Plexon Inc

Release Notes for OmniPlex

3/2/2021

Revision History (most recent last):			
DATE	REVISION	DESCRIPTION	ORIGINATOR
06/25/2012	1.6.0	Included in 1.7.0 Initial Version	Larry Spence
11/28/2012	1.7.0	Initial Version	Larry Spence
05/17/2013	1.8.0	Revised for 1.8.0	Larry Spence
06/14/2013	1.9.0	Revised for 1.9.0	Larry Spence
08/19/2013	1.10.0	Revised for 1.10.0	Larry Spence
12/11/2013	1.11.0	Revised for 1.11.0	Larry Spence
7/2/2014	1.12.0	Revised for 1.12.0	Larry Spence
1/16/2015	1.13.0	Revised for 1.13.0	Larry Spence
8/12/2015	1.14.0	Revised for 1.14.0	Larry Spence
3/25/2016	1.15.0	Revised for 1.15.0	Larry Spence
1/18/2017	1.16.0	Revised for Release 16	Larry Spence
2/22/2018	1.17.0	Revised for Release 17	Larry Spence
11/29/2018	1.18.0	Revised for Release 18	Larry Spence
7/12/2019	1.19.0	Revised for Release 19	Larry Spence
3/2/2021	1.20.0	Revised for Release 20	Larry Spence

Table of Contents

These release notes contain information on new features and changes in Release 20. The release notes for previous versions are also included, although the release notes for all but the most recent releases have been incorporated into the OmniPlex User Guide.

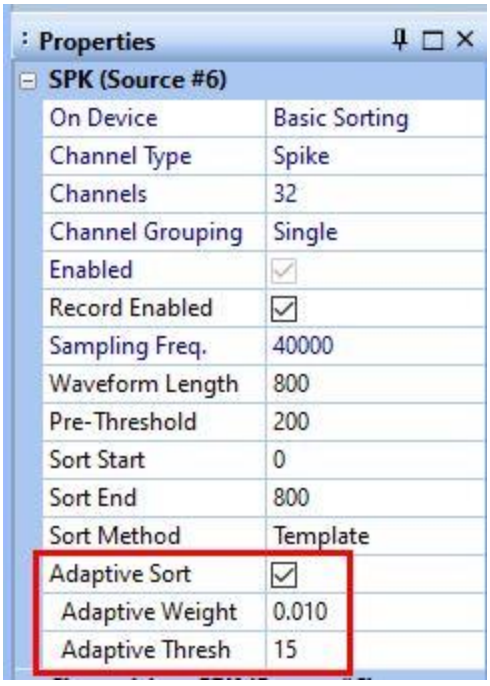
See OmniPlexChangeLog.txt for a summary of the changes, additions, and bug fixes in Release 20 and in previous releases of OmniPlex.

Adaptive template, band and 2D polygon sorting

OmniPlex Release 20 supports an adaptive sorting option where the template, band and 2D polygon sorting methods can automatically update their sorting parameters over time, in response to gradual changes in incoming spike waveforms. This also allows OmniPlex to refine and improve sorting in some cases where the initial sorting parameters were not optimal. Adaptive sorting is performed independently for each unit.

Enabling adaptive sorting

To enable adaptive sorting, start data acquisition and define one or more sorted units. Make sure that the SPK source is selected, so that the current spike sorting parameters are displayed in the per-source properties spreadsheet which is by default displayed at the left side of the main PlexControl window. You can then enable *Adaptive Sort:*



Template and band sorting

For the template and band sorting methods, each unit's template is updated using the following procedure. Note that template and band tolerances are not modified and remain at their original "pre-adaptive" values, although you can modify them manually at any time if desired.

For each defined unit, a temporary template is initialized to be the same as the unit's sorting template (the template that is being used to sort incoming spikes). The unit's temporary template is updated using each incoming spike that is sorted into that unit by the current sorting template (details are given in the next section). These updates to the temporary template do not affect the sorting template until the difference between the two templates exceeds a threshold, as described below. Once the template difference threshold is exceeded, the temporary template then replaces the sorting template, and the process continues, with incoming sorted spikes being used to update the temporary template until the next time that the difference threshold is exceeded and the temporary template again replaces the sorting template.

Note that unsorted spikes have no effect on the adaptive sorting procedure.

Updating of the temporary template

For each incoming sorted spike, the temporary template for that unit is updated using a weighted average of the incoming spike and the current value of the temporary template, using the corresponding points on the two templates. The *Adaptive Weight* parameter determines how much each incoming sorted spike affects the temporary template. If we use the following notation:

```
T = temporary template (an array of points)
S = incoming spike waveform (an array of points)
N = number of points in S and T arrays (the waveform length)
i = index into the S and T arrays
W = adaptive weight (a value between 0.005 and 0.1)
```

then a pseudocode description of the update process for each incoming sorted spike is:

```
for i = 1 to N
  T[i] = ( (1 – W) * T[i] ) + ( W * S[i] );
```

For example, if W = 0.01 (the default value), then:

```
for i = 1 to N
  T[i] = ( 0.99 * T[i] ) + ( 0.01 * S[i] );
```

The default W value of 0.01 can also be thought of as, "each incoming spike contributes 1% to updating the value of the temporary template."

You can see that for a larger value of W, the "influence" of each incoming spike will be greater, and the temporary template will potentially change more rapidly, if the incoming waveforms are changing. However, if W is too large, then the temporary template will be unduly affected by short-term waveform changes in individual spikes caused by background noise and minor waveform shape changes. The goal is for the temporary template to track longer-term changes in the *mean* unit waveform, and so the default value for the *Adaptive Weight* (W) is small and should only be increased with caution. Adaptive sorting is not intended to track brief waveform changes, such as decaying spike amplitudes during a burst.

Updating of the sorting template

As described in preceding section, the temporary template will change slightly as it is updated using each incoming spike, and it will only replace the sorting template if and when the difference between the two templates exceeds a threshold, defined by the *Adaptive Thresh* parameter. The difference threshold is based on the sum of squared differences of the two templates, where each squared difference is taken between the corresponding points on the two templates. Smaller threshold values can result in more frequent updates of the sorting template, while larger values cause less frequent updates.

In addition to the *Adaptive Weight* and *Adaptive Thresh* parameters, the rate at which the sorting template can be updated is also controlled by the *Min Update Interval* parameters in the Sorter device options in Server, as described later. However, you can leave *Min Update Interval* set to its default values until you are familiar with the use of the basic parameters, *Adaptive Weight* and *Adaptive Thresh*.

2D polygon sorting

For 2D polygon sorting, the general concept of using each incoming spike to modify a set of temporary sorting parameters, until they are different enough from the current sorting parameters to replace them, is the same. However, here the sorting parameters are the points of a 2D polygon, which may have originally been defined either manually by drawing, or automatically by an auto-sort procedure. For purposes of adaptive sorting, OmniPlex calculates the centroid (center of mass) of the polygon, and uses the feature space projection of each incoming sorted spike to slowly update the position of the temporary centroid. If we use the following notation:

```
cx = temporary centroid (first feature space coordinate)
cy = temporary centroid (second feature space coordinate)
sx = incoming spike waveform (first feature space coordinate)
sy = incoming spike waveform (second feature space coordinate)
W  = adaptive weight (a value between 0.0 and 1.0)
```

then a pseudocode description of the update process for each incoming sorted spike is:

```
cx = ( (1 – W) * cx ) + ( W * sx );
cy = ( (1 – W) * cy ) + ( W * sy );
```

For example, if W = 0.01 (the default value), then:

```
cx = ( 0.99 * cx ) + ( 0.01 * sx );
cy = ( 0.99 * cy ) + ( 0.01 * sy );
```

The effect of varying W is analogous to that described for template and line sorting, but using the centroid rather than the template.

Updating of the sorting polygon

For 2D polygon sorting, the *Adaptive Thresh* parameter determines the minimum 2D distance between the temporary centroid and the centroid of the current sorting polygon required in order for the temporary centroid to be used to update the sorting polygon. Note that the shape of the sorting polygon is not affected by adaptive sorting, only its position. In other words, the current sorting polygon is translated (offset) by the difference between its centroid and the temporary centroid.

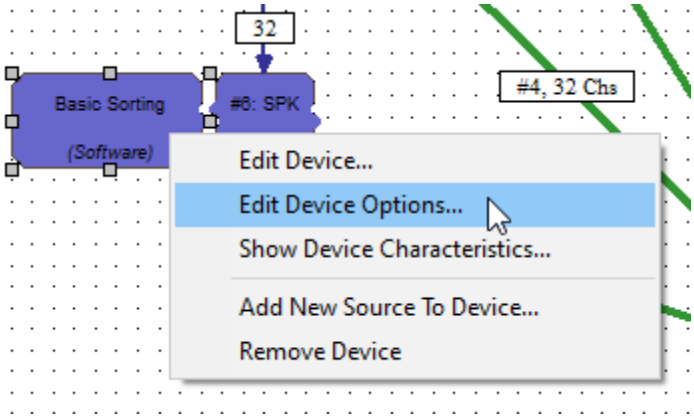
Minimum update interval

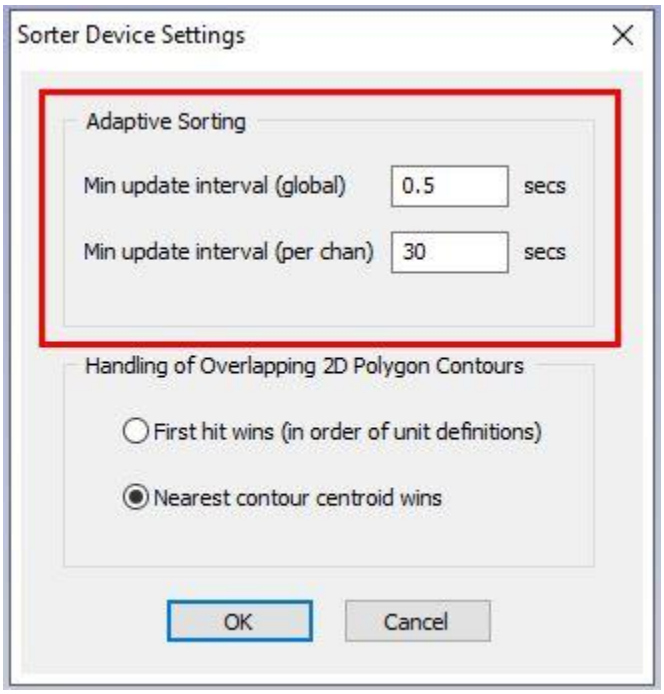
If the Adaptive Weight and Adaptive Thresh parameters are set to values that cause very frequent updating of the sorting template or polygon, there can be two undesired consequences.

First, if many channels are updating their sorting parameters frequently, significant system resources can be required, especially on high channel count systems. For example, if four units are defined on each channel of a 512 channel system, and the parameters are set such that each template or polygon is updated once per second, up to 4 * 512 = 2048 template or polygon updates per second are possible.

Second, independent of any system performance considerations, any one channel should not normally be updating its sorting parameters too rapidly, since this will result in tracking undesired short-term waveform variations caused by noise, intra-burst decay, and so on.

In order to protect against these scenarios, there are two additional adaptive sorting parameters which "throttle" the maximum rate of template or polygon updates. These are the *Min Update Interval* parameters, and are found in the *Device Options* dialog for the Sorter device in OmniPlex Server. To modify these options, stop data acquisition and right-click on the Basic Sorting device in the topology diagram in Server:



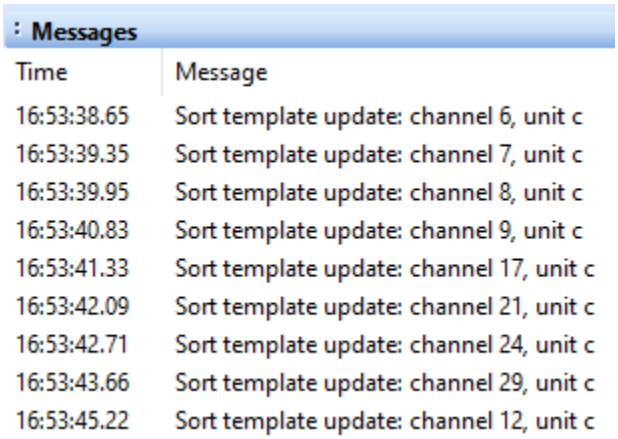


The *Min update interval (global)* parameter determines the minimum time (or equivalently, fastest rate) between template or polygon updates on any channel. For example, the default value of 0.5 seconds means that no more than two templates or polygons can be updated per second, whether on the same channel or on different channels. In effect, this value limits the maximum load on the system caused by adaptive sorting. You should only reduce this value with caution, and when doing so, be aware of any signs of excessive system load, such as stuttering displays, pauses, data drops, etc.

The *Min update interval (per chan)* parameter determines the minimum time (fastest rate) between template or polygon updates on any one channel. Every channel in the system can update at this rate, as long as doing so does not result in a global update rate that exceeds the limit set by the *Min update interval (global)* parameter. Since adaptive sorting is intended to track slow changes to waveform shapes, you should resist the temptation to set it to very short intervals (e.g. less than 10 seconds), although it can be instructive to do so when you are first learning the effects of varying the *Adaptive Weight* and *Adaptive Thresh* parameters.

Adaptive sorting notifications in Server message log window

Each time that a template or sorting polygon is adaptively updated, a notification message is displayed in Server's message log window:

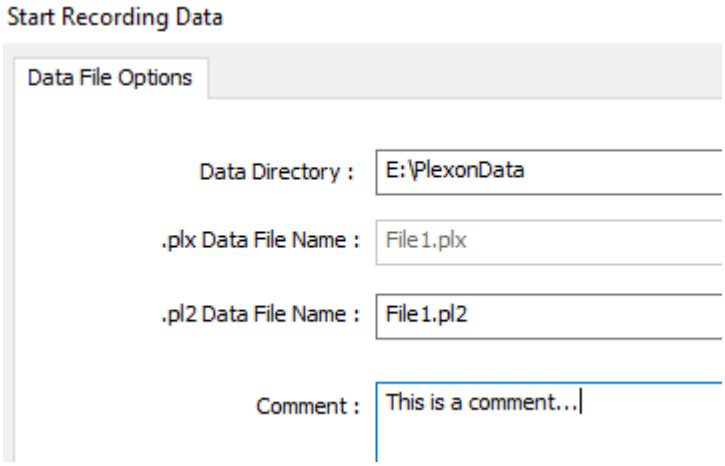


These messages can provide useful feedback to aid in tuning of the adaptive sorting parameters. Although the frequency of adaptive sorting updates is in general data-dependent, a reasonable default approach is to leave the *Adaptive Weight* parameter at its default value of 0.01, and then increase or decrease the *Adaptive Thresh* parameter until parameter update messages are only seen occasionally. You can also increase the *Minimum update interval (per chan)*, so that a larger number of spikes are used for each update.

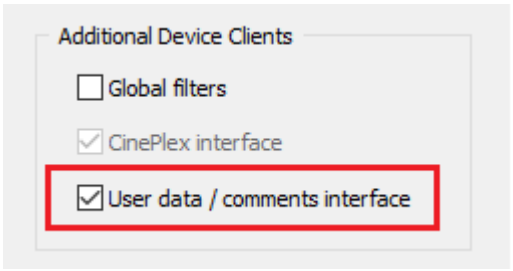
Of course, you can use the main current-channel spike display (or for polygon sorting, the 2D cluster display) in unit editing mode to view the unit templates (or polygons) for a channel in order to observe the changes that are made at each adaptive update; these changes should be incremental and smooth, not large and abrupt. If this is not the case, you can adjust the parameters described above so as to prevent the adaptive algorithm from reacting to short-term fluctuations in waveform shape that are due to noise, within-burst amplitude variations, etc.

Adding comments while recording PL2 files

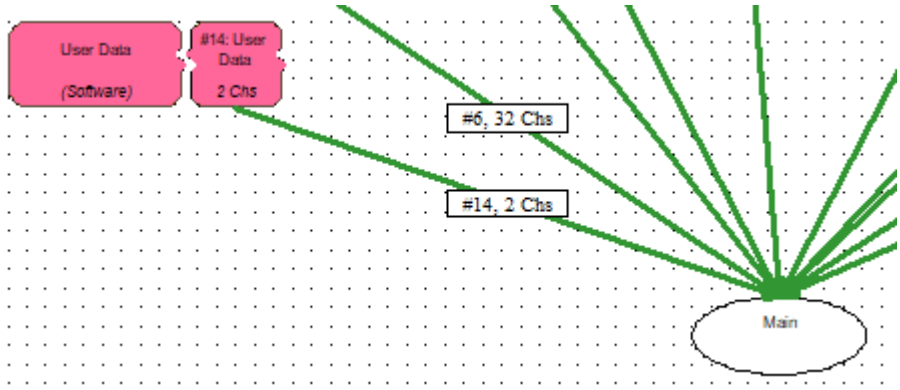
Previously, only a single block of comments could be added to a recording, via the *Start Recording Data* dialog:



Release 20 adds the ability to enter any number of comments while a PL2 recording is in progress. Each comment is timestamped and added to the PL2 file and can later be extracted using the offline file reading SDKs. To add comments during a recording, first you must create a topology which includes the User Data device client:

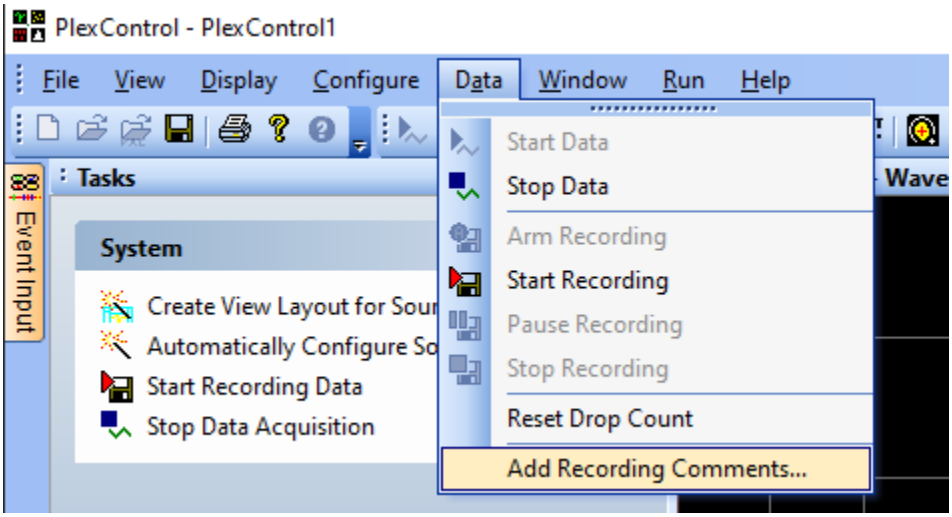


The generated topology will show the User Data device client and its associated source:



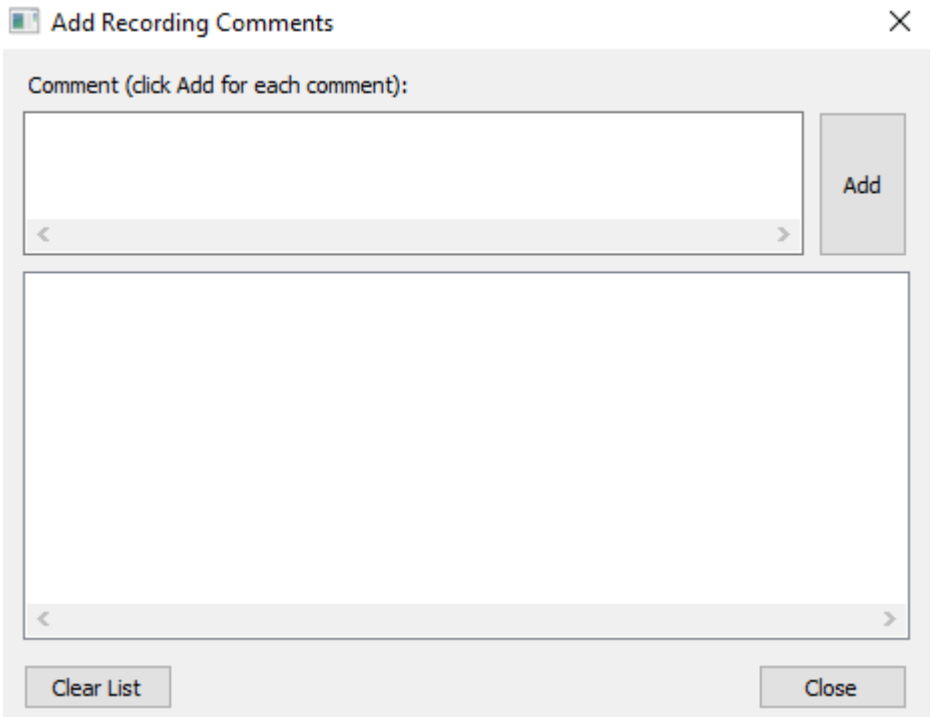
See the OmniPlex User Guide for general information on how to create a new topology with appropriate settings for your hardware configuration.

Once you have created a new topology that includes the User Data device client and restarted OmniPlex, you can add comments to a recording with the *Add Recording Comments* command:



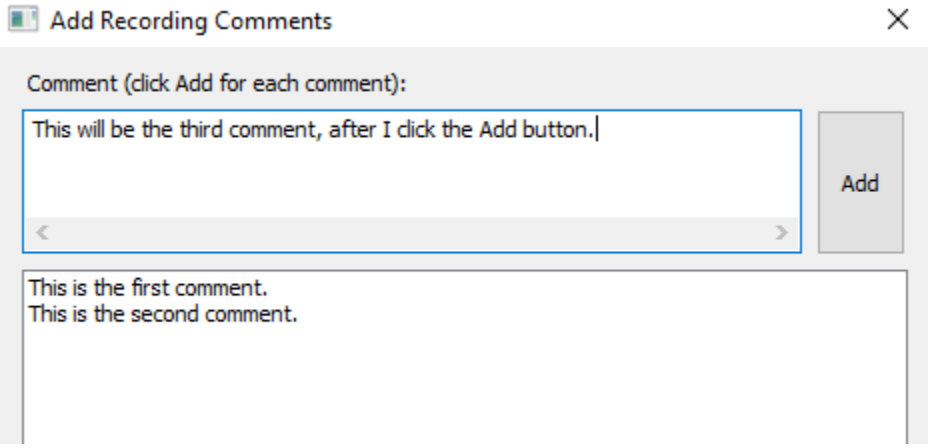
Note that the *Add Recording Comments* command is disabled if you are recording only a PLX format file, since recording comments are supported for PL2 files only. If you are recording both PL2 and PLX "in parallel," you can add comments, but they will only be available in the PL2 file. The single comment block in the *Start Recording Data* dialog is still supported for both file formats.

After you click *Add Recording Comments*, the *Add Recording Comments* dialog is displayed:

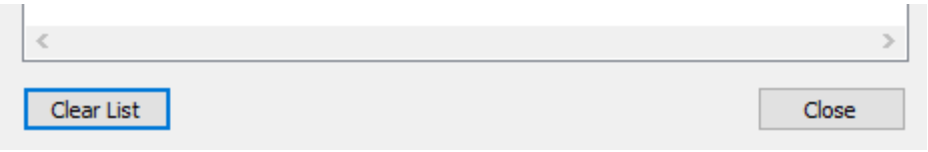


Enter each comment in the *Comment* section at the top, then click the *Add* button to add the comment to the recording. Note that the *Add* button is only enabled after you have started a recording.

Each comment can contain one or more lines, and be up to 1000 characters in length, although multiple, shorter comments are usually easier to work with. After you click Add, the comment is also added to the list of comments in the lower section:



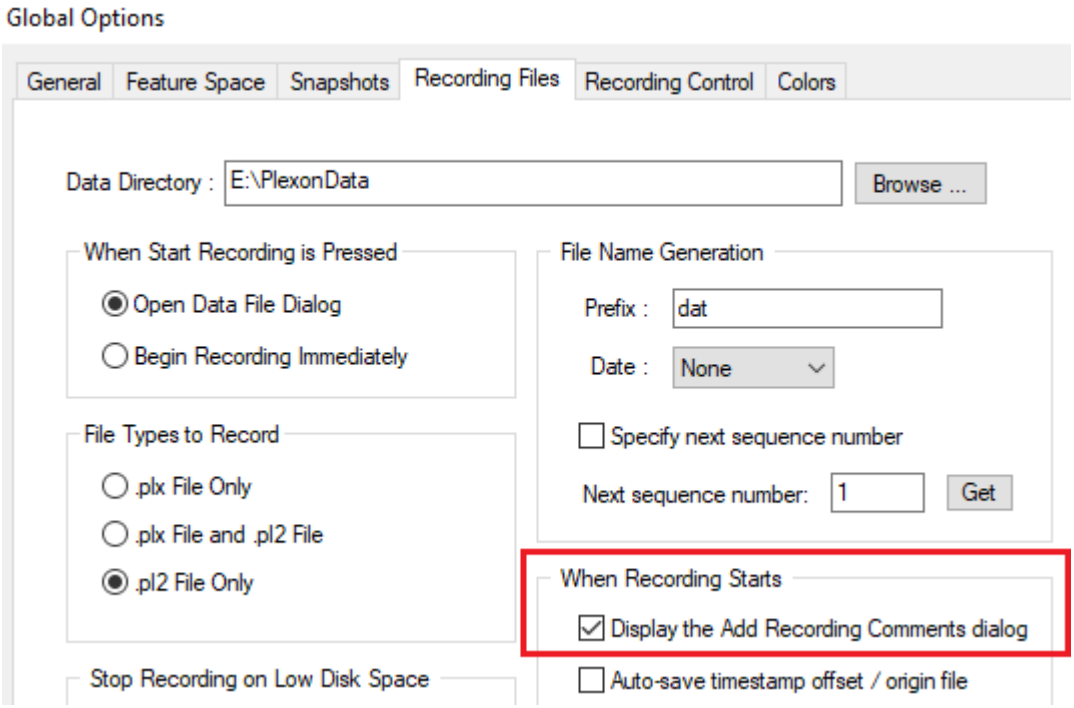
The *Clear List* button clears the contents of the lower window.



Clear List does not remove comments from the recording, it only “cleans up” the display.

The *Close* button dismisses the dialog, but you can open it again during the same recording if you later wish to add more comments. Note that any previously entered and recorded comments are not shown when you re-open the dialog.

PlexControl will automatically display the *Add Recording Comments* dialog at the start of each recording if you enable the following option in the *Recording Files* page of the *Global Options* dialog:



Reading recorded comments from PL2 files

Recording comments can be read from PL2 files using the latest version of the C/C++ and Matlab offline file reading SDKs, or using third-party applications which can read PL2 files, such as Neuroexplorer (NEX).

IMPORTANT: *Before recording comments in a PL2 file, you should first verify that your third-party application is capable of reading such files; otherwise, you may encounter an error. For example, in the case of Neuroexplorer (NEX), version 5.306 or newer is required. Check the neuroexplorer.com website for the latest version of NEX.*

It is recommended that you make a short test recording containing comments and verify that it can be read by the relevant application(s) without error. Note that some applications may choose to read these files without error but ignore the comments, for application-specific reasons.

In the C/C++ offline SDK, refer to the functions `PL2_GetCommentsInfo` and `PL2_GetComments` in the header file PL2FileReader.h.

```
PL2FILEREADER_API int PL2_GetCommentsInfo(
  int fileHandle,
  unsigned long long *numComments,
  unsigned long long *totalNumberOfCommentBytes);
```

```
PL2FILEREADER_API int PL2_GetComments(
  int fileHandle,
  long long* timestamps,
  unsigned long long* commentLengths,
  char* comments);
```

An example of how to use these functions to read comments from a PL2 file can be found in the function `PrintSampleOfComments` in PL2FileReaderTest.cpp in the SampleCode folder of the C/C++ offline SDK.

When reading a PL2 file in Matlab using the offline SDK, recording comments are available in the `NumberOfRecordingComments` field and and `RecordingComments` array in the pl2 structure returned by the `PL2GetFileIndex` function; no separate function is needed to read the comments. An example of how to read the comments is the following:

```
PL2GetFileIndex(''); % clear the index
[pl2] = PL2GetFileIndex('myfile.pl2');
fprintf('There are %u recording comments\n', pl2.NumberOfRecordingComments);
for i=1:pl2.NumberOfRecordingComments
  fprintf('comment %u: t = %f, text = "%s"\n', ...
    i, pl2.RecordingComments(i).Timestamp, pl2.RecordingComments(i).Text);
end
```

Since Matlab programs which read a PL2 file already call the `PL2GetFileIndex` function, any recording comments in the file are automatically available after this function has been called.

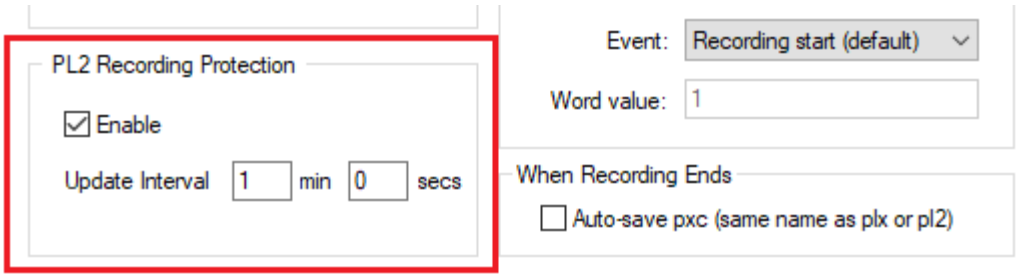
When reading a PL2 file from a Python application suing the PyPL2 API, you can use the function `pl2_comments` to read comments from the file, as in the following example:

```
from pypl2 import pl2_comments
timestamps, comments = pl2_comments('myfile.pl2')
for n in range(len(timestamps)):
  print("{} {}".format(timestamps[n], comments[n]))
```

PL2 recording protection

Plexon's PL2 file format allows large recordings, including files containing large amounts of high-bandwidth wideband (WB) and spike-continuous (SPKC) data, to be read efficiently in applications such as Offline Sorter (OFS) and Neuroexplorer (Nex), as well as in custom analysis software written in C/C++, MATLAB and Python using the offline file reading SDKs. In order to support this, when OmniPlex records a PL2 file, it uses various caching and indexing schemes supported by PL2 files to allow applications and scripts to subsequently read channels of data at high speed.

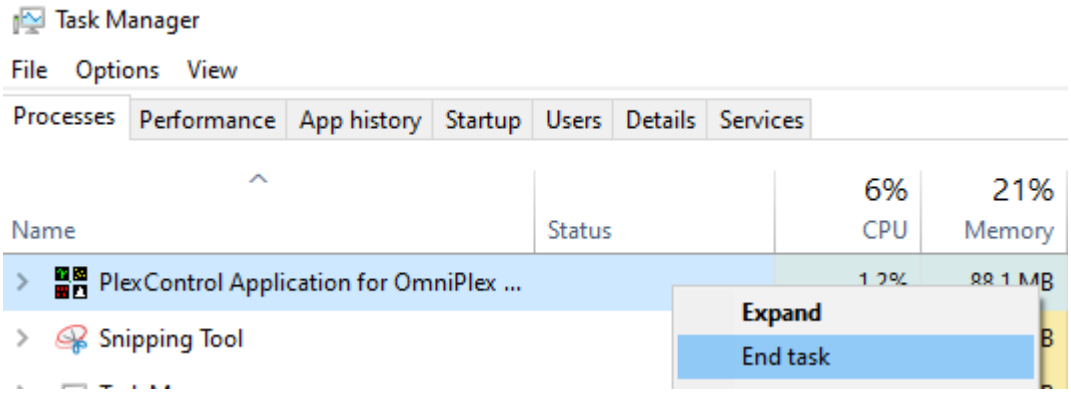
Previously, a potential drawback to this approach was that if OmniPlex unexpectedly terminated or there was a power failure during a recording, the resulting incomplete file could be unreadable. PL2 recording protection addresses this issue by periodically updating the PL2 file's indexes and caches so that in the event of an unexpected termination, the resulting file will in most cases remain readable. You can enable recording protection in the Recording Files page of the Global Options dialog:



The *Update Interval* determines how frequently the recording protection feature is run. Note that the minimum *Update Interval* is 30 seconds. In the event of the unexpected termination of a recording, at most the data acquired since the most recent protection update may be lost.

You might wonder, why not set an *Update Interval* of one second, to reduce the maximum amount of potential data loss to one second's worth? There are two main reasons. First, the periodic update flushes all cached data to the file, which, if done too frequently, would reduce some of the efficiencies of the PL2 recording scheme – the resulting files would not load as quickly. Second, doing the updates too frequently would noticeably increase the load on the system, especially at high channel counts. At an *Update Interval* of 30 seconds or longer, both of these factors are negligible.

Keep in mind that recording protection cannot guarantee that a recording will be readable in cases such as hard drive hardware failure, unprotected power line surges that cause hardware damage, operating system failure or malware that corrupts the file system, etc. However, you can verify that recording protection works as intended by using the Windows Task Manager to perform an "End Task" on PlexControl.exe in the middle of a recording, and then reading the resulting file.



Of course, Plexon does not recommend that you intentionally terminate a recording containing valuable data. Use the test wav file and an HTU, or unconnected headstages, for any such test.

Note that recording protection only applies to PL2 files, since the legacy PLX format is recorded using a much simpler scheme which is usually relatively unaffected by the unexpected termination of a recording, although at the expense of the much higher reading speed and other features of the PL2 format.

Percent-sorted sort quality metric

In addition to the existing sort quality metrics which are shown in the Extended Properties Spreadsheet, OmniPlex now also reports the per-channel percentage of spikes which are sorted, that is, assigned to any unit.

Iso Dist	PseudoF	Short ISI	Sorted
3.208	2.717	0.30	68.8
3.325	2.928	---	73.2
4.168	2.861	---	75.8
3.011	2.829	---	70.8
3.292	2.585	0.30	68.8
3.047	2.916	---	71.6
3.608	2.832	---	72.2
3.298	2.676	0.31	66.4

As with the other sort quality metrics, the percent-sorted is updated periodically on a rolling basis, using the most recent 500 spikes on each channel.

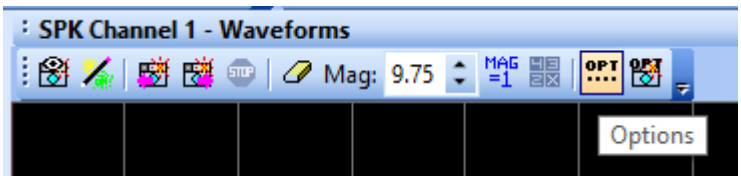
Note that percent-sorted is not a sort quality metric in the same sense as the other metrics, where a larger or smaller value is directly proportional to some aspect of the sort quality. For example, you could define a single unit on a channel which actually contains multiple units, but with a very large sorting tolerance which results in 100% of the spikes being sorted into that unit. However, the actual sorting quality, as indicated by the other metrics, would be very poor. For example, in this hypothetical "one unit for all the spikes" case, the *Short ISI* percentage would probably be very high, the *Iso Dist* would be very small, and so on, indicating that more than one unit is being "sorted into" a single unit. Ideally, you would have a high percentage of sorted spikes, in conjunction with good values for the other sort quality metrics, but it is generally not recommended to pursue a high percent-sorted as your primary goal in spike sorting.

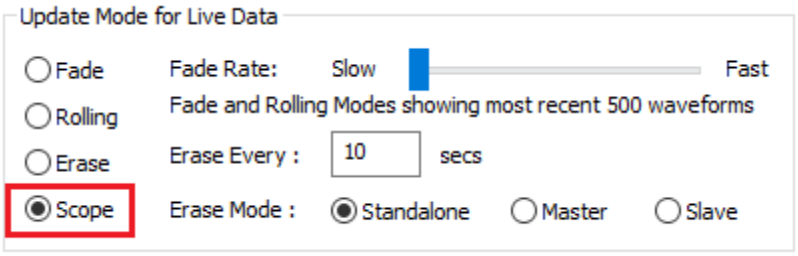
Also keep in mind that if you have set an unusually low threshold on a channel (this would be more likely with manually-set thresholds where a user is "trying to find a spike in the noise," and less often when auto-thresholding is used), it is likely that a significant number of "spikes" are actually thresholded noise. In such a case, you would want these noise spikes to remain unsorted, with a corresponding reduction of the percent-sorted metric.

High speed scope mode in the current-channel spike display

The main current-channel spike window in PlexControl, where you can edit units and adjust thresholds, has the display modes *Fade, Rolling* and *Erase*, plus a new mode called *Scope*. *Scope* mode is very similar to the *Scope* mode in the MultiPlex display, where incoming spikes are drawn and erased as rapidly as possible in an oscilloscope-like manner. This allows you to follow the dynamics of the spiking activity on a channel without the "waveform pile-up" effect that can obscure spikes, especially small spikes, in some cases.

To set the waveform display to *Scope* mode, use the *Update Mode for Live Data* section at the bottom of the *Options* dialog:

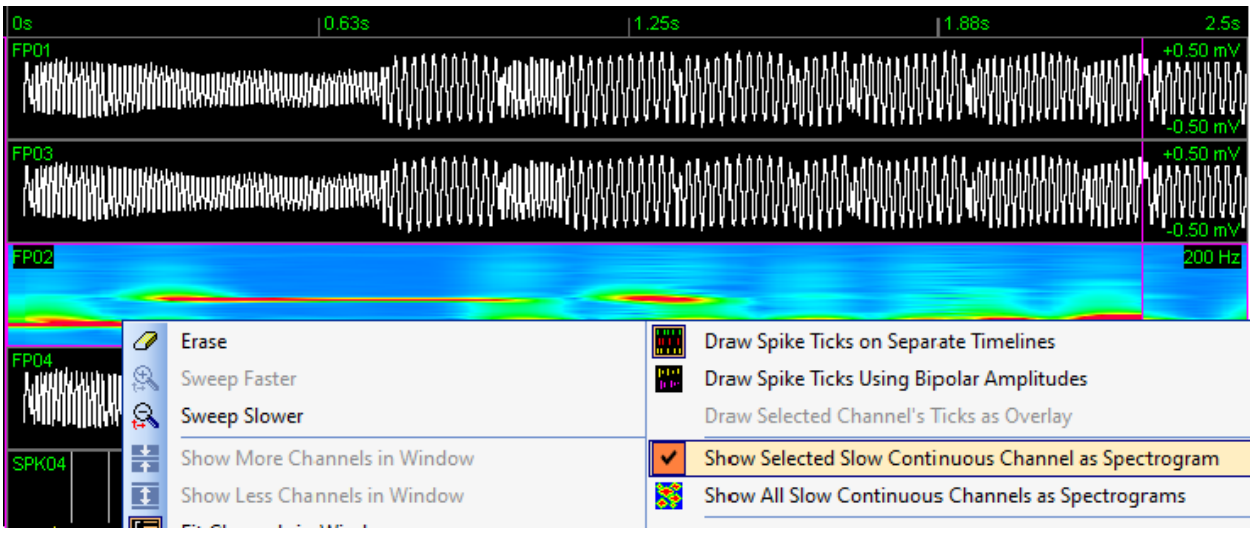




Note that *Scope* mode is automatically disabled if you enter unit-editing mode, since *Scope* mode is not helpful when editing units. *Scope* mode is generally intended for use after you have set thresholds and sorting for a channel.

Toggling spectrogram mode for individual channels in the MultiPlex display

Previously, the slow-continuous channels in the MultiPlex display could only be switched between normal and spectrogram modes as a group, using either a toolbar button or the right-button menu command. You can now toggle between these two modes on a per-channel basis, using the *Show Selected Slow Continuous Channel as Spectrogram* right-button menu command:



In the above example, FP01, FP03 and FP04 are displayed as their waveforms, while FP02 is displayed as its spectrogram.

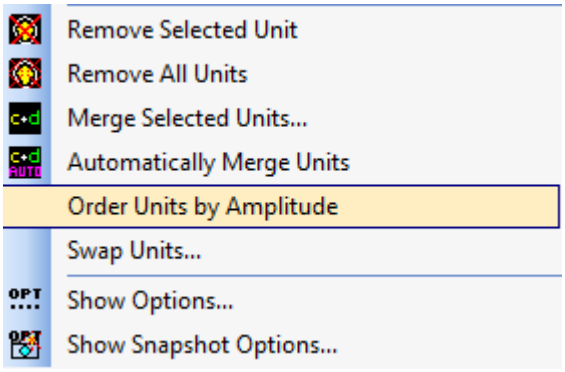
You can also toggle all the slow-continuous channels using the *Show All Slow Continuous Channels as Spectrograms* menu command or toolbar buttons, as in previous releases.

Changing the order of sorted units

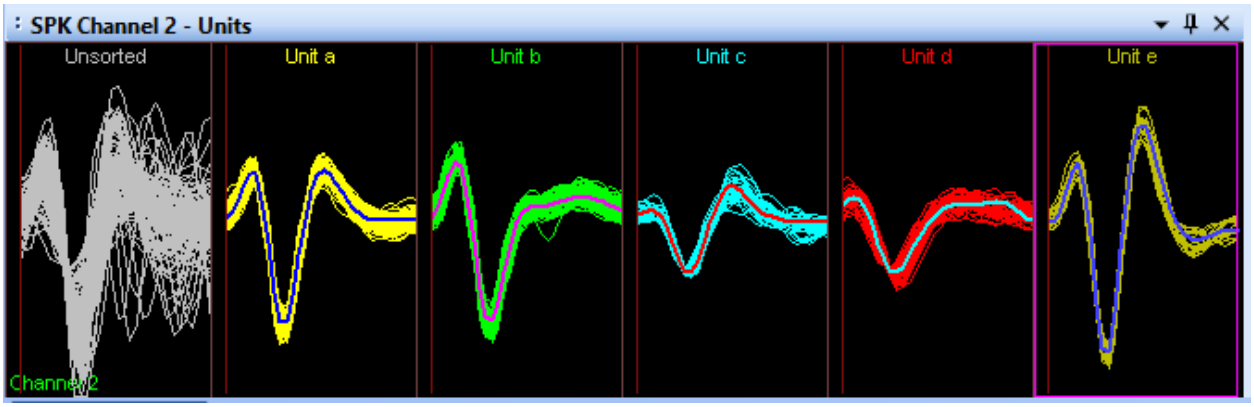
When you manually define units on a channel, they are labeled in alphabetic order (a, b, c, d…) as you add successive units. When you use automatic sorting, the unit order is somewhat arbitrary, since in most cases the unit label *order* has no meaning – units a and b could equally well be labeled as b and a. However, some analysis software may expect a particular unit order convention, such as amplitude order (unit a = largest template amplitude), quality order (unit a = "best" unit), etc. To support such workflows, OmniPlex now allows you to change the order of units, i.e. the unit labeling, on a channel. You can either automatically sort the unit order using peak-to-peak template amplitude, or manually specify the unit order by swapping units.

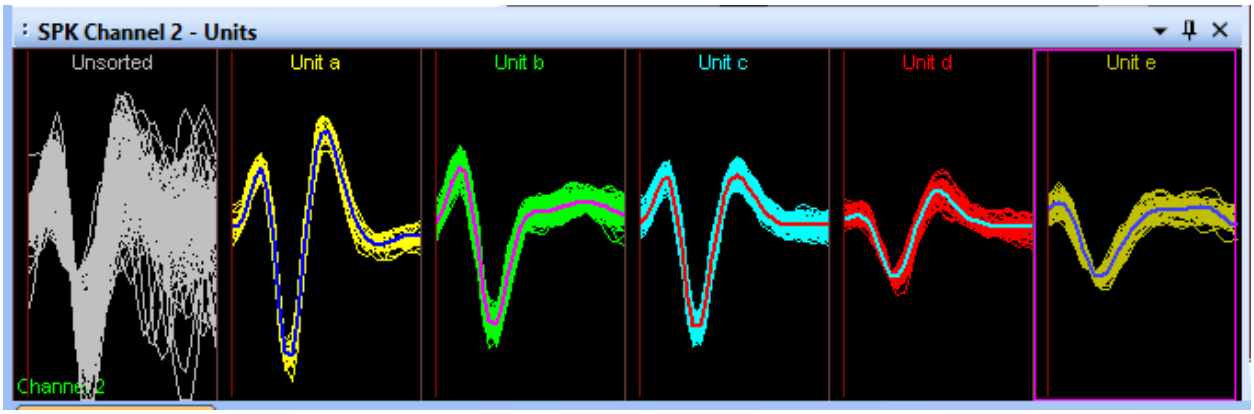
Ordering units by amplitude

To sort units in order of decreasing peak-to-peak amplitude, use the *Order Units by Amplitude* command in the right-button menu of the *Units* view.



Here is a before-and-after example:



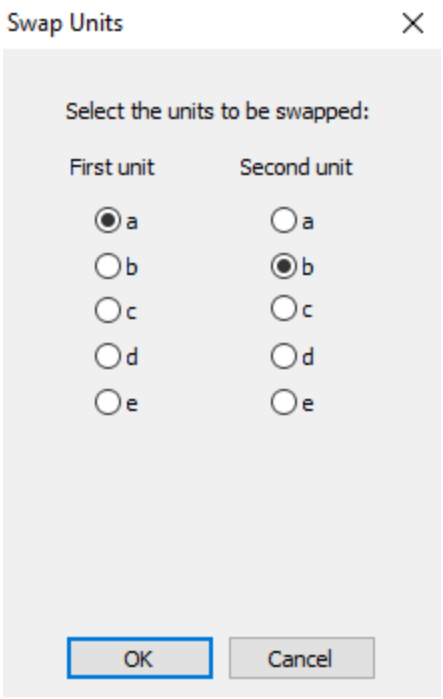


The units are reordered such that the peak-to-peak template amplitudes are in decreasing order. Note that this command is only supported for sorting methods which have explicitly defined templates, i.e, template and band sorting.

Note that the changing the unit order by amplitude is a command, not a mode. In other words, if one or more templates are later modified, deleted or added, the unit order is not automatically updated; you may need to perform another *Order Units by Amplitude* if you wish to to maintain the decreasing-amplitude unit ordering.

Changing unit order by swapping units

You can define any desired unit order by manually swapping pairs of units. From the same right-button menu shown above, select the *Swap Units* command. The *Swap Units* dialog is displayed:



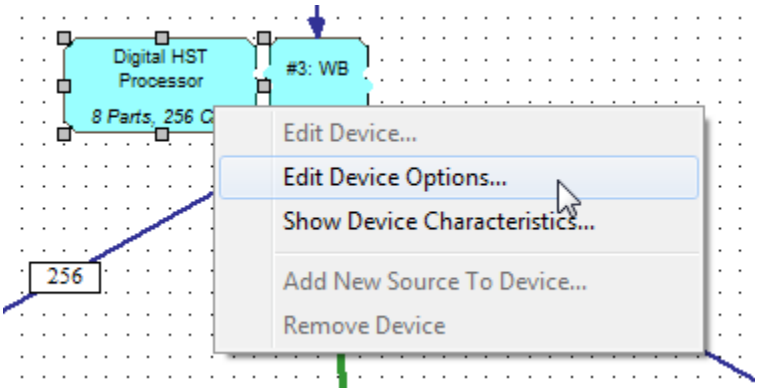
Select the pair of units to be swapped and click OK. You can repeat this procedure as needed to define a desired unit order.

New and updated digital headstage support

HST128DS digital headstage

OmniPlex Release 19 supports Plexon's new 128 channel digital headstage for DHP systems. Server will display a warning if you need to update your DHP firmware (to DADH firmware version 2.9) to support this feature. See the section on *DHP and DIN firmware updates* for more information on updating the DHP firmware.

When a 128 channel headstage is used, it must be plugged into port 1, the rightmost port on a DHP signal board when viewed end-on, and no other headstages can be plugged into the same board. To configure OmniPlex to use a 128 channel headstage, first make sure that data acquisition is stopped and then right click on the *Digital HST Processor* (DHP) device in the topology in Server:

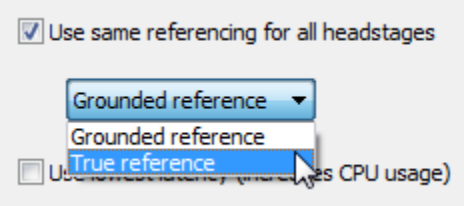


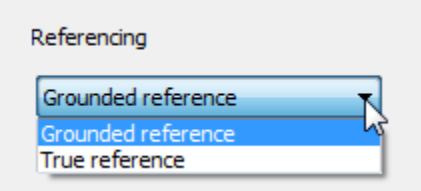
In the device options dialog, select HST128DS from the dropdown list for port H1. Note that when you do this, the headstage selection dropdowns for the remaining three ports on the board are grayed out to indicate that the HST128 is "using" the full 128 channel capacity of the board.

You can configure up to a total of four 128 channel headstages, one per DHP signal board, with each occupying the rightmost port on a board. You can use any combination of 8, 16, 32, 64 and 128 channel headstages on a single DHP, as long as you have the required number of DHP signal boards.
Hardware referencing for 64 channel digital headstages

Each type of Plexon 64 channel digital headstage (HST64D, HST64DS, HST64DSH) can be ordered with either grounded referencing or true referencing. Unlike the other digital headstages, the analog referencing in these two versions is set in the hardware and is not user-programmable via the DHP device options in Server. However, in previous releases of OmniPlex, the analog referencing options

(both *Use same referencing for all headstages* and for individual headstages) were incorrectly enabled in the user interface for 64 channel headstages, although they had no effect.

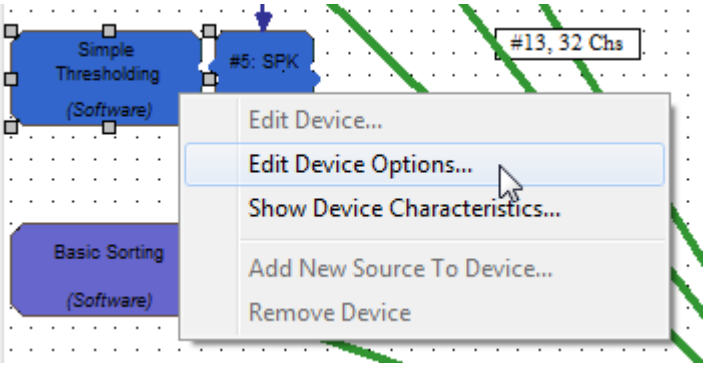


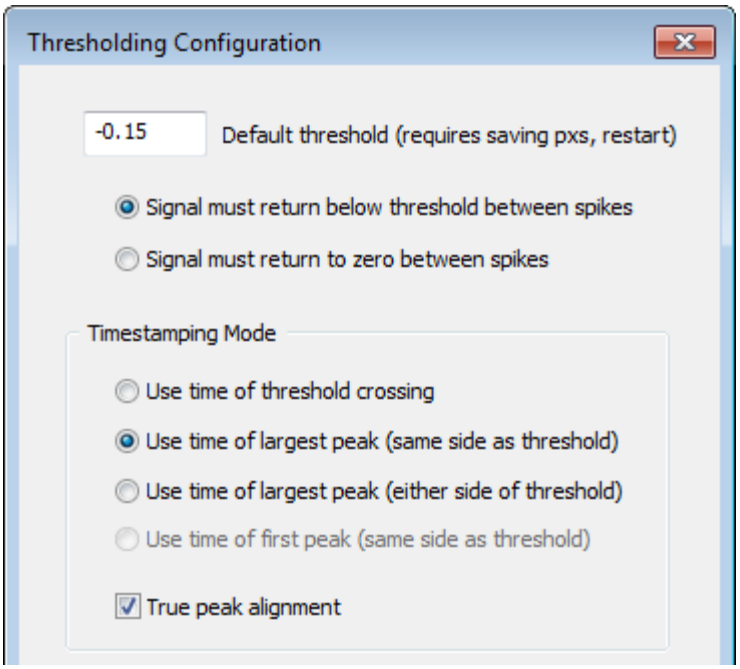


Starting with Release 19, the *Use same referencing for all headstages* checkbox and dropdown will be grayed out if you are using one or more 64 channel headstages. Likewise, the per-headstage *Referencing* dropdown will be grayed out for any port which is configured for a 64 channel headstage. Although configuring any port to use a 64 channel headstage will cause the *Use same referencing for all headstages* option to be disabled for all ports, the referencing configuration on any other headstages which you have previous set will not be affected. For example, if your configuration used four 32 channel headstages and you used *Use same referencing for all headstages* to set them all to *true reference*, and you then replaced two of the headstages with a single 64 channel headstage, the remaining two 32 channel headstages would still be set to true referencing.

True peak alignment for aligned extraction thresholding

A *True peak alignment* option can be enabled for the aligned extraction thresholding methods (*Use time of largest peak*…). With data acquisition stopped, right-click on the thresholding device in Server to display the options dialog:



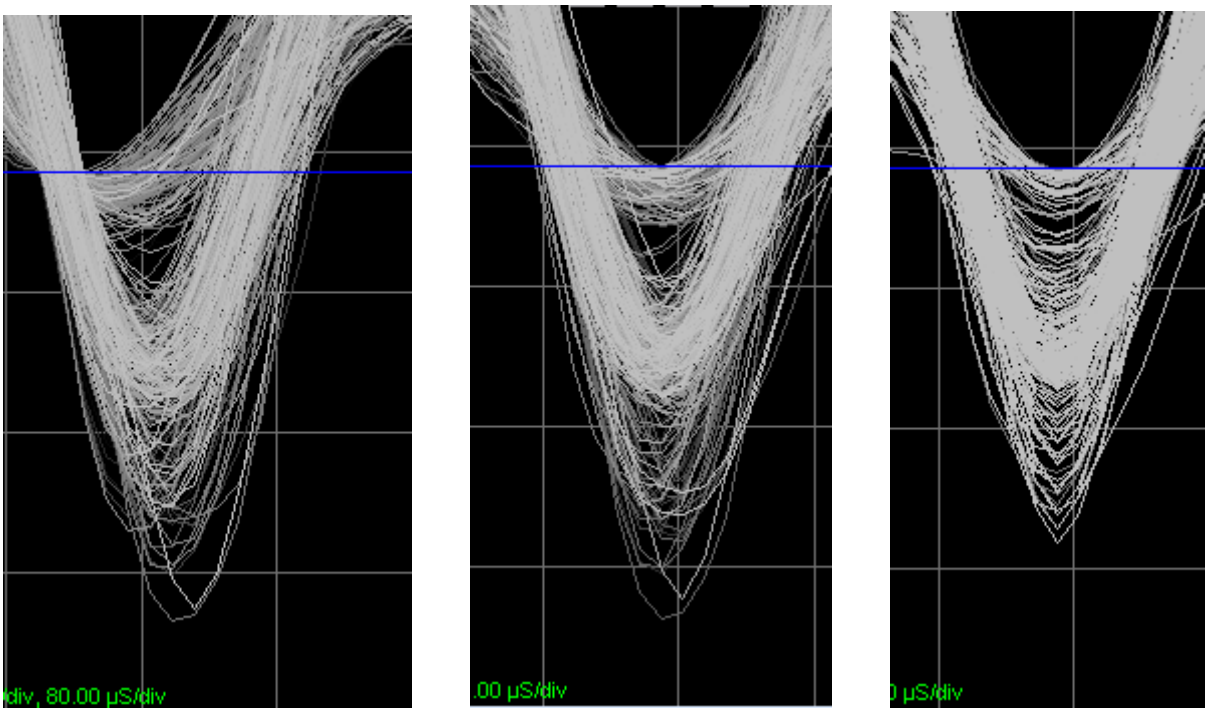


When *True peak alignment* is disabled, the normal aligned extraction method uses the timestamp of the waveform sample with the largest peak amplitude as the timestamp of the spike. However, the true peak of a waveform almost never falls directly on a sample point (time), but somewhere in between two successive samples. The result is that even if the waveform shape is constant (i.e. every spike has the same shape), the timestamp assigned to the spike can vary or "jitter" by +/- 1 sample tick. When many spikes from the same unit are extracted this way, the effect is that the "bundle" of waveforms is "smeared" in time/voltage space, or even split into what appears to be two or three time-offset groups of waveforms, which can appear as a single unit being split into two or three units.. Analogous adverse effects occur in derived feature spaces, such as PCA.

However, when *True peak alignment* is enabled, OmniPlex improves the result of an aligned extraction as follows. Each incoming detected spike is interpolated using a spline function, and the true sub-sample (between-sample) peak of the spline is determined. The spike is then resampled using the spline, such that the true peak is now defined as falling exactly on a sample tick. In order to avoid large, unexpected changes to the spike waveform in unusual cases, this resampling is only performed if the time shift of the peak would be less than or equal to one sample tick on either side of the original peak timestamp. In practice, almost all waveforms can be aligned using +/- 1 tick of offset or less.

The net result is that waveform peaks are precisely aligned with each other, as can be seen in the following example. From left to right:

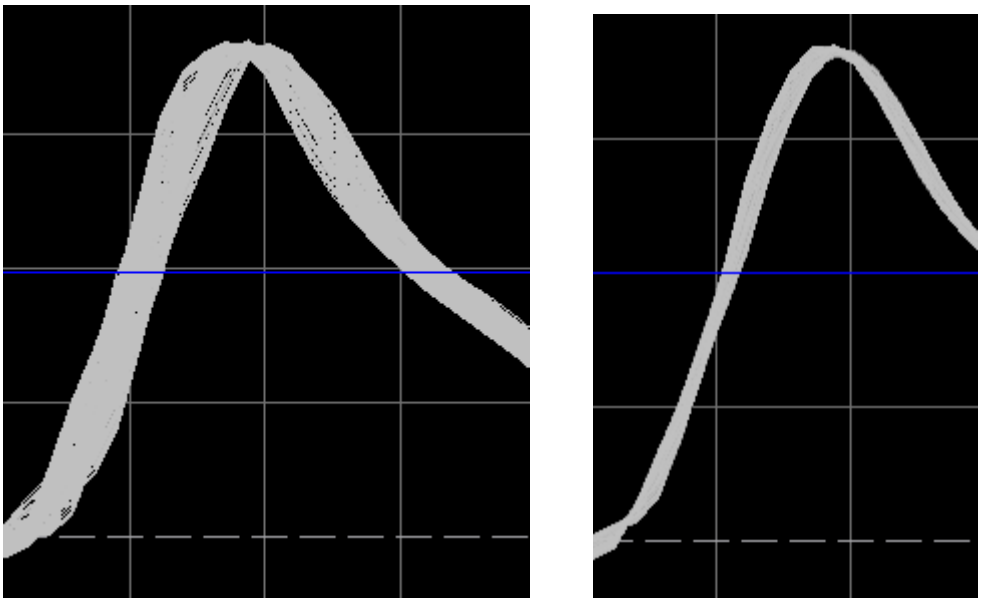
1. Standard threshold crossing, without aligned extraction.
2. Aligned extraction, with *True peak alignment* disabled.
3. Aligned extraction, with *True peak alignment* enabled.



(1) (2) (3)

Note that the set of spikes in each of the three screen shots is not identical (for example, (3) has fewer high-amplitude spikes), but taken as a whole they are representative of the differences between the three thresholding methods.

Here is another example, using a function generator waveform, with *True peak alignment* disabled (left), then enabled (right). The function generator insures that, for all practical purposes, each detected waveform has exactly the same shape before it is digitized. The tighter “waveform bundle” is clearly visible.



Since OmniPlex has access to the live continuous data preceding and following the extracted waveform, there are no issues with "zero padding" at the ends of the waveform, and the waveform is correctly extended with valid sample data as required.

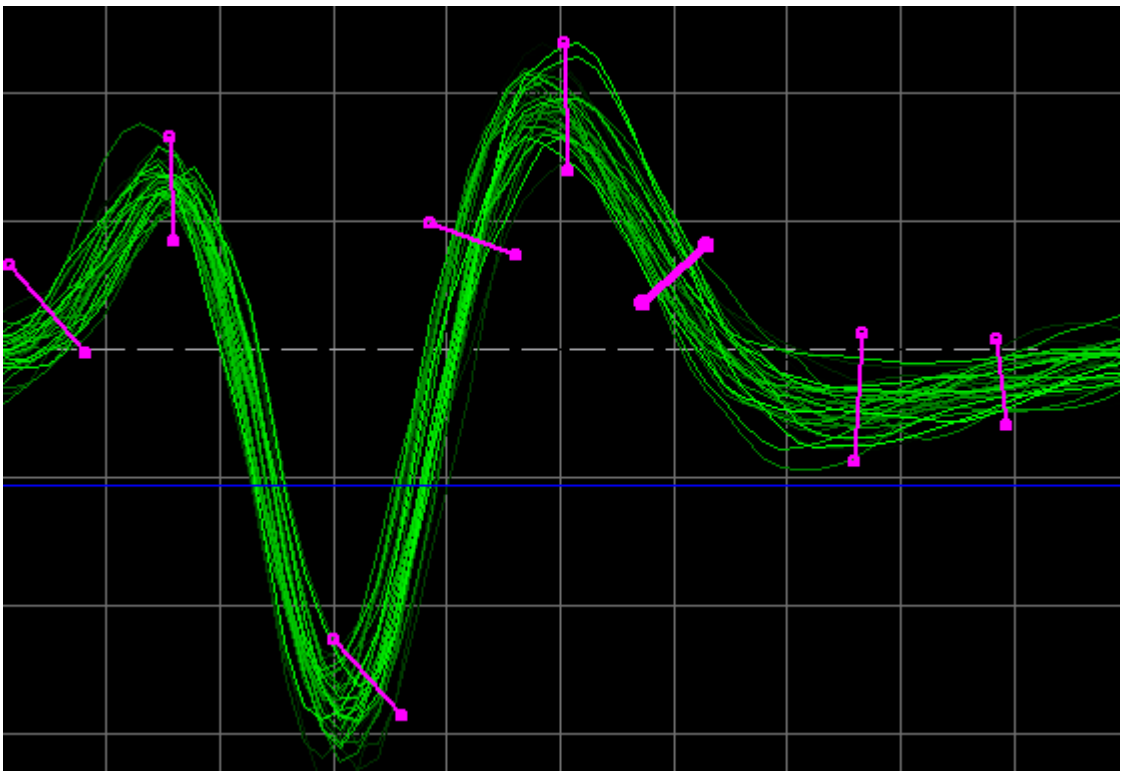
The optimized implementation of this method allows OmniPlex to perform online aligned extraction with true peak alignment on a full 512 channels of spike data, with no performance or latency issues compared to standard aligned extraction.

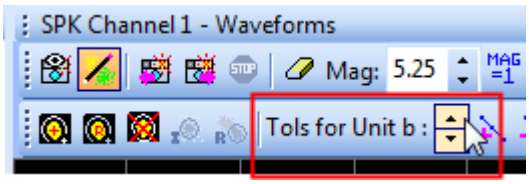
Toggling between live and snapshot modes during unit editing

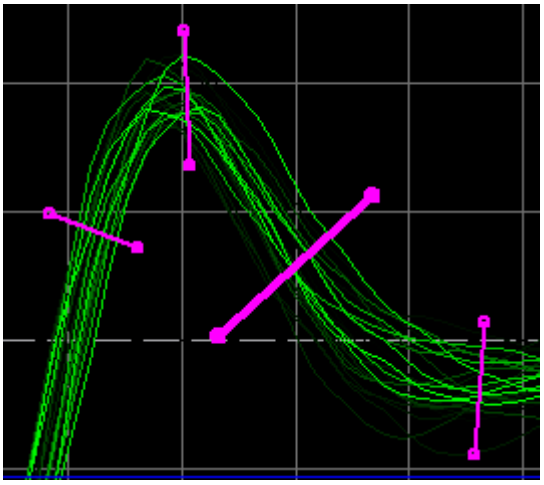
OmniPlex allows you to define, edit and delete sorted units for a spike channel while viewing either the live incoming spikes or a snapshot of previously captured spikes, and you can toggle between these two viewing modes. In previous releases, if you were editing units and then toggled from live view to snapshot view, the unit editing mode was cancelled and had to be enabled again manually. In Release 19, you can now toggle back and forth between viewing modes without affecting the editing status.

Modifying individual line lengths in line sorting

When using the line sorting method, in addition to manually editing sorting lines by dragging their endpoints, you can use the *Tols for Unit* spin arrows in the edit toolbar to make all the sorting lines longer or shorter. In Release 19, you can also use the spin arrows to change the length of an individual sorting line, simply by holding down the CTRL key while clicking the spin arrows. When this is done, only the currently selected sorting line (drawn as a bold line) will be lengthened or shortened.







If you wish to adjust the length of a different sorting line, first select it by clicking on either endpoint.

DHP and DIN firmware updates

Recommended firmware updates for both the DHP and the DIN (eChassis digital input card, also known as DINe) are included with Release19. The DHP firmware update (DADH 2.9) adds support for 128 channel headstages, while the DIN update (DIN 2,2) fixes a problem with the low-true logic option in Individual Events mode. Note that the DIN update is only needed by and applicable to the new eChassis systems; look for "DIN" on the front panel of the digital input card.

For instructions on updating the DHP and/or DIN firmware, please refer to the following documentation:

C:\Program Files (x86)\Plexon Inc\Common Files\ffu\FFU_instructions.pdf

Spectre / Meltdown mitigations and OmniPlex performance

For optimal OmniPlex system reliability, especially at high channel counts, it is important to maintain the performance of the Windows PC on which the OmniPlex software runs. Typically this involves not running other CPU-intensive or real-time applications at the same time as OmniPlex. However, Microsoft has released Windows Update patches which include mitigations (fixes) for the Spectre and Meltdown security vulnerabilities (see https://bit.ly/2Cvedgo for more information). These mitigations can cause performance issues for high channel count OmniPlex systems, especially if operating in lowest-latency mode. Therefore, we have provided a method for disabling these specific patches, which restores normal OmniPlex performance, as well as a method for re-enabling them.

It must be understood that disabling the patches could expose your OmniPlex PC the risk of Spectre or Meltdown based malware; however, as of this writing, the Spectre / Meltdown vulnerabilities are very difficult for malware creators to exploit, and no malware based on them has been observed on Windows systems. Still, you may wish to consult with your local IT personnel or network administrator to advise them that you intend to disable these protections. *Plexon cannot be responsible for any adverse effects or consequential damage as a result of disabling Spectre / Meltdown mitigations*.

If you wish to proceed, two batch files are provided in the following folder. Right-click on the batch file name and select *Run as administrator*, then follow the directions given in the command window that is displayed. Reboot your system after running either batch file to make the changes take effect.

C:\Program Files (x86)\Plexon Inc\Common Files\disable_mitigations.bat

C:\Program Files (x86)\Plexon Inc\Common Files\enable_mitigations.bat

The first file *disables* the Spectre /.Meltdown mitigations, *improving* OmniPlex performance. The second file *re-enables* the mitigations, with the accompanying *decrease* in OmniPlex performance.

It is possible that even after running disable_mitigations.bat, a future Windows Update will silently re-enable the mitigations, in which case any performance issues will reappear and it will be necessary to run disable_mitigations.bat again. This has not happened so far, but you should be aware of the possibility.

Keep in mind that if you are *not* experiencing performance issues in OmniPlex (for example, drop counts in PlexControl, hesitation or “stuttering” of displays), the above procedures are optional. It has been shown that it is definitely necessary at 512 channels and is recommended at 256 channels, especially if operating in lowest-latency mode. If in doubt, you can use the batch files to toggle the mitigations on and off to see their effect, if any, on performance. Remember to reboot after running either batch file.

OmniPlex Native Client API online SDKs

OmniPlex Release 18 includes new software development kits (SDKs) for online client programs written in C/C++, MATLAB, or Python. These SDKs support the new OmniPlex Native Client API, a set of functions for reading online spike, continuous, and event data, with full support for OmniPlex sources, making development more straightforward than when using the previous legacy APIs which were originally designed for use with Plexon MAP ("Harvey Box") systems. Each of the SDKs contains a set of sample client programs that illustrate how to use various capabilities of the Native Client API, plus documentation of Native Client API function parameters and usage. Clients written using the legacy API may still be used with all versions of OmniPlex, but the Native Client API is recommended for all new OmniPlex client development.

For the C/C++ online SDK, the Native Client API is in the file `CandC++ClientDevelopmentKit.zip`.

For the MATLAB online SDK, the Native Client API is in `MatlabClientDevelopKit-mexw.zip`.

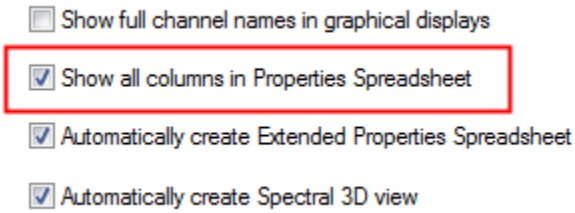
For the Python online SDK, the Native Client API is in `PythonClientDevelopmentKit.zip`.

See the documentation within each of the three zip files for descriptions of their contents and additional documentation.

PlexControl user interface changes

Show all columns in Properties Spreadsheet

A new option in PlexControl's *Global Options* dialog allows the main Properties Spreadsheet to be displayed in a reduced format, where controls for sources related to the currently selected source are not shown. The default is to show all columns.

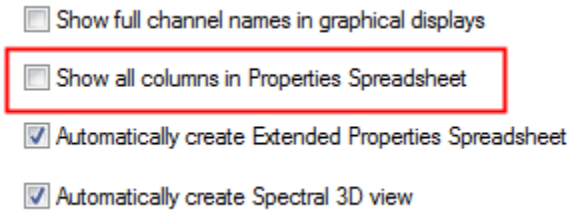


For example, if the SPK (spikes) source is currently selected, the Properties Spreadsheet will look like this when "all columns" are displayed:

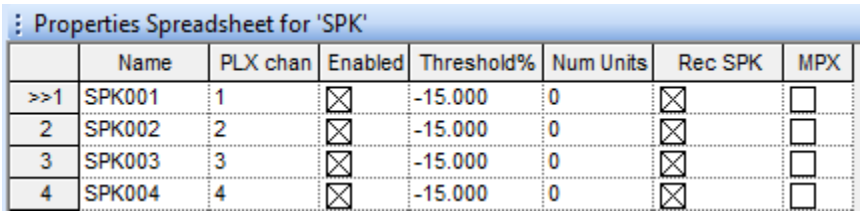
Properties Spreadsheet for 'SPK'

	Name	PLX chan	Enabled	Threshold%	Num Units	Rec SPK	Rec WB	Rec SPKC	Rec FP	DRef SPKC	DRef FP	MPX
>>1	SPK001	1	☒	-15.000	0	☒	☐	☐	☒	None	None	☐
2	SPK002	2	☒	-15.000	0	☒	☐	☐	☒	None	None	☐
3	SPK003	3	☒	-15.000	0	☒	☐	☐	☒	None	None	☐
4	SPK004	4	☒	-15.000	0	☒	☐	☐	☒	None	None	☐

Note that columns are shown for sources related to SPK: WB (wideband), SPKC (spike continuous) and FP (field potential). However, if you uncheck *Show all columns*:



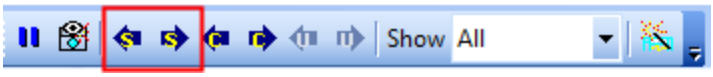
then only columns that control the selected source are displayed, for example:

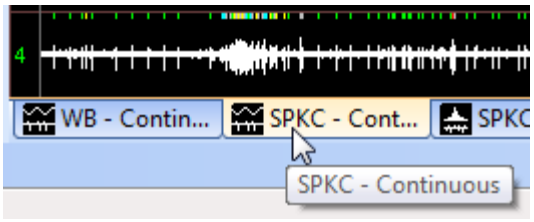


	Name	PLX chan	Enabled	Threshold%	Num Units	Rec SPK	MPX
>>1	SPK001	1	☒	-15.000	0	☒	☐
2	SPK002	2	☒	-15.000	0	☒	☐
3	SPK003	3	☒	-15.000	0	☒	☐
4	SPK004	4	☒	-15.000	0	☒	☐

The tradeoff is that the reduced view is less cluttered and more logically consistent, while the original "show all" display gives immediate access to more controls without having to switch to different sources to see them.

For example, in the above reduced view, you would have to select the SPKC source (either using the Previous Source / Next Source buttons in the main toolbar, or by clicking on the tabbed window displaying the SPKC channels) in order to view and change the *Rec SPKC* and *DRef SPKC* options.

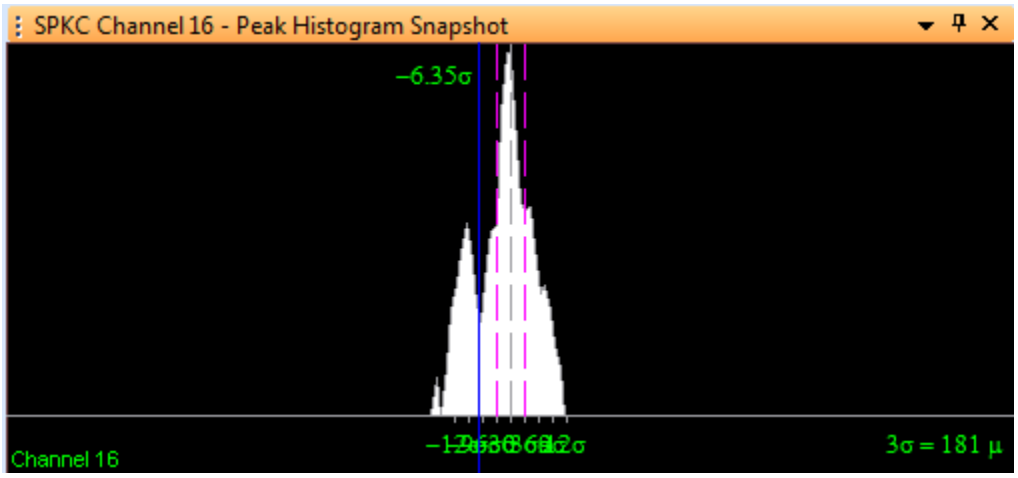




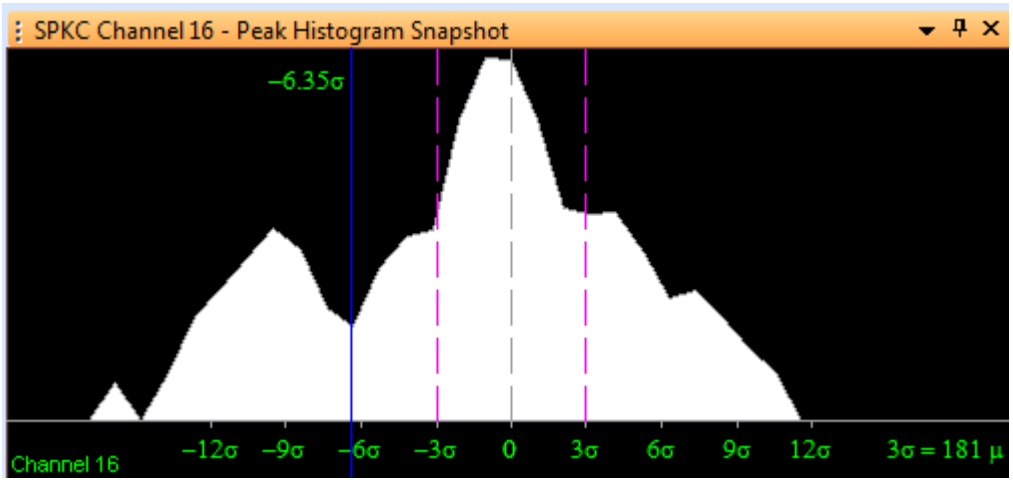
Mouse wheel control of magnification in SPKC histogram view…

Similar to the way in which you can use the mouse wheel to change the magnification in single-channel spike and continuous views, you can adjust the magnification of the SPKC histogram. Simply click in the histogram window and use the mouse wheel to increase or decrease the magnification as desired.

Before increasing magnification:



After increasing magnification:



Note that the threshold is unaffected; only the graphical display of the histogram is scaled.

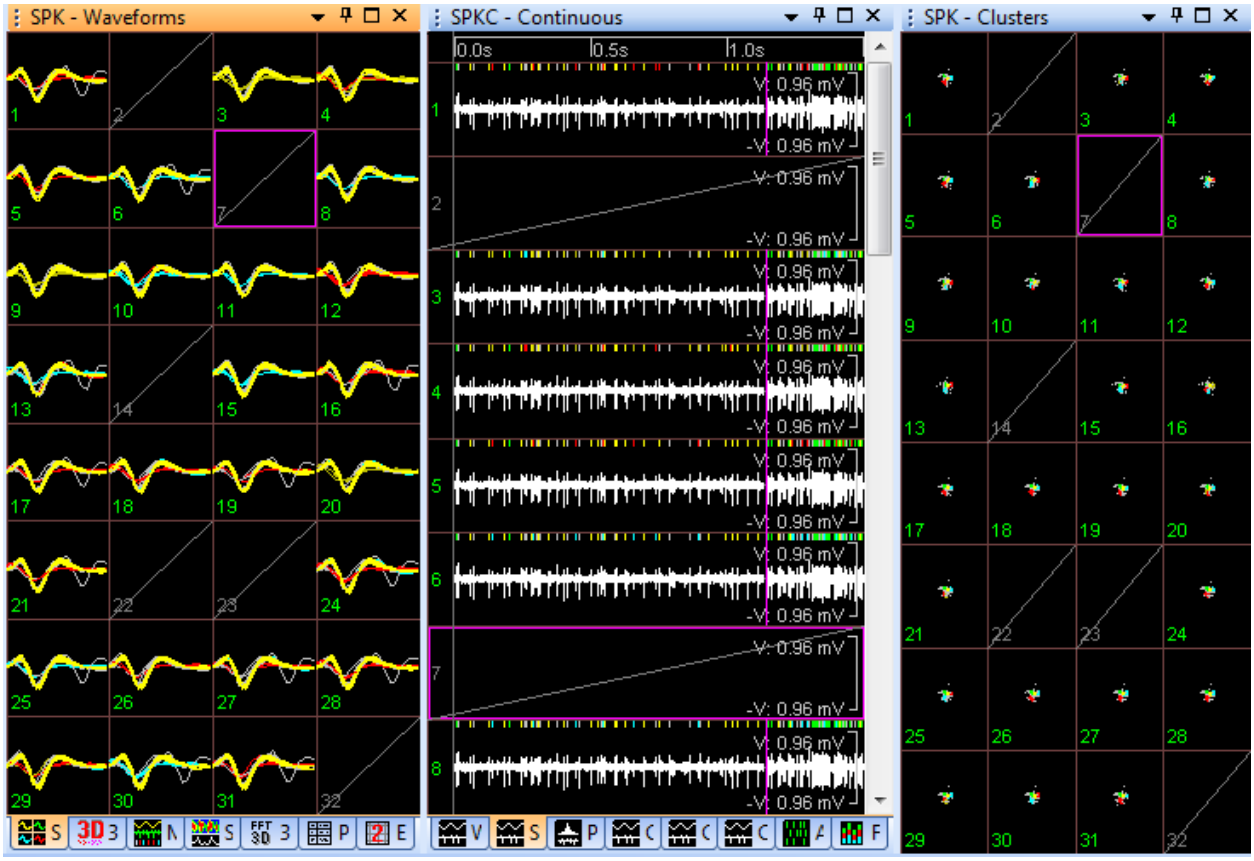
Display of disabled channels in multichannel views

In previous versions of OmniPlex, disabled channels were “crossed out” in multichannel views by displaying an “X” instead of that channel’s spikes or continuous signal. This was confusing to some users, since when a channel is enabled, its *Enabled* checkbox shows an “X” (checked).

Properties Spreadsheet for 'SPK'

	Name	PLX chan	Enabled	Threshold%	Num Units	Rec SPK	MPX
1	SPK01	1	☒	-3.886	4	☒	☐
2	SPK02	2	☐	-3.900	5	☒	☐
3	SPK03	3	☒	-3.856	5	☒	☐
>>4	SPK04	4	☐	-3.874	5	☒	☐
5	SPK05	5	☒	-3.908	4	☒	☐
6	SPK06	6	☒	-3.891	4	☒	☐
7	SPK07	7	☐	-3.862	4	☒	☐
8	SPK08	8	☒	-3.876	4	☒	☐
9	SPK09	9	☒	-3.879	5	☒	☐
10	SPK10	10	☒	-3.863	5	☒	☐

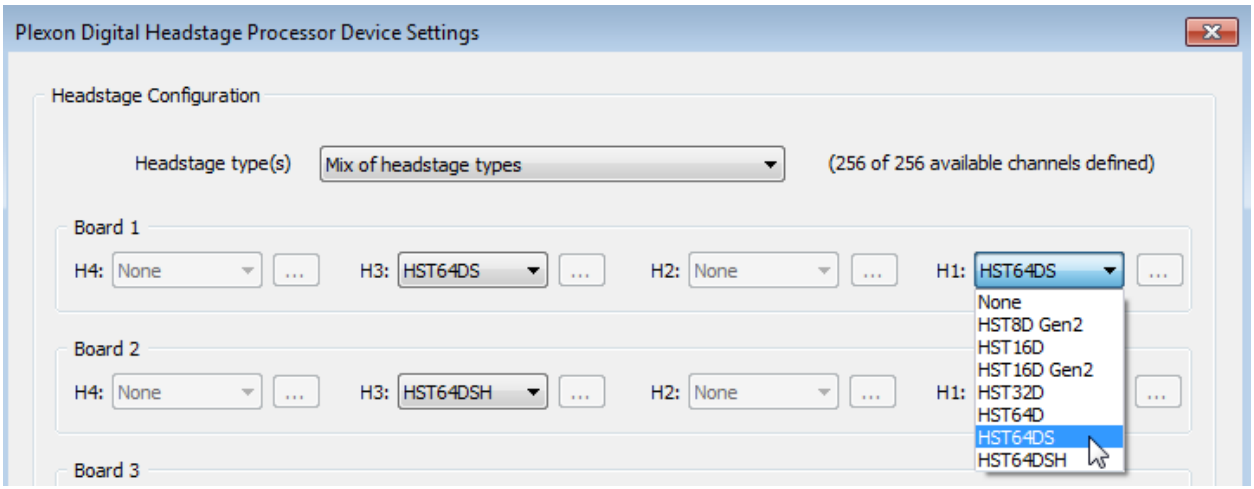
In Release 18, disabled channels are shown with a single diagonal slash “/” in multichannel displays, rather than “X”.



New 64 channel digital headstages

Release 18 adds support for two new 64 channel digital headstages, HST64DS and HST64DSH. Both are "thumbtack" designs which use Samtec connectors (hence the "S"); the "H" version differs in that its connector is oriented horizontally.

You can configure OmniPlex DHP systems to use these headstages, alone or in combination with other types of digital headstages, using the per-port headstage dropdown lists in the DHP *Device Options* dialog in OmniPlex Server.



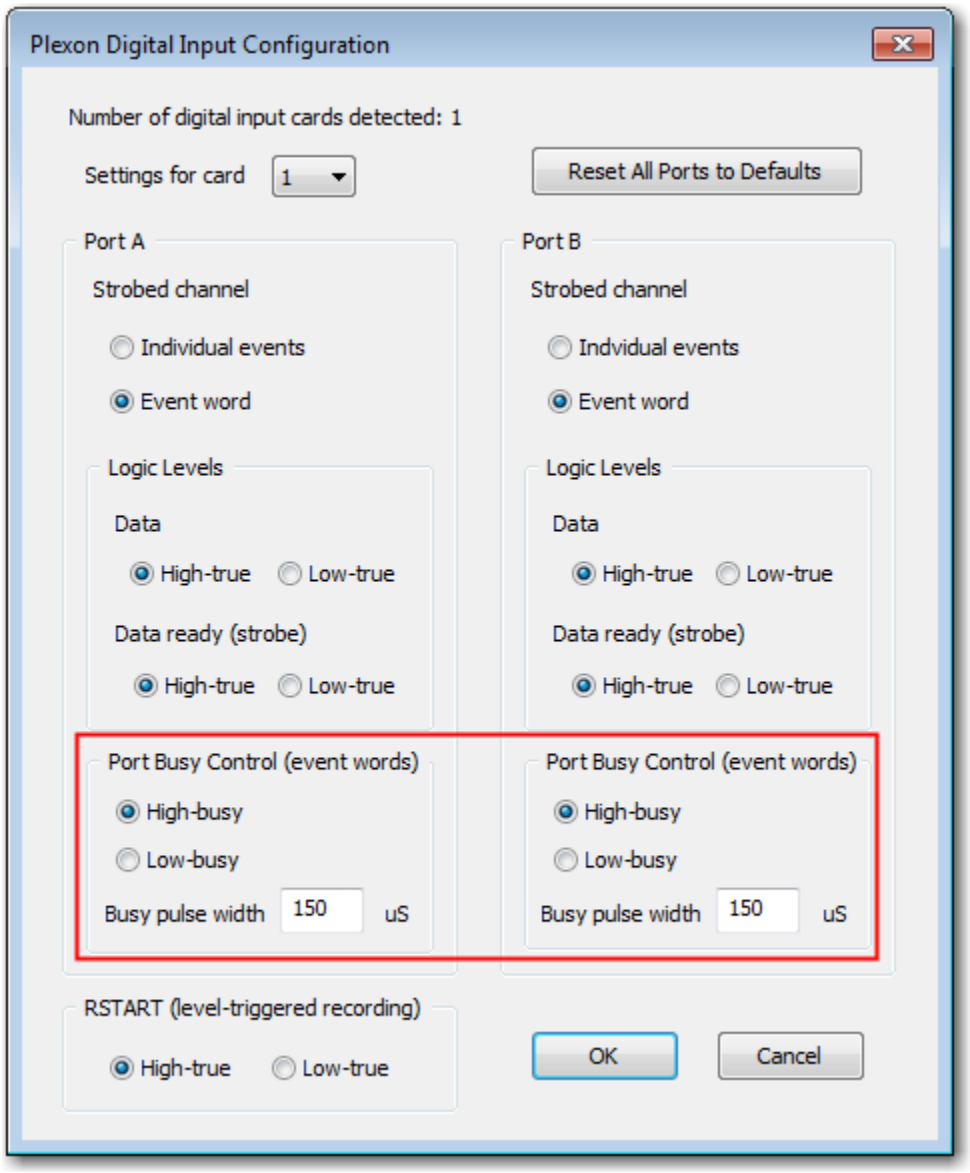
PXIe system hardware

Release 18 supports the newest version of the OmniPlex chassis and chassis cards, as well as all previous versions of the hardware. The new hardware includes a PCI Express chassis (PXIe or "eChassis") and PXIe versions of the PC-to-chassis link, TIM, DI and PDL cards; these are referred to as TIMe, DINe and PDLe respectively.

For auxiliary analog input, any OmniPlex AI card (non-PXIe) can used, either the "fast" or "slow" versions, but it must be installed in one of the "legacy" PXI slots in the right half of the PXIe chassis. Aside from the AI card, you cannot use cards from a PXI (legacy) system in a PXIe chassis, and the newer PXIe cards are not compatible with the legacy PXI chassis.

Additional options for DINe card

The *Device Options* dialog for the DINe card includes several new options which can be used when a port is configured to operate in *Event word* (strobed word) mode. For systems using the DI (not DINe) card, these options are not available and are grayed out.



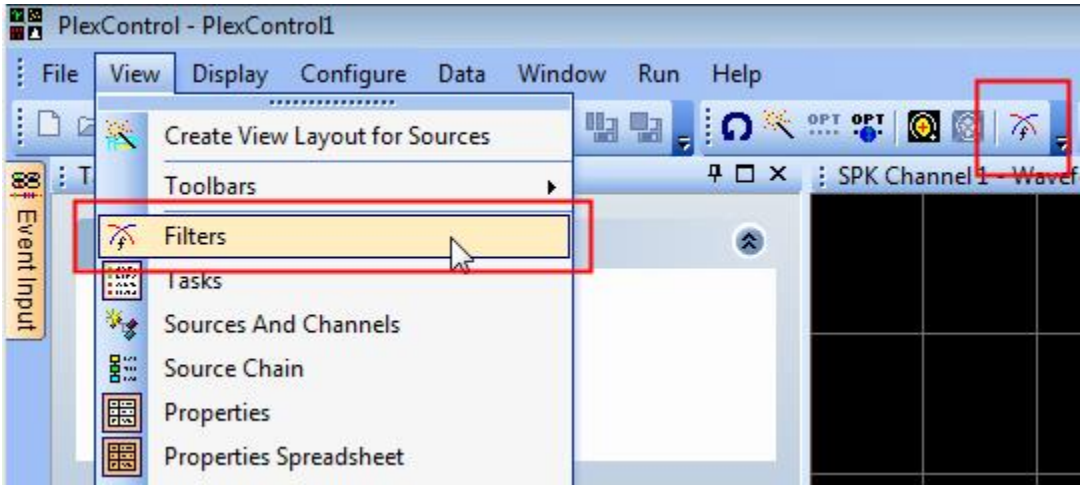
With the previous version of the card, there was no way for external hardware to determine when the DI was ready to accept each strobed word. To provide this functionality, the DINe card has a “port busy” output signal on pin 17 of each port (see the User Guide for the front panel pinouts). After the external hardware asserts the data-ready (strobe) signal to indicate that an event word is available, it should wait until port-busy is de-asserted before providing the next event word.

The options shown allow configuring the port-busy line for either *high-busy* or *low-busy* operation. The *Busy pulse width* value determines the minimum wait time between successive event words, and should usually be left at its default value of 150 microseconds, corresponding to a maximum event word rate of approximately 6000 event words per second per port. Values of less than 150 us should be used with caution, and you may wish to run tests to confirm that your system can reliably acquire event words at these rates.

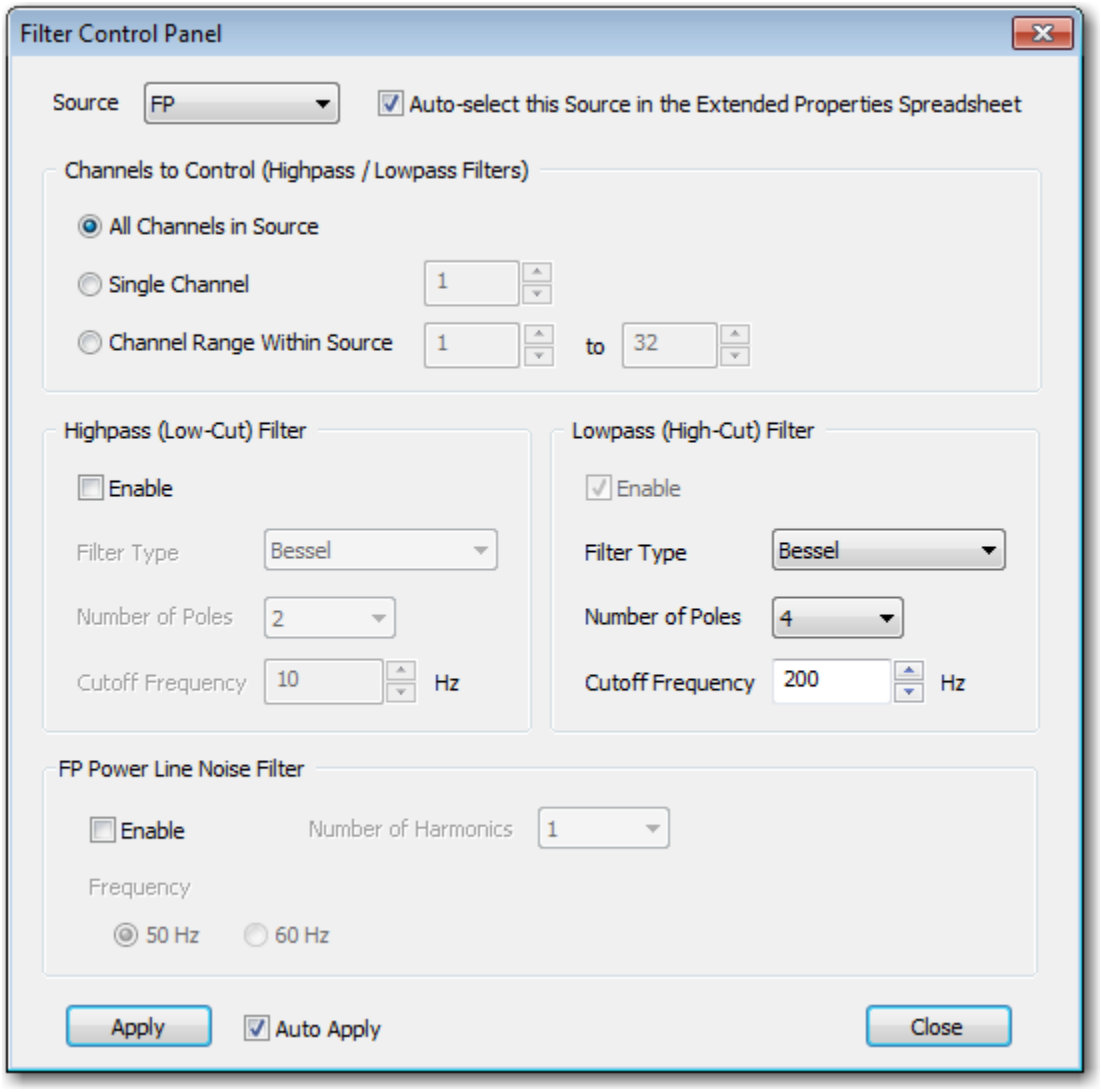
Filter Control Panel and filtering enhancements

The *Filter Control Panel* (FCP) allows you to adjust the primary digital filters in OmniPlex without having to stop and restart data acquisition. It can be accessed either from the main toolbar in PlexControl, or from the *Views* menu.

8/



The FCP is a modeless dialog box, i.e. you can continue to interact with the rest of the OmniPlex user interface while it is displayed, without having to repeatedly open and close the dialog. Note that data acquisition must be running in order to use the FCP.



Select the continuous source whose filters you wish to adjust using the Source dropdown list at the top of the dialog. The source can be SPKC, FP, or AIF. AIF (filtered AI) is the AuxAI filter, a new feature which is described in a later section. Each source can have highpass and/or lowpass filters, and for the FP source, a power line noise filter is also available.

The *Auto-select This Source in the Extended Properties Spreadsheet* option causes the *Extended Properties Spreadsheet*, which is described in a later section, to automatically select the same source as in the FCP.

Channels to Control and Auto Apply

Below the *Source* dropdown is the *Channels to Control* section, which determines which channels on the selected source are affected when you change the highpass and/or lowpass filter settings. By default, *All Channels in Source* is selected, so that any changes that you make will be applied to all the channels on the selected source. This is equivalent to changing the filter settings in the Device Options in the topology in Server.

The second option, *Single Channel*, will apply any filter settings changes to only the selected channel. For example, you might have two or more channels with similar signals, and by changing the filtering on only one of them, you can observe the differences between the channels as you adjust the filter settings.

The third option, *Channel Range Within Source*, causes changes to the filter settings to be applied only to the specified range of channels. This can be useful when, for example, different headstages acquire different types of neural signals, with different spectral characteristics or different noise profiles, or when different types of electrodes are being used on different headstages.

If you apply different settings for different channels within a source, you can see a list of the settings for all channels in the *Extended Properties Spreadsheet*.

Note that the *FP Power Line Noise Filter*, if enabled, always applies to all channels on the FP source, regardless of the setting of the *Channels to Control* options.

The second option which affects the application of filter settings is the *Auto Apply* checkbox at the bottom of the dialog box. When *Auto Apply* is enabled, any change that you make using the FCP is immediately applied to the selected source and channels. Note that the one exception for *Auto Apply* is that when you manually type in a numeric value for a filter cutoff frequency, these changes are not applied until you either click on a different control, or click the *Apply* button. To understand why this is the case, consider an example where you type in the value 300 for the SPKC highpass frequency. As you type the digits “3,” “0,” “0,” the filter cutoff would first be 3 Hz, then 30 Hz, then 300 Hz. It would be distracting (and in some cases nonsensical) to change the cutoff frequency to these “partially entered” values.

Highpass and lowpass filters

For the SPKC source, the highpass filter cannot be disabled, since it is used to remove field potentials from the wideband signal. The lowpass filter is optional; a typical use would be to remove high-frequency noise.

For the FP source, the lowpass filter cannot be disabled, since it is used to remove spikes from the wideband signal. The highpass filter is optional; a typical use would be to remove low frequency motion artifacts or near-DC drift.

For the AIF source, both the highpass and lowpass filters may be enabled or disabled as desired. Note that the AIF source itself is not present by default, and must be enabled when a topology is created, as described in a later section.

The highpass and lowpass filter parameters (type, number of poles, and cutoff frequency) are described in more detail in the User Guide. These parameters are exactly the same as the ones set in the Device Options for the spike and FP separator devices in Server. Note that the filter settings in Server act as default values which are in effect unless you override them using the FCP in PlexControl.

Uses of live filter adjustment

Here are some examples of how you can use the ability to adjust the filters in real-time while viewing live signals (continuous, spike, and spectrograms) to easily observe the effects and tradeoffs of different filter settings on spikes and field potentials.

Gradually lowering the cutoff frequency of the SPKC highpass filter will at some point allow unwanted field potentials into the SPKC signal, causing visible baseline “wobble” and making it difficult to reliably detect spikes. Changing the filter type and number of poles will also affect the degree of removal of FPs.

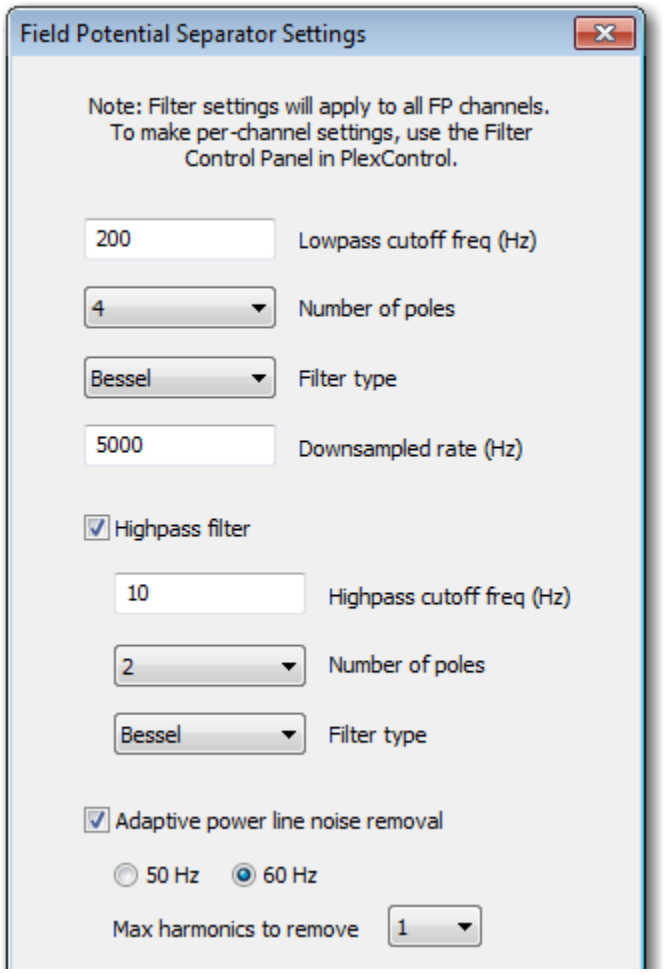
In addition, the SPKC filter settings can affect the shape of spikes; for example, the default Bessel filter causes the least spike shape change, but has a more gradual rolloff (for a given cutoff and number of poles) than the Elliptic filter, which has a sharp rolloff but causes more shape distortion, such as overshoot on steep edges. This can also affect the shape and separation of clusters in feature space.

Enabling the SPKC lowpass filter (e.g. to remove high frequency noise) and then reducing its cutoff frequency will result in smoother, less noisy spikes, but when the cutoff is reduced too far, you will see spike shapes become less distinct from each other, and the corresponding feature space clusters will become poorly separated.

For field potentials, the lowpass filter must remove spikes, which you can verify by comparing the FP and SPKC signals while adjusting the cutoffs. Also, spectral energy above the Nyquist rate (half the downsampled rate, e.g. 500 Hz for a 1 kHz sampling rate) must be removed before the FP signal is downsampled, or aliasing (“foldover” of high frequencies into the lowest frequencies) will result. You can observe the FP spectrogram views while adjusting the FP lowpass cutoff to verify that there is no significant spectral energy at frequencies at or above the Nyquist rate.

FP Separator Device Options

The Device Options for the FP Separator device in Server have been updated to reflect the additional filtering capabilities:



It is important to note that if you change the filter settings in the Device Options for the FP Separator, Spike Separator, or AI Filter devices, these settings will apply to all channels on the corresponding device, and will override any per-channel filter settings that were made with the Filter Control Panel.

Also, note that the SPKC, FP, and AIF filter settings are now saved in the pxc file, and loading a pxc with customized filter settings will also override any filter settings which were in effect before the pxc was loaded.

Power line noise filter

For the FP source, an optional power line noise filter (LNF) is available. This is an adaptive "hum filter" which specifically "looks for" components within the FP signal at a fundamental frequency of either 50 or 60 Hz (the power line frequency, e.g. 60 Hz in the US) and the harmonics (multiples) of the fundamental. This is necessary because while the AC power waveform at the source may be sinusoidal or very nearly so, in practice the waveform shape of AC line noise picked up by electrodes is significantly distorted, which equates to the presence of harmonic spectral components with amplitudes that decrease with increasing frequency.

OmniPlex also has a notch filter which is available in the optional Global Filter device in Server, but the LNF has several advantages. First, the notch filter only removes line noise at the fundamental frequency, while the harmonics are unaffected. Second, the notch filter affects frequencies near the fundamental, and increasing the narrowness of the notch (the Q value) to avoid this can cause artifacts in the signal and also make the filter less effective if the power line frequency drifts from the ideal 50/60 Hz value. By comparison, the LNF affects only the specified fundamental frequency and harmonics, and adaptively determines the phase and amplitude of each component so that it can in effect "cancel out" the power line noise. As opposed to the tradeoffs involved with the notch filter, the LNF only requires the fundamental frequency (50 or 60 Hz) and the number of harmonics to be specified, up to a maximum of five. For example, with a 60 Hz power line frequency, selecting three harmonics would result in adaptive noise removal at 60, 120, and 180 Hz. The amplitude of the higher harmonics in power line noise decreases with increasing frequency, so that unless the line noise is very heavily distorted, removing two or three harmonics will be sufficient. Specifying too many harmonics will not harm the signal, since the noise removal is applied adaptively, but at high channel counts it will use unnecessary processing resources and should be avoided.

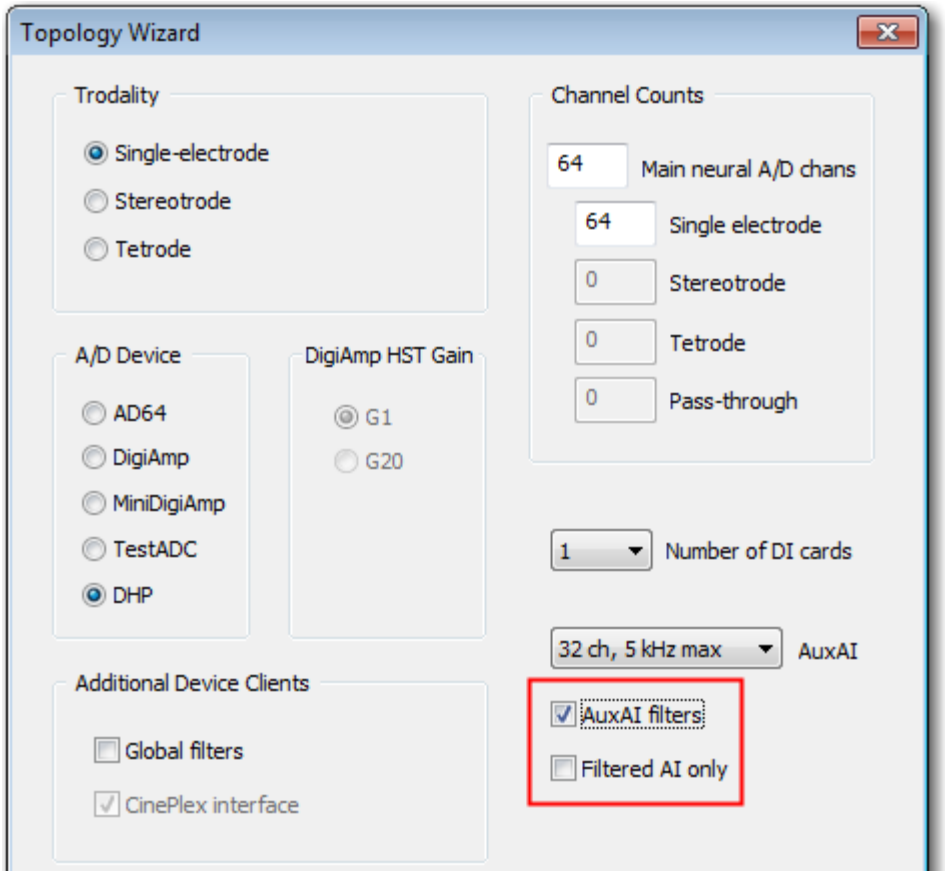
In general, it is recommended that you use the 2D and/or 3D spectrogram views and the FP continuous view to check for the presence of line noise and its harmonics. An instructive "offline exercise" is to run OmniPlex with the HTU (headstage tester unit) and a function generator as the input signal, set to 50 or 60 Hz. Observe this signal in the spectrogram and FP continuous views and experiment with the results of enabling and disabling the LNF filter and varying the number of harmonics removed. You may wish to start with a pure sine wave from the function generator (no harmonics), then switch to a triangle wave, which has odd harmonics. i.e. setting the LNF to remove five harmonics will remove the fundamental, third harmonic, and fifth harmonic.

Note that since the LNF is an adaptive filter, it does not instantly respond to changes in line noise amplitude. Typically it causes a significant reduction in line noise within a few seconds, then exhibits a slowly oscillating convergence to maximum noise removal. It can take up to roughly one minute for maximum noise removal to be achieved, but this will be somewhat signal-dependent. As long as you account for this initial settling time it should not be a problem, except in circumstances where the line noise varies rapidly, e.g. a freely-moving animal that is picking up much more line noise in one part of a cage than another. In such cases, the notch filter may be preferable, keeping in mind the disadvantages that were previously described.

A final caveat is that the line noise filter (and the notch filter) are not substitutes for proper electrical shielding. Remember that these filters are applied to the digitized signal and so cannot remove noise that is of such high amplitude that it exceeds the input range of the A/D converters and clips. You should always try to remove sources of power line noise from the area of an experiment, apply best practices for grounding and shielding, and only use the digital filters in OmniPlex to remove any remaining noise.

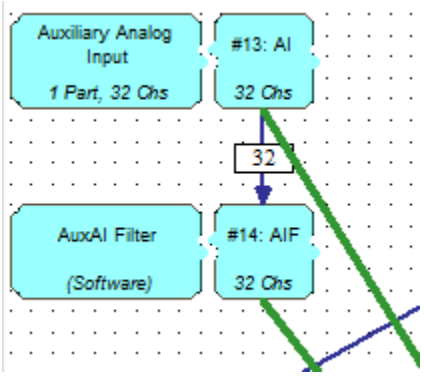
AuxAI filter (AIF)

The auxiliary analog input (AuxAI) device now supports optional digital highpass and lowpass filters, similar to those available for the SPKC and FP sources. These can be useful for noise and artifact removal, smoothing signals from sensors, and similar purposes. However, unlike the SPKC and FP filters, the AuxAI filters are not included in OmniPlex by default. To include the *AuxAI Filter* device, you must enable the *AuxAI filters* checkbox in the Topology Wizard in Server when creating a new topology:



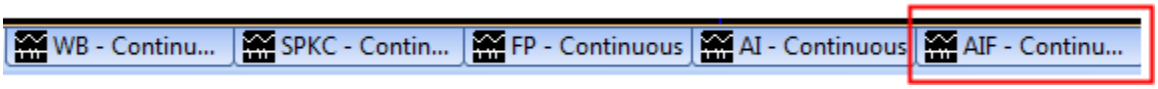
If you only check *AuxAI filters*, then both the standard AI source (unfiltered) and the new AIF source (filtered) will be available. If you also check *Filtered AI only*, then only the filtered AIF source is available, although you will still be able to disable its filters. In this context, you can think of AI as the wideband (unfiltered) signal from the AuxAI device. One reason to include both AI and AIF sources in the topology is so that you can view and/or record both the filtered and unfiltered versions of the signals. In this context you can think of AI as analogous to the WB (wideband) source for neural signals. Remember that since the AI source is usually digitized at a lower rate than the main neural source (e.g. a few kHz), recording both the raw and filtered versions often will not result in an objectionable increase in file size or processing resources.

Once you have created a topology containing the AuxAI filter, it appears in the topology like this:



In this example, we did not check *Filtered AI only*, and so the green lines (which are pointing towards the main datapool, not shown here) indicate that both AI and AIF sources will be available in OmniPlex. If we had checked *Filtered AI only*, then only the green line from AIF would be present.

In PlexControl, the AIF source is displayed in its own tabbed view, just like the other continuous sources.



Again, this example shows the case where *Filtered AI only* was not checked when the topology was created, so there are continuous views for both AI and AIF.

Extended Properties Spreadsheet

The *Extended Properties Spreadsheet* is a tabular view that is similar in appearance to the standard main Properties Spreadsheet in PlexControl. It is used for informational and monitoring purposes, as opposed to adjusting settings such as thresholds or referencing. The digital filter properties of the currently selected source are displayed, and if a spike-related source is selected, spike sorting quality metrics, if any, are displayed in the rightmost columns, as shown here (the red line was added to emphasize this):

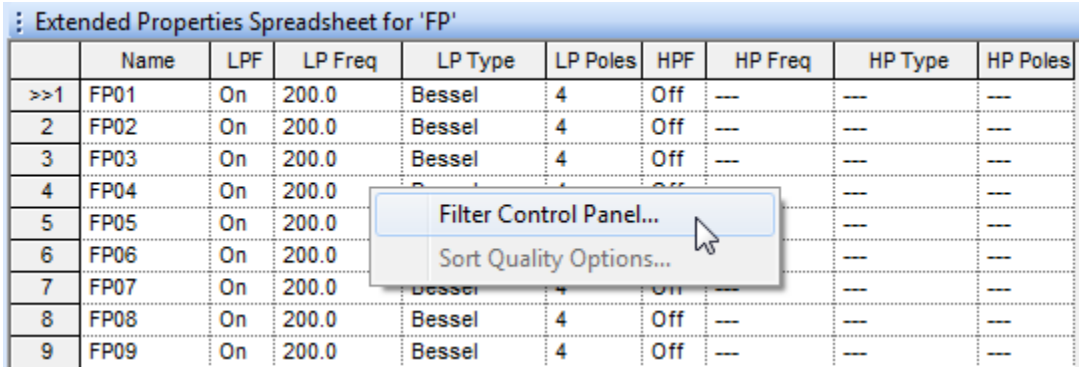
Extended Properties Spreadsheet for 'SPK'

	Name	LPF	LP Freq	LP Type	LP Poles	HPF	HP Freq	HP Type	HP Poles	Iso Dist	PseudoF	Short ISI
>>1	SPK01	Off	---	---	---	On	300.0	Bessel	4	3.393	2.779	---
2	SPK02	Off	---	---	---	On	300.0	Bessel	4	3.583	2.792	---
3	SPK03	Off	---	---	---	On	300.0	Bessel	4	3.600	2.836	0.28
4	SPK04	Off	---	---	---	On	300.0	Bessel	4	4.180	2.868	0.28
5	SPK05	Off	---	---	---	On	300.0	Bessel	4	3.027	2.777	---
6	SPK06	Off	---	---	---	On	300.0	Bessel	4	3.453	2.790	---
7	SPK07	Off	---	---	---	On	300.0	Bessel	4	3.113	2.862	---
8	SPK08	Off	---	---	---	On	300.0	Bessel	4	2.796	2.714	---

Also note that even though SPK and not SPKC is the selected source in this example, the relevant SPKC filter settings are displayed for convenience. Likewise, when SPKC is selected, the SPK sort quality metrics are displayed.

Some sources, such as the wideband (WB) and digital input (DI) sources, do not currently display any information besides their channel names in the *Extended Properties Spreadsheet* when they are the currently selected source.

The filter settings shown in the *Extended Properties Spreadsheet* update immediately when you change them in the Filter Control Panel. This is particularly useful when you are using the FCP to apply different filter settings to different ranges of channels. You cannot edit the filter settings "in place" in the spreadsheet, but you will find that it is usually easier to do so from the FCP. Note that in addition to the toolbar and menu items for the FCP that were previously mentioned, you can also access it from the right-button popup menu in the spreadsheet:

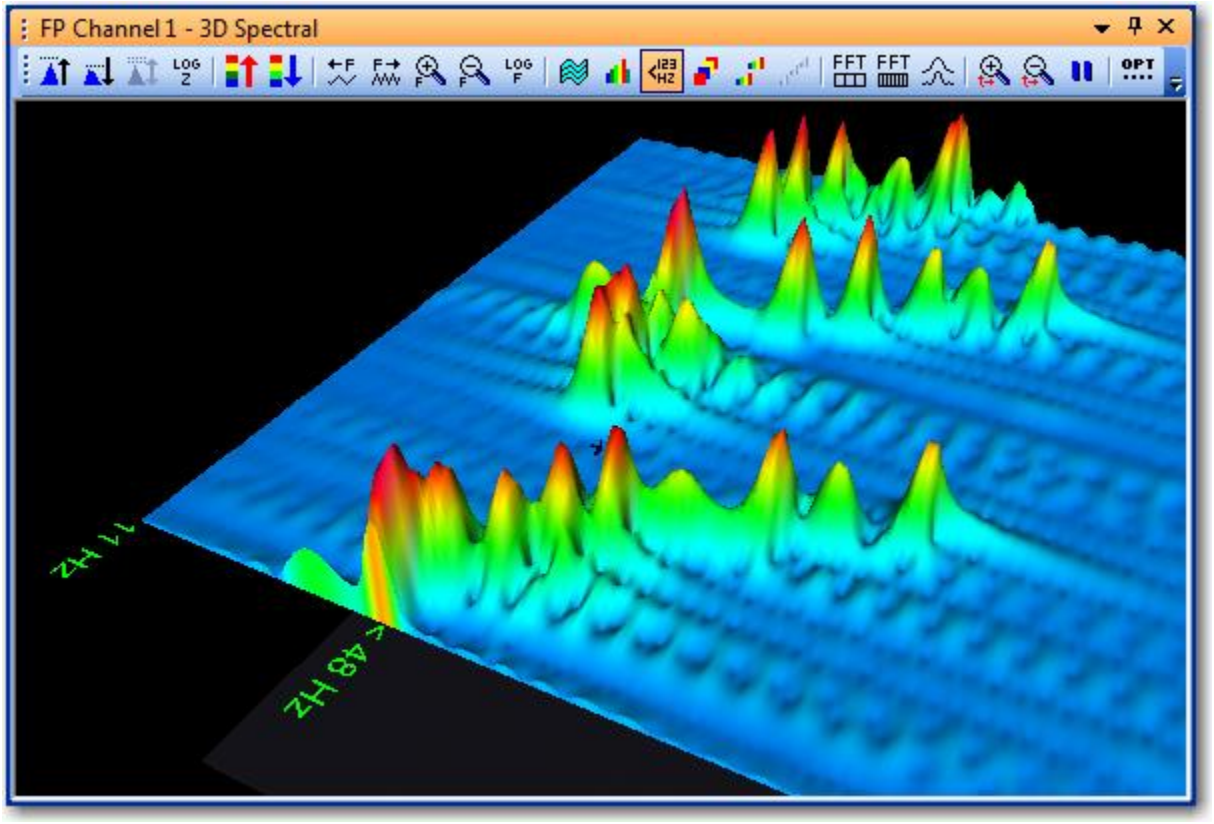


	Name	LPF	LP Freq	LP Type	LP Poles	HPF	HP Freq	HP Type	HP Poles
>>1	FP01	On	200.0	Bessel	4	Off	---	---	---
2	FP02	On	200.0	Bessel	4	Off	---	---	---
3	FP03	On	200.0	Bessel	4	Off	---	---	---
4	FP04	On	200.0					---	---
5	FP05	On	200.0					---	---
6	FP06	On	200.0					---	---
7	FP07	On	200.0					---	---
8	FP08	On	200.0	Bessel	4	Off	---	---	---
9	FP09	On	200.0	Bessel	4	Off	---	---	---

The sort quality metrics and options will be described in a separate section.

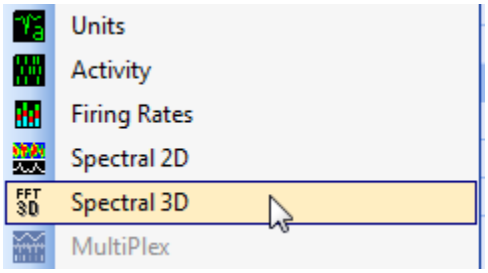
Spectral 3D view

The *Spectral 3D* view is a 3D generalization of the *Spectral 2D* (scrolling spectrogram) view. In the *Spectral 2D* view, spectral power at a given time (X position) and frequency (Y position) is displayed as a color, where blue represents low power and red represents high power. In the *Spectral 3D* view, power is displayed as the relative height of points on a 3D surface (Z position above the X/Y plane), and/or as a color. In other words, the same spectral information is presented in the 2D and 3D spectrograms, and both are based on a short time FFT (STFFT), but the 3D version can be more visually intuitive and expressive.

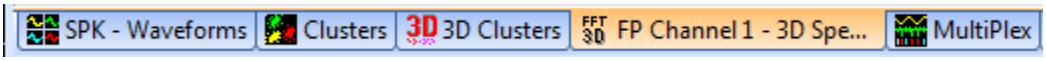


If you are not familiar with the *Spectral 2D* view, you may wish to consult the relevant section in the User Guide, since many of the concepts and features in the Spectral 3D view, such as FFT size and window functions, are the same, and will not be covered in detail here. Also, the basic 3D view manipulation techniques, such as rotating the view and zooming in and out using the mouse, are the same as in the other OmniPlex 3D views, such as the *Clusters 3D* and *Spike Sample Histogram 3D* views, and will only be mentioned briefly.

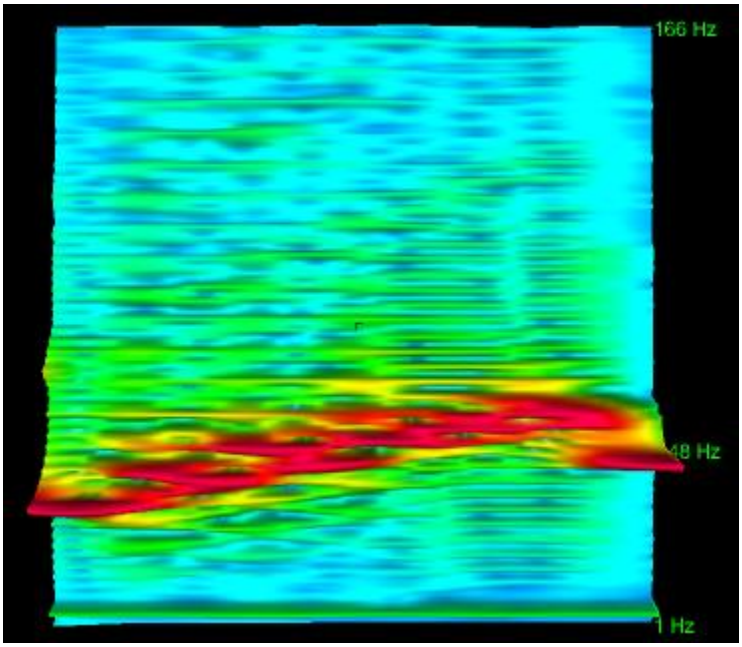
Note that the *Spectral 3D* view is not created by default in PlexControl. You must manually create the view with the *Spectral 3D* command in the View menu:



This creates a floating view which you can then move and dock with the other views. A common layout is to dock it with the multichannel spike, cluster, and spreadsheet views:

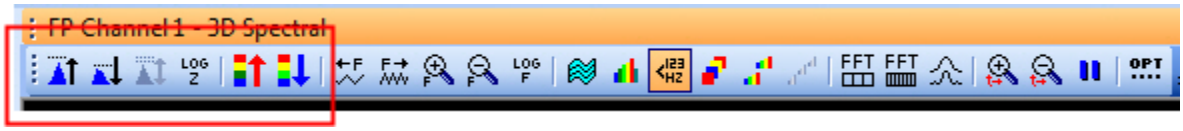


Note that the initial 3D viewing angle for the Spectral 3D view is “straight down,” as if you were looking at the flat Spectral 2D view.

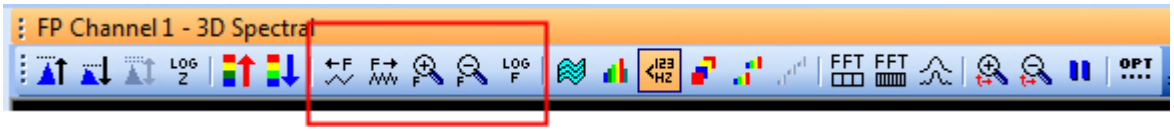


Press the left mouse button and move the mouse to rotate the view. Press the left mouse button, hold down the SHIFT key, and move the mouse to shift the view left/right/up/down. Use the mousewheel to zoom in and out. Clicking both mouse buttons together will reset the view to the default.

The features and options of the Spectral 3D view are accessed through the toolbar and the options dialog box. The following is a summary of the toolbar features:

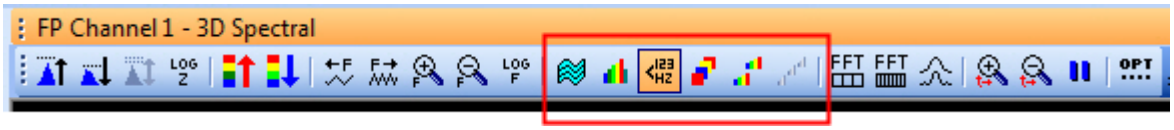


- Scale surface height up
- Scale surface height down
- (reserved for future use)
- Toggle logarithmic height mode
- Scale surface colors towards red
- Scale surface colors towards blue



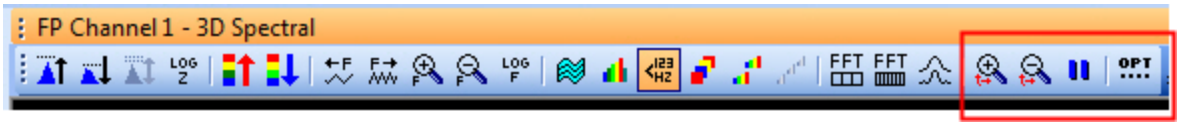
- Shift frequency range lower
- Shift frequency range higher
- Zoom in (narrower frequency range)
- Zoom out (wider frequency range)
- Toggle logarithmic frequency mode

  Note that unlike the *Spectral 2D* view, frequency zooming and shifting (offsetting) are done with toolbar buttons, not mouse moves in the display. This is because the mouse is already being used for 3D view manipulation.



- Toggle surface grid (see below)
- Toggle bar graph on front edge of surface (see below)
- Toggle peak-frequency indicator (tracks the FFT bin with maximum amplitude)
- Toggle surface/slice mode
- Decrease the number of FFTs displayed (default: 256, front to back)
- Increase the number of FFTs displayed

- Decrease the number of bins per FFT (coarser frequency resolution)
- Increase the number of bins per FFT (finer frequency resolution)
- Select FFT window function (each click cycles to the next window function)

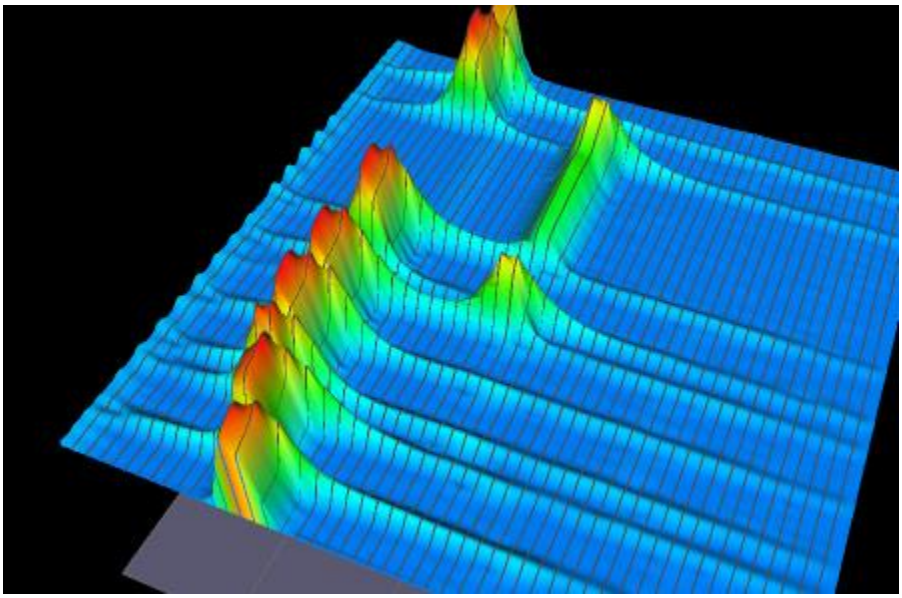


- Sweep faster
- Sweep slower
- Pause (only this display)
- Display the *Options* dialog (see below)

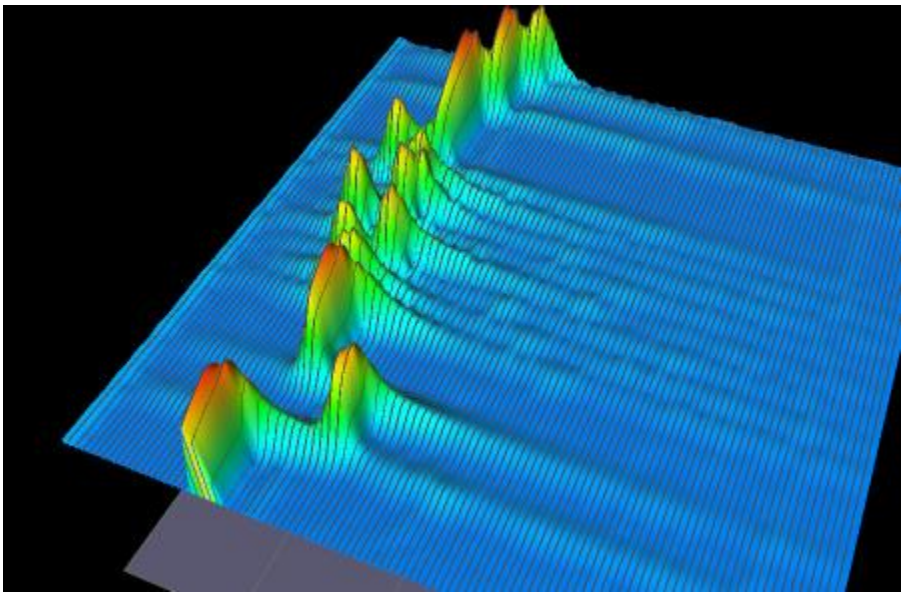
Display features - surface grid

When the surface grid is enabled, the spacing between grid lines represents FFT bins. Note that for very large numbers of FFT bins, the grid is not drawn.

Fewer FFT bins:



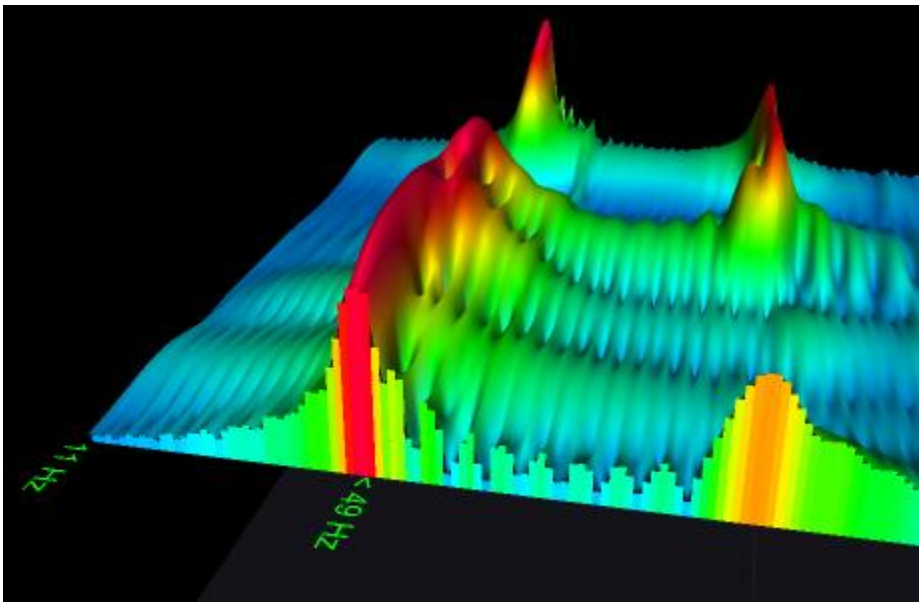
More FFT bins:



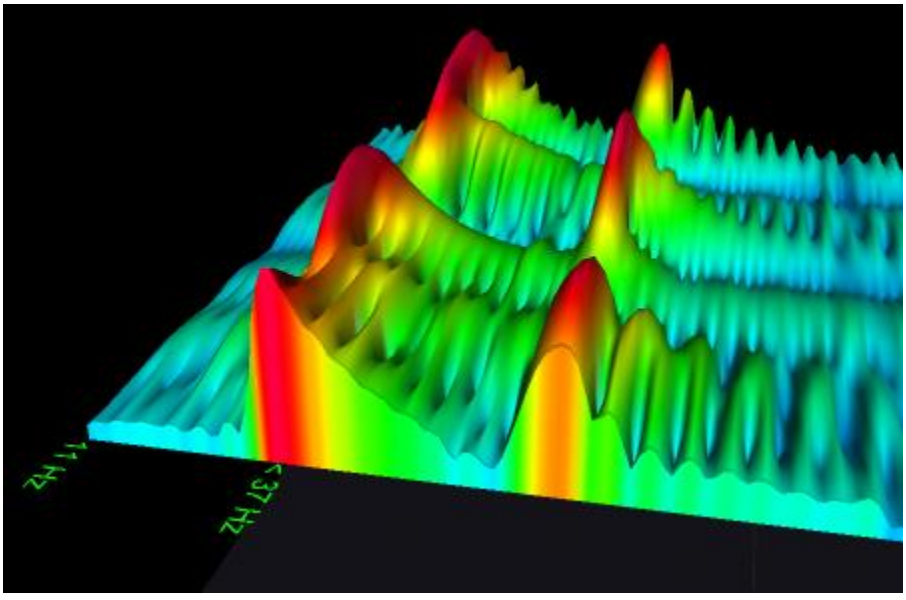
Display features – bar graph

By default, the “front edge” of the 3D surface, representing the most recently acquired FFT, is displayed as a smoothly interpolated surface, with interpolated colors across its face. However, in bar graph mode, the FFT is shown as a bar graph, with each bar as a single solid color.

Bar graph mode:

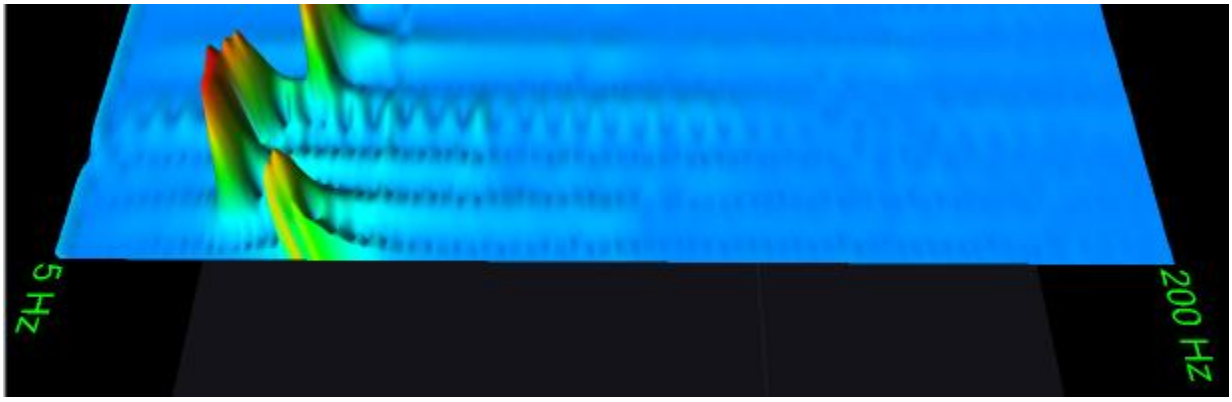


Default mode:

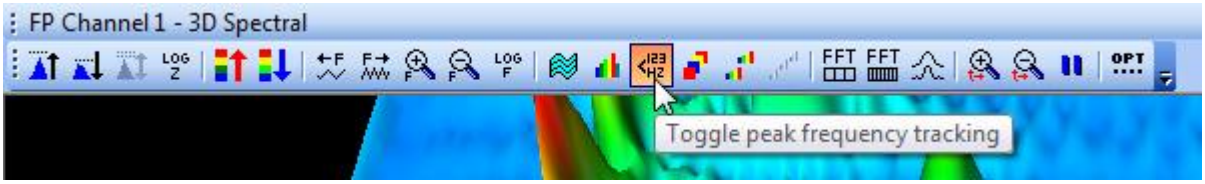


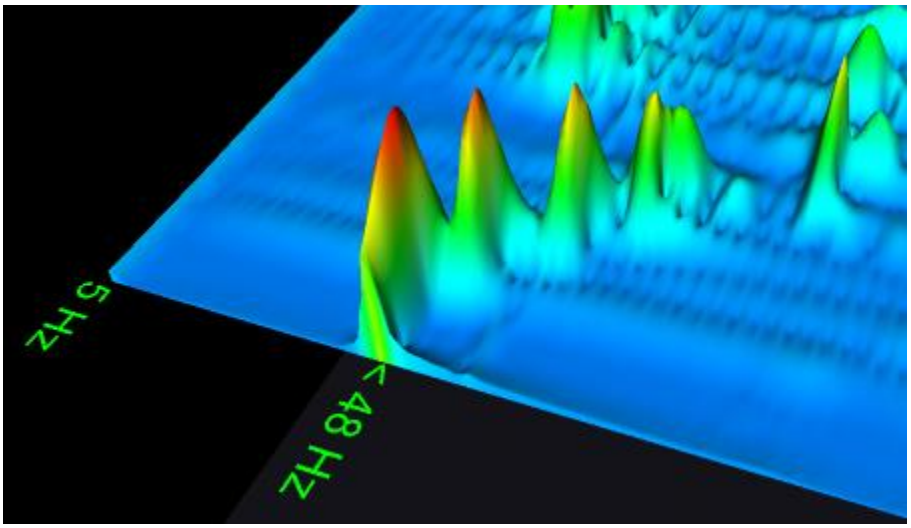
Display features – frequency labels

Labels are shown at the two corners of the spectrogram which represent the highest and lowest frequencies displayed, at the most recent time, i.e. the newest FFT.



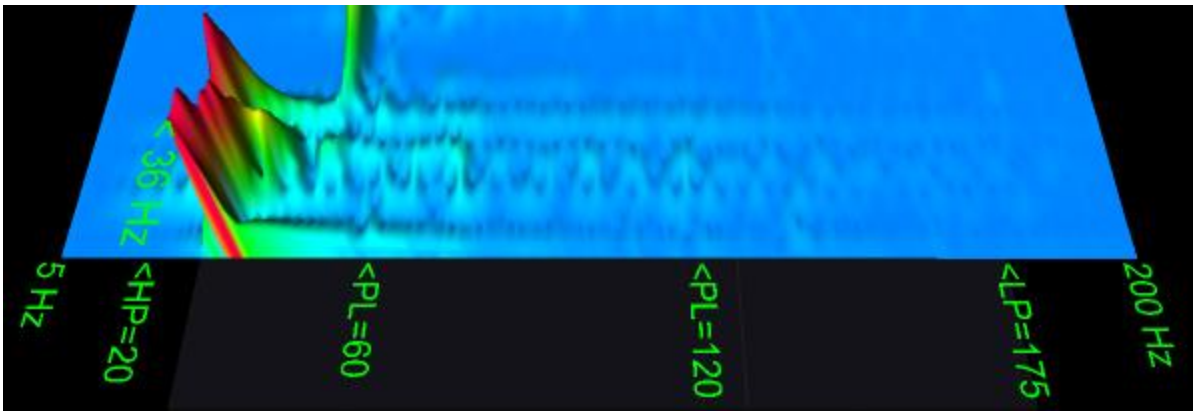
In addition, a toolbar button can be used to toggle peak frequency tracking, which displays a live indicator showing the frequency bin with the highest amplitude in the most recent FFT:





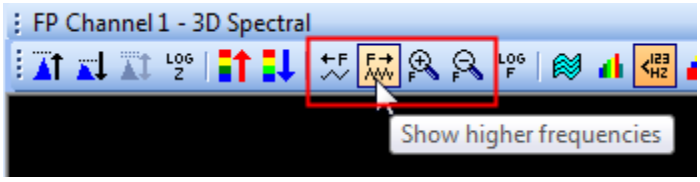
If highpass, lowpass filters, and/or the power line noise filter are enabled, you will see frequency labels for these items as well, as long as their frequencies are within the currently visible range. For example, here frequencies from 5 – 200 Hz are being displayed, with the following filters enabled:

- highpass filter at 20 Hz ("<HP=20")
- lowpass filter at 175 Hz ("<LP=175")
- power line noise filter at 60 Hz with second harmonic at 120 Hz ("<PL=60" and "<PL=120")



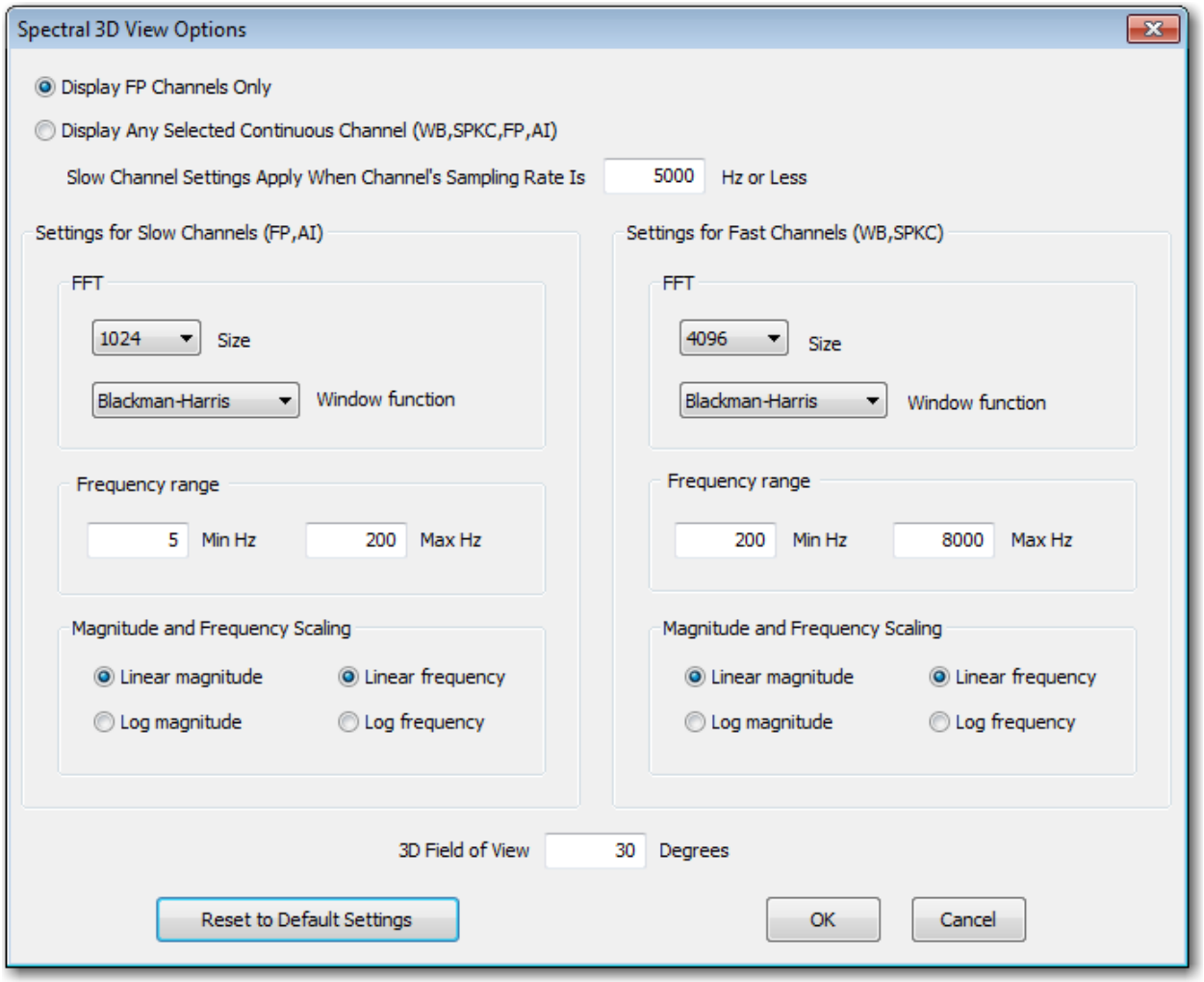
When the highpass, lowpass, and/or power line noise filters are labeled, note that the peak frequency indicator is drawn at the peak bin's height, rather than "on the ground," where it would be more likely to overlap the other labels. It is normal for the peak label to float up and down as the amplitude at the peak bin varies.

Remember that you can use the frequency zoom and shift controls in the toolbar to adjust the range of frequencies displayed, within the range of 0 Hz to half the sampling rate. For example, to shift the display towards higher frequencies:



Spectral 3D options

The *Options* dialog contains settings for FFT size, window function, frequency range, and scaling of magnitude and frequency. Note that there is a logarithmic frequency scaling option which is not present in the *Spectral 2D* view; this is mainly useful when viewing the spectrogram of wideband or spike-continuous signals. Field potentials are commonly viewed on a linear frequency scale.



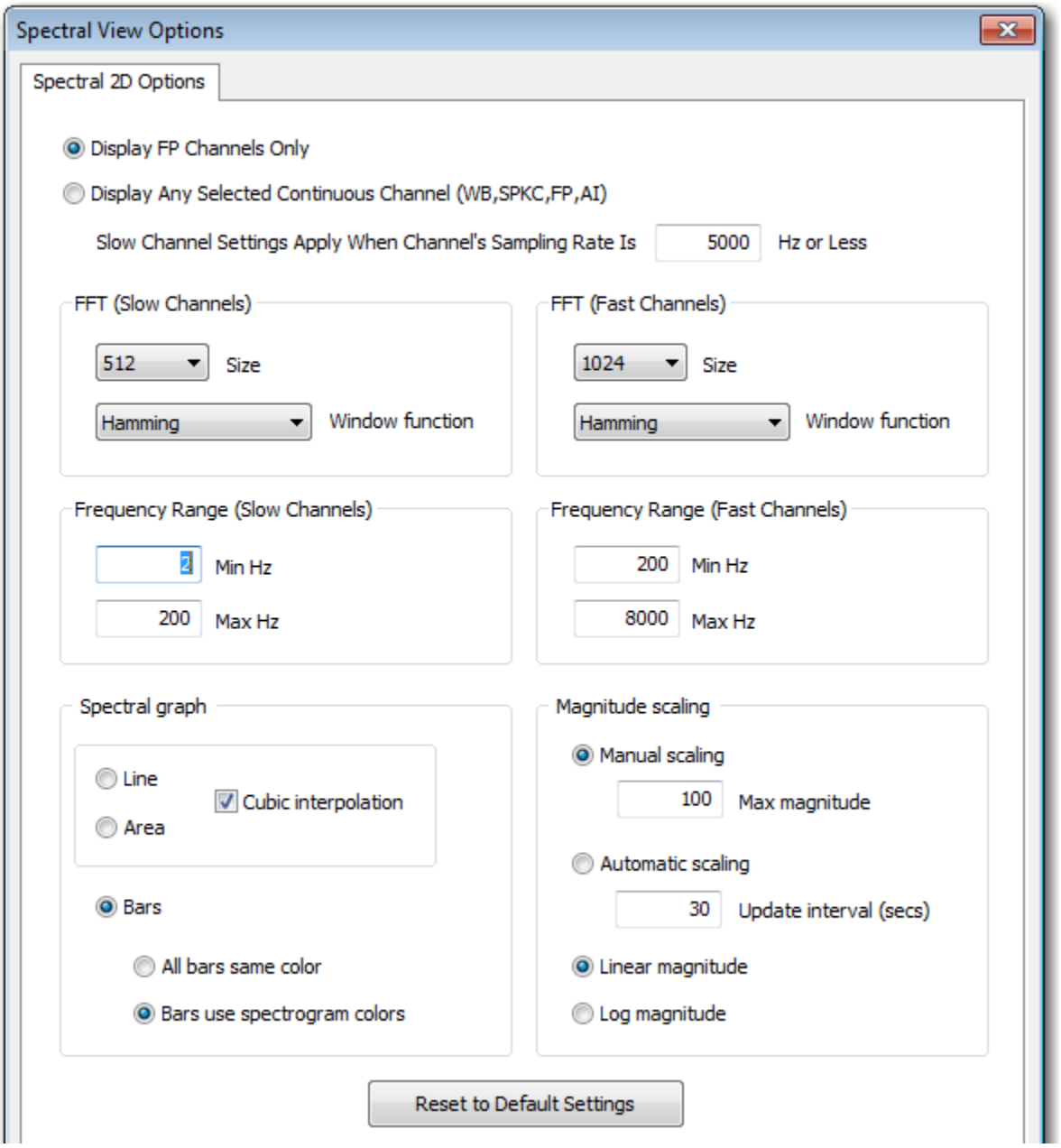
You can "lock" the spectrogram to the FP source with the *Display FP Channels Only* option, or allow it to follow the currently selected continuous source (WB, SPKC, FP, AI, or AIF) with the *Display Any Selected* option. In the latter mode, you can define separate settings for "fast" and 'slow" channels, based upon whether the selected continuous source's sampling rate is above or below a specified frequency. This removes the need to manually set appropriate frequency ranges, FFT sizes, etc, each time you switch between fast and slow sources.

The *3D Field of View* option allows you to in effect control the "camera angle," where larger values give a wide-angle lens effect, and smaller angles give a telephoto effect. You can think of larger FoV angles as "more perspective."

The *Reset to Default Settings* button restores all of the options in the dialog to their default values.

Wideband or "fast channel" mode in spectrograms

As mentioned in the section on the *Spectral 3D* view, spectrograms can either be "locked" to view only the FP source, or can view the spectra of any continuous source, including wideband (WB), spike-continuous (SPKC) or AuxAI (AI / AIF). Similar to the *Spectral 3D* view, the Options dialog for the *Spectral 2D* view now has separate sets of options for "fast" and "slow" channels, and you can define the sampling rate "breakpoint" between fast and slow channels:

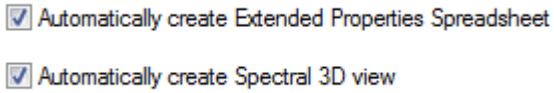


When you update from previous versions of OmniPlex, your current Spectral 2D options will appear as the slow channel options.

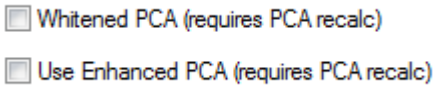
Additional PlexControl global options

The following options have been added to PlexControls' *Global Options* dialog.

On the *General* page, these two options determine whether certain views are automatically created on startup and when a *Create View Layout for Sources* is performed:



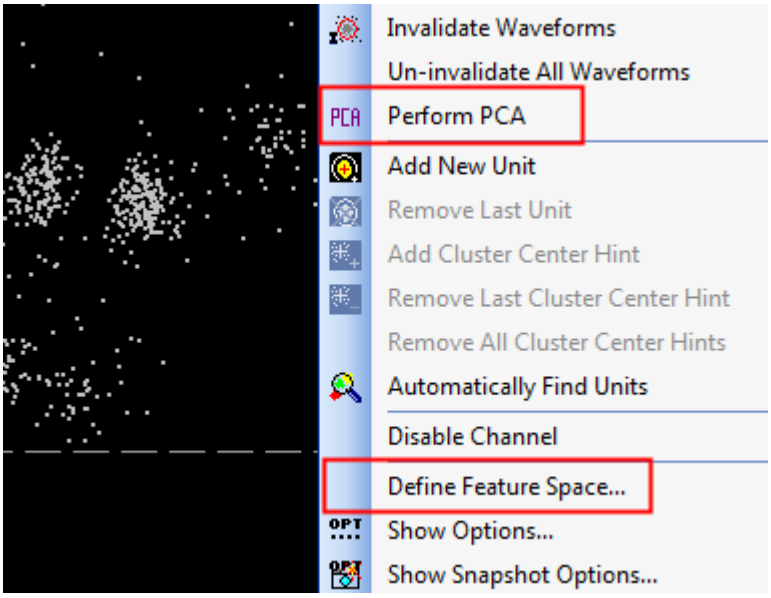
On the *Features* page, there is a new *Whitened PCA* option:



PCA whitening modifies the projection vectors used to project spike waveforms into 2D or 3D PCA space. Each projection vector is divided by the square root of its corresponding eigenvalue. This has the effect of making the PCA projection of the spike snapshot have unit variance in each direction. For this reason, PCA whitening is sometimes referred to as "sphering" the data.

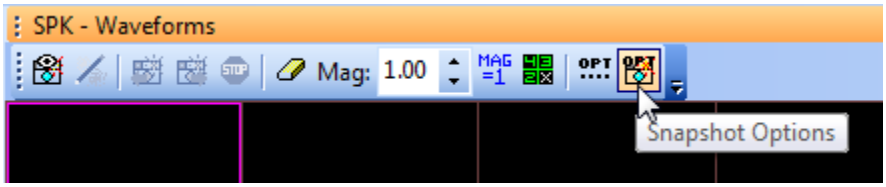
The effect of whitening is data-dependent, but it can improve the performance of auto-sorting. Whitening can be applied to either standard or enhanced PCA, i.e. the *Whitened* and *Enhanced* options are independent and can be combined.

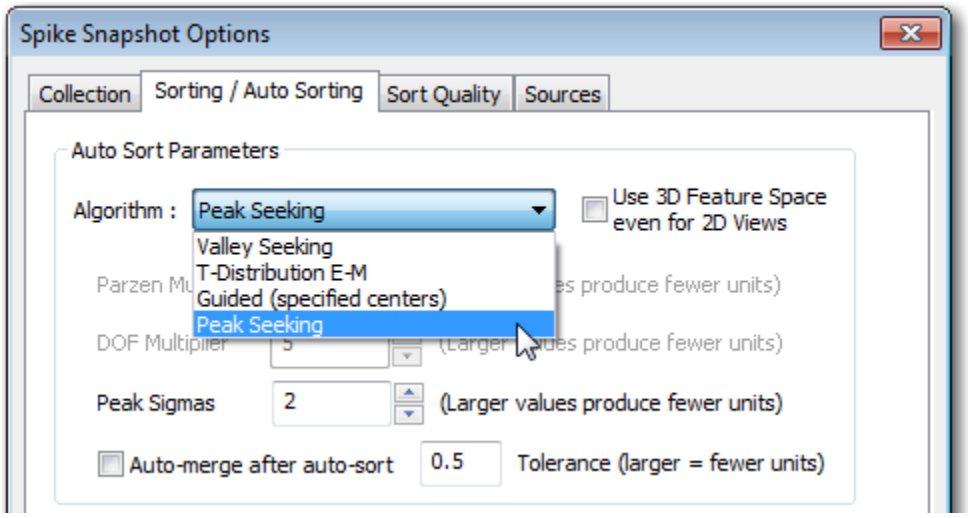
To experiment with the PCA options, capture a spike snapshot and view the PCA clusters in either the 2D or 3D cluster views. *Define Feature Space* and *Perform PCA* are available on the right button popup menu, and Perform PCA is also available as a toolbar button. Viewing the snapshot rather than the live PCA makes it easier to see the effect of the options.



Peak seeking automatic spike sorting

Peak seeking is a robust non-parametric, density-based automatic spike sorting method. It is based on the concept that good cluster centers are points of high local density which are maximally distant from points of higher density. You can select peak-seeking from the list of auto sort algorithms in the *Sorting / Auto Sorting* page of the *Spike Snapshot Options* dialog:





Similarly to the other automatic sorting algorithms, peak seeking has a tuning parameter, in this case named *Peak Sigmas*, which controls the sensitivity of the algorithm. The default value of 2 will usually detect reasonably well-defined clusters and will avoid overfitting. Larger values will detect only the largest and most well-defined clusters, and so are even "safer," but low density clusters may be missed. A value of 1 will result in more clusters being found; values less than 1 are generally not recommended.

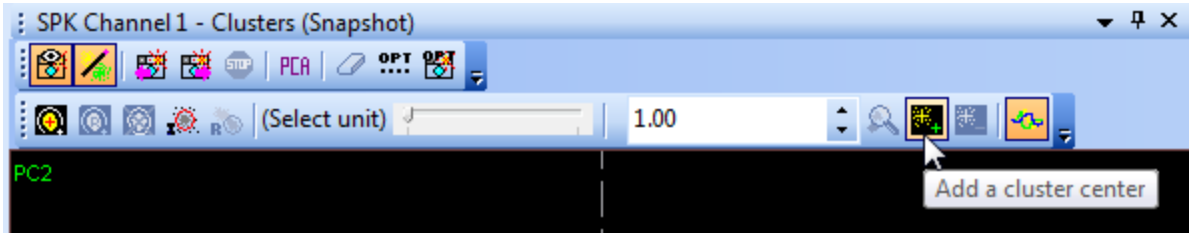
There is also an optional *auto-merge* step that post-processes the clusters found by peak seeking, merging clusters with similar templates (note that this works even if you are not using template sorting). Peak seeking using low values of *Peak Sigmas* can detect clusters that are the result of sampling jitter (note: use aligned extraction to minimize this jitter). These can be faintly distinct clusters in feature space that are in fact the waveforms from a single unit.

Because such clusters may have mean waveforms that are similar in shape but slightly offset in time, standard Euclidean distance is a poor similarity metric for auto-merging them, and OmniPlex instead uses a distance measure which accounts for minor time offsets between templates. When you enable *Auto-merge after auto-sort*, you can specify the merge tolerance, where larger values result in more merges being performed and therefore fewer units. Typical values for the merge tolerance are in the range 0.5 – 1.0. Please note that if you use the default *Peak Sigmas* value of 2, auto-merging is usually not needed and should be left disabled.

Guided (semi-automatic) spike sorting

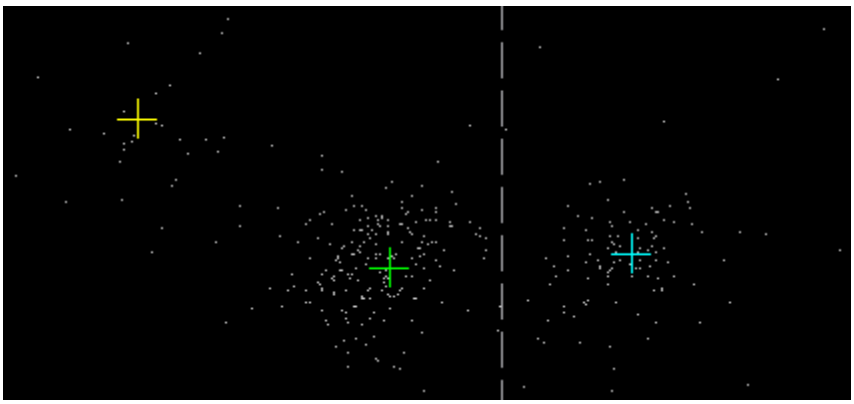
Guided sorting is listed in the dropdown *Algorithm* control shown in the section on peak seeking, but it is in fact a semi-automatic method for defining units. Like the fully automatic methods, it classifies (clusters) spikes in the spike snapshot. However, Guided sorting requires "hints" from you, in that you click the mouse to indicate the approximate center of each unit's cluster. In other words, you provide the initialization for the automatic sorting algorithm. This can be useful in situations where some units fire very infrequently, making them difficult for a fully automatic method to find, and/or clusters are very poorly separated, leading to sub-optimal results from the fully automatic methods.

To use Guided sorting, select it from the *Algorithm* dropdown, click OK, then go to the *Clusters 2D* view, enter unit editing mode and view the snapshot. You will notice that the *Find Units* toolbar button and menu item are initially grayed out, because you haven't defined any cluster centers yet. However, the *Add a Cluster Center* button to its right is enabled. Click this button to begin defining clusters:

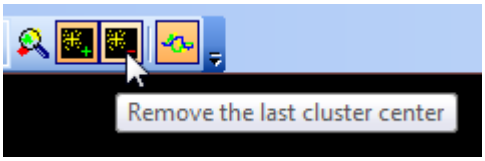


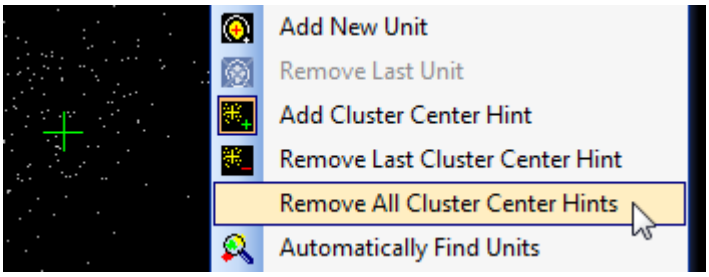
The cursor changes to a crosshair cursor:

When you click on a cluster center, the center position is shown as a colored crosshair marker. Each click defines the approximate center of a unit. Note that no spikes have been sorted yet.



If you want to remove the last cluster center (i.e. undo it), or start over, there is a toolbar button for *Remove Last Cluster Center*, and there are right-button menu items for removing the last or all centers:





When you are done defining all the cluster centers, click *Automatically Find Units*, either from the menu or the toolbar, to define units based on the hints you provided. Guided sorting is guaranteed to find the exact number of clusters you specified and unless you provide a very poor set of hints (e.g. clicking between clusters instead of near their centers), will result in cluster means that are close to the center hints you provided.

Note that the cluster center hints are temporary; they only exist until you click Find Units. They cannot be edited (except for removing the most recent hint), and if you switch to a different channel while in the middle of adding hints they will be removed.

Once you have familiarized yourself with Guided sort, you will find that defining units this way can be very fast, since you don't have to draw contours around clusters, only click once for each unit.

Spike sorting quality metrics

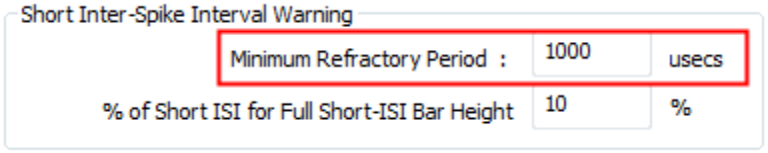
OmniPlex can calculate one or more of a set of metrics which are intended to measure the quality of unit clusters in feature space. There are multiple metrics because there is no universal agreement on the best criteria for cluster quality, although as of this writing, Isolation Distance and LRatio are widely used. A detailed description of these metrics can be found in the Plexon Offline Sorter User Guide.

OmniPlex displays the sort quality metrics in the right hand part of the Extended Properties Spreadsheet.

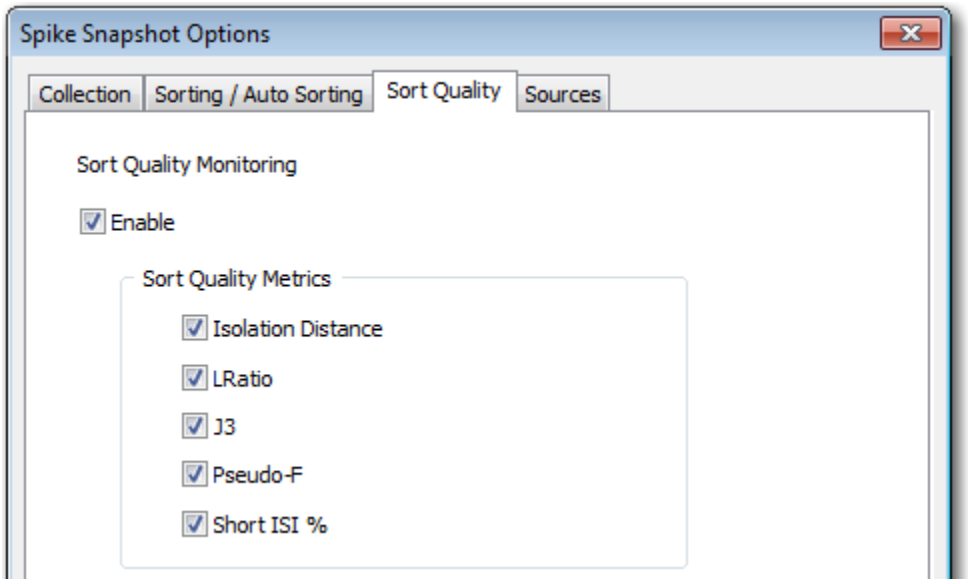
Extended Properties Spreadsheet for 'SPK'

	Name	LPF	LP Freq	LP Type	LP Poles	HPF	HP Freq	HP Type	HP Poles	Iso Dist	LRatio	J3	PseudoF	Short ISI
>>1	SPK01	Off	---	---	---	On	300.0	Bessel	4	4.895	0.184	0.951	2.788	0.71
2	SPK02	Off	---	---	---	On	300.0	Bessel	4	3.222	0.357	0.842	2.657	0.24
3	SPK03	Off	---	---	---	On	300.0	Bessel	4	5.085	0.051	1.225	2.891	0.98
4	SPK04	Off	---	---	---	On	300.0	Bessel	4	5.185	0.095	1.019	2.815	0.95
5	SPK05	Off	---	---	---	On	300.0	Bessel	4	4.398	0.205	0.977	2.800	0.71

Note that in addition to *Iso Dist*, *LRatio*, *J3*, and *Pseudo-F*, which are all cluster quality metrics calculated in feature space, the last column, Short ISI, is the percentage of spikes whose interspike interval (ISI) is less than the *Minimum Refractory Period* defined in the Units window options:

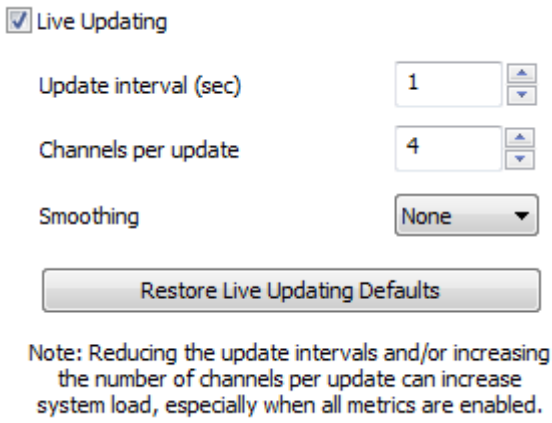


You can choose which metrics are displayed using the Sort Quality page of the spike snapshot Options dialog:



Disabling metrics that are not of interest simplifies the spreadsheet (the corresponding columns are not displayed) and reduces the amount of processing needed to periodically update the metrics, which can be an issue at high channel counts or fast update rates.

OmniPlex calculates the metrics whenever units are added or removed on a channel, based upon the most recent sorting of the channel's spike snapshot. It can also periodically recalculate the metrics based on the sorting of the live incoming spikes. This is done by recalculating the metrics on the most recent spikes on each channel, 500 spikes per channel by default. Since some metrics are somewhat expensive to calculate, particularly Isolation Distance and LRatio, this is done on a rolling scheme whereby a given number of channels are periodically updated. For example, by default, each second the next four channels are updated:

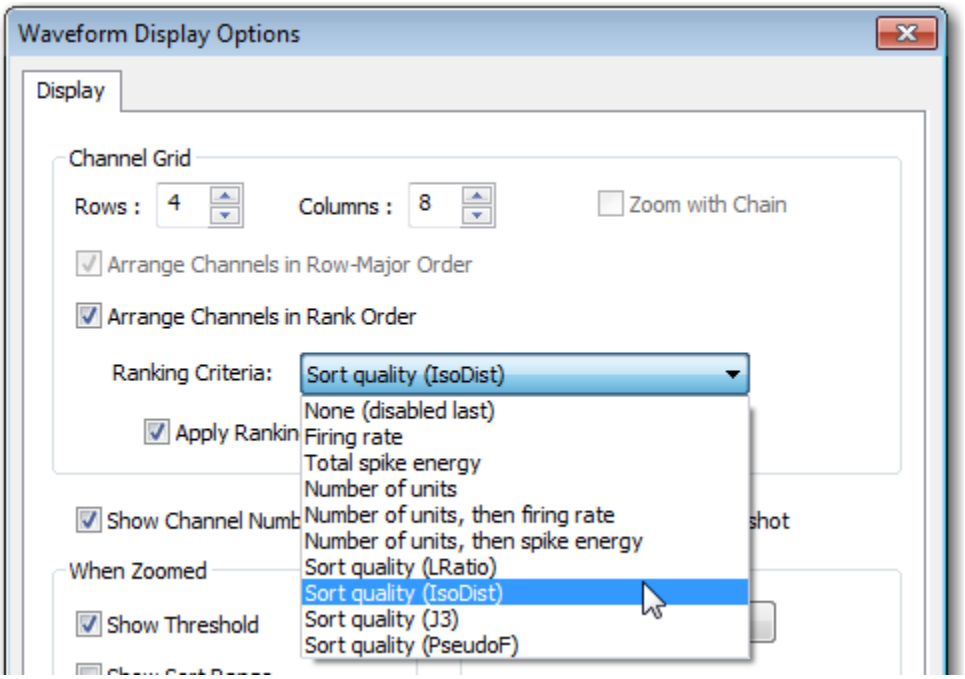


Therefore, on a 32 channel system, it will take eight seconds to update all 32 channels. The default is fairly conservative (a moderate update rate) but you should increase the update rate with caution.

By default, each time a channel's metrics are recalculated, the results based on the most recent 500 spikes are displayed. In some cases, you may wish to apply a moving average filter to smooth the results. If a *Smoothing* option other than *None* is selected, a moving average of the previous metric and the most recent metric is performed.

Channel ranking based on sort quality metrics

You can use any of the sort quality metrics as the criteria for channel ranking. To do so, simply select the desired metric from the dropdown list:

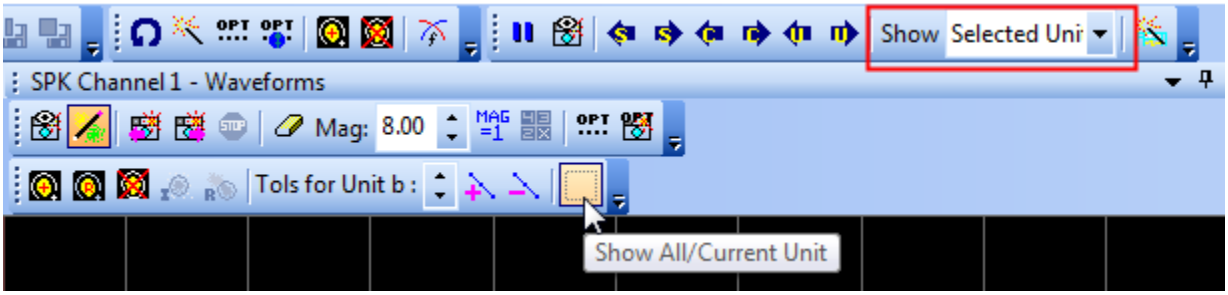


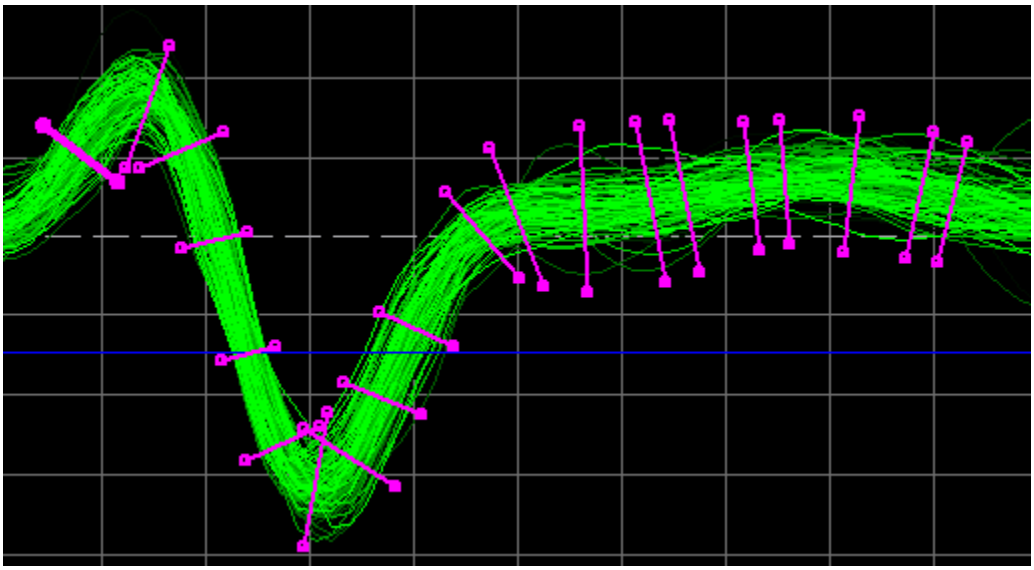
Recall that channel ranking is calculated from the spike snapshot and is not updated from the live data.

Enhancements to line and 2D polygon sorting

Automatic spike sorting for line sorting method

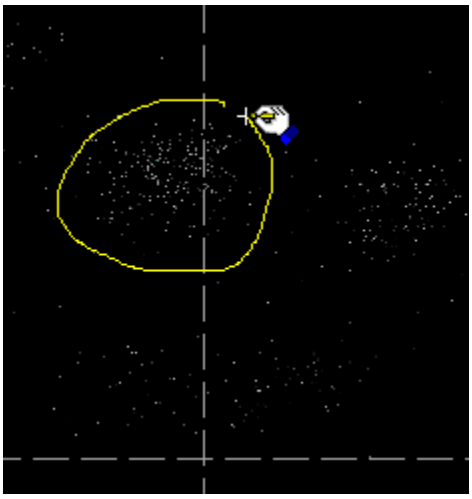
Automatic spike sorting can now be used with the line sorting method. The result is a set of sorting lines that follow the "path" of the spike waveforms for each unit. In the following picture we have set the Show Filter to Selected Unit and set Show All / Show Current Unit to Show Current Unit, to remove the waveforms and sorting lines for the other units on this channel.

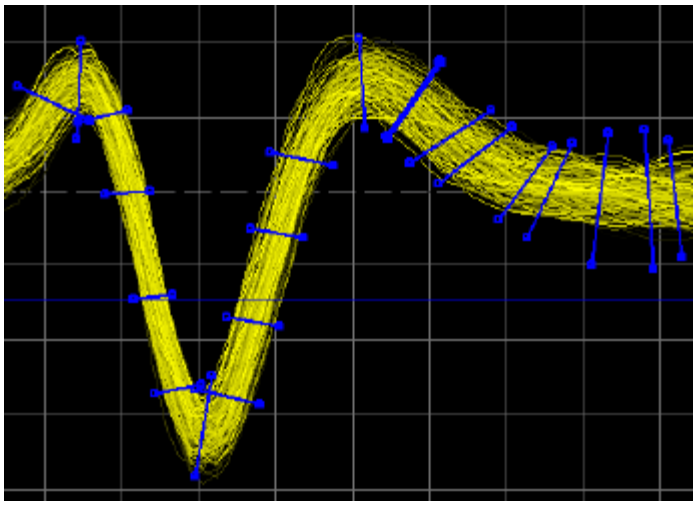




Defining line sorting units by drawing contours in cluster views

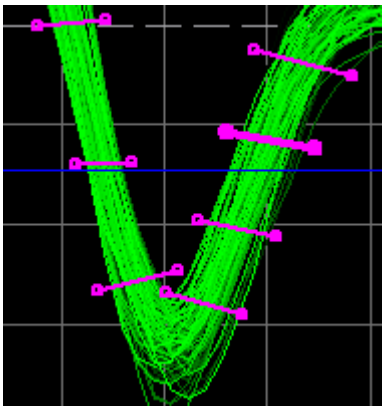
You can also define line sorting units by drawing contours around clusters in feature space, in the same way as for the other sorting methods (except box sorting, which does not support this, nor can it be used with automatic spike sorting). OmniPlex will generate sorting lines for the spikes enclosed in the drawn contour, using the same algorithm that is applied to the output of the automatic sorting algorithms.



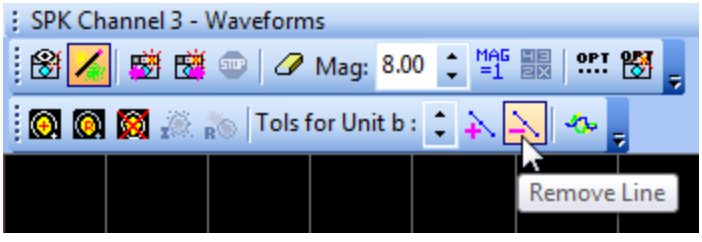


Enhancements to line sorting editing

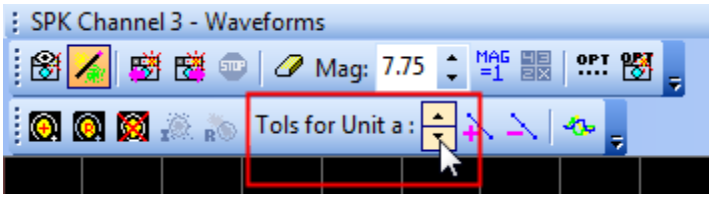
In line sorting, the currently selected sorting line is displayed as a thick line.

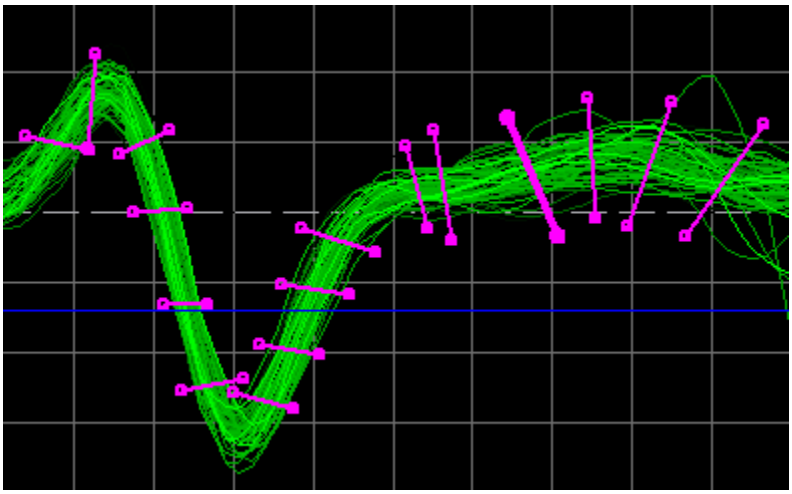


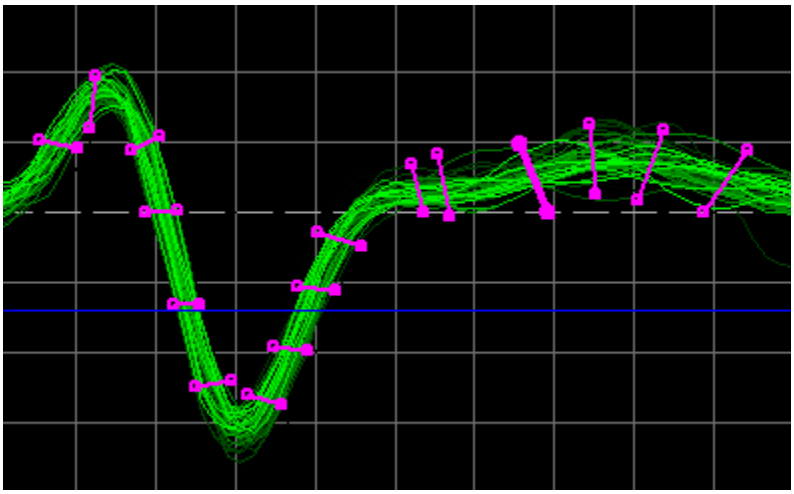
When you click on either endpoint of a line, or drag either of its handles, it automatically become the selected line. The Remove Line toolbar button always deletes the currently selected line. For example, if you wish to delete a line that was created by an automatic sort, click on an endpoint of that line and then click the Remove Line button.



You can now use the spin arrows in the unit editing toolbar to make all the sorting lines for a unit longer or shorter, similar to adjusting band tolerances in band sorting. This example shows the tolerances being reduced, i.e. shortening all sorting lines:

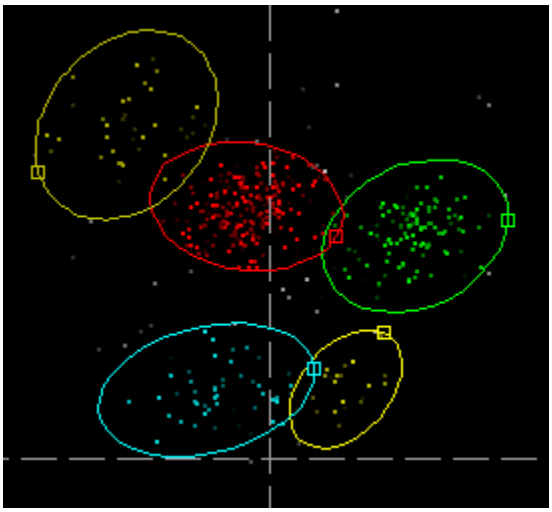




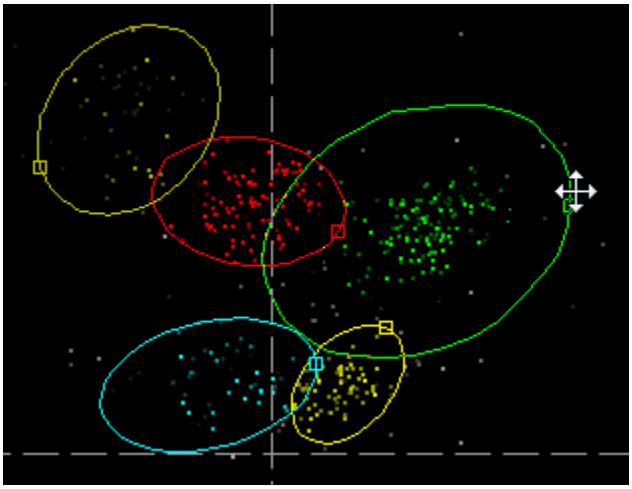


Resizing of 2D polygon contours

You can now adjust the size of a sorting contour in 2D polygon sorting, whether it was manually drawn or is the result of an automatic sort. To do so, you must be in unit editing mode, so that a square handle is displayed on the each unit's contour:



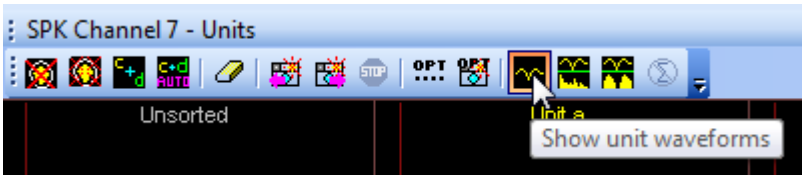
As in previous versions of OmniPlex, you can drag the handle to move the contour, or SHIFT-drag to rotate it. In addition, you can now resize the contour by holding down both SHIFT and CTRL while dragging towards or away from the center of the contour.



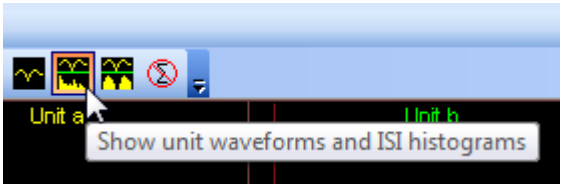
The combination SHIFT-CTRL is used because CTRL-drag is already in use as a shortcut for drawing a new unit's contour.

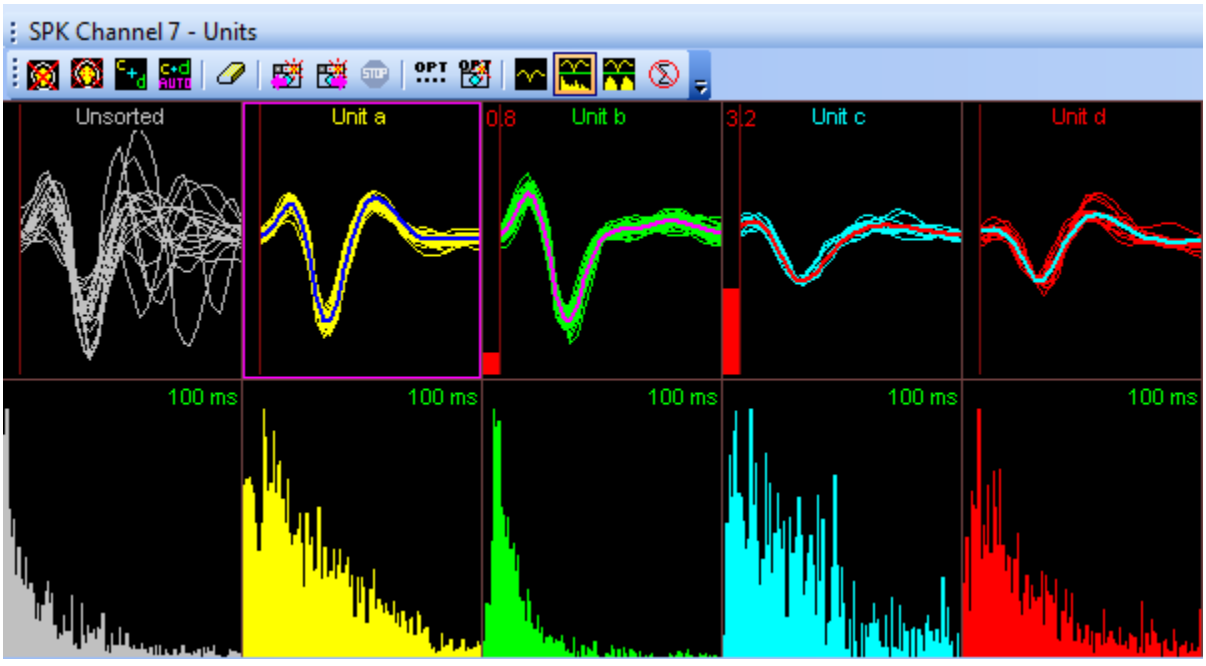
Live ISI and autocorrelation histograms

The *Units* view can now optionally display either per-unit interspike interval (ISI) histograms or autocorrelograms, in addition to the usual unit waveforms. These provide an additional means for monitoring spiking activity and verifying correct sorting. Three toolbar buttons set the display mode to waveforms-only, waveforms and ISI histograms, or waveforms and autocorrelograms.

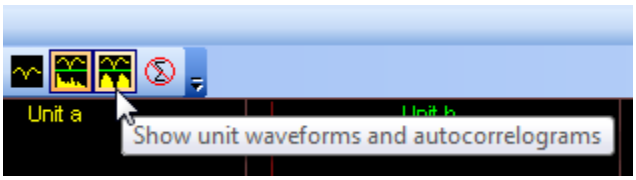


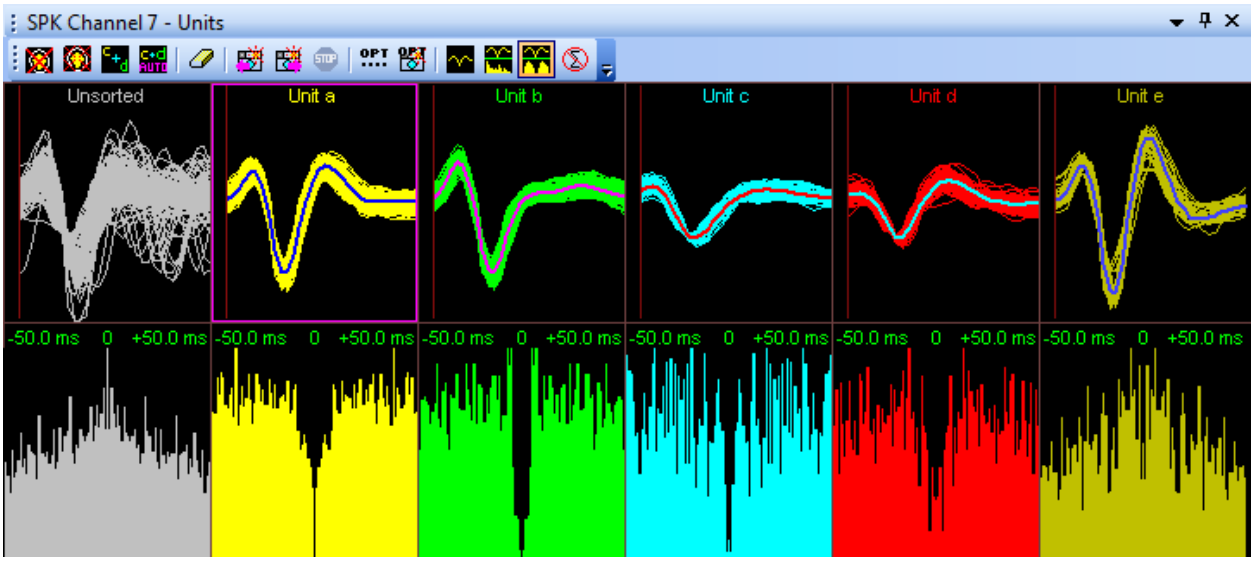
To display ISI histograms:



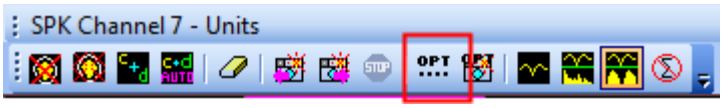


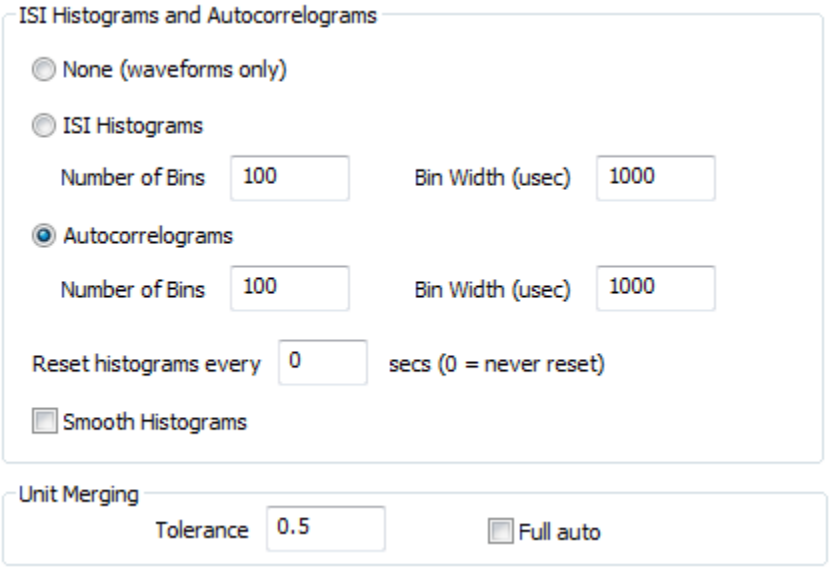
To display autocorrelograms:





Options for the ISI histograms and autocorrelograms can be configured in the Units view Options dialog:





The total histogram time width is given by the *Number of Bins* multiplied by the *Bin Width*. If the total time is T, then for ISI histograms, the time axis runs from 0 to T. For autocorrelograms, the time axis runs from –T/2 to +T/2.

Histograms start with bin counts of 0 and by default, only increment and never reset; for stable units, this allows the bin counts to become large enough that the shape of the histogram becomes evident, but you may wish to try finite refresh times, e.g. 30 seconds, to check for changes in the histogram over time. But be aware that after a reset, the histograms will appear somewhat random until the bin counts increase.

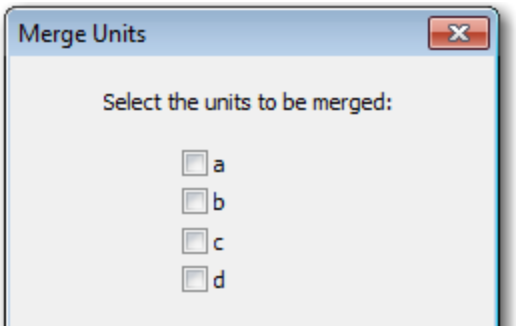
Each histogram is displayed with its height normalized, i.e. the largest bin count equals full height, no matter what that largest bin count is. This is done so that the histogram of a slowly firing unit doesn't "disappear" relative to a fast-firing unit. In other words, it is assumed that what is important, for the purposes of monitoring sorting quality, is the shape of this histogram, not the absolute height.

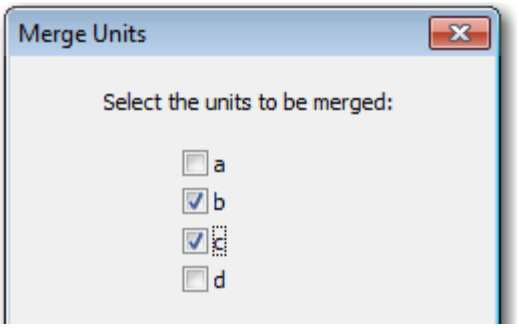
Smooth Histograms applies a simple smoothing filter to the bin counts before display. This reduces the noisiness of the histogram, but be aware that it will also smooth out the critical area near 0, and make any "notch" at 0 (a sign of a good unit) less sharp.

Manual and automatic unit merging

The *Units* view now has functions for manually or automatically merging similar units. If you know which units you want to merge, you can do a manual merge and specify exactly which units should be combined into one. To do this, click the toolbar button for *Merge selected units*:

A dialog box is displayed which allows you to select two or more units to be merged:

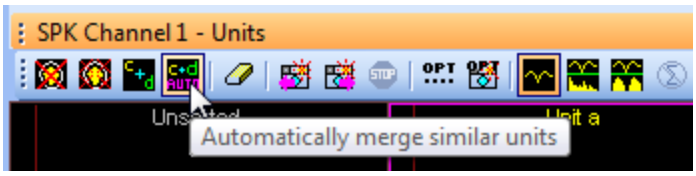




When you select the desired units and click OK, the units are merged. The results of a merge are to form the union of all the spikes in the snapshot for the specified units, and then to define a new unit from that set of spikes in the usual way for the current sorting method in effect. For example, if you merged units b and c with template sorting, the template for the merged unit will be the mean of all the waveforms in the former units b and c. The merged unit is added as the last unit for the channel, the units that were merged are deleted, and units are relabeled to remove gaps. For example, if you had units a, b, c, d and merged units b and c, the result would be:

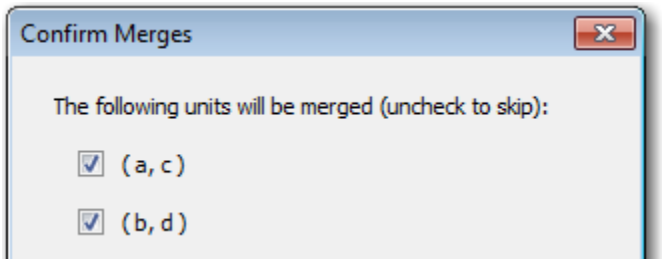
```
new unit a = old unit a
new unit b = old unit d
new unit c = merge(old unit b, old unit c)
```

There is also an automatic merge function which compares all unit templates (for one channel) against each other, finds groups of units that are similar to each other, and merges the units within each group:



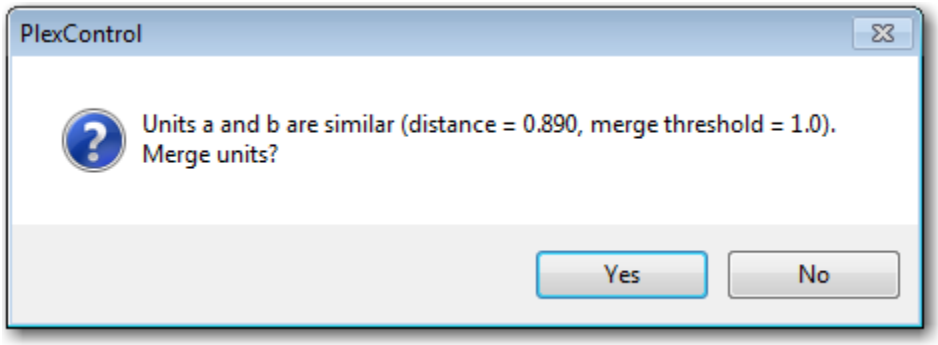
In this case, a merge tolerance (a normalized measurement of the similarity between two unit templates) is used as a threshold for similarity decisions. Typical values are in the range 0.5 to 1.5. You can control the merge tolerance using the *Tolerance* setting in the *Unit Merging* section of the *Units* view options:

When the *Allow multiple merges* option is enabled, clicking the *Automatically merge similar units* button displays a dialog showing the groups of similar units which it has found:

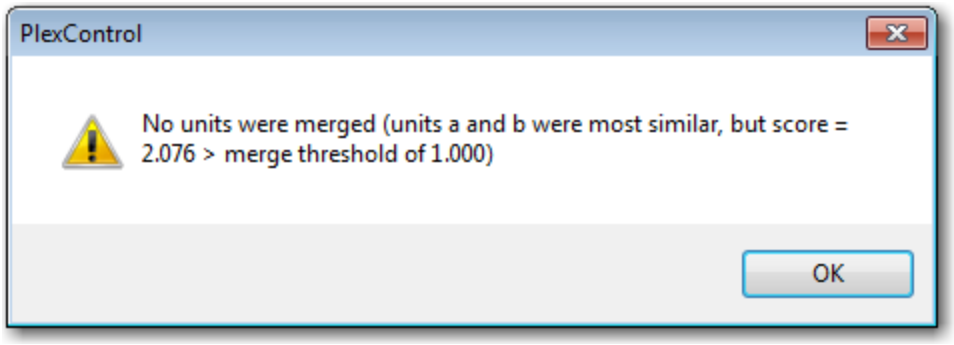


Each potential merge group (list of units which will create a new, merged unit) is shown on a separate line. Click OK to accept all the merges, or uncheck any which you do not wish to accept and click OK.

When the *Allow multiple merges* option is disabled, only the most similar pair of units (which is within the merge tolerance) is a candidate for merging, and a dialog box asks you to confirm the merge:

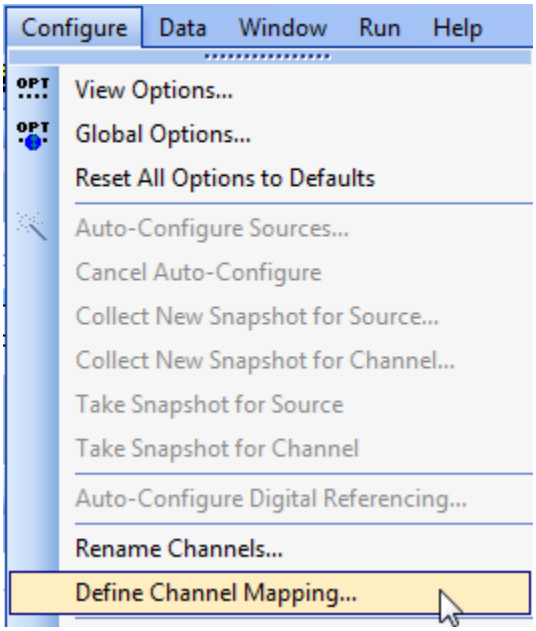


If no pairs of units were found which were within the merge tolerance, a dialog will be displayed:

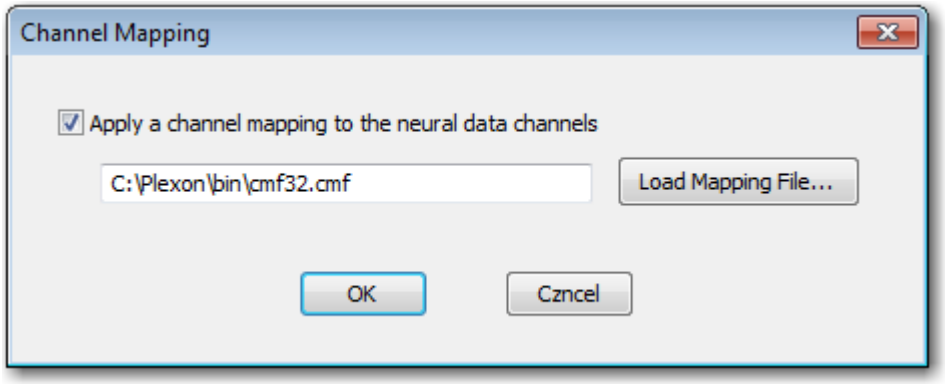


Enhancements to channel mapping (cmf files)

OmniPlex channel mapping files (cmf files) can now be specified on a per-pxc basis. In previous versions of OmniPlex, the name of the cmf file, if any, was specified in Server's Global options. This can still be done, but it is now also possible to specify the cmf file to be used via PlexControl's Define Channel Mapping menu item in the Configure menu:



This displays a dialog which allows you to specify the name of the desired cmf file.



This is similar to how the cmf is specified in Server, but has some advantages over the older method. First, you can change the cmf file while data acquisition is running, whereas doing so in Server requires stopping and restarting data acquisition. Second, when you specify the cmf file in PlexControl, the name of the cmf is saved in the PlexControl settings file (pxc file), so that the appropriate cmf is loaded for a given pxc file, as opposed to having to load both pxc and cmf files manually.

Note that the cmf file specified in Server, if any, behaves as the default cmf that is loaded when Server starts up, and if you do not manually specify a cmf in PlexControl, and do not load a pxc file that contains a cmf filename, Server's cmf determines the channel mapping.

However, if Server and PlexControl specify different cmf files, PlexControl's cmf takes priority. This is so that no matter what your cmf setup, loading a pxc which specifies a cmf always has the intended effect.

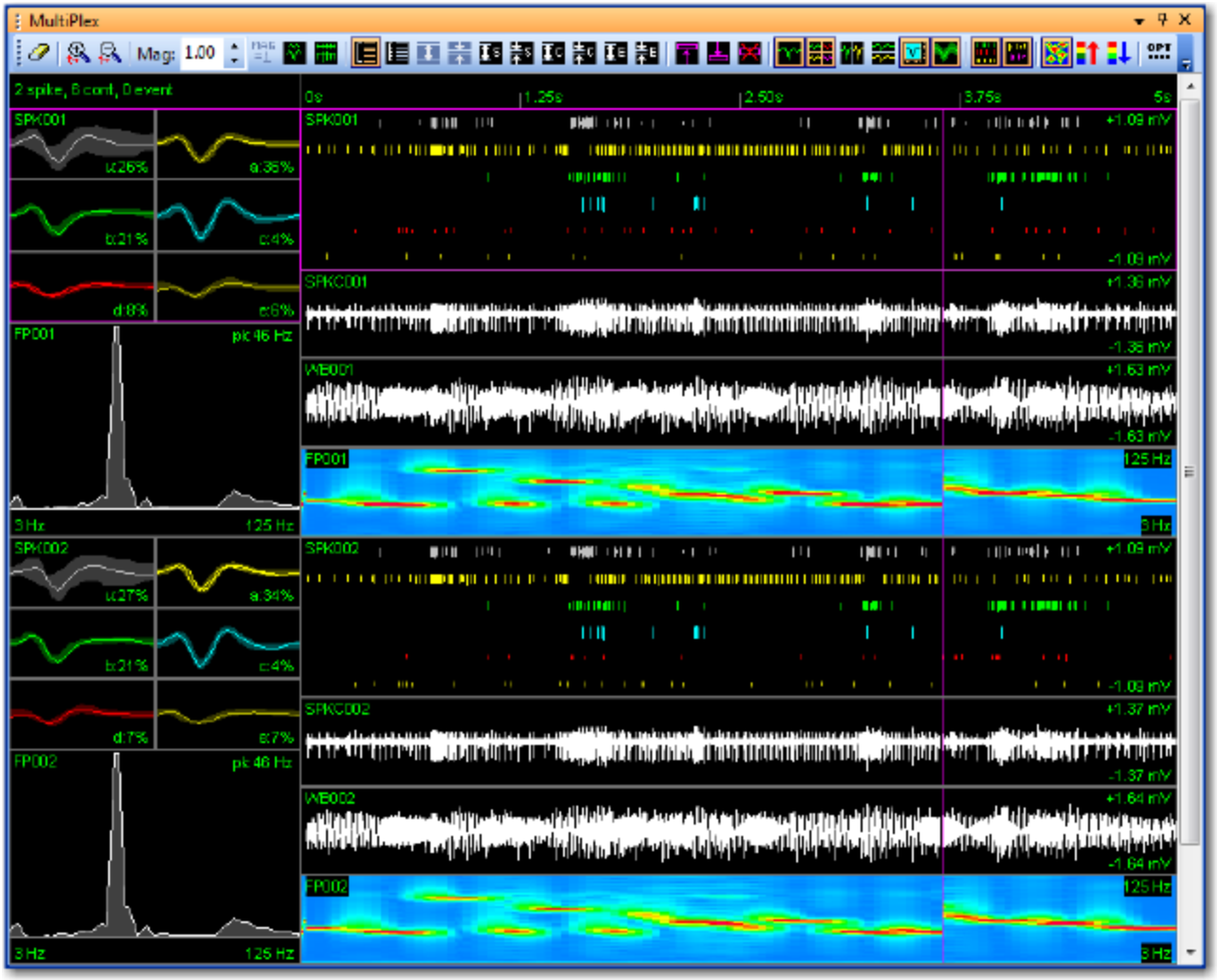
If you manually change the cmf filename in either Server or PlexControl, the cmf in both places is changed to the new filename, and the next time you save a pxc, the new cmf filename will be saved.

Remember that the two components of a channel mapping are the cmf filename, and the contents of the cmf file itself. When you save a pxc file that points to a cmf file, you are only saving the path and name to the cmf file; *the contents of the cmf file itself are not saved in the pxc, only a pointer to the cmf file*. If you modify the contents of the cmf file and resave it to the same filename, any pxc file that refers to that cmf file will now acquire the modified cmf behavior.

For example, if you made a channel renumbering error when you created a cmf file, fixing the error and resaving the cmf file without changing the filename will cause all pxc files that refer to this cmf file to automatically acquire the corrected mapping, without having to modify the pxc files in any way.

MultiPlex multi-source view

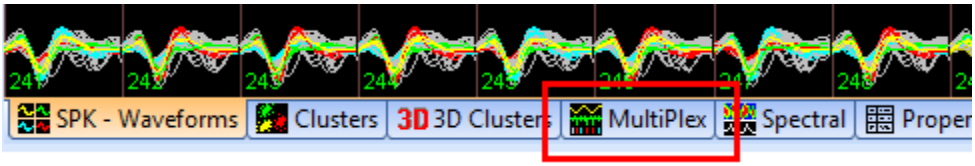
The MultiPlex view (MPX) allows you to view a customized set of spike, continuous, and event channels from any combination of sources, in any order. Channels are displayed in rows, as in the Activity view, but each row can contain any one of the three types of channels, and each type of row can be sized independently. Besides the rows of sweeping signal traces and/or ticks, an optional column of "scope" windows can be displayed to their left. For example, for a spike channel, where the main display shows spike ticks, the scope displays the waveforms for that channel, together or in individual unit windows. "Slow" continuous channels (sampling rate <= 5 kHz) can be displayed as either signal traces or as spectrograms; when in spectrogram mode, the scopes for these channels display the associated spectral graph (FFT).



Many options are available for adjusting the way in which channels are displayed, for adding and removing channels, etc. Besides the flexible display configuration, there are other new visualization features such as rolling waveform variance envelopes, an oscilloscope-like spike display mode, and tracking of spectral peak frequencies. You can scroll through hundreds of channels of online spike, continuous, and spectrogram displays, with modest CPU usage.

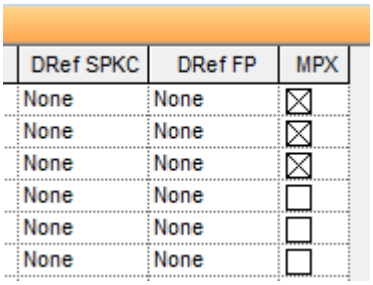
Getting Started

The MPX is automatically created when PlexControl starts up, like most other views:



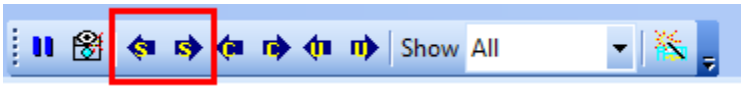
However, it is different in that by default it initially displays no channels. When you select the MultiPlex tab, a message is displayed in the middle of the empty window, prompting you to add channels. This can be done in two ways:

1) Checking a box in the "MPX" column of the main Properties Spreadsheet adds that channel to the MPX. Unchecking the box removes the channel from the MPX. You can add and remove channels at any time.

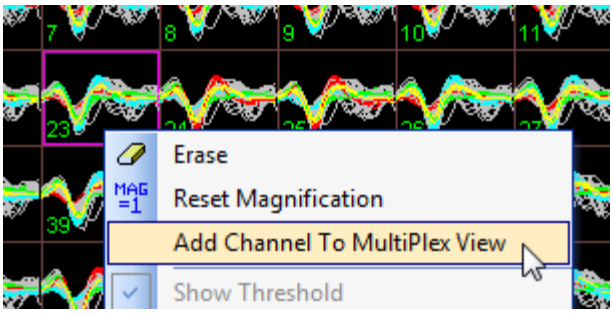


DRef SPKC	DRef FP	MPX
None	None	☒
None	None	☒
None	None	☒
None	None	☐
None	None	☐
None	None	☐

Remember that you can make a source visible in the Properties Spreadsheet either by clicking on a view that is displaying that source, or by using the Previous Source / Next Source buttons in the main PlexControl toolbar to cycle through all the available sources, including sources like CinePlex events and keyboard events.

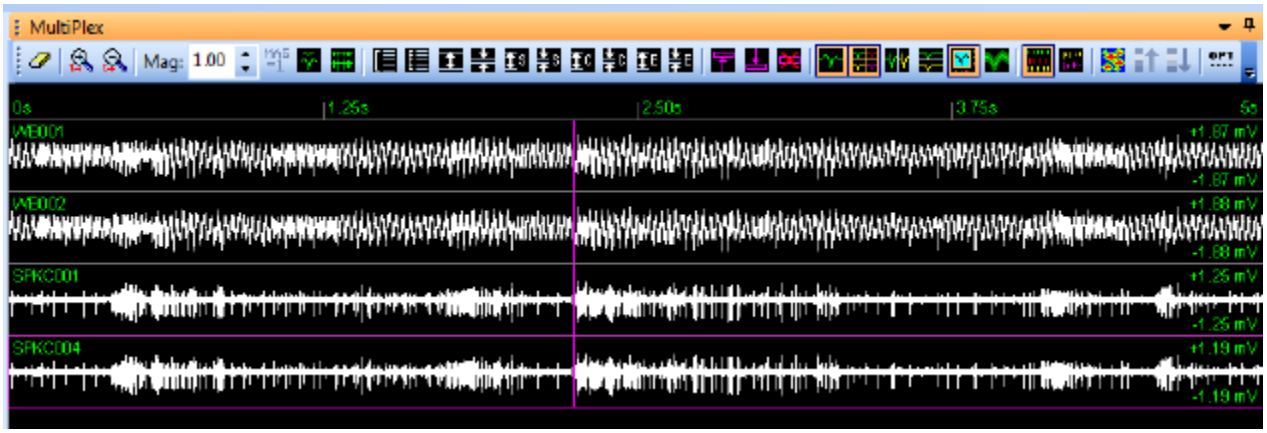


2) Right-clicking on a channel in any spike, continuous, or activity view, and selecting "Add Channel to MultiPlex View" from the right-button menu.

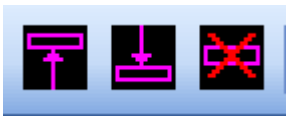


One exception to note is that from the Activity view, you can only select and add spike channels using the right-button menu, but not event channels. However, you can use the Previous Source / Next Source toolbar buttons in the main toolbar to select the desired event source into the Properties Spreadsheet and then use the MPX column to add event channels.

Using either method, each added channel results in a row being added to the MPX.



Channels are displayed in the order in which they are added, but changing this order is easy. Select a channel and, holding down the left mouse button, drag up or down to move the channel up or down in the list of channels. Alternately, you can do this by selecting a channel and then using the up-arrow/down-arrow keys while holding down Shift. There are also toolbar and menu commands to move channels and sources (i.e. all the MPX channels from the same source as the selected channel) to the top or bottom of the view. For example, these toolbar buttons move the selected channel to the top or bottom of the display, or remove it from the view:

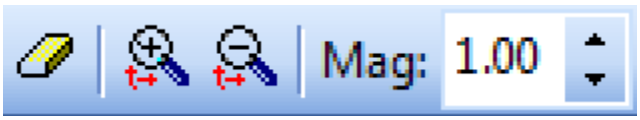


You can also delete a channel by selecting it and pressing the Delete key. The Remove All Channels command in the menu resets the view to the empty state (a message box will ask you to confirm that you really want to remove all channels).

Disabled channels are not displayed in the MPX. If a channel in the MPX is disabled from anywhere in PlexControl, it is automatically removed from the view.

Magnification tools

- *Erase*
- *Sweep faster*
- *Sweep slower*
- *Magnification readout and spin controls*



Although the above tools should be familiar from other views in PlexControl, magnification is slightly more complicated than in other views, since the MPX can contain channels from different sources. By default, changing the magnification using the spin controls changes the magnification on all spike and continuous channels in the view. If you hold down Ctrl and/or Shift while clicking the spin arrows, the behavior is as follows:

Ctrl = change magnification for only the currently selected channel

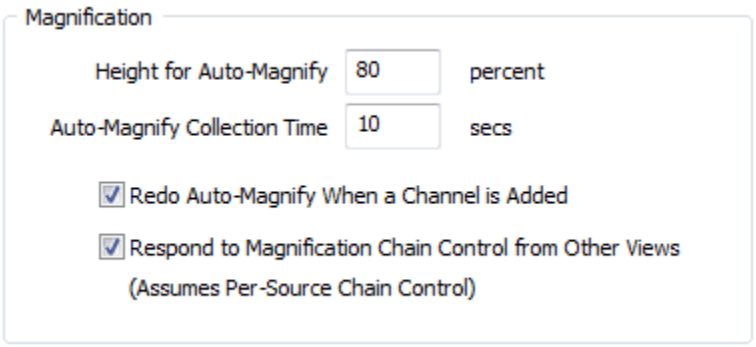
Shift = change magnification for all channels of the selected source
(i.e. the source for the currently selected channel)

A handy way to remember this is "C and S": **C**trl = **C**hannel, **S**hift = **S**ource. You can also adjust magnification using the mousewheel, as described in the appendix on keyboard/mouse shortcuts.

- *Reset magnification*
- *Auto-magnify spikes*
- *Auto-magnifiy continuous*

In practice, you may find that you don't need to manually adjust the magnification very often, but can use the auto-magnify tools instead. When you click on either button, all spike or continuous channels are monitored for a given interval (10 seconds by default, but can be changed in the Options dialog) and then the magnification is set automatically on a per-channel basis. A handy shortcut is simply to press the 'A' key (note that the MPX view must be selected first), which starts the auto-magnify procedure for all channels, both spike and continuous.

There is also an option in the Options dialog to automatically perform an auto-magnify whenever you add a channel to the view:



The last option, “Respond to Magnification Chain Control,” causes magnification changes from other spike and continuous views to also adjust the magnification of the corresponding source in the MPX.

Row layout and sizing tools

- Fit in Window

This fits all the channels in the MPX into the window, so that you never need to scroll to see them all. However, to keep the view from becoming unusably crowded, OmniPlex limits the number of channels (rows) to 64; if there are more than 64 channels in the MPX, Fit in Window is disabled.

Note that once you enable Fit in Window, it is a mode that is in effect. If you add another 20 channels, it will still make everything fit in the window. If you only have one channel, it will expand that one channel to fill the full height of the window, which may not be the ideal appearance. If the layout appears awkward, consider whether you have Fit in Window turned on, and whether it's appropriate for what you are trying to display.

The following apply to all spike, continuous, and event channels.

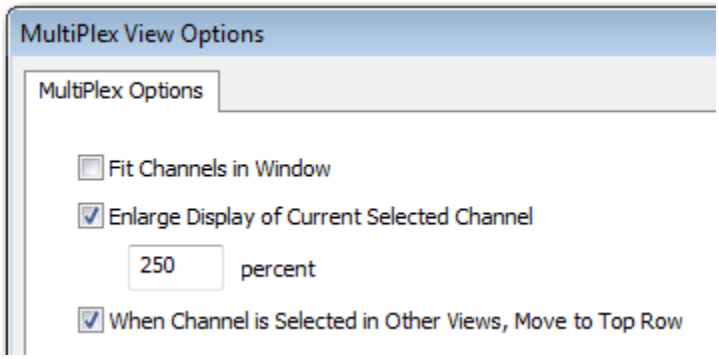
- Make All Rows Same Height
- Make All Rows Taller
- Make All Rows Shorter

The buttons with "S," "C" and "E" are also "make taller / shorter" tools, but apply only to spike, continuous, or event channels.

- Make All Spike Rows Taller
- Make All Spike Rows Shorter
- Make All Continuous Rows Taller
- Make All Continuous Rows Shorter
- Make All Event Rows Taller
- Make All Event Rows Shorter

Note that the default row heights are not the same - spike channels are the tallest and event channels are the shortest, since that works well in typical use. You can always use the above buttons to size them any way you like.

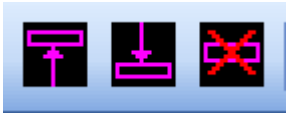
There is also a feature than currently can only be toggled from the Options dialog which automatically enlarges the currently selected channel to a specified percentage of its normal height; for example, the default value of 250% means that the selected channel is 2.5 times as tall as when it is not selected. Another option allows the currently selected channel to be automatically moved to the top row.



The combination of these two options in effect "features" a channel in the MPX, without it "taking over" the entire window like the usual OmniPlex "double-click to zoom channel" functionality.

Note that the latter option (move to top) only applies when a channel is selected from "outside" the MPX; you actually don't want selecting a channel in the MPX to suddenly pop it to the top row, and there's a tool to move a channel to the top or bottom if you do want to do that.

- Move Selected Channel to Top
- Move Selected Channel to Bottom
- Remove Selected Channel



Note that there are also menu commands for *Move Selected Source to Top/Bottom*, which act similarly to *Move Selected Channel* except that all the channels in the same source as the selected channel are moved to the top or bottom of the window.

The following two menu commands affect the top to bottom order of all the channels in the MPX.

- *Group Channels by Source*
- *Group Associated Channels*

For example, if you had the first two channels of WB, SPKC, SPK, and FP in the MPX, grouping them by source would yield this top to bottom order:

SPK01
SPK02
WB01
WB02
SPKC01
SPKC02
FP01
FP02

On the other hand, grouping associated channels would produce this order:

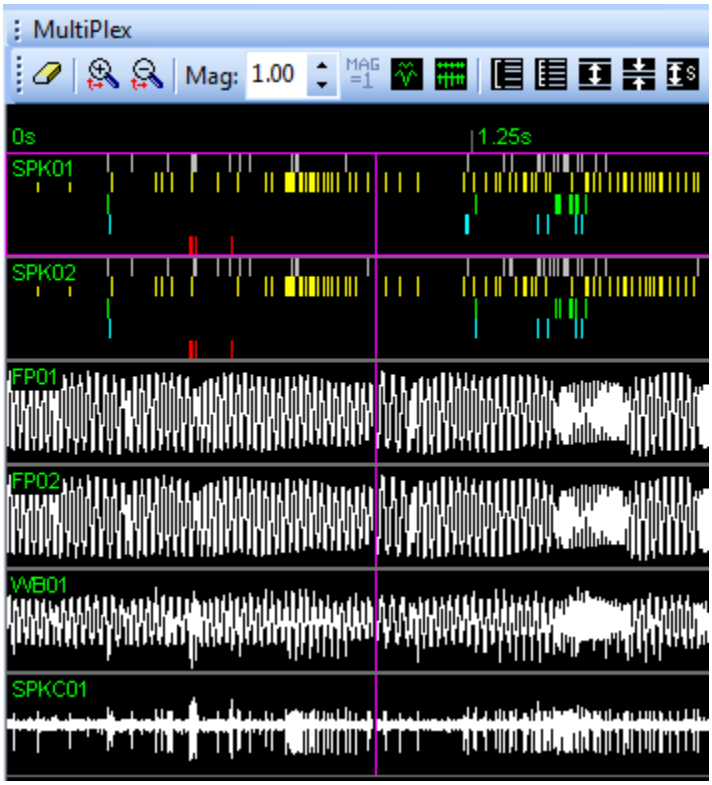
SPK01
SPKC01
WB01
FP01
SPK02
WPKC02
WB02
FP02

Note that unlike Fit in Window, these are commands, not modes; they change the display layout when invoked, but you can then continue to change the row order with other commands and/or by manually dragging channels up or down in the list. There is currently no way to specify a different ordering of sources, or of associated channels when the above commands are used (e.g. perhaps you'd prefer the source order WB, SPKC, SPK, FP). However, grouping by source, followed by use of the *Move Source to Top/Bottom* command, can achieve the same effect.

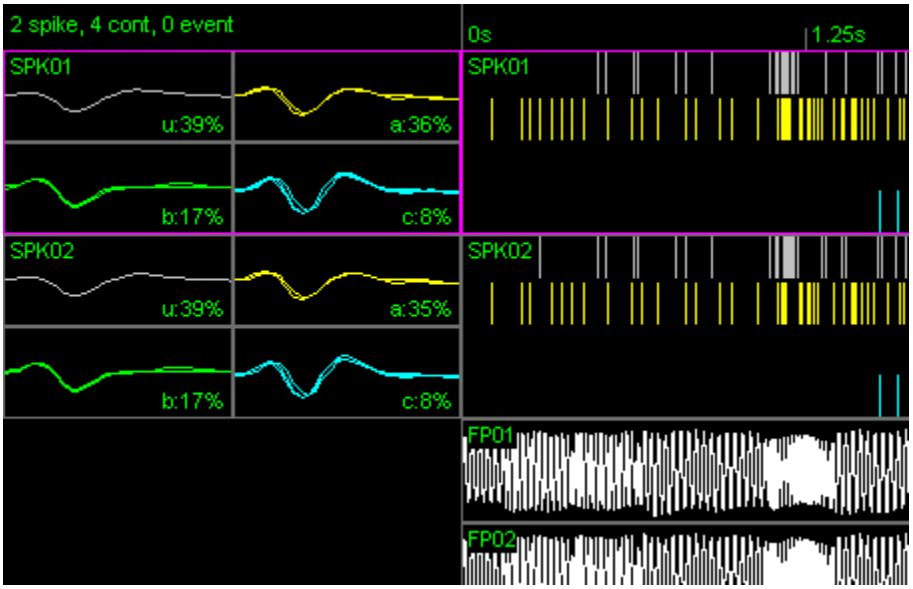
Spike display tools

- *Show Scope Windows*

This toggles the display of the column of "scope" windows to the left of the main channel rows. For example, with scopes off:



Scopes on, and with the spike channels made larger:

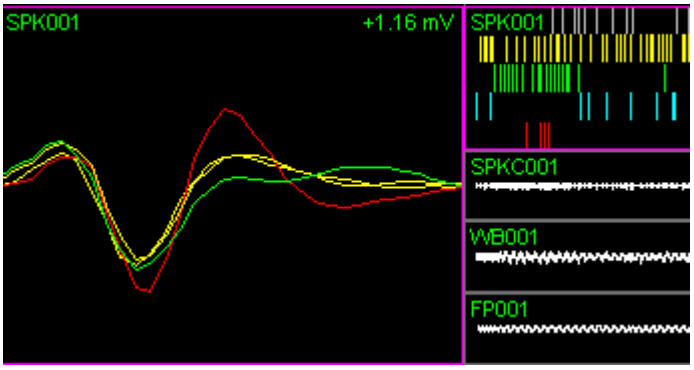


The unit windows display the current relative number of spikes detected. There is a menu command for resetting the spike counts, and an option in the Options dialog for displaying raw counts instead of percentages.

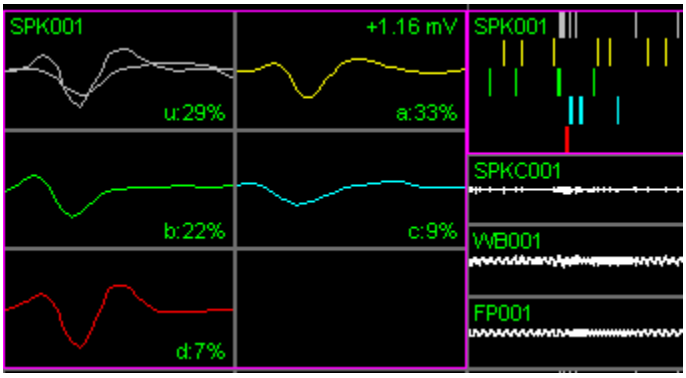
The next few toolbar buttons allow you to customize the spike and tick displays.

- Show Units in Separate Windows

With separate unit windows off:

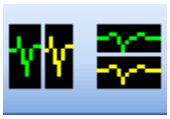


With separate unit windows on:

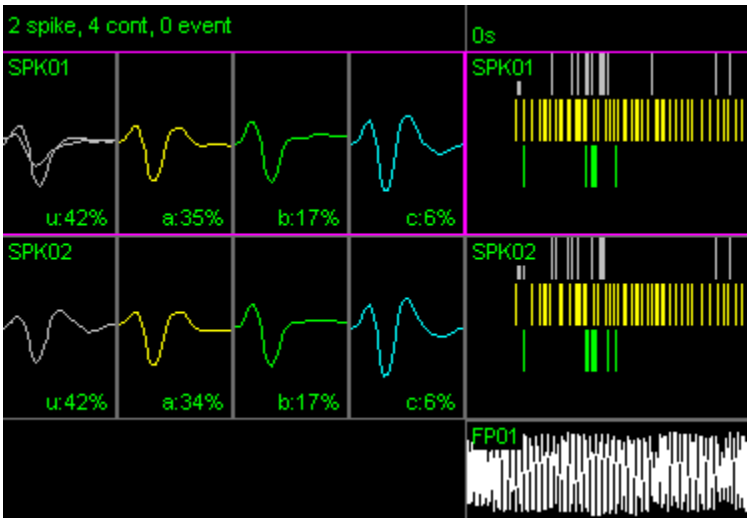


By default, the MPX automatically arranges the unit windows in rows and columns. However, the next two buttons allow you to force it to display the unit windows in rows or columns:

- Row Layout for Unit Windows
- Column Layout for Unit Windows



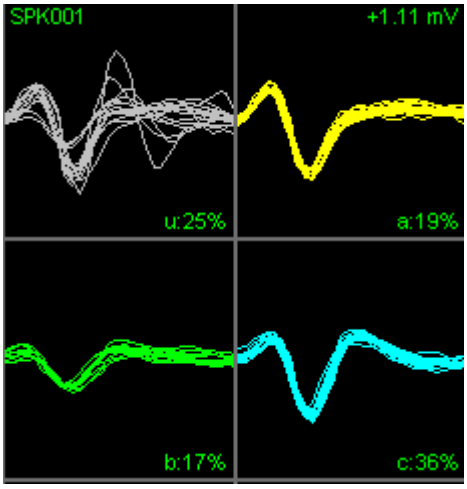
For example, with separate unit windows and a row layout:



The next button toggles high speed updating mode (“scope mode”).

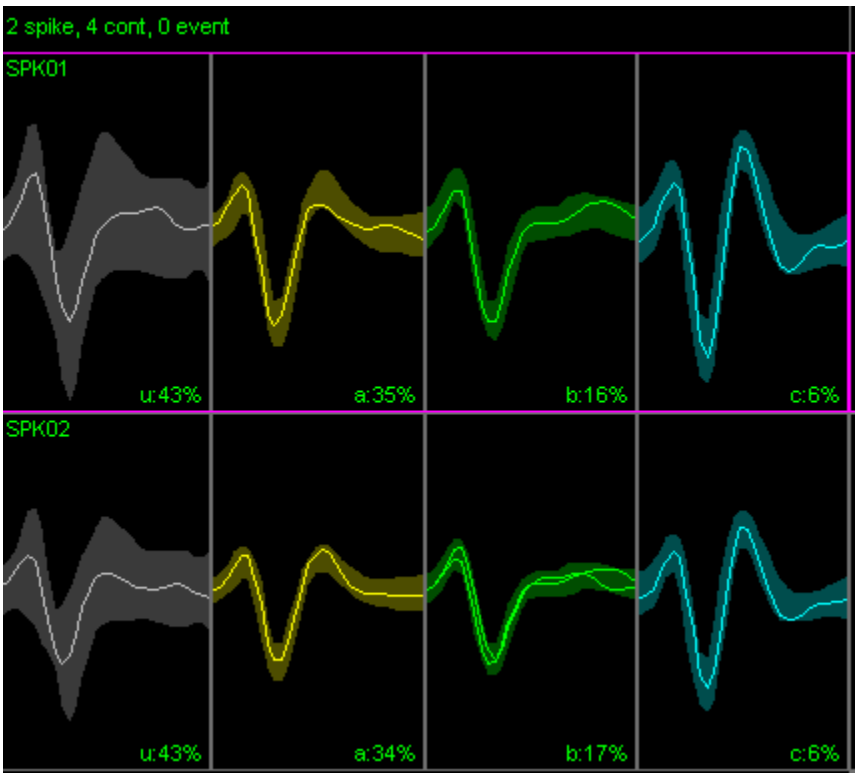
When this mode is enabled, the spike waveform displays operate in a quasi-oscilloscope mode, where each new spike erases the one before it, but the most recent spike remains until another one is seen. This gives a result similar to using an external oscilloscope, one for each channel in the MPX.

If you disable high speed updating, the display returns to the classic "accumulate and periodic erase" mode, with an erase time that you can set in the Options dialog.

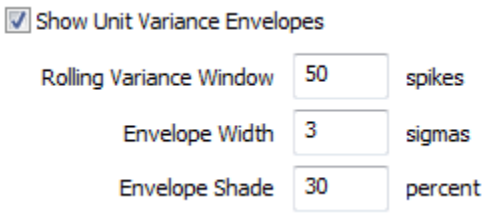


- Show Unit Variance

This button toggles display of rolling variance envelopes. For example, with display of variance enabled:



The shaded envelope indicates plus or minus N sigmas from the mean. The mean waveform itself is not displayed (it would clutter the display) but is by definition the centerline down the middle of the variance envelope. Both the mean and the variance are calculated from a moving window M spikes long, and incrementally updated on every spike. Both the length of the moving window (in spikes) and the distance of the variance envelope from the mean (in sigmas) can be set in the Options dialog.



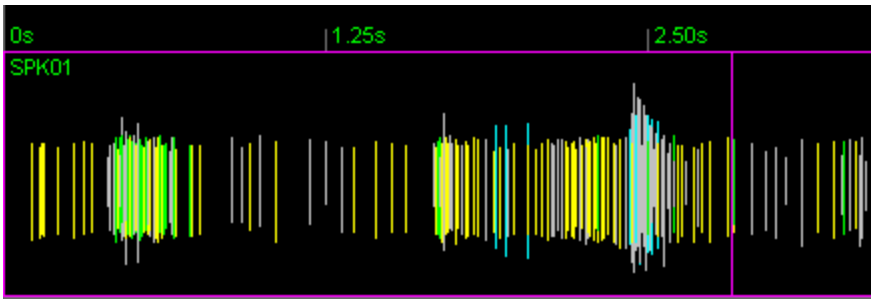
The basic idea is that a well-defined unit should have a tight variance envelope. For example, you can see that the unsorted units above have a large variance, as you would expect, since they are collections of dissimilar waveform shapes that may represent superpositions, artifacts, etc. You can think of the variance envelope as one kind of online sort quality metric - a tight variance envelope is the time domain equivalent of a tight, well-defined PCA cluster.

Note that the variance envelope does not appear until [window length] spikes have fired on a unit after you enable variance envelopes, so depending upon firing rates, it may take a few seconds before the variance envelope is displayed.

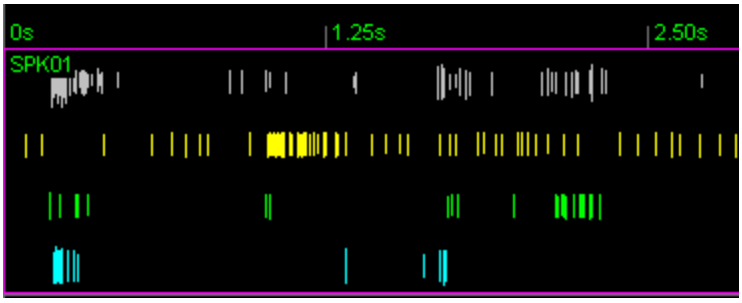
- Show Unit Ticks on Separate Timelines
- Show Ticks with Amplitudes

The first should be self-explanatory. The second causes ticks to be drawn not with uniform heights, but according to the peak positive and negative amplitude (bipolar amplitude) of each spike.

An example of all units being displayed on the same timeline, but with bipolar amplitude ticks enabled:



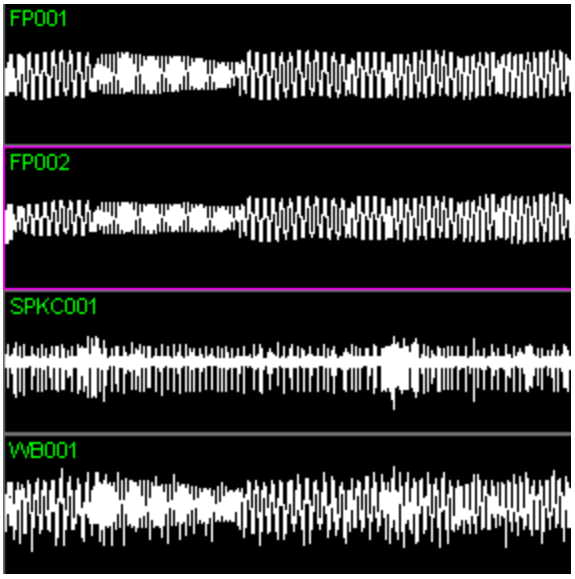
The same but with units on separate timelines:

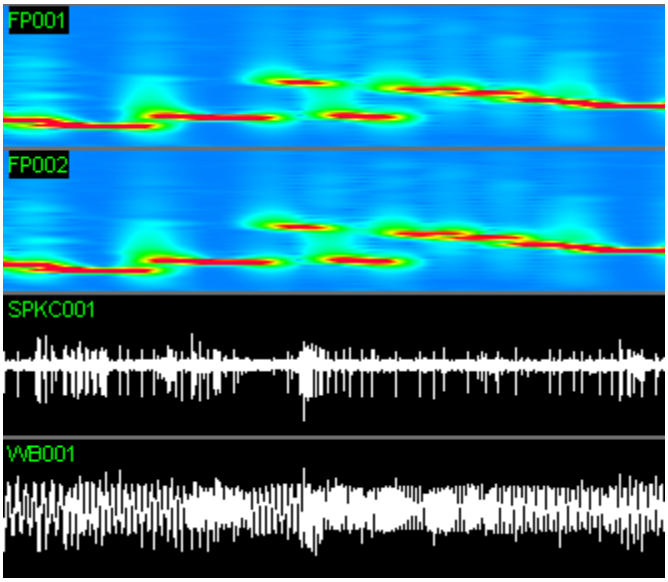


Spectrograms and Spectral Graphs

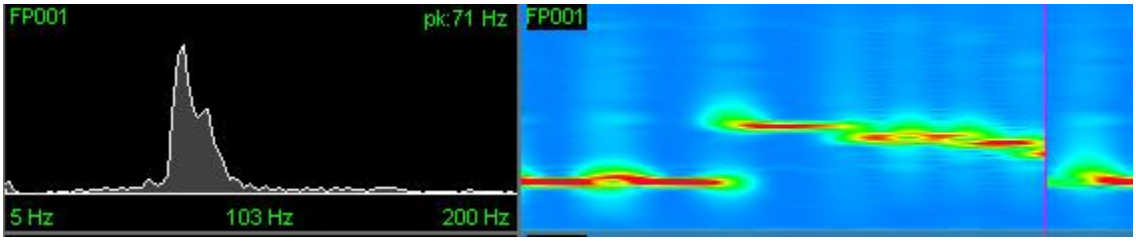
For "slow" continuous channels (sampling rate <= 5 kHz), there is an alternate display mode which shows a rolling spectrogram instead of the continuous signal, similar to the standard OmniPlex Spectral view, but with the sweep synchronized to the other channels in the view. This is enabled and controlled via the next three toolbar buttons:

The first toggles spectrogram mode on and off. For example:

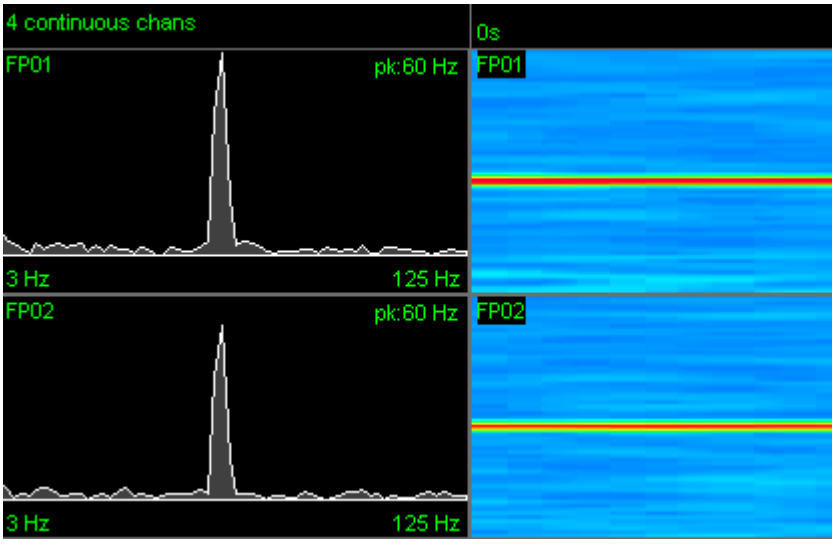




If scopes are also enabled, then in spectrogram mode a spectral graph scope appears to the left of each spectrogram. As with the standard OmniPlex Spectral view, the spectral graph can be thought of as a vertical “slice” of the spectrogram at the current sweep time:



The readout in the upper-right corner of each spectral graph indicates the frequency of the FFT bin with peak magnitude, continuously updated. For example, if you leave the inputs to the neural channels on your signals floating (disconnected), you may see a spectral peak at the 50 or 60 Hz power line frequency being picked up by the floating inputs, i.e. hum:

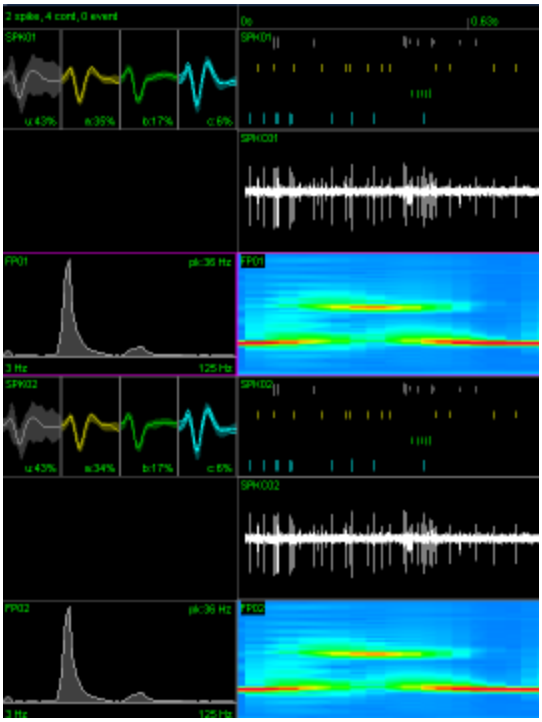


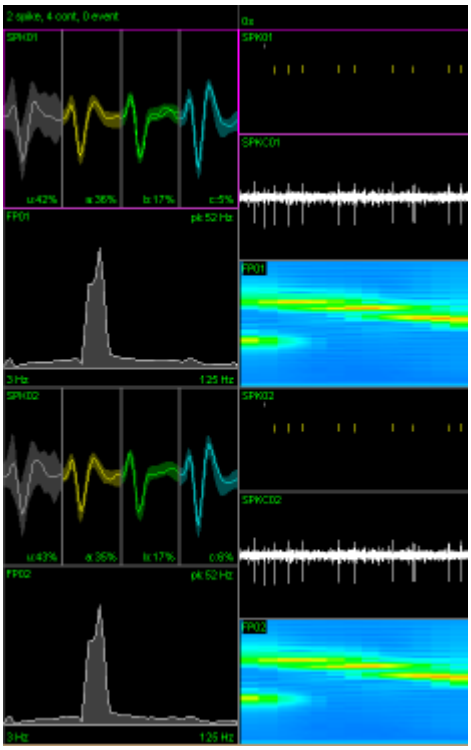
The other two spectrogram buttons control the amplitude scaling, and work the same way as in the main OmniPlex Spectral view: the red arrow scales up (more red, less blue), the blue arrow scales down (more blue, less red).

Miscellaneous

Scopes Fill Column in Fit in Window Mode

The usual rule with the scope windows is that each scope sits directly to the left of the main "channel strip" for that channel, and both are the same height. If you move a channel's row up or down, both the channel strip and its scope move together as a single row. However, when Fit in Window mode is enabled, there is an option in the Options dialog for Scope Windows Fill Column. Here is an example with the option off and then on:



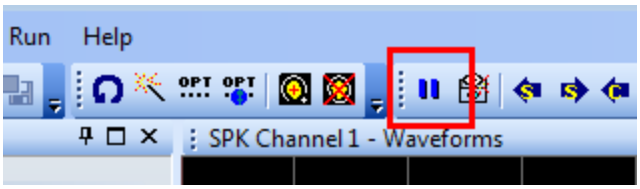


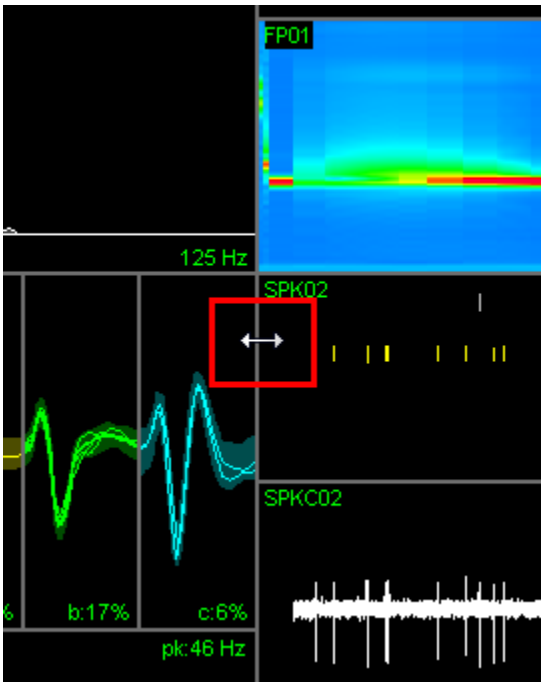
Each scope window's height is simply the total display height divided by the total number of scopes.

Note that there is a tradeoff, in that it is now not quite so obvious which scope "goes with" which channel strip. However, when you select a channel, both the channel strip and the corresponding scope are both highlighted, to help identify that they belong together.

The Splitter

The vertical splitter between the scopes on the left and the channel strips on the right can be dragged to the left or right, changing the proportion of the horizontal display space allocated to each. However, you cannot do this while the display is running; you must use the Pause Display button in the main PlexControl toolbar to pause, then drag the splitter left/right, then click the Pause button again to unpause.



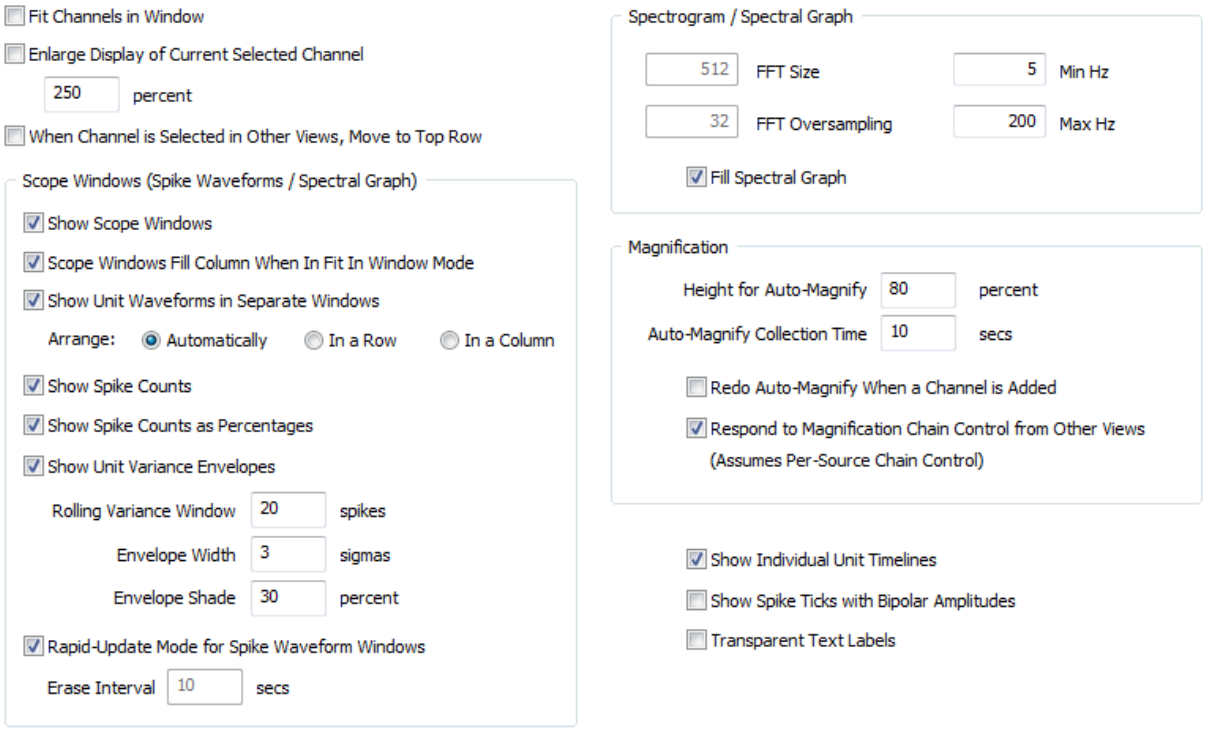


Add Associated Channels

This function adds the “parallel channels” derived from the same wideband channel. For example, if you select SPK02 and do Add Associated Channels, channels WB02, FP02, and SPKC02 will be added if they are not already in the MPX.

Options Dialog

As with other PlexControl views, you can access the Options dialog via either the “Opt …” toolbar button, or by pressing the “O” key while the MPX view is selected.



Limitations

Continuous channels with sampling rates greater than 5 kHz cannot be displayed as spectrograms. In spectrogram mode, these channels will be displayed as normal continuous signal traces.

The MultiPlex view does not currently support stereotrode or tetrode channels.

Amplitude scaling changes in the spectrogram / spectral graph apply to all channels and there is no auto-scaling of spectrograms.

Appendix: Keyboard and Mouse Shortcuts

```
T = toggle toolbar
O = show options dialog

F = toggle fit in window mode
H = make all row heights the same
I = toggle display spike ticks on individual timelines
A = auto-magnify (both spike & continuous)

W = toggle waveform / spectral windows
G = toggle display of slow continuous as spectrograms
B = toggle display of bipolar amplitude ticks
V = toggle spike variance envelopes

S = group by source (note that 'S' toggles snapshots in other views)
P = group by associated channels

D = add the first two channels of WB, SPKC, SPK, and FP,
    turn on fit in window mode, start an auto-magnify (demo mode)

up/down arrow = select prev/next chan (row)

SHIFT up/down arrow = move selected chan up/down in list

delete = remove the selected channel from this display

CTRL +/- = make the selected row type (spike, cont, event) taller/shorter

CTRL-SHIFT +/- = make all row types taller/shorter (less/more chans in
window)

mouse drag of selected channel = move channel up/down in list

mousewheel = scroll up/down

CTRL-mousewheel = change magnification of selected channel

SHIFT-mousewheel = change magnification of all channels on the selected
source

CTRL-SHIFT-mousewheel = change magnification of all channels
```

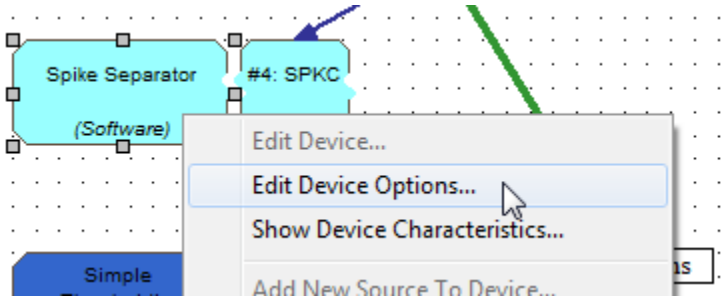

Audio monitoring of wideband or spike-continuous signals

OmniPlex 1.16 supports online monitoring of the currently selected wideband (WB) or spike-continuous (SPKC) channel using the standard audio outputs of the computer on which OmniPlex is running. You may find it useful to listen to the live signal as an aid to electrode placement and for ongoing monitoring of spiking activity once electrodes have been positioned.

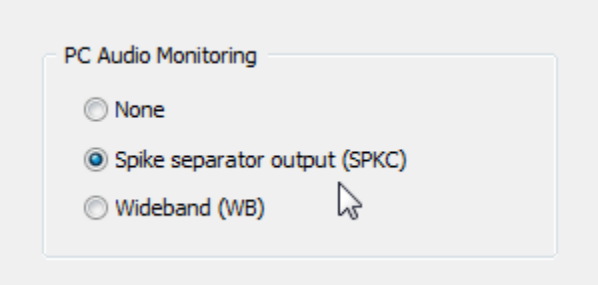
To use this feature, you can listen to the audio using the speaker built into the computer, but for better quality you can plug headphones or external speakers into the audio output jack on the front or rear of the computer. The output jack will typically be marked with an icon of a pair of headphones or a speaker, or an arrow pointing outward from the jack. You can use either mono or stereo headphones or speakers, but the audio will be mono in either case, since you are listening to a single channel.

[insert photos of jack, headphones, etc]

To enable audio monitoring and to choose wideband or spike-continuous monitoring, stop data acquisition, right-click on the Spike Separator in Server, and select *Edit Device Options*:



In the Device Options dialog, select the desired audio monitoring option and click OK:



When you start data acquisition, the selected monitoring option is enabled. When you select a channel in PlexControl, the corresponding WB or SPKC channel is automatically selected for audio monitoring.

In most cases, you will probably want to monitor the spike-continuous (SPKC) signal, since field potential signals (i.e. frequencies below the spike band) tend to have poor audibility and are not very informative. The option to monitor the unfiltered wideband (WB) signal is provided primarily for users who wish to use an external equalizer to do custom filtering of the audio signal.

Note that due to the constraints of the computer's audio output subsystem, it is possible that you may occasionally hear a very brief dropout or glitch in the audio. Also, the built-in PC audio may add a small amount of coloration or distortion, relative to the signal which is processed and recorded by OmniPlex. If

you find the audio quality inadequate, try using the audio output jack on the rear panel of the computer, as in some cases this provides a cleaner signal.

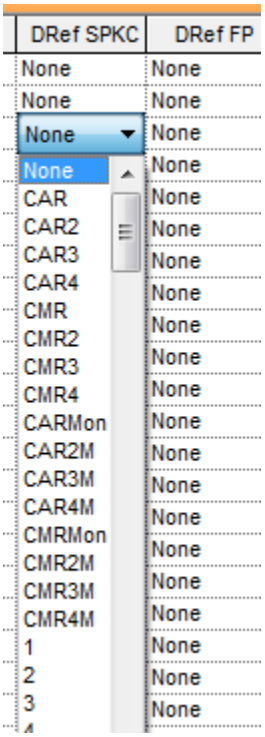
The above caveats should not be problematic in normal use, but it is important to keep in mind that the audio output is only intended for live monitoring, and is not necessarily suitable for recording or analysis.

Multiple CAR/CMR digital referencing groups

In previous versions of OmniPlex, only a single common average reference (CAR) and a single common median reference (CMR) could be defined. OmniPlex 1.16 allows up to four independent CAR groups, and four independent CMR groups to be defined simultaneously. The channels within each CAR group (e.g. CAR3) are averaged together and that average is subtracted from only the channels of that CAR group. Likewise, the sample-by-sample median of the channels within each CMR group (e.g. CMR4) is calculated and that median is subtracted from only the channels of that CMR group. Each CAR and CMR group can have an associated monitor channel. Any SPKC or FP channel can be assigned to any of the CAR or CMR groups, and the CAR and CMR groups are completely independent between SPKC and FP. For example, you could define one CAR group and three CMR groups on the SPKC channels, but two CAR groups and one CMR group on the FP channels.

Defining more than one CAR and/or CMR group can be useful in cases where various subsets of channels each exhibit unique common noise or artifacts. For example, electrodes from one headstage may be implanted in a different part of the brain than another headstage, or multiple types of electrodes may be in use simultaneously, each with varying susceptibility to noise and artifacts.

The user interface for defining multiple CAR/CMR groups and the associated monitor channels is a straightforward extension of the previous single-CAR / single-CMR scheme. When you click on a channel's entry in the DRef SPKC or DRef FP columns of the main properties spreadsheet, you will see the following choices:



Select one of CAR, CAR2, CAR3, or CAR4 to assign a channel to CAR group 1, 2, 3, or 4 respectively. CARMon, CARM2, CARM3, and CARM4 are the corresponding CAR monitor channels.

Select one of CMR, CMR2, CMR3, or CMR4 to assign a channel to CMR group 1, 2, 3, or 4 respectively. CMRMon, CMRM2, CMRM3, and CMRM4 are the corresponding CMR monitor channels.

As in previous versions, selecting a specific channel number as the reference (1, 2, 3… n) simply subtracts that specific channel, rather than using common average referencing or common median referencing.

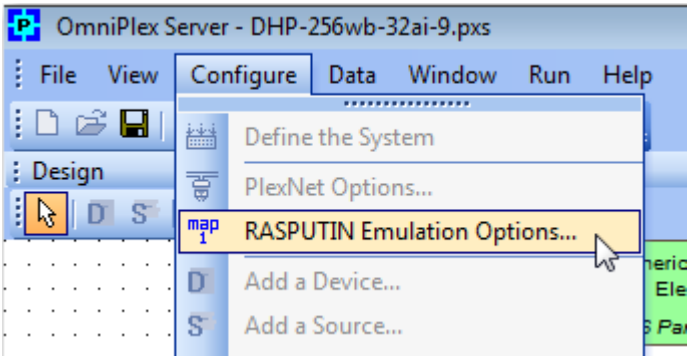
In addition to the usual caveats about the use of CAR/CMR, using multiple CAR/CMR groups can require additional caution. For the same overall channel count, defining more than one group implies that each group will contain fewer channels than if a single group were used, but it is important that each group contain enough channels that the average or median reference signal contains only artifacts and not identifiable spikes.

As before, the most important tool for ensuring that digital referencing is being applied appropriately is the monitor channel for each group. Each monitor channel should display artifacts, not spikes, and the artifacts on each monitor channel should be different than the other monitor channels; if the artifacts are the same on different monitor channels, this indicates that too many referencing groups have been defined, and you will in fact achieve better results by defining fewer groups, since more channels will then be included in the average or median of each group, helping to “average out” the spikes and to emphasize the artifacts.

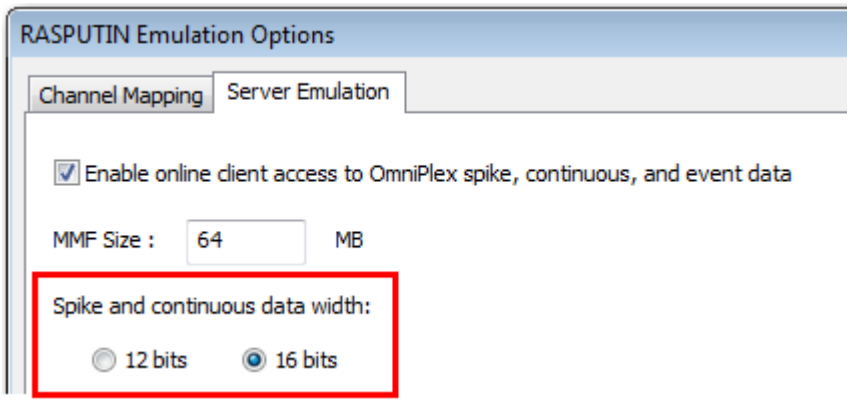
Remember that by recording the monitor channel(s), you are recording “what is being subtracted out” from the channel in each referencing group and you could potentially apply your own offline post-processing to add the reference signal(s) back to the channels in the corresponding groups and thereby reconstitute the original, unreferenced signals.

16 bit online client data

Previous versions of OmniPlex encoded all continuous and spike waveform data sent to online clients as signed 12 bit values within a 16 bit word. In other words, the raw unscaled sample values occupied a range from -2048 to +2047. This was done for compatibility with legacy online clients which expected 12 bit values, as were used in the original Plexon MAP ("Harvey Box") system. OmniPlex now supports full 16 bit resolution (sample values in the range -32768 to -32767) for online client data, which provides a factor of 16 (4 bits) more resolution than 12 bit values. To enable this, select *RASPUTIN Emulation Options* from the Configure menu in Server:



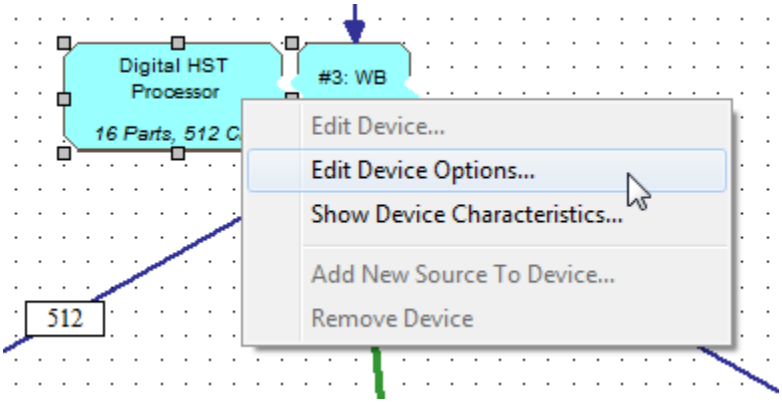
In the emulation options dialog, select the Server Emulation tab and set the desired data width:



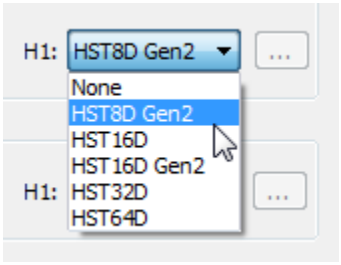
When 16 bit mode is enabled, client programs must divide sample values by an additional factor of 16 (preferably in floating point, so as to take advantage of the four bits of additional precision) to maintain correct voltage scaling. If this is not done, scaled voltages will be 16 times larger than the true values.

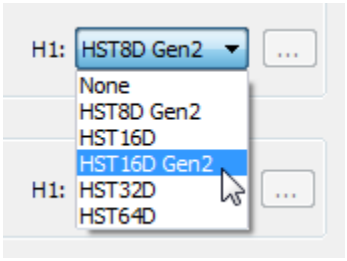
Support for new eight and 16 channel digital headstages

OmniPlex 1.15 adds support for Plexon's new Gen2 digital headstages, in eight and 16 channel configurations. As with previous digital headstages, you can use the Digital Headstage Processor (DHP) Device Options to specify the headstage type on a per-port basis. Right-click on the Digital HST Processor device in the topology in Server and select *Edit Device Options:*



Select the desired headstage type from the dropdown list for each port:





Remember that you must stop data acquisition in OmniPlex before changing the headstage options, as well as before connecting or disconnecting digital headstages from the DHP.

Please refer to the *Headstage Technical Guide* and the *Headstages Data Sheet* for specifications and additional information on the Gen2 digital headstages.

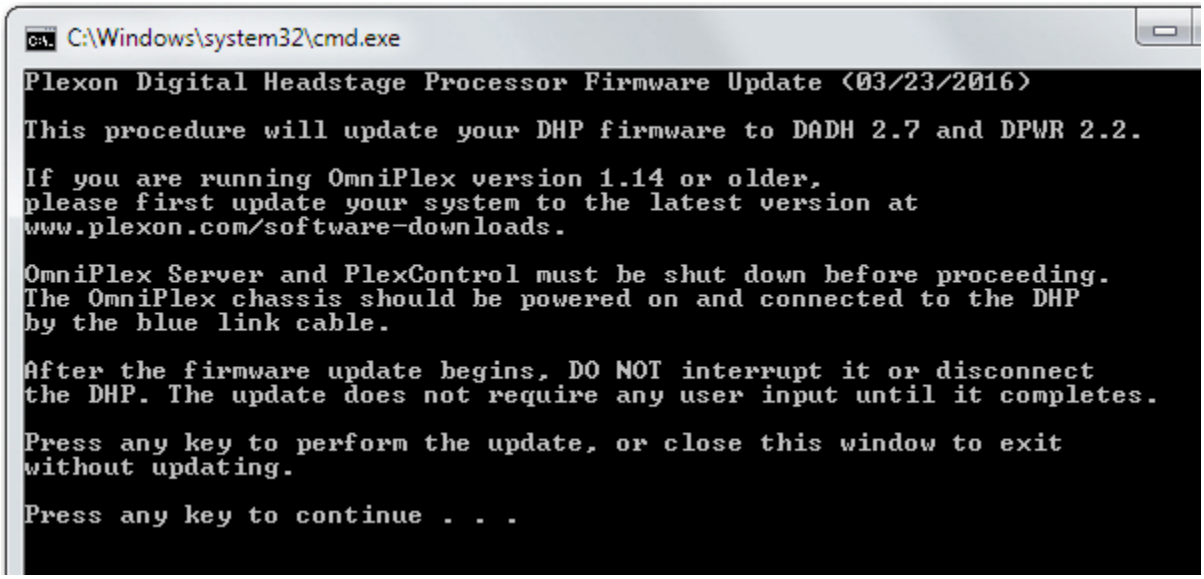
Digital headstage communications integrity protection

Digital headstages have several advantages over analog headstages. One of the most important is that whereas analog headstage cables can pick up varying amounts of electrical noise from the surrounding environment, digital headstage cables are far more robust to interference, and in normal situations the digitized signal from the headstage is received without error at the headstage processor (DHP). However, in rare cases, a strong burst of ambient noise can be so severe that it momentarily disrupts the digital communication link between the DHP and the headstage. For example, a large electrostatic discharge in a very dry room, or a switching transient caused by a motor or heater turning on or off, could in some cases cause such a disruption. A more common case would be electrical transients from headstage commutator brushes. In previous versions of OmniPlex, a brief disruption of this type could sometimes lead to groups of channels becoming "stuck" in an incorrect state until data acquisition was stopped and restarted.

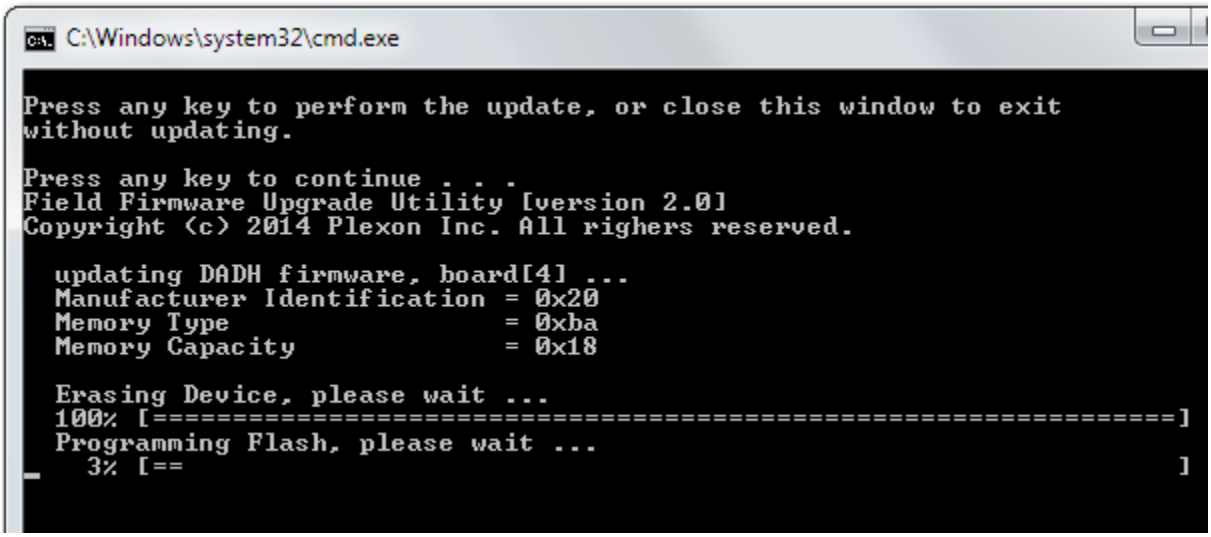
OmniPlex 1.15 includes updated firmware for the DHP which protects against these situations by continuously refreshing the state of the headstages, so that any disruption is recovered from as soon as the interference ceases. The recovery time is typically on the order of 1-2 seconds, but can be longer if the headstage highpass filters are set to a very low cutoff frequency.

In order to update your system to support the enhanced protection functionality, you must, in addition to updating the OmniPlex software to version 1.15, update the firmware in your DHP. To do this, first update the OmniPlex software to version 1.15 using the installer in the usual way, then use the following procedure:

1. If you are running OmniPlex, first shut down Server and PlexControl.
2. If you are not running OmniPlex, make sure that the OmniPlex chassis is powered on and that Windows has been rebooted, in that order.
3. Check that the DHP is connected to the Data Link card in the chassis via the blue link cable. Digital headstages do not need to be connected to the DHP.
4. In Windows, go to the folder
   `C:\ProgramFiles (x86)\Plexon Inc\OmniPlex\Common Files\ffu`
5. Double-click the file `run_ffu.bat`.
6. Follow the instructions in the command window.

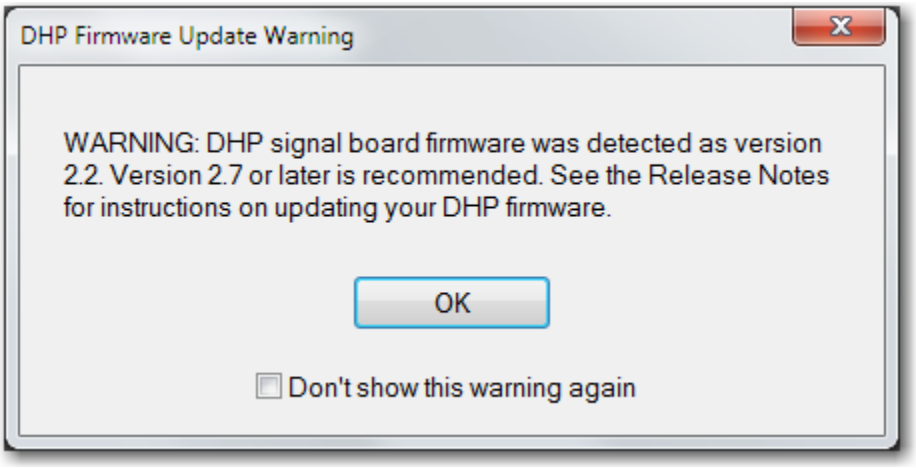


7. Once you press a key to continue the firmware update, the process requires no intervention. This can take a while, especially if you have multiple "amp boards" in your DHP. Once the actual firmware update begins, do not interrupt the update or disconnect the DHP. Messages will be displayed to indicate the progress of the update:



8. When the update is done, you will be prompted to press any key to exit the command window.
9. You can now run OmniPlex 1.15 with the updated DHP firmware.

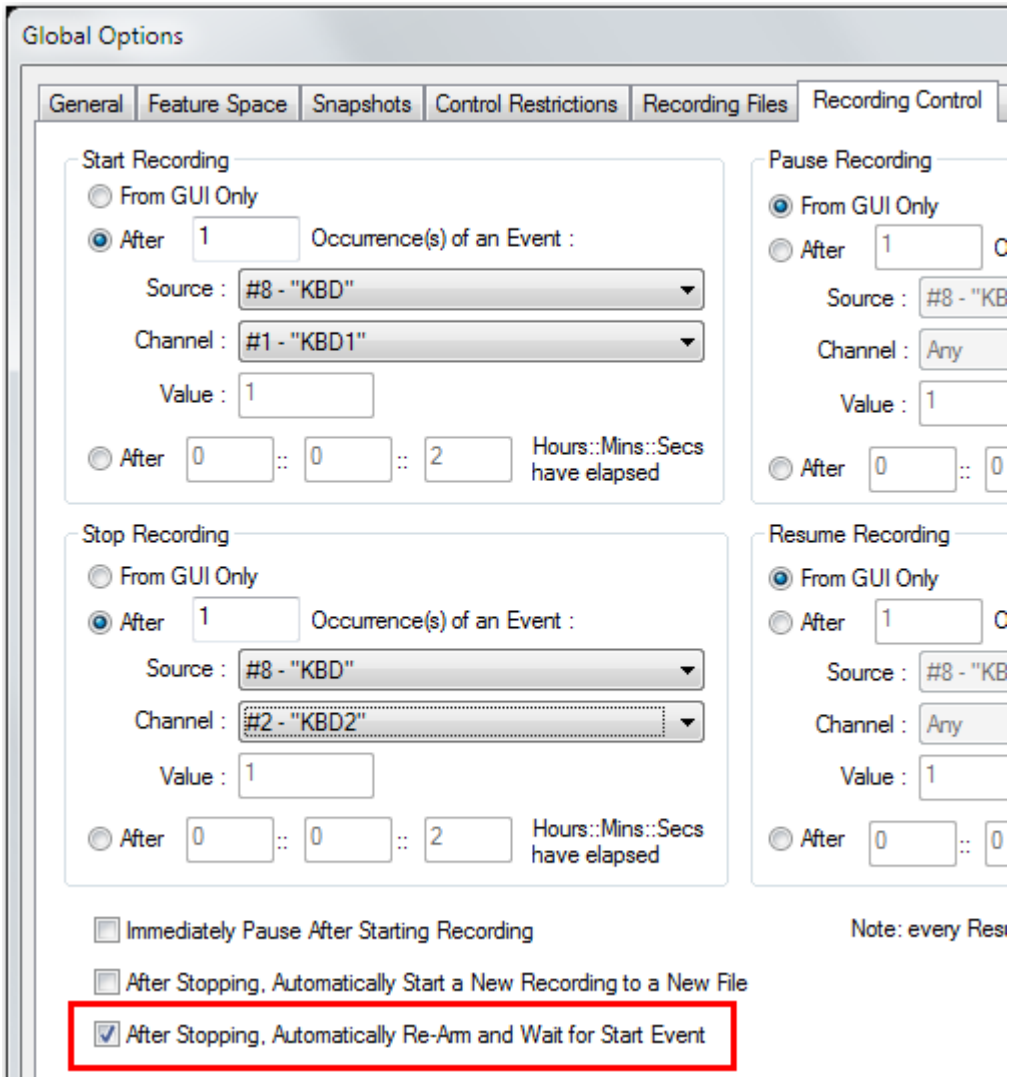
Note: *you are not required to update the DHP firmware to use OmniPlex 1.15, but you must upgrade to 1.15 to use the upgraded firmware and enable the enhanced protection*. If you start OmniPlex Server 1.15 on a system whose DHP firmware has not been updated, you will see a warning similar to the following:



The warning will be displayed each time you start Server or load a new topology. Even if you select *Don't show this warning again*, a message will still be displayed in Server's message log window until you update your DHP firmware to version 2.7.

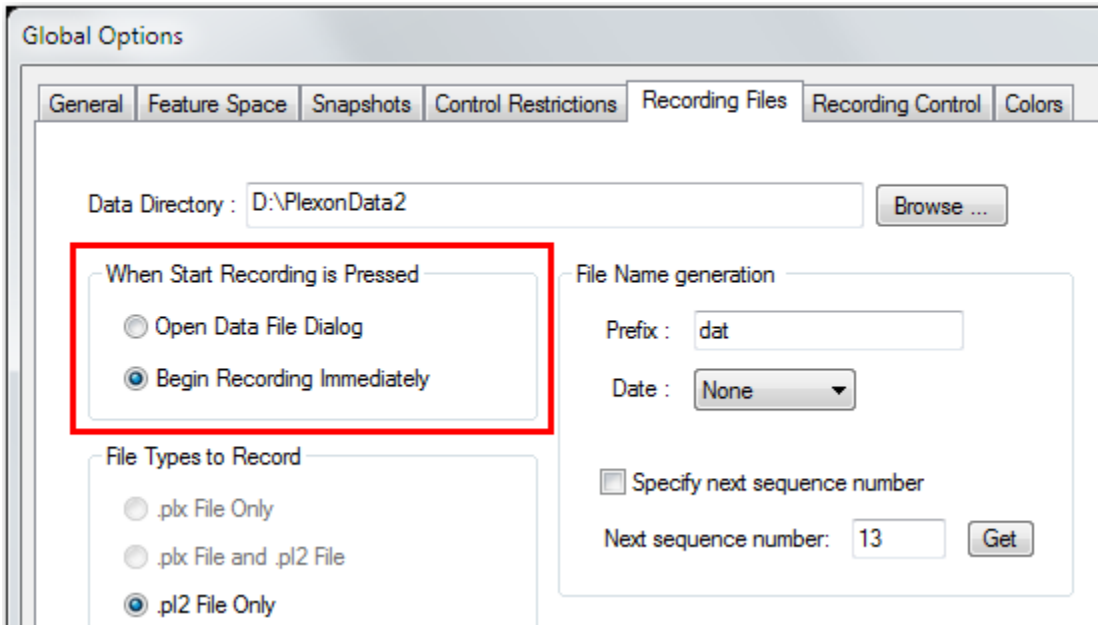
Triggered recording auto re-arming

A new triggered recording option allows automatic re-arming after recording is stopped. In PlexControl's Global Options, select the *Recording Control* page:



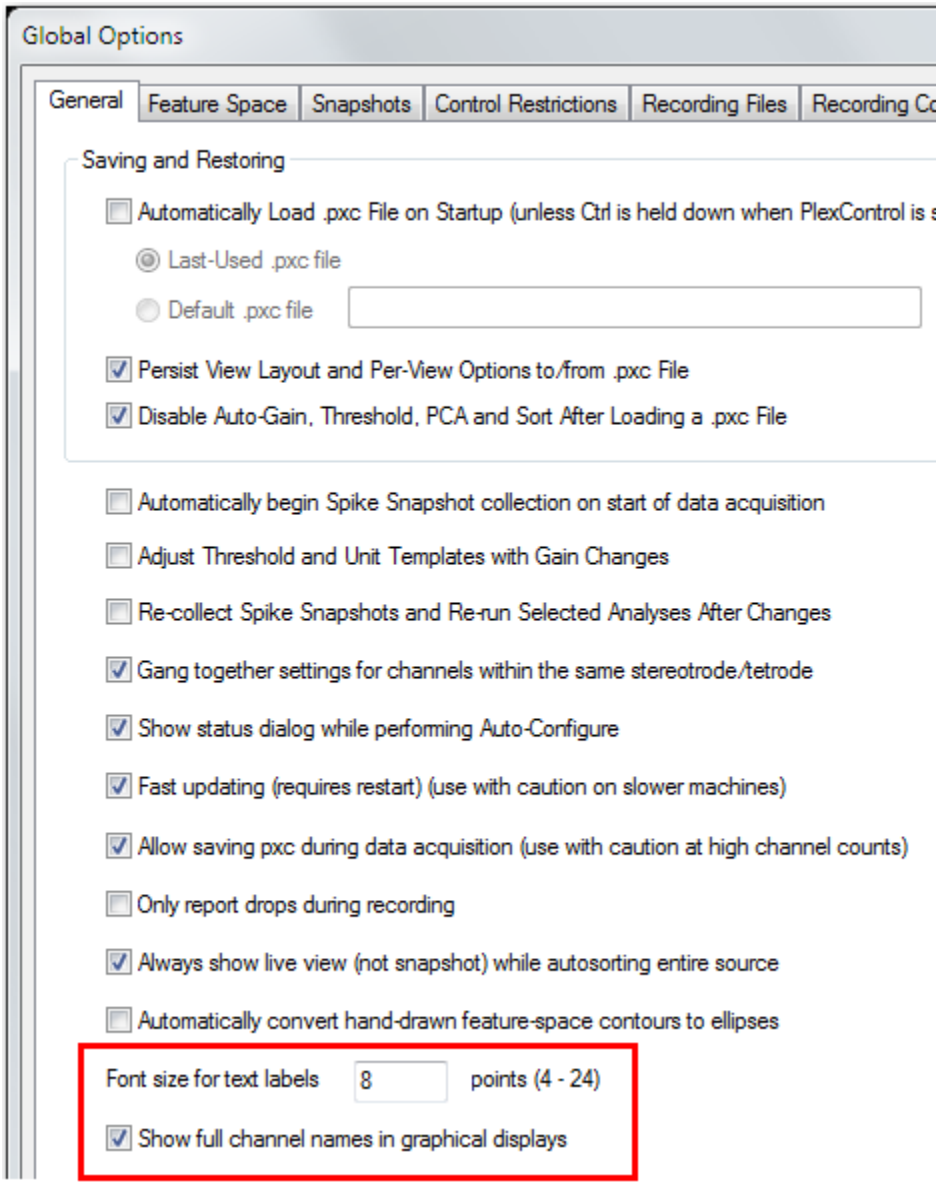
When the *After Stopping, Automatically Re-Arm and Wait for Start Event* option is disabled, a *Stop Recording* event resets the recording status to the default, i.e. disarmed. When the option is enabled, the *Stop Recording* event ends the current recording but remains in an armed state, waiting for the next *Start Recording* event. This should not be confused with the option *After Stopping, Automatically Start a New Recording to a New File*, which uses the *Stop Recording* event to both end the current recording and start a new recording, without waiting for another *Start Recording* event.

The example above shows the keyboard events KBD1 (Alt+1) and KBD2 (Alt+2) being used to start and stop recording. Each time Alt+1 is pressed, a new recording starts; each time Alt+2 is pressed, the recording ends, but the system remains ready for the next Alt+1, without having to manually re-arm recording. Typically, you will use the *Begin Recording Immediately* option on the *Recording Files* page to auto-generate filenames, but you can specify the *Open Data File Dialog* option to manually specify the name of each recording file if desired.

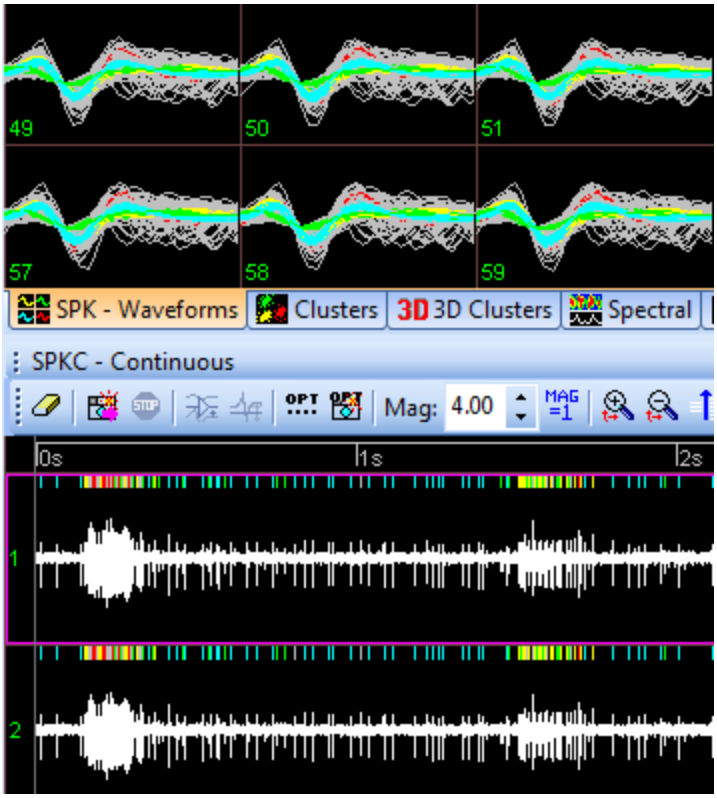


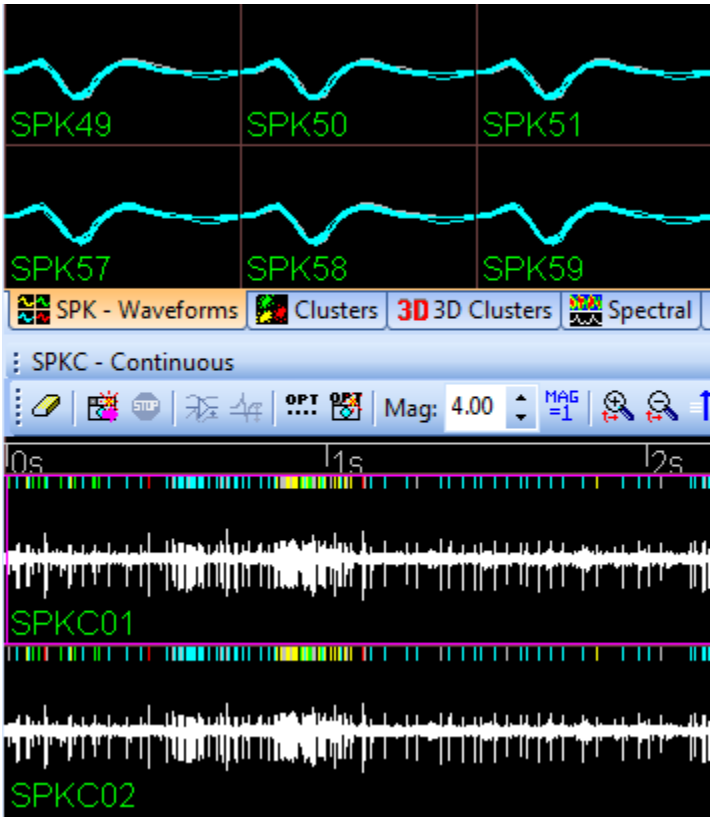
PlexControl user interface options

OmniPlex 1.15 allows the full channel names to be shown in multi-channel displays, as opposed to using only the channel number. In addition, the font size can be made larger or smaller than the default size, which can be used to optimize readability across a range of monitor sizes and system channel counts. To access these options, go to the General page in PlexControl's Global Options:



Here is an example of the default settings versus full channel names and a larger font size:





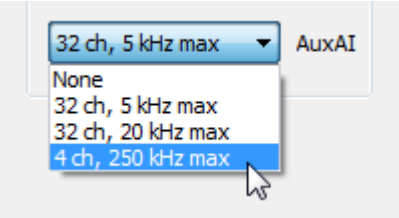
Windows 7 required

OmniPlex version 1.13 was the last release which was available for Windows XP. Microsoft discontinued support and security patches for XP in April 2014. OmniPlex 1.14 is only available for Windows 7 systems.

Faster AuxAI digitizing rates

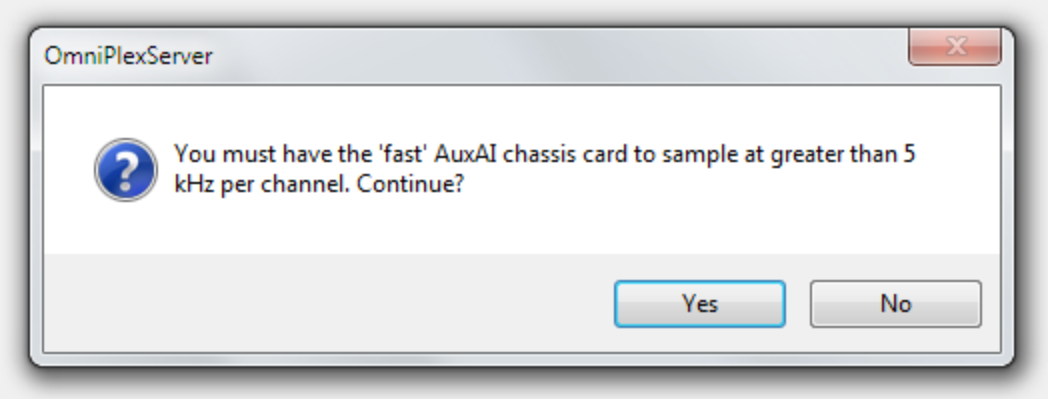
In previous releases of OmniPlex, the maximum per-channel digitizing rate for the AuxAI device was either 5 kHz (for the standard AuxAI device) or 20 kHz (for the optional "fast" card). Rates of up to 250 kHz per channel are now supported with the "fast" AuxAI card, with a maximum of four channels. This is useful for researchers who wish to record high-frequency audio or other high-frequency experimental data. Note that since the AuxAI device is intended for digitization of non-neural auxiliary signals, the digitized signals cannot be thresholded or spike sorted, and no digital filtering or other processing is currently supported on AuxAI channels.

In order to enable sampling rates greater than 20 kHz per channel, you must create a topology (pxs) with the appropriate AuxAI option using the Topology Wizard in Server. In the Topology Wizard AuxAI dropdown control, select *250 kHz max:*



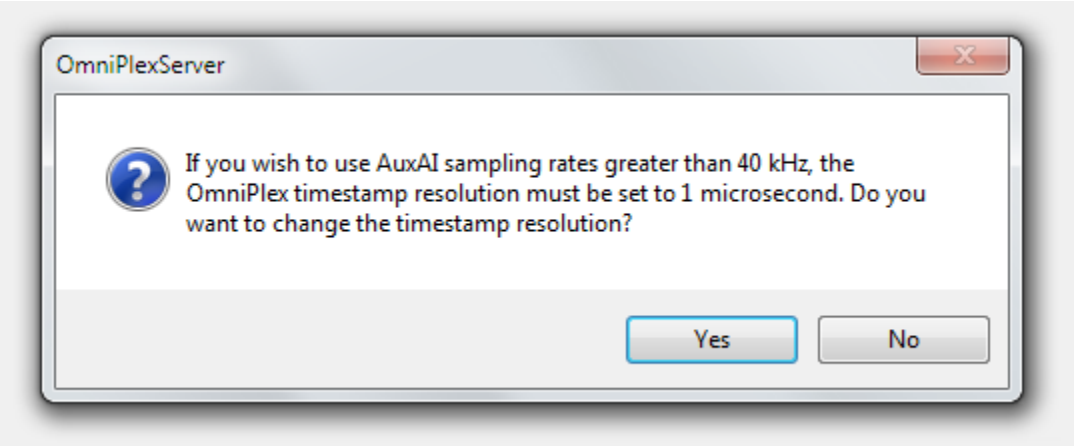
This allows the AuxAI card to be used at digitizing rates of up to 250 kHz per channel, but at these rates, a maximum of four channels (AI1 – AI4) can be used. Remember that the default (i.e. initial) digitizing rate for the AuxAI device is 1 kHz in all cases; the "max" in the above list refers to the maximum rate that can be set in the AuxAI Device Options, not the default rate.

After selecting the 250 kHz max option, a message reminds you that you must have the "fast" version of the AuxAI card for rates greater than 5 kHz per channel:



If you are not sure which version of the AuxAI card you have, or if you wish to upgrade from the standard AuxAI card, please contact support@plexon.com for assistance.

Digitizing rates greater than 40 kHz require that the OmniPlex timestamp resolution be set to one microsecond, rather than the default 25 microseconds. If the timestamp resolution is not currently set to one microsecond, the following message will ask whether it should be adjusted:



Select *Yes* to set the timestamp resolution to one microsecond.

Timestamp resolution is explained in more detail in the next section.

Timestamp resolution

Timestamp resolution refers to the smallest time increments, or “ticks” in which timestamps are stored in recording files and in data that is sent to online client programs. Both in OmniPlex and in applications such as Offline Sorter (OFS) and Neuroexplorer (Nex), the timestamps are displayed in terms of seconds, fractions of a second, microseconds, etc, and the underlying “tick” resolution is of little or no concern.

If you do not work with raw integer timestamp values, for example in client programs or custom code that directly reads blocks of data from a plx file, you can safely skip over this section.

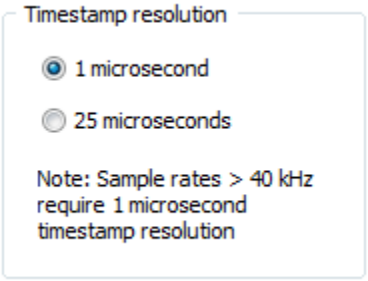
The default timestamp resolution in Plexon systems is 25 microseconds, i.e. 40 kHz. This is not the same as the digitizing rate, but the maximum digitizing rate cannot exceed the timestamp resolution.

The default timestamp resolution of 40 kHz means that in the raw integer timestamps stored in a file or sent to clients, two timestamps that differ by 40,000 represent a time difference of one second. Successive samples on a wideband (WB) or spike-continuous (SPKC) channel will typically have timestamps that increment by one tick for each sample, since in this case the 40 kHz wideband digitizing rate coincides with the 40 kHz timestamp resolution.

By comparison, successive samples from an FP or AuxAI channel, at their default 1 kHz digitizing rate, will differ by 40 ticks. This is because 40 ticks * 25 microseconds = 1000 microseconds = 1 millisecond, and 1 second / 1 millisecond = 1 kHz. Another way of looking at this is to consider that the FP or AuxAI channel is being digitized at 1/40 the rate of a wideband channel, so successive timestamps are 40 ticks apart rather than 1 tick apart. By the same logic, a channel that is digitized at 10 kHz would have timestamps that increment by four ticks from one sample to the next.

It is important to remember the distinction between the digitizing rate and the timestamp resolution. The timestamp resolution is simply the scaling factor that converts raw integer timestamps into floating point timetamps in seconds, or vice versa. Different sources, e.g. WB versus FP, may have different digitizing rates, but they will represent their timestamps in terms of the same timestamp resolution. The timestamp resolution is a single system-wide property, whereas each source can have its own digitizing rate.

In the context of the above discussion, it should be clear why the default timestamp resolution of 40 kHz is inadequate for digitizing rates greater than 40 kHz: timestamps less than one 25 microsecond tick apart cannot be represented as integers. Therefore, in order to support higher digitizing rates, OmniPlex 1.14 adds support for a one microsecond timestamp resolution mode. Any time that you set a digitizing rate greater than 40 kHz, OmniPlex will request permission to set the timestamp resolution to one microsecond, as described in the previous section. You can also manually set the timestamp resolution in Server's Global Options dialog:



You must restart OmniPlex after changing the timestamp resolution.

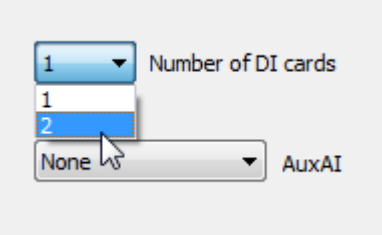
For sources whose digitizing rates are 40 kHz or less, note that the accuracy of timestamping is not affected; the only effect is to multiply the raw timestamps by 25, and this effect is invisible when you view the timestamps in OFS, Nex, and most other applications. In general, unless you are using an AuxAI digitizing rate greater than 40 kHz, you should leave the system timestamp resolution set to the default 25 microseconds.

Note that setting the timestamp resolution to one microsecond will cause the low-order 32 bits of the raw integer timestamps to roll over 25 times faster (71 minutes versus 29.8 hours). This is only an issue for legacy code which does not use the full 64 bit integer timestamp value (40 bits in plx files and in online client data).

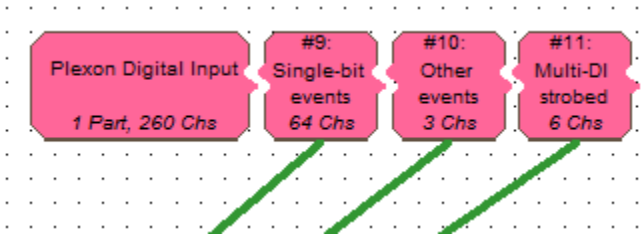
Multiple digital input cards

OmniPlex 1.14 adds support for a second digital input (DI) card. The Topology Wizard in OmniPlex Server allows you to specify the number of DI cards in your system, and the DI Device Options dialog has been extended to allow you to configure the port settings for each card.

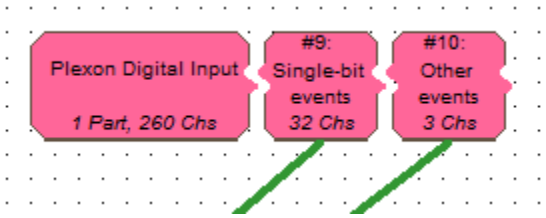
The Topology Wizard now includes a dropdown control that you can use to specify the number of DI cards in your OmniPlex chassis:



The default is one DI card. If you specify two DI cards, the DI card and its associated sources will appear in the topology as shown below:



Compare this to the same portion of the topology for a system which is configured for only one DI card:



In both cases, there is a source for *Single-bit events*, where the number of channels in the source is

*(number of single-bit events) = (number of DI cards) * 32*

since each DI card can generate 32 channels of single-bit events, if both 16 bit ports are configured in Mode I.

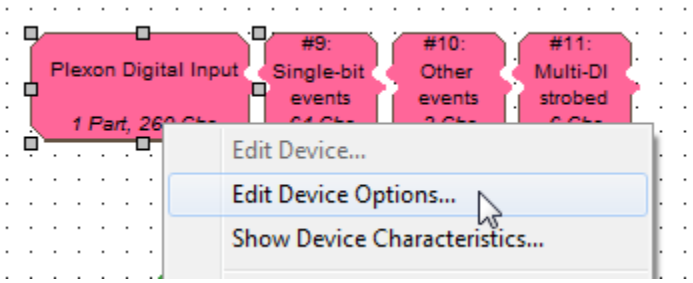
In addition, both configurations have an *Other events* source, containing one strobed channel and the RSTART and RSTOP recording-control events; this is the same, regardless of the number of DI cards, in

order to maintain compatibility with existing software. However, the system with multiple DI cards has an additional source named *Multi-DI strobed*, which contains only the strobed event channels for the second DI card.

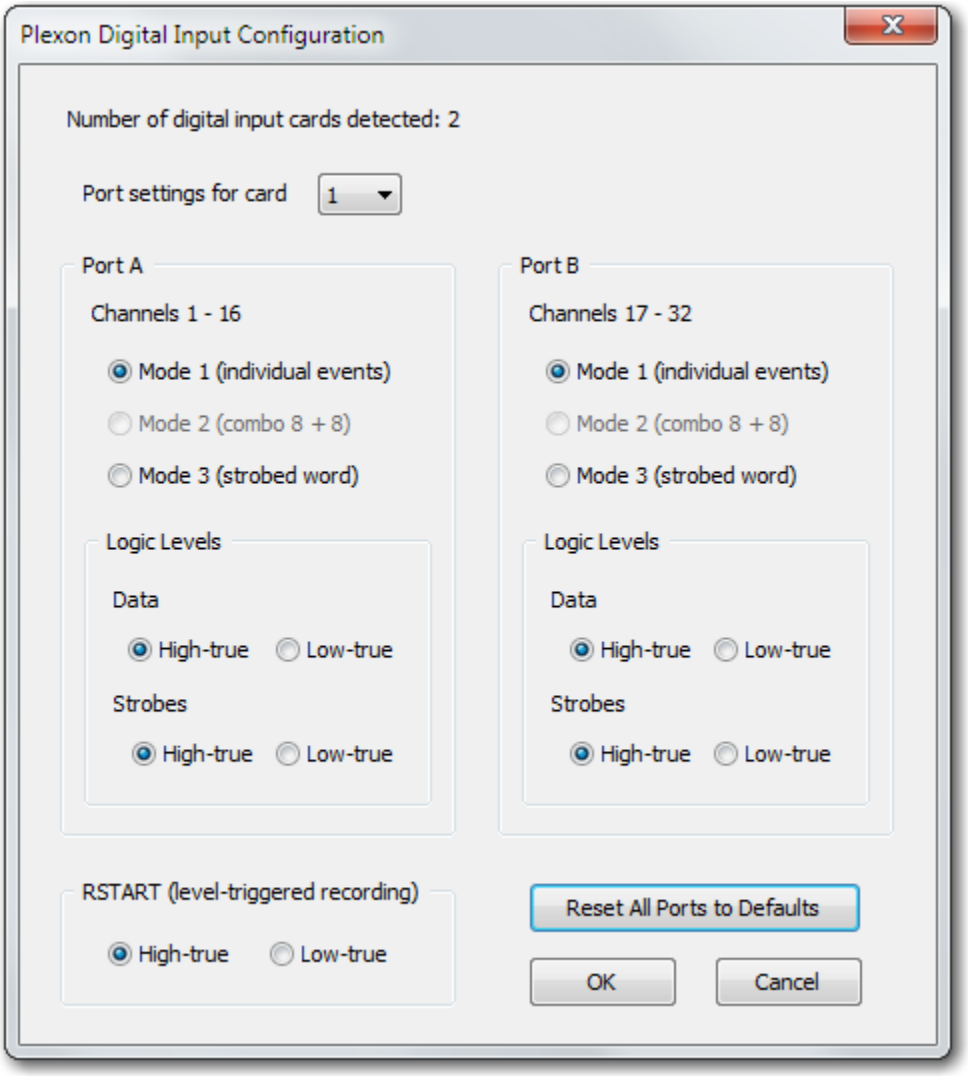
After you have created a topology which includes two DI cards and restarted OmniPlex with this topology, you can use all four ports (two per card) for digital input. The per-port options can then be configured, as described in the next section.

Digital input device options

To access the digital input device options, right-click on the Plexon Digital Input device in the topology:



The device options dialog is displayed:



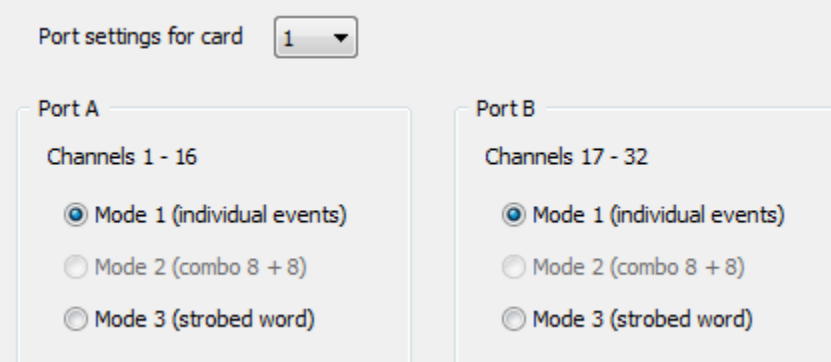
The most important change in the options dialog, compared to previous versions of OmniPlex, is the *Port settings for card* control; this allows you to view and edit the settings for each available DI card in turn. When you change the card number, the settings for ports A and B for the selected card are displayed. You can switch between each card's settings without losing any changes that you make, but the settings are not actually changed until you click OK. You can also use the *Reset All Ports to Defaults* button to reset all ports to Mode 1 and high-true logic.

Note that the settings for RSTART are not port-specific. The RSTART line on any port may be used, but you should use one and only one RSTART at a time. Sending signals into more than one RSTART input in parallel will yield unpredictable results.

The numbering of DI cards corresponds to their left-to-right order in the OmniPlex chassis, i.e. the leftmost DI card is card 1.

Event channel numbering

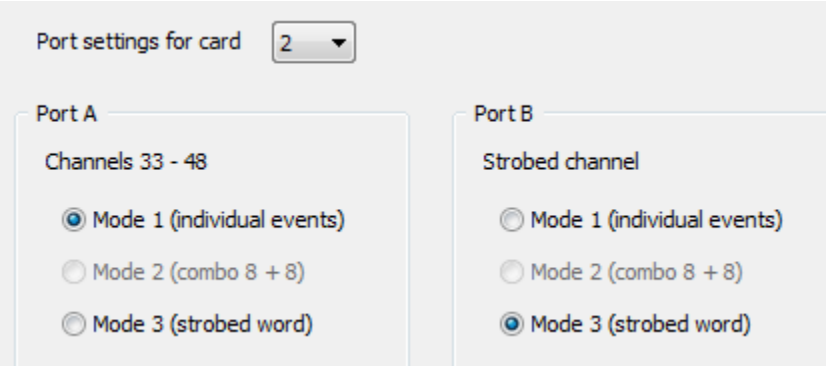
When a port is set to Mode 1 (individual single-bit events), the range of channel numbers used by that port is displayed:



For single-bit events, the channel numbering is the same for plx and pl2 recordings, as well as for event data sent to online clients:

DI card+port	Event chan#
1A	1-16
1B	17-32
2A	33-48
2B	49-65

When a port is set to Mode 3 (strobed events), this labeling is replaced with *Strobed channel*, for example:



Note that a specific channel number is not shown for strobed channels; this is because the numbering of strobed channels is different for plx and pl2 recording files (online client data uses the same channel numbering as plx files).

The following table gives the strobed channel numbering; remember that for pl2 files, event channels are identified by the combination of the source name and the channel number within that source:

DI card+port	PLX, client event chan#	PL2 source/chan#
1A	257	Other events / ch1
1B	257*	Other events / ch1
2A	241	Multi-DI strobed / ch1
2B	242	Multi-DI strobed / ch2

The asterisk * indicates the special case of Port B on the first DI card. For compatibility with the Plexon plx file format conventions, strobed data from Port B "shares" plx channel 257 with Port A, when both ports are set to strobed mode. In this case, strobed event words from Port A will always have their high bit set to 0 by OmniPlex, while words from Port B will have their high bit set to 1; thus the high bit can be used by readers of the data to distinguish the two ports. This means that when both Ports A and B are in strobed mode, the high bit (bit 16) is not available for user input, since it is overwritten by OmniPlex to indicate port A or port B. The use of channel 257 is for plx files and online clients; in pl2 files, strobed events from either port of the first DI card are recorded to channel 1 of the *Other events* source, but the "special high bit" convention still applies.

For the second DI card, the strobed channel numbering is more straightforward. Strobed events from Ports A and B always appear on two distinct channels, whether one or both ports are set to strobed mode. For plx files and online client data, channels 241 and 242 are used, while in pl2 files, channels 1 and 2 of the *Multi-DI strobed* source are used.

In a two-DI configuration, you can configure the four ports as strobed or unstrobed in any combination; for example, to avoid the "special high bit" issues in a system where two ports are to be used for strobed input, you might use ports A and B on the second card for strobed data, and ports A and B on the first card for unstrobed data.

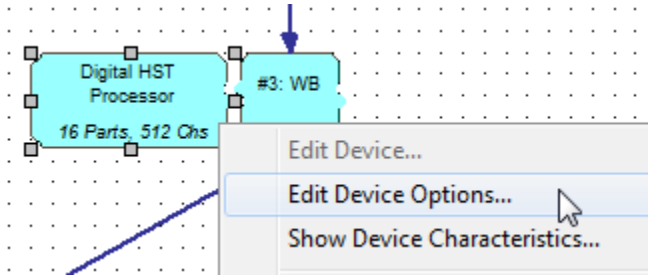
Adding digital input cards to an existing OmniPlex system

It is possible to add a second DI card to an existing OmniPlex system. However, minor hardware modifications to the existing DI card, and to the PSL or PDL (link) card are required. Do not attempt to use more than one DI card in a system without the required modifications, or unpredictable results can occur. To upgrade your system with a second DI card, please contact support@plexon.com.

64 channel digital headstages

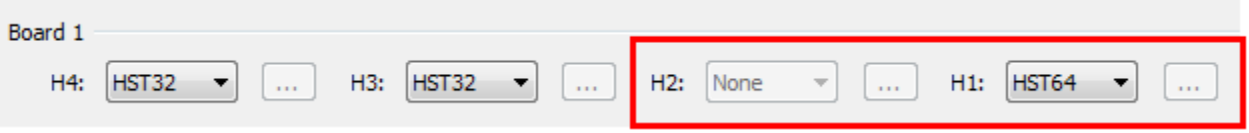
The Plexon Digital Headstage Processor (DHP) now supports 64 channel digital headstages (HST64), in addition to 16 and 32 channel headstages (HST16, HST32). You can use any combination of HST16, HST32, and HST64 whose channel counts add up to the number of channels in your topology (pxs). For example, a 128 channel topology could use two HST64, or one HST64 plus one HST32 plus two HST16. The only additional constraint when using HST64 is that they can only be plugged into every other port, starting from the rightmost port (P1) on each board. Even though the HST64 physically plugs into a single port, you should think of it as "occupying" two adjacent ports on the DHP. In other words**, *if an HST64 is plugged into P1, do not plug any headstage into P2; if an HST64 is plugged into P3, do not plug any headstage into P4.***

To define the DHP headstage configuration, right click on the *Digital HST Processor* device in the topology:



By default, a newly-created topology will assume HST32 on all ports, up to the appropriate number of ports for the total channel count. Use the per-port headstage dropdown controls to change the headstage type as desired. For example, to change the headstage on board 1, port 1 from 32 to 64 channels:

Once you have selected a 64 channel headstage, note that the controls for the adjacent port set to *None* and are disabled to indicate that the adjacent port is not available:



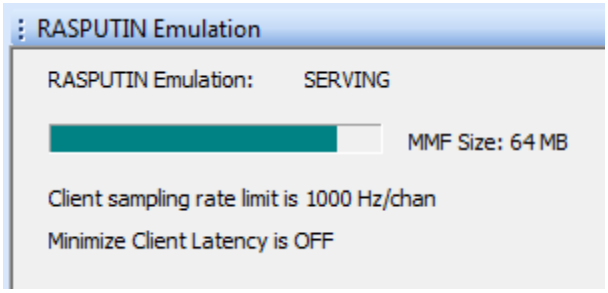
Note that there are in fact two different types of 64 channel headstages. *HST64* is a generic 64 channel digital headstage; *Intan64* is the 64 channel digital headstage made by Intan. The difference between the two is that when *Intan64* is selected, an Intan-specific channel remapping (reordering) is applied, such that the two rows of input pins on the headstage will appear in OmniPlex as channels 1-32 and 33-64. When *HST64* is selected, the special remapping is not applied, i.e. it is assumed that the headstage input pins are already in correct ascending channel order.

All the standard configuration options for *HST16* and *HST32*, e.g. filter cutoffs, referencing, etc, apply in the usual way to *HST64* and *Intan64* headstages. See the release notes for OmniPlex 1.12 and 1.13 for details.

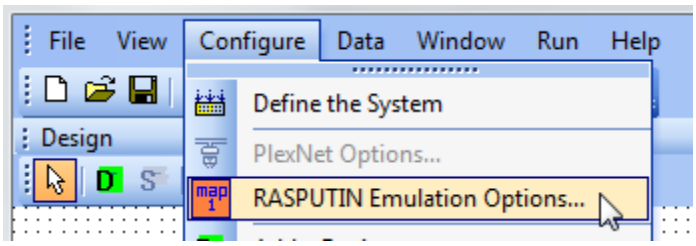
When you start data acquisition in OmniPlex, an error message will be displayed if an incorrect headstage configuration is detected. Refer to the Server message window for the specific board and port on which the error was detected.

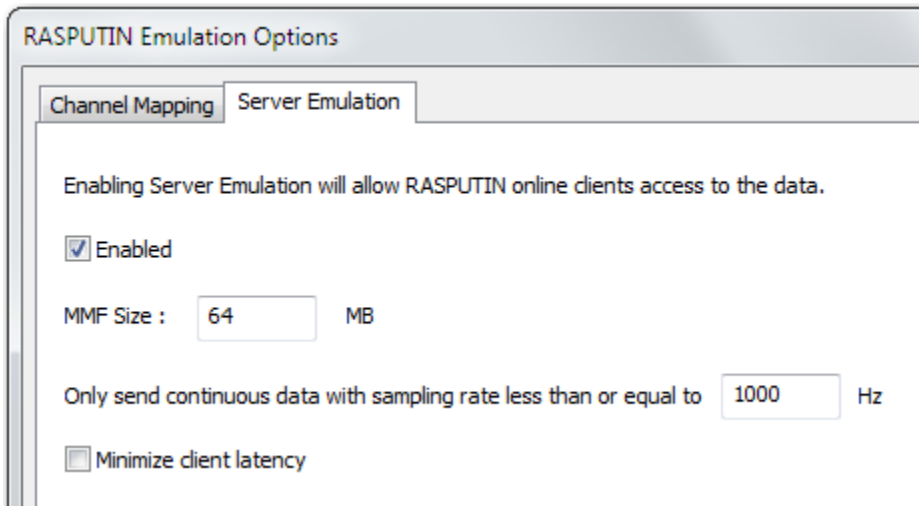
Display of online client connection settings

The current settings of parameters related to online clients (Rasputin server emulation) are now displayed in the main Server window:



As in previous versions, you can change these settings from RASPUTIN Emulation Options, in the Configure menu:

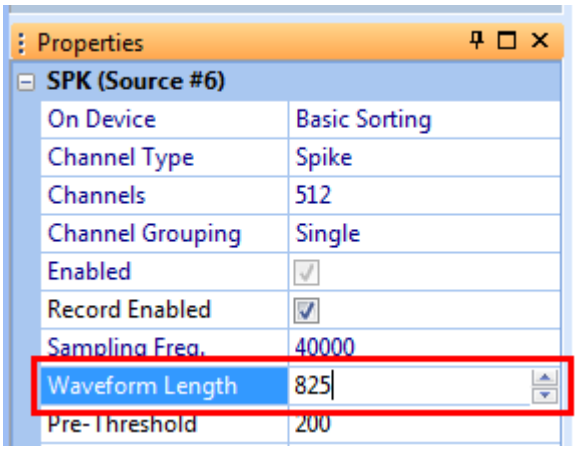




Note that before changing these settings, you must stop data acquisition and close any online client programs.

Increased maximum spike waveform length

Previous versions of OmniPlex supported detection of spike waveforms up to 56 points in length, which is a length of (56 * 25 microseconds) = 1400 microseconds = 1.4 milliseconds. OmniPlex 1.14 supports a maximum spike length of 224 points or (224 * 25 microseconds) = 5600 microseconds = 5.6 milliseconds. To change the waveform length from its default of 800 microseconds, stop data acquisition and modify the length in PlexControl:

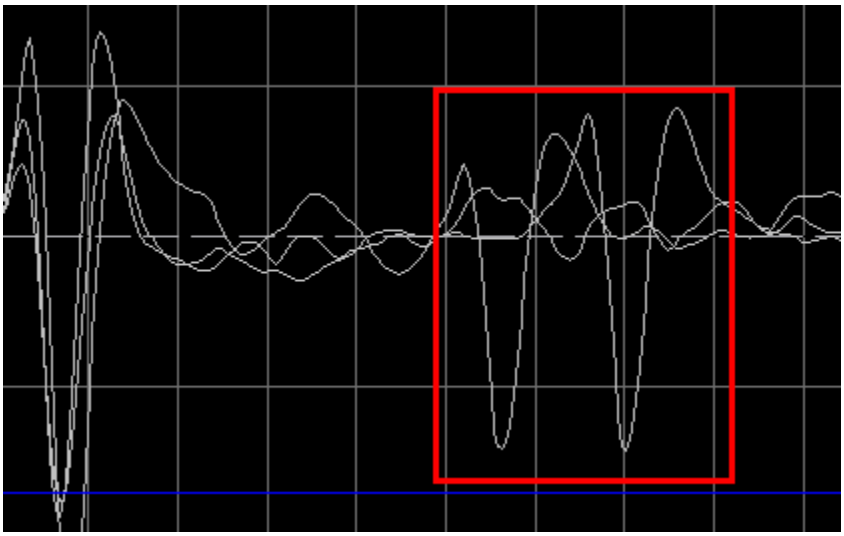


Depending on the shape of the spike waveforms, you may also wish to modify the pre-threshold interval.

The following considerations should be kept in mind when using long waveforms.

Overlaps / superpositions in the tail of spike waveforms

A common mistake is to set a very long waveform length "to make sure we get the entire spike." While it is desirable to capture the full action potential, remember that the tail of a spike decays into some combination of noise and action potentials from nearby units. If the waveform length is longer than necessary, it is more likely that the tail of the spike will unintentionally include the superposition of a portion or all of other action potentials:



This is problematic in that these "tail overlaps," which could be subsequent firings of the same unit, or action potentials from other cells, will not be detected and timestamped as separate spikes. In addition, their superposition onto the initial spike's shape can be thought of as large-amplitude noise spikes which make it difficult or impossible to sort the distorted spike shape. When viewed in PCA feature space, these overlap-corrupted waveforms tend to appear as outliers.

Plexon's Offline Sorter 4.0 has functionality which can in some cases "untangle" such overlapped spikes, but this can be a labor-intensive process, may not succeed in extreme cases, and requires that you record the continuous wideband or spike-continuous signal. Therefore, you should only increase the spike length in cases where the action potentials from the cells that you are recording are in fact significantly longer than the default 800 microseconds, and you should visually check the resulting detected spikes for excessive overlaps. However, a small percentage of overlaps are unavoidable in many cases, especially when recording highly active cells, and this can usually be tolerated without adversely affecting subsequent analyses.

Note that the line sorting and band sorting methods are more robust to the presence of overlaps in the tail of spike waveforms. In line sorting, you can avoid drawing sort lines in the tail region, so that sorting is immune to shape distortions in the tail. With band sorting, you can set narrow band widths in the "important" middle part of the spike's shape, and larger widths in the tail. In comparison, with template sorting you can only adjust a single sum-of-squared-errors tolerance value for the entire spike, with no way to indicate to the sorting algorithm that some segments of the spike waveform are more likely to be "clean" than others (e.g. the tail). Note that although line and band sorting are better able to tolerate shape distortions that only occur in a subset of the spike, overlapped waveforms that are unintentionally captured in the tail are still "missed waveforms" which are not captured and timestamped separately.

Increased processor load

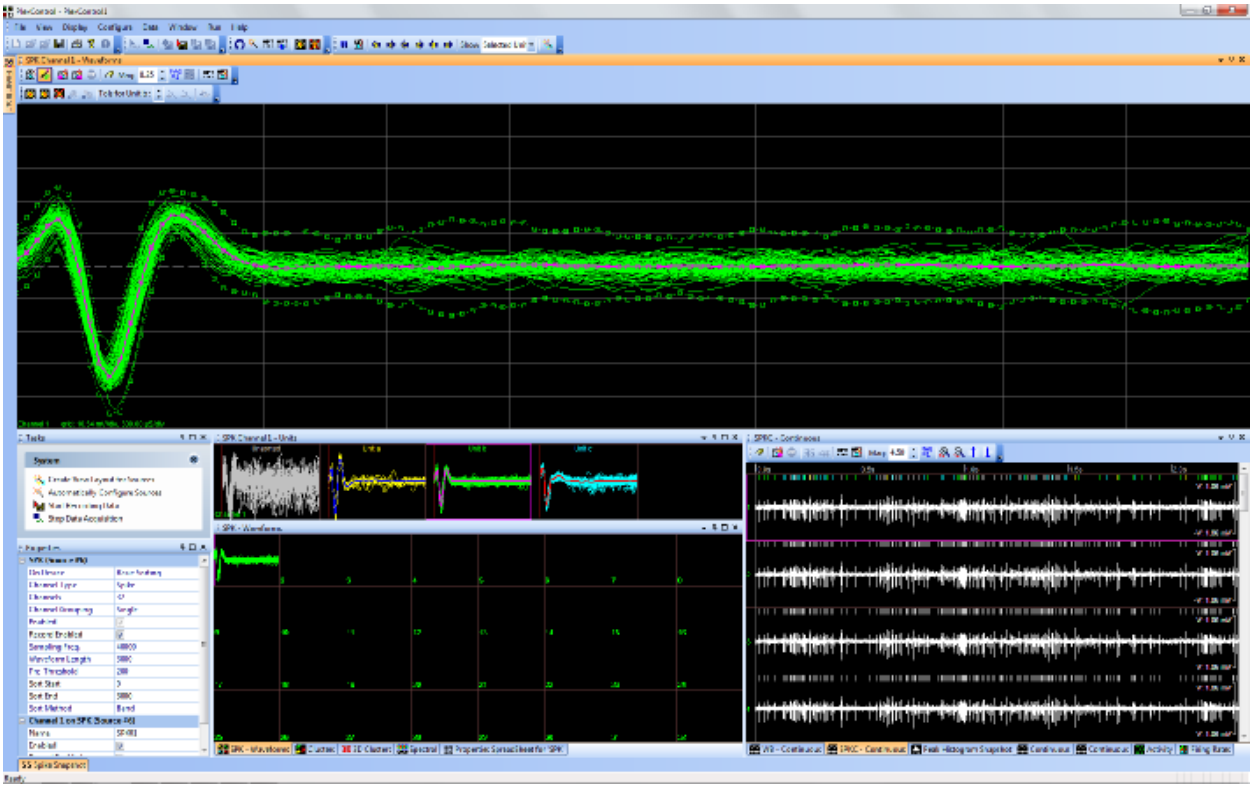
Acquiring very long spikes can increase the amount of processing power required to sort, display, and record spikes. As with normal-length spikes, processor load is also dependent on the number of channels, the spike firing rates, and can be exacerbated by unnecessarily low thresholds. If setting a large waveform length appears to cause performance problems or data drops, see the User Guide for more information on how to monitor processor usage and optimize performance.

Online clients

Online client programs (C/C++ or Matlab) can only read a maximum of 56 point spike waveforms. If the spike length is greater than 56 points, only the first 56 points are sent to clients.

User interface

When working with very long spikes, you may find that user interface elements in the main spike window become too crowded to work with comfortably. In particular, the editing handles on lines, bands, and templates can overlap, making it difficult to select and move them. In such cases, making the main spike window as wide as possible, and/or dragging it to a separate monitor, will make defining and editing units easier. See the User Guide for information on how to resize and rearrange windows within PlexControl.



Windows XP not supported in future releases

OmniPlex version 1.13 is the last release which supports Windows XP. Microsoft discontinued support and security patches for XP in April 2014. The next release of OmniPlex will only be available for Windows 7 systems. If you have an older OmniPlex system which is still installed on an XP computer, please migrate the system to a Windows 7 PC, or you will be unable to install future OmniPlex software releases. Plexon technical support (support@plexon.com) can answer questions about how to move your system from XP to Windows 7.

Support for 512 channel Digital Headstage Processor

OmniPlex 1.13 includes support for Digital Headstage Processor (DHP) configurations up to 512 channels, compared to a maximum of 256 channels in previous releases. Currently, a 512 channel system requires sixteen digital headstages of 32 channels each.

All OmniPlex systems with high channel counts (>= 128) will benefit from various performance optimizations that were made in version 1.13. OmniPlex can acquire and sort data on 512 channels with CPU usage typically under 10% (under 13% while recording), and operations such as auto-sort, auto-threshold, and toggling between live data and snapshots are faster and smoother than in previous releases.

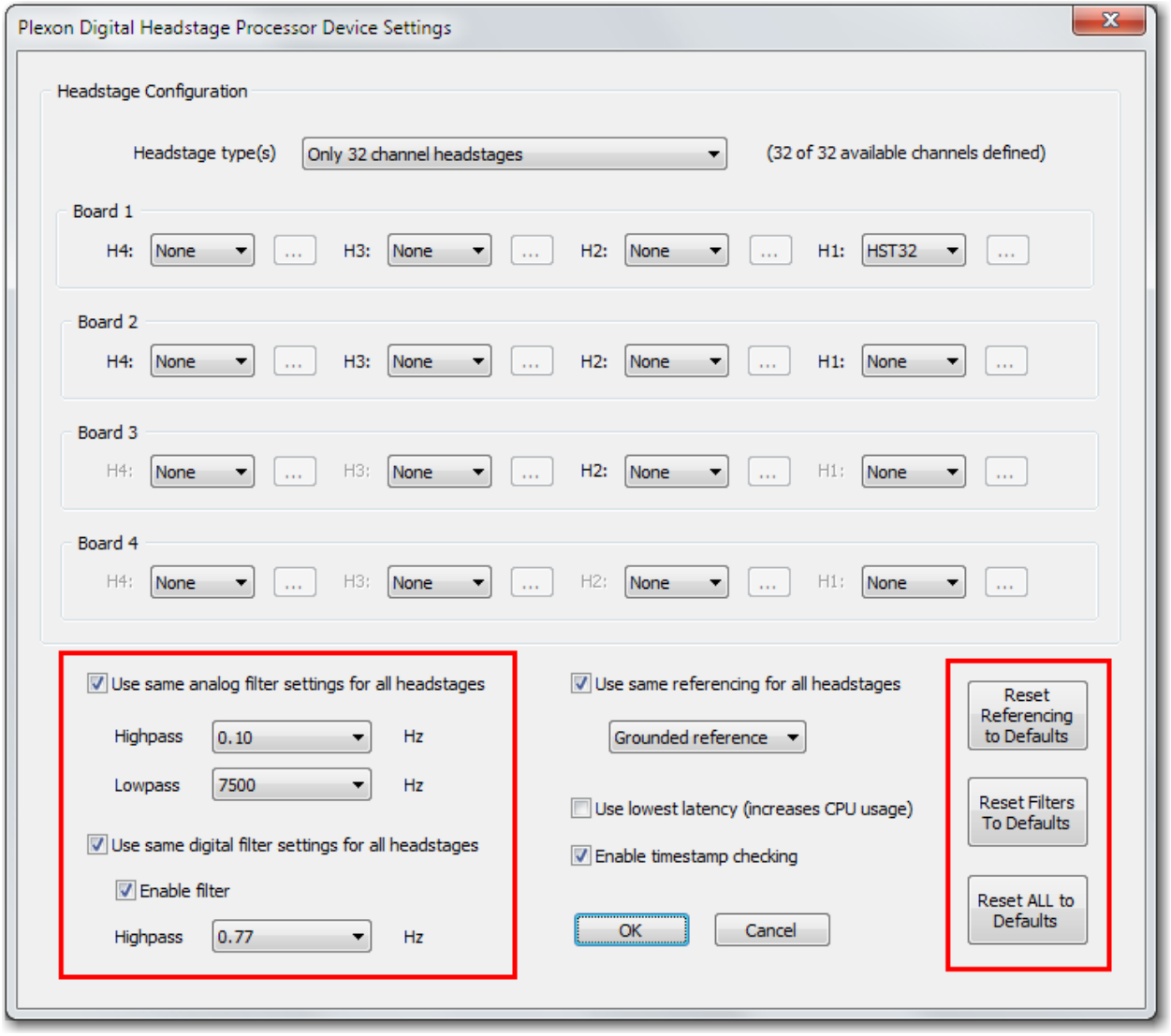
Please note that if you are upgrading an existing DHP system to greater than 256 channels, certain Windows system settings must be updated for correct operation. Contact support@plexon.com for details.

DHP systems of greater than 256 channels do not require a separate lowest-latency mode, so the “Use lowest latency” option in the DHP device options dialog will be grayed out on such systems.

For performance reasons, systems with greater than 256 channels cannot record to the older PLX file format; recording to Plexon’s newer, high performance PL2 format is required. Please contact support@plexon.com if you have questions about migrating from PLX to PL2.

Changes and additions to Digital Headstage Processor device options

The Device Options dialog for the DHP has been revised and extended. Only the changes relative to version 1.12 will be highlighted below; please refer to the release notes for OmniPlex 1.12 for general information about the DHP device options.



Analog and digital headstage filters

In OmniPlex 1.12, you were able to specify the cutoff frequencies for the analog lowpass and highpass filters which precede the analog to digital converter (A/D) in the digital headstage. These filters remove unwanted very low frequency signals, high frequency noise, and prevent aliasing caused by frequencies greater than the Nyquist rate (half the sampling rate). Version 1.13 also allows control of an optional digital highpass filter which is applied to the *output* of the A/D converter, i.e. to the digitized samples.

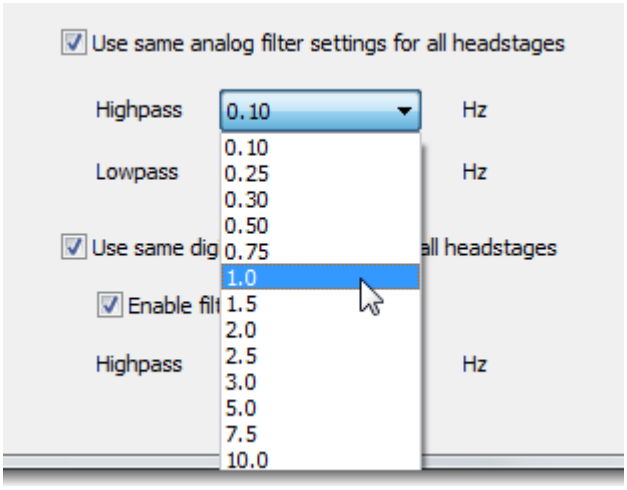
This digital filter performs two useful functions. First, it eliminates any DC offset appearing at the output of the A/D converter; this offset can otherwise be present as a byproduct of the headstage, even when the analog highpass filter is enabled. Second, by enabling both the analog and digital highpass filters, with the digital highpass set to a higher frequency than the analog filter, very low frequencies in the original analog signal can be removed in the most effective manner. This is partly due to the additional pole of highpass filtering, but for other reasons as well, as described below. If you are not concerned with low frequency phase shift correction, you can skip the following paragraph.

Consider that the analog highpass filters on each digital headstage have a small amount of inherent variation of cutoff frequency from channel to channel, due to analog component tolerances. This means that, for applications where it is important to remove any filter-induced low frequency phase shifts (group delay), for example using Plexon's FPAlign application, there will unavoidably be a small residual phase shift after correction, since FPAlign has no way of "knowing" of these slight imperfections. A digital headstage filter has no such imperfections, but by definition cannot be applied before A/D conversion, and cannot remove low frequency artifacts which can cause clipping in the A/D conversion; only an analog filter can do this.

However, if we use both the analog and digital highpass headstage filters, but set the latter's cutoff significantly higher, the effect of the variation in the analog highpass will be greatly reduced. You might think of the digital highpass as the "precision trim" that follows the "approximate first cut" from the analog highpass. Note that since both the analog and digital filters are relatively gentle one-pole filters (6 dB./octave rolloff), the digital highpass cutoff should be well above that of the analog highpass, e.g. by a factor of 4-10. The default cutoff frequencies are 0.1 Hz for the analog highpass and 0.77 Hz for the digital highpass.

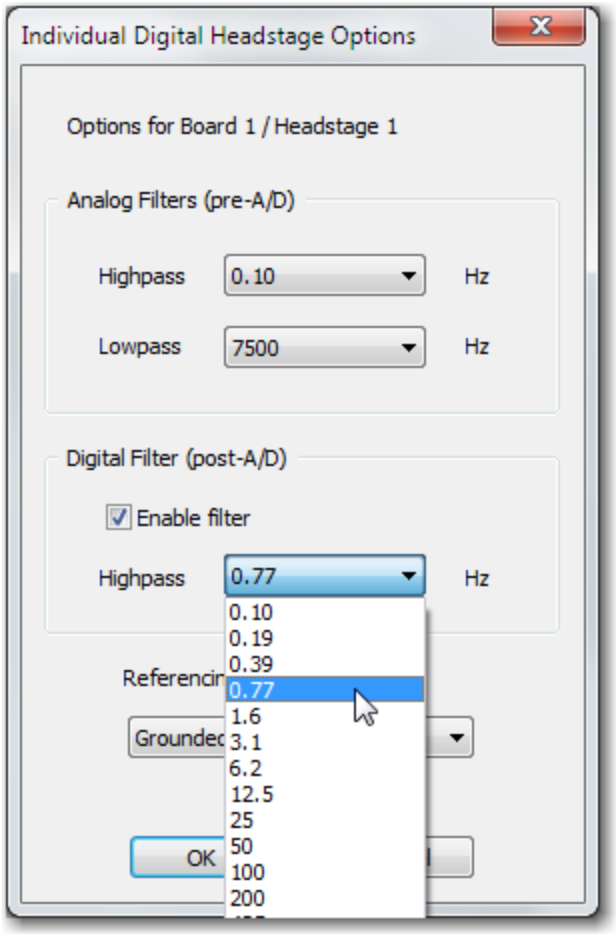
Filter cutoff frequencies as dropdown lists

In version 1.12, the frequencies for filter cutoffs had to be typed in manually. In version 1.13, you select frequencies from dropdown lists, for example:



Note that list of frequencies is restricted to the frequencies which are implemented in the digital headstage hardware; in version 1.12, any frequency which you typed in was automatically mapped to the nearest available hardware-implemented cutoff frequency.

The dropdown lists are also used in the options dialogs for individual headstages, when the appropriate "Use same…for all…" option in the main options dialog is unchecked:



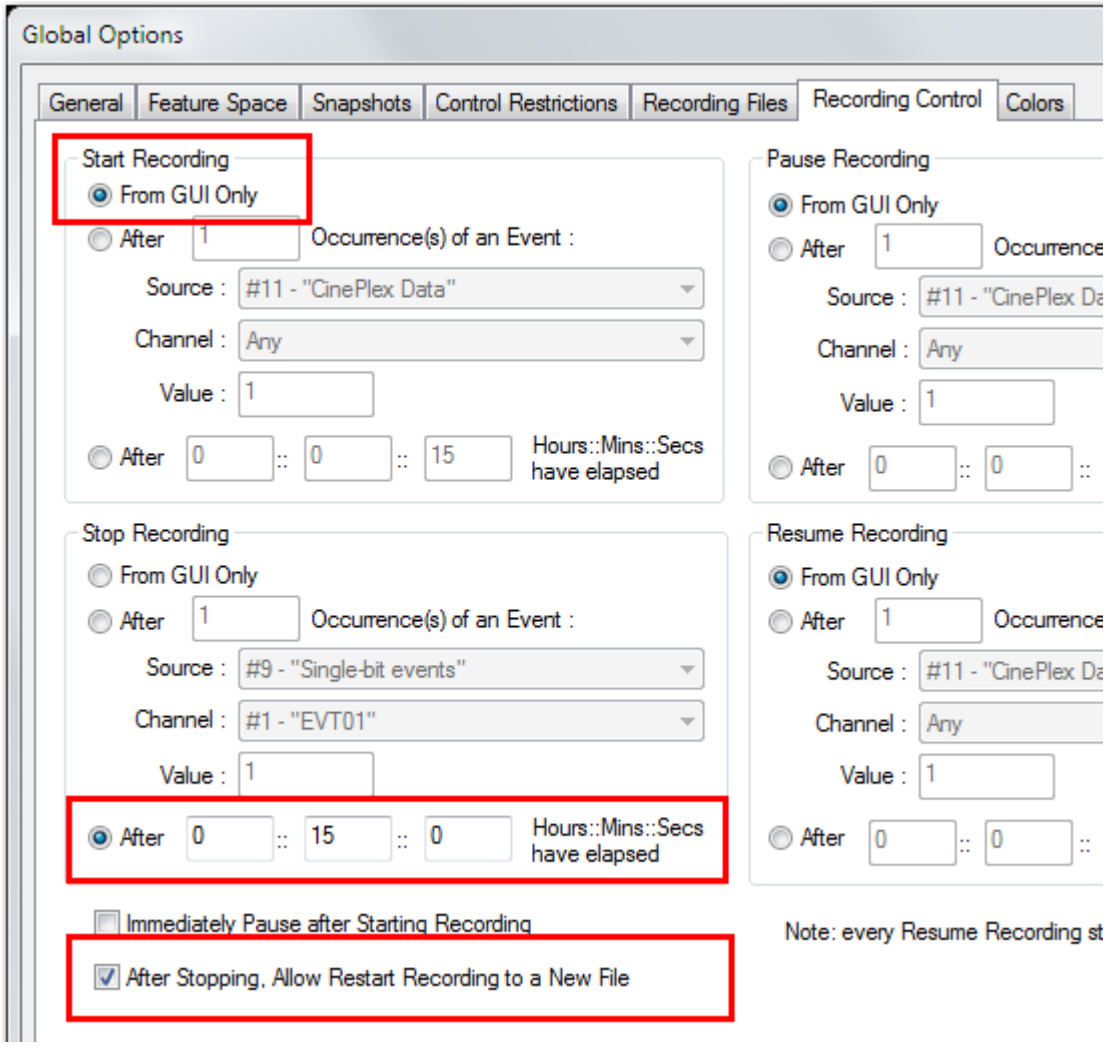
Reset referencing / filters / ALL to defaults

These buttons allow you to reset either the referencing options, filter settings, or all digital headstage options, to their default values.

Note that the ALL reset includes the configuration of 16 versus 32 channel headstages, which will revert by default to the appropriate number of 32 channel headstages required by the total channel count.

Timed and event-triggered multiple file recording

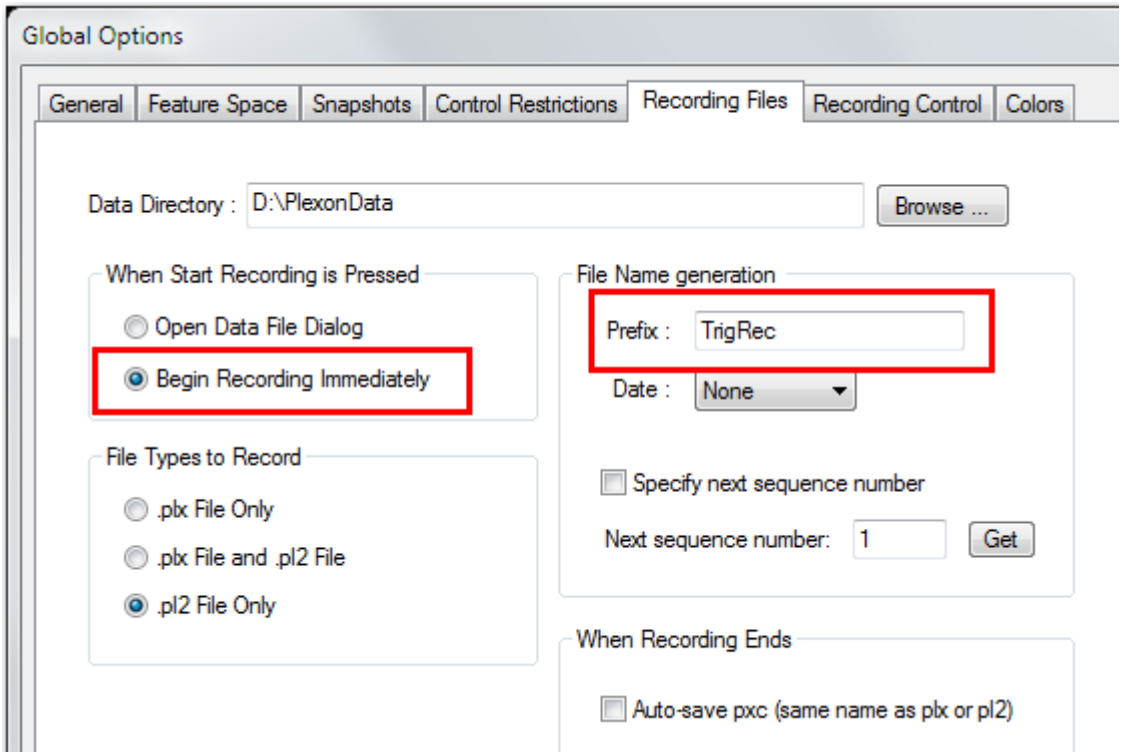
PlexControl can now automatically record multiple plx or pl2 files in sequence, based on either a specified file duration, or triggered by a digital or keyboard event. To enable timed or event-triggered recording, use the “After Stopping, Allow Restart Recording to a New File” option on the Recording Control page in PlexControl’s Global Options dialog. Here is an example of a how to enable automatic recording of files of a specified duration:



After you have set the options as shown, use the Start Recording button in the toolbar to start recording as usual:

After the specified time interval has elapsed, PlexControl will close the recording file and start recording to a new file; this process will repeat indefinitely, until you click the Stop Recording button in the toolbar to end the series of recordings:

Note that for automatic multiple-file recording, PlexControl will automatically generate a filename for each recording file, using the options that you have set in the Recording Files options in the Global Options dialog:

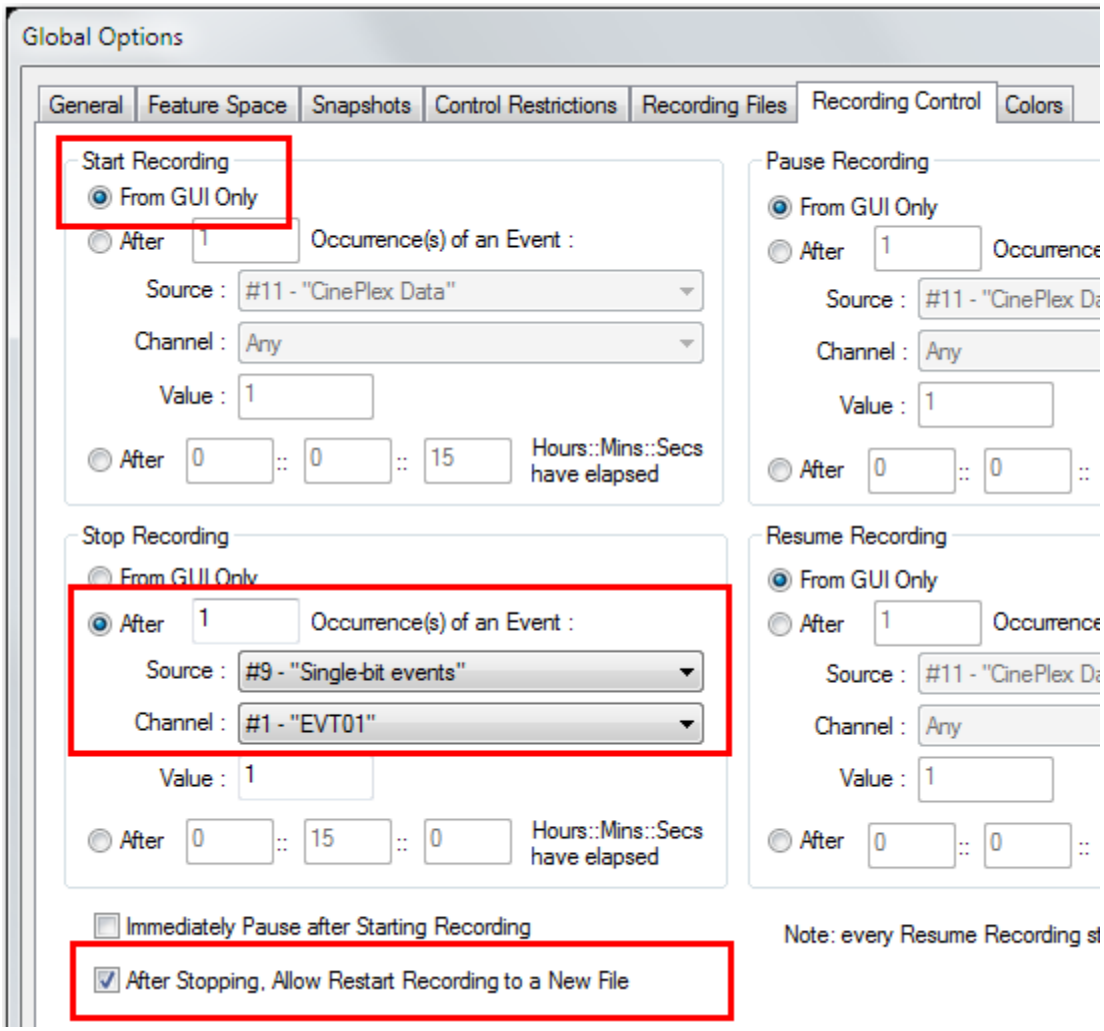


In the above example, the recording files will be named TrigRec001, TrigRec002, TrigRec003, etc. Filenames will always continue at one greater than the highest numbered file that is present in the recording folder; for example, if one series of recordings ended with TrigRec078, the next time you click Start Recording, the next file to be recorded will be TrigRec079. You can use the "Specify next sequence number" option to override this default behavior.

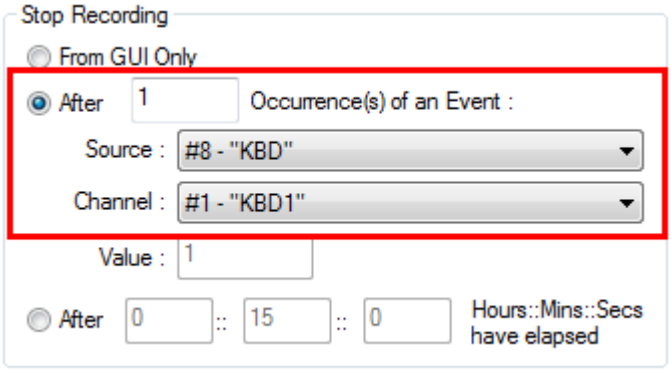
Make sure that the above options are set as desired before clicking Start Recording.

Note that the "Auto-save pxc" option (and the corresponding "Auto-save pxs" option in Server) cannot be used in timed or triggered multiple-file mode. In such cases, you should manually save the pxc/pxs before starting the timed/triggered sequence of recordings.

To automatically start a new recording file each time a specified digital or keyboard event is detected, use the "After Occurrence(s) of an Event" option. For example, to end the current recording and start a new recording each time a digital event is detected on channel EVT01:



Similarly, you can specify a keyboard event, for example KBD1, as a recording trigger, so that a new file will be started each time you press the specified key combination (e.g. Alt-1 to generate event KBD1).



Caveats

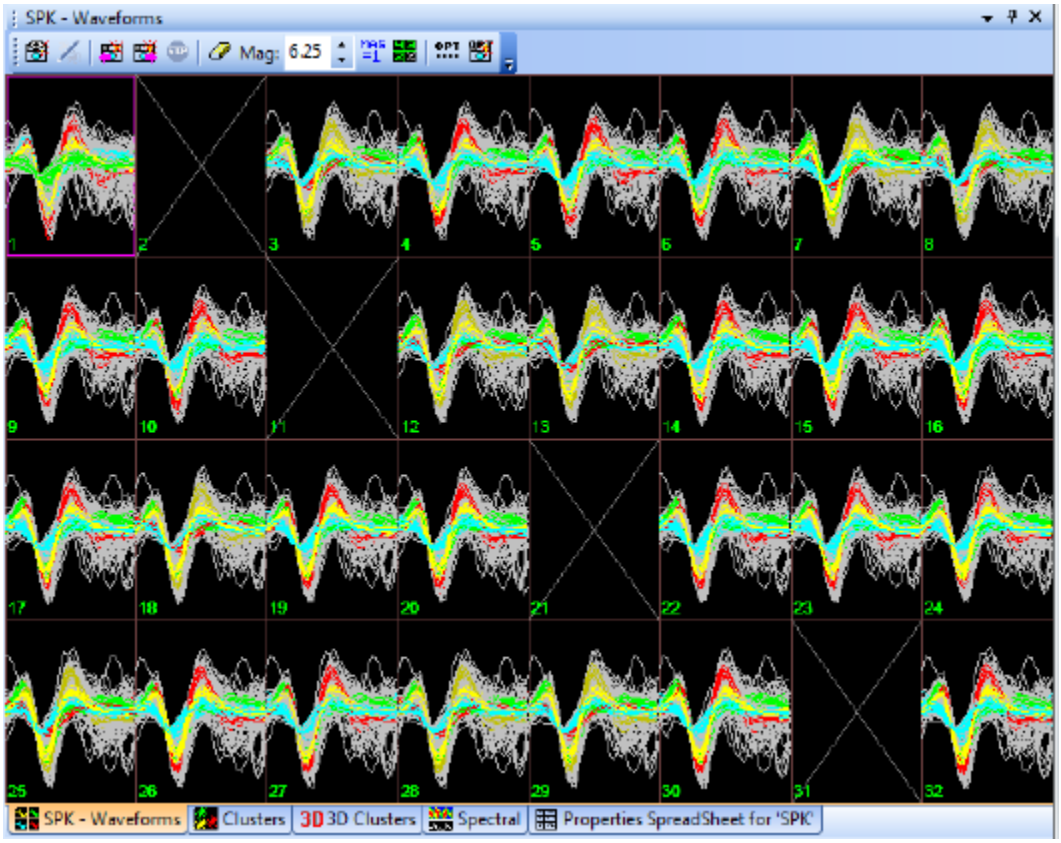
The timed/triggered recording feature is not intended to be used to record very short files. The shortest allowed file duration is approximately two seconds, and attempts to trigger recording more frequently will be ignored by PlexControl, until at least two seconds have elapsed.

You should expect a gap of approximately 1-2 seconds between each pair of recorded files, which should not be a problem for recordings of typical durations. Timestamping will still be correct within each file, but the brief interval of data that occurred between the closing of one file and the opening of the next will not be recorded. In situations where you require short, precisely timed recordings, for example recording exactly two seconds of data each time an experimental stimulus is applied, you should instead record a single longer file and use digital events recorded in the file as markers for the intervals of interest.

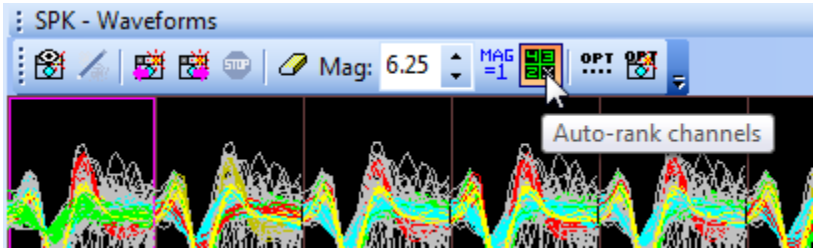
Channel ranking

A new channel ranking feature allows the order of display in the multichannel spike, spike-continuous (SPKC), wideband (WB), and field potential (FP) views to be determined by one or more selected criteria. For example, channels can be ranked such that the channel(s) with the largest number of sorted units is/are displayed first. This can help draw your attention to “interesting” channels and reduces display clutter, especially at higher channel counts and/or if you have a significant number of inactive channels.

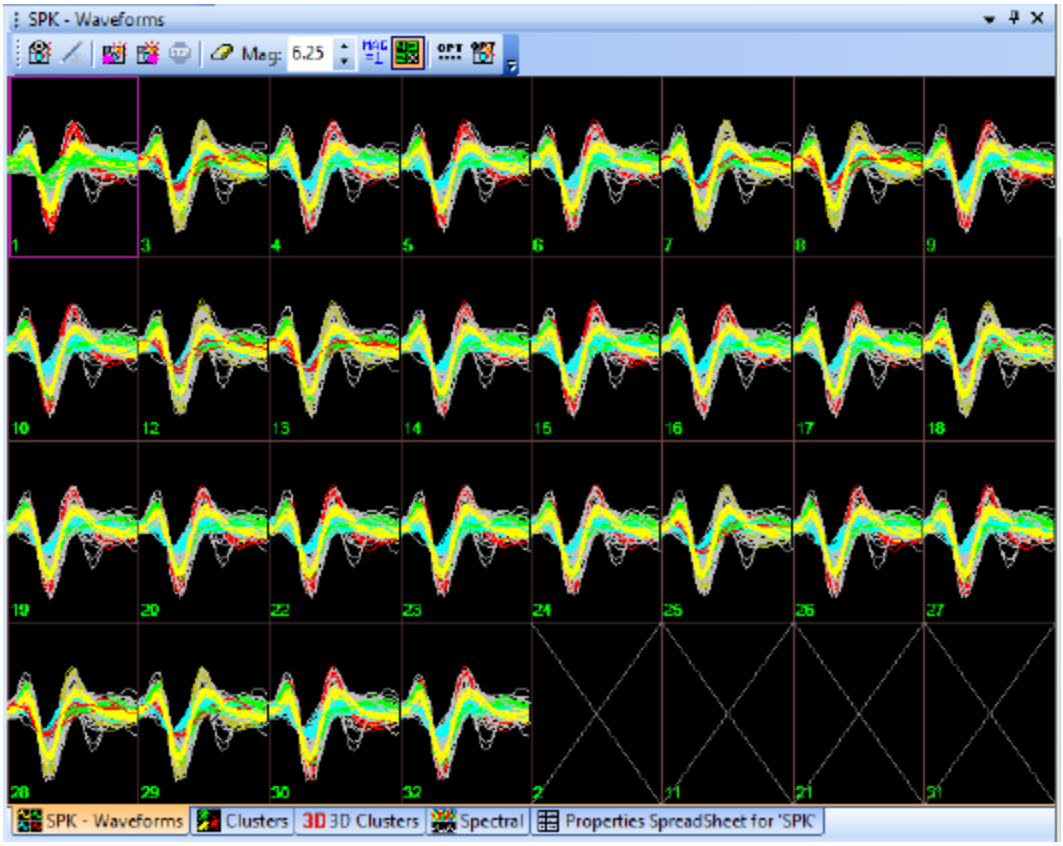
In its simplest form, channel ranking can be used to place all disabled channels last in display order. By default, disabled channels are displayed like this:



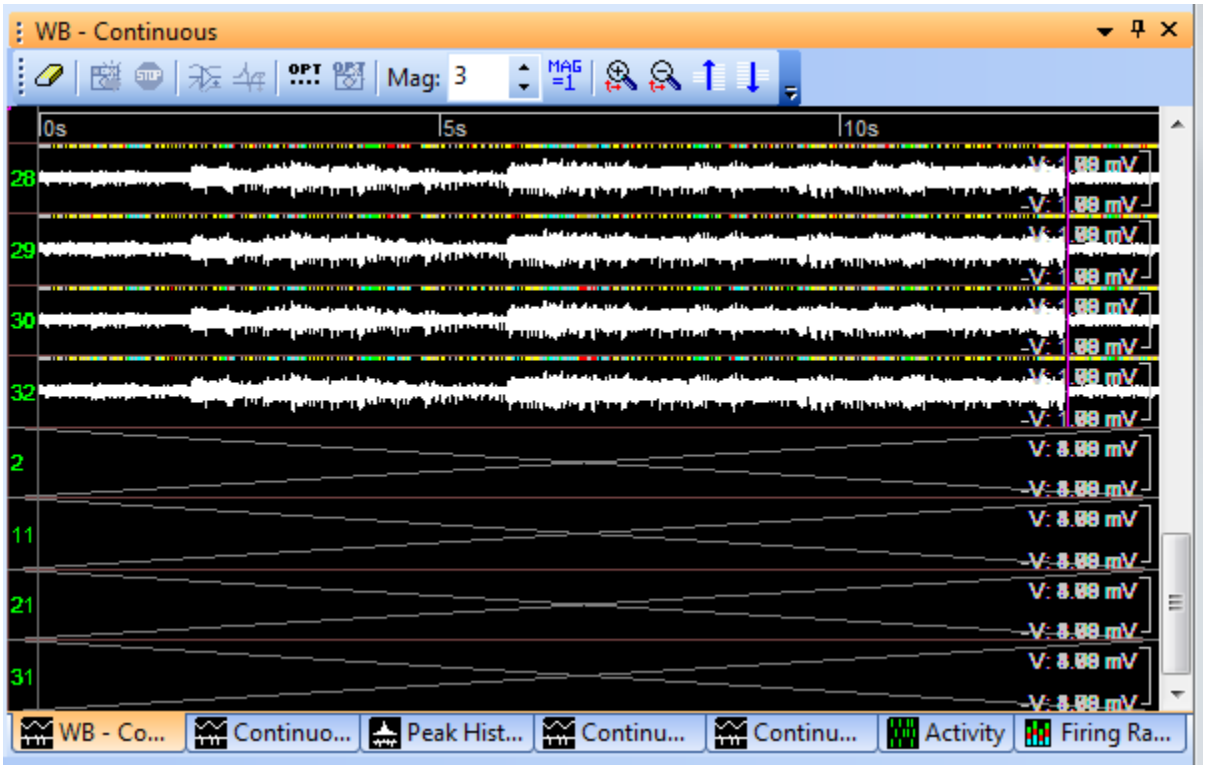
Click on the channel ranking button in the multichannel spike window’s toolbar to enable channel ranking:



With channel ranking enabled, disabled channels are pushed to the end of the display:

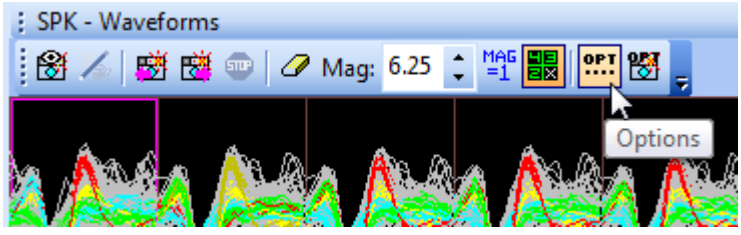


The WB, SPKC, and FP continuous views will display their channels in the corresponding order (channels 1-27 are not visible here but are in normal order above channels 28-32):

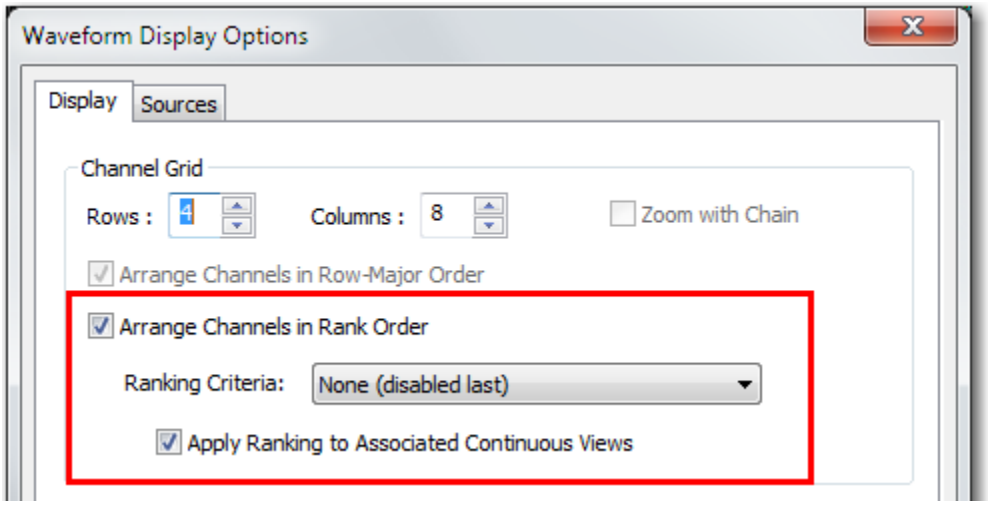


Click the Channel Ranking button again to return to the original unranked channel order. Note that channel ranking does not affect the data itself, the numbering or order of channels in recording files, clients, etc. It is purely an option for organizing the multichannel displays. Also note that the channel ranking is always a function of the channels in the SPK source; for example, if you disable different channels in the SPK and FP sources, the disabled SPK channels will determine the channel ranking.

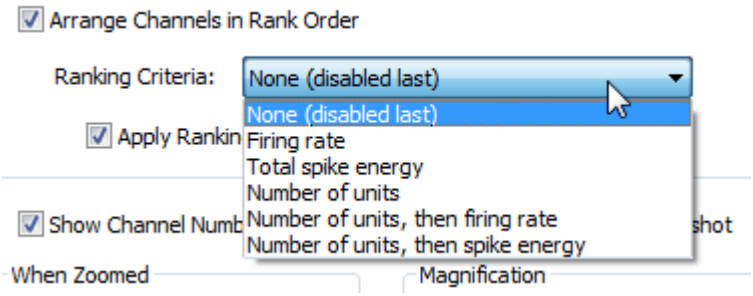
Channel ranking can be based on criteria other than (or in addition to) channels' disable status. To see the available ranking options, click on the Display Options button in the spike window toolbar:



The Display Options dialog is displayed, with the channel ranking options in the upper area as highlighted below:



Arrange Channels in Rank Order has the same effect as the toolbar button, i.e. you can use either to toggle channel ranking on and off. *Apply Ranking to Associated Continuous Views* determines whether the channel ranking in the multichannel spike (SPK) window is applied to the WB, SPKC, and FP views. The *Ranking Criteria* dropdown list allows you to use additional criteria in determining the channel ranking.



None means that no additional criteria are used, and only disabled channels determine the ranking. The remaining criteria are based on the most recent spike snapshot, so you must take a snapshot before using them.

Firing rate is the per-channel mean firing rate, within the snapshot. For example, for the default 500 spikes per channel snapshot, the mean firing rate of each channel would be:

MeanRate[channel] = 500 / (TimestampOfLastSpike[channel] – TimestampOfFirstSpike[channel])

TotalSpikeEnergy for a channel is the sum of the individual spike energies for all spikes in the snapshot, where a spike's energy is defined as the sum of its squared waveform sample values. If different channels have the same number of spikes in their snapshots, the respective total spike energies will depend entirely on the relative spike energies. If different channels have different numbers of spikes in their snapshots, either because the snapshot was taken "by time" instead of "by count," or if one or more

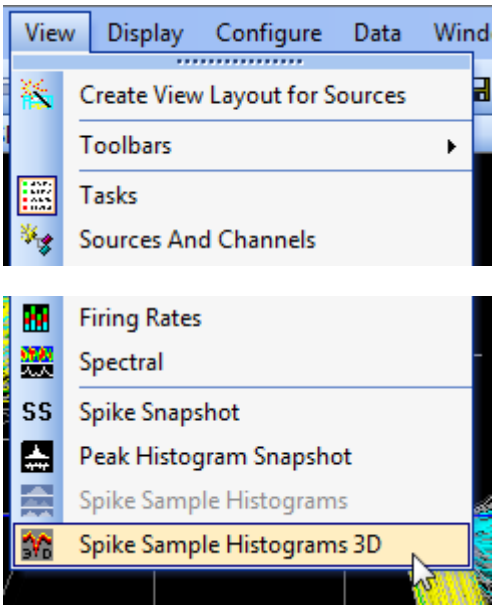
channels' snapshots timed out before their count was reached, then the total spike energies will depend on both the spike energies and the number of spikes in the snapshot.

Number of units is the number of sorted units on each channel. The three remaining criteria are based on number of units first, and then within channels that have the same number of units, firing rate or total spike energy are used as a secondary ranking criteria. For example, *Number of units, then spike energy* would assign the highest ranking to the channel with the most sorted units *and* the largest spikes.

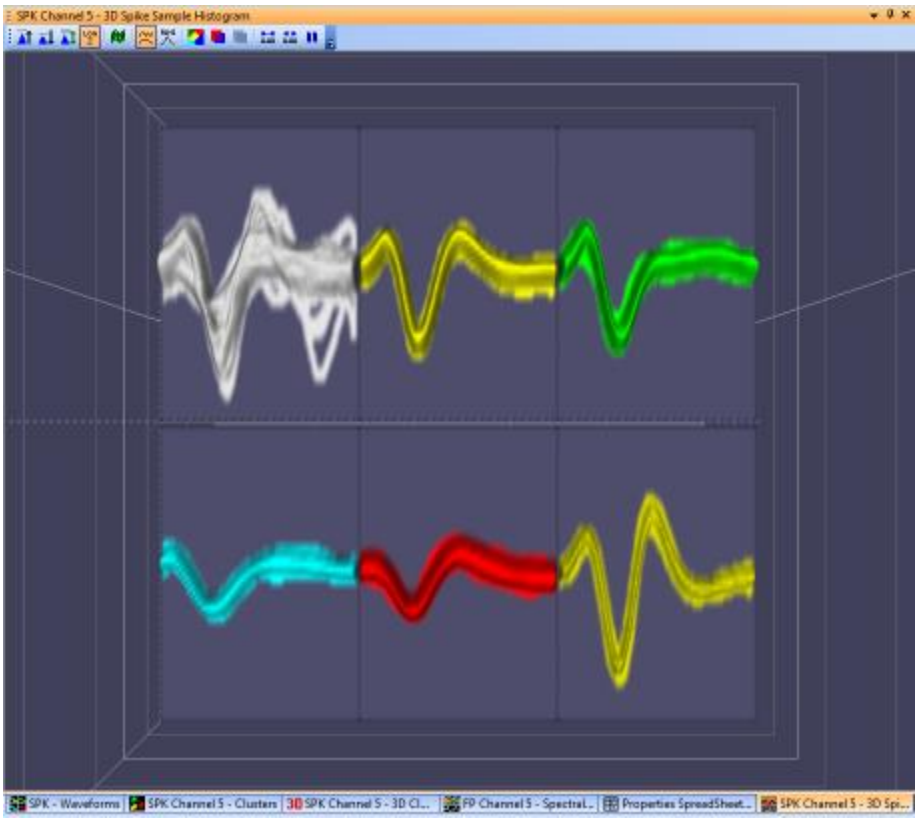
Note that channel ranking is not dynamically updated, i.e. channels do not "move around" in the multichannel display in real-time as their firing rates or number of sorted units change. In the case where disabled channels are displayed last but no other ranking criteria are being used, you can refresh the display order by clicking the Channel Ranking button twice, to disable and then re-enable ranking. For cases where criteria based on the spike snapshot are being used, you must take a new spike snapshot before toggling the ranking off and then back on. When the ranking is re-enabled, it will use the most recently taken spike snapshot.

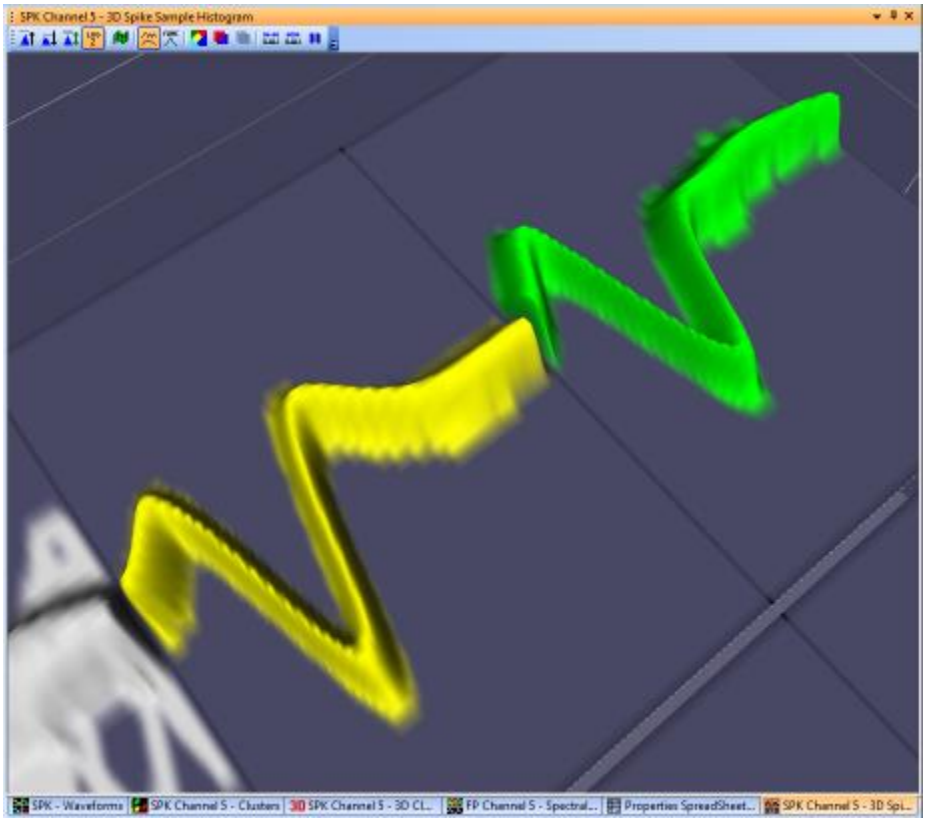
Spike Sample Histogram 3D view

The Spike Sample Histogram 3D view (SSH3D) provides an alternative form of visualization for the currently selected spike channel. It displays the same spikes as the standard main spike window, but in a way that models the distribution of spike sample (amplitude) values and the firing rate of each sorted or unsorted unit as one or more solid or semi-transparent 3D surfaces. To display the SSH3D view, select it from the PlexControl View menu:



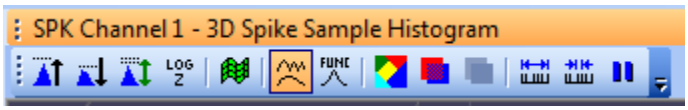
The default view angle looks straight down on the sample histograms, but you can rotate and zoom the display to view the histograms as desired, using the same mouse actions as the 3D PCA view.



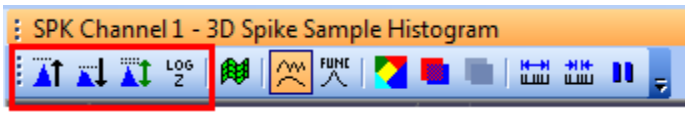


Or, for an automatic “tour” of the histograms, click anywhere in the view and press the “F” key to enter an automatic “flyaround” demo mode. Press “F” again to stop the flyaround.

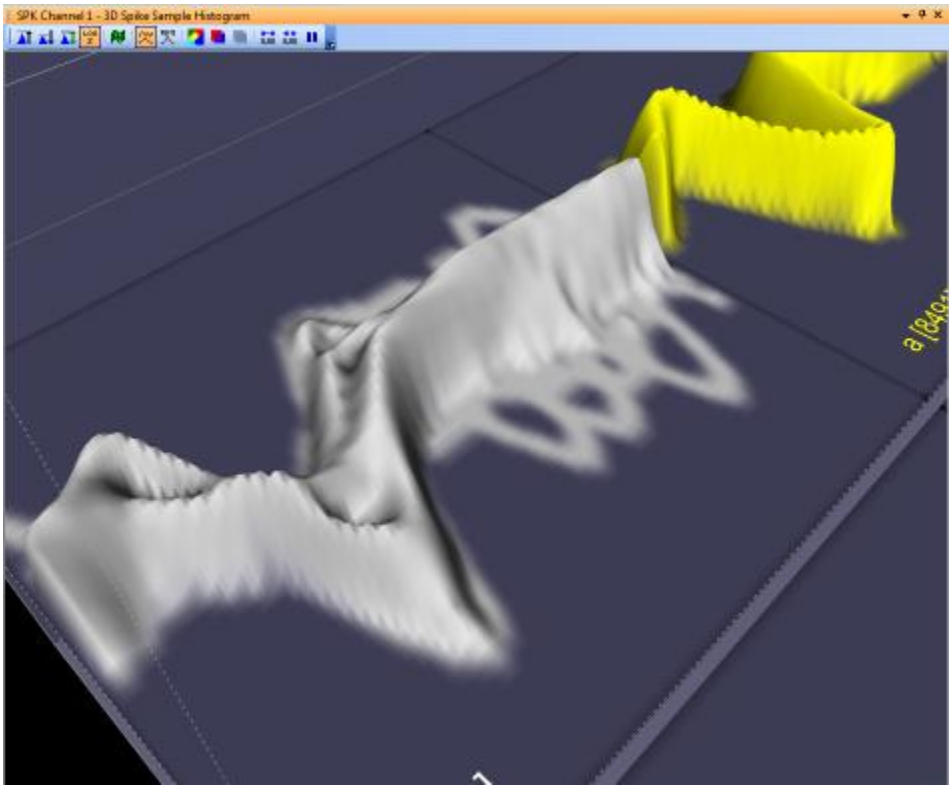
The dropdown toolbar for the SSH3D contains a number of options that are useful for adjusting the parameters used to calculate and display the sample histograms.



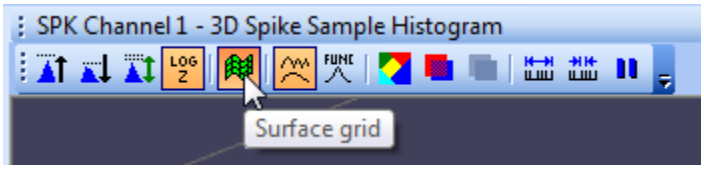
The leftmost four buttons adjust the vertical scaling of the histogram surfaces; in left to right order, they are *Scale up, Scale down, Auto-scale*, and *Log scale*:



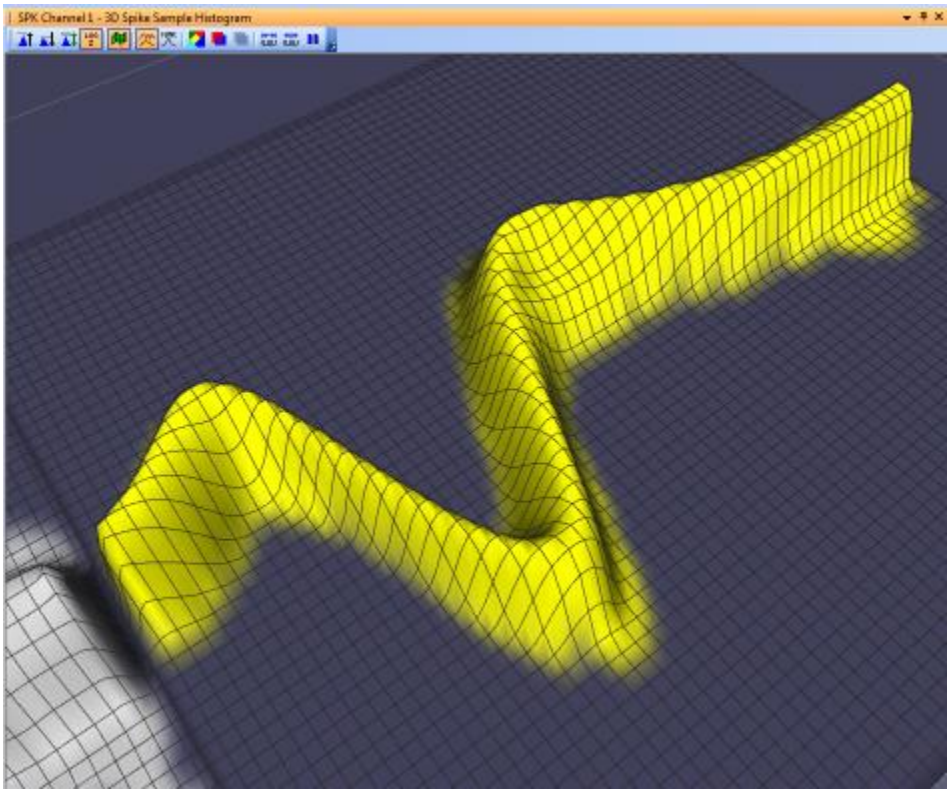
For example, after increasing the vertical scaling and zooming in:



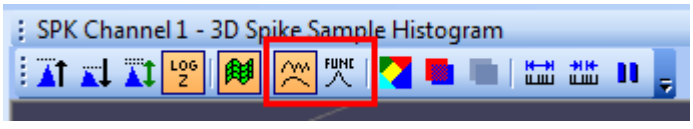
The *Surface grid* button toggles the drawing of a grid on the histogram surface:



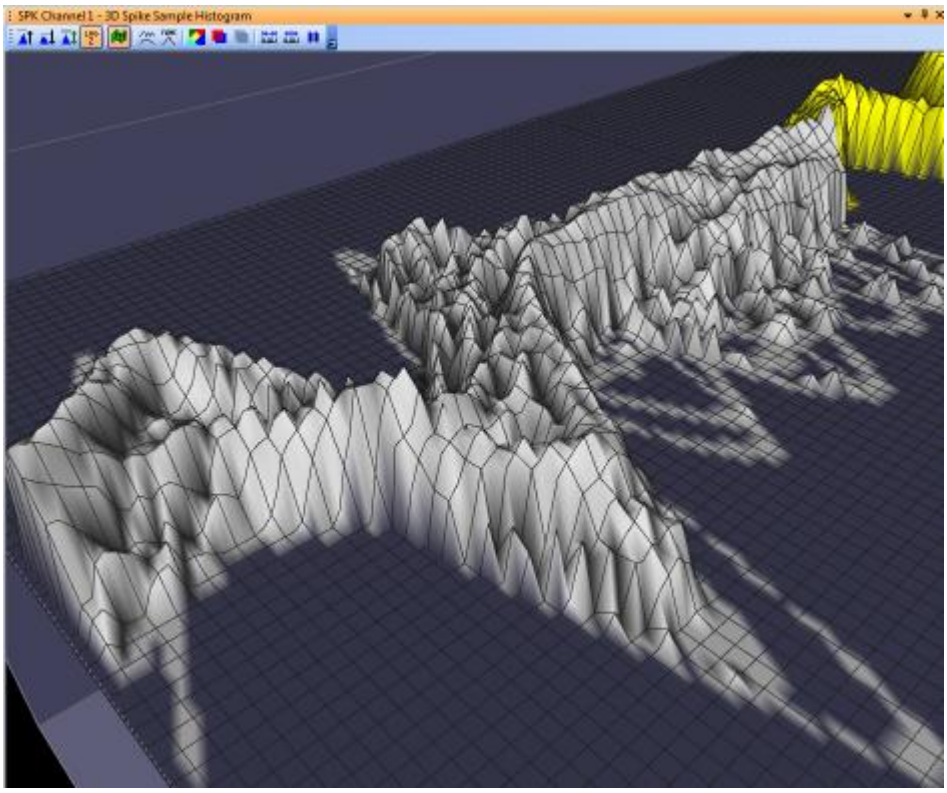
This can help emphasize the shape of the surface:

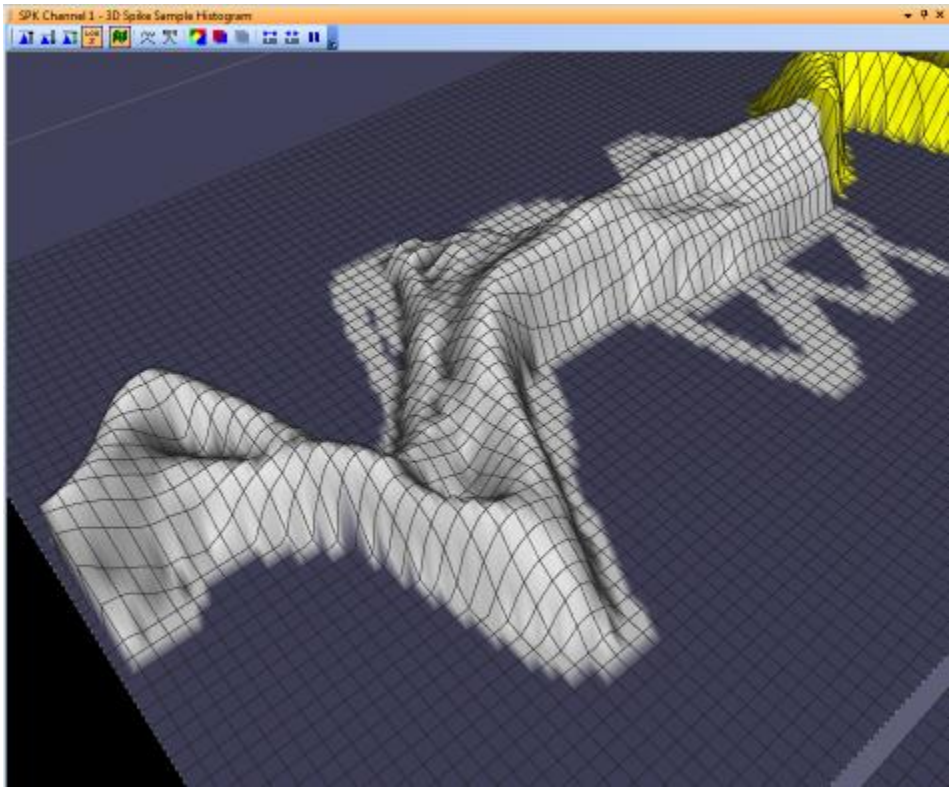


The next two buttons toggle surface smoothing on and off, and select the kernel function that is used to create the histogram from the spike waveform sample values.

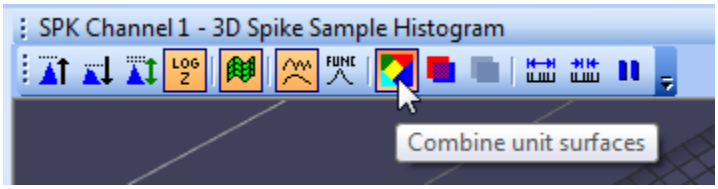


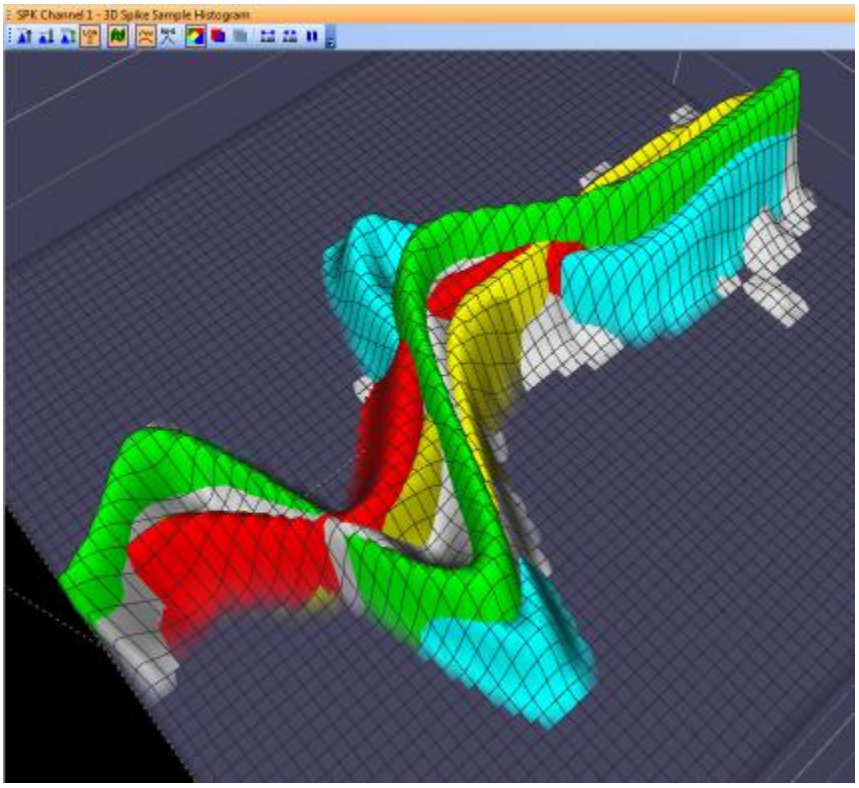
Each time you click the *Kernel function* button, the next function, from a group of five, is selected; the differences are more apparent when you disable surface smoothing.


SPK Channel 1 - 3D Spike Sample Histogram

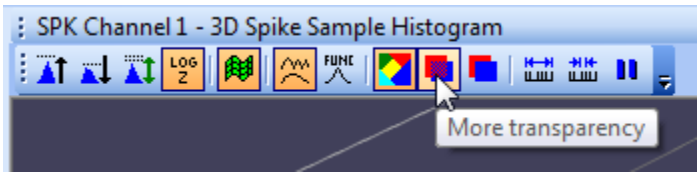

SPK Channel 1 - 3D Spike Sample Histogram

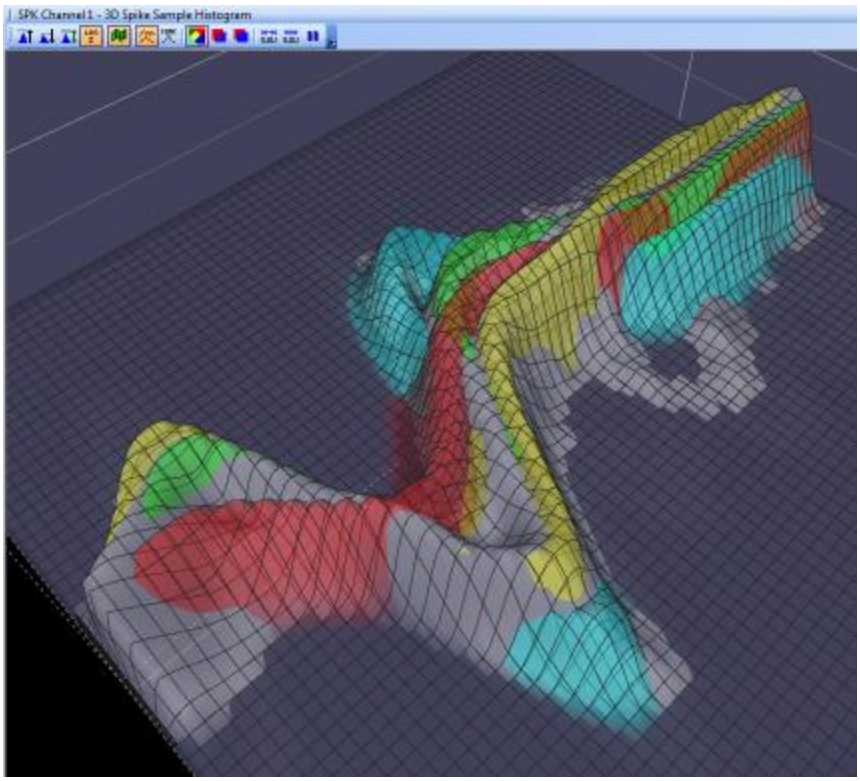
So far, the SSH3D has shown each unit's histogram separately. If you click *Combine unit surfaces*, all the units (and the unsorted unit) are shown superimposed on each other:





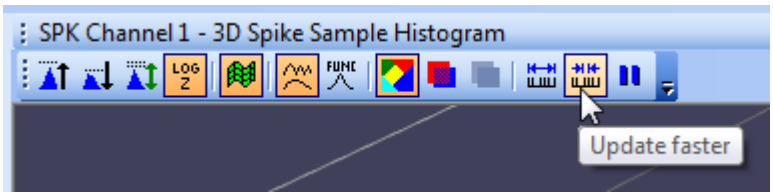
When *Combine surfaces* is enabled, the next two buttons allow you to control the degree of transparency of the surfaces, allowing you to "see through" the outer histograms:



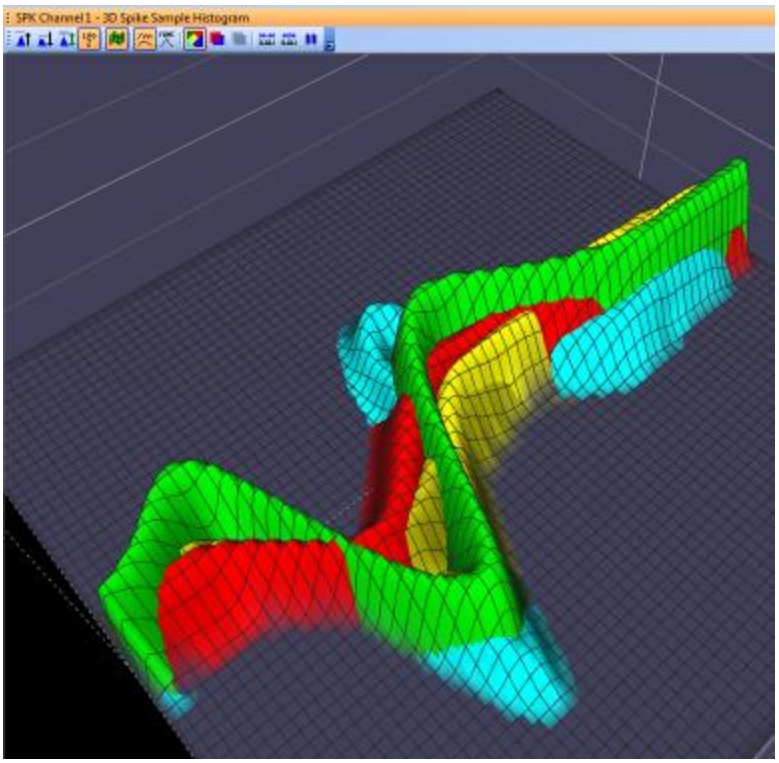


The rightmost three buttons can be used to make the animated histograms update more slowly, faster, or to pause the animation. The fastest update rate will most closely follow changes in the firing rates of the displayed units, while a slower update rate tends to smooth out short-term fluctuations in activity.

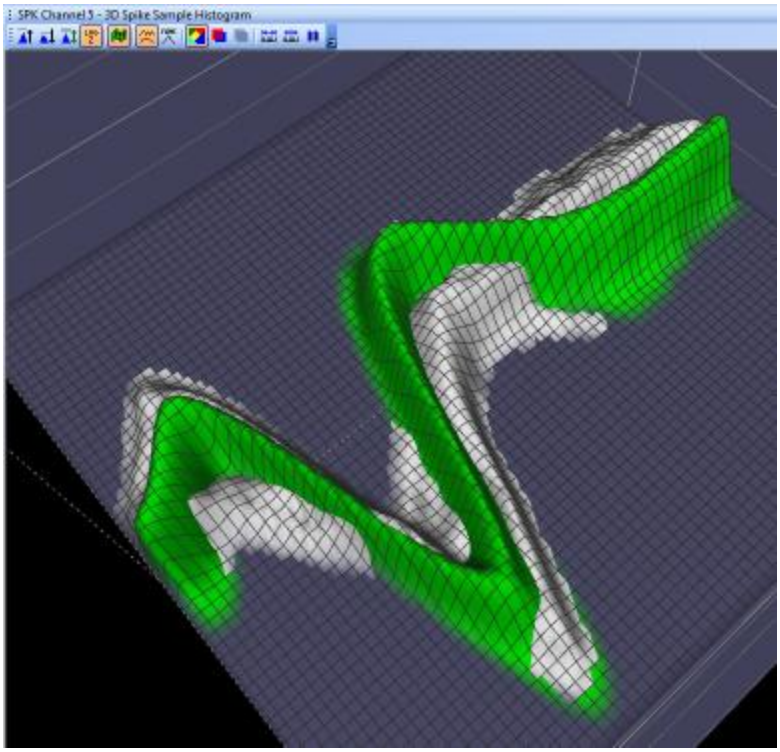
Note that the *Pause* button here is independent of the *Pause* button in the main PlexControl toolbar, so that the SSH3D view can be paused without affecting any other displays.



Note that the spike Show Filter in the main PlexControl toolbar also affects the SSH3D view. For example, setting the Show Filter to *Sorted* causes only sorted spikes to be displayed in the SSH3D:



The other Show Filter modes have analogous effects, e.g. *Selected Unit + Unsorted:*

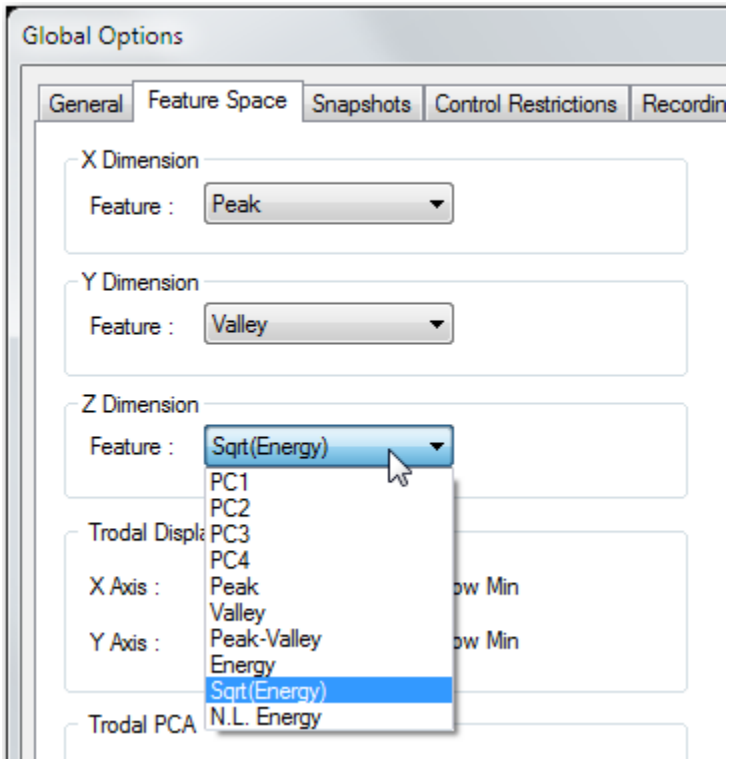


The SSH3D provides intuitive visual feedback about the quality of unit definitions and the relative activity of the different units on a channel. The unit displayed in green above is a good example of what a well-defined unit might look like, with a Gaussian distribution centered on a well-defined "spine" corresponding to the mean waveform.

Note that in stereotrode and tetrode modes, the SSH3D currently only displays the first channel of each stereotrode or tetrode.

Selectable 2D/3D feature space

By default, OmniPlex uses principal components (PCA) as the feature space into which spike waveforms are projected for cluster displays and, in the 2D Polygon mode, for spike sorting (see the User Guide for more information). The first two or three principal components (PCs) are displayed in the 2D Cluster and 3D Cluster views respectively. OmniPlex 1.13 adds the ability to select from a list of other features for any or all of the feature axes. To assign features, use the *Feature Space* page of PlexControl's Global Options dialog:



Which features are most useful in identifying clusters is very data-dependent, but for experimentation, you might try starting by leaving the first two features as PC1 and PC2, then varying the third feature. Note that you can click the Apply button to update the cluster displays with the new feature space. Depending on the features selected, you may need to adjust the scaling and position of the cluster displays to judge the results.

Stereotrode and tetrode modes use the "Trodal Display" and "Trodal PCA" options and are not affected by the choice of the X, Y, Z features.

PlexControl user interface changes

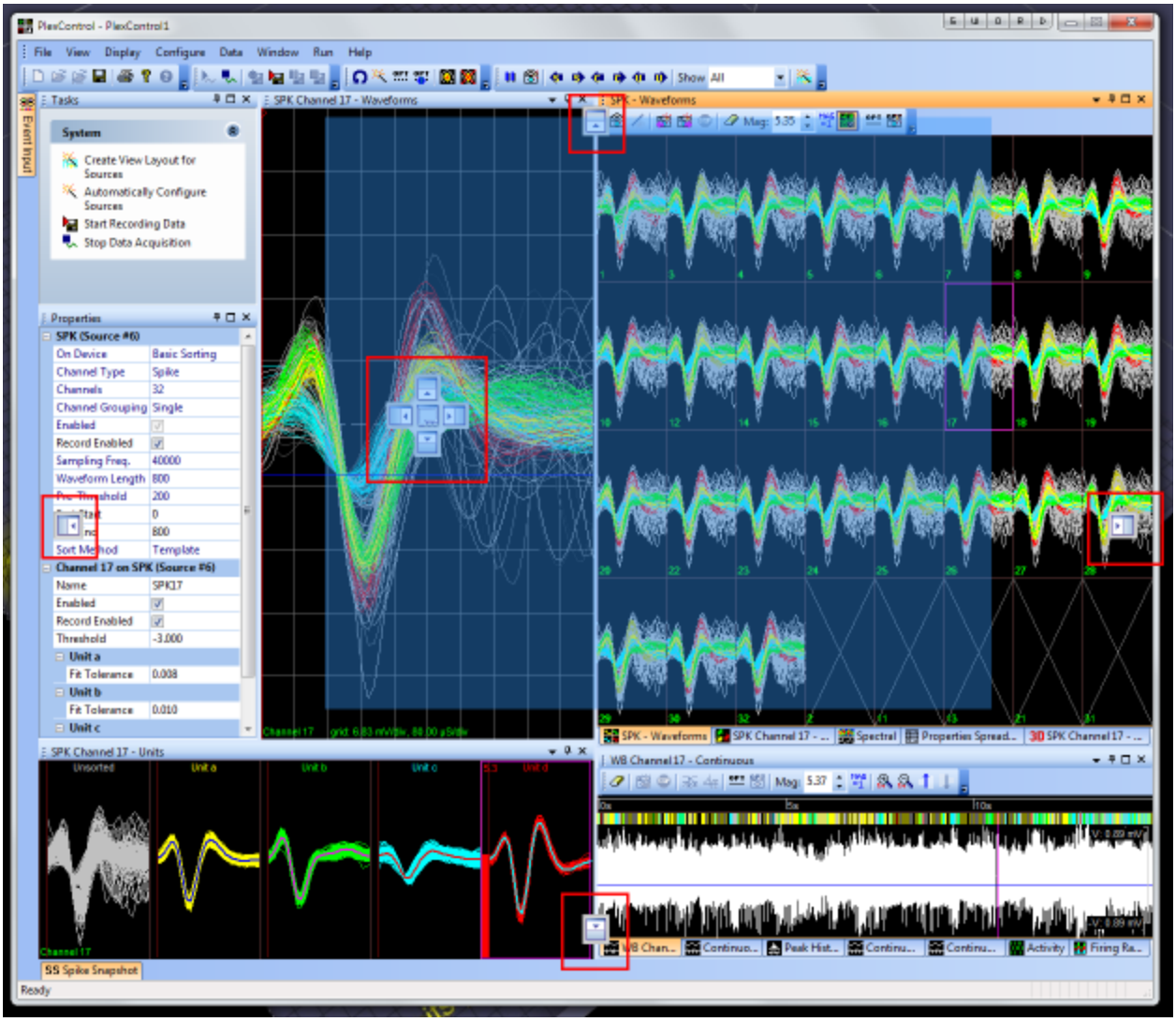
Mouse wheel control of magnification

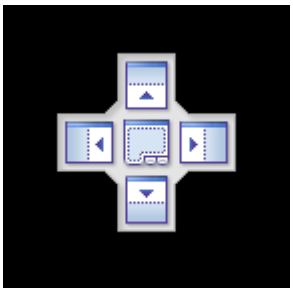
You can now use the mouse wheel to adjust the magnification in zoomed (single-channel) spike and continuous views, in the same way as in the 2D and 3D cluster views. Adjusting the magnification in the main spike window (current channel display) will by default also change the magnification in the multichannel spike window. The effect is exactly the same as if you had used the magnification up/down arrows in the corresponding toolbar. In a multichannel continuous view, you must double-click an individual channel to zoom it into single-channel mode before the mouse wheel can be used to adjust magnification; this is because in multi-channel mode, the mouse wheel is used to scroll the display up and down through the list of channels, and so is not available for magnification control.

It was previously possible to use the mouse to adjust magnification, by holding down the right mouse button and dragging vertically in a window while holding down the Shift key, but many users found this to be awkward, although it allows slightly more control over the degree of magnification than the mouse wheel method. Both methods are supported.

Updated appearance of docking controls

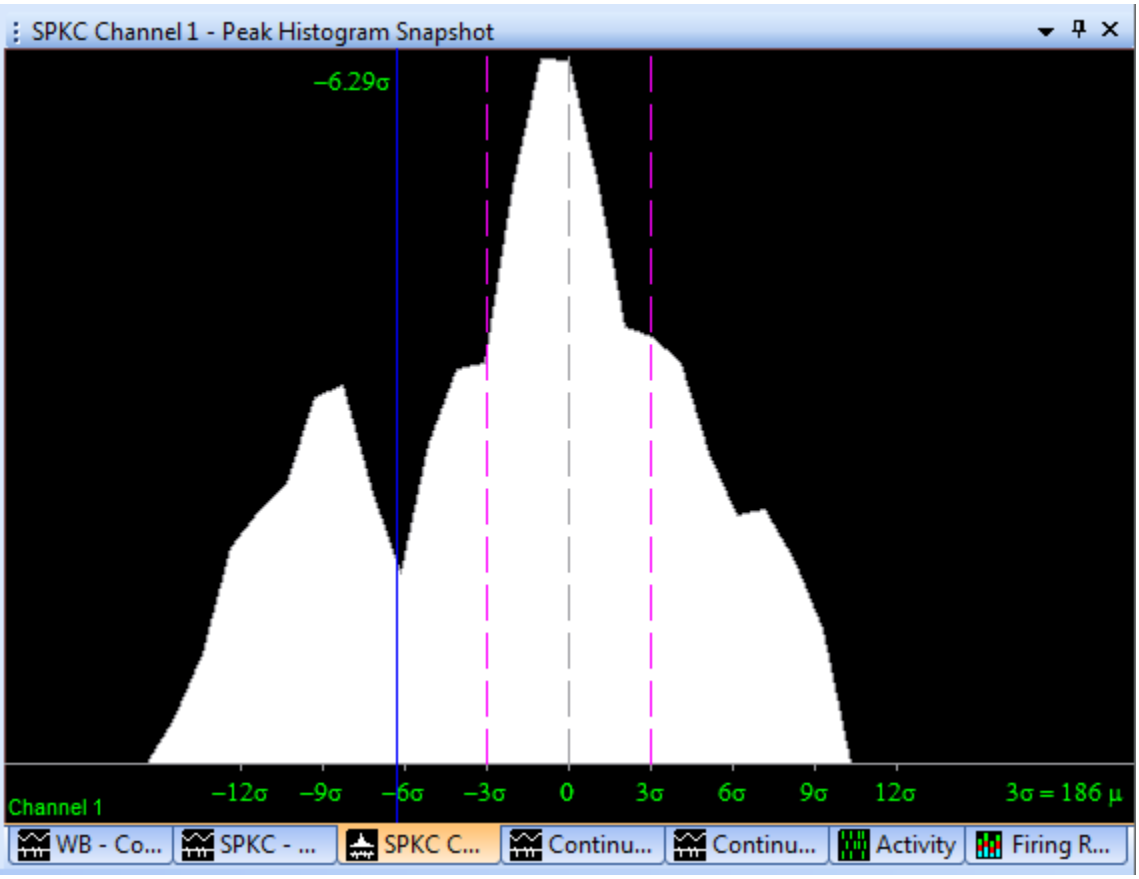
The guiding arrows which appear while you are dragging a window or tabbed window within the PlexControl main window, to indicate the available docking edges and containers, have changed in appearance, although their functionality, as described in the User Guide, is unchanged:





Display of threshold value in sigmas in SPKC histogram

The blue threshold line in the spike-continuous (SPKC) histogram view is now labeled with its value in terms of sigma:



Zcheck impedance measurement utility for digital headstages

OmniPlex now includes Zcheck, a stand-alone utility program which allows measurement of the input impedance of the digital headstages used in OmniPlex DHP systems. Zcheck is a command-line program which is run in a console window. Note that you cannot run Zcheck and OmniPlex at the same time; always shut down OmniPlex Server (and PlexControl) before running Zcheck, and vice versa. See the separate documentation for Zcheck for details on usage and supported options. Zcheck is located in the following folder, under the main OmniPlex installation directory:

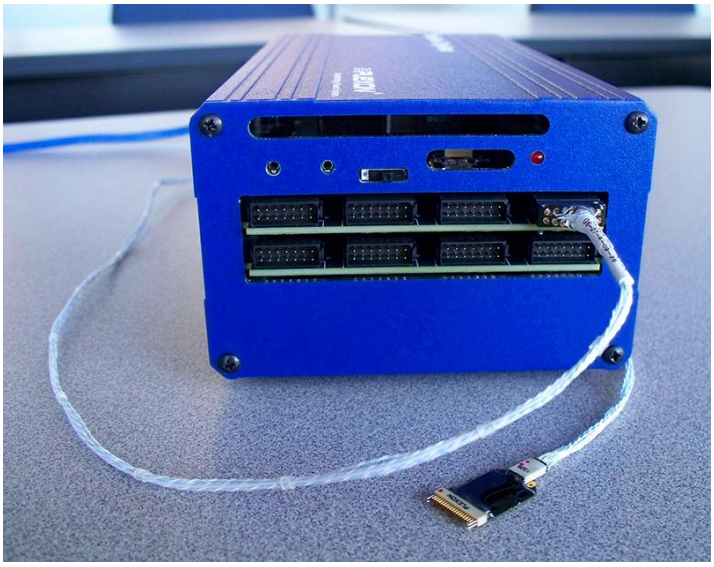
```
\Program Files (x86)\Plexon Inc\OmniPlex\Common Files\Zcheck
```

Support for Digital Headstage Processor

OmniPlex 1.12 includes support for the new *Digital Headstage Processor* (DHP), which receives data from Plexon digital headstages and provides data at an effective 40 kHz sampling rate and performs real-time digital signal processing which optimizes the time-alignment of the data across channels.

An OmniPlex system can use either the standard DigiAmp, which supports Plexon analog headstages, or the DHP. The DHP is outwardly similar to a standard DigiAmp and uses the same blue digital link cable to connect it to the Data Link card in the OmniPlex chassis:

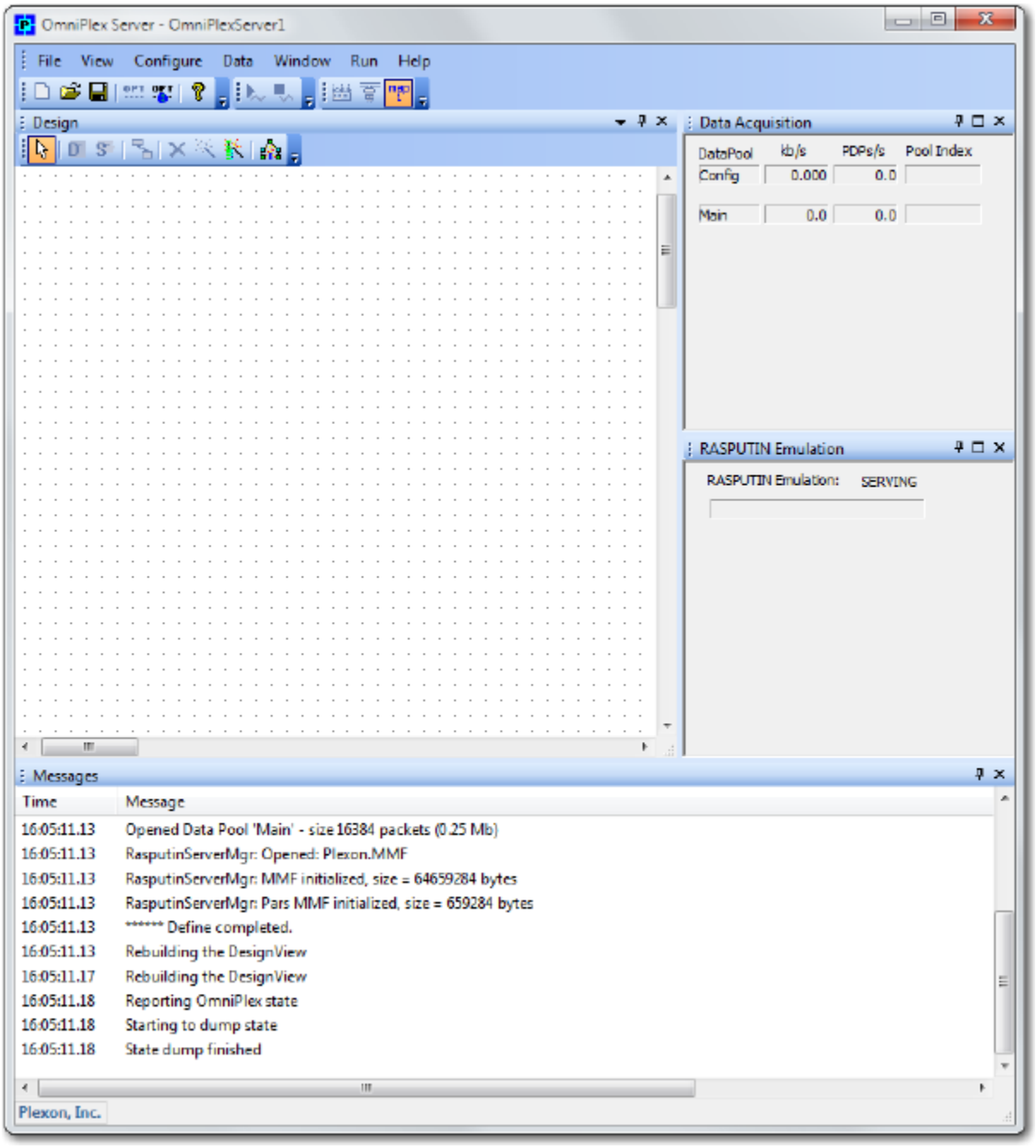
Depending on the system channel count, the DHP contains either one or two circuit boards with headstage connectors at one end of each board, into which digital headstage cables can be connected.



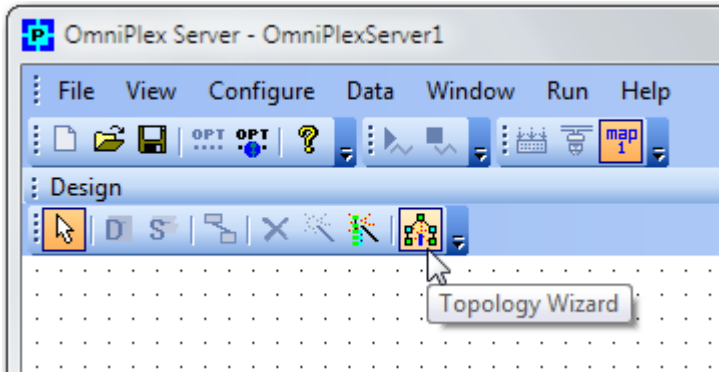
Each board includes four digital headstage connectors, called *ports*. Each port can interface to either a 16 or 32 channel digital headstage. The ports are numbered 1 to 4 *in right to left order*, and the topmost board is board 1. The white cable that connects each digital headstage to a port is a digital cable which carries commands to and sample data from the headstage. In the photo above, a single 32 channel digital headstage is connected to port 1 on board 1.

You can freely mix 16 and 32 channel headstages on different ports, as long as you use the Device Options in OmniPlex Server to define the headstage configuration, as described later. By default, OmniPlex assumes that you are using only 32 channel headstages, unless you have a 16 channel OmniPlex system, in which case a single 16 channel headstage is assumed.

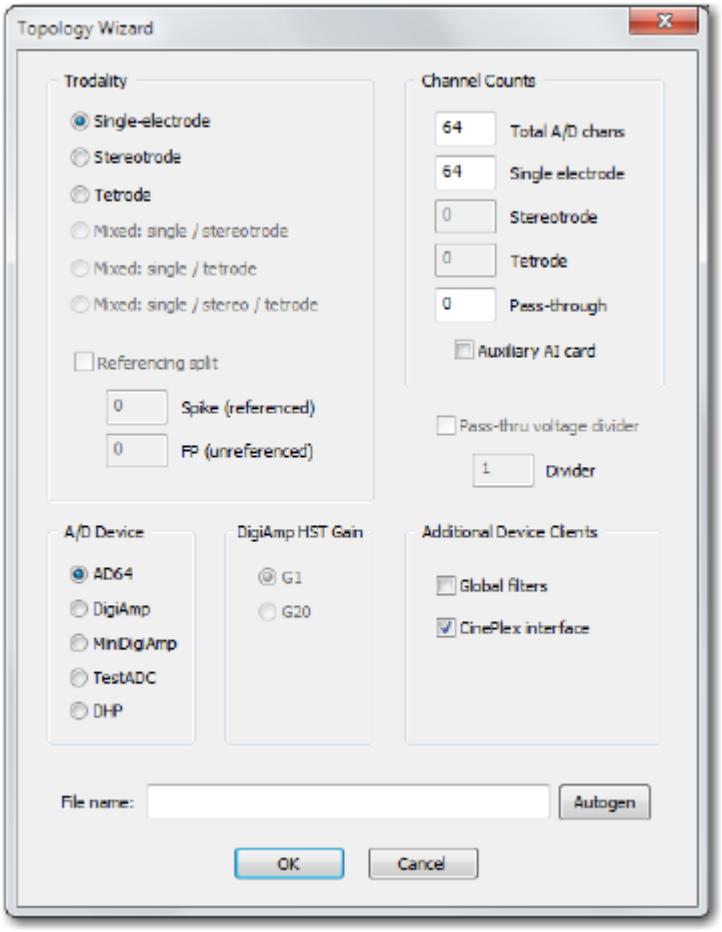
To configure your OmniPlex system for use with a DHP, first connect the DHP to the Data Link card in the chassis, using the blue digital link cable. To start the OmniPlex Server software without loading a pxs file (topology), hold down the CTRL key before starting OmniPlexServer.exe. Server will start and display a blank topology:



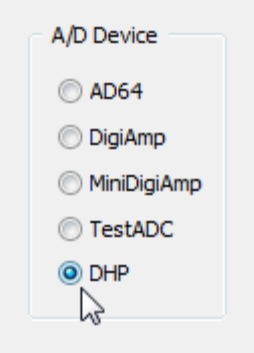
Click the Topology Wizard button in the toolbar:



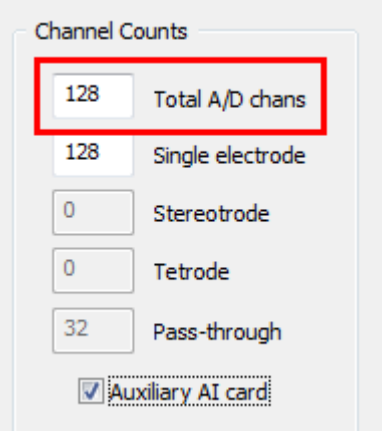
The Topology Wizard dialog is displayed:



In the *A/D Device* section, select *DHP*:



In the *Channel Counts* section, enter the desired channel count for *Total A/D chans*.



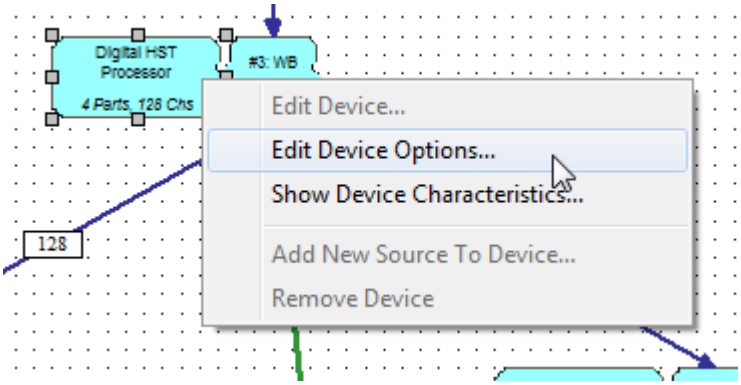
Note that this should correspond to the maximum number of headstage channels which you will use. For example, if you will be using four 32 channel headstages, enter 128 for Total A/D chans. The same would apply if you were using eight 16 channel headstages, or two 32 channel headstage and four 16 channel headstages. The total number of headstage channels cannot exceed the channel count of your system license.

Set other configuration options as desired; for example, if you are using an AuxAI analog input card, make sure that *Auxiliary AI card* is checked.

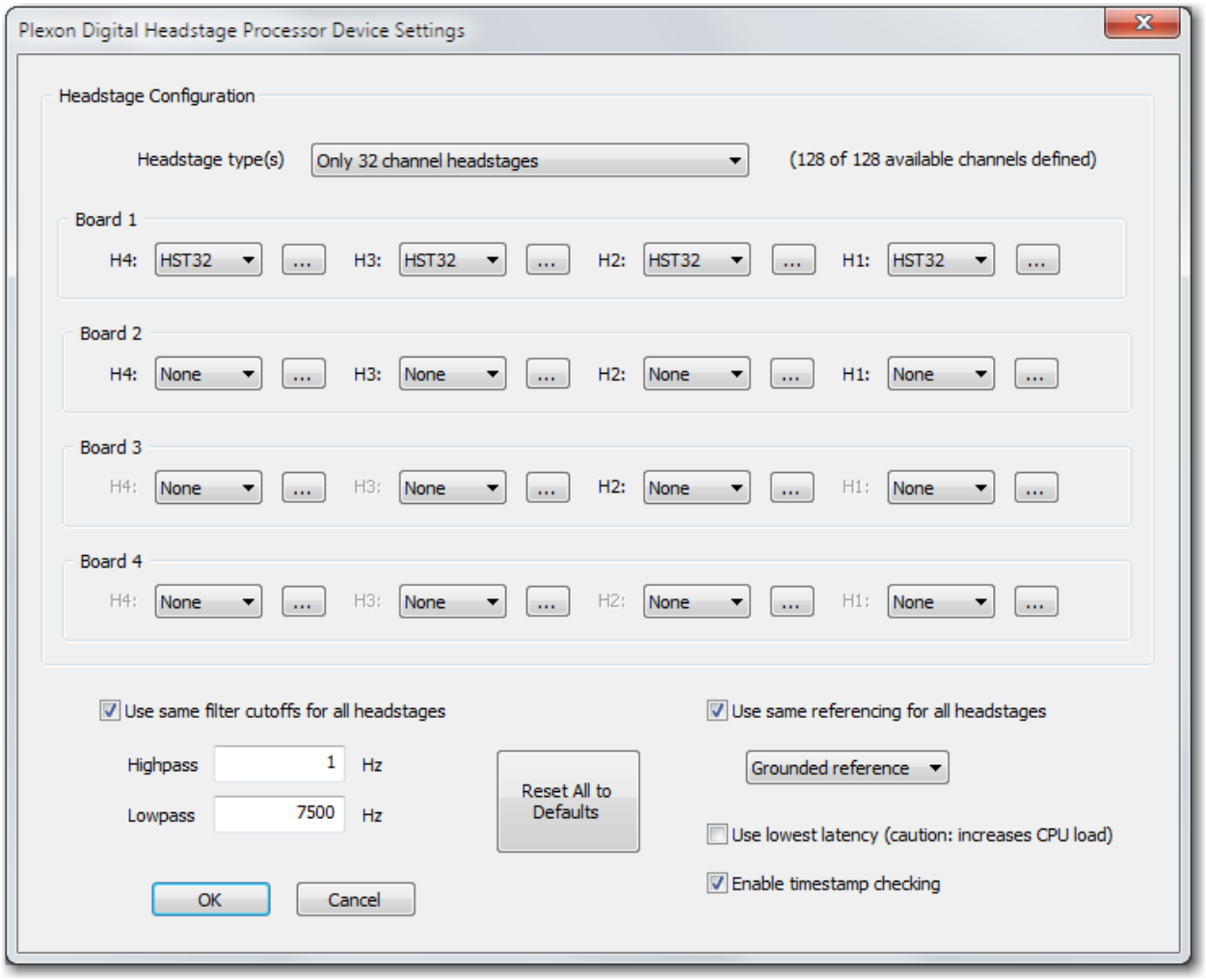
The remainder of the procedure is the same as described in the main User Guide in the section on the Topology Wizard. Click OK and accept the auto-generated pxs file name (e.g. DHP-64wb-32ai.pxs), or edit the name before saving the pxs file. When prompted, restart Server to make the new DHP topology take effect. If you are using 32 channel headstages, this is all that is required to configure the system for a DHP. If you are using 16 channel headstages, or a mix of 16 and 32 channel headstages, or wish to modify other headstage options, the following section describes the use of the DHP Device Options.

Digital Headstage Processor Device Options

When you created a new topology (pxs file) or loaded an existing pxs, the DHP device options were automatically set to default settings that are suitable for most uses. However, you may wish to use a different headstage configuration, change the headstage highpass and lowpass filter cutoff frequencies, or make other adjustments to the default settings. To display the current DHP device options, make sure that data acquisition is first stopped, then right click on the *Digital HST Processor* device in the topology and select *Device Options*.



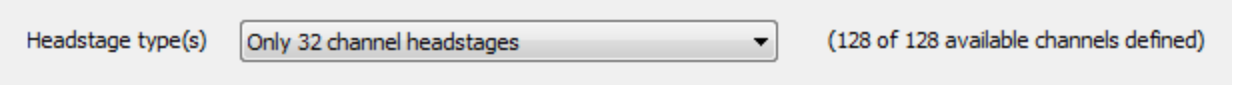
The Device Options dialog is displayed:



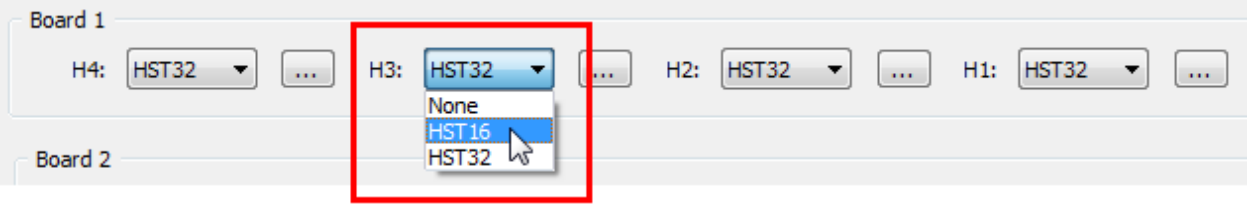
The above example shows the default settings for a 128 channel topology. 32 channel headstages are assumed, with the number of headstages appropriate for the total pxs channel count. By default, the same cutoff frequencies and referencing are used for all headstages.

The four-by-four array of headstage ports is arranged as you would see when viewing the "headstage end" of the actual DHP: from one to four boards, depending on your system, with the lowest-numbered board at the top. There are four ports on each board; **note that the ports are numbered from right to left**. Every DHP system has at least one board, with four ports, although not all ports may need to be used on smaller systems. When used with 32 channel headstages, each board supports a maximum of 128 channels; with 16 channel headstages, the maximum is 64 channels per board.

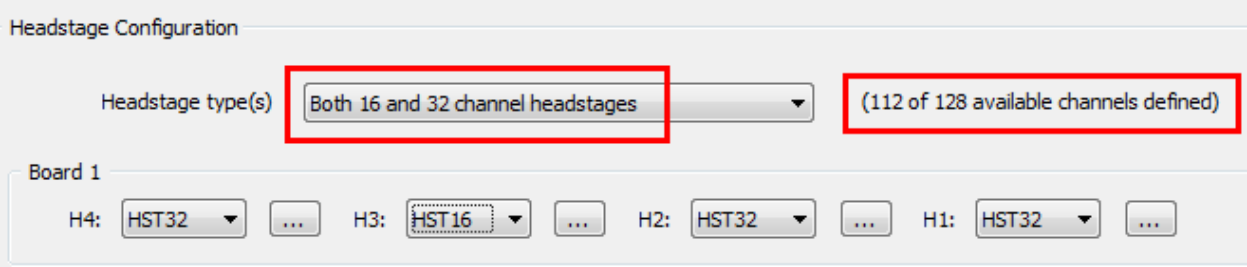
As an example of modifying the default configuration, let's say that you have a 128 channel system and wish to use two 32 channel headstages plus four 16 channel headstages, rather than the default of four 32 channel headstages. Before making any changes, note that a summary of the current headstage configuration is displayed at the top of the options dialog:



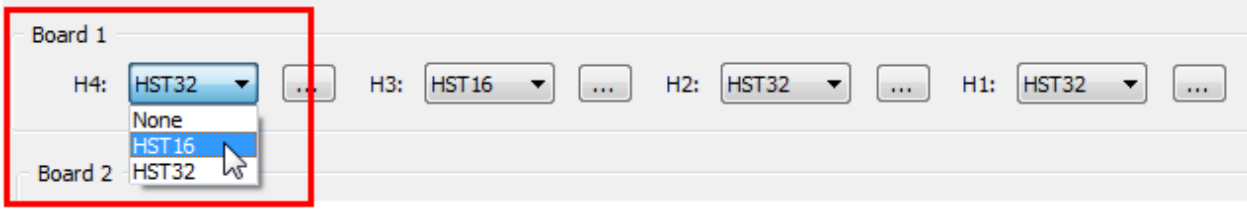
On Board 1, leave headstages (ports) H1 and H2 set to HST32, but use the dropdown control to change H3 from HST32 to HST16:



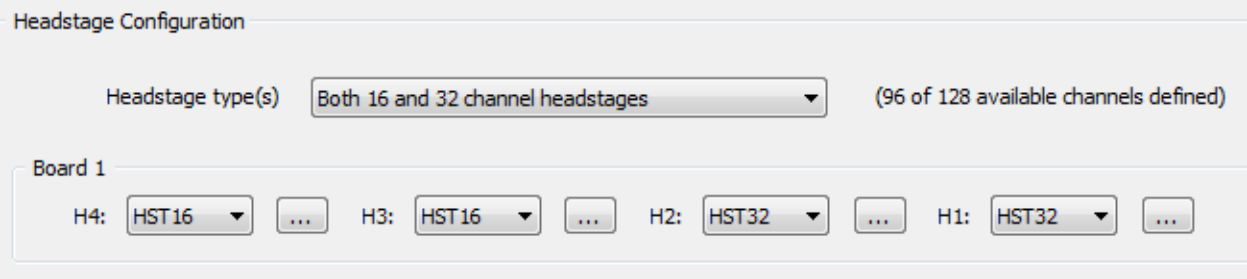
As soon as you changed H3 from HST32 to HST16, the summary display at the top changes accordingly:



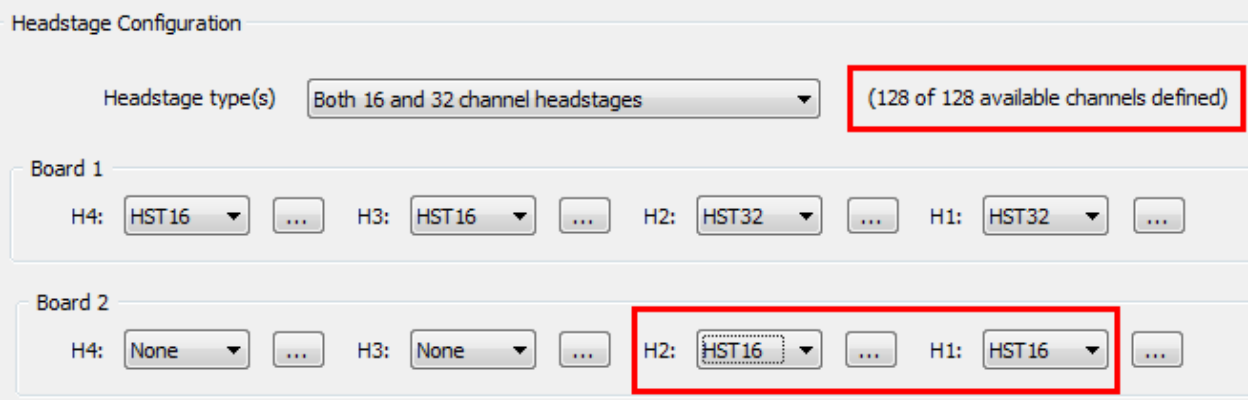
Now change H4 from HST32 to HST16:



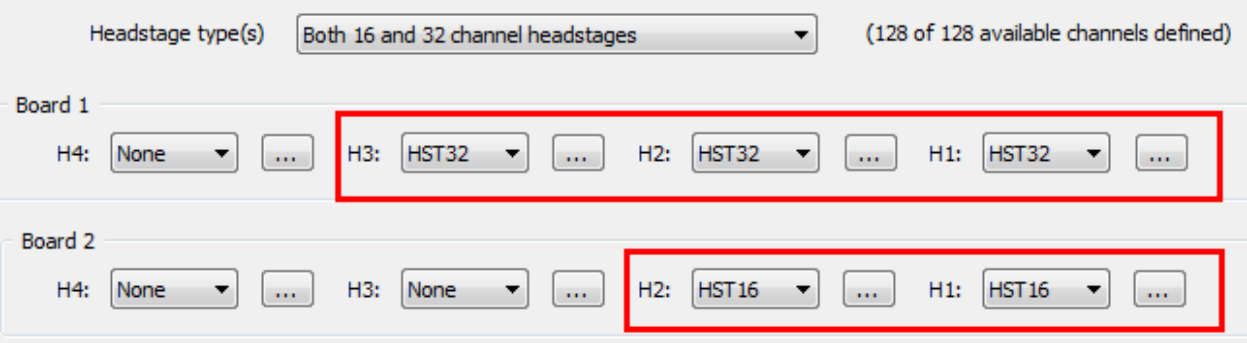
The options should now look like the following:



Continue in the same way to set H1 and H2 on Board 2 to HST16, completing your 128 channel configuration:



As a general rule, it is recommended that you assign your headstages in this manner, with all the headstages of a given channel count grouped together in consecutive port positions, but this is not required. OmniPlex allows considerable flexibility and configurations such as the following are also acceptable:

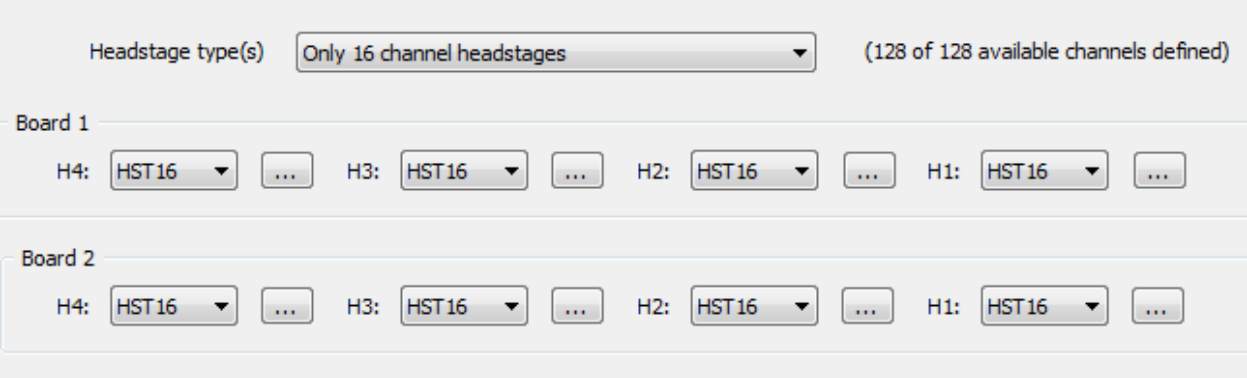


When the above headstage channels are viewed in OmniPlex, the correspondence between headstage channels and OmniPlex channels, e.g. WB001 – WB128, is determined by the following rules. The rightmost (lowest-numbered) headstage on the topmost (lowest-numbered) board corresponds to the lowest-numbered channels. Channel numbers then increase with increasing port number (right to left) and increasing board number (top to bottom). Any ports that are set to *None* have no effect on the channel numbering. In the above example, the channel numbering would be as follows:

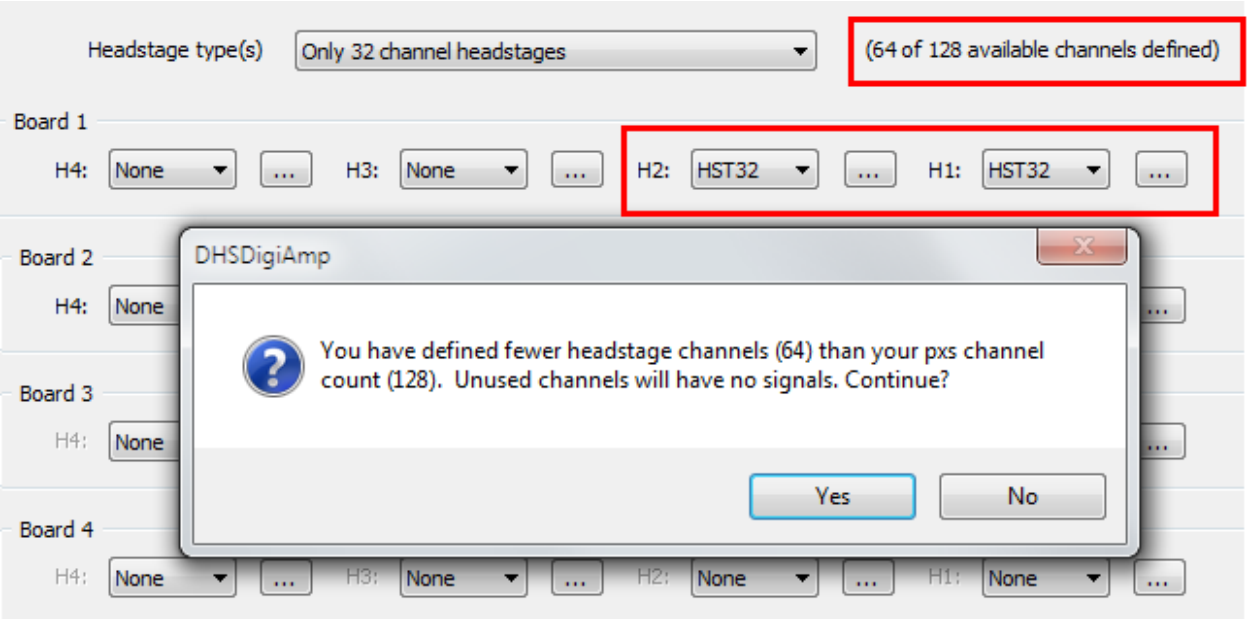
```
Board 1, H1: channels 001 - 032
Board 1, H2: channels 033 - 064
Board 1, H3: channels 065 - 096
Board 2, H1: channels 097 - 112
Board 2, H2: channels 113 - 128
```

You may have noticed that *Headstage type* in the summary at the top of the dialog is a dropdown control. It changes automatically depending on the type of headstages you assign, but you can also use it as a shortcut command. If you set it to either *Only 32 channel headstages* or *Only 16 channel headstages*, the headstage configuration will be reset to use only that type of headstage, with the appropriate number

of headstages defined for the current pxs channel count. In the above example, if we now change the *Headstage type* to *Only 16 channel headstages*, the following will be displayed:



Note that you can configure fewer headstage channels than the available number of channels defined in the pxs; unused channels will display no signals when viewed in OmniPlex. However, if you do so, OmniPlex will warn you when you click OK to exit the Device Options dialog:



If you click Yes, in this example you will still have a 128 channel configuration, but signals will only appear on the first 64 channels. If you click No, you will return to the options dialog where you can assign additional headstages to fill out the available channel count.

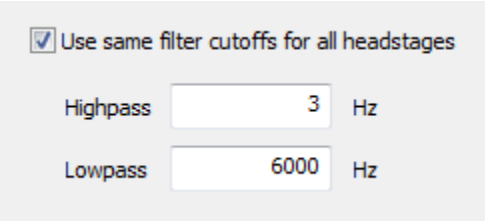
Other headstage options - filtering and referencing

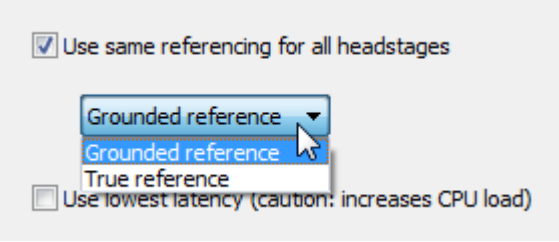
In addition to the headstage port assignments and channel counts, you can also modify the settings for headstage filtering and referencing, either globally (one setting for all headstages), or on a per-headstage basis.

Each digital headstage has an analog highpass (low-cut) filter and an analog lowpass (high-cut) filter preceding the analog-to-digital converter in the headstage. The highpass filter allows you to filter out very low frequency signals such as slow baseline drift and animal movement artifacts. The lowpass filter allows you to remove high-frequency noise and sources of aliasing. The considerations and tradeoffs involved in choosing the cutoff frequencies are similar to those for other OmniPlex systems; consult the main User Guide for more information.

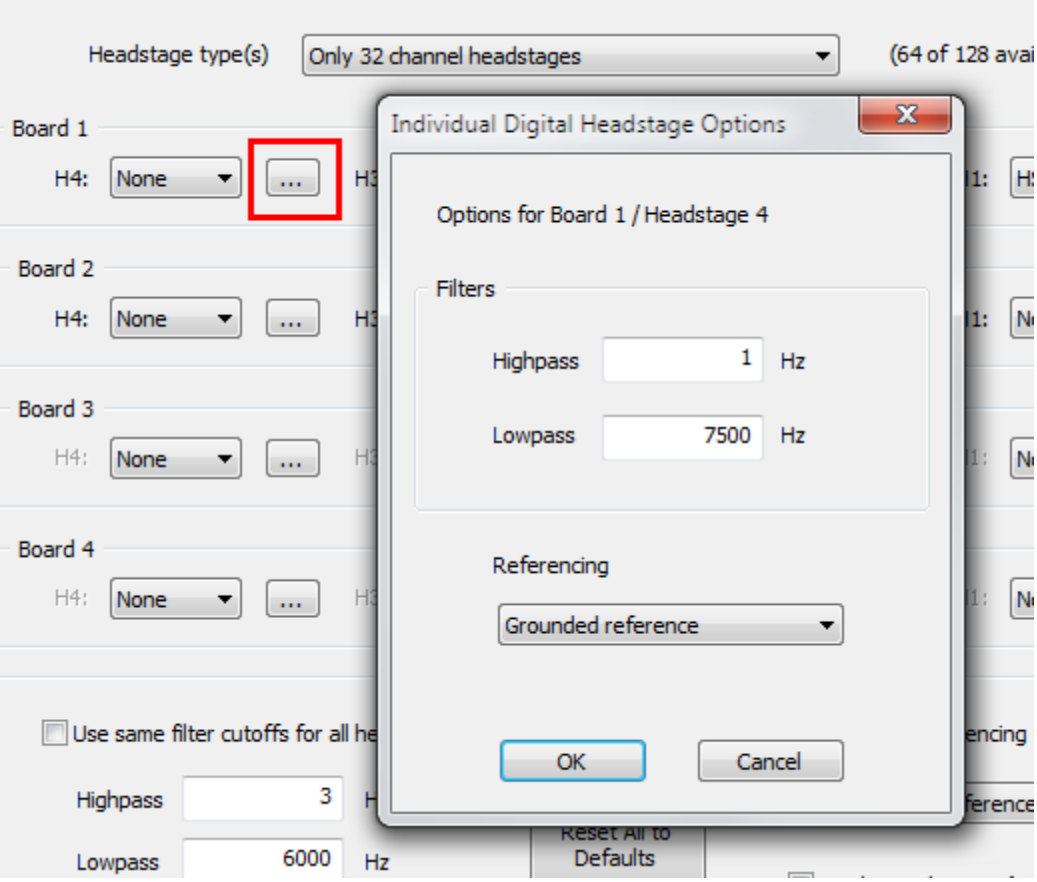
Each digital headstage also supports two analog referencing (analog signal subtraction) options, either grounded referencing or true referencing. True referencing subtracts the signal on the headstage's reference electrode from every other channel before A/D conversion. Grounded referencing is equivalent to connecting the reference electrode to headstage ground.

Global setting of the filter cutoffs and referencing can be done directly in the options dialog. Set the desired option, making sure that the corresponding "Use same" checkbox is checked:





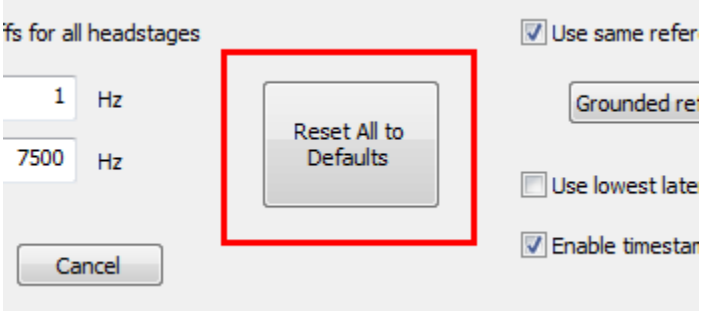
If you wish to set the filter cutoffs and/or referencing individually for each headstage, uncheck the corresponding “Use same” checkbox(es) and then click the “…” options button next to the headstage whose settings you wish to modify:



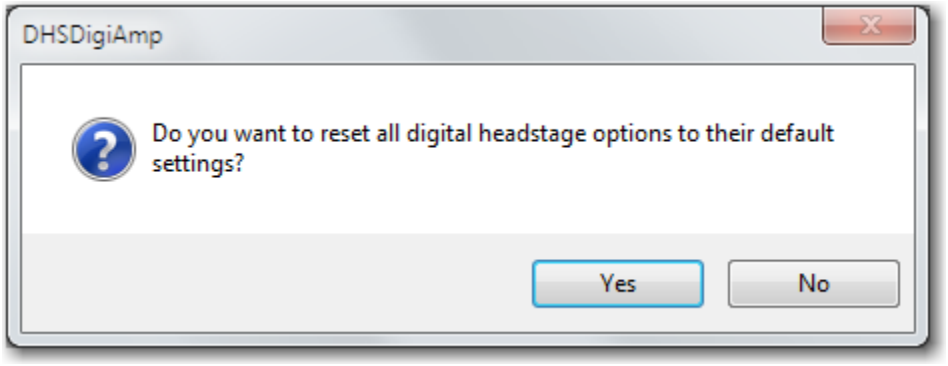
Note that if you later re-enable the “Use same” checkbox(es) in the main options dialog, the global settings will then override any per-headstage changes that you previously made.

Reset All to Defaults

If you need to restore all the headstage options, including both global and per-headstage settings, to their default values, click the *Reset All to Defaults* button.



You will be prompted to confirm that you want to reset all options:



Reset All can be useful in cases where you have modified the individual headstage options and want to start over.

Important note on connecting and disconnecting digital headstages

An important difference between the DHP and the standard DigiAmp is that with the DHP, **you should only connect and disconnect headstages from the DHP, or from the digital headstage cable, when data acquisition is stopped in OmniPlex**. Typically, unplugging a headstage or headstage cable during data acquisition will only cause loss of signal on the corresponding channels, but if you attempt to reconnect a disconnected headstage during acquisition, the corresponding channels will display invalid signals until data acquisition is stopped and restarted, which re-establishes the digital communication link to the headstages. In any case, headstages other than the one being disconnected or reconnected are not affected and their data acquisition continues normally.

However, you can disconnect the headstage itself from the source of analog signals (e.g. the electrodes) without affecting the digital communications with the DHP. In other words, the input to the headstage is analog; but everything else (headstage-to-cable connection, cable-to-DHP connection) is digital. Another way of thinking of this is that only the very last connection in the chain, typically “at the animal,” can be changed without first stopping data acquisition.

Other digital headstage considerations

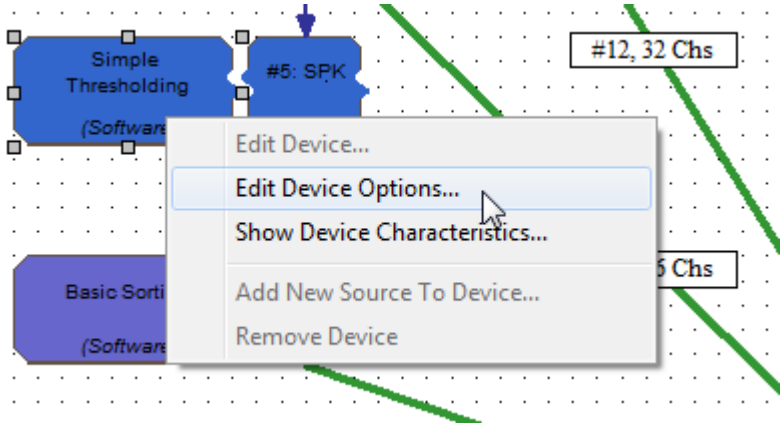
Note that the digital headstages use a fixed gain, and so there is no need to adjust gain or match gain depending on headstage type as with previous OmniPlex systems. The maximum allowed input voltage at the headstage is 10 millivolts peak-to-peak (mV pp); voltages slightly exceeding this, up to approximately 12 mV, can be applied to the headstage without causing A/D clipping but are not recommended for best results. Note that if you find that unwanted large-amplitude low frequency signals or DC drift at the electrode are causing the input voltage to exceed this range, you may be able to reduce this by raising the cutoff frequency of the headstage analog highpass (low-cut) filter, as described previously.

Threshold crossing rate limiting

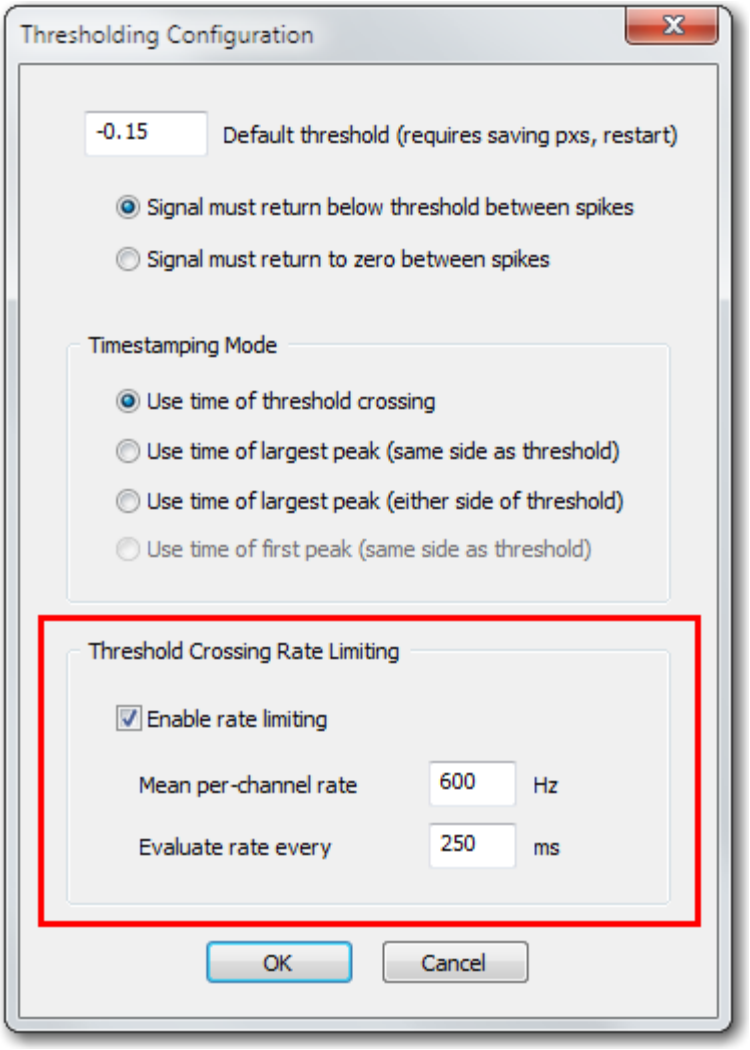
OmniPlex's thresholding algorithm extracts waveform segments from continuous signal channels in the SPKC spike-continuous source, triggered by threshold crossings. In normal circumstances, when threshold values are set appropriately, and in the absence of excessive noise, the resulting waveform segments are valid action potentials, i.e. spikes. However, in atypical situations, such as signals containing high amplitude, high frequency noise, and/or thresholds that the user sets too close to zero, OmniPlex will still proceed to extract potentially large numbers of spikes at firing rates that are physiologically improbable. For example, with the default spike length of 800 microseconds, setting a zero threshold on background noise can result in a sustained "firing rate" of 1.25 kHz per channel. In such scenarios, it would be more correct to refer to the *threshold crossing rate* rather than the firing rate, since neurons cannot fire at such rates for more than a fraction of a second, if at all.

Whether due to incorrect threshold settings or intervals of unavoidable high amplitude noise, it is preferable to suppress these spurious "noise spikes," so that they do not unnecessarily increase recording file size, clutter displays, increase the processing and memory requirements for online and offline analysis programs, or degrade system performance. The OmniPlex *threshold crossing rate limiting* option provides a method for automatically detecting the atypical situations described above and temporarily suppressing such physiologically unlikely threshold crossing rates.

To access the threshold crossing rate limiting options, first make sure that data acquisition is stopped, then right-click on the Thresholding device in the topology in Server and select *Device Options*:



The thresholding options dialog is displayed:



Note that rate limiting is enabled by default. You can completely disable it if you wish, although this is not recommended, especially with high channel count systems (96 channels or more). The default rate limit is proportional to the system channel count, ranging from 1500 Hz per channel at 48, 32, or 16 channels, down to 300 Hz per channel for a 256 channel system.

Rate limiting is controlled by two parameters, the *mean per-channel rate* and the *rate evaluation interval*. The default values for these parameters have been chosen to insure that rate limiting is applied to the thresholding process only when pathologically high threshold crossing rates are detected, and you should understand the following description of how they affect rate limiting before modifying them.

At an interval controlled by *the rate evaluation interval* parameter, by default every 250 ms, the rate limiter examines the total number of threshold crossings, summed over all spike channels, to determine the mean-per channel rate over the preceding evaluation interval. For example, if there are 128 spike channels and the total number of threshold crossings was 1078 over a 250 ms interval, the mean per-channel rate would be

```
(1078 total spikes / 128 channels) / 0.25 sec = 33.7 Hz
```

This is far below the rate limit of 600 Hz per channel, so no rate limiting will occur, and the spike data will be passed on to the sorter unchanged.

Now consider the other extreme, the "zero threshold in noise" scenario previously described. If the total number of threshold crossings in a 250 ms interval was 39137, the per-channel rate would be:

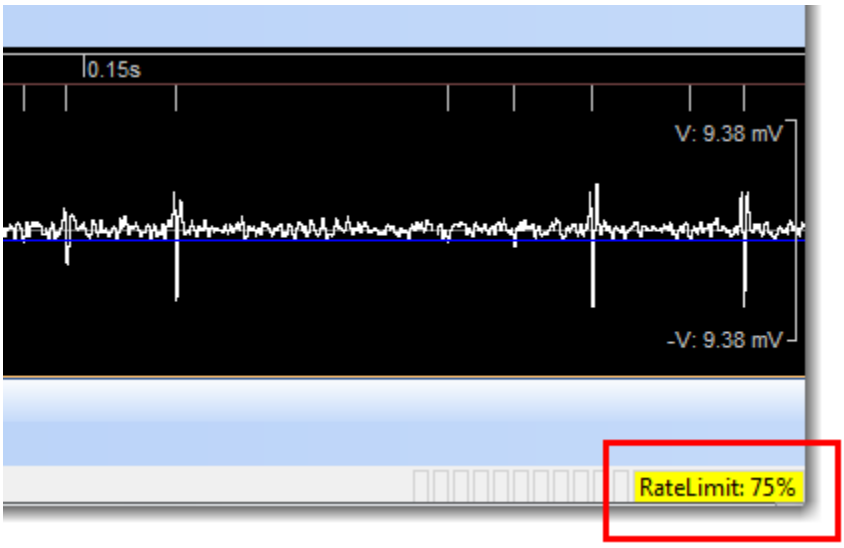
```
(39137 total spikes / 128 channels) / 0.25 sec = 1223 Hz
```

This is more than double the 600 Hz rate limit, so starting with the next 250 ms interval, spikes will be automatically culled from the data stream as necessary to limit the firing rate to 600 Hz; in this example, approximately every other spike will be removed. Every 250 ms, the aggregate spike rate across all channels will be re-evaluated, and the number of spikes culled will be updated as necessary to stay within the rate limit. As soon as the aggregate spike rate drops below the limit, rate limiting immediately stops until an excessive rate is detected again.

Note that even when rate limiting is being performed, *any individual channel on which fewer than the maximum number of threshold crossings occur within an evaluation interval will not be affected*. For example, if a brief burst of high frequency noise occurs on all channels, and therefore initiates rate limiting, but in the next 250 ms interval, only one channel's firing rate exceeds 600 Hz, no spikes on any other channel will be affected.

Since rate limiting does not occur until the interval after the interval within which the excessive rate was detected, brief bursts (by default, up to 250 ms) of even physiologically implausible activity will be passed through without change, while protecting against sustained non-neural threshold crossing rates.

When rate limiting is taking place, and spikes are being removed on one or more channels, a rate limiting indicator in the PlexControl status bar displays the rate limiting in effect:



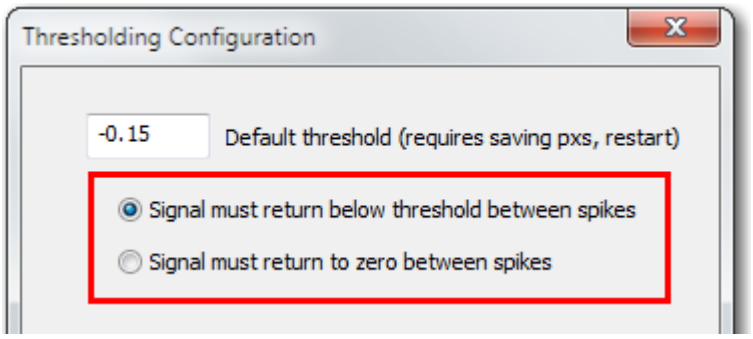
In this example, the spike rate is being limited to 75% of what it would be if rate limiting were not applied. In other words, 25% of the threshold crossings are being removed, implying that the mean crossing rate is approximately 600 Hz / 0.75 = 800 Hz. When the yellow *RateLim* indicator is not displayed, 100% of spikes are available. Again, remember that channels whose firing rate is less than the rate limit will not be affected.

Remember that rate limiting has no effect in a situation when one, or a small percentage of channels have an excessive threshold crossing rate. It is intended only to suppress pathological firing rates when they occur across many channels simultaneously, for a period longer than the evaluation interval.

Rate limiting has no effect on the latency of spikes, whether rate limiting is in effect or not. Rate limiting only affects spikes (waveform segments) and has no effect on continuous data. If you record the continuous wideband (WB) and/or spike-continuous (SPKC) sources, you will be able to apply appropriate thresholds and extract valid spikes from the recorded data offline, assuming that any rate limiting during the recording was the result of a too-low threshold, and not caused by excessive noise in the original analog signals.

Return to zero thresholding option

Another new thresholding option, *return-to-zero*, can yield improved spike detection in situations where the signal to noise ratio is poor and/or the threshold is set close to the noise level.



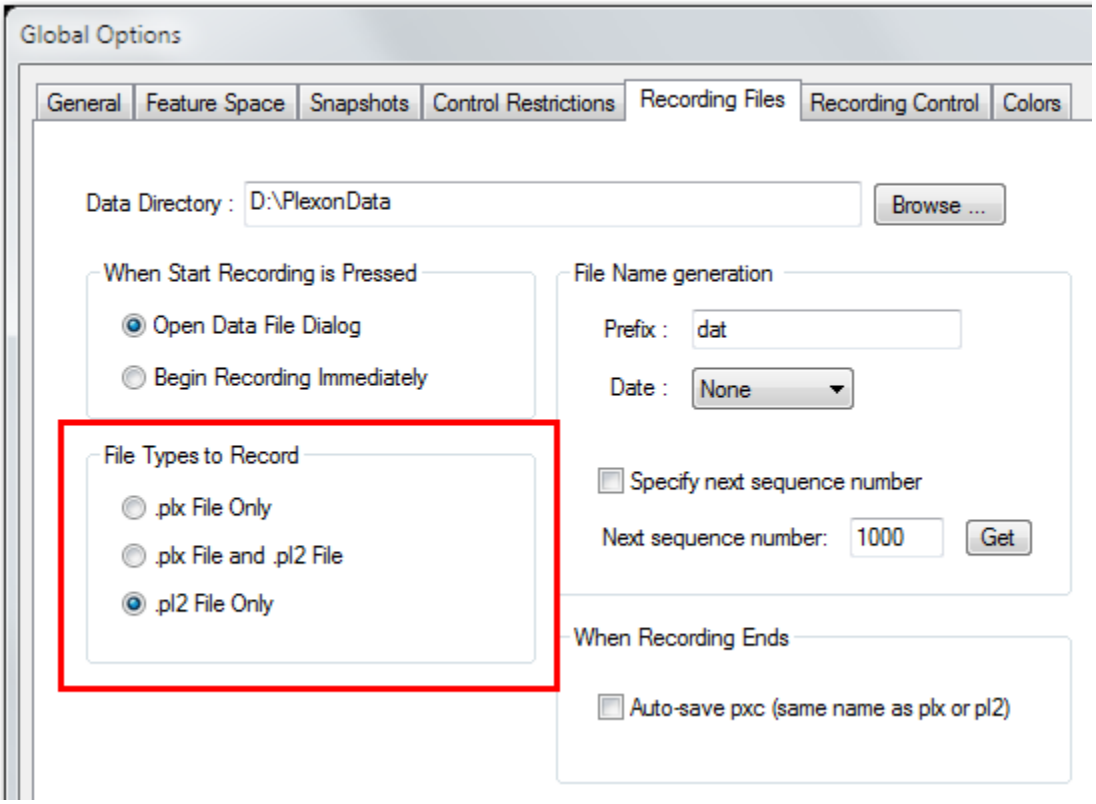
By default, OmniPlex's spike detector re-arms ("starts looking for another spike") after the end of each detected spike only after the signal level has dropped below the threshold level (i.e. towards zero); until this occurs, another threshold crossing (i.e. away from zero) by definition cannot occur. However, if the *Signal must return to zero between spikes* option is selected, a stricter rule for re-arming is used: the signal must not only drop below the threshold, it must actually return to zero before a subsequent spike can be detected.

If the threshold is set conservatively, for example by using OmniPlex's default autothresholding method (threshold at three or four sigmas from the mean or median), the difference between the two re-arming options will often be small. However, in cases where the threshold is set closer to the edge of the "noise band" on a channel, using the return to zero option can reduce the amount of false detection and premature triggering.

Note that the return to zero option is currently only implemented for single-electrode thresholding, not for stereotrodes or tetrodes.

Recording file format defaults to PL2

The default recording file format is now PL2, although recording in the legacy PLX format is still supported. You can set the recording format in the Recording Files tab of PlexControl's Global Options dialog:



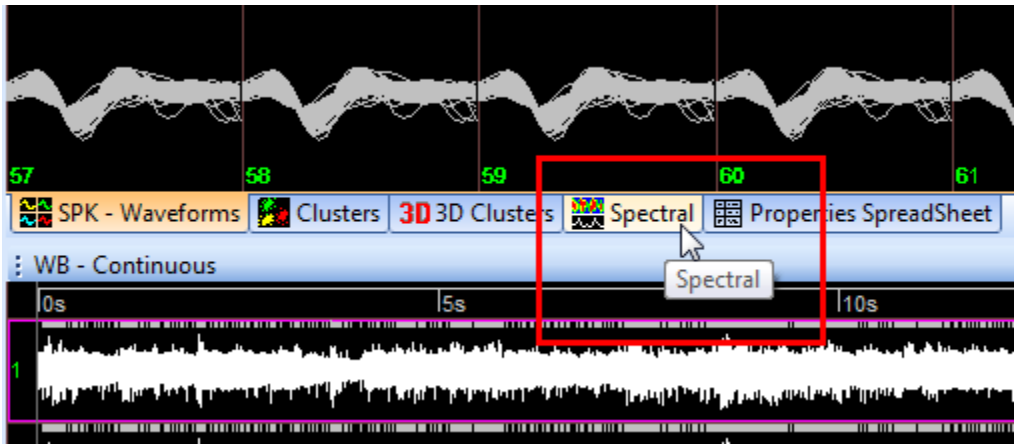
Once set, the File Types to Record setting persists between sessions, unless you use the Reset All Options to Defaults command, at which point it will revert back to the default PL2 format.

Make sure that the applications, scripts, etc, which you use to view and analyze your recorded OmniPlex data support the PL2 format. PL2 is supported by Offline Sorter (OFS), Nex, and Plexon's Matlab and C/C++ file reading SDKs. You can download the latest versions of OFS and the file reading SDKs from http://www.plexon.com.

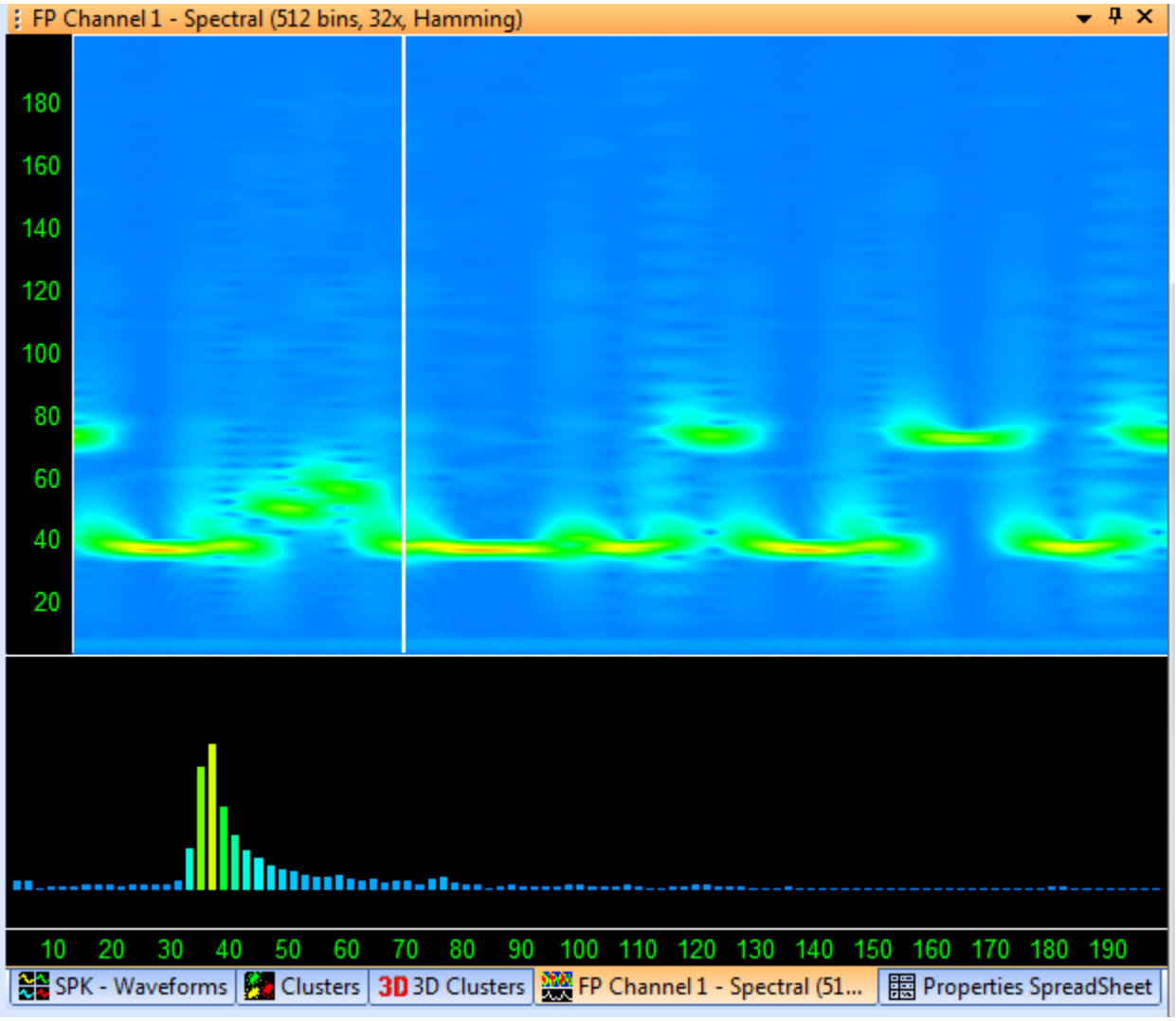
Spectral view

Overview

The new Spectral view displays a rolling color-coded spectrogram of the currently selected channel on the FP (field potential) source, plus an animated spectral graph below it. This allows you to monitor changes in spectral content, such as increase in energy in a range of frequencies, as a function of time. To view the Spectral display, click on the Spectral tab:



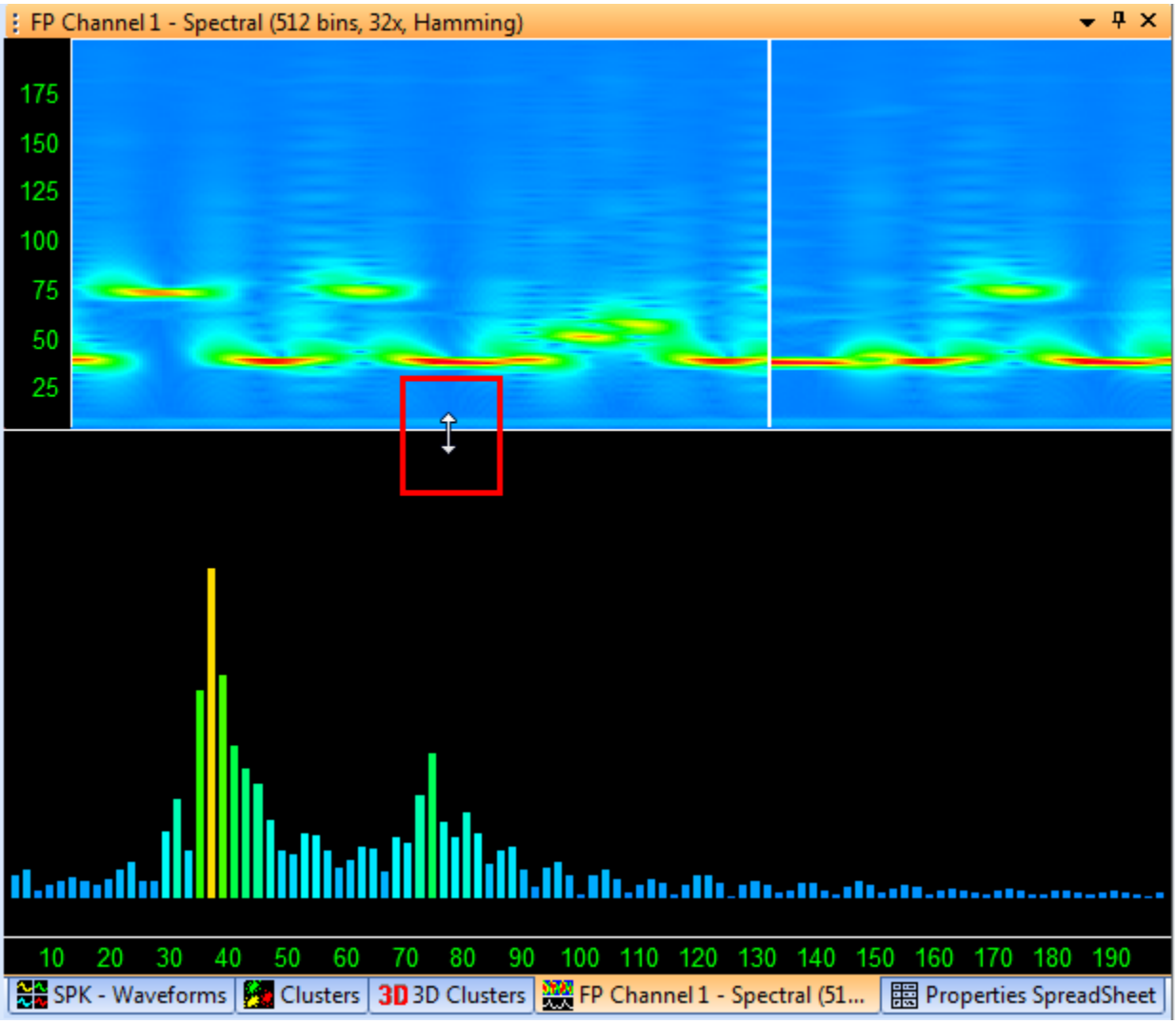
The Spectral view is displayed:



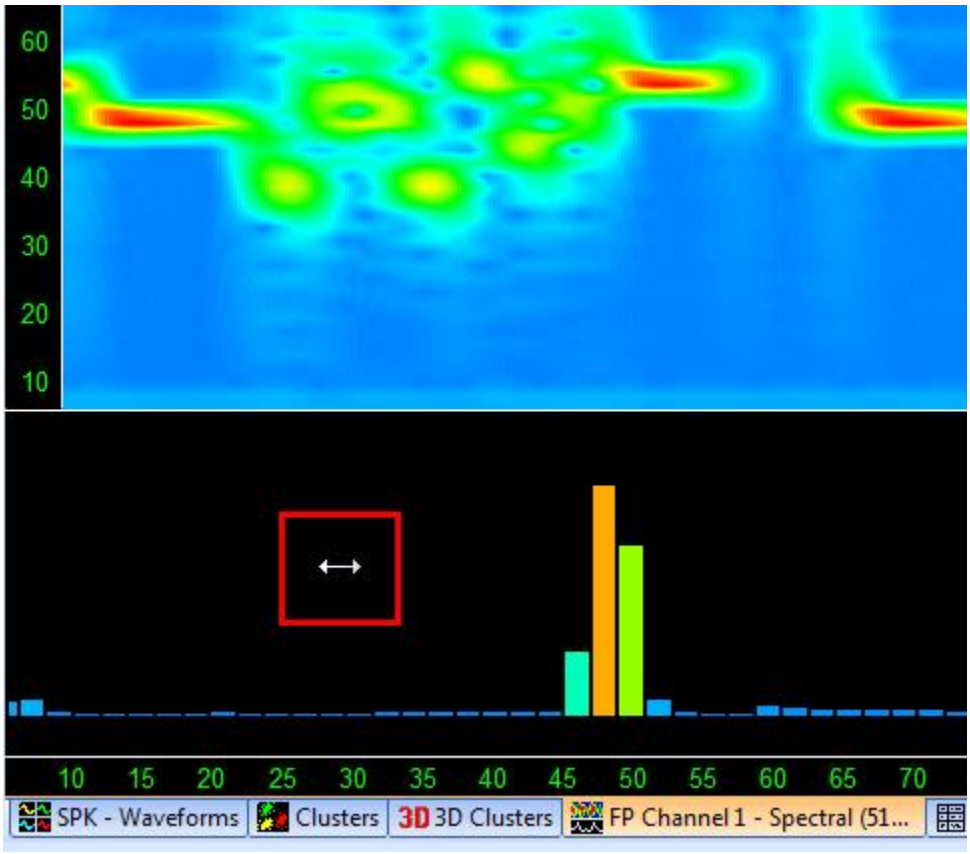
The upper area is the spectrogram, where time increases along the x axis, the y axis represents frequency, and the color at any particular time and frequency represents the relative amplitude of the frequency component, with colors progressing from blue to green to yellow to red as amplitude increases.

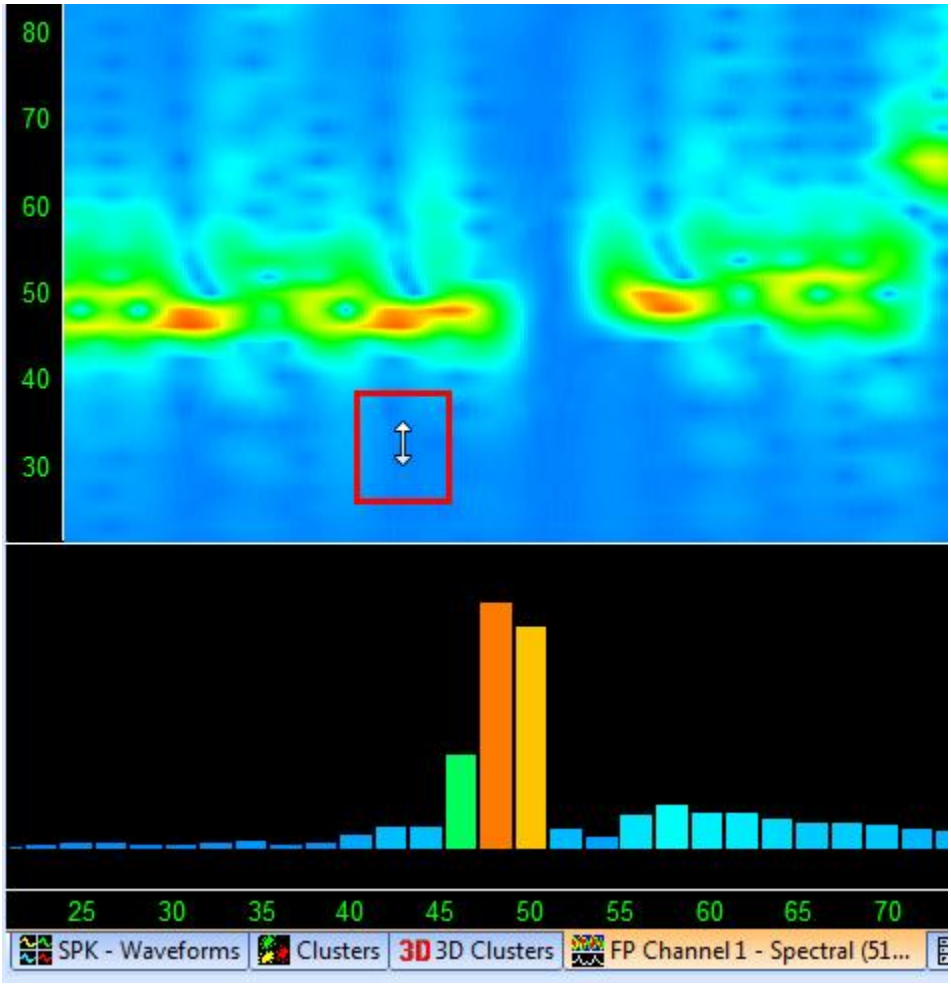
The lower area is the spectral graph, which can be thought of as a vertical "slice" of the spectrogram at the current position of the white sweep line. Here, the x axis represents frequency and the y axis represents amplitude. By default, the spectral graph is shown as a bar graph, where both the height of each bar and its color represent the amplitude at a frequency (or more precisely, the amplitude within one bin of the FFT that is used to perform the spectral analysis).

You can change the relative sizes of the spectrogram and the spectral graph by dragging the divider between them with the mouse:



The mouse can also be used to interactively adjust the frequency range that is displayed. In either display, rolling the mouse wheel zooms in and out in frequency, i.e. a larger or smaller range of frequencies are displayed. Click in the spectral display and drag left or right, or click and drag vertically in the spectrogram, to drag the display frequency range accordingly. Note that adjusting the frequency range in one display automatically makes the corresponding change in the other display.

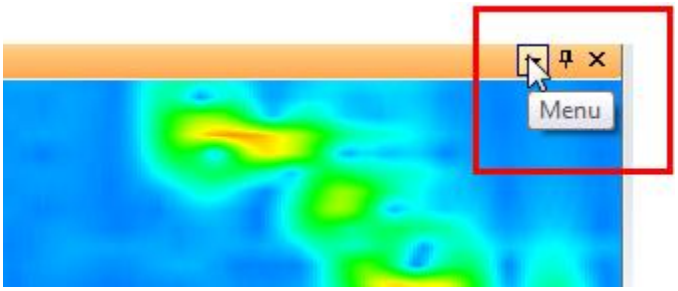

60
50
40
30
20
10
10 15 20 25 30 35 40 45 50 55 60 65 70
SPK - Waveforms
Clusters
3D 3D Clusters
FP Channel 1 - Spectral (51...

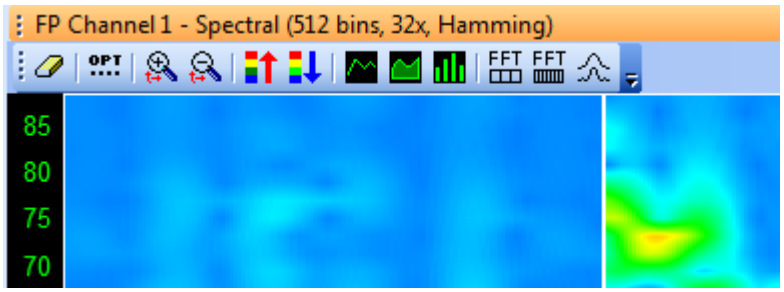


Zooming in frequency only affects the display, not the underlying FFT; in other words, the bin width remains the same, and bars (each of which represents an FFT bin) will become correspondingly larger or smaller in the spectral graph. However, the spectrogram is interpolated so as to remain smooth. When the spectral graph is in line or area mode (described below), these displays are also interpolated, although this can be disabled.

The rolling spectrogram and the spectral graph can be paused by using the global Display Pause button in the main toolbar:

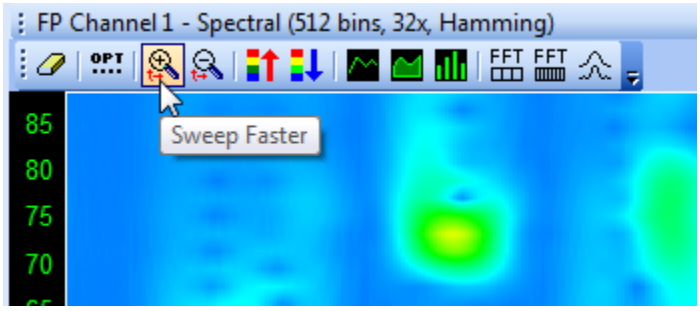
Click the down-arrow in the title bar to display the toolbar for the Spectral view:

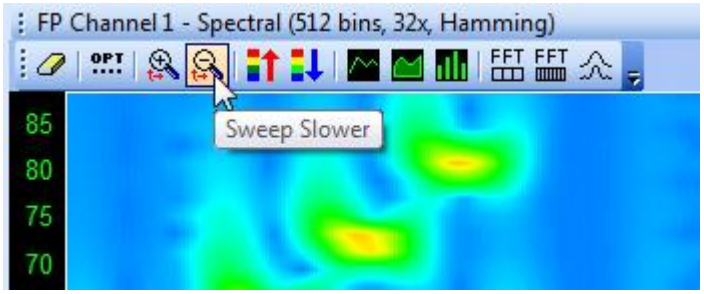




The leftmost button is Erase, which clears the display. To its right is Show Options; the Options dialog will be described later.

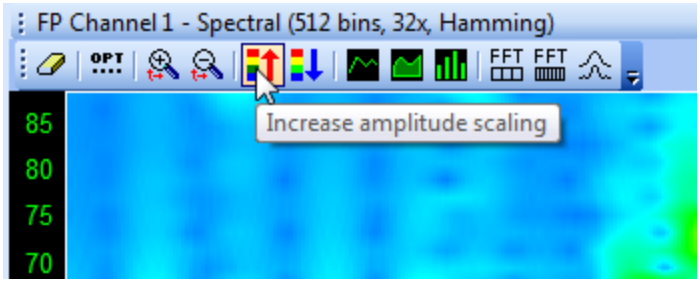
Sweep Faster and Sweep Slower adjust the speed of horizontal scrolling in the spectrogram; they also affect the rate at which the spectral graph is updated.

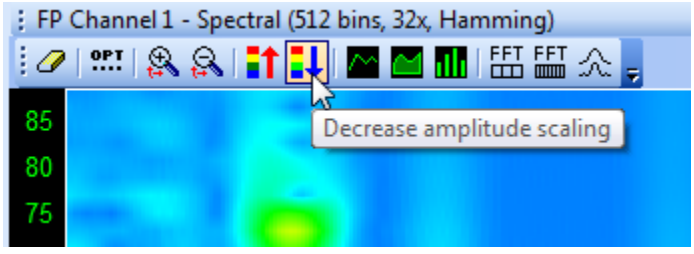




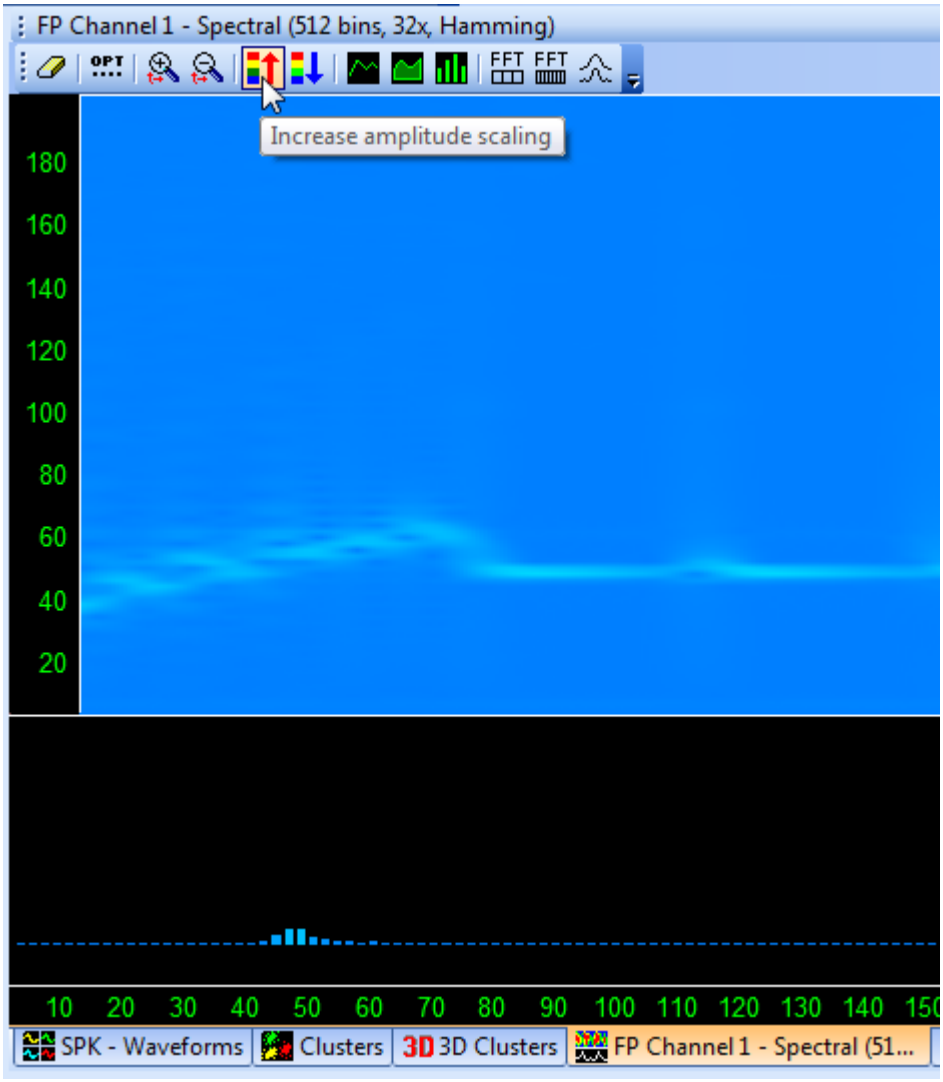
Note that the minimum and maximum scroll/update rates are also a function of the FFT size.

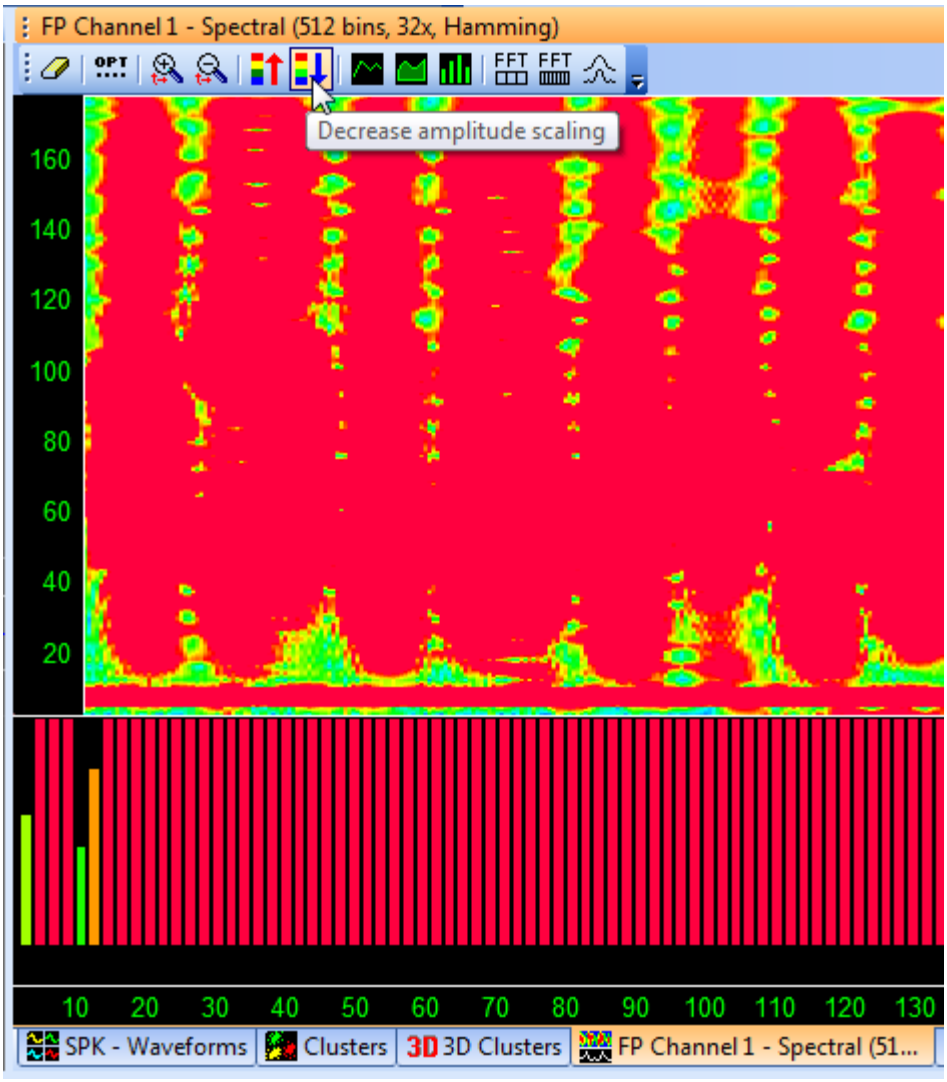
The next two buttons adjust the color scaling of amplitude; you can think of them as "more red" and "more blue" respectively, as indicated by the red up-arrow and blue down-arrow:





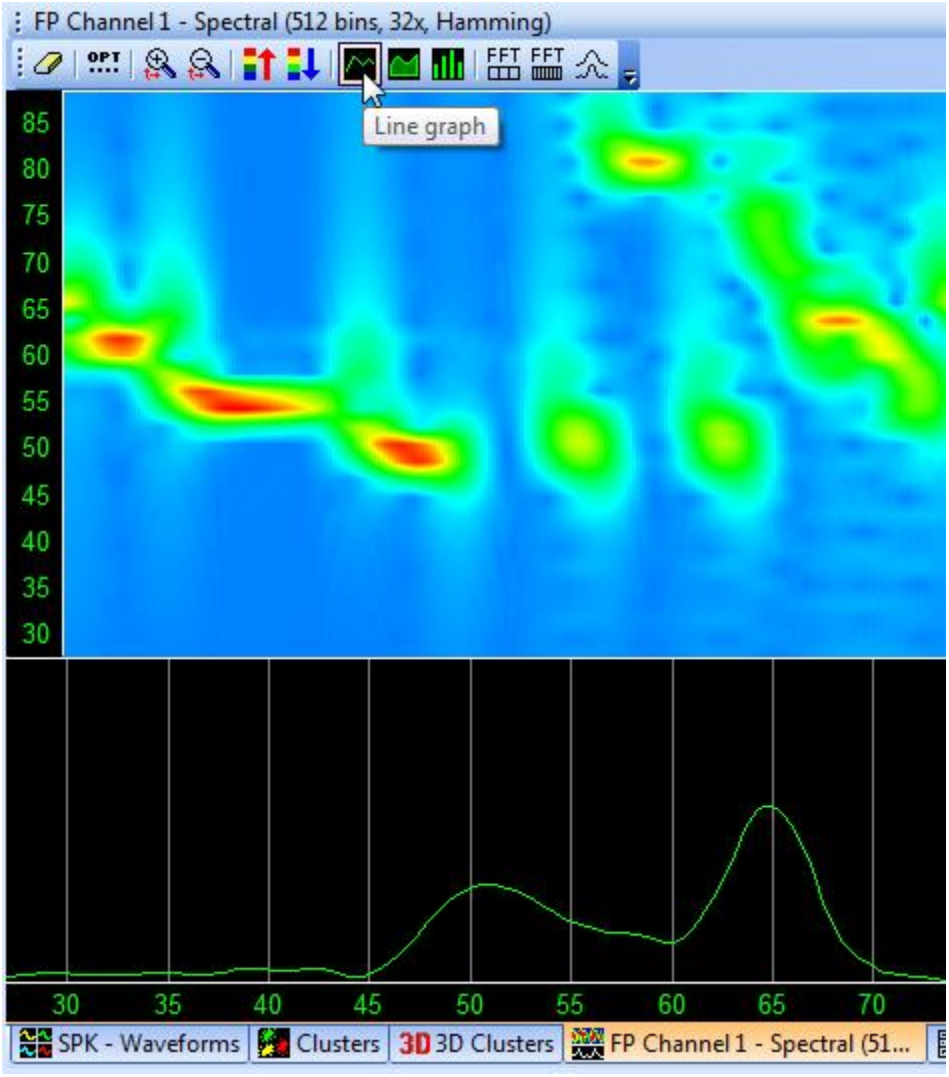
Here are examples of spectrograms where the amplitude should be increased and decreased to give a more informative spectral display:



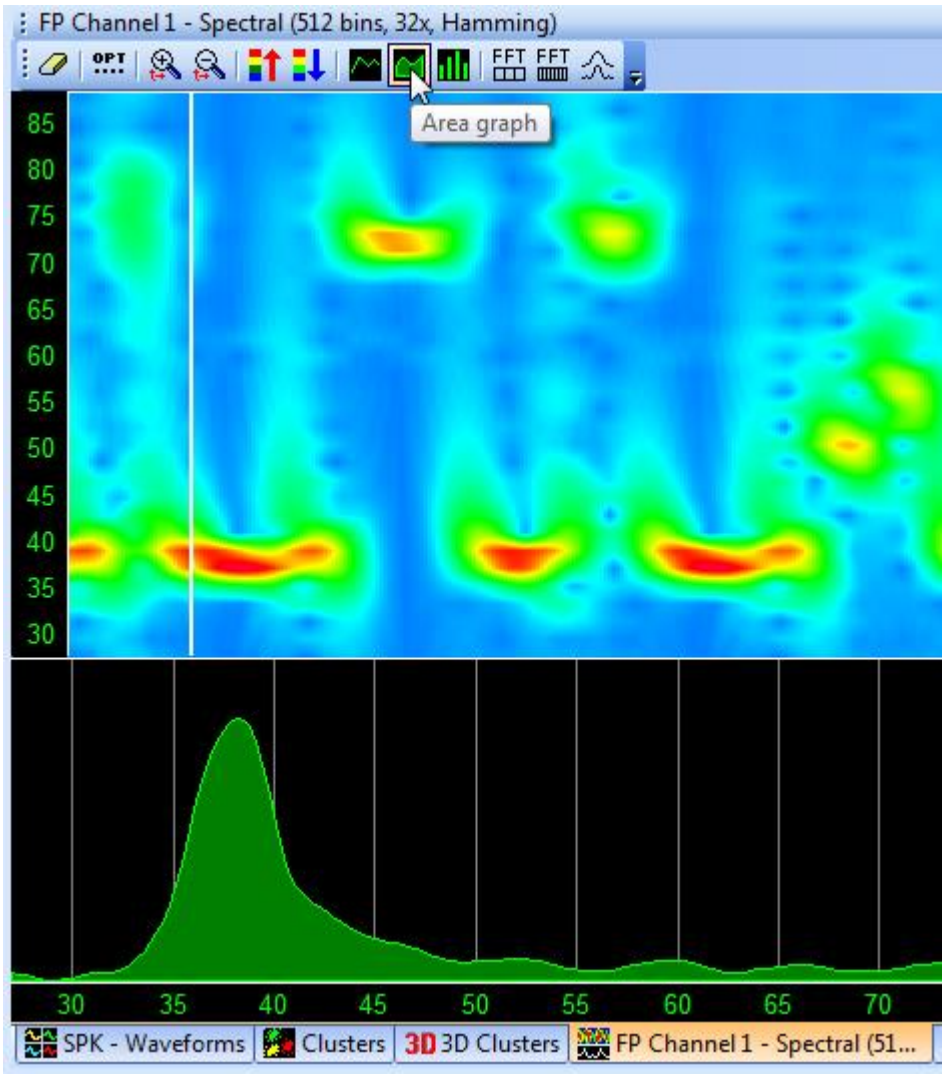

FP Channel 1 - Spectral (512 bins, 32x, Hamming)
Decrease amplitude scaling
160
140
120
100
80
60
40
20
10 20 30 40 50 60 70 80 90 100 110 120 130
SPK - Waveforms
Clusters
3D 3D Clusters
FP Channel 1 - Spectral (51...

The three graph-mode buttons set the display mode for the spectral graph, as shown below.

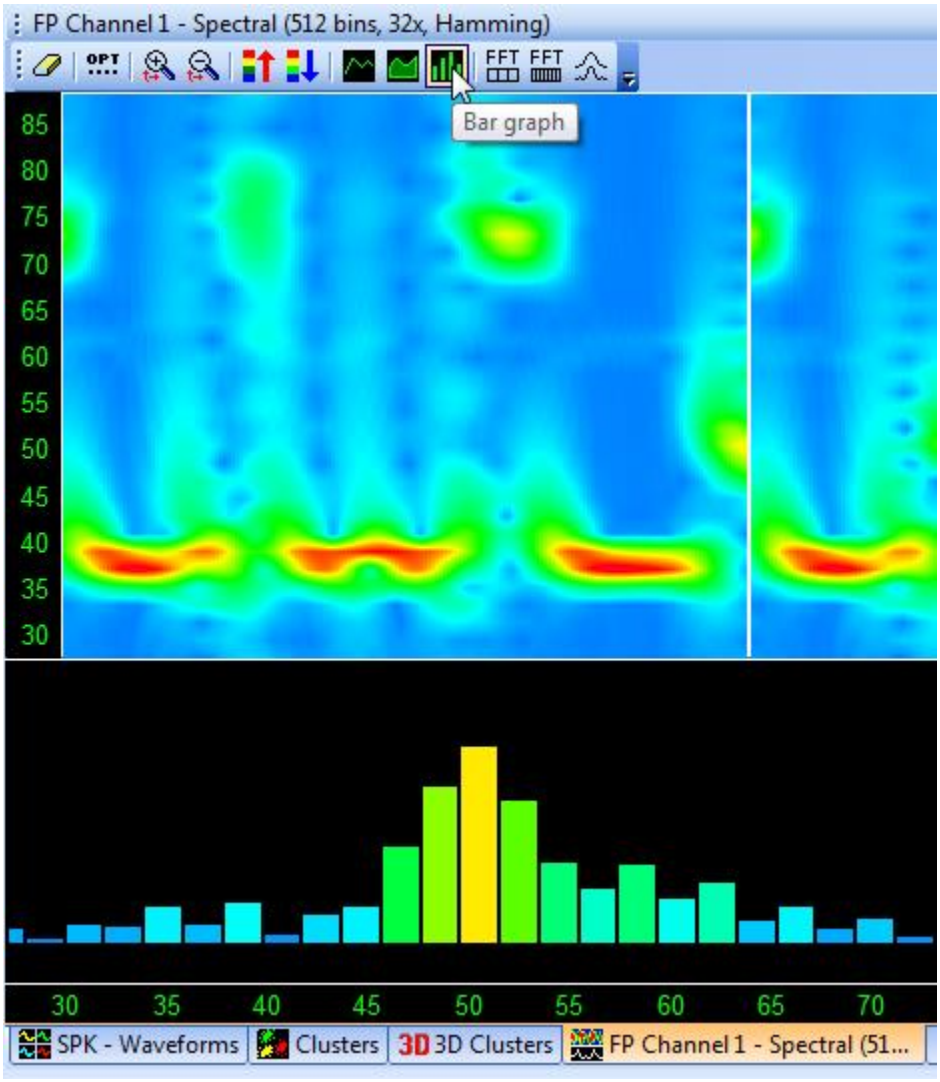
Line graph:



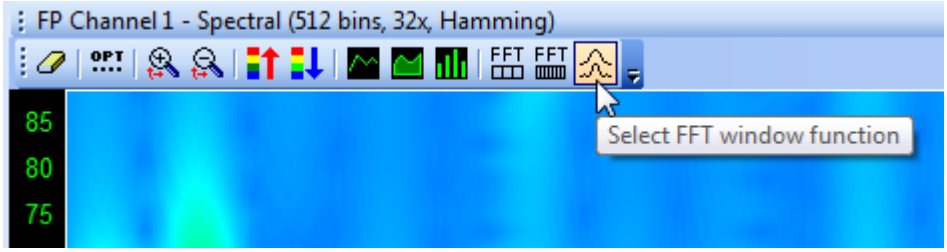
Area graph:


FP Channel 1 - Spectral (512 bins, 32x, Hamming)
Area graph
85
80
75
70
65
60
55
50
45
40
35
30
30
35
40
45
50
55
60
65
70
SPK - Waveforms
Clusters
3D 3D Clusters
FP Channel 1 - Spectral (51...

Bar graph (default):



The next two buttons decrease and increase the size of the FFT, in powers of two, and the rightmost button selects the FFT window function, selecting the next available window function each time it is clicked:



Note that the Spectral view's title bar always displays the current FFT size, oversampling (which is proportional to the sweep speed of the spectrogram), and window function:

The FFT size determines the frequency resolution of the spectral display, and the width of an FFT frequency bin is:

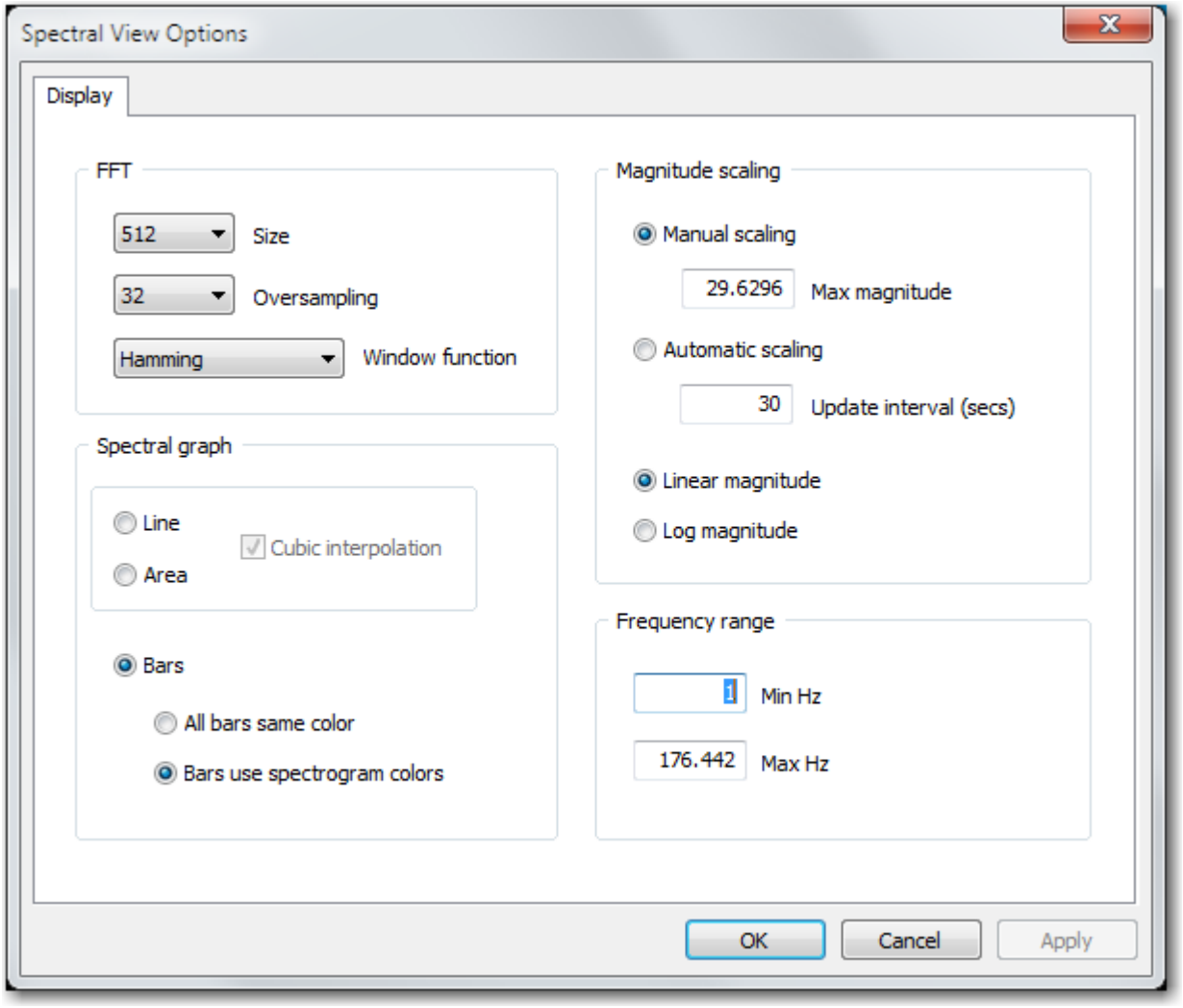
bin width = (sampling rate) / (FFT size)

The choice of window function affects spectral selectivity, side-lobe leakage pattern, and other factors. For most uses it can be left at the default (Hamming). Note that when you change the window function, you may need to adjust the amplitude scaling, unless you have enabled automatic scaling, in which case the amplitude scaling will be corrected at the next update interval.

Consult a reference on digital signal processing or spectral analysis for additional information on the tradeoffs involved in using different FFT sizes and window functions.

Options dialog

Click on the OPT... button to display the Options dialog for the Spectral view:



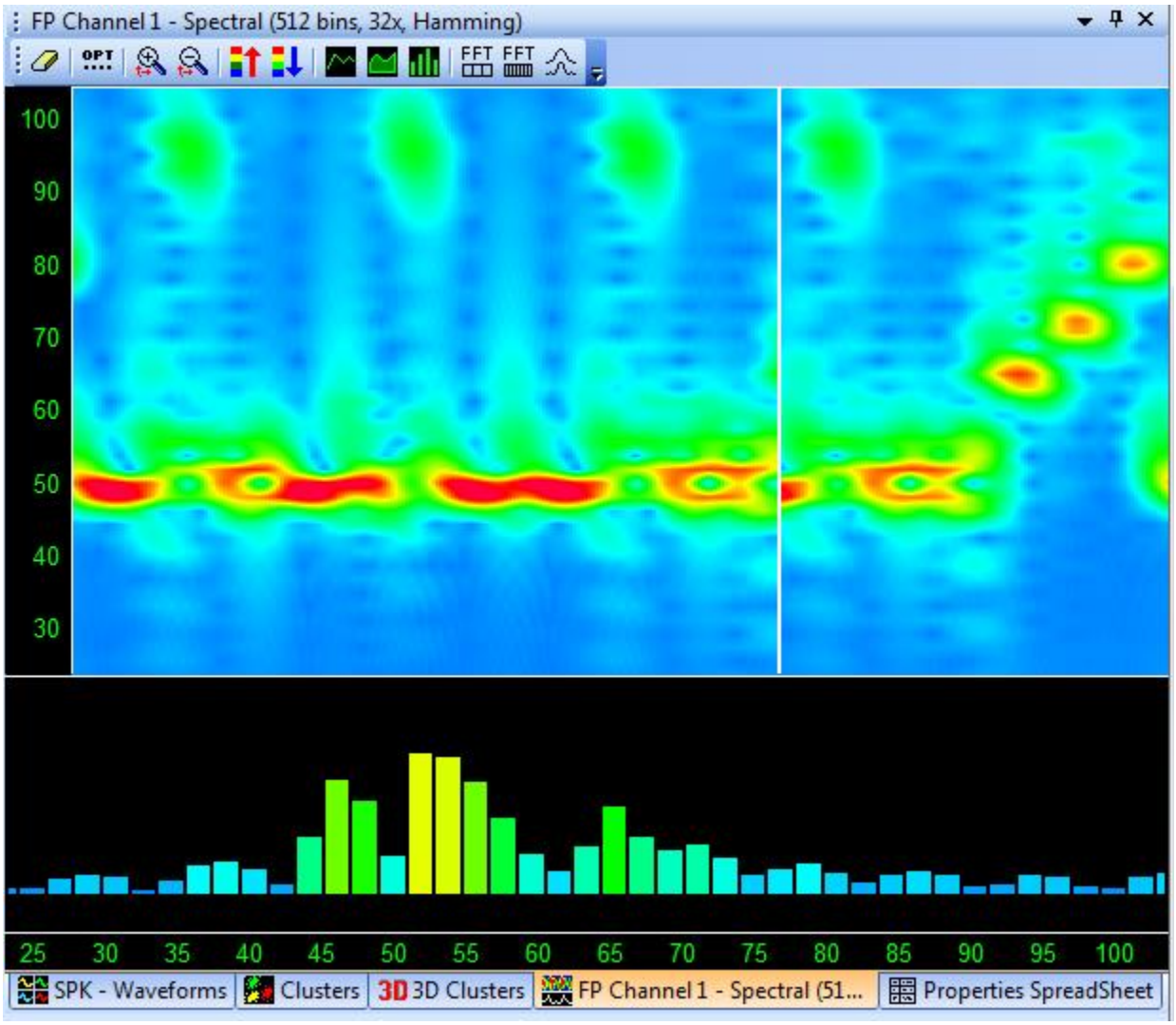
Several of these options will already be familiar from their equivalent toolbar buttons, or interactive mouse operations. These include the FFT parameters, the spectral graph display modes, and the frequency range. Others can only be set via the options dialog.

Manual / automatic scaling

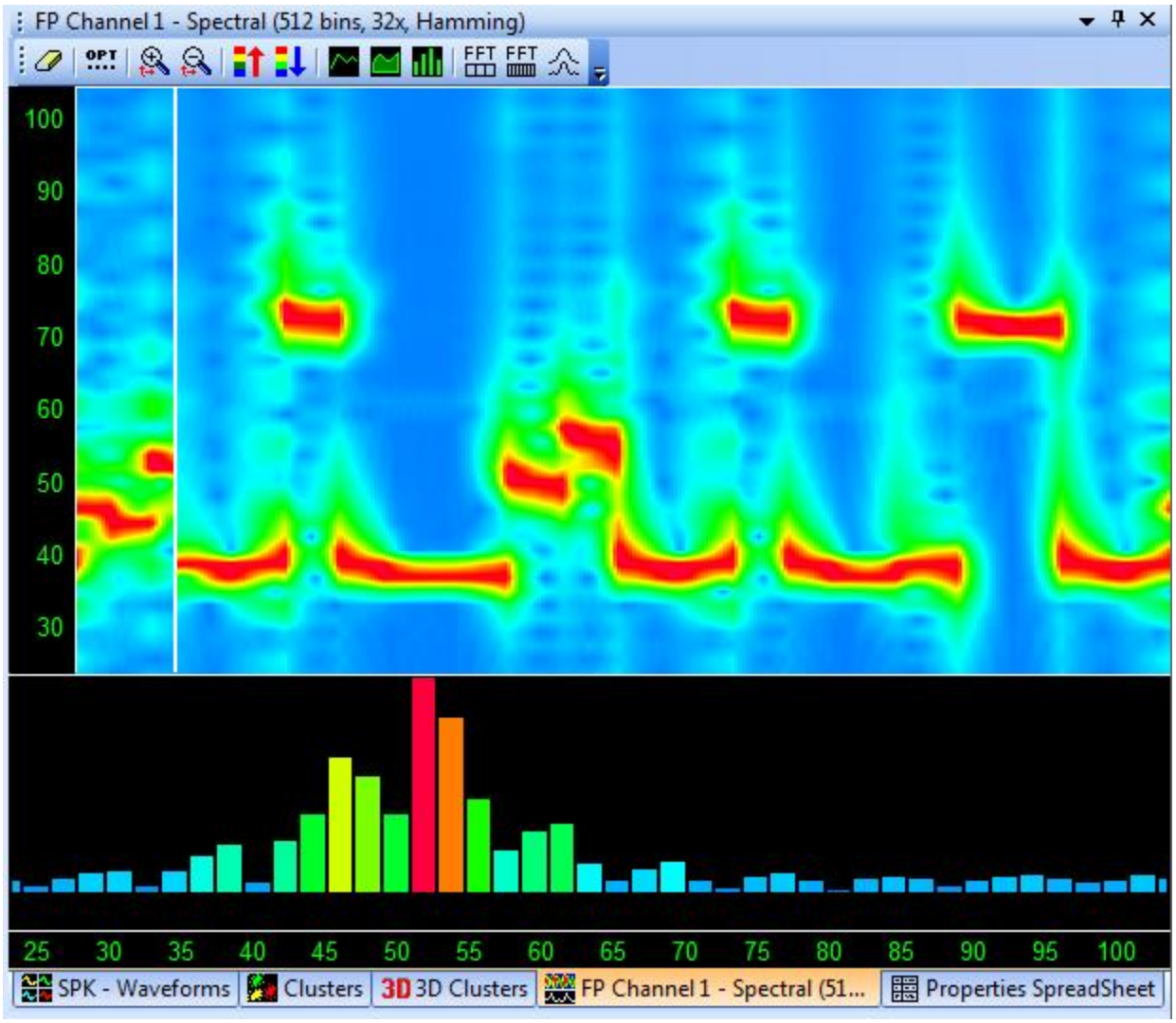
The default, manual scaling, allows you to control amplitude scaling using either the toolbar buttons or by specifying a numeric value. If you select automatic scaling, OmniPlex monitors the selected FP channel to determine its maximum amplitude in any frequency bin within a specified time interval, and periodically updates the amplitude scaling using that maximum value. For example, the default update interval of 30 seconds causes the amplitude scaling to be updated every 30 seconds, using the maximum amplitude detected within the preceding 30 seconds. This guarantees that the spectral displays will be "in the ballpark" without manual intervention, but it also means that the amplitude scaling could abruptly change

when an update occurs. Note that the special case of an update interval of 0 seconds means that the amplitude scaling will be continuously updated; in effect, this makes the spectral displays show only changes in the *relative* spectral content over time. Here is an example of normal scaling and relative scaling.

Normal scaling:



Relative scaling:

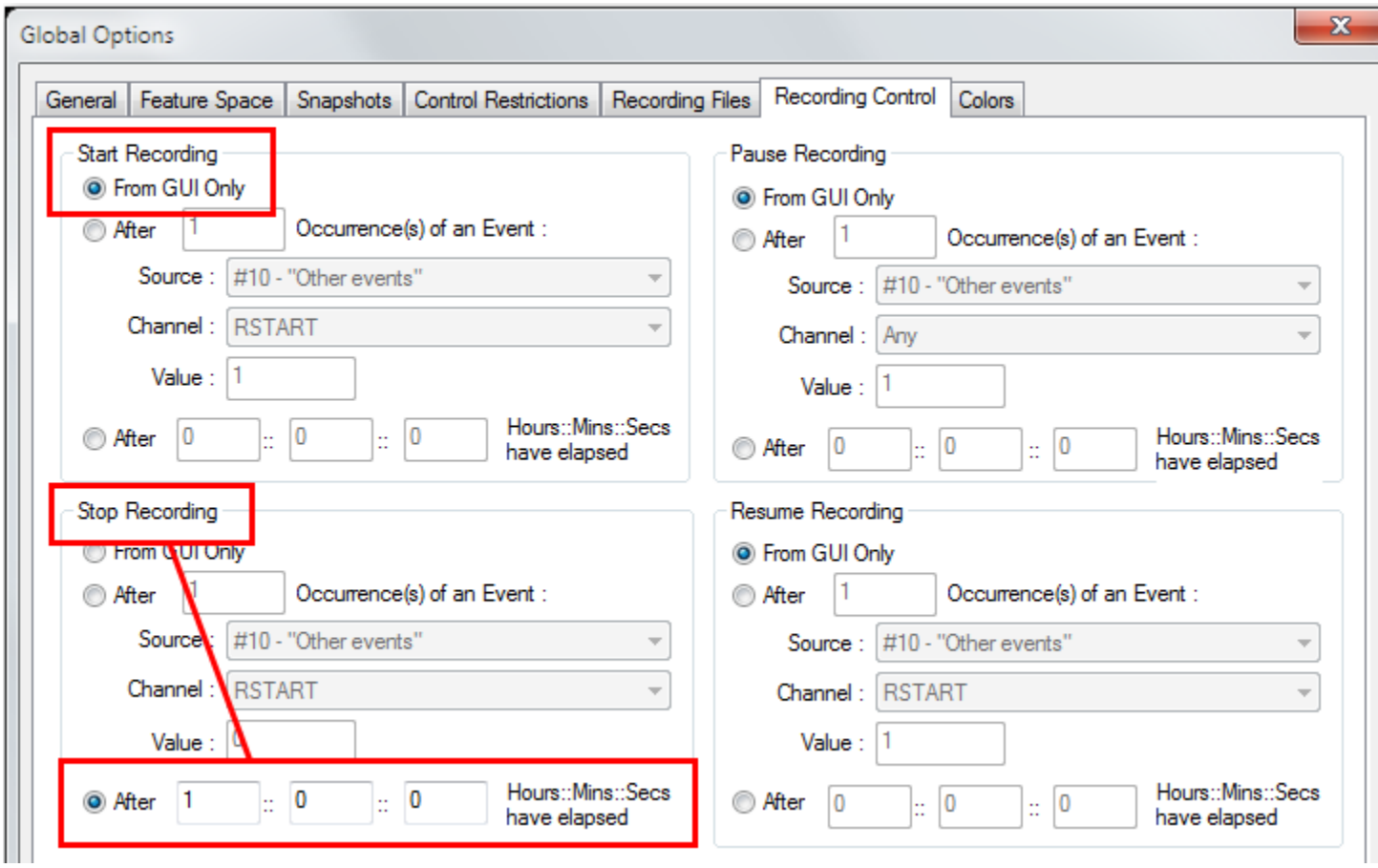


Note how with relative scaling of the spectrogram, at any given instant (x position), there is always at least one frequency (y position) that is displayed in red, i.e. scaled to maximum amplitude. The equivalent behavior in the spectral graph is that the graph will be continuously scaled such that at least one bin in the graph will always be at full height.

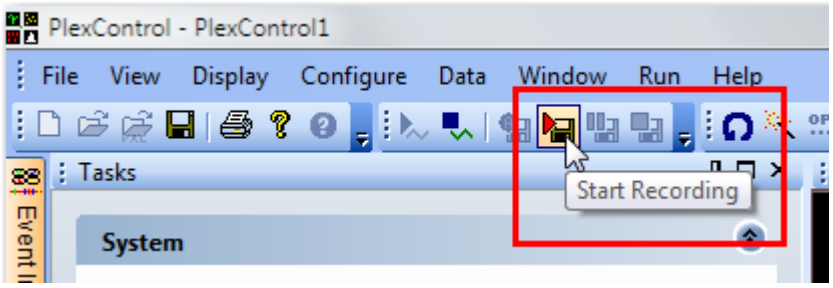
Timed recording

In the Recording Control tab of PlexControl's Global Options dialog, timed recording options are now supported. Timing of the Start, Stop, Pause, and Resume commands can be specified. There are many ways in which the timed recording options can be used, but here we will show three common examples.

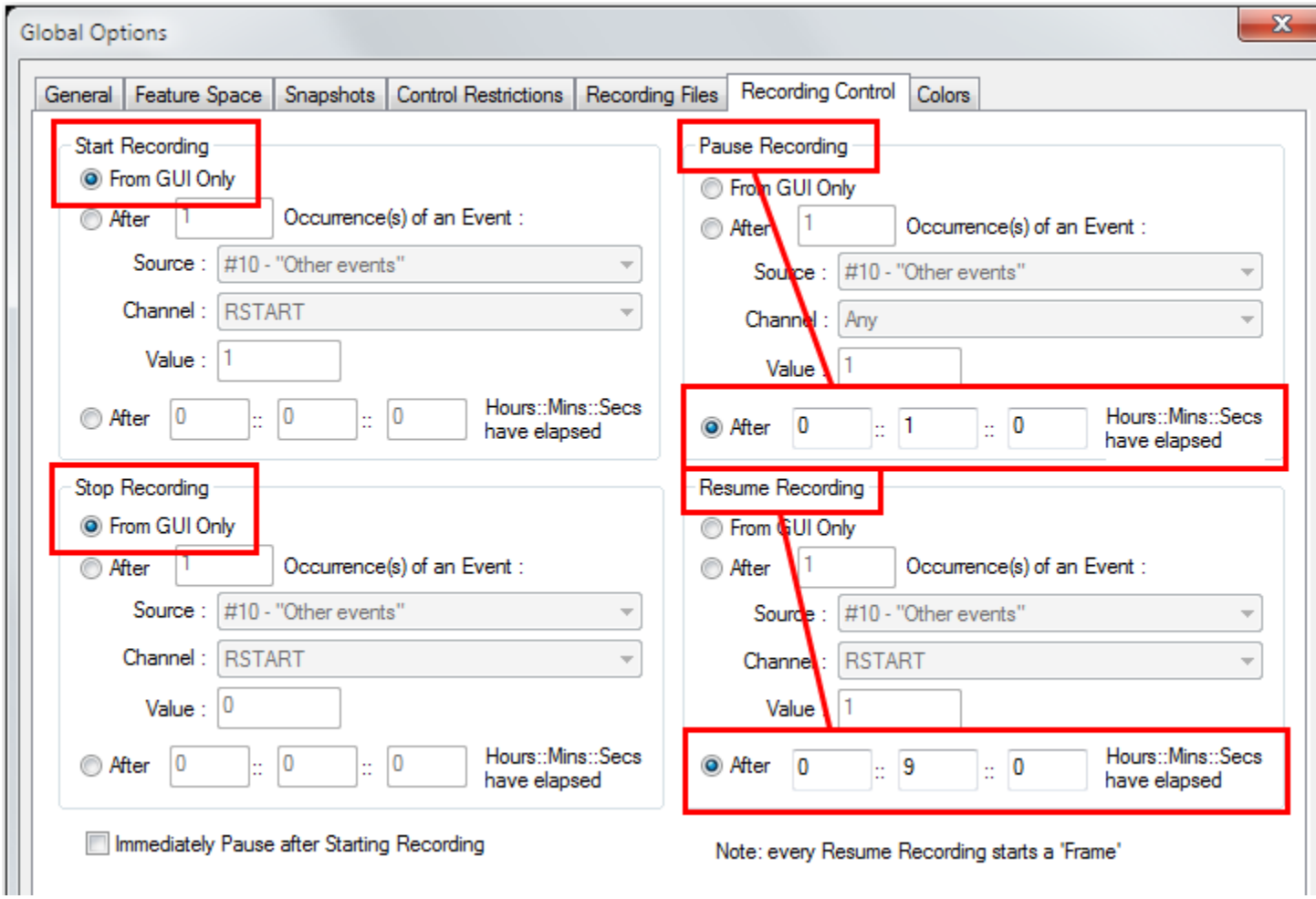
In the first example, each recording is to be started manually, using the Start Recording button in the main toolbar, and automatically ended, closing the recording file, after one hour of recording time has elapsed. This corresponds to the following settings on the Recording Control page of Global Options:



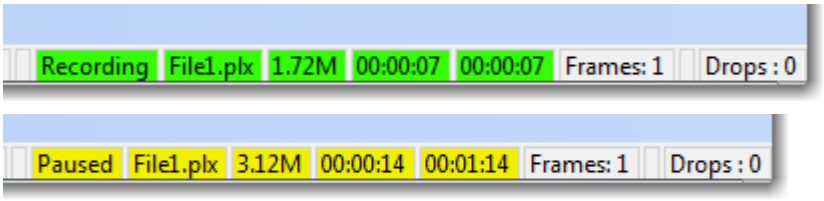
"From GUI" means that the appropriate toolbar button is used to manually start, stop, pause, or resume. In this case, only the Start Recording button is used:



In the second example, starting and stopping of recording are both controlled manually, but once recording has started, the following behavior is desired. The recording is paused after one minute of recording. The recording resumes nine minutes after the recording was paused. In other words, record one minute out of every ten minutes, repeatedly, until the recording is stopped manually, which closes the file. This corresponds to the following settings:

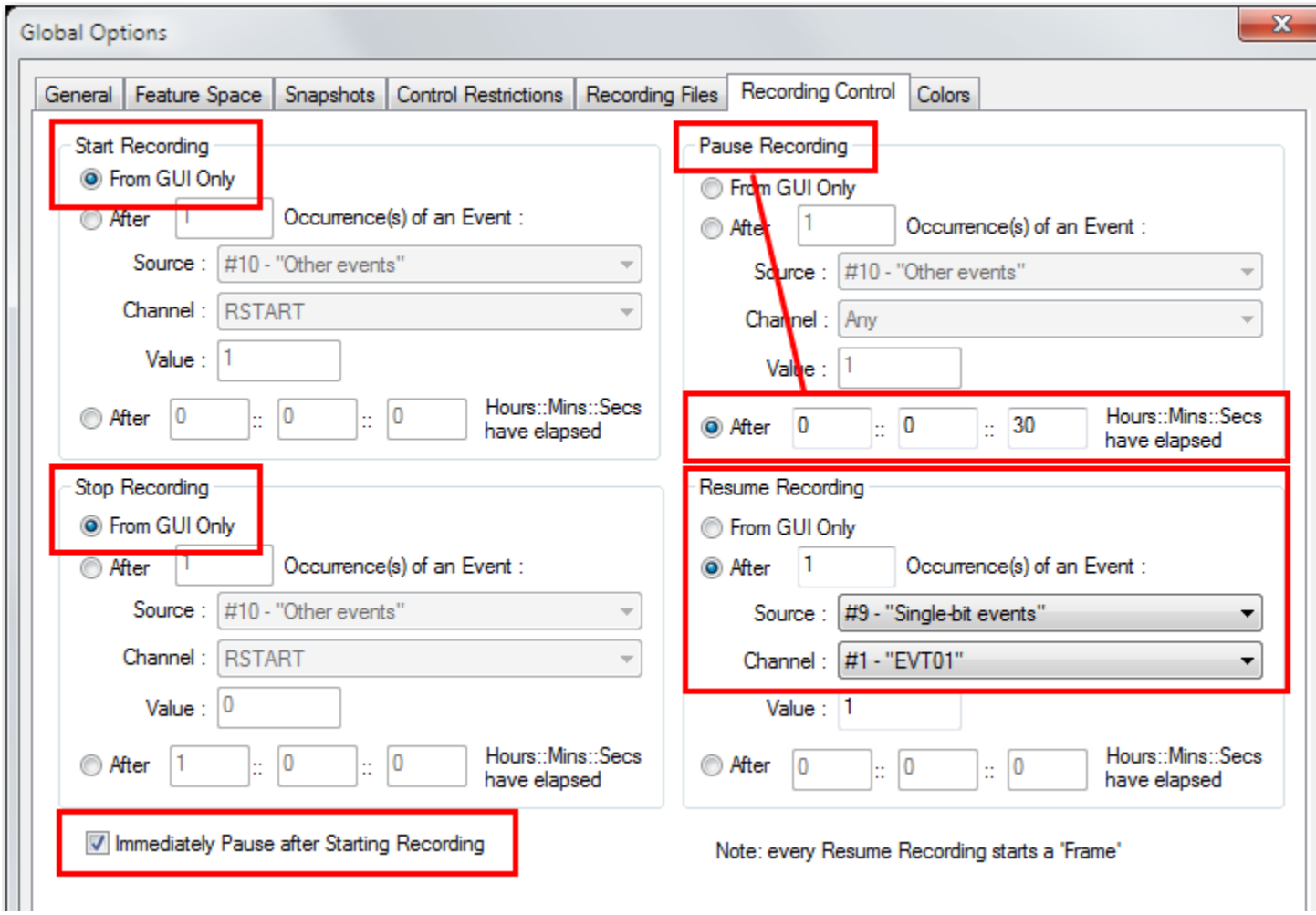


As with manual pausing and resuming of a recording, the status bar displays recording information in green while recording is in progress, and in yellow when paused:

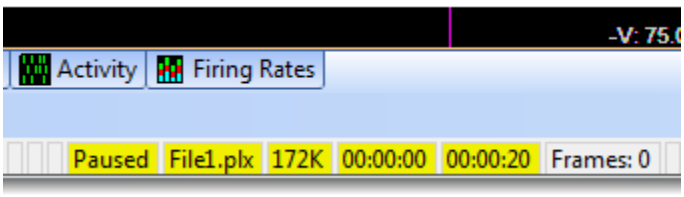


The filename is followed by the current size of the recording file, the total duration of actual recorded data (not including pauses), the elapsed time since the start of the recording (including pauses), and the number of frames (recorded intervals). The rightmost number, the drop count, should always be zero; a nonzero value indicates that there was a gap in the data stream, typically due to excessive CPU load or a conflict with another running application.

In the third example, we wish to record for 30 seconds each time that a digital event is detected on channel EVT01 of the digital input card. For example, you might have an external behavioral control system which sends out a TTL pulse at the start of each trial during an experiment; by sending this pulse into EVT01 on the DI card, you can use it to control recording in OmniPlex.

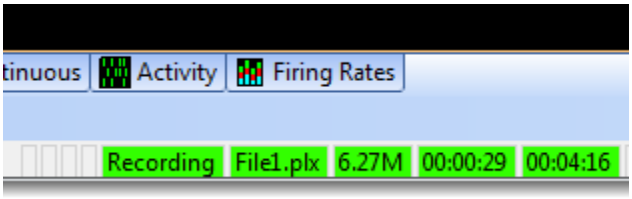


In this case, when you click Start Recording in the toolbar, no data is recorded until an EVT01 event is detected; this is indicated by the status bar showing that the recording is initially paused:

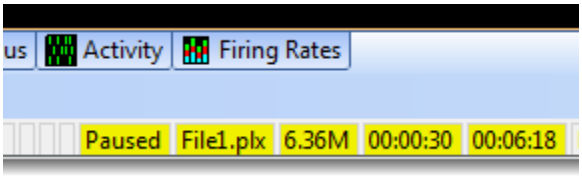


The small nonzero file size is due to the file header being recorded, not data.

When the specified event is detected, recording resumes for the specified amount of time:



Recording then pauses again, waiting for the next event:



Although we used the EVT01 digital event as the Resume trigger in this example, you can use any OmniPlex event. For example, you could use the KBD1 keyboard event (Alt-1 on the keyboard) instead of EVT01. You can use any type of events and/or the timed option for either Resume or Pause.
Note that it takes OmniPlex a fraction of a second (typically anywhere from 50-500 ms, depending on your system configuration) to actually begin recording data after an external digital event is detected by the hardware; therefore, if you need recording frames to begin at *exactly* the same time as the pulse, it is recommended that you record nonstop and record the digital events in the file to delimit the desired intervals of data, rather than using the events to pause and resume recording.

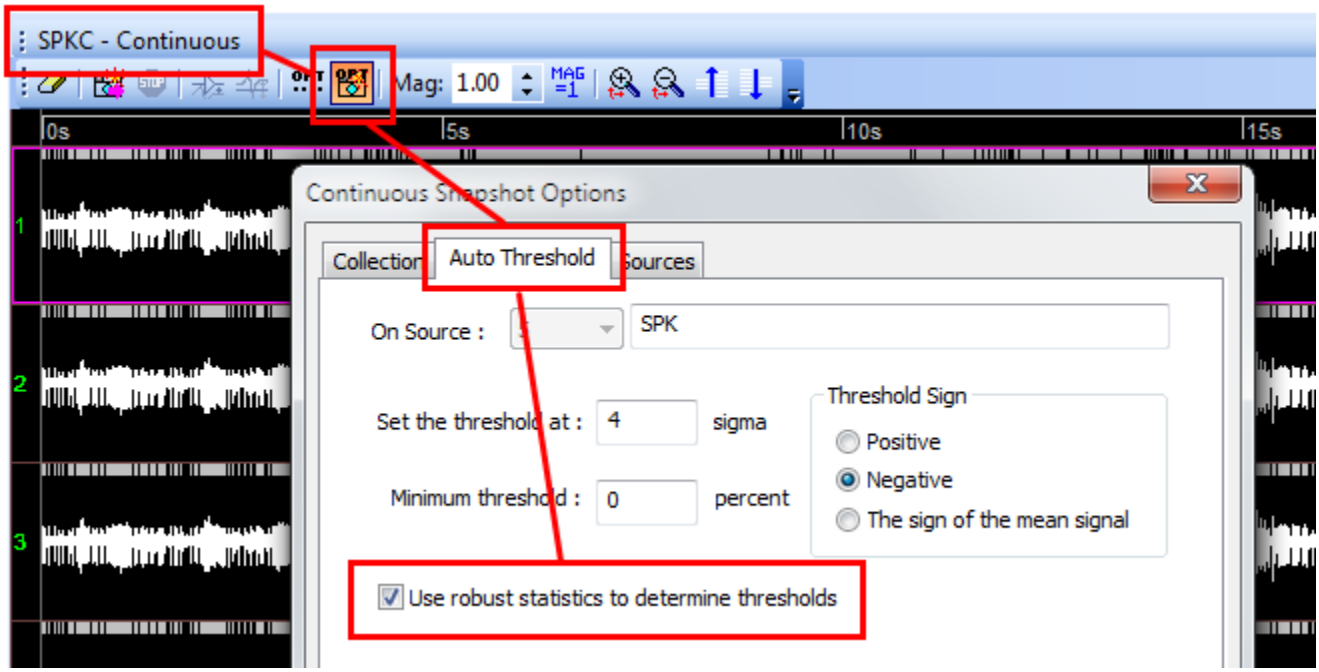
It is always a good idea to make one or more test recordings and check the recorded data (in NEX, Offline Sorter, Matlab, etc) to verify that your recording setup operates as intended before recording important experimental data.

Robust statistics

PlexControl now provides options for using robust statistics in the determination auto-thresholding and sorting parameters. The primary advantage of robust statistics is that they are more resistant to the effect of outliers. Some examples are the use of the median as a robust statistic instead of the mean, or the use of the median absolute deviation (MAD) instead of the standard deviation.

Robust auto-thresholding

To enable robust statistics for auto-thresholding, set the option in the Auto Threshold page of the SPKC snapshot options dialog:



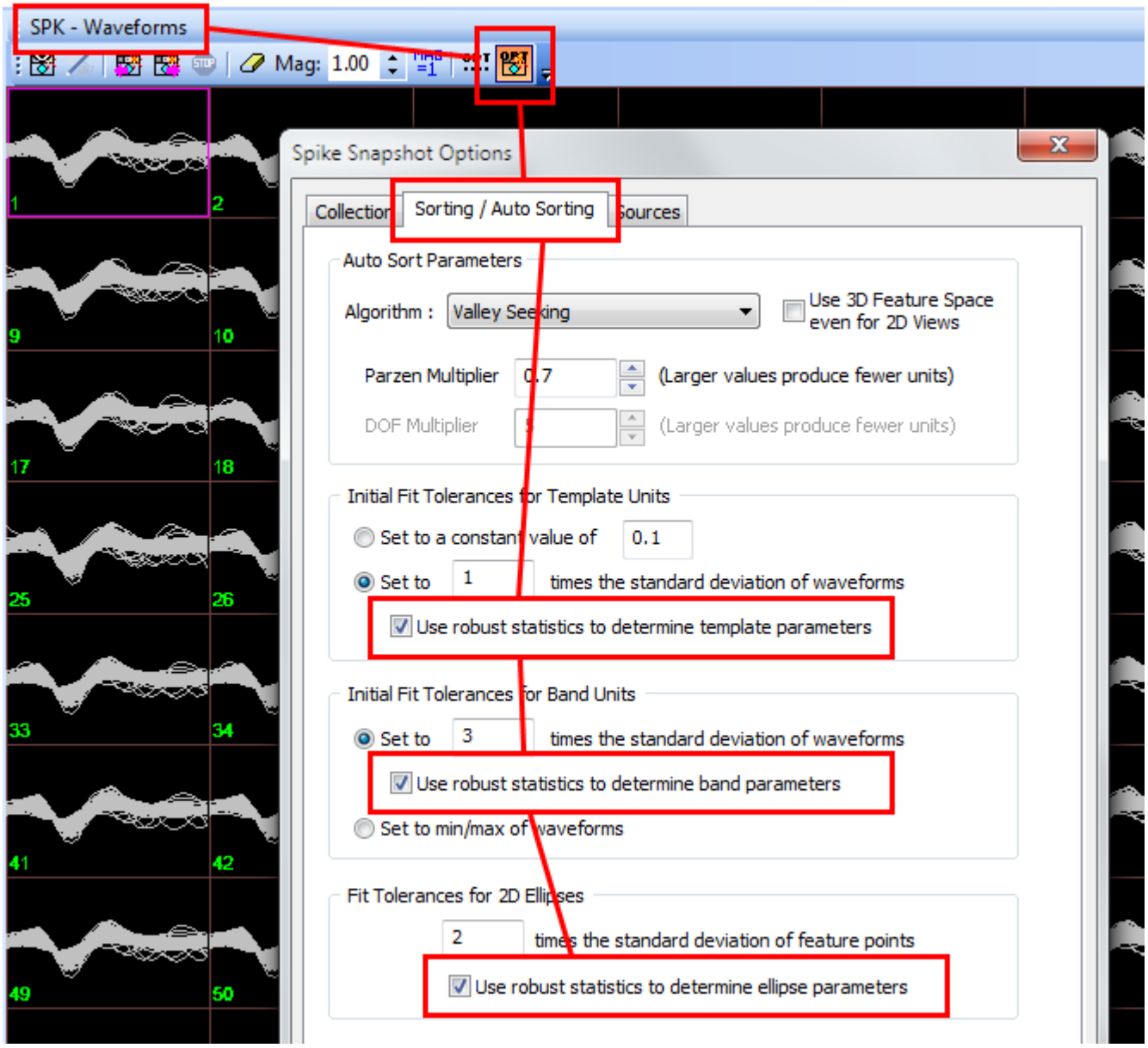
When this option is enabled, the median and MAD of the peak histogram are calculated instead of the mean and standard deviation. The threshold is still expressed in terms of sigmas, but where sigma is derived from MAD by the formula:

sigma = 1.4826 * MAD

You will typically find that using robust statistics produces a more accurate estimate of the noise distribution, with the presence of spikes having less influence on the auto-thresholding process; with conventional auto-thresholding, the more spikes that are present, the higher the threshold produced by auto-thresholding.

Robust template, band, and ellipse sorting parameters

To enable robust statistics for template, band, and ellipse sorting parameters, set the corresponding option in the Sorting / Auto Sorting page of the SPK snapshot options:



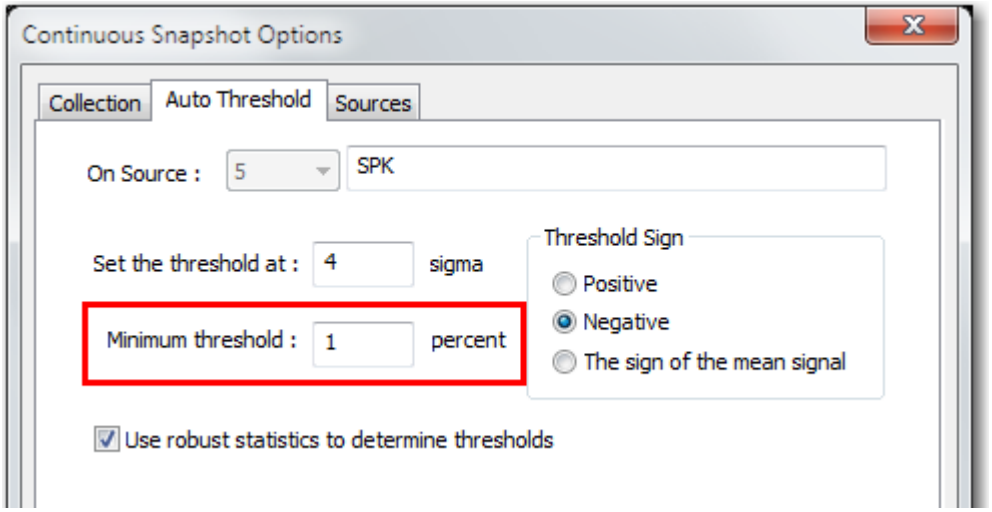
For template sorting, the median absolute deviation is calculated and used to derive sigma, using the conversion formula described in the section on auto-thresholding. For band sorting, MAD is used to derive a sigma value at each sample time within the waveform. For ellipse generation for 2D polygon sorting, the median is used instead of the mean in the standard PCA calculation. After the first two eigenvectors of the covariance matrix are obtained in the usual way, the MAD is calculated with respect to those two vectors and used to derive the sigma values for the major and minor ellipse axes. In all three sorting methods, the actual sorting of incoming spikes is performed using the standard algorithms; robust statistics are used in the calculation of the sorting parameters.

Note that for the case of hand-drawn contours ("Automatically convert hand-drawn contours into ellipses" option), 2D ellipse generation does not use robust statistics, nor the standard deviation for that matter. In this case, a special geometric algorithm is used which produces better results; a description of this algorithm is beyond the scope of these release notes.

Minimum threshold for auto-thresholding

In cases where a channel's signal contains only noise, PlexControl's auto-thresholding procedure may attempt to set a threshold so low that the spike detector triggers on noise rather than valid spikes. To prevent such behavior, you can set a minimum threshold value in percent. If the auto-thresholding procedure attempts to set a threshold whose absolute value is less than the specified percentage, it will instead set that channel's threshold to -99%, in effect disabling the channel's spike detector. However, since the channel is not completely disabled, you can still view the wideband (WB) and spike continuous (SPKC) signals for that channel, allowing you to continue to monitor it for spiking activity, adjust the threshold manually, and to take a new snapshot and re-auto-threshold it if desired. The minimum threshold value only affects auto-thresholding; you can manually set the threshold to any desired value at any time, either by dragging the threshold line or by editing the threshold value numerically.

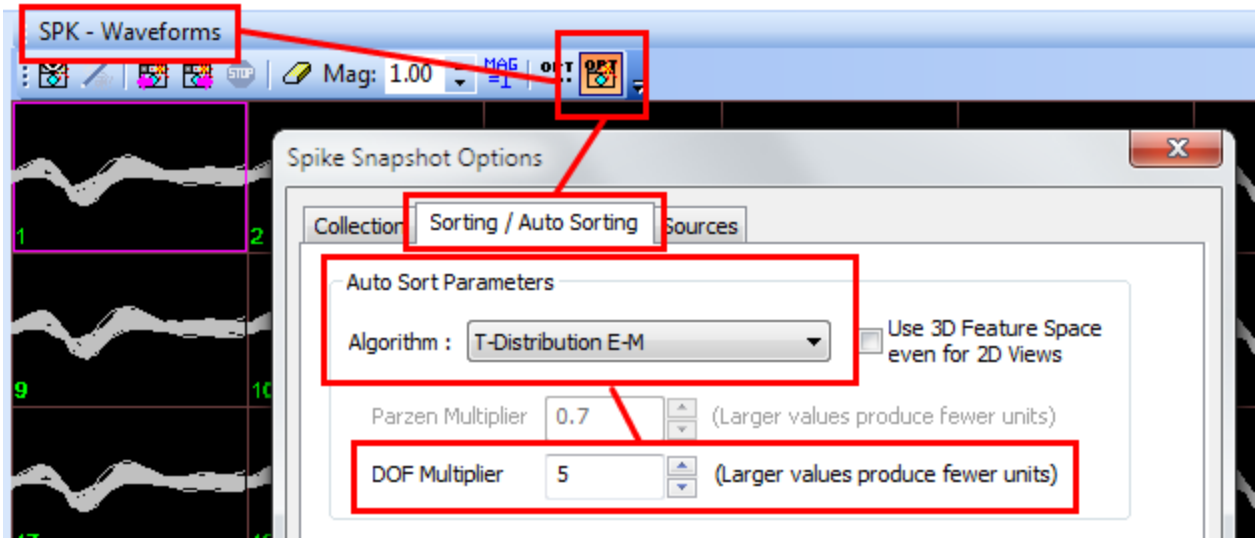
An appropriate value for the minimum threshold will be data-dependent, but should be small relative to the thresholds of channels which have obvious spiking activity, in order to avoid disabling spike detection on channels with valid low amplitude spikes. For example, if you find that auto-thresholding is producing thresholds of approximately -10% on spiking channels, you might set a minimum threshold of 10% / 10 = 1%.



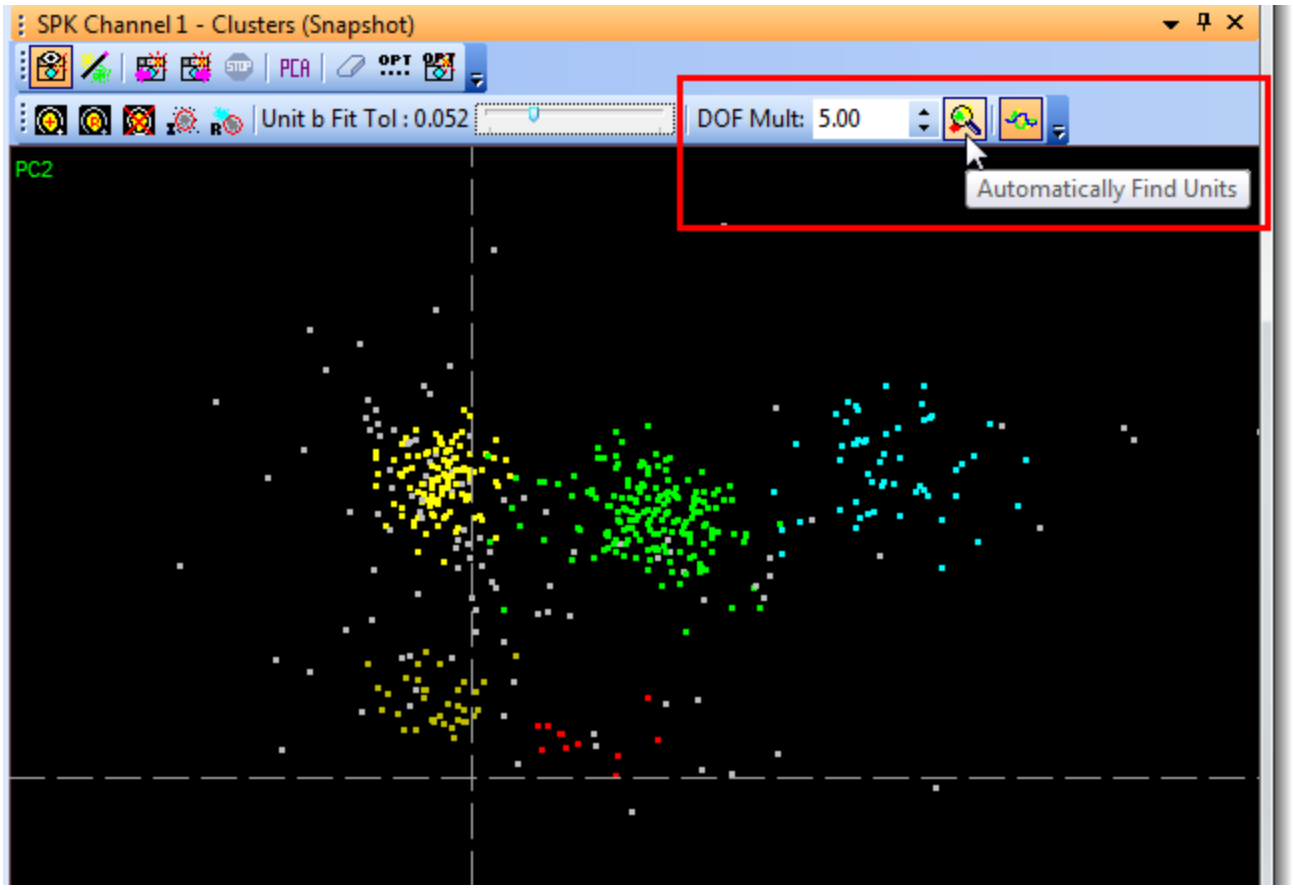
TDEM auto-sorting

Previous releases of OmniPlex supported a single auto-sorting algorithm, known as valley seeking. Valley seeking is a non-parametric method based on local density measures, and gives very good results in many cases, but it is not always ideal. OmniPlex 1.11 supports an additional auto-sorting algorithm called t-distribution expectation maximization, or TDEM for short. TDEM works on the assumption that the clusters in feature space (each cluster representing the spikes from one neuron) can be modeled as t-distributions, so that the entire set of clusters on each channel is a mixture of t-distributions. The TDEM algorithm solves a global optimization problem to find the set of t-distributions which best fit the observed clusters on each spike channel.

To choose between valley seeking an TDEM, use the Algorithm drop-down list in the Sorting / Auto-Sorting page of the spike snapshot options:



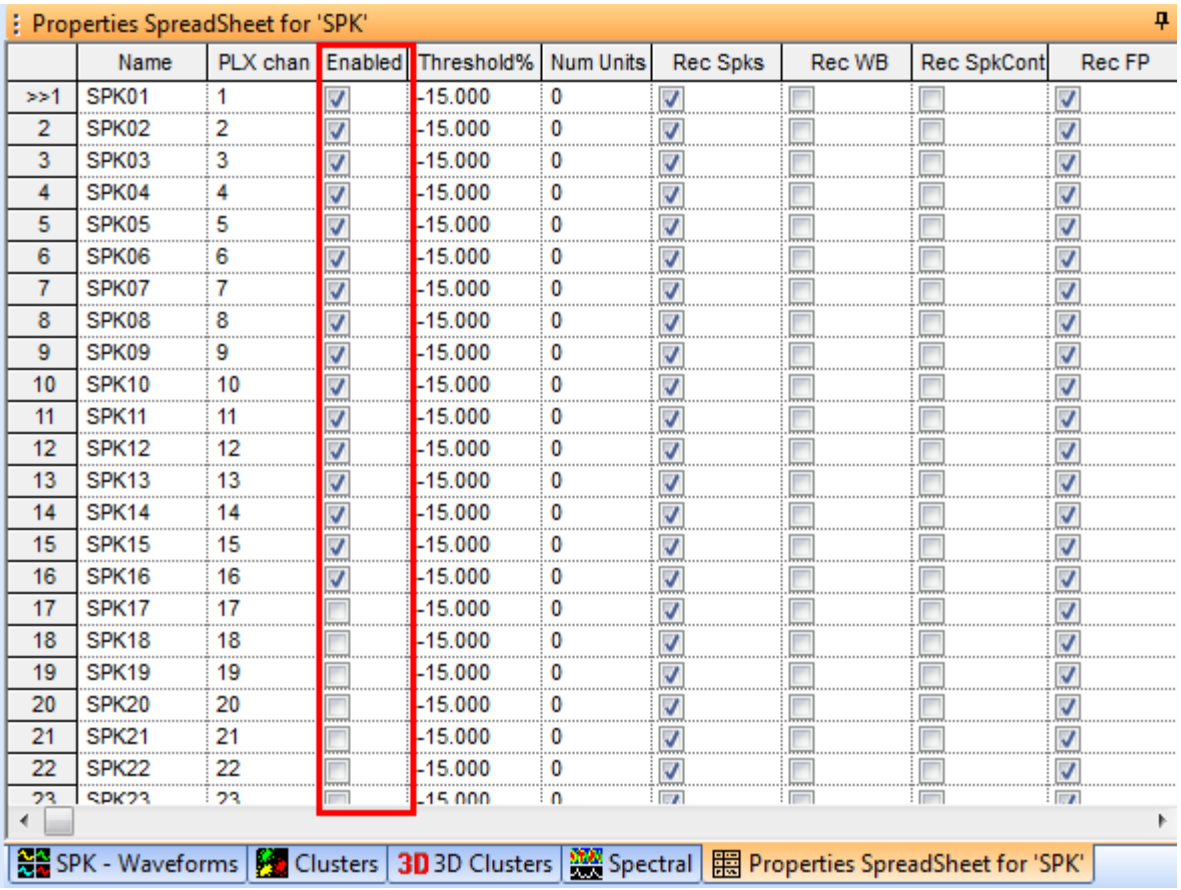
The degrees-of-freedom multiplier, or DOF multiplier for short, is analogous to the Parzen multiplier used in valley seeking. It is a tuning parameter that allows you to influence the number of clusters that are found by auto-sorting. With either algorithm, you can see the effect of adjusting the parameter while viewing the PCA snapshot, since auto-sorting is performed on the PCA snapshot before the resulting sorting parameters are then applied to the live incoming spike data. Adjust the value of the parameter and then click the Automatically Find Units button to redo the auto-sort using the current value of the parameter.



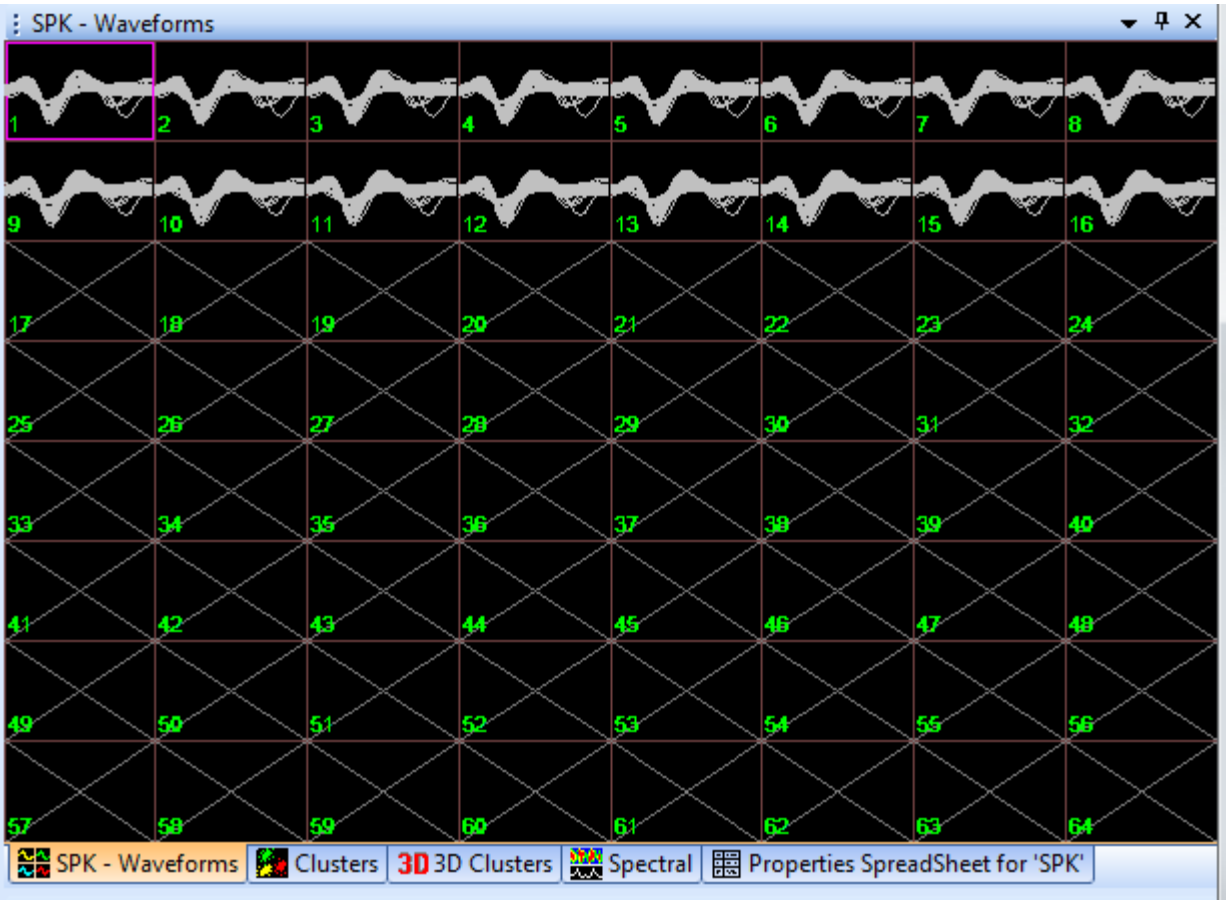
The choice of auto-sorting algorithm and the appropriate value for the DOF multiplier or the Parzen radius is somewhat data-dependent. A description of these issues is beyond the scope of these release notes, but you should work with both methods and observe the effects of adjusting their respective tuning parameter in order to get a feel for the differences and tradeoffs between them. Note that you can use Plexon's Offline Sorter (OFS) as a convenient platform for gaining experience with the auto-sorting methods using your previously-recorded data files, as opposed to live data. Refer to the Offline Sorter (OFS) manual for additional information and references on valley seeking and TDEM.

Disabling unused DigiAmp boards to reduce channel counts

In previous releases, the only way to use fewer DigiAmp channels than were physically present in the hardware was to disable channels in the PlexControl properties spreadsheet:



	Name	PLX chan	Enabled	Threshold%	Num Units	Rec Spks	Rec WB	Rec SpkCont	Rec FP
>>1	SPK01	1	☑	-15.000	0	☑	☐	☐	☑
2	SPK02	2	☑	-15.000	0	☑	☐	☐	☑
3	SPK03	3	☑	-15.000	0	☑	☐	☐	☑
4	SPK04	4	☑	-15.000	0	☑	☐	☐	☑
5	SPK05	5	☑	-15.000	0	☑	☐	☐	☑
6	SPK06	6	☑	-15.000	0	☑	☐	☐	☑
7	SPK07	7	☑	-15.000	0	☑	☐	☐	☑
8	SPK08	8	☑	-15.000	0	☑	☐	☐	☑
9	SPK09	9	☑	-15.000	0	☑	☐	☐	☑
10	SPK10	10	☑	-15.000	0	☑	☐	☐	☑
11	SPK11	11	☑	-15.000	0	☑	☐	☐	☑
12	SPK12	12	☑	-15.000	0	☑	☐	☐	☑
13	SPK13	13	☑	-15.000	0	☑	☐	☐	☑
14	SPK14	14	☑	-15.000	0	☑	☐	☐	☑
15	SPK15	15	☑	-15.000	0	☑	☐	☐	☑
16	SPK16	16	☑	-15.000	0	☑	☐	☐	☑
17	SPK17	17	☐	-15.000	0	☑	☐	☐	☑
18	SPK18	18	☐	-15.000	0	☑	☐	☐	☑
19	SPK19	19	☐	-15.000	0	☑	☐	☐	☑
20	SPK20	20	☐	-15.000	0	☑	☐	☐	☑
21	SPK21	21	☐	-15.000	0	☑	☐	☐	☑
22	SPK22	22	☐	-15.000	0	☑	☐	☐	☑
23	SPK23	23	☐	-15.000	0	☑	☐	☐	☑



Release 1.11 provides an additional method for disabling channels, such that entire DigiAmp boards (64 channels per board for the "big" DigiAmp, 16 channels per board for the Mini DigiAmp) can be disabled and entirely removed from the user interface. In order to do so, simply specify the desired number of channels in the Topology Wizard in OmniPlex Server. For example, if you have a Mini DigiAmp with 64 channels (four 16 channel boards), you can specify a configuration with 16, 32, 48, or 64 channels in the Topology Wizard. Likewise, if you have a "big" DigiAmp with 256 channels, you can specify a configuration with 64, 128, 192, or 256 channels. Using this method, you will not see "X'ed out" disabled channels in PlexControl, as is the case when you disable channels individually (as shown above); instead, the system will simply behave as if the DigiAmp box contains fewer boards

.

You can combine the two methods. For example, with a 128 channel "big" DigiAmp, you could use the Topology Wizard to create a 64 channel (one board) topology, and then in PlexControl manually disable any number of individual channels within those 64 channels. Keep in mind that although you can in effect run the system as different-sized configurations by creating or loading an appropriate pxs file, any pxc file that you save in PlexControl must be used with a pxs file that supports the same number of channels, just as if that were the actual hardware configuration. For example, if you have a 256 channel DigiAmp but create a 128 channel pxs topology for it, that 128 channel configuration will only be compatible with 128 channel pxc files.

Refer to the main User Guide for a step-by-step description of how to use the Topology Wizard to define and save a system configuration.

Performance improvements

Several existing functions operate significantly faster in release 1.11. These include auto-thresholding, the initial calculation of the PCA projections (and manual PCA recalculation using the PCA button), and Delete All Units on All Channels. These performance improvements will be especially noticeable at high channel counts

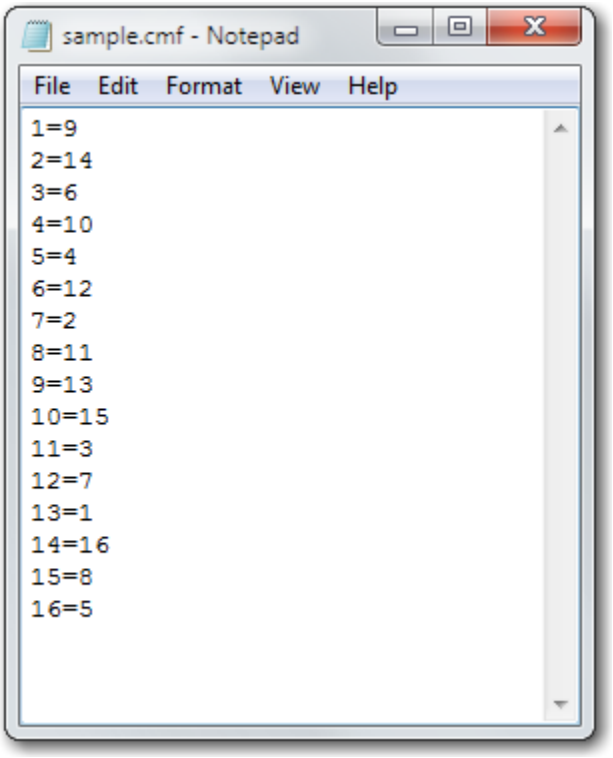
Channel mapping

Channel mapping allows users of electrodes with nonstandard or inconvenient physical channel numbering, e.g. silicon probes, to map (renumber) the channels, such that the original physical channel numbering is hidden from OmniPlex, without the use of custom adaptors or cables which were previously required. Note that currently only neural channels can be mapped; channels such as digital input and auxiliary analog (AuxAI) channels are not affected by channel mapping in any way.

OmniPlex channel mapping supports an arbitrary one-to-one mapping (renumbering) of electrode channels (also referred to as input channels) and OmniPlex channels (also referred to as output channels). Each input channel must map to exactly one output channel, and vice versa. A channel mapping is specified by loading a cmf file (channel mapping file) in OmniPlex Server. Once a cmf is loaded, it remains in effect until it is either manually disabled, a different pxs (topology) file is loaded or created in Server, or Server is started without a pxs file. You must close PlexControl before loading a new channel mapping file or disabling channel mapping in Server.

Creating a cmf file

A cmf file is a simple text file which you can create using Windows Notepad or any other text editor which can create plain text files. After creating the file in an editor, renaming the file extension from .txt to .cmf will make OmniPlex recognize it as a channel mapping file. Here is an example of a typical cmf file:



This cmf is for a 16 channel system, so all channel numbers in the file are within the range 1-16. Each line in this example specifies the mapping of one channel. The channel number on the left side of the = sign is the OmniPlex channel number as seen in PlexControl, in recording files, clients, etc. The channel number on the right side of the = sign is the original physical electrode channel number. In other words, the mapping commands are of the form:

outputchannelnumber = inputchannelnumber

or to put it another way:

visiblechannelnumber = hiddenchannelnumber

For example, say that the original electrode device was a 1D linear array probe, and the actual physical electrode channel numbers, starting from the tip of the probe, were the following:

[probe tip] 9, 14, 6, 10, 4, 12, 2, 11, 13, 15, 3, 7, 1, 16, 8, 5 [probe top]

but what you would like to see in OmniPlex is a convenient list of uniform, increasing channel numbers like this:

[probe tip 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 [probe top]

the above cmf file will accomplish this channel renumbering. In actual use, you will need to consult the documentation for your electrodes, or contact the manufacturer, to determine the electrode channel numbering, i.e. the device pinout. In a case such as the 1D probe example above, it may be obvious what the most useful channel mapping is; in other cases, where the electrodes are arranged in a complex geometry, an appropriate mapping may be a matter of preference, or there may be considerations unique to your experiment or data analysis. For example, if you are using a probe with multiple tetrode sites along a shank, you should assign consecutive channel numbers to the four channels within each tetrode, such that the tetrodes appear in OmniPlex as channels 1-4, 5-8, etc.

In many cases, a cmf file similar to the one above will be all that is necessary to define the desired mapping. However, the cmf file supports additional functionality that can make the definition of certain types of mappings easier. If you like, you can skip to the section "Loading a cmf file in OmniPlex" on a first reading, and read about the additional features later.

Default mapping

In the above example, we explicitly specified the mapping for every single channel. This was because, as in many real-world cases, every channel on the device has to be renumbered. However, imagine that we have a probe or array where only the first eight channels have "inconvenient" physical channel numbers, and the last eight channels are numbered 9 through 16 as with a "normal" set of electrodes. The corresponding cmf might look something like this:

```
1=7
2=5
3=6
4=2
5=7
6=3
7=1
8=4
9=9
10=10
11=11
12=12
13=13
14=14
15=15
16=16
```

In other words, the last eight channels are to retain their original channel numbers. In a case like this, you need only list the channels that require actual mapping; all other channels are assumed to be unchanged:

```
1=7
2=5
3=6
4=2
5=7
6=3
7=1
8=4
```

Range mapping

In some cases, you may wish to renumber contiguous blocks of channel numbers, which can be done with a *range mapping:*

```
1..4=9..12
5..8=13..16
9..12=1..4
13..16=5..8
```

The notation 1..4 means channels 1 through 4, and likewise for the other channel ranges shown. For example, the range mapping 1..4=9..12 has the same effect as the following series of mapping commands:

```
1=9
2=10
3=11
4=12
```

You can see that the above cmf commands are in effect permuting four-channel blocks within a total of 16 channels. Swapping the first 32 channels and the last 32 channels in a 64 channel system could be done with these mappings:

```
1..32=33..64
33..64=1..32
```

Note that you can use a combination of single-channel and range mappings within the same cmf file; for example:

```
1..4=9..12
5=7
6=5
7=8
8=6
9..12=1..4
13=16
14=13
15=14
16=15
```

Formatting and comments

When OmniPlex reads a cmf file, it ignores all spaces within each line of the file, so that the following commands are all equivalent:

```
1..32=33..64

1..32 = 33..64

1 .. 32 = 33 .. 64

1 . . 3 2 = 3 3 . . 6 4
```

You can insert a comment line by using either ";" as the first character of a line, or "//" as the first two characters. Blank lines are also allowed. For example:

```
; Mapping file for MySiliconProbe
; July 19, 2013

// the next two lines are range mappings
1..4 = 9..12
9..12 = 1..4


// these are single-channel mappings
5=7
6=5
7=8
8=6
13=16
14=13
15=14
16=15
```

However, note that you cannot currently put a comment on the same line as a mapping command:

```
1..4 = 9..12 // this comment is illegal
```

Overwriting mappings and strict mode

By default, OmniPlex allows you to specify mapping commands in any order, as long as the final result maps every input channel to one and only one output channel. This can include sequences of mapping commands that overwrite, or partially overwrite, a previous mapping, for example:

```
1..32=33..64
33..64=1..32
10=10
20=20
```

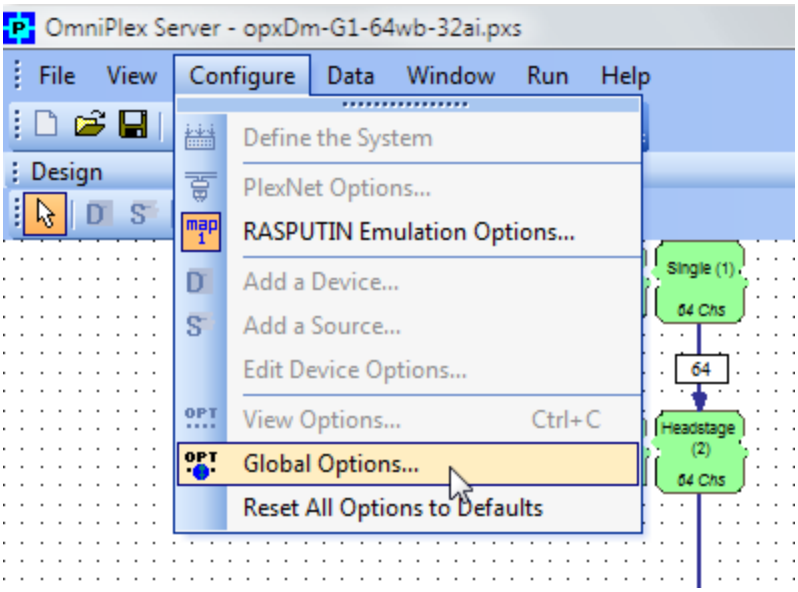
The net effect will be to swap the first 32 and last 32 channels, *except* for channels 10 and 20, which will not be mapped. This is easier than writing out a full sequence of 64 single-channel mapping commands. However, in cases where you do not need to use overwriting, you may wish to disable it, to enable OmniPlex to detect cases where an error in your cmf file results in a mapping command which unintentionally overwrites another mapping. If you add a line with the special keyword "strict" before any other mapping command in the cmf, OmniPlex will disable support for overwriting and will report an error

when a mapping command attempts to overwrite a previous mapping.

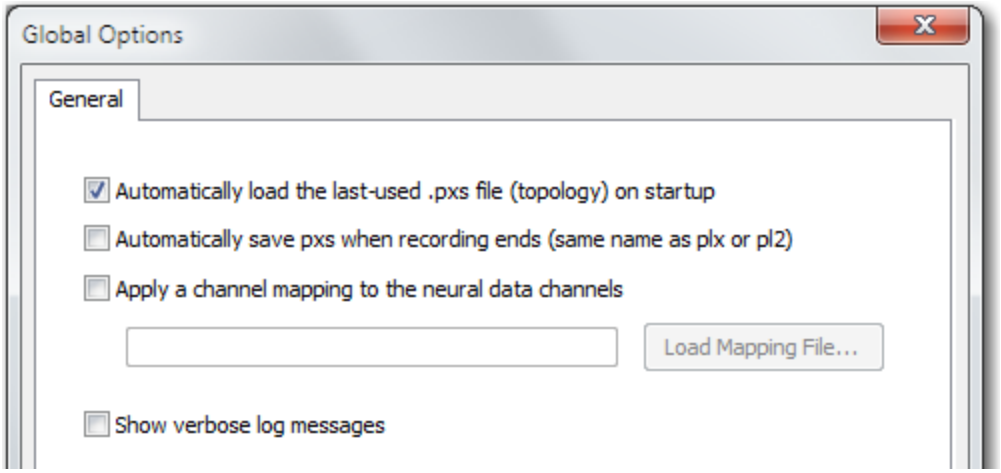
```
strict
1..32=33..64
33..64=1..32
// the next two lines will give errors when the cmf is loaded
// since they overwrite the mapping of channels 10 and 20
10=10
20=20
```

Loading a cmf file in OmniPlex

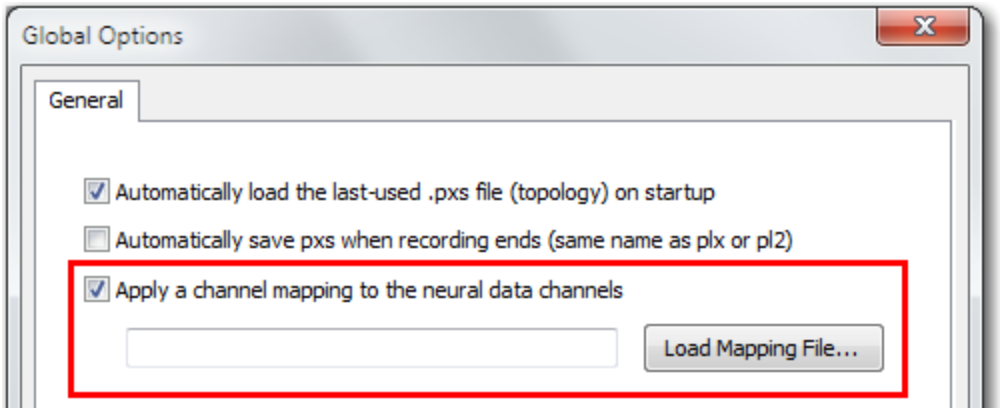
Once you have defined a channel mapping in a cmf file, loading the file in OmniPlex Server puts the mapping into effect. To load a channel mapping file, first close PlexControl, if it is open. Next, go to Configure >> Global Options:

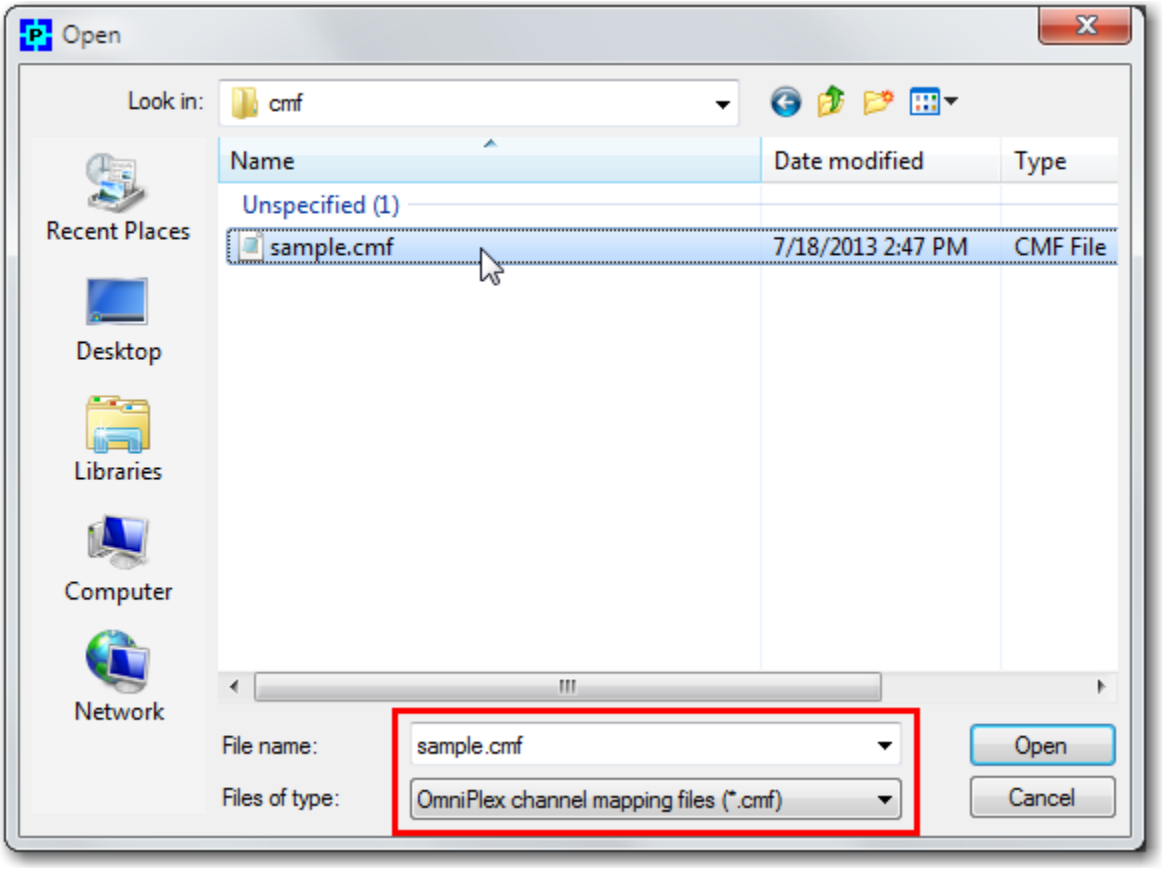


The Global Options dialog is displayed:

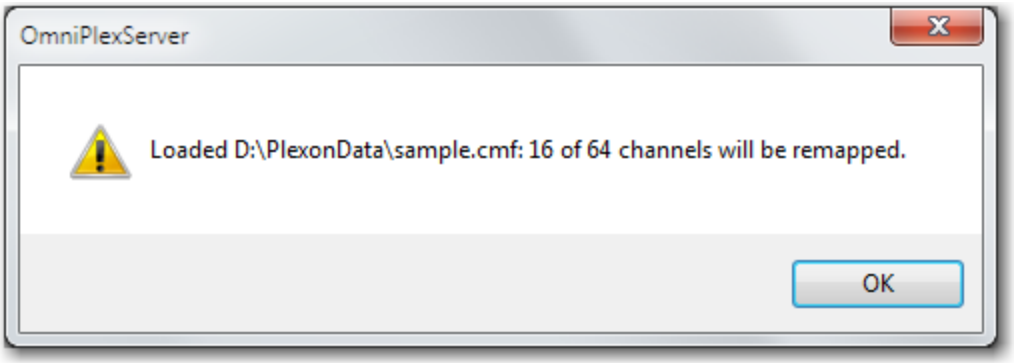


To enable channel mapping, click *Apply a channel mapping to the neural data channels* and then click the *Load Mapping File* button to specify the desired cmf file:

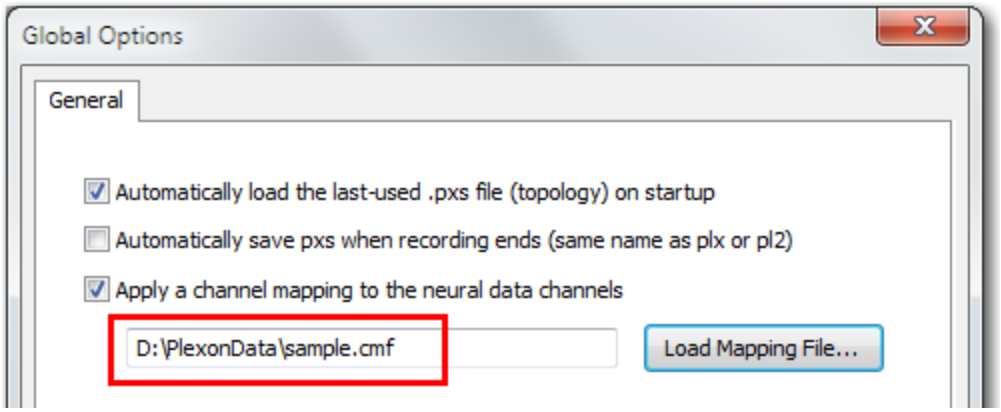




You should see a confirmation that the cmf was loaded successfully:

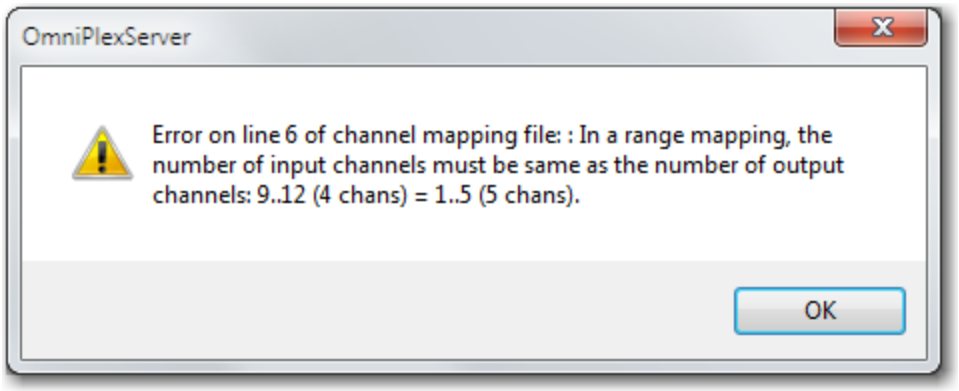


In the above example, 16 of 64 channels will be mapped (renumbered), while the other 48 will not be affected.



The channel mapping is now in effect and the original physical electrode channel numbers are no longer used in the OmniPlex user interface, in recorded data files, or in online client data. As far as an OmniPlex user is concerned, the original channel numbering is completely hidden. If for any reason you later need to identify which physical input channel corresponds to a given OmniPlex channel, for example when analyzing your data, you can refer to the cmf file as a record of the mapping that was in effect.

If any errors are detected when the cmf file is read by OmniPlex, an error message is displayed, such as:

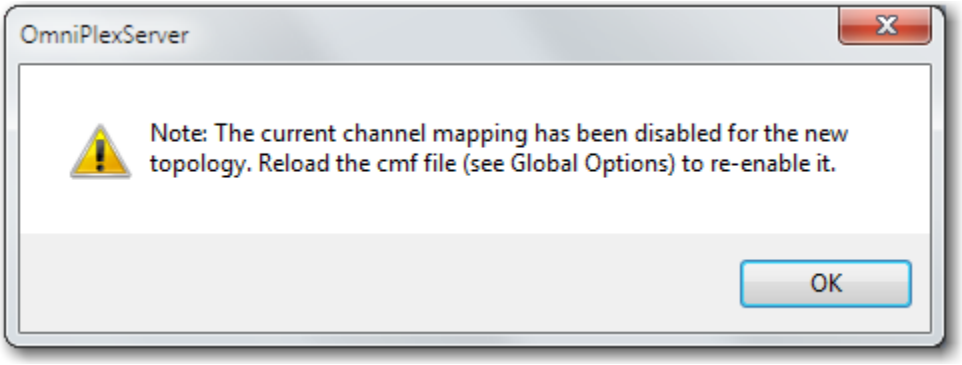


When an error is detected, OmniPlex automatically temporarily disables channel mapping, to prevent an invalid mapping from being applied. After correcting the error in the cmf (by editing the file in Notepad, etc), you will need to re-enable channel mapping and load the file again.

Once a cmf has been loaded without error, OmniPlex Server will automatically load the mapping file every time it starts, until you do one of the following:

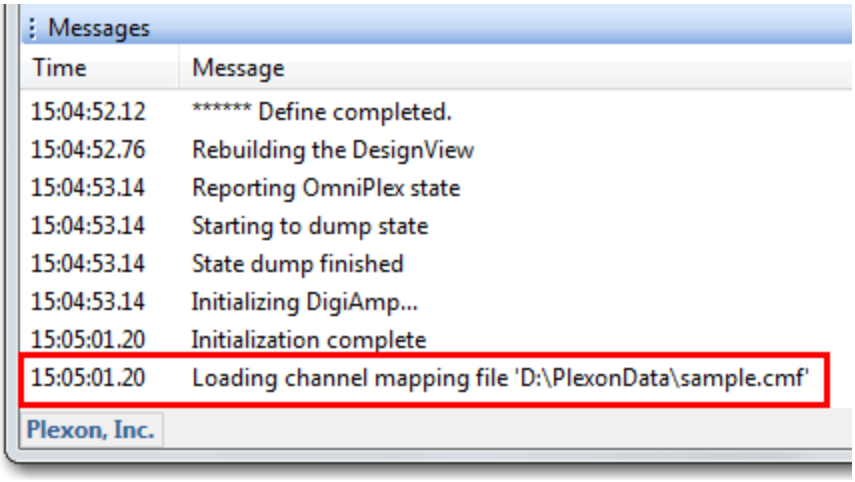
- Manually disable channel mapping in the Global Options dialog
- Load a different pxs file (topology) in Server
- Use the Topology Wizard to generate a new topology
- Start Server without auto-loading a pxs file, for example by holding down the CTRL key while launching Server

If OmniPlex automatically disables a channel mapping that was previously in effect, a warning message is displayed, for example:



Channel mapping can also be automatically disabled if Server attempts to auto-load a cmf on startup but the file has been deleted or corrupted since it was last loaded.

You can easily confirm the channel mapping file that was auto-loaded by viewing Server's Messages window as it starts up:



To change the mapping, simply display the Global Options dialog and follow the procedure previously described. Note that you must stop data acquisition and close PlexControl before loading a new channel mapping file or manually disabling channel mapping.

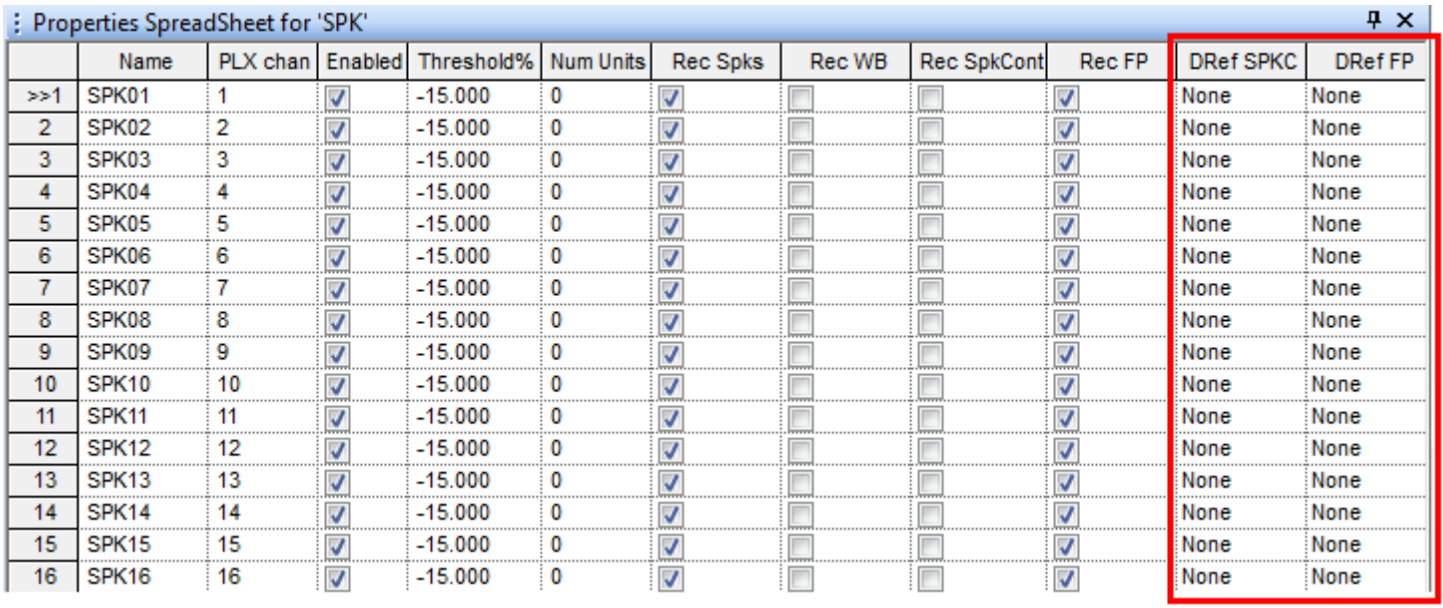
Digital referencing

Overview

Digital referencing can be configured on a per-channel basis for continuous spike (SPKC) channels and/or field potential (FP) channels. For either source, the referencing (digital subtraction of sample values) is performed immediately before the filtering operation, and consequently for the FP source, before the post-lowpass downsampling. In effect, two separate copies of the original wideband (WB) signal are subjected to independent referencing before being passed to the spike separator and FP separator. This insures that there is no unwanted interaction between the referencing operation and the chosen filters, and that it is perfomed at the full 40 kHz wideband sampling rate for maximum precision.

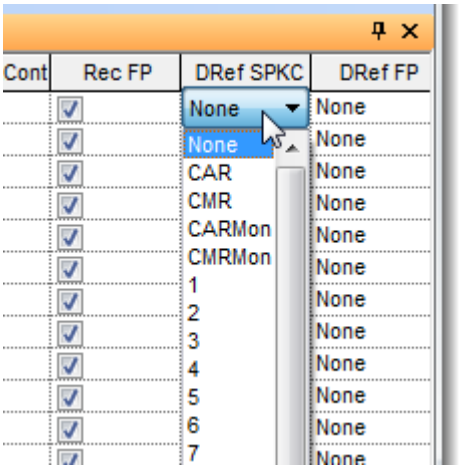
Configuring referencing in PlexControl

Digital referencing is controlled via the multichannel properties spreadsheet in PlexControl. The two columns "DRef SPKC" and "DRef FP" display the digital reference settings for each channel of the SPKC and FP sources:



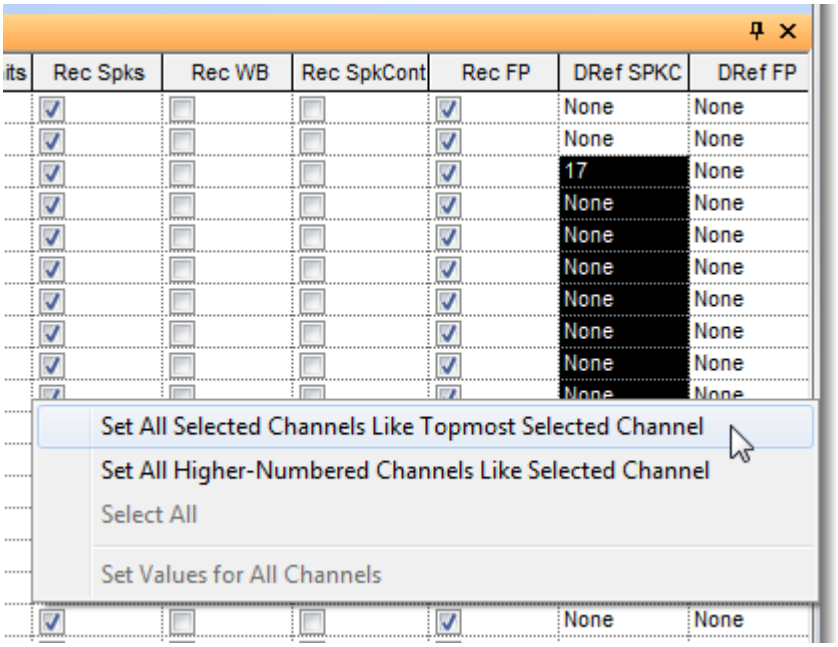
	Name	PLX chan	Enabled	Threshold%	Num Units	Rec Spks	Rec WB	Rec SpkCont	Rec FP	DRef SPKC	DRef FP
>>1	SPK01	1	☑	-15.000	0	☑	☐	☐	☑	None	None
2	SPK02	2	☑	-15.000	0	☑	☐	☐	☑	None	None
3	SPK03	3	☑	-15.000	0	☑	☐	☐	☑	None	None
4	SPK04	4	☑	-15.000	0	☑	☐	☐	☑	None	None
5	SPK05	5	☑	-15.000	0	☑	☐	☐	☑	None	None
6	SPK06	6	☑	-15.000	0	☑	☐	☐	☑	None	None
7	SPK07	7	☑	-15.000	0	☑	☐	☐	☑	None	None
8	SPK08	8	☑	-15.000	0	☑	☐	☐	☑	None	None
9	SPK09	9	☑	-15.000	0	☑	☐	☐	☑	None	None
10	SPK10	10	☑	-15.000	0	☑	☐	☐	☑	None	None
11	SPK11	11	☑	-15.000	0	☑	☐	☐	☑	None	None
12	SPK12	12	☑	-15.000	0	☑	☐	☐	☑	None	None
13	SPK13	13	☑	-15.000	0	☑	☐	☐	☑	None	None
14	SPK14	14	☑	-15.000	0	☑	☐	☐	☑	None	None
15	SPK15	15	☑	-15.000	0	☑	☐	☐	☑	None	None
16	SPK16	16	☑	-15.000	0	☑	☐	☐	☑	None	None

Determine which channel you wish to use as a reference, typically by selecting a channel where unwanted artifacts are clearly present but very few spikes are seen. Select this channel number in the DRef column(s) in the rows corresponding to the channels which are to use this reference. Clicking on a cell displays a drop-down list of the available reference options (the CAR and CMR options will be described later):

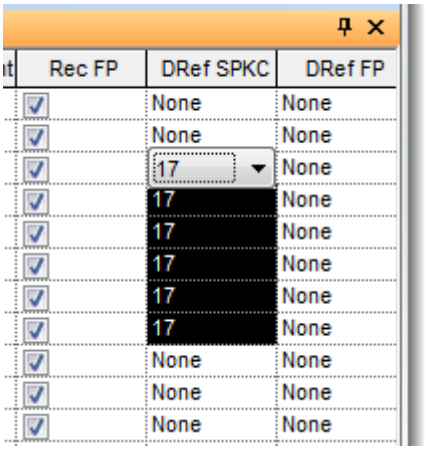


Note that unlike OPX-A analog referencing, the number is not a "reference number," but the number of the actual channel (within the same source) which is to be used as a reference for the selected channel.

Remember that you can use the right-button menu functions to quickly set a series of channels to the same reference channel. For example, to set five successive channels to all use channel 17 as their reference, set the topmost to channel 17, then drag-select the channels below it and use Set All Selected Channels Like Topmost Selected Channel.



The selected channels are all set the same reference channel as the topmost channel:



The default reference setting of None indicates that no referencing is to be performed on that channel.

There a few simple rules to keep in mind. You cannot reference a channel against itself; there is no valid reason to do so (the result is guaranteed to be exactly zero, since the subtraction is in the digital domain), and you will usually want to be able to monitor the reference signal. If you use one of the right-button functions to set a group of channels to the same reference, and the reference channel is within the range of channels, it will be automatically skipped and its reference set to None, to prevent self-referencing. Also, a channel which is being used as a reference *for* other channels cannot itself be referenced *to*

another channel - its reference must be set to None.

References within the FP source are assigned in exactly the same way as for SPKC channels. However, you should be cautious when referencing FP channels, since in many cases the field potentials can be attenuated by referencing, due to the same signal being picked up by more than one electrode.

You should use the SPKC and FP displays to monitor the effects of referencing, to verify that artifacts are being reduced or removed, while not harming the signals of interest.

Note that no matter what referencing you apply to SPKC and/or FP channels, the wideband (WB) channels are unaffected. By recording the wideband channels, you can insure that you have a record of the original signal, including artifacts, which you can later compare against the results of referencing, possibly apply offline referencing to, etc.

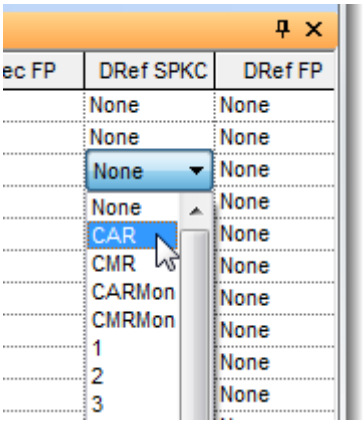
OPX-A users can continue to use the analog referencing in the preamp (via the Referencing tab in PlexControl, as usual) and/or digital referencing; the two methods are completely independent. In situations where very high amplitude artifacts would otherwise cause clipping of the A/D converters, it may be preferable to use analog referencing.

Common average referencing (CAR) and common median referencing (CMR)

In addition to standard referencing, where signals are subtracted pairwise (i.e. channel *j* is subtracted from channel *k*) in either the analog domain or digitally, OmniPlex supports two newer methods of referencing which combine multiple channels to form a composite reference signal which is then subtracted to remove or reduce unwanted components.

The basic idea of both CAR and CMR is that if many signal channels are averaged together, the averaged signal being the result of averaging corresponding sample values across channels, then artifact signals that are the same across all channels (such as AC power line noise) will "survive the averaging" in the reference signal, whereas components unique to each channel, such as spikes, will tend to "cancel out" and have a mean near zero. The difference between CAR and CMR is that with CAR, the mean of sample values at each sample time is used as the reference signal, whereas with CMR, the median is used. In many cases, CMR will give results that are more robust in the presence of amplitude outliers, i.e. it will produce a better reference signal. However, the choice of standard digital referencings versus CAR versus CMR is data-dependent and should be evaluated on a case by case basis.

To select a channel for CAR (or CMR), select CAR (or CMR) from the channel's drop-down list in the properties spreadsheet:



You can select any number of channels to be included in CAR and/or CMR, although it is recommended that for best results, you use only one or the other method, and include as many channels as is practical, in order to achieve a good average or median reference signal. Note than unlike conventional referencing, the channels that are selected for CAR or CMR are both used to form the reference signal, and this signal is then subtracted from all the selected channels.

Since the common average or common median will be subtracted from all CAR/CMR channels, OmniPlex provides a facility for monitoring and recording the CAR/CMR composite reference signal. If you designate a channel's reference as CARMon or CMRMon, that channel's original signal will be replaced by the actual CAR/CMR signal which is being subtracted from the channels whose reference is CAR or CMR respectively. For example, you can locate a channel which is otherwise unusable (e.g. due to a bad electrode) and designate it as the CARMon or CMRMon channel; the common average and common median reference signals can then be viewed in the SPKC or FP display, and recorded if desired. Alternately, you could use a standard procedure such as always allocating the last channel in SPKC/FP as the CAR/CMR monitor channel. Here is a "kitchen sink" example which should give some idea of the flexibility of this scheme; in practice, you would be unlikely to need such a complex set of references in a system with only 32 channels.

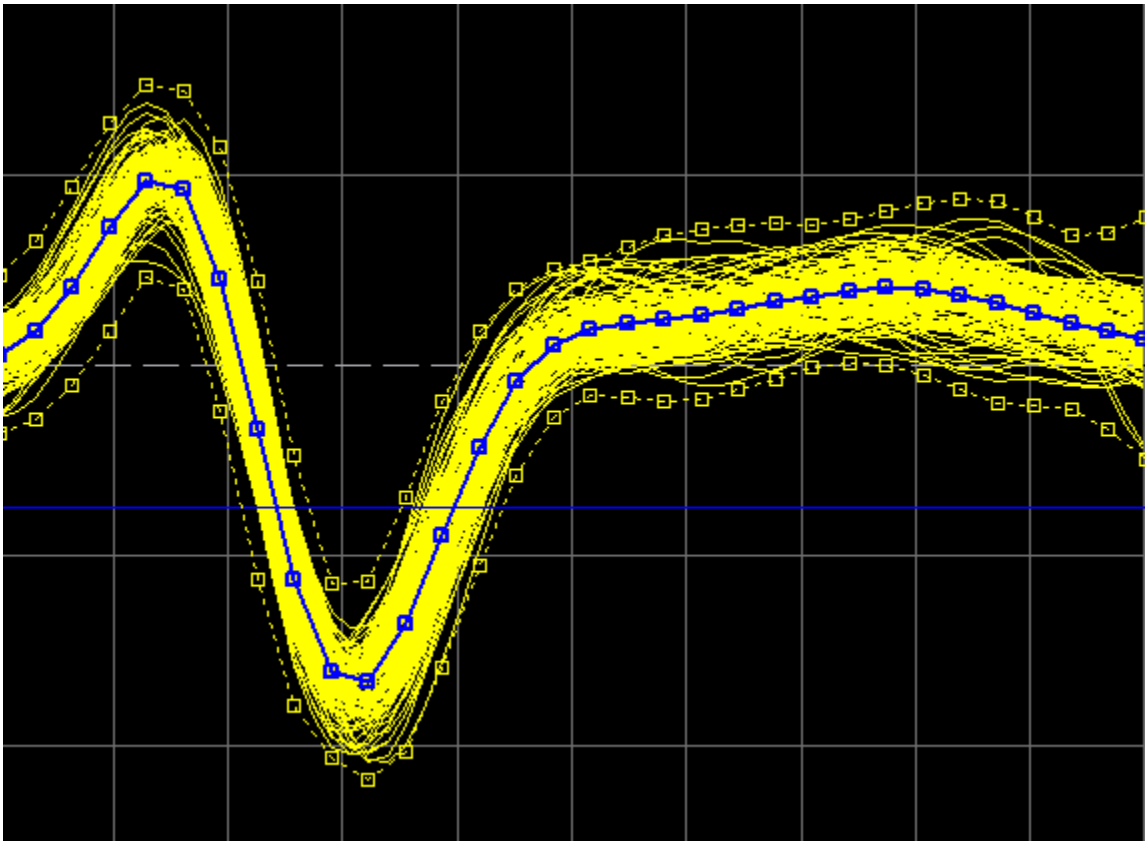
Properties SpreadSheet for 'SPK'

	PLX chan	Enabled	Threshold%	Num Units	Rec Spks	Rec WB	Rec SpkCont	Rec FP	DRef SPKC	DRef FP
>>1	1	☑	-15.000	0	☑	☐	☑	☑	4	CAR
2	2	☑	-15.000	0	☑	☐	☑	☑	4	7
3	3	☑	-15.000	0	☑	☐	☑	☑	CMR	None
4	4	☑	-15.000	0	☑	☐	☑	☑	None	3
5	5	☑	-15.000	0	☑	☐	☑	☑	CMR	7
6	6	☑	-15.000	0	☑	☐	☑	☑	4	7
7	7	☑	-15.000	0	☑	☐	☑	☑	4	None
8	8	☑	-15.000	0	☑	☐	☑	☑	4	7
9	9	☑	-15.000	0	☑	☐	☑	☑	4	7
10	10	☑	-15.000	0	☑	☐	☑	☑	CMR	CAR
11	11	☑	-15.000	0	☑	☐	☑	☑	CMR	CAR
12	12	☑	-15.000	0	☑	☐	☑	☑	CMR	CAR
13	13	☑	-15.000	0	☑	☐	☑	☑	CMRMon	CAR
14	14	☑	-15.000	0	☑	☐	☑	☑	CMR	7
15	15	☑	-15.000	0	☑	☐	☑	☑	CMR	7
16	16	☑	-15.000	0	☑	☐	☑	☑	CMR	CAR
17	17	☑	-15.000	0	☑	☐	☑	☑	CMR	3
18	18	☑	-15.000	0	☑	☐	☑	☑	4	CAR
19	19	☑	-15.000	0	☑	☐	☑	☑	4	CAR
20	20	☑	-15.000	0	☑	☐	☑	☑	CMR	CAR
21	21	☑	-15.000	0	☑	☐	☑	☑	CMR	7
22	22	☑	-15.000	0	☑	☐	☑	☑	CMR	CARMon
23	23	☑	-15.000	0	☑	☐	☑	☑	CMR	CAR
24	24	☑	-15.000	0	☑	☐	☑	☑	4	CAR
25	25	☑	-15.000	0	☑	☐	☑	☑	CMR	CAR
26	26	☑	-15.000	0	☑	☐	☑	☑	CMR	CAR
27	27	☑	-15.000	0	☑	☐	☑	☑	CMR	7
28	28	☑	-15.000	0	☑	☐	☑	☑	CMR	3
29	29	☑	-15.000	0	☑	☐	☑	☑	CMR	3
30	30	☑	-15.000	0	☑	☐	☑	☑	CMR	CAR
31	31	☑	-15.000	0	☑	☐	☑	☑	CMR	CAR
32	32	☑	-15.000	0	☑	☐	☑	☑	4	CAR

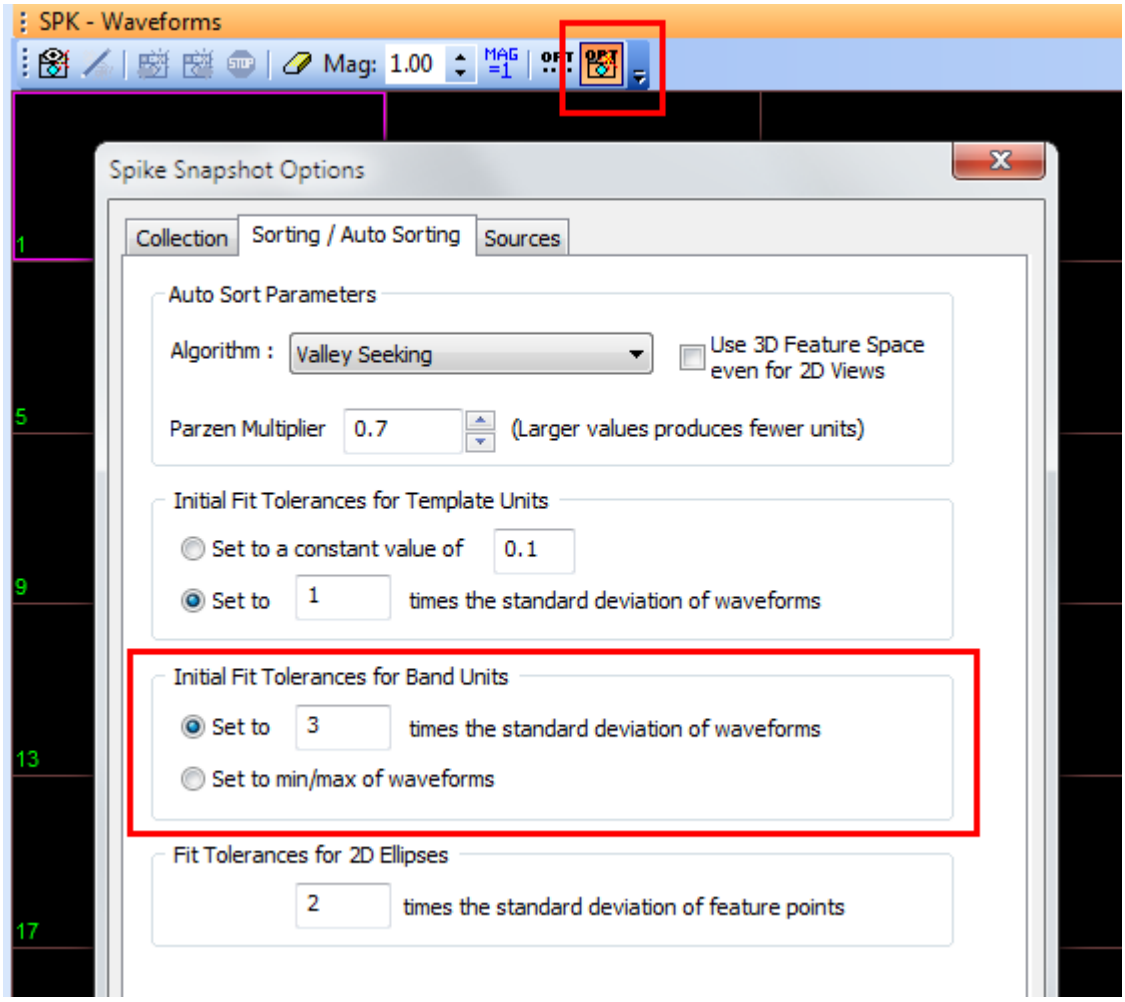
Note that each non-CAR/CMR channel which is being used as a reference (SPKC channel 4 and FP channels 3 and 7) has its own reference set to None, as required.

Specifying fit method and tolerance for band sorting

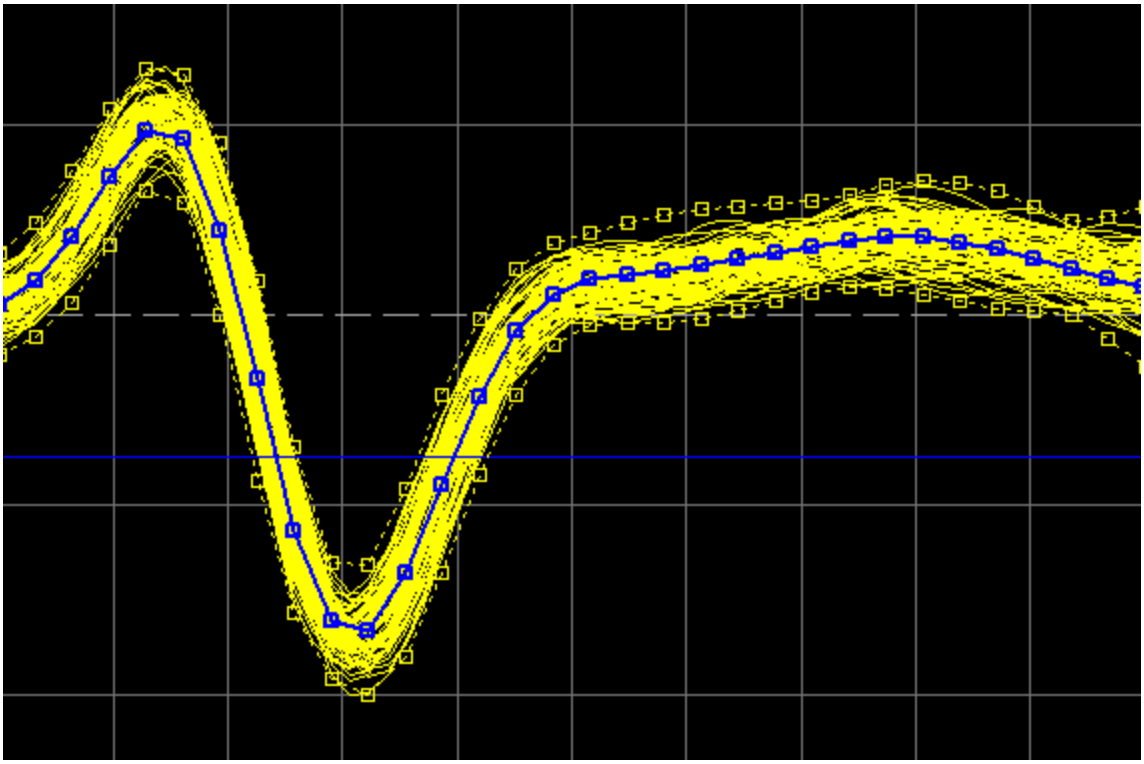
When defining sorted units for band sorting, whether by manually selecting waveforms or by auto-sorting, previous versions of OmniPlex used the following algorithm to determine the band points from a given set of spikes. First, the mean waveform of the set of waveforms is calculated, and used as the center of the band (i.e., the template). Then at each sample point of the mean waveform, the standard deviation of the corresponding points in the set of waveforms is calculated, and the band is defined as extending three sigmas on either side of the mean, symmetrically in Y (amplitude). Here is an example, using the default three sigma fit tolerance:



In version 1.10, it is possible to specify the band tolerance value in sigmas, or to select an alternate method for determining the band points, using the spike snapshot options dialog:

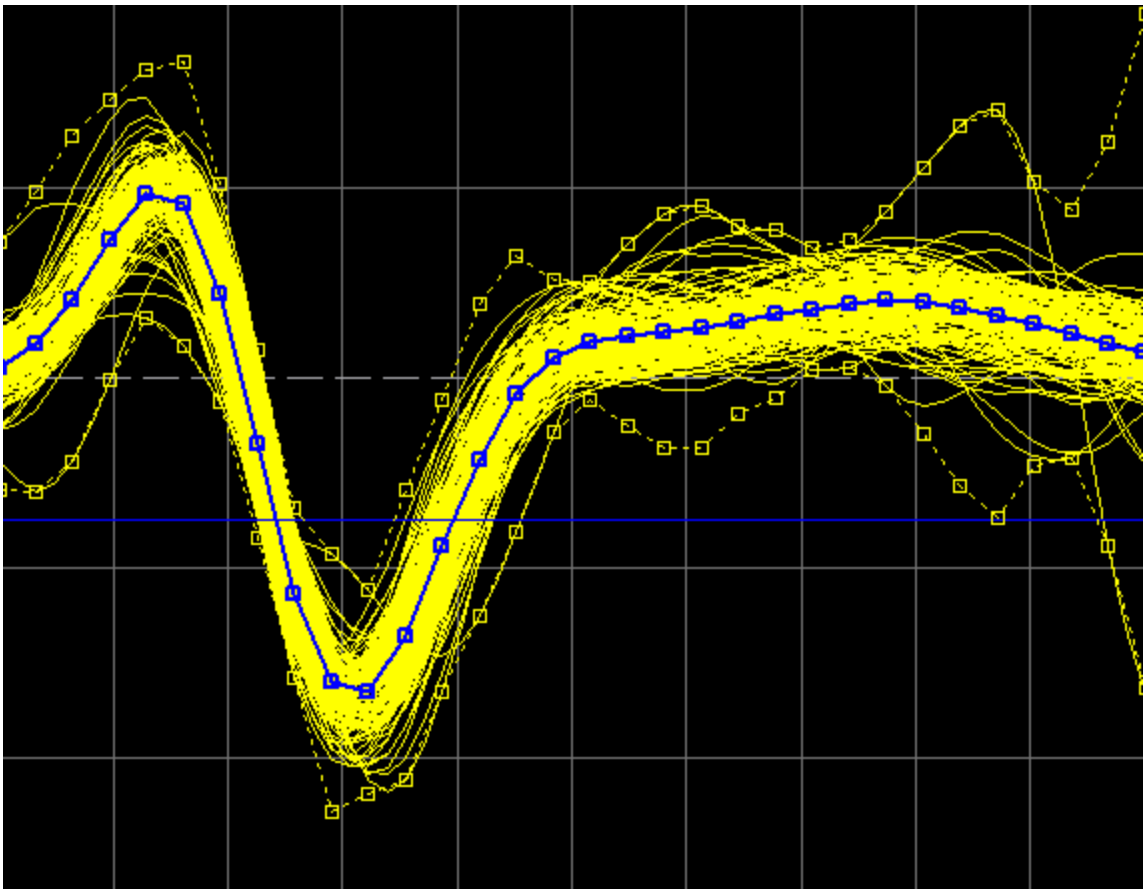


Here is the same example, but using a tighter band tolerance of two sigmas:



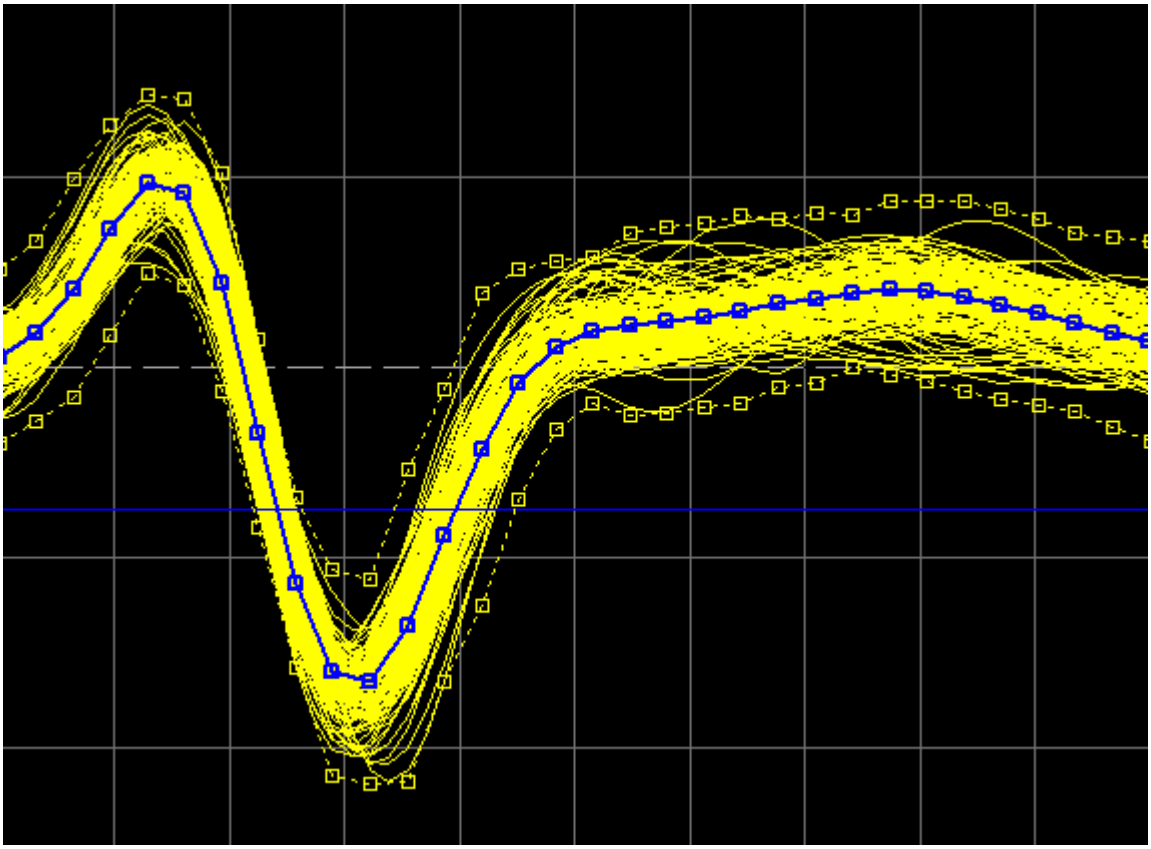
Changing the band tolerance value only affects subsequently defined units; any units that have already been defined will not be altered.

The second option, "Set to min/max of waveforms," does not use the pointwise standard deviation to define the band; rather the band width at each point is calculated as the maximum absolute difference between that point on the mean waveform, and the corresponding point on the selected waveforms. This guarantees that the resulting band will include (i.e. sort) every waveform that was used to create it, whereas the sigma-based band definition may create a band which excludes (does not sort) waveforms which were selected but which have one or more outlier samples. However, the tradeoff is that the band can be unduly influenced and distorted by outliers caused by spike superpositions, noise, etc.

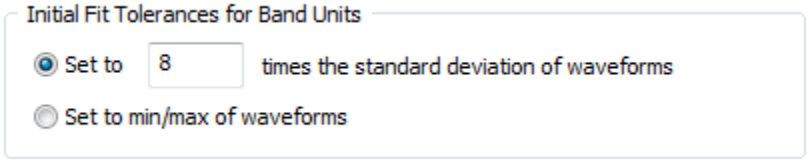


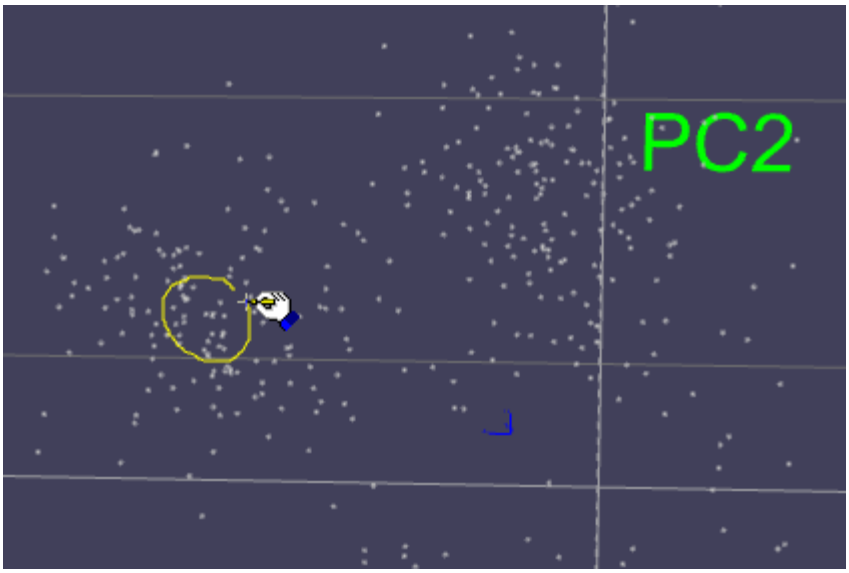
Note that, because the band is of equal width both above and below the template, an outlier point on one side of the band results in the band width being increased on *both* sides of the template. In other words, when using the min/max definition, the band is guaranteed to exactly coincide with a waveform point on at least one side of the template, but not necessarily both.

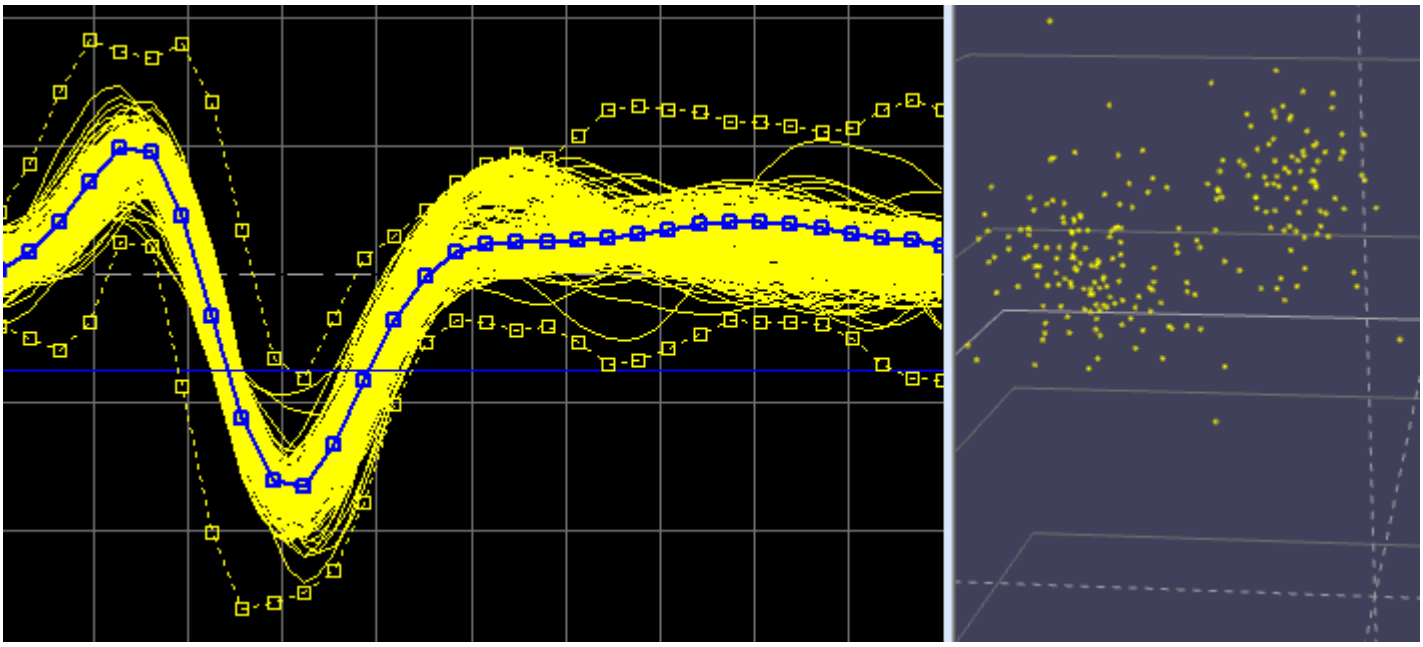
Once the initial band has been defined, you are free to edit the points on the band to remove or smooth any unwanted fluctuations. Here is the above example after manually editing the band points:



Which band definition method to use, what sigma value to use, and whether to manually post-edit the resulting band, depends upon your data (i.e. noise level, unit waveform variability), working preferences, and channel count (i.e. manual band editing is not practical at high channel counts). The defaults give the best results in many cases, but it can be instructive to define band units either by crossing waveforms, or by drawing contours around 2D and 3D PCA clusters, and observing how the resulting bands vary depending upon which band definition method is selected, and the tolerance values in sigmas for the sigma-based method. As a somewhat extreme example, if you draw a contour around only the innermost part of a large PCA cluster, but have the fit tolerance set to eight sigmas, the resulting band will probably include all the points in the cluster, and possibly even waveforms in nearby clusters:

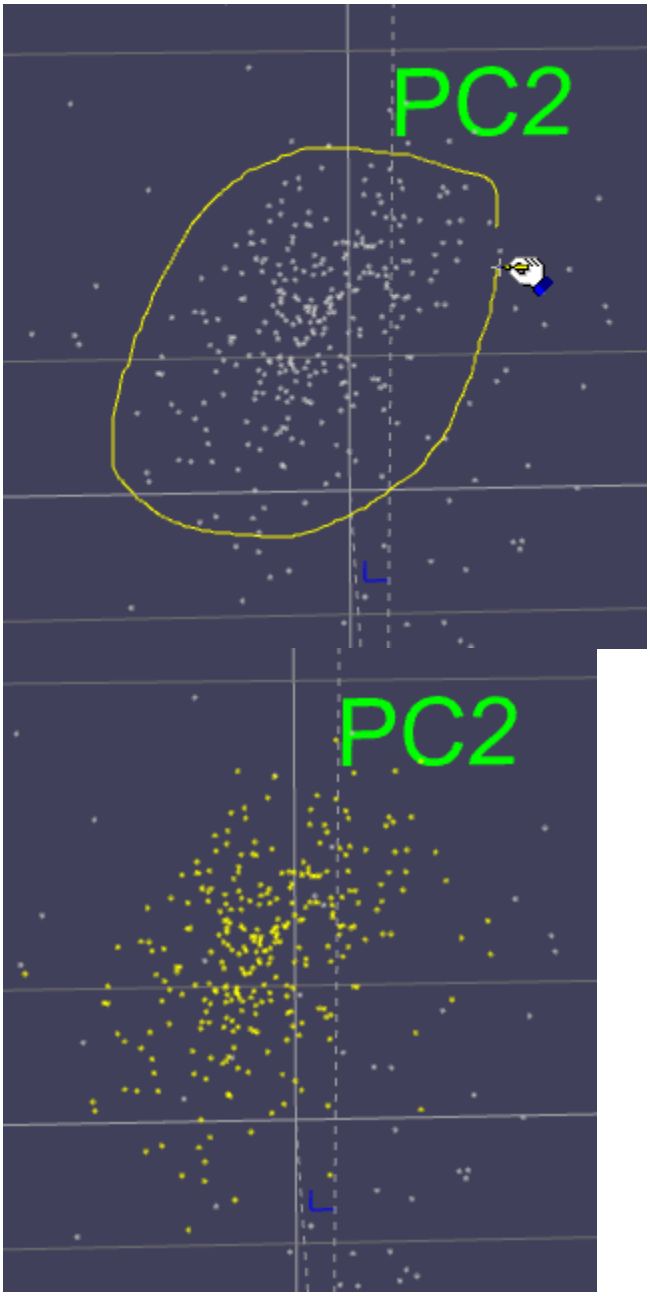



PC2

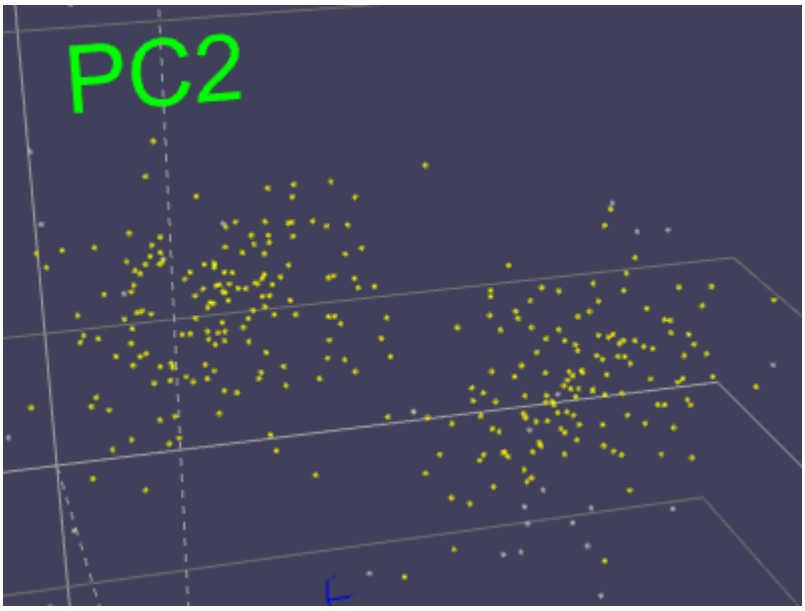


Remove waveforms from snapshot

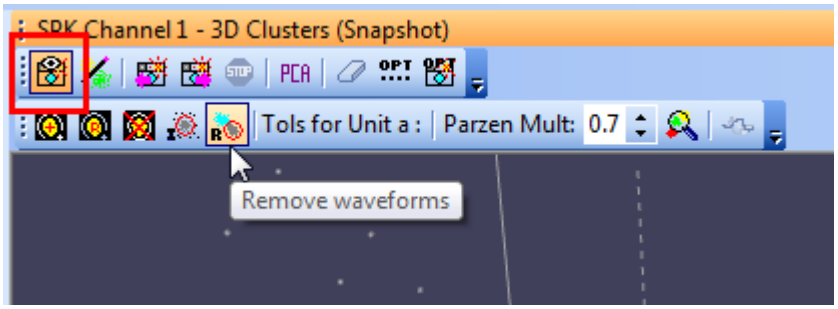
After having selected a set of waveforms for a unit definition, whether by crossing waveforms or by circling a 2D or 3D PCA cluster, you will sometimes find that you have selected waveforms which did cross the selection line, or which were inside the selection contour, but which you did not intend to include. One common case is in the 3D PCA cluster view, where you may find that a drawn contour includes PCA points from a cluster which was behind the cluster you were trying to select. For example, the following appears to be a valid 3D selection:



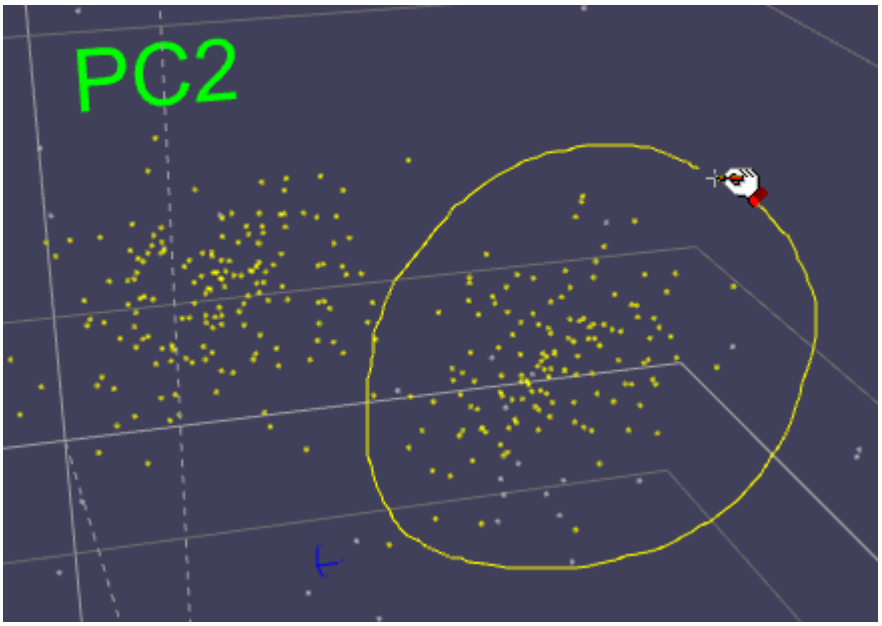
But upon rotating the 3D view, you may find that the selection was not what you intended:



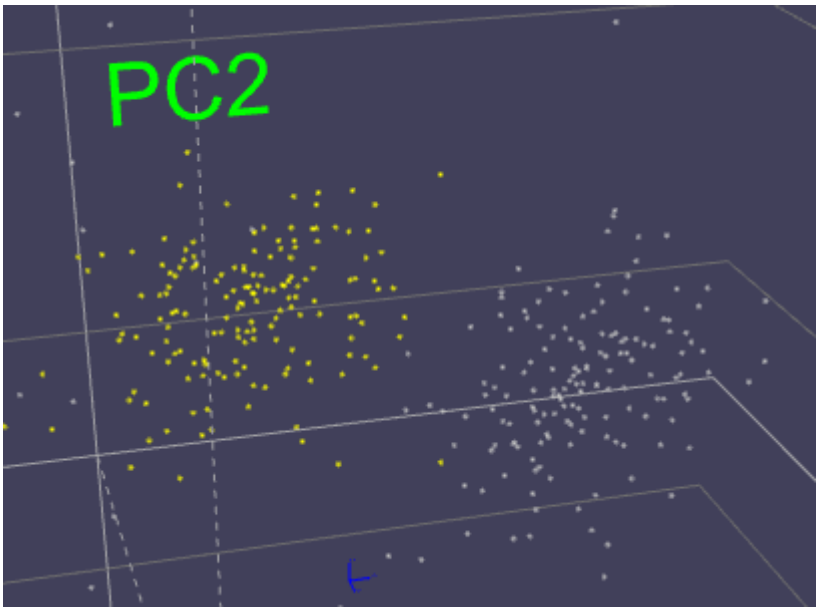
In this example, you could simply delete the unit and circle the two separate clusters; however, there are situations where it is not possible to "get a clean shot" at a cluster, i.e. to find a 3D viewing position such that a single contour encloses the desired cluster and *only* the desired cluster. In such cases, you can use the Remove Waveforms tool to remove waveforms from a unit's spike snapshot. To access the Remove Waveforms tool, you must be viewing the snapshot, not the live data, and be in unit editing mode.



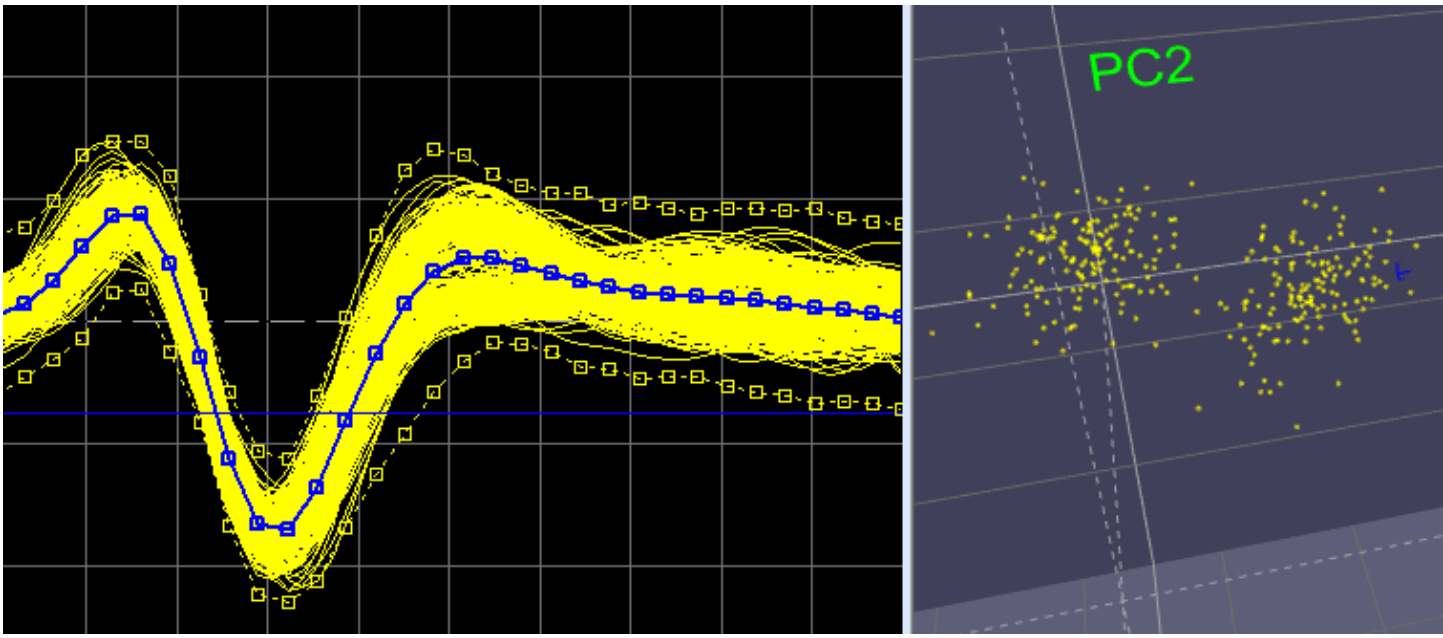
Draw a contour around the points which you wish to remove from the unit's definition:



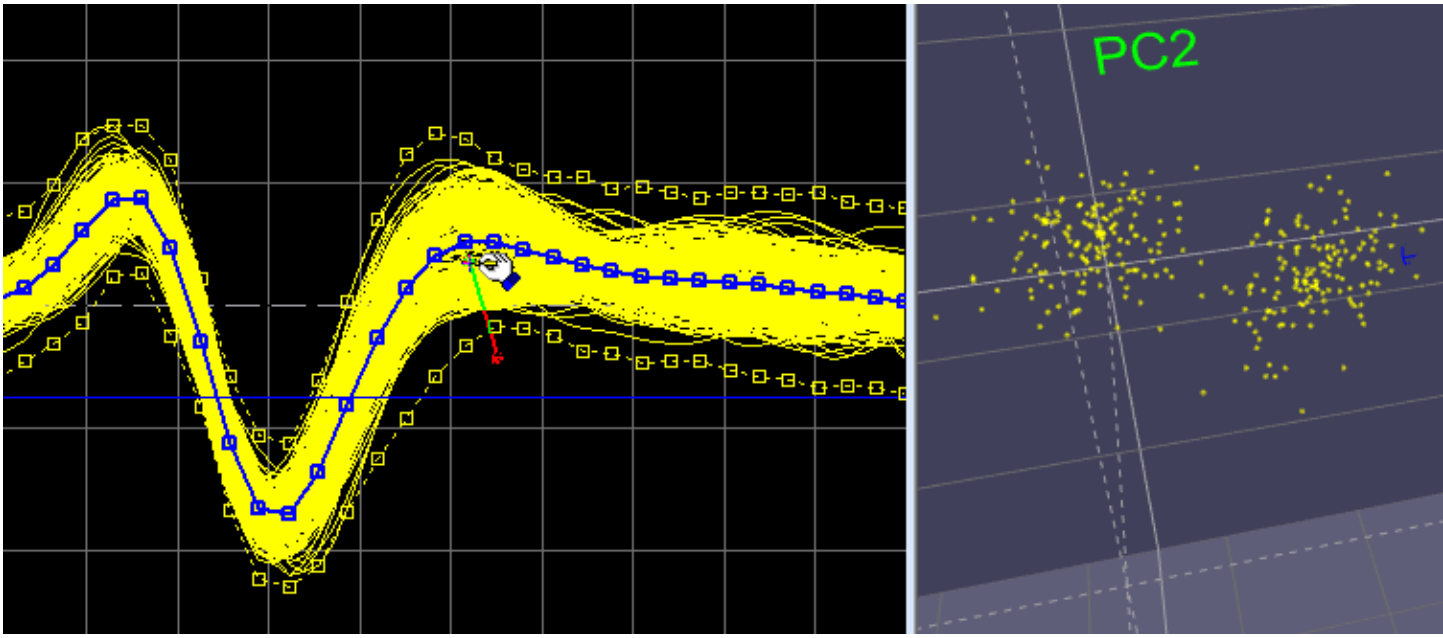
The unit is re-defined, with the waveforms within the contour removed from its definition:

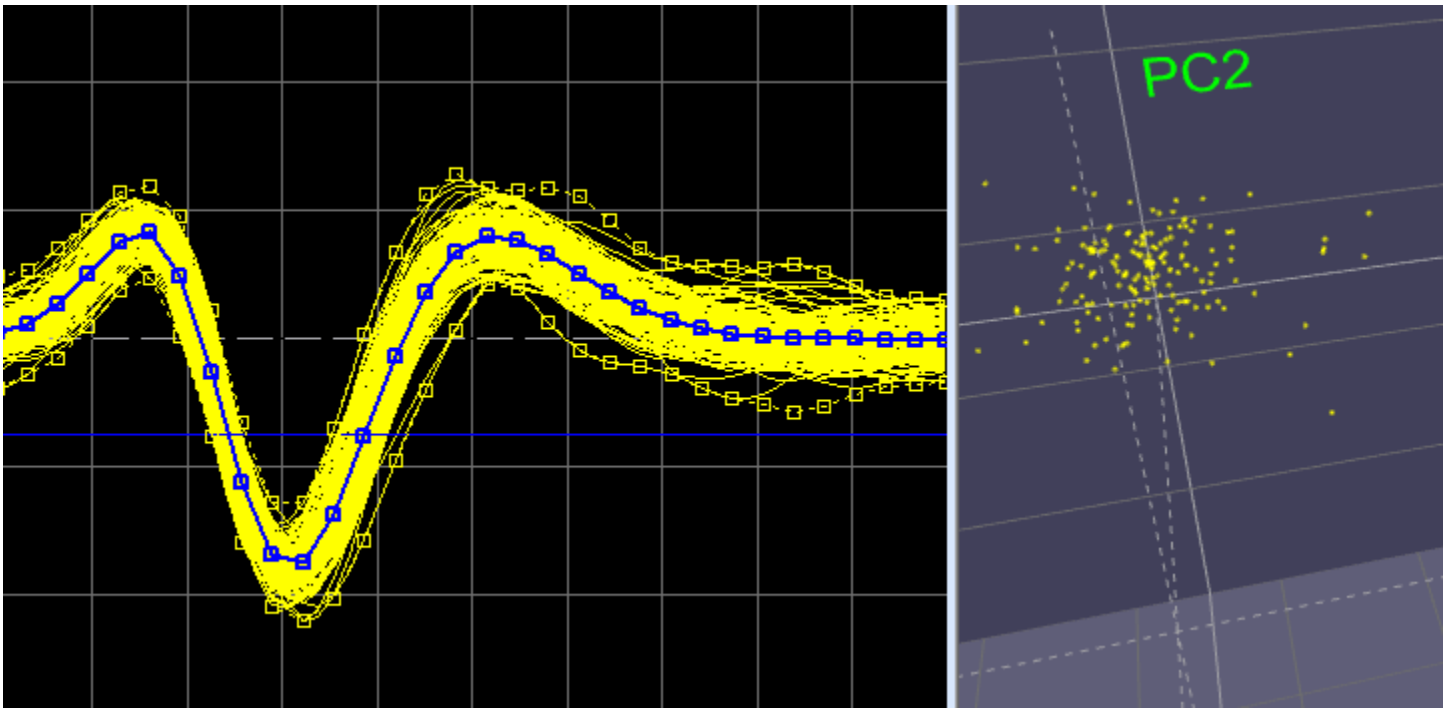


You can also perform waveform removal by waveform crossing. Here is the same example, but also showing the effects of the "overly inclusive" selection in the main spike view (to reduce visual clutter, we display only the sorted waveforms):



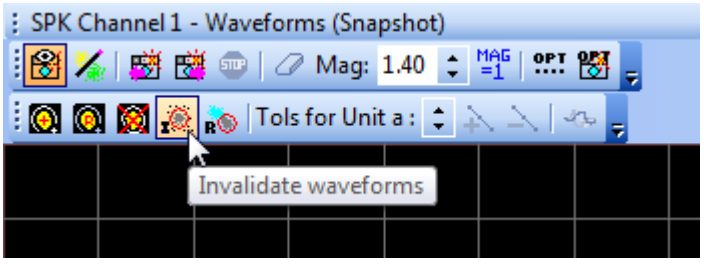
We can select the Remove Waveforms tool from the toolbar in the main spike view and draw a crossing line to select the spikes to be removed from the unit definition:

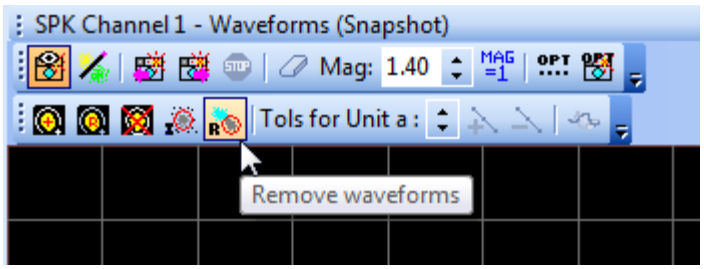




There are some caveats about waveform removal. Waveform removal is in effect replacing the currently selected unit with a new one, using the current set of sorted snapshot waveforms for that unit, minus the waveforms which you removed. The definition of this "replacement unit" is subject to the usual parameters, such as template or band fit tolerances. For example, you may cross some waveforms to remove them, but if the fit tolerance is high enough, or the removed waveforms have little effect on the statistics of the waveform set, some of the waveforms you removed may still be sorted into that unit. In general, you will find that waveform removal is somewhat conservative, in that it will rarely "cut deeper than intended," but will sometimes remove fewer spikes than expected, and so you may need to use the removal tool more than once, "cutting" a bit deeper on each pass, to get the desired result. Of course, you always have the option of simply deleting the unit and adding a new unit from scratch.

It is important to understand the difference between the Remove Waveforms tool and the Invalidate Waveforms tool (located on adjacent toolbar buttons).



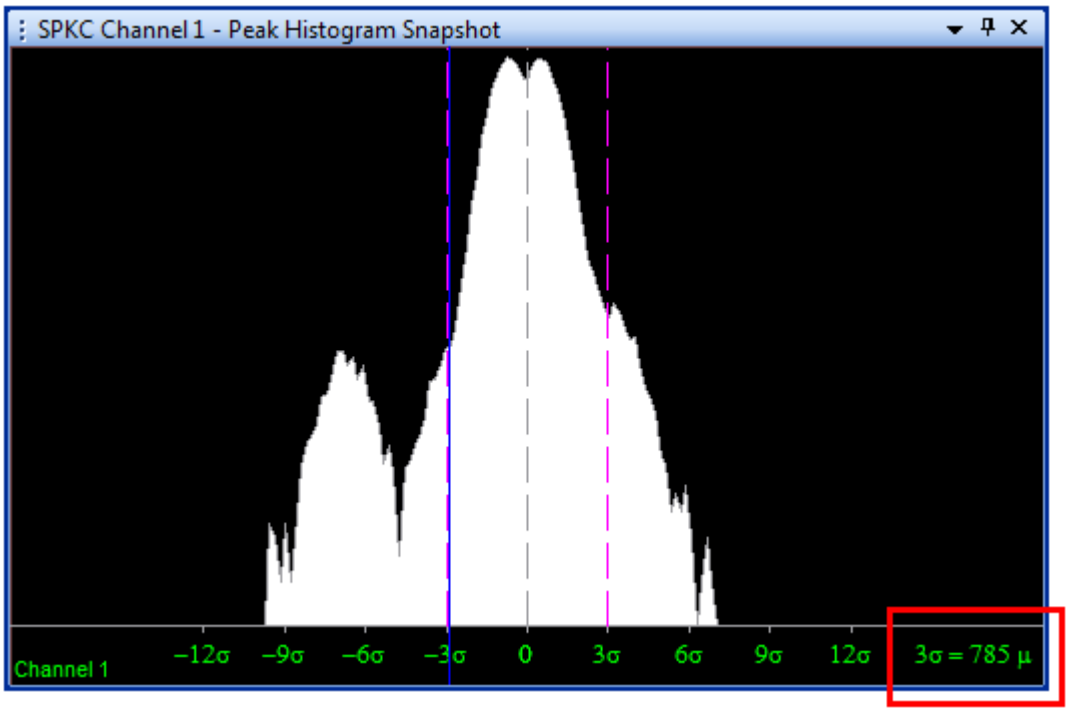


Invalidation is an operation that is not specific to a particular unit on a channel. Invalidating a waveform makes it "cease to exist from now on" as far as sorting is concerned (although previously defined units are unaffected). An invalidated waveform cannot be selected, sorted, removed, etc. You can invalidate a waveform in a snapshot at any time, whether it is sorted or not. The main use of Invalidate Waveforms is to remove "clutter" such as artifacts and other unsortable waveforms, making it easier to deal with the valid spikes.

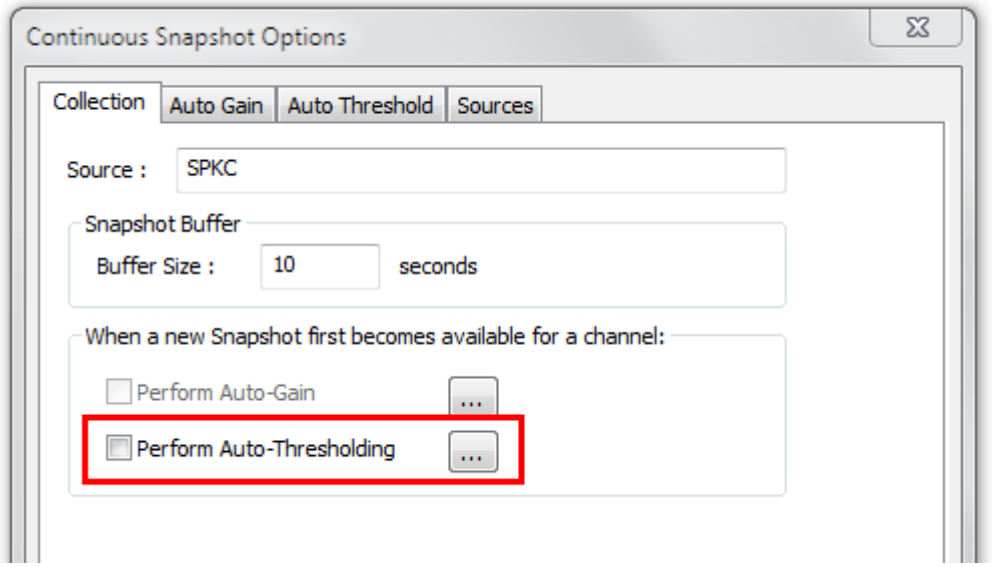
In comparison, waveform removal is specific to the currently selected unit, and removing a waveform in the currently selected unit's snapshot has the effect of "unsorting" it in the snapshot and then redefining the unit using the remaining sorted waveforms. In other words, removed waveforms are only removed from the selected unit, and can later be used to define other units if desired. The main use of Remove Waveforms is to refine and improve the definition of units.

Display of sigma in SPKC peak histogram

To provide an indication of the noise level on each spike continuous (SPKC) channel, the voltage value corresponding to three standard deviations in the SPKC peak histogram is now displayed (in microvolts) in the lower right corner of the histogram. Since the value of sigma is based on the peak histogram, i.e. based on local peaks in the SPKC signal (which is more informative than the histogram of the raw SPKC signal, for the purpose of setting thresholds), this value can differ from the sigma of the raw SPKC signal. Nonetheless, it can be useful as an indication of relative noise levels and changes in noise levels.



Remember that if you periodically take a new SPKC snapshot to update the sigma display, you should disable the Perform Auto-Threshold option in the SPKC snapshot options dialog before taking the additional snapshots, unless you do want the thresholds to be updated each time.



PCA calculation from partial snapshots now supported

In previous versions of OmniPlex, if a spike snapshot was stopped before snapshot collection was completed, no PCA was available. Version 1.10 can now produce PCA from incomplete/interrupted snapshots.

PCA projections maintained across restarts of data acquisition

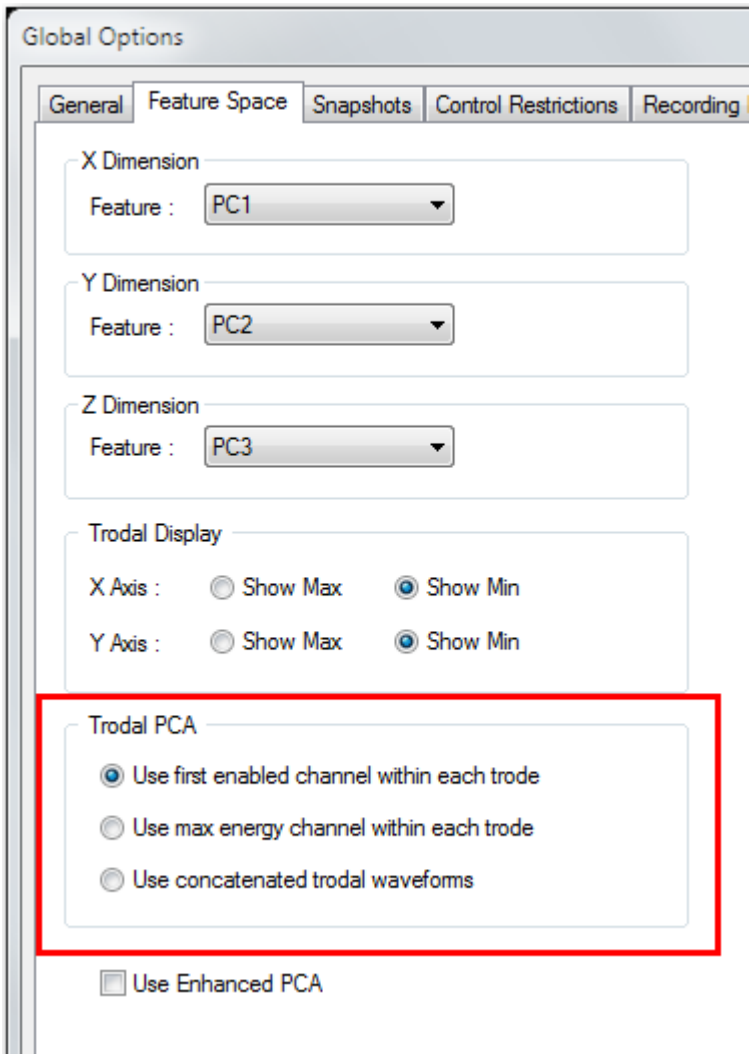
In previous versions of OmniPlex, stopping and restarting data acquisition reset the PCA projection vectors, making it necessary to collect a new snapshot and recalculate the PCA. Version 1.10 now preserves the PCA projections across data acquisition restarts, unless the sorting method or spike waveform length are changed. This is especially helpful if you are using 2D Polygon sorting and need to stop and restart data acquisition after you have defined sorted units.

Support for trodal polygon sorting

The 2D polygon sorting method (i.e. feature space contour sorting) can now be used with stereotrodes and tetrodes. Sort polygons can be defined manually or via autosorting, just as with the non-trodal acquisition modes.

New PCA options for trodal modes

Previously, PCA for stereotrode and tetrode spikes was based on the double or quad length “spike” formed by concatenating the two or four waveforms acquired for each stereotrode or tetrode spike event. In some cases, this does not give optimal results, and a better PCA projection can be obtained by using just one of the two or four waveforms. OmniPlex now allows you to select between three options for how trodal PCA is calculated:



The first option uses the first enabled channel within each trode; disabled channels are skipped.

The second option examines the spike snapshot for each channel within each trode, and for each trode, the channel with the highest total spike energy is used as the PCA channel. Spike energy is the sum of the squares of the waveform sample values; total spike energy is the sum of the spike energies for all the spikes in a channel's snapshot. Note that this heuristic can be fooled by a "dirty" channel with large amounts of high-amplitude noise; for this reason (and others), it is recommended that you identify and disable such channels before taking a spike snapshot and performing the PCA calculation. You can of course always take a new snapshot and redo the PCA (using the "PCA" button in the toolbar) after disabling or re-enabling channels.

The third option selects the "old" behavior, where the two or four waveforms in a trode are concatenated and a double or quad length PCA is calculated.

Also, note that Enhanced PCA is now supported for trodal modes.

Improved behavior of Auto Magnify All Spike Views

In previous versions, the default behavior for Auto Magnify All Spike Views was to determine the magnification for the SPKC channel with the largest amplitude, and apply that same magnification to all other SPKC channels, so the relative magnitudes were preserved visually. The new default is for each channel to be auto-magnified independently, so that all channels' signals are clearly visible. If you hold down the CTRL key when you select the Auto Magnify command, a single magnification factor will be applied to all channels, i.e. the old default behavior.

Also, when you perform an Auto Magnify, the setting of the Use Same Magnification for all Channels option in the affected views will be automatically adjusted if appropriate. For example, if you do an Auto Magnify with independent per-channel magnifications (the new default), the Use Same option will be disabled; conversely, if you Auto Magnify with the same magnification applied to all channels, the option will be enabled. This usually prevents unexpected results when you manually adjust magnification after having done an Auto Magnify, but you can change the setting of the Use Same option at any time if desired.

Note that when you first start PlexControl, the SPKC (spike continuous) view is hidden under the WB (wideband continuous) view, and is in fact the SPKC view is not initialized until the first time you click its tab to view it. If you perform an Auto Magnify before the SPKC view has been viewed for the first time, SPKC will not be updated by the Auto Magnify. If you see that SPKC has not been auto magnified, simply select the Auto Magnify command again to update all the SPK and SPKC views.

Disabled channels within trodes

This version fixes a number of problems that were encountered in previous versions when one or more channels were disabled within a stereotrode or tetrode. However, aside from actual bugs, there are some inherent (but not always obvious) issues that should be kept in mind when working with disabled channels and trodes, as described below.

Note that when you disable or enable channels within a trode which already has sorted units defined, in most cases you should delete the existing units and define new ones. For example, if you defined a unit's sorting template and tolerance while a channel was disabled within a tetrode, then later enable the

disabled channel, there is no way for OmniPlex to know what the template should be for the newly-enabled channel, and it will default to a “flat” (zero volts) template on that channel. Conversely, if you define a sorted template unit and then disable a channel, the template tolerance value will no longer be optimal, and cannot be automatically corrected. Similar considerations apply to other sorting methods. Therefore, if you attempt to enable or disable channels within a trode which already has sorted units, OmniPlex will ask you if you wish to delete the existing units first. In addition, for optimal results, you may wish to take a new spike snapshot and perform a new PCA calculation after changing the enable status of channels. Given these considerations, you may find that the most efficient workflow involves finding and disabling “bad” channels first, then setting thresholds (either manually or automatically), then defining sorted units. Of course, there may be situations where it becomes necessary to disable or enable channels in the middle of an experiment; the above is only meant to make you aware of the tradeoffs and issues involved.

OmniPlex User Guide

The new User Guide replaces the previous Quick Start Guide. The User Guide includes detailed step-by-step instructions for common tasks, coverage of important concepts such as spike/FP separation, thresholding, spike sorting, and snapshots, tips for using your system effectively, and information on advanced features such as aligned extraction, Enhanced PCA, and automatic sorting.

PL2 recording files

Version 1.8 adds support for recording in the new PL2 file format. PL2 files are optimized for efficient access to large amount of continuous data, such as wideband recordings. Large PL2 files can be loaded into Plexon's Offline Sorter and Matlab dozens to hundreds of time faster than the equivalent PLX files. A PL2 Offline SDK is available which supports reading from PL2 files using a backwards-compatible API. PL2 will be supported in the next releases of Offline Sorter, PlexUtil, and NeuroExplorer. See the User Guide for details on PL2 recording.

Additional improvements in real-time latency

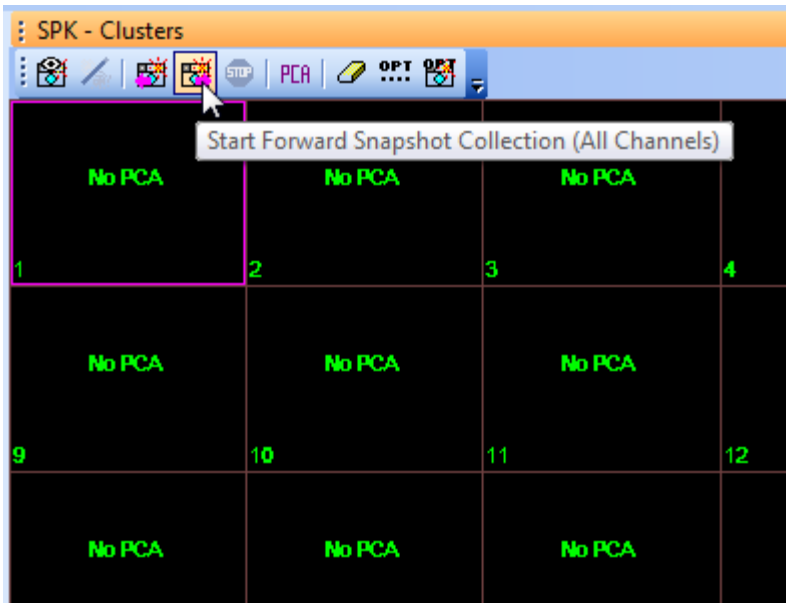
Continuing the latency improvements in version 1.7, the mean end-to-end latency in version 1.8 is now approximately 1 millisecond for DigiAmp and Mini-DigiAmp systems. See the notes for version 1.7 for details on how latency is measured.

Zoom and pan in trodal feature view

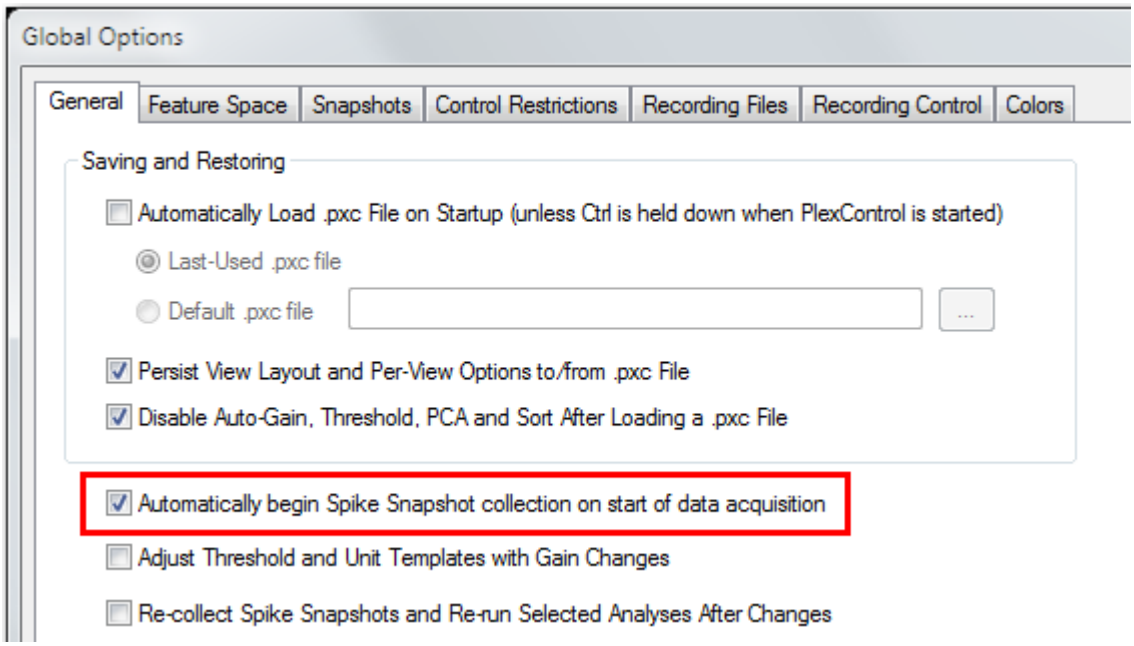
The tetrode/stereotrode feature view now supports zoom and pan, similar to the standard 2D PCA cluster display. Use the mouse wheel to zoom in and out; hold down the Shift key, press the left mouse button and drag to pan.

Changes to default spike snapshot behavior

In previous versions of OmniPlex, when data acquisition was started, PlexControl automatically began collecting a spike snapshot. In many cases, this may not be desirable, since it can result in the snapshot being collected while gains, thresholds, and other parameters are being set up, cables are being connected, etc. As a result, this is no longer the default behavior. You must explicitly collect a spike snapshot before you will be able to see PCA clusters, perform an auto-sort, or any other operation that requires a spike snapshot. Without a spike snapshot, you will see "NO PCA" in the multichannel PCA window and, after setting appropriate gain and thresholds, should use the Start Forward Snapshot button to take a snapshot and perform PCA:



However, if you wish to reinstate the old behavior, you can do so by enabling the following option in PlexControl's Global Options:



The User Guide contains more information on spike snapshots.

Auto-saving pxc and pxs files

You can now configure OmniPlex so that each time you record a plx or pl2 file, the current settings in PlexControl and/or Server will be auto-saved to a pxc and/or pxs file with the same name as the plx or pl2 file. This allows you to automatically keep track of the settings that were in effect when each recording was made. See the User Guide for details.

Mini-DigiAmp

Version 1.7 adds support for the "mini" DigiAmp, which is functionally identical to the larger DigiAmp, but more compact and which supports configurations of 16, 32, 48, and 64 channels, as compared to the 64-256 channel "big" DigiAmp. A set of 32 precanned pxs topology files is provided for common mini-DigiAmp configurations, identified by their filenames which all begin with "opx-Dm," versus "opx-D" for "big" DigiAmp systems. You can also create mini-DigiAmp topology files from scratch using the Topology Wizard in Server; selecting DigiAmp256 or DigiAmp64 under "A/D Device" determines whether a "big" or "mini" DigiAmp topology is created.

Important note for DigiAmp users upgrading from version 1.5 or 1.6

Existing DigiAmp users may require a firmware upgrade in order to run OmniPlex 1.7. If you have a "big" DigiAmp and are currently running version 1.5 or 1.6, or are unsure about compatibility please contact Plexon (support@plexon.com) *before* attempting to upgrade to version 1.7.

Improved real-time latency

Total system latency for DigiAmp systems is now less than 2 milliseconds. This figure is the actual end-to-end latency through the entire OmniPlex system from hardware input to hardware output, including an online user client program. Specifically, if a pulse is sent into a DigiAmp input channel and a client program monitors the real-time data stream for spikes on that channel, emitting "response pulses" using the PlexDO digital output library, the time between the input pulse and the response pulse, as viewed in parallel on two channels of an oscilloscope, averages less than 2 ms, using a Plexon-configured Dell T3500 Windows 7 host PC.

Aligned spike extraction

The thresholding device now supports aligned spike extraction, which can be enabled via the thresholder Device Options (stop data acquisition and right click on the Simple Thresholding device in the topology diagram in Server). In standard thresholding, a spike's timestamp is the time at which it crossed the threshold; in aligned extraction, the timestamp is the time of the sample with the maximum amplitude, in the time interval between the threshold crossing and the end of the capture window. In the device options, you can select whether the maximum amplitude must be on the same side (sign) as the threshold, or whether the largest absolute amplitude, i.e. independent of the sign of the threshold, is used.

The effect of aligned extraction is, as the name implies, to time align all the peaks of the extracted spikes on each channel. This greatly reduces the amplitude-dependent and threshold-dependent timestamp jitter that can be a side-effect of standard thresholding, thereby increasing the accuracy of timestamps. In many cases, it also "tightens up" the projections of waveforms in feature space, e.g. PCA clusters are more compact and better separated, making spike sorting easier and more accurate. Aligned extraction will also be available in an upcoming release of Plexon's Offline Sorter (OFS).

New features in 2D Polygon sorting mode

Automatic spike sorting can now be performed in 2D Polygon sorting mode, i.e. in feature space. After sorting of the spike snapshot is complete, the 2D feature points corresponding to each sorted unit are represented by an ellipse whose major and minor axes are a user-specified number of sigmas in length, along the direction of the first and second principal components. In other words, an ellipse is fitted to each cluster that is found by the auto-sort. The number of sigmas can be specified in the Auto Sort tab of the spike snapshot options; changing this value does not affect any ellipses that were previously created.

Similarly, manually crossing waveforms in the main spike display will now produce the corresponding 2D sorting ellipses, as an alternative to manually drawing contours in PCA feature space. In addition, an option in PlexControl's Global Options allows manually-drawn contours to be automatically "cleaned up" and converted to ellipses; once an ellipse (or any contour) is drawn, you can use the square contour handle to adjust its position, or if the Shift key is held down, the contour can be rotated.

You can use any combination of these automatic and manual methods to define the units on each channel.

Enhanced PCA feature space

A checkbox in PlexControl's Global Options (Feature Space tab) enables a new Enhanced PCA feature space. Enhanced PCA uses a new method to calculate the basis vectors which are used to project each spike waveform to a point in the 2D and 3D PCA feature spaces. As compared to standard PCA, which finds a projection that maximizes variance, the Enhanced PCA projection also emphasizes those components of the spike waveforms which are most informative for clustering, and de-emphasizes components which have high variance but little information for clustering. In many cases, Enhanced PCA creates a projection which will give superior cluster separation and compactness when compared to standard PCA, but the degree of improvement can vary, depending on the spike waveforms, amount of thresholded noise, and other factors. The combination of aligned extraction and Enhanced PCA will often give even better results, in terms of cluster quality, than either feature used alone. Note that when you enable or disable Enhanced PCA, this change will take effect the next time the PCA projection vectors are recalculated, either at the next spike snapshot, or the next time that data acquisition is restarted (which causes a new spike snapshot to be taken). If you are using 2D Polygon sorting mode, you will then typically need to do a fresh automatic and/or manual sorting using the new projections and clusters.

PXS and PXC files

A new set of pxs files (system configuration files / Server topologies) is included with this release. Unless you have a specific reason to do otherwise (see below), you should use one of these new pxs files in Server, or use the Topology Wizard to create an appropriate pxs for your system "from scratch" if your system configuration is not included among the provided pxs files. See the document opx160-pxs-info.txt for a guide to selecting the correct pxs file for your hardware configuration.

If you make changes to device settings and wish to save them to a pxs file, it is recommended that you use Save As to save to a new file, rather than overwriting the Plexon-provided default files, in order to avoid any future confusion.

Note that each time it is started, Server automatically loads the pxs file that was previously loaded the last time you ran Server, unless you disable this option in Global Options (in the Configure menu). In many cases, all that is necessary is to determine the correct pxs file, manually load that file in Server the first time, and then let it auto-load each time you run OmniPlex. If you need to load different pxs files, for example, with different device settings, remember that you must first shut down PlexControl before loading a pxs file in Server (informally, "you can't change a topology out from under PlexControl").

Default pxc files (PlexControl settings files), such as were included with previous versions of OmniPlex, are no longer necessary, and those pxc files should not be used in PlexControl, particularly not in conjunction with the newer pxs files provided with version 1.6. If you start PlexControl without a default pxc file and notice any problems with the layout or graphical displays, simply perform a Create View Layout for Sources, which resets the user interface to a default arrangement that is appropriate for the topology that you have loaded in Server. This command is always available in the System Tasks pane which is by default in the upper-left corner of the PlexControl interface, just below the main toolbar. However, in most cases, PlexControl will detect if the topology has changed since the last time you ran PlexControl, and will automatically do a Create View Layout for Sources for you.

In some cases, you may have existing pxs and/or pxc files which you would like to continue using with newer versions of OmniPlex, for example, a pxc file with specific gains, thresholds, sorting parameters, etc. In most cases, this is not a problem, but there are some compatibility requirements to be aware of. The most basic is source compatibility. The pxc and pxs files must contain the same devices, sources, source numbering, and connections. If this is not the case, an attempt to load the incompatible pxc file in PlexControl will result in an error message alerting you to the incompatibility with the pxs file that is currently loaded in Server. If you must use that pxc file, you will need to shut down PlexControl, find and load a compatible pxs file in Server, restart PlexControl, and attempt to load the pxc file again. In general, it is recommended that a pxc file should be used in tandem with the pxs file that was loaded in Server when the pxc file was saved.

Note that if the failed load of a pxc file was the result of an attempted auto-load (PlexControl Global Options in the Configure menu: "Automatically Load pxc File on Startup"), the auto-load option will be temporarily disabled, so that PlexControl does not try to load the incompatible pxc the next time it is run. Also, you can temporarily override the auto-load option in either Server or PlexControl by simply holding down the Ctrl key before starting the app, either from the desktop, the Windows File Explorer, or in the case of PlexControl, from the Run menu in Server.

Resetting options to defaults

Please note that upgrading to version 1.6 will reset all options (for example, Global Options) for both Server and PlexControl to their default settings. This was done partly in order to fix any problems caused by incorrect settings of options from previous versions. After you have installed 1.6, any subsequent changes you make to the options will persist between sessions, as in previous versions of OmniPlex.

In addition, both Server and PlexControl now provide a manual Reset All Options to Defaults command,

which previously could only be done by deleting system files from somewhat obscure locations. Resetting options to defaults can be a useful troubleshooting if you encounter unexpected system behavior and want to return the system to a known state. All settings that normally persist between sessions without having to be saved in a pxc file, such as all the Global Options, will be reset to their original "factory" values. The Reset All Options to Defaults command can be found in the Configure menu in both Server and PlexControl.

You can perform a reset in either application, but in a troubleshooting scenario, and for a full reset, you should do the reset in both PlexControl and Server, then shut down PlexControl, shut down Server, restart Server, and finally restart PlexControl. Note that the Server auto-load option, and the name of the pxs file that is auto-loaded, are not reset by this sequence; if you wish to use a different pxs file, simply open the desired file in Server when you restart it, and before restarting PlexControl.

Troubleshooting data drops and performance problems

PlexControl and OmniPlex Server are designed to operate efficiently and reliably, and the Windows PC on which the software runs is specially configured at Plexon for optimal performance. However, some usage scenarios (for example, wideband recording at high channel counts) are more demanding than others, and some third-party applications, particularly those with heavy CPU usage or real-time response requirements, can adversely affect the operation of OmniPlex. The following describes how to recognize when your system may be experiencing a performance problem, along with recommendations for solving such problems.

PlexControl drop count indicator

In the lower-right corner of the PlexControl main window, you will see the drop counter, which under normal conditions will show "Drops: 0." The drop count works as follows. As continuous data (wideband, spike-continuous, field-potential, etc) is acquired, but before it is displayed and recorded, PlexControl monitors it for any gaps in the data stream, as indicated by the timestamps of successive data packets. Such a gap can occur when, due to excessive load on the PC, PlexControl is unable to keep up with the incoming data from Server. In such cases, there will typically be a gap on each of the incoming continuous data sources, with the result that the drop count increments by one *for each continuous data source*. This is why the drop count usually increments by three or more at a time, rather than one; this does not mean that data was dropped three different times.

Please note that *drops/gaps do not affect the timing accuracy of the system*, which remains correct after a drop, since Server accurately timestamps all data before it is sent to PlexControl. Thus, an occasional drop is not necessarily cause for concern, and may be due to some transient high system load, such as starting another application, high network activity, etc. However, if the drop count increases frequently or continuously, or if you can actually see visible gaps in the continuous data in PlexControl, this is probably a sign of a performance problem.

AD64 systems – data acquisition stops

On AD64 systems, if data acquisition stops entirely, followed by an error message from Server, "Please restart data acquisition" (note: you may have to switch to the Server window to see this error message), this indicates that Server was unable to keep up with the incoming data from the AD64 data acquisition cards, which almost always indicates that the system is very heavily loaded, since Server runs at elevated priority to avoid interruption from other Windows applications. This is a fatal error, and you must stop and restart data acquisition to continue. Fortunately this is quite rare on a correctly configured system, unless you are attempting to run other real-time applications at the same time.
DigiAmp systems – error in DigiAmp data

On DigiAmp systems, the corresponding fatal error displayed by Server is “Error in DigiAmp data – try stopping and restarting data acquisition.” Note however that this error is also displayed if your system is not configured for the correct number of channels in your DigiAmp, or in the event of a hardware problem. Check your system configuration in before attempting to restart data acquisition.

Troubleshooting performance problems

If you encounter persistent drops or either of the above fatal data acquisition errors, first try closing PlexControl and Server and restarting. If this is unsuccessful, cycle the power on the OmniPlex chassis and then reboot Windows, taking care to not start unnecessary applications. Watch out for automatically started third party apps such as disk defragmentation utilities, media players, Skype, etc. If you find that you can operate OmniPlex reliably in a “minimalist” environment, then you can try reintroducing applications one at a time to determine the offending application. Note that if you only experience drops once in a great while, the problem could be some periodic scheduled activity such as Windows Update, a virus scan, or a disk defragmentation, although Plexon configures OmniPlex systems to avoid such problems.
If you still encounter problems, perform the “reset all options to defaults” procedure outlined in a previous section to reset OmniPlex to a known default state, load one of the predefined pxs files provided by Plexon (or use the Topology Wizard to create one from scratch) and do *not* load a pxc file in PlexControl before starting data acquisition.

If drops only occur while recording, try recording only spikes and field potentials, i.e. not wideband or spike-continuous data. Also check your hard drive for disk fragmentation, which can reduce recording performance. Whenever possible, it is recommended that you record to a drive other than C:, since the C: drive can become busy at times due to Windows system activity.

You can also use the Windows Task Manager to monitor the CPU usage of your system. Click on the Performance tab to view an animated graph of the CPU activity; warning signs include either a high number (50% or more) for the “CPU usage” bar graph at far left, or any one or more of the individual CPU Usage History graphs approaching 100%. You can also click on the Processes tab to see a list of all the running processes and the CPU usage of each. Click on the header of the “CPU” column to sort the list in order so that the highest numbers are at the top; if you see processes other than PlexControl.exe and OmniPlexServer.exe listed with CPU figures of more than a few percent, those processes may be the source of the problem. However, be very cautious about using the End Process button in Task Manager to terminate any processes unless you know exactly what they are and have verified that they are non-essential, since terminating important system processes can cause your system to crash or become unresponsive. If in doubt, consult your system administrator or Plexon technical support.

If OmniPlex itself (PlexControl.exe or OmniPlexServer.exe) is using an excessive amount of CPU, you may need to optimize your usage of certain features, especially in high channel count systems. Here are some possible sources of excessive CPU usage:

- Recording both the wideband (WB) and the spike-continuous (SPKC) sources (this is redundant, since you can filter the WB data offline to obtain the “spike-filtered” version)
- Setting many thresholds close to zero, so that OmniPlex is continuously detecting and sorting large numbers of“spikes” which are actually noise
- Setting the digital filters to very high order (e.g. 12 poles)
- Using the Global Filters device (at high channel counts, enable the lowpass filter in the spike separator instead)
- Displaying large numbers of continuous channels, especially at high sweep (refresh) rates
- Displaying a spike or cluster snapshot while an autosort is in progress; PlexControl will automatically switch to the live view when an autosort is started, in order to avoid this problem

Problems when starting OmniPlex

Some users have reported problems in running the OmniPlex software via the Windows desktop shortcut. In particular, starting OmniPlex by double-clicking the PlexControl desktop shortcut, which requires PlexControl to automatically start Server before the PlexControl window is displayed, has been known to cause occasional crashes on some systems. If you encounter this problem, a simple workaround is to instead start Server (either from the desktop shortcut or from the File Explorer), then start PlexControl from the Run menu in Server, not from the desktop.

On Windows 7 systems, depending upon how user accounts and permissions are configured, you may in some situations find that you must use “Run as Administrator” to start Server for best results. For example, if you get unexpected “Cannot write file” errors when attempting to save a pxs/pxc file, or record a plx file, try shutting down OmniPlex and restarting, right-clicking on Server and using “Run as Administrator” to start the application.

AuxAI card

Version 1.6 now supports the 32 channel AuxAI (auxiliary analog input) card. On AD64 OmniPlex systems, the AuxAI card provides an alternative to so-called "direct" channels, allowing all AD64 channels to be used for neural data acquisition, and removing the need to lowpass filter and downsample a subset of the 40 kHz channels, since the non-neural data is acquired directly at the desired sampling rate by the AuxAI card. The Topology Wizard in Server now includes an "Auxiliary AI card" checkbox which will include the 32 channel AuxAI device in topologies, although if this option is not checked, you can specify the number of direct channels as in previous versions of OmniPlex. But note that with DigiAmp systems, non-neural input channels are *only* allowed via an AuxAI card, and AD64-style direct channels are not supported. In version 1.6, only a single 32 channel AuxAI card is supported, although this limitation will be removed in a future release. Contact Plexon for information on how to add an AuxAI card to an existing system.

