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GUGER TECHNOLOGIES

g.Nautilus
WIRELESS BIOSIGNAL ACQUISITION

SIMULINK highspeed ONLINE processing

Simulink Highspeed On-line Processing

USER MANUAL V3.15.01

CONTENT:

TO THE READER

Welcome to the medical and electrical engineering world of g.tec!
Discover the only professional biomedical signal processing platform under MATLAB and Simulink. Your ingenuity finds the appropriate tools in the g.tec elements and systems. Choose and combine flexibly the elements for biosignal amplification, signal processing and stimulation to perform even real-time feedback.

Our team is prepared to find the better solution for your needs.

Take advantage of our experience!

Dr. Christoph Guger Dr. Guenter Edlinger

Researcher and Developer

Reduce development time for sophisticated real-time applications from month to hours.
Integrate g.tec's open platform seamlessly into your processing system.
g.tec's rapid prototyping environment encourages your creativity.

Scientist

Open new research fields with amazing feedback experiments.
Process your EEG/ECG/EMG/EOG data with g.tec's biosignal analyzing tools.
Concentrate on your core problems when relying on g.tec's new software features like ICA, AAR or online Hjorth's source derivation.

Study design and data analysis

You are planning an experimental study in the field of brain or life sciences? We can offer consultation in experimental planning, hardware and software selection and can even do the measurements for you. If you have already collected EEG/ECG/EMG/EOG, g.tec can analyze the data starting from artifact control, do feature extraction and prepare the results ready for publication.

Related Products

g.tec provides several biosignal analysis elements that are especially relevant to the kinds of tasks you perform with g.tec Highspeed.

For more detailed information on any of our elements, up-dates or new extensions please visit our homepage www.gtec.at or just send us an email to office@gtec.at

Conventions

Item	Format	Example
MATLAB code	`Courier`	to start Simulink, type `simulink`
String variables	*Courier italics*	`set(P_C,'`*`PropertyName`*`',...)`
Menu items	**Boldface**	Select **Save** from the **File** menu

ATTENTION

NOTE

Installation and Configuration

This chapter includes the following sections:

Hardware and Software Requirements

Hardware Requirements

g.Nautilus Highspeed requires a PC compatible desktop or a notebook workstation running Microsoft Windows.

The table below lists optimal settings:

Hardware	**Properties**
CPU	Pentium working at 3000 MHz
Harddisk	100 gigabyte
RAM	8 gigabyte
USB 2.0 high speed port	One free USB port for the g.Nautilus base station (EHCI) and one for the Hardlock Dongle

Software Requirements

g.Nautilus Highspeed requires the installation of the g.NEEDaccess, g.tec Highspeed On-line Processing, MATLAB, Simulink and Signal Processing Toolbox. Make sure that the MATLAB installation works correctly before installing the g.Nautilus Highspeed software. Depending on your Windows operating system, administrator rights might be necessary for the installation.

Software	**Version**
g.NEEDaccess Server	1.14.00
g.tec Highspeed On-Line Processing	3.15.00
MATLAB	Release 2014a
Simulink	Release 2014a
Signal Processing Blockset	Release 2014a
Windows	Windows 7 Professional Service Pack 1 English Win64
Acrobat Reader	11.0.04
Microsoft .NET Framework	4

ATTENTION

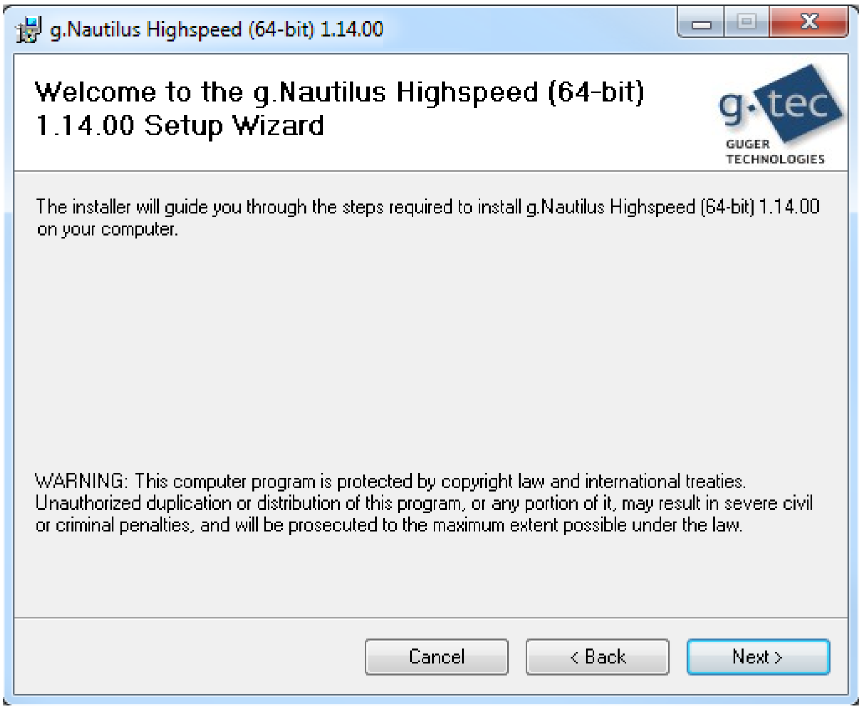
It is essential to use the correct MATLAB and Simulink versions! The package will not work correctly if other versions are used.

Installation from a CD

The installation consists of three steps:

1. Installation of g.Nautilus Highspeed

   Insert the g.tec product CD into the CD-drive, change to the `g.Nautilus Highspeed Online processing for SIMULINK` directory of your CD-drive, and double-click on the `Setup.exe` file. The installation starts and displays the welcome message. Follow the instructions on the screen.

   Click **Next** to continue installation.

2. Please read the License Agreement for g.Nautilus Highspeed

If you agree with the terms, click **I Agree** and **Next**.

3. Installation of the Hardlock

   The driver software for the Hardlock is installed automatically via Windows update, when the computer is connected to the internet. For manual installation, click the `HASPUserSetup.exe` in the Prerequisites/HaspHL folder on your g.tec CD.

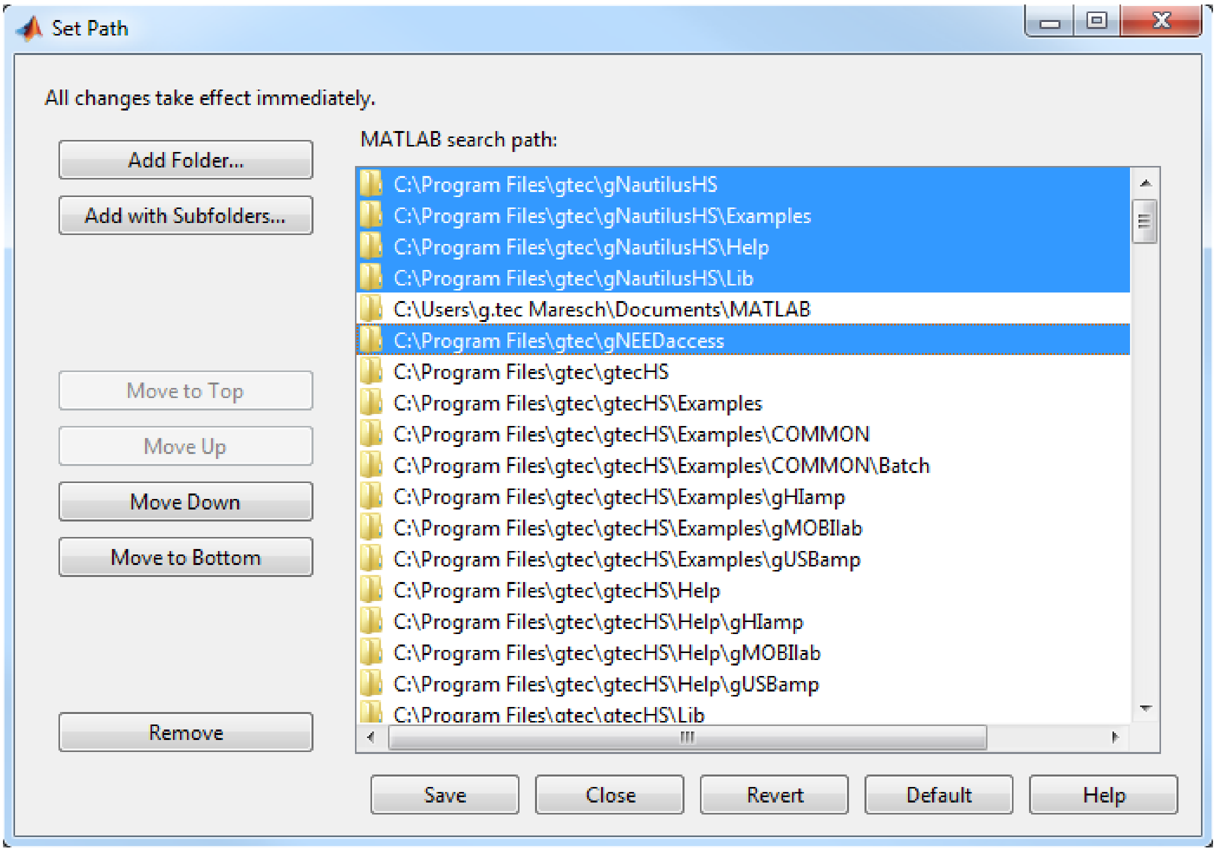
   Note that you have to uninstall the Hardlock driver separately if you uninstall the g.Nautilus Highspeed On-line Processing software

4. Set MATLAB path

To make the path settings, start MATLAB and open the **Set Path** window from the **File** menu. Then click on the **Add with Subfolders** button and select

```
C:\Program Files\gtec\gNautilus
```

to add all subdirectories.



Click the **Add Folder…** button and add

```
C:\Program Files\gtec\gNEEDaccess
```

Click **Save** and **Close** to finish.

This finishes g.Nautilus Highspeed installation.

Insert the Hardlock into a free USB slot of your PC or notebook. The light must be on if the installation was successful.

Files on your Computer

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

```
C:\Program Files\gtec\gNautilus\Lib
```

Example models and configurations - are stored in the subdirectory

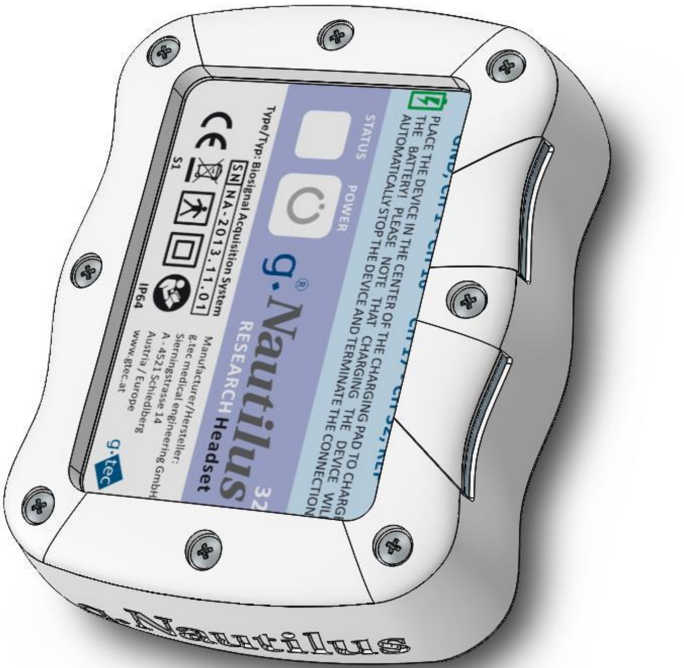
```
C:\Program Files\gtec\gNautilus\Examples
```

Help files - are stored under

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

Introduction to g.Nautilus

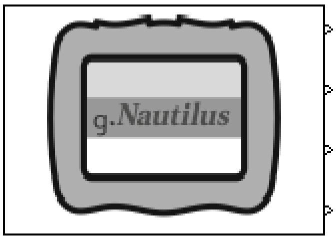
g.Nautilus Research is g.tec's biopotential amplifier with wireless data transmission technology and active wet or dry electrodes. The device can acquire EEG data with 24 Bit resolution and a sampling rate of 250 or 500 Hz.
Up to 32 analog to digital converters perform the simultaneous sampling. Each analog to digital converter operates at 1.024 MHz. A corresponding down-sampling then yields a sampling rate of 250 or 500 Hz. The user may choose this sampling rate. A sampling rate of 250 Hz means an oversampling of 4096, yielding a high signal to noise ratio.
The device is equipped with an internal impedance check to determine the electrode-skin-impedance. g.Nautilus Research is controlled via an Application Programming Interface (C-API).
A base station (Base Station) receives the digitized EEG data and can be connected to any free USB port of the PC or notebook.



Highlights

- EEG recordings without cable connection via radio signal
- active wet or dry electrodes
- up to 32 analog input channels with 24 Bit resolution
- sampling rate of 250 or 500 Hz per channel
- digital filtering
- oversampling to achieve a high signal to noise ratio
- g.Nautilus Base Station can be connected to PC or notebook
- simultaneous sample and hold for all channels
- easy and fast application of electrodes via prefixed positions
- wireless charging of the accumulator
- adjustable input sensitivity of ± 185 mV up to ± 2.25 V

g.Nautilus Highspeed Block



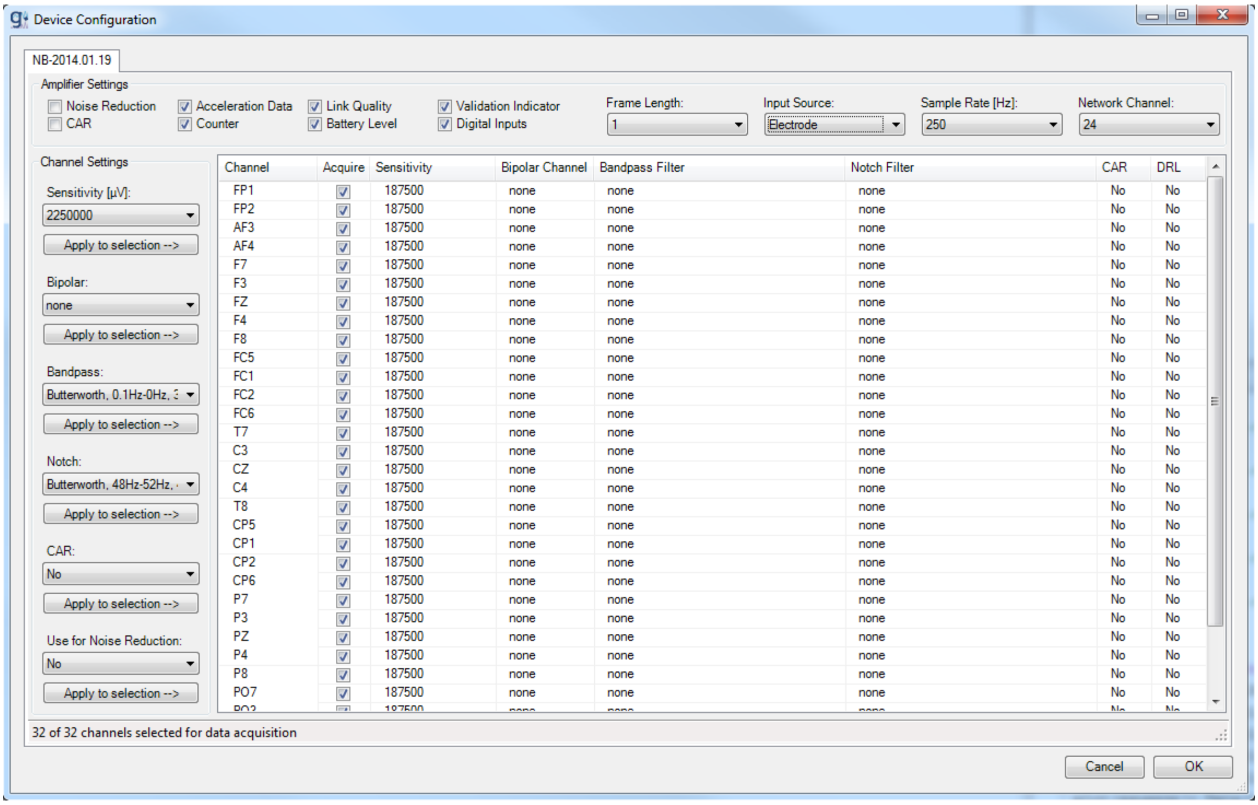
g.Nautilus

The g.Nautilus Highspeed block provides a graphical interface to the g.Nautilus hardware, which can be used under Simulink to specify the amplifier properties and to acquire the data.

Description

The g.Nautilus block has several outputs according to the settings provided in the **Device Configuration** dialog. The topmost output provides the biosignal data and the lowermost is always the network channel. Additional outputs like Acceleration Data, Counter, Link Quality, Battery Level, Digital Inputs and Validity Indicator are added in this order. The data format for the EEG data is single (float32) and it is scaled in µV. If all analog input channels (depending on hardware used and channels selected) are used, the signal dimension is 32.

Dialog Box



Amplifier Settings

Frame Length	specify the buffering block size (0 for a default block size of 8)
Input Source	specify the input source for data acquisition `Electrode`: record EEG data `Shortcut`: record with shortcut of inputs `Testsignal`: 0-15 mV square-wave @ 2 Hz (250 ms high, 250 ms low)
Sample Rate [Hz]	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 (see column **DRL**)
CAR	enable common average reference of activated channels (see column **CAR**)
Acceleration Data	acquire data from acceleration sensor. 3 dimensional vector holding x-, y-, z-accelerations in range of ± 6 g
Counter	output a counter which is incremented with every sample transmitted to the computer
Link Quality	output the wireless link quality ranging from 0-100 [0 – low quality, 100 – high quality]
Battery Level	output battery level ranging from 0 – 100 [0 - empty, 100 - full]
Validation Indicator	output if the scan was successfully transmitted [0 – invalid, 1 – valid]
Digital Inputs	output of the 8 digital inputs

NOTE

digitalinputs= din01x2⁰ + din02x2¹ + din03x2² + … + din08x2⁷

$digitalinputs = din01 \times 2^{0} + din02 \times 2^{1} + din03 \times 2^{2} + \ldots + din08 \times 2^{7}$

*Use a **Binary Decoder** to get the state of each digital input channel.*

Channel Settings

Sensitivity [µV]	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)
DRL	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)

NOTE
Gel electrodes: *use a sensitivity of 187500 µV (highest resolution, lowest acceptable DC offset).*   ***Dry electrodes:*** *use sensitivity level of 562500 µV to allow higher DC offsets as normally seen with dry electrodes.*

Perform the following steps to configure bandpass, notch and bipolar settings:

1. Select the channels in the listbox that should be edited. Use the Ctrl key or the Shift key to select multiple input channels.

2. Select the **Bandpass** filter `Butterworth, 0.1Hz - 30Hz, 8th Order, 250Hz Samplerate` and press the **Apply to selection** button to assign the bandpass to the specific channels. The selection is shown in the listbox.

3. Select the `Butterworth, 48Hz - 52Hz, 4th Order, 250Hz Samplerate` **Notch** filter to suppress the power line interference at 50 Hz and then press the **Apply to selection** button

4. To perform a bipolar derivation between channels FP1 and FP2 select the first channel in the listbox. Then select channel `FP2` under **Bipolar** and press the **Apply to selection** button. The settings appear in the listbox. This configuration subtracts channel FP2 from channel FP1 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.*

5. To perform a common average references, activate the **CAR** checkbox under **Amplifier Settings** and assign **Yes** to the selected channels

6. To perform a noise reduction using the DRL algorithm activate the **Noise Reduction** checkbox under **Amplifier Settings** and assign **Yes** to the selected channels

Press **OK** to close the window. This will store the configuration into the Simulink model workspace. Please save each model with a different name if different configurations should be stored to disk. If not the current configuration in the model workspace will be overwritten when the **OK** button is pressed.

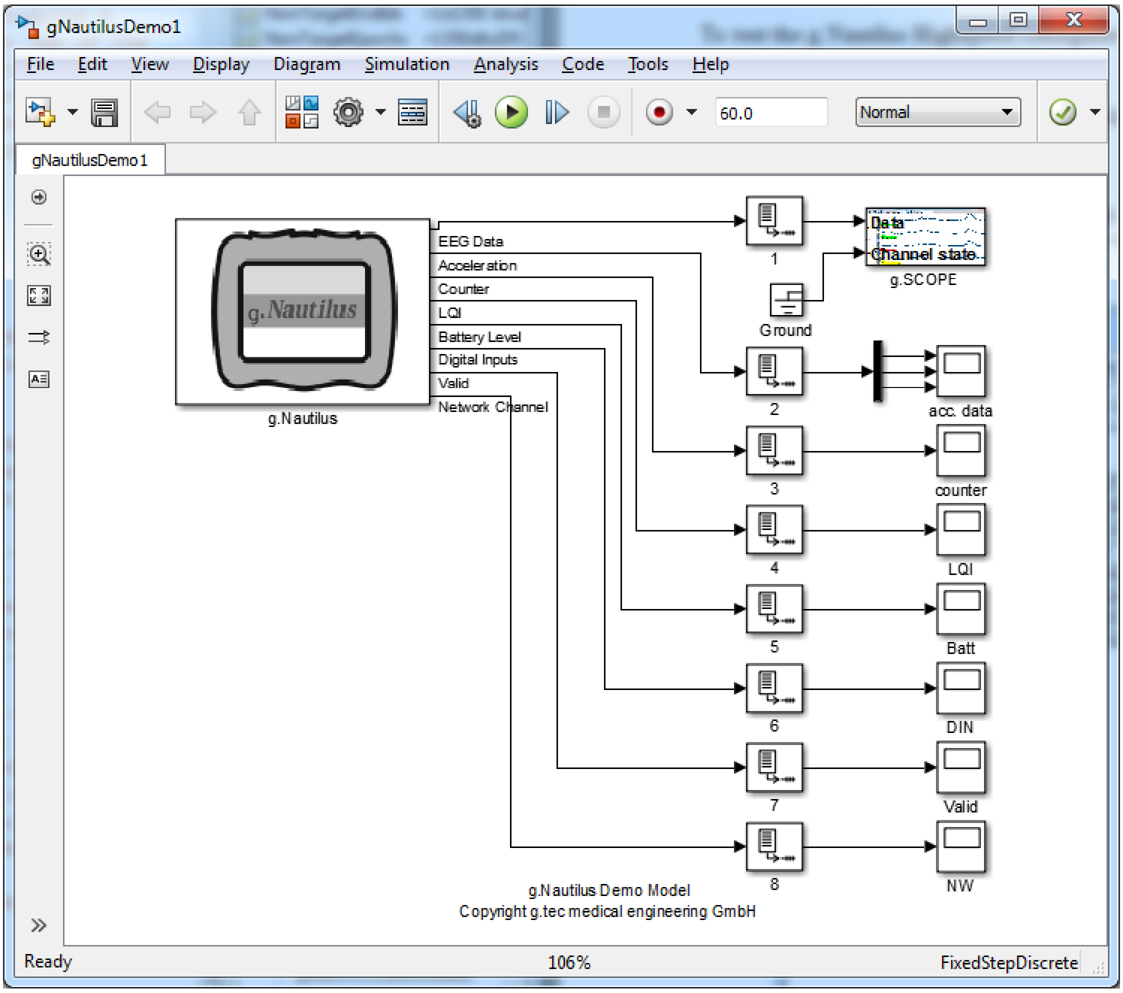
NOTE
g.Nautilus Highspeed reads in all biosignal data in µV.

Running g.Nautilus Highspeed

To test the g.Nautilus Highspeed configuration on your system, please perform the following example:

1. Start the MATLAB command window. See your MATLAB documentation if you are not sure how to do this.

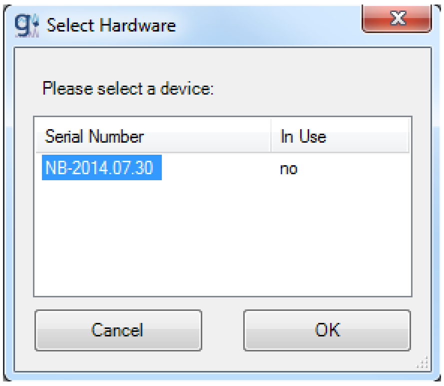
2. Open the Simulink model by typing `gNautilusDemo1` into the MATLAB command window. This command starts up Simulink and creates the following window:



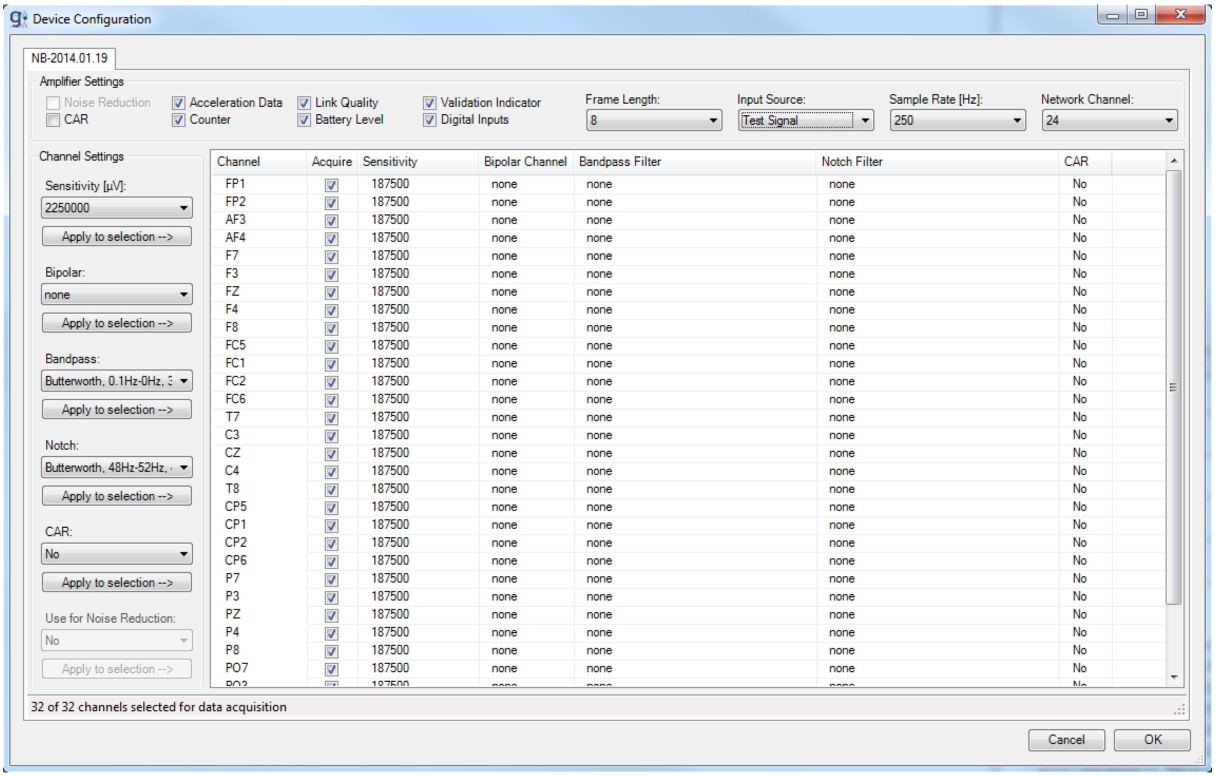
   The Simulink model contains a **g.Nautilus** block which reads in the data from the base station received by the headstage via USB. This example will acquire 32 channels of **Test signal** data of g.Nautilus. Depending on the g.Nautilus hardware capabilities, the number of channels can vary.

3. Before configuring g.Nautilus and starting the model, make sure that g.Nautilus is set up correctly according to the Instructions for Use. The power LEDs on base station and g.Nautilus headset must be blinking.

4. Double click on the **g.Nautilus** block. If the **g.Nautilus** block has never been configured before or not with the currently connected g.Nautilus device, the **Select Hardware** dialog will open:



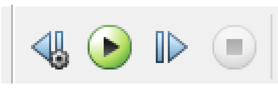
After clicking **OK** or double clicking the serial number in the dialog, the **Device Configuration** dialog opens:



The configuration shown above acquires a test signal on all analog channels and the three acceleration data channels (x, y and z) as well as the counter, the link quality, the battery level, the validation indicator and the digital inputs as separate outputs of the g.Nautilus block at a sampling rate of 250 Hz.

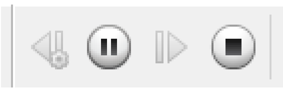
5. Apply changes by clicking **OK.**

6. Start the model by pressing the **Start** button in the Simulink model



7. To view the signals double click on the **g.SCOPE** block. Please see the g.tec Highspeed Library Description for more information on g.SCOPE block.

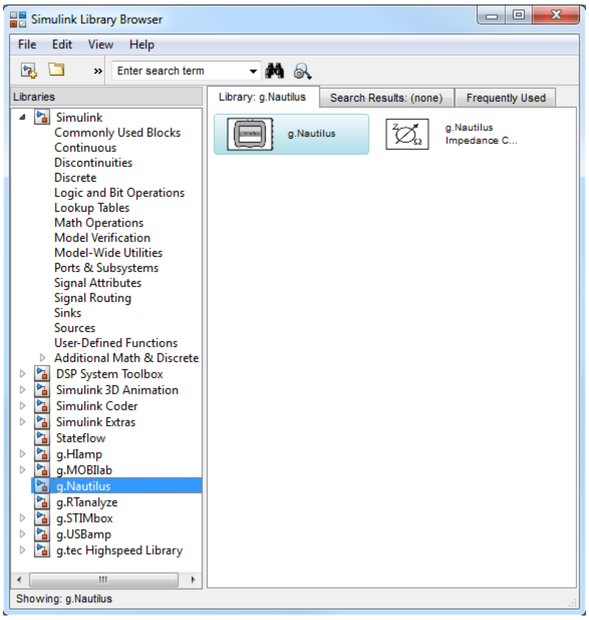
8. Stop the model with the **Stop** button and close it



Creating a Simulink Model for Biosignal Acquisition

1. To create a new Simulink model click, on the **Simulink** icon in the MATLAB window

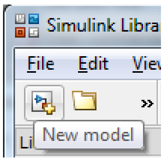
or enter `simulink` into the MATLAB command window. The **Simulink Library Browser** opens:



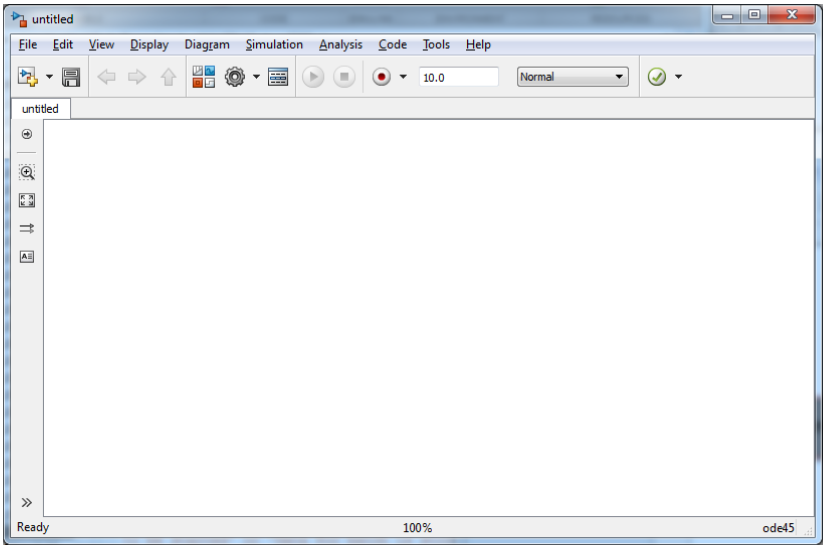
The **Simulink Library Browser** gives access to all Simulink based blocksets.

2. Scroll down to **g.Nautilus** to show the biosignal data acquisition block.

3. Press the **New model** icon in the **Simulink Library Browser**:



4. This opens an empty Simulink model:



5. Drag the **g.Nautilus** block in the **Simulink Library Browser** and drop it into the new Simulink model.

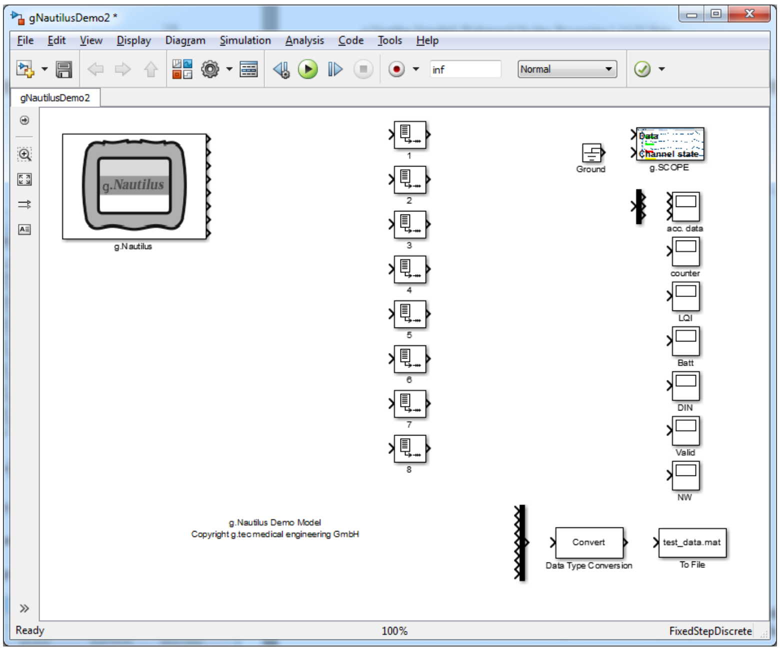
6. Open the **Signal Management\Buffers** path under the **Signal Processing Blockset** in the **Simulink Library Browser** and copy the **Unbuffer** block into the new model.

7. From the **g.tec Highspeed Library**, copy the **g.SCOPE** block.

8. From **Sinks** under **Simulink**, copy the **To File** block.

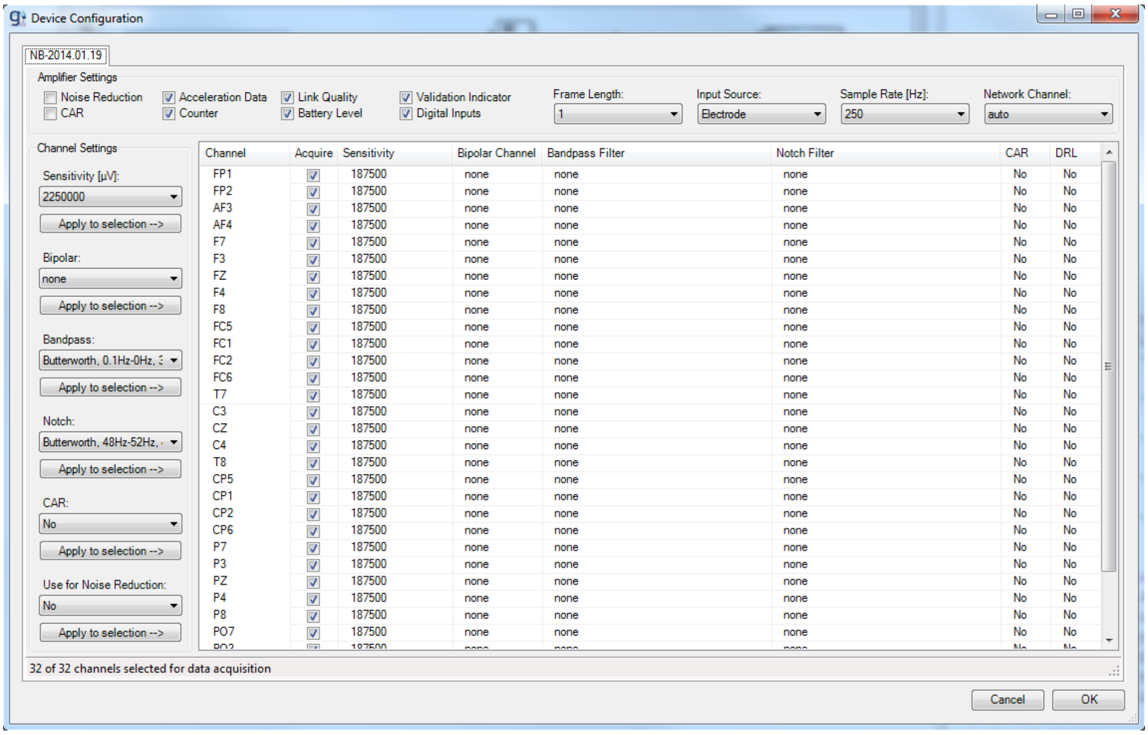
9. From **Signal Attributes** under **Simulink**, copy the **Data Type Conversion** block.

10. Now, your model should look like this:

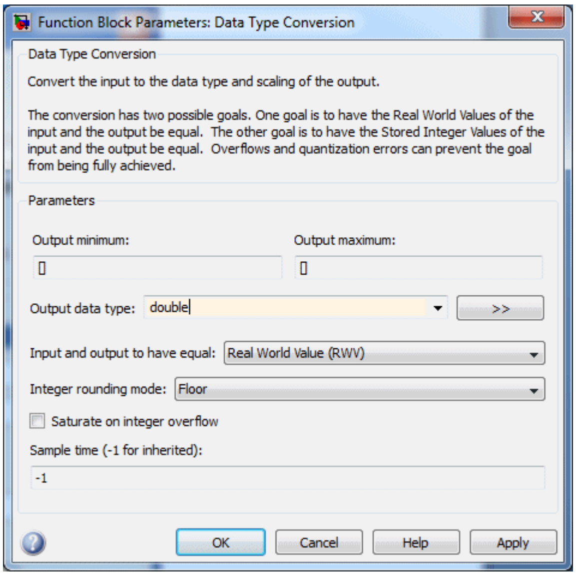


11. Make sure that g.Nautilus is connected correctly to the computer.

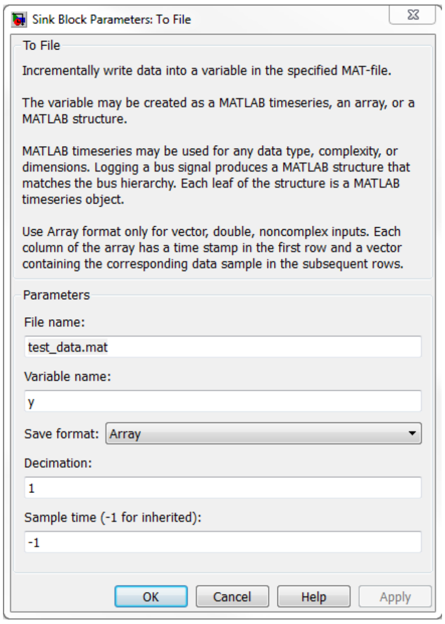
12. Double click on the **g.Nautilus** block to open the **Device Configuration**:



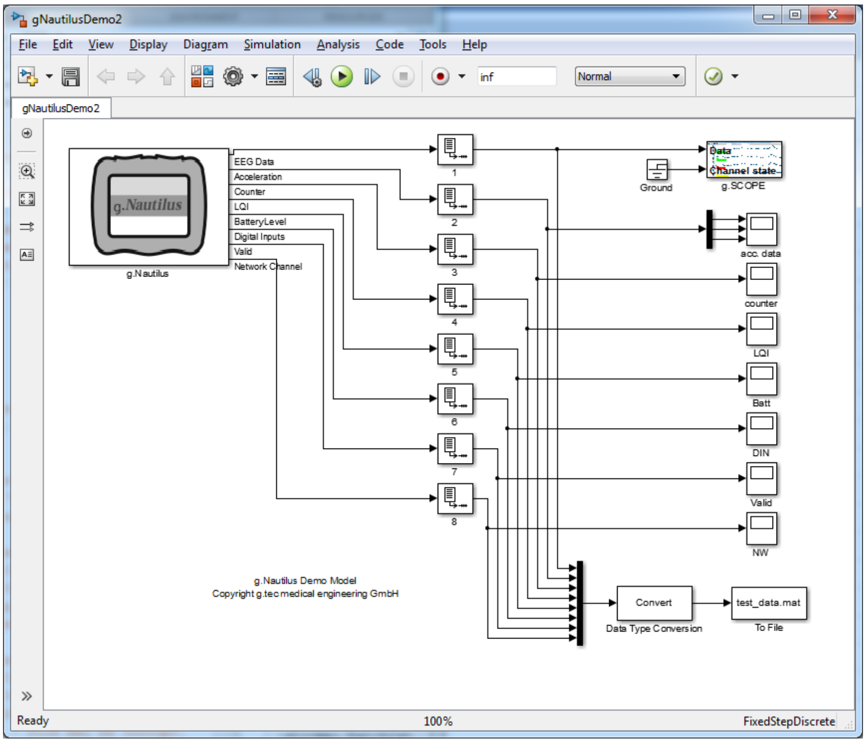
13. Double click on the **Data Type Conversion** block and change the **Output data type mode** to `double` because **g.Nautilus** is acquiring the data as single (float32)



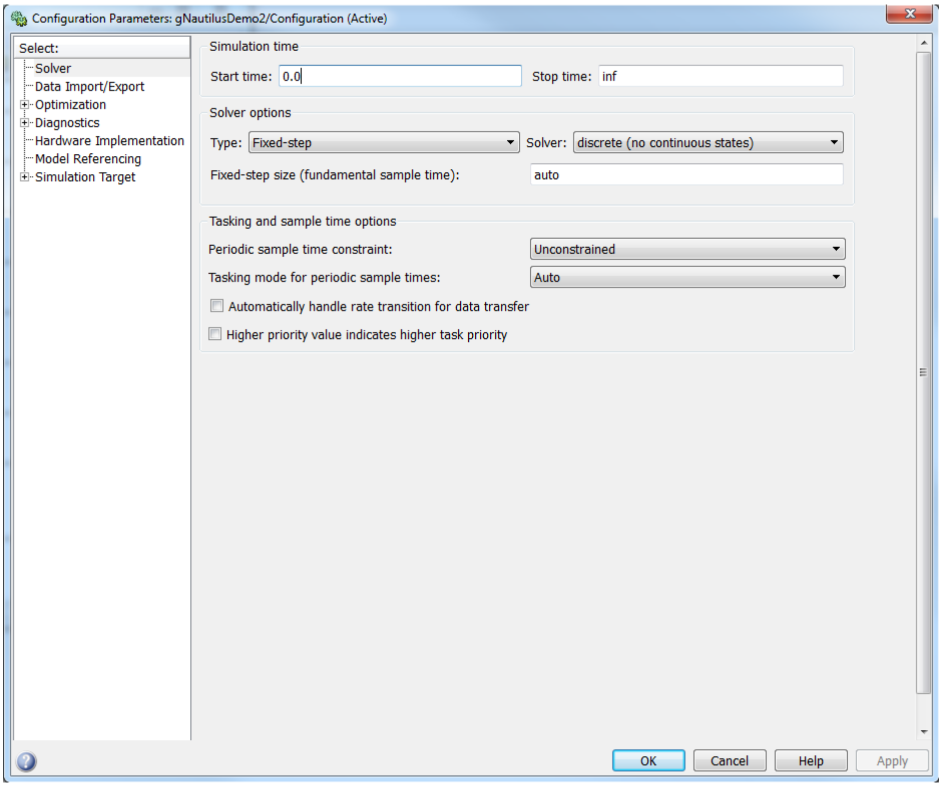
14. Double click on the **To File** block and enter the filename `test_data.mat` and change **Save Format** to **Array** to store the data as one array into variable `y`.



15. After configuring each block perform the connections as shown below:



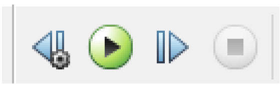
16. Click on the **Simulation** menu and select **Configuration Parameters**



Set the **Stop time** to `inf` and the **Type** under **Solver options** to **Fixed-step**. **Solver** is set to **discrete (no continuous states)**. The **Fixed-step size** is set to `auto` because **g.Nautilus** block specifies the sample rate.

17. Confirm the settings and close the window with **OK**

18. Start the model



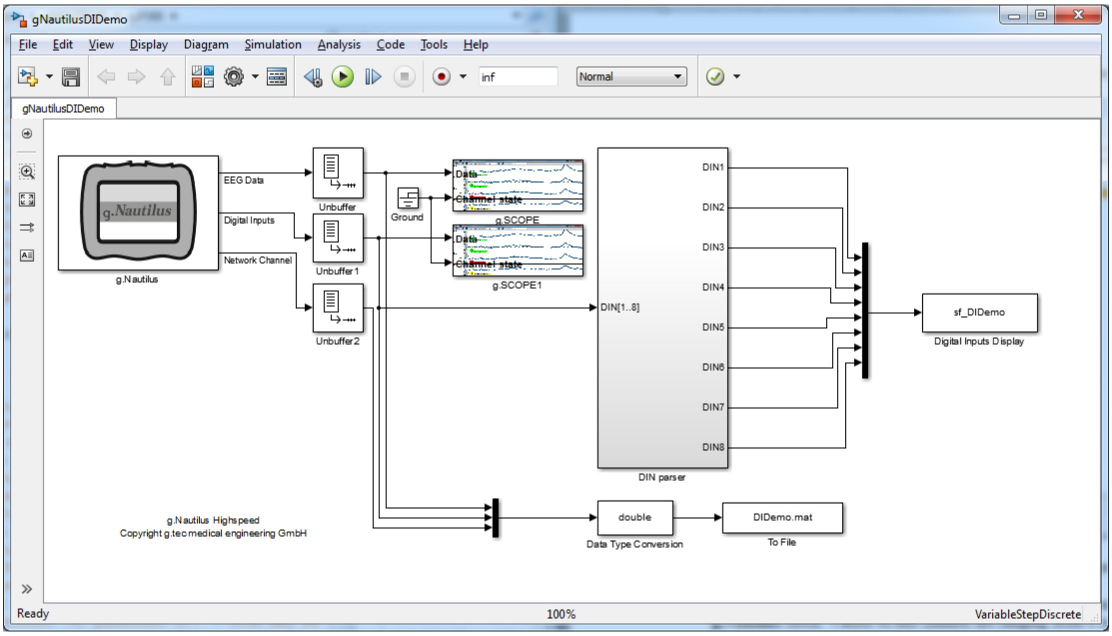
Using Digital Inputs of g.Nautilus

g.Nautilus provides 8 digital inputs, the following example will show how these digital inputs are recorded in g.Nautilus Simulink Highspeed.

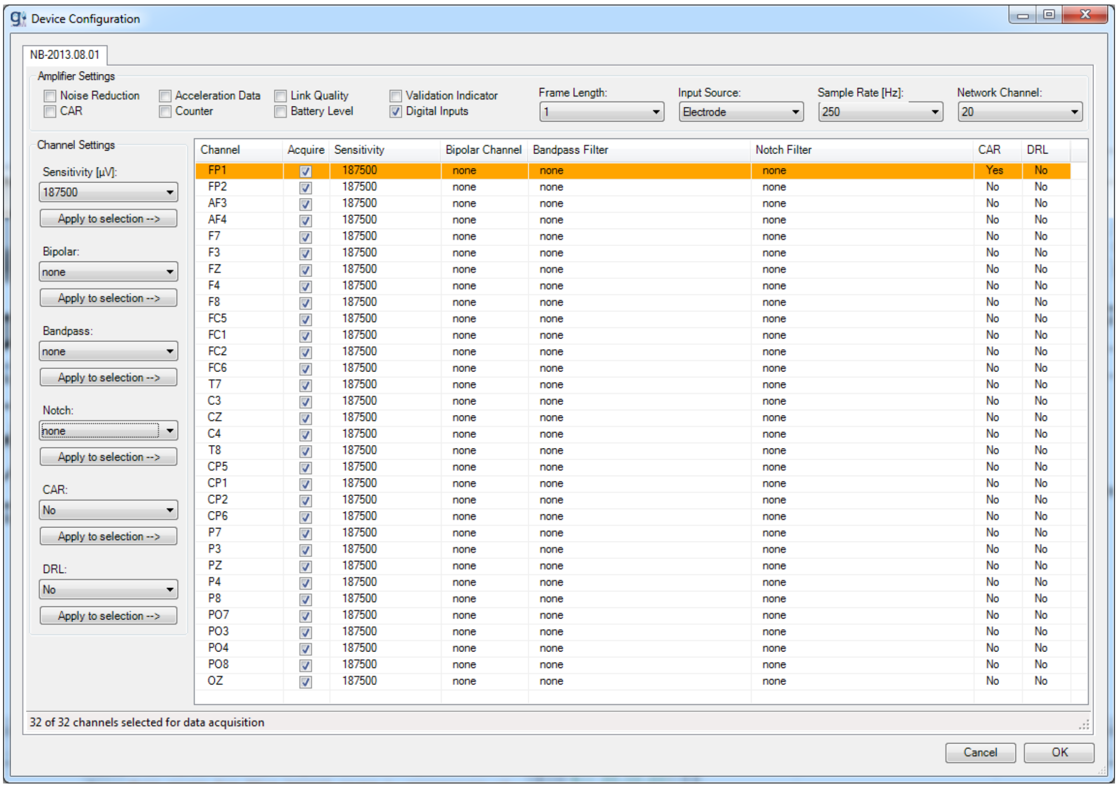
NOTE

To perform this demonstration model, g.STIMbox, Trigger cable for g.Nautilus (g.STIMbox) and a Simulink model which drives the g.STIMbox are required.

1. Open the model `gNautilusDIDemo.mdl` by typing the name into the MATLAB command window



2. Double click the **g.Nautilus** block to inspect the configuration



This configuration will record 32 channels and the **Digital Inputs** of g.Nautilus.

3. Start the model

4. Start the g.STIMbox Simulink model which output to g.Nautilus

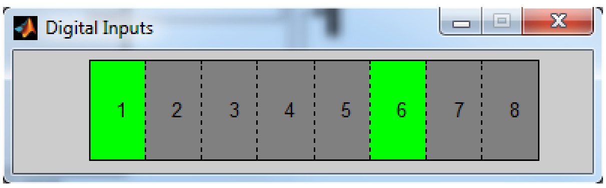
5. g.Nautilus records digital inputs as single channel as additional output port of **g.Nautilus** block. Values of this channel range from 0 to 255, corresponding to the 8 digital inputs fed to g.Nautilus.

6. **g.SCOPE** shows all EEG data, **g.SCOPE1** shows the trigger values

NOTE

*Use **DIN parser** to split the 8 triggers into 8 separate trigger channels.*

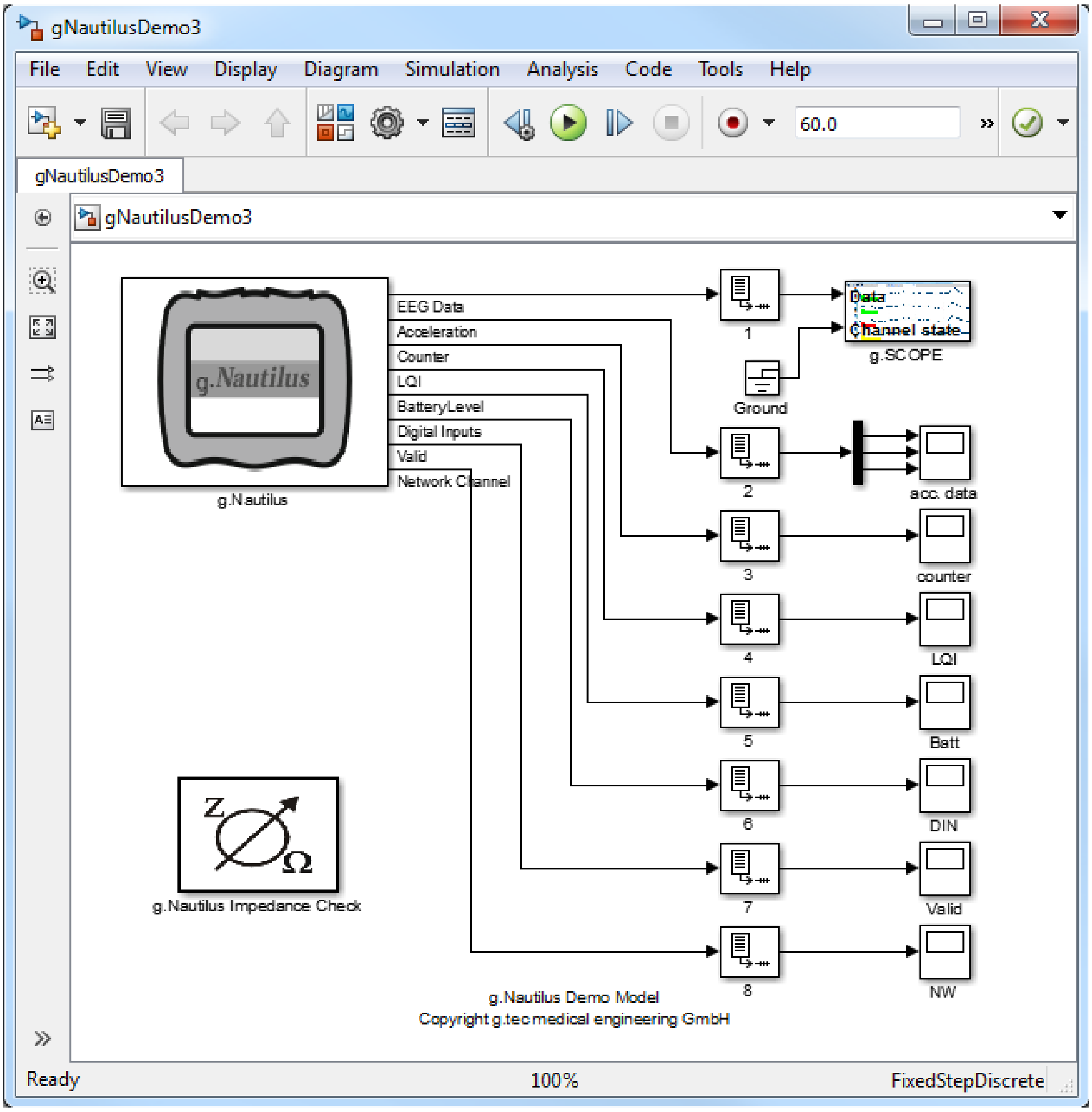
7. The current state of each digital input (**1** to **8**) is indicated either in grey for low or green for high. In the example picture below digital inputs 1 and 6 are high, the others are low.



Impedance Measurement

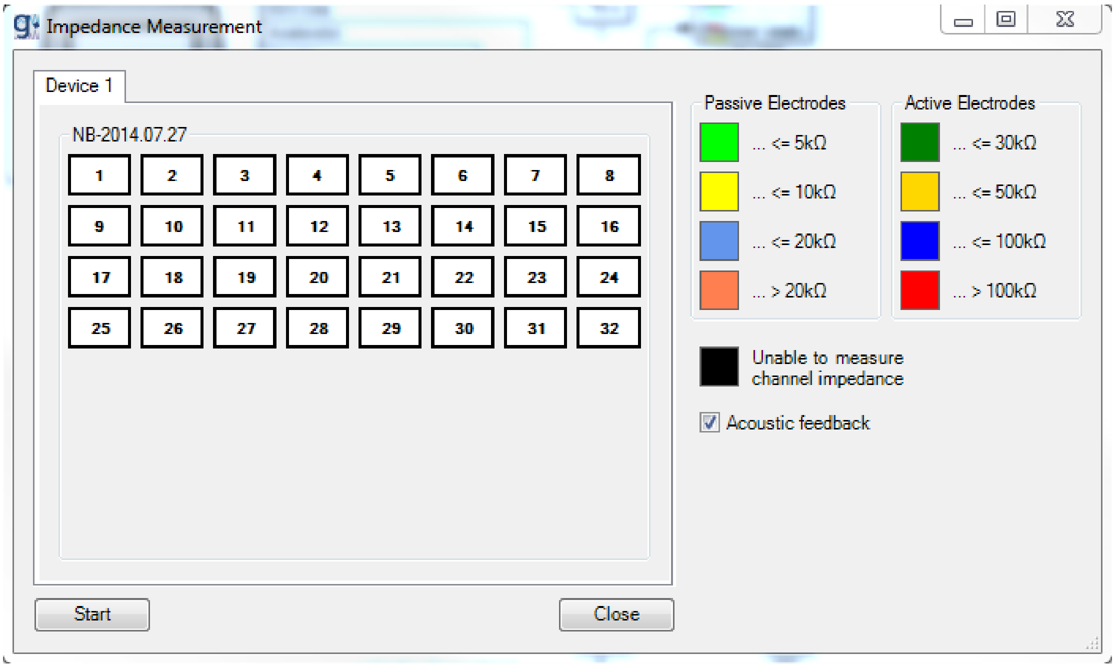
g.Nautilus is capable of measuring electrode impedances. To perform impedance measurement for active electrodes, please follow the steps below.

1. Open the `gNautilusDemo3.mdl` by typing the name into the MATLAB command window. This opens the Simulink model displayed below.



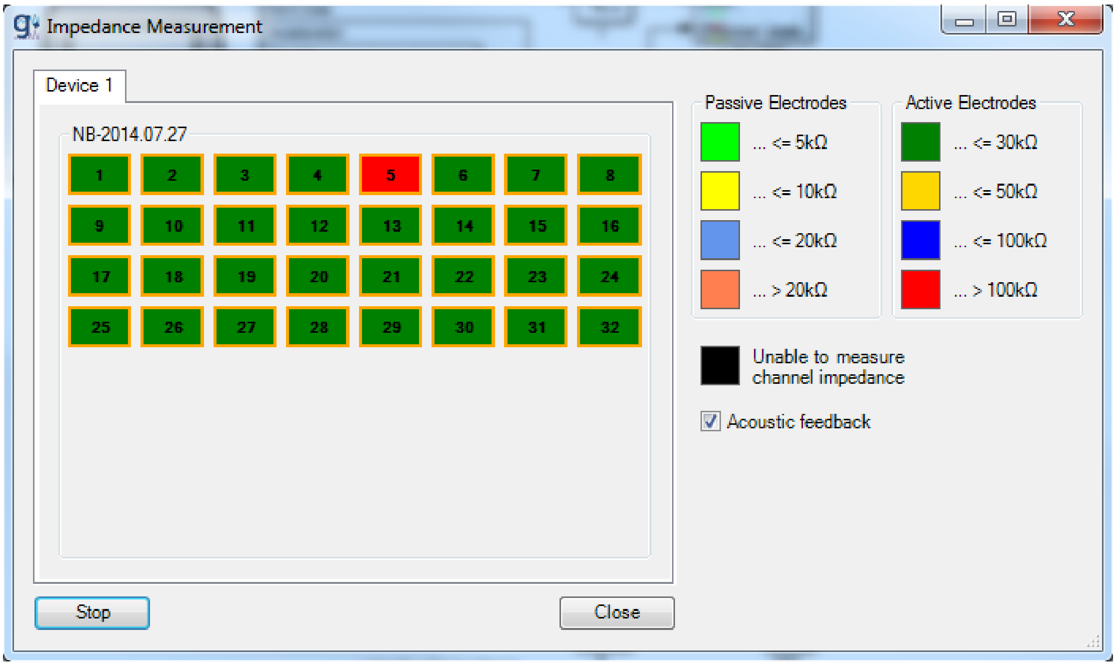
2. Double click onto **g.Nautilus** block to inspect the device configuration and make sure that the model is configured with the correct device. Close the dialog by clicking **OK**.

3. Open the **Impedance Measurement** dialog by double clicking the **g.Nautilus Impedance Check** block



4. Click **Start** to begin impedance measurement

5. The impedance for each channel is indicated by different colors. For g.Nautilus, please always refer to the **Active Electrodes** section. In the example below, channel 5 has an impedance higher than 100kΩ, while all other channels are below 30kΩ.



NOTE
Active electrodes give nice EEG signal even for impedances > 100 kΩ.

6. Click **Stop** to finish impedance measurement and **Close** to close the **Impedance Measurement** dialog.

Help

g.Nautilus Highspeed provides a printable documentation.

The printable documentation is stored under

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

named `gNautilusHS.pdf`.

Use Acrobat Reader to view the documentation.

Product Page

Please visit our homepage www.gtec.at for

- Update announcements
- Downloads
- Troubleshooting
- Additional demonstrations

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