

Restoring Confidence in Your High-Bandwidth Probe Measurements

Application Note 1419-01

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Introduction

Is your oscilloscope probe accurately showing your signal? Is your probe disturbing your signal too much? Just how well does your probe work with its various accessories, such as ground leads and socket adapters? With recent leaps in computer and communication speeds, these are questions that debug and validation engineers are asking – and rightly so.

This application note presents a simple method you can use to verify the performance of various probing configurations and restore your confidence in your high-bandwidth probe measurements.

There are two important performance issues you need to consider with an oscilloscope probe: how much does the probe disturb the signal, and how well does the probe represent the actual signal. For best performance, you need to keep probe connections short, but that is not always possible. Therefore, you need to understand the performance issues for the various probe configurations you use to understand their performance tradeoffs.

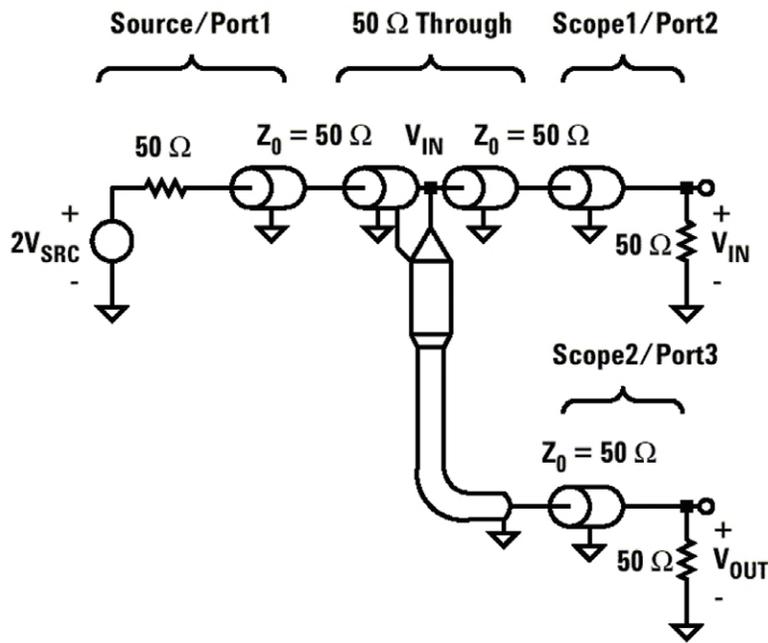


Figure 1. Setup to accurately measure a probe's input impedance and response.



Figure 2. Fifty ohm through fixture, Agilent Technologies product number E2655-66501.

To understand how the probe disturbs the signal being probed, you need to measure the effect of the input impedance of the probe. And to understand how well the probe represents the actual signal being measured, you need to measure the response or V_{OUT}/V_{IN} of the probe.

A test setup to perform both these measurements is shown in Figure 1. You can make these measurements either in the frequency domain with a three-port network analyzer, or in the time domain with a fast step pulse source and a two-channel oscilloscope.¹

In either case, the signal source (Source/Port1) drives one input of the analyzer (Port2) or oscilloscope (Scope1) via a 50 Ω transmission line. The probe's output, V_{OUT} , is connected to a second input (Scope2 or Port3). The probe's input is connected to a 50 Ω through fixture to measure V_{IN} , with whatever probe accessories you want to use. V_{IN} at Scope1/Port2 represents V_{IN} at the probe's input. A 50 Ω through fixture is shown in Figure 2.

[1] For a qualitative analysis of performance, the oscilloscope that you use with the probe will suffice. However, to accurately evaluate only the probe's performance, you should use a wide-bandwidth sampling oscilloscope.

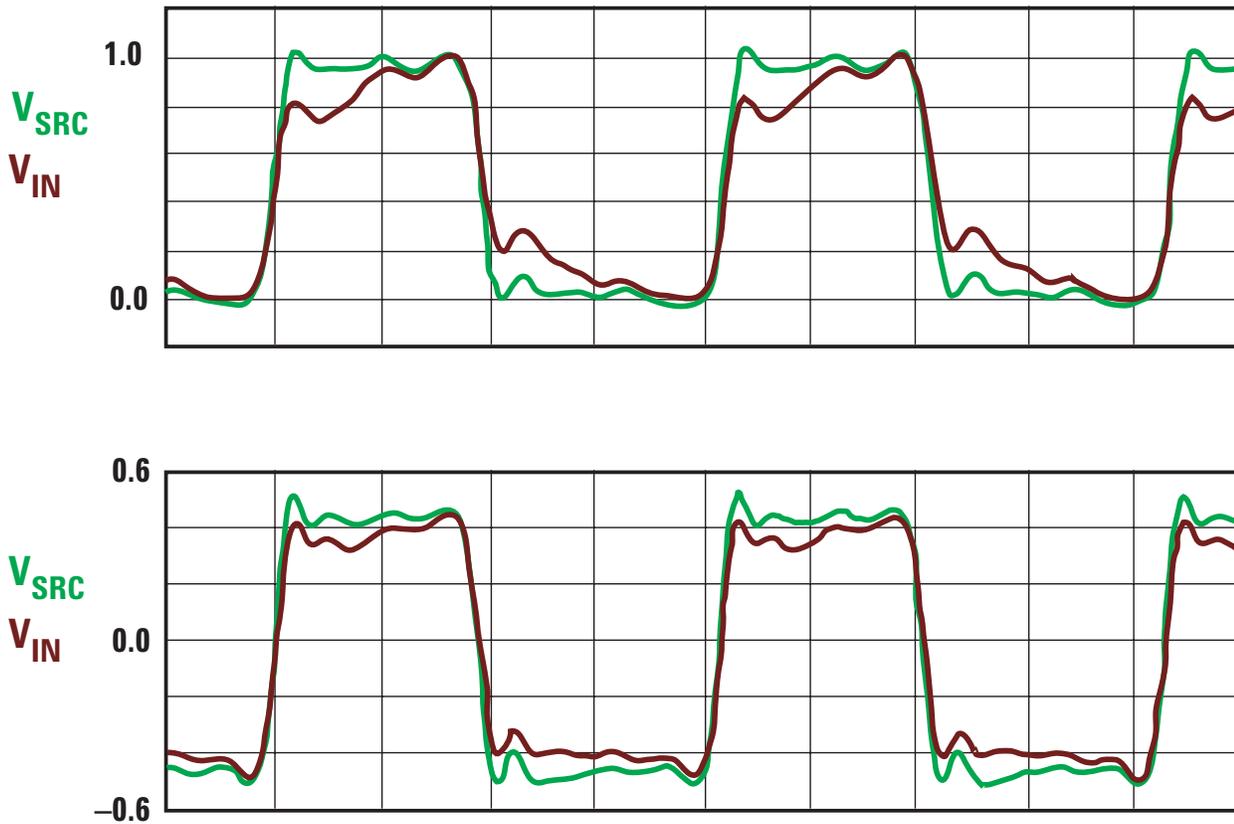


Figure 3a/b. Effect of probe input impedance on a 1.2 GHz clock signal. Upper graph (3a) shows the effect of poor probe loading. Lower graph (3b) shows the effect of good probe loading.

You can determine the effect of probe input impedance on the signal by observing how V_{IN} changes when you connect the probe to the 50 Ω through fixture. For this measurement, the time domain effect is probably of more interest.

Figure 3a shows the effect of a poor probe input impedance on a 1.2 GHz clock signal. V_{SRC} is the signal without probing, and V_{IN}

shows the signal with the probe connected. Clearly in this case, the probe is significantly disturbing the signal. This probe configuration would probably be deemed unacceptable for the measurement application.

For comparison, Figure 3b shows the same measurement with a better probe. In this case, the probe disturbs the signal much less, making it suitable for the measurement application.

You can evaluate the response of the probe by examining the ratio of V_{OUT} to V_{IN} . To accurately represent the input signal, a probe should have a flat response up to the specified bandwidth. For this measurement, a frequency domain measurement is used.

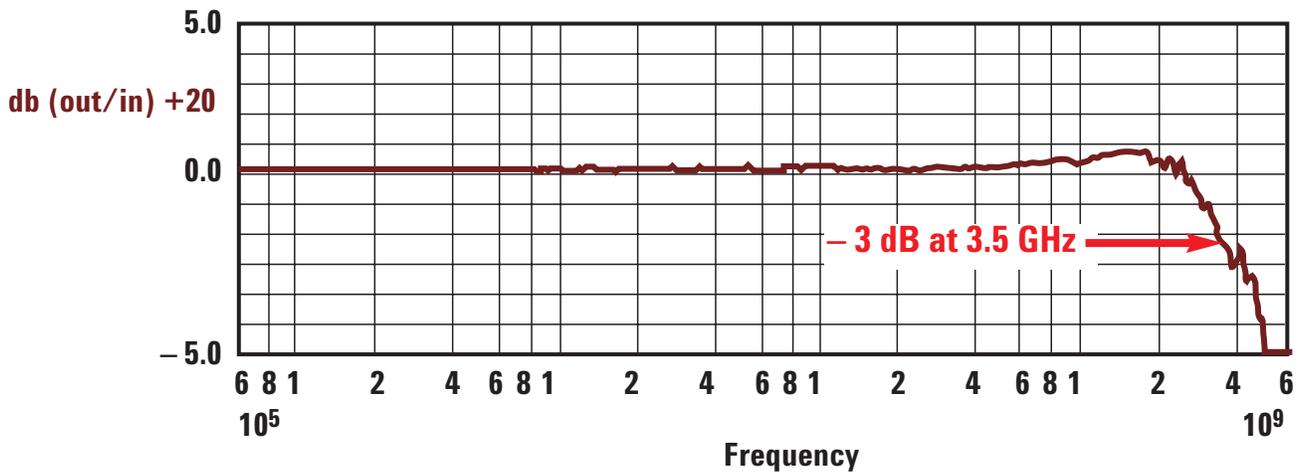
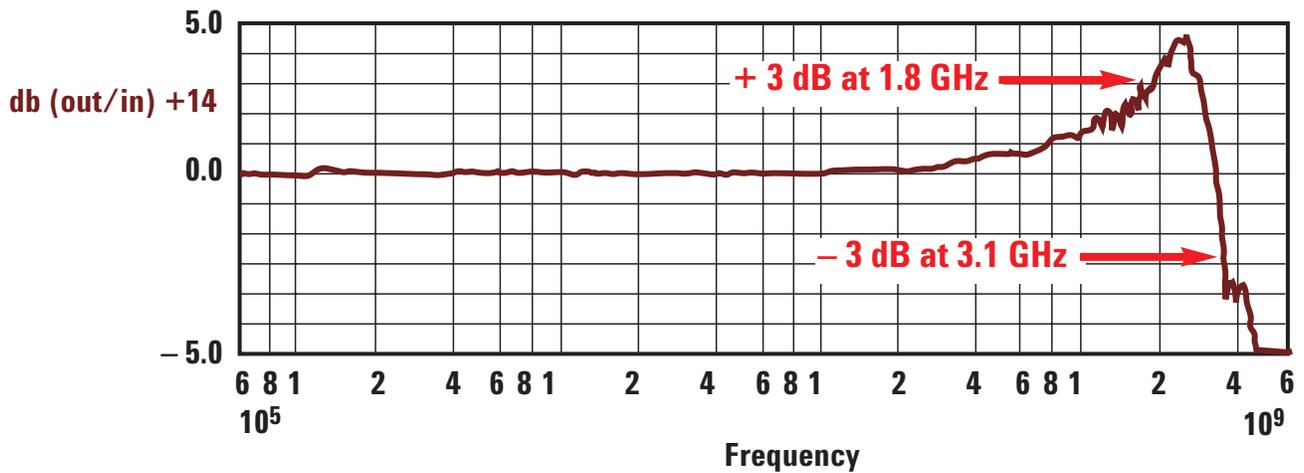


Figure 4a/b. Probe frequency response. Upper graph (4a) shows poor probe with peaking. Lower graph (4b) shows good probe with flat response.

Figure 4a shows the response of a poor probe. The + 3 dB of peaking at 1.8 GHz will result in significant overshoot and ringing when you look at signals with fast edges. Sometimes a probe's response will be peaked by design to compensate for signal loss due

to the probe's input impedance. This practice can mislead you into thinking your signal looks good, when in fact the probe is significantly attenuating the signal under test, and then hiding this error by peaking the probe's response!

For comparison, Figure 4b shows the response of a good probe. In this case, the response of the probe is flat up to 2 GHz, and then rolls off as you would expect to the 3.5 GHz bandwidth point.

Summary

To accurately measure high-bandwidth signals with an oscilloscope, your probe must not significantly disturb the signal under test, and it must accurately represent the signal at its input. You can evaluate your probe configuration with the measurement setup presented in order to confidently measure high-bandwidth signals.

Glossary

Through fixture – an exposed 50 Ω strip-line that can be probed by an oscilloscope probe. Agilent product number, E2655-66501.

Related Literature

<i>Infiniium 54800 Series Oscilloscopes</i> Product Overview	5988-3788EN
<i>Infiniium 54800 Series Oscilloscope Probes, Accessories and Options</i> Selection Guide	5968-7141EN
<i>Infiniium 54850 Series Oscilloscopes</i> <i>InfiniiMax 1130 Series Probes</i> Data Sheet	5988-7976EN
<i>Improving Usability and Performance in High-Bandwidth Active Oscilloscope Probes</i> Application Note 1419-02	5988-8005EN
<i>Performance Comparision of Differential and Single-Ended Active Voltage Probes</i> Application Note 1419-03	5988-8006EN
<i>Understanding Oscilloscope Frequency Response and Its Effect on Rise-Time Accuracy</i> Application Note 1420	5988-8008EN
<i>The Truth About the Fidelity of High-Bandwidth Voltage Probes</i> Application Note 1404	5988-6515EN

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