Chapter G: The Power Spectrum Analysis Module

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Datapac 2K2 User's Manual, Ver 3

Chapter G: The Power Spectrum Analysis Module

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G-1. Introduction

The Power Spectrum Analysis module performs two different kinds of time domain analyses: **power spectrum analysis** and **covariance analysis**. A **power spectrum analysis** measures the power of a signal as a function of frequency. The underlying assumption of this kind of analysis is that each component of a continuous frequency spectrum accounts for some portion of the overall variability in the amplitude of a signal. Thus the aim of the analysis is to assess the magnitude of the contribution of each component frequency to the overall variability. The module employs a fast Fourier transform (FFT) algorithm to decompose selected segments of a signal into discrete frequency components over a continuous spectrum and to obtain the density, or power associated with each component. The signal segment used as input to an FFT operation is subsequently referred to as a ***frame***. The result of an FFT operation is subsequently referred to as a ***spectral density function***.

A **covariance analysis** measures the strength of the relationship in the amplitude of a signal measured at successive time delays. The underlying assumption of this kind of analysis is that if the signal is periodic then the correlation between the amplitude of the signal measured at two different points in time will be high when the interval between the points being measured is equal to the cycle time, or period, of the signal. In a covariance analysis the program determines the difference in amplitude between every possible pair of sample points in a selected signal segment, and calculates the product moment

correlation coefficient for pairs of samples separated by successively greater intervals. The result of the analysis is a ***covariance function***, which relates the magnitude of the correlation coefficient as a function of frequency. As in the case of a power spectrum analysis, the signal segment used as input to a covariance analysis is referred to as a ***frame***.

G-2. Entering the Power Spectrum Analysis Module

To enter the Histogram Analysis module, select **Analysis|Power Spectrum Analysis** from the main window menu bar, or select the  icon from the main window tool bar. Doing so opens the **Power Spectrum Analysis Window**, the main interface for configuring and executing a power spectrum or covariance analysis. An example is presented in Figure G-1.

Note that the window contains three tabbed sections labeled **Analysis**, **Frame Selection**, and **Display**. The **Analysis** tab contains the parameters that control the type of analysis performed, the channels to be analyzed, the pretreatment options in effect, and a few other related things. The **Frame Selection** tab contains the parameters that control the way frames are selected for analysis. The **Display** tab contains the parameters that control access to the many kinds of graphical and table displays the module offers for the presentation of analyzed data. Details are provided in Sections G-11 through G-22.

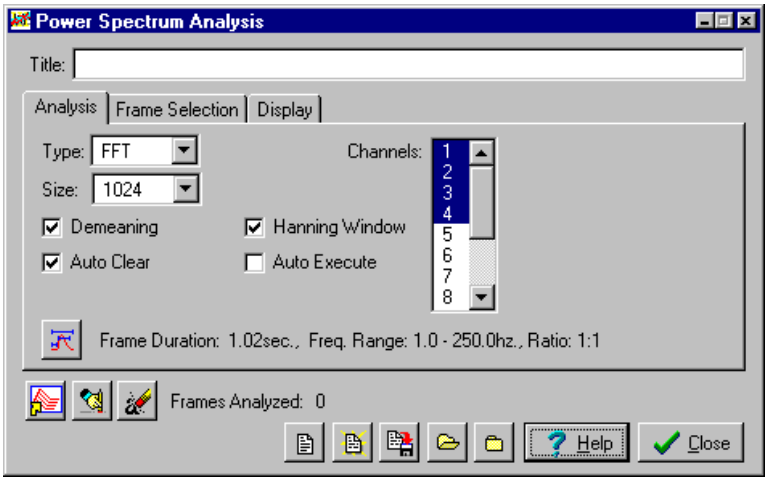


Figure G-1. An example of the Power Spectrum Analysis Window.

Table G-1. Options of the Power Spectrum Analysis Window.

Title: A line of text that you can use to describe the set of analysis parameters you have defined or will define. Generally, the title is useful only if you intend save the parameters to a parameter file, where it can be used as a long file name when retrieving the file.

Analysis Tab

Type: Determines the type of analysis to be performed: **FFT** = power spectrum analysis, **COV** = covariance analysis.

Size: Determines the number of samples (data points) in each frame.

Table G-1. Options of the Power Spectrum Analysis Window (continued)**.**

Channels: Determines the channels to be included in the analysis. Only highlighted channels are included. Click on a channel to highlight it. To highlight more than one channel, hold down the shift or Control key on the keyboard, before clicking on channel numbers.

Demeaning: Calculates the mean amplitude of each frame and sets it to zero. The demeaning option is most appropriate only when the following conditions are met:

1. You are performing a power spectrum analysis (demeaning has no effect on a covariance analysis).
2.. When the analyzed signal is biphasic and symmetric (i.e., its mean amplitude is approximately equal to its baseline amplitude).
3. When the signal has a DC bias (i.e., its mean amplitude is not equal to zero).

Hanning Window: Applies a cosine tapering function to each frame to enhance the reliability of the results *of a power spectrum analysis.* The Hanning Window option should be disabled when running a covariance analysis.

Auto-Clear: When this check box is checked, the results that were obtained from previous executions are deleted from memory before a new execution is performed. When the check box is cleared the results from previous executions are retained as the results from subsequent executions are added to memory. When results are obtained over several executions it is called *performing a multiple analysis*, and it is more fully described in Section G-7.

Auto Execute: Check this check box to automatically execute an analysis the next time you open the Power Spectrum Analysis module. The analysis employs the parameters in effect when you close the module. If any displays are open when you close the module, they will also be automatically reinstated when the analysis is completed. The Auto Execute feature has no effect while the Power Spectrum Analysis module remains open.

Frame Duration: Reports the time interval represented by each individual frame in the analysis. Also reports the frequency range of the analyzed spectrum and also the zoom ratio. To modify the frame duration, frequency range, and zoom ratio (they are all interrelated), select the  button. See Section G-5 for additional details.

Frame Selection Tab

Single Frame: The **Start Time** value determines the latency between the beginning of the data file and the beginning of the frame. You can select more than one frame with this method, but each one must be selected individually in each execution of a multiple analysis. The start time can be typed in, or you can use the  button to produce a display with a cursor that you can move to the desired location.

Sequential Frames: Selects a sequence of frames. The **Start Time** value determines the latency between the beginning of the data file and the beginning of the first frame in the sequence. Each subsequent frame begins at the termination of the preceding frame. The **Number of Frames** parameter determines the number of frames in the sequence. The start time can be typed in, or you can use the  button to produce a display with a cursor that you can move to the desired location.

Table G-1. Options of the Power Spectrum Analysis Window (continued).

Event File: Employ an event file to define the frames. To select the event file you wish to use, highlight the letter of the event buffer it is linked to in the **Buffers** list box. To limit the analysis to a particular sequence of events, check the **Event Range** check box, then enter the lowest and

highest numbered events in the desired sequence in the boxes provided. If the Event Range check box is left clear, all of the available events will be analyzed.

Display Tab

The display tab contains four identical rows of information. Each row controls one of the four display windows that you have available to you. All four can be open at the same time, each of them containing a different type of display. To produce a display, select the desired display type from the list provided, then click on the corresponding  button. Details are provided in Section G-12.

Bottom Section of Window

 (**Execute):** Performs an analysis. At its completion the **Frames Analyzed** value is incremented to reflect the number of frames that are added to the internal register.

 **(Clear All Frames):** Click this button to erase the entire contents of the internal register.

 **(Delete Frames)**: Click this button to delete individual frames. See Section G-8 for details.

 **(View Parameters):** Click this button to view a table reporting all of the currently defined analysis parameters.

 **(Load Parameters),**  **(Save Parameters):** Click the Save Parameters button to save the currently defined set of analysis parameters to a file so that they may be retrieved – using the Load Parameters button -- and reused at a later time.

 **(Load Results),**  **(Save Results):** Click the **Save Results** button to save the contents of the internal PSA register, along with the currently selected set of analysis parameters, to a parameter file. Click the **Load Results** button to retrieve (load) a previously saved results file. Results files make it possible to interrupt an analysis before its conclusion and then to return to it at a later time.

G-3. Preparing to Perform an Analysis: An Overview

The power spectrum analysis module stores the results of a power spectrum or covariance analysis in an internal memory area called the ***internal PSA register*** (or just the *internal register),* then draws on the stored information to display and report the results. The contents of the PSA register can also be stored to a file, then retrieved to be combined with newly analyzed data. The present section describes how to set up, or format, the internal PSA register. A later section, entitled Displaying the Results, describes how to produce different kinds of results displays.

When setting up an analysis the principal decisions can be itemized as follows: (1) selecting the type of analysis (power spectrum or covariance); (2) selecting the channels to be analyzed; (3) establishing the frame size and duration; (4) selecting the pretreatment options, and finally; (5) choosing the method of selecting frames. All but the last decision are made by way of the **Analysis** tab of the Power Spectrum Analysis Window. To choose the method of selecting frames, click on the **Frame Selection** tab. Details are provided below.

G-3.1. Setting up an Analysis.

Selecting the Type of Analysis:

The **Type:** list box determines the type of analysis to be performed. Select the **FFT** option to perform a power spectrum analysis. Alternatively, select the **COV** option to perform a covariance analysis.

Selecting the Channels to Analyze:

Highlight the numbers of the channels you wish to analyze in the **Channels** list box. By holding down the shift or Control key on the keyboard before clicking the left mouse button, you can highlight as many channels as you wish.

☞ If you intend to select frames using events, keep in mind that only one set of events can be used at a time. All of the channels that you select here are analyzed for each event.

Selecting a Frame Size and Frame Duration:

The **Frame Size** refers to the number of samples, or data points, contained in any one frame. The available options are 128, 256, 512, 1028, and 2056 samples. The **Frame Duration** is actually a digital zooming feature which, by skipping a selected number of sample points for each one accepted into the analysis, serves both to adjust the duration of the frame as well as to adjust the range of frequencies that are analyzed. See the topic, Selecting a Frame Duration for more information. Also be aware that ***aliasing error*** becomes more likely when the frame duration feature is employed. See Section G-6 for details.

Selecting Pretreatment Options:

The power spectrum analysis module offers two types of pretreatment options, i.e., operations that are performed prior to the analysis proper: **Demeaning** and **Hanning window tapering**. The pretreatment options are primarily intended for use with power spectrum analyses, not covariance analyses.

The **Demeaning** option calculates the mean amplitude of each frame and sets it to zero. Data demeaning has no effect on a covariance analysis, but in a power spectrum analysis the intended effect is to attenuate the low frequency bias associated with the presence of a DC offset in the signal. This assumes, however, that the signal is a biphasic signal whose average amplitude is equal to its baseline amplitude. EEG and unrectified EMG signals are good examples, as are differentially recorded whole nerve signals.

The **Hanning window** option applies a cosine tapering function to each frame to enhance the reliability of the results, *but only when applied to a power spectrum analysis.* When performing a power spectrum analysis it is a good idea to enable the Hanning window option unless you have a compelling reason to disable it. In contrast, when performing a covariance analysis, the Hanning window option is inappropriate and should be disabled.

Selecting Frames:

Click on the Frame Selection tab to select frames. The power spectrum analysis module offers three different methods for doing so. The **Single Frame** method lets you choose each frame individually by indicating where it starts in relation to the beginning of the data file. You can select more than one frame with this method, but each one must be selected individually. See the topic, Performing a Multiple Analysis for additional information. The **Sequential Frames** method lets you choose a sequence of frames of any length. The first frame starts at a user-selected latency from the beginning of the data file. Each subsequent frame begins at the termination of the preceding frame. The **Event File** method employs the event file linked to a selected event buffer to define the frames. For details about selecting frames, see Section G-4.

G-3.2. Performing an Analysis

Click the  (Execute) button to perform an analysis. As the analysis is performed, the results obtained from each frame are stored to an internal memory area called the ***internal PSA register*** (or just the *internal register)* where they become available for display and editing. When the analysis is completed the **Frames Analyzed** value (reported to the right of the  button) is incremented by the number of frames just analyzed. Note that if the **Auto Clear** checkbox (in the Analysis tab) is left clear the newly analyzed frames are appended to any frames that were analyzed in a previous execution. Alternatively, if the **Auto Clear** checkbox is checked, then previously analyzed frames are "cleared" or deleted from the internal register before the analysis proceeds. You can also clear the internal register at any time by clicking on the  (Clear All Frames) button. To delete individual frames, use the  (Delete Frames) button. Details are provided in Section G-8.

It should be noted that when the # Frames value is greater than zero the program does not allow you to change the **Type**, **Size** or **Frame Duration** parameters, because doing so would affect the integrity of the already accumulated data. You can, however, change the method used to select frames and associated parameters, as well as the **Channels**, **Hanning Window**, and **Demeaning** options. Then you can select the **Execute** button again to add new data to the data already stored in the internal register. See Section G-7 for more information about accumulating data over several executions.

G-3.3. Displaying the Results

The Power Spectrum Analysis module provides many ways to view the results contained in the internal PSA register. Some present the results in a graphics display. Others present the data in the form of a table. Up to four different kinds of displays can be open simultaneously, and they can be selected through the Display tab. Additional information is provided in Section G-12. To ensure consistency in the data presented in the different kinds of results displays, all of them share a common set of parameters. These parameters can be accessed by selecting the **Shared Display Param** button in the Power Spectrum Analysis Window or by selecting the **Shared** option in the menu bar in any of the display windows. For additional information on the shared display parameters, see Section G-11.

G-4. Frame Selection Methods

The Power Spectrum Analysis module provides three different methods for selecting the frames contributing to a power spectrum or covariance analysis. They are described separately below. Choose a frame selection method by clicking on its radio button in the **Frame Selection** tab of the Power Spectrum Analysis window. In the course of a multiple analysis the different methods can be used repeatedly or interchangeably on successive executions.

Single Frame: Selects frames individually. The **Start Time** value determines the latency between the beginning of the data file and the beginning of the frame. You can select more than one frame with this method, but each one must be selected individually in each execution of a multiple analysis. The start time value can be changed before each execution.

You can type in the desired start time value or you can select it with your mouse while viewing a display. To use the mouse method, click on the  button and wait for a display window to appear. The display contains a vertical cursor to indicate the current start time value. To move the cursor to a new location, place the mouse pointer close to its current location, then hold the shift key and the left

mouse button down as you move the mouse. When the cursor is in the desired location, release the mouse button. Finally, to update the start time value, close the display window.

Sequential Frames: Selects a sequence of frames. The **Start Time** value determines the latency between the beginning of the data file and the beginning of the first frame in the sequence. Each subsequent frame begins at the termination of the preceding frame. Consequently, as the frame duration changes, so does the interval between the beginning of each successive frame. The **Number of Frames** parameter determines the number of frames in the sequence.

You can type in the desired start time value or you can select it with your mouse while viewing a display. The mouse method is identical to that describe above for the Single Frame selection method.

☞ Since each frame always begins at the termination of the one before it, any parameter that affects the duration of a frame (specifically, the analysis size and frame duration parameters) will also affect the number of frames selected per unit of time.

Event File: Employs an event file to select frames. To select the event file you wish to use, highlight the letter of the event buffer it is linked to in the **Buffers** list box. To limit the analysis to a particular sequence of events, check the **Event Range** check box, then enter the lowest and highest numbered events in the desired sequence in the boxes provided. If the Event Range check box is left clear, all of the available events will be analyzed.

When the **Average Over Event Duration** check box is not checked, then the program will analyze one frame per event. The starting time of the frame always equals the onset time of the event. In contrast, when the check box is checked, the program will start at the onset of each event and automatically analyze as many sequential frames as possible, provided that they are all fully contained within the event. For example, if an event is 2.3 seconds long and the frame duration is 0.5 seconds, then a total of four frames will be analyzed (the final 0.3 seconds will not be analyzed because it does not constitute an entire frame). A composite average is then computed for all frames within each event, and it is the composite average, rather than the individual frames, which are stored in the internal register. Thus, only one composite average is stored down for each analyzed event, no matter how many individual frames actually contribute to the composite. The composite average is still referred to as a "frame", however.

G-5. Selecting a Frame Duration

The **Frame Duration** is a digital zooming feature that expands the frame duration by skipping a selected number of sample points for each one accepted into the analysis. The net effect is to effectively reduce the signal's sampling rate, which in turn affects the analyzed frequency spectrum as well as the frame duration.

To select a frame duration option, select the  button in the Power Spectrum Analysis Window. Doing so opens the **Frame Duration Parameter Window**. An example is presented in Figure G-2.

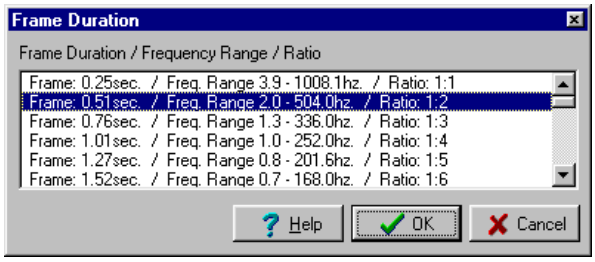


Figure G-2. An example of the Frame Duration Parameter Window, used to select the duration of each frame.

Each line in the window represents a separate option and reports three items of information: the frame duration (in seconds), the analyzed frequency range (in hertz), and the ratio between the number of sample points accepted into the analysis and the number of available points in the signal segment. For example, a ratio of 1:1 means that all available samples are accepted into the analysis. A ratio of 1:2 means that one sample out of every two is accepted. A ratio of 1:3 means that one sample out of every three is accepted, and so on. Note that the frame duration option does not affect the selected **Frame Size**, which determines the number of samples per frame**.** Thus, if the selected frame size is 512, then 512 samples constitute a frame regardless of the selected frame duration option. Since the frame size does not change, the frame duration increases as the ratio increases. Similarly, as the ratio increases the interval between successively accepted samples increases, thus proportionally reducing the effective sampling rate for the purposes of the analysis. Consequently, as the ratio increases frequency range decreases and is shifted to the lower end of the spectrum.

☞ It is important to recognize that as the frame duration increases, so does the possibility of aliasing error. See Section G-6 for details.

G-6. Avoiding Aliasing Error

Aliasing error occurs when the high frequency components of a signal are inadequately sampled, resulting in inflated estimates of the power associated with lower frequency components in an unpredictable manner. Aliasing error may arise from one or both of two sources: (1) originally sampling the signal at too low a rate, and: (2) selecting a **Frame Duration** option that results in an effective sampling rate that is inadequate to properly measure the high frequency components of the signal. The second source of error can be prevented by selecting a frame duration option yielding a frequency range that incorporates all of the frequency components of the signal or by eliminating the high frequency components of the signal using a low pass filter (the Waveform Processing module offers a low pass filter function). The first source of error can only be remedied by re-acquiring the signal using adequate sampling parameters. ***Using a low pass filter on an inadequately sampled signal does not eliminate aliasing error.***

G-7. Performing a Multiple Analysis

Each time you select the Power Spectrum Analysis window's  (Execute) button the program accumulates information into its internal PSA register. Provided that the **Auto Clear** button is left unchecked, the results obtained with each execution are added to previously obtained results. Adding data to the internal register over several executions is called a ***Multiple Analysis*****.** At the completion of each execution you can elect to open a different data file, change the method of selecting frames and the associated parameters, change the channel being analyzed, and so on. Note that you can perform a multiple analysis regardless of the frame selection method you employ -- even when you select frames individually. In which case, just change the starting time of the frame before each execution.

Additionally, you can elect to save the contents of the internal PSA register to a file at any time. The file can then be retrieved at a later time and new data can be added as desired. Click on the  (Save Results) button to save the contents of the internal PSA register to a file and click on the  (Load Results) button to retrieve them. When a results file is loaded the parameters that were in effect when the file was saved are retrieved along with the contents of the internal register, thus ensuring that the analysis is properly configured.

G-8. Removing Frames From the Internal PSA Register

The  (Delete) button in the Power Spectrum Analysis window is used to eliminate the data pertaining to one or more frames after the data has been accumulated and stored into the internal PSA register. Upon selecting the Delete button the Delete Frames window appears. An example is shown in Figure G-3.

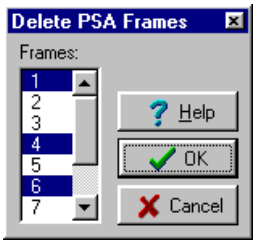


Figure G-3. An example of the Delete Frames window, used to eliminate unwanted frames from the internal PSA register.

To select a frame for deletion, highlight its number in the **Frames** list box. Hold down the shift or Control keys on the keyboard to select more than one frame at a time. Then select the **OK** button to delete the highlighted frames and return to the Power Spectrum Analysis Window.

☞ When frames are deleted the remaining frames are renumbered. Consequently, if you delete frame # 3, then the frame originally numbered 4 becomes frame # 3, and so on. The renumbering occurs after you select the OK button. Keep this in mind if you return to the Delete Frames feature.

G-9. Loading and Saving Parameter Files

Power spectrum analysis parameter files contain the parameters used to initialize a power spectrum or covariance analysis as well as the currently selected shared display parameters. The program automatically generates and uses a default parameter file, named DP3_95.PSA, to initialize the power spectrum analysis module when it is first opened. The default file is also automatically updated with the most recently selected parameters when the module is closed. Therefore, the default parameters are always the last-used parameters.

The power spectrum analysis module additionally allows users to load and save their own parameter files to initialize analyses. Select the  (Save Parameters) button to save the currently selected parameters to a file. Likewise, select the  (Load Parameters) button to load (retrieve) a previously saved parameter file.

The power spectrum analysis module also offers a related kind of file called a **results file**. A results file contains not only the parameters used to initialize an analysis and the shared display parameters, but also the data contained in the internal PSA register when the file was created. Results files therefore allow you to save an on-going analysis and return to it at a later time.

G-10. Loading and Saving Results Files

Results files are used to save the contents of the internal histogram analysis register, along with the parameters used to construct the register. Their purpose is to allow the user to save the data accumulated during an analysis and to return to the analysis at a later time. To save a results file, select the **Save Results** button in the Histogram window. To load (retrieve) a previously saved results file, select the **Load Results** button. Keep in mind that when you load a results file its contents replace the currently selected analysis parameters as well as the current contents of the internal histogram register.

Results files are used to save the contents of the internal PSA register, along with the analysis and shared display parameters. Their purpose is to allow the user to save the data accumulated during an analysis and to return to the analysis at a later time. To save a results file, select the  (Save Results) button in the Power Spectrum Analysis window. To load (retrieve) a previously saved results file, select the  (Load Results) button. Keep in mind that when you load a results file its contents replace the currently selected analysis parameters and shared display parameters as well as the current contents of the internal PSA register.

G-11. Shared Display Parameters

The power spectrum analysis module provides many individual types of display windows for viewing analyzed data. For example, one window can be used to display a spectral density function graphically while another can be used to present a table listing the power computed for each frequency component. To ensure consistency in the data presented in the various types of results displays that may be open at any given time the module is designed so that all results displays share the parameters that they all have in common. This common set of parameters is called the ***shared display parameters***, and a change in any one of them affects all of the results displays.

The shared display parameters can be accessed by selecting the **Shared Display Param** button in the Power Spectrum Analysis Parameters window or by selecting the **Shared** option in the menu bar of any results display window. An example of the shared display parameters window is shown in Figure G-4. As the example illustrates, the shared display parameters consist of the smoothing option in effect, the

display range (i.e., the range of frequency components included in the display), and whether the Y-axis is scaled in linear or logarithmic units. Details are provided in the following paragraphs.

☞ When performing a covariance analysis the **Smoothing** option and the **Y-Axis|Log** options are disabled.

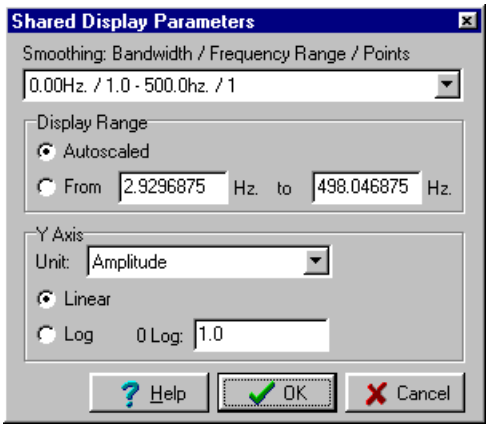


Figure G-4. An example of the Shared Display Parameters Window.

Smoothing

Smoothing is a moving average calculation that enhances the stability of the spectral density function, making dominant trends easier to see. The smoothing option is available only when performing a power spectrum analysis, not a covariance analysis.

Smoothing replaces the raw power coefficient of each frequency component in a spectral density function with the average value of the coefficients over a frequency band symmetrically placed around the original frequency component. The frequency bandwidth of the smoothing operation, along with the number of frequency components, or "points" contributing to each moving average calculation, and the frequency spectrum of the smoothed spectral density function are reported at the top of the Shared Display Parameters window. To adjust the bandwidth, click on the arrow button to the right of the current selection to open a drop-down list box containing the available options. An example is shown in Figure G-5. To select an option, click on it with your mouse.

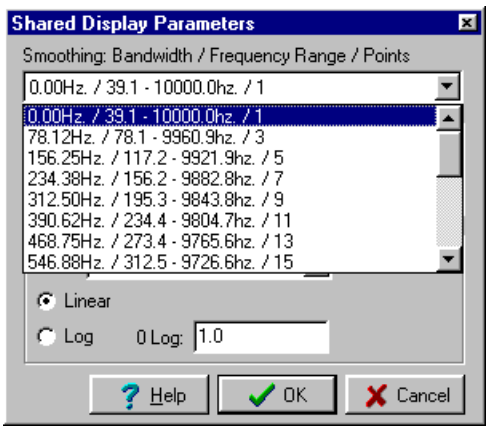


Figure G-5. An example of the smoothing list box, used to select a spectral smoothing option.

The frequency bandwidth of the smoothing operation, the frequency spectrum of the resulting smoothed spectral density function, and the number of frequency components, or "points" contributing to each moving average calculation, are reported for each available smoothing option (each line represents a separate option). Notice that the frequency band contributing to each average calculation is always composed of an odd number of frequency components since the band always includes the original component plus an equal number of components on either side. A bandwidth of 0.00 effectively turns the smoothing feature off, since only the original frequency component contributes to the moving average calculation.

Also notice that as the bandwidth increases the spectrum decreases proportionally. This is due to the fact that as more and more components are required for each moving average calculation, a symmetric frequency band cannot be placed around more and more components on the extreme ends of the available spectrum. If a symmetric frequency band cannot be placed around a given frequency component, that component is not included in the smoothed density function. Thus, the spectrum contracts.

Display Range

The display range refers to the range of frequencies reported in a table or graphics display. Select the **Autoscaled** option to ensure that the entire analyzed frequency spectrum is contained in the display. If you wish to display only a segment of the available frequency spectrum, select the **From** option and enter the minimum and maximum frequencies of the segment in the boxes provided. You can enter values that are greater than or less than the minimum and maximum frequencies of the analyzed spectrum, if desired.

Y-Axis Scaling

The **Unit** box is used to determine the units of measurement that will be used to present the data. There are two options: **Amplitude** and **Amplitude Squared (Power)**. If you select the Amplitude option, values are reported in whatever units were used to calibrate the amplitude of the channel in question. You can determine that by selecting the **File|Calibrate Channels** option from the main window's menu bar. It is quite popular to plot the amplitude of a spectral density function in units of amplitude rather than power. However, power should be used if you want to obtain a true power spectrum. Power is, of course, the square of the amplitude.

Select the **Linear** option to scale the axis in linear increments (linear scaling is the most popular). Alternatively, select the **Log** option to scale the axis in (base 10) logarithmic increments. When using the Log option you must specify a **0 Log** value, which is the magnitude of the linear power coefficient that is converted to zero log. For example, a 0 Log value of 100 causes the program to divide each power coefficient by 100 before converting it to a logarithmic value. Thus, a linear power coefficient of 100 is given a log value of 0.00, since 100/100 = 1, and the log of 1 is 0.00. Similarly, a linear power coefficient of 1000 is given a log value of 1.00, since 1000/100 = 10, and the log of 10 is 1.00.

G-12. Displaying the Results of an Analysis

To select a results display, first select the **Display** tab in the Power Spectrum Analysis Parameters window. The contents of the display tab appears as shown in Figure G-6.

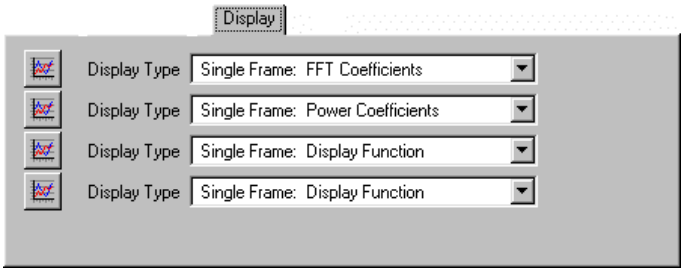


Figure G-6. The Display tab of the Power Spectrum Analysis parameters window.

Note that there are four identical rows of information. Each of them controls one of the four display windows that you have available to you. All four can be open at the same time, each of them containing a different type of display. To produce a display, select the desired display type from the list provided, then click on the corresponding  button.

☞ Display windows left open when the module is closed are automatically opened again, in the same location on the screen, when the module itself is reopened. Open windows are also automatically updated at the completion of the execution of an analysis.

The types of displays that are available at any given time partially depends upon the type of analysis you selected. Consequently, the options are listed below according to the type of analysis in which they are available. Additional information about each option is provided in Sections G-13 through G-22. You can select the same or different options for each of the four available windows.

Power Spectrum Analysis (FFT)

Single Frame: Display Function: A graphic display of the spectral density function computed from a single frame. The display can include all of the analyzed channels or any subset of them. The number of the frame can be selected and easily changed from within the display window.

Single Frame: Maximum Peaks: A table reporting the power coefficient and frequency of the 20 peaks of greatest magnitude, in descending order, within the spectral density function computed for a single frame. The number of the frame and the channel being reported can be selected and easily changed from within the table display window.

Single Frame: Power Coefficients: A table reporting the power coefficient and percent cumulative area for each frequency component in the spectral density function computed for a single frame. The number of the frame and the channel being reported can be selected and easily changed from within the display window.

Single Frame: FFT Coefficients: A table reporting the cosine (real) and sine (imaginary) components of the power coefficients in the spectral density function computed for a single frame. The number of the frame and the channel being reported can be selected and easily changed from within the display window.

Single Frame: Bandwidth Statistics: A table reporting the integrated (summed) power, mean power, and percent total area for up to 20 user-selected frequency bands in the spectral density function computed for a single frame. The number of the frame and the channel being reported can be selected and easily changed from within the display window.

Multiple Frames: Display Functions: A graphic display of the spectral density functions computed from all frames in the analysis, or from a selected range of frames. The functions are presented in a pseudo-3D "waterfall" arrangement. The channel being reported can be selected and easily changed from within the display window.

Multiple Frames: Mean, Median Freq.: A table reporting the mean and median frequencies obtained for the spectral density functions computed for all frames in the analysis, or from a selected range of frames. The channel being reported can be selected and easily changed from within the display window.

Averaged Frames: Display Function: A graphic display of the average spectral density function obtained from all frames in the analysis, or from a selected range of frames. The display can include all of the analyzed channels or any subset of them.

Averaged Frames: Maximum Peaks: A table reporting the power coefficient and frequency of the 20 peaks of greatest magnitude, in descending order, within the average spectral density function computed from all frames in the analysis, or from a selected range of frames. The channel being reported can be selected and easily changed from within the display window.

Averaged Frames: Power Coefficients: A table reporting the power coefficient and percent cumulative area for each frequency component in the average spectral density function computed from all frames in the analysis, or from a selected range of frames. The channel being reported can be selected and easily changed from within the display window.

Averaged Frames: Bandwidth Statistics: A table reporting the integrated (summed) power, mean power, and percent total area for up to 20 user-selected frequency bands in the spectral density function computed from all frames in the analysis, or from a selected range of frames. The channel being reported can be selected and easily changed from within the display window.

Covariance Analysis (COV)

Single Frame: Display Function: A graphic display of the covariance function computed from a single frame. The display can include all of the analyzed channels or any subset of them. The number of the frame can be selected and easily changed from within the display window.

Single Frame: Maximum Peaks: A table reporting the correlation coefficient and frequency of the 20 peaks of greatest magnitude, in descending order, within the covariance function computed for a single frame. The number of the frame and the channel being reported can be selected and easily changed from within the display window.

Single Frame: Correlation Coefficients: A table reporting the correlation coefficient for each frequency component in the covariance function computed for a single frame. The number of the frame and the channel being reported can be selected and easily changed from within the display window.

Multiple Frames: Display Functions: A graphic display of the covariance functions computed from all frames in the analysis, or from a selected range of frames. The functions are presented in a pseudo-3D "waterfall" arrangement. The channel being reported can be selected and easily changed from within the display window.

Averaged Frames: Display Function: A graphic display of the average covariance function obtained from all frames in the analysis, or from a selected range of frames.

Averaged Frames: Maximum Peaks: A table reporting the correlation coefficient and frequency of the 20 peaks of greatest magnitude, in descending order, within the average covariance function computed from all frames in the analysis, or from a selected range of frames. The channel being reported can be selected and easily changed from within the display window.

Averaged Frames: Correlation Coefficients: A table reporting the correlation coefficient for each frequency component in the average covariance function computed from all frames in the analysis, or from a selected range of frames. The channel being reported can be selected and easily changed from within the display window.

G-13. Single Frame: Display Function

When the analysis type is set to FFT the **Single Frame: Display Function** display option opens a display window similar to the one shown in Figure G-7. The display plots power on the Y-axis and frequency on the X axis for a single analyzed frame.

The **Frame** option in the display window's menu bar can be used to display the data obtained from different frames. The **Shared** option in the window's menu bar provides access to the group of parameters that are shared by all of the display types. See Section G-11 for details. The **Format** option provides access to the parameters that are unique to the present type of display. Such parameters include the Y axis coordinates, the color used to plot the data, whether the grid is included in the display box, and whether the multiplot option is enabled. See Section G-13.1 for additional details.

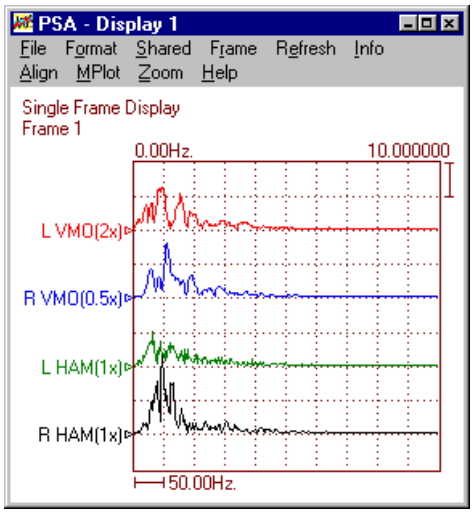


Figure G-7. An example of the Single Function: Display Function display window when performing a power spectrum (FFT) analysis.

G.13.1. The Format Window (Single Frame Display)

The Format PSA Display parameter window associated with the power spectrum analysis module's single frame display is used to edit the parameters of the display which are not shared by all of the other available display types. The same parameter window is used in the contexts of both the power spectrum (FFT) and covariance (COV) analyses. An example of the window is shown in Figure G-8.

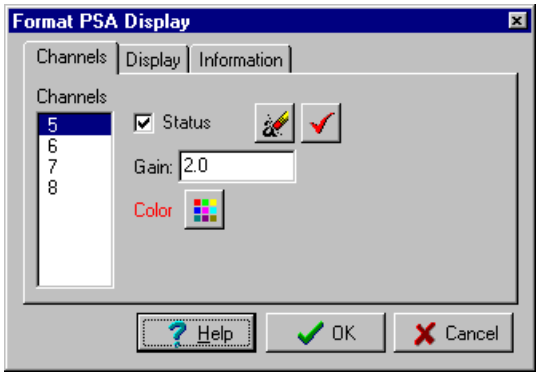


Figure G-8. An example of the display parameters window associated with the Single Frame: Display Function display type.

As you can see, the window broken down into three tabbed sections: **Channels**, **Display**, and **Information**. The contents of each tab are described briefly below. The parameters included in each tab are described in Table G-2.

Channels: Add/remove channels from the display, change their display gains and colors individually.

Display: Add, edit, or remove a title to the display, change the Y-Scale value, turn the display grid on/off and change its density, turn the multiplot mode on/off.

Information: Select the channel to monitor with the **Info** command cursors.

Only the Display and Channels tabs contain the parameters that govern the contents and appearance of the display, and their contents function almost identically to their counterparts in Datapac 2K2's standard time series displays described in Chapter 2. Consequently, if you know how to produce manipulate a standard time series display, you should be able to manipulate a spectral density function display as well. But as a short refresher: the location of the highlight within the **Channels** list box along left edge of the Channels tab determines the channel of the data file whose parameters are reported to the right. To add a channel to the display, either, (1) double-click its number in the Channels list box, or; (2) highlight its number in the Channels list box, then check the **Status** check box. Likewise, to remove a channel from the display, either double-click on its number again, or clear the Status check box.

Table G-2. Options of the Format Window

Channels Tab

Channels: This list box lists the channels that have been analyzed. All of the parameters reported in the remainder of the tab are associated with the channel currently highlighted in the list box. Consequently, as you highlight different channels or buffers the parameter values change accordingly. To include or exclude the highlighted channel in the display, check or clear the **Status** check box, respectively. To quickly add or remove all of the channels, click the  or  buttons, respectively.

Status: Check the Status check box to include the highlighted channel in the display, or clear it to exclude the channel.

Gain: Sets the display gain for the highlighted channel. It works by multiplying the amplitude value of each data point by the gain value. See also the **Y-Scale** parameter.

Color: Indicates the display color selected for the channel. To change the channel's display color, click the  button to access a color palette window. When the palette window appears, notice the box surrounding the currently selected color.

☞ Some older display adapter use a process called dithering to produce some of the colors in the palette. Dithered colors cannot be used to produce lines. Therefore the color displayed on the screen may not exactly match the color selected from the palette.

Display Tab

Title: The display title is a text string that you feel best describes the contents of the display. The title appears at the top of the display. If you save the display parameters to a parameter file, the display title also serves as the parameter file title, and can be used as a long file name when retrieving the file.

Y-Scale: Indicates the change in amplitude represented by the length of the dimension bar at the top right corner of the display. Note that the length of the dimension bar is equal to one division of the display grid. The Y-Scale value applies to all channels within the display.

☞ Also keep in mind that each channel in the display possesses its own individually adjustable gain value. Therefore, to determine the amplitude change represented by one division of the display grid for any given channel, divide the channel's gain value by the Y-Scale value. For example, if the Y-Scale value is 100, and a given channel's gain value is set at 5, then the amplitude difference represented by the distance between two successive grid lines is 20 (100 / 5 = 20).

Grid, Hor[izontal], and Ver[tical]: The **Grid** check box turns the display grid on and off. When the box is checked a grid of horizontal and vertical lines appears in the display. When unchecked the grid does not appear. The values entered in the **Hor[izontal]:** and **Ver[tical]:** boxes indicate the number of grid lines in each dimension.

Report Channel Titles: Determines whether the channel titles or the channel numbers are reported in the display. Check the check box to report channel titles, or clear it to report channel numbers.

Report Gains: Check this box if you want to report the display gains of each channel in the display. The display gains are indicated in parentheses outside the left edge of the display box, after the number, letter, or title of the corresponding channel.

☞ Divide the channel's individual gain value by the Y-Scale value to obtain a measure the signal amplitude per division of the display grid.

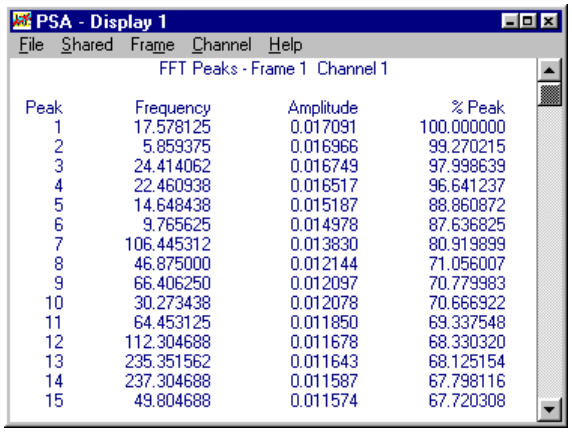
Multi-Plot: Check this check box to turn the Multi-Plot option on, or clear it to turn it off.

Information Tab

Channel: Indicates the channel monitored by the Info cursors.

G-14. Single Frame: Maximum Peaks

The **Single Frame: Maximum Peaks** option opens a window presenting the local peaks of greatest magnitude in descending order. An example is shown in Figure G-9. The frequency (in Hertz), power (in whatever calibration units are selected for the analyzed channel) and percentage of the maximum peak are reported for each peak found.

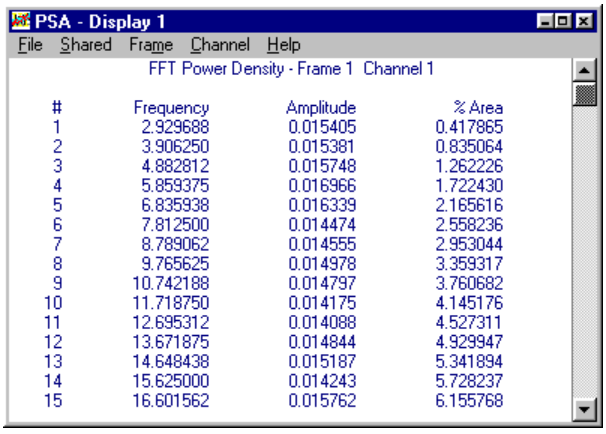


Peak	Frequency	Amplitude	% Peak
1	17.578125	0.017091	100.000000
2	5.859375	0.016966	99.270215
3	24.414062	0.016749	97.998639
4	22.460938	0.016517	96.641237
5	14.648438	0.015187	88.860872
6	9.765625	0.014978	87.636825
7	106.445312	0.013830	80.919899
8	46.875000	0.012144	71.056007
9	66.406250	0.012097	70.779983
10	30.273438	0.012078	70.666922
11	64.453125	0.011850	69.337548
12	112.304688	0.011678	68.330320
13	235.351562	0.011643	68.125154
14	237.304688	0.011587	67.798116
15	49.804688	0.011574	67.720308

Figure G-9. An example of the Single Frame: Maximum Peaks display window when performing a power spectrum (FFT) analysis.

G-15. Single Frame: Power Coefficients

The **Single Frame: Power Coefficients** option opens a window containing a table reporting the power coefficient and the percent cumulative area for each frequency component in the spectral density function computed for a single frame. An example is shown in Figure G-10.



#	Frequency	Amplitude	% Area
1	2.929688	0.015405	0.417865
2	3.906250	0.015381	0.835064
3	4.882812	0.015748	1.262226
4	5.859375	0.016966	1.722430
5	6.835938	0.016339	2.165616
6	7.812500	0.014474	2.558236
7	8.789062	0.014555	2.953044
8	9.765625	0.014978	3.359317
9	10.742188	0.014797	3.760682
10	11.718750	0.014175	4.145176
11	12.695312	0.014088	4.527311
12	13.671875	0.014844	4.929947
13	14.648438	0.015187	5.341894
14	15.625000	0.014243	5.728237
15	16.601562	0.015762	6.155768

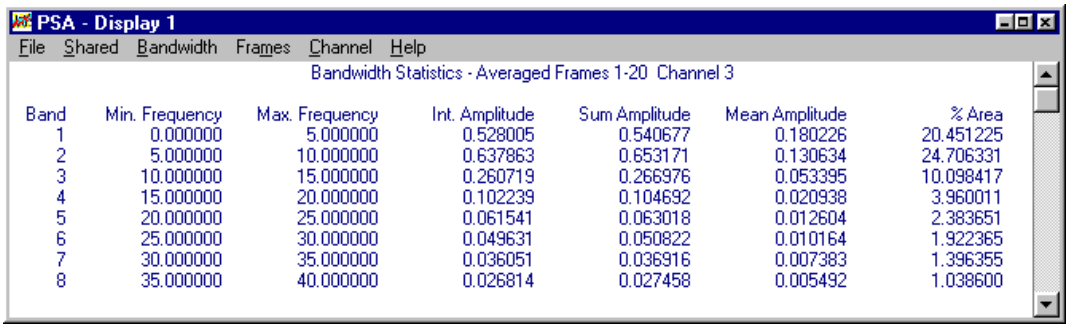
Figure G-10. An example of the Single Frame: Power Coefficients display window when performing a power spectrum (FFT) analysis.

G-16. Single Frame: Bandwidth Statistics

The **Single Frame: Bandwidth Statistics** option opens a window containing a table reporting the integrated power, summed power, mean power, and percent total area for a set of user-selected frequency bands in the spectral density function computed for a single frame. An example is shown in Figure G-11.

The columns labeled, "Min. Frequency" and "Max. Frequency" respectively report the minimum and maximum boundaries of the currently defined frequency bands. Select the **Bandwidth** option in the window's menu bar to open a parameter window allowing you to add, delete, or to edit the frequency bands reported in the table. Details are provided in Section G-16.1.

To change the frame you are viewing, select the **Frame** option from the window's menu bar and enter the number of the frame you wish to view. The vertical scroll bar can be used to view the frequency bands not currently included in the display.



Band	Min. Frequency	Max. Frequency	Int. Amplitude	Sum Amplitude	Mean Amplitude	% Area
1	0.000000	5.000000	0.528005	0.540677	0.180226	20.451225
2	5.000000	10.000000	0.637863	0.653171	0.130634	24.706331
3	10.000000	15.000000	0.260719	0.266976	0.053395	10.098417
4	15.000000	20.000000	0.102239	0.104692	0.020938	3.960011
5	20.000000	25.000000	0.061541	0.063018	0.012604	2.383651
6	25.000000	30.000000	0.049631	0.050822	0.010164	1.922365
7	30.000000	35.000000	0.036051	0.036916	0.007383	1.396355
8	35.000000	40.000000	0.026814	0.027458	0.005492	1.038600

Figure G-11. An example of the Single Frame: Bandwidth Statistics display window when performing a power spectrum (FFT) analysis.

G-16.1. The Bandwidth Parameters Window.

The Bandwidth Parameters Window allows you to add, delete, or to change the boundaries of the frequency bands reported in the associated bandwidth statistics table display. An example is shown in Figure G-12. The same parameter window is used with both the single frame and averaged frames bandwidth statistics table displays.

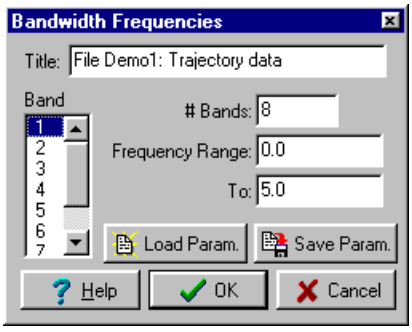


Figure G-12. An example of the bandwidth parameters window.

Title: A line of text that serves as the title of the parameter file if the currently selected parameters are saved to a parameter file (using the **Save Param** option). The title can be used as a long file name when retrieving the file (using the **Load Param** option).

Band: A list box reporting all of the currently selected frequency bands. The minimum and maximum boundaries of the frequency range associated with the highlighted band is reported in the corresponding boxes to the right. Therefore, to change the boundaries of a frequency band you must first highlight its number in this box.

 # Bands: Determines the number of frequency bands included in the bandwidth statistics table.

Frequency Range: Determines the minimum and maximum boundaries of the frequency range associated with the band that is currently highlighted in the **Band** list box.

Load Param: Use this button to retrieve a previously saved bandwidth parameter file. Parameter files saved from within the single frame and the averaged frames bandwidth statistics options can be used interchangeably.

Save Param: Use this button to save the currently selected set of bandwidth parameters to a file for later use.

G-17. Multiple Frames: Display Functions

The **Multiple Frame: Display Functions** display option opens a display window similar to the one shown in Figure G-13. As the example illustrates, the display plots power on the Y-axis and frequency on the X axis for a selected sequence of analyzed frames. Each successive frame is slightly offset above and to the right of the previous one, producing a three dimensional “waterfall” effect.

The **Shared** option in the window's menu bar provides access to the group of parameters that are shared by all of the display types. Thus, if you adjust a shared parameter in one type of display, the change is effected in all other display types. See Section G-11 for details. The **Display** option provides access to the parameters that are unique to the present type of display. Such parameters include the range of frames displayed, the Y axis coordinates, the color used to plot the data, and whether or not the grid lines appear in the display.

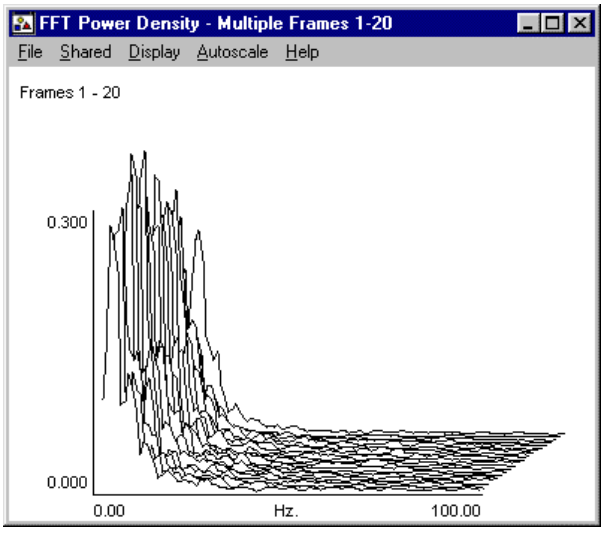


Figure G-13. An example of the Multiple Frame: Display Functions display window when performing a power spectrum (FFT) analysis.

☞ The multiple frame display does not possess a zoom feature. However, since the single frame display *does* have a zoom feature, and since the function of the zoom feature is to adjust the coordinates of the X-axis, which are considered shared display parameters, you can use a single frame display to adjust the zoom of a multiple frame display.

G-18. Multiple Frames: Mean, Median Frequency

The **Multiple Frames: Mean, Median Frequency** option opens a window containing a table reporting the mean and median frequencies obtained for each frame in the analysis. An example is shown in Figure G-14. Use the vertical scroll bar to view the data obtained for frames not currently included in the display. Select the **Channel** option in the window's menu bar to view the results obtained from a different channel.

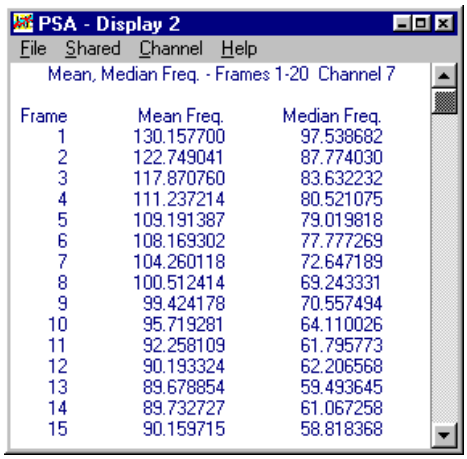


Figure G-14. An example of the Multiple Frames: Mean, Median Frequency display window when performing a power spectrum (FFT) analysis.

G-19. Averaged Frames: Display Function

When the analysis type is set to FFT the **Averaged Frames: Display Function** display option opens a display window similar to the one shown in Figure G-15. The display plots power on the Y-axis and frequency on the X axis for the spectral density function obtained by averaging the spectral density functions associated with all of the analyzed frames or a selected subset of them.

The **Shared** option in the window's menu bar provides access to the group of parameters that are shared by all of the display types. See Section G-11 for details. Select the **Frames** option of the display window's menu bar to select which frames are included in the average. Finally, select the **Format** option to adjust the formatting parameters that are not included in either the **Shared** or **Frames** options. Such parameters include the channels that appear in the display, their gains and colors, the Y axis gain, and whether or not the grid lines appear in the display. The operation of the Format option is almost identical to that associated with the single frame display windows, as described in Section G-13.1.

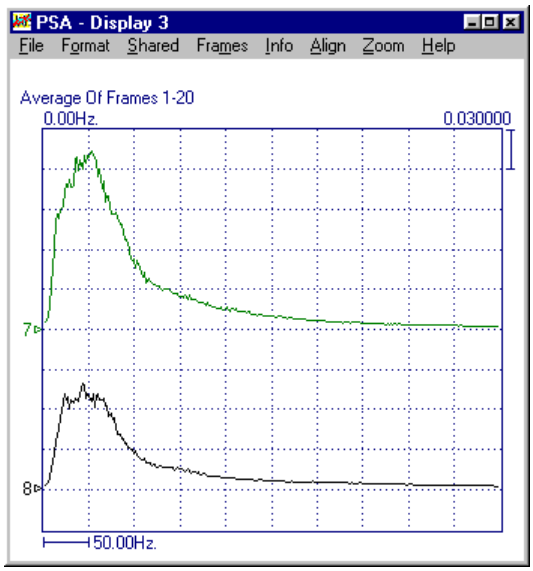
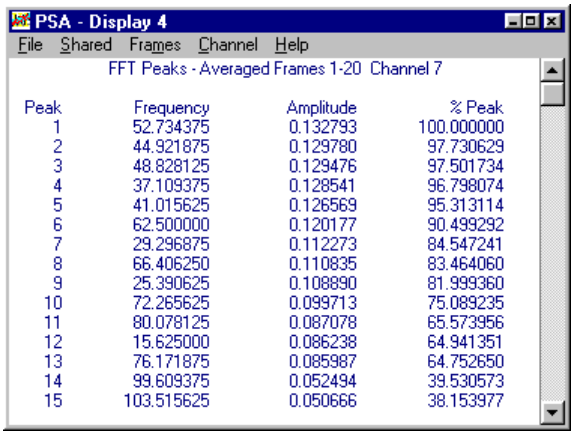


Figure G-15. An example of the Averaged Frames: Display Functions display window when performing a power spectrum (FFT) analysis.

G-20. Averaged Frames: Maximum Peaks

The **Averaged Frames: Maximum Peaks** option opens a window presenting the local peaks of greatest magnitude in descending order in the averaged spectral density function obtained by averaging the individual spectral density functions associated with all of the analyzed frames or a selected subset of them. An example of the window is shown in Figure G-16. The frequency (in Hertz), power (in whatever calibration units are selected for the analyzed channel) and percentage of the maximum peak are reported for each peak found. Select the **Frames** option of the display window's menu bar to select which frames are included in the average.

The vertical scroll bar can be used to view the data for peaks not currently included in the display. The program obtains data for each and every local peak it finds in the selected average. Consequently the table may contain several hundred lines of information.



Peak	Frequency	Amplitude	% Peak
1	52.734375	0.132793	100.000000
2	44.921875	0.129780	97.730629
3	48.828125	0.129476	97.501734
4	37.109375	0.128541	96.798074
5	41.015625	0.126569	95.313114
6	62.500000	0.120177	90.499292
7	29.296875	0.112273	84.547241
8	66.406250	0.110835	83.464060
9	25.390625	0.108890	81.999360
10	72.265625	0.099713	75.089235
11	80.078125	0.087078	65.573956
12	15.625000	0.086238	64.941351
13	76.171875	0.085987	64.752650
14	99.609375	0.052494	39.530573
15	103.515625	0.050666	38.153977

Figure G-16. An example of the Averaged Frames: Maximum Peaks display window when performing a power spectrum (FFT) analysis.

G-21. Averaged Frames: Power Coefficients

The **Averaged Frames: Power Coefficients** option opens a window containing a table reporting the power coefficient and the percent cumulative area for each frequency component in the averaged spectral density function obtained by averaging the individual spectral density functions associated with all of the analyzed frames or a selected subset of them. An example of the window is shown in Figure G-17. The vertical scroll bar can be used to view the frequency components not currently included in the display. Select the **Frames** option of the display window's menu bar to select which frames are included in the average.

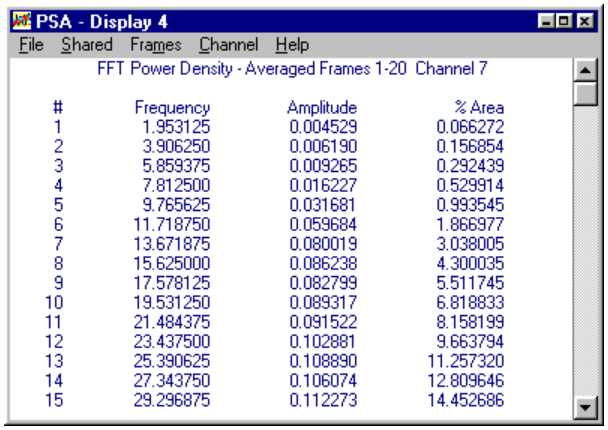


Figure G-17. An example of the Averaged Frames: Power Coefficients display window when performing a power spectrum (FFT) analysis.

G-22. Averaged Frames: Bandwidth Statistics

The **Averaged Frames: Bandwidth Statistics** option opens a window containing a table reporting the integrated power, summed power, mean power, and percent total area for a set of user-selected frequency bands in the averaged spectral density function obtained by averaging the individual spectral density functions associated with all of the analyzed frames or a selected subset of them. An example is shown in Figure G-18. The vertical scroll bar can be used to view the frequency bands not currently included in the display.

The columns labeled, "Min. Freq." and "Max. Freq." respectively report the minimum and maximum boundaries of the currently defined frequency bands. Select the **Bandwidth** option in the window's menu bar to open a parameter window allowing you to add, delete, or to edit the frequency bands reported in the table. Details are provided in Section G-16.1. The same bandwidth table parameters can be used to format bandwidth tables in both the single frame and averaged frames display contexts. Select the **Frames** option of the display window's menu bar to select which frames are included in the average.

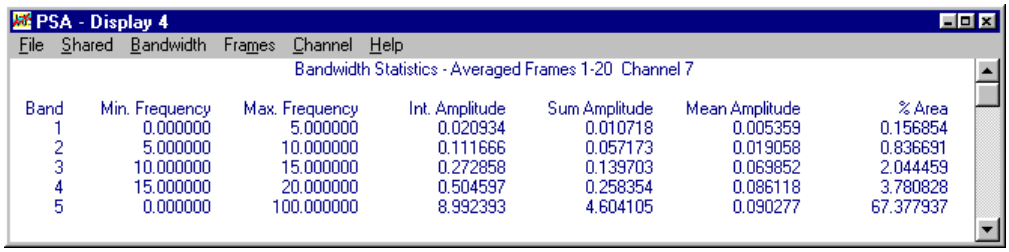


Figure G-18. An example of the Averaged Frames: Bandwidth Statistics display window.