



WAVECREST CORPORATION

SERIAL ATA JITTER MEASUREMENTS

APPLICATION NOTE No. 138

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Serial ATA Jitter Measurements

Application Note 138

Introduction

This Application Note describes how to use the SIA-3000™ to measure jitter on Serial ATA (SATA) signals. It will also provide a step-by-step procedure for acquiring jitter measurements using *Virtual Instruments Signal Integrity™ (VISI)* software.

SATA Specifications

The SATA standard defines a jitter generation specification profile as shown in Figure 1. This profile defines 3 points. The three points are the values defined in Figure 2 as 'n'. They are 5, 250, and 25,000. Dividing the bit rate by these values results in corner frequencies of 150MHz, 3MHz, and 30kHz. Table 1 also shows amplitudes of acceptable jitter at each of these compliance points referenced as the 'A' value. *WAVECREST* provides a complete jitter testing solution for this entire range, which will be described in the next section.

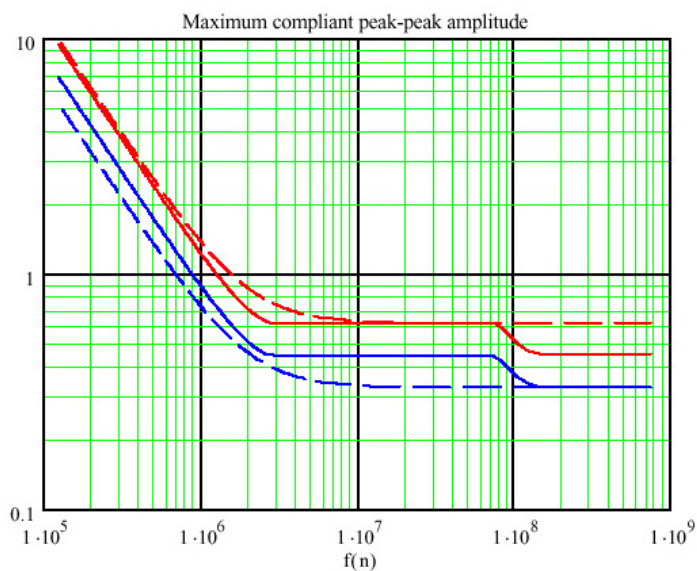


Figure 1. SATA Jitter Profile as a Function of Frequency (Red line is at receiver input, Blue line is at the driver output, and the Dotted line is Margin).

Setup and Measurement

This section will describe the setup and how to perform measurements to full compliance using the *WAVECREST* SIA-3000 and the native *VISI* Software. This section will also describe step-by-step process to acquire all the measurements required for SATA jitter compliance.

The jitter profile in Figure 1 shows two distinct frequency regions. There is the section above 3MHz ($n \leq 250$) and the section from 3MHz to 30kHz ($250 \leq n \leq 25000$). For the section from 3MHz and up to the Nyquist frequency (750MHz), the jitter components that will be measured to obtain an accurate Total Jitter (TJ) are Random Jitter (RJ), Duty Cycle Distortion and InterSymbol Interference (DCD&ISI) or Data Dependant Jitter (DDJ), and Periodic Jitter (PJ) including contributions from the spread spectrum clock. These jitter components are described in the Fibre

Descr	Driver output ¹		Driver PCB connector		Receiver PCB connector		Receiver input ²		Note ref
	DJ	TJ	DJ	TJ	DJ	TJ	DJ	TJ	
A_{0,p-p} (UI)	0.15	0.33	0.175	0.355	0.25	0.43	0.275	0.455	4,5
n₀	5	5	5	5	5	5	5	5	4,5
A_{1,p-p} (UI)	0.2	0.45	0.22	0.47	0.35	0.6	0.37	0.62	4,6
n₁	250	250	250	250	250	250	250	250	4,6
A_{2,p-p} (UI)	40		40		40		40		3,4,7
n₂	25000		25000		25000		25000		3,4,7

NOTES –

1. The driver output is the maximum jitter that a driver may exhibit to guarantee operation.
2. This field is the maximum jitter that a receiver must tolerate to guarantee operation.
3. For low frequency (trackable) jitter, total jitter is specified (DJ not broken out)
4. Does not include UI error due to frequency skew (XTAL or SSC related)
5. Primarily determined by non-tracking architecture requirements
6. Primarily determined by tracking architecture requirements
7. Primarily determined by Spread Spectrum Clocking (+/-0.25% AC portion). Doesn't include the -0.25% fixed skew (additional 26 UI).

Table 1. SATA Jitter Compliance Table.

Channel MJS document^[1]. The components can be quantified by using the Known Pattern with Marker dataCOM tool. For the region below 3MHz down to 30kHz, the dominant factor will be PJ from the spread spectrum clock. Thus, a clock like pattern (1010) can be used (disregarding DDJ) and the Low Frequency Modulation tool can be used. If a clock like pattern cannot be used, the dataCOM tool can be used as an alternative. Each of these measurements is described in the following sections.

dataCOM setup

The first 2 sections from 750MHz down to 150MHz and 150MHz down to 3MHz can be done at the same time with the Known Pattern with Marker tool.

From this initial startup screen (Figure 4), select the dataCOM Tools button (Figure 3). Next, select the Known Pattern w/Marker tool. Figure 5 shows the dataCOM tool window.

The requirements for this tool are a known pattern and a pattern marker (See the SATA spec for test patterns). The pattern marker can be used from a signal generator (pattern trigger from a BERT), the internal PM50 card of the SIA-3000 (Figure 2), or from the *WAVECREST* AG-100. The setup of the AG100 is described in the “AG-100 Quick Reference” guide^[2].

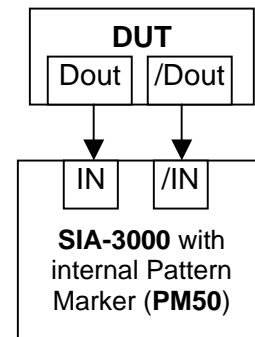


Figure 2. Measurement Setup.

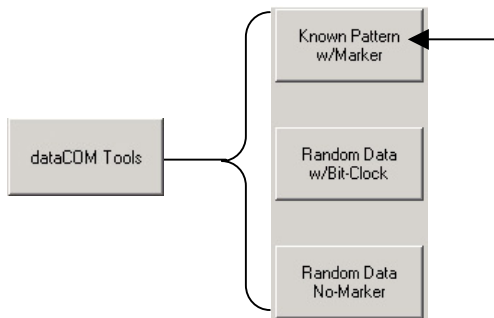


Figure 3. dataCOM Category.

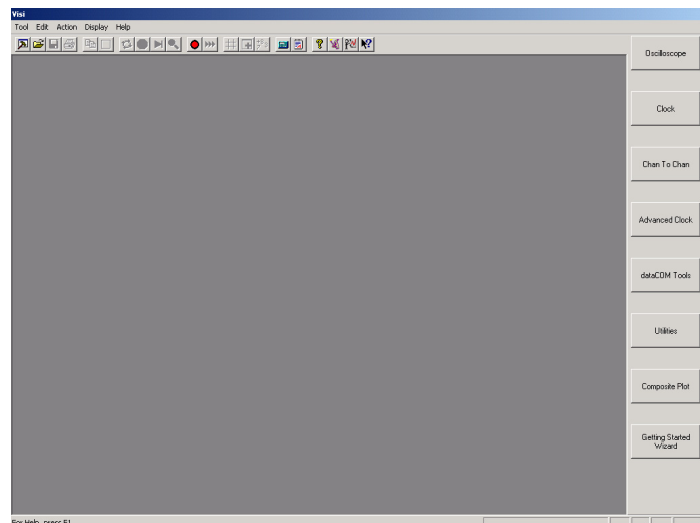


Figure 4. Initial VISI Screen.

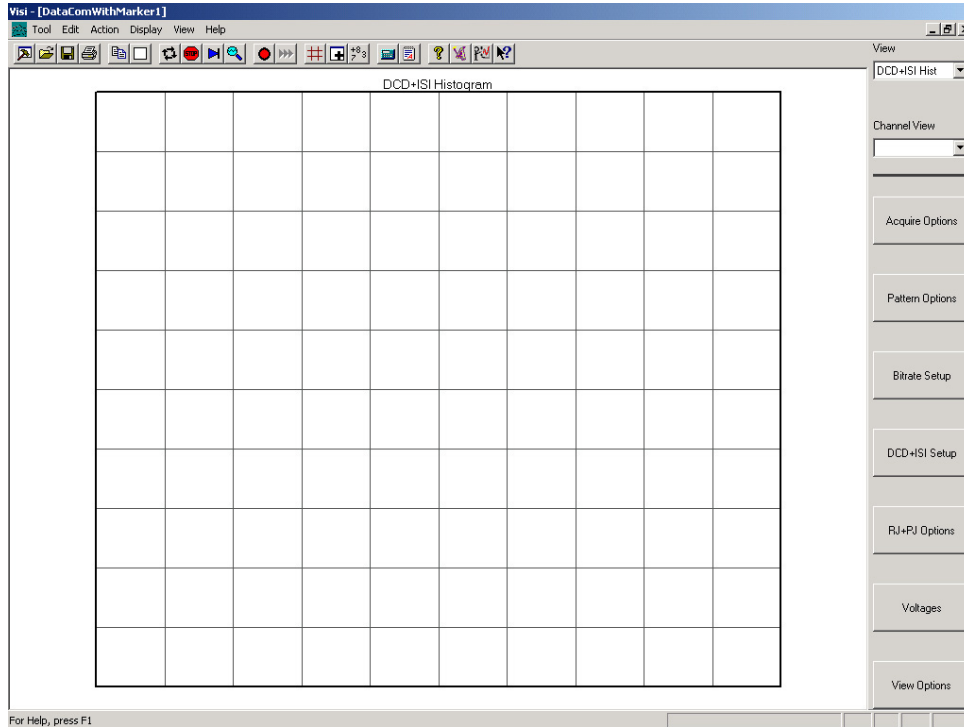


Figure 5. Initial dataCOM Screen.

Next click on the acquire options button (Figure 8). Click on the 'Arm Number' button and this will bring up the Arm selection dialog box. Use the SIA-3000 keypad to enter the channel for the Pattern Marker signal (Figure 6). If the PM50 card is to be used to generate the arm signal, ensure that the data signal is entering the channel marked "Arm Enabled". Then. Select that channel and make sure the Pattern Marker box is checked. Next select the 'Add/Del Channel' button to select the data signal channel (Figure 6). Finally, set the 'Corner Freq (kHz)' to the A1 spec level (3MHz or 3000kHz).

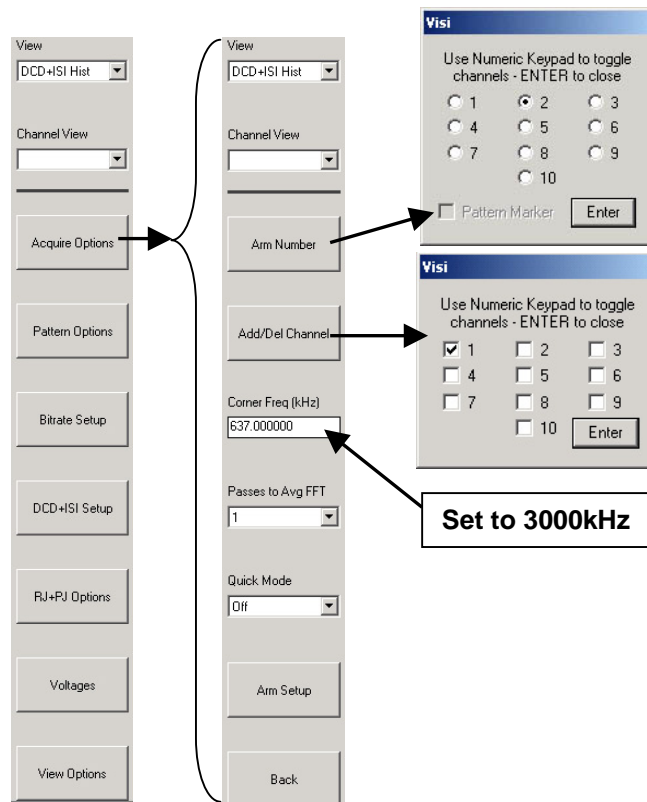


Figure 6. Acquire Options setup.

The next step is to select the data pattern. To do this, click on the 'Back' button to move back to the main menu. Next select the 'Pattern Options' button (Figure 7). You have several options for entering the pattern. If it is a standard pattern (such as K28.5, CRPAT, PRBS 2⁷-1, etc.) or if you already have the pattern saved on the SIA 3000, you can load the pattern file. Just click on the 'Load Pattern' button and select the file. If the pattern isn't stored on the SIA 3000, you have several options for entering it. The first is to click the 'Edit Pattern' button and enter the pattern in Hex or Binary. When you are finished, you are prompted to save the pattern. Make sure you give it a new name that properly describes it.

The last option is to learn the pattern. In order to use this function, you must already have a pattern marker (From a pattern generator or BERT). When you click on the 'Learn Pattern' button, the Dialog Box shown in Figure 7 appears. To learn the pattern, just enter the number of bits in the pattern and the bit rate. When you click the 'Learn' button, the instrument will go out and learn the pattern. You are then asked to save it.

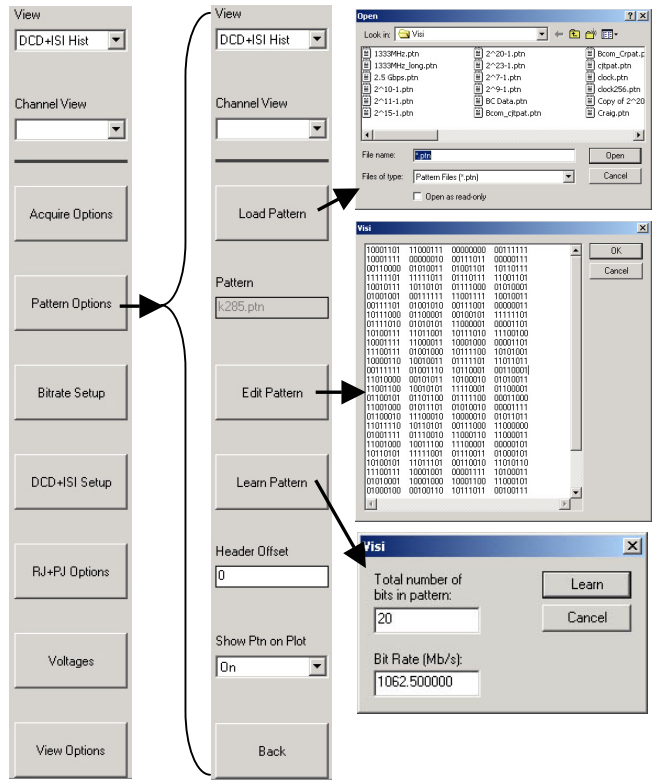


Figure 7. Pattern Setup.



You are now ready to make a measurement. Just click the 'Single Acquire/Stop Run' button  on the VISI toolbar (Figure 8).



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 in the view heading (see Figure 9). See the Help for more information on the different views. 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.

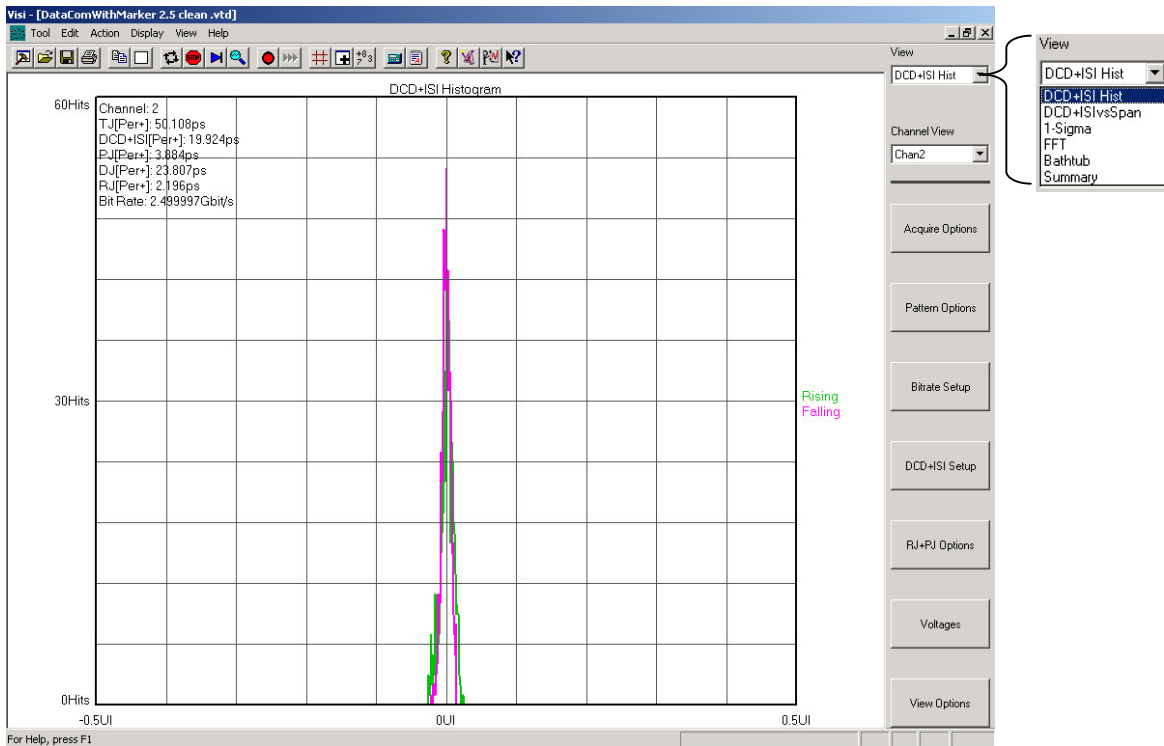


Figure 11. dataCOM results.

This covers the section from 3MHz to 750MHz. To obtain the section from 150MHz to 750MHz, simply turn on a high pass filter at 150MHz. To do this, click the 'RJ+PJ Options' button (Figure 12). Next click the 'RJ+PJ Filters' button. Now turn on the High Pass Filter (HPF) (see Figure 11). By default the HPF is set to 'Natural Rolloff'. This used the frequency that you set in Figure 8 as the low end for the RJ and PJ jitter measurements. If you select 'Brick Wall' you can then enter another frequency (above the frequency set in Figure 8) as the lowest frequency used for RJ and PJ calculations. Enter 150MHz and the jitter values will now reflect the band from 150MHz to 750MHz. Jitter values for other bands can be obtained by inputting different values for RJ+PJ HPF.

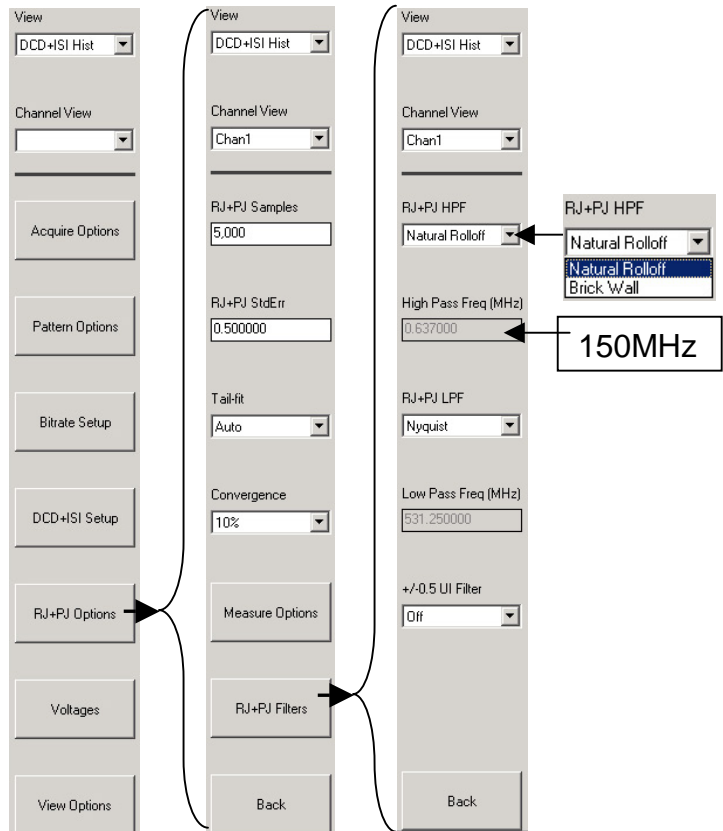


Figure 12. Filter setup.

Low Frequency Modulation Setup for dataCOM Tool

The low frequency portion of the specification (3MHz and below) is dominated by Periodic Jitter (PJ) due to the SSC. To accurately measure this, it is desired that the part is generating a clock like pattern (1010) so that the clock tools can be used to measure the PJ (see next section). If this cannot be done, you can use the dataCOM KPWM tool to measure the PJ. For this setup, open the KPWM dataCOM tool. Setup the pattern and channels as described in the previous section (dataCOM Setup). In this case, you want to set the corner frequency to 15kHz or lower (10kHz recommended). This will ensure that you see at least one full cycle of the 30kHz SSC in order to accurately measure its amplitude. If you now run this tool you will likely get the error “DCD+ISI Failure - Unknown pattern or no signal”. This is due to the large PJ amplitude. The PJ is so large (40UI) that the DCD+ISI part of the measurement will have edges that are displaced more than 0.5 UI from their ideal position. The tool will fail in its default setup. To alleviate this problem, you need to set the error checking to a higher value. This is shown in Figure 13. Go into

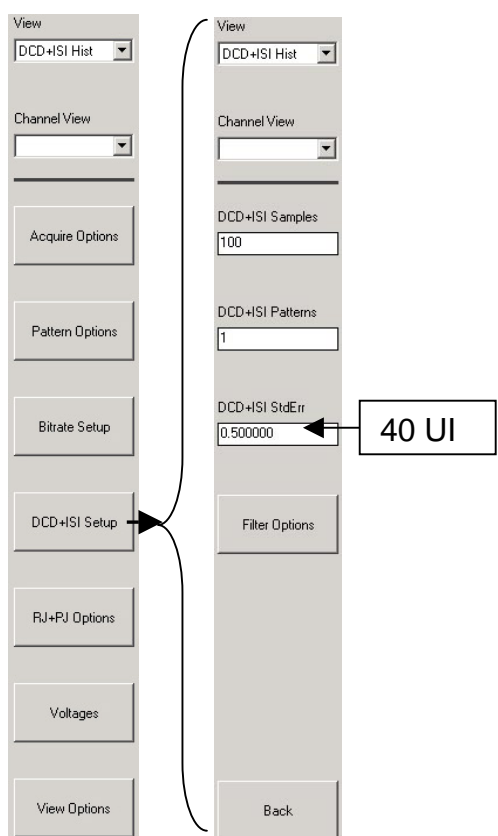


Figure 13: DCD+ISI StdErr

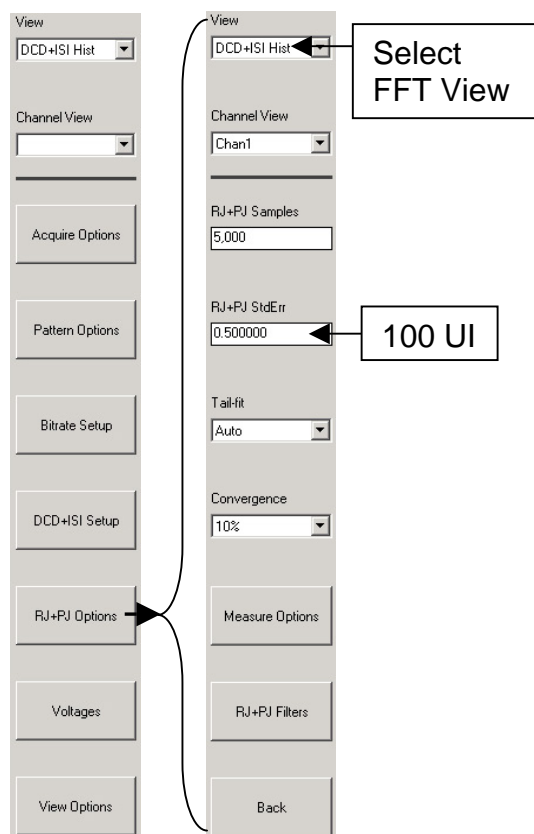


Figure 14: RJ+PJ StdErr.

the “DCD+ISI” Setup menu. Then set the DCD+ISI standard error to 40 UI. Also, set the RJ+PJ error values to 100UI to ensure that the 40UI PJ at 30kHz can be measured as shown in Figure 14. Run the tool as described in the previous section. Change your view to FFT as shown in Figure 14. The results should be similar to the ones shown in Figure 17. Because the dominant part of the TJ value is from PJ, you can use the FFT view to determine compliance at any frequency point below about 1MHz (per the specification). Simply use the mouse to zoom in on any spike in the FFT and use the cursor to measure its frequency and amplitude.

Clock-like Data using the Low Frequency Modulation Tool

The low frequency portion of the specification (3MHz and below) is dominated by Periodic Jitter (PJ). To accurately measure this, make sure that your part is generating a clock like pattern (1010). Connect this signal to the SIA 3000 and click on “Clock” on the main menu and then click on “Low Frequency Modulation” (LFM) tool (Figure 15).

Next, select “Acquire Options” and then select “Channel” (Figure 16). You can also adjust the “Maximum Freq (kHz)” to a lower frequency if you are looking at modulation around 30kHz. The lower this frequency, the more resolution you will have on modulation sources below the frequency you set.

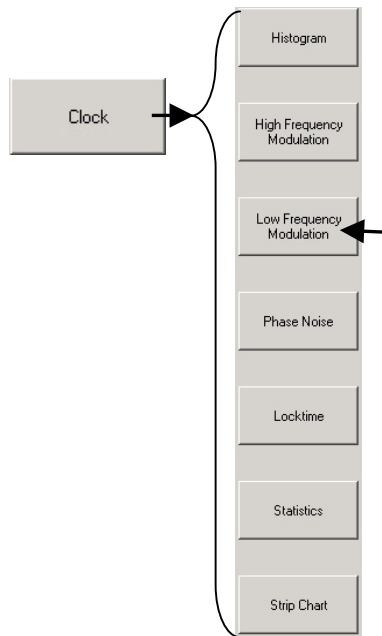


Figure 15. Low Frequency Modulation tool.

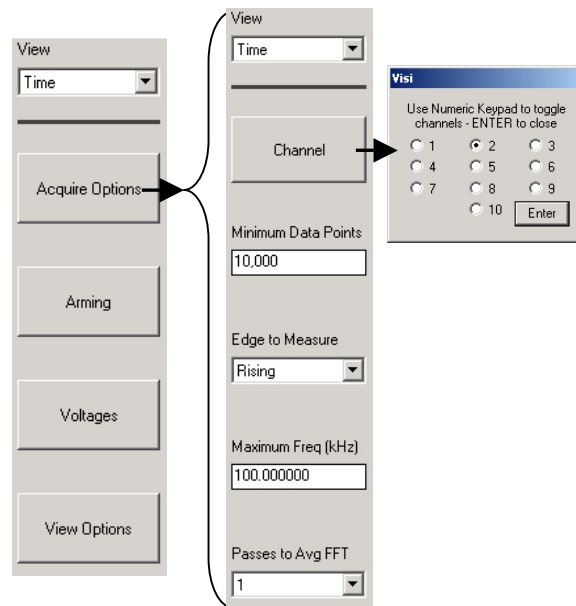



Figure 16. LFM Setup.

Next click the ‘Single Acquire/Stop Run’ button . To view the frequency and amplitude of the PJ components, change the view to “N-CLK FFT” (Figure 17). Zoom in to the area of interest (area where jitter is being applied). The plot should look like Figure 17. If you place the cursor over a spike in the FFT, you can read the amplitude and frequency in the lower right corner in the status bar (see Figure 17).

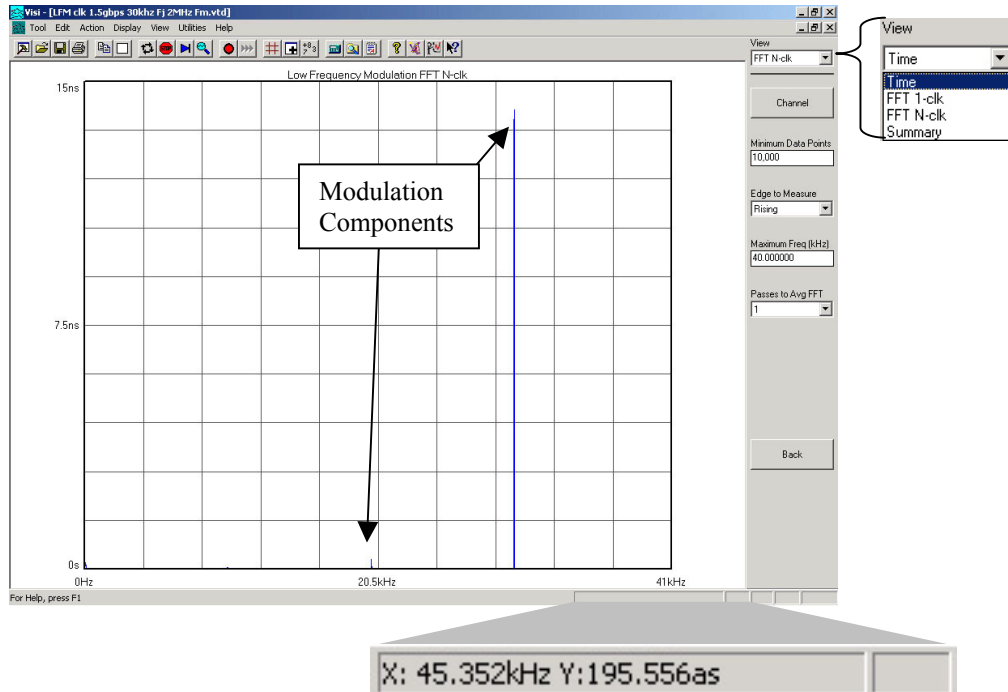


Figure 17. Low Frequency Modulation FFT N-clk view.

Jitter Tolerance

This completes the Jitter Output measurements described in Figure 2 (Driver output, Driver PCB Connector, Receiver PCB Connector). For the 'Receiver Input' section of Figure 2 (Jitter tolerance), follow the above instructions for each compliance point to measure the amount of jitter being added to the signal before you apply it to the receiver to insure full jitter compliance.

Summary

The features of the SIA 3000 VISI software along with the proven capabilities of the advanced VISI diagnostic tools combine to form a complete jitter and timing analysis software package for measuring SATA jitter. This paper has outlined a step-by-step process for measuring jitter according to the SATA standard.

Footnotes:

- [1] Fibre Channel Methodologies for Jitter Specification, Rev 10, page 30, at ftp://ftp.t11.org/t11/member/fc/jitter_meth/99-151v2.pdf
- [2] *WAVECREST CORPORATION*, "AG100 Quick Reference", part # 200012-01 Rev A.

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