RIGOL
Beyond Measure

Uncompromised Performance with

SiFi Technology & the DG1000Z Waveform Generators

Figure 1: Rigol DG1000Z Series Waveform Generator

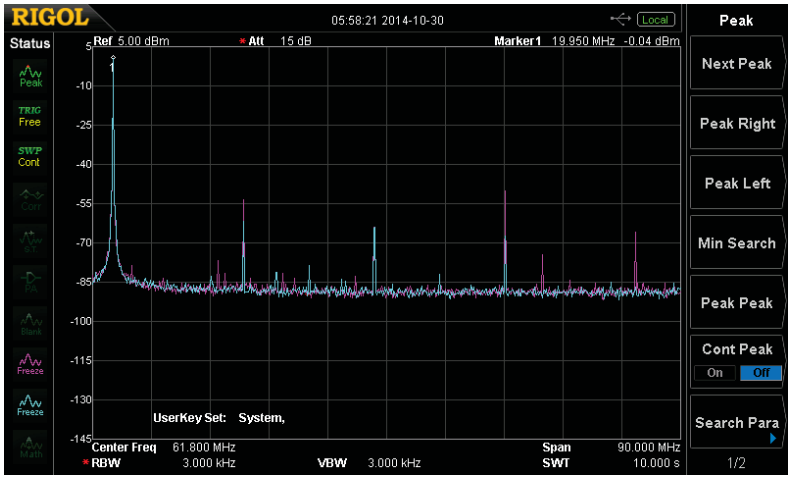

Figure 2: Spectral noise comparison between a typical DDS generator and the DG1000Z

Introduction to Waveform Generator Technology

Traditional function and arbitrary waveform generators have for many years been built on one common technology – DDS or Direct Digital Synthesis. DDS allows an instrument to create waveforms by tracking the phase of a reference clock and outputting the closest sample to the desired signal at each output sample time. DDS has enabled quality performance at a reasonable price for generations of function generators.

Today, new technologies are emerging that enable instruments to utilize both the advantages of DDS while improving signal fidelity and usability in more applications than ever before. Technologies like Keysight's TrueForm and Rigol's SiFi are designed around improving signal fidelity in waveform generators. SiFi technology was created for our latest arbitrary waveform generator family, the DG1000Z series (**Figure 1**). These instruments combine the true point to point waveform generation of arbitrary signals and redesigned output hardware to create one of the most versatile waveform generators available today. The DG1000Z series generators significantly outperform traditional DDS based generators with particular impact on the ease of generating high quality arbitrary waves.

Compared to traditional DDS instruments, Rigol's DG1000Z series arbitrary waveform generators with embedded SiFi technology create signals with higher fidelity, new capabilities like harmonic waves and deep memory, and more powerful and flexible arbitrary wave generation combining uncompromised performance with unprecedented value.

Improving Signal Fidelity

There are a number of ways to measure signal fidelity. The key attributes of a generated arbitrary signal which are most critical for engineers can be thought of as aspects of repeatability, accuracy, and noise. **Figure 2** shows the noise on a 20 MHz sine wave looking at the harmonics on a spectrum analyzer. The purple trace shows the peaks from a traditional DDS generator while the blue trace shows the noise on a similar signal from a DG1000Z generator with SiFi. Overall, the DG1000Z boasts a Total Harmonic Distortion spec of less than half the traditional DDS generator. THD is a measure of both noise and accuracy of a generator.

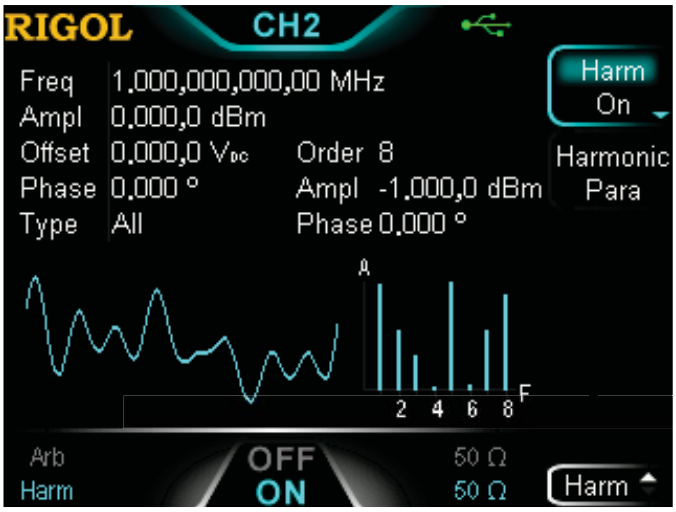

Figure 3: DG1000Z Harmonic Wave Definition from the instrument front panel

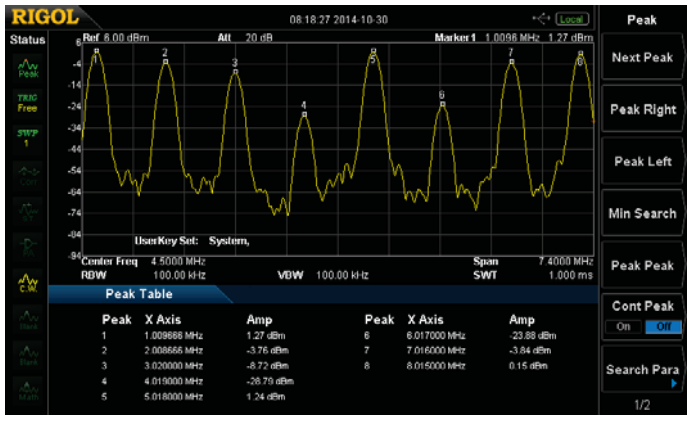

Figure 4: Harmonic Wave Spectrum Analyzer measurement

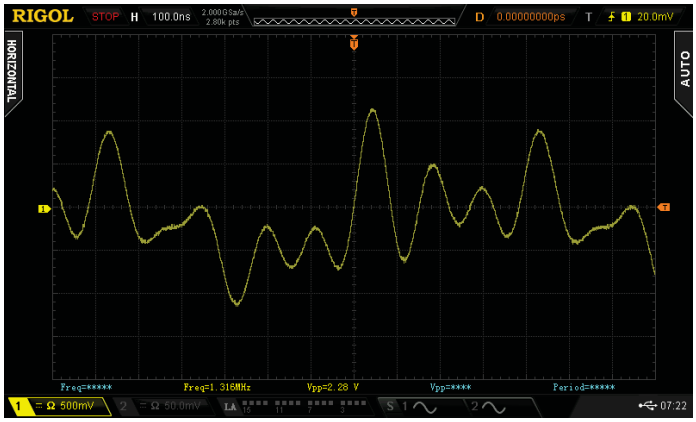

Figure 5: Harmonic Wave Oscilloscope measurement

Jitter is the specification that speaks best to repeatability. Here, the DG1000Z shows a similar 2.5 X improvement over the traditional DDS generator. When discussing signal quality for arbitrary waves SiFi makes an even more significant contribution. While DDS selects the nearest output value from the arbitrary wave to put out at every point, SiFi alters the output time so that the wave is sampled more precisely.

Assume, for example, we have a 100,000 point arb. We'd like to output it at 500 Hz. We use the equation:

arb length * arb freq = output rate

Therefore, we set the output rate to 50 MSa/s.

By matching the arb wave length and the output rate to the output frequency we are always outputting the exact arb value for that point in time. Whereas, with a DDS generator the output rate is fixed and the output will always select the closest value in time, but with no guarantees how close that value will be in voltage to the actual voltage desired at that point. Some of these artifacts are hidden by the analog bandwidth and rise time limitations of the instrument when viewed with an oscilloscope. That is one of the reasons we use measurements of spectral purity like THD to understand the accuracy of a signal.

Signal fidelity is critical to design engineers using waveform generators in their testing. Using a generator with SiFi technology improves the accuracy of waveforms you reproduce by allowing the engineer maximum flexibility in setting the output rate of their arbitrary waveform.

Enabling more functions and waveform type

Improved signal fidelity is great, but signal quality alone doesn't make a great technology or a great instrument. Rigol's SiFi technology enables the DG1000Z generators to create more waveforms including harmonic waves where the engineer describes the phase and amplitude of each harmonic element of the starting frequency. **Figure 3** shows how an engineer can define a harmonic wave from the instrument's front panel. Harmonic waves let the engineer set amplitude and phase values for the fundamental frequency up through the 8th harmonic on a DG1000Z. Traditionally, engineers who need signals more easily defined in RF space they would have to define each wave and sum them together into an arbitrary wave. Harmonic waves are much easier to create. Simply define the power and phase at each frequency at a multiple of the fundamental and the instrument automatically combines them and plays them back. **Figure 4** shows the matching spectrum to the signal defined in figure 3. **Figure 5** is the same wave captured on a scope. This in the arbitrary data a user would have to create,

Figure 6: UltraStation Freehand waveform editing software

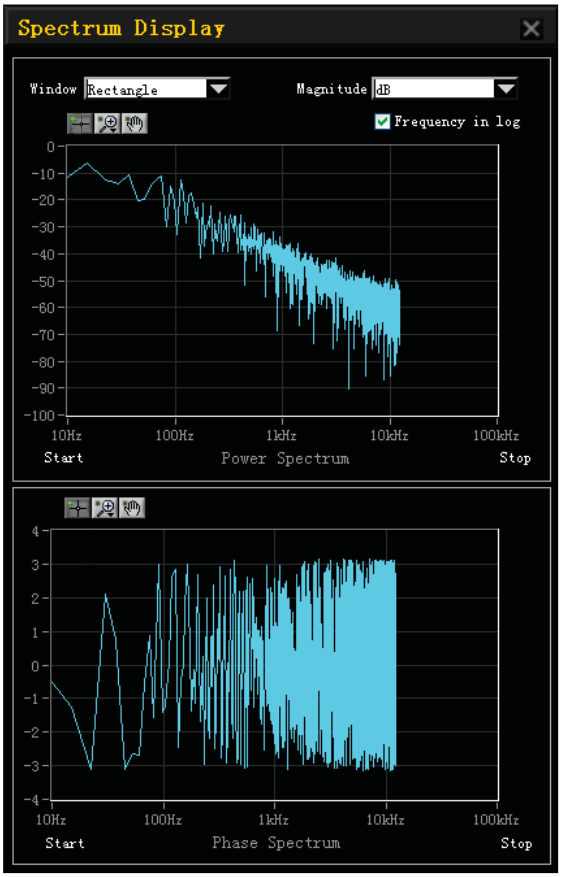

Figure 7: Arbitrary waveform spectrum view in UltraStation software

load, and configure on a traditional generator to get the same signal they can now quickly build from the front panel. With these new capabilities empowered by SiFi technology, the Rigol DG1000Z series waveform generators add significant power and flexibility to the engineer's bench.

Developing Powerful and Flexible Deep Memory Arbitrary Waveforms

The key technological advance of SiFi is the ability to deliver true point to point arbitrary waves. Without this capability arbitrary waves become notoriously difficult to generate accurately and require additional behind the scenes work by engineers slightly adjusting sampling and points to improve the overall signal fidelity. This task becomes considerably more difficult when using deep memory arbs that contain millions of points. The DG1000Zs best in class deep memory capability is important to the instrument's flexibility and value. Combined with the SiFi technology, engineers can create longer, precision arbitrary waveforms. In the adjustable sample rate mode users can define a signal that will be output at up to 60 MSa/sec. With an optional 16 Million points of memory depth it is then possible to create completely custom point to point waveforms up to 250 milliseconds in length while still maintaining the full output sample rate. The traditional difficulty with working with such long waveforms is they are a challenge to edit. For instance, Microsoft Excel 2013 only allows just over 1 million rows of data. Using a DDS generator, to make a slight change to the playback period you need to either resample the wave or deal with artifacts created by the DDS phase based sample selections. With SiFi technology, you can leave the precise waveform as sampled and simply adjust the output sample rate. This saves the considerable time and effort of editing and reloading long waveforms to the instrument.

While SiFi makes arbitrary waves easier to manipulate and more flexible once they are created, users still need a reliable method of generating, editing, and loading long waveforms to their instrument the first time. The DG1000Z series generators come with UltraStation software for waveform editing. UltraStation enables importing, combining, and freehand editing of deep memory waves. Files can be saved as TXT, CSV, or RAF. RAF files can be saved onto a USB stick and then loaded to the instrument or waves can be sent directly to the instrument over LXI or USB. **Figure 6** shows the freehand editing tool in UltraStation. In addition to the time domain, UltraStation has a spectrum view to see the power and phase of the signal you created as shown in **Figure 7**. Additional advanced filtering tools are available as part of UltraStation Advanced. Everything shown here is included in

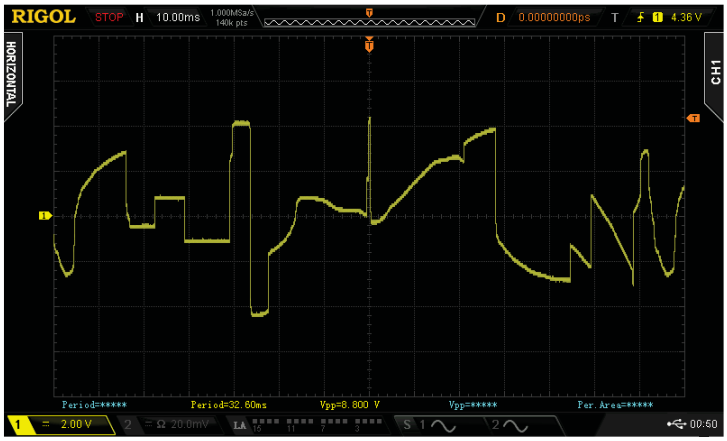

Figure 8: Custom deep memory arbitrary wave shown on an oscilloscope

the free version of UltraStation that is included. UltraStation Advanced is available as an option. The 8 million point wave we generated in the software is shown on an oscilloscope being reproduced at the maximum 60 MSa/second in **Figure 8**. The combination of deep memory and SiFi technology empowers engineers to reproduce more flexible, more precise waveforms than traditional DDS technology alone.

Unprecedented Value

Rigol's SiFi technology and the DG1000Z series waveform generators allow engineers to cover more signal reproduction applications than ever before with improved signal fidelity, flexibility, and ease of use. The deep memory capabilities and hardware design of the instruments work together with SiFi sampling technology to make these improvements possible and deliver unprecedented value to the engineer's bench.