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GUGER TECHNOLOGIES

g.MOBIlab MOBILE LABORATORY

SIMULINK highspeed ONLINE processing

Brain Computer Interface with g.MOBIlab+ and Simulink V3.12.03

Introduction

g.MOBIlab+ is a biosignal acquisition system for EEG, ECG, EMG, EOG and other sensors. In this tutorial the usage of the device for an EEG-based brain computer interface (BCI) will be shown. The Simulink Highspeed On-line Processing blockset allows to read data into Simulink in real-time and to perform the parameter estimation and classification. No additional compilation of the Simulink model is required for the on-line processing.

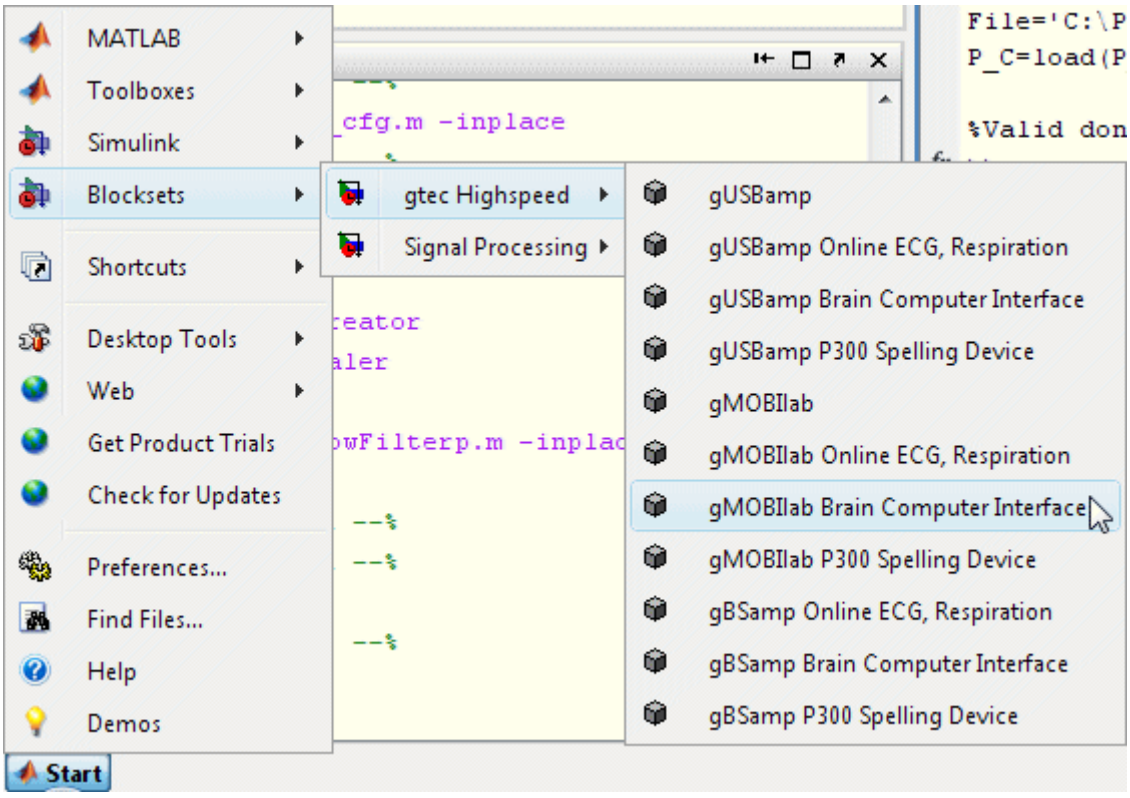
Required Components

To perform the tutorial the following components are required:

- **g.MOBIlab+** biosignal acquisition device
- **Simulink Highspeed On-line Processing** blocks for g.MOBIlab+
- **g.RTanalyze** real-time parameter extraction blocks
- EEG electrodes and EEG cap
- PC or notebook with Bluetooth or serial connector
- MATLAB and Simulink Release 2012a

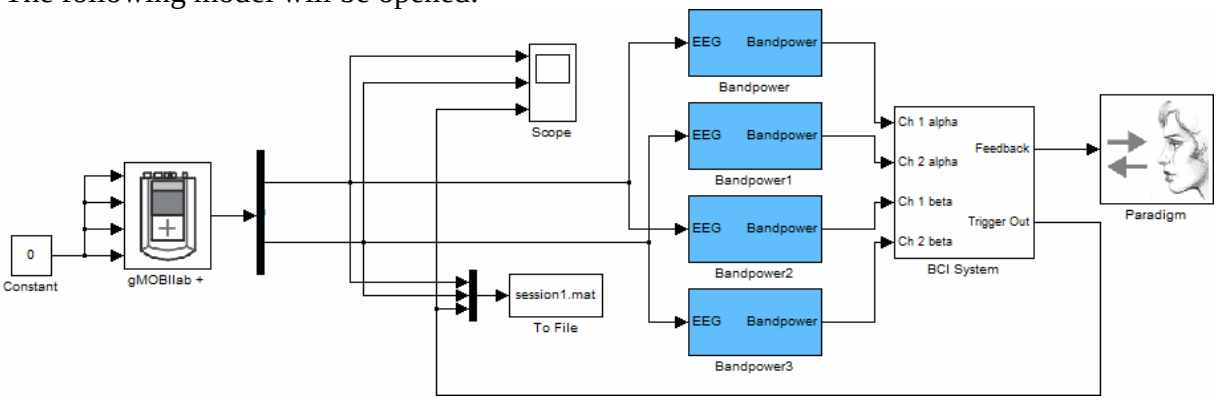
Quickstart

The corresponding Simulink model can be started from the MATLAB **Start** button.

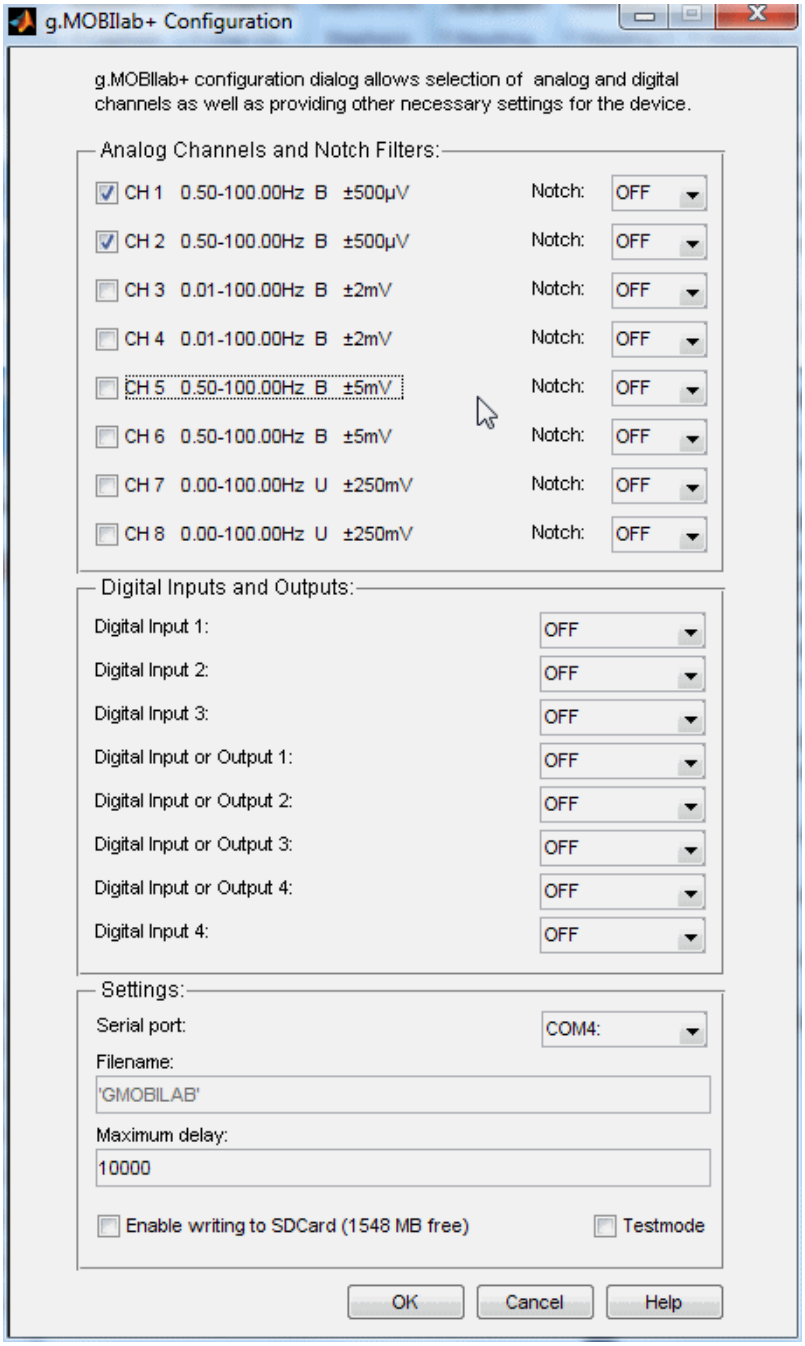


or by typing `gMOBIlabplusBCI` into the MATLAB command line.

The following model will be opened:



Double click onto the block to open the following window:



The check boxes for the analog channels (**CH 1** to **CH 8**) allow specifying the biosignal channels. Select the analog channels 1 and 2 (**CH 1** and **CH 2**) to read in two EEG channels with a lower cutoff frequency of 0.5 Hz and an upper cut-off frequency of 100 Hz. The sensitivity for both channels is ± 500 µV.

Check the 4 digital inputs (**Digital Channel 1,2,3** and **8**) and the 4 digital I/Os (**Digital Channel 4 - 7**) if digital inputs or outputs should be used. Digital lines 1, 2, 3 and 8 can be defined as inputs. The digital channels 4 to 7 can be defined either as inputs or outputs. **Digital Channel 3** can be used to read in data from the external switch that can be connected to g.MOBIlab+. Output channels are useful to send trigger signals to external devices for synchronization or to control an external device.

Max. delay (ms) allows to specify the maximum possible delay that the g.MOBIlab driver block can have. The highly optimized driver block ensures that all data from the acquisition device is read into Simulink. If the PC is busy with other tasks and can not perform the Simulink operations fast enough, the driver buffers the data. After returning to the Simulink task the operations are performed as fast as possible. If the driver block detects a buffer overflow an error message is shown.

Pull-down menu **Serial Port** can be used to select the appropriate serial port of your PC or notebook.

For this tutorial only channels **CH 1** and **CH 2** are used. For the other configuration please see figure of **g.MOBIlab+ Configuration** above. Select the correct COM port in the **Serial port** pull down menu.

Now g.MOBIlab+ is initialized correctly.

Press **OK** to accept the settings and to close the window.

Connect a **MUX** block to split the two EEG channels.

The driver block reads in the data in Microvolts.

Signal Processing

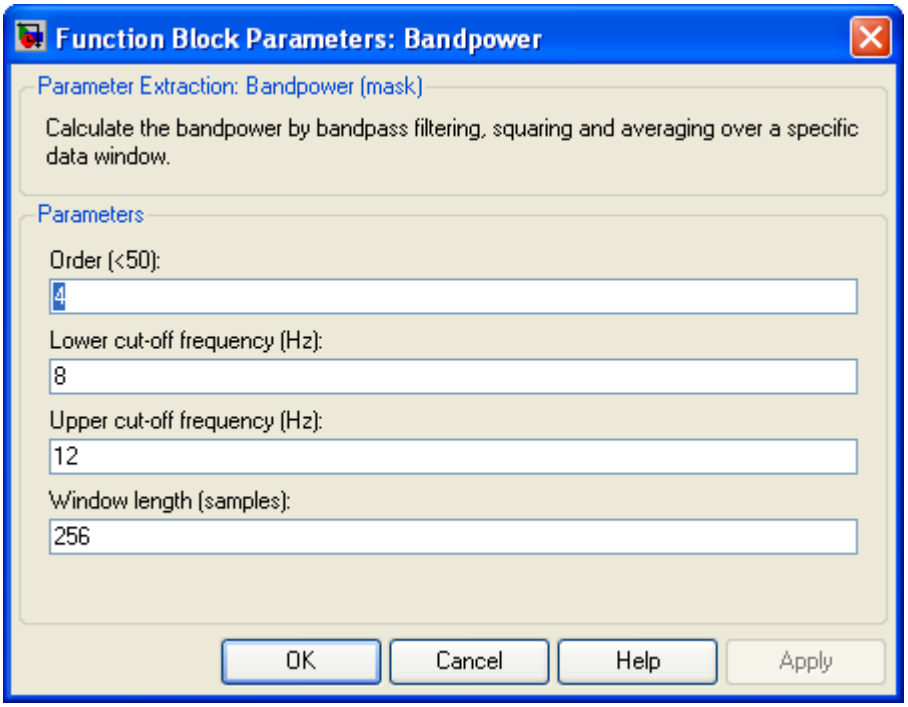
PARAMETER EXTRACTION

Go to the **Simulink Library Browser** to the **g.RTanalyze** folder and drag the **Bandpower** block into the Simulink model.

Copy the block 3 times with the right MOUSE button.

Then connect 2 blocks to channel 1 and 2 blocks to channel 2 in order to calculate of each channel the bandpower in the alpha and beta range.

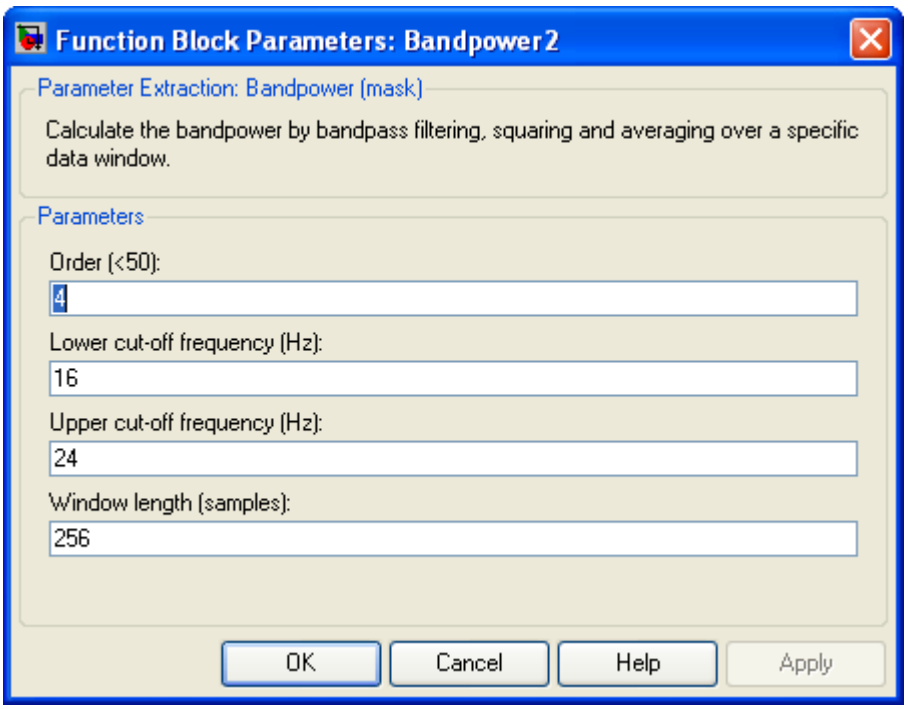
Double click the first **Bandpower** block of channel 1 and set the **Order** to `4`, the **Lower cut-off frequency** to `8` Hz, the **Upper cut-off frequency** to `12` Hz and the **Window length** to `256` samples.



Press the **OK** button to confirm the settings and to close the window.

Double click the second **Bandpower** block of channel 1 to perform the settings for the beta range.

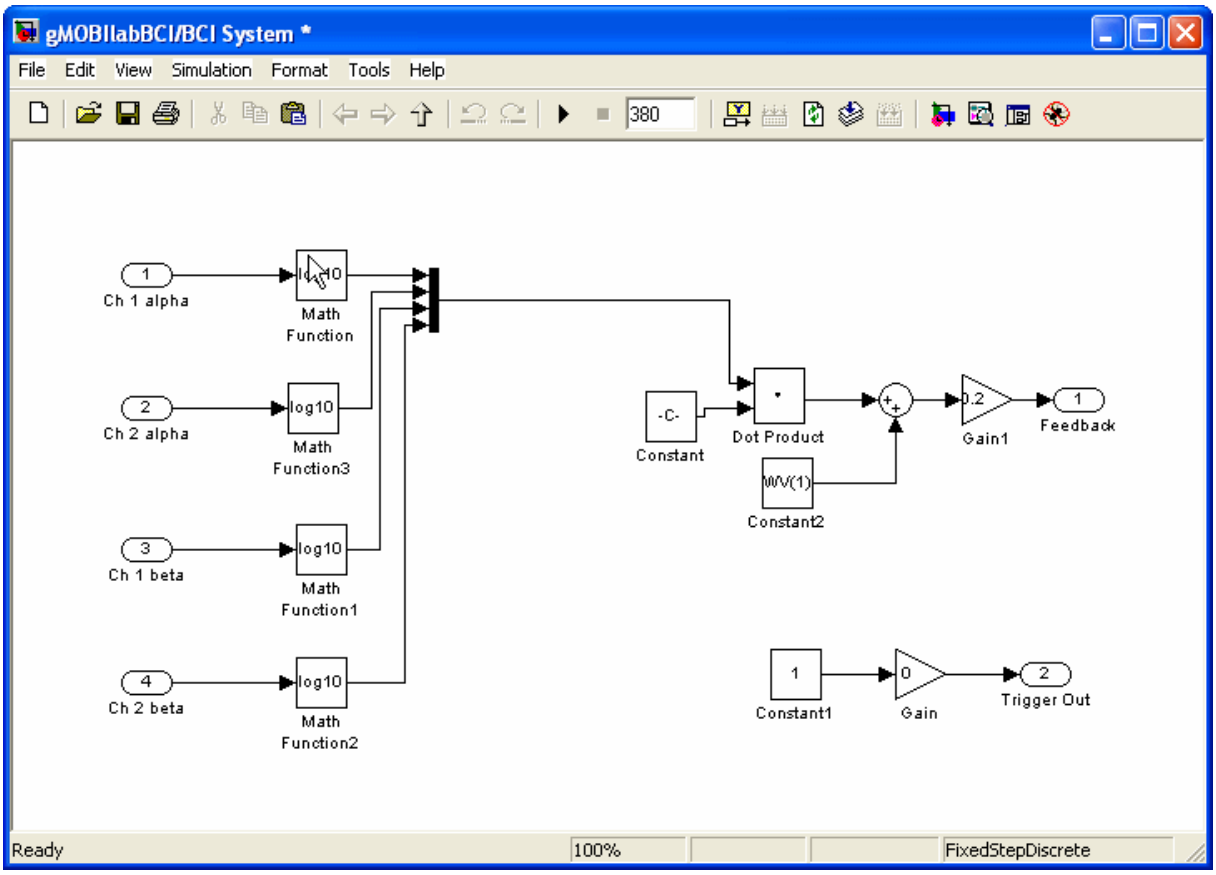
Set the **Order** to `4`, the **Lower cut-off frequency** to `16` Hz, the **Upper cut-off frequency** to `24` Hz and the **Window length** to `256` samples.



Perform the same steps for channel 2.

CLASSIFICATION

To perform an on-line classification of the parameters a linear discriminant analysis is implemented. Before weighting each parameter with the corresponding value all parameters are log transformed for normalization. Then each parameter is multiplied by its weight value and theses new values are added. Finally a bias value is added. The result is a control signal that becomes positive if the subjects imagines a foot movement and negative if the subject imagines a right hand movement.

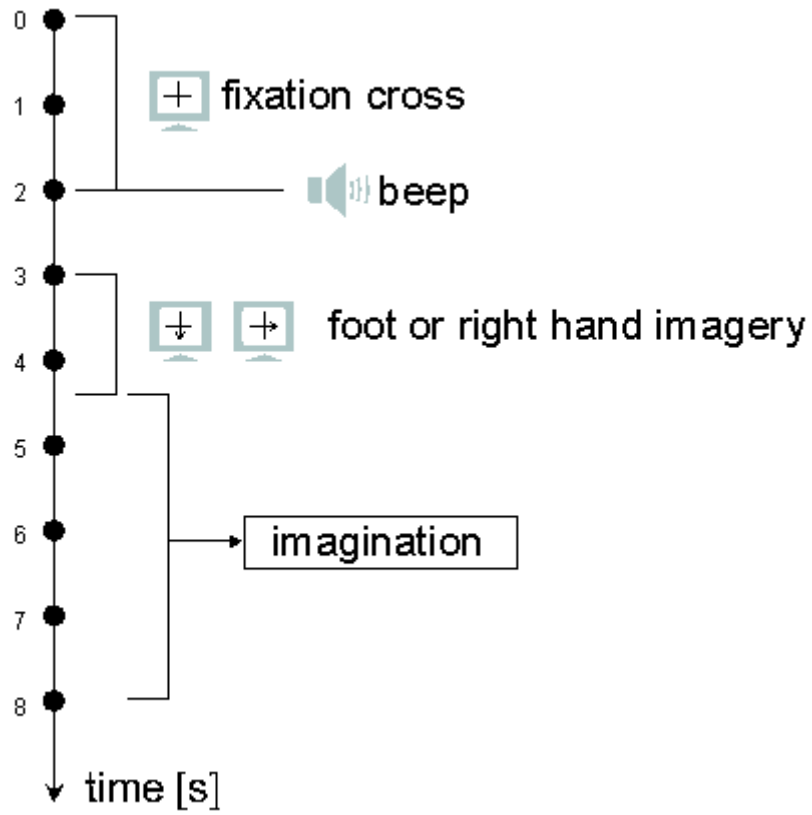


Note: the classification vector for the linear discriminant analysis must be loaded before it is possible to start the Simulink model. Set the vector `WV=ones(5,1)` if the BCI experiment is performed off-line (this is automatically done when the model is started). For the on-line experiment the weight vector must be calculated with g.BSanalyze.

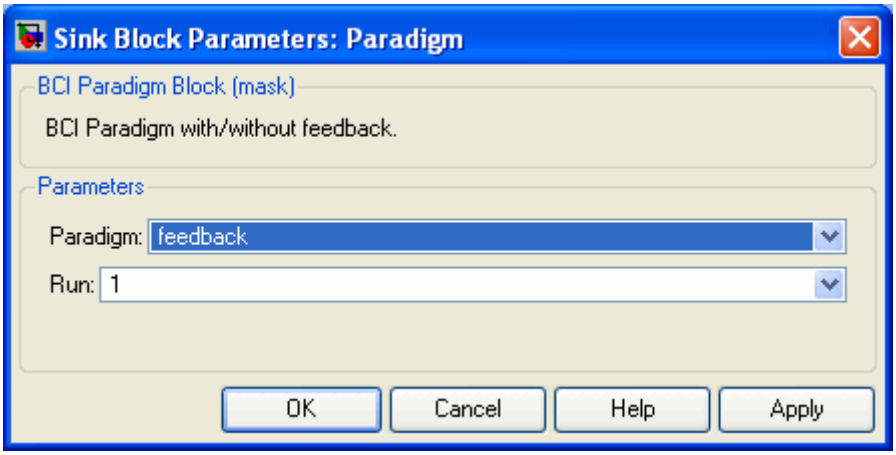
PARADIGM

The output of the BCI System is connected to the **Paradigm** block. This is a MATLAB S-Function which controls the experimental paradigm.

The figure shows the timing of one trial of the experiment. The subject sits in a comfortable armchair 150 cm in front of a computer-monitor and is instructed not to move and to keep both arms and feet relaxed and to maintain throughout the experiment the fixation at the center of the monitor. The experiment starts with the display of a fixation cross that is shown in the center of a monitor. After two seconds a warning stimulus is given in form of a "beep" and a trigger signal is set at the output of the **Paradigm** block. From second 3 until 4.25 an arrow (cue stimulus), pointing down or to the right, is shown on the monitor. The subject is instructed to imagine a foot or right hand movement, depending on the direction of the arrow until second 8. If the experiment is performed with feedback a horizontal bar is indicating the classification result. The bar extends to the right side if a right hand imagination is performed and vice versa for the bottom side.
One trial lasts 8 seconds and the time between two trials is randomized in a range of 0.5 to 2.5 seconds to avoid adaptation. The subject performs 4 runs consisting each of 40 trials

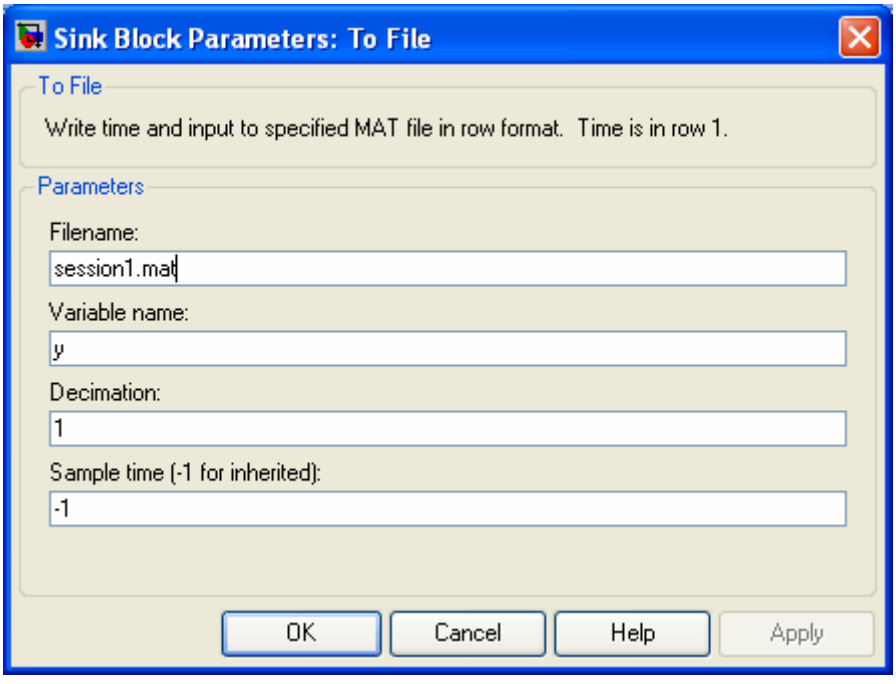


Double click on the **Paradigm** block to select whether the experiment should be with feedback or without and to select the **Run** number. Note that sessions with feedback can only be performed if a weight vector was already calculated from former BCI sessions.



Data Storage

Copy the **To file** block from the **Simulink Library Browser** into the Simulink model.



Enter under **Filename** `session1.mat` and under **Variable Name** `y`. If the **Sample time** is set to –1 the sampling frequency is inherited from the block driving this block.

Press **OK** to close the window.

Synchronization

To synchronize the paradigm with the EEG data connect the **Trigger Out** output to the **To File** block. Additionally this trigger signal is connected to the **Scope** to investigate the trigger signal.

After acquiring the data the trigger signal can be used to find the beginning of each trial in the data.

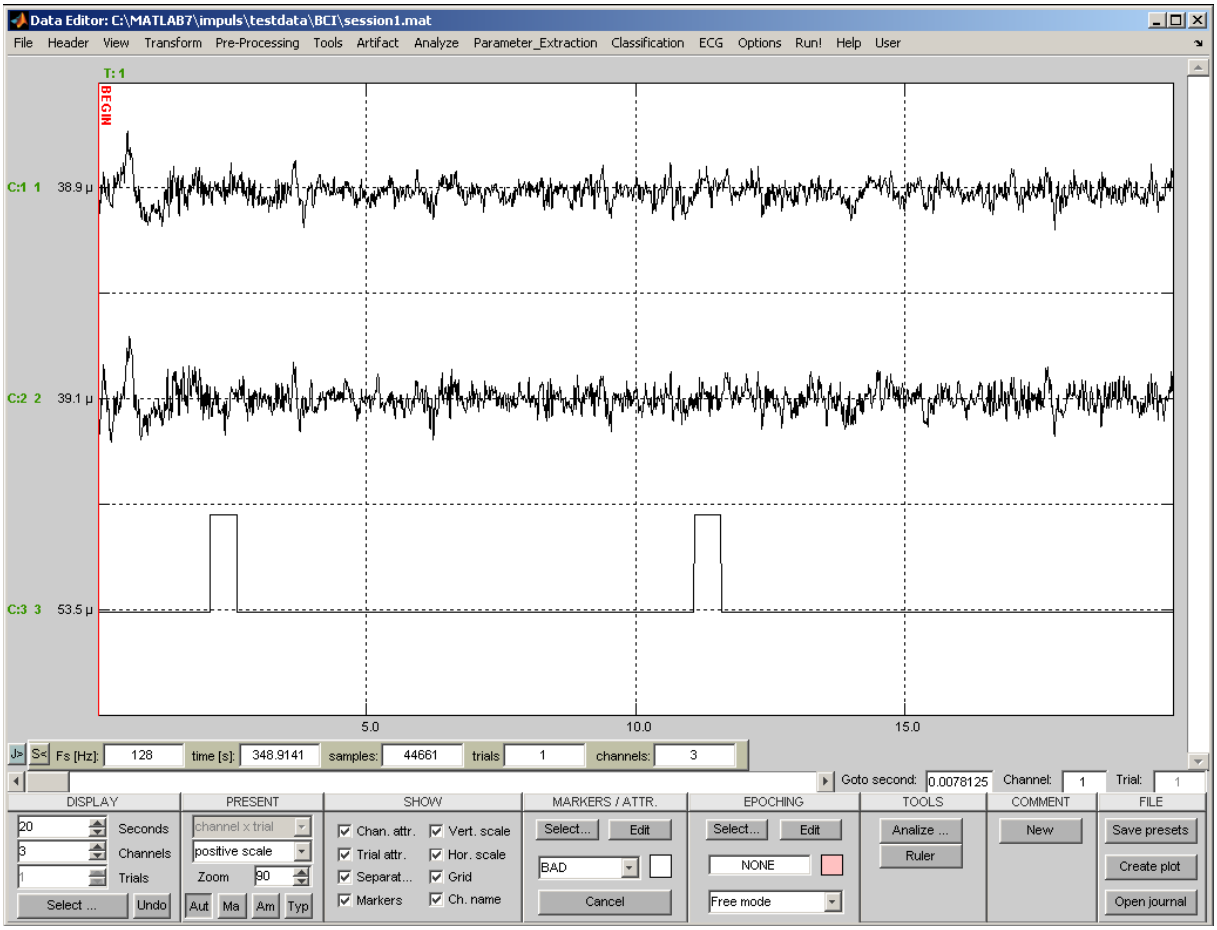
Off-line processing

Type into the MATLAB command window: `gbsanalyze` to start the Data Editor.

Load the acquired data file `session1.mat` for the calculation of a new weight vector for the next on-line experiment with feedback.

Set the Sampling rate to `256` Hz.

Begin by deleting the first channel timing signal creating by the Simulink **To File** block. Then the Data Editor should contain the 2 EEG channels and the Trigger channel.



Select **Appearance Settings** from the **Options** menu and set the **USER DIRECTORY** to

`C:\Program Files\gtec\gBSanalyze\User`

Now use the **User** menu to start the `BCIBatch`. The `BCIBatch` automatically calculates the classification accuracy and the weight vector `WV` for the next feedback session in the MATLAB workspace.

Type `WV` into the MATLAB command window to investigate the weight vector.

Summary

The new Simulink Highspeed On-line Processing block g.MOBIlab+ allows the setup of an EEG based brain computer interface.

It is not necessary to compile the Simulink model for the on-line operation and therefore the development time is reduced. The new driver block allows the usage of all Simulink blocks and S-Functions can be implemented as C or MATLAB S-Functions.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