



Neurotechnology Research Systems

User Guide

Version 2.6 February 2009

Multichannel Acquisition Processor

RASPUTIN Software



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USA



Caution

Electrostatic Discharge

Some devices can be damaged by improper handling. Use appropriate electrostatic discharge (ESD) procedures when handling these devices. See <http://www.esda.org/> for additional information on ESD procedures.



Caution

USB Security Key Damage

Before Sentinel System security key drivers are installed, *all* Sentinel USB keys must be removed from the PC. Installing a system driver with a USB key in the port causes the key to be unusable.

Multichannel Acquisition Processor

RASPUTIN Software

User Guide

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February 2009

Issue 2.5 includes the following changes:

- Added Continuous Signal Recording chapter
- Added appendices for Expansion Chassis, C-HUB Technical Brief, and BNC-16B Technical Brief Appendix
- Made modifications to Sort Client Options dialog box
- Reformatted entire document

August 2006

Version 2.4 includes the following changes:

- The RASPUTIN User's Guide includes several minor revisions.
- Front End Client (FEC) is replaced by Ref2
- PlexUtil is upgraded with a new user interface and improved functionality.

August 2004

Version 2.2 included changes that support up to four NI-DAQ devices and PLX file format changes that accommodate up to 256 continuous channels.

December 2003

This was the first edition of the Plexon RASPUTIN User's Guide. Prior to this edition, guides to some of the clients had been separately published. Revised versions of the following guides were included in this guide:

- GAC (Graphical Activity Client) Version 1.4, 5/11/2000
- FEC (Front End Client) Version 1.1, 8/01/2000
- GridMon (Grid Monitor Client) Version 1.1, 5/15/2000
- PEC (PeriEvent Client) Version 1.2, 1/09/2001
- PlexNet, 8/06/2001
- PlxUtil, 5/25/2000

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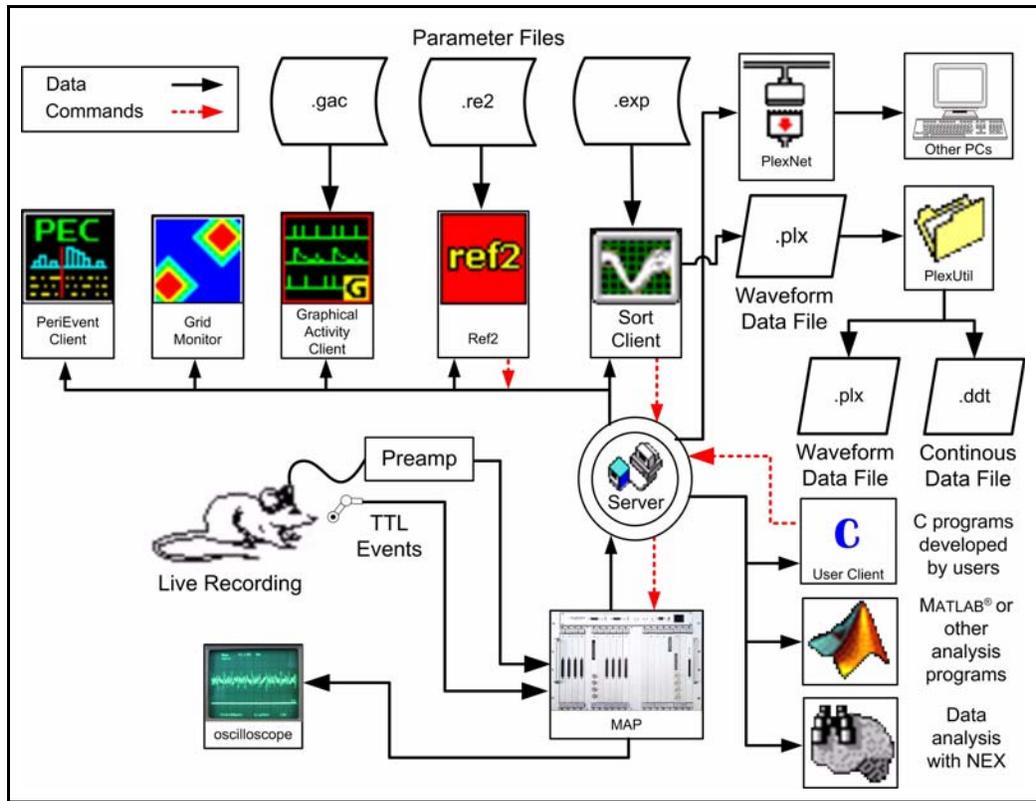
1.1 Overview

Neurons in the brain communicate by firing action potentials (spikes). These brief voltage spikes can be picked up by electrodes placed near the neurons. Each neuron typically generates a spike with a distinct waveform shape. Neurons can generate similarly-shaped spikes. The shape differences are mainly due to electrode-to-neuron distances. Thus, if cells have similar morphology and they are at the same distance from an electrode, their waveform shapes can be indistinguishable. Assigning spikes to particular neurons is an important step in most experiments. To do so, the spikes must be accurately assigned to specific neurons with a high degree of reliability.

The most prominent feature of a spike is its amplitude. If there are several electrode sites (stereotrodes or tetrodes) that are picking up the same neurons, it is less likely that the neurons are equidistant from the electrode sites. A voltage-threshold trigger is one of the simplest ways to detect spikes. The range of a detection device can also be set to display the portions of the waveform before and after the threshold crossing. This enables the characteristic shape of the waveform to be visible. The Multichannel Acquisition Processor (MAP) system (Harvey Box) is a combination of hardware and software that enables the waveforms to be viewed, the action-potential waveform segments around a voltage-threshold crossing to be captured, and permits them to be sorted in real time according to their shape.

1.2 RASPUTIN Software

The following illustration shows the relationship between the various components of the MAP system and the RASPUTIN Software.



The RASPUTIN Software is a suite of client/server programs that runs on the Microsoft Windows* operating system. A client is an online data or control program that accesses or uses a service provided by another program, in this case, a server program. The RASPUTIN Software controls spike sorting in the MAP system and it provides data visualization and data analysis in real time.

1.3 MAP

The MAP system provides programmable amplification, filtering, and real-time spike sorting of multi-electrode signals. The MAP is a modular system of plug-in circuit boards mounted in a stand-alone box that is scalable from 16 to 128 channels. The following illustration shows a 128-channel MAP system.



The MAP system can also record up to 256 continuous signals, such as field potentials, eye position, blood pressure, etc., using one or more National Instruments™ Data Acquisition (NI DAQ) devices. The RASPUTIN Software programs can record these continuous signals together with the spike and digital-event data in a single data file. The MAP includes the following key features:

- Simultaneous 40 kHz (25 msec) analog-to-digital (A/D) conversion on each channel at a 12-bit resolution.
- Multiple digital inputs for external synchronization and experiment-state variables from behavioral equipment, such as individual TTL lines or multi-bit strobed-word data.
- Optional non-spike analog-signal data acquisition for continuous digitization of field-potential data, physiological signals, behavioral signals, etc.

1.4 RASPUTIN Software Components

The RASPUTIN Software suite includes several components. The components are as follows:

- Sort Client
- MAP Server (Configuration)
- Ref2
- PLX Utilities (PlexUtil)
- PlexNet
- Graphical Activity Client (GAC)
- PeriEvent Client (PEC)
- Grid Monitor (GridMon)
- Client Development Kit
- Continuous Signal Recording

1.4.1 Sort Client

Sort Client is the primary control program for the Plexon Multi-channel Acquisition Processor (MAP) system hardware (the Harvey Box). The MAP system provides real-time spike sorting based on digital signal processors (DSP). Sort Client may be used to adjust the MAP operating parameters (amplification, filtering, etc.) and to set the specific sorting parameters for each channel. If a NI DAQ subsystem is installed in the PC, Sort Client also enables viewing of continuous signals.

With Sort Client, the user can:

- Visualize spike waveforms
- Display simple raster plots
- Record spikes and continuous data (e.g. field potentials) to a file
- Control the MAP system to threshold and sort spikes by using:
 - time-amplitude window discriminator boxes
 - template matching

1.4.2 Installation

The [Installation](#) appendix contains the instructions for installing the MAP software and the required hardware security keys.

1.4.3 MAP Server (Configuration)

MAP Server is the low-level interface for configuring the MAP. MAP Server transfers commands such as gain and filter changes or parameter settings from

the various clients to the MAP box. MAP Server also accumulates data coming from the MAP box in a circular buffer memory. The client programs connect to MAP Server to gain access to that data. MAP Server also mediates communication between the clients, keeping them informed of commands sent to the MAP from other clients.

1.4.4 Ref2

Ref2 is channel-connection control software. With Ref2, the user can:

- Designate up to seven reference channels for each preamp
- Control programmable referencing in up to four Plexon PBX preamplifiers
- Connect spike channels to the connectors on the MAP system OUT board

1.4.5 PlexNet

PlexNet broadcasts MAP data in real time to other computers within a TCP/IP (Ethernet) network. This allows running clients or NeuroExplorer (NEX) in real time on a remote computer. With PlexNet, the user can also remotely analyze data using MATLAB* or a custom client program.

1.4.6 PLX Utilities

PLX files are Plexon data files containing spike timestamps and waveforms, event timestamps, and continuous waveform data. PLX Utilities (PlexUtil) is a program for merging and extracting portions of PLX data files.

1.4.7 Graphical Activity Client

Graphical Activity Client (GAC) is a real-time observation tool for monitoring spike activity or continuous waveforms.

1.4.8 PeriEvent Client

PeriEvent Client (PEC) is a tool for displaying histograms and perievent rasters in real time.

1.4.9 Grid Monitor

Grid Monitor (GridMon) displays spike-rate activity in real time as an animated color grid.

1.4.10 Client Development Kit

The Client Development Kit contains sample code that can be used to develop custom applications. The kit also includes information on sample C programs for the MAP and MATLAB® Extensions. The Event-triggered Field Potential GUI (graphical user interface) is a MATLAB extension to the MAP software that plots a field potential signal around a spike, or external event, in real time.

1.4.11 Continuous Signal Recording

Continuous Signal Recording contains setup information and specifics on how to record continuous signals.

1.5 Hardware Requirements

The following hardware is required to use the RASPUTIN Software suite:

- A PC equipped with one of the following Microsoft operating systems:
 - Windows XP
 - Windows NT
 - Windows 2000
- A complete Plexon MAP (Harvey Box) system with the MAP-system PC components (cards and cabling) installed in a PC that is running the MAP software.
- A signal source

1.6 Terminology

1.6.1 Analog

Terms like *analog* and *analog channels* appear in various areas in Sort Client. These terms usually refers to analog data that is continuously recorded.

1.6.2 Continuous

In general, *continuous* is used throughout this manual to refer to any signal recorded continuously for as long as the data acquisition switch is turned on. *Continuous* excludes spike waveform segments and digital event data. *Continuous* includes both continuous signals sampled at high frequencies (spike and wide-band signals, EMG, etc.) and continuous signals sampled at low frequencies (field potentials and other external signals such as x,y, eye position, etc.).

1.6.3 Digital

The term *digital* refers to digital events, where Sort Client only looks for a rising edge on a signal and only saves the timestamp of that trigger crossing.

1.6.4 Fast and Slow

The terms *fast* and *slow* describe sampling rates, when there is a need to distinguish between two rates.

1.6.5 Spike Waveform Segments

The term *spike waveform segments* describes the waveform segments around threshold crossings.

Chapter 2

Sort Client

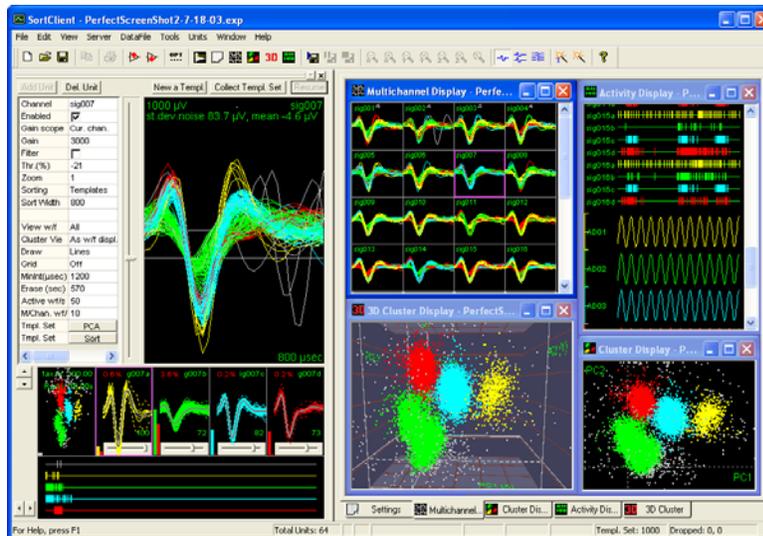
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2.1 Overview

This overview includes information about spike sorting and Sort Client, which is the main user interface in RASPUTIN Software. MAP Server supports Sort Client. For more information, see [Chapter 3 “MAP Server” on page 137](#).

In general, neurons can produce similar waveform shapes. Electrode-to-neuron distance, neuron type, and cell morphology can all have an effect on the waveform shape (spike) detected by an electrode during extra-cellular recording. Each neuron typically has a characteristic spike waveform shape. Thus, amplitude is the most prominent feature of a spike. A voltage-threshold trigger is one of the simplest ways to detect spikes. The user can also set the range of a detection device to display the portions of the waveform before and after the threshold crossing. This enables the user to see the characteristic shape of the waveform. Sort Client enables the user to capture action-potential waveform segments around a voltage-threshold crossing and sort them in real time according to their shape.

Sort Client is the primary MAP control program for real-time DSP-based spike sorting. With Sort Client, the user can adjust the MAP operating parameters (amplification, filtering, etc.) and set the specific sorting parameters for each channel. If a NI DAQ subsystem is installed in the PC, Sort Client also enables the user to view and save spike rasters, spike waveforms, and continuous signals. Sort Client is real-time MAP-control software that enables the user to sort and classify spikes. An illustration of the Sort Client main-window follows.



The user can use Sort Client to save the following items to Plexon data (PLX) files:

- Thresholded and sorted action potential (spike) waveform segments, with timestamps of threshold crossings
- Timestamped external digital events (TTL and strobed words)

-
- Continuous channel data (field potential and others)

2.2 Principles of Spike Sorting

This section contains basic tutorial information on the principles of spike sorting. For additional information, see “Related Documents” in the “About This Document” section.

Neurons in the brain communicate by firing action potentials (spikes). These brief voltage spikes can be picked up by electrodes placed near the neurons. Each neuron typically appears as a spike with a distinct waveform shape.

In most cases, each electrode receives spikes from more than one neuron. Therefore, to assign spikes to particular neurons is an essential step in most experiments. To do so, the user must be able to accurately assign the spikes with a high degree of reliability.

However, to accurately assign a spike to a specific neuron, the user must consider:

- Background noise
- Neurons in the same area with spikes of similar shape and amplitude
- Neurons in the same area with smaller spike amplitudes
- Signals from other cellular activity like axonal fibre bundles, which are typically smaller and more localized
- Local field potentials (LFPs) and other low-frequency signals upon which spikes can be superimposed



For example, look at the raw waveform in the illustration. There are several spikes. Does each spike come from a different neuron? If so, which one? There is also a considerable amount of background noise. The spikes from some neurons can also be overlapped due to nearly-coincident firing times.

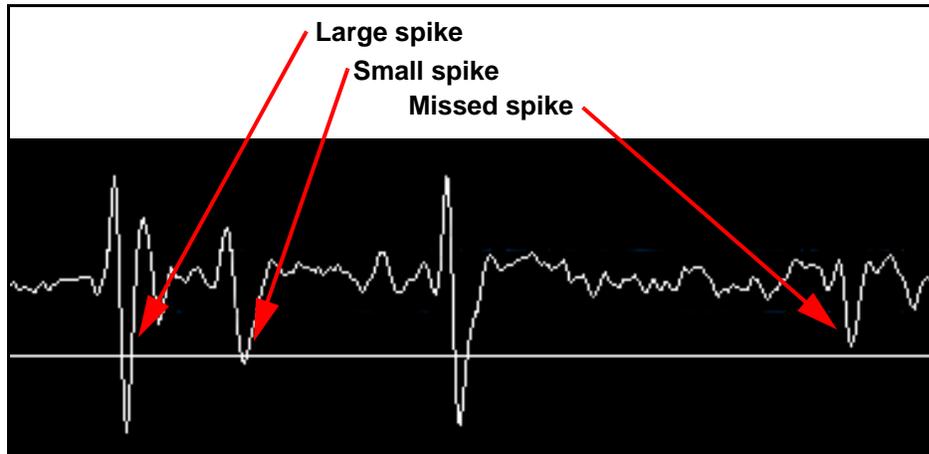
2.2.1 Spike Sorting Fundamentals

Spike sorting consists of two basic tasks: detection and classification.

2.2.1.1 Detection

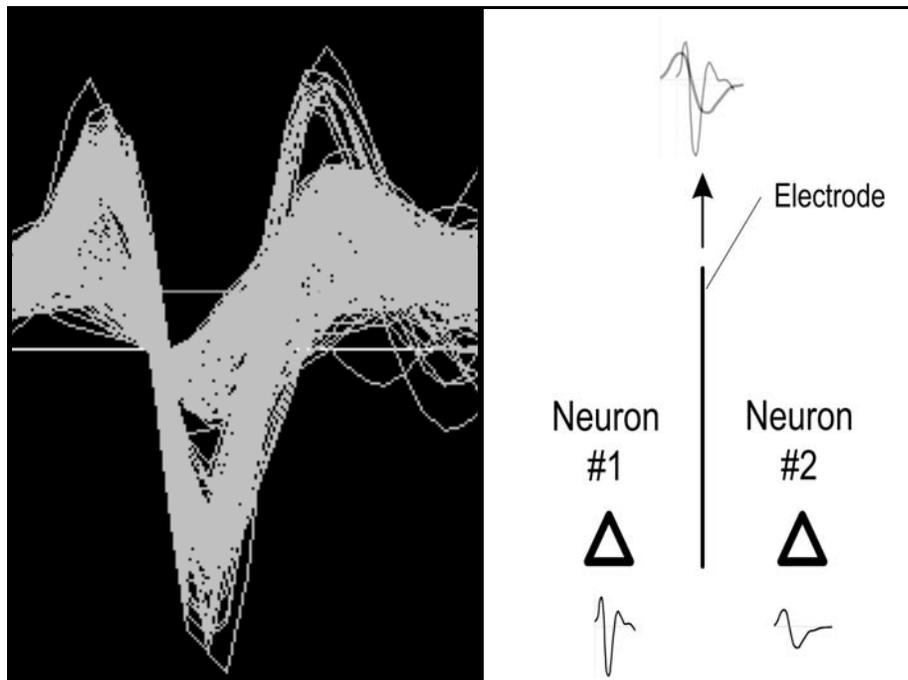
The most prominent feature of a spike is the amplitude of its peaks and troughs. The user can typically trigger the detection of spikes with an amplitude (voltage) threshold and then capture the waveform segment defined by a specified amount of time before and after the threshold crossing.

2.2.1.1.1 Detection Issues: Detection errors occur when the detection threshold is set too far from the zero (0) position. Although such a setting separates major spikes from the background activity, the user can miss smaller spikes altogether. For example, in the following illustration of a typical segment of a WaveStrip display from [Plexon Recorder](#) the threshold (horizontal line) is set too far from zero to detect all spikes. Set the voltage threshold close enough to zero to pick up smaller spikes without picking up background noise. Do not to set the threshold so low that noise is included.



2.2.1.2 Classification

After detection, a waveform must be classified by assigning it to a particular neuron, based on its distinctive waveform shape. As shown in the following illustration, neurons 1 and 2 have different waveform shapes. In the waveform window, the shapes are overlaid and aligned about the threshold crossing.

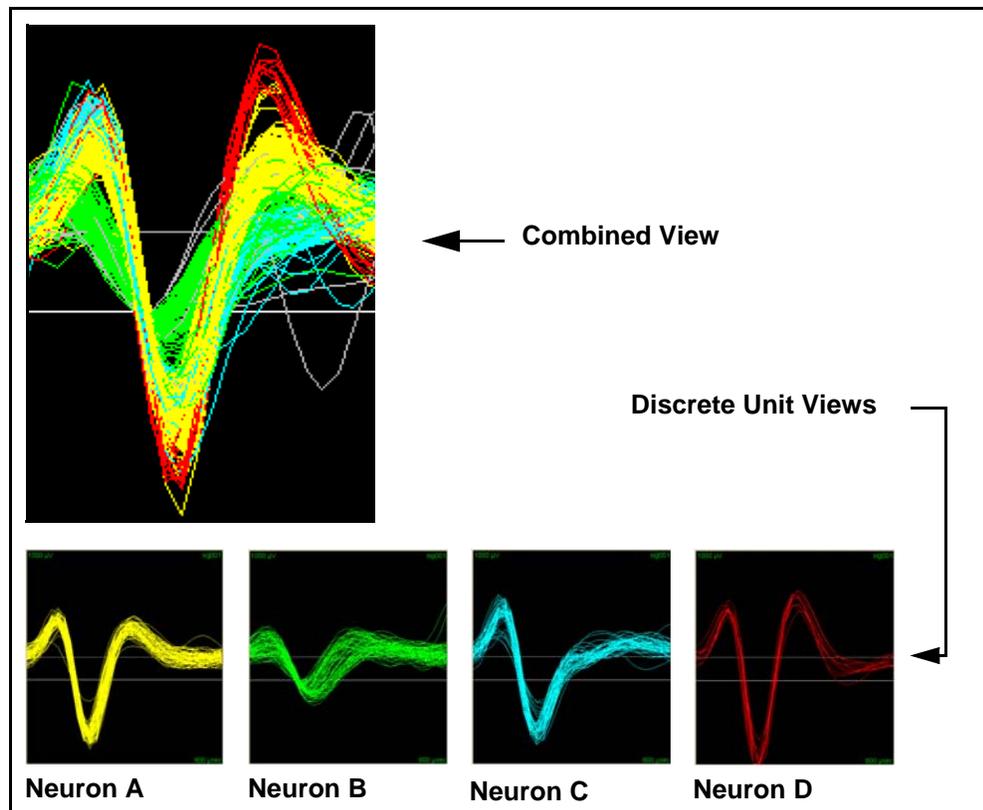


2.2.1.2.1 Classification Issues: Classification issues can occur when spikes are misclassified with or as another neuron, or as noise. There are three types of classification errors: omission, inclusion, and superposition.

- Omission
 - Omission occurs when the user detects a spike from a neuron (Neuron A) and misclassifies it as another neuron (Neuron B) or as noise. The spike is incorrectly *omitted* from its classification as Neuron A.
- Inclusion
 - Inclusion occurs the user detects noise or a spike from a neuron (Neuron B), and it is misclassified with another neuron (Neuron A). The spike or noise is incorrectly *included* in the classification for Neuron A.
- Superposition
 - Superposition occurs when two distinct neurons fire nearly simultaneously, which causes their spike waveforms to be *superimposed*. Superposition often leads to omission errors.

2.2.2 Detecting and Classifying Spikes

Although threshold detection is effective for the detection of spikes from a single neuron, spikes from multiple neurons received by the same electrode require classification. As shown in the following illustration, there are several spikes that have roughly the same amplitude, but different waveform shapes.



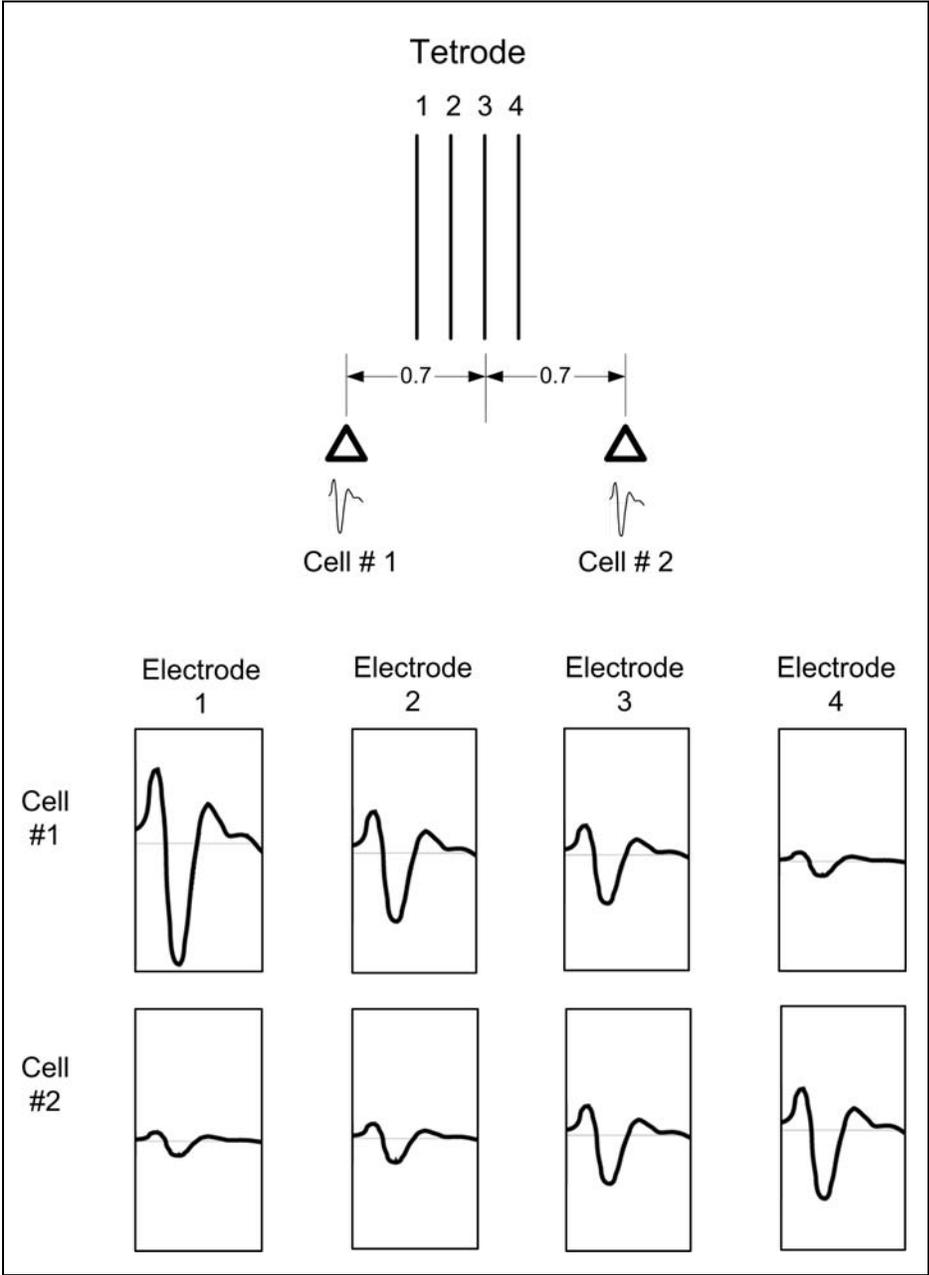
The individual colors that appear in the previous illustration reflect sets of sorted spikes that are classified by using one of the following techniques:

- Time-voltage boxes: spike waveforms are classified as a unit when they pass through a fixed set of boxes, which the user sizes and places, to distinguish only those waveforms that originate from the same neuron; see [“To use the Boxes sorting method” on page 39](#). Time-voltage boxes remain fixed and waveforms from some neurons can slowly drift out of the boxes over time.
- Waveform templates: templates are derived from a subset of waveforms by selecting bundles or clusters of waveforms whose mean values serve as templates for each unit; see [“To use the Templates sorting method” on page 45](#); waveform templates can be set to adapt to signals that drift slowly as sorting progresses. For more information, see [“Template Adjustment” on page 89](#).

2.2.2.1 Multiple Electrodes (Stereotrode and Tetraode)

The waveforms from neurons that are in close proximity to each other can be difficult to separate and classify. The user can use the signals from grouped multiple electrodes to separate the waveforms and classify them by assigning them to the appropriate neurons. Unlike individually recorded multiple electrodes, grouped multiple electrodes (stereotrode or tetraode) receive neural signals almost simultaneously from neurons that are in close proximity to each other.

The signal strength at an electrode depends on three major factors: neuron type, neuron morphology, and neuron location relative to the electrode. The following illustration shows two different neuron cells with nearly identical waveforms and their signal strengths relative to each individual electrode in the tetraode group.



2.2.2.1.1 Tetraode Detection: In the preceding illustration, when Cell #1 and Cell #2 fire, discriminating between them is difficult with a single electrode. For example, Electrode 3 is equidistant from both cells and the waveform shapes appear to be from the same cell. With a tetraode (4-electrodes) however, the signal strength is directly related to the proximity of the electrode, which makes it easy to locate the individual cell that generated the spike. The shapes detected on the remaining electrodes (1, 2, 4) clearly indicate the presence of two distinct cells.

To use tetraode detection, set the threshold for each of the four electrodes independently. If a threshold is crossed on any of the electrodes, the MAP hardware and Sort Client capture and store all four waveform segments for subsequent classification using [Plexon Offline Sorter \(OFS\)](#).

2.2.3 Importance of Manual Sorting

Although Sort Client includes several algorithms that can be applied to automatically sort and classify spikes, they work best only under ideal conditions. Manual sorting methods continue to provide a robust and reliable way to sort and classify spikes. Sort Client supports a variety of manual sorting methods and provides a wide variety of adjustments and settings to ease the task. However, the user can use the automatic sorting features in Sort Client as a starting point for additional manual adjustments. For information on Sort Client automatic sorting features, see [“Auto Procedures” on page 130](#).

2.3 Sort Client Procedures

The following table shows the steps for using Sort Client and the MAP system to view, sort, and record spikes.

Step	Action:	Follow this link:
1	Start Sort Client	Chapter 2 “Start Sort Client” on page 18
2	If a new .exp file is not needed, go to 4.	
3	Create a new .exp file and go to 5.	Chapter 2 “Create a New Sorting Parameters File” on page 19
4	Load .exp file	Chapter 2 “Load a Sorting Parameters (.exp) File” on page 60
5	Click Start	
6	Check Sort Client settings	Chapter 2 “Check Sort Client Settings” on page 60
7	Sort and Record	Chapter 2 “Sort and Record” on page 67
8	If parameters need checked...	Chapter 2 “Check Sort Client Settings” on page 60
9	Monitor recording	Chapter 2 “Monitor Recording” on page 71
10	Click Stop	

2.3.1 Setup

There are two major setup steps:

- 1 Start Sort Client, which automatically starts MAP Server. For information on MAP Server, see [Chapter 3 “MAP Server” on page 137](#).
- 2 a) Create a sorting parameters (.exp) file (See [“Create a New Sorting Parameters File” on page 19](#).)
or
b) Load an existing .exp file (See [“Load a Sorting Parameters \(.exp\) File” on page 60](#).)

Note: If the user is using Sort Client for the first time, or if the user is beginning a new experiment, a new .exp file will typically be created.

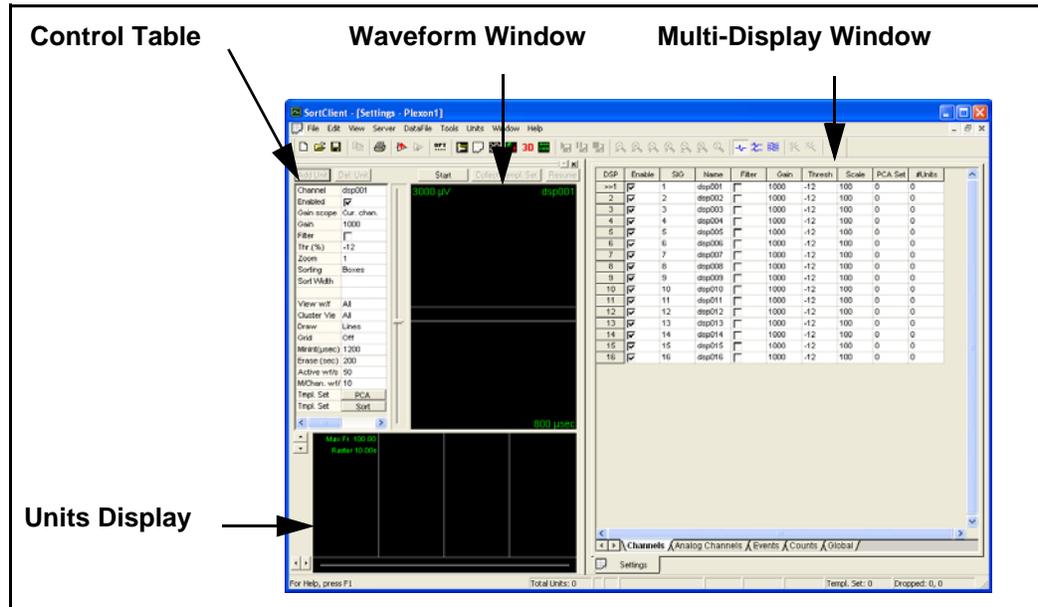
2.3.1.1 Start Sort Client

Before starting Sort Client, turn the MAP system on. When starting Sort Client, Server automatically starts. For information on starting Server independently, see [“Startup” on page 141](#).

To start Sort Client, double-click SortClient.exe in the directory where the RASPUTIN Software is installed, or double-click the Sort Client icon on the desktop.



The following illustration shows the Sort Client main window immediately after startup. The illustration also identifies the four major areas of the main window that apply to the procedures that follow. For detailed information on the features of the main window, see [“The Sort Client Main Window” on page 73](#).



2.3.1.2 Create or Load a Sorting Parameters (.exp) File

A parameter file contains the Sort Client settings for data acquisition, display, and control. When starting Sort Client, it automatically loads default sorting parameters and labels them Plexon1.exp. The default parameters only provide basic default settings that can be used to start data acquisition and to create a sorting parameters file that matches the characteristics of the experiment.

If using Sort Client for the first time, or if beginning a new experiment, a new .exp file to match the requirements is normally created. If continuing an existing experiment, the .exp file can be loaded directly, data acquisition can be started, sorting parameters can be checked, and sorting and recording can be started. If continuing an existing experiment, skip the file creation procedures and go directly to [“Load a Sorting Parameters \(.exp\) File” on page 60](#). If using Sort Client for the first time, or if beginning a new experiment, continue with the following procedures.

2.3.1.3 Create a New Sorting Parameters File

To create a new sorting parameters file, proceed through a multi-step process from initial file creation and naming to resaving the file after the final parameter is set. Several procedures must be separately repeated for each channel. Sort Client saves all settings, both global and for each channel, to the parameters file.

To create a new sorting parameters (.exp) file

- 1 From the **File** menu, click **Save Sorting Parameters File As**.
- 2 In the **Save As** dialog box, type a new name to replace the default file name **Plexon1**. Click **Save**.
Note: If someone has previously used Sort Client, and saved .exp files, an existing .exp file that approximates the experiment may be loaded and used it as a basis (instead of Plexon1) to create a new .exp file. For the procedure to load an existing .exp file, see [“To load an existing sorting parameters \(.exp\) file” on page 60](#). After loading the file, return to this step.
- 3 The new name replaces the default name **Plexon1** in the Sort Client title bar. For example, as shown in the following illustration, the new sorting parameters file name is **Test1.exp**.



- 4 Complete as many of the “Create .exp file” procedures as necessary to configure the new sorting parameters file as needed.
Note: Plexon recommends to save the sorting-parameters file frequently. From the **File** menu, click **Save Sorting Parameters File**, or click the Save button on the toolbar.



2.3.1.4 Start Data Transfer

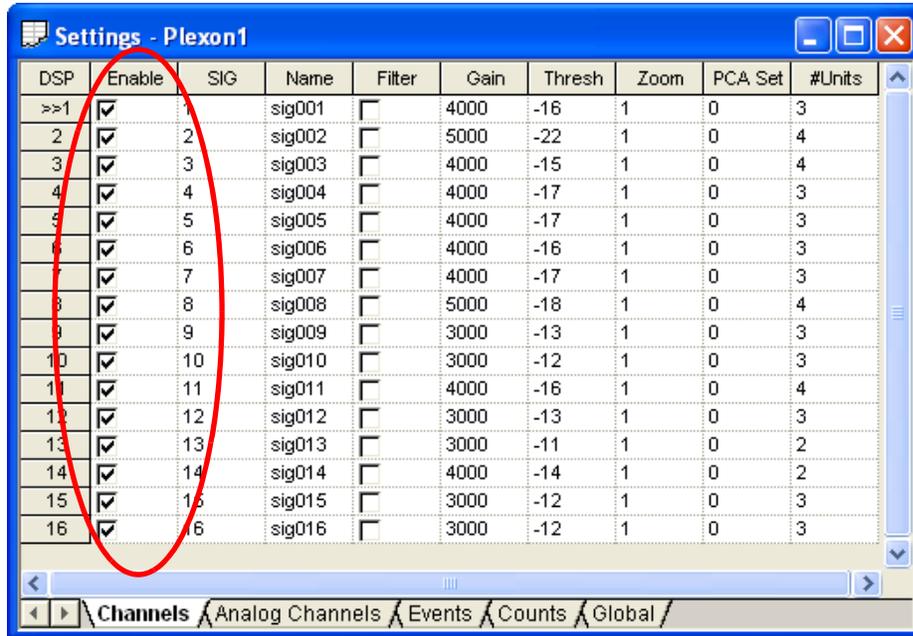
Data transfer must be started to see waveforms in Sort Client. Start data transfer from either one of the following locations.

To start data transfer

- Above the Waveform Window, click the **Start** button.
or
- From the **Server** menu, click **Start Data Transfer**.

2.3.1.5 Enable the Spike Channels

When Sort Client starts, the Settings window opens with a display of the digital signal processor (DSP) spike channels. As shown in the following illustration, all the DSP channels are enabled by default when Sort Client starts.



DSP	Enable	SIG	Name	Filter	Gain	Thresh	Zoom	PCA Set	#Units
>>1	<input checked="" type="checkbox"/>	1	sig001	<input type="checkbox"/>	4000	-16	1	0	3
2	<input checked="" type="checkbox"/>	2	sig002	<input type="checkbox"/>	5000	-22	1	0	4
3	<input checked="" type="checkbox"/>	3	sig003	<input type="checkbox"/>	4000	-15	1	0	4
4	<input checked="" type="checkbox"/>	4	sig004	<input type="checkbox"/>	4000	-17	1	0	3
5	<input checked="" type="checkbox"/>	5	sig005	<input type="checkbox"/>	4000	-17	1	0	3
6	<input checked="" type="checkbox"/>	6	sig006	<input type="checkbox"/>	4000	-16	1	0	3
7	<input checked="" type="checkbox"/>	7	sig007	<input type="checkbox"/>	4000	-17	1	0	3
8	<input checked="" type="checkbox"/>	8	sig008	<input type="checkbox"/>	5000	-18	1	0	4
9	<input checked="" type="checkbox"/>	9	sig009	<input type="checkbox"/>	3000	-13	1	0	3
10	<input checked="" type="checkbox"/>	10	sig010	<input type="checkbox"/>	3000	-12	1	0	3
11	<input checked="" type="checkbox"/>	11	sig011	<input type="checkbox"/>	4000	-16	1	0	4
12	<input checked="" type="checkbox"/>	12	sig012	<input type="checkbox"/>	3000	-13	1	0	3
13	<input checked="" type="checkbox"/>	13	sig013	<input type="checkbox"/>	3000	-11	1	0	2
14	<input checked="" type="checkbox"/>	14	sig014	<input type="checkbox"/>	4000	-14	1	0	2
15	<input checked="" type="checkbox"/>	15	sig015	<input type="checkbox"/>	3000	-12	1	0	3
16	<input checked="" type="checkbox"/>	16	sig016	<input type="checkbox"/>	3000	-12	1	0	3

The previous illustration shows that 16 channels have been enabled. If additional channels have been licensed, they must be enabled through Server. To verify the number of DSP licensed channels in Server, see [“View > Hardware Configuration” on page 144.](#)

Note: The tables in the Settings window have certain interface characteristics and behaviors that are common to other tables in Sort Client. For a description of these characteristics, see [“Typical Sort Client Interface Characteristics and Behaviors” on page 75.](#)

2.3.1.5.1 Disabling Channels: Sort Client enables all available channels by default. Disable the channels not needed. Also, disable channels with noisy or unusable signals.

There are two methods of disabling channels in Sort Client - the Settings window and the Multichannel Display. For more information, see [“Multichannel Display” on page 92.](#)

To disable channels in the Settings window

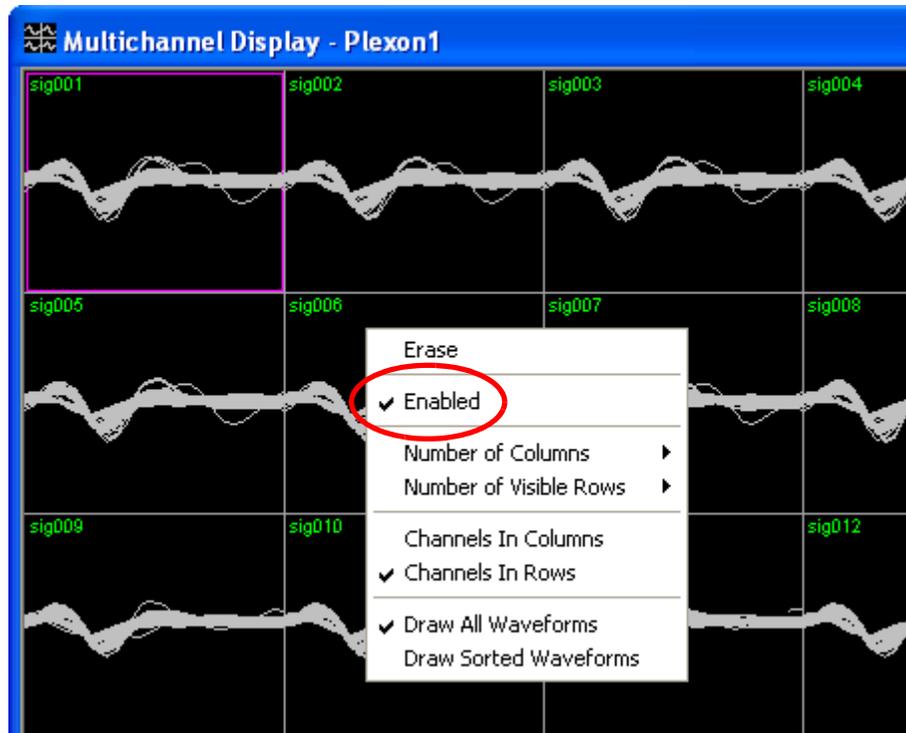
- 1 In the **Settings** window, click the **Channels** tab.
- 2 Clear the **Enable** checkbox to disable each channel that needs to be disabled.

Note: Each time a channel is disabled, Sort Client disables that channel in the Multichannel Display.

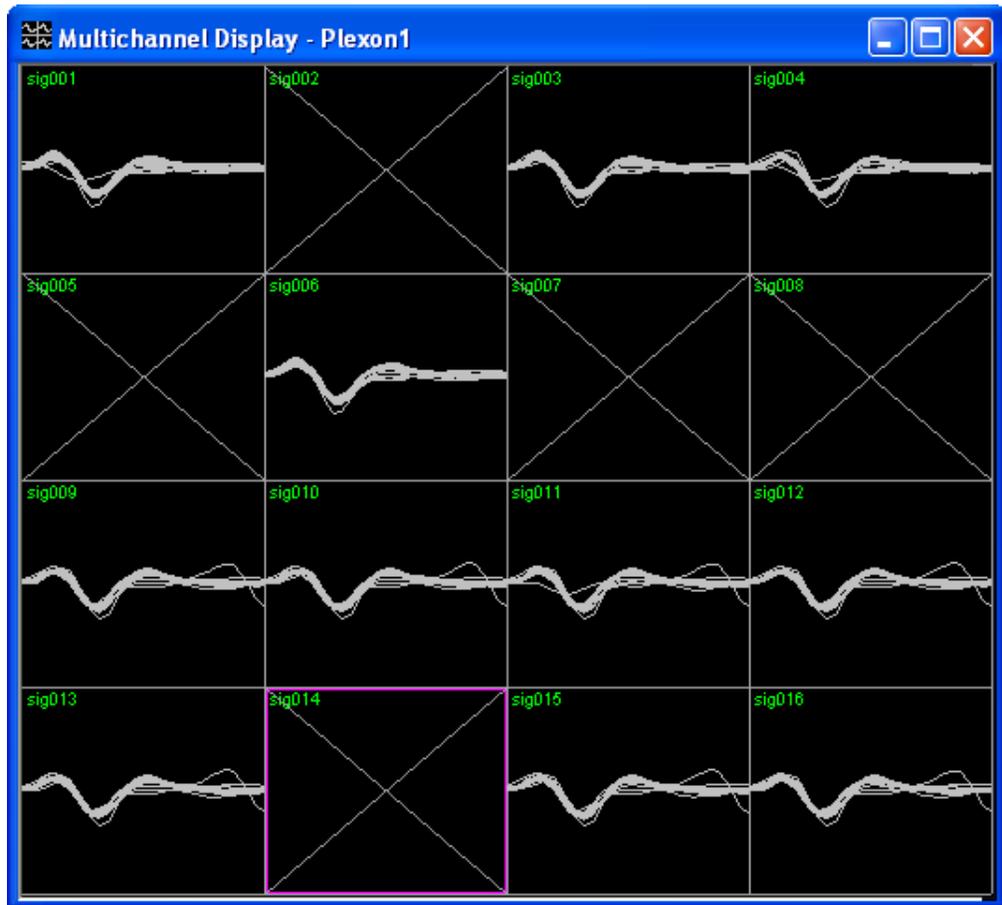
DSP	Enable	SIG	Name	Filter	Gain	Thresh	Zoom	PCA Set	#Un
>>1	<input checked="" type="checkbox"/>	1	sig001	<input type="checkbox"/>	1000	-12	1	0	0
2	<input checked="" type="checkbox"/>	2	sig002	<input type="checkbox"/>	1000	-12	1	0	0
3	<input checked="" type="checkbox"/>	3	sig003	<input type="checkbox"/>	1000	-12	1	0	0
4	<input checked="" type="checkbox"/>	4	sig004	<input type="checkbox"/>	1000	-12	1	0	0
5	<input checked="" type="checkbox"/>	5	sig005	<input type="checkbox"/>	1000	-12	1	0	0
6	<input checked="" type="checkbox"/>	6	sig006	<input type="checkbox"/>	1000	-12	1	0	0
7	<input type="checkbox"/>	7	sig007	<input type="checkbox"/>	1000	-12	1	0	0
8	<input checked="" type="checkbox"/>	8	sig008	<input type="checkbox"/>	1000	-12	1	0	0
9	<input checked="" type="checkbox"/>	9	sig009	<input type="checkbox"/>	1000	-12	1	0	0
10	<input checked="" type="checkbox"/>	10	sig010	<input type="checkbox"/>	1000	-12	1	0	0
11	<input type="checkbox"/>	11	sig011	<input type="checkbox"/>	1000	-12	1	0	0
12	<input checked="" type="checkbox"/>	12	sig012	<input type="checkbox"/>	1000	-12	1	0	0
13	<input type="checkbox"/>	13	sig013	<input type="checkbox"/>	1000	-12	1	0	0
14	<input checked="" type="checkbox"/>	14	sig014	<input type="checkbox"/>	1000	-12	1	0	0
15	<input checked="" type="checkbox"/>	15	sig015	<input type="checkbox"/>	1000	-12	1	0	0
16	<input checked="" type="checkbox"/>	16	sig016	<input type="checkbox"/>	1000	-12	1	0	0

To disable channels in the Multichannel Display

- 1 Click to select a channel in the **Multichannel Display** screen. Right-click to open the menu.
- 2 To disable a channel, click to clear the **Enabled** check mark.

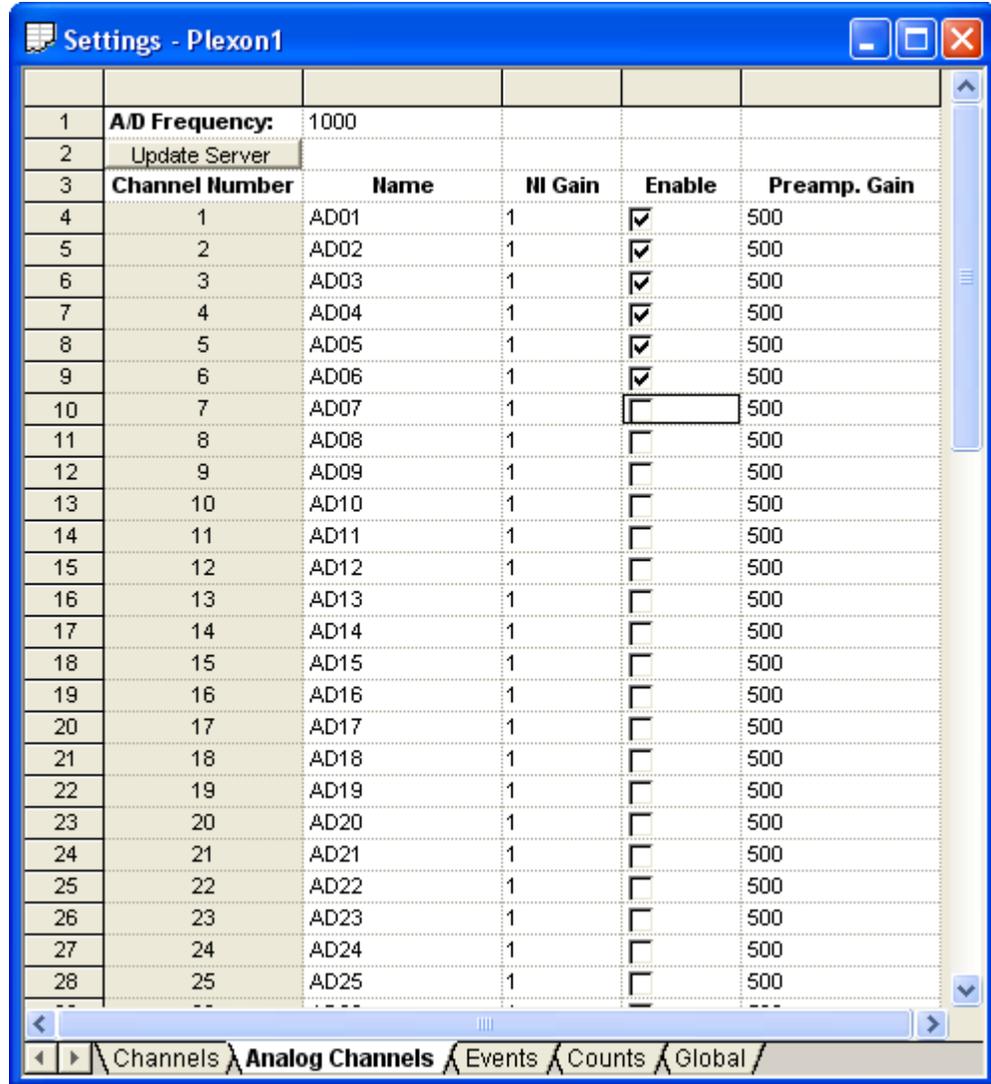


When a channel is disabled, Sort Client automatically sets the threshold for the channel to the maximum value so that no waveforms are acquired on that channel. When the channel is re-enabled, the threshold returns to its original setting. When a channel is disabled, the display for that channel is crossed out in the Multichannel Display. For example, in the following illustration channels sig002, sig005, sig007, sig008, and sig014 are disabled.



2.3.1.6 Enable the Continuous Channels

Sort Client does not enable the continuous channels by default. They must be enabled as needed. The following illustration shows the Settings window with the **Analog Channels** tab selected.



Note: If there are multiple NI-DAQ devices, Sort Client provides individually-numbered **AnalogChans** tabs for each device. For an example, see [“Continuous Channels” on page 85](#).

2.3.1.6.1 Enabling Continuous Channels: The **Analog Channels** table is the only area in Sort Client where the continuous channels can be enabled. To see the continuous channels, enable NIDAQ in Server; for more information, see [“Options: NIDAQ” on page 152](#).

To enable continuous channels

- 1 Click each checkbox in the **Enable** column. To enable all channels simultaneously, use the “Set all rows as the top row” feature. For more information on this feature, see [“Typical Sort Client Interface Characteristics and Behaviors” on page 75](#).
- 2 Click **Update Server** to store the settings.

2.3.1.6.2 Changing A/D Frequency: For digitization of higher frequency signals, increase the sampling rate on the continuous channels by changing the analog-to-digital (A/D) frequency. For more information, see [“Options: Waveforms And Frequency” on page 151](#).

To change the A/D Frequency in the Analog Channels table

- 1 Click the **A/D Frequency** value. Type a new value from 100 to 20 000 (older TIM boards) or 40 000 (newer TIM boards).
- 2 Click **Update Server** to store the setting.

2.3.1.6.3 Changing Channel Name: Sort Client assigns default channel names. The default continuous channel names start with AD followed by the channel number. The user can change the name of any channel to suit the requirements.

To change the Channel Name in the Analog Channels table

- 1 Double click the channel name in the **Name** column. Type a new channel name.
- 2 Click **Update Server** to store the setting.

2.3.1.6.4 Changing the NI Gain: Sort Client can be used to change the gain on the National Instruments (NI) data acquisition (DAQ) device in the PC. The gain can be changed on individual channels or on all channels simultaneously.

To change the NI Gain in the Analog Channels table

- 1 Click the table cell in the **NI Gain** column to see a drop-down list of available gains. Click a gain setting. To set the same NI Gain setting for all channels, use the “Set all rows as the top row” feature described on [page 75](#).
- 2 Click **Update Server** to store the setting.

2.3.1.7 Enable Event Channels

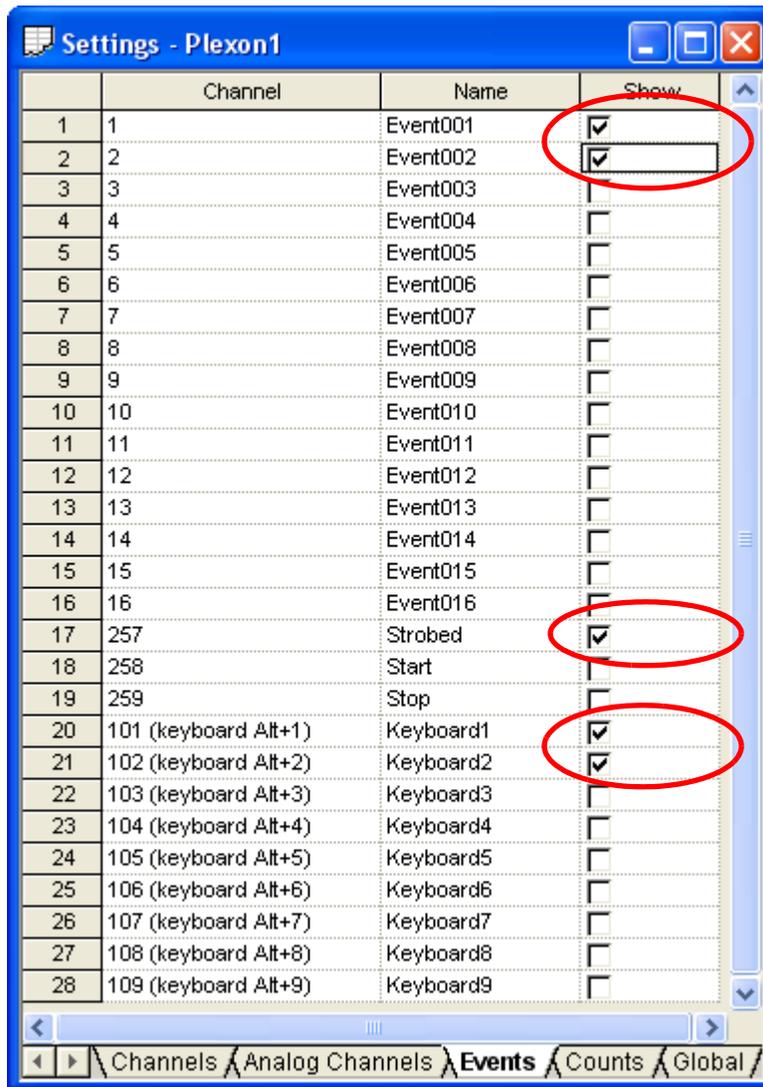
The MAP system can detect, time stamp, and record external events. External events typically originate in behavioral control systems or stimulus generation devices. Sort Client defines four types of events under the **Events** tab in the **Settings** window:

- The first type is individual TTL events such as the start of a trial, the press of a lever, or the switching on of a light. These individual events are a single bit of information (thus the signal can be carried on a single wire or a wire pair) that can be recorded on separate channels.
- The second type of event is a “strobed” word. For information on the second type of event, see [“Strobed Words” on page 27](#).

- The third type of event is a TTL signal that starts or stops data recording.
- The fourth type of event is manual input from the keyboard. If there is no TTL signal available for an event, a keyboard event can be entered to indicate the approximate time. Up to nine individual events can be entered by using the ALT key plus any number from 1 to 9.

The following illustration indicates that the following channels are selected to “Show” in the Activity Display:

- Event001
- Event002
- Strobed
- Keyboard1
- Keyboard2



2.3.1.7.1 Showing Event Channels: Sort Client provides a real-time display of event channels in the **Activity Display** window. The user can display the activity on any of the event channels. For more information on the Activity Display, see [“Activity Display” on page 99](#).

Note: All Events Are Saved: Events need not be shown in the Activity Display to save them to disk. Sort Client saves *all* event data, even if the event channel does not show in the Activity Display.

2.3.1.7.2 Changing Event Channel Names: Sort Client assigns a default name to each event channel. The user can change event channel names to suit the requirements. The event names entered appear in the **Activity Display** window.

To change Event Channel names

- Click in the cell in the **Name** column. Double click the channel name. Type a new channel name.

2.3.1.7.3 Strobed Words: The second event type is for events that an external device encodes as an 8-bit or 15-bit data word. For example, a visual stimulus of up to 256 patterns, or a trial number from 0 to 255, can be encoded as an eight-bit word. The external device that generates the digital word must also provide a pulse to indicate when the data word is valid. This data-ready signal is called a strobe pulse. To use strobed words, set the Digital Signal Processor (DSP) digital input (DI) board to strobed-word mode by setting jumpers on the board. For complete information on DI board modes, refer to the [Setting Up MAP System Digital Input and Output, 01-01-C-3003](#).

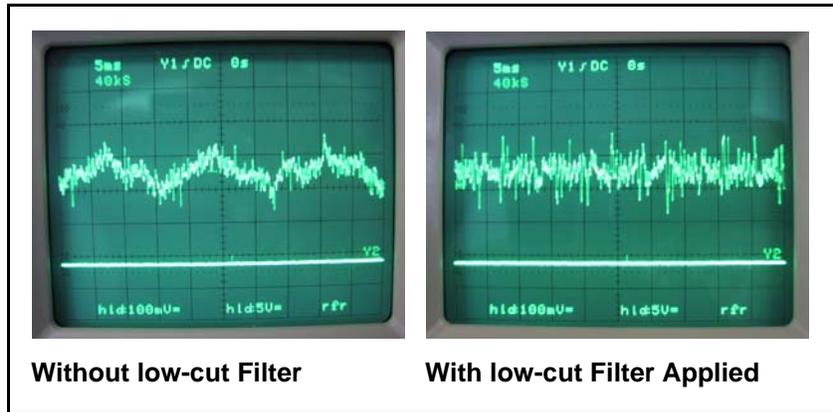
2.3.2 Channel Specific Procedures

The following procedures must be sequentially applied to each channel of interest until all the channel-specific parameters have been set for each channel. Repeat the “apply filter” through “adjust sort parameters” procedures for each channel. Return to this point for each channel to be configured.

2.3.2.1 Apply Filter

Apply a filter to remove low-frequency noise and artifacts, if required. The MAP provides a software-switchable per-channel analog 2-pole low-cut filter that can be applied from the Control table, or from the Settings table in the Multi-Display Window.

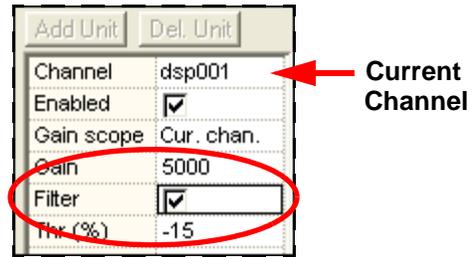
Before applying the filter, view the raw unfiltered spike signals on an oscilloscope. Connect the oscilloscope to a BNC connector on the OUT board. Use Ref2 to assign the channel to the BNC connector. For information on Ref 2, see [“Using Ref2 with the OUT Board” on page 160](#). Set the oscilloscope time base to view 60-Hz signals (waves with ~16-millisecond periodicity). See the examples in the following illustration.



Before applying the filter, try to minimize any 60-Hz hum or other low-frequency noise, by applying shielding, using additional grounding, or by other means. For general information on grounding principles, see [“Grounding and Referencing Basics” on page 169](#). Then apply the software-programmable filter to remove any remaining low-frequency noise. The filter can be enabled from two areas in Sort Client.

To apply the low-cut filter from the Control Table

- In the Control Table, click the **Filter** checkbox. This applies the filter to the current channel only. To apply the filter to another channel, select the channel as the current channel and click the **Filter** checkbox. To disable a filter, click to clear the **Filter** checkbox.



To apply the low-cut filter from the Multi-Display Window

- From the **Settings** tab in the Multi-Display Window, click the **Channels** tab. Click the checkbox in the **Filter** column to apply the filter to a channel. To apply the filter to all or several channels simultaneously, use the “Set all rows as the top row” feature on [page 75](#). To disable the filter, click to clear the **Filter** checkbox.

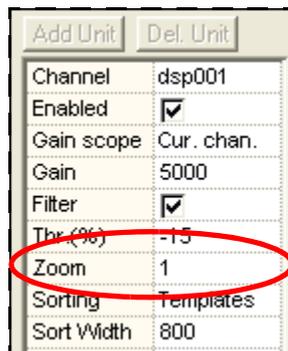
DSP	Enable	SIG	Name	Filter	Gain
>>1	<input checked="" type="checkbox"/>	1	dsp001	<input checked="" type="checkbox"/>	5000
2	<input checked="" type="checkbox"/>	2	dsp002	<input type="checkbox"/>	3000
3	<input type="checkbox"/>	3	dsp003	<input type="checkbox"/>	3000

2.3.2.2 Set the Zoom Factor

Make sure that the display vertical scale is set to one. To make the entire dynamic range of the window available, set the Zoom factor (vertical scale) to the lowest value before setting the gain. For more information on Zoom and Gain, see “Gain” on [page 77](#).

To set the Zoom from the Control Table

- Click the table cell next to **Zoom** and type or select 1.



To set the Zoom from the Multi-Display Window

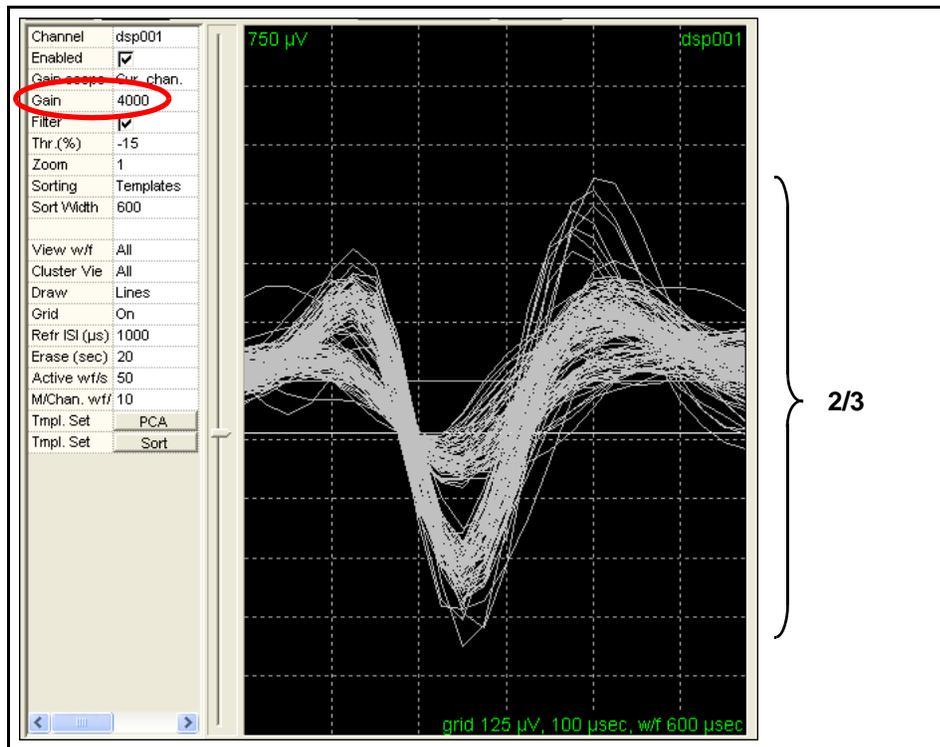
- From the **Settings** tab in the Multi-Display Window, click the **Channels** tab. Click a table cell in the **Zoom** column and type or select 1. To set the same Zoom setting for all channels, use the “Set all rows as the top row” feature on [page 75](#).

Settings - Plexon1									
DSP	Enable	SIG	Name	Filter	Gain	Thresh	Zoom	PCA Set	
>>1	<input checked="" type="checkbox"/>	1	dsp001	<input checked="" type="checkbox"/>	4000	-14	1	45F	
2	<input type="checkbox"/>	2	dsp002	<input type="checkbox"/>	4000	-25	1	0	
3	<input type="checkbox"/>	3	dsp003	<input type="checkbox"/>	4000	-18	1	0	

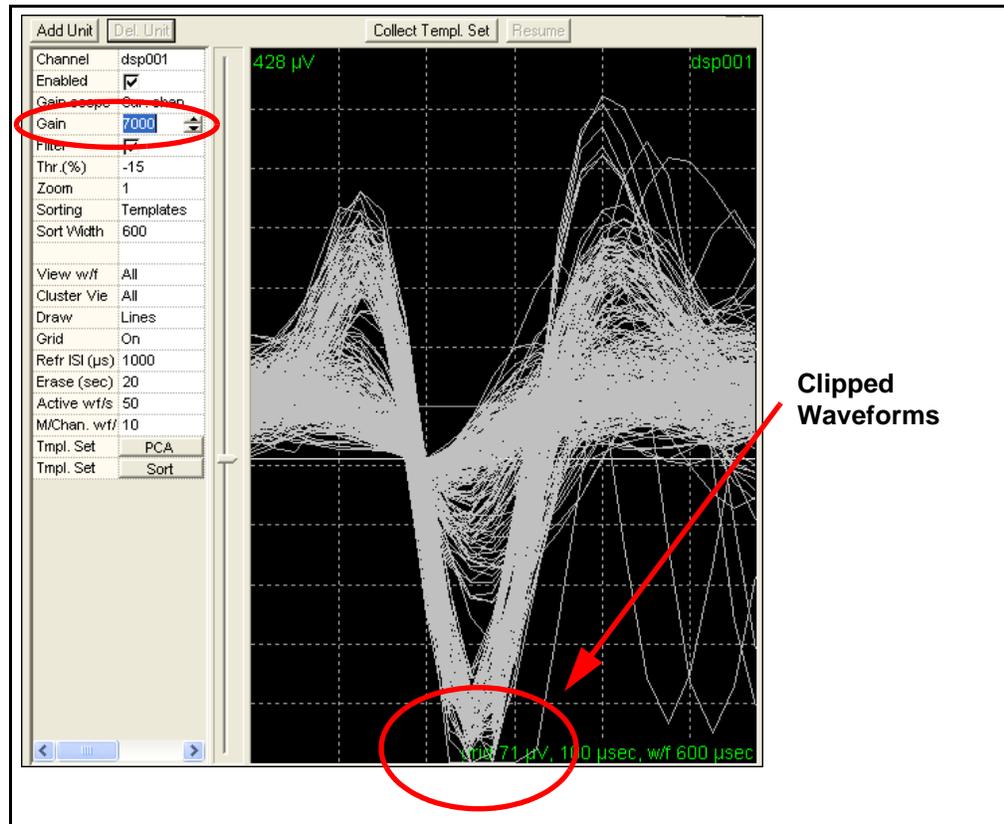
2.3.2.3 Set the Gain

Set the gain at a value that allows viewing waveforms in the Waveform Window without clipping. Set the gain so that the largest-amplitude waveforms take up approximately 2/3 of the total voltage range (Y axis) of the Waveform Window. Do not set the gain so high that the waveforms are “clipped” by exceeding the maximum voltage range. See the following illustrations for examples.

Correct Gain Setting



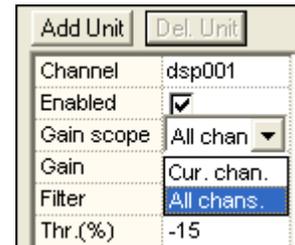
Gain Setting Exceeds Maximum Voltage Range



Clipped Waveforms

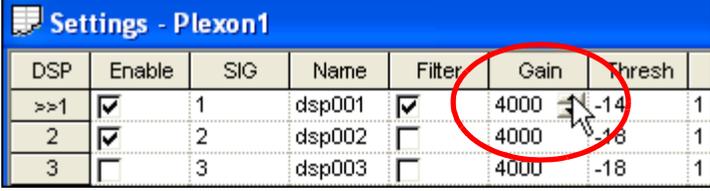
To adjust the gain using the Control Table

- 1 In the Control Table, to adjust the gain for the current channel only, set **Gain scope** to **Cur. chan.** To adjust the gain for all channels simultaneously, set **Gain scope** to **All chans.**
- 2 Click the table cell next to **Gain** and type or select a gain setting that displays the largest-amplitude waveforms in approximately 2/3 of the waveform window.



To adjust gain settings using the Channels table

- Under the **Settings** tab in the Multi-Display Window, click the **Channels** tab. Click the table cell in the **Gain** column and type or select a gain setting. To set the same gain for all channels, set the gain for one channel and then use the "Set all rows as the top row" feature on [page 75](#).



DSP	Enable	SIG	Name	Filter	Gain	Thresh	
>>1	<input checked="" type="checkbox"/>	1	dsp001	<input checked="" type="checkbox"/>	4000	-14	1
2	<input checked="" type="checkbox"/>	2	dsp002	<input type="checkbox"/>	4000	-18	1
3	<input type="checkbox"/>	3	dsp003	<input type="checkbox"/>	4000	-18	1

2.3.2.4 Set the Threshold

To capture spikes, set the threshold for each channel to a setting that allows distinguishing between noise and spikes. Distinguishing noise from spikes requires an understanding of waveform shapes.

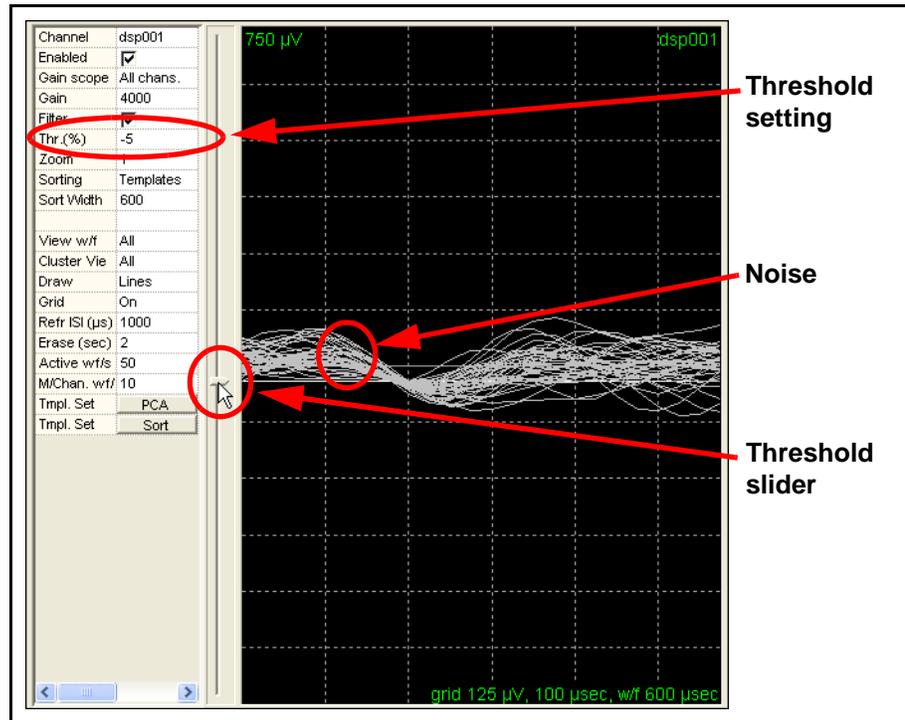
When a signal crosses the threshold, it triggers the MAP system to capture a waveform segment and the MAP cannot capture a new waveform segment for the duration of the capture window. If the threshold setting is too close to zero, noise can cross the threshold and trigger the capture of spurious waveform segments, which typically results in actual spikes firing within the duration of the spurious capture window. For more information, see [“To Avoid Missing Spikes” on page 34](#).

Set the threshold by dragging the threshold slider in the Waveform Window. To set the threshold, use the following procedure.

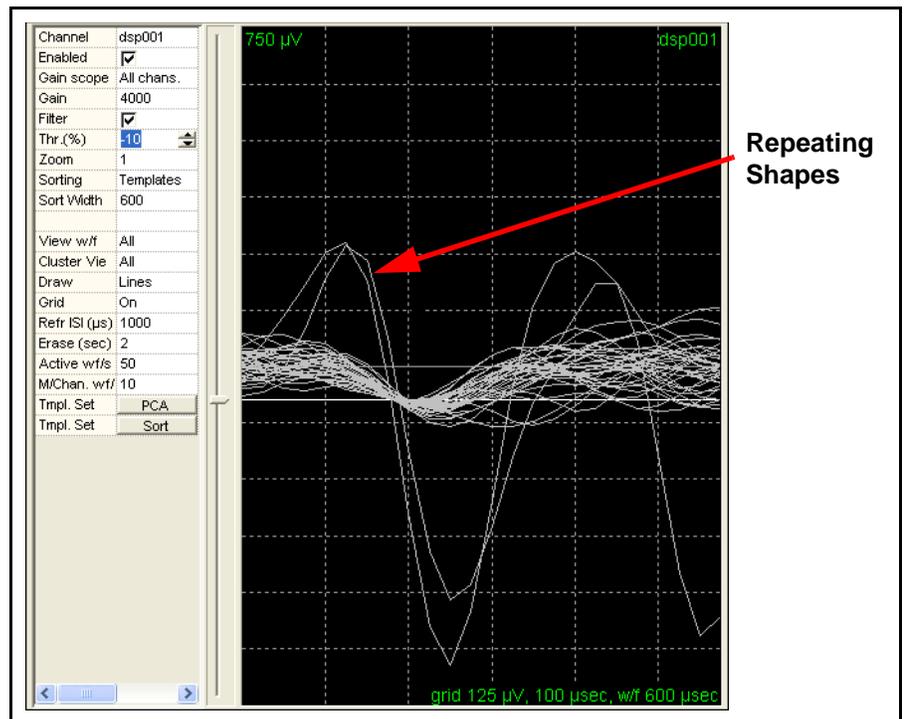
To set the threshold by using the slider in the Waveform Window

- 1 In the Waveform Window, drag the threshold slider to the center line.

- 2 Progressively drag the slider away from the center line until the captured waveforms are small-amplitude noise signals as shown in the following illustration.

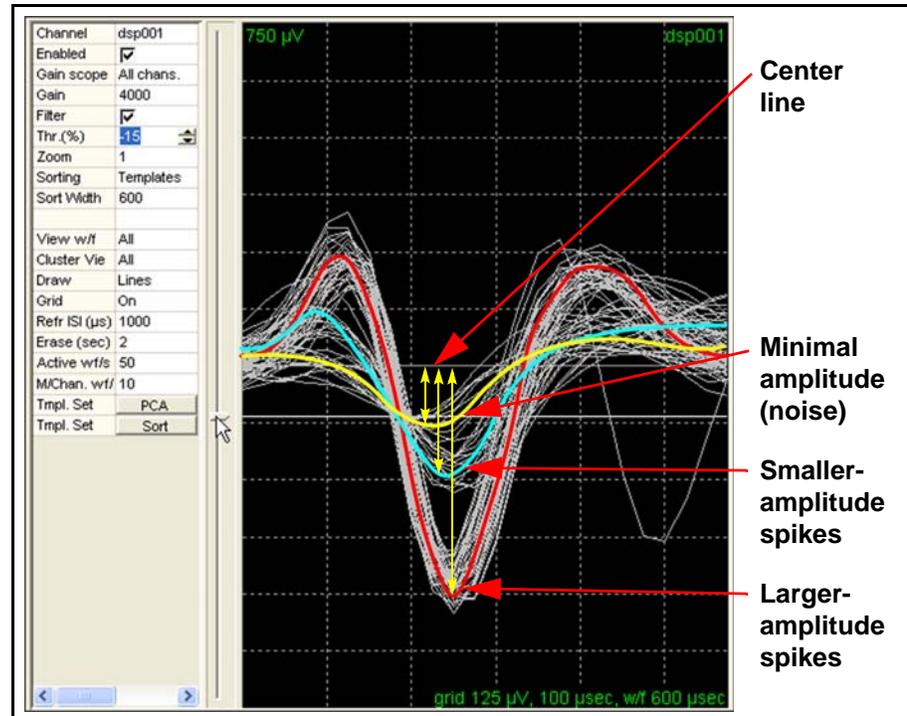


- 3 Continue to drag the slider away from the center line until larger-amplitude waveforms with consistent repeating shapes appear.



- 4 Drag the threshold slider up or down until the following conditions exist:
- Only a few small-amplitude noise signals cross the threshold.
 - Smaller- and larger-amplitude spike waveforms of interest cross the threshold. The user can distinguish these waveforms from noise signals by their distinctive size and shape.
 - The display shows enough waveforms to reveal a pattern of similar waveform shapes. Use the following illustration as a guide.

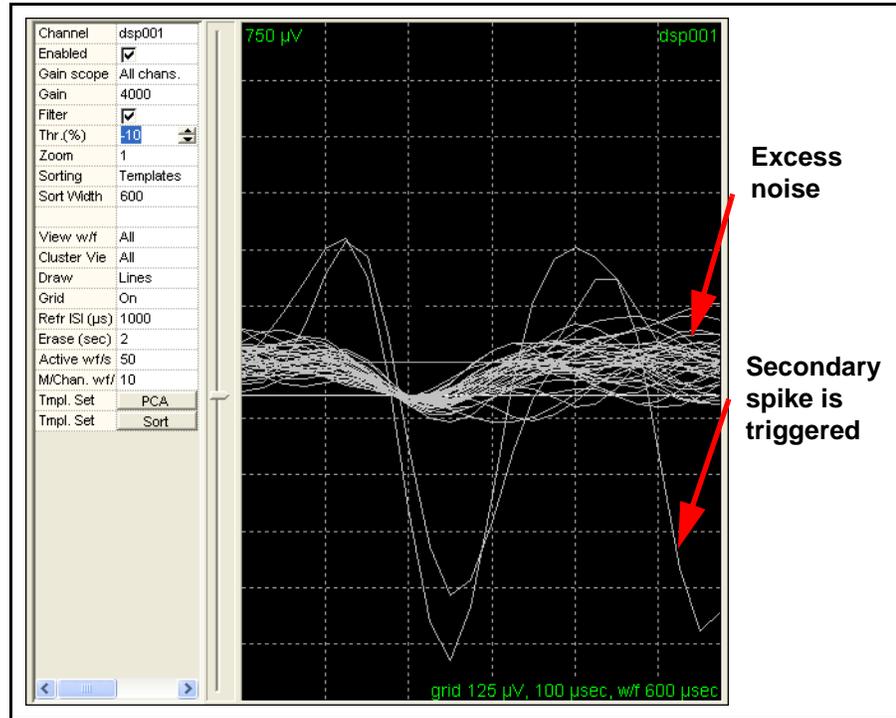
Guide to waveform shapes



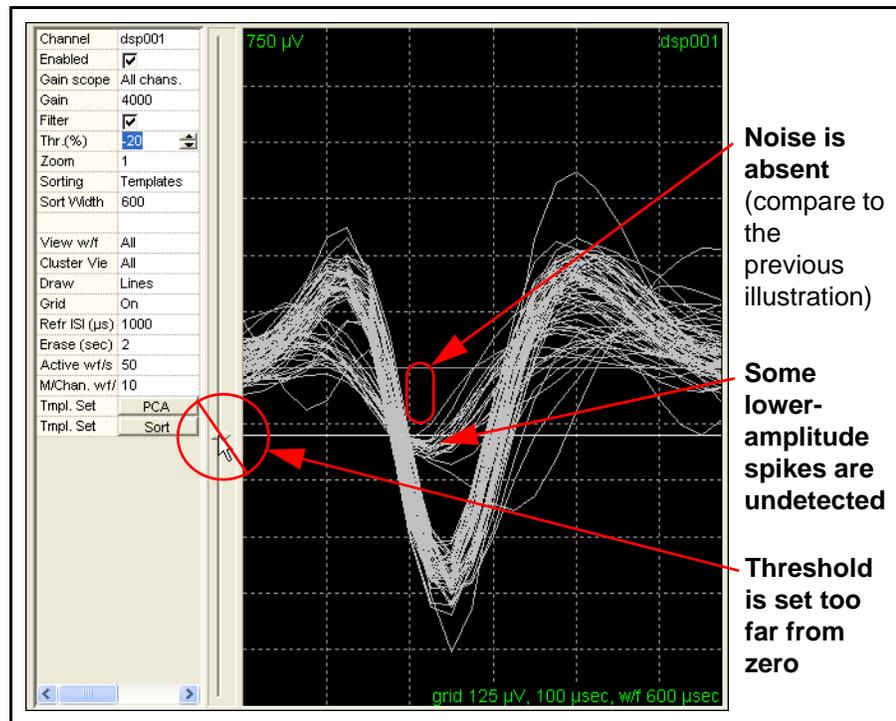
HINT To Avoid Missing Spikes

Because only one waveform can be detected per thresholded-capture window (typically 600 to 800 μsec), drag the threshold far enough from the center line to avoid picking up too many noise signals and secondary spikes. Every threshold crossing by a noise signal introduces a 600- to 800- μsec “dead time” before the next threshold detection can occur. However, to avoid missing spikes, do not drag the slider an excessive distance from the center line. See the following illustrations for examples of incorrect threshold settings.

Threshold Setting too close to the center line (e.g. -10%)



Threshold Setting too far from the center line (e.g. -35%)

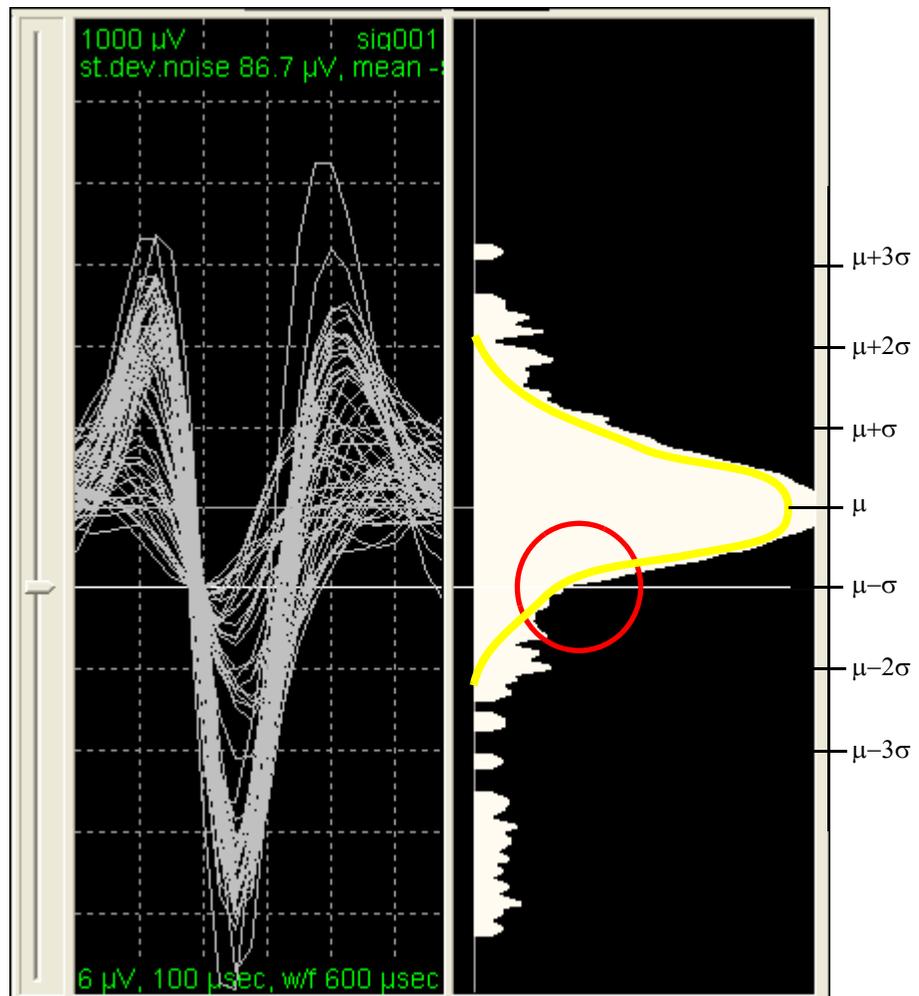


- 5 As an additional verification of the threshold setting, use the Gaussian distribution of the noise as a guideline. A good initial location for the threshold slider is where the peak histogram data begins to diverge from a smooth Gaussian distribution.

From the **View** menu, click **Histogram of Peaks** to open the histogram window, which appears in the right side of the Waveform Window area. To plot a histogram, from the **Tools** menu, select **Auto Threshold Current Channel**, which starts the **AutoThr** counter at the bottom right side of the Sort Client window.



When the **AutoThr** counter stops, Sort Client plots a histogram similar to the following illustration.



Verify the position of the threshold slider. The previous illustration shows the slider positioned where the peak histogram data begins to diverge from a smooth Gaussian distribution.

Also, set the threshold for one, several, or all channels simultaneously by using the Channels table.

To adjust threshold settings using the Channels table

- Under the **Settings** tab in the Multi-Display Window, click the **Channels** tab. Click the table cell in the **Thresh** column and type or select a threshold setting. To set the same threshold setting for all channels, set the threshold for one channel and then use the “Set all rows as the top row” feature from [page 75](#).

DSP	Enable	SIG	Name	Filter	Gain	Thresh	Zoom	PCA Set	#Units
>>1	<input checked="" type="checkbox"/>	1	sig001	<input type="checkbox"/>	4000	-15	1	0	0
2	<input type="checkbox"/>	2	sig002	<input type="checkbox"/>	3000	-15	1	0	4
3	<input type="checkbox"/>	3	sig003	<input type="checkbox"/>	3000	-15	1	0	4

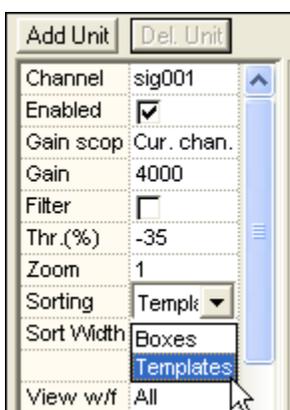
2.3.2.5 Select a Sorting Method

After setting the threshold, choose a sorting method, either boxes or templates. Either method may be used on different channels to sort spikes into units.

If the waveforms in the Waveform Window are distinct, appear in well-separated groups, and the peaks are easy to distinguish, the boxes method is the quickest and easiest method to use for that channel. The user can quickly set pairs of boxes to classify the units on the channel and move on to the next channel. However, if the waveforms in the Waveform Window are mixed together, not clearly grouped, and their peaks intermingle, the templates method is the preferred one to ensure good separation and accurate unit classification. The templates method uses the principal component analysis (PCA) statistical method to plot each waveform as a point in two-dimensional (2D) or three-dimensional (3D) space. Use these plots to create sorting templates.

In practice, the boxes method uses pairs of corresponding colored boxes in the Waveform Window. The boxes represent voltage/time windows. The MAP system classifies waveforms that pass through both boxes as a unit.

In practice, the templates method uses a set of collected and plotted waveforms to create templates that represent the mean spike waveform of each unit in the set. Sort Client sends the templates to the MAP system and the MAP compares all incoming waveforms to each unit template and sorts them accordingly.



As shown in the illustration, to choose a sorting method for the current channel, click next to the **Sorting** field in the Control Table and select **Boxes** or **Templates**.

2.3.2.5.1 1. Boxes: The box sorting method uses pairs of time-voltage windows (boxes) in the Waveform Window to sort spike waveforms. Waveforms that pass through both boxes are sorted as a unit. Boxes can be sized and positioned to classify groups of waveforms of the same shape.

The boxes method uses a sequence of up to four pairs of boxes. The four pairs of boxes are identified as Units a, b, c, and d. Sort Client attempts to match each incoming waveform first against Unit a boxes. If the waveform passes through the Unit a boxes, Sort Client classifies the waveform as Unit a. If the waveform does not match Unit a boxes, Sort Client sequentially attempts to match the waveform against Unit b, Unit c, and Unit d boxes before it leaves the waveform unclassified. When Sort Client classifies a waveform with one set of boxes, it cannot be reclassified by subsequent boxes.

2.3.2.5.2 2. Templates: The template sorting technique uses a set of spike waveforms that are collected to create templates to sort spikes. There are three steps to creating templates:

- 1 Collect a set of waveforms—the Template Set.
- 2 Apply Principal Component Analysis (PCA) to create a cluster plot of the Template Set.
- 3 Mark “bundles” or “clusters” of waveforms, which are subsets of the template set, to create a template for each unit on the current channel.

Sort Client averages the bundles or clusters that are marked to create templates (mean waveforms) for each unit. Sort Client sends the templates to the MAP system. The MAP uses the templates to sort incoming waveforms into units.

To mark (select) waveforms for the current channel, use one, two, or all three of the following displays:

- Waveform Window—to mark bundles of waveforms
- Cluster Display—to circle clusters of PCA points in two dimensions
- 3D Cluster Display—to orient and circle clusters of PCA points in three dimensions

Note: For complete information on how to open and use the cluster displays, see the detailed instructions that describe how to use the [“Multi-Display Window” on page 79](#).

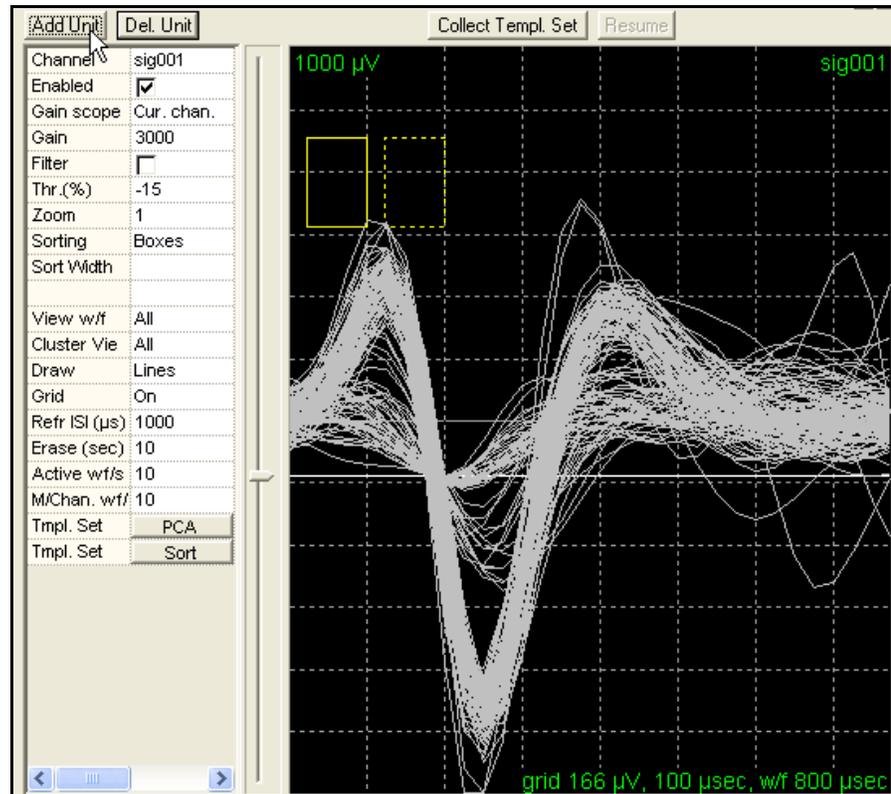
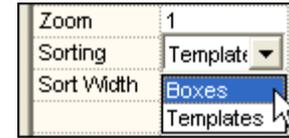
Sort Client uses principal component analysis (PCA) to create the 2D and 3D cluster plots of each waveform as data points in PCA space. PCA is a projection that maximizes the variance of the waveforms.

2.3.2.6 Adjust Sorting Parameters

After choosing a sorting method, use the following procedures to adjust the sorting parameters to deliver the best unit classification with that method. The first procedure covers the Boxes sorting method. The second procedure covers the Templates sorting method. These procedures are the last in the loop of setup procedures that apply to each channel.

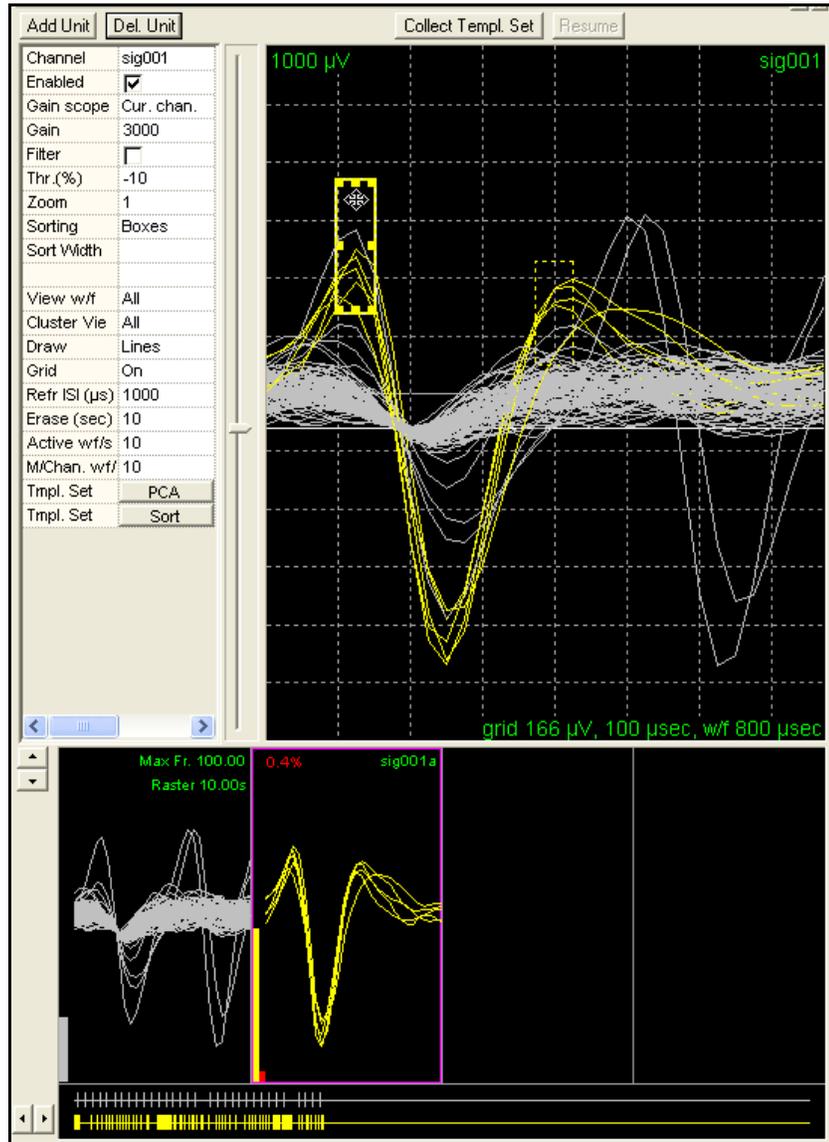
To use the Boxes sorting method

- 1 In the Control Table, click next to **Sorting** to open the menu. Click **Boxes**.
- 2 To prompt Sort Client to display the first pair of boxes, click **Add Unit**. Sort Client displays a pair of boxes of the same color in the top left corner of the Waveform Window: one box has a solid outline; the other box has a dotted outline.



- 3 Position and size each pair of boxes to classify incoming waveforms as a particular unit, either a, b, c, or d. Use each pair of boxes according to the following rules:
 - **Rule 1:** To be classified as a unit, waveforms must pass through both boxes in the pair.
 - **Rule 2:** At least one digitized point representing the waveform path must appear in each box.
 - **Rule 3:** Waveform paths must enter the solid box only once.

As the following illustration shows, drag the boxes to appropriate locations to capture a distinct feature (i.e., a peak or a trough) of the waveform of the first unit to be sorted. Resize the boxes to selectively capture waveform peaks by dragging the handles on the boxes. While positioning and resizing the boxes, note that the vertical edges of the boxes are constrained to align to the sample time positions; the Waveform Window illustration in [Step 5 on page 41](#) shows a Points view, which shows the boxes aligned with the digitized points.

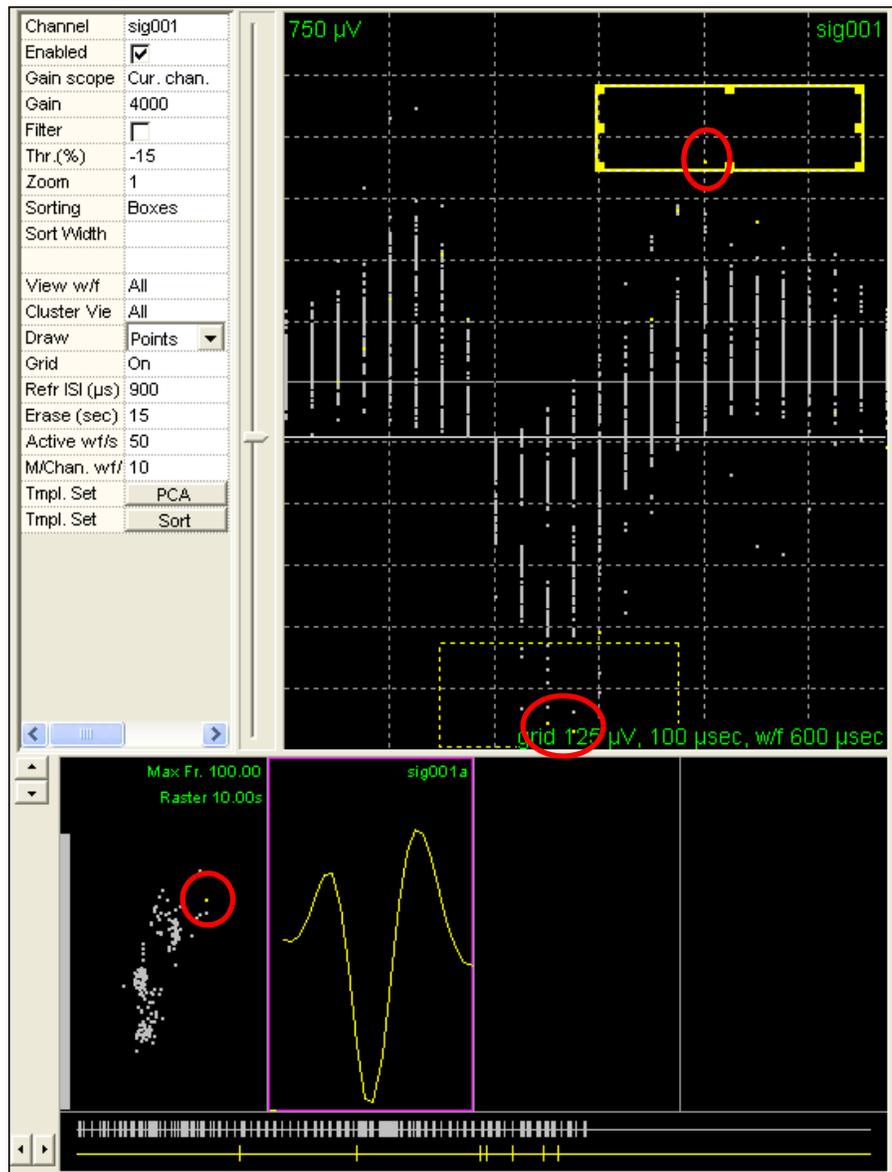


Note: If digitized points on the waveform path appear in the solid box and a subsequent point on the path appears outside the solid box, Sort Client classifies the waveform as a unit. However, if an additional subsequent point on the path (representing reentry of the waveform) appears in the solid box, Sort Client rejects the waveform for that unit.

- 4 By default, the Waveform Window shows each waveform as the curve that connects its individual digitized points. However, when using the box sorting method, the user can also choose to view the digitized points alone. This "Points" view can be useful to see if particular points on a curve are actually inside the relevant boxes. To display a Points view, click next to **Draw** and select **Points**.

View w/f	All
Cluster Vie	All
Draw	Lines
Grid	Points
Refr ISI (μ s)	Lines
Erase (sec)	15

- 5 The illustration that follows is a Points view of the Waveform Window. Sort Client plots each data point that generates the curve for each digitized waveform. The data points occur at evenly-spaced time intervals, which can eventually appear to be a series of vertical lines as the data points abut or overlap.



In the preceding illustration, the waveform sorted by the boxes method is **sig001a** (Unit a). The waveform shape represented by the digitized points appears in the units display at the bottom of the illustration. Two yellow points in the dotted box and a single yellow point in the solid box represent the digitized path of the waveform through the boxes. The sorted waveform also appears as a yellow dot in the cluster plot. The raster plot (tick marks) across the bottom shows the times of occurrence of the captured spikes. The gray ticks represent unsorted spikes. The yellow ticks represent the sorted Unit a.

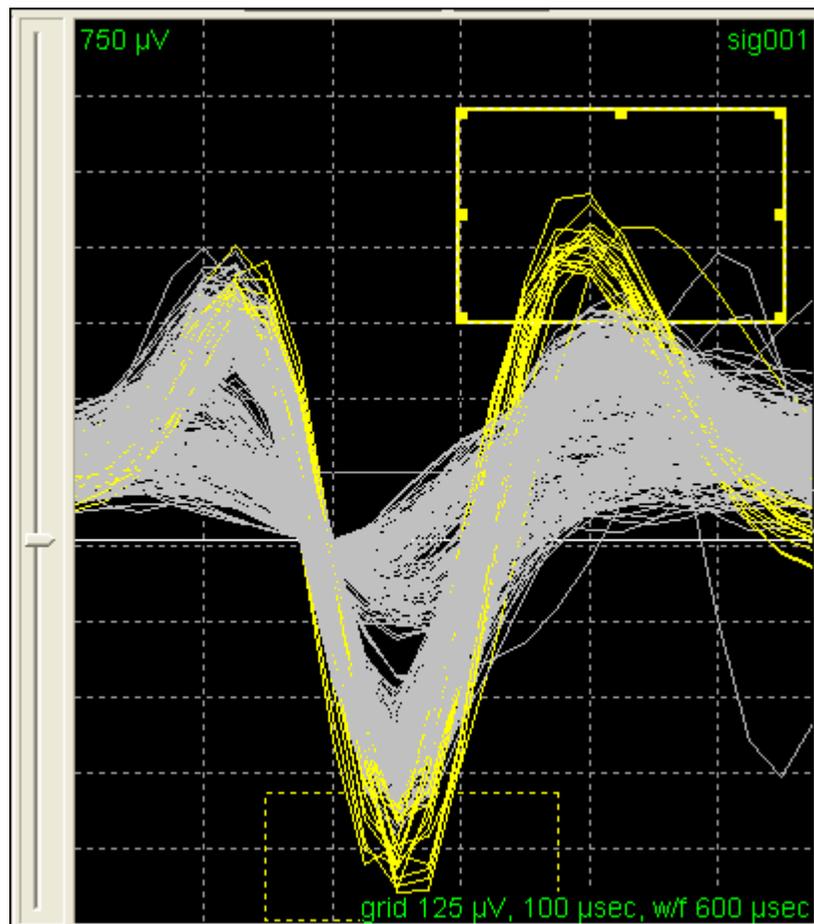


HINT

Capture Largest Amplitudes First

The largest-amplitude spikes are usually distinctly visible. Position the “Unit a” boxes to capture the largest amplitudes first. This makes the other spikes easier to distinguish.

The following illustration shows the “Unit a” boxes (yellow) roughly positioned to intercept the largest amplitude waveforms. With the largest-amplitude waveforms classified as Unit a, the remaining waveforms in this view are more distinct, which makes it easier to position subsequent boxes to correctly classify the remaining waveforms. Then the Unit a boxes may be repositioned more precisely.





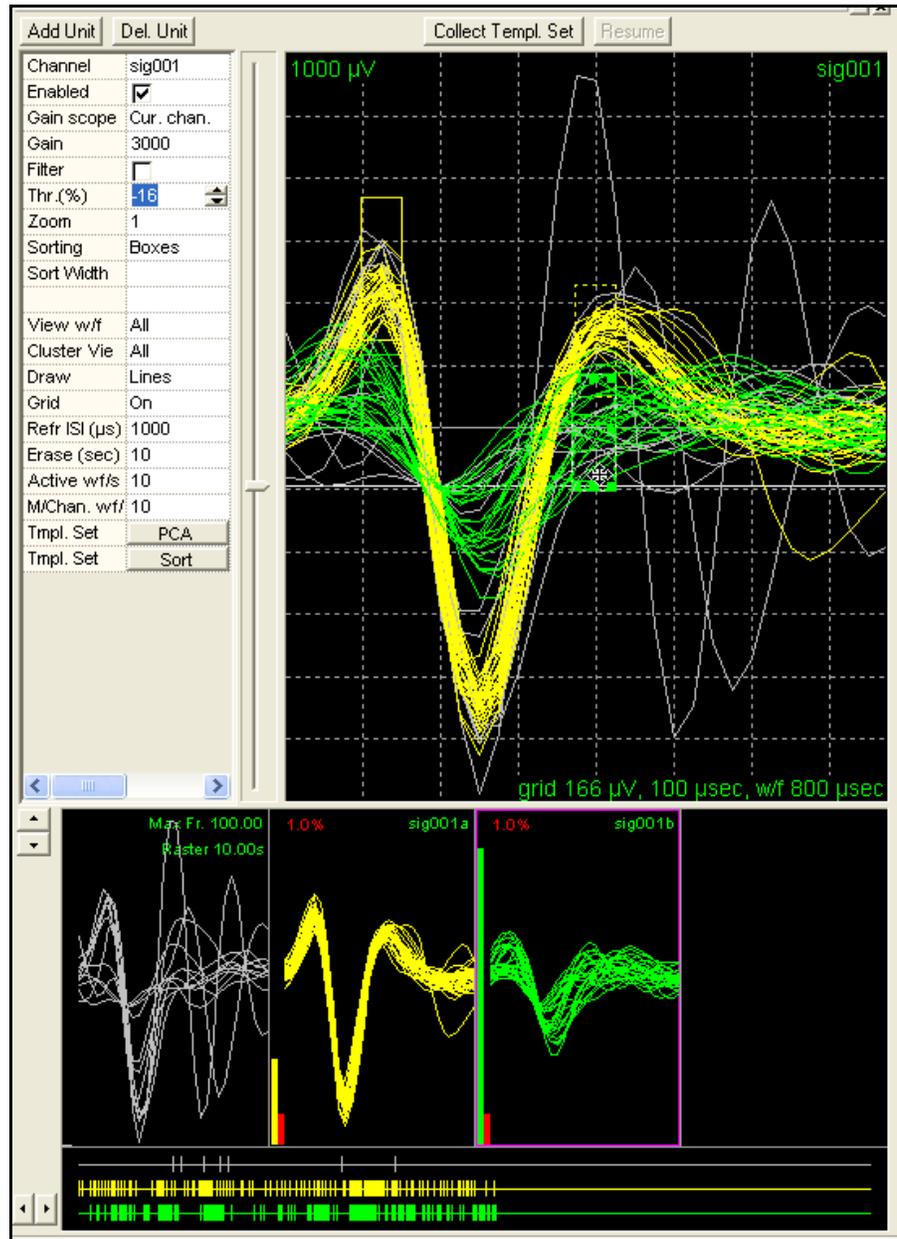
HINT

Large Amplitude Waveforms

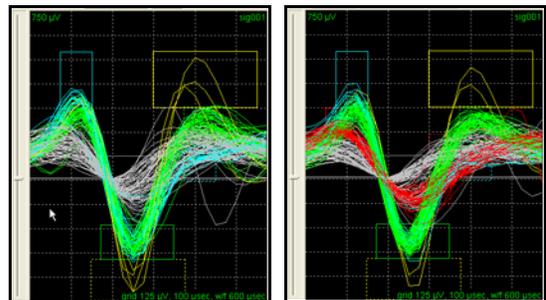
Although it goes against the normal gain setting rules, a mixture of large- and small-amplitude waveforms can require an intentional gain setting that sets the peak of some large-amplitude waveform outside the boundaries of the Waveform Window. To ensure capturing of these waveforms, reverse the order of the “Unit a” boxes on the waveform path (dotted box first, solid box second), which helps to include these waveforms. As shown in the previous illustration, the trough of several waveforms can pass out of a solid box and thus be excluded from classification. Because a dotted box does not reject reentries, alternating the order of the boxes accepts these otherwise out-of-bounds waveforms for classification.

- 6 To prompt Sort Client to display a second pair of boxes, click the **Add Unit** button. Sort Client displays a second pair of different-colored boxes (Unit b) in the top left corner of the Waveform Window. In this case, Unit b is green. Drag the boxes to an appropriate location to capture a distinctive feature of other waveforms to be sorted. Resize the boxes as needed by dragging the handles on the boxes.

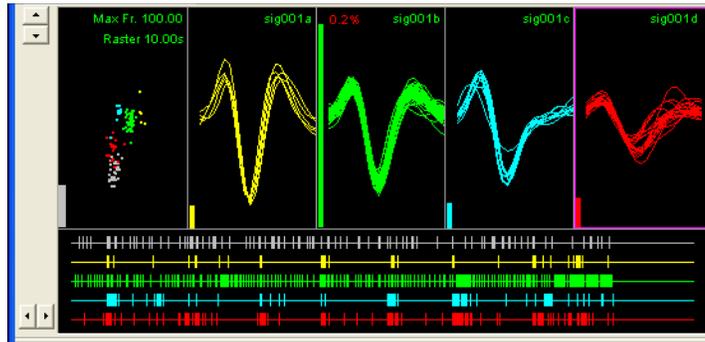
In the following illustration, the second set of Unit b boxes are green.



- As shown in the illustrations, Steps 2 through 6 may be repeated up to two more times as needed to classify a total of four sorted units on the current channel.



The PCA Cluster plot and Units Display for the four sorted units appear as follows:



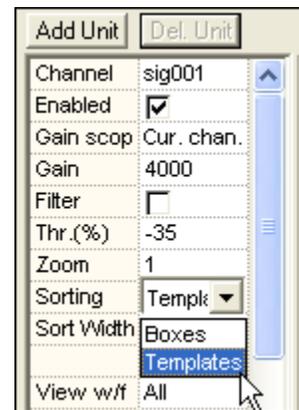
To use the Templates sorting method

Although bundles of waveforms or clusters of PCA points must be used, to select the waveforms for a particular unit, add subsequent units to the current channel by using either method.

- 1 In the Control Table, click next to **Sorting** to open the menu. Click **Templates**.
- 2 Click the Collect Template Set button.



Sort Client collects waveforms to be marked as templates. As shown in the following illustration, Sort Client displays a running count of the waveforms as it collects them.



Note: Sort Client collects a template set for the current channel only. The user can collect templates sets for all channels by using the Auto procedures on the **Tools** menu. For more information, see [“Auto PCA Algorithm” on page 131](#).

By default, Sort Client collects 1000 waveforms on the current channel to create a template set. However, when enough waveforms to create templates have been collected, stop waveform collection by clicking the Stop Template Collection button.



Note: If a channel has little or no activity on it, template collection can run on indefinitely until the Stop Template Collection button is clicked. To

avoid this problem, disable the affected channels. For more information, see [“Disabling Channels” on page 21](#).

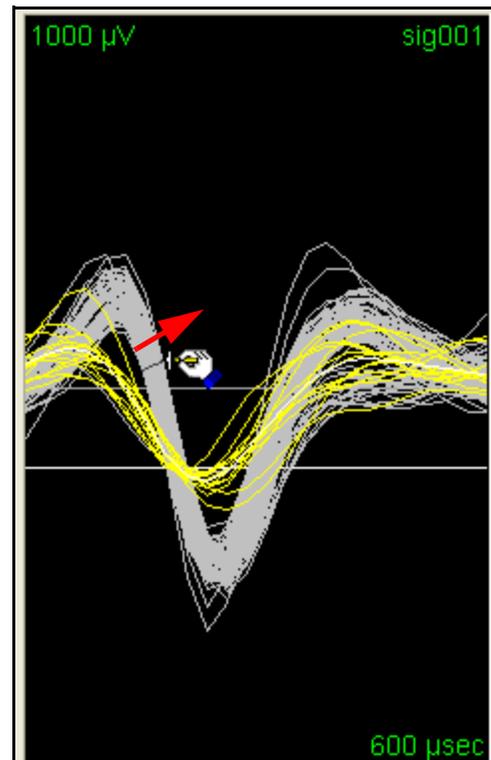


HINT

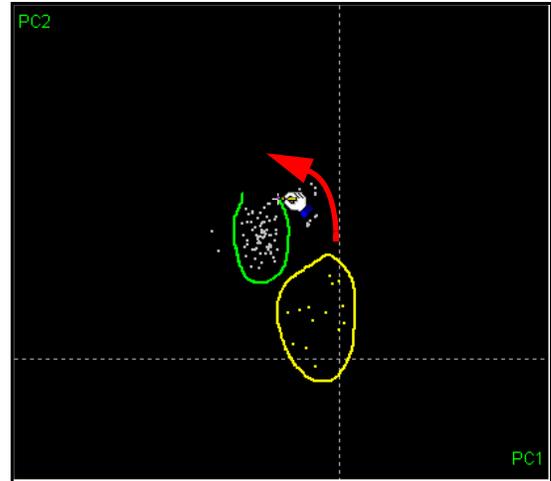
Collect fewer waveforms for easier marking

If collecting a template set to mark bundles in the Waveform Window, observe the waveforms as they accumulate in the Waveform Window. As soon as there are a sufficient number of waveforms to identify each unit, click the Stop Template Collection button. This reduces the number of waveforms in the window, which makes the bundles more distinct and easier to accurately mark for template creation. However, if marking clusters in PCA space, a full template set makes the clusters easier to distinguish. For more information, see [“Select a Sorting Method” on page 37](#).

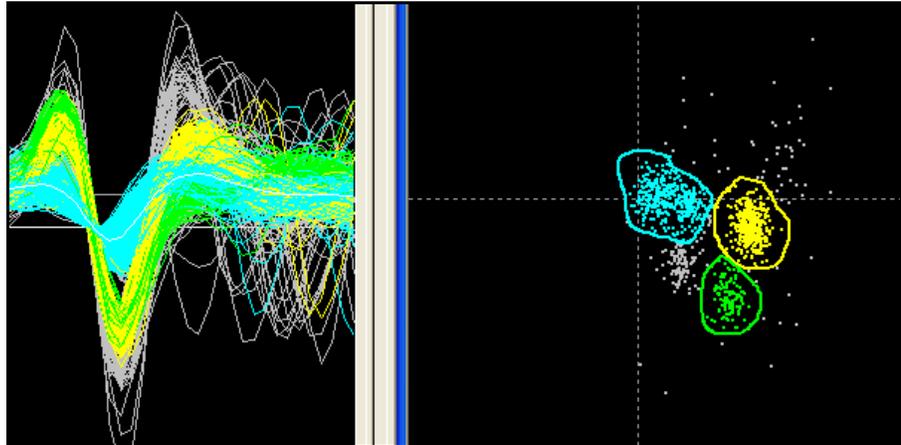
- 3 Click the **PCA** button. Sort Client performs PCA calculations on the waveforms in the collected template set and shows the results in the Cluster Display and 3D Cluster Display.
- 4 To mark subsets of the waveforms in the template set, click **Add Unit**. The cursor changes to this shape. 
- 5 In the Waveform Window, drag the cursor to mark a bundle of waveforms to average and serve as a template. Sort Client selects all the waveforms that cross the line drawn. In the accompanying illustration, the first bundle of waveforms has already been marked (yellow) and the cursor is marking a second bundle of waveforms.



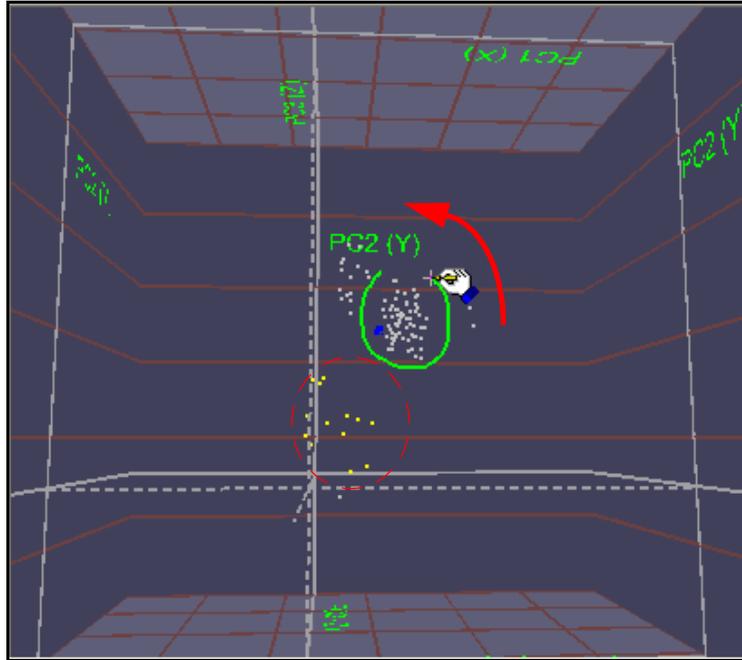
In the Cluster Display, use the cursor to mark clusters of waveform points that have been plotted in two-dimensional space. For information on how to open and use this two-dimensional display, see ["Cluster Display" on page 93](#). In the accompanying illustration of a Cluster Display, the first cluster of waveform points has already been marked (yellow) and the cursor is marking a second cluster of points.



As the following illustration shows, when marking clusters of waveform points in the Cluster Display the corresponding spikes appear as marked bundles in the Waveform Window.



In the 3D Cluster Display, use the cursor to orient and mark clusters of waveform points that have been plotted in three-dimensional space. For information on how to open and use this three-dimensional display, see “3D Cluster Display” on page 95. In the following illustration of a 3D Cluster Display, the first cluster of waveform points has already been marked (yellow points highlighted in red circle) and the cursor is marking a second cluster of points.



Choose whichever method provides the best separation. Sort Client averages the waveforms selected to build a mean (average) template.

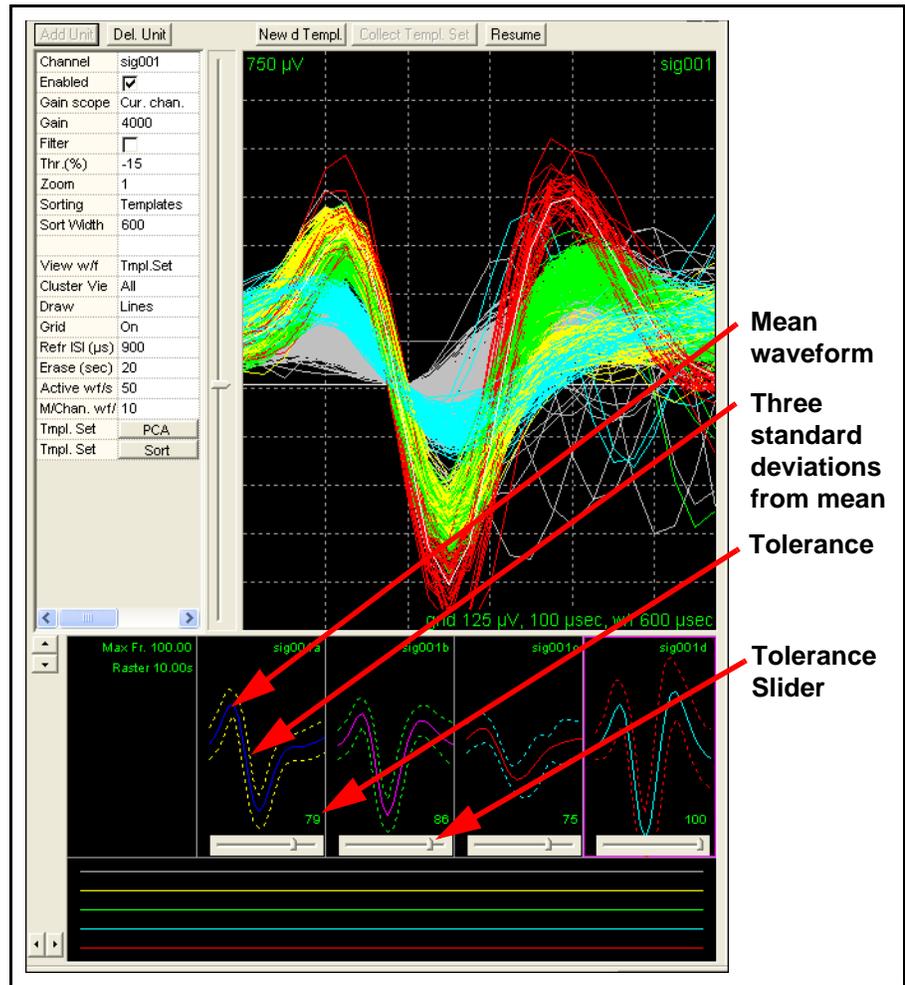
To cancel adding a selection, press the Esc key. To correct an error or to revise a selection, delete the selection for a unit and reselect the waveforms. To do so, in the Units Display, click the unit to be revised, then click the Delete Unit button and make another selection.

Del. Unit

The user can also choose to revise template selections. To do so, in the Units Display, click the unit to revise and click the New Template button. Sort Client displays the letter of the selected unit on the button. The illustration shows the New Template button label for Unit a.

New a Templ.

- 6 The following illustration shows a marked template set and the corresponding view of each unit template.



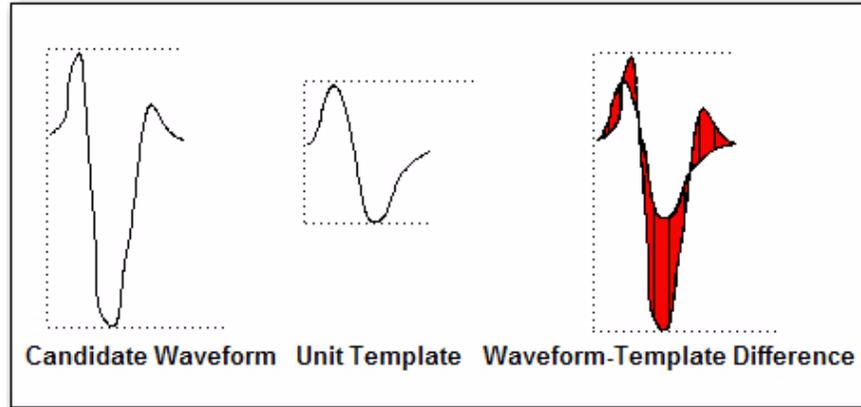
Based on the marked sets, Sort Client creates a mean-waveform template for each unit and displays each template (solid line) and three standard deviations from the mean (dotted lines) in the Units Display. Sort Client calculates the standard deviations from the waveforms in the template set.

Each unit display has a template tolerance-setting slider below the display; for more information, see [“Template Adjustment”](#) on page 89. To be classified as a unit, incoming waveforms must match the unit template within its tolerance setting. The slider controls the tolerance setting, which is based on the sum-of-squares distance (dw) between the waveform and the template.

The following illustration shows a candidate (unclassified) waveform, a template, and the difference between them. The vertical lines in the red area between the waveform and the template represent the distance between corresponding waveform- and template-point amplitudes (w_i and t_i). For each candidate waveform, the MAP system:

- calculates the sum-of-squared distances from the waveform to each of the templates (Units a, b, c, and d)

- finds the unit template (a, b, c, or d) with the minimum sum-of-squared distances
- assigns the waveform to this unit only if the minimum sum-of-squared distances are less than the tolerance setting for this template; otherwise, the waveform remains unsorted



The formula for the sum-of-squared distance (dw) follows

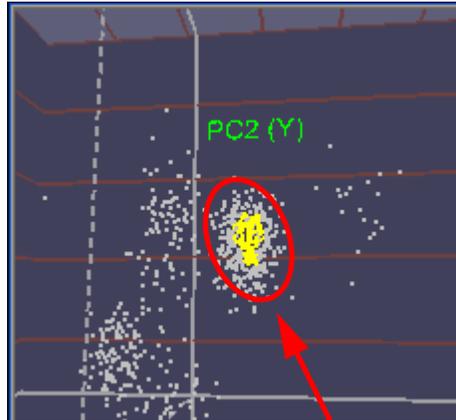
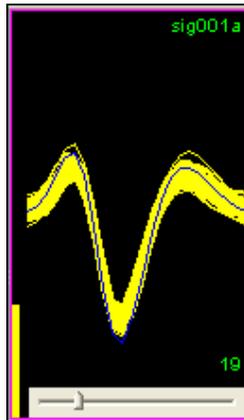
$$dw = \sum_{i=0}^M (w_i - t_i)^2$$

where $(w_i - t_i)^2$ represents the square of the distance between the i th waveform point w_i and corresponding template point t_i , and M is the sort width for the current channel (in data points). For more information on the sort width, see ["Template Adjustment" on page 89](#).

To begin using the templates to sort waveforms, click the **Resume** button.

- 7 Set all the tolerance adjustment sliders to 0 (zero). For more information on tolerance, see ["Fit Tolerance Range" on page 117](#). Begin with the slider for Unit a and slowly increase the tolerance setting until the incoming waveforms in Unit a are correctly classified. Do not increase the tolerance setting to the point where waveforms from neighboring clusters should be included. The following matching illustrations of slider settings and 3D displays show three slider positions: 1) Too low, 2) Optimum, 3) Too high.

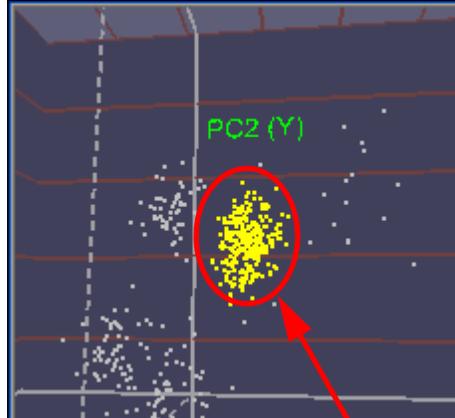
1) Too Low



Slider setting is too low to include most of the whole cluster

A large portion of the cluster is excluded

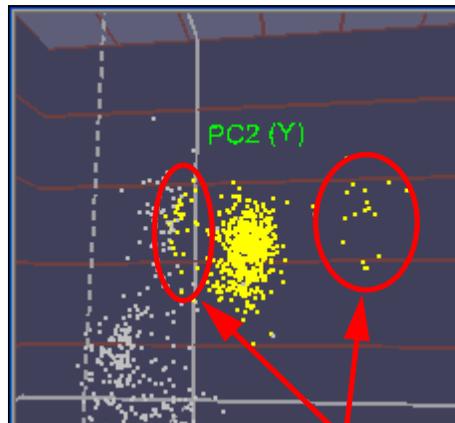
2) Optimum



Slider setting is optimum and includes most of the cluster

Most of the cluster is included

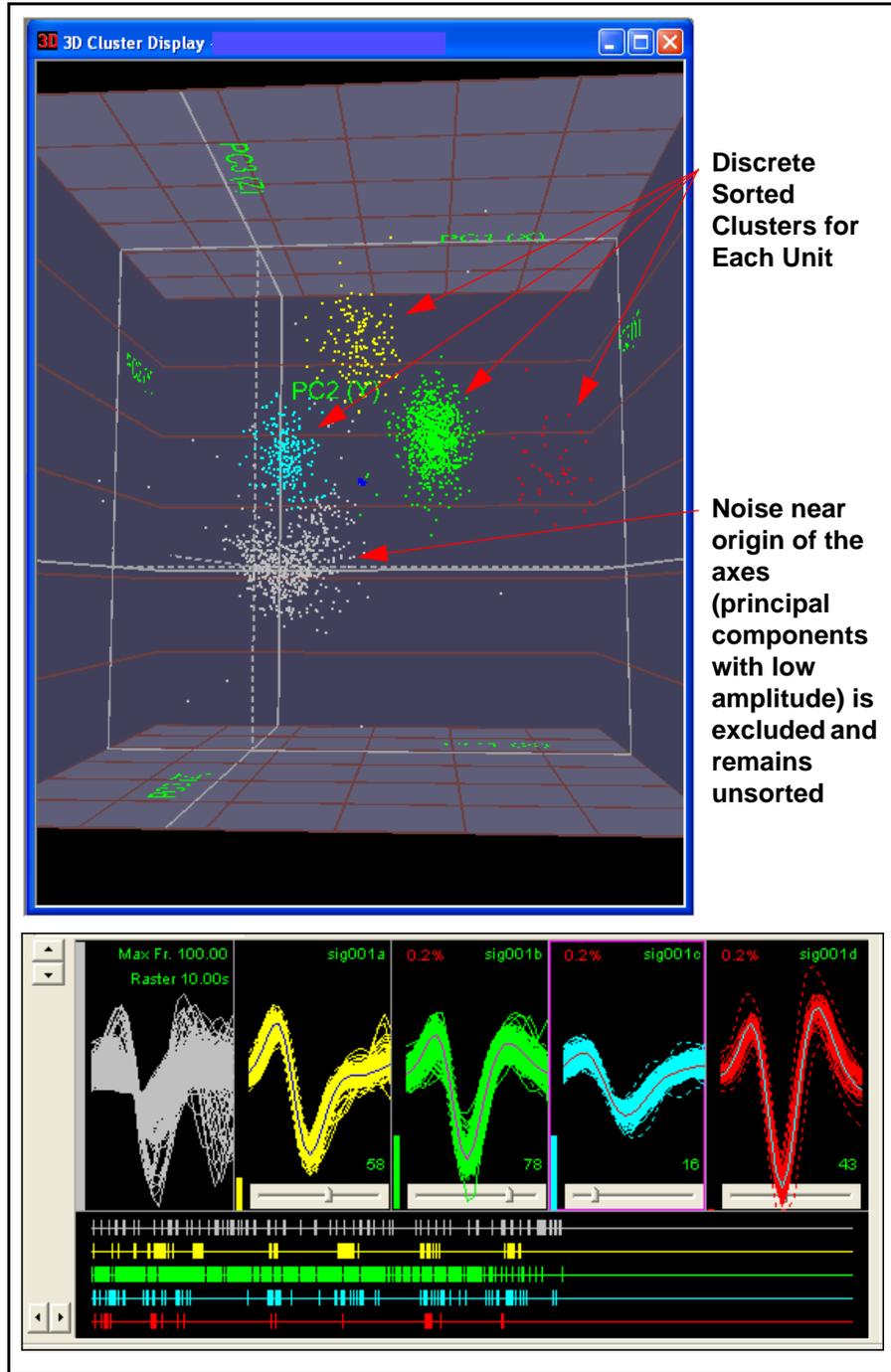
3) Too High



Slider setting is too high.

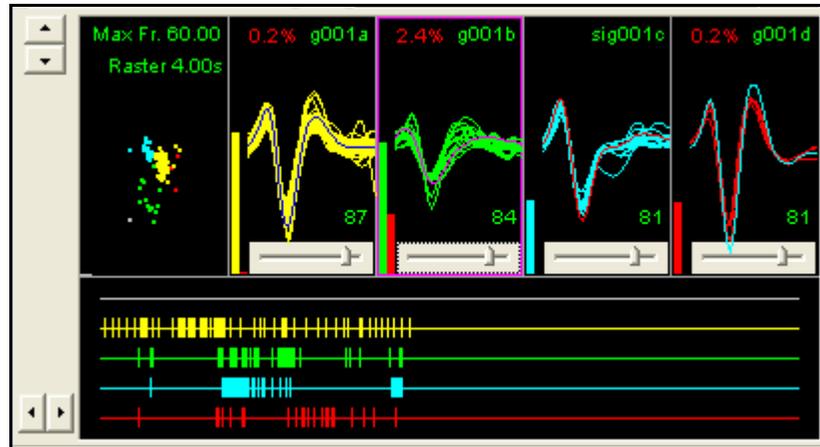
Portions of nearby clusters are included

The following illustration includes a 3D Cluster Display view of the template matching results for the slider settings shown in the Units Display below it.



For more information on setting fit tolerances, see [“Unit waveforms” on page 104](#). See also [“Fit Tolerance Range” on page 117](#). For information on adaptive template adjustment, see [“Template Adjustment” on page 89](#).

- 8 The user can also adjust the Units Display; for complete information see [“Units Display” on page 103](#). To set the maximum frequency, click the vertical arrows at the top left of the Units Display. To set the raster range, click the horizontal arrows at the bottom left. In the following illustration, the frequency appears as **Max Fr. 60.00** and the range appears as **Raster 4.00s**.



For a complete detailed description of these items and other characteristics, see [“Units Display” on page 103](#).

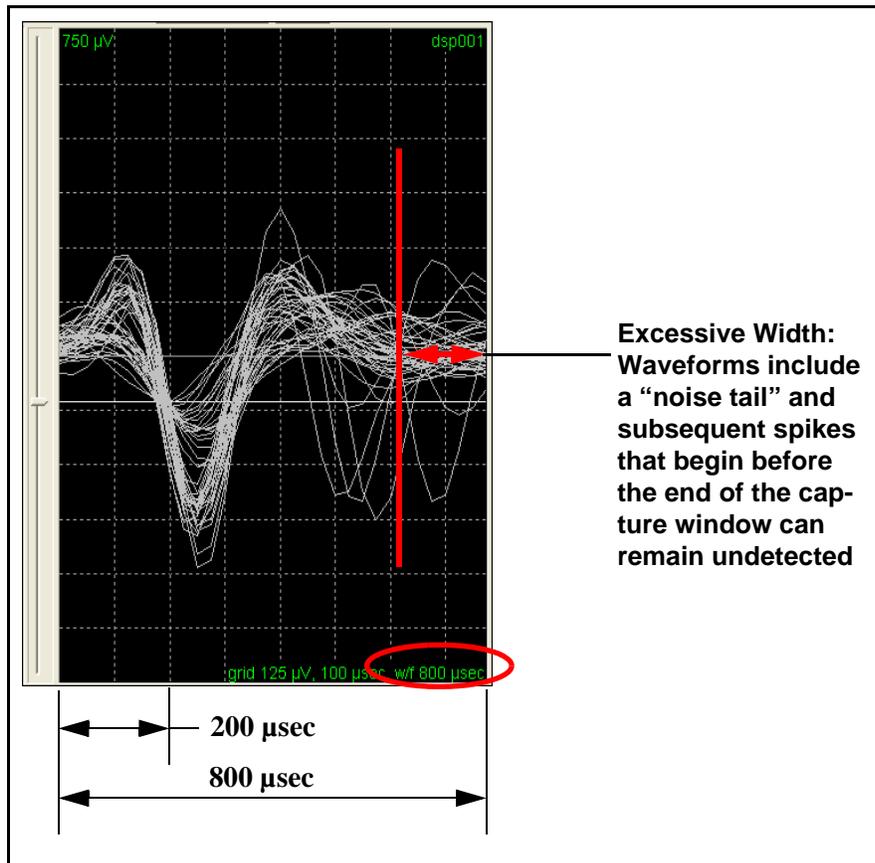
- From the **File** menu, click **Save Sorting Parameters File**, or click the save button on the toolbar.

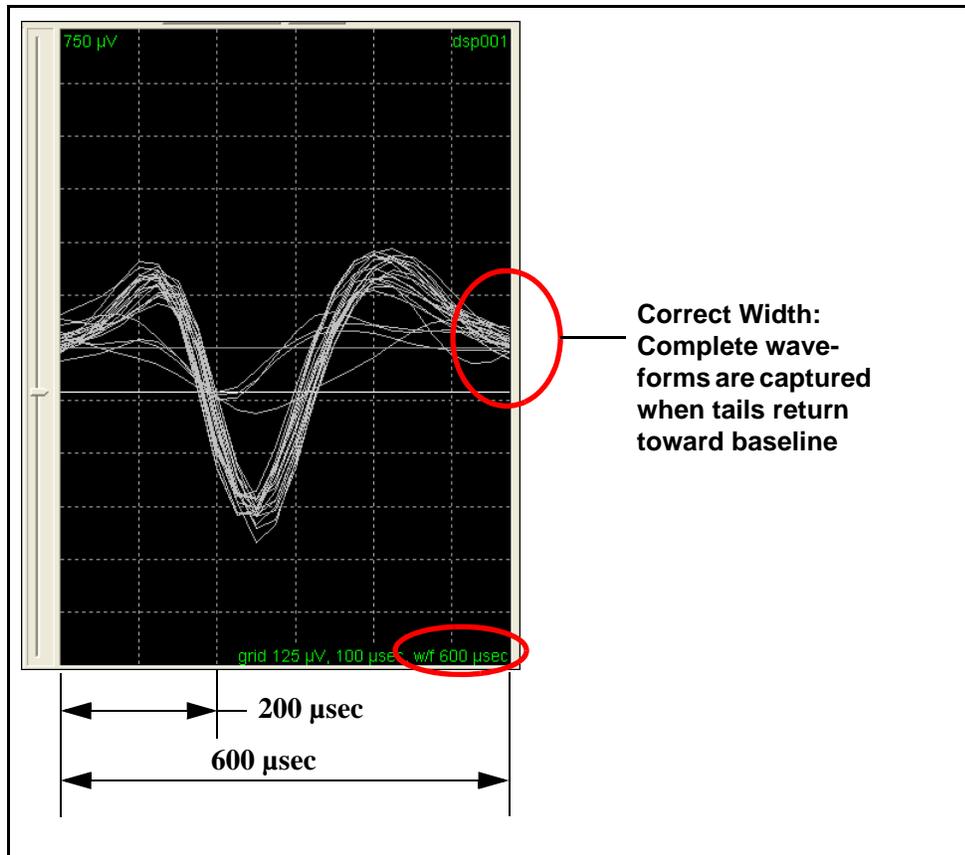


This is the last step in the procedure loop that applies to each channel. If all the needed channels have not been configured, select the next channel, return to [“Apply Filter” on page 27](#), and repeat the procedures to this point.

2.3.2.7 Set the Window Width and Pre-threshold Time

Because only one waveform can be triggered within the width of the Waveform Window, an ideal window width and pre-threshold time combination is one that captures a complete waveform shape. Excessive pre-threshold time and an excessively-wide window typically include “noise tails”, which can adversely affect the template matching calculations. Also, an excessively-wide window increases the chance that another spike waveform will begin before the end of the capture window and it will therefore be undetected. The following illustrations show a window with excess width and a correctly-sized window.





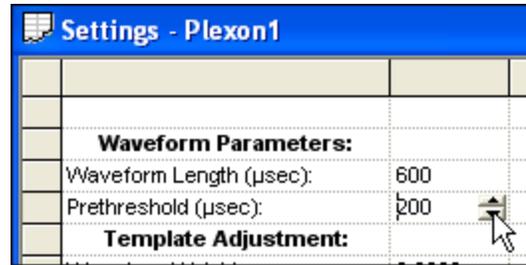
To set the window width and prethreshold time

- 1 Under the **Settings** tab in the Multi-Display Window, click the **Global** tab. Under **Waveform Parameters**, click the table cell in the **Waveform Length (μsec)** row and use the arrows to increase or decrease the window width.

Settings - Plexon1	
Waveform Parameters:	
Waveform Length (μsec):	600
Prethreshold (μsec):	200
Template Adjustment:	
Waveform Weight:	0.0000
Update Template. Thr.:	20.0

Note: For information on adaptive template adjustment, see [“Template Adjustment”](#) on page 89.

- 2 Under **Waveform Parameters**, click the table cell in the **Prethreshold (μsec)** row and use the arrows to increase or decrease the Prethreshold setting to accommodate the head of the waveform. Plexon recommends a preliminary prethreshold setting of 200 μsec .



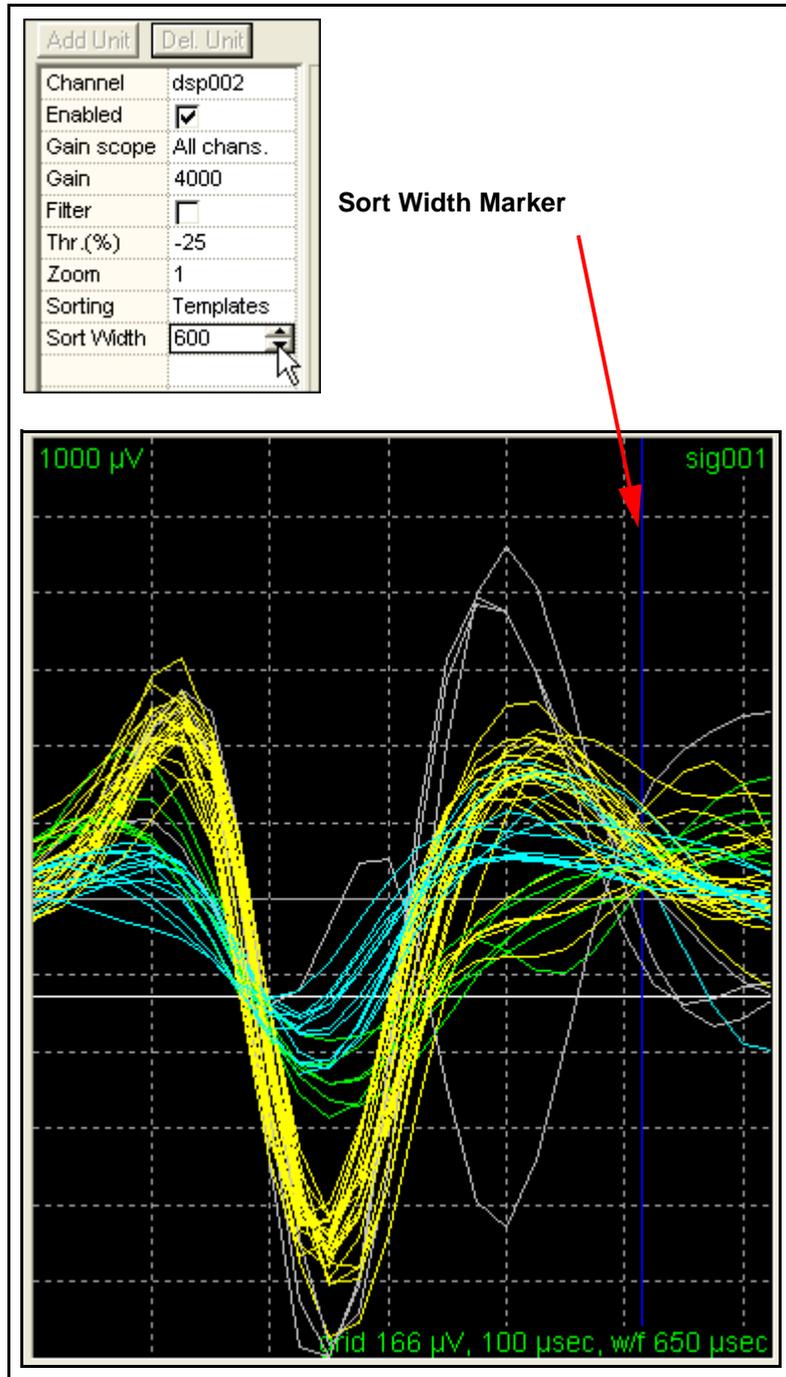
Settings - Plexon1	
Waveform Parameters:	
Waveform Length (μsec):	600
Prethreshold (μsec):	200
Template Adjustment:	

The same waveform length parameter can be used for all channels, however, the width of the spike waveforms on different channels can be markedly different in duration. For example, waveforms can be 1.2 msec long on some channels and 0.6 msec on other channels. If the waveforms are markedly different, proceed as follows.

To accommodate waveforms of different durations

- 1 Under the **Global** tab, set the **Waveform Length (μsec)** to capture the longest waveform.
- 2 Reduce the Sort Width on the channels with short-duration waveforms: In the Control Table, select a short-duration channel in the **Channel** row and then click the table cell in the **Sort Width** row. Use the arrow to decrease the Sort Width until the "noise tail" is excluded from the sorting calculations.

Note: Although the noise tail remains visible in the Waveform Window, as the sort width is decreased, a blue line moves to left to indicate the cutoff point for the sort width. As shown in the following illustrations, the window width remains at 650 μ sec, but the sort width (represented by the blue line) can be set to a lower value. When classifying waveforms, the MAP only uses those points within the Sort Width.



2.3.2.8 Set the Server Mode

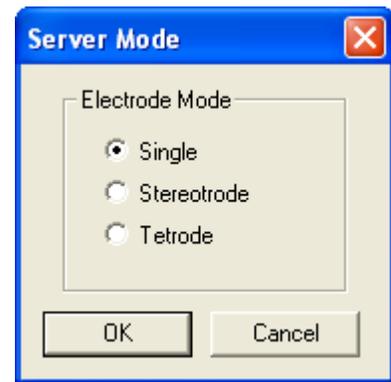
By default, Sort Client detects thresholded spikes from each electrode (channel) independently. However, Sort Client can also collect unsorted stereotrode or tetraode data. These modes can be used to record spikes from cells that are in close proximity to each other. Sort Client provides three different recording modes:

- single (one electrode)
- stereotrode (two electrodes)
- tetraode (four electrodes)

To set single, stereotrode, or tetraode mode

- 1 On the **Server** menu, click **Server Mode** to open the **Server Mode** dialog box.
- 2 In the **Electrode Mode** area, select **Single** or **Stereotrode** or **Tetraode**.
- 3 Click **OK**.

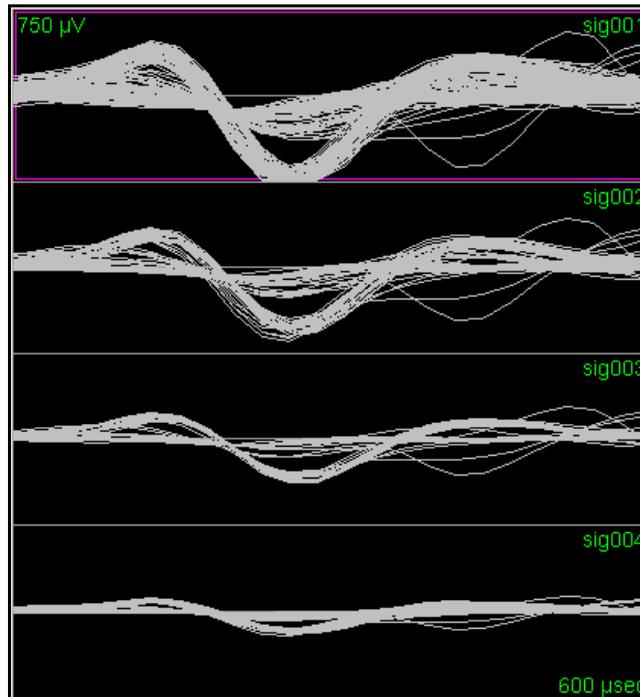
Note: The mode-control buttons on the toolbar can also be used. For information on the toolbar buttons, see [“Toolbar Icons” on page 105](#).



Sort Client sequentially assigns channels in groups of two for stereotrode mode or in groups of four for tetraode mode. The user can still select the channels in a stereotrode group or tetraode group and view them individually.

In stereotrode mode, the Waveform Window divides into two vertically-stacked displays. In tetraode mode, the Waveform Window divides into four vertically-stacked displays. The stacked displays show the time-coincident activity on each channel of the stereotrode or tetraode group.

The following illustration shows the four-channel stack of a tetrode-mode display.



Note: While data is being recorded to disk, the stereotrode-mode and tetrode-mode settings cannot be changed.

Note: Stereotrode and tetrode waveforms may not be sorted in real time with the MAP system; They must be captured, saved to disk, and sorted offline with [Plexon Offline Sorter](#).

2.3.2.9 Save the .exp File

This is the last step in the “Create a New Sorting Parameters File” procedure list. To make the sorting parameters previously specified in each procedure available for future use, save the .exp file. Plexon recommends that the sorting parameters file be saved after setting the parameters for each channel.

To save the .exp file

- From the **File** menu, click **Save Sorting Parameters File**, or click the save button on the toolbar.



As shown in “[Sort Client Procedures](#)” on page 17, after completing all the steps to create a new sorting parameters file, proceed directly to the step “[Sort and Record](#)” on page 67.

2.3.2.10 Load a Sorting Parameters (.exp) File

When Sort Client starts, it automatically loads default sorting parameters and labels them Plexon1.exp. If someone has previously used Sort Client, and saved .exp files, an existing .exp file can be loaded as follows.

To load an existing sorting parameters (.exp) file

- 1 From the **File** menu, click **Open Sorting Parameters File**.
- 2 In the **Open** dialog box, choose an .exp file. Double-click the file to enable the sorting parameters stored in the file.
- 3 Click **Start** to start data transfer.
- 4 Proceed to “[Check Sort Client Settings](#)” on page 60.

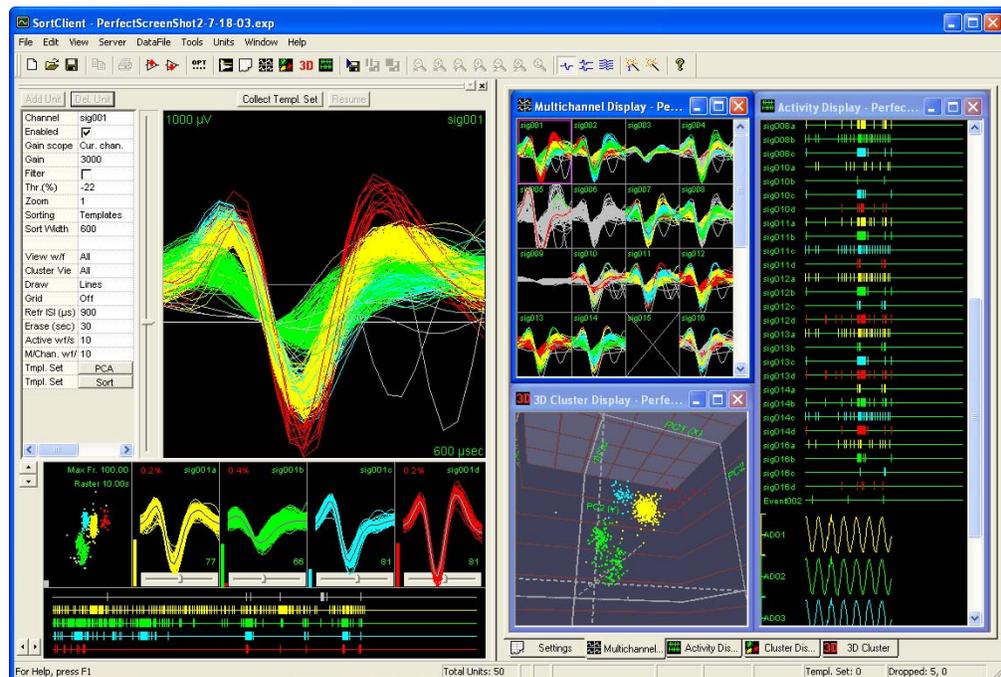
Note: The user can also set up Sort Client to automatically load a parameter file on startup; see “[File](#)” on page 108.

2.3.3 Check Sort Client Settings

This section includes the basic steps needed to check the sorting parameters prior to or during recording. There are two basic check steps:

- 1 Set up the Sort Client Main Window.
- 2 Check the sorting parameters on each channel.

When Sort Client is set up and data transfer starts, arrange the items in the Sort Client Main Window as shown in the following illustration. This is a typical arrangement that allows quick checking of the sorting parameters. For more on how to arrange items, see “[The Sort Client Main Window](#)” on page 73.

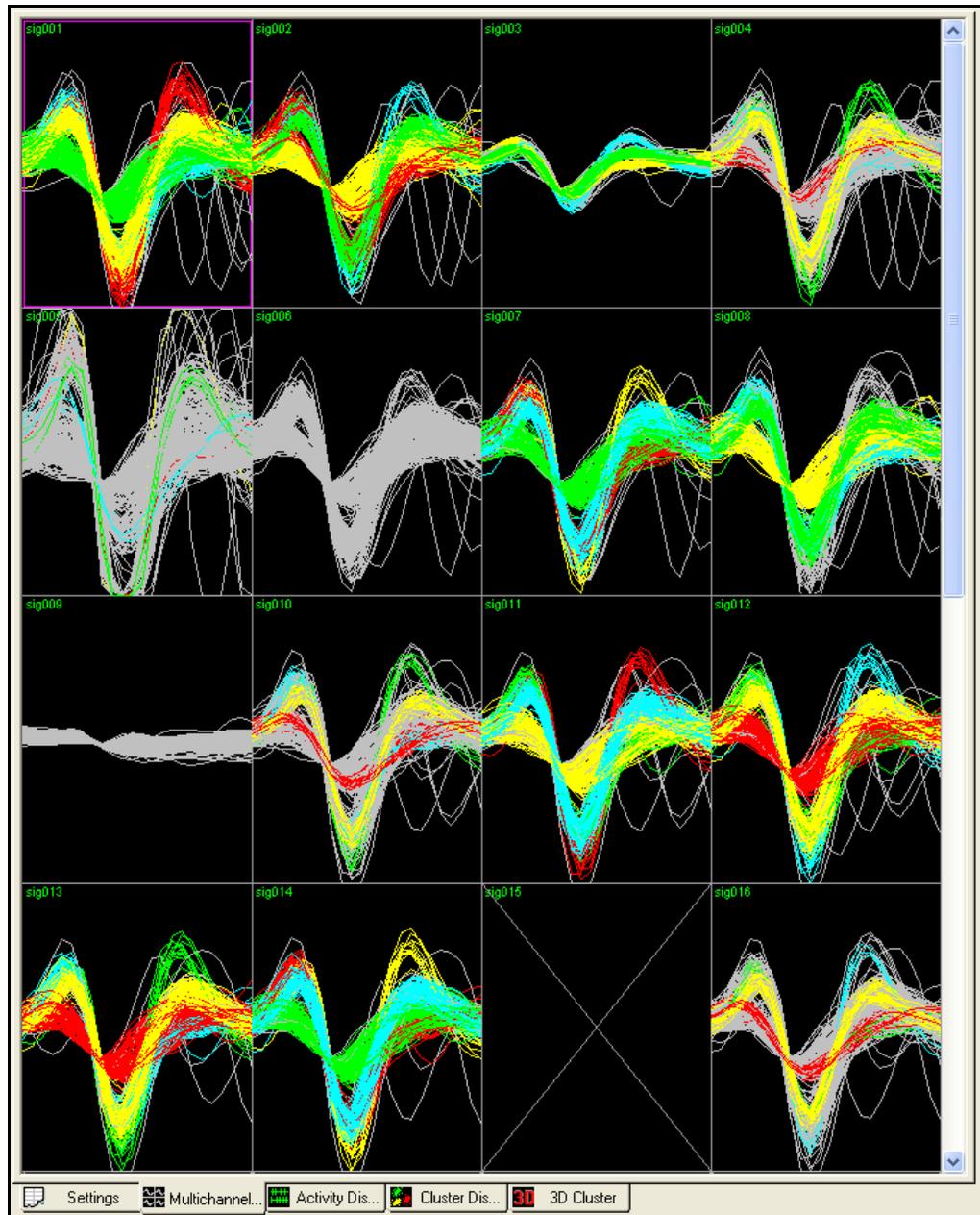


2.3.3.1 Check Sorting Parameters and Other Settings

Use the Multichannel Display to alert of possible problems with the sorting parameters. Anomalies that appear in the Multichannel Display can often point to problems with the sorting parameters for a particular channel. However, after data transfer is started, Plexon recommends to check the following sorting parameters and other settings:

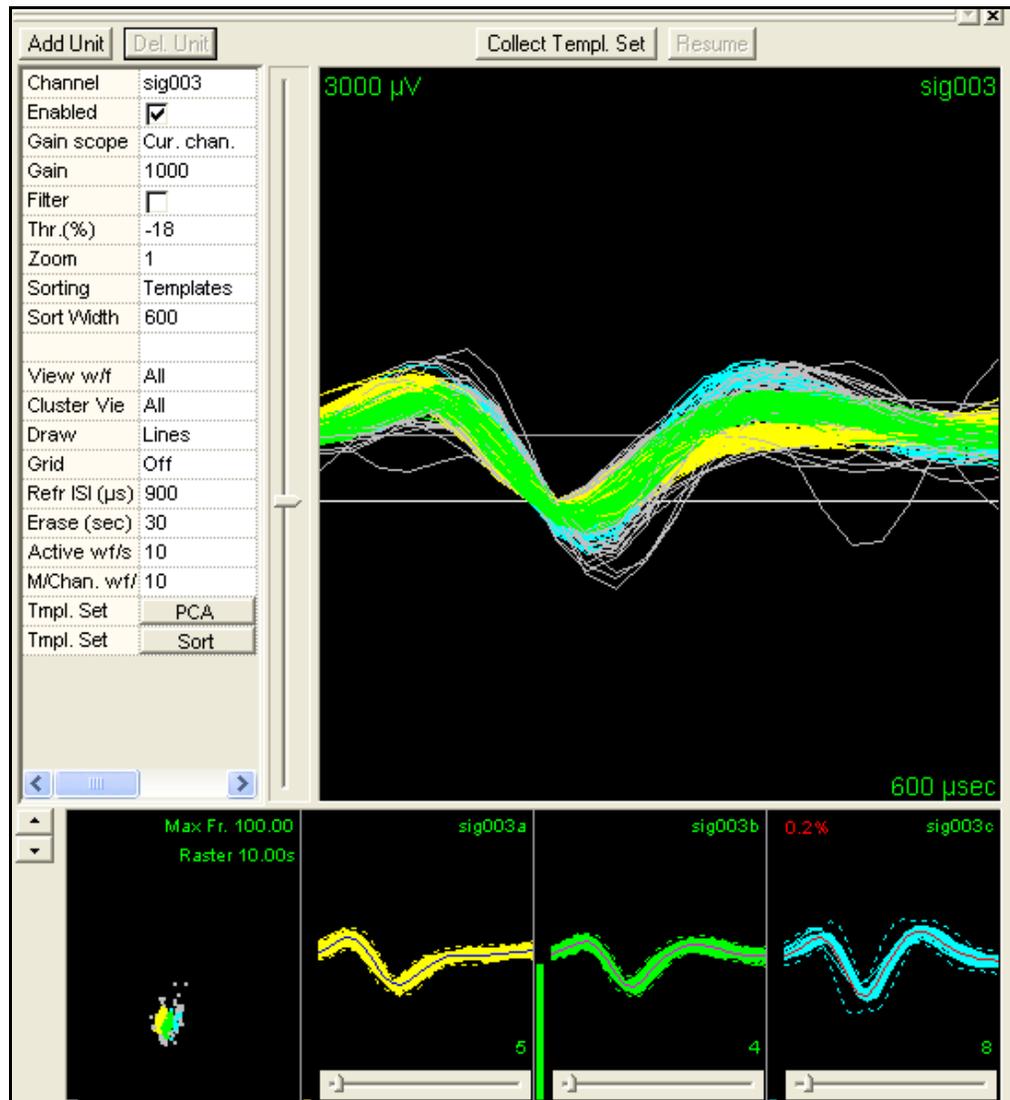
- Gain settings: Are waveforms clipped or missing?
- Threshold: Is the threshold set close enough to zero to avoid missing spikes?
- Template tolerance: Are the waveform points in the cluster displays still grouped in contiguous clusters?
- Events: Do the events selected for show appear in the Activity Display?
- Field potentials: Do the enabled continuous channels appear in the Activity Display?
- If a sorting parameters (.exp) file were loaded from a previous or ongoing experiment, the following section explains how to determine if:
 - All the units from the previous experiment are still present
 - The units are still optimally sorted
 - Any new units have appeared in the previously sorted or previously disabled channels

An expanded view of the Multichannel Display from the previous illustration follows. Examine channels sig003, 004, 005, 006, 008, 009, and 015. Each of these channels represent parameters that can typically require adjustment. Expanded descriptions of the adjustments required for these channels follow.



2.3.3.2 Low Gain Setting (sig003)

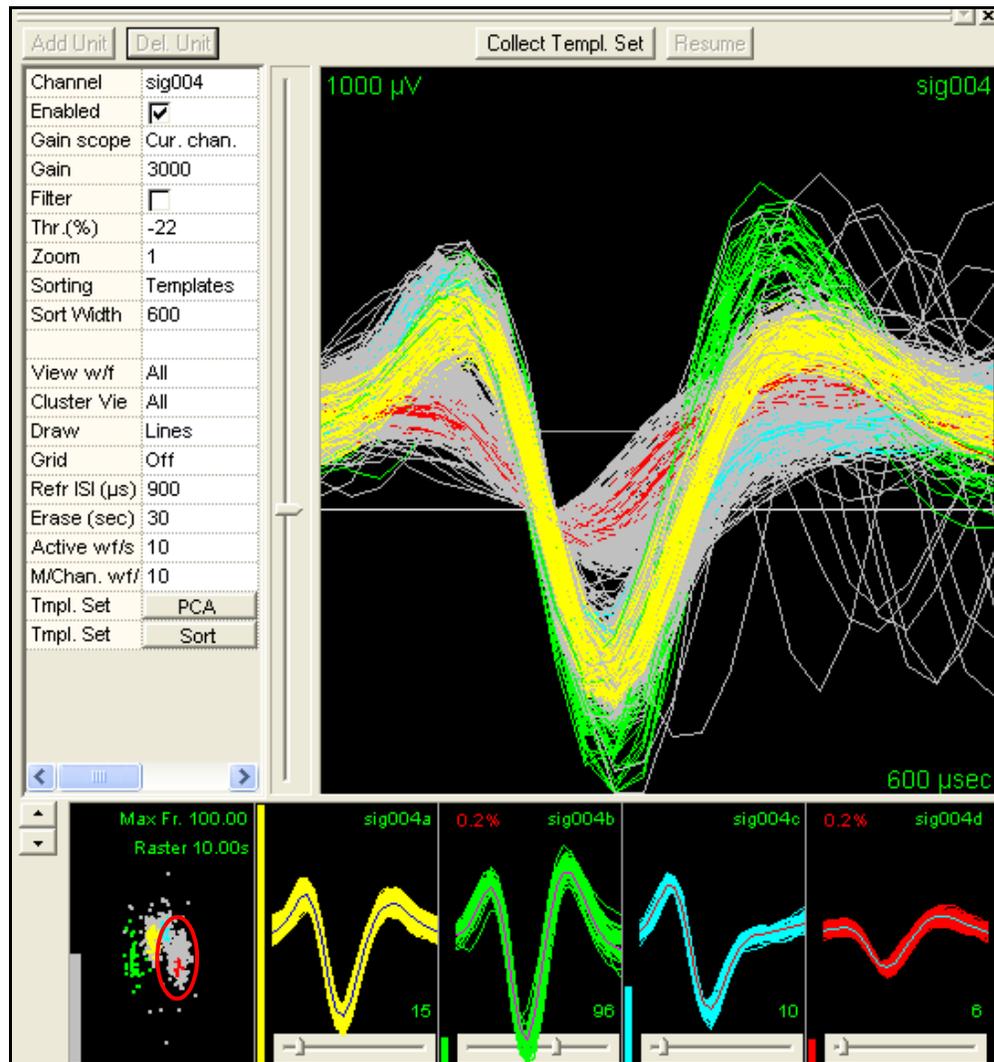
The gain setting on channel sig003 is set too low.



Plexon recommends a gain setting that results in the largest amplitude spikes occupying approximately 2/3 of the height of the Waveform Window. If the gain is set too low, spikes can remain undetected. For information on gain settings, see [“Set the Gain”](#) on page 30.

2.3.3.3 Incorrect Template Tolerance Settings (sig004)

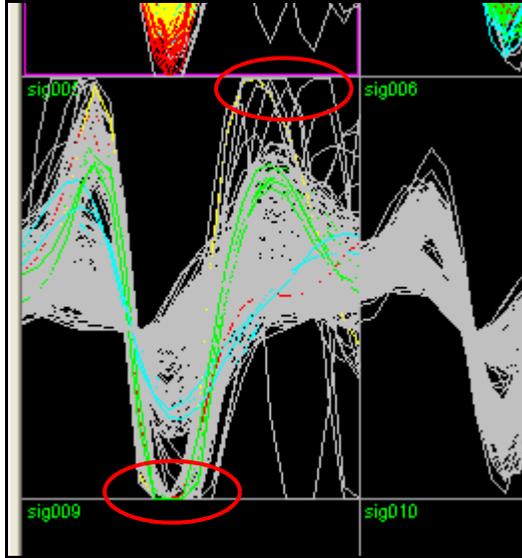
The template tolerance settings on channel sig004 are not correct.



The tolerance slider settings on **sig004a**, **sig004c**, and **sig004d** are set too low to include most of the clusters representing each of the units. A large number of spikes from these units have been left unsorted (gray). For example, see unit d in the cluster view (circled in red). For information on correct tolerance settings, see Step 7 on [page 50](#).

2.3.3.4 Clipped Waveforms (sig005)

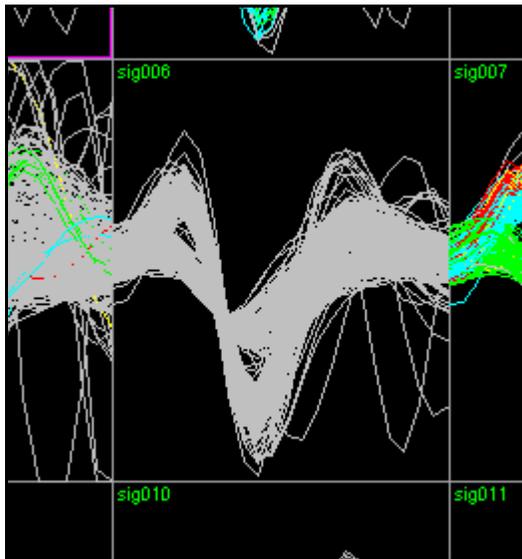
The gain on channel sig005 is set too high. As shown in the following illustration from the Multichannel Display example, the high-amplitude waveforms are “clipped” (circled areas).



Plexon recommends a gain setting that results in the largest amplitude spikes occupying approximately 2/3 of the height of the Waveform Window. If the gain is set too high, large spikes are “clipped” and their waveform shapes are distorted and cannot be sorted. For information on gain settings, see [“Set the Gain” on page 30](#).

2.3.3.5 Unsorted Waveforms (sig006)

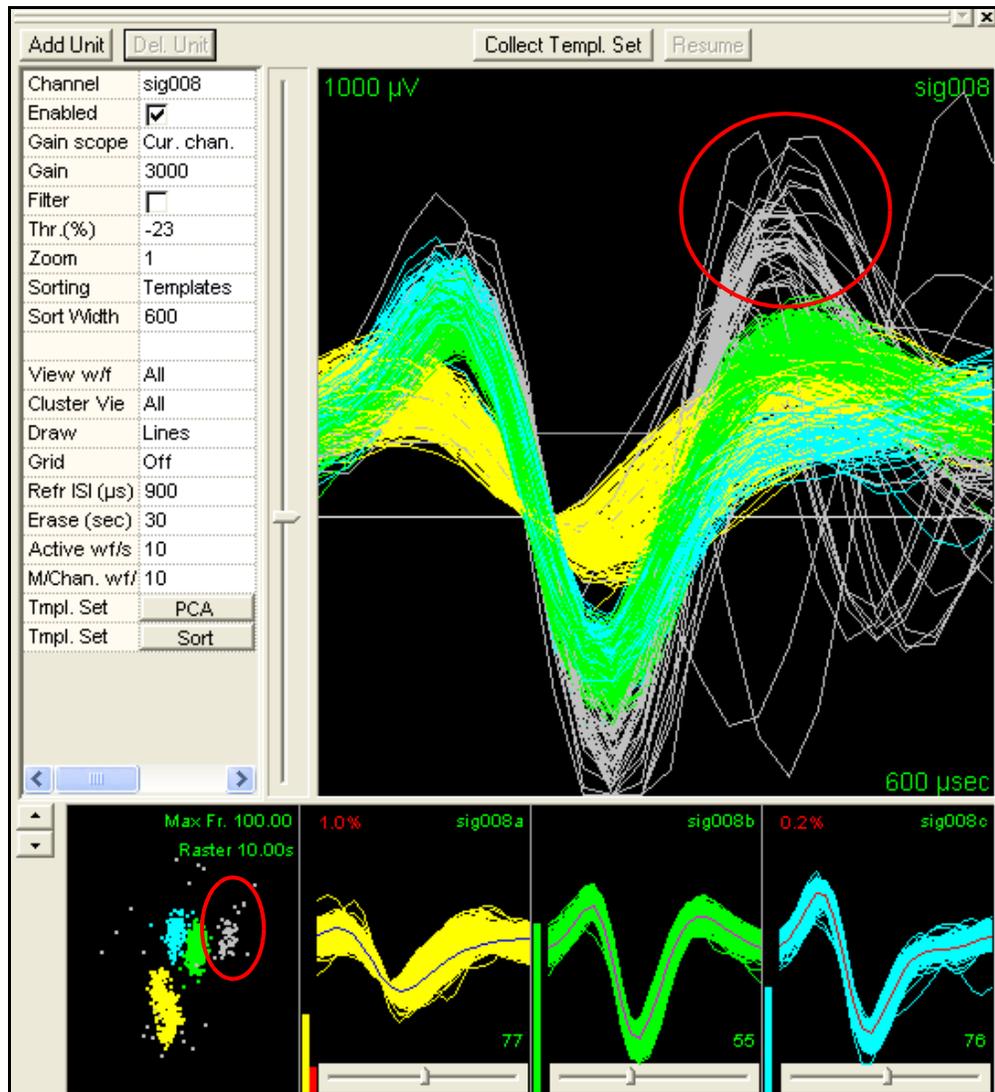
The waveforms on channel sig006 are unsorted. As shown in the following illustration from the Multichannel Display example, the waveforms on channel sig006 are all colored gray (not sorted).



Perhaps this channel was overlooked in the initial setup. To set up this channel, complete the steps in the individual-channel procedures loop that begins at [“Channel Specific Procedures” on page 27](#).

2.3.3.6 Missed Spike (sig008)

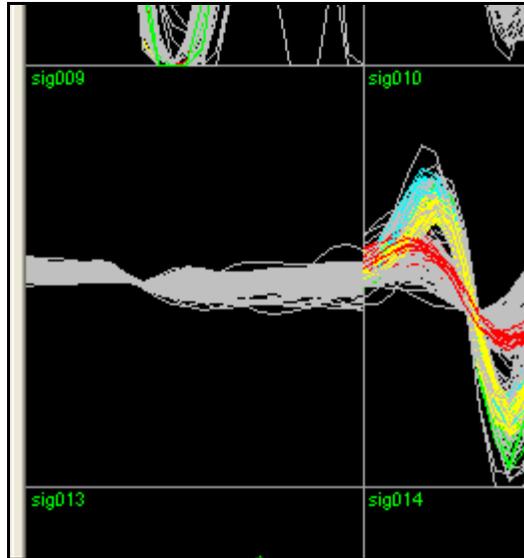
A unit on channel sig008 is not classified. As shown in the following illustration, a fourth unit is present, but it is not classified (circled areas).



Perhaps this spike was overlooked in the initial setup or it is a new spike. To add this unit, complete the steps in the individual-channel procedures loop that begins at [Step 4 on page 46](#).

2.3.3.7 No Spikes Present (sig009)

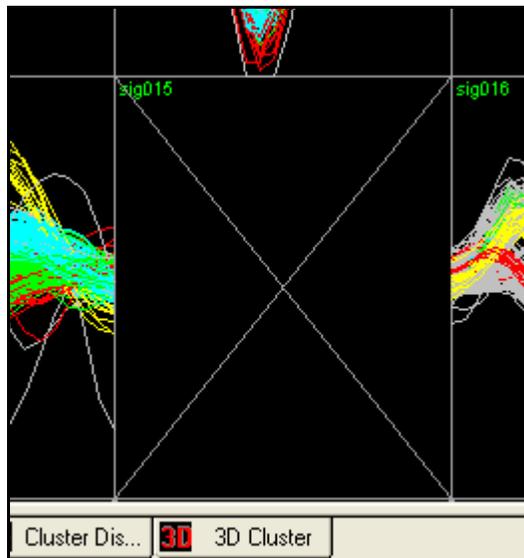
Channel sig009 appears to have only noise present on the channel. As shown in the following illustration from the Multichannel Display example, there are no spikes present on channel sig009.



To make sure there are in fact no spikes present on a channel, verify that the sorting parameters are correctly set for that channel. If an excessive amount of noise is detected, move the threshold away from zero.

2.3.3.8 Disabled Channel (sig015)

Channel sig015 is disabled. As shown in the following illustration from the Multichannel Display example, channel sig015 appears as an X.



To make sure there are in fact no spikes present on a disabled channel, enable the channel and verify that the sorting parameters are correctly set for that channel.

2.3.4 Sort and Record

There are three basic recording steps:

- 1 Start recording.

- 2 Add a file name and optional comments. Other items that may be specified are:
 - Separate start recording and stop recording settings
 - The type of data that the file can contain
- 3 If using manual control, stop recording when completing the recording session.

2.3.4.1 Start Recording

When starting a recording session, Sort Client opens the **Data File Options** window to provide a convenient area to set recording options.

To start recording

- To start a recording session, from the **Datafile** menu, click **Start Recording** or click the start-recording button on the toolbar.



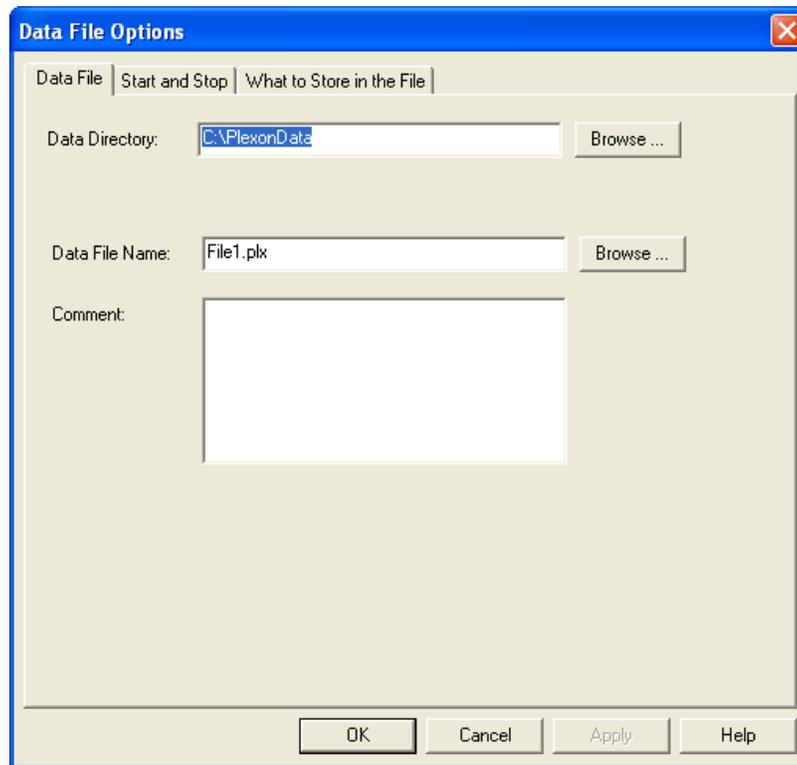
*Sort Client opens the **Data File Options** window.*

2.3.4.2 Add File Name, Comments, and Other Settings

Before recording a file, specify a file name and add a comment statement.

To specify a file name and add a comment statement to a file

- 1 In the **Data File Options** window, click the **Data File** tab.



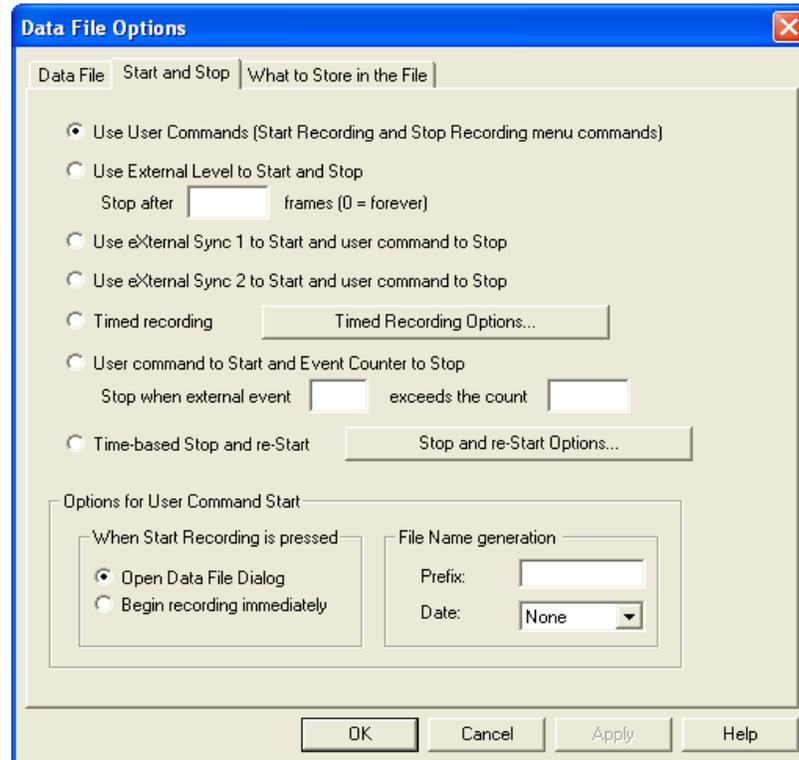
- 2 In the **Data Directory** field, Sort Client provides a default directory name. Accept the default name or type a new directory name. To select an existing directory name, click **Browse** and locate the directory.
- 3 In the **Data File Name** field, Sort Client provides a default file name. Accept the default file name or type a new file name.
- 4 In the **Comment** field, type a comment statement of up to 1000 alphanumeric characters.

Note: Although the **Comment** field accepts up to 1000 characters, only 100 characters can be viewed in typical applications.

2.3.4.2.1 Recording Options: Sort Client provides several recording options. The user can choose to start and stop recording manually or automatically, or a combination of both.

To set recording start and stop options

- 1 Click the **Start and Stop** tab.



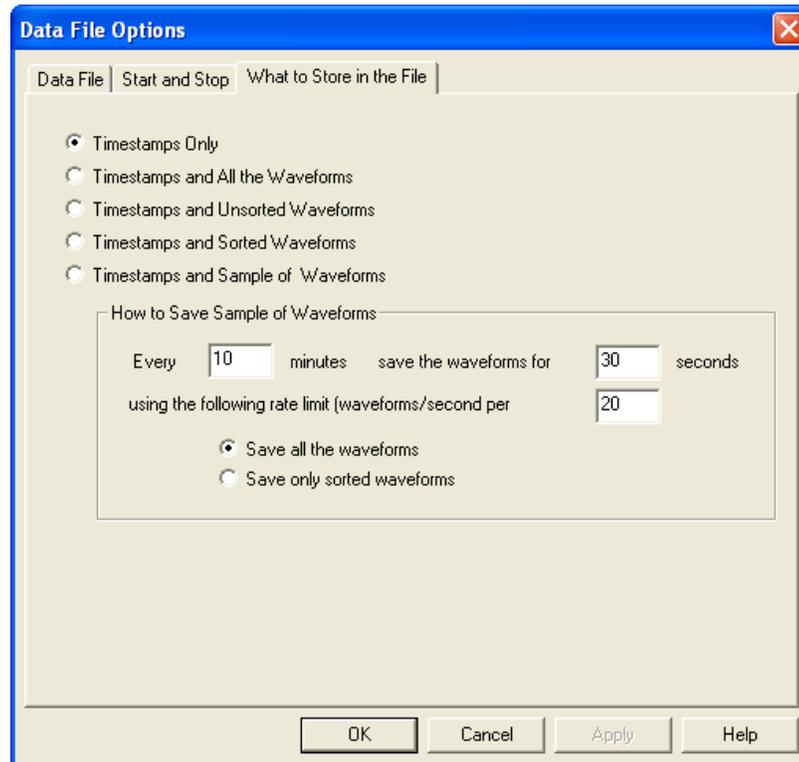
- 2 Choose a start-and-stop option. To use the default mode **Use User Commands** to start recording, set a start option in the **Options for User Command Start** area.

Note: For a complete description of all the start-and-stop controls, see the "Start and Stop" tab description on [page 126](#).

2.3.4.2.2 File Contents: Sort Client provides several options to specify the content of recorded files. The user may choose timestamps or combinations of timestamps and waveforms, both sorted and unsorted.

To select a file content option

- 1 Click the **What to Store in the File** tab.



- 2 Click a content option. Selecting a sample waveform recording allows setting of the sampling parameters in the **How to Save Sample of Waveforms** area.

Note: For a complete description of all the file-contents options, see the “What to Store in the File” tab description on [page 129](#).

2.3.4.3 Monitor Recording

After setting up the data file options, start recording data. If controlling the recording manually, the toolbar recording buttons or the recording commands from the **DataFile** menu may be used.

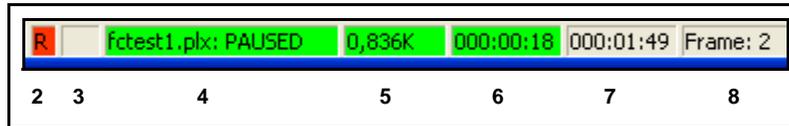
To record data to file with manual controls

- 1 In the **Data File Options** window, click **OK** to start recording data to the specified file.
- 2 After recording starts, Sort Client displays the following information about the recorded file in the fields in the status bar at the bottom of the main window. For complete information on the status bar, see [“Status Bar” on page 74](#).



The **R** in field 2, which is highlighted in red, indicates that recording is in progress. When waveforms are also recorded, field 3 shows “Wf” on a yellow background. Fields 4, 5, and 6, which are highlighted in green, indicate the file name, file size, and elapsed-time recording to file respectively.

- 3 To pause recording at any time, click the **Pause** button . When recording pauses, Sort Client shows the following information in the status bar.



In addition to the information displayed while recording, the file name area in field 4 now includes the word **“PAUSED”**. While recording is paused, the file elapsed-time indicator in field 6 stops counting. However, the total elapsed-time indicator, which is in field 7, continues to count. Each time a recording is paused, the frame indicator in field 8 increments the frame count by one.

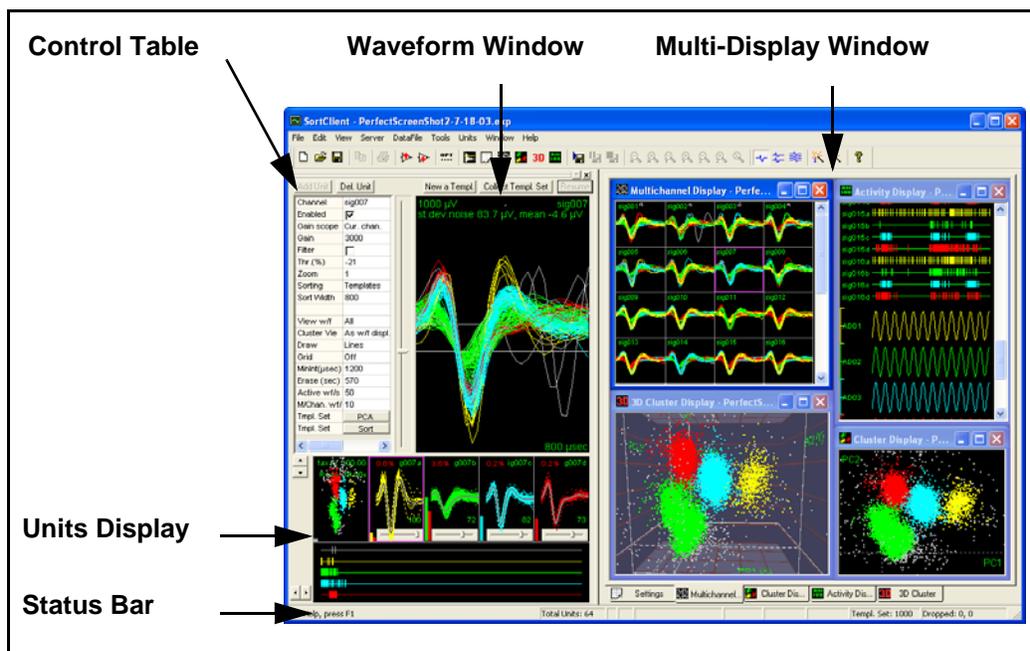
- 4 To stop recording, click the **Stop** button . Sort Client stops recording to the file, saves the file to the location specified, and removes the recording information from the status bar.

2.4 Sort Client Reference

This section contains reference information to help identify and use the items in the Sort Client interface.

2.4.1 The Sort Client Main Window

The Sort Client main window contains the following major areas.



2.4.1.1 Control Table

The Control Table contains both channel-specific and global spike sorting parameters such as the gain, filter settings, sorting mode, waveform drawing rates, etc.

2.4.1.2 Waveform Window

The Waveform Window shows the thresholded waveform segments for the selected channel.

2.4.1.3 Multi-Display Window

The Multi-Display Window can contain the following components:

- Settings Window
- Multichannel Display
- Cluster Display
- 3D Display
- Activity Display

Note: To provide a comprehensive view of the Multi-Display Window, the preceding illustration shows all the components arranged in a tiled layout. The default lay-

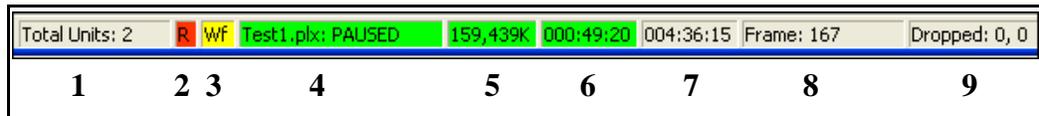
out for the Multi-Display Window is a single maximized window that displays the active windows for the tabs selected. To restore the default layout, from the **Window** menu click **Default Layout**.

2.4.1.4 Units Display

The Units Display shows the templates (average waveforms) for each sorted unit and a raster display of both the sorted and unsorted spikes on the selected channel.

2.4.1.5 Status Bar

The Status Bar includes nine fields:



- 1 **Total Units** indicates the total number of units classified for the current channel.
- 2 When recording is in progress, an **R** on a red background appears in this field.
- 3 When a recording includes waveforms, a **Wf** on a yellow background appears in this field.
- 4 This field contains the name of the file being recorded. If the recording is paused, the word **PAUSED** appears next to the file name.
- 5 This field indicates the size of the file in kilobytes (K) and updates dynamically as recording progresses.
- 6 This field shows the time accumulated while recording to file. When recording pauses, this field stops incrementing. The units are hours, minutes, and seconds.
- 7 This field shows the total elapsed time since recording started. When recording stops, this field resets to zero. The units are hours, minutes, and seconds.
- 8 **Frame** indicates the number of frames in the file. Whenever recording is paused and resumed, Sort Client creates a new frame in the file.
- 9 **Dropped** shows two counts for dropped spikes. The first count is the spikes dropped by the MAP; the second count is the spikes dropped by the PC. Whenever dropped counts occur, the background flashes red.

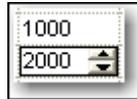
Note: The MAP can drop spikes when too many spikes occur before the host PC can read the MAP. The host PC drops spikes when it is running too slow to read all the data from the memory mapped file (MMF). This usually occurs when other processes take CPU time from Sort Client; to improve performance, end non-essential processes.

2.4.2 Typical Sort Client Interface Characteristics and Behaviors

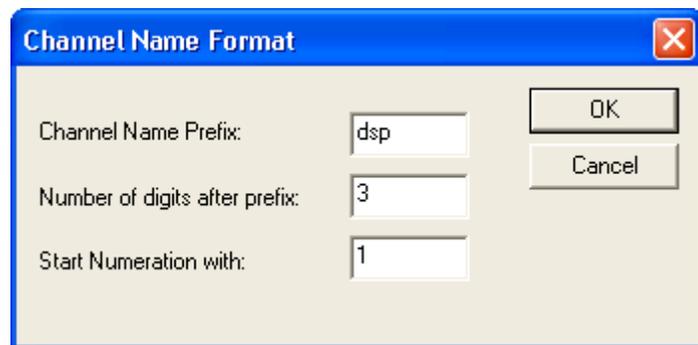
The various elements in the Sort Client interface have a common set of features and behaviors.

The following characteristics and behaviors are typical of the lists and tables in Sort Client:

- Individual cells: some cells in tables have menus or scroll arrows that appear only when the mouse is clicked in an individual cell



- Table: the user can click in the top left corner to select the entire table, or the user can select a range of cells with the mouse, and right click to open a shortcut menu with the following selections:
 - **Set all rows as the top row** sets the values in all the selected columns (except Name) of every selected row to the same values as the top row in the table
 - **Set name prefix** changes the naming assignment format in the **Name** column for each row in the table when the appropriate information is entered in the following dialog box:



- Columns: the user can click any column header to select the entire column and then right click to open a shortcut menu with one or both of the previous selections.

2.4.3 Control Table

The following illustration shows the Control Table. The Control Table always displays the information for the channel selected as the “current channel.” To select another channel as the current channel, click in the box in the second column next to **Channel** and select a channel from the drop-down menu. The other parameters in the Control Table can be changed in a similar way by clicking the appropriate box in the second column. For more information on the control-table, see “[Typical Sort Client Interface Characteristics and Behaviors](#)” on page 75.

Add Unit	Del. Unit
Channel	dsp001
Enabled	<input checked="" type="checkbox"/>
Gain scope	Cur. chan.
Gain	1000
Filter	<input type="checkbox"/>
Thr.(%)	-17
Scale (%)	100
Sorting	Templates
Sort Width	800
← Divider row	
View w/f	All
Cluster Vie	All
Draw	Lines
Grid	Off
MinInt(usec)	1000
Erase (sec)	20
Active wf/s	50
M/Chan. wf/	10
Tmpl. Set	PCA

{ **Current-Channel Parameters**
 { **Global Parameters**

The user can use the Control Table to set some parameters for the current channel only and some parameters for all channels simultaneously. The upper portion of the table includes the parameters for the current channel. The lower portion includes the parameters that apply to all channels. A blank row divides the portions.

2.4.3.1 Current-channel Settings

The following settings in the Control Table apply only to the current channel (except Gain; see [Gain scope](#) that follows). The **Channels** tab in the **Settings** window shows the changes made using the Control Table. For more information, see “[Channels](#)” on page 83.

2.4.3.1.1 Channel: The Channel setting indicates the name of the current channel.

2.4.3.1.2 Enabled: The Enabled setting indicates the state of the current channel. Click the checkbox to enable or disable the channel.

2.4.3.1.3 Gain scope: The Gain Scope controls the effect of any changes made by using the **Gain** control. If **Cur. chan.** is selected, Sort Client applies the changes in gain to the current channel only. If **Global** is selected, Sort Client applies the changes in gain to all the spike channels simultaneously.

2.4.3.1.4 Gain: The Gain setting provides a menu of selectable gain (amplification) values in increments of 1000. The range is 1000 to 32,000. For more information, see [“Gain” on page 84](#).

2.4.3.1.5 Filter: The Filter setting enables or disables the low-cut filter for removing 60 Hz noise and other low-frequency noise.

2.4.3.1.6 Thr.(%): The Threshold Percent field indicates the position of the threshold slider in the Waveform Window as a percent of window height. The range is -100% to +100%.

2.4.3.1.7 Zoom: The Zoom setting indicates the vertical scale of the Waveform Window. The range is 1 to 120. For more information, see [“Zoom” on page 84](#).

2.4.3.1.8 Sorting: The Sorting setting indicates the sorting mode. The user can select **Boxes** mode, which provides time/voltage window discriminators, or the user can select **Templates** mode, which enables the manual selection of waveforms in the Waveform Window, or the Cluster Displays, to create templates. The **Templates** mode also supports the automatic creation of templates using the Auto Configuration procedures. For more information on Auto Configuration, see [“Tools” on page 130](#).

2.4.3.1.9 Sort Width: The Sort Width setting indicates the duration of the Waveform Window for the current channel. The range is 50 to 1400 microseconds (μsec). The Template Sorting algorithm uses the Sort Width value. When Sort Width is set to a lower value, less of the waveform tail is used in template creation and sorting.

2.4.3.2 Global Settings

The following settings in the Control Table apply to all spike channels.

2.4.3.2.1 View w/f: The View Waveforms (w/f) setting provides the following menu of views for the Waveform Window:

- **All:** The All setting shows all waveforms that cross the threshold, both sorted and unsorted.
- **Unsorted:** The Unsorted setting shows only the unsorted waveforms.
- **Sorted:** The Sorted setting shows only the sorted waveforms.
- **Sel.Unit:** The Selected Unit setting shows only the unit that is selected in the Units Display (e.g. sig001b).
- **Templ.Set:** The Template Set setting shows only the collected set of waveforms that Sort Client uses to generate the templates.

2.4.3.2.2 Cluster View: The Cluster View setting provides the following menu of views for the Cluster Display:

- **All:** The All setting shows all waveforms that cross the threshold.
- **As w/f displ:** The As Waveforms Displayed setting shows only those waveforms selected for viewing with the **View w/f** parameter.

2.4.3.2.3 Draw: The Draw setting provides a choice to display digitized **Points** in the Waveform Window or to display interpolated **Lines** through the sampled points.

2.4.3.2.4 Grid: The Grid setting toggles the grid in the Waveform Window **On** or **Off**.

2.4.3.2.5 Refr ISI (μ s): The Refractory ISI setting indicates the minimum (refractory) interspike interval (ISI) in microseconds. Sort Client represents spikes with interspike intervals less than the Refr ISI setting with red activity level bars to the left of the templates in the Units Display. The percentage of spikes with interspike intervals less than the Refr ISI setting appears in red in the upper left-hand corner of each sorted unit in the Units Display. The range is 100 to 10 000 microseconds.

2.4.3.2.6 Erase (sec): The Erase setting is the time interval at which the waveforms are erased in the Waveform Window, Units Display, Multichannel Display, and Cluster Display. The range is 5 to 10 000 seconds.

2.4.3.2.7 Active wf/s: For the current channel, the Active Waveforms-per-second (wf/s) setting indicates the maximum number of waveforms drawn per second in the Waveform Window and the Units Display.

Note: One second of time is divided into ten 100-msec bins for drawing purposes.

2.4.3.2.8 M/Chan. wf/s: For all channels except the current channel, the Multichannel Waveforms-per-second setting indicates the maximum number of waveforms drawn per second for each channel in the Multichannel Display.

2.4.3.2.9 Tmpl. Set-PCA: The Template Set PCA button performs PCA calculations on the waveforms in the Collected Template Set and shows the results in the Cluster Display and the 3D Cluster Display.

2.4.3.2.10 Tmpl. Set-Sort: The Template Set Sort button performs template sorting on the Collected Template Set using the current template tolerance values, which are set using the sliding adjustment bars in the Units Display. Use this feature to check actual template sorting of the Collected Template Set using specific tolerance values before resuming data acquisition.

2.4.3.2.11 Parzen Mult.: The Parzen Multiplier controls automatic sorting. The larger the number, the fewer units will be created by the automatic sorting routine. Generally values in the 0.6 – 1.0 range produce the best sorting results. For more information on the Auto Sort parameters, see [“Auto Sort Algorithm” on page 132](#). After setting a new value, pressing the ‘AutoSort’ button on the next line will perform the automatic sorting with the new value.



HINT

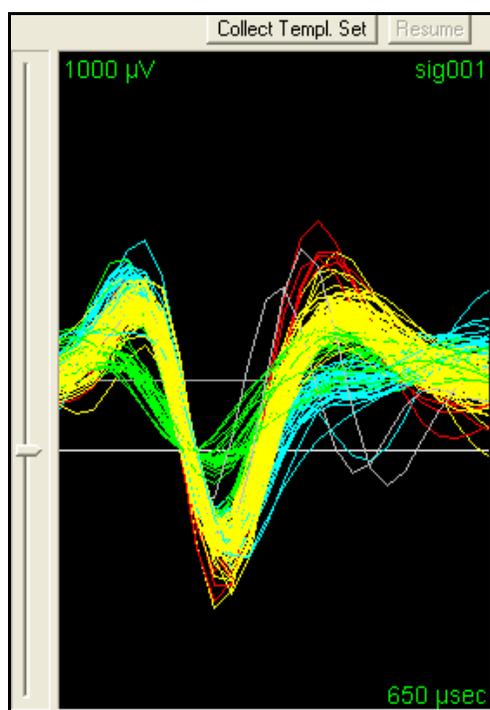
Changing the Parzen Multiplier

To change the Parzen Multiplier and quickly resort the current channel, hold down the Alt key while clicking the up or down arrows in the spin box for the Parzen Multiplier. The channel is resorted after each click.

2.4.3.2.12 Tmpl. Set – AutoSort: will perform an automatic sort on the current channel, which will destroy all existing units and create new ones. The current value of the Parzen Multiplier is used.

2.4.4 Waveform Window

The Waveform Window displays the waveforms for the current channel. The following illustration shows the Waveform Window display with superimposed sorted waveforms aligned at the threshold crossing times.



The threshold level can be changed by dragging the slider to a new position. Any changes made with the slider are reflected directly in the **Thr. (%)** setting in the Control Table.

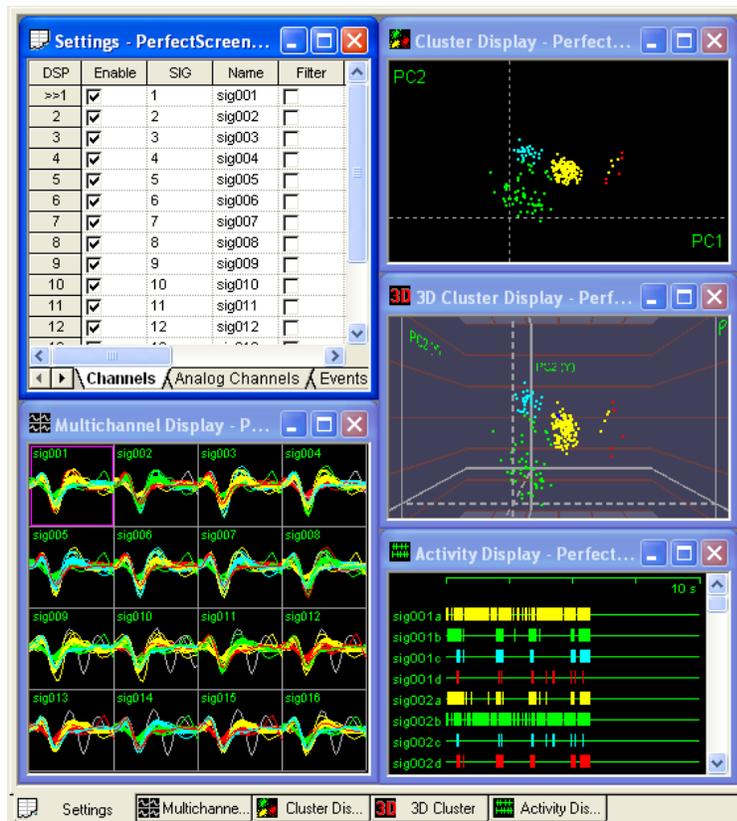
2.4.5 Multi-Display Window

The Multi-Display window contains the following components:

- Settings Window

- Multichannel Display
- Cluster Display
- 3D Cluster Display
- Activity Display

The user can position the window components in cascaded or tiled arrangements. The user can also access each component of the display by selecting the tabs at the bottom of the Multi-Display Window. The following illustration shows a tiled arrangement of the Multi-Display Window.



To open the displays click the icons on the tool bar or select the items on the **View** menu. Descriptions of the components and their tool-bar icons follow.

Note: For a description of the many mouse-key capabilities available in the Multi-Display Window, from the main menu click **Help** and select **Quick Reference**, or see “Quick Reference” on page 135.

2.4.5.1 Settings Window

The Settings window contains the following controls:

- Global sorting parameters such as the waveform length and template adjustment rates

-
- Channel-specific sorting parameters such as gain, filtering, channel name, etc.
 - Event channels
 - Continuous channels
 - Spike counts and event counts

For more information, see [“Settings Window” on page 82](#).

2.4.5.2 Multichannel Display

The Multichannel Display simultaneously shows the waveforms on all spike channels. The user can select individual channels for viewing in the Window and Units Displays by clicking on a channel box in the Multichannel Display.

For more information, see [“Multichannel Display” on page 92](#).

2.4.5.3 Cluster Display

The Cluster Display shows the waveforms as points in feature space (principal component space). The user can zoom and rotate the Cluster Display to obtain maximum visual separation of the clusters. Then the user can select waveform clusters (units) to generate templates for spike sorting.

For more information, see [“Cluster Display” on page 93](#).

2.4.5.4 3D Cluster Display

The 3D Cluster Display shows the waveforms as points in three-dimensional feature space (principal component space). The user can select waveform clusters (units) in the 3D Cluster Display by zooming and rotating the 3D view to display maximal separation of the clusters.

For more information, see [“3D Cluster Display” on page 95](#).

2.4.5.5 Activity Display

The Activity Display shows the activity on each spike channel as tick marks on a timeline. The user can also view continuous channels. The user can increase or decrease the time span of the display.

For more information, see [“Activity Display” on page 99](#).

2.4.5.6 Trodal Peak/Valley Display

The Trodal Peak/Valley Display is only relevant when the Data Mode is set to Stereotrode or Tetrode. In Tetrode mode, the Trodal Peak/Valley Display shows 2D cluster plots of peak heights (or valley depths) between all 6 permutations of electrodes within the tetrode. For example, when the display is set to show peak heights, the 6 plots will be Peak of Electrode 1 vs Peak of Electrode 2, Peak of Electrode 1 vs. Peak of Electrode 3, ..., Peak of Electrode 3 vs Peak of Electrode 4. In stereotrode mode, the Trodal Peak/Valley Display will show the single permutation of Peak or Valley of Electrode 1 vs Peak or Valley of Electrode 2.

For more information, see ‘Trodal Peak/Valley Display’ on page X-XX

2.4.6 Settings Window

To open the Settings Window, from the **View** menu, click **Settings Window**, or click the Settings Window button on the toolbar:



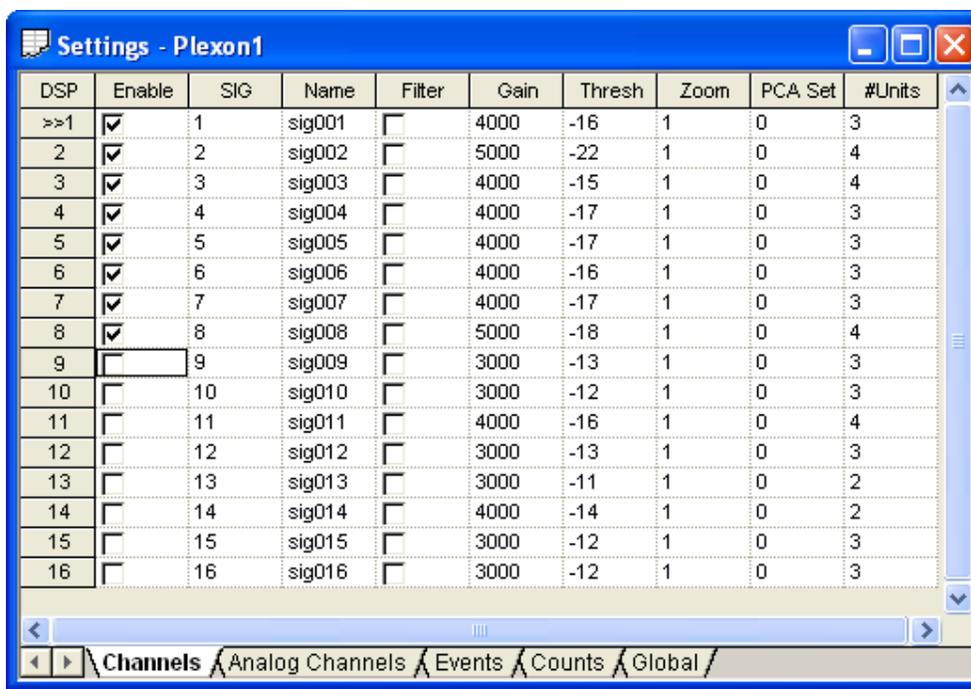
The Settings window includes tabs for the following tables:

- Channels
- Continuous Channels
- Events
- Counts
- Global

Descriptions follow for each of these tabs.

2.4.6.1 Channels

The following illustration shows the **Settings** window with the **Channels** tab selected. The user can use the settings in the Channels table to make changes to a single channel, multiple channels, or all channels simultaneously.



DSP	Enable	SIG	Name	Filter	Gain	Thresh	Zoom	PCA Set	#Units
>>1	<input checked="" type="checkbox"/>	1	sig001	<input type="checkbox"/>	4000	-16	1	0	3
2	<input checked="" type="checkbox"/>	2	sig002	<input type="checkbox"/>	5000	-22	1	0	4
3	<input checked="" type="checkbox"/>	3	sig003	<input type="checkbox"/>	4000	-15	1	0	4
4	<input checked="" type="checkbox"/>	4	sig004	<input type="checkbox"/>	4000	-17	1	0	3
5	<input checked="" type="checkbox"/>	5	sig005	<input type="checkbox"/>	4000	-17	1	0	3
6	<input checked="" type="checkbox"/>	6	sig006	<input type="checkbox"/>	4000	-16	1	0	3
7	<input checked="" type="checkbox"/>	7	sig007	<input type="checkbox"/>	4000	-17	1	0	3
8	<input checked="" type="checkbox"/>	8	sig008	<input type="checkbox"/>	5000	-18	1	0	4
9	<input type="checkbox"/>	9	sig009	<input type="checkbox"/>	3000	-13	1	0	3
10	<input type="checkbox"/>	10	sig010	<input type="checkbox"/>	3000	-12	1	0	3
11	<input type="checkbox"/>	11	sig011	<input type="checkbox"/>	4000	-16	1	0	4
12	<input type="checkbox"/>	12	sig012	<input type="checkbox"/>	3000	-13	1	0	3
13	<input type="checkbox"/>	13	sig013	<input type="checkbox"/>	3000	-11	1	0	2
14	<input type="checkbox"/>	14	sig014	<input type="checkbox"/>	4000	-14	1	0	2
15	<input type="checkbox"/>	15	sig015	<input type="checkbox"/>	3000	-12	1	0	3
16	<input type="checkbox"/>	16	sig016	<input type="checkbox"/>	3000	-12	1	0	3

The Channels list includes the following items:

2.4.6.1.1 DSP: The DSP column indicates the digital signal processor (DSP) channel number.

2.4.6.1.2 Enable: The Enable column indicates the state of each channel. To enable a channel, click the checkbox. To disable a channel, click to clear the checkbox.

2.4.6.1.3 SIG: The SIG column lists the signal (SIG) channel number. The DSP and SIG values are identical, unless there are unequal quantities of SIG and DSP channels and a SWH (switch) board in the MAP is being used.

2.4.6.1.4 Name: The Name column lists the name assigned to each channel. The Name field can be up to 30 alphanumeric characters.

2.4.6.1.5 Filter: The Filter column indicates the state of a low-cut filter in the SIG board, which can be used to remove 60 Hz noise. For all MAP systems produced since 2003, the filter is a 250 Hz, 2-pole, low-cut filter. Click the checkbox to toggle the filter on or off.

2.4.6.1.6 Gain: The Gain column lists the gain setting for each channel. To change the gain, click a **Gain** field to open a menu. Changes in gain apply to the analog amplification of the signal before it enters the analog-to-digital converter on the SIG board in the MAP, whereas a change in **Zoom** (see later in this section) changes only the Waveform Window view of the signal. Both gain and zoom change the voltage range displayed in the top left corner of the Waveform Window; if **Grid** in the Control Table is set to **On**, the grid spacing also changes. The Gain setting range is 1000 to 32,000 in multiples of 1000.

2.4.6.1.7 Thresh: The Threshold column indicates the setting of the threshold level for each channel. The range is -100 to +100.

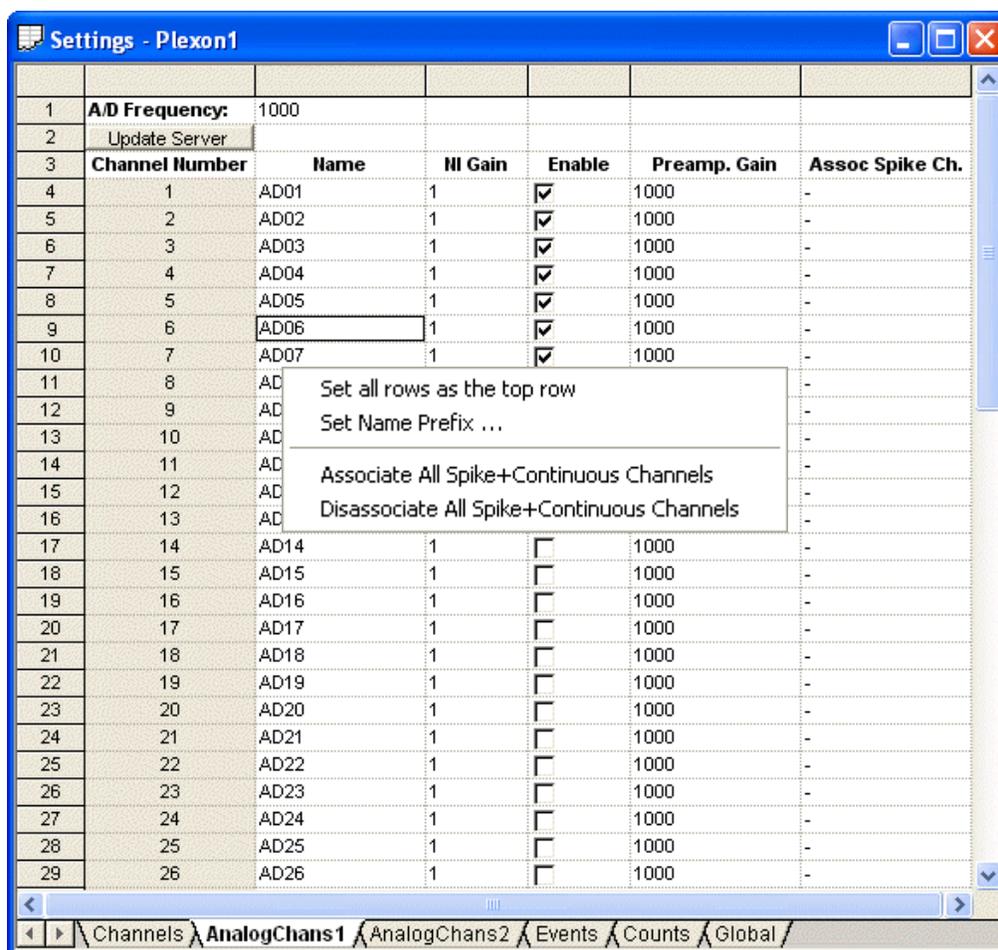
2.4.6.1.8 Zoom: The Zoom column indicates the vertical scale factor of the Waveform Window view for each channel. A change in zoom does not change the electrical amplification of the signal, whereas a change in **Gain** (see earlier in this section) does amplify the signal. The Zoom range is 0.5 to 100. For information on setting the Zoom menu-arrow increments, see “Zoom control steps ...” on [page 118](#).

2.4.6.1.9 PCA Set: After a template set has been collected, the PCA Set column indicates the number of waveforms in the template set for the channel.

2.4.6.1.10 #Units: After sorting has been completed, the #Units column indicates the number of neural units identified on the channel.

2.4.6.2 Continuous Channels

The following illustration shows the Settings window with the **AnalogChans1** tab selected and the shortcut menu open. If there should be more than one NI DAQ device installed, an analog channel tab appears for each device as shown in the following illustration.



Note: If only one NI DAQ device is installed and configured, the Settings window shows only the **Analog Channels** tab. The entries in the tables are the same for each channel tab.

2.4.6.2.1 A/D Frequency: The A/D Frequency setting is the per-channel sampling rate of the National Instruments (NI) data acquisition (DAQ) analog-to-digital (A/D) converter. The TIM board can have a sub-board installed that provides an 80-kHz clock signal. If an optional sub-board is installed, a 9-pin sub-board connector is located on the faceplate above the standard TIM-board 36-pin connector. Without a TIM sub-board, the NI DAQ devices receive a 40-kHz clock signal from the MAP. The 40-kHz clock signal can be divided by an integer value equal to or greater than two. This results in an input range for the A/D Frequency (sampling rate) of 100 to 20 000. The default value is 1000.

Note: For more than one NI DAQ device installed, each analog-channel tab represents a NI DAQ device. For an installed TIM sub-board, all NI DAQ devices can run at a rate up to the fast rate of 40 kHz. For a slower (e.g. 1 kHz) rate for any device, that rate must be applied to all other slow devices. Only two rates are simultaneously available: the fast rate (40 kHz or 20 kHz) and a desired slow rate (1 kHz or 4 kHz or 8 kHz or ...). Any device can run at either the fast or the slow rate. For example, for a four-device setup:

Acceptable (only 2 rates)	Unacceptable (3 rates)	Acceptable without TIM mezzanine
Device 1: 1 kHz	Device 1: 1 kHz	Device 1: 8 kHz
Device 2: 1 kHz	Device 2: 2 kHz	Device 2: 8 kHz
Device 3: 40 kHz	Device 3: 2 kHz	Device 3: 20 kHz
Device 4: 40 kHz	Device 4: 40 kHz	Device 4: 20 kHz

2.4.6.2.2 Update Server: To change any settings in the Analog Channels table or tables, click the **Update Server** button to make the changes take effect in the NI DAQ device.

Note: If there are multiple analog channel tabs, separately click **Update Server** on each tab to make the changes take effect.

2.4.6.2.3 Channel Number: The Channel Number column shows the fixed number assigned to each continuous channel.

2.4.6.2.4 Name: The Name column shows the default name assigned to the channel by Sort Client. Any channel may be renamed. The name can be up to 30 alphanumeric characters.

2.4.6.2.5 NI Gain: The NI Gain column shows the analog gain setting on the NI-DAQ device in the PC. The following gain settings can be set: 1, 2, 5, 10, 20, 50, and 100.

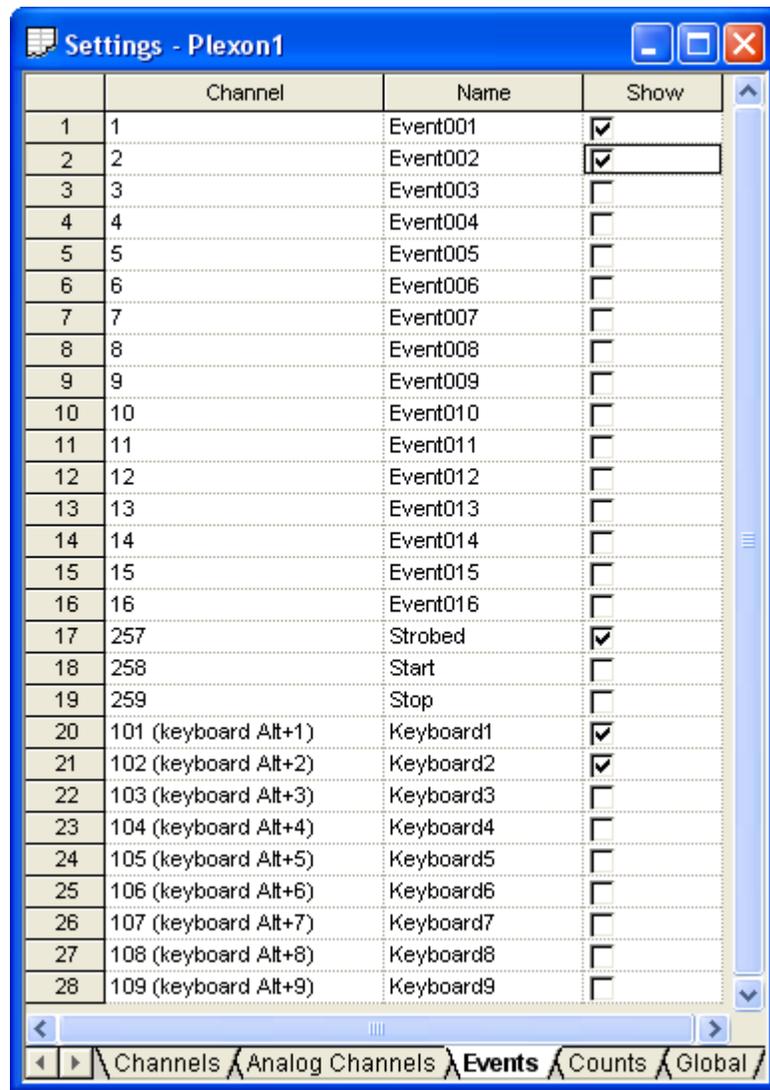
2.4.6.2.6 Enable: The Enable column indicates the state of each channel. Click the checkbox in the **Enable** column to enable a channel. All enabled channels appear as continuous traces in the Activity display. Enabled channels are also recorded as blocks of Type 5 (continuous data) in the PLX file. Enabling too many channels can affect performance; see [“CPU-Intensive Functions” on page 101](#).

2.4.6.2.7 Preamp Gain: The Pre-amplifier Gain column indicates a fixed value set in the preamp hardware (a combination of the headstage gain multiplied by the PBX gain). The default value provided by Sort Client is 1000. For a preamp that has a different fixed gain, to ensure accurate results enter that value in the analog channel table or tables. However, the values entered in the table *do not* control the preamp.

2.4.6.2.8 Assoc Spike Ch. The Associated Spike Channels column indicates the spike channels that have been associated with the continuous channels. This column appears if there are enabled channel associations and **Associate All Spike+Continuous Channels** has been selected from the shortcut menu. Sort Client saves the associations in the PLX file. To enable channel associations, see “Allow Association of Spike and Continuous Channels” on [page 118](#).

2.4.6.3 Events

The following illustration shows the Settings window with the **Events** tab selected.



2.4.6.3.1 Channel: The Channel column indicates the channel number, which is fixed and assigned by Sort Client.

2.4.6.3.2 Name: The Name column indicates the default names that Sort Client assigns to each channel. Change these names by typing new names.

2.4.6.3.3 Show: Click the checkbox in the **Show** column to make a channel appear in the Activity Display. For an example of the Activity Display for an event, see “[Activity Display](#)” on page 99.

Note: All Events Are Recorded: Sort Client records events regardless of whether they are shown in the Activity Display.

2.4.6.4 Counts

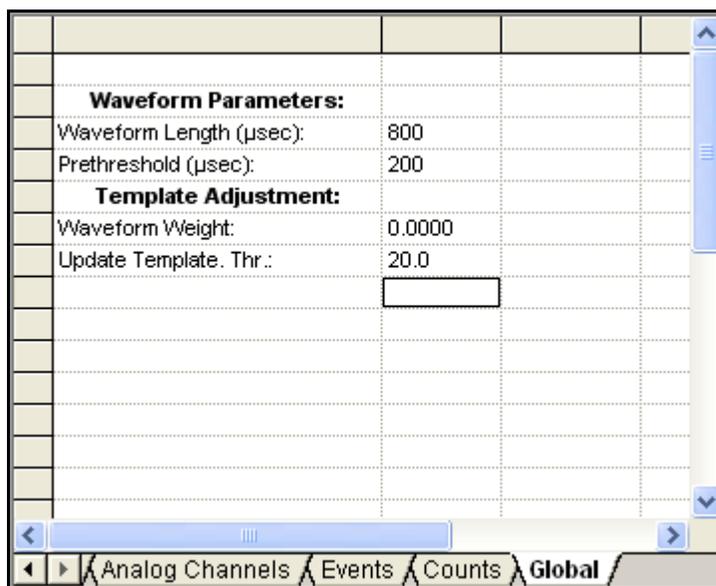
After recording starts, Sort Client maintains a count of timestamps and events on each channel. Sort Client automatically adds enabled channels (timestamps or events) and count values to the Counts table when recording starts. With the **Counts** tab selected, the following illustration shows the contents of the Settings window after a recording session.

	Variable	Count
36	sig009d	216
37	sig010a	1460
38	sig010b	832
39	sig010c	1056
40	sig010d	1183
41	sig011a	1856
42	sig011b	1390
43	sig011c	220
44	sig011d	1057
45	sig012a	1398
46	sig012b	1054
47	sig012c	226
48	sig012d	1916
49	sig013a	1400
50	sig013b	215
51	sig013c	1068
52	sig013d	1937
53	sig014a	218
54	sig014b	1894
55	sig014c	1392
56	sig014d	1063
57	sig015a	1395
58	sig015b	219
59	sig015c	1057
60	sig015d	1915
61	sig016a	1460
62	sig016b	785
63	sig016c	1058
64	sig016d	1174
65	Keyboard1	0
66	Keyboard2	2

00:00:49 000:00:49 Frame: 1 Dropped: 0, 0

2.4.6.5 Global

Global settings affect the way Sort Client captures and sorts waveforms. Waveform Parameters define the length of waveform segments. Template Adjustment affects how the adaptive template algorithm works to dynamically update the Sort Client templates. These parameters apply identically to all spike channels. The following illustration shows the Settings window with the **Global** tab selected.



2.4.6.5.1 Waveform Parameters: Two parameters control the length of the captured waveform segments and affect the display in the Waveform Window:

- **Waveform length (µsec)** sets the spike-capture width of the Waveform Window. The range is 50 to 1400 microseconds (µsec).
- **Prethreshold (µsec)** is the pre-threshold interval that precedes the spike threshold crossing point. The range is 0 (zero) to 600 microseconds (µsec). The pre-threshold value is included in the waveform length, that is, if the pre-threshold value is changed, do not change the overall width of the capture window.

Note: For an illustration of these settings, see [“Set the Window Width and Pre-threshold Time”](#) on page 54.

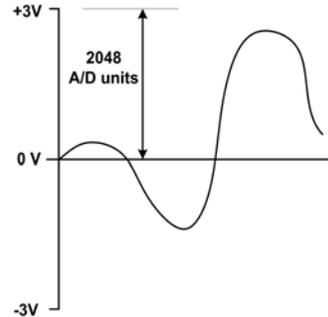
2.4.6.5.2 Template Adjustment: Sort Client templates can adapt to the incoming waveforms. Two parameters control the adaptive template adjustment. See the description of the adaptive template algorithm that follows to understand how the following parameters affect templates.

- **Waveform Weight** is the multiplier applied to incoming waveforms that Sort Client uses to create a temporary template. The range is 0 (zero) to 1. Zero (0) disables template adjustment. In the following algorithm, the waveform weight is represented by W .

- **Update Template Thr.** is the threshold value that must be exceeded to update the template. The range is 0 (zero) to 2048. In the following algorithm, the update-template threshold is represented by T .

The template adjustment works only if the **Waveform Weight** is set to a value greater than ($>$) 0. Let N be the number of points in the waveform, W be the **Waveform Weight** and T be the update threshold. All the template and waveform values are in raw A/D converter units, i.e. they are integers from -2048 to +2047 for a 12-bit conversion. Since the zero-to-peak voltage range is 3V, the magnitude of the input signal (in mV) in terms of AD units is

$$\left(\frac{3000 \cdot ADunits}{2048 \cdot TotalGain} \right)$$



If

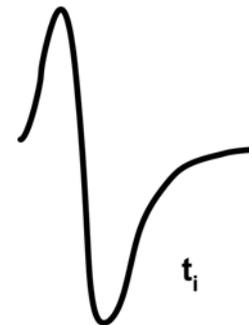
$$t_i, i = 1, \dots, N, \text{ where } N \text{ is the number of points in the waveform,}$$

then t_i the template currently used for sorting. Then, when the template adjustment is enabled, Sort Client creates (for each unit on each channel, for example: DS027b) a temporary template

$$s_i, i = 1, \dots, N$$

and sets it equal to t :

$$s_i = t_i, i = 1, \dots, N$$



Then, when Sort Client receives the waveform

$$w_i, i = 1, \dots, N$$

it updates s using the following formula:

$$s_i = s_i \cdot (1 - W) + t_i \cdot W, i = 1, \dots, N$$

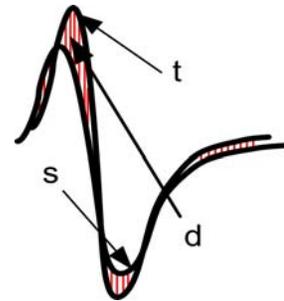


for example, if $W = 0.1$

$$s_i = s_i \cdot (1 - 0.1) + t_i \cdot 0.1$$

and compares the updated (temporary) template s with the original template t :

$$d = \sqrt{\frac{1}{M} \sum_{i=1}^M (s_i - t_i)^2}$$



where M is the sort width for the current channel in data points:

$$M = \frac{\text{SortWidth(usec)}}{\Delta t}$$

where $\Delta t = \frac{1}{\text{DigitizingFrequency}}$

If

$$d > T,$$

then Sort Client makes s the new template for the current channel and unit:

$$t_i = s_i, i = 1, \dots, N$$

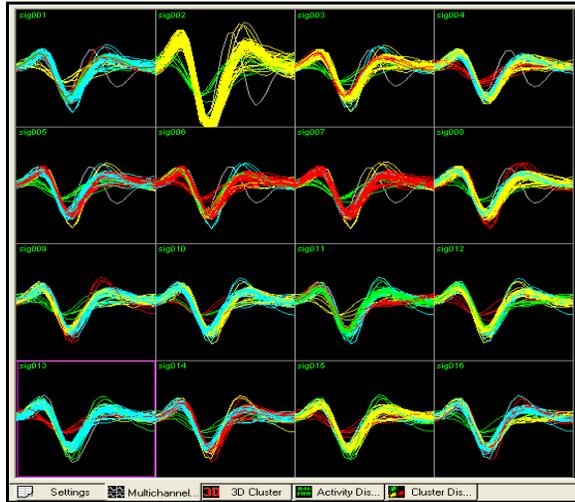
Note: Sort Client uses only sorted waveforms to separately update the adaptive templates for each unit on each channel. Unsorted units have no effect on any adaptive template whatsoever.

Note: The value d represents the difference required to adjust the sorting template. If d exceeds the value entered for T in the **Update Template Thr.** field, Sort Client replaces the current sorting template with the temporary template. For example, entering 20 represents a difference of $(20/2048) = 1\%$ in A/D units. The value W in the **Waveform Weight** field represents how fast Sort Client

updates the temporary template (tracks incoming changes). Plexon recommends an initial entry of 0.01.

2.4.6.6 Multichannel Display

To open the Multichannel Display, from the **View** menu, click **Multichannel Display**, or click the Multichannel Display button on the toolbar.



The illustration shows the Multi-Display Window with the **Multichannel Display** tab selected.

Note: When clicking a channel in the Multichannel Display, Sort Client places a pink box around it. Sort Client also directs the MAP to send a pulse to the EVT connector on the TIM board whenever any unit on that channel fires.

The accompanying illustration shows the menu that appears when right-clicking in the Multichannel Display.

2.4.6.6.1 Erase: After a channel is selected, **Erase** clears the display for that channel only.

2.4.6.6.2 Enabled: After a channel is selected, the waveforms on that channel appear in the Multichannel Display when **Enabled** is checked. Otherwise, the channel appears as an “X” in the Multichannel Display.

Erase	
<input checked="" type="checkbox"/> Enabled	
Number of Columns	▶
Number of Visible Rows	▶
Channels In Columns	
<input checked="" type="checkbox"/> Channels In Rows	4
<input checked="" type="checkbox"/> Draw All Waveforms	8
Draw Sorted Waveforms	10
	12
	14
	16

2.4.6.6.3 Number of Columns: This item opens a menu where the number of columns that appear in the Multichannel Display may be selected.

2.4.6.6.4 Number of Visible Rows: This item opens a menu where the number of rows that appear in the Multichannel Display may be selected.

2.4.6.6.5 Channels in Columns: This item displays channels in order from top to bottom.

2.4.6.6.6 Channels in Rows: This item displays channels in order from left to right. For example, the previous illustration shows the channels displayed in numerically-ordered rows from the top left corner.

2.4.6.6.7 Draw All Waveforms: This item displays all waveforms in the Multi-channel Display.

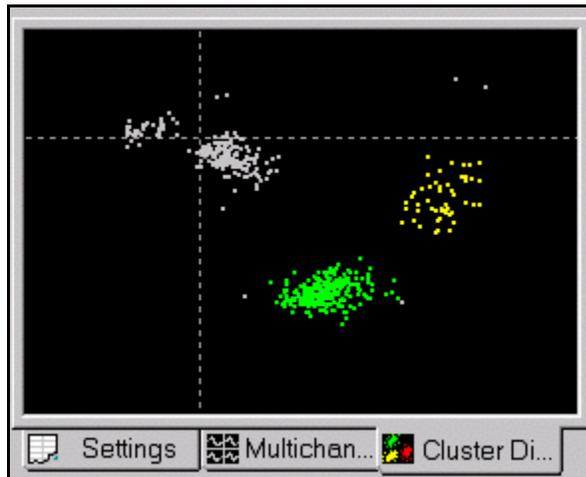
2.4.6.6.8 Draw Sorted Waveforms: This item displays only sorted waveforms in the Multichannel Display.

2.4.7 Cluster Display

To open the Cluster Display, from the **View** menu, click **Cluster Display**, or click the Cluster Display button on the toolbar.



The following illustration shows the Multi-Display Window with the **Cluster Display** tab selected.

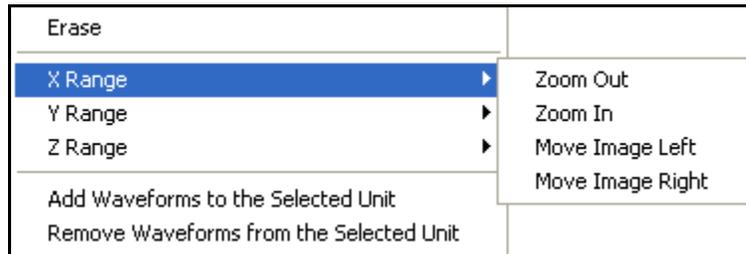


The keyboard commands in the following table control the view shown in the Cluster display. To see a quick reference to the following commands, from the main menu click **Help** and select **Quick Reference**.

Table 1: Cluster Display Mouse and Keyboard Commands

Key & Mouse Commands	Effect on Cluster Display
Right-Click, Drag	Zoom viewpoint in or out
SHIFT+Left-Click, Drag	Move the “Look-At” point in the plane of the screen
SHIFT+Right-Click, Drag	Zoom in or out on the Y axis
ALT+Right-Click	Open a menu
n	Next channel
p	Previous channel

The following illustration shows the menu that appears when the menu command (ALT+Right-Click) in the Cluster Display is used.



Note: Because the Cluster Display has only two axes, the Z-range menu is not available.

2.4.7.1 Erase

Erase clears the display.

2.4.7.2 X Range

The X-range menu consists of the following items:

- **Zoom Out** moves the data points away from the user along the X axis.
- **Zoom In** moves the data points toward the user along the Y axis.
- **Move Image Left** moves the data points to the left.
- **Move Image Right** moves the data points to the right.

2.4.7.3 Y Range

The Y-range menu consists of the following items:

- **Zoom Out** moves the data points away from the user along the Y axis.
- **Zoom In** moves the data points toward the user along the Y axis.
- **Move Image Up** moves the data points up.
- **Move Image Down** moves the data points down.

2.4.7.4 Z Range

The Z Range menu is unavailable with the 2D Cluster Display.

2.4.7.5 Add Waveforms to the Selected Unit

This item changes the mouse pointer to the accompanying shape (blue) to enable selection of one or more waveforms to add to the selected unit.



2.4.7.6 Remove Waveforms from the Selected Unit

This item changes the mouse pointer to the accompanying shape (red) to enable selection of one or more waveforms to remove from the selected unit.



2.4.8 3D Cluster Display

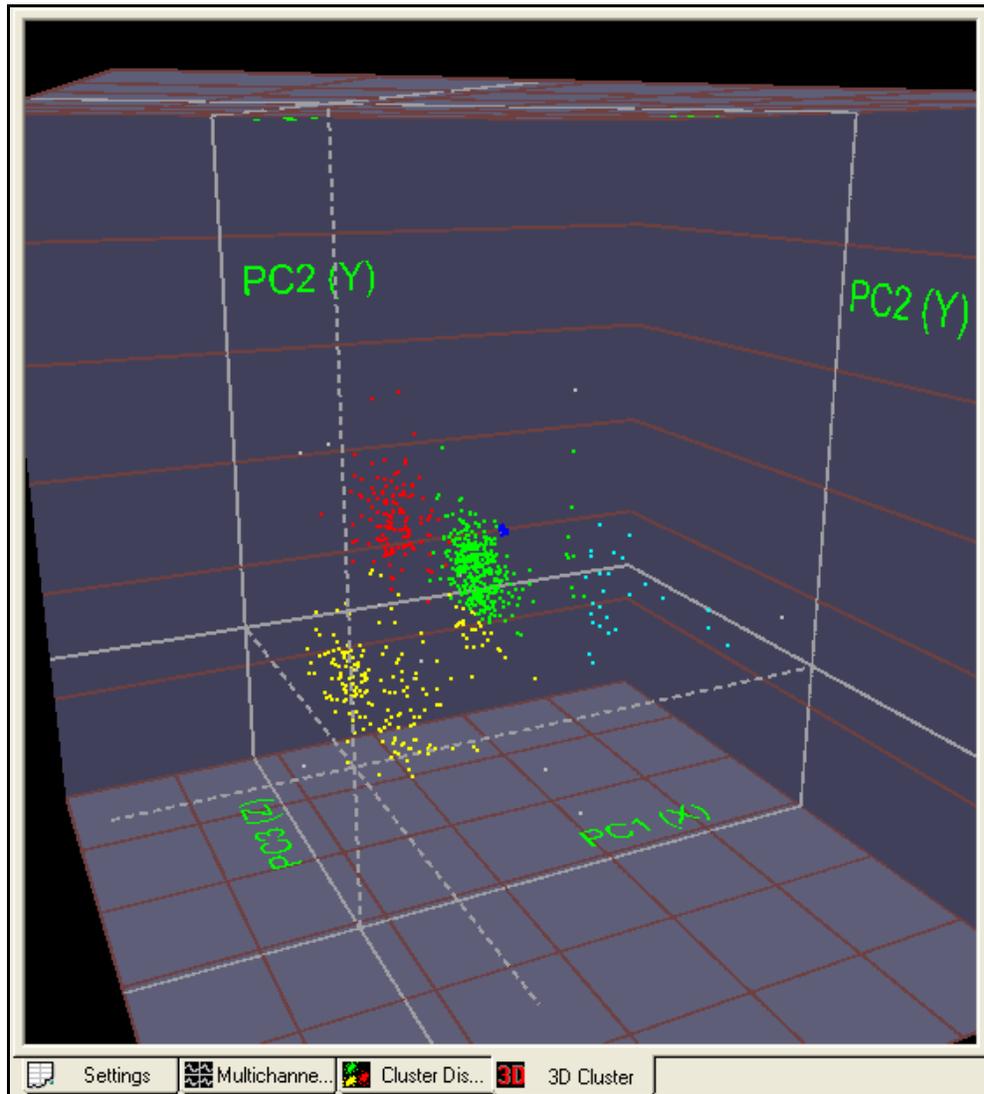
To open the 3D Cluster Display, from the **View** menu, click **3D Cluster Display**, or click the 3D Cluster Display button on the toolbar.



Sort Client provides the 3D Cluster display in addition to the Cluster Display (2D) that opens when the **PCA** button is clicked. The third (Z) axis on the 3D Cluster display is the projection onto the 3rd principal component (PC3).

To select units in the 3D Cluster display, zoom, or rotate the 3D viewpoint to display maximal cluster separation and then draw contours in screen space around the clusters. Optimize unit selection by repeatedly rotating the display to get the tightest concentration for each unit cluster and then drawing its contour. To achieve the tightest concentration for a unit by rotating the display until the view is looking along the axis of a virtual cylinder that encompasses the maximum number of points for that unit.

The following illustration shows the Multi-Display Window with the **3D Cluster** tab selected.



See the following table for a list of the 3D Cluster mouse and keyboard commands. To see a complete list of the mouse and keyboard commands, click **Help** and select **Quick Reference**. The 3D Cluster display is similar to the 3D display in Plexon [Offline Sorter](#) data analysis software.

Table 2: 3D Cluster Display Mouse and Keyboard Commands

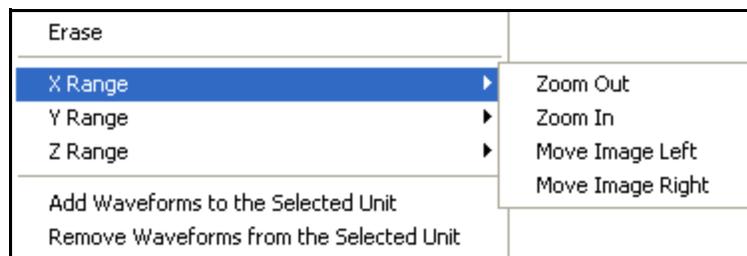
Key & Mouse Commands	Effect on 3D Clusters Display
Left-Click, Drag	Rotate 3D viewpoint
Right-Click, Drag	Zoom 3D viewpoint in or out

Table 2: 3D Cluster Display Mouse and Keyboard Commands (Continued)

Key & Mouse Commands	Effect on 3D Clusters Display
SHIFT+Left-Click, Drag	Move the Look-At point in the plane of the screen
SHIFT+Right-Click, Drag	Move the Look-At point towards or away from the eye location
CTRL+Left-Click, Drag	Start drawing contour for new unit (contour sorting only)
ALT+Left-Click	Select nearest point when viewing a template set
ALT+Right-Click	Opens a menu
a	Toggles animated rotation mode
c	Move Look-At point to center of mass of next cluster
e or Spacebar	Erases display
n	Next channel
p	Previous channel

Note: For the 3D Cluster display, Plexon recommends a graphics card with hardware-accelerated 3D graphics and OpenGL drivers. Earlier graphics cards can generate the 3D Cluster display extremely slowly, which makes the display unusable—this can also adversely affect data acquisition by using too much CPU time. If the display is slow, do not use the 3D Cluster display.

The following illustration shows the menu that appears when the menu command (ALT+Right-Click) in the 3D Cluster display is used.



2.4.8.1 Erase

This item clears the display.

Note: The following range descriptions are based on an “unrotated” view where the X range represents the width of the screen, the Y range represents the height, and the Z range represents the depth.

2.4.8.2 X Range

The X-range menu consists of the following items:

- **Zoom Out** moves the data points away from the user along the X axis.
- **Zoom In** moves the data points toward the user along the X axis.
- **Move Image Left** moves the center of the image to the left.
- **Move Image Right** moves the center of the image to the right.

2.4.8.3 Y Range

The Y-range menu consists of the following items:

- **Zoom Out** moves the data points away from the user along the Y axis.
- **Zoom In** moves the data points toward the user along the Y axis.
- **Move Image Up** moves the center of the image up.
- **Move Image Down** moves the center of the image down.

2.4.8.4 Z Range

The Z-range menu consists of the following items:

- **Zoom Out** moves the data points away from the user along the Z axis.
- **Zoom In** moves the data points toward the user along the Z axis.
- **Move Image Away** moves the center of the image away from the user along the Z axis.
- **Move Image Closer** moves the center of the image toward the user along the Z axis.

2.4.8.5 Add Waveforms to the Selected Unit

This item changes the mouse pointer to the following shape (blue) to enable selection of one or more waveforms to add to the selected unit.



2.4.8.6 Remove Waveforms from the Selected Unit

This item changes the mouse pointer to the following shape (red) to enable selection of one or more waveforms to remove from the selected unit.

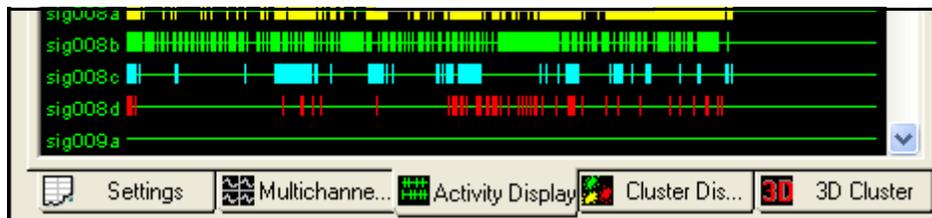


2.4.9 Activity Display

To open the **Activity Display** window, from the **View** menu, click **Activity Display**, or click the Activity Display button on the toolbar.



The following illustration shows the Multi-Display Window with the **Activity Display** tab selected.



This menu appears when right-clicking in the Activity Display.

2.4.9.1 Erase

This item clears the display.

2.4.9.2 Increase Time Span

Each time this item is clicked, Sort Client increments the time span by 10 seconds. The time span is shown in the top right corner of the display.

2.4.9.3 Decrease Time Span

Each time this item is clicked, Sort Client decrements the time span by 10 seconds. The time span is shown in the top right corner of the display.

2.4.9.4 Increase Amplitude Zoom for Analog Channels:

If analog channels are selected for display, selecting this will increase the zoom factor for displaying them, making the waveforms appear larger. Pressing the 'Zoom In Y' toolbar button performs the same function.



2.4.9.5 Decrease Amplitude Zoom for Analog Channels:

If analog channels are selected for display, selecting this will decrease the zoom factor for displaying them, making the waveforms appear smaller. Pressing the 'Zoom Out Y' toolbar button performs the same function.

2.4.9.6 Reset:

resets both the time span and the analog channel zoom factor to the default. Pressing the 'Reset Zoom' toolbar button performs the same function.

2.4.9.7 Show More Channels :

shows more channels in the Activity Display (without scrolling) by showing each channel in a smaller amount of vertical space, thus crowding them together. Pressing the 'o' key performs the same function.

2.4.9.8 Show Fewer Channels :

shows fewer channels in the Activity Display by showing each channel in a larger amount of vertical space, thus spreading them apart vertically. Pressing the 'i' key performs the same function.

2.4.9.9 Fit All Channels On Screen:

adjusts the amount of vertical space allocated for the display of each channel so that all channels fit without scrolling.

2.4.9.10 Always Fit All Channels On Screen:

same as above, except each time the Activity Display is resized, or units are added/removed, the display will again be automatically adjusted so that all channels are displayed without scrolling.

2.4.9.11 Only Show the Current Channel:

When this is selected, the Activity Display will only show the units from the current selected spike channel, along with any analog channels that are associated with the spike channel.

2.4.9.12 High Quality Display of Analog Channels:

toggles the high-quality display of the analog channels. This display mode can be expensive when many analog channels are being displayed.

2.4.9.13 Highlight Current Channel:

when selected, will draw a selection box around the time lines for the units belonging to the current spike channel. If analog channels are associated with the current spike channel, they are also highlighted.

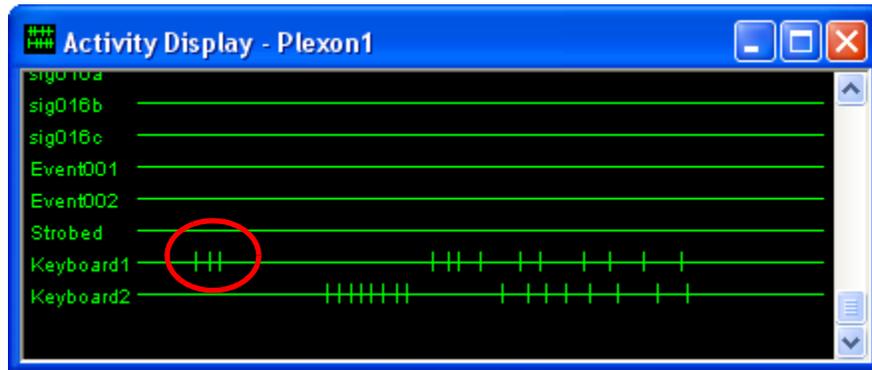
2.4.9.14 Show Guide/Zero Line:

when selected, draws a horizontal line for each line of ticks, and a line representing zero amplitude for the analog channels.

2.4.9.15 Show Amplitude Scale for Analog Channels:

when selected, a scale denoting the amplitude on the left side of each analog channel trace.

The illustration that follows is an example of the Activity Display for event channels. The event channels in this illustration are those selected in the “Show” column on [page 26](#). Events appear as vertical bars or “ticks” on a time line.



To show Event channels in the Activity Display

- For each event channel that should appear in the Activity Display window, in the **Settings** window, click the checkbox in the **Show** column. Select each channel individually. The “Set all rows as the top row” feature is not available for Events.

To show Strobed events in the Activity Display

- In the **Settings** window, click the checkbox in the **Show** column next to Channel **257 (Strobed)**.

Note: It is not necessary to show events in the Activity Display to save them to disk. Sort Client saves *all* event data, even if the event channel does not show in the Activity Display.

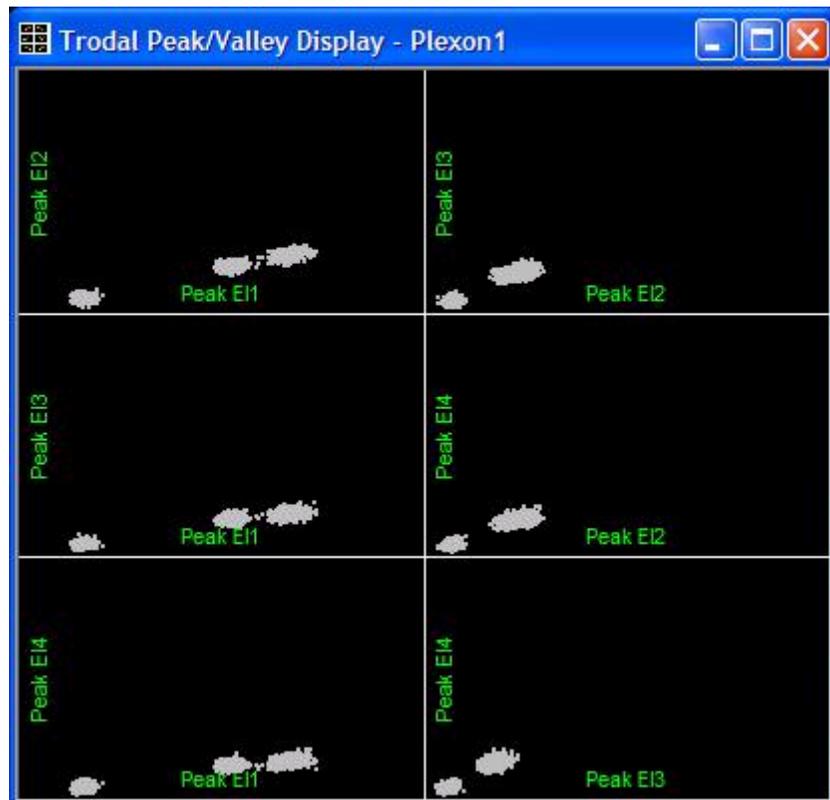
2.4.9.16 CPU-Intensive Functions

Avoid running the Activity Display at its slowest speeds (longest time width) when displaying many continuous channels. This can have a significant effect on computer performance, which can be assessed by using the Windows Task Manager. Ideally, keep the total CPU usage at 20% or less, although this is a conservative figure and many systems are able to run reliably at CPU usages of up to 30%.

2.4.10 Trodal Peak/Valley Display

The purpose of the Trodal Peak/Valley Display is to allow the user to determine if units are present while in stereotrode or tetrode mode, by displaying the peak or valley height of each electrode within the trode plotted against the peak or valley height from each other electrode in the same trode. While the MAP system does not support online sorting while in a trodal mode, it is useful to see if units are present in order to determine whether or not to advance an electrode (for example).

To open the Trodal Peak/Valley Display window, from the View menu, click Trodal Peak/Valley Display, or click the corresponding button on the toolbar. The Trodal Peak/Valley Display is only useful if when SortClient is set to acquire stereotrode or tetrode data, and will just show a message if the system is in single-electrode mode.

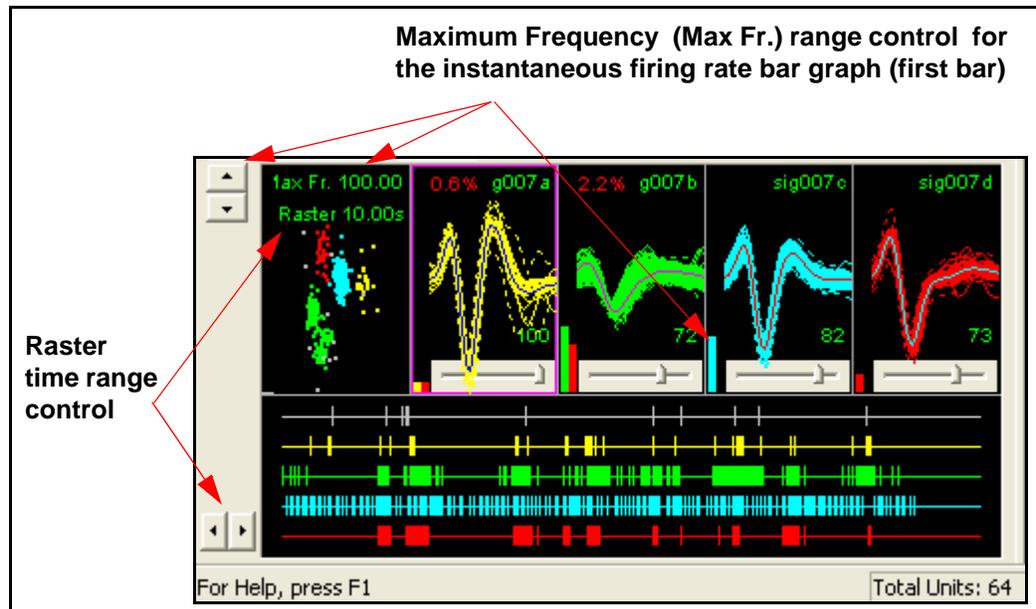


The Trodal Peak/Valley Display can be configured via the right-click menu to either show the Peak amplitude of the waveforms, or the Valley amplitude (a negative peak). It is important to set this appropriately for the data, otherwise the display will not allow the user to discern units optimally. That is, if the units differ mainly by having different peak heights, but the display is set to show valley, the display may not be very useful.

For Tetrode data, the Trodal Peak/Valley Display will show all six permutations of peak height (or valley depth, if selected) between electrodes; E11 vs E12, E11 vs E13, E11 vs E14, E12 vs E13, E12 vs E14, and E13 vs E14. For StereoTrode data, it will show just the one permutation, E11 vs E12.

2.4.11 Units Display

Up to four unit windows may be displayed for the current channel. Adjust the tolerances used in Template Sorting by using the slider control bars below each sorted unit. The user can also adjust the frequency range for the instantaneous firing rate bars and the time range of the raster display.

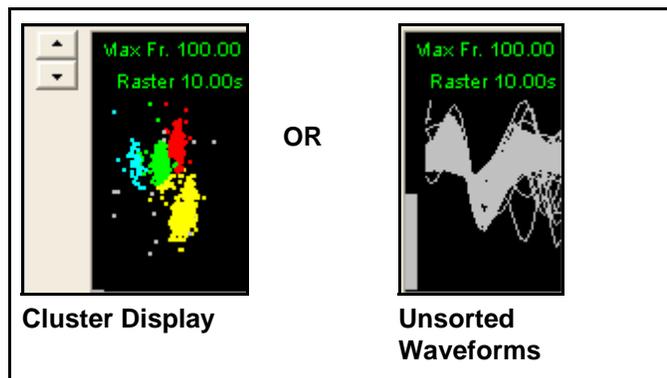


There are three major components of the Units Display:

2.4.11.1 Left Panel

The following illustration shows the two types of information that can appear in the Left Panel of the Units Display.

- The Left Panel is a small-scale view of either the Cluster Display shown in the Multichannel Display or the unsorted waveforms shown in the Waveform Window.

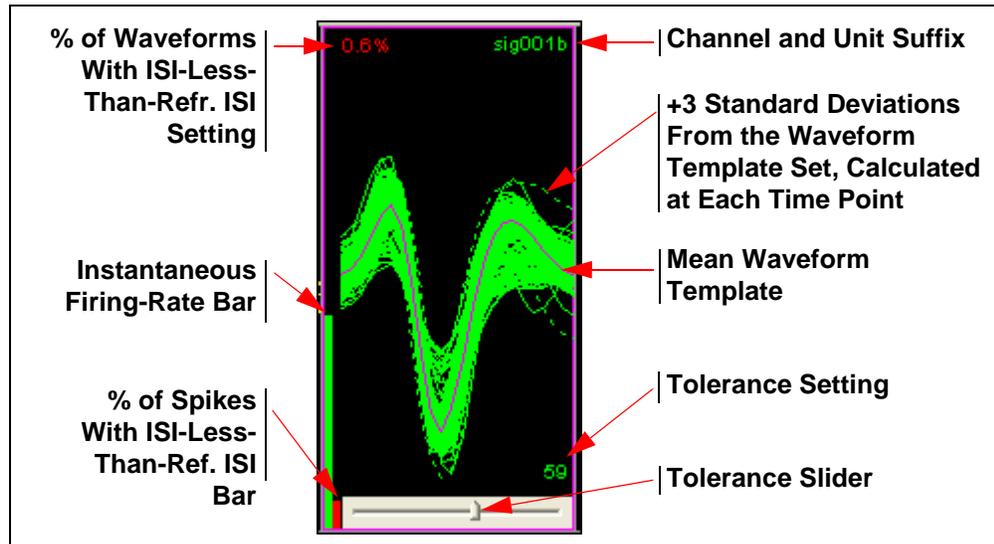


To change the Left Panel display, see "Show in Left Panel" on [page 117](#).

- The Left Panel includes readouts for the **Max Fr.** (Maximum Frequency) in spikes per second and the **Raster** time range in seconds.

2.4.11.2 Unit waveforms

The following illustration shows the sub-window for a single unit in the Units Display.



- The unit-waveform display can display up to four units. Each display includes the channel number and an alphabetic suffix for each unit on that channel. For example, in the preceding illustration the unit is from channel **sig001** and the unit is the second one marked for that channel, so the suffix is **b**.

Note: When a unit-waveform display is clicked, Sort Client places a pink box around it. Sort Client also directs the MAP to send a pulse to the EVT connector on the TIM board whenever that unit fires.

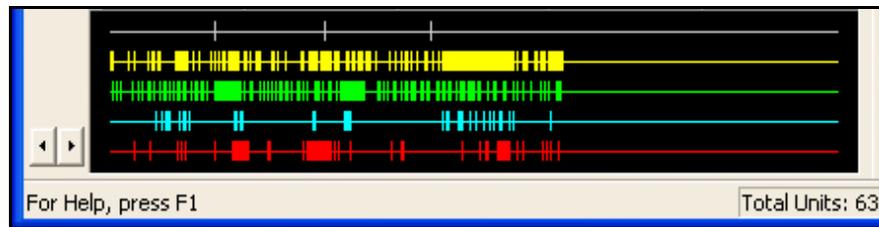
- In the preceding illustration, the line that represents the mean waveform template appears at the center of the collection of green waveforms.
- The slider at the bottom of each unit display controls the template “fit tolerance” for that unit. Fit tolerance is a unitless value that can be applied to the template to control how closely a waveform must match the template to be classified to the unit. In the illustration, the current value is set to **59**. For more information on the fit tolerance, see “Fit Tolerance Range” under the View Options Display tab on [page 117](#).
- The bar at the left edge of the window, which is green for this unit, rises and falls in response to the short-term firing rate of the spikes that meet the sorting criteria for the unit. The scale represented by the bar is spikes per second, which can be adjusted with the **Max Fr.** range control.
- The red bar, which is red in all unit-waveform displays, represents the percent of spikes with an inter-spike interval (ISI) that is less than the minimum ISI

setting. For information on the ISI setting, see “Refr ISI (μs)” on page 78. All units have a refractory ISI. Because a unit cannot fire again within its refractory ISI, which is typically 1 millisecond, a large percentage indicates that more than one unit is being classified as Unit b. The indicator value also appears in red at the top of the display. In this illustration, the value is **0.6%**. A high value, typically greater than 6%, means that there is a high probability that more than one unit is being erroneously classified as a single unit. However, a low value is not by itself a guarantee of correct classification.

Note: The MAP provides an output pulse each time Sort Client detects a selected unit. To select a unit, in the Units Display, click the unit to highlight it with a purple box. For example, the previous illustration shows unit sig001b highlighted with a purple box. Each time Sort Client detects that unit, the MAP provides—at the **EVT** connector on the **TIM** board—a +5V square-wave pulse for a duration of 0.5 milliseconds.

2.4.11.3 Raster plot

The following illustration shows the raster plot for the sorted units of the Units Display.



- The raster plot provides a real-time representation of the firing times for all the sorted units on the current channel. The grey line with tick marks at the top of the raster plot represents unsorted spikes. The user can adjust the raster range with the arrows on the left side of the plot. The value of the range is displayed in the Left Panel portion of the Units Display. The raster range for the preceding illustration is 10.0 seconds. Each tick on the topmost grey bar represents a 10-second interval.
- Sort Client can display up to four raster plots of sorted units in color. Each tick on a unit bar represents a sorted waveform that meets the sorting acceptance criteria for the unit.
- The total number of sorted units on all channels is shown in the status bar below the raster plot. For example, the illustration shows **Total Units: 63**.

2.4.12 Toolbar Icons

Most features and commands are available on the Sort Client toolbar.



See the following list to identify each toolbar icon and its function.

-  - New Sorting Parameters File (.exp - experiment configuration file)
-  - Open Sorting Parameters File (.exp file)
-  - Save Sorting Parameters File (.exp file)
-  - Copy from the Settings Spreadsheet Tables
-  - Print Settings Spreadsheet Table
-  - Increase Amplifier Gain
-  - Decrease Amplifier Gain
-  - Open the **Options** dialog box
-  - Show/Hide Peak Histogram Display in Waveform Window
-  - Opens Settings Spreadsheet Tables
-  - Opens Multichannel Display
-  - Opens Cluster Display
-  - Opens 3D Cluster Display
-  - Opens Activity Display
-  - Assisted Sort



- Troval Peak/Valley Display



- Display Pause



- Start Recording



- Pause Recording



- Stop Recording



- Range Control Buttons (in Cluster Displays and Activity Display)



- Single Electrode Mode



- Stereotrode Mode (two electrodes)



- Tetrode Mode (four electrodes)



- Auto-Configure Only the Current Channel



- Auto-Configure All Channels



- About SortClient (version info)

2.4.13 Sort Client Menus

The following sections describe each Sort Client menu in detail. The user can also use the Toolbar buttons to implement many of the commands that appear on the following Sort Client menus.



2.4.13.1 File

The accompanying illustration shows the Sort Client **File** menu. The File menu is divided into four areas: file commands, print commands, recording commands, and a file list.

2.4.13.1.1 File commands: File commands apply only to Plexon Sorting Parameters (.exp) files.

File	
New Sorting Parameters File	Ctrl+N
Open Sorting Parameters File...	Ctrl+O
Close Sorting Parameters File	
Save Sorting Parameters File	Ctrl+S
Save Sorting Parameters File As...	
Print...	Ctrl+P
Print Preview	
Print Setup...	
Open Data File/Start Recording	
Pause Recording	
Close Data File/Stop Recording	
1 PerfectScreenShot2-7-18-03.exp	
2 PerfectScreenShot-7-18-03.exp	
3 ScreenShots-7-17-03.exp	
4 Plexon1.exp	
Exit	



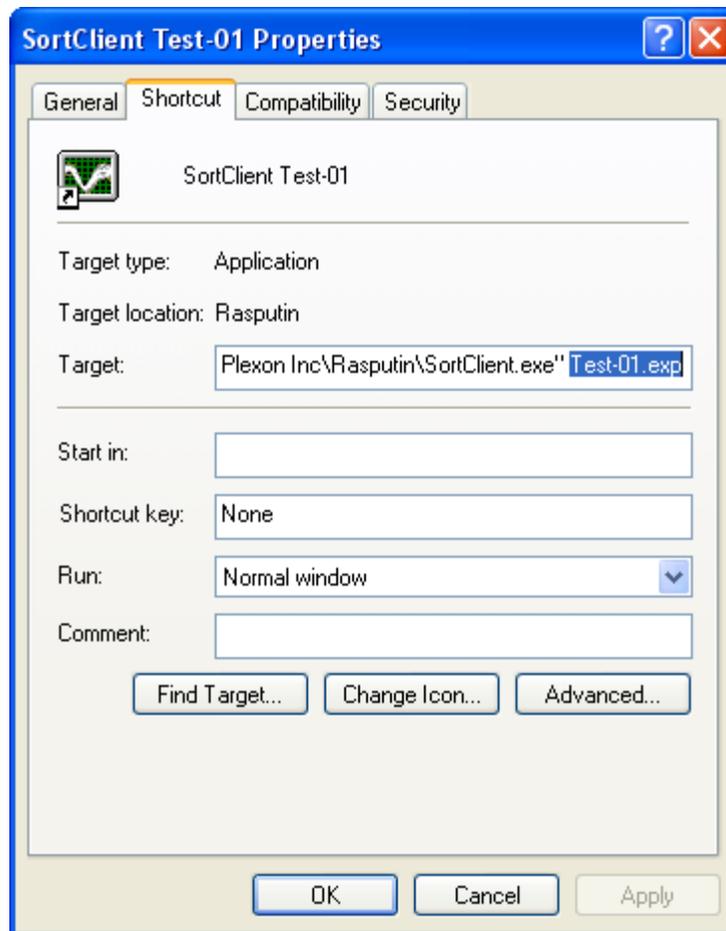
HINT

If there are many parameter files

If one or more parameter files are opened on a routine basis, instead of using the **Open Sorting Parameters File** command, Sort Client can automatically load parameter files by using customized desktop icons. When a customized icon is clicked, Sort Client starts in the normal manner, but opens directly with the specified parameter file instead of the default Plexon1.exp. Use the following procedure to set up customized Sort Client icons.

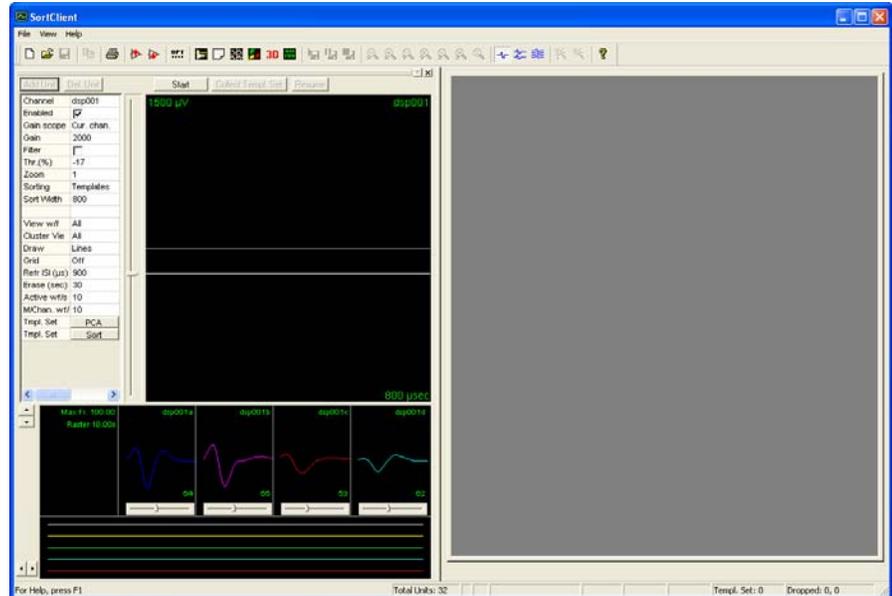
To make Sort Client automatically load .exp files on startup

- 1 Click the Sort Client desktop icon. Right-click and select **Copy**. Click a clear area on the desktop for the desired location of the customized icon. Then right-click and select **Paste Shortcut**. A copy of the Sort Client icon appears with the name "SortClient (2)".
- 2 Click the SortClient (2) icon. Right-click and select **Rename**. Type a new name for the icon. For example, the accompanying icon is renamed "Test-01".
- 3 Click to select the renamed icon. Right-click and select **Properties**. Click the **Shortcut** tab. In the **Target** box, at the end of the file location string, type a space and the name of the .exp file that Sort Client should open on startup when this icon is clicked. For example, in the following illustration the file name typed in the **Target** box is **Test-01.exp**, which matches the renamed icon. Click **OK**.



Note: This procedure may be repeated to create as many customized desktop icons as required. Each customized icon starts Sort Client and automatically loads the file specified.

Clicking **Close Sorting Parameters File** disables all Sort Client sorting parameters. Until another sorting parameters file is opened, the Sort Client main window appears as shown in the following illustration.



2.4.12.1.2 Print commands: The print commands are standard Windows print commands.

2.4.12.1.3 Recording commands: The recording-file parameter settings in the DataFile Options window effect the recording start and stop commands. For detailed information, see “Options” on page 124.

2.4.12.1.4 File list: The file list is a standard Windows list that includes up to the last four files opened in Sort Client.

2.4.12.1.5 Exit: Shuts down Sort Client.

2.4.12.2 Edit

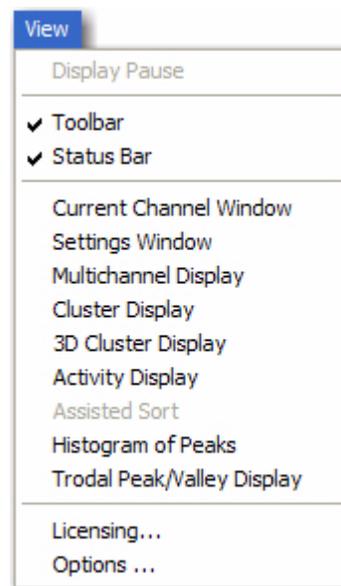
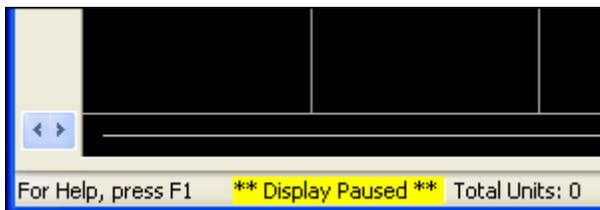
The accompanying illustration shows the Sort Client **Edit** menu. The **Edit** menu includes a **Copy** command only. The **Copy** command is available only when the **Settings** tab is selected.



2.4.12.3 View

The accompanying illustration shows the Sort Client **View** menu. The **View** menu includes window settings and commands that open new windows.

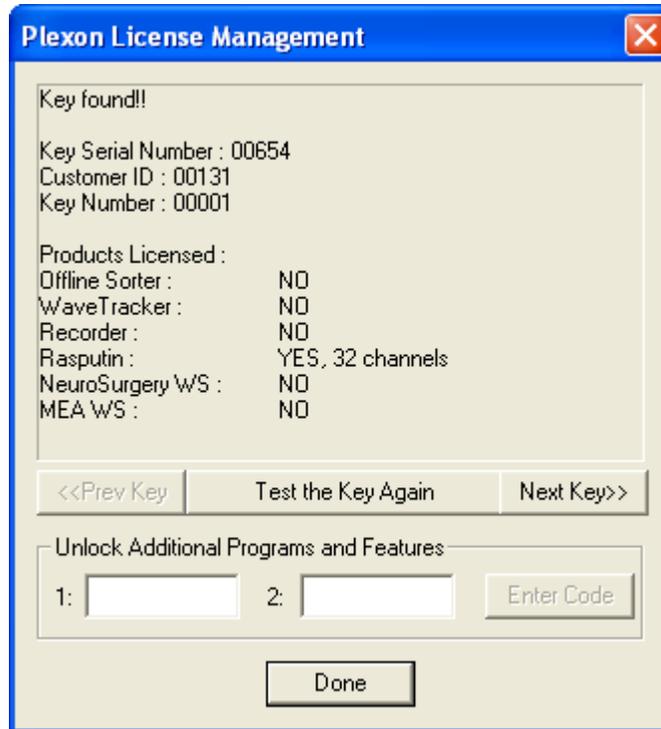
2.4.12.3.1 Display Pause: Click this item to pause the display. When the display is paused, Sort Client stops updating all views, but continues to record all data to the file. When the display is paused, a yellow indicator flashes in the Sort Client status bar.



2.4.12.3.2 Window Settings: The **Toolbar** and **Status Bar** may be shown or hidden. To hide these items, click to clear the checkmarks.

2.4.12.3.3 Display Commands: Any of the individual displays or windows may be opened from this menu or from the toolbar icons.

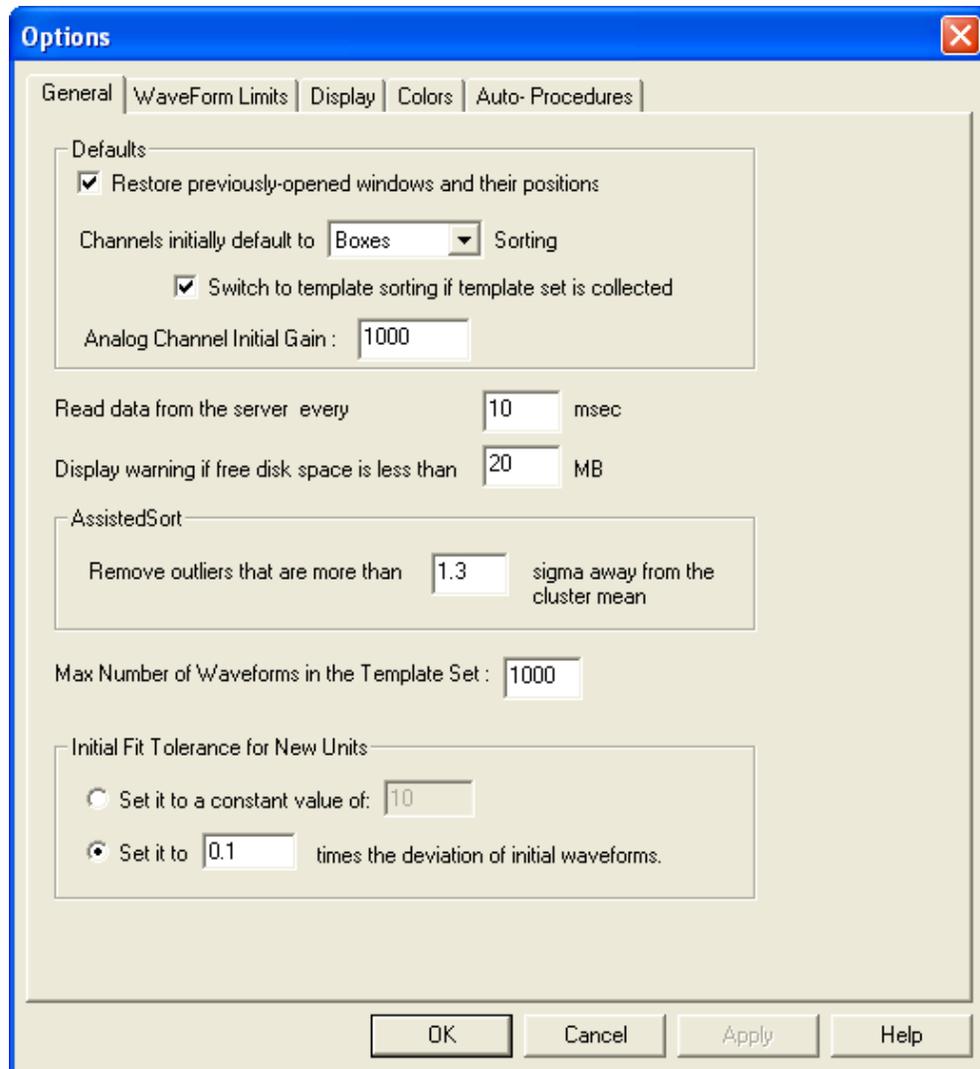
2.4.12.3.4 Licensing: The licensing item opens the **Plexon License Management** window, which includes complete licensing information for all the Plexon products installed on this PC. The window includes the following three areas: information, key testing, and code entry.



- The information area includes information on license keys and the license status of all the Plexon products currently licensed on this PC.
- The key testing area is a convenient tool to test license keys to ensure they function correctly.
- Use the **Unlock Additional Programs and Features** area to enter the unlock codes for optional programs and features. Instructions for entering codes and testing keys are included with Plexon installation programs.

2.4.12.3.5 Options: This item opens the **Options** window that includes the following tabs: **General**, **WaveForm Limits**, **Display**, **Colors**, and **Auto-Procedures**.

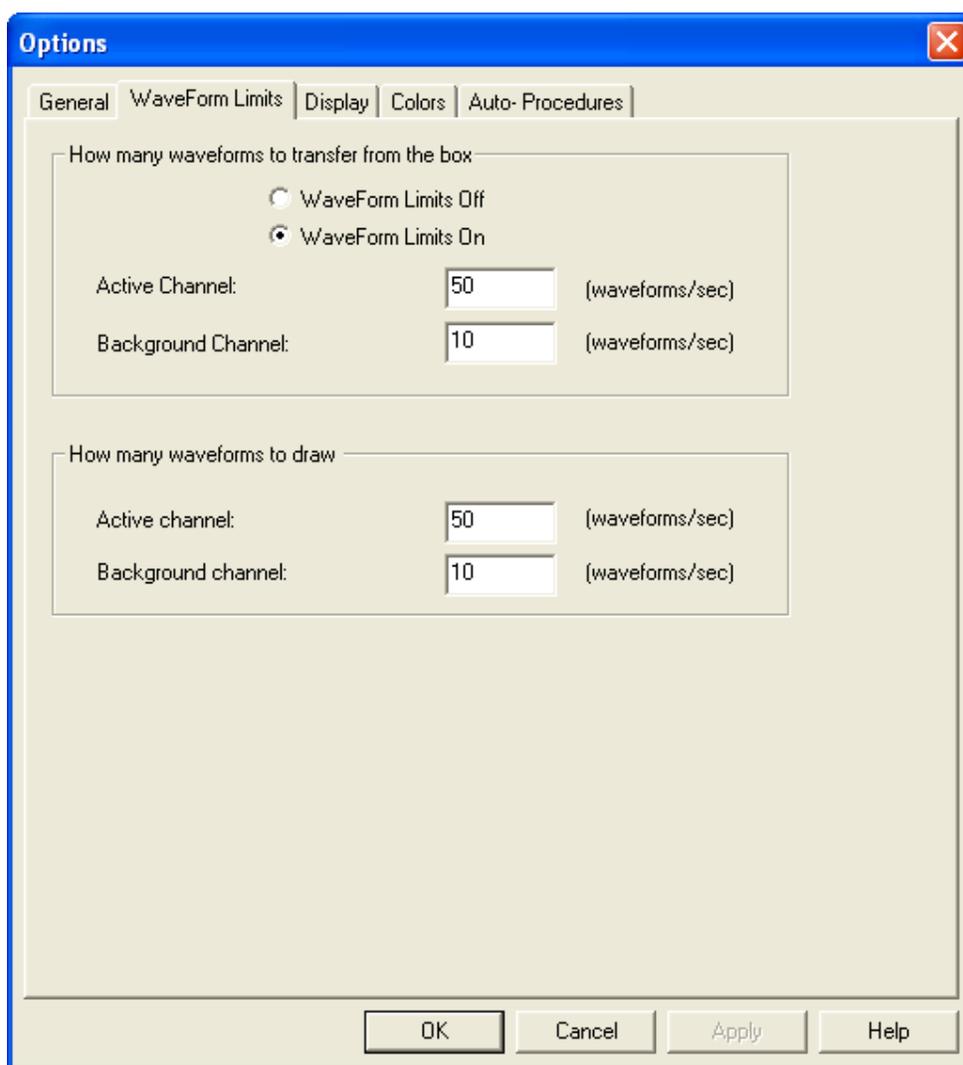
The following illustration shows the **General** tab of the **Options** window, where the Sort Client initial parameters are set.



- **Restore opened windows and their positions:** Click this item to open all iconized windows and restore them to their previously-opened positions when Sort Client is restarted.
- **Channels initially default to __ Sorting:** This item sets the default value for the **Sorting** field in the Control Table. Choose **Boxes** or **Templates** from the drop-down menu.
- **Switch to template sorting if template set is collected:** Click this item to automatically reset Sort Client to template sorting mode if a template set is collected.

- **Analog Channel Initial Gain:** Type the default value for the continuous channel gain setting.
- **Read data from the server every __ msec:** This item sets the frequency of data polling by Sort Client. In most cases, the default setting of 10 milliseconds can be used. The range is 10 to 100000 milliseconds.
- **Display warning if free disk is less than __ MB:** Enter the warning threshold for the minimum amount of free space that must remain on the disk drive on the PC.
- **Assisted Sort** is an automated sorting tool that can be selected from the **Tools** menu. A value can be set in the **Assisted Sort** area to automatically remove outliers in PCA space that are more than a minimum number of standard deviations from the mean of the cluster. When **Assisted Sort Current Channel** is selected on the **Tools** menu, Sort Client opens a window with a selection of candidate sorts. For more information, see [“Assisted Sort” on page 133](#).
- **Max Number of Waveforms in the Template Set:** Enter the limit on the number of waveforms that Sort Client collects to create a template set.
- **Initial Fit Tolerance for New Units:** When new units are added to a channel, Sort Client uses this value. To set a constant value for all units, click **Set it to a constant value of** and type a number. To set a multiplier based on the standard deviation of the template-set waveforms for the unit, click **Set it to __ times the deviation of initial waveforms** and type a number.

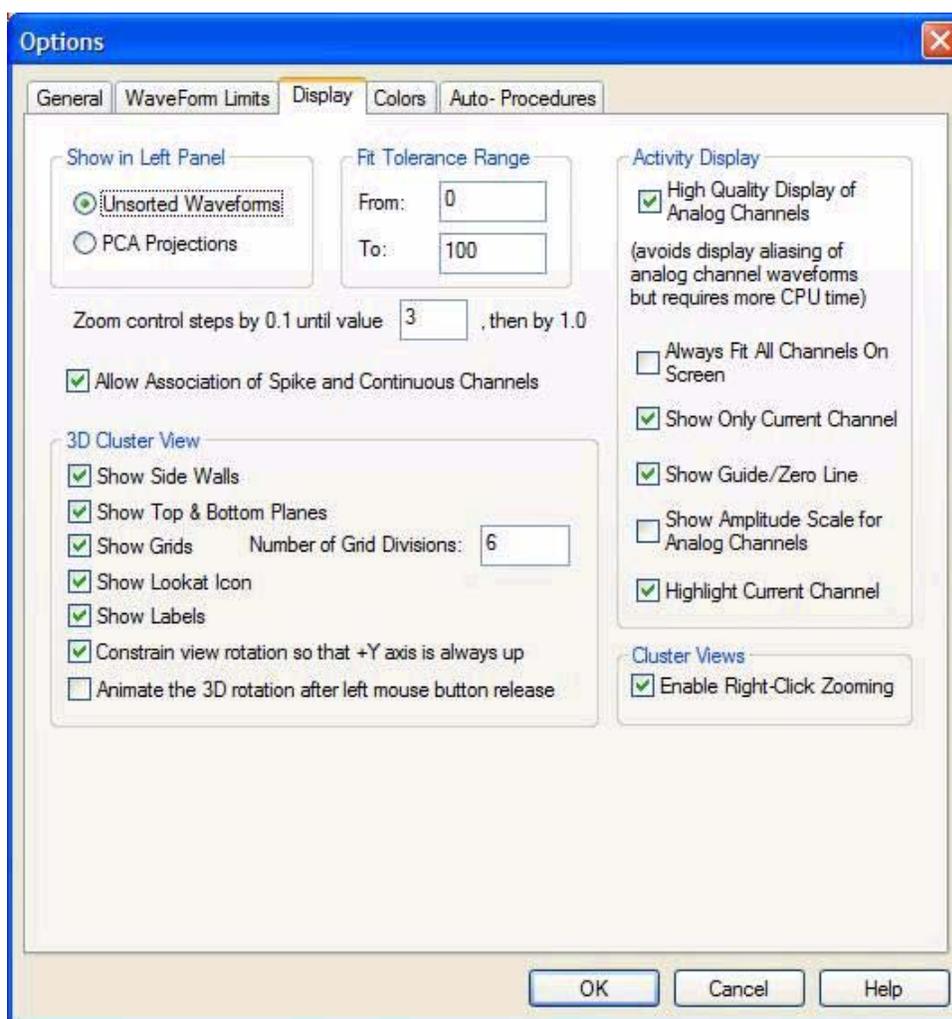
The following illustration is the **WaveForm Limits** tab of the **Options** window.



- **How many waveforms to transfer from the box** is the area where the maximum transfer rate is set for the waveforms to be transferred from the Multi-channel Acquisition Processor (MAP) box to Sort Client.
 - To transfer all waveforms to Sort Client, click **Waveform Limits Off**.
Note: If the HLK2 (Host Link 2) is used to connect the MAP box to the PC, this setting can be used to transfer all waveforms to Sort Client.
 - To limit the transfer of waveforms to Sort Client, click **Waveform Limits On** and enter the limit values as follows:
 - **Active Channel:** For the current channel, enter a suitable value that meets the performance limitations of the the PC and host link. The default value is 50 waveforms per second. The range is 0 (zero) to 100000.

- **Background Channel:** For the other channels, enter a suitable value that meets the performance limitations of the PC and host link. The default value is 10 waveforms per second (waveforms/sec). The range is 0 (zero) to 100000.
- **How many waveforms to draw** is the setting for how many waveforms Sort Client will draw in the WaveForm Window. There are separate settings for the active and background channels as follows:
 - **Active Channel:** For the current channel, enter a suitable value that meets the performance limitations of the PC and graphics card. The default value is 50 waveforms per second.
 - **Background Channel:** For the other channels, enter a suitable value that meets the performance limitations of the PC and graphics card. The default value is 10 waveforms per second.

The following illustration shows the **Display** tab of the **Options** window.

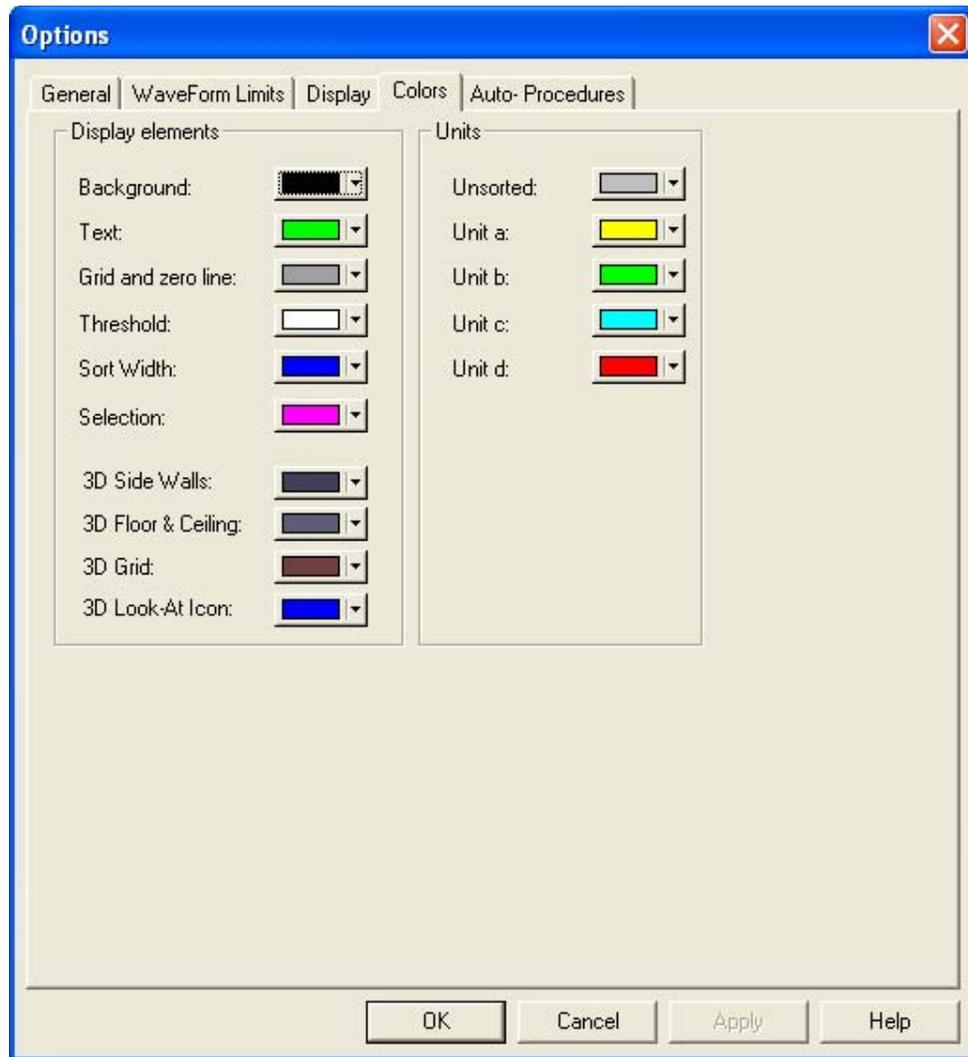


- **Show in Left Panel:** The items in the Left Panel of the Units Display may be changed here. For an illustration of these settings, see [“Left Panel” on page 103](#):
 - **Unsorted Waveforms:** Click to display the waveforms shown in the Waveform Window in unsorted (monochrome) mode.
 - **PCA Projections:** Click to show the points from the Cluster Display.
- **Fit Tolerance Range:** Fit tolerance is a unitless value that can be applied to each template to control how close a waveform must conform to the template to be accepted as belonging to the unit. In this area the range of the template “fit tolerance” may be set as follows:
 - **From:** Enter a value to define the lowest value of the fit-tolerance range. The default value is 0 (zero).

- **To:** Enter a value to define the highest value of the fit-tolerance range. The default value is 100.
- **Zoom control steps by 0.1 until __, then by 1.0:** Enter a zoom transition point. Each click of the Zoom-menu scroll arrows steps the zoom factor by 0.1 until the zoom factor reaches the level entered here. When the zoom factor reaches the level entered, the steps increment by 1.0. For more information on Zoom, see [“Channels” on page 83](#).
- **Allow Association of Spike and Continuous Channels:** Click to enable the association of spike channels and continuous channels. To associate spike and continuous channels, see [“Continuous Channels” on page 85](#).
- **3D Cluster View:** In this area the background and display characteristics of the 3D Cluster display in the Multi-Display Window can be controlled. Any combination of the following items may be chosen:
 - **Show Side Walls:** Click to show the 3D plot with three side walls.
 - **Show Top & Bottom Planes:** Click this item to show the 3D plot contained within top and bottom planes. When this item is used in combination with **Show Side Walls**, the plot is contained within a 3D box.
 - **Show Grids:** Click this item to apply grid lines to the 3D view. Set the scale of the grid as follows:
 - **Number of Grid Divisions:** Enter a value to set the scale of the grid divisions. This a unitless value that provides a comparison scale for the 3D view. The default value is 6. The range is 0 (zero) to 1000. Depending on the quality of the PC video display, grid divisions greater than 300 can appear as a solid background.
 - Note:** To be visible, grid lines must have a background. To see the grid lines, select **Show Side Walls** or **Show Top & Bottom Planes**.
 - **Show Lookat Icon:** Click this item to show a 3-axis icon, which is useful for orientation after zooming to a close-up view of the plot.
 - **Show Labels:** Click this item to show labels on the grid lines and on the Lookat Icon.
 - **Constrain view rotation so that +Y axis is always upwards:** Click this item to limit the rotation of the 3D view about the X and Z axes to 180 degrees.
 - **Animate the 3D rotation after left mouse button release:** Click this item to produce a continuous animated rotation of the 3D view when the left mouse button is released.
- **Activity Display:** controls the behavior of the Activity Display in the Multi-Display Window.

-
- **High Quality Display of Analog Channels:** when checked, the continuous channels are drawn in a way that avoids an aliasing effect, but it costs more CPU time to rendering in this way. For older PCs or when showing a large number of analog channels, it is best to uncheck this checkbox.
 - **Always Fit All Channels On Screen:** enables a mode that will compress all channels vertically so that they always fit on screen without scrolling.
 - **Show Only Current Channel:** when checked, the Activity Display will show only the units from the current spike channel, and also any analog channels that are associated with the current spike channel.
 - **Show Guide/Zero Line:** draws a horizontal line for each horizontal row of ticks and a zero line for any analog channel traces.
 - **Show Amplitude Scale for Analog Channels:** when checked, shows a amplitude scale on the left side of each analog channel trace.
 - **Highlight Current Channel:** when checked, a selection box will be drawn around the units from the current spike channel. A selection box will also be drawn around any analog channels that are associated with the current spike channel.
 - **Enable Right-Click Zooming:** when checked, holding down the right mouse button and dragging within the 2D or 3D Cluster Views will zoom the display in and out. Holding down the Alt key while pressing the right mouse button will produce the right-click menu. When this checkbox is unchecked, the above situation is reversed: pressing the right mouse button will produce the right-click menu, and holding down the Alt key while pressing the right mouse button will zoom the display in and out. Note that the mouse wheel will also zoom the 3D Cluster View in and out.

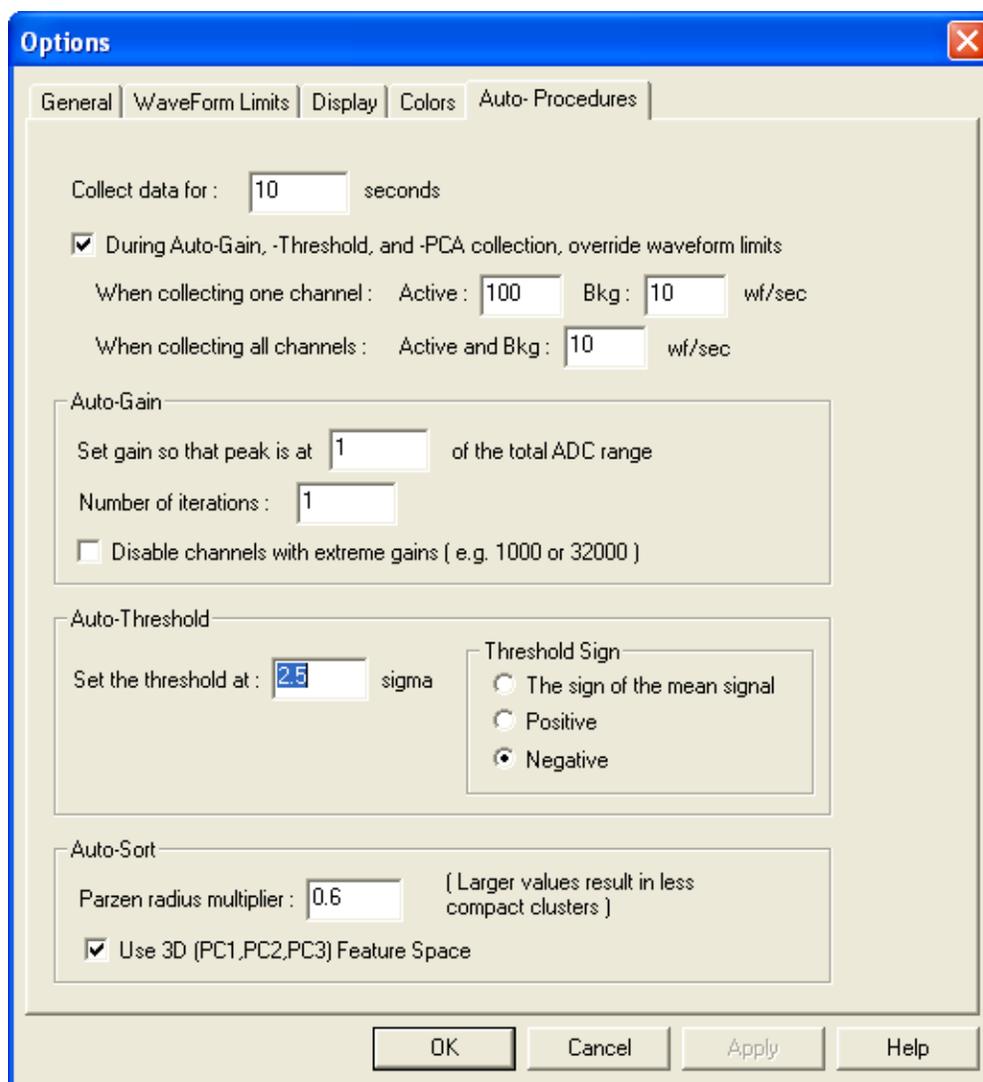
The following illustration shows the **Colors** tab of the **Options** window:



- **Display elements:** In this area may be set the colors of the supporting items that make up the Sort Client display, such as backgrounds, text, and grid lines. The preceding illustration shows the default colors.
- **Units:** In this area may be set the colors of the data elements shown in the various unit displays. The preceding illustration shows the default colors.

The following illustration shows the **Auto-Procedures** tab of the **Options** window:

Note: For more information on the Auto Procedures, see “Tools” on page 130.



- **Collect data for __ seconds:** Type the maximum time for the Auto Procedures to collect data before computation begins.
- **During Auto-Gain, -Threshold, and -PCA collection, override waveform limits:** Clicking **WaveForm Limits On** in the **WaveForm Limits** tab of the **Options** window allows clicking this item to override those limits and enter revised values as follows:

Note: If using an HLK2 in the MAP system, waveform limits may be ignored. See “How many waveforms to transfer from the box” on page 115.

- **When collecting one channel:** Selecting **Auto Gain Current Channel** or **Auto Threshold Current Channel** from the **Tools** menu allows the waveform limits to be overridden separately as follows:
 - **Active:** For the current channel, type a suitable value that meets the performance limitations of the PC and host link. The default value is 100 waveforms per second (wf/sec).
 - **Bkg:** For the background channels, type a suitable value that meets the performance limitations of the PC and host link. The default value is 10 waveforms per second.
- **When collecting all channels:** Selecting **Auto Gain All Channels** or **Auto Threshold All Channels** from the **Tools** menu allows both waveform limits to be overridden simultaneously as follows:
 - **Active and Bkg:** Type a suitable value that meets the performance limitations of the PC and host link. The default value is 10 waveforms per second (wf/sec). The range is 0 (zero) to 100000.
- **Auto-Gain:** In this area may be set the parameters for the Auto Gain Algorithm. For more information on the Auto Gain parameters, see [“Auto Gain Algorithm” on page 131](#).
 - **Set gain so that peak is at __ of the total ADC range:** Type the peak value for the gain as a portion of the analog-to-digital converter (ADC) range. The default value is 1.
 - **Number of iterations:** Type the number of iterations that the Auto Gain Algorithm must perform to enable it to converge on the appropriate gain.
 - **Disable channels with extreme gains (e.g. 1000 or 32000):** Click to automatically disable channels that have extremely low (1000) or extremely high (32,000) gains, which usually implies either noise or a dead channel.
- **Auto-Threshold:** In this area may be set the parameters for the Auto Threshold Algorithm. For more information, see [“Auto Threshold Algorithm” on page 131](#).
 - **Set the threshold at __ sigma:** Type the number of standard deviations (sigma) away from the mean peak height to set the threshold. The default value is 2.5.
 - **Threshold Sign:** Set the sign of the threshold to one of three positions:
 - **The sign of the mean signal:** Click to set the sign of the threshold at the same setting as the mean signal.
 - **Positive:** Click to set a positive threshold.
 - **Negative:** Click to set a negative threshold.

- **Auto-Sort:** In this area may be set the parameters for the Auto Sort Algorithm. For more information on the Auto Sort parameters, see [“Auto Sort Algorithm” on page 132](#).
 - **Parzen radius multiplier:** Type a value for the Parzen radius multiplier. Large values result in fewer less-compact clusters. The default value is 0.6. The range is 0 (zero) to 10000000.
 - **Use 3D (PC1,PC2,PC3) Feature Space:** By default, the Auto Sort procedure runs in 3D space. To run a faster Auto Sort in 2D feature space, click to clear the checkbox for this item.

2.4.12.4 Server

The accompanying illustration shows the Sort Client **Server** menu.

Note: During normal operation, Sort Client starts and stops data transfer automatically. Under normal conditions, do not attempt to manually start and stop data transfer.



2.4.12.4.1 Start Data Transfer: Select this item to start data transfer from the MAP Server.

2.4.12.4.2 Stop Data Transfer: Select this item to stop data transfer from the MAP Server.

2.4.12.4.3 Server Mode: This item opens the **Server Mode** window. Sort Client can collect unsorted stereotrode or tetrode data. For more information on Server Mode, see [“Select a Sorting Method” on page 37](#).

- **Electrode Mode:** Select one of three modes from this area:

- **Single:** Click to separately display the signals from each electrode.
- **Steretrode:** Click to display the signals from adjacent electrodes as time-coincident pairs.
- **Tetrode:** Click to display the signals from four co-located electrodes as time-coincident quartets.

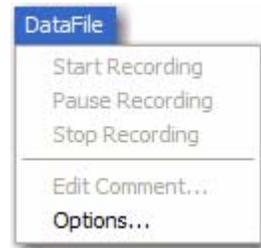


Note: Server modes can also be selected by using the toolbar. See [“Toolbar Icons” on page 105](#).

2.4.12.5 DataFile

The accompanying illustration shows the Sort Client **DataFile** menu.

2.4.12.5.1 Recording Controls: The recording control items on this menu perform the same function as the Tool-bar recording controls. The **Start Recording** and **Stop Recording** controls are effected by the parameters that are set in **DataFile Options** window. For information on the start and stop recording parameters, see [page 126](#).



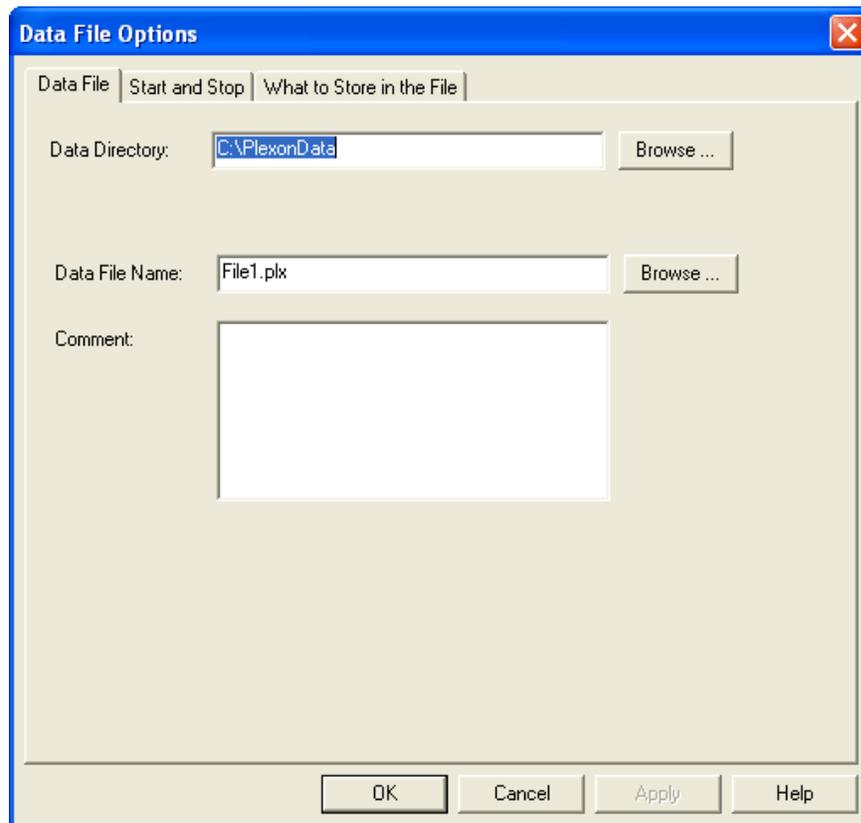
2.4.12.5.2 Edit Comment...: This selection is only enabled while data is being recording. It brings up a dialog that allows editing or appending text to the Comment that is stored with the recorded .plx file.

2.4.12.5.3 Options: This item opens the **DataFile Options** window, which includes the following tabs:

- Data File
- Start and Stop
- What to Store in the File

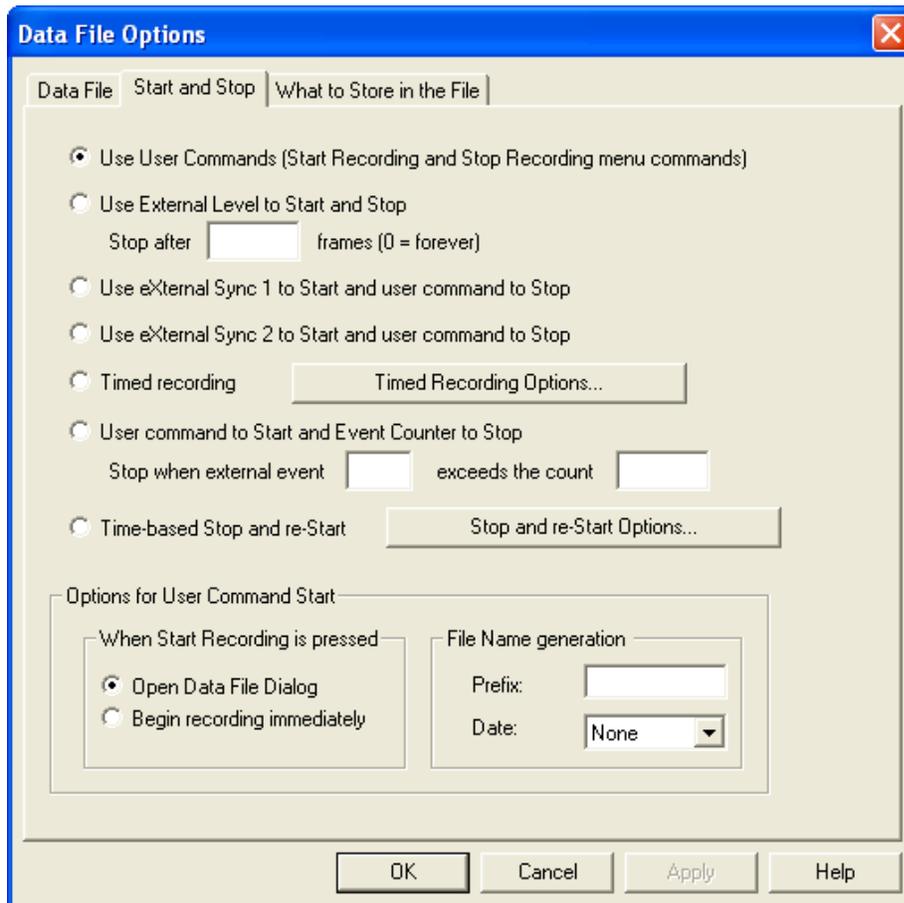
Sort Client records data in Plexon data (PLX) file format. Plexon has optimized PLX files for recording thresholded segments of waveforms.

The following illustration shows the **Data File** tab in the **Data File Options** window:



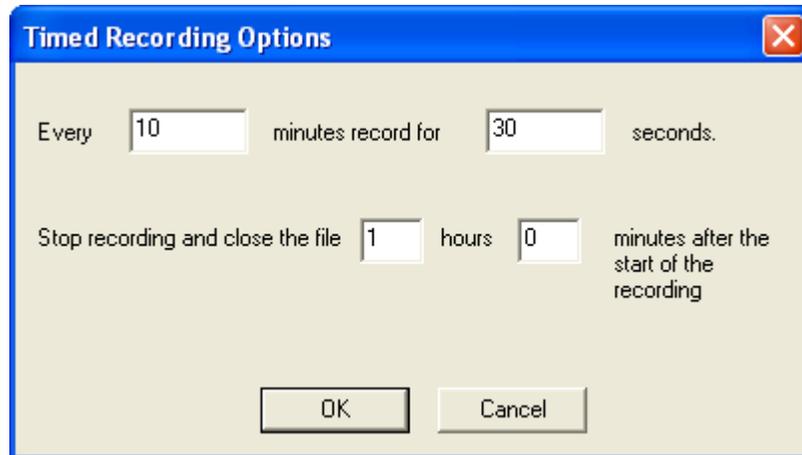
- **Data Directory:** This is the storage location for the data file. The default entry is C:\PlexonData. Type an alternative location or click **Browse** and choose a directory.
- **Data File Name:** This is the data-file name. Type a name or click **Browse** and choose a name.
- **Comment:** This field can accept a comment of up to 1000 alphanumeric characters. Although this field accepts 1000 characters, typical applications can only view 100 characters.

The following illustration shows the **Start and Stop** tab in the **Data File Options** window:



- **Use User Commands (Start Recording and Stop Recording menu commands):** Click to manually control recording from the Sort Client Toolbar or from the **DataFile** menu.
- **Use External Level to Start and Stop:** Click to use an external stop and start signal, which can be received by the remote record start/stop (RSTART) input on the MAP DSP board. For more information on RSTART, see the “[Setting Up MAP System Digital Input and Output](#)” datasheet.
 - **Stop after __ frames (0 = forever):** Type the number of frames to record before Sort Client stops automatically. If 0 (zero) is typed, Sort Client continues to record until it is manually stopped with a toolbar button or menu command. The default value is 0 (zero).
- **Use eXternal Sync 1 to Start and user command to Stop:** Click to use a pulse on the External Sync 1 (XS1) connector on the TIM board to start recording and a user command from the toolbar or **DataFile** menu to stop recording.

- **Use eXternal Sync 2 to Start and user command to Stop:** Click this item to use a pulse on the External Sync 2 (XS2) connector on the TIM board to start recording and a user command from the toolbar or **DataFile** menu to stop recording.
- **Timed Recording:** Click this item to set up periodic timed recording intervals and a timed stop. Set the intervals as follows:
 - **Timed Recording Options:** Click this button to open the following window and set the recording intervals.



- **Every __ minutes record for __ seconds:** In the first box, type the period of the recording interval. In the second box, type the duration of the recording interval. The range is 0 to 2147483647.
 - **Stop recording and close the file __ hours __ minutes...:** Type the duration of the recording session. In the first box, type the hours after the start of recording. In the second box, type the minutes after the start of recording.
- **User command to Start and Event Counter to Stop:** Click to use a toolbar or menu command to start recording and to stop recording when a cumulative number of external events occur on a designated channel. Set the stop recording parameters as follows:
 - **Stop when external event __ exceeds the count __:** In the first box, type the external event channel. The range is 1 to 16. In the second box, type the cumulative event count for that channel.
- **Time-based Stop and re-Start:** Click to set up time-based multiple file recording.

- **Stop and re-Start Options:** Click this button to open the following window and set the time intervals.



- **Stop recording and close the file __ hours __ minutes after...:** Enter the duration of the interval to record to the file. In the first box, type the duration hours. In the second box, type the duration minutes.
- **Options for User Command Start:** This area includes two sub-areas that may be used to control recording and file naming, when recording is started by using toolbar buttons or menu commands:
 - **When Start Recording is pressed:** This area includes two options that control how Sort Client responds when clicking the **Start Recording** button on the toolbar (or choosing **Start Recording** on the **DataFile** menu). Click one of the following options:
 - **Open Data File Dialog:** Click this option to have Sort Client prompt with **Data File Options** window each time **Start Recording** is selected. This option allows typing a file name and file location for each file created.
 - **Begin recording immediately:** Click this option to have Sort Client automatically generate a new consecutively-numbered file name and immediately begin recording to that file. To set up file names, see the following paragraph.
 - **File Name generation:** This area includes two file naming parameters that can be preset. Sort Client sequentially names each file using a file name prefix, the current date, and a three-digit consecutive file number, as follows:
 - **Prefix:** Type a file name prefix. The default value is **dat**.

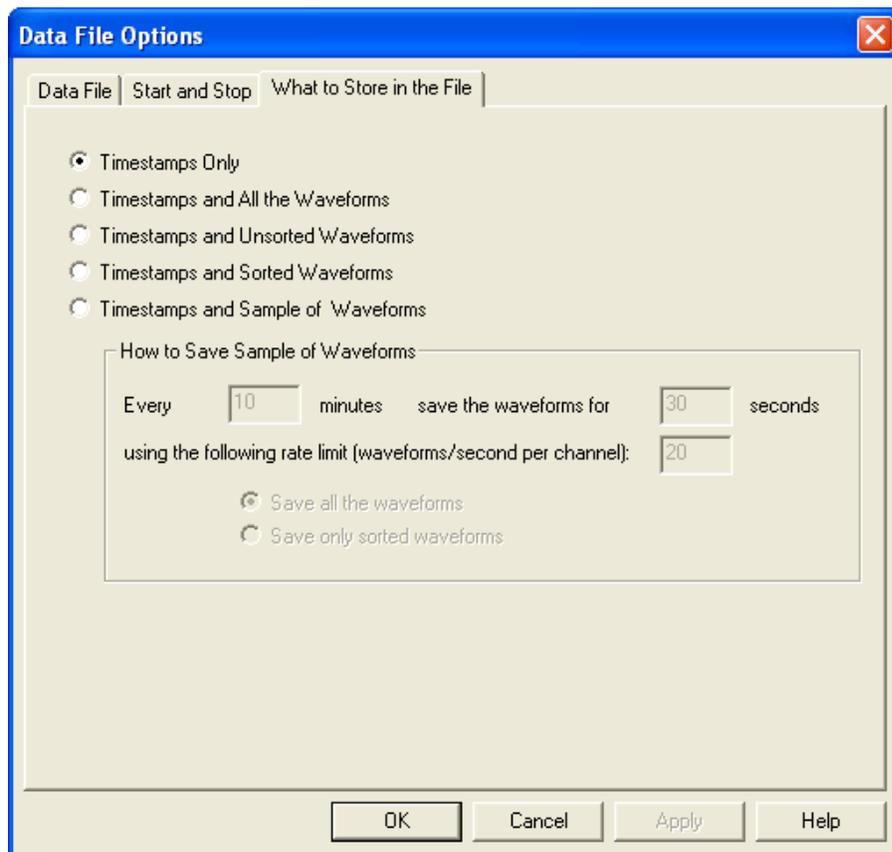
- **Date:** Choose a format for the date (**mmddy**, **ddmmyy**, etc.), or choose **None** to have the date excluded from the file name. An example of a typical file name follows:

dat090503001.plx

where “dat” is the prefix, “090503” is the date in mmddy format, and “001” is the three-digit sequential file number

- Note:** Use long file names with caution. Make sure the software and network can use long file names.

The following illustration shows the **What to Store in the File** tab in the **Data File Options** window.



To define what to store in the data file, choose one of the following options:

- **Timestamps Only:** Click to save only timestamps to the data file. This option creates the smallest files, but the files cannot be re-sorted offline.
- **Timestamps and All the Waveforms:** Click to save timestamps and all the waveforms, both sorted and unsorted. This option creates larger files that can be re-sorted offline.
- **Timestamps and Unsorted Waveforms:** Click to save timestamps and only the unsorted waveforms.

- **Timestamps and Sorted Waveforms:** Click to save timestamps and only the sorted waveforms.
- **Timestamps and Sample of Waveforms:** Click to save timestamps and only a sample of the waveforms. The sample is defined as follows:
 - **How to Save Sample of Waveforms:** This area includes the period, duration, and rate that define the waveform sample.
 - **Every __ minutes save the waveforms for __ seconds:** In the first box, type the sample duration in minutes. The default value is 10 minutes. In the second box, type the sample duration in seconds. The default value is 30 seconds.
 - **using the following rate limit (waveforms/second per channel):** This value defines the data storage rate for the waveform sample. Type a value that meets the performance limitations of the PC and host link. The default value is 20.
 - **Save all the waveforms:** Click to save all waveforms to the sample file.
 - **Save only sorted waveforms:** Click to save only sorted waveforms to the sample file.

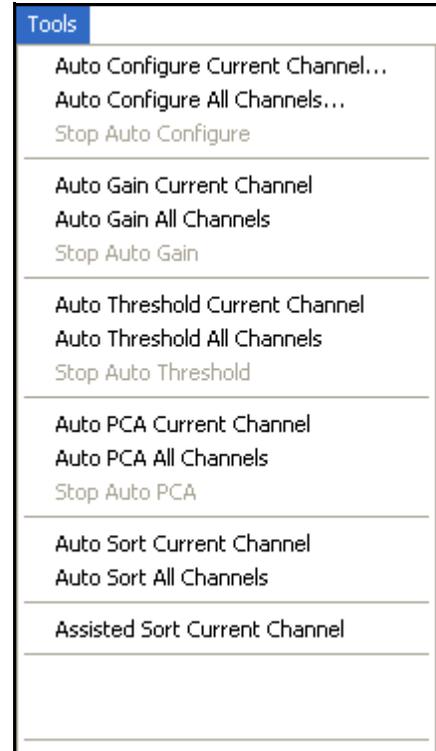
2.4.12.6 Tools

The accompanying illustration shows the **Tools** menu with the various Auto procedures listed.

2.4.12.6.1 Auto Procedures: All of these procedures may be run on the current channel only or on all channels simultaneously. These procedures can be run individually or together as a chain in the following sequence:

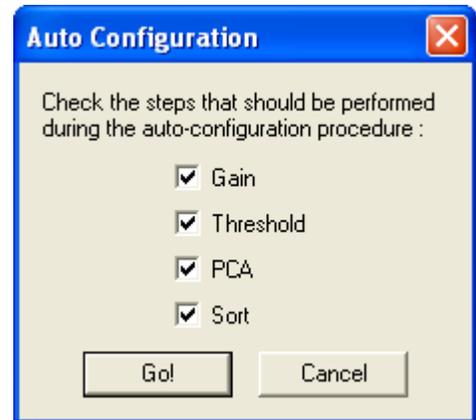
- Gain
- Threshold
- PCA
- Sort

2.4.12.6.2 Auto Configure: When chaining the Auto procedures together and run them on all channels simultaneously, they provide a powerful, one-step, automated experimental setup feature called Auto Configure. With the Auto Configure feature, all or only a subset of the Auto algorithms can be run in sequence.



The accompanying illustration shows the default view of the **Auto Configuration** window with all the auto-configuration procedures selected.

2.4.12.6.3 Auto Gain Algorithm: The Auto Gain algorithm is similar to the Auto Threshold algorithm. It collects data for a configurable number of seconds and then it determines the peak amplitude of any signal that arrived during the collection period. Then the Auto Gain algorithm calculates the gain needed to make that peak amplitude take up a configurable fraction (0.7 by default) of the total analog-to-digital converter (ADC) range.



When the Auto Gain algorithm makes a first-pass analysis on a channel, it uses the gain that is set for that channel to collect data. If the gain is too high or too low, the algorithm can fail to set an ideal gain in one pass. For example, if the gain was initially set far too high on a channel, all the waveforms would be clipped. The peak height would then be the full ADC range and the first pass of the Auto Gain algorithm would reduce the gain by the default value of 0.7. This reduced gain can still be too high, which results in clipped waveforms. To ensure adequate waveforms, run the Auto Gain algorithm through a sufficient number of iterations to enable it to converge on the appropriate gain for the channel.

The Auto Gain algorithm can also automatically disable channels that are found to require extremely low gains of 1000, which usually implies a great deal of noise on the channel, or extremely high gains of 32,000, which usually implies a dead channel. For more information on disabling channels, see [“Disabling Channels” on page 21](#).

Also, a burst of noise on a channel, such as an electromyogram (EMG) burst, can adversely affect the calculated gains during the Auto Gain procedure.

2.4.12.6.4 Auto Threshold Algorithm: The Auto Threshold algorithm temporarily sets the threshold to 0 (zero) and collects data for a configurable number of seconds, calculates the peak-to-peak distribution (noise ends where the Gaussian envelope ends), and then sets the threshold to be a configurable number of standard deviations away from the mean peak height. For an illustration of the manual process, see [Step 5 on page 36](#).

2.4.12.6.5 Auto PCA Algorithm: The Auto PCA algorithm runs in two phases. The first phase collects a set of waveforms to use in principal component analysis (PCA). This set of waveforms is referred to as a PCA set or a template set. The second phase runs a PCA on that template set. Auto PCA continues to collect the template set until a configurable number of waveforms have been collected or the collection is stopped by clicking **Stop Templ. Coll.** When the collection of the template set stops, PCA runs automatically.

The Auto PCA procedure is the manual equivalent of starting and stopping the collection of a template set and then clicking **PCA** for each channel. However, Auto PCA enables this same procedure to be run on all channels simultaneously. When a template set is collected and PCA is run on it, the 2D and 3D Cluster Displays show the waveforms as points in PCA space, where they can be clustered to form templates.

2.4.12.6.6 Auto Sort Algorithm: The Auto Sort algorithm uses the same valley-seeking sorting algorithm as Plexon [Offline Sorter](#). The Auto Sort algorithm attempts to cluster the points of a channel's current template set in either 2D or 3D PCA space. The Auto Sort algorithm can automatically select an appropriate number of clusters and assign cluster membership to each point in the current template set. After Auto Sort determines cluster membership, the template waveform for each unit is calculated from the clusters and used for subsequent online sorting.

From the **View** menu, in the **Options** window under the **Auto Procedures** tab, the Parzen radius multiplier can be set to control how aggressively the valley-seeking sorting algorithm splits or combines nearby clusters. For complete information, see the Auto Procedures tab description on [page 121](#). Larger values of this multiplier generally result in a smaller number of larger, looser clusters; smaller values of this multiplier result in a larger number of tighter, smaller clusters. By default, Auto Sort uses 3D (PC1, PC2, PC3) feature space, but it can also use 2D feature space.

The Auto Sort algorithm currently makes no attempt to discern noise clusters from unit-firing clusters, as a result, noise clusters can be assigned to a unit. With the Auto Configure feature, all or only a subset of the Auto algorithms can be run in sequence.

To run Auto Configure

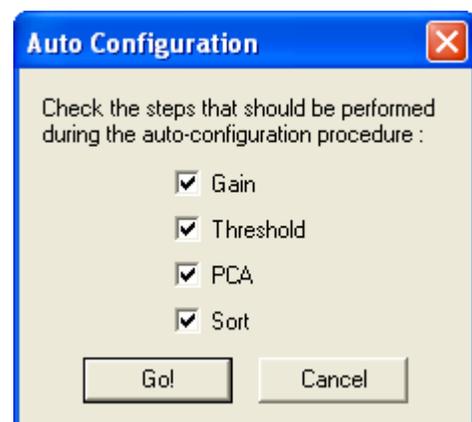
- 1 From the **Tools** menu, click **Auto Configure Current Channel** or **Auto Configure All Channels**. Sort Client opens the **Auto Configuration** window.

Note: The first time Auto Configure is used, the **Auto Configuration** window opens with all the checkboxes selected.

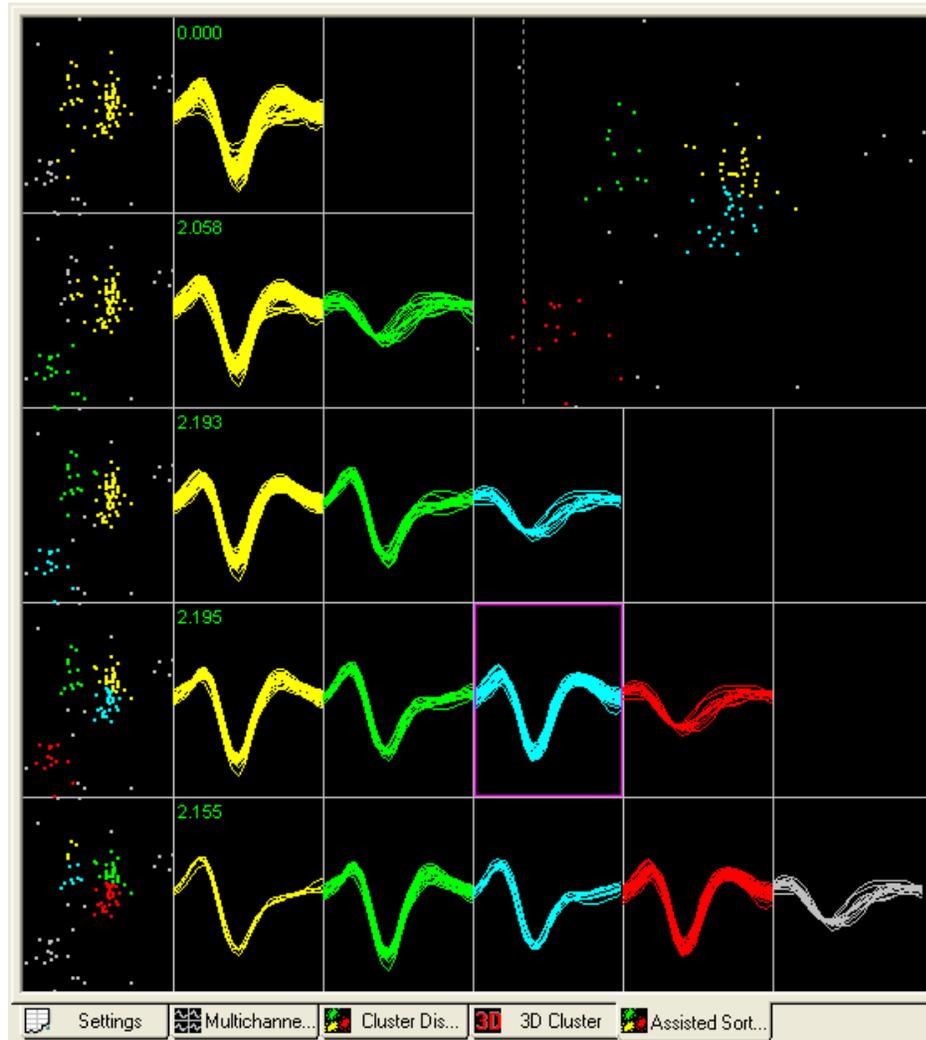
- 2 Click the sequential steps to run.

Note: The steps must be selected in sequence—for example, if only two steps are selected, **Gain** and **Threshold** can be selected but not **Gain** and **Sort**.

- 3 Click **Go!**

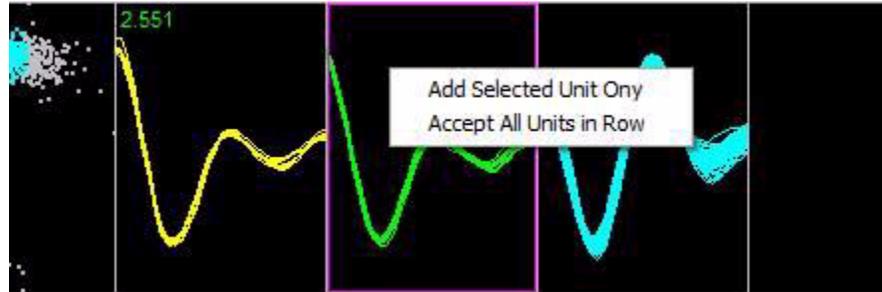


2.4.12.6.7 Assisted Sort: Assisted Sort is an automated sorting feature that is based on the K-Means algorithm. Assisted Sort provides a selection of several candidate sorts for the current channel. When **Assisted Sort Current Channel** on the **Tools** menu is selected, Sort Client runs the K-Means sorting algorithm on the waveforms in the current channel and opens the view shown in the following illustration, which shows the **Assisted Sort** tab in the Multi-Display Window.



This view shows a number of candidate sorts for each unit as 2D plots and sorted waveforms. A candidate sort can be chosen that best represents a distinct unit. Sort Client can present up to five candidate sorts for each unit. As shown in the

following illustration, when a unit to add is chosen, right click to open a shortcut menu.

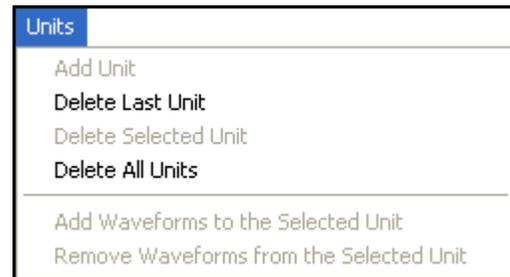


2.4.12.6.8 Add Selected Unit Only: adds only the one currently highlighted unit.

2.4.12.6.9 Accept All Units In Row: adds all the units in the selected row.

2.4.12.7 Units

The **Units** menu lists the commands that apply to sorting waveforms into units. The availability of items on the **Units** menu depends on the active view, the unit selected, or current state of the template. As shown in the accompanying illustration, several items are unavailable because this illustration represents the **Units** menu after the maximum number units are defined for the current channel.



2.4.12.7.1 Add Unit: This menu item performs the same function as the **Add Unit** button above the Control Table. After a template set has been collected, select this item to add a unit to the channel. When the maximum number of four units is added to a channel, Sort Client makes this item unavailable.

2.4.12.7.2 Delete Last Unit: This menu item deletes the last unit added on this channel. This menu item performs the same function as the **Del Unit** button above the Control Table. This item is unavailable until at least one unit is added to the channel.

2.4.12.7.3 Delete Selected Unit: This menu item deletes a selected unit. This item is unavailable until at least one unit is added to the channel.

2.4.12.7.4 Delete All Units: This menu item deletes all units.

2.4.12.7.5 Add Waveforms to the Selected Unit: This menu item enables the selection tool cursor in the Cluster Display and in the 3D Cluster views. For information on how to use the selection tool, see [“Cluster Display” on page 93](#). The selection tool in Cluster Display and 3D Cluster views can be used only to select individual waveforms to add to the selected unit. Sort Client recalculates the unit template using the new set of waveforms.

2.4.12.7.6 Remove Waveforms from the Selected Unit: This menu item enables the removal tool cursor in the Cluster Display and in the 3D Cluster views. For information on how to use the removal tool, see [“Cluster Display” on page 93](#). The removal tool in the Cluster Display and the 3D Cluster views can be used only to select individual waveforms to add to the selected unit. Sort Client recalculates the unit template using the new set of waveforms.

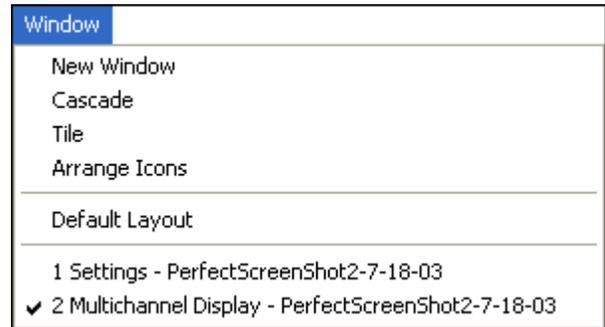
2.4.12.8 Window

The accompanying illustration shows the **Window** menu, which includes three areas: top, default, and window list.

2.4.12.8.1 Top area: The top area includes standard Microsoft Windows commands.

2.4.12.8.2 Default Layout: This item returns the Sort Client Main Window to the default layout.

2.4.12.8.3 List area: This area lists the Sort Client windows in the order they were opened.



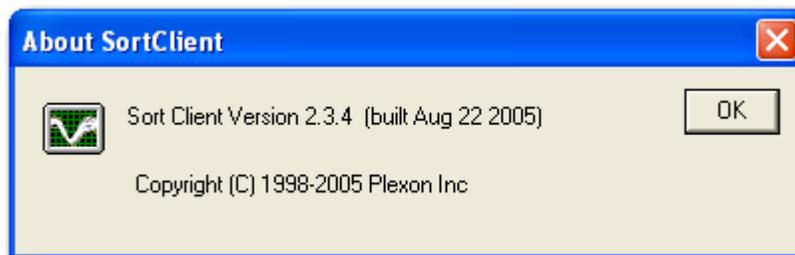
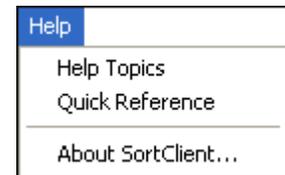
2.4.12.9 Help

The accompanying illustration shows the **Help** menu.

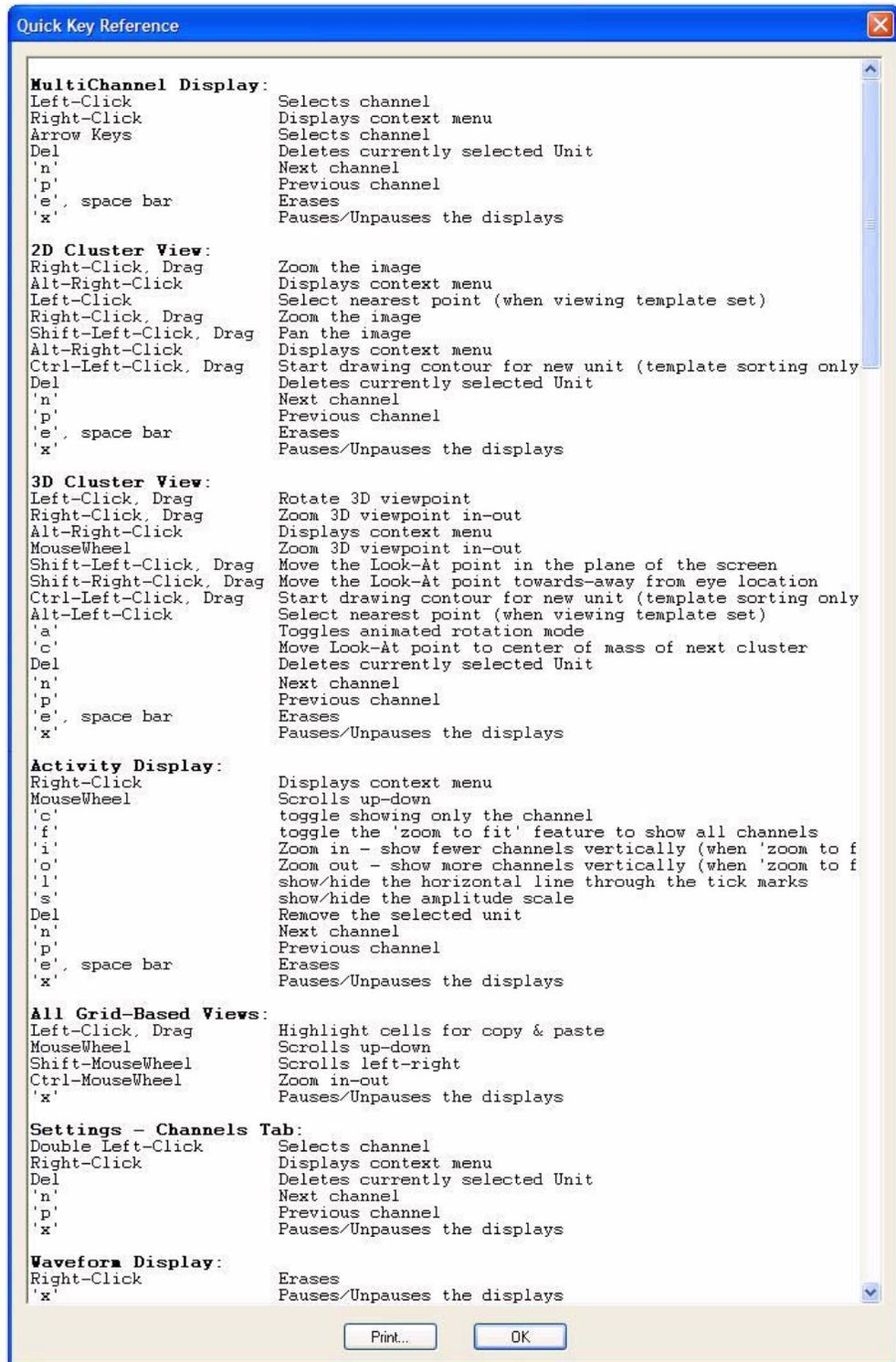
2.4.12.9.1 Help Topics: This item opens the online PDF version of this manual.

2.4.12.9.2 Quick Reference: This item opens the Quick Reference list illustrated on the following page.

2.4.12.9.3 About SortClient: This item opens the **About SortClient** window, which contains the version number and build date.



2.4.12.10 Sort Client Quick Reference List



Chapter 3

MAP Server

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3.4 MAP Server Main Display Window.....	143
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3.1 MAP Box Configuration

Plexon configures MAP Server software for each MAP system. For information on Server, see “[MAP Server Overview](#)” on page 141. However, if any changes are made to the MAP system, verify that the MAP Server settings match the MAP system configuration. The following items must match the MAP Server settings:

- Number of channels provided with the license key
- Number of SIG boards in the MAP box
- Number of DSP boards in the MAP box
- Number of digital input (DI) and output (DO) sub-boards on the DSP board
- Number and type of NI DAQ devices
- Device numbers assigned to NI DAQ devices in NI MAX
- Number of output connectors on the OUT board
- Link board: Host Link 2 (HLK2) or a Multisystem eXtension Interface (MXI)

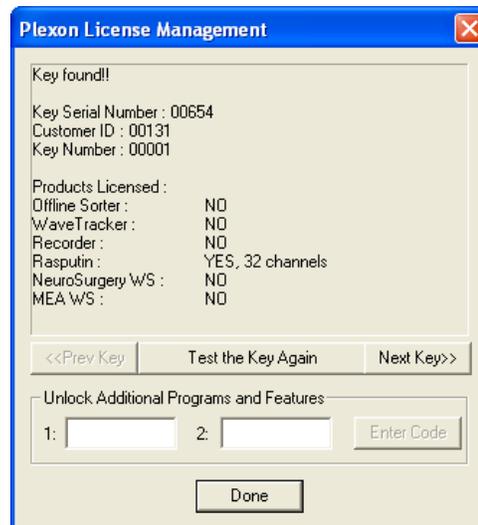
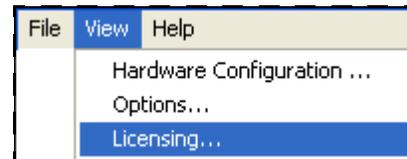
3.1.1 License Key

The software license key limits the number of channels That can be used.

To verify the number of licensed channels

- 1 Start Server. For instructions, see “[Startup](#)” on page 141.
- 2 From the **View** menu, click **Licensing**.

The Plexon License Management window opens.



- 3 In the **Plexon License Management** window next to **Rasputin**, observe and record the number of channels. The number of channels can be 16, 32, 64, 96, or 128.

3.1.2 Boards In the MAP

The following illustration shows a MAP box with a full complement of components for 128 channels. In most cases, MAP systems include an equal number of SIG and DSP channels. Each SIG board processes 16 channels. Each DSP board can process either 16 or 32 channels, depending on the configuration.



Verify the number of boards and channels on the MAP box

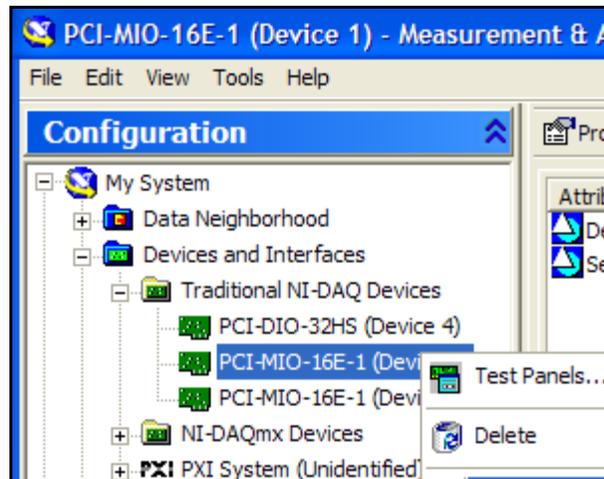
- 1 At the MAP box, count and record the number of SIG boards. Multiply the count by 16 to get the number of available SIG channels on the MAP box.
- 2 Remove each DSP board. For illustrations and board removal instructions, refer to the Plexon Guide [Setting Up MAP System Digital Input and Output, 01-01-C-3003](#). Count and record the number of processors at the rear portion of the card. A 16-channel DSP board has two processors; a 32-channel DSP board has four processors. Multiply the number of channels per board by the number of boards to get the number of DSP channels. In most cases, the number of DSP channels is equal to the number of SIG channels. For example, in the previous illustration there are four 32-channel DSP boards to match the 128-channel capacity of the MAP box.
- 3 Replace all the DSP boards except the board in the rightmost DSP slot, which is the DSP board that can support up to four digital input (DI) daughter boards or digital output (DO) daughter boards, or both. If daughter boards are present, count and record the number of DI daughter boards; DI boards are numbered "DI03nn" and they are normally located at the top of the DSP board. Also count and record any DO daughter boards; DO boards are numbered "DI01nn" and they are normally located below any DI boards.
- 4 Replace the rightmost DSP board.

3.1.3 Channel Count of the NI DAQ Device

The National Instruments (NI) data acquisition device (DAQ) can support a number of A/D channels, which can be different from the channel count on the MAP box. Use the NI software to verify the NI DAQ channel count.

To determine the device type using NI software

- 1 From the **Start** menu, locate the **National Instruments** folder and click **Measurement and Automation**.
- 2 In the **Measurement & Automation Explorer** window, expand the **Devices and Interfaces** folder. Record the device names.



- 3 Close the **Measurement & Automation Explorer** window.

A list of typical devices follows:

- PCI-6040E (250 kSamples/sec, 16 channel, 12-bit resolution)
- PCI-6070E (1.25 MSamples/sec, 16 channel, 12-bit resolution)
- PCI-6071E (1.25 MSamples/sec, 64 channel, 12-bit resolution)

3.1.3 Connectors On the OUT Board

To configure the RASPUTIN Software software, the number of connectors on the OUT board need to be entered. At the MAP box, count and record the number of connectors on each OUT board. For more information on the OUT board connectors, see [“Using Ref2 with the OUT Board” on page 160](#).

3.1.4 Link Board Type

To configure the RASPUTIN Software, the type of host-link board must be selected. At the MAP box, check the label of the link board in the rightmost slot. Determine if the host-link board is a host link 2 (HLK2) or a Multisystem eXtension Interface (MXI).

3.1.5 Configuration Consistency

The following chart shows consistent combinations of components. Before configuring MAP Server, verify the component counts and device types to make sure they match one of the following combinations.

Licence Key	SIGs	DSPs	NI DAQ
16	1	1 x 16	PCI-6040E or PCI-6070E
32	2	1 x 32 ch	PCI-6071E
64	4	2 x 32 ch	PCI-6071E
96	6	3 x 32 ch	PCI-6071E
128	8	4 x 32 ch	PCI-6071E

3.1.5.1 DSP Sub-Boards

The MAP box can support up to four digital signal processor (DSP) sub-boards on the first (rightmost) DSP board. The sub-boards can be either digital input (DI) or digital output (DO) boards. If the system includes DSP sub-boards, the DI sub-boards must occupy the DSP sections in prescribed orders based their mode settings. For more information on DSP sub-boards and strobed words, refer to the Plexon Guide [Setting Up MAP System Digital Input and Output, 01-01-C-3003](#).

3.2 MAP Server Overview

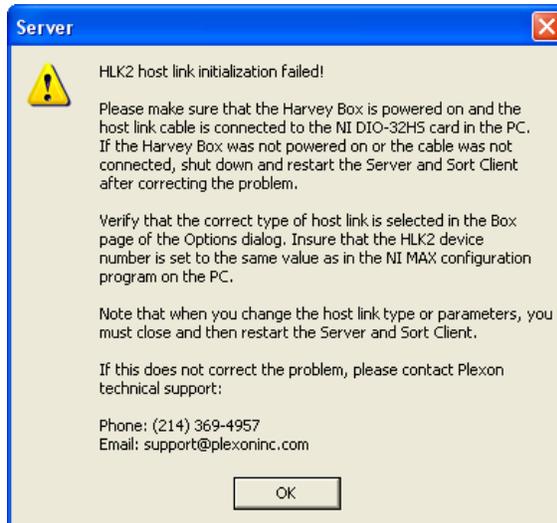
Plexon MAP Server (Server) interacts directly with the MAP box and establishes two-way communication between the MAP box and the various client programs on the PC, such as the Sort Client, PeriEvent Client, etc. Server transfers commands such as gain and filter changes or parameter settings from the various clients to the MAP box. Server distributes spike and continuous waveform data from the MAP box to the client programs. After Server is set up, very few changes are required under normal use.

3.3 Startup

Before Server can be run, the MAP system must be turned on. To run Server, double-click Server.exe in the directory where the RASPUTIN Software is installed, or double-click the Server desktop icon.



If an attempt is made to start Server with the MAP box (Harvey Box) turned off, the following warning appears. Shut down Server, turn the MAP box on, and then restart Server.



3.4 MAP Server Main Display Window

The accompanying illustration shows the Plexon MAP Server main display window.

3.4.1 Settings

The area below the menu displays information about the data transfer rates between the PC and the MAP box as follows:

3.4.1.1 kw/s

This setting means kilowords transferred per second (16-bit words)

3.4.1.2 ts/s

This setting means timestamps per second

3.4.1.3 wf/s

This setting means waveforms per second

3.4.1.4 MMF

The setting means Memory Mapped File—shows activity in the buffer that distributes data from the MAP to the RASPUTIN Software clients

3.4.1.5 NI

This setting contains the bandwidth of the continuous signals digitized by the NI DAQ device in kilosamples per second

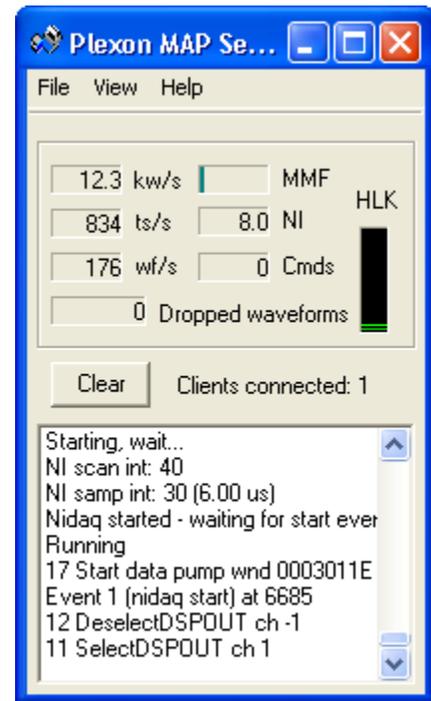
3.4.1.6 Cmds

This setting contains the number of commands waiting to be sent to the MAP box

3.4.1.7 Dropped waveforms

This setting contains the number of spikes (timestamps and waveforms) lost due to errors of data-transfer rate limitations; this value is 0 (zero) under normal conditions.

Note: This field shows the number of waveforms that Server drops because of limitations in the bandwidth of the host link. The older slower link is the MXI. The newer faster link is the HLK2. With the MXI, bandwidth limitations can occur when there are more than 64 channels and all the waveforms (not just the timestamps) are being recorded. This rarely occurs with the HLK2 due to its increased bandwidth. If this number is greater than zero, increase the size of the MMF. For more information, see [“Size of the memory-mapped file \(MB\)”](#) on page 150.



3.4.1.8 HLK

This setting shows the data transfer rate between the PC and the MAP box

The lower area of the window contains an action button, a client counter, and a scroll box:

3.4.1.9 Clear

Click the **Clear** button to clear the information in the scroll box at the bottom of the dialog-box window

3.4.1.10 Clients connected

This setting provides a count of the number of clients (Sort Client, Ref2, GAC, etc.) that are connected to Server

The lower panel includes a window that displays status information that can safely be ignored during normal operation.

3.5 Menu Commands

The following sections include information about each menu command.

3.5.1 File > Exit

Use the **Exit** command to shut down Server.

To shut down Server

- 1 Exit Sort Client and all other RASPUTIN Software client programs.
- 2 From the **File** menu, click **Exit**.

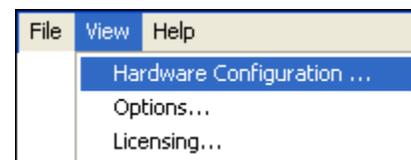


3.5.2 View > Hardware Configuration

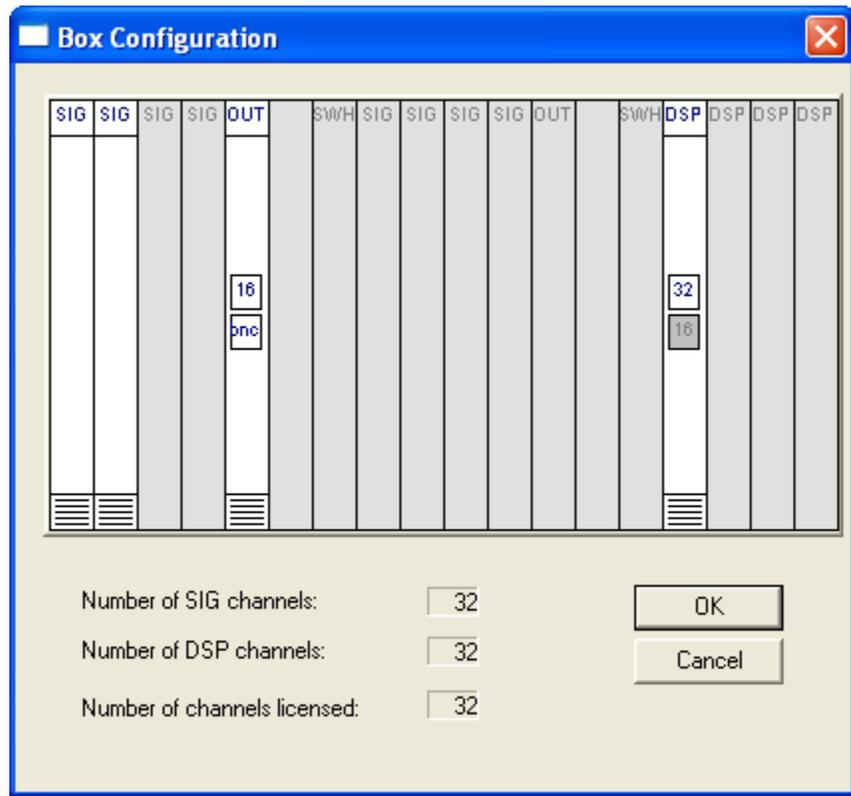
Use the **Hardware Configuration** command to change the MAP configuration.

To change the MAP configuration

- From the **View** menu, click **Hardware Configuration**.



A **Box Configuration** window similar to the following one opens.



Note: The **Box Configuration** window shows the current hardware configuration of the MAP box. The window shows the MAP slots and which type of circuit board occupies each slot. Activated boards are white; deactivated boards are gray.

3.5.2.1 Boards

Each type of board is represented by one of the following three-letter codes:

3.5.2.1.1 SIG: represents a 16-channel Signal (SIG) input board:

- SIG boards receive pre-amplified neural signals from a PBX or other preamp
- SIG boards provide programmable gain, filtering, and A/D conversion for 16 electrode channels
- SIG-board slots must be populated sequentially from left to right—click on the left-most SIG slot or SIG board to activate or deactivate it

3.5.2.1.2 OUT: represents an Output (OUT) board, which directs up to 20 input signals (after SIG board gain and filtering, but before A/D conversion) to continuous outputs on the faceplate of the board.

Note: The MAP system currently supports only a single OUT board for use with the first 64 channels.

Ref2 controls the assignment of the input channels to continuous output channels under program control. For more information, see [“Ref2” on page 155](#). The following items represent the connectors on the faceplate of the OUT board:

- **16** - represents the 16 analog-output channels on the 34-pin connector—click to activate or deactivate the 34-pin connector
- **bnc** - represents the four analog-output BNC connectors—click to activate or deactivate the four BNC connectors

3.5.2.1.3 SWH: represents a Switch (SWH) board that enables a subset of the SIG channels to be connected to the Digital Signal Processor (DSP) channels under program control—click to activate or deactivate the SWH boards.

Note: If there are more SIG channels than DSP channels, the MAP includes an SWH board.

3.5.2.1.4 DSP: represents a Digital Signal Processor (DSP) board that captures waveforms and performs spike sorting operations:

- Each DSP board contains either two (16-channel board) or four (32-channel board) Motorola digital signal processors; each processor receives 8 channels of A/D data from a SIG board—click **16** or **32** to select the number of channels. For more information on DSP-board processors, see [“Boards In the MAP” on page 139](#).
- Server represents the order of the DSP boards sequentially from left to right—click on the left most DSP slot or DSP board to activate or deactivate it. The actual boards in the MAP chassis are physically located sequentially from right to left.

3.5.2.1.5 Number of SIG channels: indicates the total number of Signal channels configured for the MAP box

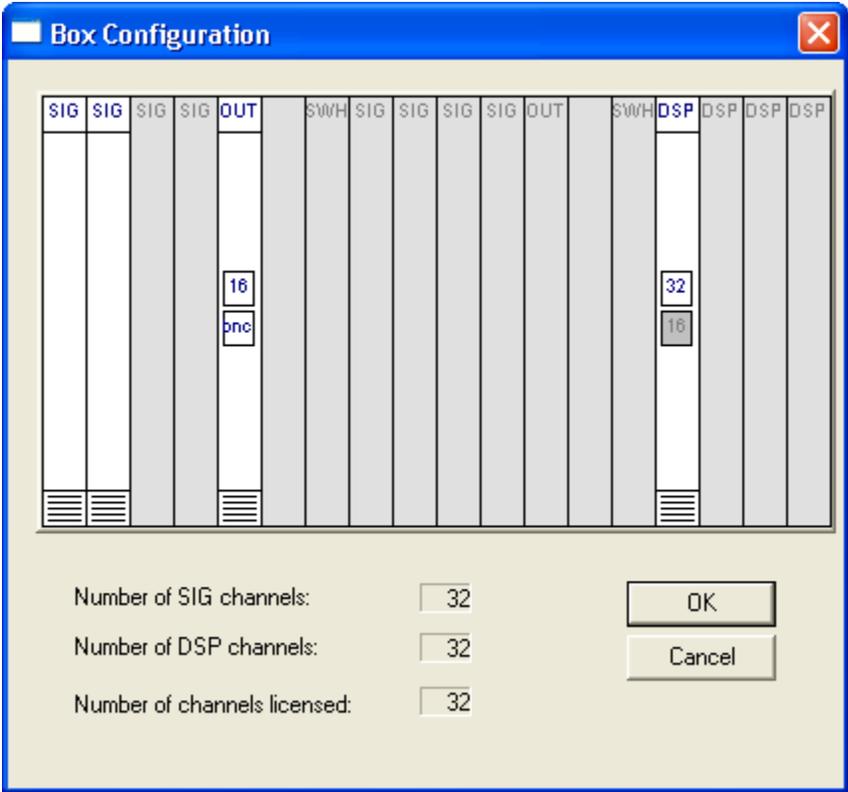
3.5.2.1.6 Number of DSP channels: indicates the total number of DSP channels configured for the MAP box

Note: For most hardware configurations, the number of SIG channels is equal to the number of DSP channels. If there are more SIG channels than DSP channels, the MAP includes an SWH board.

3.5.2.1.7 Number of channels licensed: indicates the total number of MAP channels that are licensed on the Sentinel hardware key mounted on the PC connected to this MAP box. For information on license keys, see [“View > Licensing” on page 154](#).

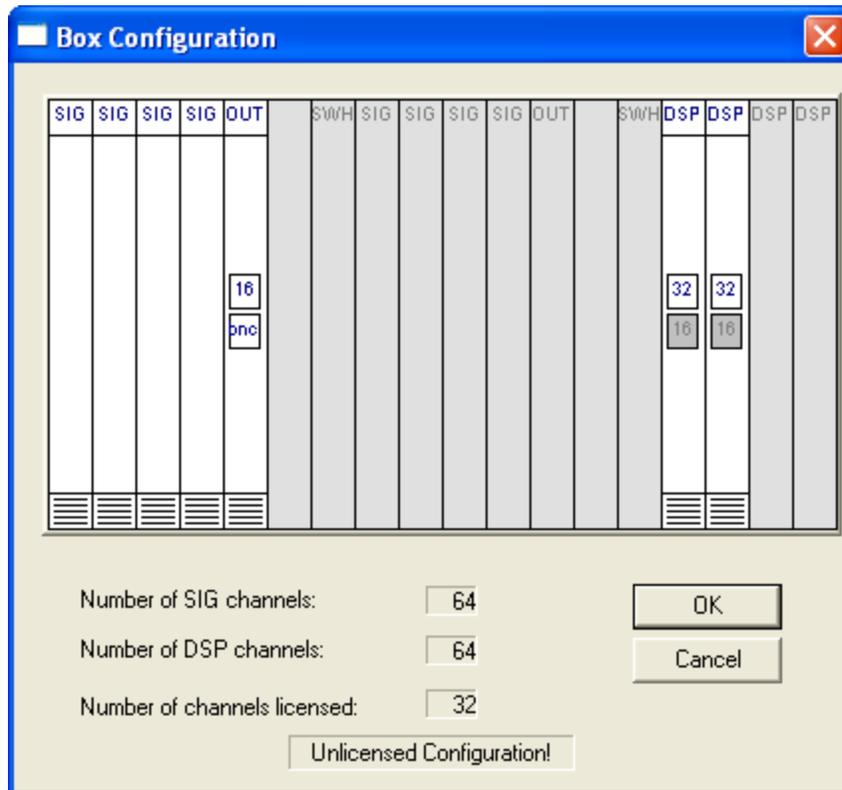
3.5.2.1 Example Hardware Configurations

The following illustration shows a **Box Configuration** window that represents a MAP system with a total of 32 licensed channels (32 channels each for SIG and DSP) with four BNC outputs and 16 non-BNC outputs.



The illustration that follows is a **Box Configuration** window that shows a MAP box with a total of 64 channels (32 channels each for SIG and DSP) with four BNC outputs and 16 non-BNC outputs.

Note: As the illustration that follows also shows, the user has attempted to activate more than the licensed number of channels. If there is an attempt to enable more channels than the license allows, a box with **Unlicensed Configuration!** appears. The MAP in the illustration is only licensed for 32 channels, not 64.

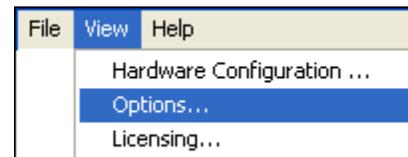


3.5.3 View > Options

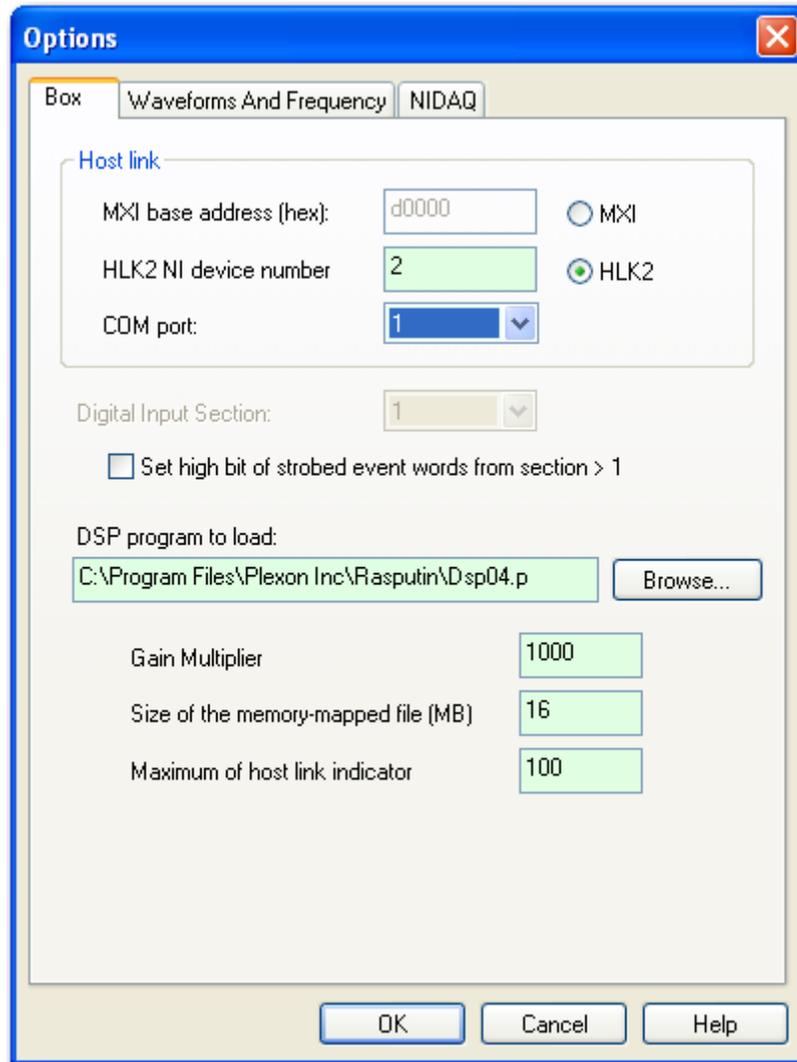
Use the **Options** command to open the **Options** window.

To change Server Options

- From the **View** menu, click **Options**.



The **Options** window opens with the **Box** tab selected.



3.5.3.1 Options: Box

The **Box** tab contains options that control the operation of the MAP box and the link to the host computer.

The **Host Link** area contains the following host-link settings:

3.5.3.1.1 MXI: If the MAP box has a Multisystem eXtension Interface (MXI) board, click **MXI**.

3.5.3.1.2 HLK2: If the MAP box has a Host Link 2 (HLK2) board, click **HLK2**.

3.5.3.1.3 MXI base address (hex): This field contains the address of the memory segment used by the MXI card to communicate with the MAP box; most PCs (Dell Dimension and Optiplex, Gateway, etc.) use d0000 and Dell Workstations use e0000.

3.5.3.1.4 HLK2 NI device number: This field contains the number of the National Instruments (NI) device that connects the PC to the HLK2 board. This number must be the same device number as the NI MAX utility reports for the NI 6533 device installed in the PC (older systems can report this as DIO-32HS instead of 6533).

Note: Server supports up to four NI DAQ devices plus the NI 6533. The HLK2 device and each NI DAQ device must be assigned unique device numbers. For example:

- the first 6071E is assigned as device number 1
- the second 6071E is assigned as device number 2
- the HLK2 is assigned as device number 3

For more information, see [“Options: NIDAQ” on page 152](#).

3.5.3.1.5 COM port: This field contains the serial communications (COM) port that connects the PC to the MAP box.

3.5.3.1.6 Digital Input Section: The default value for this setting is correct for most applications.

3.5.3.1.7 Set high bit of strobed event words from section > 1. For strobed words that originate from a DI sub-board located on a DSP2, DSP3, or DSP4, check this box to set the high bit to 1. When the high bit is set to 1, two strobed DI sub-boards are allowed, with one sub-board on DSP1 and one sub-board on DSP2, DSP3, or DSP4; the high bit of the strobed word indicates which strobed DI sub-board the event came from. For a more information, see [“DSP Sub-Boards” on page 141](#).

3.5.3.1.8 DSP program to load: This field contains the location and the name of the DSP program file (ends in a .p suffix).

3.5.3.1.9 Gain Multiplier: This field contains the gain multiplier, which consists of the headstage gain × the spike-preamp gain × SIG-board jumper gain setting. A typical gain configuration follows:

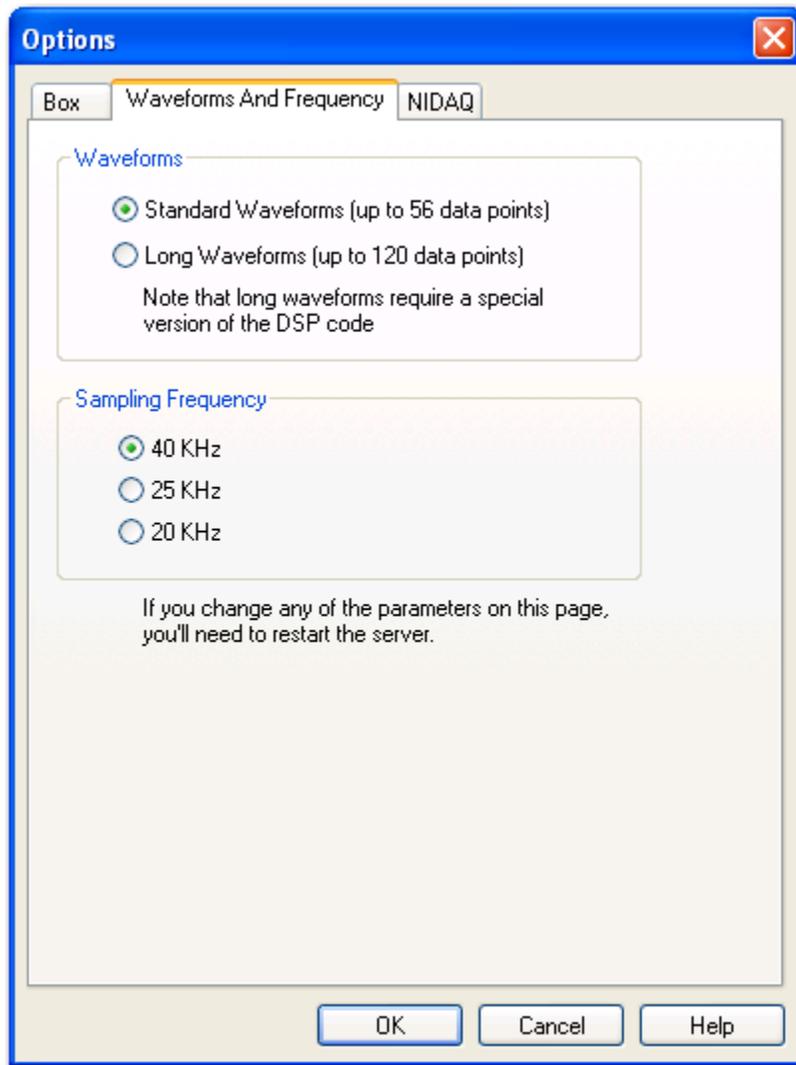
$$20 \text{ (headstage)} \times 50 \text{ (spike preamp)} \times 1 \text{ (SIG-board jumper)} = 1000 \text{ (Gain Multiplier)}$$

3.5.3.1.10 Size of the memory-mapped file (MB): This field contains the size of the circular memory buffer that Server makes available to the client programs; the default value is 16 MB.

3.5.3.1.11 Maximum of host link indicator: This field indicates the maximum relative value that the HLK bar represents in the Server main window. For more information on the HLK bar, see [“HLK” on page 144](#).

3.5.3.2 Options: Waveforms And Frequency

The **Waveforms And Frequency** tab contains options that control the maximum waveform length and the sampling frequency.



The **Waveforms** area contains the following options:

3.5.3.2.1 Standard Waveforms (up to 56 data points): Use this setting to sort action potentials of less than 1.4 milliseconds in duration and select 40 KHz (25 μ sec) in the **Sampling Frequency** area. This setting can be used with the standard DSP code.

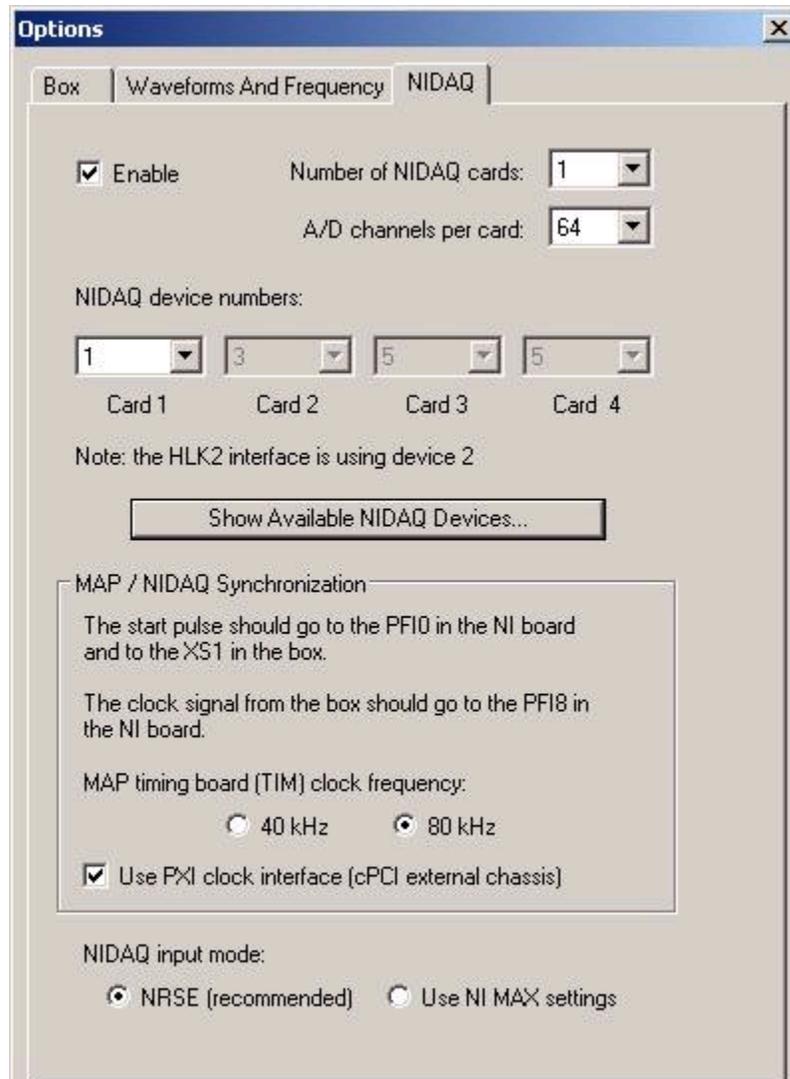
3.5.3.2.2 Long Waveforms (up to 120 data points): Use this setting for sorting action potentials greater than 1.4 milliseconds in duration. In the **Sampling Frequency** area, select a lower sampling frequency of 20 or 25 KHz. This setting requires a special version of the DSP code. For more information on this code, contact support@plexoninc.com.

The **Sampling Frequency** area contains the sampling frequency selections that correspond to the waveform selections in the **Waveforms** area.

Note: If any changes are made to the waveform and frequency settings, Server must be restarted along with any client programs that have been started.

3.5.3.3 Options: NIDAQ

The **NIDAQ** tab contains settings for the NI DAQ devices and wiring instructions for start pulse and clock signals.



3.5.3.3.1 Enable: If the system is using National Instruments Data Acquisition (NI DAQ) devices (cards) to record continuous signals simultaneously with the spike data from the MAP, **Enable** must be selected. This does not affect the NI 6533 device connected to the HLK2 board.

3.5.3.3.2 Number of NIDAQ cards: Enter the number of NI DAQ cards (devices) installed in the PC. Up to 4 cards may be installed, which must all be

the same model. When **Enable** is clicked, the default value 1 appears. Do not include the NI 6533 device (card) connected to the HLK2.

Note: Prior to adding or configuring a NI DAQ card, run the NI MAX procedure [“To determine the device type using NI software” on page 140](#) to get the correct device numbers.

3.5.3.3.3 A/D channels per card: Enter the number of A/D channels on the NI DAQ cards; 16 (default value) or 64, depending on the NI DAQ devices, for example:

- PCI-6040E (250 kSamples/sec, 16 channel, 12-bit resolution)
- PCI-6070E (1.25 MSamples/sec, 16 channel, 12-bit resolution)
- PCI-6071E (1.25 MSamples/sec, 64 channel, 12-bit resolution)

Note: All NI DAQ devices used for continuous data must be the same type. To determine the NI DAQ device type, see [“Channel Count of the NI DAQ Device” on page 139](#).

3.5.3.3.4 NI device numbers for NIDAQ cards: Select a device number for each NI DAQ device. Observe the note below the selection boxes and do not select the NI device number assigned to the HLK2 interface. If necessary, change the NI device number assigned to the HLK2 on the **Box** tab may be changed; see [“Options: Box” on page 149](#).

The device numbers selected must match the device numbers listed in NI MAX, otherwise, a warning can appear, which means that Server must be restarted.

3.5.3.3.5 Show Available NIDAQ Cards: This button displays a dialog box that shows the existing NIDAQ devices and their corresponding device numbers. If the device numbers do not match what the NIMAX program shows, set the device numbers as described in the previous paragraph.



3.5.3.3.6 MAP/NIDAQ Synchronization: This area contains instructions for connecting the start pulse and clock signals from the MAP box to the NI DAQ device. The default setting for the MAP timing (TIM) board is 40 kHz. If the TIM board is equipped with a mezzanine board, set the clock frequency to 80 kHz. If the system includes a MAP System Extender chassis, click **Use PXI clock interface (cPCI external chassis)**.

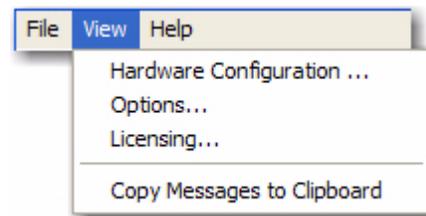
3.5.3.3.7 NIDAQ input mode: Click the analog input (AI) mode for the NI DAQ device. Plexon recommends the default **NRSE** (non-referenced single ended) setting. To enable alternative settings, set the device properties in NI Measurement and Automation Explorer (NI MAX) and click **Use NI MAX settings**.

3.5.4 View > Licensing

Use the **Licensing** command to view license information, test licensing keys, and unlock additional programs and features.

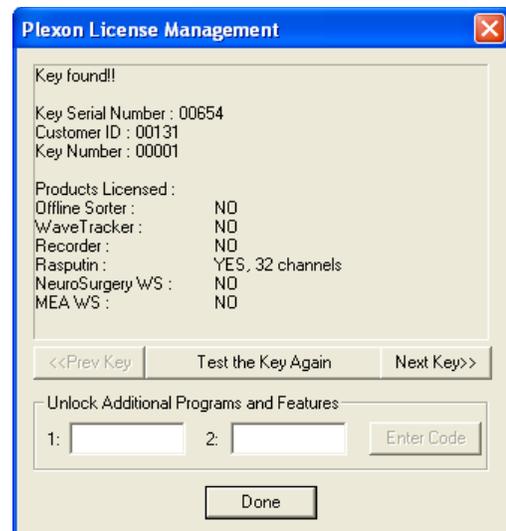
To view licensing information

- From the **View** menu, click **Licensing**.



*The **Plexon License Management** window opens.*

As shown in the illustration, the **Plexon License Management** window includes information on the current RASPUTIN Software license key and the keys for other Plexon products. This window can also be used to test keys and to enter new codes received from Plexon to unlock supplementary features.



3.5.5 View>Copy Messages to Clipboard:

copies the contents of the Server messages window into the Windows clipboard, so that it can be pasted into an E-mail or another file. Plexon Customer Support may ask to perform this function and E-mail the results to Plexon, as the messages can be useful in helping Plexon diagnose system problems.

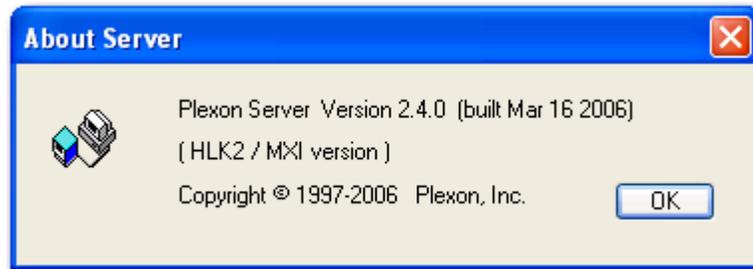
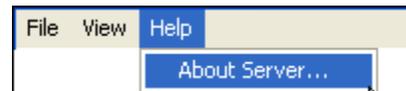
3.5.6 Help > About Server

When Plexon is contacted about MAP Server, the information in the **About Server** window will be needed. Use the **About Server** command to view the version and release information for the installed copy of Server.

To view Server information

- From the **Help** menu, click **About Server**.

*The **About Server** window opens.*



Chapter 4

Ref2

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- 4.7 Operating Ref2 with Multiple PBXs166
- 4.8 Ref2 General Information166

4.1 Overview

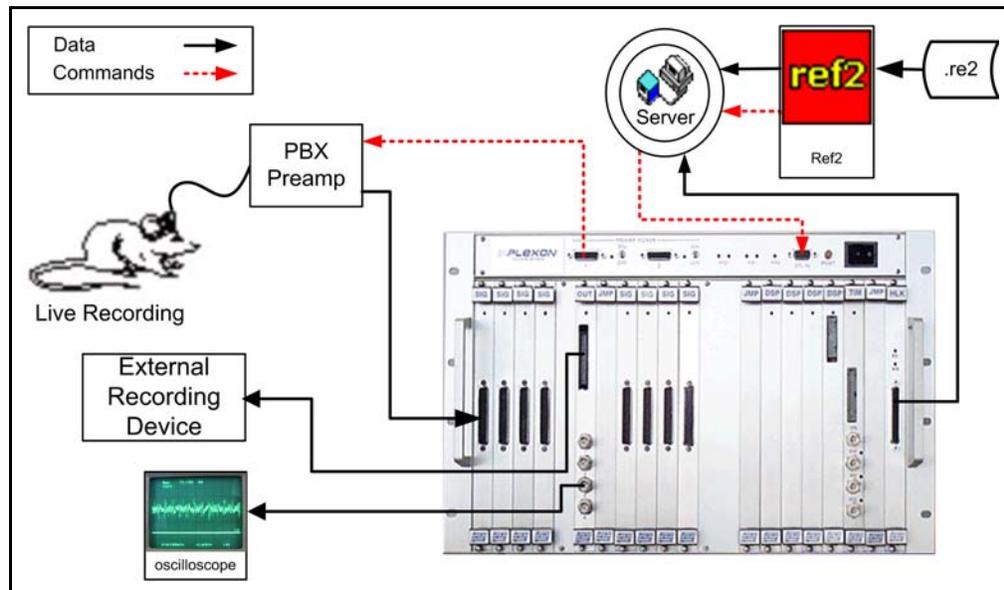
Ref2 v1.1 (06/06) (Ref2.exe) is a Windows XP program that can be used in conjunction with RASPUTIN Software Server and Sort Client. With Ref2, reference channels can be set up in the Plexon PBX and channels may be connected to the MAP system OUT board.

Referencing enables subtracting, or differencing, the signal on one channel from the signal on other channels. This can be a very effective way to remove noise or artifacts from otherwise acceptable signals. For more information on referencing, see [“Grounding and Referencing Basics” on page 169](#). Ref2 can:

- Create up to seven references.
- Control the programmable referencing boards in up to four PBX preamps.
- Assign references to spike and field potential channels.

Ref2 can also select individual channels and direct the output to the connectors on the faceplate of the OUT board; for more information, see [“Using Ref2 with the OUT Board” on page 160](#). Ref2 configurations can also be saved in a .re2 file for future use.

The following illustration shows a typical use of Ref2 with a programmable PBX preamp for referencing and an OUT board connected to an external recording device and oscilloscope.



Ref2 includes the functionality of the earlier Front End Client (FEC) program and completely supersedes it. In addition, Ref2 supports multiple PBX preamps and referencing for field potential channels. Ref2 is not compatible with FEC; do not run both programs simultaneously.

4.2 Using References in Ref2

Ref2 can assign references as follows:

- Spike (SP) channels can be references only for other spike channels.
- Field potential (FP) channels can be references only for other FP channels.
- References can be assigned only within the same programmable PBX preamp.

4.2.1 Assigning and Applying References

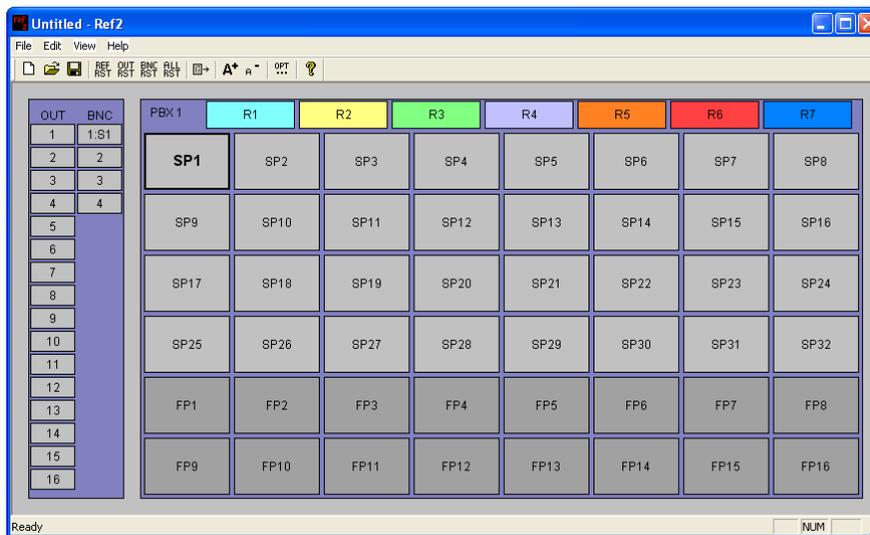
This example procedure shows how to use Ref2 to assign a channel as a reference, and then apply that reference to other channels to remove noise or artifacts from the signals.

Example procedure for using references

This example assumes that there is an artifact on spike channel SP12. The same artifact also appears on unused spike channel SP10. To remove the artifact, assign spike channel SP10 as reference R1, then apply reference R1 to spike channel SP12.

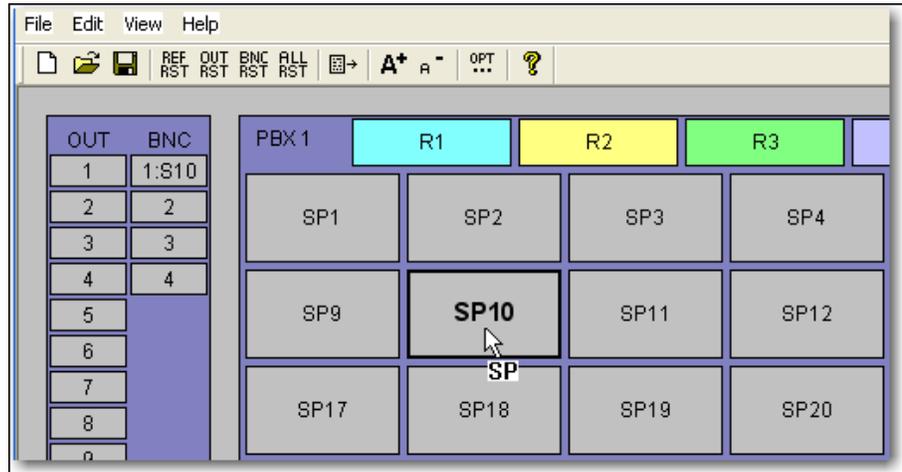
- 1 Double click on the Ref2 desktop icon to start Ref2.

*The **Ref2** window opens. The seven colored reference buttons are beneath the toolbar. The OUT and BNC connections are on the left side. The center area consists of a grid of channel buttons.*



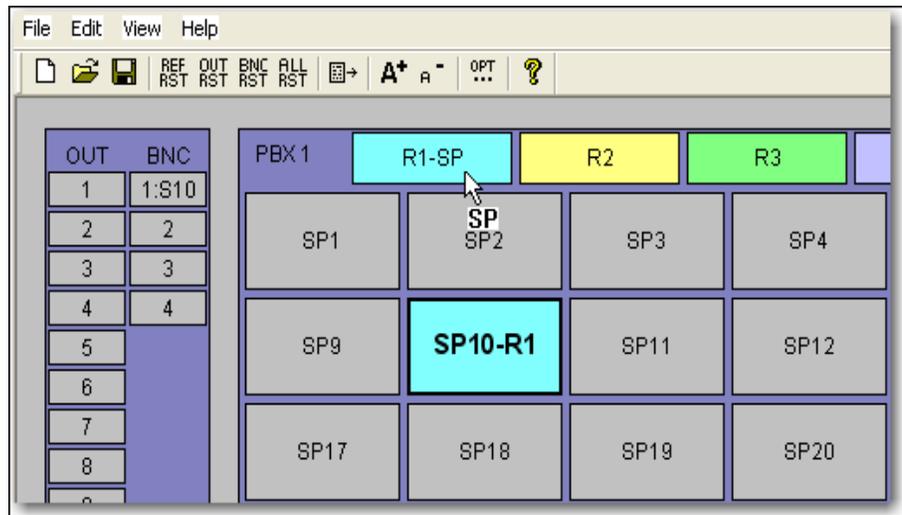
- 2 Click spike channel **SP10**.

*Ref2 adds the label **SP** to the mouse pointer to indicate a spike channel.*



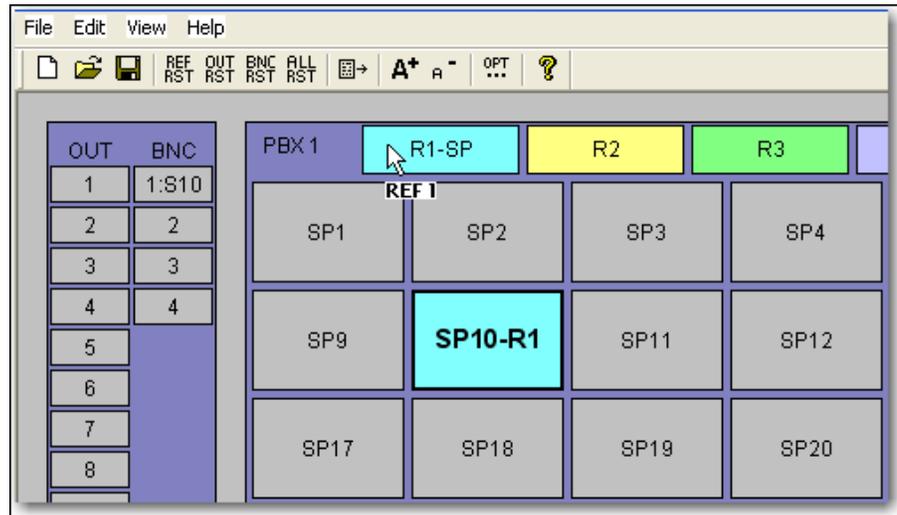
- 3 Move the **SP** pointer to reference **R1**. Click **R1**.

***SP10** changes label and color to indicate its assignment as **R1**. **R1** adds **SP**.*



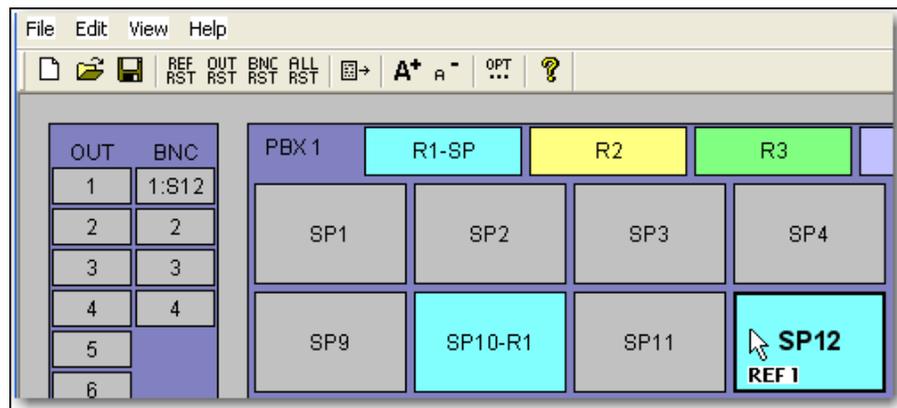
- 4 To apply reference **R1** to **SP12**, click **R1-SP**.

*The mouse pointer label changes to **REF1**.*



- 5 Move **REF1** to **SP12**. Click **SP12**.

***SP12** changes color to indicate reference **R1-SP** is applied.*



Note: It is possible to continue to move and click **REF1** to assign **R1-SP** to other channels. To clear the pointer label, right-click in the dark-blue background area or press the ESC key.

4.2 Using Ref2 with the OUT Board

The OUT board includes an LED, a 34-pin connector, and four BNC connectors. The LED flashes when connections are made with Ref2. It is possible to connect signals to the connectors on the OUT board as follows:

- Connect any spike (SP) channel to any pair of channel pins on the 34-pin connector. The connector channel numbers appear under **OUT**.
- Connect any SP channel to any BNC connector. The BNC connector numbers appear under **BNC**.
- Field potential (FP) channels cannot be connected to the OUT board because they are not processed through the MAP box.



4.2.1 Connecting Channels to the OUT Board Connectors

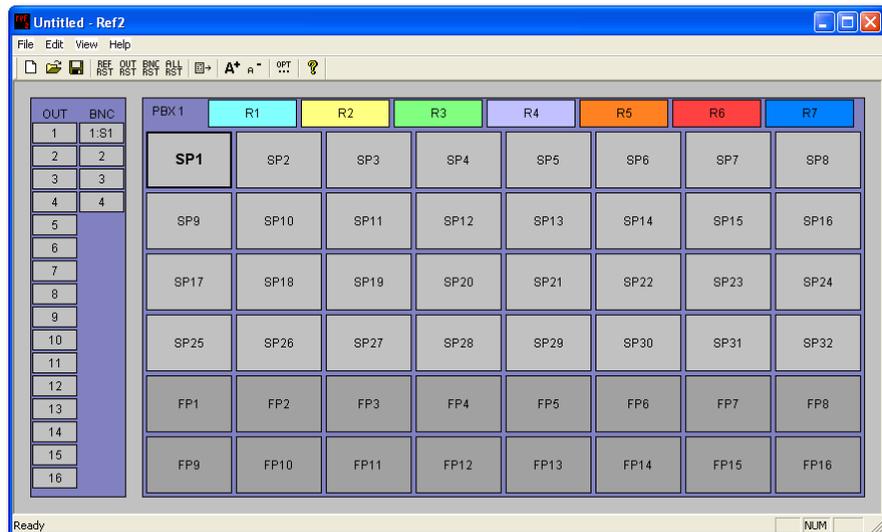
This example procedure shows how to use Ref2 to connect spike channels to the connectors on the OUT board.

Example procedure using Ref2 with the OUT board

This example assumes that the signals from spike channel SP10 through channel 1 on the OUT connector are being sent to an external device, and that an oscilloscope connected to BNC 1 is being used to view the SP10 signal.

- 1 Double click on the Ref2 desktop icon to start Ref2.

The **Ref2** window opens. The seven colored reference buttons are beneath the toolbar. The OUT channels and BNC connectors are on the left side. The center area consists of a grid of channel buttons.

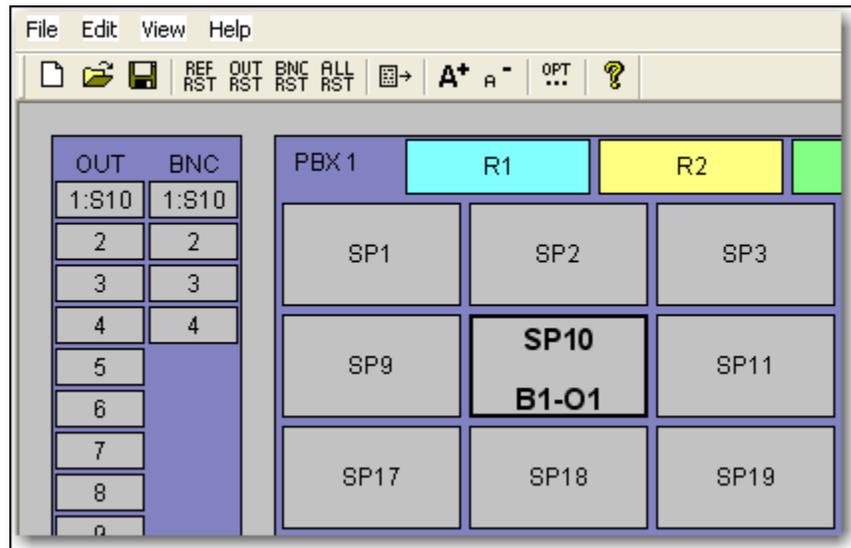


2 Click **SP10**.

*The mouse pointer label changes to **SP**.*

3 Move the **SP** pointer to channel 1 on the **OUT** list. Click **OUT 1**. Click **SP10**. Move the **SP** pointer to connector 1 on the **BNC** list. Click **BNC 1**.

*The **SP10** channel button shows its connections as **B1-O1**. **OUT** channel 1 and **BNC** 1 show connection **S10**.*



Note: If the Ref2 window is expanded, **B1-O1** in the preceding example expands to **BNC1-OUT1**.

4.3 Disconnecting and Resetting References

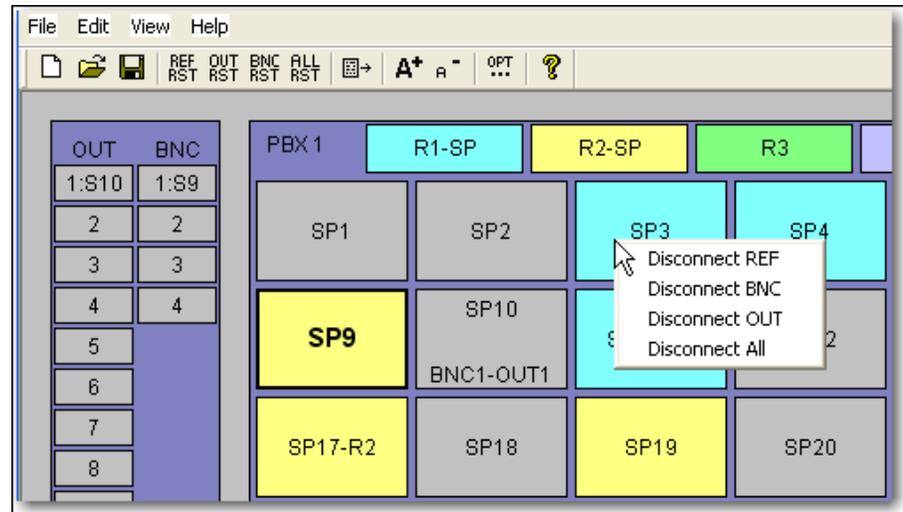
References can be connected one at a time, or all at once. References can be disconnected or reset in three ways:

- Disconnect a reference from a single channel.
- Disconnect a reference from all channels and clear the reference.
- Disconnect and clear all references at once.

Disconnecting a reference from a single channel

- 1 Move the pointer over the referenced channel and right click.

The disconnect menu opens.



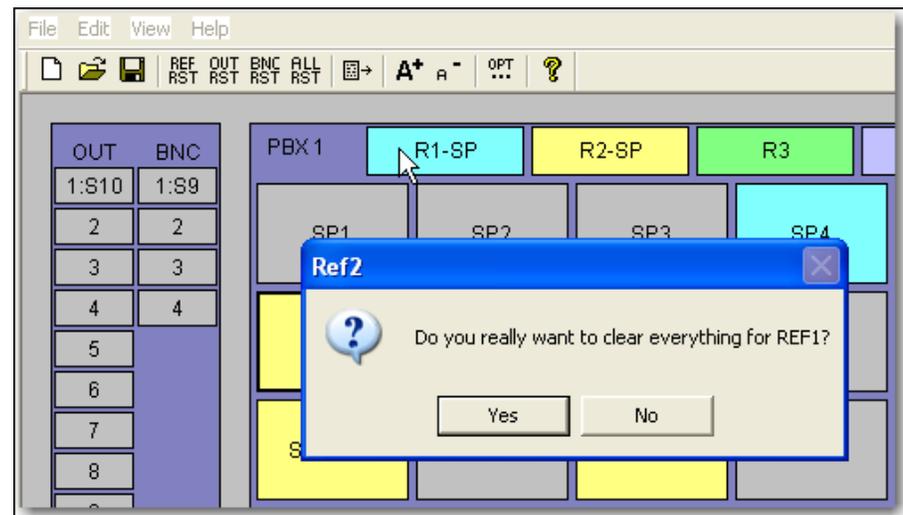
- 2 On the disconnect menu, click **Disconnect REF**.

The channel loses the reference color and returns to gray.

Clearing a reference button

- 1 Move the pointer over a reference and right click.

The following Ref2 dialog box appears.



- 2 To clear the reference assignment and all its applications, click **Yes**.

All channels with that reference applied return to gray. The reference button clears and becomes available for use with another reference channel.

Clearing all references at once

- Clear *all* reference channels and disconnect *all* reference assignments from *all* channels at the same time, click the **Disconnect all REFs** button on the toolbar.



Ref2 disconnects all reference applications and clears all channels from the reference buttons. All buttons in the channel grid return to gray. Connections to OUT channels and BNC connectors remain.

Note: The **Disconnect all** button performs the same action as the **Disconnect all REFs** button, but it also disconnects OUT channels and BNC connections. The **New (reset all)** button also resets all references and connections. For more information on these buttons, see [“Toolbar” on page 167](#).

4.4 Replacing References

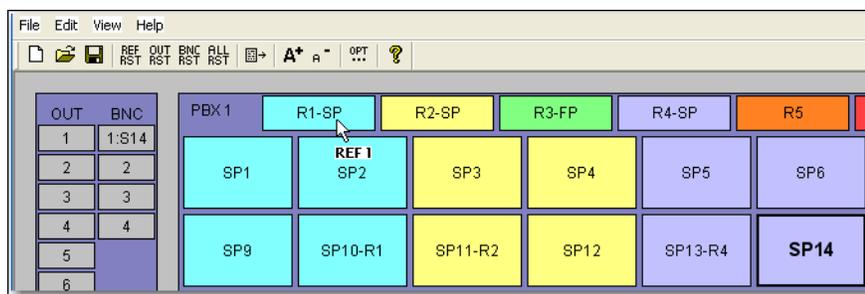
One reference may be replaced with another reference. When this is done Ref2 automatically updates all the referenced channels in the grid with the replacement reference.

Replacing one reference with another

This example shows how to replace reference R4 with reference R1.

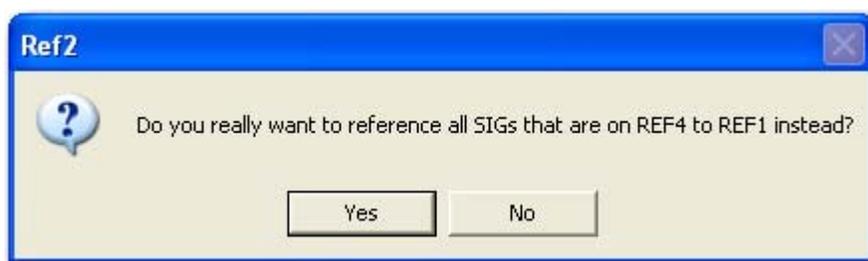
- 1 Click **R1**.

*The mouse pointer label indicates **REF 1**.*



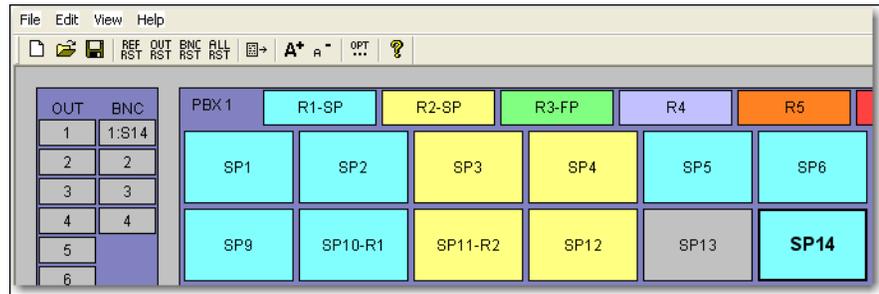
- 2 Move the mouse pointer to **R4**. Click **R4**.

*A **Ref2** dialog box opens to confirm the selection.*



Make sure the selection is correct, then click **Yes**.

The channels with the purple **R4** reference change to blue **R1**. The channel assigned as reference R4 (SP13) is clear.



4.5.1 Invalid Referencing

It is possible to make some invalid reference assignments that result in Ref2 warnings. The illustration shows a typical warning dialog box.



4.5 Setting Ref2 Options

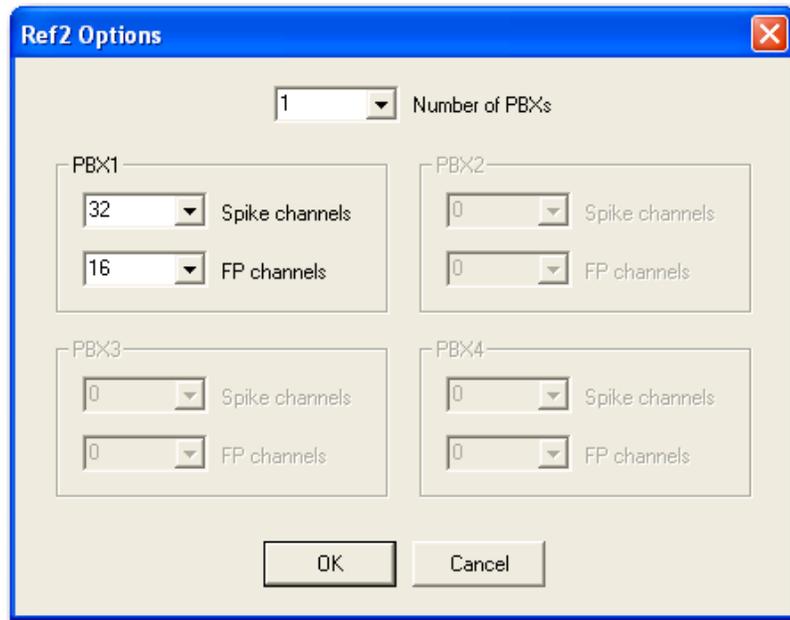
For most MAP systems, Plexon configures Ref2 to correctly match the number of PBX preamps and the number of programmable spike and field potential boards in each PBX. However, if the PBX hardware changes, the programmable preamp (PBX) settings in Ref2 must also change.

Changing PBX preamp settings

- 1 On the toolbar, click the **Options/PBX config** button.



The **Ref2 Options** window opens and shows the current settings.



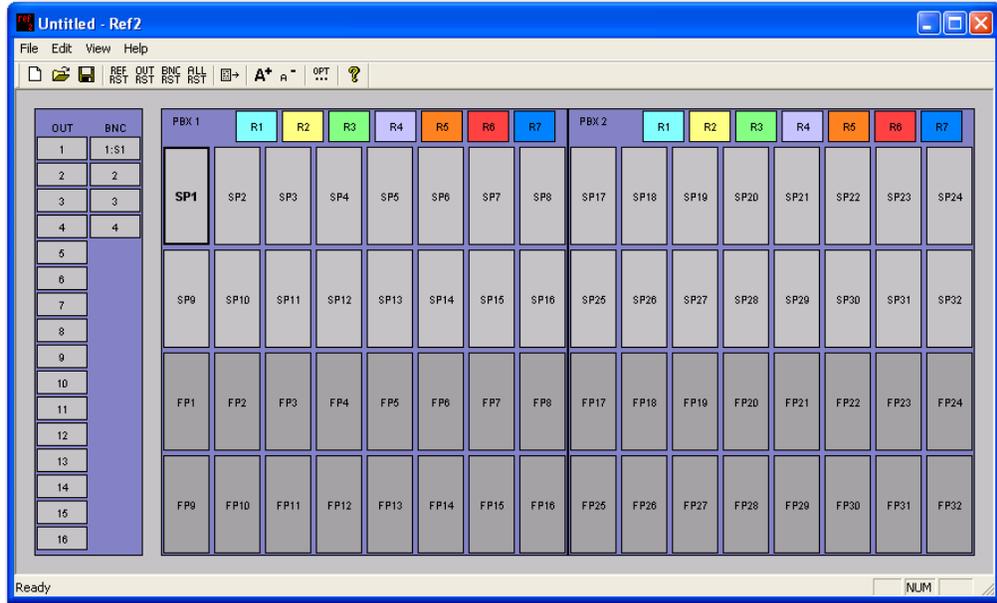
- 2 In the **Number of PBXs** box, select the number of PBX preamplifiers connected to the MAP system. The maximum Ref2 supports is four PBXs.
- 3 In each **PBXn** area, set the **Spike channels** box and the **FP channels** box to match the programmable boards in each PBX.
- 4 Click **OK** to close the **Ref2 Options** window.
- 5 Click **Yes** to close the **Ref2** advisory window. Restart Ref2.

4.6 Sort Client Interactions with Ref2

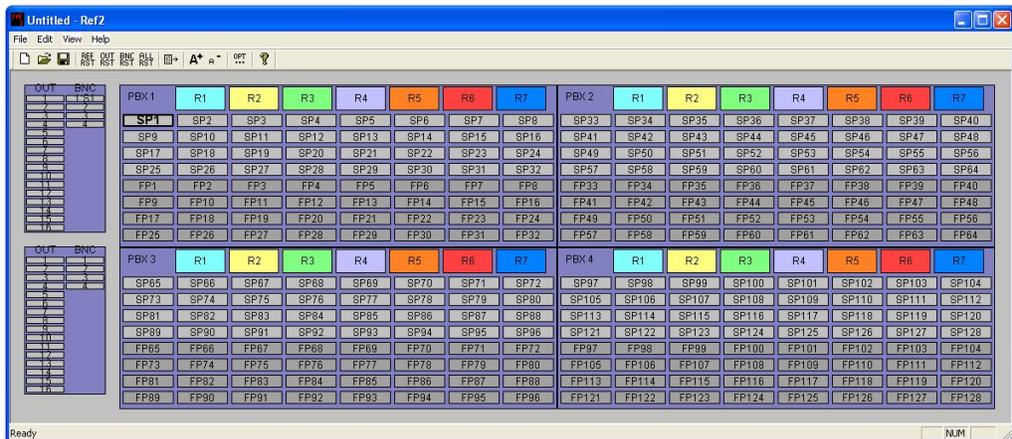
When a different SP channel in Ref2 is selected, Sort Client simultaneously switches to that channel in its main window; likewise, when a different channel is selected in the Sort Client Multichannel Display, Ref2 displays that channel as the selected channel. Ref2 also automatically assigns BNC1 to that same channel.

4.7 Operating Ref2 with Multiple PBXs

This section contains two examples of Ref2 configured for multiple PBXs. The following illustration shows Ref2 with a MAP that contains one OUT board and two PBXs each with 16-channel SP and FP boards.



The illustration that follows shows a MAP system configured to maximum capacity with two OUT boards and four PBXs. Each PBX contains two SP and two FP boards, for a total of 128 spike channels and 128 field potential channels. The maximum capacity of a MAP system is 128 spike channels. OUT board 1 only works with PBXs 1 and 2; OUT board 2 only works with PBXs 3 and 4.



4.8 Ref2 General Information

This section contains reference information for Ref2. It also includes some basic information on grounding and referencing for electrodes.

4.8.1 Toolbar

As shown in the following illustration, the Ref2 toolbar consists of four sections:

- File operations
- Connections
- Display appearance
- Configuration options



4.8.1.1 File Operations



4.8.1.1.1> New (reset all): Click to create a new .re2 file. This button resets all references and all connections, and resets the PBX preamps.



4.8.1.1.2> Open: Click to load a configuration file with the extension .re2. For more information, see [“Saving and Loading a Configuration”](#) on page 168.



4.8.1.1.3> Save configuration: Click to save all references and all connections to a configuration file.

4.8.1.2 Connections



4.8.1.2.1> Re-send commands: Normally, Ref2 issues commands to the MAP box and PBXs immediately as the commands are assigned, e.g. an SP connection to an OUT. However, to resend all the current settings to the MAP box and PBXs, click **Re-send commands**. Depending on the number of channels on the MAP, and the settings in the MAP Server options, it can take several seconds for Ref2 to send all the commands.



4.8.1.2.2> Disconnect all REFs: This command disconnects all references from SP and FP channels and clears all channels from all reference buttons. This button resets all referencing functions in the PBX.



4.8.1.2.3> Disconnect all OUTs: This command is similar to **Disconnect all REFs**, but it disconnects all OUTs from SP channels.



4.8.1.2.4> Disconnect all BNCs: This command is similar to **Disconnect all REFs**, but it disconnects all BNCs from SP channels.



4.8.1.2.5> Disconnect all: Click to clear all reference buttons and disconnect all OUTs, BNCs, and REFs.

4.8.1.3 Display Appearance



4.8.1.3.1> Larger fonts: Click to increase the font size in the boxes.



4.8.1.3.2> Smaller fonts: Click to decrease the font size in the boxes.

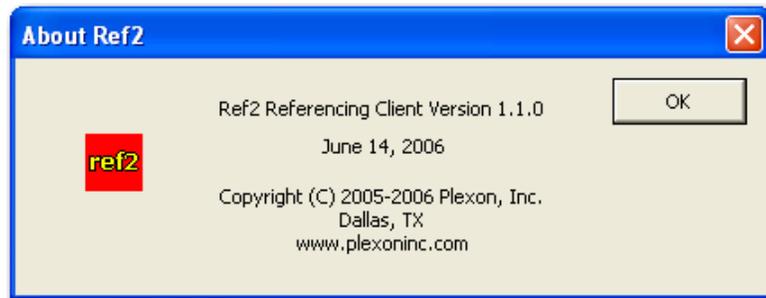
4.8.1.4 Configuration Options



4.8.1.4.1> Options: Click to open the **Ref2 Options** window. For information on setting Ref2 options, see [“Setting Ref2 Options” on page 164](#).



4.8.1.4.2> Help: Click to open the **About Ref2** window, which indicates the current version of the Ref2 and its release date.



4.8.2 Saving and Loading a Configuration

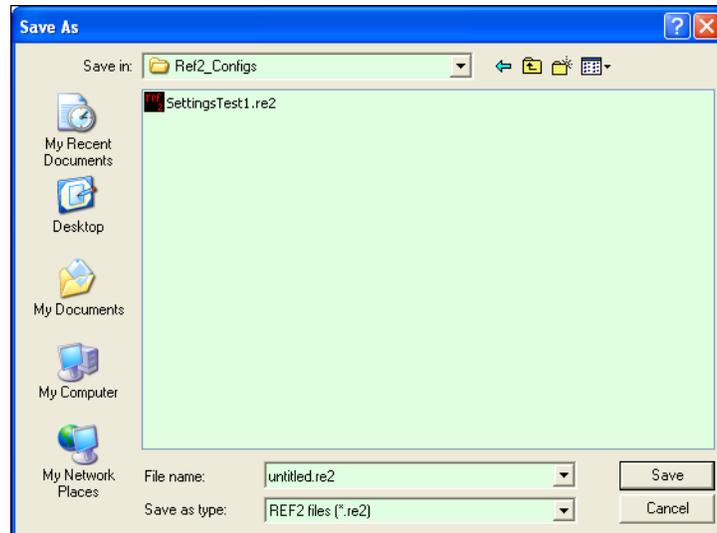
Current Ref2 settings may be saved and restored the configuration the next time Ref2 runs. Ref2 saves the following information in a .re2 file:

- the PBX configurations (number of preamps and the number of SP and FP channels per preamp)
- reference information (reference assignments and applications)
- OUT and BNC connections

Saving a Ref2 configuration

- 1 On the **File** menu, click **Save**.

*The Ref2 **Save As** window opens.*



Note: As the preceding illustration shows, Ref2 provides an icon for .re2 files to help locate them more easily.

- 2 Type a file name in the **File Name** box. Click **Save**.

Loading a Ref2 configuration

- 1 Start Ref2.
- 2 On the **File** menu, click **Open**.
- 3 In the **Open** window, click the desired configuration file, then click **Open** to load the configuration settings.

Ref2 opens with the window size and configuration settings from the .re2 file.

4.8.3 Grounding and Referencing Basics

This section includes some basic information on signal types, grounds, and referencing.

4.8.3.1 Signal Properties and Sources

Neural signals and noise can be roughly classified as follows:

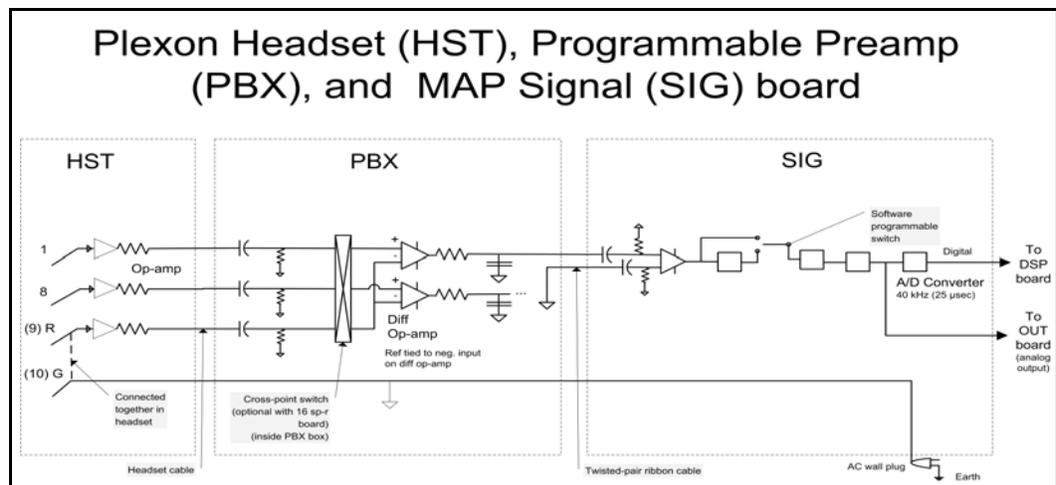
- Low-frequency signals, such as local field potentials (LFP), where the signal spectrum is typically below 200 Hz
- Mid-band signals, typically spike waveforms, where the signal spectrum is typically 300 Hz – 5000 Hz
- Low-frequency noise, such as 50/60 Hz AC hum, animal motion artifacts, etc., where the noise spectrum is typically below 100 Hz

- High-frequency noise, such as thermal noise, induced electrical noise, etc., where the noise spectrum varies with the source

4.8.3.2 Ground

An effective ground reduces noise by providing a reliable foundation for low-voltage signals.

4.8.3.2.1> Headstages and Preamps. As the following subset of the [MAP System Circuit Diagram](#) shows, Plexon systems provide a common ground throughout the signal path from the headstage (HST), through the preamp (PBX), and into the MAP box AC power supply. This illustration shows an example circuit for an 8-channel HST and a PBX that includes 16-channel spike boards with optional cross-point switches (PRA/16 sp-r) for use with Ref2. PRA/16sp-r boards are only available on PBXs with 1-pole filtering.



4.8.3.2.2> Headstage Ground and Referencing Links: The headstage (HST) section of the preceding schematic shows a link from the referencing pin [(9)R] to the ground pin [(10)G]. Plexon headstages can be configured to support a dedicated referencing electrode by disconnecting this ground link on the headstage circuit board. Headstages from Plexon may be ordered with the ground link connected, which are configured as grounded (GR), or with the ground link disconnected to provide a true referencing (TR) configuration. For more information on referencing, see “[Plexon Referencing Options](#)” on page 172.

All 8-channel headstages have links between the referencing and ground links. Sixteen- and 32-channel very-large scale integration (VLSI) headstages do not have links between the referencing and ground pins. Instead, these headstages have true referencing connections that pass through to the preamp. For more information, refer to the appropriate headstage pinout information and schematics at <http://www.plexoninc.com/Headstages.htm>.

A good ground connection from the ground pin (G) on the headstage to the brain is *very* important. Use one of the following methods to make a good ground connection to the animal:

- skull screws touching the brain
- a wire on top of the brain in underneath the dura
- a wire or guide tube actually in the brain

In general, all signal sources should be grounded. For a floating source such as a battery-powered amplifier, contact Plexon for assistance.



HINT

Grounding the apparatus

Animal Ground: One of the most important things to remember is to have the animal, or its stereotaxis, grounded at one point—at the PBX preamp. That is, the ground wire pin of the headstage (pin 10 on an 8-ch HST) can be used to ground the animal via a wire in the brain or skull screw, but then also using a clip lead from the stereotaxis to the ground jack on the front of the PBX. Plexon supplies a green ground wire for this purpose with each PBX. Unless unavoidable, do not connect other grounds to the animal or frame.

Some stereotaxis advancer mechanisms have insulating parts between the major metal mechanical parts, so *short* clip leads can be used to connect the pieces together. Make any ground leads as short as possible. Use alligator clips and cut wires to length so that the leads are very short. Use a multimeter to check the continuity to ground.

Support Structures: Make sure that the stereotaxis frame is either insulated from any underlying metal table and that the table is grounded, or use a non-conducting table. A metal table may be grounded to the third-prong (safety-ground) of a wall-socket. A metal table is a big 50/60 Hz sink and it must be grounded to the wall at one point.

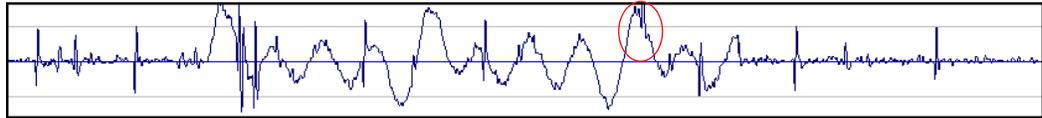
4.8.3.3 Referencing

With referencing, artifacts that can appear on several channels may be reduced or eliminated. Referencing is the subtraction or differencing of the signal on one channel from the signal on other channels. Referencing can be a useful way to remove artifacts from the signal on some channels. Artifacts are undesirable or unavoidable elements of a signal that usually result from animal activities extraneous to the experiment at hand. Typical animal behaviors that cause artifacts are chewing, scratching, or sudden head movements.

An example of artifact removal appears in the three illustrations that follow. The first illustration shows the signal from a spike channel, which includes a large

artifact that resulted from chewing—the red circle highlights a spike waveform superimposed on the artifact. The second illustration shows the signal from a suitable referencing channel, which includes the same artifact but does not include any spikes. The third illustration shows the spike channel after the signal on the referencing channel is subtracted from it, which removes the artifact—the red circle highlights the true spike waveform shape.

Channel 1: Spikes with a chewing artifact



Channel 2: Artifact only with no spikes (not connected to a neural signal source)



Channel 1 - Channel 2: reference applied to remove the artifact



The following guidelines apply to choosing and applying a referencing channel:

- The signal on the referencing channel cannot include significant spike activity.
- The referencing channel must include the same artifact that appears on the target channels.
- The artifact must be the same shape and phase on the referencing channel and the target channels.
- The artifact must be common to all target channels.

4.8.3.4 Plexon Referencing Options

The Plexon MAP system provides the following referencing options:

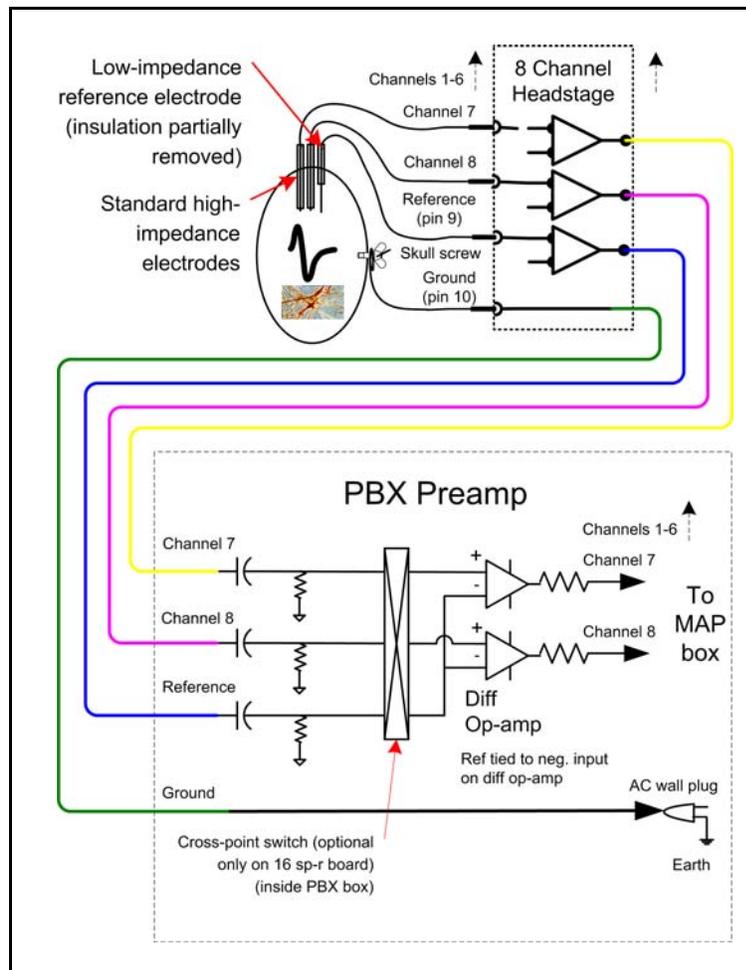
- 1 Hardware referencing with dedicated reference electrodes
- 2 Software-controlled referencing connections that can be selectively changed with Ref2 software

4.8.3.4.1> Hardware Referencing: To use hardware referencing, prepare a dedicated low-impedance electrode by removing the insulation at the tip to expose a larger area of the electrode surface. This effectively reduces the ability of the reference electrode to pick up signals from individual neurons without effecting its

ability to pick up the same noise and artifacts as the other electrodes attached to the headstage.

To use a dedicated referencing electrode, Plexon headstages can be modified by severing the link between the referencing pin and the ground pin, as described in [“Headstage Ground and Referencing Links”](#) on page 170. A dedicated reference electrode also requires settings in the preamp as shown on [page 174](#). The illustration that follows shows an example of an 8-channel headstage with a dedicated referencing electrode and separate ground connection that uses a skull screw. The electrode connections occur in the headstage but the referencing (or subtraction) occurs in the PBX preamp, where the signal from reference electrode is tied to the negative input of the differential operational amplifiers (op-amp) in the PBX. The cross point switch in this illustration is required to use Ref2; see [“Software-Controlled Referencing”](#) on page 175.

Example of a Dedicated Reference Electrode

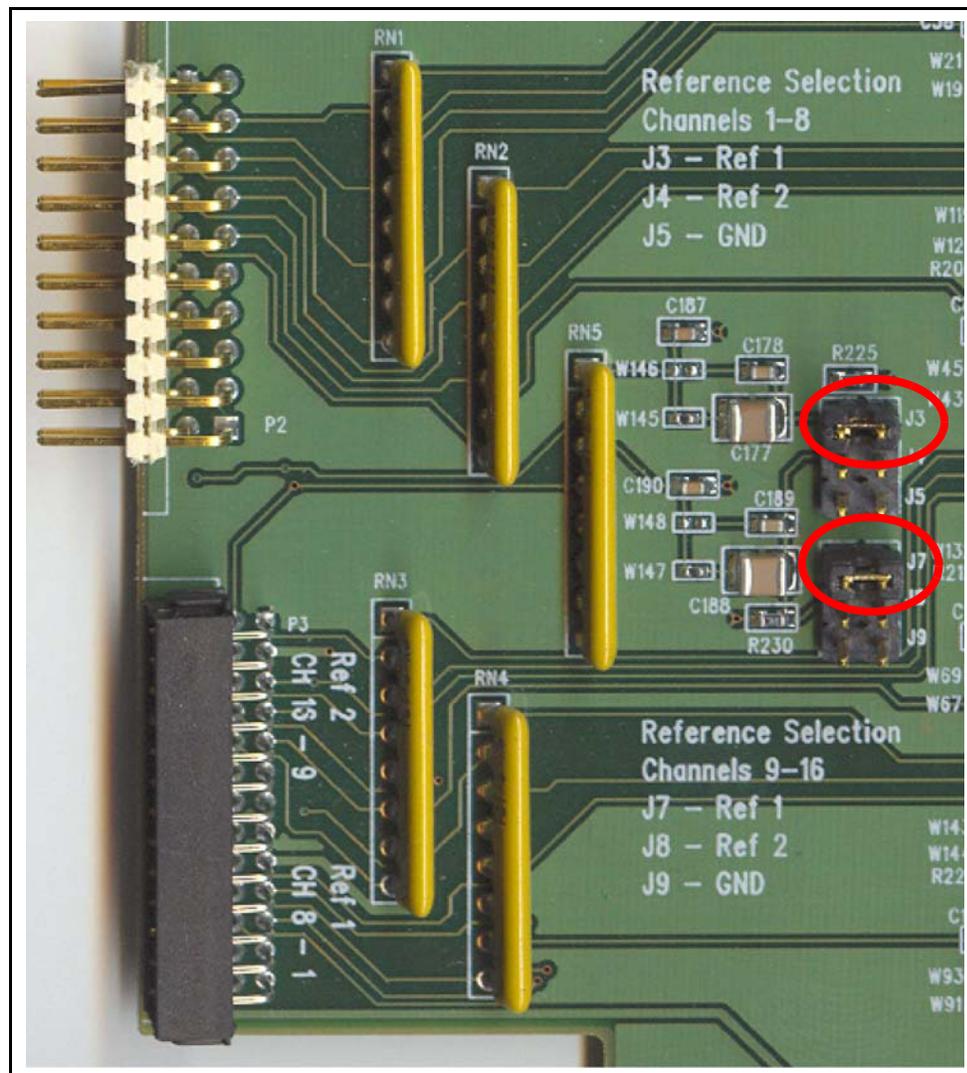


To use a dedicated referencing electrode, the jumpers on the PBX circuit boards must be correctly set. There are two types of PRA signal boards in Plexon PBXs:

- PRA2/16, with 2-pole low-cut and 4-pole high-cut filtering, and no programmable referencing (PRA-F type printed circuit board)
- PRA/16-r, with 1-pole low-cut and 1-pole high-cut filtering, with cross-point switches for programmable referencing (PRA-E type printed circuit board).

The illustration that follows shows the PRA2/16 board. To use a dedicated reference electrode on an 8-channel headstage with the PRA2/16 board, in addition to severing the ground-to-reference link, place jumpers on pins J3 for Channels 1-8 and on pins J7 for Channels 9-16. This is the default jumper setting and Plexon ships all PRA2/16 boards with these jumpers in place.

PRA2/16 Board Jumper Settings for Dedicated Reference Electrodes

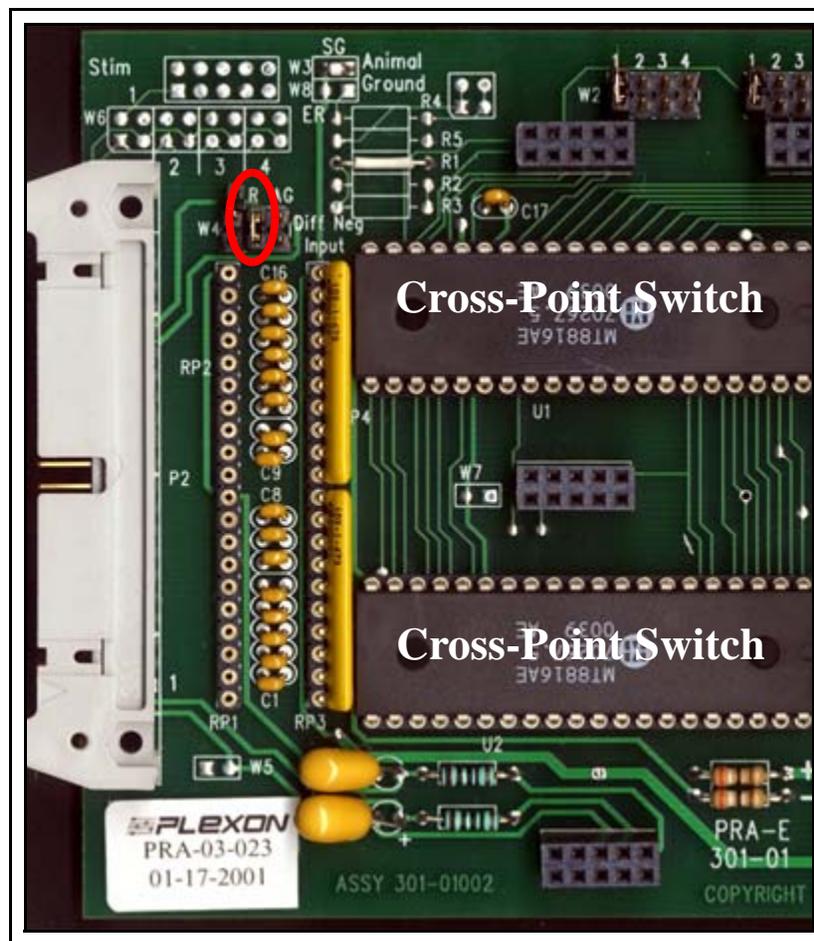


Note: Ref 2 in the preceding illustration refers to a second reference electrode—it does not relate to the *Ref2* software described in this chapter.

Ref 1 is the reference connection for headstage channels 1 through 8. Ref 2 is the reference connection for channels 9 through 16. In the preceding illustration, the Ref 1 setting applies to both the 8-channel and 16-channel headstages. That is, the reference connection for channels 1-8, which is pin 9 on an 8-channel headstage, applies to all channels from 1 to 16. With 32-channel headstages, both the Ref 1 and Ref 2 settings can be used. Plexon configures the headstage-to-PBX cables to provide the correct connections for all headstage and PBX combinations.

The following illustration shows the PRA/16-r board. To use a dedicated reference electrode with the PRA/16-r (PRA-E) board, in addition to severing the headstage link, a jumper must be in place across the R pins. Plexon ships all PRA/16-r boards with this jumper in place as the default setting.

PRA/16-r Board Jumper Setting for Dedicated Reference Electrode



4.8.3.4.2> Software-Controlled Referencing: The Ref2 software controls the cross-point switches shown in the preceding illustration. Ref2 requires PRA/16-r (PRA-E) boards with cross-point switches. Ref2 can allow setting the cross-point switches to select any electrode as a reference and subtract its signal from any other electrode, or combination of electrodes.

Note: If the reference connections on PBX circuit boards need to be changed to use other references, contact Plexon customer support for assistance.

Chapter 5

PLX Utilities

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5.1 Overview

PLX Utilities (PlexUtil) is a program for organizing .plx and .ddt data files. For complete information on these file formats, see [“Understanding PLX and DDT Data Files” on page 195](#). PlexUtil can:

- *scan* .plx files for errors and inconsistencies and repair the files
- *create subsets* of files that include:
 - all channels
 - the selection of spike, event, and continuous channels
 - the selection of start and end times
 - the choice of file name
- *split* files with the choice of the following options:
 - include all channels
 - include the selection of spike, event, and continuous channels
 - split the file into multiple files by:
 - channels
 - time
 - space
 - frames
 - the choice of file name
- *convert* the continuous channels of a .plx file to a .ddt file, and the .ddt file to a .plx file, which only contains continuous channels. The convert function provides the following choice of options:
 - all continuous channels
 - selected continuous channels
 - include all data
 - specify start and end times
 - the choice of file name
- *re-order* .plx files using either system temp or output directories
- *merge* two or more compatible files as follows:
 - data blocks by timestamps
 - consecutively with a time gap between files
 - the choice of file name

With all functions that accept a time input, the time in fractions of a second may be specified. The time entered in seconds is converted to timestamps. For example, if the data in a file is clocked at 40 kHz, the actual time resolution is 25 microseconds.

With all functions that accept a disk space (file size) input, the space in fractions of a megabyte may be specified. The resulting files are never larger than the size specified, which includes all headers and data. PlexUtil attempts to create the largest valid file, which is equal to or less than the size specified.

Any operation may be cancelled at any time. When an operation is cancelled, PlexUtil:

- cancels the activity
- deletes all output files
- deletes all temporary files
- provides a message describing the action

5.2 Opening, Scanning, and Repairing Files

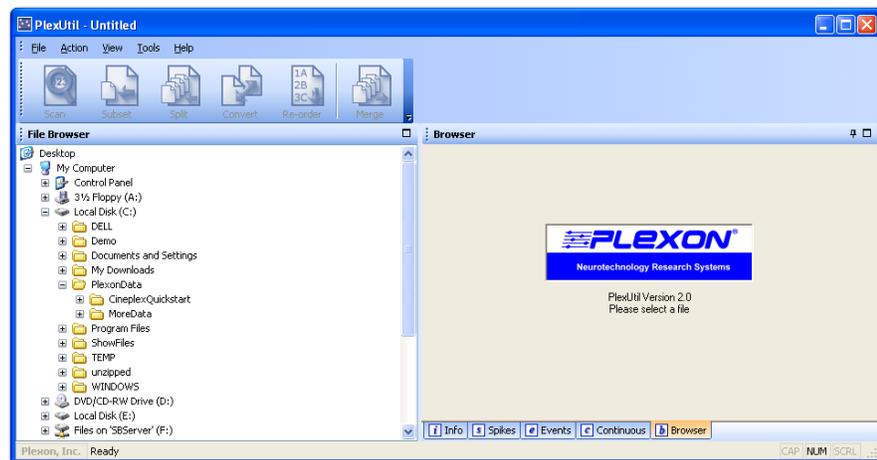
PlexUtil includes a file browser to locate .plx files on the computer or on a network. When PlexUtil starts, it opens with a file browser pane that includes the same view as in Windows Explorer. The PlexUtil toolbar buttons remain unavailable until a file is clicked.

To start PlexUtil and open a file

- 1 To start PlexUtil, double-click the **PlexUtil** icon on the desktop.



PlexUtil opens with the start screen.



- 2 In the PlexUtil **File Browser** pane, navigate to a .plx file and click on the file to open it.

*PlexUtil scans and opens the .plx file with a summary in the **Info** pane.*

Item	Header Value	Data Value
Plexon PLX File Name: C:\Documents and Settings\vrank\Desktop\PlexUtilMrgTst\plxUtilMergeTst.plx		
spikes: 204915, events: 751257, continuous: 1811614, bad: 3, warn: 1		
Size:	108.8M (114,064,438 bytes)	
Creation Time:	Wednesday, April 19, 2006 15:20:50	
Version:	103	
Comment:	V1 cell only / v1 stimulus / RF; -4.2, -4.3	
Acquired On:	Thursday, August 04, 2005 17:36:22	
Spikes Chs:	16	
Event Chs:	28	
Continuous Chs:	64 (enabled 3)	
Spike AD Frequency:	40,000 Hz	
Last Timestamp:	377,424,552 ticks (9435.61 seconds)	5,521,214,013,440 ticks (1.3803e+008 seconds)
Data Type:	Single Electrode	
Spike Bits/Sample:	12	
Continuous Bits/Sample:	12	
Spike Max Magnitude:	3000 mV	
Continuous Max Magnitude:	5000 mV	
Spike Pre-amp Gain:	unspecified	
Selected Spikes Chs:	1	
Selected Event Chs:	5	
Selected Continuous Chs:	3	

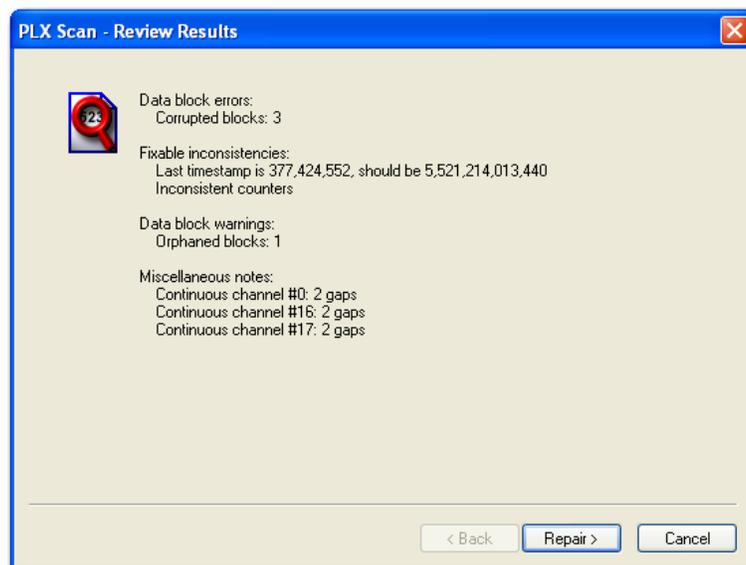
The **Info** pane displays three columns of information derived from three sources, which are highlighted as follows:

- Green: data from the file system; file size and creation time
- Yellow: data directly from file headers
- Red: information from actual data blocks, which is updated after scanning because PlexUtil automatically selects all channels with non-zero counts before scanning, then it updates the counts to reflect actual data.

Note: For complete information on the items that PlexUtil checks while doing a scan, see [“What Scan Does” on page 197](#).

- 3 After the file opens, PlexUtil provides a summary of the items found during the scan in the top right corner of the **Info** pane. To see a full report, click **Review**.

*The **PLX Scan - Review Results** window opens.*



Note: The review window contains a **Repair** button. For more information on repairing files, see [“What Repair Does” on page 199](#).

To proceed without repairing the file, click **Cancel** to close the review window.

- 4 To look at the contents of the file, click the tabs at the bottom of the right pane. The **Spikes**, **Events**, and **Continuous** tabs list the information in the same format as Sort Client. Scan updates the **Counts** and **Data Size** columns for more correct estimation of subsets or splits. The **Browser** tab shows the data blocks in numerical order with the following colors for each data type: Spikes = white, Events = yellow, and Continuous = green.
- 5 To close the file, click on any folder in the **File Browser** pane.

5.3 Creating a Subset of a File

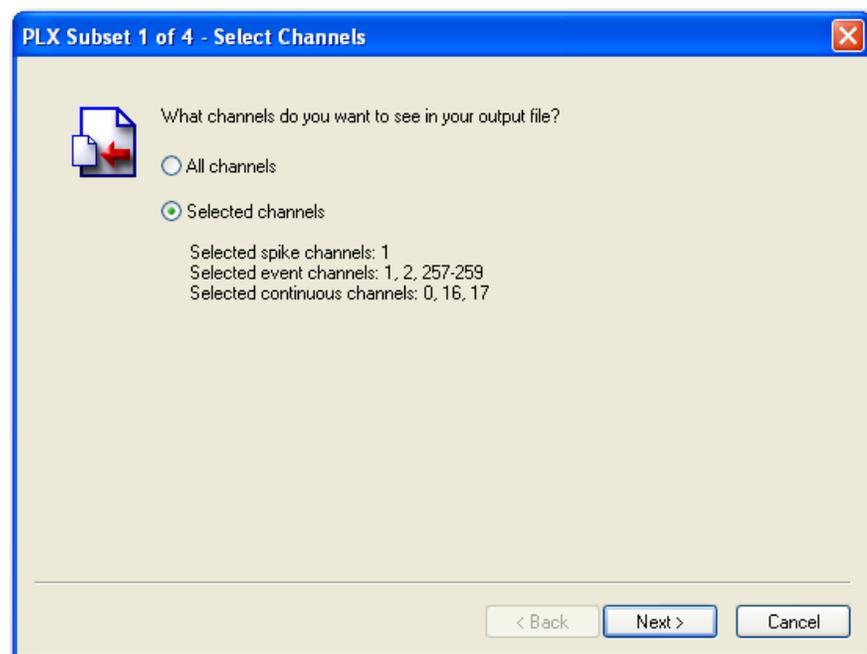
PlexUtil can create a new subset file of a .plx file. When the subset file is created, the original .plx file remains intact. It is possible to select which channels to include in the subset file, which part of the file to include in the subset based on start and end times, and the name and location of the new subset file. Numerous subset files can be created with different content and distinct names.

To create a subset of a file

- 1 Start PlexUtil. In the **File Browser** pane, click the file to create a subset of.
- 2 When the file opens, review the contents and make any repairs. For more information, see [“What Repair Does” on page 199](#).
- 3 If the subset of the file should only include certain channels, select those channels now; on the **Spikes**, **Events**, and **Continuous** tabs, select each channel to include in the subset of the file.
- 4 On the toolbar, click the **Subset** button.

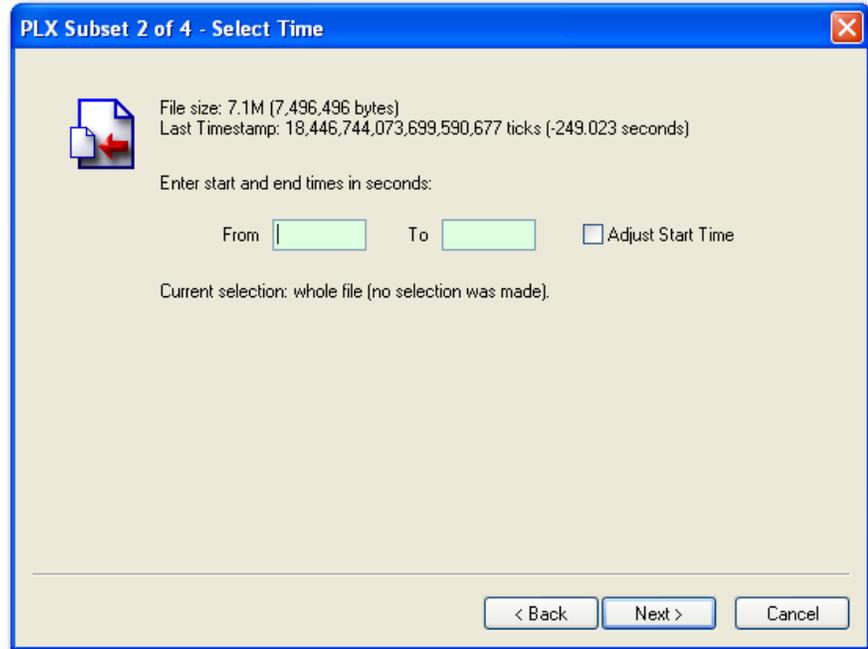


The **PLX Subset 1 of 4 - Select Channels** window opens.



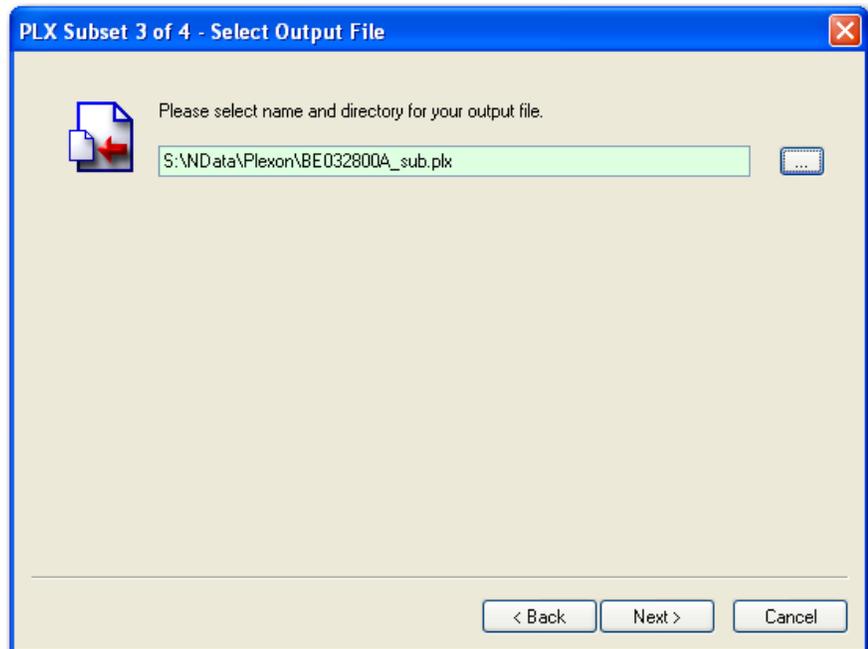
- To include all spike, event, and continuous channels, click **All channels**. To include only those channels selected in [Step 3](#), click **Selected channels**. Click **Next**.

The **PLX Subset 2 of 4 - Select Time** window opens.



- If only a portion of the file is to be based on time, enter the start and end times. To update the **Acquired On** time in the header of the subset file and to reset all timestamps accordingly, click **Adjust Start Time**. Click **Next**.

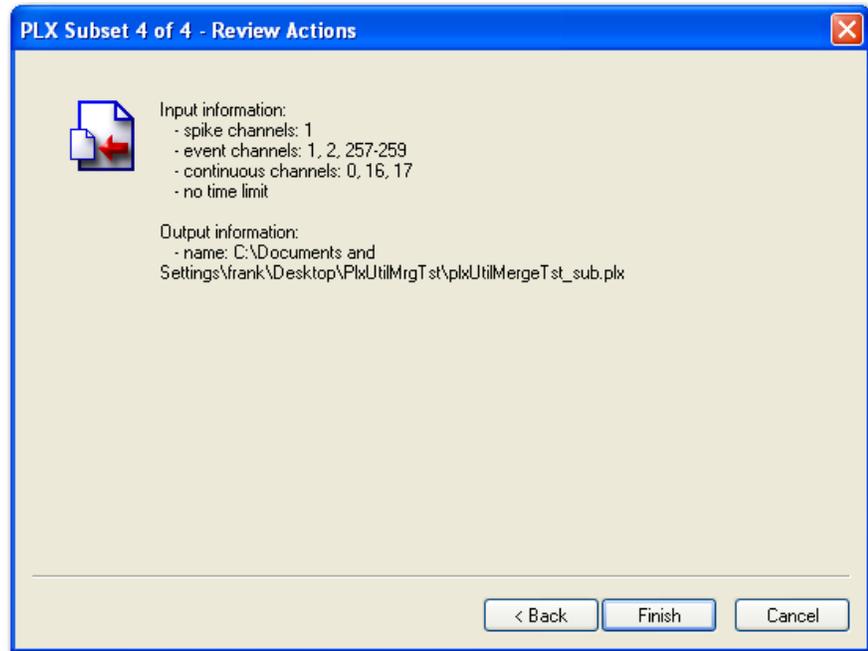
The **PLX Subset 3 of 4 - Select Output File** window opens.



Note: PlexUtil automatically adds **_sub** to the subset file name.

- 7 In the **PLX Subset 3 of 4 - Select Output File** window, type or select a location and a name for the subset file. To continue, click **Next**.

The **PLX Subset 4 of 4 - Review Actions** window opens.



- 8 Review the **Input Information** and **Output Information** areas to make sure PlexUtil creates the needed split files, then click **Finish** to create the file and close the subset window.

5.4 Splitting Files

PlexUtil can split a .plx file into multiple new files. When a split operation is completed, PlexUtil preserves the original .plx file and creates multiple new .plx files that include the characteristics specified. It is possible to specify which channels to include in the split files. Files may be split by:

- channels
- time slices in seconds
- file size increments in megabytes
- frame segments that are bounded by start and stop events

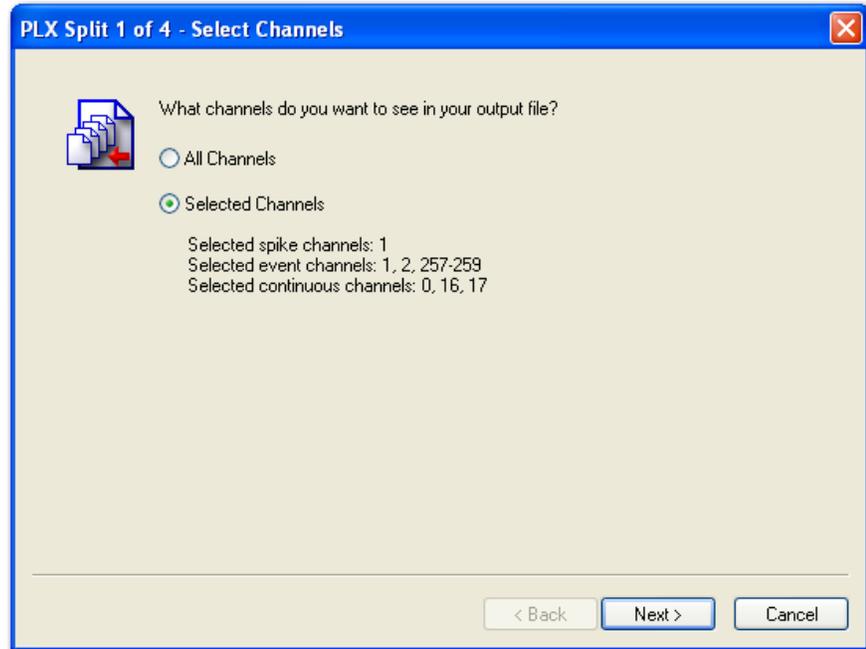
To split files by channels

- 1 In the **File Browser** pane, select the file to split.
- 2 When the file opens, review the contents and make any repairs. For more information, see [“What Scan Does” on page 197](#) and [“What Repair Does” on page 199](#).

- 3 If the split files should only include certain channels, select those channels now; on the **Spikes, Events, and Continuous** tabs, select each channel to include in the split files.
- 4 On the toolbar, click the **Split** button.

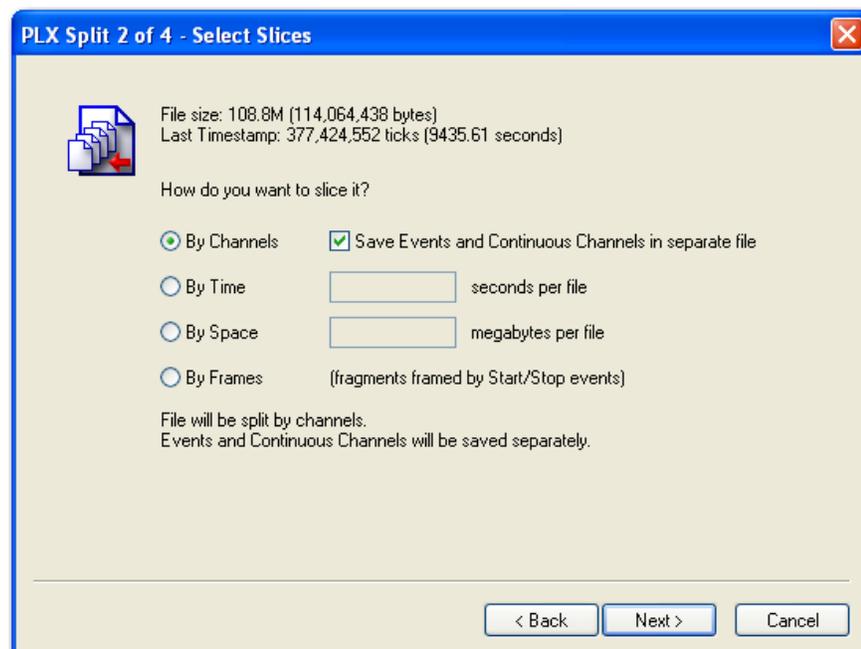


The **PLX Split 1 of 4 - Select Channels** window opens.



- 5 To include all spike, event, and continuous channels, click **All channels**. To include only those channels selected in [Step 3](#), click **Selected channels**. Click **Next**.

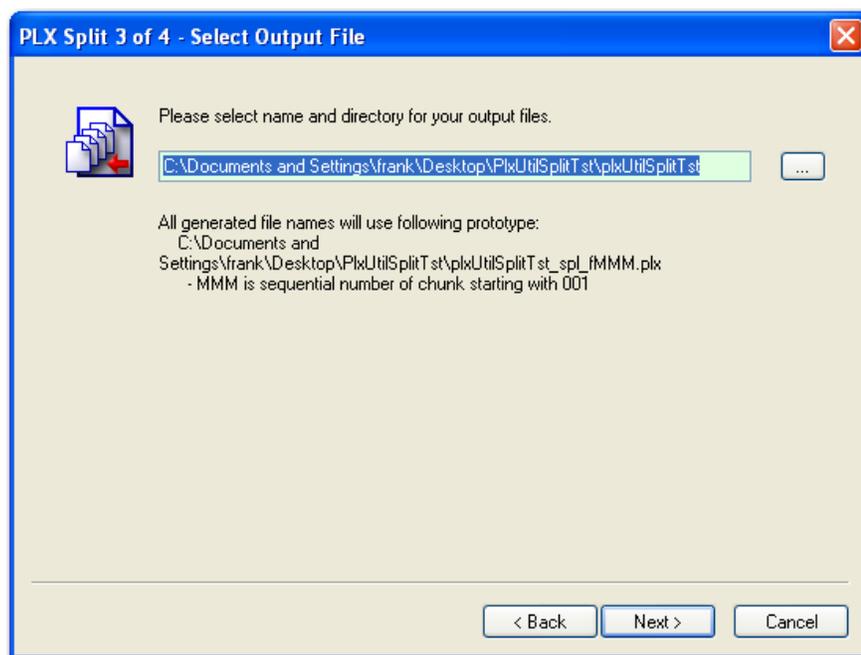
The **PLX Split 2 of 4 - Select Slices** window opens.



- 6 In the **PLX Split 2 of 4 - Select Slices** window, chose one of the following options:
- **By Channels:** Click to create a separate file for each spike channel. To create a separate file for all the non-spike channels, click **Save Events and Continuous Channels in separate file**. Otherwise, click to clear the check box to ignore the event and continuous channels. Each split-by-channels file is in the format myfile_spl_cNNN.plx.
- Note:** If channels are selected with 0 in the **Units, Unsorted, or Count** columns, PlexUtil initially sets up file names for these channels. These file names can appear briefly in the **File Browser** pane. When PlexUtil determines that there is no data for these channels, PlexUtil automatically deletes the file names.
- **By Time:** Click to create separate files based on time slices. Type the duration of each file in seconds. If the box blank is left blank, PlexUtil does not split the file. If a duration is entered that is greater than the initial file duration, PlexUtil does not split the file. Each split-by-time file is in the format myfile_spl_tNNN.plx.
 - **By Space:** Click to create separate files based on file size. Type the size of the files in megabytes. If the box blank is left blank, PlexUtil does not split the file. If a size is entered that is greater than the initial file size, PlexUtil does not split the file. Each split-by-space file is in the format myfile_spl_sNNN.plx.
 - **By Frames:** Click to create separate files based on start and stop events. Each split-by-frames file is in the format myfile_spl_fNNN.plx.

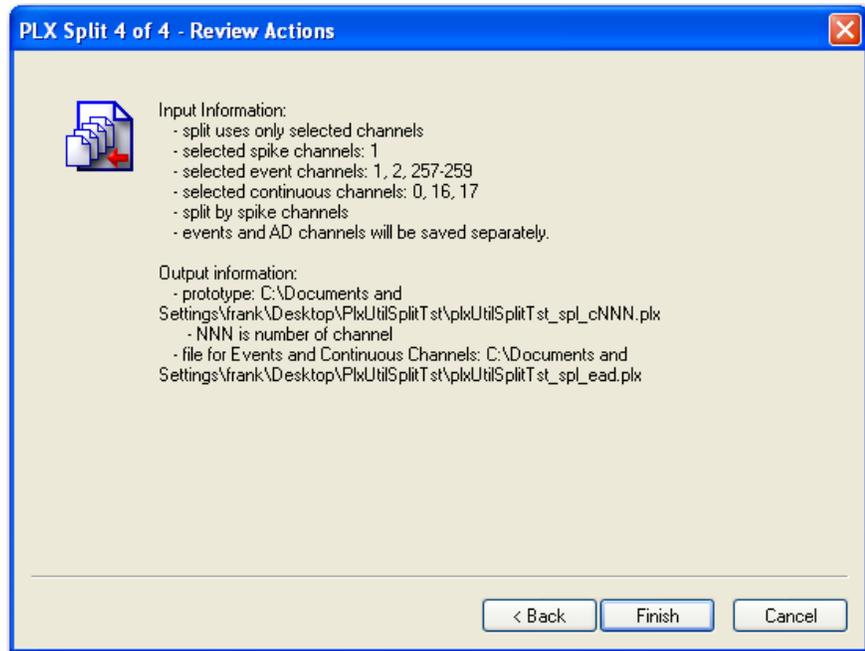
Click **Next**.

The **PLX Split 3 of 4 - Select Output File** window opens.



- 7 In the **PLX Split 3 of 4 - Select Output File** window, type or select a location and name for the split files. Click **Next**.

The **PLX Split 4 of 4 - Review Actions** window opens.



- 8 Review the **Input Information** and **Output Information** areas to make sure PlexUtil creates the split files needed. Click **Finish** to create the file and close the split file window.

5.5 Converting Files

PlexUtil can convert a .plx file into a .ddt file, or conversely, a .ddt file to a .plx file. When a file conversion is completed, PlexUtil preserves the original .plx or .ddt file and creates a new .ddt or .plx file that includes the characteristics specified. It is possible to specify which channels to include in the converted files and to specify a time interval to convert.



HINT

Repair data blocks before conversion

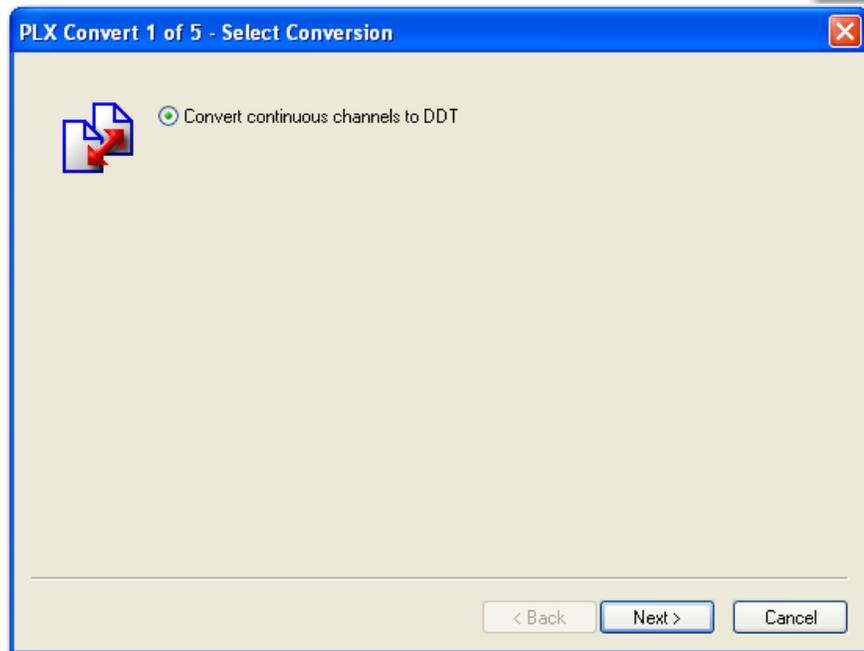
If the PlexUtil file scan reveals bad blocks when a file is opened, repair the data blocks before converting the file, otherwise the following error message can appear. For more information, see [“What Repair Does” on page 199](#).



To convert a file

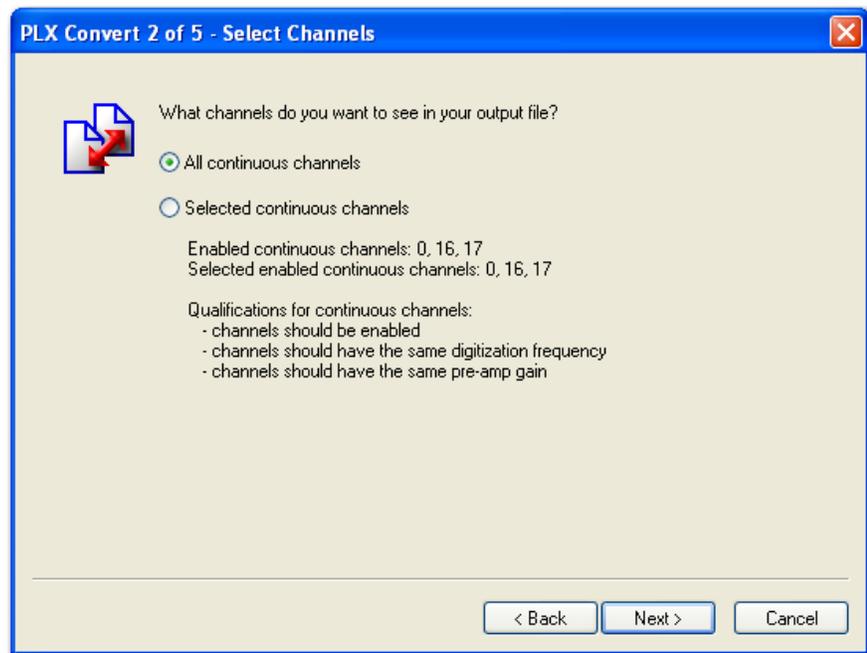
- 1 In the **File Browser** pane, select the file to convert, either a .plx file or a .ddt file.
Note: For simplicity, this procedure shows a .plx to .ddt file conversion. A .ddt to .plx conversion can also be done, which means the .plx file only contains continuous channels.
- 2 When the file opens, review the contents and make any repairs. For more information, see [“What Repair Does” on page 199](#).
- 3 If the converted file should only include certain channels, select those channels now; on the **Continuous** tab, select each channel that should be included in the converted file.
- 4 On the toolbar, click the **Convert** button.

The **PLX Convert 1 of 5 - Select Conversion** window opens.



Make sure that the file to be converted is correct, either .plx to .ddt or .ddt to .plx, then click **Next**.

The **PLX Convert 2 of 5 - Select Channels** window opens.



- 5 To convert all continuous channels, click **All continuous channels**. To convert only the channels selected, click **Selected continuous channels**.

Note: If the continuous channel data is inconsistent, the following messages can appear.



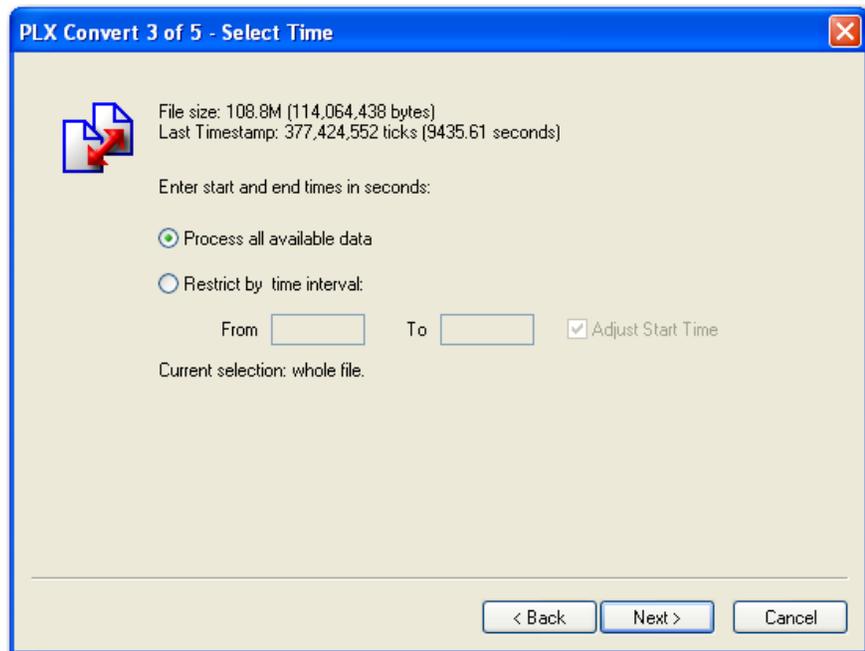
To avoid these problems, in the **Continuous** tab, make sure that the channels selected indicate:

- Enabled = yes
- Frequency = <the same for all selected channels>
- Preamp Gain = <the same for all selected channels>
- Count = <the same for all selected channels>

Note: Some .plx files can have disordered continuous data blocks that result in errors during conversion. This often happens with files that were converted to .plx from other formats. In these cases, it can be beneficial to re-order the .plx file before converting it to .ddt. For more information, see [“Re-Ordering Files” on page 191](#).

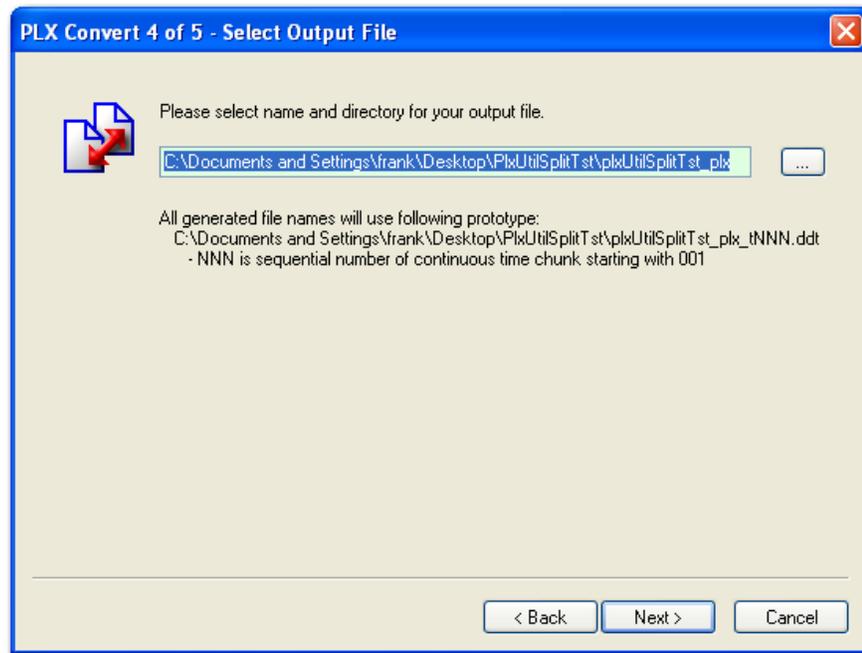
Click **Next**.

The **PLX Convert 3 of 5 - Select Time** window opens.



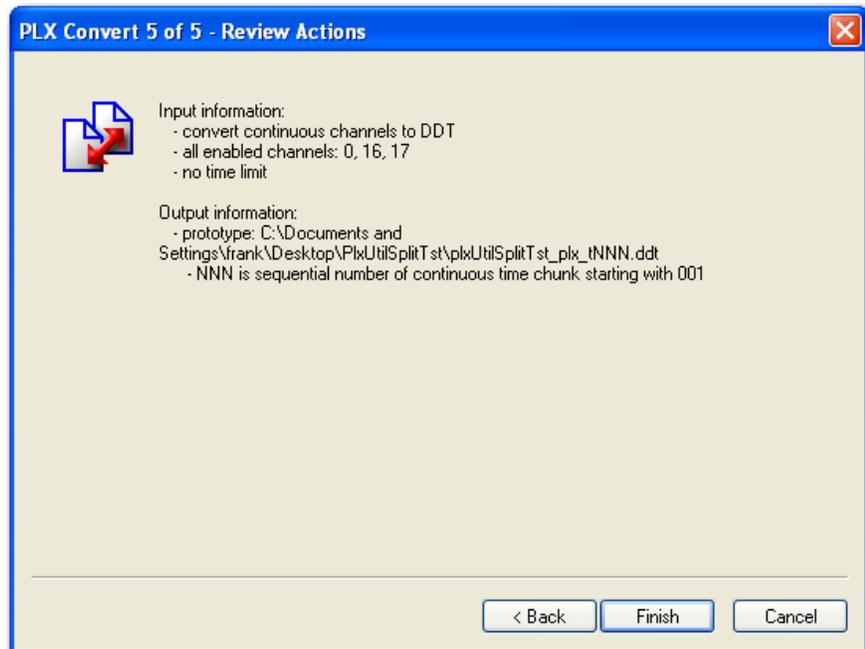
- 6 To include all the data for the channels selected, click **Process all available data**. To include only the data for a specific time interval, click **Restrict by time interval** and type the time in seconds in the **From** and **To** boxes. Click **Next**.

The **PLX Convert 4 of 5 - Select Output File** window opens.



- 7 In the **PLX Convert 4 of 5 - Select Output File** window, type or select a location and name for the subset file. Click **Next**.

The **PLX Convert 5 of 5 - Review Actions** window opens.



- 8 Review the input and output information. If it's correct, click **Finish** to create the file and close the convert window.

Note: Some .plx files have gaps in them. This is a normal situation that occurs when an experiment is suspended for awhile. However, .ddt files cannot have gaps in them. This is why the conversion from .plx to .ddt can produce several .ddt files. The only place to keep timestamps in .ddt file is in the header, which is accurate up to one second. This means that a .plx to .ddt to .plx conversion can produce different timestamps.

5.6 Re-Ordering Files

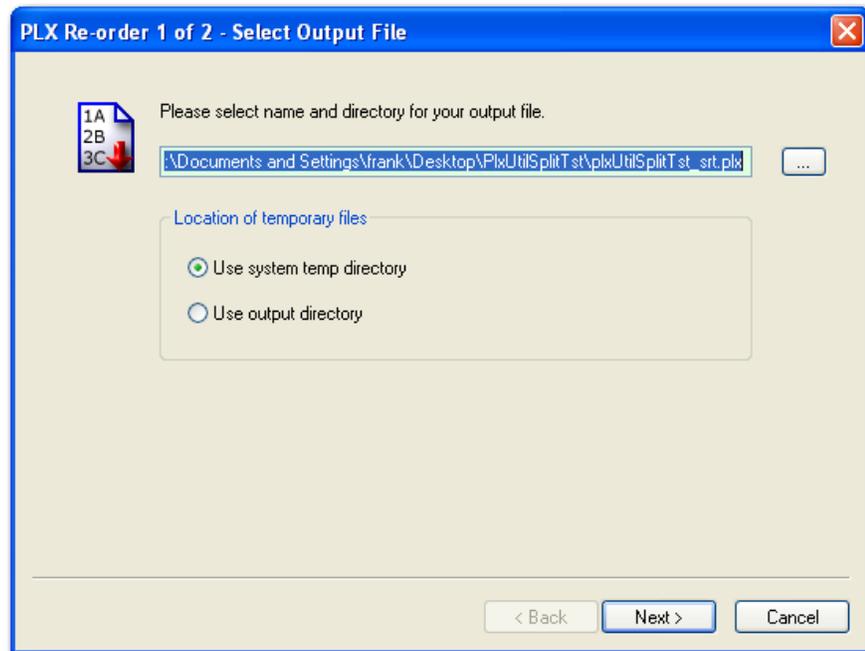
The PlexUtil re-order function can arrange all the data blocks in a file in their timestamp order, from the earliest to the latest. When the file is arranged in timestamp order, PlexUtil can easily determine duplicate data blocks.

To re-order a file

- 1 In the **File Browser** pane, select the file to re-order.
- 2 When the file opens, review the contents and make any repairs. For more information, see [“What Repair Does” on page 199](#).
- 3 On the toolbar, click the **Re-order** button.

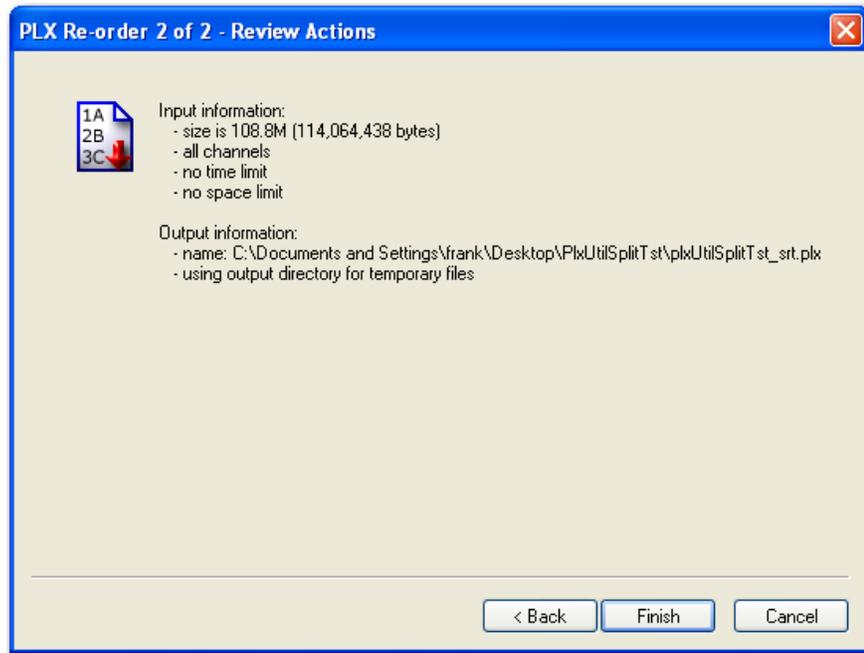


The **PLX Re-order 1 of 2 - Select Output File** window opens.



- 4 Type a path and name for the re-ordered file. PlexUtil can generate large temporary files during the re-order process. If there exists adequate room on the computer hard drive, click **Use system temp directory**. If the output directory is located on another disk drive or a server with adequate capacity, click **Use output directory**. Re-order speed is also a consideration; the local system temp directory is typically much faster than any remote drive. Click **Next**.

The **PLX Re-order 2 of 2 - Review Actions** window opens.



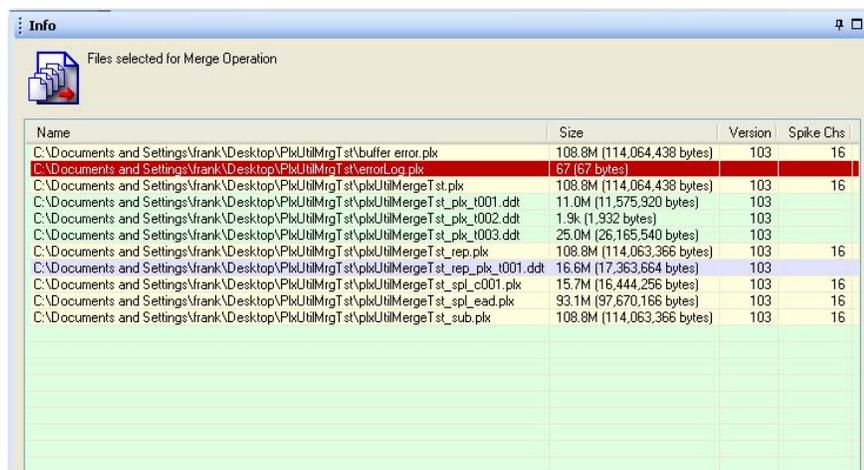
- 5 Make sure the information is correct. Click **Finish** to re-order the file and close the re-order window.

5.7 Merging Files

The PlexUtil merge function can merge .plx or .ddt files. A single merged .plx file may be created from multiple .plx files, or a single merged .ddt file from multiple .ddt files.

To merge files

- 1 In the **File Browser** pane, select one or more files to merge.
- 2 PlexUtil switches to the **Info** tab and displays a list of the files selected.



Color codes identify the suitability of each file for the merge operation according to the following list:

- Green = files that can be merged
- Other colors = files that cannot be merged with the green files
- Red = files that are incompatible or corrupt and they cannot be merged with any file

Note: To merge the files in consecutive order from top to bottom as indicated in [Step 4](#), select a file and use the **Move Up** and **Move Down** buttons to correctly position the file in the list. It is possible to merge only files of the same type; it is not possible to mix .ddt and .plx files.

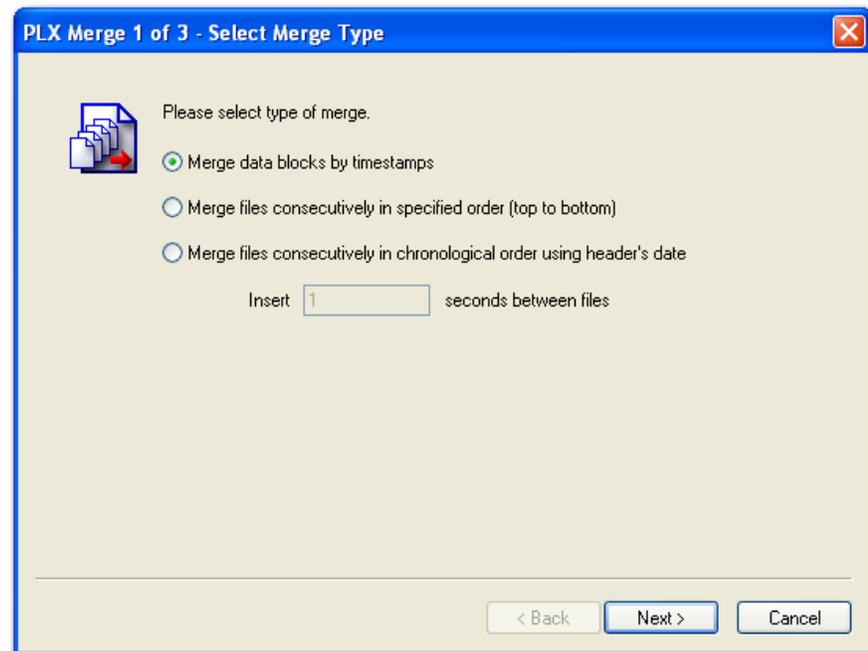
- 3 Click the **Merge** button.



For selected incompatible files, the following message appears. Make sure all the files selected appear green in the file list.



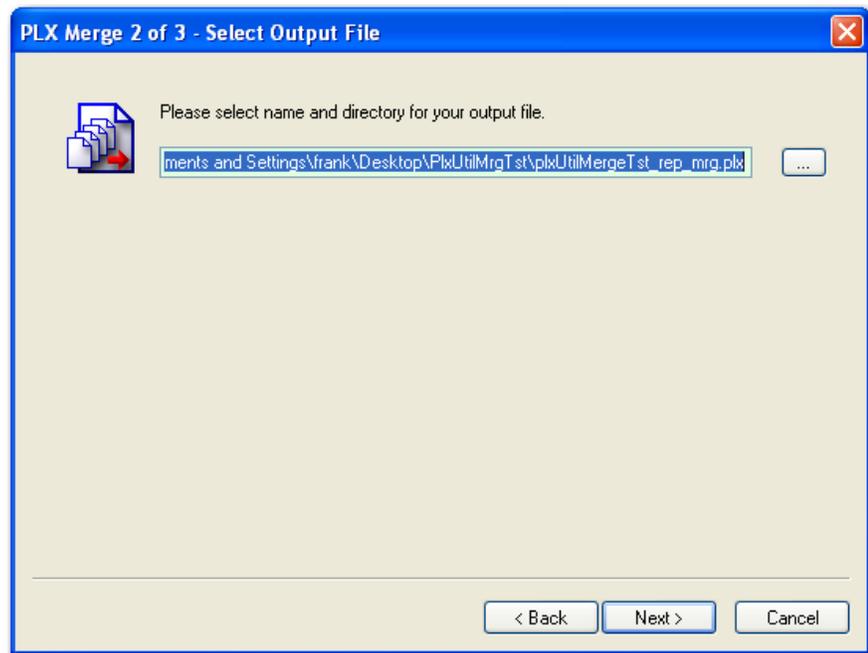
*For selected compatible files, the **PLX Merge 1 of 3 - Select Merge Type** window appears.*



- 4 Select the merge type:
 - **Merge data blocks by timestamps:** Click to merge the data blocks of all the files in the order of their timestamps.
 - **Merge files consecutively in specified order (top to bottom):** Click to concatenate files in the order established in [Step 2](#). Enter the separation time for the files in the **Insert _ seconds between files** box.
 - **Merge files consecutively in chronological order using header's date:** Click to concatenate the files in chronological order. Enter the separation time for the files in the **Insert _ seconds between files** box.

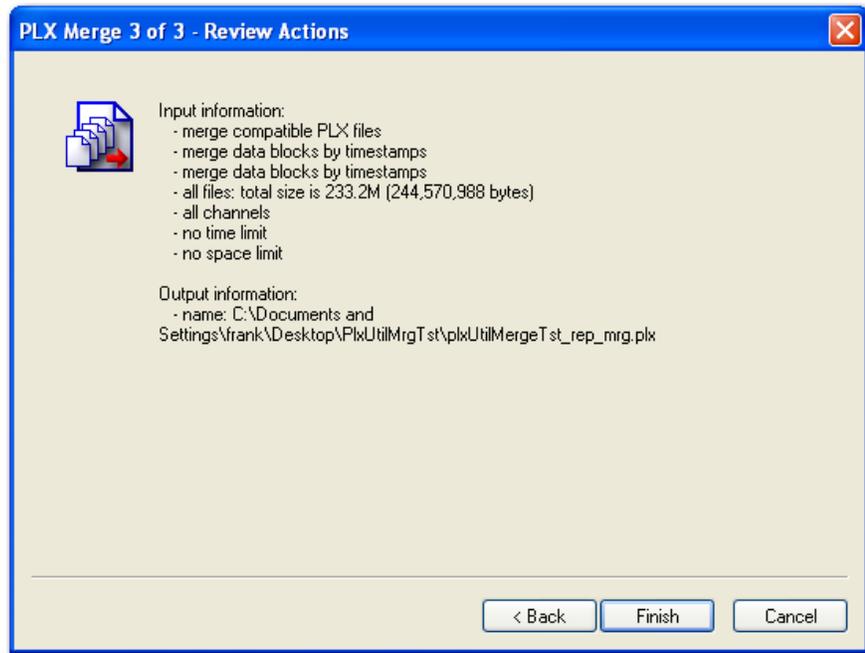
Click **Next**.

*The **PLX Merge 2 of 3 - Select Output File** window opens.*



- 5 Type the directory and file name. PlexUtil automatically adds **_mrg** to the file name. Click **Next**.

The **PLX Merger 3 of 3 - Review Actions** window opens.



- 6 Make sure the information is correct and that there exists sufficient disk space to accommodate the new merge file. Click **Finish** to start the merge.

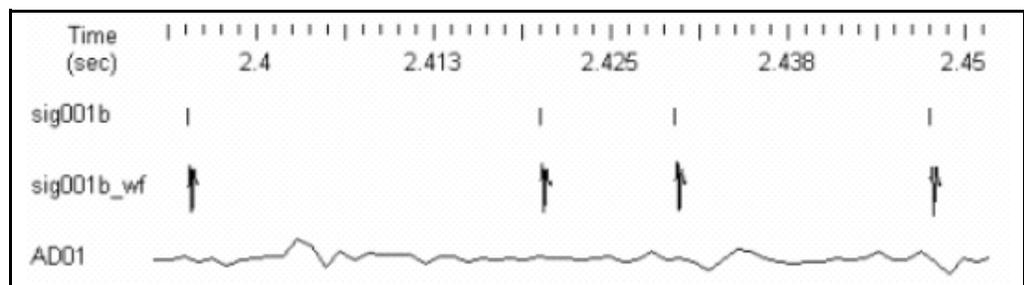
5.8 Understanding PLX and DDT Data Files

This overview section describes each data file type in detail. It also lists the purpose of each PlexUtil function.

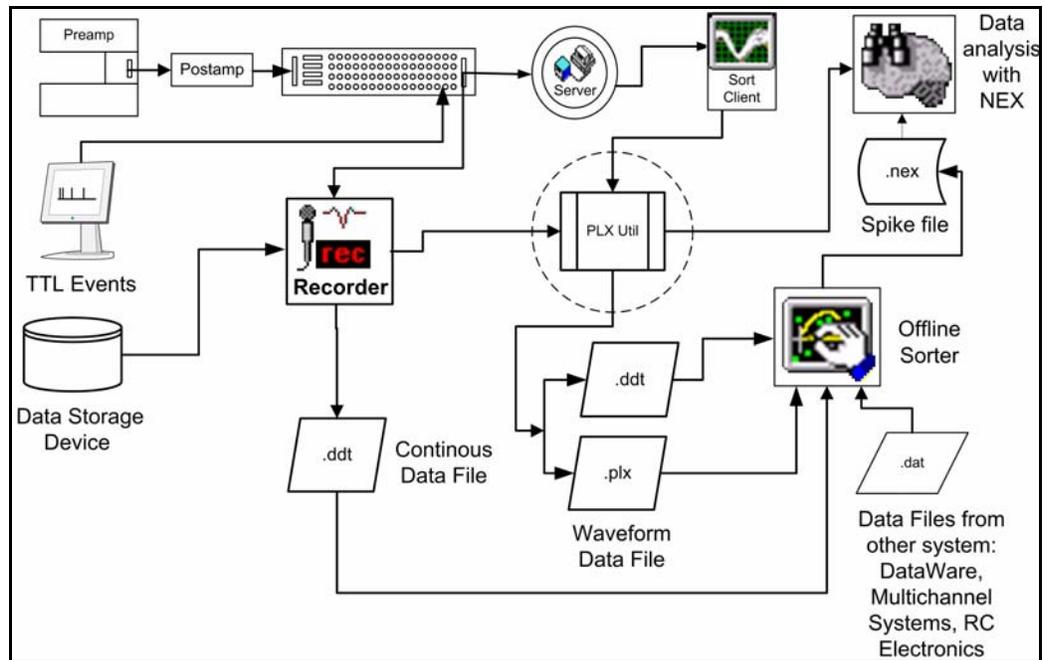
5.8.1 PLX Data Files

PLX files are Plexon data files containing action-potential (spike) timestamps and waveforms, event timestamps, and continuous variable data. PLX files are optimized for recording segments of waveforms where thresholds have been applied. However, low-digitizing-rate continuous channels can be saved in a .plx file. Some .plx utilities can be used to merge .plx files and extract portions of .plx data files to .ddt files.

The following illustration shows a portion of a .plx file containing the spike train sig001b and its accompanying waveform segments sig001b_wf together with the continuous variable AD01, as seen by NeuroExplorer.



A number of different Plexon software programs can generate output in the form of a .plx file including Sort Client, [Plexon Offline Sorter](#), and [Plexon Recorder](#). Offline Sorter can sort spike waveforms in .plx files and they can be analyzed together with the continuous variables by using [NeuroExplorer](#).



Large PLX files: When recording either digitized waveform segments, or spike timestamps and waveforms using the MAP box and Sort Client, .plx data files can sometimes grow in excess of 50 MB.

The time needed to load large .plx files into Offline Sorter can be significant. To reduce this time, a .plx file can be split into separate channel files (file.plx001, file.plx002, etc.), plus a header file (file.plx0). Then the header file can be opened in Offline Sorter and the individual channel files automatically open when individual channels are selected. All the header files and channel files must be located in the same directory. Alternatively, the size of the .plx file size can be reduced by saving a subset of the channels or by saving a subset of the .plx file.

When separate files are made for each channel and a subset of channels is saved, PlexUtil passes the event timestamps, continuous variables, and corresponding spike waveforms to the destination .plx or .plx0 file.

5.8.2 DDT Data Files

The .ddt data file type is optimized for continuous (streaming) recording where every channel is continuously recorded without gaps and the recording includes any “dead time” between spikes. If many channels are recorded, .ddt files can be very large. The .ddt file type is appropriate for:

- Continuous signals such as local field potentials (LFP).

-
- Spikes when the data thresholds are changed off line.
 - Custom processing methods that require continuous data.

5.9 What Scan Does

When a .plx file is opened or scanned, PlexUtil performs the following checks:

- Checks that the last timestamp corresponds to the actual data.
- Checks that PLX counters match the actual statistics.
- If the size of any data block is bigger than the size of the available data, PlexUtil marks the data block as corrupted.
- If any data block is of unknown data type, PlexUtil marks it as corrupted.
- PlexUtil processes each type of recognized data block as follows:
 - Spikes
 - If the number of waveforms is negative or more than 1, PlexUtil marks it as corrupted.
 - If a unit is negative or a block contains more than 26 units, PlexUtil marks it as corrupted.
 - If the number of words in a waveform is negative or more than 480, PlexUtil marks it as corrupted.
 - If a channel does not correspond to any spike channel declaration in the header, PlexUtil marks it as orphaned.
 - If a good block has a timestamp that is less than a timestamp of a previous block from the same channel, PlexUtil marks it as out-of-order.
 - If a good block has a timestamp that is equal to a timestamp of a previous block from the same channel, PlexUtil marks it as a duplicate.
 - Events
 - If a channel is greater or equal to 261, PlexUtil marks it as corrupted.
 - If the number of words in a waveform is negative or more than 480, PlexUtil marks it as corrupted.
 - If a channel doesn't correspond to any event channel declaration in the header, PlexUtil marks it as orphaned.
 - If a good block has a timestamp that is less than a timestamp of a previous block from the same channel, PlexUtil marks it as out-of-order.

- If a good block has a timestamp that is equal to a timestamp of a previous block from the same channel, PlexUtil marks it as a duplicate.
- Continuous
 - If the number of waveforms is negative or more than 1, PlexUtil marks it as corrupted.
 - If the number of words in a waveform is negative or more than 1024, PlexUtil marks it as corrupted.
 - If a channel doesn't correspond to any continuous channel declaration in the header, PlexUtil marks it as orphaned.
 - If a good block has a timestamp that is less than a timestamp of a previous block from the same channel, PlexUtil marks it as out-of-order.
 - If a good block has a timestamp that is equal to a timestamp of a previous block from the same channel, PlexUtil marks it as a duplicate.
 - If a good block overlaps the data from a previous block for any period of time, PlexUtil marks it as overlapped.
 - If there is a time gap between a good data block and a previous block, PlexUtil marks it as a gap.

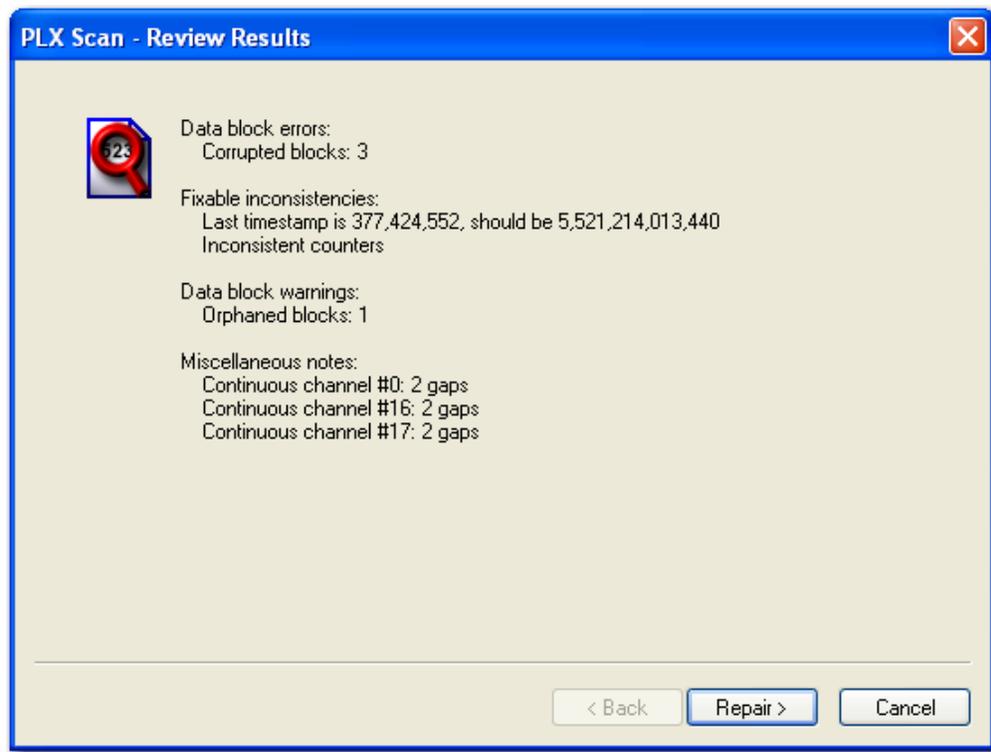
After scanning, PlexUtil reports problems under the following headings in the **PLX Scan - Review Results** window:

- **Data block errors:** The total number of corrupted blocks.
- **Fixable inconsistencies:** Inconsistent last timestamps and inconsistent counters. For example, a last timestamp with a lower value than a preceding timestamp.
- **Data block warnings:** The total number of orphaned blocks.
- **Miscellaneous notes:**
 - For spike channels:
 - The total number of out-of-order blocks for each channel.
 - The total number of duplicate blocks for each channel.
 - For event channels:
 - Total number of out-of-order blocks for each channel.
 - Total number of duplicate blocks for each channel.
 - For continuous channels:
 - The total number of out-of-order blocks for each channel.

-
- The total number of duplicate blocks for each channel.
 - The total number of gaps in continuous data for each channel.
 - The total number of overlaps for each channel.

5.10 What Repair Does

If PlexUtil finds any problems after scanning a file, the **Review** button appears in the top right corner. When **Review** is clicked, the **PLX Scan - Review Results** window opens with a list of all the problems PlexUtil found.



PlexUtil can repair some of these problems. If PlexUtil finds errors, warnings, or fixable inconsistencies, the **Repair** button appears in the **PLX Scan - Review Results** window. PlexUtil can repair all fixable inconsistencies. When **Repair** is clicked, PlexUtil creates a new copy of the file that includes the following repairs:

- All counters and the last timestamp are replaced with the actual values.
- All corrupted blocks are skipped and not copied to the new file.
- Repair also corrects headers and recalculates statistics.
- The file-name format for the repaired is myfile_rep.plx.

The PlexUtil Scan and Repair functions do not repair out-of-order blocks. The Re-order function must be used to repair out-of-order blocks. For more information, see [“Re-Ordering Files” on page 191](#).

5.11 PlexUtil Output File-Name Suffixes

Each PlexUtil function creates files with unique file-name suffixes. Here is a list of file-name suffixes and the PlexUtil function that produces that format:

- `_rep.plx` = a **Repaired** (rep) file
- `_sub.plx` = a **Subset** (sub) of file
- `_spl_cNNN.plx` = a file **Split** (spl) by **channels** (c) with the numeric (N) sequence of each split file starting at 001
- `_spl_tNNN.plx` = a file **Split** (spl) by **time** (t) with the numeric (N) sequence of each split file starting at 001
- `_spl_sNNN.plx` = a file **Split** (spl) by file-size **space** (s) with the numeric (N) sequence of each split file starting at 001
- `_spl_fNNN.plx` = a file **Split** (spl) by **frames** (f) with the numeric (N) sequence of each split file starting at 001
- `_plx_tNNN.ddt` = a .plx file **Converted** to .ddt format with a sequential number (N) of time (t) chunks starting at 001
- `_ddt_tNNN.plx` = a .ddt file **Converted** to .plx format with a sequential number (N) of time (t) chunks starting at 001
- `_rord.plx` = a re-ordered (rord) file produced by the **Re-order** function
- `_mrg.plx` = a file merged (mrg) file produced by the **Merge** function

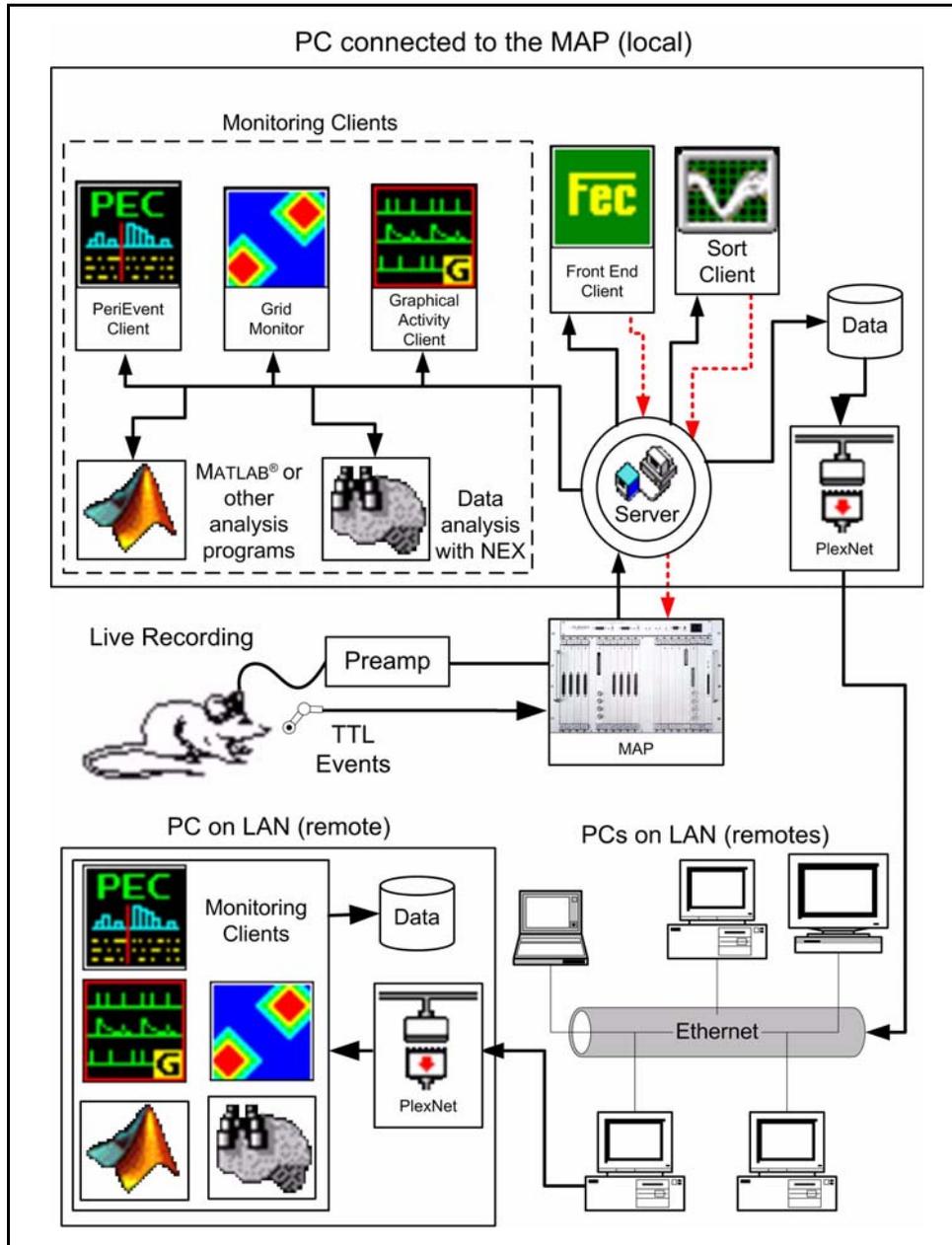
Chapter 6

Plexon Networking (PlexNet)

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6.1 Overview

Plexon Networking (PlexNet) is a unique data-transfer program that establishes network connections between computers (PCs) to broadcast MAP (Harvey Box) data in real time over a TCP/IP Ethernet network. The following illustration shows the general arrangement of the network.



PlexNet can do any or all of the following tasks:

- 1 View and analyze spike event, spike waveform, external event, field potential, and other analog data on multiple PCs in real time.

-
- 2 Run data clients (GAC, PEC, GridMon, Nex, MATLAB, or other analysis programs) on remote PCs on the local area network (LAN).
 - 3 Run remote clients on remote PCs.

6.2 Setup

The RASPUTIN Software installation program automatically installs PlexNet on the local MAP-host PC. See the installation appendix for complete information on installing all RASPUTIN Software components.

To use PlexNet, network connections must be set up between the local PC and each remote PC. To do so, PlexNet must be installed on each remote PC. If a RASPUTIN Software suite is installed on a remote PC, the following procedure is not required.

To install PlexNet on a remote PC not equipped with RASPUTIN Software

- 1 At the local PC, locate PlexNet.exe. In a typical installation, the PlexNet files are in the following directory:
`C:\Program Files\Plexon Inc\RASPUTIN Software`
- 2 Copy the following files to a directory on each remote PC:
 - PlexNet.exe
 - PlexNetRemote.exe
 - PlexClient.dll
- 3 Firewalls interfere with the network connections used by PlexNet. Disable interfering firewalls or configure the firewalls to allow each connection to a computer that uses PlexNet. Because this can make the network vulnerable through an unprotected connection, before making any changes contact the network administrator to determine the appropriate action for the installation.

6.3 Establishing PC-to-PC Connections

To establish PC-to-PC connections, MAP Server, Sort Client, and PlexNet must be running on the local PC connected to the MAP box before remote PCs may be connected with PlexNet. When PlexNet is started on the local PC, PlexNet automatically provides the IP address of the local PC. Record this address for use at the remote PCs.

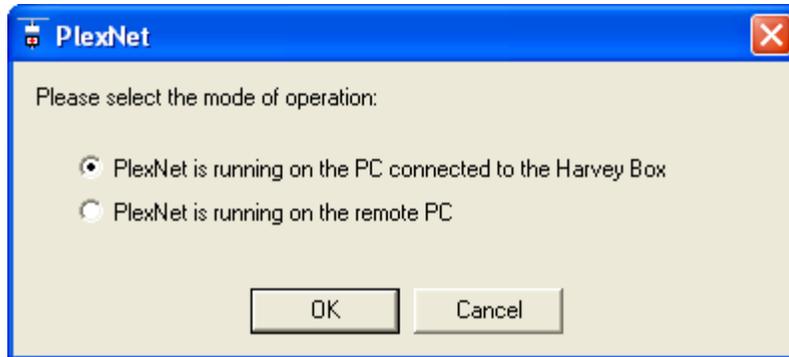
To run PlexNet on the local PC connected to the MAP box (Harvey Box)

1 At the local MAP-host PC, start Sort Client.

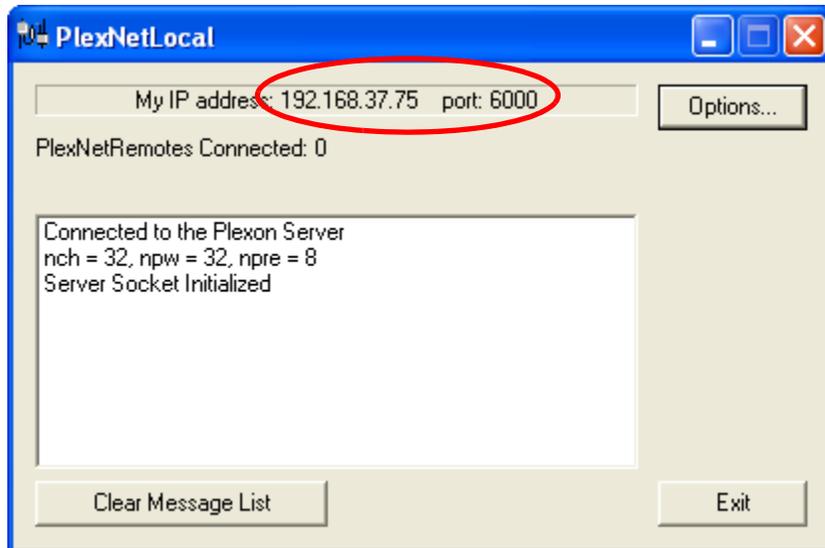
2 On the desktop, double click the **PlexNet** icon.



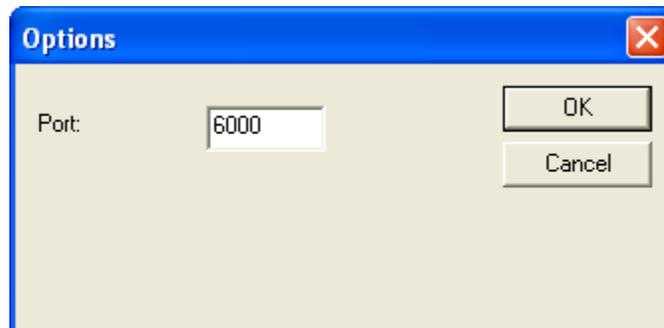
3 In the **PlexNet** window, click **PlexNet is running on the PC connected to the Harvey Box**. Click **OK**.



4 In the **PlexNetLocal** window, record the IP address and the port number of the local PC. For example, in the following illustration the IP address is **192.168.37.75** and the port number is **6000**.



Note: Port 6000 is the PlexNet default value. In most cases use this value. If a value other than 6000 is required, click **Options** to open the **Options** window. Type another value in the **Port** field. Click **OK**.



HINT

If there is more than one NIC in the local PC

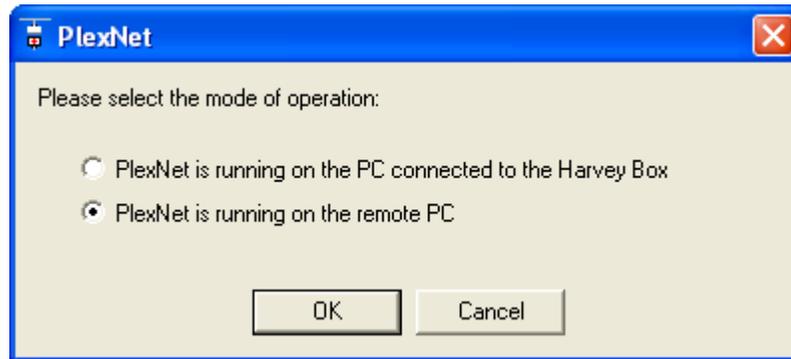
If there is more than one network interface card (NIC) in the local MAP-host PC, the **PlexNetLocal** window can display an alternate IP address instead of the IP address of the NIC connected to the local area network (LAN). If this occurs, try these alternatives:

- Instead of the IP address, type the PC name in [Step 4 on page 206](#)
- At the local PC, determine the correct IP address by using the Windows **ipconfig** command
- At the remote PC, determine the correct IP address by using the Windows **ping** command with name of the local PC

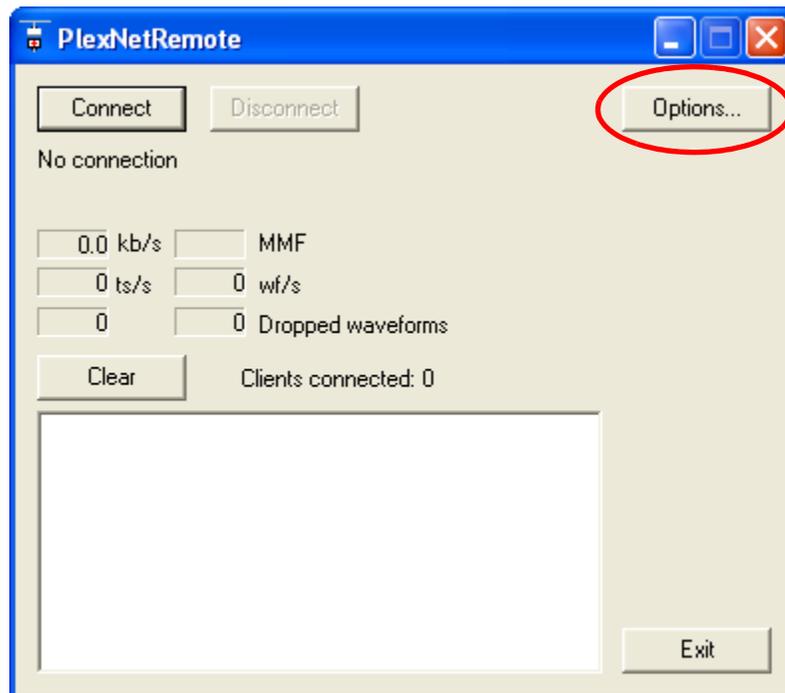
For assistance with these commands, consult the network administrator.

To run PlexNet on a remote computer

- 1 To start PlexNet, double click the desktop icon or double click plexnet.exe in its installed directory under ["To install PlexNet on a remote PC not equipped with RASPUTIN Software" on page 203.](#)
- 2 In the **PlexNet** window, click **PlexNet is running on the remote PC**. Click **OK**.

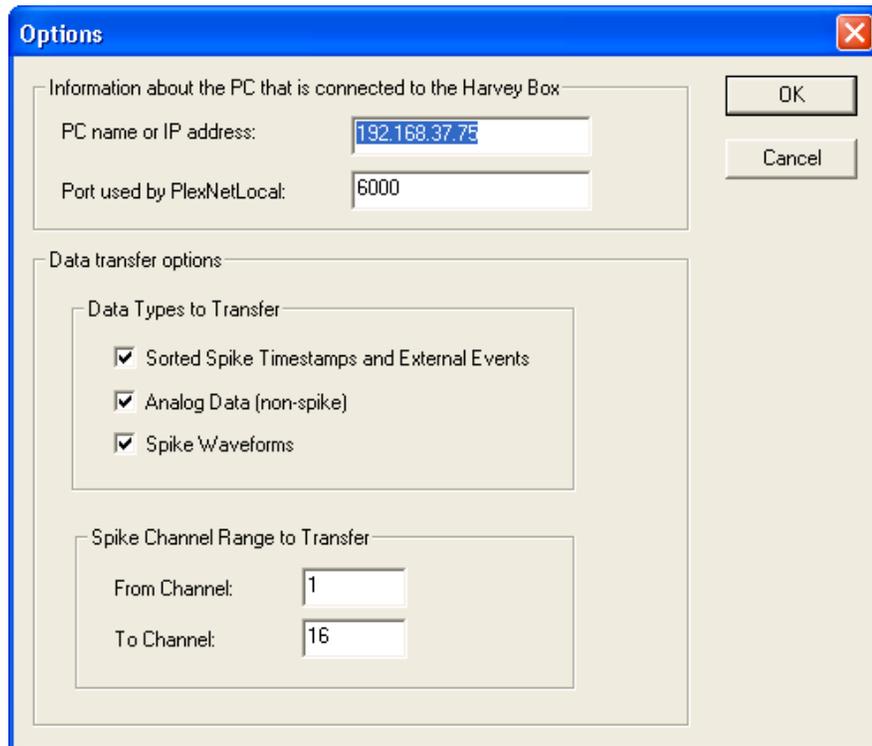


- 3 In the **PlexNetRemote** window, click **Options** to open the **Options** window.



- 4 In the **Information about the PC that is connected to the Harvey Box** area in the **Options** window, type the IP address recorded in [Step 4 on](#)

page 204 in the **PC name or PC address** field. Type the port number recorded in [Step 4 on page 204](#) in the **Port used by PlexNetLocal** box.



In the **Data transfer options** area, choose the type of data to transfer and the channel range as follows:

- In the **Data Types to Transfer** area, click each type of data to transfer. Choose one, two, or all three types.

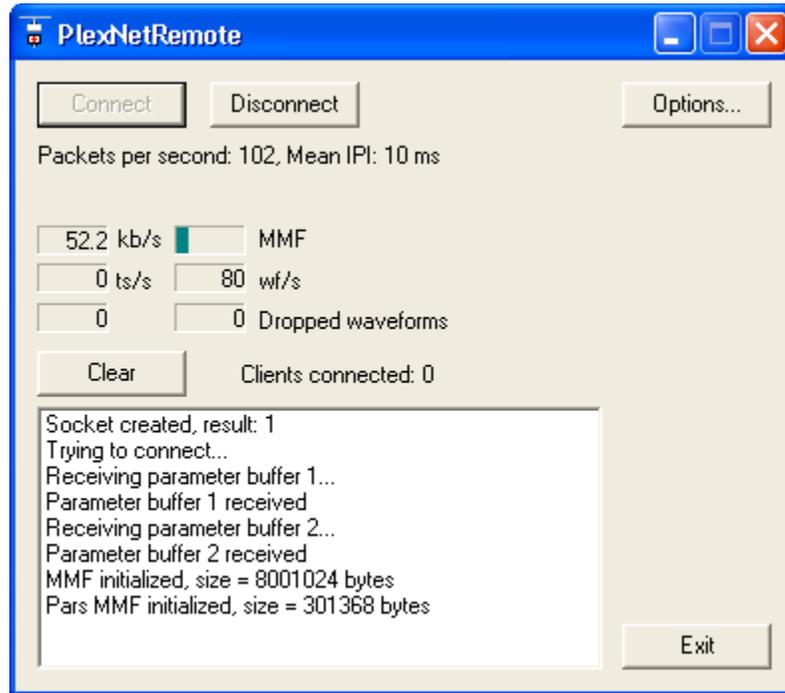
Note: Timestamps use very little network bandwidth. However, analog data and spike waveforms, especially for a large number of channels, require significantly more bandwidth.

- In the **Spike Channel Range to Transfer** area, type the channel-range values for the data transfer in the **From Channel** box and **To Channel** box.

Click **OK**.

- 5 Click **Connect** to start data transfer. The **PlexNetRemote** window displays the following information: the packets transmitted per second and the inter-packet interval (IPI), which appear below the **Connect** button. For a complete

explanation of the other items, see [“MAP Server Main Display Window”](#) on page 143.



Use the **Disconnect** and **Connect** buttons at any time without restarting PlexNet. However, to avoid data loss, do not disconnect while the remote analysis programs are running.

- 6 With PlexNet connected and transferring data, it is possible to run data clients such as GAC, PEC, GridMon, Nex, Matlab, or other analysis programs on the remote PC to analyze the transferred data. These data clients run as if a copy of MAP Server is also running on the remote PC. However, because the PlexNet connection is unidirectional toward the remote PC, Sort Client, Ref2, and other programs that send commands to the MAP box cannot be used as remote clients.

Chapter 7

Graphical Activity Client

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7.1 Overview

This chapter describes Graphical Activity Client (GAC) v1.3.6 (01/11/05). GAC (gac.exe) is a Windows XP or NT application, which can be used in conjunction with Sort Client and MAP Server, to visually monitor neural activity on multiple unit channels, as well as the continuous waveforms digitized using the data acquisition (DAQ) device.

Sort Client must be used first, to sort the units, and then GAC may be started to monitor the activity on those channels. GAC does not record activity to a file or control Sort Client. GAC only presents one or more real-time scrolling views of the activity as it is happening.

Each view occupies one window within the GAC workspace, and each view can run at a different time scale, have a different view type—see “Views” on [page 213](#)—and each view can be paused and unpaused independently. GAC view windows can be automatically tiled within the workspace and one or all the views can be printed without pausing the view. Essentially, GAC is a full-featured version of the Activity Display in Sort Client.

7.2 Requirements and Installation

GAC runs on Windows XP or NT 4.0 or above with the same hardware requirements as Sort Client.

If GAC was not automatically installed with RASPUTIN, GAC may be installed by simply creating a directory such as \gac and copying the contents of the GAC download to this directory. The following files must be present to run GAC:

- gac.exe
- PlexClient.dll
- plexutil.dll

Typically, PlexClient.dll has already been installed by Sort Client.

To minimize GAC latency and to update the screen smoothly, MAP Server must run with a fast polling rate. If necessary, GAC can operate correctly with a polling interval as long as 50 milliseconds.

To change the polling interval

- 1 Before starting GAC, start MAP Server.
- 2 From the **View** menu, click **Options**.
- 3 Set the **Polling interval (milliseconds)** to 10.
- 4 Click **OK**.
- 5 For the new polling interval to take effect, close and restart MAP Server.



A shortcut on the desktop can be created for GAC. This is an illustration of the GAC desktop icon.

7.3 Startup

To run GAC, Sort Client must be already running with an experiment file loaded. Double-click the desktop shortcut or double-click `gac.exe` in its installed directory. GAC remains blank until some activity occurs on at least one unit channel. The following illustration is a typical default initial view of GAC.



GAC displays the raw activity (spike events) on as many active channels as it can comfortably fit in the window. The view scrolls from right to left as new events appear at the right edge of the view. The arrow keys or the PAGE UP and PAGE DOWN keys may be used to scroll vertically through all the channels. GAC is like a virtual strip-chart recorder with invisible “pens” at the right edge marking new events as they occur.

7.4 Interface Characteristics

The GAC user interface consists of two parts: the toolbar and one or more view windows.

7.4.1 Views

When GAC starts, a default single-view window fills the workspace area below the toolbar. Spike events appear as simple tick marks. When there is only one

view, all tools in the toolbar apply to this view. When there is more than one view, the tools apply to the active view. A view can be added by clicking on a create view buttons. See [“View Control Tools” on page 224](#). To close a view, click the close box (X) in the upper right corner. When a view is closed, GAC re-tiles the remaining views to fill the available space.

Many operations, such as changing the time scale, apply to the active view. To select a view, click on it, or use CTRL-TAB to cycle through the views. Views are independent. For example, changing the time scale or pausing the scrolling of one view does not affect the other views. The graphics in all views are updated in real-time, even if the view is not active.

7.4.2 Scrolling

GAC uses scrolling to update views efficiently. However, scrolling has some unintended behavior. For example, if another application window partly obscures one or more GAC views, GAC cannot draw its view correctly by scrolling. Move the other window away from GAC. Pressing the SPACEBAR key once can completely update all GAC views at any time. If several views are open or there are many channels, or both, GAC can take a fraction of a second to do a total redraw, although no data is lost. Do not hold down the SPACEBAR key to force GAC to redraw continuously.

7.4.3 Toolbar

To accommodate scrolling behavior, Plexon designed GAC for use with the toolbar and the keyboard, instead of pull-down menus. Long pull-down menus drop down into the GAC views and interfere with scrolling.

Avoid resizing and moving the individual view windows so that they overlap, because this can cause incorrect scrolling. It is possible to move and resize the windows by dragging on their borders. If the view windows overlap, clicking on one of the window tiling tools will restore the views to a neatly arranged layout. For more information, see [“Miscellaneous Tools” on page 226](#). At least one view must be open; GAC prevents the last view from being deleted.

GAC is a real-time window into the activity as it is happening. It is not possible to scroll forwards and backwards in time, record, or replay the data. To do this, record the data in Sort Client and use [NeuroExplorer](#) or other programs to view the data off-line.

7.4.4 Menu

The GAC menu items are **File**, **Edit**, **View**, and **Help**. All GAC menus use standard interface characteristics with the exception of the **Options** item on the **View** menu. **Options** is a dynamic menu item that changes to match the active view. For more information on views, see [“Views” on page 213](#).

It is possible to view and change the parameters of the active view by selecting the view and then clicking the **Options dialog** button on the toolbar. The Options window has three tabs:

- The first tab changes with the selected view.
- The second tab is **Printing** options.
- The third tab is **General** options. The **Printing** and **General** tabs are the same for all views.

For more information on the **Printing** and **General** tabs, see [“Common Options” on page 230](#).

7.5 Views

GAC provides the following six distinct views, each of which appears in a separate window in the GAC interface. See the following table for a list of matching view-window names, Options tab names, toolbar buttons, and button names.

View window name	Options tab name	Toolbar button	Toolbar button name
raw events view	Spike Ticks		Add ticks graph
activity graph view	Activity		Add activity line graph
slow rate view	Rate Bars		Add rate graph
integrated activity graph view	Integrated		Add burst graph
NIDAQ wave view	NIDAQ		Add NIDAQ graph
MMEP activity grid view	MMEP		Add MMEP color activity graph

To change the options for a view

- 1 Select the view to make it the active window.
- 2 From the **View** menu, click **Options**.

The Options window opens. See each view for an illustration of the window.

- 3 Change the options in the tab that matches the view (see the preceding table).
- 4 Close the Options window.

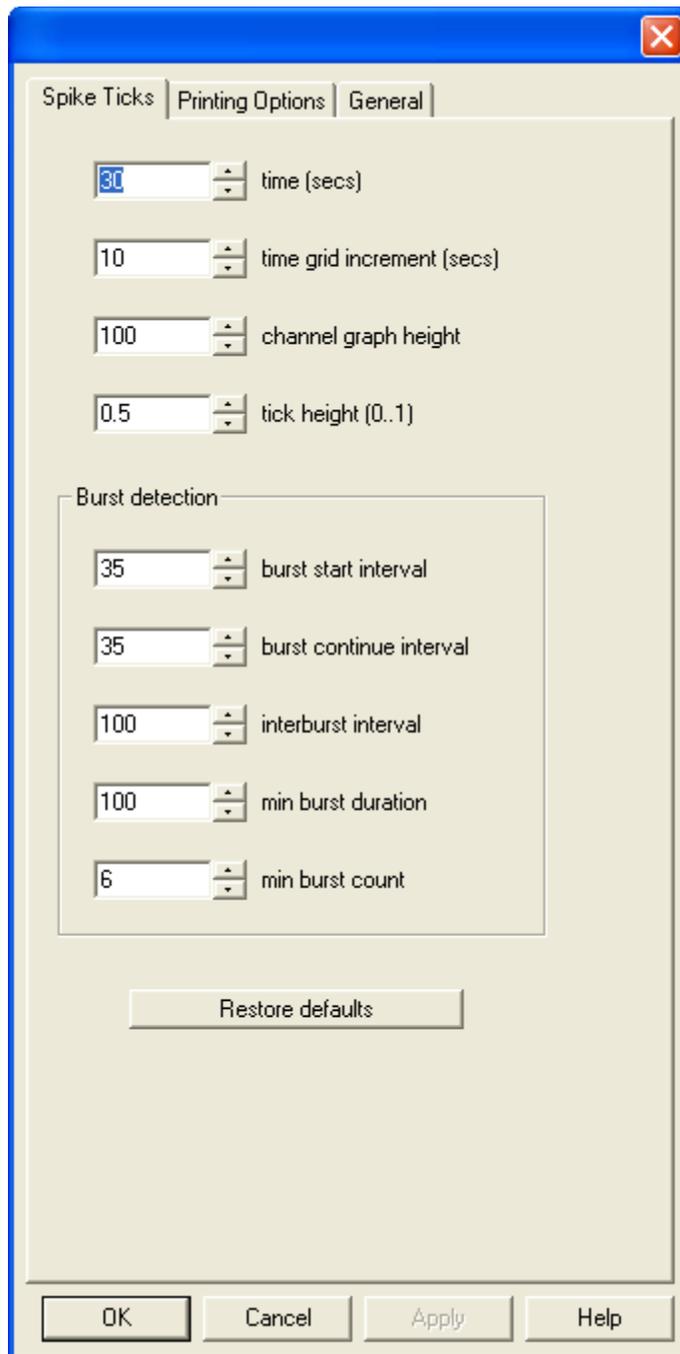
Each view window shows the current real-time activity in a different graphical or statistical manner, or both. There can be more than one view of a particular type. For example, activity can be shown at different time scales or with a different subset of channels in each window. When a view is active, any of the view adjustment tools or the values in the Options window affect that view only. For example, one view may be clicked and the toolbar used to increase the length of its time axis, then a different view may be clicked and the same tool used to decrease the length of the time axis for that view.

As each view scrolls, a vertical blue bar with a time label will periodically appear. The spacing for this time grid may be set in the Options window. Also, if any of the keyboard event keys (ALT+1 through ALT+9) are pressed in Sort Client, GAG draws a corresponding vertical bar in all view windows, which includes a time label and a bracketed digit adjacent to it, for example [7]. This may be used to index significant times or events in the data. Sort Client recognizes keyboard events and records them in the data file, so a Sort Client window must be open and active when the keys are pressed to signal a keyboard event.

7.5.1 Raw Events View

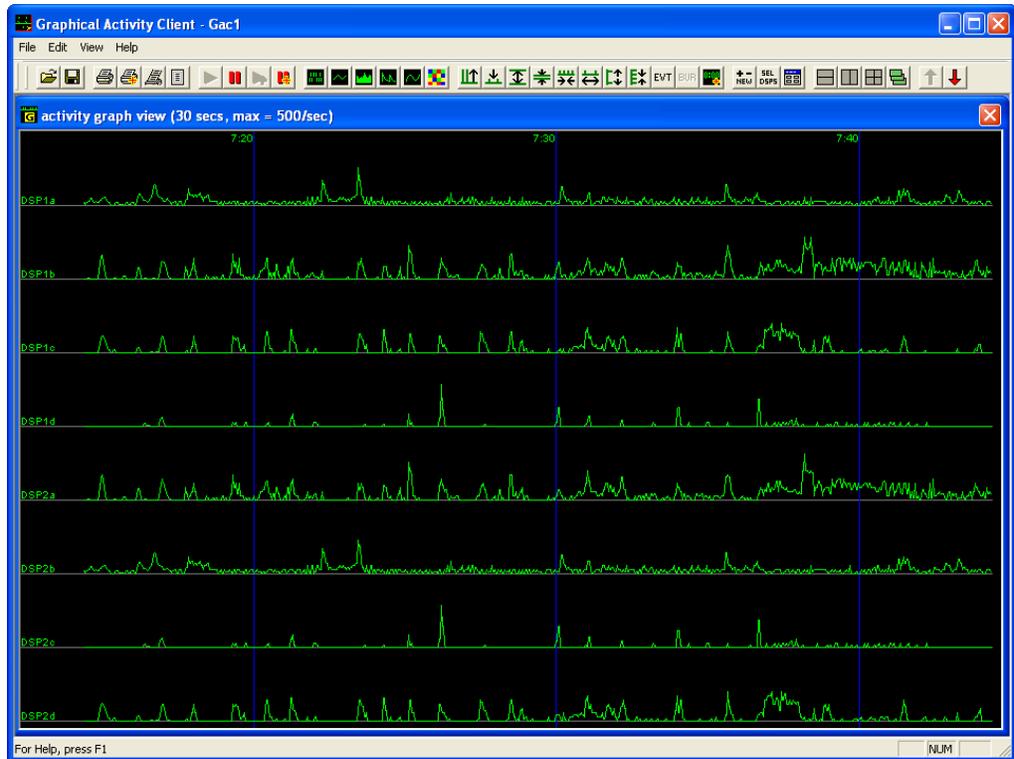
When GAC starts, the **raw events view** window appears by default. GAC displays each channel with sorted units in Sort Client as one row, with the channel name on the left side. GAC shows spike events as simple tick marks, which are similar to the tick marks in the Sort Client Activity Display. As the display scrolls, blue vertical bars with time labels appear every N seconds, where N can be set in the Options window.

The following illustration shows the Options window for the **raw events view**.

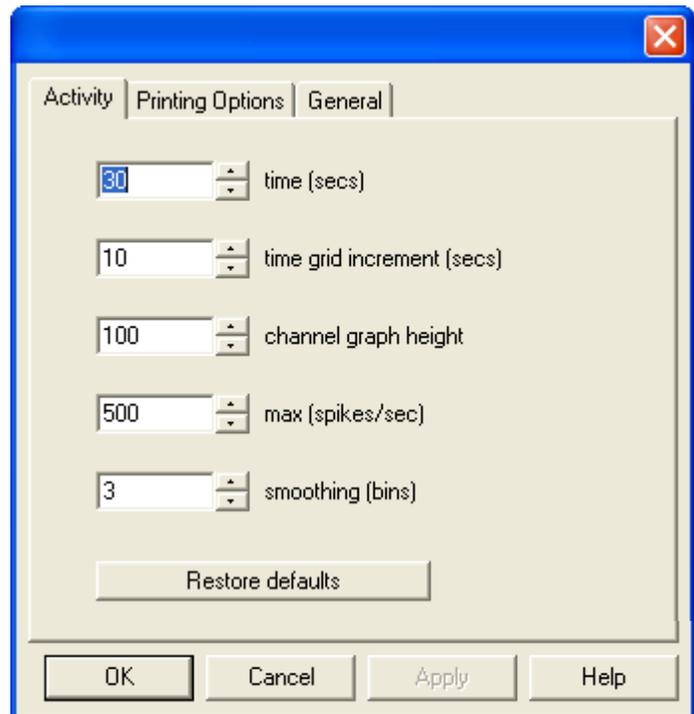


7.5.2 Activity Graph View

The **activity graph view** window shows one graph line per channel. The height of the line indicates the firing rate in spikes/sec.



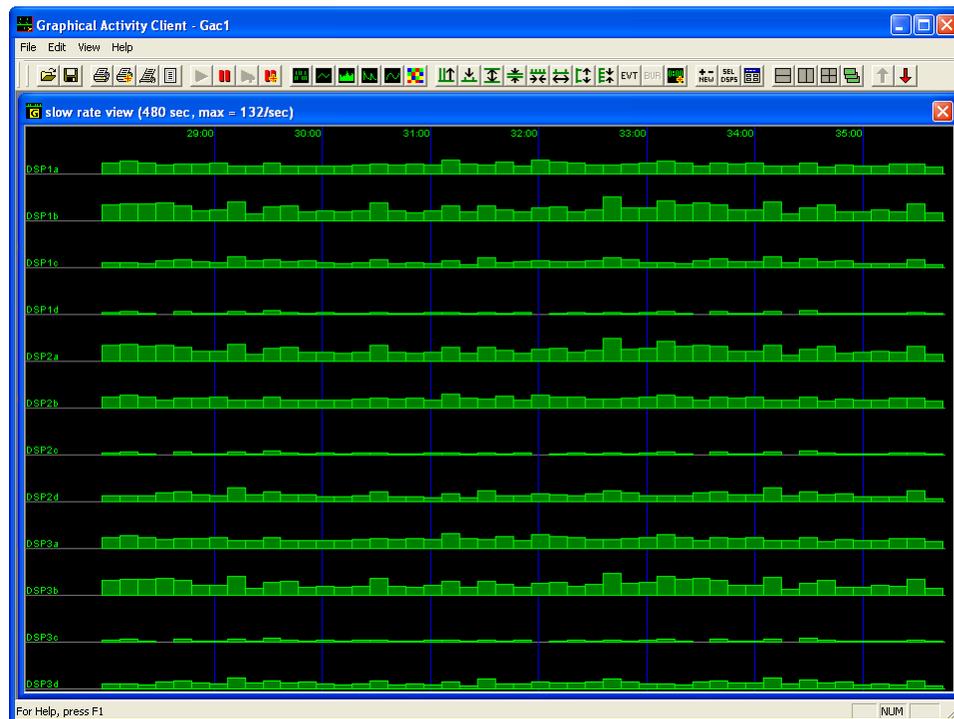
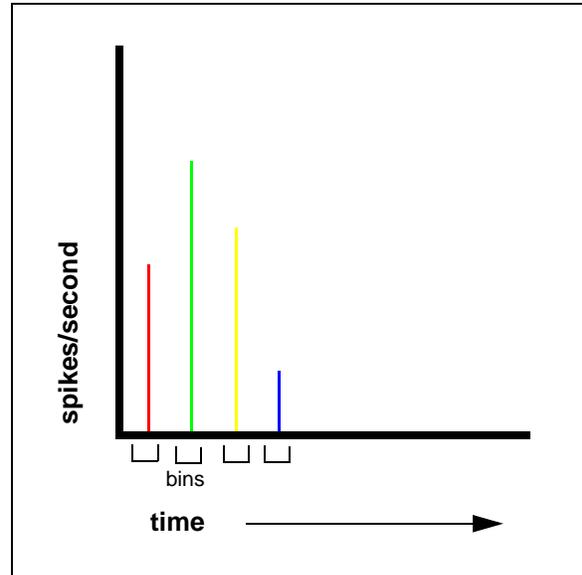
The vertical scale may be set by using the view adjustment tools or the Options window. The value for the bin size is the same as one pixel—for example, if the time axis is 300 pixels wide on the screen, and the time axis corresponds to 30s, each pixel represents a 100 millisecond bin.



This illustration shows an example of bins.

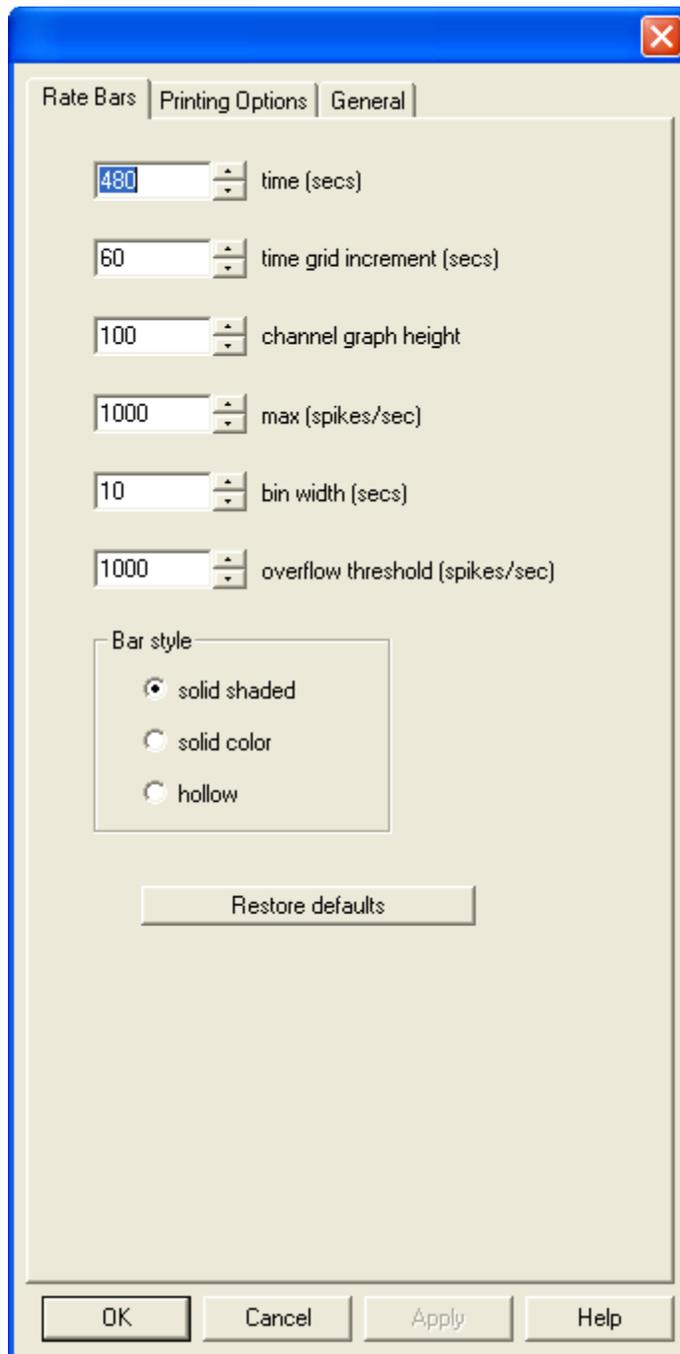
7.5.3 Slow Rate View

The **slow rate view** window displays a bar graph showing the binned firing rate over a long period of time (minutes to hours). Whereas the other GAC view types create their graphs from the raw spike data, the long-term-rate view stores bin counts, so that very-long periods can be monitored without excessive memory consumption. If the bin size is changed in the Options window, GAC deletes the existing bin counts and restarts from zero. Therefore, select the desired bin size before beginning long-term monitoring. The following illustration shows the **slow rate view** window at a time setting of 480 seconds.



In addition to the usual parameters, from the Options window may be set an overflow threshold for the bar graph. GAC displays a red bar when data exceeds that threshold.

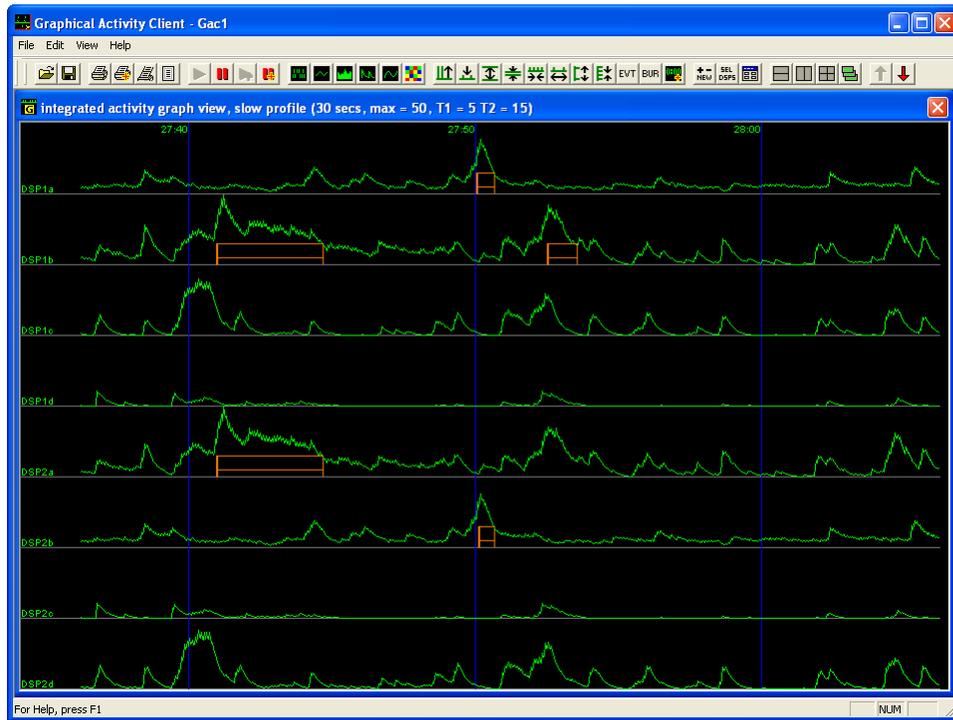
The following illustration shows the **Rate Bars** tab in the Options window.



7.5.4 Integrated Activity Graph View

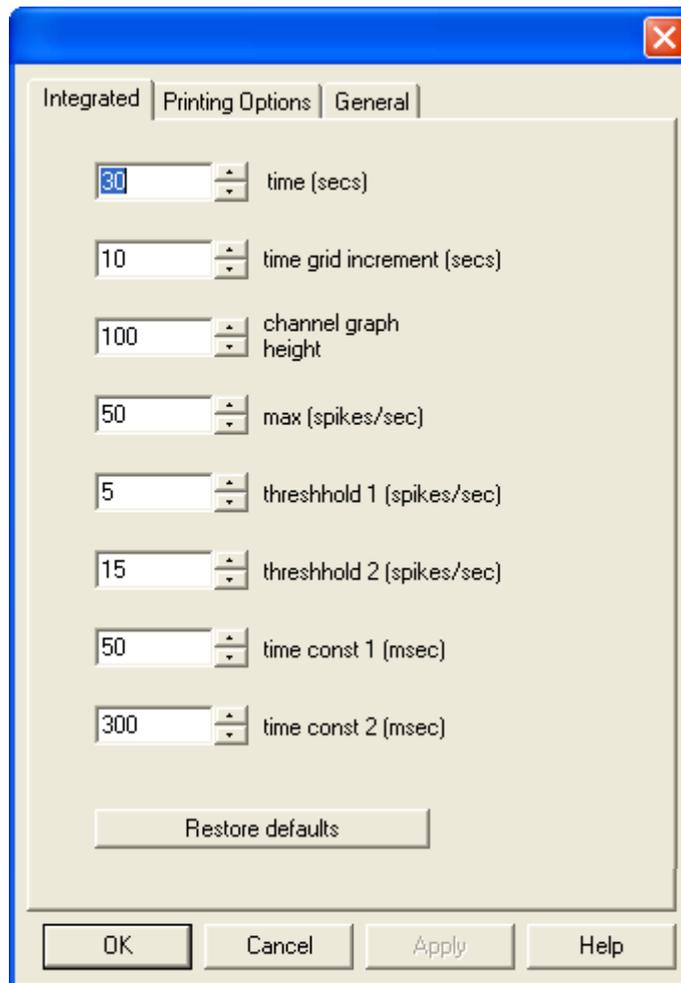
The **Integrated activity graph view** displays two activity graphs and a set of burst rectangles for each channel. The green graph shows the slow-integrated activity for a channel. The white graph shows fast-integrated activity for a channel. The integration time constant may be set in the Options window.

The orange boxes in the following illustration represent detected bursts using a two-threshold method.



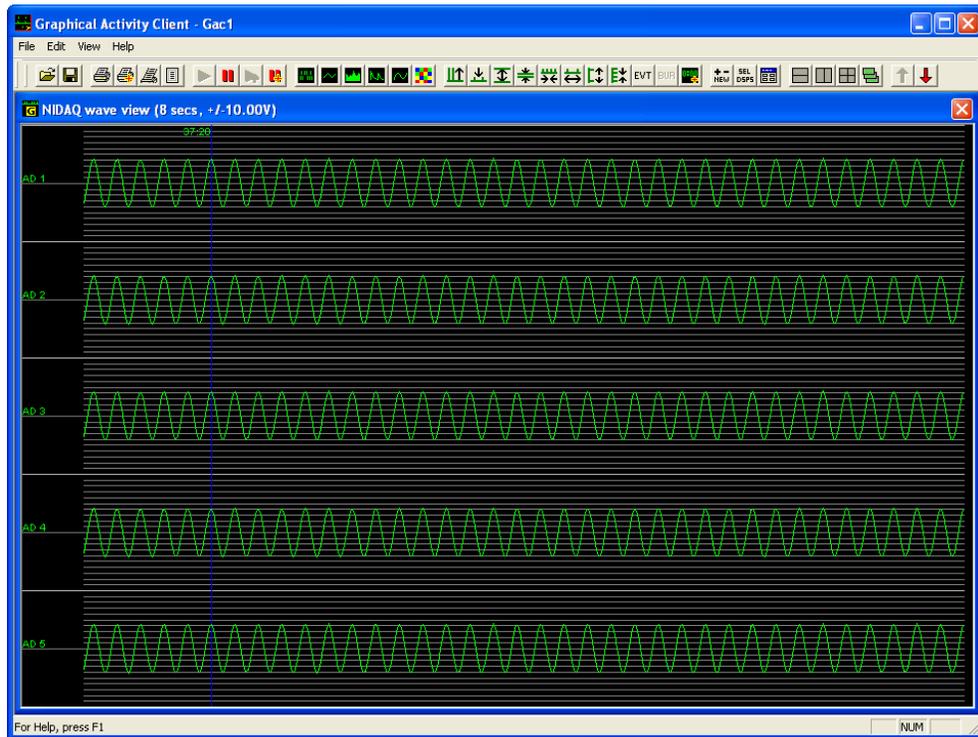
The thresholds may be set by dragging the horizontal threshold lines up or down with the mouse, or the thresholds may be set in the Options window. The title bar on the **Integrated activity graph view** shows the current numeric values of the thresholds.

The following illustration shows the Options window with the **Integrated** tab.

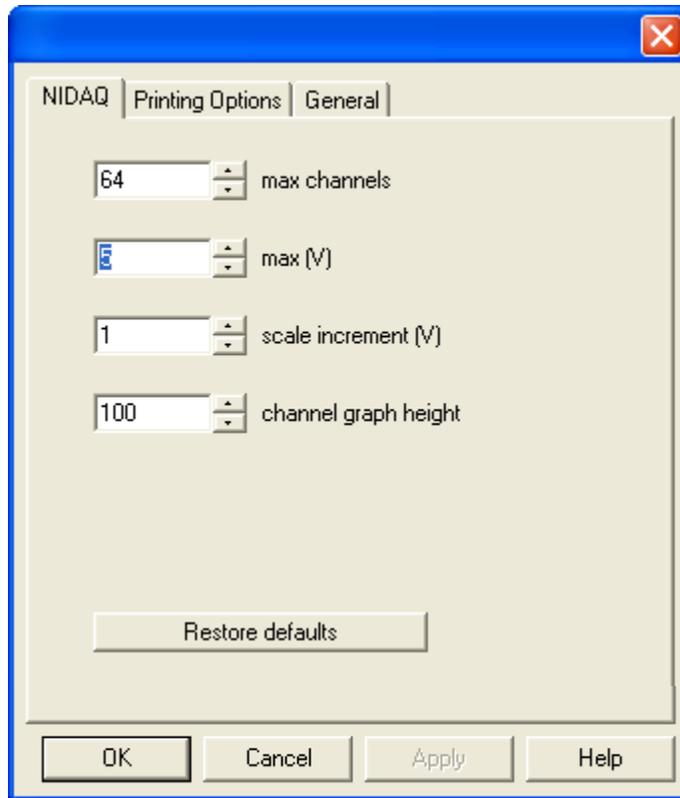


7.5.5 NIDAQ Wave View

The **NIDAQ wave view** displays up to 16 channels of continuous digitized waveforms from the NIDAQ device. The NIDAQ device must be installed in the PC and enabled in Sort Client. These channels are the “slow channels” in Sort Client, where the NIDAQ sampling rate can be set. A typical sampling rate for these channels is 1 kHz or less.



The NI DAQ device digitizes all channels at the same rate. GAC displays the first N channels, where N is currently less than or equal to 16. Fewer than 16 channels in a **NIDAQ wave view** may be displayed by setting the value of **max (V)** in the Options window to a smaller number, as the following illustration shows.



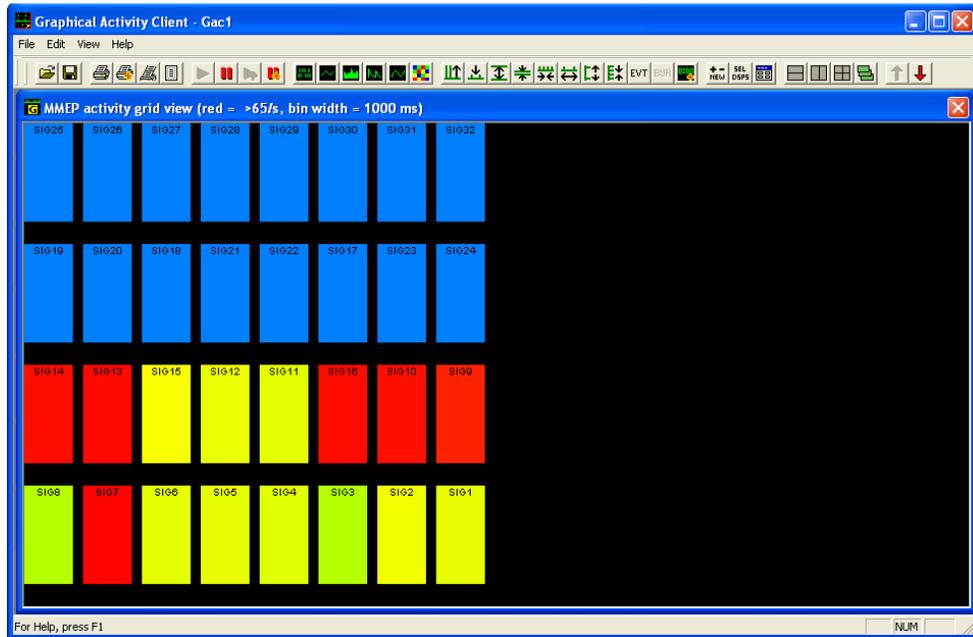
In **NIDAQ wave view**, the baseline for each channel represents an analog input voltage of 0V, and the default scale represents a voltage range of -5V to +5V, which occupies the full height of each channel. The toolbar buttons can adjust the appearance and time scale of a **NIDAQ wave view**. For example, the **Scale up** and **Scale down** buttons can adjust the voltage scaling.

If the NIDAQ channels are scaled up using the **Scale up** button, a horizontal grid appears on each channel with vertical scaling labels. This grid indicates the voltage scaling and allows rough visual measurements of waveform voltages to be made. Use **More scale ticks** and **Less scale ticks** to increase or decrease the fineness of the grid. Set the spacing of the labels at the left end of the grid with the **NIDAQ scale increment (V)** field in the Options window. If no labels are visible, make the channels taller, or decrease the number of ticks, or both.

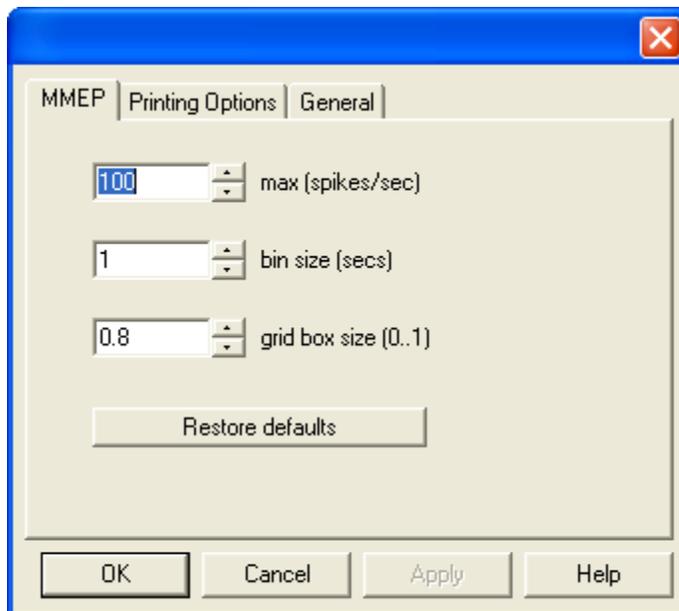
The **NIDAQ wave view** can be memory and processor-intensive. Although any NIDAQ sampling rate may be set in Sort Client up to the limits of the NI DAQ device, GAC currently supports sampling rates of no more than 1 kHz in order to reduce the CPU load. If the application requires somewhat higher sampling rates, please contact Plexon support. However, the **NIDAQ wave view** does not currently support MAP-grade sampling rates (e.g. 40 kHz).

7.5.6 MMEP Activity Grid View

For a 64-DSP channel system, the **MMEP activity grid view** displays a four-row by sixteen-column grid of colored squares that can be arranged to match the pattern of the electrodes on a multi-microelectrode plate (MMEP). The color of each square represents the activity on the corresponding SIG channel, where blue represents no activity and red represents maximum activity.



As the following illustration shows, from the toolbar or from the Options window, it is possible to set the maximum activity scaling and the bin width that GAC uses to calculate the activity.



7.6 Toolbar

The complete GAC tool bar contains the following buttons:



7.6.1 Printing Tools

GAC provides four printing tools. The buttons are all grouped together on the toolbar.



Print view prints the active view. Shortcut: press the **p** key—not CTRL-P, just **p**.



Print all prints all views, one view per page.



Auto-print prints the active view every N seconds, where N is the setting in the Options window. Click **Auto-print** to toggle auto-print mode on or off. If a different view is activated after starting auto-printing, the original view that was active when **Auto-print** was clicked automatically prints.



Page setup sets margins and paper orientation (landscape or portrait). The default orientation is landscape.

7.6.2 View Control Tools

GAC provides four view-control tools. The buttons are grouped together on the toolbar.



Go un-pauses the active view. GAC does not display any activity in this view since the preceding pause.



Pause pauses the scrolling of the active view. Any activity in the view is frozen until **Go** is clicked. GAC draws a red vertical bar across all channels in the active view, with a time label, to indicate that a pause occurred.



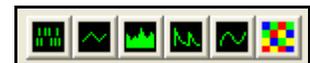
Go all un-pauses all paused views.



Pause all pauses the scrolling of all views. GAC draws a red vertical bar across all channels of all views, with time labels, to indicate that a pause has occurred. **Go** can then un-pause views one at a time, or **Go all** can simultaneously un-pause all paused views.

7.6.3 View Creation Tools

GAC provides six view-creation tools. The buttons are grouped together on the toolbar.



Add ticks graph opens a new **raw events view** window that displays raw spike events as tick marks.



Add activity line graph opens a new **activity graph view** window that displays activity rates as a line graph.



Add rate graph opens a new **slow rate view** window that displays activity rates over long periods of time as a bar graph.



Add burst graph opens a new **integrated activity graph** window that displays integrated activity using specified time constants and bursts detected using a two-threshold method. It is possible to display any combination of fast and slow integration graphs or bursts, or both. For more information, see [“Burst Detection In the Integrated Activity Graph View”](#) on page 236.



Add NIDAQ graph opens a new **NIDAQ wave view** that displays up to 16 channels of continuous waveforms from the NI DAQ device.



Add MMEP color activity graph opens new **MMEP activity grid view** windows that display activity at each electrode of an MMEP as a color from blue, which represents no activity, to red, which represents maximum activity. The squares in the grid equal the number of DSP channels available in the MAP box.

7.6.4 View Adjustment Tools

GAC provides 11 view-adjustment tools. The buttons are grouped together on the toolbar.



Note: These tools have slightly different interpretations when used with the **MMEP activity grid view**, as opposed to the various line views. See the note following each tool description.



Scale up increases the height of graphs in the active view, without changing the number of channels per screen.

Note: In the MMEP activity view, **Scale up** scales the colors towards red and away from blue.



Scale down decreases the height of graphs in the active view, without changing the number of channels per screen.

Note: In the MMEP activity view, **Scale down** scales the colors towards blue and away from red.



Make channels taller displays fewer channels per screen in the active view, each one taller.

Note: In the MMEP activity view, **Makes channels taller** makes the colored squares larger, with less empty space between them.



Make channels shorter displays more channels per screen in the active view, each one shorter.

Note: In the MMEP activity view, **Make channels shorter** makes the colored squares smaller, with more empty space between them.



Longer time scale extends the time scale of the active view. Graphs appear more compressed and scroll more slowly.

Note: In the MMEP activity view, **Longer time scale** increases the width of the bin used to calculate the colors. Colors vary more slowly and smoothly, at the expense of missing rapid fluctuations in activity.



Shorter Time Scale reduces the time scale of the active view. Graphs appear more stretched out and scroll more rapidly.

Note: In the MMEP activity view, **Shorter Time Scale** decreases the width of the bin used to calculate the colors. Colors vary more rapidly. The minimum bin width is 32 milliseconds.



Less scale ticks increases the spacing of tick marks on the y-axis scale at the left side of channel graphs, that is, the increment between scale ticks is larger. This button only effects the **NIDAQ wave view** window.



More scale ticks decreases the spacing of tick marks on the y-axis scale at the left side of channel graphs, that is, the increment between scale ticks is smaller. This button only effects the **NIDAQ wave view** window.



Reset views time to 0 immediately resets the time scale on all views to 0:00. This only affects the labeling of the time axis.



Toggle event display turns the display of event markers on or off.



Toggle burst display turns the display of burst markers on or off. This button only effects the **integrated activity graph view** window.

Many display parameters may also be numerically set with the Options window. It is possible to view and change the parameters for the active view by selecting the view and then clicking the **Options dialog** button on the toolbar. It is also possible to modify the parameters for the active view, while the other views remain unchanged. The changes made with the toolbar buttons are also reflected in the Options window. For more information, see [“Common Options” on page 230](#).

7.6.5 Miscellaneous Tools

GAC provides nine miscellaneous tools, which are grouped together on the toolbar.



Update unit channels automatically inserts any new unit channels to all views except NIDAQ, and deletes any unit channels that are no longer present in Sort Client. GAC briefly pauses and then un-pauses all channels as it updates the list of channels.



Select chans displays a window to add or delete one or more unit channels from the set displayed in the active view. GAC automatically pauses

all views the window is opened, and un-pauses them when the window is closed.



Options dialog displays a window that to set various parameters for the active view, or to change the active view from one type of view to another type of view.



Tile in rows: If there are two or more views, **Tile in rows** causes them to be tiled one above another.



Tile in columns: If there are two or more views, **Tile in columns** causes them to be tiled left to right.



Tile in grid: If there are two or more views, **Tile in grid** causes them to be tiled in a rectangular grid.



Always on top keeps the window for the GAC application on top of all other applications. Click a second time to return GAC to normal.



Page up scrolls the active view up one page, the same as the PAGE UP key.



Page down scrolls the active view down one page, the same as the PAGE DOWN key.

Note: The PAGE UP, PAGE DOWN, HOME, END, UP ARROW, and DOWN ARROW keys on the keyboard may be used to scroll vertically through all the channels. For performance reasons, GAC does not use the standard Windows scroll bars.

7.6.6 Saving and Loading GAC Configurations

GAC provides two configuration management tools. The buttons are grouped together on the toolbar.



Load configuration loads a GAC configuration file. A GAC configuration file saves the position and size of the GAC main window and of all the other view windows. It also saves the parameters for each view, such as time scale, channel height, thresholds, time constants, etc. The GAC file also includes the **Printing** and **General** options. See [“Common Options” on page 230](#). It does not save the channel lists for each view. Instead, GAC loads the list of sorted channels that are in effect in Sort Client when the configuration loads. When GAC loads a configuration, GAC removes any views on the screen and creates and activates the set of views saved in the file. Configurations may be loaded and saved at any time.



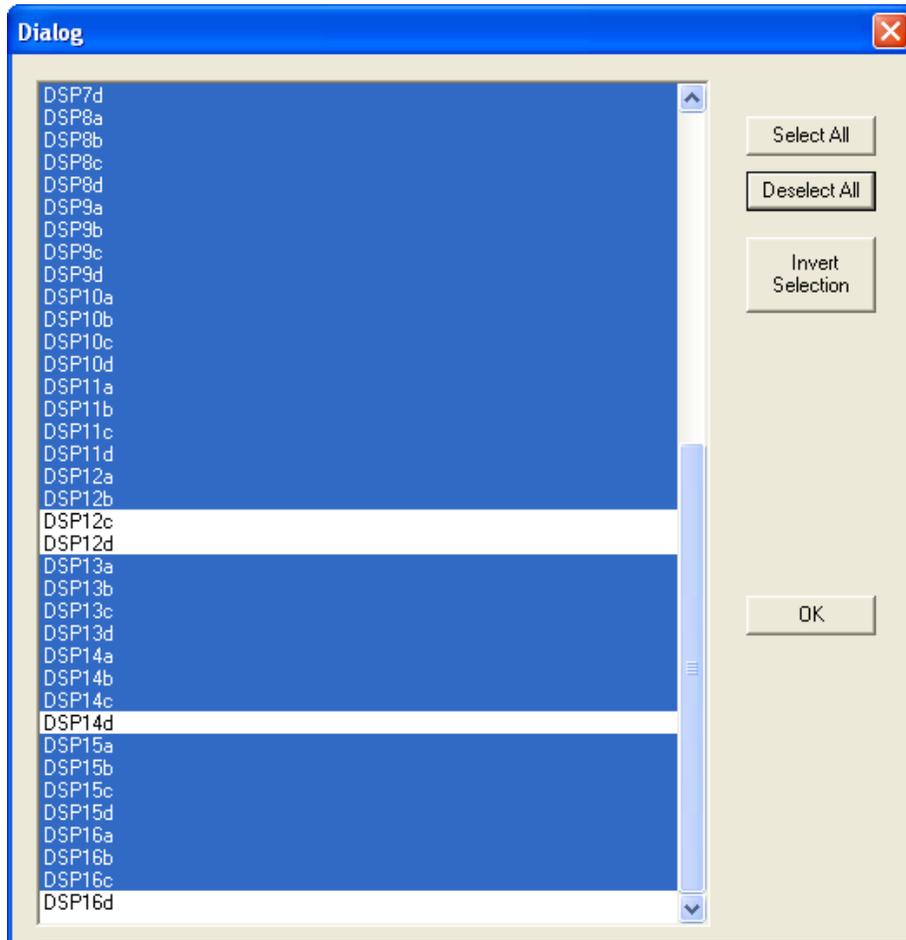
Save configuration saves a GAC configuration file, which is described under “Load configuration” earlier in this section. Configuration files have the extension `.gac` and they are plain text files.

Note: A `.gac` file is not a recording file that saves timestamps or other MAP data; it is a collection of parameters that controls how GAC displays data from the MAP

box. It is possible to record the actual MAP data using the Sort Client's .plx files.

7.7 Adding and Deleting Unit Channels From a View

By default, when a view in GAC is added, the view displays all the channels that have sorted units from Sort Client. If there are more channels than the view window can hold, it is possible to scroll through them, to make the channels shorter so more of them can fit in the view, or both. However, to view just a subset of the available unit channels, select the view and click **Select chans** on the toolbar to open the channel **Dialog** window.



GAC lists all units that are currently sorted in Sort Client in the list box. Use the scroll bar to view all the channels. Highlighted channels display in the active view. By default, GAC selects all of the sorted unit channels. Click a channel name to deselect it. Click a deselected channel name to select it. It is not necessary to hold down CTRL or any other key to select or deselect channels.

The **Dialog** window contains the following buttons:

- **Select All** selects every unit channel.
- **Deselect All** deselects every unit channel. To select just a few channels, just click on **Deselect All** and then click on the desired individual channels.

- **Invert Selection** deselects all selected channels and selects all deselected channels.
- **OK** accepts the currently selected unit channels to display in the active view.

The unit channel selections may always be changed later, for example, if units are added or deleted in Sort Client. One can do this either by clicking **Select Chans** and editing the list of channels using the **Dialog** window, or by clicking **Update unit channels**, which adds all newly-sorted units and deletes all units that are no longer present in Sort Client. **Update unit channels** is the quickest way to ensure that all the currently sorted units are visible. If the sorted units have not changed, **Update unit chans** has no effect.

Note: A NIDAQ view shows the first N channels ($N \leq 16$) of continuous waveform channels. By default, GAC displays all 16 channels, but it is possible to choose fewer channels in the NIDAQ wave view Options window.

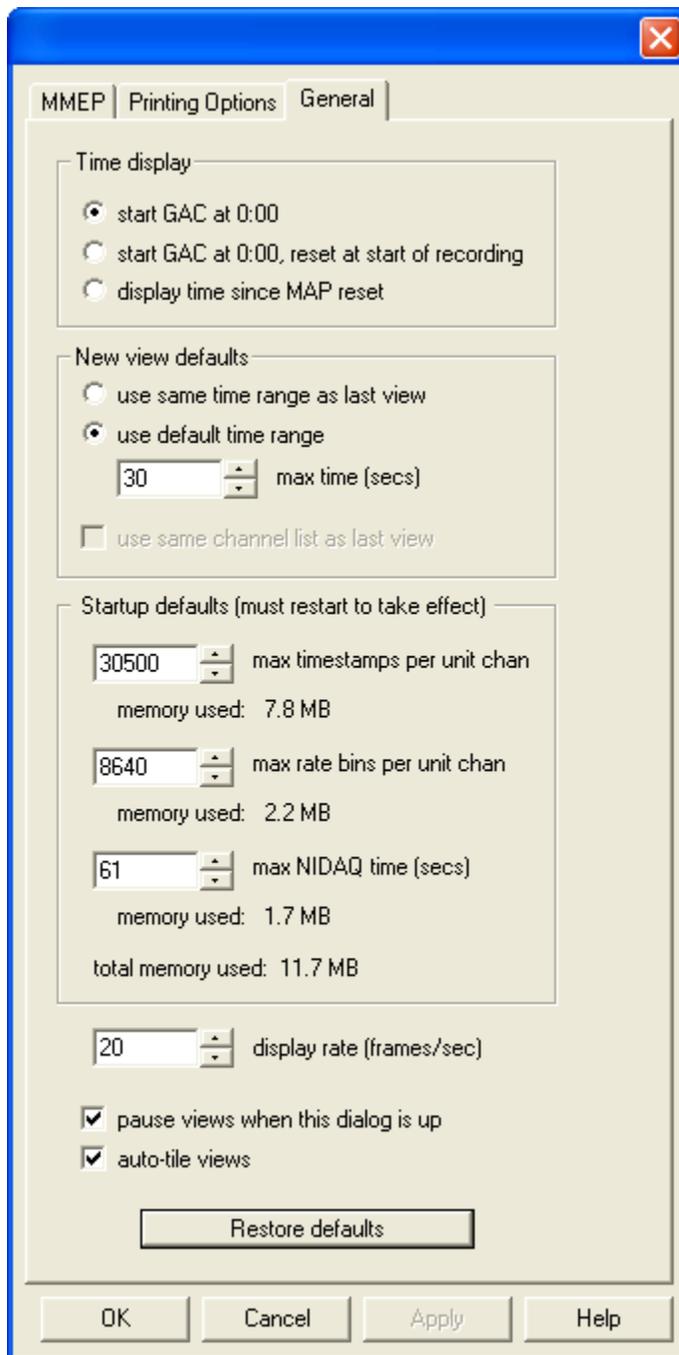
7.8 Common Options

Options is a dynamic menu item that changes to match the active view. This section describes the options that are common to all views. It is possible to view and change the parameters for the active view by selecting the view and then clicking the **Options dialog** button on the toolbar. The Options window has three tabs:

- The first (topmost) tab changes with the selected view.
- The second tab is **Printing** options.
- The third tab is **General** options. The **Printing** and **General** tabs are the same for all views.

7.8.1 General Options

The **General** tab may be used to view and edit several general options such as memory usage, views, and miscellaneous interactive behavior.



7.8.1.1 Time Display Area

The **Time display** area contains the following controls to format the time labels in the GAC views:

- **start GAC at 0:00:** This is the default time format. The first time label is 0:00 (0 hours, 0 minutes), regardless of how long the MAP box has been running before GAC is started. In other words, this format is “time since GAC started.”
- **start GAC at 0:00, reset at start of recording:** This is the same format as above, except the time is reset to 0:00 whenever Sort Client starts recording a .plx file. Each time a new recording is started, GAC resets the time again to 0:00; GAC displays times to the left of 0:00 in all views as negative times. This format is essentially “time since Sort Client started its most recent recording.”
- **display time since MAP reset:** This format displays the time since the MAP box internal timestamp clock has been reset to zero. This reset occurs when the MAP is first powered up, and whenever **Start** is clicked in Sort Client after loading an experiment file.

When the time display mode is changed and **OK** is clicked to close the window, GAC displays the time labels in all views in the chosen format.

Note: IMPORTANT! Internally, the MAP box, Sort Client, and GAC use an integer counter to mark time. This counter rolls over (wraps around through zero) approximately every 29 hours. GAC does not currently compensate for this roll-over. The only situation where this would be a problem is when the MAP box has been running without a reset (that is, when a new experiment file is loaded) for less than 29 hours, but passes the 29 hour mark while GAC is running. As a workaround, the current GAC setup may be saved to a .gac file, close GAC, restart GAC, and load the saved configuration. The wraparound causes no problem with the saved configuration.

7.8.1.2 New View Defaults

The **New view defaults** area contains the controls that determine the length of the time axis for each view as it is created:

- **use same time range as last view:** When this control is selected and a new view is added, the new view inherits the same length of time axis as the view that is currently active. For example, if there is one view whose time axis is 60 seconds long, each subsequently added view also inherits a time axis that is 60 seconds long.
- **use default time range:** By default, a view displays 30 seconds of activity. This default may be changed to a longer or a shorter time. GAC saves this default time, like all the other values and options in the Options window, to .gac configuration file which may be loaded at a later time.

7.8.1.3 Startup Defaults

The controls in the **Startup defaults (must restart to take effect)** area control the amount of memory allocated by GAC for its internal buffers. These values should not be changed without good reason, because, if inappropriate values are selected, GAC could be rendered unusable. GAC saves the following values in the Windows Registry, not in the configuration file, and they do not take effect until GAC is closed and restarted:

- **max timestamps per unit chan:** GAC allocates one timestamp buffer per active unit channel (e.g. DSP14c). The amount of activity this buffer stores is directly proportional to the average firing frequency of the unit on this channel. For example, the default is 30 500, which corresponds to 30 seconds of activity at a constant 1 kHz, 5 minutes at an average rate of 100 Hz, 10 minutes at an average of 50 Hz, etc. The extra 500 timestamps (30 500 vs 30 000) results from extra internal buffering done by GAC. Below the control, GAC displays the amount of RAM needed for the specified number of timestamps, multiplied by the number of active unit channels. The **memory used** value is updated as the number of timestamps changes.
- **max rate bins per unit chan:** GAC allocates a long-term rate buffer for each active unit channel. Each entry in the buffer holds the count for one “rate bin.” By default, a rate bin counts the activity for an interval of 10 seconds. Thus, if the rate buffer is 360 bins long, the long-term rate “sees” display-rate information for the preceding 360×10 seconds = 3600 seconds = 1 hour. Unlike the other view types, GAC does not generate the **slow rate view** directly from the raw timestamp data. Instead, GAC bins and stores the timestamp data in the rate bin buffer, from which it derives the bar graph. This is due to the huge amount of RAM that would be required to store the raw timestamps for hours of activity. Below the control, GAC displays the amount of RAM needed for the specified number of rate bins, multiplied by the number of active unit channels. GAC updates the **memory used** value as the number of bins changes.
- **max NIDAQ time (secs):** GAC allocates a sample buffer for each enabled NIDAQ channel. Depending on the NIDAQ sampling rate, which is usually 1 kHz or less for our purposes, digitized continuous data can quickly take up very large amounts of RAM. If a low sampling rate is selected, it may be possible to increase the maximum buffered NIDAQ time above the default. Although the samples from the supported NIDAQ device are 12 bits wide, they are stored as 16-bit words, so each NIDAQ channel requires RAM equal to the total time multiplied by the sampling rate multiplied by 2 bytes per sample. Below the control, GAC displays the total amount of RAM used by all the NIDAQ channels. GAC updates the **memory used** value as the maximum time changes.

At the bottom of the **Startup defaults** area, GAC displays a value for the overall **total memory used**, which includes timestamps, rate bins, and NIDAQ samples. This value is very close to the total memory GAC uses.

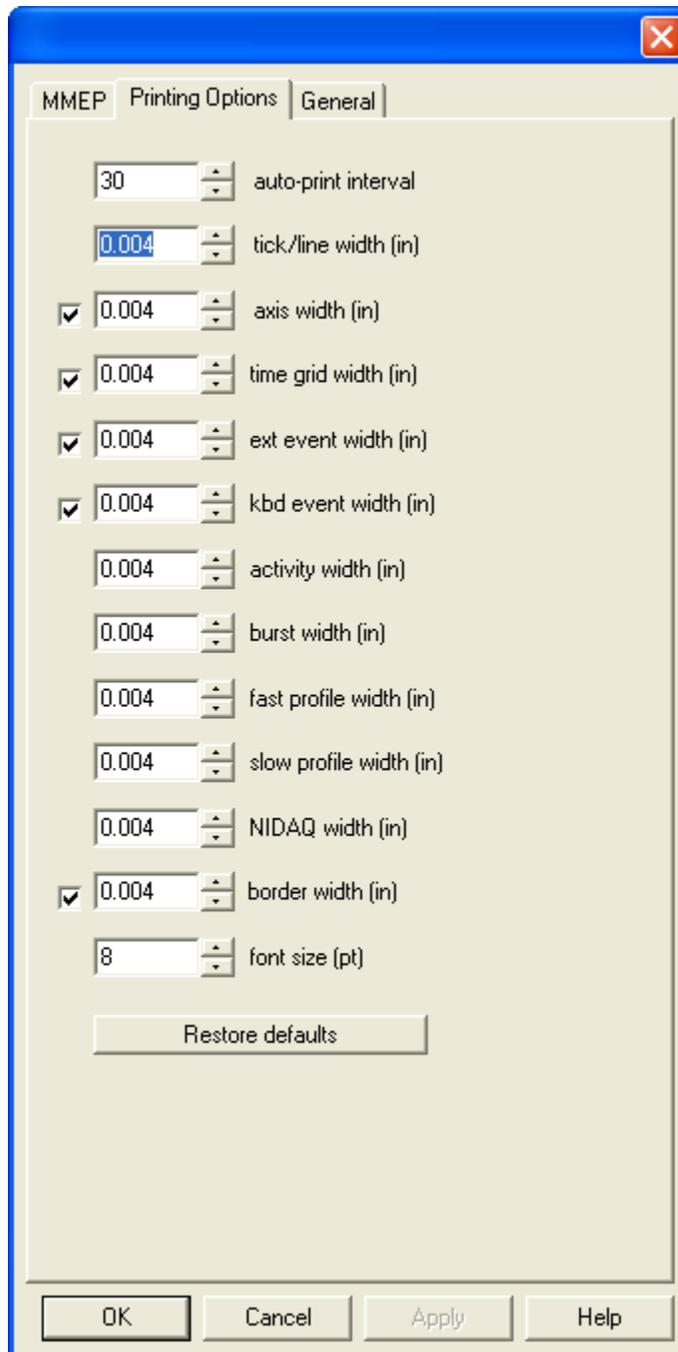
7.8.1.4 Miscellaneous

The bottom area contains the following miscellaneous items:

- **display rate (frames/sec):** Updating the screen frequently enough to give the illusion of continuous motion provides the smooth scrolling of views in GAC. This is similar to television (30 frames per second) or movies (24 frames per second). Below a certain update rate, around 10-15 frames per second, the scrolling starts to become jerky. However, higher update rates substantially increase the load on the computer and video card. If the computer is very slow, or if it is loaded down with other running applications (e.g. compute-intensive recalculations in [NeuroExplorer](#) or MATLAB) to where performance is an issue, the GAC display rate may need to be reduced.
- **pause views when this dialog is up:** By default, when the Options window is opened, GAC pauses all views and then un-pauses them when clicking **OK** or **Cancel**, because views cannot be scrolled efficiently with a dialog window open. However, this has the side-effect of not displaying the data for the interval when the dialog window is open, even after the dialog box is closed. If the temporarily incorrect scrolling while the dialog window is open is preferred, click to clear the **pause views when this dialog is up** option.
- **auto-tile views:** By default, GAC automatically tiles the view windows as either rows (the default), columns, or in a rectangular grid. Regardless of the arrangement, GAC maintains the tiled layout when moving or resizing the main window, and GAC updates the layout as new views are added or views are closed. GAC thus ensures that all views are always visible, are of equal sizes, and do not overlap. However, it is possible to move and resize the individual view windows to a custom arrangement. For example, there may be one large view with two smaller views adjacent to it. If this is done with auto-tile enabled, as soon as the main window is resized, all the views snap back to their automatically laid out positions. To prevent this automatic tiling, click to clear the **auto-tile views** check box. With auto-tiling disabled, it is still possible to obtain neat tiling by clicking on one of the tiling buttons, but the views remain in their relative positions no matter what happens to the main window. Also, when auto-tiling is disabled, new views pop up on top of existing views. In many cases this causes the scrolling views underneath the new view to display incorrectly, and the views must be manually adjusted so that they do not overlap, or click a tiling button to tile them.

7.8.2 Printing options

The **Printing Options** tab can control the appearance of views when printing them. These following options apply to all views:



- **auto-print interval:** This option sets the time interval for automatic printing. All views use the same auto-print interval.

- **... width:** The *width* options determine the line widths used to print various elements of the graphs, such as the vertical time-grid lines, the fast and slow graphs in the integrated view, the NIDAQ waveforms, etc. The default value is 0.004 inches, which is equivalent to a resolution of 250 dots per inch (dpi). This value ensures that the lines do not become too thin, even on high-resolution printers (1200 dpi). To make the corresponding graph element bolder, increase the line width value.
- **check boxes:** The user may omit some graph elements (axes, grids, borders) from the printed output by clicking to clear the corresponding checkbox.

7.9 Type Specific Options

The top tab in the Options window displays the options for the type of view selected when the window was opened. Most graphs have options for time scale length, time grid interval, channel height, and maximum graph value. Some graphs have additional options, which depend on the view type. Some parameters are available in the Options window that are not accessible through the toolbar, e.g. the time grid increment and the time constants and burst thresholds. Others, such as graph maximum value, can be adjusted with the toolbar buttons, or by specifying a value in the Options window.

Note: While the Options window is open, GAC pauses all views, and GAC automatically unpauses when the window is closed. This behavior may be disabled in the **General** options tab.

7.10 Burst Detection In the Integrated Activity Graph View

Type the **s** key to toggle the display of the slow integration graph. Type the **f** key to toggle the display of the fast integration graph. Type the **b** key to toggle display of the detected bursts. It is possible to view any combination of slow or fast graphs, or bursts, or all three. For viewing the fast graph only, the user can *scale up* the graphs to improve the view over the slow graph. When inspecting and adjusting bursts, the user can increase the size of the channels considerably to allow easier manipulation.

The user can directly adjust the upper or lower thresholds by dragging them. The top of the orange burst rectangle represents the slow threshold. The horizontal orange line within the rectangle represents the fast threshold. Dragging either one of these lines adjusts the threshold in real time, and the number and sizes of bursts change correspondingly. GAC only looks at the Y coordinate while dragging; it is not necessary to begin or remain on a visible threshold bar (orange), although it can be more intuitive to do so.

GAC displays the value of the new threshold in real time in the window title bar. If the fast (lower) threshold is not visible, it is probably close to the zero baseline. Try pointing the mouse at or just above the baseline and dragging upward. If no bursts are visible, it is always possible to bring up the Options window and specify either threshold numerically. GAC applies the fast and slow thresholds to all

channels in the same integrated/burst view; however, different views can have different thresholds.

The two thresholds that are currently used to define bursts use a simple algorithm as follows. A burst is defined as a time interval in which the slow integration curve remains entirely above the slow threshold and the fast integration curve remains entirely above the fast threshold.

Note: GAC prints whichever combination of fast and slow graphs and burst rectangles that are seen on screen.

7.11 Caveats

There must be an experiment file loaded and started in Sort Client before GAC is started. If a different experiment file is loaded in Sort Client after starting GAC, the next experiment file resets the clock in the MAP box while GAC is in the middle of acquiring data from it. It is possible to work around this by closing GAC before loading the new experiment file in Sort Client and restarting GAC after the file has been loaded and started. If the layout and parameters of the current views need to be preserved, save a configuration (.gac) file before closing GAC and reload that configuration after restarting GAC.

If there is not any unit activity occurring when GAC starts up, nothing appears in the initial view until some activity occurs; one spike is sufficient activity. When GAC sees some initial activity, it does not matter whether there are pauses in the activity on any or all channels.

GAC does not recognize the 29-hour wraparound of MAP timestamps. If GAC is running and the MAP box has also been running continuously without a reset or without loading a new experiment file for 29 hours, GAC must be shut down and restarted after the wraparound has occurred. Contact Plexon for assistance if running experiments longer than one day in continuous duration.

On some systems, GAC cannot display every timestamp after approximately 45 minutes to 1 hour of continuous operation. If this occurs, close and restart GAC.

The GAC NIDAQ view is intended to view slowly varying waveforms that are digitized at a low sampling rate, typically 1kHz or less. If the waveform being

viewed has a short period relative to the width of the time axis, there can be some aliasing in the displayed waveform. If the default 30-second time scale is used, with waveforms whose lowest frequency component is less than 5 Hz, aliasing is not a problem. If aliasing is visible, shorten the time scale until the aliasing is eliminated.

Chapter 8

PeriEvent Client

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8.1 PeriEvent Client Overview

This chapter provides information on PeriEvent Client (PEC) v1.2.6 (01/11/05). PEC (pec.exe) is a Windows application used in conjunction with Sort Client to visually display perievent histograms in real-time. When an event occurs, PEC automatically updates its displays immediately on the specified event channel, as opposed to every N seconds in the peristimulus time (PST) histograms in [NeuroExplorer](#). PEC also displays perievent rasters for a specified number of previous trials beneath the PST histogram. Think of PEC as an “event triggered” display.

Sort Client must be used first to discriminate the desired units, and then PEC can be started to monitor the peri-event activity on those channels. There must be an external event source, because PEC only displays peri-event activity.

8.2 Requirements and Installation

PEC runs on Windows XP or NT 4.0 or later with the same hardware requirements as Sort Client. If PEC has not automatically installed, one may install PEC by creating a directory such as \pec and copying the contents of the PEC files to this directory. One can also put it in the directory where the other Plexon applications are located, such as \rasputin.

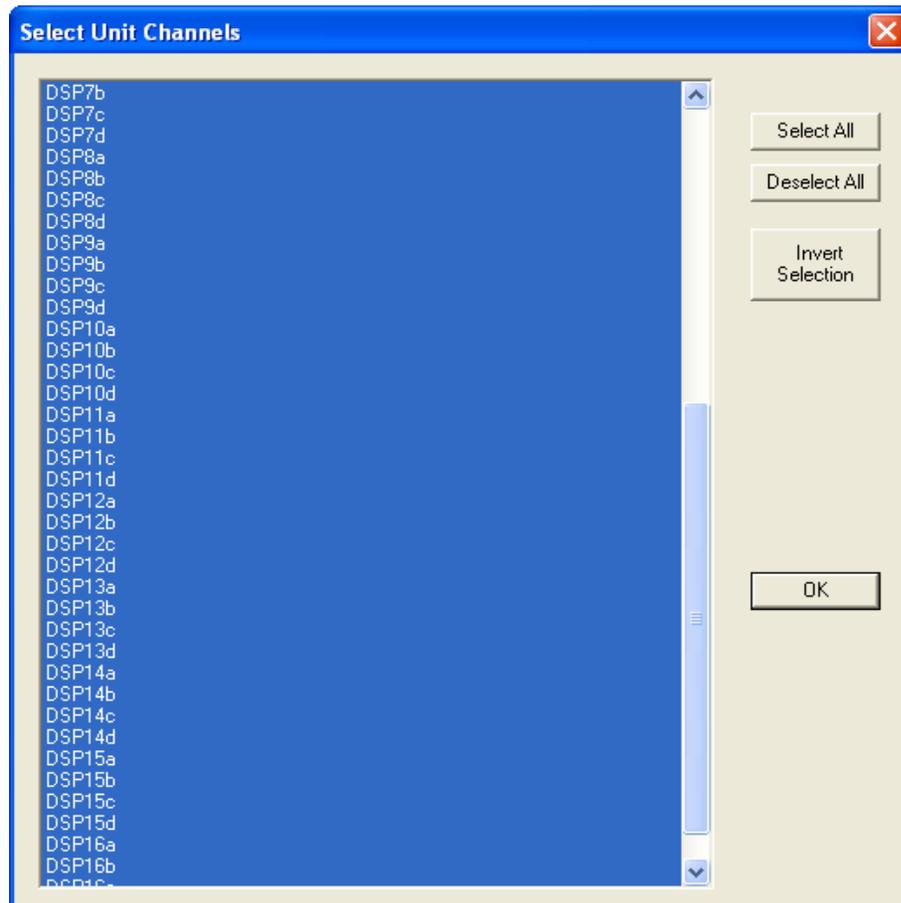
A shortcut on the desktop for PEC can be created. This is an illustration of the PEC desktop icon.



8.3 Startup

Make sure that Sort Client is already running with an experiment file loaded. To run PEC, double-click the desktop icon or the pec.exe file in the directory where it is installed.

On startup, PEC displays the **Select Unit Channels** window, where selection can be made for the unit channels on which to observe peri-event activity.



All units that are currently sorted in Sort Client appear in the list box; scroll to see all the channels. By default PEC, selects all of the unit channels. Click on a channel name to select a channel. Click on a selected channel to deselect the channel. It is not necessary to hold down CTRL or any other key to select or deselect. The four buttons perform the following functions:

Select All: Click to select every unit channel.

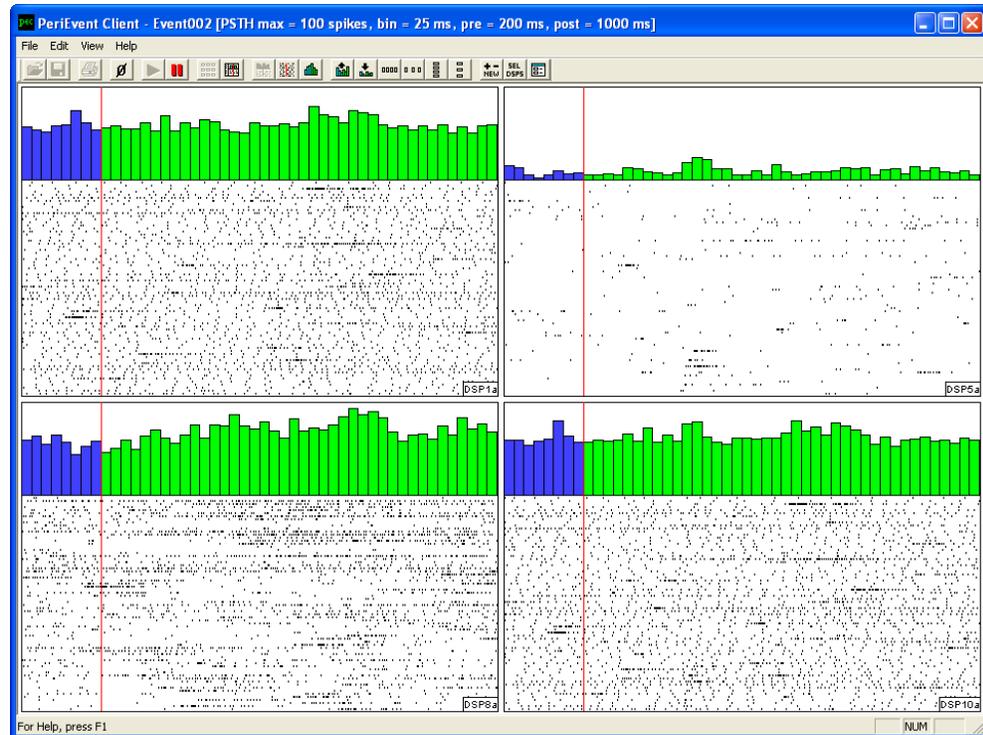
Deselect All: Click to deselect every unit channel. To select just a few channels, just click **Deselect All** and then click the desired individual channels.

Invert Selection: Click to deselect all selected channels and simultaneously select all deselected channels.

OK: Click to accept the currently selected unit channels as the active view.

The unit channel selections may always be changed later, for example, if units are added or deleted in Sort Client. For more information, see “Add/delete new channels:” on [page 242](#).

To set up a simple display using PEC, click **Deselect All**, then click on a few unit channels to display. Click **OK** to view these channels in the main display. After a few external events and some unit activity have occurred, the PEC window typically looks like the following illustration:



Each graph represents one of the sorted unit channels selected, with the channel name in the lower right corner. The PST histogram for the channel is displayed at the top, with the peri-event rasters below it. The red vertical line represents the time when the event occurred. Pre-event activity is to the left (blue bars) and post-event activity is to the right (green bars). PEC displays the most recent peri-event raster at the top, and as new events occur, the rasters scroll down one row.

8.4 Toolbar

To control PEC functions, click on the toolbar buttons or change the values in the **Options** window. The following illustration shows a section of the PEC toolbar.



Note: The buttons that appear to the left of the preceding ones are not functional for this release of PeriEvent Client.

-  **Zero bin counts:** Click to reset all PST histogram bin counts to zero. Peri-event rasters are unaffected.
-  **Go:** Click to un-pause the PEC display. PEC updates its displays each time an external event occurs.

 **Pause:** Click to pause the PEC display. PEC ignores any subsequent external events and unit activity until **Go** is clicked. When PEC is paused, one can toggle between multi-channel view and single-channel view. For more information, see the following button descriptions.

 **Multi-channel view:** Click to display all the selected unit channel graphs in a grid of rows and columns. In the multi-channel view, one can change to a zoomed view of a single channel by double-clicking on that channel. Click on the multi-channel button to return to the multi-channel view.

 **Single-channel view:** Click to display a single-unit channel graph, which enlarges to fill the PEC window. This button is active only when the view is changed from a single-channel view to a multi-channel view. Click on the single-channel button to return to the zoomed view of the channel.

 **View PSTH and rasters:** The default channel graph shows both a PST histogram and the channel rasters. If only the PSTH or only the rasters are visible, click this button to display both the PSTH and the rasters.

 **View rasters only:** Click to display only the peri-event rasters, which fits more rows of rasters in the window.

 **View PSTH only:** Click to display only the PST histograms, which displays the bar graph at a larger size.

 **Scale PSTH bars up:** If activity is low, click this button to scale up the bars, that is, to decrease the graph maximum value.

 **Scale PSTH bars down:** If activity is high, click this button to scale down the bars and increase the maximum value for the graph. When a bar overflows the maximum value for the graph, it is possible to control whether the bars are automatically rescaled, or the bin counts are reset to zero, by using the **Options** window. For more information, see [“Options Window” on page 243](#).

 **Show more columns:** By default, PEC shows an approximately equal number of rows and columns of channel graphs. Click this button to add one additional column of graphs only to the multi-channel view.

 **Show fewer columns:** By default, PEC shows an approximately equal number of rows and columns of channel graphs. Click this button to remove one additional column of graphs only to the multi-channel view.

 **Show more rows:** By default, PEC shows an approximately equal number of rows and columns of channel graphs. Click this button to add one additional row of graphs only to the multi-channel view.



Show fewer rows: By default, PEC shows an approximately equal number of rows and columns of channel graphs. Click this button to remove one additional row of graphs only to the multi-channel view.



Add/delete new channels: Click to add channel graphs for all newly-sorted units and delete channel graphs for all units that are no longer present in Sort Client. **Add/Delete New Channels** is the quickest way to insure that all the currently sorted units are visible. If there is no change in sorted units, **Add/Delete New Channels** does nothing.

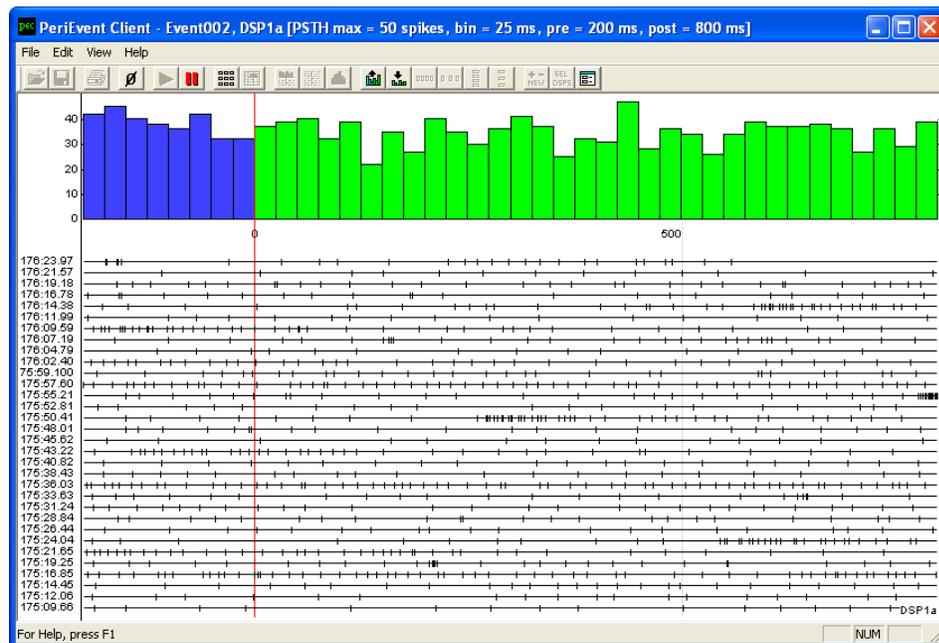


Select unit channels: Click to display the **Select Unit Channels** window to manually select which sorted unit channels to monitor. This is the same window that appears when PEC is started; for more information, see [“Startup” on page 238](#). When **OK** is clicked in the **Select Unit Channels** window, PEC updates the display to show the channel graphs only for the selected units.



Options dialog: Click to display the **Options** window, where the user can set the pre-event and post-event times, bin width, event channel, etc. It is also possible to use the toolbar buttons, or the items may be numerically set in the **Options** window. Any changes made with the toolbar appear in the **Options** window. For more information, see [“Options Window” on page 243](#).

By default, PEC displays a multichannel view with all the selected sorted-unit channels displayed in a grid of channel graphs. To view any channel in detail, double-click the channel graph to have PEC redraw the channel graph so that it fills the PEC display.

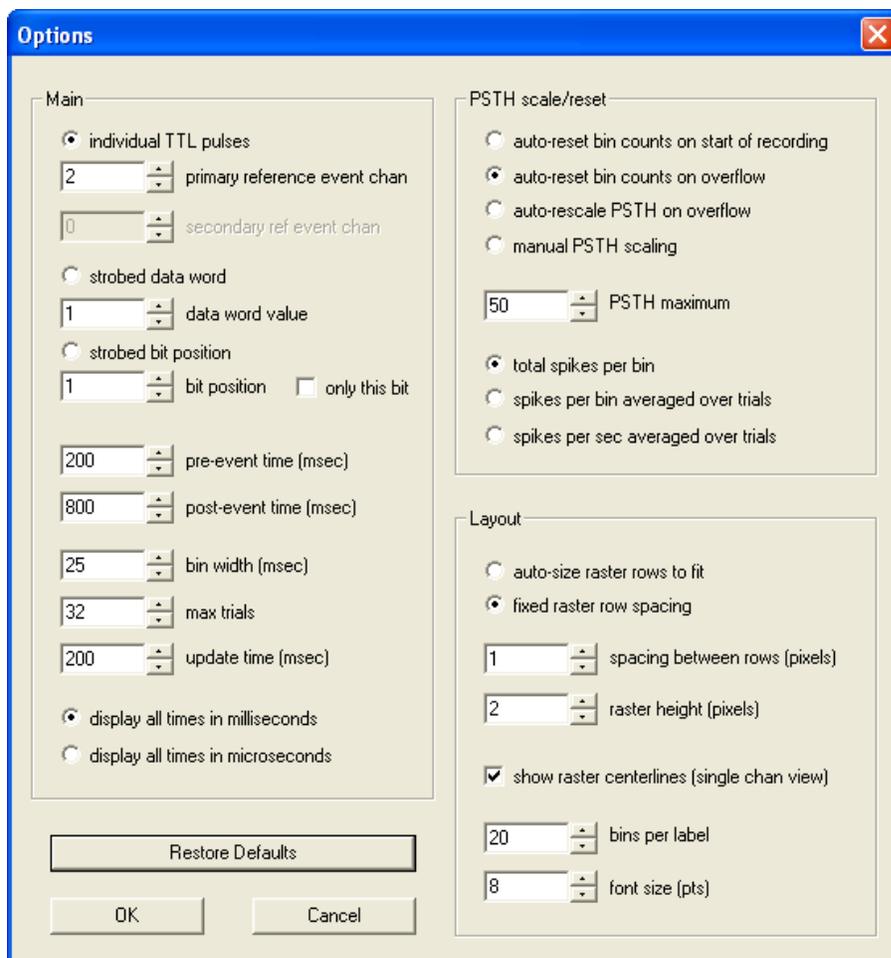


In the multichannel view, PEC draws the PSTH graph with scale and bin time labels. PEC labels each peri-event raster with the time in minutes, seconds, and hundredths of a second. The peri-event rasters scroll down one row each time an external event occurs, just as in the multi-channel view.

Click on the **Multi-channel view** button to return to the multi-channel view. In the multi-channel view, it is possible to switch back to the single-channel view of a channel by clicking on the **Single-channel view** button, or to view any other single channel by double-clicking directly on the channel graph.

8.5 Options Window

In the **Options** window, the values for the parameters for the PSTH and peri-event rasters may be set. The following illustration shows the **Options** window.



8.5.1 Main

The following settings control what appears in the PEC main window:

individual TTL pulses: Click to select individual pulses as the event marker and then select the channel number in the **primary reference event chan** box. This

number is the event channel for PSTH histograms and peri-event rasters. All unit channels are referenced against this event channel. The vertical red line in each channel display shows the time when the reference event occurs.

strobed data word: Click to select a strobed word as the event marker and then select its value in the **data word value** box.

strobed bit position: Click to select a strobed bit as the event marker and then set its position in the **bit position** box. If this bit is the only even bit, click **only this bit**.

pre-event time: Select the time interval to display preceding each external event.

post-event time: Select the time interval to display following each external event.

bin width: Select the width of each bin (graph bar) in the PST histogram.

max trials: Select the maximum number of trials (peri-event rasters) to display for each channel. The user can further limit the number of peri-event rasters visible for each channel by specifying the sizes for each raster and the spacing between rasters. For more information, see [“Layout” on page 245](#).

update time: Select the time interval to dynamically update the graphs. For more information, see [“Dynamic Updating of Graphs and Events” on page 246](#).

display all times in milliseconds: Click to show pre- and post-event times, bin times, etc., in units of milliseconds. In milliseconds, the smallest bin width that can be selected is one millisecond, which corresponds to one MAP clock tick at a 40 kHz sampling rate.

display all times in microseconds: Click to show pre- and post-event times, bin times, etc., in units of microseconds. In microseconds, the smallest bin width that can be selected is 25 microseconds, which corresponds to one MAP clock tick at a 40 kHz sampling rate.

8.5.2 PSTH scale/reset

Use the following items to set the vertical scale of the PSTH bar graphs:

auto-reset bin counts on start of recording: Click to automatically clear all channel bin counts each time recording begins in Sort Client.

auto-reset bin counts on overflow: Click to automatically clear all channel bin counts whenever any bar for any channel exceeds the current maximum.

auto-rescale PSTH on overflow: Click to automatically double the PSTH bar maximum whenever any bar for any channel exceeds the current maximum. This insures that the bar graphs always fit, no matter how large the bin counts get.

manual PSTH scaling: Click to use a fixed graph maximum set in the **PSTH maximum** field (see next item). If any bars overflow this maximum value, they appear in red. To manually clear the bin counts, click the **Zero bin counts** button.

PSTH maximum: Select the maximum bin count for the bars in the PST histogram. This value only takes effect when **manual PSTH scaling** is selected.

total spikes per bin: Click to have each bar in the PSTH indicate the total number of spikes in that bin. The bins grow as there are more trials and spikes, unless one of the auto-scale or auto-reset options is selected.

spikes per bin averaged over trials: Click to have each bar in the PSTH indicate the total number of spikes in that bin, which is divided by the total number of trials. The bar height indicates the average number of spikes in the bin, over all trials.

spikes per sec averaged over trials: Click to have each bar in the PSTH indicate the total number of spikes in that bin, divided by the total number of trials and the bin width. The bar height indicates the average firing rate (frequency) in that bin, over all trials.

8.5.3 Layout

auto-size raster rows to fit: Click this item to automatically shrink the height and spacing of peri-event rasters as necessary to fit the specified number of trials into the graph.

Note: This layout feature is not implemented in this release.

fixed raster row spacing: Click to use the values specified in the following boxes for spacing between rows and raster height.

* **spacing between rows:** Select the number of pixels to place between two successive rows of peri-event rasters.

* **raster height:** Select the height in pixels of each peri-event raster. A value of 1 shows rasters as rows of dots; larger values show rasters as ticks of increasing height.

show raster centerline (single chan view): Click to have PEC draw a horizontal line through each row of raster-spike tick marks. Otherwise, PEC draws only the rasters. PEC does not draw the horizontal line in the multichannel view because there is not enough room for the line and the line clutters the display.

bins per label: Select the spacing of the labels along the x-axis (time scale) of the PSTH bar graph in single-channel view. For example, if 4 bins per label for a bin width of 25 milliseconds is specified, post-event bin labels appear at 0, 100, 200, 300, ... milliseconds, as well as pre-event labels at -100, -200, ... milliseconds. This option does not apply to the multichannel view, because the channel displays are too small to draw bin labels.

* **font size (points):** Select the font size in points for the text of the label channel names, event times, bins, etc.

Note: The user can set the parameters marked with an asterisk * separately for the multichannel view and the single-channel view. If the **Options** window is opened while in multichannel view, the parameters for that view are visible and can be changed. The same is true for the single-channel view. For example, it is possible to set a font size of 6 points for the multichannel view and a larger 10-point font size for the detailed single-channel view.

8.6 Dynamic Updating of Graphs and Events

PEC updates all its graphs each time that an external event occurs. Events occur on the channel specified in the **Options** window, which by default is event channel 2 connected to the XS2 BNC connector. However, after the event occurs, PEC must also display the post-event activity. The user can control how quickly and smoothly PEC *draws in* the post-event activity by specifying the update-time value in the **Options** window. For example, the default value of 200 milliseconds (5 Hz) means that every 200 milliseconds after an event occurs, PEC draws in 200 milliseconds of post-event activity, until the specified post-event time has elapsed. It also means that there is up to a 200-millisecond lag between the event occurring and the first post-event activity being drawn.

For most uses, the 200-millisecond update time is a reasonable balance between immediate, real-time display of the post-event activity, and the additional processing time required to frequently update the display. On a fast PC, this time could be reduced to as low as 50 milliseconds (20 Hz) to provide the smoothest possible display. If the fastest updates and minimum latency are required, make sure the MAP Server polling time is set as low as possible (10 milliseconds). For more information, see [“View > Options” on page 148](#).

If the external event occurs frequently (faster than 1 Hz), make sure that the update time is fast enough that the display can keep up. If the update rate is too slow, PEC prompts with a warning that it should be reduced. A general rule of thumb is that the update time should be no more than half the interval between external events. For example, if events are occurring at a maximum rate of 2 Hz (500 milliseconds), set the update time to less than 250 milliseconds. An update time of one-fourth the minimum event interval provides optimal display updating. Thus, if the update time is set to 50 milliseconds, PEC displays events occurring at a rate of at least 5 Hz. If it is necessary to display events that occur at a rate greater than 5 Hz, contact Plexon.

8.7 Saving and Loading PEC Configurations

PEC does not use a configuration file. When PEC starts, it recalls the settings that were last in use, including window size and position, and all the settings in the **Options** window. When PEC closes, it automatically saves all the settings. The first time PEC runs, it uses default values for all settings.

Chapter 9

Grid Monitor Client

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9.1 GridMon Overview

This chapter provides information on Grid Monitor (GridMon) v1.14 (01/11/05). GridMon (GridMon.exe) is a Windows XP application that can be used in conjunction with the MAP Server and Sort Client to visually display activity in real-time, by using a colored animated grid. GridMon may be used to visualize the activity on a regularly-spaced array of electrodes, such as a multi-microelectrode plate (MMEP).

First, start Sort Client and sort the desired units, then start GridMon to monitor the activity on those channels. The GridMon options can be used to select the electrode layout and to adjust the appearance of the animated color-grid display.

The electrode configurations supported by GridMon are:

- MMEP1 (64 electrodes in 4 rows and 16 columns)
- MMEP4 (64 electrodes, 8 rows x 8 columns)
- MEA56 (64 electrodes, 8 x 8)
- Generic (2 x 8, 4 x 8, 8 x 8, and 8 x 16)

9.2 Requirements and Installation

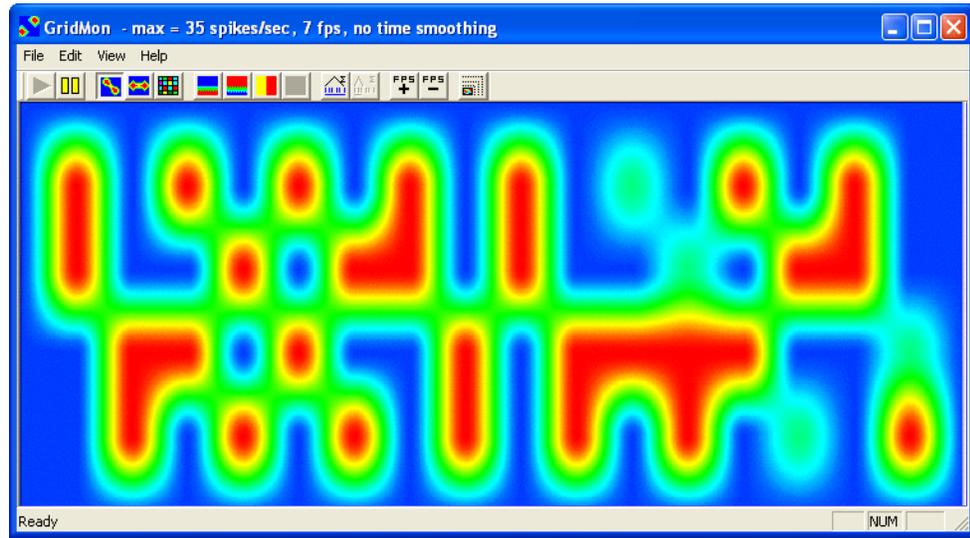
GridMon is designed to run on Windows XP or later with the same hardware requirements as Sort Client. If GridMon has not installed automatically, it can be installed by copying the executable file GridMon.exe into the directory where the other Plexon applications are located, such as \rasputin.

Plexon strongly recommends that the Windows display be set to at least 16-bit color mode (65536 colors). It is possible to run GridMon in 8-bit mode (256 colors), but the appearance of the animated color display is very poor compared to 16-bit and higher modes. Internally, GridMon maintains 24-bit color precision.

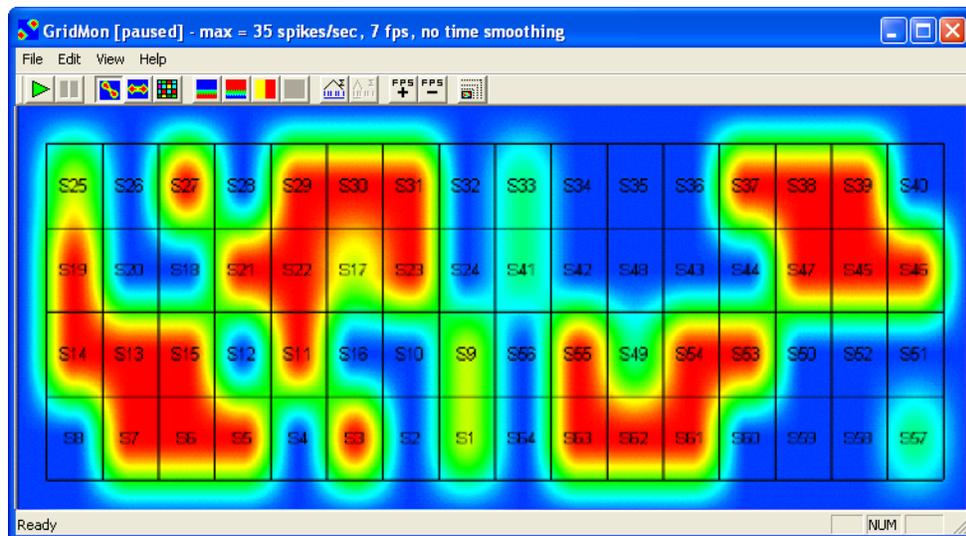
9.3 Startup

Run Sort Client with an experiment file loaded. To run GridMon, double-click GridMon.exe in its installed directory. A desktop shortcut for GridMon may also be created.

As the following illustration shows, at startup the GridMon display appears and defaults to the MMEP1 (4 X 16) electrode layout.



GridMon continuously displays activity on the first 64 electrodes. If the **Pause** button is clicked, the display stops until the **Go** button is clicked. For more information, see [“Go, Pause: These buttons pause and unpause the GridMon display.” on page 252](#). As the following illustration shows, when paused, GridMon shows an overlay grid indicating the layout of the electrodes (SIG channels).



Before using the functions available for adjusting the appearance of the GridMon display, review the theory of operation described in the following section.

9.4 Theory of Operation

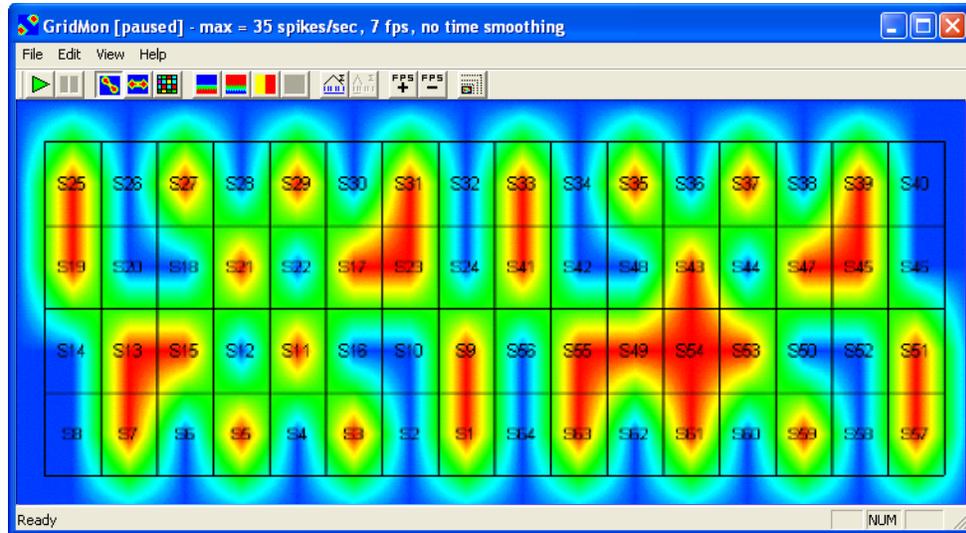
GridMon periodically counts the spikes that occur on each electrode (SIG) channel and displays the activity level (count per unit time) as a color. Red is the most active and blue is totally inactive. Strictly speaking, the firing rates (activity) are only known at the electrode sites (the centers of the grid squares in the previous illustration), but GridMon interpolates between the electrode sites to create a smoothly flowing display that is useful in visualizing dynamic patterns of activity. The activity on all units on each SIG channel (e.g. SIG 23a, SIG 23b, SIG23c, SIG23d) is summed into a single activity value for that electrode site.

With the GridMon temporal smoothing feature turned off, each frame that GridMon displays represents the activity within the preceding frame time without reference to preceding frames. For example, if the frame rate is set to the default value of 10 frames per second (fps), every 0.1 seconds GridMon displays a picture of the activity in the preceding 0.1 seconds. In effect, the display is the equivalent of watching a 10 fps animated movie of the activity at the electrode sites.

If only a few widely separated electrodes have significant activity, each active electrode site appears as discrete colored circles that change shade from red (or green, if there is less activity) in the center to blue at the edges. However, when adjacent electrodes have activity, the interpolation across the grid becomes more apparent. For example, in the preceding illustration, in the left-most column S8 is relatively inactive, S14 is very active, with decreasing activity through S19 and S25. There are two methods of interpolation: bicubic and bilinear. The preceding illustration shows bicubic interpolation.

Bicubic Interpolation: The default method is to use a grid of bicubic polynomial interpolants, with an activity level being interpolated at each grid intersection (electrode site). This interpolant assumes that the partial derivatives of activity with respect to the directions of the grid rows and columns is zero at the electrode sites, so that the individual bicubic interpolants *stitch* together with first-order continuity. If the activity were represented as heights instead of colors, so that the electrode sites are *hills* of varying heights, this would be equivalent to saying that the top of each hill is level, and that the *ground* smoothly slopes away from one *hilltop* to the adjacent ones. Although the bicubic interpolant provides a smooth slope, sometimes a more abrupt slope can be preferable.

Bilinear Interpolation: Bilinear is the alternative interpolation method, which yields a *chunkier* display because it only performs a linear interpolation in each direction between the electrode sites. See the example in the following illustration.



The red centers that indicate high activity tend to be more tightly separated and unnaturally diamond-shaped, due to the linear interpolation. Other unusual visual artifacts can occasionally be seen for two reasons. First, a grid of bilinear interpolants in general has unavoidable discontinuities along the grid lines. Second, a bilinear interpolant cannot truly interpolate four arbitrary activity levels at its corners. Continuing the analogy of hilltops, if each of four hilltops is at a different height, there is in general no plane that touches all four hilltops, because a plane is defined by only three points in space. In the case where the four activity levels at the corners are unequal, GridMon performs a pseudo interpolation that is orientation-dependent. In most cases, this works acceptably well, given that a general display of activity dynamics is the goal.

Note: We cannot know what the true activity is in between the actual electrode sites. The only *true* display would consist of a single colored dot at each electrode site. GridMon displays a mathematical interpolation of the known activity levels, no more and no less. Be careful not to read too much into the GridMon interpolated display.

9.5 Toolbar

GridMon provides access to most functions from these buttons on the toolbar.



All parameters may be adjusted while the GridMon display is running. It is not necessary to pause the display to adjust it.



Go, Pause: These buttons pause and un-pause the GridMon display.



Bicubic interpolation: This button starts bicubic interpolation, which provides a smoother display that runs more slowly.



Bilinear interpolation: This button starts bilinear interpolation, which provides a *chunkier* display that runs faster.



No interpolation: This button sets the display to the non-interpolated mode, which is a grid of colored squares.



More blue, More red: These buttons adjust the color scaling of the GridMon display. Use the **More blue** button when activity is high to *cool down* the colors. Use the **More red** button when activity is low and the display is showing mainly blue and green. The number of spikes per second that corresponds to red (maximum activity) appears in the title bar.



More banded, less banded: By default, GridMon displays the interpolated color grid as smoothly as possible up to the limit of the display settings (preferably 16-bit color or better) on the PC. However, one may experiment with lower resolutions, which provide an interesting *contour map* or *isobar* appearance where the colors are more banded looking. The **More banded** button reduces the color resolution. The **Less banded** button increases the color resolution. **More banded** can require several clicks before the banding becomes obvious, depending on the graphics card and other factors.



More time smoothing, less time smoothing: By default, GridMon shows a color display of the activity counts for the current frame, independent of previous frame activity. If the frame rate is high, this can produce a very fast-changing display that can be difficult to follow. The **More time smoothing** button causes GridMon to use a moving average (using a simple triangular filter) of the preceding N frame counts, which causes a smoothing over time, at the expense of blurring the details in time. If the activity at a single electrode briefly goes very high, one can click **More time smoothing** to make it *fade* in and out on the GridMon display, rather than *blinking* in and out.



Frame rate faster, frame rate slower: These buttons adjust the rate at which the display updates in frames per second (fps). The minimum rate is 1 fps and the maximum rate is 30 fps. If GridMon is run at the largest window size and at rates above 10 to 15 fps, GridMon can use significant amounts of processing power, particularly if the PC has a slow graphics card. Use fast frame rates with caution. At frame rates approaching 30 fps, the buttons on the GridMon toolbar can become very slow to respond or completely unresponsive. A frame rate of 10 to 15 fps is usually adequate to get smooth animation.



Select window size: In order to optimize the display performance, GridMon only supports three specific window sizes for each grid layout: small, medium, and large. The large window size can use considerable processing

power at higher frame rates. A window size may be chosen by selecting it from the **View** menu, or by clicking on the **Select window size** button to cycle through the three sizes. It is not possible to stretch the window to an arbitrary size; although the outer window frame may be stretched, the actual display remains at one of the three optimized sizes.

9.6 Selecting the Electrode Grid Layout

The appropriate electrode layout (e.g. MMEP1, MMEP4) may be chosen by selecting it from the **View** menu. As with the other parameters, this may be done at any time, whether GridMon is paused or not.

9.7 General Tips for Adjusting the Display

The parameters interact with each other somewhat. For example, if the time smoothing is increased it tends to shift the display towards blue, because the contribution of a given amount of activity is spread out across several frames. Adjust the parameters as desired. Also, if the frame rate is very low or the amount of time smoothing is high, or both, there will be an unrealistic slowly-varying display that hides rapid changes in activity.

What is the difference between slowing down the frame rate and increasing the amount of time smoothing? At any given frame rate, the frame interval (e.g. 0.1 sec at 10 fps) serves in effect as a bin width—GridMon lumps all spikes within each frame interval together into a single count for each electrode. This is integration in time with a box filter. However, the time smoothing function uses a triangular *hat* filter to further smooth these frame counts over the course of several frames. The user should experiment with varying both the frame rate and the time smoothing function to get a feel for the interaction between them. Optimal settings depend on the dynamics of the cells being monitored and the desired personal viewing preferences.

Note: It is possible that viewing rapidly varying color displays could cause seizures in persons with neurological problems such as epilepsy. Plexon can assume no responsibility for such problems, and appropriate caution should be exercised.

9.8 Saving and Loading GridMon Configurations

GridMon does not use a configuration file. When GridMon starts, it recalls the settings that were last in use, including window size and position. When GridMon closes, it automatically saves all the settings. The first time GridMon runs, it uses default values for all settings.

Chapter 10

Client Development

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10.1 Overview

Plexon provides two client development *kits*, one for C and C++ and one for MATLAB®, to help develop custom applications. These kits can be used to develop custom applications and to transfer Plexon data into commercial off-the-shelf software programs. The kits include tutorials to show how to create applications and, in some cases, the kits also include coded *building blocks* that can be incorporated into development projects. Each kit includes a SoftServer application that emulates the MAP system and an application programming interface (API) client for National Instruments (NI) devices to help develop and test on-line clients.

Each client development kit consists of a series of files bundled together in a single WinZip®* file. WinZip 8.0 or later is necessary to open the zipped files. WinZip is available from WinZip Computing Inc., P.O. Box 540, Mansfield, Connecticut 06268 USA. An evaluation copy of WinZip may be downloaded from www.winzip.com.

10.2 C and C++ Client Development Kits for the MAP System

The C and C++ kits include two versions of the sample client programs and applications, which illustrate how to read spike timestamps and how to retrieve NI DAQ digitized waveform data from the MAP system:

- **SimpleRead** demonstrates the basics of writing and building a client program for the MAP system.
- **TimeStampRead** demonstrates how to display individual spike timestamps.
- **VTRead** reads Plexon Video Tracker files and extracts timestamps and x/y position data.
- **NIDAQRead** demonstrates how to retrieve and display digitized data from a NI DAQ card.
- **EventWait** combines the functionality of **TimeStampRead** and **NIDAQRead** and uses Win32 synchronization events to enable minimum-latency operation.
- **PlexDO** is an API client that controls one or more National Instruments (NI) “E” series cards to perform basic digital output functions, such as setting individual bits high or low, outputting pulses, and generating clock signals.
- **SoftServer** is a special version of the MAP server software that emulates the operation of the MAP box. SoftServer is an invaluable tool when the Plexon client development kits are used to create custom client applications.

Each sample client includes both a Win32 console-mode (text only, non-GUI) version and a Microsoft Foundation Classes (MFC) version. Try the samples in the preceding order because they progress from simple to complex. The source for each sample is in a .cpp file with the same name as the sample program. For the console-mode version, Plexon primarily used basic C computer programming language with a minimum of Windows-specific code.

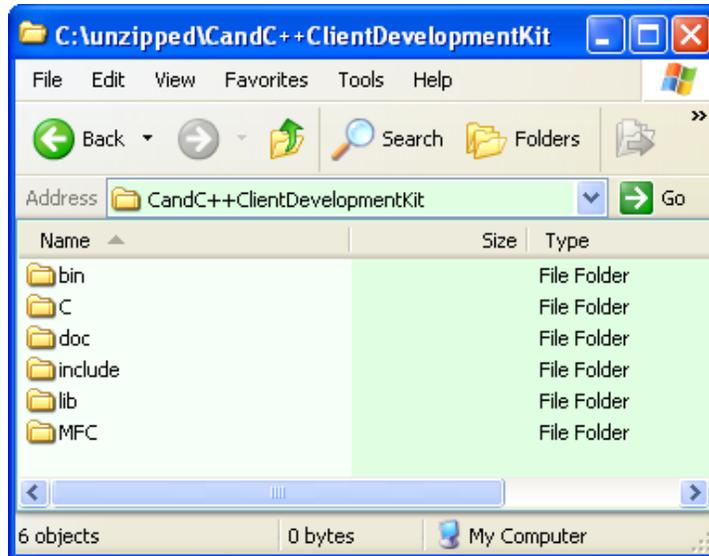
10.2.1 Unzipping and Building the Sample Programs

Plexon provides the sample clients as one .zip file, which contains both the C samples and the MFC samples, plus documentation files in MS Word. When RASPUTIN is installed, the files are typically located in the following directory:

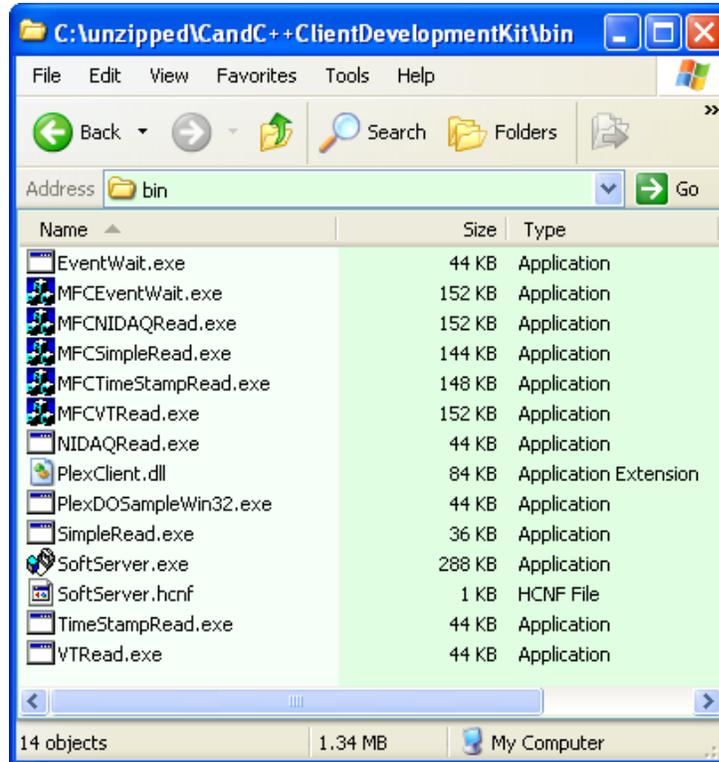
C:\Program Files\Plexon Inc\Documents\ClientDevelopment



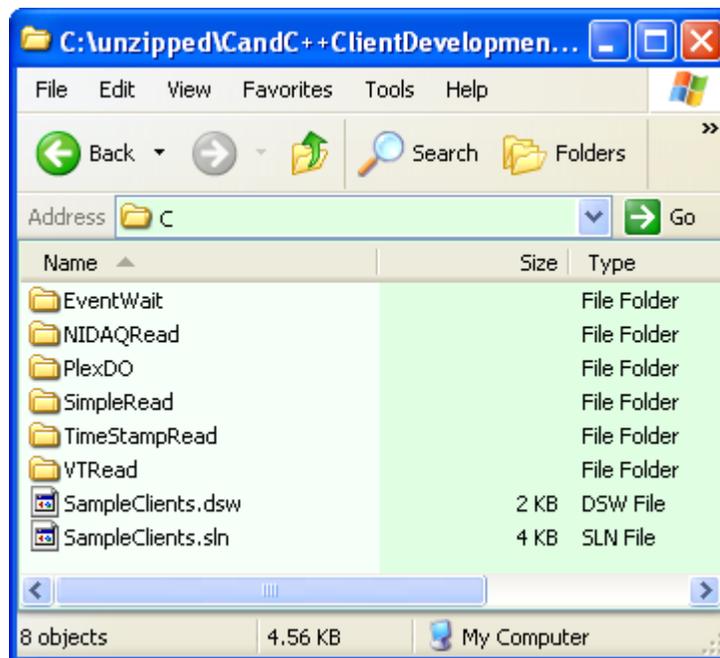
When the files are unzipped, WinZip creates the following directory structure.



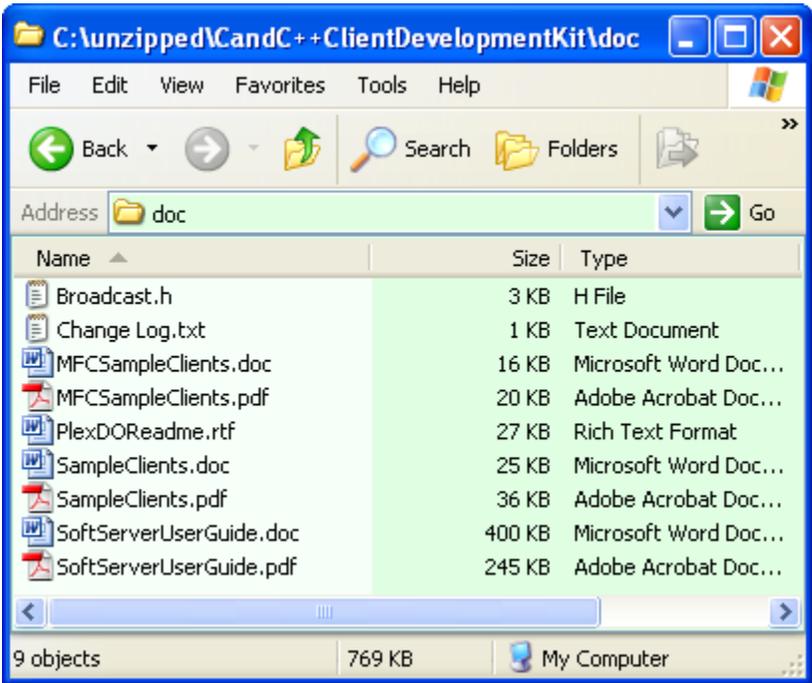
The **bin** folder contains the executable files for the applications.



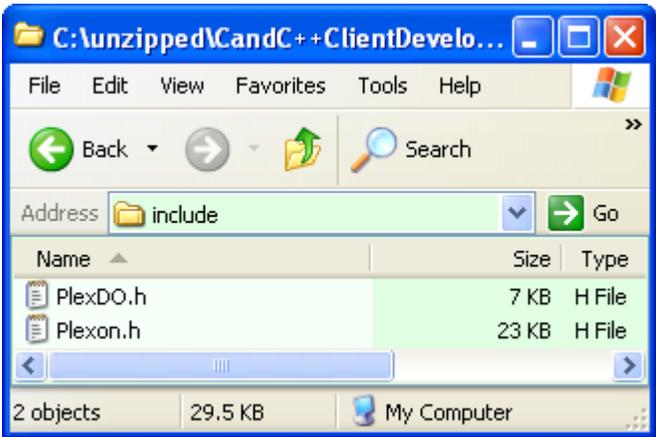
The C folder contains the Microsoft Visual C++ workspace file and the program file directories:



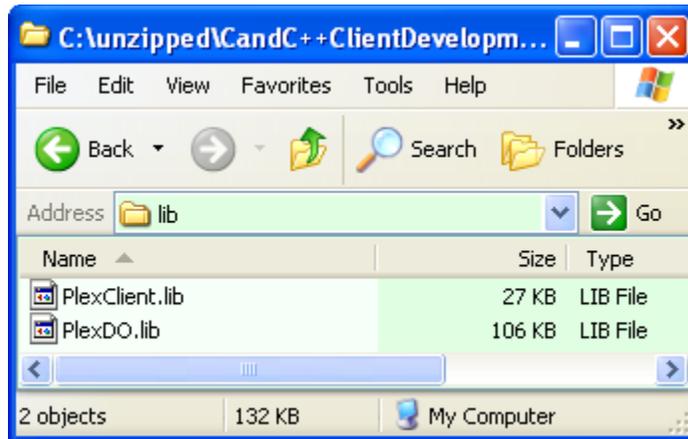
The **doc** folder contains more information on each item in the kit, in both MS Word and PDF format. This folder also contains the change log for this release.



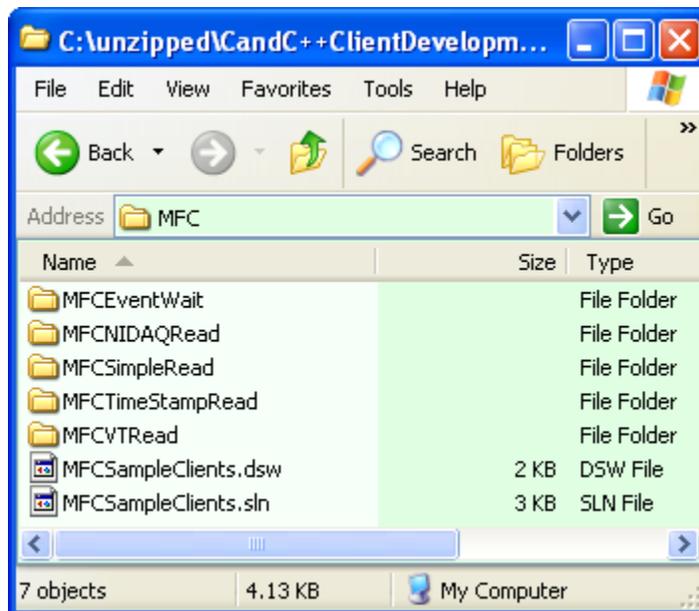
The **include** folder contains Plexon header files.



The **lib** folder contains Plexon library files.



The **MFC** folder contains the Microsoft Foundation Classes (MFC) workspace file and the MFC sample client file sub-directories.



10.2.2 Using the Sample Clients

As shown in the preceding file lists, each bottom-level subdirectory contains one client, for example, CandC++ClientDevelopment\C\TimeStampRead. All the clients were built using Microsoft Visual C++ version 6.0, and so each client project is represented by a .dsw workspace file.

To work with a sample client

- 1 Before running a sample client, start MAP Server and SortClient, and sort some active units.

Note: Instead of starting the MAP and running Server, SoftServer can also be used with most clients.

- 2 Start Visual C++.
- 3 Use **Open Workspace** to open the .dsw file.
- 4 Do **Rebuild All** and the sample client is ready to execute.

The source code for each sample client includes the header file Plexon.h, which contains declarations of the Plexon functions and related constants. The source code also includes standard C header files such as stdio.h and stdlib.h as needed. Each sample client includes links to the library PlexClient.lib, in addition to the usual Windows libraries.

10.2.3 Client Reference Information

This section includes detailed information on each sample client. Because C and C++ clients and the MFC clients are similar, this section includes information for both types. Read the detailed information for each sample client in the order that follows, because the sample clients increase in complexity as they build on concepts and code introduced in previous clients. In some cases, only the differences are described.

To use the MFC sample clients, a familiarity with the basics of building a simple dialog-based application using MFC is necessary. For more information on MFC, refer to Microsoft or other third-party documentation. In some cases MFC sample clients have slightly different functionality than their console-mode equivalents, due to the dialog-based GUI display versus the line-by-line text output from the console applications.

10.2.3.1 SimpleRead

SimpleRead reads timestamps from MAP Server or SoftServer, once per second, each time printing a line to the console window showing the total number of spike timestamps read. SimpleRead consists of a single main function that executes in the following sequence:

- 1 SimpleRead calls PL_InitClientEx3(), which connects SimpleRead to Server (MAP Server or SoftServer). This call registers SimpleRead with Server, which must be done before any other Server functions can be called. Omitting to start Server and SortClient will result in a long pause as Server loads and starts before this call returns to SimpleRead.
 - Any number of independent clients can each register with Server in any order at any time, and each client can read data from Server completely independently of the other clients. From the perspective of each client, Server reads data from the MAP box and provides the data to that client alone.

- 2 SimpleRead calls `PL_IsSortClientRunning()`; if Sort Client is running, the call returns TRUE. This call insures that there are sorted units with timestamps available.
 - The `malloc()` allocates a buffer in which Server returns the timestamps. The buffer is an array of structures of type `PL_Event`, which is the basic data for a single spike timestamp.
- 3 SimpleRead enters an infinite loop, until the window is closed by clicking on the Close “X” box. With each pass through the loop, SimpleRead calls `PL_GetTimeStampStructures()`, which copies the latest batch of timestamps from Server into the allocated buffer and sets `NumTimeStamps` to the actual number of timestamps in the buffer.
 - The value that SimpleRead passes in for `NumTimeStamps` is the maximum number of timestamps passed back to SimpleRead each time. If `NumTimeStamps` is 0 after the call, there was no activity since the last time SimpleRead called `PL_GetTimeStampStructures()`. On the other hand, if `NumTimeStamps` is unchanged, this indicates that the buffer is completely filled; when this occurs there can be more timestamps in Server that were not returned on this call, but which are returned in the next call to `PL_GetTimeStampStructures()`.
- 4 SimpleRead steps through the array of `PL_Event` structures returned from `PL_GetTimeStampStructures()`. The loop in SimpleRead adds up the number of sorted spikes on all channels. This total depends on how many units Sort Client sorts and the level of activity present.
- 5 The `printf()` function writes the number of `PL_Events` and the number of timestamps to the console window. SimpleRead then goes into an idle state for one second, using the `Sleep()` function. Then, SimpleRead returns to the top of the loop to fetch another batch of timestamps.

Note: It is important to insert a call to `Sleep()` in a loop such as this, so that other applications can run during the sleep interval.

Although it is not important with the SimpleRead client, be aware that within a batch of `PL_Events` returned by Server to a client, channels can occur in any order. Code the clients to maintain per-channel buffers or any other suitable internal data structure as needed.

For simplicity, this sample client assumes that the user closes the client by clicking on the close box in the upper right corner of the console window. However, this action immediately exits the program without disconnecting from Server, which is bad coding practise. When a real client is created, recognize some condition within the infinite loop (a command, or the end of data) as an indication to break out of the loop and clean up. In this case, SimpleRead cleans up by freeing the buffer and calling `PL_CloseClient()` to disconnect from Server.

10.2.3.1 TimeStampRead

TimeStampRead is similar in overall structure to “SimpleRead” on page 261, but it decodes the PL_Event in more detail and dumps information on every timestamp to the console window. The setup is identical aside from the call to PL_GetTimeStampTick(), which is a function that returns the timestamp resolution in microseconds. For most MAP systems this is 25 microseconds, which corresponds to a sampling rate of 40 kHz.

The infinite loop is the same, except that for each timestamp, TimeStampRead extracts the channel, unit, and actual time and prints them to the console window. Each PL_Event that represents a spike timestamp has fields for Channel, Unit, and TimeStamp:

- Channel is a 1-based DSP channel number (DSP01, DSP02, ...) and Unit indicates the sorted unit on that channel. For example, if Channel = 29 and Unit = 3, this is channel DSP29c.
- TimeStamp is a 32-bit integer representing the time at which the spike crossed the threshold, in units of MAP clock ticks. For example, on a 40 kHz MAP system, a timestamp of 400000 corresponds to 10 seconds after the MAP clock is started or reset. The clock resets on powerup and whenever a new experiment file loads and the **Start** button is clicked. For each timestamp that appears in the console window, TimeStampRead divides the timestamp by the MAP sample rate to get the time in seconds.

The remainder of the code is identical to SimpleRead.

10.2.3.2 VTRead

VTRead is similar in overall structure to “SimpleRead” on page 261, but it decodes the PL_Event and extracts x/y position data for every timestamp that corresponds to a strobed event. VTRead then dumps the x/y coordinates to the console window. The setup is identical to SimpleRead.

VTRead steps through the array of PL_Event structures returned from PL_GetTimeStampStructures(). The loop in VTRead looks for event timestamps on all channels and only extracts VT data from the strobed events. VTRead verifies the data, adds it to the accumulator, and displays the timestamp and coordinates in the console window.

The remainder of the code is identical to SimpleRead.

10.2.3.3 NIDAQRead

NIDAQRead demonstrates how to read digitized data from a National Instruments (NI) DAQ device. If the system does not have a NI DAQ device, this sample client can be skipped.

Note: NIDAQRead does not work with SoftServer.

Before NIDAQRead is run, NIDAQ must be enabled in MAP Server, and preferably have only the first NI DAQ channel (ACH0) enabled in the SortClient Analog Channels window. Due to the large volume of data generated with multiple channels and the fact that this client dumps all of the samples to the console window, NIDAQRead works best when only one channel is enabled. Also, to further reduce the amount of data, set a low NI DAQ sampling rate, for example 100 Hz. Even with these settings, to observe the output when NIDAQRead runs, it may be necessary to hit Control-S to pause the screen.

NIDAQRead setup is similar to TimeStampRead, with the following two changes:

- 1 Instead of using the PL_Event structure, NIDAQRead allocates memory for an array of PL_WaveLong. This structure contains extra information for returning the NI DAQ samples.
- 2 There is a call to the function PL_GetSlowInfo(), which returns the NIDAQ sampling rate. NIDAQRead ignores the second and third parameters, which contain Dummy values.

Within the infinite loop, NIDAQRead calls PL_GetLongWaveFormStructuresEx2(), which fills in the allocated array of PL_WaveLong. This command is essentially a superset of the SimpleRead PL_GetTimeStampStructures() command, which returns timestamps in an array of PL_Event. In other words, PL_GetLongWaveFormStructuresEx2() returns both spike timestamps and NI DAQ digitized waveform samples. As with a PL_Event, the Type field of each PL_WaveLong indicates which type of data it contains.

Whereas the TimeStampRead client looked for spike timestamps (Type == PL_SingleWFType), NIDAQRead looks for blocks of NI DAQ samples, where Type == PL_ADDDataType. With spike timestamps, each PL_Event structure represents one spike. However, with digitized NI DAQ data, each PL_WaveLong contains several consecutive samples on a single channel. Therefore, within the loop that steps through all the PL_WaveLong structures, when NIDAQRead finds a block of NI DAQ samples, it steps through all of the samples in that block. In this sample client, NIDAQRead only looks for blocks on Channel 0 to keep things manageable.

PL_WaveLong contains the number of samples in the block and the timestamp (in MAP clock ticks) of the first sample in the block. Each subsequent sample in the block has an implicit timestamp of one NI DAQ sampling tick later than the previous sample. Because the NI DAQ sampling rate is less than the MAP sampling rate, a little thought reveals that the increment between NI DAQ samples, in terms of MAP clock ticks, is $\text{MAPSampleRate}/\text{NIDAQSampleRate}$. In the per-sample loop, NIDAQRead adds this increment each time it advances to the next sample, which provides the time for that sample. NIDAQRead displays the actual digitized value and the timestamp (converted to seconds) for each sample.

For a typical setup, the NI DAQ device digitizes waveforms into 12-bit signed samples, for example within a range of -2047 to +2048. Clients can of course scale this raw data into any convenient range for their own calculations.

The remainder of the code is identical to SimpleRead and TimeStampRead.

10.2.3.4 EventWait

EventWait combines the functionality of TimeStampRead and NIDAQRead and introduces a method for synchronizing operation with MAP Server. EventWait can also be used with SoftServer.

In the previous sample clients, the client and the Server are completely asynchronous. That is, Server continually fetches timestamps from the MAP box through the MXI interface hardware, and Server also continually fetches digitized samples from the NI DAQ device, when one is present. MAP Server places the timestamps and samples in a buffer called the memory mapped file (MMF). Fetching the information works fine as long as a given client reads the data from Server by calling `PL_GetTimeStampStructures()` or `PL_GetLongWaveFormStructuresEx2()` before the data expires in the MMF. Server never waits on clients to read the data; Server simply makes the data available for clients to read if and when clients call for it. This works because the MMF is fairly large, typically several megabytes, and the MMF size can be set in the Server options.

However, the client can obtain the latest timestamps and digitized data from Server as soon as they are available and with minimum latency. In order to do this, it is necessary to use a Win32 synchronization object referred to as an *event*.

Note: In the context of Win32 programming, an *event* refers to a type of Win32 synchronization object; this is completely different from the Plexon *PL_Event* data structure type, whose name derives from the common practice of referring to a spike firing as a *spike event*. Any time a Plexon function or data type has *event* as part of its name, it refers to a spike event, not a Win32 synchronization object.

A discussion of Win32 synchronization in general is beyond the scope of this tutorial. If more information is needed, consult a book on Win32 programming techniques for details. However, one can use the technique in this sample client as part of a client that handles reading data from Server in one thread of execution while other threads handle computation and user interface chores. EventWait, which is not multithreaded, uses only the simplest synchronization to insure that it can read from Server as soon as new timestamps are available.

EventWait calls the Win32 function `OpenEvent()` to obtain a handle to the standard Plexon Server synchronization event. This is sometimes referred to as the *server event* or the *polling event*, because Server signals it every time that it completes reading timestamps from the MAP box and digitized data from the NI DAQ device.

Most of the EventWait main loop consists of what amounts to the timestamp decoding from TimeStampRead plus the NI DAQ decoding from NIDAQRead. PL_GetLongWaveFormStructuresEx2() gets both the spike timestamps and the NI DAQ samples, again using the Type field of each PL_WaveLong structure to distinguish them. However, instead of a simple Sleep(1000) call, EventWait uses a call to the Win32 function WaitForSingleObject(). When execution reaches this call, the system yields control to other processes, as does the Sleep() function; however, rather than this being for a fixed interval such as one second, execution resumes only when Server signals the server event.

The waiting interval is approximately the same as the polling interval set in Server options, which is typically well under 100 ms, so that the loop executes at a rate over 10 Hz. If Server has a polling interval set to 20 ms, this means that roughly every 20 ms Server polls the MAP hardware, transfers data to the MMF, then immediately signals the server event, which effectively restarts all clients that are waiting on the server event. When the flow of execution in EventWait hits WaitForSingleObject() again, it waits until the server again signals the event after the next MAP polling cycle.

The duration of a Windows time slice determines the lower limit on the length of the polling interval. On a single-CPU machine, the polling interval is usually 10 ms; on a multi-CPU machine, it is usually 15.625 ms. This corresponds to time-slice rates of 100 Hz and 64 Hz respectively.

The remainder of the code in EventWait is the same as the previous clients, with the addition of a call to CloseHandle() to close the server event.

The screen output scrolls by very quickly in the console window at typical Server poll intervals (10-50 ms), even if there is little activity. To more easily see the timestamp counts, set the poll interval in Server **Options** window to a larger value, such as 100 ms or more.

Note: Before using the MAP system for regular work again, change the polling interval back to its original value so SortClient and other clients run smoothly.

10.2.3.5 MFCSimpleRead

MFCSimpleRead reads timestamps from Server (MAP Server or SoftServer) once per second. Each time MFCSimpleRead reads a timestamp, it sets the text of a dialog item to the total number of spike timestamps read.

Note: Because the MFC AppWizard inserts many comments in the source code, the Plexon-specific comments appear with `/**` rather than `//`.

When click **Connect**, a one-time initialization occurs that invokes the OnConnect() function. This includes the call to PL_InitClientEx3(), the



check for `PL_IsSortClientRunning()`, and the allocation of the buffer into which Server returns MAP events.

At the end of `OnConnect()`, a one-second timer starts using `SetTimer()`. This timer replaces the `Sleep(1000)` call inside the infinite loop in the console-mode sample clients. When a `WM_TIMER` message arrives, the `OnTimer()` calls `PL_GetTimeStampStructures()` and then displays the **MAP events** read.

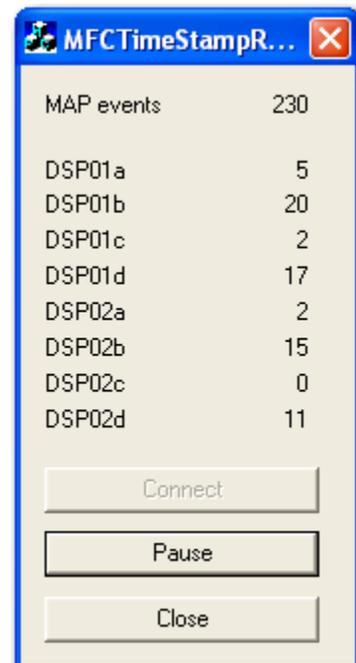
When the window closes, the `OnDestroy()` handler kills the timer and performs other cleanup tasks.

10.2.3.6 MFCTimeStampRead

`MFCTimeStampRead` is similar in overall structure to `MFCSimpleRead`, but it decodes the `PL_Event` in more detail. For each of the first eight unit channels, `DSP01a` through `DSP02d`, `MFCTimeStampRead` counts the number of timestamps (spikes).

After `MFCTimeStampRead` loops through all the MAP events, the count of spikes on each channel appears in the window. For each timestamp on the first eight unit channels, `MFC-TimeStampRead` also dumps the DSP channel number, unit, and time in seconds to the Visual C++ debug window, using the standard `TRACE` macro.

The remainder of the code is identical to `MFC-SimpleRead`.

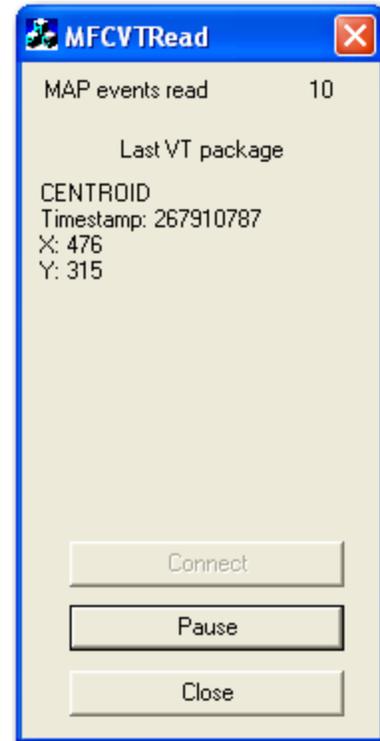


10.2.3.7 MFCVTRed

MFCVTRed is similar in overall structure to MFCSimpleRead, but it decodes the PL_Event and extracts x/y position data for every timestamp that corresponds to a strobed event. MFCVTRed then dumps the x/y coordinates to the window. The setup is identical to MFCSimpleRead.

MFCVTRed steps through the array of PL_Event structures returned from PL_GetTimeStampStructures(). The loop in MFCVTRed looks for event timestamps on all channels and only extracts VT data from the strobed events. MFCVTRed verifies the data, adds it to the accumulator, and displays the timestamp and coordinates in the window.

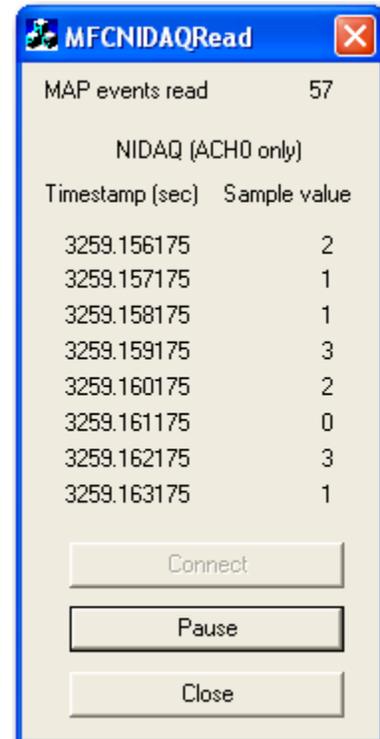
The remainder of the code is identical to MFCSimpleRead.



10.2.3.8 MFCNIDAQRead

MFCNIDAQRead demonstrates how to read digitized data from the National Instruments (NI) DAQ card. The NI DAQ-specific code is similar to the console-mode NI DAQ sample, except for the display of the NI DAQ data. Each time MFCNIDAQRead gets a new batch of MAP events from Server, MFCNIDAQRead loops through the events, only looking for NI DAQ sample blocks on the first channel (ACH0). For this channel, MFCNIDAQRead displays the first eight samples in the block in the window, including the timestamp and the digitized value for each sample. If a low-frequency triangle wave (1 Hz) is run into ACH0, there will be a set of eight consecutive samples, updated once per second. If the NI DAQ sampling rate is set to 100 Hz this is about $8/100 = 0.08$ sec of digitized waveforms.

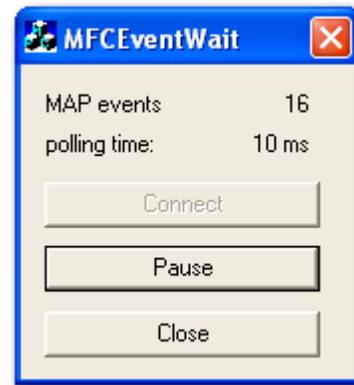
The remainder of the code is identical to MFCSimpleRead and MFCTimeStampRead.



10.2.3.9 MFCEventWait

MFCEventWait is similar to the console-mode EventWait sample, but it also shows basic multi-threading techniques. MFCEventWait starts a second *reading* thread that is dedicated to waiting on Server.

When **Connect** is clicked, after the usual initialization, MFCEventWait calls the function `StartReadThread()`. `StartReadThread()` begins by resetting `KillDataThreadEvent`, a Win32 event that runs on shutdown to signal to the reading thread to kill itself. Next, MFCEventWait opens the Server poll event, as in the console-mode EventWait. Finally, MFCEventWait uses the MFC function `AfxBeginThread()` to actually begin execution of the reading thread, whose thread function is `ReadThreadFunc()`. `AfxBeginThread()` also passes a pointer to `KillDataThread` so that the reading thread can use it to determine when to kill itself.



`ReadThreadFunc()` does three main things inside of an infinite loop:

- 1 First, it waits on the kill event, but with a timeout of 0, so that execution continues immediately unless it receives the kill event. This happens on shutdown from `OnDestroy()`, where the call to `KillDataThreadEvent.SetEvent()` is made. When this event is signaled, the reading thread calls the MFC function `AfxEndThread()` and terminates.
- 2 Second, assuming that the kill event has not been signaled yet, the reading thread sends a `WM_USER+1` message to the main thread, which indicates that it should read a batch of MAP events from Server. Because this is a `SendMessage()`, as opposed to a `PostMessage`, the reading thread waits until the main thread has processed the `WM_USER+1` message before continuing.
- 3 Last, after the main thread finishes processing the message, the reading thread waits on the Server polling event. MFCEventWait suspends the reading thread until Server signals the polling event again.

`OnServerReady()` handles the `WM_USER` message. The MFC technique for associating this function with the `WM_USER+1` message is to manually add an `ON_MESSAGE` entry in `CMFCEventWaitDlg` message map. `OnServerReady()` reads a batch of timestamps from Server and displays the number of events in the window. The more detailed decoding of spike timestamps, or NI DAQ samples, or both, which is found in the other clients, is omitted here for simplicity.

As already mentioned, when the window is closed, `OnDestroy()` in the main thread signals the reading thread to kill itself. `OnDestroy()` also frees the timestamp buffer and closes the handle to the Server poll event.

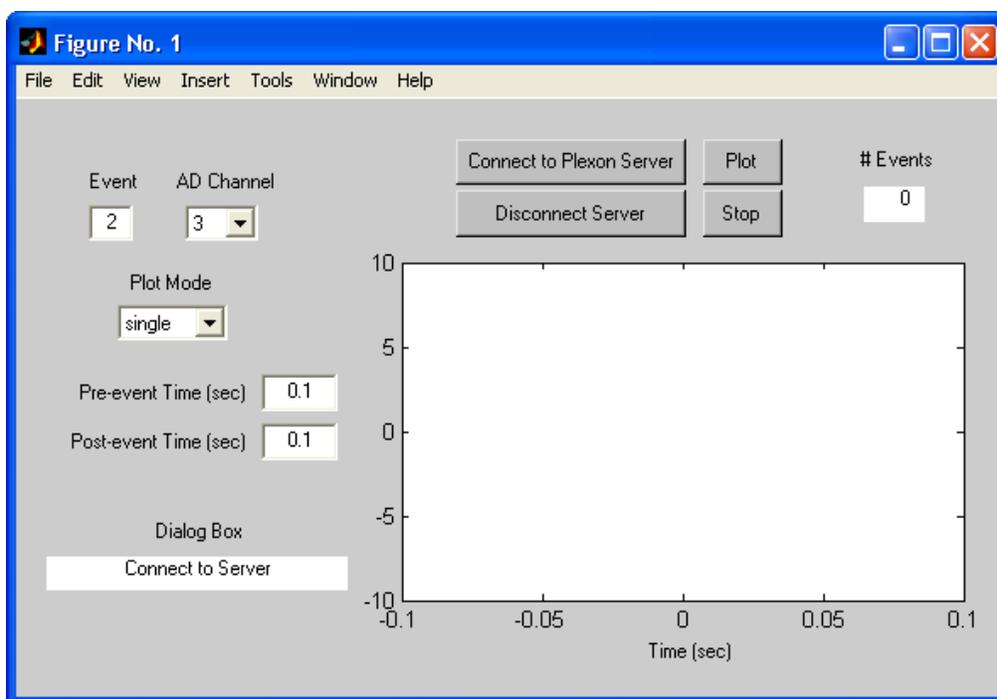
A more advanced client can have several threads, for example, one for reading data from Server, one for updating displays, one for handling user interaction, etc. Such techniques are beyond the scope of this sample; please contact Plexon for more information.

10.3 MATLAB® Extensions

MATLAB®* Extensions is a series of Matlab functions that can be used with Matlab to transfer data from the Plexon MAP server. MATLAB, Version 6 or later, must be installed on the PC to use these functions. Matlab is available from The MathWorks, Inc., 3 Apple Hill Drive, Natick, MA 0176-2098 USA (www.mathworks.com).

10.3.1 Event-Triggered Field Potential GUI

The Event-Triggered Field Potential Graphical User Interface (GUI) is a Matlab display that plots a field potential signal around a spike or external event in real-time. The field potential display can be averaged over all events or it can be set to single-trial mode. The following illustration shows the **Figure No. 1** Matlab GUI prior to the establishment of a connection to the MAP Server.



For information about the Matlab **Figure No. 1** window and the Matlab menu, see “Using Matlab Graphics” in the Matlab documentation set. The following items are specific to this extension:

Event: The external event input, either XS1 or XS2.

AD Channel: The number of the analog-to-digital (AD) channels to plot.

Connect to Plexon Server: Click to open a connection to the Plexon MAP Server.

Disconnect Server: Click to close the connection to the MAP Server.

Plot: After a connection has been established to the MAP Server, click **Plot** to view the data.

Stop: Click to stop the data plot.

Events: This field maintains a running count of the number of events represented in the plot.

Plot Mode: From the menu, chose to view a plot of each **single** event or a plot of the running **average** of all events.

Pre-event Time (sec): Type the time in seconds to plot on the X-axis prior to the event.

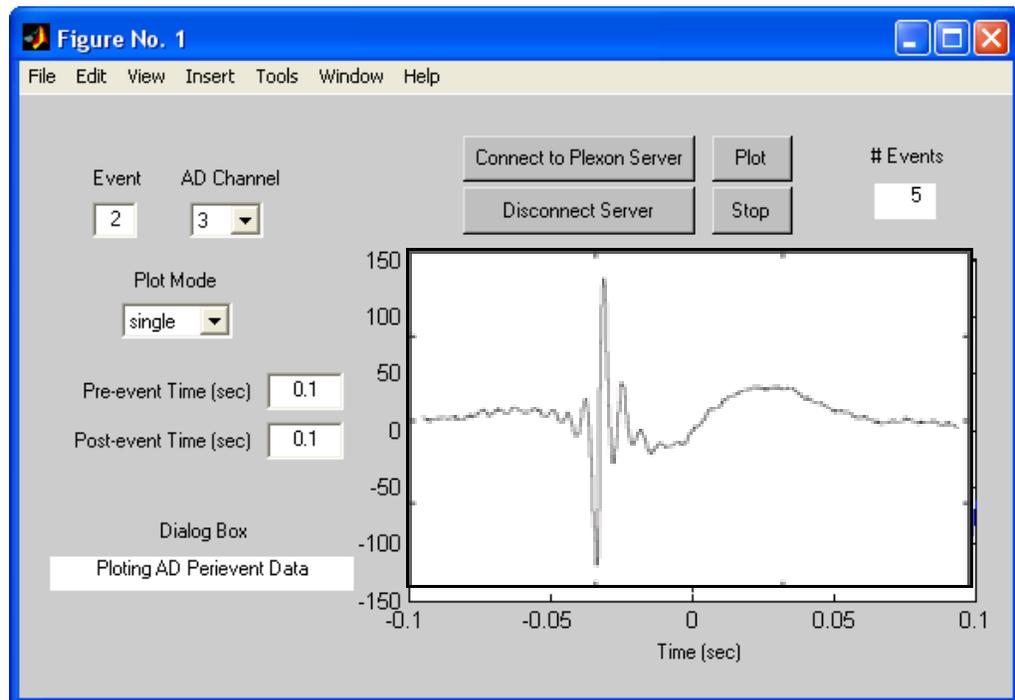
Post-event Time (sec): Type the time in seconds to plot on the X-axis after the event.

Dialog Box: This field indicates the current state of the GUI, which can be one of the following:

- **Connect to Server:** Establish a connection to Server before data is plotted.
- **Error: First Connect to Server:** There has been an attempt to plot data without opening a connection to Server.
- **Connected to Server:** The connection to Server is open.
- **Disconnected from Server:** The connection to Server is closed.
- **Plotting AD Perievent Data:** The GUI is currently plotting data.

The plotting area displays **Time** in seconds on the X axis and raw A/D converter units on the Y axis. For a 12-bit conversion, A/D converter units are integers from -2047 to +2048.

The following illustration shows a **Figure No. 1** perievent data plot.



10.3.2 Unzipping and Running Matlab Extensions

Plexon provides the Matlab Client Development Kit as one .zip file, which contains the following items:

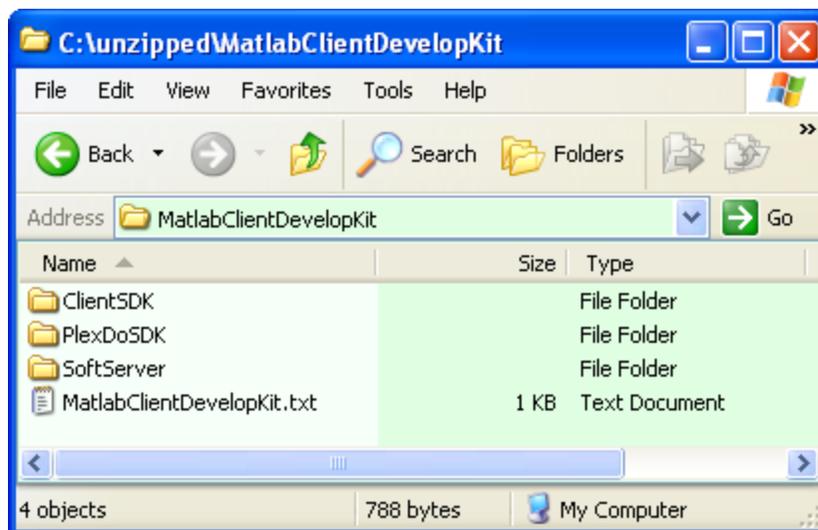
- **ClientSDK**, which includes Matlab scripts to access online data from the Plexon MAP system.
- **PlexDO**, which is a Matlab version of the Plexon client API that controls one or more National Instruments (NI) “E” series cards to perform basic digital output functions, such as setting individual bits high or low, outputting pulses, and generating clock signals.
- **SoftServer**, which is a special version of the MAP server software that emulates the operation of the MAP. SoftServer is an invaluable tool when using the Plexon client development kits to create custom client applications.

The files are bundled with RASPUTIN software and they are typically located in the following directory:

```
C:\Program Files\Plexon Inc\Documents\ClientDevelopment
```



The following illustration shows the file list after unzipping the Matlab Extensions.



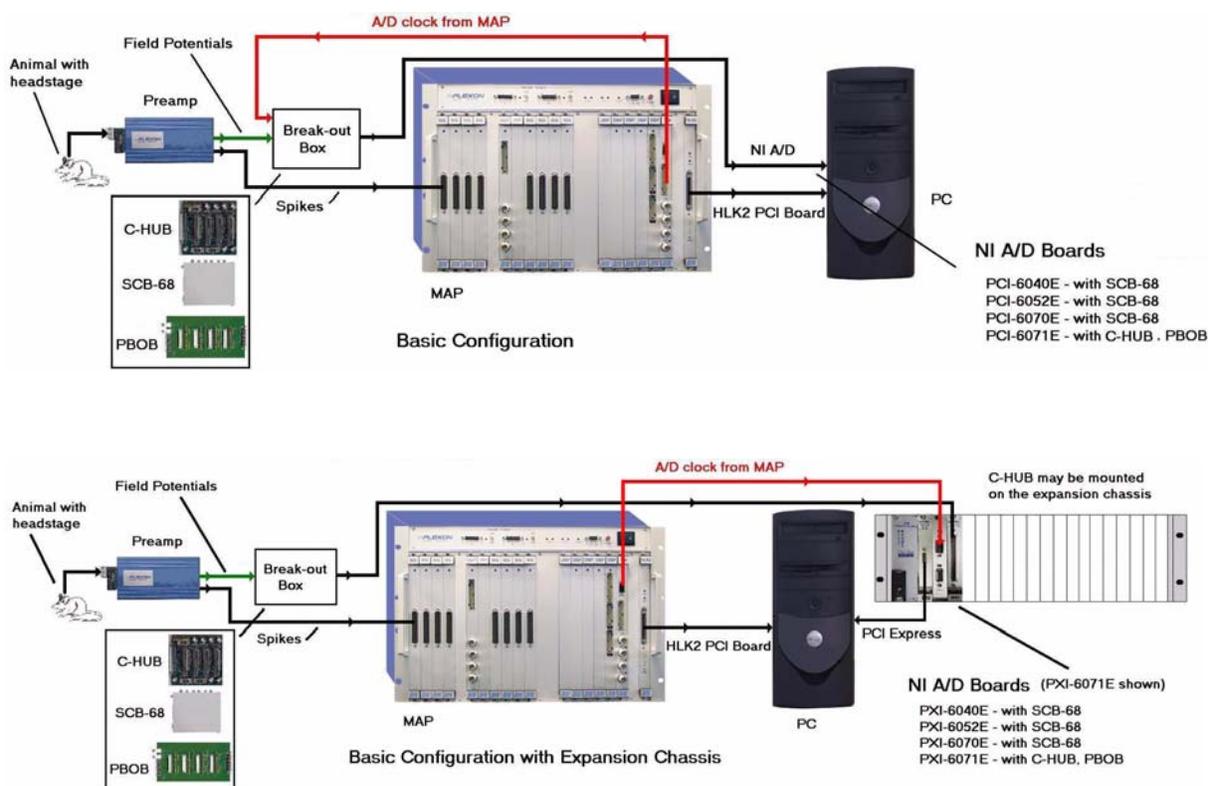
Chapter 11

Continuous Signal Recording

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11.1 Overview

Continuous analog data signals (e.g. LFP, EEG, eye coil positions, continuous spike and wide band [spike + LFP] signals, and other such signals) can be recorded simultaneously with spike data from the MAP box using one or more National Instruments A/D (NIDAQ) boards in the host computer or in an external chassis. A connection between the TIM board in the MAP box and the NIDAQ board synchronizes the recordings of the spike and continuous signals. Several different physical configurations are supported. For example, an SCB-68, a PBOB, or a C-HUB may be used in a basic configuration or in conjunction with an expansion chassis (PCI/exp or PCI/exp4). There are also other configurations, such as those that include CinePlex. The diagrams below show the basic configuration with and without the expansion chassis.



The MAP system software can support up to four A/D boards, though the boards in an individual system must be identical. The channels on a given board must be run at the same sampling rate, but different boards can be run at different sampling rates (e.g. at 1 kHz for slow signals like local field potentials, and at 20 kHz or 40 kHz for fast spike signals). The MAP software can only support a maximum of two different sampling rates across all the boards, however: a fast rate and a slow rate. Therefore, if one has three A/D boards with the first board sampling at a slow rate of 1 kHz and a second board sampling at a fast rate of 40 kHz, then the sampling rate on the third board must be set to either 1 kHz or 40 kHz. The sampling rates are set on the Analog Channels settings in Sort Client.

Note: An expansion chassis is required for 40 kHz continuous recording; otherwise, the maximum is 20 kHz.

Supported NIDAQ boards include (channel counts based on a sampling rate of 1 kHz):

- PCI-6040E [PCI-MIO-16E-4] (250 kSamples/sec, 16-channel, 12-bit resolution)
- PCI-6052E (333 kSamples/sec, 16-channel, 16-bit resolution)
- PCI-6070E [PCI-MIO-16E-1] (1.25 MSamples/sec, 16-channel, 12-bit resolution)
- PCI-6071E (1.25 MSamples/sec, 64-channel, 12-bit resolution)

Preamp filtering for local field potential (LFP) signals is typically 0.7 Hz - 300 Hz, although preamps are available with other filtering bandpass values. The FP signals come from the same electrodes as the spikes. Other analog signals that can be recorded through the break-out box include:

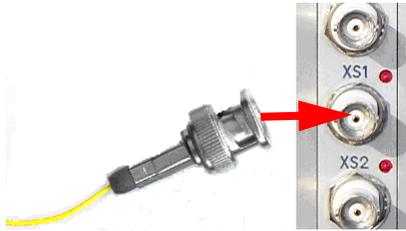
- Physiological - such as blood pressure, EKG, EMG, etc.
- Behavioral - such as eye position, arm angle, head direction, etc.

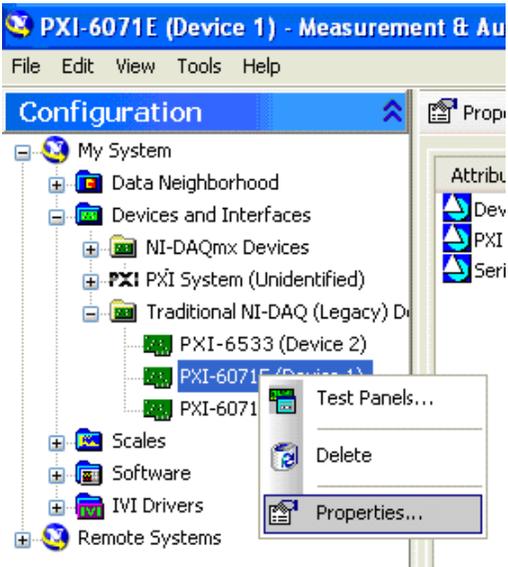
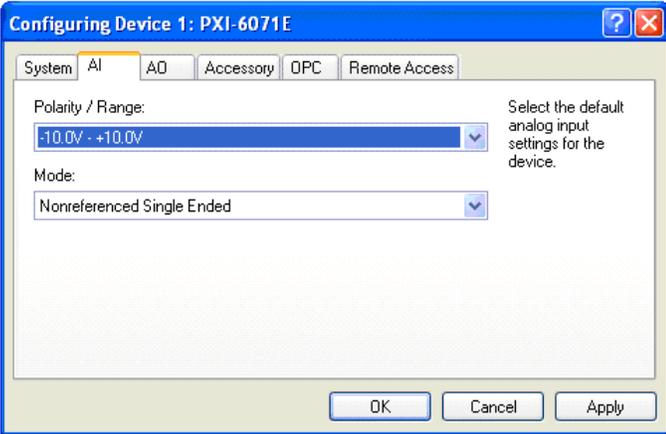
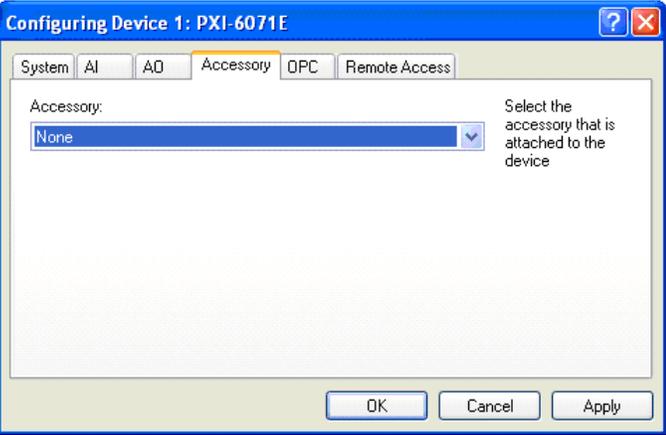
Consult the C-HUB (or PBOB) Technical Brief and the SCB-68 Data Sheet for information on interfacing to 64- and 16-channel NIDAQ boards, respectively.

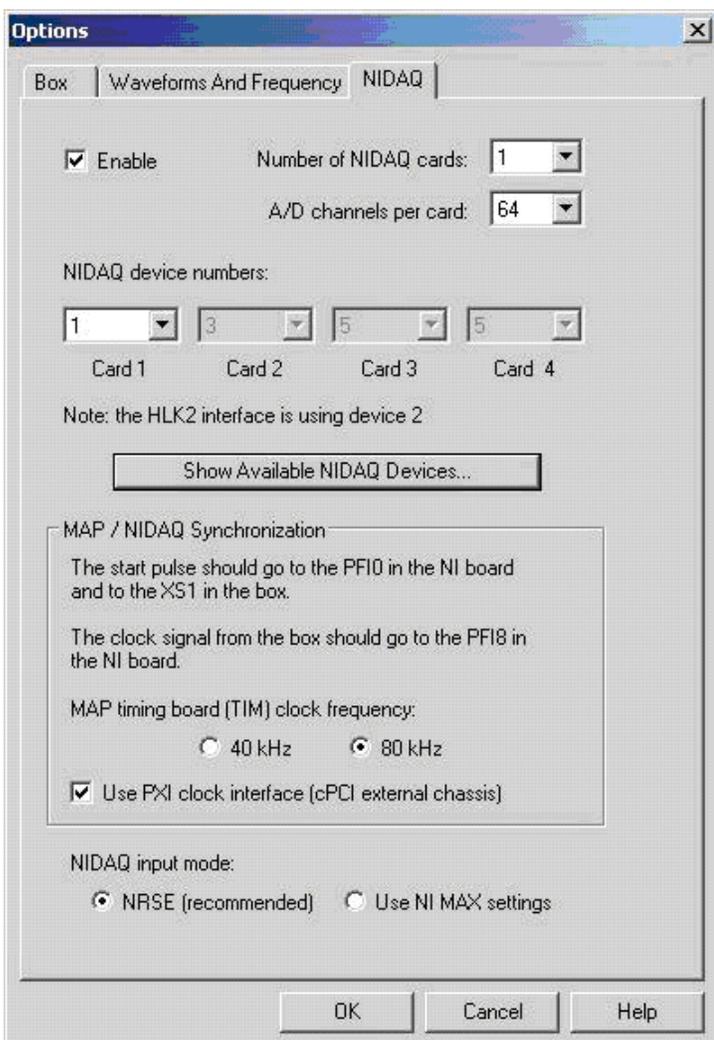
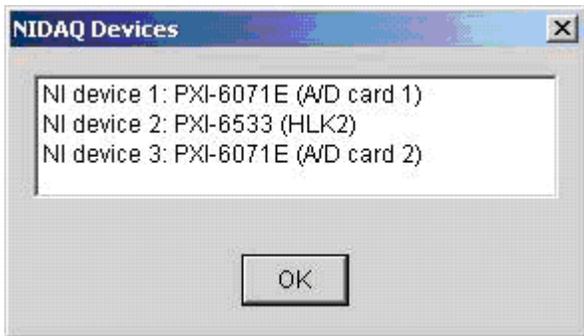
11.2 Setup of NIDAQ Boards

Typically, Plexon will have already installed the NIDAQ software and cards leaving the user to install cables to signal sources. For completeness, the table below shows the procedures to set up the NIDAQ cards and breakout boxes.

Step	Action	Diagram/Comments
1	Run the installation program from the National Instruments CD.	This step assumes that there are no NIDAQ board(s) installed in the PC. Only very seldom would a user have to perform this process (which actually contains a number of steps), so this is just included for completeness.
2	Insert the National Instruments A/D (NIDAQ) board in the 32-bit (short) PCI slot (typically white).	The NIDAQ (PXI version only) board may also be inserted into the expansion chassis, if used. For more details, see Appendix B: PXI Expansion Chassis .
3	Connect the SCB-68, the C-HUB, or PBOB to the NIDAQ board.	SCB-68 for 16-channel NIDAQ boards PBOB for 64-channel NIDAQ boards C-HUB for 64-channel NIDAQ boards See the Map System Installation Guide for details.

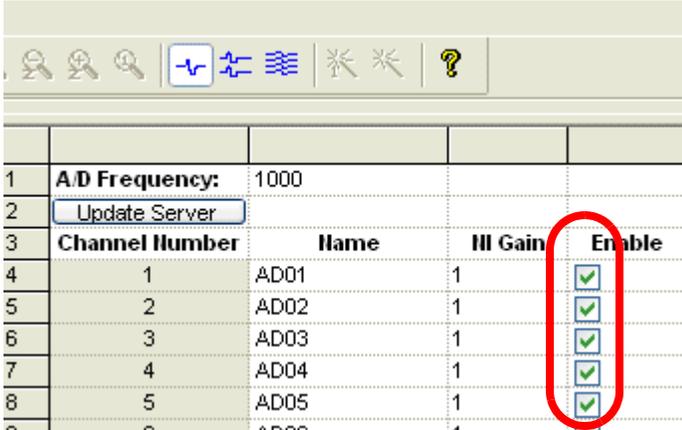
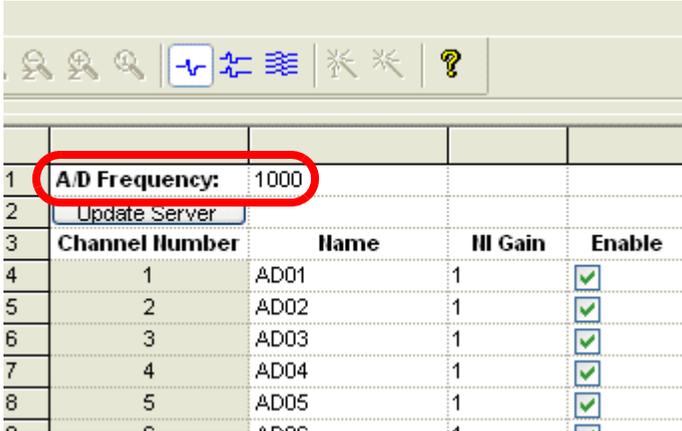
Step	Action	Diagram/Comments
4	Connect the rainbow ribbon cable carrying the continuous analog signals (from the field potential preamp board, or other sources) to the DB37 connector on the breakout box or BNC panel.	See the MAP System Installation Guide for details.
5	Connect the cable from the TIM board in the MAP box to the DB9 TIM input connector on the breakout box.	If the expansion chassis is used, connect the TIM cable from the MAP box to a PXI-TIM board in the expansion chassis. See “Connecting a PXI-TIM Card to the MAP System TIM Card” on page B-16.
6	The diagrams at the right show the configuration of the XS1 connector on the MAP TIM board for systems shipped before 2008 and those shipped in 2008 and later. If the system configuration is unknown, contact Plexon.	<p>Pre-2008 systems require the TIM cable yellow wire with BNC connector to be connected to the XS1 connector on the MAP TIM board as shown below.</p>  <p>Systems shipped in 2008 and later have a cap on the XS1 connector of the MAP TIM board. In case this cap is missing or needs to be replaced due to damage, refer to the diagram below.</p> 

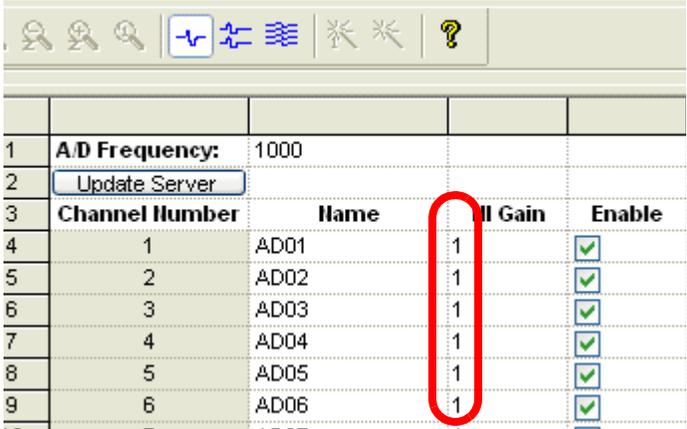
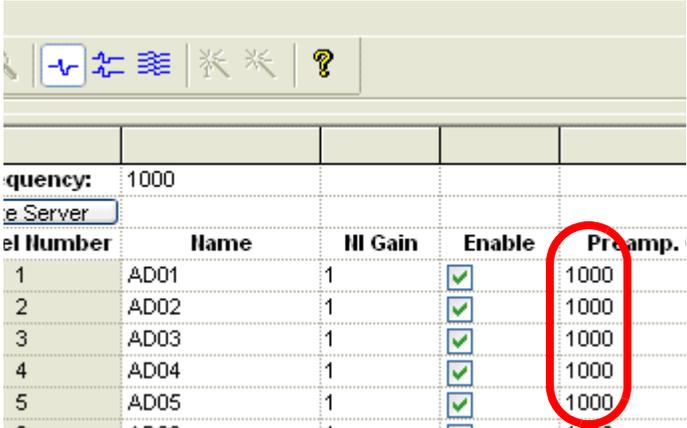
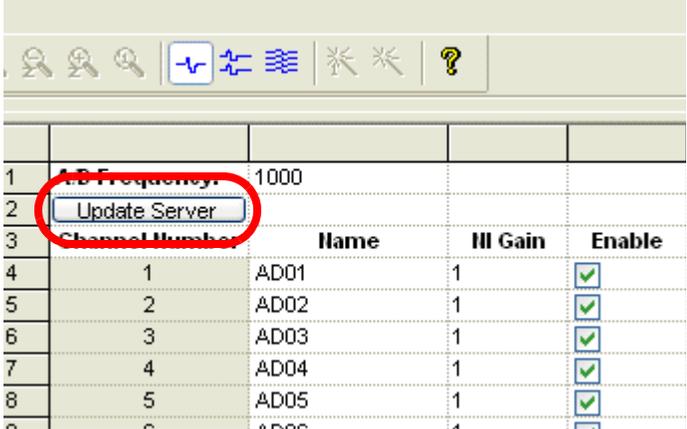
Step	Action	Diagram/Comments
7	<p>Run the National Instruments Measurement & Automation program. Select Devices and Interfaces. Select Traditional NI-DAQ (Legacy) Devices. Right-click on the board and select Properties.</p> <p>(NOTE: The board name will depend on which model is installed.)</p> <p>NOTE: The NI-MAX program may be accessed by selecting Measurement & Automation from the computer's Start->All Programs->National Instruments.</p>	
8	<p>On the AI tab set:</p> <p>Polarity/Range: -10V - +10V Mode: Non-referenced Single Ended.</p> <p>NOTE: NIDAQ specifies +-10V at 1/2 gain. Therefore, the working range at 1x gain is +-5V.</p>	
9	<p>On the Accessory tab select the appropriate breakout box or BNC panel as the Accessory (e.g. SCB-68). If using PBOB or C-HUB, select None (because neither are on the dropdown list).</p>	

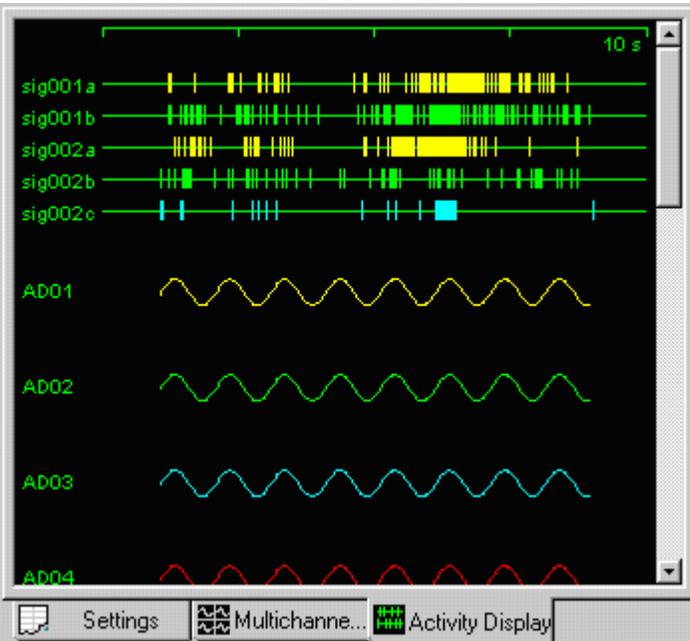
Step	Action	Diagram/Comments
10	<p>For this step open Server and select View Options. On the NIDAQ tab, check the Enable checkbox and select the number of analog channels (16 for 16-channel NIDAQ boards 64 for 64-channel NIDAQ board). Ensure that the Use PXI clock interface (cPCI external chassis) checkbox is checked. Select the appropriate clock frequency (40KHz or 80KHz). If finished, click OK to close the Options dialog box. To see the NIDAQ devices and their device numbers, go to step 11. Close and restart Server after enabling NIDAQ.</p> <p>Note: All boards must be of the same type. Each A/D board's channels will be displayed on a separate tab in the Analog Channels display in Sort Client (shown below in the next section).</p>	 <p>The screenshot shows the 'Options' dialog box with the 'NIDAQ' tab selected. The 'Enable' checkbox is checked. The 'Number of NIDAQ cards' is set to 1, and 'A/D channels per card' is set to 64. Under 'NIDAQ device numbers', the values are 1, 3, 5, and 5 for Card 1, Card 2, Card 3, and Card 4 respectively. A note states 'the HLK2 interface is using device 2'. There is a 'Show Available NIDAQ Devices...' button. The 'MAP / NIDAQ Synchronization' section contains instructions about pulse and clock signals, and the 'MAP timing board (TIM) clock frequency' is set to 80 kHz. The 'Use PXI clock interface (cPCI external chassis)' checkbox is checked. The 'NIDAQ input mode' is set to 'NRSE (recommended)'.</p>
11	<p>Ensure that the NI device numbers and boards match what is shown in the Configuration window of Step 7. Click Show Available NIDAQ Devices to get to the list of NIDAQ devices shown to the right. Close Server when finished.</p>	 <p>The screenshot shows the 'NIDAQ Devices' dialog box with a list of three devices: 'NI device 1: PXI-6071E (A/D card 1)', 'NI device 2: PXI-6533 (HLK2)', and 'NI device 3: PXI-6071E (A/D card 2)'. There is an 'OK' button at the bottom.</p>

11.3 Configuration of Continuous Signals in Sort Client

The procedure below shows how to configure the continuous signals in Sort Client.

Step	Action	Image/Comments																																								
1	Enable Analog channels in Sort Client : Use the Enable checkboxes in the AnalogChans page(s) in Settings to enable the desired channels on each A/D board.	<p>NOTE: When the file is opened in NEX or OFS, the amplitude of the signal at the electrode is expressed in mV. NEX and OFS use the preamp gain value to calculate what the size of the signal at the electrode was. The Preamp Gain is a combination of the gain of the headstage multiplied by the gain of the field potential board in the preamp.</p>  <table border="1"> <thead> <tr> <th></th> <th>A/D Frequency:</th> <th>1000</th> <th></th> <th></th> </tr> </thead> <tbody> <tr> <td>2</td> <td colspan="4">Update Server</td> </tr> <tr> <th>3</th> <th>Channel Number</th> <th>Name</th> <th>III Gain</th> <th>Enable</th> </tr> <tr> <td>4</td> <td>1</td> <td>AD01</td> <td>1</td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>5</td> <td>2</td> <td>AD02</td> <td>1</td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>6</td> <td>3</td> <td>AD03</td> <td>1</td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>7</td> <td>4</td> <td>AD04</td> <td>1</td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>8</td> <td>5</td> <td>AD05</td> <td>1</td> <td><input checked="" type="checkbox"/></td> </tr> </tbody> </table>		A/D Frequency:	1000			2	Update Server				3	Channel Number	Name	III Gain	Enable	4	1	AD01	1	<input checked="" type="checkbox"/>	5	2	AD02	1	<input checked="" type="checkbox"/>	6	3	AD03	1	<input checked="" type="checkbox"/>	7	4	AD04	1	<input checked="" type="checkbox"/>	8	5	AD05	1	<input checked="" type="checkbox"/>
	A/D Frequency:	1000																																								
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2	Set the sampling rate on the A/D channels (A/D Frequency).	 <table border="1"> <thead> <tr> <th></th> <th>A/D Frequency:</th> <th>1000</th> <th></th> <th></th> </tr> </thead> <tbody> <tr> <td>2</td> <td colspan="4">Update Server</td> </tr> <tr> <th>3</th> <th>Channel Number</th> <th>Name</th> <th>III Gain</th> <th>Enable</th> </tr> <tr> <td>4</td> <td>1</td> <td>AD01</td> <td>1</td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>5</td> <td>2</td> <td>AD02</td> <td>1</td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>6</td> <td>3</td> <td>AD03</td> <td>1</td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>7</td> <td>4</td> <td>AD04</td> <td>1</td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>8</td> <td>5</td> <td>AD05</td> <td>1</td> <td><input checked="" type="checkbox"/></td> </tr> </tbody> </table>		A/D Frequency:	1000			2	Update Server				3	Channel Number	Name	III Gain	Enable	4	1	AD01	1	<input checked="" type="checkbox"/>	5	2	AD02	1	<input checked="" type="checkbox"/>	6	3	AD03	1	<input checked="" type="checkbox"/>	7	4	AD04	1	<input checked="" type="checkbox"/>	8	5	AD05	1	<input checked="" type="checkbox"/>
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8	5	AD05	1	<input checked="" type="checkbox"/>																																						

Step	Action	Image/Comments																														
3	<p>Set the desired gain on the A/D channels (NI Gain).</p> <p>NOTE: Normal default hardware gain for field potential channels is 1000.</p>	 <table border="1"> <thead> <tr> <th>Channel Number</th> <th>Name</th> <th>NI Gain</th> <th>Enable</th> </tr> </thead> <tbody> <tr><td>1</td><td>AD01</td><td>1</td><td><input checked="" type="checkbox"/></td></tr> <tr><td>2</td><td>AD02</td><td>1</td><td><input checked="" type="checkbox"/></td></tr> <tr><td>3</td><td>AD03</td><td>1</td><td><input checked="" type="checkbox"/></td></tr> <tr><td>4</td><td>AD04</td><td>1</td><td><input checked="" type="checkbox"/></td></tr> <tr><td>5</td><td>AD05</td><td>1</td><td><input checked="" type="checkbox"/></td></tr> <tr><td>6</td><td>AD06</td><td>1</td><td><input checked="" type="checkbox"/></td></tr> </tbody> </table>	Channel Number	Name	NI Gain	Enable	1	AD01	1	<input checked="" type="checkbox"/>	2	AD02	1	<input checked="" type="checkbox"/>	3	AD03	1	<input checked="" type="checkbox"/>	4	AD04	1	<input checked="" type="checkbox"/>	5	AD05	1	<input checked="" type="checkbox"/>	6	AD06	1	<input checked="" type="checkbox"/>		
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5	AD05	1	<input checked="" type="checkbox"/>																													
6	AD06	1	<input checked="" type="checkbox"/>																													
4	<p>Set the preamp gain.</p> <p>NOTE: The value to be entered in the 'Preamp Gain' column is actually the product of the headstage gain and the preamp gain, or more generally, the total fixed gain before the signal enters the NI board.</p> <p>NOTE: The preamp gain is typically only entered once (unless the preamp changes), whereas the NI 'board gain' can be changed on a per-channel basis during the experiment (but not during recording).</p>	 <table border="1"> <thead> <tr> <th>Channel Number</th> <th>Name</th> <th>NI Gain</th> <th>Enable</th> <th>Preamp.</th> </tr> </thead> <tbody> <tr><td>1</td><td>AD01</td><td>1</td><td><input checked="" type="checkbox"/></td><td>1000</td></tr> <tr><td>2</td><td>AD02</td><td>1</td><td><input checked="" type="checkbox"/></td><td>1000</td></tr> <tr><td>3</td><td>AD03</td><td>1</td><td><input checked="" type="checkbox"/></td><td>1000</td></tr> <tr><td>4</td><td>AD04</td><td>1</td><td><input checked="" type="checkbox"/></td><td>1000</td></tr> <tr><td>5</td><td>AD05</td><td>1</td><td><input checked="" type="checkbox"/></td><td>1000</td></tr> </tbody> </table>	Channel Number	Name	NI Gain	Enable	Preamp.	1	AD01	1	<input checked="" type="checkbox"/>	1000	2	AD02	1	<input checked="" type="checkbox"/>	1000	3	AD03	1	<input checked="" type="checkbox"/>	1000	4	AD04	1	<input checked="" type="checkbox"/>	1000	5	AD05	1	<input checked="" type="checkbox"/>	1000
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5	AD05	1	<input checked="" type="checkbox"/>	1000																												
5	<p>Click Update Server.</p> <p>NOTE: Update Server must be clicked on each AnalogChans page where changes are made.</p>																															

Step	Action	Image/Comments
6	<p>View analog signals in the Sort Client Activity Display. Select View Activity Display or click the Activity Display button on the toolbar.</p> <p>NOTE: Amplitude measurements for continuous channels are not provided in Sort Client. For amplitude measurements, use NEX.</p>	 <p>The screenshot shows a software interface with a black background. At the top, there are five digital signal traces labeled sig001a, sig001b, sig002a, sig002b, and sig002c, each displaying a series of vertical bars. Below these are four analog signal traces labeled AD01, AD02, AD03, and AD04, each showing a continuous sine wave. A scale bar at the top right indicates a 10 s duration. At the bottom, there is a toolbar with three buttons: 'Settings', 'Multichanne...', and 'Activity Display'.</p>

11.4 NIDAQ Multichannel Sampling Characteristics

This section provides information on the between-channel sampling offsets of National Instruments data acquisition (NIDAQ) devices and includes charts with sampling offsets for the following NIDAQ devices:

- PCI-6070E (formerly PCI-MIO-16E-1): 1.25 MS/sec, 16 channels, 12-bit resolution
- PCI-6071E: 1.25 MS/sec, 64 channels, 12-bit resolution
- PCI-6052E: 333 kS/sec, 16 channels, 16-bit resolution
- PCI-6040E (formerly PCI-MIO-16E-4): 250kS/sec, 16 channels, 12-bit resolution

11.4.1 Instrumentation Preamp Settling Time and Sampling Offsets

The NIDAQ devices supported by Plexon hardware use a single, very-high-speed analog-to-digital (A/D) converter, which is multiplexed (shared) by all the input channels. Within a single sample period (e.g. 25 microseconds at a 40 kHz sampling rate), the A/D converter scans all the input channels in rapid succession and sends an A/D value (sample value) to **Server** for each channel. Because of the speed at which the converter scans, under most circumstances the effect is the same as having a dedicated A/D converter per channel. Although the NIDAQ scanning introduces a small inter-channel time offset, this is less than one sample period and therefore it has little or no effect on the acquired data.

However, an instrumentation grade preamplifier (on the NIDAQ device) precedes the NIDAQ A/D converter. This preamplifier requires a finite amount of time to “settle” from a high-voltage level to a lower-voltage level, especially when the gains are very different on adjacent channels. The worst-case situation is a large-amplitude input signal on channel i with a gain of 1, followed by a very-small input signal on channel $i+1$ with a gain of 100; this situation requires the longest settling time between channels for the instrumentation preamp to reproduce the signal on channel $i+1$ accurately. The net effect is similar to a “leakage” between channels; the voltage on channel i can affect the value of channel $i+1$. Ideally, signal levels are similar across channels and require moderate NIDAQ gains of 1 to 10; in this case, settling time is generally not a problem.

The default NIDAQ hardware behavior is to scan through the channels as rapidly as possible within each sample period, which is necessary if the full bandwidth of the device is used. For example, 31 channels at 20 kHz per channel on a 1.25 megasamples/sec board like the NI 6071E results in an inter-channel scan interval of about 1613 nanoseconds. However, when less than the maximum bandwidth of the board is used, the Sort Client software automatically reduces the channel scanning rate (within each sample period) in order to maximize the amount of time available for the instrumentation preamp to settle between channels.

Note: This reduction in the scanning rate does not affect the sampling rate, only the rate at which channels are scanned within each sample period. This reduces the number of available channels on the A/D board. NIDAQ never increases the inter-channel scan interval to more than one sample period, or 6 microseconds, whichever is shorter.

The following tables show the inter-channel scan intervals that Plexon software automatically selects for various combinations of channel count and digitizing rate (fast spike rate) for the NIDAQ device it supports. The values highlighted in green have sufficient settling time to enable accurate digitalization, even in the worst case described earlier. The values highlighted in yellow denote the combinations that can have reduced accuracy when there are widely differing gains set on adjacent channels. The values highlighted in red denote combinations that cannot be selected in Sort Client because they exceed the bandwidth of the NIDAQ device.

For additional information, refer to the NI PCI E Series User Manual (available on the National Instruments website), which describes the accuracy of various E series DAQ boards as a function of the inter-channel sampling offset.

Color Legend for Tables

	Meets the NI worst-case settling time specification for equal gain on all channels (this range provides accurate digitization)
	Possible problems for mixed gains (this range could cause inaccurate digitization)
	Sampling rate exceeds device capacity (this range exceeds the bandwidth of the NIDAQ device)

11.4.1.1 PCI-6071E Device

The NI “worst-case” specification for this device is 1.4 microseconds.

Samp. Freq → (kHz) Ch # ↓	1	2	4	5	8	10	16	20	24	25	31.25	40	50
1	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
2	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
3	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
4	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.0
5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.0	4.0
6	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.2	4.0	3.2
7	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.8	5.6	4.4	3.4	2.8
8	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.2	5.0	4.0	3.0	2.4
9	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.4	4.6	4.4	3.4	2.6	2.2
10	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.0	4.0	4.0	3.2	2.4	2.0
11	6.0	6.0	6.0	6.0	6.0	6.0	5.6	4.4	3.6	3.6	2.8	2.2	1.8
12	6.0	6.0	6.0	6.0	6.0	6.0	5.2	4.0	3.4	3.2	2.6	2.0	1.6
13	6.0	6.0	6.0	6.0	6.0	6.0	4.8	3.8	3.2	3.0	2.4	1.8	1.4
14	6.0	6.0	6.0	6.0	6.0	6.0	4.4	3.4	2.8	2.8	2.2	1.6	1.4
15	6.0	6.0	6.0	6.0	6.0	6.0	4.0	3.2	2.6	2.6	2.0	1.6	1.2
16	6.0	6.0	6.0	6.0	6.0	6.0	3.8	3.0	2.6	2.4	2.0	1.4	1.2
17	6.0	6.0	6.0	6.0	6.0	5.8	3.6	2.8	2.4	2.2	1.8	1.4	1.0
18	6.0	6.0	6.0	6.0	6.0	5.4	3.4	2.6	2.2	2.2	1.6	1.2	1.0
19	6.0	6.0	6.0	6.0	6.0	5.2	3.2	2.6	2.0	2.0	1.6	1.2	1.0
20	6.0	6.0	6.0	6.0	6.0	5.0	3.0	2.4	2.0	2.0	1.6	1.2	1.0
21	6.0	6.0	6.0	6.0	5.8	4.6	2.8	2.2	1.8	1.8	1.4	1.0	0.8
22	6.0	6.0	6.0	6.0	5.8	4.4	2.8	2.2	1.8	1.8	1.4	1.0	0.8
23	6.0	6.0	6.0	6.0	5.4	4.2	2.6	2.0	1.8	1.6	1.2	1.0	0.8
24	6.0	6.0	6.0	6.0	5.2	4.0	2.6	2.0	1.6	1.6	1.2	1.0	0.8
25	6.0	6.0	6.0	6.0	5.0	4.0	2.4	2.0	1.6	1.6	1.2	1.0	0.8
26	6.0	6.0	6.0	6.0	4.8	3.8	2.4	1.8	1.6	1.4	1.2	0.8	X
27	6.0	6.0	6.0	6.0	4.6	3.6	2.2	1.8	1.4	1.4	1.0	0.8	X
28	6.0	6.0	6.0	6.0	4.4	3.4	2.2	1.6	1.4	1.4	1.0	0.8	X
29	6.0	6.0	6.0	6.0	4.2	3.4	2.0	1.6	1.4	1.2	1.0	0.8	X
30	6.0	6.0	6.0	6.0	4.0	3.2	2.0	1.6	1.2	1.2	1.0	0.8	X
31	6.0	6.0	6.0	6.0	4.0	3.2	2.0	1.6	1.2	1.2	1.0	0.8	X
32	6.0	6.0	6.0	6.0	3.8	3.0	1.8	1.4	1.2	1.2	1.0	X	X
33	6.0	6.0	6.0	6.0	3.6	3.0	1.8	1.4	1.2	1.2	0.8	X	X
34	6.0	6.0	6.0	5.8	3.6	2.8	1.8	1.4	1.2	1.0	0.8	X	X
35	6.0	6.0	6.0	5.6	3.4	2.8	1.6	1.4	1.0	1.0	0.8	X	X
36	6.0	6.0	6.0	5.4	3.4	2.6	1.6	1.2	1.0	1.0	0.8	X	X

Samp. Freq → (kHz) Ch # ↓	1	2	4	5	8	10	16	20	24	25	31.25	40	50
37	6.0	6.0	6.0	5.4	3.2	2.6	1.6	1.2	1.0	1.0	0.8	X	X
38	6.0	6.0	6.0	5.2	3.2	2.6	1.6	1.2	1.0	1.0	0.8	X	X
39	6.0	6.0	6.0	5.0	3.2	2.4	1.6	1.2	1.0	1.0	0.8	X	X
40	6.0	6.0	6.0	5.0	3.0	2.4	1.4	1.2	1.0	1.0	0.8	X	X
41	6.0	6.0	6.0	4.8	3.0	2.4	1.4	1.2	1.0	0.8	X	X	X
42	6.0	6.0	5.8	4.6	2.8	2.2	1.4	1.0	0.8	1.0	X	X	X
43	6.0	6.0	5.8	4.6	2.8	2.2	1.4	1.0	0.8	1.0	X	X	X
44	6.0	6.0	5.6	4.4	2.8	2.2	1.2	1.0	0.8	1.0	X	X	X
45	6.0	6.0	5.4	4.4	2.6	2.2	1.2	1.0	0.8	1.0	X	X	X
46	6.0	6.0	5.4	4.2	2.6	2.0	1.2	1.0	0.8	1.0	X	X	X
47	6.0	6.0	5.2	4.2	2.6	2.0	1.2	1.0	0.8	1.0	X	X	X
48	6.0	6.0	5.2	4.0	2.6	2.0	1.2	1.0	0.8	1.0	X	X	X
49	6.0	6.0	5.0	4.0	2.4	2.0	1.2	1.0	0.8	1.0	X	X	X
50	6.0	6.0	5.0	4.0	2.4	2.0	1.2	1.0	0.8	1.0	X	X	X
51	6.0	6.0	4.8	3.8	2.4	1.8	1.2	0.8	0.8	X	X	X	X
52	6.0	6.0	4.8	3.8	2.4	1.8	1.2	0.8	0.8	X	X	X	X
53	6.0	6.0	4.6	3.6	2.2	1.8	1.0	0.8	X	X	X	X	X
54	6.0	6.0	4.6	3.6	2.2	1.8	1.0	0.8	X	X	X	X	X
55	6.0	6.0	4.4	3.6	2.2	1.8	1.0	0.8	X	X	X	X	X
56	6.0	6.0	4.4	3.4	2.2	1.8	1.0	0.8	X	X	X	X	X
57	6.0	6.0	4.2	3.4	2.0	1.6	1.0	0.8	X	X	X	X	X
58	6.0	6.0	4.2	3.4	2.0	1.6	1.0	0.8	X	X	X	X	X
59	6.0	6.0	4.2	3.2	2.0	1.6	1.0	0.8	X	X	X	X	X
60	6.0	6.0	4.0	3.2	2.0	1.6	1.0	0.8	X	X	X	X	X
61	6.0	6.0	4.0	3.2	2.0	1.6	1.0	0.8	X	X	X	X	X
62	6.0	6.0	4.0	3.2	2.0	1.6	1.0	0.8	X	X	X	X	X
63	6.0	6.0	3.8	3.0	1.8	1.4	0.8	X	X	X	X	X	X
64	6.0	6.0	3.8	3.0	1.8	1.4	0.8	X	X	X	X	X	X

11.4.1.2 PCI-6070E (PCI-MIO-16E-1) Device

The NI “worst-case” specification for this device is 1.5 microseconds.

Samp. Freq → (kHz) Ch # ↓	1	2	4	5	8	10	16	20	24	25	31.25	40	50
1	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
2	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
3	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
4	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.0
5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.0	4.0
6	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.2	4.0	3.2
7	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.8	5.6	4.4	3.4	2.8
8	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.2	5.0	4.0	3.0	2.4
9	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.4	4.6	4.4	3.4	2.6	2.2
10	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.0	4.0	4.0	3.2	2.4	2.0
11	6.0	6.0	6.0	6.0	6.0	6.0	5.6	4.4	3.6	3.6	2.8	2.2	1.8
12	6.0	6.0	6.0	6.0	6.0	6.0	5.2	4.0	3.4	3.2	2.6	2.0	1.6
13	6.0	6.0	6.0	6.0	6.0	6.0	4.8	3.8	3.2	3.0	2.4	1.8	1.4
14	6.0	6.0	6.0	6.0	6.0	6.0	4.4	3.4	2.8	2.8	2.2	1.6	1.4
15	6.0	6.0	6.0	6.0	6.0	6.0	4.0	3.2	2.6	2.6	2.0	1.6	1.2
16	6.0	6.0	6.0	6.0	6.0	6.0	3.8	3.0	2.6	2.4	2.0	1.4	1.2

11.4.1.3 PCI-6052E Device

The NI “worst-case” specification for this device is 4.0 microseconds.

Samp. Freq → (kHz) Ch # ↓	1	2	4	5	8	10	16	20	24	25	31.25	40	50
1	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
2	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
3	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
4	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.0
5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.0	4.0
6	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.2	4.0	3.2
7	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.8	5.6	4.4	3.4	2.8
8	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.2	5.0	4.0	3.0	2.4
9	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.4	4.6	4.4	3.4	2.6	2.2
10	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.0	4.0	4.0	3.2	2.4	2.0
11	6.0	6.0	6.0	6.0	6.0	6.0	5.6	4.4	3.6	3.6	2.8	2.2	1.8
12	6.0	6.0	6.0	6.0	6.0	6.0	5.2	4.0	3.4	3.2	2.6	2.0	1.6
13	6.0	6.0	6.0	6.0	6.0	6.0	4.8	3.8	3.2	3.0	2.4	1.8	1.4
14	6.0	6.0	6.0	6.0	6.0	6.0	4.4	3.4	2.8	2.8	2.2	1.6	1.4
15	6.0	6.0	6.0	6.0	6.0	6.0	4.0	3.2	2.6	2.6	2.0	1.6	1.2
16	6.0	6.0	6.0	6.0	6.0	6.0	3.8	3.0	2.6	2.4	2.0	1.4	1.2

11.4.1.4 PCI-6040E (PCI-MIO-16E-4) Device

The NI “worst-case” specification for this device is 4.0 microseconds.

Samp. Freq → (kHz) Ch # ↓	1	2	4	5	8	10	16	20	24	25	31.25	40	50
1	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
2	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
3	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
4	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.0
5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.0	4.0
6	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.2	4.0	3.2
7	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.8	5.6	4.4	3.4	2.8
8	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.2	5.0	4.0	3.0	2.4
9	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.4	4.6	4.4	3.4	2.6	2.2
10	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.0	4.0	4.0	3.2	2.4	2.0
11	6.0	6.0	6.0	6.0	6.0	6.0	5.6	4.4	3.6	3.6	2.8	2.2	1.8
12	6.0	6.0	6.0	6.0	6.0	6.0	5.2	4.0	3.4	3.2	2.6	2.0	1.6
13	6.0	6.0	6.0	6.0	6.0	6.0	4.8	3.8	3.2	3.0	2.4	1.8	1.4
14	6.0	6.0	6.0	6.0	6.0	6.0	4.4	3.4	2.8	2.8	2.2	1.6	1.4
15	6.0	6.0	6.0	6.0	6.0	6.0	4.0	3.2	2.6	2.6	2.0	1.6	1.2
16	6.0	6.0	6.0	6.0	6.0	6.0	3.8	3.0	2.6	2.4	2.0	1.4	1.2

11.5 Signal Mapping Between C-HUB and NI PCI-6071E

The table below shows the signal mapping between the C-HUB and the NI PCI-6071E A/D board. See the NI PCI E-series User Manual (NI 320945D-01) on the National Instruments website for more information about each signal.

C-HUB to PCI-6071E Signal Mapping

Plexon Signal Name	National Instruments Signal Name
AD01	ACH0
AD02	ACH1
---	---
AD64	ACH63
AISENSE	AISENSE
AISENSE2	AISENSE2
AIGND	AIGND
DO1	DIO0
DO2	DIO1
---	---
DO8	DIO7
DGND*	DGND*
CTR1 (Line 2)**	GPCTR1
A/D Clock	PFI8/GPCTR0_Source
A/D Start	PFI0_TRIG1
CPX Clock	GPCTR0_OUT
AO1	DAC0_OUT
AO2	DAC1OUT
AOGND*	AOGND*

* The NI signals DGND and AOGND are shorted together on the C-HUB.

**CTR1 is called "Line 2" in the PlexDO utility.

Appendix A Installation

A.1 Before Beginning A-2
A.2 Hardware A-2
A.3 Software A-2

This appendix provides information on the following topics:

- What is needed before installing the Plexon RASPUTIN Software
- RASPUTIN Software installation
- Hard key installation

A.1 Before Beginning

Before beginning the RASPUTIN Software installation, ensure that the following hardware and software are installed and configured correctly on the PC.

A.2 Hardware

To install RASPUTIN software, it is necessary to have the following hardware

- Plexon recommends a PC with
 - An Intel Pentium 4 1-GHz processor or faster
 - A minimum 512 Mbyte of memory
 - 10 Gbytes of hard disk space—this can vary depending on the recording requirements
 - Microsoft Windows NT4.0 or Windows XP operating system
- A complete Plexon Multi-channel Acquisition Processor (MAP) system. For hardware information, refer to the [Plexon MAP System Installation Guide](#).
- A Rainbow Technologies Sentinel* System security key, which can be either a parallel-port key or a USB key. Parallel-port keys have two oblong connectors—one male and one female, which enables several keys to be stacked together. USB keys have a single male connector.

A.2.1 Hardware Installation

Determine if the RASPUTIN Software Sentinel System key is a parallel-port key or a USB key. Keys are channel-count specific and they are available in 16, 32, 64, 96, and 128-channel capacities. Locate a suitable port to install the key. If assistance is needed with the port locations on the PC, refer to the PC manufacturer's instructions. Do not install the key until the software installation is completed. See the Caution on [page A-7](#).

A.3 Software

If a complete MAP system is installed and configured, the RASPUTIN Software automatically uses it.

A.3.1 Installing the RASPUTIN Software

There are three major steps to installing the RASPUTIN Software:

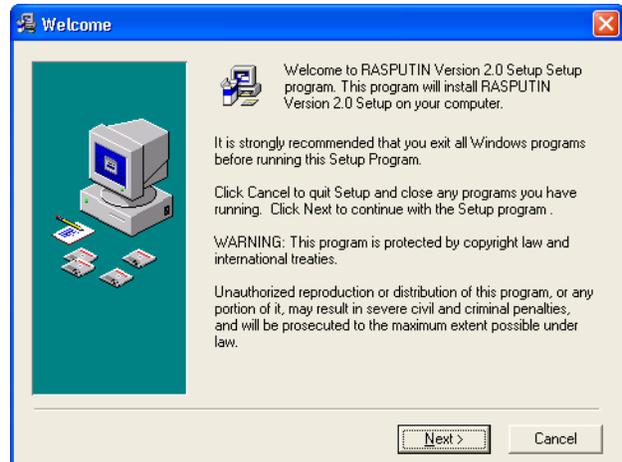
- Install the RASPUTIN Software files and run the setup program.

- Install and configure the Rainbow Sentinel system drivers.
- Install the Sentinel hardware key.

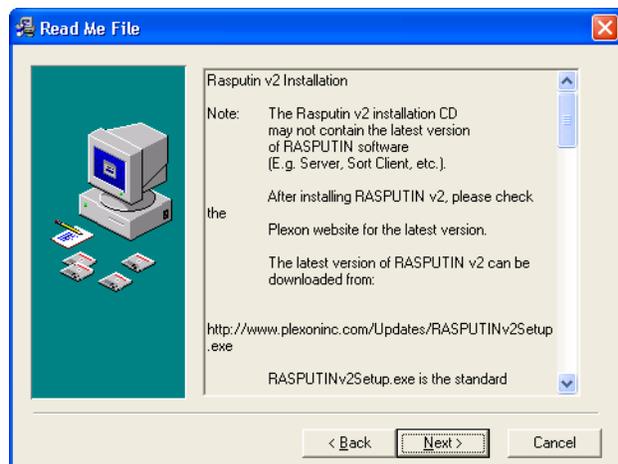
To install the RASPUTIN Software files

- 1 Close all applications.
- 2 Place the RASPUTIN Software setup CD in the computer's CD-ROM drive.
- 3 Find the RASPUTINv2Setup.exe file on the CD.
- 4 Double-click **RASPUTINv2Setup.exe**.

- 5 When the **Welcome** screen appears, follow the on-screen instructions. Click **Next** to acknowledge acceptance of the copyright warning and to proceed with installation.



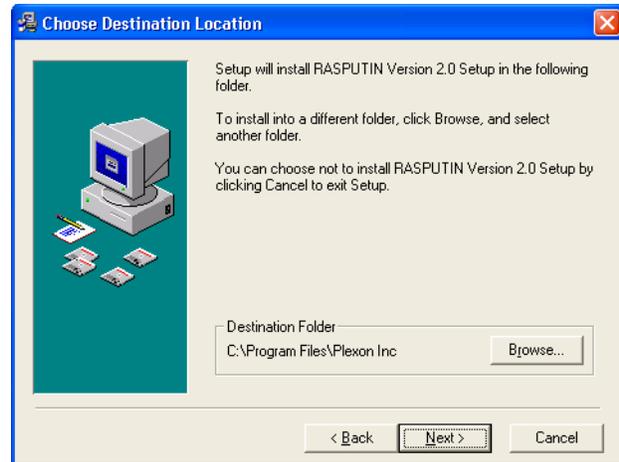
- 6 Review the information in the **Read Me File** window.



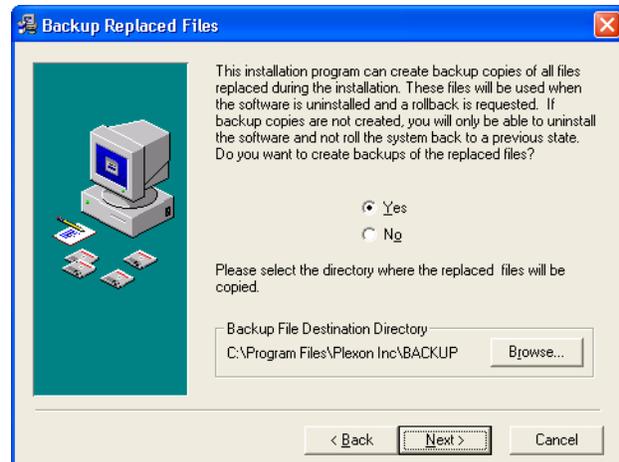
Note: If **Cancel** is clicked, the **Install** window opens. Click **Exit Setup** to cancel.



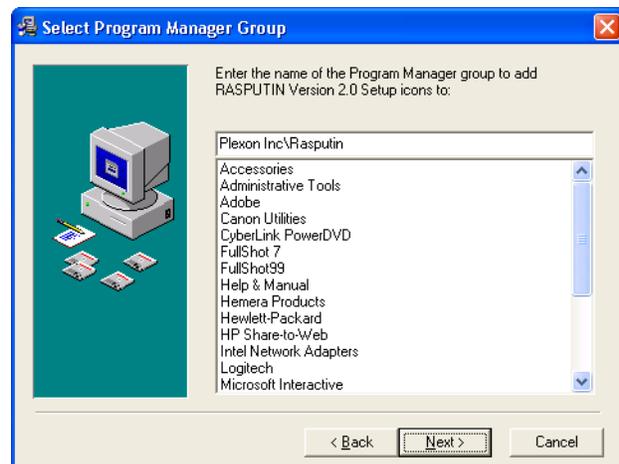
- 7 In the **Choose Destination Location** window, a location for the RASPUTIN Software files can be specified. Click **Browse** to choose a different location. Otherwise, click **Next** to accept the default location.



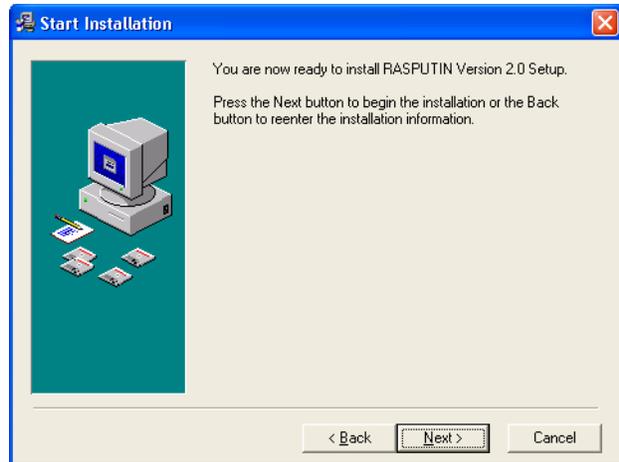
- 8 To upgrade from RASPUTIN Version 2.2, in the **Backup Replaced Files** window, click **Yes** to create backup copies of the Version 2 software. Make sure Version 2.4 is working correctly before deleting the backup copies. Click **Next** to continue the installation.



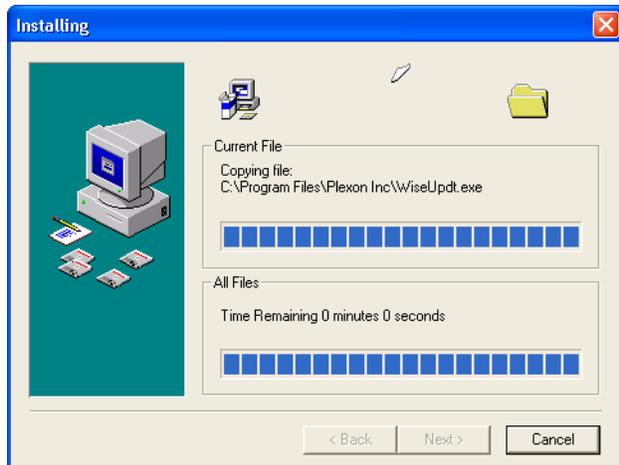
- 9 In the **Select Program Manager Group** window, a program group for the RASPUTIN Software icons may be chosen. To accept the default group and proceed with the installation, click **Next**.



- 10 At the **Start Installation** window, to return to the previous window to change information, click **Back**. Otherwise, click **Next** to begin the RASPUTIN Software installation.



- 11 The **Installing** window includes a progress bars that will show when the installation is complete.



- 12 When the RASPUTIN Software installation process is complete, the **Sentinel System Driver - InstallShield Wizard** welcome window opens. Click **Next** to proceed with driver installation.



- 13 In the **Program Maintenance** window, click **Modify** and then click **Next** to continue the installation.



- 14 In the **Custom Setup** window, click the driver that matches the Sentinel System security key. To determine type of key is installed, see [“Hardware Installation” on page A-2](#). The following illustration shows the installation window with the parallel-port key driver selected.



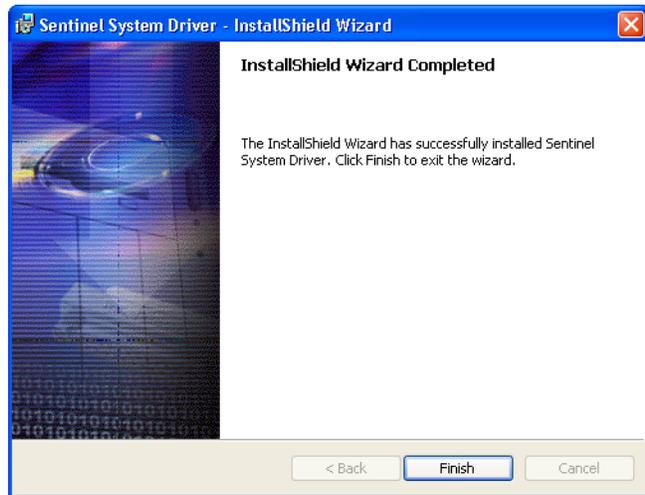
Caution
USB Security Key Damage

Before installing Sentinel System security key drivers it is necessary to remove *all* Sentinel USB keys from the PC. If a system driver is installed with a USB key in the port, the key becomes unusable.

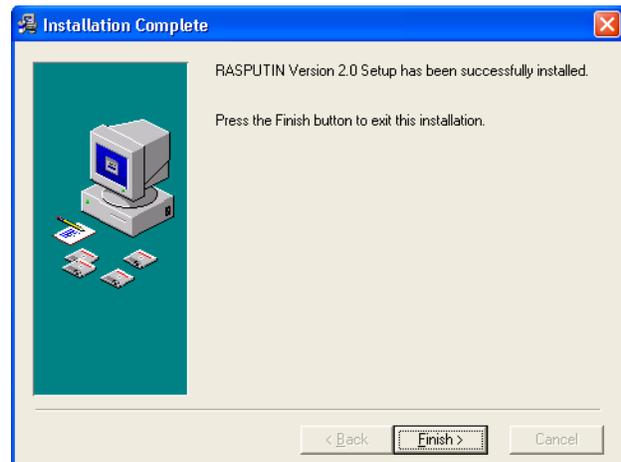
- 15 Ensure that all USB keys have been removed from the PC. Click **Install** to proceed with the driver installation.



- 16 When the Sentinel driver installation completes, the following window opens. Click **Finish** to complete the driver installation.



- 17 When the **Sentinel System Driver - InstallShield Wizard** window closes, the **Installation Complete** window is visible. Click **Finish** to complete the RASPUTIN Software software installation.



To install the Sentinel hardware key

- 1 Plexon provides two types of hardware keys with RASPUTIN Software: a Universal Serial Bus (USB) key and parallel-port key. Each key is marked with "R" to indicate that it is a RASPUTIN Software key. Determine which ports are available on the computer and choose the appropriate key.
- 2 If a USB key has been chosen, locate an available USB port on the computer and insert the USB key.
– or –
If a parallel-port key has been chosen, locate an available parallel port on the computer and continue with Step 3.

Note: If the computer has only one parallel port, parallel-port devices like printers or Zip drives may be temporarily removed to connect the key. After installing the key, these devices may be reconnected to the parallel port on the key.

- 3 Insert the key into the computer parallel port. Tighten the mounting screws.
- 4 Reconnect any other parallel-port devices to the key.

Note: If a printer is to be connected to the computer through a Sentinel key, Sentinel recommends using shielded printer cables.

Note: More than one parallel-port key can be attached to the same parallel port. SentinelSuperPro* keys, which are provided with [Plexon Offline Sorter](#) software, can be cascaded (one key connected to another key in a series) with other Rainbow Technologies keys that support cascading. If cascaded keys are used, the SentinelSuperPro key must be the last key in the series, that is, the one located farthest from the computer port.

Appendix B

PXI Expansion Chassis

B.1 Introduction	B-2
B.2 Interface Modules.....	B-5
B.3 Installation.....	B-10
B.4 Power Up and Initialization	B-26

B.1 Introduction

B.1.1 Overview

In a typical Plexon MAP System, additional PCI slots may be needed for A/D boards (the MAP system supports up to 4 A/D boards), the HLK2 interface, digital I/O boards for CinePlex, etc. However, PCs have a limited number of PCI slots, and there may not be enough available slots to accommodate individual needs. To provide a solution to this problem, Plexon offers the Plexon Expansion Chassis. With the Plexon Expansion Chassis it is not necessary to be dependent on the PC manufacturer for the number of PCI slots available.

Note: The PC uses PCI cards while the expansion chassis uses smaller PXI cards (otherwise known as compact PCI or cPCI). The PCI and PXI cards are different and are not interchangeable.

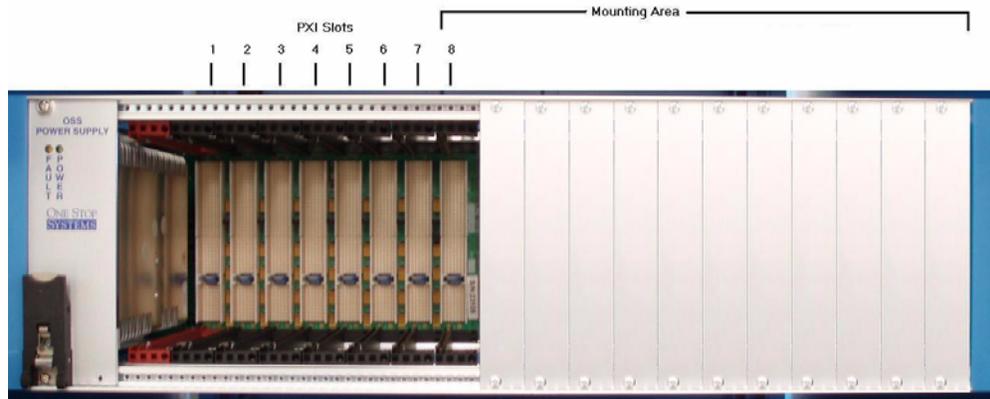
B.1.2 Expansion Chassis Models

Plexon offers three models of the Expansion Chassis (PXI/exp, PXI/exp4, and PXI/exp4-RM).

B.1.2.1 PXI/exp

The PXI/exp consists of a chassis which has 8 usable cPCI slots on the left half of the chassis. The space over unused slots in the chassis may be used for mounting C-HUB and BNC-16B panels (break out panels used to interface to or to provide access to A/D channels). If nothing is mounted in this area, filler panels cover the space - as shown in the diagram below. Any of the unused slots are also covered with filler panels. The chassis has space for 10 slots, but the first two are taken up by the power supply. This means that the slot numbering begins after the first two slots; a point that is illustrated in the diagram below.

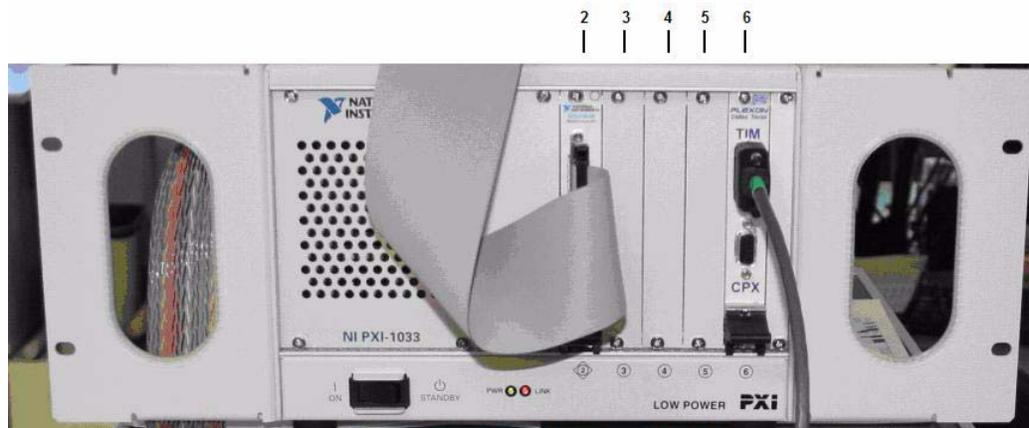
To the right of the power supply, the PXI-8360 link card is mounted in Slot 1 and the Plexon PXI-TIM card is mounted in Slot 2. If CinePlex and the digital video recording system is used with the expansion chassis, a FireWire® card for connecting a CinePlex camera will likely be installed in Slot 3. A/D cards may be installed in any remaining slots (The Plexon system supports up to 4 A/D cards). A/D cards installed in the expansion chassis must all be of the same type (for example, all 6071E, all 6070E, or etc.).



The top picture shows an empty expansion chassis (except for the power supply), and the bottom picture shows the expansion chassis in a typical installation with cards and breakout boxes.

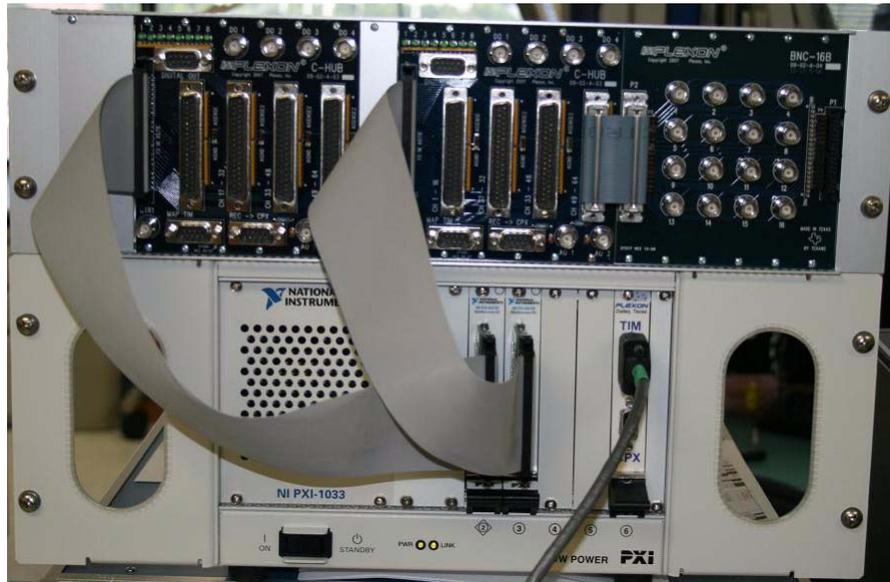
B.1.2.2 PXI/exp4 and PXI/exp4-RM

The PXI/exp4 is a National Instruments PXI-1033 chassis which contains a 5-slot PXI backplane. The PXI/exp4 and PXI/exp4-RM both contain an embedded PC interface with a connector on the back of the chassis.



The PXI/exp4-RM is the same as the PXI/exp4 except that it has a rack mount on the top. The rack mount is used to mount various combinations of Plexon's inter-

face cards (C-HUB and BNC-16B) as shown in the sample mounting picture below. If additional space is needed, multiple rack mounts can be used together.



B.2 Interface Modules

B.2.1 Expansion Chassis Modules

The table below describes the modules used for the PXI/exp, PXI/exp4, and PXI/exp4-RM.

Expansion Chassis Modules

Module	Image	Description	Comments
Chassis Power Supply		The Expansion Chassis power supply occupies the left-most area (covering two slots) of the PXI/exp.	Built into PXI/exp4 and PXI/exp4-RM
PXI-8360 Controller		The PXI-8360 controller module provides a data link between the Expansion Chassis and the PC. This NI module occupies Slot 1 in the PXI/exp.	Built into PXI/exp4 and PXI/exp4-RM and accessed using the connector on back of chassis
PXI-TIM card		This Plexon module occupies Slot 2 in the PXI/exp, the PXI/exp4, or PXI/exp4-RM. This module receives timing and control signals from the MAP system and distributes the timing signal to the other cards in the PXI expansion chassis. It has two 9-pin connectors on the faceplate. The TIM connector provides a connection to the TIM board in the MAP. Currently, the CPX connector is reserved for future use with the Plexon CinePlex Video Capture and Tracking System.	PXI/exp, PXI/exp4, and PXI/exp4-RM need this module. The PXI-TIM card contains jumpers to send either a 40kHz or 80kHz clock signal to the A/D cards in the expansion chassis. The NI A/D cards divide this clock signal by 2, so that a 40kHz clock signal is required to run the A/D cards at a 20kHz sampling frequency. An 80kHz clock signal is required to run the A/D cards at a 40kHz sampling frequency.

Expansion Chassis Modules

Module	Image	Description	Comments
A/D cards		<p>The NI A/D cards may occupy any available PXI slot. They are normally positioned to the right of the PXI-TIM and PXI-8252 FireWire card. The image shows the ADC/PXI-6071E, which it provides up to 64 channels of analog input with 12-bit resolution.</p>	<p>Other supported NI A/D cards include: PXI-6040E PXI-6052E PXI-6070E</p> <p>NOTE: If more than one A/D card is installed in an expansion chassis, Sort Client requires all of them to be the same type.</p>
PXI-8252 FireWire card		<p>The National Instruments PXI-8252 FireWire card is used to connect the camera for the Plexon CinePlex system. It can be placed in any slot between slots 3 and 6 in the PXI/exp4 and PXI/exp4-RM. Typically, this card will reside in Slot 3 of the PXI/exp. This will allow an A/D card to be placed in close proximity to a C-HUB; should they need to be connected.</p>	<p>If a CinePlex camera needs to be connected and there is no expansion chassis, the FireWire card must be installed in the PC.</p>

B.2.2 Nose Cards

A nose card is an adaptor board that is mounted directly on the front of another card. There are two types of nose cards. One type connects preamps directly to the A/D cards and the other type connects breakout cards to the A/D cards. The

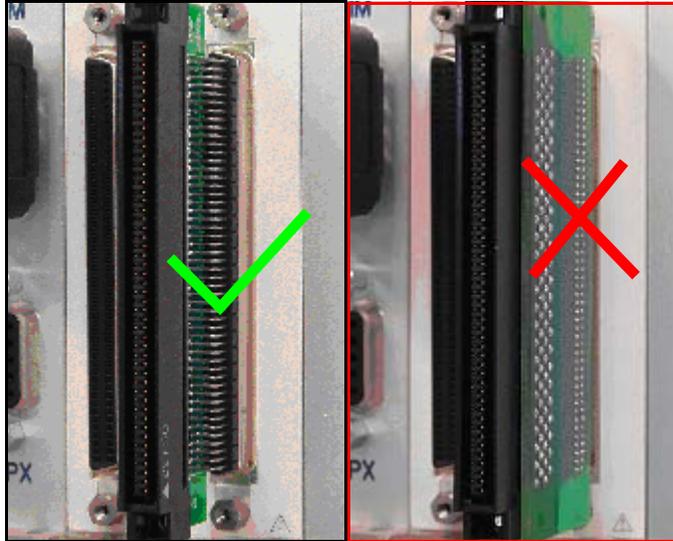
nose cards permit the use of shorter, more flexible cables. The table below describes the various nose cards.

Nose Cards

Module	Image	Description	Comments
PXI-6071E P50E-100 Adaptor		The Plexon PXI-6071E P50E-100 Adaptor card connects the PXI-6071E I/O Module to the C-HUB.	Damage can result if the card is installed backwards. See below for details.
ADP/PXI6071E-DB37m		This adaptor connects a preamp output directly to the PXI-6071E, circumventing the need for a breakout box. Only 16 of the 64 channels are used, and the unused 48 channels are grounded.	Damage can result if the card is installed backwards. See below for details.
PXI-6070E Adaptor		This adaptor connects a preamp output directly to the PXI-6070E 16-channel A/D card. This card may also be used to connect a BNB-16B to the PXI-6070E.	The connectors are beveled - this prevents this card from being installed backwards.

The diagrams below show the Plexon PXI-6071E P50E-100 nose card, but they also apply to the ADP/PXI6071E-DB37m nose card.

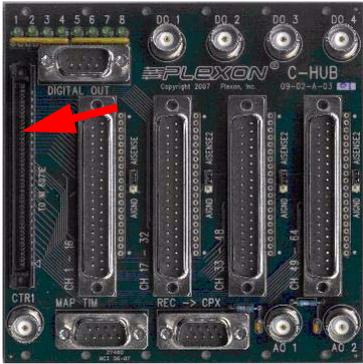
The illustration on the left is correct, and the illustration on the right is incorrect. Note that in the incorrect illustration, the printed circuit side of the card is on the right - the card should be rotated by 180 degrees to be correct. The printed circuit side of the card should be on the left.



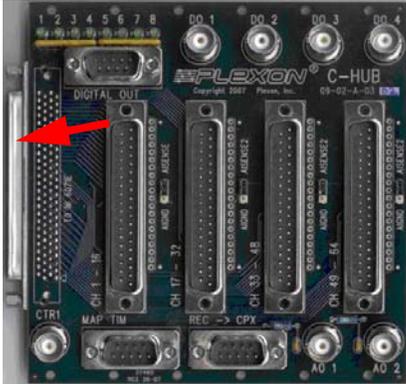
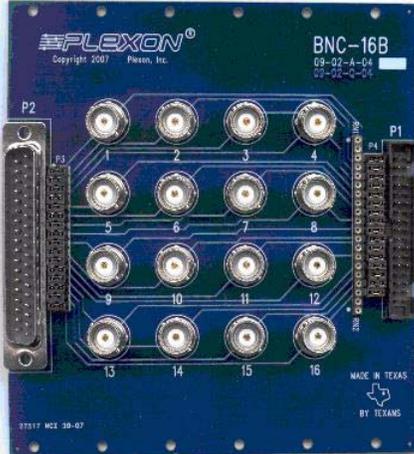
B.2.3 Breakout Cards

There are two types of breakout cards - rack-mounted and remotely-mounted. The table below describes the breakout cards that may be used in conjunction with any of the expansion chassis models. These cards are mounted on a rack above the PXI/exp4 and PXI/exp4-RM or may be mounted directly on the PXI/exp. They do not plug into any of the expansion chassis slots.

Breakout Cards

Module/Image	Description	Comments
<p>C-HUB-r</p> 	<p>The C-HUB-r (rack-mounted) has the PXI-6071E connector mounted perpendicular to the circuit card as shown in the image at the left.</p> <p>C-HUB-r uses a gray ribbon cable to connect to the PXI-6071E. Rainbow-colored twisted-pair cables are used to connect to the DB37 connectors on the C-HUB-r.</p>	<p>C-HUB and C-HUB-r are interfaces to the National Instruments 6071E A/D cards. For more details, see C-HUB Technical Brief.</p> <p>The C-HUB-r uses the PXI-6071E P50E-100 adaptor to connect to the PXI-6071E described in the previous section. See “Connecting an A/D Card to a C-HUB-r or PBX” on page B-12 for pictures of the cabling.</p>

Breakout Cards

Module/Image	Description	Comments
<p>C-HUB</p> 	<p>The C-HUB (remotely-mounted) has the PXI-6071E connector mounted in-line with the circuit card as shown in the image at the left. This version is the table-top version.</p> <p>C-HUB uses a thick, black, inflexible cable to connect to the PXI-6071E. Rainbow-colored twisted-pair cables are used to connect to the DB37 connectors on the C-HUB.</p>	<p>NOTE: This model is not intended to be mounted on the rack. If it is mounted on the rack, it may be difficult or impossible to connect the cable to the PXI-6071E connector. For more details, see C-HUB Technical Brief</p> <p>See “Connecting an A/D Card to a C-HUB-r or PBX” on page B-12 for cabling pictures.</p>
<p>BNC-16B</p> 	<p>The BNC-16B (rack- or remotely-mounted) mounts on the PXI/exp, on the rack of the PXI/exp4(-RM), or in a table-top configuration with the C-HUB.</p> <p>The BNC-16B uses BNC cables to connect to the individual channels. For other input and output the BNC-16B uses a DB37 connector (P2) and a 34-pin box header connector.</p>	<p>The BNC-16B is a breakout box for the C-HUB. It connects to the C-HUB and provides access of up to 16 channels of analog signals for straight-through connection, signal substitution, or signal monitoring. For more details see BNC-16B Technical Brief.</p> <p>See “Connectors” on page D-4 and “Connecting Signals to the BNC-16B” on page D-6 for details on the connectors and pictures of the cabling.</p>

B.3 Installation

The appropriate cards will already be installed prior to shipment. Connecting the required cables between the correct expansion chassis connectors and the appropriate connectors in the PC, MAP system, or other devices is all that is required. To install a card into the expansion chassis, see [“Expansion Chassis Cards and Cabling” on page B-20](#). The following may also need to be performed:

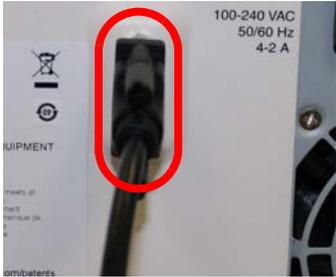
- Connect the link controller in the expansion chassis to the PC - see [“Connecting the Link Controller to a PC” on page B-11](#).
- Connect one or more expansion chassis A/D cards to a C-HUB - see [“Connecting an A/D Card to a C-HUB-r or PBX” on page B-12](#).
- Connect an expansion chassis FireWire card to the CinePlex camera - see [“Connecting a FireWire Card to the CinePlex Camera” on page B-15](#).
- Connect an expansion chassis Plexon PXI-TIM card to the MAP system - see [“Connecting a PXI-TIM Card to the MAP System TIM Card” on page B-16](#).
- Set the jumpers on the Plexon PXI-TIM card to determine clock frequency - see [“Setting PXI-TIM Jumpers” on page B-17](#).
- Connect a C-HUB to a BNC-16B - see [“Connecting a BNC-16B to a C-HUB-r/C-HUB” on page B-19](#).

There are other interface options for the C-HUB. For information on those connections, see C-HUB Technical Brief. There are also other interface possibilities for the BNC-16B. For details see BNC-16B Technical Brief.

B.3.1 Connecting the Link Controller to a PC

The table below contains the procedure to connect the expansion chassis link controller to a PC.

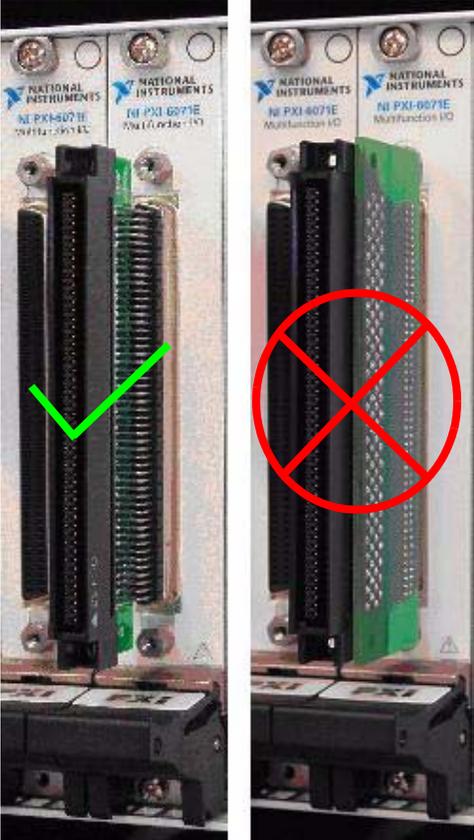
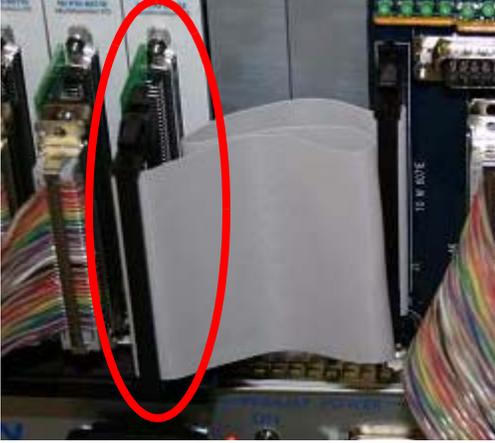
Link Controller to PC

Step	Action	Image/Comments
1	Ensure the PC power and the expansion chassis power are both turned OFF .	Damage to the equipment is possible if the power is on.
2	Connect the link cable to the PCI Express card in the PC (see the red rounded rectangle). Use the left-most port (Port 1) - at the left of Port 1 are two LEDs (one orange and one green).	
3a	For the PXI/exp4 or PXI/exp4-RM expansion chassis, connect the other end of the link cable to the connector on the back of the PXI/exp4 or PXI/exp4-RM expansion chassis.	
3b	For the PXI/exp expansion chassis, connect the other end of the link cable to the connector on the front of the PXI-8360 Controller card in the PXI/exp expansion chassis.	

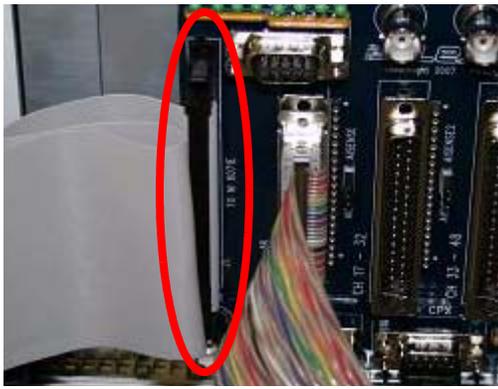
B.3.2 Connecting an A/D Card to a C-HUB-r or PBX

The table below contains the procedure to connect an expansion chassis PXI-6071E A/D card to a C-HUB-r using an adaptor card.

A/D Card to C-HUB-r with the PXI-6071E P50-100 Adaptor Card

Step	Action	Image/Comments
1	Ensure the PC power and the expansion chassis power are both turned OFF .	Damage to the equipment is possible if the power is on.
2	Connect the PXI-6071E P50-100 adaptor card to the A/D card in the expansion chassis. Ensure that the adaptor card is inserted correctly as shown in the top diagram. Damage could result if the adaptor card is inserted as shown in the right diagram.	
3	Connect the gray A/D ribbon cable to the PXI-6071E P50-100 adaptor card.	

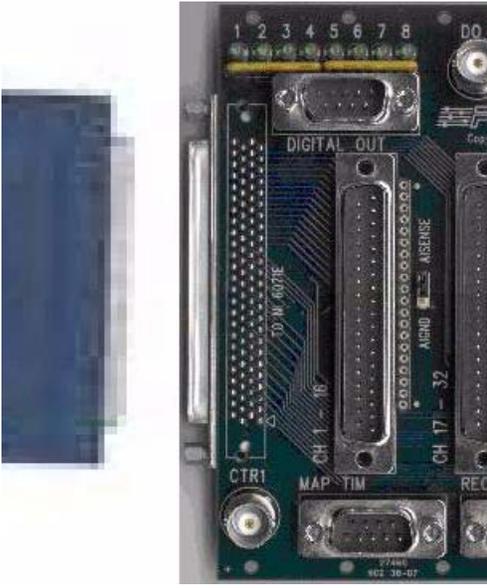
A/D Card to C-HUB-r with the PXI-6071E P50-100 Adaptor Card

Step	Action	Image/Comments
4	<p>Connect the other end of the gray A/D ribbon cable to the C-HUB-r.</p> <p>NOTE: The C-HUB-r has the PXI-6071E connector mounted perpendicular to the circuit card.</p>	

A/D Card to PBX with ADP/PX-6071E-DB37m Adaptor

Step	Action	Image/Comments
1	Ensure the PC power and the expansion chassis power are both turned OFF .	Damage to the equipment is possible if the power is on.
2	Connect the PXI-6071E DB37m adaptor to the A/D card in the expansion chassis. Ensure that the adaptor card is inserted correctly as shown in the top diagram. Damage could result if the adaptor card is inserted incorrectly. Note: The correct circuit card orientation is the same as it was for the previous procedure.	
3	Connect the rainbow A/D ribbon cable to the PXI-6071E DB37 adaptor card.	
4	<p>Connect the other end of the rainbow A/D ribbon cable to the PBX.</p> <p>Note: Connection could be made to the MAP OUT card instead of a PBX. Contact Plexon for assistance, if needed.</p>	

A/D Card to C-HUB (in-line connector)

Step	Action	Image/Comments
1	Ensure the PC power and the expansion chassis power are both turned OFF .	Damage to the equipment is possible if the power is on.
2	Connect the NI cable to the connector on the PCI-6071E.	
3	Connect the other end of the NI cable to the PCI-6071E output connector on the C-HUB. NOTE: The C-HUB has the PCI-6071E connector mounted in-line with the circuit card.	

B.3.3 Connecting a FireWire Card to the CinePlex Camera

The table below contains the procedure to connect a FireWire card in the expansion chassis to the CinePlex camera.

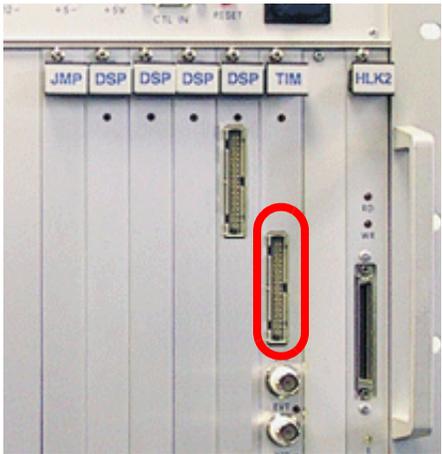
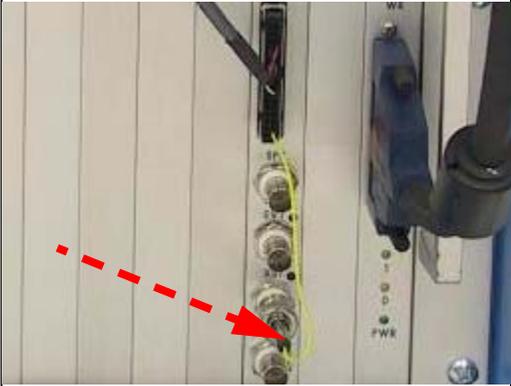
FireWire Card to Camera

Step	Action	Image/Comments
1	Ensure the CinePlex camera and expansion chassis are both turned OFF .	Damage to the equipment is possible if the power is on.
2	Connect the FireWire cable to any connector on the FireWire card in the expansion chassis.	
3	Connect the other end of the FireWire cable to the single or left-most connector of the CinePlex camera (depending on the type of camera to be installed - Plexon offers two types of cameras as shown in the diagram).	

B.3.4 Connecting a PXI-TIM Card to the MAP System TIM Card

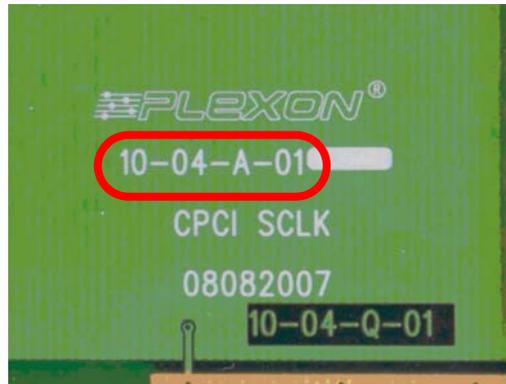
The table below contains the procedure for connecting a Plexon PXI-TIM card in the expansion chassis to the MAP System TIM board.

PXI-TIM Card to PC

Step	Action	Image/Comments
1	Ensure the MAP System power and the expansion chassis power are both turned OFF .	Damage to the equipment is possible if the power is on.
2	Connect the DB9 end of a TIM cable to the TIM connector on the Plexon PXI-TIM card in the expansion chassis. For details on settings the jumpers for 40K and 80K clock speeds, see “Setting PXI-TIM Jumpers” on page B-17	
3	Connect the other end of the TIM cable to the connector on the MAP System TIM board.	
4	For a pre-2008 MAP System, connect the yellow wire on the TIM cable to the XS1 BNC connector on the MAP TIM board (indicated by the red arrow). This step is not needed for MAP systems built in 2008 and later, which are shipped with a cap on the XS1 BNC connector. The cap should remain on the XS1 connector on these newer MAP systems at all times.	

B.3.5 Setting PXI-TIM Jumpers

Some clock modules have jumpers to set clock speeds of 40 kHz or 80 kHz. Look at the lower right corner of the circuit card to determine if the proper jumpers are present. Above the name of the card (CCPI SCLCK) there will appear an engineering number (10-04-A-01) if the proper jumpers are there as shown in the diagram below. The engineering number is not present on earlier versions of the card.

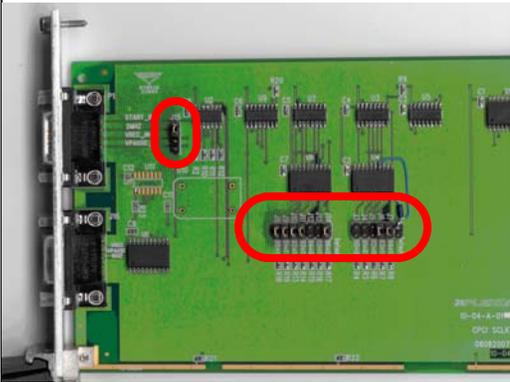


Typically, the clock speed is 80 kHz, which corresponds to a 'fast' sampling rate of 40 kHz. If a smaller file size is desired or there is a need to digitize more spike channels at 40 kHz per channel than the card's bandwidth will allow, set the jumpers for a 40 kHz clock, which corresponds to a 20 kHz maximum sampling rate.

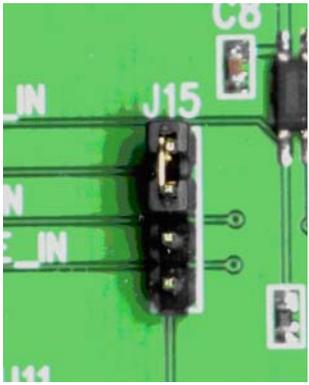
Note: A 20 kHz sampling rate will result in spikes being recorded less accurately than at 40 kHz; make sure that a 20 kHz rate is adequate before using the lower rate.

The table below shows how to set the jumpers on the PXI-TIM card for clock speeds of 40KHz or 80KHz.

PXI-TIM Jumper Settings

Step	Action	Image/Comments
1	Locate the jumper settings on the PXI-TIM circuit card.	

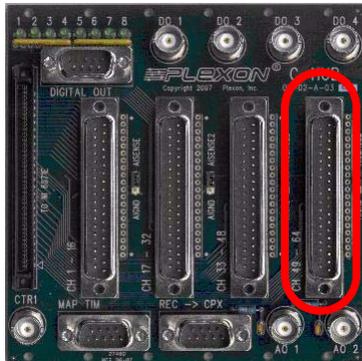
PXI-TIM Jumper Settings

Step	Action	Image/Comments
2	Ensure that the J15 jumper is set according to the image at the right (Jumper across the top two pins).	
3a	For an 80KHz clock signal, ensure that jumpers J3 through J14 are set according to the image at the right (Jumpers on J6-J11 and J14). An 80kHz clock signal is required to run the A/D cards in the chassis at a 40kHz sampling rate (the A/D cards divide the incoming clock signal by 2).	
3b	For a 40KHz clock signal, ensure that jumpers J3 through J14 are set according to the image at the right (Jumpers on J3, J7-J10, and J13). A 40kHz clock signal is required to run the A/D cards in the chassis at a 20kHz sampling rate (the A/D cards divide the incoming clock signal by 2).	

B.3.6 Connecting a BNC-16B to a C-HUB-r/C-HUB

The table below contains the procedure for connecting a C-HUB-r or a C-HUB to a BNC-16B.

C-HUB-r/C-HUB to BNC-16B

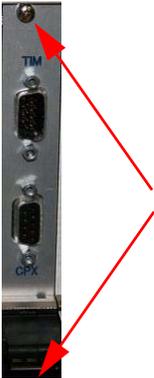
Step	Action	Image/Comments
1	Ensure the all power supplies of devices connected to the C-HUB and BNC-16B are turned OFF .	Damage to the equipment is possible if the power is on.
2	Connect one end of a ribbon jumper cable to the right-most connector of the C-HUB. NOTE: The diagram shows a C-HUB-r (PXI-6071E connector mounted perpendicular to the circuit card). The procedure is the same for the C-HUB.	
3	Connect the other end of the ribbon jumper cable to the left-most connector of the BNC-16B. For additional details about the other BNC-16B connectors, see BNC-16B Technical Brief.	
4	The resulting connection looks like this.	

B.3.7 Expansion Chassis Cards and Cabling

This section describes how to remove and install cards in the PXI/exp expansion chassis and how to arrange the cabling.

Cards may never need to be installed or removed from the expansion chassis, but follow the procedures below, if necessary.

Removing Cards from the PXI/exp Expansion Chassis

Step	Action	Image/Comments
1	Make sure the MAP and the expansion chassis are plugged into an AC power source.	The power cord provides a ground for the chassis and protects components from electrical damage while removing the card.
2	Turn off the chassis power.	
3	Unscrew the two (2) bracket-retaining screws on the faceplate of the card. NOTE: The screw at the bottom is below the ejector handle.	NOTE: PXI bracket-retaining screws are captive and cannot be removed from the card. 
4	Touch the metal part of the chassis to discharge any static electricity from clothes and body.	

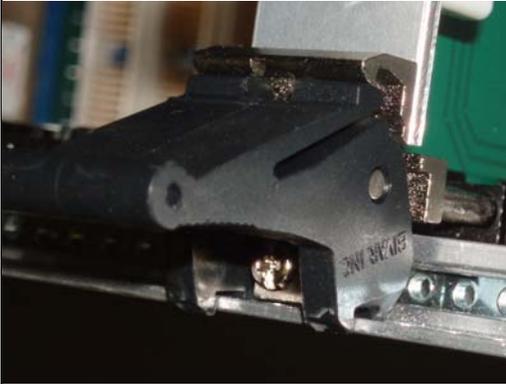
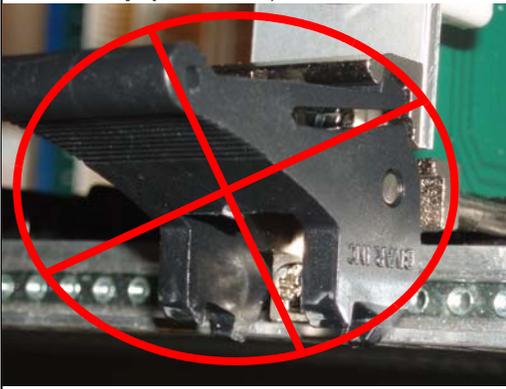
Removing Cards from the PXI/exp Expansion Chassis

Step	Action	Image/Comments
5	Push down on the ejector handle to unseat the card connector.	
6	Carefully remove the card from the chassis while being careful not to snag components on adjacent cards during the card's removal.	CAUTION: Some devices can be damaged by improper handling. Use appropriate electrostatic discharge (ESD) procedures when handling these devices. See http://www.esda.org/ for additional information on ESD procedures.
7	Place the card in an anti-static package or follow ESD procedures while handling the card.	

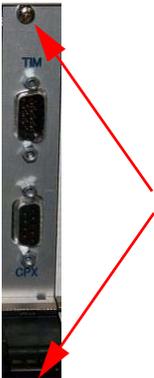
Installing Cards in the PXI/exp Expansion Chassis

Step	Action	Image/Comments
1	Make sure the rack and the expansion chassis are plugged into an AC power source.	The power cord provides a ground for the chassis and protects other components from electrical damage while installing the card
2	Turn off the chassis power.	
3	Clear any obstructions that might cause misalignment of the card on insertion.	
4	Touch the metal part of the chassis to discharge any static electricity from clothes and body.	

Installing Cards in the PXI/exp Expansion Chassis

Step	Action	Image/Comments
5	Set the injector handle in the down position. Remove any packaging and any protective caps from the retaining screws and connectors.	
6	Align the bottom edge of the circuit card with the guide channel in the bottom of the slot. Carefully tilt the card up and align the top edge of the circuit card with the guide channel in the top of the slot.	<p>When the PXI cards are installed, make sure the injector handle is in the down position. Otherwise, the handle interferes with correct seating of the card. Handle Down (correct)</p>  <p>Handle Up (incorrect)</p> 
7	Hold the card by the injector handle and carefully slide the card into the chassis until the injector handle catches on the rail.	

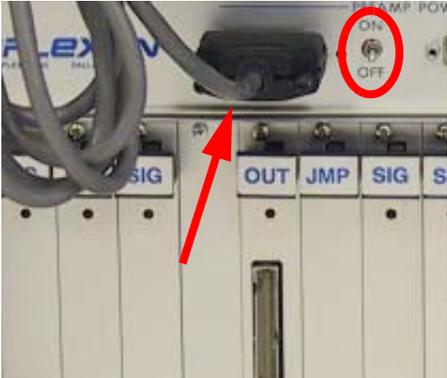
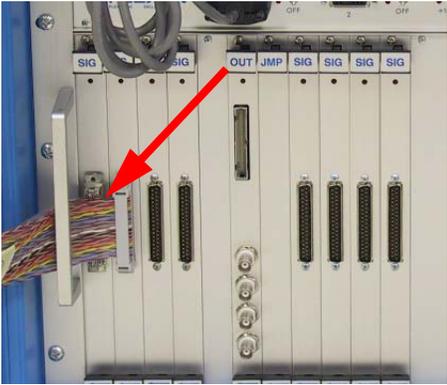
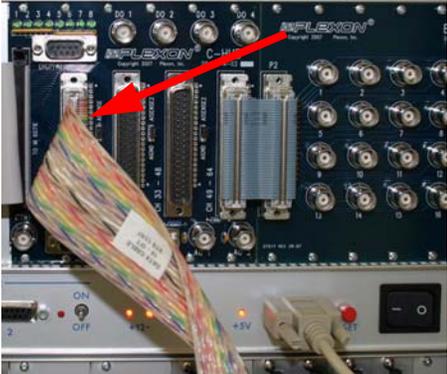
Installing Cards in the PXI/exp Expansion Chassis

Step	Action	Image/Comments
8	Raise the injector handle to fully seat the card in the chassis. Make sure the front panel of the card is even with the front panel of the chassis.	
9	Tighten the two (2) bracket-retaining screws on the faceplate of the card.	

The remainder of this section includes explanations and illustrations of rack-cabling arrangements that include the MAP Expansion Chassis.

To simplify packaging and shipping, some cables must be attached after unpacking the expansion chassis. Use the following procedure to complete the cabling.

Cabling the PXI/exp Expansion Chassis

Step	Action	Image/Comments
1	Follow the procedure in “Connecting a PXI-TIM Card to the MAP System TIM Card” on page B-16 to connect the PXI-TIM card to the MAP TIM board.	
2	Place the PBX preamp in a convenient location. Connect one end of the PBX power cable to the power connector on the preamp. For more information on PBX connections, refer to the Plexon MAP System Installation Guide . At the MAP, turn the PREAMP POWER switches OFF (see the red oval). As shown in the illustration, connect the other end of the cable to PREAMP POWER outlet 1 on the MAP.	
3	Connect ribbon cables from the spike boards in the PBX preamp to the SIG boards in the MAP. For more information on PBX connections, refer to the Plexon MAP System Installation Guide .	<p>The illustration shows a basic connections for a single PBX with two spike boards.</p> 
4	Connect ribbon cable(s) from the field potential board(s) in the PBX to the Plexon C-HUB-r card(s) as shown in the following illustration.	

Cabling the PXI/exp Expansion Chassis

Step	Action	Image/Comments
5	Complete the installation by connecting the PC peripherals to the connectors on the patch panel. Connect monitors to the VIDEO connectors. Connect the keyboard and mouse to USB ports. Use the LAN connector to connect the computer to a network.	
6	Before powering down, see “Power Up and Initialization” on page B-26.	

B.4 Power Up and Initialization

Pay attention to the following sequence when powering on Plexon MAP System equipment.



CAUTION

MAP System Power On/Off Sequence

Required power-on sequence for the MAP system:

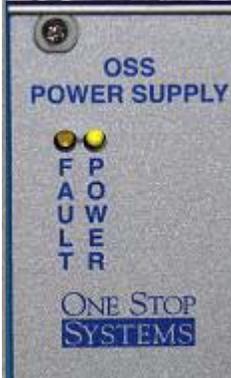
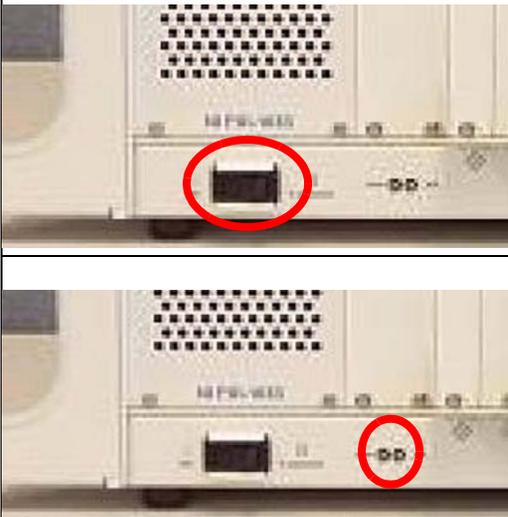
1. PXI Expansion Chassis, if present
2. MAP box main power
3. Preamp power switch (on MAP box)
4. Preamp power switch (on preamp box)
5. The power to any other digital input device.
3. The MAP system PC

Reverse this sequence to power off the MAP system.

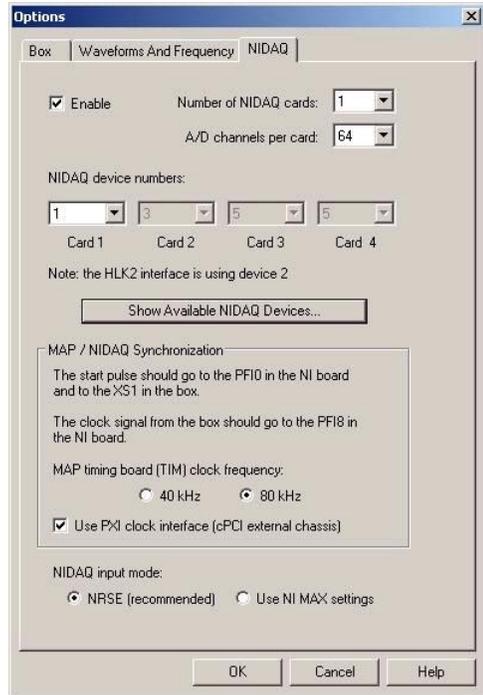
Using the PXI Expansion Chassis with a MAP System

Step	Action	Image/Comments
1	Plug the MAP system into a grounded AC outlet. Make sure the PC power switch is off.	<p>NOTE: Do not turn the PC on at this step. All PXI devices are treated as a single chassis. The PC BIOS and operating system assume that all PXI devices are available as soon as code execution begins when the PC power switch is turned on. This means that all expansion chassis must be turned on before the PC. If there are more than one expansion chassis, they can be turned on in any order.</p>
2a	(Applicable to PXI/exp) From the front of the rack, reach above and behind the left side of the expansion chassis to locate the chassis power switch, which is shown in the following illustration. Toggle the power switch to the on position (located on the back left of the expansion chassis).	

Using the PXI Expansion Chassis with a MAP System

Step	Action	Image/Comments												
2b	(Applicable to PXI/exp) In the left-most slot of the expansion chassis, the power supply includes two LEDs labelled FAULT and POWER . When the chassis power switch is turned on, the yellow FAULT LED blinks briefly before the green POWER LED turns on. Proper operation is with the FAULT light off and the POWER light on.	<p>NOTE: If the POWER LED is off, verify that the rack AC power is connected.</p> 												
3a	(Applicable to PXI/exp4 and PXI/exp4-RM) On the front of the PXI/exp4 (or PXI/exp4-RM) turn the expansion chassis power switch on - shown in the top diagram. Ensure that the POWER LED is on - shown in the bottom diagram.													
	<p>The PWR and LINK LEDs display a variety of conditions as follows:</p> <table border="1"> <thead> <tr> <th>LED</th> <th>COLOR</th> </tr> </thead> <tbody> <tr> <td rowspan="3">PWR</td> <td>Off</td> </tr> <tr> <td>Red</td> </tr> <tr> <td>Green</td> </tr> <tr> <td rowspan="5">LINK</td> <td>Off</td> </tr> <tr> <td>Green</td> </tr> <tr> <td>Alternating Green and Red</td> </tr> <tr> <td>Red</td> </tr> <tr> <td>Blinking Red</td> </tr> </tbody> </table>	LED	COLOR	PWR	Off	Red	Green	LINK	Off	Green	Alternating Green and Red	Red	Blinking Red	<p>MEANING</p> <p>No power Power problem - call Plexon for assistance Power OK</p> <p>Link not established Link established Link established and activity on PXI bus Link corrupted -- call Plexon for assistance Link corrupted -- call Plexon for assistance</p>
LED	COLOR													
PWR	Off													
	Red													
	Green													
LINK	Off													
	Green													
	Alternating Green and Red													
	Red													
	Blinking Red													

Using the PXI Expansion Chassis with a MAP System

Step	Action	Image/Comments															
3b	<p>(Applicable to PXI/exp only) On the left side of the expansion chassis, locate the PXI-8360 module. Observe the PWR and LINK LEDs. When the chassis power is within specifications and a link to the PC is established, both LEDs are green. The meanings of the PWR and LINK LEDs are as follows:</p> <table border="1"> <thead> <tr> <th>LED</th> <th>COLOR</th> <th>MEANING</th> </tr> </thead> <tbody> <tr> <td rowspan="3">PWR</td> <td>Off</td> <td>No power</td> </tr> <tr> <td>Red</td> <td>Power out of spec</td> </tr> <tr> <td>Green</td> <td>Power within spec</td> </tr> <tr> <td rowspan="2">LINK</td> <td>Off</td> <td>Link not established</td> </tr> <tr> <td>Green</td> <td>Link established</td> </tr> </tbody> </table>	LED	COLOR	MEANING	PWR	Off	No power	Red	Power out of spec	Green	Power within spec	LINK	Off	Link not established	Green	Link established	<p>NOTE: If the PWR LED is red, contact Plexon for assistance.</p> 
LED	COLOR	MEANING															
PWR	Off	No power															
	Red	Power out of spec															
	Green	Power within spec															
LINK	Off	Link not established															
	Green	Link established															
4	<p>At the MAP chassis, turn the power switch on and then push RESET (This will reset the clock and reset all power in the MAP).</p>																
5	<p>At the PC, turn the PC power on. Wait for the PC to boot and log on.</p>	<p>See the computer user manual for the location of the PC power switch.</p>															
Device Configuration																	
6	<p>(Performed only the first time the system is used or when hardware configuration changes) This step is performed at Plexon but should be confirmed. At the PC, start the MAP Server. From the Server View menu, click Options. The Options dialog box opens. Select the NIDAQ tab and the illustration at the right appears. Ensure that the Use PXI clock interface (cPCI external chassis) checkbox is checked. Select the appropriate clock frequency (40KHz or 80KHz). If finished, click OK to close the Options dialog box and go to step 9. To see the NIDAQ devices and their device numbers, go to step 7.</p>																

Using the PXI Expansion Chassis with a MAP System

Step	Action	Image/Comments
7	<p>(Performed only the first time the system is used or when hardware configuration changes) This step is performed at Plexon but should be confirmed. Clicking the Show Available NIDAQ Devices button scans the available devices and displays a dialog box (a sample appears at the right). Verify that the device numbers are the same as shown in the NI-MAX program. If not, click OK to close this dialog box and correct the device numbers on the NIDAQ tab of the Options dialog box. When finished, click OK to close the Options dialog box.</p> <p>NOTE: The NI-MAX program may be accessed by selecting Measurement & Automation from the computer's Start->All Programs->National Instruments.</p>	
8	<p>(Performed only the first time the system is used) Restart the PC to set the PXI interface.</p>	<p>CAUTION: Do not remove any PCI cables when the PC is on. Removing the PCI Express cable between the expansion chassis and the PC while the PC is on can cause the PC to hang or cause errors in applications communicating with the expansion chassis.</p>
End of Device Configuration		
9	<p>When finished working, turn off the PC power switch <i>then</i> turn off the expansion chassis power switch.</p>	<p>CAUTION: PC operating systems and drivers assume PCI devices are present from power on to power off. Do not turn the expansion chassis power off before turning the PC power off. Turning off the expansion chassis while the PC is running can cause the PC to hang or crash.</p>

Appendix C

C-HUB Technical Brief

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C.3 Reference Jumpers C-3

C.4 Input Filtering..... C-3

C.5 Card Versions C-4

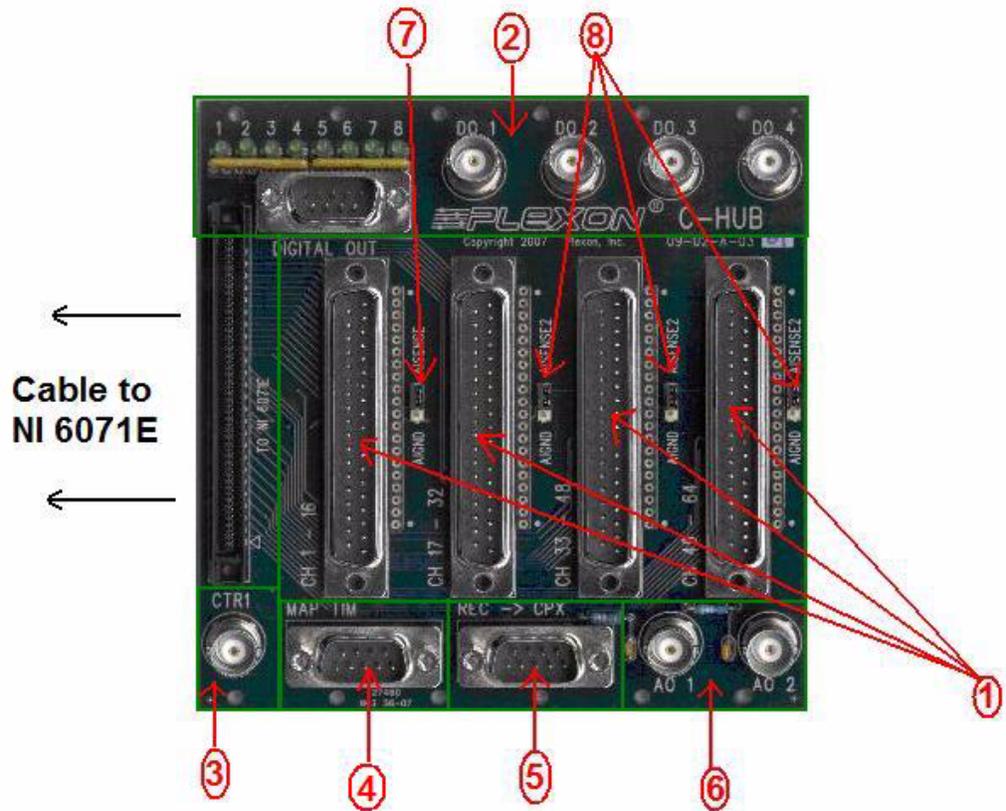
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C.7 Connectors..... C-6

C.8 Connecting Signals to the C-HUB C-10

C.9 Examples of Input Connector Configurations..... C-11

C.1 Block Diagram



- 1 - Analog Inputs
- 2 - Digital Outputs
- 3 - Counter (GPCTR1)
- 4 - MAP system interface
- 5 - Recorder output (CinePlex)
- 6 - Analog Outputs
- 7 - AISENSE/AIGND Jumpers
- 8 - AISENSE2/AIGND Jumpers

C.2 Description

The C-HUB (Cable Hub) is an interface to most of the inputs and outputs of the National Instruments 6071E cards. The 6071E cards provide 64 channels of analog to digital conversion. Physically, C-HUB provides access to the 64 channels through four 16-channel connectors. Functionally, however, the 64 channels of the 6071E are divided into two groups. The first group consists of channels 1-16 and the second group consists of channels 17-64. When the 6071E cards are configured in the non-referenced single-ended (NRSE) configuration, as recommended by Plexon, the output of each channel is the amplified difference

between the channel input and a common reference input called AISENSE or AISENSE2. AISENSE is the common reference input for channels 1-16 and AISENSE 2 is the common reference input for channels 17-64. The differential recording between the channel input and the AISENSE input helps remove common mode noise and ground fluctuations from the recorded signal.

- Example 1: The output of channel 3 is the amplified difference between the input to channel 3 and the input to AISENSE.
- Example 2: The output of channel 43 is the amplified difference between the input to channel 43 and the input to AISENSE2.

The C-HUB provides an interface to the MAP system. When used without an expansion chassis, a clock signal from the MAP TIM board is connected to the MAP TIM input connector on the C-HUB. When used with an expansion chassis, it is not necessary to insert a clock signal into the MAP TIM connector on the C-HUB. C-HUB also has a Digital Output connector with eight digital outputs (DO 1 to DO 8). There are individual BNC digital outputs for digital outputs DO 1 through DO 4. C-HUB also provides an interface to connect the NI-based Recorder system output to CinePlex via the REC->CPX output connector as well as two BNC analog outputs (AO1 and AO2) and a counter output (CTR1). Each of the inputs and outputs are discussed in more detail in later sections. For more details, see [“Connectors” on page C-6](#).

C.3 Reference Jumpers

For each 16-channel input connector there is a jumper to determine whether or not to use the differential reference input for those channels. In most cases the reference input should be used to take advantage of the noise rejection it provides. The jumper for channels 1-16 should be placed in the AISENSE position, and the jumpers for channels 17-32, 33-48, and 49-64 should be placed in the AISENSE2 position.

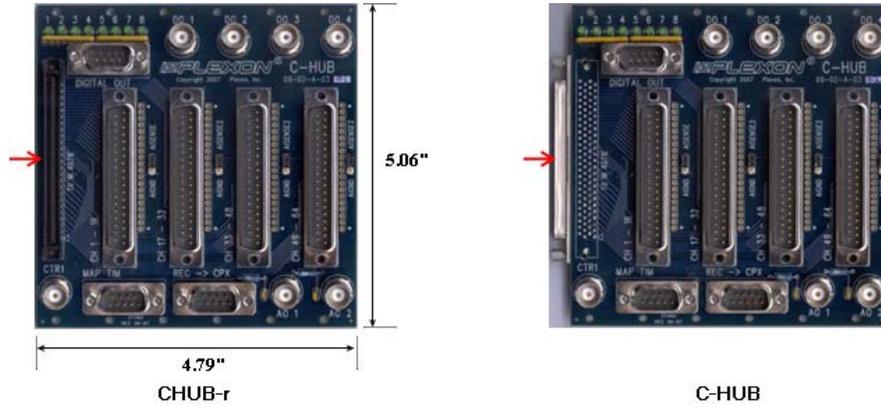
The only time one or more input connectors may be disconnected from the reference input is when it is desired to have more than two signal sources and it is necessary to connect two different sources to the same group of C-HUB inputs. In this case, disconnect the source with the highest amplitude signals from the reference input.

C.4 Input Filtering

On the C-HUB, there are no input filters and, therefore, no need for the bypass jumpers. All of the inputs are passive and DC-coupled.

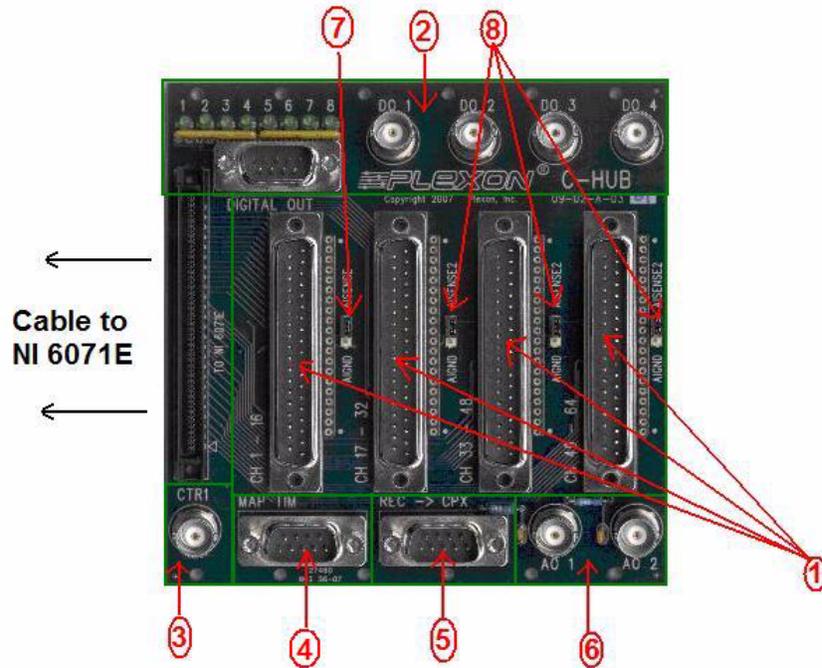
C.5 Card Versions

C-HUB is manufactured in two configurations based on the mounting of the 6071E A/D output connector. Version 09-02-A-03-01 (CHUB-r) is manufactured with the output connector perpendicular to the circuit card while version 09-02-A-03-02 (CHUB) is manufactured with the output connector in-line with the circuit card. The images below show the two configurations with the main difference noted by the red arrows.



C.6 Connector Layout Diagram

The diagram below identifies the connectors and shows their location on the circuit card.



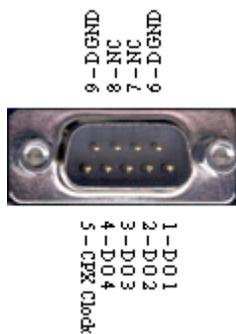
- 1 - Analog Inputs
- 2 - Digital Outputs
- 3 - Counter (GPCTR1)
- 4 - MAP system interface
- 5 - Recorder output (CinePlex)
- 6 - Analog Outputs
- 7 - AISENSE/AIGND Jumpers
- 8 - AISENSE2/AIGND Jumpers

C.7 Connectors

The following sections describe the various input and output connectors.

C.7.1 MAP TIM Input

The MAP TIM Input Connector is a male DB9 connector that can be used to bring external timing signals to the 6071E A/D board. When used in conjunction with a MAP system, the TIM Input Connector receives a clock signal and a start signal from the MAP. When used with a chassis, it is not necessary to use the MAP-TIM input. If it is used, it would receive a clock signal and start signal from the PXI-TIM card. These signals ensure that the continuous data acquired by the A/D card is synchronized with the spike data recorded by the MAP box.



C.7.2 Analog Inputs

These four connectors provide access to the 64 analog input channels AD01 To AD64 (in four groups - AD01-AD16, AD17-AD32, AD33-AD48, and AD49-AD64). There are also reference signals AISENSE (channels 1-16), AISENSE2 (channels 17-64), and AIGND (all channels). A jumper is used to select whether several pins are connected to AISENSE/AISENSE2 or AIGND. When the jumper next to CH 1 - 16 is set on AIGND, the AISENSE signal is also connected to AIGND. A socket is provided next to each connector for installing optional pull-down resistors (resistor from the input to AISENSE or AIGND depending on the jumper setting). Standard 10-pin resistor SIPs may be installed in these sockets (e.g. Bourns 4610X-101-223LF).

Plexon does not recommend the use of pull-down resistors. However, they may be used if it is necessary to isolate inputs that are not being used or possibly to dampen AC hum that may be on certain input channels.

C.7.2.1 Channels 1-16 Connector



C.7.2.2 Channels 17-32 Connector



C.7.2.3 Channels 33-48 Connector



C.7.2.4 Channels 49-64 Connector

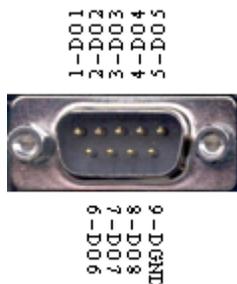


C.7.3 Output to NI PCI-6071E A/D Card

The National Instruments PCI-6071E Output is a 100-pin connector that connects to the National Instruments 6071E A/D card. This output is the primary output of the C-HUB.

C.7.4 Digital Out

This connector provides access to all eight digital output lines (DO1-DO8) which may be controlled with the PlexDO utility (The PlexDO readme file may be accessed from the C and C++ Client Development Kit or the MATLAB Client Development Kit found at <http://www.plexoninc.com/support/softwaredev-kit.html>). The LEDs indicate when the corresponding digital output is 5V.



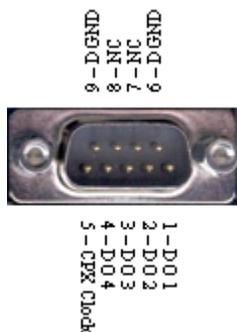
C.7.5 DO1, DO2, DO3, and DO4

These connectors provide BNC access to four of the digital output lines.



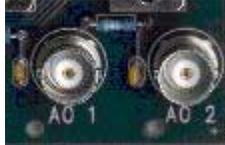
C.7.6 REC->CPX

This connector is used to output a clock signal and control signals from the Plexon Recorder data acquisition software to a CinePlex video tracking and recording system.



C.7.7 AO1 and AO2

AO1 is Analog Output 1 channel, used by the Plexon Recorder as a monitor channel. AO2 is not currently used.



C.7.8 CTR1 (GPCTR1)

This connector provides access to GPCTR1 which can be used to output precision pulses or clock signals using the PlexDO utility.



C.8 Connecting Signals to the C-HUB

The C-HUB was primarily designed to receive the output of up to 64 channels from Plexon field potential preamplifiers, but it may be used with a wide variety of signal sources. Before connecting multiple signal sources to the C-HUB, it is necessary to consider the number of signal sources and the number of outputs coming from each source. The goal is to keep the signals from each source isolated from each other and to take advantage of the common mode noise rejection provided by the AISENSE and AISENSE2 inputs whenever possible. For example, sources of more than 16 signals should be connected to the second group of inputs (channels 17-64) since the first group can only accommodate 16 channels.

When there are more than two distinct signal sources it is not possible to have a distinct reference input for each source. In this case, consider the type and amplitude of the signal source before deciding how to connect the sources. For sources with low amplitude signals, take advantage of the common mode noise rejection provided by having a reference input. Digital (TTL) signals or large amplitude signals may not require this noise rejection. The examples on the following pages illustrate these points.

Feel free to contact Plexon with questions about connecting more than two sources to the C-HUB.



CAUTION **Ground-reference Sources**

All signal sources should be ground-referenced, not 'floating.' If there is a 'floating' signal source such as a battery-powered device, please contact Plexon for assistance in connecting it to the C-HUB.

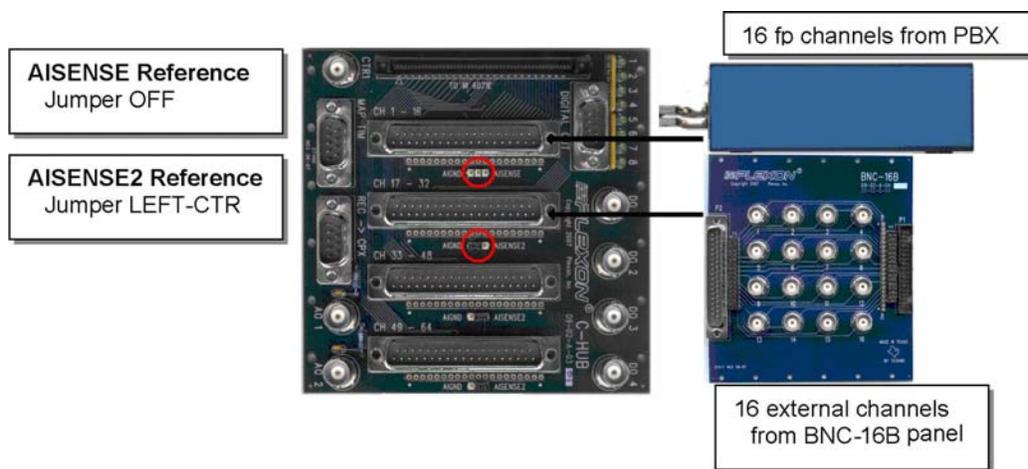
C.9 Examples of Input Connector Configurations

C.9.1 Example 1 (Two Sources)

The primary signal source is a 16-channel preamplifier. The second source has up to 16 channels. The BNC-16B panel provides a convenient mechanism for bringing signals to the C-HUB from sources with standard BNC connectors.

Connect the primary source to the first group of C-HUB inputs, channels 1-16. The reference jumper for channels 1-16 should be placed in the AISENSE position (no jumper).

Connect the secondary signal source to the second group of channels, channels 17-32. The reference jumper for channels 17-32 should be set to AISENSE2.

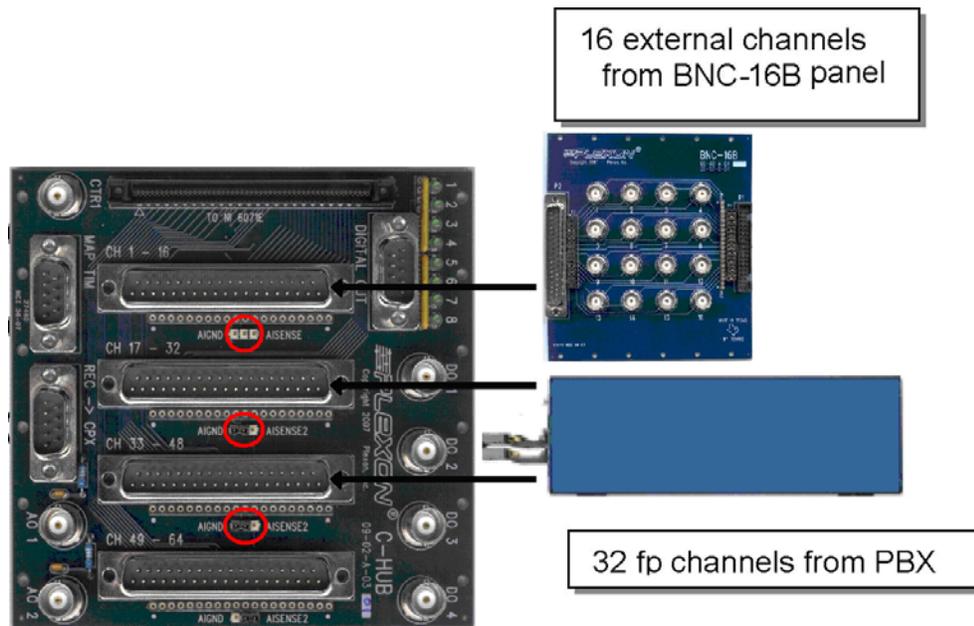


C.9.2 Example 2 (Two Sources)

The primary signal source is a 32-channel preamplifier. The second source has up to 16 channels.

Connect the primary source to the second group of C-HUB inputs, channels 17-48. The reference jumper for channels 17-32 and for channels 33-48 should be set to AISENSE2.

Connect the second signal source to the first group of C-HUB inputs, channels 1-16. The reference jumper for channels 1-16 should be placed in the AISENSE position.



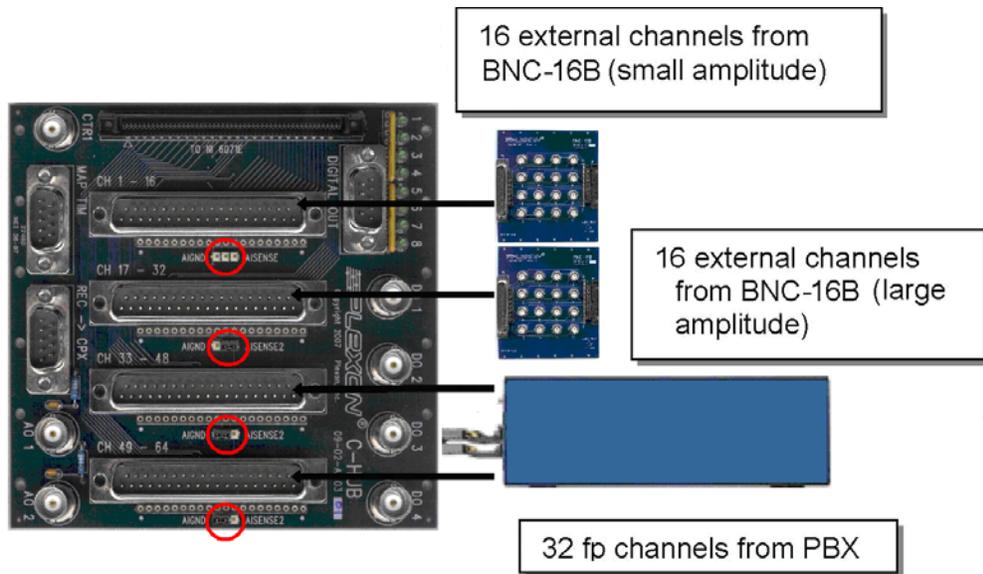
C.9.3 Example 3 (Three Sources)

The primary source is a 32-channel preamplifier. The second source has up to 16 channels and has low amplitude signals. The third source has up to 16 channels and has large amplitude signals.

Connect the primary signal source to the second group of C-HUB inputs, channels 17-64. In the example it is connected to channels 33-64. The reference jumper for channels 33-48 and 49-64 should be set to the AISENSE2 position.

Connect the second signal source (with low amplitude signals) to the first group of C-HUB channels (1-16) to take advantage of the reference input AISENSE. The reference number for channels 1-16 should be set to the AISENSE position.

Connect the third signal source to the remaining channels in group 2, channels 17-32. To prevent ground noise from this source from coupling onto the other channels of group 2, set the reference jumper for channels 17-32 to the AIGND position (or remove the jumper completely).



Appendix D

BNC-16B Technical Brief

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D.6 Examples of BNC-16B Connections	D-7

D.1 Description

The BNC-16B is a break-out panel with 16 BNC connectors, a 37-pin D-sub connector, and a 34-pin box header connector.

In a typical Plexon data acquisition system Dsub connectors are often used as input connectors for 16 recording channels and 34-pin box headers are often used as output connectors for 16 recording channels. The BNC-16B provides easy access to individual input and output channels.

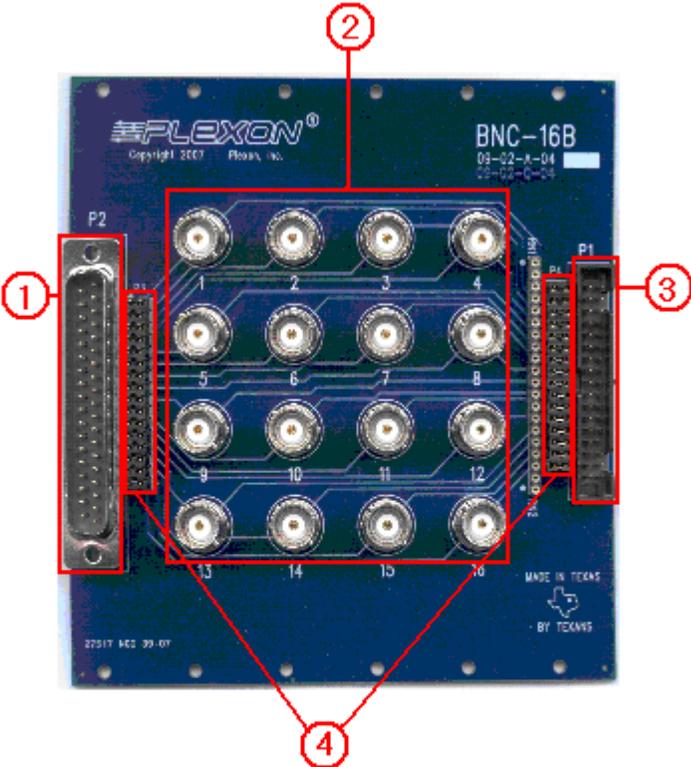
The BNC-16B may also be inserted between a signal source and its destination to provide the means of monitoring the signals by a third device. The BNC-16B also provides the means of interrupting signal flow on selected channels and injecting alternate signals in their place by using jumper blocks dedicated to this purpose.

D.2 Card Configurations

The BNC-16B may be used in two configurations. One configuration is to mount the BNC-16B on a rack or chassis (3U) and the other is to use it on a table top by attaching the feet included with the BNC-16B.

D.3 Connector Layout Diagram

The diagram below identifies the connectors and shows their location on the circuit card.



- 1 - 37-pin Dsub Connector
- 2 - 16 BNC Connectors
- 3 - 34-pin Block Header Connector
- 4 - Jumper Blocks

D.4 Connectors

The following sections describe the various input and output connectors.

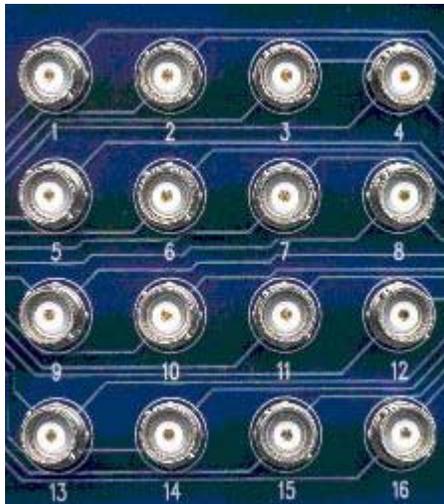
D.4.1 Dsub Connector (37-pin)

The 37-pin Dsub connector may be used to connect input signals from a PBX, OUT, or DO board. It may also be used to connect the output from the BNC-16B to a C-HUB.



D.4.2 BNC Connectors

The BNC connectors may be used to monitor signals by connecting one or more to a third device, such as an oscilloscope. These connectors may also be used for signal injection by removing the appropriate jumpers next to one of the main connectors (the 37-pin Dsub or the 34-pin block header - later examples show how this is accomplished).



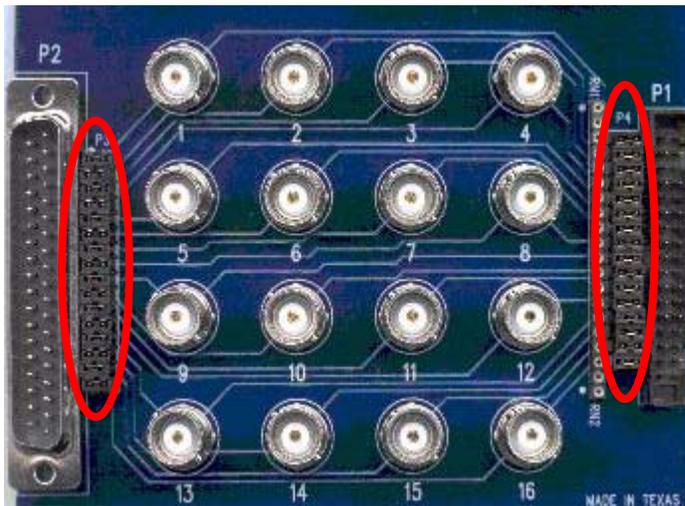
D.4.3 Box Header (34-pin)

The 34-pin box header connector may be used to connect inputs from a PBX, OUT board, or DO board. It may also be used to connect the output of the BNC-16B to a C-HUB, PBOB, or SIG board.



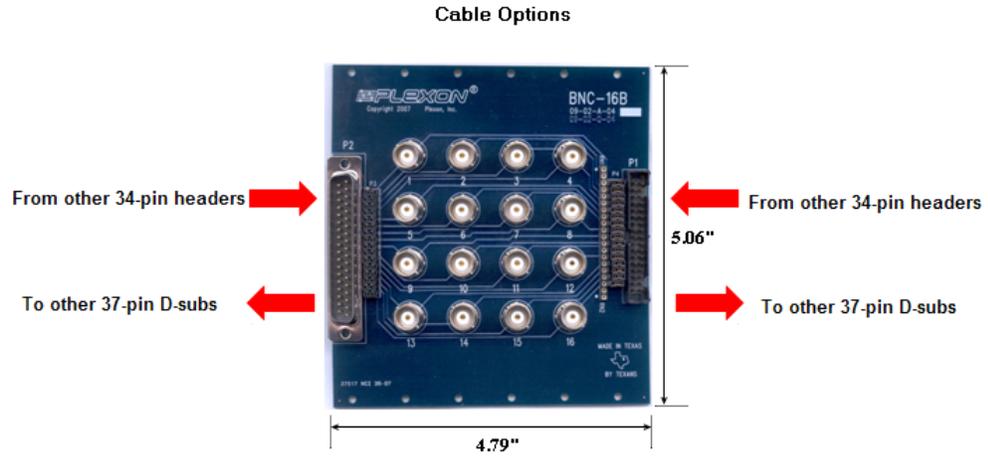
D.4.4 Jumper Blocks

Each jumper block has 16 jumpers corresponding one-to-one to the BNC connectors. There is a jumper block (P3) between the BNC connectors and the 37-pin Dsub connector and a jumper block (P4) between the BNC connectors and the 34-pin block header. Mounting the jumper on the posts connects the BNC connector to the adjacent pin on the 37-pin or 34-pin connector. Examples that show how to input signals are shown later in the technical brief.



D.5 Connecting Signals to the BNC-16B

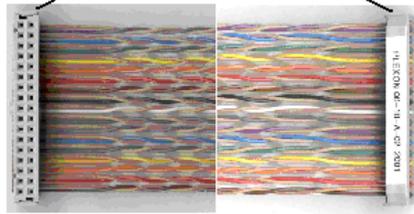
The diagram below shows how inputs and tap signals for outputs may be connected to the BNC-16B.



DB37 connectors



34-pin box connectors

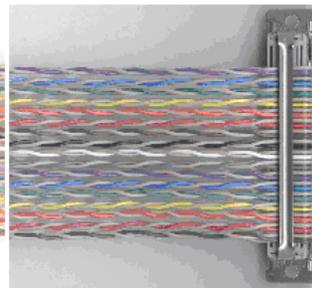


Typical twisted-pair, digital input, and digital output cables

34-pin box connector



DB37 connector

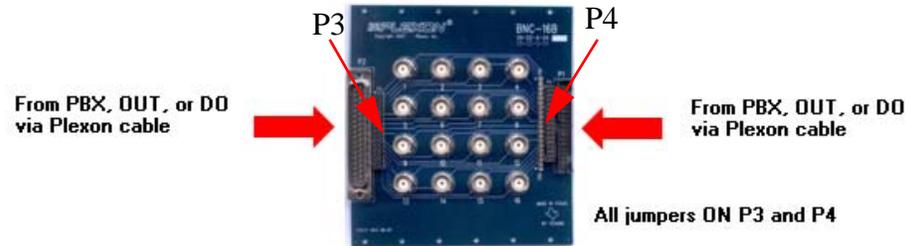


D.6 Examples of BNC-16B Connections

The BNC-16B may be used in a variety of configurations. The following sections show the various configurations.

D.6.1 Example 1 (Accessing Outputs)

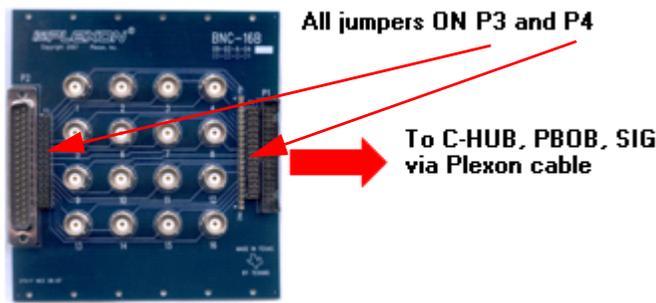
The output from a Plexon preamplifier (PBX) or a Plexon MAP System analog board, OUT/32 board, or digital output (DO) board may be connected to the BNC-16B. Both of these connections are shown in the diagram below.



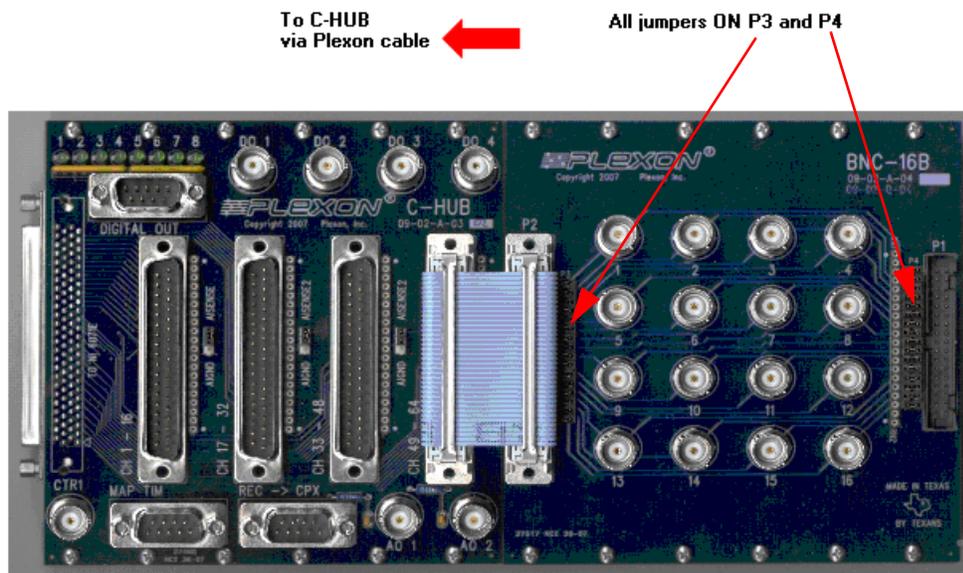
D.6.2 Example 2 (Accessing Inputs)

The BNC-16B may be used to feed signals into an A/D subsystem through a C-HUB interface by connecting the 34-pin header to the C-HUB using Plexon cable 06-18-A-03-xxxx as shown in the diagram below. The xxxx in the part number identifies the cable type number and the length of the cable as described below:

x (left digit)	xxx (right 3 digits)
cable type = 1, 2, or 3	length of cable (inches) e.g. 095 = 9.5 inches
	Note: the right digit designates the fractional part of an inch.

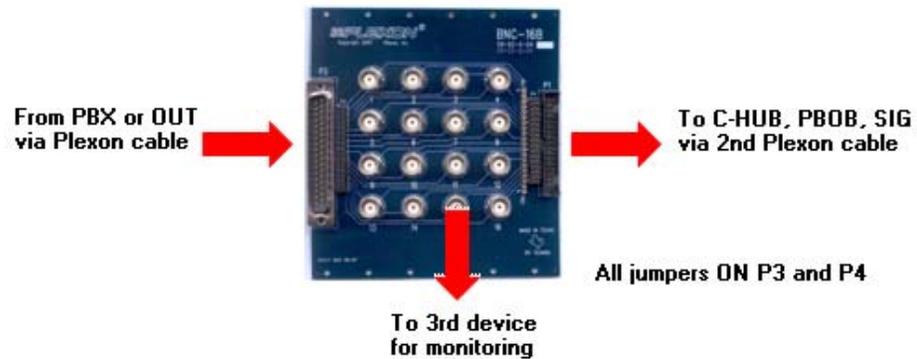


When a BNC-16B is mounted very close to a C-HUB, it is convenient to connect the BNC-16B to the C-HUB using Plexon cable 06-18-A-01-xxxx as shown in the diagram below.

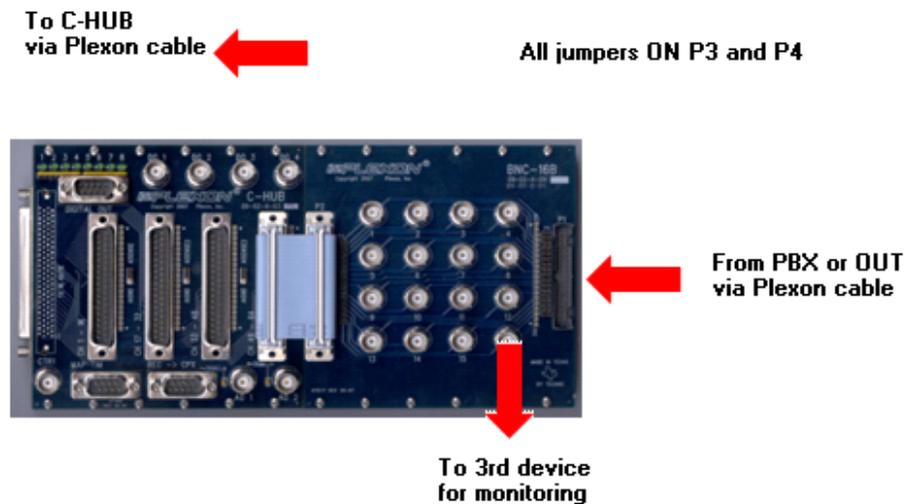


D.6.3 Example 3 (Signal Monitoring)

The BNC-16B may be inserted between a signal source and its destination to monitor signals flowing through the BNC-16B by using a third device, such as an oscilloscope. For example, a preamplifier may be connected to the 37-pin Dsub connector using Plexon cable 06-18-A-03-xxxx while the 34-pin header is connected to an A/D subsystem using a second Plexon cable 06-18-A-03-xxxx as shown in the diagram below.

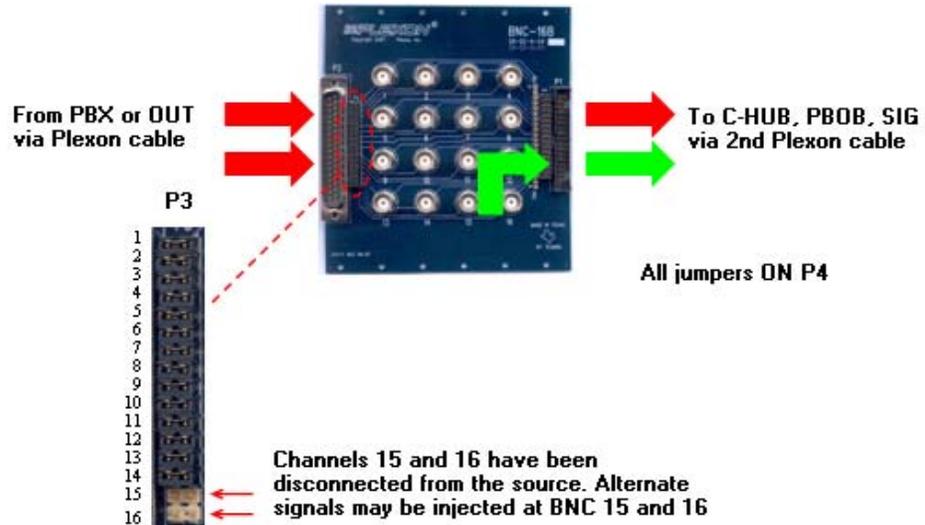


In this case the signal source (i.e. PBX or OUT) should be connected to the 34-pin header using Plexon cable 06-18-A-02-xxxx as shown in the diagram below.

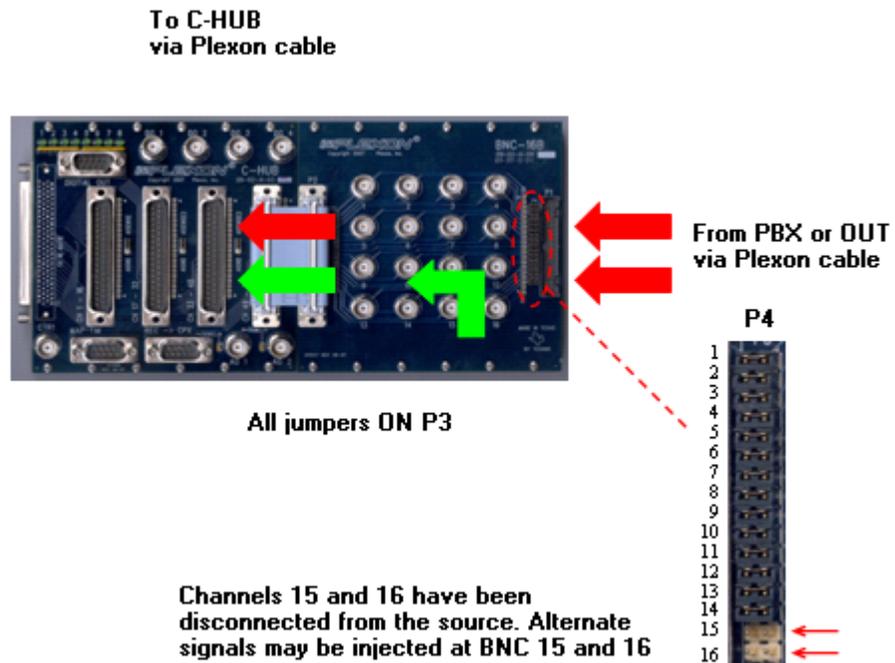


D.6.4 Example 4 (Signal Substitution)

When the BNC-16B is used in the Signal Substitution configuration, any of the individual signal channels may be disconnected from the source using the jumpers on the BNC-16B (P3 or P4). After the signal channel has been disconnected from the source, an alternate input signal may be connected to the BNC connector as shown in the diagram below.



The diagram below shows a Signal Substitution example when a BNC-16B is mounted very close to a C-HUB.



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Multichannel Acquisition Processor
RASPUTIN Software
User Guide

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