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NeuroPort Biopotential Signal Processing System

Instructions for Use

Revision 6.00 / LB-0323 – NeuroPort Biopotential Signal Processing System IFU – 2021/06

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What This Manual Covers

The NeuroPort Biopotential Signal Processing System (NeuroPort System) is designed to record and process neural signals from up to 512 surface or penetrating electrodes in addition to auxiliary analog signals and digital experimental events. The system can acquire a variety of biopotential signal types including electrocorticography, electroencephalography, and electromyography. The system can perform real-time signal processing algorithms on neural signals, including noise cancellation, digital filtering, simultaneous extraction of spike and field potentials, and manual and automatic online spike sorting.

The NeuroPort Biopotential Signal Processing System is not a monitoring system. No physiological alarms are provided. The acquisition and display of biopotential signals is for the interpretation and use of the clinician.

Intended Use/Indications for Use

The NeuroPort Biopotential Signal Processing System supports recording, processing, and display of biopotential signals from user-supplied electrodes. Biopotential signals include: Electrocorticography (ECoG), electroencephalography (EEG), electromyography (EMG), electrocardiography (ECG), electrooculography (EOC) action potentials (AP), and evoked potentials (EP).

Contraindications, Warnings, and Precautions

Contraindication

- The NeuroPort System is a recording system and should not be used in applications involving stimulation.

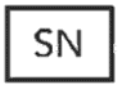
Warnings

- Read this entire manual prior to using the device.
- A thorough understanding of the technical principles and risks associated with electrophysiological recording is necessary before using this product.
- Completion of the Blackrock Microsystems user training program is recommended prior to the use of the NeuroPort System.
- Always operate the NeuroPort System in a clean environment.
- Only connect NeuroPort System components to properly tested, grounded and dedicated AC outlets using only the Blackrock provided power cable to reduce the risk of electrical shock or malfunction of product. Do not use an adapter for ungrounded wall outlets.
- Do not connect the NeuroPort System to an outlet controlled by a wall switch, multiple socket-outlet or extension cord to avoid fires or other electrical hazards.
- Do not use the NeuroPort System in the presence of flammable anesthetic agents.
- Do not use the NeuroPort System for any use other than its listed intended use.
- Avoid strong static discharges from sources like televisions or computer monitors because it can damage the electrical components of the system.
- Keep the NeuroPort System away from liquids. Contact with water, shower spray, or wet surfaces can lead to the patient receiving an electrical shock.
- Connection of external instruments may compromise electrical safety compliance with IEC 60601-1.
- The NeuroPort System should be disconnected from any electrodes during cardiac defibrillation.
- The conductive parts of electrodes and their connectors, including neural electrodes, should not contact other conductive parts including earth.
- Place the NeuroPort system in a secure location.
- Avoid tripping on cords connected to the NeuroPort system.
- Repair or maintenance is not allowed during equipment operation.
- Only plug in Blackrock approved equipment into the NeuroPort system.
- Do not connect the computer hosting the Central software to the internet.
- Disabling firewalls and antivirus software can leave your system vulnerable to cyber attacks.
- Do not touch any exposed electrical conductors or use damaged Data Cables when using the Digital Hub
- Only connect headstages to the Digital Hub.

Precautions

- Follow the restrictions of use for third party electrodes or arrays.
- Third party recording or control systems connecting to the NeuroPort System and components must be electrically isolated for subject safety.
- Note that the fiber-optic cable is very delicate. Do not bend it (bend radius of 5.0 cm) or crush it.
- Inspect the NeuroPort System and cables prior to use for damage. If damaged, do not use.

Symbols

ISO 15223-1:2016 Medical Devices – Symbols to Be Used with Medical Device Labels, Labeling, and Information to Be Supplied			
Reference	**Symbol**	**Title**	**Meaning**
5.1.1		**Manufacturer**	Indicates the medical device manufacturer.
5.1.3		**Date of Manufacture**	Indicates date of manufacture and is accompanied by a date.
5.1.4		**Use-by Date**	Indicates the date after which the medical device is not to be used.
5.1.5		**Batch Code**	Indicates the manufacturer's batch code so that the batch or lot can be identified.
5.1.6		**Catalog Number**	Indicates the manufacturer's catalog number so that the device may be identified. For Blackrock Microsystems it is called the Part Number (PN).
5.1.7		**Serial Number**	Indicates the manufacturer's serial number so that a specific medical device can be identified.
5.2.3		**Sterilized Using Ethylene Oxide**	Indicates that the device has been sterilized using ethylene oxide.

ISO 15223-1:2016 Medical Devices – Symbols to Be Used with Medical Device Labels, Labeling, and Information to Be Supplied			
Reference	**Symbol**	**Title**	**Meaning**
5.2.6		**Do Not Resterilize**	Indicates a medical device that is not to be resterilized.
5.2.7		**Non-Sterile**	To indicate that the device that is normally provided sterile in the same or similar packaging has not been sterilized.
5.2.8		**Do Not Use if Package is Damaged**	Indicates that a medical device should not be used if the package has been damaged or opened.
5.4.2		**Do Not Reuse**	Indicates a medical device that is intended for one use, or for use on a single patient during a single procedure.
5.4.3		**Consult Instructions for Use**	Indicates the need for the user to consult the instructions for use, which you are currently reading.
5.4.4		**Caution**	Indicates the need for the user to consult the instructions for use for important cautionary information such as warning and precautions that cannot, for a variety of reasons, be presented on the medical device itself.

IEC 60601-1, Edition 3.1 Medical Electrical Equipment – Part 1: General Requirements for Basic Safety and Essential Performance			
Reference	**Symbol**	**Title**	**Meaning**
ISO 7010-M002		**Follow Instructions for Use**	Indicates the need for the user to consult the instructions for use for important cautionary information such as warning and precautions that cannot, for a variety of reasons, be presented on the medical device itself.
IEC 60417:2002 DB Graphical Symbols for Use on Equipment			
Reference	**Symbol**	**Title**	**Meaning**
5007		**On (Power)**	To indicate connection to the mains, at least for mains switches or their positions, and all those cases where safety is involved.
5008		**Off (Power)**	To indicate disconnection from the mains, at least for mains switches or their positions, and all those cases where safety is involved.
5009		**Standby (Power)**	To identify the switch or switch position by means of which part of the equipment is switched on in order to bring it into the stand-by condition, and to identify the control to shift to or to indicate the state of low power consumption.

IEC 60417:2002 DB Graphical Symbols for Use on Equipment			
Reference	**Symbol**	**Title**	**Meaning**
5019		**Protective Earth Ground**	To identify any terminal which is intended for connection to an external conductor for protection against electric shock in case of a fault, or the terminal of a protective earth (ground) electrode.
5021		**Equipotentiality Connector**	To identify the terminals which, when connected together, bring the various parts of an equipment or of a system to the same potential, not necessarily being the earth (ground) potential, e.g. for local bonding.
5036		**Dangerous Voltage**	To indicate hazards arising from dangerous voltages.
5333		**Type BF Applied Part**	To identify a type BF applied part complying with IEC 60601-1.
5334		**Electrostatic Sensitive Devices**	To indicate packages containing electrostatic sensitive devices, or to identify a device or a connector that has not been tested for immunity to electrostatic discharge.
		**Prescription Only**	Caution: Federal (U.S.A.) law restricts this device to sale by or on the order of a physician.

System Requirements

The specifications listed below are the minimum required by the software to run. Blackrock supplies an optional Host PC that is configured and tested by our engineers before it ships with your NeuroPort system. Please contact sales@blackrockmicro.com for more information.

- Microsoft Windows 10 (x64)
- AMD or Intel 2.0 GHz Dual Core CPU
- 4 GB of RAM
- 1x Gbps Ethernet interface card
- 1 TB 3 Gbit/s SATA II HDD

Cybersecurity Requirements

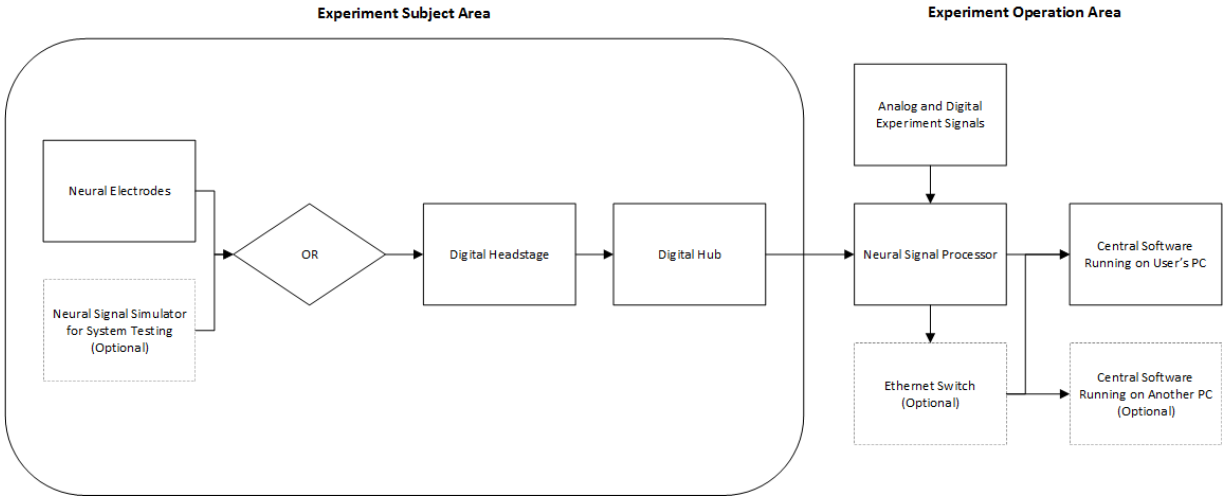
- Host Computer Windows Firewall turned on
- Latest version of Malware/Virus Software installed and enabled
- Do not connect the computer hosting the Central software to the internet
- Host computer enabled windows login with password
- Host computer auto-logout enabled with a minimum of 5 minutes of inactivity set.

System Description

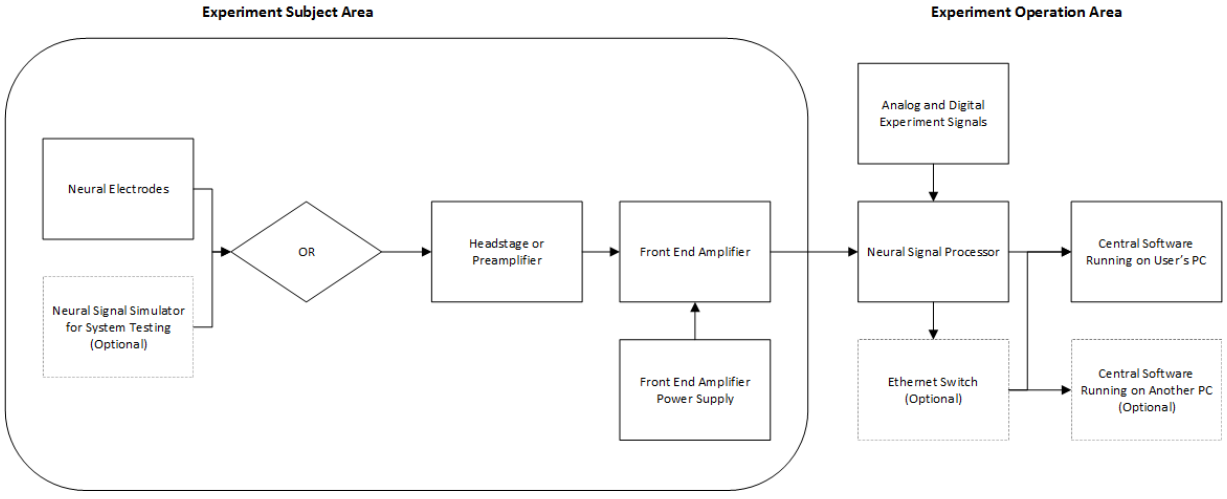
The NeuroPort System is available in two versions: standard or digital. Both systems have the same purpose, intended use, and indications for use, but differ in their subcomponents. The Digital NeuroPort System integrates the headstages/preamplifiers with the amplifier circuitry to digitize the neural signal closer to the electrodes.

The diagrams below show an overview of the assembled system and subcomponents. Refer to the sections below for more detailed information on each component.

Digital NeuroPort System



NeuroPort System



Specifications

Model Name	**NeuroPort Neural Signal Processor**
Power Requirements	110 VAC 60 Hz 6.0 A / 240 VAC 50 Hz 3.0 A
Line Noise Serviceable Fuses	5 x 20mm, 250V, 1.6A, Slow Blow
Compliance Standards	IEC 60601-1, IEC 60601-1-2, IEC 60601-2-26, CSA listed
Type of Protection Against Electric Shock	Class I
Degree of Protection	Type BF Applied Part
Mode of Operation	Continuous
Ingress Protection	Ordinary Equipment, not fluid resistant, IPX0
Operating Environment	10˚C to 35˚C, 5 to 85% R.H. (non-condensing)
Storage Environment	-20˚C to 50˚C, 5 to 95% R.H. (non-condensing)

Guidance and manufacturer's declaration – electromagnetic immunity			
The NeuroPort System is intended for use in the electromagnetic environment specified below. The customer or the user of the NeuroPort system should assure that it is used in such an environment.			
Immunity test	**IEC 60601 test level**	**Compliance level**	**Electromagnetic environment — guidance**
Conducted RF IEC61000-4-6	3 Vrms 150 kHz to 80 MHz	3 Vrms	Portable and mobile RF communications equipment should be used no closer to any part of the NeuroPort system, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter. **Recommended separation distance** $d = 1.2\sqrt{P}$ **150 kHz to 80 MHz** $d = 1.2\sqrt{P}$ **80 MHz to 800 MHz** $d = 2.3\sqrt{P}$ **800 MHz to 2.5 GHz**
Radiated RF IEC 61000-4-3	3 V/m 80 MHz to 2.5 GHz	3 V/m	where *P* is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer and *d* is the recommended separation distance in meters (m). Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey[a] should be less than the compliance level in each frequency range[b]. Interference may occur in the vicinity of equipment marked with the following symbol: 
NOTE 1 At 80 MHz and 800 MHz, the higher frequency range applies. NOTE 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.			
[a] Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the NeuroPort system is used exceeds the applicable RF compliance level above, the NeuroPort system should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as reorienting or relocating the NeuroPort system. [b] Over the frequency range 150 kHz to 80 MHz, field strengths should be less than *3V*/m.			

Table 204–Guidance and manufacturer's declaration – electromagnetic immunity – for all EQUIPMENT and SYSTEMS that are not LIFE-SUPPORTING (refer to 60601-1-2).

Recommended separation distances between portable and mobile RF communications equipment and the NeuroPort system

The NeuroPort system is intended for use in an electromagnetic environment in which radiated RF disturbances are controlled. The customer or the user of the NeuroPort system can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the NeuroPort system as recommended below, according to the maximum output power of the communications equipment.

Rated maximum output power of transmitter W	Separation distance according to frequency of transmitter m		
	150 kHz to 80 MHz $d = [\frac{3.5}{V_1}]\sqrt{P}$	80 MHz to 800 MHz $d = [\frac{3.5}{E_1}]\sqrt{P}$	800 MHz to 2.5 GHz $d = [\frac{7}{E_1}]\sqrt{P}$
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 rated at a maximum output power not listed above, the recommended separation distance *d* in meters (m) can be estimated using the equation applicable to the frequency of the transmitter, where *P* is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

NOTE 1 At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.

NOTE 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

Table 206–Recommended separation distances between portable and mobile RF communications equipment and the EQUIPMENT or SYSTEM - for EQUIPMENT or SYSTEMS that are not LIFE-SUPPORTING (refer to 60601-1-2).

Hardware

Both available NeuroPort Systems include the Neural Signal Processor. The Digital NeuroPort System includes the Digital Hub, while the standard NeuroPort System includes the Front End Amplifier and its power supply.

Neural Signal Processor (NSP)

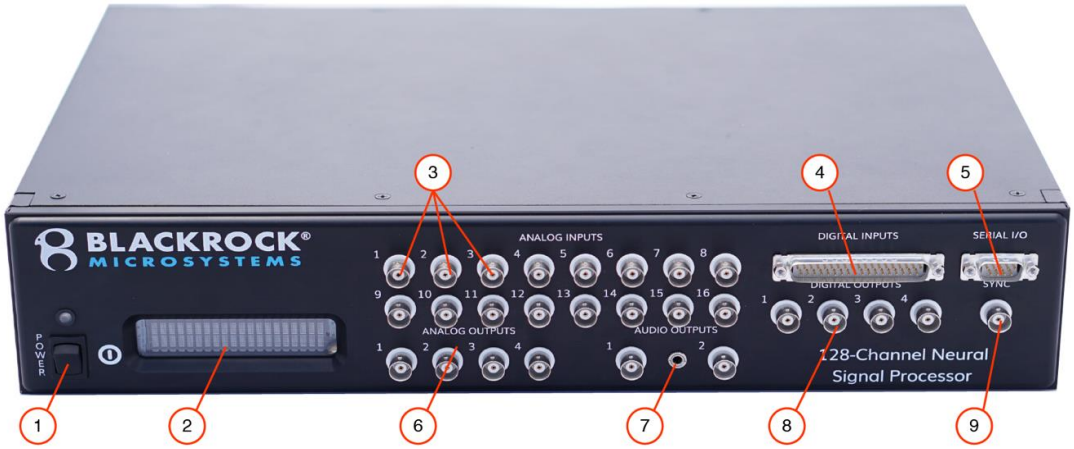


Figure 1–NSP Front

NSP showing the power switch (1), LCD display (2), analog inputs (3), digital inputs (4), serial I/O (5), analog outputs (6), audio outputs (7), digital outputs (8), and sync port (9).

Note: The fiber optic link input connector has been relocated to the back panel in NSP versions 1.75 and above. The location of this port was previously under the sync port on the front panel

The NSP is the real-time processor of the system. It performs all the digital processing of the signals, such as digital filtering, spike extraction, spike sorting. It also processes the data and transmits it to the Host PC through Ethernet UDP protocol. The NSP has multiple analog and digital input and outputs that can be programmed through the software or one of the supplied Software Development Kits (SDKs). Multiple NSPs may be synchronized for recording signals from a very large quantity of electrodes.

1. **Power Switch:**
   It is used to turn the NSP ON and OFF. The LED above the switch will illuminate blue when the unit is on.
   Note: On NSP PN-7530, PN-9650, and PN-10411 this switch is a momentary switch to power down the NSP and does not turn main power to the device ON/OFF. See rear panel for mains switch for mentioned part numbers.
2. **LCD Display:**
   It displays the current operating status of the unit. The statuses include, “Initializing”, “NSP Startup”, “NSP Running”, “NSP Standby”, and “Synchronized”.
3. **Analog Inputs:**
   Auxiliary analog signals can be recorded through 16 analog input BNC ports. The analog source may range ± 5.0 V and should come from a source impedance of less than 100 Ω. The coupling of each input channel can be manually selected in

the software. By default, channels 1-8 are AC-coupled and channels 9-16 are DC-coupled.

4. **Digital Input:**
   Digital events can be recorded through the 16-bit DB37 input port. The pin diagram is shown below. DS is the digital strobe pin. D0-15 are data pins. EOP is reserved. SYNC is an output pin and can be used with external equipment to indicate when the port is scanned. Input range is 0V-5V TTL levels. The port is polled every 1/30000 of a second. Strobed data is buffered up to 10 strobes per 1/30000 of a second and is latched on the rising edge of the DS pin.

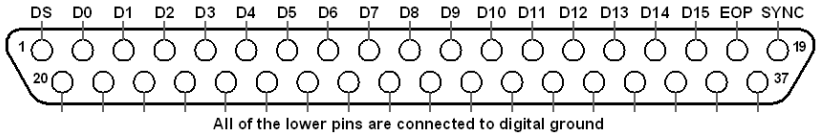


Figure 2–Digital In Pin Diagram

5. **Serial I/O:**
   The port is an RS232 DB9 digital input/output port. The pin diagram is shown below. Currently, the software only supports this port as an input. Pin 2 is “Receive Data”, pin 3 is “Transmit Data”, and pin 5 is “Ground”. The configuration of the port is: Baud rate: 115200, Data bits: 8, Parity: none, Stop bits: 1, Flow control: disabled.

Figure 3–Serial I/O Pin Diagram

6. **Analog Outputs:**
   Four ± 5.0 V analog output BNC connectors can be used to send monitoring signals or stimulus waveforms to other connectors.
7. **Audio Output:**
   The system sends a ± 1 V line-level audio signal of the selected data channel to two BNC ports (Left and Right channeled respectively) and one 3.5mm female stereo audio connector simultaneously.
8. **Digital Outputs:**
   Four single-bit digital BNC outputs can be programmed for monitoring or timing functions. These ports can be setup to send a TTL signal if spike activity is detected on any particular neural channel. They can also be configured to output a digital pulse train at a user-defined frequency and duty cycle. Digital Output 1 can also be used for syncing external equipment by sending a unique pulse every 14 seconds. The entire sync pattern will repeat every hour. See the Central Software Suite User Manual for more details.
9. **Sync Port:**
   A synchronization pulse can be set as an optional line to inform external equipment when the NSP neural signal inputs and front panel ports are scanned. It is active on the rising edge of the signal.

NSP PN-4176

NSP PN-7530

NSP PN-9650

NSP PN-10411

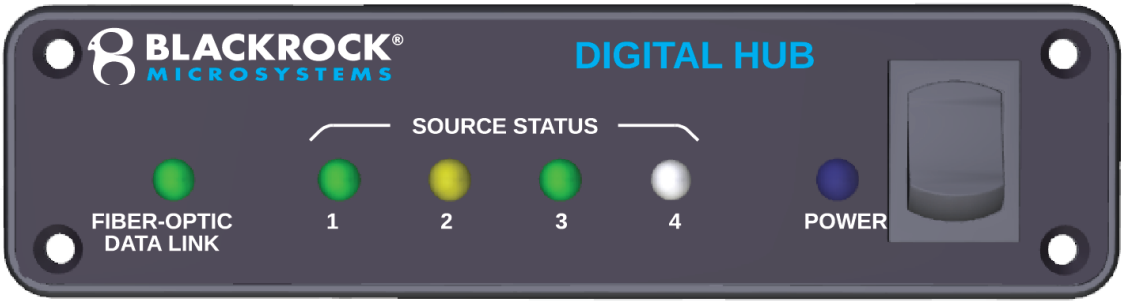
Figure 4–NSP Back

10. **Line Noise Cancellation Port:**
    On PN-4176 hardware Line Noise Cancellation receptacle is combined with the main power receptacle. On PN-7530, PN-9650 and PN-10411 a separate power receptacle is used for hardware line noise cancellation. To use this feature, plug a standard power cable into this port and enable the feature in software as described in the Central Software Suite User Manual.
    Note: This receptacle is optional and is not required to power and operate the NSP under normal conditions.
11. **Synchronization Port:**
    This DB9 port is located on the back of the NSP and it is used to synchronize two NSPs. The synchronization occurs automatically as Central runs on both computers if the sync cable (Blackrock PN-5584) is properly connected between two NSPs. Some models may not have this port. To add synchronization capability to your NSP, please contact Blackrock Microsystems support at sales@blackrockmicro.com
12. **Fiber-optic Link:**
    This port connects to the Amplifier using a fiber-optic cable. An LED to the right of the connector turns green when a link is established and turns yellow when the link is broken.
13. **Mains Power Entry:**
    This supplies main power to the NSP and is required to power and operate the NSP.
14. **Mains Power Switch:**
    Power switch used to turn main power ON/OFF to the NSP. Ensure this switch is in the ON position marked by the “I” on the switch.

Digital Hub

The Digital Hub receives digital signals from attached digital headstage accessory devices. Note that these accessory devices are not described in this instruction and are contained within their own instructions for use.

The Digital Hub allows connection of multiple digital headstages. It is responsible for providing the sampling clock signal to the digital headstages as well as taking incoming digital information from the headstages and converting it into the optical domain to transfer to the Neural Signal Processor via a fiber-optic link, which is immune to electromagnetic field interference.



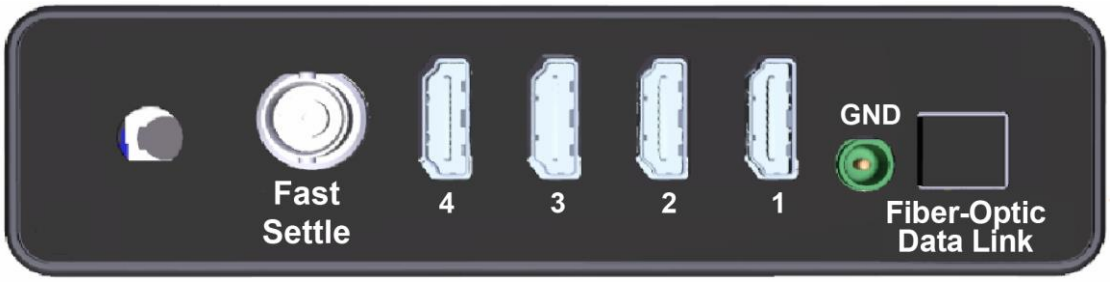
Status LEDs

There are six LEDs on the Digital Hub which can give the user information about the device status.

If the Digital Hub is powered (plugged in) the “Power” LED will be blue. The Digital Hub is powered by a medical grade power supply that is included as part of the Digital Hub packaging.

If the fiber-optic connection between the NSP and the Digital Hub is present, the “Fiber Optic Data Link” LED will be green (otherwise yellow).

Finally, LEDs 1-4 show the source status of the incoming data streams. If the LED is green for an input, then the Digital Hub is receiving data from a connected digital headstage correctly. If the LED is yellow then data is not being transmitted to the Digital Hub correctly. If the input LED is not lit then there is either no data being received or the Digital Data Cable is not plugged into the input slot.



Digital Inputs

The Digital Hub is designed so that input one has the highest priority, then input two, and so forth. This means that if two 96 channel Digital Headstages are connected, in inputs two and three respectively, input two will send the entire 96 channels to the Neural Signal Processor (NSP) but input three will send only the first 32 channels to the NSP. The Digital Hub will always send the first 128 channels to the NSP in this way, unless there are less than 128 channels in which case it will send all channels.

Patient Ground

This rear panel of the device has a green connection labeled GND. This is the patient ground connector if needed for a reference ground.

Fiber Optic Link

The fiber optic link connector is located on the back panel of the Digital Hub and provides a connection to the Blackrock Neural Signal Processor via a fiber optic cable.

Fast Settle

The fast settle input connector is located on the back panel of the Digital Hub. This connector is tied to each of the four Digital Data Cable inputs. The signal fed into the BNC connector is passed through the system to the connected digital headstages, providing a fast settle signal to the attached digital headstage(s). When the fast settle input receives a TTL high it will blank the signal.

Neural Signal Amplifier

The Amplifier receives analog signals directly from the electrodes or via headstages (e.g. unity-gain voltage followers) depending on the impedance of the electrodes. The analog signals are amplified, filtered (1st-order high-pass at 0.3 Hz and 3rd-order low-pass at 7,500 Hz), and digitized (30 kHz, 16-bits at 250 nV resolution), converted into the optical domain and then transmitted to the NSP via a fiber-optic link, which is immune to electromagnetic field interference. At a later stage, digital filtering will allow these two signals to be separated and recorded in different data files.

Figure 5–Neural Signal Amplifier

The Amplifier case is not connected to the earth ground. The Amplifier ground is isolated and floating. There are ESD shunt circuits that will conduct differences of 1000 V or more.

The Amplifier has four 34-pin banks. Each bank consists of 32 channels, a bank reference pin, and a ground pin. The electrodes within each bank are differentially amplified with respect to the reference input of the same bank. If channels on all banks are to be electrically measured with respect to a common reference, this reference needs to be connected to the reference input on every bank.

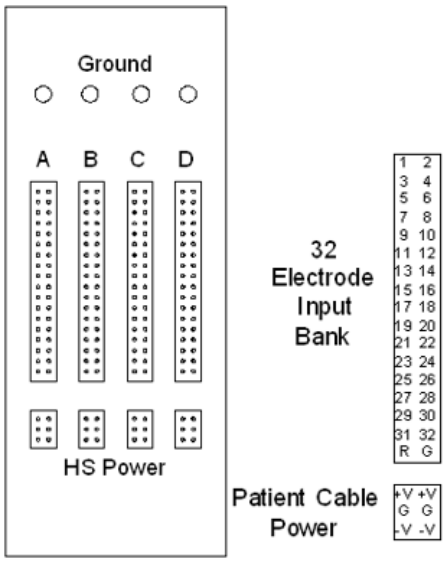


Figure 6–Amplifier Input Schematic

Additionally, four 6-pin APS banks provide power (± 5V) to the headstage and can deliver 130 mA of combined current from the Amplifier. The ground pins on every bank are tied together. For best results, the Amplifier should be the central grounding point for electrical ground connections to the patient.

Amplifier Power Supply (APS)

The APS consists of five analog and digital supply channels with monitoring, sequencing, and emergency shutdown controls.

Figure 7–Amplifier Power Supply

The On/Off switch is located on the back of the unit. Once it is switched on, the APS will start a power-up sequence of analog and digital supplies ending with the green ON LED illuminating. When the power switch is turned off this sequence is reversed, and the output of the APS is tied to ground. In the event of an error in voltage or power delivery, the APS will shut down and a red error LED will turn on. After checking all Amplifier and patient cable connections for any inadvertent shorting, turn off the APS and turn it back on to reset the error.

Cables

In addition to the above hardware components, the system also comes with a few cables. Note that standard power cables for the NSP, Front End Amp Power Supply, and/or Digital Hub are included, but not shown below. The fiber-optic cable is used to connect the Front End Amplifier or Digital Hub to the Neural Signal Processor, the Ethernet cable is used to connect the Neural Signal Processor to the recording computer, and the Front End Amplifier Power Supply cable is used to connect the Front End Amplifier to its power supply.

Figure 8–Fiber-optic Cable

Figure 9–Crossover Cable

Figure 10–Amplifier Power Supply (APS) Cable

Accessories

Blackrock sells accessories for use with the system. Primarily, these include headstages for interfacing the patient contacting electrodes to the system. The Digital Hub may have Digital Headstages attached to it and the Front End Amplifier may have analog headstages attached to it.

Digital Headstages

Digital Headstages are required to allow the Digital NeuroPort System to interface with electrodes. Which digital headstage to select depends on the connector type of the electrodes. These connector types and the selection process is not explained here, but is explained in the contents of the instructions for use for each digital headstage. The currently available digital headstages include:

- NeuroPlex E128 (PN 10906, 10907)
- NeuroPlex E96 (PN 10908, 10909)

Analog Headstages

The high input impedance and low bias current of the Amplifier inputs make it possible to connect microelectrodes with 20 kΩ (at 1kHz) or lower impedance values directly to the Amplifier inputs without the need for a headstage. This configuration has the advantage of avoiding noise added to the signals by the headstage, but it makes the application more susceptible to environmental electromagnetic noise. To minimize environmental noise, it is recommended to keep direct electrode connections shorter than 20 cm (8 inches). For longer connections, headstages from Blackrock Microsystems are recommended. Headstages allow microelectrodes with impedances up to 5-MΩ (at 1kHz).

Which analog headstage to select is dependent on the connector type on the electrodes. These connector types and the selection process is not explained here, but is explained in the contents of the instructions for use for each headstage. The currently available analog headstages include:

- 64 Channel Splitter Box (1-64) (PN 6832)
- 64 Channel Splitter Box (65-128) (PN 7121)
- 16 Ch Macro Cabrio Butterfly Adapter (PN 7698)
- 32 Ch Cabrio Butterfly Adapter (PN 6852)
- Cabrio Butterfly Adapter (PN 6480)
- Quad IDC-10 Adapter (PN 7341)
- Patient Cable with Impedance Tester (PN 4460)
- Patient Cable with Filament Film (PN 6735, 6736)

Digital Neural Signal Simulator (DNSS)

The Digital Neural Signal Simulator (DNSS) supplies simulated field potentials and action potentials (spikes) as well as sine waves at different frequencies. It can be used to test a recording system in lieu of being connected to a subject.

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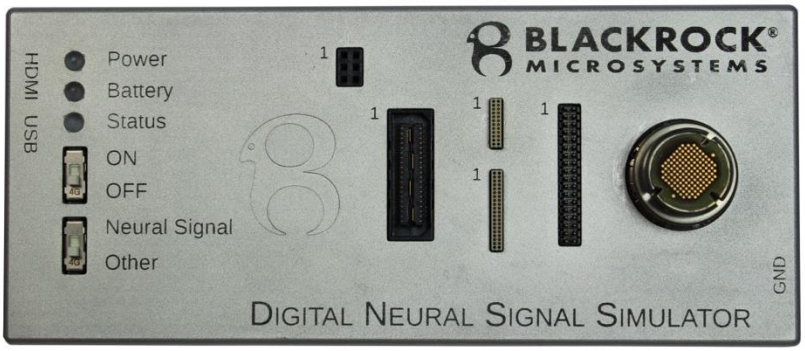


Figure 11–Digital Neural Signal Simulator

Software

Central can be run from the desktop shortcut, the Start menu shortcut, or by navigating to the executable in the Blackrock Microsystems directory in Program Files. The Central main application connects to a Blackrock Neural Signal Processor to configure hardware channels and acquire data. Incoming data can be processed and visualized in various ways before being saved for future analysis.

Central Main Window

Figure 12–Central Main Application

The Central Main window provides access to all functions, features, and settings within the Central Software Suite.

Hardware Configuration contains individual channel configurations as well as system settings. The main panel displays channels in icon or list view as selected in the tool bar. Double clicking selected channels will open the channel properties window for editing. Channels are filtered by clicking the categories listed on the left pane of the window. Additional settings are found under the Settings heading at the bottom of the left pane.

Spike Panel displays detected spikes on the front-end amplifier channels in a grid-graph form and is often the fastest way to visualize overall system function. If spike-sorting rules are defined, the spikes belonging to different units will be displayed in different colors. Double click any channel to display the Single Neural Channel Window.

Raster Plot displays the occurrence of spike events on many channels over time. All channel types may be shown in this window. Continuous traces and comments can also be shown on the plot.

Single Neural Channel displays the selected channel in a continuous data trace, strip chart, and waves panel. Use this window to define spike sorting rules and to view single channel activity.

Activity Map color codes the firing rate of neurons recorded by each electrode on a two-dimensional grid. An electrode map file dictates the spatial arrangement of channels. Use this window to quickly visualize spike rates over all channels.

File Storage contains the controls to start and stop recording. Additional settings, such as file type, name and path may be edited here.

Signal to Noise Ratio displays the ratio of signal to noise for each channel. Use this window to view and record valuable information about signal quality and electrode functionality.

Neural Modulation displays a histogram of changes in firing frequency over time. Use this window to see which channels are recording from neurons with variable firing rates.

Thresholding allows the user to set a global spike detection threshold as a value or a multiplier of the root mean squared signal energy.

Impedance Tester measures and displays the impedance of each electrode. Use this window to assess electrode functionality.

Crosstalk measures and displays the amount of signal shared between channels. Use this window to mark and disable redundant channels.

N-Trode allows configuration and visualization of N-Trode groups. The Spike Display at the top of the window shows spikes on each channel. The Peak/Valley panel is used to define spike units for the group. The Continuous Data Display shows the full signal from the group.

Oscilloscope visualizes the signal acquired by any channel. Use this window to view, measure and compare signals with custom triggers.

Digital Filter Editor is a MATLAB utility that creates custom digital filters which can be applied to acquired signals.

Add Comment creates a time-stamped text comment which is included in the neural events (.nev) file.

nPlay loads and replays saved data files for analysis and re-recording.

System Load displays the volume of incoming data from the Neural Signal Processor.

Menu Bar

The menu bar is found at the top of the Central Main window and contains File, Tools, and Windows drop-downs.

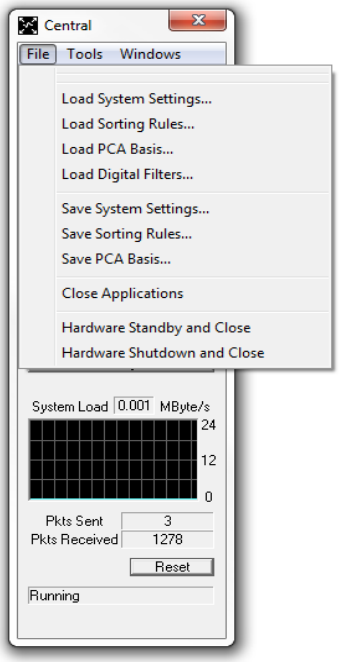


Figure 13–Central File Menu

File

The File menu contains functions to load and save various configuration files as well as the option to close applications and shut down the Neural Signal Processing hardware.

Load System Settings: Load channel settings in the '.ccf' and '.rcf' formats.

Load Sorting Rules: Load system-calculated Histogram Peak Count sorting rules in the '.csr' format.

Load PCA Basis: Load system-calculated principle component analysis basis vectors in the '.cfsd' format.

Load Digital Filters: Load digital filters in the '.xml' format created by the Digital Filter Editor.

Save System Settings: Saves the channel settings currently set in Hardware Configuration.

Save Sorting Rules: Saves spike-sorting parameters.

Save PCA Basis: Saves PCA basis vectors calculated during spike sorting.

Close Applications: Closes Central Suite programs while leaving the hardware running.

Hardware Standby and Close: Closes Central Suite programs and puts hardware into standby mode. The system must be in standby mode for firmware updates.

Hardware Shutdown and Close: Closes Central, all its associated applications and shuts down the Neural Signal Processor. Manually turn off the system power switch to complete hardware shutdown.

Tools

The Tools menu contains functions regarding thresholding, spike-sorting and general application settings. The spike sorting options are discussed on Page 39.

Options

Sets various general options for the Central Software Suite.

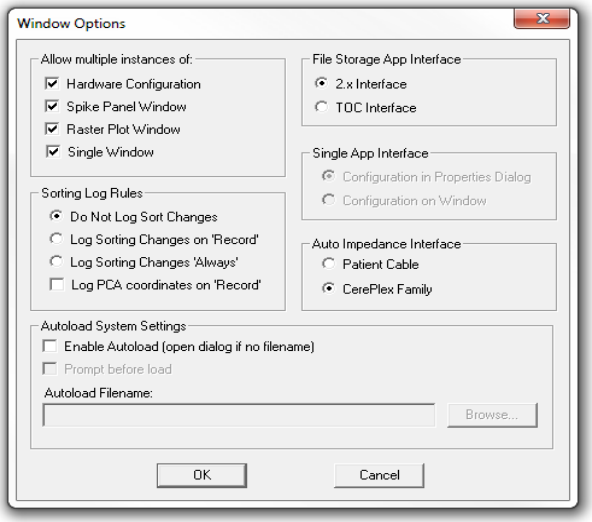


Figure 14–Central Options

Allow Multiple Instances Of

Allows more than one instance of each checked window type to be opened.

Sorting Log Rules

Sorting rules are the manually or automatically defined spike unit classifications used to recognize and separate neural spike events.

Do Not Log Sort Changes: Disables sort change logging.

Log Sorting Changes on ‘Record’: Will automatically log the spike-sorting model, the signal to noise ratio summary, and the crosstalk summary if rebuilt during recording.

Log Sorting Changes ‘Always’: Will log the spike-sorting model, the signal to noise ratio summary, and the crosstalk summary any time it is rebuilt.

Log PCA coordinates on ‘Record’: Will log the spike-sorting model only when recording begins.

File Storage App Interface

Choose to save files in the 2.x interface or the TOC interface. The TOC interface is designed to be used in a clinical setting where patient information is entered. The 2.x interface is preferable in a research setting where files are manually named. For more information of file types see Page 48.

Single Neural Channel App Interface

Allows changes to the channel configuration in Single Neural Channel viewer or in the *Edit > Properties* menu.

Auto Impedance Interface

Configures impedance testing for the Patient Cable or CerePlex headstages.

Autoload System Settings

Upon opening Central, the ‘.ccf’ file input below will be loaded. If the field is left blank, Central will prompt the user to select a ‘.ccf’ file.

Windows

The Windows menu contains system and software summary information as well as shortcuts to Central applications

About: Displays the version of the software and the firmware of the system. These version numbers may be needed if you contact Blackrock support.

System Summary: Displays average number of units per channel if using automatic histogram peak-count sorting. Options to disable cross talking channels and launch the impedance tester are also found here.

Hardware Configuration

The Hardware Configuration panel contains individual channel configurations as well as system settings. The main panel displays channels in icon or list view as selected in the tool bar. Double clicking selected channels will open the channel properties window for editing. Channels are filtered by clicking the categories listed on the left pane of the window. Additional settings are found under the Settings heading at the bottom of the left pane.

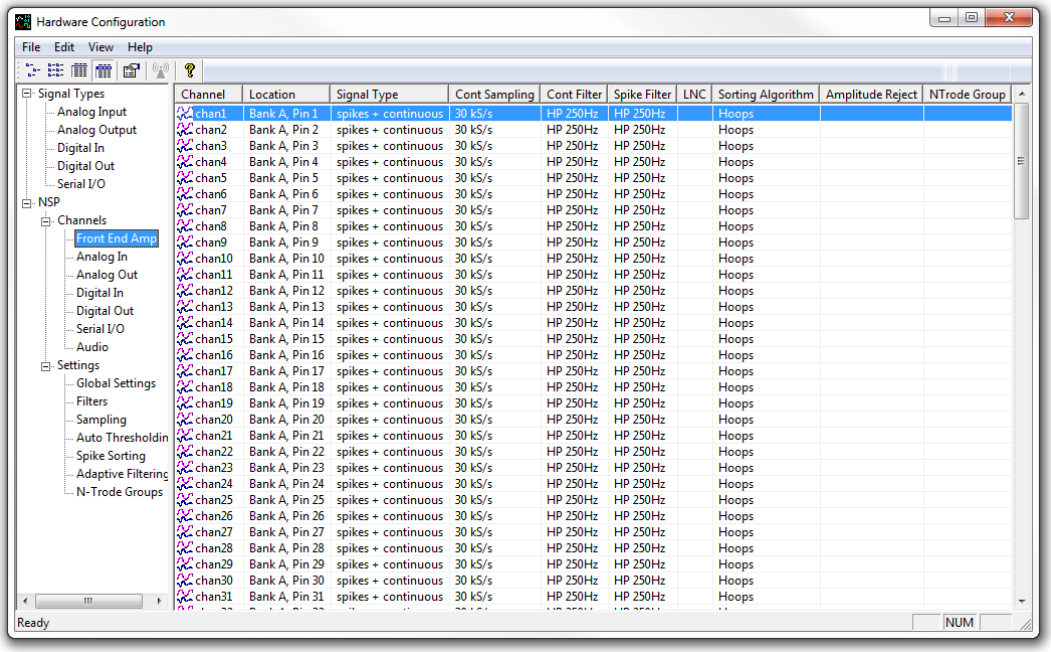


Figure 15–Hardware Configuration

Channel Sorting

Central Suite supports front end amplifier inputs, as well as analog, digital and serial inputs and outputs. Channels can be viewed in icon, list, or full row detail modes selectable in the tool bar on the toolbar. Each channel can be sorted based on function under Signal Types, or based on physical location under NSP Channels.

Configuring Channel Properties

Select one, or multiple channels in the right pane of the Hardware configuration window. Once all channels of interest are selected, right-click then select properties, or click the Channel Properties icon in the toolbar. Each channel type, and their respective options are described below.

Front End Analog Inputs

All parameters for front end input channels are listed below.

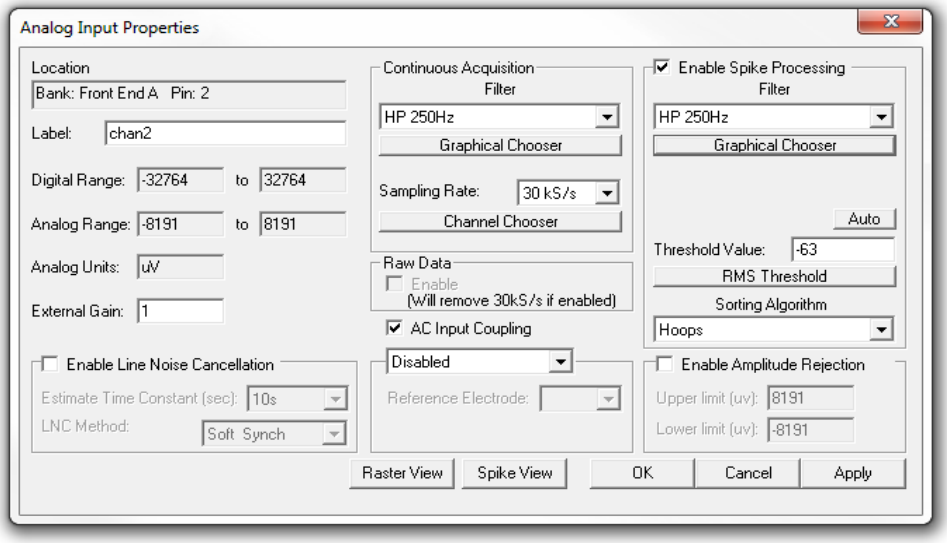


Figure 16–Analog Input Properties

Label: A user-defined name for the specific channel. Multiple channels labels can be automatically assigned

Digital Range: Fixed entry showing the range of digital values that analog signals are mapped to.

Analog Range: Fixed entry showing the range of analog values measured.

Analog Units: Unit of analog signal measurement displayed for reference.

External Gain: Gain value of the headstage. All Blackrock systems use a gain of 1.

Figure 17–Edit Multiple Labels

Enable Line Noise Cancellation: Enables cancellation of 50 or 60 Hz noise.

Estimate Time Constant: The period over which line noise parameters are determined.

LNC Method: Selects software or hardware line noise cancellation.

Filter: Select a digital filter to apply to continuous data.

Graphical Chooser: Visualize the continuous signal filter in place.

Sampling Rate: Select the sampling rate of data acquisition.

Channel Chooser: Select the sampling rate for data acquisition on any channel.

Raw Data: Record raw data stream before filtering or sorting is applied.

AC Input Coupling: High pass filter to remove DC offset.

Software Reference Selection: Apply software referencing to local field potential or both Local field potential and spike data.

Reference Electrode: Select channel to use as software reference.

Enable Spike Processing: Allow detection of spike events on channel.

Filter: Filter selection for spike event processing.

Graphical Chooser: Allows visualization of the spike processing filter in place.

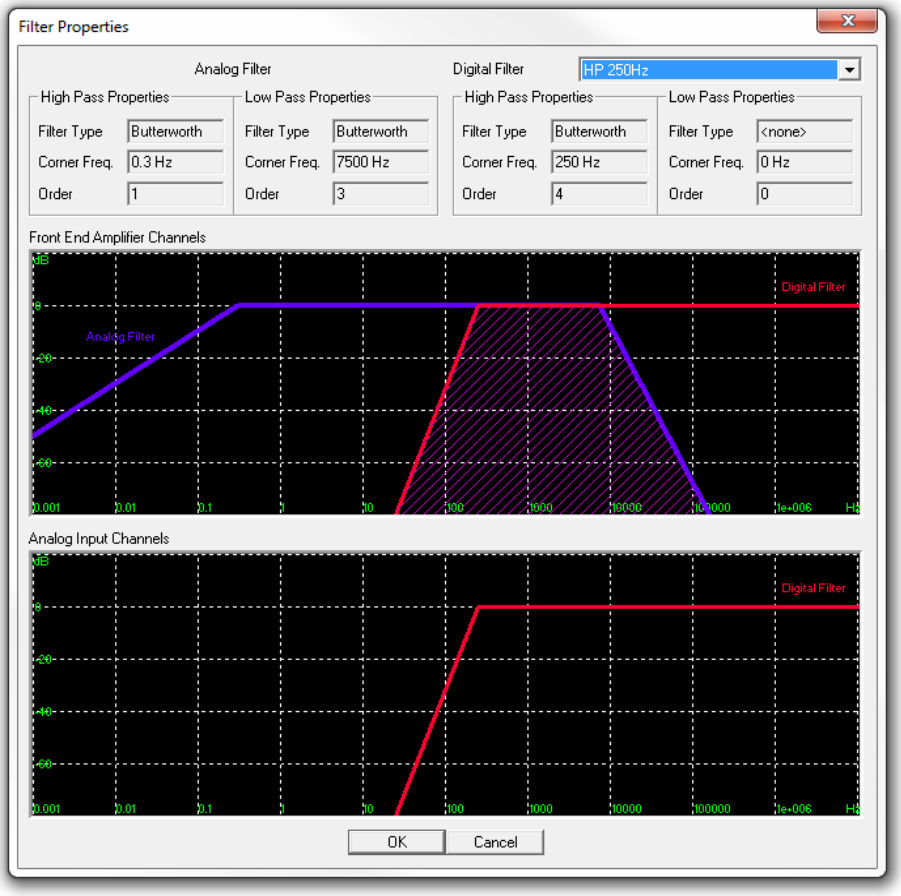


Figure 18–Filter Properties

Threshold Value: Voltage threshold for classification of a spike event in mV.

RMS Threshold: Set parameters for auto-threshold calculation.

Sorting Algorithm: Set the sorting algorithm for a channel as described in Spike Sorting on Page 39.

Enable Amplitude Rejection: Rejects waveforms exceeding a specified amplitude.

Upper/Lower Limit (uV): Voltage limits for amplitude rejection.

Analog Output

Analog output properties are accessed from the left side bar of the Hardware Configuration window and allows the user to set the properties of the analog output ports. Analog outputs can function as monitor channels, directly mirroring signals of interest, or as waveform generators. Each modality has output and triggering parameters defined below.

Label: User-defined channel label.

Function: Assigns the analog channel function.

Analog Output: Continuous Monitor

An analog output channel configured as a continuous monitor will scale a user input signal into a plus or minus 5 V output signal.

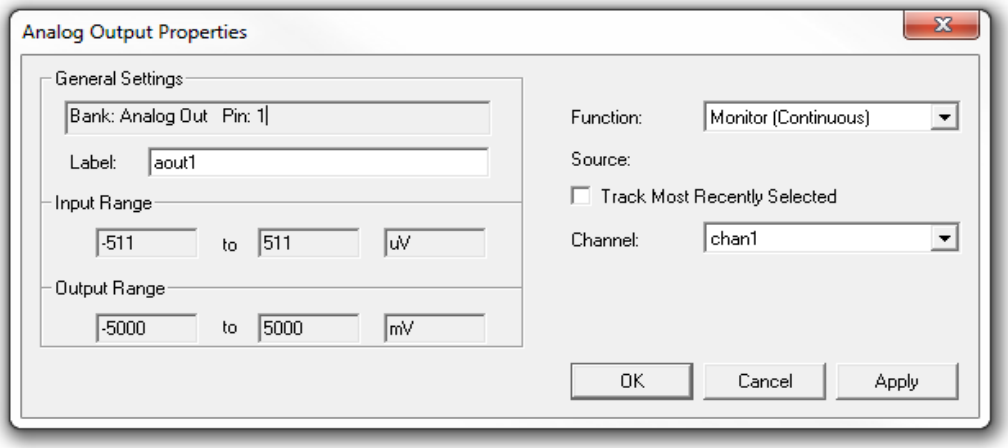


Figure 19–Analog Output: Continuous Monitor

Input Range: Input voltage range displayed for reference.

Output Range: Output voltage range displayed for reference.

Track Most Recently Selected: When enabled, the channel selected in Spike Panel, Single Neural Channel, or Raster Plot view is used as the monitor input.

Channel: An analog output channel configured as a spike monitor will scale a user selected input signal into a plus or minus 5 V output signal.

Analog Output: Spike Monitor

An analog output channel configured as a spike monitor will scale a user selected input signal into a plus or minus 5 V output signal containing only identified spike events.

Input Range: Input voltage range displayed for reference.

Output Range: Output voltage range displayed for reference.

Track Most Recently Selected: When enabled, the channel selected in Spike Panel, Single Neural Channel, or Raster Plot view is used as the monitor input.

Channel: An analog output channel configured as a spike monitor will scale a user input signal into a plus or minus 5 V output signal containing only identified spike events.

Analog Output: Sine Waveform

An analog output channel configured as a sine waveform generator will produce a user defined sine wave on a user defined trigger stimulus.

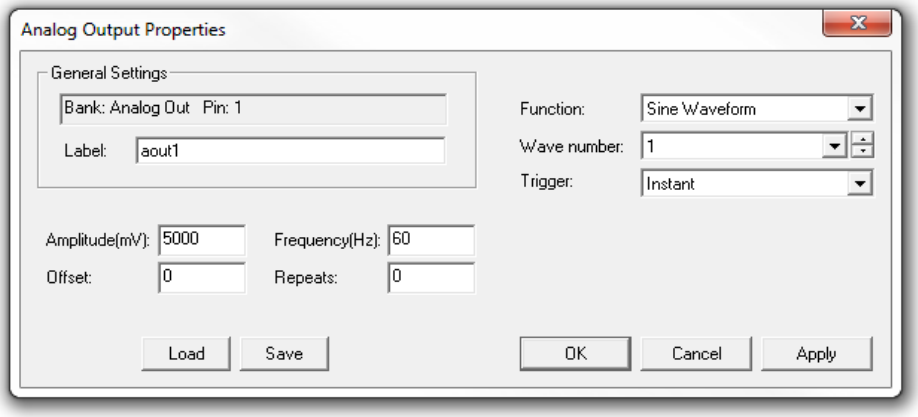


Figure 20–Analog Output: Sine Generator

Amplitude (mV): Amplitude of the output sine wave.

Frequency (Hz): Frequency of the output sine wave.

Offset (mV): DC offset of the output sine wave.

Wave Number: Select which of five waveforms are configured and used.

Trigger: Triggering options are explained on Page 34.

Analog Output: Custom Waveform

An analog output channel configured as a custom waveform generator will produce a user defined waveform on a user defined trigger stimulus.

Wave Number: Select which of five waveforms is configured and used.

Number of Phases: Number of voltage phases in the waveform. 248 are available.

Offset (mV): DC offset of the waveform.

Phase: Selects which phase is being configured.

Amplitude (mV): Phase amplitude.

Duration (ms): Phase duration.

Repeats: Indicates the number of times to repeat the waveform once triggered. A value of 0 will repeat the waveform indefinitely.

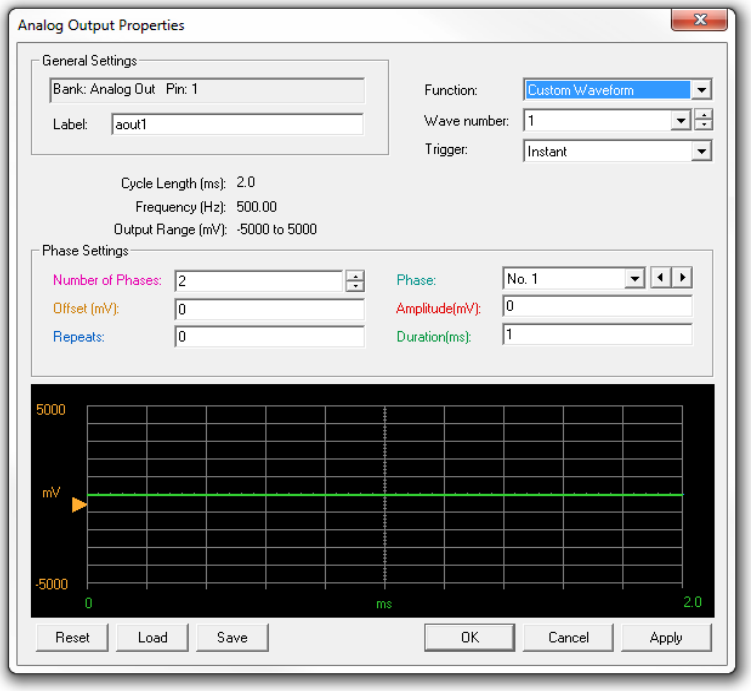


Figure 21–Analog Output: Custom

Analog Output: Triggering

Sine and custom waveforms can be triggered by different conditions listed below.

Instant: Waveform triggers when OK or Apply are clicked.

Digital Input Rising Edge: Waveform triggers when a user defined digital input pin transitions from low to high. A digital input bit must be selected.

Digital Input Falling Edge: Waveform triggers when a user defined digital input pin transitions from high to low. A digital input bit must be selected.

Spike Unit: Waveform triggers when a sorted unit is detected on a defined channel.

NeuroMotive ROI: Triggers when a subject enters or exits a selected region of interest.

Extension: Waveform triggers based on custom extension code loaded onto hardware.

Digital Input

Digital input properties are accessed from the left side bar of the Hardware Configuration Window and allows the user to set the properties of the digital input ports. Digital inputs can synchronize external hardware and pass digital data into neural recordings. Digital Inputs may take on the functions listed below.

16-bit on word strobe: Reads 16 bits on the rising edge of the strobe pin.

16-bit on bit changes: 16-bit read when any bit changes from LOW to HIGH or from HIGH to LOW.

16-bit on rising edge: 16-bit read when any bit changes from LOW to HIGH. Each bit indicates if a LOW to HIGH change occurred on each digital pin.

16-bit on falling edge: 16-bit read when any bit changes from HIGH to LOW. Each bit indicates if a HIGH to LOW change occurred on each digital pin.

8-bit strobe / 8-bit bit changes: Reads bits 0-7 on the rising edge of the strobe pin and reads bits 8-15 if bits 8-15 changed from LOW to HIGH or HIGH to LOW.

8-bit strobe / 8-bit bit rising edge: Reads bits 0-7 on the rising edge of the strobe pin, and bits 8-15 indicate if digital pins D8-D15 changed from LOW to HIGH.

8-bit strobe / 8-bit bit falling edge: Reads bits 0-7 on the rising edge of the strobe pin, and bits 8-15 indicate if digital pins D8-D15 changed from HIGH to LOW.

Digital Output

The Digital Output Window is accessed from the left side bar of the Hardware Configuration Window and allows the user to set the properties of the digital outputs. Digital outputs can function as spike detection monitors, timed function generators, or triggered events.

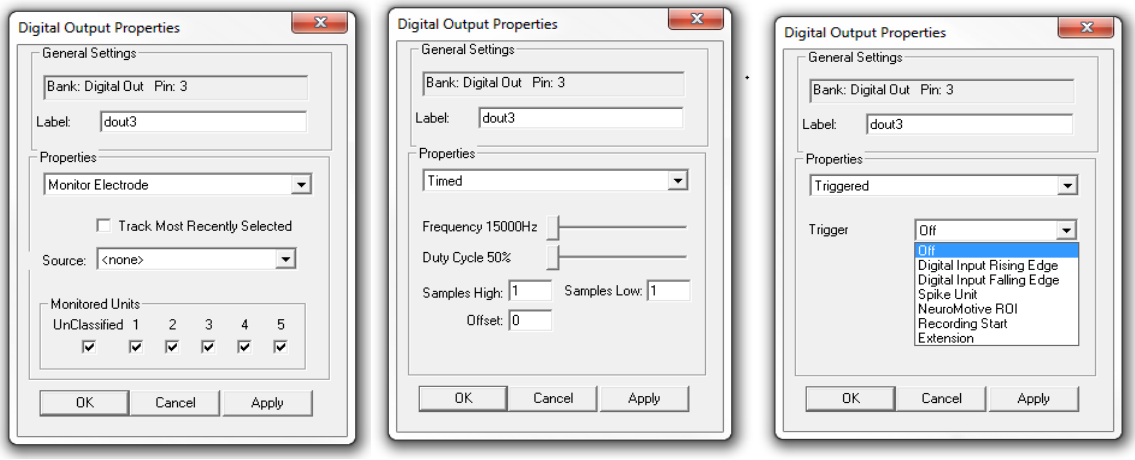


Figure 22–Digital Output Properties

Digital Output: Monitor Electrode

A digital output in monitor electrode mode will send a high pulse when a sorted spike unit is detected on a defined channel.

Track Most Recently Selected: When enabled, the channel selected in Spike Panel, Single Neural Channel, or Raster Plot view is used as the monitor input.

Source: Select which channel to monitor.

Monitored Units: Select which spike unit classifications to trigger on.

Digital Output: Timed

A digital output in timed mode will send a pulse train with specified parameters. The signal can be configured by setting frequency and duty cycle, or samples high and low.

Frequency (Hz): The number of pulses per second.

Duty Cycle: The percentage of time a pulse train is high.

Samples High: Number of 30kHz sample periods output should be held high.

Samples Low: Number of 30kHz sample periods output should be held low.

Offset (mV): DC offset voltage of the digital output.

Digital Output: Triggered

A digital output in triggered mode will send a pulse when the selected trigger stimulus occurs.

Digital Input Rising Edge: Waveform triggers when a user defined digital input pin transitions from low to high. A digital input bit must be selected.

Digital Input Falling Edge: Waveform triggers when a user defined digital input pin transitions from high to low. A digital input bit must be selected.

Spike Unit: Waveform triggers when a sorted unit is detected on a defined channel.

NeuroMotive ROI: Waveform triggers when a subject enters or exits a region of interest.

Extension: Waveform triggers based on custom extension code loaded onto hardware.

Serial I/O

The Serial I/O Properties window displays the serial communication parameters and allows the user to name and enable the serial port. Serial communication parameters cannot be changed.

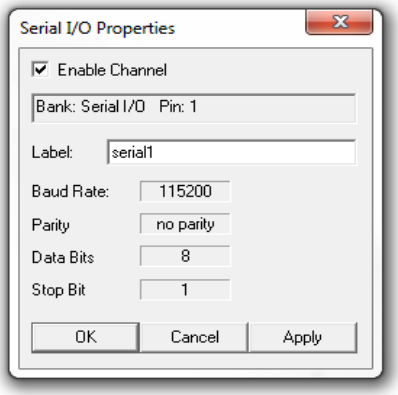


Figure 23–Serial I/O

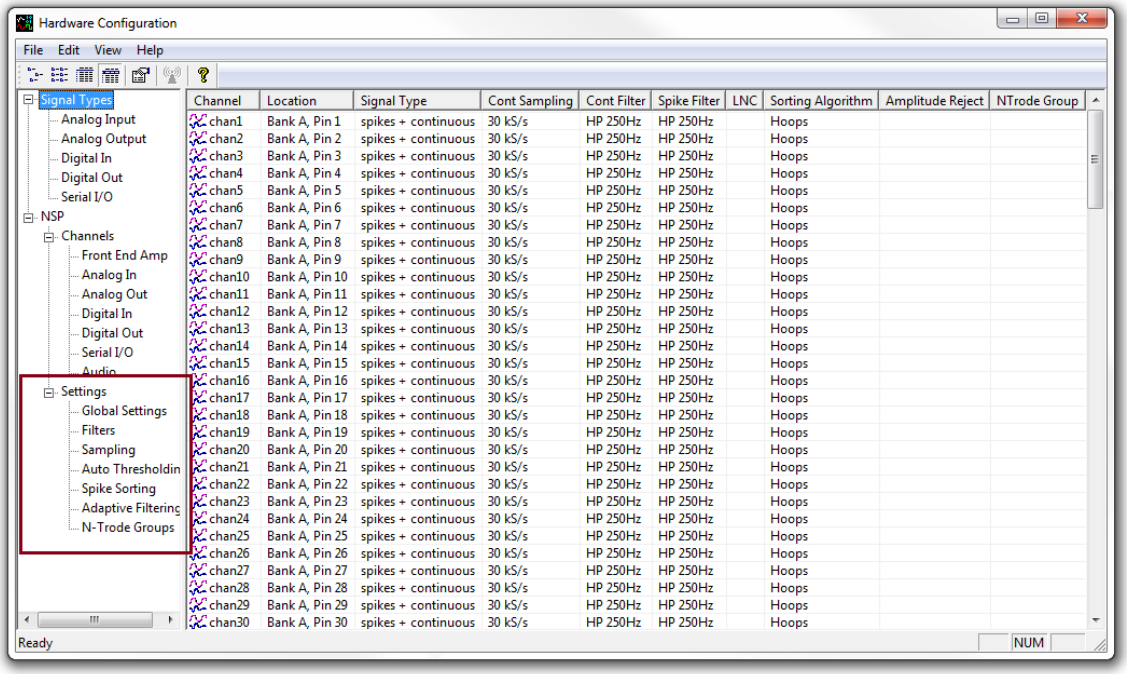


Figure 24–Hardware Configuration Settings

Global Settings

Spike Width (samples): The number of samples recorded around a detected spike event.

Pre-threshold Samples: The number of samples to record preceding a threshold crossing.

Line Noise Frequency (Hz): The line frequency of the system, either 50 Hz or 60 Hz.

LNC Reference Channel: The reference channel used to compute system line noise. The extracted line noise template for each channel can be viewed in Single Neural Channel when the Raw/LNC button is checked.

Filters

This window displays the details of a selected digital filter in a bode plot and key numerical parameters.

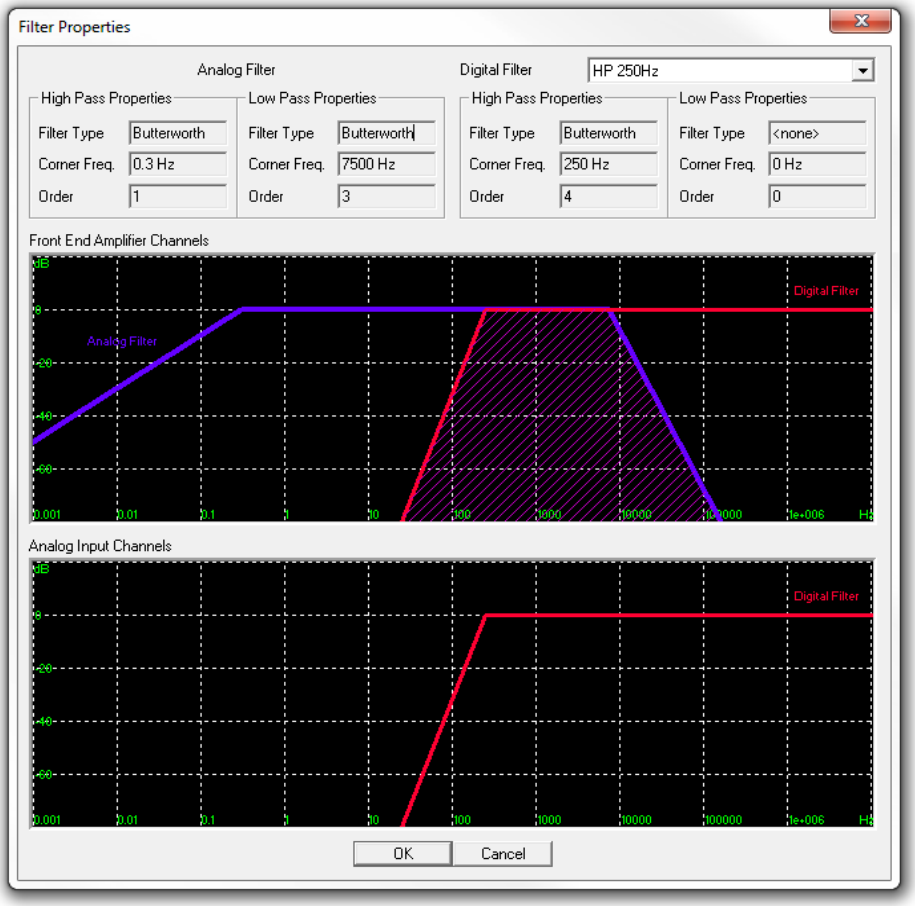


Figure 25–Filter Properties Display

Auto Thresholding

This window allows the user to specify the auto thresholding properties for spike detection.

Threshold Multiplier: To register as a spike event, signal energy between 1 and 5 kHz must exceed the energy of the noise by a factor of the threshold multiplier level.

Channel: Applies noise boundary properties to this channel.

Dimensions of the Ellipsoid: Radius of the noise ellipsoid in the along each axis.

Center of Ellipsoid: Center of the noise ellipsoid in cartesian coordinates.

Rotation of Ellipsoid: Rotation angle of the noise ellipsoid around each axis.

Spike Sorting

The Spike Sorting Properties Window allows the user to specify the rules and settings for the spike sorting algorithms. The default settings are recommended but altered settings may produce better results in unique use cases. Four spike sorting methods are available: Manual PCA, k-means PCA, DBSCAN PCA, and Histogram Peak Count. Each method is described below.

Manual PCA

Manual PCA uses principle component analysis to generate a feature point for each spike event. The user manually defines unit classifications by drawing an ellipsoid around each cluster of feature points within the feature space.

Wave Basis Size: The number of waveforms to use to calculate the PCA basis vectors.

Update Basis Multiplier: The PCA basis vectors will be recalculated after the number of samples exceeds the basis size times the basis multiplier. Zero means don't recalculate.

k-means PCA

k-means PCA algorithms automatically generate ellipsoids around k number of clusters to sort recorded units.

Wave Basis Size: The number of waveforms to use to calculate the PCA basis vectors.

Update Basis Multiplier: The PCA basis vectors will be recalculated after the number of samples exceeds the basis size times the basis multiplier. Zero means don't recalculate.

Outlier Removal: Removes outliers exceeding this number of standard deviations from the centroid of each group.

Minimum Group Size: Remove any groups that have fewer than this number of spikes.

Merge Centroids: Merge two groups if the merged group has a standard deviation less than this multiplier times the product of the standard deviations of both groups.

Number k-means groups: Number of k-means groups to use for sorting.

DBSCAN PCA

Density Based Spatial Clustering of Applications with Noise is a principle component analysis method that automatically chooses the quantity, radius, and position of each cluster based on point density.

Wave Basis Size: The number of waveforms to use to calculate the PCA basis vectors.

Update Basis Multiplier: The PCA basis vectors will be recalculated after the number of samples exceeds the basis size times the basis multiplier. Zero means don't recalculate.

Histogram Peak Count

Collected waveforms are broken down into high frequency and low frequency components. Each spike event is plotted on an axis composed of these two components. A histogram is constructed and clusters are estimated by determining peaks and valleys.

Valley Percentage: A valley is identified at a height less than the first peak height times the valley percentage value.

Close Peak Percentage: The second peak is identified at the height of the valley plus the height of the three-point mean centered at the valley multiplied by the close peak percentage.

Freeze Time (minutes): Time spent analyzing the number of units on each channel.

Update Rate (# spikes): The number of spikes that must be collected within each unit before the histogram is updated.

Minimum Peak Percentage: Minimum peak height is calculated by adding the valley height to the total number of samples used times the minimum peak percentage.

Artifact Rejection

Maximum Simultaneous Channels: If more than the maximum number of channels contain simultaneous spike events, the events are all rejected.

Refractory Period: The number of samples for which spike detection is barred after a spike event.

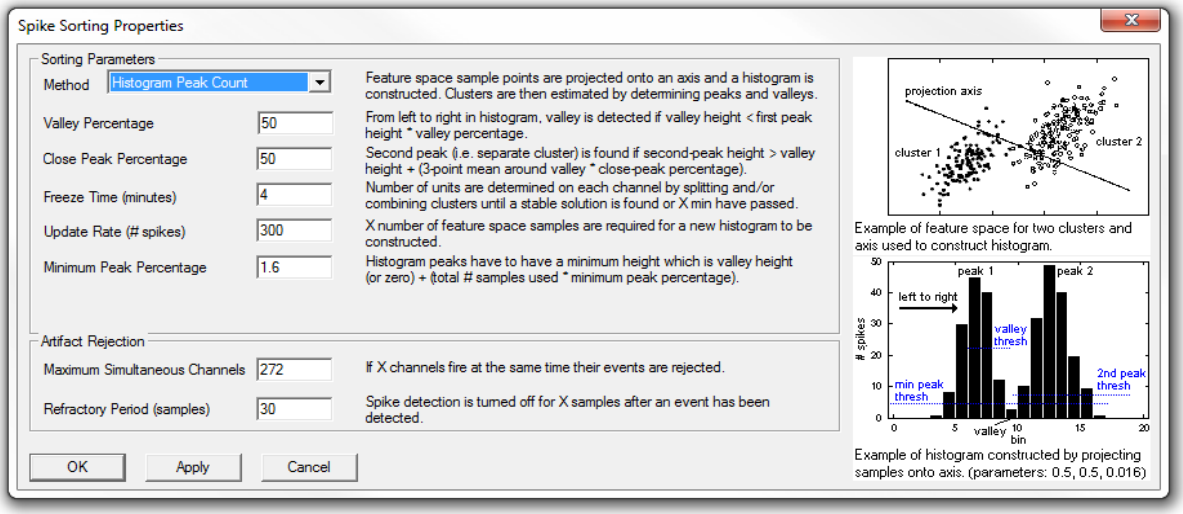


Figure 26–Spike Sorting Properties

Tools Menu

The main Central Window Tools menu contains several Spike Sorting options.

Thresholding: Set the manual threshold level for all channels as an RMS multiplier or a fixed voltage value.

Options: See below.

Lock Unit Statistics: Disables continuous updates of spike sorting rules.

Rebuild Spike-sorting Model: Restarts the automatic spike-sorting function.

Continuous Spike Sorting: Selecting this item will continuously adjust the spike-sorting statistics including the splitting and merging of units. This is not recommended for use while recording.

Build PCA: Builds the PCA basis vectors for all channels with PCA based spike sorting.

Assisted Spike Sorting: Enable k-means, DBSCAN, or all PCA methods for spike sorting.

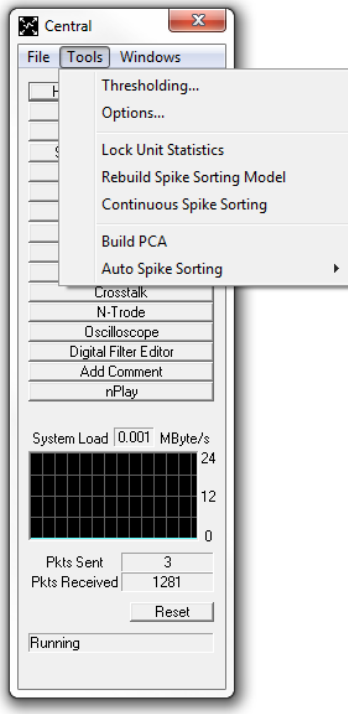


Figure 27–Tools Menu

Adaptive Filtering

Recorded signals may contain unwanted information from sources of external noise, such as magnetic eye-tracking systems, monitors, and subject reward systems. The Adaptive Filtering feature can use a noise signal as a reference for neural signal channels.

Adaptive Filtering: Choose one or two channels to reference.

Reference Channels: Select channels to be used as references.

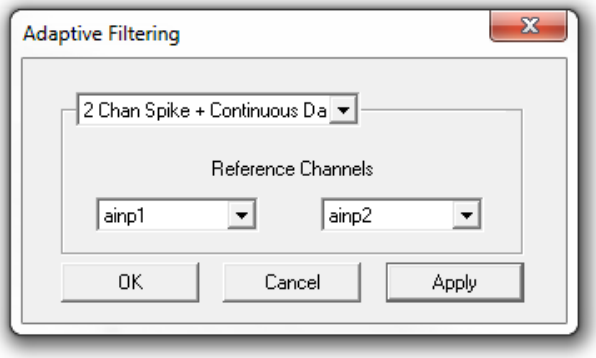


Figure 28–Adaptive Filtering

N-Trode Groups

N-Trode channel groupings are user defined electrode subsets created to record signals from proximal regions. When any single unit spike is detected within the N-Trode, the signals from all component electrodes are saved and registered as events. The Central Suite supports multiple N-Trode sets containing up to four electrodes each. Multiple single channels are linked and spike sorting occurs on the N-Trode as a single entity. To define N-Trode groups, open a group and add channels to it with the arrow buttons or by double clicking.

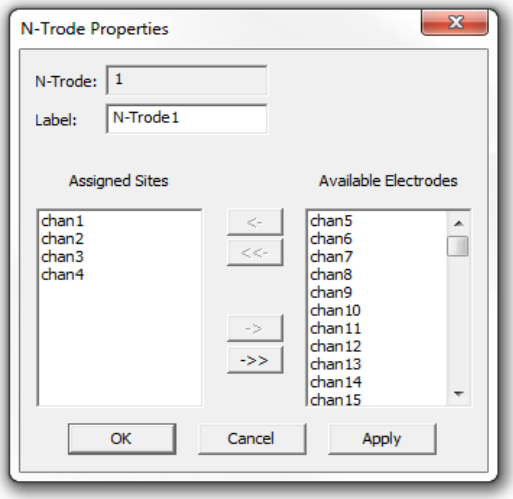


Figure 29–N-Trode Properties

Spike Panel

Spike panel displays detected spikes on the front-end amplifier channels in a grid-graph form and is often the fastest way to visualize overall system function. Double click any channel to display the Single Neural Channel window. The layout and graphical settings of the grid and individual channels can be changed in the right-click menu or the toolbar. A map file can be applied to the display to change the spatial arrangement of the channels on the screen to match the electrode array in use. If spike-sorting rules are defined, the spikes belonging to different units will be displayed in different colors.

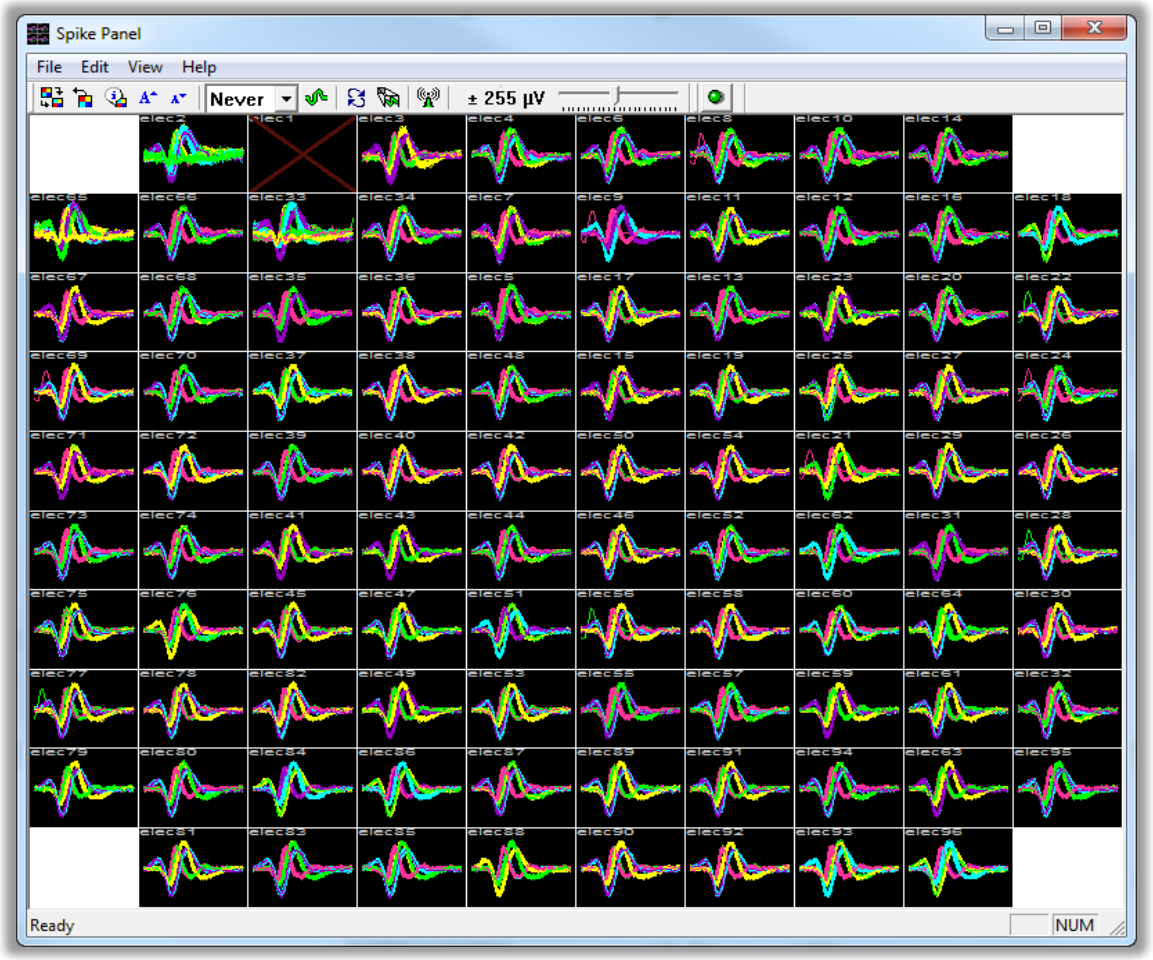


Figure 30–Spike Panel

Spike Panel Settings

Load Map File: The default map file for the spike panel is a 16x8 grid. Custom map files matching the spatial arrangement of your electrode ship with each Blackrock Electrode Array. Contact Blackrock Support at support@blackrockmicro.com for an additional copy of this file.

Load Default Map File: The default channel map will be loaded.

Map File Information: Display information about the current map file.

2 sec **Time to Screen Refresh**: Set the length of time spike waveforms will trace without refreshing.

Open Selected Channels: Individual or groups of channels can be viewed by selecting Open Selected Channels in the right-click menu or the top menu bar.

Show Labels: Display channel information on the cursor.

Refresh Screen: Manually refresh the spike panel display.

Magnify Current Channel: Toggle mouse-hover magnification

± 255 µV **Spike Scale**: Adjust the visual amplitude of displayed spikes.

Broadcast Channel Selections: Duplicate channel selection on other instances of Central running on computers connected to an Ethernet switch.

Level of Criticality: Display the current application load.

Raster Plot

The Raster Plot displays the occurrence of spike events on many channels over time. All input channel types may be added, removed, moved, and scaled in this window. Continuous traces and comments can also be shown on the plot.

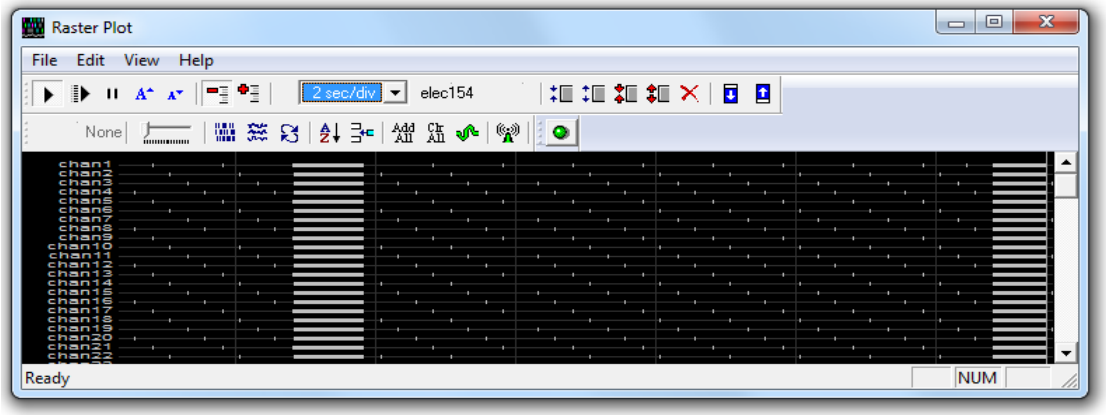


Figure 31–Raster Plot

Tool Bar

 Play: Configure the display to fill and then refill repeatedly.

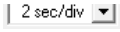
 Scroll: Configure the display to scroll right to left.

 Pause: Pause the display.

 Increase/Decrease Font Size: Change the font size of channel labels.

 One Line per Channel: Display all units from each channel on one line.

 Split Channels: Display each unit on a separate line.



Seconds per Division: Change the time scale markers on the plot.

 Decrease/Increase Size: Change the size of selected channels.

 Minimize/Maximize Size: Minimize or maximize the size of selected channels.

 Delete: Remove selected channel from the plot.

 Move Up/Down: Move selected channels through the channel list.

Continuous Data Scale: Set the amplitude of continuous signals.

 Show Neural Events: Display neural events as impulses on the raster plot.

 Show Continuous Data: Display continuous channel trace.

Raw Toggle: Toggle between filtered continuous and raw data.

 Update: Refresh the display.

 Sort: Sort channels in the raster plot display by Channel ID, Recording Mode, or Unit ID.

 Choose Channels: Select channels to display.

 Add All: Display all channels.

 Clear All: Remove all channels from display.

 Open Selected Channels: Open selected channels in Single Neural Channel.

 Broadcast Channel Selections: Duplicate channel selection on other instances of Central running on computers connected to the Ethernet switch.

 Level of Criticality: Display the current application load.

Single Neural Channel

Single Neural Channel visualizes the selected channel in a continuous data trace, strip chart, and waves panel. Spike sorting is configured in this window.

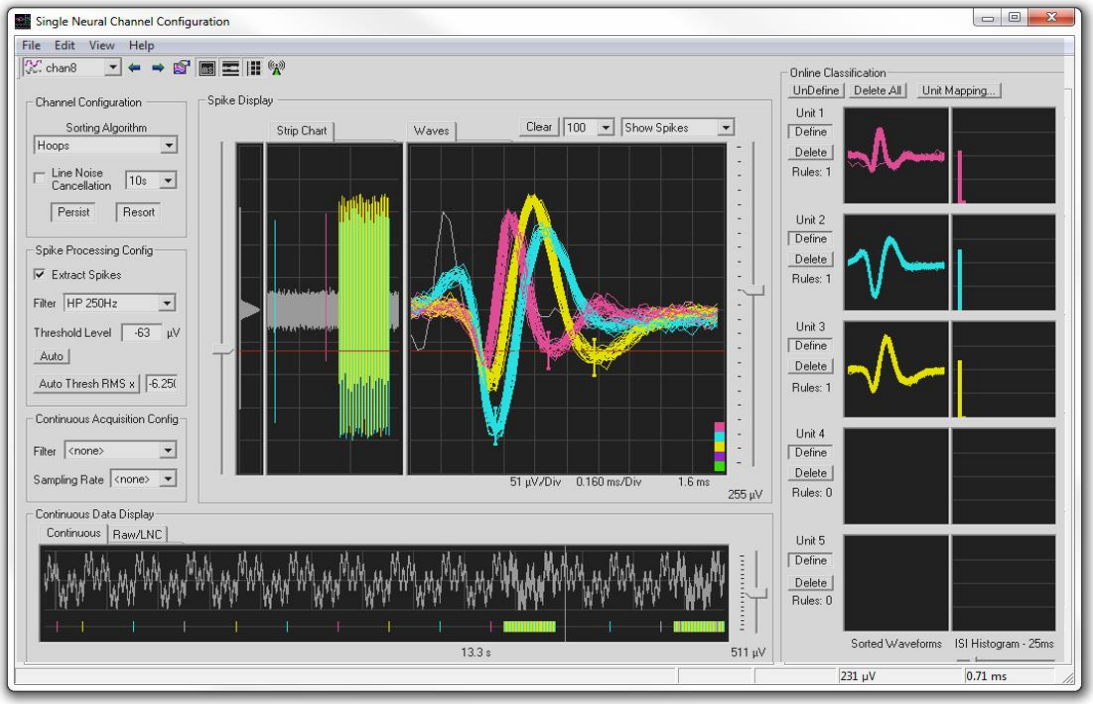


Figure 32–Single Neural Channel

Channel Configuration

chan3 Channel ID: Select a channel from the drop-down menu.

Channel Selector: Scroll through channels.

Channel Properties: Open the Channel Properties window.

Persist Spikes: When selected, the last detected spikes will remain in the wave viewer for sorting.

View Tool Tip: Display time and amplitude values at the cursor position.

View Continuous: Toggle the Continuous Data Display.

View Classification: Toggle the Online Classification Display.

Broadcast Channel Selections: Duplicates channel selection on other instances of Central running on computers connected to the Ethernet switch.

Spike Display

The spike display panel shows neural events. It contains the wave panel where spikes can be visualized and sorting hoops can be defined, as well as the strip chart. Use the vertical slide button at the right of the panel to set the voltage range. The default time scale of the spike display window is 1.6 milliseconds. The samples width of each spike can be defined in the Global Settings section in the Hardware Configuration module within a range of 1.0 to 4.3 milliseconds.

Clear: Clear the spike display. Automatic clearing will occur as well, maintaining the number of spikes shown in the drop-down menu.

Show Spikes: Select which spike units to display.

Hoops Spike Sorting: To define a spike unit, click Define next to a unit window box on the right side of the window. A color box will appear in the lower right of the spike window. Drag the selector to include all contacted waveforms in the unit. Only waveforms within a selection will be classified. The Define All button will initialize all five units.

Unit Mapping: Select unit definitions to remap, combine, or map to noise.

3D PCA On-line Spike Classification: If manual PCA is selected, spike sorting is performed using online PCA analysis within the PCA space. PCA spike sorting can classify up to five different signals per channel, each selected signal receives a separate color. An ISI Histogram is also displayed for each classified spike.

A user can sort an individual channel by clicking on the Feature tab. Click the Define button next to the classified spike to sort that unit. Hold the Ctrl key and draw around the cluster. An ellipsoid will be created which is used to define a unit. You may also change the size of the ellipsoid by pressing R then moving the handle.

k-means & DBSCAN PCA: Generates ellipsoids when the k-means or DBSCAN PCA is selected in the Feature tab.

Manual Override Options

Automatic spike sorting can be overridden on an individual channel by clicking on the Pattern view. Click the Edit button next to the classified spike to resort to a manual sorting option. Press <C> to see all available controls. Hold down the <Ctrl> key and draw an ellipse in the Pattern view around the cluster that you would like to define as a spike. You may also change the diameter of the ellipse. Once the ellipse is placed around a cluster of points. The word “Overridden” will appear next to the sorted unit.

File Storage

Central Software Suite supports file storage via the TOC and 2.x interfaces. 2.x is the most common basic file interface for research. The TOC interface names files with a timestamp and patient name, as well as file splitting long recordings. Data files are saved in .nsx format. .nsx data is stored in bits with 250 nV/bit resolution. Timestamps appended to filenames by Central use Greenwich Mean Time (GMT) referencing your local computer's clock and time zone information.

TOC Interface

The TOC interface allows the user to enter patient information and select a path for the files that are created when the session is initiated. The Central Software Suite assigns a numeric name to the files which indicates the date and time of the recording. For example, 20110124-152145 indicates that the data file was recorded on January 24, 2011 at 3:21:45 PM GMT. System settings will be saved in the same folder as the data file.

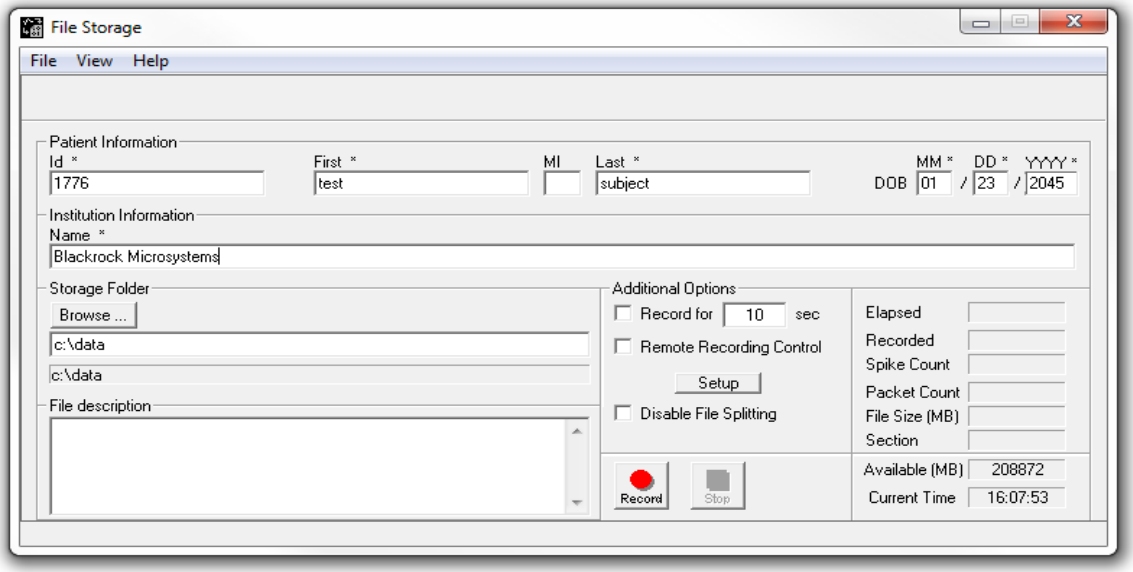


Figure 33–TOC Interface

File Splitting: Splitting large files into smaller sizes may aid offline analysis. File size limit is defined in the *View* > *Options* menu. To disable file splitting, check the disable file-splitting box in the file storage module.

File Description: Up to 256-character comments can be entered here to be saved with the file. Comments need to be entered prior to recording a data file.

Record For: Specify an amount of time that the Central Software Suite will record data. Once the time has expired, the recording will stop automatically.

Remote Recording Control: Allows digital in signals to Start, Stop, Pause, and Resume file recording through the digital input port, or the serial I/O port. Click the Setup button below the remote recording check box to set user-defined hex values for each remote recording function. For an example of remote recording control see Page 64.

Record: Begin recording data.

Pause: Pause recording.

Stop: Stop recording and save file.

2.x Interface

The 2.x interface allows the user to specify a file name and path for the next data set. Recording can be started and stopped from this window or set to stop after a specified duration.

File Options: Select sampling frequency of recorded data.

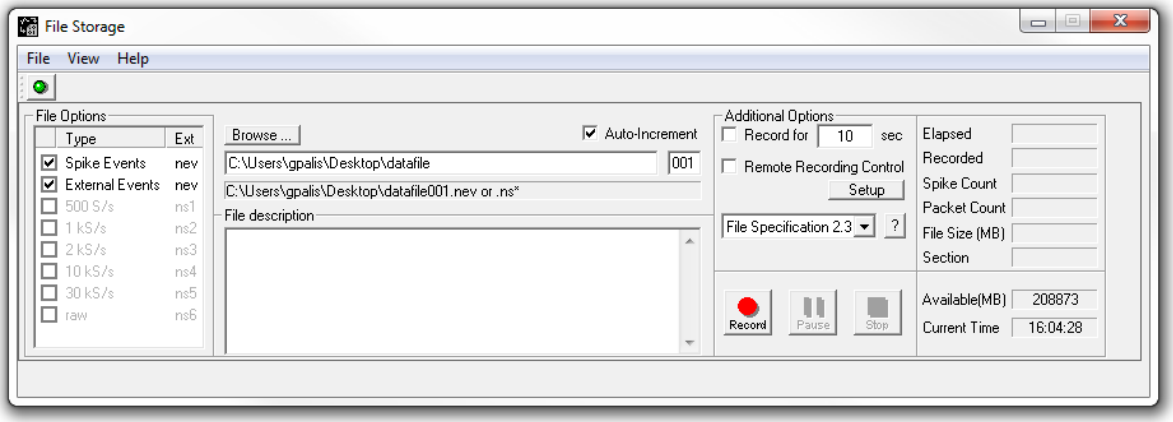


Figure 34–2.x Interface

File Name and Path: Browse to, or type in, the desired file name and path.

Auto-Increment: Enable automatically incrementing the data file names with an appended numeral.

File Specification: Choose between the different file specifications. It is advised to always use the most current specification.

File Storage Options

After opening the File Storage Window, options can be found under View menu.

Enable Sync Pulse: Send a unique waveform pattern every 14 seconds and repeat patterns hourly.

Invert Sync Pulse: Invert the high and low phases of the sync pulse.

Remove Noise: Do not save waveforms classified as noise during spike sorting.

Sync with NeuroMotive Recording: Enable syncing with the NeuroMotive video recording and tracking system.

Split File Interval: Enter either a duration or file size limit for each file segment. If file size is specified, click on “Calculate Time” to automatically populate the “Estimated Time” field.

Digital Oscilloscope

The digital oscilloscope can display and measure two input channels on screen at a resolution of 0.1 milliseconds per division. Signals can be viewed continuously or on a specified trigger. Frequency spectra can also be displayed.

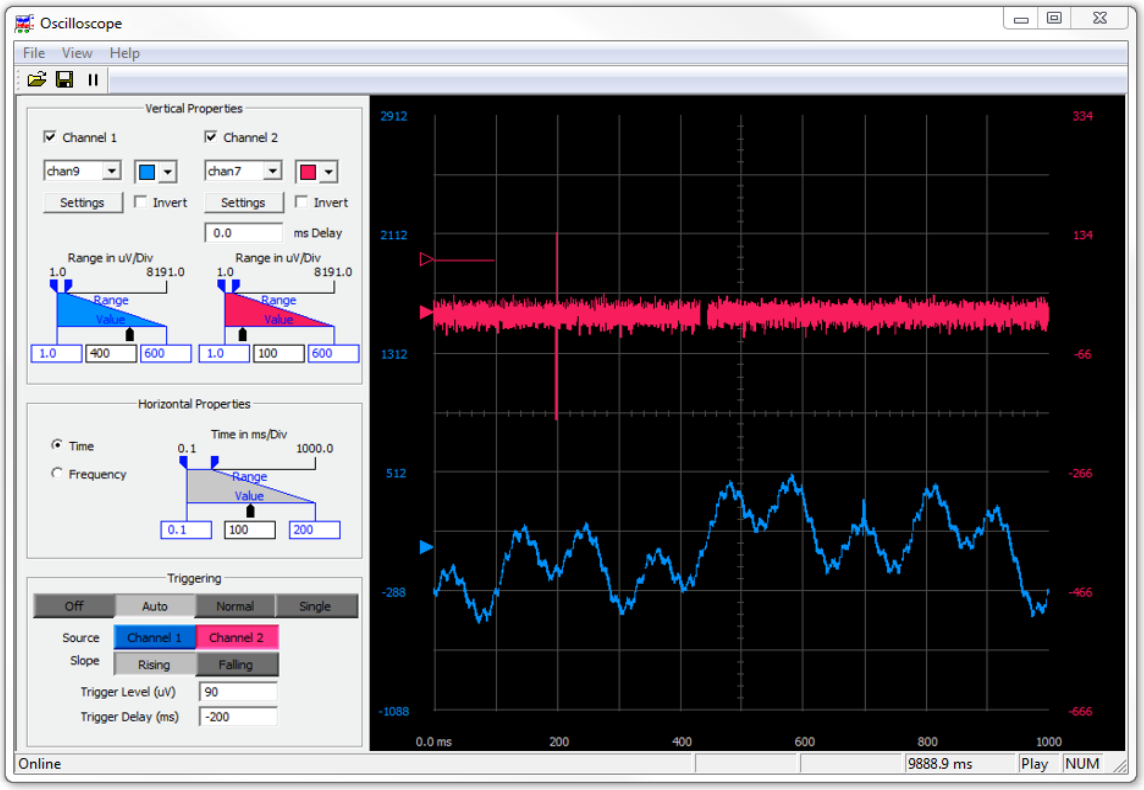


Figure 35–Digital Oscillloscope View

Channel Enable: Two channels may be viewed per instance of the oscilloscope.

Channel Selection: Select any channel from the drop-down menu.

Color Selection: Select a color for either trace.

Settings: Open the properties window for the selected channel.

Invert: Invert the trace for a given channel.

Trace Amplitude: Modifying the sliders for each channel will change the signal amplitude. The top slider changes the range and the lower slider selects a value within the given range.

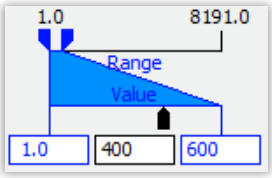


Figure 36–Trace Amplitude

Time/Frequency selection: Set the oscilloscope into time or frequency mode.

Time Resolution: Modifying the sliders will change the time resolution of the trace. The upper sliders change the range of resolution and the lower slider is used to choose a value within the given range.

If no continuous trace is visible on the oscilloscope, confirm that the channel of interest is being sampled from in the Analog Input Properties window. If no trace appears despite sampling from the channel there may be a compatibility issue with your graphics adapter. Please contact Blackrock at support@blackrockmicro.com.

Trigger Type

Different triggers can be used to position and display waveforms on the oscilloscope.

Auto: Continuous signal will be displayed until the trace crosses the user defined trigger level. When the trigger level is crossed, the trace will pause for two seconds, then resume until another triggering event occurs.

Normal: The trace will freeze as soon as the trace crosses threshold until the trace crosses the trigger level again in which case the screen will update with the new trace.

Single: A single trace is captured as soon as it crosses the trigger level. To capture another threshold-crossed trace click on Single again.

Trigger Level: Trigger level can be entered in the field or by manually sliding the trigger line on the display.

Assign a trigger delay: Adjust the trigger position on the time axis. At 0 delay, the trigger will be placed at the left edge of the screen and may not be visible. Set a negative value to push the trigger point to the right.

Digital Filter Editor

The Digital Filter Editor can generate custom filters to be used in Central Suite. It requires the Matlab Compiler Runtime to be installed. Contact support@blackrockmicro.com for a copy of this software.

Filter type and corner frequencies are defined in the Editing Tools section on the left side of the window. The stability of the filter is shown in the Filter Status section below. The Bode Plot and the Nyquist Plot of the designed filter are displayed. Once the filter parameters are set, click on Save to save the digital filter.

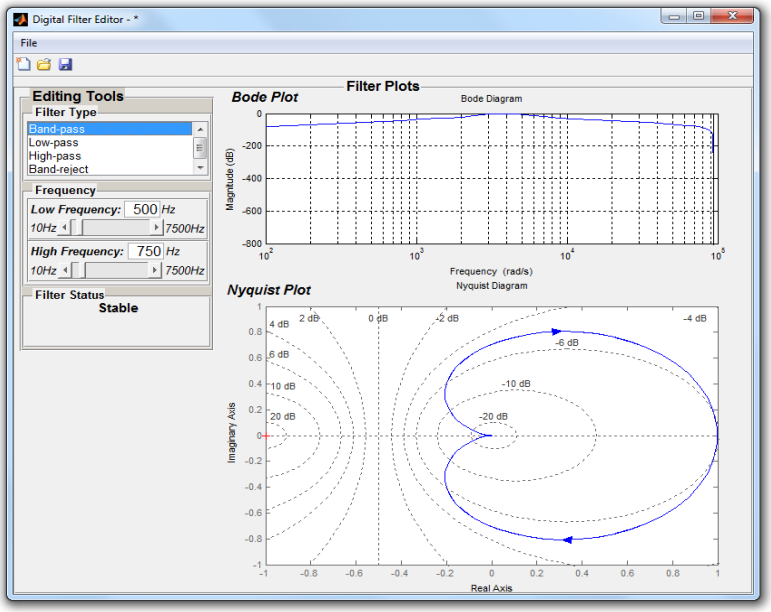


Figure 37–Digital Filter Editor

Activity Map

The activity map color codes the firing rate of neurons on a two-dimensional map. An electrode map file assigns each channel to a location. The spiking activity of each channel is binned and smoothed over a fixed time window of 20 milliseconds. Smoothing adds steps between events and non-events both between channels and over time.

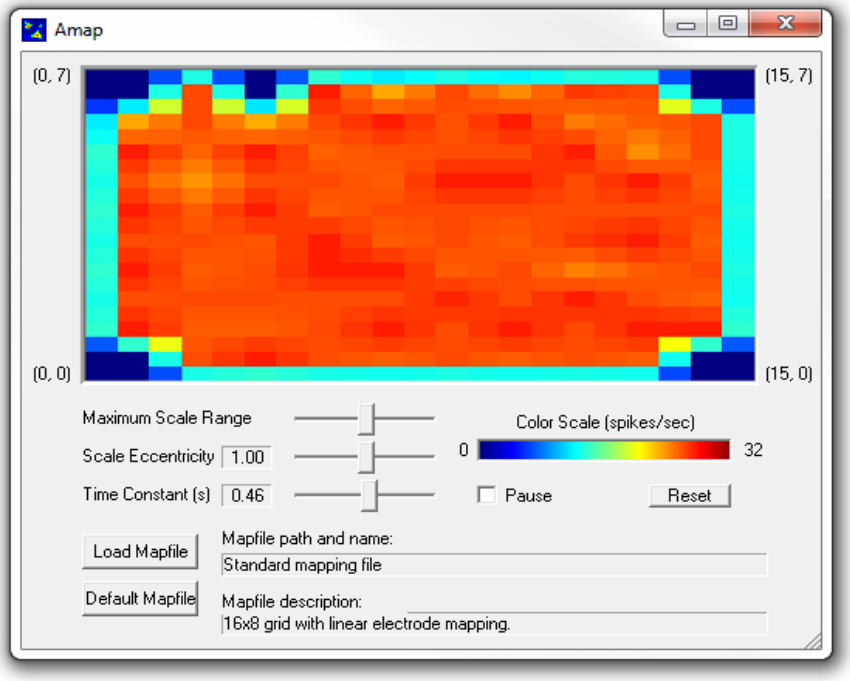


Figure 38–Activity Map

Maximum Scale Range: Set the maximum value of the color scale in spikes per second.

Scale Eccentricity: Skews the mapping of spike rate to color towards high or low values.

Time Constant: Set the time constant controlling activity decay.

Pause: Pause the display until unchecked.

Reset: Clear current activity data and refresh visualization.

Load Map File: Load a map file to change the orientation of the display.

Default Map File: Return to the default 16x8 grid map file.

Signal-to-Noise Ratio

Signal-to-Noise Ratio (SNR) displays the running amplitudes of the signal, noise, and signal-to-noise ratio for units on each channel. It also displays the signal-to-noise ratio as a function of time, which allows changes in signal quality to be monitored. This information can be saved as a tab-delimited text file and opened in Excel or a compatible program for further analysis. In the example below the SNR for elec11 unit 3 is 9.50 meaning that the signal is 9.5 times bigger than the noise.

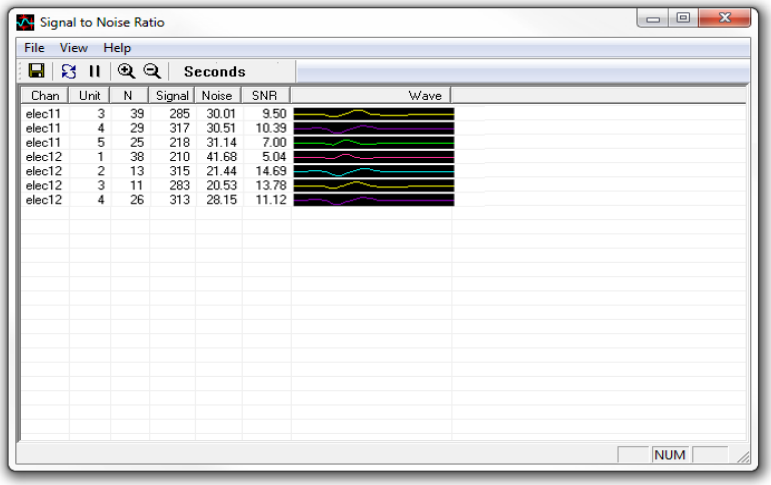


Figure 39–Signal to Noise Ratio

Neural Modulation

Neural Modulation displays a histogram of changes in firing frequency over time. The Modulation Index is the variance of the histogram entries and covers a range of 0 to 12.0. A range of 2 to 5 is considered normal when recording neural signals.

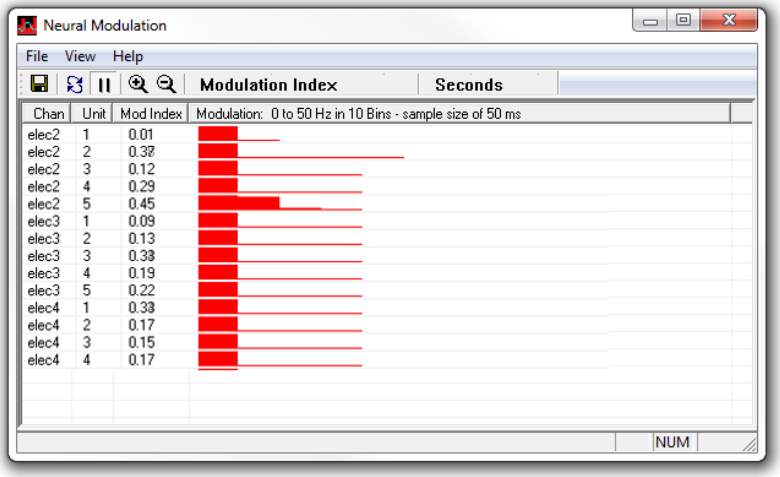


Figure 40–Neural Modulation

Impedance Tester

Impedance Tester measures and reports electrode impedance on each channel. To function properly the impedance mode must be selected in Central, click *Tools* > *Options* > *Auto Impedance* Interface. Either mode begins by asking for array information, including the serial number, implantation date, type of sterilization and comments.

Special equipment may be required for impedance measurements. Contact Blackrock Microsystems sales at sales@blackrockmicro.com for more information.

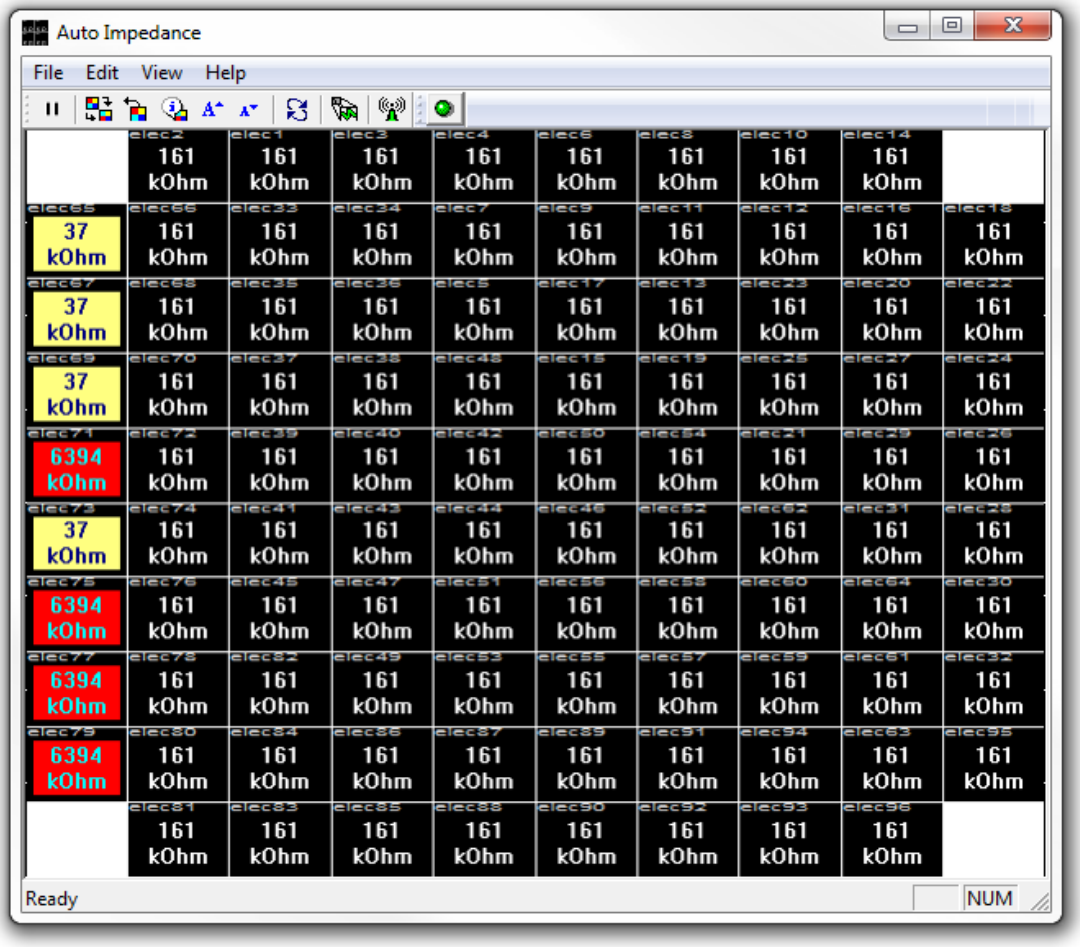


Figure 41–Auto Impedance

Crosstalk

The Crosstalk Diagnostic window compares each channel to identify cross correlation. The Crosstalk Diagnostic feature will display each channel as green, yellow, or red, indicating the amount of unique signal on each electrode.

Green: No cross correlation to any other channel was found.

Yellow: Possible cross correlation found. Examine signals closely to determine best use.

Red: High levels of cross correlation found. Consider removing these channels from recordings.

Figure 42–Crosstalk

N-Trode

Multiple single channels can be linked into N-Trode channel groupings. These are user defined electrode subsets created to record signals from proximal regions when any single unit spike is detected within the N-Trode. N-Trodes allow for neural events detected on one channel within an N-Trode to force the creation of neural events on the other N-Trode channels. When an event is detected on a channel within an N-Trode, all other N-Trode channels record a neural event with the same timestamp, spike width samples, pre-threshold samples, and refractory period (see Global Settings). Central supports multiple N-Trode sets containing up to four electrodes each. Define N-Trode configurations in the Hardware Configuration window or within the N-Trode application window.

Note: Spike sorting occurs on the N-Trode as a single entity. This causes neural events on all N-Trode channels to be subject to refractory periods caused by a neural event detected on any N-Trode channel.

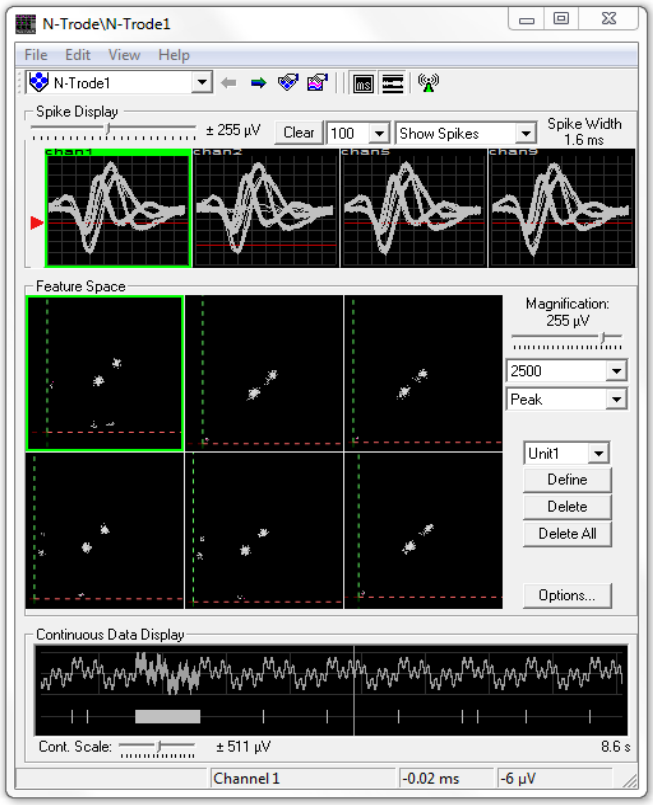
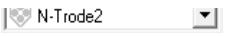


Figure 43–N-Trode Utility



N-Trode: Use the drop-down menu to select an N-Trode group.

Scroll: Use the arrows to scroll through N-Trodes.

N-Trode Properties: Define or modify an N-Trode group.

Channel Properties: Open the Analog Input Properties window for all channels in the selected N-Trode group.

View Tool Tip: Display time and amplitude values at the cursor position.

Hide Continuous: Toggle the Continuous Data Display on the bottom of the window.

Broadcast Channel Selections: Duplicates channel selection on other instances of Central running on computers connected to the ethernet switch.

Options…: See a list of keyboard and mouse commands to manipulate the N-Trode GUI.

Spike Display

Spike Threshold: Adjust the voltage threshold for spike detection on all channels.

Clear: Clear the spike display. Automatic clearing will occur to maintain the number of spikes shown in the drop-down menu.

Show Spikes: Select which spike units to display.

Add Comment

The Add Comment feature allows the user to add a timestamped text comment to the Neural Event file. Comments can be visualized in the Raster Plot view. When in the Raster Plot window or the Central Main Window, a comment time stamp is initiated by typing and completed when the <Enter> key is pressed.

nPlay Server

nPlay Server loads and replays recorded neural data in '.nsx' or '.nev' formats for viewing and analysis in Central. When playing back the continuous data files, the user can filter, sort spikes, and down sample. A Neural Signal Processor does not need to be connected to the PC to use this utility.

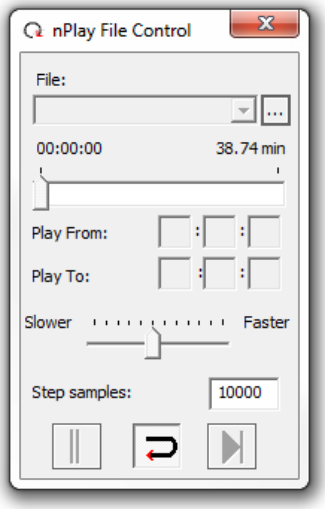


Figure 44–nPlay Server

Spike Sorting

The Central software offers three automatic and manual methods for real-time spike sorting.

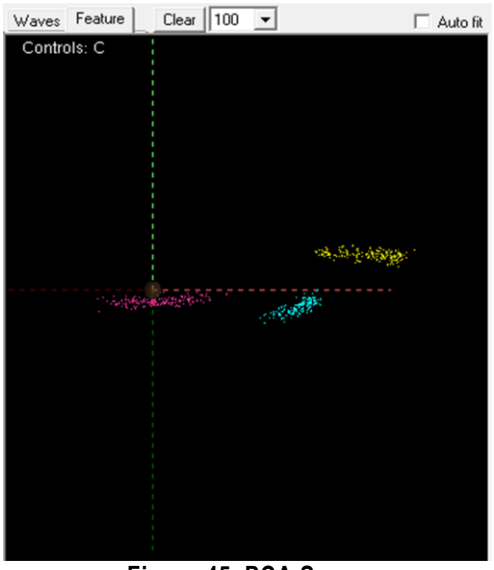


Figure 45–PCA Space

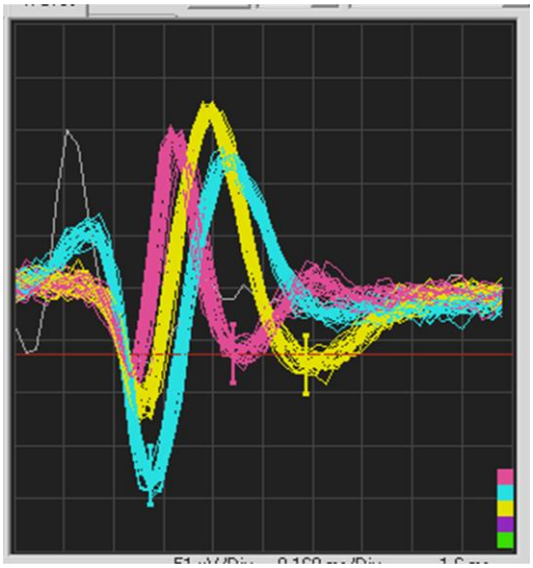


Figure 46–Sorted Spikes

Histogram Peak Count (Automatic)

1. Open the Hardware Configuration window and select channels of interest.
2. Right click and choose Properties or click on the “Properties” icon.
3. Choose Histogram Peak Count from the spike-sorting drop down menu.
4. Click OK.
5. In Central, click *Tools* > *Rebuild Spike Sorting*. This step may take a few minutes and must be repeated for each experimental session. Each time the sorting is rebuilt, new classifications are calculated based on current data.
   Note: To save Histogram Peak Counts sorting rules in Central, click *File* > *Save Sorting Rules….* To load Histogram Peak Counts sorting rules, click *File* > *Load Sorting Rules….*

Hoops (Manual)

1. Open the Hardware Configuration window and select channels of interest.
2. Right click and choose Properties or click on the “Properties” icon.
3. Choose “Hoops” from the spike-sorting drop down menu.
4. Open Single Neural Channel and select the desired channel.
5. Make sure the view classification icon is pressed down so you can see the units window.
6. Click on the define button for a unit. A series of colored boxes will appear on the spike panel in the lower right corner.
7. Drag each colored box out of its place and an amplitude band will appear.
8. Place the band so that it intersects spikes to be classified in this unit.

9. Four bands may be placed for each unit classification.
10. Five individual units may be defined on each channel.
    Note: To save Hoops sorting rules in Central, click *File* > *Save System Settings*…. To load Hoops sorting rules, click *File* > *Load System Settings*….

Manual PCA

1. Open the Hardware Configuration window and select channels of interest.
2. Right click and choose Properties or click on the “Properties” icon.
3. Choose “Manual PCA” from the spike sorting drop down menu.
4. Open Single Neural Channel and select the desired channel.
5. Make sure the unit icon is pressed down so you can see the units window.
6. Click on the Feature tab.

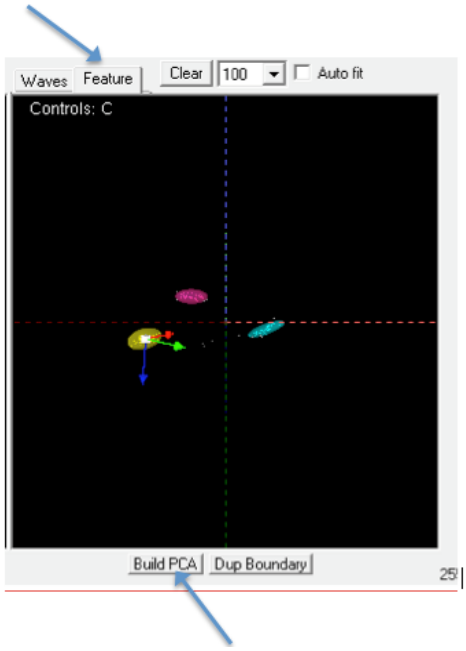


Figure 47–PCA Space

7. Click on Build PCA. By default the program needs 250 waveforms to build the PCA basis vectors. The time required to record 250 waveforms will depend on your spike rates and may take several minutes. You can modify the number of waveforms used in *Hardware Configuration* > *Spike Sorting*.
8. Click the Define button for your first unit.
9. Hold down the <Control> key and draw a line around a given cluster. The program will automatically create an ellipsoid around the cluster. Repeat this process for all the other units and channels.
    Note: To save Manual PCA sorting rules in Central, click on *File* > *Save System Settings*…. To load Manual PCA sorting rules, click *File* > *Load System Settings*…. To save PCA basis vectors, click *File* > *Save PCA Basis*…. To load PCA basis vectors, click *File* > *Load PCA Basis*….

k-means PCA

1. Open the Hardware Configuration window and select one channels of interest. Multiple channels may be selected and sorted at once.
2. Right click and choose Properties or click on the “Properties” icon.
3. Choose “k-means PCA” from the spike sorting drop down menu.
4. From the Central Suite main window select *Tools* > *Auto Spike Sorting Method* > *All PCA Spike Sorting* to begin the sorting process on all channels previously selected.
5. Open Single Neural Channel and select the channel of interest from the drop-down menu.
6. Make sure the unit icon is pressed down so you can see the units window.
7. Click on the Feature tab.

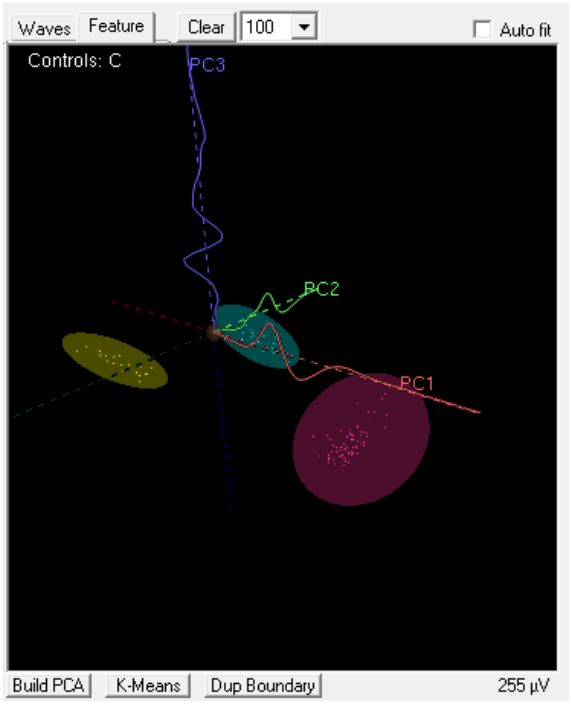


Figure 48–PCA Basis Waveforms

8. Click on Build PCA. By default the program needs 250 waveforms to build the PCA basis vectors. The time required to record 250 waveforms will depend on your spike rates and may take several minutes. You can modify the number of waveforms used in *Hardware Configuration* > *Spike Sorting*.
9. Wait for feature points to be generated. Clustering accuracy will improve as the number of feature points increases.
10. Click on the k-means button to define separate groups.
    Note: To save k-means PCA sorting rules in Central, click *File* > *Save System Settings*…. To load k-means PCA sorting rules, click *File* > *Load System Settings*…. To save PCA basis vectors, click *File* > *Save PCA Basis*…. To load PCA basis vectors, click *File* > *Load PCA Basis*….

DBSCAN PCA

1. Open Hardware Configuration window and select the channels of interest.
2. Right click and choose Properties or click on the “Properties” icon.
3. Choose “DBSCAN PCA” from the spike sorting drop down menu.
4. Open Single Neural Channel and select the channel of interest from the drop-down menu.
5. Make sure the unit icon is pressed down so you can see the units window.
6. Click on the Feature tab.
7. Click on Build PCA. By default the program needs 250 waveforms to build the PCA basis vectors. The time required to record 250 waveforms will depend on your spike rates and may take several minutes. You can modify the number of waveforms used in *Hardware Configuration* > *Spike Sorting*.
8. Wait for feature points to be generated. Clustering accuracy will improve as the number of feature points increases.
9. Click on the DBSCAN button.
   Note: To save DBSCAN PCA sorting rules in Central, click *File* > *Save System Settings….* To load DBSCAN PCA sorting rules, click *File* > *Load System Settings….* To save PCA basis vectors, click *File* > *Save PCA Basis….* To load PCA basis vectors, click *File* > *Load PCA Basis….*

How to Use Adaptive Filtering

Adaptive filtering can be used to remove a known noise signal from neural data. Common noise sources include experimental monitors, subject reward systems, and equipment racks. Identify the potential external noise source and connect it to the NSP using an analog input BNC connector.

1. Plug the peripheral noise source into an analog input channel.
2. Open Hardware Configuration > Adaptive Filtering.
3. Right click the channel icon and select properties.
4. Select one or two channel operation.
5. Select the analog inputs used for the noise sources as reference channels.

Create a Digital Filter

Central Suite includes preset high pass, low pass and band pass filters. Filter parameters can be viewed in *Hardware Configuration* > *Settings* > *Filters*. The Digital Filter Editor allows you to construct custom filters.

1. Open Central.
2. Click on Digital Filter Editor. This tool requires MATLAB Compiler Run-time which is available on the Central Software Suite Installation CD and www.blackrockmicro.com
3. Choose a filter type and the corner frequencies desired. If the filter is unstable the filter design tool will warn you and suggest ways to make the filter more stable.

4. Save the filter in a known location and exit the Digital Filter Editor.
5. In Central, click on *File > Load Digital Filters*.
6. Select up to four custom filters in the loading dialog.
7. All newly added filters will be available in the drop-down menu under Hardware Configuration for analog inputs.

Renaming Multiple Channels

Central has a built-in automatic channel naming scheme with several parameters.

1. Open Hardware Configuration.
2. Select non-contiguous channels by holding down <Control> while selecting or select a range of channels by holding down the <Shift> key and clicking the upper and lower bounds of your selection.
3. Right click and choose Properties. Alternatively, you can click on the “Properties” icon in the toolbar.
4. Click the Edit button next to Label.
5. Enter a label prefix you want across all selected channels.
6. Choose a numbering scheme to be applied to each file after the prefix:
   a. **Use current numbering**: Maintain current channel numbering.
   b. **Number channels sequentially starting at**: Increment numbering from the start value by adding one to each additional channel.
   c. **Number using channel ID**: Number with the channel ID value going from 1 to 128.
   d. **Use terminal numbering**: Number with the pin and bank value of the channel location on the front-end amplifier.

Figure 49–Label Options

Remotely Control Data Recording

Central software can be configured to start and stop recording when triggered by a digital input coming from other hardware, such as a behavioral control system. When using the TOC file format, the recording can be remotely started, stopped, resumed, or a new session can be initiated. When using the2.x file format, the recording can be remotely started, stopped, paused, and resumed. To setup remote recording using the DB-9 serial port or DB-37 digital input port do the following:

1. Open the File Storage app, check the Remote Recording box, and click Setup.
2. Select Digital Bit Input for any of the four remotely controllable tasks.
3. On the second column choose a bit to be used for this function.
4. On the third column choose high or low for triggering.

For example, to remotely begin recording when digital bit 3 on the digital input port is set high, configure as shown below.

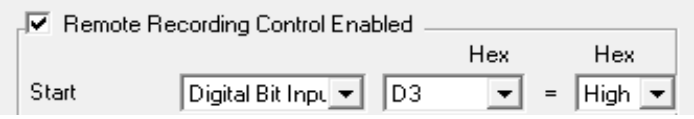


Figure 50–Example Settings for Remote Recording

Visualize an Input Channel on the Digital Oscilloscope

The Digital Oscilloscope enables you to visualize two channels at high resolution. Setting a trigger can improve visualization of signals. To setup the oscilloscope, follow the instructions below.

1. Open Central and in the main window click the Oscilloscope.
2. Enable Trace 1 and/or Trace 2.
3. Select a channel for each trace from the drop-down menu.
4. Click on Settings to verify all channel settings. Make sure a sampling rate is selected for the given channel. If <none> is selected for sampling rate then a trace will not appear in the Oscilloscope.
5. Set the amplitude of each trace by changing the slider bar for each channel. The upper slider modifies the range of values and the lower slider selects a value within the selected range. The units are µV/division.
6. Move the trace location up or down by dragging the small triangle on the left of the trace.
7. Set the time resolution by changing the resolution slider bar. The upper slider modifies the range of values and the lower slider selects a value within the selected range. The highest resolution is 0.1 milliseconds.
8. A trigger can be set for the traces.
   a. Choose a channel source for the trigger.
   b. You can set the trigger level by entering a voltage value in the field or by sliding the trigger line up and down on the display.

   c. Assign a trigger delay. At a default of zero, the trigger will be placed at the left edge of the screen and may not be visible. Negative values move the trigger to the right.
9. Select a trigger type of Single, Normal, or Auto.
   a. **Auto**: Continuous signal will be displayed until the trace crosses the user defined trigger level. When the trigger level is crossed, the trace will pause for two seconds, then resume until another triggering event occurs.
   b. **Normal**: The trace will freeze as soon as the trace crosses threshold until the trace crosses the trigger level again in which case the screen will update.
   c. **Single**: A single trace is captured as soon as it crosses the trigger level. To capture another threshold-crossed trace click on Single again.

Configure Raster Plot

The Raster Plot can display the occurrence of spike events or continuous signals for many channels over time. The plot can be configured to match your experimental setup.

1. Begin by removing all channels from the display using the  clear all button.
2. Open the  choose channels display and select the channels of interest.
3. Use the  move buttons to order the selected channels.
4. All channels can be  split into component channels. This will display a line for each classified spike unit as well as a continuous signal trace
5.  Delete any unwanted channel components.
6.  Resize channels of interest. It is often helpful to increase the size of continuous data traces.
7. Adjust the 

seconds per division of the markers on the plot.
8.  Change the font size for channel labels to be easily read.

For an explanation of further Raster Plot functionality see Page 44.

Change Electrode Map (Create a Map File)

It is possible to re-arrange the electrode positions on Spike Panel and Activity Map. A plain text “map” file contains the location assignments of each channel. A sample map file is included below.

```
// 8-Channel NSP map file demo
//
// Data is as follows, 'C(olumn) r(ow) b e l'
//   c - 0 based column from left to right
//   r - 0 based row from bottom up
//   b - bank name - values can be A, B, C, or D
//   l - label used to rename channels in Central
//
// Comments begin with '//'
// First non-comment line is the Mapfile description
//
8 Channel NSP mapping
0   1       A       4 elec08
1   0       A       8 elec07
2   1       A       3 elec06
3   0       A       6 elec05
0   0       A       5 elec01
1   1       A       2 elec02
2   0       A       7 elec03
3   1       A       1 elec04
```

Figure 51–Sample CMP File

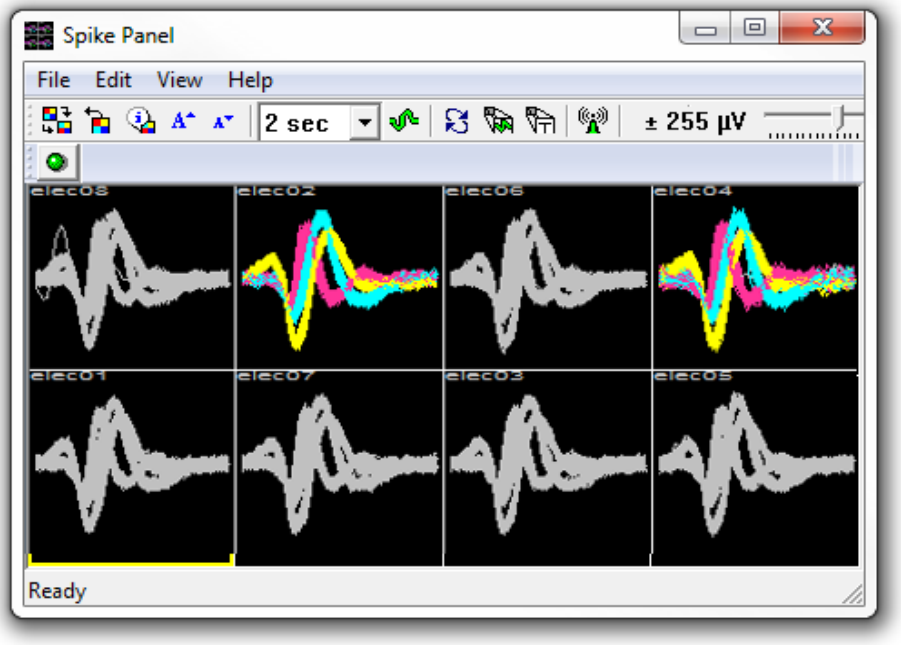


Figure 52–Sample Spike Panel

The map file contains five columns. The first column indicates the location of the spike window on the x-axis. The second column indicates the location of the spike panel on the y-axis. Point 0,0 is on the lower left corner of the screen. The third column indicates the bank the physical channel is located on (A, B, C, or D) and the fourth column indicates the bank pin the channel is connected to. The fifth column is optional and defines the label for the channel.

In the example above, the first line indicates that the channel on bank A pin 4 is named elec08 and it's located on the 1st column from left (0) and the 2nd row from the bottom (1). The last line indicates that the channel on bank A pin 1 (channel 1) is named elec04 and it should be placed on the 4th column (3) from left and the 2nd row from bottom (1). Location positions start from 0. Any line that starts with "//" will be used as comment and will be ignored. The first line after the last // line is the name of the map file as referenced in the apps and will also be ignored.

Setup

Hardware Setup

Digital NeuroPort System

1. Remove the NSP and Digital Hub from the shipping boxes.
2. Attach the NSP rack-mount brackets to install it in an equipment rack, or rubber feet to place it on a table.
3. Plug in the NSP and Digital Hub to electrical outlets.
4. Connect one end of the fiber-optic cable to the NSP and the other end to the Digital Hub.
5. Attach headstages to the Digital Hub and connect them to electrodes. Make sure the connections are secure.
   Warning: Only connect headstages to the Digital Hub.
6. Turn on the NSP and Digital Hub.
7. The LED near the fiberoptic port of the NSP and Digital Hub should turn green.
   Note: Maximum channel capacity setup may include up to four NeuroPlex E headstages, four Digital Hubs, and two 256ch NSPs.

NeuroPort System

1. Remove the NSP, Amplifier and APS from the shipping boxes.
2. Attach the NSP rack-mount brackets to install it in an equipment rack, or rubber feet to place it on a table.
3. Plug in the NSP and APS to electrical outlets.
4. Connect one end of the APS cable to the APS and the other end to the Amplifier. The cable needs to click and lock in place.
5. Connect one end of the fiber-optic cable to the NSP and the other end to the Amplifier.
6. Attach optional headstages to the amplifier inputs and connect them to electrodes.
7. Turn on the NSP and APS
8. The LED on the APS, Amplifier, and the NSP should turn green.

Software Setup

Installing Central Software Suite

1. Uninstall any previously existing versions of Central Suite through Programs and Features in Windows Control Panel.
2. Run the Central Suite installer (.msi) from the installation CD or www.blackrockmicro.com
3. Install the MATLAB Compiler Runtime from the supplied installation CD or www.blackrockmicro.com

Blackrock recommends that a dedicated PC be used to run Central. Refrain from installing any additional software or connecting the PC to the internet. Make sure to disable Windows auto-updates.

Setting up the Ethernet Connection

Note: If you purchased the NeuroPort Host PC, the Ethernet card is pre-installed and configured in your PC.

1. Once installed, the card needs to be configured to connect to the NSP.
2. Click on Start and search for “View Network Connections”.
3. Right click on the correct Ethernet Adaptor (usually, Local Area Connection) and click on Properties.
4. Uncheck all services except for Internet Protocol (TCP/IP) or Internet Protocol Version 4 (TCP/IPv4).
5. Click on Internet Protocol (TCP/IP) and click on Properties
6. For IP Address enter 192.168.137.1, for Subnet Mask enter 255.255.255.0 and leave the rest blank.
7. Click on OK to save changes.

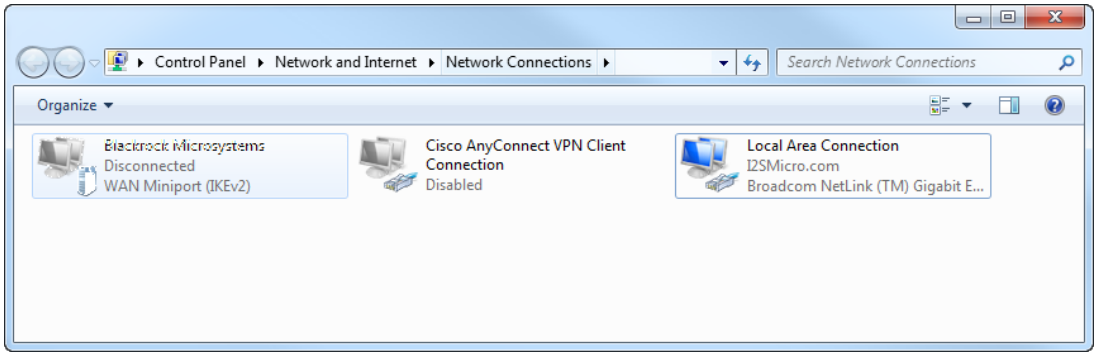


Figure 53–Network Connections Window

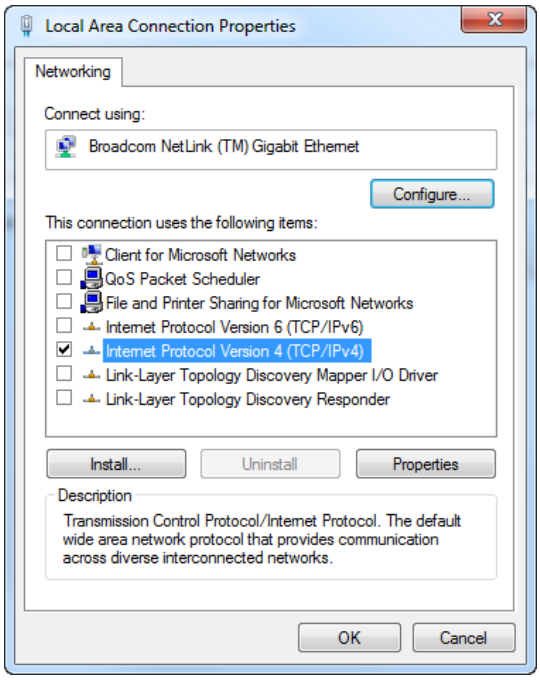


Figure 54–Local Area Connections Properties

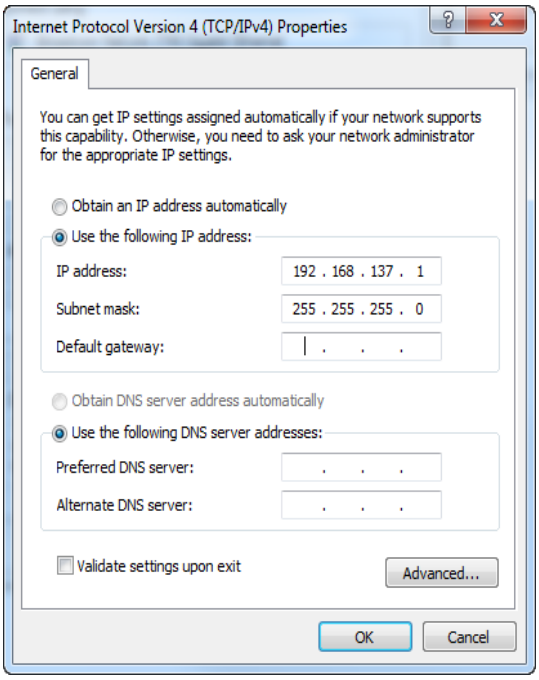


Figure 55–IPv4 Properties

Note: Up to 16 PCs can be connected to the same NSP using a business class 1-Gbps network switch with QoS feature. For other PCs connected using a network switch, IP addresses should increment, such as 192.168.137.2, 192.168.137.3, etc.

Note: For your reference, the NSP's IP address is 192.168.137.128.

Sterilization, Cleaning, Maintenance, and Disposal

Sterilization and Cleaning

The only components of the NeuroPort System that are provided sterile are the Patient Cable, NeuroPlex E and Digital Data Cables. The remaining components cannot be sterilized, but devices may be cleaned by wiping surfaces. To clean the NeuroPort System, the exterior of NeuroPort System devices may be wiped down water or isopropyl alcohol. Sanitizing wipes should not be used on the Digital Hub or other plastic components of the system. Dust and debris on the exterior connectors/ports may be removed with compressed air.

Maintenance

The system does not require any scheduled maintenance or calibration. Maintenance on interior components of the NeuroPort System should only be carried out by or on the instructions of an authorized Blackrock Microsystems representative. For issues with the system, see the troubleshooting section and/or RMA sections below.

Disposal

All devices, both used and unused, should not be disposed with household waste. Return to a recycling point for electric and electronic devices.

Magnetic Resonance

The NeuroPort System has not been evaluated for safety and compatibility in the MR environment. The NeuroPort System has not been tested for heating, migration, or image artifact in the MR environment. For this reason, the device is not considered safe to use in an MR environment.

Troubleshooting/Error Messages

Problem	Symptom	Failure	Potential fix
No data displayed	Yellow LED on Amplifier or Digital Hub	System not receiving valid packets	If NeuroPort is turned on and running but there is no apparent activity on any of the channels from an implant or from the simulator, verify the following: Verify all cables are securely plugged in. Open Central.exe and verify that packets are being received from the NeuroPort system. If the PC is not receiving packets from the NeuroPort system, see troubleshooting section “Lost Packet Error Notification” above. Verify that the fiber optic data link between the Amplifier/Digital Hub and the NeuroPort NSP is plugged in and that the green light next to the fiber optic data port on the NSP is illuminated. If the light is red, there is no fiber optic link present. Check the LED next to the fiber optic port on the back of the Amplifier or front of the Digital Hub to verify that it has power. **Standard System** If the LED is not illuminated, check the APS and verify that it is turned on and not in standby mode. **Digital System** Possible compatibility issue or damaged cable – replace cable otherwise contact support@blackrockmicro.com with serial number of Digital Hub and headstages and cable lengths

Problem	Symptom	Failure	Potential fix
Noise	Poor Signal to Noise Ratio or Excess High Frequency Signal	Uncontrolled noise sources and/or poor referencing or grounding scheme	The system is sensitive to electromagnetic signals. It is designed to detect microvolt level signals. Cable arrangement and external noise source management are important. Avoid allowing cables of the system near other power cables, monitors, light sources, or other electrical equipment. Change which electrode is used as reference to better remove common noise or use noise cancellation in Central to remove noise from the recording.
System Not Turning On	No Lights on LCD of Neural Signal Processor	Secondary Power Supply Switch is Off	Verify that the NeuroPort system is plugged into a working outlet, and verify that all power cords are plugged into the NeuroPort. Verify the position of the power switch in the rear of the Neural Signal Processor is ON. If the power switch is in the ON position, turn it to the off position then wait at least five seconds before turning the NSP back on. (It is recommended that when restarting the NSP, always wait at least five seconds before turning the unit back on. This will ensure a proper system reset.)
NSP Is Stuck in Initializing	LCD of Neural Signal Processor Says “Initializing” for more than 2 minutes and/or Central gives an error that says “The System is Initializing”	Poor Software Initialization or Disconnected Cables within the Neural Signal Processor	Try turning the NSP OFF using the rear power switch. Toggle the front power switch 5 times on and off. Wait 5 minutes. Turn the NSP back on. If the NSP is still not initializing then contact support@blackrockmicro.com

Problem	Symptom	Failure	Potential fix
Instrument Network Has Failed	Error Message In Central and No Data	Disconnected Ethernet Cable or Powered Off Device	Check that the NSP is powered on and that the ethernet cable is connected. Check that the ethernet switch is powered on if it is being used.
Data Recording Restarted	Error Message from Central	High Data Rate	High data rates or busy hard drives can cause this error. Disable non-essential applications such asDefender, system sounds, and Automatic Updates. Ensure hard drives are not near full, defragment hard drives, or utilize hard drives with faster write speeds, such as solid state drives. Alternatively, reduce the number of continuously sampled channels. Warning: Disabling Firewalls and Anti-Virus software can leave your system vulnerable to cyberattacks.
Packets Lost	Error Message from Central Indicating Lost Packets	Poor Ethernet Communication or Excess CPU load	Check that the ethernet cable is CAT6. Ensure that the ethernet port is capable of gigabit operation. Check ethernet connection and reduce CPU load. Allow Central to communicate through the firewall.

Central error messages and common solutions are listed here. Once these steps are exhausted please contact Blackrock Support.

Files are currently being recorded. Do you want to stop recording and close the app?

The user has attempted to close the Central Main Window while recording is ongoing. To avoid this error, always stop recording before attempting to close the software.

Unable to allocate shared Memory

Both Central Software Suite and another utility have attempted to connect to the NSP via UDP. To remedy this, shut down any utilities, such as cbMEX, or cbSDK, that may be attempting to communicate with the NSP.

Recording is currently blocked by another utility. Please close that utility and try again.

A utility within the Central Suite is interfering with recording. Check to see if impedance mode is running. If not, restart your Host PC and try recording again.

Unable to open the Central Application!

An error has occurred within the Central Main Window startup. Restart your Host PC and reinstall Central Suite.

The basis vectors have not yet been calculated for this channel. Please Build PCA then retry

The user has attempted to save spike sorting settings before generating sorting rules. Define spike sorting rules in the Single Channel Viewer Window before saving.

There may not be enough data points to effectively calculate the ellipsoids. Would you like to continue?

An insufficient number of detected spikes have been recorded to create ellipsoid groupings on the PCA space. Wait until more spikes are recorded before attempting to define ellipsoids. Proceeding with fewer spike events is possible but may not produce accurate unit definitions.

Unable to Open Instrument Network

OR

It appears that the instrument network has failed.

Central cannot communicate with the NSP. If this occurs, confirm that:

1. The NSP is powered on.
2. An ethernet cable connects the NSP and the Host PC.
3. If a switch is used, it is connected correctly and powered on.
4. The Ethernet port has been configured as described on Page 69.

Once confirmed, restart the NSP and Host PC.

Network packets have been lost between the NSP and this PC.

This is most likely caused by the system load being higher than 8 MB/s.

OR

Network packets have been lost between the PC and the instrument

These errors occur when the Central Software Suite intermittently fails to communicate with the NSP over ethernet. To remedy this, confirm that:

1. The NSP is still powered on, and is connected to the Host PC with an ethernet cable.
2. No other applications are consuming significant system resources.

If so, attempt the following:

1. Disable Windows Firewall, Defender, Restore, Sound, Automatic Update, System Notifications, and other Ethernet ports.
   Warning: Disabling Firewalls and Anti-Virus software can leave your system vulnerable to cyberattacks.
2. Uninstall anti-virus and any unnecessary software.

The system is initializing, please wait.

If the system doesn't respond, click the Reset NSP button below.

This error occurs when the Central Software Suite recognizes an NSP that is not initialized. When this error message occurs, confirm that the NSP screen also shows the “Initializing” message. If so, wait for up to a minute before resetting the NSP. Attempt to reset with the software button included in the error message before doing a hardware reset with the switch on the front of the NSP.

Network packets have been lost between the NSP and this PC.

This is caused by the system load being higher than 12 MB/s

This error occurs when data is possibly lost within the NSP and is not sent to the PC. To remedy this error, confirm that your NSP is running the latest firmware available in the Software Downloads section of www.blackrockmicro.com.

Data Recording Restarted.

The data load to the PC is extremely high and data storage has been restarted. Please reduce the burden on your PC and restart data collection.

This error occurs periodically in very long duration recordings. To remedy this, attempt the following:

1. Disable Windows Firewall, Defender, Restore, Sound, Automatic Update, System Notifications, and other Ethernet ports.
2. Uninstall anti-virus and any unnecessary software.
3. Close any other active applications.
4. Reduce the number and rate of continuously sampled channels.
5. Consider a faster PC or hard drive, such as a solid state drive.

Return Merchandise Authorization

In the unlikely event that your NeuroPort system needs to be returned to Blackrock for repair or maintenance, do not send any equipment back without a Return Merchandise Authorization Number. An RMA number will be issued to you by a Blackrock representative. If you need to obtain an RMA number, you may contact a support representative at +1 (801) 582-5533 or via email support@blackrockmicro.com.

Once an RMA number has been issued, it is important to safely pack the returned item for shipping back to Blackrock. It is preferred that you save the original boxes and packing materials that your NeuroPort system arrived in for return shipment. Please address the package as follows:

Blackrock Microsystems
ATTN: RMA #
630 S. Komas Drive, Suite 200
Salt Lake City, UT 84108 USA
Tel: +1 (801) 582-5533

Warranty

Blackrock Microsystems (“Blackrock”) warrants its products are free from defects in materials and manufacturing for a period of one year from the date of shipment. At its option, Blackrock will repair or replace any product that does not comply with this warranty. This warranty is voided by: (1) any modification or attempted modification to the product done by anyone other than an authorized Blackrock employee; (2) any abuse, negligent handling or misapplication of the product; or (3) any sale or other transfer of the product by the original purchaser.

Except for the warranty set forth in the preceding paragraph, Blackrock provides no warranties of any kind, either express or implied, by fact or law, and hereby disclaims all other warranties, including without limitation the implied warranties of merchantability, fitness for a particular purpose, and non-infringement of third-party patent or other intellectual property rights.

Blackrock shall not be liable for special, indirect, incidental, punitive, exemplary or consequential damages (including without limitation, damages resulting from loss of use, loss of profits, interruption or loss of business or other economic loss) arising out of non-compliance with any warranty. Blackrock’s entire liability shall be limited to providing the remedy set forth in the preceding paragraph.

Support

Blackrock prides itself in its customer support. For additional information on this product or any of our products, you can contact our Support team through the contact information below:

Manuals, Software Downloads, and Application Notes
www.blackrockmicro.com/technical-support

Complaints

When filing a complaint, please provide the product description, product number, software version, lot number, complainant's name and address, and the nature of the complaint.

Issues or Questions
www.blackrockmicro.com/technical-support
support@blackrockmicro.com
U.S.: +1 (801) 582-5533

Notice to the user and/or patient that any serious incident that has occurred in relation to the device should be reported to the manufacturer.

CAUTION

Federal law restricts this device to sale by or on the order of a physician.

This device complies with part 18 of the FCC rules