arrow keys while the evoked potentials viewer window has focus decreases/increases the displayed amplitude range of each channel by a certain factor.

It is possible to change channel names, signal type, units and sensitivity range in the **channel settings** dialog. Channel names can be loaded from montage files.

By default, all plots are arranged in a square matrix. It is possible to change rows columns and arrangement in the **arrangement settings**. Topographic arrangement of the plots can be loaded from montage files.

The **color settings** allow the user to change the appearance of all elements of the evoked potential plots.

It is possible to **show/hide measurement cursors** in default mode as well as when a channel is maximized (see below).



It is also possible to **reset** the currently displayed averages and trial counts during a session. Previously averaged trials are then lost. A reset of averages is not included in the recorded data file; i.e. previously recorded trials are kept in the file and a replay of the file in review mode would not reflect the reset (as if the reset never happened).

Double-clicking any particular plot within the signal drawing area maximizes it over the whole window. A maximized plot shows two movable, vertical measurement cursors for determination of differences in time and each signals' amplitude within the range spanned by those two cursors. Double-clicking a maximized plot restores the original view of all channels again.

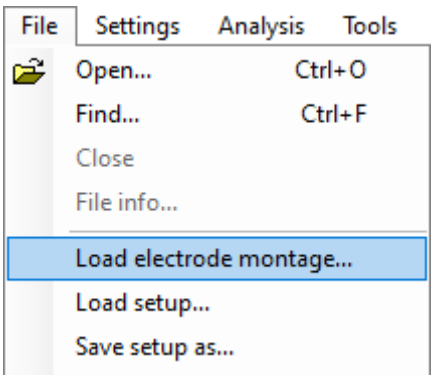
Press the left mouse button within the signal drawing area and drag it to the left or the right zooms into the selected range in time. Restore to the complete time range by double-clicking the time axis labels of the plot.

Dragging the vertical axis' ticks with the left mouse button modifies the displayed amplitude offset. Dragging the vertical axis' ticks with the right mouse button modifies the displayed amplitude range. Double-clicking the vertical axis' ticks auto-scales to the best fitting amplitude range and offset for the corresponding plot.

3.7 LOAD ELECTRODE MONTAGE

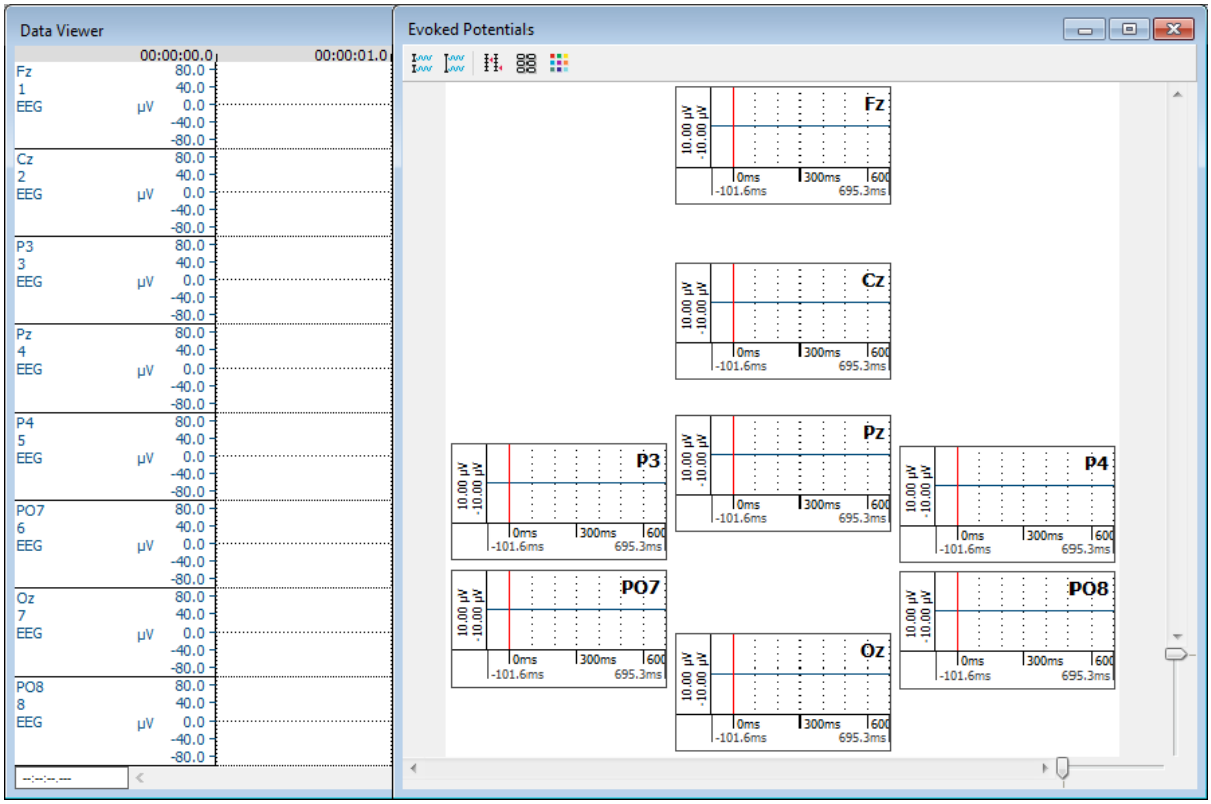
XML montage files created with **Montage Creator** (g.tec medical engineering GmbH, Austria) can be loaded to assign predefined names and the topographic arrangement of an electrode cap to the current configuration.

Montage files can be loaded by selecting **Load electrode montage…** in the **File** menu.



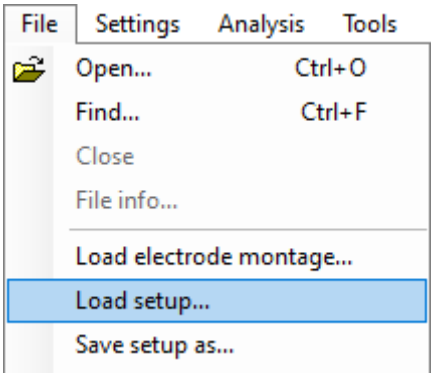
Montages for pre-assembled g.tec caps are located in the g.Recorder directory under the user's documents folder (see section 2.3 Files on your computer).

The Data Viewer assigns channel names to the acquired analog channels. The Evoked Potentials Viewer, if enabled, arranges the evoked potential plots in a topographic way according to the 2D electrode positions in the file.



3.8 LOAD CONFIGURATION

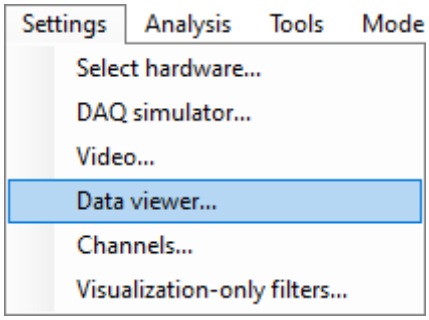
Previously saved configurations can be loaded by clicking on the **Load setup…** button in the **File** menu.



g.Recorder will be initialized with all necessary hardware and software settings.

3.9 DISPLAY SETTINGS

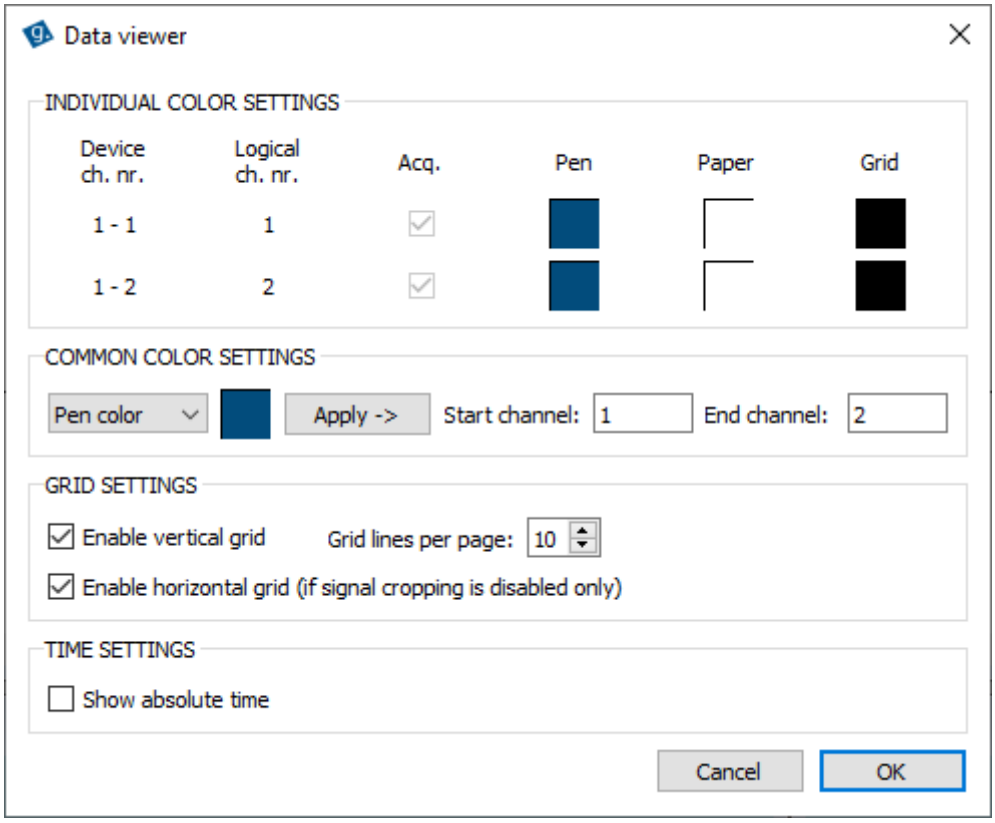
From the **Settings** menu choose **Data viewer…** to change the data representation.



The **Color settings** can be set in the **Data viewer** dialog. The Pen color sets the color of the data recorded and the channel labels, the **Paper** color sets the background color and Grid color sets the color of the grid. It is possible to change the settings of each channel individually in the **Individual color settings** group, or for multiple channels at once in the Common color **settings** group.

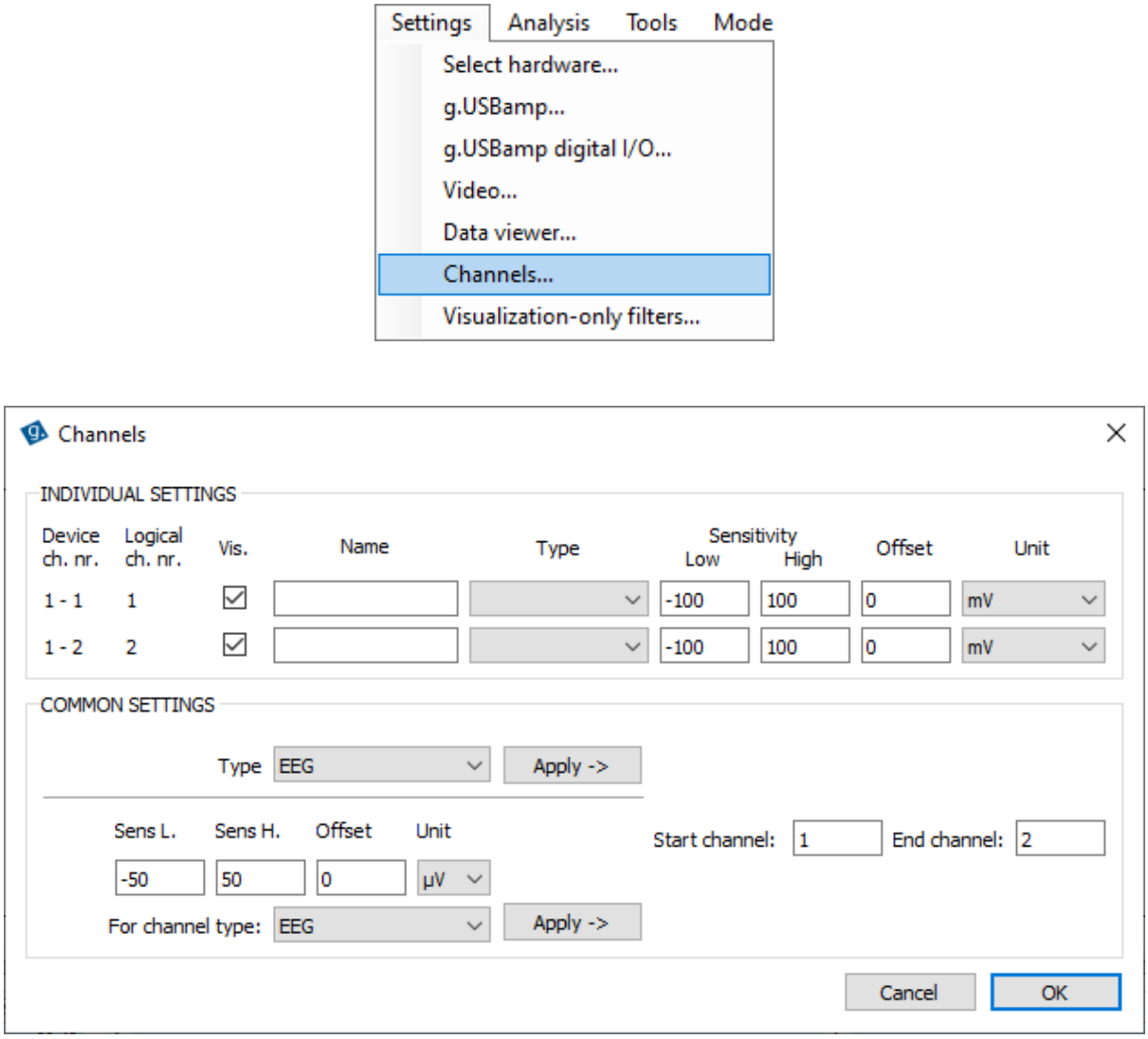
In the **Grid settings** area, the horizontal and vertical grid lines can be shown or hidden separately, and the number of vertical grid lines can be selected.

The normal time scale of the **Data Viewer** is the elapsed measurement time. If the **Show absolute time** checkbox is checked, then the system time is shown.



3.10 CHANNEL SETTINGS

A specific number, name, sensitivity and channel type can be assigned to every acquired channel. Click onto **Channels...** in the **Settings** menu to open the dialog.



3.11 INDIVIDUAL SETTINGS

The first column, Device **ch nr.,** shows the device number and also the channel number (e.g. 1-1 for the first amplifier and channel 1, 2-1 for the second amplifier and channel 1). The second column, **Logical ch. nr.,** shows the logical channel number. If two amplifiers with each 16 channels are used then the **Logical ch nr.** goes from 1 to 32.

The **Vis**. checkbox can be used to hide channels in the **Data Viewer**. Hidden channels are still recorded, just not displayed.

In the **Name** column a name for the channel can be entered and in the **Type** column EEG, ECG, EMG, EOG, ECoG, Resp., TRIG can be selected. With the channel type selection, the **Sensitivity** of the channel is changed automatically.

The **Sensitivity** and an **Offset** of each channel can be entered manually. The Unit can be µV, mV or V. This **Sensitivity** affects only the visualization of the raw data.

COMMON SETTINGS

The same settings can be applied to multiple channels at once in the **Common settings** section.

To only apply a **Type** to a range of channels, select the Start channel and the **End channel** and the **Type** in the upper half and click **Apply** next to it.

To apply a common sensitivity, an offset and a unit to a specific **Type** of channels, select the lower sensitivity **(Sens L.),** the upper sensitivity **(Sens H.),** the **Offset** and the **Unit** and choose the **Type** of the channels you want to apply those settings on, and click **Apply**.

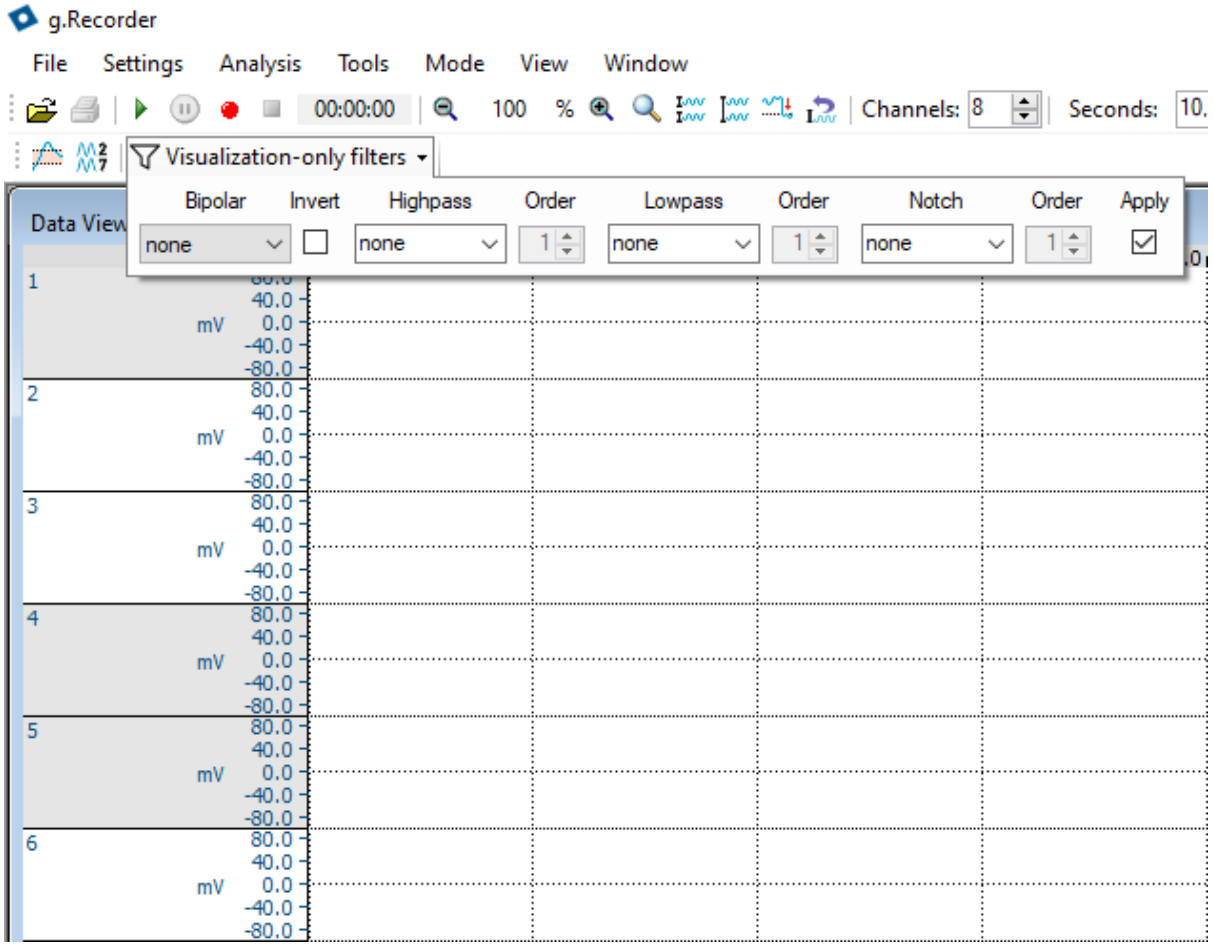
NOTE

For specific channel types that assume g.tec sensors connected to the amplifier, data is automatically scaled to the unit and range that is the default for the corresponding sensor's channel. For instance, if temperature is selected, values acquired by the Temperature Sensor (default output range of 0-200 mV) are converted and scaled to 20-45 °C (temperature [°C] = (measured mV * 25 / 200 mV + 20).

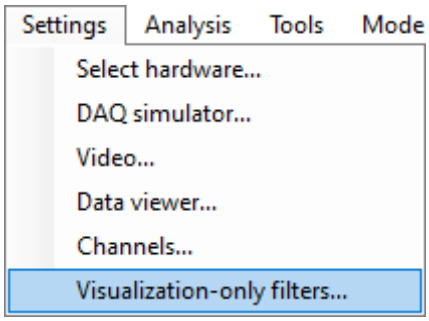
3.12 VISUALIZATION-ONLY FILTERING

Filters that are only applied to the visualized data in the **Data Viewer** but not to the recorded raw data can be configured directly via the **Toolbar** for the currently selected channels in the **Data Viewer** or via a dialog. Visualization-only filter settings are not stored in the recorded data file. They can be stored separately together with the application configuration/setup.

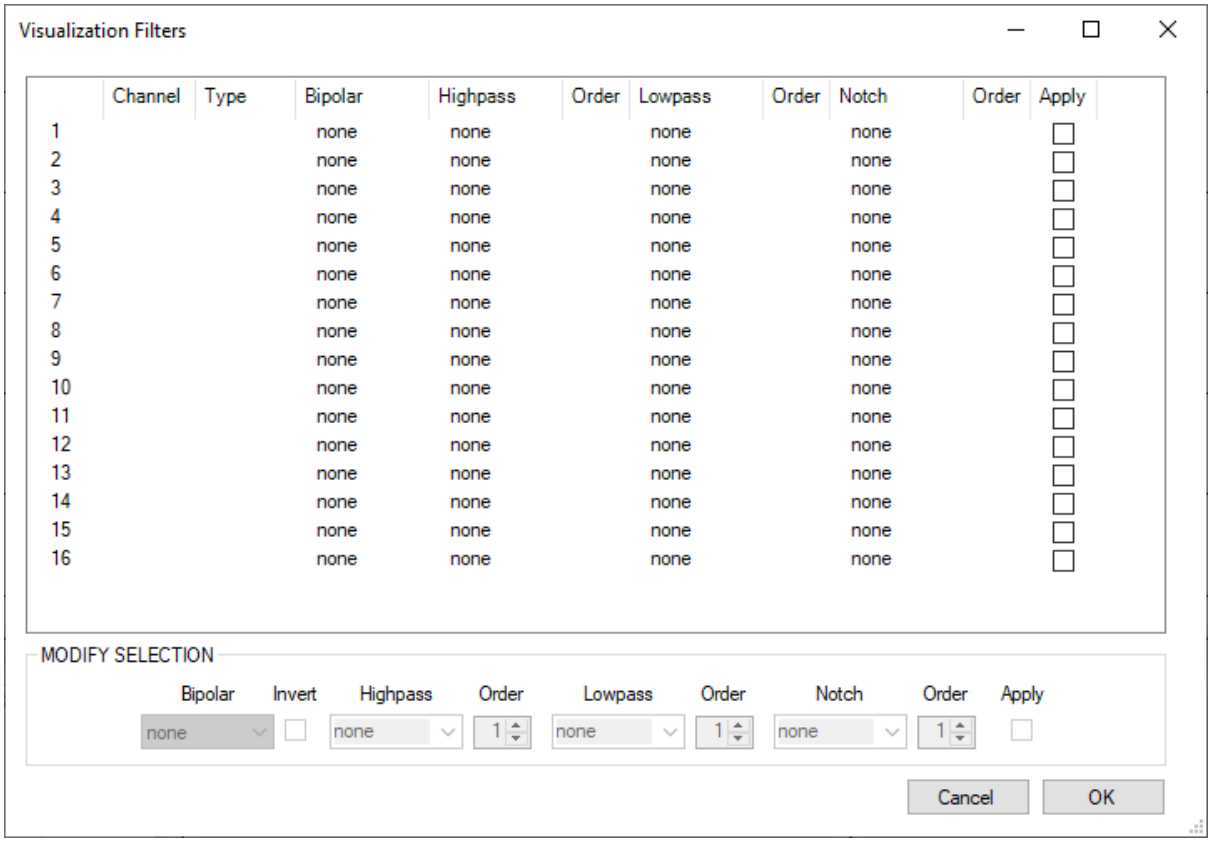
To configure filters directly in the **Data Viewer** using the **Toolbar**, first select the channels to change filters for by left-clicking the channels' axes labels with the mouse (left from the axis scaling). Use the Ctrl key or the Shift key to select multiple channels. Selected channels are indicated by a gray background color of the channel label. After selecting the channels to change the filter settings for, click the **Visualization-only filters** button to open the filter settings for the selected channels.



To configure filters via the **Visualization Filters** dialog, select **Visualization-only filters**... from the **Settings** menu.



The **Visualization Filters** dialog opens now, showing the current visualization-only filter settings for each acquired logical channel number.



Highlight the channels to change filters for by left-clicking their corresponding row in the table. Rows of selected channels are indicated by orange background color. Use the Ctrl key or the Shift key to select multiple channels, or press Ctrl+A to select all channels. The filter settings for selected channels can then be modified using the controls in the **Modify selection** area below the table. Configuring the filters is then similar for both ways.

The Toolbar and the **Modify** selection area show the visualization-only settings of the currently selected channels. If different settings are applied to the channels, they're indicated by a note or a blank field instead of the selected value. The individual setting of those channels will not change unless a different value is selected, which is then applied to all the selected channels.

Check the **Apply** checkbox to enable modification of the filters for the selected channels. If the **Apply** checkbox is unchecked, the selected filters are not applied. In the dialog, either the **Apply** checkbox in the table or from the **Modify selection** group can be used.

Highpass, Lowpass, and **Notch** filters can either be selected from a list of pre-defined filters or specified manually by just entering the cutoff frequencies in Hertz. For the **Notch** filter, a frequency range can be specified by separating the two cutoff frequencies with a hyphen (e.g. "48 – 52"). A single cutoff frequency will automatically span a ±2 Hz range around the entered center frequency. Cutoff frequencies must be greater than zero and lower than half of the selected sampling frequency. The Order of each filter can also be changed. Unstable filters will be indicated by an error message and cannot be applied (reducing the order or the sampling frequency should help in this case).

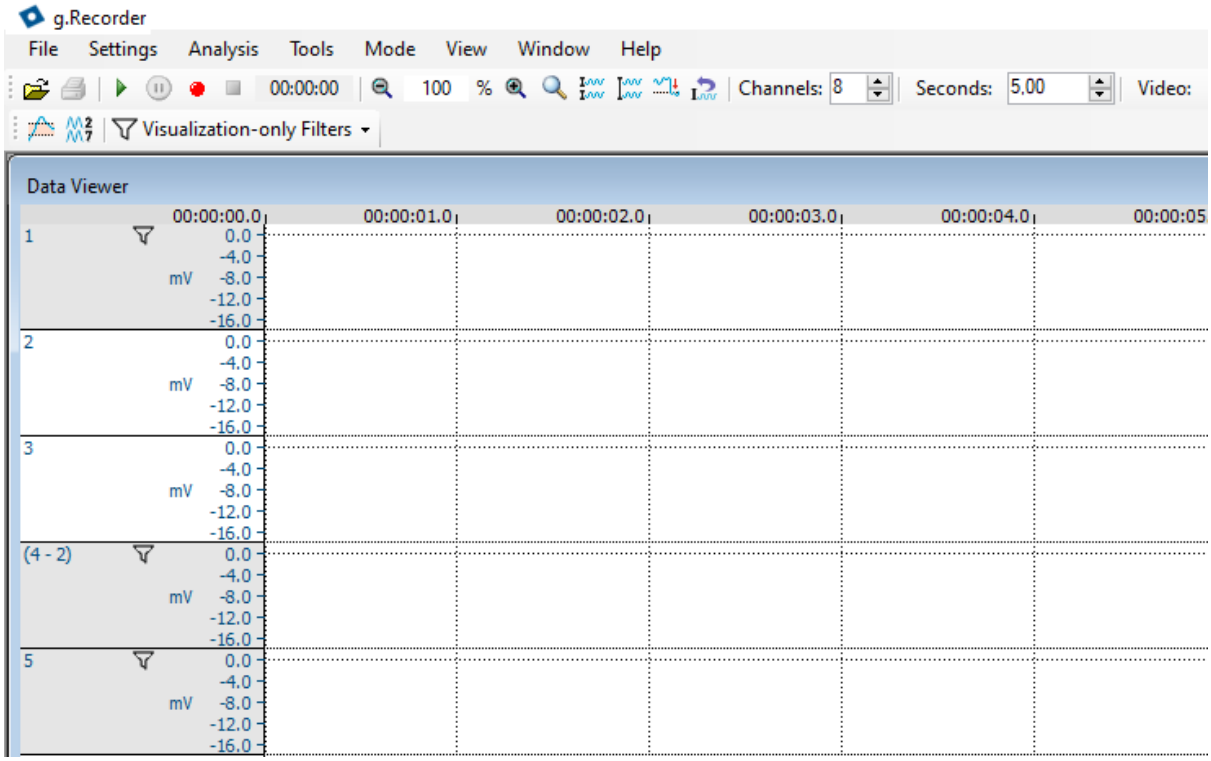
Bipolar derivation and the **Invert** channel feature can only be used for channels that have no bipolar derivation set in the amplifier's configuration. The **Bipolar** setting of a channel allows to select one of the acquired channels to be selected for bipolar derivation and return the result on the target channel. Channel names are displayed instead of numbers if given. The **Bipolar** column in the dialog's table

will already show the calculation result. The calculation result can be inverted by checking the **Invert** checkbox.

Filter settings are applied immediately if changed via the **Toolbar**. If errors occur, the user will be notified immediately. Only the erroneous filter settings for a channel will not be applied in this case, the remaining filters will be applied though.

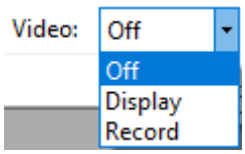
Filter settings in the **Visualization Filters** dialog are applied after clicking the **OK** button. Valid filter settings will be applied immediately, even if some errors occur. If errors occur, the user will be notified and the dialog remains open, indicating an error for a channel by an error icon left of the channel number in the table. Hovering with the mouse over that icon will give details on the occurred error. Correct the errors to be able to close the dialog.

Channels that have visualization-only filters currently applied are indicated by a funnel icon in their axis label like in the following figure. Visualization-only bipolar derivation and inversion are additionally indicated by showing the result of the bipolar derivation instead of just the target channels' number or name in the axis label in parentheses.

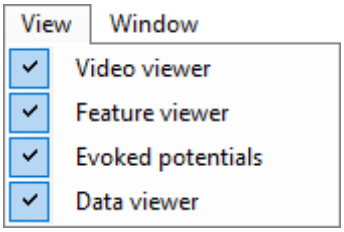


3.13 VIDEO CAMERA

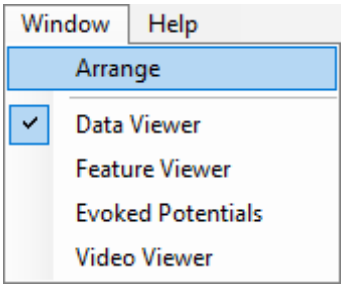
When a video camera is connected to the PC, the video images can be displayed and recorded with **g.Recorder**. In the menu bar it can be chosen if the video should not be displayed (**Off**), just be displayed but not recorded (**Display**) or be displayed and recorded (**Record**).



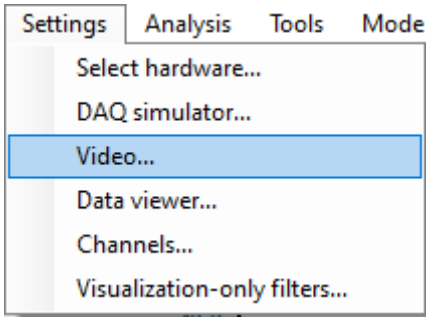
To see the video images in the main window of **g.Recorder**, select **Video Viewer** from the **View** menu.



The **Data Viewer**, the **Video Viewer** and the **Feature Viewer** can be automatically arranged by selecting **Arrange** in the **Window** menu.



To configure the camera device and resolution to use, select **Video**... from the **Settings** menu. The camera can only be configured while video is not displayed (set the Video option in the toolbar to **Off** before).



WARNING

Not all PCs support all the listed file formats/codecs. To avoid unintentionally empty video files, perform a quick test recording and check the video file's content for validity.

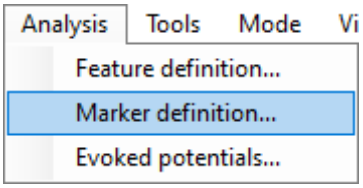
IMPORTANT

Do not disconnect the camera while Display or Record is set!

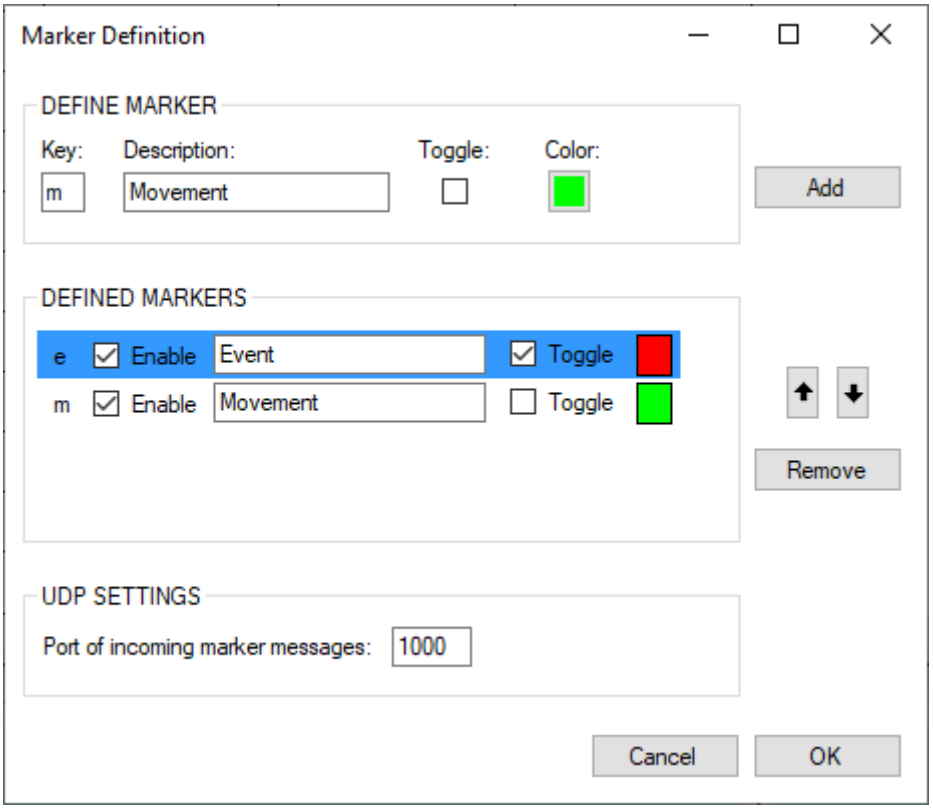
3.14 MARKERS

Markers can be used during measurement to highlight certain events. **g.Recorder** allows the user to define keyboard markers which (i) indicate an event specific at a certain time point and (ii) region markers or toggle markers which can be switched on and switched off to mark a longer lasting event.

Click on **Marker definition…** under the **Analysis** menu.



to open the following window:



Here, two markers are defined that can be set either by clicking on the marker button in the **Toolbar** of g.Recorder or by pressing the keys on the keyboard. Marker e – Event is a Toggle marker, marker m – Movement is a time marker.

If e is pressed the signal is marked in the selected marker color until the marker button is pressed again. If m is pressed then only the event at a certain time point is marked.

Markers can also be set via UDP messages. The UDP message for setting a marker must be sent to the Port of incoming marker messages specified in the Marker Definition window and must be of the following text format:

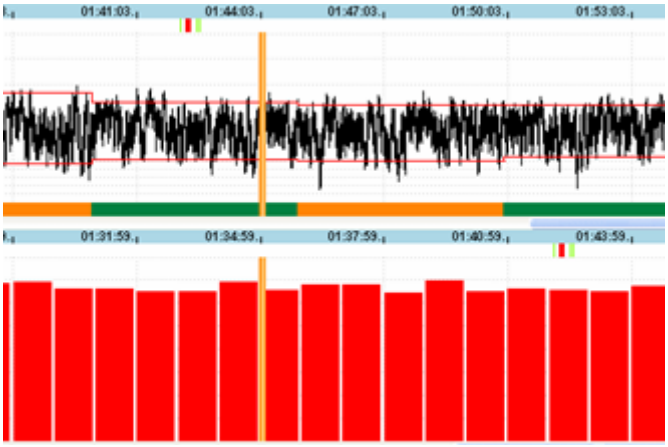
```
<gRecorder>
```

```
        <DAQ.KeyboardMarkerUdpMessage assembly="gRecorder" name="m" />
</gRecorder>
```

The name attribute in the UDP message represents the key of a defined marker to set and can be changed accordingly. The example message above sets the previously defined Movement marker. The `<gRecorder>` element can contain one or multiple `<DAQ.KeyboardMarkerUdpMessage>` elements, which are then set at the very same time of reception.

The window below shows the visualization of the markers in the **Data Viewer:**

The set markers for the different events are also indicated by small bars near the top of the individual features' channels in the **Feature Viewer**.



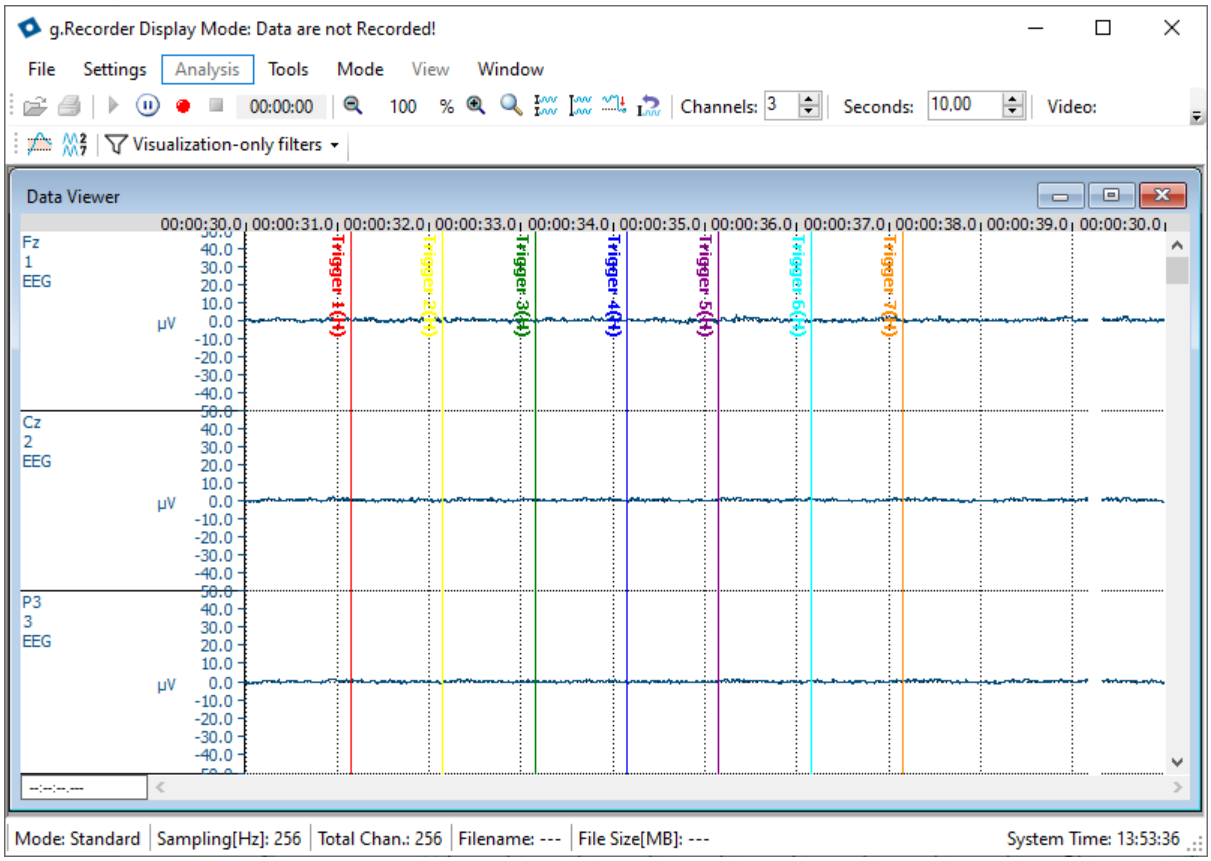
3.15 DIGITAL INPUTS

Devices may provide digital inputs that are sampled synchronously with the raw data samples. Digital inputs can be acquired and displayed with g.Recorder. A rising or falling edge of an acquired digital input is represented as a vertical line including a description consisting of trigger number, value and name.

Some types of devices allow the user to choose if each of those trigger channels should be treated individually or if several trigger channels should be combined.

3.15.1 INDIVIDUAL TRIGGERS

By default, trigger channels selected for acquisition are treated individually. Depending on their configuration, each occurrence of such a trigger channel is represented as a separate event with a value of HIGH **(H)** for rising edges or LOW **(L)** for falling edges.



3.15.2 COMBINED TRIGGERS

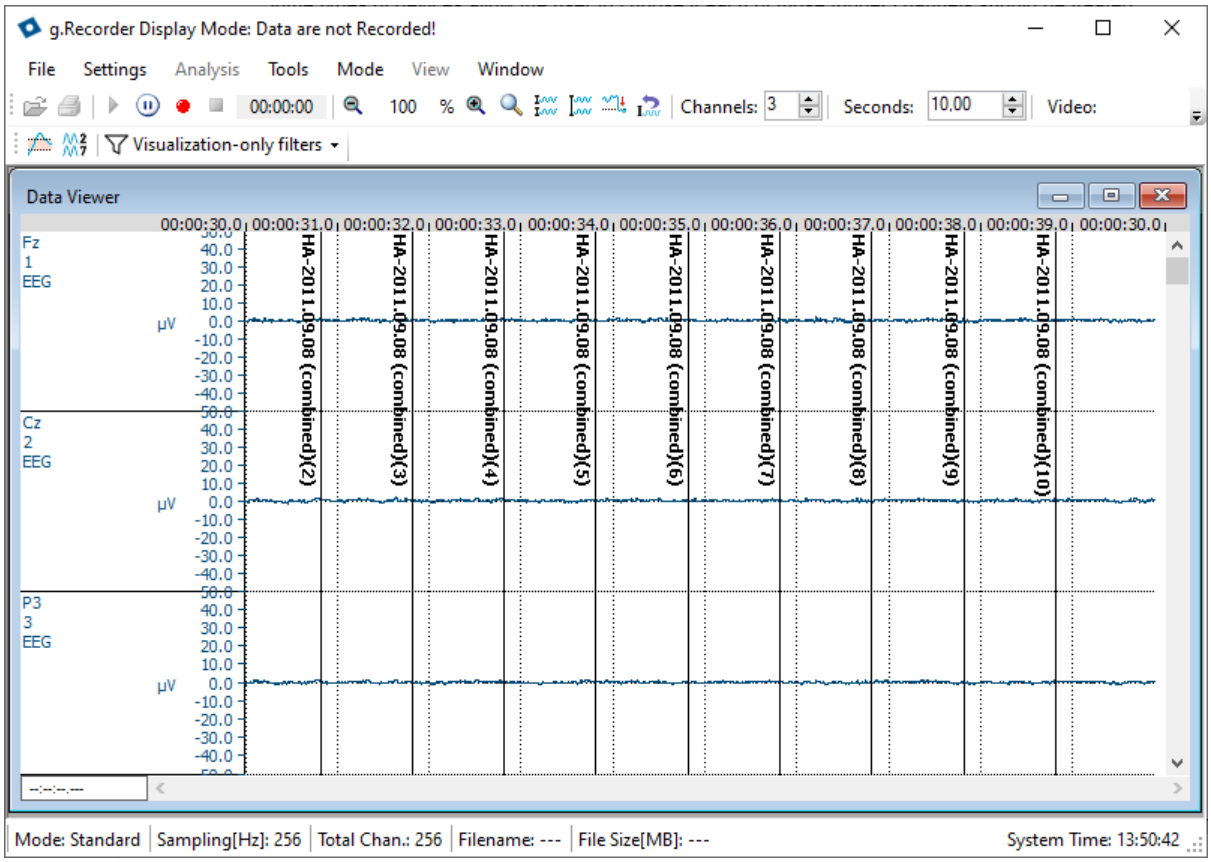
The individual trigger channels can also be combined per device. In this mode, all trigger channels of a device are represented by the same event for that device and the value is a binary coded decimal made up of the current high or low values of the individual trigger channels. For instance, a combined decimal value of 10 is achieved when trigger channels 2 and 4 are high; this gives a binary code of 0000 1010_b where the least significant bit (right-most) is trigger channel 1 which is low (zero), then trigger channel 2 is high (1), trigger channel 3 is low (zero), trigger channel 4 is high (1) and channels 5 to 8 at the left-most are low (0). Similarly, a combined decimal value of 3 is achieved when trigger channels 1 and 2 are

high, resulting in a binary code of 0000 0011$_b$. The triggers are represented as vertical lines including a description consisting of device's serial number, combined trigger tag, event code and name.

This enables reception and interpretation of binary coded trigger values sent via the parallel port. **g.Recorder** supports external stimulation software like **Presentation®** (Neurobehavioral Systems, Inc., www.neurobs.com) and **E-Prime®** (Psychology Software Tools, Inc., www.pstnet.com) by acquiring event codes sent via parallel port.

NOTE

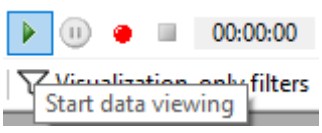
E-Prime® and Presentation® are trademarks by their respective owners.



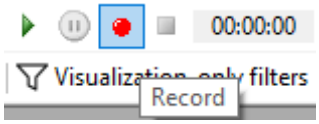
3.16 START/STOP RECORDING

When all desired settings are done, the measurement can be started.

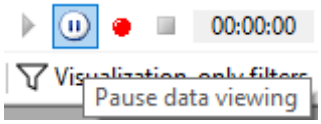
To display data in the **Data Viewer** without saving it, click on the **View data** button in the **Toolbar** or select **Start data viewing** from the **File** menu.



To record data to the hard disk on your PC, click the Record button or select **Record** from the **File** menu.



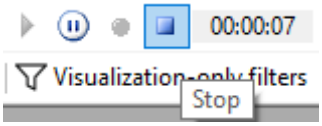
To stop data acquisition in **Standard** mode or pause the data display in the Recording mode, press the **Pause data viewing** button or select **Pause data viewing** from the **File** menu.



NOTE

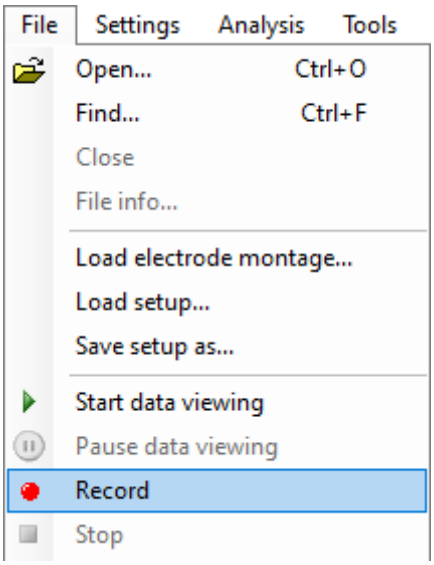
If the button is pressed in Recording mode, only the visualization of the data on the display is stopped, but the g.Recorder continues to store data to the HDF5 file.

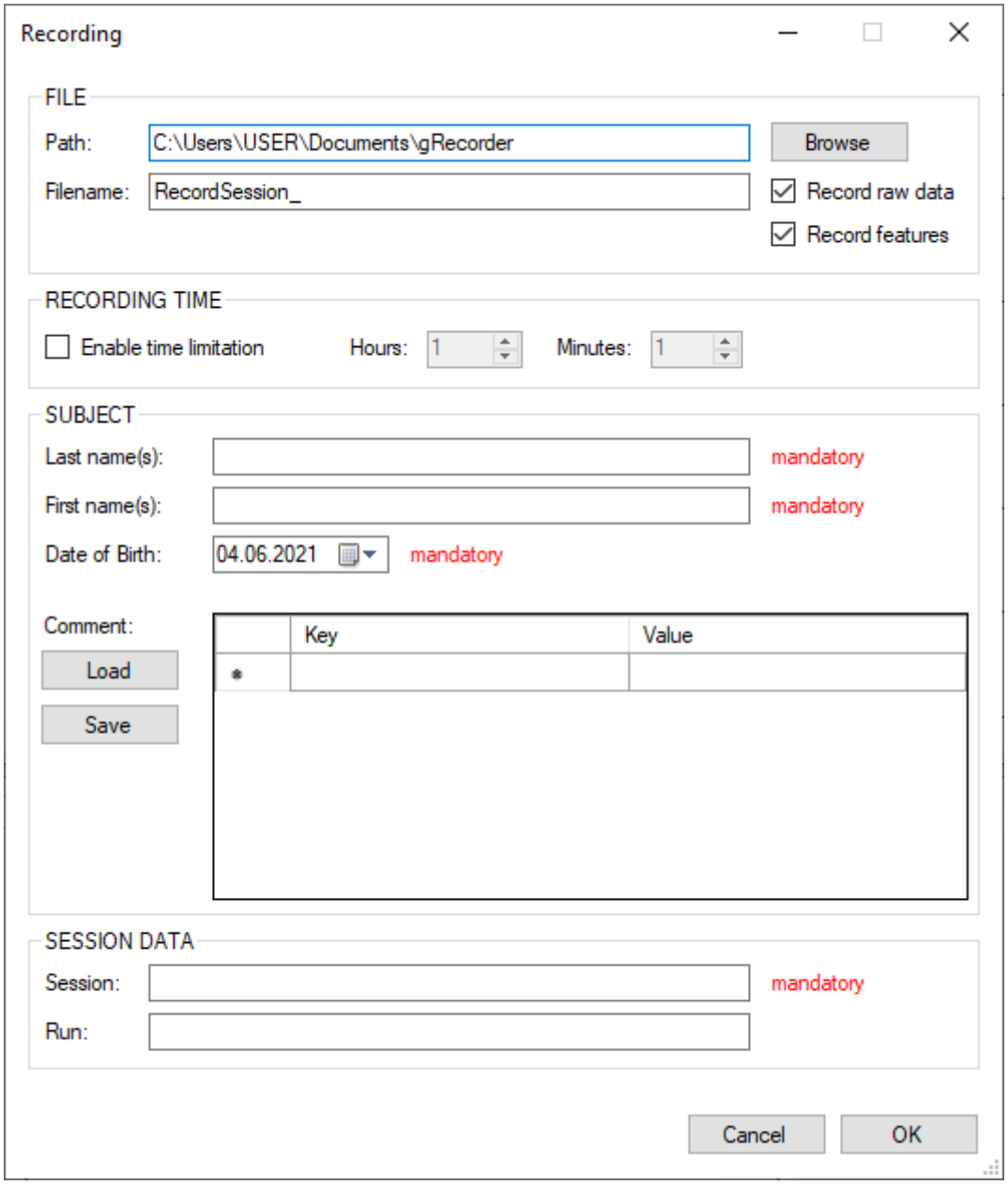
Click on the **Stop** button or select **Stop** from the **File** menu to stop data acquisition.



3.16.1 RECORDING INFORMATION

The **Recording** dialog opens when the **Record** button either in the **File** menu or the task bar is pressed.





File

A **Path** for the data file can be entered or the desired path can be chosen by clicking on the **Browse** button.

The **Filename** defines the name of the data file. The default filename is RecordSession_ with date and time added. When the measurement is started the data and the time are added automatically to the filename (e.g. `RecordSession_2016.11.09_11.36.02.hdf5`). The data is stored in the HDF5 file format. For more information about this format see http://www.hdfgroup.org/or refer to the MATLAB help.

The **Record raw data** checkbox toggles whether the raw data from the amplifier is stored to the HDF5 file. The **Record features** checkbox toggles whether data from calculated features (including evoked potential trials and results) should be stored to the HDF5. Both options can be used to reduce the size of the recorded data file on disk by skipping data that is not required to be recorded, to the

disadvantage of losing that data of the non-selected options. For offline processing after measurement, it is recommended to record both if disk space allows.

Recording time

A time limitation for the measurement can be set with the Enable time limitation checkbox in the Recording time section. After this time, the measurement is stopped automatically.

Subject

Information about the subject like Last name(s), First names(s) and Date of birth can be entered in the Subject section. Additional information (e.g. medications) can be added in the Comment section.

Session data

Enter the Session and Run identifier for your recordings.

After finishing these settings click OK.

NOTE

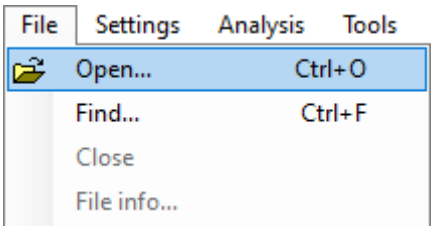
Mandatory fields (the keyword mandatory is displayed next to this field) must be filled out correctly. Otherwise the recording cannot be started.

3.17 LOAD, FIND, CONVERT AND REPLAY RECORDED FILES

3.17.1 LOAD, FIND AND REPLAY HDF5 FILES

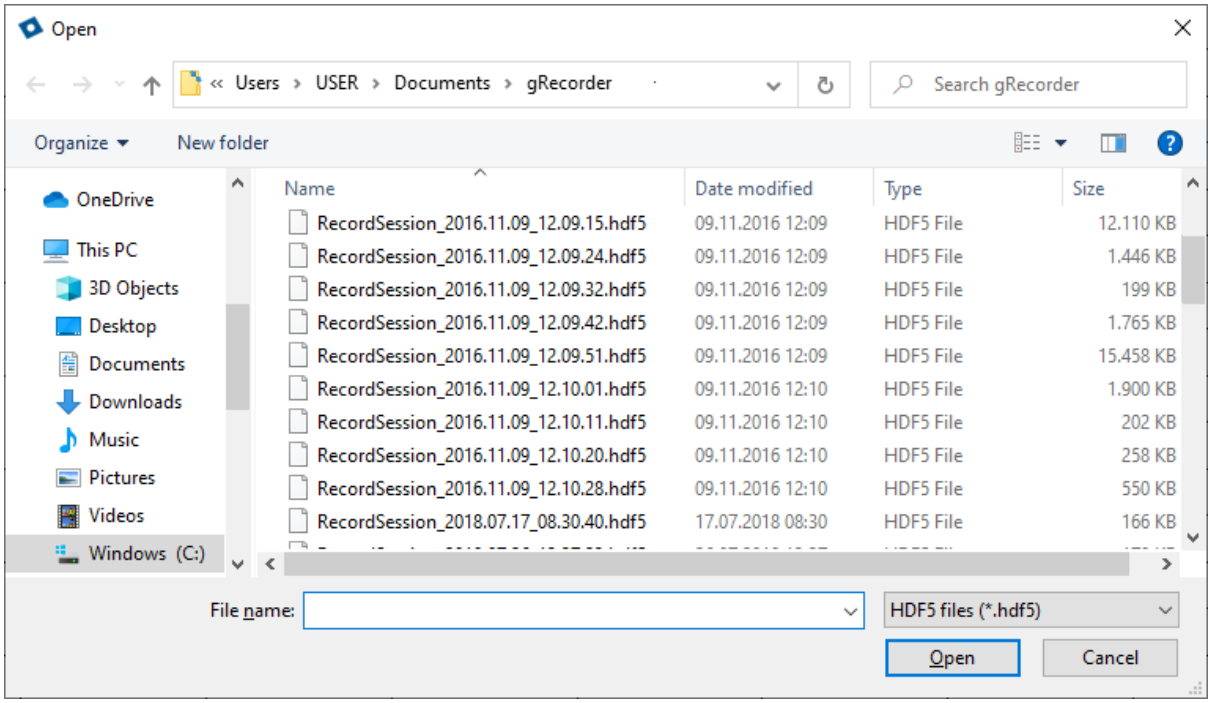
A recorded data file in HDF5 format can be loaded and reviewed with **g.Recorder**.

In the **File** menu select **Open...**



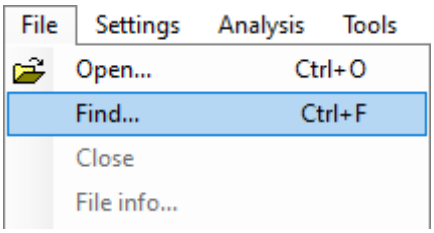
Then select the data file you want to load into g.Recorder. The default path of the recorded files is

`My Documents/gRecorder`

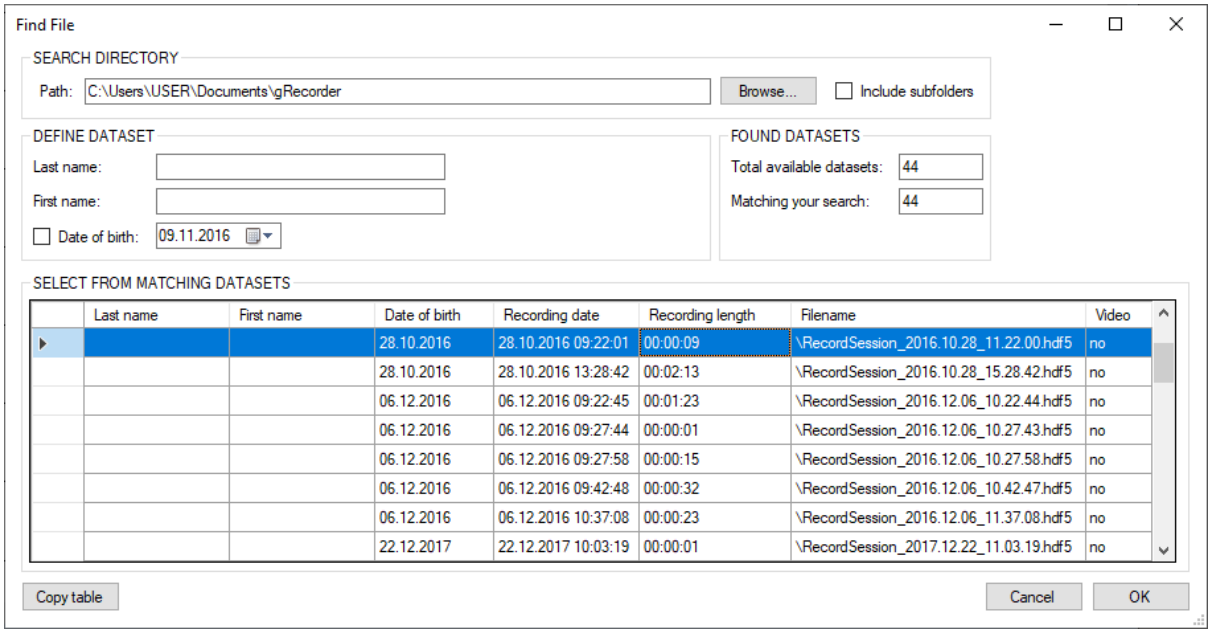


Select file `RecordSession_2016.11.09_10.10.28.hdf5` and press Open.

If you want to find a specific file from the database, please select Find… in the File menu.



This displays all HDF data files found in your specific working directory.



The **Search directory** of data files can be set in the **Path** field. Use the **Browse** button to find the desired directory. If the **Include subfolders** option is enabled, the data files found in the selected path including all subdirectories are listed.

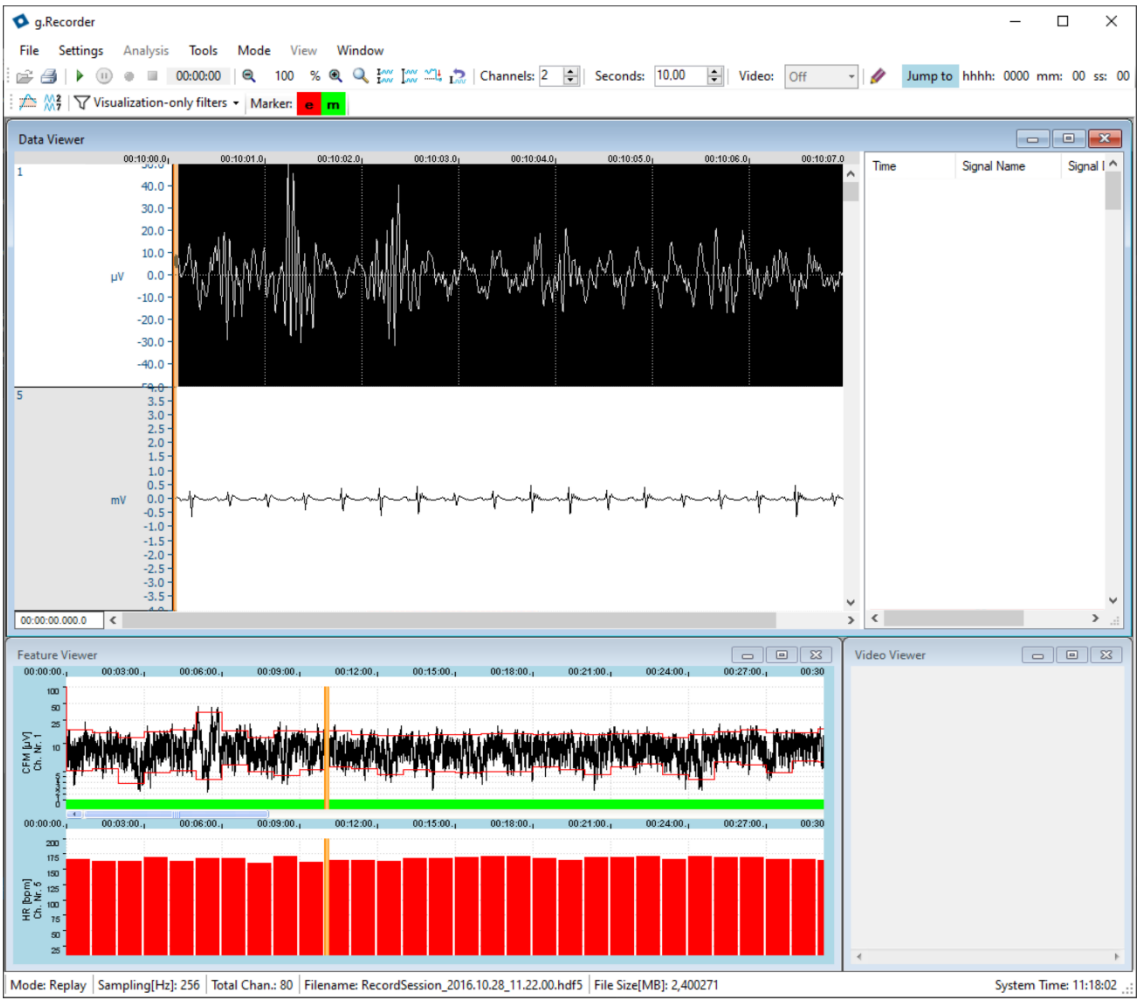
Define datasets enables optionally searching for data sets including **Last name** and First name and if selected the **Date of birth** of a subject. Results are displayed immediately after typing in the first letter.

Found datasets yields information about the search request.

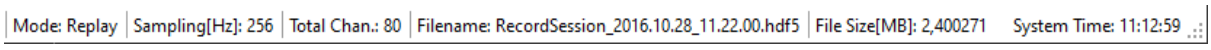
The desired data set can be selected by highlighting the data set. Double clicking or selecting the **OK** button loads the data set for review. Additional short information is given for the data set including the last name, first name, date of birth, recording data, recording length, filename and if a video information is available. Data sets can be sorted by clicking on one of the row headers e.g. on the Video entry.

The entire table can be copied to the clipboard for further use by clicking the **Copy table** button.

g.Recorder opens the acquired data for off-line visualization. The **Data Viewer** shows the recorded EEG data on channel 1 and the acquired ECG data on channel 2. The **Feature Viewer** shows the calculated CFM and HR features.



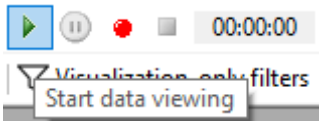
The recorded measurement's information is displayed in the **Status Bar.**



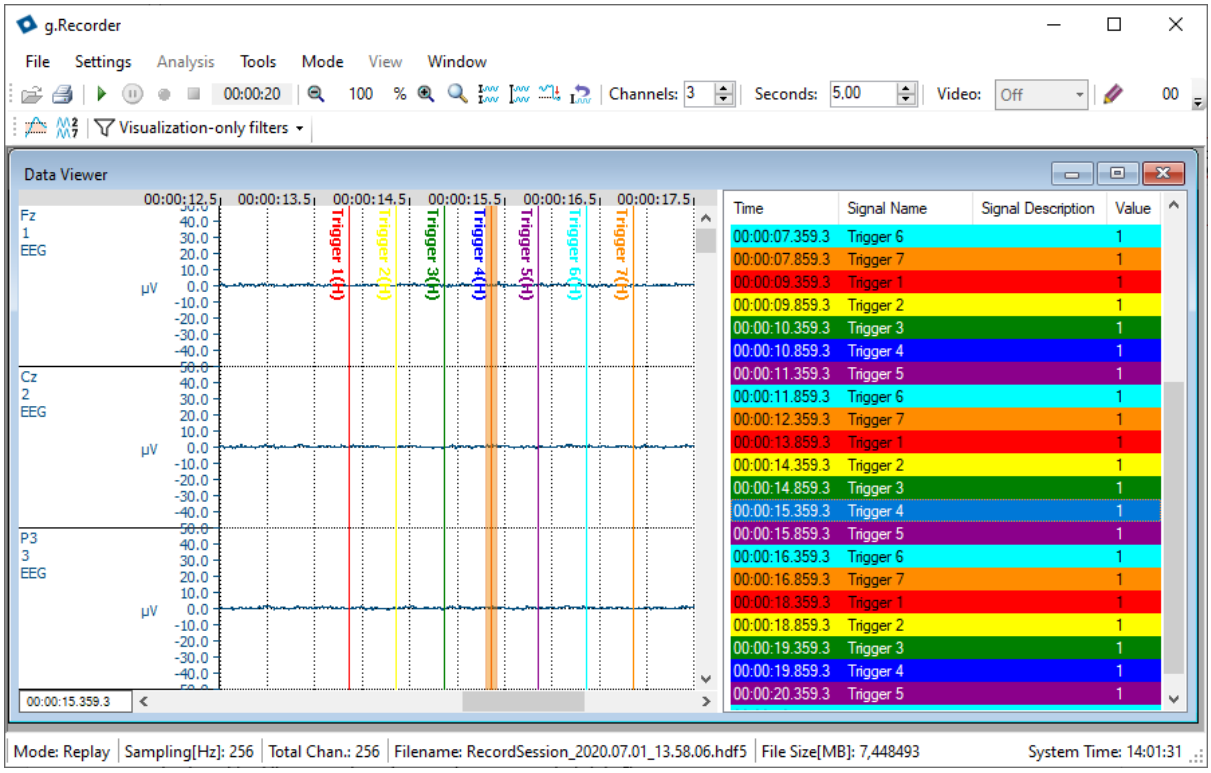
The **Mode** is Replay, the **Sampling** frequency is 256 Hz, the number of recorded channels (**Total Chan.**) is 16. The **File Name** is `Record_Session_2016.10.28_11.22.00.hdf` and the **File Size** is 0.413 megabytes.

You can use the scroll bars on the bottom of a window or the orange vertical position marker in any of the g.Recorder windows to move to an arbitrary position in the file.

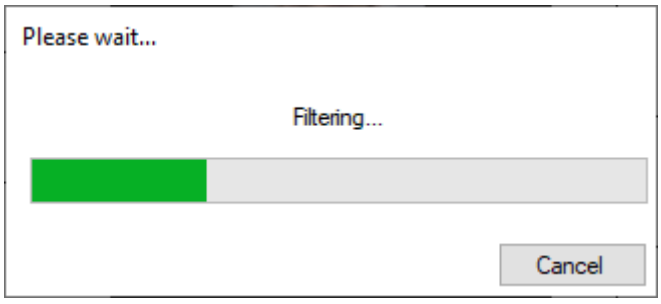
To review data online from the selected position, click on the **Start data viewing** button.



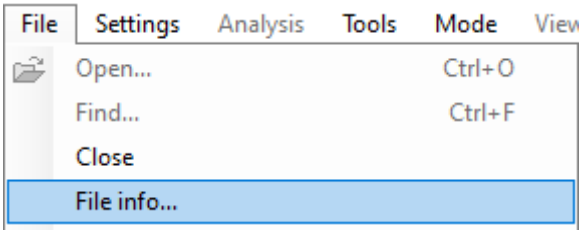
Synchronous and asynchronous events are loaded and displayed on the right-hand side of the **Data Viewer** in Replay mode. The navigator on the right-hand side allows the user to jump to a specific event by selecting it in the list. The ruler is set to the selected signal's time of occurrence and the current page is updated (like in the example below for Trigger 4 at 00:00:15.359). The event list features the time of occurrence, signal name, signal description, trigger value and selected color.



Visualization filters can be applied to the recorded analog signals in Replay mode. A progress bar is displayed for filtering and rendering a large amount of data.

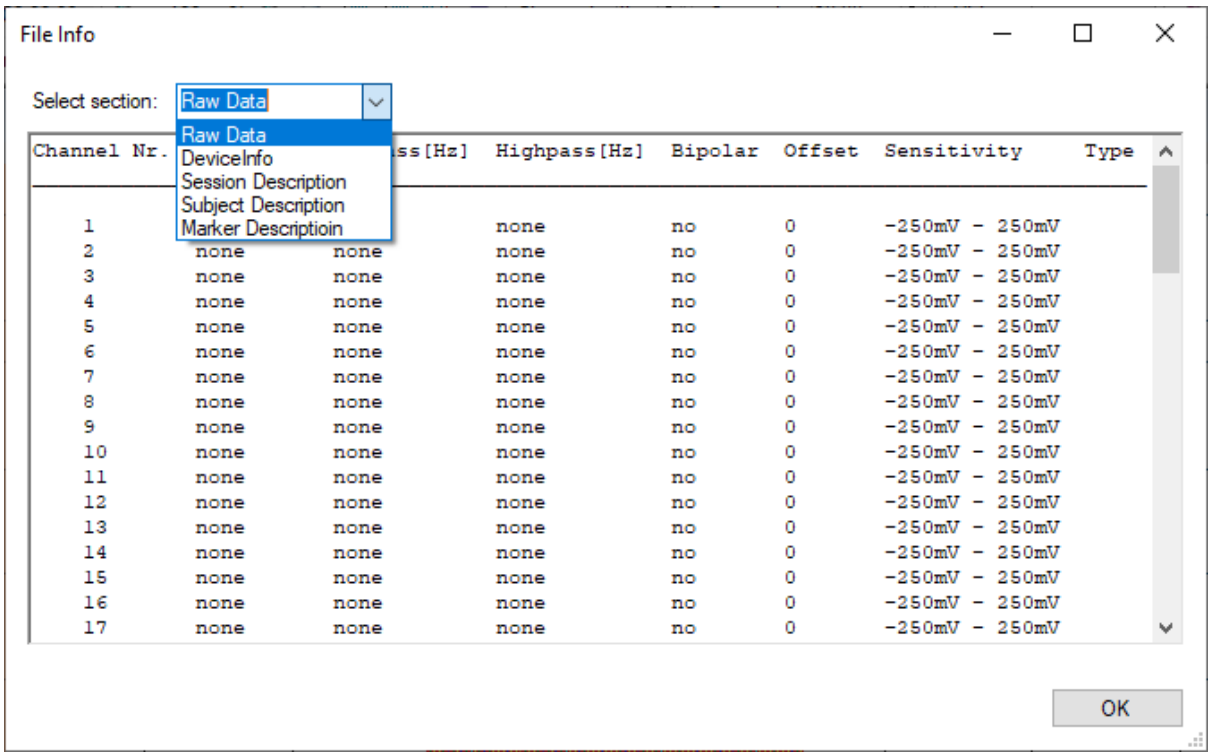


To view the file information, select **File Info**... from the **File** menu.



This opens the **File Info** window yielding information about the data set. To view the file information use the **Select Section** pull down menu (the list contains **Raw Data, DeviceInfo, Session Description, Subject Description, Marker Description** and the recorded features).

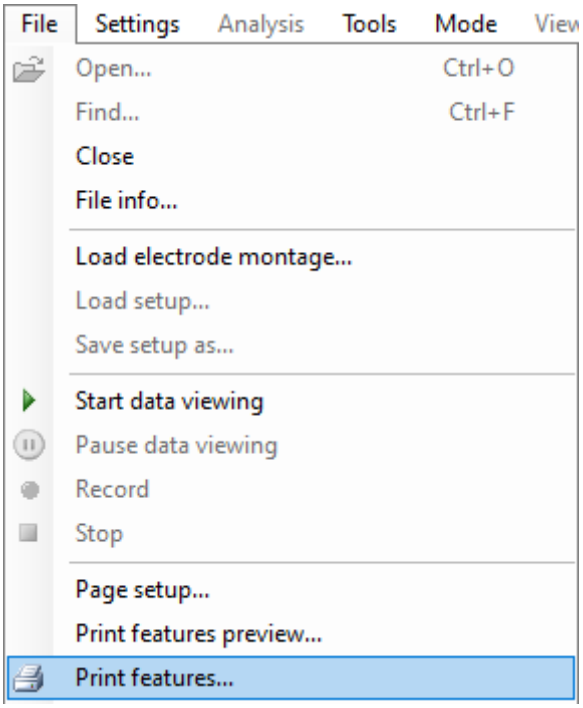
Select `Raw Data` to show the settings for each channel:



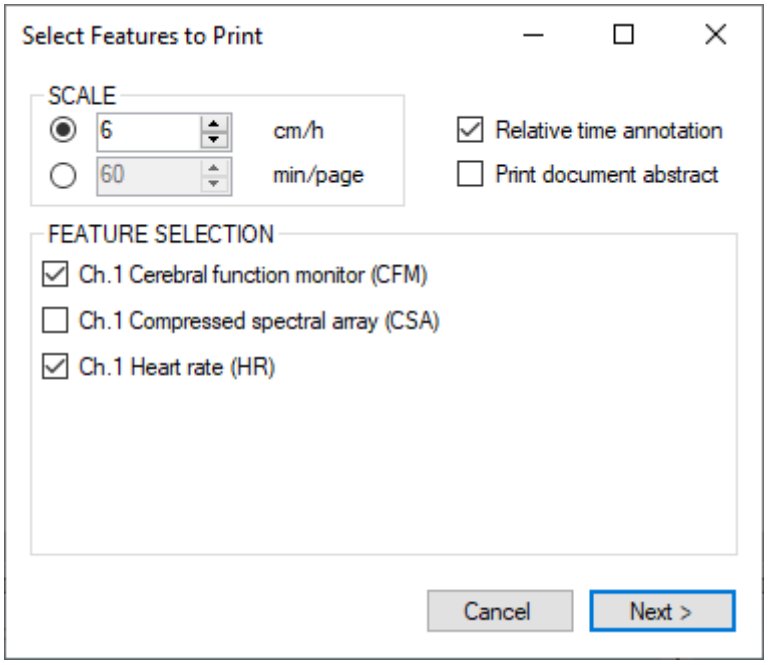
Click **OK** to close the dialog.

3.17.2 PRINT RECORDED FILES

The recorded features and the recording information can be printed by selecting **Print features...** from the **File** menu.


File
Settings
Analysis
Tools
Mode
View
Open... Ctrl+O
Find... Ctrl+F
Close
File info...
Load electrode montage...
Load setup...
Save setup as...
Start data viewing
Pause data viewing
Record
Stop
Page setup...
Print features preview...
Print features...

In the **Select Features to Print** dialog, you can choose the features to be printed.



Scale

The **Scale** of the printed feature can either be in cm/h (centimeters per hour) or min/page (minutes per page). When selecting the setting 6 cm/h a dataset of 3 hours would need a total space of 18 cm on the paper. If the same 3-hour data set is printed with the selection of 60 min/page then 3 pages would be printed.

The time scale in the printed document can be set with the checkbox **Relative time annotation**. The time is given in absolute format (e.g. 17:05:01) or relative to the measurement time (e.g. 00:05:14).

Select the **Print document abstract** to print the file and subject information.

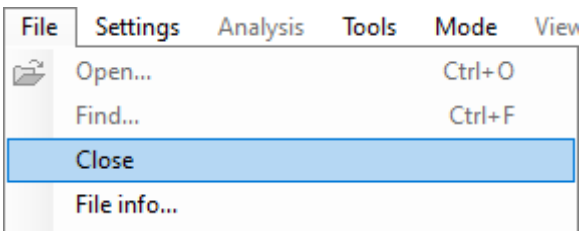
Feature Selection

Under **Feature selection** select the features that should be printed.

Click **Next** to go to the **Print** dialog, select a printer and print the file.

3.17.3 CLOSING THE REVIEW MODE IN G.RECORDER

To return from *Replay* mode to *Recording* mode select the **Close** button from the **File** menu.

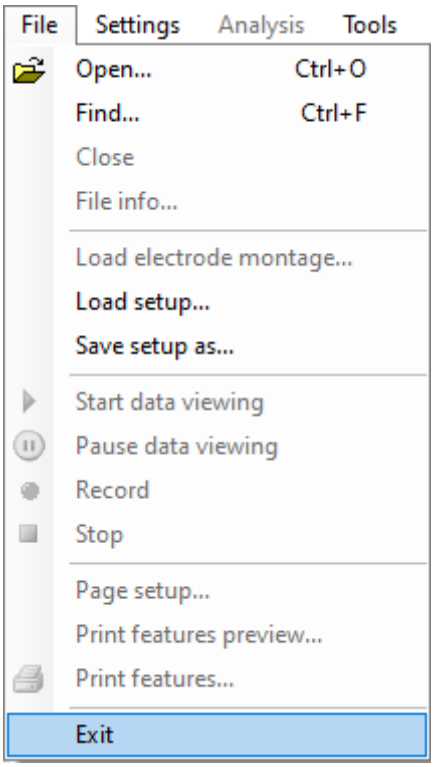


3.18 CLOSING G.RECORDER

In the **File** menu select **Exit** or click on the cross button in the top right corner of **g.Recorder** to close the application.

NOTE

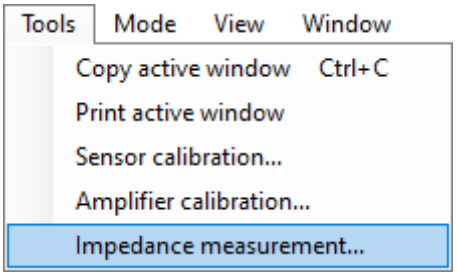
If you are in *Replay* mode you must close the file first with the **Close** function in the **File** menu before you can exit **g.Recorder**.



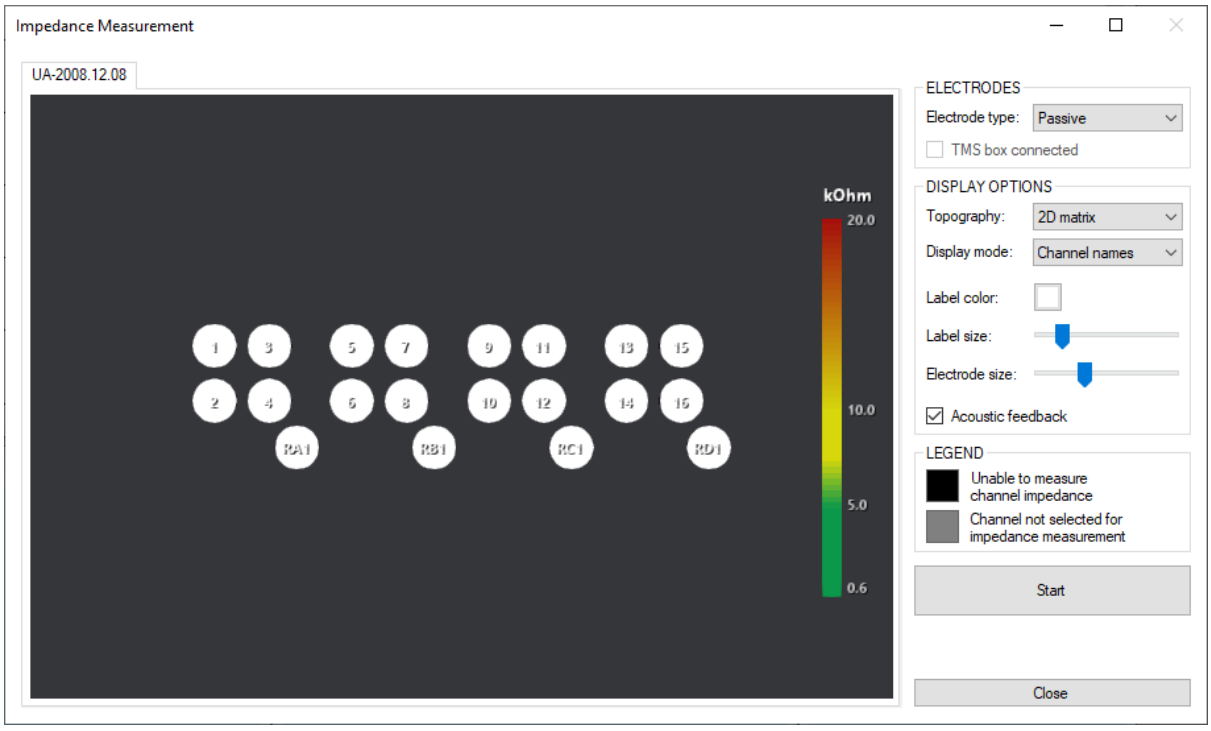
3.19 g.USBAMP-SPECIFIC FEATURES

3.19.1 IMPEDANCE MEASUREMENT WITH g.USBAMP AND g.RECORDER

The impedance of electrodes connected to a g.USBamp can be measured in g.Recorder. To start this tool, click on the **Impedance measurement...** button in the **Tools** menu.



This opens the dialog shown below.



Select or deselect the channels to use for impedance measurement by clicking on the appropriate channel number. Selected channels have a white background, those not selected have a gray background.

Use the mouse wheel to zoom, or press and hold the middle wheel button on the mouse to move the electrode montage. The **Electrode size** and **Label size** can be adjusted without zooming the whole montage. The impedance color bar can be moved or resized using the left mouse button.

Click **Start** to begin impedance measurement. Channels will be measured in succession and updated. The channel being measured is indicated by reduced electrode size while it is being measured.

The channel coloring indicates the impedance of the connected electrode. Optimal values for EEG recordings with passive electrodes should be below 5 kilo-ohm (color-coded in green). Acceptable impedance values are in the range around 10 kilo-ohm (color code yellow). Non-connected channels or bad impedance values above 20 kilo-ohm are color-coded in red.

NOTE

For EEG measurements the impedance should be below 10 kilo-ohm for optimal recording quality.

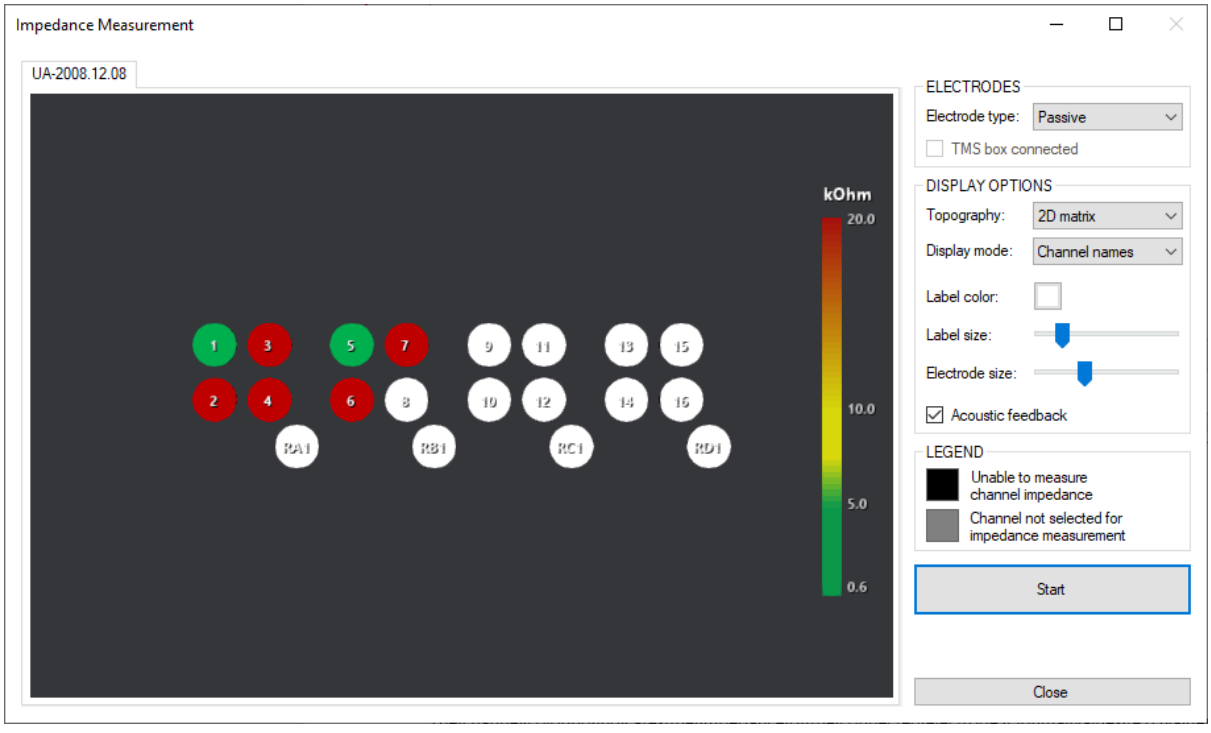
Click **Stop** to halt impedance measurement, even if impedance measurement has aborted with a connection error, and close the dialogue by clicking **Close**. An example of this is if the device was disconnected during measurements.

When **Acoustic feedback** is checked, a short beep is produced on the PC speaker when the impedance of any electrode changes from red to an improved impedance value. The better the impedance value, the higher the frequency of the beep. If the impedance of an electrode changes to red, a long beep sounds. To turn off acoustic feedback, uncheck the **Acoustic feedback** checkbox.

The **Display mode** setting specifies whether channel names, channel numbers or the measured impedance values should be displayed for each channel. Channel names can be assigned beforehand in the **Channel Settings** dialog. If no name was assigned for a channel, its logical channel number is displayed instead. The **Label color** can be changed for better visibility on certain impedance background colors. Impedance values are displayed in kilo-ohm. If impedance values cannot be measured but only be estimated, **LOW** is displayed instead of a value for estimated low/good impedances, and **HIGH** for estimated high/bad impedances.

The **Topography** setting allows for arranging the electrodes in a 2D topographic layout if an electrode montage has been loaded beforehand. If channel names were assigned according to the international 10-20, 10-10, or 10-5 system (as the **Montage Creator** automatically does), electrodes can also be arranged in a 3D topographic layout. In 3D topographic layout, icons in the lower-right corner allow for different split screen layouts or quick default views.

The figure below shows good impedance values for channels 1 and 5.



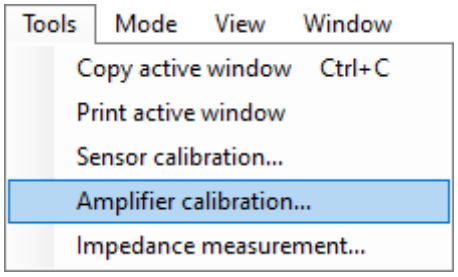
NOTE

The impedance of electrodes connected to channels 1-16 and the reference channels are measured against the ground **G** of each group. To measure the impedance of all 16 channels and 4 references against only one ground, connect the ground **G** of each group to ground **G** of group **D**.

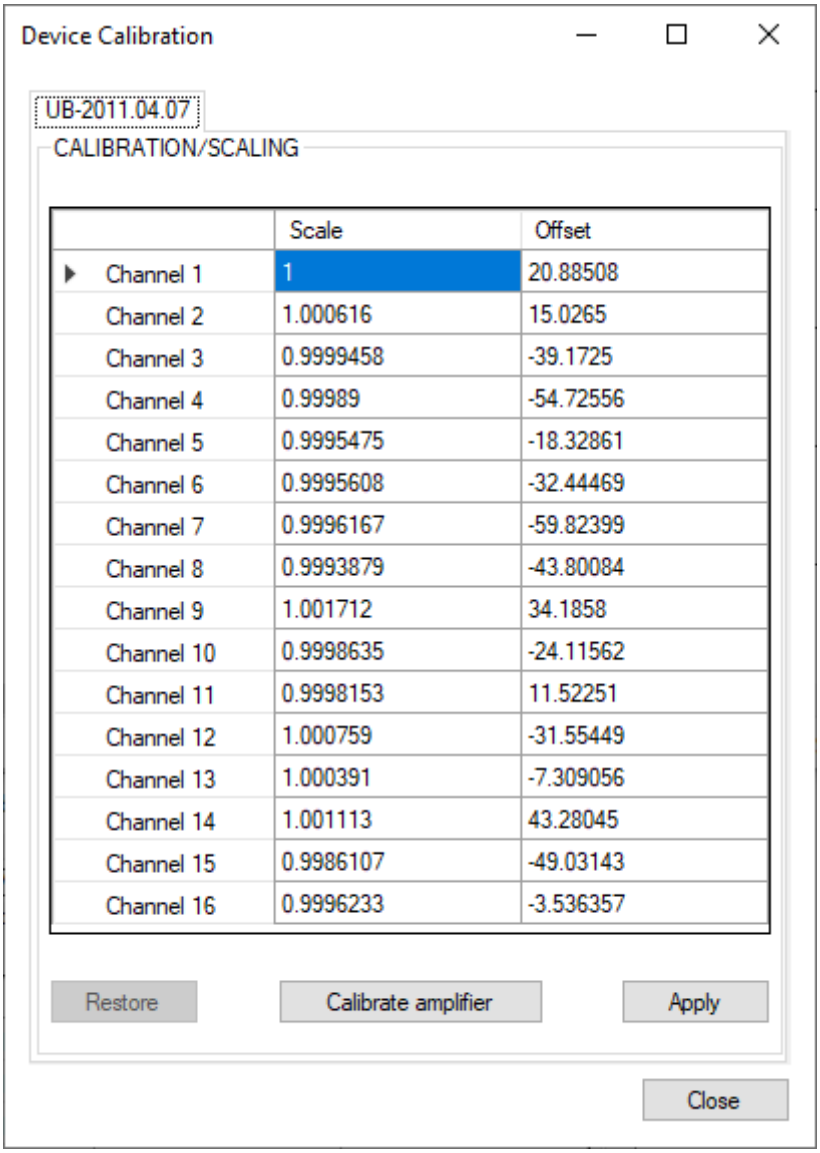
3.19.2 CALIBRATION OF g.USBAMP WITH g.RECORDER

g.Recorder has a built-in function to calibrate a g.USBamp.

Select **Amplifier calibration...** from the **Tools** menu.



This opens the g.USBamp calibration dialog. Click on the **Calibrate amplifier** button to measure offset and gain of each channel. Confirm the following dialog reminding you to apply the calibration set by clicking **OK**.



A dialog will inform you after calculation has been completed. The actual calibration values are then visualized for each channel, but not applied yet.

If at least one channel could not be calibrated due to broken channels or a broken calibration set, for example, a dialog will inform you about the involved channels and their calibration value entries are displayed as **NaN** ("not a number").

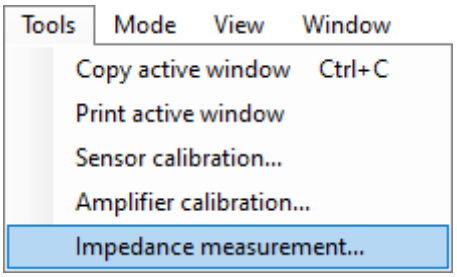
Press the **Apply** button to transmit the newly calculated calibration values to the g.USBamp and apply them on the device. Press the **Restore** button to restore the old values in the dialog. To edit the calibration values manually, double-click the desired cell and enter your value for scaling and offset (the settings will actually be transmitted and applied after the **Apply** button is pressed).

For channels that received **NaN** values as calibration result, 1.0 will be set for scaling and 0.0 for offset on pressing the **Apply** button.

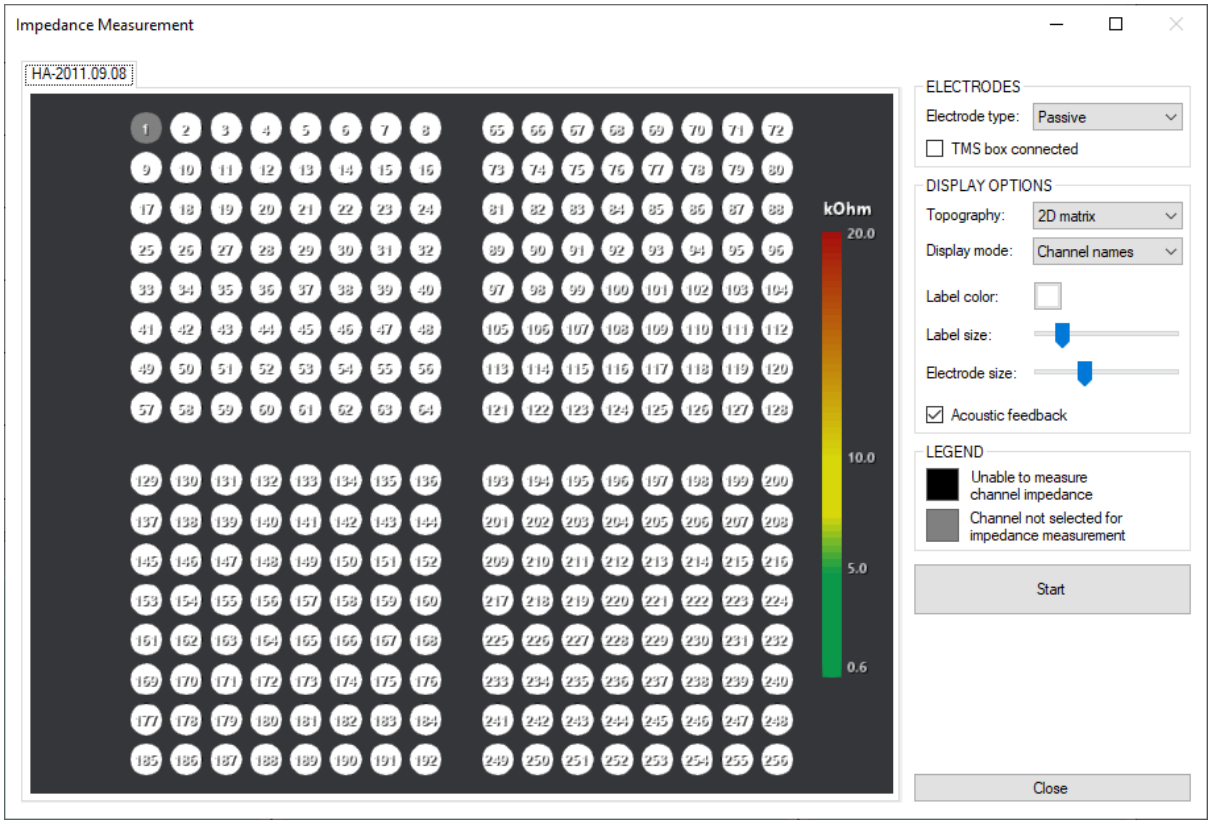
3.20 g.HIAMP-SPECIFIC FEATURES

3.20.1 IMPEDANCE MEASUREMENT WITH g.HIAMP AND g.RECORDER

The impedance of electrodes connected to a g.HIamp can be measured in g.Recorder. To start this tool, click on the **Impedance measurement...** button in the **Tools** menu.



This opens the dialog shown below.



Select the type of electrode connector boxes that are currently connected to each of the four groups of the g.HIamp in the **Electrode type** field. Either passive or active electrode connector boxes can be used. All groups must use the same type of electrodes even if no box is connected to a specific group. At least channel 1 (Group A) and the ground electrode must be connected.

IMPORTANT

If an active electrode box is connected to group A, a special electrode has to be used at channel 1. Please see the documentation of the 64-channel active electrode connector box for details on impedance measurement.

If a TMS connector box is connected to the g.HIamp, check the **TMS box connected** checkbox to correct the impedance values by the offset added by that box.

Select or deselect the channels to use for impedance measurement by clicking on the appropriate channel number. Selected channels have a white background, those not selected have a gray background.

Use the mouse wheel to zoom, or press and hold the middle wheel button on the mouse to move the electrode montage. The **Electrode size** and **Label size** can be adjusted without zooming the whole montage. The impedance color bar can be moved or resized using the left mouse button.

Click **Start** to begin impedance measurement. Impedance measurement is performed periodically for all channels at once and lasts a few seconds for each run.

The channel coloring indicates the impedance of the connected electrode.
Optimal values for EEG recordings with passive electrodes should be below 5 kilo-ohm (color-coded in green). Acceptable impedance values are in the range around 10 kilo-ohm (color code yellow). Bad impedance values above 20 kilo-ohm are color-coded red. Channels whose impedance couldn't be measured properly are color-coded black.
Optimal values for EEG recordings with active electrodes should be below 30 kilo-ohm (color-coded in green). Acceptable impedance values are in the range around 100 kilo-ohm (color code yellow). Bad impedance values above 200 kilo-ohm are color-coded in red. Channels whose impedance couldn't be measured properly are color-coded black.

Channel 1 and the ground electrode are used as the reference for impedance measurement of all other channels. No impedance can be measured for those channels. Hence, channel 1 is always grayed and no impedance value will be assigned. However, if the reference signal measured on channel 1 is not valid, no impedance value can be calculated and color code black will be assigned to all other channels. This might occur when the skin contact is too poor, when no electrode is connected on that channel, or when artifacts mess up the measured signal on that channel.

If the reference signal measured on a specific channel is not valid, no impedance value can be calculated and color code black will be assigned to that specific channel. This might occur when the skin contact is too poor, or when no electrode is connected on that channel, or when artifacts mess up the measured signal on that channel.

Click **Stop** to halt impedance measurement, even if impedance measurement has aborted with a connection error, and close the dialog by clicking **Close**. An example of this is if the device was disconnected during measurement.

When **Acoustic feedback** is checked, a short beep is produced on the PC speaker when the impedance of any electrode changes from red to an improved impedance value. The better the impedance value, the higher the frequency of the beep. If the impedance of an electrode changes to red or black, a long beep sounds. To turn off acoustic feedback, uncheck the **Acoustic feedback** checkbox.

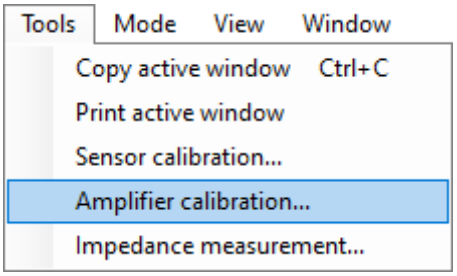
The **Display mode** setting specifies whether channel names, channel numbers or the measured impedance values should be displayed for each channel. Channel names can be assigned beforehand in the **Channel Settings** dialog. If no name was assigned for a channel, its logical channel number is displayed instead. The **Label color** can be changed for better visibility on certain impedance

background colors. Impedance values are displayed in kilo-ohm. If impedance values cannot be measured but only be estimated, **LOW** is displayed instead of a value for estimated low/good impedances, and **HIGH** for estimated high/bad impedances.

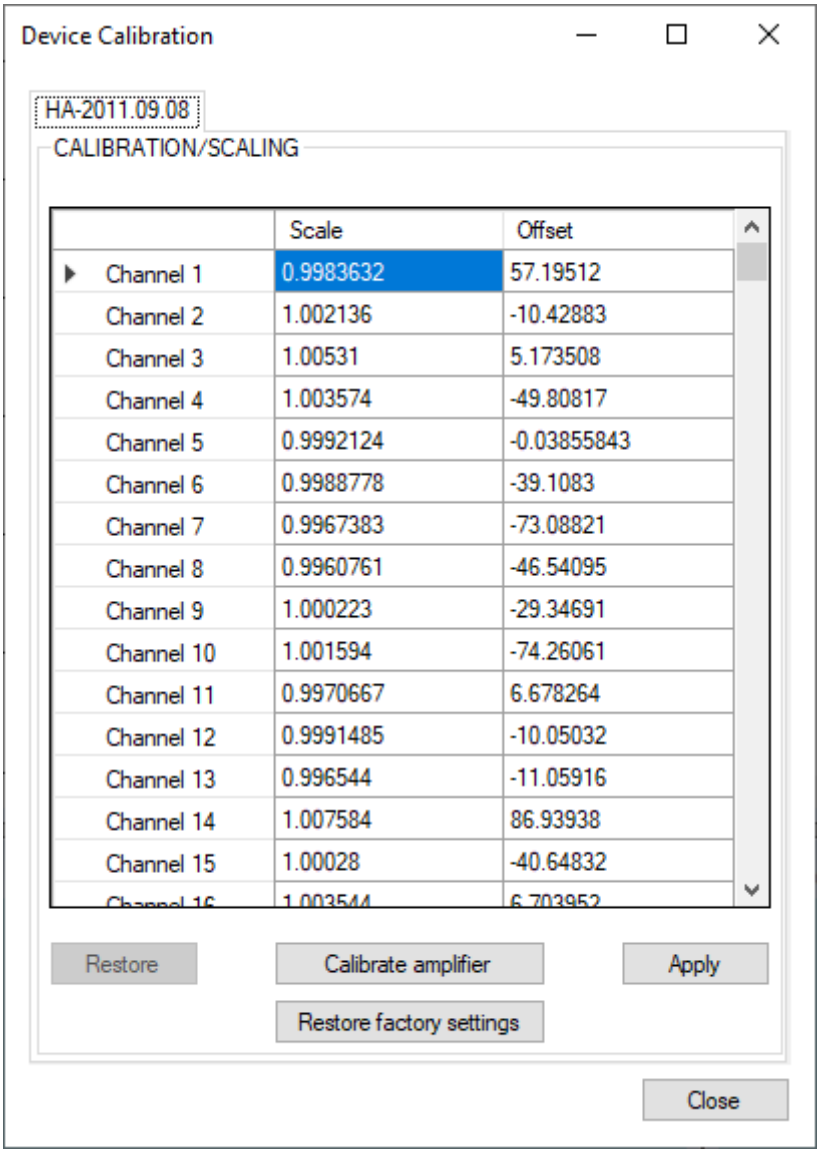
The **Topography** setting allows for arranging the electrodes in a 2D topographic layout if an electrode montage has been loaded beforehand. If channel names were assigned according to the international 10-20, 10-10, or 10-5 system (as the **Montage Creator** automatically does), electrodes can also be arranged in a 3D topographic layout. In 3D topographic layout, icons in the lower-right corner allow for different split screen layouts or quick default views.

3.20.2 CALIBRATION OF g.HIAMP WITH g.RECORDER

g.Recorder has a built-in function to calibrate a g.HIamp device. Select **Amplifier calibration...** from the **Tools** menu.



This opens the g.HIamp calibration dialog. To calculate new calibration values for the device, ensure that the calibration set is applied onto the amplifier at first. See the manual of the calibration set for detailed instructions on how to do this. Then click the **Calibrate amplifier** button to measure offset and gain of each channel. Confirm the following dialog reminding you to apply the calibration set by clicking **OK**.



Calculation of new calibration values lasts about 10 seconds. A dialog will inform you after calculation has been completed. The actual calibration values are then visualized for each channel, but not applied yet.

If at least one channel could not be calibrated due to broken channels or a broken calibration set, for example, a dialog will inform you about the involved channels and their calibration value entries are displayed as **NaN** ("not a number").

To restore the initial factory calibration values, click **Restore factory settings**.

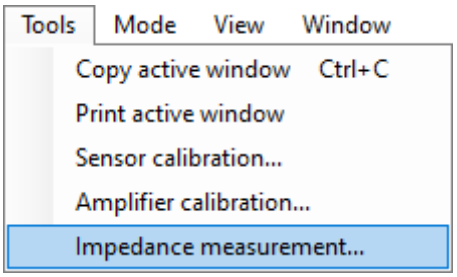
Press the **Apply** button to transmit the newly calculated or restored factory calibration values to the g.HIamp and apply them on the device. Press the **Restore** button to restore the old values in the dialog. To edit the calibration values manually, double-click the desired cell and enter your value for scaling and offset (the settings will actually be transmitted and applied after the **Apply** button is pressed).

For channels that received **NaN** values as calibration result, 1.0 will be set for scaling and 0.0 for offset on pressing the **Apply** button.

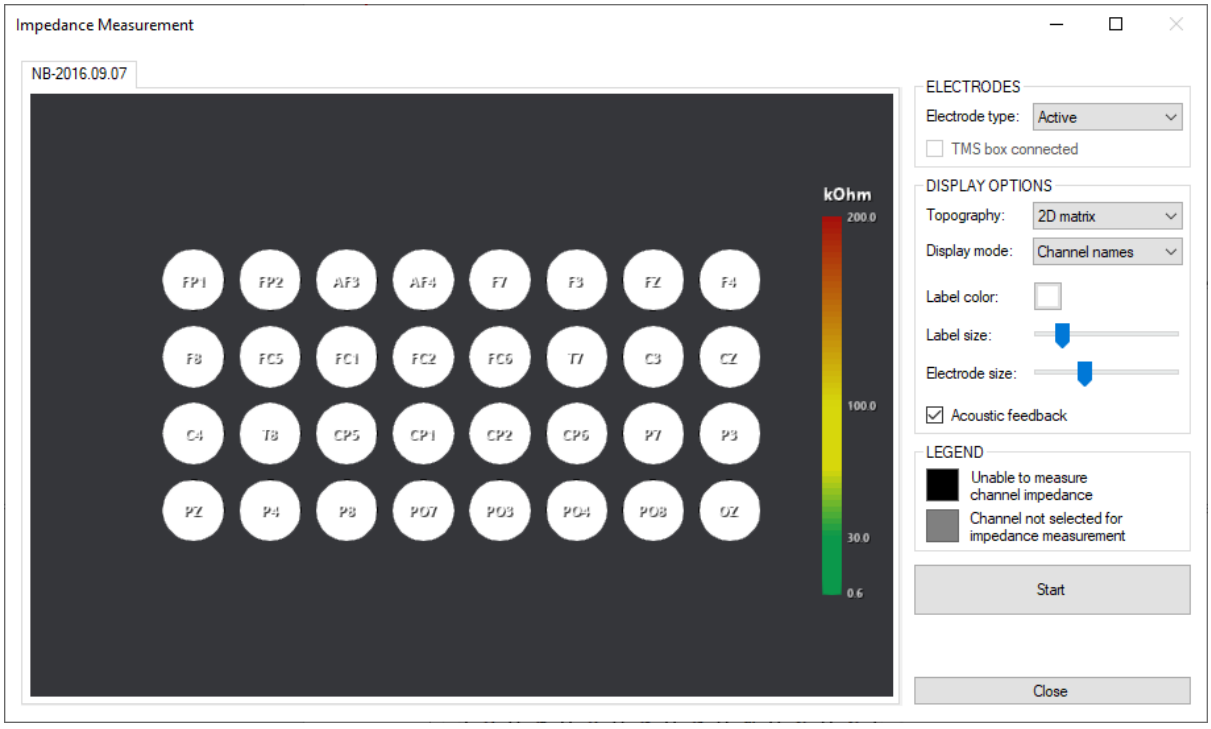
3.21 G.NAUTILUS-SPECIFIC FEATURES

3.21.1 IMPEDANCE MEASUREMENT WITH g.NAUTILUS AND g.RECORDER

The impedance of electrodes connected to a g.HIamp can be measured in g.Recorder. To start this tool, click on the **Impedance measurement...** button in the **Tools** menu.



This opens the dialog shown below.



Select or deselect the channels to use for impedance measurement by clicking on the appropriate channel number. Selected channels have a white background, those not selected have a gray background.

Use the mouse wheel to zoom, or press and hold the middle wheel button on the mouse to move the electrode montage. The **Electrode size** and **Label size** can be adjusted without zooming the whole montage. The impedance color bar can be moved or resized using the left mouse button.

Click **Start** to begin impedance measurement. Impedance measurement is performed periodically for all channels simultaneously, and lasts a few seconds for each run.

The channel coloring indicates the impedance of the connected electrode. Optimal values for EEG recordings with active electrodes should be below 30 kilo-ohm (color-coded in green). Acceptable impedance values are in the range around 100 kilo-ohm (color code yellow). Bad impedance values above 200 kilo-ohm are color-coded in red. Channels whose impedance couldn't be measured properly are color-coded black.

The Cz electrode and the ground electrode are used as the reference for impedance measurement of all other channels. If the reference signal measured on channel Cz is not valid, no impedance value can be calculated and color code black will be assigned to all other channels. This might occur when the skin contact is too poor, or when no electrode is connected on that channel, or when artifacts affect the measured signal on that channel.

If the reference signal measured on a specific channel is not valid, no impedance value can be calculated and color code black will be assigned to that specific channel. This might occur when the skin contact is too poor, or when no electrode is connected on that channel, or when artifacts affect the measured signal on that channel.

Click **Stop** to halt impedance measurement, even if impedance measurement has aborted with a connection error, and close the dialog by clicking **Close**. An example of this is if the device was disconnected during measurement.

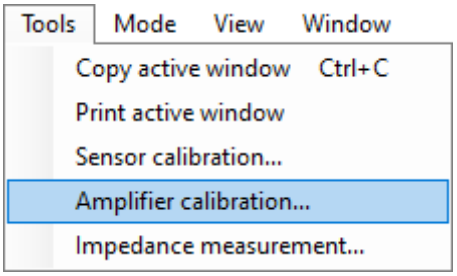
When **Acoustic feedback** is checked, a short beep is produced on the PC speaker when the impedance of any electrode changes from red to an improved impedance value. The better the impedance value, the higher the frequency of the beep. If the impedance of an electrode changes to red or black, a long beep sounds. To turn off acoustic feedback, uncheck the **Acoustic feedback** checkbox.

The **Display mode** setting specifies whether channel names, channel numbers or the measured impedance values should be displayed for each channel. Channel names can be assigned beforehand in the **Channel Settings** dialog. If no name was assigned for a channel, its logical channel number is displayed instead. The **Label color** can be changed for better visibility on certain impedance background colors. Impedance values are displayed in kilo-ohm. If impedance values cannot be measured but only be estimated, **LOW** is displayed instead of a value for estimated low/good impedances, and **HIGH** for estimated high/bad impedances.

The **Topography** setting allows for arranging the electrodes in a 2D topographic layout if an electrode montage has been loaded beforehand. If channel names were assigned according to the international 10-20, 10-10, or 10-5 system (as the **Montage Creator** automatically does), electrodes can also be arranged in a 3D topographic layout. In 3D topographic layout, icons in the lower-right corner allow for different split screen layouts or quick default views.

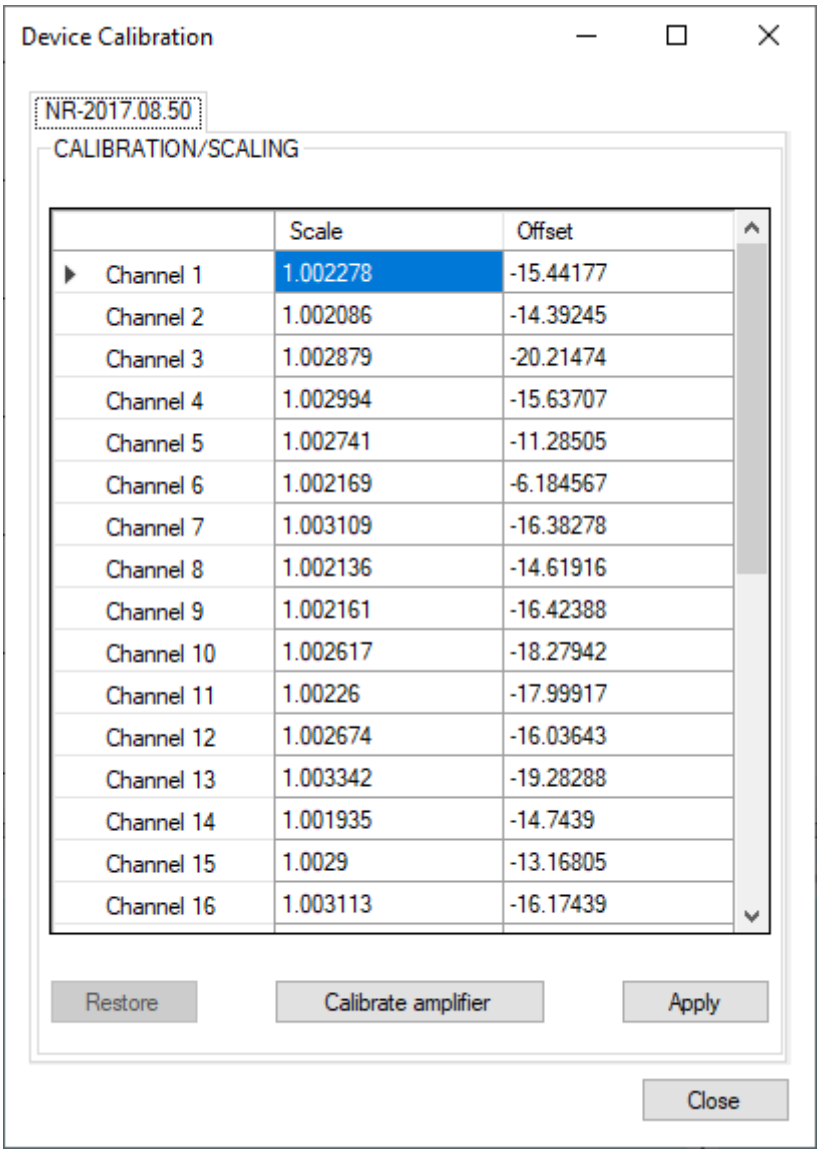
3.21.2 CALIBRATION OF g.NAUTILUS WITH g.RECORDER

g.Recorder has a built-in function to calibrate a g.Nautilus device. Select **Amplifier calibration...** from the **Tools** menu.



This opens the g.Nautilus calibration dialog. Click the **Calibrate amplifier** button to measure offset and gain of each channel. Confirm the following dialog reminding you to apply the calibration set by clicking **OK**.

A dialog will inform you after calculation has been completed. The actual calibration values are then visualized for each channel, but not applied yet.



4 RUNNING g.RECORDER IN ADMINISTRATOR MODE

The Administrator mode allows the user to configure a g.HIamp, g.USBamp or g.Nautilus amplifier and add and configure the different feature extraction methods of g.Recorder.

NOTE

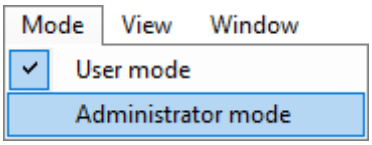
This mode requires an administrator password for the software.

NOTE

If no administrator password is set, g.Recorder starts into administrator mode automatically.

4.1 ACTIVATE ADMINISTRATOR MODE

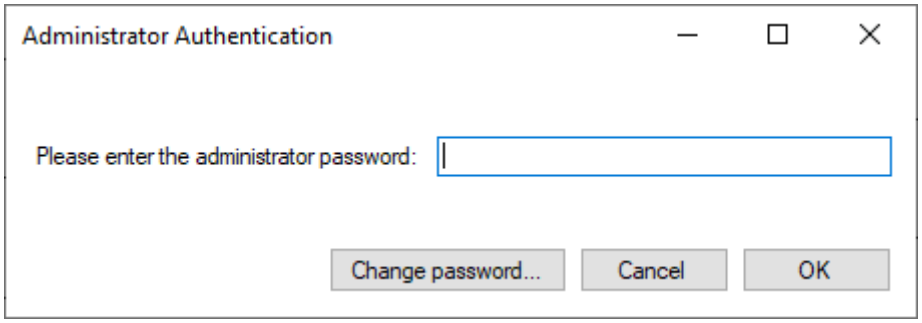
To change from user mode into the administrator mode click on Administrator mode under the Mode menu.



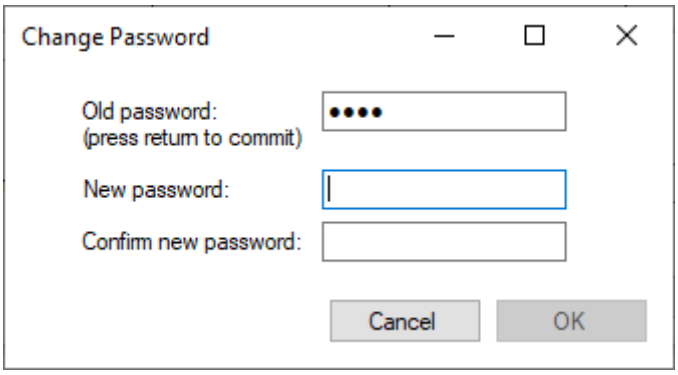
NOTE

Per default, no administrator password is set.

If a password is set, enter the password and click OK in the Administrator Authentication dialog to activate the Administrator mode. If no password is set, just click OK.

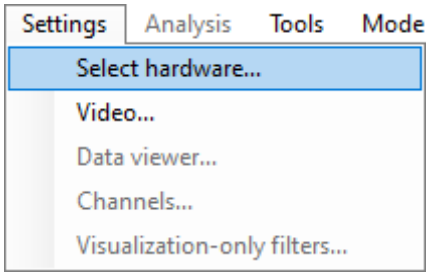


To change the password, click on Change password and enter the Old password. Then, press the Enter key and enter the New password, then enter the password again in the Confirm new password field, press the Enter key and click OK.

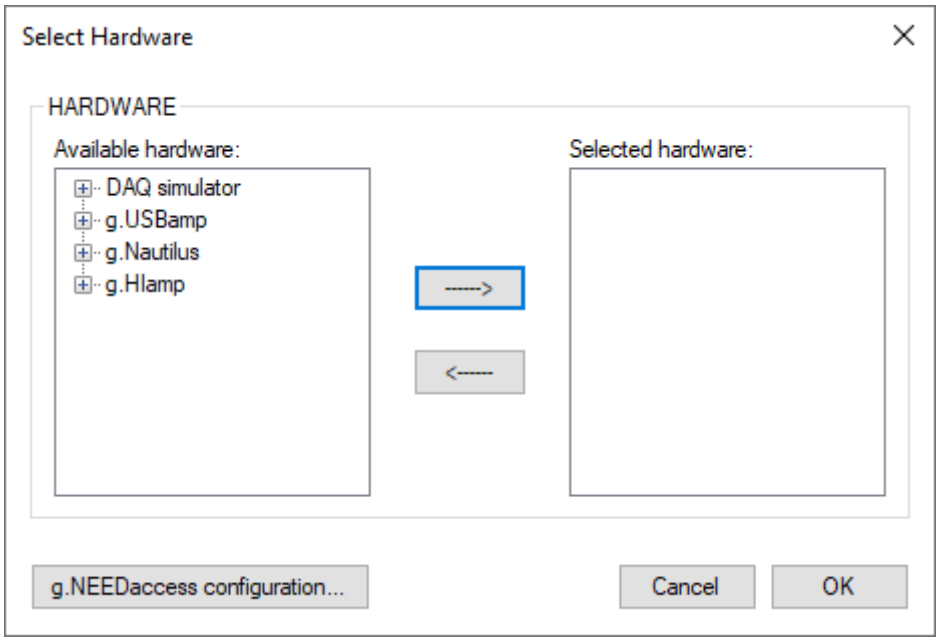


4.2 SELECT AND CONFIGURE HARDWARE

In the Settings menu, select **Select hardware...**



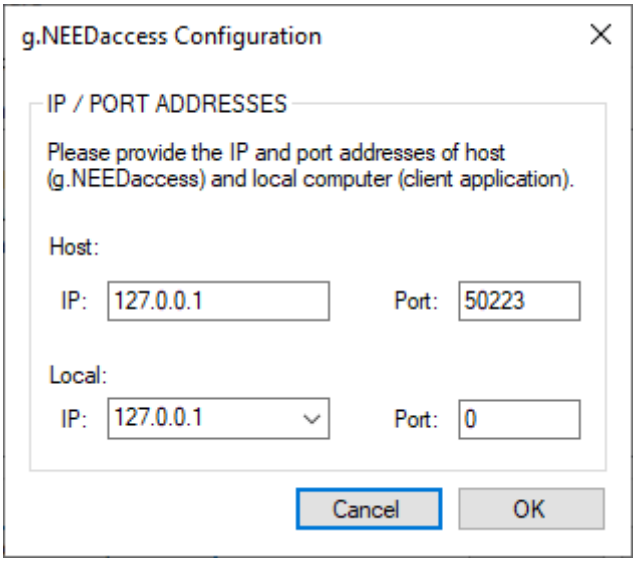
The Select Hardware dialog opens:



4.2.1 g.NEEDACCESS CONFIGURATION

For g.USBamp, g.HIamp, and g.Nautilus devices, the network location of the g.NEEDaccess Server can be changed if not running on the same machine as g.Recorder. This way, the devices and g.NEEDaccess Server can be running on a different machine and stream data to g.Recorder on a machine in the same network.

To change the network location of the g.NEEDaccess Server, click the **g.NEEDaccess** configuration... button.



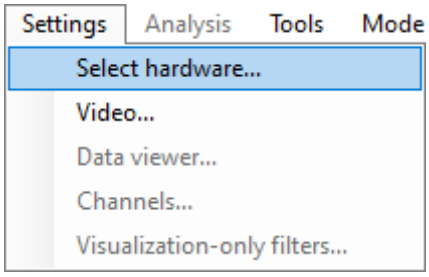
If the devices are connected to the same machine that runs g.Recorder, the default configuration can be used specifying the IP address of the loopback adapter (127.0.0.1) for both host (the machine that runs g.NEEDaccess Server) and the local client (the machine that runs g.Recorder). By default, g.NEEDaccess Server always runs on port 50223. If port 0 is used for the client, a free port is determined automatically.

If an IP address other than the loopback adapter address is used for any, both host and local client must use an existing IP address instead of the loopback adapter address.

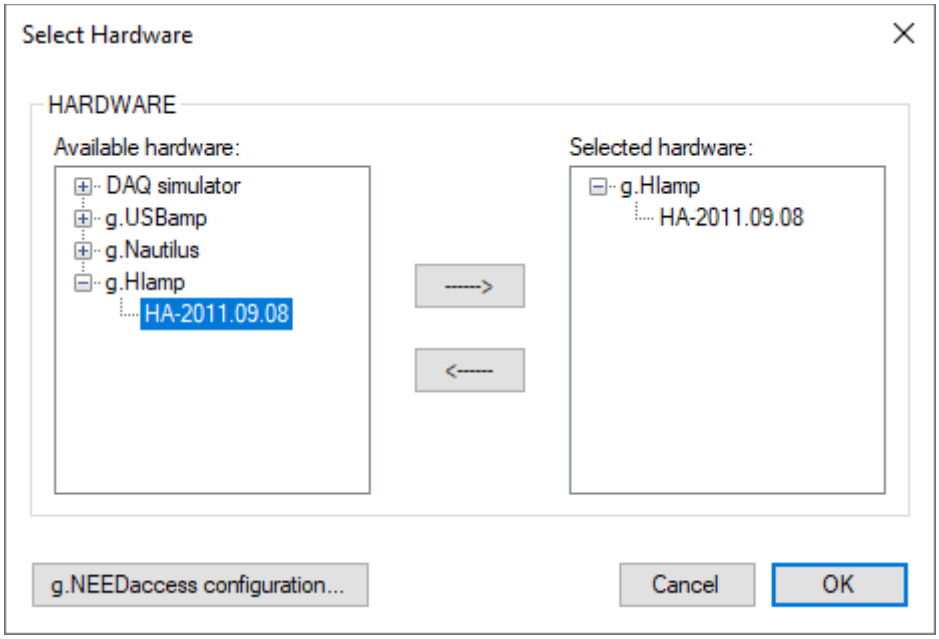
If the selected devices are already in use by another application (or another instance of g.Recorder on a different machine), g.Recorder is still able to connect to them and use them. In this case, the devices can only be configured by the application that opened the devices first. g.Recorder will only deliver a copy of the data stream from the other application.

4.2.2 g.HIAMP

In the Settings menu, select **Select hardware...**



The Select Hardware dialog opens:

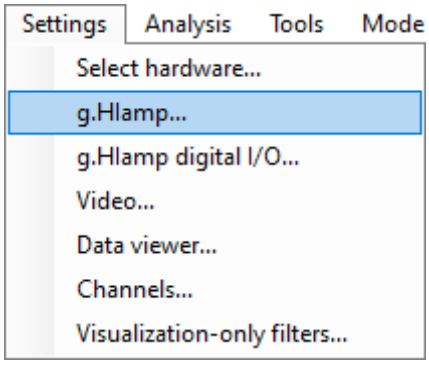


If the g.NEEDaccess Server is not running, g.Hlamp devices cannot be used. No error message will be shown. The installation and GDS service status should be checked, if connected devices are not found.

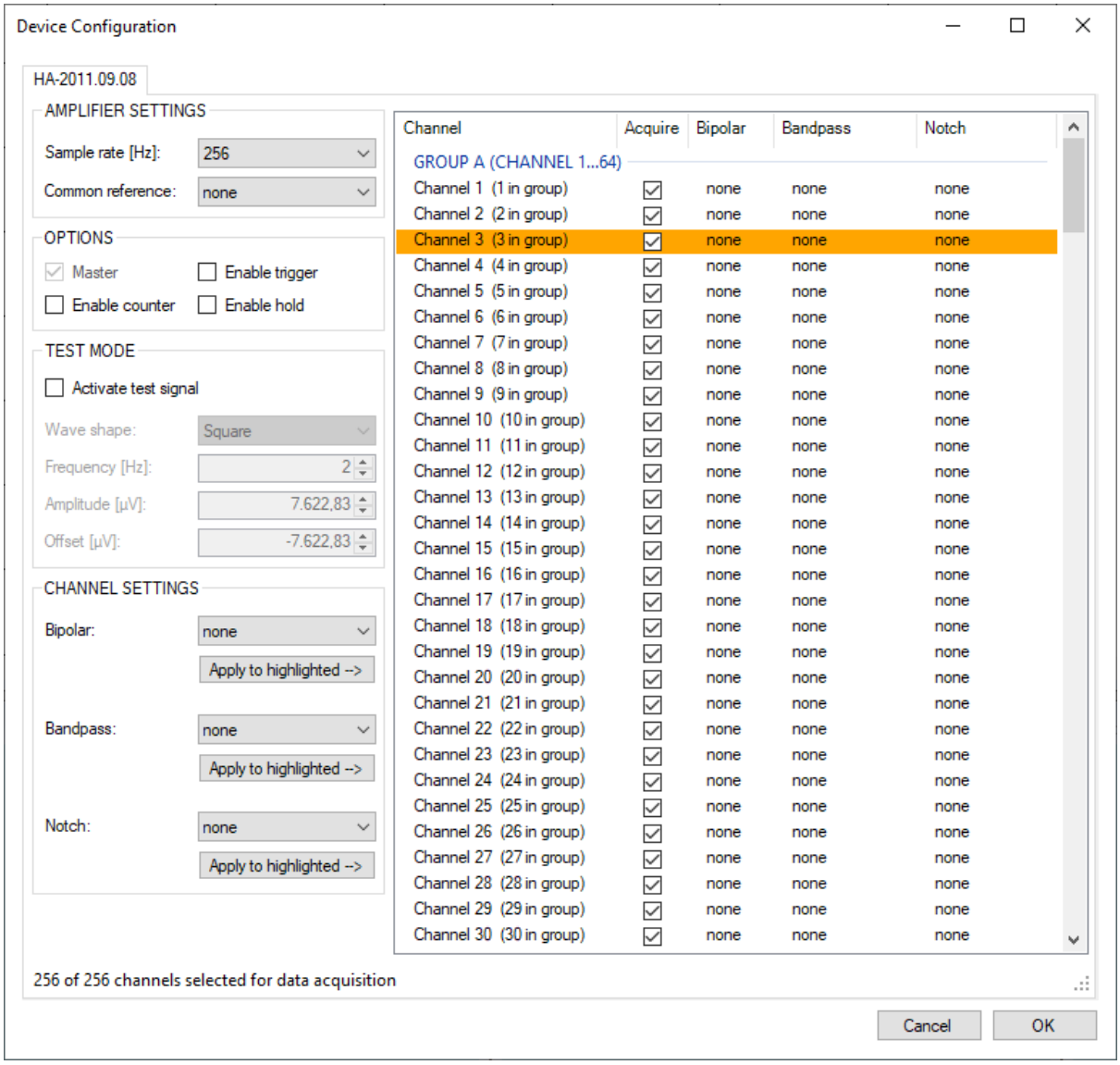
Select the desired g.Hlamp device that should be used for measurement from **Available hardware** and click on the arrow button. This g.Hlamp and its serial number are displayed in the **Selected hardware** box.

Click **OK** to finish hardware selection

To configure the selected **g.Hlamp** device, click on **g.Hlamp**... in the **Settings** menu.



The configuration dialog opens with the amplifier's serial number:



Amplifier settings	
Sample rate [Hz]	specify the sampling frequency of the g.HIamp in Hz.
Common reference	specify one of the device's channels as the common reference channel. This is a quick way to set the selected channel as a bipolar channel for all other channels of the device. Existing settings for bipolar channels will be overwritten.

Options	
Master	set the amplifier to master mode.
Enable trigger	indicates if the digital trigger input line is acquired as well. This checkbox will be enabled automatically if at least one trigger line is selected to acquire (see the digital IN settings section for further details).
Enable counter	a sample counter is applied on the first acquired channel, which overruns at 1000000.
Enable hold	enable/disable the signal hold function.

Test mode	
Activate test signal	enable/disable the internal test signal generator, which generates a test signal using the specified settings on the GND (ground) connector.
Wave shape	specify the wave shape of the test signal.
Frequency [Hz]	specify the frequency of the test signal.
Amplitude [µV]	specify the amplitude of the test signal in microvolts.
Offset [µV]	specify the offset of the test signal in microvolts.

Channel settings	
Bipolar	perform a bipolar derivation between 2 input channels.
Bandpass	perform a digital bandpass filtering of the input channels.
Notch	perform a bandstop filtering to suppress the power line frequency of 50 Hz or 60 Hz.

Perform the following steps to configure the highlighted channels:

- Highlight the channels in the list box that should be edited. Use the Ctrl key or the Shift key to highlight multiple channels. To select all channels, use Ctrl+A. To highlight all channels of one group, click the group header. Highlighted channels are represented with an orange background color, as illustrated for channel 3.
- Check or uncheck the checkbox of one of the selected channels in the **Acquire** column to include the highlighted channels in data acquisition or exclude them.
- If no common reference has been set before, or you want to change the reference/bipolar channel for a specific channel, select the desired bipolar channel from the **Bipolar** list and press the corresponding **Apply to highlighted** button right below.

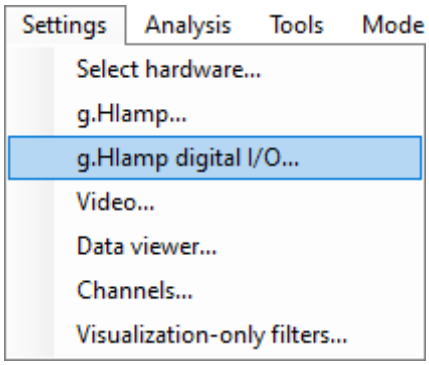
- Select a bandpass filter from the **Bandpass** list and press the corresponding **Apply to highlighted** button right below.
- Select a notch filter from the **Notch** list and press the corresponding **Apply to highlighted** button right below.

If no channel is highlighted when one of the **Apply to highlighted** buttons is clicked, the system instead informs the user of this error and the settings do not change.

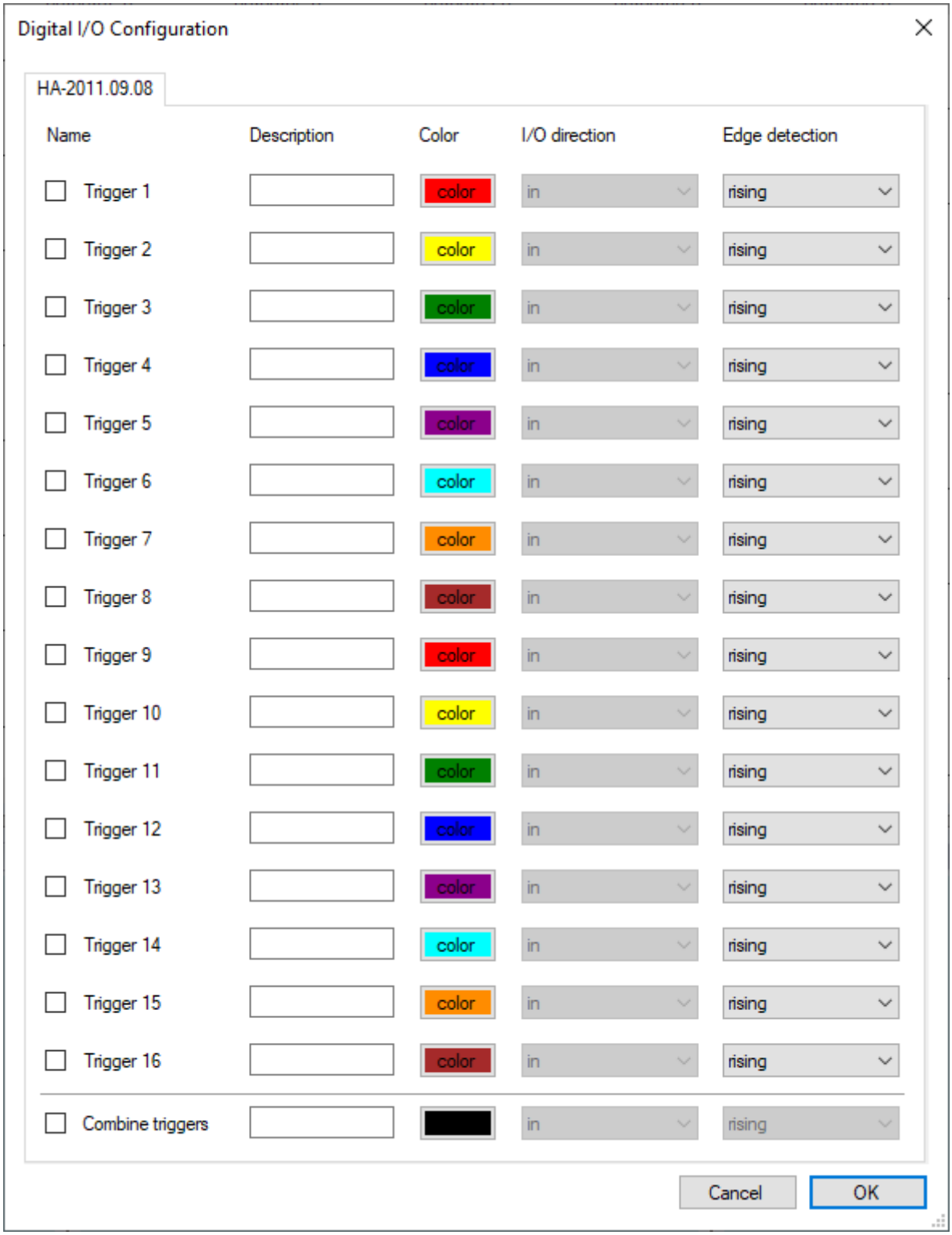
Click **OK** to finish the configuration of the g.HIamp and apply it to the device.

4.2.3 DIGITAL INPUTS FOR g.HIAMP

In the **Settings** menu, click on **g.HIamp digital I/O...** to open the configuration dialog for the digital I/O settings.



The **Trigger** inputs are sampled synchronously with the analog input channels.



Check the box of the desired channels, enter a **Description**, select a color by clicking on the **Color** button (**Color**), and define the edge (**Edge detection**).

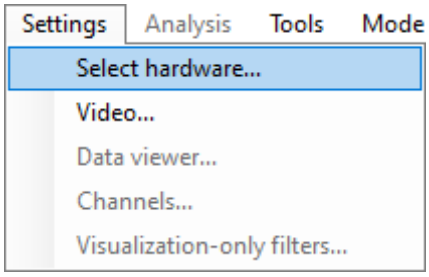
Confirm the settings and close the dialog with **OK**.

If the event occurs, a marker is generated and visualized with the biosignal data.

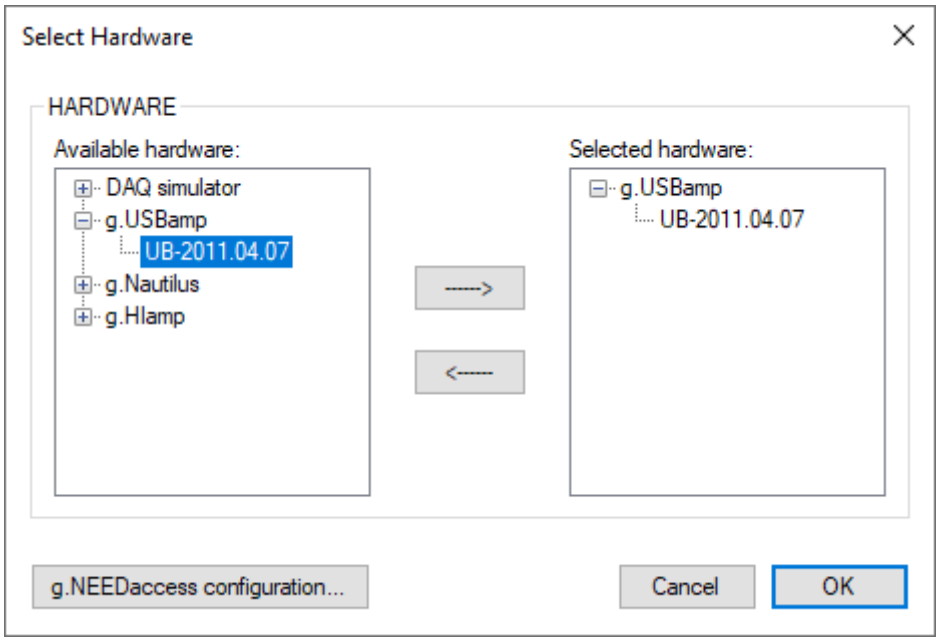
If **Combine triggers** is selected, all individual trigger channels are enabled and the individual channel selection becomes disabled. Combined triggers are always configured to detect rising edges. It is possible to change the **Color** and **Description** for combined triggers. The displayed marker name and color for a combined trigger are always the same. The marker's value will be the binary coded decimal made up of the current HIGH and LOW values of all individual trigger channels with trigger channel 1 as least significant bit and trigger channel 16 as most significant bit.

4.2.4 g.USBAMP VERSION 2.0 AND VERSION 3.0

In the **Settings** menu, select **Select hardware...**



The **Select Hardware** dialog opens:

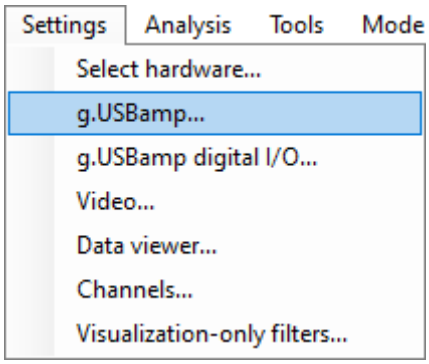


If the g.NEEDaccess Server is not running, g.USBamp devices cannot be used. No error message will be shown. The installation and GDS service status should be checked, if connected devices are not found.

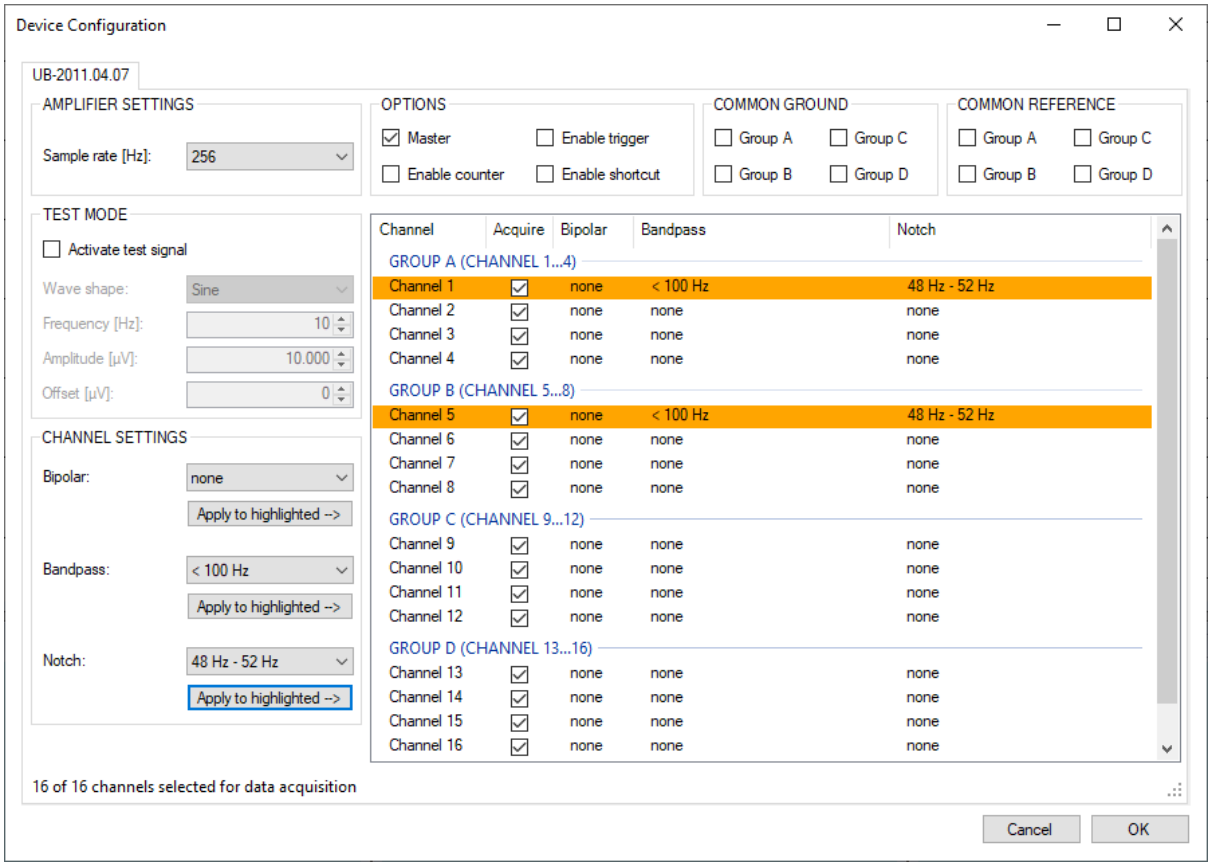
From **Available hardware**, select the g.USBamp device that should be used for the measurements and click on the arrow button, as shown in the figure above. This g.USBamp with the serial number is now displayed in the **Selected hardware** box.

Click **OK** to finish hardware selection.

To configure the g.USBamp, click on **g.USBamp...** in the **Settings** menu.



The configuration window opens with the amplifier serial number:



Amplifier settings

Sampling rate [Hz]	specify the sampling frequency of the g.USBamp in Hz.

Options	
Master	set the amplifier to master mode if multiple units are used.
Enable counter	a sample counter is applied on channel 16 if acquired, which overruns at 1000000.
Enable shortcut	enable/disable the shortcut input.
Enable trigger	indicates if the digital trigger input line is acquired as well. This checkbox will be enabled automatically if at least one trigger line is selected to acquire (see the digital IO settings section for further details).

Common ground	
Group A...D	check the channel group on the amplifier whose group ground channel should be connected to common ground.

Common reference	
Group A...D	check the channel group on the amplifier whose group reference channel should be connected to common reference.

Test mode	
Activate test signal	enable/disable the internal test signal generator, which generates a test signal on all acquired input channels.  **NOTE** The test signal works for sampling rates equal or below 600 Hz.
Wave shape	specify the wave shape of the test signal.
Frequency [Hz]	specify the frequency of the test signal.
Amplitude [µV]	specify the amplitude of the test signal in microvolts.
Offset [µV]	specify the offset of the test signal in microvolts.

Channel settings

Bipolar	perform a bipolar derivation between 2 input channels.
Bandpass	perform a digital bandpass filtering of the input channels.
Notch	perform a bandstop filtering to suppress the power line frequency of 50 Hz or 60 Hz.

Perform the following steps to configure the selected channels:

- Highlight the channels in the list box that should be edited. Use the Ctrl key or the Shift key to highlight multiple channels. To select all channels, use Ctrl+A. To highlight all channels of one group, click the group header. Highlighted channels are represented with an orange background color, as illustrated for channel 1 and 5.
- Check or uncheck the checkbox of one of the selected channels in the **Acquire** column to include the highlighted channels in data acquisition or exclude them.
- To perform a bipolar derivation between channels 1 and 2, select the first channel in the listbox. Then select channel 2 under **Bipolar** and press the **Apply** button. The settings appear in the listbox. This configuration subtracts channel 2 from channel 1 and the bipolar derivation will be visible on channel 1.

NOTE

Select **none** under **Bipolar** and assign it to the channel if no bipolar derivation should be performed.

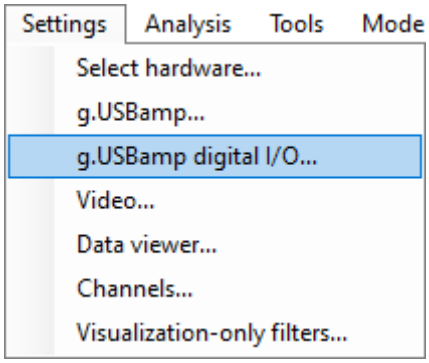
- Select a bandpass filter from the **Bandpass** list and press the corresponding **Apply to highlighted** button right below.
- Select a notch filter from the **Notch** list and press the corresponding **Apply to highlighted** button right below.

Finish the configuration of the g.USBamp by clicking the **OK** button.

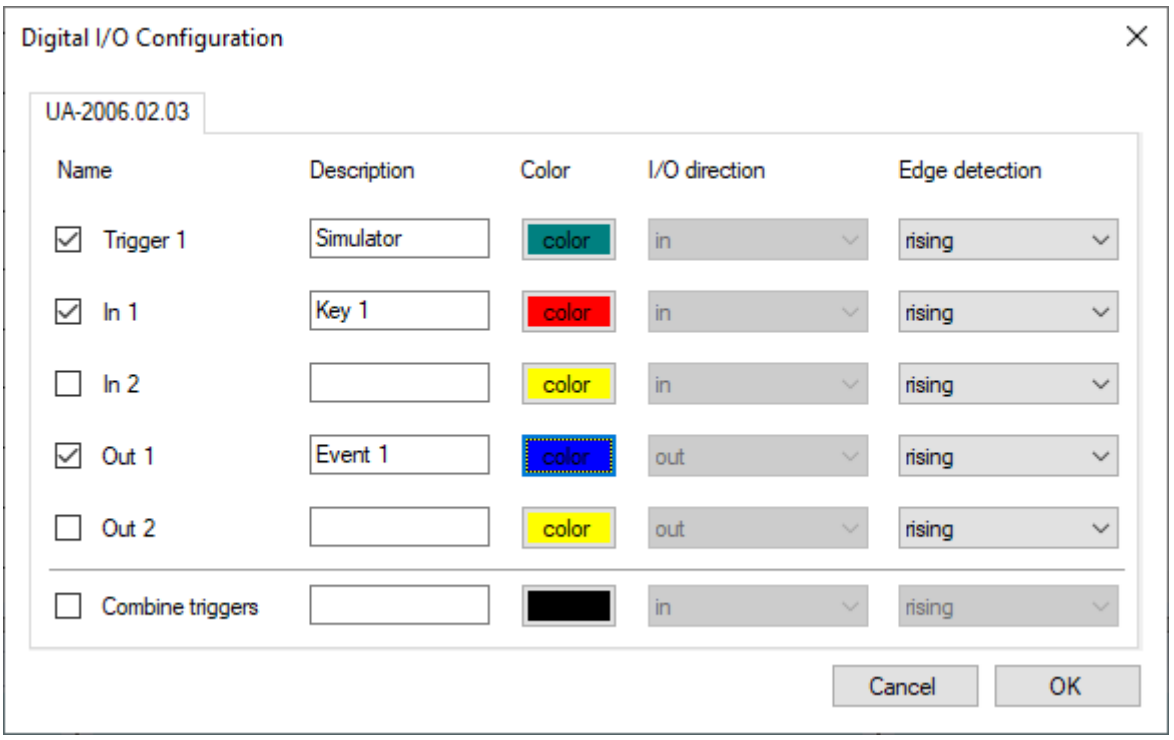
4.2.5 DIGITAL I/O FOR g.USBAMP VERSION 2.0

The serial number for a g.USBamp 2.0 starts with UA-xxxx.xx.xx

g.USBamp 2.0 has 3 digital inputs and 2 digital outputs. In the **Settings** menu click on **g.USBamp digital I/O...** to open the dialog.



The **Trigger 1** input is sampled together with the analog input channels and therefore gives a synchronous response. The inputs and outputs **In 1**, **In 2**, **Out 1** and **Out 2** are sampled asynchronously.



Check the box of the desired channels, enter a **Description**, select a color (**Color**) and define the edge (**Edge detection)**.

Then close the dialog with **OK**.

If the event occurs, a marker is generated and visualized with the biosignal data.

If **Combine triggers** is selected, all individual trigger channels are enabled and the individual channel selection becomes disabled. Combined triggers are always configured to detect rising edges. It is possible to change the **Color** and **Description** for combined triggers. The displayed marker name and color for a combined trigger are always the same. The marker's value will be the binary coded decimal made up of the current HIGH and LOW values of all individual trigger channels with trigger channel 1 as the only bit in that value.

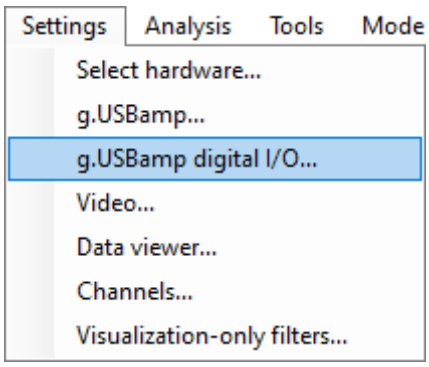
NOTE

The **Trigger 1** input must be used if very accurate timing is needed.

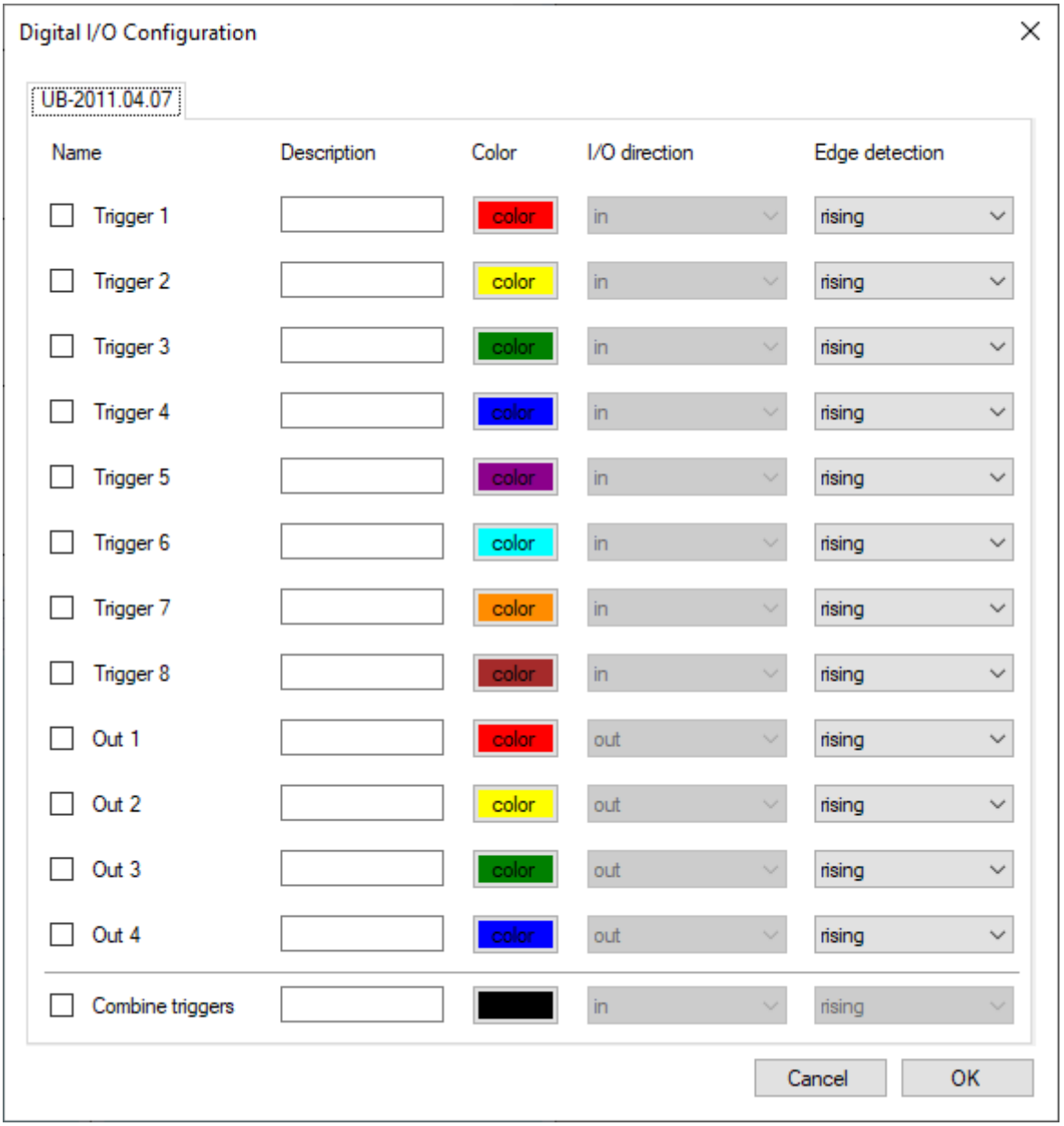
4.2.6 DIGITAL I/O FOR g.USBAMP VERSION 3.0

The serial number for a g.USBamp 3.0 starts with UB-xxxx.xx.xx

g.USBamp 3.0 has 8 digital inputs and 4 digital outputs. In the **Settings** menu, click on **g.USBamp digital I/O…** to open the dialog.



The trigger inputs **Trigger 1** to **Trigger 8** are sampled synchronously with the analog input channels. The outputs **Out 1** to **Out 4** are sampled asynchronously.



Check the box of the desired channels, enter a **Description**, select a color (**Color**) and define the edge (**Edge detection)**.

Then close the dialog with **OK**.

If the corresponding trigger event occurs, a marker is generated and visualized along with the biosignal data.

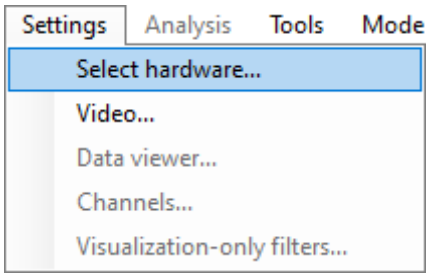
If **Combine triggers** is selected, all individual trigger channels are enabled and the individual channel selection becomes disabled. Combined triggers are always configured to detect rising edges. It is possible to change the **Color** and **Description** for combined triggers. The displayed marker name and color for a combined trigger are always the same. The marker's value will be the binary coded decimal made up of the current HIGH and LOW values of all individual trigger channels with trigger channel 1 as least significant bit and trigger channel 8 as most significant bit.

NOTE

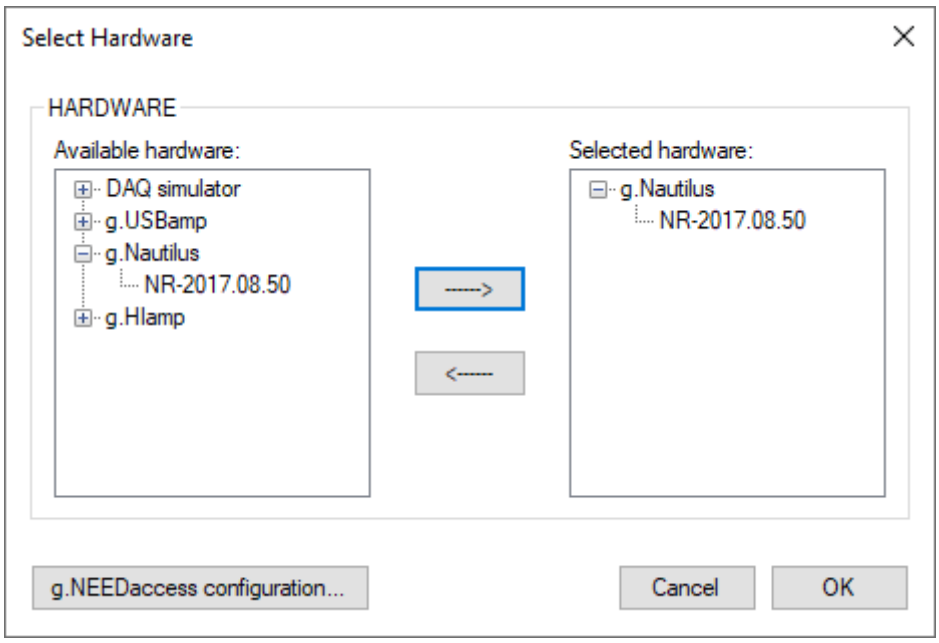
A very accurate timing is obtained for all trigger channels.

4.2.7 g.NAUTILUS

In the Settings menu, select **Select hardware...**



The **Select Hardware** dialog opens:

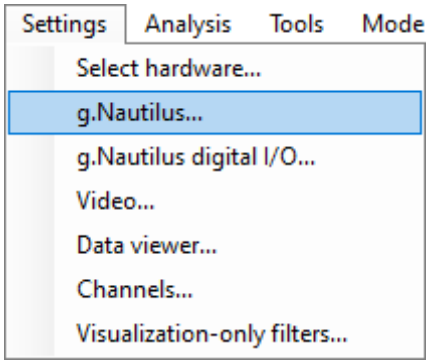


If the g.NEEDaccess Server is not running, g.Nautilus devices cannot be used. No error message will be shown. The installation and GDS service status should be checked, if connected devices are not found.

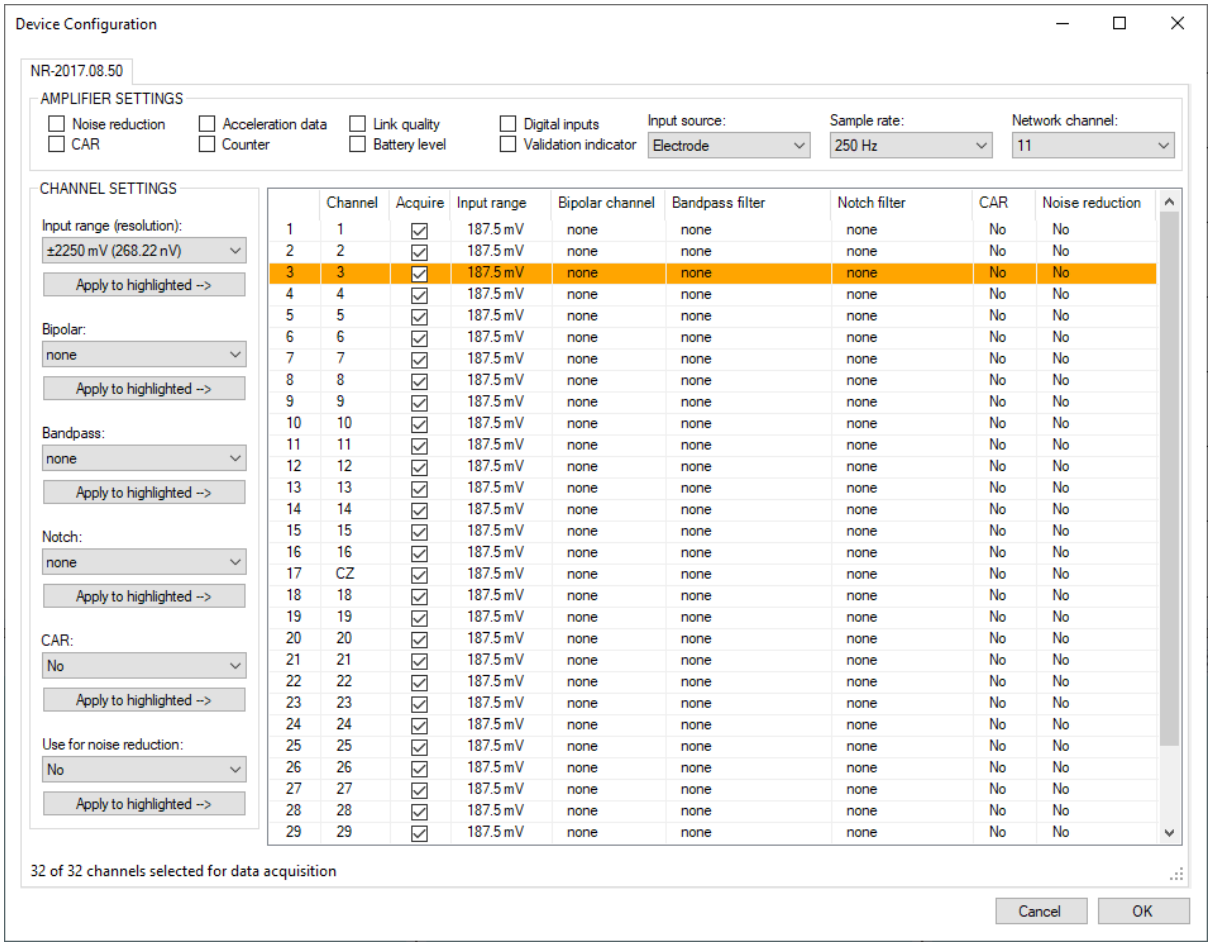
Select the **g.Nautilus** that should be used for the measurements from **Available hardware** and click on the arrow button as shown in the figure above. Now this **g.Nautilus** with the serial is displayed in the **Selected hardware** box.

Click **OK** to finish hardware selection.

To configure the g.Nautilus, select **g.Nautilus...** from the **Settings** menu.



The configuration window opens with the amplifier serial number:



Amplifier settings

Input source	specify the input source for data acquisition. Electrode: record EEG data Shortcut: record with shortcut of inputs Test signal: enables the internal test signal generator, which generates a square wave test signal on each channel.

Sample rate	specify the sampling frequency in Hz.
Network channel	Set the network channel used for data transmission.
Noise reduction	enable noise reduction using DRL (driven-right leg) algorithm of activated channels.
CAR	enable common average reference of activated channels (see column CAR).
Acceleration data	if enabled, the measured acceleration in x, y, and z directions in the range of ± 6 g come as three additional channels after the analog channels.
Counter	if enabled, a sample counter comes as an additional channel after the acceleration data channels.
Link quality	if enabled, wireless link quality in percent comes as an additional channel after the counter channel.
Battery level	if enabled, battery level (state of charge) in percent comes as an additional channel after the link quality channel.
Digital inputs	indicates if the digital trigger input line is acquired as well. This checkbox will be enabled automatically if at least one trigger channel is selected to be acquired (see the digital IN settings section for further details). Setting or clearing this checkbox by the user has no effect. if enabled, the digital input channels come encoded in a single additional channel after the battery level channel.
Validation indicator	if enabled, the validation indicator indicating successful wireless transmission of a sample (1 for valid, 0 for invalid) comes as an additional channel after the digital inputs channel.

Channel settings	
Sensitivity	set channel sensitivity of analog input channels.
Bipolar	perform a bipolar derivation between 2 input channels.
Bandpass	perform a digital bandpass filtering of the input channels.
Notch	perform a bandstop filtering to suppress the power line frequency of 50 Hz or 60 Hz.
CAR	select channels for common average reference calculation (CAR checkbox must be enabled to active the filter).
Use for noise reduction	select the channels that should be used for calculating the DRL signal for noise reduction (Noise reduction checkbox must be enabled to active the DRL function).

Perform the following steps to configure the highlighted channels:

- Highlight the channels in the list box that should be edited. Use the Ctrl key or the Shift key to highlight multiple channels. To select all channels, use Ctrl+A. To highlight all channels of one group, click the group header. Highlighted channels are represented with an orange background color, as illustrated for channel 3.
- Check or uncheck the checkbox of one of the selected channels in the **Acquire** column to include the highlighted channels in data acquisition or exclude them.
- If you want to change the reference/bipolar channel for a specific channel, select the desired bipolar channel from the **Bipolar** list and press the corresponding **Apply to highlighted** button right below.
- Select a bandpass filter from the **Bandpass** list and press the corresponding **Apply to highlighted** button right below.
- Select a notch filter from the **Notch** list and press the corresponding **Apply to highlighted** button right below.
- If the **CAR** checkbox is checked and you want to include the highlighted channels in CAR calculation, select **Yes** from the **CAR** list and press the corresponding **Apply to highlighted** button right below.
- If the **Noise reduction** checkbox is enabled and you want to consider the highlighted channels for noise reduction, select **Yes** from the **Use for noise reduction** list and press the corresponding **Apply to highlighted** button right below.

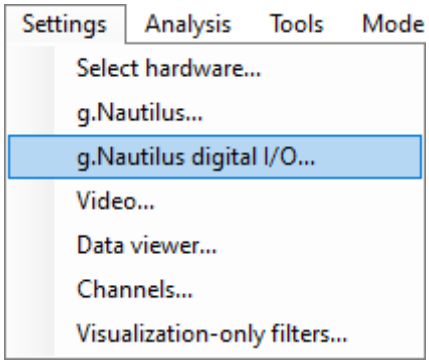
If no channel is highlighted when one of the **Apply to highlighted** buttons is clicked, the system instead informs the user of this error and the settings do not change.

Click **OK** to finish the configuration of the g.Nautilus and apply it to the device.

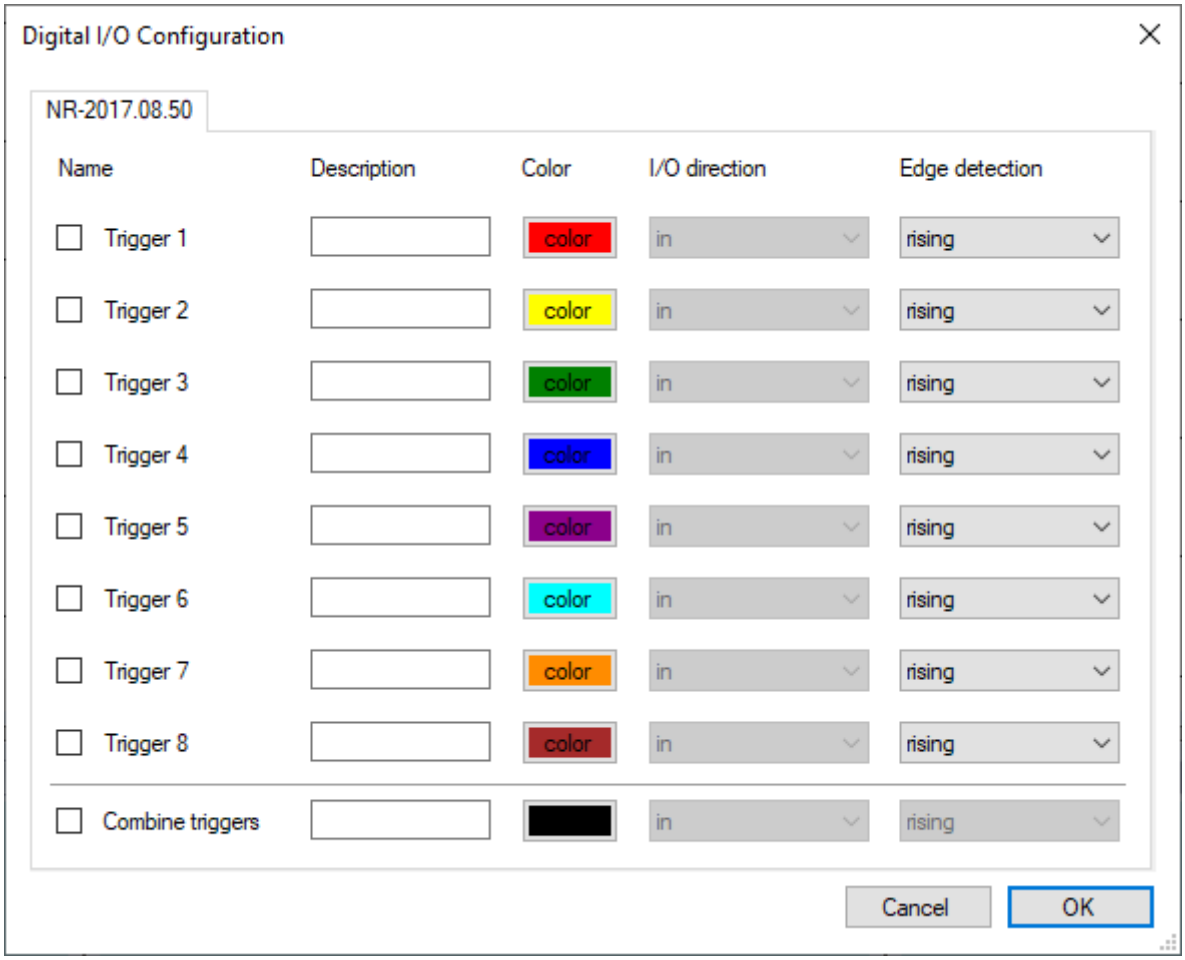
4.2.8 DIGITAL INPUTS FOR G.NAUTILUS

The serial number for a g.Nautilus starts with NB-xxxx.xx.xx

g.Nautilus has 8 digital inputs. In the **Settings** menu, click on **g.Nautilus digital I/O...** to open the dialog.



The trigger inputs **Trigger 1** to **Trigger 8** are sampled synchronously with the analog input channels.



Check the box of the desired channels, enter a **Description**, select a color (**Color**) and define the edge (**Edge detection)**.

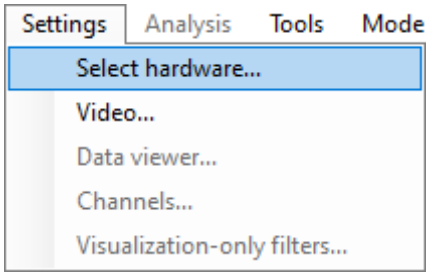
Then close the dialog with **OK**.

If the corresponding trigger event occurs, a marker is generated and visualized along with the biosignal data.

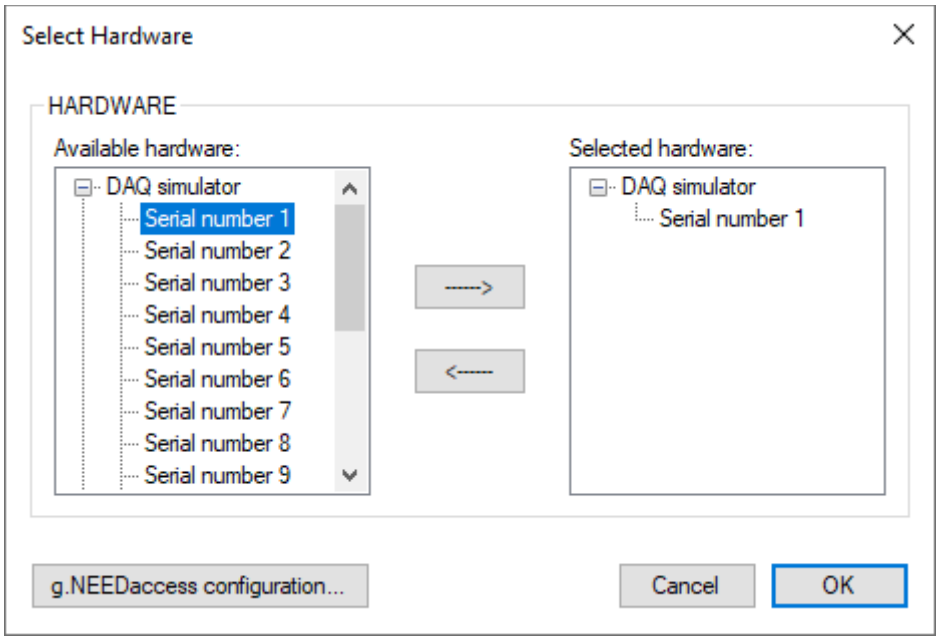
If **Combine triggers** is selected, all individual trigger channels are enabled and the individual channel selection becomes disabled. Combined triggers are always configured to detect rising edges. It is possible to change the **Color** and **Description** for combined triggers. The displayed marker name and color for a combined trigger are always the same. The marker's value will be the binary coded decimal made up of the current HIGH and LOW values of all individual trigger channels with trigger channel 1 as least significant bit and trigger channel 8 as most significant bit.

4.2.9 DAQ SIMULATOR

In the **Settings** menu, select **Select hardware...**



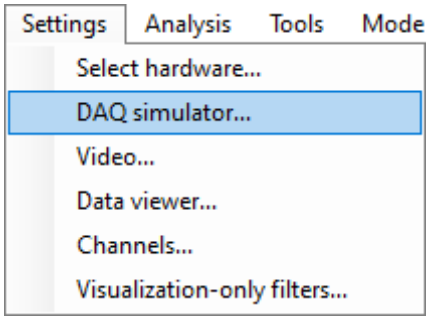
The **Select Hardware** dialog opens:



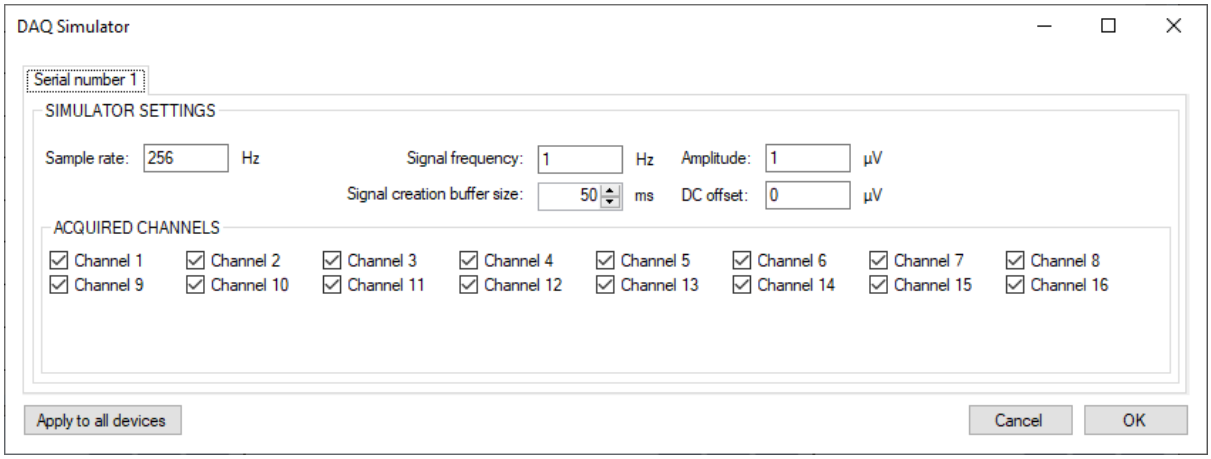
Select **Serial number 1** from the **Available hardware** list and click on the arrow button to add it to the **Selected hardware** list. If more than 16 channels should be simulated, add as many **DAQ simulator**s as needed.

Click **OK** to close the dialog.

To configure the DAQ Simulator, select **DAQ simulator** from the **Settings...** menu.



The configuration window opens with the simulator serial number (e.g. 1):



Sampling rate [Hz]	specify the sampling frequency of the DAQ Simulator in Hz
Signal frequency [Hz]	specify the frequency of the test signal
Amplitude [µV]	specify the amplitude of the test signal
Time interval [ms]	set the interval between the imports of the samples. (e.g. set the Timer Interval to 50 ms at a sampling rate of 1 kHz then every 50 ms 50 samples are drawn)
DC offset [µV]	specify the offset of the test signal
ACQUIRED CHANNELS	select the channels to be recorded

If multiple simulators are configured use the **Apply to all devices** button to perform the settings for all amplifiers.

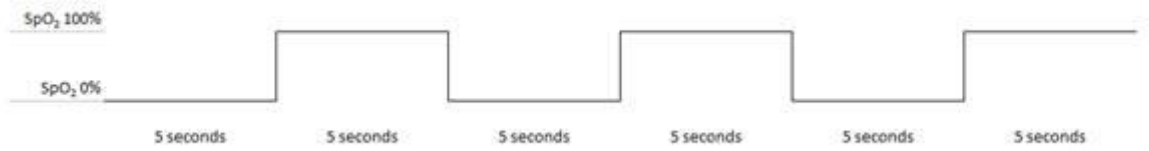
NOTE

data in the **DAQ simulator** is not sampled equidistantly! Performance of data generation might drop for higher sampling rates.

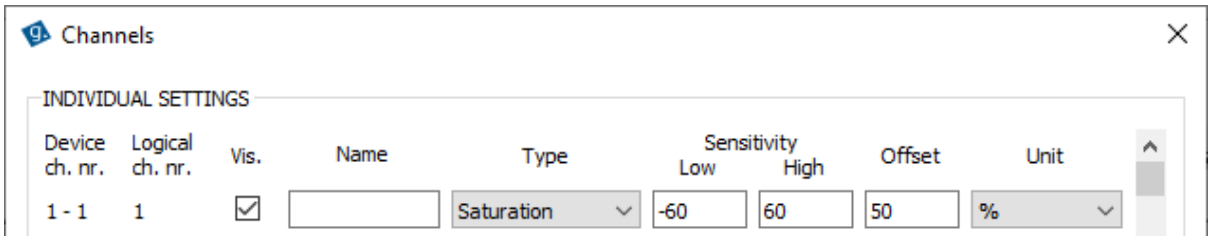
4.3 SENSOR CALIBRATION

g.Recorder provides a software-side calibration possibility of external g.tec sensors that are attached to the amplifiers. The sensors usually provide a calibration functionality as well that outputs the minimum and maximum voltage in between which they operate, which correspond to the minimum and maximum output values defined in the datasheet. Due to hardware tolerances, those voltages usually do not match exactly the definition in the data sheet. Thus, g.Recorder provides the possibility to match the minimum and maximum output values to the actual minimum and maximum voltage that the sensor delivers.

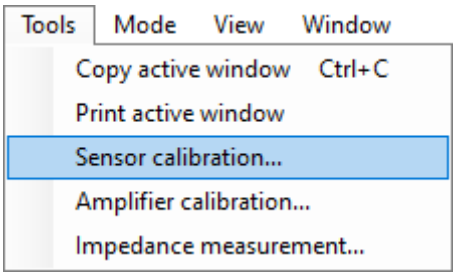
For example, the calibration cycle of the g.SpO2 sensor outputs the minimum voltage that corresponds to 0% SpO2 saturation for 5 seconds, followed by the maximum voltage that corresponds to 100% SpO2 saturation for 5 seconds and repeats that cycle several times.



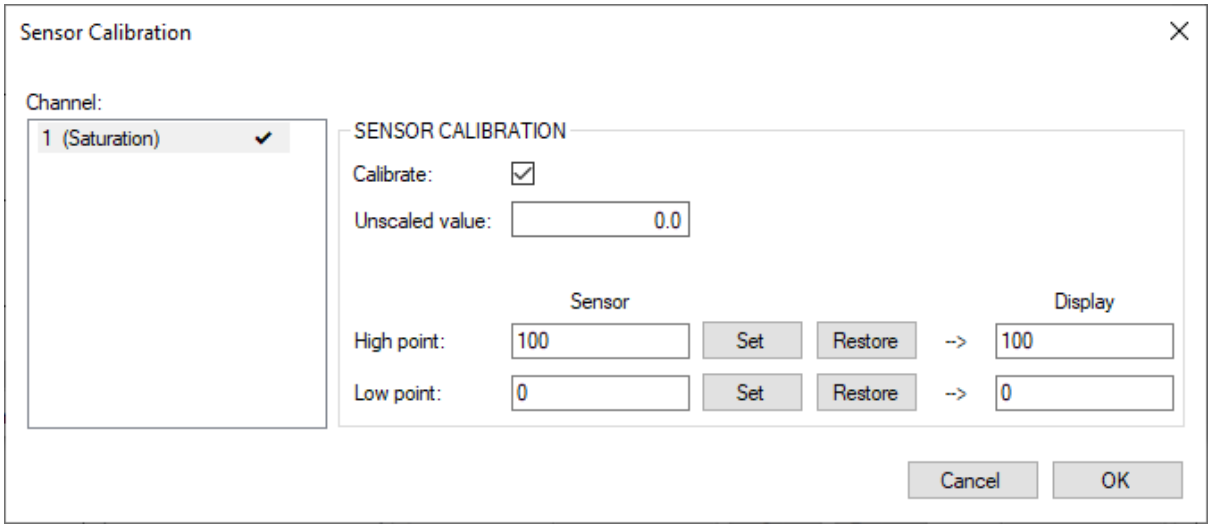
To match the actually delivered output voltages to the 0% and 100% values, the correct signal type (in this case it's "Saturation") must be selected for the channel that the sensor is attached to via the data viewer's **Channel Settings** dialog. In this example, the g.SpO2 sensor is connected to channel 1.



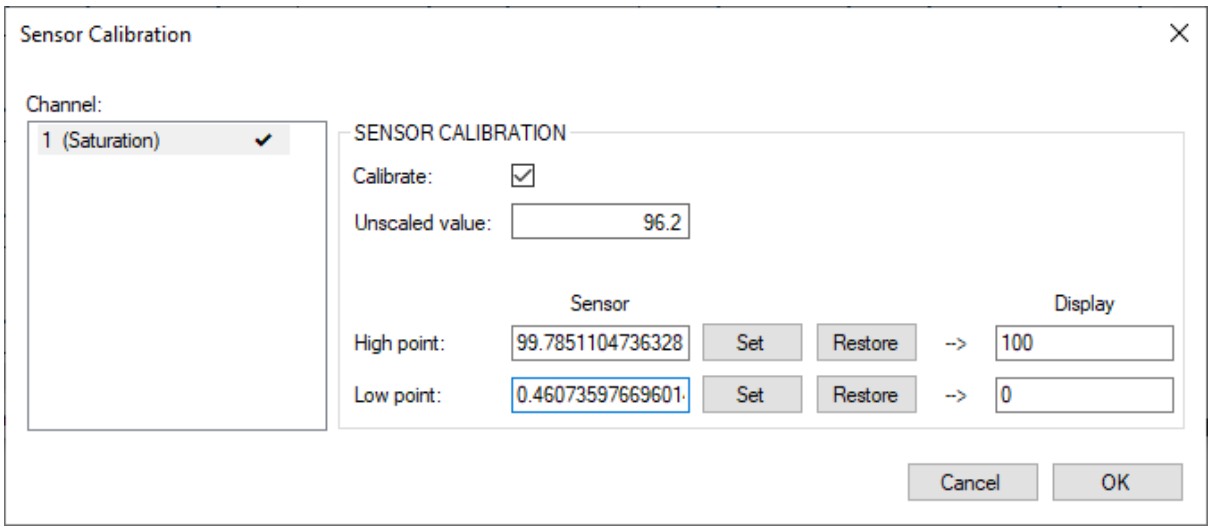
While data acquisition is running, open the **Sensor Calibration** dialog by selecting **Sensor calibration…** from the **Settings** menu.



In the **Sensor Calibration** dialog, click on the channel that the sensor to calibrate is connected to (channel 1 in this example) and check the **Calibrate** checkbox.



The **Unscaled value** field displays the uncalibrated value that is currently measured. During the sensor's calibration cycle, click the **Low point**'s **Set** button once while the sensor outputs the minimal possible value during the calibration cycle and click the **High point**'s **Set** button once while the sensor outputs the maximum possible value during the calibration cycle. This will set the **Low point**'s and **High point**'s actually measured **Sensor** value. A possible result could look like in following picture.



In the case above, the sensor reached an actual output range between 0.46 % and 99.78 % (**Sensor**) during the calibration cycle, which will be mapped to a range between 0 % and 100 % (**Display**) in the displayed and recorded data. Confirm the dialog by clicking **OK** to apply sensor calibration.

To remove sensor calibration, uncheck the **Calibrate** checkbox for the corresponding channel.

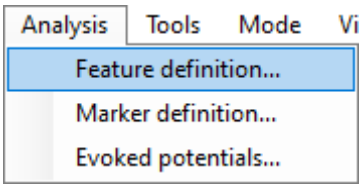
4.4 FEATURE DEFINITION

g.Recorder allows the user to calculate in real-time specific features which are shown in the Feature Viewer. **g.Recorder** supports the **Cerebral function monitor (CFM)** feature, the **Heart rate (HR)** feature and the **Compressed spectral array (CSA)** feature.

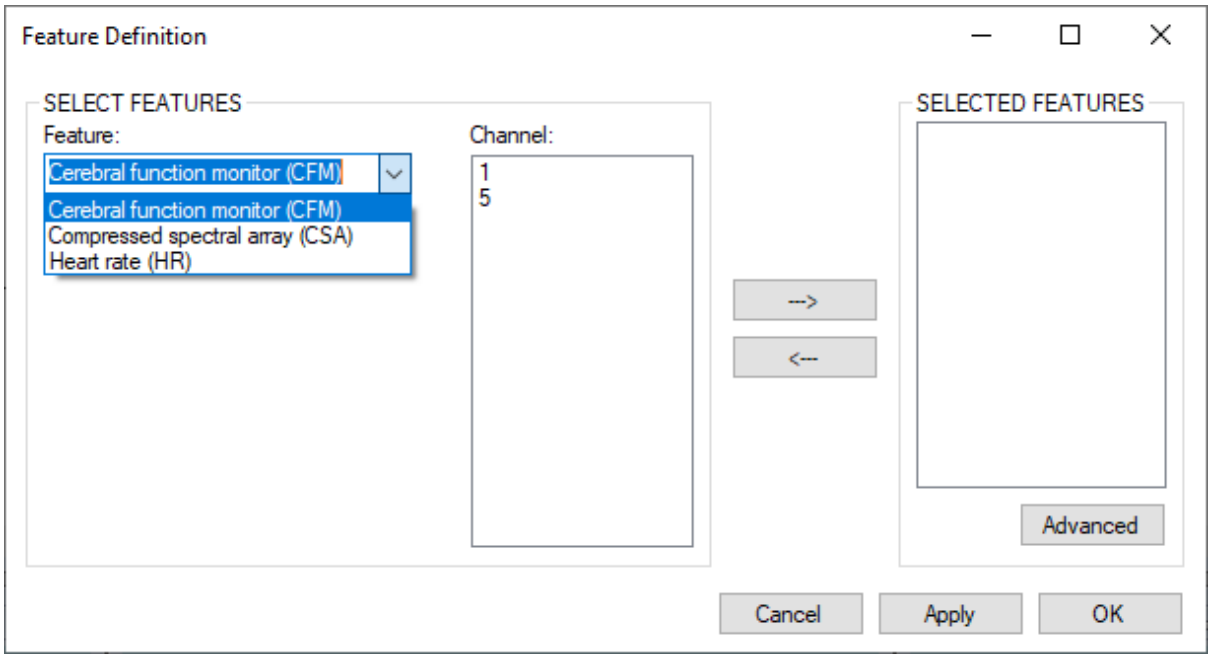
WARNING

High sampling rates, many channels or extensive feature calculation can overload the PC's hardware resources, resulting in data loss. This might occur immediately or even after some time after starting acquisition. Please plan feature calculation meaningfully and carefully.

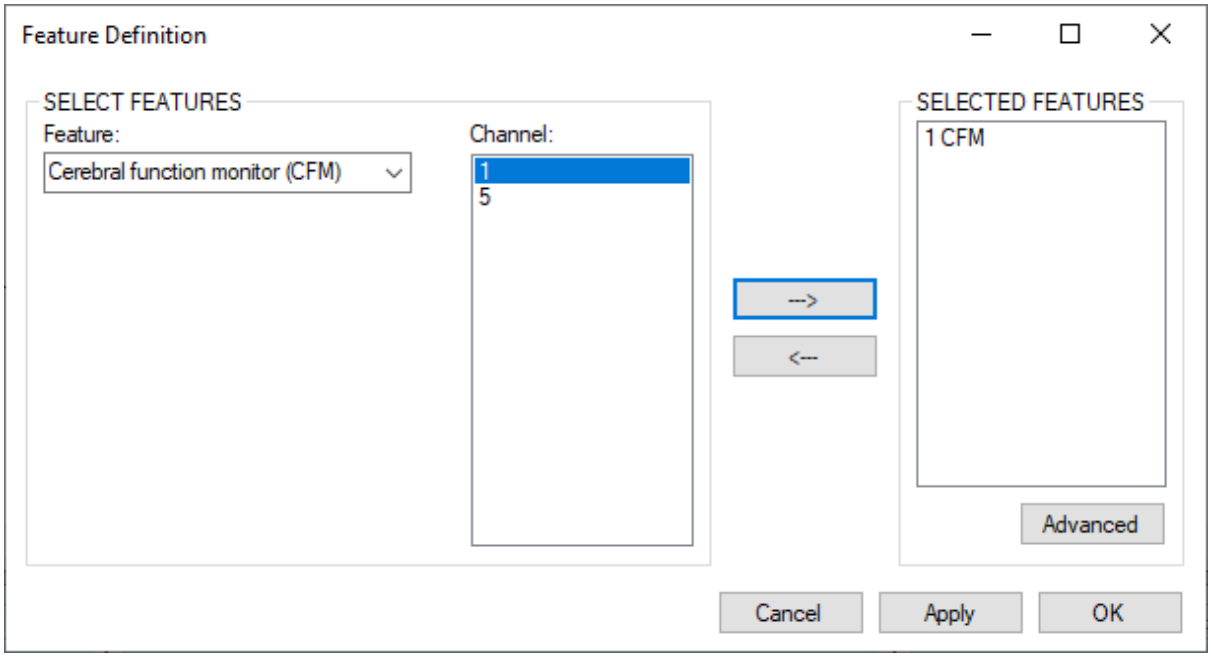
Select **Feature definition...** from the **Analysis** menu



In the **Feature Definition** dialog, select the **Cerebral function monitor (CFM)** feature.

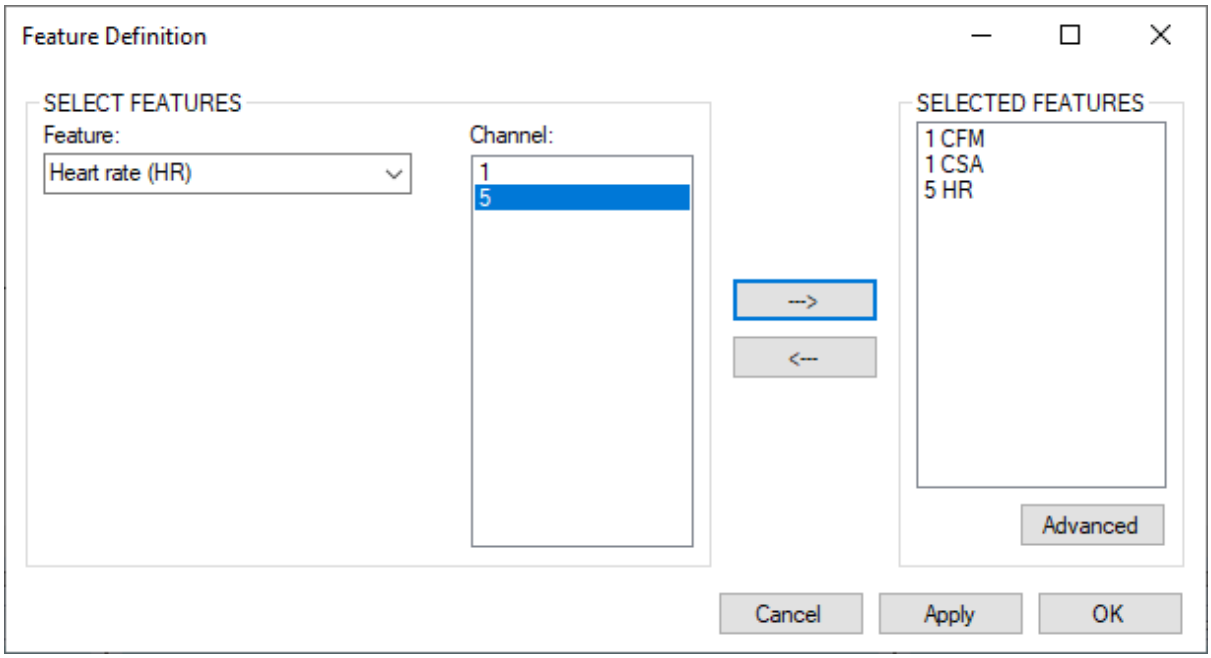


Then select the EEG **Channel** that is used to calculate the feature and add the feature with the arrow button.



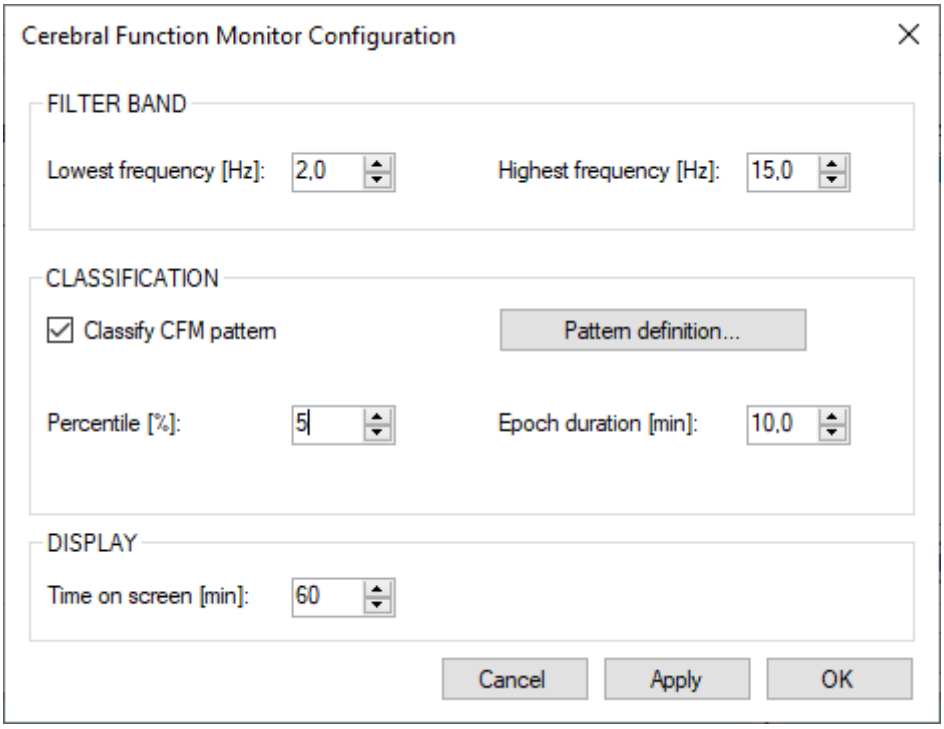
The channel number and the selected feature are displayed on the right side.

Similarly, define calculation of the **Heart rate (HR)** from the ECG channel 5 and the **Compressed spectral array (CSA)** also from EEG channel 1.



4.4.1 CONFIGURE CFM

To configure the CFM feature select it and click on the **Advanced** button. This opens the **CFM Configuration** dialog below.

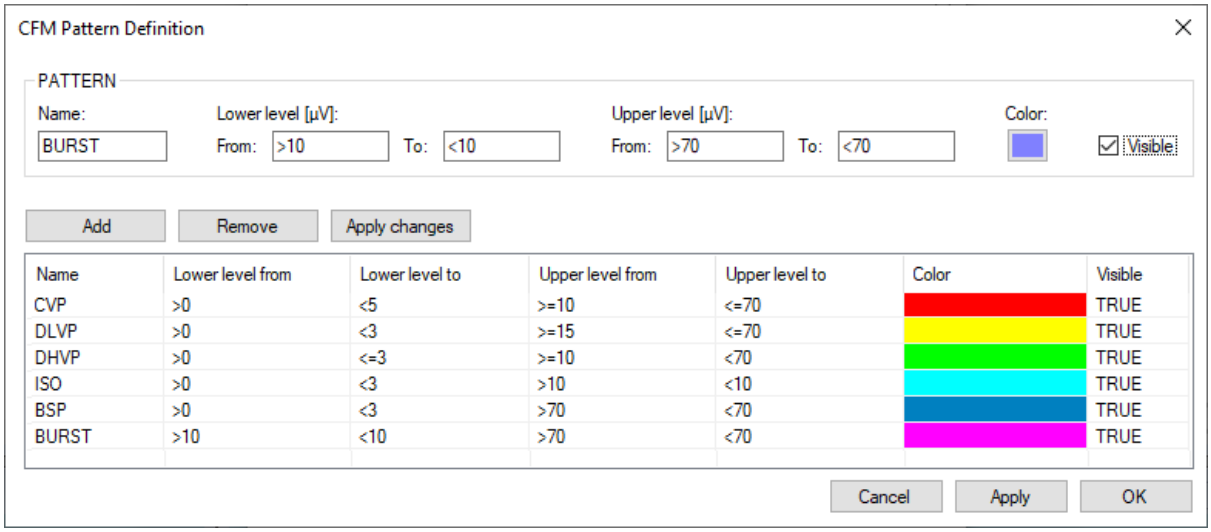


Filter band	
Lowest frequency [Hz]	select the lower cutoff frequency for the CFM calculation
Highest frequency [Hz]	select the upper cutoff frequency for the CFM calculation

Classification	
Classify CFM pattern	check to automatically classify the CFM signal
Percentile [%]	the percentile specifies the lower and upper signal amplitude border for the segmentation
Epoch duration [min]	specify the segment size in minutes
Pattern definition	specify the segmentation rules

Display	
Time on screen [min]	enter the minutes shown on one page in the Feature Viewer

Click the **Pattern definition...** button to open the following dialog:



Then enter a **Name**, the **Lower level**, the **Upper level** and define a **Color** for the specific pattern.

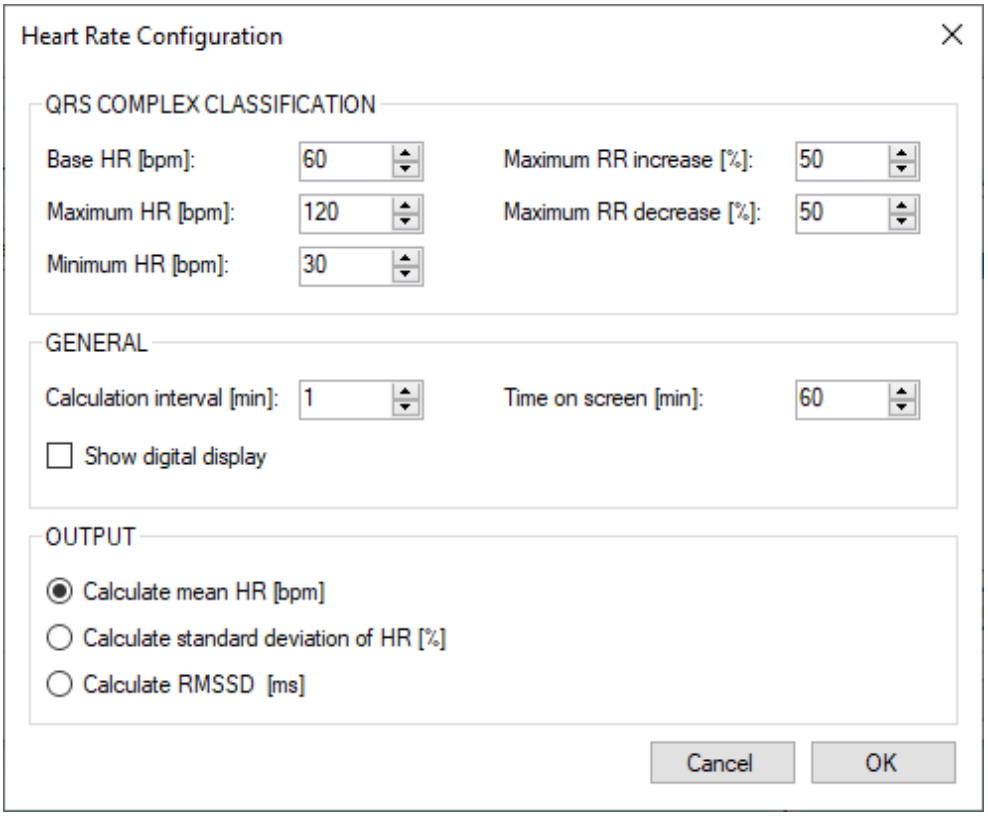
Click the **Add** button to add the pattern to the list. With **Remove**, a selected pattern can be removed from the list. With the **Apply changes** button, the settings for a selected pattern in the list can be applied.

The figure above shows the standard classification used for neonatal recordings.

Close the dialog with the **OK** button.

4.4.2 CONFIGURE HEART RATE

Select the **HR** feature and click on the Advanced button to open the following dialog:



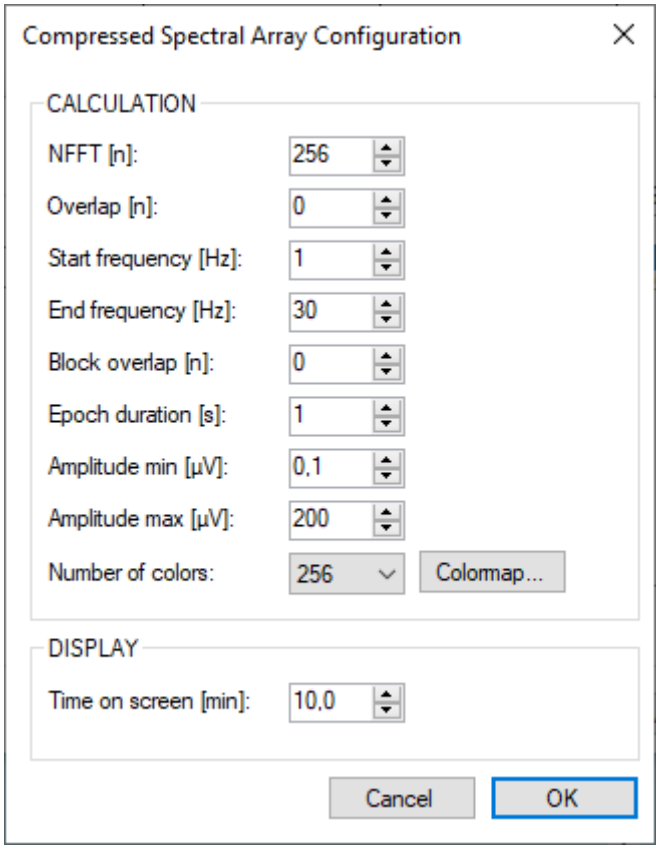
QRS complex classification	
Base HR [bpm]	base heart rate in beats per minute
Maximum HR [bpm]	maximum heart rate in beats per minute
Minimum HR [bpm]	minimum heart rate in beats per minute
Maximum RR increase [%]	maximum allowed increase of interval between two QRS complexes in percent
Maximum RR decrease [%]	maximum allowed decrease of interval between two QRS complexes

General	
Calculation interval [min]	specify the interval that is used to calculate the HR
Time on screen [min]	enter the minutes shown on one page in the Feature Viewer
Show digital display	if selected, the actual information for heart rate or heart rate variability is displayed right next to the feature channel.

Output	
Calculate mean HR [bpm]	mean HR of **Calculation interval**
Calculate standard deviation of HR [%]	standard deviation of HR in **Calculation interval**
Calculate RMSSD [ms]	root mean square of successive differences of HR in the **Calculation interval**

4.4.3 CONFIGURE CSA

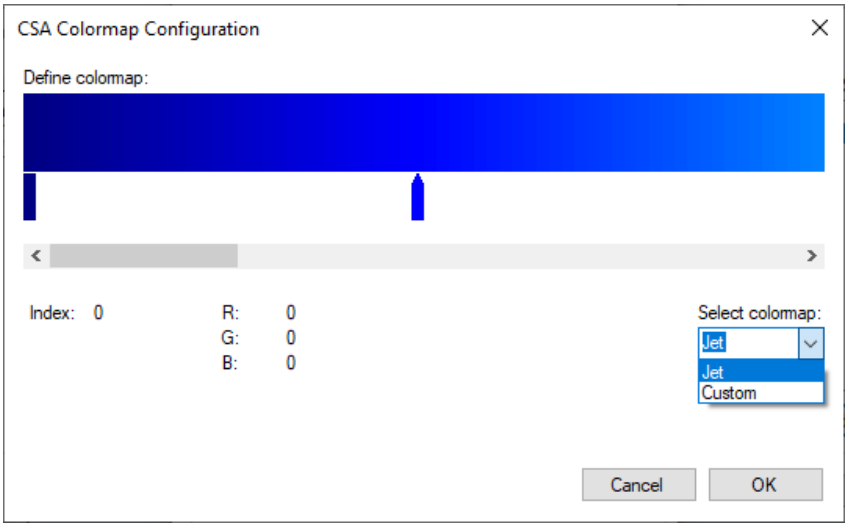
Select the **CSA** feature and click on the **Advanced** button to open the following dialog:



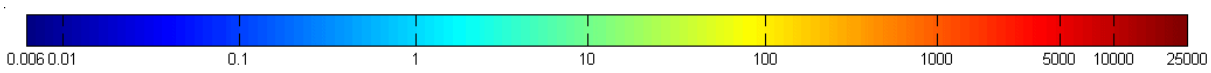
Calculation	
NFFT	number of samples for the FFT
Overlap	number of samples that overlap
Start Frequency	lower value of y-axis scaling in Hz
End Frequency	higher value of y-axis in Hz
Block overlap	number of samples that overlap with preceding epoch
Epoch Duration	duration between calculated FFT outputs
Amplitude min [µV]	minimal amplitude coded in the colormap
Amplitude max [µV]	maximal amplitude coded in the colormap
Number of Colors	number of color used for the CSA colormap

Display	
Time on screen [min]	enter the minutes shown on one page in the Feature Viewer

Click the **Colormap...** button in the **Calculation** section to define the colormap used for the CSA. This opens the following dialog:



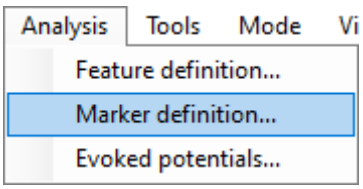
The CSA is plotted in $\mu V^2/Hz$ ranging from **Amplitude min** to **Amplitude max**. In the example below, the different colors in the color bar represent the power of the signal recorded with a logarithmic scale ranging from 0.006 to 25.000 $\mu V^2/Hz$ with 256 colors.



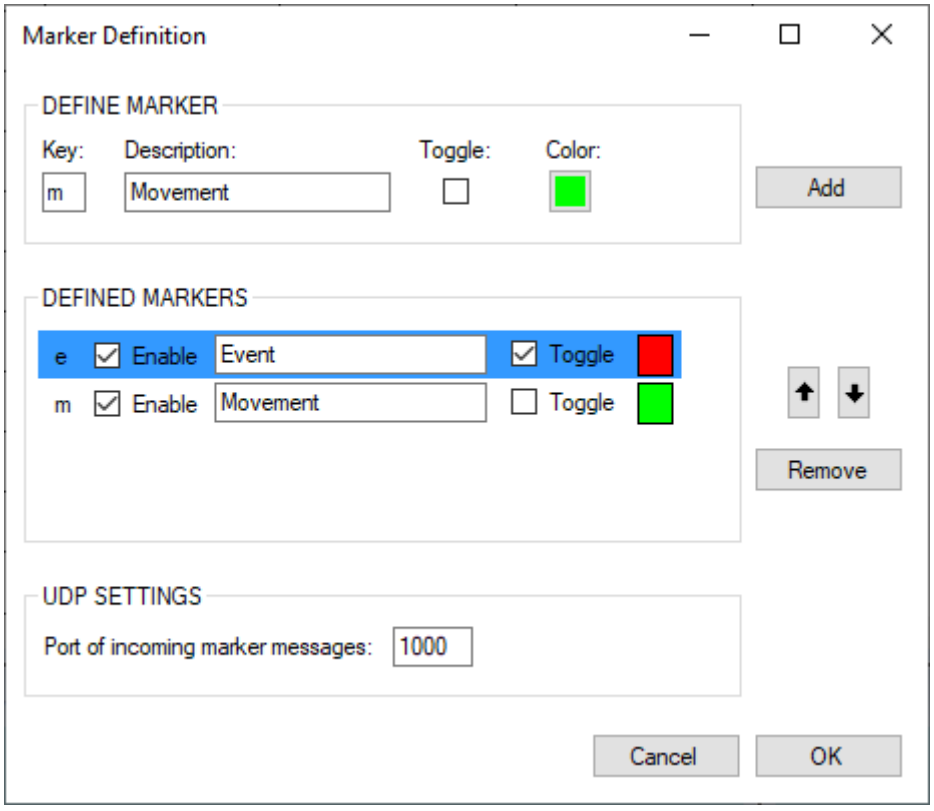
4.5 MARKER DEFINITION

Markers can be used during measurement to highlight certain events. **g.Recorder** allows the user to define markers which indicate a specific time point, and region markers which indicate a time window.

Click on **Marker definition...** under the **Analysis** menu.



to open the following window:



Define one marker with the key `m` and name `Movement`, select the green color. Do not check the **Toggle** checkbox to have a marker that indicates a specific point in time. Use the **Add** button to define the marker.

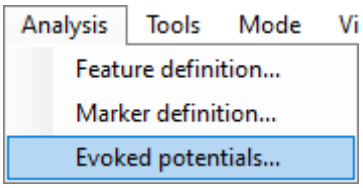
Then define key `e` as a region marker by checking the **Toggle** checkbox. Set the description to `Event`.

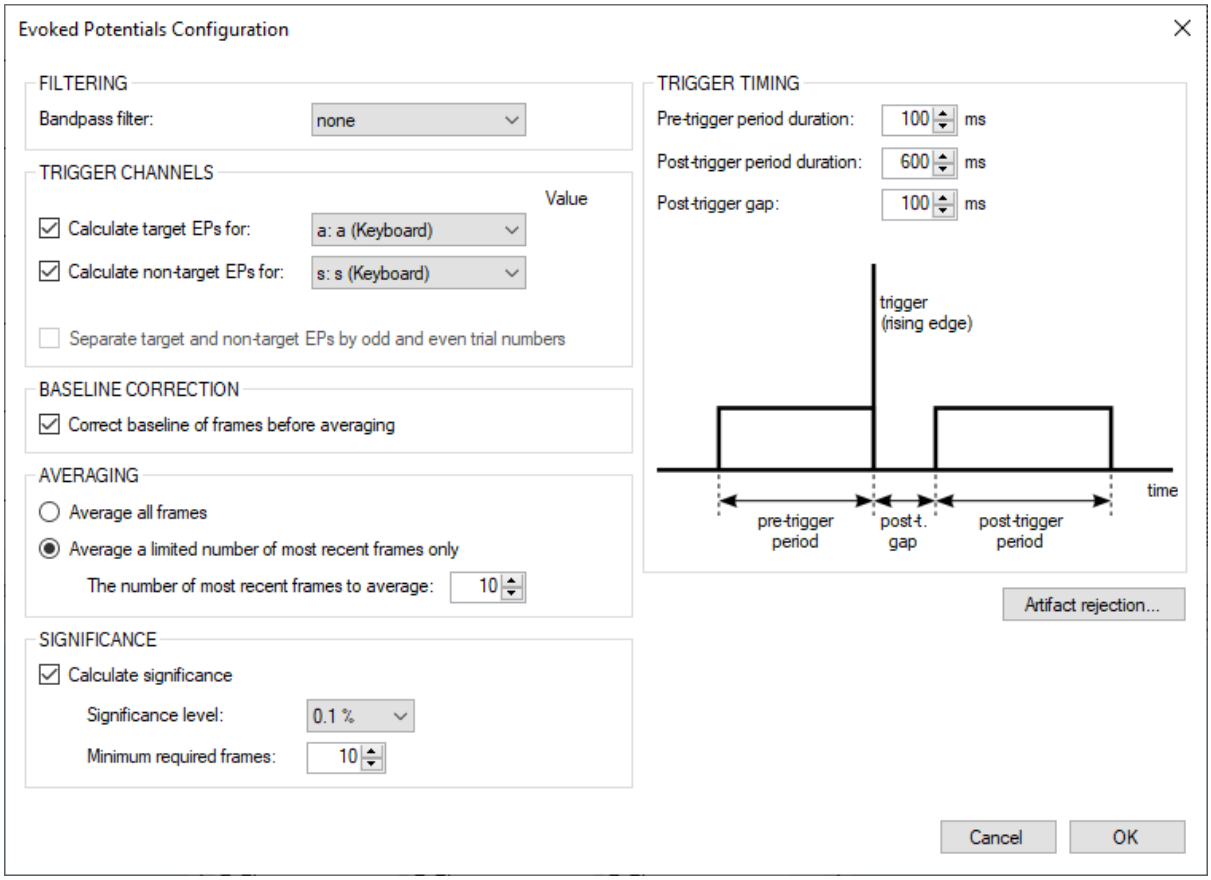
Finally, close the window.

4.6 EVOKED POTENTIALS DEFINITION

The **Evoked Potentials Configuration** dialog allows the user to configure the calculation of evoked potentials.

Click on **Evoked Potentials** at the **Analysis** menu.





FILTERING

- **Bandpass filter** – contains a list of previous defined filters to preprocess incoming raw data. The filter is applied before the data is framed by the occurrence of a trigger. The filter is only applied for EP calculation, not to recorded or displayed raw data in the **Data Viewer**.

TRIGGER CHANNELS

- Enable/disable calculation of evoked potentials for **target** and/or **non-target EPs**.
- Select a trigger source from the list of acquired digital inputs or defined keyboard markers. In the example above, keyboard marker **a (Keyboard)** is selected as the trigger for calculation of

target EPs and keyboard marker **s (Keyboard)** is selected as the trigger for calculation of non-target EPs.
- If a combined trigger is used, define the **Value** that triggers calculation of the corresponding class of evoked potentials.
- If only one class of evoked potentials (e.g. target EPs) is selected and has a trigger assigned, the **Separate target and non-target evoked potentials by odd and even trial numbers** option can be used to assign each second occurrence of the same trigger to the other class of evoked potentials (non-target EPs) automatically.

BASELINE CORRECTION

- Enable/disable **Correct baseline of frames before averaging** to either remove or allow offsets for evoked potential calculations. If enabled, the offset of the pre-trigger period is removed from the whole frame for each channel and each trial individually.

AVERAGING

- Select **Average all frames** to average up each triggered frame of the same class as long as the session lasts. Select **Average a limited number of most recent frames only** to only include the selected number of most recently triggered frames of the corresponding class in the averaged result.

SIGNIFICANCE

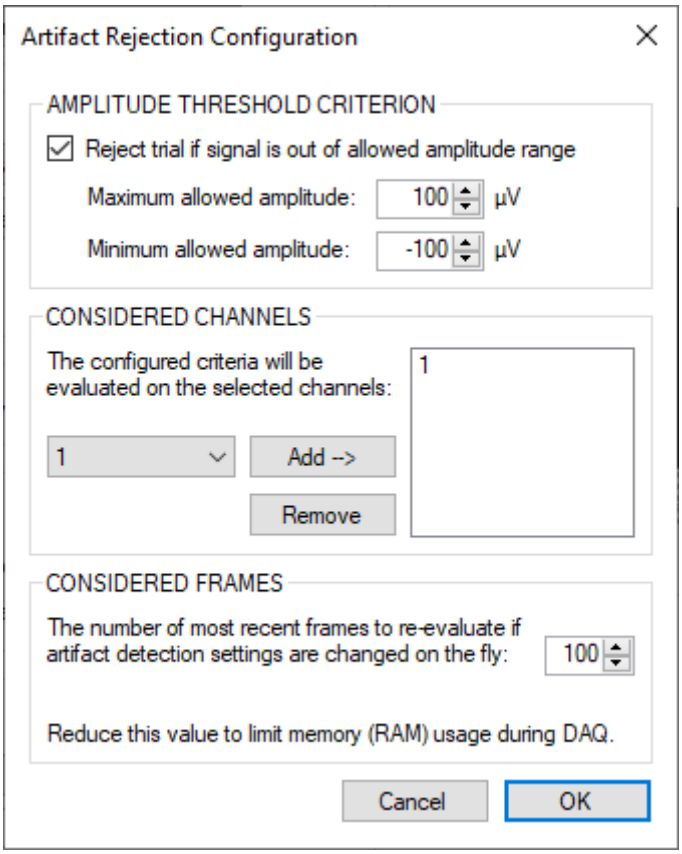
- **Calculate significance** – Enable/Disable highlighting of statistically significant differences between the target and non-target evoked potential classes. This option will only be available if two classes of evoked potentials are calculated.
- The **Significance level** is the maximum acceptable probability of error for significance calculation in percent.
- Select the number of **Minimum frames required** for calculation and display of significance.

TRIGGER TIMING

- Set the **Pre-trigger period duration** to define the acquired time before the trigger occurrence.
- Set the **Post-trigger gap** to define the gap to leave blank after the trigger occurrence. This can be useful to suppress artifacts that accompany the stimulus (e.g. audio trigger artifacts) in display only. The **Post-trigger gap** is not excluded from calculation.
- Set the **Post-trigger period** duration to define the acquired time after **Post-trigger gap**.

4.6.1 ARTIFACT REJECTION

The **Artifact Rejection Configuration** dialog allows to configure detection of artifacts within an evoked potential trial and rejection of trials that contain artifacts. Click on the **Artifact rejection...** button in the **Evoked Potentials Configuration** dialog.



The dialog allows to configure each artifact detection criterion individually. If an artifact is detected within an evoked potential frame on any of the selected considered channels for any of the enabled and configured criteria, the frame gets rejected and is not included in the displayed averages.

Signals in the post-trigger gap are not considered for artifact detection.

The configuration of the individual criteria can also be changed on-the-fly during acquisition or replay. This would result in a re-calculation of the current averages considering the new artifact rejection configuration. Only the configured number of most recent frames is considered for re-evaluation of artifacts. All frames that were produced before are not included in the averages and trial counts anymore.
This feature requires to keep all individually produced data frames of a session in the memory, which can result in a very huge amount of RAM memory required for a session depending on the configured sampling rate, number of channels and trial windows. With the considered frames setting, the maximum required memory can be limited because only that number of frames need to be kept in memory for re-calculation if everything too old is ignored. This way, a memory overload can be avoided for huge sessions, which could result in severe problems during the measurement and thus in loss of all recorded data.

WARNING

It is recommended to perform a test run with the expected number of trials (keyboard markers and dummy data can be used) if the available memory is sufficient enough for the configured number of considered frames, sampling rate and number of channels before actually performing a real measurement.

AMPLITUDE THRESHOLD CRITERION

- Enable/disable rejection of trials if the amplitude is out of the configured allowed range on at least one of the selected considered channels.
- Set the **minimum allowed amplitude** to a value below which a trial is considered to contain an artifact.
- Set the **maximum allowed amplitude** to a value above which a trial is considered to contain an artifact.

CONSIDERED CHANNELS

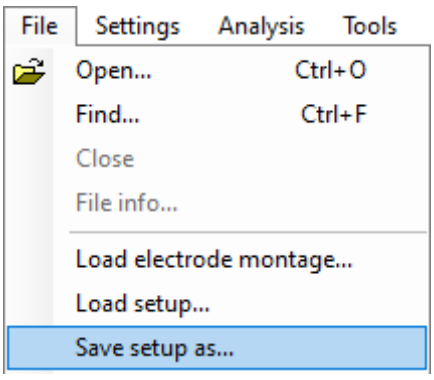
- The channels that are considered for artifact detection. Trials will get rejected if an artifact is detected on one of the selected channels based on the configured criteria. Artifacts on other channels are not detected.

CONSIDERED FRAMES

- The number of most recent frames to re-evaluate for artifacts and include in re-calculation of averages and trial counts if the configured artifact detection criteria are changed on-the-fly during the measurement or during replay.

4.7 SAVE CONFIGURATION

To store the settings select **Save setup as…** function in the **File** menu.



The last configuration is loaded automatically at the next program start.

4.8 LOAD CONFIGURATION FROM THE COMMAND LINE

g.Recorder can be initialized by previous stored configurations using the command line option

`grecorder \d [configuration file].`

If the configuration file cannot be found at startup, then the last used configuration will be loaded. This option is useful for providing specific study setups.

5 QUICKSTART FOR EEG/ECG RECORDING

5.1 REQUIREMENTS FOR THIS QUICKSTART

The following equipment is needed to perform this quickstart properly:

5.1.1 WITH g.USBAMP

Hardware	
g.USBamp	To acquire biosignal data from 1 EEG and 1 ECG channel
Accessories	Electrodes and electrode cables
Video camera	Webcam

5.1.2 WITH g.HIAMP

Hardware	
g.HIamp	To acquire biosignal data from 1 EEG and 1 ECG channel
Accessories	Electrodes and electrode cables

5.1.3 WITH g.NAUTILUS

Hardware	
g.Nautilus	To acquire biosignal data from 2 EEG channels
Accessories	Electrodes and electrode cables

5.1.4 SOFTWARE

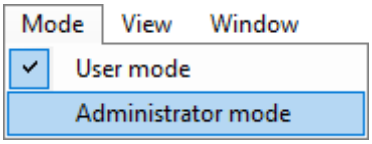
Software	Version
g.Recorder	1.20.03 (Professional license)
g.NEEDaccess Server	1.20.01

5.2 QUICKSTART

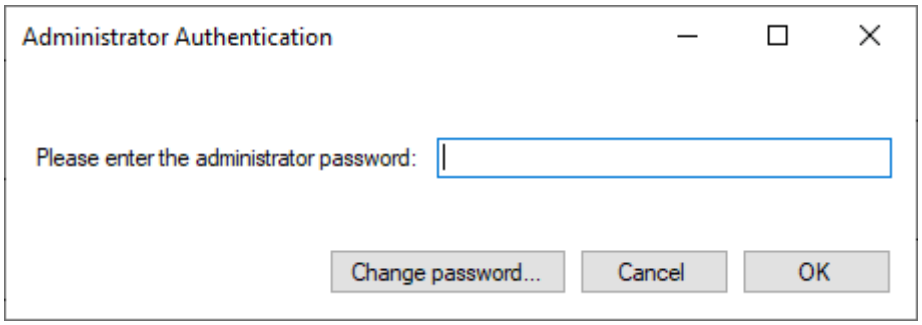
This chapter will give a short introduction on how to use g.Recorder with g.USBamp and g.HIamp. The controls for other g.tec biosignal amplifiers are very similar, so these examples can be performed with other g.tec devices too.

It is recommended to turn off Microsoft Windows' automatic updates while operating g.Recorder. Concurrent Windows updates could interfere with g.Recorder functionality.

The two examples of this quickstart can only be run in **Administrator mode**. If administrator mode is not already activated, select **Administrator mode** from the **Mode** menu.



If an **administrator password** is set, enter it and click **OK**. Otherwise, leave the text field blank and click **OK**.

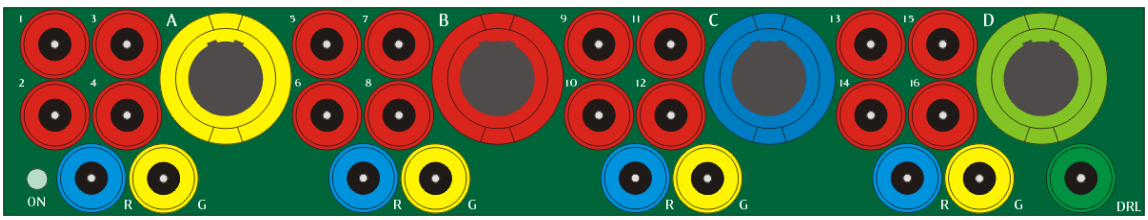


5.2.1 USING g.USBAMP FOR EEG AND ECG INCLUDING VIDEO RECORDING

The setup of g.USBamp with g.Recorder for acquisition of 1 EEG channel and 1 ECG channel is explained here. This section also describes how to define keyboard markers and record the cerebral function monitor (CFM) and heart rate (HR) from EEG and ECG channels. Digital video recording is synchronized to the EEG and ECG recording.

To perform this quickstart, follow the steps below:

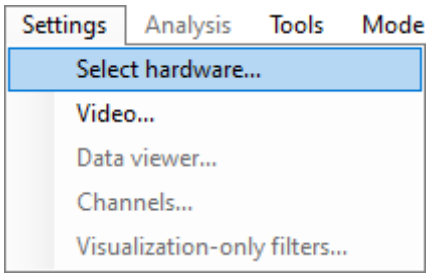
- Connect the electrodes to the g.USBamp in the following way. The picture below displays the front side of g.USBamp. The front side is divided into four groups (**A, B, C, D** from left to right). Each group consists of four red connectors (**1**-**4**, **5**-**8**, **9**-**12**, **13**-**16**) for connecting biosignal electrodes (EEG, ECG, EMG, etc.), one blue connector for the reference electrode (**R**) and one yellow connector for the ground electrode (**G**).



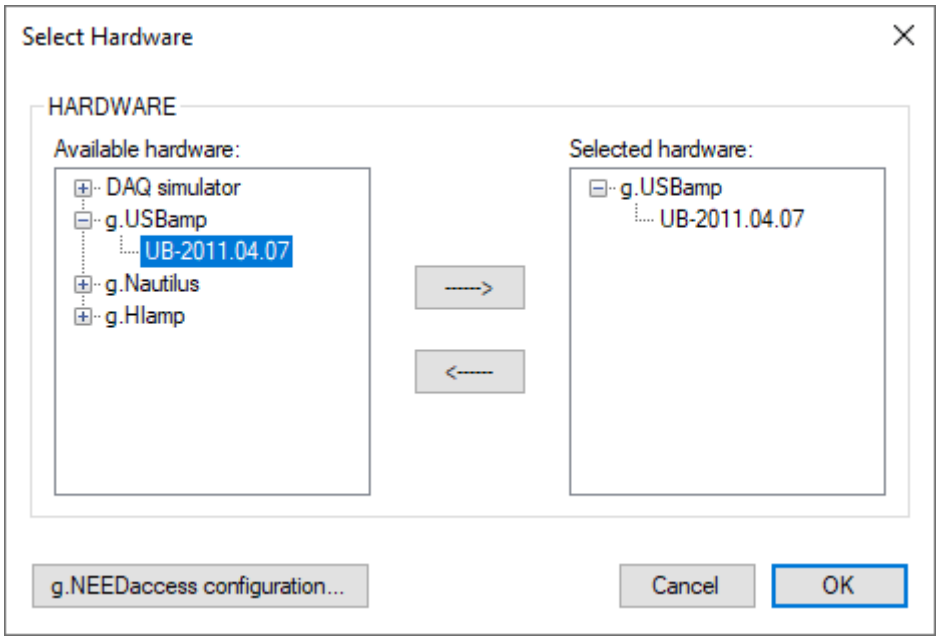
For the EEG measurement, all electrodes for EEG are connected to group **A** (first group on the left side of g.USBamp). One EEG electrode is connected to channel 1 of group **A** (red connector), the reference electrode to reference **R** of group **A** (blue connector) and the ground electrode is connected to ground **G** of group **A** (yellow connector).

For the ECG measurement, all electrodes for ECG are connected to group **B** (second group from left). One ECG electrode is connected to channel 5 of group **B** (red connector), the reference electrode to reference **R** of group **B** (blue connector) and the ground electrode is connected to ground **G** (yellow connector).

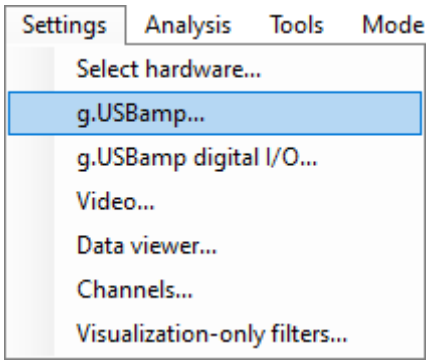
- Make sure that your g.USBamp is switched on and connected to the PC. Then click **Select hardware...** in the **Settings** menu.



Click on the **g.USBamp** menu entry in the **Available hardware** list and select the serial number of your g.USBamp (e.g. UB-2011.04.07). Add the device to the **Selected hardware** list by clicking the right arrow button. Click **OK** to close the dialog.

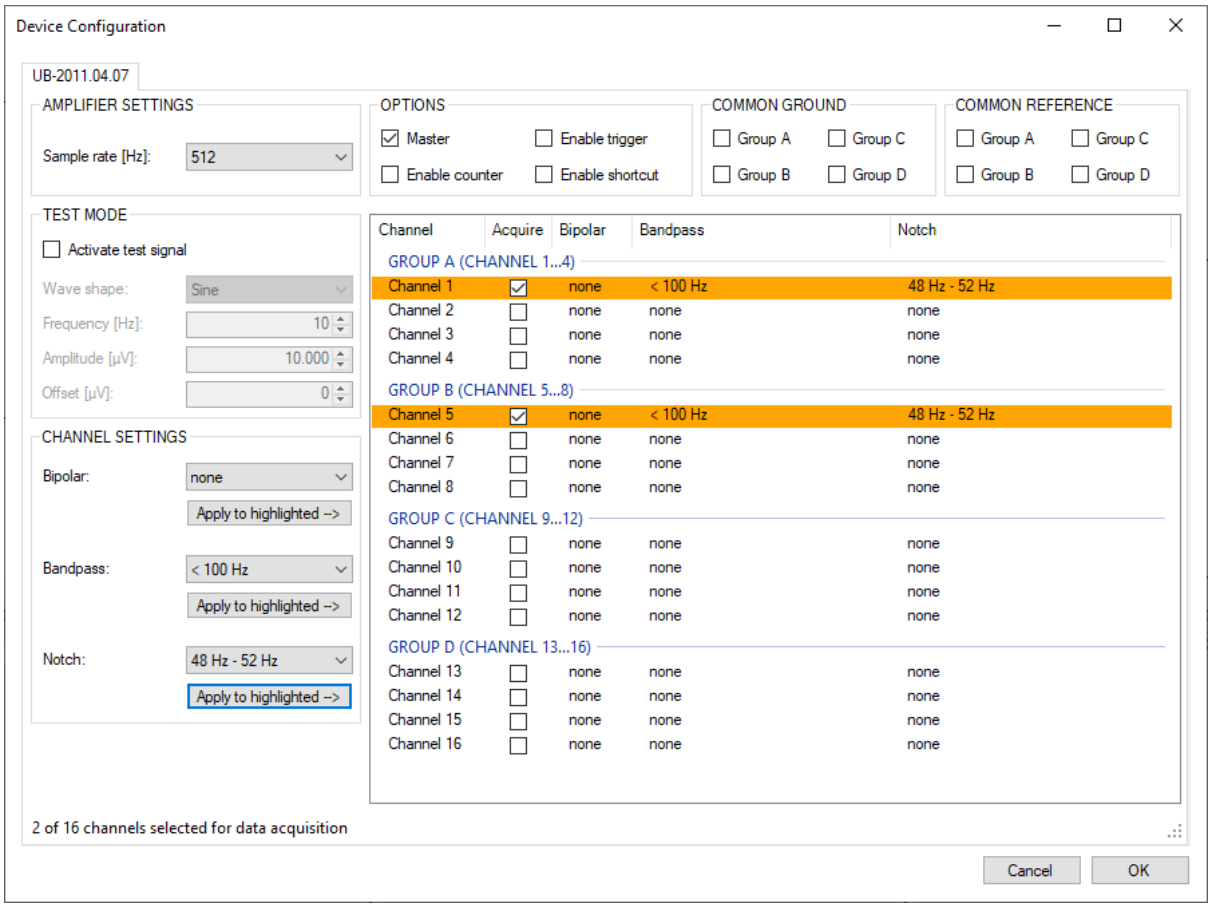


- Click **g.USBamp...** in the **Settings** menu to perform g.USBamp configuration.

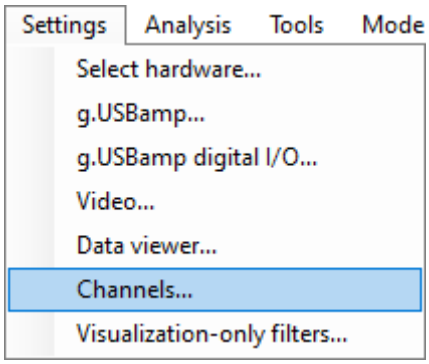


Set the **Sampling rate** in the **AMPLIFIER SETTINGS** section to 512 Hz and select **Channel 1** and **Channel 5** with the corresponding checkboxes.

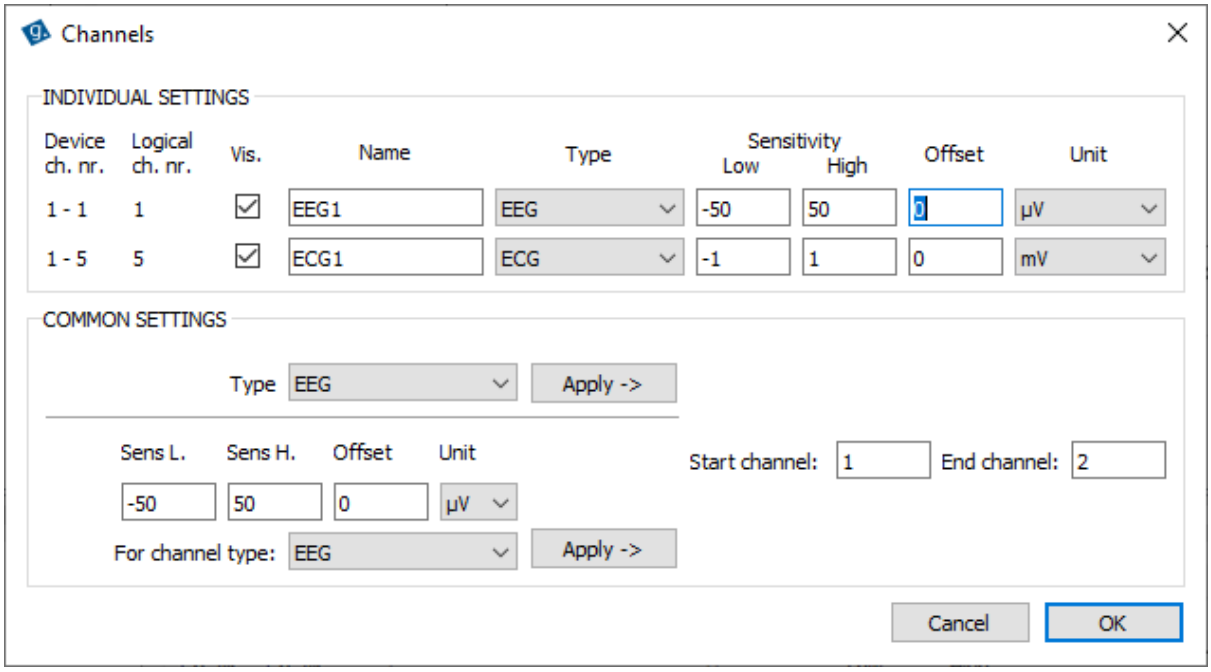
In the **CHANNEL SETTINGS** section select the channels 1 and 5 apply a **Bandpass** filter with **< 100Hz** and a **Notch** filter with **50Hz** or **60Hz**, depending on your local power line hum. Click **OK** to apply the settings.



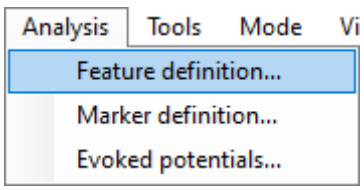
- Configure the g.Recorder display by opening the **Channels** dialog from the **Settings** menu.

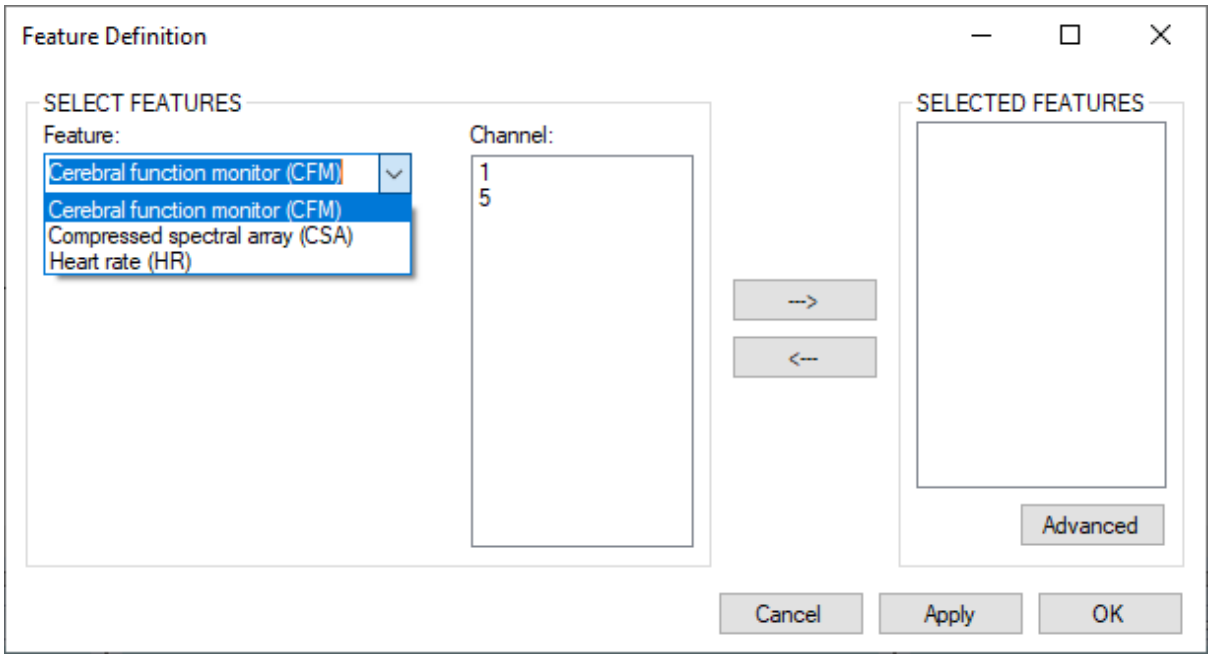


Provide a proper **Name** (e.g. `EEG1`) and a **Type** (e.g. **EEG**) for the channels selected in g.USBamp configuration dialog. The **Sensitivity** is set automatically, but can be changed manually. However, these changes influence data visualization in the Data Viewer window only. Click **OK** to close the dialog. Use the **Use default values of device** to apply device settings to the data display in the Data Viewer.

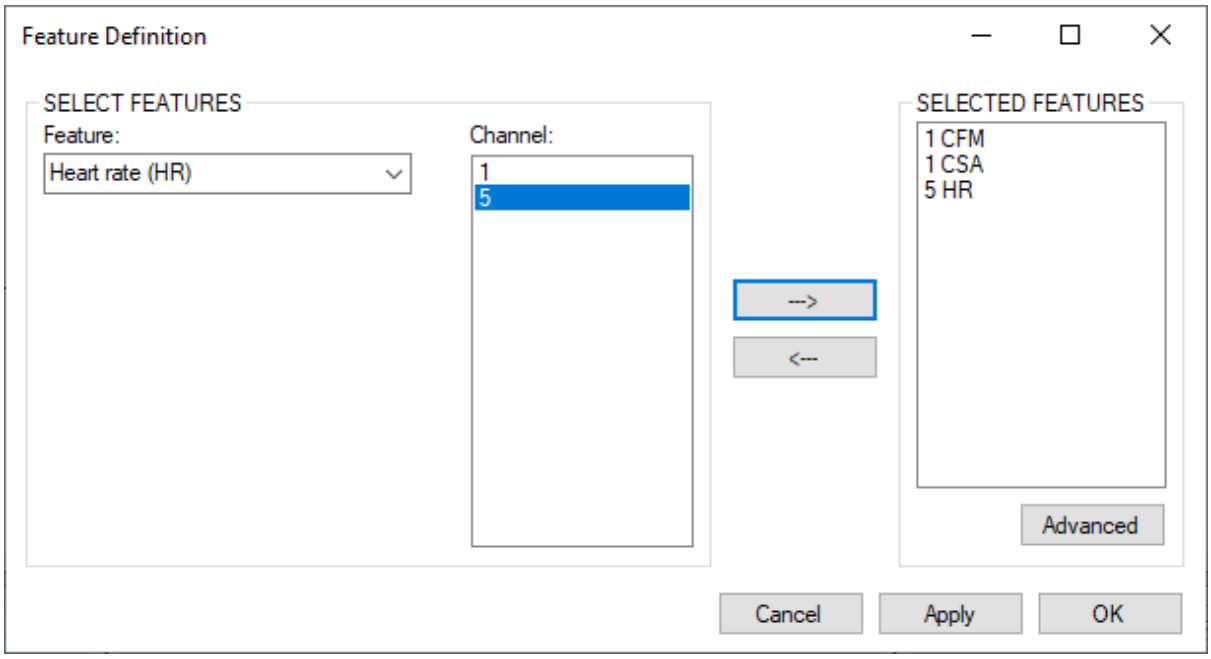


To configure features, click **Feature definition...** in the **Analysis** menu.

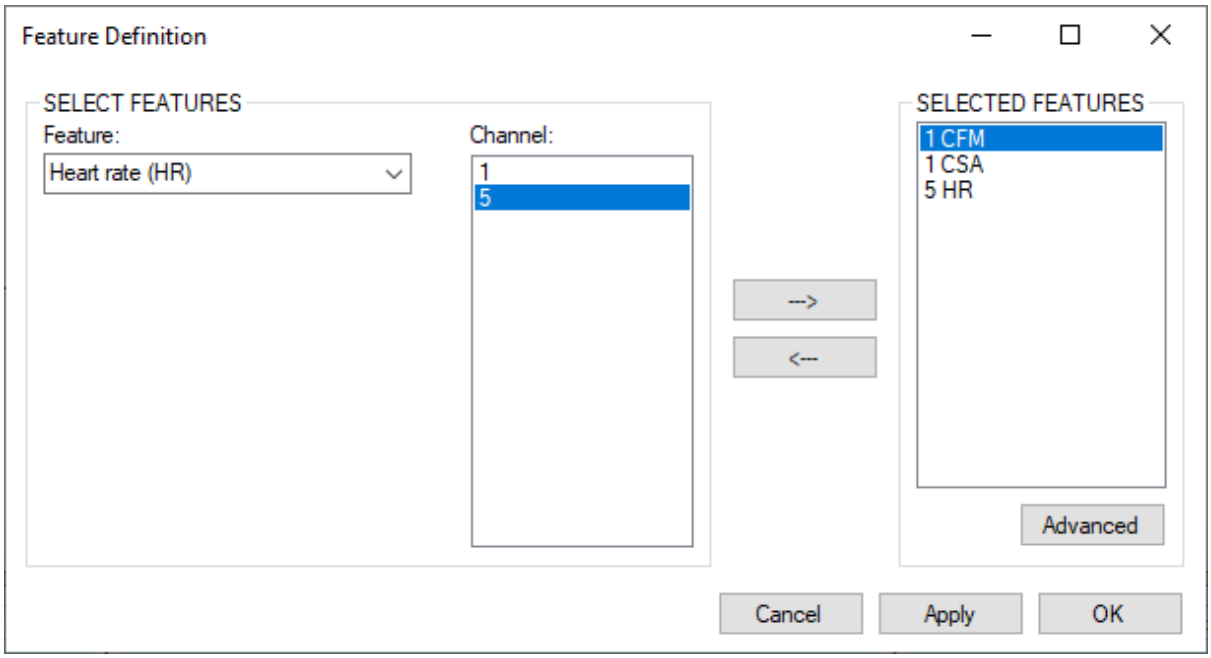




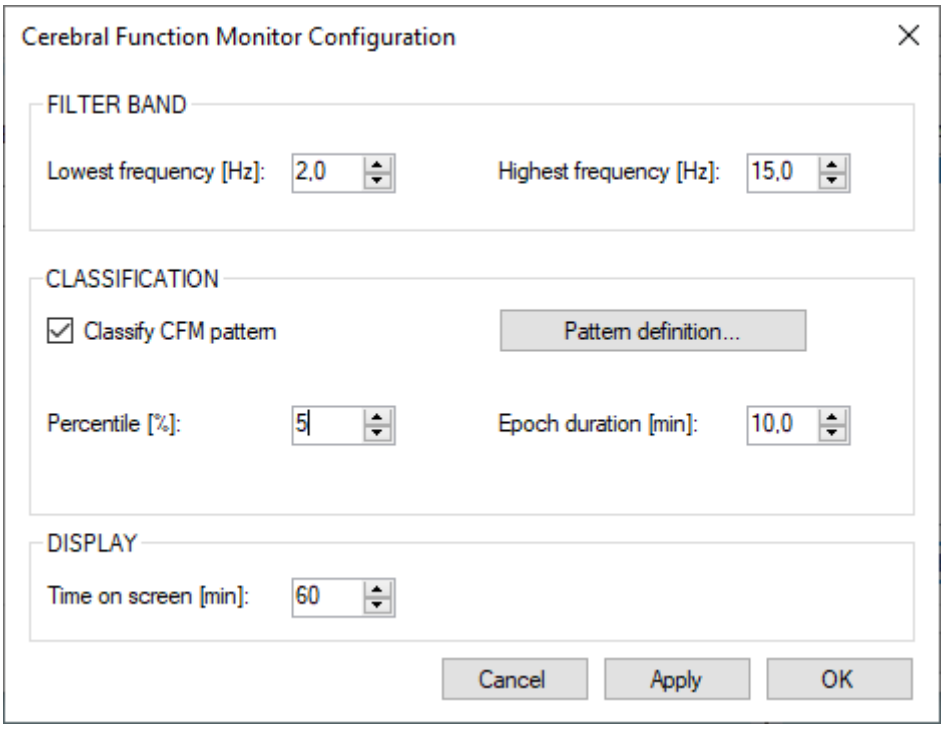
In the Feature listbox, select **Cerebral function monitor (CFM)** and 1 from the **Channel** list. Click the right arrow button to add the CFM feature to the **Selected features** list. Then select the **Compressed spectral array (CSA)** and 1 from the channel list and add the feature to the **Selected features**. Finally, select **Heart rate (HR)** and 5 from the channel list and add the feature to the **Selected features**.



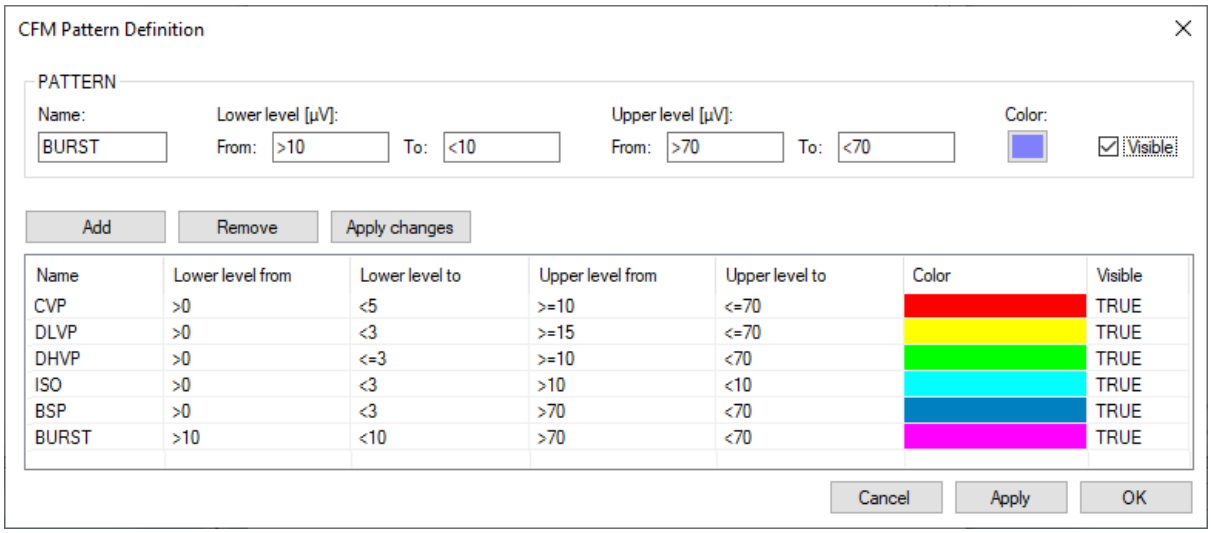
After feature selection, proceed with the feature definition. To do so, select the feature `1 CFM` from the **Selected features** list and click the **Advanced** button.



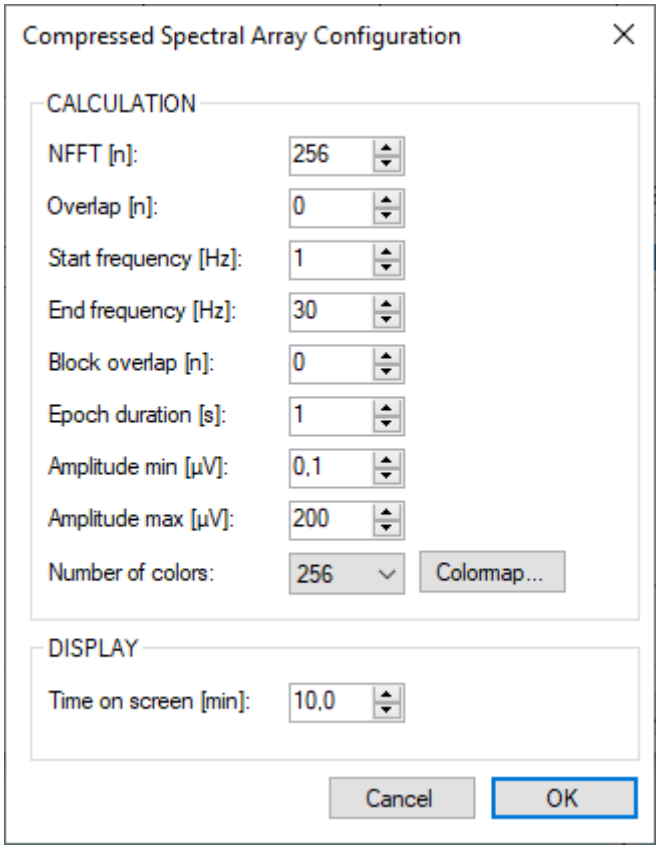
Provide all settings as shown in the dialog below and click the **Pattern definition...** button.



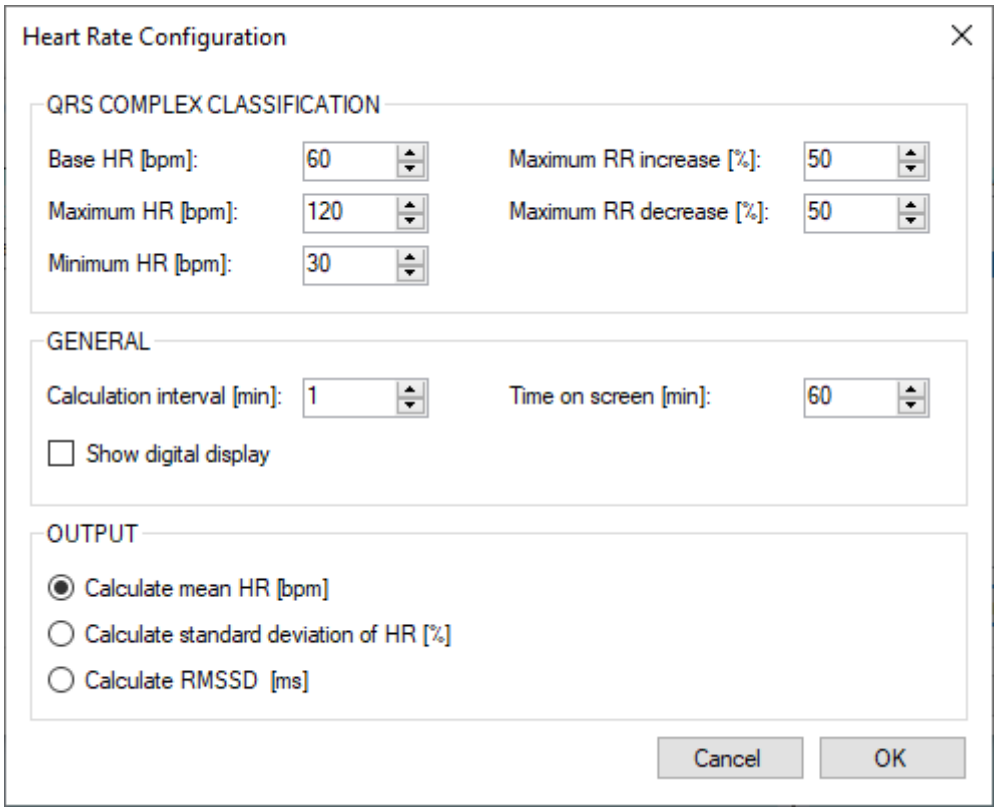
Define all patterns as shown in the dialog below. Close the **CFM Pattern Definition** and the **Cerebral Function Monitor Configuration** dialog by clicking the **OK** button.



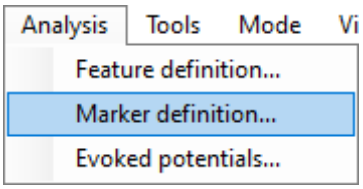
In the **Feature Definition** dialog, select the `1 CSA` feature and click **Advanced**. In the upcoming **Compressed Spectral Array Configuration** dialog set all variables as shown below. Close the dialog with the **OK** button.



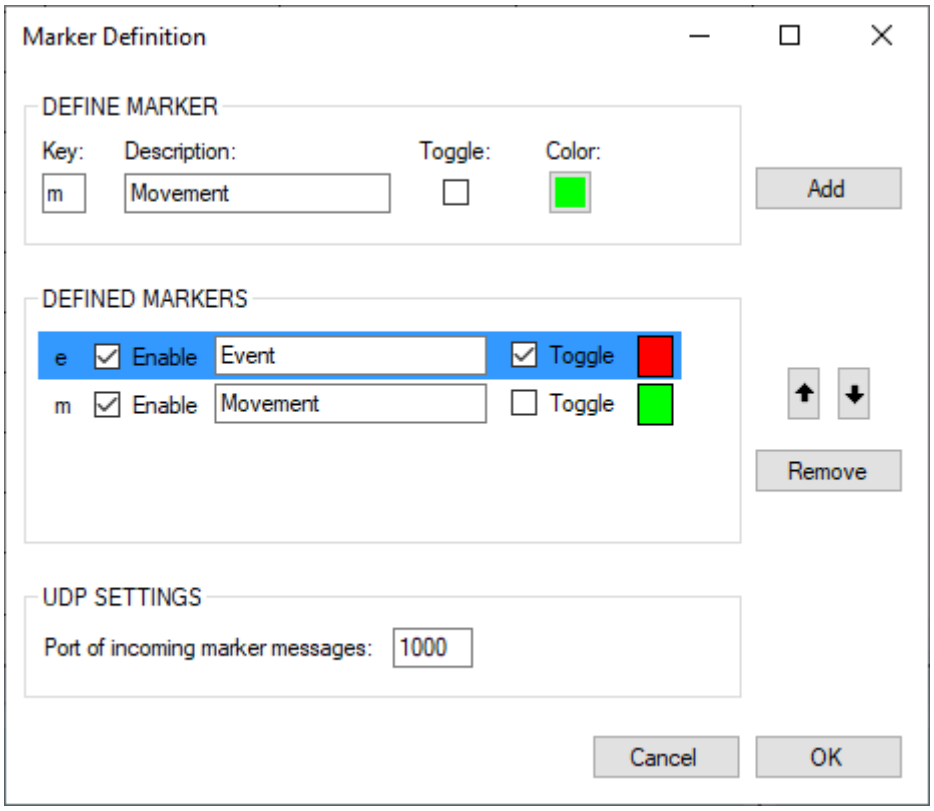
- To configure the heart rate feature, select the `5 HR` feature in the **Feature Definition** dialog and click **Advanced**.
- As for the other features, provide the settings as shown below (in this case, heart rate settings for an adult person) and close all dialogs with their respective **OK** buttons.



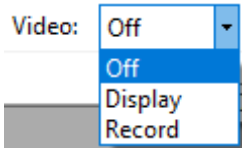
- In the Analysis menu, click **Marker definition...** to define markers.

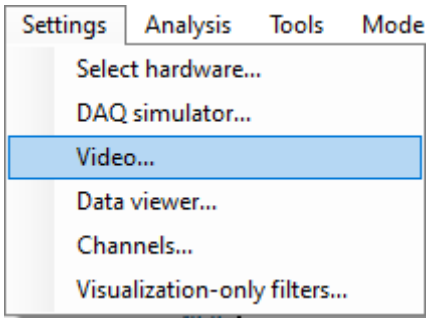


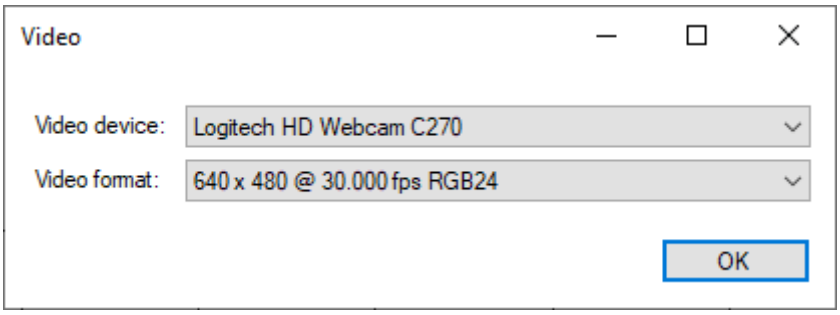
Enter a **Key**, a **Description**, set the **Toggle** checkbox, select a **Color** and click **Add** to add the marker to the **Defined markers** list. Click **OK** to finish marker definition.



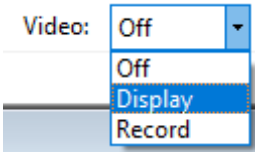
- Video can be recorded if a webcam is plugged into the PC. Ensure that the **Video** option in the toolbar is set to **Off** and click the **Video...** button in the **Settings** menu to view camera settings.



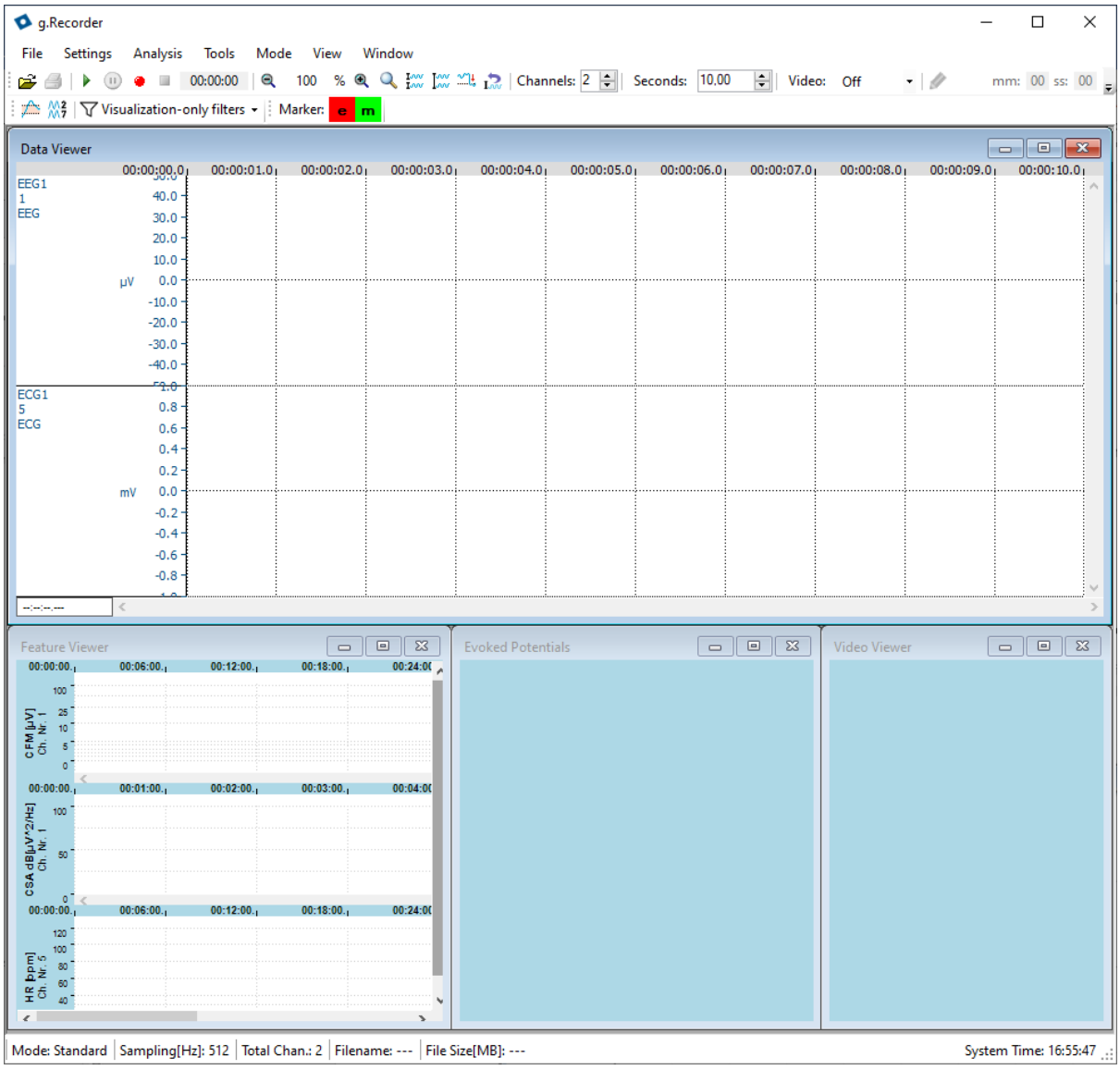




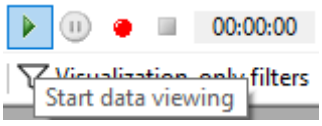
In the toolbar, set the **Video** option either to **Off** to not show the video, to **Display** to just show the video or to **Record** to store the video to hard disk.



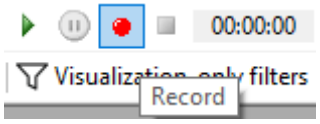
- After providing all the settings as described in the step above, the g.Recorder window should look like the picture below.



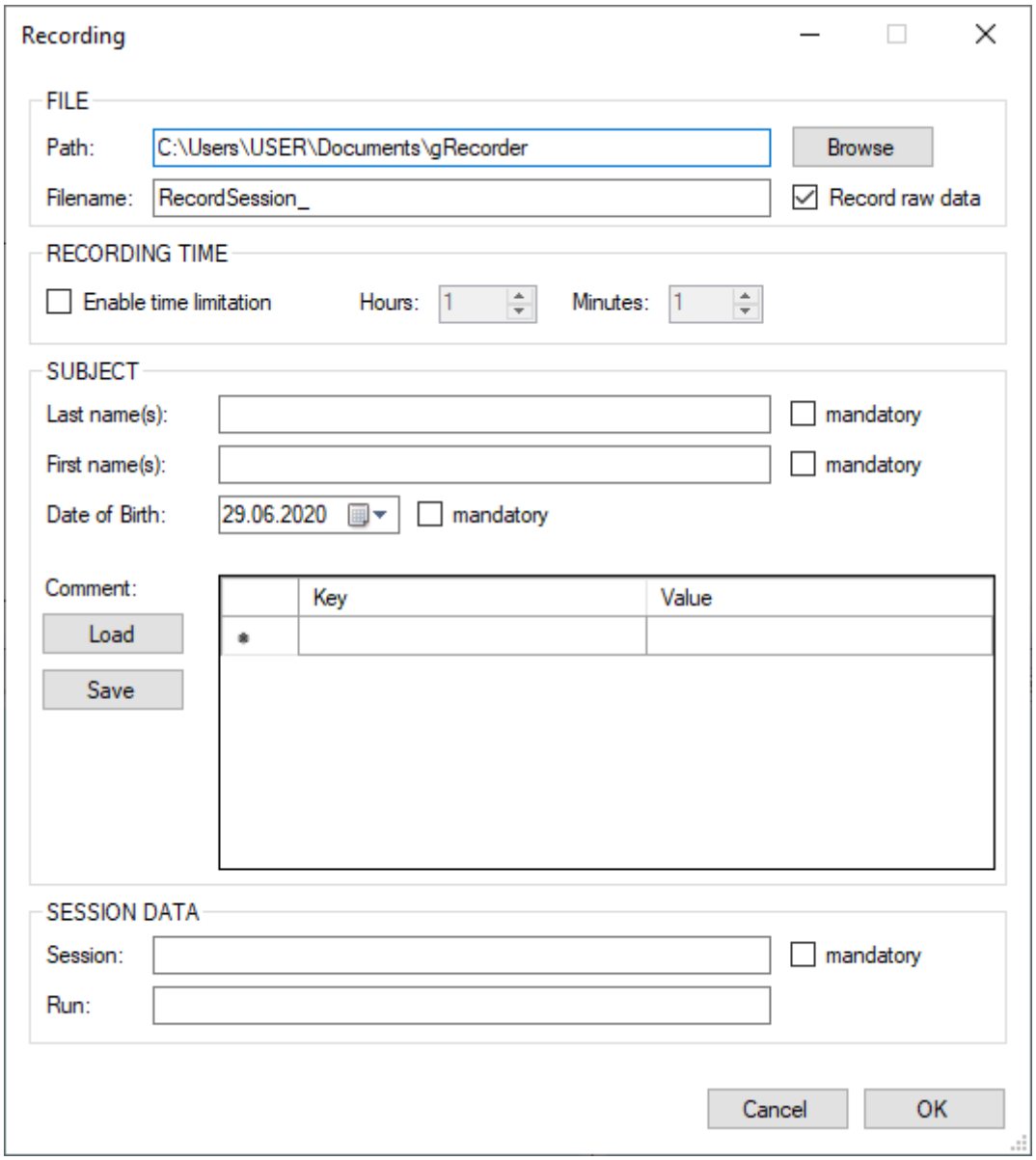
- Start data acquisition either by clicking the **Start data viewing** button to display data without recording it to the hard disk:



or by clicking the **Record** button to store acquired data to the hard disk:



- When the **Record** button is clicked, the **Recording** dialog opens.



FILE

A **Path** for the data file can be entered or the desired path can be chosen by clicking on the **Browse** button.

The **Filename** defines the name of the data file. The default filename is `RecordSession_` with date and time added. When the measurement is started, the data and the time are added automatically to the filename (e.g. `RecordSession_2020.06.29_16.59.34.hdf5`). The data is stored in HDF5 file format. For more information about this format, see www.hdfgroup.org or refer to the MATLAB help.

The checkbox **Record raw data** can be used to decide whether or not the raw data from the amplifier is stored in the HDF5 file. For offline processing after measurement it is recommended to record raw data.

RECORDING TIME

In the **Recording time** section with the **Enable time limitation** checkbox, a time limitation for the measurement can be set. After this time, the measurement is stopped automatically.

SUBJECT

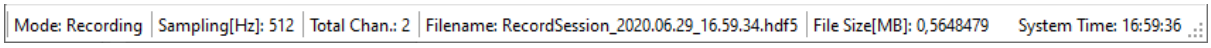
In the **Subject** section information about the subject like **Last name(s)**, **First names(s)** and **Date of birth** can be entered. In the **Comment** section additional information (e.g. medications) can be added.

SESSION DATA

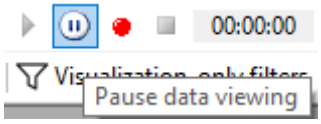
Enter the **Session** and **Run** identifier for your recordings.

After finishing these settings, click **OK**.

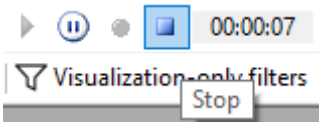
- The current mode of data acquisition is shown in the bottom left corner of g.Recorder in the status bar. **Standard** is displayed, if data is acquired without storing it to the hard disk, **Recording** if data is stored to the hard disk.



- To stop data acquisition, click the **Pause data viewing** button, which stops data acquisition in display mode or data display in recording mode (recording to the file continues in the background).



To finish recording click the **Stop** button.



5.2.2 USING g.HIAMP FOR EEG AND ECG

The setup of g.HIamp with g.Recorder for acquisition of 1 EEG channel and 1 ECG channel is explained.

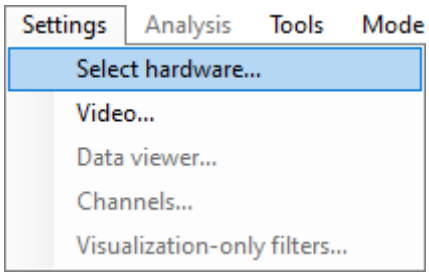
To perform this quickstart, please follow the steps below:

- Connect the electrodes to the g.HIamp in the following way.
  For EEG measurement, connect one EEG electrode to channel 1. Connect the EEG reference electrode to channel 2.
  For ECG measurement, connect one ECG electrode to channel 3. Connect the ECG reference electrode to channel 4. Connect the ECG ground electrode to the ground connector (yellow connector).

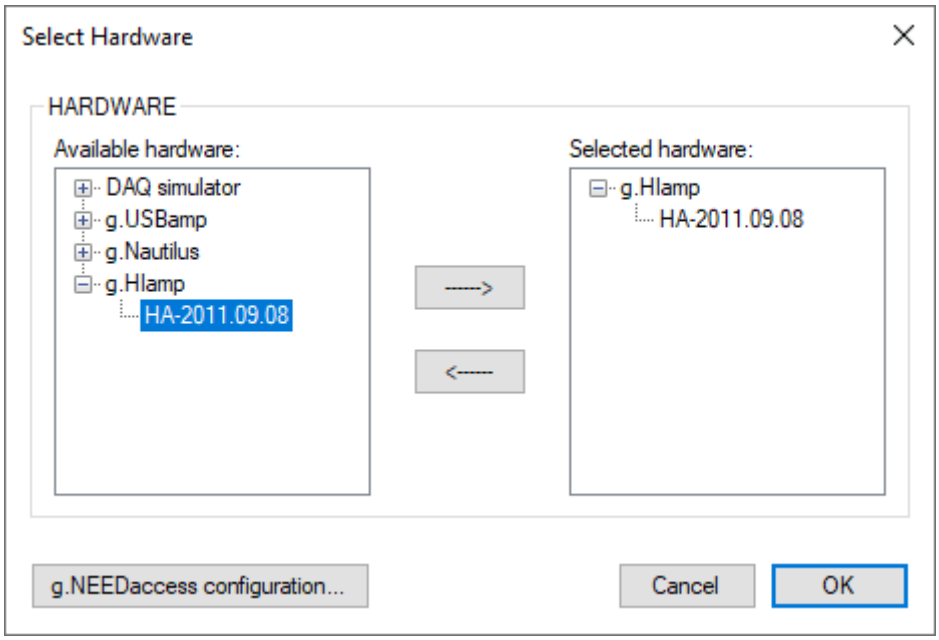
NOTE

only one ground electrode is used for both measurements. In this case, the ECG ground electrode is also used as ground electrode for the EEG electrode.

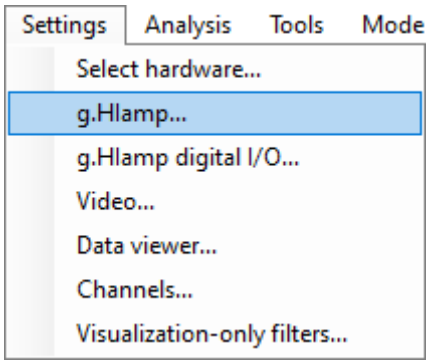
- Ensure that your g.HIamp amplifier is turned on and connected to the PC. Click **Select hardware...** in the **Settings** menu.



Click on the **g.HIamp** menu entry in the **Available hardware** list and select the serial number of your g.HIamp (e.g. HA-2011.09.08). Add the device to the **Selected hardware** list by clicking the right arrow button. Click **OK** to close the dialog.



Click **g.HIamp...** in the **Settings** menu to configure the g.HIamp device.

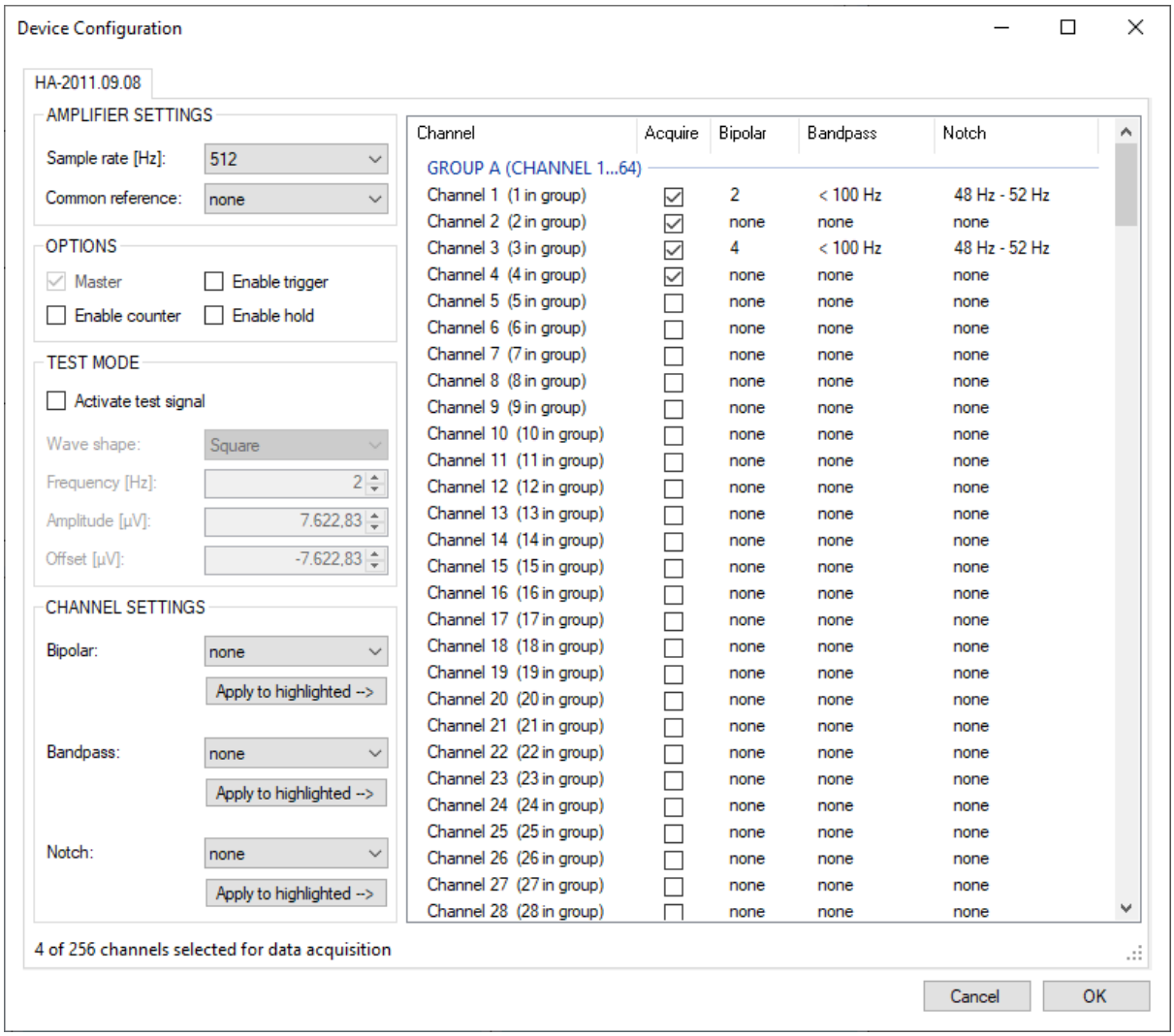


Set the **Sample rate** in the **Amplifier settings** section to 512 Hz and ensure that the **Acquire** checkboxes of channel 1 to channel 4 are checked only. You can use the shift key or the control key to select multiple channels. You can use the keystroke combination Ctrl + A to select all channels. To check or uncheck the **Acquire** checkboxes of the selected channels, click the **Acquire** checkbox of one of them.

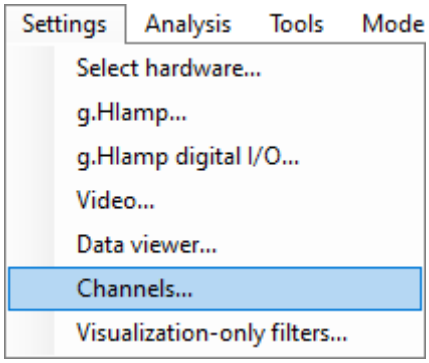
Select channels 1 and 3, apply a **Lowpass** filter **<100Hz** and a **Notch** filter with **48Hz-52Hz** or **58Hz-62Hz**, depending on your local power line hum.

For channel 1, apply **Bipolar** derivation with channel 2. For channel 3, apply bipolar derivation with channel 4.

Click **OK** to close the dialog.

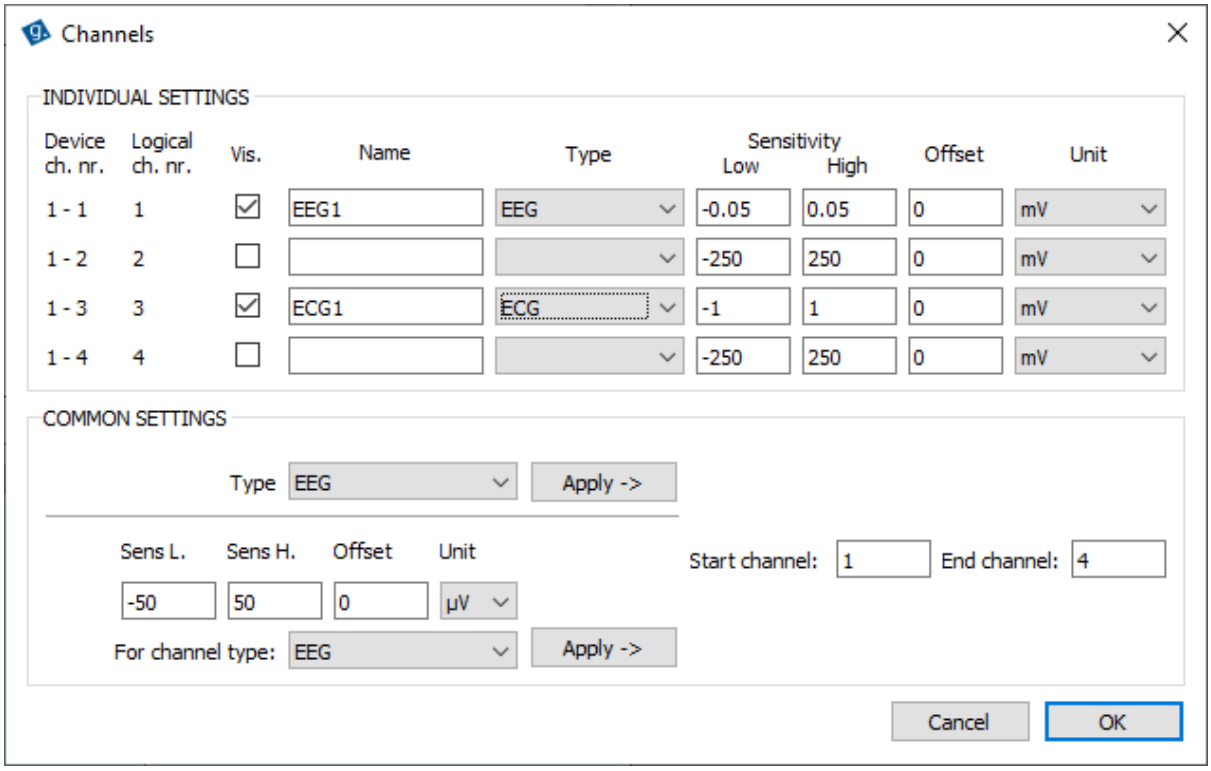


- Configure the g.Recorder display by opening the **Channels** dialog from the **Settings** menu.

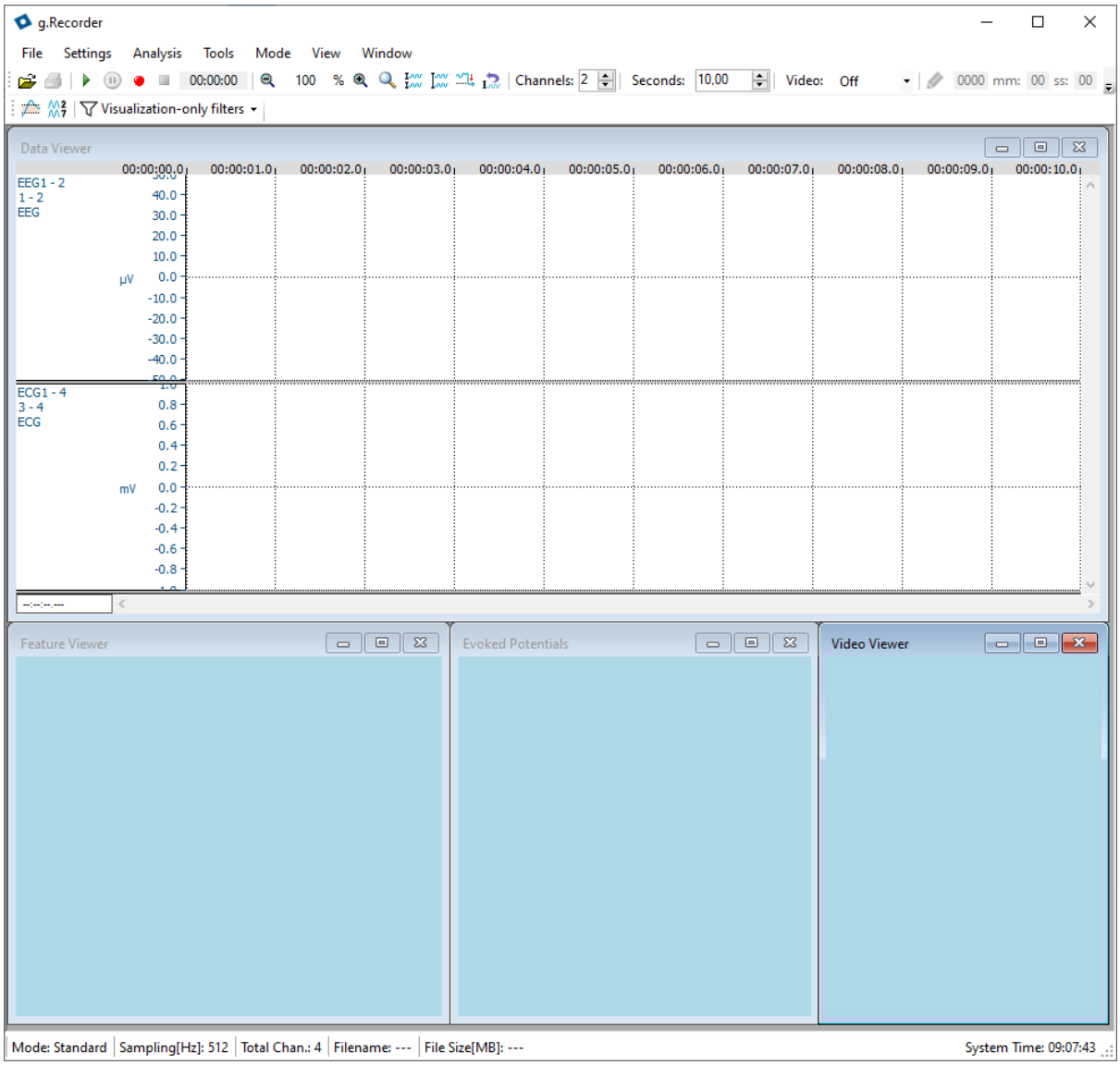


Uncheck the **Vis.** checkbox for channels 2 and 4 (as we don't need them) and provide a proper **Name** (e.g. `EEG1` for channel 1 and `ECG1` for channel 3) and a **Type** (e.g. **EEG** for channel 1 and **ECG** for channel 3) for the channels selected in the g.Hlamp configuration dialog. The **Sensitivity** is set

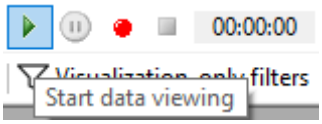
automatically, but can be changed manually. However, these changes influence data visualization in the Data Viewer window only. Click **OK** to close the dialog.



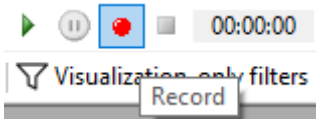
- After providing all the settings described in the steps above, the g.Recorder window should look like in the picture below.



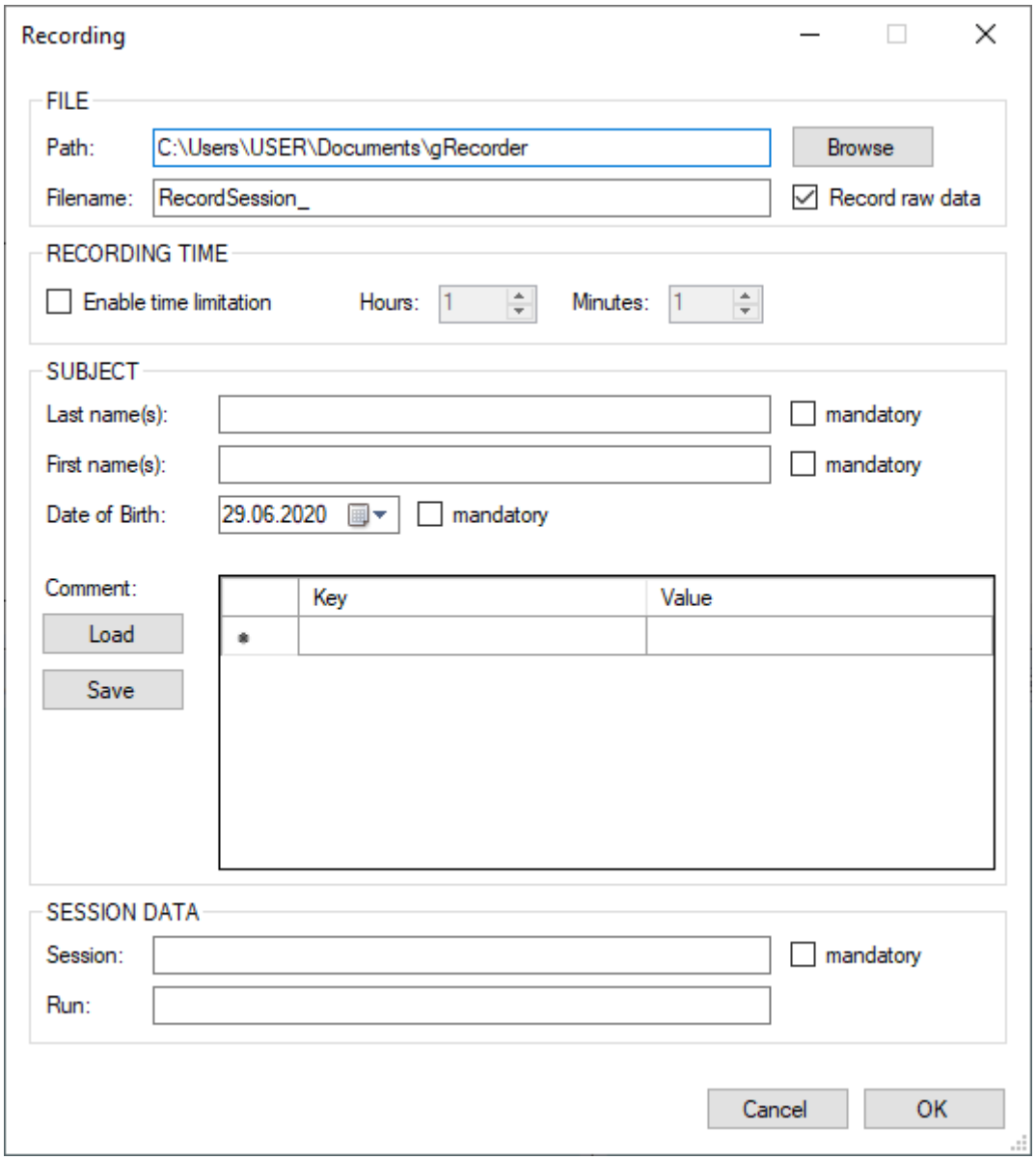
- Start data acquisition either by clicking the **Start data viewing** button to display data without recording it to the hard disk



or by clicking the **Record** button to store acquired data to the hard disk.



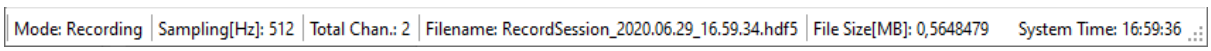
- When the **Record** button is clicked, the **Recording** dialog opens.



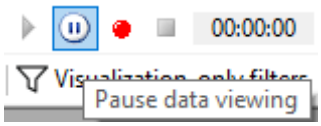
This dialog has already been described in the chapter *Using g.USBamp for EEG and ECG including video recording*. See that section for a detailed description of the available options.

Click the **OK** button to start data acquisition and recording.

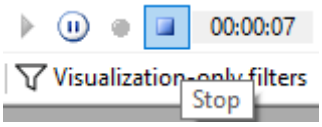
- The current data acquisition state is shown in the status bar at the bottom left corner of g.Recorder. **Standard** is displayed, if data is acquired without storing it to the hard disk, **Recording** if data is stored to the hard disk.



- To stop data acquisition, click the **Pause data viewing** button, which stops data acquisition in display mode or data display in recording mode.



To finish recording, click the **Stop** button.

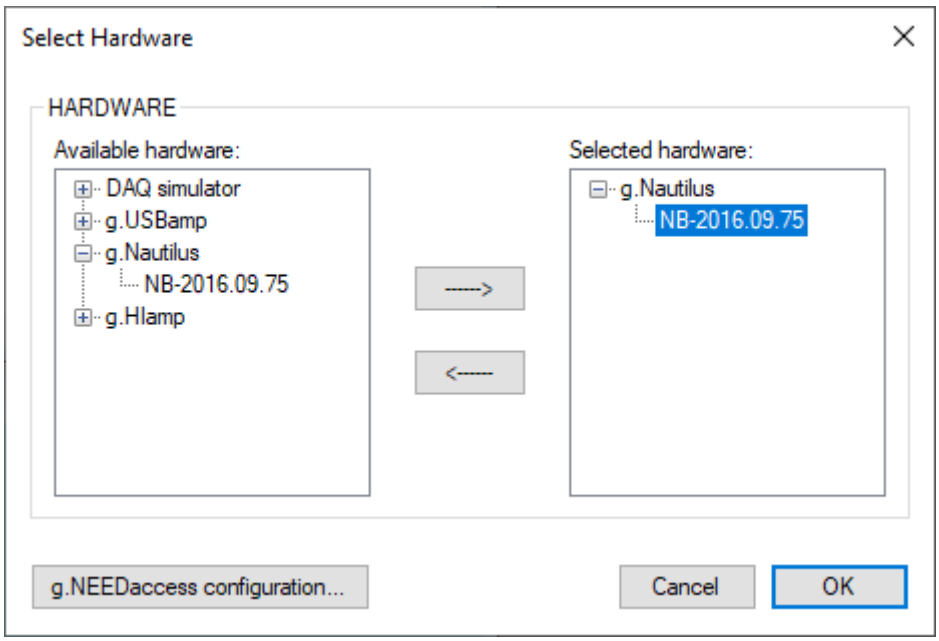


5.2.3 USING g.NAUTILUS FOR EEG

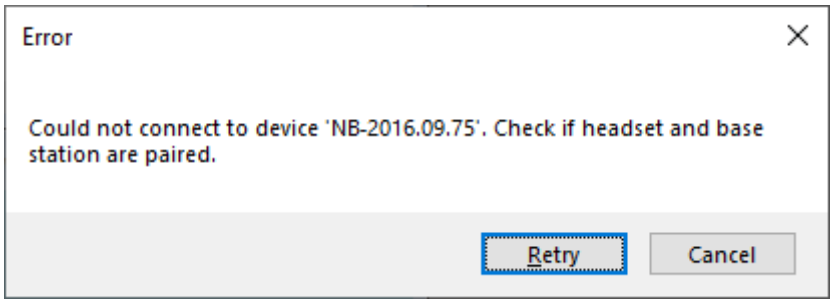
This section describes the setup of g.Nautilus for EEG data acquisition with g.Recorder.

To perform this example, please follow the steps below:

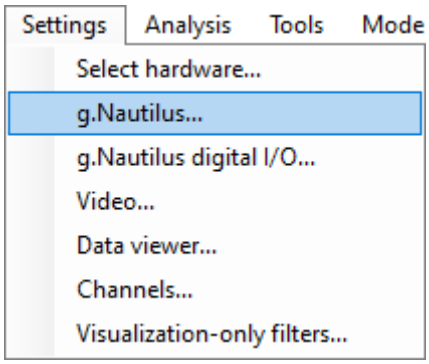
- Connect the g.Nautilus base station to the PC and open the hardware selection dialog by clicking **Select hardware...** in the **Settings** menu.



Click on the **g.Nautilus** menu entry in the **Available hardware** list and select the serial number of your g.Nautilus (e.g. NB-2016.09.75). Add the device to the **Selected hardware** list by clicking the right arrow button. Make sure that the g.Nautilus base-station and headset are paired and close the dialog with OK. If the devices are not paired, an information dialog will pop up. Turn the g.Nautilus headset on, then wait until base-station and headset are paired. Finally, terminate the dialog with **Retry.**



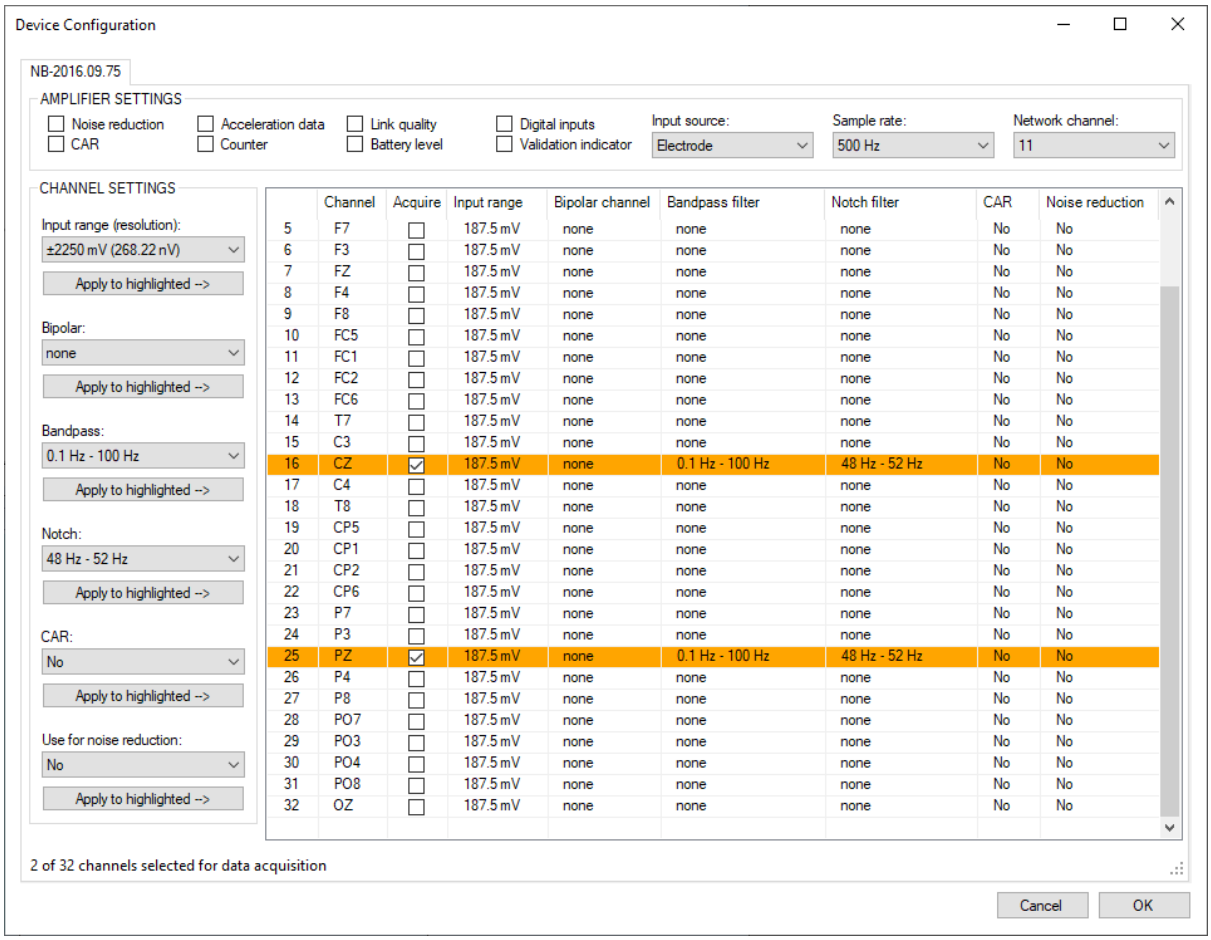
- Click **g.Nautilus...** in the **Settings** menu to configure the g.Nautilus device.



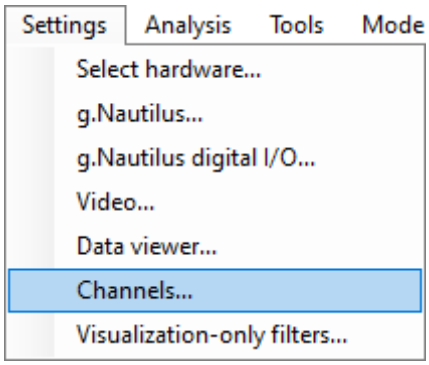
Set the **Sample rate** in the **Amplifier settings** section to 500 Hz and ensure that only the **Acquire** checkboxes of channel CZ and channel PZ are checked. You can use the shift key or the control key to select multiple channels. You can use the keystroke combination Ctrl + A to select all channels. To check or uncheck the **Acquire** checkboxes of the selected channels, click the **Acquire** checkbox of one of them.

Select channels CZ and PZ, apply a **Bandpass** filter **0.1 Hz – 100 Hz** and a **Notch** filter with **48Hz-52Hz** or **58Hz-62Hz**, depending on your local power line hum.

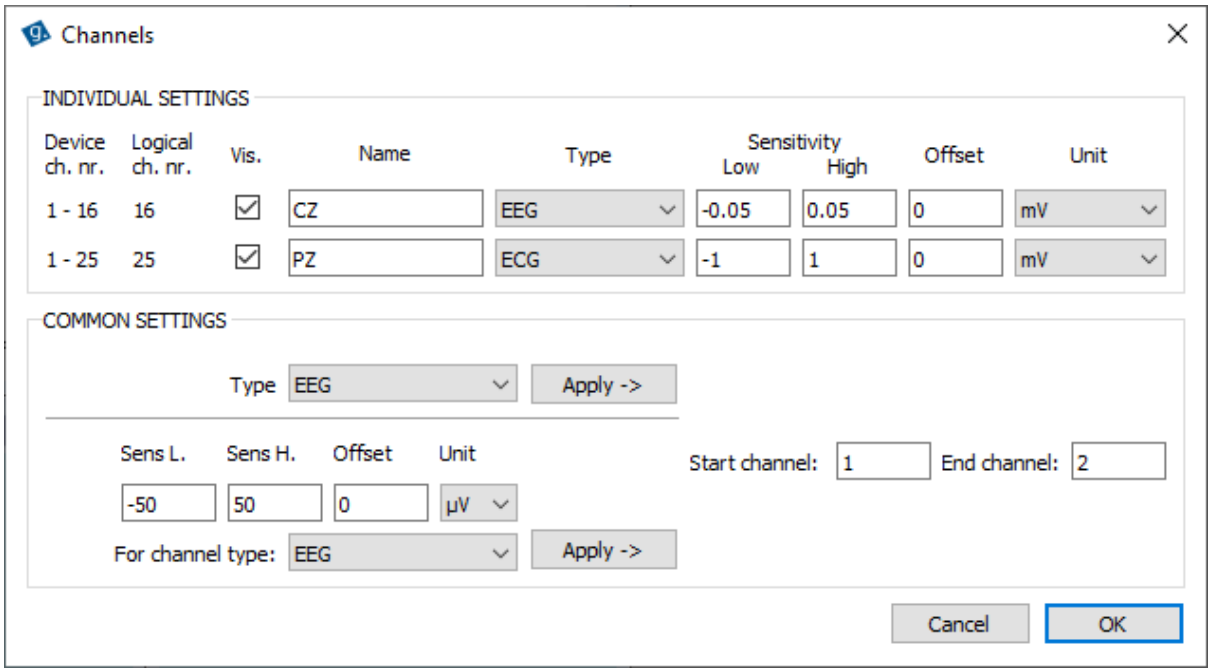
Click **OK** to close the dialog.



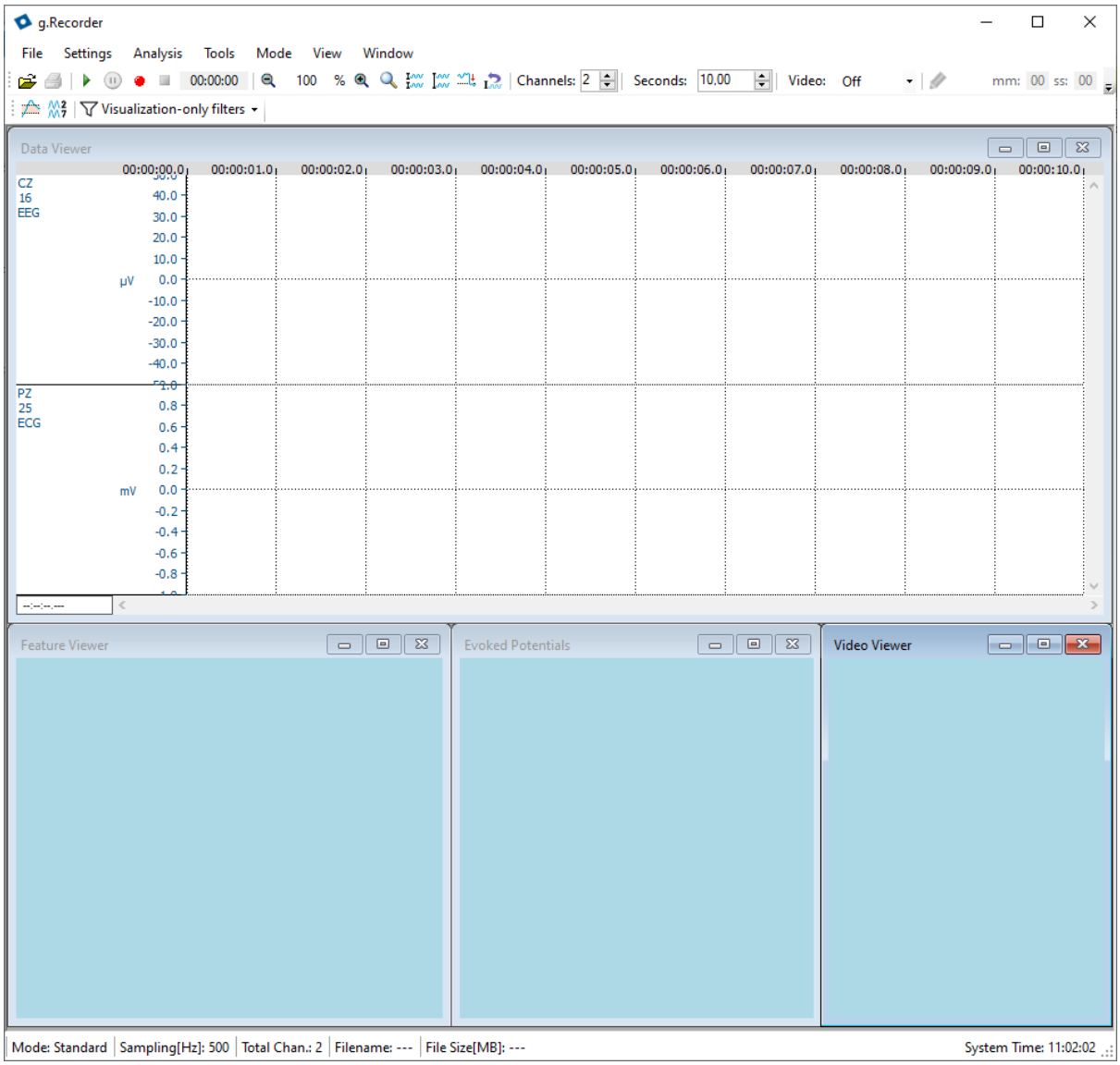
- Configure the g.Recorder display by opening the Channels dialog from the Settings menu.



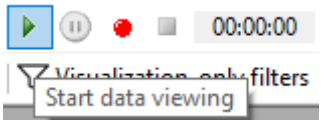
The channel **Name** of each in the configuration dialog selected channel should be assigned automatically. Provide a proper **Type** (e.g. **EEG**) for the selected channels. The **Sensitivity** is set automatically, but can be changed manually. However, these changes influence data visualization in the Data Viewer window only. Click **OK** to close the dialog.



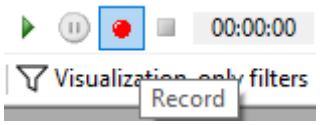
- After providing all the settings described in the steps above, the g.Recorder window should look like in the picture below.



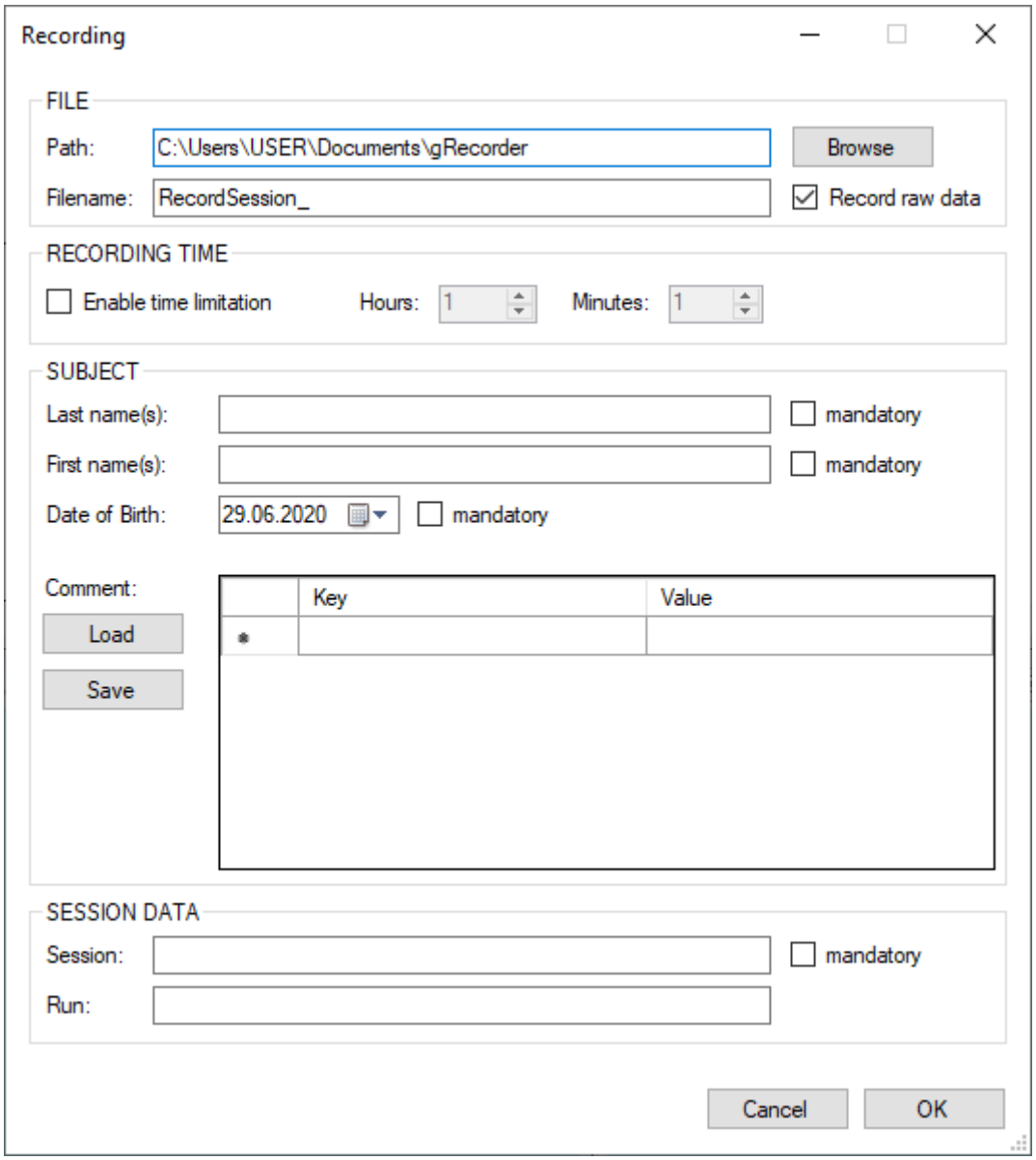
- Start data acquisition either by clicking the **Start data viewing** button to display data without recording it to the hard disk



or by clicking the **Record** button to store acquired data to the hard disk.



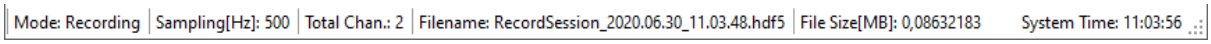
- When the **Record** button is clicked, the **Recording** dialog opens.



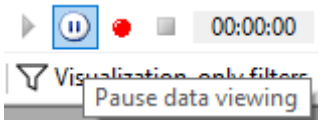
This dialog has already been described in the chapter *Using g.USBamp for EEG and ECG including video recording*. See that section for a detailed description of the available options.

Click the **OK** button to start data acquisition and recording.

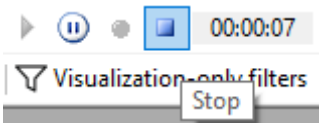
- The actual data acquisition state is shown in the status bar at the bottom left corner of g.Recorder. **Standard** is displayed if data is acquired without storing it to the hard disk, while **Recording** is displayed if data is stored to the hard disk.



- To stop data acquisition, click the **Pause Data Viewing** button, which stops data acquisition in display mode or data display in recording mode.



To finish recording, click the **Stop** button.



6 QUICKSTART FOR EVOKED POTENTIALS WITH g.USBAMP

6.1 REQUIREMENTS FOR THIS QUICKSTART

The following equipment is required to perform this quickstart correctly.

6.1.1 HARDWARE

Hardware	Description
g.USBamp	To acquire biosignal data and triggers
g.STIMbox	To create triggers and forward them to the g.tec amplifier
g.GAMMAbox	To use active electrodes
g.GAMMAcap with 8 electrodes	To acquire biosignal data
Accessories	Electrodes and electrode cables Trigger cable for g.USBamp UB Adapter cable for trigger cable

6.1.2 SOFTWARE

Software	Version
g.Recorder	1.20.03 (Professional license)
g.NEEDaccess Server	1.20.01
g.HIsys	1.20.04 (no license)
g.STIMbox Driver	1.20.00
MATLAB® / Simulink® (The MathWorks, Inc., www.mathworks.com)[1]	R2020a

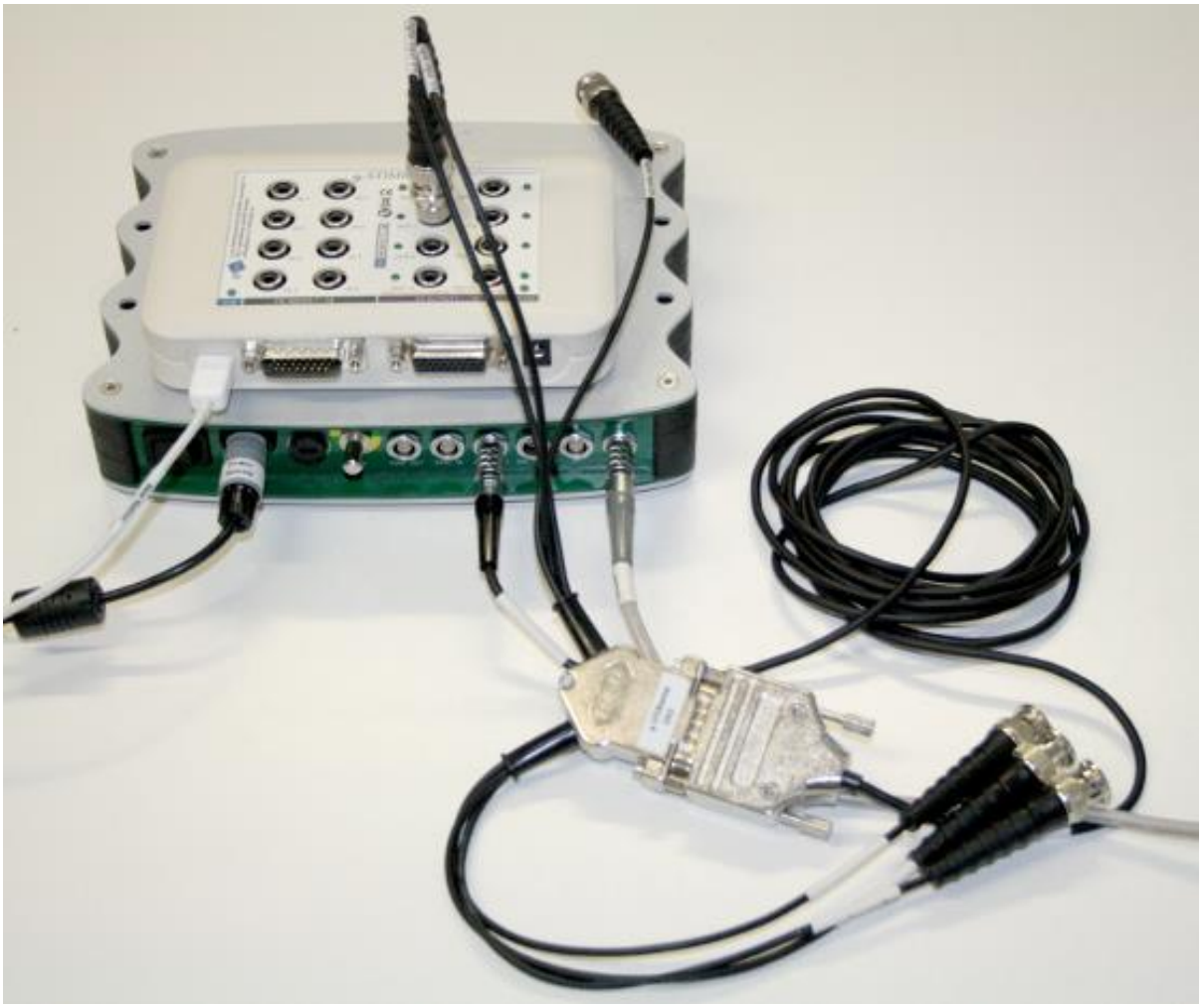
6.2 INTRODUCTION

It is possible to record, calculate and display evoked potentials in **g.Recorder**. This quickstart will give a short introduction on how to perform an evoked potentials experiment with **g.Recorder** using a **g.USBamp**, a **g.STIMbox** and **g.HIsys**.

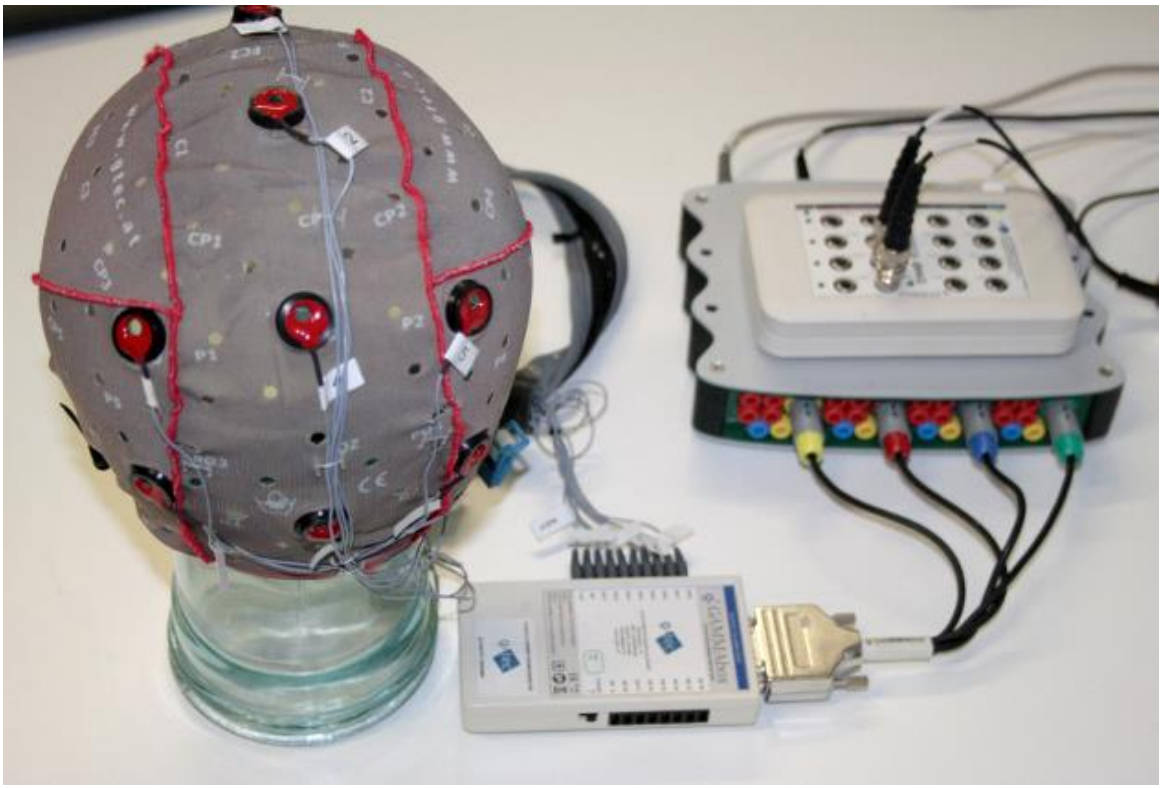
[1] MATLAB® and Simulink® are registered trademarks of The MathWorks, Inc.

6.3 HARDWARE SETUP

Connect the power supply and the USB cable to the **g.USBamp**. Connect the **g.STIMbox** to the PC with the other USB cable. Connect the first two output channels of the **g.STIMbox** to the first two digital input channels of the **g.USBamp**'s **DIG I/O 1** port using the corresponding trigger cables as shown in the picture below.

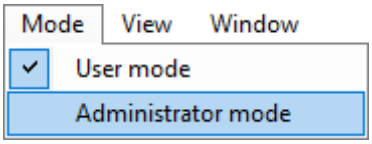


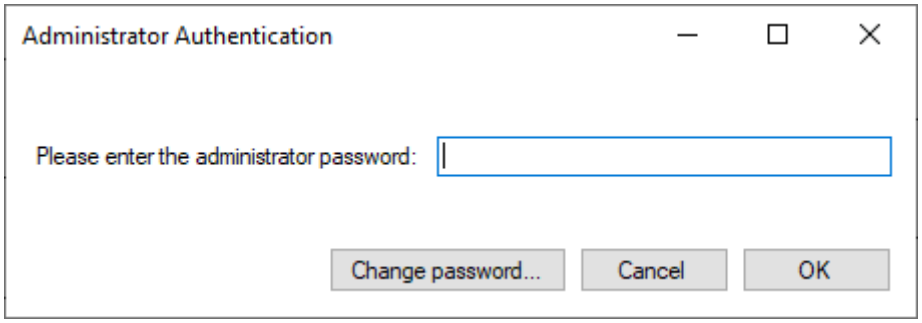
Connect a **g.GAMMAcap** with a typical P300 arrangement (eight electrodes) to the **g.GAMMAbox** properly. Connect the **g.GAMMAbox** with the **g.USBamp** as shown in the pictures below.



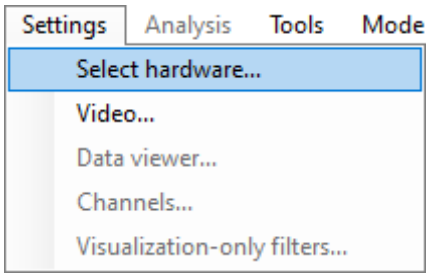
6.4 CONFIGURING g.RECORDER

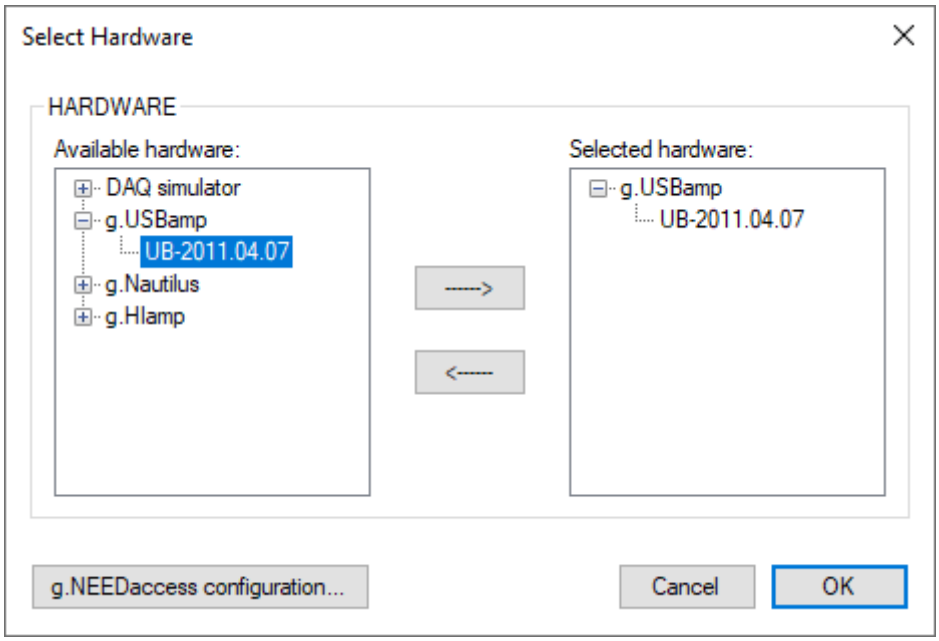
Open g.Recorder and change into administrator mode. To activate this mode, select **Administrator mode** from the **Mode** menu. If an **administrator password** is set, enter it and click **OK**. Otherwise, leave the text field blank and click **OK**.



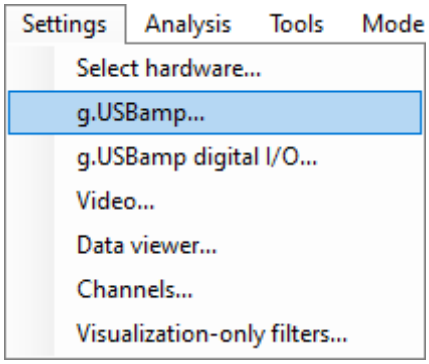


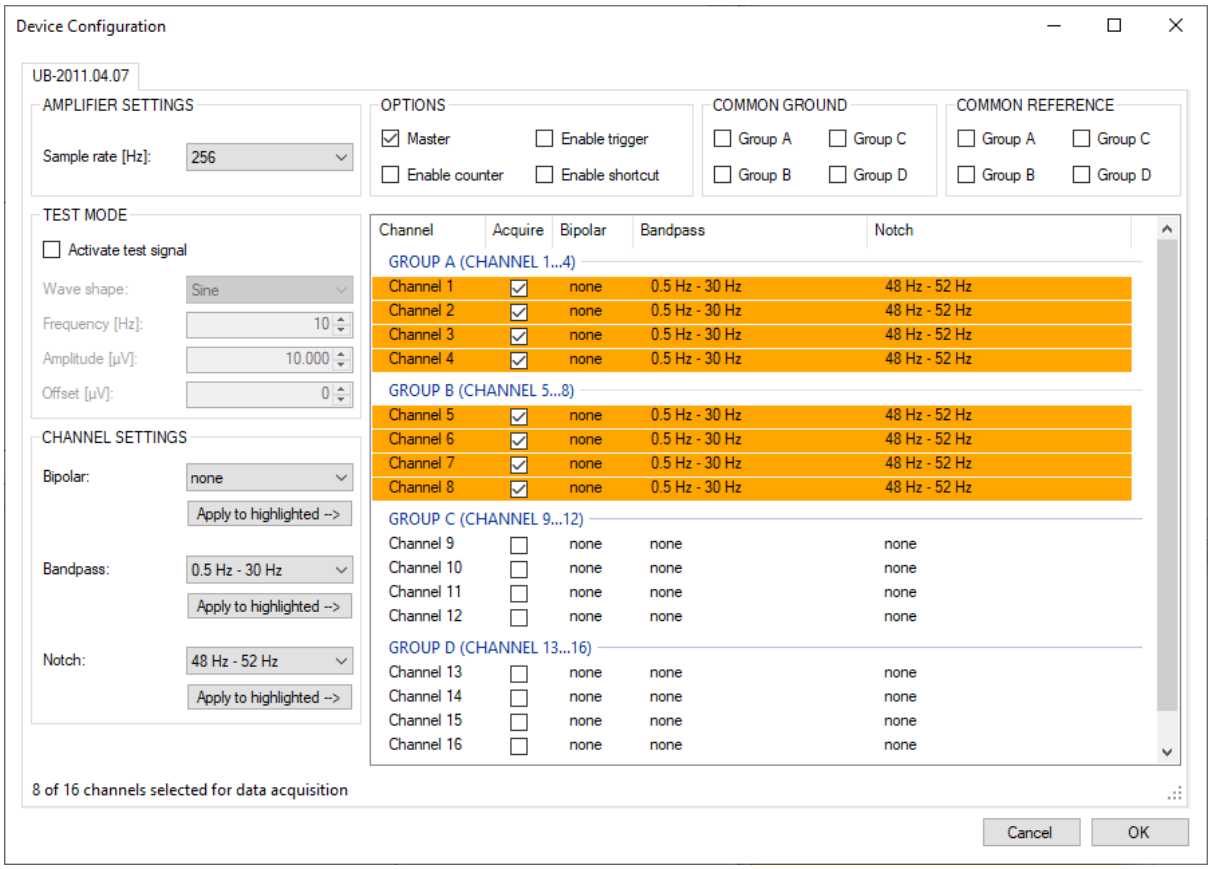
Connect the g.USBamp to your computer and select it in g.Recorder for data acquisition by opening the **Select Hardware** dialog from the **Settings** menu and selecting the desired g.tec amplifier.



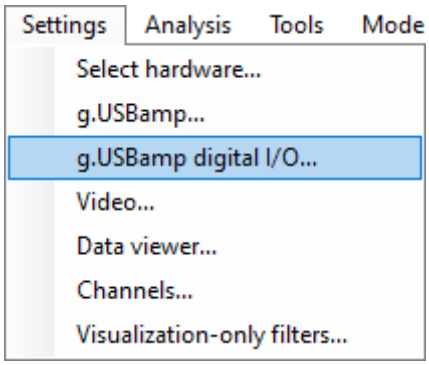


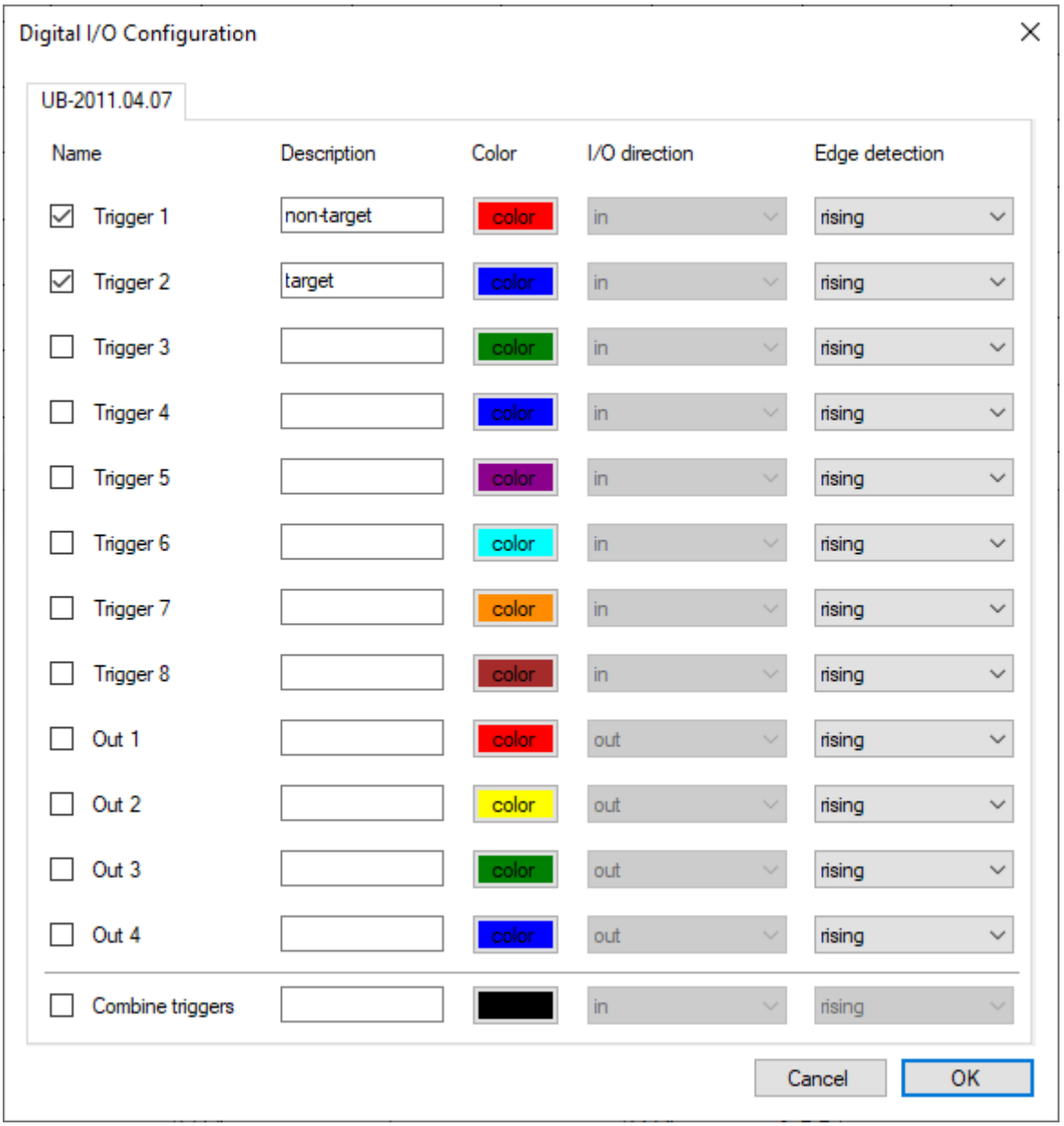
Open the **Device Configuration** dialog from the **Settings** menu. Select 8 channels for data acquisition. Apply a 0.5 – 30 Hz bandpass filter to all aquired channels. Additionally add a 50 Hz or 60 Hz notch filter according to your local power line hum. Confirm the dialog with **OK** to apply the configuration to the g.tec amplifier.



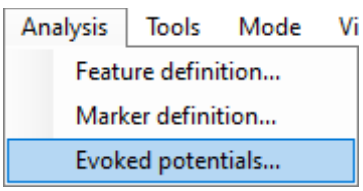


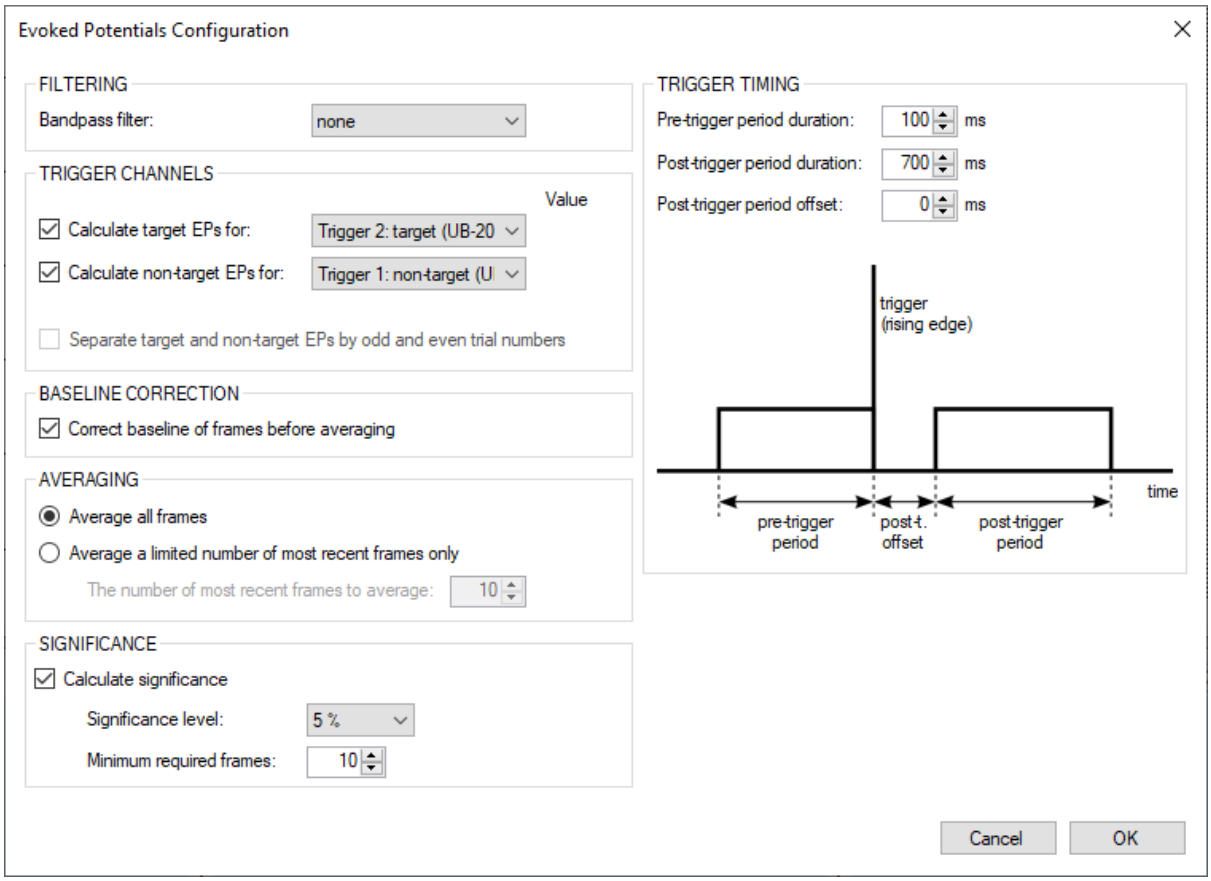
Open the **Digital I/O Configuration** dialog of the selected amplifier from the **Settings** menu and enable the first two trigger lines. Configure the edge detection to rising edge for both triggers.



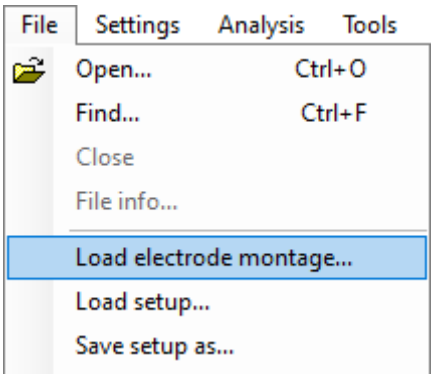


Open the **Evoked Potentials** dialog from the **Analysis** menu. Enable **Calculate target EPs for:** and select **Trigger 2** from the combobox. Enable **Calculate non-target EPs for:** and select **Trigger 1** from the combobox. Enable **Baseline correction** and **Calculate significance**. Set the significance level to 5%.

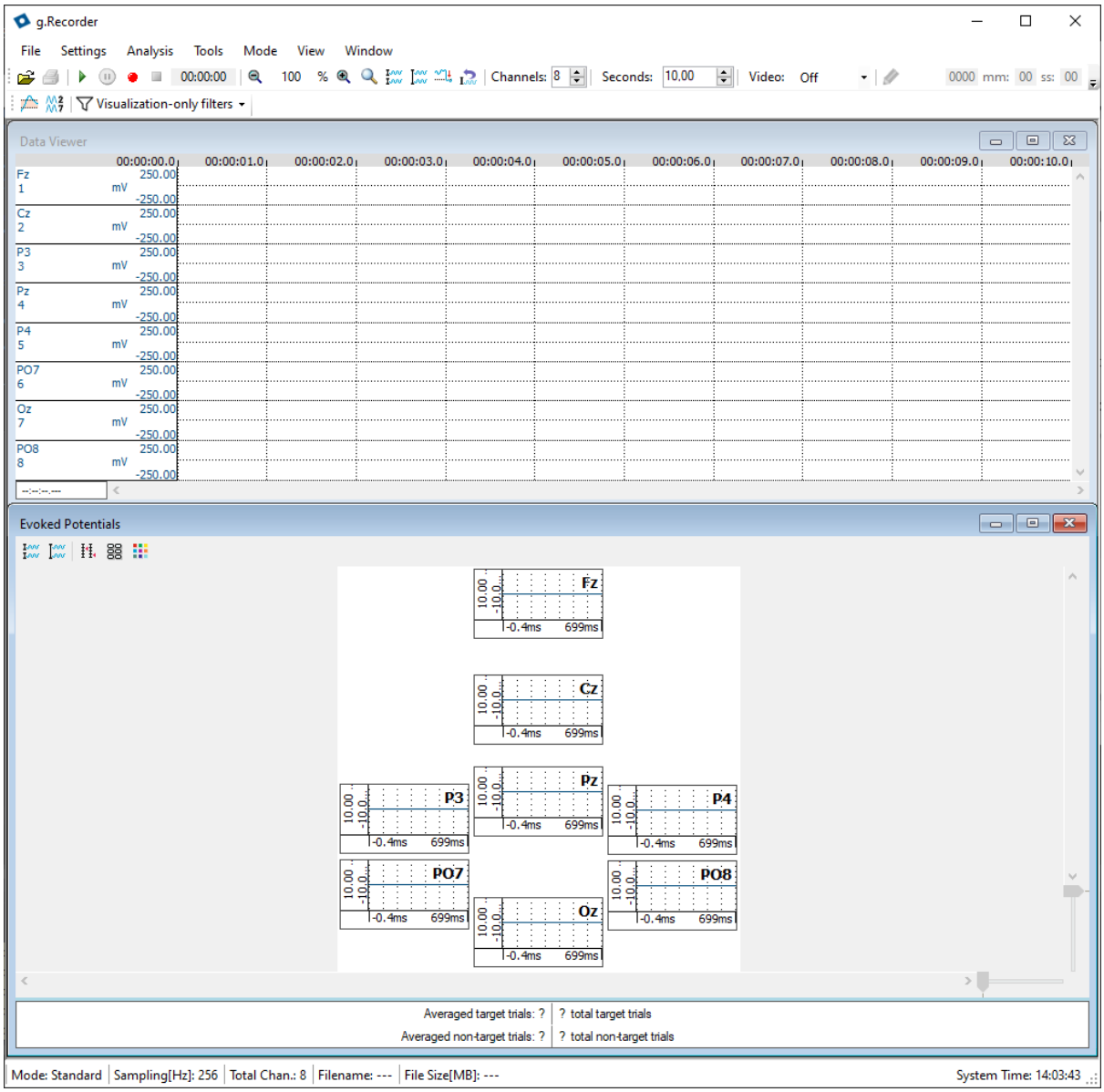




It is possible to load a montage file to import electrode configuration, channel names, and the topographic arrangement of electrodes on the used electrode cap. If no montage file is present, the electrodes will be named with numbers from 1-8 and the evoked potential plots will be arranged in a matrix. Click **Load electrode montage…** in the **File** menu to load an 8-channel electrode montage file for visual P300 experiments.

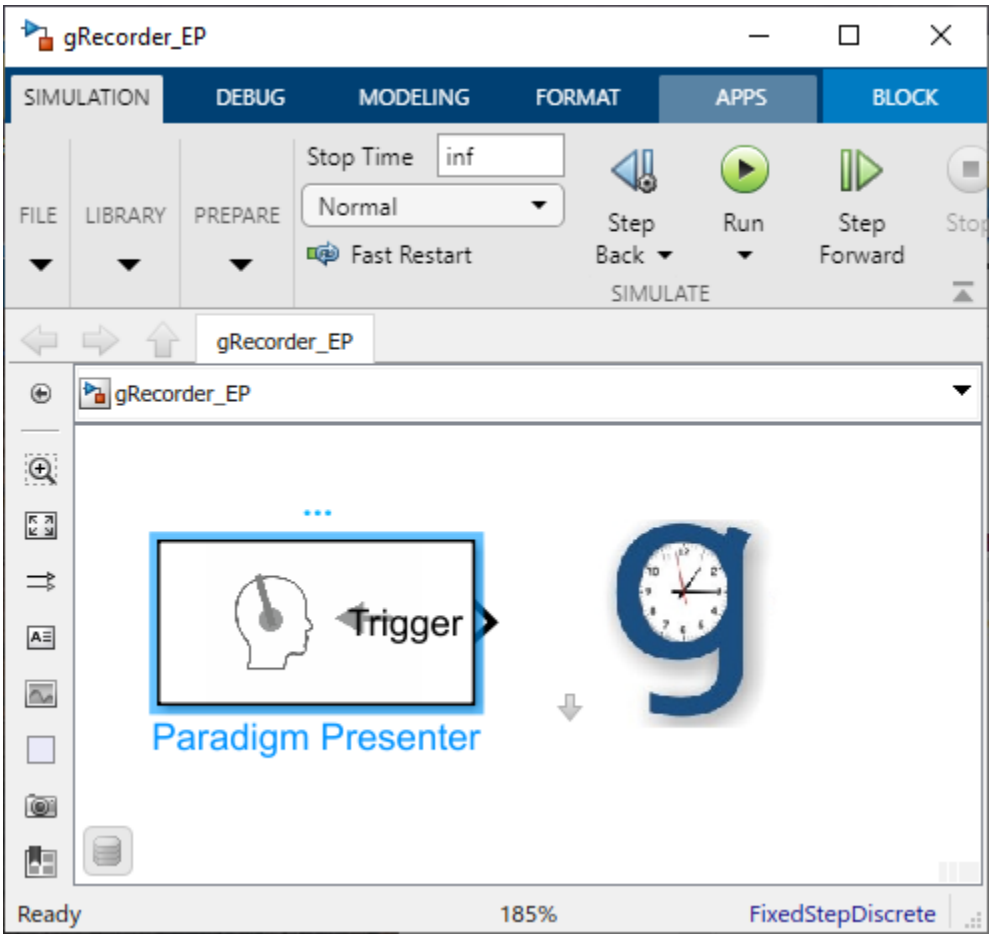


Channel names will be loaded and the evoked potential plots will be arranged in a topographic layout according to the loaded montage.

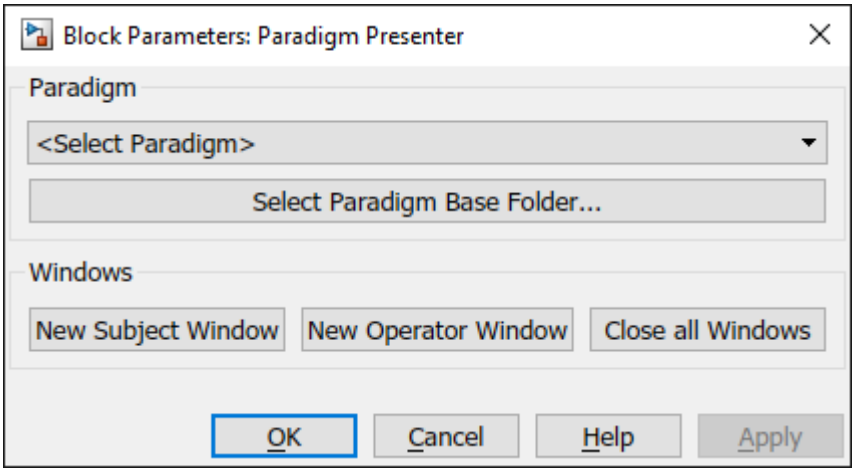


6.5 CREATING THE PARADIGM PRESENTATION WITH MATLAB® / SIMULINK®

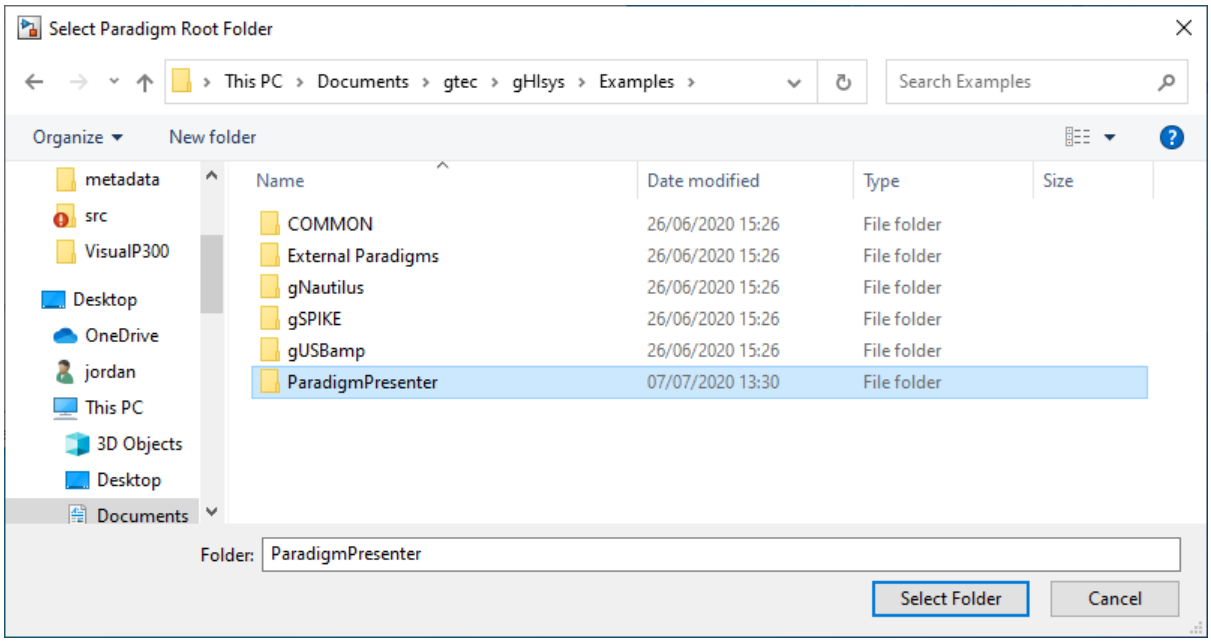
Create a new Simulink model containing a **Paradigm Presenter** block and a **Real Time Clock** from the **g.HIsys** library. Assemble the items as shown underneath. Save the model into your documents folder under `Documents/gtec/gHIsys/Examples`. Drag the blocks into the models and connect them as shown underneath.



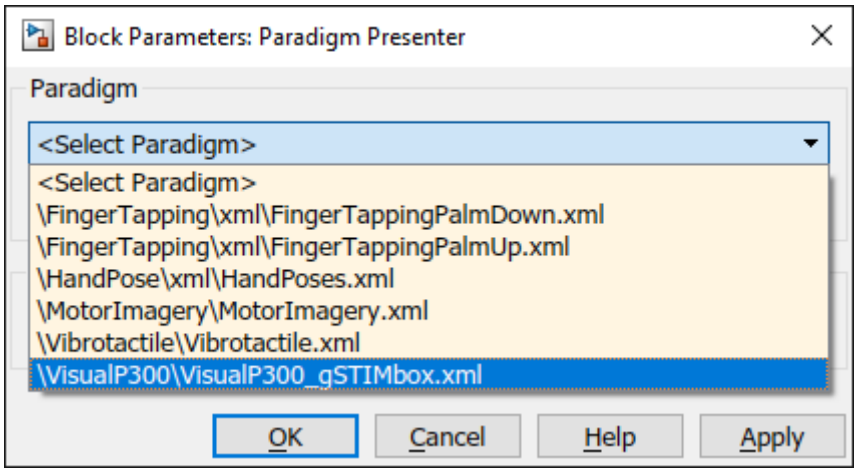
Double-click the **Paradigm Presenter** block and click the **Select Paradigm Base Folder...** button.



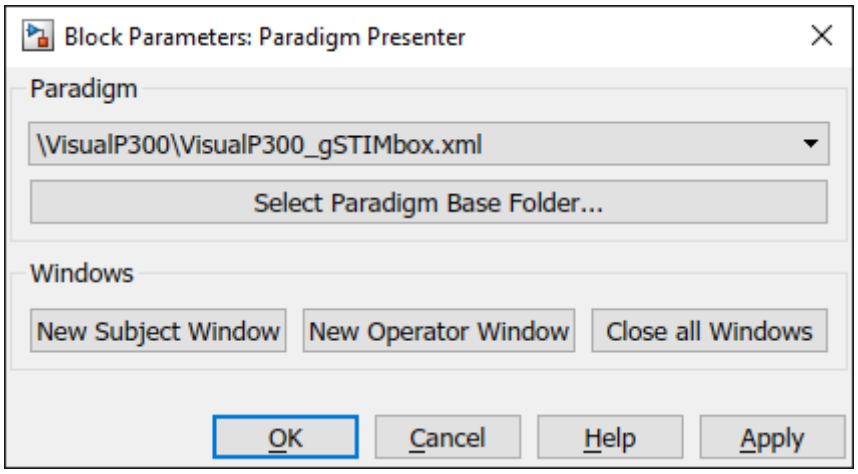
Navigate to the folder that contains the g.HIsys example paradigms under `Documents/gtec/gHIsys/Examples/ParadigmPresenter` and click **Select Folder**.



Now, select the `\VisualP300\VisualP300_gSTIMbox.xml` paradigm from the list under **<Select Paradigm>**.



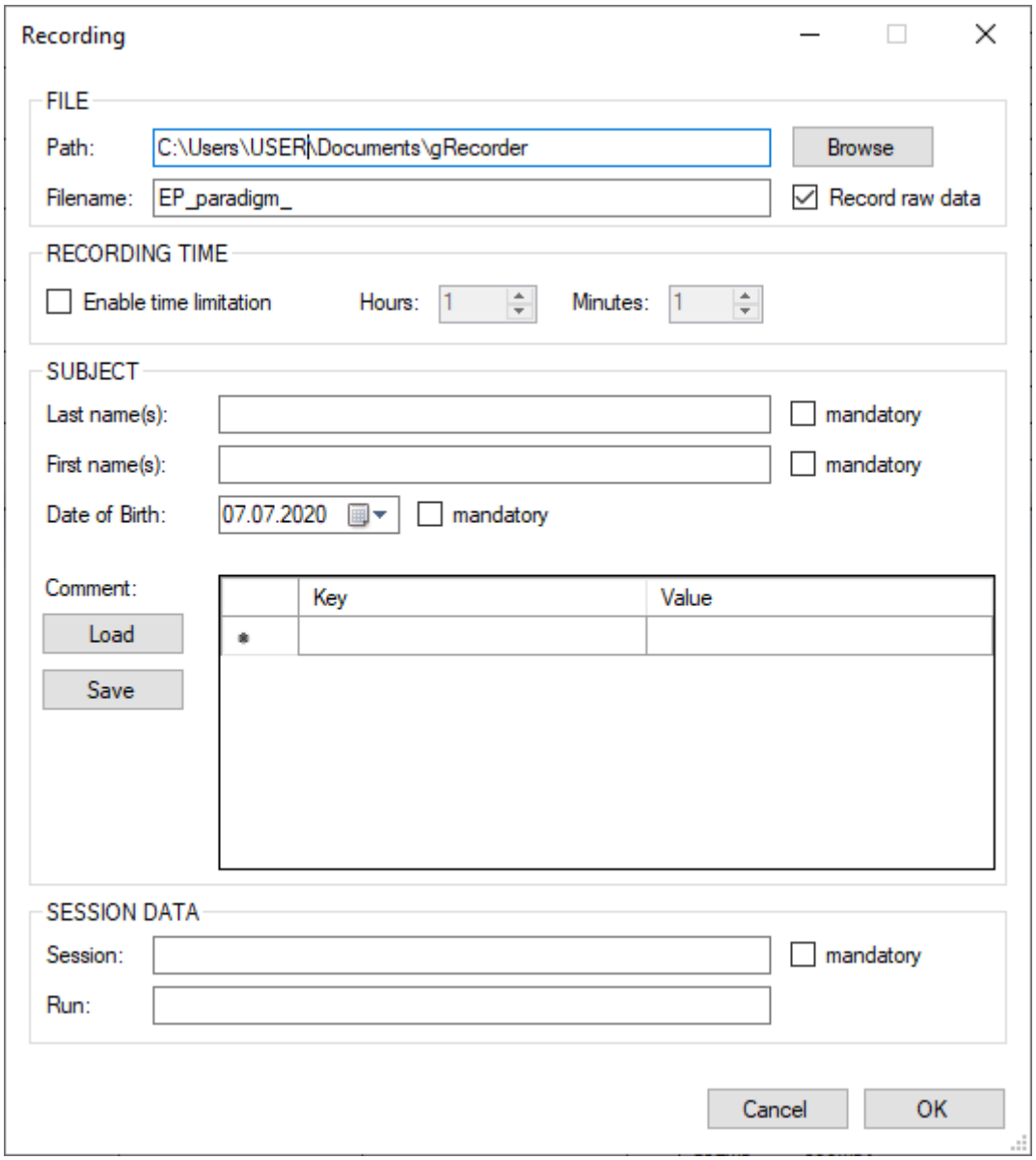
Confirm the dialog below by clicking **OK**.



6.6 RUNNING THE EXPERIMENT

Perform an impedance check before you run the paradigm and ensure that you have a good EEG signal quality by investigating the signals during display mode ( ).

Start a recording session by clicking Record ( ), enter **Path** and **Filename** of the data file to record and confirm the recording dialog with **OK**.

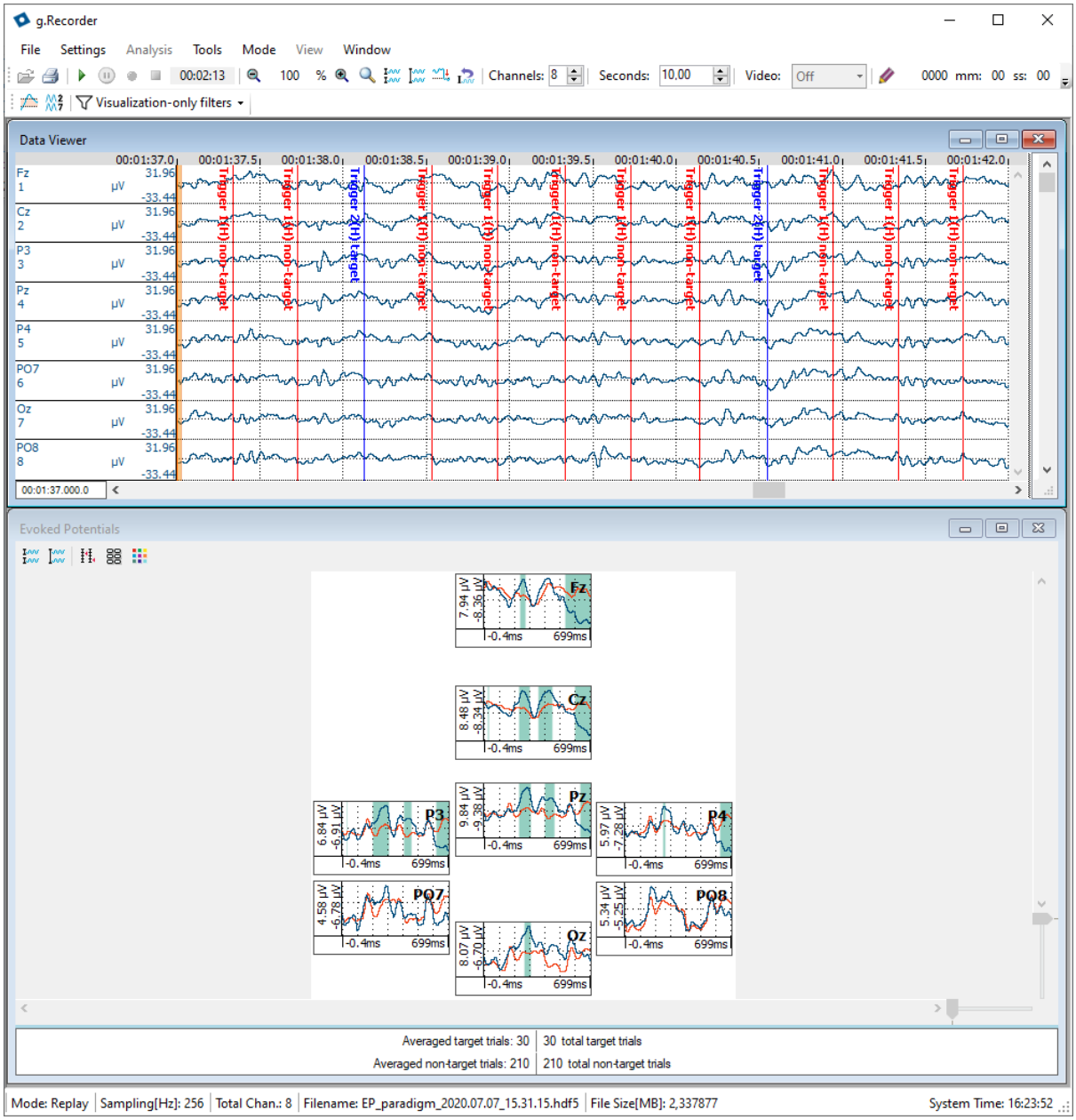


Run the Simulink model from the previous step. The paradigm presentation window will present a white fixation cross for the first five seconds before the paradigm actually starts. For about 1 minute and 45 seconds, it will present several instances of different grayscale images showing landscapes (non-target images) and a colored image showing a vacation paradise (target image). For each displayed non-target image, the g.STIMbox will send a trigger to channel 1 at the picture onset, for each displayed target image, the g.STIMbox will send a trigger to channel 2. Those triggers are recorded via g.USBamp and recognized by g.Recorder for calculation of evoked potentials.

The participant is asked to focus on the target image and count the target image appearences in mind, while ignoring the non-target image appearences. The resulting responses of the brain to the displayed images in the EEG signal will create the measured P300 evoked potential at the target trigger channel.

The evoked potential plots in g.Recorder will update with each trigger and display significant differences between target and non-target EPs after enough triggers have been received. Stop ( )

the recording session after the paradigm is finished. If the everything worked as expected, a peak should be displayed in the plots at 300 ms after the trigger onset.



7 QUICKSTART FOR TRIGGERS VIA PARALLEL PORT (E-PRIME®/PRESENTATION®)

7.1 REQUIREMENTS FOR THIS QUICKSTART

The following equipment is needed to perform this quickstart properly:

7.1.1 WITH g.USBAMP

Hardware	Description
PC with native parallel port	To send hardware triggers to g.USBamp via parallel port
g.USBamp	To acquire biosignal data and receive parallel port data
Accessories	Electrodes and electrode cables, parallel port to g.USBamp digital in cable

7.1.2 WITH g.HIAMP

Software	Version/Details
g.Recorder	1.20.03 (Professional license)
g.NEEDaccess Server	1.20.01
E-Prime®	(Psychology Software Tools, Inc., www.pstnet.com)
Presentation®	(Neurobehavioral Systems, Inc., www.neurobs.com)

NOTE

E-Prime® and Presentation® are trademarks by their respective owners.

7.2 INTRODUCTION

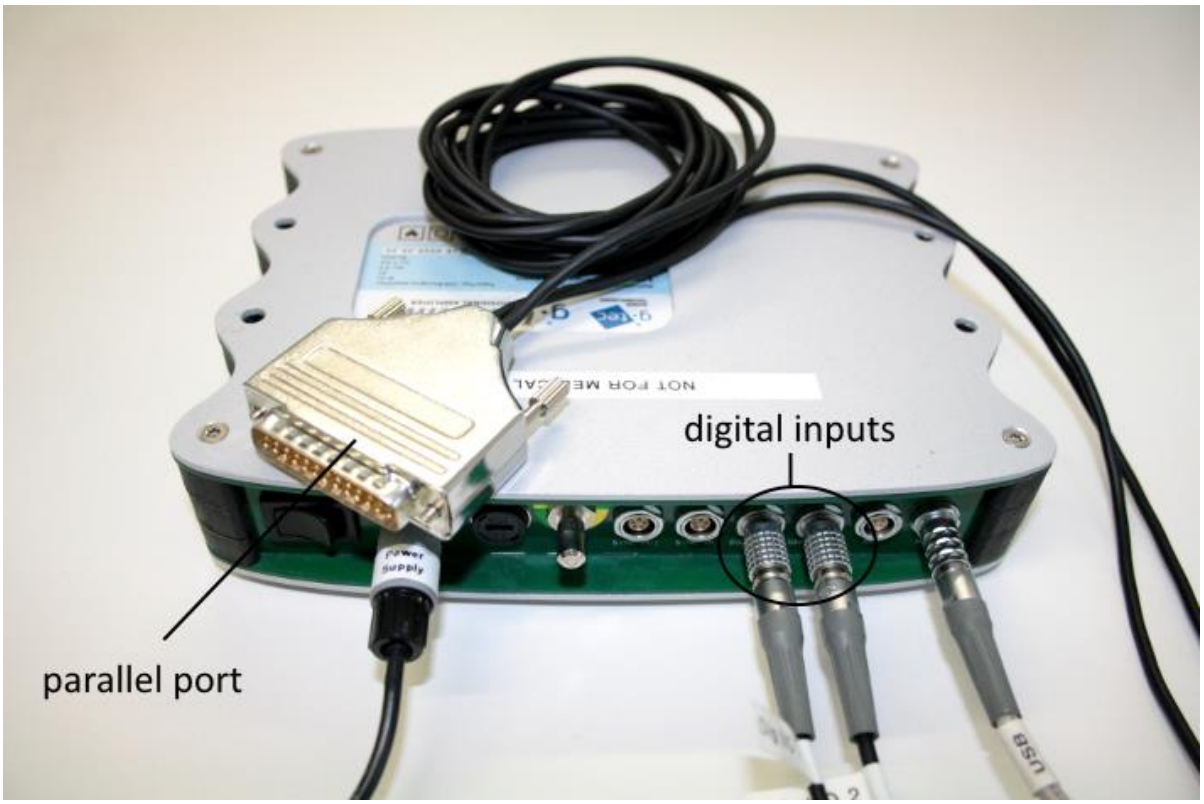
This quickstart will give a short introduction on how to use the parallel port with g.Recorder and g.HIamp or g.USBamp devices to communicate with stimulus delivery software like **E-Prime®** (Psychology Software Tools, Inc., www.pstnet.com) or **Presentation®** (Neurobehavioral Systems, Inc., www.neurobs.com).

g.Recorder supports external stimulation software like **Presentation** and **E-Prime** by acquiring event codes sent via parallel port. The parallel port is connected to the digital I/O module of the g.tec amplifier (available for g.USBamp, g.HIamp) using an amplifier-specific adapter cable (see product catalogue).

7.3 HARDWARE CONFIGURATION

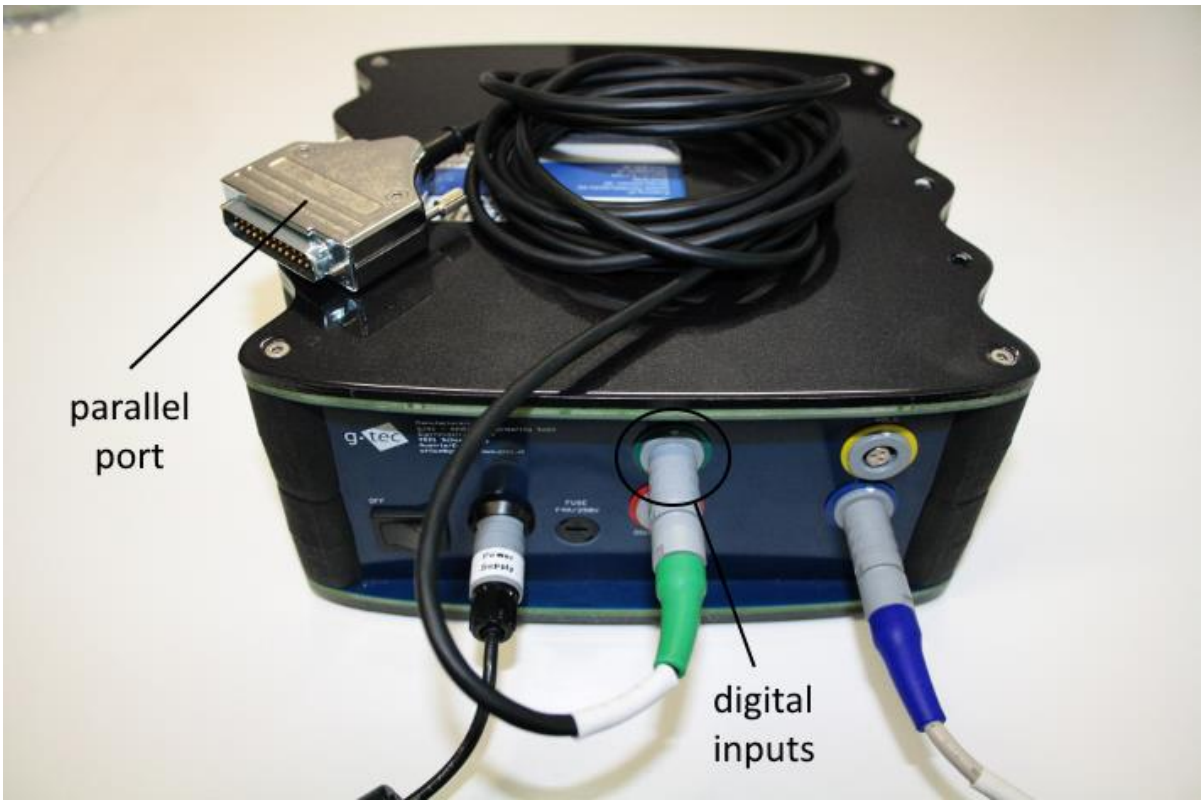
7.3.1 g.USBAMP

Connect the power supply and USB cable to the g.USBamp. Connect the two digital input ports of the g.USBamp with the parallel port of computer using the corresponding **digital input to parallel port cable**.



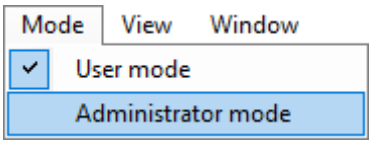
7.3.2 g.HIAMP

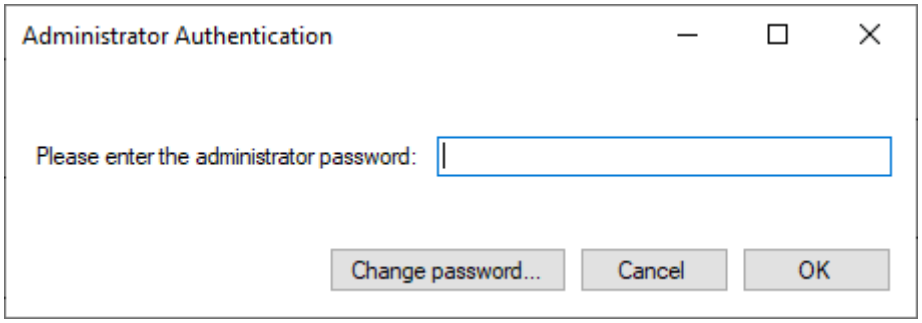
Connect the power supply and USB cable to the g.HIamp. Connect the first digital input port of the g.HIamp with the parallel port of the computer using the corresponding **digital input to parallel port cable**.



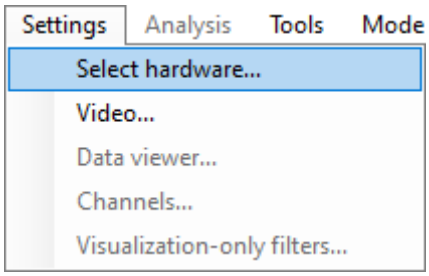
7.4 g.RECORDER CONFIGURATION

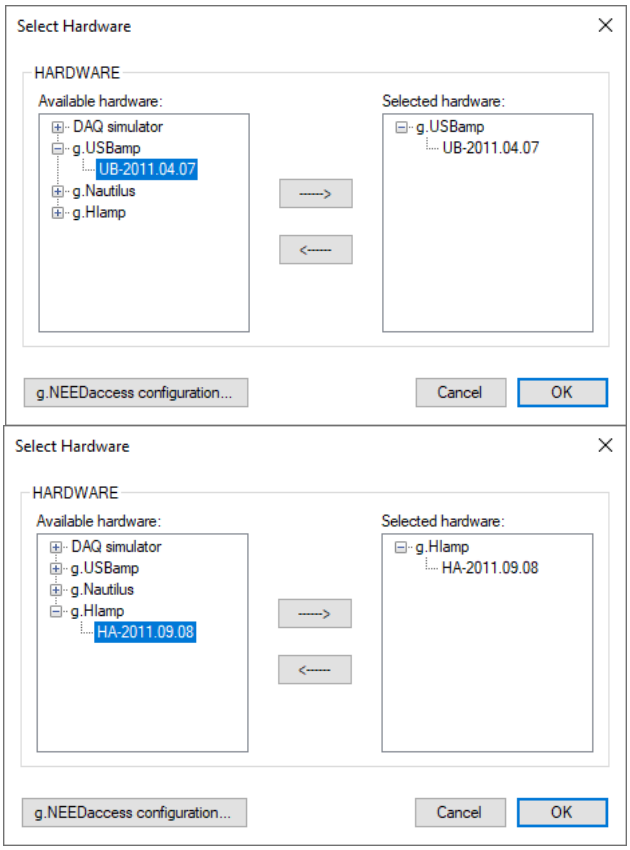
Open g.Recorder and change into administrator mode. To activate this mode, select **Administrator mode** from the **Mode** menu. If an **administrator password** is set, enter it and click **OK**. Otherwise, leave the text field blank and click **OK**.



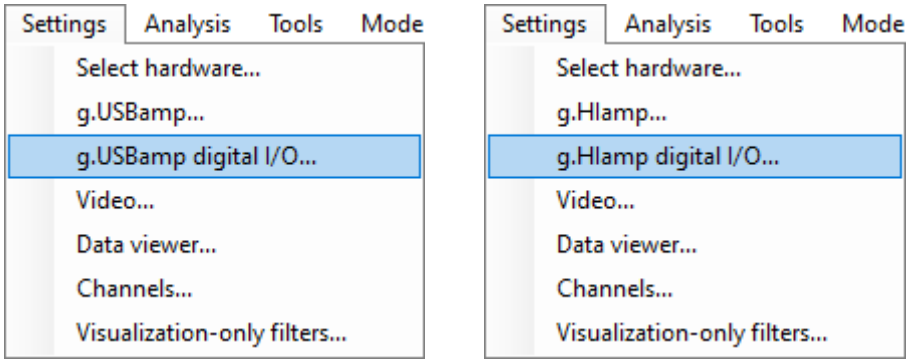


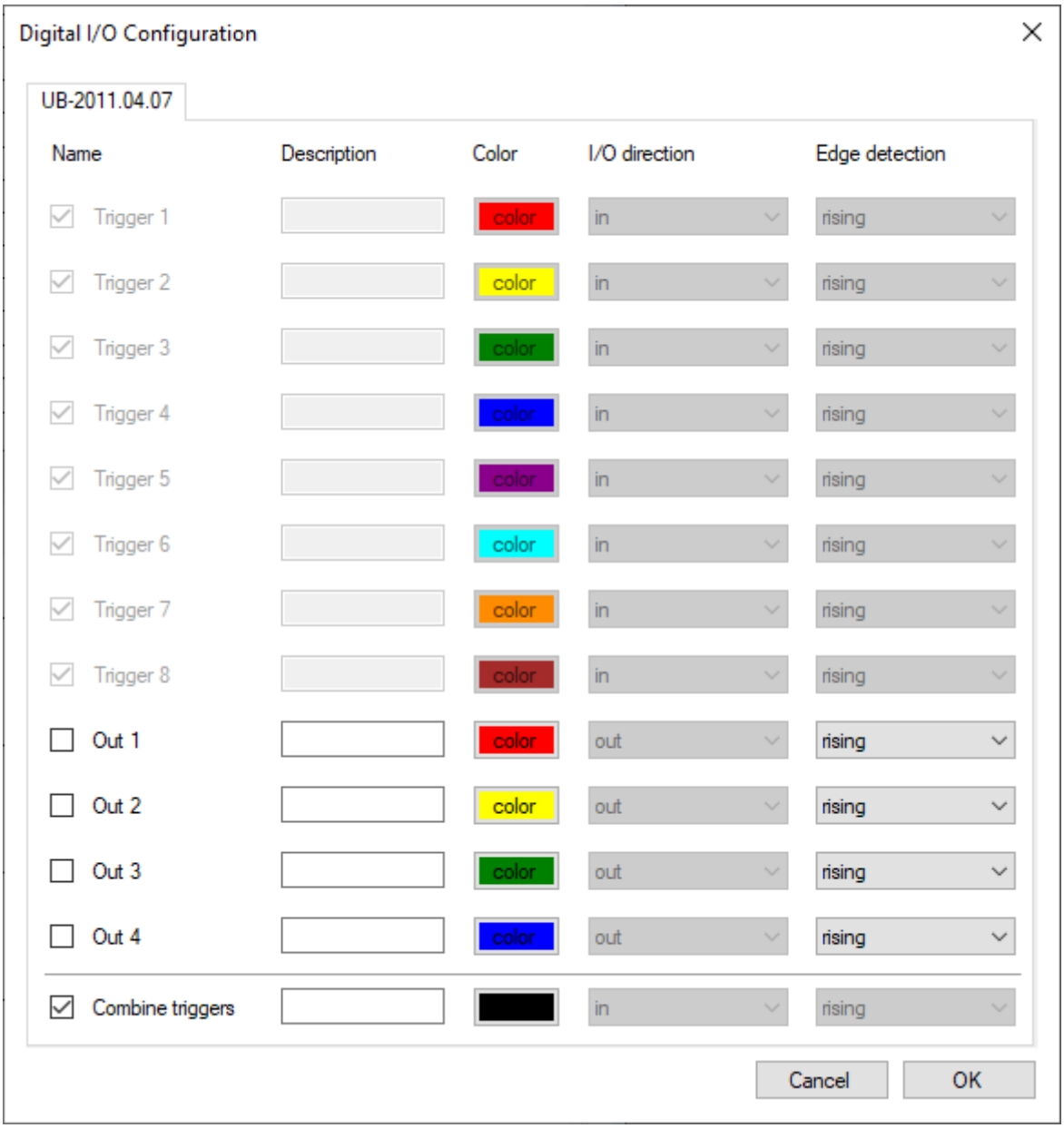
Select a g.HIamp or a g.USBamp for data acquisition. Open the **Select hardware** dialog from the **Settings** menu and select the desired g.tec amplifier.



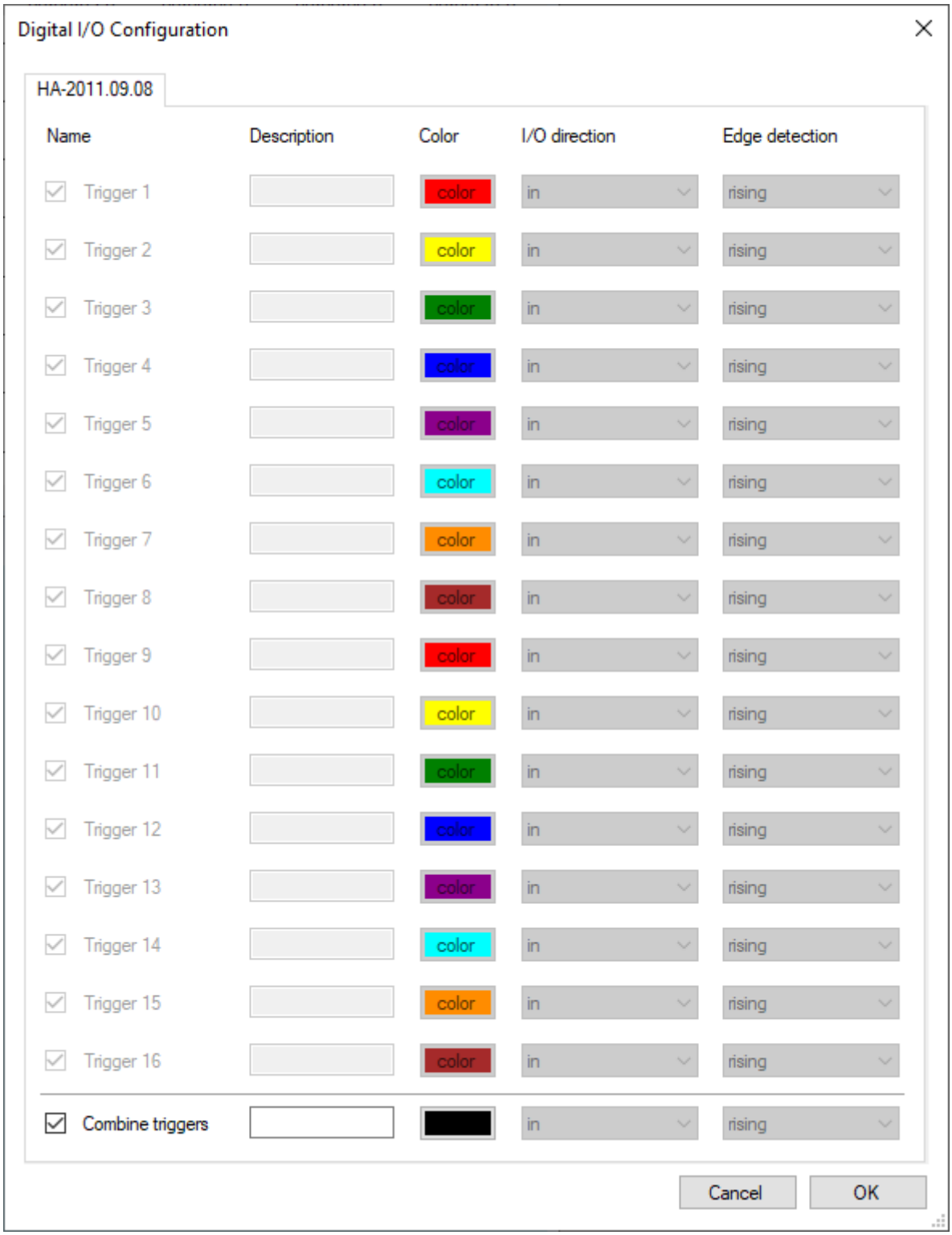


Open the **Digital I/O Configuration** dialog of the selected amplifier from the **Settings** menu and enable **Combine triggers** in the **Digital I/O Configuration** dialog. The combine triggers feature allows for acquisition of multiple trigger lines sychronously and assignment of event codes depending on the trigger appearence. This allows data to be received and interpreted via the parallel port.





Digital I/O Configuration dialog for g.USBamp

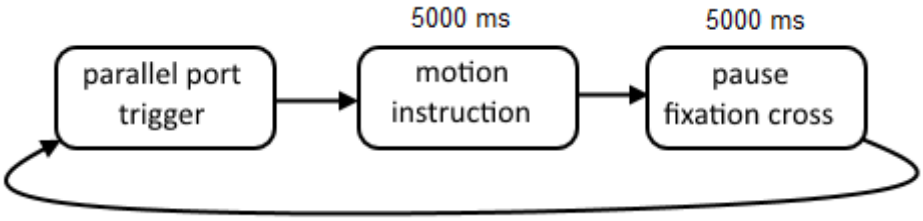


Digital I/O Configuration dialog for g.HIamp

7.5 PARADIGM CREATION

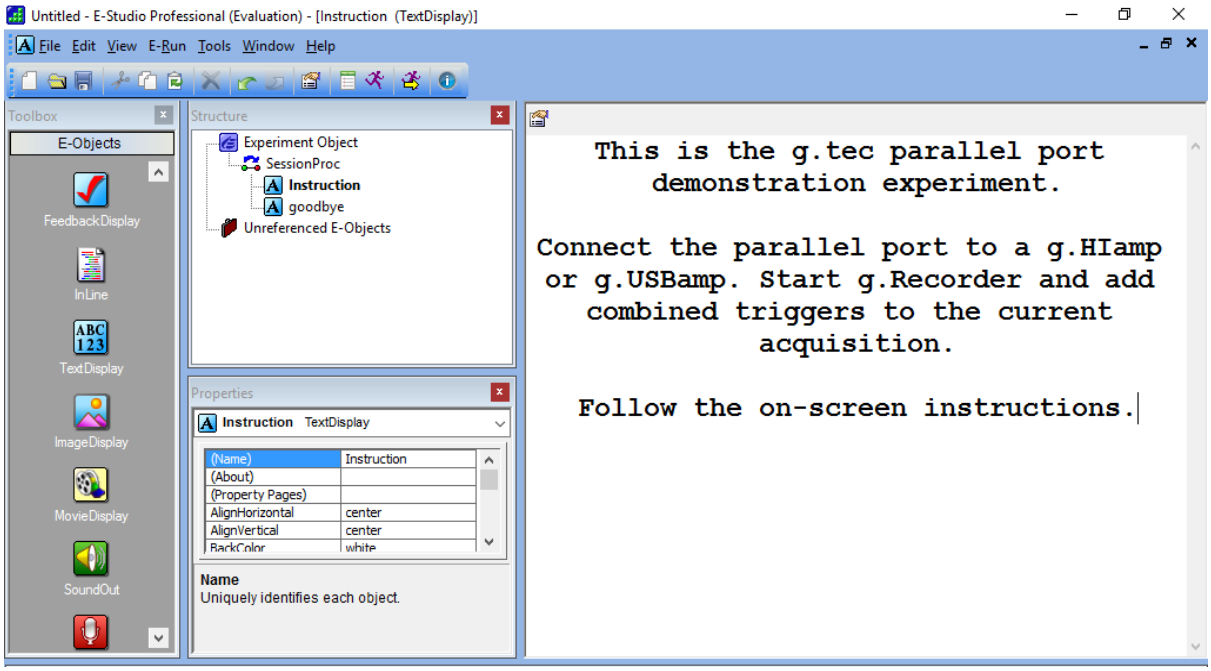
A simplified motor imagery paradigm is used to illustrate the collaboration of **g.Recorder** and **E-Prime** or **Presentation**. The subject has to follow the instructions on the screen and move their left or right arm or leg according to the instruction that is displayed. At the start of a movement instruction,

an event code is sent via parallel port to a g.tec amplifier and consequently to g.Recorder. One cycle lasts eight seconds consisting of the trigger transmission, a four second motion instruction and a four second break. The whole cycle is executed 25 times.

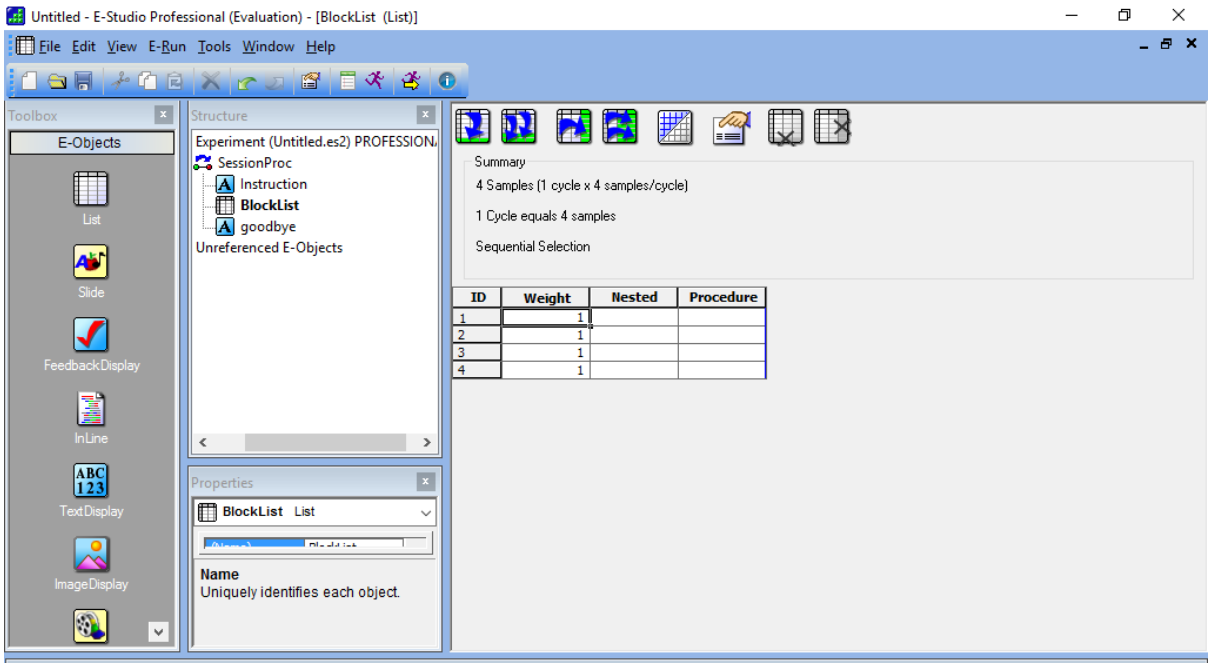


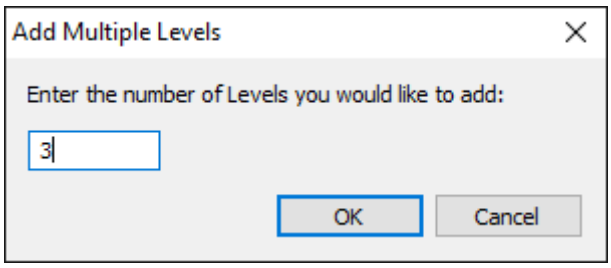
7.5.1 E-PRIME

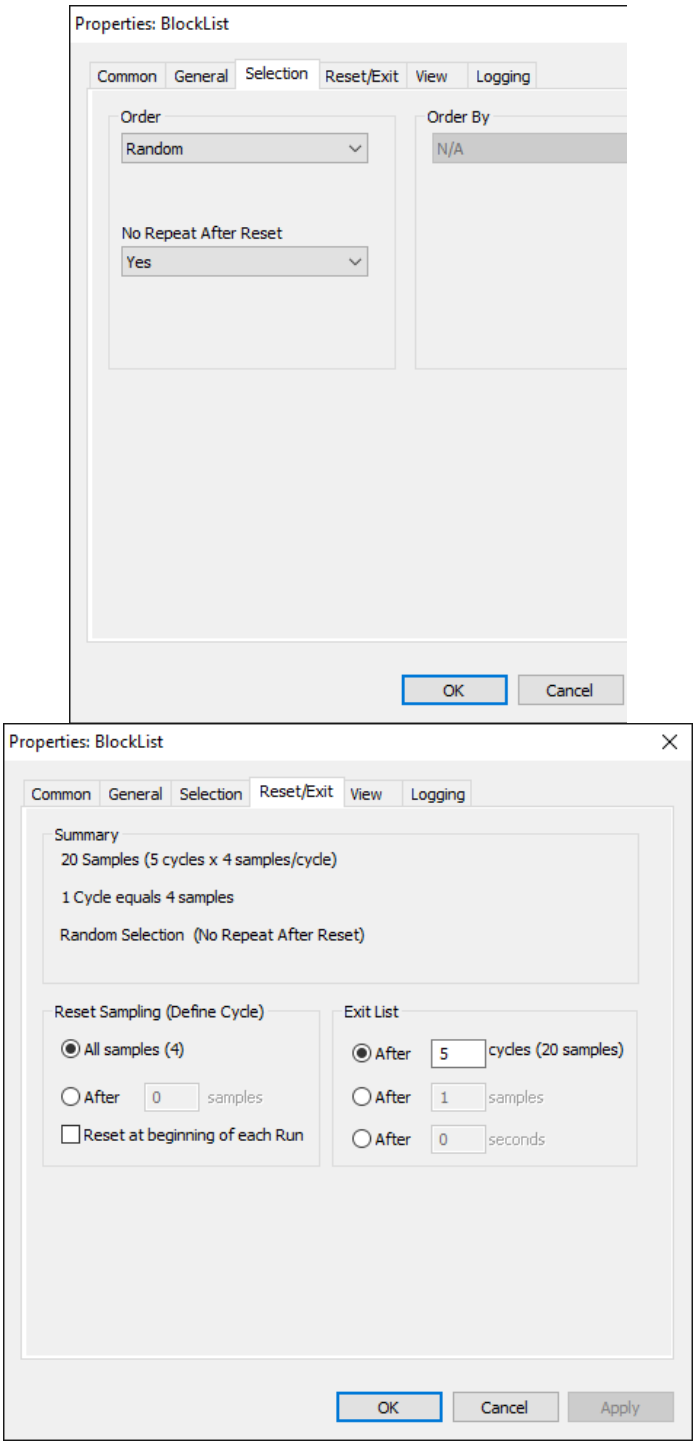
Start **E-Prime** 2.0 and create a new experiment. Add some instruction text by dragging a **Text Display** object from the **E-Objects** at the left-hand side into the main procedure called **SessionProc**. Set the duration to 5000 ms.



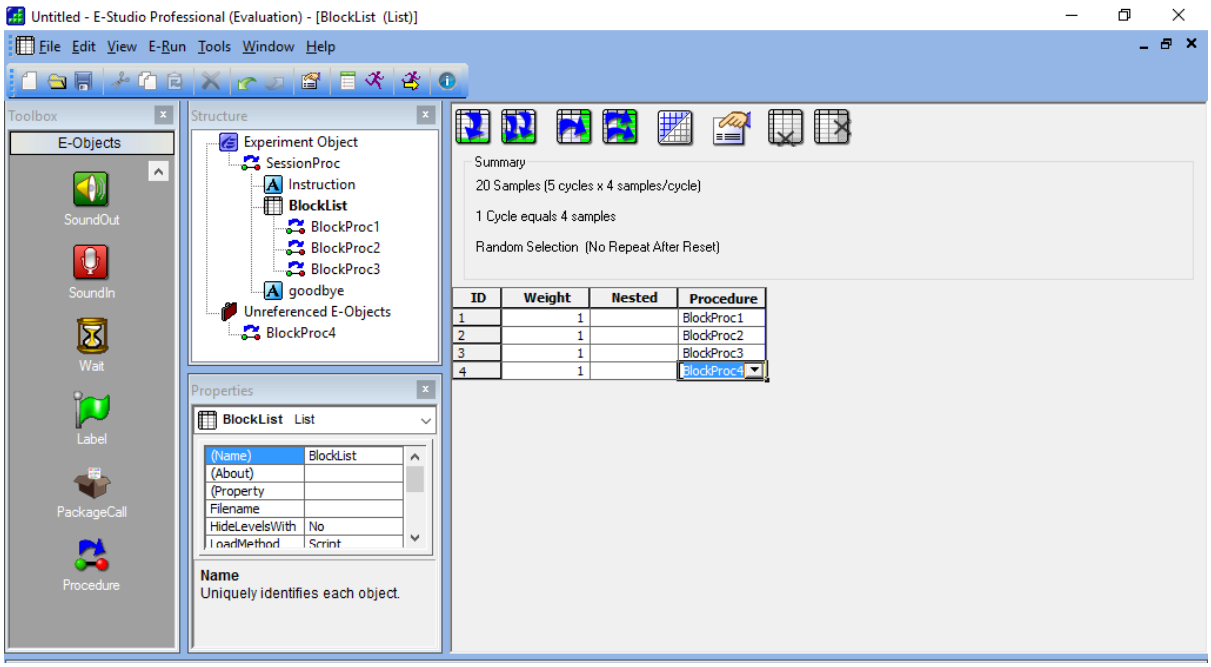
Add a **List** object to the current experiment. Select **Add Multiple Levels** and add three additional lines to the list. Open the list properties and set the order to random at the **Selection** tab. Set the number of cycles to 5 at the **Reset/Exit** tab.


Untitled - E-Studio Professional (Evaluation) - [BlockList (List)]
File Edit View E-Run Tools Window Help
Toolbox
E-Objects
List
Slide
FeedbackDisplay
InLine
TextDisplay
ImageDisplay
Structure
Experiment (Untitled.es2) PROFESSIONAL
SessionProc
Instruction
BlockList
goodbye
Unreferenced E-Objects
Properties
BlockList List
Name
Uniquely identifies each object.
Summary
4 Samples (1 cycle x 4 samples/cycle)
1 Cycle equals 4 samples
Sequential Selection
ID
Weight
Nested
Procedure
1
2
3
4

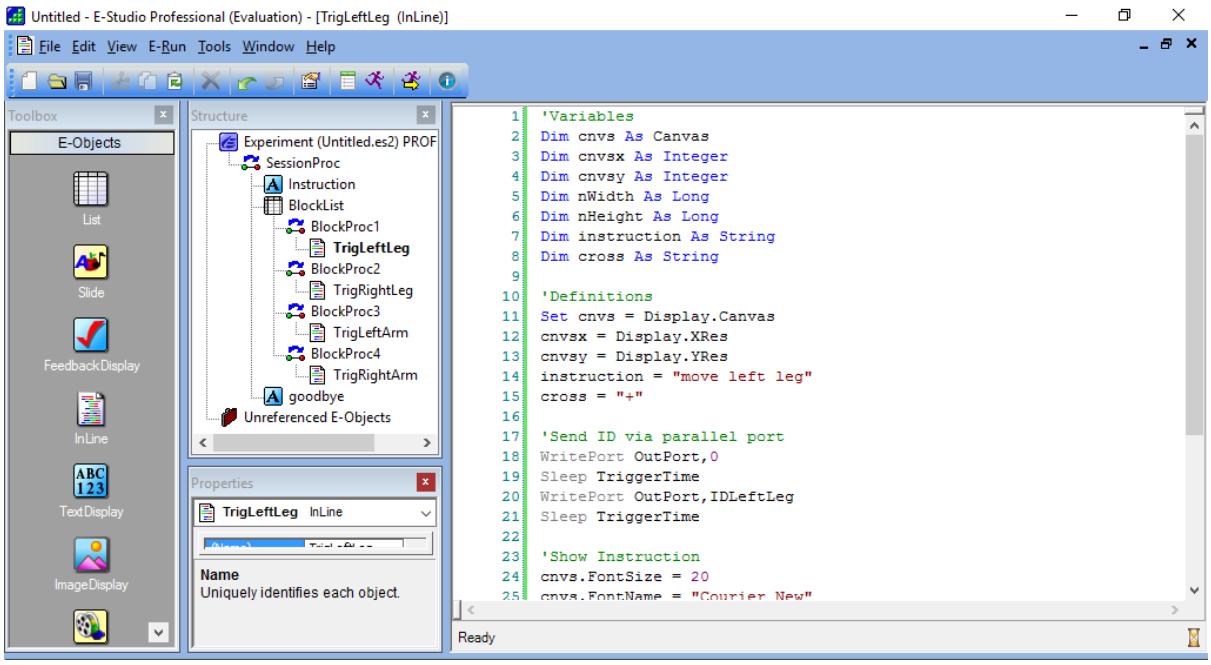

Add Multiple Levels
Enter the number of Levels you would like to add:
3
OK
Cancel



Drag four **Procedure** objects from the **E-Objects** list to **Unreferenced E-Objects** in the experiment. Assign the procedures to the list by selecting the procedures in the intended column of the table.



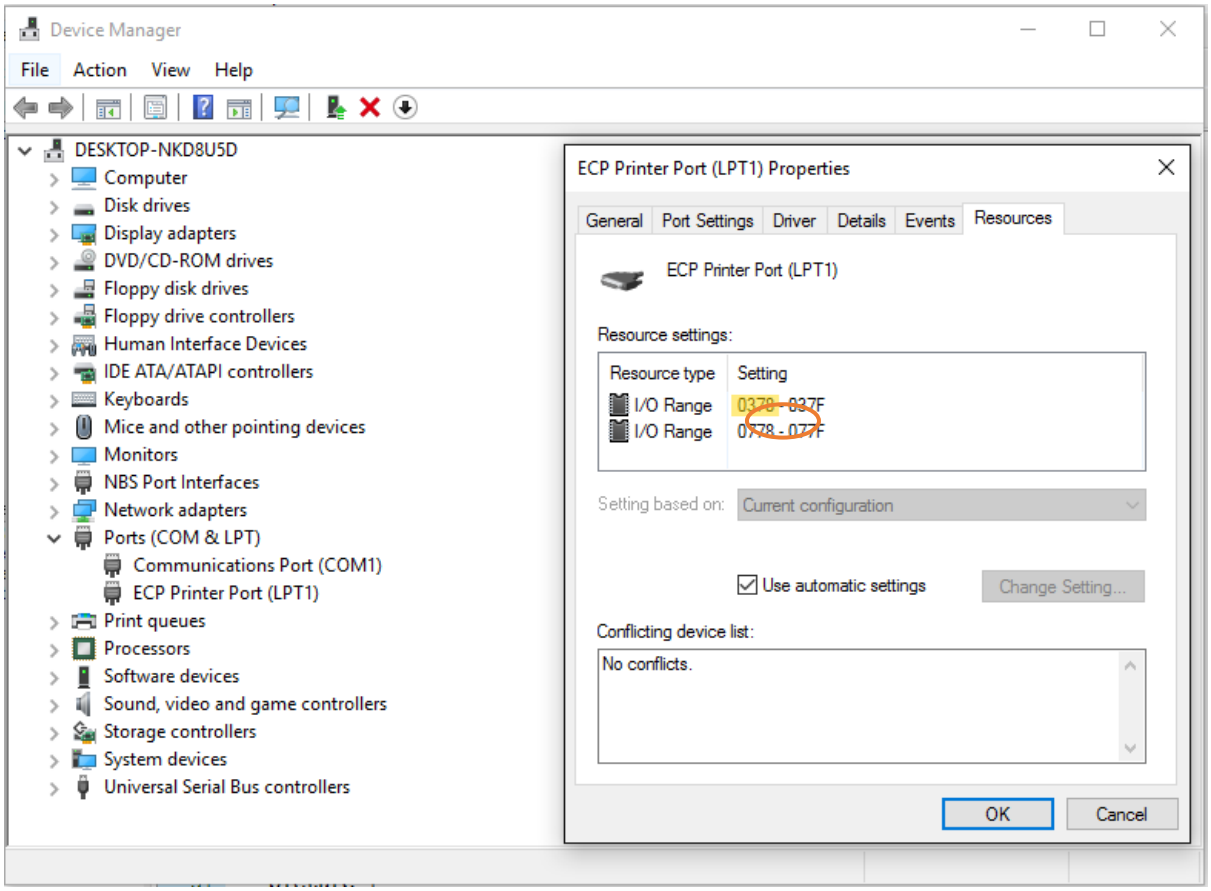
Add an **InLine** object to every procedure in the list. Each **Procedure** containing an **InLine** object represents a trigger → motion instruction → pause cycle. Copy the code underneath into each **InLine** object and change `IDLeftLeg` to `IDRightLeg`, `IDRightArm` or `IDLeftArm`; and the instruction in quotes from the line `instruction = "move left leg"` to `"move right leg"`, `"move left arm"` or `"move right arm"`.



Code

```
'Variables
Dim cnvs As Canvas
Dim cnvsx As Integer
Dim cnvsy As Integer
Dim nWidth As Long
Dim nHeight As Long
Dim instruction As String
Dim cross As String

'Definitions
Set cnvs = Display.Canvas
cnvsx = Display.XRes
cnvsy = Display.YRes
instruction = "move left leg"
cross = "+"

'Send ID via parallel port
WritePort OutPort,0
Sleep TriggerTime
WritePort OutPort,IDLeftLeg
Sleep TriggerTime

'Show Instruction
cnvs.FontSize = 20
cnvs.FontName = "Courier New"
cnvs.Clear
cnvs.CalculateTextSize instruction, nWidth, nHeight
cnvs.Text cnvsx/2-nWidth/2, cnvsy/2-nHeight/2, instruction
Sleep Pause

'Pause
Display.Canvas.Clear
cnvs.CalculateTextSize cross, nWidth, nHeight
cnvs.Text cnvsx/2-nWidth/2, cnvsy/2-nHeight/2, cross
Sleep Pause
```

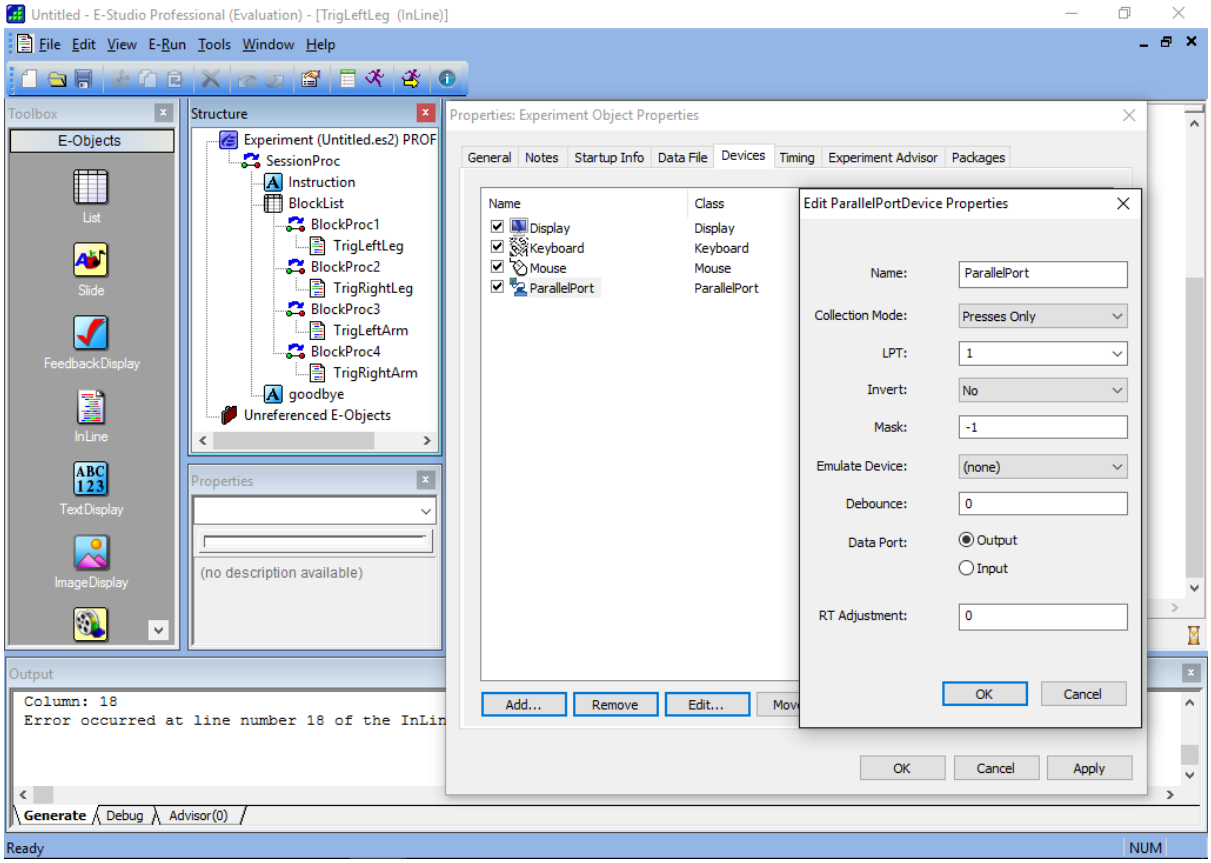
Press **Alt+5** and open the **User** tab at the left corner. Copy the code below and change the **OutputPort** to your individual parallel port address. The timing and event codes sent via parallel port can be changed in the code snippet. The parallel port address can be found at the **Resources** tab of the parallel port's **Properties** window under the **Ports (COM & LPT)** section in Windows' **Device Manager**. The parallel port address range is highlighted in the **Resource settings** table as displayed in the image below.



Code

```
'Parallel Port configuration
Const OutPort As Integer = &h378

'Time Settings for trigger, instructions and pause
Const TriggerTime As Integer = 1
Const Pause As Integer = 4000

'Trigger IDs
Const IDLeftLeg As Integer = 10
Const IDRightLeg As Integer = 20
Const IDLeftArm As Integer = 30
Const IDRightArm As Integer = 40
```

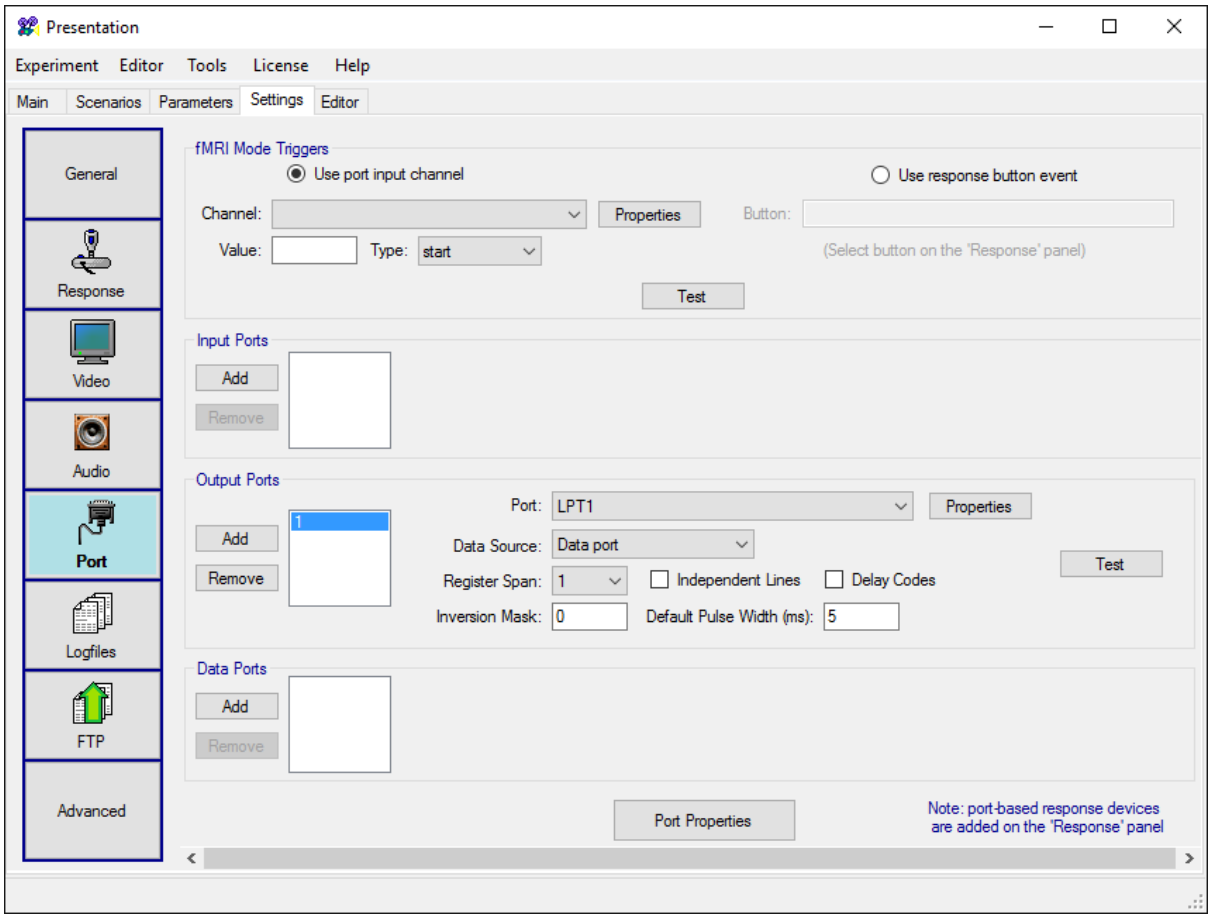
Double-click **Experiment**, change to the **Devices** tab and add the parallel port to the device configuration.



Finally, start the experiment by clicking run ( ).

7.5.2 PRESENTATION

Open **Presentation** and create a new experiment. Open the **Settings** tab and add the parallel port to the current experiment. Open the **Editor** tab and copy the code underneath.



Code

```
default_font_size = 48;
write_codes = true;
pulse_width = 10;
begin;

#screen instructions
array {
   text { caption = "move left leg"; }txt;
   text { caption = "move right leg"; };
   text { caption = "move left arm"; };
   text { caption = "move right arm"; };
} txtarr;

#stimulus event/display instruction and send event code
trial {
   trial_duration = 5000;
   stimulus_event {
            picture {
```

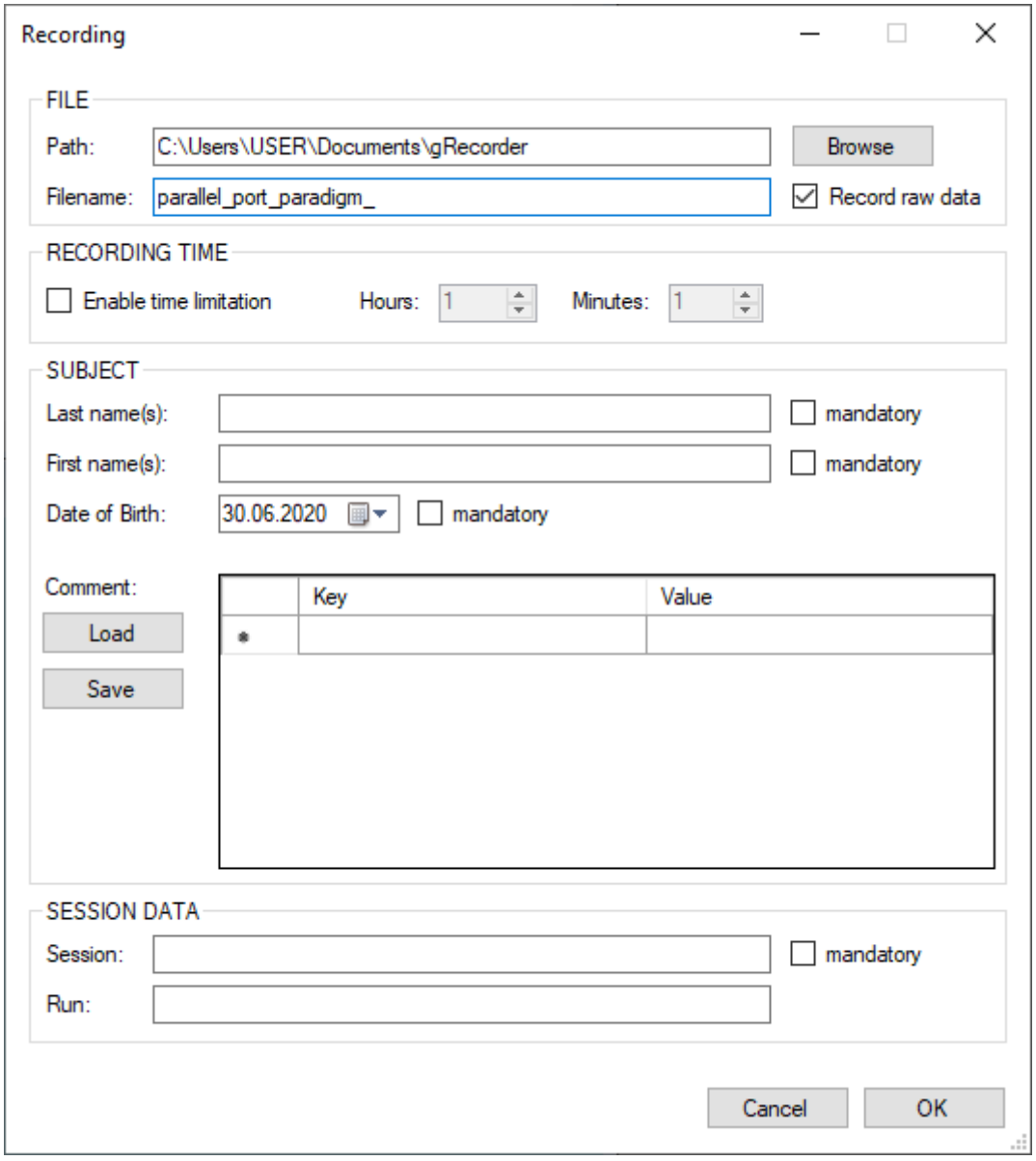
```
         text txt;
         x = 0; y = 0;
      } pic0;
      time = 0;
      duration = 4000;
      port_code = 10;
   } event1;
} main_trial;

#fixation cross
trial{
      picture {
            text {caption = "+";};
            x = 0; y = 0;
      } pic1;
      time = 0;
   duration = 4000;
}cross;

#introduction
trial{
      picture {
            text {caption = "This is the g.tec parallel \n port
demonstration experiment.\n \n Connect the parallel port to a g.HIamp. \n
Start g.Recorder and add combined \n triggers to the current
acquisition.";};
            x = 0; y = 0;
      } pic2;
      time = 0;
   duration = 5000;
}intro;

#outro
trial{
      picture {
            text {caption = "Enjoy working! \n \n your g.tec-team";};
            x = 0; y = 0;
      } pic3;
      time = 0;
   duration = 5000;
}outro;

#main function
begin_pcl;

array <int> eventcodes[4] = { 10, 20, 30, 40};

intro.present();
loop int j = 1 until j > 5 begin
      loop int i = 1 until i > txtarr.count() begin
            int rand = random(1,4);
            pic0.set_part( 1, txtarr[rand] );
            event1.set_event_code( txtarr[rand].description() );
            event1.set_port_code(eventcodes[rand]);
            main_trial.present();
            cross.present();
            i = i + 1
      end;
      j = j + 1;
```

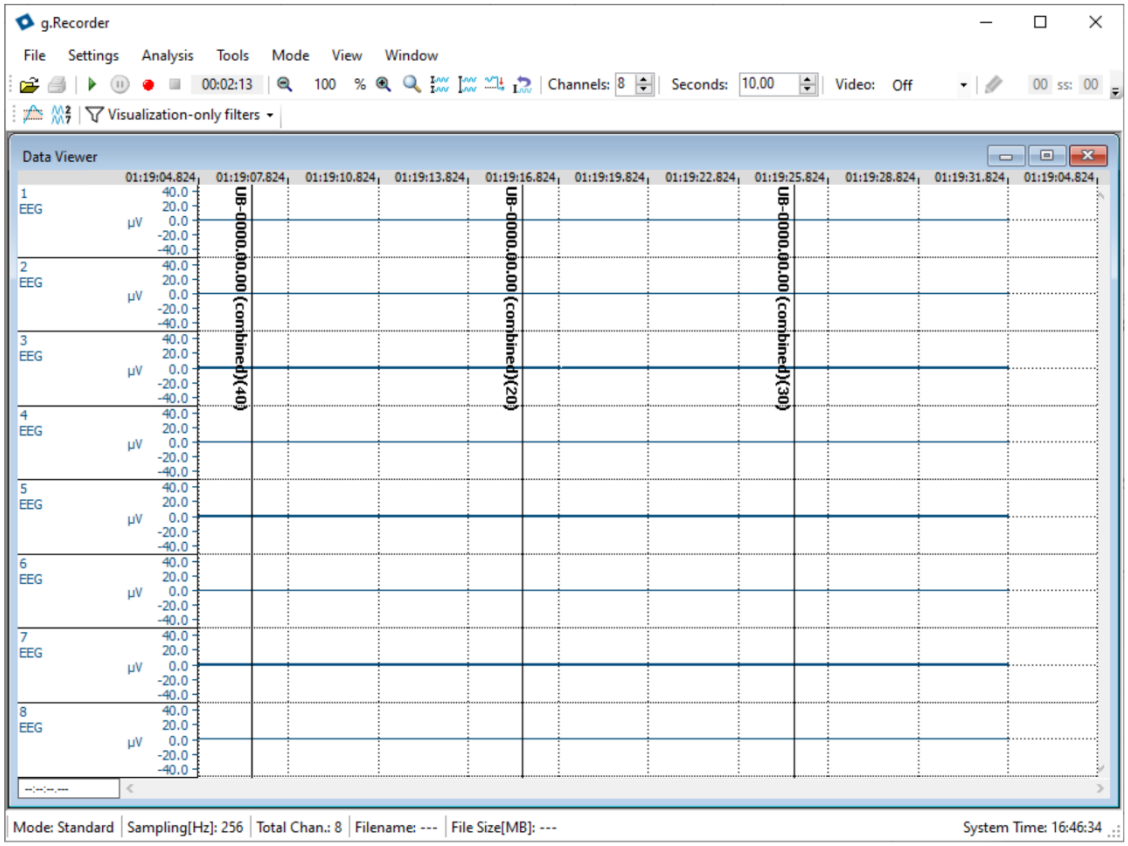
```
end;
outro.present();
```

Finally, start the experiment by clicking **Run Scenario** ( ) in the **Editor** tab.

7.6 RUNNING g.RECORDER

Connect to a g.HIamp or a g.USBamp and configure g.Recorder as described previously. Start a recording session by clicking Record ( ), enter a **Path** and **Filename** and confirm the recording dialog with **OK**. Run the previously configured **E-Prime** or **Presentation** paradigm. The event codes defined in the paradigm should be received, displayed and recorded by g.Recorder. Stop ( ) the recording session after the paradigm is finished.




g.Recorder
File
Settings
Analysis
Tools
Mode
View
Window
00:02:13
100
%
Channels: 8
Seconds: 10,00
Video: Off
Visualization-only filters
Data Viewer
01:19:04.824
01:19:07.824
01:19:10.824
01:19:13.824
01:19:16.824
01:19:19.824
01:19:22.824
01:19:25.824
01:19:28.824
01:19:31.824
01:19:04.824
UB-0000.00.00 (combined)(40)
UB-0000.00.00 (combined)(20)
UB-0000.00.00 (combined)(30)
EEG
µV
40.0
20.0
0.0
-20.0
-40.0
Mode: Standard
Sampling[Hz]: 256
Total Chan.: 8
Filename: ---
File Size[MB]: ---
System Time: 16:46:34


g.RECORDER
BIOSIGNAL RECORDING SOFTWARE