The Memory Depth of a USB Modular Oscilloscope

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Introduction

Selecting the right oscilloscope to carry out your daily work is an important task. As you start the selection process, you probably will compare the specifications and features of various oscilloscopes. The first few things that you will need to look into are the bandwidth range of the oscilloscope, the sampling rate speed, the number of channels supported, and of course, the price as well as the accessories that is bundled along. However, a specification that you should not overlook is the memory depth of the oscilloscope.

In this application note, you will discover how a deep memory provides numerous advantages to benefit you in your measurement. Towards the end of this document, you will also learn how to use the bundled software that comes with every purchase of the Agilent U270xA — the Agilent Measurement Manager (AMM) — to transfer data points captured in the U270xA oscilloscope memory into your computer and to make a conversion program of your choice to translate the data points into actual amplitude values for post processing and analysis.

Why is memory depth important?

To understand the importance of memory depth in an oscilloscope, we must first examine how the sampling rate affects the operation of an oscilloscope. A high sampling rate is an important advantage for every oscilloscope. However, the sampling rate specification stated in its data sheet will only show you the maximum achievable sampling rate of the oscilloscope. You will notice that the sampling rate starts to drop when you increase the oscilloscope time base setting above a certain duration. In other words, the sampling rate will not constantly stay at the maximum value (as published in its data sheet) throughout the time base range of the oscilloscope.

It is important that you notice that the sampling rate is reduced as the time base[1] setting is increased. The sampling rate is reduced to size the number of points accordingly so the points can be stored in the oscilloscope's memory. In an oscilloscope with a deeper

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[1] *Time base refers to the record length of an oscilloscope by multiplying the volt/div setting and the number of horizontal division available.*

memory, the number of points that can be stored is higher. Therefore, we can say that the deeper the oscilloscope memory, the longer the time span of the maximum achievable sampling rate — allowing more data points to be viewed.

Sampling rate specification in digital oscilloscopes

In digital oscilloscopes, the sampling rate indicates how many samples per second the ADC can acquire. The maximum sampling rate is usually given in units of megasamples per second (MSa/s). The faster the oscilloscope can sample, the more accurate it can represent the fine details in a fast signal. The minimum sample rate may also be important if you need to look at the slowly changing signals over a long period of time. Typically, the sample rate changes with the changes made to the sec/div control to maintain a constant number of waveform points in the waveform record.

Comparing memory depth size

Figure 1 shows a comparison graph between two oscilloscopes that has the same sampling rate stated in their respective data sheet. However, they have different memory depth specifications. The Agilent U270xA Modular Oscilloscope has up to 64 Mpts of memory depth while Oscilloscope B has 125 kpts of memory depth.

The record length of a digital oscilloscope indicates how many waveform points the oscilloscope is able to acquire for one waveform record. Some digital oscilloscopes allows you adjust the record length, while others fixed the length based on the sampling rate and the time per division values. The maximum record length is dependant on the amount of memory in the oscilloscope.

Every oscilloscope can only store a finite number of waveform points and that depends on the memory size that is on board — resulting in a trade-off between the waveform details and the record length.
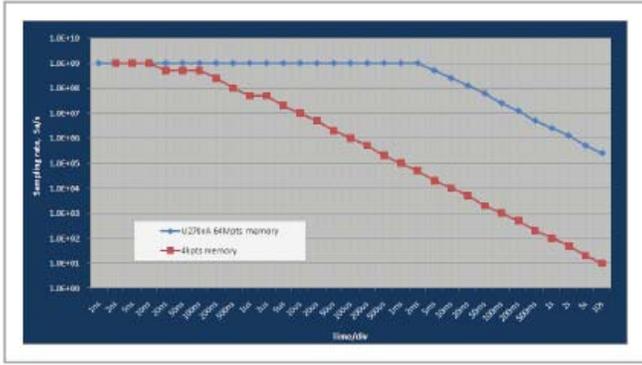
Figure 1. Comparison Chart

The difference in the memory depth size resulted in two major effects: the U270xA is able to maintain its highest sampling rate over a much broader range of time base setting as compared to a 4 kpts memory oscilloscope, and in the case of where an even broader time base is set, the U270xA is able to minimize the extend of the sampling rate reduction. For example, at 100 ms/div, a 4 kpts memory oscilloscope can only sample at 100 kSa/s, while the U270xA can sample at 25 MSa/s. This translates into a 250 fold improvement — a significant result that is hard to ignore.

You have learn numerous advantages of having a larger memory oscilloscope. Now, let's look at how you could retrieve the data captured from the U270xA oscilloscope to your computer for post processing and to perform further analysis.

> **memory depth = sampling rate x time base**

Extracting and Converting Your Data

With the AMM (version 1.8.5 and above) or the U270xA IVI driver (version 1.3 and above), you can retrieve all the data points that the U270xA oscilloscope has captured. The data points captured in the U270xA oscilloscope memory is in the form of the binary file format (*.bin).

There are three easy steps involved to manipulate the binary data to actual magnitude: **Transfer**, **Convert**, and **Calculate**.
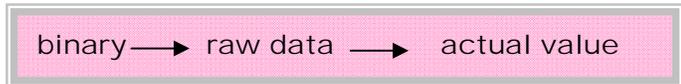
> **binary ⟶ raw data ⟶ actual value**

Figure 2. Data conversion flow

Step 1: Transfer the data points from the oscilloscope memory to your computer

Retrieving data points from the U270xA oscilloscope is easy with the AMM. After the waveform is displayed on the AMM panel, go to **File** > **Oscilloscope** > **Save Full**

Waveform on the menu bar of the AMM to transfer the data points captured to your computer.
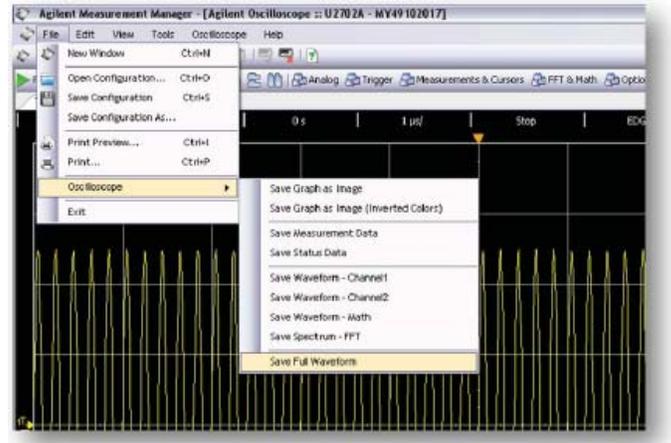

Figure 3. Get the data from your oscilloscope through the AMM

If you are creating a program to control the U270xA oscilloscope, the data points captured in the U270xA memory can be transferred to your computer by sending the *Measurements. Item. Read Full waveform* command. Both methods above transfers the binary data captured in the U270xA to your computer and saves it as a .bin file.

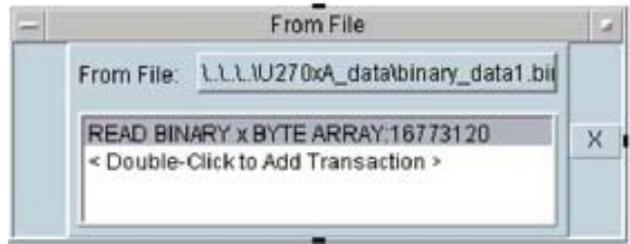### Step 2: Convert the binary data to raw data in ASCII

Figure 4. Converting binary data into bytes using the Agilent VEE Pro software

The VEE object on the left, for example, will access the binary file at its designated location and convert the binary data into a byte array with a 16,773,120 data size. Another way of converting the binary data into raw data (in ASCII format) is by using .NET codes. You can use *System. IO .File. Read All Bytes* method to perform the conversion.

> **[Raw data x ((vertical scale)/32) - (4 x vertical scale) + offset} x probe attenuation**

Step 3: Calculate the actual amplitude values from the raw data. This step can be done using a simple formula as shown below along with several oscilloscopes settings when the binary data is stored. The oscilloscope settings required in this calculation are vertical scale (volt/div), offset value, and probe attenuation.

The vertical scale used in the formula above can be replaced with the *channels. item. range* property in the IVI property if you are creating your program using the AgilentU2701A IVI Driver Release (version 1.3.0.0 and above). *Range* is a property in the IVI standard to describe the absolute value of the input range that an oscilloscope can acquire. The unit used is volts. For example, if your signal is spanning from –2 V to 2 V, set your U270xA oscilloscope range to 4 V or higher.

The U270xA has 8 vertical divisions, and hence the above formula can be rewritten by replacing the vertical scale with range, which could be obtained through programming.

$$[\text{ Raw data} \times ((\text{range})/256)- ((\text{range})/2)+ \text{offset}] \times \text{probe attenuation}$$

The value of the probe attenuation can be set or acquired through the *channels. item. probe attenuation* property. For more details on how to program your U270xA oscilloscope, refer to the USB Modular Scopes Programmer's Reference at www.agilent.com/find/scopeiviguide. A sample program is available under Drivers and Software tab in the U270xA product page.

Conclusion

As you have read in this application note, the memory depth specification is equally important as other oscilloscope specifications. A larger memory oscilloscope does not just offer more space in storing acquired data, but also lengthens the time base of the highest achievable sampling rate of an oscilloscope. Couple with the latest AMM and U270xA IVI driver, now you can retrieve the full 64 Mpts of data captured by the U270xA oscilloscope. By using the conversion method shown above, you can be assured of your measurement without missing out something.

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