Keysight Technologies

Using an Oscilloscope with Time Gated Fast Fourier Transforms for Time Correlated Mixed Domain Analysis

Application Note

For many cases, the ability to debug in both the time domain and the frequency domain can be valuable. In the cases where you want to debug multiple places on a board, time correlation between these signals can be very important; however it can also be a challenge when using multiple test instruments. Another problem faced while making mixed domain measurements is the ability to look at frequency changes over time. Most oscilloscopes are useful measurement tools to look at both the time and frequency domain because of their Fast Fourier Transform capabilities, but Keysight's InfiniiVision 3000T and 4000 X-Series oscilloscope's time-gated FFT's help you gain insight into your time and frequency domain signals at specified times.

Take, for example, a Voltage Controlled Oscillator (VCO). VCO's can be enabled by an event on your device under test (DUT). In this example we will use a rising clock edge to enable an oscillator that will sweep through various frequencies; shown in Figure 1. Shown on the oscilloscope display is the enabling clock (green) and the output of the oscillator (fuchsia).By default this particular oscillator starts at 700 kHz and will sweep through frequencies until it reaches 3 MHz. By looking at the color grading on the oscillator waveform, you can see that it gets slightly darker in time, which could be an indication that the frequency is increasing, but let's take a look at this signal in the frequency domain to verify.

On the 3000TX and 4000X oscilloscopes it is easy to set the start and stop frequencies to 650 kHz and 3.3 MHz using the keyboard on the capacitive touchscreen (Figure 2). You can also set these parameters with the span and center frequency (Figure 1). Setting the appropriate span is important to make sure that all the swept frequencies will be included in the FFT. With these settings alone, the FFT will be calculated on full screen data, but it won't show if the frequency changed over time. Since that is what we are interested in capturing, we will need to use a time gated FFT.

In Figure 3, the time gated FFT has been turned on. The top half of the oscilloscope displays the captured time domain waveforms and the gate, which can be resized depending on how much information you want to analyze. The window is set around the time that the enabled signal was activated. Displayed below are the pieces of the time domain waveforms and the FFT of the oscillator waveform within the gate. Here is an example of how time correlation and time gating are beneficial because now we can see that at the time the oscillator was enabled, its frequency was about 700 kHz, which was to be expected. You can see on the right of the screen, there is an event table that is showing the frequency peaks. In this case there is only one frequency component but with multiple peaks this can be a quick measurement tool.

Figure 1. Enable clock (green) and oscillator output (fushia) options to set spectrum parameters.

Figure 2. Use the keypad on the capacitive touch screen to enter values for start and stop frequencies.

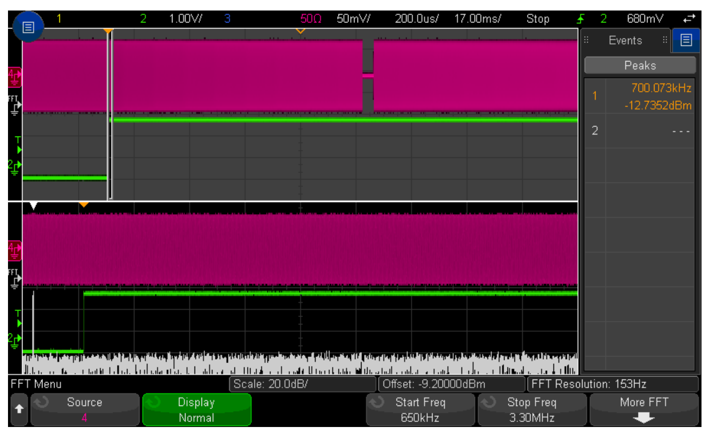

Figure 3. Time gated FFT, calculating the FFT only in the time specified window.

Moving the time gate around is easy, it can be done manually using the touch screen or with the navigation keys which let you play through the entire time record; shown in Figure 4. As the gate moves along the waveform, you can see the frequency is increasing. In this display there are two peaks in the event table because there is a frequency change within the gate, you can see this visually on the FFT waveform.

As you may have noticed, there seems to be gap in the oscillator time domain waveform, could it have reach 3 MHz and turned off? The frequency measurement right before the gap is about 1.97 MHz and as shown in Figure 5, the frequency after the gap is at about 2.08 MHz.

These measurements indicate that the oscillator did not reach 3 MHz but instead stalled; by turning on the cursors we can measure the exact timing of this error. Notice now that the sidebar has the cursor measurements included below the event table, it appears that the gap happened about 78 ms after it was enabled. With this information, we could use the scope to see what else is happening on the DUT at this time, and possibly determine the cause or if the oscillator itself is not working properly. Keep in mind that by looking at the waveform in both domains we were able to clearly see that there was a problem, which could have been easily missed if we just did a sweep across the frequency domain with a different measurement instrument like a spectrum analyzer.

Continuing the navigation shows that the oscillator has stopped increasing and stabilized at 3 MHz, 140 ms after it was enabled (Figure 6). Being able to look at different parts of the signal helped to verify that the oscillator did reach the desired frequency.

In this application note a simple VCO was used as an example, but the gated FFT is not limited to just a signal with changing frequencies. Gated FFT's can be useful tools when looking at other signals, such as bursty signals, or trying to determine other signals coupling into your DUT at a specific time. Frequency domain measurements using FFT's on oscilloscopes are good debugging tools but using Keysight's InfiniiVision 3000T and 4000 X-Series time gated measurements provide even more analysis with the ability to time correlate your measurements in both domains.

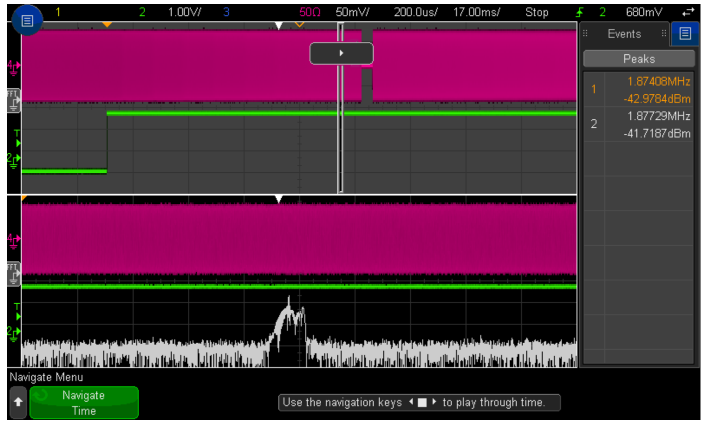

Figure 4. Navigate along the waveform to see the entire spectrum.

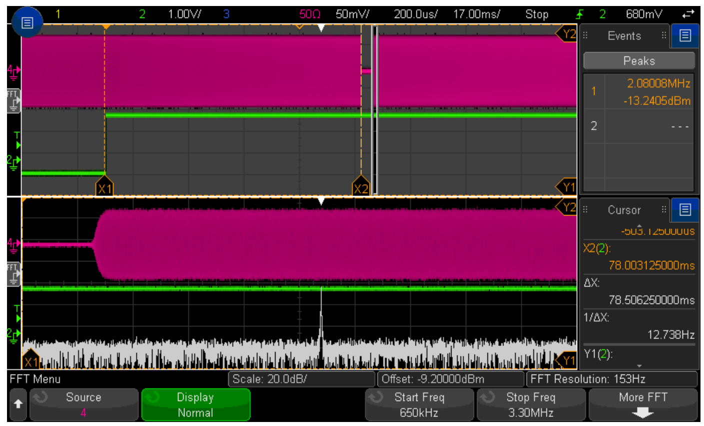

Figure 5. Use cursors to measure the time at which the oscillator stalled.

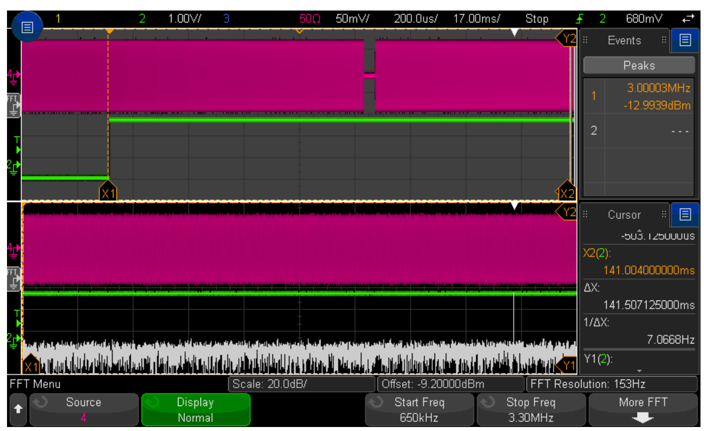

Figure 6. Use cursors to measure when the oscillator stabilized to 3 MHz.

myKeysight

www.keysight.com/find/mykeysight
A personalized view into the information most relevant to you.

www.axiestandard.org
AdvancedTCA® Extensions for Instrumentation and Test (AXIe) is an open standard that extends the AdvancedTCA for general purpose and semiconductor test. Keysight is a founding member of the AXIe consortium. ATCA®, AdvancedTCA®, and the ATCA logo are registered US trademarks of the PCI Industrial Computer Manufacturers Group.

www.lxistandard.org
LAN eXtensions for Instruments puts the power of Ethernet and the Web inside your test systems. Keysight is a founding member of the LXI consortium.

www.pxisa.org
PCI eXtensions for Instrumentation (PXI) modular instrumentation delivers a rugged, PC-based high-performance measurement and automation system.

Three-Year Warranty
www.keysight.com/find/ThreeYearWarranty
Keysight's commitment to superior product quality and lower total cost of ownership. The only test and measurement company with three-year warranty standard on all instruments, worldwide.

Keysight Assurance Plans
www.keysight.com/find/AssurancePlans
Up to five years of protection and no budgetary surprises to ensure your instruments are operating to specification so you can rely on accurate measurements.

www.keysight.com/go/quality
Keysight Technologies, Inc.
DEKRA Certified ISO 9001:2008
Quality Management System

Keysight Channel Partners
www.keysight.com/find/channelpartners
Get the best of both worlds: Keysight's measurement expertise and product breadth, combined with channel partner convenience.

www.keysight.com/find/3000TX-Series

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at:
www.keysight.com/find/contactus

Americas	
Canada	(877) 894 4414
Brazil	55 11 3351 7010
Mexico	001 800 254 2440
United States	(800) 829 4444
Asia Pacific	
Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 6375 8100
Europe & Middle East	
Austria	0800 001122
Belgium	0800 58580
Finland	0800 523252
France	0805 980333
Germany	0800 6270999
Ireland	1800 832700
Israel	1 809 343051
Italy	800 599100
Luxembourg	+32 800 58580
Netherlands	0800 0233200
Russia	8800 5009286
Spain	800 000154
Sweden	0200 882255
Switzerland	0800 805353
	Opt. 1 (DE)
	Opt. 2 (FR)
	Opt. 3 (IT)
United Kingdom	0800 0260637

For other unlisted countries:
www.keysight.com/find/contactus
(BP-09-23-14)

Published in USA, November 3, 2014
5992-0244EN
www.keysight.com