Keysight Measurement Forum 2016

Chang Jae-Yong

Tips for Overcoming Probing Challenges

KEYSIGHT TECHNOLOGIES

HARDWARE+SOFTWARE+PEOPLE=INSIGHTS

Agenda

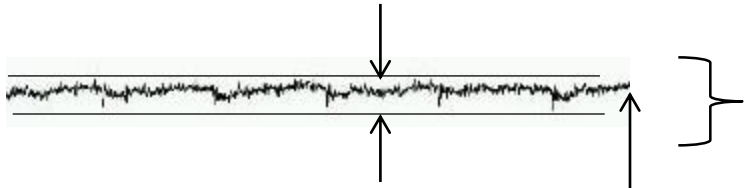
- 큰 오프셋이 존재하는 상태에서의 작은 신호 측정
- 극한온도에서의 신호 프로빙
- Infiniimax 프로브 사용요령
- 프로빙효과(Probing effect)없애는 방법

Agenda

- **큰 오프셋이 존재하는 상태에서의 작은 신호 측정**
- **극한온도에서의 신호 프로빙**
- **Infiniimax 프로브 사용요령**
- **프로빙효과(Probing effect)없애는 방법**

Measuring small signal in the presence of large offset

Fundamental Challenge



Tolerance Band

Challenge: Measure small ac signal on top of large dc signal

Issues to overcome:

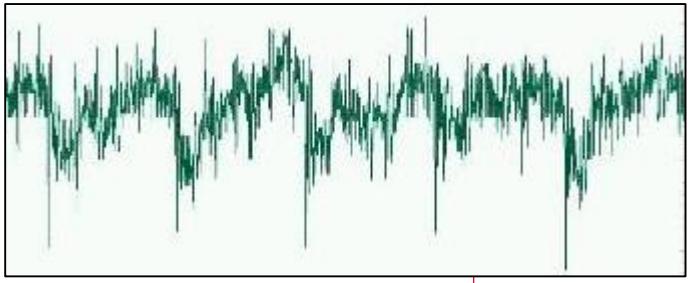
1. Measurement system noise
2. Large signal offset

DC

Probing “golden” rule:

3. Do no harm (probe loading)

Measurement System Noise
(Scope, Probe, Connection…)

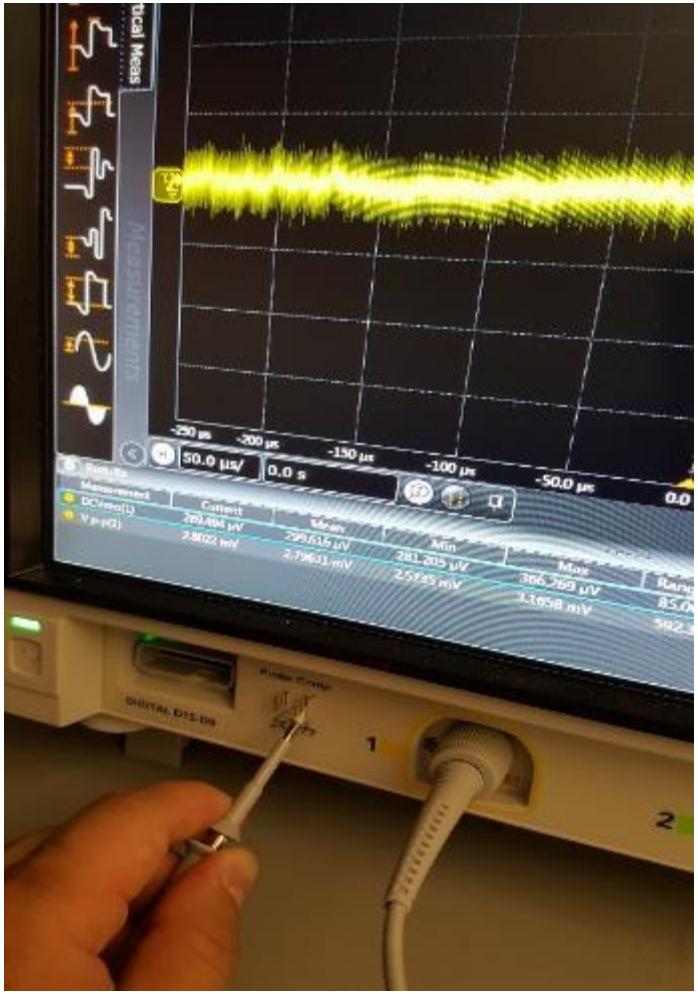


Measuring small signal in the presence of large offset

First things first—Null Measurement (Sanity Check)

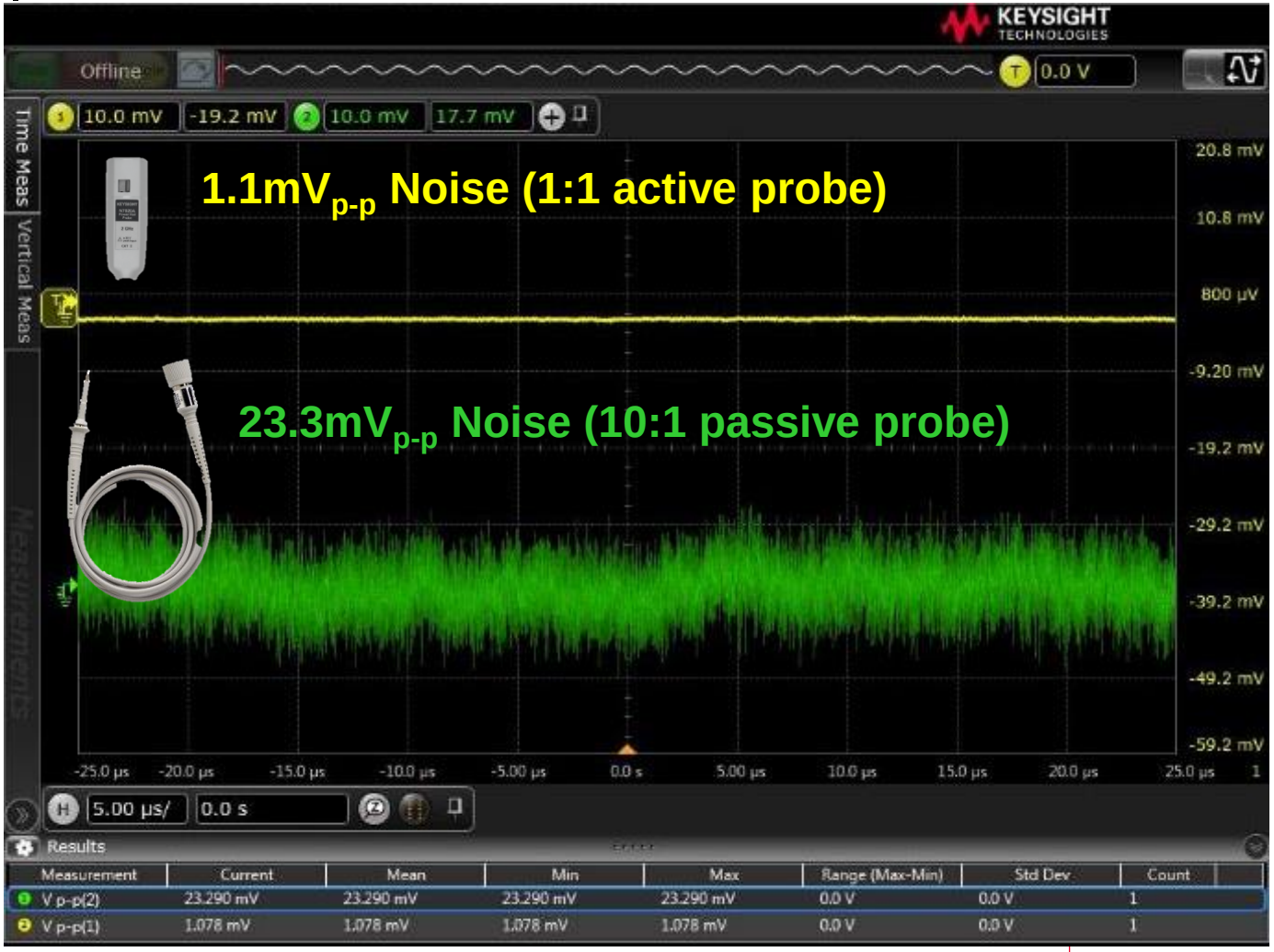
Null measurement: Baseline noise of the oscilloscope measurement system to verify that the tools being used are appropriate for the task at hand.

- Set-up you scope and probe as they will be used—V/div, connection accessories…
- Short the input and measure the baseline noise.



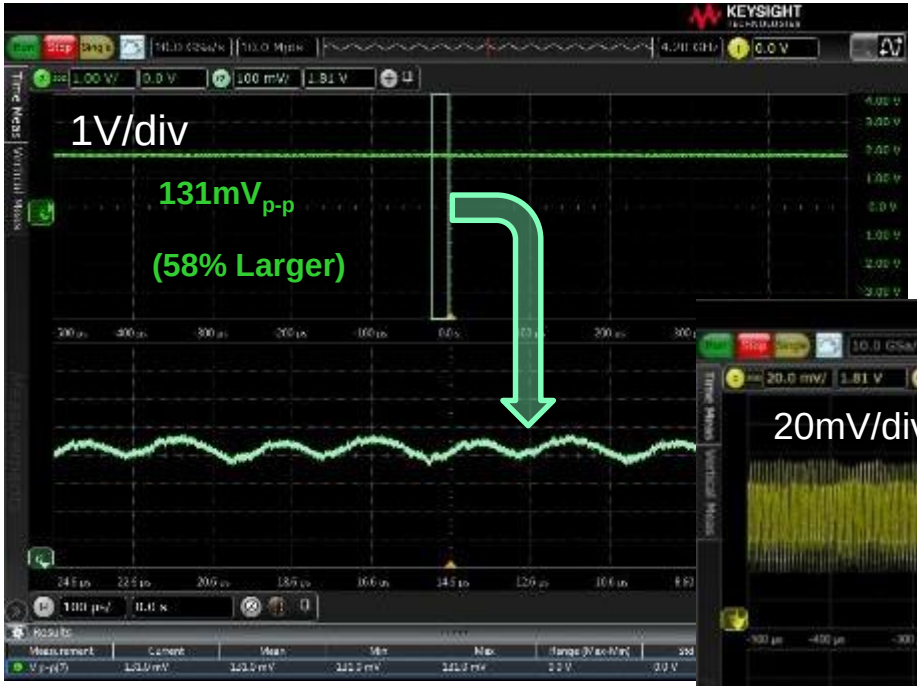
Measuring small signal in the presence of large offset

For small signal measurement, choose a probe with lower attenuation ratio.



Measuring small signal in the presence of large offset

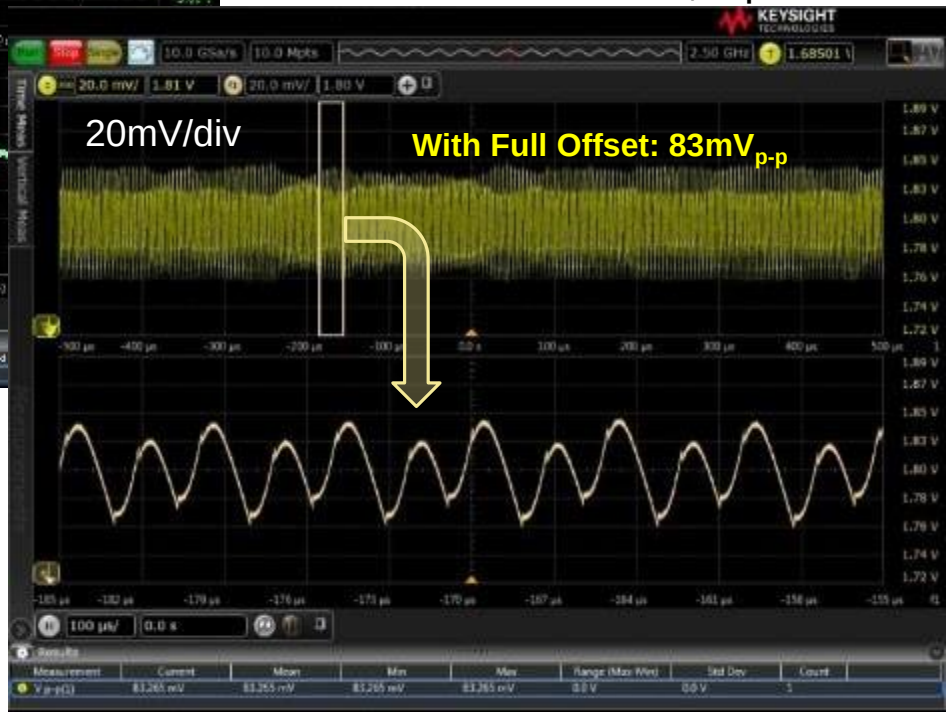
Large DC Signal Offset



At larger V/div

- Sensitivity is decreased
- Scope noise relative to small ac signal is increased.

So.. Use the small V/div, if possible.



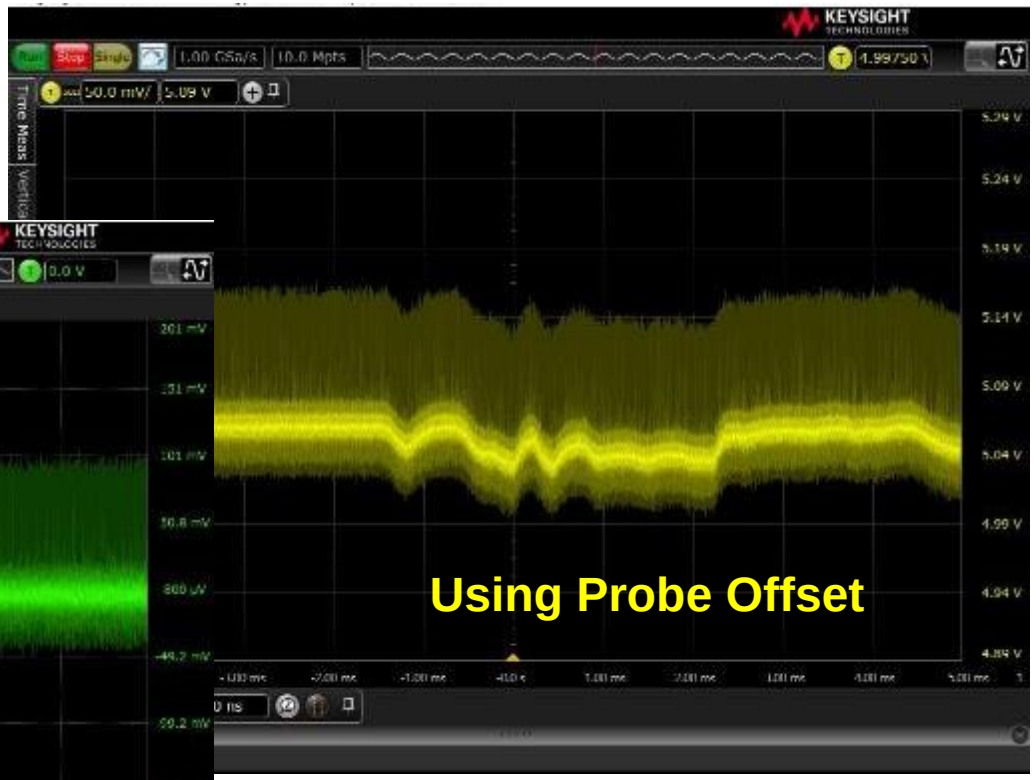
Remove DC Signal Offset

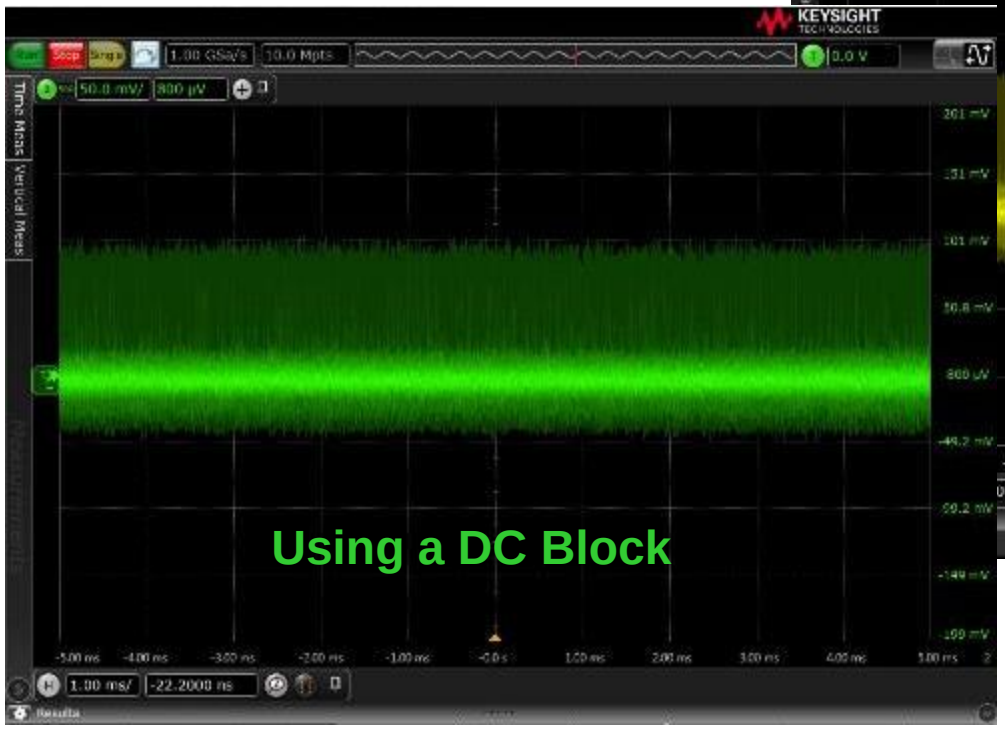
- Probe Offset
- DC Block

Power Integrity Measurements

Removing Large DC Signal—Probe Offset or DC Block?

DC blocking cap removes DC as well as low frequency AC contents. Probe offset does not.





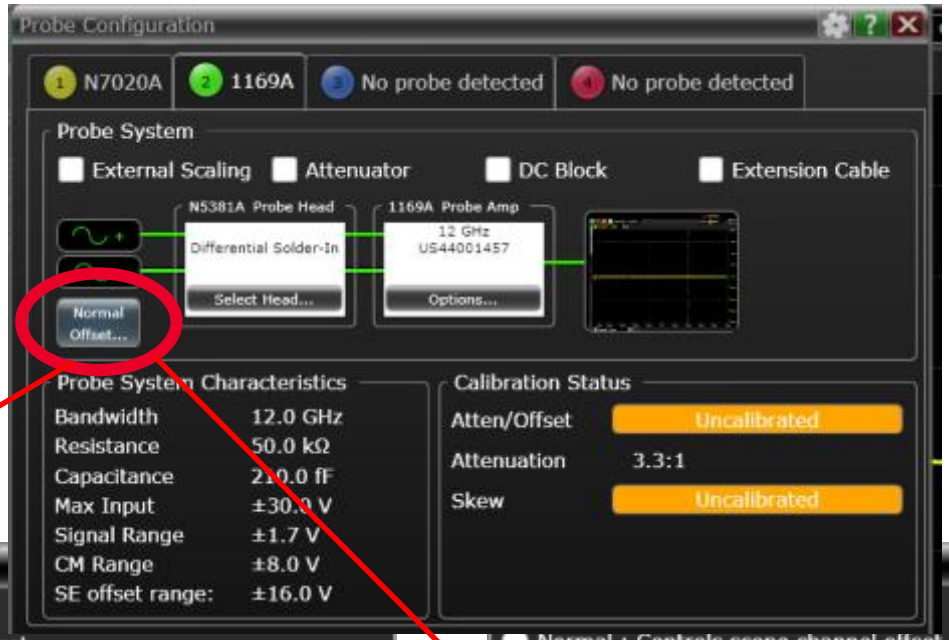
DC Block

Take advantage of large “probe” offsets provided by Keysight active probes

Model Number	Description	Offset Range
N2795A/96/97A	Single-ended Active probes	±12 V
N2750A/51A/52A	InfiniiMode Differential probes	±15 V
N7020A	Power rail probes	±24 V
1130A – 34A	InfiniiMax I probes	±12 V
1168A/69A	InfiniiMax II probes	±16 V
N2800A-03A, N2830A-32A, N7000A-04A	InfiniiMax III/III+	±16 V

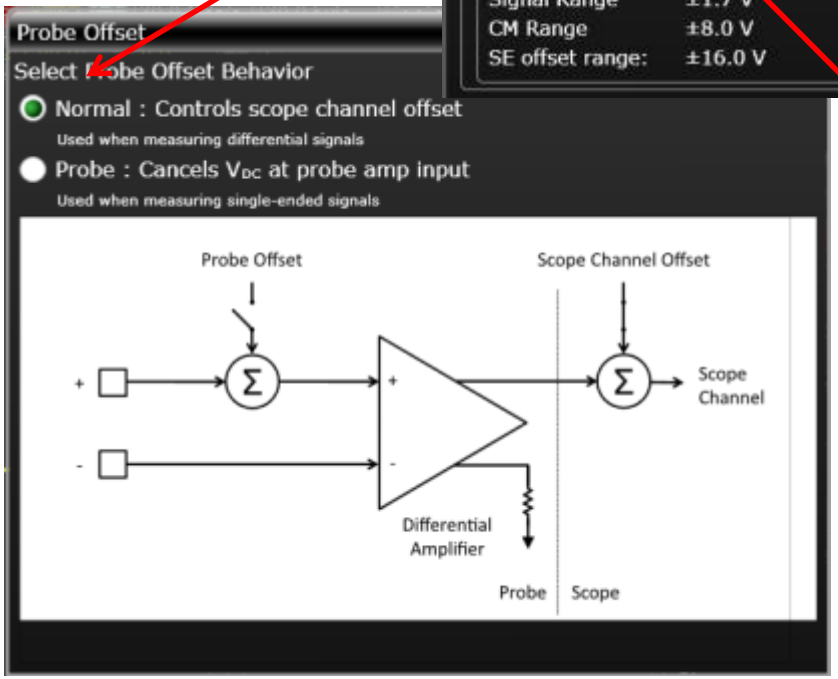
Large probe offset can be applied at any V/div settings, while scope offset is V/div dependent.

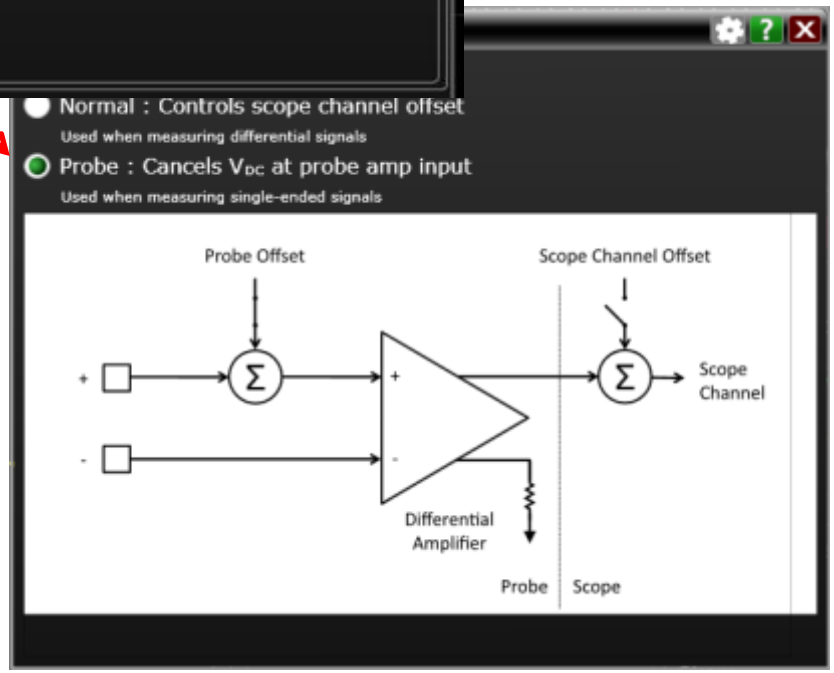
Offset Menu in New Infiniium GUI



Scope offset – proportional to V/div setting

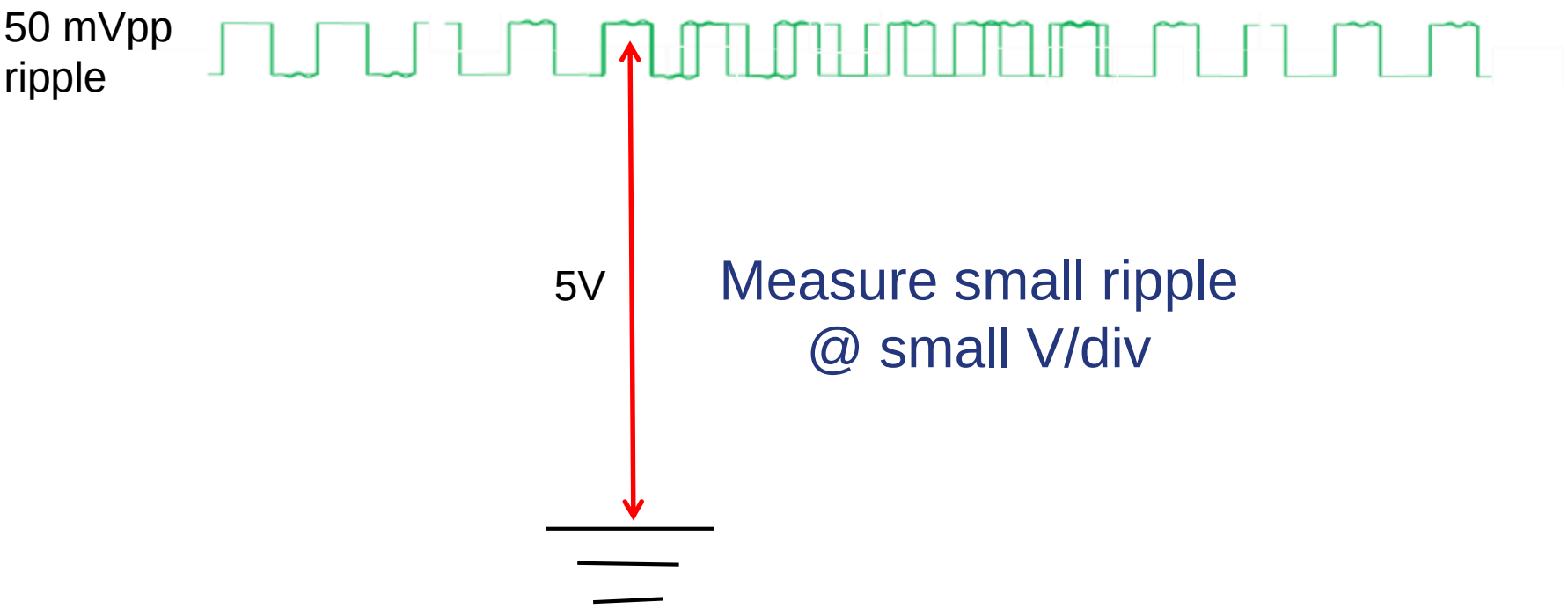
Probe offset – same offset range offered independent of V/div setting



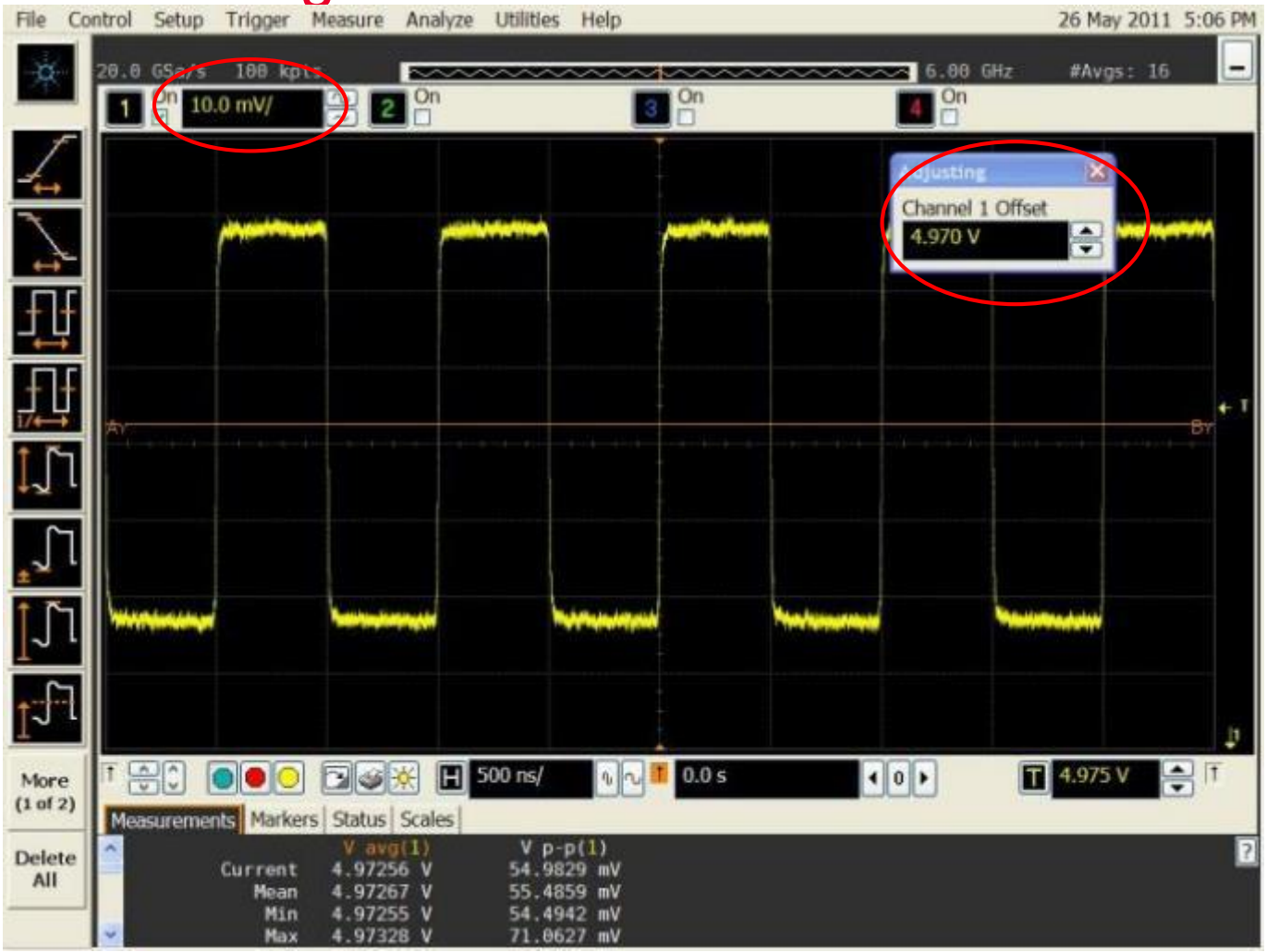


Understanding Offset in InfiniiMax Probes

How would I measure small ripple riding on top of large DC offset with InfiniiMax probe?



Understanding Offset in InfiniiMax Probes



50 mVpp signal on top of 5V measured with InfiniiMax probe applying -5V offset to the target

Agenda

- 큰 오프셋이 존재하는 상태에서의 작은 신호 측정
- **극한온도에서의 신호 프로빙**
- Infiniimax 프로브 사용요령
- 프로빙효과(Probing effect)없애는 방법

Extreme Scope Probing
Extended Operating Temperatures

Traditionally tested for survival

- Product/device “running” at extended temperatures in chamber or under hood while monitoring for failures.
- If/when failures occur a postmortem is conducted
- Changes are implemented and temperature testing resumes

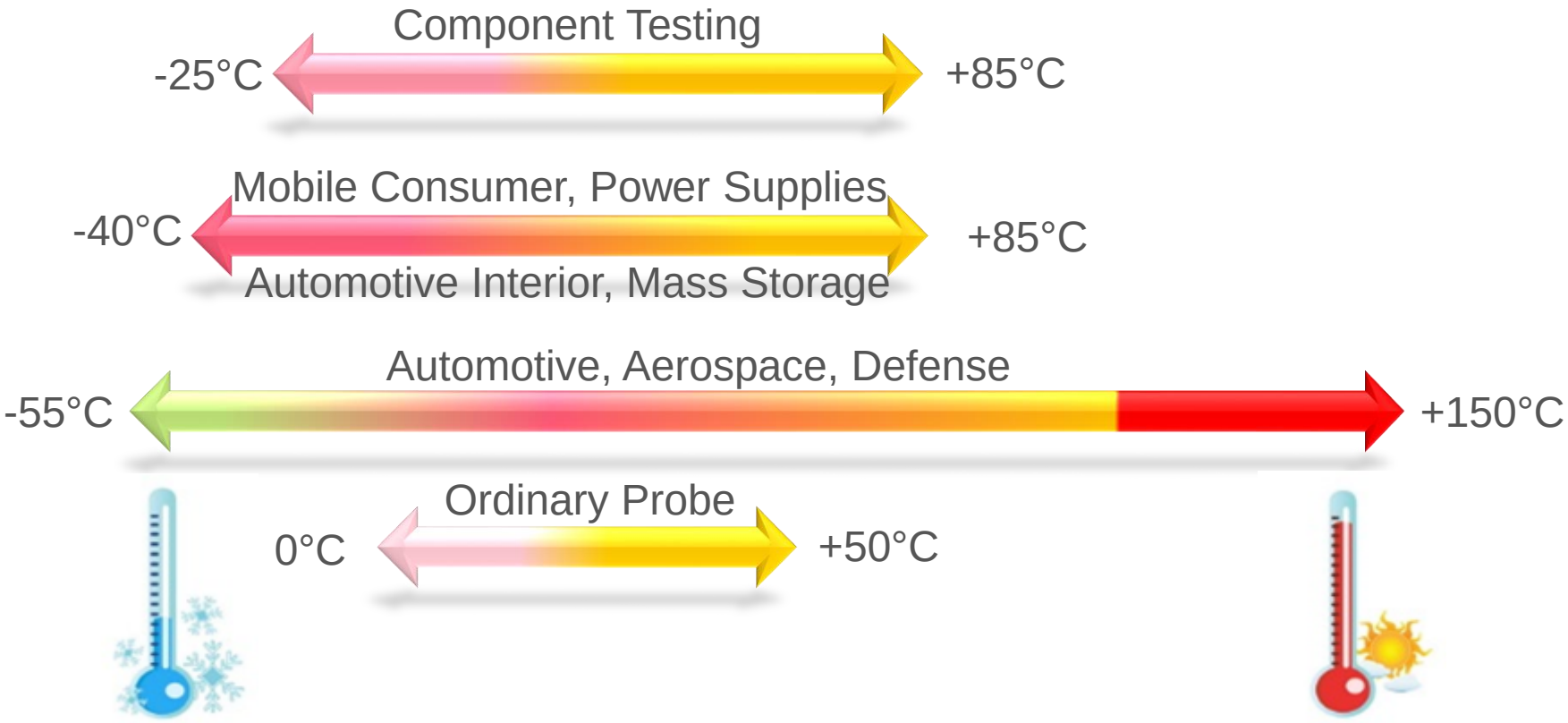
Desire for quantitative data and margin analysis

- Preference for understanding amount of margin
  - Identify opportunities for improved reliability
  - Identify opportunities for improved economics

Extreme Scope Probing

Extended Operating Temperature

Temperature test ranges and applications

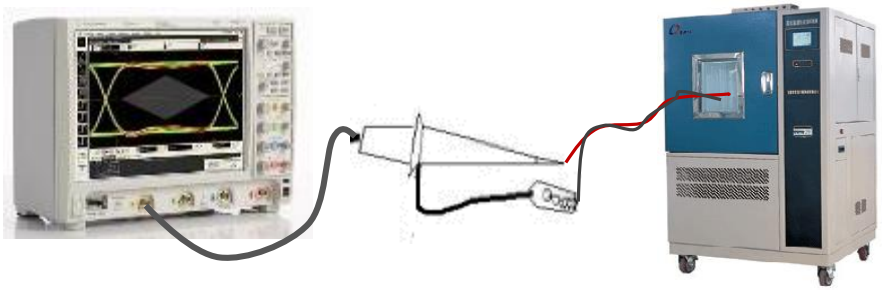


Extreme Scope Probing

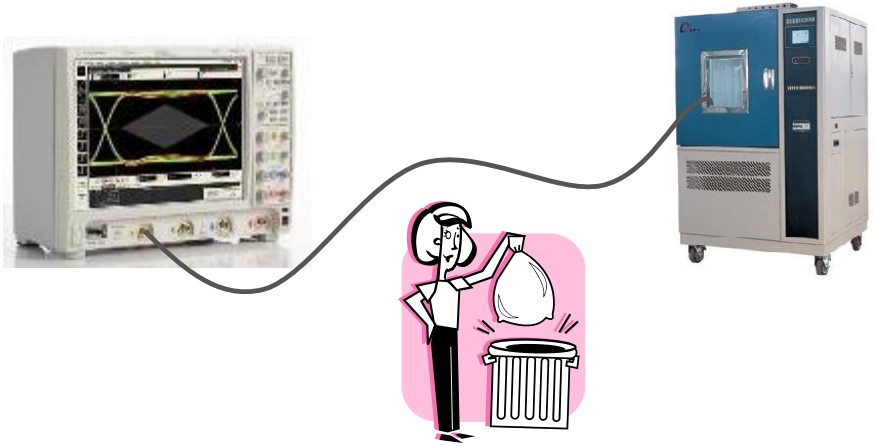
Extended Operating Temperature

Two most common methods today

- **Probe connected to DUT via long extensions**
  - Limited bandwidth and non-flat frequency response
  - Noise couples onto extension wires



- **Probe is placed directly into chamber**
  - Cost of “disposable” probes
  - Probe failures create false readings



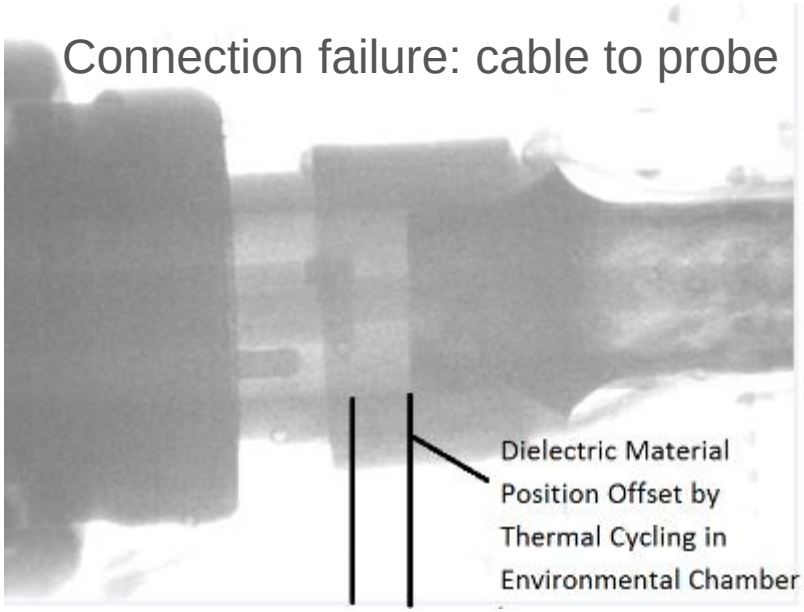
Extreme Scope Probing

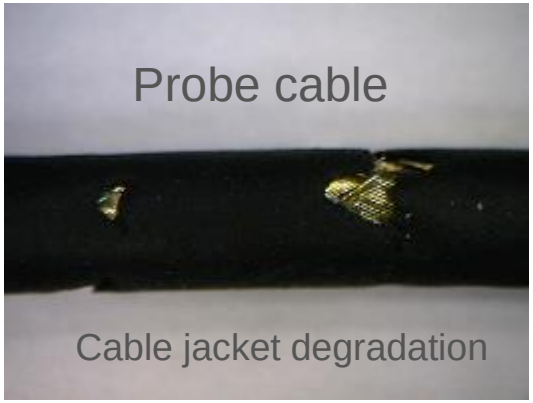
Extended Operating Temperature

Common Failure Modes (with ordinary probes)

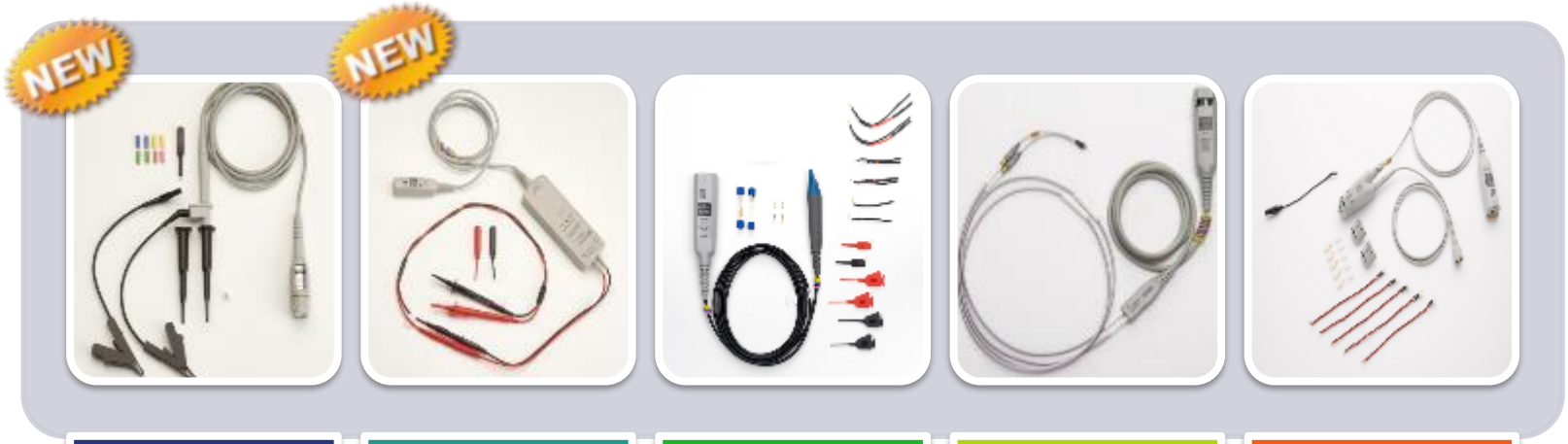
- Coax cable damaged due to thermal expansion
  - Termination failures
  - Discontinuities
- “Plastics”
  - Working range up to ~60°C
  - Deformation, degradation, discoloration
  - Mechanical failures
- Frequency response degradation

Connection failure: cable to probe





Keysight's Extreme Temperature Probing Solution



N7007A	N7013A	N2797A	InfiniiMax + N5450B extension cable + probe head	N2820A/21A High-sensitivity current probe
Single-ended Passive	Probing kit for differential probe	**Single-ended Active**	Differential & SE Active	Current
400 MHz	70 MHz	1.5 GHz	1.5 GHz – 16 GHz	3 MHz
10MΩ input R	Compatible with N2790A, N2791A, N2792A, and N2818A	1MΩ input R	50 kΩ input R	1.5 GΩ input R
2 m long cable	70 cm long cable	2 m long cable	-55 to +150 °C	-55 to +150 °C
-40 to +85 °C	-40 to +85 °C	-40 to +85 °C		

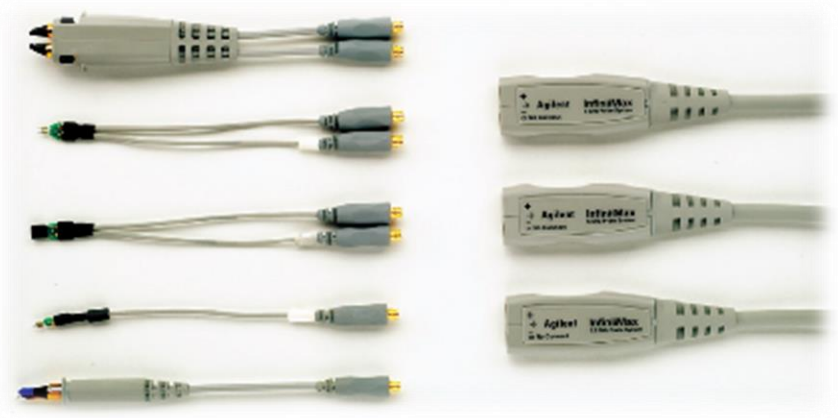
Keysight offers the broadest selection of extreme-temperature oscilloscope probing solutions.

Extreme Scope Probing

Extended Operating Temperature

N5450B extension cable
Full Bandwidth
-55 °C to +150 °C

InfiniiMax Probes



Probe Heads Probe Amps

Up to 16 GHz bandwidth with InfiniiMax III

With N5381A/B, N5441A solder-in head: -55 °C to +150 °C
With E2677A/B solder-in, E2678A/B socketed, N5425A/26A ZIF: -25 °C to +80 °C

Extreme Scope Probing
Extended Operating Temperature

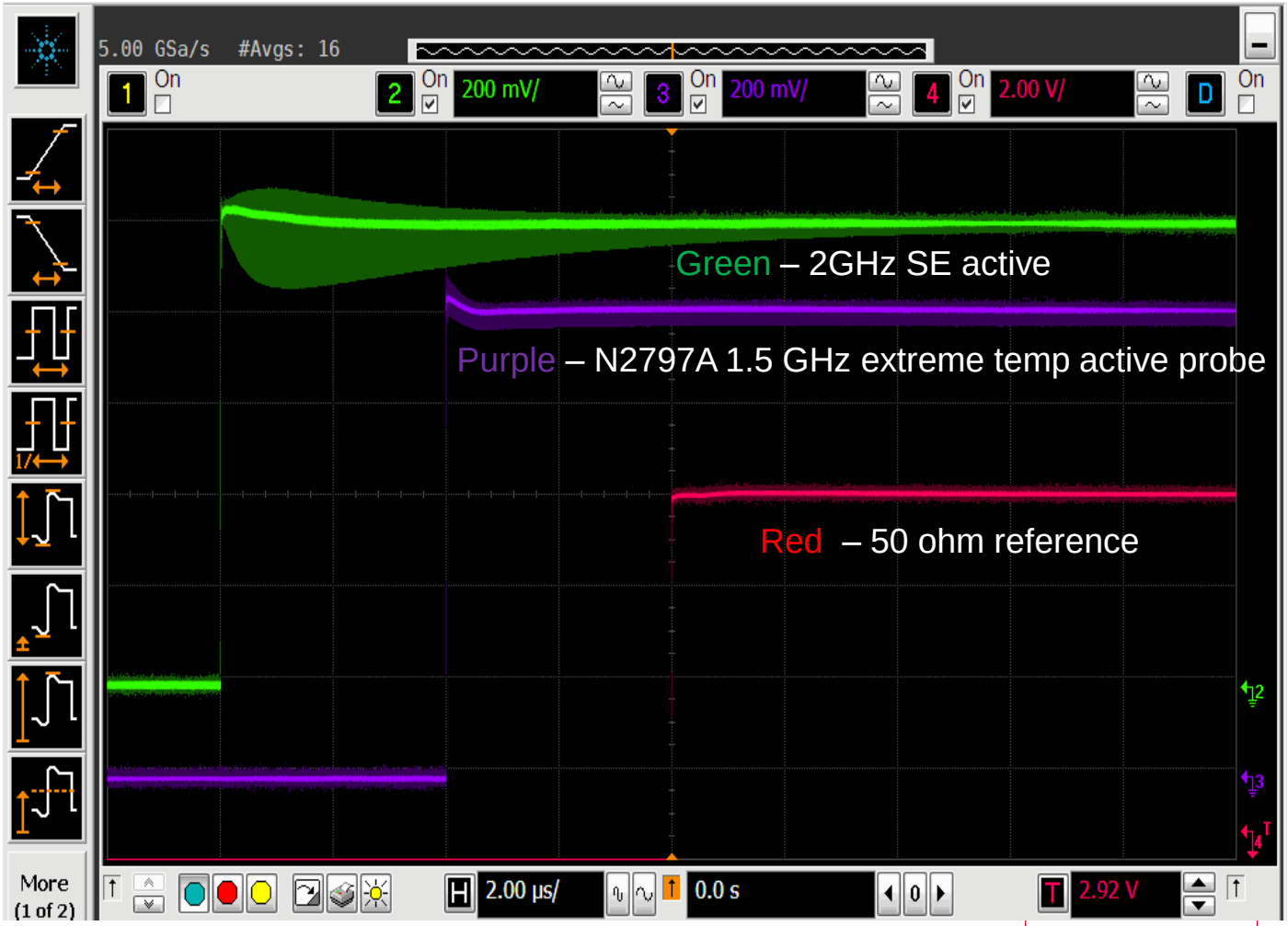
N2797A : 1.5GHz Single-Ended Active Probe

- Designed and tested specifically for chamber applications
- Operating range: -40 - +85°C
- 1 Mohm input impedance (@DC)
- 2 meter cable with silicone jacket
- Accessories specifically for chamber use
- Positioners/holders available

Extreme Scope Probing

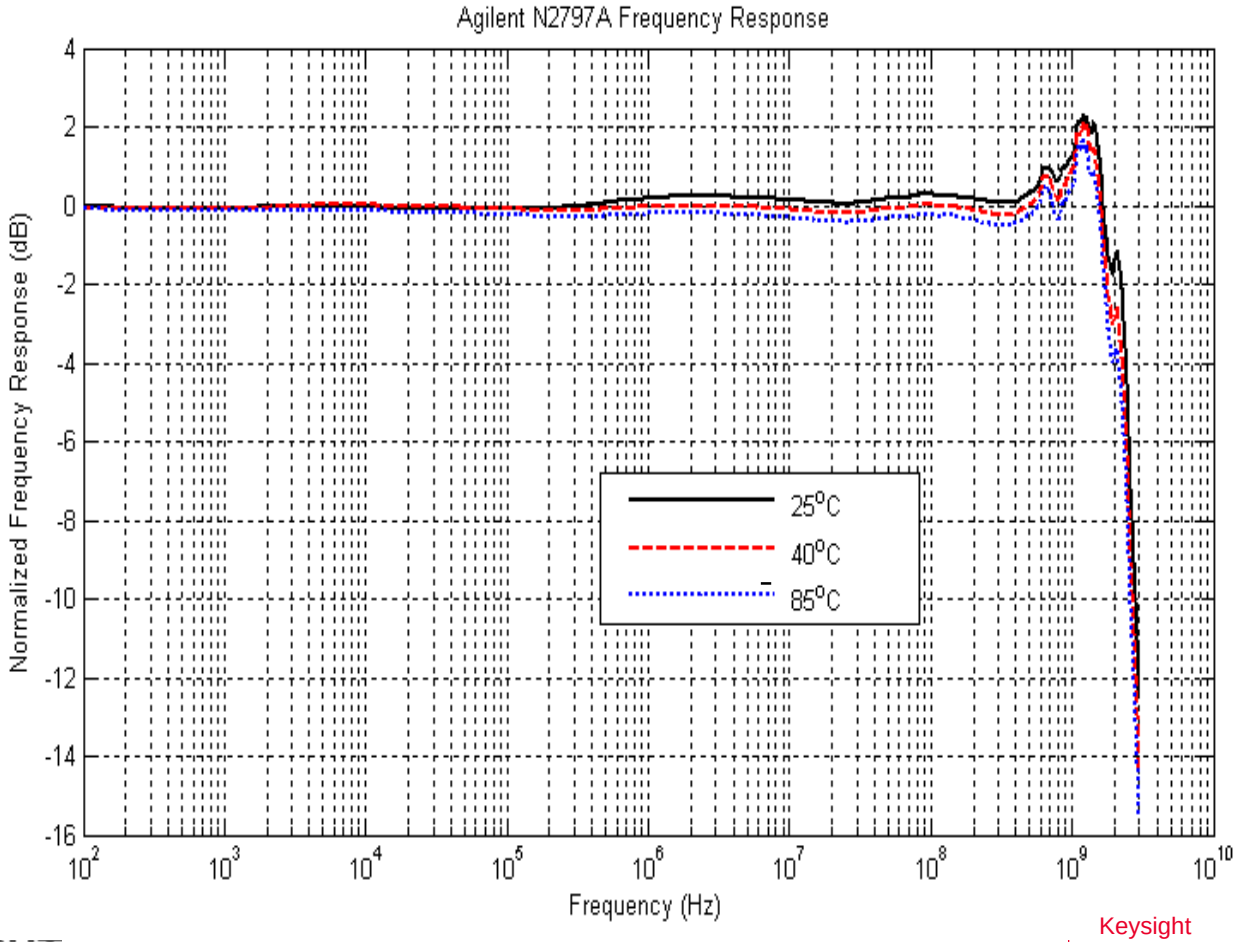
Extended Operating Temperature

N2797A Step response testing - scope set to Infinite persistence from -45 – +90°C



Extreme Scope Probing
Extended Operating Temperature

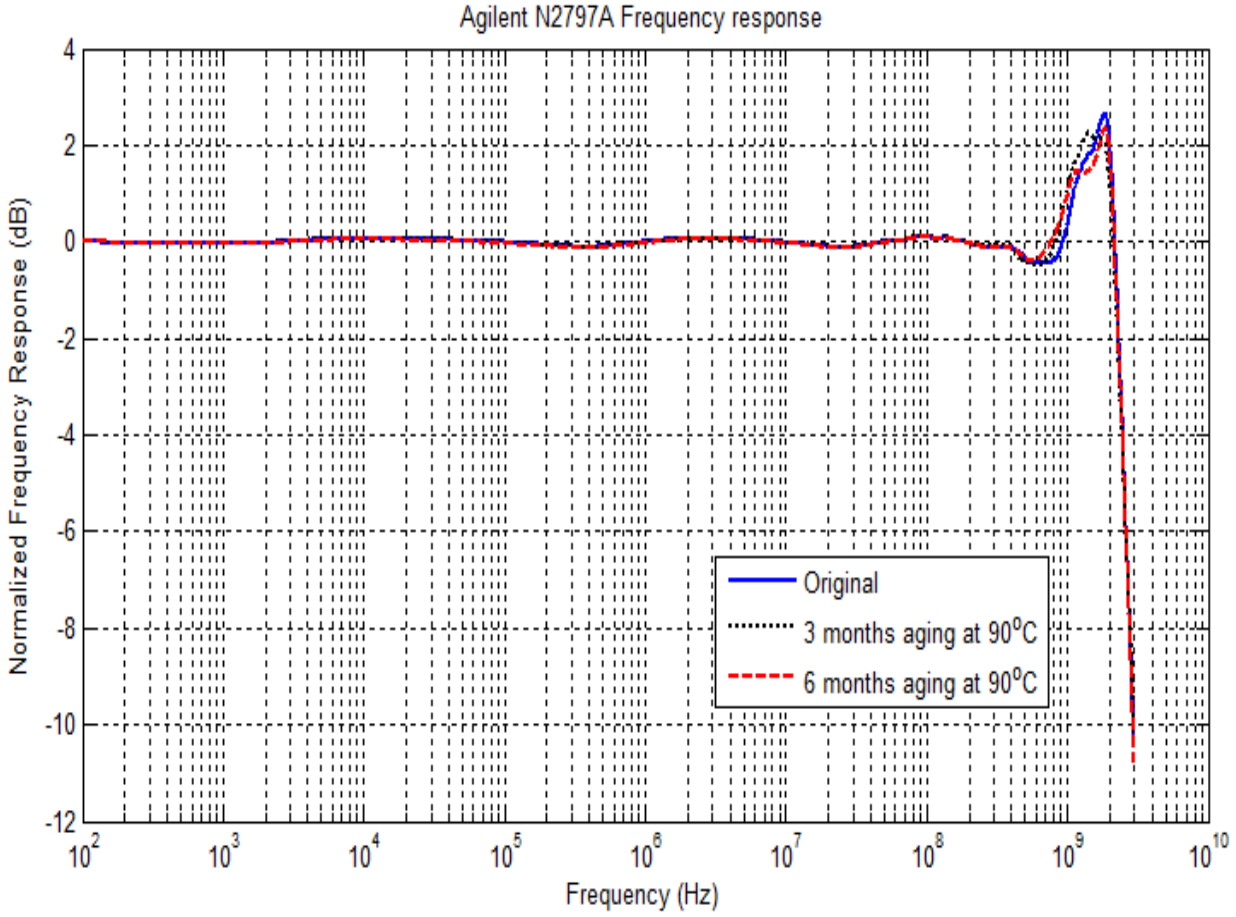
N2797A Frequency response over extreme temperature



Extreme Scope Probing

Extended Operating Temperature

N2797A aging test @90 °C over 6 months



Extreme Scope Probing

Extended Operating Temperature

N2797A Extreme Temperature Active Probe

Agilent Technologies

Ambient Operating Temperature: –40°C to +85°C (–40°F to +185°F), otherwise specified

Visit the Probe Resource Center at www.agilent.com/find/PRC

Recommended Probe Configurations

1 Rigid Tip or Solderable Tip with Ground Blade

Bandwidth: 1.5 GHz

2 6 cm Y-Leads with 0.1″ Headers

Bandwidth: 1.0 GHz

3 Solderable Tip with Right-Angle Ground

Bandwidth: 800 MHz

4 9 cm Y-Leads with 0.1″ Headers

Bandwidth: 800 MHz

5 Y-Leads with Flexible Nose Clips or Pico Hook Tips

–20°C to +80°C (–4°F to +176°F)

Bandwidth: 500 MHz

N2798A Accessory Kit

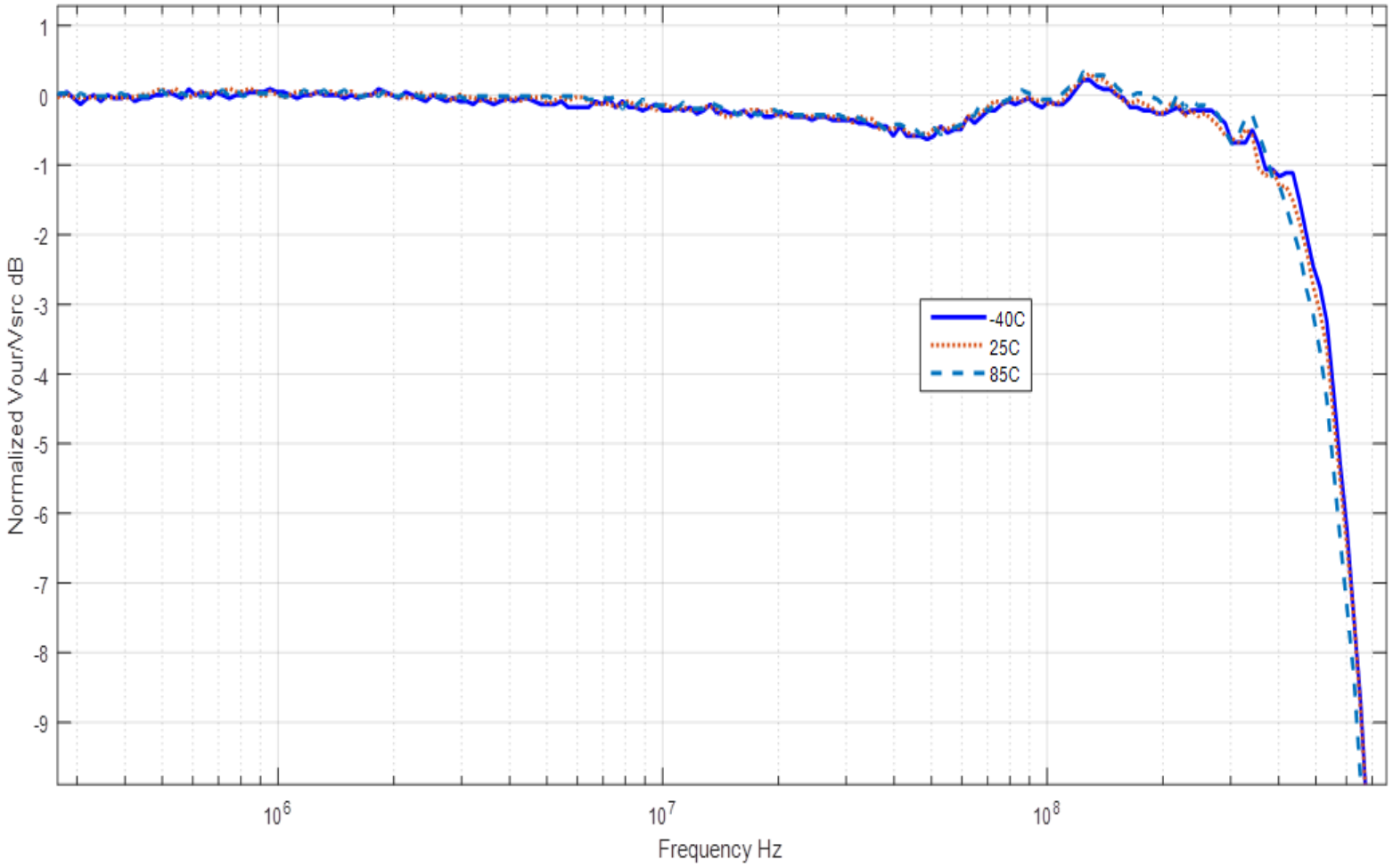
Quantities listed are also the quantities included with the probe.

N7007A 400 MHz passive probe with extreme temperature and humidity range

- 400 MHz bandwidth passive probe
- **Operating temp: -40 ºC to +85 ºC**
- **Operating humidity: 40 ºC 90%RH**
- 10:1 attenuation ratio
- **2m cable length**
- 10 MΩ input R when terminated into 1 MΩ scope input
- **1000 V CAT II, 600 V CAT III**
- Comes with an alligator ground clip, hook clip and spring ground tip
- Low cost

Low cost high Z passive probe ideal for a broad range of general-purpose extreme temperature applications

Frequency response variation over temperature (-40 to +85 degC, N7007A)



Step response variation over temperature

(two N7007A probes tested in -40 to +85 degC with Infinite persistence mode on)

N7013A 70 MHz extreme temperature extension kit

- High-voltage differential extension cable for extreme temperature measurement
- **Up to 70 MHz with N2790A/91A/92A/N2818A diff probe**
- **Operating temp: -40 ºC - +85 ºC**
- Comes with pairs of 70 cm extension cable (damped), hook tips, and socketed head adapters
- Primarily for power supply or automotive bus testing including CAN/CAN FD
- Available now

Enabling your high/medium voltage differential probe into an extreme temp probing solution

Extreme Scope Probing

Extended Operating Temperature

Extreme Probe Options in Detail

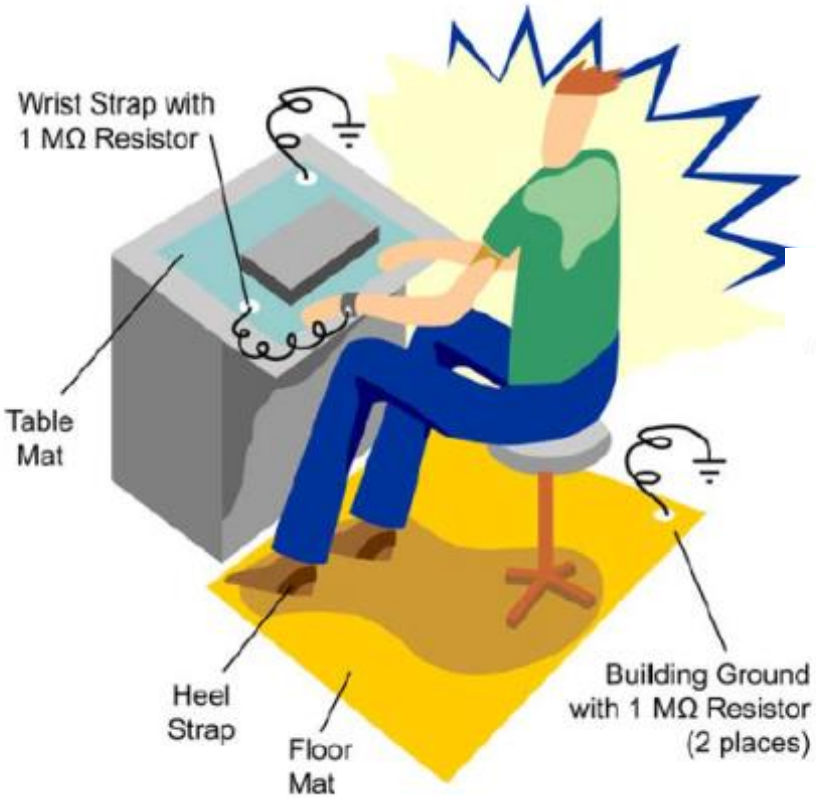
	N7007A Passive probe	N7013A Differential extension	N2797A SE active probes	InfiniiMax with N5450B
Bandwidth	DC to 400 MHz	DC to 70 MHz	DC to 1.5 GHz	DC to 26 GHz
Operating temp	-40 °C - +85 °C	-40 °C - +85 °C	-40 °C - +85 °C	-55 °C - +150 °C or -25 °C - +80 °C
Single-ended or Diff?	Single-ended	Differential	Single-ended	Single-ended or Differential
Max input range	1,000 V CAT II, 600 V CAT III	Max input rage of compatible probe (N2790A,N2791A, N2792A, N2818A)	-8V to +8V (dynamic range) ±12V (offset range)	3.3Vpp (w/ InfiniiMax II 1168A/69A) 5Vpp (w/ InfiniiMax I 1130A-34A)
Input loading	10 MΩ, 15 pF input	Input loading of compatible probe	1 MΩ, 1 pF input	50 kΩ diff, <0.5 pF input C

For more information, check out www.keysight.com/find/extreme

Agenda

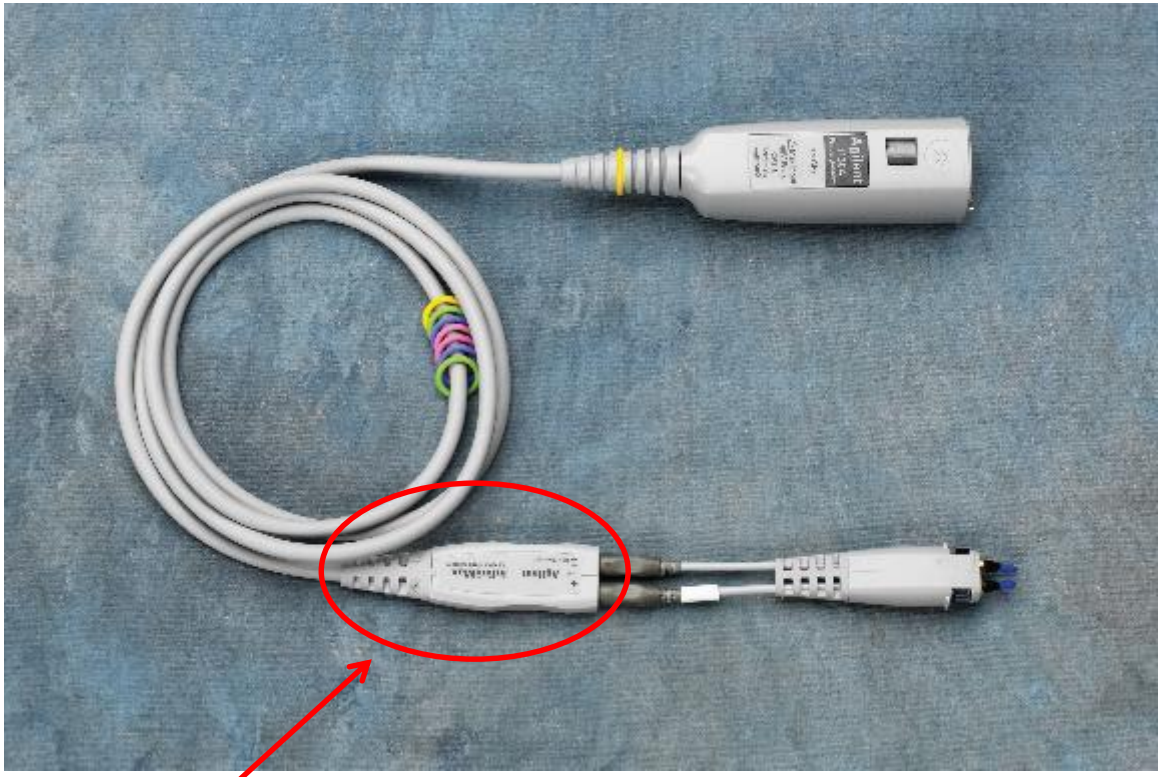
- 큰 오프셋이 존재하는 상태에서의 작은 신호 측정
- 극한온도에서의 신호 프로빙
- **Infiniimax 프로브 사용요령**
- 프로빙효과(Probing effect)없애는 방법

“Always” use a static safe workstation and wear a grounded ESD wrist strap



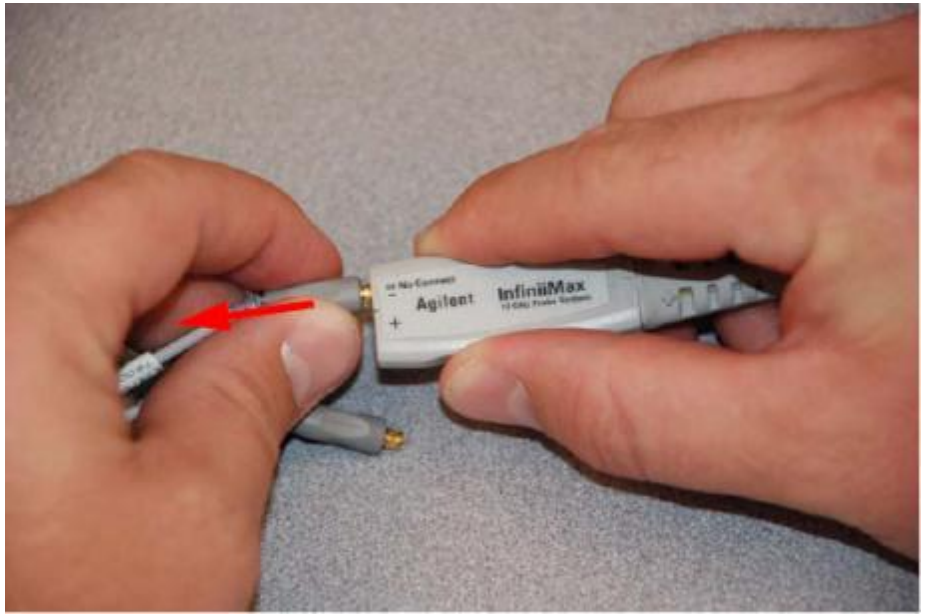
InfiniiMax probes and accessories are ESD sensitive devices and should be treated with care!

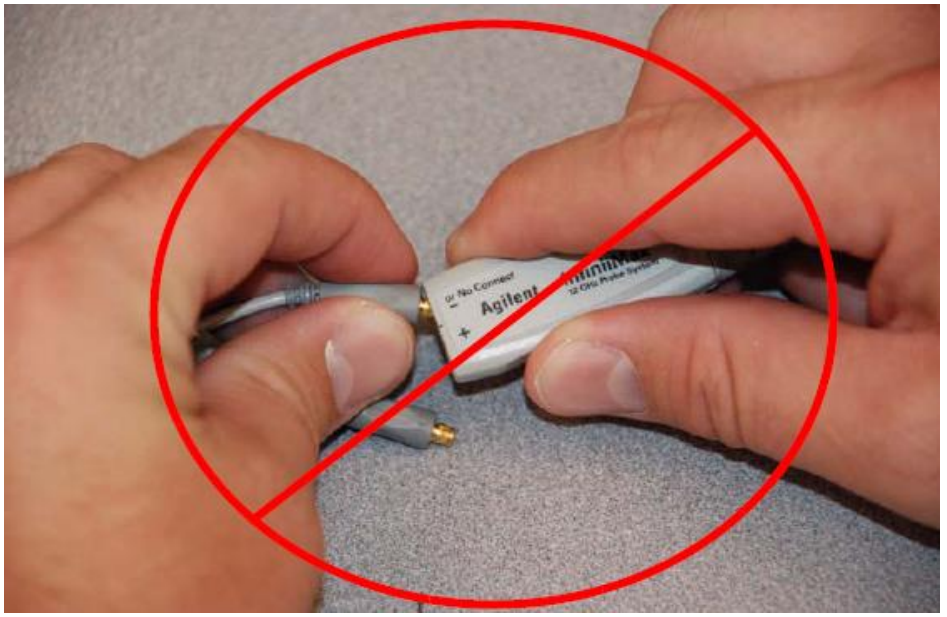
Handling InfiniiMax probe amp



Delicate active circuits are located here. So, treat this part carefully and take general precautions. **No mechanical shock (dropping, smashing) and getting wet etc.**

Mating/Unmating probe heads



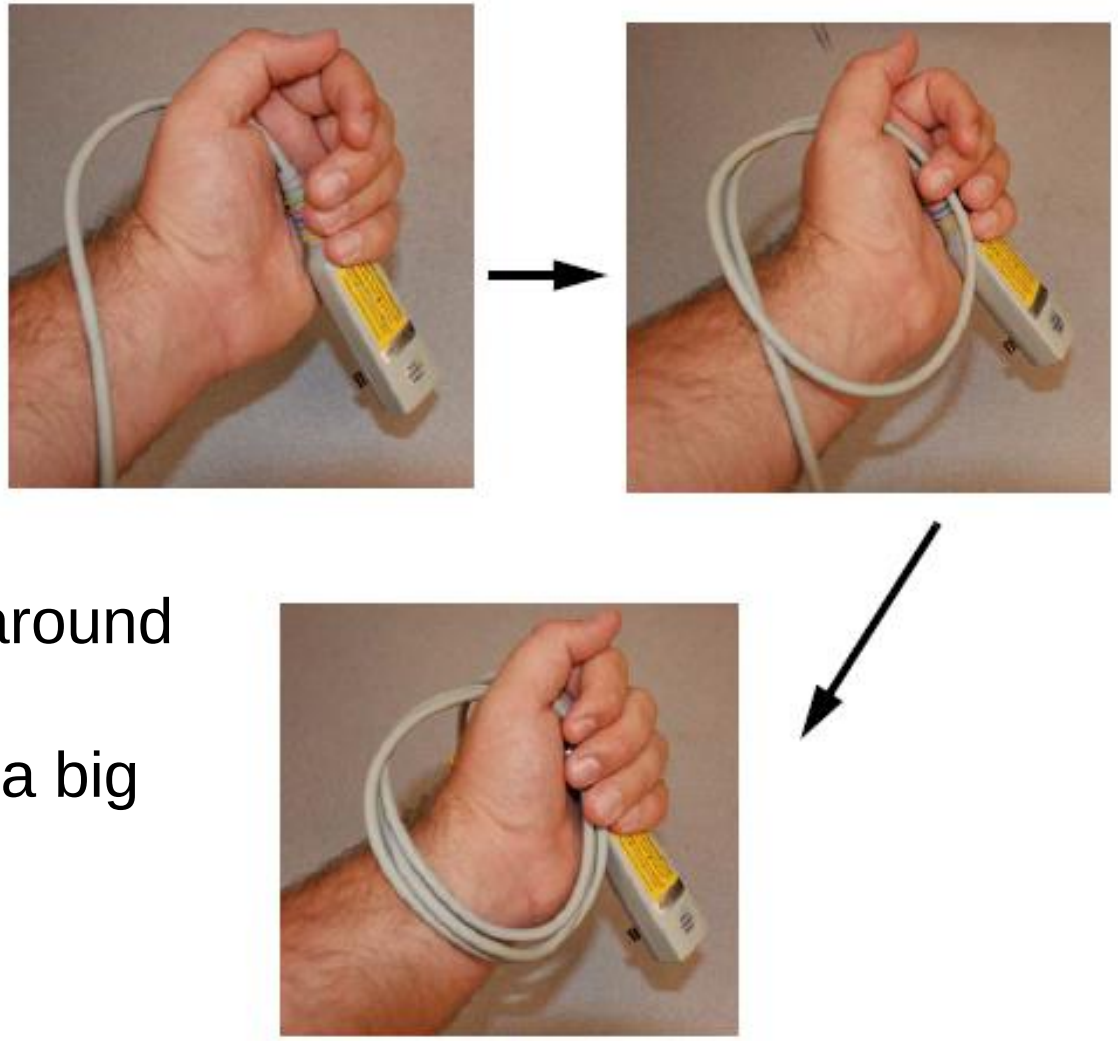


Straight out/Straight in

Never bend, wiggle or twist the head

We've tested them to 2000 cycles and the electrical performance was solid.

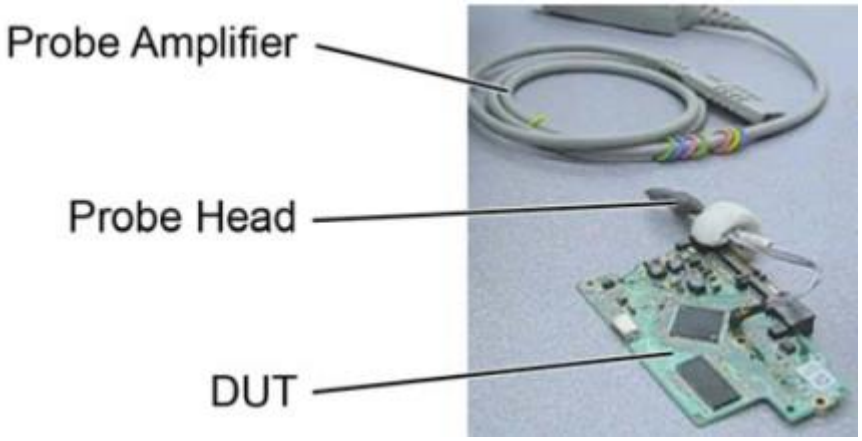
Recommended method to coil and store your probe



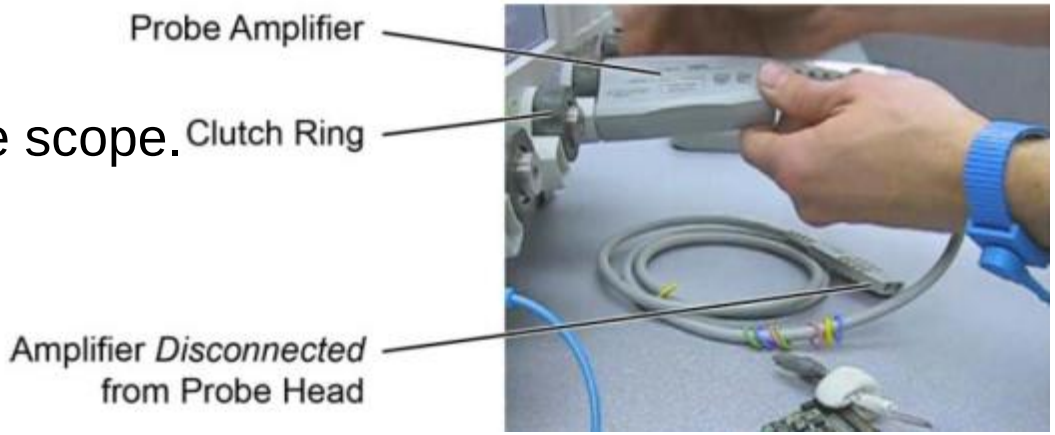
- Wrap the cable around your thumb.
- Coil the cable in a big radius.

Recommended connection steps

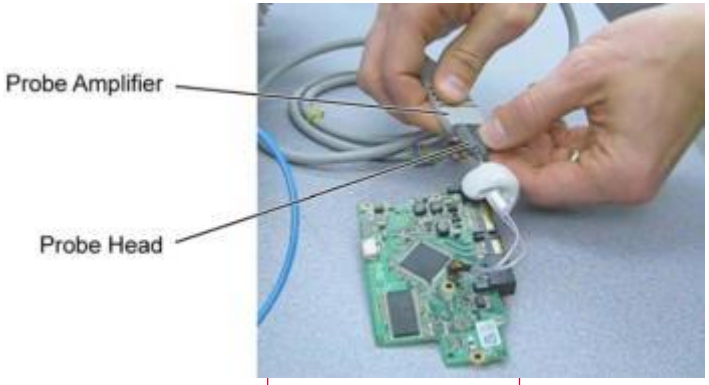
1. Attach the probe head to the DUT.



2. Connect the probe amp to the scope.



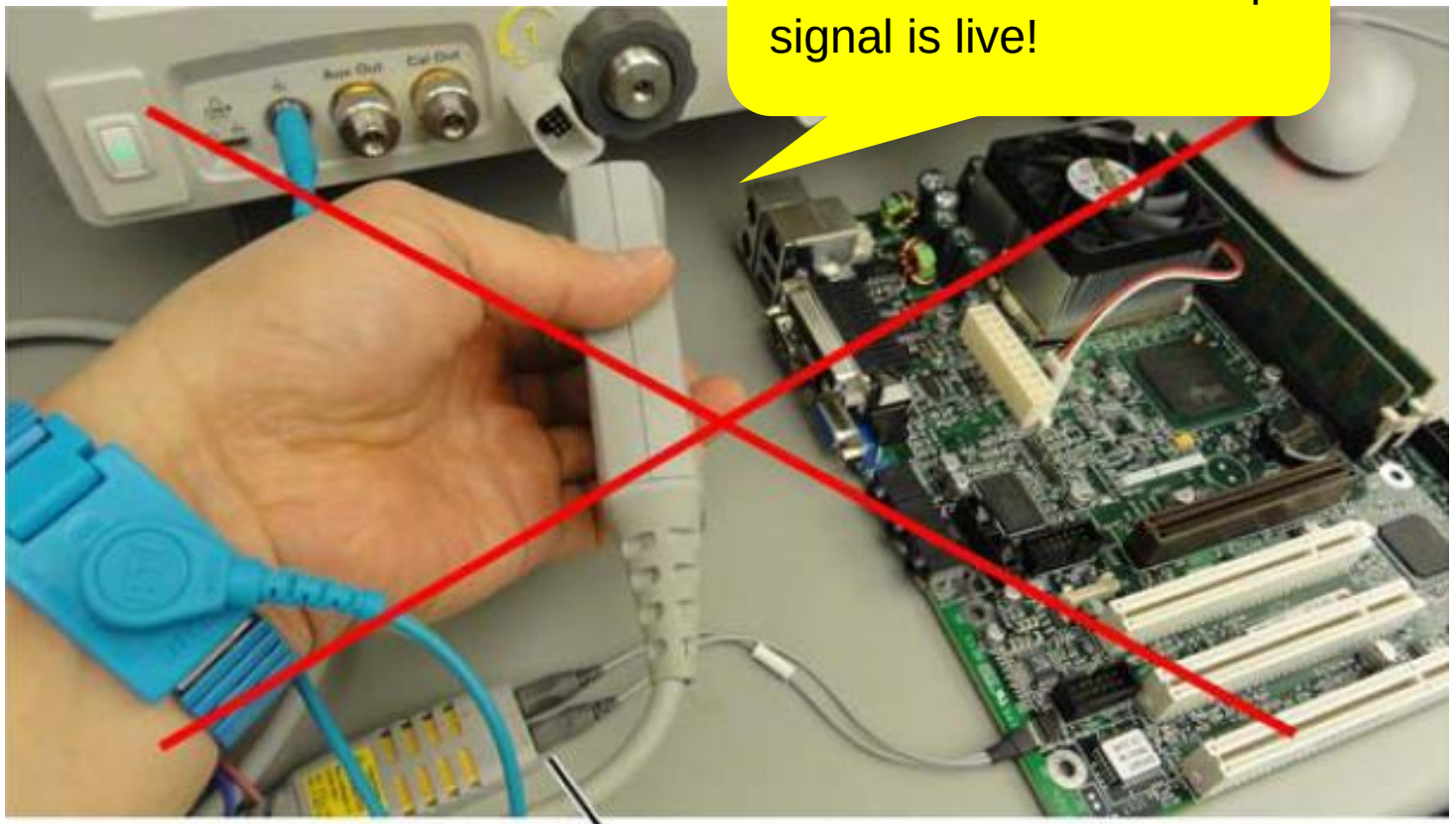
3. <u>Connect the probe head to the probe amp as a last step.</u>



KEYSIGHT TECHNOLOGIES

When disconnecting probe

Never leave the probe “unterminated” while input signal is live!



Always disconnect Probe Head from Probe Amplifier First!

What is strain relief? 압력완화

The **strain relief** is typically a series of ridges at the point where the cabling meets the connector or plug that allows flexibility in the cable without putting stress on that vulnerable point in the cord.

Strain relief can enhance flex life performance

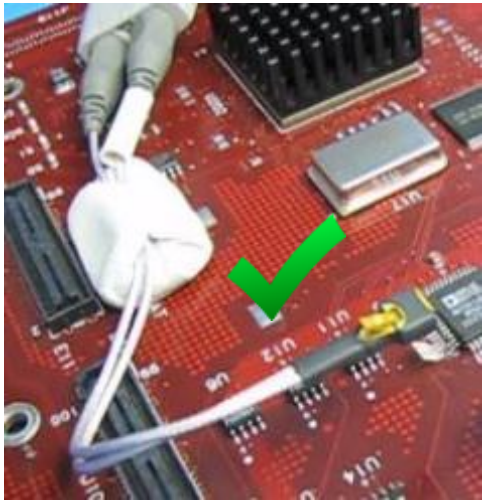
An effective strain relief should prevent any load applied to the cable from being transferred to conductor terminations.

Strain relief methods

Provide some “strain relieves” to secure the probe amp to the DUT

Velcro

Kapton tape

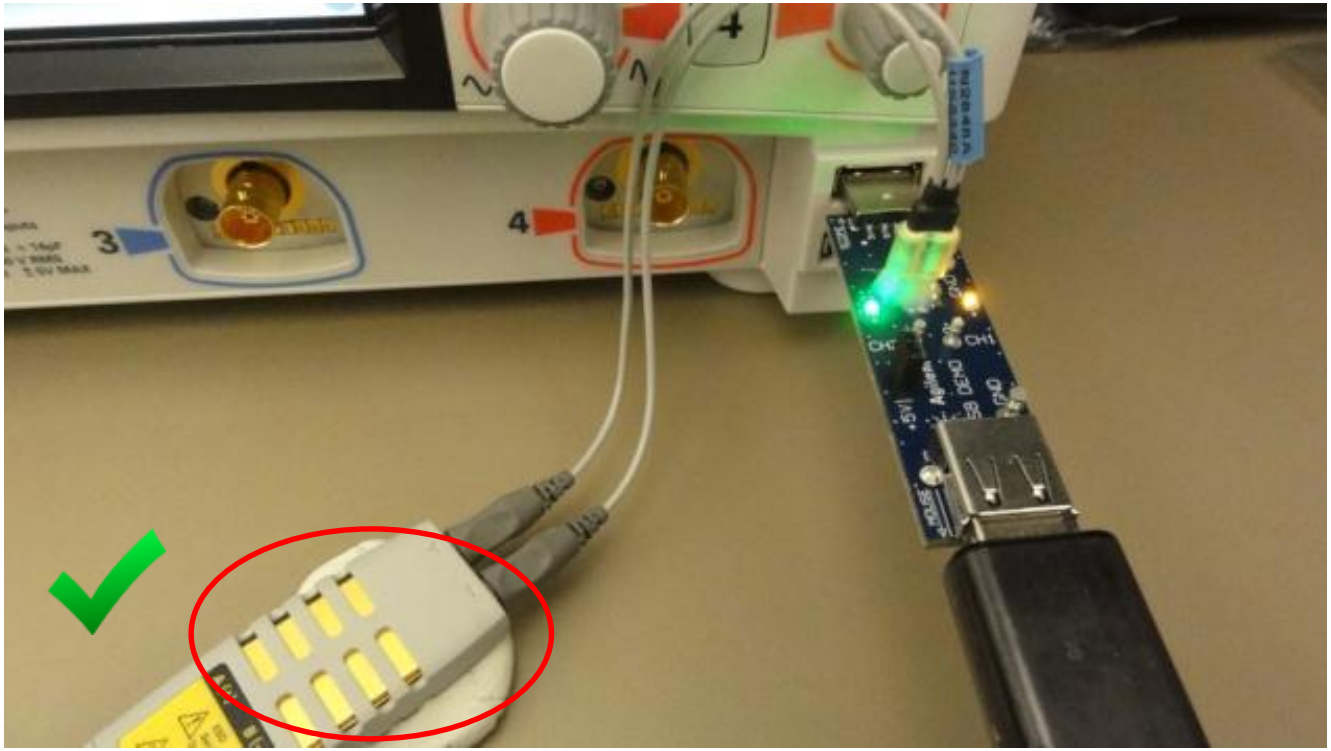


Tack Putty

Low temp glue gun

Housing with built-in strain relief (for N5380B SMA head)

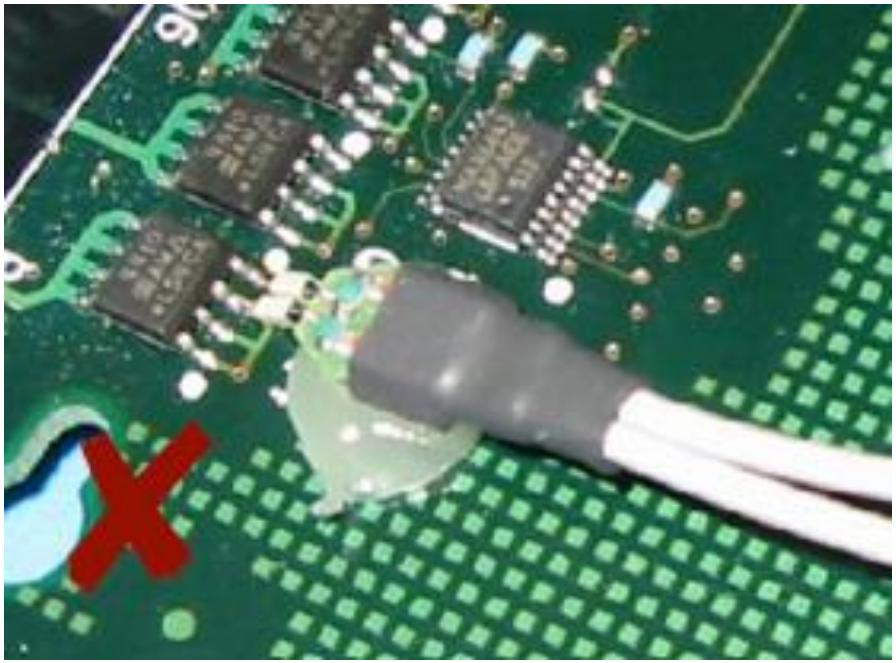
N2848A QuickTip needs strain relief



Make sure you securely “**strain relieve”** the probe amp before connection

Strain relief putty Keysight part number : N5439-65201 ($21)

When glue gun is used



- Do not use the hot glue on the probe head (PC board or tip leads)
- Use it on the probe head cables only
- Never use super glue!

Soldering Tips (1/2)

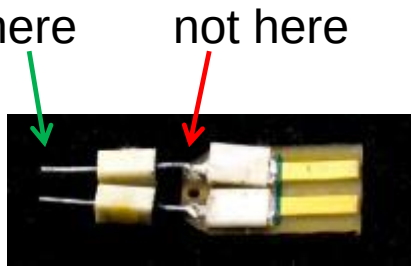
1. Use a temperature-controlled soldering iron station, if possible, such as Metcal (http://www.okinternational.com/metcal).
2. Set the iron tip temperature to between 370 °C – 420 °C (for non RoHS standards).
3. Use the smallest tip possible.
4. Use optical aids of some sort (microscope, MagniVisor or preferred). www.carsonoptical.com/Magnifiers (model MV-23)

4. Use minimal dwell times on the joint (<2 sec).

If dwelling too long, it will boil off the flux and the joint will Not be shinny and it will be weak.

Soldering Tips (2/2)

1. You should also only be soldering the tip of the wire onto your DUT. The solder should not get close to the existing solder ball on the tip.

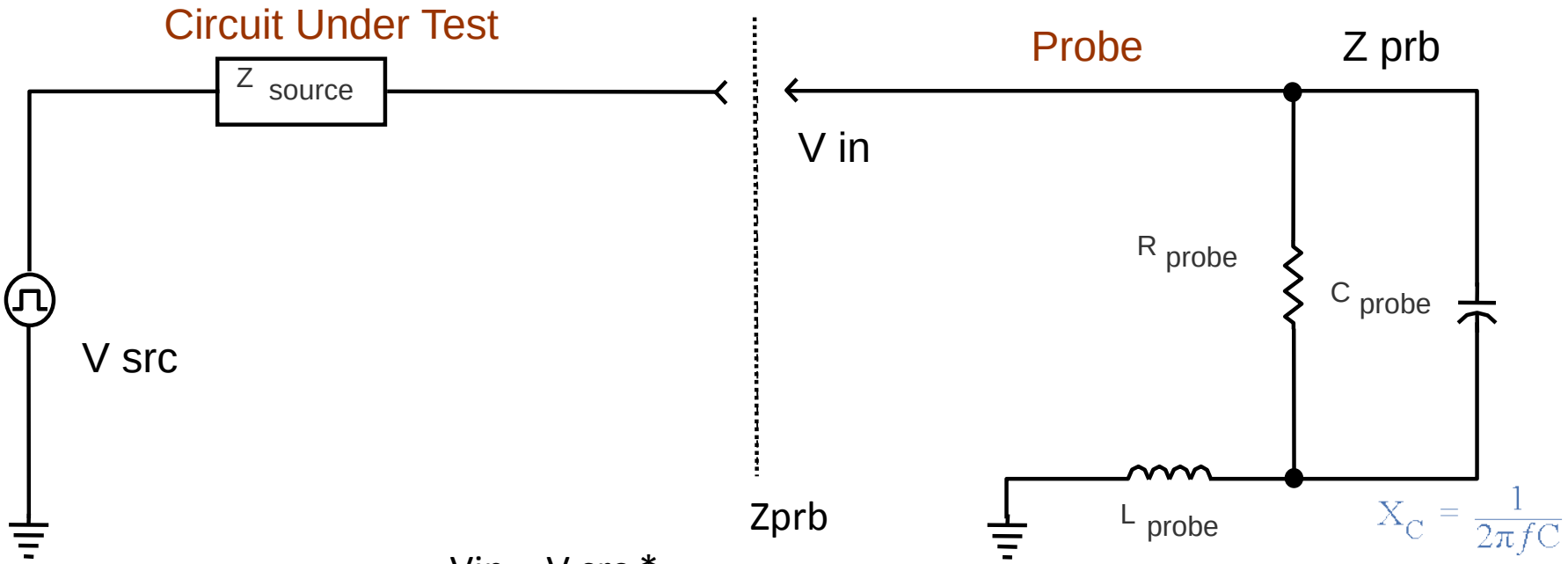


2. Use flux when soldering the tips into a DUT. Use a flux pen (http://www.kester.com/sidemenu/products/handsolderingmaterials/fluxpens/tabid/263/default.aspx) to coat the tip wires and the target. The solder will flow much faster and wet the surface quickly so you can remove the heat as soon as possible and therefore do less damage. You SHOULD NOT rely on the flux core in their solder; it's never enough and it boils away too quickly.

Agenda

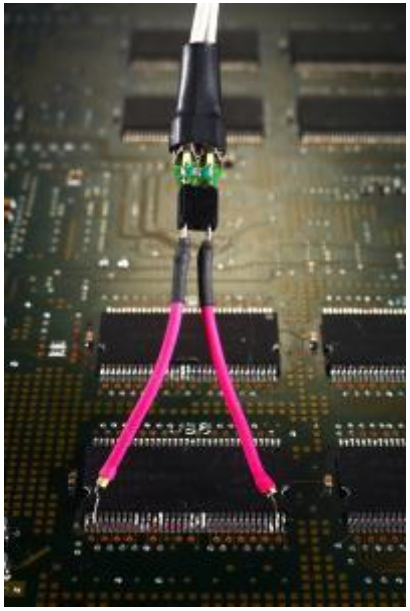
- 큰 오프셋이 존재하는 상태에서의 작은 신호 측정
- 극한온도에서의 신호 프로빙
- Infiniimax 프로브 사용요령
- **프로빙효과(Probing effect)없애는 방법**

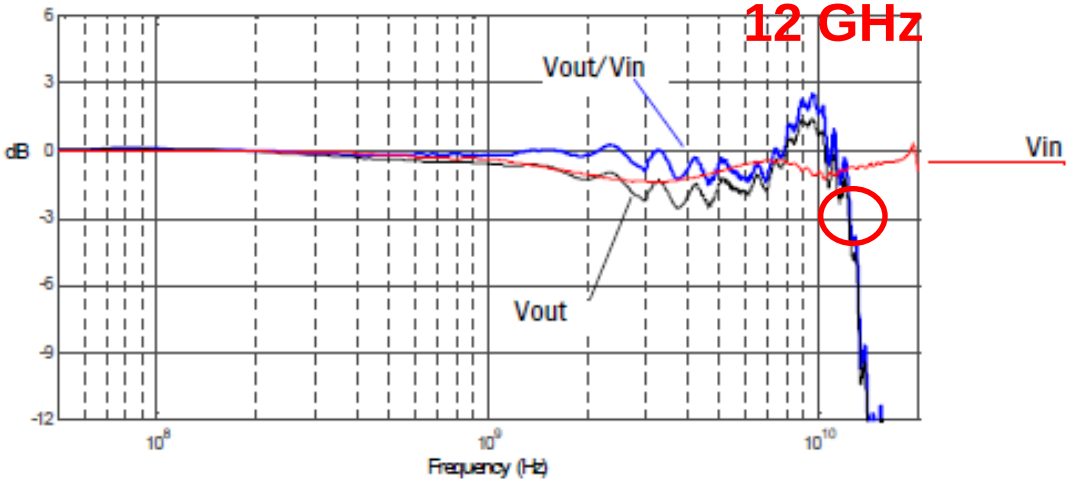
What causes probe loading?

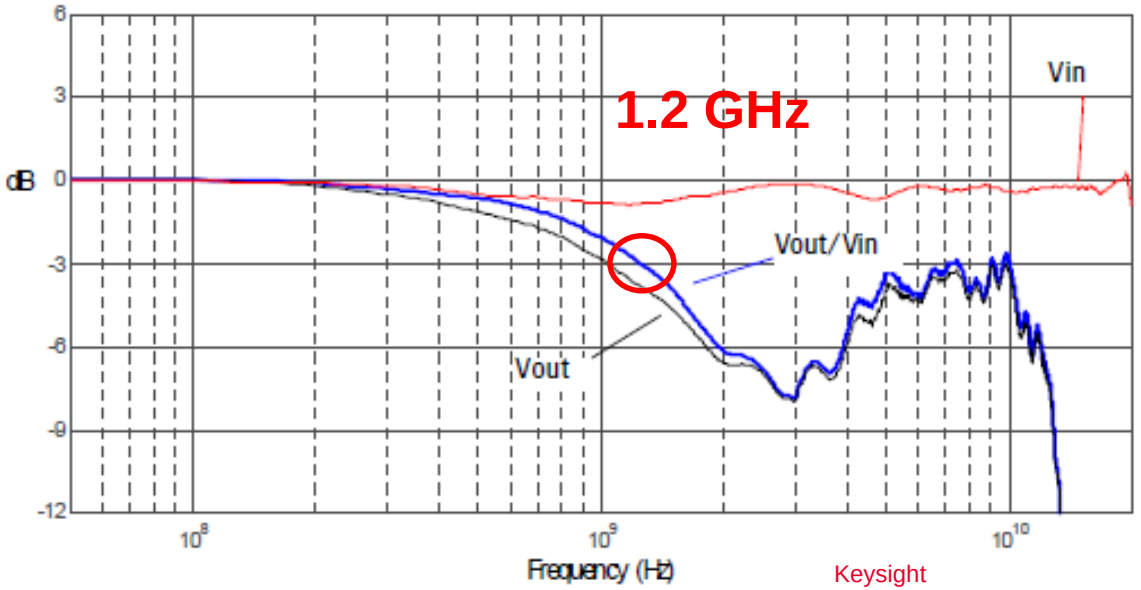


As the capacitive loading increases, more signal is taken away by probe resulting in more reduction in signal amplitude as the signal frequency goes up.

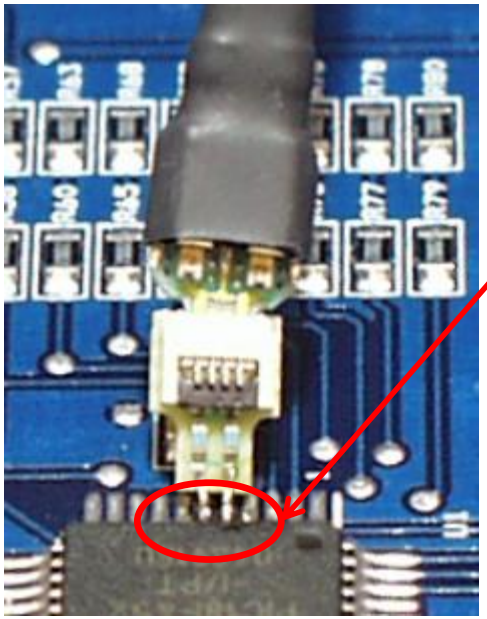
The problem: Extended leads cause bandwidth reduction



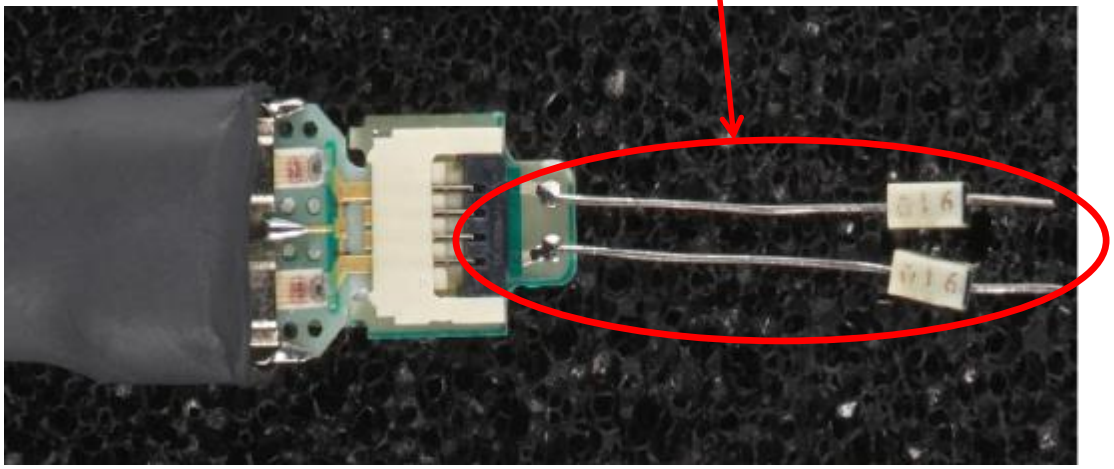




The Problem: Effects of varying lead length/span



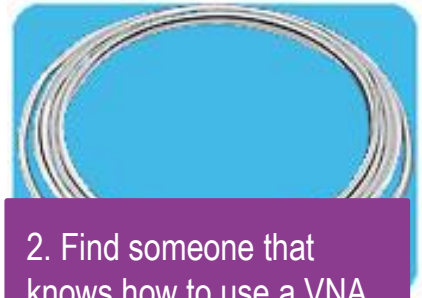
N5425A ZIF head with	Lead length	Separation between legs	Bandwidth
N5426A ZIF tip	2 mm	0 deg	12.3 GHz
N5451A LW ZIF tip	7 mm	0 deg	9.9 GHz
	7 mm	60 deg	4.4 GHz
	11 mm	0 deg	5 GHz
	11 mm	60 deg	3.3 GHz



Longer input wire → *lower bandwidth, higher loading, non flat response, more variation in response as span and tip wire environment changes*

Correction using VNA and S-Parameter Models

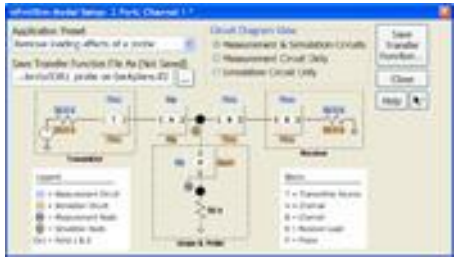
1. Find a VNA



2. Find someone that knows how to use a VNA and measure the probe/cable

3. Create S-parameter file

4. Save S-parameter file to thumbdrive and load on scope



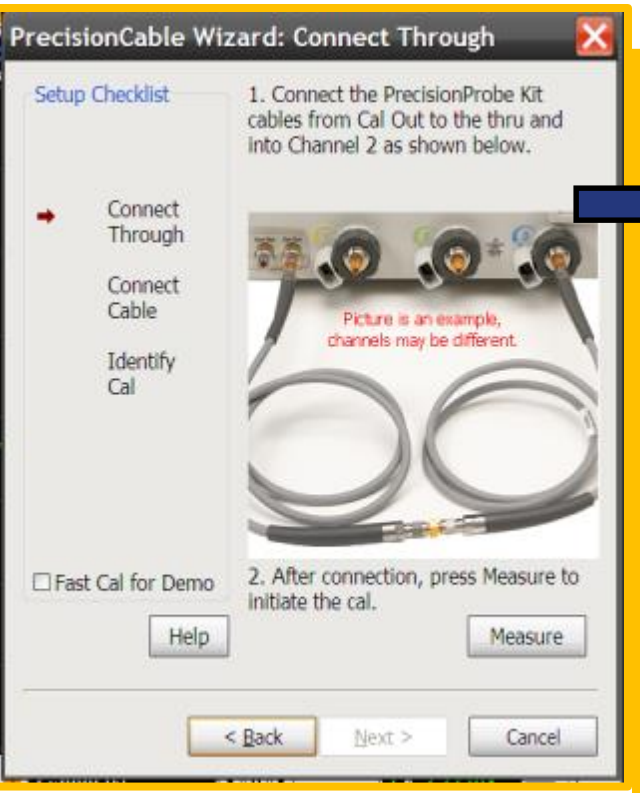
5. Use waveform transformation software and correctly remove loss

6. Analyze the data

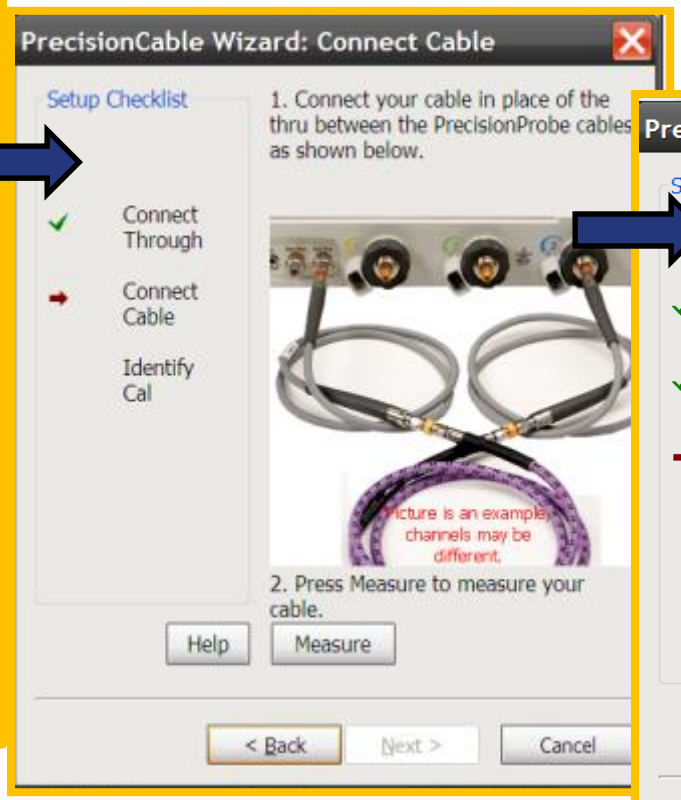
Huge effort and time involved. As a result, we tend to ignore the probe/cable loss entirely.

PrecisionProbe characterizes and corrects in a few easy steps using just the oscilloscope

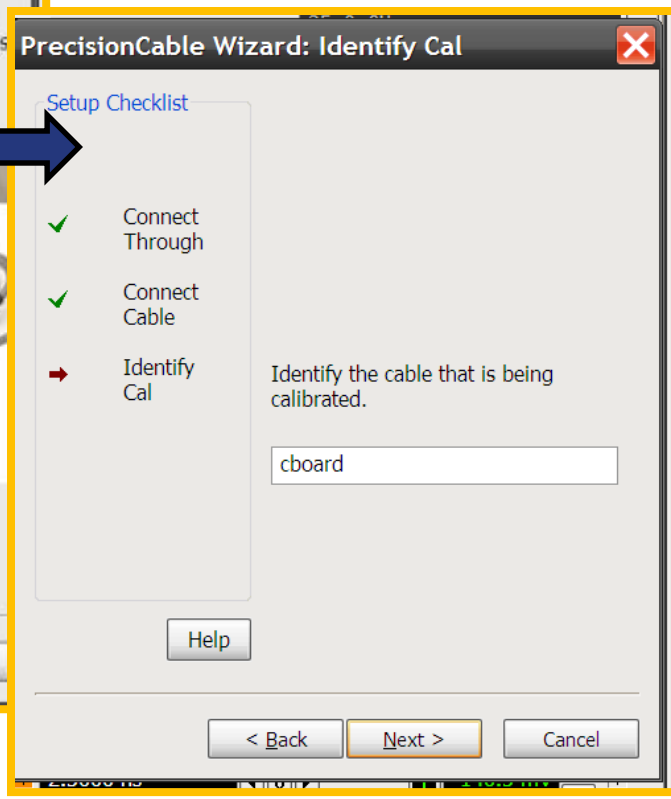
www.keysight.com/find/precisionprobe



1. Measure baseline of a fast edge.

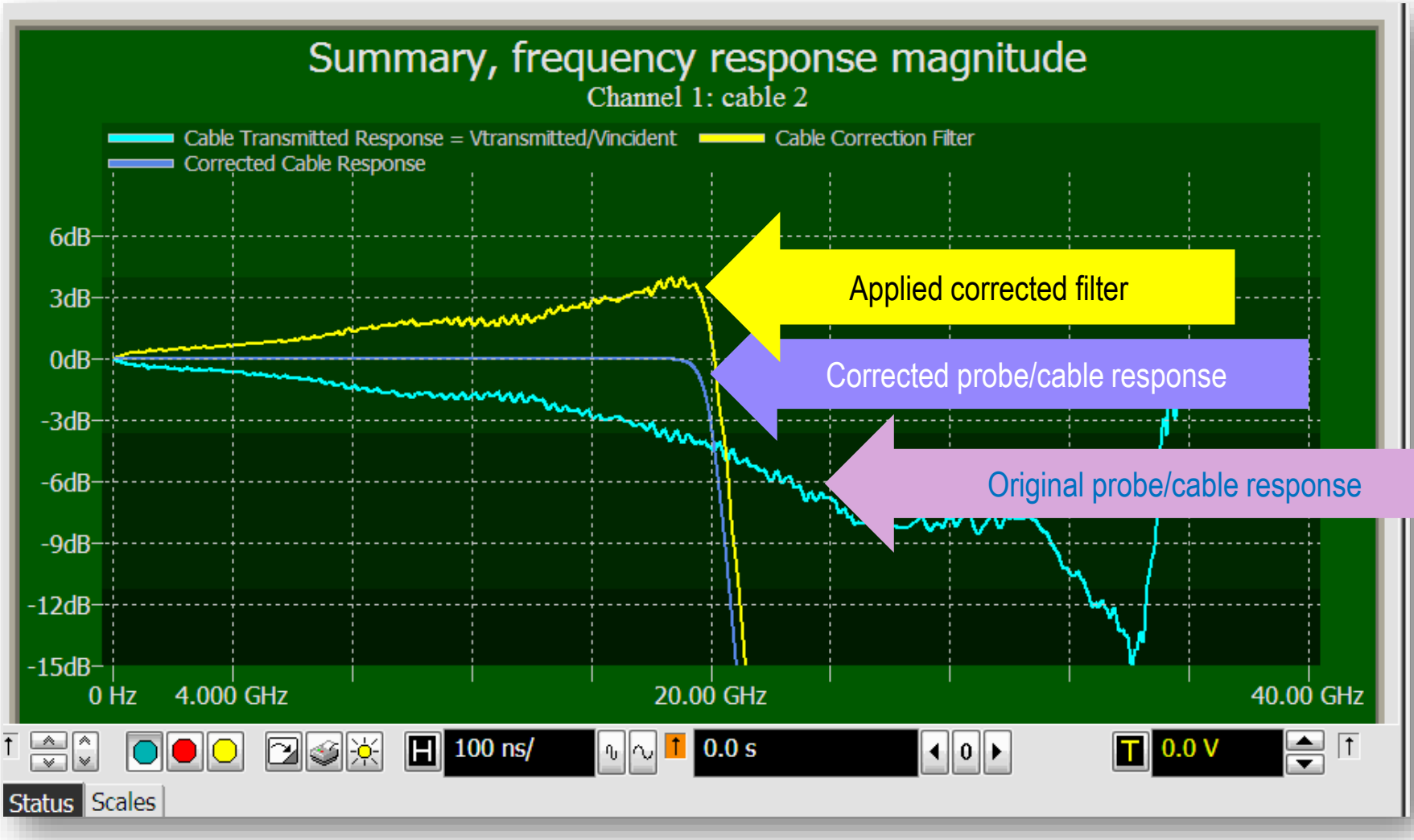


2. Add the cable/probe to the measurement path and measure loss due to probe/cable

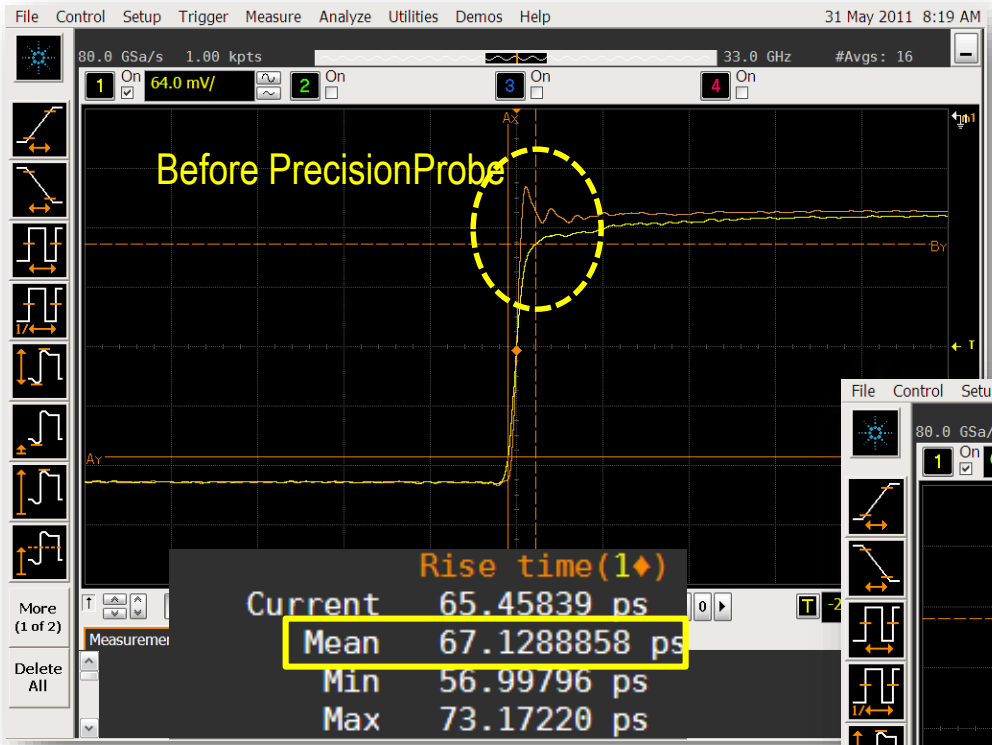


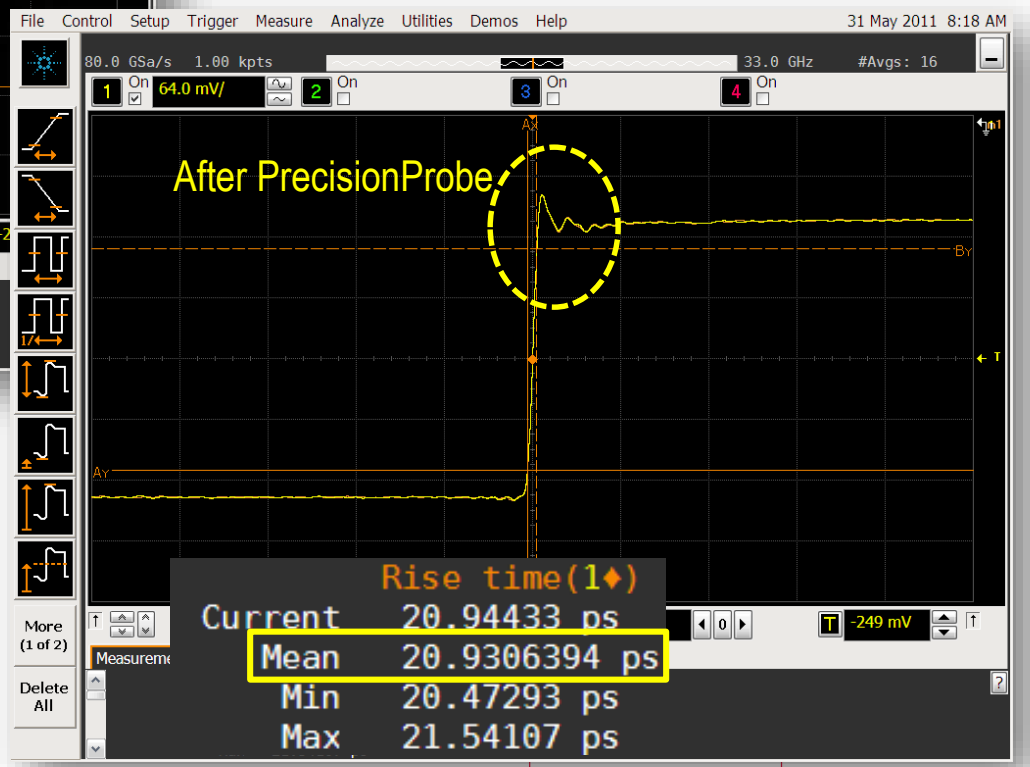
3. Save correction file. Scope applies the transfer function continuously.

PrecisionProbe: Corrected Cable Response



PrecisionProbe : Results Improvement (Cable)





S21 probe loss and probe delay is removed through compensation.

Rise Time improves from 67ps to 21ps!

KEYSIGHT TECHNOLOGIES

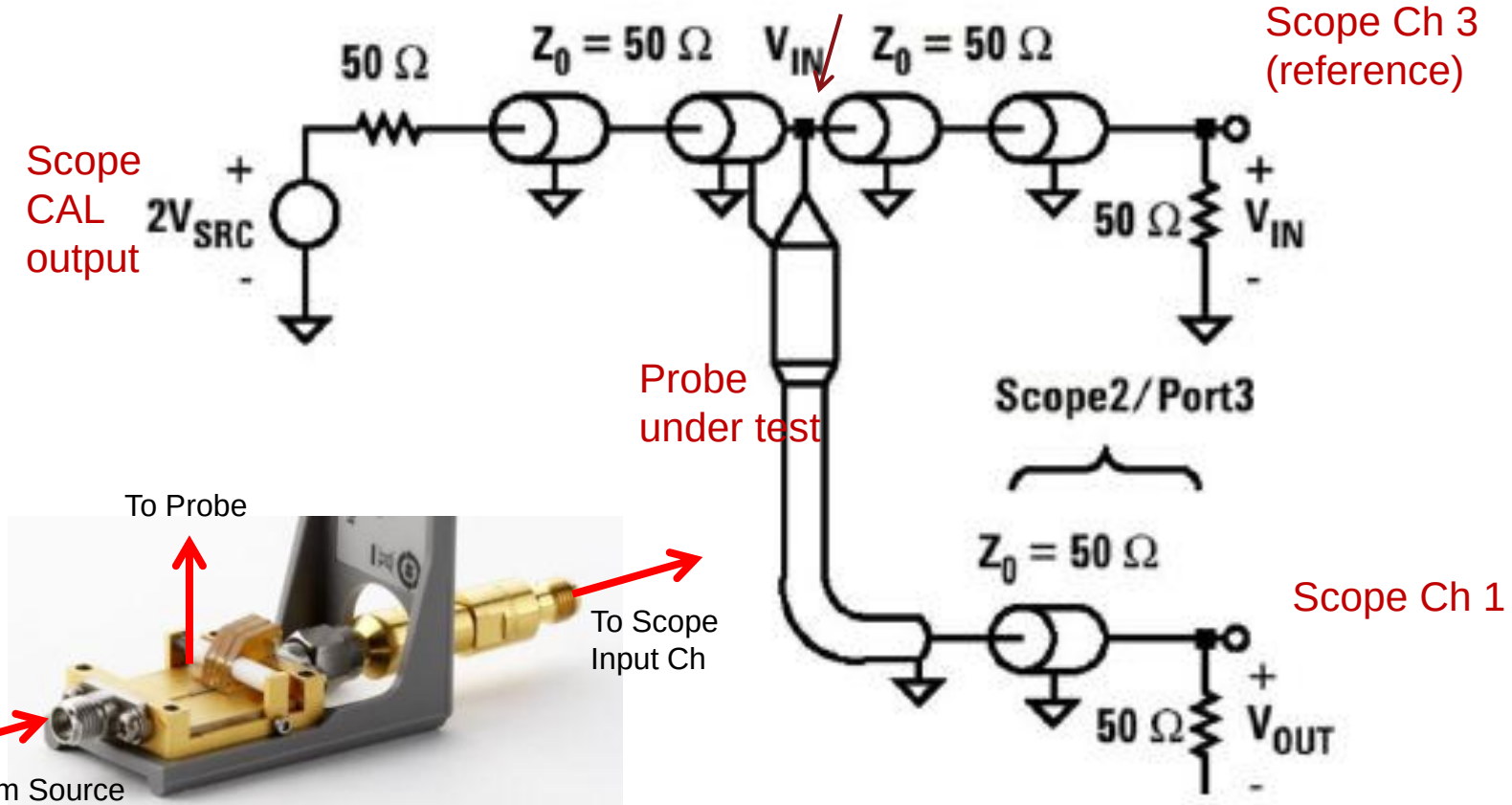
PrecisionProbe -- How it works

Test setup to perform PrecisionProbe testing

25Ω source impedance

E2655C or N5443A PV and deskew fixture

Scope Ch 3 (reference)



How it works (Cont)

With reference cable setup, follow these steps to get Vsrc response.

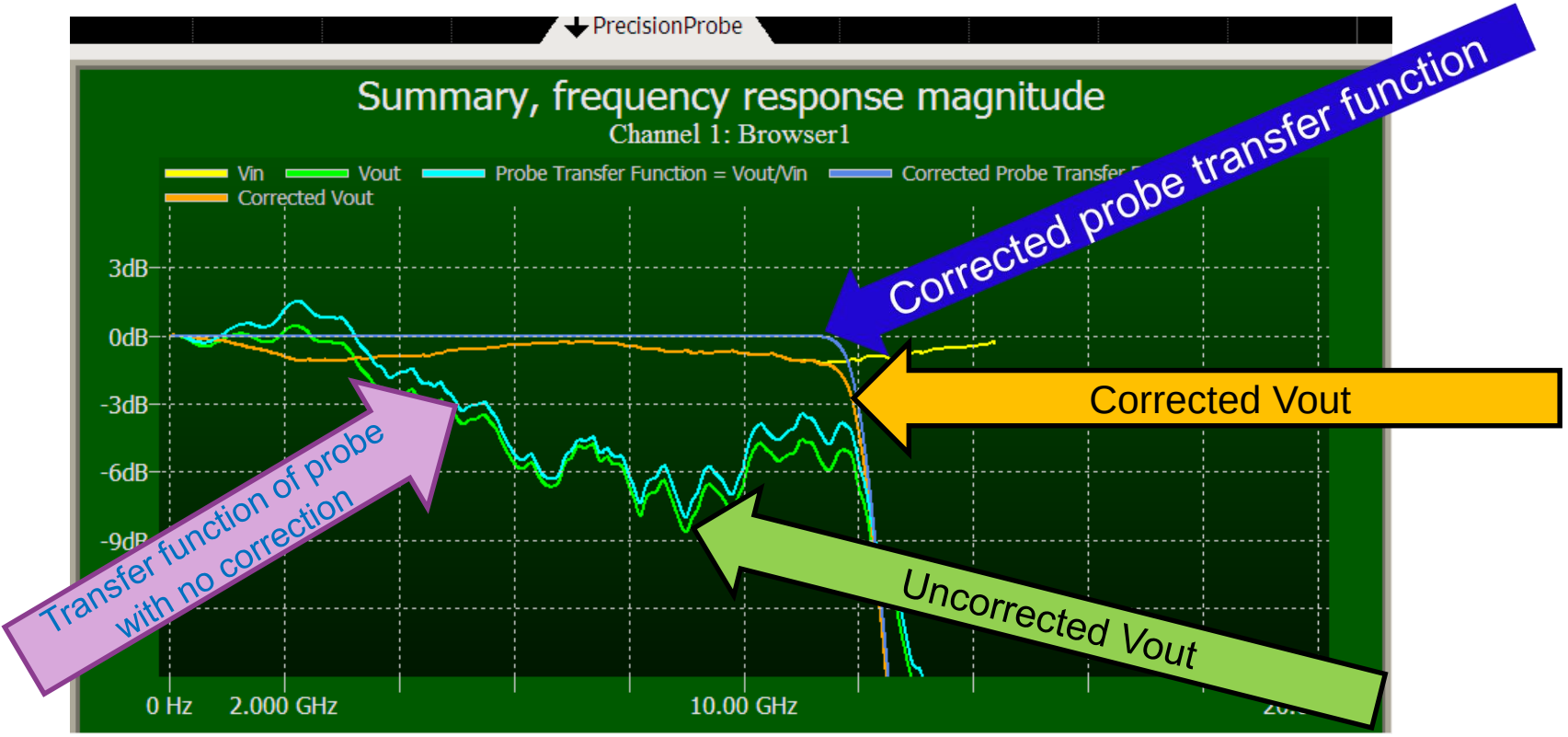
1. Take a fast step signal source from scope's built-in CAL out port.
2. Apply the differentiate (or derivative) to this step, you get the impulse response.
3. Then take the FFT of the impulse response to obtain the frequency response of the system.

With the probe attached or cable inserted, repeat steps 1-3 to get Vin and Vout response.

Now we know the transfer function (Vout/Vin) and software creates inverse filter to get nice flat response.

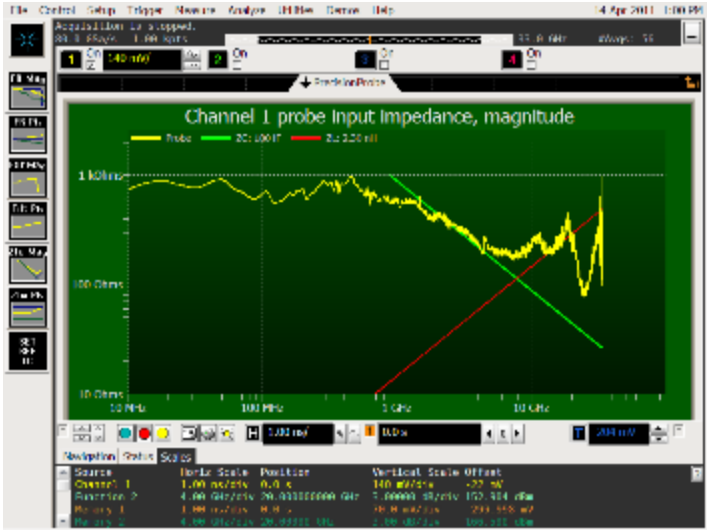
KEYSIGHT TECHNOLOGIES

PrecisionProbe : Results Improvement (Probe)

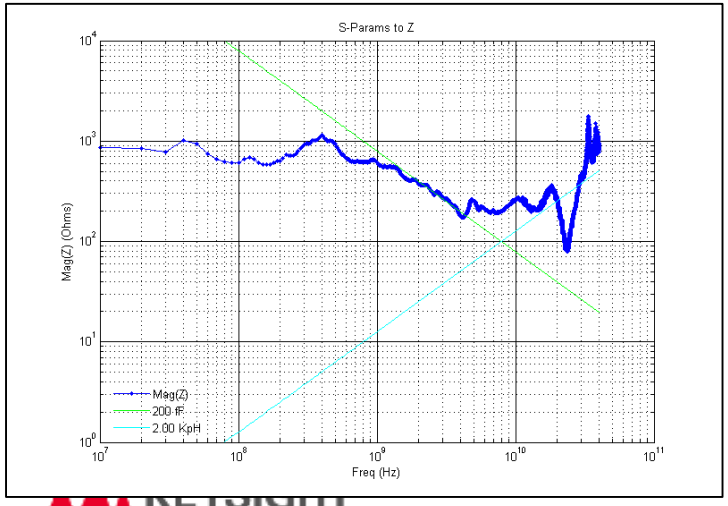


1. After running PrecisionProbe, now ***Vout is directly on top of Vin*** indicating a corrected Vout/Vin transfer function
2. Transfer function is now ***flat for the entire bandwidth*** of the probe
3. **6dB of loss is now compensated**

Understanding the tools of PrecisionProbe (Probe)

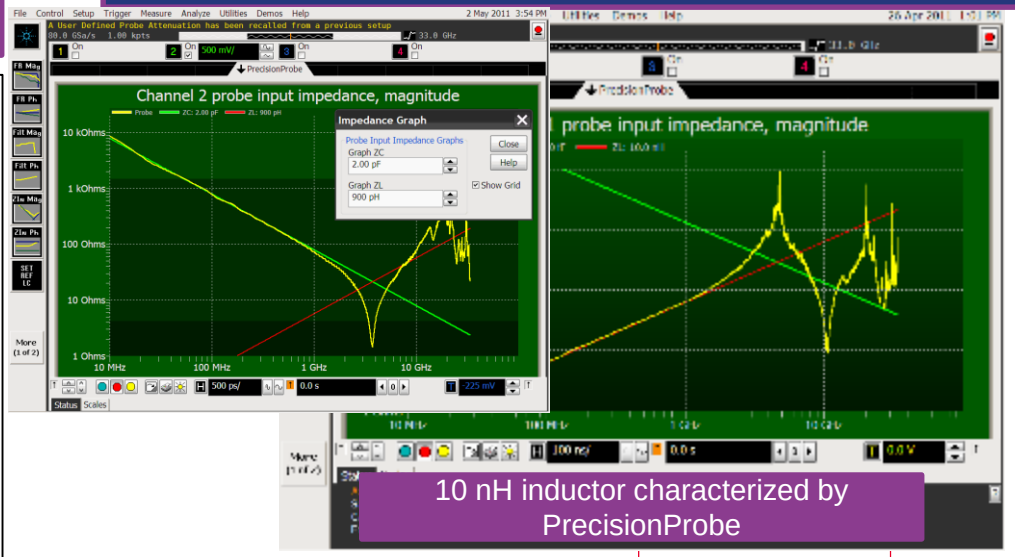


Figures show a solder in probe characterized by PrecisionProbe and a VNA. Notice how closely the characterization matches both systems



Impedance Characteristics of Your Probe

- PrecisionProbe
  - Characterizes the impedance of your probing system
  - Allows you to see where the changeover is from inductive to capacitive and what the loading of the probe is without a VNA



10 nH inductor characterized by PrecisionProbe

PrecisionProbe vs InfiniiSim

	PrecisionProbe	InfiniiSim
What it does	Characterize cable or probe quickly/easily and remove unwanted cable loss or probe loading with a scope	De-embedding and waveform transformation toolset providing means to render waveform anywhere in the system link
Use model	For simple characterization and correction without need of a VNA or a complex simulation SW	Very broad- Remove unwanted channel effect or insert channel effect, view waveforms in physically unprobable location, remove probe loading effect etc
When to use	For quick and easy Vout/Vin or Vout/Vsrc correction and probe input impedance measurement	When you have a s-parameter file or a measurement expertise and want full 4-port modeling
Limitation	* Only for S21 insertion loss removal of cable or probe • No return loss • Limited bandwidth boost due to elevated noise floor	• Takes extra equipment (VNA, TDR) • Takes effort and time

Feedback?

KEYSIGHT
TECHNOLOGIES