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1 System Overview

The Cerebus 128 Data Acquisition System allows researchers to record and process neural signals from up to 128 electrodes as well as record additional analog and event signals from experiments. The system is capable of recording from both surface and extracellular microelectrodes, and the system provides several online processing options for neural signals including line noise cancellation, adjustable digital filters, simultaneous extraction of spike and field potential recordings from microelectrodes, and automatic / manual online spike classification.

Figure 1-1 Application Overview

Packing List
1. Cerebus-128 Neural Signal Processor
1. Power Cord
2. Rack Mounting Ears
4. Screws
4. Rubber Mounting Feet
1. Cerebus-128 Front End Unit Amplifier, Power Cord (to Power Supply)
1. Power Supply Unit, Power Cord
1. NSS-128 Neural Signal Simulator
1. Fiber Optic Cable
1. Triple CHA-32 Board Assembly + 1 CHA-32 Board
4. Front End Ribbon Cables (40-conductor, 6" long)
1. Ethernet Interface Card (1GB)
1. Ethernet Cross-Over Cable
1. Cerebus Software CD-ROM
1. Cerebus Manual
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2 Hardware

2.1 Amplifier

The amplifier is a digitizer/amplifier module that receives electrode level signals directly from electrodes or from headstages with unity gain. The signals are amplified, filtered, digitized then transmitted to the Neural Signal Processor (NSP) via the fiber-optic data link. The unit is mounted near the research subject using any of the ¼ inch, 20-TPI mounting sockets on the case. These sockets mate with standard camera tripods and optical fixtures.

The amplifier filters the signals with a first order high-pass filter at 0.3 Hz in and a third-order low-pass filter at 7.5 kHz. The filtered neural signals from each electrode are digitized with 16-bit resolution at 1 uV per bit with a sampling rate of 30,000 samples/sec.

The analog filtering of the electrode signals allows both low frequency field potentials and extracellular spike signals to pass through. The neural signals are later separated into low frequency and spike signals by digital filtering in the Neural Signal Processor (NSP).

Ground in the amplifier is NOT directly connected to the ground pin (building earth) of the three-prong AC power connector. There are ESD shunt circuits that will conduct differences of 1000 V or more, but the amplifier ground is essentially isolated and floating. Both the building ground and the animal can be connected to the grounding post on the amplifier.

2.2 Amplifier Power Supply

The power supply for the amplifier consists of five analog and digital supply channels with monitoring, sequencing and emergency shutdown control. In the event of an error in voltage or power delivery, the power supply will shut down and a red error light will come on. If this is observed, check all amplifier and patient cable connections for inadvertent shorting of headstage power supplies. The power supply must be turned off then turned back on to clear the error.

The On/Off-switch for the power supply is located on the back of the unit. Once it is switched on, the power supply will start a power-up sequence of analog and digital supplies ending with the green ON light illuminating. When switched off at the back, the power supply sequence is reversed and the power supply lines are connected to the amplifier ground.
2.3 Neural Signal Processor (NSP)

The Neural Signal Processing (NSP) performs final filtering and on-line analysis of the neural signals then transmits the processed data to a host PC system via Ethernet data link.

![Neural Signal Processor (NSP)](image)

**Figure 2.3-1  Neural Signal Processor (NSP)**

**Power Switch (1):** Use the power switch to turn on the NSP. An LED just above the power switch will illuminate the color blue to indicate that the unit has power.

**LCD Display (2):** The LCD display shows the current operating status of the NSP. The status can read “initializing,” “NSP Startup,” or “NSP Running.” When first turned on, it will display the version number when ready. The NSP also includes the following inputs for recording external experimental information:

**Analog Inputs (3).** Analog experiment information or stimulus channels are connected to the 16 analog input BNC connectors. The analog signal sources may range ± 5.0 V and should come from source impedances of less than 100Ω. Channels 1 to 8 are AC coupled and channels 9 to 16 are DC coupled depending on the signal type you wish to input.

**Digital Inputs (4).** Digital signals can be connected to the 16-bit DB-37 input port. The pin diagram of the digital input port is shown below.

![Digital Input Connectors](image)

**Figure 2.3-2  Digital Input Connectors**

All of the lower pins are connected to digital ground

DS = Data Strobe, active on rising edge when enabled
D0 through D15 = data lines
EOP = Currently not used. Reserved for end of packet strobe, active high when enabled

**Output Pin.** SYN = Synchronization OUTPUT, optional line to inform equipment when port is scanned (active on rising edge).

**Strobed Data Format.** The port is checked 30,000 times a second for new data, the FIFO buffer in the port is 10 words deep, and the maximum data strobe rate for the input port is 1 MHz. This means that data can be written up to 300,000 words per second, or data can be written in bursts of up to 10 words at up to 1 MHz, as long as the burst are spaced at least 34µs apart. Although it is not necessary, the SYN output can be used to synchronize to the data writes to the port to the data reads.
Serial I/O Port (5). The system has a RS232 DB-9 digital input/output port. The pin diagram of the digital I/O port is shown below.

![Pin Diagram](image)

**Figure 2.3-3 Serial I/O configuration**

The pins used in the DB-9 RS232 port:
- Pin 2: Receive Data
- Pin 3: Transmit Data
- Pin 5: Ground

Analog Outputs (6). Four ± 5.0 V analog output BNC connectors can be used to send monitoring signals or stimulus waveforms to other devices.

Audio Outputs (7). The system sends a ± 2 V line-level audio signal of the selected data channel to two BNC and one 3.5mm female audio connector.

Digital Outputs (8). Four single-bit digital BNC outputs can be programmed for monitoring functions.

Sync (9). A synchronization pulse can be set as an optional line to inform equipment when the NSP neural signal inputs and front panel ports are scanned (active on rising edge)

Fiber-Optic Link (10). This is the port that the fiber optic cable will connect to from the Front-End Amplifier. An LED on the Neural Signal Processor will illuminate the color red when there is no connection made to the Front-End Amplifier. The LED will illuminate the color green when the cable is connected to the Front-End Amplifier.

2.4 Connectors

2.4.1 Headstage Requirements

The high input impedance and low bias current of the of the front end inputs make it possible to connect microelectrodes with 1 Mega ohm or lower impedance directly to the Front End 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 and power line noise. To minimize environmental noise pickup, it is preferable to keep direct electrode connections shorter than 20 cm (8 inches). For longer connections, HSF-32 headstage units from Cyberkinetics are recommended. These units allow microelectrodes with impedances up to 5 MΩ, and cables up to 1 meter (3.5 feet) in length.
2.4.2 Input Connections

The neural signal inputs are located at the front of the amplifier and are grouped into four banks of 32 channels each. Each bank contains a reference electrode input and a ground input. The electrode inputs within each bank are differentially amplified with respect to the reference electrode input of the same bank. If all electrode channels on all banks are to be electrically measured with respect to a common reference electrode, this reference electrode must be connected to the reference input on every bank.

Below each 34-pin electrode input connector is a 6-pin power supply output for powering headstage assemblies. The output voltage is 5 Vdc and the power connectors are capable of sourcing up to 130 mA combined for the entire amplifier. The pin diagram for the headstage power supply connector is shown at right.

All of the Ground pins on every connector of the Front End Amplifier module are internally connected together, including the grounding post on the back side of the unit. For best results, the Front End module should be used as the single “star” or central grounding point for electrical ground connections to the research subject.

The metal case and mounting sockets on the Front End Amplifier module are also grounded, but these sockets are anodized and do not provide a reliable ground contact point.

2.4.3 ICS Connector

The HSF-32 is built around connectors from Samtec (www.samtec.com) and designed to mate with the ICS family of array holders from Cyberkinetics. If you are using the ICS array holders without head stages, you will need to use HBA-32 head stage bypass adapters in place of the head stages.
The diagram below outlines all of the connectors and adapters for the ICS devices along with pin legend and Samtec part numbers. On the ICS-96, the reference pins for banks A, B, and C are connected to Ref1, Ground, and Ref2, respectively.

To use the ICS-96, you will need a group of three CHA-32 adapters that mounted together with a shared reference. To select Ref 1 or Ref 2 on the ICS-96, you will need to place a reference jumper on the CHA-32 board connected to Bank A or Bank C.

The diagram below shows how an array is connected to the 128-channel amplifier and the Neural Signal Processor.
The connector board has up to four Samtec FTSH 36-pin connectors; pins 1-32 are the electrodes, pin 33 is the reference, pins 34 and 35 is ground, and pin 36 is bus. It is connected to either 1X headstage followers (HSF-32) or Headstage bypass adapter boards (HBA-32) and then connected to the inputs of the amplifier with Samtec ribbon cables; J1 to A, J2 to B, etc.

The Front-End Amplifier unit connects to the Neural Signal Processor unit through a fiber-optic cable. An LED on the Neural Signal Processor will shine red when there is no connection made to the Front-End Amplifier, and green when the cable is connected.

2.5 Headstage Assembly

The headstage, on the left, is shown connected to the ribbon cable. Connect the headstage to the cable then attach the headstage to the simulator. Do not connect the ribbon cable directly to the simulator.

![Headstage Assembly](image)

In addition to providing connection from the subject to Cerebus, the headstage filters noise from the environment resulting in a more accurate reading of the neural signals.

2.6 Simulator

The simulator is used to test the system before hooking up a subject. It is powered by four AA batteries. To change the batteries, remove the four screws securing the back panel of the NSS.

![Cerebus Simulator and Amplifier](image)
2.7 Computer Setup

The Neural Signal Processor is connected to the computer through an Ethernet connection. The Cerebus requires a dedicated 1Gbps Ethernet card in the PC for its operation.

The Cerebus NSP can be connected to the PC Ethernet port with either: (a) with a cross-over cable, or (b) through an Ethernet switch using an Ethernet patch cable. It CANNOT be connected through an Ethernet hub. If you use a switch, ensure that all ports are 1GB.

A 1-Gigabit Ethernet card is included with the Cerebus system. Your PC will need one PCI slot available for the card. The Ethernet card uses a 64-bit PCI interface. If the only available PCI slot in your computer is a 32-bit interface, you may still use the included Ethernet card, but the last 32 connector pins on the card will have no connection inside the PC.

Once the Ethernet card has been installed into your PC, Windows 2000 or Windows XP / Vista will recognize the card with the plug and play drivers. In the event that drivers are requested by the Windows operating system you may contact Cyberkinetics Customer Support to obtain the drivers.

The card must be configured through an account with Administrator privileges. Use the Local Area Connection Properties panel to uncheck all services except for Internet Protocol (TCP/IP).

The IP address of the first computer should be entered as 192.168.137.1 and the Subnet Mask as 255.255.255.0. Leave all other fields blank including gateway and name-server fields.

If using an Ethernet switch to connect multiple PCs to the instrument network, each additional PC must also have an Ethernet connection that is dedicated for the instrument network. The IP addresses for these computers should be incrementally numbered: 192.168.137.2, 192.168.137.3, etc. You may connect up to 16 PCs to the instrument network. (For reference, the IP address of the NSP is 192.168.137.128.)
3 Cerebus Central Software

The user interface software runs under Microsoft Windows 2000 Professional Edition, Windows XP Professional, or Windows Vista. The Cerebus software can be installed from the supplied CD, by running the setup.exe program. The installation will install the following applications on your PC in the C:\Program Files\Cyberkinetics\NSP GUI:

- Amap.exe Activity map viewer program
- Autoimpedance.exe Impedance Measure program (Impedance / rec cable required)
- Central.exe Cerebus Central Control program.
- CentralSim.exe Cerebus Central Control simulation program.
- Centralplay.exe Playback of pre recorded data program
- Crosstalk.exe Crosstalk Diagnostics Utility Program
- HW.exe Hardware Configuration Settings program.
- DINwatch.exe A utility program to view the Digital input port status
- File.exe File Storage configuration program.
- Panel.exe Spike Panel program.
- Raster.exe Raster Plot program.
- Single.exe Single Neural Channel display program.
- RmsThreshold.exe System wide auto threshold Program. (Manual Sorting Version)

To start the program open Central.exe from the desktop shortcut that was created by the installation program, or it can be run from the installed directory C:\Program Files\Cyberkinetics\NSP GUI. The Central program is the core program and has to run in order to perform any data acquisition or processing operations. The main screen has buttons that provide access to each module. Cerebus consists of ten basic modules:

- Hardware Configuration
- Spike Panel (overview of all channels in spike processing)
- Raster Plots (channel panel view)
- Neural Channel (single channel view)
- Activity Map (for all channels)
- File Storage
- Signal to Noise Ratio
- Neural Modulation
- Impedance Tester (Requires impedance / recording cable)
- Crosstalk Diagnostic Utility (for all channels)

Click the buttons to open the modules or use the Windows drop down menu.

The Central display includes a System Load indicator. It displays the load on the PC connected to Cerebus, not the Cerebus itself. If the PC system load is too high, a warning message will be displayed if any data packets are being lost.

Figure 2.7-1 Cerebus Central Main Menu
When Central is opened, you will be asked if you wish to run the spike sorting module and startup diagnostics. When you select "yes", the Automatic Spike Sorting Progress window is displayed. Let it run for the initial four (4) minutes. During this time, the system is performing initial spike detection, adaptive threshold settings, and spike classification across all channels. (Details of the automatic spike detection, automatic spike classification, and adaptive threshold can be found on page 3-4 through 3-8.) A diagnostic test will also be performed as it checks for any crosstalk. A report at the end of the 4 minute process will be displayed. The report will display the number of active channels, the number of spikes found, average signal to noise ratio, and any channels with possible crosstalk. A text file of this diagnosis is also saved in C:\Cyberkinetics folder on your PC hard drive.

![Spike Sorting Progress](image)

3.1 File Menu

Two types of configuration information can be saved and later retrieved. The first is the general system settings such as which channels to record, the second is the specific settings determined by the Cerebus™ System after performing the program load routines. Select **Load System Settings** and **Save System Settings** to open and save general settings. Select **Load Sorting Rules** and **Save Sorting Rules** to load and save the model of neural activity from a specific patient saved on a specific day.

**Load System Settings**

Load channel settings previously saved in Hardware Configuration.

**Load Sorting Rules**

Load previously saved user defined sorting rules.

**Save System Settings**

Channel settings can be saved in files created by the user.

**Save Sorting Rules**

Spike sorting parameters can be saved to a directory created by the user.

**Close Applications**

This feature closes Central and all associated applications. It leaves the NSP running.
Hardware Standby and Close

This feature causes the system to stop gathering data. File storage can be paused causing the NSP to go into “Standby” mode. The NSP must be in “Standby” mode to update the firmware.

Hardware Shutdown and Close

This feature closes Central and all associated applications then stops the NSP. Manually turn off the power.

3.2 Tools Menu

Central Tools Menu

Window Options

Click Window Options to allow multiple windows of Hardware Configuration to be opened at one time.

Rebuild Spike Sorting Model

This option restarts the automatic spike sorting function.

Spike Sorting Progress
3.3 Specifications of Automated Spike Sorting:

This section describes the details of how the Cerebus systems automatic spike detection, channel threshold, and automatic spike classification are performed.

3.3.1 Spike Detection

Summary

Spikes are detected using an envelope detector. This is done in two processing steps: 1) the detection threshold adapts to the amount of noise in the signal and 2) the threshold is applied to the envelope signal. The approach was to only detect events that at least have similar frequency characteristics than spikes to reduce the number of false positives the classification step has to deal with.

Adaptive threshold

The incoming signal is passed through a bandpass filter between 1 and 5 kHz for determining the appropriate spike detection threshold. The algorithm calculates the average noise level in the band every second by downsampling and smoothing the signal, i.e. filtering out spike and other rapidly changing signals. The threshold used for detection is then calculated by multiplying the estimated noise with a user definable threshold multiplier.

Detection on envelope signal

The envelope is determined by taking the absolute value of the 1-1.5 kHz bandpassed signal and low pass filtering it. When this low pass filtered "envelope" passes the determined threshold a spike is detected.

The advantage of the envelope detector is that it averages somewhat, thus lessening the effect of noise. That is, it is better at picking out smaller spike candidates that might otherwise be too small to trigger. Because the envelope is a heavily processed version of the signal, one sees a high frequency transient for every spike representing the initial ‘fast’ up or downward going portion of a spike waveform. Some noise might show the same frequency characteristics but these can be dealt with in the classification step.

3.3.2 Feature Space

Summary

Because spikes are detected from a heavily processed version of the signal, they have to be aligned before they can be transformed into the feature space and spike classification can be performed. A fixed, 2-dimensional feature space has been selected here. Four different clustering algorithms have been implemented to classify spikes but only three are described here. All take the approach to initially assume one unit and then perform iterative splitting and combining of clusters until a stable model is reached.

Alignment

Alignment is performed on the 1-5 kHz filtered signal because the signal provides better resolution for determining the start of a pulse. To improve the timing of the spike event, we search for the maximum point and average over the three points closest to the maximum. Ideally, the processed signal is correlated with a ‘high-frequency’ benchmark signal, i.e. a spike waveform template in the 1-5 kHz frequency range, but this approach was not chosen for computational reasons.

Recorded ‘spike-like’ artifacts that are present on at least 30 channels (user definable) are discarded as falsely detected events.
Feature Space Transformation

The nature of our approach to this point is to break the neural signal into two bands, 250 Hz to 1 kHz and 1 kHz to 5 kHz. Benchmark signals in each frequency band were empirically generated from a spike waveform template. The low frequency and high frequency version of each incoming waveform are correlated with the corresponding benchmark signals which produce the x and y values for that waveform in the feature space. Thus, we have a fixed transformation into the feature space which allows us to save processing time/memory, compare channels, easily analyze changes over time and apply algorithm-overwriting rules.

Noise tends to form clusters around the origin of the feature space, neural waveforms tend to form clusters away from the origin. The x-axis is roughly representative of initial fast peak of a spike waveform; the y-axis is representative of the following slower opposite going peak.

3.3.3 Spike Classification in Feature Space

Three different clustering algorithms have been implemented with only algorithm 1, ‘Spread Factor’, and algorithm 2, ‘Histogram Peak Count’. All algorithms assume that clusters are two dimensional Gaussian distributions in the feature space. The user sets how many waveforms are required for the model to update the number of clusters found, typically about 150.
Algorithm 1 - Spread Factor

The model we assume for clusters in a feature space is a Gaussian mixture model where different neurons create clusters of obviously different mean, but also different covariance.

A second order model for the classification is used based upon two dimensional Gaussian distributions. The classifier is implemented using log likelihood and the boundaries between clusters are conic sections, i.e. ellipses oriented about the cluster center or mean. The vector mean is updated on a sample-by-sample basis and to do that we use a gradient descent approach.

Example of feature space. Initially, one cluster is assumed, then two, then four and finally the correct three.

Given a set of data points, a separating hyperplane from the eigendecomposition of the covariance matrix is generated and the cluster is divided in half. If the ratio of sub-cluster variance to distance between centers goes down significantly, two separate clusters are declared and the group is split. Likewise, there is an inverse technique. A cluster and its nearest neighbor are combined and checked in a similar fashion. If the ratio falls below a certain level, the two clusters are declared to be one.

After a user-defined amount of time, the numbers of units on each channel are frozen but the cluster stats (ellipse center and orientation) are allowed to further adapt.
Algorithm 2 – Histogram Peak Count

This approach is based on projecting the feature space sample points onto an axis, constructing a histogram from the projected data and estimating clusters by determining peaks and valleys in the histogram.

The major principle component is used as the axis to project data points onto when the number of clusters is unknown, i.e. when the classification model is initialized. The Fisher linear discriminant is used when the cluster model is established and just updated. The histogram is constructed with a fixed number of bins (default 20) and the range of values is limited to capture the mean + six standard deviations of the projected data or to the approximate limits of the data to include low hit, outlying clusters.

The cluster finding algorithm is based on a peak/valley search algorithm. The histogram-based cluster splitting and combining algorithm constructs a histogram based on all the samples collected, based on the samples belonging to an assumed cluster or based on the samples of two neighboring assumed clusters. The first peak of the histogram is detected by searching for the first peak encountered from one side. The valley neighboring the first peak is detected by finding the closest, smallest data point away from the first peak that has a value below a valley detection threshold (e.g. 50% of first peak). Once a valley has been detected, the second peak may be detected as the largest data point away from the first peak and valley that is above a peak detection threshold (e.g. 50% larger than valley found). If both a valley and a second peak are found the samples used remain or are split into two clusters. If no valley or no second peak are found the samples remain belonging to or are combined to one cluster. Based on the location of the peaks and valleys boundaries are defined in the feature space to help determine which cluster incoming samples belong to.
Manual Override Options

Noise circle
A circle can be defined around the origin of the feature space to reject noise. The events within the circle are discarded before automated clustering is applied.

Manual mapping
The user can remap the units on each channel. For example, unit 3 can be mapped to be unit 1 in which case it would effectively be combined with the cluster that was identified as unit 1. Clusters can also be mapped to noise.

Manual spike sorting using feature space circles
Users can draw circles in the feature space to override the results of the automated algorithm. The manual clustering is applied after the automated clustering.
3.4 Hardware Configuration

The input as well as output channels can be configured in **Hardware Configuration**. To access these settings, click the <Hardware Configuration> button on the Central main menu. By default, only one session of **Hardware** Configuration can be opened. If multiple sessions need to be opened, select **Tools / Window Options** then check the box to allow multiple sessions.

All of the NSP inputs and outputs can be grouped by function or by their location on the NSP. Signal Types are grouped by function. NSP Channels are grouped based on their physical location on the NSP.

The NSP Channels consist of Front-End Amplifier Inputs, Analog Inputs, Analog Outputs, Digital Inputs, Serial I/O, and Audio outputs.

![Figure 3.4-1 Hardware Configuration Window](image)

The Hardware Configuration window contains buttons in the upper left corner to change the view of the window. The buttons (from left to right) are Icon View, List View, Detail View, and Full Row Details. Each entry represents a probe, or channel, on the array and the neural signal being received.

To configure any of these channels, select the channel type on the left side of the window. Each individual channel is displayed on the right side of the window for the channel type that was selected. You can configure the channels individually, by groups of channels, or select all channels. To configure an individual channel, double click the channel to display the channel properties. To configure a group of channels, hold down the <Shift> key on the PC keyboard then select the group of channels to be configured. Hold down the <Ctrl> key then click the individual channels to select them. Once the group of channels to configure has been selected, click the Channel Properties icon located at the top right side of the window or right click the selected group of channels then select **Channel Properties**.
3.4.1 Front-End Amplifier

The Front-End channel settings can be set individually, or as a group. To configure these channels, select the channel or group of channels you wish to configure, followed by selecting the channel properties.

![Front-End Amplifier Inputs](image1)

**Figure 3.4-2 Front-End Amplifier Inputs**

![Front-End Input Channel Properties](image2)

**Figure 3.4-3 Front-End Input Channel Properties**
• **Label.** Each channel can be labeled to any name that the user specifies in this box. The name of each channel will appear by default as elec# unless specified otherwise. When configuring a group of channels, you can label the channels on a global basis by selecting the “edit” button.

• **Digital and Analog Range.** These are fixed values for informational purposes. Neural inputs through the Front-End Amplifier have a voltage range of +/- 8mV.

• **Line Noise Cancellation.** The Line Noise Cancellation box, when checked enables the line noise cancellation filter. With the LNC filter enabled, you can set the time constant in the LNC Rate drop down menu to adapt to the 60 Hz line noise. A time constant of 10s is the default and recommended setting. However, you may set the time constant from 1s to 60s, instantaneous or to hold.

• **Continuous Acquisition.** By enabling the continuous acquisition, you have the option to record continuous waveforms by selecting a bandwidth. The appropriate sampling rate for the continuous waveform is automatically selected with the corresponding bandwidth.

• **Continuous Acquisition Bandwidth - Sample Rate.** Descriptions of the waveform types vs. bandwidth are detailed below:

  0.3 Hz – 250 Hz – 1kS/s: This selected bandwidth is used for continuous narrow band, low frequency Local Field Potential waveforms sampled at 1000 samples per second.

  10 Hz – 250 Hz – 1kS/s: This selected bandwidth is used for continuous low frequency EMG / EEG waveforms sampled at 2000 samples per second.

  0.3 Hz – 500 Hz – 2kS/s: This selected bandwidth is used for continuous wide band, low frequency Local Field Potential waveforms sampled at 2000 samples per second.

  0.3 Hz – 7.5 kHz – 30kS/s: This selected bandwidth is used for continuous waveforms of the “raw data” from the front-end amplifier sampled at 30000 samples per second.

  250 Hz – 7.5 kHz – 30kS/s: This selected bandwidth is used for continuous Spikes / Action Potential waveforms sampled at 30000 samples per second.

• **Spike Extraction.** When enabled (default), Cerebus will display the spike triggered events.
3.4.2 Analog Input Properties

Figure 3.4-4 Analog Input Properties
• **Label.** Each channel can be labeled to any name that the user specifies in this box. The name of each channel will appear by default as ainp# unless specified otherwise. When configuring a group of channels, you can label the channels on a global basis by selecting the “edit” button.

• **Digital and Analog Range.** These are fixed values for informational purposes. Analog Inputs have a voltage range of +/- 5V.

• **Line Noise Cancellation.** The Line Noise Cancellation box, when checked enables the line noise cancellation filter. With the LNC filter enabled, you can set the time constant in the LNC Rate drop down menu to adapt to the 60 Hz line noise. A time constant of 10s is the default and recommended setting. However, you may set the time constant from 1s to 60s, instantaneous or to hold.

• **Continuous Acquisition.** By enabling the continuous acquisition, you have the option to record continuous waveforms by selecting a bandwidth. The appropriate sampling rate for the continuous waveform is automatically selected with the corresponding bandwidth.

• **Continuous Acquisition Bandwidth - Sample Rate.** Descriptions of the waveform types vs. bandwidth are detailed below:
  
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  10 Hz – 250 Hz – 1kS/s: This selected bandwidth is used for continuous low frequency EMG / EEG waveforms sampled at 2000 samples per second.
  
  0.3 Hz – 500 Hz – 2kS/s: This selected bandwidth is used for continuous wide band, low frequency Local Field Potential waveforms sampled at 2000 samples per second.
  
  0.3 Hz – 7.5 kHz – 30kS/s: This selected bandwidth is used for continuous waveforms of the “raw data” from the front-end amplifier sampled at 30000 samples per second.
  
  250 Hz – 7.5 kHz – 30kS/s: This selected bandwidth is used for continuous Spikes / Action Potential waveforms sampled at 30000 samples per second.

• **Spike Extraction.** When enabled (default), Cerebus will display the spike triggered events.
### 3.4.3 Analog Output Properties

![Analog Output Properties](image)

**Label.** Each Analog Output channel can be labeled to any name that the user specifies in this box. The name of each channel will appear by default as aout# unless specified otherwise.

**Input and Output Range.** These are fixed values for informational purposes.

**Track Most Recently Selected.** With the **Track Most Recently Selected** box checked, the designated channel will change to follow any channel selected from Spike Panel, Neural Channel, or Raster Plot.

**Source Type.** Use the **Source Type** drop down menu to select Spike Events or Local Field Potential / Continuous Waveform to be displayed from the Analog Output port.

**Source Channel.** Use the **Source Channel** drop down menu to select the individual channel to display from the Analog Output port.
3.4.4 Digital Input Properties

- **Digital Input Label.** Change the label to name the digital input. For the DB-37 digital input specifications, see chapter 0 on page 2-2 for port pin out information.

- **Digital Input Function.** Digital Input functions include 16-bit on word strobe (default), 16-bit on bit change, 16-bit on rising edge, 16-bit on falling edge, or disable. For the DB-37 digital input specifications, see chapter 0 on page 2-2 for port pin out information.
3.4.5 Digital Output Properties

- **Digital Output Label.** Each Analog Output channel can be labeled to any name that the user specifies. The name of each channel will appear by default as dout# unless specified otherwise.

- **Track Most Recently Selected.** With the **Track Most Recently Selected** box checked, the designated channel will change to follow any channel selected to be viewed from Spike Panel, Neural Channel, or Raster Plot.

- **Source.** Select a source channel to monitor.

- **Monitored Units.** The user can select which units to monitor from the source channel through the digital output ports. Monitor unclassified units and / or classified units defined online.
3.4.6 Serial I/O Properties

![Serial I/O Properties](image)

**Figure 3.4-8 Serial I/O Properties**

**Serial I/O.** With the Serial I/O box enabled (default), the 9-pin serial port can be used as an 8-bit digital input or a digital output port. See chapter 0 on page 2-2 for the serial port pin-out diagram.
3.4.7 Audio Output Properties

- **Label.** Each Audio Output channel can be labeled to any name that the user specifies in this box. The name of each channel will appear by default as audio# unless specified otherwise.

- **Track Most Recently Selected.** With the Track Most Recently Selected box checked, the designated channel will change to follow any channel that you select to view from Spike Panel, Neural Channel, or Raster Plot.

- **Source Type.** From the Source Type drop down menu, select the Spike Events or Local Field Potentials (LFP) / continuous waveform to audibly listen to from the Audio Output port using a pair of amplified speakers.

- **Source Channel.** From the Source Channel drop down menu, select the individual channel to audibly listen to the events from the audio output port.
3.4.8 **Global Settings**

The Global Settings window allows a user definable number of samples to be collected in the spike triggered processing window. The default value is 48 samples. This would collect spike triggered waveforms for 1.6 ms. You can set the spike width to a range of 30 samples up to 128 samples. (1.0 ms to 4.3 ms spike triggered sample width.)

![Global Settings Window](image-url)

**Figure 3.4-10 Global Settings Window**
3.4.9 Spike Sorting

The Spike Sorting configuration window allows the user to specify the automatic spike sorting settings used when detecting spikes and determined threshold. The default settings are recommended, but can be changed to user preference. The detailed specifications of the automatic spike sorting model are defined on pages 3-4 to 3-8.

![Spike Sorting Configuration Window]

Figure 3.4-11 Spike Sorting Configuration Window

The settings descriptions are as follows:

- **Detection Threshold Value**: The signal is filtered between 1-5 kHz (2nd order Butterworth) for spike detection and the noise in that band is estimated. The signal value has to cross the average noise times the Threshold Value. This value should be between 2.0 and 3.0.

- **Detection Multiplier**: Once a spike is detected, no spike can be detected until the processed signal drops below a certain value which is: `detection peak` – (`noise` * `Multiplier`).

- **Noise Boundary Radius**: Radius of the Noise circle in the feature space. This parameter can also be set graphically by dragging the outside of the circle.

- **Artifact Rejection Maximum Simultaneous Channels**: Minimum number of channels a simultaneous event (artifact) has to be detected on before it is discarded as an artifact.

- **Artifact Rejection Refractory Period (samples)**: The number of samples no spike can be detected after a spike detection (refractory period).

- **Freeze Time**: Time Specified in minutes that the spike sorting process of determining the number of units per channels runs.

- **Update Rate**: Specifies the number of spikes that needs to be collected per unit before spike sorting statistics are updated. Assume one unit per channel at the beginning.

- **Algorithm Type Settings**: Four sorting algorithms are available of which two are preferred: The Histogram Peak Count and Histogram Peak Count (Fisher) methods. Both algorithms plot a histogram using either the principle component axis or the Fisher linear discriminant axis. The algorithm then counts the peaks and valleys assuming at least one peak is present.

- **Valley Percentage**: The first peak from the origin is detected and marked. The peak has to drop by `Peak Value` * `Valley Percentage` before a found valley is declared.

- **Close Peak Percentage**: If the valley drops to zero (no spikes), see the Minimum Peak Percentage parameters. Otherwise, the next peak has to be at least `Valley Value` * `Close Peak Percentage` larger than the valley.

- **Minimum Peak Percentage**: If the valley drops to zero, the next valley has to be at least `# Spikes in histogram` * `Minimum Peak Percentage` in size.
3.4.10 Adaptive Filtering

Recorded signals equal the neural signal plus noise. Any known sources of external noise, such as an eye coil box, can be plugged into the Cerebus system and tested for extraneous noise levels. The **Adaptive Filtering** utility provides a means to determine how much of the recorded signal is comprised of noise so that parameters can be set to eliminate the noise from the signal.

![Figure 3.4-12 Adaptive Filtering](image)

Plug the peripheral equipment into the Cerebus NSP then click **Adaptive Filtering**, right-click the channel icon then select Properties. Click the **Enable** box to activate the settings. The Learning Rate is preset and should be very low. The Reference Channels are those ports on the front of the Cerebus into which the test cable is plugged. Click <Apply> to activate filtering. The noise level is automatically computed by Cerebus.

3.4.11 Software Reference Electrode

As an alternate to the hardware reference, this selection allows you to specify a software reference electrode:

![Software Reference Electrode](image)
Spike Panel

Spikes can be displayed by channel (electrode) using Spike Panel. Spike Panel displays an overview of the neural activity on each channel. When spike classification is activated, the spikes will be displayed in different colors.

Figure 3.5-1  Spike Panel

Double-click a single channel or multiple channels to display the neural signal window for the channel(s) selected. Hold down the <Shift> or <Ctrl> keys to select multiple channels. The toolbar in the spike panel display includes additional functions for the module. These functions are defined below:

- **Load Map File.** The default map file for the spike panel is the 16X8 Grid as shown in Figure 3.5-1. A map file can be loaded to change the layout of this grid. For example, a 10X10 grid of 100 channels may be loaded with specific channels in a preferred order and location.
- **Load Default Map File.** By selecting this button, the default 16X8 grid of 128 channels will be loaded.
- **Map File Information.** Displays information about the map file currently loaded.
- **Time to screen refresh.** The drop down tool allows the user to select the time until the spike panel display will refresh. The refresh rate can be set to refresh every 2, 5, 10, or 20 seconds, or Never to stop the refresh rate.
- **Open Selected Channels.** After selecting a channel, or group of channels to display in the neural channel module, click this button to open the selected channels or right click after selecting channels then click Open Selected Channels.
- **Refresh Screen.** Select the refresh button to manually refresh the spike panel display.
Magnify Current Channel. Select this button to magnify the channels in the spike panel. Move the mouse over the channel to magnify the channel. When magnify is turned on, the channels will only be magnified if the spike panel display window has been sized down.

![Figure 3.5-2 Spike Panel -- Magnify Enabled](image)

Broadcast Channel Selections. Select this button broadcast the channel to other computers that may also be connected to the Cerebus system through an Ethernet connection.

- Level of Criticality (LOC). The LOC button displays the load on the PC. Four different symbols are displayed on this dialog.

![Figure 3.5-3 Level of Criticality](image)
3.6 Raster Plots

Raster Plot provides an overview of neural and experimental activity of all channels.

![Raster Plot](image)

**Figure 3.6-1 Raster Plot**

- **Play.** When the <Play> button is selected, Raster Plot displays wrap.
- **Scroll.** When the <Scroll> button is selected, Raster Plot displays scroll versus wrap to the beginning of the display like the <Play> button.
- **Pause.** When the <Pause> button is selected, the Raster Plot display will pause.
- **One Line Per Channel.** When selected, all spike events on a channel will be displayed on one line.
- **Split Channel.** Splits single channels in the raster plot display as shown in Figure 3.6-1. A channel can be displayed by online classification rules and continuous waveforms.
- **Rate.** Lets the user select the scrolling speed at which the raster plot displays the data. Set the range from 10 ms/pix to 250 ms/pix (milliseconds per pixel).

**Decrease size, Increase size, Minimize, and Maximize Channels.** Select a channel (or group of channels) in the raster plot to increase or decrease the size of the selected channels.
Delete Channel. Click the <Delete> button after selecting a channel or group of channels, to delete them from the raster plot display.

Move Down, Move Up. Use the <Move Down> / <Move Up> buttons to select a channel or group of channels then move them up or down in order on the raster plot display.

Scale Continuous Data. Use this button to display continuous waveform in the raster plot module and adjust the scale for display.

Update Display. Updates and refreshes the raster plot display.

Sort. The <Sort> button sorts the channels in the raster plot display. Click the drop down arrow to display the sorting types then select sort by Channel ID, Recording Mode, or Unit ID.

Choose Channels, Add All, Clear All. Click the <Choose Channels> button to select a group of channels to add or remove from the raster plot display. To add all channels to the display, click the <Add All> button. The <Clear All> button will remove all channels from the raster display.

Open Selected Channels. After selecting a channel or group of channels to display in Neural Channel, click this button to open the selected channels.

Broadcast Channel Selections. Click this button to broadcast the selected channel(s) to other computers connected to the Cerebus system through an Ethernet connection.

Level of Criticality. This button displays the load on the PC. Four different symbols appear on this button.

![Figure 3.6-2 Level of Criticality](image)
3.7 Neural Channel

**Single Neural Channel** can be launched from the Central Application. It is also displayed when a specified channel is double clicked from **Spike Panel** or **Raster Plot**. **Single Neural Channel** displays the settings and activity of an individual channel / electrode.

![Neural Channel Configuration](image)

**Figure 3.7-1 Neural Channel Configuration**

- **Channel ID.** From the drop down box, change the channel displayed.
- **Properties:** Display and change the settings of the current channel.
- **Spike Display.** The signal is displayed as time stamped events. Use the horizontal slide button at the top of the screen to set the voltage range. The default time scale of the spike display window is 1.6 ms / 48 samples spike width. The time scale / spike width samples can be defined in the Global Settings section in the Hardware Configuration module in a range from 1.0 ms to 4.3 ms / 30 samples to 128 samples.
- **Clear.** The <Clear> button clears the spike display until new spikes are triggered. Specify in the drop down box how many events will be displayed before clearing.
- **Show Spikes Drop Menu:** You may specify which waveform types are displayed in the spike display.
- **Waves / Pattern:** View spikes in waveform or 2 dimensional Principal Component view.
- **Cont Signal.** This allows the display of the continuous waveform signal and spike display in raster format.
- **Raw / LNC.** Click this button to display the raw data, view any applicable line noise, or to cancel.
• **Online Spike Classification.** Spike sorting is performed automatically. Auto 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.

![Image of online spike classification](image1)

• **Manual Override options.** A user can override the automatic spike sorting on an individual channel by clicking on the “Pattern” view / 2 dimensional PC display of the spike activity. Click the “Edit” button next to the classified spike to override the auto spike sorting function for that sorted unit and resort to a manual sorting option. A circle for the color of the unit will appear in the Pattern display. You can then drag the circle to the cluster that you would like to define as a spike. You may also change the size of the circle to make the diameter larger or smaller. Once the circle is placed in the cluster that you are defining, the word “overridden” will appear next to the sorted unit. You can also change the threshold radius by changing the diameter of the grey circle in the center of the Pattern Display. Any units that occur in the grey circle will not be displayed as a spike.

![Image of manual override option](image2)

• **Unit Mapping.** Another override option can be performed by clicking the unit mapping button. You can apply rules that combine classified units or select a unit as noise.
3.8 Activity Map

The firing rate per second of spikes on all electrodes is displayed in real-time in Activity Map. The range of the color scale used to indicate the firing rate can be changed and the first-order filter that is used to smooth the activity map can be changed.

Figure 3.8-1 Activity Map

- **Pause.** When this box is checked, the display will pause. The activity map will resume when the box is clicked again to clear.
- **Show Dis.** When this box is checked, the activity map will show disabled channels.
- **Reset Button.** Press the <Reset> button to restart the display of the firing rates.
- **Load Map File.** The default map file for the activity map is the 16X8 grid shown in figure Figure 3.8-1. A map file can be loaded to change the layout of the grid. For example, a 10X10 grid of 100 channels can be loaded with specific channels in a preferred order and location.
3.9 File Storage

Use the File Storage screen to enter patient information and select a path for the files that are created when the session is initiated. The Cerebus™ Software assigns a numeric name to the files. File Storage will also save the settings at the beginning of a recording session. The performance of the data acquisition system is strongly dependent on the speed of the file media being used so data should only be stored real-time on the hard drive then moved later to slower media such as floppy disks, Jazz or Zip disks, or network drives.

![Figure 3.9-1 File Storage](image)

After the required fields are filled in, click <Record> to start recording the session. Click <Stop> to stop or pause recording. Patient information does not need to be re-entered within a session. To start a new session, open the File menu then select New Session. The new patient information will have to be entered before recording is possible.

- **File Splitting.** The software can split recorded data files during a recording session to allow smaller file sizes for offline analysis. The file size and time limit before the system will create a new file can be user defined by clicking the view drop down menu "options". To disable file splitting, check the disable file splitting box in the file storage module.

- **File Description.** Use the dialog to add comments up to 256 characters long to the data files. Multiple lines can be entered with <Ctrl>+<Enter> but users should not enter more than eight lines in this field. Comments need to be entered prior to recording a data file.

- **Record For** With the Record For box checked, specify an amount of time (in seconds) that Cerebus will record data. Once the time has expired, the recording will stop automatically.

- **Start / Stop Recording.** Press the <Stop Recording> button to abort the data acquisition cycle (this button only appears during acquisition cycles). This is an acceptable way to routinely stop acquisition cycles as it simply closes the data file and preserves all file content up to the point of acquisition termination.

- **Remote Recording Control.** Check the remote recording box to Start, Stop, Pause, and Resume file recording from an external source 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.
3.10 Signal to Noise Ratio

Signal to Noise Ratio (SNR) displays the peak-to-peak amplitude of the signal and the peak-to-peak estimate of the noise in micro volts. It also displays the signal-to-noise ratio so that the quality of the signal can be monitored. Readings can be saved as a text file and opened in Excel or another program for future analysis. The SNR for electrode #1 in the example below is 4.30 meaning that the signal is 4.3 times bigger than the noise.

![Signal to Noise Ratio](image)

**Figure 3.10-1 Signal to Noise Ratio**
3.11 Neural Modulation

Neural Modulation displays changes over time of the firing frequency. The Modulation Index covers a range of 0 to 12.0 but a range of 2-5 is considered normal.

![Table: Neural Modulation]

Figure 3.11-1 Neural Modulation
3.12 Impedance Tester

Impedance Tester analyses each channel to display impedance values of each electrode. When selected, a dialog box is displayed instructing the user to turn the impedance switch located on the patient cable to the on position, marked with a + sign. (Patient Cable Sold Separately.) Data cannot be recorded when the system is in impedance mode.

Figure 3.12-1 Impedance Switch

NOTE
Impedance Tester function requires an optional cable sold separately from a Cerebus System.

Step 1
Click <Impedance Tester> on the Central main menu to open the impedance application. If the system is recording, a dialog will be displayed instructing the user to stop recording or cancel the impedance test. The user will also be given the chance to stop the recording from the dialog. Auto Impedance checks the impedance switch to ensure it is in the correct position.

Figure 3.12-2 Checking Impedance Mode
Step 2  A dialog box will be displayed notifying that the system is checking the impedance switch. The impedance switch on the patient cable should be in the off (--) position during normal operation. A dialog will be displayed instructing the user to switch system to impedance (+). Move the switch to the on position (+).

![Figure 3.12-3  Set Switch to Impedance Mode](image1)

Step 3  Auto Impedance checks the array reference wires before beginning.

![Figure 3.12-4  Checking References](image2)
Step 4  Impedance data is collected then the Auto Impedance screen is displayed. All channels are measured simultaneously. The measurement takes less than one minute. Impedance readings are displayed for every channel.

Figure 3.12-5  Auto Impedance Screen

Tolerance is defaulted to 100 – 800. If any channels display numbers outside tolerance the box will turn yellow indicating below tolerance or red indicating above tolerance. If a high percentage of channels show out of tolerance disconnect then reconnect the patient cable from the pedestal then rerun the test.

Step 5  Open View then click Options to display the Impedance Calculation Settings.
Step 6  Open the Edit menu or right-click one of the bad channels to display the properties menu.

Step 7  Select **Disable Bad Channels**. The out-of-tolerance channels will display a border.

Step 8  When the other Central modules are opened, the disabled channels will be blank or missing.
Step 9  Click **File/Save Values** to save the settings to a text file on the hard drive.

![Figure 3.12-9 Save Values](image)

Step 10  Click **File/Exit** to quit Impedance testing. Auto Impedance will check the switch.

![Figure 3.12-10 Checking Normal Mode Switch](image)
A dialog will be displayed instructing you to turn the Impedance switch to the OFF position. When the switch has been toggled to the off position, Auto Impedance will close. Do not leave the impedance switch in the on position when not in the Auto Impedance feature. If the switch is accidentally switched to the On position when not testing, significant noise will be present invalidating the recorded data.

Step 11  Auto Impedance restores previously saved channel settings before it closes.
3.13 Crosstalk Diagnostic Utility

If you suspect that you may be looking at the same neural activity on more than one channel, the Crosstalk Diagnostic module will compare each channel for cross correlation. The Crosstalk Diagnostic Module will display each channel as green, Yellow, or Red.

- **Green Channels**: Indicates that no cross correlation to any other channel / electrode was found.

- **Yellow Channels**: Indicates that possible cross correlation is found with another marked yellow channel / electrode, but not exact cross correlation. It is suggested that the user closely compare any channels that turn yellow to determine if you believe it is possible crosstalk.

- **Red Channels**: Indicates that exact cross correlation is found with other red marked channels.

You can flag any channels as “bad” and disable them from the “Edit” Drop Down Menu.
4 Central Play

The Central Play utility is used to play recorded data. Using Central Play, view previously recorded sessions. The only data editing Central Play allows is new hoops placed in **Single Neural Channel** then it records to a new data file. Refer to paragraph 3.7, for more information about Single Neural Channel.

Central Play is opened from the Cerebus Release folder.
This page intentionally left blank.
## System Specifications

<table>
<thead>
<tr>
<th><strong>128-CHANNEL FRONT-END AMPLIFIER</strong></th>
<th><strong>128-CHANNEL NEURAL SIGNAL PROCESSOR</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input Range</strong></td>
<td>±7.5mV</td>
</tr>
<tr>
<td><strong>Gain and Conversion</strong></td>
<td>± 8.095 mV input / 16-bit digital output, with 1 µV per bit resolution</td>
</tr>
<tr>
<td><strong>Input Impedance</strong></td>
<td>&gt; 10^{12} ohms</td>
</tr>
<tr>
<td><strong>Input Bias/Leakage</strong></td>
<td>+5pA typical, ±20pA max</td>
</tr>
<tr>
<td><strong>Input Referred Noise</strong></td>
<td>&lt; 3.0µVrms (14µVp-p)</td>
</tr>
<tr>
<td><strong>Common Mode Rejection Ratio</strong></td>
<td>&gt; 90 dB at 50/60 Hz</td>
</tr>
<tr>
<td><strong>Common Mode Input Range</strong></td>
<td>up to ±3.0 V between inputs and ground</td>
</tr>
<tr>
<td><strong>Differential Input Range</strong></td>
<td>up to ±3.0 V between electrode and reference inputs</td>
</tr>
<tr>
<td><strong>Maximum Input Voltage Range</strong></td>
<td>up to ±5.0 V between any input and ground</td>
</tr>
<tr>
<td><strong>Crosstalk between channels</strong></td>
<td>&lt; 1 LSB for all configurations</td>
</tr>
<tr>
<td><strong>Filter characteristics</strong></td>
<td>4th order Butterworth (high), 3rd order Butterworth (low)</td>
</tr>
<tr>
<td><strong>High Pass Cutoff Freq</strong></td>
<td>0.3 Hz (full-bandwidth mode) 250 Hz (fast-settle mode)</td>
</tr>
<tr>
<td><strong>Low Pass Cutoff Freq</strong></td>
<td>7.5 kHz</td>
</tr>
<tr>
<td><strong>Headstage Power Supply</strong></td>
<td>±5.0 V output, up to 150 mA for powering optional headstages</td>
</tr>
<tr>
<td><strong>Control/Data Output Connection</strong></td>
<td>MT-RJ fiber-optic port with 2-way 150 Mbps 8B/10B encoded data-stream and 32-bit CRC data validation</td>
</tr>
<tr>
<td><strong>External Power Supply</strong></td>
<td>Five channel with monitoring, sequencing, and emergency shutdown control</td>
</tr>
<tr>
<td><strong>Input:</strong></td>
<td>(240 VAC 50 Hz Available)</td>
</tr>
<tr>
<td><strong>Outputs:</strong></td>
<td>~5.0 V, 500 mA analog, +3.3 V, 300 mA quiet digital, +3.3 V, 500 mA digital, +5.0 V, 300 mA digital</td>
</tr>
</tbody>
</table>
6 Troubleshooting

6.1 Extraneous Noise

You will find that the Cerebus system is very sensitive to extraneous electromagnetic signals. It is designed to detect microvolt level signals.

When the simulator is attached to the system, touching or just holding your hand near the ribbon cables will cause noise on Spike Panel and Raster Plot. This is not a fault but an indication that the location and arrangement of the connecting cables is critical to optimal performance.

Make sure that the cables connecting the amplifier to the Cerebus NSP are kept away from the ribbon cables that input signals to the amplifier to avoid feedback problems and cross-talk between channels. The simulator is an excellent tool to detect subtle problems in the system setup.

Computer monitors can also be a major source of noise and should be kept away from the instrumentation field.

6.2 Windows Compatibility issues

On certain PCs running the Windows operating system, some of the software modules or executable files rarely experience graphical issues. If this happens, set the compatibility mode in the file properties of the software to correct the issue.
Open the Release folder that Cerebus installed on your PC then right-click the module / executable file. Select the “properties” option in the drop down menu.

Figure 6.2-2  Cerebus Central Properties
From the file properties screen, click the Compatibility tab at the top of the window then click the box in the Compatibility mode section to run the program in compatibility mode for Windows 2000.

![Figure 6.2-3 Compatibility Mode](image)

6.3 No Power to Cerebus System

In the event that the Cerebus system does not power on, check the following:

1. Verify that the Cerebus system is plugged into a working outlet or power strip, and verify that all power cords are plugged into the Cerebus.
2. Verify the position of the power switch and make sure it is in the ON position. If the power switch is in the ON position, turn it to the off position then wait at least five seconds before turning the Cerebus back on. (It is recommended that when restarting the Cerebus, always wait five seconds before turning the unit back on. This will ensure a proper system reset.)
3. Contact Product Support at (866) 806-3691, or (801) 582-5533 for assistance.

6.4 Lost Packets Error Notification

If an error message is displayed that network packets were lost during analysis or recording, or that no packets are being received when running Cerebus Central, verify the following:

1. Check the Ethernet Cat5-e cable and verify that it is secure in the 1 Gigabit Ethernet card in the PC and the RJ-45 port on the back of the Cerebus labeled “To PC.”
2. Look at the Central Control module and verify that the PC system load is not too high. If the PC system load is too high, adjust the thresholds on all channels to lower the load on the PC or lower the sample rate for continuous waveforms if they are enabled. Are any other programs running on the Cerebus PC? If so, close any open programs that do not need to be running while using the Cerebus system.

3. Does the Cerebus PC meet the minimum specifications for the Cerebus system? Contact product support for the PC specifications at (801) 582-5533 or (866) 806-3692.

4. Is a firewall enabled on the Cerebus PC? Some issues with firewalls have been known to block data packets between the Cerebus system and the PC. Disable the firewall then reboot the Cerebus PC.

6.5 No Neural Activity on all Channels

If Cerebus 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:

1. Open Central.exe and verify that packets are being received from the Cerebus system. If the PC is not receiving packets from the Cerebus system, see troubleshooting section 6.4 above.

2. Verify that the fiber optic data link between the amplifier and the Cerebus 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 to verify that it has power. If the LED is not illuminated, check the power supply and verify that it is turned on and not in standby mode. Are the cables securely plugged in?
7 Warranty

Cyberkinetics Neurotechnology Systems, Inc. warrants that its products are free from defects in materials and manufacturing for a period of one year from the date of shipment. Cyberkinetics will, at its option, 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 Cyberkinetics' employee

2. Any abuse, negligent handling or misapplication of the product.

This constitutes the sole warranty made by Cyberkinetics, Inc. There are no other warranties, expressed or implied, which extend beyond those described herein or to anyone other than the original purchaser, including the implied warranties of merchantability and fitness for a particular purpose. In no event shall Cyberkinetics Neurotechnology Systems, Inc. be liable for any incidental or consequential damages, or for the infringement of any patent rights or third party rights due to the use of its products. The equipment detailed in this user manual is intended for research with animal subjects only and is not suitable for experimentation with human subjects.

7.1 Return Merchandise Authorization

In the unlikely event that your Cerebus system needs to be returned to Cyberkinetics 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 Cyberkinetics representative. If you need to obtain an RMA number, you may contact a product support representative at (801) 582-5533 or toll free at (866) 806-3692.

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

Cyberkinetics, Inc.
ATTN: RMA#
391 Chipeta Way, Suite G
Salt Lake City, UT 84108 USA
Tel: (801) 582-5533
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