



# HISTOGRAM

## Getting Started – Clock/Single Channel Measurements

### Applications of Histogram tool

- Gives the user information about the distribution of the measured events such as period, Rise time, Fall time, Positive pulse width, and Negative pulse width.
- Displays a histogram of the samples taken during a single burst of measurements.
- Analysis of long term signal integrity in a short test time. TailFit™ option separates the gaussian and deterministic components from the measured distribution. For a multimodal distribution, Tail-fit gives accurate information about the effects of jitter on long term and short term signal integrity.

### Introduction

The focus of this guide is to familiarize the user with the basic Histogram tool to allow quick and easy measurements and interpretation of results. Refer to the user's manual and the VISI help files for more in depth information.

### Theory of Operation

The Histogram tool allows the user to make single channel time measurements of different clock parameters (rise or fall time, period, or pulse width). The time measurements are asynchronously sampled at random intervals to give a solid, statistical set. The randomization ensures that no jitter is masked out by a constant sampling rate. The user has the ability to measure multiple periods and display the information as a histogram. The Histogram tool can obtain data from a single burst of measurements, displaying recent (labeled normal) or a continuous accumulation of measurements (labeled accumulated). The Histogram tool also incorporates the TailFit™ algorithm which separates the jitter and the Random and Deterministic components. When operating in TailFit™ mode, there is also a Bathtub Curve plot available which provides a representation of the Error Probability or long-term signal integrity. Note TailFit™ is available only in the Advanced Clock VISI 6 software.

### Histogram Panel

#### 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.

#### VISI Panel

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

#### Statistics View

“Normal” shows data from the most recent run. “Accumulated” shows data collected from multiple runs (using Cycle). “Hits” shows

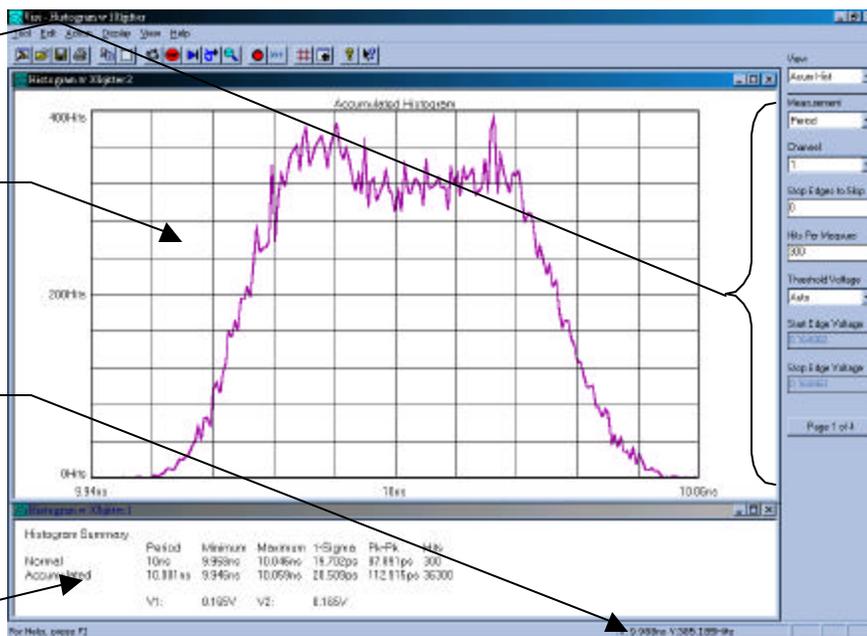


Figure 1. Histogram Plot

the samples per histogram.

## Dialog Bar, Page 1 of 4

**View menu –**  
Select the View (plot) type. Choose between Norm, Acum, Maxi, Bathtub, and Summary views

**Measurement menu –**  
Select the signal parameter to be measured; Period, Rise Time, Fall Time, PW+, and PW-.

**Input Channel –**  
Select which input channel is being used. Choose between Channel 1 & 2.

**Hits Per Edge –**  
Select the sample size. The number of samples for each histogram.

**Threshold Voltage-**  
During a Period, PW+, or PW- measurement, “Auto” sets the threshold to the 50% point of the selected input signal. During Rise or Fall time measurements the threshold is set to either the 20-80% or 10-90% points. USER VOLTS allows the user to set the threshold voltage.

The dialog bar on the right shows the following settings: View: Acum Hist; Measurement: Period; Channel: 1; Stop Edges to Skip: 0; Hits Per Measure: 300; Threshold Voltage: Auto; Start Edge Voltage: 0.000000; Stop Edge Voltage: 0.000000. A 'Page 1 of 4' button is at the bottom.

Figure 2. Dialog bar, Page 1 of 4

## Dialog Bar, Page 2 of 4, Arming Menus

Page 2 of 4 of the Histogram dialog bar menus allows the user to control the arming of the instrument. Different Arming modes include External, Arm On Start, and Arm On Stop. Both the “Arm On Start”, and “Arm On Stop” Modes relate to the instrument’s Auto-arming capability. The default Arming configuration for the Histogram tool is the Arm on Stop Mode.

Observe Figure 3. Notice, that when either “Arm On Stop” or “Arm On Start” modes are selected all other menus on this page are grayed out. This is because the rest of these menus relate to the setup of the External Arm function. When “External” is selected as the Arming mode these menus allow control of the ARM1 and ARM2 setup.

For more in-depth information concerning the Arming features of the DTS, users should refer to the Quick References titled “Auto Arming” and External Arming”. Users may also refer to the Arming section of the user’s manual and/or the Help files included in the Visi 6.0 software for more detailed information.

The dialog bar on the right shows the following settings: View: Acum Hist; Arming Mode: Arm On Stop; Start Arm: Arm1; Stop Arm: Arm1; Arm1 Voltage: 0.000000; Arm2 Voltage: 0.000000; Arm1 Edge: Rising; Arm2 Edge: Rising. A 'Page 2 of 4' button is at the bottom.

Figure 3. Dialog Bar, Page 2 of 4 , Arming menus

## Dialog Bar, Page 3 of 4

### Filtering Menus

Page 3 of 4 of the Histogram dialog bar menus allow the user to configure the instrument filters. This allows the time-range filtering of the window filter. This window is a post-processing filter that ignores DTS measurements acquired outside of the filter parameters specified on the menus of this page.

Users may enable the window filter by one of two ways:

- Enter values for the Minimum and Maximum parameters of the Window.

OR

- Enter values for the Center and Width parameters of the Window.

Figure 3. Dialog Bar, Page 3 of 4, Filtering menus

## Dialog Bar, Page 4 of 4 TailFit™ & Bathtub Curve Menus

### TailFit™ -

Enable, activates the Tail-fit algorithm which separates and quantifies the DJ and RJ to give an accurate TJ value.

### Stop on Success-

Part of the TailFit™ options. Turning “Stop on Success” On instructs the algorithm to stop gathering data when it has enough data to perform the TailFit™

### Total Jitter Spec -

Part of the Bathtub curve menu. The width used in the Bathtub View to assess the Error Probability in nanoseconds.

### Bit Error Rate-

Used in the Bathtub curve as the number of clock cycles, or BER for DataCOM, at which TJ will be calculated at using extrapolated TailFit™ data.

### Bathtub X-axis -

Selects the unit of measure for the plot’s horizontal axis. Either in Unit Interval or in Time.

Figure 4. Dialog Bar, Page 4 of 4 / TailFit™ & Bathtub curve menus

## Making a Measurement

On the Dialog bar menu along the right side of the initial VISI screen, select **Clock** then **Histogram**. The Dialog Bar menu default settings allow users under most conditions to immediately begin making measurements. Once the tool is open, users may reconfigure the Dialog bar menus for optimum viewing. Once the menus are configured a basic measurement can be made.

- Verify that a signal is connected to CH1 or CH2 and that the proper channel is chosen in the menu.
- On the top toolbar press Pulse Find . Verify the voltage levels and close out the pulse find box.
- Press the Single Acquire button  or press the Run/Cycle button  allowing the DTS to accumulate a continuous series of measurements.
- Press the Single Acquire button  or the Stop button  to stop the cycling process.

If the histogram distribution is Multimodal as in Figure 5, the 1-sigma and Pk-Pk values don't accurately reflect the random component of jitter. This is because the cause of a non-gaussian distribution is deterministic. Therefore, in the presence of DJ the 1 $\sigma$  value incorrectly states the true RJ.

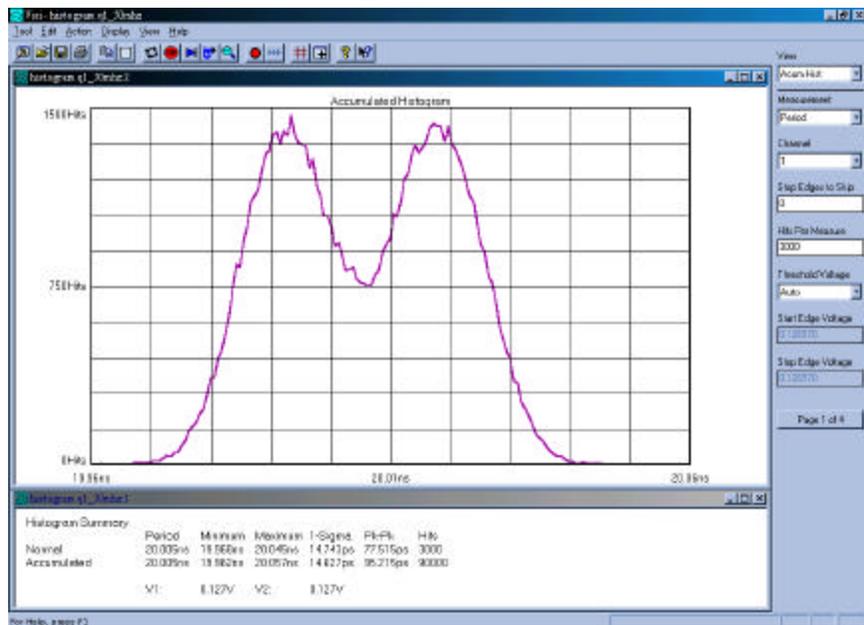


Figure 5. Histogram without TailFit™

The Histogram tool produces three different views: Norm, Acum, and Maxi Histogram (Refer to Figure 2, Dialog Bar Pg1of 4). The “Acum” view (see figure 5) puts all measurements from multiple acquisitions into one histogram. The “Maxi” view (see figure 6.) is useful to see low frequency or 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 can be seen in this view.

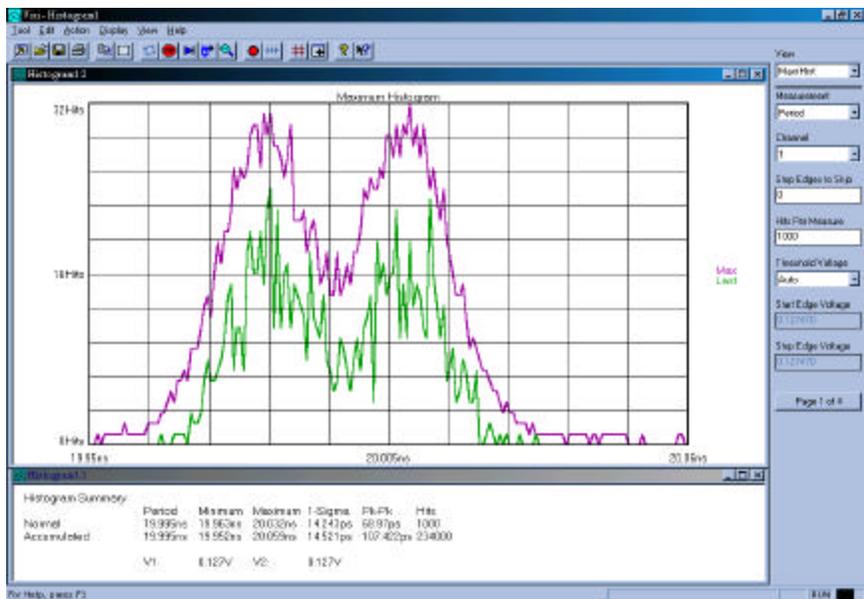


Figure 6. Histogram using Maxi View

## Enabling TailFit™ and Taking a measurement (VISI 6 Advanced Clock tools only).

While in the Histogram tool, go to [Page 4 of 4](#) of the Dialog Bar. In the **Tail-fit** pull down menu select "ON". 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". This is also on [Page 4 of 4](#) of the Dialog Bar. Once these steps are completed the field under the **Min Hits** on [Page 4 of 4](#) will read 50,000. This is the minimum number of samples that the instrument will take to allow for a successful TailFit™. To make a measurement, press the Run/Cycle button .

The TailFit™ 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, in general has a Gaussian-type distribution. The TailFit™ 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 7, 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.

Both Figures 5 and 8 have about the same 1-sigma and Pk-Pk values, but Figure 8 separates the jitter into its individual components. A DJ value is now displayed in the statistics 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 statistics window; it is derived from the bathtub curve below.

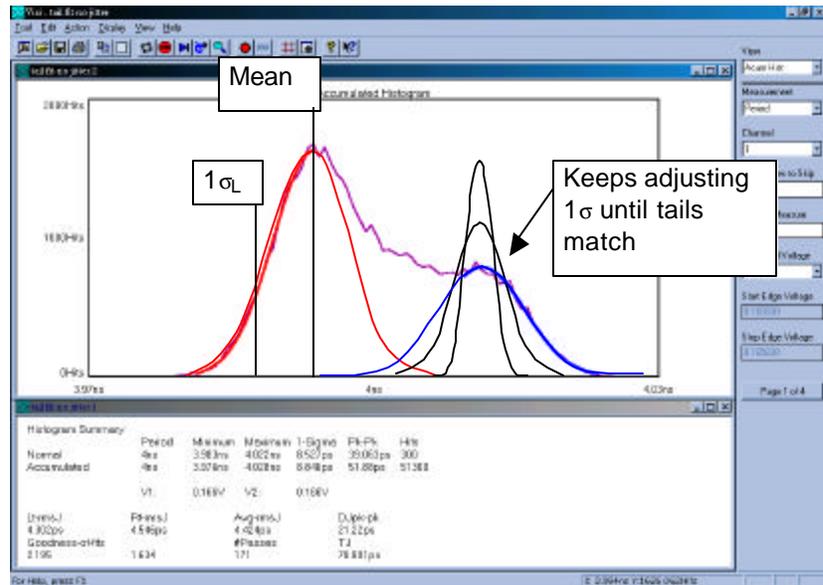


Figure 7: TailFit™ algorithm.

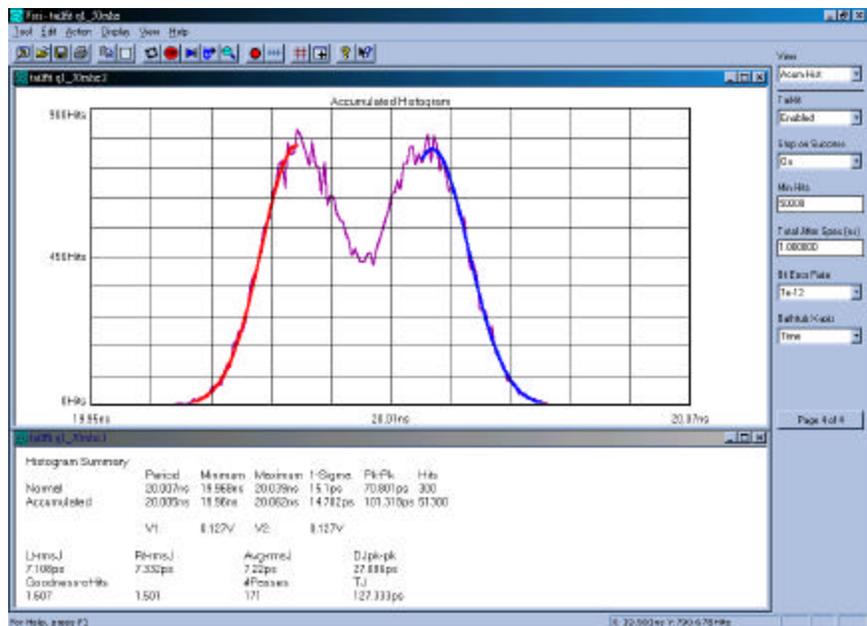


Figure 8. Histogram with TailFit™ enabled

## Bathtub Curve View

Figure 9 shows a Bathtub Curve also referred to as an “error probability density plot”. This plot is derived from a convolution of DJ and RJ values from TailFit™. 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 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 9 & 10 show a clock's TJ calculated to  $10^{12}$  cycles or  $10 \times 10^3$  seconds of a 50MHz clock. In Figure 9, the specification is set to 1000 ps, so that at  $10^{12}$  cycles or  $10 \times 10^3$  seconds, Total Jitter (TJ) = 127.333ps.

A specification failure would be indicated if the lines met above the “bit error rate” set in the dialog menu. In Figure 10, the spec is set to 120ps (for the same clock used in Figure 9). 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  $1 \times 10^{-11}$  seconds.

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

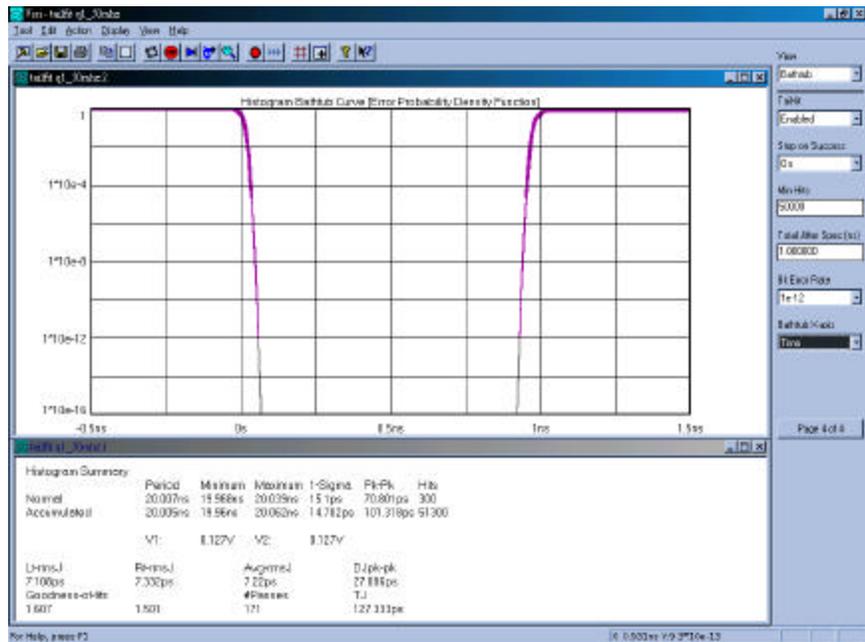


Figure 9. Bathtub Curve

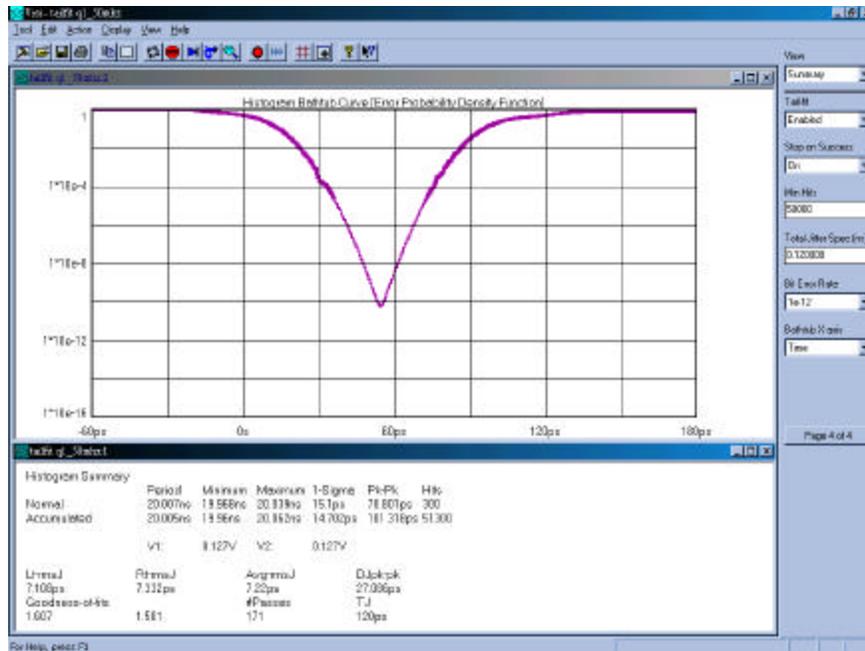


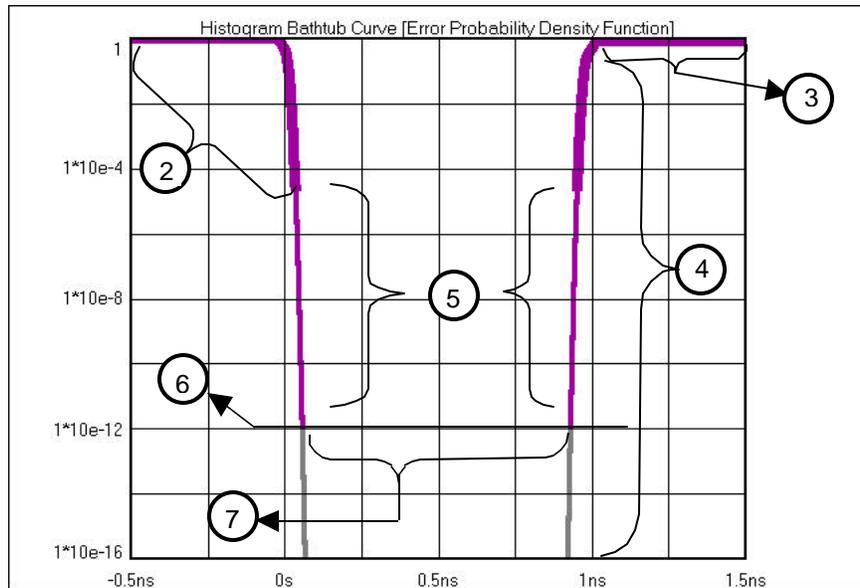
Figure 10. Bathtub Curve showing failing spec

## Bathtub Curve Interpretation

1) The lines on this plot are inversely proportional to the TailFit™ curves in Figure 8. Here, the left line corresponds to the right tail-fit, and the right line corresponds to the left tail-fit.

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.



**Figure 11. Bathtub Curve Interpretation**

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.

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

6) The point at which the lines become grayed signifies the specific number of cycles of the clock or bit error rate that the user asked the software to test to. It is at this point, where the TJ value is read.

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 Opening" is selected by entering an amount under Bit Error Rate on Page 4 of 4 of the dialog bar menus along the side of the VISI screen.

### 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.

## Rise / Fall time Measurements – Voltage Threshold Settings

As noted in the threshold voltage description of Page 1 of 4 of the Dialog Bar, setting the threshold voltage to “Auto” during a Rise or Fall time measurement sets the threshold voltage to the 20-80% or 10-90% points of the input signal.

Users may select either of these two settings by going to **Edit** along the top of the Visi screen and selecting **Configuration...**. This will open the Configuration menu window. Next, go to the pull down tab labeled **Rise/Fall %** (see circled section of Figure 12) and select either the 20-80% or 10-90% points. Before closing this window, press the **Apply** button to activate any changes that may have been made. The “Auto” voltage threshold setting used during a Rise / Fall time measurements will default to the setting in the Configuration menu.

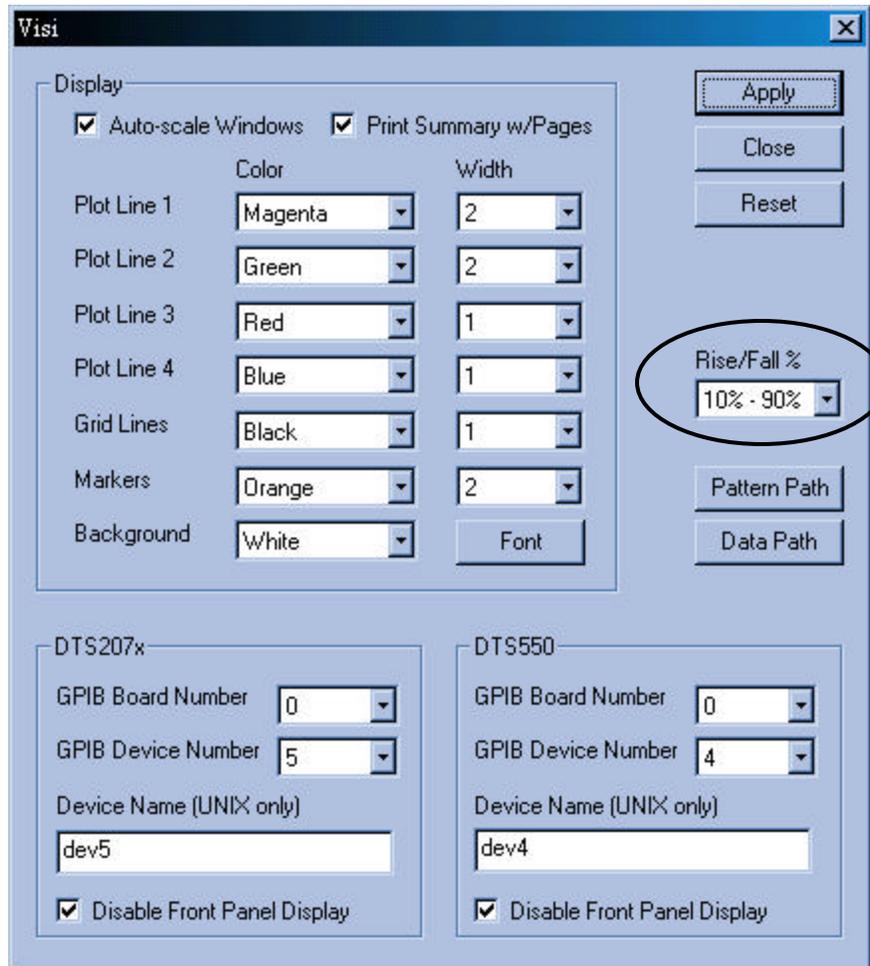


Figure 12. The Visi 6.0 Configuration Menu

## Summary

The Histogram 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 TailFit™ algorithm and Bathtub curve view are also available in all dual channel measurements (The Propagation Delay and Skew tools) and DataCOM tools.

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