

*WAVECREST CORPORATION*

PCI Express Measurements with the  
*WAVECREST SIA-3000™*

Application Note No. 141

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# PCI Express Measurements with the WAVECREST SIA-3000™

Application Note 141 (200141-00 REV A)

## Introduction

This guide describes how to use the SIA-3000 to measure jitter on PCI Express (3GIO) signals. It will also provide a step-by-step procedure for acquiring jitter measurements using *Virtual Instrument Signal Integrity™ (VISI)* software.

## PCI Express Specification

The PCI Express standard defines Total Jitter (TJ) and its relationship to Bit Error Rate (BER) in Section 4.3.2.2, Jitter and BER, PCI Express Base Specification Rev 1.0. This section states, "Jitter is categorized into random sources (Rj) and deterministic sources (Dj). The total jitter (Tj) is the convolution of the probability density functions for all the independent jitter sources, Rj and Dj. The nature of Rj can be approximated as Gaussian and is used to establish the bit error rate (BER) of the link. The UI allocation is given as the allowable Tj at the target BER. The UI allocation must meet a maximum BER of  $10^{-12}$  for the Tj. The allocation to Rj and Dj is not specified."

## Setup and Measurement

Figure 1 shows the setup. With true differential inputs and internal pattern marker generation, all the user needs to do is send the differential data into channel one of the SIA-3000. All other setup and pattern marker generation is done internally through the software. The next section will describe the process for acquiring all the measurements required by the PCI Express specification for voltage and timing compliance.

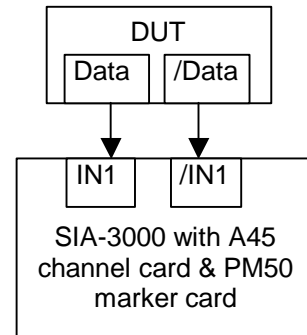


Figure 1 - Measurement Setup

## Setup for Tj at $10^{-12}$ BER and UI Measurements

To obtain the Total Jitter (TJ) value at  $10^{-12}$  and the Unit Interval (UI) as required by the PCI Express specification, the Known Pattern With Marker (KPWM) *VISI* tool can be used. This tool will give the user the TJ value as well as the UI value. Also, the individual components of jitter are determined, providing a more comprehensive analysis of the jitter performance. This information goes beyond the specification requirements by giving the user additional diagnostic information.

The components of total Jitter (TJ) are Random Jitter (RJ) and Deterministic Jitter (DJ). DJ breaks down into Duty Cycle Distortion and InterSymbol Interference (DCD&ISI) or Data Dependant Jitter (DDJ), and Periodic Jitter (PJ) components. These jitter components are described in the Fibre Channel MJS document<sup>[1]</sup>. All of these components are quantified by using the Known Pattern with Marker dataCOM tool.

From the initial SIA-3000 startup screen (Figure 2), select the dataCOM Tools button (Figure 3). Next, select the Known Pattern w/Marker tool. Figure 4 shows the dataCOM tool window.

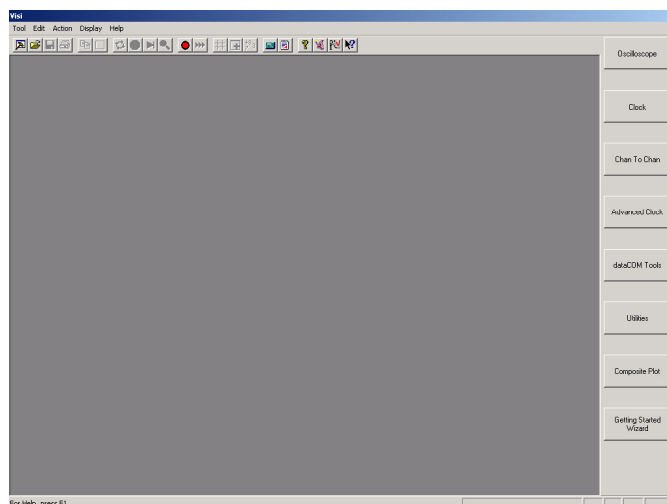


Figure 2 - Initial VISI Screen

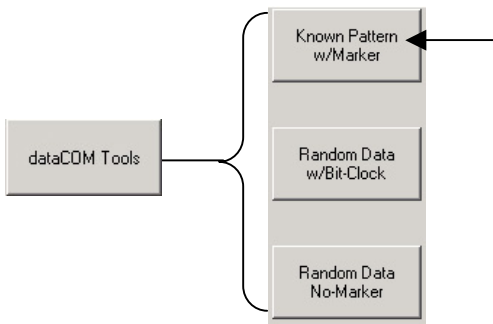


Figure 3 - dataCOM Category

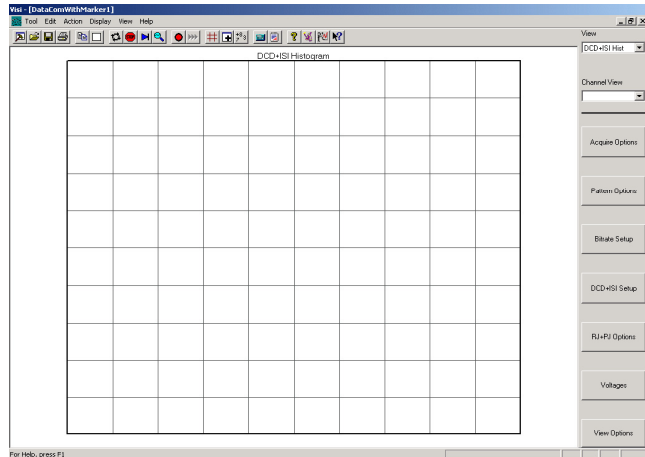


Figure 4 - Initial dataCOM Screen

The requirements for this tool are a known pattern and a pattern marker. The PCI Express specification specifies a test pattern to be used for all of these tests. This pattern is composed of the following bits: K28.5, D21.5, K28.5, D10.2, which is 0011111010 1010101010 1100000101 0101010101 in binary or 3eaac1555 in Hex. This can be manually entered into the tool by selecting the 'Pattern Options' button and then selecting the 'Edit Pattern' button (Figure 5). If you already have the pattern saved, you can simply load it by pressing the 'Load Pattern' button.

The internal PM50 will be used as a pattern marker or pattern synchronization signal. Select the 'Back' button to return to the main options screen. Then, select the 'Acquire Options' button (Figure 6).

Next, click on the 'Arm Number' button. This will bring up the Arm selection dialog box. Use the SIA-3000 keypad ('e' on the keypad) or the mouse to select channel one and then check the Pattern Marker box to generate the pattern marker with the internal PM50 card (Figure 6). Next, select the 'Add/Del Channel' button to ensure that channel one is selected (Figure 6). Finally, set the 'Corner Freq (kHz)' to the PCI Express specified frequency. PCI Express specifies that measurements be made over 250 consecutive UI. This implies a frequency response equivalent to the bit rate divided by 2\*250 (2.5Gbps/2\*250=5MHz). Set the 'Corner Freq (kHz)' to 5MHz or 5000kHz as shown in Figure 6.

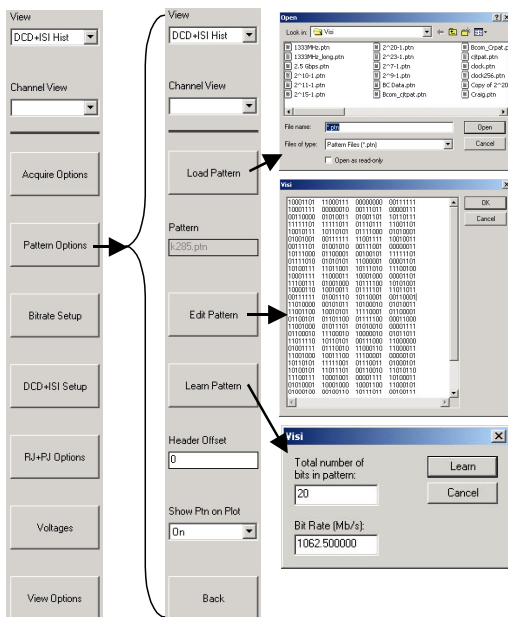


Figure 5 - Pattern Setup

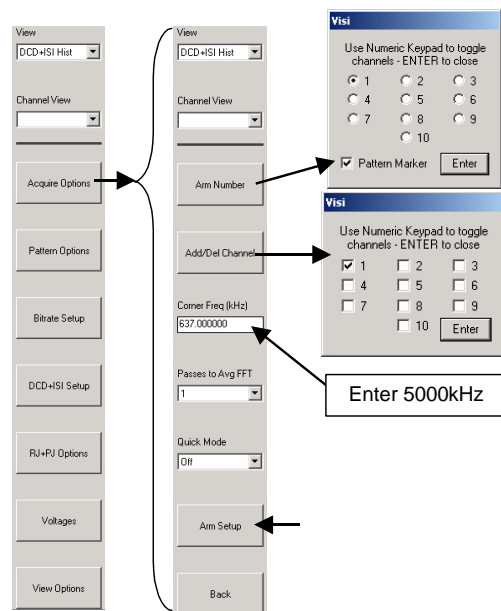



Figure 6 - Acquire Options setup



The last thing that needs to be done is to finish the setup of the PM50 pattern marker. Click the 'Arm Setup' button in the 'Acquire Options' menu screen (Figure 6). This brings up the menu screen shown in Figure 7. Next, select 'Pattern Match' in the 'Patn Mkr Mode' pull down menu. Then, select the proper bit rate in the 'Patn Mkr Standard' selection box. Choose the 'Infiniband 2.5Gbps' standard as seen in Figure 7. Press the 'Perform Placement' button. This will automatically set up the internal pattern marker placement. You can also press the 'Open PM Utility' window to use some of the more advanced features of the PM50 card like bit error counting and bit error rate calculation.<sup>[2]</sup>

You are now ready to make a measurement.

First, click the 'Pulse Find'  button on the VISI toolbar to automatically set the voltage levels (Figure 8).

Then, click the 'Single Acquire/Stop Run' button  on the VISI toolbar (Figure 8).

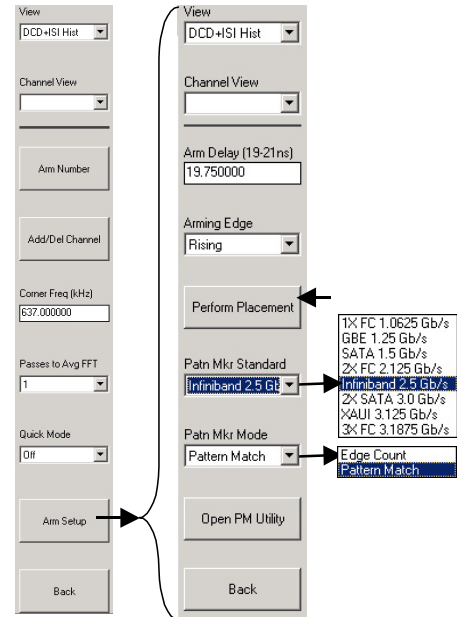



Figure 7 - Arm setup



Figure 8 - VISI Toolbar

You should see results similar to Figure 9. You can toggle through the different data plots by selecting the pull down menu under the 'View' heading (see Figure 9).

To view the results on every plot, click the "Values on Plot" button . If you get an error message "Failed..." see the Help under "Arm Delay" to fix this problem or rerun the arm placement described in Figure 7. This will give you the TJ and Bit Rate or Unit Interval (UI) measurements required by the PCI Express specification. You can also do extensive debug and analysis of the various components of jitter in the different plots generated by the dataCOM tool. To view these plots, select the pull down menu under the 'View' heading shown in Figure 9. See the Help for more information on the different views.

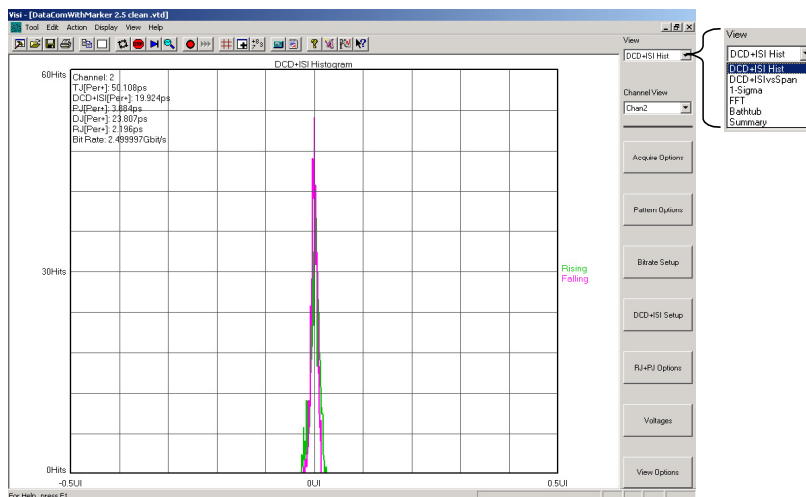



Figure 9 - dataCOM results.

## Setup For Voltage Measurements

This section will describe the setup required for all of the voltage measurements required by the PCI Express specification. The SIA-3000 integrated Oscilloscope can be used to automatically perform these measurements. From the startup screen, simply press the 'Oscilloscope' tool button (Figure 2). Or, if you already have the dataCOM tool open, you can pull the tool selection menu back up by pressing the 'New Tool' button  on the menu bar. Then select the 'Oscilloscope' tool button.

The SIA-3000 with A45/A25 channel cards has an integrated 6GHz sampling oscilloscope on each differential input. This enables single-ended and differential voltage measurements. The initial Oscilloscope screen should look similar to Figure 10.

Select channel one in the 'Add/Del Channel' popup. Press the Trigger button to enter the trigger setup menu screen. Press the trigger button and select channel one and then check the Pattern Marker box to enable the internal pattern marker as the trigger. Select Pattern Match in the 'Patn Mkr Mode' box. Select 'Infiniband 2.5Gbps' data rate in the "Patn Mkr Pattern" selection box. Press the 'Open PM Utility' button to open the pattern marker utility window.

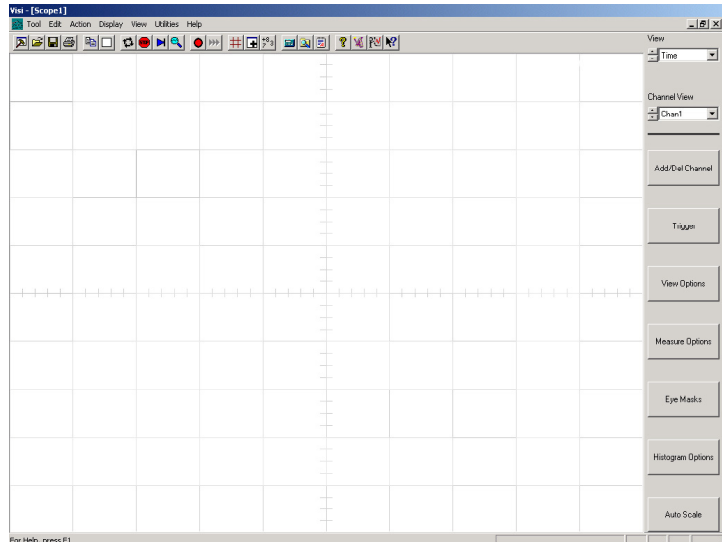



Figure 10 - Oscilloscope startup screen

You need to select the PCI Express pattern you saved in the dataCOM measurement section above. To do this, press the 'Pattern Options' button. Then select 'Load Pattern' and load the PCI Express pattern. Return to the Oscilloscope view and Maximize the window.

You are now ready to take a measurement.

Press the 'Run' button . The Oscilloscope will now begin acquiring data. You can use the Horizontal and Vertical knobs on the front of the SIA-3000 (Figure 11) just like a traditional oscilloscope. Adjust the vertical amplitude and offset so that the signal is centered on the screen and the signal fills the screen vertically. Then adjust the horizontal scaling so you can see one full repeat of the data pattern. Let enough data accumulate so you have a good picture of the waveform. You can now turn on the voltage measurements required by the PCI Express specification.

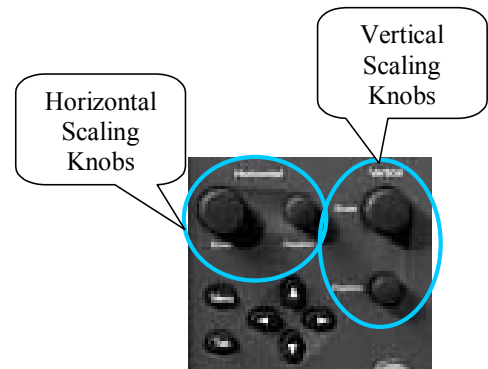


Figure 11 - Oscilloscope Horizontal and Vertical scaling knobs

The following values can be measured:

- Rise-time
- Fall-time
- Differential Peak-to-Peak Voltage
- De-emphasized Differential Output Voltage (ratio)
- AC peak common mode output voltage
- Absolute Delta of DC Common Mode Voltage During LO and Electrical Idle
- Absolute Delta of DC Common Mode Voltage between D+ and D-
- Electrical Idle Differential Peak Output Voltage

You can select these values to be displayed on to the left of the Oscilloscope view by pressing the 'Signal Analysis' button and then selecting the 'Voltage Measures' button. Then just press the button corresponding to the measurement desired. You should see a view similar to Figure 12. All of the selected voltage measurements will be displayed on the left side of the screen.

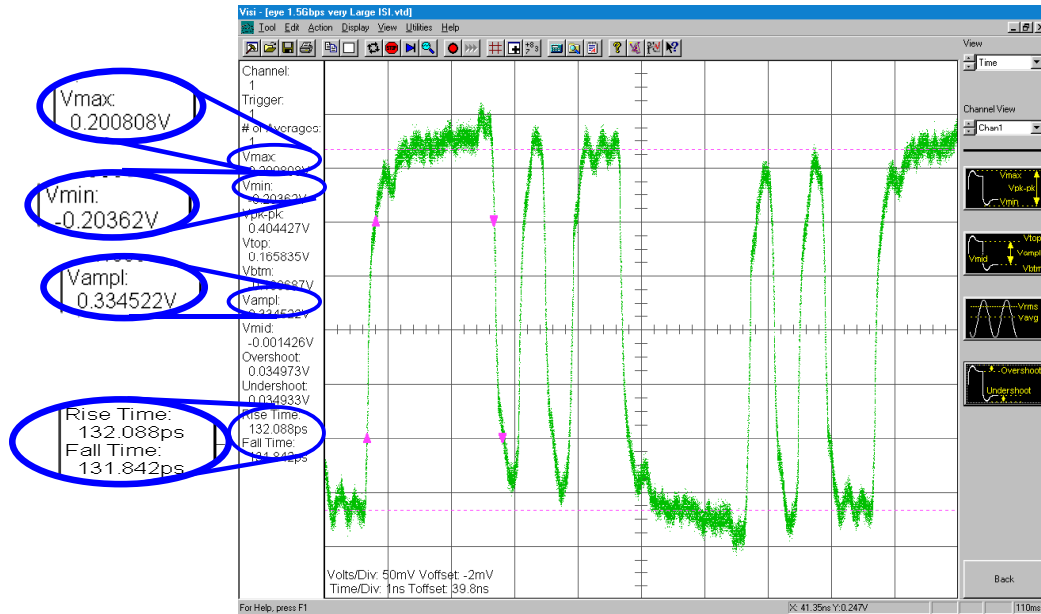


Figure 12 - Oscilloscope screen.

## Summary

The features of the SIA-3000 timing and voltage hardware engines along with the proven capabilities of the advanced *VISI* diagnostic tools combine to form a complete jitter timing and voltage analysis software package for measuring PCI Express signals. *WAVECREST* provides a complete testing solution for  $10^{-12}$  BER measurements as well as all voltage and amplitude measurements. This paper has outlined a step-by-step process for measuring all jitter and voltage parameters required in the PCI Express standard.

## Footnotes:

- [1] National committee for information technology standardization (NCITS), "Fibre Channel Methodologies for Jitter Specification", Rev 10.0, June 9, 1999.
- [2] WAVECREST Corporation, SIA-3000 User Guide and Reference Manual, 2002.

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