Chapter H: The Scientific Spreadsheet Module

Datapac 2K2 User's Manual, Ver 3

Chapter H: The Scientific Spreadsheet Module

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H-1. Introduction

The Scientific Spreadsheet is a signal-oriented spreadsheet package with the ability to measure and report multiple characteristics of the events from multiple event files and to assess their relationships. Pre-defined characteristics, or “attributes” include onset time, offset time, duration, on-on, off-on, and off-off intervals, instantaneous rate, peak amplitude, mean amplitude, and integrated amplitude, peak and mean velocity, and many more. Logical, mathematical, and statistical functions can also be used to derive additional information such as relative onset times, normalized durations, amplitudes or latencies measured relative to group means, and more. Finally, the Scientific Spreadsheet module contains several event editing tools not found in the Event Selection and Editing module, including the virtual events, recalculate events, time filter, and the manual and graphical range filter features.

H-2. Entering the Scientific Spreadsheet module

To access the Scientific Spreadsheet module, select the **Analysis|Scientific Spreadsheet** option from the main window menu bar or select the  icon from the main window tool bar. Either way, the result is to open the Scientific Spreadsheet Control Panel window. An example is shown in Figure H-1.

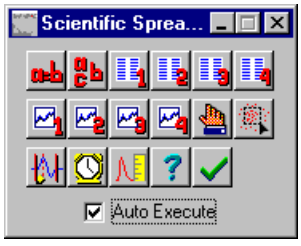


Figure H-1. The Scientific Spreadsheet Control Panel.

Defining Attribute Variables:

Before you can do anything else in the Scientific Spreadsheet module you must define the attribute variables you wish to use. There are four types of attribute variables: primary, equation, function, and range variables. A ***primary attribute variable***, the most basic form of attribute variable, specifies a kind of measurement (peak amplitude, duration, etc.) to be performed on a specific set of events, when those events are applied to a particular channel. ***Equation variables*** specify a mathematical relationship between two other variables. ***Function variables*** apply a function to another variable. Finally, **range variables** apply a statistical operation to the values obtained for selected sequences of events. For example, range variables make it possible to obtain the mean peak amplitude of every 10 events in a set, or the mean peak amplitude of all the events in one set that occur over the duration of each event in another set. To define attribute variables, select the control panel's  **(Define Variables)** button. Additional details are provided in Section H-3.

Virtual Events:

The Virtual Events feature is a new feature introduced in Version 2 that allows you to create sets of imaginary events using attribute variables to define their onset and offset boundaries. Virtual events are particularly useful as a quick and easy way to subdivide existing events into individual components, thereby making it possible to define additional attribute variables to measure the characteristics of each component separately. Additional details are provided in Section H-10.

Producing Attribute Tables:

After you have defined the attribute variables that you wish to use, you are ready to present them in an attribute table. Attribute tables itemize, for each event, the measurements obtained for selected variables. Additional details are provided in Section H-11.

Producing Scatter Plots and Line Plots:

Another way to present the attribute variable data is in the form of a scatter plot or line plot. Scatter plots and line plots are two-dimensional arrays where each point in the array represents the measurements obtained for one event (or the same-numbered event in two different event files) on two variables. One variable is plotted along the X-axis and one variable is plotted along the Y-axis. Additional details are provided in Section H-12.

Editing and Sorting Events:

The Scientific Spreadsheet module also provides several options for editing and sorting events: the Manual and Graphical Range Filters, the Recalc. Boundaries, and the Time Filter options. The **Manual Range Filter** and **Graphic Range Filter** options can be used to eliminate events with measured values which fall either inside or outside a specified range. The **Recalc. Boundaries** option can be used to adjust the onset and/or offset boundaries of the events in a selected event buffer to equal the values obtained for any other attribute variable. The **Time Filter** option can be used to rearrange the events in one or more event buffers so that they fall within a specified interval of the events within a event buffer selected as the reference. Additional details are provided in Sections H-14 through H-17.

Automatically Calibrating Channel Amplitudes:

The Scientific Spreadsheet module also provides a feature for automatically calibrating channel amplitudes. The Auto Calibrate Channels feature makes all the power and versatility of the module's attribute variables features available to you for the task of automatically calibrating the amplitudes of your input signals. See Section H-18 for details.

H-3. Defining Attribute Variables

In the simplest case the term, "***attribute variable***" refers to a type of measurement made for each event in a selected event buffer when applied to a particular channel. But the term can also refer to an equation that specifies a relationship between other attribute variables, or a function that is performed on a variable. The simplest type of attribute variable is called a **primary variable**. Attribute variables that specify a relationship between other variables are called **equation variables.** Those that specify a function performed on another variable are called **function variables**. Primary, equation, and function variables all return a value for each event in the relevant event buffer. In contrast, a fourth type of attribute variable, called **range variables**, return a single value for each of a *group* of values obtained for some other variable. An example of a range attribute variable is the mean peak amplitude computed for those events in event buffer B which occurred within the duration of each event in event buffer A. The values obtained for the attribute variables you define can be reported in the form of tables (called attribute tables) or in scatter plots and line plots. But you can't generate any tables or scatter plots until you define the attribute variables you wish to use.

To define one or more attribute variables, first select the **Define Variables** option from the scientific spreadsheet control panel. Doing so opens the Define Attribute Variables parameter window. An example is shown in Figure H-2.

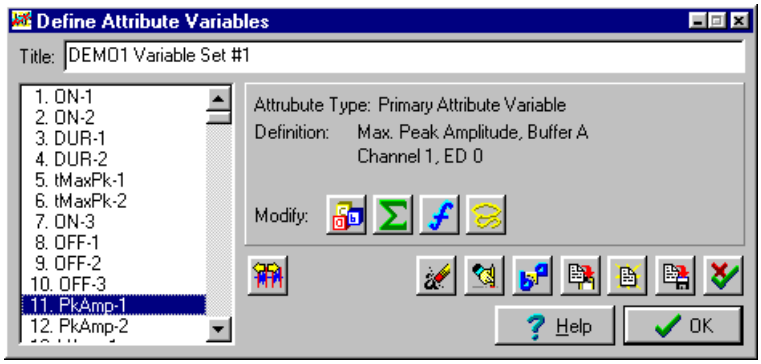


Figure H-2. The Define Attribute Variables parameter window.

The list box on the left side of the parameter window lists the names of the variables that have already been defined, if any. Blank spaces appear where no variables have been defined. You can define up to 500 different variables if need be.

The area to the right of the list box describes the variable whose name is currently highlighted in the list box. For example, the highlighted variable in the example shown in Figure H-2 is named "PkAmp-1". The area to the right of the list box indicates that the variable is a primary variable and that it measures the maximum peak amplitude of the events in event buffer A, when applied to Channel 1. The "ED 0" at the end means that events are not "displaced". For more information on the event displacement feature, refer to Section H-4.

Immediately below the area that describes the highlighted variable is a row of four buttons:  (Primary Attribute),  (Equation Attribute),  (Function Attribute), and  (Range Attribute). These buttons are used to define or redefine the highlighted variable as one of the four types of attribute variables: **Primary**, **Equation**, **Function**, and **Range** attributes, respectively. For additional information on defining these types of variables, see Sections H-4 through H-7.

Another series of ten buttons are provided below the three buttons just described. The functions of the **Help** and **OK** buttons should be obvious enough, but the functions of the remaining eight buttons are described in the following paragraphs.

 **(Virtual Event Buffers):** Click this button to access the virtual events feature. Virtual events are imaginary events that are computed on the basis of variable values obtained for specified attribute variables. Once a set of virtual events is created, they can be used just like any other event buffer for the purposes of defining other attribute variables. See Section H-10 for additional information.

 **(Clear):** This button deletes the currently highlighted variable. The variable's name is erased and its definition is set to a constant value of zero.

 **(Clear All):** This button deletes all of the currently defined variables. Once they are deleted they cannot be retrieved, so **USE THIS OPTION WITH GREAT CAUTION.**

 **(Replace Labels, Buffers, Channels):** Use this option to edit one or more attribute variables by replacing the buffer or channel identified in it with another, or by replacing a text string that appears in their labels with another. Buffers, channels, and labels can all be replaced at the same time. See Section H-9 for additional information.

 **(Copy Variables):** Use this button to copy one or more attribute variables from one location to another. For example, you can use this button to copy the variables listed as #1 through #10 to the locations listed as #51 through #60. See Section H-9 for additional information.

☞ The copy operation produces two identical sets of variables. **When two variables have the same label, (regardless of whether or not they are identical in other respects) the program recognizes only the variable in the lower numbered location.** Consequently, after you copy a set of variables from one location to another, it is a good idea to either clear the variables from their original locations or to modify one set by changing their labels, the event buffers, or the channels to which the measurements are applied. The **Replace Labels, Buffers, Channels** button, described above, is provided for that purpose.

 **(Load Variables):** Use this button to replace the currently defined set of variables and virtual event buffers with a set retrieved from a file previously saved to disk with the **Save Variables** button.

 **(Save Variables):** Use this button to save the currently defined set of variables and virtual event buffers to a file. Once saved the file can be retrieved at a later date so that you may restore the same set of variables and virtual event buffers to memory.

H-3.1. Saving and Retrieving Attribute Variables and Virtual Events

Whenever the Scientific Spreadsheet Module is closed the attribute variables and virtual event buffers defined at that time are saved as the default set. Those variables and virtual event buffer definitions are then automatically presented the next time the module is opened. Users can also elect to save and then to retrieve their own sets of variables and virtual event buffers at any time while the Scientific Spreadsheet Module is open. To save the currently defined set of attribute variables and virtual event buffers to a file, select the  **(Save Variables)** button in the Define Attribute Variables parameter window. Likewise, to later retrieve a previously saved set, select the  **(Load Variables)** button.

H-4. Defining Primary Variables

Primary variables are the simplest and most basic form of attribute variable. In general, they define a specific type of measurement to be obtained for each event in a selected event buffer when applied to a selected channel. For example, **integrated amplitude calculated for the events in event buffer A when applied to Channel 1** is an example of a primary attribute variable. *Before you can do anything else in the Scientific Spreadsheet module you must define at least one primary attribute variable.* You can produce no attribute tables nor any scatter plots or line plots until you have defined the attribute variables you wish to include in them. Moreover, since equation variables and function variables are both ultimately derived from one or more primary variables, at least one primary variable must be defined first. Of course, you can define many more than one if desired – up to 500 at any one time. Most applications will require you to define several.

To define a primary variable, place the highlight at the desired location of the attribute variable list box in the Define Attribute Variables window, then select the  **(Primary Attribute)** button to the right of the list box. Doing so opens the **Define Primary Attribute Variable window**. An example is shown in Figure H-3. Each option in the window is briefly described in Table H-1, and in more detail in the remaining paragraphs of this section.

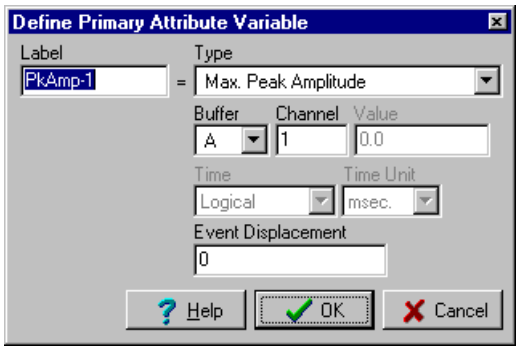


Figure H-3. The Define Primary Attribute Variable parameter window.

Label, Type, Buffer, and Channel

Each variable that you define must be given its own name, or "label". That is what the **Label** box is for. The label can be any string of up to 15 characters, and it will be used in all other locations within the module to identify the variable that you define using the set of seven boxes to the right. As mentioned in an earlier paragraph, a primary variable typically defines a specific type of measurement to be obtained for each event in a selected event buffer when applied to a selected channel. The **Type**, **Buffer** and **Channel** boxes, respectively, are used to insert the necessary information. Thus, as the example in

Figure H-3 illustrates, the label "PkAmp-1" has been given to the primary variable that specifies that the maximum peak amplitude will be obtained for each event in Buffer A, when applied to Channel 1. Many different types of primary attribute measurement options are available. A list of all of the different types of primary attribute measurements is provided in Section H-4.1.

Depending upon the type of measurement you choose, additional items of information may be required to uniquely and adequately define the variable. Other times, however, it is not even necessary to define the three items of information just mentioned. For example, it is not usually necessary to specify a channel when the selected type of attribute involves a simple measure of time. At any rate, **whenever a particular item of information is not needed, the box or boxes associated with it are grayed out and inaccessible.** For example, in the illustration shown in Figure H-3, the Value, Time and Time Unit boxes are grayed out because they are not needed to define a variable based on a maximum peak amplitude measurement.

Table H-1. Options of the Define Primary Attribute Variable Window.

Label: Use this box to enter or edit the name that is attached to the attribute variable you are specifying. The label can be any string of 15 characters or less, and it is used to specify the defined variable in all other locations in the Scientific Spreadsheet module.

Type: This box indicates the type of primary attribute the program will measure. During regular operation, click on the box to access a list the available alternatives. See Section H-4.1 for descriptions of them.

Buffer: This box lets you select the event buffer linked to the event file containing the events you wish to measure.

Channel: This box lets you select the channel you will measure.

Value: This parameter is used for different things depending upon the type of attribute measurement you select. For example, when you select the **Constant Value** attribute type, the Value box indicates the value of the constant. When you select the **Amplitude of % to UPA** attribute type (UPA is an acronym for "upper peak amplitude") then the Value box indicates the percentage value used in the calculation.

Time: This box lets you choose whether time values are expressed in logical or physical coordinates.

Time Unit: This box lets you specify the unit of measurement used to express time values.

Event Displacement: This box allows you to effectively adjust the numbering of events to make it easier to compare events with different numbers. For example, if the event displacement option is set to "4", then each event number in the specified buffer is reduced by 4. Event # 5 is therefore considered Event # 1. Event # 6 is considered Event # 2, and so on.

Value, Time, Time Unit, and Event Displacement:

Finally, other kinds of information are sometimes necessary to completely define a primary variable. Note that the Define Primary Attribute Variable window also includes boxes labeled **Value**, **Time**, **Time Unit** and **Event Displacement**. Their functions are described below. The items of information needed to define each type of primary attribute variable are presented in Table H-2.

Value: This box provides a way of indicating a numerical value that is employed in certain types of measurements. For example, the measurement type **Constant Value** returns a constant for each event. The value of the constant is indicated in the Value box. Additionally, many different types of measurements involve the calculation of percentage amplitude. The Value box indicates the percentage value in question. For example, the measurement type **Amp. of Onset to % Max. Peak** measures the change in amplitude between the onset boundary of an event to a selected percentage of its maximum peak amplitude. The percentage you wish to employ is entered in the Value box.

Time: This box indicates whether time values are reported in physical or logical time coordinates. When a data file was acquired in continuous fashion, with no gaps in between, then there is no difference in physical and logical time coordinates. They may be used interchangeably. However, when a data file was acquired discontinuously, such as a series of individual trials, then the physical and logical time coordinates may differ. Care must be taken to select the correct type of coordinates for the intended task.

Time Unit: This box indicates the units of measurement used to report time values such as onset time, duration, interval, and the like. The options are microseconds, milliseconds and seconds.

Event Displacement: This box allows you to effectively adjust the numbering of events to make it easier to compare events with different numbers. For example, if the event displacement option is set to "4", then each event number in the specified buffer is reduced by 4. Event # 5 is therefore considered Event # 1. Event # 6 is considered Event # 2, and so on. The event displacement value can be either positive or negative. A value of "0" effectively turns the displacement option off. If a negative value is selected then the first "n" events are considered null events. For example, if the event displacement value is set to "-3", then Events # 1, 2, and 3 are null, and the original Event # 1 is considered Event # 4. Likewise, the original Event # 2 is considered Event # 5, and so on.

H-4.1. Types of Primary Attributes

Raw Value, Column 1: Directly reports the values contained in column 1 of the selected event buffer (Column 1 of the event buffer normally contains event onset times in physical time notation, but they may have been replaced with other values).

Raw Value, Column 2: Directly reports the values contained in column 2 of the selected event buffer (Column 2 of the event buffer normally contains event offset times in physical time notation, but they may have been replaced with other values).

Raw Value, Column 3: Directly reports the values contained in column 3 of the selected event buffer (Column 1 of the event buffer normally contains event onset times in logical time notation, but they may have been replaced with other values).

Constant Value: Reports the value contained in the **Value** box. The same value is reported for each event.

Event Number: Reports the index number of each event.

Event Status: Reports a value of 1 for valid events and a value of 0 for null events.

Onset Time: Reports the time of the onset boundary of each event in either physical logical time coordinates. The units of measurement used to report the values depends upon the **Time Unit** option that you select.

Table H-2. Information Needed for Individual Primary Attribute Variables.
(Event Displacement is never required and therefore omitted from this table)

Type	Buffer	Channel	Value	Time	Time Unit
Raw Value, Column 1:	X				
Raw Value, Column 2:	X				
Raw Value, Column 3:	X				
Constant Value			X		
Event Number					
Event Status	X				
Onset Time	X			X	X
Offset Time	X			X	X
Onset Amplitude	X	X			
Duration	X			X	X
Onset to Onset Interval	X			X	X
Offset to Offset Interval	X			X	X
Rate	X			X	X
Integrated Amplitude	X	X			X
Mean Amplitude	X	X			
S.D. of Amplitude	X	X			
Variance of Amplitude	X	X			
RMS Amplitude	X	X			
Max. Peak Amplitude	X	X			
Min. Peak Amplitude	X	X			
Time of Max. Peak	X	X		X	X
Time of Min. Peak	X	X		X	X
Mean Velocity	X	X			X
Max. Velocity	X	X	X		X
Min. Velocity	X	X	X		X
Time of Max. Velocity	X	X	X	X	X
Time of Min. Velocity	X	X	X	X	X
Length of Path	X	X			
Normalized Length of Path	X	X			X
First Upper Peak Amplitude	X	X			
First Lower Peak Amplitude	X	X			
Time of First Upper Peak	X	X		X	X
Time of First Lower Peak	X	X		X	X
Amp. of Onset to % Max. Peak	X	X	X		
Amp. of Onset to % Min. Peak	X	X	X		
Amp. of Offset to % Max. Peak	X	X	X		
Amp. of Offset to % Min. Peak	X	X	X		
Time of Onset to % Max. Pk (onset)	X	X	X	X	X
Time of Onset to % Max. Pk (offset)	X	X	X	X	X
Time of Onset to % Min. Pk (onset)	X	X	X	X	X
Time of Onset to % Min. Pk (offset)	X	X	X	X	X
Time of Max. Pk to % Max. Pk (onset)	X	X	X	X	X
Time of Max. Pk to % Max. Pk (offset)	X	X	X	X	X
Time of Min. Pk to % Min. Pk (onset)	X	X	X	X	X
Time of Min. Pk to % Min. Pk (offset)	X	X	X	X	X

Offset Time: Reports the time of the offset boundary of each event in either physical logical time coordinates. The unit of measurement depends upon the **Time Unit** option that you select.

Onset Amplitude: Reports the amplitude of each event at its onset boundary point. The unit of measurement depends upon the calibration parameters established for the selected channel.

Offset Amplitude: Reports the amplitude of each event at its offset boundary point. The unit of measurement depends upon the calibration parameters established for the selected channel.

Duration: Reports the duration of each event measured from its onset to its offset boundary. The unit of measurement depends upon the **Time Unit** option that you select.

Onset to Onset Interval: Reports the interval between the onset of each event and the onset of the next higher numbered event. If the next higher numbered event is a null event the reported value of the variable is null. The unit of measurement depends upon the **Time Unit** option that you select.

Offset to Offset Interval: Reports the interval between the offset of each event and the offset of the next higher numbered event. If the next higher numbered event is a null event the reported value of the variable is null. The unit of measurement depends upon the **Time Unit** option that you select.

Rate: Reports the instantaneous rate as measured between the onset of each event and the onset of the next higher numbered event. If the next higher numbered event is a null event the reported value of the variable is null. The unit of measurement depends upon the **Time Unit** option that you select. For example, to report rate in terms of events per second, set the Time Unit option to **seconds**.

Integrated Amplitude: Sums the amplitude of each event over its duration. The unit of measurement depends upon the calibration parameters established for the selected channel as well as the selected **Time Unit** option. For example, if the calibration parameters establish "microvolts" as the unit of measurement used to measure amplitude, and the selected Time Unit option is "milliseconds", then the unit of measurement used to report integrated amplitude is "microvolts*milliseconds".

Mean Amplitude: Sums the amplitude of each event and divides by its duration. The unit of measurement depends upon the calibration parameters established for the selected channel.

S.D. of Amplitude: Calculates the value of one standard deviation unit around the mean amplitude of each event.

Variance of Amplitude: Calculates the variance around the mean amplitude of each event.

RMS Amplitude: Computes the root mean square of the amplitude of each event over its duration. The root mean square is computed by calculating the mean of the squared amplitude values of all the data points within each event, then obtaining the square root of the resulting value. The unit of measurement depends upon the calibration parameters established for the selected channel.

Max. Peak Amplitude: Reports the maximum amplitude of each event. The unit of measurement depends upon the calibration parameters established for the selected channel.

Min. Peak Amplitude: Reports the minimum amplitude of each event. The unit of measurement depends upon the calibration parameters established for the selected channel.

Time of Max. Peak: Reports the time at which the maximum amplitude was attained in each event in either physical logical time coordinates. The units of measurement used to report the values depends upon the **Time Unit** option that you select.

Time of Min. Peak: Reports the time at which the minimum amplitude was attained in each event in either physical logical time coordinates. The unit of measurement used to report the values depends upon the **Time Unit** option that you select.

Mean Velocity: Reports the slope of the regression line calculated for the duration of each event. The unit of measurement depends upon the amplitude calibration parameters established for the selected channel as well as the selected **Time Unit** option. For example, if the calibration parameters establish "microvolts" as the unit of measurement for amplitude, and the selected Time Unit option is "seconds", then the unit of measurement used to report mean velocity is "microvolts/second".

Max. Velocity: Calculates the slope of a regression line computed for successive moving intervals over the duration of each event and then selects the maximum of the obtained values. The interval over which each regression line is computed is determined by the **Value** option (in milliseconds). The unit of measurement of the obtained velocity values depends upon the amplitude calibration parameters established for the selected channel as well as the selected **Time Unit** option. For example, if the calibration parameters establish "microvolts" as the unit of measurement for amplitude, and the selected Time Unit option is "seconds", then the unit of measurement used to report velocity is "microvolts/second".

☞ Although you can enter 0.00 as the Value option, the program requires at least three samples to calculate a regression. Therefore, in reality, the minimum regression interval is equal to two sample periods.

Min. Velocity: Calculates the slope of a regression line computed for successive moving intervals over the duration of each event and then selects the minimum of the obtained values. The interval over which each regression line is computed is determined by the **Value** option (in milliseconds). The unit of measurement of the obtained velocity values depends upon the amplitude calibration parameters established for the selected channel as well as the selected **Time Unit** option. For example, if the calibration parameters establish "microvolts" as the unit of measurement for amplitude, and the selected Time Unit option is "seconds", then the unit of measurement used to report velocity is "microvolts/second".

☞ Although you can enter 0.00 as the Value option, the program requires at least three samples to calculate a regression. Therefore, in reality, the minimum regression interval is equal to two sample periods.

Time of Max. Velocity: Calculates the velocity over a moving interval, as described above, then determines the time at which the maximum occurred. The resultant time value reflects the center of the interval for which the maximum velocity was obtained in each event. The values can be reported in either physical or logical time coordinates. The unit of measurement used depends upon the **Time Unit** option that you select.

Time of Min. Velocity: Calculates the velocity over a moving interval, as described above, then determines the time at which the minimum occurred. The resultant time value reflects the center of the interval for which the minimum velocity was obtained in each event. The values can be reported in either physical or logical time coordinates. The unit of measurement used depends upon the **Time Unit** option that you select.

Length of Path and **Normalized Length of Path:** The Length of Path variable measures the cumulative change in amplitude over the duration of each event. The change is always considered a positive value regardless of whether amplitude increases or decreases over the interval measured. The Normalized Length of Path normalizes the length of path value to a particular unit of time, which is determined by the Time Unit option you select.

First Upper Peak Amplitude: Scans each event, starting at its onset, for the first sample whose amplitude is greater than the amplitude of the samples on either side. Amplitude is reported in the calibration units established for the selected channel. If no peak is detected in an event (i.e., if the amplitude rises or falls monotonically for the entire duration of the event) a null value is returned. A moving average algorithm can be applied to compensate for noise in the signal. The **Value** option determines *time constant* of the moving average algorithm in milliseconds -- i.e., the duration over which an average amplitude value is calculated for each sample. The time constant is always symmetrically applied, meaning that it uses the same number of samples before and after each target sample to calculate the average amplitude of a given point. For example, if the sample period of a given signal is 1 msec and a time constant of 4 msec is selected, then each moving average calculation is performed over an interval containing five samples: the original sample plus two samples on either side. If you do not wish to employ a moving average, select a **Value** of **0.00**.

First Lower Peak Amplitude: Scans each event, starting at its onset, for the first sample whose amplitude is less than the amplitude of the samples on either side. Amplitude is reported in the calibration units established for the selected channel. If no minimum peak is detected in an event (i.e., if the amplitude rises or falls monotonically for the entire duration of the event) a null value is returned. A moving average algorithm can be applied to compensate for noise in the signal. The **Value** option determines *time constant* of the moving average algorithm in milliseconds -- i.e., the duration over which an average amplitude value is calculated for each sample. The time constant is always symmetrically applied, meaning that it uses the same number of samples before and after each target sample to calculate the average amplitude of a given point. For example, if the sample period of a given signal is 1 msec and a time constant of 4 msec is selected, then each moving average calculation is performed over an interval containing five samples: the original sample plus two samples on either side. If you do not wish to employ a moving average, select a **Value** of **0.00**.

Time of First Upper Peak: Calculates the time, in either physical or logical coordinates, that the first upper peak amplitude occurred in each event. The first peak is selected according to the method described above for the First Upper Peak Amplitude attribute. Results are reported in the units selected for the **Time Unit** option.

Time of First Lower Peak: Calculates the time, in either physical or logical coordinates, that the first lower peak amplitude occurred in each event. The first peak is selected according to the method described above for the First Lower Peak Amplitude attribute. Results are reported in the units selected for the **Time Unit** option.

Amp. of Onset to % Max. Peak: Calculates the difference between each event's onset amplitude and a specified percentage of its maximum amplitude. The percentage is determined by the **Value** option. The unit of measurement depends upon the calibration parameters established for the selected channel.

Amp. of Onset to % Min. Peak: Calculates the difference between each event's onset amplitude and a specified percentage of its minimum amplitude. The percentage is determined by the **Value** option. The unit of measurement depends upon the calibration parameters established for the selected channel.

Amp. of Offset to % Max. Peak: Calculates the difference between each event's offset amplitude and a specified percentage of its maximum amplitude. The percentage is determined by the **Value** option. The unit of measurement depends upon the calibration parameters established for the selected channel.

Amp. of Offset to % Min. Peak: Calculates the difference between each event's offset amplitude and a specified percentage of its minimum amplitude. The percentage is determined by the **Value** option. The unit of measurement depends upon the calibration parameters established for the selected channel.

Time of Onset to % Max. Peak (onset): Calculates the time associated with the point where the amplitude of the event first attained a specified percentage of its maximum amplitude. This attribute uses the event's onset amplitude as the amplitude = 0 reference. The percentage is determined by the **Value** option. The reported time is measured relative to the start of the data file and can be expressed in either physical or logical coordinates, and the unit of measure is determined by the **Time Unit** option. The manner in which the time point is determined is illustrated in Figure H-4.

Time of Onset to % Max. Peak (offset): Calculates the time associated with the point where the amplitude of the event first attained a specified percentage of its maximum amplitude. This attribute uses the event's offset amplitude as the amplitude = 0 reference. The percentage is determined by the **Value** option. The reported time is measured relative to the start of the data file and can be expressed in either physical or logical coordinates, and the unit of measure is determined by the **Time Unit** option. The manner in which the time point is determined is illustrated in Figure H-4.

Time of Onset to % Min. Peak (onset): Calculates the time associated with the point where the amplitude of the event first attained a specified percentage of its minimum amplitude. This attribute uses the event's onset amplitude as the amplitude = 0 reference. The percentage is determined by the **Value** option. The reported time is measured relative to the start of the data file and can be expressed in either physical or logical coordinates, and the unit of measure is determined by the **Time Unit** option.

Time of Onset to % Min. Peak (offset): Calculates the time associated with the point where the amplitude of the event first attained a specified percentage of its minimum amplitude. This attribute uses the event's offset amplitude as the amplitude = 0 reference. The percentage is determined by the **Value** option. The reported time is measured relative to the start of the data file and can be expressed in either physical or logical coordinates, and the unit of measure is determined by the **Time Unit** option.

Time of Max. Peak to % Max. Peak (onset): Calculates the time associated with the point where the amplitude of the event dropped from its maximum amplitude to a given percentage of maximum amplitude for the first time. This attribute uses the event's onset amplitude as the amplitude = 0 reference. The percentage is determined by the **Value** option. The reported time is measured relative to the start of the data file and can be expressed in either physical or logical coordinates, and the unit of measure is determined by the **Time Unit** option. The manner in which the time point is determined is illustrated in Figure H-4.

Time of Max. Peak to % Max. Peak (offset): Calculates the time associated with the point where the amplitude of the event dropped from its maximum amplitude to a given percentage of maximum amplitude for the first time. This attribute uses the event's offset amplitude as the amplitude = 0 reference. The percentage is determined by the **Value** option. The reported time is measured relative to the start of the data file and can be expressed in either physical or logical coordinates, and the unit of measure is determined by the **Time Unit** option. The manner in which the time point is determined is illustrated in Figure H-4.

Time of Min. Peak to % Min. Peak (onset): Calculates the time associated with the point where the amplitude of the event rose from its minimum amplitude to a given percentage of minimum amplitude for the first time. This attribute uses the event's onset amplitude as the amplitude = 0 reference. The percentage is determined by the **Value** option. The reported time is measured relative to the start of the data file and can be expressed in either physical or logical coordinates, and the unit of measure is determined by the **Time Unit** option.

Time of Min. Peak to % Min. Peak (offset): Calculates the time associated with the point where the amplitude of the event rose from its minimum amplitude to a given percentage of minimum amplitude for the first time. This attribute uses the event's offset amplitude as the amplitude = 0 reference. The percentage is determined by the **Value** option. The reported time is measured relative to the start of the data file and can be expressed in either physical or logical coordinates, and the unit of measure is determined by the **Time Unit** option.

Calculating Times for Percentage Amplitude To and From Peak

This section is provided to help you understand how the **Time of Onset to % Max. Peak (onset), Time of Onset to % Max. Peak (offset), Time of Onset to % Min. Peak (onset), Time of Onset to % Min. Peak (offset), Time of Max. Pk to % Max. Peak (onset), Time of Max. Pk to % Max. Peak (offset), Time of Min. Pk to % Min. Peak (onset),** and **Time of Min. Pk to % Min. Peak (offset)** attributes are calculated. Figure H-4 shows a signal with several relevant points labeled. Points **a** and **g** respectively indicate an event's onset and offset points. Point **d** indicates the maximum peak amplitude within the event. The vector shown to the left of the signal indicates the amplitude of the maximum peak when measured relative to the event's onset amplitude. The bar on the vector indicates 75% maximum amplitude, again as measured relative to the event's onset amplitude. Points **c** and **e** indicate the locations where the amplitude of the signal intersect the point of 75% maximum amplitude. Notice that point **c** occurs between the event's onset point and its maximum peak. The time of point **c** (relative to the

beginning of the data file) is what is measured by the **Time of Onset to % Max. Peak (onset)** attribute. Likewise notice that point **e** occurs between the event's maximum peak and its offset point. The time of point **e** (relative to the beginning of the data file) is what is measured by the **Time of Max. Pk. to % Max. Peak (onset)** attribute. In other words, the **Time of Onset to % Max. Peak (onset)** attribute is intended to measure the time of critical points in the rising phase of a signal whereas the **Time of Max. Pk. to % Max. Peak (onset)** attribute is intended to measure the time of critical points in the falling phase of a signal, when the onset amplitude of the signal is the desired reference point.

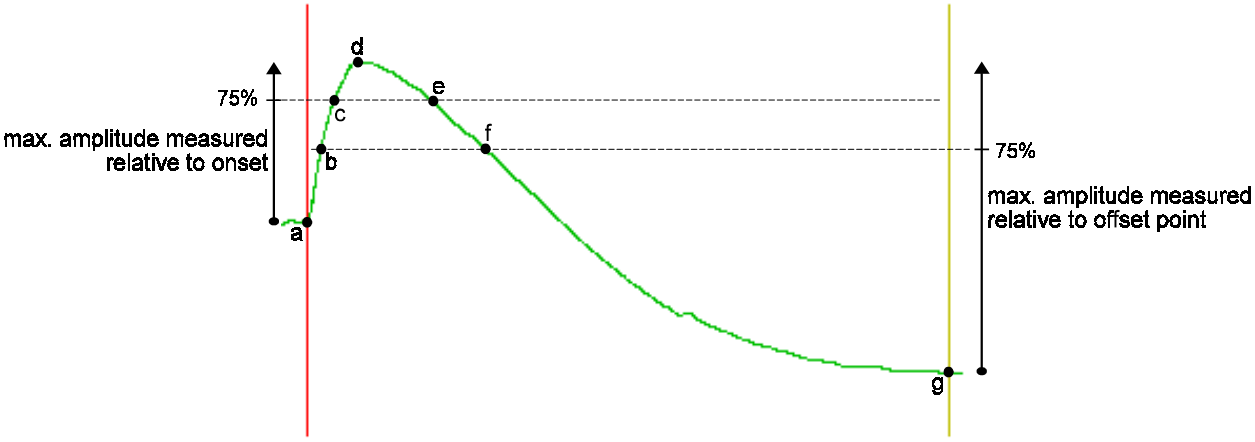


Figure H-4. An example illustrating the selection of points to report times of percentage amplitude to and from peak. See text for details.

Points **b** and **f** also indicate the locations where the amplitude of the signal intersect the point of 75% maximum amplitude. But this time peak amplitude is measured relative to the event's offset amplitude, as indicated by the vector to the right of the signal. The bar on the right vector again indicates the point of 75% maximum amplitude. Like points **c** and **e**, points **b** and **f** indicate the locations where the amplitude of the signal intersect the point of 75% maximum amplitude. Since the event's offset amplitude is not the same as its onset amplitude, point **b** is not the same as point **c** and point **f** is not the same as point **e**. Consequently, two additional attributes were developed. Specifically, time of point **b** (relative to the beginning of the data file) is what is measured by the **Time of Onset to % Max. Peak (offset)** attribute whereas the time of point **f** (relative to the beginning of the data file) is what is measured by the **Time of Max. Pk. to % Max. Peak (onset)** attribute. In other words, the **Time of Onset to % Max. Peak (offset)** attribute is intended to measure the time of critical points in the rising phase of a signal whereas the **Time of Max. Pk. to % Max. Peak (offset)** attribute is intended to measure the time of critical points in the falling phase of a signal, when the *offset* amplitude of the signal is the desired reference point.

The **Time of Onset to % Min. Peak (onset), Time of Onset to % Min. Peak (offset), Time of Min. Pk to % Min. Peak (onset),** and **Time of Min. Pk to % Min. Peak (offset)** attributes are calculated in analogous manner to the **Time of Onset to % Max. Peak (onset), Time of Onset to % Max. Peak (offset), Time of Max. Pk to % Max. Peak (onset),** and **Time of Max. Pk to % Max. Peak (offset)**, respectively, except that they are intended to measure intervals to or from a specified percentage of the event's minimum amplitude. For these attributes to work as anticipated it is assumed that you are measuring a negative-going signal; i.e., a signal that drops in amplitude from onset to peak.

H-5. Defining Equation Variables

Equation variables express a mathematical relationship between two other attribute variables. For example, the relative onset times of two different sets of events can be obtained by subtracting the onset time of each member of one set of events from the onset time of the corresponding member of another set of events. The specified equation is solved for each individual event in a event buffer or, if two or more event buffers are involved in the selected variables, the equation is solved for ***corresponding events***[1]

To define an equation variable, place the highlight at the desired location of the attribute variable list box in the Define Attribute Variables window, then select the  (**Equation Attribute)** button to the right of the list box. Doing so opens the **Define Attribute Variable Equation window**. An example is shown in Figure H-5.

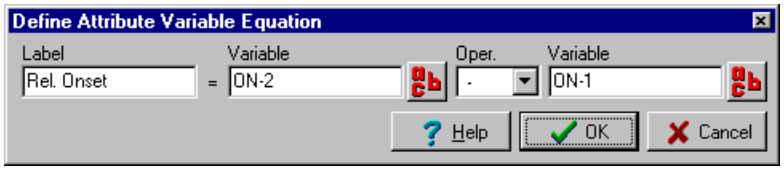


Figure H-5. The Define Attribute Variable Equation window.

Each equation variable that you define must be given its own unique name, or "label". That is what the **Label** box is for. The label can be any string of up to 15 characters, and it will be used in all other locations within the Scientific Spreadsheet module to identify the equation that you define using the three boxes to the right. The middle box is labeled **Oper.**, and it is used to specify the mathematical operator that defines the relationship between the variables indicated in the **Variable** boxes on either side. The available operators are described below. You can use any two variables in the equation, regarless of whether they are primary variables, function variables, or other equation variables, as long as they are already defined.

Types of Equation Variable Operators

- **+** **Addition:** adds the values obtained for the selected variables, as measured for each event.
- **-** **Subtraction:** subtracts the values obtained for the selected variables, as measured for each event.
- **x** **Multiplication:** multiplies the values obtained for the selected variables, as measured for each event.
- **/** **Division:** divides the value obtained for the variable indicated in the left Variable box by the value of the variable indicated in the right variable box, as measured for each event.
- **>>** **Greater Than** (both values must be present): Compares the values obtained for the two selected variables and selects the greater value, as measured for each event. If one of the obtained values is a null value, then a null value is returned.
- **>** **Greater Than:** Compares the values obtained for the two selected variables and selects the greater value, as measured for each event. If one of the obtained values is a null value, then the valid value is returned. In other words, this option requires only one of the compared values to exist.
- **<<** **Less Than** (both values must be present): Compares the values obtained for the two selected variables and selects the lesser value, as measured for each event. If one of the obtained values is a null value, then a null value is returned.

---

[1] Corresponding events are defined as events in different event buffers (and thus, different event files) which are identified with the same number. For example, Event #5 in buffer A and Event #5 in buffer B are corresponding events.

< **Less Than:** Compares the values obtained for the two selected variables and selects the lesser value, as measured for each event. If one of the obtained values is a null value, then the valid value is returned. In other words, this option requires only one of the compared values to exist.

The variables that you use in an equation variable can be primary variables, function variables, range variables, other equation variables, or some combination. In any case, the variables that you use in your equation must already exist. To select a variable, highlight the desired Variable box and either type in the label of the variable you wish to use or click on the  (**List Labels)** button to open a window listing all of the currently defined variables. The List Labels window is described in Section H-13

H-6. Defining Function Variables

Function variables apply a mathematical function to another attribute variable. For example, a function variable lets you obtain the natural log of the peak amplitude of each event in a event buffer. Depending upon the type of function that you select, a value is obtained for each individual event in a event buffer, or one value is obtained for all events. If two or more event buffers are involved in the definition of the selected variable, the function is solved for *corresponding events*, meaning the same numbered events in different event buffers. Details are provided in a later paragraph in this section.

To define a function variable, place the highlight at the desired location of the attribute variable list box in the Define Attribute Variables window, then select the  (**Function Attribute)** button to the right of the list box. Doing so opens the **Define Function Variable window**. An example is shown in Figure H-6.

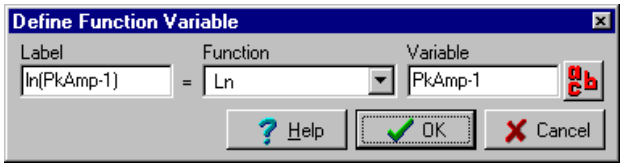


Figure H-6. The Define Function Variable window.

Each function variable that you define must be given its own name, or "label". That is what the **Label** box is for. The label can be any string of up to 15 characters, and it will be used in all other locations within the module to identify the variable that you define using the Function and Variable boxes to the right. The **Function** box is used to specify the function that is applied to the variable whose label is indicated in the **Variable** box. It should be noted that there are actually two different kinds of functions available -- math functions and statistical functions. Math functions return a value for each value contained in the specified variable. In contrast, statistical functions return a *single* value for the entire variable. Specifically, they return the relevant statistic calculated from the values of the specified variable. The intended purpose of the statistical function variables is to allow you to compare the relevant statistic with the values obtained for some other, standard variable. For example, you can obtain the difference between the duration of each event in a given event file and the mean duration of all events in that file or another file by using the mean function variable option as input into a general equation variable. When you include one of the five statistical function "variables" in an attribute table the same value appears on every line. Likewise, if used in a scatter plot the same value is paired with each value in the other variable being plotted.

Math Functions:

Square: Squares each value obtained for the specified variable.
Square Root: Obtains the square root of each value obtained for the specified variable.
Log: Obtains the base 10 log of each value obtained for the specified variable.
Ln: Obtains the natural log of each value obtained for the specified variable.

Absolute: Obtains the absolute value of each value obtained for the specified variable.

Statistical Functions:

Mean: Obtains the mean of **all** values obtained for the specified variable.
Standard Deviation: Obtains the standard deviation of the mean of **all** values obtained for the specified variable.
Variance: Obtains the variance of the mean of **all** values obtained for the specified variable.
Maximum: Obtains the maximum of **all** values obtained for the specified variable.
Minimum: Obtains the minimum of **all** values obtained for the specified variable.
Sum: Obtains the sum of **all** values obtained for the specified variable.
Sum of Squares: Obtains sum of the squares of **all** values obtained for the specified variable.
Valid Event Count: Obtains a count of the number of valid events associated with the specified variable.

The variable that you use in a function variable can be a primary variable, an equation variable, or another function variable. In any case, the variable that you use must already exist. To select a variable, highlight the Variable box and either type in the label of the variable you wish to use or select the **(List Labels)** button to open a window listing all of the currently defined variables. See Section H-13 for details about using the List Labels option.

H-7. Defining Range Variables

Range variables perform a statistical operation on another attribute variable whose values have been grouped in some way. One value is returned for each group. For example, a range variable lets you obtain the average peak amplitude of the events contained in event buffer B which occurred within the duration of each event in event buffer A.

To define a range variable, place the highlight at the desired location of the attribute variable list box in the Define Attribute Variables window, select the **(Range Attribute)** button to the right of the list box, and wait for the **Define Range Variable window** to appear. An example of the Define Range Variable Window is shown in Figure H-7.

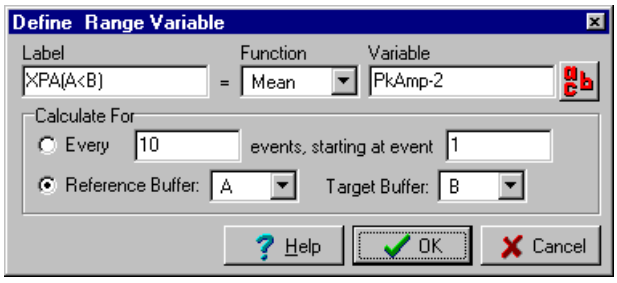
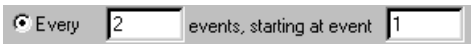


Figure H-7. The Define Range Variable window.

Each range variable that you define must be given its own name, or "label". That is what the **Label** box is for. The label can be any string of up to 15 characters, and it will be used in all other locations within the module to identify the variable that you define here. The **Function** box is used to specify the function you wish to apply to the variable that you indicate in the **Variable** box. The types of functions that are available are listed at the bottom of this topic. The variable that you use in a range variable can be a primary variable, an equation variable, a function variable, or even another range variable. In any case, the variable that you use must already exist. To select a variable, highlight the Variable box and either

type in the label of the variable you wish to use or select the  **(List Labels)** button to open a window listing all of the currently defined variables.

The last paragraph described how to define what your range variable will measure. Now we will explain what it will measure it for -- in other words, we will now describe how values in the variable you elected to employ are grouped. That is the purpose of the **Calculate for** section of the window. Note that there are two radio buttons in this section of the window. They correspond to the two different ways that you can group values. Specifically, you can group values in terms of the numbers of the events for which they were measured or in terms of whether or not the corresponding events occurred within the duration of some event in another event buffer. To group values in terms of the numbers of the events for which they were measured, select the upper radio button, indicate the number of events in each group, and indicate where in the sequence of events the first group starts. For example, if the line reads...



it means that the values obtained for every two events, starting with event 1, are grouped together. Thus, the values obtained for events 1 and 2 are grouped together, as are the values obtained for events 3 and 4, and so on.

Likewise, select the lower radio button to group values in terms of whether or not the values were obtained for events which occurred within the duration of an event in another event buffer. In this case, the "other" event buffer is referred to as the **Reference Buffer**. The events for which corresponding values are obtained are contained in what is referred to as the **Target Buffer**. For example, if the line reads...

it means that the values obtained for each event in event buffer D are grouped together according to whether the events in event buffer D occurred during an event in event buffer A. Thus, if four events occurred in buffer D throughout the duration of event 1 in buffer A, then four values are grouped together. If nine events occurred in buffer D throughout the duration of event 2 in buffer A, then there would be nine events in the next group.

Available Functions:

Mean: Obtains the mean of each group of values.
Standard Deviation: Obtains the standard deviation around the mean of each group of values.
Variance: Obtains the variance of the mean of each group of values.
Maximum: Obtains the maximum of all values within each group.
Minimum: Obtains the minimum of all values within each group.
Sum: Obtains the sum of all values within each group.
Sum of Squares: Obtains sum of the squares of all values within each group.
Valid Event Count: Reports the number of valid events for which values were obtained in each group.

H-8. Copying Attribute Variable Definitions

The **Copy Variables** feature copies a selected set of variables to a new sequence of index numbers. However, it should be noted that two identical sets of variables are not very useful. However, once they are copied the channel and/or buffer used to define one set of variables, or the labels used to identify them, can be subsequently changed using the **Replace Labels, Buffers, Channels** feature described in Section H-9.

To use the Copy Variables option, first click on the  button in the Define Attribute Variables parameter window and wait for the parameter window shown in Figure H-8 to appear.

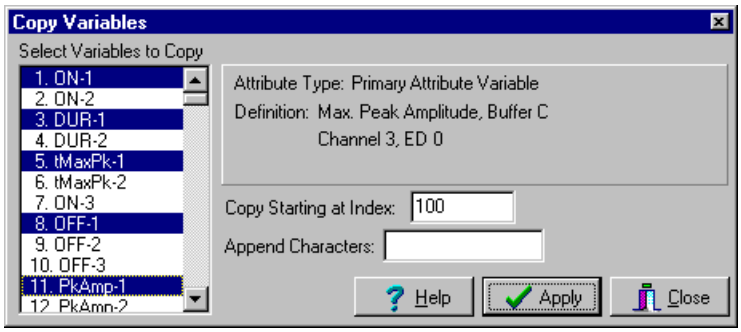


Figure H-8. The Copy Variables window.

You can copy more than one variable simply by highlighting more than one variable in the **Select Variables to Copy** list box. Use the shift key to highlight a continuous sequence of variables, or the Control key to highlight a discontinuous sequence of variables. In either case the highlighted variables will be copied to a continuous sequence of indexes, starting with the index number indicated in the **Copy Starting at Index** box. For example, five variables are highlighted in the illustration shown in Figure H-8 and the value "100" is entered in the **Copy Starting at Index** box. Thus, five new variables will be created and assigned to index numbers 100 - 104.

You can also elect to append a text string to each variable label by entering them in the **Append Characters** box. However, it should be recognized that even if you append a text string to the labels of the variables you copy, you still end up with two sets of variables with identical definitions. You can, however, easily remedy the situation using the **Replace Labels, Buffers, Channels** feature described in Section H-9.

☞ A variable label can be a maximum of 15 characters long, including spaces. If the character string that you enter in the Copy Variables window causes a label to exceed the 15-character limit, then one or more of the original characters will be replaced. For example, if the original label of a variable was "12345678901234" (which is a total of 14 characters), and you elected to append the character string "abc" to the label of each variable that is copied, then the resulting label for that variable would be "123456789012abc". In contrast, if the additional characters do not cause a label to exceed 15 characters, then the new characters are simply appended to the end of the original label. For example, if the original label of a variable was "12345678901" (a total of 11 characters), and you elected append the character string "abc" to the label of each variable that is copied, then the resulting label for that variable would be "12345678901abc". If you don't want to append any characters to the existing variable labels, just leave the **Append Characters** box blank.

H-9. Replacing Labels, Buffers, and Channels in Variable Definitions

The **Replace Labels, Buffers, Channels** feature can be used to replace one text string with another, one status buffer letter with another, or one channel number with another, when the indicated items are found within a selected set of attribute variables. In fact, it is possible to replace a text string, buffer letter and channel number all at the same time.

☞ The **Replace Labels, Buffers, Channels** feature can be used to replace buffer or channel definitions in primary attribute variables only. Labels, on the other hand, can be replaced regardless of the type of variable.

To use this option, first click on the  button in the Define Attribute Variables parameter window and wait for the parameter window shown in Figure H-9 to appear.

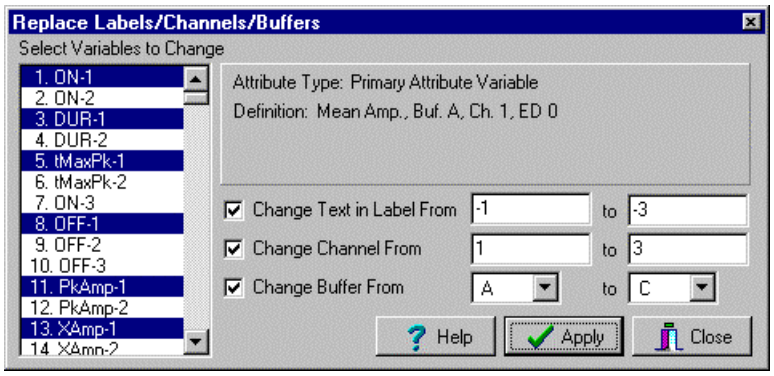


Figure H-9. The Replace Labels/Channels/Buffers window.

To replace all or part of a variable's label, or its buffer or channel definitions, first highlight the variable's label in the **Select Variables to Change** list box. You can highlight more than one variable by clicking on one variable's label, then holding down the left mouse button as you drag the mouse pointer up or down the list, or by holding down the shift or Control keys and clicking on several variable labels. Note that in the example in Figure H-9 a total of six variables are highlighted.

To change the text in a variable's label, check the **Change Text in Label From** checkbox, then indicate the text string you want to search for in the left box on the same line, and the text string you want to change it to in the right box. For example, in the illustration shown in Figure H-9, whenever the text string "-1" is encountered in the label of a highlighted variable, it will be changed to "-3".

To change the channel defined in a variable, check the **Change Channel From** checkbox, then indicate the channel number you want to search for in the left box on the same line, and the channel number you want to change it to in the right box. For example, in the illustration shown in Figure H-9, whenever channel 1 is encountered in the definition of a highlighted variable, it will be changed to channel 3. ***This option operates on primary variables only***.

To change the buffer defined in a variable, check the **Change Buffer From** checkbox, then indicate the buffer letter you want to search for in the left box on the same line, and the buffer letter you want to change it to in the right box. For example, in the illustration shown Figure H-9, whenever buffer A is encountered in the definition of a highlighted variable, it will be changed to buffer C. ***This option operates on primary variables only***.

To effect the selected changes, click on the Apply button. Upon completion of the operation the highlights are removed from all of the variables in the **Select Variables to Change** list box and you are ready to set up another operation.

H-10. The Virtual Events Feature

The Virtual Events feature allows you to create sets of imaginary events based on the calculations obtained for selected attribute variables, and to store them in imaginary event buffers. Once they are

created virtual event buffers can be used just like any other event buffer to define additional attribute variables. Virtual events are particularly useful as quick and easy way to subdivide existing events into parts and to measure various attributes of each part individually.

To access the virtual events feature, open the Define Attribute Variables window and click the  **(Virtual Event Buffer)** button. Doing so opens the **Define Virtual Event Buffers parameter window**. An example is shown in Figure H-10.

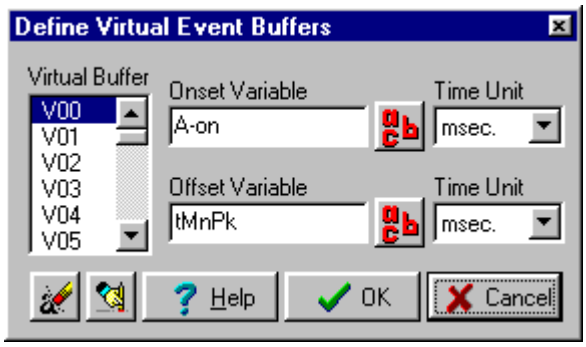


Figure H-10. The Define Virtual Event Buffers window.

Unlike actual event buffers, which are assigned a single letter to identify them, virtual event buffers are identified by a three character code -- a "V" followed by a number between 00 and 99. Thus you can define up to 100 different virtual event buffers at a time. The identification codes are listed in the **Virtual Buffer** list box located on the left side of the Define Virtual Event Buffers window. To define a virtual event buffer, first highlight the identification code you wish to use for it, then enter the labels of the attribute variables you wish to use to determine the values of the onset and offset boundaries of the virtual events in the **Onset Variable** and the **Offset Variable** boxes, respectively.

Any attribute variable can be used to define the onset and offset boundaries of virtual events. However, it is important to keep in mind that regardless of the variables you use for that purpose, their values are always interpreted as time values. Even more specifically, they are always interpreted in terms of time relative to the beginning of the data file, in physical time coordinates, and in the units specified in the **Time Unit** boxes to the right of the Onset and Offset Variables boxes. Consequently, it is usually best to use variables that are themselves defined in the same terms.

Using Virtual Events: An Example

Virtual events are particularly useful when you need to subdivide existing events into parts and to measure the attributes of each part individually. For example, Figure H-11 shows a case where the actual event is an (extracellularly recorded) action potential, from the beginning of the depolarization phase to the end of the relative refractory phase. Without the virtual event feature it is possible to measure characteristics of the event only in its entirety. You can, for example, measure such attributes as the durations of the depolarization and refractory phases and the peak-to-peak amplitude of the signal. However, if one wished to measure the maximum velocity of the signal during the depolarization, absolute refractory, and relative refractory phases independently, it would be necessary to subdivide the event accordingly. That is what the virtual event feature allows you to do.

Before you can define a set of virtual events it is necessary to define the attribute variables you intend to use to locate their onset and offset boundaries. Thus, for the present example, it is necessary to create four primary attribute variables to obtain: (1) the onset times of the original events; (2) the offset times of the original events; (3) the time that the minimum peak was achieved, and (4) the time that the maximum

peak was achieved. In Figure H-11 the onset and offset times are marked with solid lines whereas the times of the minimum and maximum peaks are marked with broken lines.

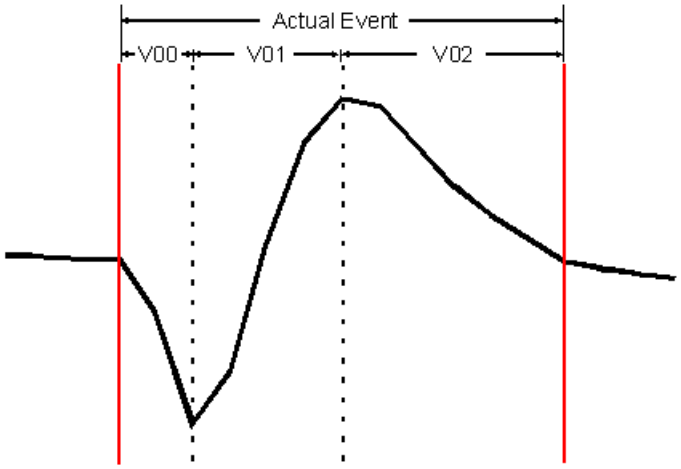
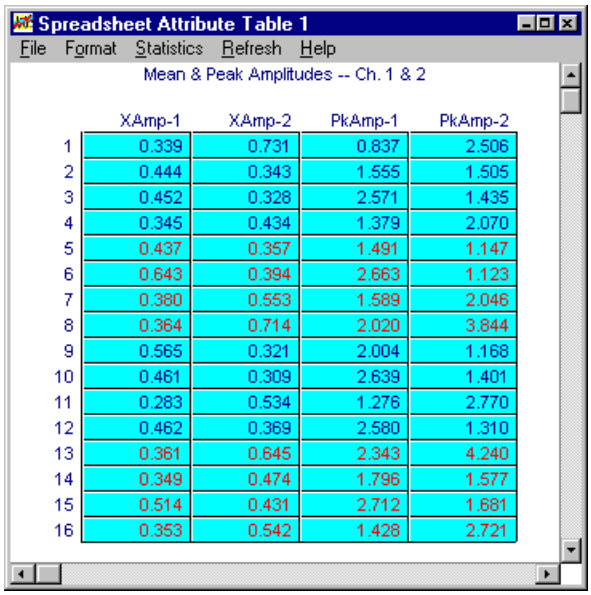


Figure H-11. An example showing an actual event parsed up into three individual virtual events.

Recall that virtual event buffers are identified by the letter "V" followed by a number between 00 and 99. For our example we only need to define three: V00 will be defined as the interval spanning the original event onset and the time that the minimum peak amplitude occurred. V01 will be defined as the interval between the minimum and maximum peaks. Finally, V02 will be defined as the interval between the maximum peak and the original event offset. Once each region is defined as a virtual event, then it is possible to define additional attribute variables to measure the velocities of each region independently. Thus, we can define primary attribute variables to obtain the minimum velocity of each event in virtual buffer V00, the maximum velocity of each event in virtual buffer V01, and the minimum velocity of each event in virtual buffer V02. And if we were interested in other characteristics of each subregion we have defined as a virtual event, we can define additional attribute variables to measure them as well.

H-11. Generating an Attribute Table

Attribute tables provide itemized reports of the values obtained for selected attribute variables. Their appearance is similar to a financial spreadsheet, and it is for them that the Scientific Spreadsheet module was named. To produce an attribute table, select one of the **View Table** buttons ( ,  ,  , or ) in the Scientific Spreadsheet control panel. Doing so opens a window similar to the one shown in Figure H-12.



	XAmp-1	XAmp-2	PkAmp-1	PkAmp-2
1	0.339	0.731	0.837	2.506
2	0.444	0.343	1.555	1.505
3	0.452	0.328	2.571	1.435
4	0.345	0.434	1.379	2.070
5	0.437	0.357	1.491	1.147
6	0.643	0.394	2.663	1.123
7	0.380	0.553	1.589	2.046
8	0.364	0.714	2.020	3.844
9	0.565	0.321	2.004	1.168
10	0.461	0.309	2.639	1.401
11	0.283	0.534	1.276	2.770
12	0.462	0.369	2.580	1.310
13	0.361	0.645	2.343	4.240
14	0.349	0.474	1.796	1.577
15	0.514	0.431	2.712	1.681
16	0.353	0.542	1.428	2.721

Figure H-12. An example of an attribute table display.

Attribute tables are always arranged in rows and columns. Each column of data reports the values obtained for an individual attribute variable, and the label of the variable is indicated at the top of the column. Each row is numbered along the left edge of the table. Row numbers usually correspond to event numbers. Thus, for example Row 1 reports the values obtained for each variable included in the table, as measured for Event #1. Likewise, Row 2 reports the values obtained for Event #2 and so on. Certain types of function variables, specifically, the statistical functions, return a single value for all events in an event buffer. When these types of function variables are included in an attribute table the same value is repeated in each row of the table[2].

The attribute table shown in Figure H-12 contains six columns of data, each reporting the values obtained for a selected attribute variable. The maximum number of columns in any one table is 20. However, you can generate up to four tables at a time. Attribute tables can be very large, and consequently may not be able to be viewed on the screen in their entirety. The scroll bars, located along the right and bottom edges of the table display window, allow you to view any location in the table you desire. The horizontal scroll bar lets you move the location of the display sideways through the table whereas the vertical scroll bar lets you move the display through the table from top to bottom. For additional information on using the scroll bars to move through the table, see Section H-11.1.

The **Format** option in the menu bar along the top of the attribute table window is used to select the variables included in a table[3], the number of variables included in the table, the width of each column, and many other parameters that govern the appearance of the table. For additional information on the Format option, see Section H-11.2.

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2 The statistical functions are repeated so that they may be easily combined with variables that return different values for each individual event.

3 Attribute variables must already be defined before they can appear in a table. See Sections H-3 through H-7 to learn how to define the variables you wish to report.

H-11.1. Scrolling Through an Attribute Table

Attribute tables can contain as many as 20 columns of data and as many lines as there are events in any event buffer. Often, therefore, it is not possible to view the entire table on the screen at one time. The vertical and horizontal scroll bars, built into the right and bottom edges of the display window, make it easy to move the display view any portion of the table. Click on the left and right arrows of the horizontal scroll bar to move one column to the left or right. Click on the spaces between the arrows and the middle button to move five columns to the left or right. Click and hold down the middle button to move left or right through the table to any desired degree.

The vertical scroll bar works in an analogous fashion except in the vertical dimension. Specifically, click on the up or down arrows at the edges of the vertical scroll bar to move up or down through the table in increments equal to the number of rows specified by the **Scroll Increment** parameter contained in the table format parameters window (see Section H-11.2). Click on the spaces between the arrows and the middle button to move five scroll increments up or down. Click and hold down the middle button to move up or down through the table to any desired degree.

H-11.2. Formatting an Attribute Table

To format an attribute table, select the **Format** option in the table window's menu bar to gain access to the **Format Attribute Table** window. An example is shown in Figure H-13. As the example illustrates, the window is organized into top and bottom sections. The top section is composed of three tabs – **Content**, **Output**, and **Statistics** – each of which contain different sets of parameters. The contents of the three tabs, as well as the parameters contained in the lower section of the window, are described separately in following paragraphs. For information about how to save the formatting parameters you specify in the Format Attribute Table window and to retrieve them for later use, see Section H-11.4.

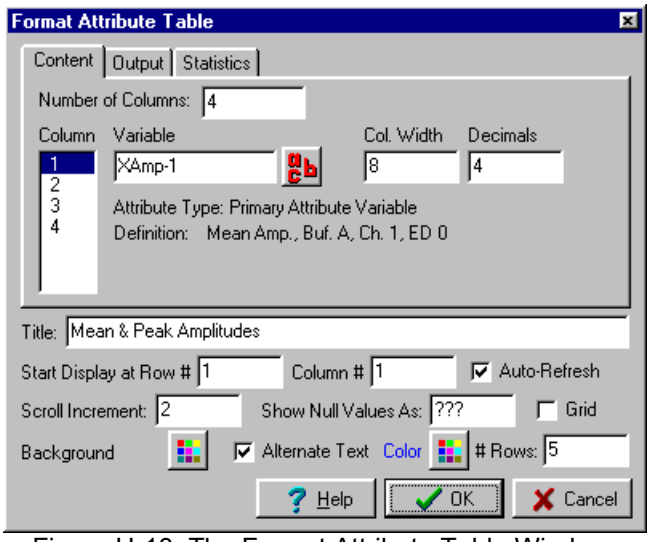


Figure H-13. The Format Attribute Table Window.

The Content Tab:

The content tab determines the number of columns in the table and the variables that appear in each of them. An example is shown in Figure H-14. The **Number of Columns** box determines the number of columns in the table. The number of entries in the **Column** list box is equal to the selected number of columns. To view a description of the variable currently assigned to a given column, highlight the column number in the Column list box, then read the **Attribute Type** and **Definition** information supplied in the space to the right of the list box. To change the variable reported in a column, highlight the column number in the Column list box, then change the variable indicated in the **Variable** box. To change the

variable you can either type in the label of the variable you desire, or select the  (List Labels) button beside the Variable box to obtain a list of all the currently defined variables. The **Col. Width** and **Decimals** boxes further to the right of the Variable box on the same line, respectively determine the width of the column (in terms of the total number of character spaces) and the number of decimal places to which the obtained values are reported.

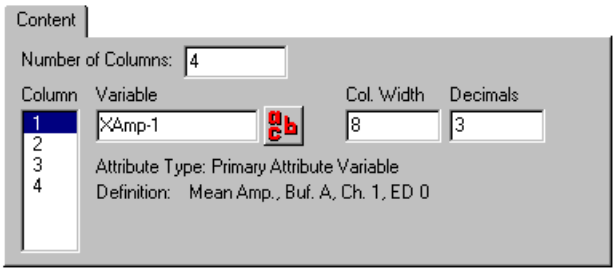


Figure H-14. An example of the Content tab of the format parameters window associated with the attribute table display.

The Output Tab:

The output tab controls which of the elements of the table will be output to printer or to an ASCII file when the table is exported using the **File|Print** or **File|Export Table** options of the table window's menu bar. An example of the Output tab is presented in Figure H-15. By checking or clearing the appropriate checkboxes, respectively, you can elect to include or exclude the table title, the column labels, or the row numbers. Likewise, by checking or clearing the **Only Columns** or **Only Rows** checkbox you can limit the output to only certain rows and columns or include all rows and columns that may exist in the table.

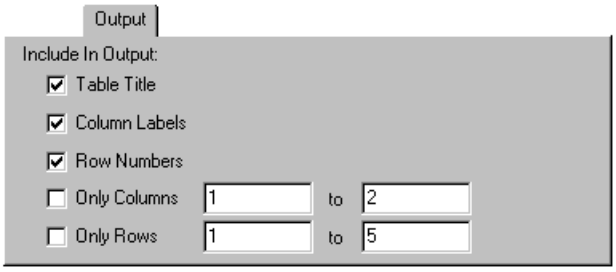


Figure H-15. An example of the Output tab of the format parameters window associated with the attribute table display.

The Statistics Tab:

The Statistics tab determines the kinds of statistics that appear in the statistics table when you select the attribute table window menu bar's **Statistics** option. An example of the Statistics tab is shown in Figure H-16. Check the appropriate check box to include the corresponding statistic or clear the check box to omit it. For more information on the statistics option, see Section H-11.3.

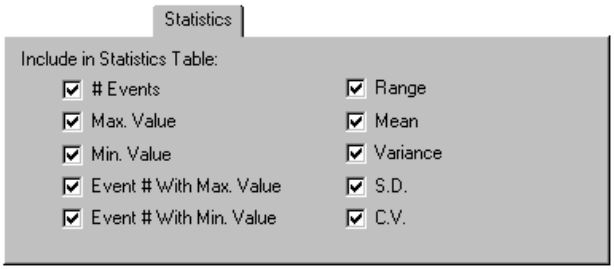


Figure H-16. An example of the Statistics tab of the format parameters window associated with the attribute table display.

The Lower Section of the Format Attribute Table

The lower section of the Format Attribute Table window controls the general appearance of the attribute table display. The function of each item is described below.

Title: A string of text that appears at the top of the table display. The title is also saved along with the other formatting parameters if you elect to save them to a file. When you later attempt to retrieve the parameter file the title can be used as a long file name to identify the parameter file.

Start Display at Row #, Column #: These boxes determine the row and column that appears in the upper left corner of the display when it first appears. In other words, you can use these parameters to quickly jump to any location in the table. Most of the time, however, you will probably keep both of these parameters set to 1, then use the vertical and horizontal scroll bars to move to different locations in the table.

Auto-Refresh: When this check box is checked, the contents of the table are automatically recalculated and presented each time the program focus returns to the table after a change is made. Most of the time you will probably want to keep this option checked. However, if the program takes too long to regenerate the table you may find it more efficient to clear this check box, then use the **Refresh** option in the table's menu bar to regenerate the table only when necessary.

Scroll Increment: This box determines the number of rows the table moves up or down each time you click the up or down arrow buttons at the ends of the vertical scroll bar.

Show Null Values As: This box determines the text string the program uses to indicate "null values" (values that cannot be measured, usually because it is associated with a null event).

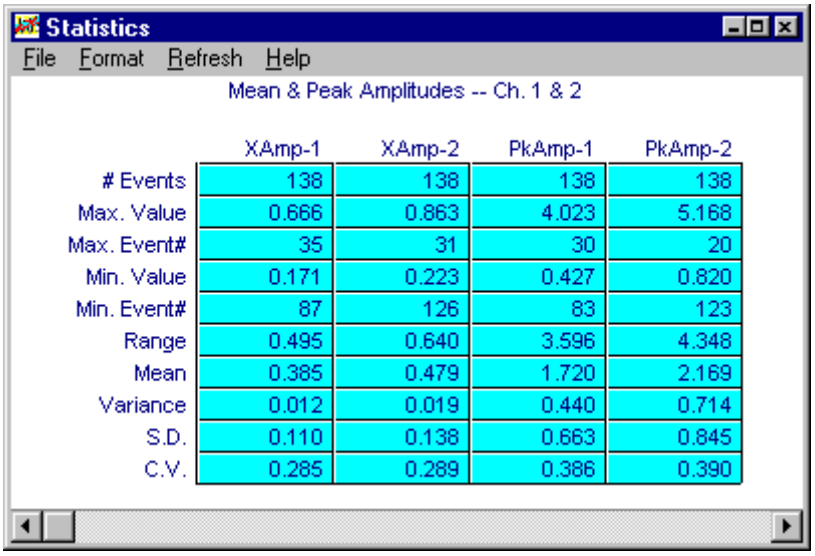
Grid: This check box determines whether lines are drawn to outline each row and each column in the table.

Background Color: This option determines the background color of each cell in the table. The word "color" is presented in the current background color. To change the color, click on the  button to the right.

Alternate Text, Color, # Rows: The **Alternative Text** check box determines whether successive rows of the table are presented in different colors to improve readability. The **Color** reports the currently selected color of the alternate text and the **#Rows** box determines how many rows appear in the same color before the color is alternated. To change the alternate text color, click on the  button to the left of the **# Rows** box.

H-11.3. Obtaining Statistics on an Attribute Table.

Each attribute table display window has a **Statistics** option in its menu bar which opens an associated statistics window. Its purpose is to provide a report of a series of descriptive statistical operations performed on the data contained in an attribute table. An example is shown in Figure H-17. Each statistic is described below.



	XAmp-1	XAmp-2	PkAmp-1	PkAmp-2
# Events	138	138	138	138
Max. Value	0.666	0.863	4.023	5.168
Max. Event#	35	31	30	20
Min. Value	0.171	0.223	0.427	0.820
Min. Event#	87	126	83	123
Range	0.495	0.640	3.596	4.348
Mean	0.385	0.479	1.720	2.169
Variance	0.012	0.019	0.440	0.714
S.D.	0.110	0.138	0.663	0.845
C.V.	0.285	0.289	0.386	0.390

Figure H-17. An example of the statistics table associated with an attribute table.

 # Events: The number of valid events in the variable named at the top of the column.
Max. Value: The value of greatest magnitude within the variable named at the top of the column.
Max. Event #: The number of the event possessing the value of greatest magnitude.
Min. Value: The value of least magnitude within the variable named at the top of the column.
Max. Event #: The number of the event possessing the value of least magnitude.
Range: The difference between the values of greatest and least magnitude.
Mean: The computed average value.
Variance: The variance of the mean.
S.D.: The standard deviation of the mean.
C.V.: The coefficient of variation (S.D./Mean).

The **Format** option in the statistics window's menu bar opens the exact same table formatting parameters window as does the corresponding option in the menu bar of the table display window itself. Most of the parameters contained in the formatting window apply to both the attribute table display and the statistics table display. However, the contents of the **Statistics** tab applies to the statistics table display only. The Statistics tab contains a checklist of all of the available statistical measures. Only the statistics whose associated check boxes are checked will appear in the statistics table display.

H-11.4. Saving and Retrieving Table Format Parameters

If you intend to use the same set of attribute table formatting parameters at some time in the future, it is a good idea to save them to a file once you have them set the way you want them. To save a set of table formatting parameters, select the **File|Save Parameters** option from the menu bar at the top of the table display window. Likewise, to retrieve a previously saved set of parameters, select the **File|Load Parameters** option. When retrieving (loading) a parameter file you can use the table title as a long file name to identify the file. Keep this in mind when you enter a title for your table.

☞ Table formatting parameter files record the labels of the variables that appear in the table but not the definitions of the variables themselves. Thus, it is also important to remember to save the attribute variables that you have defined to their own parameter file, and to retrieve that file before retrieving the table parameter file to ensure that it operates correctly. See Section H-3.1 for information about loading and saving attribute variable parameter files.

H-12. Generating Scatter Plots and Line Plots

Scatter plots and line plots provide a way to visualize attribute variable data. Scatter plots and line plots are both two dimensional graphs where individual points represent the values obtained for *corresponding values* obtained for a pair of attribute variables. One attribute variable is plotted along the X-axis and another is plotted along the Y-axis. The term *corresponding values* means that they are obtained for the same event or from same-numbered events in different event buffers. Regression lines, correlation coefficients, and descriptive statistics can also be obtained for the relationships between the plotted values.

The Scientific Spreadsheet module makes no distinction between scatter plots and line plots other than the fact that the data points that comprise a scatter plot are not connected with lines whereas in a line plot they are. Other than that, scatter plots and line plots are produced and modified in exactly the same way, using exactly the same kinds of parameters. In fact, as the example shown in Figure H-18 illustrates, you can produce a combination of scatter plots and line plots at the same time within the same display window.

To produce a scatter plot or line plot, select one of the **View Plot** buttons ( ,  ,  , or ) from the Scientific Spreadsheet control panel. Doing so opens a window similar to the one shown in Figure H-18.

It is possible to include up to four individual scatter plots or line plots in a single display window. In the example shown in Figure H-18 there are two: one with the points plotted with crosses and one with the points plotted with squares. Notice that the data points represented with crosses are connected with lines, making it a line plot. In contrast, the points plotted with squares are not connected, making it a scatter plot. The pair of variables comprising each individual plot reported across the top of the display, just below the display's title, and they appear in the same color as the corresponding data. The coordinates of the X and Y axes can be independently set for each plot, and as the example shown in Figure H-18 illustrates, the minimum and maximum coordinate values are reported at the left and bottom corners of the display in the same color used to plot the corresponding data.

Select the **Format** option in the menu bar at the top of the display to add or delete individual plots and to adjust the parameters that control the appearance of the display. Details are provided in Section H-12.2.

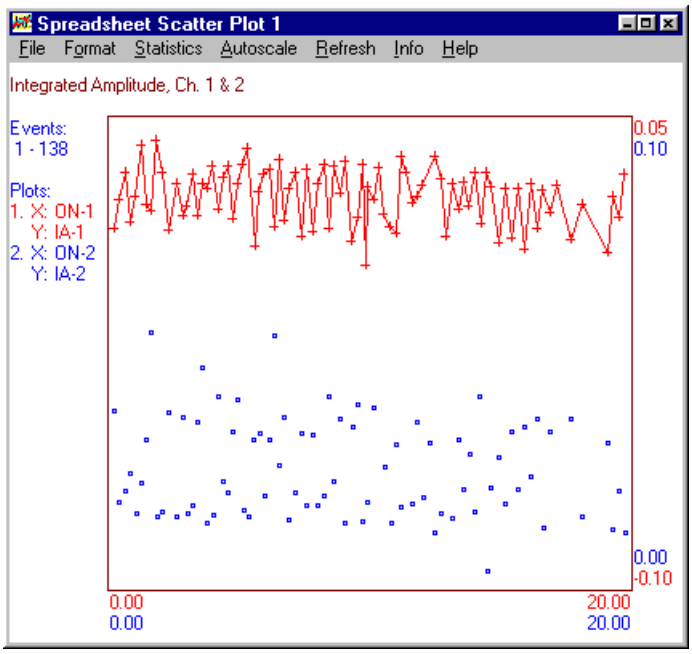


Figure H-18. An example of a scatter plot display window.

H-12.1. Formatting a Scatter Plot Display

Select the **Format** option in the display window's menu bar to open the Format parameter window. An example of the parameter window is shown in Figure H-19. As you can see, the parameter window contains five tabbed sections, **Display** and **Plot 1** through **Plot 4**. The Display tab provides access to the parameters that control the general appearance of the display, that is, the parameters that all of the plots have in common. The four plot tabs, on the other hand, provide access to the parameters that are specific to each of the four possible plots. The Display and Plot tabs are discussed separately below.

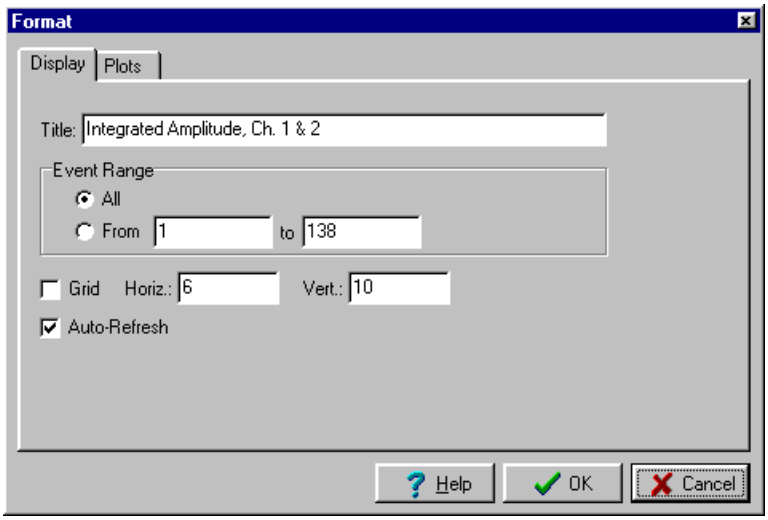


Figure H-19. The Format parameter window associated with a scatter plot display.

The Display Tab

The Display tab controls the general appearance of the display. It lets you enter a display title, select the range of events to be plotted, and whether or not a grid is included in the display. The function of each parameter in the Display tab is described in the remaining paragraphs of this section.

Title: Allows you to enter a title for the display. The title appears at the top of the display window itself, directly below the menu bar. If you save the display parameters to a file for later use, the title can also be used as if it were a long file name when later attempting to retrieve the file.

Event Range: This section determines the sequence of events for which attribute values are obtained and plotted in the display. The same event range applies to all plots in the display. There are two alternatives: **All** and **From:/To:**. Select the **All** option to ensure that the values obtained for all events are plotted. Select the **From:/To:** option plot only the values obtained for a selected sequence of events. Then insert the lowest numbered and highest numbered events in the desired sequence in the From and To boxes, respectively.

☞ Statistics are computed only for events which appear in the display.

Grid, Horizontal, and Vertical: 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.

Auto-Refresh: Turns the auto-refresh feature on and off. When the auto-refresh feature is on the display is automatically regenerated (refreshed) whenever any characteristic of the display is changed (e.g., when the display is resized, or when a characteristic of a plot is changed). When auto-refresh feature is off the display is only refreshed when you select the **Refresh** option in the menu bar along the top of the display window. Usually it is a good idea to turn the auto-refresh feature off only when it takes a long time to refresh the display.

The Plot Tabs

The Plot tabs contain the parameters that allow you to add or remove individual plots from the display, to select the variables to be plotted in each and the color and symbol to be used, to adjust the X and Y coordinates and decide whether they appear in the display, to add and remove lines connecting the individual points, and to add or remove the regression line computed for each plot. An example of a representative plot tab is shown in Figure H-20. The structure of all of the plot tabs are the same. The only difference is the number of the plot to which each pertains.

To add or remove an individual plot, first click on the corresponding Plot tab, then check or clear the **Status** check box, respectively. To change the attribute variable plotted along one or the other axis, select the **Variable** box in the corresponding area of the window, then either type in the label of the variable you wish to use or click on the  **(List Labels)** button to obtain a list of the currently defined variables.

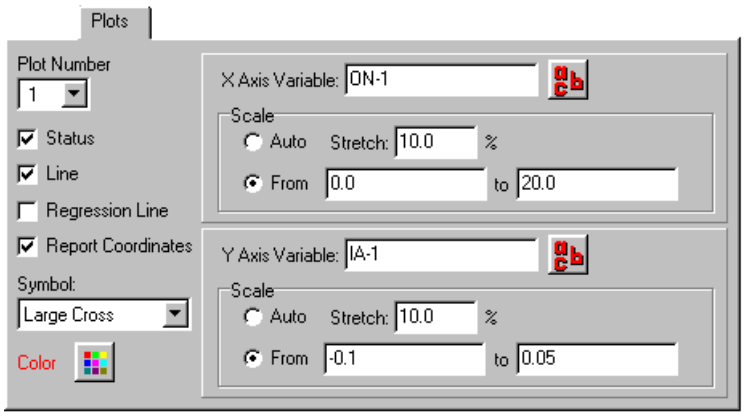


Figure H-20. An example of the Plots tab of the format parameters window associated with the scatter plot display.

Plot Number: Indicates the number of the plot whose parameters are reported in the remainder of the plot tab. Consequently, as you change the plot number the values of the other parameters change accordingly. A display can include up to four individual plots, and thus there are four options in this list box.

Status: Check this box to include the presently defined plot in the display or clear this box to eliminate it from the display

Line: This list box determines whether successively plotted points are connected with lines or not. This is the option that determines whether the plot is a scatter plot or a line plot.

Regression Line: Check this box to include the regression line of Y on X for the present plot in the display or clear the box to eliminate it.

Report Coordinates: Check this checkbox to report the minimum and and maximum X and Y coordinates of the plot in the display, or clear it to eliminate them.

Symbol: This list box determines the kind of symbol used to mark the location of each data point in the present plot.

Color: The Color parameter reports the color used to plot the data points in the present plot. The same color is used to report the attribute variables contributing the data as well as the minimum and maximum coordinates of the X and Y axes within the display. To change the color, select the  (**Change Color)** button to produce a color palette.

X-Axis - Variable: This box determines the attribute variable that is plotted along the X-axis in the display. To change the variable, either highlight the contents of the box and type in the label of the desired variable or click on the  **(List Labels)** button to obtain a list of the currently defined variables.

X-Axis - Scale: The Scale option determines the minimum and maximum coordinates of the X-axis. There are two alternatives available: **Auto** and **From:/To:**. Select the **Auto** option to automatically set the minimum and maximum coordinates of the axis relative to the minimum and maximum values obtained for the attribute variable plotted along it. The **Stretch** option lets you add a selected percentage of the difference between the minimum and maximum values to the upper and lower axis coordinates, and its purpose is to move the plot away from the very edges of the display. Select the **From:/To:** option to manually input the minimum and maximum values that you wish to use.

Y-Axis - Variable: This box determines the attribute variable that is plotted along the Y-axis in the display. To change the variable, either highlight the contents of the box and type in the label of the desired variable or click on the **(List Labels)** button to obtain a list of the currently defined variables.

Y-Axis - Scale: The Scale option determines the minimum and maximum coordinates of the Y-axis. There are two alternatives available: **Auto** and **From:/To:**. Select the **Auto** option to automatically set the minimum and maximum coordinates of the axis relative to the minimum and maximum values obtained for the attribute variable plotted along it. The **Stretch** option lets you add a selected percentage of the difference between the minimum and maximum values to the upper and lower axis coordinates, and its purpose is to move the plot away from the very edges of the display. Select the **From:/To:** option to manually input the minimum and maximum values that you wish to use.

H-12.2. Saving and Retrieving Plot Parameters

If you intend to use the same set of plot display parameters to set up a scatter plot or line plot sometime in the future, it is a good idea to save them to a file. To save a set of plot display parameters to a file, select the **File|Save Parameters** option from the menu bar at the top of the plot display window. Likewise, to retrieve a previously saved set of parameters, select the **File|Load Parameters** option. When retrieving (loading) a parameter file you can use the display title as a long file name to identify the file. Keep this in mind when you enter title for your display.

☞ Scatter plot display parameter files record the labels of the variables that appear in the display but not their definitions. Thus, it is also important to remember to save the attribute variables that you have defined to their own parameter file, and to retrieve that file before retrieving the table parameter file to ensure that it operates correctly. See Section H-3.1 for information about loading and saving attribute variable parameter files.

H-13. Selecting Attribute Variables (The List Labels Window)

In every location where you are asked to specify an attribute variable the Scientific Spreadsheet module provides a **List Labels** option ( ). Selecting the List Labels option opens the **Select Attribute Variable** window and allows you to select a variable from the list of attribute variables that you have already defined. For example, a List Labels option is provided when defining of an equation variable or a function variable, when selecting attribute variables to appear in an attribute table or a scatter plot, or when setting up one of the event sorting or editing features. But regardless of the situation the function and operation of the Select Attribute Variable window is the same. An example is shown in Figure H-21.

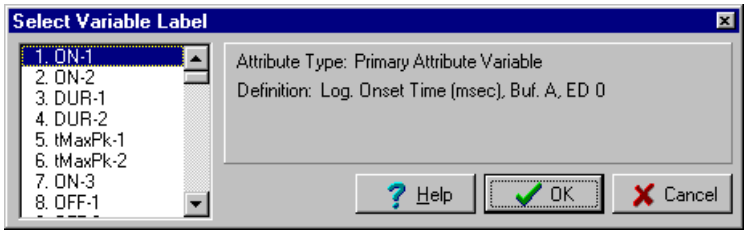


Figure H-21. The Select Attribute Variable window.

To select a variable, highlight its label in the list box on the left side of the window. When you highlight a variable, its definition appears to the right of the list box. For example, in the illustration presented above the label, "ON-1" is highlighted. As indicated to the right, this label represents a primary variable defined as the logical onset time (in milliseconds) of the events in the event file linked to event buffer A. After highlighting the variable you wish to use, click the **OK** button to insert the selected variable into the location where the List Labels option was selected.

H-14. The Manual Range Filter

The **Manual Range Filter** option can be used to eliminate events from one or more event buffers when the values obtained for a selected attribute variable fall either within or outside a specified range. The Graphic Range Filter option, described in Section H-15, performs the same general function. The differences between the two are that the manual range filter requires you to specify only one variable at a time and to enter its range boundaries using the keyboard. In contrast, the graphic range filter uses one or more scatter plots as its primary interface. Each scatter plot requires you to specify two variables, and the boundary values of the filtering operation must be adjusted with your mouse rather than entering them from the keyboard.

Select the  **(Manual Range Filter)** button in the Scientific Spreadsheet control panel to gain access to the **Manual Range Filter parameters window**, the window that the manual range filter option employs for establishing the filter's parameters. An example is shown in Figure H-22.

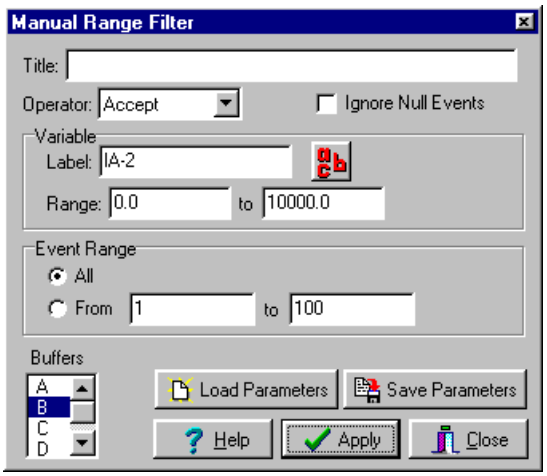


Figure H-22. An example of the Manual Range Filter parameters window.

There are five basic decisions you must make when performing a manual range filter. In no particular order, they are:

(1) In the **Variables** section, select the attribute variable to be used as the filter operation's reference. This is the variable whose values are measured to decide which events are retained and which are eliminated. The **Variable** box is used to specify the variable you wish to use. You can either type in its label or click the **List Labels** button () to select the desired variable from a list.

(2) Also in the **Variables** section, enter the minimum and maximum boundary values of the desired range in the boxes on the **Range** line.

(3) Decide whether events corresponding to values falling within the specified range are accepted (retained) or rejected. This is determined with the **Operator** box. Select the **accept** option to *retain* the events that correspond to values falling within the specified range, or select the **reject** option to *eliminate* those same events (thus retaining only the events which correspond to values falling outside the specified range).

(4) Check or clear the **Ignore Null Events** check box. If the check box is checked, corresponding events in the edited buffers are retained when a value cannot be calculated for the selected reference attribute variable. If the check box is cleared, on the other hand, corresponding events are eliminated from the edited buffers when a value cannot be calculated for the variable.

(5) Select which event buffers will be edited by the filter. The **Buffers** list box is used for that purpose. Highlight a buffer to include it, or remove the highlight to exclude it. Using the Control or Shift keys, you can highlight any combination of buffers.

It is important to recognize that the buffers you decide to edit and the variable you decide to use for that purpose are completely independent decisions. In other words, you can decide to edit buffers even when they are not used to measure the values of the specified variable. For example, you can use the filter to eliminate events in event buffer B using a variable that measures the duration of the events in event buffer A. In such a situation, the filter acts on events in buffer B according to the events to which they correspond in buffer A.

If you intend to use the same set of manual range filter parameters more than once, you may find it helpful to save them to a parameter file so that you can retrieve them when you need them. Select **the Save Parameters** button to save the established set of parameters to a file. Likewise, use the **Load Parameters** button to retrieve a previously saved set of parameters. When saving a parameter file you may find it useful to give the file a title because the title can be used as a long file name when later retrieving the file. That is what the Title box is for.

H-15. The Graphic Range Filter Option

The graphic range filter lets you eliminate events from one or more event buffers when the values obtained for one or more attribute variables fall either within or outside a specified range. As the name implies, the graphic range filter employs a display window containing one or more scatter plot diagrams as its main interface. The boundaries of the range filter appear as the edges of a rectangle or an ellipse that is superimposed on one of the scatter plot diagrams in the display. The elliptical range filter is shown in the right hand panel of the example shown in Figure H-23.

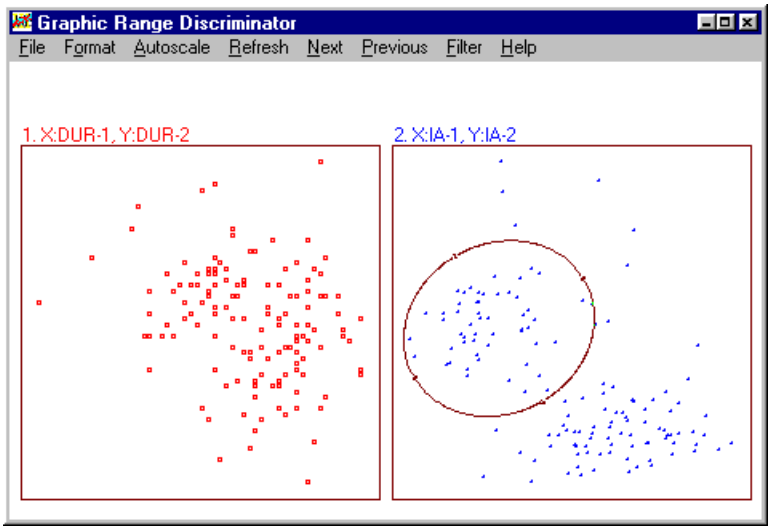


Figure H-23. An example of the graphic range filter display window. This example contains two scatter plot panels. Up to four panels are possible.

To access the graphic range filter feature, select the  **(Graphic Range Filter)** button on the Scientific Spreadsheet control panel and wait for the **Graphic Range Filter display window** to appear. An example is presented in Figure H-23. The graphic range filter display window can contain 1, 2, 3, or 4 scatter plot panels. Each panel can present different variables, thus providing different views of your data. As you can see, the example display presented below contains two scatter plot panels. Each panel contains a scatter plot showing a different pair of attribute variables. The variable titles are reported above each plot. For example, the variables plotted along the X and Y axes of the scatter plot in the left panel of Figure H-23 are DUR-1 and DUR-2, respectively.

H-15.1. Formatting the Graphic Range Filter Display

To add or delete a scatter plot panel, or change the characteristics of an existing panel, select the **Format** option in the display window's menu bar. Doing so opens the main **Format Display parameters window.** An example is presented in Figure H-24. As you can see, the parameter window contains five tabbed sections, **Display** and **Panel 1** – **Panel 4**. Each are described separately below.

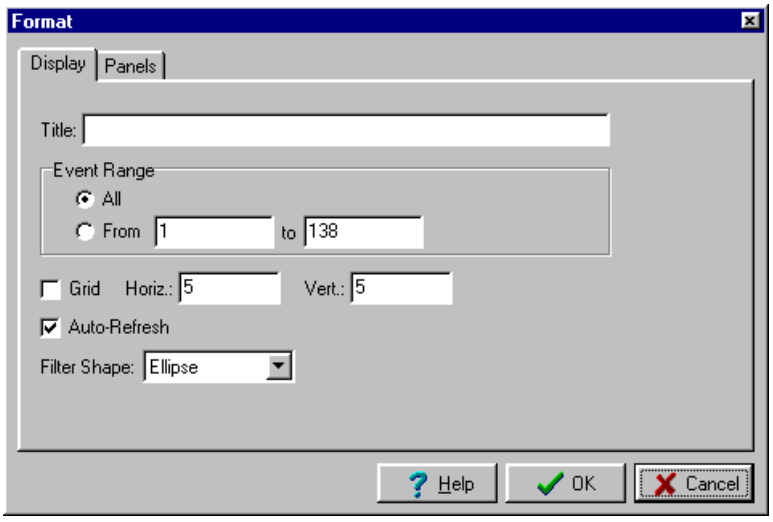


Figure H-24. An example of the Format parameters window associated with the graphical range discriminator display.

The Display Tab

The Display tab controls the general appearance of the display. It lets you enter a display title, select the range of events to be plotted, and whether or not a grid is included in the display. The operation of each parameter in the Display tab is explained in the remaining paragraphs of this section.

Title: Allows you to enter a title for the display. The title appears at the top of the display window itself, directly below the menu bar. If you save the display parameters to a file for later use, the title can also be used as if it were a long file name when later attempting to retrieve the file.

Event Range: This section determines the sequence of events for which attribute values are obtained and plotted in the display. The same event range applies to all plots in the display. There are two alternatives: **All** and **From:/To:**. Select the **All** option to ensure that the values obtained for all events are plotted. Select the **From:/To:** option plot only the values obtained for a selected sequence of events. Then insert the lowest numbered and highest numbered events in the desired sequence in the From and To boxes, respectively.

☞ Statistics are computed only for events which appear in the display.

Grid, Horizontal, and Vertical: 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.

Auto-Refresh: Turns the auto-refresh feature on and off. When the auto-refresh feature is on the display is automatically regenerated (refreshed) whenever any characteristic of the display is changed (e.g., when the display is resized, or when a characteristic of a plot is changed). When auto-refresh feature is off the display is only refreshed when you select the **Refresh** option in the menu bar along the top of the display window. Usually it is a good idea to turn the auto-refresh feature off only when it takes a long time to refresh the display.

Filter Shape: Determines the initial shape of the range filter. The options are **Rectangle** and **Ellipse**. The filter shape can subsequently be changed directly from the display using the **Filter|Shape** option in the display window's menu bar.

The Panel Tabs

The Panel tabs (Panel 1 – Panel 4) each contain the parameters that allow you to add or remove one of the four possible plots from the display and to adjust the parameters that control the appearance of the corresponding panel. Such parameters include the variables to be plotted in the selected panel and the color and symbol to be used, the X and Y coordinates of the panel, whether individual points in the plot are connected with lines, and whether a regression line is computed and displayed in the plot. A representative example of a Panels tab is shown in Figure H-25. The operation of each parameter in the tab is explained in the concluding paragraphs of this section.

To add or remove a selected panel, first click on the corresponding tab, then check or clear the **Status** check box, respectively. To change the attribute variable plotted along one or the other axis, select the **X-Axis Variable** or **Y-Axis Variable** box in the corresponding area of the window, then either type in the label of the variable you wish to use or click on the  **(List Labels)** button to obtain a list of the currently defined variables.

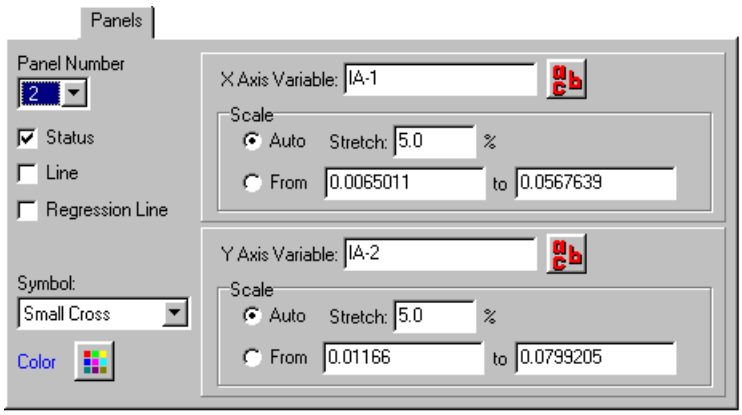


Figure H-25. An example of the Panels tab of the format parameters window associated with the graphical range filter display.

Status: Check this box to include the presently defined plot in the display or clear this box to eliminate it from the display

Line: This list box determines whether successively plotted points are connected with lines or not. This is the option that determines whether the plot is a scatter plot or a line plot.

Regression Line: Check this box to include the regression line of Y on X for the present plot in the display or clear the box to eliminate it.

Symbol: This list box determines the kind of symbol used to mark the location of each data point in the present panel.

Color: The Color parameter reports the color used to plot the data points in the present panel. The same color is used to report the attribute variables contributing the data as well as the minimum and maximum coordinates of the X and Y axes within the display. To change the color, select the  (**Change Color)** button to produce a color palette.

X-Axis - Variable: This box determines the attribute variable that is plotted along the X-axis in the panel. To change the variable, either highlight the contents of the box and type in the label of the desired variable or click on the  **(List Labels)** button to obtain a list of the currently defined variables.

X-Axis - Scale: The Scale option determines the minimum and maximum coordinates of the X-axis. There are two alternatives available: **Auto** and **From:/To:**. Select the **Auto** option to automatically set the minimum and maximum coordinates of the axis relative to the minimum and maximum values obtained for the attribute variable plotted along it. The **Stretch** option lets you add a selected percentage of the difference between the minimum and maximum values to the upper and lower axis coordinates, and its purpose is to move the plot away from the very edges of the panel. Select the **From:/To:** option to manually input the minimum and maximum values that you wish to use.

Y-Axis - Variable: This box determines the attribute variable that is plotted along the Y-axis in the panel. To change the variable, either highlight the contents of the box and type in the label of the desired variable or click on the  **(List Labels)** button to obtain a list of the currently defined variables.

Y-Axis - Scale: The Scale option determines the minimum and maximum coordinates of the Y-axis. There are two alternatives available: **Auto** and **From:/To:**. Select the **Auto** option to automatically set the minimum and maximum coordinates of the axis relative to the minimum and maximum values obtained for the attribute variable plotted along it. The **Stretch** option lets you add a selected percentage of the difference between the minimum and maximum values to the upper and lower axis coordinates, and its purpose is to move the plot away from the very edges of the panel. Select the **From:/To:** option to manually input the minimum and maximum values that you wish to use.

H-15.2. Performing a Filter Operation

Though you can display up to four scatter plots in a single display, only one at a time can be used for the range filter operation. The scatter plot that is currently selected for that purpose contains the rectangle or ellipse representing the boundaries of the range filter. An example of an elliptical range filter is apparent in the right hand panel of the illustration presented above. To move the filter to a different panel, select either the **Next** or **Previous** options of the display window's menu bar until the filter box appears in the panel you wish to use. Likewise, to switch between a rectangular and elliptical shape, select the **Filter|Shape** option in the display window's menu bar.

The filter contains four "handles", appearing as small squares in the lines demarking the filter's boundary. The handles are used to resize the filter, as described next.

Sizing the Rectangular Shape

The rectangular shape has handles at each of its four corners that can be used to adjust the size of the rectangle. To move a corner, hold down the shift key, position the mouse pointer close to the corner you want to move (while still remaining within the borders of the plot), then hold down the left mouse button as you move the mouse. The X and Y axis coordinates associated with the current positions of the edges of the box are always reported at the top of the display, just below the menu bar. These coordinates are constantly updated as you move the corners of the box, so you always know what the boundaries of your filter are.

Sizing and Orienting the Elliptical Shape

The elliptical shape has handles, appearing as small squares, at its upper, lower, left and right tangents. To increase or decrease the size of the ellipse in its horizontal or vertical dimension, hold down the shift key, position the tip of the mouse pointer close to one of the handles, then hold down the mouse left mouse button as you move the mouse. The ellipse will stretch or shrink as you move. To reposition the entire ellipse, hold down the shift key, put the tip of the mouse pointer inside the ellipse, then hold down the mouse left mouse button as you move the mouse. Finally, to rotate the ellipse, hold down the shift key, put the tip of the mouse pointer outside the ellipse, then hold down the mouse left mouse button as you move the mouse left or right.

Once you have the corners of the filter shape positioned where you want them, select the **Filter|Apply Filter** option in the display window's menu bar to initiate the filter operation. The **Buffers to Edit window** then appears on the screen. An example is shown in Figure H-26. The Buffers to Edit window is used to select the event buffers you wish to edit, and to determine whether events in those buffers are either retained or eliminated when the variable values to which they correspond fall within the boundaries of the filter. Select an event buffer by highlighting its letter in the **Buffers** list box. You can select multiple buffers by holding down the Control or the Shift key prior to clicking on a letter with your mouse. To retain only the events corresponding to variable values that fall within the boundaries of the established range, set the **Operator** option to **Accept** (all of the events corresponding to values that fall outside the established range are thus eliminated). Conversely, to eliminate the events corresponding to variable values that fall within the boundaries of the established range, set the **Operator** option to **Reject** (only the events corresponding to values that fall outside the established range are thus retained).

Finally, the **Ignore Null Events** check box determines the fate of events in the selected buffers that correspond to null values in the variables being plotted. If you wish to retain such events, check the Ignore Null Events checkbox. If you wish to eliminate them, clear the check box.

Figure H-26. An example of the Buffers to Edit window.

☞ The graphic range filter feature does not limit you to editing only event files linked to the event buffers employed to calculate the values of the attribute variables you are plotting in your scatter plots. In fact, from the program's standpoint, the instructions you give it regarding which attribute variables to plot are completely separate from the instructions you give it regarding which event buffers to edit. You can even elect to edit only event files that have nothing to do with the variables being plotted. Consequently, there can be times when a filtering operation yields no visible change in the display.

☞ When a range filter is executed, autoscaled axes are automatically switched to manual (To/From) scaling in the scatter plot panel used for the filtering operation. This is done to prevent the coordinates of the X and Y axes from being recalculated unexpectedly.

H-16. Recalc. Boundaries

The **Recalculate Boundaries** feature allows you to replace the onset and/or offset times of a selected set of events with the values obtained for any other variable. The Recalculate Boundaries feature is very similar to the Virtual Events feature in that its primary purpose is to allow you to adjust the boundaries of a set of events so that they occur at some other relevant point in time. For example, like the Virtual Events feature you can use the Recalculate Boundaries feature to move the offset boundaries of a given set of events so that they are placed where the maximum or minimum peak amplitude occurred in each of the original events, where the first upper or lower peak occurred, and so on. The major difference is that the Recalculate Boundaries feature moves the boundaries of the events in an actual event buffer whereas the Virtual Events feature creates an imaginary set of events in an imaginary event buffer. Since actual event buffers can be used in other modules, whereas virtual event buffers cannot, the Recalculate Boundaries feature is the one to use if you intend to employ the recalculated event times in another module.

To use the Recalculate Boundaries option to move a set of event's onset or offset boundaries, be sure that the variable you use measures time relative to the beginning of the data file, because that is the way event onset and offset times are reported as well. Be aware, however, that the Recalculate Boundaries option does not limit you to the use of time variables measured relative to the beginning of the data file. You can use any variable you want. It does not matter whether it is a primary, equation, function, or range variable, and it does not matter whether it measures time, amplitude, or anything else. The Recalculate Boundaries option can therefore be used to store any kind of values that you want to store inside an event file. Once stored inside an event file, the values can then be used by other modules. For example, you can use them in a histogram analysis to generate a histogram using measurements the histogram analysis module cannot calculate by itself -- e.g., 10% to 90% rise times, duration at 1/2 amplitude, and so on.

☞ Although you are allowed to use any kind of variable you want to recalculate event boundaries, keep in mind that the resulting values are always interpreted as time values in the time units you select. Just ignore the time units if they are irrelevant.

To perform a recalculation, first select the  **(Recalculate Boundaries)** button in the Scientific Spreadsheet control panel. Doing so produces the Recalculate Event Times parameter window. An example is presented in Figure H-27. As the figure illustrates, the window contains four edit boxes. The **Buffer** and **Boundary** boxes respectively determine which set of events and which event boundary (either onset or offset) are to be changed by the operation of the Recalculate Boundaries option. Note that the name and title of the event file that is linked to the selected buffer, along with the number of events in the file, are reported below the row of edit boxes. The **Variable** box determines the variable supplying the new values to use in place of the original event boundary times. To change the variable, click on the  button and highlight the one you wish to use. The **Time Unit** box indicates the time units that are used to interpret the values of the specified variable. When you are finished entering all four items of information, select the **Apply** button to perform the recalculation. The window remains open to facilitate its repeated use.

☞ When using time variables in the Recalculate Boundaries option, *make sure that you use the same Time Units option that you used when you defined the variable.* For example, milliseconds were selected to report the values of the selected variable, then set the **Time Unit** option to **msec**. [To determine the units you used for the variable, use the button to the right of the Variables box, select the List Labels option, then highlight the variable you wish to use. The time units are reported in the description of the variable.] If you are using a variable that is not a time variable, then just ignore the time units.

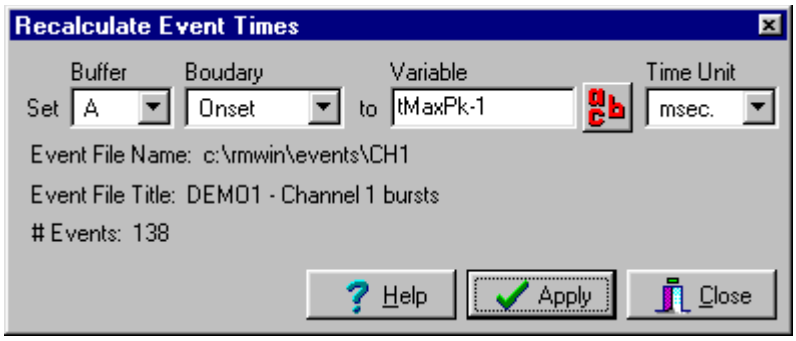


Figure H-27. An example of the Recalculate Event Times parameter window.

H-17. The Time Filter

The Time Filter option makes it possible to rearrange the events in two or more event files so that events which occur closely in time are considered *corresponding events* (corresponding events are events in different event files that are assigned the same number). This is important because many of the comparisons and equations that the Scientific Spreadsheet performs are performed on corresponding events. For example, to obtain relative onset times, you would define an equation variable that subtracts the onset times of the events in one event file from the onset times of the *corresponding* events in another event file. When making cross-file comparisons like the one in this example, it is important to ensure that the events in the two event files are paired correctly. That is the purpose of the Time Filter.

To perform a time filter operation, first select the **(Time Filter)** button from the Scientific Spreadsheet control panel and wait for the **Time Filter Parameters window** to appear. An example is shown in Figure H-28.

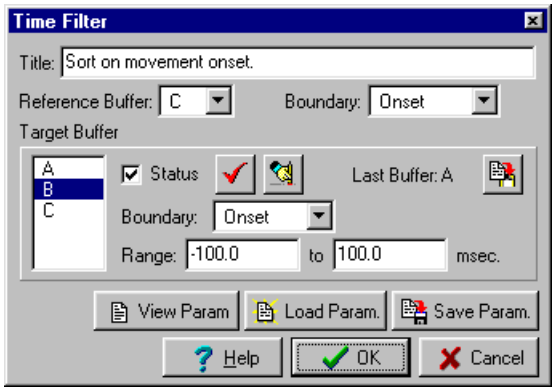


Figure H-28. The An example of the Time Filter parameters window.

In a time filter operation one of the event buffers must be designated as the **Reference Buffer**. The reference buffer is the one whose onset or offset boundary times of the events contained in it serve as the set of reference points to rearrange the events in the designated *"target buffers"*. A buffer is designated as a target buffer by highlighting its letter in the **Target Buffer** list box and checking the **Status** check box. To rapidly select all of the buffers as target buffers, use the **(Select All)** button. Likewise, to rapidly deselect all of the buffers as target buffers, use the **(Clear All)** button.

In addition to selecting the reference and target buffers, you must also indicate how the events contained in them must correspond in time in order to be considered corresponding events. Specifically, you must determine whether the onset or the offset boundaries of the reference events are considered the time = 0 reference points by selecting the appropriate option in the corresponding **Boundary** box. Then, for each target buffer, you must determine a **Range**, measured relative to each reference point. Additionally, you must decide whether the onset or the offset **Boundary** of each target event is measured relative to each reference point. If the onset or the offset of a target event occurs within the specified range of a reference event it is designated as a corresponding event to that reference event (i.e., it is assigned the same number as the reference event). The range is defined by entering its boundary values in the two edit boxes provided. A negative value means that the range boundary precedes the reference point while a positive value means that the range boundary occurs after the reference point. In the example shown in Figure H-28, note that the range boundary values are -100 and 100, meaning that an event must begin in the target buffer within an interval starting 100 milliseconds before and ending 100 milliseconds after the onset of a reference event.

A separate set of range boundaries must be established for each target buffer. The  **(Copy Last Buffer)** button can be used to simplify the task: if you want to set the range of one target buffer to the same values as another target buffer, first highlight the letter of the buffer you want to copy from, then highlight the letter of the buffer you want to copy to, then select the  button. Note that the source buffer is always the buffer that was highlighted just before the currently highlighted buffer, and it is reported as the **Last Buffer Selected** just to the left of the  button.

If you intend to use the same set of time filter parameters on many data files, select the **Save Param** button to save them to a file. Likewise, use the **Load Param** button to retrieve a previously saved set of parameters. When saving a parameter file you may find it useful to give the file a title because the title can be used as a long file name when later retrieving the file. That is what the **Title** box is for. Select the **View Param** button to open a window reporting all of the currently selected window filter parameters. The contents of the view window can be printed to obtain a hard copy record of the parameters you used.

Important Considerations When Using the Time Filter

Ordering Events

The time filter option assumes that the events in the reference and target buffers are arranged in ascending order of their onset times. In other words, the onset time of event #(n) in a given analysis buffer must be less than or equal to the onset time of event #(n+i), where i = any positive number. Erroneous results are possible if this rule is violated. Null events do not apply.

Target Events Not Included in any Reference Range

Events in a target buffer which do not occur within a range associated with a reference event are deleted from the event file linked to the target buffer.

Multiple Target Events Within the Same Reference Range

Normally, primacy takes precedence if more than one event in the same target buffer begins within the same reference range; i.e., the first target event to occur is made to correspond with the reference event. Subsequent target events are normally deleted from the event file. However, this "primacy rule" is sometimes superseded when ranges overlap, as is explained in the next paragraph.

Target Events Within Overlapping Reference Ranges

The program allows you to overlap the ranges associated with two or more successive reference events. If the range is very long, or if events in the reference buffer occur with sufficient frequency, many successive ranges may overlap. In such a situation a single target event may begin within

the ranges of more than one reference event. In fact, several target events may occur within the same set of reference ranges. The conventions established to deal with such situations were designed to achieve the condition in which one and only one target event corresponds to one and only one reference event. Figure H-29 is used to illustrate the process of determining which target event is made to correspond with a given reference event. To simplify the illustration only the onset times are indicated for the events occurring in the two buffers, and they are indicated by the short vertical lines emerging from a horizontal baseline. Buffer A has been selected as the reference buffer. Reference event onsets are labeled (A), (B), and (C). Event onsets in Buffer B are labeled 1 through 6. The ranges associated with each reference event onset are indicated with brackets.

Note that event #1 in Buffer B does not begin within any reference range. It is therefore deleted from the target buffer. Within the range associated reference event (A) a total of 3 events occurred in Buffer B. In accordance with the primacy rule discussed above, the first target event to occur (i.e., Event #2) is selected to correspond with reference event (A). Within the range associated with reference event (B) there are a total of 5 events in Buffer B. Event #2 is the one which occurs earliest. However, since it has already been selected to correspond with reference event (A) it is not considered a candidate a second time. Instead, Event #3 is selected to correspond with (B) since it is the event that occurs earliest in the range associated with (B) which has not already been selected to correspond with another reference event. Event #6 is selected to correspond with reference event (C) since, although it begins within the range associated with reference event (B), it was not selected to correspond with (B). Notice that target events #4 and #5 are not selected to correspond with any reference event in spite of the fact that they occur within at least one reference range. Yet, since they are not selected to correspond with any reference event they too are deleted from the target event file.

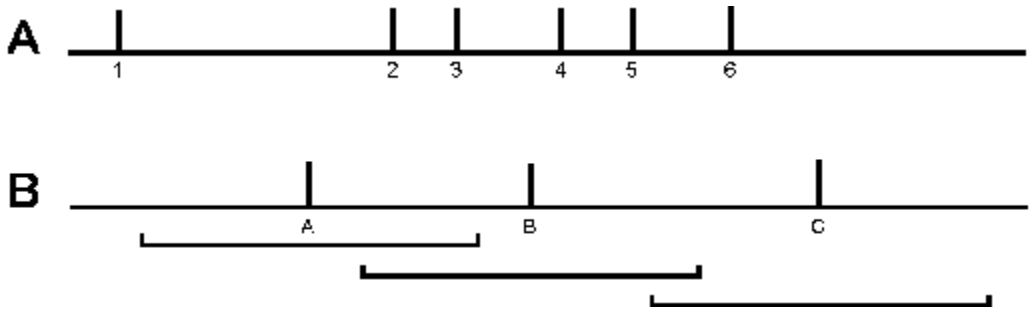


Figure H-29. An example illustrating how the Time Filter option selects target events. See text for details.

H-18. Auto Calibrate Channels

The Auto Calibrate Channels feature is intended as an alternative to the regular Calibrate Channels feature described in Chapter 1, Section 1-8. With it, you have all the power and versatility of the module's attribute variables features to automatically calibrate the amplitudes of your input signals. Specifically, the Auto Calibrate feature makes it possible to insert values calculated for selected attribute variables into the Zero Offset and 1 Volt Scale parameters of each input channel.

To access the Auto Calibrate Channels feature, click on the  (Auto Calibrate Channels) button in the module's control panel. Doing so opens the **Auto Calibrate Channels window**. An example is shown in Figure H-30. Readers familiar with the Calibrate Channels window will notice that the Auto Calibrate Channels window looks very similar to it. Each channel in the data file is reported in the list box along the left edge of the window. When a channel number is highlighted, its calibration parameters appear to the right. There are four such parameters: **Channel Title**, **Unit Label**, **Zero Offset**, and **1 Volt Scale**. Of these, the Channel Title and Unit Label are labels and do not affect the amplitude of the signal. So actually they are not really calibration parameters. But they appear here so that they can be accessed easily. The **Zero Offset** and the **1 Volt Scale** parameters are the actual calibration parameters.

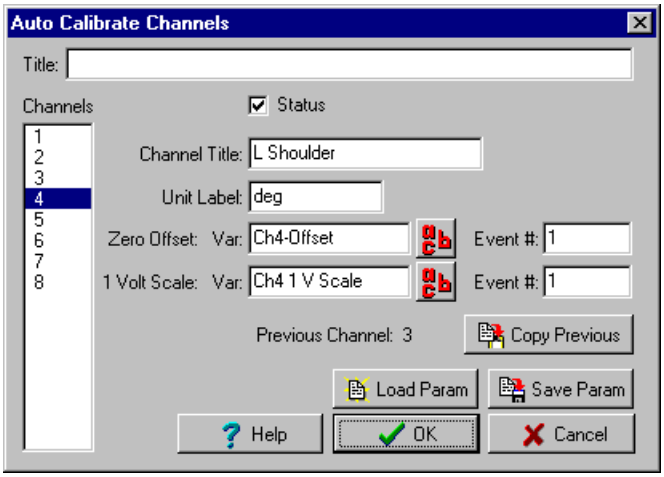


Figure H-30. An example of the Auto Calibrate Channels window.

As in the Calibrate Channels feature, the the **Zero Offset** parameter specifies the raw voltage value that will be interpreted as amplitude = 0 after calibration. Likewise, the **1 Volt Scale** parameter determines how a 1 volt change in raw voltage will be interpreted after calibration. Unlike the Calibrate Channels feature, however, you to not directly insert the values you want to use for these parameters. Rather, you specify the attribute variables that will be used to calculate the values, along with the event number for which each value will be calculated.

Any type of attribute variable can be used to supply the calibration parameters, including variables whose values are calculated for virtual events. Consequently, the Auto Calibrate Channels feature provides an exceptionally verstatile platform for calibrating your signals regardless of your specific needs.

Using the Auto Calculate Channels Feature: An Extended Example:
The following example provides a step-by-step illustration of how to use the Auto Calibrate Channels feature to calibrate the amplitude of a signal. The signal employed for the example was obtained from an electrogoniometer, and the specific purpose of the example is to translate the raw voltage values of the input into joint angles expressed in degrees. But the principles involved can be applied to almost any situation.

To calibrate any signal one must obtain two signal segments (or data points) whose amplitudes are known. Ideally, one of those signal segments should represent an amplitude of 0.00, because the amplitude = 0 point can be obtained directly. But as long as their amplitudes are known the amplitude = 0 point can be extrapolated from them. Figure H-31 shows a signal containing two three-second segments at the beginning whose desired amplitudes are known. Specifically, we want the amplitude of the first segment to be interpreted as 0.00, and the second as 90.00. But raw voltage signals are rarely absolutely stable, and certainly aren't in this case. Consequently, we will obtain the average amplitudes of the two segments and convert them to the desired values.

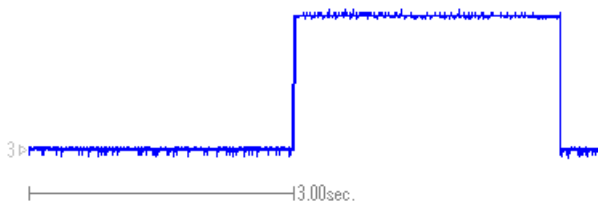


Figure H-31. The portion of a signal containing two 3-second segments of known amplitude.

The first task in the calibration process is to define a set of attribute variables that will provide us with the calculations we need to calibrate the signal. And since attribute variables are measured for events, we need to define the segments as events before we can define the variables themselves. If the file was acquired using Datapac 2K2, and if each segment represents successive acquisition sessions, then that task was automatically accomplished at the time of acquisition and stored in the companion event file linked to event buffer Z. To simplify our discussion we will assume that was the case in this example. But if that was not the case, then it is necessary to select events in some other manner -- or use the virtual events feature. At any rate, we have an appropriate set of events, we are ready to define our attribute variables.

Our task as we described it requires us to define five attribute variables in all:

1. A primary variable to obtain the mean amplitude of the first signal segment. We will label this variable as "Mean Amp Seg1".
2. A primary variable to obtain the mean amplitude of the secong signal segment. We will label this variable as "Mean Amp Seg2".
3. An equation variable to obtain the difference between the two mean amplitudes. We will label this variable as "Seg2-Seg1".
4. A primary variable which is actually a constant value equal to the desired change in amplitude between the two means, which in this example is 90 units of amplitude. We will label this variable as "C90".
5. An equation variable in which the desired change in amplitude (i.e., variable C90) is divided by the actual, or raw, change in amplitude (i.e., variable Seg1-Seg2). We will label this variable as "1 V Scale Ch3".

Figure H-32 shows the list of attribute variables after all five have been defined. Note that the definitions of "Mean Amp Seg1" and "Mean Amp Seg2" are exactly identical except for the event displacement (ED) value. In the case of "Mean Amp Seg1" it is 0 and for "Mean Amp Seg2" it is 1. This is important because equation variables compare values for corresponding events. Normally, events correspond only when they are identically numbered. In this case we want to compare -- the value obtained for the first event in an event file with the value obtained for the second event in the same event file. That is what the "Seg2-Seg1" does, and the event displacement parameter allows us to do that. Finally, note also that the channel specified in the first two variables is 3, because that happens to be the channel containing the signal we wish to calibrate. Likewise, the specified event buffer is Z, for reasons discussed earlier.

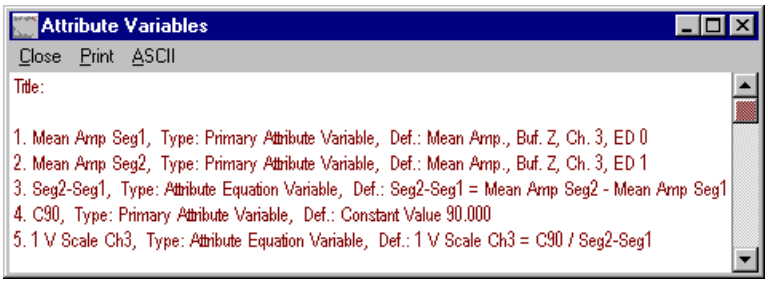


Figure H-32. A View Variable window showing the definitions of the five defined attribute variables.

Now we are ready to insert the variables into the Auto Calculate Channels window. Figure H-33 illustrates the proper way do that, given the attribute variables we defined. Note that Channel 3 is highlighted, because that is the channel we wish to calibrate with the variables we defined. The **Zero Offset** parameter and the corresponding **Event #** parameter are set to "Mean Amp Seg1" and "1", respectively, because that is the variable, and the event within that variable, that supply the amplitude value we wish to define as amplitude = 0.00. Similarly, the **I Volt Scale** parameter and its corresponding **Event #** parameter are set to "1 V Scale Ch3" and "1" because that is the variable, and the event within the variable, that supply the relationship between the raw and desired difference in amplitude measured for the two signal segments. Also note that the **Status** check box is checked, indicating that Channel 3 will be calibrated when the Auto Calibrate procedure is executed. To execute the procedure, click the **OK** button.

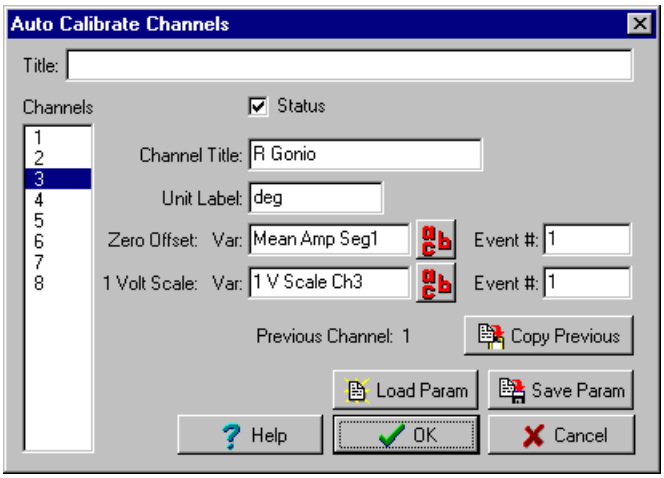


Figure H-33. An example of the Auto Calibrate Channels window with the proper parameters established.

Now that you have the necessary variables defined and the Auto Calibrate Channels window set up, all you have to do to calibrate your signal in similarly organized data files is to open the file and execute the calibration procedure. Note also that in this example we made no mention of the initial raw voltage values within the two signal sements we are using for our calibration. That is because we don't have to know what they are. We let the program do those calculations – and then automatically insert them into the equations needed to obtain the desired values.