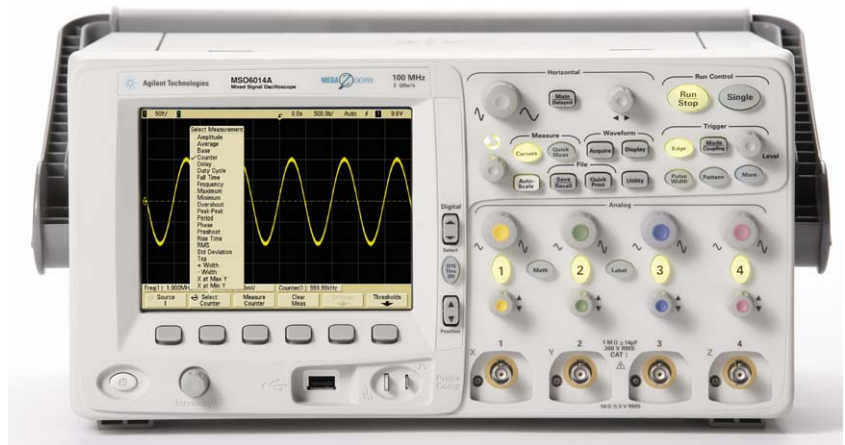


# Making High-Resolution Frequency Measurements with Agilent 6000 Series Oscilloscopes

Application Note 1581



Oscilloscope users often need to make higher-resolution frequency measurements than their conventional oscilloscope is designed to handle. Most digital oscilloscopes available today are capable of making only about 4-digit frequency measurements. If you need to make higher-resolution frequency measurements, you can use a universal frequency counter such as the Agilent Technologies

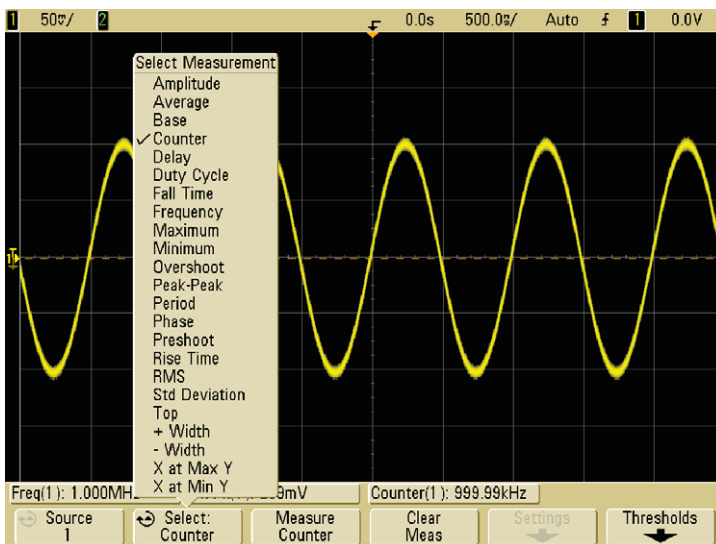
53131A. Frequency counters can make much more accurate frequency measurements with frequency resolution typically up to 12 digits, and they offer a complete set of test and analysis features. In this application note, we examine an alternative to making frequency measurement with up to 8 digits of resolution using the built-in counter function on the 6000 Series oscilloscopes.



### Standard 5-digit resolution

The Agilent 6000 Series oscilloscopes come with an internal hardware counter to accommodate accurate, high-resolution frequency measurements. The scope counter measurement provides 5 digits of resolution, which gives you approximately 5 digits of accuracy. This feature allows you to make much more accurate frequency measurements on signals. Five digits is one part in one hundred thousand, or about 0.001% of the displayed number. Relative to the standard frequency measurement of the

oscilloscope based on the delta time measurement of the digitized waveform samples, the counter measurement accuracy is much less dependent on the time base settings and the sample rate of the on-screen measurement. The frequency measurement is most accurate when one cycle occupies the whole screen. The scope's counter measurement itself is designed to be very easy to use. It uses the trigger level of the scope as the trigger level for the counter. The measurement is invoked and displayed like any other oscilloscope measurement.



**Figure 1. Agilent 6000 Series oscilloscopes come with an internal 5-digit hardware counter to accommodate accurate, high-resolution frequency measurements.**

### Up to 8 digit resolution with external time base

If you use an external 10-MHz reference, the counter is as accurate as the externally fed 10-MHz signal, and the measurement resolution is increased. The 10-MHz REF BNC connector on the rear panel is provided so you can supply a more accurate clock signal to the scope.

To drive the scope's time base from an external clock reference, connect a 10-MHz square or sine wave reference signal to the 10-MHz REF BNC input on the rear panel and go to the **Utility > Options > Rear Panel** menu and select **Ref signal mode to 10 MHz input**. The working 10-MHz input voltage is 180 mV to 1 V in amplitude, with a 0-V to 2-V offset. To get the highest resolution, the time/div setting should be at 200 mS/div or slower. With this setting, the resolution is increased to up to 8 digits, which is what would be displayed if you used an external 10-MHz reference. When the internal reference is used (Ref signal mode is set to off), the scope displays counter measurement in 5 digits. The counter measurements can measure frequencies up to the bandwidth of the scope. The minimum frequency supported is 1/(2x gate time).

The Agilent 33250A function/arbitrary waveform generator has more accurate 3 ppm time base output. So any



**Figure 2.** If an external 10-MHz reference is used, the counter is as accurate as the externally fed 10-MHz signal and the measurement resolution is increased to up to 8 digits.

test set up or bench with both a 33250A and a 6000 Series scope can get much improved counter measurements from the scope if the time base is supplied by the function generator. Also, the scope time base is then exactly matched to the stimulus, so you can delay out 1,000 cycles of an arbitrary waveform and be sure you are in the right place.

### Accuracy

Basically, the counter measurement with the 6000 Series oscilloscope is as accurate as the time base reference that is used. The 6000 Series oscilloscope's time base uses a built-in 10-MHz reference that has an accuracy of 15 ppm or

0.0015%. This means that the number we display is within 0.0015% of the actual number. If you are measuring a 66,667-Hz signal using the scope's counter measurement, you are measuring the signal with approximately 1 Hz accuracy.

$$66,667 \text{ Hz} \times 15 \text{ ppm} (0.0015\%) = \pm 1.000005 \text{ Hz}$$

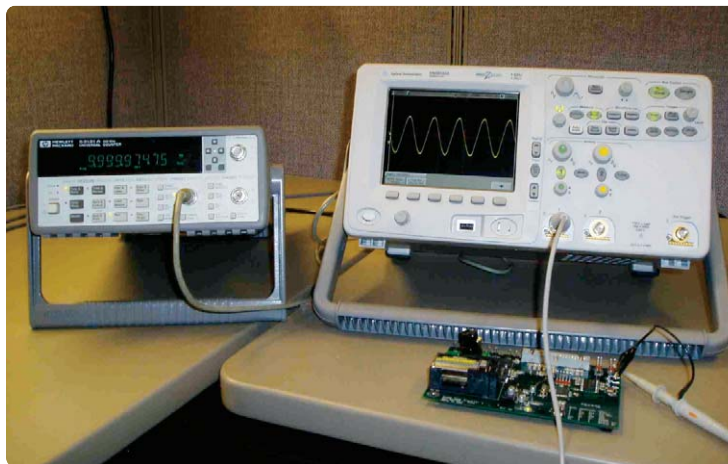
If you use the 33250A function/arbitrary waveform generator reference (3 ppm), the measurement accuracy is increased.

$$66,667 \times 3 \text{ ppm} (0.0003\%) = \pm 0.200001 \text{ Hz}$$

### Driving an external frequency counter

To make even more accurate frequency measurements, you can make a coordinated frequency measurement with the 6000 Series oscilloscope and an external frequency counter. You can select either Source Frequency or Source Frequency/8\* to be output at the trigger out BNC connector on the rear panel of the oscilloscope. In this mode, the trigger out BNC is connected to the output of the trigger comparator. In other words, the comparator output of input signals is present at the trigger out terminal, so you can connect the trigger out of the scope and the input of an external frequency counter to make higher accuracy/resolution frequency measurements on the counter while the signal waveform is monitored on the scope. This is a particularly useful application when it comes to making crystal oscillator frequency measurements in the manufacturing test environment.

\* Source Frequency/8 mode is available on the 6000 Series 300-MHz to 1-GHz scope models.



**Figure 3.** To make even more accurate frequency measurement, you can make a coordinated frequency measurement with the 6000 Series oscilloscope and an external frequency counter.

### Conclusion

For frequency measurements with increased resolution on the Agilent 6000 Series oscilloscopes, try using a built-in 5-digit hardware counter measurement. The counter resolution can be increased up to 8 digits with an external 10-MHz reference.

### Related Literature

Publication Title	Publication Type	Publication Number
<i>Agilent 6000 Series Oscilloscopes</i>	Data Sheet	5989-2000EN/EUS
<i>Agilent 6000 Series and 54600 Series Oscilloscope Probes and Accessories</i>	Data Sheet	5968-8153EN/EUS

### Agilent Technologies' Test and Measurement Support, Services, and Assistance

Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Two concepts underlie Agilent's overall support policy: "Our Promise" and "Your Advantage."

#### Our Promise

Our Promise means your Agilent test and measurement equipment will meet its advertised performance and functionality. When you are choosing new equipment, we will help you with product information, including realistic performance specifications and practical recommendations from experienced test engineers. When you receive your new Agilent equipment, we can help verify that it works properly and help with initial product operation.

#### Your Advantage

Your Advantage means that Agilent offers a wide range of additional expert test and measurement services, which you can purchase according to your unique technical and business needs. Solve problems efficiently and gain a competitive edge by contracting with us for calibration, extra-cost upgrades, out-of-warranty repairs, and on-site education and training, as well as design, system integration, project management, and other professional engineering services. Experienced Agilent engineers and technicians worldwide can help you maximize your productivity, optimize the return on investment of your Agilent instruments and systems, and obtain dependable measurement accuracy for the life of those products.

### Agilent Open

[www.agilent.com/find/open](http://www.agilent.com/find/open)

Agilent Open simplifies the process of connecting and programming test systems to help engineers design, validate and manufacture electronic products. Agilent offers open connectivity for a broad range of system-ready instruments, open industry software, PC-standard I/O and global support, which are combined to more easily integrate test system development.

### Agilent Email Updates

[www.agilent.com/find/emailupdates](http://www.agilent.com/find/emailupdates)

Get the latest information on the products and applications you select.

### Agilent Direct

[www.agilent.com/find/agilentdirect](http://www.agilent.com/find/agilentdirect)

Quickly choose and use your test equipment solutions with confidence.

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](http://www.agilent.com/find/contactus)

#### Phone or Fax

##### United States:

(tel) 800 829 4444  
(fax) 800 829 4433

##### Canada:

(tel) 877 894 4414  
(fax) 800 746 4866

##### China:

(tel) 800 810 0189  
(fax) 800 820 2816

##### Europe:

(tel) 31 20 547 2111

##### Japan:

(tel) (81) 426 56 7832  
(fax) (81) 426 56 7840

##### Korea:

(tel) (080) 769 0800  
(fax) (080) 769 0900

##### Latin America:

(tel) (305) 269 7500

##### Taiwan:

(tel) 0800 047 866  
(fax) 0800 286 331

##### Other Asia Pacific Countries:

(tel) (65) 6375 8100  
(fax) (65) 6755 0042

Email: [tm\\_ap@agilent.com](mailto:tm_ap@agilent.com)

Contacts revised: 05/27/05

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

© Agilent Technologies, Inc. 2006

Printed in USA, August 1, 2006

5989-5526EN

