

## NeurOne User Manual

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## Intended Use of NeurOne System

Electroencephalograph.

An electroencephalograph is a device used to measure and record the electrical activity of the patient's brain obtained by placing two or more electrodes on the head.

## Classification of NeurOne System

According to MDD 93/42/EEC and amended by Directive 2007/47/EC: **Class IIa product**

NeurOne equipment is designed according to and fulfils the requirements of following standards:

EN60601-1 (IEC60601-1) Medical electrical equipment. Part 1: General requirements for safety

EN60601-1-2 (IEC60601-1-2) Medical electrical equipment. General requirements for safety.  
Electromagnetic compatibility - Requirements and safety

EN60601-2-26 (IEC60601-2-26) Medical electrical equipment. Particular requirements for the safety of electroencephalographs.

The complete system, including personal computer, shall comply with EN60601-1-1 (IEC60601-1-1) requirements.

NeurOne is according to EN60601-1 externally powered class 2 equipment.

## Manufacturer Information

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Bittium Biosignals Ltd reserves all rights to improve, change and modify the products and the contents of the User Manual without prior notice.



Connect only items that have been specified as part of the NeurOne System or that have been specified as being compatible with the NeurOne System. The assembly of the NeurOne System and modifications during the actual service life requires evaluations are the requirements of EN60601-1-1 standard still met.

To avoid danger of electrical shock and electromagnetic disturbances the computer and associated equipment used with the NeurOne should comply with the following standards (or national variants):

EN 60950	Information technology equipment and office equipment safety.
EN 60601-1	Medical electrical equipment: General safety requirements.
EN 60601-1-2	Medical electrical equipment: Electromagnetic compatibility.

Connect only items that have been specified as part of the NeurOne System or that have been specified as being compatible with the NeurOne System.

If a computer that does not comply with the EN 60601-1 requirements is used with the NeurOne in patient environment, the computer and peripherals must be plugged in using an isolation transformer that fulfills the requirements (see EN 60601-1-1 for detailed requirements).

Parts of non-medical equipment (PC computer and its accessories) and PATIENT shall not be touched simultaneously by the OPERATOR.



This device is not to be used with patients, who have active implantable medical device (like heart pacemaker etc.).



Conductive parts of ELECTRODES and their connectors, including the NEUTRAL ELECTRODE, should not contact other conductive parts including earth.



This ELECTROENCEPHALOGRAPH is not intended to be used simultaneously with the cardiac defibrillator or with high frequency (HF) surgical equipment.



For the NeurOne Main Unit use only the Power Supply supplied by Bittium Biosignals Ltd.

If MULTIPLE PORTABLE SOCKET-OUTLETS are used these shall only be used for supplying power to equipment which is intended to form part of the SYSTEM to ensure that leakage currents do not exceed. The MULTIPLE PORTABLE SOCKET-OUTLET shall meet EN 60601-1-1 requirements (see standard for detailed requirements).

Ensure that the maximum permitted load for any MULTIPLE SOCKET-OUTLET(S) used with the NeurOne System does not exceed with connected equipment.

Additional MULTIPLE SOCKET-OUTLET or extension cord shall not be connected to the NeurOne System.



Devices that produce electro-magnetic field, such as mobile phones, radio transmitters and electric motors could cause distortions in measured data. Make sure that environment of the measurement is free from such devices.

If a computer that does not comply with the EN 60601-1-2 requirements is used with the NeurOne, the computer may cause EMC disturbance.

Ensure specially that all NeurOne cables are free from EMC disturbances.



Carry out all adjustment and cleaning PROCEDURES specified in instructions.

# 1 INTRODUCTION

## 1.1 Using This Manual

This manual has been written for the users of the NeurOne Biosignal Monitoring Device. Users of the device should be acquainted with EEG measurements and measurement setups before using the device.

In order to use the NeurOne System safely, all users must read this manual paying attention to the warnings and cautions. Explanations for the various symbols can be found in the following pages.

The manual is divided into three main parts: the first section focuses on the device and its installation, while the second section addresses the software and its usage. The final section contains device troubleshooting, declarations, regulatory and statutory requirements and appendices.

Please note that some maintenance and service procedures specified in this manual, require the use of special tools or devices. Some of these devices are available only from Bittium Biosignals Ltd. Other devices are available on the market, but should comply with the specification given in this manual. If not specified otherwise you may also use common tools and devices.

### **IMPORTANT!**

Before taking any action with the system parts, please read this manual thoroughly and retain it for future reference.



**Warning.** These statements identify conditions or practices that could result in personal injury or loss of life.



**Caution.** These statements identify conditions or practices that could result in damage to the equipment or other property.



**Note.** These statements identify condition or practices that could result in performance loss of the equipment or must be otherwise paid attention to.

## 1.2 Symbols Used with the Device



The device is CE-marked for the conformity to Council Directive 93/42/EEC as amended by the Directive 2007/47/EC regarding medical devices.



The device is equipped with type BF applied parts fulfilling the EN 60601-1 (IEC60601-1) standard.

**IP20**

The enclosure protection class is IP20 according to EN60529.



Caution.



Warning.



Follow operating instructions.

~

Alternating current (A.C.)

—

Direct current (D.C.)



ESD sensitive connector.



For EU only: This symbol indicates that this device shall be disposed according to European Union directive 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE).

## 1.3 User Responsibility

This product shall be assembled, operated, maintained and repaired in accordance with the instructions provided.

A defective product should not be used. Parts that are broken, worn, missing, incomplete, distorted or contaminated should be replaced immediately. Should any repair or replacement become necessary, we recommend that the device is delivered to your local distributor or Bittium Biosignals Ltd for service.

The user of the product is solely responsible for any malfunction resulting from improper use, faulty maintenance, improper repair, damage or alteration by anyone other than Bittium Biosignals Ltd or their authorized service personnel.



**NeurOne system does not provide any automatic analysis or diagnosis.**

## 1.4 Warranty

All repairs on products under warranty must be performed or approved by Bittium Biosignals Ltd. Unauthorized repairs will void the warranty. The warranty terms are as follows:

Warranty: 24 months unless otherwise specified herein below.

Coverage: Parts and labor unless otherwise specified herein below.

All warranties will be invalidated if unauthorized repairs are made to any parts of the overall system.

The liability of Bittium Biosignals Ltd is limited to the repair of the product under warranty and specifically excludes consequential loss. The warranty covers all labour and parts associated with normal use. The warranty does not cover travelling expenses in case the repair is needed at end-user's facilities.

Bittium Biosignals Ltd guarantees the spare part supplies for at least 5 years after delivery date of the product.

Installation of additional equipment that is not specified or approved by Bittium, or is such quality to render the unit inoperable, may invalidate the warranty.

This warranty does not cover accidental damage or misuse.

The end-user shall ensure that the environment and electrical supply are suitable for the equipment and are maintained in accordance with the specification of Bittium Biosignals Ltd.

The end-user shall keep and operate the equipment in a proper and prudent manner and ensure that only competent persons are allowed to operate it.

The end-user shall not make any addition, modification or adjustment to the equipment without the prior written consent of Bittium Biosignals Ltd, nor allow persons other than Bittium staff or authorized agents to adjust repair or maintain it.

### **Special terms and conditions for parts of the system:**

#### **Measurement unit**

Warranty: 24 months.

Coverage: Parts and labour except disposable / single use parts.

#### **Interface Cables and Battery Packs**

Warranty: 12 months. The warranty does not cover faults caused by improper handling.

## 2 GENERAL HANDLING

### 2.1 Product Overview

The NeurOne system includes sensitive electronics. Follow these general instructions when handling the system:

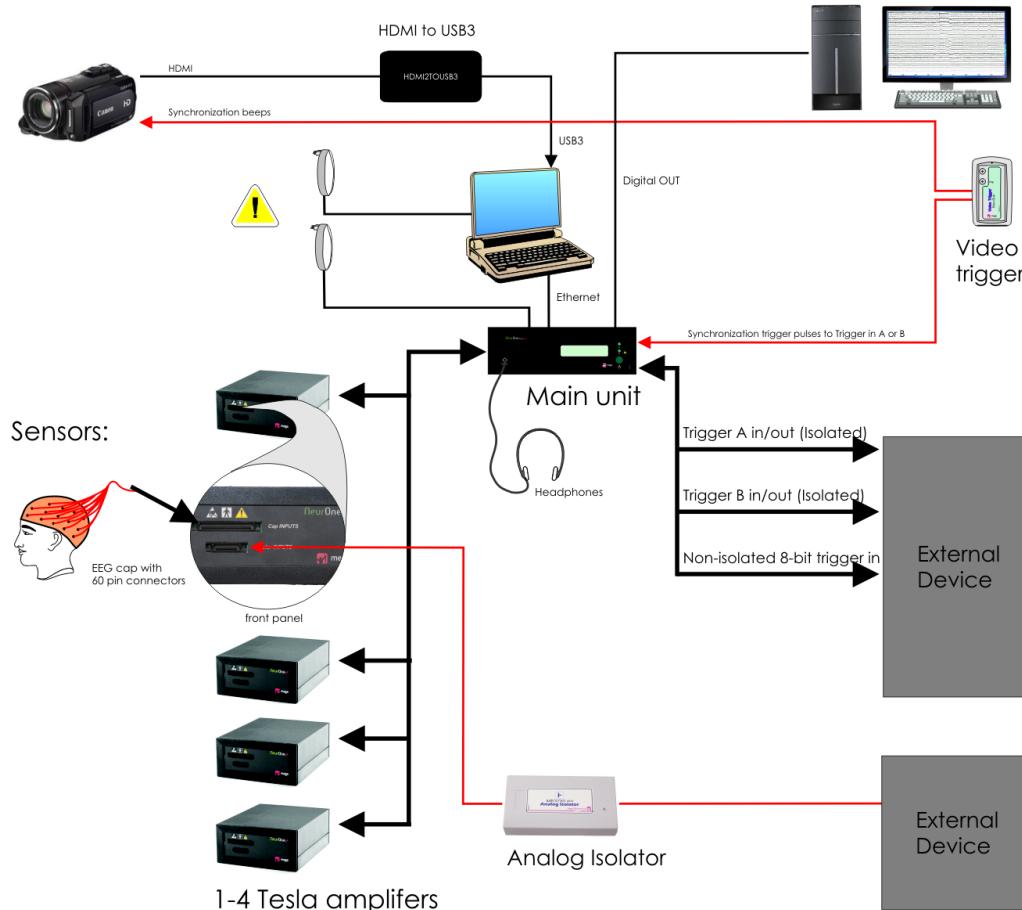
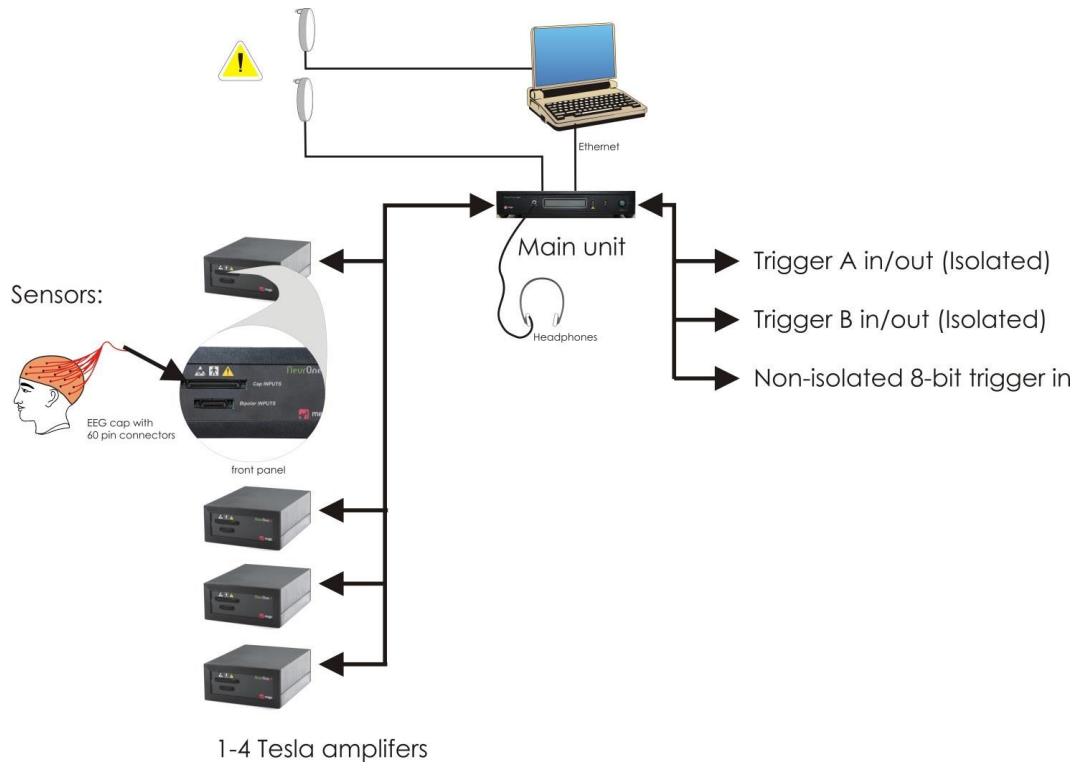
- Handle the device carefully.
- Be careful not to drop the device on hard surfaces.
- Be careful not to batter the device.
- Do not wash the device with water and avoid extremely high humid conditions. Do not use for over 30 minutes in humid place (relative humidity over 80%) without proper protection.
- Do not expose to temperatures under 0 °C / 32 °F / 273 K or above 35 °C / 95 °F / 308 K or relative humidity over 80 % without proper isolation. These include also storing and transportation of any part of the device.
- Do not open the device or any other sealed part of the system.
- When disconnecting a cable from the device, pull at the connector. Do not pull at the cable and do not rotate the connectors.

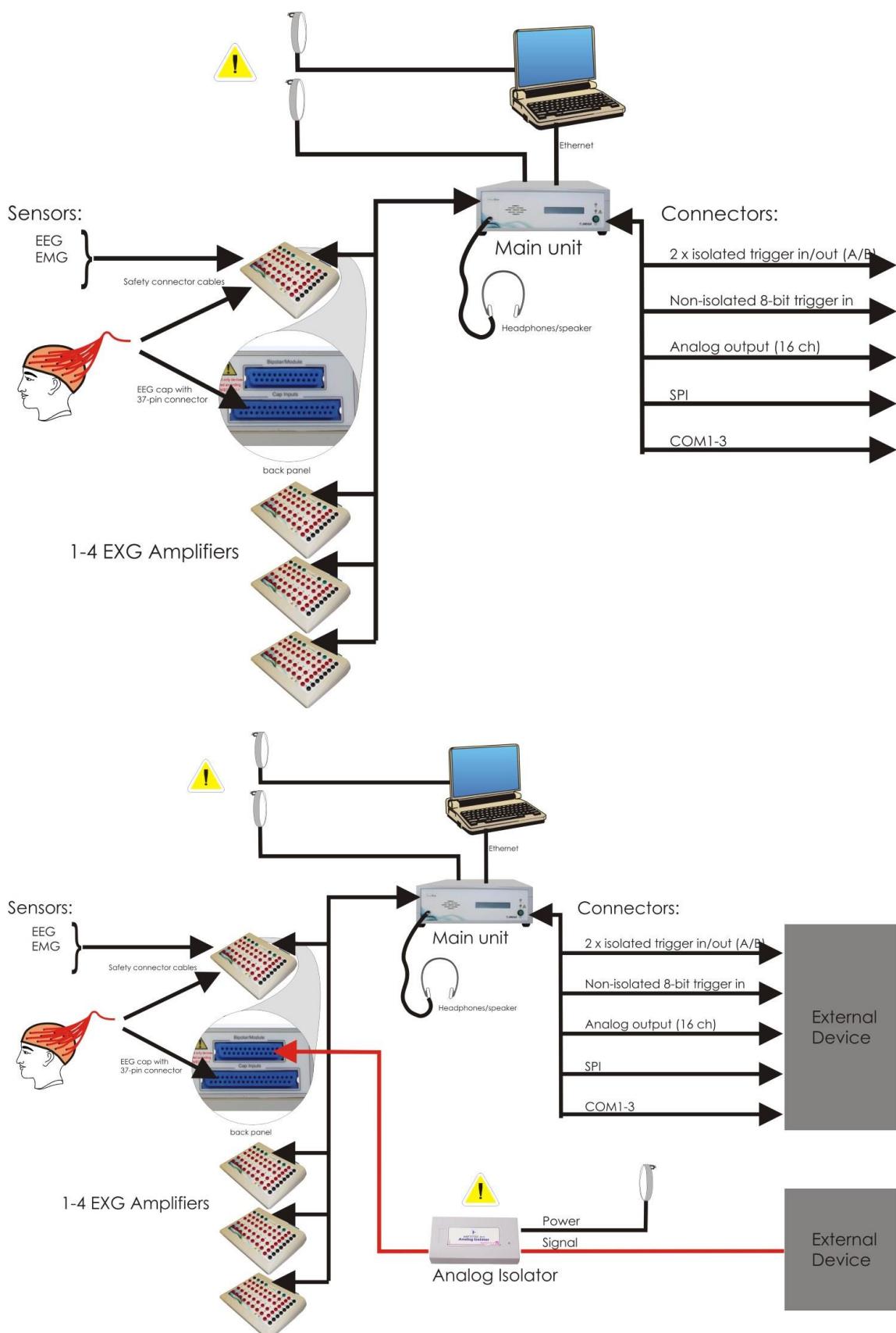


You should inspect your device and cables regularly. If there is visibly something broken, it is best to have it repaired at your local distributor or Bittium Biosignals Ltd.

Use only the power source, cables, electrodes and other accessories specified by Bittium Biosignals Ltd.

## 2.2 System Diagrams





Note: SPI and COM port are not yet available and will be enabled by future updates.

## 2.3 System Functions

NeurOne System is a monitoring solution for neuroscience measurements. It is developed for the needs of medical professionals and scientists to detect high accuracy neurological signals from multiple channels simultaneously without compromising data integrity. §

System consists of NeurOne Main unit (NeurOne Black) and up to 4 Tesla amplifiers which are used to collect polygraphic biosignals (EEG, ECG and EMG etc.). One Tesla amplifier can measure up to 32 unipolar and 8 bipolar channels. Complete NeurOne system with 4 Tesla amplifiers can measure 160 channels. NeurOne system includes NeurOne PC operating software which must be installed on the PC. EEG caps, ECG and EMG electrodes are used as the sensors.

NeurOne PC-software has tools to control all measurement related functionality commanding NeurOne Main unit through an Ethernet connection. The Main unit controls the Tesla amplifiers and consolidates incoming data from the amplifiers to a common data stream that's sent to the PC. Incoming event triggers are fused to data stream in the Main unit. Audio output from defined sources takes place in Main unit.

Tesla amplifiers are connected to the NeurOne Main unit via an optic link. Synchronized measurement takes place in Tesla amplifiers: data acquisition, filtering and down sampling.

NeurOne PC stores the measured data and provides viewing tools and possibilities to export data to be used in other applications.

## 2.4 Usability

The Operator profile for this device is: Healthcare professionals / EEG researcher with up to date basic computer skills.

The operating principle of the device is designed to keep the operator profile in mind. If the user is not familiar with EEG measurements, patient isolation principles or result interpretations it is recommended to have knowledge of this area prior use of this device.

The device operation does not require repeatable maneuvers which could have ergonomic influences.

When the system is used with computer and its accessories, please read the computer manufacturers ergonomic guidelines. It is computer manufacturer's responsibility to provide guidelines for proper workstation setup, posture, and health and work habits for computer users.

## 2.5 Maintenance and Service

Please follow the maintenance and calibration instructions. You should inspect the system devices and cables regularly. If there is visible damage, it is best to have it repaired at your local distributor or Bittium Biosignals Ltd.

### 2.5.1 Cleaning

You can clean the device using a non-fluffing cloth dampened in cleaning fluid, such as water and mild hand soap solution. For accessories, like EEG cap, follow the instructions provided with the accessory.



Disconnect the power supply before cleaning. Be careful not to rub too forcefully. Do not use alcohol based fluids or corrosive chemicals! Do not sink the device or cables into the cleaning fluid!

### 2.5.2 Calibration

The equipment is calibrated at the factory and it does not require regular calibration.



Do not try to open the device, the Power Supply, the cables or other sealed parts of the system. Only technical personnel, authorized by Bittium Biosignals Ltd, are allowed to open these parts, subject to the instructions given by Bittium Biosignals.

## 2.6 Disposal and Environmental Issues

The packaging material is cardboard. It can be re-cycled according to local regulations.

When the device is not used, consider disconnecting it from the mains current. Note also that when the device is used according to instructions the service need for the device is minimized and the life time of the device is optimized.

Please follow your local environment safety regulations when disposing of the system, or any parts of it. In many countries the electronics re-cycling is possible or even obligatory.



For EU only: This symbol indicates that this device shall be disposed according to European Union directive 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE). If the device is contaminated the directive does not apply.

## 3 SOFTWARE INSTALLATION

### 3.1 System Requirements for the Computer

The NeurOne PC Software requires the following hardware specifications as a minimum:

Processor:	Intel i5 3.0 GHz or better
Screen Resolution:	Full HD 1920x1080
Memory (RAM):	4 GB
Graphics card:	1 GB internal memory, dedicated graphics (DirectX 10 compatibility recommended)
Hard Drive:	1 TB (1000 GB)
Optical Drive:	DVD-ROM
Ethernet port:	RJ45, 100 / 1000 Mb/s
USB:	One USB3 port for video option
Operating System:	Windows 7 Professional 64 bit

Recommended PC requirements:

Processor:	Intel i7 3.0 GHz or better
Screen Resolution:	Full HD 1920x1080
Memory (RAM):	8 GB
Graphics card:	1 GB internal memory, dedicated graphics (DirectX 10 compatibility recommended)
Hard Drive:	1 TB (1000 GB)
Optical Drive:	DVD-ROM
Ethernet port (2 pcs):	RJ45, 100 / 1000 Mb/s
USB:	One USB3 port for video option
Operating System:	Windows 7 Professional 64 bit

### 3.2 Video Camera Requirements for NeurOne Video Option

When using NeurOne Video Option, the requirements for video camera are:

Video resolution:	Full HD (1080p)
Audio Input:	Microphone Input
Video Output:	HDMI Output

### 3.3 Installing the NeurOne PC Software

If you are upgrading to NeurOne PC Software v.1.5.x from NeurOne PC Software version older than 1.4.1.55 you must first install NeurOne 1.4.1.64 and manually back up your database. Manual database backup is done by copying `NeurOneDB.mdf` and `NeurOneDB_log.ldf` in database folder (default: `C:\ProgramData\Mega Electronics Ltd\NeurOne64\`) to a safe location when NeurOne software isn't running.

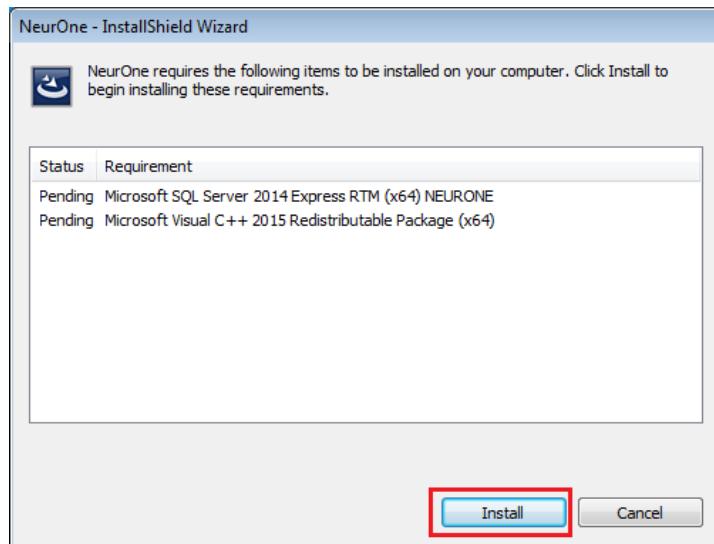
Then install new version 1.5.x as instructed in this chapter.

NeurOne PC Software is a 64-bit application. It uses the Microsoft .NET Framework 4.0, Microsoft Visual C++ 2015 redistributable library and Microsoft SQL Server 2014 Express. The installer will install or update these system parts automatically if they are not found. Installing the NeurOne PC Software, and the above software components requires administrative rights on the Windows operating system.



**Restart the PC prior to installation.**

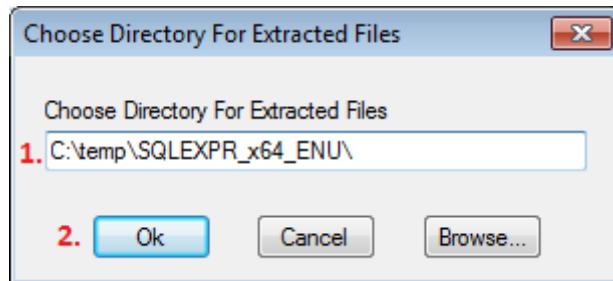
The installation should start automatically when the installation DVD is inserted into PC (installation package – NeurOne Installer <version>.exe). The following dialog should appear (see picture below):



The dialog informs you what components are needed to be installed. Click **Install**. If you already have all required requisites installed, this dialog will not be shown.

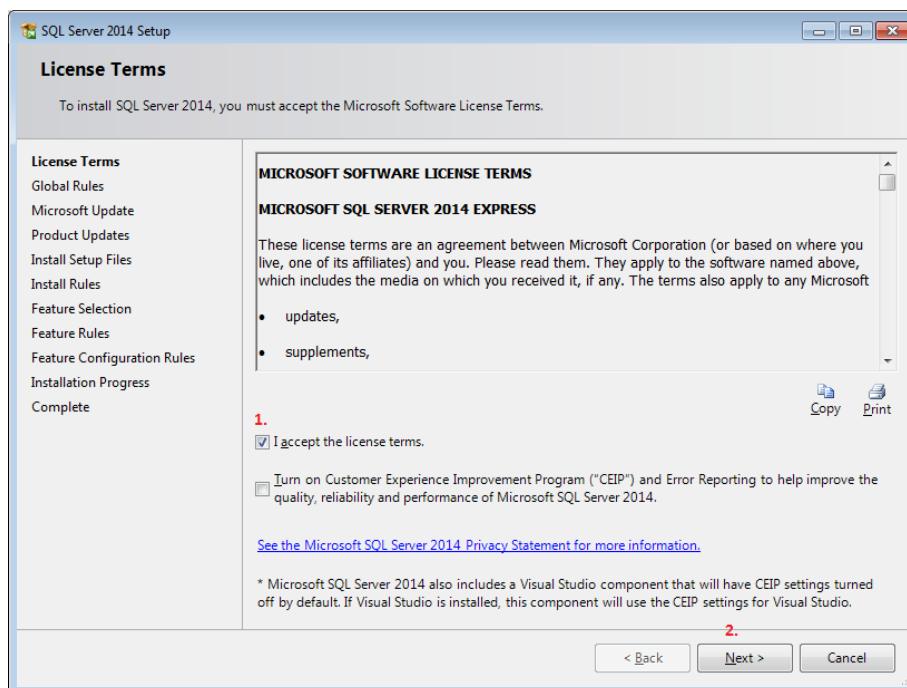
#### 3.3.1 SQL Server 2014 Installation

SQL Server installer will open with extraction path of the installation files. Make sure that the name of the directory that the files will be installed is short. For example you can (1) select the folder C:\temp and (2) press OK.

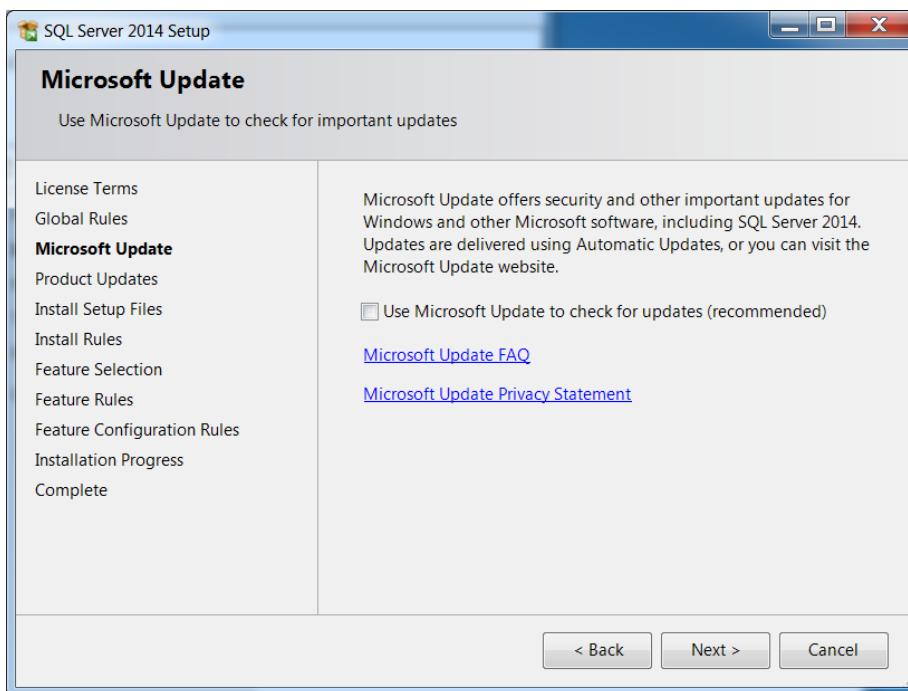


After extraction the installer automatically starts installation of a new database server instance

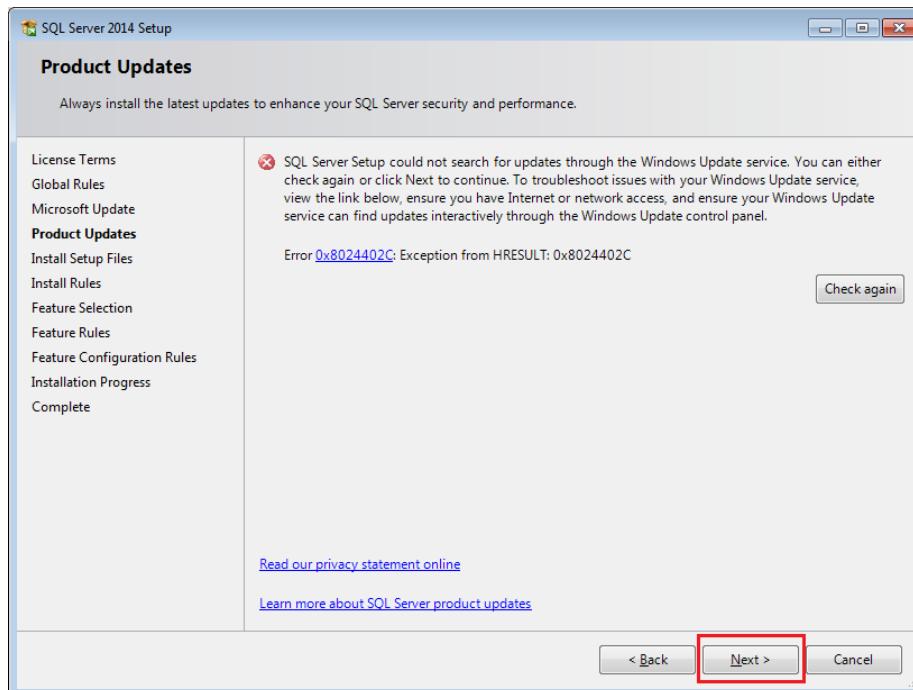
Then opens the license terms page. (1) Check “I accept license terms.” and (2) click Next >.



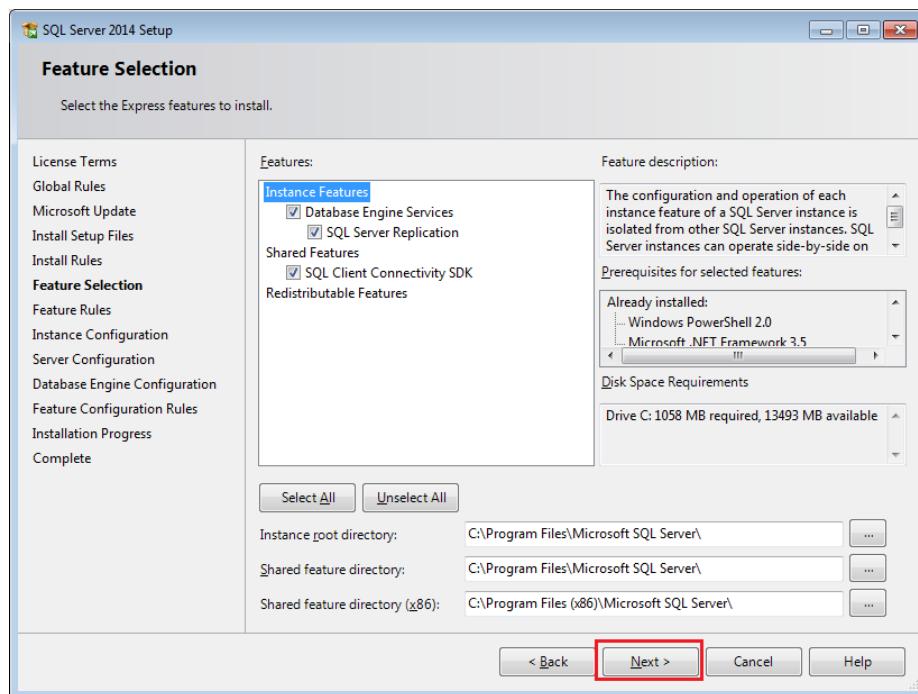
If Microsoft Update is requested click Next>  
**(DO NOT CHECK THE CHECKBOX)**



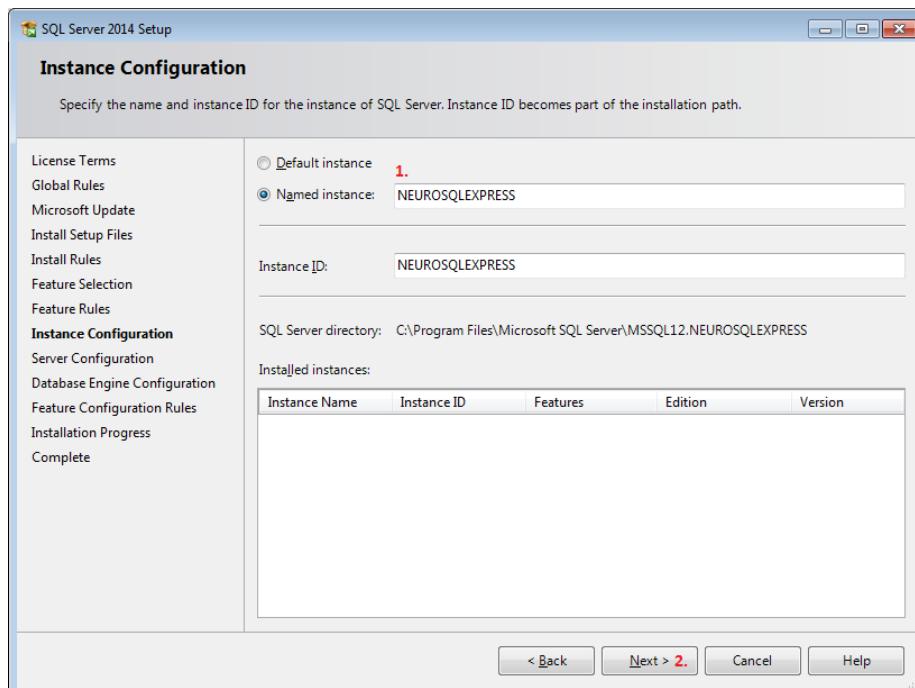
At Product updates click **Next>**



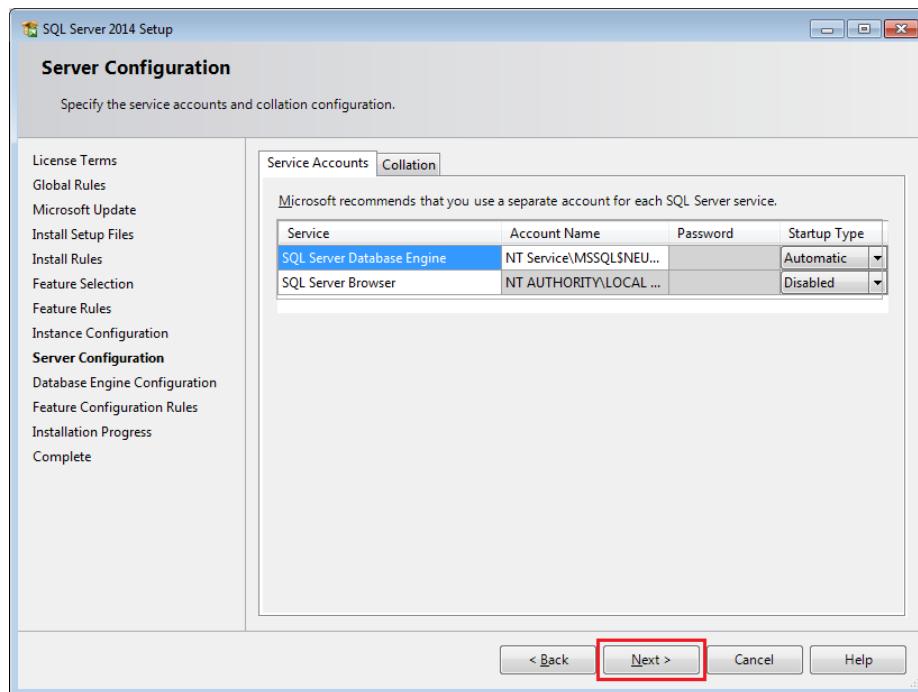
On the feature selection page make sure all features are selected and click **Next >**.



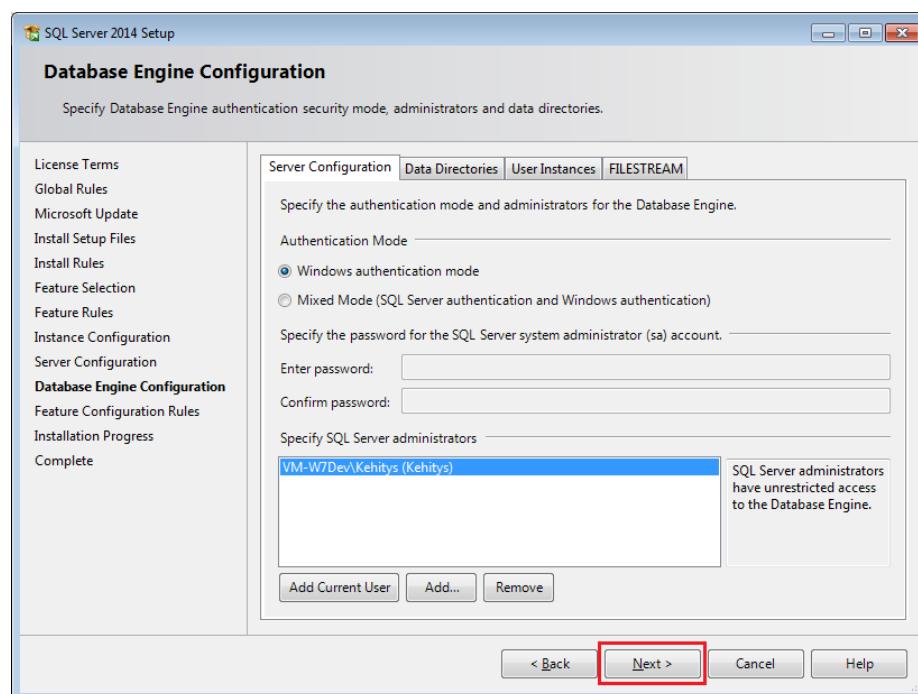
On the Instance configuration page (1) ensure that the *Named instance* and *Instance ID* fields are set to value **NEUROSQLEXPRESS** and (2) click **Next >**

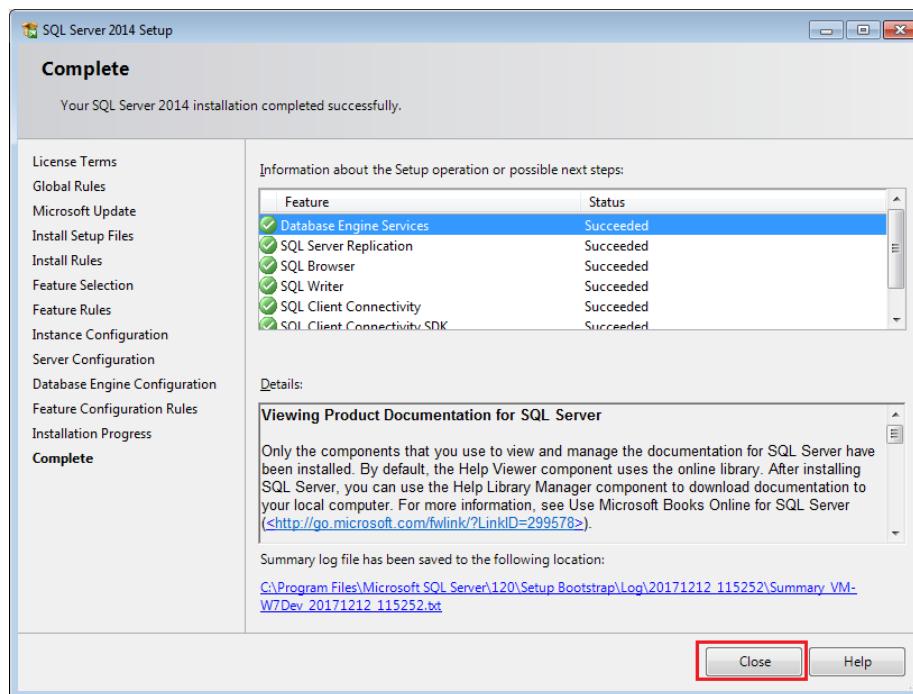


On Server Configuration click **Next >**



In database engine configuration leave selection to default. Click **Next >**.

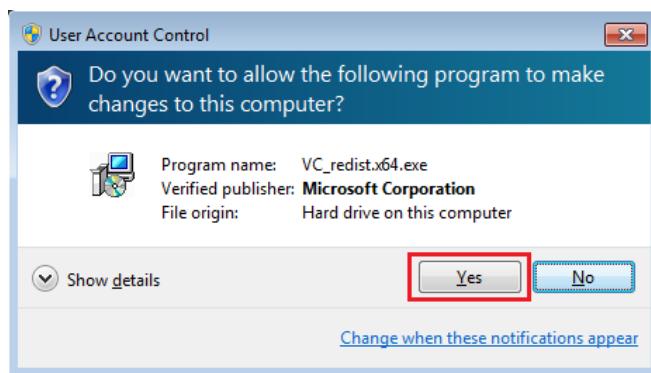




Click **Close** to exit SQL Server 2014 Setup .

### 3.3.2 Visual C++ 2015 Redistributable Installation

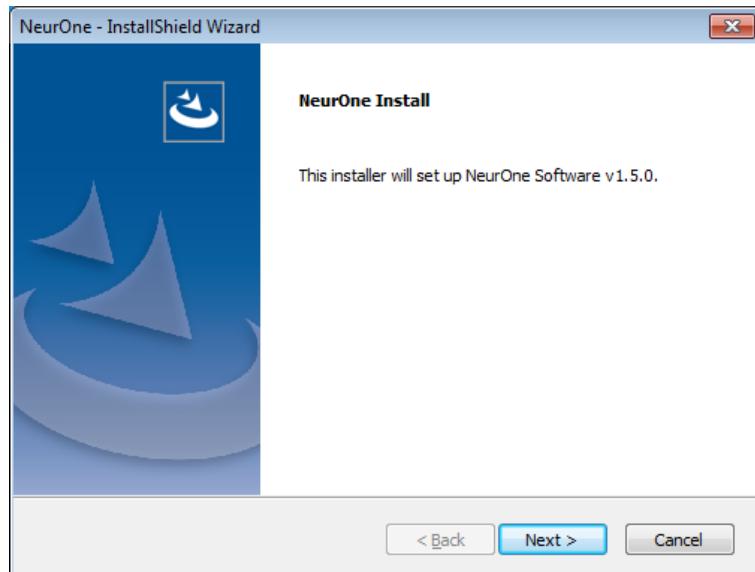
If the Visual C++ 2015 Redistributable x64 is not installed, the installer will install it next.



Allow changes by clicking **Yes**.

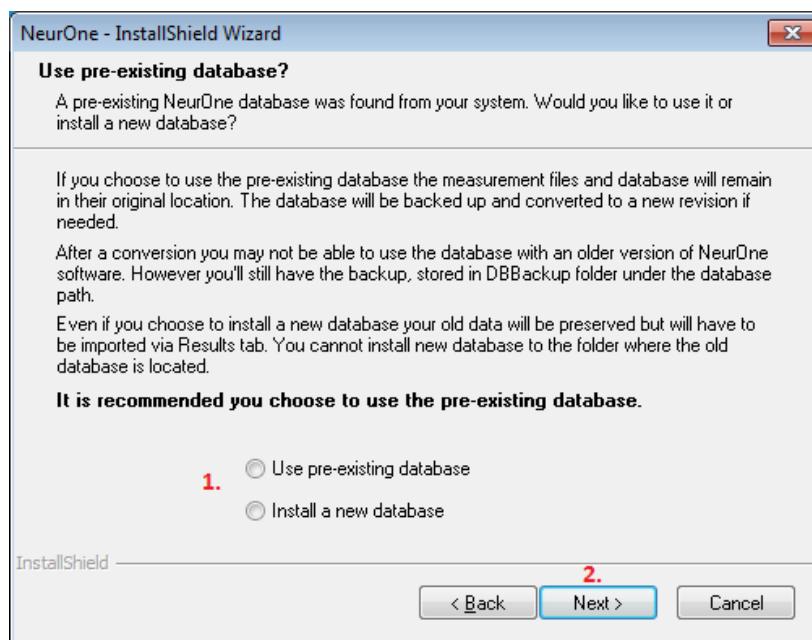
### 3.3.3 NeurOne software Installation

The installation continues now with the actual installation of NeurOne software.

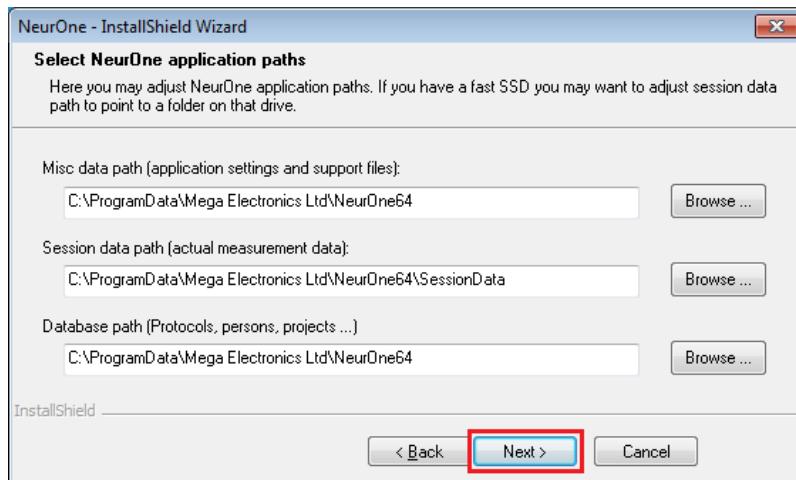


Click **Next >**.

If former version of NeurOne PC SW is installed on the PC and it is detected the setup program asks to choose (1) either existing or new database for installation and (2) Click **Next >**. If you're upgrading from an older version of NeurOne PC Software it's recommended to use pre-existing database. This way your new NeurOne 1.5.0 installation will have automatically have access to all your protocols and projects and you don't need to import anything manually from the older version.

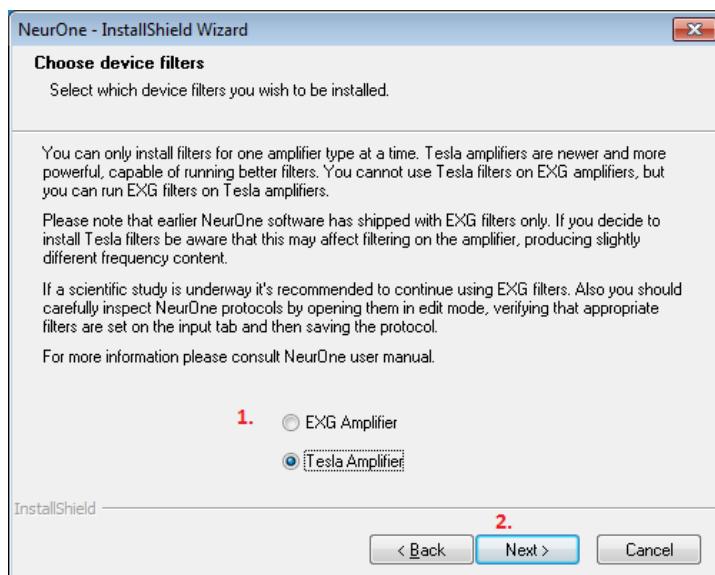


The following dialogs have the selection controls for Misc data path, Session data path and Database path. Use default location or select the desired path by browsing and Click **Next >**.



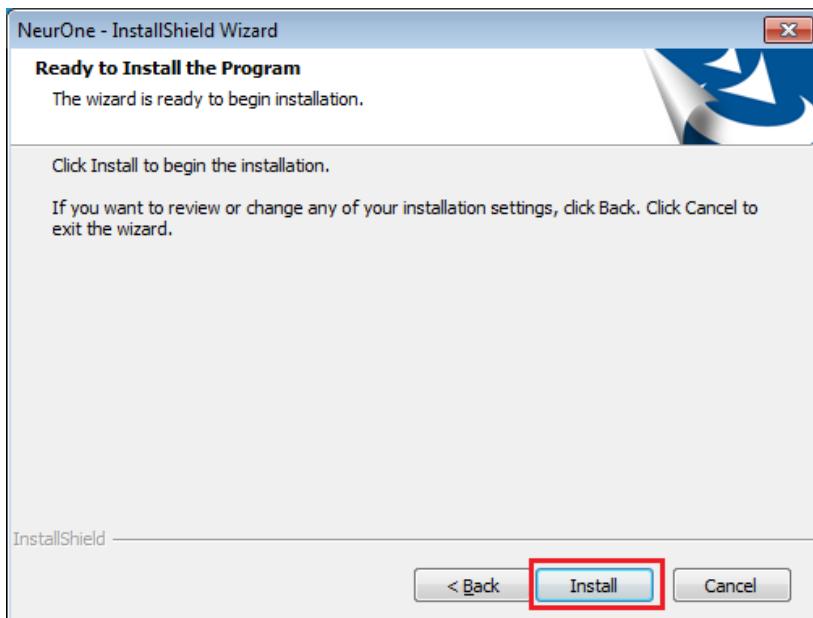
	<b>If pre-existing database is chosen database path cannot be changed in application path selection (controls are disabled).</b>
	<b>If you've selected a Session data path on a drive with less than 20 GiB free space the installer will show you a warning.</b>

Then select the device filters to be installed by (1) selecting the amplifier type you are using and (2) Click **Next >**. Note that if you install Tesla filters and you have any pre-existing protocols using EXG filters, the software will (with your permission) try to convert those protocols to use Tesla filters.



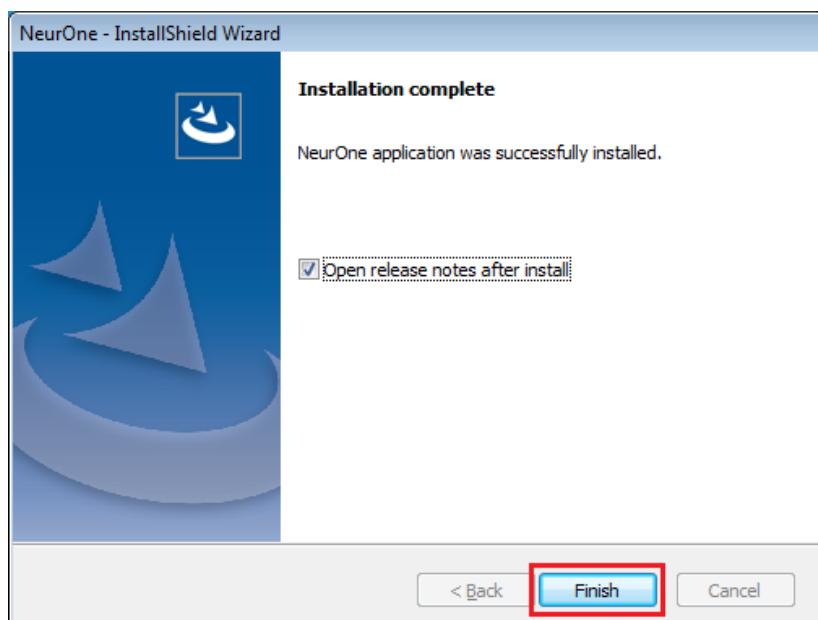
## Now the Installer is ready to install NeurOne Software.

Click **Install** and all NeurOne program files are installed to the folder C:\Program Files\Bittium Biosignals Ltd\NeurOne\.



**During the installation the calibration files (\*.hbc) of the amplifiers found on the installation media are copied to the sub-folder HBC in Misc data folder. These calibration files are then activated in NeurOneDrvMw.ini.**

Wait until the copying ends.



Installation complete window will appear indicating successfully made installation. Click **Finish** button. If checkbox “Open release notes after install” is checked, the release notes are opened.

**Now you are ready to start using NeurOne software.**

### 3.3.4 NeurOne Database Conversion

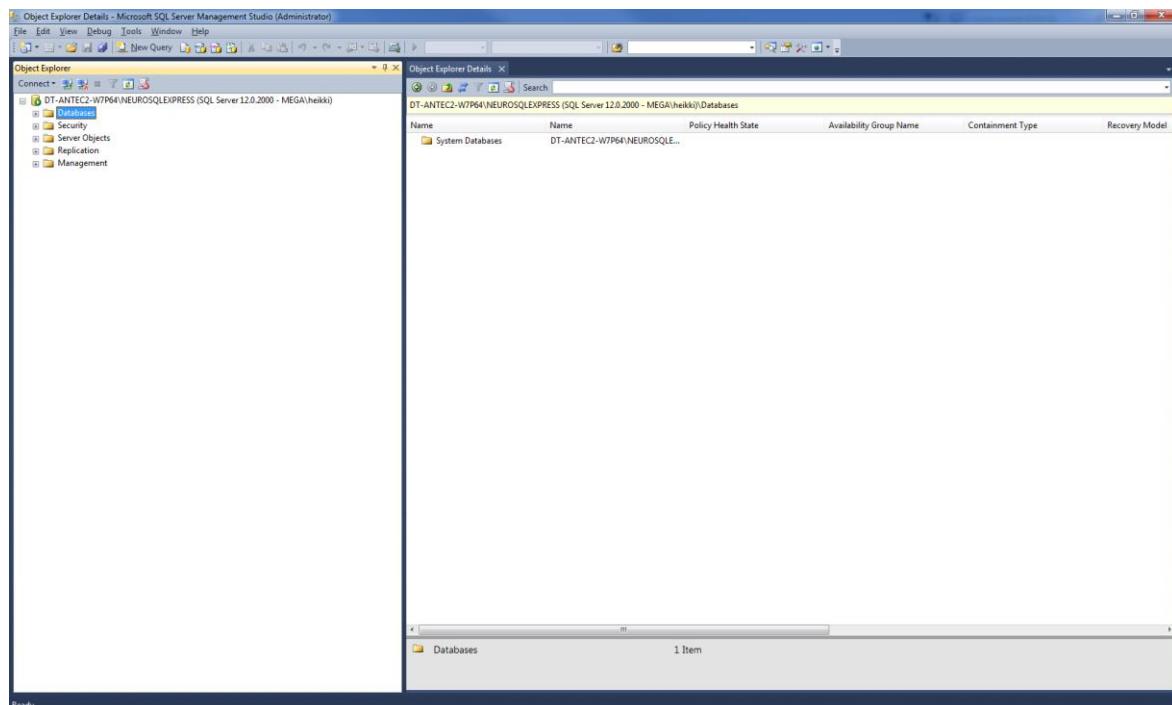
If you have an older NeurOne version (1.3.x) that uses SQL Server 2005 for database, you need to convert the NeurOne database file so that it will work with new version of NeurOne.

First install SQL Server 2014 express with management studio to your computer. **This is not contained in the NeurOne installer. You need to download it.**

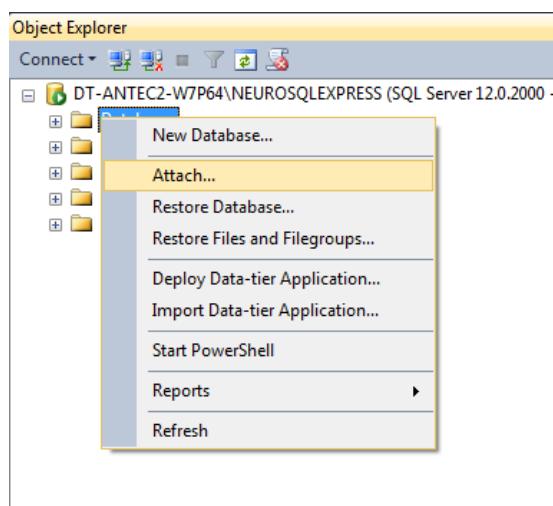
Open SQL Server 2014 Management Studio from:

Start Menu\All Programs\Microsoft SQL Server 2014\SQL Server 2014 management studio.

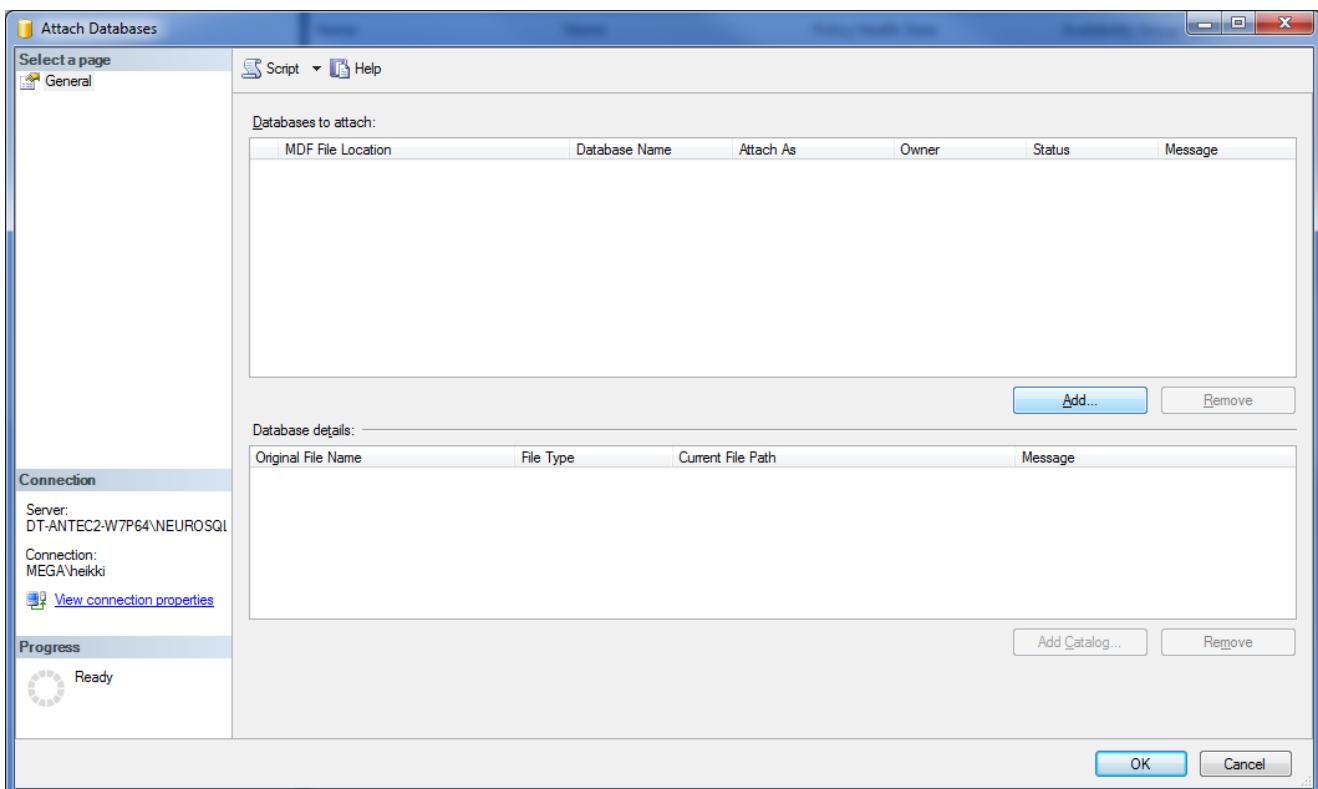
In the window that opens up, go the server name and select the SQL Server that contains the name NEUROSQLEXPRESS. Click connect. The window below should appear:



Make sure that you are connected to the right version for the SQL Server 12.0.2000. Then right-click on the database and click Attach.



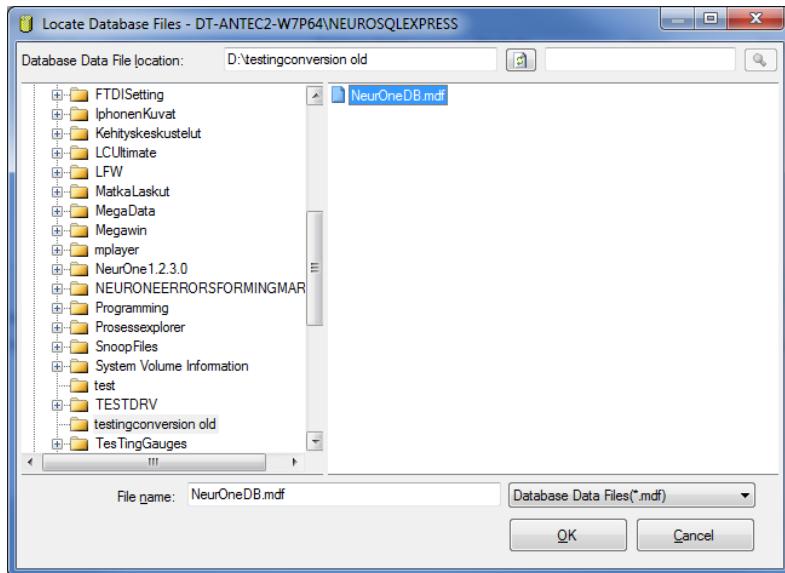
Then select Add.



Browse to the location you have selected for database, by default it is **C:\ProgramData\Mega Electronics Ltd\NeurOne\** or **C:\ProgramData\Mega Electronics Ltd\NeurOne64\**

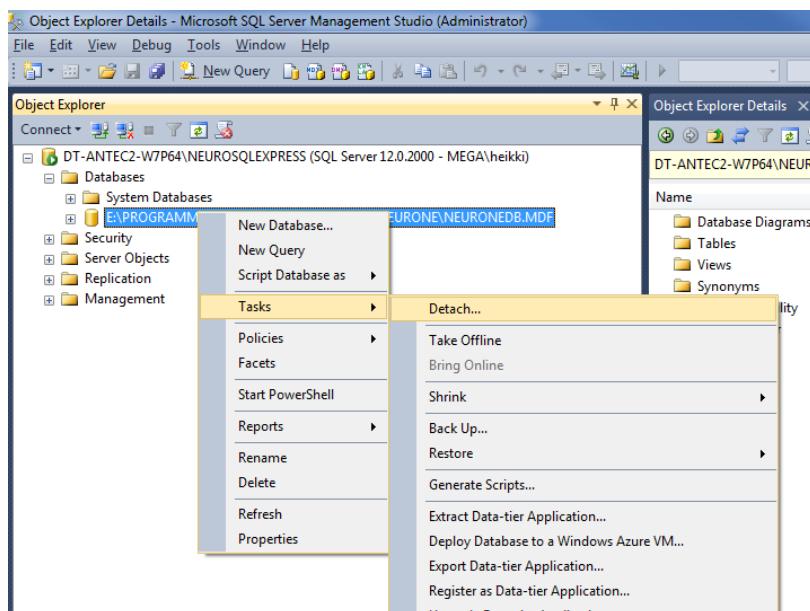
Select the NeurOne database file **NeurOneDB.mdf**. Make sure that you make backup form the database files before you do this conversion. This is done so that you just copy the **NeurOneDB** files to some secure location before conversion.

Then click OK.



Click OK. Now the conversion has been done and you need detach the database to be able to use it in NeurOne software.

Right-click the attached database, select task\detach and click OK. Database will disappear from under the system database and is now ready for use in the new version of NeurOne software. Close the SQL server management studio and start NeurOne.



### 3.4 Installing NeurOne Video Option

Locate the installation exe file on your installation media.

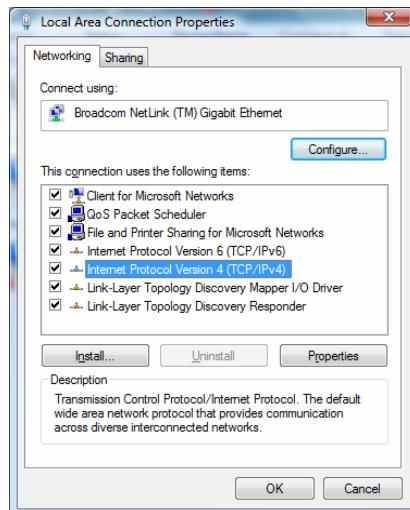
Run NeurOneVideoOption\_x.x.x\_Setup.exe and complete the installation. Then the NeurOne Video Option is installed.

### 3.5 Configuring the Ethernet Address for the Computer

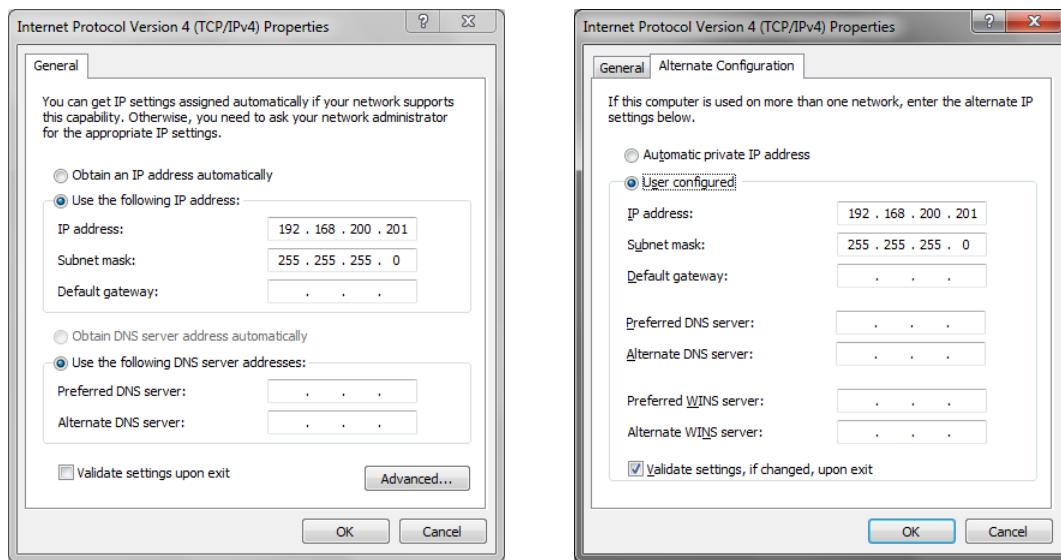
All communication between the NeurOne system and the PC, including transmission of measurement data, is carried out using the TCP/IP (over Ethernet). To enable the communication, you need to configure the TCP/IP settings of your PC as described below.

In Windows 7, you can view and edit the TCP/IP settings in the following way:

- Open the *Control Panel*, select *Network and Sharing Center* and click on *Change adapter settings*.
- Right-click on *Local Area Connection* and select *Properties*.
- In the *Networking* tab, select *Internet Protocol Version 4 (TCP/IPv4)* and click *Properties*:



- You can configure the TCP/IP settings in two ways:
- You can dedicate the Ethernet port for NeurOne use and set the IP address and Subnet mask in the General tab. For an example, see the figure on the left hand side.
- If you have only one Ethernet port on your PC, and you want to use the port for other connections (email, internet) as well, you can use the Alternate Configuration tab for NeurOne communication settings, and leave the settings for other connections in the General tab. This way Windows can automatically choose the proper TCP/IP settings based on which cable is connected to the Ethernet port. For an example, see the figure on the right hand side:



In Windows Vista, start setting the TCP/IP settings by navigating to the *Control Panel* and *Network and Sharing Center*, and by selecting *Manage network connections*. From there on, follow the above instructions. In Windows XP, navigate to the *Control Panel* and from there to *Network Connections*, and follow the above instructions.

### 3.5.1 NeurOne IP address

The following table defines the control IP address of NeurOne Main unit when used as Stand-alone (without SyncBox) and as Master/Slave Main unit with SyncBox:

Main unit	Control IP address
Stand-alone	192.168.200.200
SyncBox Master	192.168.200.101
SyncBox Slave1	192.168.200.102
SyncBox Slave2	192.168.200.103
SyncBox Slave9	192.168.200.110

In order to check the accessibility to desired Main Unit you may use Ping tool. Example how to check accessibility to Main Unit in default IP address:

```
C:\Windows\system32\cmd.exe
C:\Users>ping 192.168.200.200

Pinging 192.168.200.200 with 32 bytes of data:
Reply from 192.168.200.200: bytes=32 time=2ms TTL=255

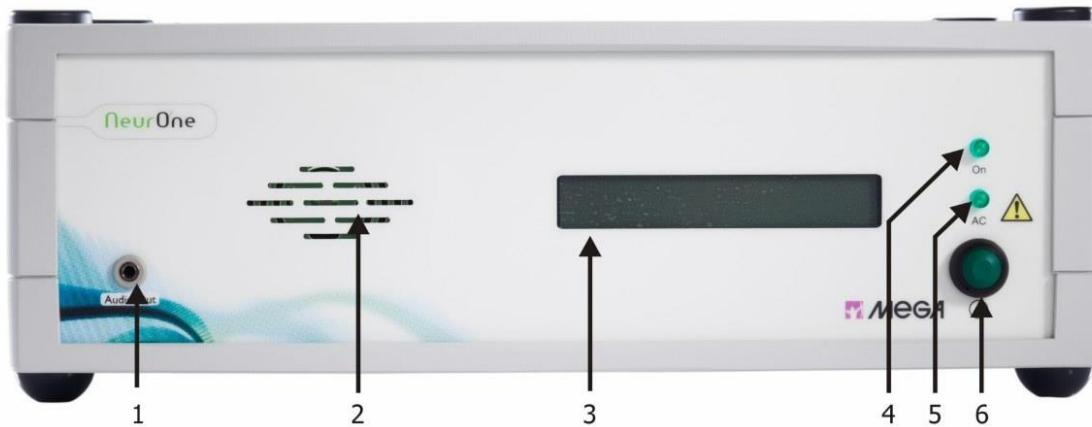
Ping statistics for 192.168.200.200:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 2ms, Maximum = 2ms, Average = 2ms
```

## 4 HARDWARE INSTALLATION

The NeurOne system consists of:

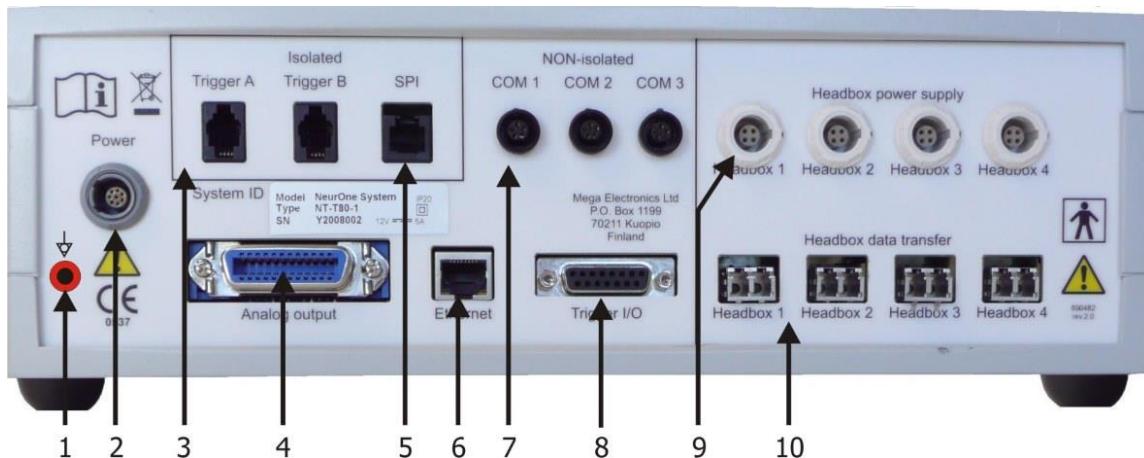
- Setup A:
  - Main Unit, model: Extended
  - Amplifiers (1 – 4 pcs)
    - Model: EXG amplifier or Tesla amplifier
  - Main Unit power cable (with AC/DC transformer)
  - Amplifier power cables (1 – 4 pcs)
  - Optical cables (between Main Unit and Amplifier, 1 – 4 pcs)
  - Trigger cable (for isolated trigger)
  - Ethernet cable (RJ45)
  - Potential equalization cable
  - Battery Pack for Tesla amplifier, battery power cable, battery charger
  - Battery Pack for EXG amplifier, battery power cable, battery charger
  - Ethernet isolator and isolation transformer
- Setup B:
  - Main Unit, model: Black (without power outputs, analog out, SPI and COM ports)
  - Amplifiers (1 – 4 pcs)
    - Model: EXG amplifier or Tesla amplifier
  - Main Unit power cable (with AC/DC transformer)
  - Amplifier power cables (1 – 4 pcs)
  - Optical cables (between Main Unit and Amplifier, 1 – 4 pcs)
  - Trigger cable (for isolated trigger)
  - Ethernet cable (RJ45)
  - Potential equalization cable
  - Battery Pack for Tesla amplifier, battery power cable, battery charger
  - Battery Pack for EXG amplifier, battery power cable, battery charger
  - Ethernet isolator and isolation transformer
- Setup C:
  - Main Unit, model: Black High
  - Amplifiers (1 – 4 pcs)
    - Model: EXG amplifier or Tesla amplifier
  - Main Unit power cable (with AC/DC transformer)
  - Amplifier power cables (1 – 4 pcs)
  - Optical cables (between Main Unit and Amplifier, 1 – 4 pcs)
  - Trigger cable (for isolated trigger)
  - Ethernet cable (RJ45)
  - Potential equalization cable
  - Battery Pack for Tesla amplifier, battery power cable, battery charger
  - Battery Pack for EXG amplifier, battery power cable, battery charger
  - Ethernet isolator and isolation transformer

## 4.1 Main Unit – model Extended



The front panel of the Main Unit has following components:

1. **Audio Out** – 3.5 mm connector for headphones in audio applications.
2. **Speaker** – Speaker for audio applications.
3. **Display** – Display for measurement information and device diagnostic purposes.
4. **Power On Led (ON)** – Indicates that the Main Unit is operational.
5. **Power Indicator Led (AC)** – Indicates that the Main Unit is connected to mains power (green).
6. **Power Button (green)** – ON/OFF-switch, selecting display mode
  - Default mode “NeurOne, press button for info” →
  - Tesla amplifier voltages →
  - Trigger counters →
  - SyncBox info →
  - Digital Out info →
  - CPU loads of EXG/Tesla amplifiers →
  - Firmware upgrade →



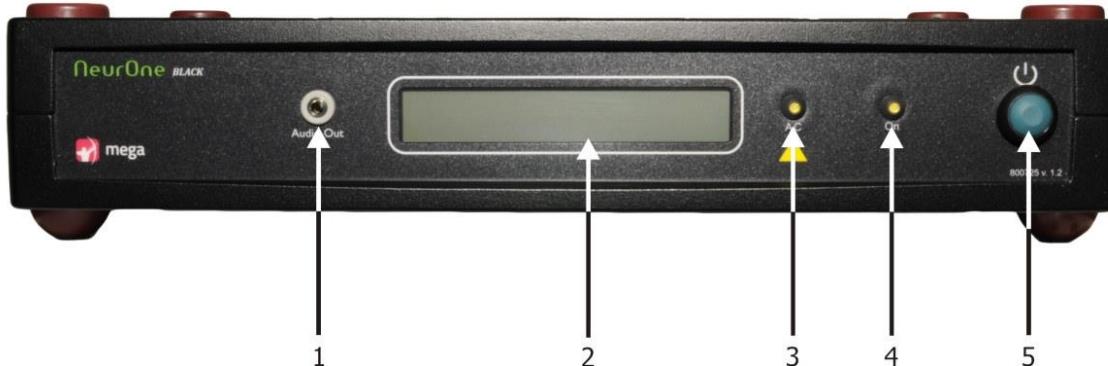
Main unit back panel connections:

1. **Potential equalization** – connector for potential equalization cable that should be connected to the potential equalization rail in the measurement room. It helps to reduce power line interference (50/60 hz)
2. **Power** – medical approved power supply (100 – 240 vac in, 12 vdc out)
3. **Trigger** – isolated triggers a and b (rj11)
4. **Analog output** – analog output for 16 channels (configurable from neurone pc software)
5. **Spi** – spi connection (not yet available)
6. **Ethernet** – ethernet connection to the pc (100 mb/s, rj45)
7. **Com ports** – three serial ports for input connections (not yet available)
8. **Trigger I/O (8-bit trigger)** – non-isolated 8-bit triggers in (8-bit input)
9. **Amplifier power supply** – power connection to the amplifiers
10. **Amplifier data transfer** – optical connection to the amplifiers/SyncBox

**Digital OUT** - Connection for UDP transfer to other PC (RJ45, optional), see the figure in chapter 4.3

See chapter 4.9 for instructions on how to connect cables to the connectors.

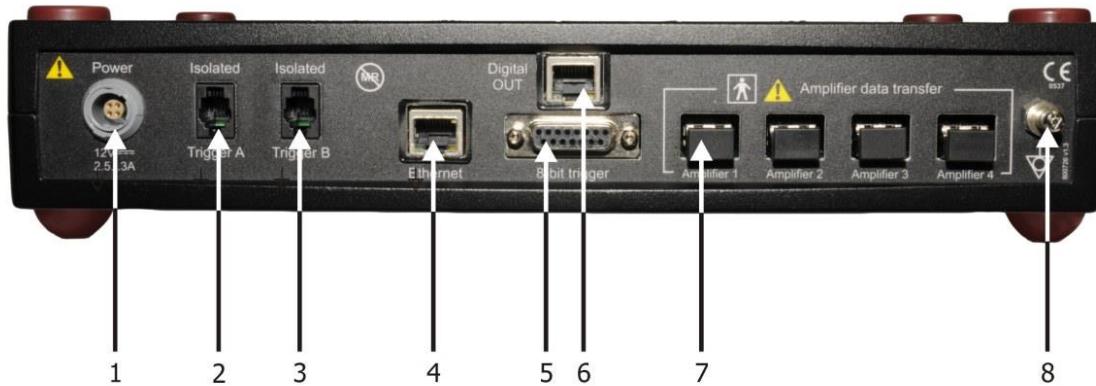
## 4.2 Main unit – model black



The front panel of the main unit has following components:

1. **Audio out** – 3.5 mm connector for headphones in audio applications.
2. **Display** – display for measurement information and device diagnostic purposes.
3. **Power indicator led (AC)** – indicates that the main unit is connected to mains power (green).
4. **Power on led (ON)** – indicates that the main unit is operational.
5. **Power button (green) ) – on/off-switch, selecting display mode**
  - default mode “neurone, press button for info” →
  - tesla amplifier voltages →
  - trigger counters →
  - SyncBox info →
  - digital out info →
  - cpu loads of exg/tesla amplifiers →

- firmware upgrade →

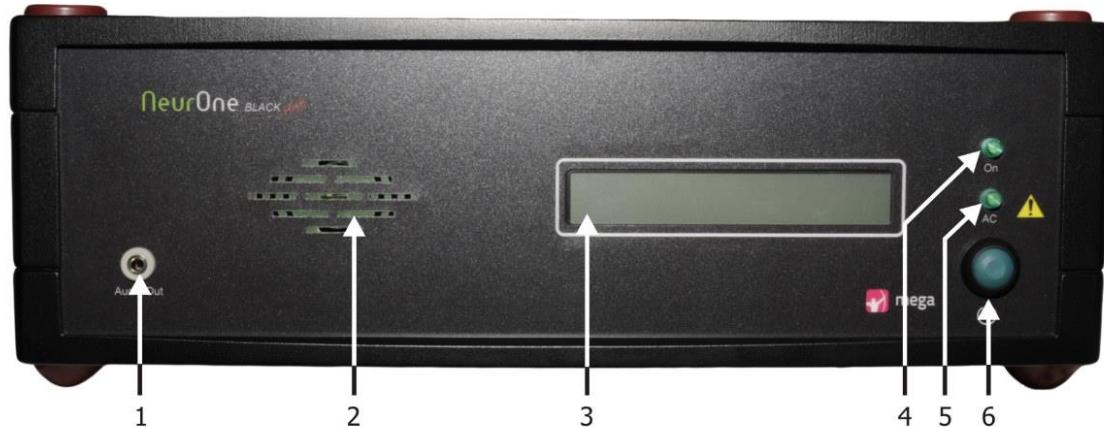


Main Unit back panel connections:

- Power** – Medical approved power supply (100 – 240 VAC in, 12 VDC out)
- Trigger A** – Isolated trigger A (RJ11)
- Trigger B** – Isolated trigger B (RJ11)
- Ethernet** – Ethernet connection to the PC (100 Mb/s, RJ45)
- 8-bit trigger** – Non-isolated 8-bit triggers in (8-bit input)
- Digital OUT** – Connection for UDP transfer to other PC (RJ45)
- Amplifier Data Transfer** – Optical connection to the Amplifiers/SyncBox
- Potential Equalization** – Connector for potential equalization cable that should be connected to the potential equalization rail in the measurement room. It helps to reduce power line interference (50/60 Hz)

See chapter 4.9 for instructions on how to connect cables to the connectors.

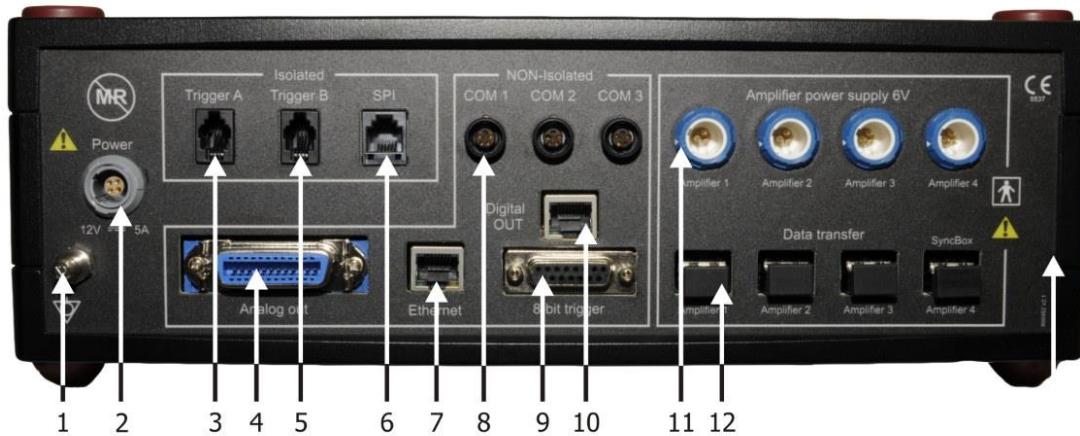
### 4.3 Main unit – model Black High



The front panel of the Main Unit has following components:

- Audio Out** – 3.5 mm connector for headphones in audio applications.

2. **Speaker** – Speaker for audio applications.
3. **Display** – Display for measurement information and device diagnostic purposes.
4. **Power On Led** – Indicates that the Main Unit is operational.
5. **Power Indicator Led** – Indicates that the Main Unit is connected to mains power (green).
6. **Power Button (green)** – ON/OFF-switch, selecting display mode
  - Default mode “NeurOne, press button for info” →
  - Tesla amplifier voltages →
  - Trigger counters →
  - SyncBox info →
  - Digital Out info →
  - CPU loads of EXG/Tesla amplifiers →
  - Firmware upgrade →



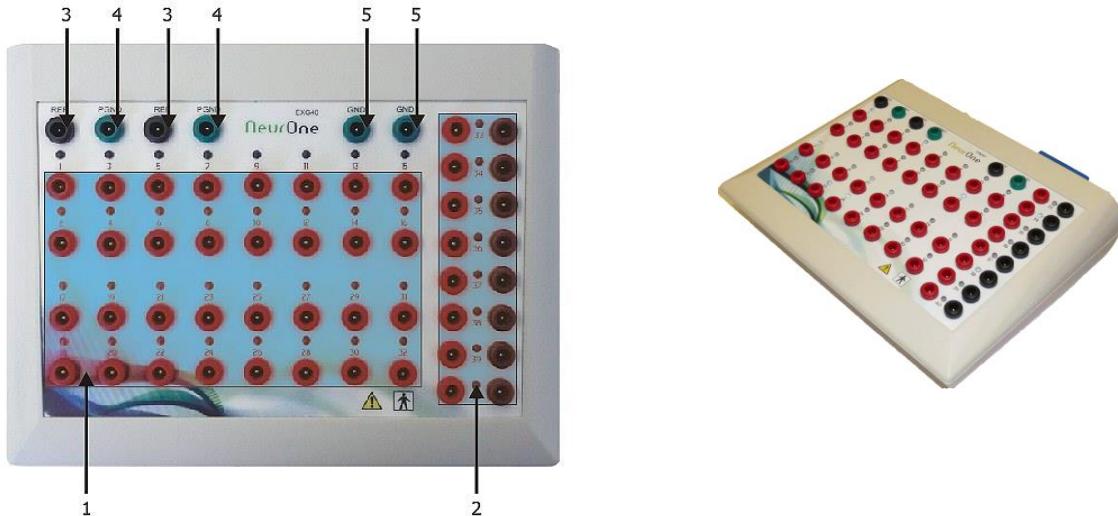
Main unit back panel connections:

1. **Potential equalization** – connector for potential equalization cable that should be connected to the potential equalization rail in the measurement room. It helps to reduce power line interference (50/60 hz)
2. **Power** – medical approved power supply (100 – 240 vac in, 12 vdc out)
3. **Trigger A** – isolated trigger a (rj11)
4. **Analog output** – analog output for 16 channels (configurable from neurone pc software)
5. **Trigger B** – isolated trigger b (rj11)
6. **SPI** – SPI connection (not yet available)
7. **Ethernet** – ethernet connection to the pc (100 mb/s, rj45)
8. **Com ports** – three serial ports for input connections (not yet available)
9. **8-bit trigger** – non-isolated 8-bit triggers in (8-bit input)
10. **Digital OUT** – Connection for UDP transfer to other PC (RJ45)
11. **Amplifier power supply** – power connection to the amplifiers (6V output)
12. **Amplifier data transfer** – optical connection to the amplifiers/SyncBox

See chapter 4.9 for instructions on how to connect cables to the connectors.

## 4.4 EXG Amplifier

A single NeurOne EXG amplifier offers 32 monopolar channels and 8 bipolar channels, allowing up to 40 available measurement channels. You can use either the safety connectors in the front panel or the D-connectors in the back panel for each channel.

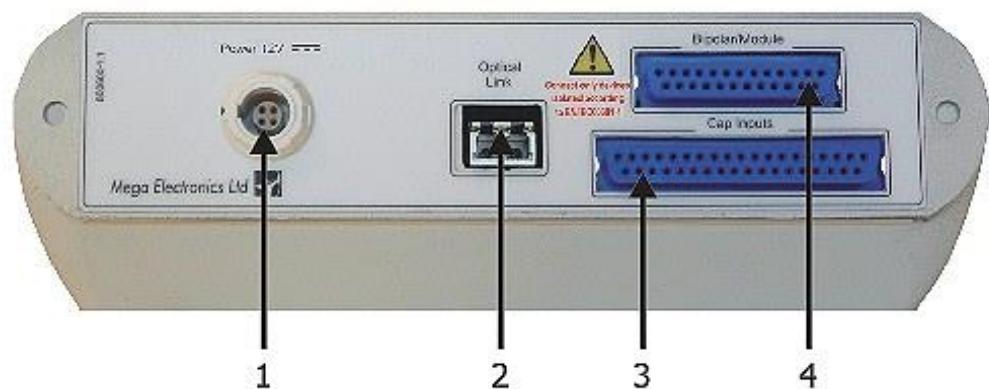


Amplifier front panel connections:

1. **Monopolar inputs** – Channels 1 – 32 with safety connectors.
2. **Bipolar inputs** – Channels 33 – 40 with safety connectors: red = signal, black = reference.
3. **Reference inputs (REF)** – The reference input for all monopolar channels.
4. **Patient ground (PGND)** – Used for both monopolar and bipolar channels.
5. **Ground (GND)** – Electric ground, used for modules/sensors that are not directly electrically connected to skin like GSR module, breathing belt, piezo sensors etc.



**Use patient ground (PGND) to connect the ground electrode.**



Amplifier back panel connections:

1. **Power** – to Main Unit or to Battery Pack, 12 V.
2. **Optical link** – to Main Unit.
3. **Cap Inputs** – 37 pin D-connector for EEG caps.
4. **Bipolar/Module** – 25 pin D-connector for bipolar channels and external sensors.

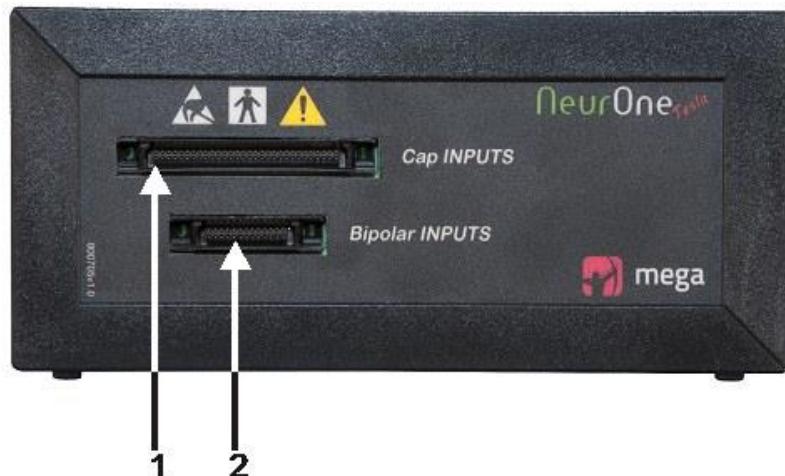
Each Amplifier in NeurOne system has an identification label in the left upper corner of the front panel. The first Amplifier 1 of the system is labeled “1”, Amplifier 2 is “2” etc...



**With EXG amplifier you can also use 12 V Battery Pack.**

## 4.5 Tesla Amplifier

A single NeurOne Tesla amplifier offers 32 monopolar channels and 8 bipolar channels, allowing up to 40 available measurement channels. For signal connection you can use either the flat cable connectors on front panel or additional JackBox providing 80 safety connector inputs. There are 2 versions of Teslas (Tesla being beige and Tesla MRI being black in color).



Tesla front panel connections:

1. **Cap inputs** – 60 pin KEL-connector for EEG cap and bipolar inputs (all 40 channels).
2. **Bipolar inputs** – 26 pin KEL-connector for bipolar channels and external sensors.



Tesla back panel connections:

1. **Optical link** – to Main Unit.
2. **Power on LED** – Indicates that the Tesla is operational.
3. **Power on/off switch** – ON/OFF-switch.
4. **Power** – Battery Pack, 6 V.



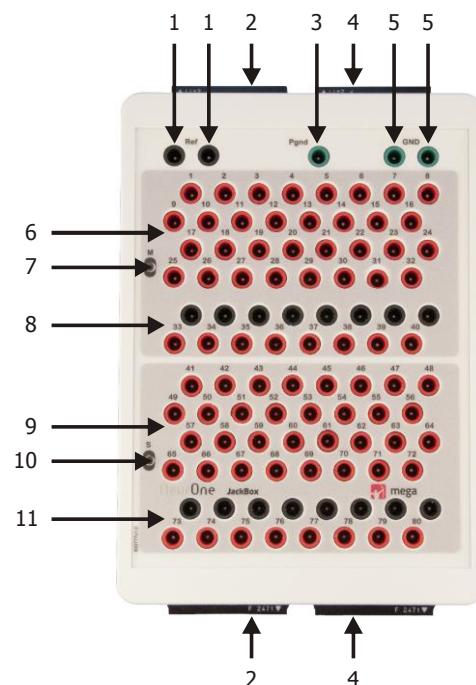
**With Tesla amplifier you must use 6 V or 7.2 V Battery Pack. See chapter 4.14.**

## 4.6 JackBox

NeurOne JackBox is meant to be used with Tesla amplifier and when using TMS cap (each cap having own JackBox). JackBox provides inputs for two amplifier, master and slave. The master amplifier has inputs 1 – 40 and slave inputs 41 – 80.

JackBox interface:

1. **Reference inputs (REF)** – Two reference inputs for all monopolar channels.
2. **Inputs 41 – 80** – 60 pin KEL-connector for slave amplifier.
3. **Patient ground (PGND)** – Used for both monopolar and bipolar channels.
4. **Inputs 1 – 40** – 60 pin KEL-connector for master amplifier.
5. **Ground (GND)** – Electric ground, used for modules/sensors that are not directly electrically connected to skin like GSR module, breathing belt, piezo sensors etc.
6. **Monopolar inputs 1-32** – Safety connectors for master amplifier.
7. **Master connected LED** – Indicates that master amplifier is connected. Master



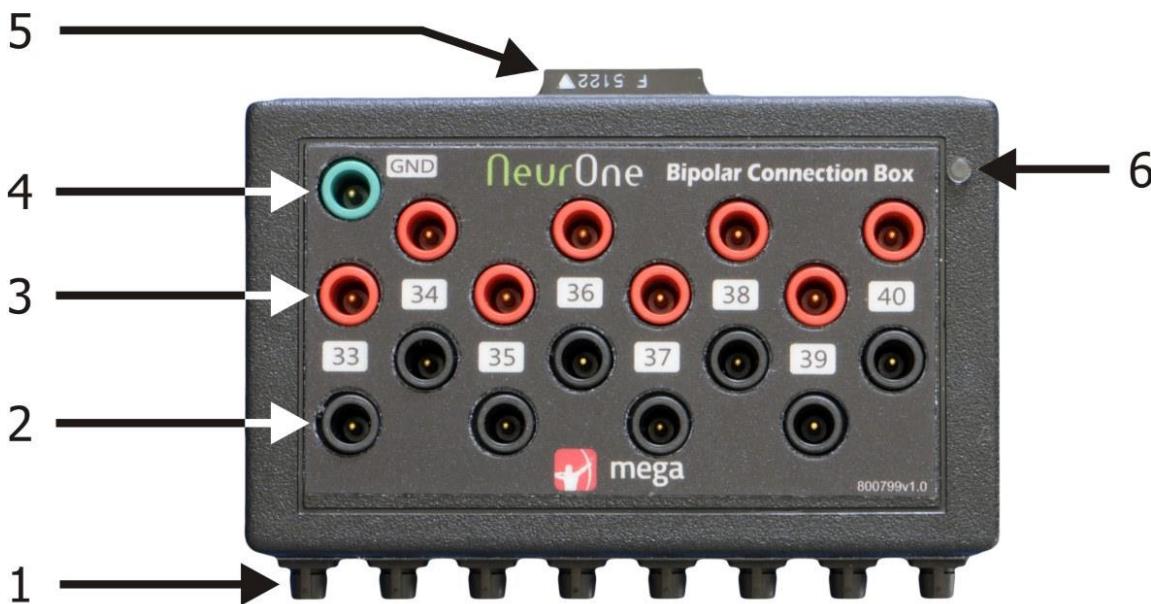
- amplifier is the amplifier that is driving Patient Ground (Driven right leg circuit)
- 8. **Bipolar inputs 33-40** – Safety connectors: red = signal, black = reference.
  - 9. **Monopolar inputs 41-72** – Safety connectors for slave amplifier.
  - 10. **Slave connected LED** – Indicates that slave amplifier is connected.
  - 11. **Bipolar inputs 73-80** – Safety connectors: red = signal, black = reference.

JackBox can be piled with two Tesla amplifiers as shown in the following picture:



## 4.7 Bipolar Connection Box

NeurOne Bipolar Connection Box is meant to be used with Tesla amplifier to measure external sensors such as GSR, accelerometer, Respiration and bipolar EMG, EEG and ECG signals. Bipolar Connection Box provides 8 bipolar inputs and GND and it is connected using flat ribbon cable to the Bipolar Inputs connector of Tesla amplifier.



Bipolar Connection Box interface:

1. **Input connectors** – 5-pole Binder connector.
2. **Reference inputs** – Black safety connectors.
3. **Active inputs** – Red safety connectors.
4. **Ground (GND)** – Electric ground, used for modules/sensors that are not directly electrically connected to skin like GSR module, breathing belt, piezo sensors etc.
5. **Bipolar Out** – 26 pin KEL-connector for connection to Tesla amplifier.
6. **Power ON (yellow) LED** – Indicates that Bipolar is connected to Tesla amplifier and power is turned on.

For each input there are two types of connectors: safety connectors (active and reference) and 5-pole Binder connector. Default labeling for input are “33 - 40”. GND input is safety connector type.

As default Bipolar Connection Box is configured for “Bipolar ExG” use (EMG, EEG and ECG). Then each input has additional 9.1 kOhm protective resistor, no signal attenuation.

All possible configurations (using internal DIP switches) for Bipolar Connection Box are explained in Appendix 9.



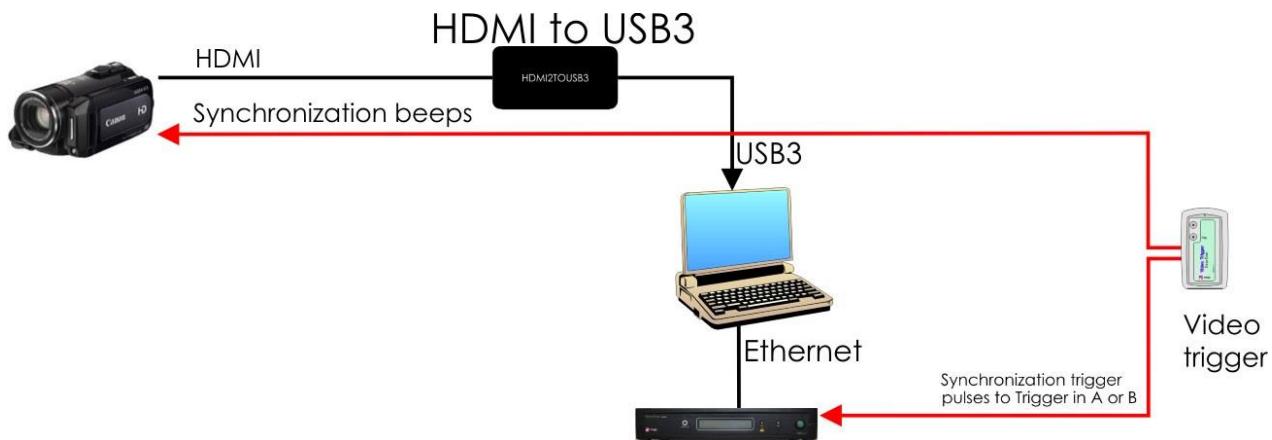
**SEE APPENDIX 9 BEFORE CHANGING CONFIGURATION IN  
BIPOLAR CONNECTION BOX!**

## 4.8 Video Option

The NeurOne video option consists of:

- Video camera (Full HD, audio input, HDMI output)

- XI100DUSB - HDMI to USB3 video capture dongle
- HDMI cable (between video camera and XI100DUSB)
- USB3 cable (between XI100DUSB and PC)
- NeurOne Video Trigger unit
- NeurOne Video Trigger interface cable:
  - Synchronization signal (beeps) to video camera audio input
  - Synchronization trigger pulses to Trigger IN ( A or B)
- External microphone (optional)



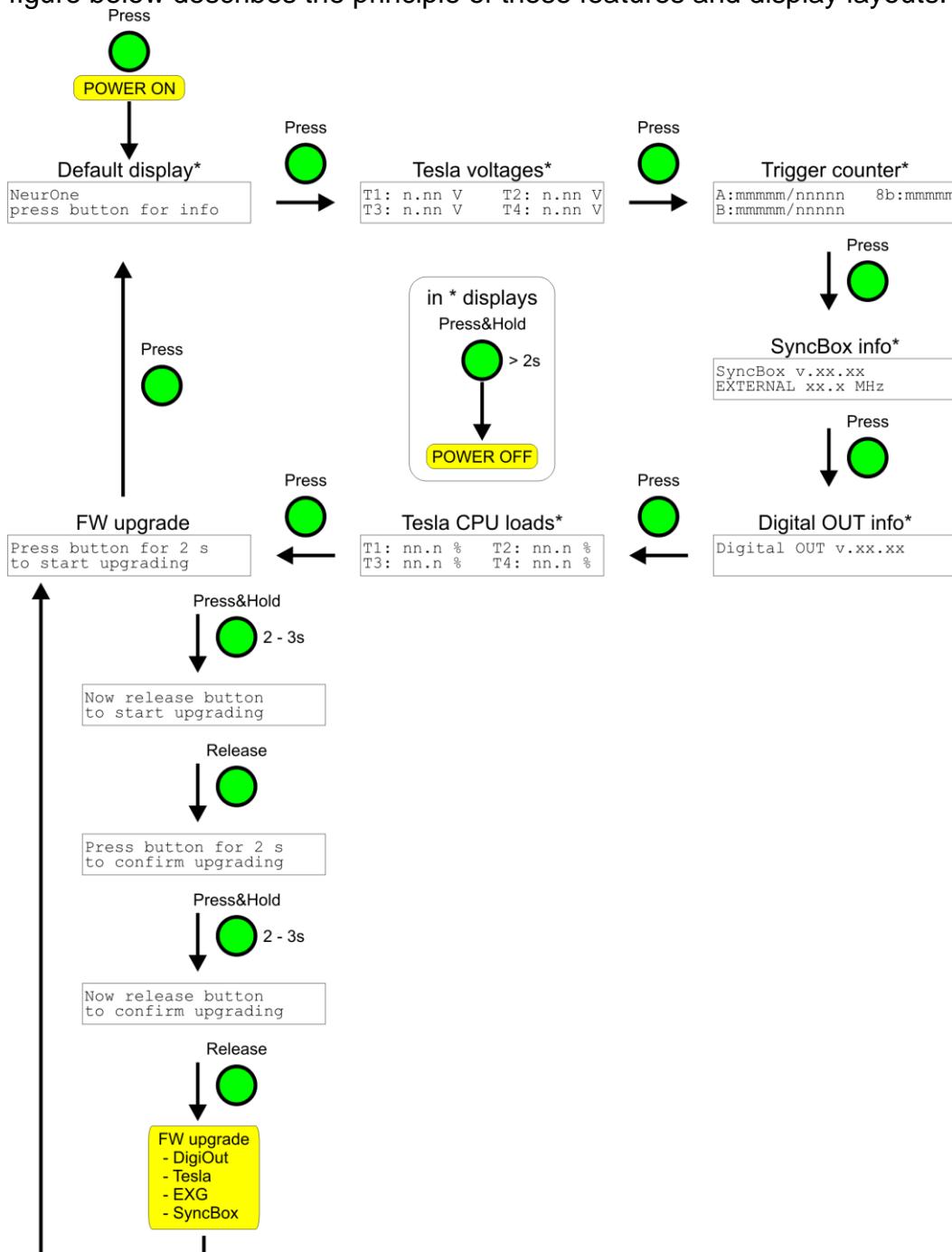
## 4.9 Getting NeurOne System operational

1. Connect isolation transformer to Mains power.
2. **All NeurOne system (AC powered) devices shall be powered through the isolation transformer!**
3. Charge the Battery Pack(s) of NeurOne system according to the instructions in chapter 4.14.5 Charging the Battery Pack.
4. Connect each EXG amplifier **power cable** to the Amplifier power supply connector on the Main Unit. Use the connector labeled "Amplifier 1" for the Amplifier 1. Connect the other end of the Amplifier power cable to the Amplifier. Repeat for all Amplifiers.  
If Battery Pack is used, connect the amplifier (EXG or Tesla) power supply connector on the Battery Pack. Refer the Battery Pack use in chapter 4.14.
5. Connect the **optical cable** to the optical cable connector (Amplifier data transfer) on the Main Unit: use the connector labeled "Amplifier 1" for the Amplifier 1. Connect the other end of the optical cable to the Amplifier. Repeat for all Amplifiers.
6. Connect **Trigger cable** to Main Unit for external trigger signals.
7. Connect **Ethernet cable** between the Main Unit and Computer.

8. Connect **Potential equalization cable** to the Main Unit and to the corresponding wall connector or grounding point. If Battery Pack is in use, the potential equalization cable is not needed.
9. Connect the Main Unit to **mains power** using the Main Unit power cable.  
If video option is not used continue at step 13.
10. Connect XI100DUSB to PC (USB3) using USB3 cable
11. Connect Video camera to XI100DUSB using HDMI cable
12. Connect Video trigger interface cable to Video Trigger unit
13. Connect BNC connector of Video trigger interface cable to NeurOne Trigger cable, which is connected to NeurOne Main unit. Set the Input pulse trigger type to Video sync trigger.
14. Connect Audio plug of Video trigger interface cable to MIC input of video camera
15. Optional: connect external microphone to external microphone socket of Video trigger interface cable
16. Turn on the PC and start NeurOne PC SW. When requested, input your license information or copy and paste them from license file
17. Create test protocol for the measurement purposes. Set trigger for video if its used.
18. Start the NeurOne Main Unit by pressing the **Power Button**. Turn battery pack ON and if Tesla amplifier used turn them ON. If video option used turn video camera and Video Trigger unit on.
19. NeurOne system is now ready for EEG measurement setup and measurements
20. Run test measurement.

#### **4.9.1 Operations controlled by the Power button of Main Unit**

NeurOne Main Unit Power button controls the following operations: Power ON /OFF, Display mode change and FW upgrades to the amplifiers, SyncBox and Digital out. The figure below describes the principle of these features and display layouts.



#### 4.9.1.1 Switching off NeurOne System

The Main Unit and Amplifiers powered from Main Unit can be switched off with the Power Button, by pressing it for over two seconds, until the Display backlight switches off. Power off is possible in all other display modes except FW upgrade (see the figure in chapter 4.9.1).

Turn off Tesla amplifiers and battery pack(s). If video option is also in use, turn off video camera and Video Trigger unit.

### 4.10 Manual activation of calibration files and FW version check

The calibration files (\*.hbc) have been copied and activated for use automatically during calibration and by default they are operational and ready for measurement.

In case of missing calibration file the following procedure is required:

1. By default NeurOne calibration file(s) of the amplifier(s) are located in the **Hbc** subfolder in Misc data folder:

C:\ProgramData\Mega Electronics Ltd\NeurOne64\Hbc

Calibration file name syntax is:

**TMS <serial number><date>.hbc**

**MRI <serial number><date>.hbc**

**EXG <serial number><date>.hbc**

2. If the desired calibration file is not found, please, ask for the calibration file of desired amplifier.
3. Then copy calibration file to **HBC** subfolder located in defined Misc data folder.
4. Start NeurOne System as instructed in chapter 4.9.
5. In NeurOne PC SW: Go to *Settings | Core | Manager...*
6. In the NeurOne Manager topology, move mouse pointer on top of the amplifier icon, which shows *no Active calibration file* for that amplifier. 
7. Press mouse right button on amplifier icon, press **Calibrate ...** on the pop-up menu.
8. *Headbox calibration* dialog is opened and calibration file of the amplifier is shown on the calibration file list.
9. Press **Set active**. Now the selected Amplifier is calibrated and ready for measurement.
10. Repeat steps 6 – 9 for all Amplifiers of the system.
11. Check by placing mouse pointer on top of each amplifier icon the firmware version of the amplifier shown on the tooltip. If needed upgrade the firmware version as instructed in the chapter 5.8.1.1 NeurOne manager.

The amplifiers with activated calibration file are now ready for EEG measurements.

## 4.11 Connecting Sensors

When preparing a subject for measurement, connect the EEG caps that have a NeurOne compatible connector to the cap connector in the EXG amplifier back panel (or Tesla front panel / JackBox). Separate electrode cables can be connected to the safety connectors in the EXG amplifier front panel or Tesla JackBox.

Bipolar sensors using the NeurOne connector can be connected to the Bipolar/Module connector in the EXG amplifier back panel or Tesla front panel. Separate electrode cables can be connected to the safety connectors in the EXG amplifier front panel or Tesla JackBox.

For more details and instructions on customization, see the pinouts of KEL connectors in the appendix 1 and the D-connectors in the appendix 2.

## 4.12 Connecting External Devices

### 4.12.1 Isolated Trigger In/Out: Trigger A / Trigger B

The NeurOne Main Unit provides two isolated trigger I/O connectors: Trigger A and Trigger B. Both connectors have one Trigger In and one Trigger Out line. In the NeurOne PC Software, you can define which operational mode these triggers will be used in. Available input modes are

1. Stimulus trigger
2. Video synchronization trigger
3. Mute trigger

For more details on setting up the triggers in the NeurOne PC Software see Chapter 5.8.1 Core - System Settings.



**Trigger signal requirement: TTL pulse.**

### 4.12.2 Non-Isolated 8-bit Trigger in

There is a 15-pin D-connector on the Main Unit providing 8-bit non-isolated trigger input and output, labeled “Trigger I/O”. The NeurOne PC Software can recognize the desired bit combinations (1-255) sent to the input from an external device and save them to measurement data. You can set the trigger active in the PC Software: System Settings and Protocol. For details, see Chapter 5.8.1 Core - System Settings and Appendix 3 (connector pinout).

### 4.12.3 Analog Output

There is a 24-pin Centronics connector providing 16 channels analog output on the Main Unit. In the NeurOne PC Software, the user can define the channels or the difference between two channels to be directed to the analog output. See Appendix 4 for the pinout of the analog output connector.

The output range of the NeurOne analog output is 0 – 2.5 V (zero level 1.25 V). For making your own analog output cable, please refer to Appendix 4 or contact Bittium Biosignals for more information.



**External devices connected to Amplifier shall be always connected via EN/IEC 60601-1 approved 4 kV isolator!**

**Failure to do this may cause electrical shock and serious injuries!**

### 4.12.4 Digital OUT

NeurOne system can be configured to emit digital measurement data via an optional add-on Ethernet port called “Digital OUT”. This is ideally suited for real-time solutions that require data with minimal latency.

#### 4.12.4.1 Specification

The following parameters can be configured by the user:

- Inputs that are directed to digital out port
- Destination IP address and UDP port for emitted digital out packets
- Digital out packet delivery frequency

The configuration itself is dependent on the user application driving NeurOne measurement hardware and is thus out of scope of this manual.

#### 4.12.4.2 Features

The emitted data is delivered at the sampling rate the measurement is running (i.e. there's no additional downsampling performed), at regular intervals. The chosen delivery rate (i.e. how often UDP datagrams are emitted) depends on measurement configuration and cannot be higher than the measurement sampling rate. User can request delivery rates of 100 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 3 kHz, 4 kHz and 5 kHz.

## 4.13 AC Adapters

Use only the AC adapter delivered with NeurOne system. Available AC adapter models for NeurOne Main unit are:

- Powerbox AC power adapter, EXM 80 5118
- PROTEC POWER, Model: PMP60-12
- FSP GROUP INC. AC/DC Adapter, FSP030-RCAM (**only for model Black**)

## 4.14 Battery Pack Use

EXG amplifier can be powered by mains power directed through the Main Unit or by external Battery Pack 12 V.

Tesla amplifiers can be powered by Battery Pack 6 V or by Battery Pack 7.2 V or through Main Unit (model Black High).



### **Battery Pack 7.2 V may not be used in MRI!**

The Main Unit is always powered by mains power.

The Battery Pack can be used in any conditions, but it is especially useful in restrictive measurement environments, such as inside a magnetic resonance imaging scanner or where a stable electrical ground is not available.

You can use one Battery Pack to power one or two EXG or Tesla amplifiers, with the correct Battery cable.

### **4.14.1 New Battery Packs with battery type and low battery state detection**

There are new types of Battery Pack available for Tesla amplifiers. These provide battery type detection and low battery state indication to Tesla amplifier. The requirements for these new features are:

- New type of Tesla amplifier identified by letter "B" in serial number
- New type of battery identified by symbol "i" on the label
- New type of power cable

Currently there is a 7.2 V Battery Pack available with these new features.

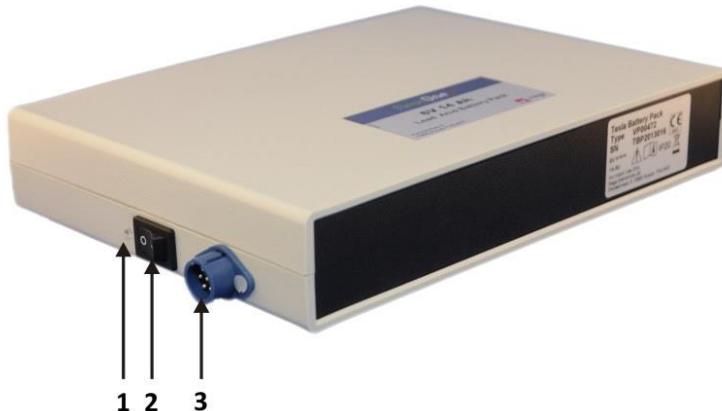
## 4.14.2 Battery Pack 12 V for EXG amplifier



The back panel of the Battery Pack 12 V contains the following components.

1. **Power Switch**
2. **Power Out / Charger** – To EXG Amplifier or to Battery Charger.
3. **Orange Indicator Led** – Indicates low output voltage (below 12 V).
4. **Green Indicator Led** – Indicates high output voltage.

## 4.14.3 Battery Pack 6 V for Tesla amplifier



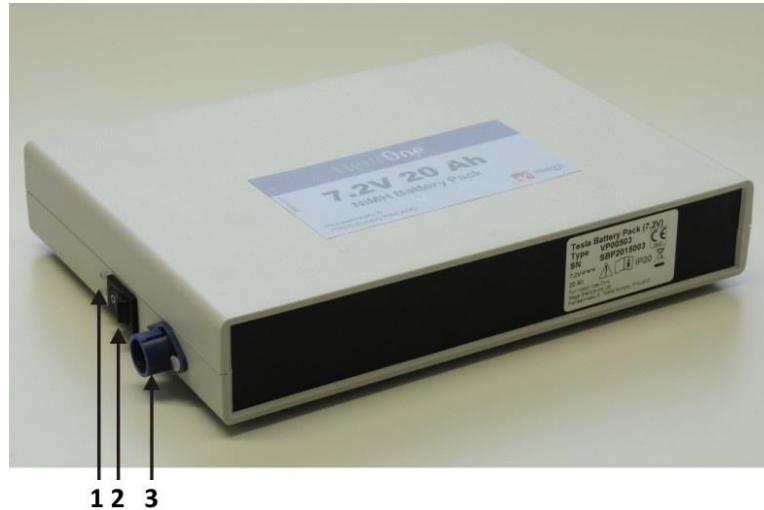
The side panel of the Battery Pack 6 V contains the following components.

1. **Green/ orange Indicator Led** – Green light indicates high output voltage and orange light indicates low output voltage (below 6 V).
2. **Power Switch**
3. **Power Out / Charger** – To Tesla amplifier or to Battery Charger for Battery Pack 6 V

The battery type of Battery Pack 6 V is lead acid.

#### 4.14.4 Battery Pack 7.2 V for Tesla amplifier

The side panel of the Battery Pack 12 V contains the following components.



1. **Green/Orange Indicator Led** – Green light indicates high output voltage and orange light indicates low output voltage (below 5.5 V).
2. **Power Switch** -
3. **Power Out / Charger** – Tesla amplifier or to Battery Charger for Battery Pack 7.2 V.

The battery type of Battery Pack 7.2 V is NiMH.

#### 4.14.5 Charging the Battery Pack

##### 4.14.5.1 Battery Pack 12V of EXG amplifier



First, make sure that the power of the Battery Pack is switched off. Connect the Battery Charger to the Battery Pack and the Battery Charger to mains power. The **indicator led (1)** on the Battery Charger is red during charging. When the Battery Pack reaches

full capacity, the indicator led turns to green. Typical charging time is approximately 5 hours.

#### 4.14.5.2 Battery Pack 6V of Tesla amplifier



First, make sure that the power of the Battery Pack is switched off. Connect the Battery Charger to the Battery Pack and the Battery Charger to mains power. The **indicator led** on the Battery Charger is blinking green during charging. When the Battery Pack reaches full capacity, the indicator led glows green. Typical charging time is approximately 5 hours.

Depending on the depth of discharge and operating temperature, the Battery Pack 6 V provides 200 to 300 discharge/charge cycles.

Please, see YPC2A12 User Guide.pdf for further instructions for battery charger.

#### 4.14.5.3 Battery Pack 7.2V of Tesla amplifier



First, make sure that the power of the Battery Pack is switched off. Connect the Battery Charger to the Battery Pack and the Battery Charger to mains power. The **indicator led** on the Battery Charger is blinking green during charging. When the Battery Pack reaches full capacity, the indicator led glows green. Typical charging time is approximately 5 hours.

Depending on the depth of discharge and operating temperature, the Battery Pack 7.2V provides 500 discharge/charge cycles.

## 4.14.6 Connecting the Battery Pack

When the Battery Pack is fully charged, disconnect the Battery Charger from the mains and from the Battery Pack.

Connect the Battery Pack 12V to the EXG Amplifier(s) or Battery Pack 6V to Tesla amplifier(s) with the appropriate Amplifier Power Cable. Make sure NeurOne Main Unit is turned on. Turn the Battery Pack on.

Typical operating times using one Battery Pack:

- EXG Amplifier      13 h / Amplifier and 6.5 h / 2 Amplifiers
- Tesla Amplifier      10 h / Tesla Amplifier and 5 h / 2 Tesla Amplifier



**Connect Battery Pack power cable only to the corresponding amplifier(s)!**

**Do not connect Battery Pack power cable to any power connector in Main Unit!!**



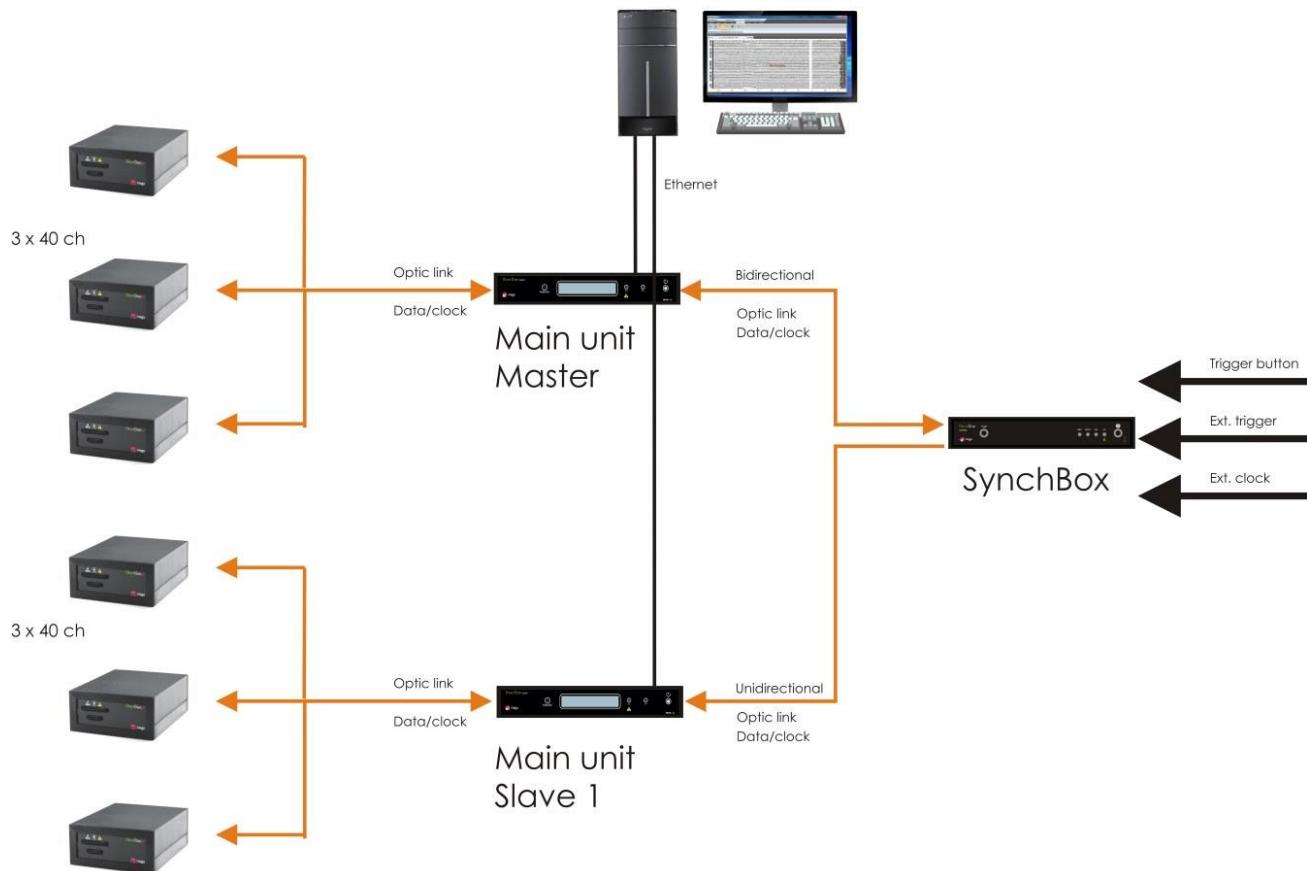
**When using several amplifiers/batteries please keep in mind that all amplifiers that share common electrode (REF) must be connected so that:**

- electrical ground from every amplifier (GND) is connected together (with battery cable or jumper cable)
- REF is connected to all amplifiers
- GND electrode is connected to PGND on amplifier #1

**This guarantees correct operation of active patient ground.**

## 4.15 Special configurations using SyncBox

By using the NeurOne SyncBox it is possible to run several NeurOne Main units (all models) in parallel providing expandable system up to 1200 channels. Example of 240 channels NeurOne system with two Main Units synchronized by NeurOne SyncBox is shown in the following illustration:



In the special configuration there can be two or several Main Units connected to SyncBox. The following features are available:

- SyncBox distributes common clock pulse to each Main Units (connected to SyncBox). The main clock can be oscillator in SyncBox or created from external clock signal. In the SyncBox the clock signal is transformed to 40.000 MHz, which is delivered to Main Units.
- SyncBox informs all Main Units about the true clock frequency.
- Main Unit connected to SyncBox Master opto connection is informed about the “Master” status. The other connected Main Units (connected to Slave connections) have the status “Slave”.
- SyncBox delivers trigger signals without any changes to each Main Unit.

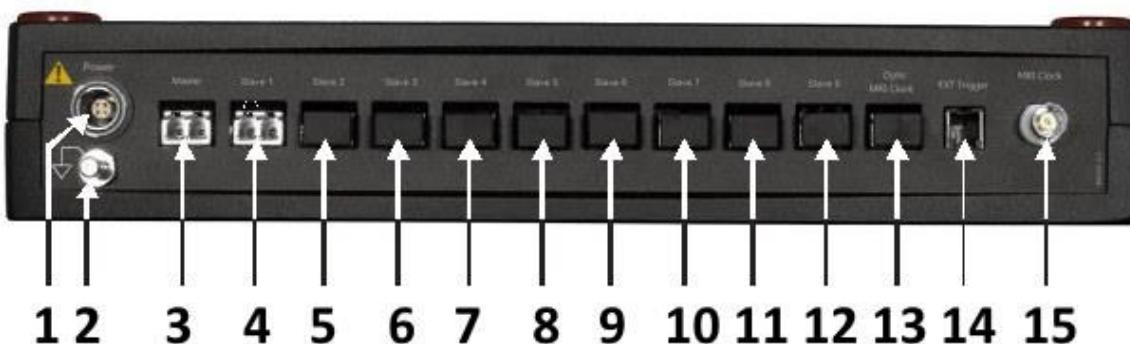
- Master Main Unit sends trigger to SyncBox that is distributed to all Main Units (Master included). This trigger starts the actual data acquisition simultaneously on all channels defined in measuring protocol.

The front panel of the NeurOne SyncBox has following components:



- 1. Trigger** – Trigger button.
- 2. LED (BNC)** – Indicates that external clock is detected in BNC connector.
- 3. LED (OPTO)** – Indicates that external clock is detected in Optic Clock connector.
- 4. Power On Led (ON)** – Indicates that the SyncBox is operational. If LED is ON, there is connection between SyncBox and Main Unit. If LED is blinking, Main Unit connection does not exist.
- 5. Power Indicator Led (AC)** – Indicates that the SyncBox is connected to mains power.
- 6. Power Button** – ON/OFF-switch.

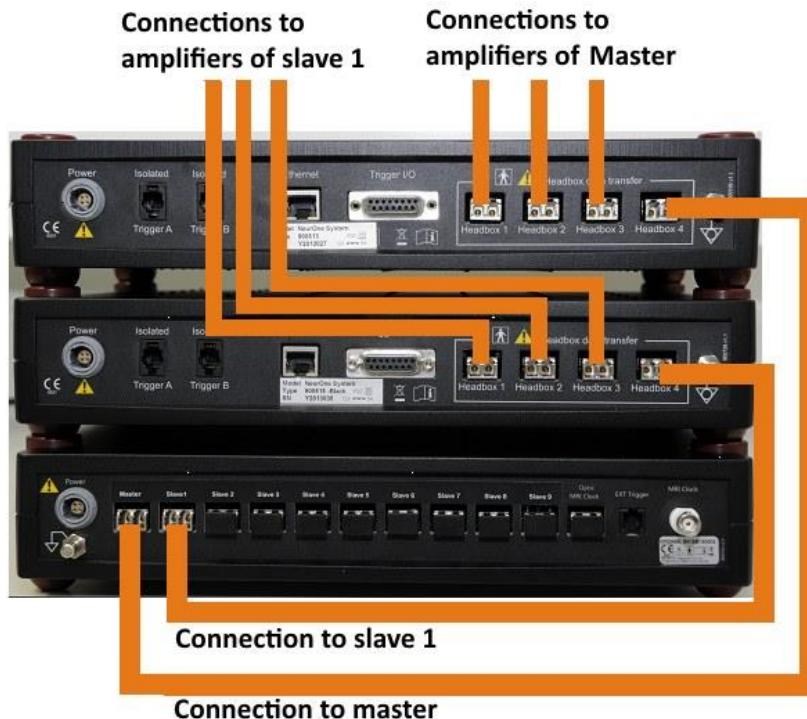
SyncBox back panel connections:



- 1. Power** – Medical approved power supply (100 – 240 VAC in, 12 VDC out)
- 2. Potential Equalization** – Connector for potential equalization cable that should be connected to the potential equalization rail in the measurement room. It helps to reduce power line interference (50/60 Hz).
- 3. Master** – Optical connection to Master Main unit.
- 4. Slave 1** – Optical connection to Slave 1 Main unit.
5. – 12. **Slave 2... Slave 9** – Optical connection to other Slave Main units.

13. **Ext. Clock OPTO** – Optical connection for external clock.
14. **EXT Trigger** – Trigger input for external trigger signal (RJ45)
15. **Ext. Clock BNC** – BNC connection for external clock.

Optic connections with SyncBox:



**Connect each Main Unit to SyncBox using Optic connector 4! (connector for Amplifier)**

Ethernet connections by using switch:

- Connect Ethernet cable from PC to port 1 (of the switch)
- Connect Ethernet cable from Main Unit Master to port 2
- Connect Ethernet cable from Main Unit Slave to port 3

Follow the instruction of chapter 4.9 to finalize NeurOne system setup for measurement.

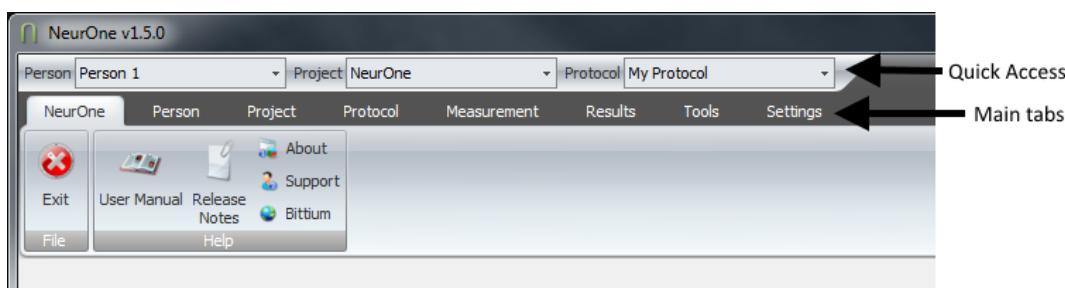


**Turn SyncBox power on first. After that start Master Main Unit and all Slave Main Units and finally all amplifiers.**

## 5 USING THE SOFTWARE

Double click the NeurOne icon to start NeurOne software. Pass the login dialog by clicking OK.

The software is controlled with tabs which are located on the upper part of the main window. They divide the functions of the software into groups: NeurOne, Person, Project, Protocol, Measurement, Results, Tools and Settings. To select a tab and to view the functions it contains, simply click on the name of the tab. When started NeurOne software opens the last tab viewed during previous run.



The software also has a *Quick Access Bar*, located above the main tabs. It contains quickselectors for choosing measurement specific configuration: the active Person (the subject of the measurement), the active Project and the active Protocol (measurement setup).

The status bar, located at the bottom of the window, displays Institute name of your user license, SyncBox status, SyncBox clock source information (MHz) and free disk space indicator when corresponding information is available.

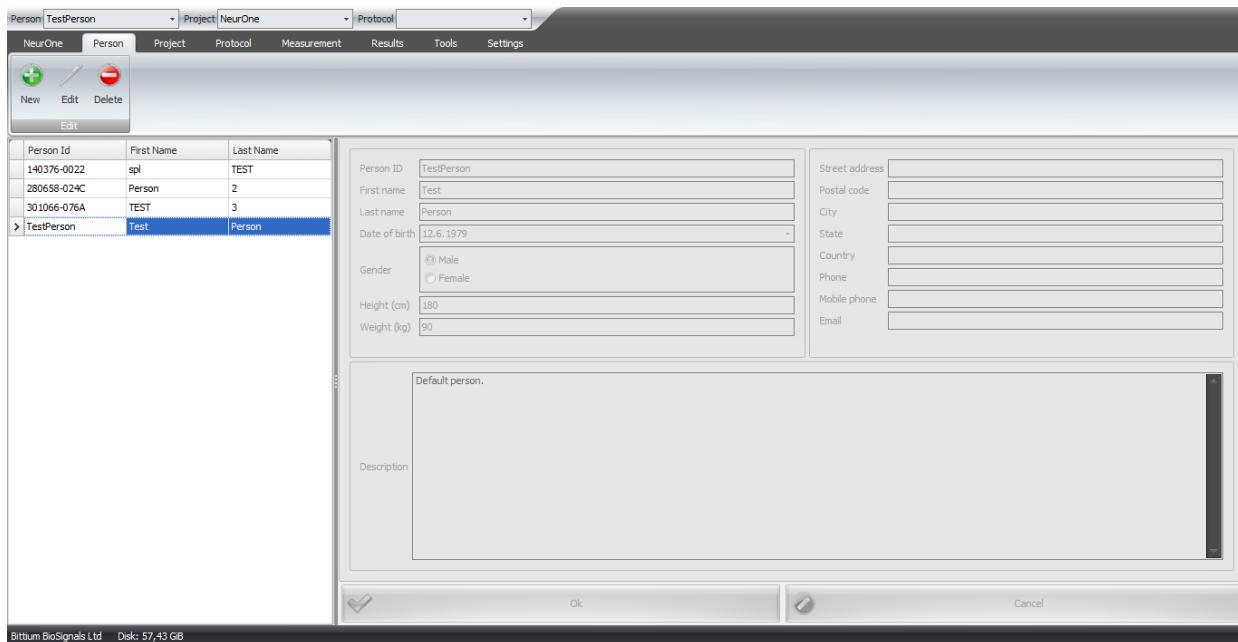
During recording the free disk space indicator also shows remaining time that can be recorded. The indicator turns red if remaining time is less than 30 minutes. If recording is not ON (data monitoring) the indicator does not display time. Video recording is not yet taken into account in the indicator.

Bitium BioSignals Ltd Sync: BNC, clock: 10,000 MHz Disk: 319,59 GiB (2383h02m58s)

### 5.1 Person Details

The Person tab is the second tab from the left and it's opened by clicking the title. At least one Person must be entered into the database before a measurement can take place. After filling in the Person details, the Person information appears in the Person List on the left hand side and is automatically selected as the active Person. The name of the active Person appears also in the Person field of the Quick Access Bar. Clicking any name on either of the lists will change the active Person and list the personal details in the right hand side.

When NeurOne PC SW is started, Person is preselected according to previous application run.



The Person Tab contains the following parts:

#### Toolbar:

New – Add a new Person to the Person List. To accept any changes you have made, click “Ok”. Click “Cancel” to exit the adding mode without saving changes.

Edit – Edit Person details with the editable fields located on the right.

Delete – Delete a Person from the Person list. Select the Person to be deleted and click this button. The software asks you to confirm or cancel the deletion.

#### Person List:

A list of all persons entered into the NeurOne database. The fields can be sorted by clicking the label of the wanted column. Clicking a name selects a Person from the list and displays the Person details on the right.

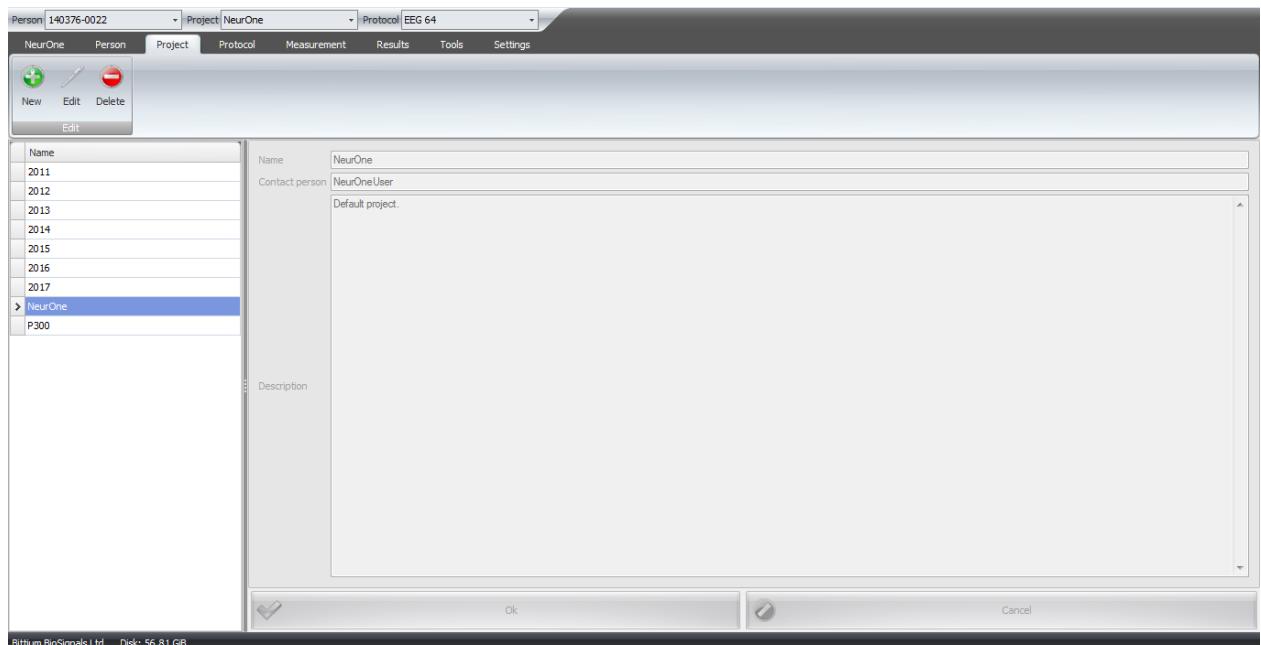
#### Person Editor:

Displays the details of the selected Person. Initially the Person information is in display-only -mode and inactive. When you click “Edit” or “New”, the Person information fields become editable. To leave the edit mode, select either “Ok” or “Cancel” from the bottom of the editor.

The Person ID is a unique ID for identification purposes (e.g. a social security number). It's also a required field for every Person. The input format for Date of birth is DD.MM.YYYY (day.month.year). This can either be written in the field or selected with the available calendar tool.

## 5.2 Projects

The Project is a convenient way to group and sort out your measurements. You can create a Project e.g. for each new study you conduct. When NeurOne PC SW is



started, Project is preselected according to previous application run.

If you don't want to group your measurements you can use the predefined Project called NeurOne.

You can manage the Projects with the following buttons:

**New** – Create a new Project under which to place measurements.

**Edit** – Edit the selected Project.

**Delete** – Delete the selected Project.

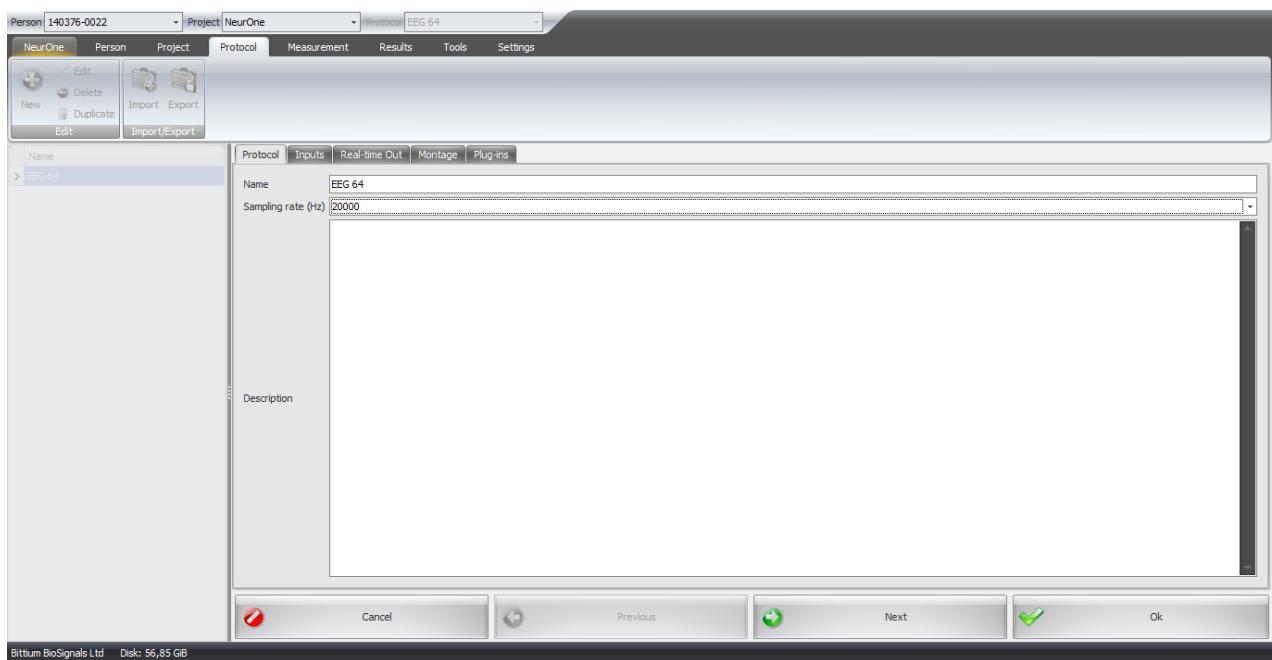
You can set the Project name, the Project contact person and a description to appear in measurements under a specific Project.

## 5.3 Protocol - Measurement Protocol

The Protocol tab is the most important entity of the NeurOne software. The Protocol defines all the details of a measurement session, including the amount and type of signal inputs. It also defines e.g. how the measured signals are filtered in hardware and how they are shown on screen during the measurement.

### 5.3.1 Front Page of the Protocol Tool

The Protocol tab is divided into the toolbar in the upper area of the window, the Protocol List on the left and Protocol subtabs on the right.



The protocol toolbar contains basic controls for creating and manipulating Protocols:

**New** – The mode for creating a new protocol. Enables editing the fields in the Protocol subtabs. Confirm changes with “Ok” or cancel creating a Protocol anytime by clicking “Cancel”.

**Edit** – Edit existing protocols with the Protocol subtabs. To be able to click “Ok”, make sure that you have at least given a name for the Protocol. You can cancel editing a Protocol anytime by selecting “Cancel”.

**Delete** – Delete the Protocol selected in the list. The program asks you to confirm or cancel the deletion.

**Duplicate** – Clones the selected Protocol in the list under another name.

**Import** – Import a Protocol from an XML file. Import is possible when the selected Protocol is not in Edit mode.

**Export** – Export the Protocol to an XML file, e.g. to another installation of NeurOne. Export is possible when the selected Protocol is not in Edit mode.

The Protocol subtabs are Protocol, Inputs, Real-time Out, Montage and Plug-Ins. Clicking on a Protocol in the Protocol list will activate the selected Protocol and present the details in the subtabs on the right.

You can browse through and modify the Protocol details by clicking the desired subtab title, or by clicking the Previous and Next buttons located on the bottom right. The Protocol subtabs are described in more detail in the following.

### 5.3.2 Main Properties - Protocol subtab

**Name** – Input field for the name of the Protocol.



**Protocol editor now appends a sequential number to protocol name if a protocol with given name already exists.**

**Sampling Rate** – Sampling rate selection for the Protocol. Possible selections are 80 kHz, 40 kHz, 20 kHz, 10 kHz, 5 kHz, 2 kHz, 1 kHz, 500 Hz and 250 Hz.



**Selecting a high sampling rate for the Protocol results in large amounts of data stored to disk. Please ensure that you have sufficient storage space.**

**Description** – Free text field for a description of the Protocol.

### 5.3.3 Signal Inputs

In the “Inputs” subtab, you can define the inputs which the Protocol uses.



Add a new input row.



Add Many adds several input rows. Before you add several rows modify the latest line suitable for the Protocol i.e. input number, type, unit and AC/DC selection.



Delete selected input row(s).

To move between fields, you can either select the field by left-clicking, or by pressing the tabulator on your keyboard.

Each row represents one input; a physical signal input on an Amplifier. The numbers on the first column represent channel numbers on the physical Amplifier. Therefore, connecting sensors to the Amplifier channels one and two correspond to rows one and two in this Input list.

The Unipolar inputs have white background color and the rows representing bipolar inputs are highlighted gray background color.



**Some user-configurable parameters (e.g. the device filter) affect the hardware and thus can affect the measured signal. If you wish to alter parameters to affect only the displayed data, only modify the Montage.**

Input Number	Name	Device Filter	Signal Type	Unit	AC	Range	Range As Calibr...	Mode	Calculator	Source Inputs
20	FC1	LP_5000 Hz (80...	EEG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		
21	FC2	LP_5000 Hz (80...	EEG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		
22	CP1	LP_5000 Hz (80...	EEG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		
23	CP2	LP_5000 Hz (80...	EEG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		
24	FC5	LP_5000 Hz (80...	EEG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		
25	FC6	LP_5000 Hz (80...	EEG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		
26	CP5	LP_5000 Hz (80...	EEG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		
27	CP6	LP_5000 Hz (80...	EEG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		
28	TP9	LP_5000 Hz (80...	EEG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		
29	TP10	LP_5000 Hz (80...	EEG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		
33	HEOG	LP_5000 Hz (80...	EOG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		
34	VEOG	LP_5000 Hz (80...	EOG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		
35	ECG	LP_5000 Hz (80...	ECG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		
41	F1	LP_5000 Hz (80...	EEG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		
42	F2	LP_5000 Hz (80...	EEG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		
43	C1	LP_5000 Hz (80...	EEG	µV	<input checked="" type="checkbox"/>	0; 1	0; 1	Normal		

The Inputs subtab contains the following columns for each Input.

**Input Number** – The number of the physical signal input connector on the Amplifier. In the case of multiple Amplifiers in a measurement setup, the input numbers of the Amplifiers are the following:

- Amplifier 1: Inputs 1 – 40
- Amplifier 2: Inputs 41 – 80
- Amplifier 3: Inputs 81 – 120
- Amplifier 4: Inputs 121 – 160



**Minimum number of inputs required for impedance measurement is 2 unipolar (if only unipolar signals are measured) and 2 unipolar and 2 bipolar (if also bipolar signals are measured) on each Amplifier used in the measurement.**

**Name** – Name of the electrode or sensor (free text field).

**Device Filter** – Selected device filter from drop-down list. Filters are dedicated for selected sampling frequency.



**There must be device filter selected for each channel. Always make sure that the filter is proper as anti-aliasing filter for selected sampling frequency.**



**If you have changed the sampling frequency while editing the Protocol, make sure that selected device filter is the correct one.**

The name of pre-defined device filters describes the filter as follows:

For example in the filter LP\_1500 Hz (80kHz\_ 10kHz)

1500 Hz	= cut-off frequency of the filter
80 kHz	= fundamental sampling frequency of hardware
10 kHz	= actual (output) sampling frequency defined in protocol

**Signal Type** – Type of the signal to be measured (for example EEG, EMG, ECG).

**Unit** – Unit of the signal to be measured (for example  $\mu$ V, BPM).

**AC** – If checked the input is measured in AC mode; i.e. the measurement bandwidth is from 0.16 Hz. The gain in AC mode is 1000/50 (EXG/Tesla). If AC is not checked, the mode is DC with bandwidth from DC, gain is 10/10 (EXG/Tesla). See chapter 8 for further information.

**Range** – This field is for external signal calibration. The content of the field is min; max (note the separator is semicolon between the numbers). Those numbers are values measured during the calibration. Refer to appendix 6: Use of external signals. Do not change the default number before calibration measurement has been done.

**Range As Calibrated** – This field is for external signal calibration. The content of the field is actual min; actual max (note the separator is semicolon between the numbers). Those numbers are true signal values corresponding to the measured min and max

during the calibration. Please refer to appendix 6: Use of external signals. Do not change the default number before calibration measurement has been done.

**Mode** – Defines the type of the input:

- *Normal*: The input signal is measured directly from the selected physical sensor. The input corresponds to the Input Number of the input row in the table.
- *Calculation*: The input signal is a result of a calculation of one or more physical inputs. The source for calculation is defined with the Source inputs parameter. The calculation method is defined with the Calculator parameter.

**Calculator** – Defines the calculation method for the data coming from Source Inputs. Select the desired calculation method from the dialog of available calculators. The dialog shows the name of the calculator, default unit and the maximal number of source input for the calculator.



**Functionality of calculation inputs have been disabled in current SW version. Please, use ONLY normal inputs!**

**Source Inputs** – Defines the physical inputs, which is used as source for the calculation in (mode=calculation) input. Select the desired input(s) from the dialog of available inputs.

If value for all inputs in some row needs to be changed, make the desired change to a single row first. Then exit the cell under edition e.g. selecting another cell and select that cell again. Then click mouse right button and select command “Apply to all” in pop-up menu. Hint: click the first cell on the selected line. The character “>” indicates that the line is no more under edition mode.

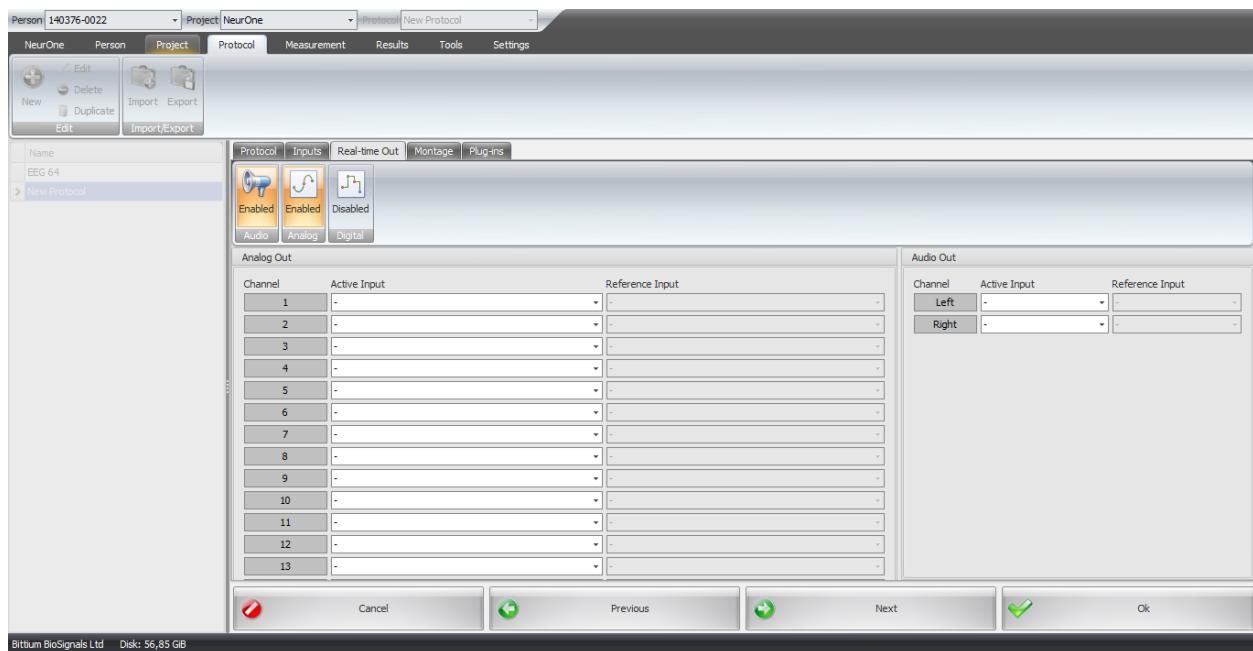
To move forward from the Inputs subtab, please select “Next”. If you want to move back to the Protocol front page, select “Previous”.

#### 5.3.4 Real-time Out

The “Real-time Out” subtab provides controls for Audio Output, Analog Output and Digital Output. Audio Output can be used in parallel with either Analog Output or Digital Output.



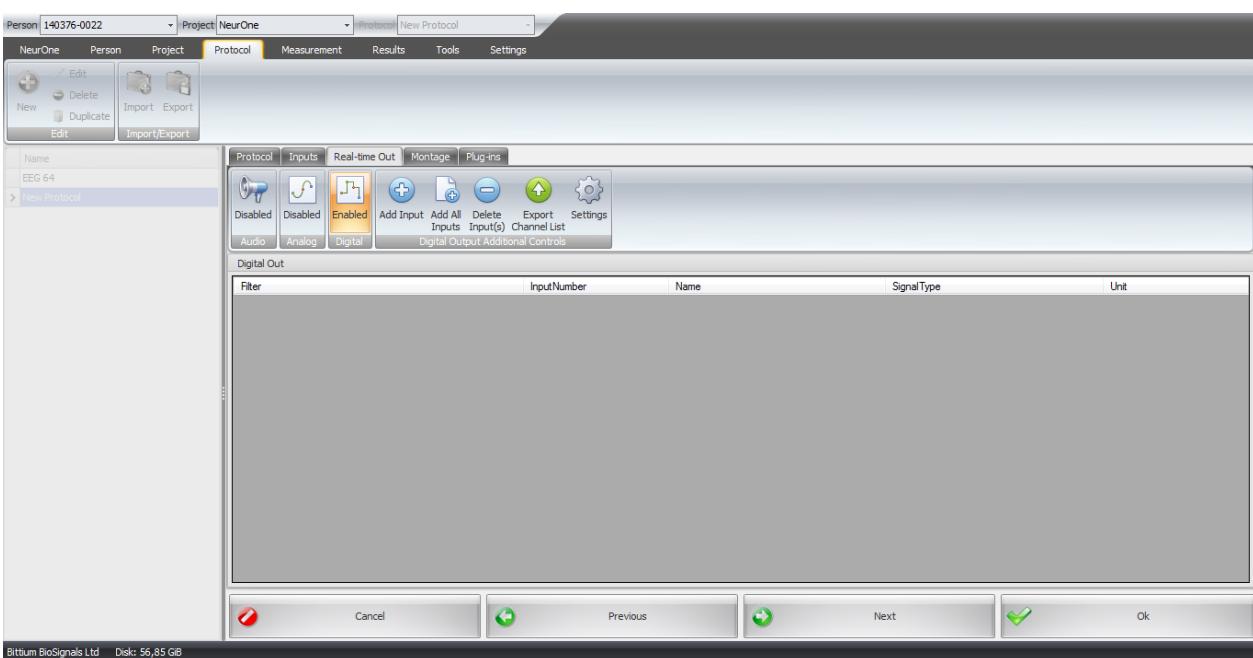
**Either Digital Output or Analog Output can be select for output use at a time.**



If enabled Audio Output contains controls for Left (L) and Right (R) audio channels and Analog Output contains the controls for 16 analog output channels. Select either single channel or channel pair for desired analog or audio channel. If channel pair is selected the channel difference of selected channels will control the output.



**Data sampled with the set sampling frequency will be fed directly to the analog output. It is recommended to take care of appropriate anti-aliasing filtering before A/D conversion in the target system.**



If enabled Digital Output provides additional control buttons on the tool bar:



Add the input from defined input list of the protocol to the Digital OUT list. The inputs on that list will be transferred through Digital OUT. Inputs are added in order as they are defined in the input list.



Add all inputs from defined input list of the protocol to be the Digital OUT list.



Delete selected input from the Digital OUT list.



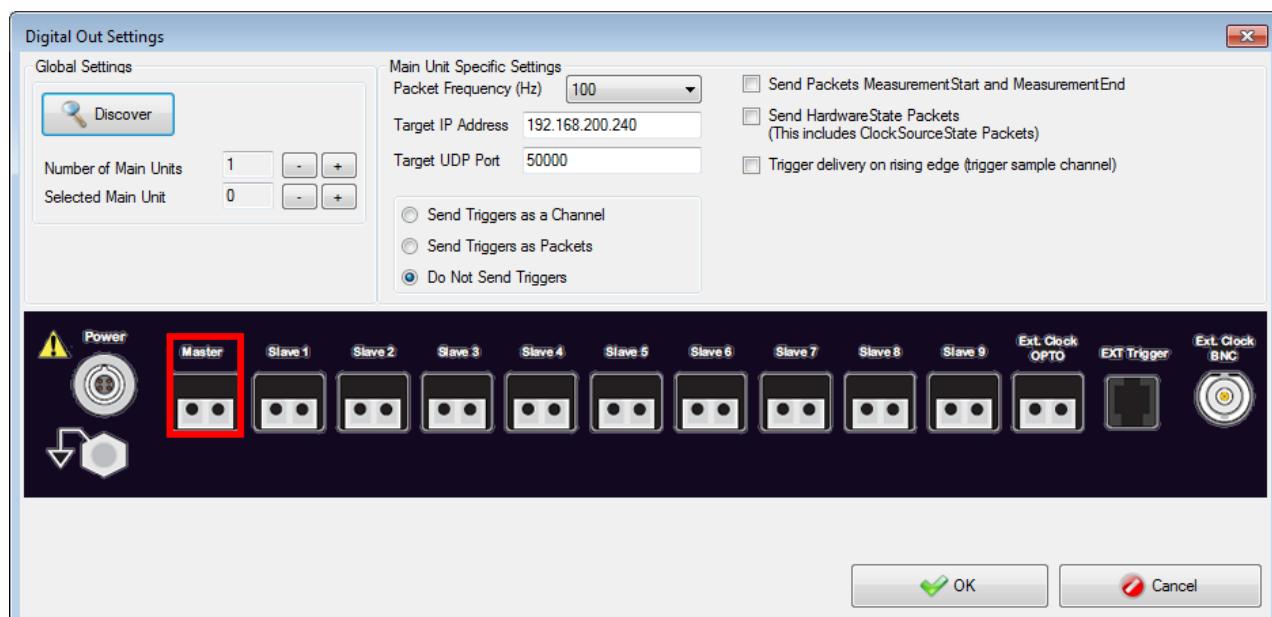
Exports the list of Digital OUT channels as \*.txt file to the desired target folder.



Settings of Digital OUT.

#### 5.3.4.1 Digital OUT settings

The UI of Digital OUT settings contains the graphic presentation of SyncBox rear panel for Main Unit selection.



**Discover** button scans the NeurOne system in order to find out if SyncBox is available and the number of Main Units in the system and updates that parameter on the UI.

Select the desired Main Unit for Digital OUT definition (the parameter: Selected Main Unit). Red rectangle indicates the selection. Main Unit number of Master = 0 and unit number 1...9 stands for Slave 1... Slave 9.

In case there is only one Main Unit (standalone) without SyncBox in the system, the Master is the only available choice on the UI and Number of Main Units = 1.

## Main Unit specific Settings

<b>Packet frequency (Hz)</b>	The emitted data is delivered at the sampling rate the measurement is running (i.e. there's no additional downsampling performed), at regular intervals. The chosen delivery rate (i.e. how often UDP datagrams are emitted) depends on measurement configuration. User can request delivery rates of 100 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 3 kHz, 4 kHz and 5 kHz. The higher the delivery rate, the less latency there'll be.
------------------------------	---

<b>Target IP Address</b>	IP Address of the receiving real-time system where the Digital OUT is transmitting the data packets to.
--------------------------	---



**Make sure that IP address definition in is defined correspondingly in TCP/IP settings of TARGET PC!**



**Make sure that Digital OUT cable is connected to the target PC prior to system start-up.**

<b>Target UDP Port</b>	UDP Port of receiving real-time system.
------------------------	---

<b>CheckBox:</b>	<b>Send packets MeasurementStart and MeasurementEnd</b>
------------------	---

If checked, MeasurementStart and MeasurementEnd packets are sent.

MeasurementStart packet is sent by NeurOne when it starts measuring, before any measurement data (samples / triggers) is emitted and also upon reception of Join\* packet.

MeasurementEnd packet is sent by NeurOne to indicate the end of the measurement. It's the last packet emitted when measurement hardware is stopped.

\* The Join packet is sent by the system receiving NeurOne digital out data. Main purpose of this packet is to enable MeasurementStart packet re-emission by NeurOne in cases where the receiver system comes online after NeurOne measurement has already been started.

**CheckBox:****Send HardwareState Packets  
(This includes ClockSourceState Packets)**

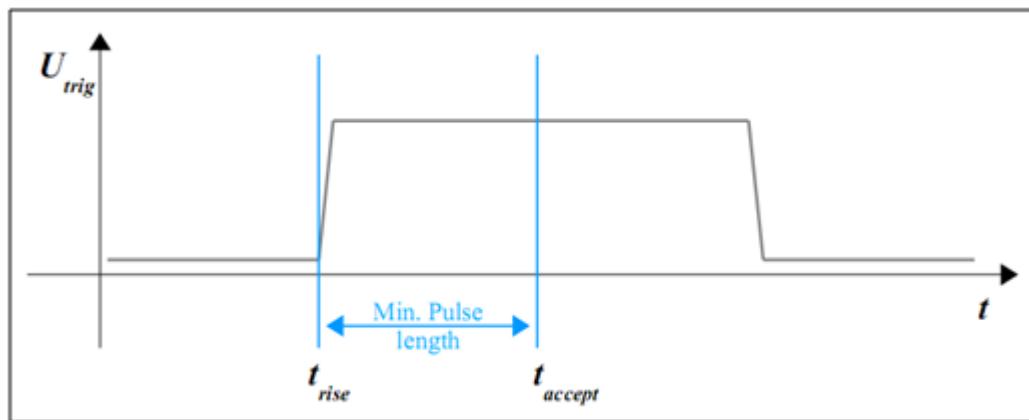
If checked, HardwareState packet is sent.

HardwareState packet relays information about measurement hardware state, which can be considered metadata in regards to the measurement. It's sent by applicable NeurOne main units at the start of the measurement after MeasurementStart packet before any measurement data (samples / triggers) is emitted and also upon reception of a Join packet. Note that this packet can contain different payloads which depend on the situation.

**CheckBox:****Trigger delivery on rising edge (trigger sample channel)**

If checked and triggers are sent as a channel, trigger delivery takes place at the site of rising edge of incoming trigger pulse.

Sending triggering information among the samples poses an additional problem; after a rising edge on a trigger port the hardware must wait for a specified time to ensure the configured trigger pulse length is satisfied (see figure below). If trigger must occur on the sample of the rising edge the system must stall digital out sample delivery in order to deliver the trigger on the correct sample ( $t_{rise}$ ). Alternatively, the trigger can be delivered on the sample it is accepted on, i.e. the sample when trigger pulse length is satisfied on ( $t_{accept}$ ). The former causes jitter in sample packet delivery timing. The latter causes trigger to be sent late in relation to the rising edge.



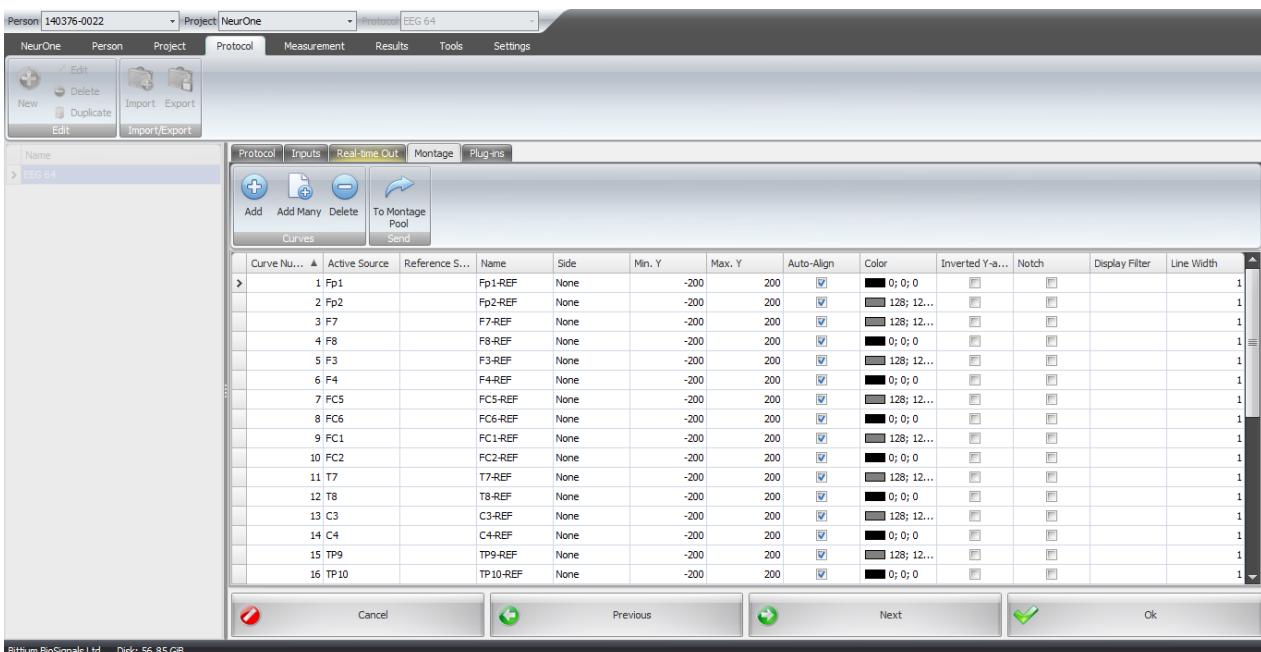
## Settings of sending triggers

There are three alternatives for trigger sending:

- Send Triggers as a Channel
- Send Triggers as Packets
- Do Not Send Triggers

### 5.3.5 Montage

The “Montage” subtab is used to create the **default** Montage for the Protocol to be used during the recording. This Montage will be shown as “default” when selecting/changing the Montage.



To add channels or curves (new lines) to the selected Montage click **Add** button on the top of selected tab. In order to add several channels click **Add Many** button. Before you add several lines modify the latest line suitable for the Protocol i.e. reference, side, use notch and filter. To remove a channel from the table select it and click **Delete** button.

The Montages subtab contains the following the fields:

**Curve Number** – Draw order of curve.

**Active Source** – The active sensor (input) of the sensor pair.

**Reference Source** – The reference sensor (input) of the sensor pair. You can select also some of available input group as reference source.

Reference source can be selected using radio buttons:

- None
- Input
- Input group

- *None*: physical REF connector is used as reference source. If selected, Reference Source field is left empty.
- *Input*: one of available inputs is selected to be used as Reference Source.
- *Input group*: one of available input groups is selected to be used as Reference Source. An input group is an average reference, which is calculated using the inputs of the input group. Input groups are defined in Tools | Input Group Pool (Chapter 5.7.1).

**Name** – Channel name (as seen in the monitor views).

**Side** – Side information, i.e. left or right (optional).

**Min. Y** – Minimum of Y-scale of the drawing area.

**Max. Y** – Maximum of Y-scale of the drawing area.

**Auto-Align** – If checked the curve will be forced to stay on the drawing area by changing the Y-scaling but keeping the user defined range (=Max. Y – Min. Y). Auto-Align control (when set) affects on the raw monitor as well as on the response monitor.

**Color** – The default drawing color for the channel (can be changed during monitoring).

**Inverted Y-axis** – If checked the channel is drawn inverted.

**Notch** - If checked this channel will be notch filtered while drawing.

**Display Filter** - If other than None this channel will be filtered by selected display filter.

**Line Width** - Curve width (in pixels).

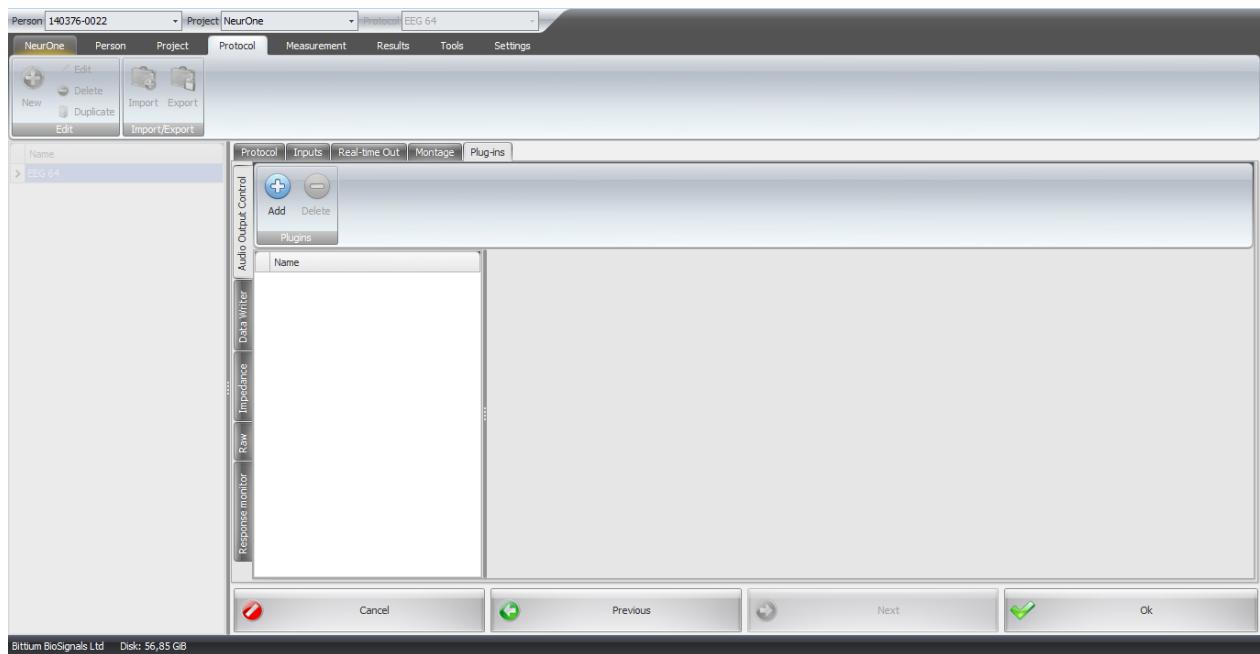
Defined Montage can be copied to the Montage Pool by clicking **To Montage Pool** button. This feature can be used to modify/save all possible montages needed during the measurement. Finally edit the desired default Montage of the Protocol to be used when Protocol is started.

Later on, additional montages can also be defined in Tools | Montage Pool.

Click “Next” to enter the last phase of the Protocol creation: to the subtab called “Plug-Ins”.

## 5.3.6 Plug-Ins

The “Plug-Ins” subtab is used for defining all monitors and measurement tool which the



Protocol needs during the measurement for visualizing measured data and for data storage purposes. The subtab “Plug-Ins” has five pages: Audio Output Control, Data Writer, Impedance, Raw, Response monitor and Video monitor (requires video option).



**Plug-Ins that take too long time (>3s) to process data during the measurement session are disabled for the rest of that session.**

Each page has **Add** and **Delete** buttons for adding and removing corresponding plug-in. New plug-in name appears on the list top of the page. The corresponding definition parameters for plug-in are under that list area.

Activate the definition parameters by selecting the plug-in name line on top of the page.



**Voltage monitor plug-In is replaced by new amplifier voltage monitor in measurement tab.**

### 5.3.6.1 Audio Output Control

If there is Audio Output Control defined on this page it is possible to change desired inputs to be played on left and right audio channel during the measurement.



**There must be default audio definition enabled on the Real-time Out tab in order to allow audio control during the measurement.**

### 5.3.6.2 Data Writer

Data Writer plugin is responsible for recording the measured signals (and events) to disk (for details on the data format, see Appendix 5: NeurOne Data format). It has the following settings:

**Name** – Name of the Data Writer

**File Size Limit (Mbytes)** – Maximum file size in megabytes. One recording may be split to several files with the files size according to this parameter. If value of File size Limit is 0 or negative then file splitting is not used.

Activate the definition fields by selecting the name line on top of the page.



**Data Writer is automatically added when creating a new protocol.**



**If the Protocol has no Data Writer it can be used only for monitoring purposes.**

There can be only one Data Writer defined.

### 5.3.6.3 Impedance

This page defines the monitor for impedance test to be used in the measurement.

The Impedance page contains the following definition fields/controls:

**Name** – Name input field of the Impedance test monitor.

**Write impedance values to file** – On/Off control button. When set ON impedance result are written to the file in person data folder. The file is also suffixed with a datetime stamp (file name = “ImpedanceData<datetime>.txt”). Optionally this file can be moved either previous or next measurement session folder depending on user choice. Refer chapter 5.4.2 Impedance test for further information.

**One reference for all amplifiers** – On/Off control button. When set only one reference impedance value (smallest) from all amplifiers is shown.

**Bipolar negative inputs visible** – On/Off control. When set the measurement and display of impedances from bipolar negative inputs is allowed (this feature can be used only with Tesla amplifier).

**Select background image** – Button for selecting background image to be used in impedance measurement. Image path field shows the path and filename of selected background image.

**Image path** – Shows the path to the impedance background image location.

**High threshold ( $\Omega$ )** – Setting for impedance threshold between acceptable and poor impedance. In impedance monitor and in EXG amplifier this is the threshold between orange and red indication color.

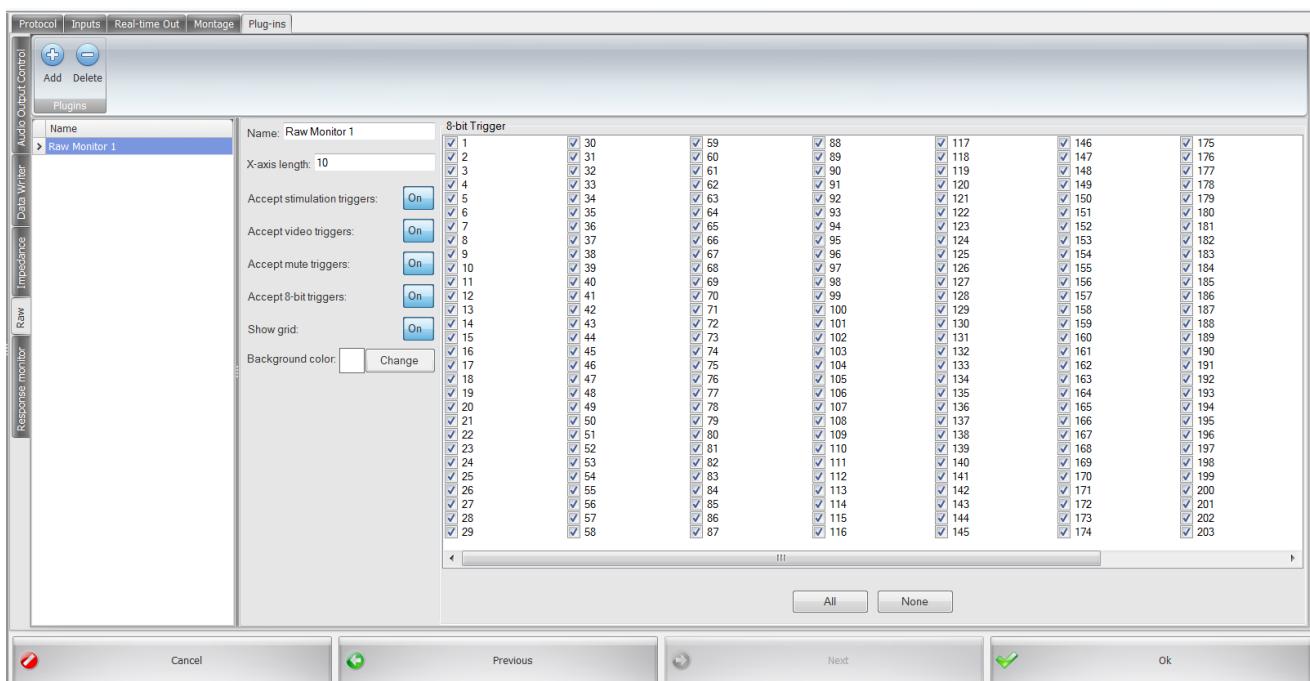
**Low threshold ( $\Omega$ )** – Setting for impedance threshold between good and acceptable impedance. In impedance monitor and in EXG amplifier this is the threshold between green and orange indication color.

#### 5.3.6.4 Raw Signal Monitor

This page defines the raw data monitor(s) (EEG monitoring) to be used in the Protocol. There can be several raw monitor definitions on this page.



**One Raw Signal Monitor is automatically created during creation of new Protocol.**



The Raw page contains the following definition fields:

**Name** – Name of the Raw monitor.

**X-Axis length (s)** – The time range of the monitor view in seconds (default 10 s).

**Accept stimulation triggers** – If set on, the monitor shows incoming stimulation triggers.

**Accept video triggers** – If set on, the monitor shows incoming video triggers.

**Accept mute triggers** – If set on, the monitor shows incoming mute triggers.

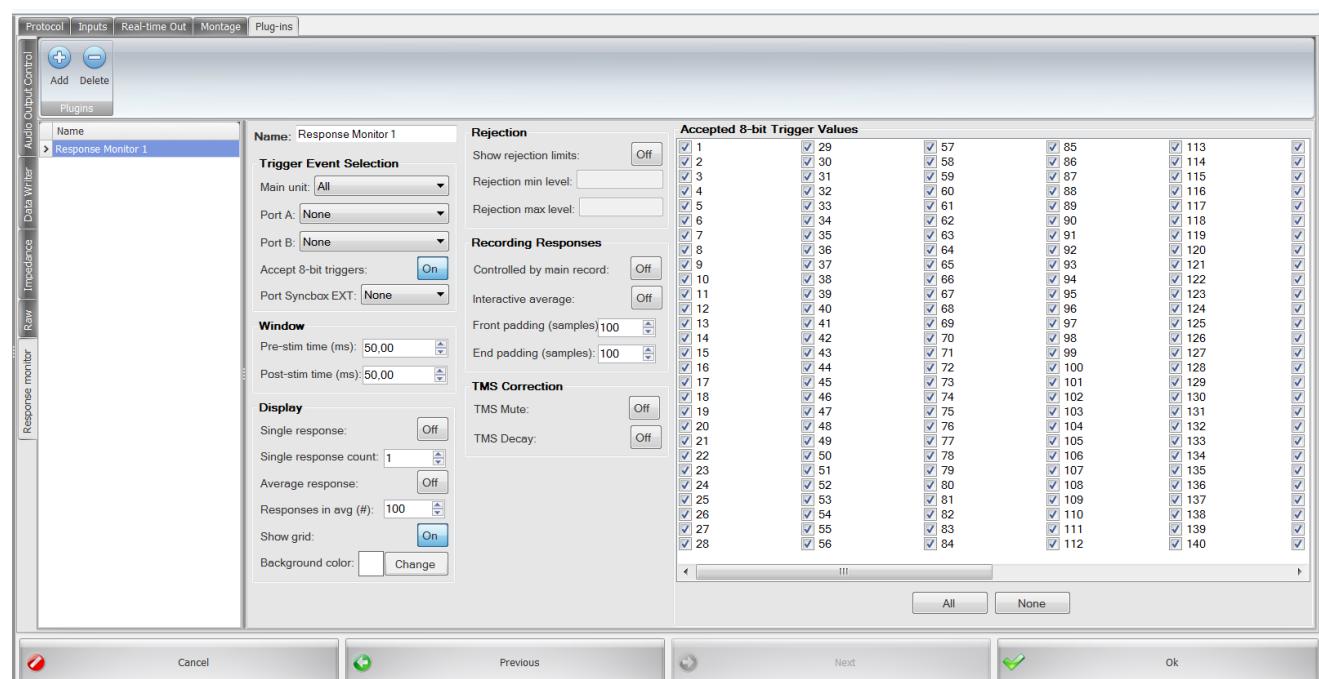
**Accept 8-bit triggers** – If set on, trigger selection control appears. The control has the list of checkboxes for each 8-bit combination 1 – 255. Check the desired combination to be accepted during the measurement. There are also buttons **All** and **None** for selecting/deselecting all.

**Show grid** – If set on, grid of the drawing area is shown.

**Background color** – Opens the control for background color selection of measurement raw monitor.

### 5.3.6.5 Response Monitor

This page defines the response monitor(s) (EP monitoring) to be used in the Protocol.



There can be several response monitor definitions on this page.

The Response page contains the following definition fields:

**Name** – Name of the Response monitor.

#### Trigger event Selection

**Main unit** – Definition which Main unit(s) are active inputting/outputting triggers.

**Port A** – Accepted response trigger type selection for port A.

**Port B** – Accepted response trigger type selection for port B.

**Accept 8-bit triggers** – If set defined 8-bit trigger combination are accepted. Accepted trigger combination are selected on the control on the right of the tab (refer Raw signal monitor).

**Port SyncBox EXT** – SyncBox Ext trigger type selection.

## Window

**Pre-stimulation time (ms)** – Defines the data length (in ms) before stimulus trigger in the response monitor (adjustable range 2...1000 ms).

**Post stimulation time (ms)** – Defines the data length (in ms) after stimulus trigger in the response monitor (adjustable range 0...5000 ms).

## Display

**Single response** – If set on, single responses are shown on the response monitor.

**Single response count** – Defines how many responses (current + previous) from one channel is shown.

**Average response** – If set on, average responses are shown on response monitor

**Responses in average (#)** – Count of accepted responses to be averaged (adjustable range 1...9999 ms).

**Show grid** – If set grid of the drawing area is shown.

**Background Color** – Opens the control for background color selection of response monitor.

## Rejection

**Show rejection limits** – If set on, rejection limits are shown.

**Rejection min level** – If stimulus response is below min level it is rejected.

**Rejection max level** – If stimulus response exceeds max level it is rejected.

## Recording responses

**Controlled by main record** – If set the main record button in raw monitor controls also the saving of responses.

**Interactive average** – if set response monitor waits for the users action to proceed when the averaged count is reached. Responses are saved while resetting the average. If interactive average is set off, response monitor resets the average response curves after the averaged count is reached and starts the averaging again.

**Front padding (samples)** – additional buffer for data before response for data viewing and saving.

**End padding (samples)** – additional buffer for data after response.

## TMS Correction

The TMS (transcranial magnetic stimulation) artefact removal in NeurOne consists of two operations: TMS Mute and TMS Decay.

**TMS Mute** – This operation replaces a section of the signal with a ramp, starting 1 ms before the trigger zeropoint. The ramp connects the last point before the ramp, and the first point after the ramp. If set, additional adjustable control parameters is shown:

**Decay fit start (ms)** – Clearing time, the duration of software mute in milliseconds. Note that the “mute ramp” starts at -1 ms.

**TMS Decay** – TMS Decay fits and removes an exponential function into the section of the signal after the muted section. If set, additional adjustable control parameters are shown:

**Decay fit start (ms)** – Clearing time, the duration of software mute in milliseconds. Note that the “mute ramp” starts at -1 ms.

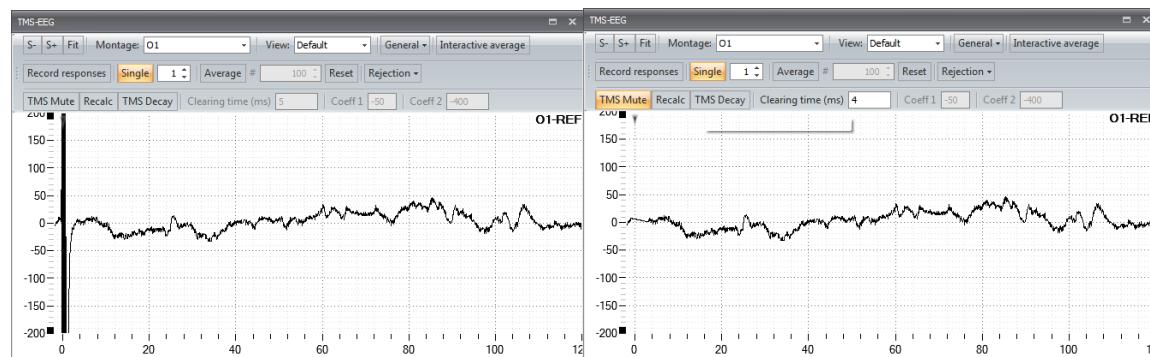
**Coefficients 1 & 2** – (Active only if TMS Decay is selected) Determine the shape of the exponential decay function, which is fitted on the response. Use is recommended only if there actually is a substantial exponentially decaying artefact following the TMS artefact. The decay can be caused by relatively slow discharging of a charge accumulated on the scalp from the TMS pulse. The function is

$$y(t) = \theta_1 e^{-a \frac{f_s}{20000} t} + \theta_2 e^{-b \frac{f_s}{20000} t} + \theta_3$$

where a and b are slope coefficients (these are the user settable coefficients), fs is sampling frequency and  $\theta_1$ ,  $\theta_2$  and  $\theta_3$  are fitting parameters determined by the fit for each TMS-EEG response, to best match the curve to the response.

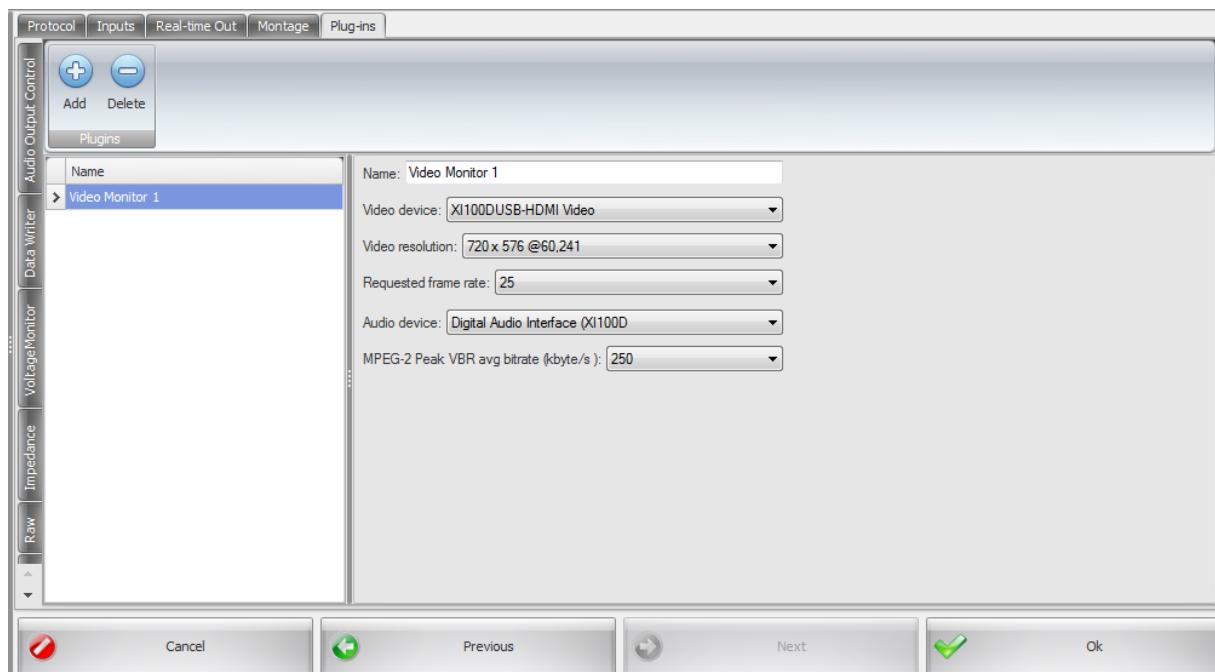
The shape of the function with negative slope coefficients a and b is a decaying exponent. With positive slope coefficients, the function would be an increasing exponent, which would not make much sense in this context. With larger slope coefficients, the function falls to a lower value more slowly. Slope coefficients are equal in the sense that a = -50, b = -400 gives the same result as a = -400, b = -50.

In the figure below, Left: original EEG response to a TMS pulse. Right: Response after using software TMS Mute with a duration.



### 5.3.6.6 Video Monitor

This page defines the video monitor to be used in the Protocol.



The Video monitor page contains the following definition fields:

**Name** – Name of the Video monitor.

**Video device** – Imaging device selection for video option.

**Video resolution** – Selection of video resolution for capturing – only PAL available.

**Requested frame rate** – Video frame rate selection.

**Audio device** – Sound controller selection for video option.

**Average bitrate (kbyte/s)** – Selection for **average bit rate** in MPEG-2 encoding of the captured video. Higher bit rate indicates lighter compression providing better video quality and lower bit rate means heavy compression and poorer video quality.

**Recommendation:**

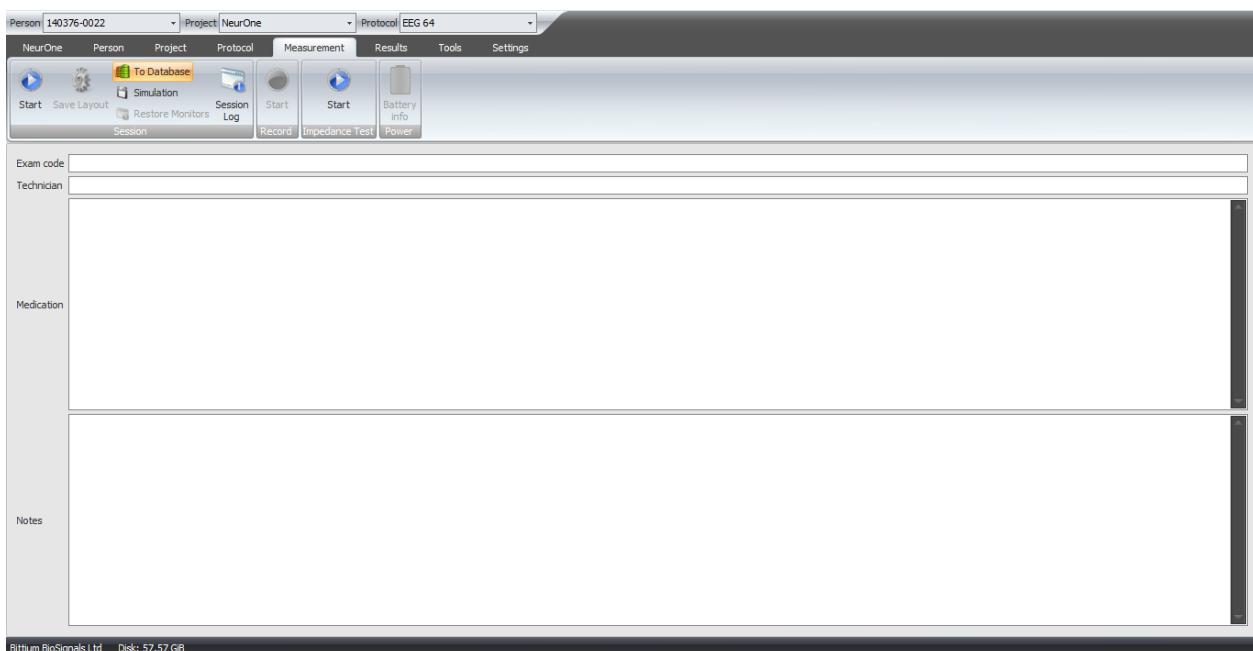
**Use PAL settings according to the screenshot.**

### 5.3.7 Finalizing the Protocol

After you have completed Protocol definitions on all subtabs (create or edit) click OK button to complete this procedure.

## 5.4 Measurement

The Measurement tab is the page from where all the measurements using the NeurOne software are started. In order to be able to access the Measurement tab, user needs to have selected a Person, a Project and a Protocol for the measurement. The selected Person, Protocol and Project should be visible in the status bar of the software. **Note!** After start-up the software pre-select Person, Project and Protocol used during previous application run.



The Measurement tab allows the user to fill in measurement related data before continuing with the actual measurement. The fields are:

**Exam code** – Exam code of the session data e.g. archiving number.

**Technician** – The current technician/doctor/nurse conducting the measurement.

**Medication** – Any medication used by the Person studied.

**Notes** – Free text field for any comments.



**The measurement page fields are voluntary; you don't have to fill them.**

Buttons/Checkboxes:

**“Start” (Session)** - Starts the actual measurement.

**“Save Layout”** - Stores the current parameters, positions and sizes of monitors shown on the screen. Next time running the same protocol the stored layout will be used. See APPENDIX 12 and APPENDIX 13 for the details what parameters are saved in Save Layout.

**“To database”** - If checked the recorded data will be stored to the database (default). If it is not checked the data will be written to the data file without any link to the database.

**“Simulation”** - If checked the simulation measurement asks the data file to be simulated. Simulation starts also if NeurOne HW is not connected to the PC.

**“Restore Monitors”** – Opens the monitors which have been closed during the measurement session.

**“Session Log”** – Opens NeurOne Session Log showing info messages, warning and error messages during the measurement session. Also SyncBox clock changes and free disk space warnings are included to Session log messages. The log is also saved into the session folder if data is recorded with a data writer plug-in.

**“Start” (Record)** - The second “Start” button from left starts active recording. The recording will start automatically if checkbox “Recording starts automatically” is checked (in Settings, see chapter 5.8.1). If checkbox “Recording starts automatically” is not checked, the button “Start” (Record) must be clicked in order to start data recording.

**“Start” (Impedance test)** - The third “Start” button starts the impedance measurement. This button is active if impedance test is defined in the Protocol. The impedance test can be started when measurement is not running.

**“Stop”** – Stops the ongoing measurement, recording or impedance measurement depending on which one of available “Stop” button is clicked.

**“Battery info”** – Opens Battery Info dialog showing battery voltages, battery type and status info (OK/LOW BATT) of all amplifiers used in the measurement. **NOTE!** The measurement system requires new HW models of amplifier, and battery in order to provide all described information.

The measurement phase will be covered in more detail in the following chapters.



A warning is shown at the start of measurement if any of the used amplifiers have been assigned a calibration file with default values.



Starting a session is prevented if battery voltage is low.



Measurement cannot be started when the current person/project/protocol is being edited.



A warning is displayed if used main units or amplifiers don't have the same firmware version.



Entering person/project/protocol edit mode during a measurement is prevented.



It is prevented to change the selected person/project/protocol during a measurement session.



An XML file describing system configuration (serials, HBC files, etc.) is now saved to the session folder of every measurement.



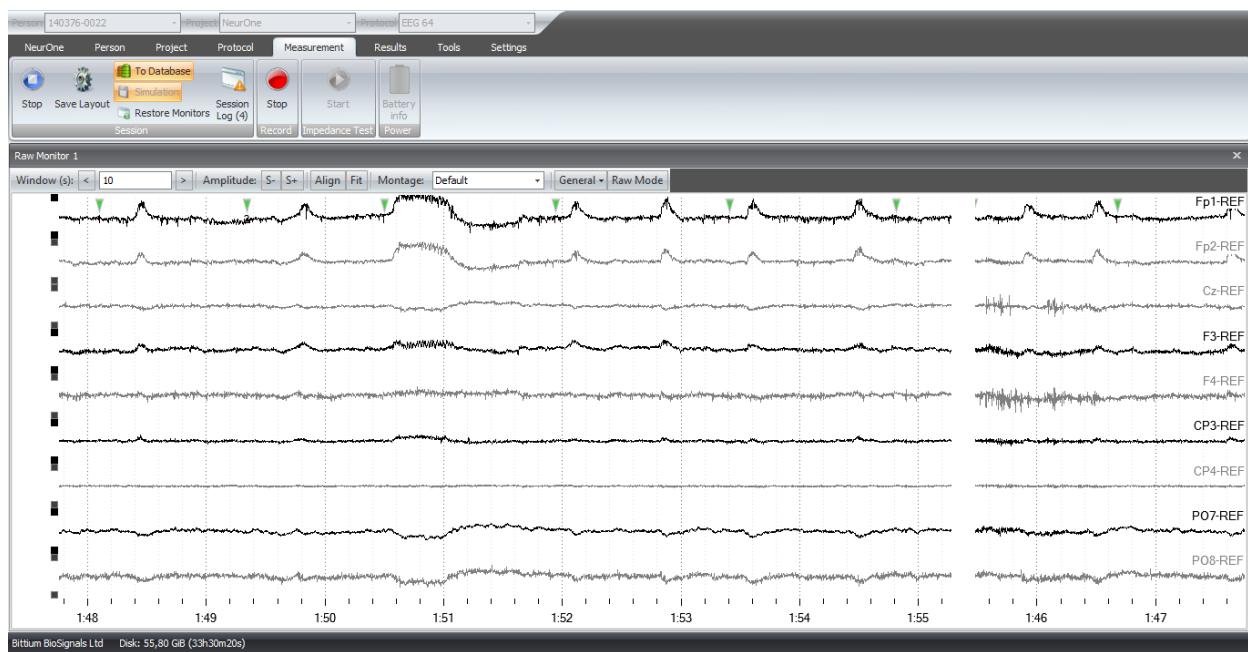
If any data is dropped, recording is stopped and a new recording cannot be started without restarting the session.



When a low battery state is detected during measurement, the user has 5 minutes to replace a fresh battery (battery fork cable required). If the 5 minute countdown elapses, the measurement is stopped to ensure data integrity. \*

\*) This feature is available only with new Tesla amplifier and batteries (see chapter 4.14.1)

#### 5.4.1 Monitors



NeurOne software measurement view is based on a unique monitor structure, where each monitor (raw, response and impedance) is totally scalable and movable. This feature allows monitor windows to be placed in different screens in a multiple displays setup and enables monitors to be hidden, placed on top of each other, stacked, minimized or maximized. To move monitor, select the window by dragging from the header bar with the left mouse button. If not otherwise indicated, the moved monitor will be placed to the exact position of the mouse at the time the mouse button is released. When the desired monitor layout is reached it can be saved for that protocol by using "Save Layout" feature.

The monitors can be closed from view by clicking the close window (x) at the top right of the monitor. Closed monitors can be reopened by using "Restore Monitors" feature.

The monitors of the measurement view can also be controlled using the buttons on the Toolbar of the monitor. These buttons control the layout, scaling, sweep time, triggers and Montage selection for the monitors.

The triggers are shown on top of the monitor area. Trigger symbol (=arrowhead pointing downwards) of each trigger type has own color.

#### 5.4.1.1 Raw Monitor Properties

**Raw monitor will receive data at 1 kHz** (or lower if protocol sampling frequency is below 1kHz) and all display filtering is done on that frequency. Therefore, display filters should be designed at sampling rates of 250, 500 or 1000 Hz.

Raw monitor tool bar:



**Window (s):** The time range of the monitor view in seconds. To change the value use arrow buttons (< or >) or edit the value. If edited press enter to activate the change.

**Amplitude:**

**S-**: Decrease vertical axis sensitivity.

**S+**: Increase vertical axis sensitivity.

**Align:** The curve is placed in the middle of draw area without Y range change.

**Fit:** The curve is scaled with best fit on the drawing area.

**Montage selection:** "Default" Montage defined in Protocol is shown as default. Drop down menu for changing the active Montage.



**In raw monitor curve scale set via S/S+ (or using shortcut keys) is now remembered by the montage for the duration of the measurement (montage now remembers its color, scale and filters).**

**General:** Additional set of controls for raw monitor.

✓	Accept stimulation triggers
✓	Accept mute triggers
✓	Accept video triggers
	Accepted 8-bit triggers ▶
✓	Labels (L)
✓	Grid
	Baseline ▶
	Auto-align ▶
✓	Fit by signal type
	Polarity (y-axis) ▶
	Last values ▶
	Enable notch filter
	Disable notch filter
	Display filter <input type="button" value="None"/> ▾
	Restore montage

**Accept Stimulation Trigger:** On/off selection

**Accept Video Trigger:** On/off selection

**Accept Mute Trigger:** On/off selection

**Accept 8-bit Triggers▶:**

On/off selections for all available combinations 0 – 255.

**Labels (L):** On/off selection: if selected, shows the label of the channel.

**Grid:** On/off selection: if selected the grid is on the drawing area of the monitor.

**Baseline▶:**

**Show all:** Sets baseline visible for all channels.

**Hide all:** Removes baseline from all channels.

**Auto align▶:**

**Enable all:** Forces the curves to be shown on the monitor (Auto align)

**Disable all:** Disable Auto align.

**Fit by signal type:** If set, curves are fitted according to largest range of each signal type.

**Polarity▶:**

**Positive up (all curves):** Positive values above the 0 line.

**Positive down (all curves):** Positive values below the 0 line.

**Last values▶:**

**Show all:** Numeric values of data of all channels are shown.

**Hide all:** Numeric values are hidden.

**Show for calibrated:** Shows numeric values of data of channels with external signal calibration.

**Hide for calibrated:** Hides numeric values of data of channels with external signal calibration.

(Last value...)

**Show all:** Numeric values of data of all channels are shown.

**Number of decimals:** Number of decimals in last value.

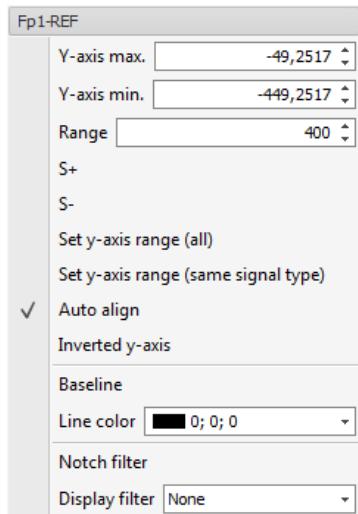
**Enable notch filter:** Sets on the notch filtering of the data.

**Disable notch filter:** Sets off the notch filtering of the data.

**Display filter:** Selection of display filter defined in Tools | Display Filter Pool.

**Raw Mode:** When selected signals are shown at the original sampling frequency. In "Raw Mode" display filtering is not available. In this case only min/max decimation is applied.

In curve drawing area of raw monitor: right-clicking on top of a single channel in a monitor opens a settings window for individual channels:



**Y-axis max.:** Sets Y-axis maximal level of the channel.

**Y-axis min.:** Sets Y-axis minimum level of the channel.

**S+ :** Increase vertical axis sensitivity of the channel (for quick scale adjustment).

**S- :** Decrease vertical axis sensitivity of the channel (for quick scale adjustment).

**Set Y-axis range (all):** Y-axis range to all channels according to min – max settings.

**Set Y-axis range (same signal type):** Y-axis range to all channels with same signal type according to min – max settings.

**Auto-align:** – If checked the curve will be forced to stay on the drawing area by changing the Y-scaling but keeping the user defined range (= Max. Y – Min. Y).

**Inverted y-axis:** If selected inverts the y-axis of the channel.

**Baseline:** Sets baseline visible (on/off) of the channel.

**Line color:** Color of the channel definition in the measurement (does not affect the default color set in the Protocol tool).

**Notch filter:** Sets Notch filter on/off for the channel.

**Display filter:** Sets selected display filter for the channel.

The following shortcut keys can be used during measurement, when the raw monitor is selected:

<b>R</b>	Raw mode on/off
<b>A</b>	Align signals
<b>F</b>	Fit signals vertically to view
<b>L</b>	Channel names on/off
<b>+ or - (keypad)</b>	Increase/decrease vertical scale
<b>PgUp or PgDn</b>	Switch to previous/next montage in list
<b>x or ÷ (keypad)</b>	Change window time base

### 5.4.1.2 Response Monitor Properties

**Response monitor will receive and process data at the sampling frequency defined in the protocol.** Therefore, display filters should be designed for the sampling rate defined in the protocol.



**Mouse wheel:** Change window time base

**S-** : Decrease vertical axis sensitivity

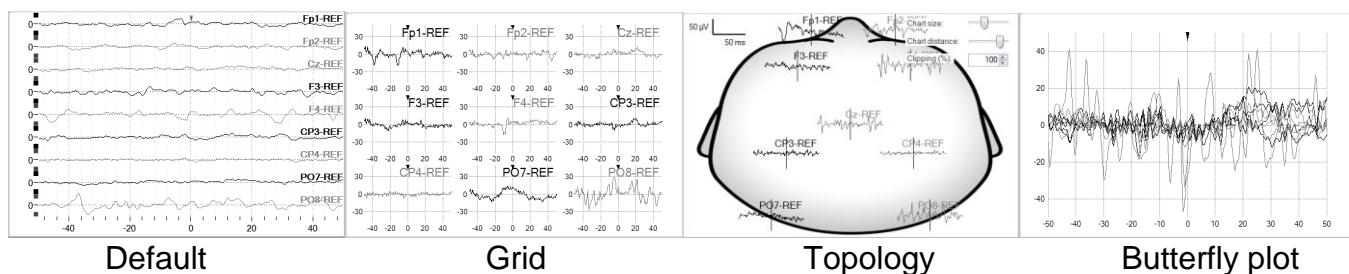
**S+** : Increase vertical axis sensitivity

**Fit:** The curve is scaled with best fit on the drawing area

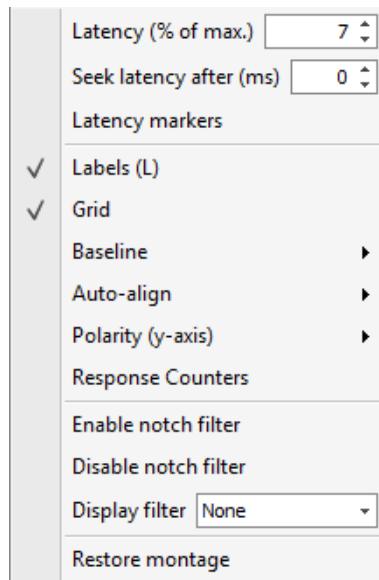
**Montage selection:** Drop down menu for changing the active Montage

**View selection:** Four view modes are available:

- Default – NeurOne basic response monitor
- Grid - Shows responses in a two-dimensional grid
- Topography – Topography plot with a head image
- Butterfly plot – Shows all responses laid on top of each other



**General:** additional set of controls for response monitor



**Latency (% of max):** Trigger level for latency calculation

**Seek latency after (ms):** Stimulus artifact ignore time

**Latency markers:** On/off selection: If set shows latency markers in the response monitor's **default** view (View selection = default).

**Labels (L):** On/off selection: Shows the labels of the channels.

**Grid:** On/off selection: Shows grid of the drawing area.

**Baseline▶:**

**Show all:** Sets baseline visible for all channels.

**Hide all:** Removes baseline from all channels.

**Auto-align▶:**

**Enable all:** Auto-align enabled for all response curves.

**Disable all:** Auto-align disabled for all response curves.

**Calculate from (ms) [ nn ]:** Definition of start time **nn** for align level calculation. Minus sign of nn indicates time before stimulus trigger. Start time is limited by pre-stim time of response monitor.

**Calculate to (ms) [ mm ]:** Definition of end time **mm** for align level calculation. Minus sign of mm indicates time before stimulus trigger. End time is limited by post-stim time of response monitor.



**In response monitor Auto-align now operates on average response only if it's visible. Otherwise single response is used.**

**Polarity▶:**

**Positive up (all curves):** Positive values above the 0 line.

**Positive down (all curves):** Positive values below the 0 line.

**Response Counters:** On/off selection: Shows/Hides response counters. If single responses are shown, response counter shows only number of detected responses. If averaging is set response counter is shown as format **aa; bb; cc** where

aa = number of responses in average  
bb = number of rejected responses  
cc = number of total responses detected

**Enable notch filter:** Sets on the notch filtering of the data.

**Disable notch filter:** Sets off the notch filtering of the data.

**Display filter:** Selection of display filter defined Tools | Display Filter Pool.

**Restore montage:** Return the original settings of the montage in use.

**Interactive average:** if set on, response monitor waits for the user action to proceed when the averaged count is reached. Responses are saved when reset is pressed (if saving is on). If set off, response monitor resets the average response curves after the averaged count is reached and start the averaging again.

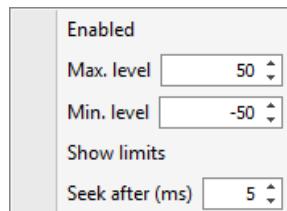
**Record responses:** if set on, responses are recorded to own data folder as reviewable data.

**Single #:** When set on (button is highlighted) the monitor shows n latest responses/ch. Number (n) of responses defined in the control. Single responses from the same curve are now laid out on top of each other, in a butterfly fashion. Baseline is calculated from the start of pre-stim time to 1 ms before stimulus and removed from response segments before displaying. The saved responses still contain the baseline.

**Average #:** When set on (button is highlighted) average stimulus response is calculated and **shown**. Number (n) of averaged responses defined in the control.

**Reset :** Resets the average calculation and starts averaging again.

**Rejection :** Additional set of controls for defining rejection limits.



**Enabled :** On/off selection

**Max level [uV] :** If stimulus response exceeds max level it is rejected.

**Min level [uV] :** If stimulus response is below min level it is rejected.

**Show limits :** On/off selection: shows the rejection limits.

**Seek after [ms] :** Time period from trigger after which rejection seek is active.

Rejection limits are now remembered by curve name and not forgotten when the montage changes.

Rejection seek start offset is now shown on chart as a blue marker when rejection limits are visible.

Rejection limits (min and max) are now switched when user drags min over max or vice versa.

**TMS Mute** – if set on, TMS Mute is selected.

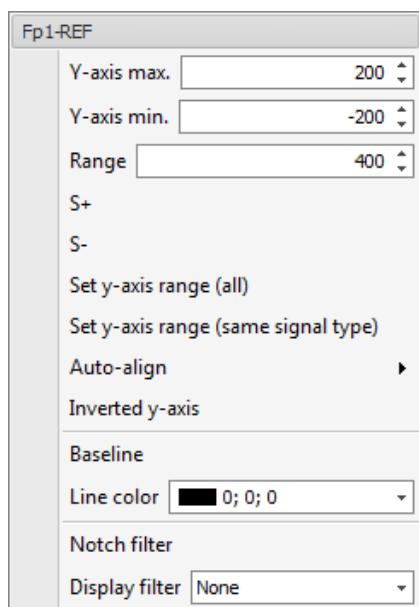
**TMS Decay** – if set on, TMS Decay is selected.

**Recalc** – Performs the selected TMS artefact removal operations (TMS Mute & TMS Decay) on the latest raw (unprocessed) response on demand. The recalculated response isn't taken into average, but only shown on screen. This functionality is meant for adjusting TMS removal parameters at the start of measurement.

**Decay fit start (ms)** – See chapter 5.3.6.5.

**Coefficients 1 & 2** – See chapter 5.3.6.5.

In curve drawing area of response monitor: right-clicking on top of a single channel in a monitor opens a settings window for selected channel:



**Y-axis max.:** Sets Y-axis maximal level of the channel.

**Y-axis min.:** Sets Y-axis minimum level of the channel.

**S+ :** Increase vertical axis sensitivity of the channel (for quick scale adjustment).

**S- :** Decrease vertical axis sensitivity of the channel (for quick scale adjustment).

**Set Y-axis range (all):** Y-axis range to all channels according to min – max settings.

**Set Y-axis range (same signal type):** Y-axis range to all channels with same signal type according to min – max settings.

**Auto-align▶:**

**Off:** Auto-align disabled

**Bind to single:** Forces the single responses to be shown on the monitor.

**Bind to average:** Forces the average responses to be shown on the monitor.

**Inverted y-axis:** If selected inverts the y-axis of the channel.

**Baseline:** Sets baseline visible (on/off) of the channel.

**Line color:** Color of the channel definition in the measurement (does not affect the default color set in the Protocol tool).

**Notch filter:** Sets notch filter on/off for the channel.

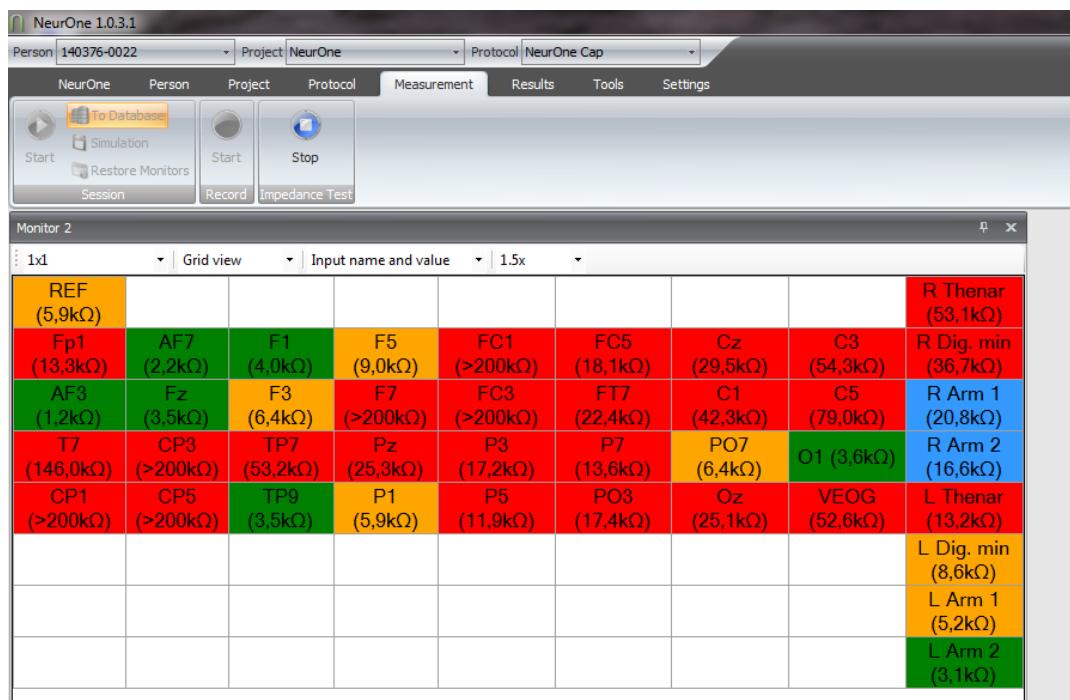
**Display filter:** Sets selected display filter for the channel.

The following shortcut keys can be used during measurement, when the response monitor is selected:

<b>F</b>	Fit curves vertically
<b>+ or - (keypad)</b>	Increase/decrease vertical scale
<b>PgUp or PgDn</b>	Switch montage
<b>M:</b>	Toggle TMS Mute
<b>N:</b>	Toggle TMS Decay

#### 5.4.2 Impedance Test

Impedance measurement is an independent part of measurement session. You may start it prior to an EEG/EP recording in order follow the minimization of electrode impedances by preparing the skin-electrode interface properly. If needed, the impedance measurement can be performed between measurement sessions. Just stop the actual measurement before switching to the impedance test.

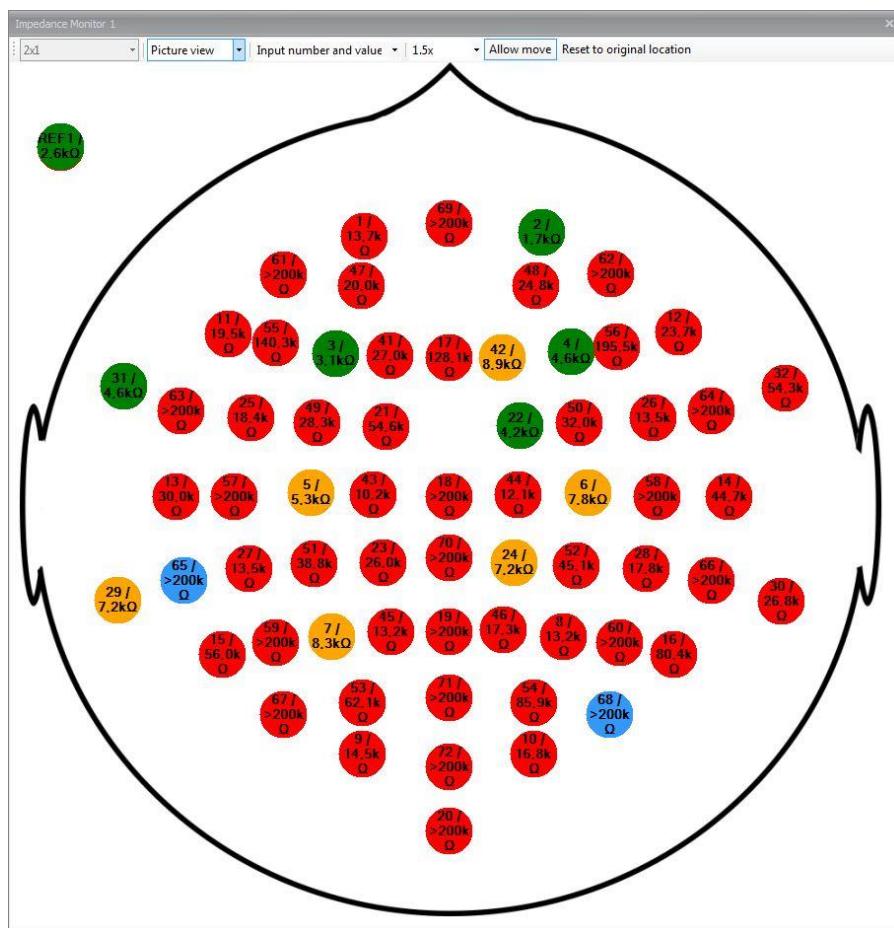


To start an impedance test, click Start (Impedance Test) button. Impedance monitor will be opened on the window and the impedance results of all channels selected for

the measurement will appear one by one on the monitor. The values of each channel are shown on a *grid view* (default, example shown above): each cell shows the input name and the status color.

Status color is depending on the measured impedance value vs. acceptance limit defined in the protocol (Impedance plug-in settings, chapter 5.3.6.3). If the impedance value is below the lower limit the color is **green**, if the value is between the limits the color is **orange**. If the value is above upper limit the color is **red**. The indicator LEDs of the channels on the Amplifier (only in EXG) shows simultaneously the corresponding **green – orange – red** light during the impedance measurement.

If the viewing mode is selected to *picture view*, it shows the impedance of the electrodes on the background image defined in the impedance plug-in of the protocol. In this mode it is possible to move the electrodes to the desired location and finally save the layout to be used during next measurement session. For this *picture view* background image “Head.bmp” is available in NeurOne program data folder. For most of standard electrodes the location is calculated when this image is used as background.



The following controls are available in the impedance monitor:

- Arrangement of impedance monitor
- Viewing mode

- Displayed items:
  - input name
  - input number
  - input name and number
  - input number and value
  - input name and value
- Text size
- Allow move – when set electrodes can be moved on the bitmap (only in *picture view mode*)
- Reset to original location – reset the electrodes to original locations

The grid view updated when new impedance results are available. The cells of most recent results are highlighted by **blue** color.

**During the impedance test:** first prepare **REF** and **PGND** electrodes as well as possible. Then continue the preparing of other electrodes depending on the status information until the impedances of all electrodes are sufficient for proper measurement.



**Use REF always when measuring impedance! In EXG amplifiers: also if only bipolar channels are used!**



**Use PGND when measuring impedance. Do not use GND!**



**In Tesla amplifiers reference electrodes of bipolar channels are measured during impedance measurement. In EXG amplifier bipolar references are not measured.**



**If several Amplifiers are used in the measurement connect REF input between all Amplifiers in use.**



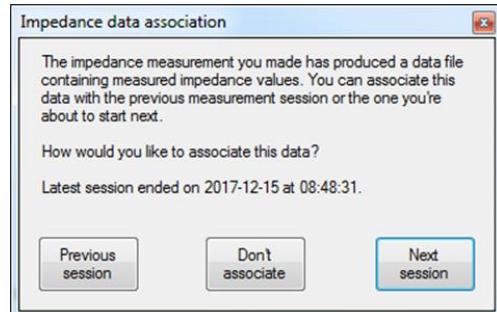
**Impedance measurement can be performed properly if at least 2 unipolar and/or 2 bipolar inputs are used on each Amplifier.**

**Impedance test results** are saved in text file into **person data folder** (primary location for the impedance results).

The text file name syntax is *ImpedanceData-[yyyy]-[mm]-[dd]T[hh][mm][ss].txt*.  
The final location of **impedance results file** is determined as follows:

- After Impedance test:

- If no measurement for current person was made in last 60 minutes, assume the file is going to be associated with next measurement session
- Else the user will be asked whether to (a) associate with previous, (b) leave unassociated or (c) associate with next measurement

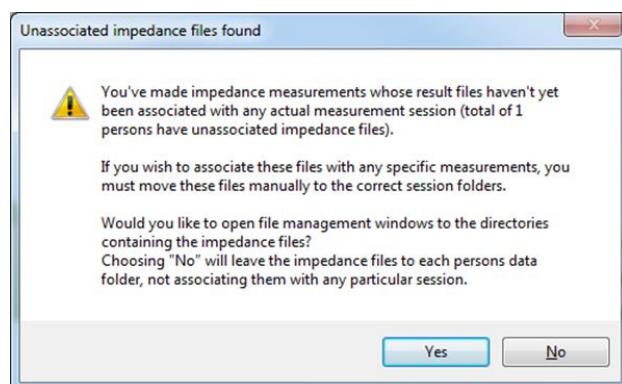


- If "Previous session" is chosen the file is moved to previous session folder. However, if that measurement is older than 10 minutes, the software gives the warning and possibility to cancel the choice
- If "Next session" is chosen the file is left to person data folder (primary location) and will be moved to session folder at the end of next measurement session where data has been saved



**Only Data writer (plug-in) generated session folders taken into account, i.e. impedance file is not transferred to session folders generated by Response monitor.**

- At application exit the warning is shown if there are any unassociated impedance files that were created during the application run time



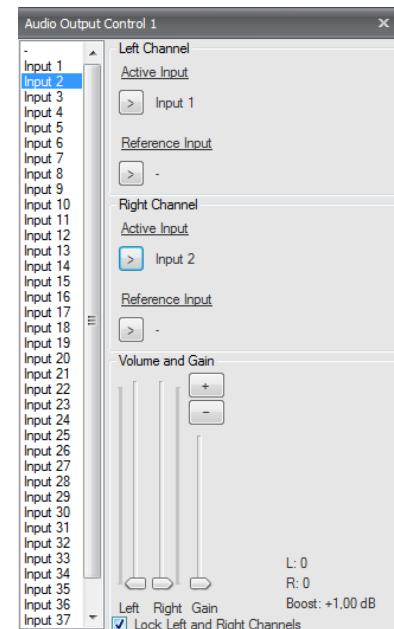
- By choosing Yes the explorer window is opened to the affected person data folders

## 5.4.3 Audio output control

With the audio output control you can change active input and reference input for left and right audio channel separately. The default input(s) has been defined on the Analog/Audio Output plug-in definition. The measurement starts playing audio from default inputs.

On the audio output control there are:

- Input selection list
- Selection buttons for:
  - Active input      – Left
  - Reference input    – Left
  - Active input      – Right
  - Reference input   – Right
- Volume control Left      (Left)
- Volume control Right     (Right)
- Gain control                (Gain)
- Increase Boost            
- Decrease Boost              
(Boost adjust by 1 dB steps)



- Checkbox to lock volume controls:
  - Unchecked – adjust left and right side separately
  - Checked – locked left/right adjustment
  - Checked – balanced/locked left/right adjustment

To change the active or reference input during the measurement:

- Select the desired input on the input list on the left
- Click **Active Input** or **Reference Input** button for left or right side

## 5.4.4 EEG recording – entering comments

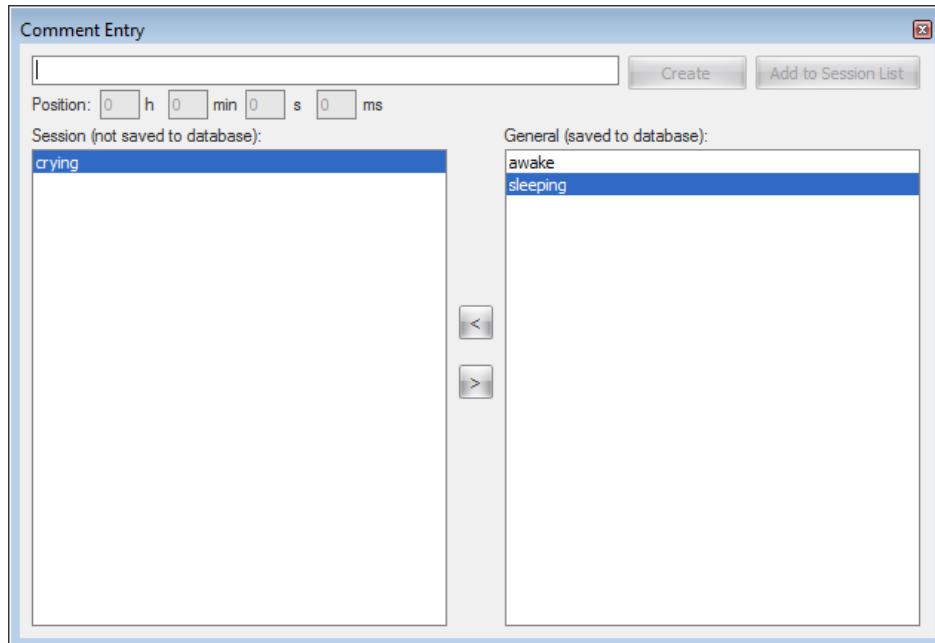
For basic EEG recording is the raw monitor used and it works as described in section 5.4.1.1.

Comments can be added in “Comment Entry” dialog as follows:

1. Press space button.



Comments can be entered only during recording!



2. “Comment Entry” dialog as is opened.
3. Type comment on the comment line on the top of dialog.
4. Click **Create** button or press enter – the comment is attached **to the moment you pressed the space bar**. This is to ensure that comments are always linked in time to comments in the actual measurement.

You may also add comments from Session list and from General list by double-clicking the desired comment.

After the creation of new comment it is moved to the Session list on the left side of the dialog. These comments are not saved to the database and therefore, they are available only during current measurement session.

You can add inputted comment directly to Session list without causing marker event into data by clicking **Add to Session List** button.

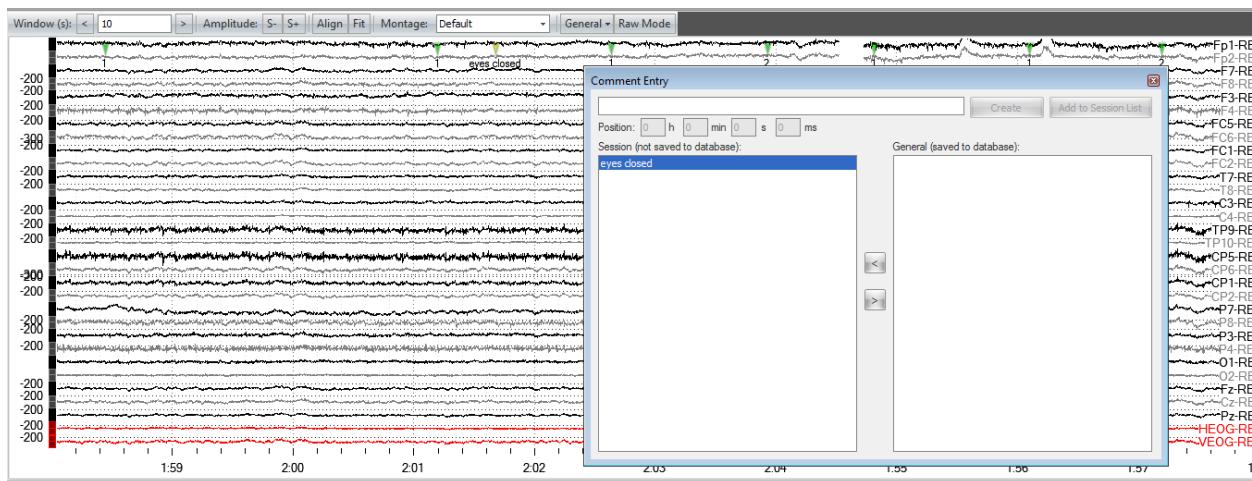
On the right side of the dialog there is General list for comments, which are stored into the database. Move the comments between Session and General list as follows:



Move selected comment from General list to Session list.



Move selected comment from Session list to General list.



#### 5.4.5 EP recording

For EP monitoring is the response monitor used and it works as described earlier in this manual (5.3.6.5, 5.4.1.2). This monitor is usable for ERP, SEP, BAEP and other evoked potentials measurements.

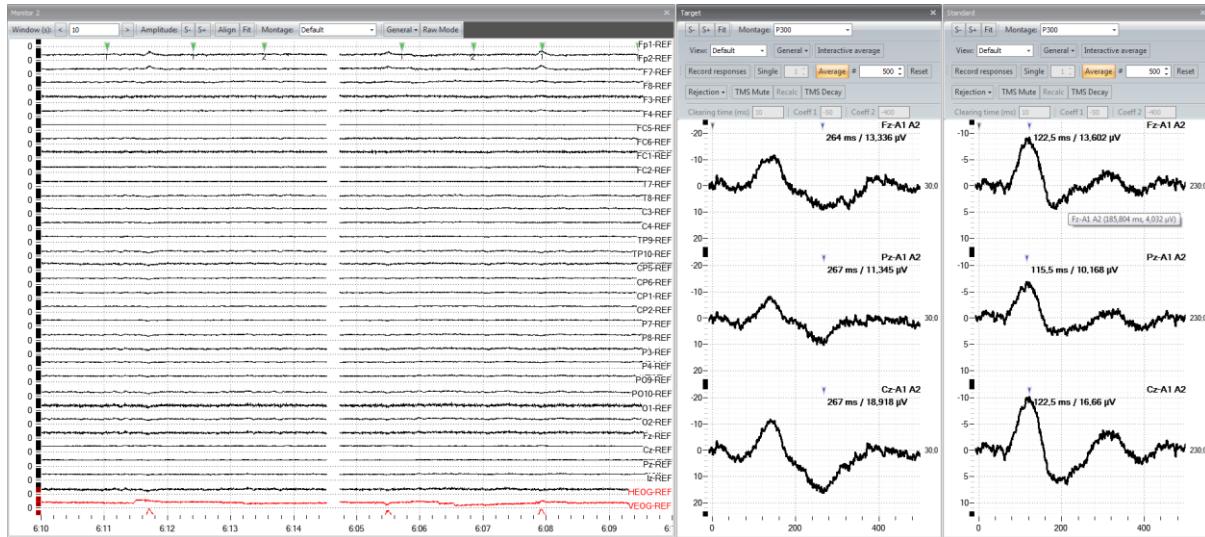
Depending on Protocol and monitor setup definitions, the EP monitoring layout may consist of several monitors. Also the number of monitors defines the default layout, which can be changed and saved during the Protocol session.



**Latency markers are operational only in Default view.**

The following picture shows an example of a monitor layout: on the left there is a raw monitor showing the measured signals in real-time, in the middle and on the right there are response monitors. Both response monitors show the averaged responses but it is also possible to monitor the single responses by clicking the Single button. The response counters are enabled from the General button and the values are shown on the right side of the curve.

For saving responses, click **Record responses** button on the Response monitor.



### Latency markers:

When using the Default view mode and only average or average and one single, the latency markers can be used. The latency markers find the maximum and minimum values of the response and mark the location of the maximum or minimum with blue flag. The location is set to be the one that occurs first. Next to the blue flag, there are the time stamp and the absolute value of the difference between the maximum and minimum. Latency markers can be set to find the latency after certain time instant. In the middle response monitor, the latency markers are set to find the latency after 230 ms and thus only the values after 230 ms are included. Now looking at the curve Fz-A1 A2 the minimum is at 264 ms and the maximum at around 400 ms so the blue flag is placed to the minimum.

Response monitor has also the mouse tooltip that shows channel name together with the signal time stamp and amplitude.

### 5.4.6 Video recording

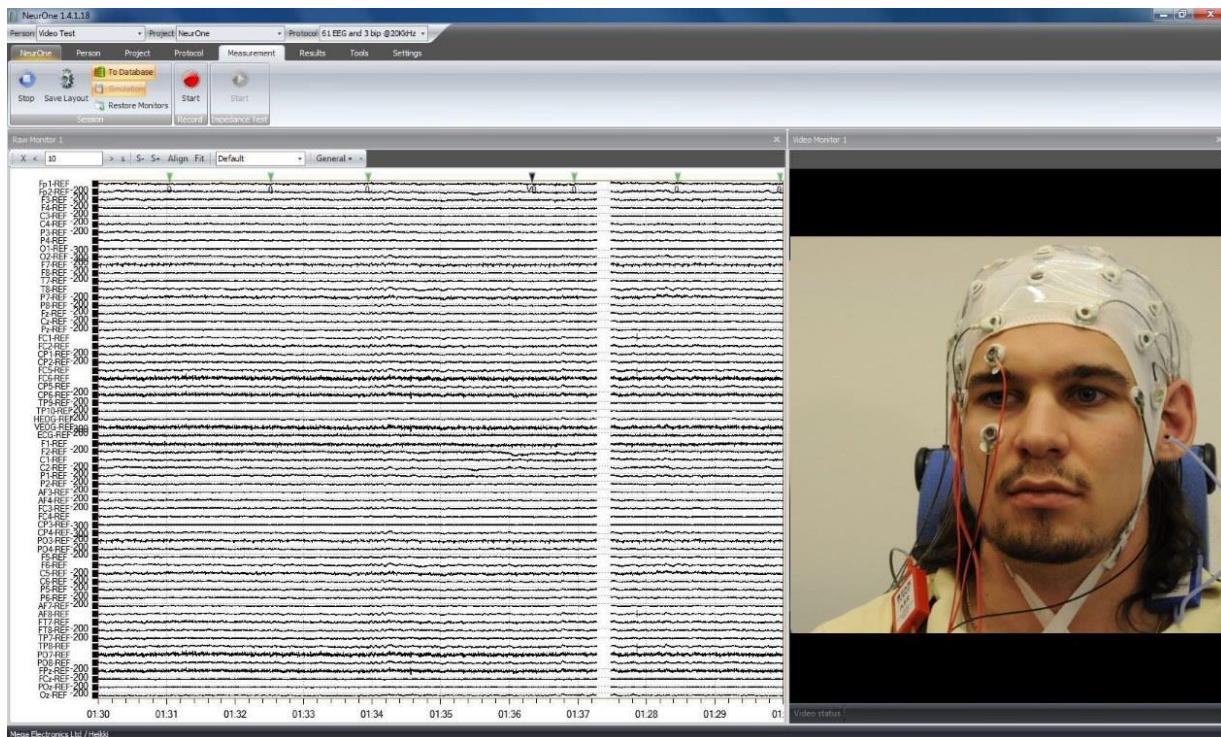
First make sure the video camera and the video trigger box are connected according the schema on the chapter 4.8 Video Option.

Add Video Monitor to Protocol with the following settings:

- Video device: XI 100D USB-HDMI Video
- Video resolution: 720 x 576 @60,241

- Requested frame rate: 25
- Audio device: Digital Audio Interface (XI 100D USB-HDMI...)
- MPEG-2 Peak VBR avg bitrate (kbyte/s): 250

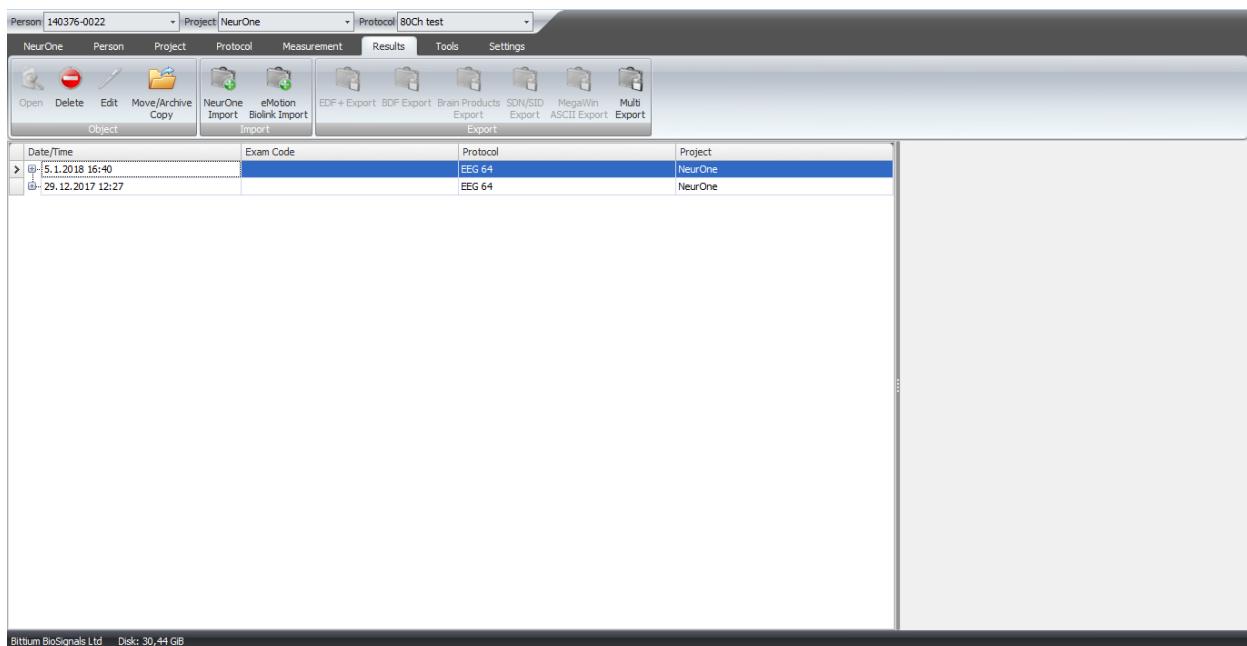
Start measurement and set recording on. Switch the Video Trigger unit on and press the Trig button. The Video trigger unit sends video sync pulses at 10 Hz that are seen as triggers indicated with blue triangles in Raw Monitor. Before stopping the recording first press the Trig button on the Video Trigger Unit and then stop the recording.



**Stop video trigger output from Video Trigger unit before you stop recording!**

## 5.5 Viewing the results

The Result tab allows the user to browse, review, import and export all measurements in the selected database. In order to access the result tab, a Person needs to be selected. After selecting a Person, the list of stored sessions corresponding to this Person will be updated on the results tab.



The measurement data is divided into a result list on the left of the tab. The measurements are placed on order by date and time, the newest on top of the list. As default there are columns Exam code, Protocol and Project on the result list. To access or close the result, click on the box on the right of the list. To select a single measurement, open the list object and select the time field.

The Results tab contains the following operations for selected data:

It is possible to modify the results view:

- Keep mouse pointer on the result list header
- Press mouse right button
- Select from pop-up menu “Column chooser”
- Drag columns from/to Customization list

If dragged to the result list the column “Measurement length” shows the sum of the recording lengths in selected session.

**Open** – Opens the selected data in the Review window.

**Delete** – Deletion of the selected data. The program asks you to confirm or cancel the deletion.

**Edit** – Edition of measurement details ( Exam code, Technician, Medication, Notes) the of selected measurement.

**Move/Archive Copy** – Provides features either move or archive copy of Session data.

**NeurOne Import** – Import of NeurOne data.

## eMotion Biolink Import – Import of Biolink data.

## EDF+ Export – Export to EDF+ data format.

When NeurOne exports data measured with 24 bit ADC resolution it scales signals:

- AC mode: data is exported to 16 bit data with 0.1 uV resolution (full scale of EDF+ signal: +/- 3.27 mV)
- DC mode: data is exported to 16 bit with 16 uV resolution (full scale of EDF+ signal: +/- 523 mV)
  - with exception of channel having calibrated range (e.g. GSR, temperature, acceleration) => data is scaled: +/- calibrated range x 10
    - => Accelerometer signal calibrated with 0 G and 1 G is exported so that full scale of EDF+ signal is +/- 10 G

## BDF Export – 24 bit data format export.

## Brain Products Export – Direct export to Brain Products raw data format (to analyze it you need the Brain Products or BESA license purchased).

## SDN/SID Export – Export to NeurOne simulation files (.sdn or .sid).

## MegaWin ASCII Export – Exports the channels of selected montage to MegaWin import compatible ASCII format.



**Only 16 channels can be imported to MegaWin. For that purpose use montage with max. 16 channels!**

## Multi Export – Export of several measurement sessions.

Opens dialog with:

- Session search parameters
  - person
  - project
  - protocol
  - period of time

Search sessions according to search parameters

Clear search parameters

Move selected sessions to Export list

Remove selected session from Export list

- Definition of export **Root file path**

- Definition of **File name format**

- Possibility to modify selected file name individually

- Definition of **Data format**

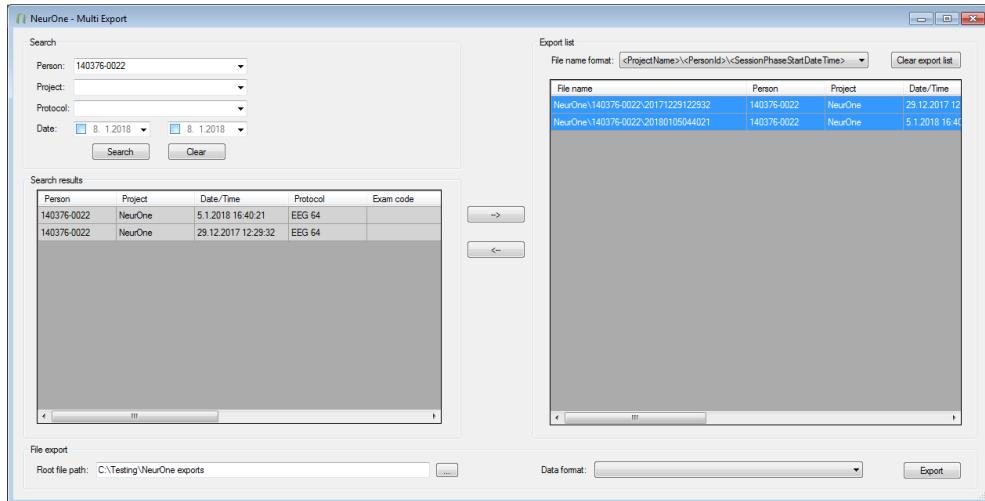
- **EDF+**

- **BDF**

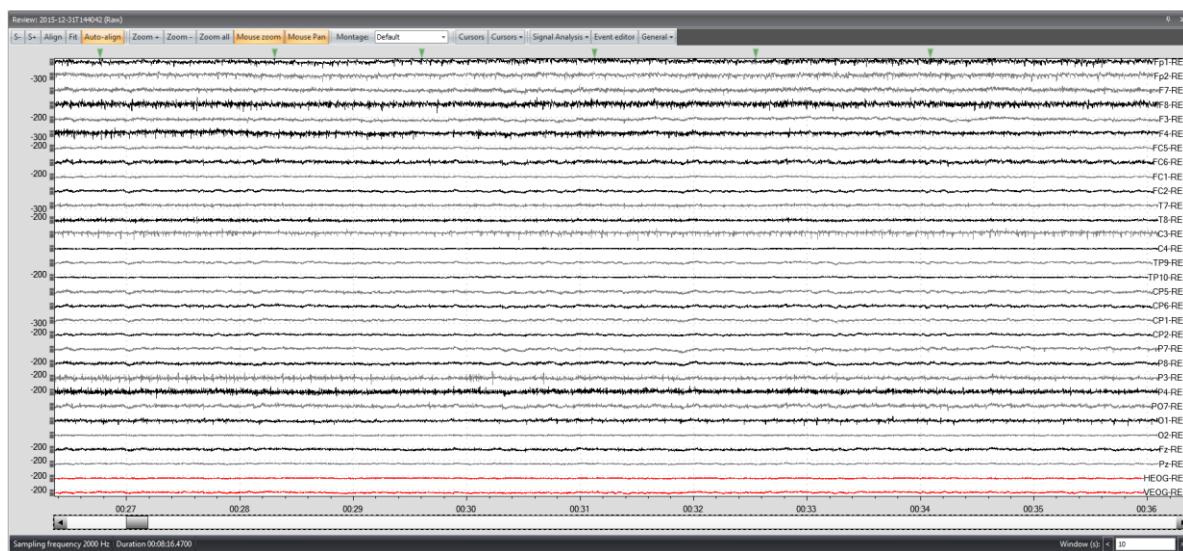
- Brain Products
- SDN
- SID
- MegaWin ASCII

Remove selected session from Export list

Export selected sessions



## 5.5.1 Review window



Review window provides data inspection tools with scaling, zooming and panning as follows:

**S+** : Increase value range sensitivity (for quick scale adjustment).

**+ key** of keyboard: Increase value range sensitivity (shortcut key).

**S-** : Decrease value range sensitivity (for quick scale adjustment).

**- key** of keyboard: Decrease value range sensitivity (shortcut key).

**Align:** Places the curve to the drawing area without scaling by using current sensitivity.

**Fit:** the curve is scaled with best fit on the drawing area.

**Auto-Align:** If set on (button is highlighted), Align operation is performed automatically when curve draw area changes.

**Zoom +:** Zoom in on the displayed data.

**Zoom - :** Zoom out on the displayed data.

**Zoom all:** Shows all the data.

**Mouse zoom:** Zoom in – move mouse pointer to the location of the area to be zoomed (left edge). Click the left mouse button and while keeping it down, move the mouse pointer to the right edge of the area to be zoomed. Release the mouse button. (as default this operation is set on).

**Mouse Pan:** Panning of the in the zoomed data. (as default this operation is set on).

**Montage:** Montage selection. It is possible to change the montages available for the Protocol related to viewed data.

**Cursors (on/off button):** Hides/shows allowed cursor(s).

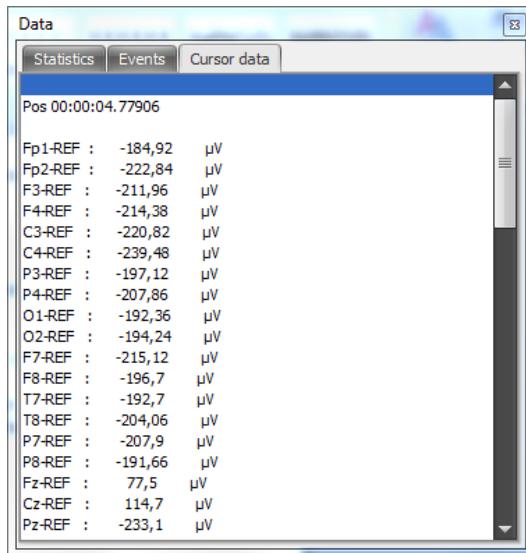
**Cursors ▼ (pop-up selection):** There are two types of cursors available for precise data viewing.

**Tracking cursor:** points the data point at the site of the cursor using the symbol X drawn on the curve.

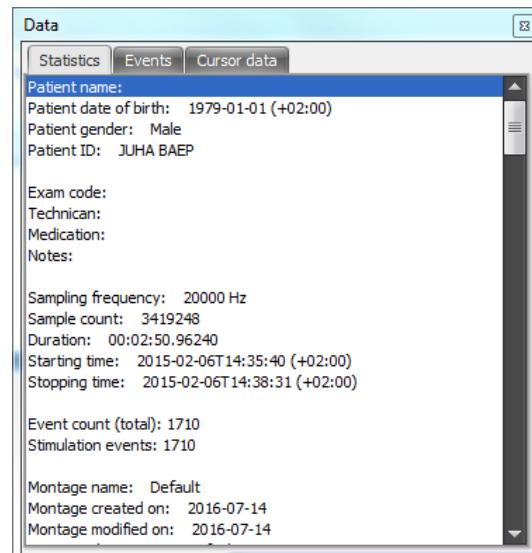
**Trace amplitude cursors:** draws the pair of cursors for difference inspections. As default the left cursor is for locating the start point and the right cursor for the adjustment of the data length.

Cursors move: click the left mouse button on top of the cursor. Keep the left button down and move the cursor to desired location. Selecting cursor opens Data window with Cursor data tab selected (as default).

Cursor data tab:  
Shows numeric values of the data and the time at the site of the cursor. You may keep numeric values constantly shown by setting the parameter **Keep cursor values visible**.



Statistic tab:  
Shows general information about the recording, montage and inputs.



Events tab:  
Shows the information about the events of the recording. On this tab it is possible to set and remove the event filter in order to get the list of desired events. Buttons **Configure** and **Remove (event filter)**.

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<table border="1"><tbody><tr><td>0</td><td>00:00:00.02010</td><td>402</td><td>SA</td><td>402</td><td></td></tr><tr><td>1</td><td>00:00:00.12010</td><td>2402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>2</td><td>00:00:00.22010</td><td>4402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>3</td><td>00:00:00.32010</td><td>6402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>4</td><td>00:00:00.42010</td><td>8402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>5</td><td>00:00:00.52010</td><td>10402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>6</td><td>00:00:00.62010</td><td>12402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>7</td><td>00:00:00.72010</td><td>14402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>8</td><td>00:00:00.82010</td><td>16402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>9</td><td>00:00:00.92010</td><td>18402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>10</td><td>00:00:01.02010</td><td>20402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>11</td><td>00:00:01.12010</td><td>22402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>12</td><td>00:00:01.22010</td><td>24402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>13</td><td>00:00:01.32010</td><td>26402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>14</td><td>00:00:01.42010</td><td>28402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>15</td><td>00:00:01.52010</td><td>30402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>16</td><td>00:00:01.62010</td><td>32402</td><td>SA</td><td>2000</td><td></td></tr><tr><td>17</td><td>00:00:01.72010</td><td>34402</td><td>SA</td><td>2000</td><td></td></tr></tbody></table>					0	00:00:00.02010	402	SA	402		1	00:00:00.12010	2402	SA	2000		2	00:00:00.22010	4402	SA	2000		3	00:00:00.32010	6402	SA	2000		4	00:00:00.42010	8402	SA	2000		5	00:00:00.52010	10402	SA	2000		6	00:00:00.62010	12402	SA	2000		7	00:00:00.72010	14402	SA	2000		8	00:00:00.82010	16402	SA	2000		9	00:00:00.92010	18402	SA	2000		10	00:00:01.02010	20402	SA	2000		11	00:00:01.12010	22402	SA	2000		12	00:00:01.22010	24402	SA	2000		13	00:00:01.32010	26402	SA	2000		14	00:00:01.42010	28402	SA	2000		15	00:00:01.52010	30402	SA	2000		16	00:00:01.62010	32402	SA	2000		17	00:00:01.72010	34402	SA	2000	
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### Signal Analysis:

Signal analysis tools:

Calculates the spectrum over the user defined area of the **selected** channel:

- Select command FFT Analyze.
- Click the left mouse button on top of the curve area and move the mouse pointer to the desired location of the data while keeping the left button down.
- Release the left mouse button.
- Release the left mouse button.
- Double-click desired curve.
- On the right side of the window appear numeric values, data curve of selected data area and spectrum of selected data of selected channel.

### Event editor:

Editing tool for events.

This tool provides features to modify and change the event definitions with following functions:

**Save:** saves current changes to the measurement.

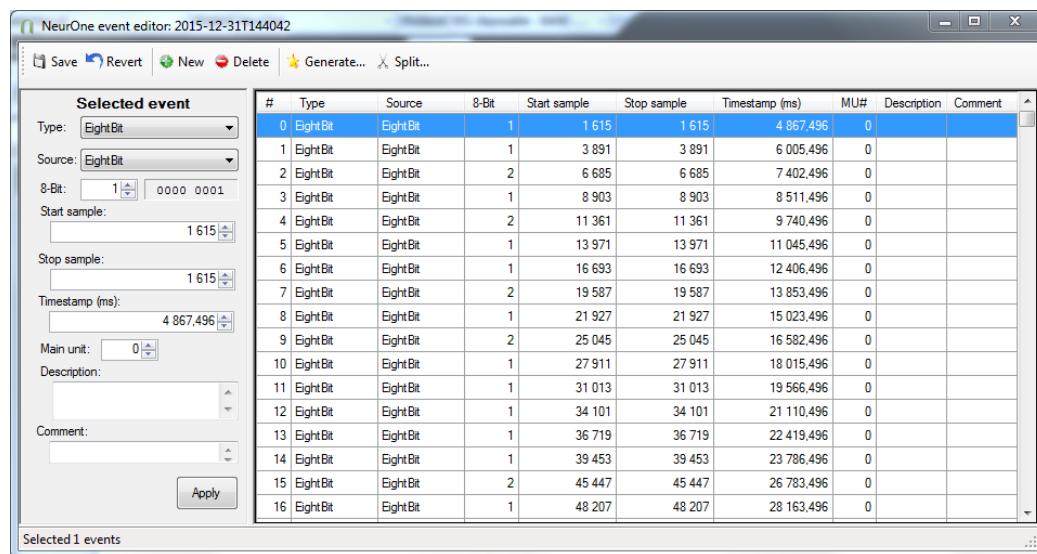
**Revert:** discards all changes and returns back to the state of previous save.

**New:** creates a new event at the current tracking cursor position.

**Delete:** deletes the selected event(s).

**Generate....:** creates new events based on signal changes.

**Split....:** splits 8-bit markers to multiple markers based on given bit boundaries.



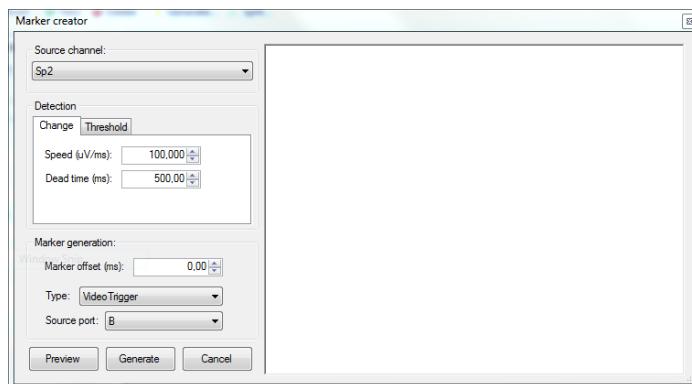
## New event definition

For the new event definition move the tracking cursor to the desired position, press **New** button. Define Type and source and press **Apply** button.

## Generating events

Event generation is based on defined signal change speed of selected channel or if signal of the selected channel exceeds or goes under defined threshold level.

Pressing **Generate** on NeurOne event editor opens Marker creator control with the following definition parameters:



**Source channel:** defines the channel for event generation.

**Detection / Change:** for defining marker creation based on signal change.

**Speed (uV/ms):** change speed that generates the marker.

**Dead time (ms):** no detection during this period of time after last found marker.

**Detection / Threshold:** for defining marker creation based on signal exceeding or undershoot vs. defined threshold level.

**Threshold (uV):** signal level for marker creation.

**Dead time (ms):** no detection during this period of time after last found marker.

**Direction:**

*Rising* – marker is generated if signal exceeds the threshold level.

*Falling* – marker is generated if signal goes under the threshold level.

**Marker generation:**

**Marker offset (ms):** time offset for the marker to be generated.

**Type:** type of trigger to be generated.

**Source port:** source port of trigger to be generated.

NeurOne event editor provides following definition functions:

**Preview:** displays the pre-view of markers generated using set parameters.

**Generate:** generates new markers for the data using set parameters.

**Cancel:** cancel the operation.

**General:** additional set of controls for viewing the data:

**Grid:** Allows grid on the drawing area. On/off selection.

**Millimeter grid:** Allows millimeter grid on the drawing area. On/off selection.

**Millimeter grid for ECG:** Allows millimeter grid on the drawing area for ECG monitoring. On/off selection.

**Anti-aliased lines:** Curve smoothing. On/off selection.

**Line width:** Curve width (in pixels).

**Set display filter:** Filters the displayed data with selected filter.

**Enable notch:** Sets on the notch filtering of the data.

**Disable notch:** Sets off the notch filtering of the data.

**Notch filter frequency:** Selection of notch filter frequency (50Hz/60Hz).

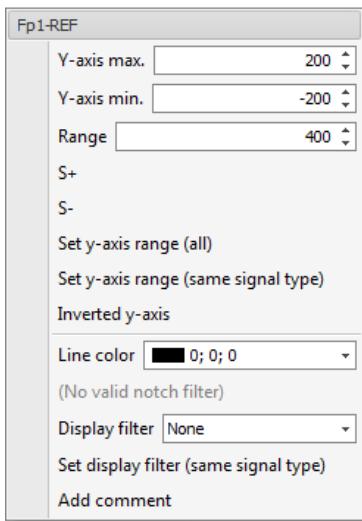
**Print chart:** Prints the selected data.

**Set y-axis inverted:** Inverts the y-axis.

**Set y-axis non-inverted:** Returns normal y-axis orientation.

**Add comment:** manual comment entry into data by opening Comment entry dialog (see chapter 5.4.4) with additional Position control. As default comment is added at the site of tracking cursor or at the time stamp pointed by position control. Alternative ways to open Comment entry dialog: by pressing spacebar or mouse right-click + pop-up menu command.

Curve pop-up menu allows change setting for desired curve. Press mouse right button on top of chosen curve amplitude range area.

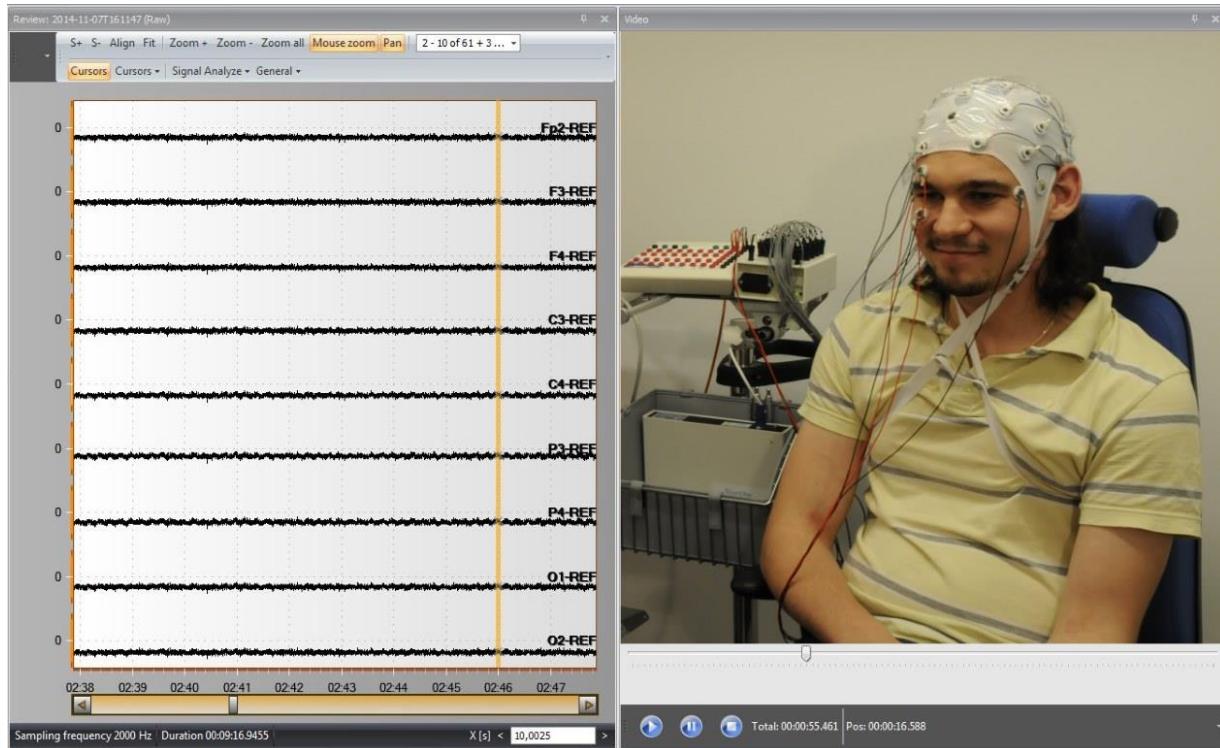


Pop-up menu contains the operations that are explained in chapter 5.4.1.1 Raw monitor properties, excluding auto-align and baseline. In addition, this menu provides possibility also to set display filter for signal same type and add comment.

If the whole data is not shown on the drawing area there is the horizontal slider, arrow left and arrow right on the bottom of the Review window for choosing desired data area. In addition, visible data area can be moved using following shortcut keys: PgUp – to left and PgDn - to right.

## 5.5.2 Viewing data with video

Video monitor is displayed together with data when data with associated video is opened for review. Data/video synchronization is performed when the data is first time opened for review.



With synchronized video the following review features are available:

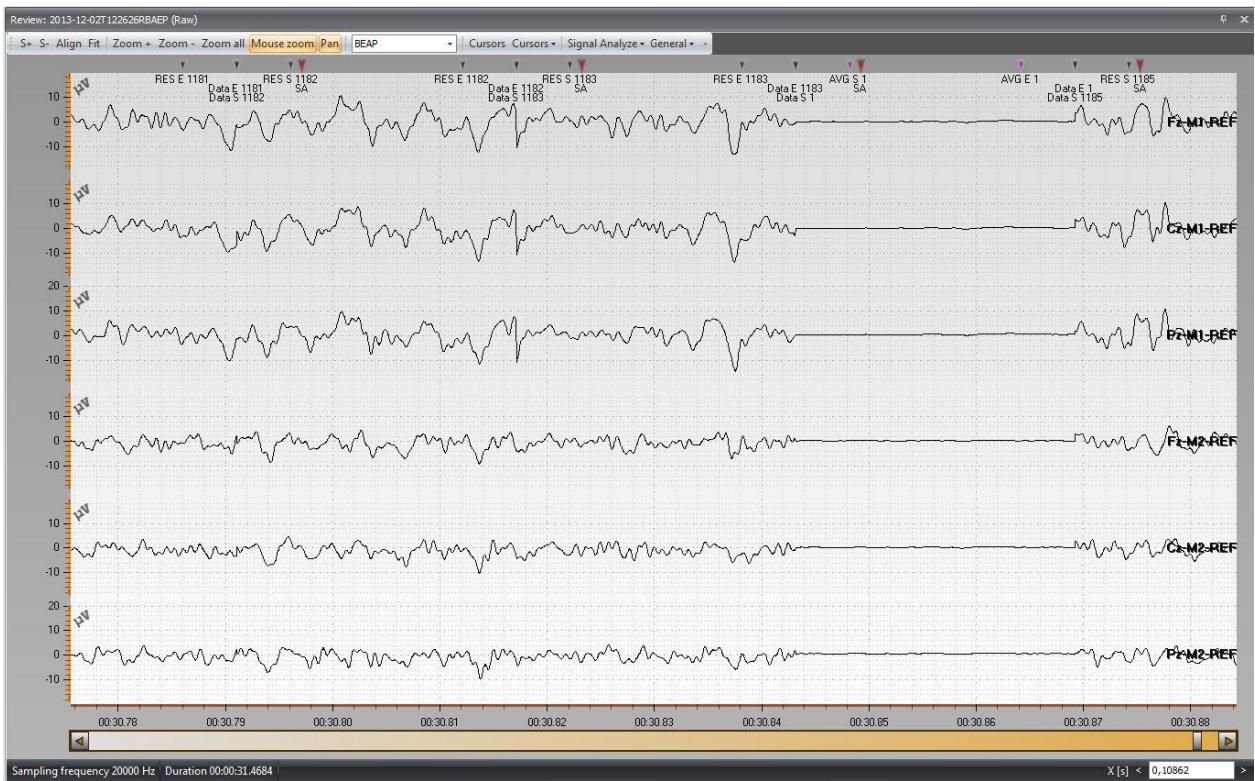
- Play (Video monitor) starts video play at the current video location and corresponding location in the data is pointed with the tracking cursor in data review.
- Pause (Video monitor) pauses the video play.
- Stop (Video monitor) stops the video play.
- Slider (below video area) controls manually video play and corresponding data location is pointed with tracking cursor in data review.
- Video play can be controlled using tracking cursor while video is paused in video review.
- Video review informs the total duration of video and the time stamp of the current video frame.
- Add comments: open comment entry dialog from menu, space button or mouse right click.



**Comments are available also in exported data, for ex. when inspecting data with MATLAB.**

## 5.6 Recorded responses

Depending on the response saving settings of the protocol in the recorded response data there are single responses, averaged responses or both.



Recorded responses are stored to the data in the form corresponding to the normal continuous signal data storage. Therefore, recorded responses can be viewed in the same way as EEG curves. However, each recorded response is marked by using new types of triggers in order to ease the further data analysis.

If single responses (SR) and average responses (AR) are stored the data structure is:  
SR1, SR2, SR3, ..., SRN, AR1, SR1, SR2, ..., SRN, AR2, SR1...

Where

SR1 is the first single response in the average

N number of the responses in average

AR1 is the first averaged response

Each response, single and average is stored as the data block. The data block consists of front padded data, response data and end padded data with the following additional triggers:

**Data S N** – Start trigger of N<sup>th</sup> stored response data block

**RES S N** – Start trigger of N<sup>th</sup> stored actual response

**RES E N** – End trigger of N<sup>th</sup> stored actual response

**Data EN** – End trigger of N<sup>th</sup> stored response data block

Averaged response is triggered as follows:

**Data SN** – Start trigger of N<sup>th</sup> stored averaged response data block

**RES SN** – Start trigger of N<sup>th</sup> stored actual averaged response

**RES EN** – End trigger of N<sup>th</sup> stored actual averaged response

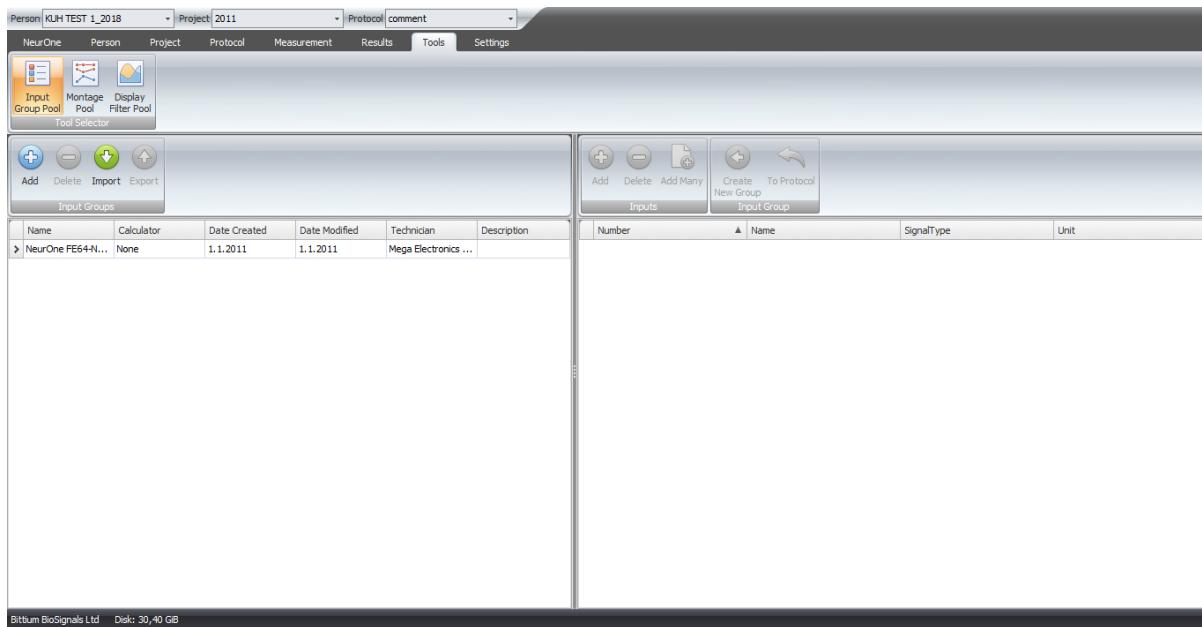
**Data EN** – End trigger of N<sup>th</sup> stored averaged response data block

## 5.7 Tools for universal input groups, montages and display filters

The Tools tab allows the user to create Input Groups, Montages and Display Filters to be used during measurements. On the left side of the tab is the Tool selector with the following selections:

- Input Group Pool for Input Group creation/modification
- Montage Pool for Montage creation/modification
- Display Filter Pool for display filter creation/modification

### 5.7.1 Input Group pool



An input group is the tool for defining the group of inputs, over which the average is calculated. This average can be used as reference.

On the left side of the Input Group Pool page is the list of available Input Groups. Left side contains the following fields:

**Name** – Name of Input Group.

**Calculator** – Type of calculation method for the group of inputs (Only Average is available). Calculator used with an input group. Current software version provides averaging as available calculator. If there are curves defined with input group reference then software calculates the average value for each input group to be used as corresponding reference.

**Date Created** – Creation date.

**Date Modified** – Date when Input Group has been modified.

**Technician** – The current technician/doctor/nurse defined this Input Group.

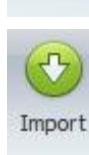
**Description** – The description of the Input Group.



Add new Input Group to the list of Input Groups.



Remove selected Input Group from the list and from database.



Import new Input Group from XML file.



Export selected Input Group to XML file.

On the right side of the tab is the Input Group definition of selected Input Group. It contains the following fields:

**Number** – Number of the input

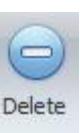
**Name** – Name of the input

**Signal type** – Type of the signal to be measured (for example EEG, EMG, ECG )

**Unit** - Unit of the signal to be measured (for example  $\mu$ V, BPM).



Add inputs to the selected Input Group. The button is active, when Input Group is selected on the list of Input Groups.



Remove the selected inputs from selected Input Group.



Add several inputs to the selected Input Group.



Create new Input Group using selected inputs.



Overwrite the input list of the protocol by the inputs of selected Input Group.  
**To Protocol** button is active, if some protocol is in **edit mode**.

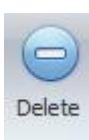
If Shift key + is pressed simultaneously input list of the protocol is appended.

### 5.7.2 Montage pool

On the left side of the Montage Pool page is the list of available montages.



Add new Montage to the list of Montages.



Remove selected Montage from the list and from database.



Import new Montage from XML file.



Export selected Montage to XML file.

Name	Date Created	Technician	Date Modified	Description
10	30.6.2014		30.6.2014	
240 ch	30.6.2014		30.6.2014	
80 ch	30.6.2014		30.6.2014	
77-80	30.6.2014		30.6.2014	
60 - 80	30.6.2014		30.6.2014	
Brainstatus bipol	9.4.2015	NeurOneUser	9.4.2015	
Montage 1	27.4.2015	NeurOneUser	27.4.2015	
SpO2	22.5.2015		22.5.2015	
33 - 40	9.6.2015		9.6.2015	
BrainStatus Cap	14.10.2015	NeurOneUser	14.10.2015	
Default1	31.12.2015		31.12.2015	
ERP 8ch REF	5.1.2018		5.1.2018	

On the right side of the tab is the Montage definition of selected Montage. It contains the following fields:

**Curve Number** – Draw order of curve.

**Active Source Name** – The active sensor of the sensor pair. This definition must match with the Name of the input in Protocol with which this Montage will be used.

**Reference Source Name** – The reference sensor of the sensor pair. This definition must match with the available reference names in Protocol with which this Montage will be used.

**Name** – Channel name (as seen in the monitor views).

**Side** – Side information (optional).

**Min. Y Value** – Minimum of Y-scale of the draw area.

**Max. Y Value** – Maximum of Y-scale of the draw area.

**Auto-Align** – If checked the curve will be forced to stay on the drawing area by changing the Y-scaling but keeping the user defined range (= Max. Y – Min. Y).

**Inverted Y-axis** – If checked the channel is drawn inverted.

**Notch** – If checked this channel will be notch filtered while drawing.

**Display Filter** – If other than None this channel will be filtered by selected display filter.



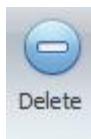
**User can now select any filter in montage editors, and it's up to the user to ensure a filter with the same name exists for all necessary sampling frequencies.**

**Color** – The default drawing color for the channel (can be changed during monitoring)

**Line Width** – Curve width (in pixels)



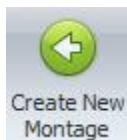
Add channel (curve) to the selected Montage. The button is active, when Montage is selected on the list of Montages.



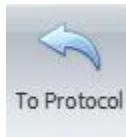
Remove the selected channels from selected Montage.



Add several channels to the selected Montage.



Create new Montage using selected channels.



Overwrite default Montage of the protocol by the selected Montage.  
To Protocol button is active, if some protocol is in **edit mode**.



**Active input name must match with the Name of the input in the Protocol with which this Montage will be used.**

**Reference input name must match with the available reference names in Protocol with which this Montage will be used.**

**If those names will not fulfill the above mentioned rules, that channel will not be drawn during the measurement.**

### 5.7.3 Display filter pool

The Display filter pool has two vertical tabs: IIR Filters and FIR filters. In both tab there are set of filter design parameters for filters to be used in the Protocol. On the bottom of the subtab there is the chart tabs for frequency, unit step and impulse response of above selected filter.



**For Raw monitor use:** Set sampling frequency of the display filter to 1000 Hz for the protocols with sampling frequency  $\geq$  1000 Hz. Otherwise use same sampling frequency as in the protocol.



**For Response monitor use:** Set sampling frequency of the display filter as defined in the protocol.

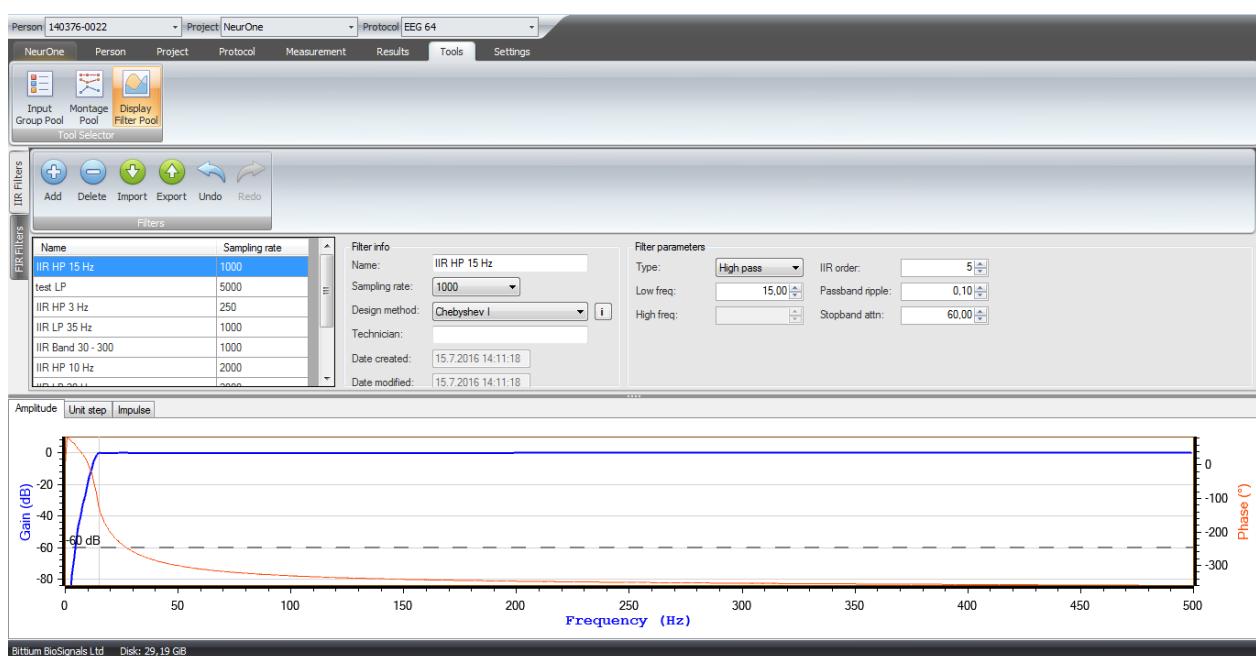


**Common predesigned IIR filters shipped with NeurOne PCSW are not visible in filter designer.**



**Recommendation:** For high sampling rates (>2k) design SOS cascade filters with MATLAB.

First, select either **IIR Filters** or **FIR Filters** tab.



Add new Display filter to the list of display filters.



Remove selected Display filter from the list and from database.



Import new Display filter from XML file.



Export selected Display filter to XML file.



Undo the latest change



Redo the latest change

Design parameters for IIR filter are:

**Name** – Name of the filter

**Sampling rate** – Sampling frequency of the data to be filtered\*

**Design method** – Windowing method used in the filter\*\*

**Technician** – Filter designer

**Type** – Type of the filter

**Low Freq.** – Low frequency of pass band

**High Freq.** – High frequency of pass band

**Order** – Order number of the IIR filter

**Passband Ripple** – Value for pass band ripple in dB

**Stopband Attn.** – Value for stop band attenuation in dB

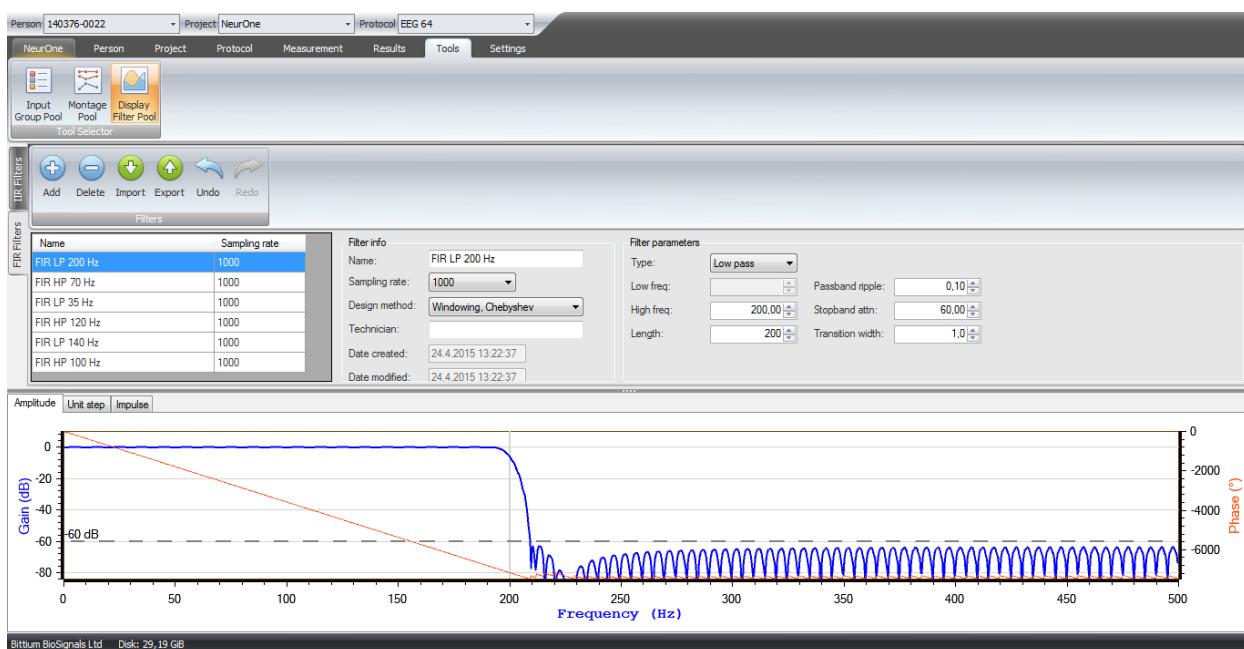
**Date created** – Creation date\*\*\*

**Date modified** – Modification date\*\*\*

\* Note the limitations for raw monitor use!

\*\* Info button for the description about design method

\*\*\* Updated automatically



Design parameters for FIR filter are:

**Name** – Name of the filter

**Sampling frequency** – Sampling frequency of the data to be filtered\*

**Design method** – Windowing method used in the filter

**Technician** – Filter designer

**Type** – Type of the filter

**Low Freq.** – Low frequency of pass band

**High Freq.** – High frequency of pass band

**Length** – Number of points in FIR filter

**Passband Ripple** – Value for pass band ripple in dB

**Stopband Attn.** – Value for stop band attenuation in dB

**Transition Width** – Transition width (in Hz) from pass band to stop band

**Date created** – Creation date\*\*

**Date modified** – Modification date\*\*

\* Note the limitations for raw monitor use!

\*\* Updated automatically

Filter design chart has zoom stack for closer inspection of the response on the chart:

**Zoom in** – Move mouse point on the chart from top left to bottom down across the desired data area

Filters defined in Display filters pool can be selected as “display filters” during the measurement if the sampling frequency of the filter match with the sampling frequency of the Protocol (note the sampling rate limitations for raw monitor).

## 5.8 Accessing settings

The Settings tab is used for controlling all the settings related to the NeurOne Main Unit and the Amplifiers. Also software settings, including data connections, file systems and networking and license management.

The Settings tab contains the following buttons in the Command Region:

**Core** – Device related and measurement settings.

**Remote Control** – Remote control settings.

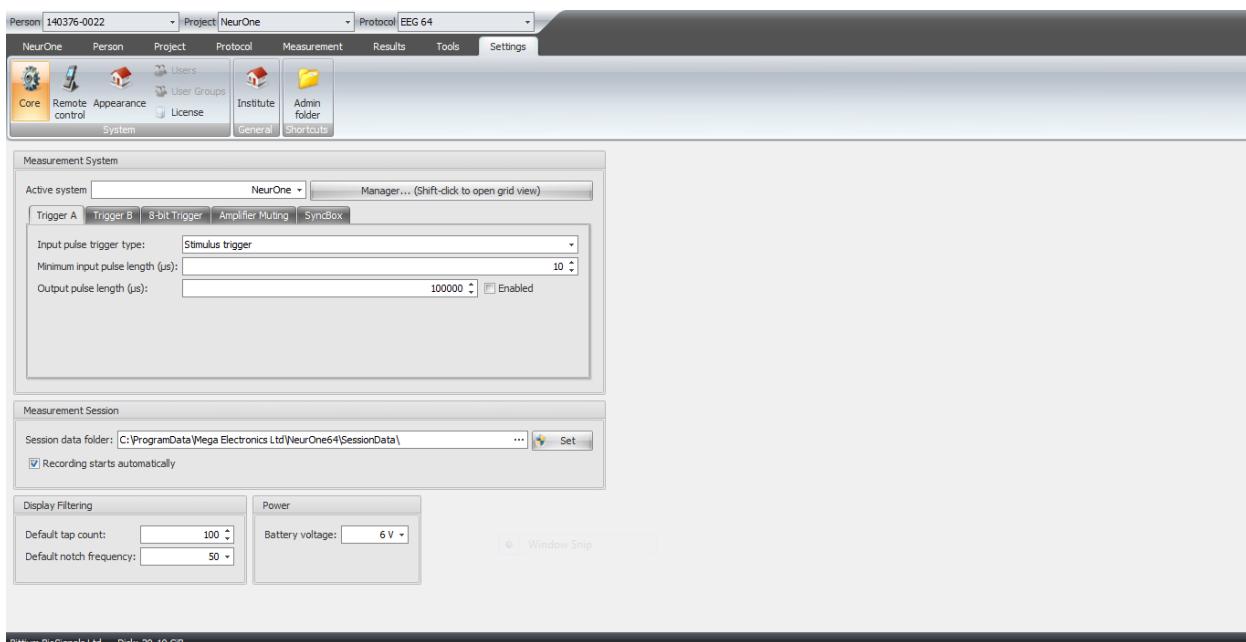
**Appearance** – User preferences for the appearance of the NeurOne software.

**License** – Control of license information in NeurOne software.

**Institute** – Control of institute information in NeurOne software.

**Admin Folder** – Opens NeurOne software misc data folder.

## 5.8.1 Core - System settings



This subtab is divided into four subsections:

### Measurement System

In the Measurement System section, there is selection for the active measurement system. As default **NeurOne** is selected.

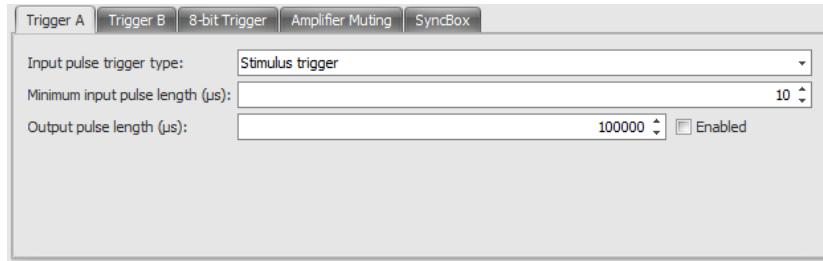
**Manager...** button opens the control that allows the user to establish and test the data connection with the NeurOne device, control calibration information of the Amplifiers, update the firmware of the Main Unit and the Amplifiers and create new filters. By pressing Shift-key simultaneously with Manager... button grid view style NeurOne manager is opened. See more in the following chapter 5.8.1.1 NeurOne manager.

NeurOne section has also controls tabs for trigger inputs A, B, 8-bit trigger, Amplifier Muting. An incoming trigger launches a trigger out pulse if trigger out is allowed in PC Software. Duration of the output pulse is adjustable in the software.



**When using NeurOne trigger A or B, you define the incoming trigger type in system settings and allow/select triggers also in Protocol.**

On the Trig I/O A and Trig I/O B tabs there are the following control parameters:



**Input pulse trigger type** – Selection of incoming trigger type. (None, Stimulus trigger, Video trigger, Mute trigger).

**Minimum input pulse length (μs)** - Minimum length of accepted trigger pulse

**Output pulse length (μs)** – Length of output pulse from trig out.

**Enabled** – If set incoming trigger activates trigger out pulse. If input trigger type in *Stimulus* or *Video*, output trigger will be sent immediately when input trigger is detected by the Main Unit. In case trigger type is *Mute*, Output trigger will be sent when muting is complete set on.

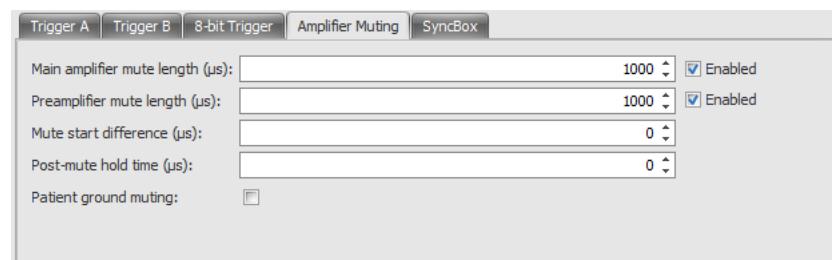
On the Non-isolated 8-bit trigger input tab there are the following control parameters:



**Enabled** – If set allows incoming triggers to non-isolated 8-bit trigger input.

**Minimum input pulse length (μs)** - Minimum length of accepted trigger pulse.

On the Amplifier Muting tab there are the following control parameters:



**Magnetic stimulus input mute (Main amplifier)** – If set allows the main amplifier is muted, when mute trigger comes in.

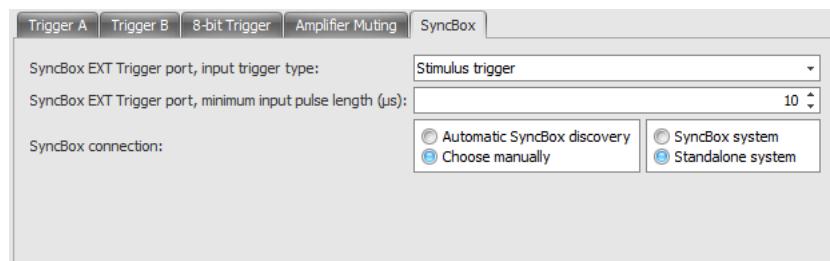
**Magnetic stimulus input mute (Switch)** – If set allows the switches are muted, when mute trigger comes in.

**Mute start difference** - Time difference (in μs) between switch mute and main amplifier mute. If value is positive switches are muted first.

**Post mute hold time** – Defines the hold time in data drawing (in  $\mu$ s) after mute. Data drawing is allowed after the hold time.

**Patient ground muting** – If the checkbox checked that allows Patient ground to be muted during the muting of Main and pre-amplifier.

On the SyncBox tab there are the following control parameters:



**SyncBox EXT Trigger port, input trigger type** – Selection of incoming trigger type to SyncBox EXT Trigger port. (None, Stimulus trigger, Video trigger).

**SyncBox EXT Trigger port, minimum input pulse length ( $\mu$ s)** – Minimum length of accepted trigger pulse.

**SyncBox connection** – If Automatic SyncBox discovery is set, NeurOne software automatically checks during the measurement start-up if SyncBox is available. If Choose manually is set, the user selects either SyncBox system (NeurOne system with SyncBox) or Standalone system (NeurOne system without SyncBox).



- If SyncBox system is selected NeurOne recording expects to find the Master Main Unit at address 192.168.200.101.
- If NeurOne system is selected NeurOne recording expects to find the Master Main Unit at address 192.168.200.200.

## Measurement Session

The Measurement Session section allows the user to define the data path of the measurement data. The path can be set into a network drive or a local drive. Please note that using a network drive with high sampling rate measurement requires network data bandwidth.

If checked, the checkbox “Recording start automatically” allows automatic data recording when the measurement session is started. If not checked there is a separate Start button on the Measurement tab for starting the data recording.

## Display filtering

The display filtering section is used to set the filter tap count and the notch frequency which are used in Protocol. The optimal filter tap count depends on computer performance and notch frequency on network voltage. If not otherwise instructed, use the default settings.

## Power

The power section is used to set manually the battery type to be used. This selection is recommended to select. Available choices are 6V, 6.6V and 7.2V.

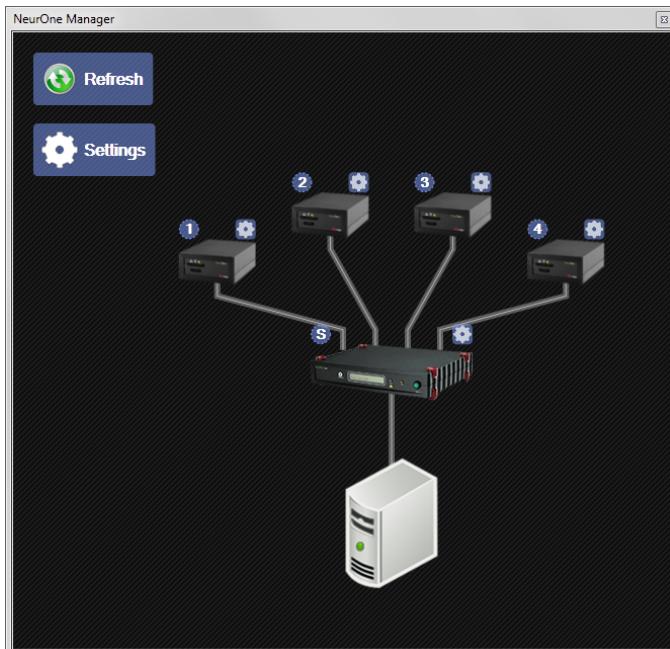
### 5.8.1.1 NeurOne manager

Manager... button opens NeurOne manager providing the topology of active NeurOne system. The topology shows PC, Main Unit and all amplifiers connected to the Main Unit as well as SyncBox if connected to Main Unit(s). Refresh and Setting buttons are on the left top corner of the window.

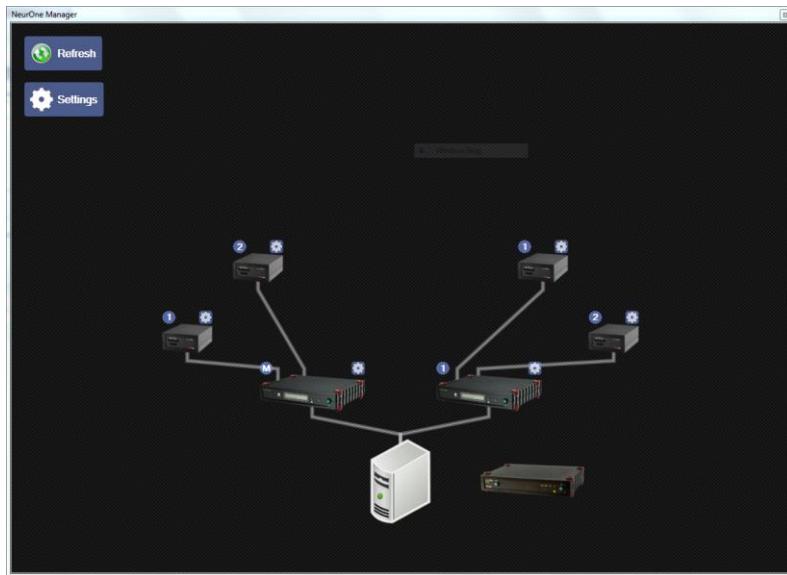


**Make sure the all devices are properly connected and turned on in order to get them visible in NeurOne manager topology.**

The symbol  above the Main Unit icon stands for “Standalone” meaning there is no SyncBox connection with this Main Unit.



If there is the symbol  above the Main Unit icon, that Main Unit is connected as Master to the SyncBox. Main Unit serving as Slave is labeled with the number icon “1”, “2”, “3”, etc...



## Main Unit firmware update/change

The tooltip shows IP address, serial number and firmware version of Main Unit when mouse pointer is placed on top of Main Unit icon.



Firmware upgrade can be launched via configuration icon above Main Unit.

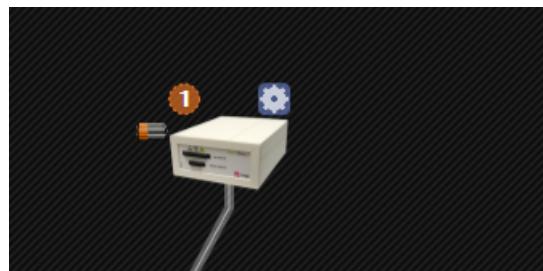
Press **Update firmware...** button and browse to the folder location with the upgrade file for update exists and select the file. Press open. The Upgrade starts. Main Unit display shows the progress of the **upgrade**. When ready “NeurOne - press button for info” text is on display of Main Unit.

## Information of connected Amplifier

When mouse pointer is placed on the Amplifier icon the tooltip shows serial number, firmware version and battery voltage of chosen Amplifier.



If the battery voltage state is below low battery level, the slowly **blinking** battery icon is displayed on the left side of the Amplifier icon.



## Upgrading Amplifier firmware

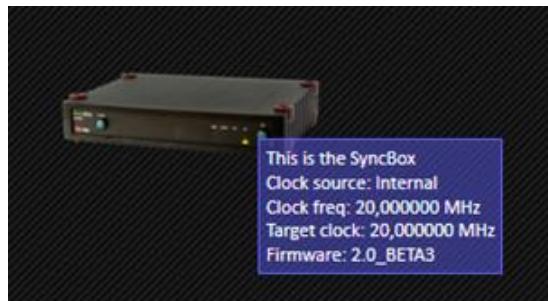
- Make sure Amplifier(s) are on and connected to NeurOne Main Unit.
- Press the power button according to the instructions in chapter 4.9.1 Operations controlled by the Power button of Main Unit.
- Select the operation for upgrading - Main Unit display: Press button for 2 s to start upgrading
- Press Power button for 2 – 3 s.
- Display: Now release button to start upgrading
- Release the button.
- Display: Press button for 2 s to confirm upgrading
- Press Power button for 2 – 3 s.
- Display: Now release to confirm upgrading
- Release the power button immediately.
- Upgrading starts.
- Wait until the upgrading procedure is completed. Display text then is: Press button for 2 s to start upgrading
- If upgrading EXG Amplifier(s) turn it/them off now and then on again
- You may now open the NeurOne manager
- Check the firmware versions



**Do not turn off the Amplifier(s) while upgrading the firmware.**

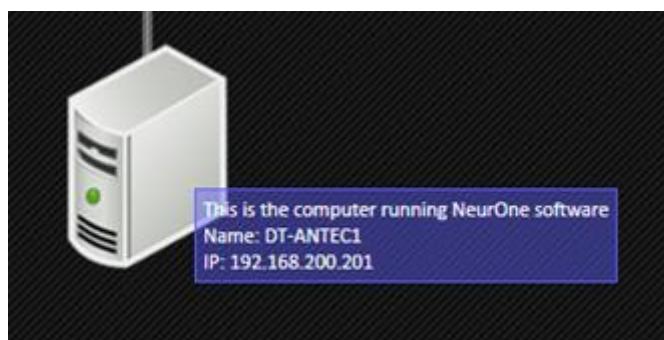
## Information of connected SyncBox

When mouse pointer is placed on the SyncBox icon the tooltip shows clock source in use, actual clock frequency, target clock frequency and firmware version.



## Information of the NeurOne PC

When mouse pointer is placed on the PC icon the tooltip shows name of the PC and IP address.



## Global settings

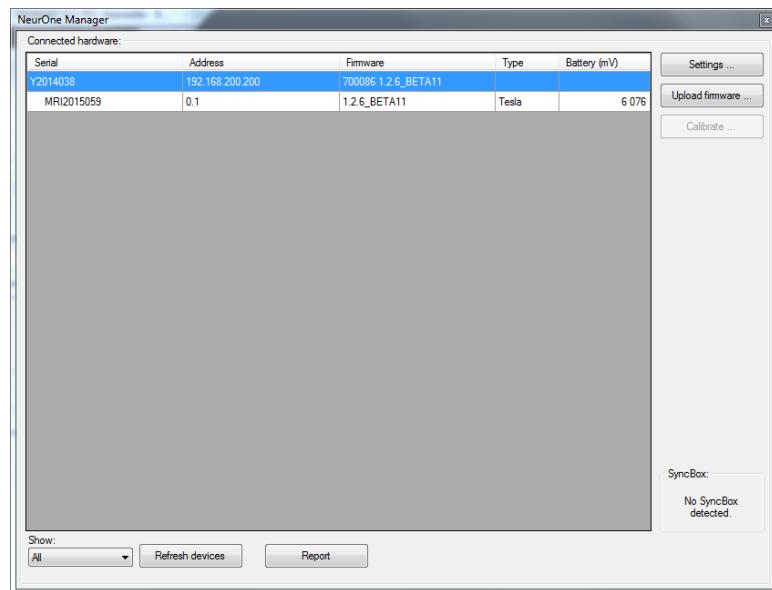
Pressing  opens global setting window, where:

On the Impedance tab it is possible to set threshold levels for impedance measurement.

On the SyncBox tab: if Ext. Clock Marker compensation is checked all marker timestamps are re-adjusted based on the external clock fed to SyncBox. This setting has no effect if SyncBox isn't in use. This setting has an effect only for FW versions 1.3.x.y and older.

## NeurOne manager – table form

Pressing Shift key and Manager... buttons simultaneously NeurOne manager in table form is opened. It shows available Main Units and all amplifiers connected to the Main Units. Serial number, IP Address, Firmware version, Device type and Battery status is shown if available.



**Settings...** button opens NeurOne Global Setting window, which is explained previously in this chapter.

**Update firmware...** initiates the firmware update procedure to NeurOne Main Unit.

NeurOne Manager table view shows all devices or only Main Units or Amplifiers.

**Refresh devices** update the table view.

**Report** copies the information on the table to clipboard.

## 5.8.2 Remote Control

NeurOne TCP Remote Control is a new feature introduced in NeurOne 1.4.1.39. It enables remote controlling (start recording, stop recording, stop session) of a running measurement and supports multiple clients. All connected clients are notified of measurement state changes (Idle, Monitoring, Recording).

### 5.8.2.1 *Remote control settings*

The Remote control has the following settings:

**Enabled** – Enables or disables the remote control component. If the server is disabled it's not listening for connections. It's advisable to disable the server for security reasons if it's not being used. Defaults to false.

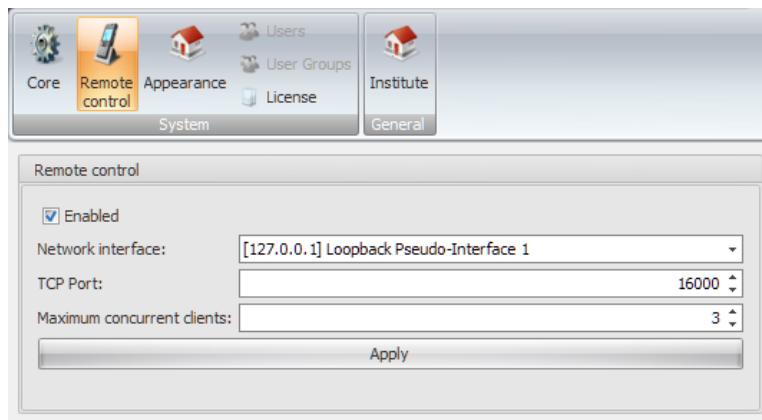
**Network Interface** - The network interface the remote control listens to. If you control NeurOne from the same computer, choose 127.0.0.1. Else choose the interface that's connected to your LAN. This setting has no default value.

**TCP Port** – Length of output pulse from trig out.

**Maximum concurrent clients** – Maximum number of clients that can be connected to the server at any given time. Allowed range is 1...10. If maximum number of clients is connected the server will immediately disconnect any new clients trying to connect.

**Apply** – Immediately applies the settings. Remote control is restarted with the new settings. Any previously connected clients will be disconnected.

The network interface selection input shows only interfaces that are operational and support IPv4 (i.e. network cable connected and have an IPv4 address).



The settings are stored within a single XML element:

```
<RemoteControl      Enabled="True"      Port="16000"      MaxClients="3"
NetworkInterfaceId="{846EE342-7039-11DE-9D20-806E6F6E6963}" />
```

Note that the selected network interface is stored as a machine-specific interface ID. A plain IP cannot be stored, because the selected interface may be configured by DHCP.

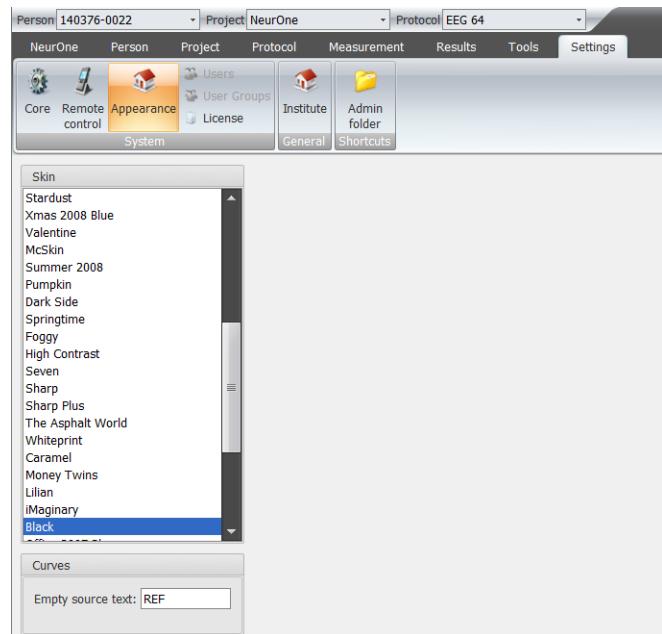
For further information about Remote Control refer Appendix 8.

### 5.8.3 Appearance – user preferences

The Appearance subtab allows the user select a desired “skin” by clicking on the name of the skin in the list. The changes in the color and outlook of the software will reflect that change immediately.

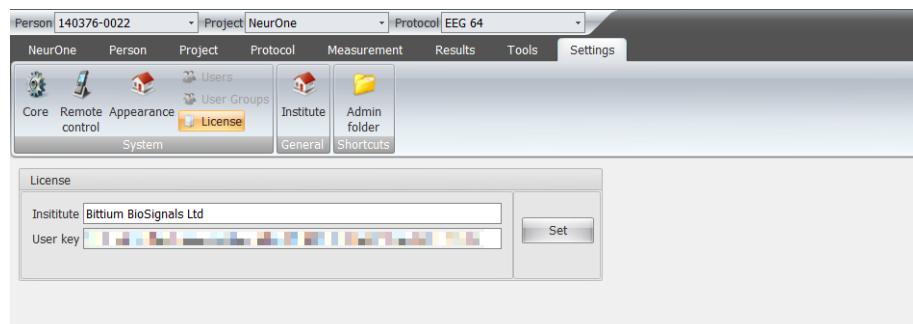
In Curves control the user can define the Reference input text. If the reference to be used in the measurement is the referential input of the amplifier (reference selection none) the reference input field in montage is empty, but the corresponding text in curve name is defined here. As default “Empty source text” is REF.

In the Review control there is the tool to calibrate millimeter grid.



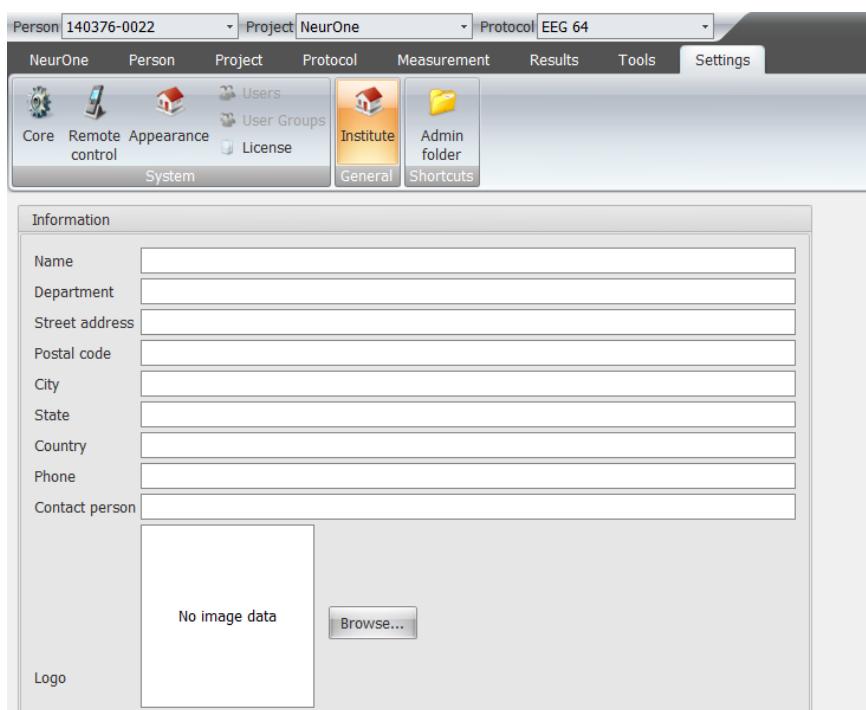
### 5.8.4 License settings

The License subtab shows the current license information and allows the user to modify license information to enable new options. The options section below the license section displays the current configuration and the enabled options. Edit your institute name and license key information to the corresponding fields and click “Set”.



## 5.8.5 Institute settings

The Institute subtab is used to fill in institute information placed into reports created with the NeurOne system. Edited information will be stored automatically to the database. Besides information, you can also select a logo to be placed on the reports. Browse the selected picture/logo using the **Browse** button. The selected picture/logo will appear on the preview window.



## 5.9 Calibration



**The amplifiers of NeurOne system are calibrated by the manufacturer and it's always required to use calibration files delivered in the system package on DVD or memory stick (\*.hbc files in HBC folder). Please, refer the chapter 4.10 Manual activation of calibration files and FW version check.**

If there is a need for calibration, NeurOne Tesla amplifier/EXG amplifier gain and offset (in AC and DC) are recommended to be calibrated as combination of available internal and external calibration method. Complete calibration procedure requires 4 separate measurements of AC gain, DC gain , AC offset and DC offset.

### 5.9.1 Calibration adapters

External offset calibration:

- Offset Calibration Adapter for Tesla amplifier
- Offset Calibration Adapter for EXG Amplifier

Internal gain calibration:

- No adapter needed for Tesla amplifier
- Calibration Adapter for EXG Amplifier



**For external gain calibration a stable and accurate signal source is needed for providing required signal levels.**

### 5.9.2 Recommended calibration method

1. Connect Tesla amplifier/EXG Amplifier to be calibrated to Main Unit. Use optic port 1. Make sure that Tesla/EXG is shown NeurOne Manager topology.
2. Place Offset Calibration Adapter to Cap INPUTS connector (in Tesla)  
Place Offset Calibration Adapter to Cap and Bipolar/module connectors (in EXG)

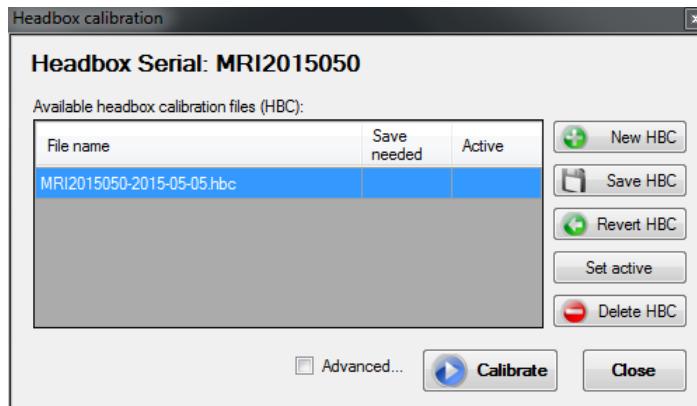


**In Tesla amplifier: make sure that Offset Calibration Adapter is connected to Cap Inputs connector for external offset calibration.**

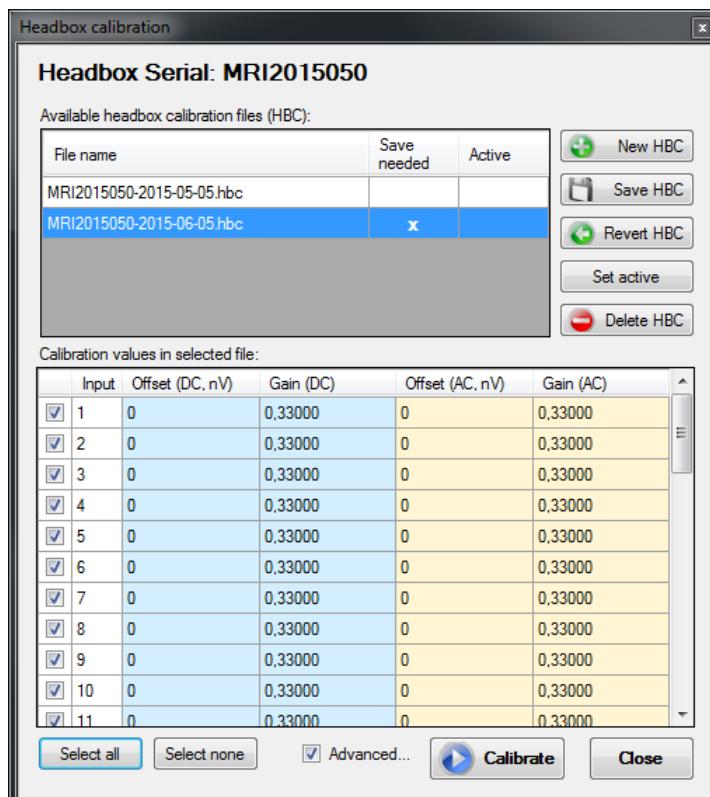


**In EXG amplifier: make sure that Offset Calibration Adapter is connected to Cap and Bipolar/module connectors for external offset calibration.**

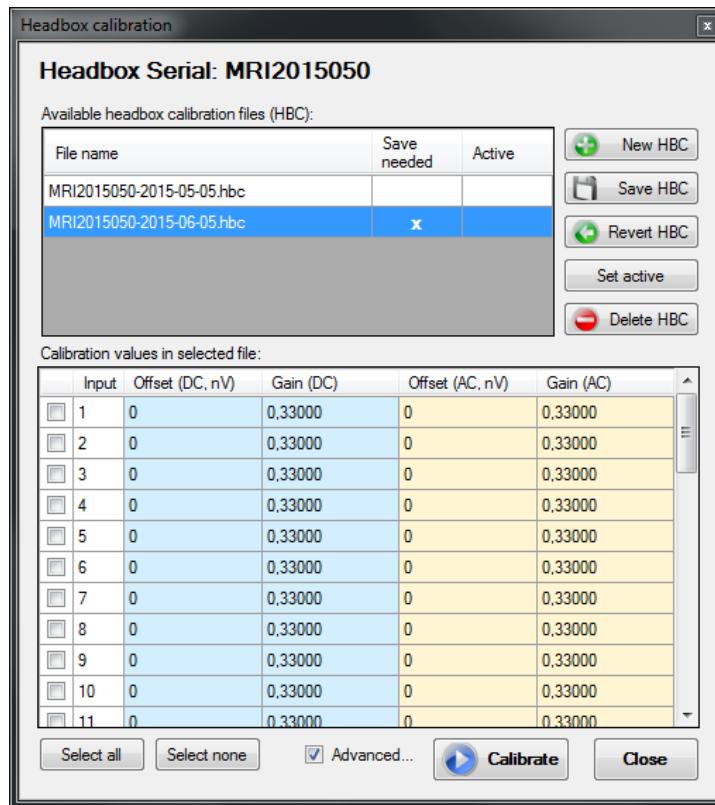
3. Prepare measurement by using the protocol with settings 40 ch, sampling frequency 20 kHz. Run measurement at least 10 minutes.
4. Stop measurement.
5. Start NeurOne Manager.
6. Press configure icon of Tesla amplifier/EXG Amplifier and press Calibrate...



7. Amplifier calibration window shows the list of available Amplifier calibration files (\*.hbc). For new calibration press **New HBC** button.
8. New calibration file to be used in calibration pops up on the list.
9. Check Advanced... checkbox.

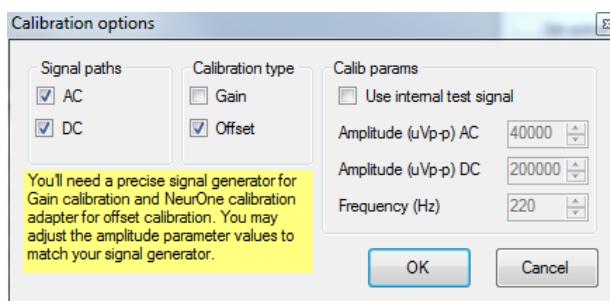


10. Current calibration values Offset DC, Gain DC, Offset AC and Gain AC for all channels of the calibration file are shown.
11. Press **Select all** button to select all channels for calibration or select desired channels.

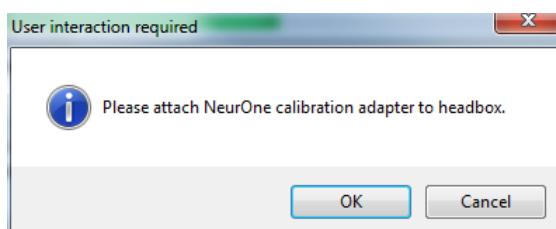


**12. Press Calibrate.**

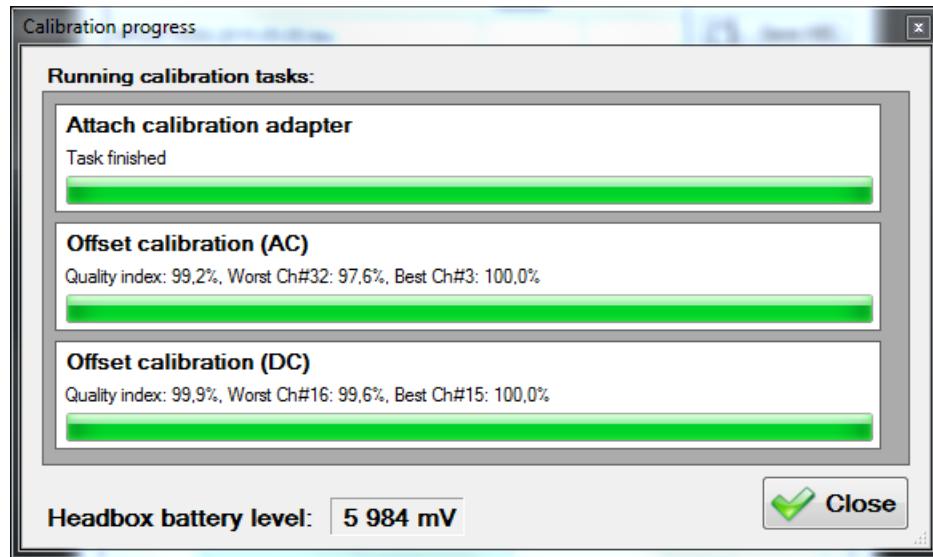
13. In Calibration options window: set AC and DC signal path, set Calibration type Offset. Uncheck Use internal test signal. Run the offset calibration with setting shown below.



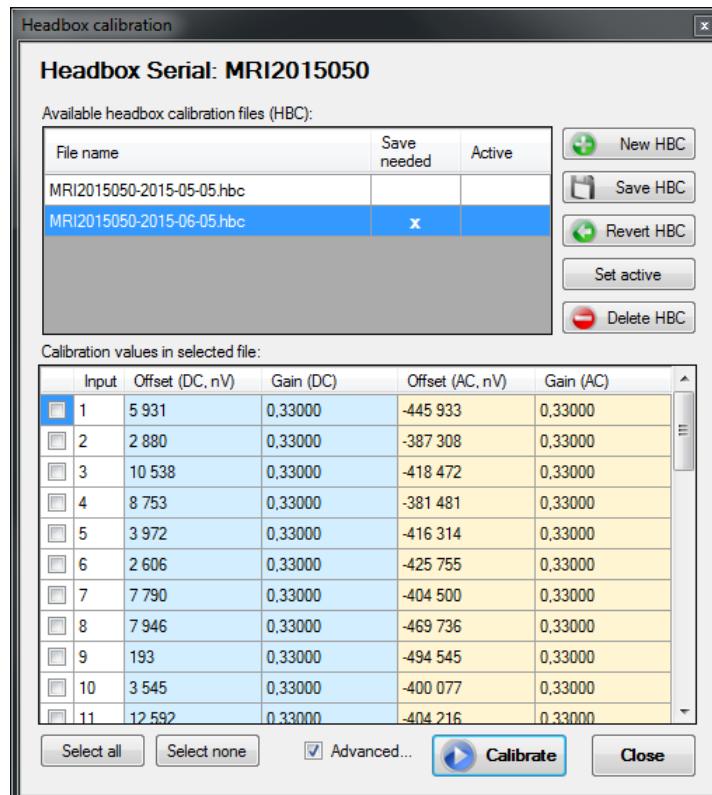
14. The reminder message (shown below) for the user to check that the adapter is attached as instructed in step 2.



15. Press OK to proceed.



16. Calibration progress window shows the progress all calibration steps defined to be executed.
17. When AC and DC offset calibration is completed close the window.
18. The calibration values of Offset DC and Offset AC are updated in Amplifier calibration windows according to measurement data.



19. **Tesla amplifier:** disconnect Offset Calibration Adapter from Cap INPUTS connector.

**EXG Amplifier:** disconnect Offset Calibration Adapter from Cap and Bipolar/module connectors. Connect Calibration Adapter to Cap and Bipolar/module connectors.

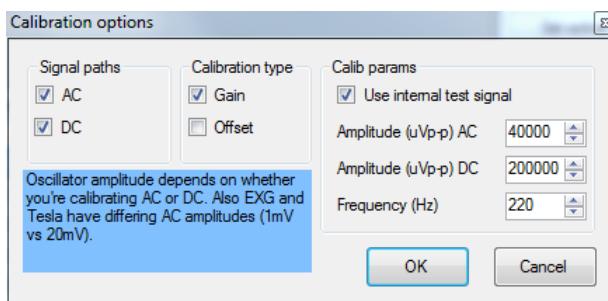


**In EXG amplifier: make sure that Calibration Adapter is connected to Cap and Bipolar/module connectors for internal gain calibration.**

20. Press **Select all** button to select all channels for calibration or select desired channels.

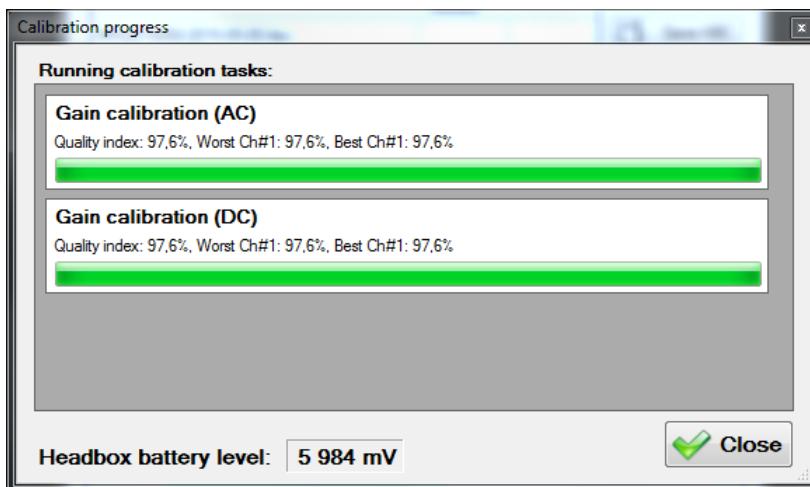
21. Press **Calibrate**.

22. In Calibration options window: set AC and DC signal path, set Calibration type Gain. Check Use internal test signal. Run the offset calibration with settings on the following figure.



23. Press OK to proceed.

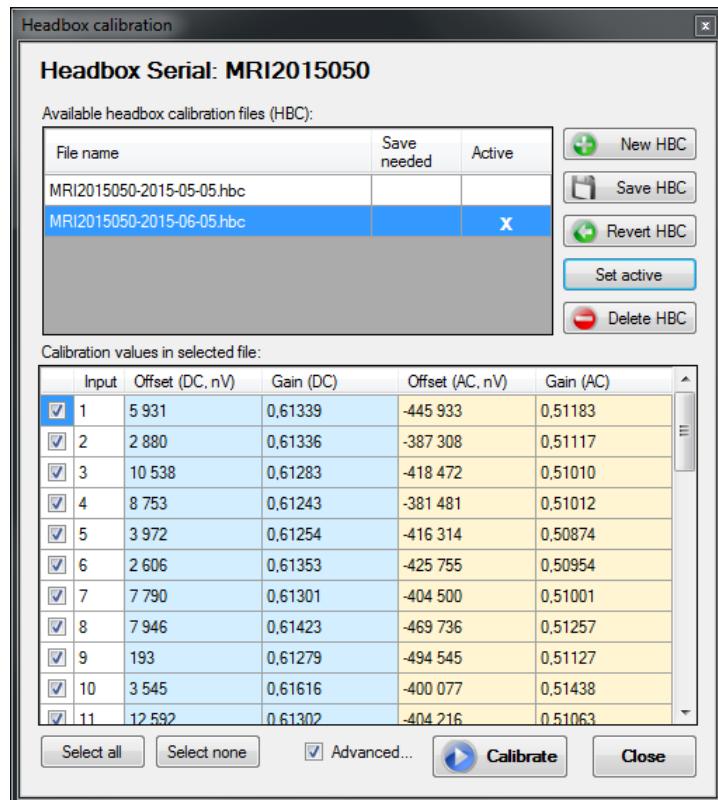
24. Calibration progress windows shows the progress all calibration steps defined to be executed.



25. When AC and DC gain calibration is completed close the window.

26. The calibration values of Gain DC and Gain AC are updated in Amplifier calibration windows according to measurement data.

27. Save the calibration values to selected calibration file – press **Save HBC**.
28. Save needed x marking disappear.
29. Set the new calibration active for the amplifier / Amplifier under calibration – press **Set active**.
30. New calibration file has been set active for the amplifier.



In above Amplifier calibration window example new calibration file is saved and set active for the Tesla amplifier.

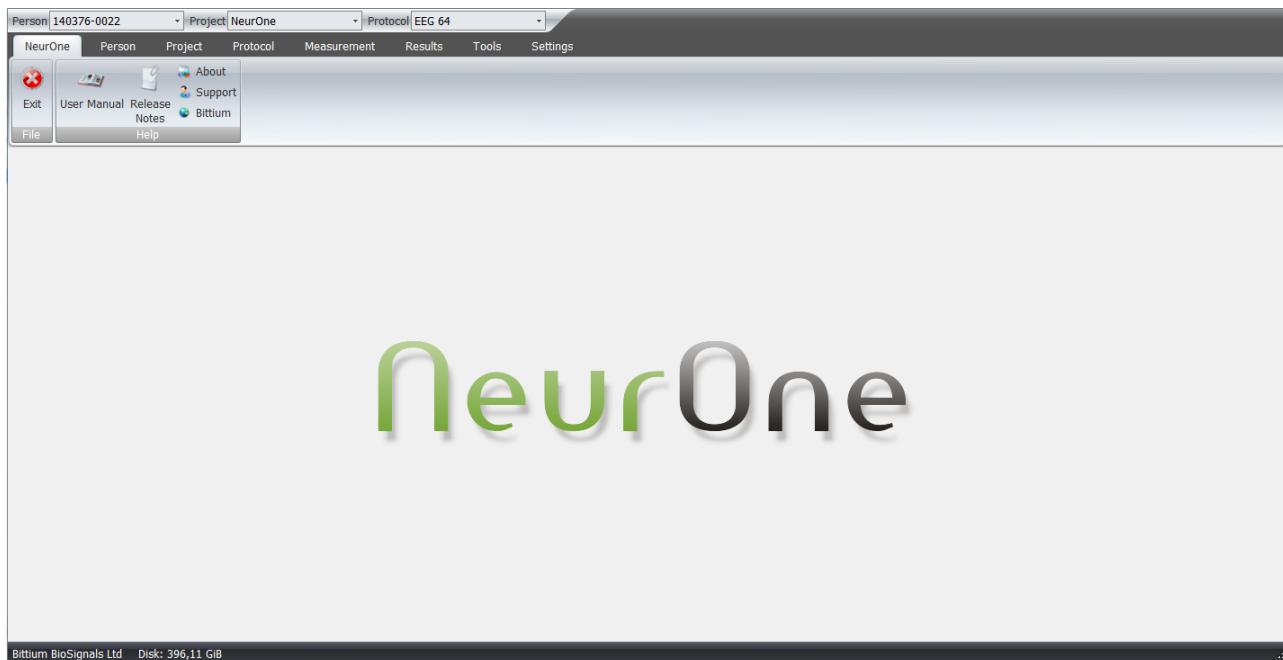


**As the result of improper calibration the calibration file may consist only of default calibration values. Attempt to save this or set this active for the amplifier causes warning. Therefore, it is not recommended to use such a calibration file.**



**Headbox calibration files used in the measurement are now copied into a zip file in the measurement folder.**

## 5.10 Getting help



The NeurOne tab of the NeurOne software provides the user with help on using the software through the user manual (opens as an –pdf file, please make sure you have the free Adobe Acrobat –reader installed, ask Bittium Biosignals for more information) and information on the software. The User manual can be opened by clicking the **User manual** button.

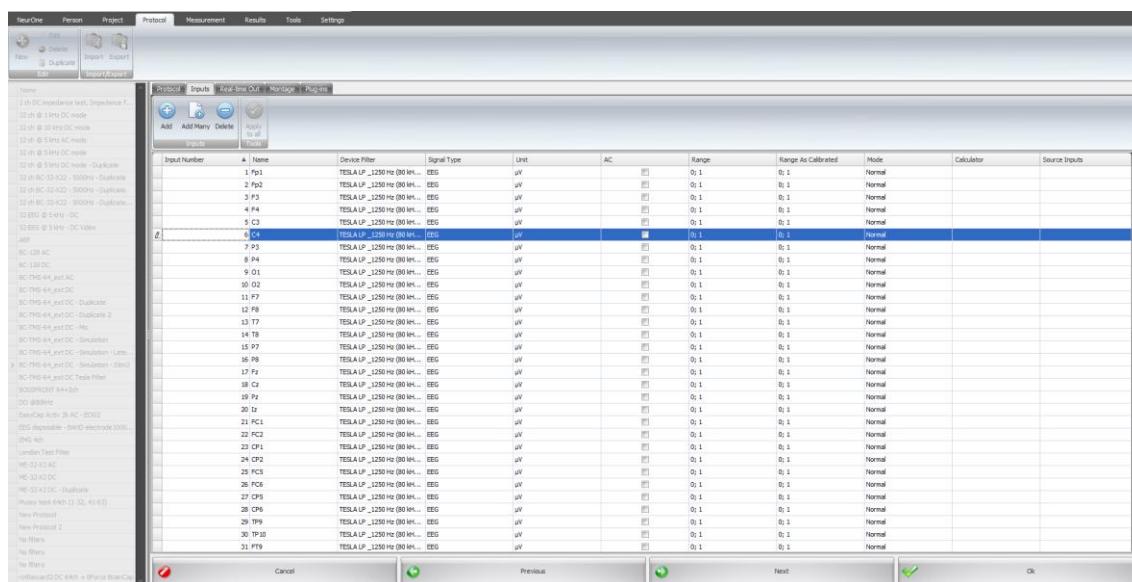
"Release notes" opens the file ReleaseNotes.txt.

**About** button opens About dialog containing the information about software version and user license. **Support** opens default e-mail program and prepares the e-mail message with details about the NeurOne system. **Bittium** button opens the Home page of Bittium Biosignals Ltd.

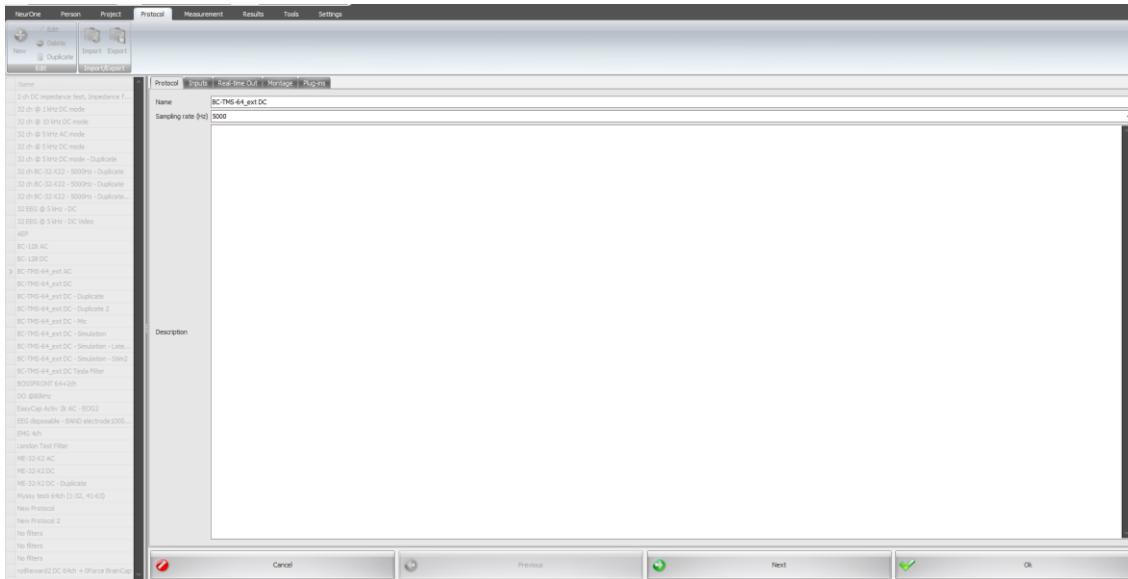
## 6 EXAMPLE CASE: P300

In this chapter we will look into creating a simple Protocol and using it to conduct a test measurement. The measurement in question will be a simple auditory evoked potential P300 measurement. An additional software and hardware for generating the stimulus audio signals and associated triggers are required to perform the example case. For example, Presentation software and StimTracker with a response pad.

To begin a new measurement with a brand new measurement Protocol (i.e. measurement setup) the work begins with the creation of a new Protocol. Open the Protocol tool by clicking on the Protocol tab on the top left and start a new Protocol by selecting “New” in the Protocol tool tab. The fields on the right of the screen will activate and enable you to fill in and select values in the text boxes and drop-down menus. Name the Protocol as you wish. Set the sampling rate at 5,000 Hz. When you are finished, proceed by clicking the green “Next” in the bottom row of buttons.

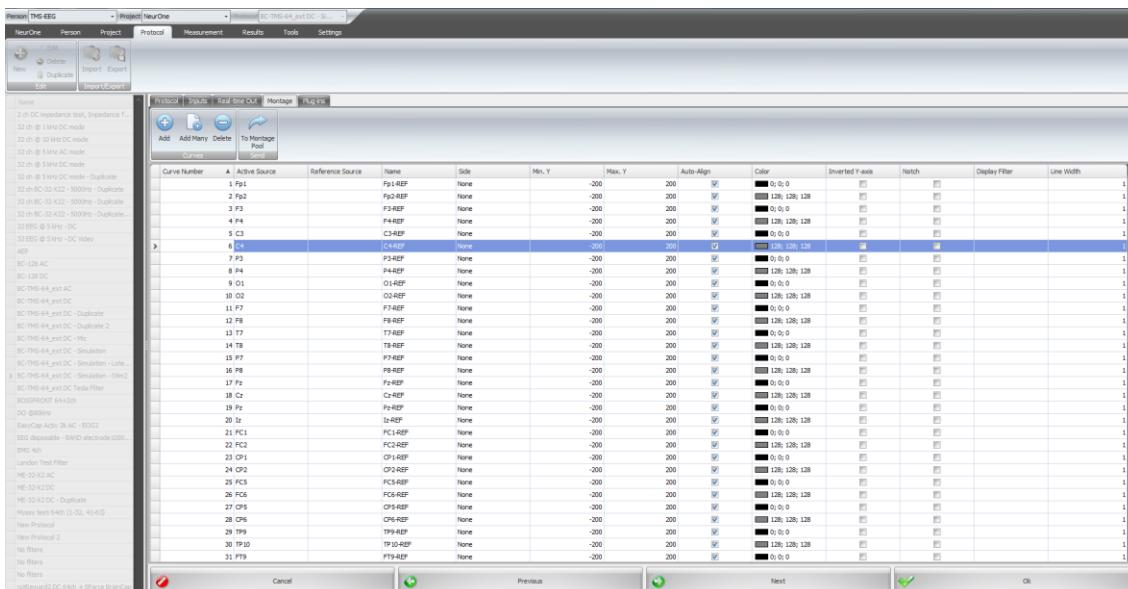


The second window in Protocol creation will prompt you to fill in the sensors you will be using in the measurement. In this Protocol, we will be using 64 EEG channels. Fill in the table by selecting the type and name of the sensors. You can jump through the fields by clicking the tabulator or selecting the wanted field with a mouse. The software will populate most of the fields for you, but you are free to edit any fields if needed. To add / delete sensors click Add, Add Many and Delete buttons accordingly. If you already have a protocol for your cap, you can import the protocol with the Import button. When you have finished filling in the information, click “Next” to proceed.



In this example no Real-time out features are used so we can click “Next” to proceed.

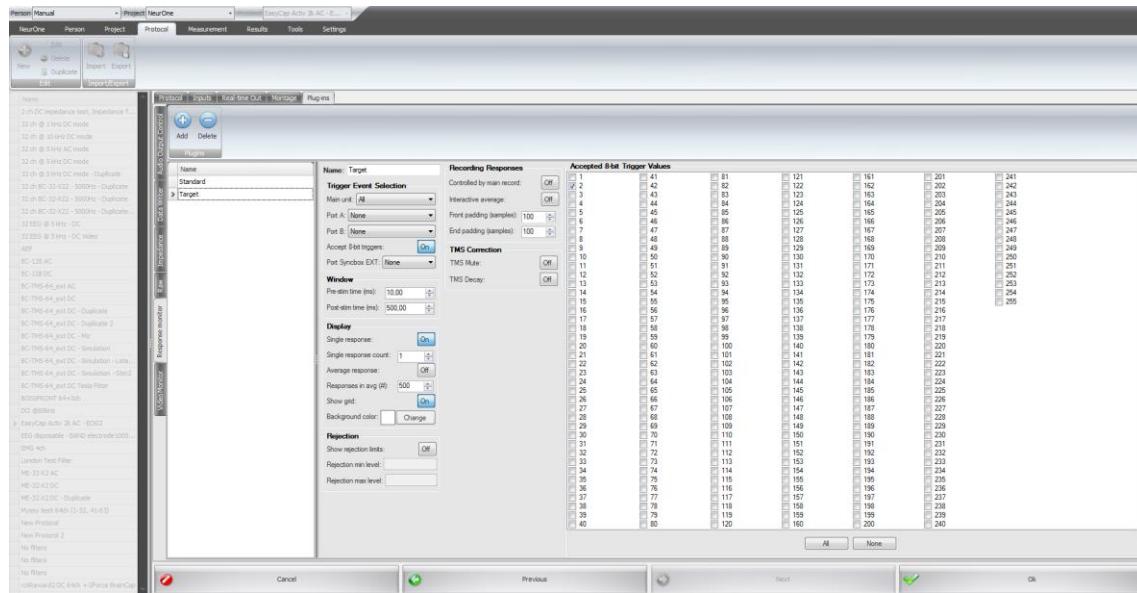
In the fourth page you define how many channels will be displayed and what channels will be used to draw them. The “Active” and “Reference” drop-down menus hold the names of all the sensors filled in the previous menu (with reference and average as additional options) to be selected in creating the display channels. Note that information



from all sensors will be recorded regardless of what display channels are created. Choose the active and reference electrodes and the software will suggest a conventional name for you. To move between fields, use the same controls as in the Inputs menu. In this table you can also set the default colors for all channels. The right hand side holds the default (starting) parameters for the measurement. These can be changed at any time using the measurement and only affect the way the data is displayed. You can set

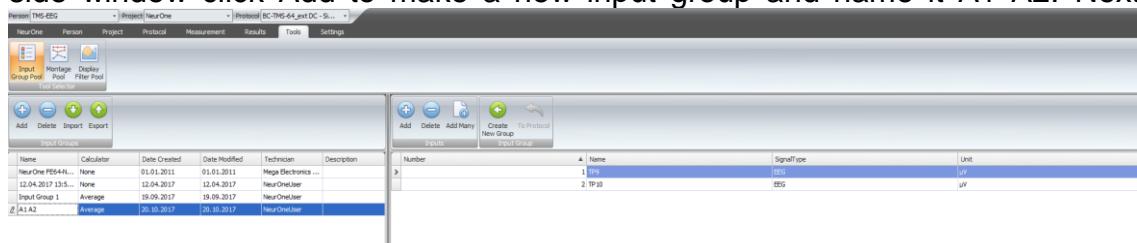
default values or leave them as they are for now. Now before moving on, copy the montage to Montage Pool for later modification simply clicking **To Montage Pool** button.

On the fifth page of the Protocol tool you define what plugins are used. As a default “Data Writer” and “Raw” are added in every protocol. In this example, we will add



**Impedance and Response Monitor.** First, select Impedance plugin, click Add button and to the impedance monitor is added to the protocol. Now select the Response monitor and click “Add”. In P300 measurement two auditory stimulus signals are used so the used protocol should also have two response monitors. The second Response monitor is added by clicking Add button. Next step is to give name to the response monitor and set its settings. The first response monitor is named to be P300 standard and the second P300 target. Other settings except Accepted 8-bit Trigger Values will be similar and the following settings are set: Window: Pre-stim time (ms): 50, Post-stim time (ms): 500. Set P300 standard to accepted only 8-bit value 1 by check its box and P300 to accept only value 2. To save the protocol, click Ok button. Note that 8-values might be different depending on the used software and hardware that generate the auditory stimulus.

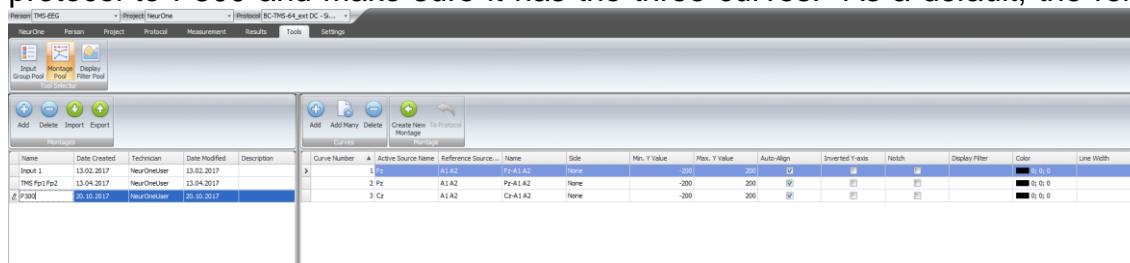
Now we have the measurement protocol ready and next we will make P300 montage for response monitors. This P300 montage will have three curves Fz, Pz, and Cz with linked mastoid (the average of A1 and A2) as a reference. First we need to make the input group for the reference. Go to Tools tab and select Input Group Pool. In the left hand side window click Add to make a new input group and name it A1 A2. Next, set the



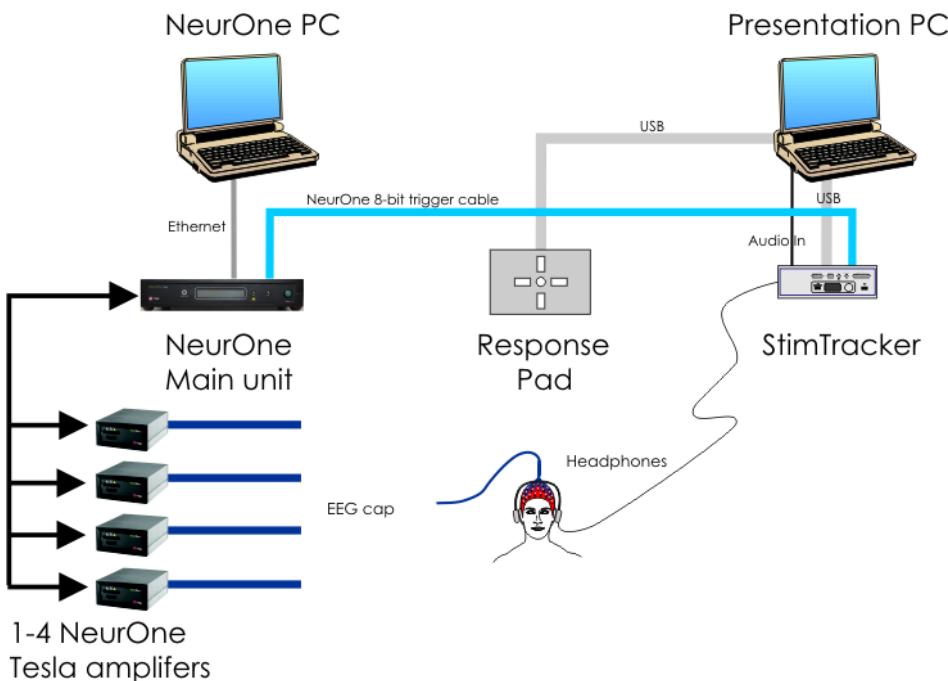
calculator to be average. After this, add two inputs using Add button on the right hand side window. Now these inputs must have the same name as the input name in the

protocol. In this example the mastoids are the inputs named TP9 and TP10 and these names are written in the Name field.

Next, we go to the Montage pool to make the P300 montage. Now you should see the inputs of the protocol just made it with its name in the Montage list on the left hand side window. Select this protocol and on the right hand side window in the input list select the Fz, Pz, and Cz inputs and click Create New Protocol. A new protocol will appear in the montage list with named after the date and time stamp of creation. Now rename this protocol to P300 and make sure it has the three curves. As a default, the reference is



set to be reference and now this must be changed to A1 A2 that was made in the input group pool. Select Reference source and choose the A1 A1 on the drop down menu. Now we have all the measurement settings ready for EEG measurement.

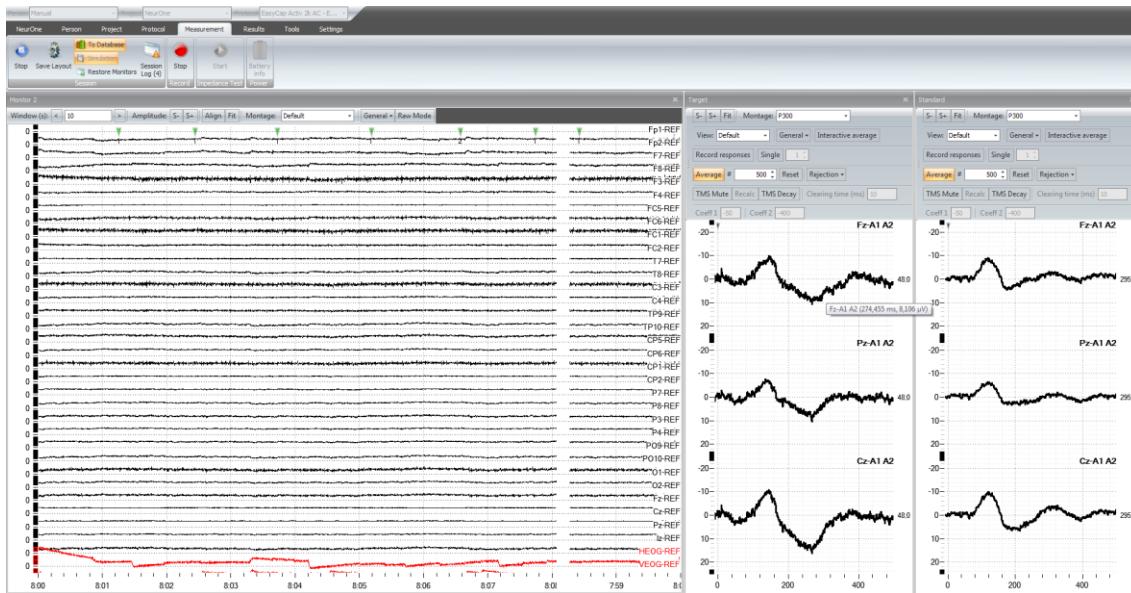


Connect StimTracker to Presenation PC with a USB cable. Note that drivers for StimTracker need to be installed. Next connect response pad to Presentation PC with a USB cable. To get accurate triggering for auditory stimuli, the stimuli are routed through StimTracker. For that purpose, connect audio jack cable between PC earphone and StimTracker Audio in and finally connect the test subject's earphone to StimTracker Audio Out. To finalize the measurement system, the 8-bit trigger cable is connected between StimTracker and NeurOne Main Unit. Now the measurement system is ready

for the cap preparation but before that make sure the NeurOne system is connected properly.

The “Measurement” tab is the starting point for all measurement activities. The tab will be active when you have selected both a patient and a Protocol. The starting page of the session allows you to fill in measurement related data to help in review or diagnosis. You can also select a Project to help find and group measurements later. Fill in the fields as you wish and start impedance measurement by clicking “Start” on the Impedance Test box. Prepare all the electrodes until you have reached your target impedance value level and stop the impedance measurement by clicking “Stop”. Now start the EEG measurement by clicking “Start” on the left top corner and start recording simply clicking the green “Start” button. If the monitors are not properly aligned, move/size the windows the way you like. If you have several display monitors, drag windows to other monitors to get a clear view of all the monitors at the same time. Using the “Settings magnet”, you can attach the settings monitor to the signal monitor it controls to avoid confusion. You can save the sizes and location of the monitors by clicking the Save Layout button.

An oddball paradigm is used to measure P300 and this is done with Presentation software. We will use paradigm that has beep (standard) and boop (target) sounds and



the test subject's task is press a button every time boop (target) is the stimuli. For simplicity open the file NeurOne P300 in Presentation. If you don't have the NeurOne P300 file please contact your local distributor or [medical.support@bittium.fi](mailto:medical.support@bittium.fi).

Next run the scenario from Presentation and you should see signals together with 8-bit triggers on the raw monitor and responses on the response monitors. P300 is seen on the Target response monitor after a few triggers. Once you have acquired enough data for your purposes then stop the recording by clicking the red stop button.

## 7 TROUBLESHOOTING

- ❖ **Problem:** Data is not seen in the database, but physical data files exist. This situation is caused by the unexpected interruption of the measurement.
- ✓ **Solution:** Import the data from the default location to the results tab. Make sure that data is correct by opening it for review.
  
- ❖ **Problem:** Measurement won't start. Error message "Unable to load all active calibration files. Files are missing?"
- **Possible cause:** The calibration file dedicated for the amplifier in use is not located in the defined HBC folder = <NeurOne configuration folder>\HBC
- ✓ **Solution:** Copy the calibration file (\*.hbc) to the defined HBC folder.
  
- ❖ **Problem:** Measurement is running, but no curves are shown.
- **Possible cause:** 1) No curves is defined in the default montage tab of the protocol.  
2) No monitor is defined in the protocol.
- ✓ **Solution:** 1). Define curves for default montage. 2) Define raw monitor(s) for the protocol.
  
- ❖ **Problem:** Recording START button is not active during the measurement.
- **Possible cause:** Data writer is missing.
- ✓ **Solution:** Add data writer to protocol.
  
- ❖ **Problem:** Comment cannot be inputted during the measurement.
- **Possible cause:** Recording is not set on.
- ✓ **Solution:** Start recording
  
- ❖ **Problem:** No responses on the response monitor during the measurement.
- **Possible cause:** Single and/or Average button are not pressed on in order to enable response show on the response monitor. Single responses and/or Average responses are not allowed in the protocol.
- ✓ **Solution:** Enable response show on the monitor or allow responses in the protocol.
  
- ❖ **Problem:** Impedance measurement will not start.
- **Possible cause:** Display setting is not set to "Smaller" – 100 %.
- ✓ **Solution:** Select Control panel | Appearance and Personalization | Display - Set Display setting to "Smaller" – 100%.

Please contact Bittium Biosignals Ltd or your local dealer for assistance.

## 8 SPECIFICATIONS

### NeurOne system

Intended use: Electroencephalograph

#### 8.1 Main unit (model Extended)

Intended use:	Electroencephalograph
Storage methods:	<b>Online</b> to PC (Raw)
Amplifiers (EXG) :	Max. 4 pcs 40 channel amplifier boxes ("EXG" )
or	
Amplifiers (Tesla):	Max. 4 pcs 40 channel amplifier boxes ("Tesla" )
Power source:	Powerbox, AC power adapter, 100-240 V AC / 50 – 60Hz, Max 1.7 A (12 V DC ---- 5A) (UL60601-1 compatibility) or PROTEC POWER, Model: PMP60-12
Power Input voltage:	12 V
Current consumption:	Max 3.0 A
Connectors:	Analog Out (16 ch, Centronics 24 pin) Audio Out (3.5mm connector for headphones/external audio amplifier) Isolated trigger A Out/In Isolated trigger B Out/In 8-bit trigger IN (8 input lines, non-isolated, D-Sub 15) Isolated SPI socket for external sensors Ethernet connection to PC Optical link for fibres to Amplifier (4 pcs) Isolated Amplifier power connector (10 V output, 4 pcs) Serial port (3 pcs)
Enclosure class:	IP20
Display:	Two row display, 24 character/row
Loudspeaker:	Integrated
Dimensions:	33 x 12 x 27 cm
Weight:	3.6 kg

#### 8.2 Main unit (model Black)

Storage methods:	<b>Online</b> to PC (Raw)
Amplifiers (EXG) :	Max. 4 pcs 40 channel amplifier boxes ("EXG" )
or	
Amplifiers (Tesla):	Max. 4 pcs 40 channel amplifier boxes ("Tesla" )

Power Input voltage:	12 V
Power source:	Powerbox, AC power adapter, 100-240 V AC / 50 – 60Hz, Max 1.7 A (12 V DC ---- 5A) (UL60601-1 compatibility) or FSP GROUP INC. AC/DC Adapter, FSP030-RCAM
Power Input voltage:	12 V
Current consumption:	Max 3.0 A
Connectors:	Audio Out (3.5mm connector for headphones/external audio amplifier) Isolated trigger A Out/In Isolated trigger B Out/In 8-bit trigger IN (8 input lines, non-isolated, D-Sub 15) Digital OUT (Optional) Ethernet connection to PC Optical link for fibres to Amplifier (4 pcs)
Enclosure class:	IP20
Display:	Two row display, 24 character/row
Loudspeaker:	N/A
Dimensions:	33 x 7 x 27 cm
Weight:	2.9 kg

### 8.3 Main unit (model Black High)

Intended use:	Electroencephalograph
Storage methods:	<b>Online</b> to PC (Raw)
Amplifiers (EXG) :	Max. 4 pcs 40 channel amplifier boxes ("EXG" )
or	
Amplifiers (Tesla):	Max. 4 pcs 40 channel amplifier boxes ("Tesla" )
Power source:	Powerbox, AC power adapter, 100-240 V AC / 50 – 60Hz, Max 1.7 A (12 V DC ---- 5A) (UL60601-1 compatibility) or PROTEC POWER, Model: PMP60-12
Power Input voltage:	12 V
Current consumption:	Max 3.0 A
Connectors:	Analog Out (16 ch, Centronics 24 pin) Digital OUT (Optional) Audio Out (3.5mm connector for headphones/external audio amplifier) Isolated trigger A Out/In Isolated trigger B Out/In 8-bit trigger IN (8 input lines, non-isolated, D-Sub 15) Isolated SPI socket for external sensors Ethernet connection to PC Optical link for fibres to Amplifier (4 pcs) Isolated Amplifier power connector (6 V output, 4 pcs)

Enclosure class:	Serial port (3 pcs)
Display:	IP20
Loudspeaker:	Two row display, 24 characters/row
Dimensions:	Integrated
Weight:	33 x 12 x 27 cm
	3.6 kg

## 8.4 EXG Amplifier

Weight:	2.9 kg
Monopolar channels:	32 channels per Amplifier (max 128 for one Main Unit)
Bipolar channels:	Max 8 per Amplifier, connected through isolated analog adapter (to bipolar channels)
Sampling method:	All channels sampled simultaneously
Sampling rate (Hz) :	250, 500, 1000, 2000, 5000, 10000 (160 ch), 20000 (120 ch), 40000 (40 ch), 80000 (20 ch)
Sampling rate per channel:	80kHz / up to 20ch 40kHz / up to 40ch 20kHz / up to 80 ch 10kHz / up to 160 ch
A/D Resolution:	24 bit
ADC range:	-2.5 v...+2.5 V
System Gain (AC mode):	1000
System Gain (DC mode):	10
Full Scale Input Range:	AC mode: $\pm 4.3$ mV DC mode: $\pm 430$ mV
Sensitivity:	AC mode: 0.51nV/bit DC mode: 51 nV/bit
RMS noise:	< 0.8 uV RMS (AC mode 0..200 Hz) < 3.5 uV RMS (AC mode, full-band) < 0.8 uV RMS (DC mode 0..200 Hz) < 3.7 uV RMS (DC mode, full-band)
Input impedance:	> 1 G $\Omega$
CMRR:	Typically 106 dB
Bandwidth (AC):	0.16 Hz – 7 kHz
Bandwidth (DC):	DC – 10 kHz
High level input range:	$\pm 5$ V or $\pm 10$ V (with isolated analog adapter, settable)
Impedance measurement:	1 – 200 k $\Omega$
Transient Artifact Protection:	Limiter ( 0,7 V, speeds up the recovery time) / High Speed Switch (settable)
Mute:	Mute for AC mode (multiple settable parameters)
Dimensions:	20 x 7 x 16 cm
Weight:	0.680 kg
Amplifier connections:	Power 12 V, Fibers, Cap connection (D-sub 37), Bipolar/Module (D-sub 25 +/- 5V available max 1000 mA)
Power source:	Main Unit (10V DC) / Battery Pack (12 V DC)

Current consumption:	Max 800 mA
Connectors:	Unipolar inputs – Channels 1 – 32 Bipolar inputs – Channels 33 – 40 Reference inputs (REF, 2pcs) Patient ground (PGND, 2pcs) Ground (GND, 2pcs) Power (10 V ... 12 V DC) Optical link for fiber to Main Unit Optical link for fiber to Main Unit Bipolar/module (D-sub 25 pin, $\pm$ 5 V available, max. 1000 mA) Cap connector (D-sub 37 pin)
Enclosure class:	IP20

## 8.5 Tesla amplifier

Monopolar channels:	32 channels per Amplifier (max 128)
Bipolar channels:	Max 8 per Amplifier, connected through isolated analog adapter (to bipolar channels)
Sampling method:	All channels sampled simultaneously
Sampling rate (Hz) :	250, 500, 1000, 2000, 5000, 10000 (160 ch), 20000 (120 ch), 40000 (40 ch), 80000 (20 ch)
Sampling rate per channel:	80kHz / up to 20ch 40kHz / up to 40ch 20kHz / up to 80 ch 10kHz / up to 160 ch
A/D Resolution:	24 bit
ADC range:	-2.5 v...+2.5 V
System Gain (AC mode):	50
System Gain (DC mode):	10
Full Scale Input Range:	AC mode: $\pm$ 86 mV DC mode: $\pm$ 430 mV
Sensitivity:	AC mode: 10.25nV/bit DC mode: 51 nV/bit
RMS noise (NeurOne Tesla):	< 0.6 uV RMS (AC mode 0..200 Hz) < 1.5 uV RMS (AC mode, full-band) < 0.8 uV RMS (DC mode 0..200 Hz) < 2.0 uV RMS (DC mode, full-band)
Input impedance:	> 1 G $\Omega$
CMRR:	Typically 106 dB
Bandwidth (DC):	DC – 3.5 kHz
Bandwidth (AC):	0.16 Hz – 3.5 kHz
High level input range:	$\pm$ 5 V or $\pm$ 10 V (with isolated analog adapter, settable)
Impedance measurement:	1 – 200 k $\Omega$
Transient Artifact Protection:	High Speed Switch (settable)
Mute:	Mute for AC mode (multiple settable parameters)

Amplifier size:	20 x 7.5 x 16 cm
Amplifier weight:	1.26 kg
Amplifier connections:	Power 6 V, Fibers, Cap connection (60 pin KEL connector), Bipolar/Module (26 pin KEL connector, $\pm$ 5V available max 1000 mA)
Power source:	Battery Pack (6 V DC)
Current consumption:	Max 900 mA
Connectors:	Cap inputs: Unipolar and bipolar inputs, Channels 1 – 40, REF, GND, pGND, Shield, -5V Bipolar inputs: Channels 33 – 40, GND, -5 V, +5 V Power (6 V DC) Optical link for fiber to Main Unit
Enclosure class:	IP20

## 8.6 JackBox

Safety connectors:	Inputs 1-32 (Unipolar) Inputs 33-40 (Bipolar) Inputs 41-72 (Unipolar) Inputs 73-80 (Bipolar) 2 x REF 2 x GND 1 x PGND
KEL connectors:	2 x Inputs 1 - 40 (for Master) 2 x Inputs 41 -80 (for Slave)
Indicator LEDs:	Master amplifier connected Slave amplifier connected

## 8.7 SyncBox

Power source:	Medical approved power supply (100 – 240 VAC in, 12 VDC out)
Buttons:	Power ON/OFF Trigger
LED indicators:	AC - SyncBox is connected to mains power ON – SyncBox is operational OPTO – Sync clock on Optic clock input BNC - Sync clock on BNC clock input
Connectors:	12 V Power Potential Equalization 1 x Optical connection to Master Main unit 9 x Optical connection to Slave Main units Ext. clock BNC Ext. clock OPTO 2 MHz, 4 MHz, 5 MHz, 7.5 MHz, 8 MHz, 10 MHz and 20 MHz
Synchronization frequencies:	

## 8.8 Battery Pack 6V

Dimensions:	40 x 165 x 225 mm
Weight:	2,3 kg
Box type:	G747 , Multicomp , 20075416899
Cable length:	50 cm
Connector type	RPC2-12RB-7P , 7 –pin connector
Short-circuit protection:	RGEF700-16 , Reychem
Operating temperature:	0 – 50 °C
Capacity:	14 Ah (2 x 7Ah)
Nominal voltage:	6 V
Cell dimensions:	34 x 90 x 150 mm
Cell type:	LC-R067R2P (Lead acid)
Number of cells:	2
LoBatt level	5.5 V
Charger type	YPC2A6 (Yu-Power)
Charger connector:	RPC2-12P-7S
Charging current (max):	2 A

## 8.9 Battery Pack 7.2V

Dimensions:	35 x 165 x 225 mm
Weight:	2,0 kg
Box type:	G747 , Multicomp , 20075416899
Cable length:	30 cm
Connector type	RPC2-12RB-7P , 7 –pin connector
Short-circuit protection:	RGEF700-16 , Reychem
Operating temperature:	0 – 50 °C
Capacity:	20 Ah
Nominal voltage:	7.2 V
Cell dimensions:	34 x 130 x 180 mm
Cell type:	1.2 V NiMH
Number of cells:	12
LoBatt level:	5.5 V
Charger type:	CP88A0096V2500
Charger manufacturer:	Nordic Power
Charger connector:	RPC2-12P-7S
Charging current (max):	2.5 A

## 9 REGULATIONS AND DECLARATIONS

### Device Certification

EU Risk Classification IIa. Type BF applied part.

### Safety Specifications

EN60601-1, EN60601-1-1, EN60601-1-2, EN60601-1-4, EN60601-2-26

### EC Declaration of Conformity

We hereby declare under our sole responsibility that the products mentioned below comply with the European Medical Directive 93/42/EEC as amended by the Directive 2007/47/EC

NeurOne product family:                  NeurOne System  
    NeurOne Software

Manufacturer's Name:                  Bittium Biosignals Ltd (Bittium Biosignals Oy)

Address:                                  Bittium Biosignals Ltd  
    Pioneerinkatu 6  
    FI-70800 Kuopio, Finland

Classification:                            IIa

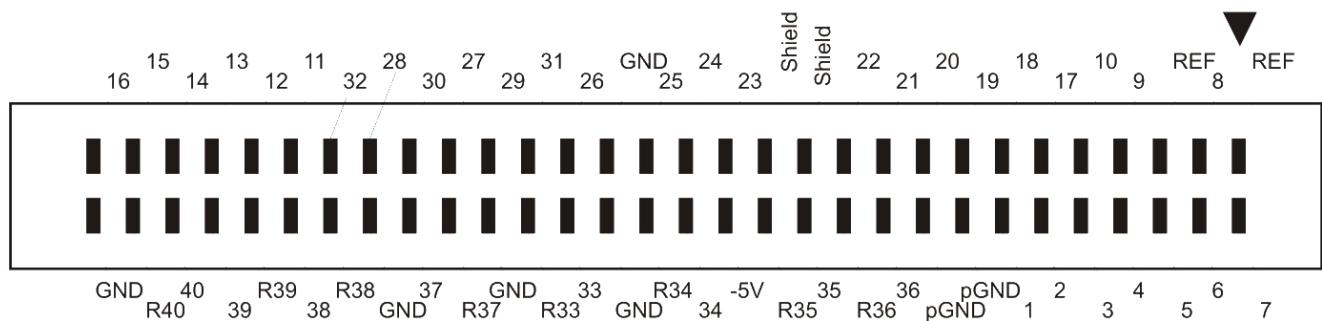
Assessment route:                      Annex II, Section 3 (full quality assurance system)

Manufacturer's Declaration - Electromagnetic Emissions					
The NeurOne is suitable for use in an electromagnetic environment as described below. The users should ensure that the device is used in such an environment.					
Emission Tests	Compliance	Electromagnetic Environment			
Conducted and radiated RF emissions CISPR11	Group 1	The NeurOne uses HF energy exclusively for its internal function. Thus the HF emission is very low and it is unlikely that nearby electronic devices would be disturbed.			
HF emissions acc. to CISPR11	Class B	The device is intended for use in all facilities including living quarters and such ones which are connected directly to a public power supply that supplies also buildings used for living purposes.			
Harmonic emissions IEC61000-3-2	Class A				
Emission of voltage fluctuation/flicker acc. to IEC61000-3-3	Compliance				
Manufacturer's Declaration - Electromagnetic Interference Resistance					
The NeurOne is suitable for use in an electromagnetic environment as described below. The users should ensure that the device is used in such an environment.					
Interference Resistance Test	IEC 60601- Testing Level	Accordance Level	Electromagnetic Environment - Guidelines		
Electrostatic discharge (ESD) acc. to IEC 61000-4-2	± 6 kV contact discharge ± 8 kV air discharge	± 6 kV contact discharge ± 8 kV air discharge	Floors should be of wood, concrete or ceramic tiles. If the floor is tiled with synthetic material the relative air humidity must have 30 % at least.		
Fast transient electric disturbances / bursts acc. to IEC 61000-4-4	± 2 kV for power lines ± 1 kV for input and output lines	± 2 kV for power lines ± 1 kV for input and output lines	The quality of the supply voltage should conform to a typical business or clinic environment. EFT disturbances to the AC line may cause disturbances to the measurement data.		
Surge voltage acc. to IEC 6100-4-5	± 1 kV normal mode voltage ± 2 kV common mode voltage	± 1 kV normal mode voltage ± 2 kV common mode voltage	The quality of the supply voltage should conform to a typical business or clinic environment.		
Voltage drops, short interruptions and variations in supply voltage acc. to IEC 61000-4-11	< 5 % UT (>95 % break of UT for 0,5 period) 40 % UT (60% break of UT) for 5 periods 70 % UT (30% break of UT) for 25 periods < 5 % UT (>95 % break of UT for 5 seconds)	< 5 % UT (>95 % break of UT for 0,5 period) 40 % UT (60% break of UT) for 5 periods 70 % UT (30% break of UT) for 25 periods < 5 % UT (>95 % break of UT for 5 seconds)	The quality of the supply voltage should conform to a typical business or clinic environment.  If the user requires a sustained operation of the device after interruption, it is recommended to install an uninterrupted power supply unit.		
Magnetic field at the supply frequency (50/60 Hz) acc. to IEC 61000-4-8	3 A/m	3 A/m	Magnetic fields at the supply frequency should conform to the typical values as they occur in the business or clinic environment.		
NOTE: UT is the AC mains voltage before the use of testing levels.					

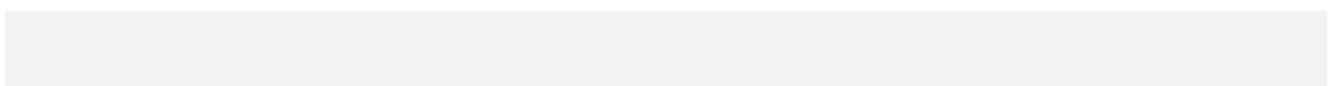
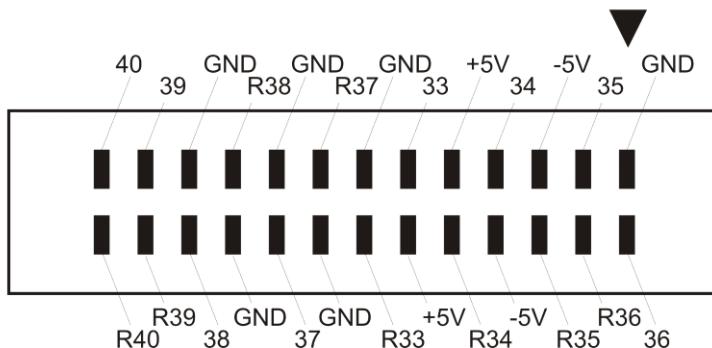
Manufacturer's Declaration - Electromagnetic Interference Resistance			
The NeurOne is suitable for use in an electromagnetic environment as described below. The users should ensure that the device is used in such an environment.			
Interference Resistance Test	IEC 60601-Testing Level	Accordance Level	Electromagnetic Environment - Guidelines
Conducted HF disturbances acc. to IEC61000-4-6	3 V <sub>Eff</sub> 150 KHz to 80 Mhz	3 V <sub>Eff</sub>	<p>Portable and mobile radio sets should be used in a no less distances to the device including the cables than it is recommended by the equation for the frequency.</p> <p><b>Recommended safety distance:</b>  <math>d=1.2</math>  <math>d=1.2 \sqrt{P}</math> 80 MHz to 800 MHz  <math>d=1.2 \cdot 800 \text{ MHz to } 2.5 \text{ GHz}</math>  <math>P</math> is the nominal power of the transmitter in watt (W) according to the specifications of the transmitter manufacturer; <math>d</math> is the recommended safety distance in meters (m). (a)</p> <p>The field strength of stationary transmitters should be lower than the accordance level for all frequencies according to a testing on location.(b)</p> <p>Disturbances are possible near devices with the following symbol:</p> 
Radiated HF disturbances acc. to IEC61000-4-3	3 V/m 80 MHz to 2,5 GHz	3 V/m	
<b>NOTE 1:</b> For 80 Hz and 800 MHz the higher frequency range is valid. <b>NOTE 2:</b> These guidelines may not be applicable for all cases. The propagation of electromagnetic values is influenced by absorptions and reflections of buildings, objects and people.			
<small>a) The field strength of stationary transmitters such as fixed parts of cellular phones and mobile radio sets, amateur radio stations, AM and FM radio and television cannot be determined exactly in theory. To detect the electromagnetic environment in regard to stationary transmitters a study of the location should be considered. If the measured field strength at the location where the device is being used exceeds the accordance level above the device should be watched to verify the proper functions. If unusual features are watched additional actions might be necessary such as a modified orientation or another location of the device.</small> <small>b) For the frequency range of 150 kHz to 80 MHz the field strength should be lower than 10 V/m.</small>			
Recommended safety distances between portable and mobile HF Telecommunication Devices and the NeurOne			
The NeurOne is intended for use in an electromagnetic environment with controlled HF disturbances. The user of the NeurOne can help to avoid electromagnetic disturbances by keeping the minimum distance between portable and mobile telecommunication devices (transmitters) and the device - depending on the output power of the telecommunication devices as described below.			
Nominal power of the transmitter  W	Safety Distance Depending on the Frequency m		
	150 kHz to 80 MHz $d=1.2 \sqrt{P}$	80 MHz to 800 MHz $d=1.2 \sqrt{P}$	800 MHz to 2,5 GHz $d=2.3 \sqrt{P}$
0.01	0.12	0.12	0.23
0.1	0.38	0.38	0.73
1	1.2	1.2	2.3
10	3.8	3.8	7.3
100	12	12	23
For transmitters with a maximum nominal power not mentioned above: To detect the recommended safety distance use the equitation in the corresponding column. $P$ is the maximum nominal power of the transmitter in watt (W) according to the specifications of the transmitter manufacturer.			
<b>NOTE 1:</b> For 80 Hz and 800 MHz the higher frequency range is valid. An additional safety factor of 10/3 was applied to reduce the probability of interference of a mobile device brought into the patients area.			
<b>NOTE 2:</b> These guidelines may not be applicable for all cases. The propagation of electromagnetic values is influenced by absorptions and reflections of buildings, objects and people.			

## APPENDIX 1: PINOUTS OF TESLA AMPLIFIER KEL CONNECTORS

Cap connector pinout (outside view)

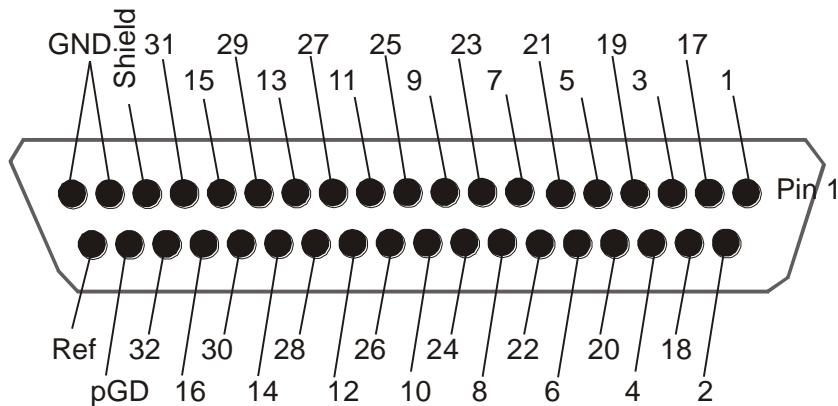


Bipolar/Module connector pinout (outside view)

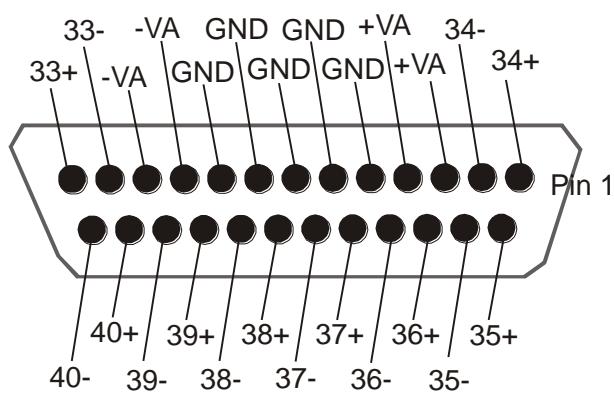


## APPENDIX 2: PINOUTS OF EXG AMPLIFIER D-CONNECTORS

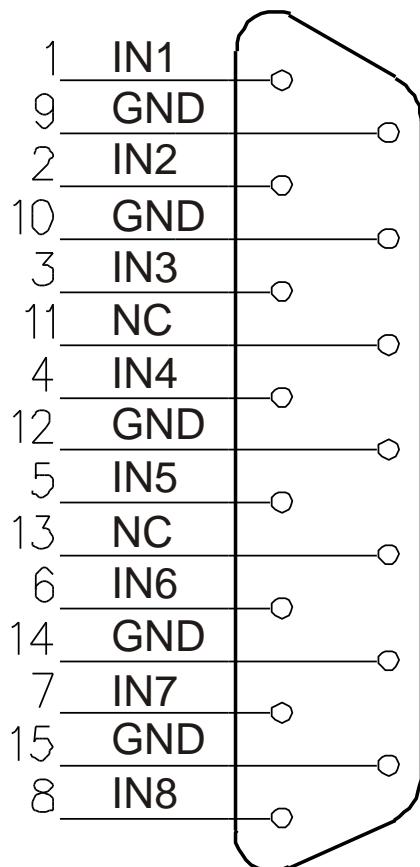
Cap connector pinout (outside view)



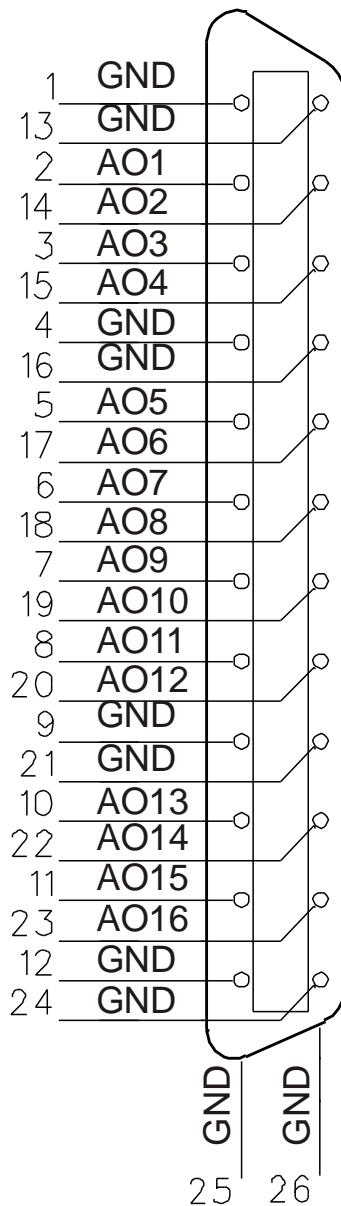
Bipolar/Module connector (outside view)



## APPENDIX 3: PINOUT OF NON-ISOLATED 8-BIT TRIGGER



## APPENDIX 4: PINOUT OF ANALOG OUTPUT



## APPENDIX 5: NEURONE DATA FORMAT

This description of NeurOne Data format applies for PC-software version 1.5.0.

NeurOne stores measurement data as a set of files in a folder structure and a pointer file beside the folder.

The parent folder is named using the starting date and time of the measurement. For example, the recording “2009-12-22T123937” has been started on 2009-12-22 (YYYY-MM-DD) starting at 12:39:37 (hh:mm:ss). This is in local time, no time zone information is embedded into the format.

File or Folder	Description
Binary folder (1, 2, ...)	The signal data files (EEG or other measured signals) and event files.
CalibrationFiles.zip	Calibration files of all amplifiers that participated in the measurement.
DataSetProtocol.xml	Full database export of the Protocol of the measurement. For NeurOne software internal use, subject to change.
DataSetSession.xml	Full database export of information about the measurement Session. For NeurOne software internal use, subject to change.
Protocol.xml	Limited collection of protocol information that can be used when reading the measurement data into an analysis program.
Session.xml	Limited collection of session information that can be used when reading the measurement data into an analysis program. This is used by some software (e.g. BESA) as a pointer to the measurement folder.
SystemInfo.xml	Description of the specific NeurOne HW/SW setup used in the measurement.
HeadBoxVoltages.txt	Log file of battery voltages of amplifiers that participated in the measurement (valid only for Tesla amplifiers).

### Binary Files

When user starts a recording in NeurOne PC software, a folder named “1” is created for the binary files: signal files and event files. If within the same session the recording is stopped and restarted, another SessionPhase and a folder for it is created, named “2”, “3” etc.

### Signal Files

The signal data is 32 bit signed integer, containing the calibrated signal values as nanovolts. Each .bin file is a stream of channel-multiplexed data, meaning that the file contains the value received simultaneously from all inputs as a bundle, which is followed by a bundle of data from all inputs at the next time point.

If the size of the measurement exceeds the file size limit set in the Protocol (Plug-Ins/Data Writer), the measurement data is split into several files: 1.bin, 2.bin etc. If the file size limit is set to zero, there will be only one file: 1.bin.

## Event Files

Events received during measurement from e.g. trigger ports or textual comments, are stored in a set of event files:

### **events.bin**

This file holds the most important information of each event. File consists of consecutive event structures and size of one event structure is 88 bytes:

Field name	Bytes	Offset	Description
Revision	4	0	Event format version (currently 6)
RFU	4	4	[Reserved for future use]
Type	4	8	See EventType table below
Source port	4	12	See EventSourcePort table below
Channel number	4	16	Number of the input, corresponding to the amplifier pinout, such that input 41 is the first input of amp 2
Code	4	20	Value of 8-bit trigger
Start sample index	8	24	Index in binary signal data, to which this event is bound
Stop sample index	8	32	Index of event stopping point in binary signal data
Description length	8	40	Length of event description in eventDescriptions.bin
Description offset	8	48	Address of first byte of event description written to eventDescriptions.bin
Data length	8	56	Length of event data in eventData.bin
Data offset	8	64	Address of first byte of event data written to eventDescriptions.bin
Time stamp	8	72	Microseconds counting from the beginning of the measurement. This can be different than 1/sampFreq * StartSampleIndex, because of finer temporal precision
DeviceIndex	4	80	Main unit, from which the event comes from
RFU	4	84	[Reserved for future use]

EventType can have the following values:

Name	Value	Description
N/A	0	Not applicable
Stimulation	1	Stimulation trigger
Video	2	Video sync trigger
Mute	3	Mute trigger
EightBit	4	8-bit trigger (255 different trigger alternatives)
Out	5	Trigger out event
Comment	6	User-entered comment

EventSourcePort can have the following values:

Name	Value	Description
N/A	0	Not applicable (e.g. comment)
A	1	Event is from NeurOne isolated A
B	2	Event is from NeurOne isolated B
EightBit	3	Event is from 8-bit trigger port
SyncBoxBtn	4	Event is from SyncBox button
SyncBoxExt	5	Event is from SyncBox external trigger port
Software	6	Event is generated by software (e.g. comment)

### **eventData.bin**

This file holds additional data for each event. Data can be anything (e.g. bitmap data, serialized object, etc.) and therefore only each event object knows how to handle the data. Data is read the same way as event description; using “Data length” and “Data offset” in events.bin. E.g. the comment string of comment events is added to this file.

### **eventDescriptions.bin**

This file holds description for each event in Unicode (2 bytes/character) format. Description is optional so if there are no events with description the file size and “Description length” in event.bin are zero. Length of event description is not limited and each event’s description is read using “Description length” and “Description offset” in events.bin file. This file is not used in this version of the data format.

## Protocol.xml

This XML file contains all information of the Protocol needed to read the data. The format of this file is fixed, while the format of DataSetProtocol.xml might change during further development of NeurOne. There may be additions to Protocol.xml also in future versions, but the elements listed here are guaranteed to stay as they are.

Section	Field	Description
TableProtocol	ActualSamplingFrequency	The sampling frequency actually used during measurement. This can be different than SamplingFrequency, if a simulation file is used, which has a different sampling frequency than defined in the Protocol.
	SamplingFrequency	The sampling frequency defined in the Protocol.
	ProtocolName	The name of the Protocol given in NeurOne PC Software
TableInput	AlternatingCurrent	AC-mode or DC-mode amplification used for the input.
	Filter	Hardware filter used during measurement.
	RangeAsCalibratedMaximum	True max level/Calibrated value (e.g. temperature high).
	RangeAsCalibratedMinimum	True min level/Calibrated value (e.g. temperature low).
	RangeMaximum	Maximum raw signal level corresponding to true max measured in calibration.
	RangeMinimum	Minimum raw signal level corresponding to true min measured in calibration.
	Name	Name of the input.
	InputNumber	Sequential number of the input, not to be confused with PhysicalInputNumber. For example, if PhysicalInputs are 2,4,5 – the corresponding InputNumbers are 1,2,3 (always starting from 1).
	SignalType	Type of the measured signal, e.g. EMG or EEG.
	Unit	Unit of the measured signal, e.g. nV or °C.
TableInfo	IsReferential	True if the input is measured as unipolar against the physical REF lead on the amplifier. False, if the input is a bipolar input.
	PhysicalInputNumber	Number of the input, corresponding to the amplifier pinout, such that input 41 is the first input of amp 2.
	Revision	Version of the Protocol file format.
	NeurOneVersion	Version of NeurOne PC Software used during the last update to the Protocol. This field is also updated when measurement is imported to the NeurOne PC Software.

## Session.xml

This XML file contains information of the actual measurement, for example starting time, textual notes and information about the Person. The format of this file is fixed, while the format of DataSetSession.xml might change during further development of NeurOne. There may be additions to Session.xml also in future versions, but the elements listed here are guaranteed to stay as they are

Section	Field	Description
TablePerson	FirstName	First name of the Person.
	LastName	Last name of the Person.
	DateOfBirth	Date of birth, in format YYYY-MM-SSThh:mm:ssZ as defined in ISO 8601.
	PersonID	Identification field given to the person in NeurOne PC Software.
TableSession	ProtocolName	Name of the Protocol used in this measurement Session.
	StartTime	Starting time of this session.
	StopTime	Starting time of this session.
	ExamCode	A free text identification string for the session.
	Technician	Name or ID of the EEG technician responsible for the session.
	Medication	Medication the Person was under during measurement.
	Notes	Free text notes.
TableSessionPhase	FileCount	Number of .bin files in this session phase. Session can be divided into phases.
	Folder	Path of the binary files of this phase.
	StartTime	Starting time of this phase.
	StopTime	Ending time of this phase.
TableInfo	Revision	Version of the Session file format.
	NeurOneVersion	Version of NeurOne PC Software used during the last update to the Protocol. This field is also updated when measurement is imported to the NeurOne PC Software.

## SystemInfo.xml

System information of the specific NeurOne HW/SW setup used in the measurement, containing information on

- PC Software: PC software version and NeurOne driver version
- Main unit: Firmware version, Digital out installed, Serial number, SyncBox slot and Endpoint address

- Connected amplifiers: Firmware version, Serial number, Device type (EXG / Tesla), Opto slot and Active calibration file
- SyncBox: FW version (if available)

Example SystemInfo.xml file:

```
<?xml version="1.0" encoding="utf-8"?>
<SystemInfo>
  <PCSoftware>
    <PCSoftwareVersion>1.5.0</PCSoftwareVersion>
    <NeurOneDriverVersion>2017.11.14.158</NeurOneDriverVersion>
  </PCSoftware>
  <MainUnits>
    <MainUnit>
      <FirmwareVersion>700086 1.4.24</FirmwareVersion>
      <DigitalOutInstalled>True</DigitalOutInstalled>
      <SerialNumber>Y2016102</SerialNumber>
      <SyncBoxSlot>0</SyncBoxSlot>
      <EndpointAddress>192.168.200.200</EndpointAddress>
      <Amplifiers>
        <Amplifier><FirmwareVersion>1.4.24</FirmwareVersion>
        <SerialNumber>TMS2016115B</SerialNumber>
        <DeviceType>Tesla</DeviceType>
        <OptoSlot>1</OptoSlot>
        <ActiveCalibrationFile>TMS2016115B-2017-10-11.hbc</ActiveCalibrationFile>
      </Amplifier>
    </Amplifiers>
  </MainUnit>
  <SyncBox />
</SystemInfo>
```

## HeadBoxVoltages.xml

This file contains a log of battery voltages measured at each amplifier during measurement. Please note that only Tesla amplifiers support battery voltage measurement. Each line in the session log starts with the timestamp of format YYYY-MM-DD hh:mm:ss.

Example file:

```
2018-02-01 15:01:47          Session started
2018-02-01 15:01:47          TMS2016115B (6 V *): 5602 mV / info: 5789 mV
2018-02-01 15:01:47          TMS2016116B (6 V *): 5705 mV / info: 5789 mV
2018-02-01 15:01:48          Recording started
2018-02-01 15:02:47          TMS2016115B (6 V *): 5602 mV / info: 5789 mV
2018-02-01 15:02:47          TMS2016116B (6 V *): 5705 mV / info: 5789 mV
2018-02-01 15:03:47          TMS2016115B (6 V *): 5599 mV / info: 5789 mV
2018-02-01 15:03:47          TMS2016116B (6 V *): 5705 mV / info: 5789 mV
2018-02-01 15:04:47          TMS2016115B (6 V *): 5599 mV / info: 5789 mV
2018-02-01 15:04:47          TMS2016116B (6 V *): 5695 mV / info: 5789 mV
2018-02-01 15:05:47          TMS2016115B (6 V *): 5599 mV / info: 5789 mV
2018-02-01 15:05:47          TMS2016116B (6 V *): 5695 mV / info: 5789 mV
2018-02-01 15:06:47          TMS2016115B (6 V *): 5599 mV / info: 5789 mV
2018-02-01 15:06:47          TMS2016116B (6 V *): 5695 mV / info: 5789 mV
2018-02-01 15:07:03          Recording stopped
2018-02-01 15:07:03          Session stopped
```

## APPENDIX 6: USE OF EXTERNAL SIGNALS

### General

This appendix describes how external sensors such as Accelerometer (3D), Polar HR and GSR shall be prepared, calibrated and used in the measurement.

### Getting started

Connect external signal connector box to the bipolar/module connector of the NeurOne Amplifier.

Connect sensor cables to the external signal connector box corresponding to the markings on the cables and connector box.

### Creating the Protocol

When creating the Protocol for external sensors the following shall be noticed:

- Measurement **mode** shall be **DC**
- Input numbers for the sensor (in Input tab of the Protocol)
  - Use Inputs 33 – 40 for external sensors
  - Check the further information how into which input sensors are connected
- **Range** (min; max) parameters corresponding the **Range As Calibrated** values (=known actual min;max) on the Input tab must be measured and defined during calibration sequence corresponding to known actual signal level (explained later in this document). This is the goal of the calibration procedure.
- **Do not change Range (min=0; max=1) and Range As Calibrated (actual min=0; actual max=1) parameters default values before calibration measurement**

### Sensor calibration

The following steps shall be performed:

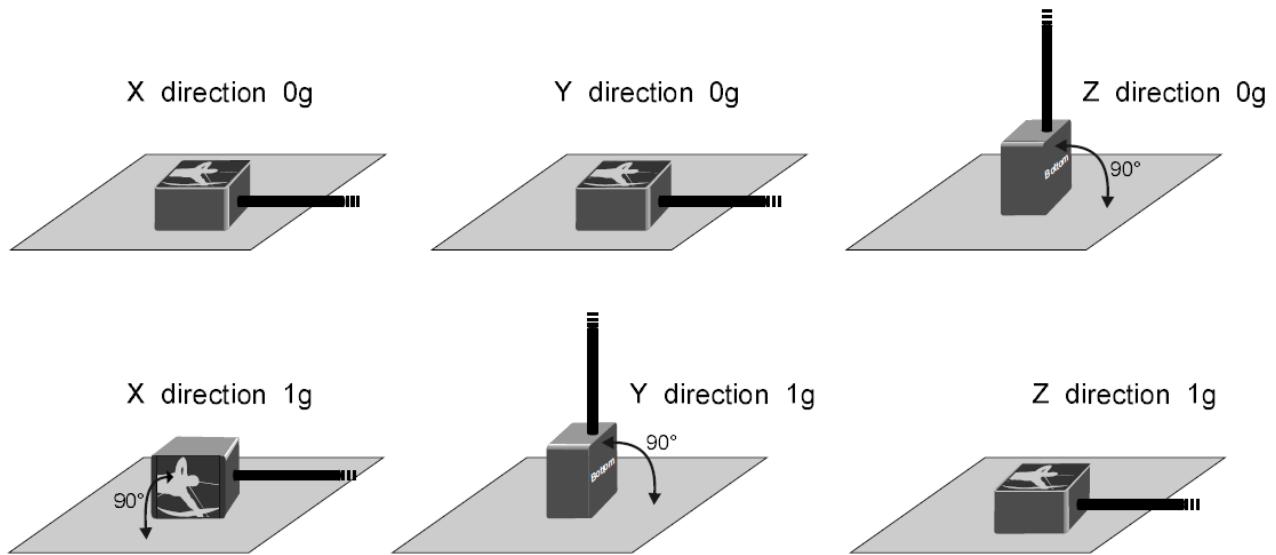
- Run the calibration measurement
  - Start measurement
  - Set recording on
  - Set sensor to measure known minimum level = actual min
  - Give event/trigger at the site of minimum level
  - Set sensor to measure known maximum level = actual max

- Give event/trigger at the site of maximum level
- Stop the recording/measurement
- Review the recorded data - Because of noise and signal variation at the site of minimum and maximum level it is better to define area for average calculation. Then average level represents minimum and maximum in calibration.
  - Locate the data area of known minimum level with the aid of event/trigger
    - Use Signal Analyze tool:
    - Click FFT Analyze
    - Define the area for average by clicking the left mouse button and when defined release the button
    - Move area/borders in order to finalize the area definition
    - Click the data curve (under calibration)
    - On the right side of the window FFT calculation results are shown
    - Write down the reading of parameter **average** (= min )
  - Locate the data area of known maximum level with the aid of event/trigger
    - Use Signal Analyze tool as explained above
    - Finally, write down the reading of parameter **average** (= max )
- Edit the Protocol
  - Modify the parameters Range(min;max), Range As Calibrated (actual min; actual max) according to the readings from review of the data

**Now NeurOne system is ready to measure calibrated external signal.**

**Note! Depending on the sensor in use the calibration details may vary (see examples).**

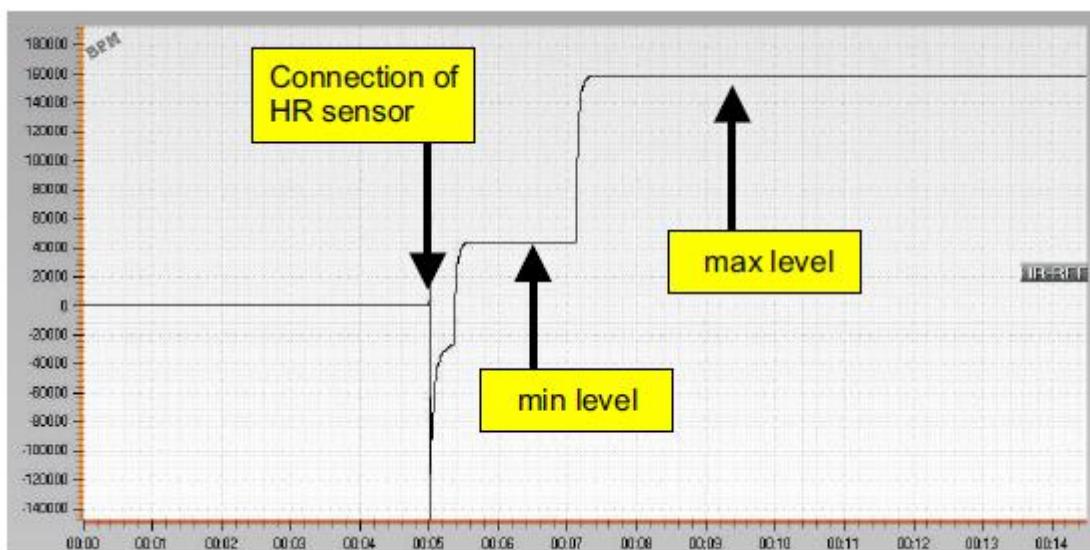
## Example 1 – Accelerometer (3D)



- During the calibration measurement adjust the known (actual levels, 0g and 1g) acceleration levels as described in the figure above.
- Range As Calibrated (min = 0g)
- Range As Calibrated (max = 1g)

## Example 2 – Polar HR (heart rate)

- During the calibration measurement the Polar sensor calibration data is sent automatically from the sensor when it is connected to the connector box and the power is on in the NeurOne system.
- The sensor sends two reference signals corresponding to the known actual values:
  - Lower level: 40 BPM = Range As Calibrated (min)
  - Higher level: 150 BPM = Range As Calibrated (max)



- In this example measured min = 44225, max = 159250

## Example 3 – GSR

- Use resistors in calibration in order to simulate conductance. Connect resistor to snap connector of the sensor.
- It is recommended to use resistors with value 100 kΩ (= 10uS) and 300 kΩ (= 3,3 uS) as known calibration levels (references).
- In this example:
  - 100 kΩ: measured raw value 43630 corresponds to 10uS
  - 300 kΩ: measured raw value 59708 corresponds to 3,3uS
  - In protocol **Range** parameters are (43630; 59708)
  - In protocol **Range As Calibrated** parameters are (10; 3,3)

## APPENDIX 7: EEGLAB PLUG-IN

EEGLAB Plug-In Manual, Version 1.1

Instructions for the EEGLAB plug-in to import NeurOne file format data.

### EEGLAB

EEGLAB is an open source EEG analysis software built on the Matlab platform. It can be downloaded from the developers website at <http://sccn.ucsd.edu/eeglab/>. Bittium Biosignals does not take responsibility of the function of EEGLAB.

### Installation

To install the EEGLAB plug-in, copy the plug-in folder *neuroneimport1.0.3.4* into your EEGLAB plug-ins folder. Restart Matlab, if it was running during the installation.

### Usage

After installation, you can see a new menu item in the EEGLAB menu bar:

*File → Import data → From a NeurOne file (.ses).*

The NeurOne file format consists of a .ses file and a folder containing the measurement data. To open a NeurOne measurement with the plug-in, open the .ses-file in the window that opens from the menu item above.

### Use Restrictions

This plug-in works only with the version of EEGLAB, which runs on top of a full Matlab installation. You cannot include this plug-in into a precompiled EEGLAB. You can however compile a version of EEGLAB, in which you can include this plug-in as well. For this you need a full Matlab installation and the Matlab Compiler. See instructions in the EEGLAB documentation.

## APPENDIX 8: REMOTE CONTROL

### Supported commands

Command protocol is line-based. Supported line terminators are CR (\r), LF (\n) or CRLF (\r\n). The used text encoding is ASCII. One line constitutes one command. The server responds to a single command with a single line, terminated by a CRLF.

Single command length is limited to 1000 characters. If a longer command is received the server terminates the client connection immediately.

For most commands the server immediately responds by sending

```
OK:commandText\r\n
```

where *commandText* is the command initially sent by the client (see command examples below). E.g.

```
OK:RESTART\r\n
```

If the server encounters an error while processing the given command (e.g. unknown command or wrong session state) it responds with an error:

```
ERROR:errorIdentifier:description\r\n
```

where *errorIdentifier* is a textual identifier for error reason and *description* is a human readable more specific reason for the error; e.g.

```
ERROR: StateNotMonitoring:To start recording the system needs to  
be in monitoring state.\r\n
```

List of all commands is shown below:

Command	Description
RECSTART	Starts recording. Corresponds to clicking the "Start" button in record toolbar.
RECSTOP	Stops recording. Corresponds to clicking the "Stop" button in record toolbar.
SESSTOP	Stops the monitoring session. Corresponds clicking the "Stop" button in session toolbar.
STATUS	Responds with the current session state. See session state descriptions below. Response format is: STATE:<StateName> [*]. The client can use this command to query the current session state e.g. right after it has connected. If the StateName is succeeded by an asterisk it means that the system is currently changing state.

Session state	Description
Idle	A measurement isn't running.
Monitoring	The measurement hardware is running and supplying data. Nothing is being recorded yet.
Recording	The measurement hardware is running and PC software is recording data.
ImpedanceTest	Measurement is running in impedance test mode.

Error identifier	Description
UnknownError	Reason for the error is unknown.
CommandUnknown	An unknown command was issued.
StateInTransition	A state transition is already in progress.
StateNotIdle	The system needs to be in idle state for the given command.
StateNotMonitoring	The system needs to be in monitoring state for the given command.
StateNotRecording	The system needs to be in recording state for the given command.

## Command examples

Here blue text denotes the commands sent by the client and red text responses sent by the server. Green text is comments.

### Command example 1: Start recording

Client issues recording start:

**Client:** RECSTART\r\n

Server immediately responds that the command is being processed:

**Client:** OK:RECSTART\r\n

Later when the recording has been started the server notifies of state change:

**Client:** STATUS:Recording\r\n

## Command example 2: Stop recording (with 2 clients)

**Client 1:** RECSTOP\r\n

**Client 1:** OK:RECSTOP\r\n

**Client 1:** STATUS:Monitoring\r\n

The server also notifies client 2 of session state change:

**Client 2:** STATUS:Monitoring\r\n

## Command example 3: Status query

Client requests current state information:

**Client:** STATUS\r\n

Server responds that it's currently idle:

**Client:** STATUS:Idle\r\n

## Command example 4: Recording start fails

Client issues recording start:

**Client:** RECRECORD\r\n

Server immediately responds that the command cannot be executed because the measurement system isn't running:

**Client:** ERROR:StateNotMonitoring: To start recording the system needs to be in monitoring state.\r\n

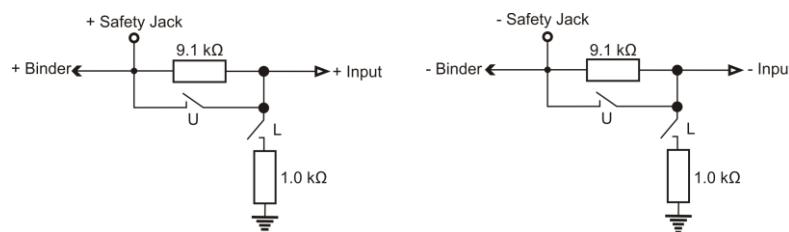
## APPENDIX 9: BIPOLEAR CONNECTION BOX

### Configuration – adjustable DIP switches

NeurOne Bipolar Connection Box is 8 channel bipolar signal interface for Tesla amplifier. External sensors such as GSR, accelerometer, Respiration and bipolar EMG, EEG and ECG signals can be used with it.

Each channel has two types of input connectors: safety connectors (active and reference inputs) and 5-pole Binder connector. + input is safety connector type. Please note, that safety connector and Binder connector of the channel are connected together, so only one can be used at a time.

Each channel can be configured by using two DIP switches (U and L) on positive input line as well as on negative input line.



As default Bipolar Connection Box is configured for “Bipolar ExG” use (EMG, EEG and ECG), configuration = 2. Then the DIP switches are set OFF, i.e. switches are open. Inputs have 9.1 kOhm protective resistors, no signal attenuation.

Each channel has four DIP switches providing 16 configuration combinations, but here it is important to note that only a subset (6) of configurations are allowed to be used. For MRI use there are more limitations providing 4 possible configurations.

Inside of the Bipolar Connection Box on the bottom lid there is instruction label as reference for configuration procedure. In order to recognize configured Bipolar Connection Box, it is required (in MRI use) and recommended (in NON-MRI use) that Adhesive Configuration Template sticker with correct markings corresponding to configurations is placed on the Bipolar Connection Box.



**In MRI use: if Adhesive Configuration Template sticker is missing, check the configuration according to the subchapter “Configuration change / check” of this Appendix.**

## Accepted configurations

All accepted configurations for Bipolar Connection Box are shown on the following table:

CONFIGURATION	DIP SETTINGS	FUNCTION	SENSOR / NOTE
1		Inputs have NO protective resistors, NO attenuation.	 No MRI use
2		Inputs have 9.1 kOhm protective resistor, NO attenuation.	Bipolar ExG (Safety Jack)
3		Input has attenuation of 1:10, negative input connected through 1 kOhm resistor to ground. In both GSR sensor cables there are 15 kOhm protection resistors.	GSR Accelerometer (5-pole connector)
4		Input without attenuation. Positive input with 9.1 kOhm protective resistor. Negative input is bound to Ground through 1kOhm resistor.	Respiratory (Safety Jack)
5		Inputs are connected through 1 kOhm resistor to ground.	Channel Not Used
6		Inputs have attenuation of 1:10.	Bipolar sensor

Table 1. Allowed Configurations of Bipolar Connection Box in NeurOne System  
 (Ch n indicates the bipolar channel to be configured – n is in bipolar channel range)



**It's possible to use configuration 1 in standard ERP laboratory use ( NON-MRI use).**

## Configuration change / check



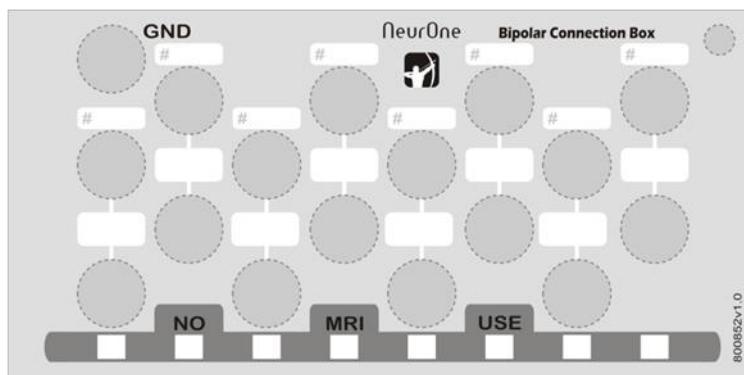
**MRI use: it is mandatory to follow instructions of this subchapter.  
 NON-MRI use: it is recommended to follow instructions of this subchapter.**

If Bipolar Connection Box default or current (previously changed) configuration will be changed / checked, the following configuration steps shall be complied with:

1. Only authorized and trained person is allowed to perform the configuration of Bipolar Connection Box. The person must be trained by Bittium Biosignals Ltd or the official local distributor of Bittium Biosignals Ltd.
2. Disconnect Bipolar Connection Box from the NeurOne system and reserve small screwdriver, one Bipolar Connection Box Adhesive Configuration Template sticker (800852) and marking pen for configuration change/check procedure.
3. Turn the Bipolar Connection Box rear side up. Open two plastic screws and disconnect the bottom lid and flip it on long side as shown on the photo below.



4. Keep Adhesive Configuration Template sticker beside the opened Bipolar Connection Box while making the changes/check to configuration.

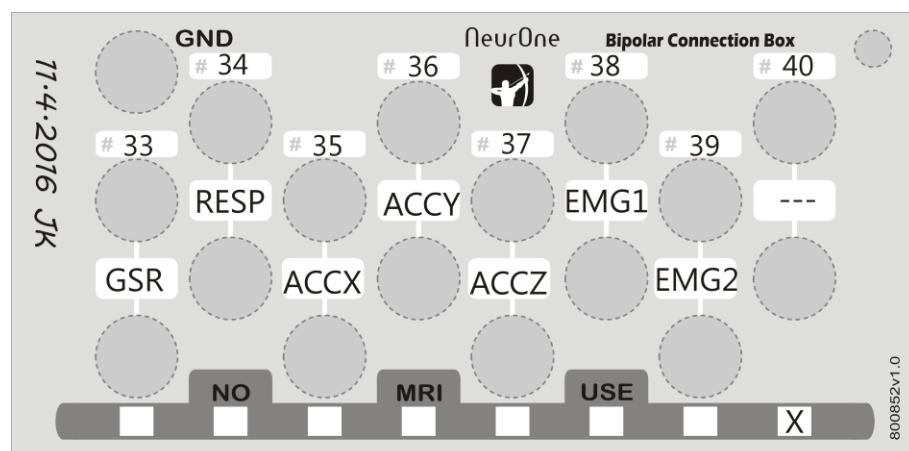


5. Make the configuration change/check one channel at a time. Choose the configuration from the list of allowed configurations (Table 1) based on intended use and make the corresponding DIP switch changes. After DIP switch changes make the markings on the Adhesive Configuration Template sticker on the marking fields (# field for channel number and blank field for signal name). For channel numbers use channel number range that corresponds to physical location of those inputs in NeurOne system, for ex. 33 – 40, 72 – 80, ... etc.
6. If configuration 1 or configuration 5 is used, note, that the **NO MRI USE checkbox** of corresponding channel is checked on the Adhesive Configuration Template sticker!

	<b>If configuration 1 is set, the MRI use of Bipolar Connection Box is prohibited!</b>
	<b>If configuration 5 is set to certain channel, no signal connection is allowed to that channel, conditional MRI use of Bipolar Connection Box is still possible!</b>

**Repeat step 5 to 6 until all channel to be changed/checked are handled!**

7. Finally write Date of change / check and initials of person performed the change / check on the free space on the Adhesive Configuration Template sticker (left side, see example at step 10).
8. Place the bottom lid of Bipolar Connection Box back on the device and fasten two plastic screws. Turn the device top side up.
9. Remove backing paper of Adhesive Configuration Template sticker.
10. Place the Adhesive Configuration Template sticker on top of the device sticker. (If there is already previous Adhesive Configuration Template sticker on the device, it shall be removed.)





**In MRI use:** If configured as in the example above the 8th channel (labeled as 40) shall not be used. This channel is terminated using the configuration 5. No signal connection is allowed on this channel!

11. Connect Bipolar Connection Box to Tesla Amplifier.
12. Bipolar Connection Box is ready for sensor connection and measurement.

## Prior to new measurement session



**MRI use:** it's mandatory to follow instructions of this subchapter.

**NON-MRI use:** it's recommended to follow instructions of this subchapter.



If Adhesive Configuration Template sticker is missing, check the configuration according to the subchapter "Configuration change / check" of this Appendix.



If any NO MRI USE checkboxes on the Adhesive Configuration Template sticker are checked open the device and check that markings on the sticker correspond to the DIP switch settings in the device.

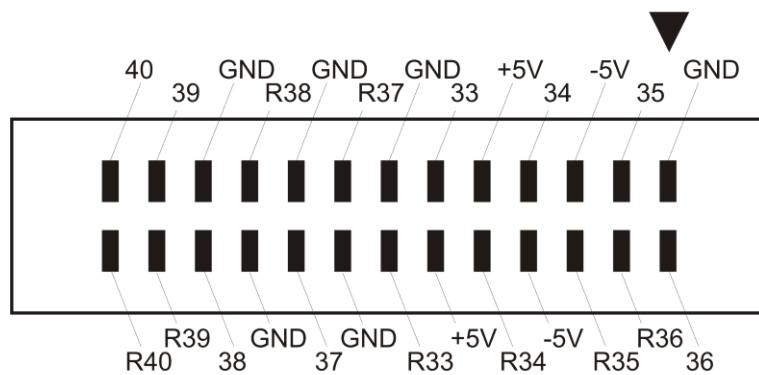
	If configuration 1 is set, the MRI use of Bipolar Connection Box is prohibited!
	If configuration 5 is set to certain channel, no signal connection is allowed to that channel, conditional MRI use of Bipolar Connection Box is still possible!



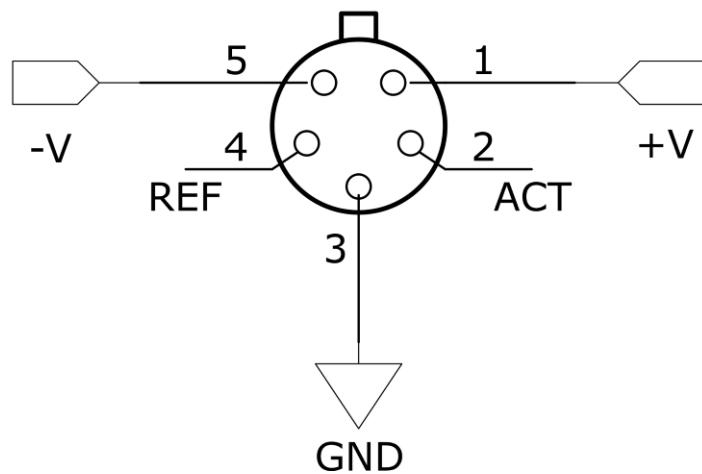
In general, it is recommended to check that the markings on the sticker correspond to the DIP switch settings in the device.

## APPENDIX 10: PINOUTS OF CONNECTORS ON BIPOLAR CONNECTION Box

Bipolar Out connector pinout (outside view)



Binder connector pinout (outside view)



## APPENDIX 11: DIGITAL OUT

### Features

The emitted data is delivered at the sampling rate the measurement is running at regular intervals. The chosen delivery rate (i.e. how often UDP datagrams are emitted) depends on measurement configuration. User can request delivery rates of 100 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 3 kHz, 4 kHz and 5 kHz. Data packets cannot be delivered at 1ms intervals if measurement sampling rate is below 1 kHz.

NeurOne digital out Ethernet port will be assigned an IP address relative to the control Ethernet port IP address. The control Ethernet port address is in turn determined by connection to SyncBox:

Main unit	Control IP address	Digital Out IP address
Stand-alone	192.168.200.200	192.168.200.220
SyncBox master	192.168.200.101	192.168.200.121
SyncBox slave1	192.168.200.102	192.168.200.122
SyncBox slave2	192.168.200.103	192.168.200.123
...		
SyncBox slave 9	192.168.200.110	192.168.200.130

Triggering information can be transmitted in packet or sample mode (or both). If packet mode transmission is enabled digital out will emit Triggers packets. If sample mode transmission is enabled digital out will emit an extra sample channel as the last channel in Samples packet.

There is no ACK mechanism for digital output. NeurOne handles only a single type of packet sent to its digital output interface (the Join packet). All other packets received by NeurOne are discarded.

UDP datagram length is limited by Ethernet MTU (IP layer fragmentation isn't supported). Each packet has at most 1472 bytes.

### Packet types

There are many kinds of packets that NeurOne can emit to digital out. The emission of most of these can be enabled / disabled, depending on the actual needs of the user and the capabilities of the system receiving digital out data.

Packet type specifics are described in the following subchapters. Every field is encoded in big-endian byte order (i.e. most significant byte first). A packets type is identified by its first byte. This way the receiving system may trigger conditional parsing based on packet type – or even decide to discard certain packets.

The data types referenced in packet type descriptions are:

Type	Description
int8	8-bit signed integer
uint8	8-bit unsigned integer
int16	16-bit signed integer
uint16	16-bit unsigned integer
int32	32-bit signed integer
uint32	32-bit unsigned integer
int64	64-bit signed integer
uint64	64-bit unsigned integer
t [N]	Array of values, each of type <i>t</i> . If <i>N</i> is specified it denotes array length. If N isn't given (i.e. "[]") the array is variable-length.

## MeasurementStartPacket

This packet is sent by NeurOne when it starts measuring, before any measurement data (samples / triggers) is emitted and also upon receival of Join packet. The emission of this packet is optional and may be enabled / disabled per-measurement. By default this packet isn't emitted.

The MeasurementStart packet structure is shown below:

Type	Name	Description																		
uint8	FrameType	1 = MeasurementStart																		
uint8	MainUnitNum	Indicates which main unit the packet is coming from (see MainUnitNum field in Samples packet).																		
uint8 [2]	Reserved	Reserved for future use																		
uint32	SamplingRateHz	Sampling frequency (Hz)																		
uint32	SampleFormat	Currently this field has a fixed value (0x80000018),																		
uint32	TriggerDefs	Indicates which trigger type is assigned to each source port. The type of each port is expressed as a value encoded in 3 bits: <table border="1"><thead><tr><th>Bits</th><th>Trigger port</th></tr></thead><tbody><tr><td>0-2</td><td>Isolated A</td></tr><tr><td>3-5</td><td>Isolated B</td></tr><tr><td>6-8</td><td>Parallel trigger</td></tr><tr><td>9-11</td><td>SyncBox button</td></tr><tr><td>12-14</td><td>SyncBox external</td></tr></tbody></table> Value meaning: <table border="1"><thead><tr><th>Value</th><th>Trigger type</th></tr></thead><tbody><tr><td>0</td><td>Disabled</td></tr><tr><td>1</td><td>Stimulus</td></tr></tbody></table>	Bits	Trigger port	0-2	Isolated A	3-5	Isolated B	6-8	Parallel trigger	9-11	SyncBox button	12-14	SyncBox external	Value	Trigger type	0	Disabled	1	Stimulus
Bits	Trigger port																			
0-2	Isolated A																			
3-5	Isolated B																			
6-8	Parallel trigger																			
9-11	SyncBox button																			
12-14	SyncBox external																			
Value	Trigger type																			
0	Disabled																			
1	Stimulus																			

		<table border="1"> <tr><td>2</td><td>Video</td></tr> <tr><td>3</td><td>Mute</td></tr> <tr><td>4</td><td>Parallel</td></tr> <tr><td>5-7</td><td>Reserved</td></tr> </table>	2	Video	3	Mute	4	Parallel	5-7	Reserved														
2	Video																							
3	Mute																							
4	Parallel																							
5-7	Reserved																							
uint16	NumChannels	Number of active digital out channels.																						
uint16[N]	SourceChannels	<p>Variable-length array of input numbers, indicating which analog input is mapped to each active digital out channel. (N = NumChannels).</p> <p>E.g.</p> <p>SourceChannels[0] = 2 =&gt; digitalOut1 = input2          SourceChannels[1] = 5 =&gt; digitalOut2 = input5          SourceChannels[2] = 4 =&gt; digitalOut3 = input4          SourceChannels[3] = 65535 =&gt; digitalOut4 = triggers</p> <p>Main units may transmit input numbers as follows</p> <table border="1"> <thead> <tr> <th>Main unit</th> <th>Input range</th> <th>Trigger Ch#</th> </tr> </thead> <tbody> <tr><td>Stand-alone</td><td>1..160</td><td>65535</td></tr> <tr><td>SyncBox master</td><td>1..120</td><td>65534</td></tr> <tr><td>SyncBox slave 1</td><td>121..240</td><td>65533</td></tr> <tr><td>SyncBox slave 2</td><td>241..360</td><td>65532</td></tr> <tr><td colspan="3">...</td></tr> <tr><td>SyncBox slave 9</td><td>1080..1200</td><td>65524</td></tr> </tbody> </table>	Main unit	Input range	Trigger Ch#	Stand-alone	1..160	65535	SyncBox master	1..120	65534	SyncBox slave 1	121..240	65533	SyncBox slave 2	241..360	65532	...			SyncBox slave 9	1080..1200	65524	
Main unit	Input range	Trigger Ch#																						
Stand-alone	1..160	65535																						
SyncBox master	1..120	65534																						
SyncBox slave 1	121..240	65533																						
SyncBox slave 2	241..360	65532																						
...																								
SyncBox slave 9	1080..1200	65524																						
uint8[N]	ChannelTypes	<p>Variable-length array of input channel metadata (N = NumChannels). Each 8-bit entry is as follows:</p> <table border="1"> <thead> <tr> <th>Bits</th> <th>Meaning</th> </tr> </thead> <tbody> <tr><td>0-2</td><td>Channel type (AC / DC) 000: AC 001: DC Rest of the values are reserved</td></tr> <tr><td>3-4</td><td>Amplifier type (EXG / Tesla) 00: EXG 01: Tesla Rest of the values are reserved</td></tr> <tr><td>5-7</td><td>Reserved</td></tr> </tbody> </table> <p>Trigger channel is an exception to the channel type presented above; its channel type is 0x80 (1000 0000<sub>2</sub>).</p>	Bits	Meaning	0-2	Channel type (AC / DC) 000: AC 001: DC Rest of the values are reserved	3-4	Amplifier type (EXG / Tesla) 00: EXG 01: Tesla Rest of the values are reserved	5-7	Reserved														
Bits	Meaning																							
0-2	Channel type (AC / DC) 000: AC 001: DC Rest of the values are reserved																							
3-4	Amplifier type (EXG / Tesla) 00: EXG 01: Tesla Rest of the values are reserved																							
5-7	Reserved																							

## Samples Packet

This packet contains measured digital samples. The samples are delivered in bundles. A bundle contains a sample for every channel for the same time instant, and cannot be broken into multiple sample packets. In other words, the samples are delivered as channel-interleaved and the samples of every channel from a single moment in time are delivered within the same sample packet.

This packet also describes the sample index and time stamp for the first sample contained. The Samples packet structure is shown below:

Type	Name	Description
uint8	FrameType	2 = Samples
uint8	MainUnitNum	Indicates which main unit the samples packet is coming from: 0: Stand-alone 1: SyncBox master 2: SyncBox slave 1 ... 10: SyncBox slave 9
uint8 [2]	Reserved	Reserved for future use
uint32	PacketSeqNo	Packet sequence number (incremented by 1 for each sample packet sent)
uint16	NumChannels	Number of channels (constant throughout the measurement)
uint16	NumSampleBundles	Number of sample bundles in this packet
uint64	FirstSampleIndex	Sample index of first bundle in this packet
uint64	FirstSampleTime	Timestamp of first bundle in this packet
int24 [N] [C]	Samples	Sample bundles; each bundle contains 1 sample from each channel. (N = NumSampleBundles, C = NumChannels).

It should be noted that the sample values may need to be scaled by the receiver. The sample scaling factor depends on the amplifier hardware (amplifier type, input type (AC / DC)). This information is supplied in the MeasurementStart packet. The scaling factors (i.e. dividers) are shown below:

Amplifier type	Channel type	Scaling factor
EXG	AC	1
EXG	DC	100
Tesla	AC	20
Tesla	DC	100

## Send Triggers as a Channel Mode

When Send Triggers as a Channel mode is enabled the samples packet will contain an additional sample channel (always the last channel in the packet). The triggering information contains only the source port the trigger occurred on. Trigger types are defined in MeasurementStart packet. When a trigger occurs its corresponding bit will be high for the duration of 1 sample in the sample channel.

As triggers are relayed as samples, the temporal accuracy of triggering information is dictated by the measurement sampling rate. If the same trigger occurs multiple times during

a single sample triggering information will be lost. If more accurate timing information is needed, it's advisable to use the Triggers packet which enables microsecond accuracy.

If trigger must occur on the sample of the rising edge the system must stall digital out sample delivery in order to deliver the trigger on the correct sample ( $t_{rise}$ ). Alternatively, the trigger can be delivered on the sample it is accepted on, i.e. the sample when trigger pulse length is satisfied on ( $t_{accept}$ ) (see Figure 1).

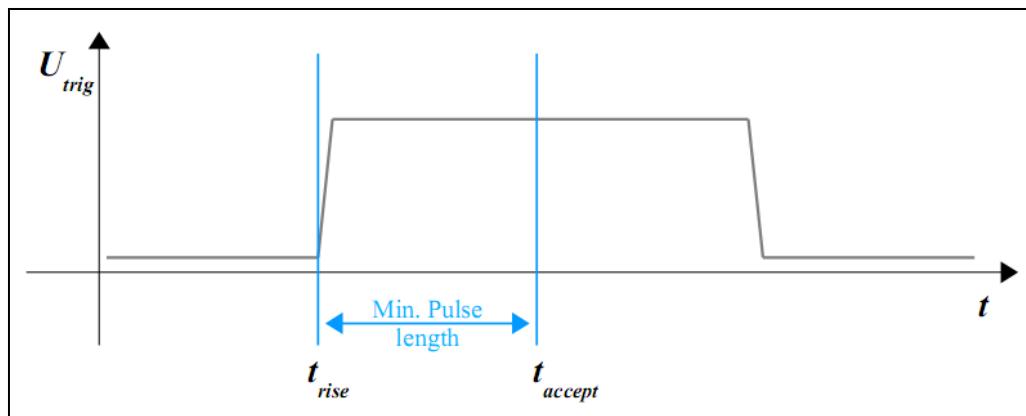


Figure 1. Trigger signal rising edge and accept timing.

Each trigger sample has the following information:

Bits	Name	Description
0	Res	Reserved for future use
1-2	Ai/Ao	Isolated A in (bit 1) / out (bit 2)
3-4	Bi/Bo	Isolated B in (bit 3) / out (bit 4)
5	SBB	SyncBox button
6	SBEi	SyncBox external trigger in
7	Res2	Reserved for SyncBox external trigger out
8-15	Par8	8-bit trigger code
16-23	Res3	Reserved for future use

## Trigger Packets

This packet contains information about one or more trigger events registered by the measurement hardware. The emission of this packet is optional and may be enabled / disabled. By default this packet isn't emitted.

The Trigger packet structure is shown below:

Type	Name	Description																		
uint8	FrameType	3 = Triggers																		
uint8	MainUnitNum	Indicates which main unit the triggers packet is coming from (see MainUnitNum field in Samples packet).																		
uint16	NumTriggers	Number of triggers in this packet																		
uint32	Reserved	Reserved for future use																		
Trigger [N]	Triggers	Array of structures, each describing a single trigger event: (N = NumTriggers) <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Type</th> <th>Name</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>uint64</td> <td>MicroTime</td> <td>Trigger position relative to start time of measurement (microseconds)</td> </tr> <tr> <td>uint64</td> <td>SampleIndex</td> <td>Index of sample tied to trigger</td> </tr> <tr> <td>uint8</td> <td>Type</td> <td>4/4 bits; trigger source channel id and mode.</td> </tr> <tr> <td>uint8</td> <td>Code</td> <td>Parallel trigger code.</td> </tr> <tr> <td>uint8 [2]</td> <td>Reserved</td> <td>Reserved for future use</td> </tr> </tbody> </table>	Type	Name	Description	uint64	MicroTime	Trigger position relative to start time of measurement (microseconds)	uint64	SampleIndex	Index of sample tied to trigger	uint8	Type	4/4 bits; trigger source channel id and mode.	uint8	Code	Parallel trigger code.	uint8 [2]	Reserved	Reserved for future use
Type	Name	Description																		
uint64	MicroTime	Trigger position relative to start time of measurement (microseconds)																		
uint64	SampleIndex	Index of sample tied to trigger																		
uint8	Type	4/4 bits; trigger source channel id and mode.																		
uint8	Code	Parallel trigger code.																		
uint8 [2]	Reserved	Reserved for future use																		

The value of trigger type field is divided into upper and lower 4 bits; the upper 4 bits denote the physical channel the trigger came from. The lower 4 bits indicate the mode the trigger hardware was configured for:

Source id (upper 4)	Description
1	Isolated port A
2	Isolated port B
3	Parallel trigger
4	SyncBox button
5	SyncBox external trigger

Mode (lower 4)	Description
1	Stimulation trigger
2	Video trigger
3	Mute trigger
4	Parallel trigger
5	Trigger output

## MeasurementEnd Packet

This packet is sent by NeurOne to indicate the end of the measurement. It's the last packet emitted when measurement hardware is stopped. The emission of this packet is optional and may be enabled / disabled per-measurement. By default this packet isn't emitted.

The MeasurementEnd packet structure is shown below:

Type	Name	Description
uint8	FrameType	4 = MeasurementEnd
uint8	MainUnitNum	Indicates which main unit the packet is coming from (see MainUnitNum field in Samples packet).
uint8 [2]	Reserved	Reserved for future use
uint64	FinalSampleCount	Total number of sample bundles sent during this measurement

## HardwareState Packet

This packet relays information about measurement hardware state, which can be considered metadata in regards to the measurement. It's sent by applicable NeurOne main units at the start of the measurement after MeasurementStart packet before any measurement data (samples / triggers) is emitted and also upon receipt of a Join packet. Note that this packet can contain different payloads which depend on the situation.

The emission of this packet is optional and may be enabled / disabled per-measurement. By default this packet isn't emitted.

The HardwareState packet structure is shown below:

Type	Name	Description
uint8	FrameType	5 = HardwareState
uint8	MainUnitNum	Indicates which main unit the packet is coming from (see MainUnitNum field in Samples packet).
uint8	StateType	Type of the payload: 1 = ClockSourceState
uint8	Reserved	Reserved for future use
uint8 []	StatePayload	Payload depending on StateType

## ClockSourceState Packet

This state payload contains information about the current clock source of SyncBox system. It's not emitted on standalone systems. Every main unit sends this payload at the start of the measurement after MeasurementStart packet before any measurement data (samples / triggers) is emitted and also upon receipt of a Join packet.

The payload structure is as follows:

Type	Name	Description
uint64	MicroTime	Clock source change time relative to start time of measurement (microseconds), according to sampling clock.
uint32	ClockFreq	Actual input clock frequency in Hz.
uint32	TargetClockFreq	Target (ideal) clock frequency in Hz.
uint16	ClockSrc	The clock source used by SyncBox: 1 = SyncBox internal 2 = BNC clock port of SyncBox 3= Fiber clock port of SyncBox

## Join Packet

The Join packet is sent by the system receiving NeurOne digital out data. Main purpose of this packet is to enable MeasurementStart packet re-emission by NeurOne in cases where the receiver system becomes online after NeurOne measurement has already been started.

The Join packet structure is shown below:

Type	Name	Description
uint8	FrameType	128 = Join
uint8[3]	Reserved	Must be filled with zeros, contents are discarded.

Upon receipt of Join packet NeurOne sends a MeasurementStart in the following circumstances:

- a) if digital out is sending to a unicast address: NeurOne responds to Join only if it originates from that same address.
- b) If digital out is sending to a broadcast address: NeurOne responds to Join only if it originates from the same subnet (255.255.255.0). The MeasurementStart packet is sent as unicast to the IP address the Join was received from. This is for situations where a single client needs to acquire MeasurementStart.

It should be noted that the action of submitting a Join packet to NeurOne and NeurOne responding with a MeasurementStart packet may cause momentary jitter to digital out frame delivery timing.

Note: the receiving system does not need to send this packet unless it explicitly wants a new MeasurementStart packet.

Note: NeurOne will respond to Join packet only if emission of MeasurementStart packet is enabled in NeurOne configuration.

Note: The Join packet must be sent to UDP port 5050.

## Examples

This chapter contains a number of packet flow examples for different digital out configurations. The time column indicates wall-clock time elapsed from the start of the measurement.

**Case 1:** MeasurementStart / MeasurementEnd / Trigger packet emission isn't enabled. Sampling rate 5 kHz, delivery rate 1 kHz.

Time (ms)	Packet	Description
<i>Measurement is started</i>		
1.0	Samples	Samples 0..4 for each output channel PacketSeqNo = 0 NumSampleBundles = 5 FirstSampleIndex = 0 MicroTime = 0
2.0	Samples	Samples 5..9 for each output channel PacketSeqNo = 1 NumSampleBundles = 5 FirstSampleIndex = 5 MicroTime = 1 000
3.0	Samples	Samples 10..14 for each output channel PacketSeqNo = 2 NumSampleBundles = 5 FirstSampleIndex = 10 MicroTime = 2 000
...		
<i>Measurement is stopped</i>		

**Case 2:** MeasurementStart / MeasurementEnd packet emission isn't enabled. Sampling rate 5 kHz, delivery rate 500 Hz.

Time (ms)	Packet	Description
<i>Measurement is started</i>		
2.0	Samples	Samples 0..9 for each output channel PacketSeqNo = 0 NumSampleBundles = 10 FirstSampleIndex = 0 MicroTime = 0
4.0	Samples	Samples 10..19 for each output channel PacketSeqNo = 1 NumSampleBundles = 10 FirstSampleIndex = 10 MicroTime = 2 000
4.2	Triggers	One or more triggers relating to samples sent in previous Samples packet.
6.0	Samples	Samples 20..29 for each output channel PacketSeqNo = 2 NumSampleBundles = 10 FirstSampleIndex = 20 MicroTime = 4 000

...  
*Measurement is stopped*

**Case 3:** Emission of all packet types is enabled. Sampling rate 10 kHz, delivery rate 1 kHz.

Time (ms)	Packet	Description
<i>Measurement is started</i>		
0.0	MeasurementStart	Indicates start of measurement
0.0	HardwareState (ClockSourceState)	Relays hardware state metadata
1.0	Samples	Samples 0..9 for each output channel PacketSeqNo = 0 NumSampleBundles = 10 FirstSampleIndex = 0 MicroTime = 0
2.0	Samples	Samples 10..19 for each output channel PacketSeqNo = 1 NumSampleBundles = 10 FirstSampleIndex = 10 MicroTime = 1 000
2.2	Triggers	One or more triggers relating to samples sent in previous Samples packet
3.0	Samples	Samples 20..29 for each output channel PacketSeqNo = 2 NumSampleBundles = 10 FirstSampleIndex = 20 MicroTime = 2 000
...		
1501.0	Samples	Samples 15000..15009 for each output channel PacketSeqNo = 1500 NumSampleBundles = 10 FirstSampleIndex = 15000 MicroTime = 150 000
<i>Measurement is stopped</i>		
1501.7	MeasurementEnd	Indicates end of measurement

Next part contains examples of how to parse sample packets. Examples can be repeated using the GNU Octave codes. GNU Octave is freely distributed software that is intended for numerical computations. The GNU Octave scripts need the GNU Octave sockets package. By default, the received values in the sample packets are in 8-bit unsigned format.

**Example 1.** Only one channel is directed to the digital out and both the sampling rate and packet delivery frequency are set to be 500 Hz.

Byte	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Value uint8	2	0	0	0	0	0	0	24	0	1	0	1	0	0	0	0
Byte	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Value uint8	0	0	0	24	0	0	0	0	0	0	187	128	255	114	58	

Type	Description	Value uint8	Value
uint8	Sample packet identifier	2	2
uint8	Main unit indication	0	0
uint8	Not in use	0	0
uint8	Not in use	0	0
uint32	Packet sequence number	0 0 0 24	24
uint16	Number of channels	0 1	1
uint16	Number of sample bundles	0 1	1
uint64	Sample index of the first bundle	0 0 0 0 0 0 0 24	24
uint64	Time stamp of the first bundle	0 0 0 0 0 187 128	48000
int24	Data samples	255 114 58	-36294

**Example 2.** Two channels are directed to the digital out and both the sampling rate and packet delivery frequency are set to be 500 Hz.

Byte	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Value uint8	2	0	0	0	0	0	0	30	0	2	0	1	0	0	0	0	0
Byte	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Value uint8	0	0	0	30	0	0	0	0	234	96	248	231	55	248	232	51	

Type	Description	Value uint8	Value
uint8	Sample packet identifier	2	2
uint8	Main unit indication	0	0
uint8	Not in use	0	0
uint8	Not in use	0	0
uint32	Packet sequence number	0 0 0 30	30
uint16	Number of channels	0 2	2
uint16	Number of sample bundles	0 1	1
uint64	Sample index of the first bundle	0 0 0 0 0 0 0 30	24
uint64	Time stamp of the first bundle	0 0 0 0 0 0 234 96	60000
int24	Data sample channel1	248 231 55	-465097
int24	Data sample channel2	248 232 51	-464845

**Example 3.** Only one channel is directed to the digital out and the sampling rate and packet delivery frequency are set to be 500 Hz and 100 Hz, respectively.

Byte	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Value uint8	2	0	0	0	0	0	0	51	0	1	0	5	0	0	0
Byte	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Value uint8	0	0	0	0	255	0	0	0	0	0	7	200	48	249	247
Byte	31	32	33	34	35	36	37	38	39	40	41	42	43		
Value uint8	34	249	233	27	249	218	135	249	210	6	249	205	203		

Type	Description	Value uint8	Value
uint8	Sample packet identifier	2	2
uint8	Main unit indication	0	0
uint8	Not in use	0	0
uint8	Not in use	0	0
uint32	Packet sequence number	0 0 0 51	51
uint16	Number of channels	0 1	1
uint16	Number of sample bundles	0 5	5
uint64	Sample index of the first bundle	0 0 0 0 0 0 0 255	255
uint64	Time stamp of the first bundle	0 0 0 0 0 7 200 48	60000
int24	Data sample sample index255	249 247 34	-395486
int24	Data sample sample index256	249 233 27	-399077
int24	Data sample sample index257	249 218 135	-402809
int24	Data sample sample index258	249 210 6	-404986
int24	Data sample sample index259	249 205 203	-406069

## GNU Octave script for receiving UDP sample packets:

```
pkg load sockets %loads the needed sockets packet
buff_size=50; %buffer size must be greater than the packet size
rcv_port=50000; %target port number
rcv_sck=socket(AF_INET, SOCK_DGRAM, 0);
bind(rcv_sck,rcv_port);
[str,len_s]=recv(rcv_sck,buff_size); %the first packet is empty packet

for n=1:10
    [pckt(n,:),len_s]=recv(rcv_sck,60); % buffer must be greater than the packet
size
end
```

Note: This script is intended only for test purposes. It is not suitable for real-time measurements.

## APPENDIX 12: RAW MONITOR CONTROL PARAMETERS

Raw Monitor control parameters		During measurement		
Parameter name	Edit in protocol editor	Edit	Save (with "Save Layout"). Changes not saved for Default Montage.	Edit/save in montage editor
Monitor Name	yes	no	no	no
Monitor size and location	no	yes	yes	no
X-axis Length	yes	yes	yes	no
Accept Stimulation Triggers	yes	yes	no	no
Accept Video Triggers	yes	yes	no	no
Accept Mute Triggers	yes	yes	no	no
Accept 8-bit Triggers	yes	yes	no	no
List of accepted 8-bit Triggers	yes	yes	no	no
Show Grid	yes	yes	no	no
Monitor Background Color	yes	no	no	no
Selected Montage	no	yes	yes	no
Display Curve Labels	no	yes	no	no
Display Last Values	no	yes	no	no
Use Notch Filter	no	yes	no	no
Modify Curve Polarity (inversion)	no	yes	no	no
Show Baseline	no	yes	no	no
Fit by signal type	no	yes	no	no
Raw mode (IIR decimation off)	no	yes	no	no
Curve: Number (order of curves)	yes (default montage)	no	yes	yes
Curve: Active Input	yes (default montage)	no	no	yes
Curve: Reference Input	yes (default montage)	no	no	yes
Curve: Name	yes (default montage)	no	yes	yes
Curve: Side	yes (default montage)	no	no	yes
Curve: Y-axis Min	yes (default montage)	yes	yes	yes
Curve: Y-axis Max	yes (default montage)	yes	yes	yes
Curve: Auto-align Enabled	yes (default montage)	yes	yes	yes
Curve: Polarity (inversion)	yes (default montage)	yes	no	yes
Curve: Notch filter	yes (default montage)	yes	no	yes
Curve: Display Filter	yes (default montage)	yes	yes	yes
Curve: Color	yes (default montage)	yes	no	yes
Curve: Line Width	yes (default montage)		no	yes
Curve: Show baseline (zero)	no	yes	no	no

## APPENDIX 13: RESPONSE MONITOR CONTROL PARAMETERS

Response Monitor control parameters		During measurement		
Parameter name	Edit in protocol editor	Edit	Save (with "Save Layout"). Changes not saved for Default Montage.	Edit/save in montage editor
Monitor Name	yes	no	no	no
Monitor size and location	no	yes	yes	no
Triggers: Main unit selection	yes	no	no	no
Triggers: Port A trigger type	yes	no	no	no
Triggers: Port B trigger type	yes	no	no	no
Accept 8-bit triggers	yes	no	no	no
List of accepted 8-bit triggers	yes	no	no	no
Triggers: Port SB EXT trigger type	yes	no	no	no
Pre-stim time	yes	no	no	no
Post-stim time	yes	no	no	no
Display single responses	yes	yes	yes	no
Number of displayed single responses	yes	yes	no	no
Display average responses	yes	yes	yes	no
Number of responses in average	yes	yes	no	no
Show grid	yes	yes	yes	no
Monitor background color	yes	no	no	no
Enable rejection	no	yes	yes	no
Show rejection limits	yes	yes	yes	no
Rejection min level	yes	yes	yes	no
Rejection max level	yes	yes	yes	no
Rejection seek after (ms)	no	yes	yes	no
Recording of responses controlled by main record	yes	no	no	no
Recording responses: interactive average	yes	yes	no	no
Recording responses: front padding	yes	no	no	no
Recording responses: end padding	yes	no	no	no
TMS Mute activated	yes	yes	yes	no
TMS Mute length	yes	yes	yes	no
TMS Decay activated	yes	yes	yes	no
TMS Decay Coefficient 1	yes	yes	yes	no
TMS Decay Coefficient 2	yes	yes	yes	no
Selected montage	no	yes	yes	no
Show latency markers	no	yes	yes	no
Seek latency after (ms)	no	yes	yes	no

Parameter name	Edit in protocol editor	Edit	Save (with "Save Layout")	Edit/save in montage editor
Latency signal level (% of max)	no	yes	yes	no
Show labels	no	yes	yes	no
Show baseline	no	yes	no	no
Auto-align	no	yes	no	no
AutoAlignCalculateFrom (ms)	no	yes	yes	no
AutoAlignCalculateTo (ms)	no	yes	yes	no
Polarity (inverse)	no	yes	no	no
Response counters	no	yes	yes	no
Notch filter	no	yes	no	no
Display filter	no	yes	yes	no
Curve: Number (order of curves)	yes (default montage)	no	yes	yes
Curve: Active Input	yes (default montage)	no	no	yes
Curve: Reference Input	yes (default montage)	no	no	yes
Curve: Name	yes (default montage)	no	yes	yes
Curve: Side	yes (default montage)	no	no	yes
Curve: Y-axis Min	yes (default montage)	yes	yes	yes
Curve: Y-axis Max	yes (default montage)	yes	yes	yes
Curve: Auto-align Enabled	yes (default montage)	yes	yes	yes
Curve: Auto-align bound to single response	no	yes	yes	no
Curve: Auto-align bound to average response	no	yes	yes	no
Curve: Polarity (inversion)	yes (default montage)	yes	yes	yes
Curve: Notch filter	yes (default montage)	yes	yes	yes
Curve: Display Filter	yes (default montage)	yes	yes	yes
Curve: Color	yes (default montage)	yes	yes	yes
Curve: Line Width	yes (default montage)	no	no	yes
Curve: Show baseline (zero)	no	yes	yes	no
Curve: RejectionMinLevel	no	yes	yes	no
Curve: RejectionMaxLevel	no	yes	yes	no
Curve: TopographyPositionX	no	yes	yes	no
Curve: TopographyPositionY	no	yes	yes	no
View: Selected view type	no	yes	yes	no
View: ChartSize	no	yes	yes	no
View: ChartDistance	no	yes	yes	no
View: ChartClipping	no	yes	yes	no
View: ShowBackground	no	yes	yes	no
View: LockCharts	no	yes	yes	no

## APPENDIX 14: MR CONDITIONAL STATEMENT OF COMPLIANCE FOR NEURONE TESLA AMPLIFIER, BATTERY PACK AND ACCESSORIES

NeurOne System parts: Tesla amplifier, battery pack, Bipolar Connection Box and MRI EEG cap have been demonstrated to be MR Conditional



The MR Conditional marking information is based on non-clinical testing in various MRI environments. The guideline for testing has based on the standards:

- ASTM F2182 Standard Test Method for Measurement of Radio Frequency Induced Heating On or Near Passive Implants During Magnetic Resonance Imaging
- ASTM F2213 Standard Test Method for Measurement of Magnetically Induced Torque on Medical
- ASTM F2052 Standard Test Method for Measurement of Magnetically Induced Displacement Force on Medical Devices in the Magnetic Resonance Environment
- ASTM F2119 Standard Test Method for Evaluation of MR Image Artifacts from Passive Implants

Tests have demonstrated that stated NeurOne system parts are conditional with listed MRI scanners. Listed scanners are suitable for working with NeurOne system without any foreseeable operational issues of the scanner having a negative effect on the MR conditional labeled NeurOne system parts or vice versa.

## MRI Information

Non-clinical testing has demonstrated the NeurOne Tesla amplifier, battery pack, Bipolar Connection Box and MRI cap accessories are MR conditional. MR Conditional system parts are labeled with MR Conditional symbol.



***MR Conditional system parts are for INVESTIGATIONAL USE ONLY!***

## Static Magnetic Field

Based on non-clinical testing the above devices can be scanned safely in a MR environment under the following

- Static magnetic field of 3 Tesla only
- Spatial gradient field of 253 T/m (25.300 gauss/cm) and less
- Spatial gradient field product of 684 T<sup>2</sup>/m and less
- Theoretically estimated maximum whole body averaged (WBA) specific absorption rate (SAR) of < 2 W/kg at 3 Tesla, (related to 2.3°C temperature increase) for 15 minutes of continuous MR scanning.

The following MRI scanner has been used in non-clinical testing:

- Siemens Trio 3T
- Siemens Prisma 3T
- Philips Achieva 3.0 tx

Maximum duration of single scan based on non-clinical testing: 15 min of EPI

## MRI related RF heating

For safe use in doing the combined EEG/MR measurements it is essential to understand how to avoid the risks on the test subject that is caused by the total amount of RF energy exerted onto **watery-gel filled electrode cavities over time**.

Based on published study of fMRI safety issue it has been shown that normal EPI BOLD measurement there is practically no temperature increase over time at all. With SPGR sequence the temperature increase over the same time is a bit larger than for the EPI, but without physiological significance. In the same study Fast Spin Echo (FSE) recording with multiple echoes (up to 16) largely inflated total RF over time, causing the temperature rapid increase immediately after the onset of the measurement and that temperature increase shall be considered dangerous from the physiological point of view.

As conclusion of those results **only** the total amount of RF energy on the watery-gel over time that governs whether there is or there is not any heating. If there is a constant influx of RF energy, it does not take much for this to be a positive heating>cooling ratio which in process of the time **causes the hazardous heating on the brain tissue of test subject**.

It is essential to understand that safe legal SAR threshold according to SAR calculation do not assume the presence of water on the outside of the skin i.e. the gel on the electrode. Even though **sequence including the TSE/FSE class** which is safe and legal according to the SAR calculation **might cause fatal temperature increase and is therefore absolutely forbidden to use**.

## For safe use

- **MR Conditional labeled system parts are scientific equipment for INVESTIGATIONAL USE ONLY!**
- NeurOne System MR conditional parts are to be used in MR systems up to 3T field strength and that the only sequences it is intended for use with are stock EPI BOLD sequences.
- The flip angle shall be reduced to less than 90° and thus reduce the total RF over time (e.g. Gradient Echo, FLASH and SPGR sequences).
- **Only use sequences which have a low number of RF pulses are allowed.**
- **Never use acceleration factor greater than 2 with Siemens MPRAGE T1.**
- **Never use sequences that have more than one additional inversion pulse.**
- **Never use anything with "Fast" or "Turbo" in its name, since these sequences typically are VERY high in total RF over time.**

- **Never use other sequences and especially ones that excite with more total RF over time, e.g. the multi-slice, multi-band sequence classes.**

## For safe use

Based on non-clinical tests image artefacts based on Tesla amplifier and battery pack are not significant. Electrodes on EEG-cap and other test arrangements might cause image artefacts.

NeurOne Syncbox shall be used during MRI data acquisition in order to remove MRI scanner artifact in post-processing of EEG data.