Boosting Performance Oscilloscope Versatility, Scalability

Rising data communication rates are driving the need for very high bandwidth real-time oscilloscopes in the range of 60-70 GHz. These instruments are essential for validating and debugging new designs in coherent optical modulation analysis, high energy physics research, high speed data communications amongst other areas. With the DPO70000SX Performance Oscilloscope series, Tektronix delivers real-time signal acquisition with an ultra-high bandwidth of 70 GHz, along with a real-time sample rate of 200 GS/s (5ps/sample resolution), making it ideal for such applications.

Contained in a compact 5.25-in. instrument package, the DPO70000SX as shown in Figure 1 can operate either as a single channel system with 70 GHz, 200 GS/s sample rate, for use with RF and optical applications, pulsed laser studies and similar high energy physics applications, or as a two-channel system, each with 33 GHz, 100 GS/s sample rate, for high-speed serial and bus designs used in computing or data communications applications that require differential signaling inputs.

Figure 1: The DPO70000SX series unit is a compact 5.25 inches tall, allowing it to fit in a standard 3U rack space.

Tektronix' precision timing synchronization technology called UltraSync™ enables precise channel-to-channel timing stability needed for high performance multichannel measurement systems. Up to four DPO70000SX units are able to operate together as one multi-channel instrument while delivering the same level of measurement precision and usability as a standalone, monolithic, oscilloscope.

With its compact form factor and UltraSync technology, along with several other new innovations including Asynchronous Time Interleaving technology (ATI), the DPO70000SX opens the door to unprecedented ultra-performance oscilloscope capabilities. The 200 GS/s sample rate and deep memory options combine to deliver 5ps/sample resolution over long time durations.

As detailed in the Tektronix white paper "Techniques for Extending Real-Time Oscilloscope Bandwidth," ATI is a unique method for digitizing the full input signal spectrum. It features signal path symmetry that preserves signal-to-noise ratio for higher fidelity. The entire input signal is digitized by each of two symmetrical acquisition paths and reassembled with a patented method that preserves the signal and reduces noise.

This document discusses some of the key advantages inherent in using a compact form factor. These advantages include scalability via multi-unit configurations, distributed processing for faster signal analysis, flexible layouts, and a shorter signal path between DUT and scope. It also goes into greater detail regarding Tektronix' UltraSync technology.

Shrinking the Form Factor

The DPO70000SX is designed to fit in a 3U rack space. It is significantly smaller than other oscilloscopes in the ultra-high bandwidth class. Despite its small physical dimensions, each DPO70000SX unit delivers the full range of features and functionality of traditional bench oscilloscopes. It comes with the same advanced capabilities for jitter analysis, signal path de-embedding or spectral analysis as the current MSO/DPO70000 oscilloscopes do today, and can take advantage of the full range of software solutions, probes, fixtures, and other accessories

One consideration that has long defined the physical dimensions of oscilloscopes is the need to include a built-in monitor screen large enough for comfortable viewing for hours at a time. Whereas in the past, monitor size may have been an important consideration, this is no longer the case for oscilloscopes intended for lab use due to the ready availability of inexpensive, large external flat screen monitor.

The preferred option for most engineers today is to connect an external monitor, along with a keyboard and mouse, as shown in Figure 2, to the oscilloscope. Some do so in order to separate the instrument area from the work location, creating a more convenient and comfortable arrangement. Others do so because current optical modulation applications and large analytic software environments such as MATLAB are easier to use with a screen that has more display area and a higher resolution than an oscilloscope could reasonably offer.

Figure 2: High Speed Differential Serial Bus Measurements using DPO70000SX Oscilloscope with remote panel and large monitor.

The DPO70000SX supports multiple external monitors – including touch screens to boost productivity. Additionally, many users go a step further and use Remote Desktop -- a standard component of Microsoft

Windows – to escape noisy lab environments to access and manage their oscilloscopes from the comfort of their desks or even home offices.

In addition to the smaller display, the number of front panel controls on the oscilloscope has been minimized for the DPO70000SX. Instead, an optional Auxiliary Front Panel (shown in Figure 3) is available which provides user controls that are identical to the controls and indicators provided on the Tektronix DPO7000 and MSO/DPO70000 series oscilloscopes. The AFP includes the familiar Run/Stop button that provides immediate control. It also includes vertical, horizontal and trigger settings, multi-purpose coarse and fine adjustment and other controls common to Tektronix oscilloscopes. The AFP allows users to fully control the DPO70000SX from a convenient location and at the same time position the oscilloscope optimally for signal acquisition.

Figure 3: Shown here is the optional Auxiliary Front Panel, which provides user controls that are identical to the controls and indicators provided on the Tektronix DPO7000 and MSO/DPO70000 series oscilloscopes.

Multiple Channels with UltraSync™

With the advent of the Tektronix UltraSync High Performance Synchronization and Control Bus, multi-unit systems with up to four DPO70000SX units are now possible.

The UltraSync architecture coordinates triggers across a multi-instrument acquisition system for inherent channel-to-channel jitter that is equivalent to that found in monolithic oscilloscopes. This means that when multiple DPO70000SX units are connected together with UltraSync cables, as shown below, they offer the functional equivalent of a single high performance oscilloscope with multiple high-speed channels. For instance, a two-unit system synchronizes two units to provide two channels at 70 GHz, 200 GS/s, or four channels at 33 GHz, 100 GS/s.

Figure 4: UltraSync Master and Extension unit connections showing sample clock reference, trigger bus connection, and high-speed data connections.

As shown in Figure 4, UltraSync technology uses a 12.5 GHz sample clock reference signal, which is sourced by the master unit and used by each extension unit to synchronize sample placement in the digitizing process. The extension units are controlled by a PCI Express, Gen 2, x4 link that is capable of a fast 2 GB/s data transfer rate and manages data transfer to the master. UltraSync controls the triggering for all instruments in a multi-unit system, so that any unit can be the source for coordinated triggers.

Figure 5: Multiple DPO70000SX units can easily be connected together (up to four total) to scale up performance and capabilities as testing needs change.

The reliable performance of the UltraSync technology is best illustrated in a 2-unit configuration commonly used for measurement of high-speed serial differential signals like 25Gb Ethernet. In the first example shown in Figure 6, a 65 GHz Sinewave was sent to channels on both the extension and master unit. The amount of jitter between the two channels was just 48.5 femtoseconds RMS over several thousand acquisitions.

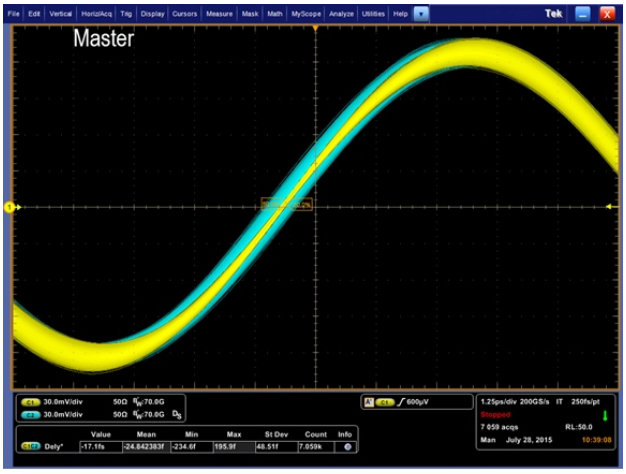

Figure 6: 65 GHz sinewave capture on two ATI channels illustrates inherently high channel-to-channel skew stability.

In a second example, a comparison was made to illustrate channel to channel timing performance compared to a leading competitor's monolithic oscilloscope. Using the IEEE 1057 Sinewave Fit Method to eliminate variable noise, the resulting performance (Figure 7) shows that UltraSync technology operates with lower average skew across frequencies than a monolithic, non-scalable instrument.

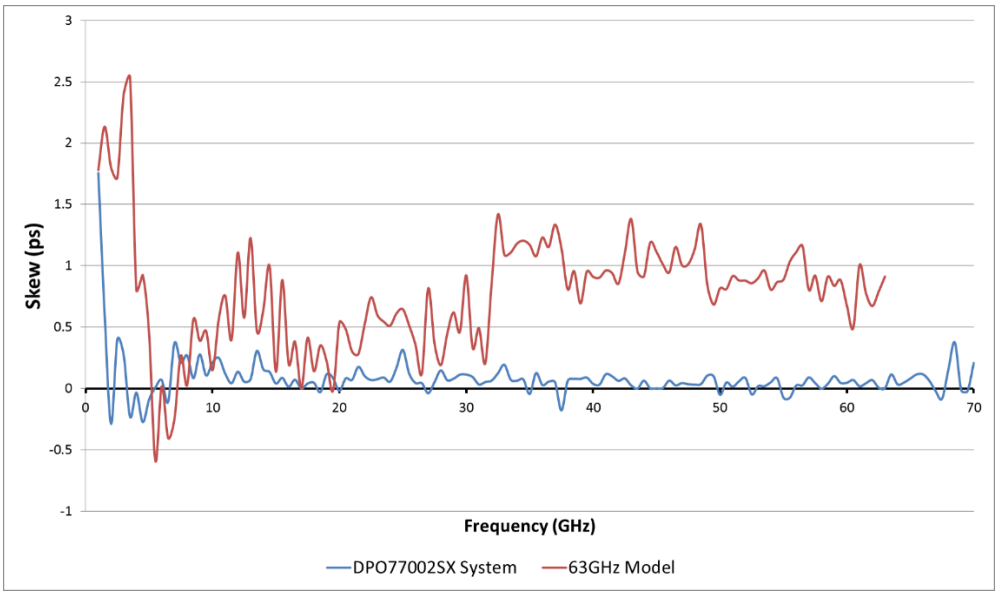

Figure 7: DPO70000SX system shows lower channel-to-channel skew variation over its full frequency range than other vendor's monolithic instrument.

Another advantage inherent in the UltraSync architecture comes from distributed processing: each extension instrument delivers fully calibrated data to the master. The waveforms are already fully

processed by the time they reach the master, and the master does not need to do any additional processing. This creates a distributed processing environment that reduces the computational load on the master unit.

Any instrument can operate as either a master or extension unit; there is no need for a separate control unit. The master unit is determined by how UltraSync cables are connected and the designation is easy to change by simply moving the cable connections. A graphical configuration manager as shown in Figure 8 helps validate cable connections and indicates channel identities. Once the connections are in place, the oscilloscopes automatically establish the network and determine timing relationships across units.

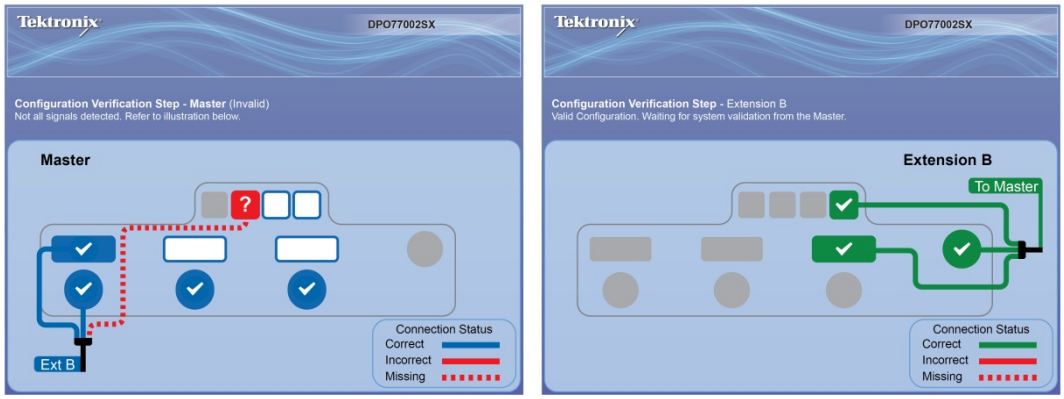

Figure 8: The UltraSync configuration manager coordinates multi-unit startup and verifies connections.

From a user perspective, the UltraSync bus is easy to setup. Cables are color coded to make set-up simple and the connections are verified by the UltraSync configuration manager. At the same time, UltraSync significantly improves system flexibility and scalability.

Redefining Scalability

A traditional performance oscilloscope that has four built-in acquisition channels, while powerful in its own right, actually limits scalability. It has four channels, no more no less and is not subject to change. The DPO70000SX changes that dynamic by letting engineering needs at a given point in time dictate the appropriate configuration for the task at hand. This can lead to significant productivity gains while lowering CAPEX.

This kind of scalability makes it economical to invest sequentially in oscilloscope systems as performance or channel count needs change. For example, a lab could purchase two DPO70000SX units providing two 70 GHz channels at a 200 GS/s rate to meet today's testing needs. This lab will be well positioned to scale up in the future for next generation applications requiring four 70 GHz channels by simply adding two more units to the system.

Conversely, systems can easily be scaled down with multiple units divided and redeployed to other projects as needed, maximizing the use of a capital investment. For instance, when a project requiring four 70 GHz channels comes to an end, a lab has the ability to easily redeploy the oscilloscopes to other labs. A four-unit configuration can be divided in half to create two systems or further subdivided into

single-unit stand-alone instruments by simply removing UltraSync cables, allowing four projects to each use one instrument. See Table 1 below for a few of the possible testing applications available using DPO70000SX and UltraSync technology.

	Instrument Bandwidth	Channels Needed	Recommended System*
Computer Bus Serial Interfaces			
SAS 4 (22 Gb/s)	40GHz	2 - Differential	*DPS75004SX - 2 Channel 50GHz
PCIe4 (16 Gb/s)	32 GHz	2 - Differential	DPO73304SX - 2 Channel 33GHz
Datacom Standards			
Ethernet			
- 40/100GBASE CRn,KRn	50GHz	2 - Differential	*DPS75004SX - 2 Channel 50GHz
- 25 Gb Phy KR, CR for 100G	40GHz	2 - Differential	*DPS75004SX - 2 Channel 50GHz
Fibre Channel			
-16Gb	30GHz	2 - Differential	*DPS75004SX - 2 Channel 50GHz
-32Gb	45GHz	2 - Differential	*DPS75004SX - 2 Channel 50GHz
OIF-CEI 3.0			
- CEI-25G	40GHz	2 - Differential	*DPS75004SX - 2 Channel 50GHz
OIF-CEI 3.1			
- CEI-56G (PAM4)	40GHz	2 - Differential	*DPS75004SX - 2 Channel 50GHz
- CEI-56G (NRZ)	40GHz	2 - Differential	*DPS75004SX - 2 Channel 50GHz
Optical Modulation Standards			
Coherent Optical			
- 200Gb/sec DP-QPSK	70GHz	4 Channels	*2 ea. DPS77004SX - 4 Channel 70GHz
*Note: UltraSync enabled			

Table 1: Examples of high speed standards that benefit from UltraSync and DPO70000SX.

This level of flexibility is missing in multi-unit systems offered by other vendors. For example, the LeCroy 10Zi, requires a separate controller unit for system operation and the master and extension units are pre-configured at the factory and cannot be separated by the user.

For convenience, Tektronix offers the option of purchasing two DPO70000SX series units configured together as the DPS70000SX oscilloscope system. The DPS77004SX system provides two 70 GHz channels at 200 GS/s, which is ideal for applications like differential high speed serial signal analysis. Two DPS77004SX systems can be configured and operated together to provide a multi-unit system with a total of four 70 GHz channels. The DPS73308SX provides four 33 GHz channels at 100 GS/s, useful for applications such as dual polarization coherent optical modulation analysis.

Unprecedented Layout Options

With its compact size, the DPO70000SX can be integrated into a smaller rack space, in tighter layouts and in more flexible ways than typical bench-sized instruments. This flexibility plays an important role in minimizing the path between the DUT and the ATI input connector.

The compact dimensions of the DPO70000SX mean that when one unit is stacked on top of another, the combined system is comparable in height to a Tektronix high-performance oscilloscope (see Figure 9) and shorter than systems offered by other vendors. For instance, two stacked DPO70000SX units are only 12 inches in height, which is shorter than the 13.3 inches of the Keysight Infiniium Z Series unit. Despite its smaller physical size, a dual-DPO70000SX configuration is actually the higher bandwidth system: the Keysight Z Series feature two channels at 63 GHz, while a system of two DPO70000SX units cabled together provides two 70 GHz channels.

Figure 9: The compact size of the DPO70000SX enables efficient use of rack space for higher channel count. Shown here are two DPO77002SX units, with 4 channels at 33 GHz, next to an MSO73304DX with 2 channels at 33 GHz.

Engineers need flexibility in the physical placement of their oscilloscopes, DUTs and other instruments, as each individual test situation might be optimized by a slightly different layout. UltraSync cables are available in both 1- and 2-meter lengths in order to accommodate virtually any physical set-up without compromising performance or precision.

The 1-meter cable is useful for typical two- and four-unit configurations of uniformly stacked instruments like the high speed datacom standards configuration shown in Figure 10.

Figure 10: High Speed Differential Measurements made using the DPO70000SX on two 70 GHz channels with UltraSync.

By using the longer 2- meter cable length, multiple instruments can be arranged at various angles in order to suit a specific DUT layout. For instance, instruments can be placed at right angles for a card-and-backplane situation or placed face-to-face, as shown in Figure 11, for coherent optical modulation applications. The cable lengths can be matched, with the system time de-skewed for precise channel-to-channel time alignment. Or, as in this example, the bottom units can be inverted to position the center inputs very close to each other to enable very short cables all of the same length.

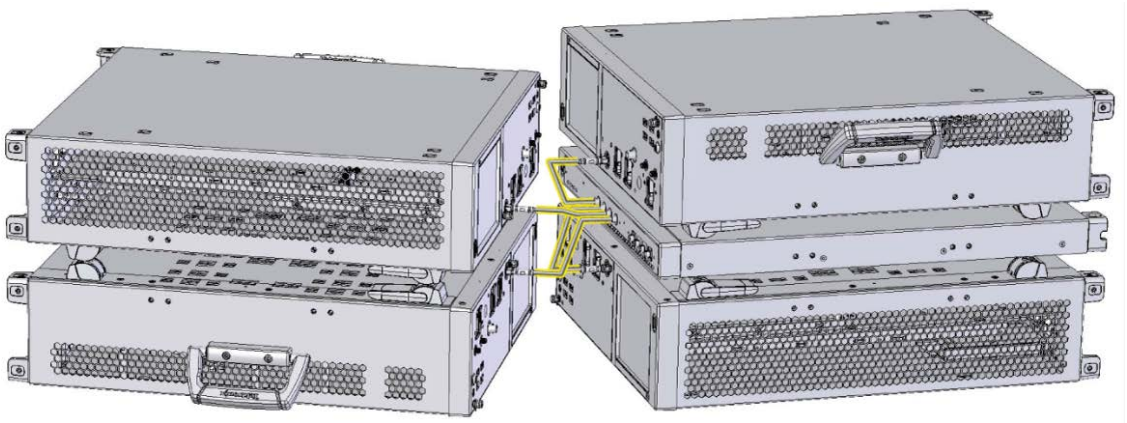

Figure 11: Graphical depiction of two DPS70000SX units and an OM4245 Optical Modulation Receiver positioned face-to-face for 200G coherent optical modulation applications.

The location and spacing of the input connectors on the DPO70000SX have been designed so that inversion of one oscilloscope provides a shorter signal path length. When one unit is flipped upside down and stacked beneath another one, the 70 GHz ATI inputs are both located in the center of the oscilloscope within inches of each other (Figure 12). Other design considerations to make this as simple and stable as possible include special reconfigurable instrument feet that match "dimples" in the sheet metal to prevent stacked units from sliding and drilled/tapped holes in side panel for bolting multiple units together using brackets.

As a result of these and other design decisions, the DPO70000SX system is highly flexible, and makes very short signal paths from DUT to scope feasible, preserving signal fidelity and ensuring best analysis results.

Figure 12: Coherent optical configuration showing the DPO70000SX system where one unit is inverted so ATI ports can be located near the optical receiver in the middle to preserve signal fidelity.

Summary

Applications that involve working with high speed signals, including coherent optical, RF, laser spectroscopy research, 100G data communications, and high speed serial analysis with differential signaling, are starting to require oscilloscope bandwidth in the 70 GHz range for current applications and to support future requirements. But these applications require more from an oscilloscope than just raw performance, including configuration flexibility and scalability to adapt to changing needs.

With its compact form factor and UltraSync technology, the DPO70000SX ultra-high bandwidth oscilloscope addresses these requirements and more, allowing customers to scale up performance and capabilities as needed, to benefit from faster signal analysis via distributed processing, to take advantage of flexible layouts, and to shorten the signal path between DUT and scope.

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