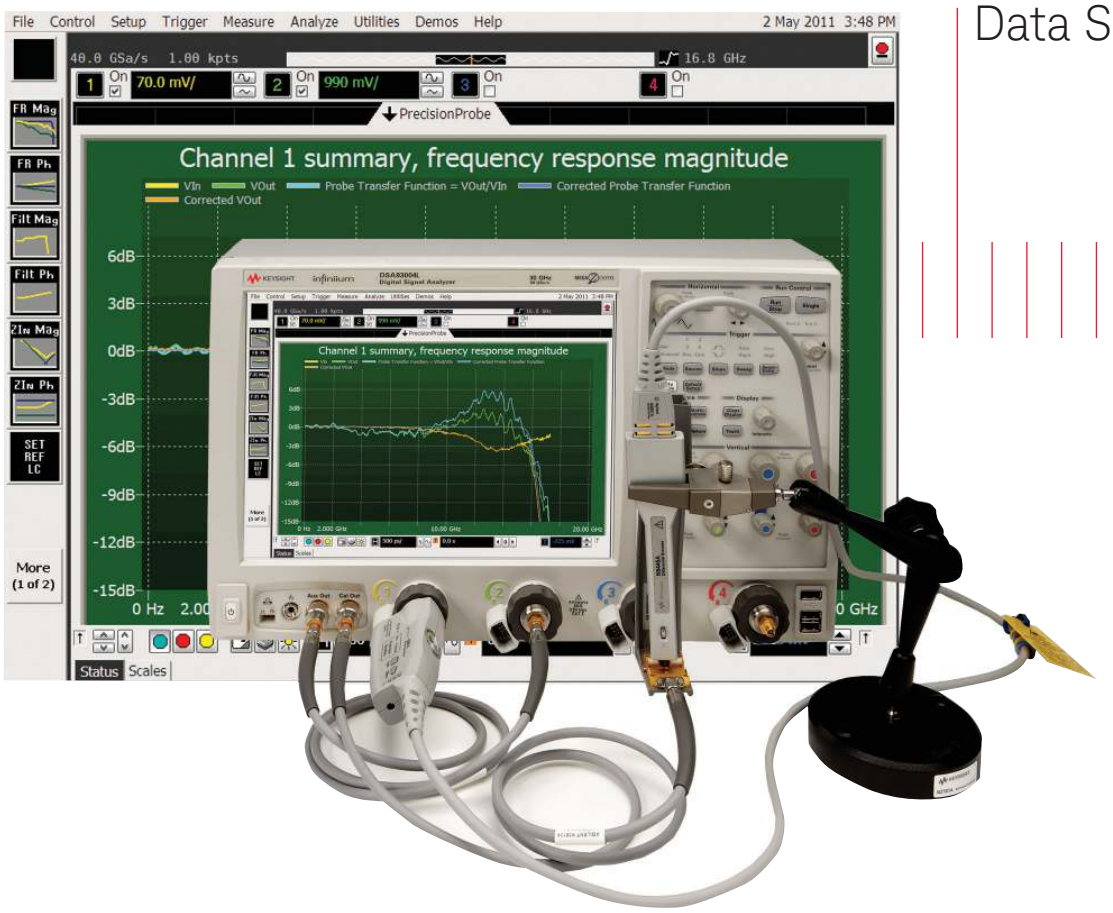
Keysight Technologies
PrecisionProbe for Bandwidths up to 33 GHz

Data Sheet



KEYSIGHT TECHNOLOGIES

Introduction

PrecisionProbe solves measurement challenges by allowing you to:

- Measure input impedance and response of any probe and the loss of any cable
- Quickly correct for probe and cable loss (without extra instruments such as VNA or TDR)
- Correct probing issues such as phase non-linearity, magnitude non-flatness, and see the effect of probe loading
- Quickly gain insight into the impedance/capacitance that defines your connection

The Keysight Technologies, Inc. PrecisionProbe software (N2809A) allows you to characterize and correct your measurement system quickly and accurately, up to 33 GHz of bandwidth without adding expensive equipment.

Test & Measurement World's TOP 50 2011

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Background – PrecisionProbe

Probes and cables have inherent loss and variation. The loss at times can be substantial, or merely different enough from the nominal to cause variation in measurements. To compensate for the inherent loss, oscilloscope vendors use probe correction via DSP. The vendor uses a "golden" model and base, all compensation/correction on the single model. While this strategy solves some of the loss and variability, it also still means that if a probe's characteristics have changed/drifted or were not close to the model to begin with, the compensation is no longer correct for the probe. There are also a myriad of probe heads to attach to probe amplifiers for maximum accuracy when every combination must be measured. The end result is that you can get unwanted inaccuracies or probe to probe variability.

You also use custom probes and probe heads. While this provides great convenience for you it means that the oscilloscope vendor no longer can even provide a "golden" system. Meaning that custom probes are uncorrected and inaccurate, but convenient.

You may also want to add something between the probe amplifier (such as Keysight's 30 GHz N2803A) probe amplifier and (such as Keysight's 30 GHz N5444A browser probe head), including a cable to add length or a switch matrix. This adds inaccuracies as the probe amplifier and browser head are compensated to the model, the newly created probe now has no model. The result is that you must except the inaccuracies that have been added or try to characterize the additional element in the probe link. While accepting both of these trade-offs can be sufficient, it is time consuming to evaluate the element every time and not characterizing the element causes loss of margins (including higher jitter, smaller eyes, and slower rise times). This can also be the cause of differences between numbers measured in simulation and the number actually achieved in actual measurements.

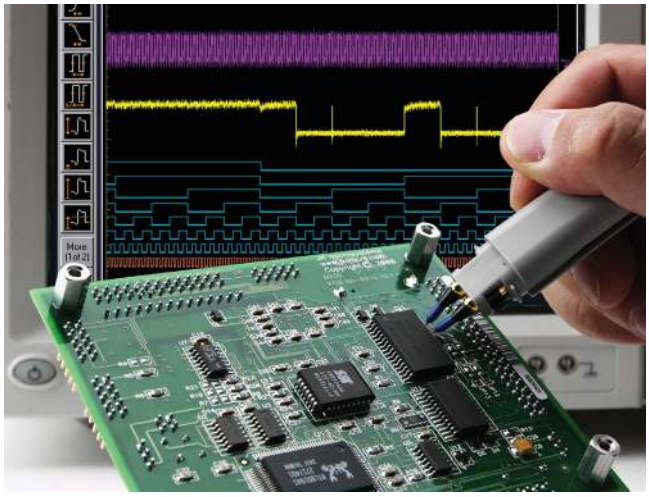


Figure 1: Probe browser with a non-standard pitch

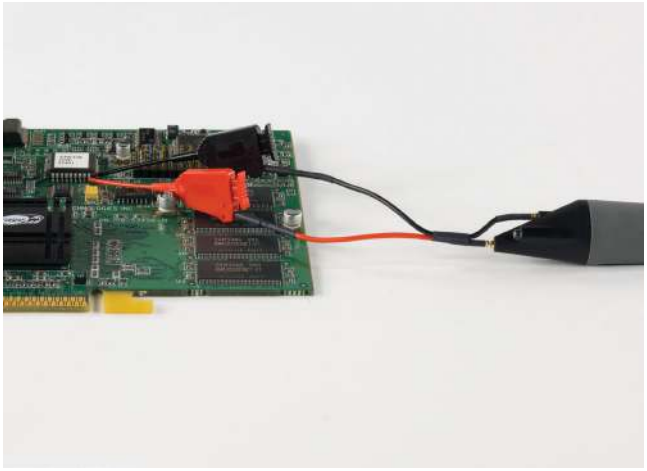


Figure 2: Image of custom probe

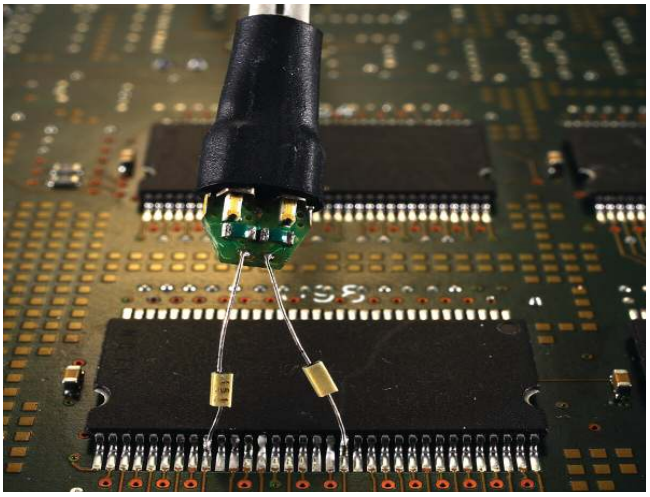


Figure 3: Image using LW ZIF Head

Background – PrecisionProbe (continued)

Cables pose many of the same problems as probes with cable-to-cable variability. Oscilloscope vendors now mitigate this problem with the use of de-embedding software (Keysight's InfiniiSim N5465A software). Typically for cables, you must characterize the cable using either a TDR or a VNA. Both of these methods provide characterization and s-parameters, but take time. It is the time required that typically will mean that you will characterize only one or two cables, and use that characterization (s-parameter file) to do the measurements of every similar cable they own, causing cable-to-cable variability if the cables characteristics vary from the "golden" cable.

PrecisionProbe

PrecisionProbe can solve the problems outlined in the background information by allowing quick characterization of your entire probe system (including cables and switches).

The innovative software takes advantage of the fast "cal output" signal on the 90000 Q-Series, 90000 X-Series, and 90000A Series oscilloscopes to properly characterize cables and probes.

The software quickly (less than five minutes in most cases) and accurately characterizes the desired element in the system without adding more equipment. PrecisionProbe

- Characterizes probe input impedance
- Properly Creates Custom Probe Transfer Function = VOut / VIn or VOut/VInc = VOut/VSrc
- Removes unwanted cable loss

Now every probe and cable in the system can have the exact same response probe to probe or cable to cable, without the inaccuraies that using one model can produce. Custom probes can now be properly characterized and unwanted responses can be removed.

Not only does PrecisionProbe characterize the cables, it allows for immediate use on the same instrument. When combining PrecisionProbe with the 90000 Q-Series, 90000 X-Series, and 90000A Series oscilloscopes one can characterize their measuring system and be using it within five minutes without adding more complicated, expensive equipment. PrecisionProbe saves time and money while increasing accuracy.

When combining Infiniimax probes with switches between the amplifier and the probe head, PrecisionProbe allows for full correction and automation of each probes path. Full automation is then available to allow for quick swapping of the inputs.

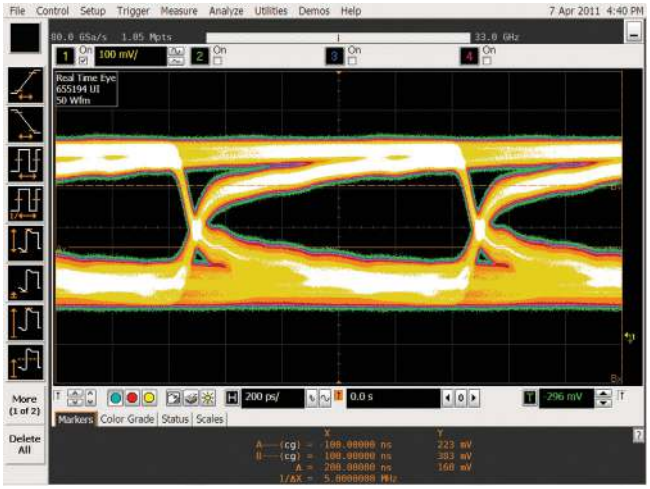


Figure 4: Eye diagram with no correction, notice the minimized eye margins due to fixture loss

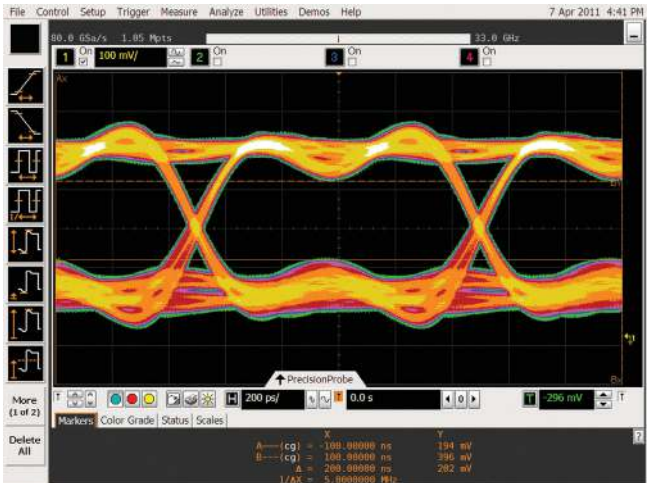


Figure 5: Same setup using PrecisionCable correction to compensate for fixture loss

PrecisionProbe Correction

Two methods exist for correcting probe responses, Vout/Vin and Vout/Vsource

Vout/Vin Correction

Vout/Vin characterizes the output of the probe as a function of the input at the probe tips. Defining the response this way allows you to evaluate the probe's accuracy in reproducing the actual signal present in your system with the probe attached. This correction is known as Vout/Vin, which is what you'd see with a real band limited probe that has finite input impedance. PrecisionProbe corrects the "Vout/Vin" response to be flat with frequency and phase to your defined bandwidth limit. It does not correct the loading effects of the probe. It should be noted that Keysight' s probe frequency response corrections are typically defined using Vout/Vin.

Vout/Vsource Correction

The second way to correct probes is an estimate known as Vout/Vsource, this method corrects the probe as "what would be there if the probe were not present." There are oscilloscope and probe manufacturers that design their probes and DSP correction software to display what the waveform "would have been" in the absence of the probe. One drawback of defining the probe's response in this manner is that if the probe's loading causes your circuit to lose some timing or amplitude margin, you probably want to know that when you make a measurement. Vout/Vsource compensation will hide these effects from you. PrecisionProbe also gives you the freedom to choose this method of correction, which can be effective if probing at the transmitter.

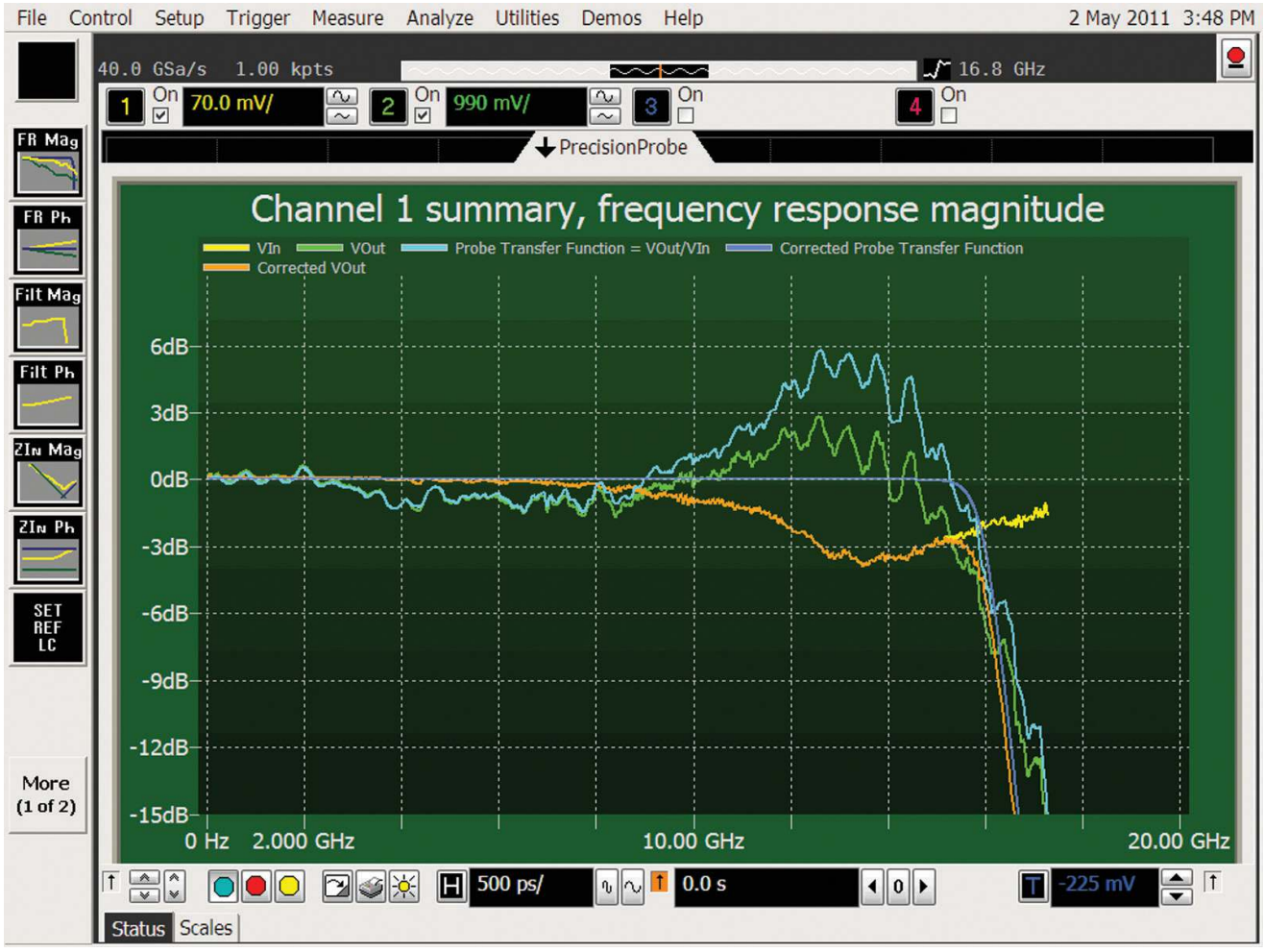


Figure 6: A probe that has perfect transfer function shows an exact copy of a signal at the input. A probe that has a perfect system response shows the signal at the input of probe boosted by the estimate amount of loading due to the probe.

PrecisionCable Correction

S21 Insertion Loss Correction

PrecisionCable can be used to remove insertion loss caused by cables and fixtures up to 33 GHz. Previously the only way to do this analysis was to characterize the cable using simulation, TDR, or a VNA. All of these methods can be accurate and can yield the desired results. You would then take the newly created s-parameter file to the oscilloscope and use the de-embedding software to remove the insertion loss of the fixture or cable. While this method works, it requires extra equipment and effort. Precision Cable allows for this characterization to be done inside of the same oscilloscope that the measurements will be taken. Characterizing the cables and fixtures takes less than five minutes in many cases which saves significant time.

Note: This measurement does require access to both ends of the fixture or cable, similar to methods such as VNA and TDR.

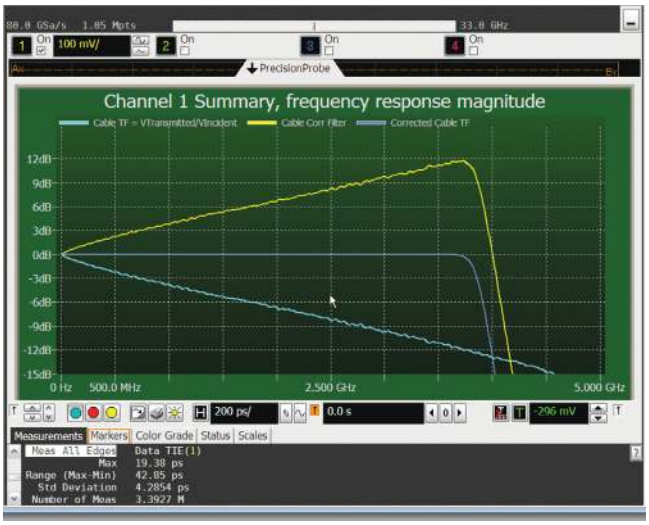


Figure 7: E.xample of frequency response correction of a cable. The 3 dB down point moved from 1 GHz to 4 GHz.

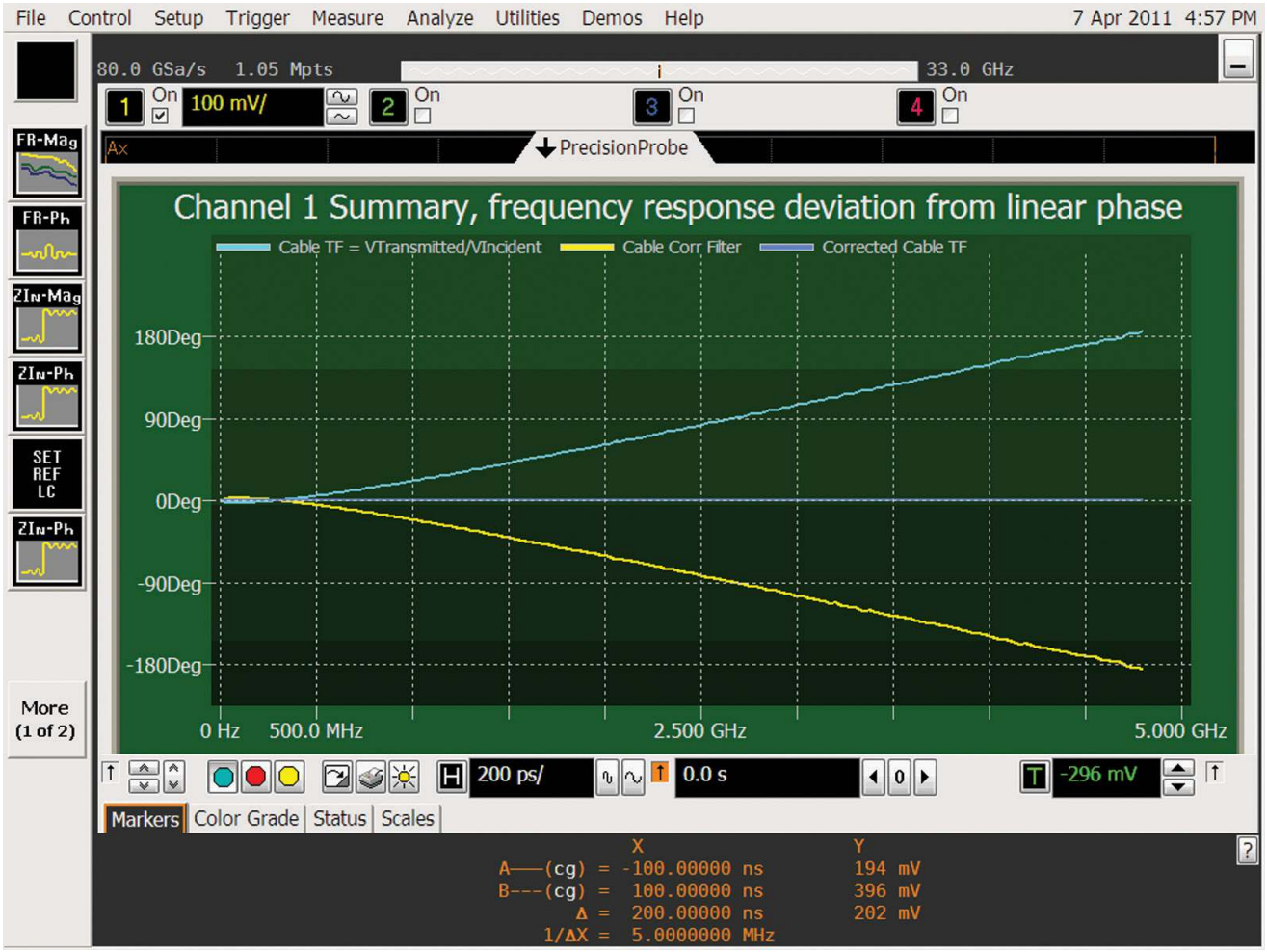


Figure 8: PrecisionProbe corrects phase non-linearities, notice the new flat phase.

Analysis Tools

PrecisionProbe provides many tools to allow you to know exactly what has been characterized and what parameters have been improved by the innovative software.

PrecisionProbe Wizard

PrecisionProbe provides an easy to follow guide with its wizard. The wizard takes you step by step through the set up of the software and ensures that your measurements are taken with the highest signal integrity.

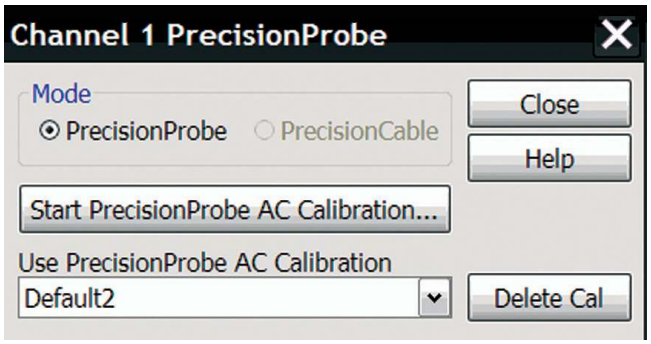


Figure 9: Starting the PrecisionProbe wizard

Probe correction

To maximize margins it is important to correct each probe identically and to ensure the correction method is the same. The Probe Correction menu allows you to change between Vout/Vin and Vout/Vsource. PrecisionProbe also allows for the source impedance via s-parameter file or an estimate. This is important when measuring Vout/Vsource to ensure a high level of accuracy as assuming an ideal 50 ohm environment can cause unwanted errors.

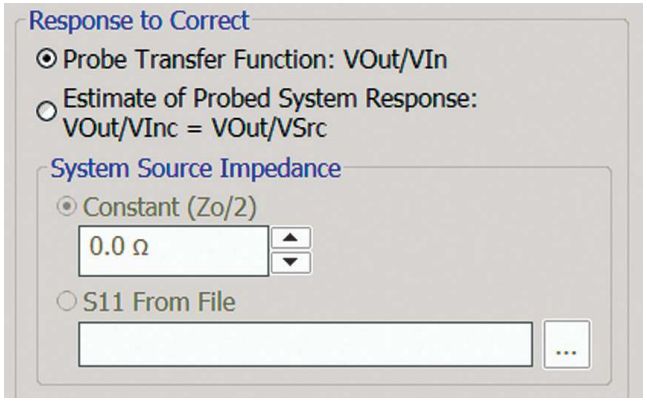


Figure 10: Choosing the probe correction that you need

Bandwidth Control

Software such as PrecisionProbe can amplify high frequency noise when correcting for the loss of a probe or cable. The high frequency noise can then cause unwanted noise and inaccuracies. Bandwidth control allows you to remove unwanted high frequency noise by providing a filter. PrecisionProbe also provides the ability to control the amount of gain that is applied to the signal. You can increase the amount of boosting which improves risetimes but also increases noise, or you can decrease the amount of boosting which decreases noise but degrades rise times.

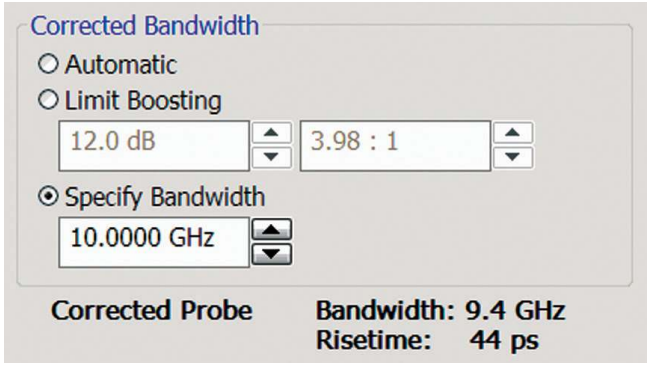


Figure 11: Use bandwidth control to maximize margins

Understanding the Analysis Charts

PrecisionProbe comes with many analysis charts that make understanding the characterization and correction very easy and provide insight that is unique to Keysight oscilloscopes.

The Summary Chart

The summary chart shows the frequency response of the corrected probe or Vout (notice how flat the response is). The chart also shows the transfer function (TF) that is applied to the signal.

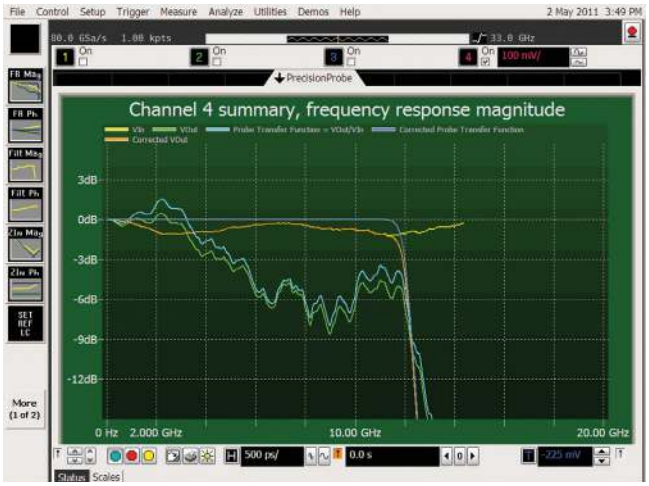


Figure 12: The summary chart

Probe Input Impedance

Knowing the impedance profile of the probe allows you to estimate the loading of the probe system. PrecisionProbe allows for you to characterize the impedance profile, along with quickly determining the capacitance, impedance and inductance. Markers allow for easy viewing of the capacitance and inductance at each frequency

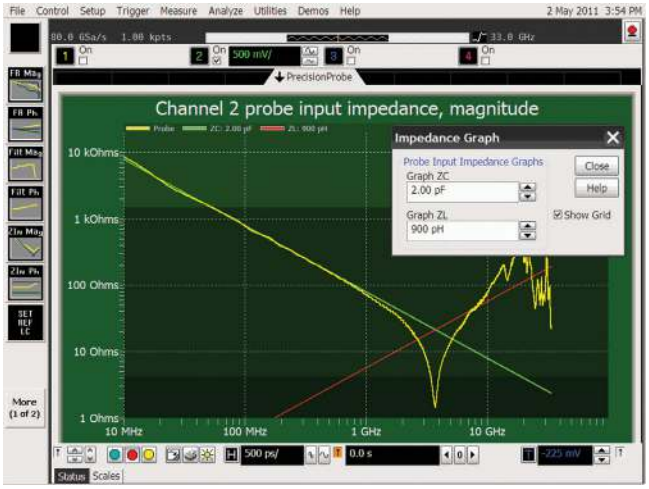


Figure 13: PrecisionProbe properly characterizes a 2 pF capacitor

Probe Correction Filter

The probe correction filter simply shows the filter that is being applied to adjust for the probe. This filter is designed to ensure the signal stays perfectly flat.

Figure 14: Probe correction summary

Conclusion

Using PrecisionProbe provides the highest level of accuracy without requiring additional equipment. PrecisionProbe will help with accuracy in the following ways:

- Characterize the impedance of your probe
- Remove probe to probe variation
- Remove insertion loss caused by cables
- Correct custom probes
- Correct for browser variability caused by span and length variation
- Correct for solutions such as switch matrices

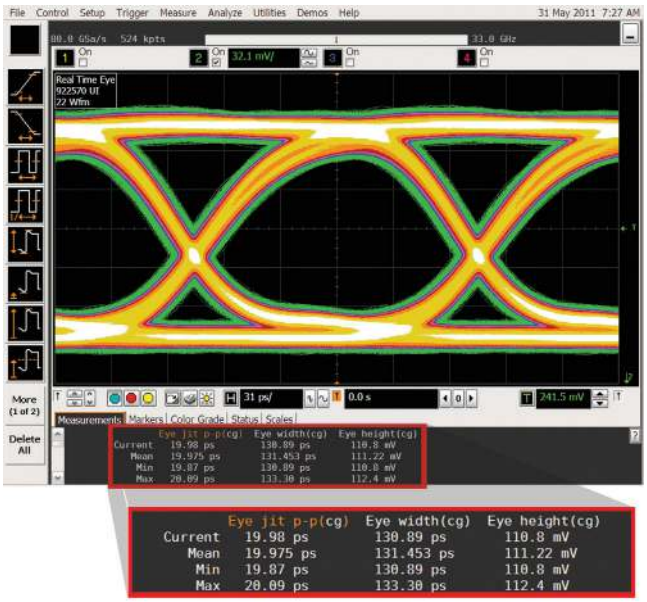


Figure 15: Real time eye with uncorrected cable loss

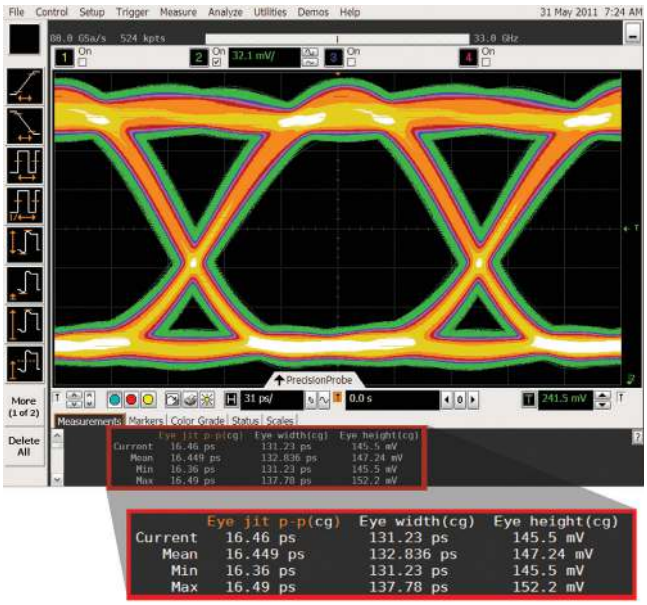


Figure 16: Real time eye with corrected cable using PrecisionProbe

Need PrecisionProbe for Bandwidths >33 GHz?

The N2807A PrecisionProbe Advanced kit allows for full characterization and insertion loss removal of cables, probes, and other circuit elements to 63 GHz of bandwidth

High bandwidth is enabled by Keysight's N2806A calibration pulse generator, included in the PrecisionProbe Advanced kit, capable of producing rise-times of less than 7 ps.

Using this external hardware the "Cal Out" edge of the oscilloscope can be accelerated to speeds necessary to characterize and remove insertion loss at > 60 GHz measurement bandwidth using the same PrecisionProbe software.

See the product page for the N2807A for more details at: www.keysight.com/find/PPA

Ordering Information

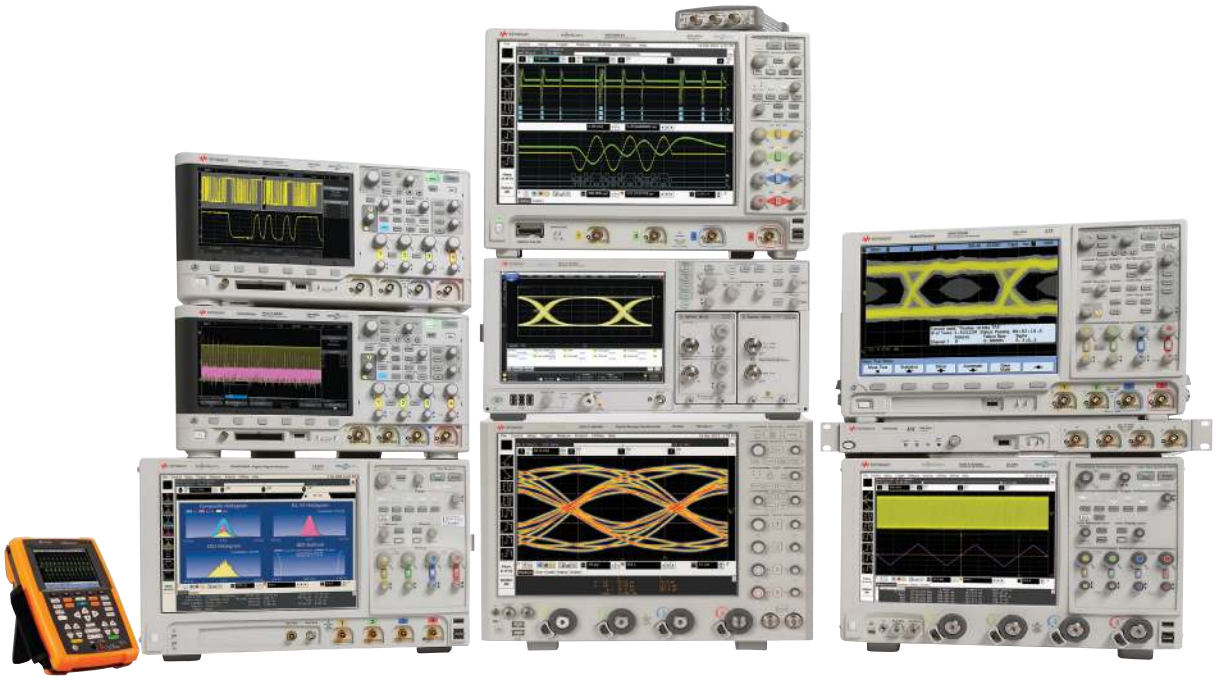
	Option	Standalone
DSO 90000 X-Series	DSOX90000-001	N2809A-001
DSO90000A	DSO90000-001	N2809A-002
DSO9000A	None	None

Included Equipment

N2809A-001 or DSOX90000-001	Quantity	N2809A-002 or DSO90000-001	Quantity	Description
N2812A cables	3	N2812A cables	3	High Performance Input Cable – 3.5MM – 1m
5061-5311	2	5061-5311	2	Connector Assembly - 3.5 mm Female to Female
		11636B-FG	1	DC TO 26.5 GHz Power Divider

Recommended Equipment

N2809A-001 or DSOX90000-001	Quantity	N2809A-002 or DSO90000 -001	Quantity	Description
N5443A	1	E2655B	1	Performance Verification and Deskew Fixture
N2787A	1	N2787A	1	3-D Probe Positioner
		54855-67604	2	Precision BNC adaptor



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