# PROPAGATION DELAY & SKEW

*FOR THE SIA*

## Applications of Propagation Delay & Skew tool

- Determine signal propagation delay time
- Detect skewing between channels on rising or falling edges
- Create histograms of different edge relationships

## Introduction

The focus of this guide is to familiarize the user with the basic *Propagation Delay & Skew* tool, to allow quick and easy measurements and interpretation of results. Refer to the SIA User's Manual and the GigaView help files for more information.

## Theory of Operation

The *Propagation Delay & Skew* tool makes time measurements of different clock signals with respect to one another. The time measurements are asynchronously sampled (without a trigger) at random intervals to give a solid, statistical population. The randomization ensures that no jitter is masked out by a constant sampling rate. The time measurements are displayed as a histogram; measured values are on the x-axis and number of hits is on the y-axis. The *Propagation Delay & Skew* tool also incorporates the Tail-Fit™ algorithm, which separates the jitter into random and deterministic components (RJ and DJ). When operating in Tail-Fit™ mode, a "Bathtub Curve" provides an accurate estimation of Total Jitter (TJ), or long-term signal integrity. Tail-Fit™ is available only with the "Advanced Clock" VISI software module.

## Propagation Delay & Skew Tool

(With two views open)

**Dialog Bar**
Contains tool settings menus.

**Plot area**
Zoom in—hold down left mouse button, expand zoom box over area of interest.
Zoom out—double click left mouse.

**GigaView Panel**
Cursor coordinates - Displayed in the box at lower right portion of the front Panel. Units are same as those in plot.

**Bathtub View**
Shows long term reliability of each of the tested signals.

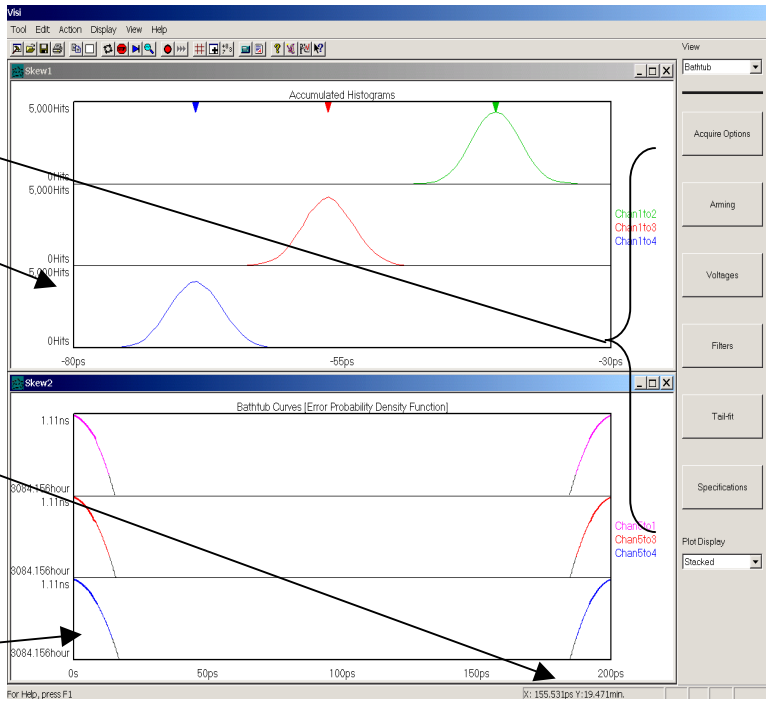
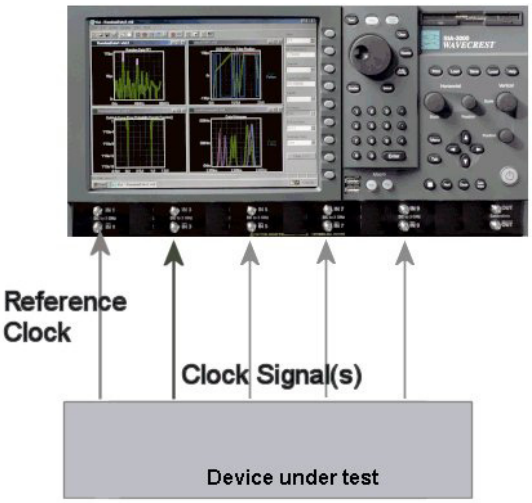



**Figure 1. Skew Plot**

## Making a Measurement

On the Dialog bar menu along the right side of the initial screen, select Chan To Chan then Propagation Delay and Skew Menu default settings allow users under most conditions to immediately begin making measurements.

- Verify that a reference signal is connected to one of the input channels, and that clock or data signals are connected to one or more additional channels.
- Go to the "Acquire Options" menu and select "Reference Channel". In the dialog box, check the channel intended for reference. Press <Enter>
- Select "Add/Delete Channel". In the dialog box, check the channels intended for measurement. Press <Enter>
- On the Front Panel or on the top toolbar press "Pulse Find" . Verify the voltage levels and close the Pulse Find box.
- On the Front Panel or on the Tool Bar, press the "Single/Acquire" button or press the "Run" button to accumulate a continuous series of measurements.




- Press the "Single/Acquire" button or the "Disable All" button to stop the cycling process.

## Histogram Information

The number of histograms displayed on the screen will be the same as the number of measurement channels chosen. These histograms represent the relationship of the measured clock/data edge to the reference clock edge. Both the shape and information obtained in these histograms is the same as in the *Histogram* tool. For convenience, that information is reiterated here.

Any feature, which makes the distribution deviate from a perfect Gaussian distribution, is evidence of deterministic jitter (DJ). Therefore, in the presence of DJ, the 1σ value cannot be used as the true RJ value. If the histogram distribution is multimodal, as in Figure 2, the 1-Sigma value does not accurately reflect the random jitter component. Additionally, the peak-to-peak value does not offer valuable information. It too is a combination of both the RJ and DJ components.

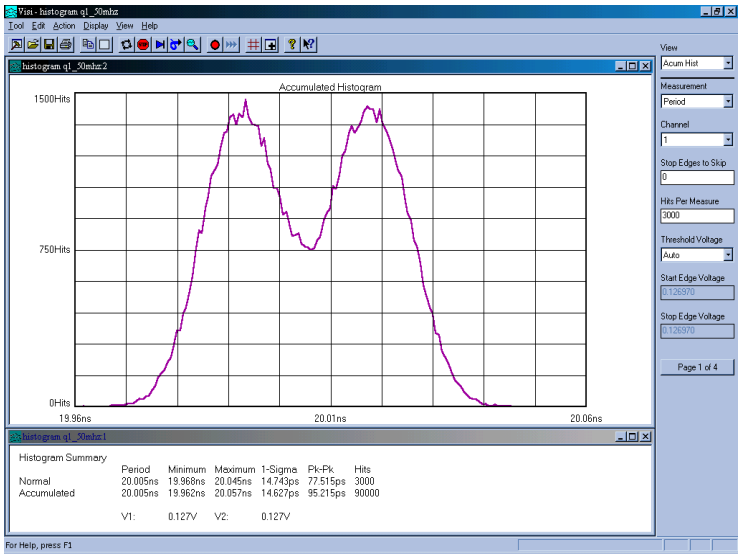



**Figure 2. Histogram without TailFit™**

The *Propagation Delay & Skew* tool, as with the *Histogram* tool, produces four different views: Accum, Max, Bathtub and Summary. The "Accum" view (Figure 2) puts all measurements from multiple acquisitions into one histogram. The "Max" view (Figure 3.) is useful to see low frequency or low probability events as outliers. Rather than auto-scaling all measurements into one histogram, the most recent histogram is shown in addition to the maximum extents of all previous histograms. Period drift or wander can be seen in this view. The "Bathtub" view, described later in this document, illustrates long-term reliability of the measurements, and "Summary" is a text view of all pertinent information.

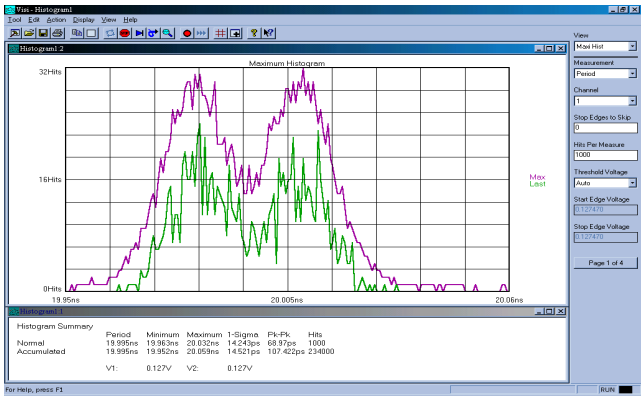



**Figure 3. Histogram using Maxi View**

## Enabling Tail-Fit™ and Taking a Measurement

While in the *Propagation Delay & Skew* tool, go to the Tail-Fit menu of the dialog bar. In the Tail-Fit pull-down menu select "Enabled". The standard Tail-Fit method will not return a result until a number of statistical requirements are met. Therefore, the user should enable the "Stop on Success" option by selecting "ON". To make a measurement, press the Run/Cycle button .

The Tail-Fit™ algorithm is used to separate and accurately quantify the Random and Deterministic components of Jitter. Random jitter is naturally modeled by a Gaussian function (bell shaped distribution). Therefore, the tail of a histogram distribution reflects the random jitter process, which has a Gaussian-type distribution. The Tail-Fit™ algorithm identifies a Gaussian curve with a symmetrical tail region to that of the distribution under evaluation. Two gaussian curves are fitted against each of the tail regions of the distribution until optimal matches are found. As demonstrated in Figure 4, the matched Gaussian distributions are not necessarily the same for each tail. The rms ($1\sigma_L$ for the left side) of the matched curve is used as the standard deviation multiplier for that particular tail. The left and right rms values are found and averaged to provide an avg rmsJ value. Once the random component is quantified, a total DJ value can be determined.

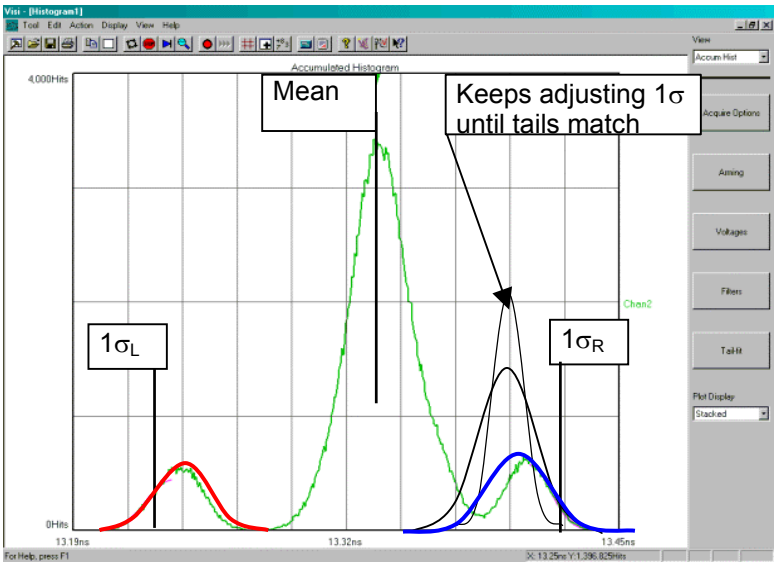



**Figure 4. Tail-Fit Algorithm**

Both Figures 3 and 5 have about the same 1-sigma and Pk-Pk values, but Figure 5 separates the jitter into its individual components. A DJ value is now displayed in the summary window. RJ is displayed as Left side (Lt-rmsJ), Right side (Rt-rmsJ), and Average (Avg-rmsJ), which can be used if the left and right RJ's are different. Note that the 1-sigma value is larger than the Avg-rmsJ, which represents the true random component. A Total Jitter (TJ) value is now present in the summary window; it is derived from the bathtub curve below.

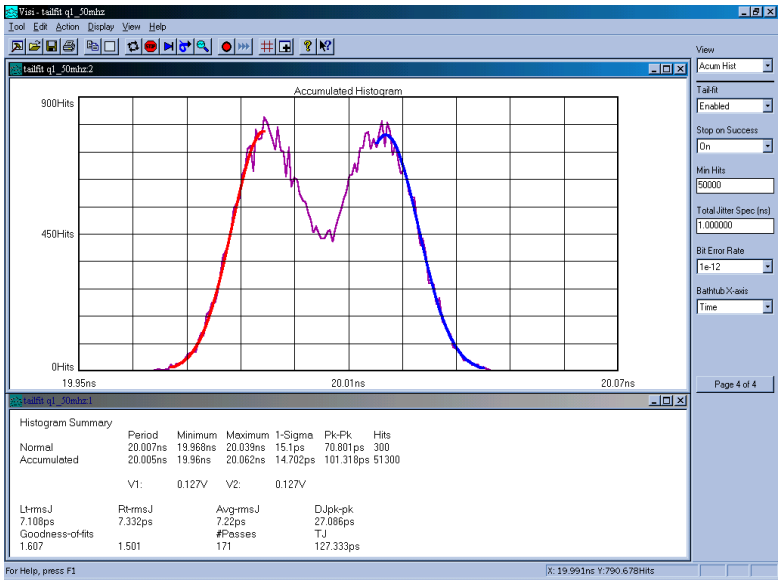



**Figure 5. Histogram with TailFit™ enabled**

## Bathtub Curve View

Figure 6 shows a Bathtub curve, also referred to as an "error probability density plot". This plot is produced by a convolution of the DJ and RJ probability density functions (PDF's) acquired from Tail-Fit™. The plot shows a view of the long-term reliability of the signal under test. Total Jitter (TJ) is extracted directly from this plot and is defined as a pk-pk value at a specific bit error rate, or number of clock cycles. The TJ value is read from the curve at the point that the color turns to grey.
The Y-axis in these examples represents a number of cycles of the clock.

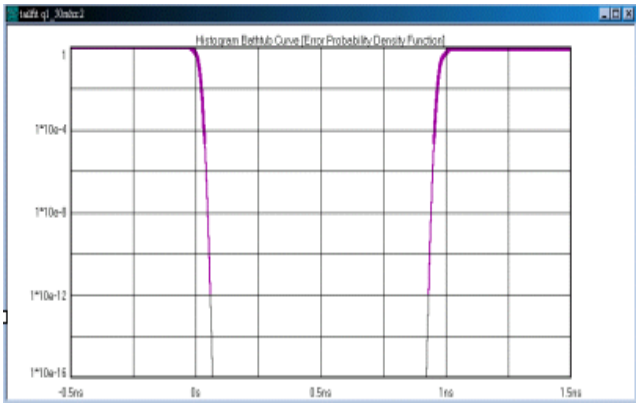


**Figure 6. Bathtub Curve Passes @ BER 10^-12**

A specification failure would be indicated if the lines met above the "bit error rate" set in the dialog menu. In Figure 7, the spec is set to 120ps (for the same clock used in Figure 6). Note that this plot shows TJ=120ps, since the actual TJ=127.333ps the clock failed the 120ps spec. The plot indicates that the device under test is predicted to fail the spec at just over 1^10e-11 seconds.

The use of TailFit™ and the Bathtub curve view, makes it possible for the user to determine not only if the device under test passes, but also how much margin remains before a specification would be violated.

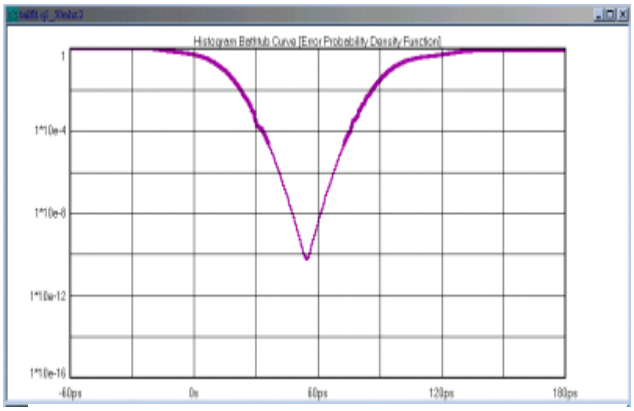


**Figure 7. Bathtub Curve Fails @ BER 10^-12**

## Bathtub Curve Interpretation

**1)** The lines on this plot are inversely proportional to the TailFit™ curves in Figure 5. Here, the left line corresponds to the right tail-fit, and the right line corresponds to the left TailFit™.

**2)** The thick portion of both lines represents data that has actually been acquired.

**3)** The portion of the thick colored line prior to the line's final downward turn represents the deterministic component. This is symbolic of the bounded nature of DJ, since DJ does not grow over time.

**4)** The vertical portion of the lines represents the random component. The stretching of the lines downward along the Y-axis demonstrates the unbounded nature of RJ and how it grows over time.

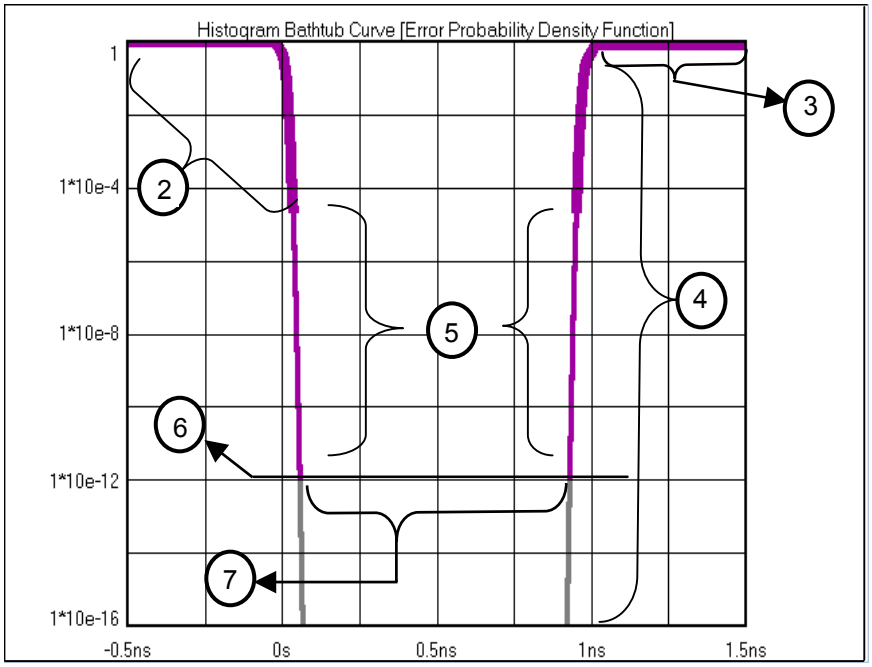



**Figure 8. Bathtub Curve Interpretation**

**5)** The thin portion of the colored line represents data from the TailFit™ extrapolation.

**6)** The point at which the lines become gray signifies the specific number of cycles of the clock or bit error rate set in the TailFit™ Menu. It is at this point, where the TJ value is calculated.

**7)** The area between the lines can be compared to the eye opening, or the amount of margin above a specification. The amount of opening or margin is directly proportional to the amount of jitter present. If at this point, the right and left lines have NOT met, the signal has passed its Jitter Spec. The "Total Jitter Spec" is selected in the "TailFit™" Menu.

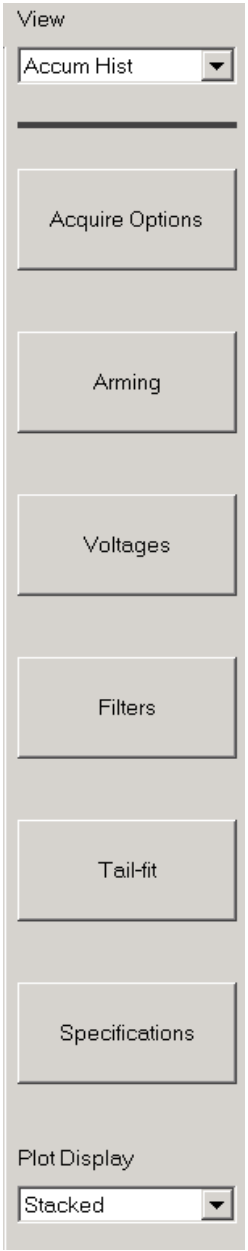
## Additional Bathtub Curve Notes

- The deterministic component of jitter pushes the lines together.
- The Random component of jitter affects the slope of lines.
- The plot's right line represents short cycles of a clock in a clock application or short pulses in a dataCOM application.
- The plot's left line represents long cycles of a clock in a clock application or long pulses in a dataCOM application.

## Dialog Bar Details

The next section provides a detailed description of all of the Dialog Bars and associated Menus. Specific controls are described. The “Back” button on any of the menus will take you to the previous Dialog Bar. To exit the “Main Menu”, you must exit the tool.

### *Propagation Delay & Skew Main Menu*




**View**
The View pull-down menu provides several different ways to see the acquired measurement data. “Accum Hist” displays all accumulated measurements (when Run is pressed). “Max Hist” shows the most recent histogram with an ‘envelope’ of all previous measurements; it is useful to detect outliers or wander. “Bathtub” shows the TJ at a specific time. “Summary” shows a text output of the acquired values.

**Acquire Options**
Opens the Acquire Options Menu. Choose channels, sample size, etc.

**Arming**
Opens the Arming Menu.

**Voltages**
Opens the Voltages Menu. Select to use pulsefind or to set User Volts to specify the threshold voltage.

**Filters**
Opens the Filters Menu. Settings allow time filters that will discard measurements outside of a time window.

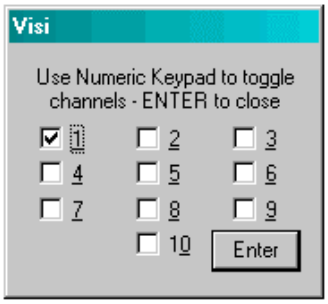
**Tail-Fit**
Opens the Tail-Fit Menu.

**Specifications**
Opens the Specifications menu.

**Plot Display**
If measurements on more than one channel are made, this will display the plots for each channel separately (stacked) or on top of each other (overlaid).

## *Acquire Options Menu*


**Reference Channel**
Check the channel that the reference signal is connected to. Use the keypad on the SIA-3000 front panel, or your mouse, to select and deselect channels. Press <Enter> when complete.




**Add/Del Channel**
Choose one or more channels to make a measurement.

**Measure Edge**
Indicate the edge relationship to be considered between the reference signal and the clock/data signals to be measured.

**Reference Edge Count**
Sets the number of edges skipped from the end of an Arm Delay to the measurement edge on the reference signal.

**Measurement Edge Count**
Sets the number of edges skipped from the end of an Arm Delay to the measurement edge on the clock/data signals.

**Hits Per Pass**
Defines the number of hits in a given histogram for each measurement

## *Arming Menu*


**Arm Delay (19-21ns)**
The arm delay sets the minimum time from an arm event to the first measurement edge. There is a user selectable 19 to 21 ns delay. Once armed, the SIA-3000 measures edges after the Arm Delay has elapsed.

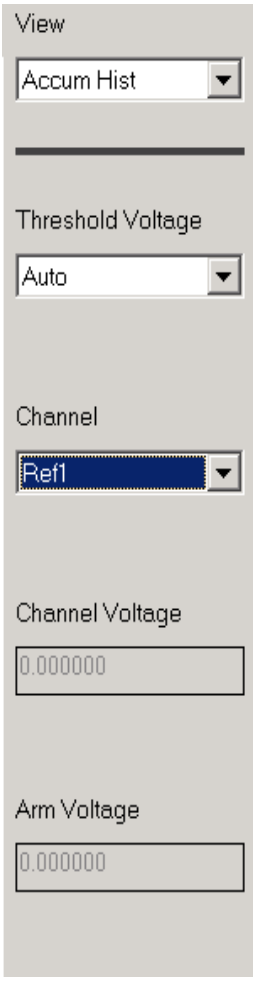
**Arming Mode**
An arm is required to make every measurement.

- Set to “Reference”, the measurement will Arm off the reference channel clock signal.
- Set to “External Arm”, a channel and edge can be selected and used to arm the measurement.

**Arm Number**
When External Arm is selected, Arm Number allows a channel to be chosen and used to Arm the measurement.

**Arming Edge**
Choose the edge type to arm the measurement. This is only available with External Arm.

## *Voltages Menu*




**Threshold Voltage**
When set to Auto, the start and stop threshold reference voltages are based on the minimum and maximum pulse level found on each channel. For all measurements, the 50% point is used.

The voltages are shown in the voltage display boxes after a pulsefind is completed.
Selecting "User Voltage", allows manual entry of the threshold voltage in the channel voltage box. A pulsefind cannot be performed when User Volts is selected.

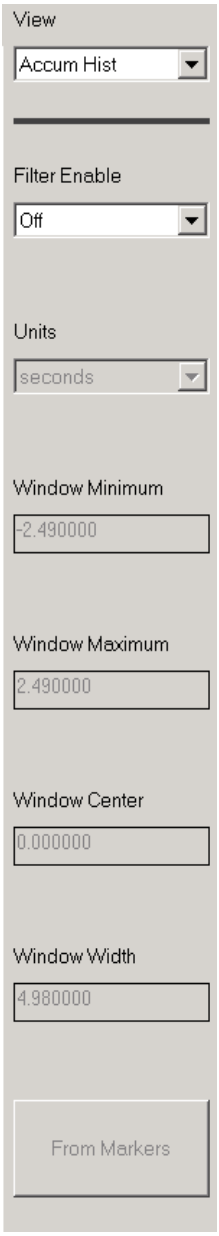
**Channel**
When "Threshold Voltage" is set to AUTO, use the "channel" control to view a particular channel's threshold voltages derived from PULSEFIND. Voltages are displayed under "Channel Voltage", and "Arm Voltage".

When "Threshold Voltage" is set to USER VOLTS, use the "channel" control to choose a particular channel where you wish to specify or change the threshold voltages to be used for the measurement.

**Channel Voltage**
Displays the Channel threshold voltage in AUTO. In USER VOLTS, the voltage can be set here.

**Arm Voltage**
Displays the Arm threshold voltage in AUTO. In USER VOLTS, the voltage can be set here.

## *Filters Menu*



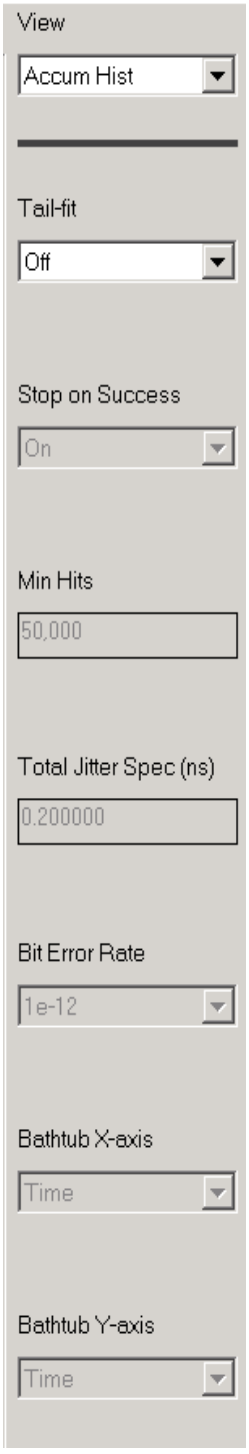

**Filter Enable**
Enables/disables time and range filtering.

The Window Filter is a post-processing filter that discards measurements acquired outside of the filter parameters. The summary window will show the statistics from the measurements within the filter window and the histogram view will display the filtered region. The filter does not change the number of samples that fall within the filtered area, so the Hits Per Edge reflects the total unfiltered histogram.

To increase the number of samples falling in the filtered area, the Hits Per Edge will have to be increased. For example, if there are two roughly equal distributions displayed without filters, and the hits per edge is set to 1000, the probability of a value occurring in either distribution is equal. Therefore, the filtered data may contain approximately 500 hits.

The window filter can be enabled in three different ways: choose “Window Minimum” and “Window Maximum”; choose “Window Center” and “Window Width”; or enable markers and choose “From Markers”.

## *Tail-Fit Menu*

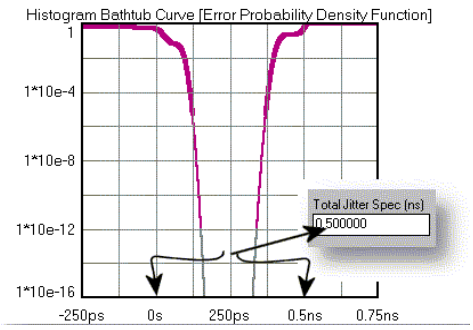



**Tail-Fit**
Pull-down menu list for enabling/disabling tail-fit feature. When Tail-fit is "enabled", Random Jitter and Deterministic Jitter can be separated in order to calculate Total Jitter. When the histogram is not Gaussian, Tail-fit is necessary to accurately predict long-term clock performance. "Force-fit" will force a Tail-fit after a set number of samples; this setting may not provide the best fit and is generally used in a production environment when a fixed test time is required.

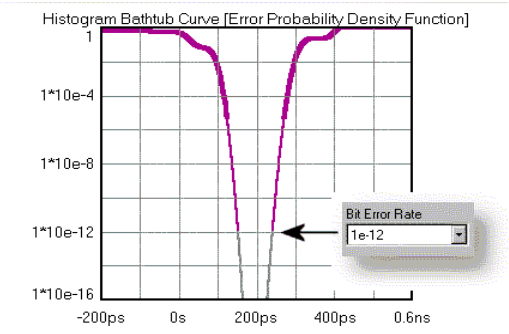
**Stop on Success**
The Tail-fit option has certain quality requirements that must be met in order to successfully separate RJ and DJ. If there is a large DJ component, this may require several passes. Enable this option and then use <Run> in order to accumulate until the requirements are met.

**Min Hits**
A Tail-fit is not attempted until the number of hits specified is acquired.

**Total Jitter Specification (ns)**
The width used in the Bathtub View to assess the Error Probability in nanoseconds. Different specs will yield different bathtub curves without re-acquiring measurements.



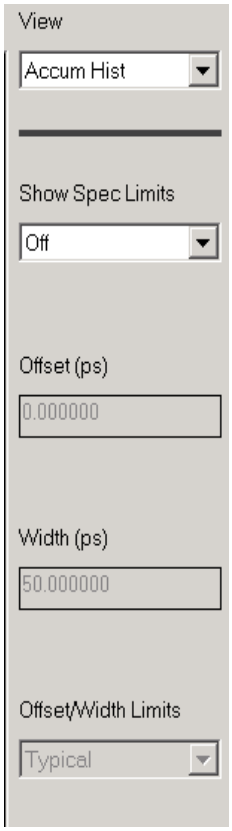

**Bit Error Rate**
Determines the Bit Error Rate to be used when extracting total jitter from the Bathtub Curve. The default value is 1e-12. This setting has a direct effect on the TJ value that is calculated. For example, TJ at 1e-6 will be lower (smaller) than TJ at 1e-12.




**Bathtub X-axis**
Displays spec in time or UI

**Bathtub Y-axis**
Displays axis in time or BER

## *Specification Menu*




The “Specification” menu sets up a window in the histogram view that characterizes an area where the signal will pass or fail a user-defined specification.

**Show Specification Limits**
Enables the specification window and window settings.

**Offset (pS)**
Offsets the center of the specification window from zero.

**Width (pS)**
Defines the width of the specification window.

**Offset/Width Limits**
Sets the pass/fail parameters.

- “Typical” setting will fail a measurement if the histogram mean falls into the specification window.
- “Worst Case” will add the left and right total jitter value to the mean, and fail a measurement if that value falls into the specification window.

## Summary

The *Propagation Delay & Skew* tool, without the TailFit™ enabled, provides very basic statistical information (1-Sigma and Pk-Pk). With the TailFit™ algorithm activated, critical data can be obtained, enabling the user to separate and quantify the individual components of jitter (RJ and DJ). From this information, a TJ value can be extrapolated. This provides a more realistic view of the long-term effects of jitter on signal integrity. The Tail-Fit™ algorithm and Bathtub curve view are also available in all dual channel measurements (The Histogram tool) and DataCOM tools.

For more information contact:

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