APPLICATION NOTE

High-Integrity Signal Simulation with Keysight True*form* Waveform Generators

Achieve precise and reliable signal testing with advanced True*form* technology and flexible output filters

KEYSIGHT

Introduction

In research and development (R&D) and manufacturing, the integrity of the signal source is not a luxury; it is a foundational requirement. The industry has long relied on Direct Digital Synthesis (DDS) with a fixed clock, a technology that, by design, introduces a critical compromise. To match a fixed sampling rate, these generators are forced to add or remove data points from your waveform. This quantization error, a form of signal distortion, means the output is a simulation of your intended signal, not a faithful reproduction. The result is jitter and instability that can corrupt your test data and invalidate your results.

The Keysight True*form* waveform generators represent a new paradigm; they operate on a variable-rate sampling principle, ensuring that every single point of your designed waveform is generated and played back with absolute fidelity. This is not a matter of a higher sample rate; it is a fundamental shift in architecture that eliminates the inherent compromises of fixed-clock systems. True*form* delivers a signal that is predictable, clean, and precisely aligned with your design specifications.

This application note explores the test challenges and explains how Keysight True*form* Waveform Generators can help you generate accurate signals for all your test needs.

#1 Reproducing an arb with designed glitches

You need to test the robustness of your design by pushing it to its breaking point, and you design a test signal packed with noise, overshoot, fast voltage spikes, and dropouts, every transient glitch your design might encounter. But when you use a standard DDS-based waveform generator, you notice the glitches are not being reproduced as you designed them. The problem is fundamental to DDS architecture: to meet its rigid, fixed-clock rate, it is forced to add or skip data points from your signal. This introduces a quantization error that smooths over the very transient events you rely on for a comprehensive stress test.

How Keysight True*form* waveform generators overcome this

True*form* waveform generators were engineered to eliminate this compromise. This technology plays every single point of your signal with absolute fidelity, so the signal you design is the signal you get. This ensures that every glitch and every spike is reproduced precisely, giving you a reliable signal source for a truly rigorous test of your design's robustness.

#2 Simulating a complex signal

Simulating a complex signal with a standard arbitrary waveform generator can be a frustrating process. You spend time designing a signal with many points and fast, critical transitions, only to find out that the output does not match your design. This is not a simple bandwidth issue; it is a flaw in the fundamental design of DDS-based generators. Their fixed-clock architecture forces them to approximate the waveform by skipping or repeating points. The result is a distorted output that fails to recreate the fast characteristics you need accurately. It does not even look the same from cycle to cycle.

How Keysight True*form* waveform generators overcome this

This patented technology in the waveform generators ensures every single point of your complex signal is generated exactly as you designed it. With a 1 GSa/s sample rate in the 33600A Series, True*form* gives you the precise, reliable signal you need to test your designs confidently.

#3 Running arbs at a fast frequency with the same signal from cycle to cycle

When you are running arbitrary waveforms at a fast frequency, you expect a consistent, repeatable signal; unfortunately, with traditional DDS-based arbitrary waveform generators, that is often not the case. The core limitation of DDS technology is that it can only provide an approximation of your designed signal. To meet its fixed clock rate, it unpredictably skips or repeats data points from your waveform. This fundamental flaw introduces significant problems into your test setup. It can lead to severe distortion and additional jitter, especially as you increase the frequency. But the most critical issue is the inconsistency. The distortion itself can be different from one cycle to the next, creating a non-repetitive waveform. Even worse, the nature of that distortion can change with different frequencies, making your test results unreliable and difficult to trust.

How Keysight True*form* waveform generators overcome this

True*form* waveform generators ensure that every single point of your arbitrary signal is generated exactly as you designed it. The result is a more accurate waveform with less than 1 ps of jitter and significantly less distortion than DDS. With True*form*, you get a clean, reliable, and repeatable signal source that you can count on for all your high-speed testing.

#4 Needing the best signal quality possible

When you are choosing a waveform generator, signal quality is non-negotiable for both your current and future needs. True*form* waveform generators can deliver superior signal integrity across the board. Their sine waves offer 5x better harmonic distortion than other generators. For jitter-sensitive applications, the 33600A Series provides an incredible 200x better jitter performance than DDS-based models. Furthermore, this patented technology is the only one in this class that can play every point of a custom arbitrary waveform exactly as you designed it, at any frequency, without compromise.

How Keysight True*form* waveform generators overcome this

To give you complete control, True*form* waveform generators offer three different output filters: **Normal**, **Step**, and **None**, allowing you to optimize your output for any application. With up to 120 MHz of bandwidth and 1 GSa/s sample rates, the True*form* waveform generators' performance rivals that of far more expensive Point-Per-Clock (PPC) generators, all while maintaining a competitive DDS-class price.

True*form* Versus DDS

The problem with DDS generators lies in their fixed-clock architecture. To output a waveform, they must step through the data points. If they output one unique point per clock cycle, you would be locked into a single frequency. To generate a slower frequency, the generator must repeat points, and to generate a faster frequency, it must skip them. The faster the frequency, the more points are skipped, making the output less and less like your original signal. Furthermore, DDS generators use internal algorithms that prioritize the signal's phase, meaning they don't always skip the same samples in every cycle. This can lead to distortion that changes from cycle to cycle, making your waveform unpredictable.

True*form* waveform generators use exclusive, patented technology that allows your waveforms to maintain the same shape and integrity regardless of the frequency. Whether you're working at 1 Sa/s or the maximum rate of 1 GSa/s, your signal remains consistent. This means you can reliably reproduce complex waveforms with modulation, transients, and pulses with the same characteristics every time, avoiding the cycle-to-cycle distortion common with DDS-based arbitrary waveforms.

As you can see in Figure 1, the difference between DDS and True*form* generators is clear. Both signals are set to the same frequency, but the DDS generator on Channel 1 (yellow) distorts and loses critical signal characteristics. The True*form* waveform generator on Channel 2 (green), on the other hand, accurately reproduces the signal. Notice how the True*form* signal clearly shows three distinct, small bumps, which are essential to the waveform. The DDS-based signal distorts one of those bumps and sometimes even fails to reproduce it altogether, resulting in a signal that is different from cycle to cycle.

Figure 1. Measuring two signals at the same frequency using different waveform generators.

Another key benefit of the True*form* architecture is its exceptional jitter performance. The 33600A Series specifies a cycle-to-cycle jitter of less than 1 ps across all waveforms, including arbitrary, sine, and square waves. That's about 200 times less jitter than you will find on comparable DDS-based generators.

To verify this performance, you need a highly precise instrument. Figure 2 shows a signal source analyzer, one of the few tools capable of measuring jitters at this level. The screenshot demonstrates a 40 MHz sine wave with a measured jitter of less than 800 fsec, a clear testament to the superior stability design.

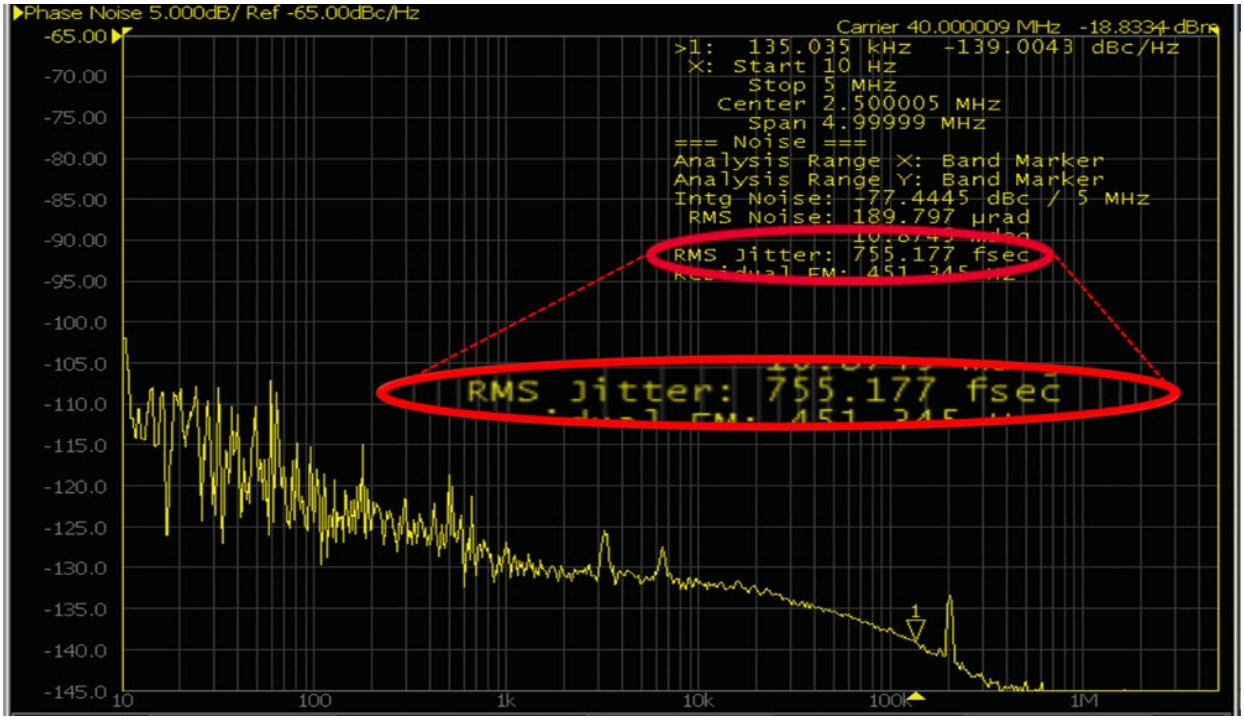

Figure 2. Signal source analyzer measurement screen.

Next, this specific arbitrary waveform (Figure 3) was created to demonstrate how DDS generators skip points visually. The test waveform is a basic square wave with seven aberrations, each with an amplitude smaller than the one before it. As you can see in Figure 3, at a low frequency of 1 kHz, both the DDS signal (yellow) and the True*form* waveform generator signal (green) reproduce all seven aberrations accurately. This establishes a baseline where both technologies perform well.

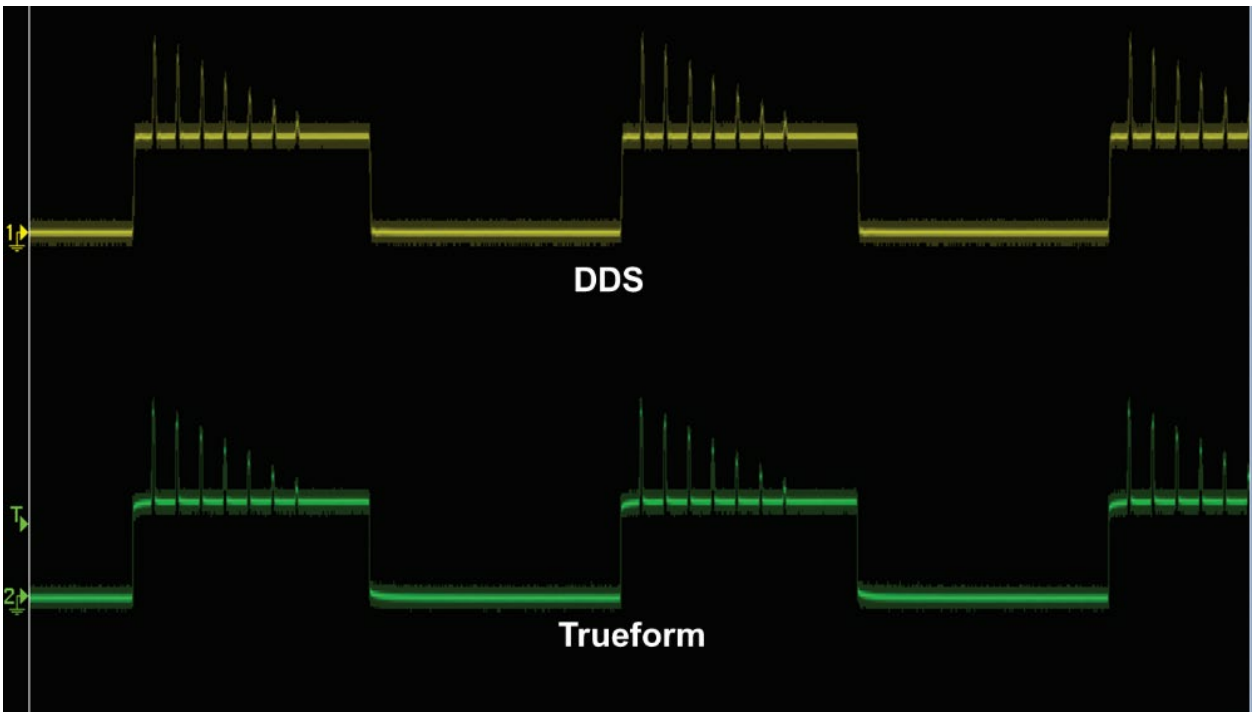

Figure 3. Same arb at 1kHz.

However, the problem becomes evident when the frequency increases. When the arb frequency is bumped to 2 MHz, the DDS signal is now missing the first three aberrations (see Figure 4), while the True*form* signal continues to generate all seven points perfectly. At even higher frequencies, the aberrations from the DDS-based generator can be played intermittently, have varying amplitudes, or disappear altogether, making the output unreliable.

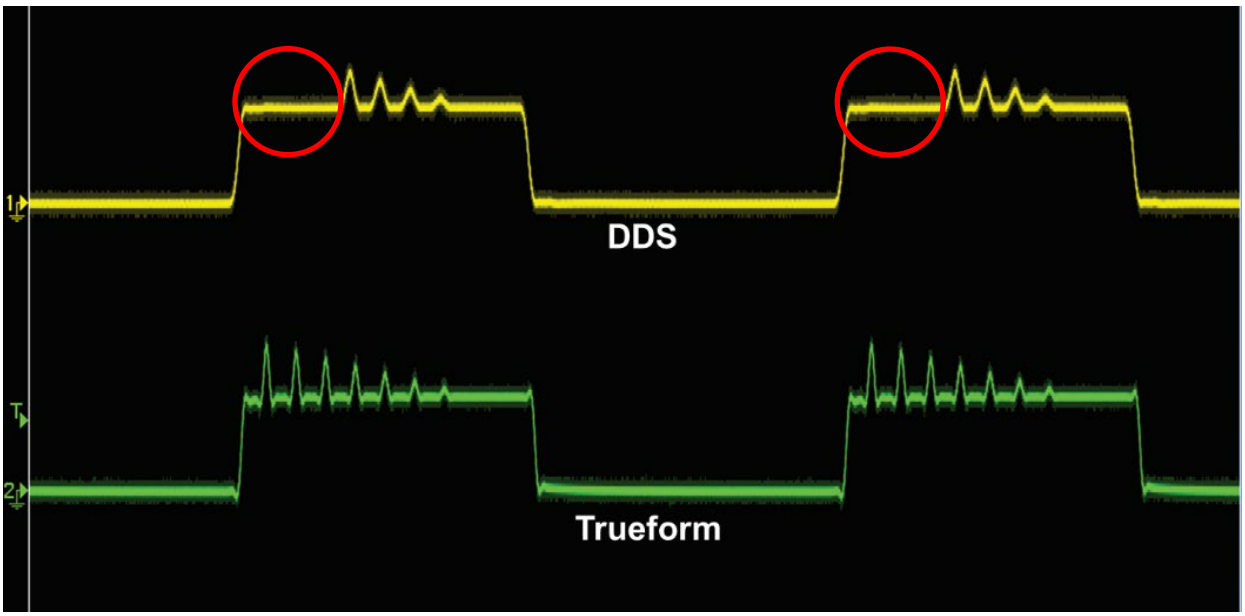

Figure 4. The DDS signal is missing the first three aberrations when the arb frequency is bumped to 2 MHz.

Measurement tips:

- Even if you are looking for a simple sine wave generator, the 33600A Series waveform generators, with their minimal distortion (< 0.03% THD), can help clean up your signals.
- The shape of the output filter can affect the arbitrary waveforms. For digital waveforms on the 33600A Series, use the “No” filter path for sharper edges. This limits your sample rate to 250 MSa/s so that the analog output hardware can keep up.
- Generating an arbitrary waveform is simpler than you might think. You have a few straightforward options to create and transfer the waveforms you need for your tests:
  - Spreadsheet: Build a custom waveform in a CSV file using spreadsheet software, then transfer it directly to your waveform generator.
  - Oscilloscope: Capture a real-world waveform from an oscilloscope and then transfer it to your generator to recreate the signal.
  - PathWave BenchVue: Use the built-in tools in Keysight's PathWave BenchVue software to design and generate your arbitrary waveforms.

Conclusion

For decades, DDS has been the go-to technology for waveform generators, offering a balance of good signal quality and affordability compared to expensive Point-Per-Clock (PPC) generators. However, DDS technology comes with inherent compromises.

Keysight set a new bar with the True*form* waveform generators. This technology improves on the very areas where DDS falls short: **superior jitter performance**, **improved signal integrity**, and the ability to **reproduce** every single point of your custom **arbitrary waveform exactly as** you **designed** it. You can get all this enhanced performance and fidelity at the same competitive price point as DDS-based generators.

How can you benefit from True*form* technology

True*form* waveform generators give industry-leading signal integrity with:

- Jitter at < 1 ps
- Plays every point as designed without having to force-fit a number of samples
- Output voltage with load settings
- None of the weaknesses of DDS (e.g., distorted signals and stretched points)
- 14-bit resolution

Keysight enables innovators to push the boundaries of engineering by quickly solving design, emulation, and test challenges to create the best product experiences. Start your innovation journey at www.keysight.com.

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