Low Frequency Modulation

For the SIA

Applications of Low Frequency Modulation Analysis Tool

- View accumulated low frequency (<100 kHz) jitter in the time domain.
- View low frequency (<100 kHz) jitter components in the frequency domain.

Introduction

The focus of this guide is to familiarize the user with the Low Frequency Modulation tool allowing 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

Assume an ideal clock with period T_0. The SIA measures the accumulated time t for a burst of N clock cycles. The system resets during the dead time τ_{Dead}, after which another burst of N clock cycles is measured. The whole process is repeated for a total of M times. Fig. 1 shows the measurement and analysis processes for this tool.

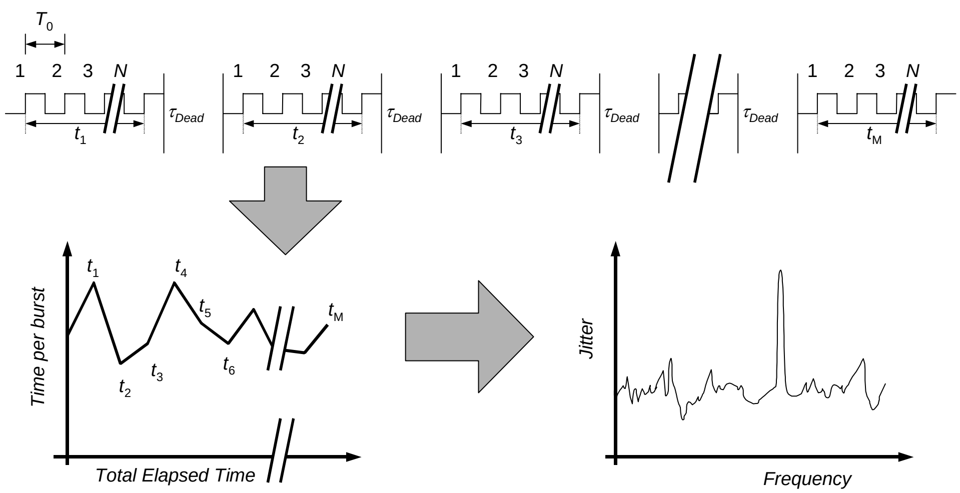


Fig. 1 Illustration of jitter measurements with the Low Frequency Modulation tool.

The measured value t is related to the jitter Δt accumulated over N cycles by $\Delta t = t - NT_0$. The measured values of t can be plotted against the total elapsed time to show the trend of the jitter. This jitter time series can also be transformed by FFT and plotted as the jitter frequency spectrum. The sampling rate of this measurement scheme is approximately $NT_0 + \tau_{Dead}$. Thus, the jitter spectrum has a Nyquist frequency given by

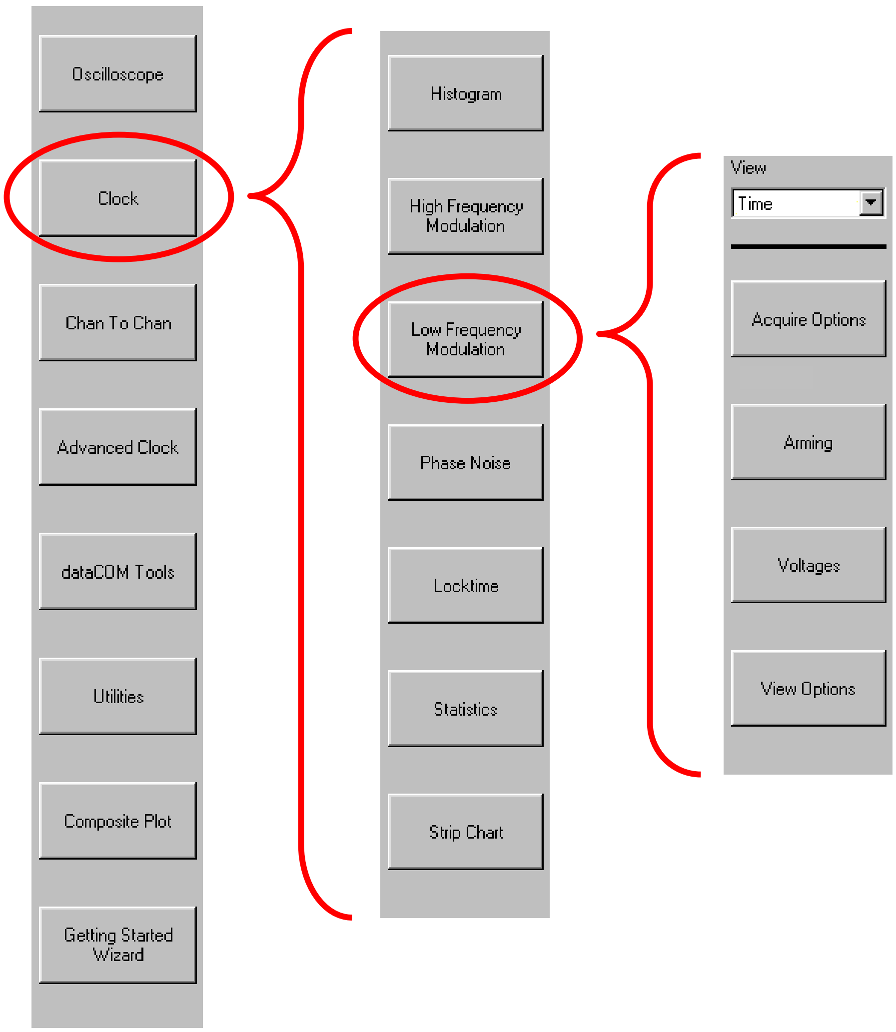
Eq. 1
$$f_N = \frac{1/2}{NT_0 + \tau_{Dead}}.$$

The frequency resolution Δf of the spectrum is determined by the number of measurements M,

Eq. 2
$$\Delta f = \frac{2 f_N}{M}.$$

Low Frequency Modulation Tool Main Menu

The main menu of the Low Frequency Modulation tool is found in the GigaView menu path shown below.



View
Provides the user with several different ways (**Time**, **FFT N-clk**, **FFT 1-clk**) to visualize the acquired data.

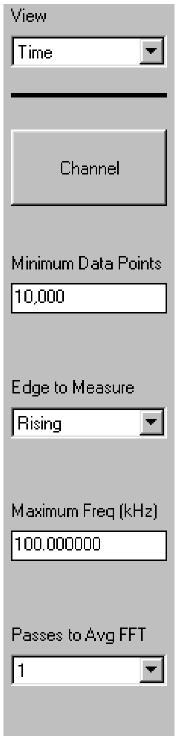
Acquire Options
Opens the Acquire Options menu.

Arming
Opens the Arming menu.

Voltages
Opens the Voltages menu.

View Options
Opens the View Options menu.

Acquire Options Menu



Channel
Opens the channel selection menu. Use the keypad to select a measurement channel

Minimum Data Points
Sets the minimum number of data points that will be acquired in the time domain. The actual number of data points is the first power of two greater than the value entered. E.g., if the user enters 1000, the actual number of data points will be 1024. Note that, in the frequency domain, the single-sided spectra will have half the number of data points as in the time domain. The corresponding spectral resolution is given by Eq. 2. For small values of Δf, the noise floor of the measurement will decrease, as the noise energy per frequency bin must be conserved.

Edge to Measure
Select **Rising** or **Falling** edge to measure.

Maximum Freq (kHz)
Sets the Nyquist frequency and sampling rate of the measurement as expressed in Eq. 1. For the SIA, τ_{Dead} = 3.9 μs, thus limiting the maximum frequency to approximately 100 kHz.

Passes to Avg FFT
Selects the number of acquisitions to average for the FFT output. Averaging will generally reduce the fluctuation of the FFT but increase the processing time of the measurement.

Arming Menu

Arm Delay (19-21ns)
Sets the minimum delay time from an arm event to the first measurement edge.

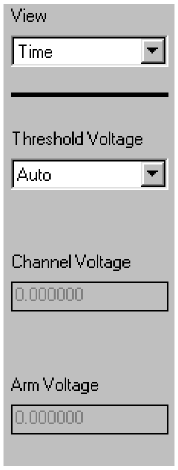
Arming Mode
Arming is required to make every measurement.

- **Arm on Stop** uses a falling edge from the measurement channel to arm the instrument.
- **Arm on Start** uses a rising edge from the measurement channel to arm the instrument.
- **External Arm** uses a signal from a channel different than the measurement channel to arm the instrument.

Arm Number
Opens the channel selection menu for choosing a channel to be used for arming when **External Arm** is selected.

Arming Edge
Selects **Rising** or **Falling** edge to arm the measurement when **External Arm** is selected.

Voltages Menu



Threshold Voltage

- **Auto** sets measurement start and stop reference voltage based on the minimum and maximum levels of the measurement channel (found from **Pulsefind**). The threshold is automatically set to the 50% point. The voltages are shown in the **Channel Voltage** display after a successful **Pulsefind** is completed.
- **User Volts** allows the user to set the reference voltage.

Channel Voltage
Either sets or displays the reference voltage for the measurement channel, depending on the setting of the **Threshold Voltage**.

Arm Voltage
Either sets or displays the arming voltage for the measurement channel, depending on the setting of the **Threshold Voltage**.

View Options Menu

X-axis
Selects the parameter plotted on the x-axis when **View** is set to **Time**.

- **Hit Number** plots the index of the measurement on the x-axis.
- **Elapsed Time** plots the total elapsed time of the measurement on the x-axis.

FFT Window
Selects the windowing function applied to the FFT to reduce spectral distortion. The choice of window will affect the shape of the spectrum. Each windowing function has unique advantages/disadvantages over other windows.

Padding Multiplier
Selects the amount of zero padding to be applied to the measured data prior to FFT. Padding effectively increases the total number of data points and consequently increases the frequency resolution of the FFT. However, a high padding value will increase calculation time.

Alpha Factor
Sets the ratio of spectral peak width and side lobe rejection for the **Kaiser-Bessel** window. As alpha increases, the spectral peak widens and the side lobes decrease in amplitude, and vice versa.

Sample Measurement with the Low Frequency Modulation Tool

Experimental Setup

As an example, we perform low frequency jitter measurements on a clock signal modulated with periodic jitter.

The experimental set up is shown in **Fig. 2**. For this example, the signal source is a Marconi 2041 low noise signal generator. The signal has a carrier frequency of f_0 = 1 GHz. The carrier is frequency modulated at f_m = 6 kHz with a deviation of Δf = 1 kHz.

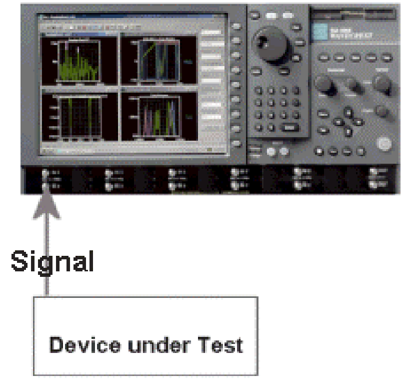


Fig. 2 SIA with signal source.

Acquiring Data

The following steps describe the data acquisition process in VISI:

1. Open the Low Frequency Modulation tool.
2. Connect the signal to a measurement channel (**Fig. 2**). Set the measurement channel in VISI by going to the **Acquire Option** menu and choosing **Channel**.
3. Confirm that a valid signal exists at the measurement channel by using **Pulsefind**
4. For this example, **Minimum Data Points** is 2049 and **Maximum Frequency** is 10 kHz.
5. Begin acquisition by pressing **Single/Stop** button on the front panel .
6. When acquisition is complete, the **Single/Stop** button will cease to illuminate.

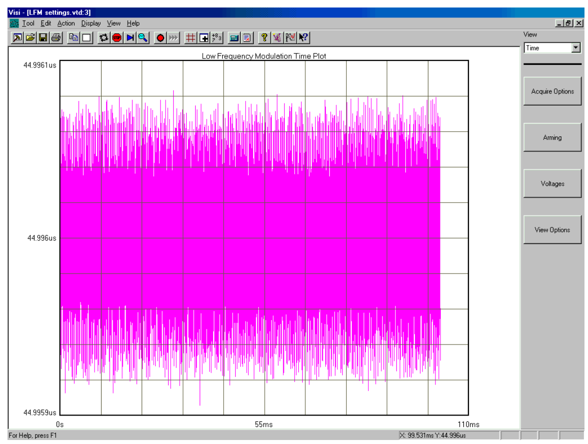


Fig. 3 Measured jitter time series.

Viewing Data in Time Domain

The initial default view is the time series shown in **Fig. 3**. The time series view can be selected by choosing **Time** under the **View** menu.

The x-axis shows the total elapsed time of the measurements. The y-axis shows the measured edge-to-edge time over N clock cycles (see **Theory of Operation**).

The mean value of the time series is NT_0. The fluctuation about the mean value is the edge-to-edge jitter Δt accumulated over N cycles.

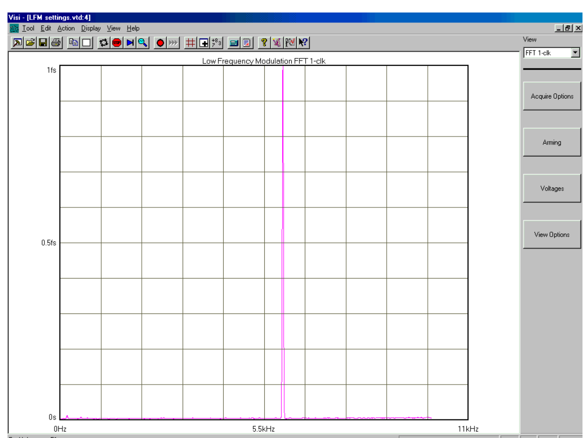


Fig. 4 Calculated FFT 1-clk jitter spectrum.

Viewing Data in Frequency Domain

VISI calculates two distinct jitter spectra from the jitter time series: **FFT 1-clk** (**Fig. 4**) and **FFT N-clk** (**Fig. 5**). To view these spectra, make the selection under the **View** menu. **FFT 1-clk** is the spectrum of edge-to-edge jitter. **FFT N-clk** is the spectrum of edge-to-ideal clock jitter. 1-clk jitter is essentially a time derivative of N-clk jitter. Thus, the **FFT N-clk** spectrum is functionally related to the **FFT 1-clk** spectrum by 1/f.

In both spectra, we see a baseline of RJ with a PJ peak near 6 kHz, as expected. Note that RJ is approximately flat in the **FFT 1-clk** spectrum, therefore, RJ has a 1/*f* dependence in the **FFT N-clk** spectrum.

The magnitude of the PJ can be found by pointing the mouse cursor at the peak. The status bar at the bottom displays the PJ frequency as 6.003121 kHz and the PJ peak magnitude as 0.999 fs. The theoretical peak 1-clk jitter is given by

Eq. 3 $$PJ_{Peak} = \frac{\Delta f}{f_0^2}.$$

Given the frequency modulation parameters of the signal, PJ_{Peak} = 1 fs, which is in excellent agreement with the measured data.

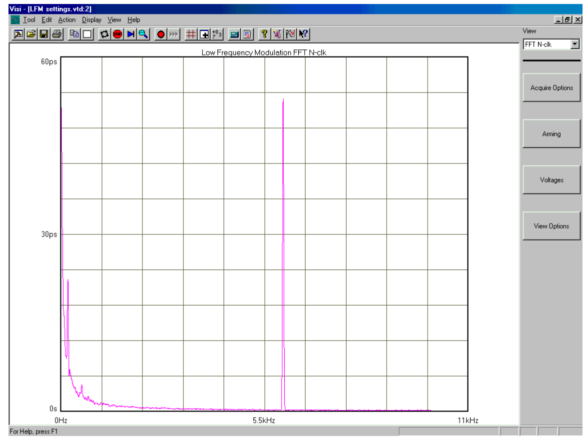


Fig. 5 Calculated FFT N-clk jitter spectrum.

Viewing Data Summary

To view a summary of the measured data, choose **Summary** under the **View** menu (**Fig. 6**). The summary includes information about the edge-to-edge measurement period, clock frequency, and any PJ peaks detected.

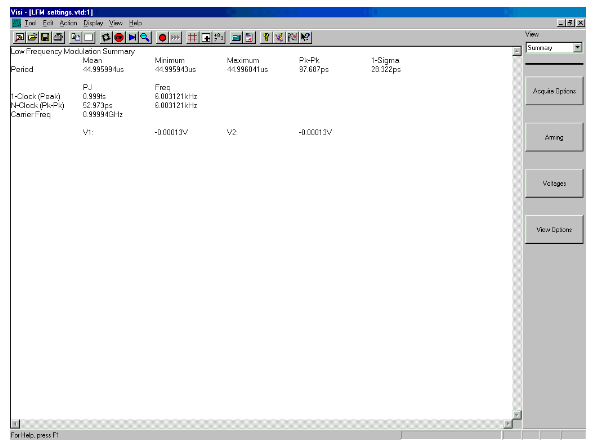


Fig. 6 Data summary.

Summary of the Low Frequency Modulation Tool

The Low Frequency Modulation tool allows users to study low frequency (<100 kHz) jitter present in clock and oscillator circuits. By selection of the Nyquist frequency and the number of data points, the user can measure the low frequency jitter and display it in both time and frequency domains. In the frequency domain, the user can view the spectral components of jitter present in the signal under test. Furthermore, the user can study the frequency spectra of the edge-to-edge (FFT 1-clk) jitter as well as edge-to-ideal clock (FFT N-clk) jitter.

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