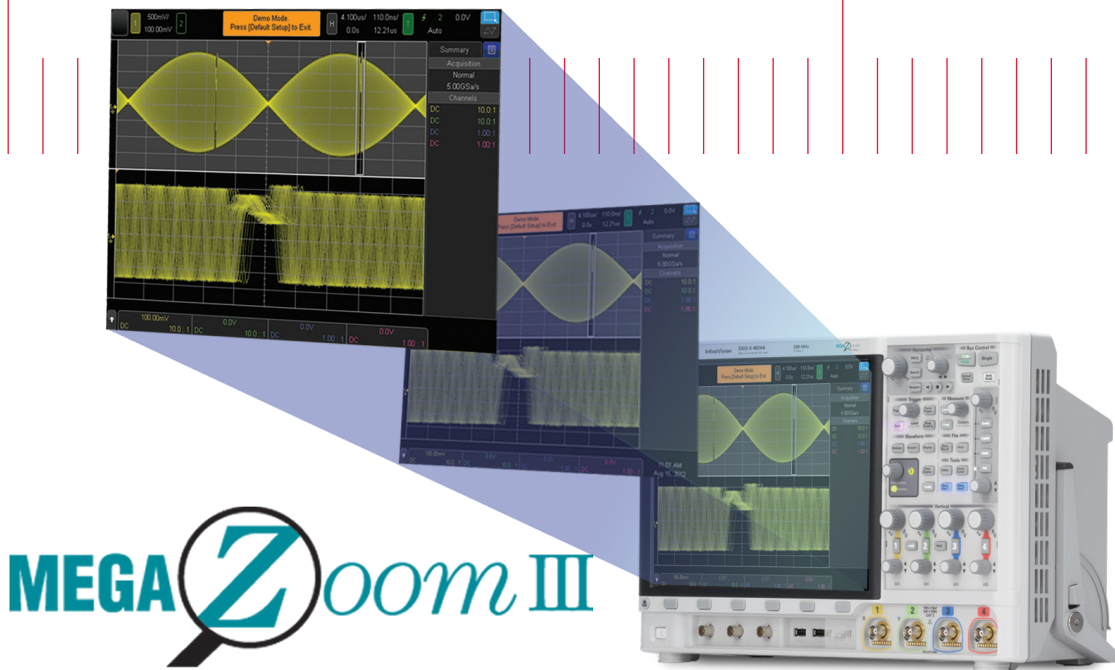


Keysight Technologies

# Oscilloscope Display Quality Impacts Ability to View Subtle Signal Details

Application Note





## Introduction

The quality of your oscilloscope's display can make a big difference in your ability to troubleshoot your designs effectively. If your oscilloscope has a low-quality display, you may not be able to see critical signal anomalies. A scope that is capable of showing signal intensity gradations can reveal important waveform details, including signal anomalies, in a wide variety of both analog and digital signal applications.

Keysight Technologies, Inc. InfiniiVision oscilloscopes are engineered to give you the best signal visibility. With MegaZoom IV technology, InfiniiVision scopes are able to capture up to 1,000,000 waveforms per second, showing you more subtle signal details and infrequent events than other scopes.

### The third dimension: intensity modulation

Engineers traditionally think of digital storage oscilloscopes (DSOs) as two-dimensional instruments that graphically display voltage versus time. But there is actually a third dimension to a scope: the z-axis. This third dimension shows continuous waveform intensity gradation as a function of the frequency of occurrence of signals at particular X-Y locations. In analog oscilloscope technology, intensity modulation is a natural phenomenon of the scope's vector-type display, which is swept with an electron beam. Due to early limitations of digital display technology, this third dimension, intensity modulation, was missing when digital oscilloscopes began replacing their analog counterparts.

Display intensity gradation can be extremely important when you are looking for signal anomalies, especially when you are viewing complex-modulated analog signals such as video, read-write disk head signals, and digitally controlled motor drive signals. Intensity gradation is also helpful in a wide variety of mixed-signal applications found in embedded microprocessor and microcontroller technologies common in the automotive, industrial, and consumer markets. But even when you are viewing purely digital waveforms, intensity gradation can show statistical information about edge jitter, vertical noise, and the relative occurrence of anomalies.

Recently, all major digital oscilloscope vendors have begun to provide z-axis intensity gradation—with varying degrees of success—in order to emulate the display quality of an analog oscilloscope.

## Complex-modulated analog signal applications

If you are working with complex-modulated signals, you need a scope with sufficient display quality to let you look at the big picture and then zoom in to see the details.

## Composite video signals

Many engineers are familiar with standard NTSC or PAL composite video signals, which are complex-modulated analog signals. Figure 1 shows one frame of composite video photographically captured from an analog oscilloscope's display. Even though the display “flickers” when you view this waveform at 5 ms/div, there is important information embedded within the displayed waveform envelope. An experienced video design engineer can quickly determine the quality of analog signal generation from this display.

Figure 2 shows an older digital oscilloscope display without z-axis intensity modulation. This is also representative of some of today's entry-level DSOs. Although this scope that captured this waveform has sufficient sample rate and memory depth to capture details of this signal even at 5 ms/div, all captured points are displayed with the same display intensity. Waveform detail within the signal's envelope is visually lost. Given a choice between analog oscilloscope technology and older digital display technology, it's no surprise that today's video labs are filled with older analog oscilloscopes.

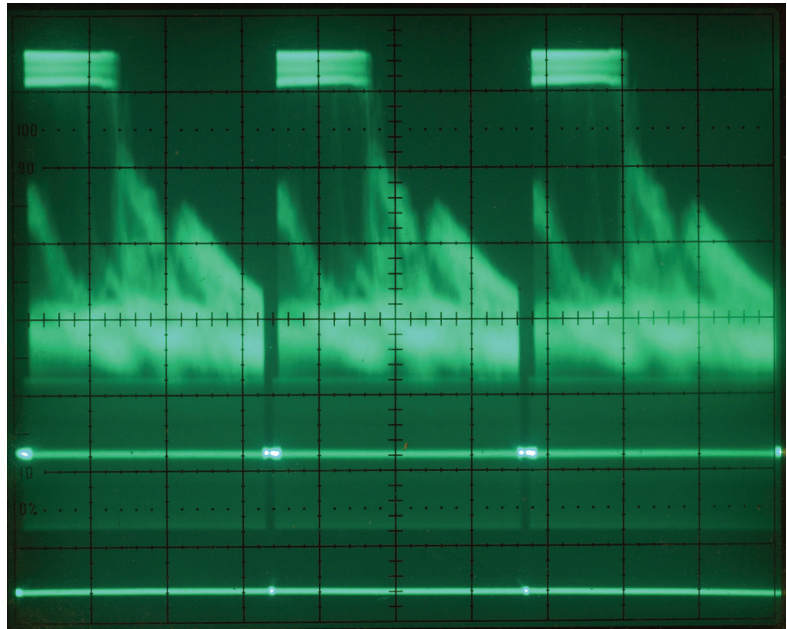


Figure 1. Full frame of composite video displayed on a 100-MHz analog oscilloscope

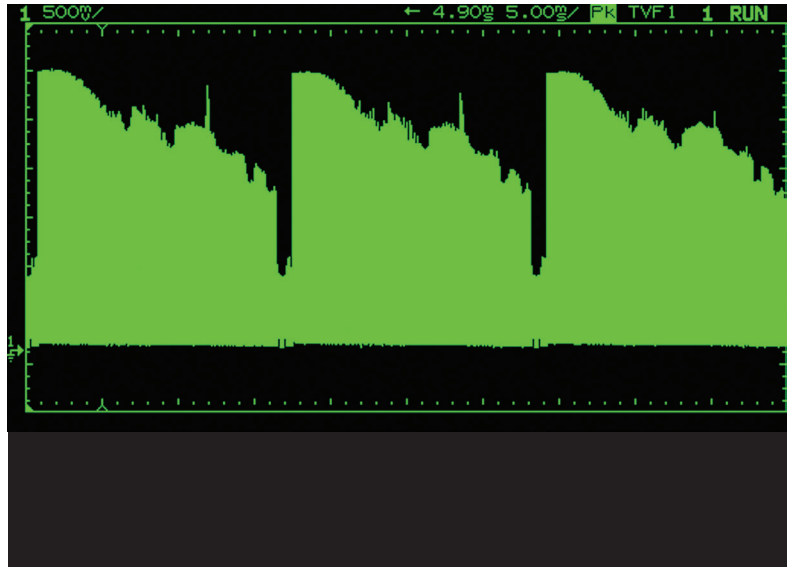


Figure 2. Full frame of composite video displayed on an older digital oscilloscope without intensity gradation capability

However, the visual quality of an analog oscilloscope's display has finally been matched in a digital oscilloscope. Figure 3 shows the real-time capture of a video signal using a Keysight InfiniiVision Series oscilloscope. This scope uses Keysight's proprietary MegaZoom technology that provides up to 256 levels of color intensity gradation for each pixel based on deep memory acquisitions (up to 8 MB) mapped to a high-resolution display (XGA). This digital oscilloscope can display a repetitive analog signal with quality similar to (or perhaps better than) an analog oscilloscope, and it can also capture, display, and store complex single-shot signals with the same visual resolution. This is where conventional analog oscilloscopes fall short of their digital counterparts. Analog scopes can only display repetitive waveforms. Figure 4 shows a zoomed-in/windowed display of a single line of the composite video captured from the same acquisition that is shown in Figure 3. But since analog oscilloscopes can't digitally store waveforms, we are unable to show a similar zoomed-in single-shot display using an analog oscilloscope.

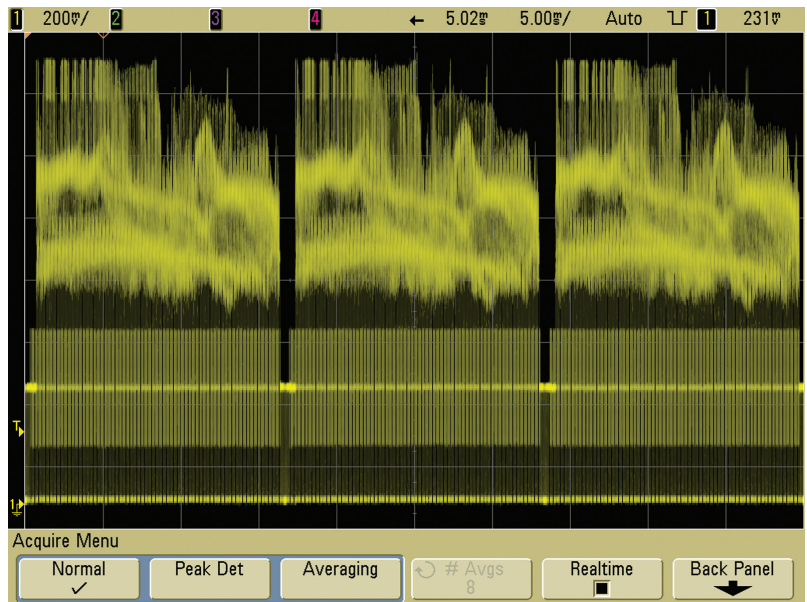


Figure 3. Full frame of composite video displayed on a Keysight InfiniiVision Series scope

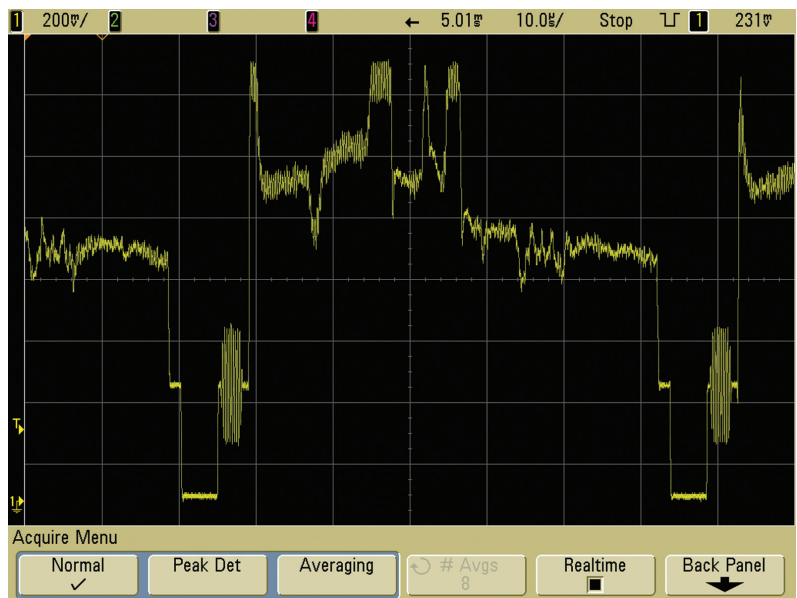


Figure 4. Zoomed-in display of a single line of video using a Keysight InfiniiVision Series scope

## Digitally controlled motor drive signal

Another example of a complex analog signal is a digitally controlled motor drive signal.

A one-time start-up cycle of a motor would be classified as a single shot phenomenon. Figure 5 shows how a Keysight InfiniiVision Series mixed signal oscilloscope (MSO) is able to reliably capture one phase of this single-shot start-up motor drive signal. You can also use this scope's digital/logic channels to synchronize and trigger the waveform capture based on the digital control signals of the motor.

This capability can be extremely important when you attempt to synchronize acquisitions on not only power-up sequences, but also on particular motor positioning commands. Although not shown, this oscilloscope could just as easily capture all three phases of the motor drive signals simultaneously using its four channels of analog acquisition.

Also shown in Figure 5 are two zoomed-in images taken from the same single-shot acquisition. With this scope's MegaZoom III technology, we can see a bright vertical vector (near the center of the display) in the middle image after zooming-in by a factor of 100. Further waveform expansion (20,000:1) on the pulse-width modulated (PWM) burst reveals a glitch, as shown in the image on the right.

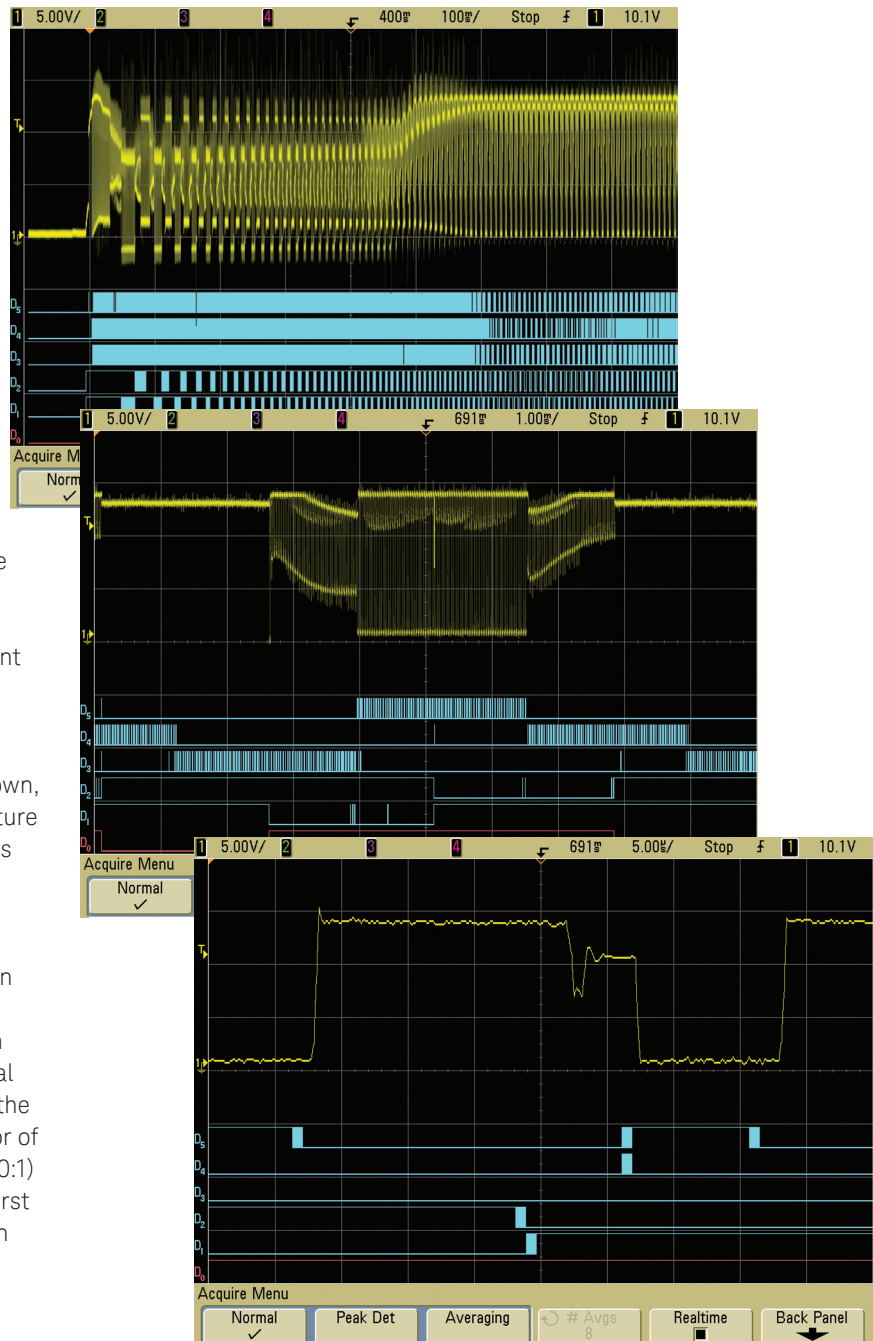


Figure 5. Motor drive signal start-up sequence with digital control signal triggering and various levels of zoom to reveal a "runt" pulse using a Keysight InfiniiVision Series MSO

## Digital signal applications

The visual effects of a digital oscilloscope's intensity gradation capability are most dramatic when you view complex-modulated analog signals such as the composite video and motor drive signals just shown.

However, intensity gradation is also extremely important for uncovering signal anomalies when you are debugging digital circuitry. Figure 6 shows an example of uncovering a runt pulse embedded within a PWM signal. The bright spot near the center of each burst is an indication that our scope has captured a signal anomaly. By zooming-in on one of the bright spots, we can clearly see details of the signal anomaly, as shown in Figure 7.

Although an analog oscilloscope will also show the bright spots with repetitive sweeps, the analog scope is incapable of zooming-in on stored waveforms.

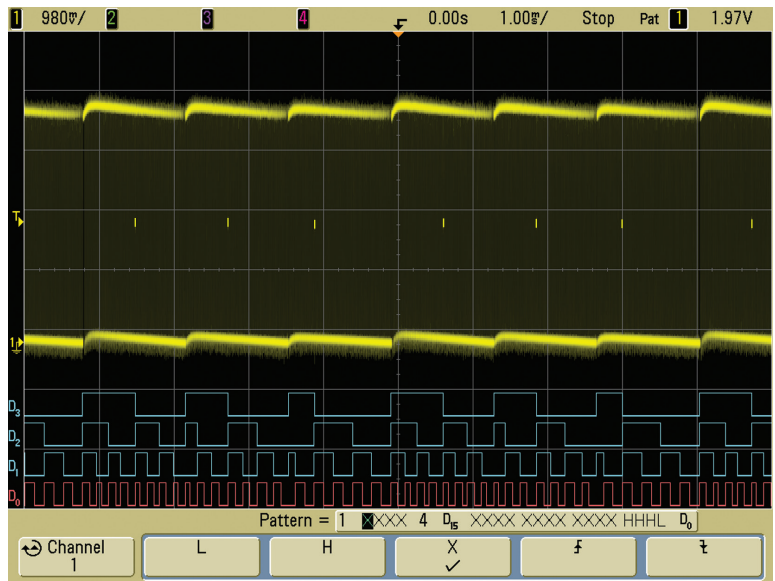


Figure 6. A Keysight InfiniiVision Series scope reveals "bright spots" buried within each digital burst

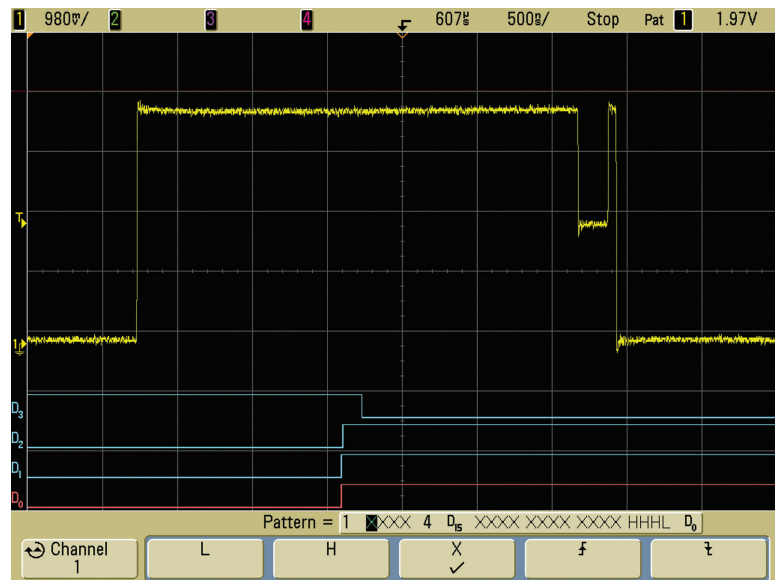


Figure 7. Zooming-in on a "bright spot" reveals a runt pulse

Display intensity gradation is also very important when you view waveforms that contain jitter, noise, and infrequent events. Levels of display intensity can help you interpret the relative frequency of occurrence of signal anomalies, and sometimes it can help you visually determine the type of jitter or noise in your system—based on display intensity dispersion—without resorting to sophisticated waveform analysis software.

Figure 8 shows an example of a digital signal that includes timing jitter (near the left side of screen), vertical noise (top and bottom of waveform), and a very infrequent glitch (near the center of screen). Because of the relative dimness of the displayed glitch, we know that this particular glitch occurs very infrequently. We can also see that the nature of the jitter is very complex and probably includes a large component of deterministic jitter (DJ). If the dispersion of display intensity on the signal's edge appeared to be Gaussian in distribution, we would suspect that the jitter might be dominated by random jitter (RJ). For a more in-depth discussion on the different types of jitter, refer to application note, "Jitter Analysis," listed at the end of this document.

Figure 9 shows the same signal displayed on an analog oscilloscope. Unfortunately, we are unable to show the jittering edge because it occurs before the trigger reference point (rising edge). But the signal edge that sometimes produces the infrequent glitch can be viewed. However, we can't see the glitch on the analog scope's display because it occurs too infrequently for conventional analog scope technology to display, even with the display intensity adjusted to full brightness.

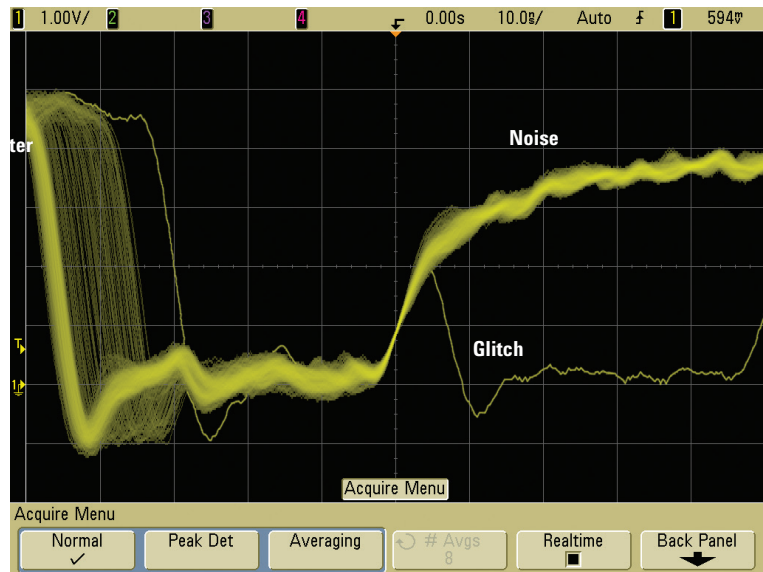


Figure 8. Display intensity gradation shows characteristics of jitter, noise, and signal anomalies on a Keysight InfiniiVision Series oscilloscope

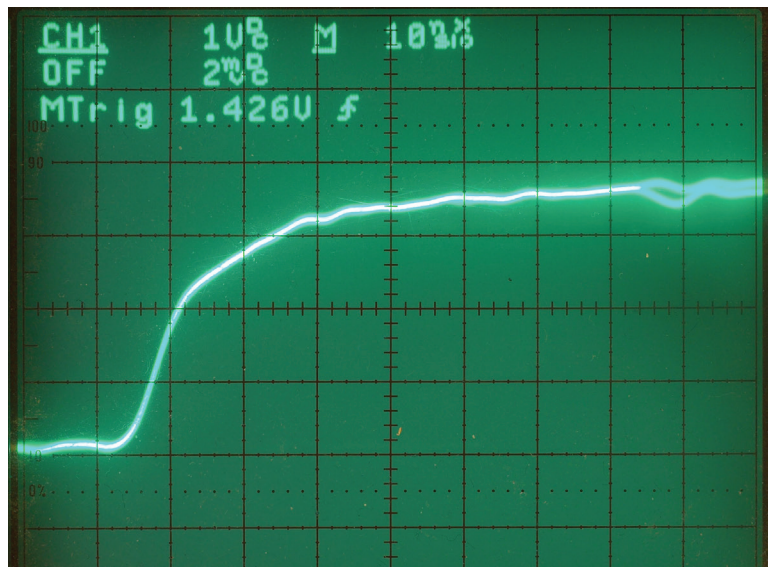


Figure 9. The analog oscilloscope fails to show the infrequent glitch

## Glossary

<b>MegaZoom IV technology</b>	A Keysight-proprietary acquisition and display technology that provides a digital storage oscilloscope with extremely fast waveform update rates (up to 1,000,000 real-time waveforms per second) and a high-resolution display quality that meets or exceeds the display quality of traditional analog oscilloscopes
<b>Intensity gradation</b>	A variation of display intensity at particular X-Y or pixel display locations based on the signal's frequency-of-occurrence at these locations
<b>Mixed signal oscilloscope (MSO)</b>	An oscilloscope with additional channels of logic timing analysis with direct time-correlation and combinational logic/pattern triggering across both analog and digital inputs
<b>Pulse-width modulation (PWM)</b>	A technique where widths of digital pulses are varied; when filtered, they generate varying levels of DC voltage
<b>Real-time sampling</b>	Digitizing an input signal from a single-shot acquisition using a high rate of sampling

## Related Literature

Publication title	Publication type	Publication number
<i>InfiniiVision 2000 X-Series Oscilloscopes</i>	Data Sheet	5990-6618EN
<i>InfiniiVision 3000 X-Series Oscilloscopes</i>	Data Sheet	5990-6619EN
<i>InfiniiVision 4000 X-Series Oscilloscopes</i>	Data Sheet	5991-1103EN
<i>InfiniiVision 6000 X-Series Oscilloscopes</i>	Data Sheet	5991-4087EN
<i>Oscilloscope Sample Rates vs. Sampling Fidelity</i>	Application Note	5989-5732EN
<i>Jitter Analysis</i>	Application Note	5991-4000EN
<i>Oscilloscope Waveform Update Rate Determines Probability of Capturing Elusive Events</i>	Application Note	5989-7885EN
<i>Evaluating Oscilloscopes to Debug Mixed-Signal Designs</i>	Application Note	5989-3702EN
<i>Evaluating Oscilloscope Bandwidths for your Applications</i>	Application Note	5989-5733EN

## For More Information

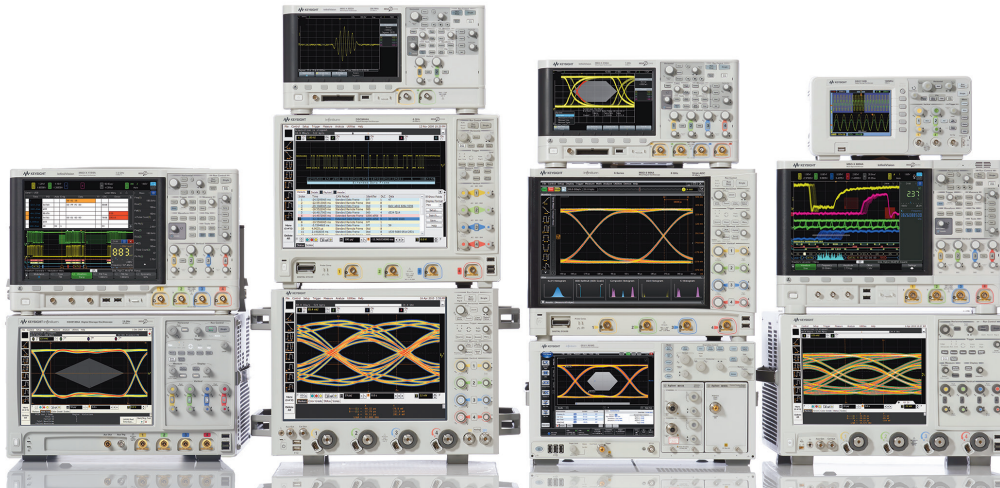
For the most up-to-date and complete application and product information, please visit our product Web site at: [www.keysight.com/find/scopes](http://www.keysight.com/find/scopes)



InfiniiVision oscilloscopes are available in a variety of form factors ranging from the 1U high 6000L to the large display of the 4000 and 6000 X-Series. MegaZoom technology in every InfiniiVision scope provides responsive deep memory allowing you to see subtle signal details and infrequent events that other scopes miss. The InfiniiVision Series oscilloscopes are engineered to give you the best signal visibility.

InfiniiVision scopes include:

- Patented MegaZoom shows elusive details by capturing up to 1,000,000 waveforms per second
- Responsive deep memory is always available to show more of your signal with more detail
- Localized user interface available in multiple languages.
- Standard 3-year warranty
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