

MEASUREMENT TIPS

Volume 10, Number 5

Waveform Capture and Playback Made Easy



Introduction

A good way to test your designs under worst-case conditions is to capture a known good waveform on a scope, download it into an arbitrary waveform generator (arb) and then modify various signal parameters to emulate worst-case input conditions. Now there is an easy way to accomplish this task. When you use recently introduced Agilent instruments, the only equipment required is a scope, a generator and a USB memory stick. In the past, you also needed a PC and special waveform editing software.

In this application brief, we show an example of capturing and storing 10 bytes of known good RS232/UART transmit serial bus signals using an Agilent 3000 X-Series oscilloscope. We download the stored waveform data into an Agilent 33522A function/arbitrary waveform generator for replay. We show how you can easily modify the signal's baud rate and amplitude and add random noise to the signal, so you can test your designs under worst-case input conditions.

You can apply the techniques presented in this application brief to test for worst-case conditions using virtually any kind of analog or digital signals that may be present in your designs, not just serial bus signals.



Agilent Technologies

Capturing a “Golden” Waveform on the Oscilloscope

Begin by setting up the scope’s vertical and horizontal scaling to “window” the portion of the waveform you want to capture and store. In this case, we have set the scope’s timebase to 1.000 ms/div to capture 10 bytes of 19.2 kbps RS232/UART serial bus traffic, as shown by the time-correlated decode trace below the waveform in **Figure 1**.

We are capturing serial bus traffic that comes in bursts, so it is fairly easy to establish the beginning and end of the waveform during signal idle time. However, if you were attempting to capture and store one period of a repetitive analog waveform without any signal idle time, you would need to carefully “window” the scope’s timebase (sec/div and delay) to capture exactly one period of the signal — no more, no less. Otherwise your waveform will have a discontinuity when you import it and replay it repetitively on the arbitrary waveform generator. Agilent’s InfiniiVision Series oscilloscopes have a continuously variable timebase setting (fine adjust), so adjusting the horizontal scaling to capture exactly one period is relatively easy. Note that not all scopes have continuously variable timebase settings

After “windowing” on the portion of the waveform you want to capture, select the **Save/Recall** menu to save this waveform to your USB memory device. Within the Save menu you will see that you have the ability to save various types of files including images (bit maps), setups, pass/fail masks, and several types of waveform files. To import this waveform into the Agilent 33500 Series arbitrary waveform generator, we need to save it as an “ASCII XY data (.csv)” file. But before saving the waveform data, we must first decide how many points we want to save. Agilent’s 3000 X-Series scopes have up to 4M points of acquisition memory. But it may not be necessary — and it may be terribly inefficient — to save this many points.

Since the baud rate of our signal is 19.2 kbps, and our “windowed” time span covers just 10 ms (1.0 ms/div x 10 divisions), saving just 10,000 points will provide us with sufficient resolution to accurately reproduce this waveform. 10,000 points over a 10 ms time span will provide us with an effective/decimated sample rate of 1 MSa/s.

Once we have selected the proper file type (ASCII XY, .csv) and the desired the number of points to store (10,000 in this example), we save the waveform data to our USB memory device. This saved waveform data can now be imported into various software packages including Microsoft® Excel spreadsheets, MATLAB, and numerous other waveform processing/editing applications. But most importantly, we can import this waveform data directly into the Agilent 33500 Series function/arbitrary waveform generator — without using a PC.

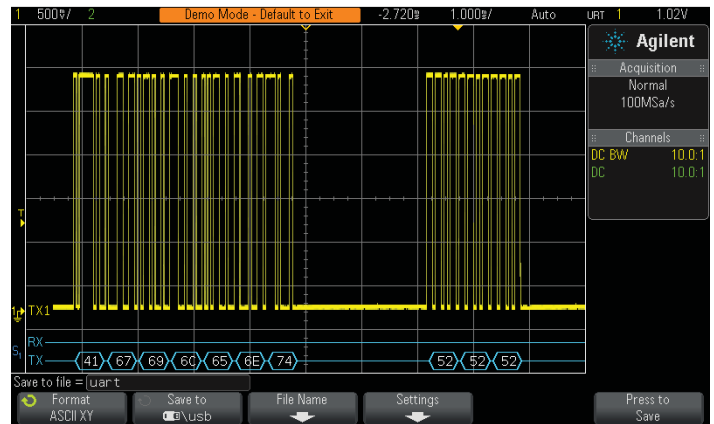


FIGURE 1. “Windowing” on the desired waveform to capture and store it

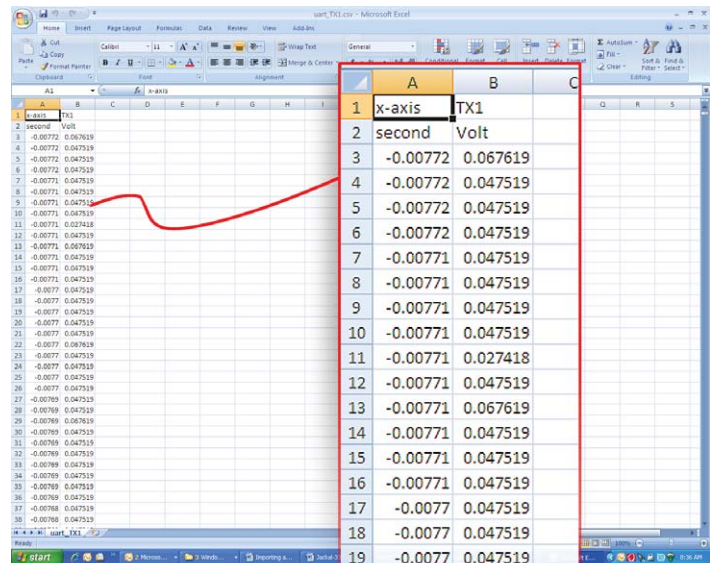


FIGURE 2. Saved waveform data imported into an Excel spreadsheet

Downloading the “Golden” Waveform into the Arb

To import the saved waveform into the Agilent 33520 Series function/arbitrary waveform generator, begin by transferring your USB memory device from the scope to the arb. Next, select the **Waveforms** front-panel key; then select the **Arb** menu key. Within this menu you can quickly navigate to the saved .csv waveform file to be imported.

When you instruct the arb to import the selected CSV file, it will initially analyze data in the file for valid formatting. When it is finished, press the **Import Data** menu key to complete the importation of the waveform data into the arb’s non-volatile memory. When importing has been completed, the arb will display this message: “File imported successfully as CSV_NAME.arb.” Now press the **Done** menu key.

Now that the oscilloscope waveform has been successfully imported and stored into the arb’s waveform memory, we can replay it continuously. To do this, press **Select Arb** and navigate to the .arb file where it was stored; then press **Select**.

Remember that the stored waveform consisted of 10,000 points that covered a time-span of 10 ms; this provided an effective/decimated oscilloscope sample rate of 1 MSa/s. The 33522A will take the time data from the CSV file and automatically set the sample rate of the arb to match it (in this example 1 MSa/s). Now simply turn on channel-1’s output and see the reproduced waveform. It should look similar to the originally captured waveform shown in Figure 1.

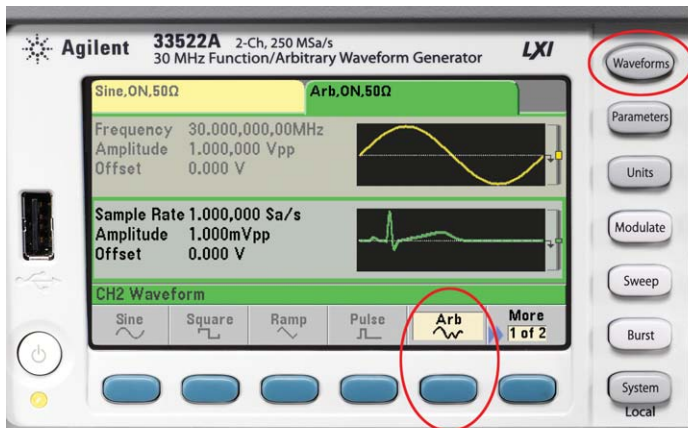


FIGURE 3. Agilent 33522A Arb menu

Modifying the Baud Rate and Amplitude and Adding Noise

Now that we’ve reproduced the original “golden” waveform, we can easily modify it in order to test for worst-case input conditions. Let’s assume that you know that your receiver responds correctly to the signal conditions of the “golden” waveform running at 19.2 kbps and with normal signal amplitudes and minimum noise. But what if you wanted to test your system running at a much faster baud rate (1.3824 Mbps), and perhaps with minimum specified signal amplitude and additional noise?

Let’s first change the baud rate of this RS232/UART signal to 1.3824 Mbps. Remember that the original baud rate was 19.2 kbps. Since 1.3824 Mbps is 72 times faster than 19.2 kbps, we should change the arb’s sample rate to 72.0 MSa/s (1 MSa/s x 72).

Changing the signal’s amplitude to emulate worst-case minimum input signal levels is also very easy by simply changing the amplitude and offset in the **Parameters** menu. To perform more advanced waveform editing of the signal use the 33522A’s built-in Waveform Editor. The built-in Waveform Editor can be accessed under the **Arb** menu.

You can add random noise to the signal using the **Modulation** menu on the 33522A. Additive noise can be created using the Sum modulation feature, while noise in the form of jitter can be created using the PM modulation feature. In either case, the bandwidth of modulation noise can be set from 0.10 MHz to 30 MHz.

Figure 4 shows an example of the modified test signal now running at 1.3824 Mbps with minimum signal amplitude and with additional random noise. As you can see, the scope is showing multiple decoding errors under these modified worst-case input signal conditions.

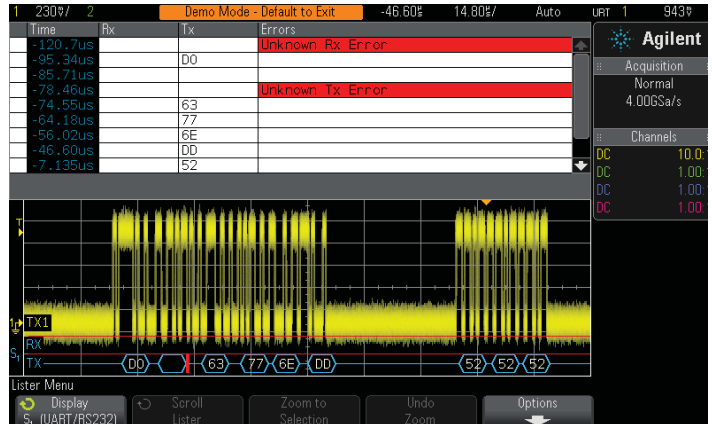


FIGURE 4. Modified test signal running at a higher baud rate, reduced signal amplitude and with added noise that causes system errors

Continued on back cover



Summary

The combination of Agilent's 3000 X-Series oscilloscope and Agilent's 3350 Series function/arbitrary waveform generator can be a very valuable tool set to help you test designs under worst-case signal conditions. And transferring captured waveforms from the scope to the generator, as well as modifying signal characteristics, couldn't be any easier.

This measurement tip focused on the Agilent 3350 Series function/arbitrary waveform generators. For other Agilent function generators, such as the 33200 Series, the free IntuiLink waveform editing software is available to run on your PC.

www.agilent.com

For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

www.agilent.com/find/contactus



Learn more about Agilent 3350 Series function/arbitrary waveform generators and 3000 X-Series oscilloscopes at

www.agilent.com/find/functiongenerators

www.agilent.com/find/morescope



Microsoft is a registered trademark of Microsoft Corporation in the United States and/or other countries.

Product specifications and descriptions in this document subject to change without notice.

© Agilent Technologies, Inc. 2011
Printed in USA, June 1, 2011
5990-8167EN



Agilent Technologies