Menu Wave Guide

DISCLAIMER

Sending Your Comments and Critiques: We'd like to hear from you. Your comments and suggestions for improving this document are welcome and appreciated. Please e-mail your feedback to BrainX@live.com

Thank you.

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Warnings and Cautions

This software supports both magnetoencephalography (MEG) and electroencephalography (EEG) data. Though MEG and EEG waveforms appear similar, they have different unit in amplitude. If the MEG and EEG data recorded simultaneously, their time unit or temporal resolution is typically the same.

Modern MEG/EEG systems typically have MEG/EEG sensor/electrode channels as well as other channels. For example, trigger channel, head-localization channels and additional ADC (analog-to-digital) channels. To avoid problems, please pay attention to the channel names and the amplitude value/unit. Their values may be of different orders of magnitude. Unexpected results may occur if their values are mixed in measurements.

When performing waveform analysis, regardless of whether MEG or EEG or both are displayed, ensure that the data are appropriately filtered with DC-offset/linear-trend removal. If the waveforms had very large amplitude (e.g. > 3 pt), it is recommended that you identify possible noise.

The following warnings and cautions appear in this guide. Please ensure you are aware of all the operations and interpretations.

Preface

The Wave menu provides graphic user interface (GUI) for access several functions dealing with the waveforms of the MEG/EEG. Several windows or dialogs such as Filters, Contour maps

Intended Audience

This guide is intended for anyone needing to view or edit data collected using a MEG/EEG system. It assumes the reader is familiar with standard MEG/EEG procedures and with the Windows operating systems.

Document Structure

Documents are generally provided in both Microsoft Word® format and Adobe® Acrobat® PDF (Portable Document Format). All editions are distributed on Flash Driver, CD or websites with the related software, and include bookmarks and hyperlinks to assist navigating the document. Please feel free to send your critiques, corrections, suggestions and comments to MEG_Processor@live.com.

Conventions

Numeric: Numeric values are generally presented in decimal but in special circumstances may also be expressed in hexadecimal or binary. Hexadecimal values are shown with a prefix of 0x, in the form 0x3D. Binary values are shown with a prefix of 0b, in the form 0b00111101. Otherwise, values are presumed decimal.

Units: Units of measure are given in metric. Where measure is provided in imperial units, they are typically shown in parenthesis after the metric units. Magnetic signal strength is given in Teslas (T), the SI unit of flux density (or field intensity) for magnetic fields, also known as the magnetic induction. Typical signal strengths in MEG measurements are in the order of pT (picoteslas = 10^{-12}) or fT (femtoteslas = 10^{-15}).

Waveform Menu

The Wave menu provides graphic user interface (GUI) for access several functions dealing with the waveforms of the MEG/EEG. Several windows or dialogs such as Filters, Contour maps.

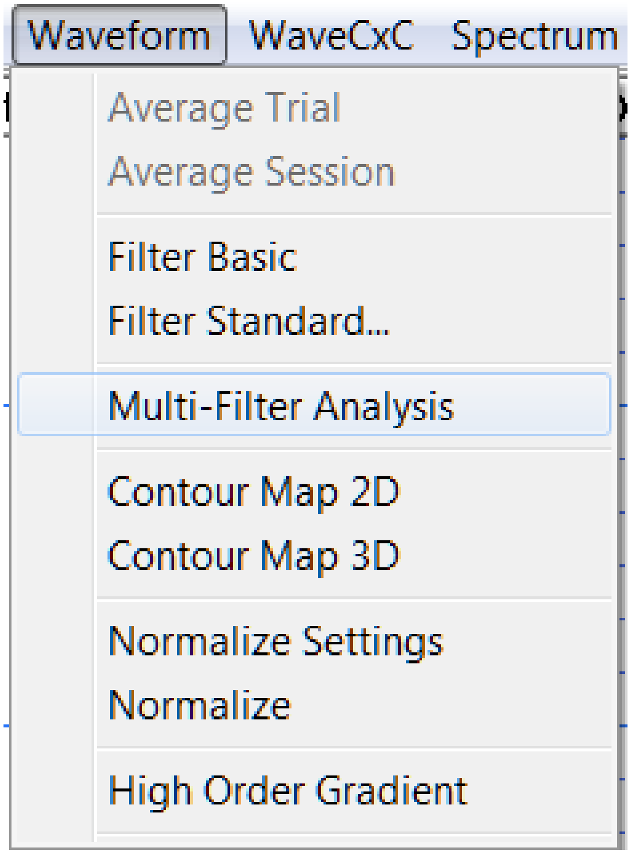

Figure 1. Waveform Menu.

Average Trial

The window of Averager can be launched by selecting the “Average Trial” Menu. Averager is used to generate an average of the data in a single dataset and store the averaged data in a new dataset. Before generating the average, the data to be averaged can be restricted to specific trials and events within a trial.

Averaging In MEG/EEG

In evoked response procedures, a large number of trials are usually recorded. Each includes some stimulus trigger and may involve capturing a response activity by the subject, such as a button press. These stimulus and (optionally) response events are marked in the dataset. Data averaging is used to de-emphasize the signals from brain activity that are not related to a particular evoked response or identifiable event. This process is necessary in order to isolate evoked responses that may become lost in the “noise” of normal brain function. Averaging is commonly used in functional mapping to identify the area of the brain that responds to a stimulus. During each individual trial, the brain's response to the stimulus appears as just one among many brain activities. Averaging a large number of trials tends to "level out" the waveform of the general asynchronous brain activity while preserving a noticeable signal that is synchronized to the known stimulus reference point. The averaged dataset can then be used to analyze the waveform or localize the area responding to the stimulus.

Averaging is performed after a dataset has been acquired and reviewed. Bad channels and trials should have already been classified using waveform viewer to remove them from subsequent processing and analysis. In addition, a specific subset of the data may have been explicitly classified or marked for averaging or other processing. Following averaging, waveform viewer is used to review the resulting averaged dataset and produce reports from it. The averaged data can also be used by other processes such as contour maps, time-frequency analysis and source scanning.

Trials and Epochs

At the foundation of averaging is the concept of an epoch — a range of data synchronized to some identifiable point. An epoch is typically defined by the following:

- A start time offset relative to the target triggering marker
- A reference point, called a target triggering marker
- An end time offset relative to the target triggering marker

In the simplest form, an epoch is an entire trial, defined by the trial synchronization point (time zero), and the time range from the start of the trial to the end. An epoch can be defined by a marker (placed at one or more locations in one or more trials in the dataset) plus time offsets relative to it. The marker is called the "target marker". The epoch is referred to as a "target event".

After finding a set of candidate epochs, you can apply test criteria to select only those candidates that meet the requirements of your particular protocol.

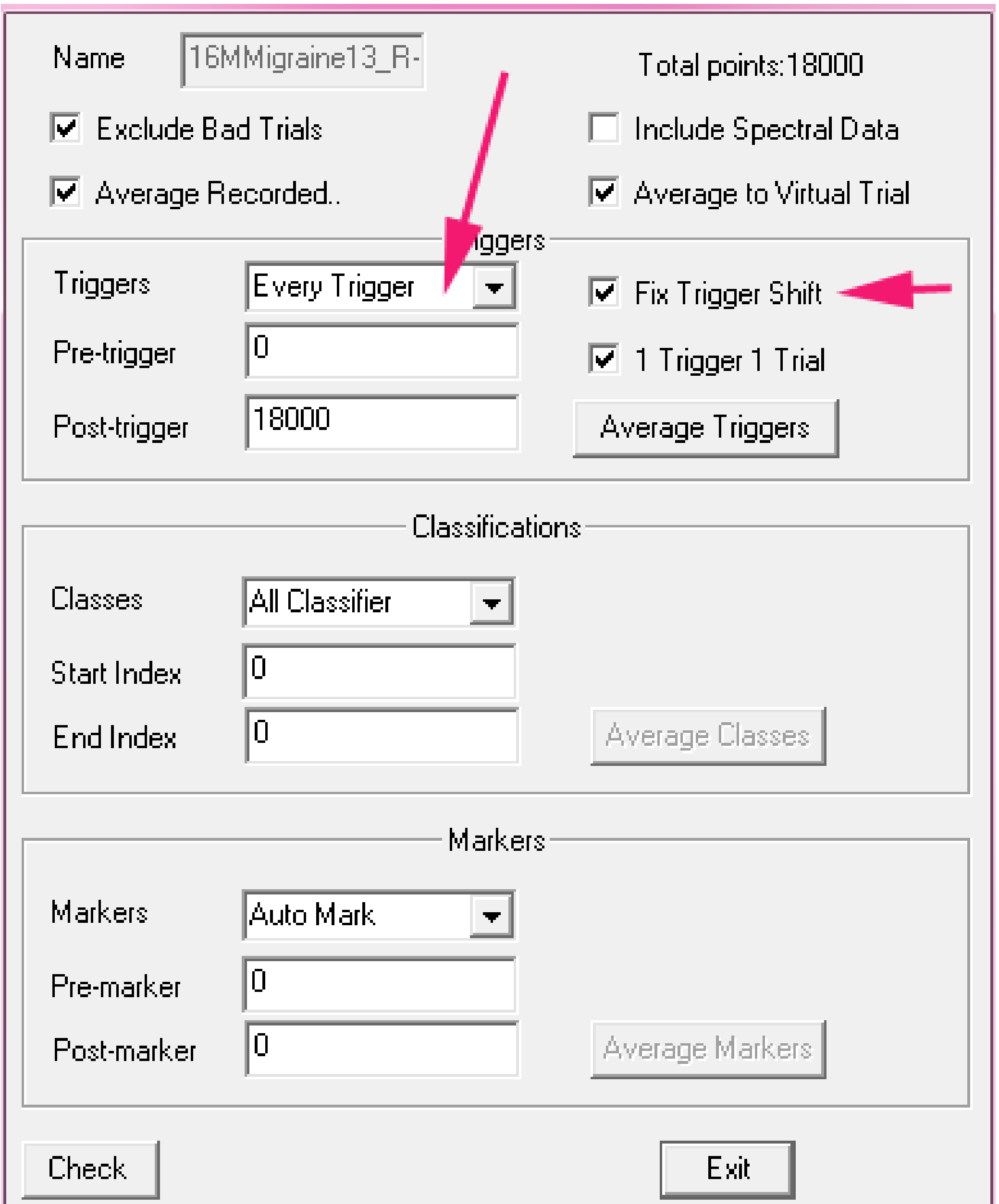

Figure 2. Averager Main Window.

Selecting Dataset and Trial

By default, the active dataset in the Main Frame Viewer will be selected by the averager. To generate an averaged trial, more than one trials are necessary.

"Exclude Bad Trials" check box: defines if the averaging will excluded bad trials. "Bad Trial" can be set in the Main Frame viewer. The information about "bad" or "good" trial is displayed at the left-bottom corner of the main frame viewer.

“Average Recorded” check box: defines if the averaging will include recorded trials. This software supports both recorded trials and the “virtual trials”. Virtual trials can be averaged trials.

“Include Spectral Data” check box: if the trials have spectral data, the averaging process can include the spectral data. The spectral size (time and frequency dimension) must be the same for all the trials.

“Average to Virtual Trial” check box: since the software supports both recorded and virtual trials, the averaged trials can be stored as virtual trials in the current document. If this check box is unchecked, a new dataset with the averaged trial will be saved to a new document.

Selecting Triggers (Events)

During the process of averaging, you can select to include some candidate epochs and exclude others. Given the basic definition of an epoch, you can apply tests to decide if an event should or should not be included in the average.

In the trigger group, the trigger combo box shows the all possible and available averaged triggers or events. In addition to average each specific trigger, the software has two unique categories: All Trials and Every Trigger.

All trial averaging is one of the common averaging, which is to average all trials.

Every Trigger averaging is to perform averaging for each trigger and then generate a “All Trial Averaged trial.

The pre-trigger edit field provides the capability for users to manually define the time window before the triggers.

The post-trigger edit field provides the capability for users to manually define the time window after the triggers.

By default, the program will automatically check the data and define the best pre- and post-trigger window.

Trigger Shift

In functional MEG/EEG recordings, triggers can be responses or feedbacks such as visual-cue finger tapping or sound-cue finger tapping. Some “triggers” may occur during a recording window and become as “junk” or non-synchronized triggers, which do not initialize or synchronize the recordings. In this case, the time of “junk trigger” may vary among trials. Averaging all trials for such kind of “junk triggers” may not be able to reveal the brain response.

One function in this program is to “Fix Trigger Shift”. The Fix Trigger Shift check box enable the program to automatically check the time-shift for a group of particular triggers and then shift the epoch data to average.

“1 Trigger 1 Trial”: in some functional MEG/EEG experimental designs, the triggers may occur several times in one epoch recordings, such as the auditory-cued finger tapping, subject may tapping more than one time. In this case, the “1 Trigger 1 Trial” may automatically exclude some junk triggers.

Start Averaging

By clicking the "Average Triggers" button, the program will start to average according to the aforementioned settings.

Of note, the title bar of the averaging window shows the progress of the processing.

Selecting Classifications (Events)

During the process of averaging, you can select to include some candidate epochs and exclude others with classifications. Given the basic definition of an epoch, you can apply tests to decide if an event should or should not be included in the average. Since the classification seems to be objective, this function is only available in some version of the software.

By default, trials classified as "bad" are excluded; however, an option exists to include them, if desired. Averager always excludes any "bad" channels from the averaged dataset.

You can use the following criteria to select data that meets specific requirements:

- Include only trials of a specified class
- Exclude trials of a specified class
- Include events that contain another marker (called a "conditional marker") that occurs within a specified time range of the target marker
- Exclude events that contain a conditional marker that occurs within a specified time range of the target marker

Averager is used to set parameters for the more commonly used selection options.

Selecting Markers (Events)

During the process of averaging, you can select to include some candidate epochs and exclude others with markers. Since the classification seems to be objective, this function is only available in some version of the software.

Data Filter

There are several ways to filter MEG/EEG data. Data filtering is a conceptually simple, though powerful technique to extract signals within a predefined frequency band of interest. This off-line data pre-processing step is the realm of digital filtering: an important and sophisticated subfield of electrical engineering. Applying a filter to the data presupposes that the information carried by signals will be mostly preserved, to the benefit of attenuating other frequency components of supposedly, no interest.

Not every digital filter is suitable to the analysis of MEG/EEG traces. Indeed, the performances of filters are defined from basic characteristics such as the attenuation outside the bandpass of the frequency response, stability, computational efficiency and most importantly, the introduction of phase delays. This latter is a systematic by-product of filtering and some filters may be particularly inappropriate in that respect: infinite impulse response (IIR) digital filters are usually more computationally efficient than finite impulse response (FIR) alternatives, but with the inconvenient of introducing non-linear frequency-dependent phase delays; hence some non-equal delays in the temporal domain at all frequencies, which is unacceptable for MEG/EEG signal analysis where timing and phase measurements are crucial. FIR filters delay signals in the time domain equally at all frequencies, which can be conveniently compensated for by applying the filter twice: once forward and once backward on the MEG/EEG time series.

Note however some possible edge effects of the FIR filter at the beginning and end of the time series, and the necessity of a large number of time samples when applying filters with low high-pass cutoff frequencies (as the length of the filter's FIR increases). Hence it is generally advisable to apply digital high-pass filters on longer episodes of data, such as on the original 'raw' recordings, before these latter are chopped into epochs of shorter durations about each trial for further analysis.

Bringing more details to the discussion would reach outside the scope of these pages. The investigator should nevertheless be well aware of the potential pitfalls of analysis techniques in general, and of digital filters in particular. Although commercial software tools are well equipped with adequate filter functions, in-house or academic software solutions should be first evaluated with great caution.

Filter Basic

One of the data filtering modules in this program is Filter Basic that allows filtering MEG/EEG data sets with minimum distortion. The basic filter can be used to suppress unwanted low and high frequency noise or to enhance a periodic pattern around the frequency of interest. This function supports low-pass, high-pass, band-pass, notch and Power Noise filter types.

Filter types, repetition and orders can conveniently be changed via the interface. In addition, DC offset and linear trend can be specified to minimize the background activity in MEG/EEG signals.

The Low pass filter and the High pass filter check boxes allow specifying a filtering range. Importantly, enabling the low but not the high cut-off defines a high-pass filter, whereas enabling the high but not the low cut-off defines a low-pass filter. Enabling both cut-offs defines a band pass filter. A notch filter is also available for suppression of noise in narrow frequency bands, with a customizable central frequency.

The Power Noise check box enables specifying a filter around power line noise and its harmonics.

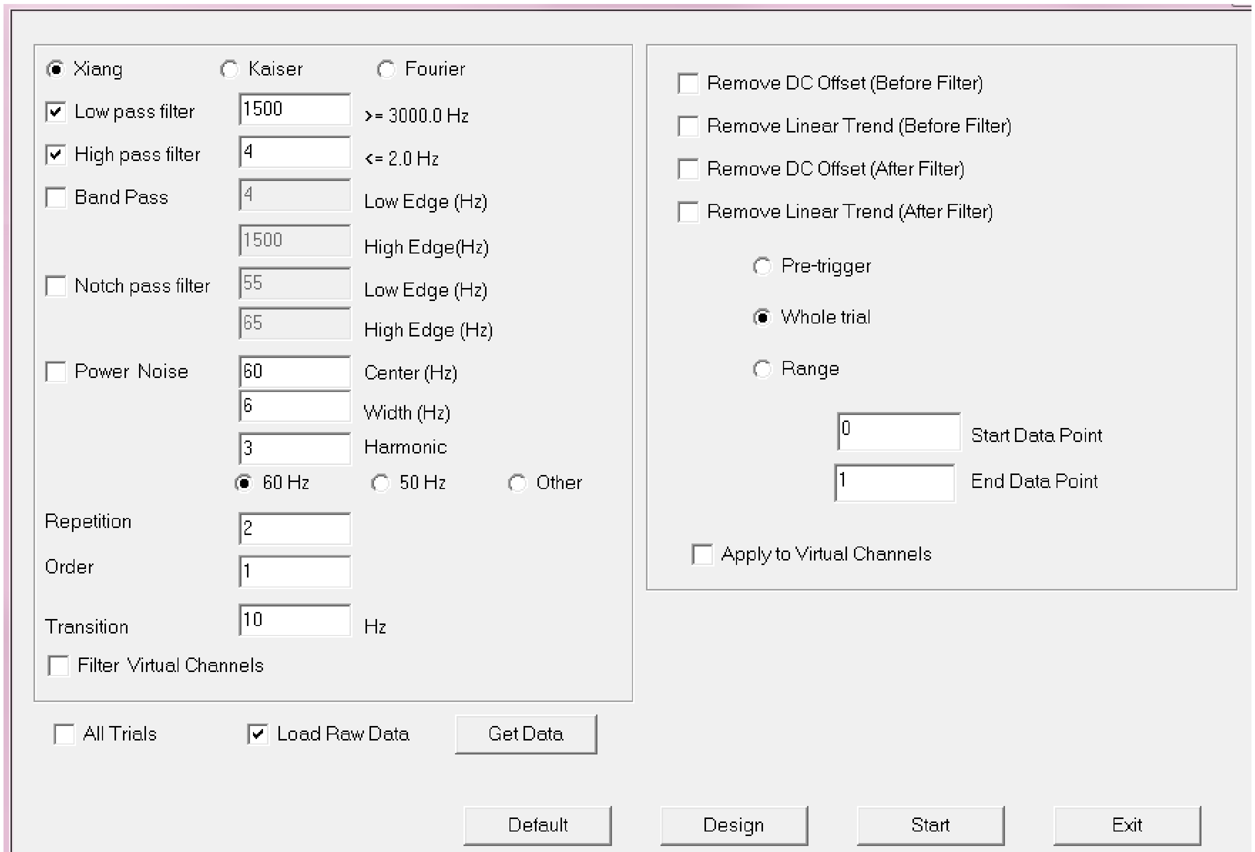

Figure 3. Basic digital filter for MEG/EEG data.

Filter Standard

Another data filtering module in this program is Filter Standard that allows filtering MEG/EEG data sets with sharp waveform. The standard filter can be used to suppress unwanted low and high frequency noise or to enhance a periodic pattern around the frequency of interest. This function supports low-pass, high-pass, band-pass, notch, and Power Noise filter types.

Filter types, repetition and orders can conveniently be changed via the interface. In addition, DC offset and linear trend can be specified to minimize the background activity in MEG/EEG signals.

The Low pass filter and the High pass filter check boxes allow specifying a filtering range. Importantly, enabling the low but not the high cut-off defines a high-pass filter, whereas enabling the high but not the low cut-off defines a low-pass filter. Enabling both cut-offs defines a band pass filter. A notch filter is also available for suppression of noise in narrow frequency bands, with a customizable central frequency.

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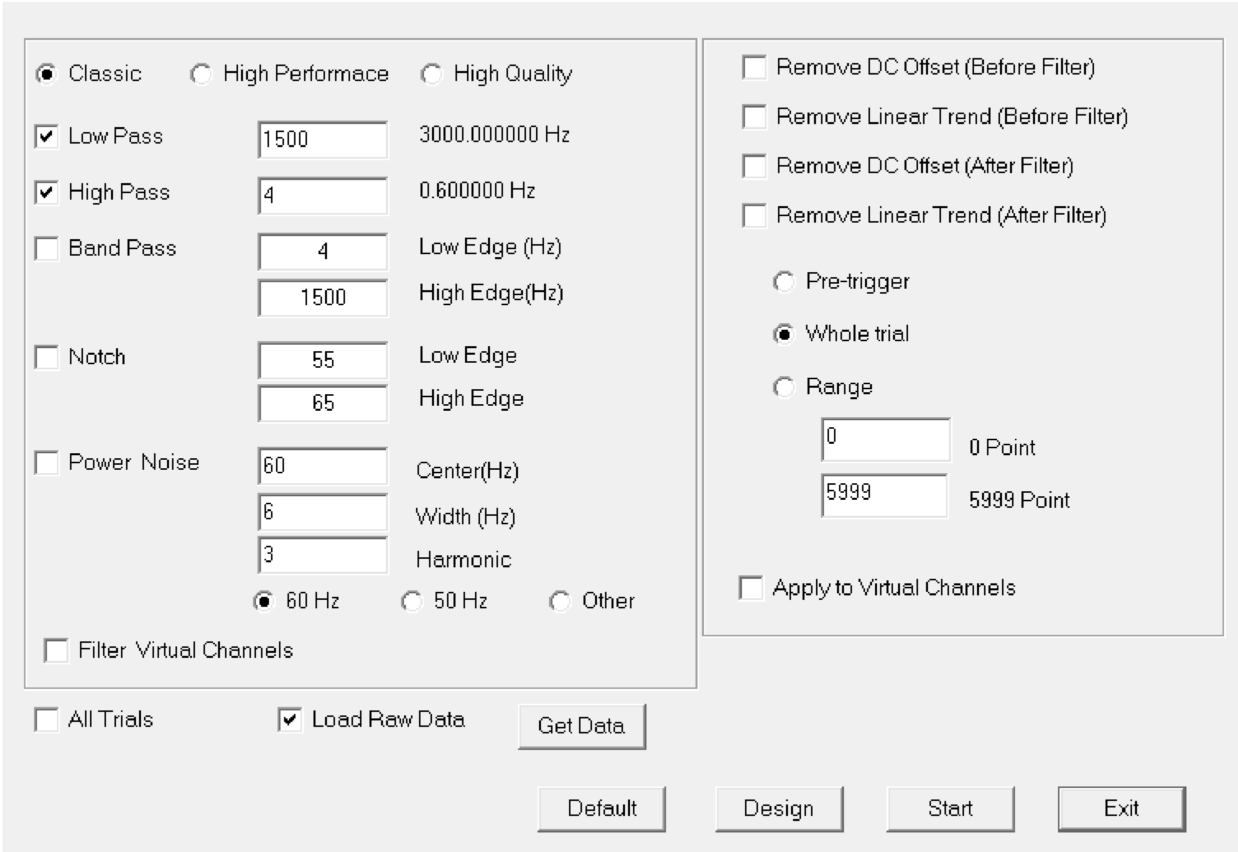

Figure 4. Standard digital filter for MEG/EEG data.

Multi-Filter Analysis

There is no standardized numbers for low-pass, high-pass, band-pass, notch, and Power Noise filter types. Users typically select the filter numbers which result in good waveform. Multi-filter analysis enables the selection of filter parameters much easier by showing the waveforms from a set of filters.

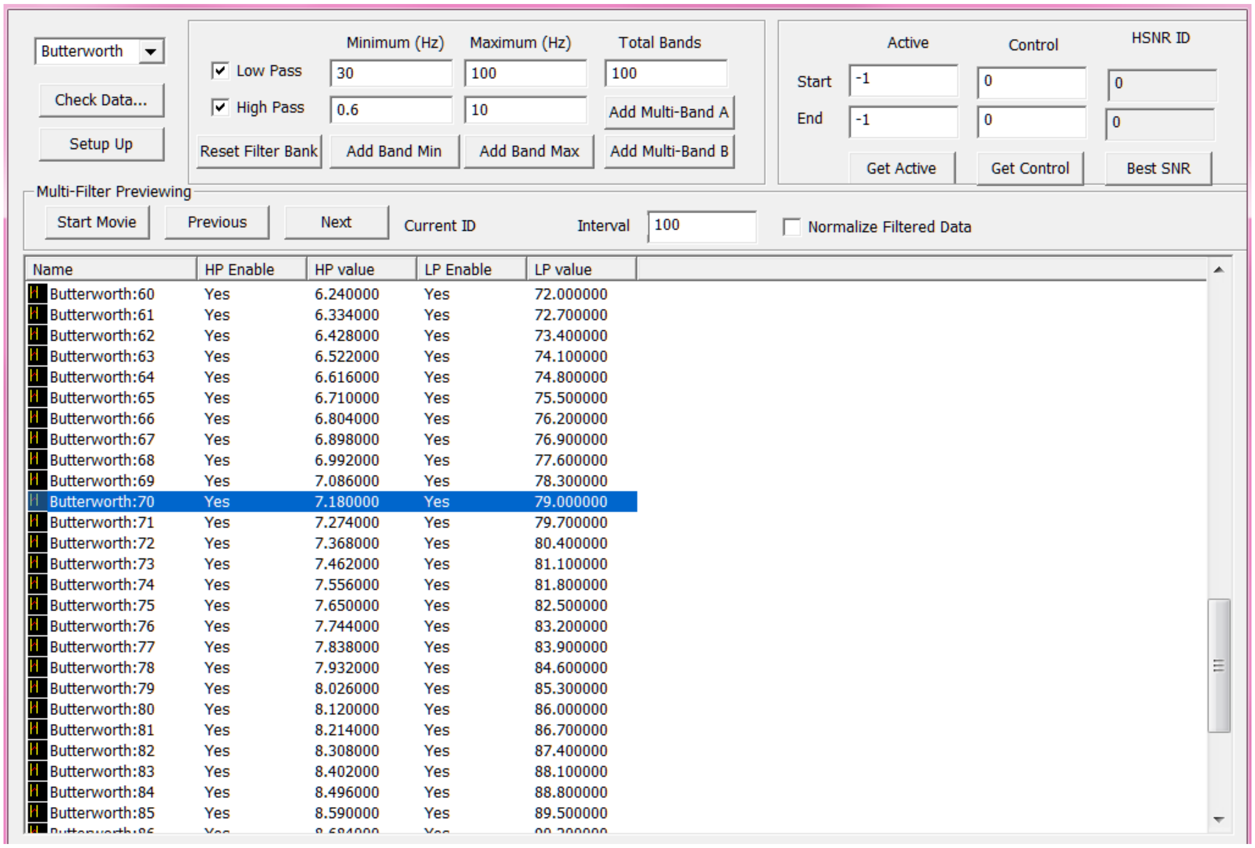

Figure 5. Multi-filter analyses.

Contour Map 2D

You can open a map display panel by selecting Contour Map 2D menu. This function is similar to the Contour Map 2D icon in the main frame.

The Map Display window from which you can display a representation of the trace data in contour map format, complete with the position of each MEG sensor/EEG electrodes.

Contour Field Map 2D

If Field check box is checked, the map shows the field distribution among all sensors.

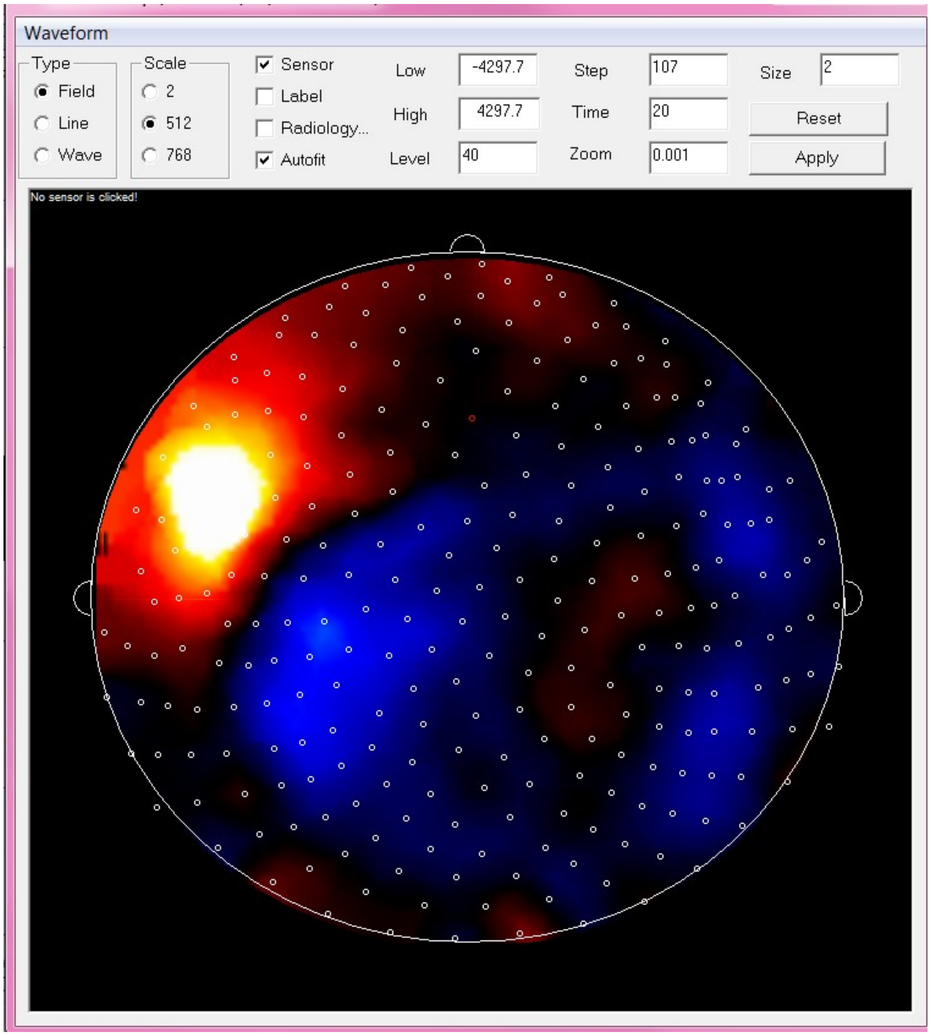

Figure 6. Contour map field 2D.

In the Contour Map 2D window, the small circles represent the positions of each of the MEG and EEG sensors. The time point (defined below each map) is determined by the cursor in the main frame viewer.

The Low (Min) and high (Max) text boxes, appearing under each map, allow you to enter new values for the scale of the contour colors. Any value at or below the minimum value appears black, stepping up through red, into white according to the scale bar. Values at or above the maximum setting appear white and step down through cyan, blue, and indigo, into black. By selecting a value closer to zero, the range of values over which the colors are spread diminishes, giving higher resolution to the values within the range. There are a fixed number of contour lines applied (vary among color scales), so spreading them over a smaller range yields smaller steps between them.

Contour Line Map 2D

If the line check box is checked, the map shows the contour line distribution among all sensors. By selecting a value closer to zero, the range of values over which the colors are spread diminishes, giving higher resolution to the values within the range.

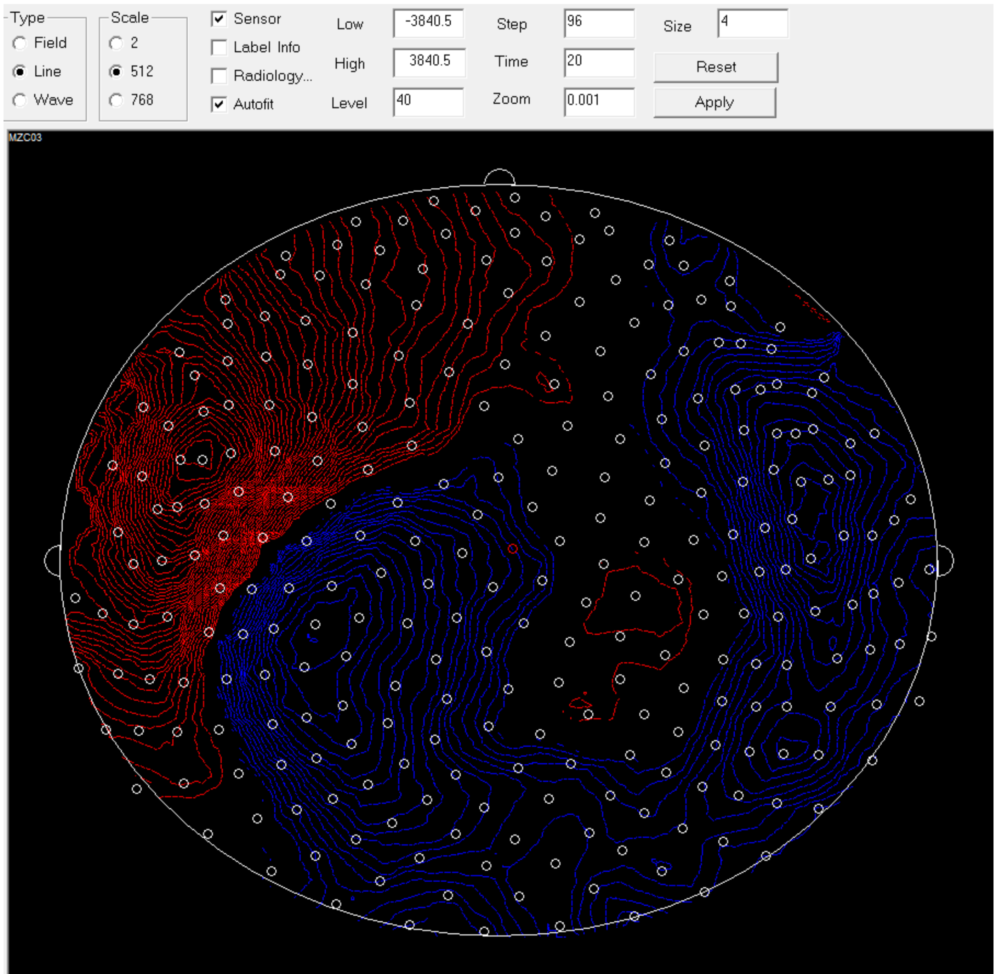

Figure 7. Contour map field 2D.

Contour Wave Map 2D

If the wave check box is checked, the map shows the contour waveform distribution among all sensors. By selecting a value closer to zero, the range of values over which the colors are spread diminishes, giving higher resolution to the values within the range.

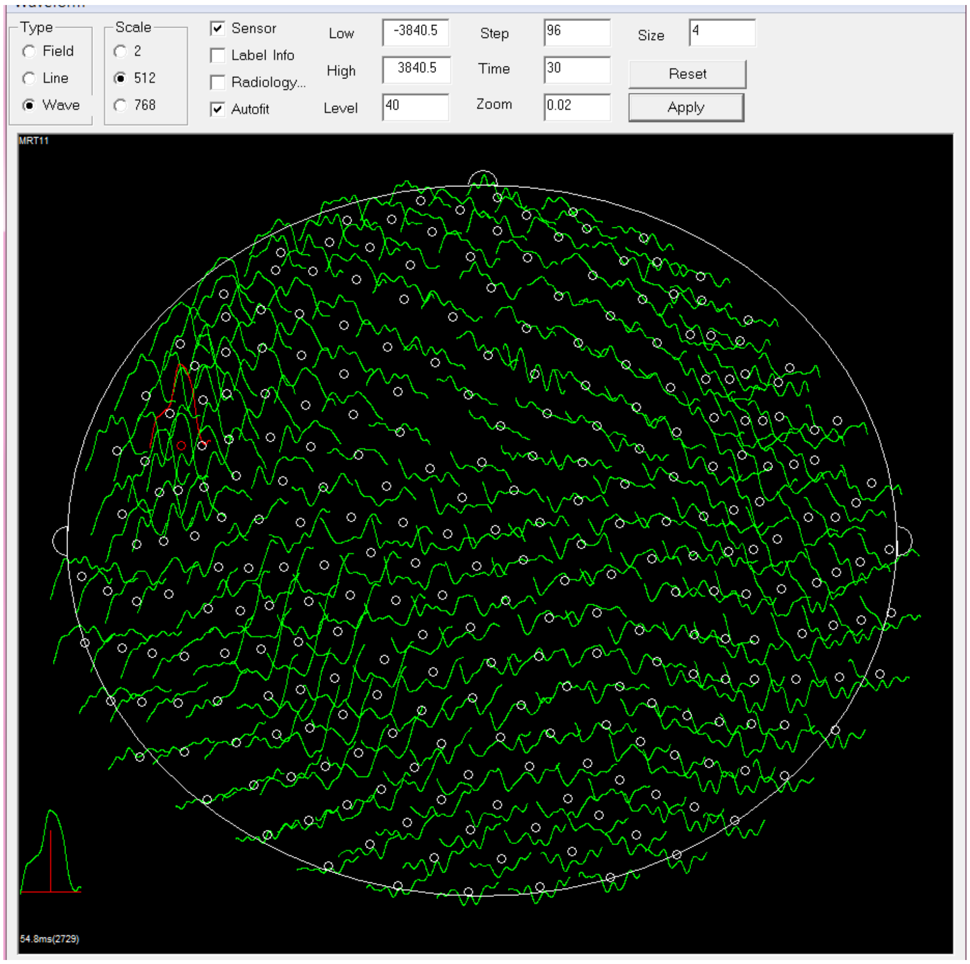

Figure 8. Contour map waveform 2D.

Contour Map 3D

The contour Map 3D provides the distribution of MEG/EEG signals among sensors in 3D. There are several options for display 3D contour map.

Autofit Color: automatically adjust the color scale for any changes of the selection of the waveform.

Autofit Place: automatically adjust the size and position of the contour map according to the size of the window.

Sensor: show/hide the sensors in the contour map

Sensor Act: show/hide the color of the sensor in the contour map. The color in the sensor encodes the amplitude of the waveform.

Contour Map: show/hide the contour map which is formed by all the sensors.

Contour Act: show/hide the color of the contour map. . The color in the contour map encodes the amplitude of the waveform.

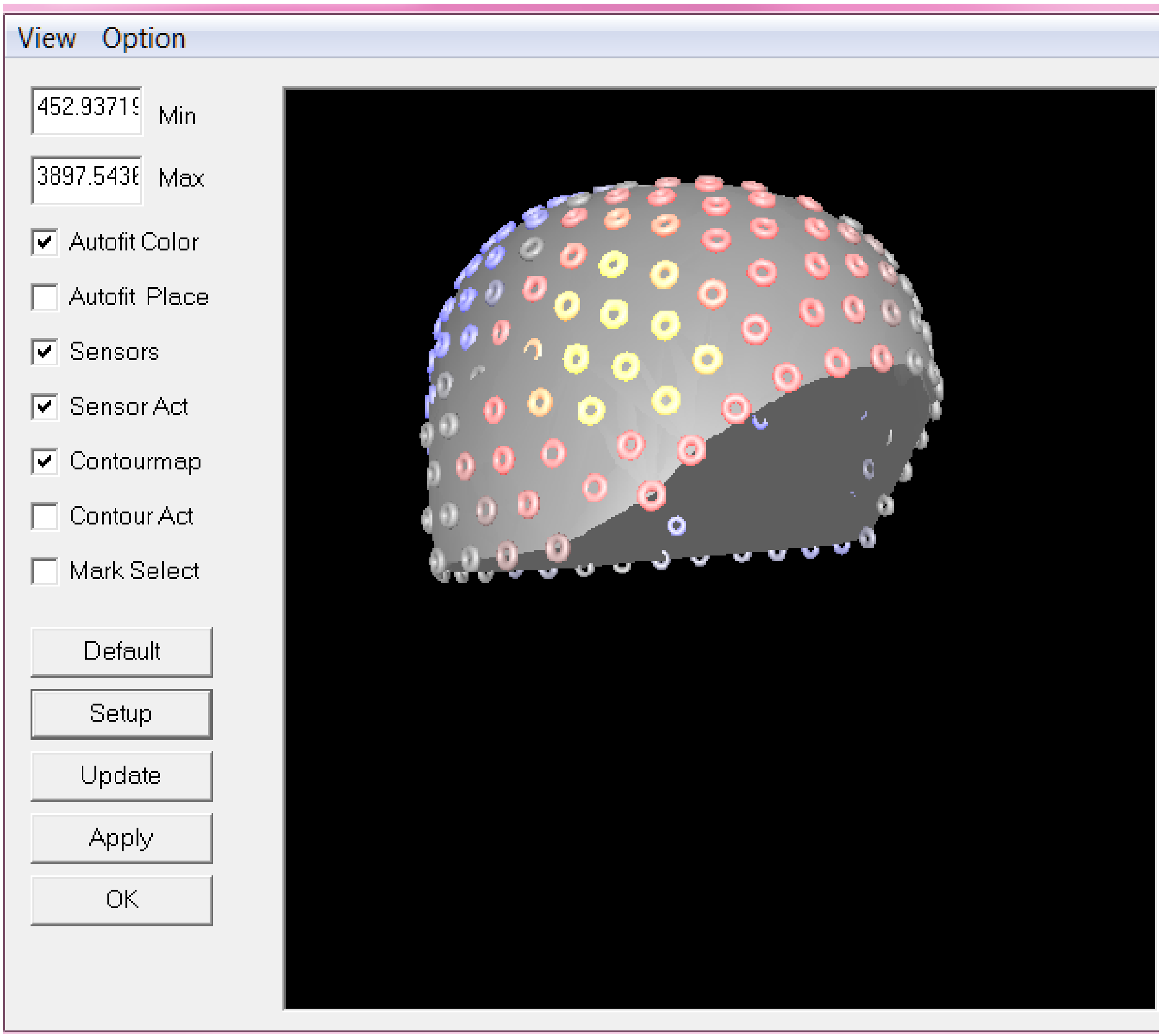

Figure 9. Contour map 3D.

Mark Select: high-light the selected sensor with a 3D cross.

Normalization Settings

The normalization Settings provides the capability to normalize the waveform data by removing the spatial mean. In addition, normalization allows normalizing the amplitude with manually selected ratio.

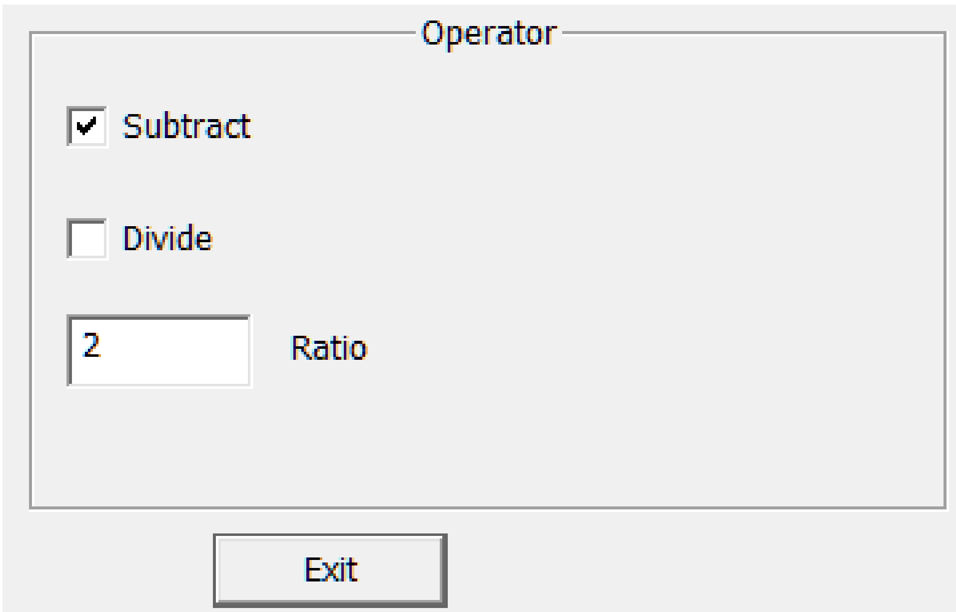

Figure 10. Settings for normalization of MEG/EEG waveform data.

Normalize

By selecting the "Normalize" menu, the program performs the normalization of MEG/EEG data. If the data are normally distributed, the normalization may appear to be similar to the non-normalized data. Otherwise, the spatial distribution of the waveform data may be significantly changed.

High Order Gradient

By selecting the "High Order Gradient" menu, the program launches the high-order gradient window. The window provides all information about the gradient of the MEG system (e.g. coil construction).

Of note, high order gradient varies among MEG system. In addition, EEG systems rarely have high-order gradient.

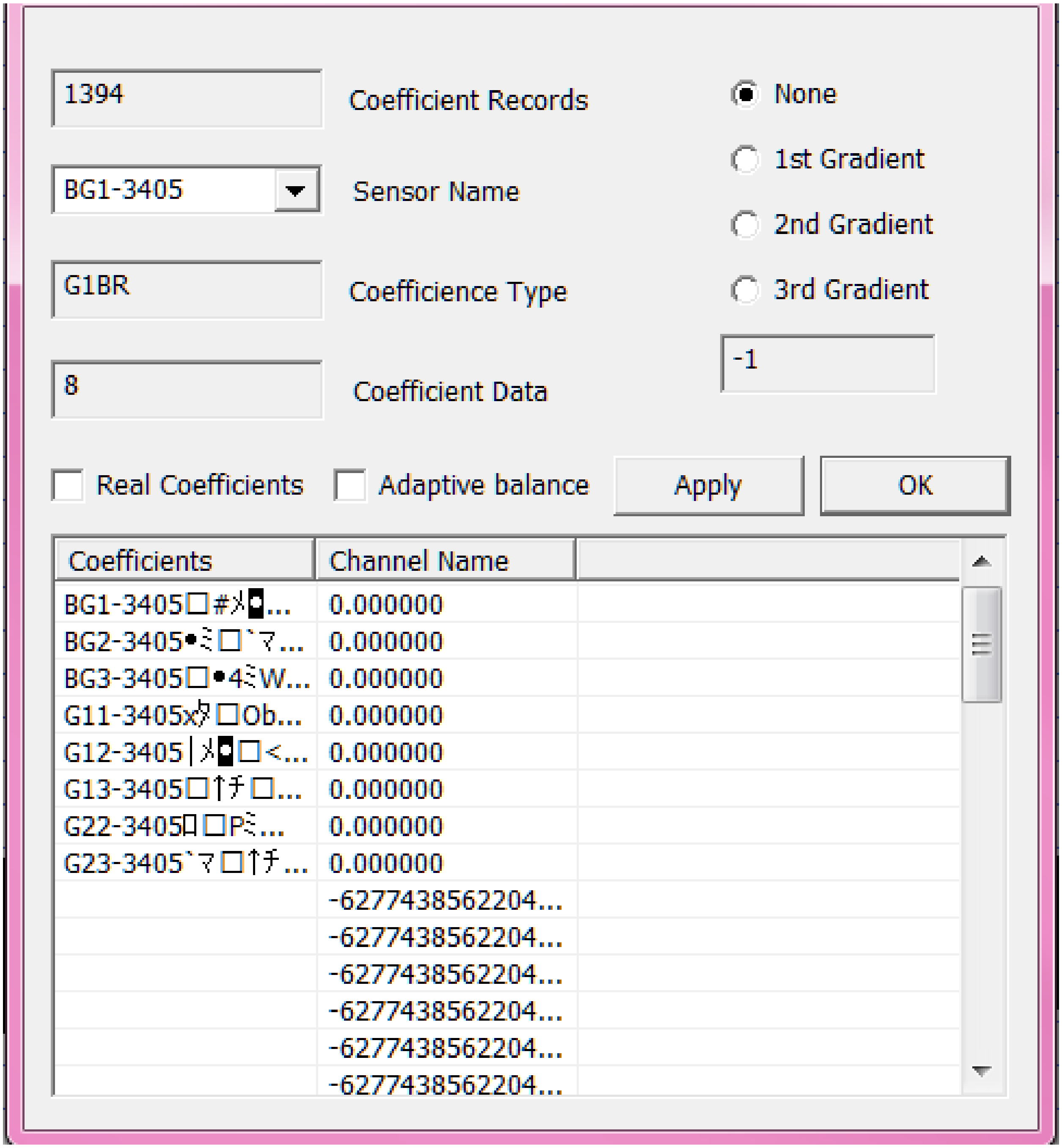

Figure 11. High-order gradient window.

High-order gradient varies significantly among different type of MEG systems. The software typically handle this issues on case-by-case bases.

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