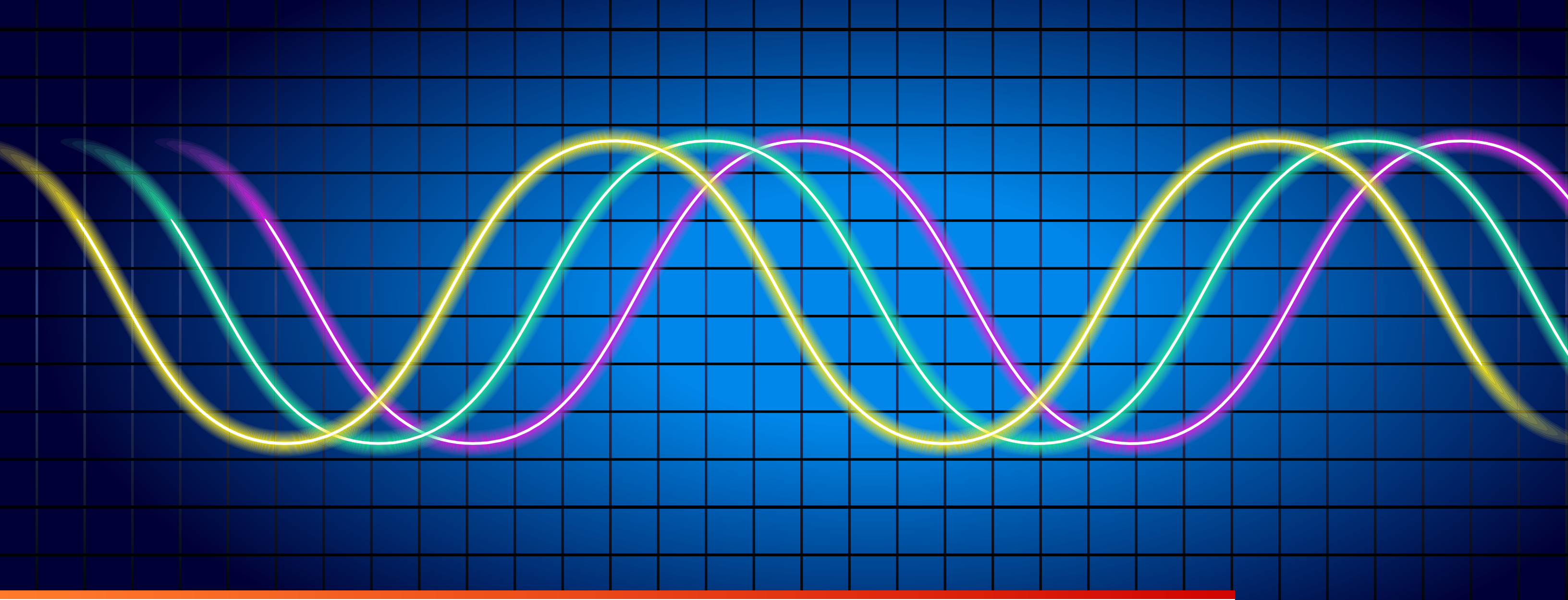

APPLICATION NOTE

Bandwidth Boosting Techniques for the Infiniimax Probe Amp and Probe Head

Have you ever wished your probe could perform at a slightly higher bandwidth than what's rated on the label?

Keysight InfiniiMax differential probes are DSP corrected to have a flat magnitude and phase response to provide the highest possible accuracy. The bandwidth chosen to correct to is typically around 3dB non-corrected bandwidth. Usually, extending the bandwidth much beyond that point will increase the noise floor, and if pushed even further, can cause unrealistic noise artifacts.

However, the N5381A/B solder-in probe head in combination with the InfiniiMax 1169A/B probe amp is an excellent candidate for extending the bandwidth beyond the 3dB point because the N5381A/B is peaked past the normal 12 GHz bandwidth, and the peaking of the probe head can help compensate for the roll-off of the probe amp bandwidth.

This application note presents the techniques used to extend the bandwidth performance of the InfiniiMax 1169A/B and the N5381A/B solder-in head using the PrecisionProbe application on Infiniium realtime oscilloscope.

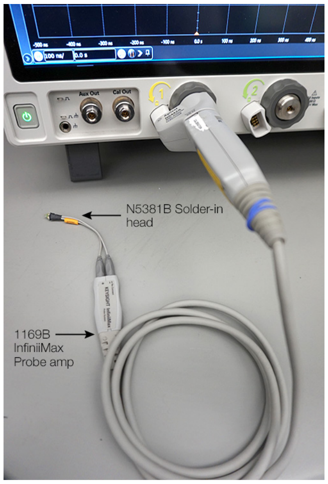

Figure 1 - InfiniiMax 1169B probe amp and N5381B solder-in head.

KEYSIGHT TECHNOLOGIES

Inherent Frequency Response of the InfiniiMax Probe

Figure 2 represents a plot of the frequency response of the InfiniiMax 1169A/B probe amp (red) and the N5381A/B probe head (blue). The N5381A/B has a zero in its response and therefore rises in frequency until it flattens out around 5 GHz. The 1169A/B has a pole in its response until it flattens out around 5 GHz. These responses combine to produce a flat overall response. Ideally, both responses would flatten out above 5 GHz until they hit their inherent bandwidth. You can see the 1169A/B response turning down at around 12 GHz which is the normal bandwidth. However, the N5381A/B response actually turns up around 12 GHz and peaks nearly at around 8 dB.

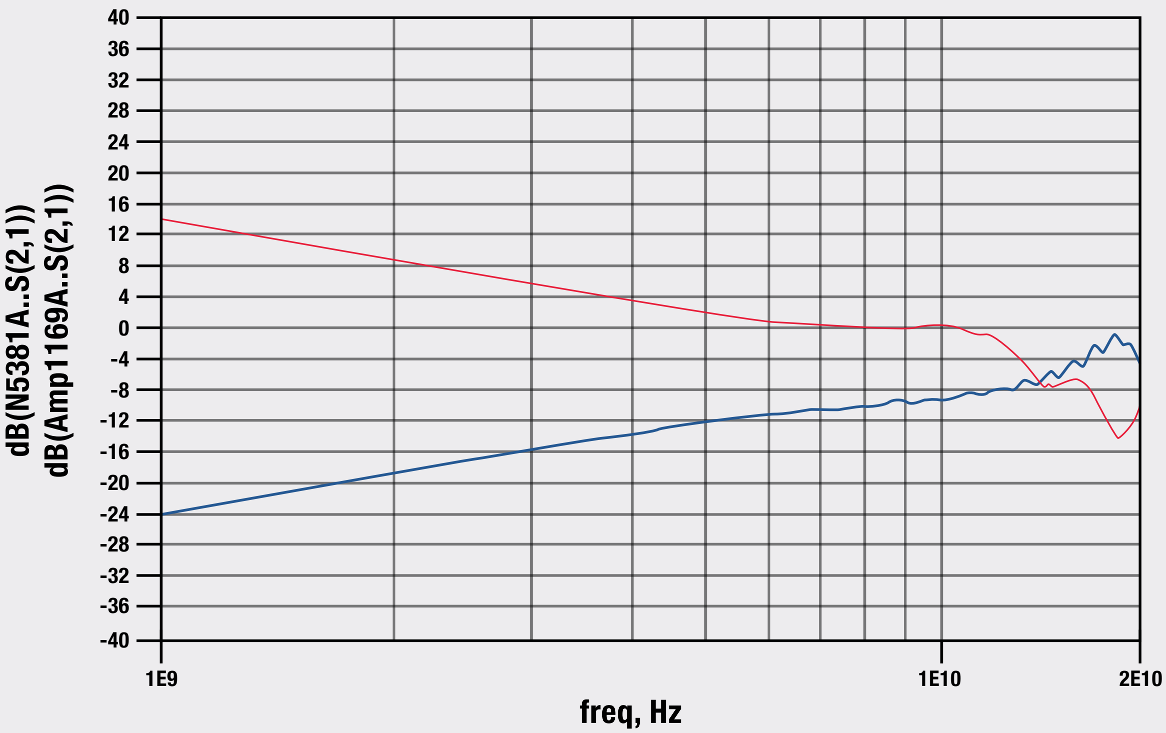

Figure 2 - The frequency response of the InfiniiMax 1169A/B probe amp (red) and the N5381A/B probe head (blue).

The peaking of the N5381A/B is not an issue for the normal 12 GHz bandwidth, but it provides greater signal to the probe amp above 12 GHz and makes extending the bandwidth of the N5381/1169A/B combination more feasible.

PrecisionProbe Calibration Process

Keysight's Infiniium oscilloscopes have an application option called PrecisionProbe (N2909A), which performs an AC calibration of a probe and may allow the bandwidth of the probe to be extended past the normal bandwidth as long as the level of signal boosting is not excessive. Given the peaking of the N5381A/B, the overall probe response has been determined to be extendable to 15 GHz from 12 GHz without excessive boost in noise.

This PrecisionProbe application uses the fast calibration step signal built-in or externally applied to the scope, a high-performance probe verification fixture (N5443A), and phase-matched coax cables to accurately measure and correct for the response of any probe. Note that for PrecisionProbe calibration with the 1169A/B, using the N5443A high-performance probe verification fixture is highly recommended instead of using the E2655C general-purpose probe verification fixture. Also recommended is the N2787A 3D probe positioner to help position the InfiniiMax probe amp with a probe head in place while calibrating.

Any channel can be used to create a custom correction file for a probe but channel 1 will be used here for this example. The correction file created is stored away on the scope hard drive and can be used on any channel that the probe is connected to.

The first step is to perform a DC calibration before running the AC calibration. The probe to be calibrated should be allowed at least a few minutes to warm up. The figure 3 is the setup that will be used here to do the DC calibration.

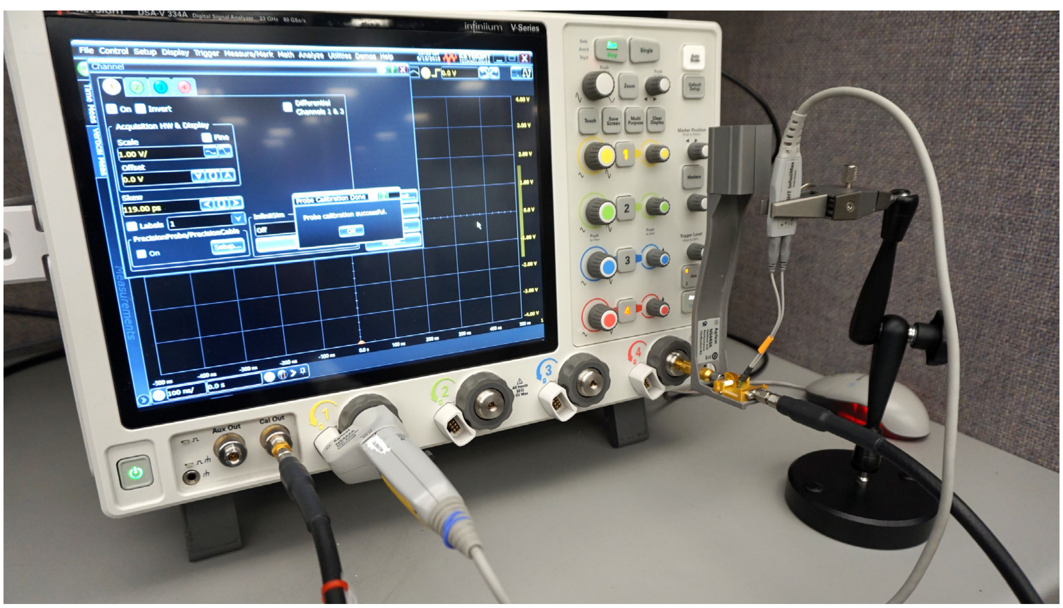

Figure 3 - The setup for the DC calibration of the 1169A/B and the probe head.

Once the DC calibration is successful, the PrecisionProbe AC calibration can be done. Select the “PrecisionProbe/PrecisionCable” radio button and then press the “Start PrecisionProbe” button.

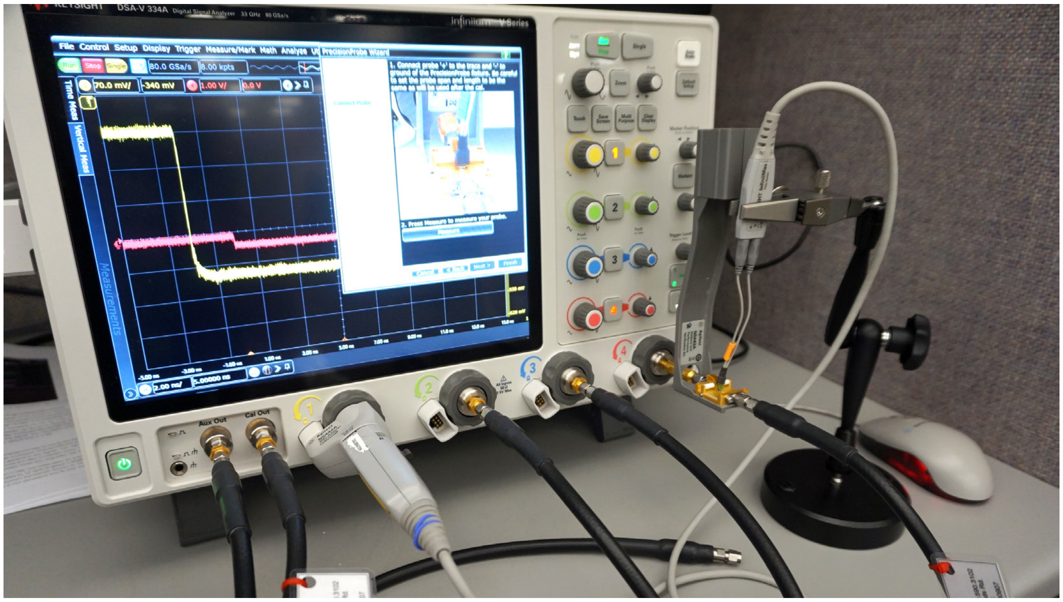

Figure 4 - The setup for the PrecisionProbe AC calibration of the 1169A/B and the probe head.

Follow the instructions to complete the PrecisionProbe calibration. At the end of the successful PrecisionProbe calibration, the software will prompt you to name the new transfer function file for this probe. Input a file name that contains the serial number of the probe amp. Now this file can be used on any channel where the 1169A/B with the N5381A/B is used.

The “PrecisionProbe/ProbeCable” uses the measured probe response obtained during a PrecisionProbe (or Precision Cable) calibration. Note that the PrecisionProbe Calibration takes care of AC correction from the probe amp to the tip end. The gain and offset calibration corrects the DC parameters of the probe. Additionally, the skew calibration should still be done even if a PrecisionProbe calibration has been done.

Figure 5 - The Corrected Bandwidth is set to Automatic and the PrecisionProbe calibration has made the bandwidth of the probe 15.8 GHz.

On Figure 5, notice that the Corrected Bandwidth is set to Automatic and the PrecisionProbe calibration has adjusted the bandwidth of the probe to 15.8 GHz. Different probe amps will achieve slightly different bandwidths but measurements have shown that the probe amps should achieve at least 15 GHz. It is preferable that every probe calibrated has the same bandwidth so that comparisons can be made between probed signals. In that case, the Corrected Bandwidth can be set to Specify Bandwidth and 15.0 GHz entered. Limit Boosting option under Corrected Bandwidth menu lets you control the maximum amount of gain applied to the signal. You can select a limit from 3 dB to 12 dB (or the equivalent ratio) where the default limit is 6 dB.

Vertical Noise Ramifications

One of the inevitable byproducts of using the PrecisionProbe to boost the bandwidth is an increase in vertical noise as the bandwidth increases. PrecisionProbe provides the ability to control the amount of gain that is applied to the signal. You can increase the amount of boosting which improves rise times but also increases noise, or you can decrease the amount of boosting which decreases noise but degrades rise times.

At the normal 12 GHz bandwidth of the N5381/1169, the noise seen on a Infiniium 33 GHz scope with the system bandwidth limited to 12 GHz is about 1.2mVrms. At the extended bandwidth of 15 GHz with the system bandwidth limited to 15 GHz, the noise is now 1.46mVrms. Since the boosting is not excessive and is only over a small percentage of the overall BW, the increase in noise is minimal and the rise time gets faster from 47 psec at 12 GHz to 39.8 psec at 15 GHz.

These are the plots for the noise increase as the bandwidth is boosted from 12 to 15 to 16 GHz. The figure 6 is at 12 GHz. The rms noise is 1.2mVrms at this bandwidth.

Figure 6 - The rms noise at 12 GHz is 1.2mVrms.

The noise has gone up from 1.2mVrms to 1.46mVrms – up 21%, as the bandwidth is boosted to 15 GHz (figure 7).

Figure 7 - The noise has gone up from 1.2mVrms to 1.46mVrms – up 21%, as the bandwidth is boosted to 15 GHz.

As a comparison, the figure 9 is at 16 GHz. The noise is now at 2.5mVrms, up 2x from 12 GHz. Note how “bursty” and “sine wavy” the noise appears on the screen. This is what you may begin to experience with over boosting. From the response plots below, we can see that PrecisionProbe is boosting 16 GHz by around 17dB, which is much too high.

Figure 8 - The noise is at 2.5mVrms at 16 GHz, up 2x from 12 GHz and is “bursty” and “sine wavy”.

Now, let’s take a look at the step response for the different bandwidths. The figure 9 is for 12 GHz bandwidth and the rise time at 10-90% is 47.1 psec.

Figure 9 - At 12 GHz bandwidth, the rise time at 10-90% is 47.1 psec.

At 15 GHz on figure 10, the rise time gets faster at 39.8 psec. However, we are starting to see a little bit of the “sine wave” nature in the base and top.

Figure 10 - At 15 GHz, the rise time gets faster at 39.8 psec.

The figure 11 is at 16 GHz. Now the bursty and sine wavy nature is obvious in the base and top, indicating that the bandwidth boosting is not very realistic at this bandwidth.

Figure 11 - At 16 GHz, the bursty and sine wave nature is obvious in the base and top so the bandwidth boosting is not very realistic at this bandwidth.

Conclusion

- Keysight's PrecisionProbe application provides the AC calibration of a probe that accurately measures and corrects for the response of any probe.
- If a probe has significant signal content beyond its stated bandwidth like the combined performance of the 1169A/B and the N5381A/B, the PrecisionProbe can extend the bandwidth of the probe and enhance its usefulness. Other probes can be used to extend the bandwidth beyond the rated bandwidth of the probe, but the probe's response should not roll off excessively in order not to increase the noise too excessively.
- From extensive evaluations of many 1169B samples, we concluded that the bandwidth boost of 1169A/B with N5381B solder-in head up to 15 GHz (<12 dB) provides a reasonable performance boost with decent compromise in noise.

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