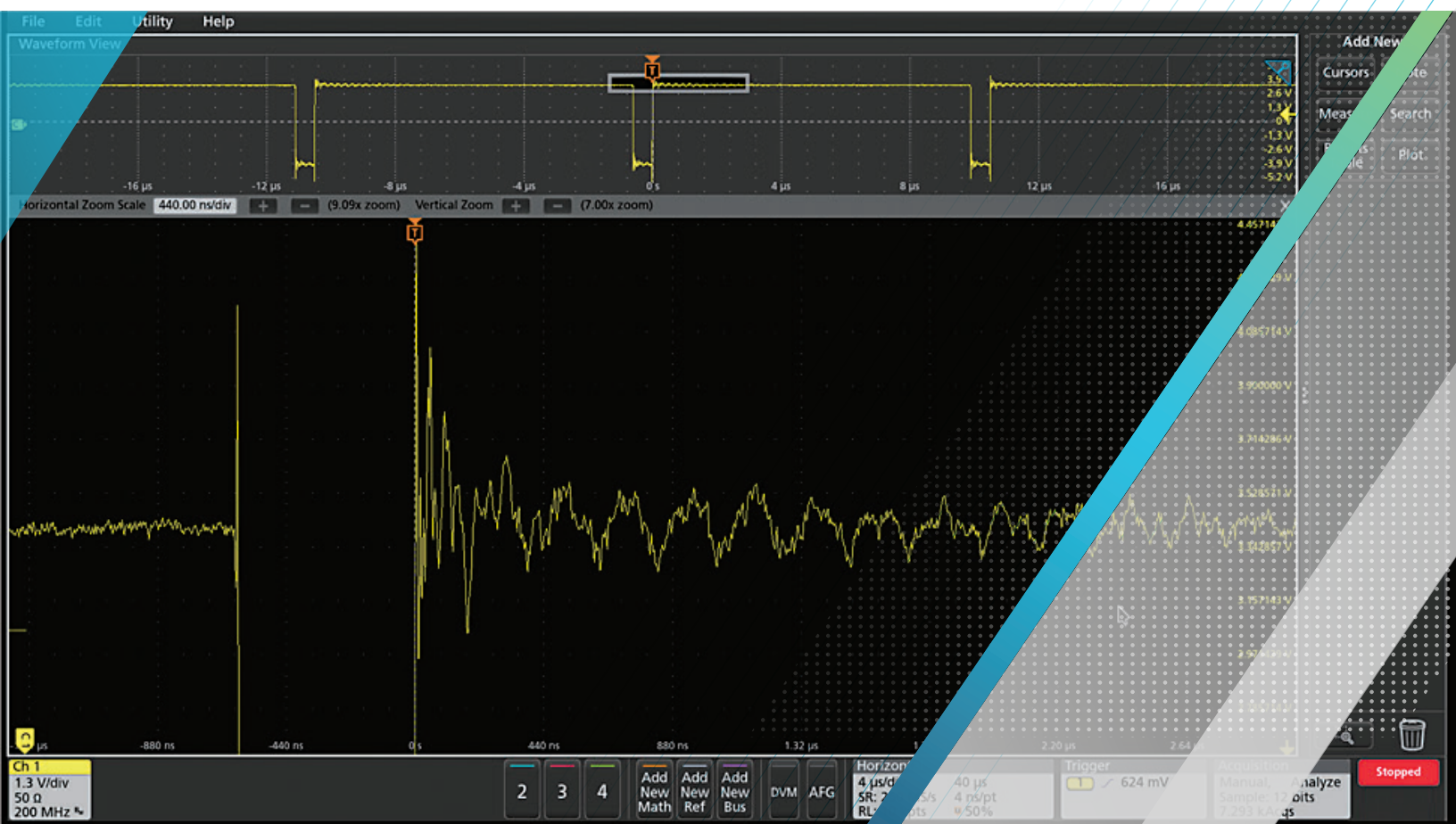


# Making Higher Accuracy Oscilloscope Measurements

12-bit analog-to-digital converters deliver higher resolution on the 4, 5 and 6 Series MSO oscilloscopes

## TECHNICAL BRIEF



## Introduction

One of the most important functional blocks in a digital oscilloscope is the analog-to-digital converter or ADC. This technical brief explains why ADC resolution (number of bits) has become a more important consideration in oscilloscopes, especially for measuring small signal details.

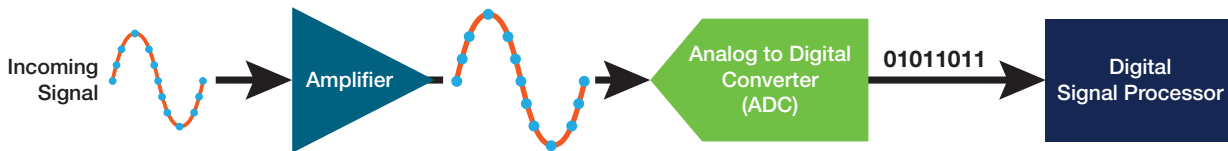


FIGURE 1. A generalized signal flow through a digital oscilloscope.

Many high-precision instruments use high numbers of bits in their ADC's. For example, a precision digital multimeter (DMM) like the Keithley 2002 can make measurements with up to 28 bits. So why has oscilloscope resolution traditionally been lower? Oscilloscopes have traditionally used 8-bit ADCs because oscilloscope ADC technology has prioritized sample rate. 8-bit ADCs can provide high sample rates and therefore excellent time resolution. Even relatively inexpensive oscilloscopes now sample at GS/s. In contrast, the sampling rates of DMMs are much lower — roughly on the order of tens to hundreds of samples per second.

The 8-bit ADC in an oscilloscope provides a good balance between acquisition speed and amplitude accuracy for signals with frequencies in the hundreds and TTL voltage levels on the order of 0 to 5 V. For this type of signal 8-bit resolution is usually sufficient.

However, as we move into new technologies such as IoT devices, mobile devices, and autonomous vehicles that rely on high-speed networks, low interference, and low power consumption, engineers are facing new challenges of validating very small amplitude signals with greater accuracy.

This need to address smaller signal details is driving the need to increase the number of ADC bits, while carefully keeping oscilloscope noise low.



FIGURE 2. Adding just a few bits to the ADC significantly improves the number of voltage levels the ADC can resolve.

Traditional 8-bit ADCs (ignoring oversampling and post-processing provide  $2^8 = 256$  vertical digitizing levels. This can be too coarse for applications like power supply design which demands higher vertical resolution over relatively high voltage ranges. In contrast, a 12-bit ADC can deliver up to  $2^{12} = 4096$  vertical digitizing levels for an extremely large increase in vertical resolution (**Figure 2**).

## ASICs at the Heart of Tektronix 12-bit Oscilloscopes

Tektronix' new 4 Series, 5 Series, 6 Series MSO oscilloscopes are equipped with 12-bit ADC technology to help you accurately capture tiny signal details. High resolution is delivered by a custom ASIC called the TEK049, which is shown in **Figure 3** and is at the heart of every Tektronix 4, 5 and 6 Series MSO (mixed signal oscilloscope). These scopes support high-definition displays, up to 8 FlexChannel® inputs, 12-bit vertical resolution, and up to 16 bits of resolution with oversampling, all thanks to circuitry integrated into the TEK049. It is a highly-integrated mixed signal system on chip (SOC), with 400 million transistors and 2 billion connections, consisting of four ADCs and signal processing. The ADCs can achieve sample rates up to 25 GS/s.



**FIGURE 3.** The TEK049 ASIC is designed specifically for the latest generation of oscilloscopes

## A Measurement Case Study: Power Supply Switching Measurements

In this example, we are evaluating a switching section in a power supply. This measurement is challenging because we want to look at the periodicity of ringing on a rather large switching signal. The oscillations are relatively small, compared to the amplitude of the switching signal.

**Figure 4** shows the same test using oscilloscopes with different vertical resolutions. The switching circuit rings after each cycle and the goal is to examine the oscillations. To see the entire switching cycle, the vertical scale must be set to around 1 V/div to fit the signal into the 10 divisions of the display.



**FIGURE 4.** Zooming in on a switching signal with an 8-bit MDO4000C (left) and 12-bit 4 Series MSO (right) oscilloscopes

Measurement Results.

Figures 5 and 6 show the two oscilloscopes under the same conditions: (250 MSa/s sampling rate, 10 k samples, 1 V per division). The same IsoVu optically isolated voltage probe was used on both instruments, to virtually eliminate the effects of probe noise. You can see that with the 8-bit oscilloscope the results with high zoom factor are limited, because significant quantization steps appear, making it difficult to analyze the oscillations. However, the 12-bit oscilloscope clearly shows the oscillations at a comparable zoom setting.

The new 4, 5 and 6 Series MSOs offer 12-bit vertical resolution, making it possible to see more signal detail and make more accurate measurements.

For more information on the techniques used to achieve higher-resolution acquisition details download the white paper [Achieve Higher Vertical Resolution for More Precise Measurements.](#)



FIGURE 5. Ringing on MDO4000C oscilloscope with 8-bit resolution



FIGURE 6. Ringing on new 4 Series MSO oscilloscope with 12-bit resolution

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