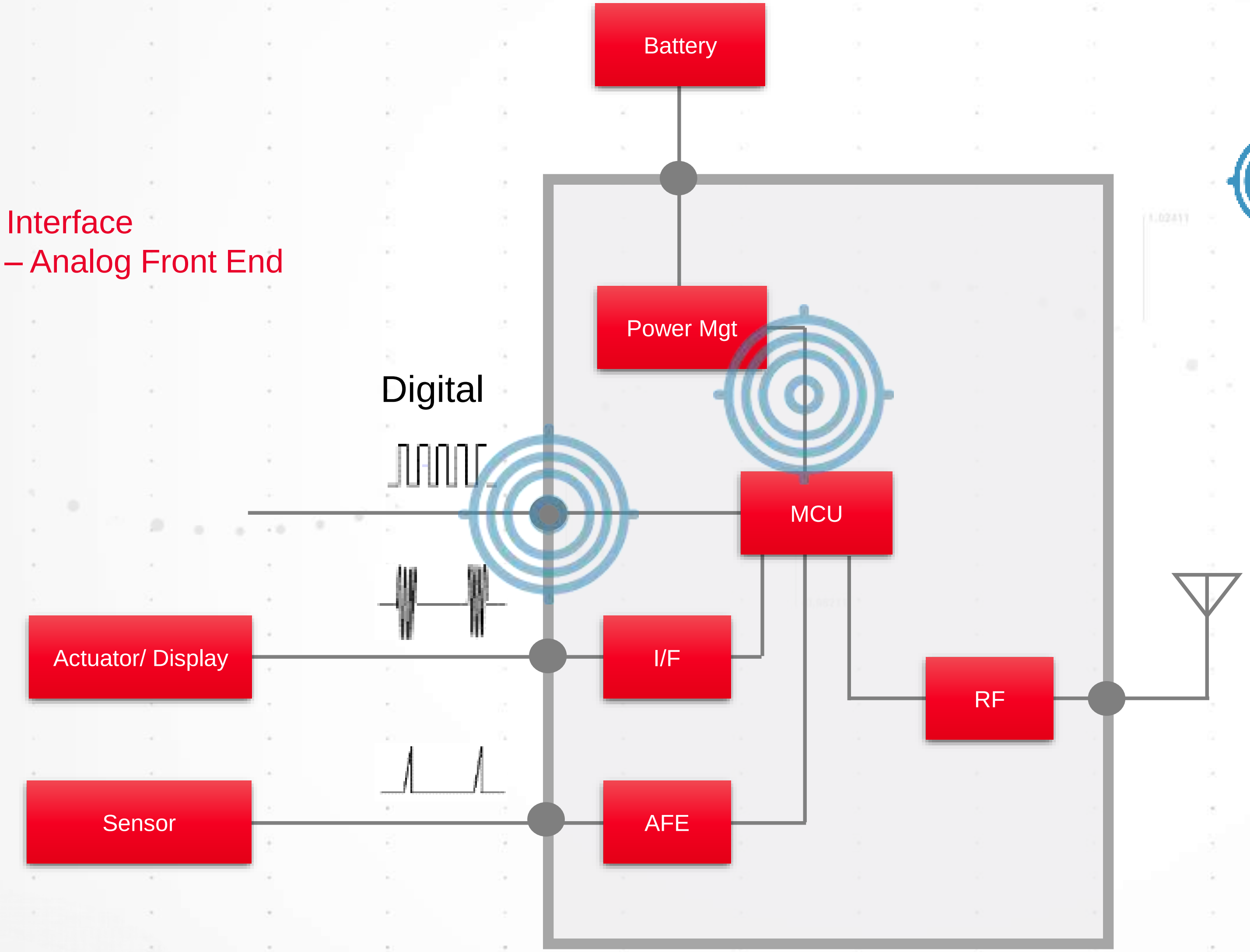
Probing Techniques for IoT Devices

POWER INTEGRITY MEASUREMENTS AND MORE

KEYSIGHT
TECHNOLOGIES

Typical IoT Module Block Diagram

I/F – Interface
AFE – Analog Front End



Are my digital signals within my jitter and noise budgets?

How to I identify these small ripples and transients?

Is my power supply the victim or aggressor in my design?

Is all the work it takes to clean up my signals even worth it?

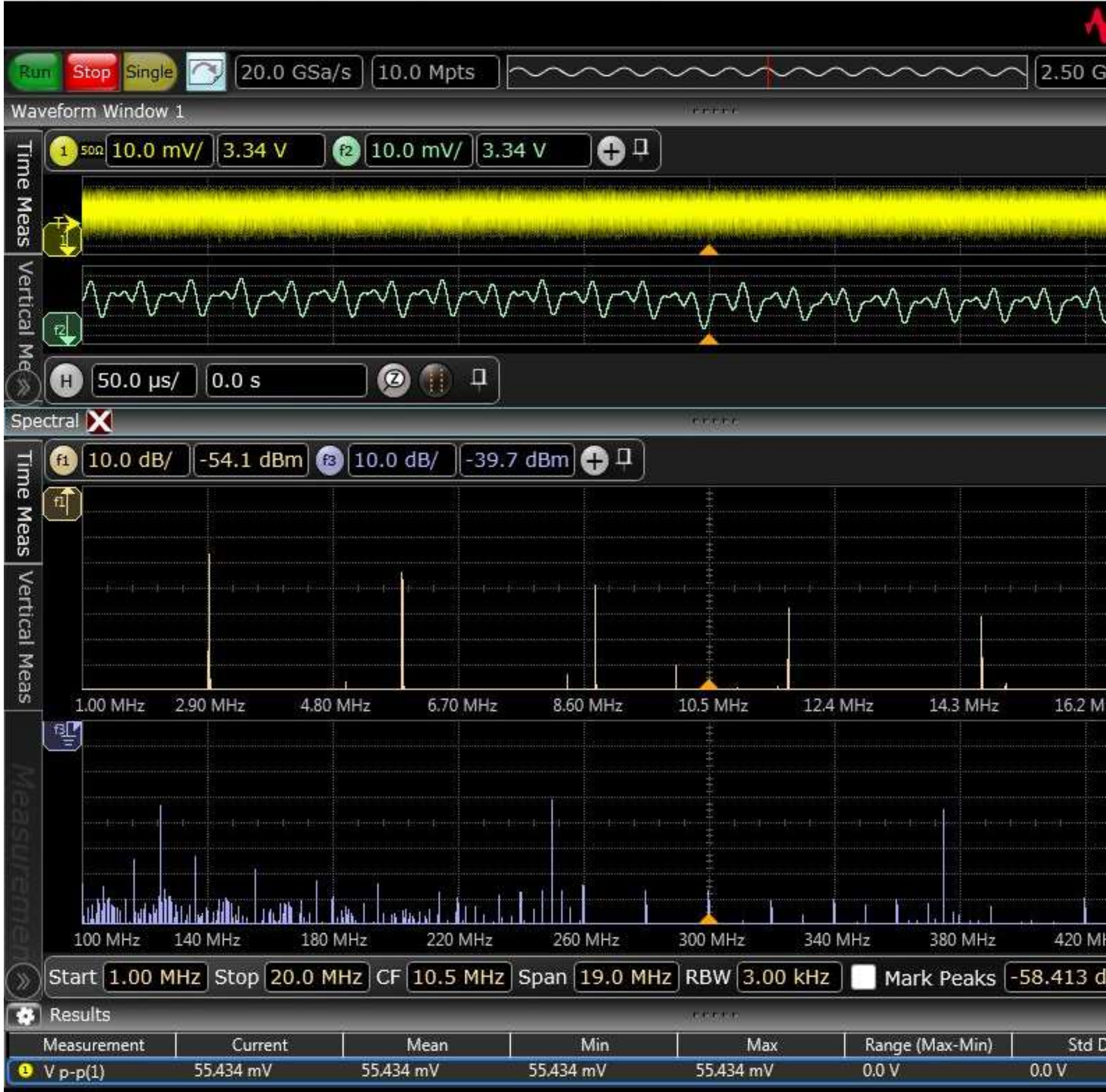
KEYSIGHT TECHNOLOGIES

Goals or Outcome

WHAT WE'LL LEARN TODAY

Show you some things you can do to:

- Debug and test PDN's (power distribution networks) with more precision, accuracy and confidence.
- More easily isolate root cause of PDN noise.
- Avoid false negative (or positive) test results.
- Become aware of specialized tools that can make your job easier.

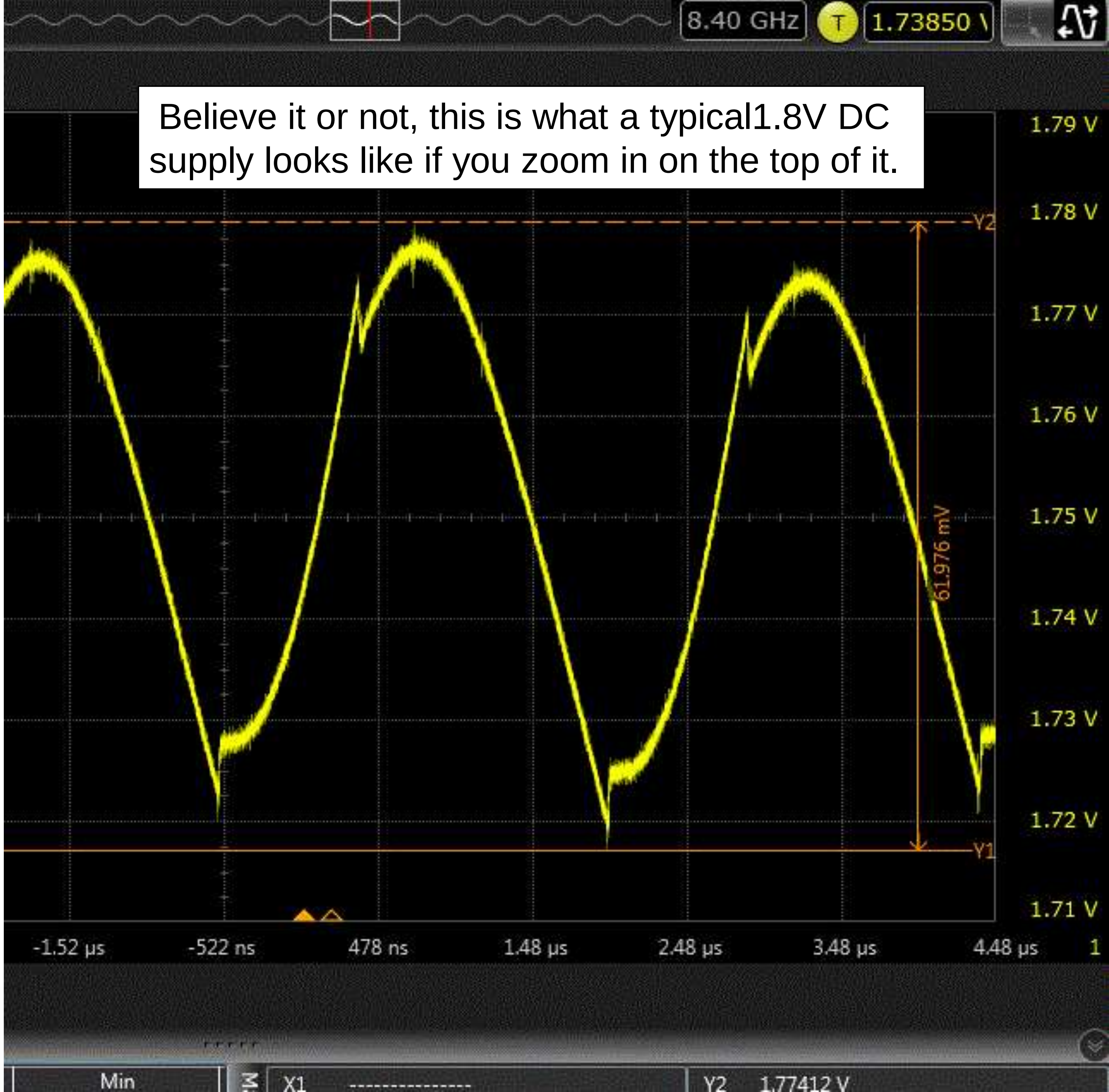


KEYSIGHT TECHNOLOGIES

Power Integrity Measurements

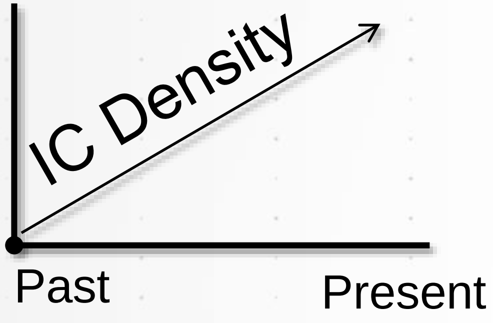
WHY DO WE NEED THESE MEASUREMENTS?

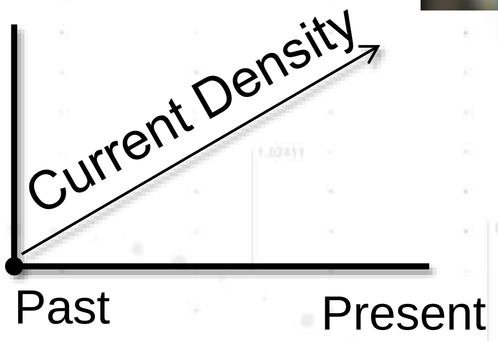
- Increased functionality, higher power density and higher frequency operation drives need for lower supply voltages
- Power rail tolerances are much tighter (from +/- 5% down to +/- 1%)
- Ripple, noise and transients riding on these lower DC supplies can adversely affect clocks and digital data—Power Supply Induced Jitter (PSIJ)



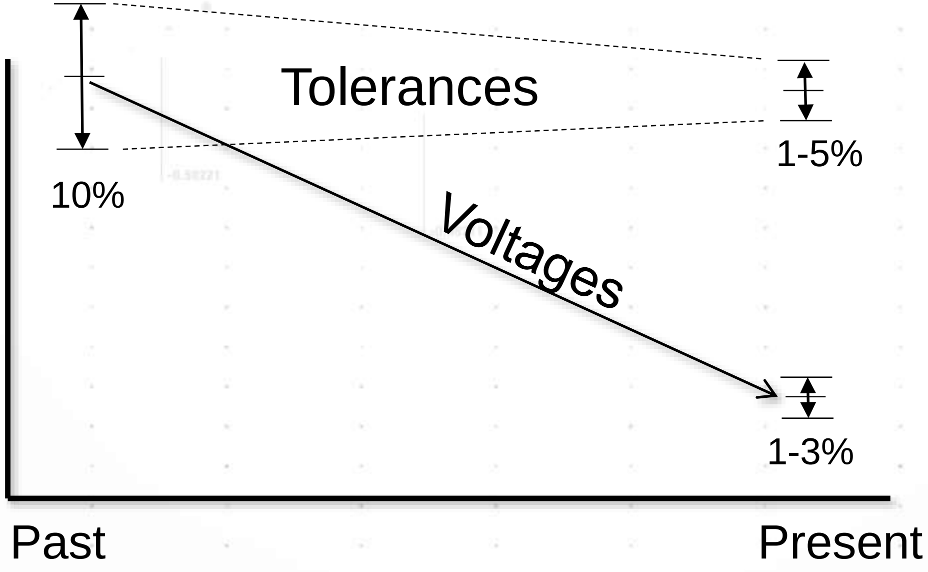
The Case For Power Integrity

MOORE'S LAW: TRANSISTORS ON AN IC DOUBLE EVERY TWO YEARS



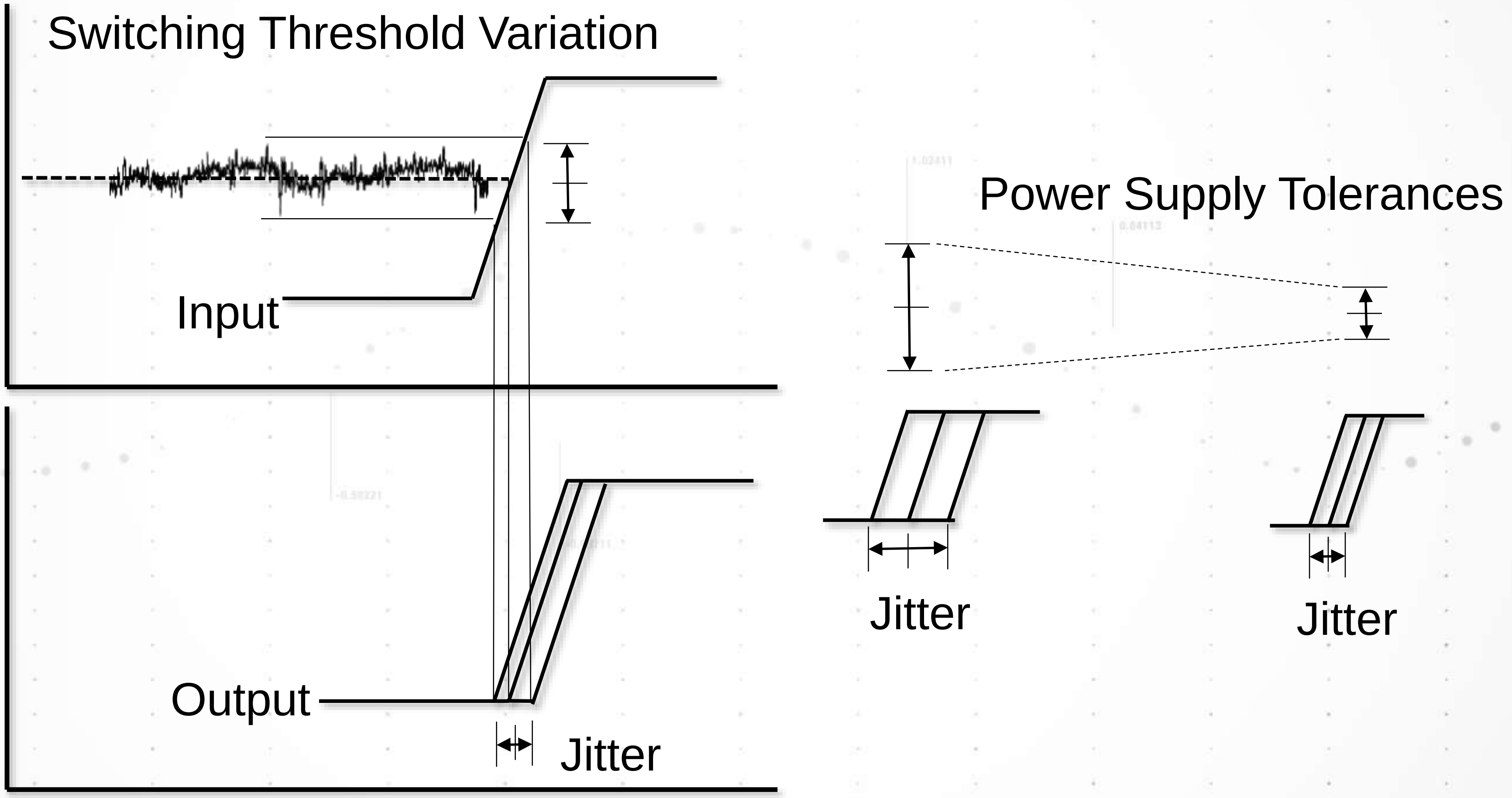


Goal: improve power consumption with each generation



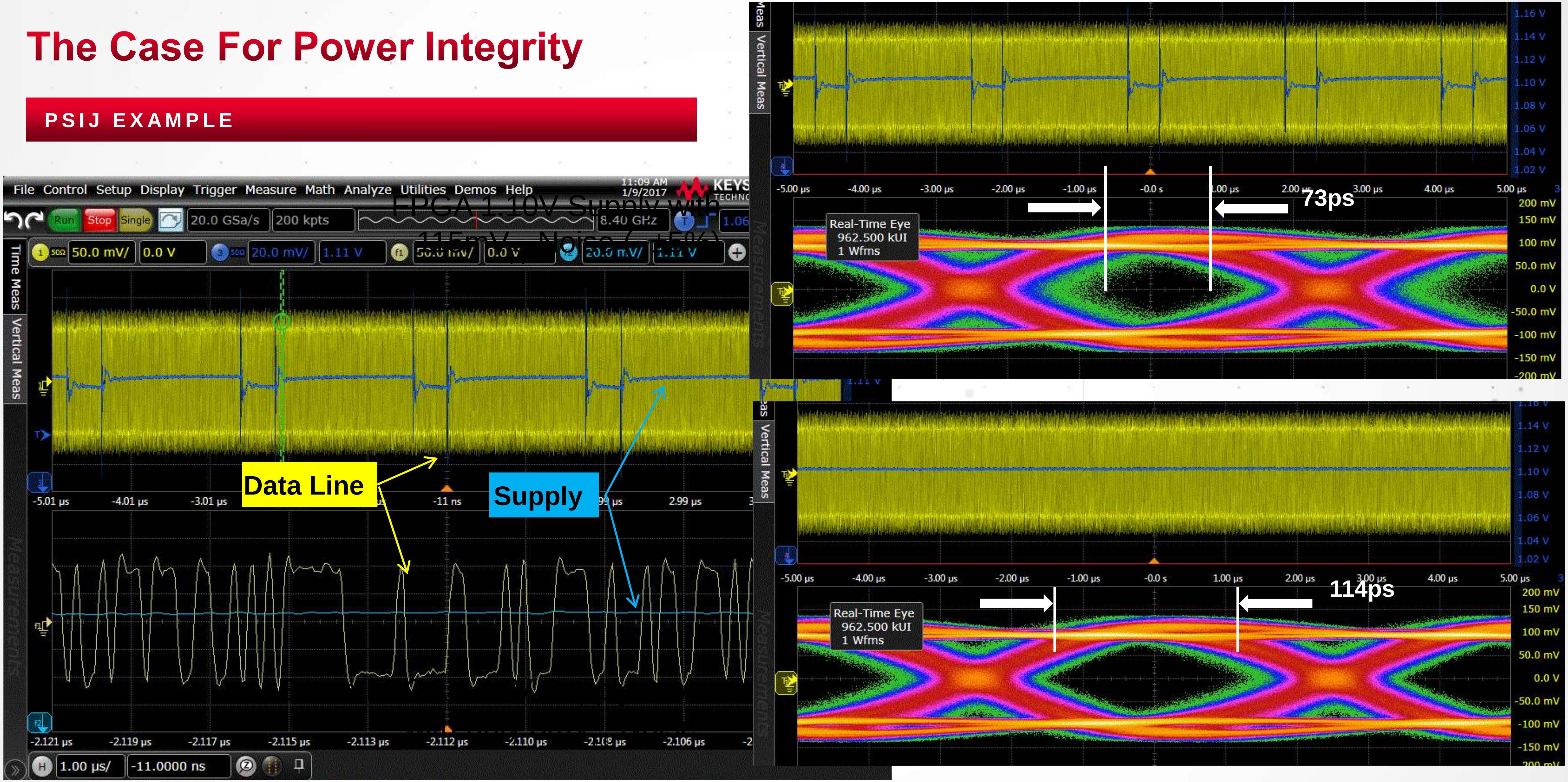
The Case For Power Integrity

POWER SUPPLY NOISE CAUSES CLOCK/DATA JITTER



The Case For Power Integrity

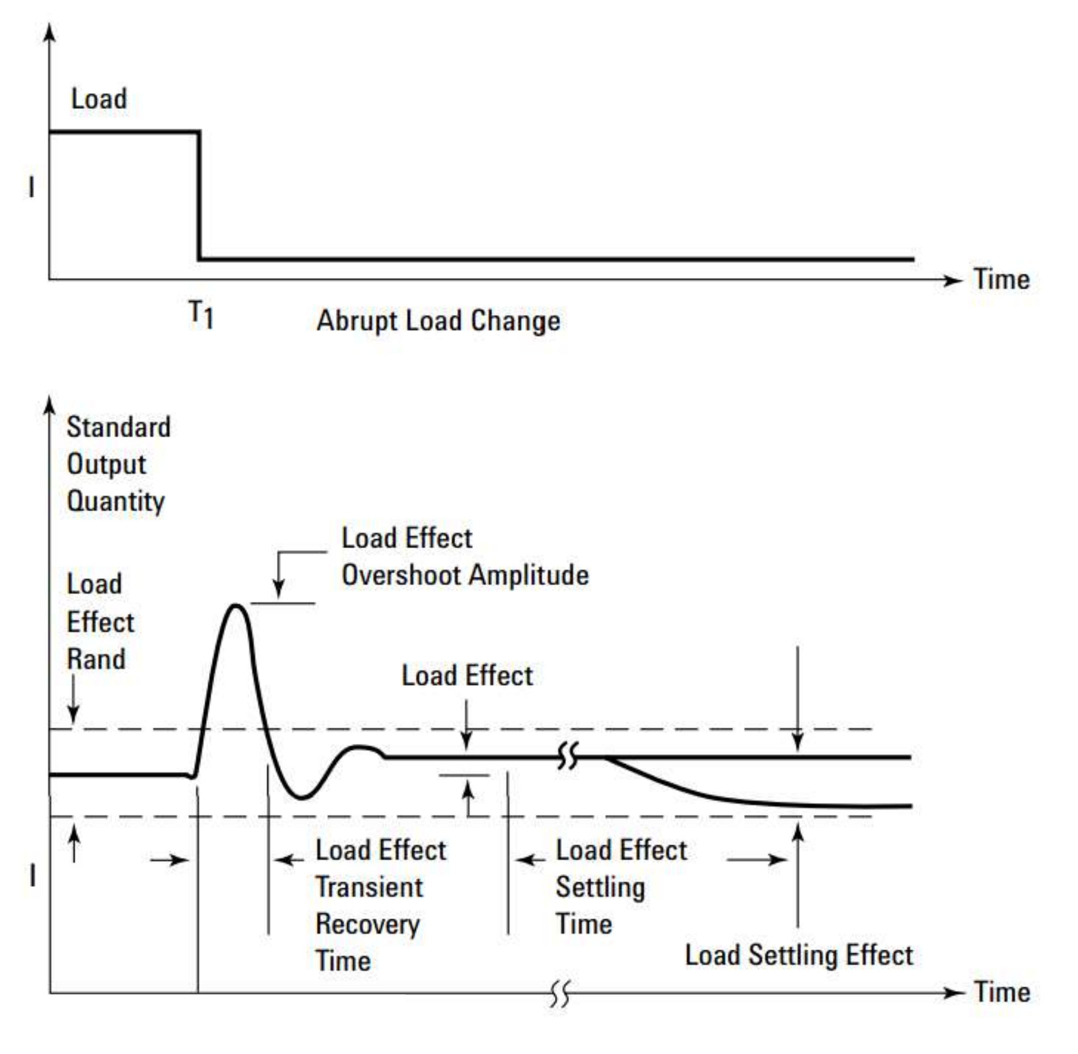
PSIJ EXAMPLE

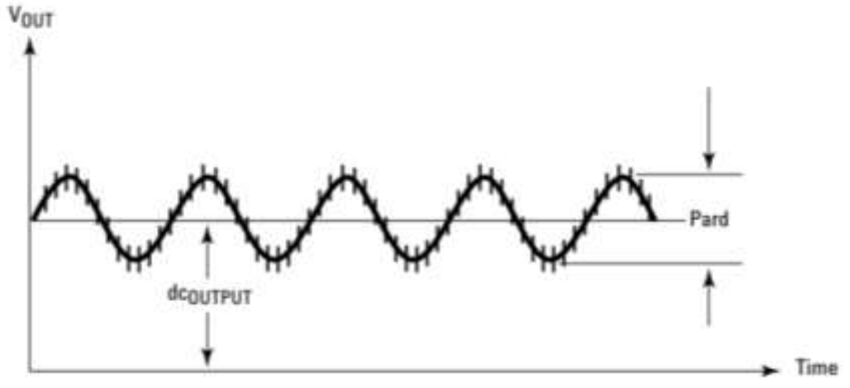


Power Integrity Measurements

COMMON POWER INTEGRITY MEASUREMENTS

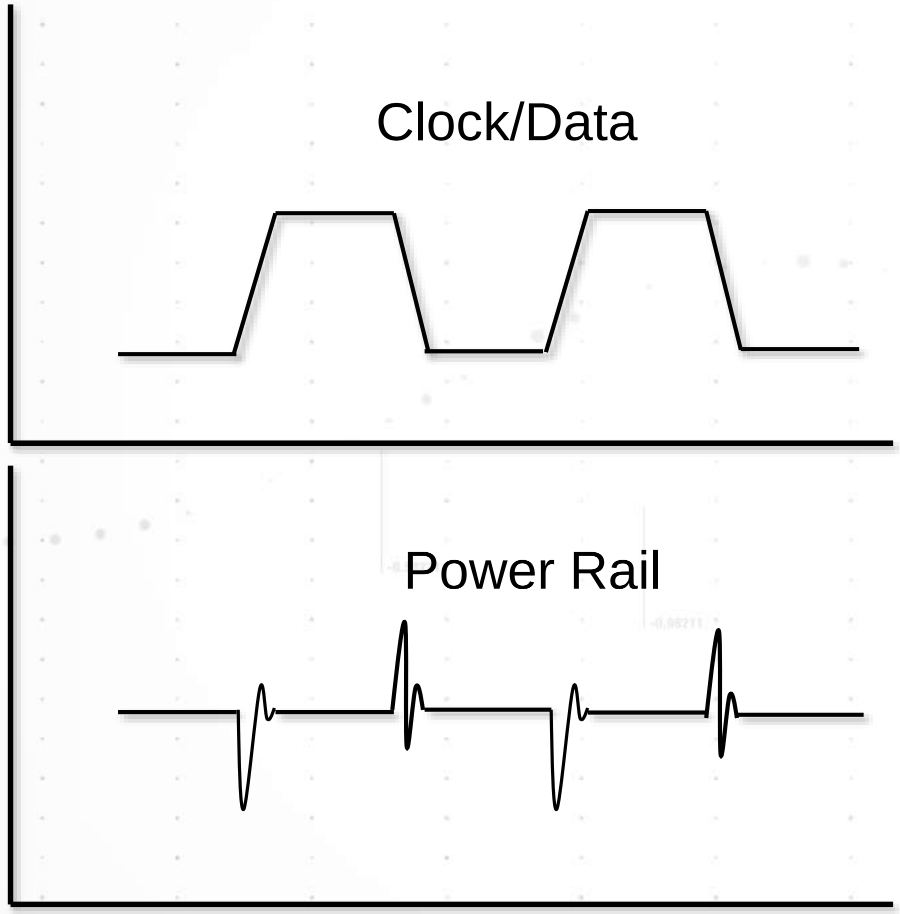
- Supply drift
- PARD (Periodic and Random Disturbances)—noise, ripple and switching transients on power rails.
- Static and dynamic load response.
- Programmable power rail response.
- High frequency transients and noise.
- Product electrical validation at extended temperatures.





Power Integrity Measurements

ADDITIONAL CHALLENGE

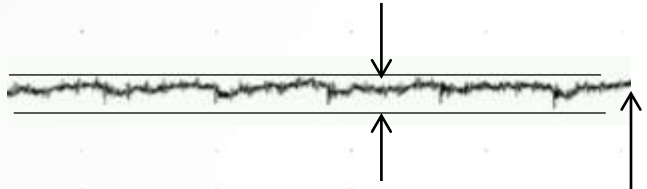


Switching loads can cause high frequency supply noise.

Example of How Switching Loads Affect Power Quality

Power Integrity Measurements

FUNDAMENTAL CHALLENGE



Tolerance Band

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

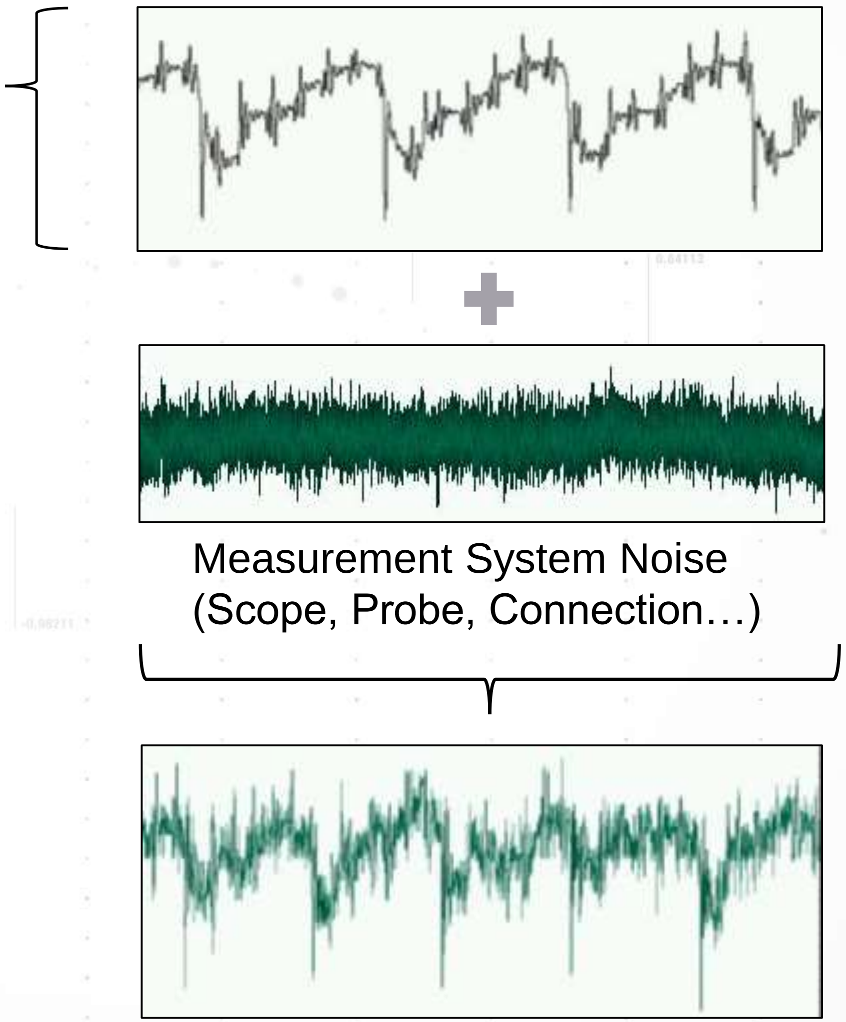
Issues to overcome:

DC

1. Measurement system noise
2. Large signal offset

Probing “golden” rule:

3. Do no harm (probe loading)



Power Integrity Measurements

BOTH ENDS OF THE SPECTRUM

Specialized

N7020A Power Rail Probe

General Purpose

10:1 Passive Probe

Power Integrity Measurements

BOTH ENDS OF THE SPECTRUM

Specialized ⟷ General Purpose

N7020A Power Rail Probe
Termination: 50Ω
Attenuation: 1:1
Bandwidth: 2GHz
Gnd connect: Coax “pigtail”

Passive Probe
Termination: 1MΩ
Attenuation: 10:1
Bandwidth: 500MHz
Gnd connect: “Alligator” clip

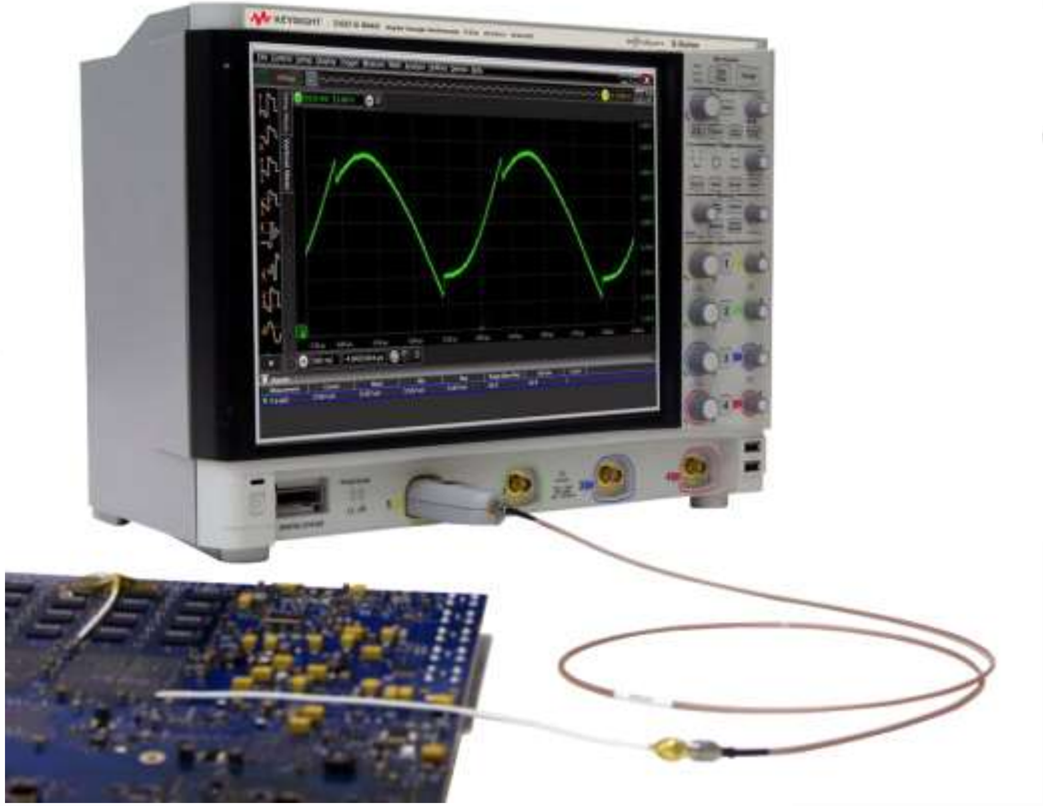
Good for quantitative measurements

Good for qualitative measurements

Power Integrity Measurements

THE SET-UP

Infiniium S-Series High-Definition Oscilloscope



Power Integrity Measurements

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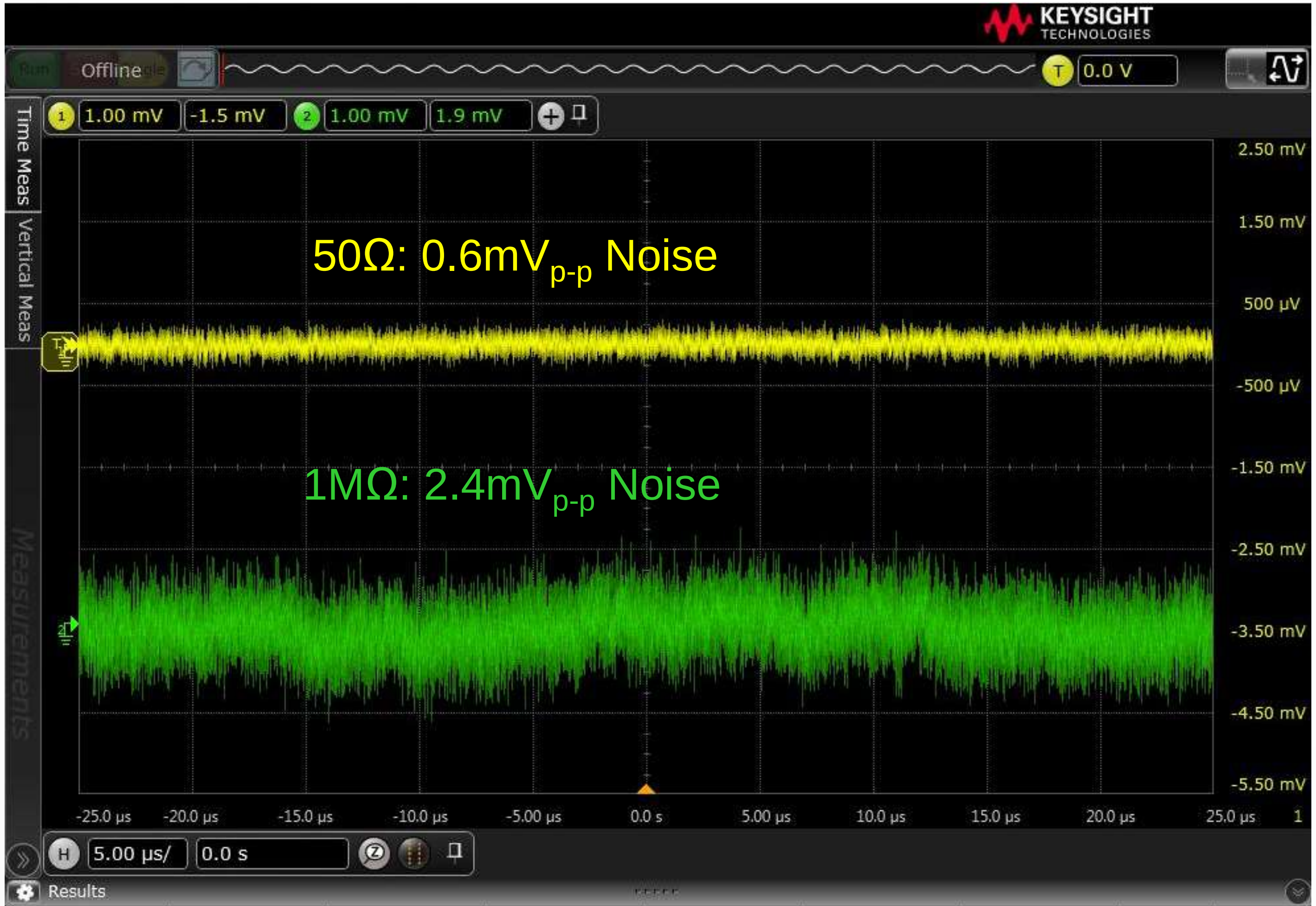
Power Integrity Measurements

SCOPE INPUT TERMINATION—LOWEST NOISE PATH



Measurement	Current	Mean	Min	Max	Range (Max-Min)	Std Dev	Count
V p-p(2)	2.3808 mV	2.3808 mV	2.3808 mV	2.3808 mV	0.0 V	0.0 V	1
V p-p(1)	643.3 µV	643.3 µV	643.3 µV	643.3 µV	0.0 V	0.0 V	1

Power Integrity Measurements Pro Tip:

Choose the lowest noise path based on the oscilloscope you are using, and if that isn't sufficient, select a lower noise oscilloscope.

Measurement Basics in an IoT World

Keysight Technologies

Power Integrity Measurements

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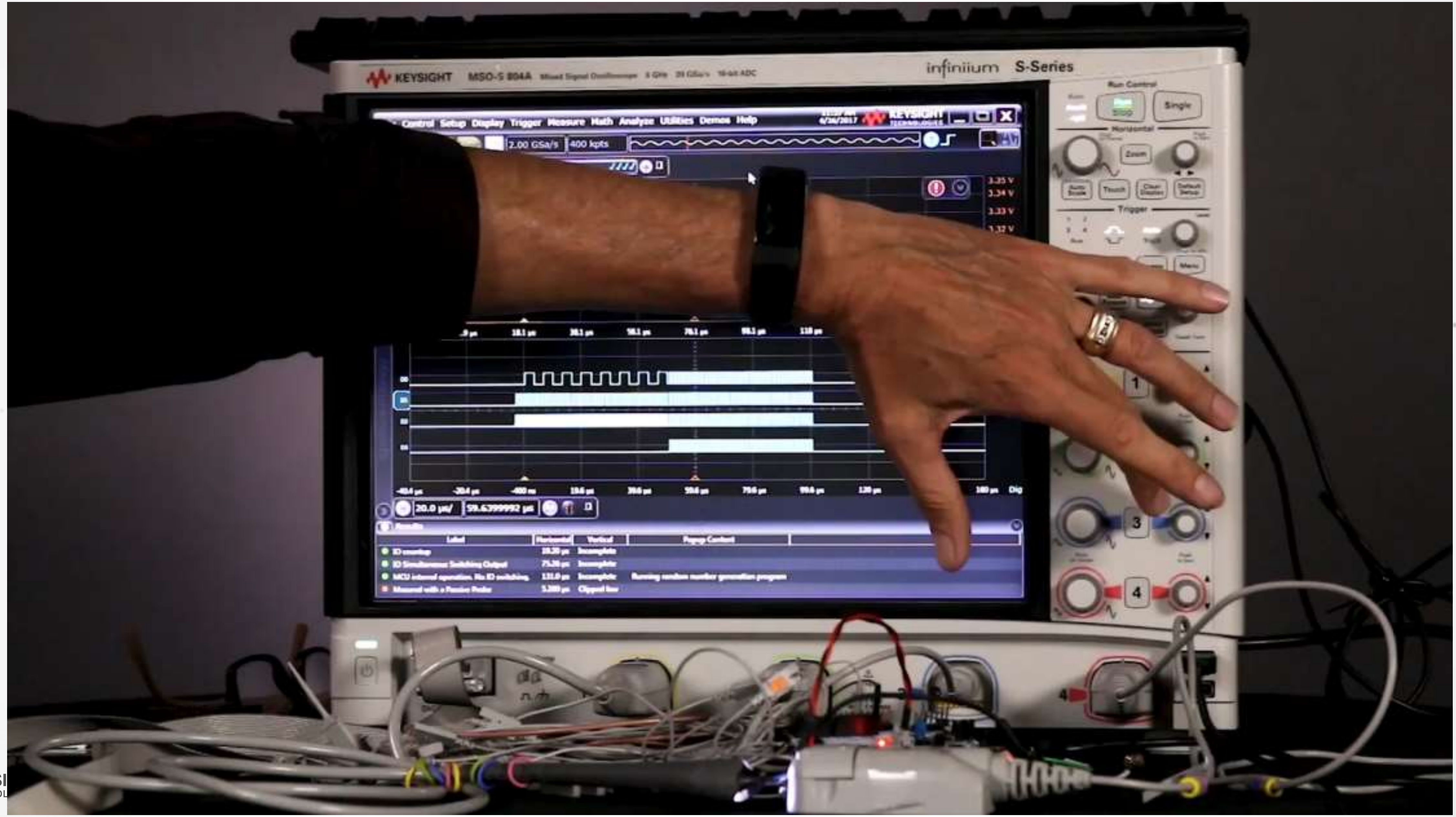
How Attenuation Ratio Affects Measurement Accuracy



Power Integrity Measurements Pro Tip:

Reduce the probe attenuation ratio to improve the signal to noise ratio between your DUT and your measurement system.

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Power Integrity Measurements

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Good for <u>quantitative</u> measurements

Good for <u>qualitative</u> measurements

Power Integrity Measurements

BW EFFECTS NOISE—EX. N7020A PROBE/S-SERIES SCOPE

Measurement	Current	Mean	Min	Max	Range (Max-Min)	Std Dev	Count
ACVrms(1)	60.5171 µV	58.6411 µV	50.0973 µV	66.7368 µV	16.6395 µV	3.48820 µV	84
V p-p(1)	481.7 µV	460.16 µV	396.3 µV	545.9 µV	149.7 µV	34.09 µV	84

“

Power Integrity Measurements Pro Tip:

Use only the bandwidth you need to avoid an excessively high noise floor…

Measurement Basics in an IoT World

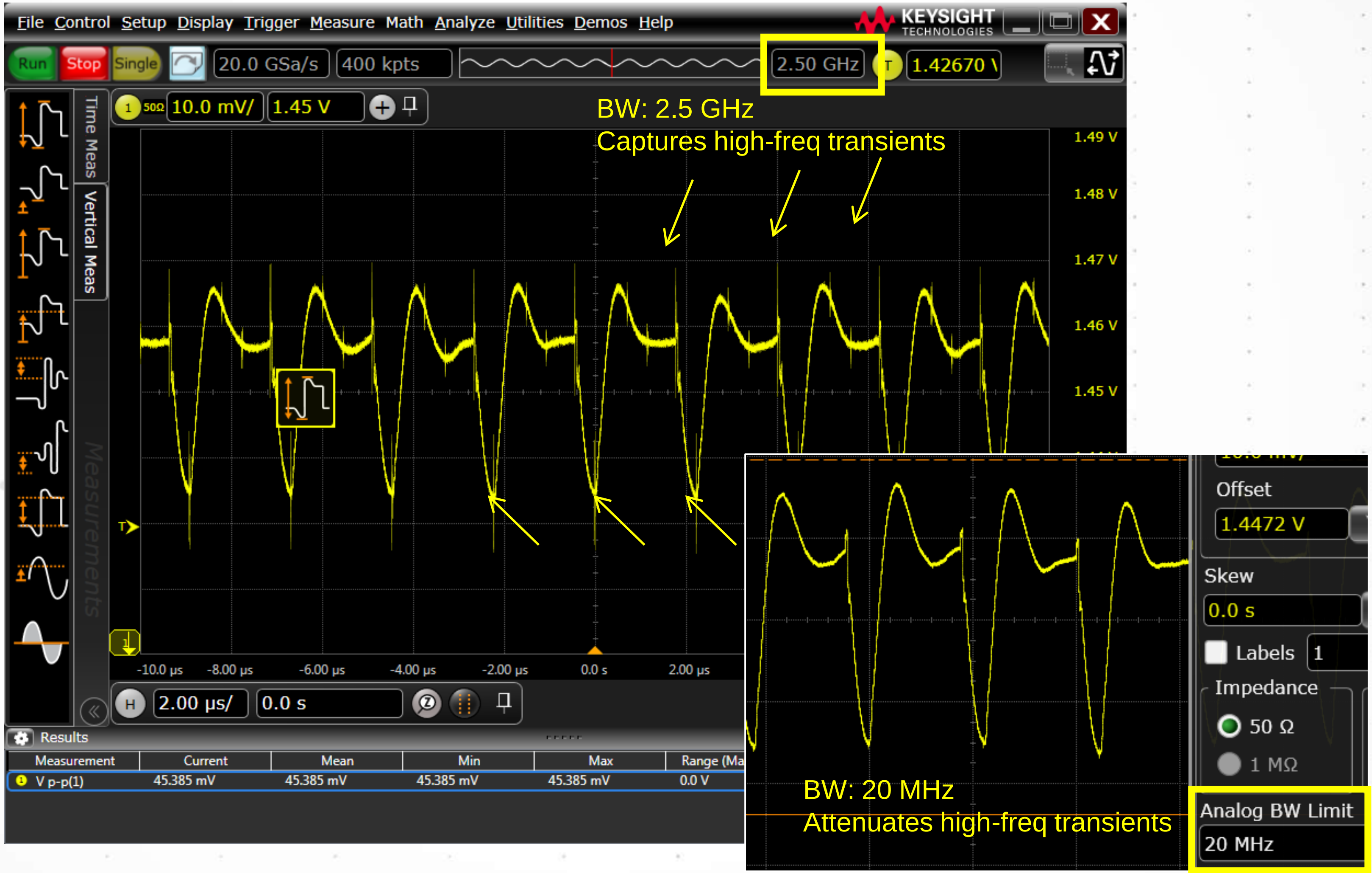
Keysight Technologies

Power Integrity Measurements

TRADEOFF WITH BW LIMITING—USE WHAT IS NEEDED

Switching currents cause transients that can easily exceed 1GHz.

Supply noise is a leading cause of clock/data jitter.



KEYSIGHT TECHNOLOGIES

Power Integrity Measurements

HAVING ENOUGH BW IS CRITICAL

General Purpose

N2870A **35 MHz**, 1:1

Specialized

N7020A **2 GHz**, 1:1

“

Power Integrity Measurements Pro Tip:

Use only the bandwidth you need to avoid an excessively high noise floor…. But use enough bandwidth to capture high speed transients in your design.

Measurement Basics in an IoT World

Keysight Technologies

Power Integrity Measurements

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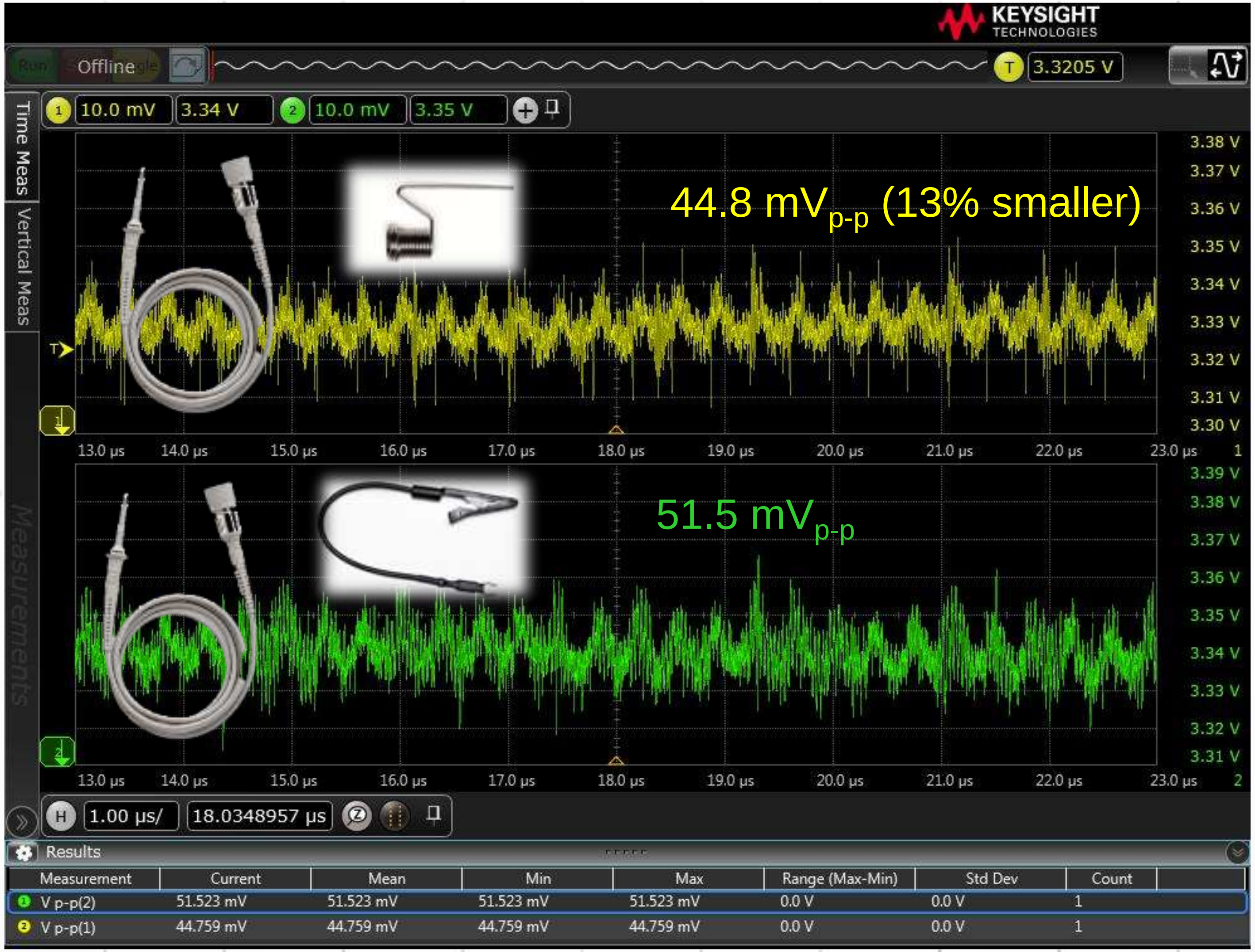
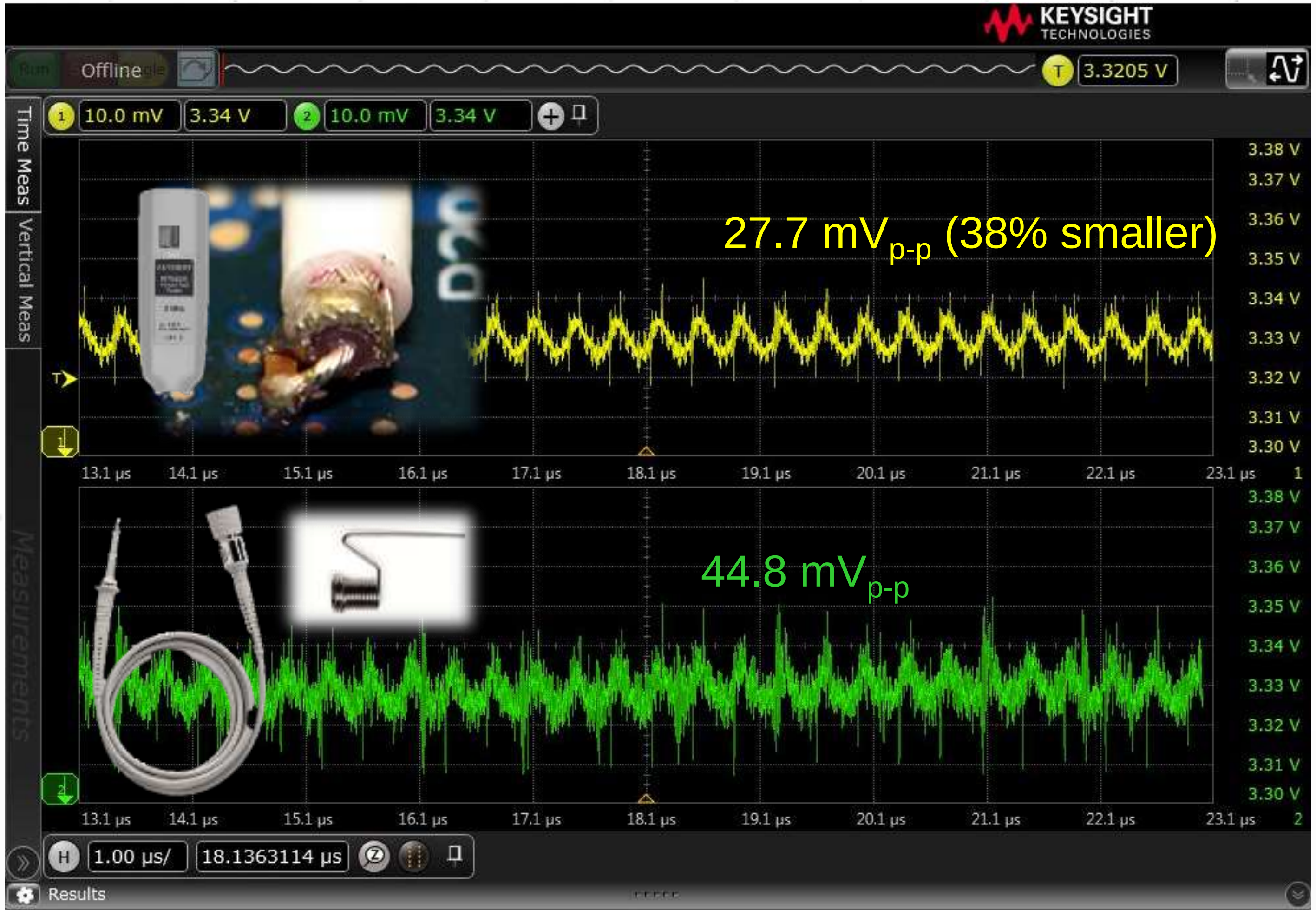
Power Integrity Measurements

GND CONNECTION LENGTH EFFECTS NOISE: EX. PASSIVE PROBE



Power Integrity Measurements

GND CONNECTION LENGTH EFFECTS NOISE



Measurement	Current	Mean	Min	Max	Range (Max-Min)	Std Dev	Count
V p-p(2)	44.759 mV	44.759 mV	44.759 mV	44.759 mV	0.0 V	0.0 V	1
V p-p(1)	27.661 mV	27.661 mV	27.661 mV	27.661 mV	0.0 V	0.0 V	1

Power Integrity Measurements Pro Tip:

Minimize ground loop area to reduce environmental noise coupled into your probe.

Measurement Basics in an IoT World

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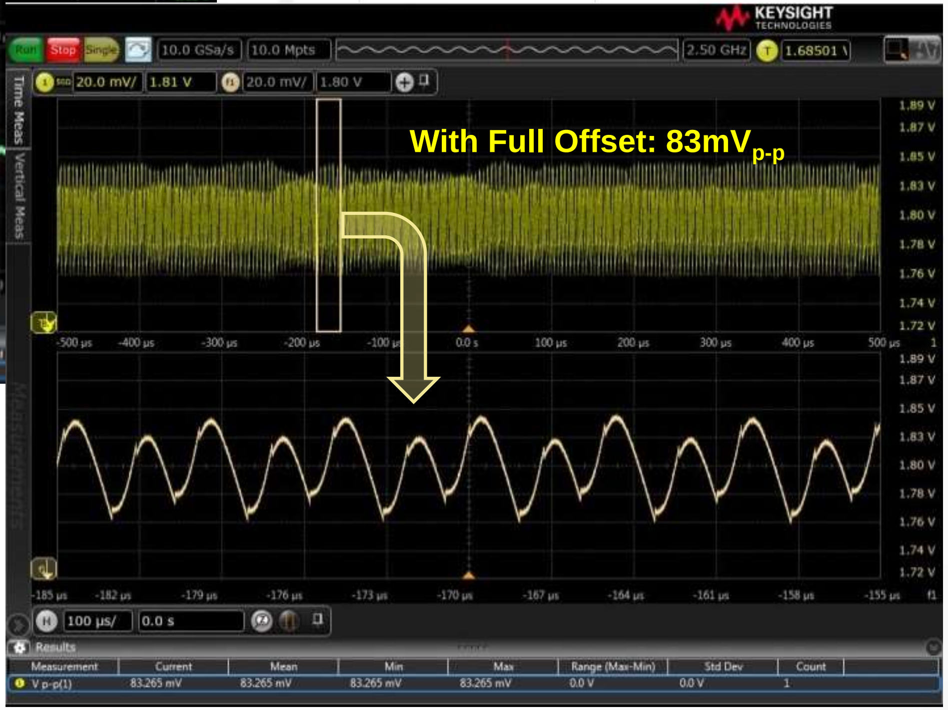
Power Integrity Measurements

LARGE DC SIGNAL OFFSET

At larger V/div

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

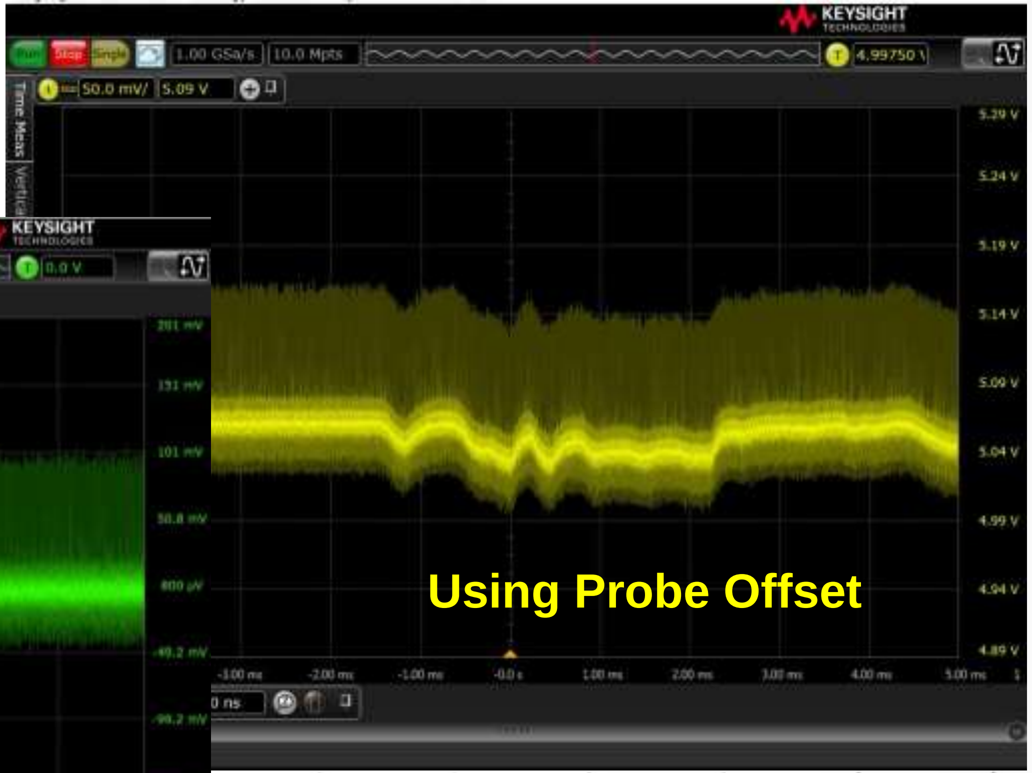


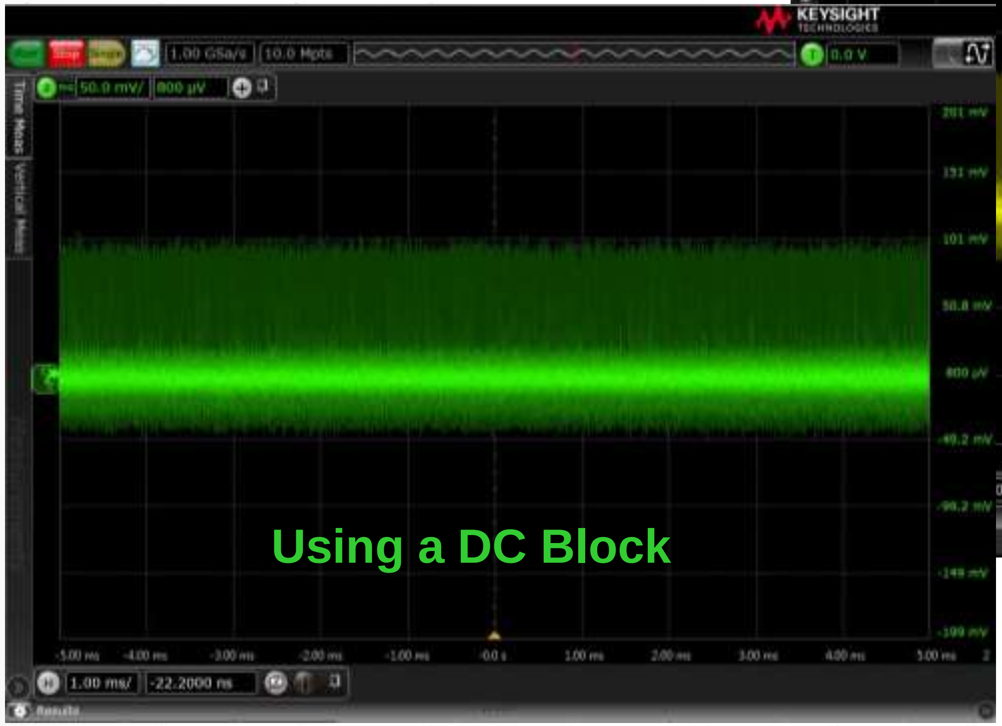
Remove DC Signal Offset

- Probe Offset
- DC Block

Power Integrity Measurements

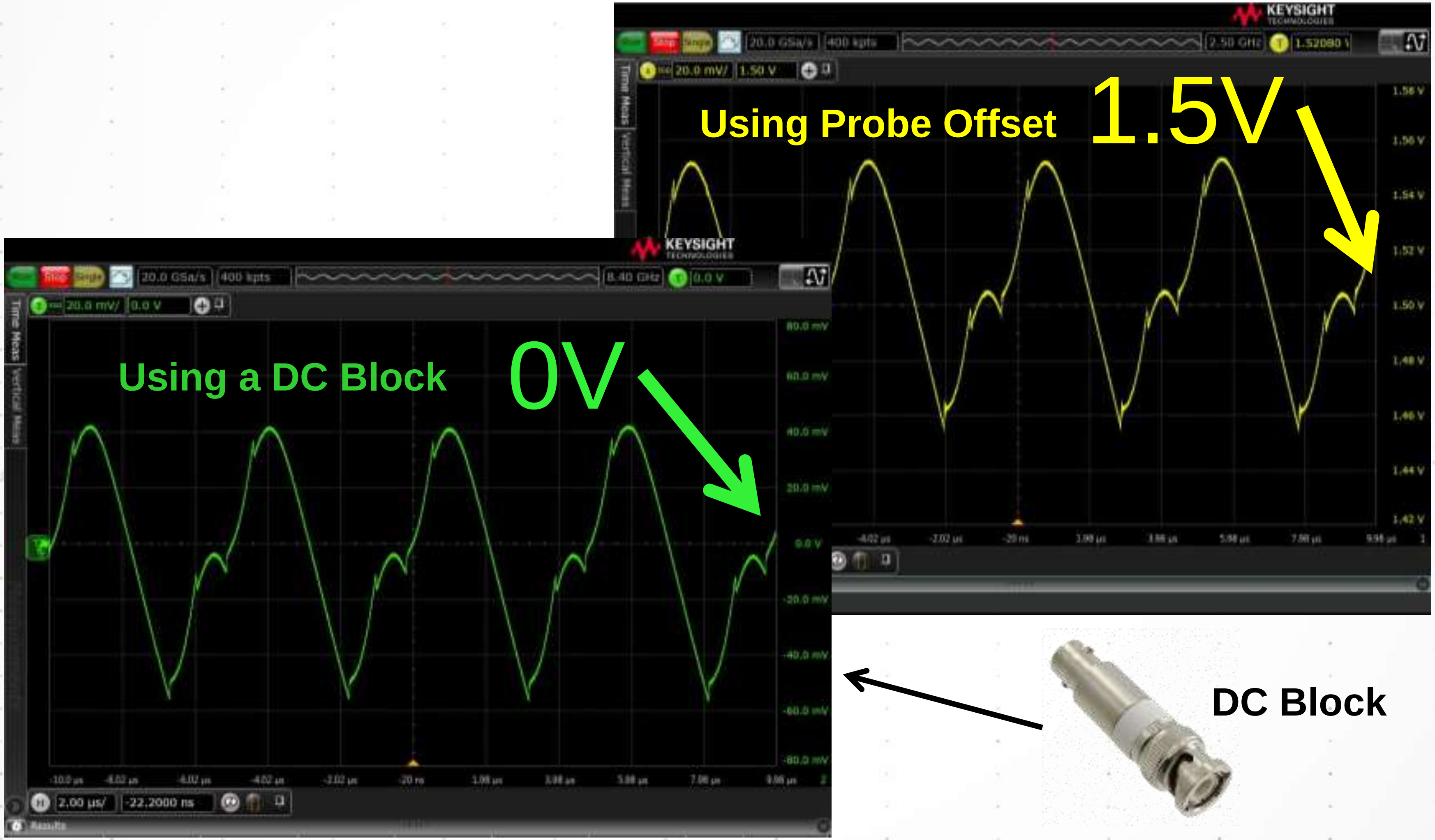
REMOVING LARGE DC SIGNAL—PROBE OFFSET OR DC BLOCK





Power Integrity Measurements

REMOVING LARGE DC SIGNAL—PROBE OFFSET OF DC BLOCK



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Power Integrity Measurements Pro Tip:

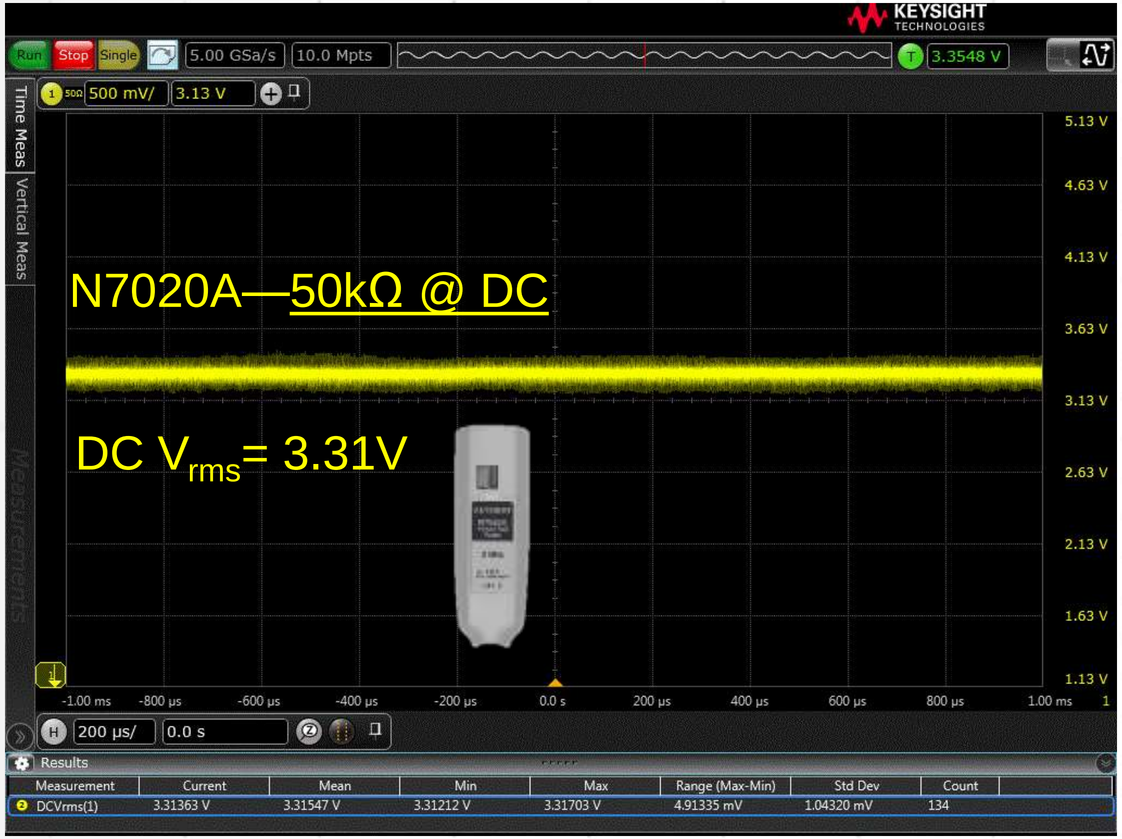
Use probe offset instead of a DC block to get accurate measurements and prevent oscilloscope damage.

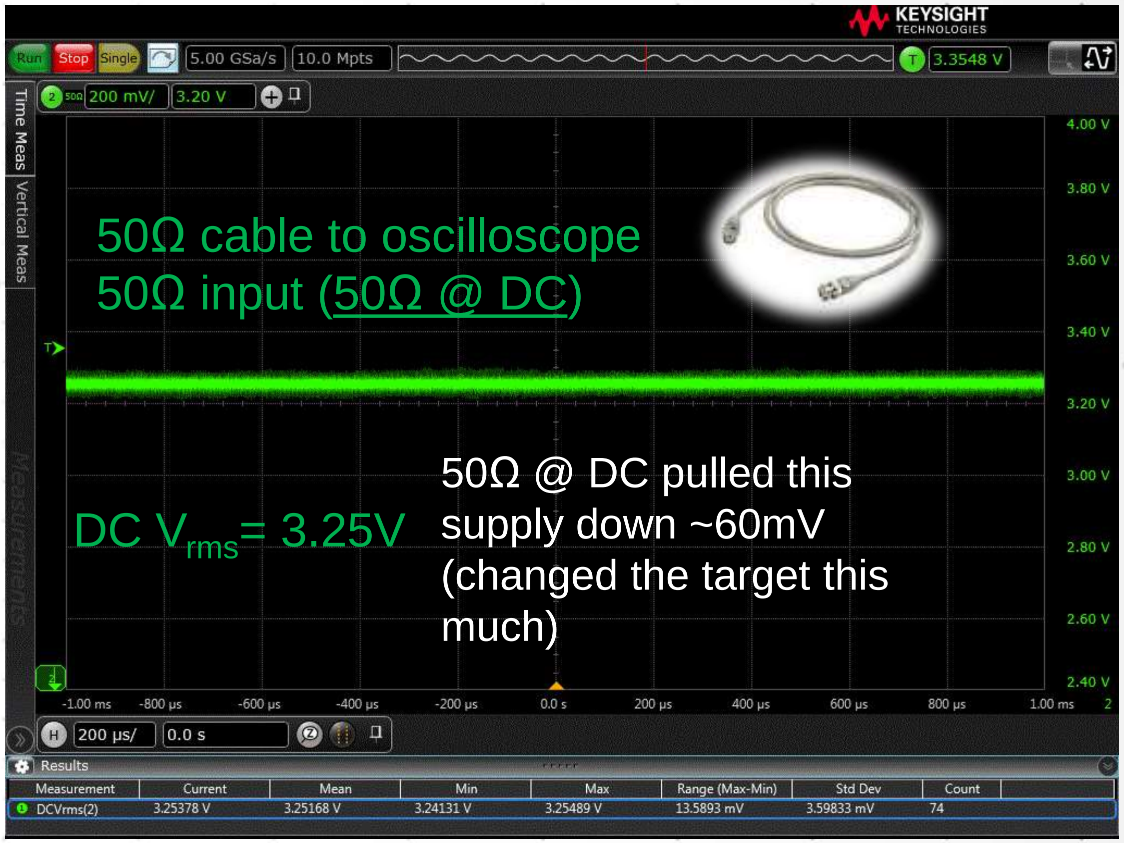
Measurement Basics in an IoT World

Keysight Technologies

Power Integrity Measurements

A WORD OF CAUTION: DIRECT 50Ω CONNECTION





Specialized

The scope you are using may have enough frame offset for some signals.
Beware of 50Ω load at dc.

General Purpose

Power Integrity Measurements Pro Tip:

Minimize probe loading to get the most accurate representation of your DUT in an unprobed state.

Measurement Basics in an IoT World

Keysight Technologies

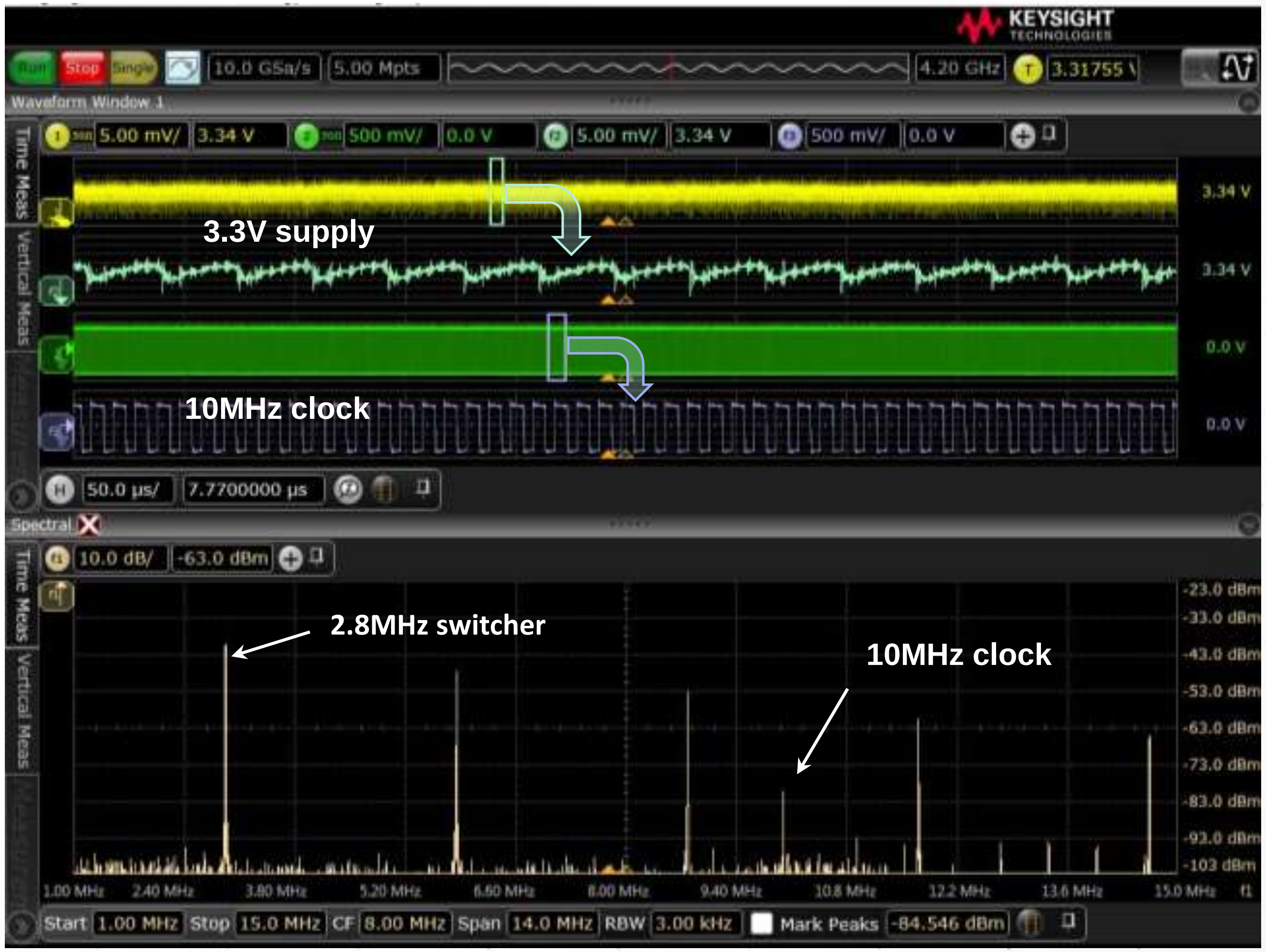
Power Integrity Measurements

TRACK DOWN NOISE SOURCES WITH TRIGGER AND AVERAGING.

Example:

Using FFT's we see that the digital circuits are causing noise on the 3.3V supply.

Is it worth making changes (how much are they effecting the supply)?

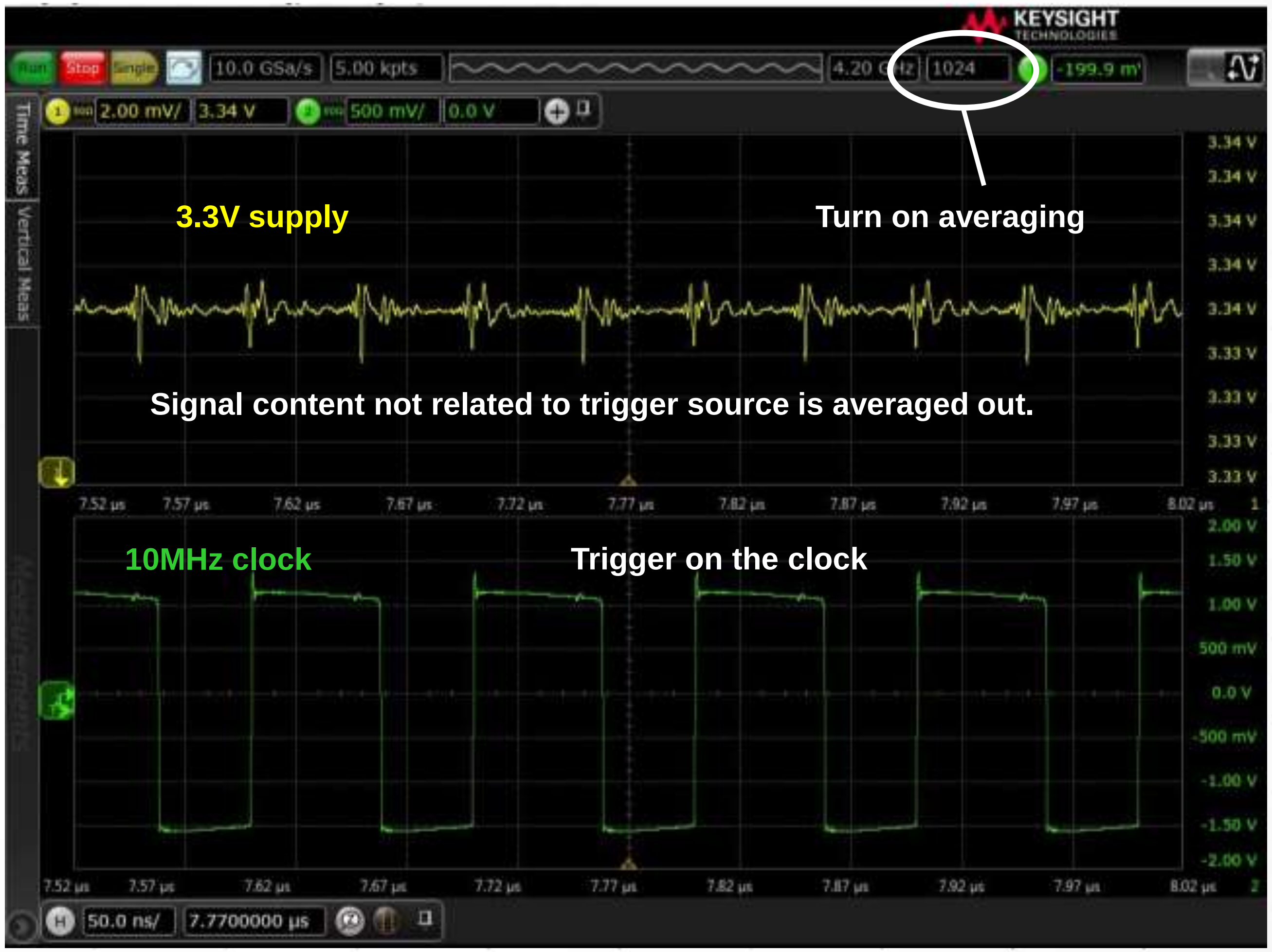


Power Integrity Measurements

TRACK DOWN NOISE SOURCES WITH TRIGGER AND AVERAGING.

Example:

Triggering on possible noise source and enabling averaging shows the noise on the supply that is coherent to the noise source.



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Power Integrity Measurements Pro Tip:

Use triggering and averaging as a way to determine the aggressors in your design.

Measurement Basics in an IoT World

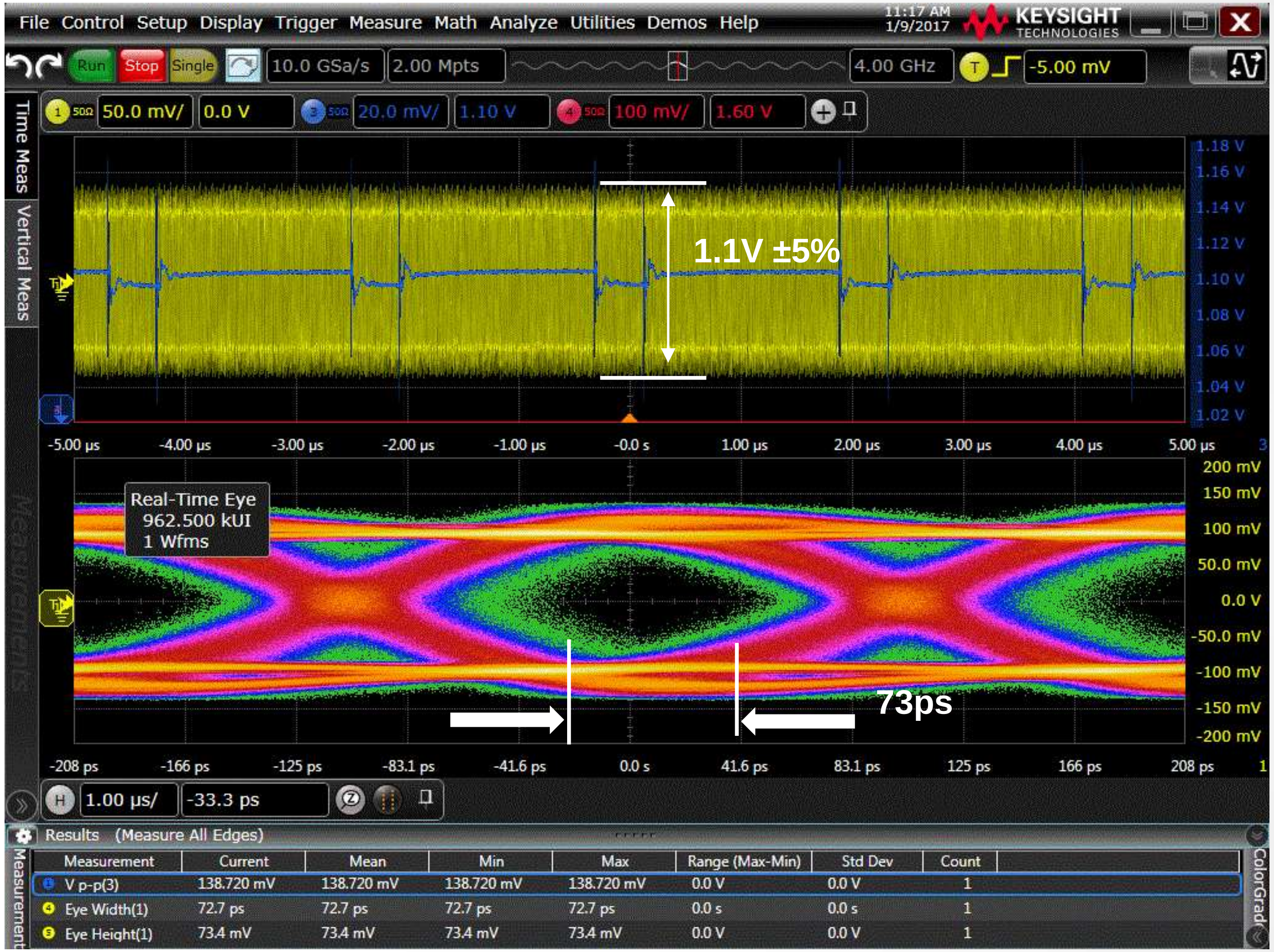
Keysight Technologies

Power Integrity Analysis

NEXT STEP AFTER GOOD POWER INTEGRITY MEASUREMENTS

“I wish there was a button I could push that would tell me if it’s worth [making design changes]”.

“Sure, we can always make it better, but we have limited resources and face schedule and product price pressure… Before I model, simulate, redesign, re-layout, fabricate, load and retest the board again I’d like to know if it’s worth it.”



KEYSIGHT TECHNOLOGIES

N8846A Power Integrity Application

QUICK AND EASY WAY TO TELL IF IT'S WORTH IT

- Before-and-after views for easy visual qualitative assessment.
- Automatic quantitative analysis unique to the victim signal type.
- No simulation or modeling required.
- Quick an easy setup wizard.
- Automatically identifies signals probed by N7020A probe as power supplies.
- Waveforms are automatically labeled for easy recognition.
- Additional measurements can be performed on before/after waveforms (math functions, waveform measurements, jitter analysis, et cetera).

Supply as aggressor

Before/After

Signal

Eye Diagram

Supply as victim

Before/After

Signal

FFT

Vpp

Power Integrity Measurements

SUMMARY

Good for <u>quantitative</u> measurements

Specialized

General Purpose

Good for <u>qualitative</u> measurements

1. Choose the low noise path.
2. Reduce attenuation ratio.
3. BW—use what is needed.
4. BW—have enough.
5. Minimize ground loop area.
6. Use probe offset.
7. Minimize loading.
8. Use triggering and averaging.

Bonus Tip: Use a specialized tool such as the N7020A probe or PI Application!

KEYSIGHT TECHNOLOGIES

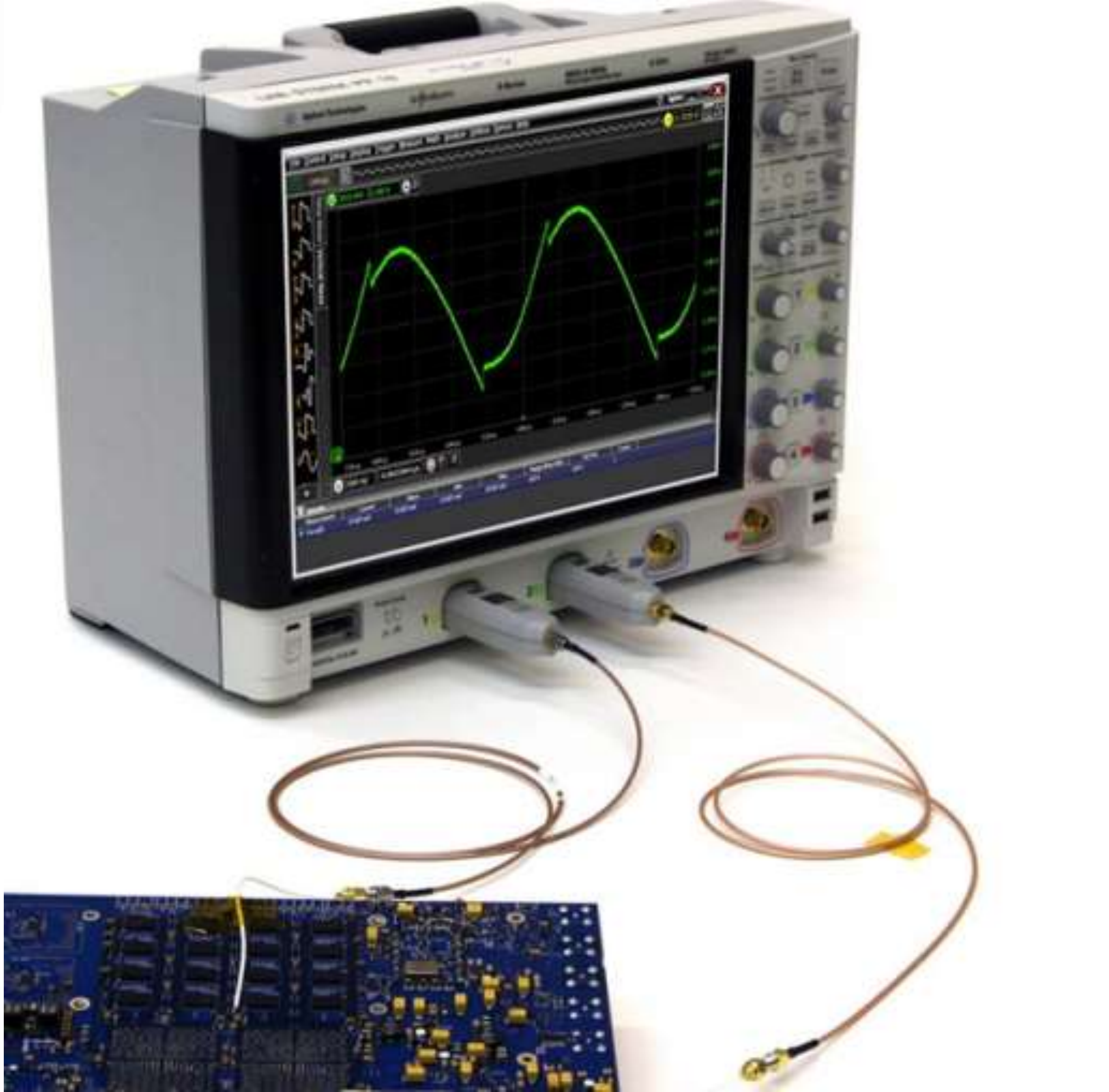
Power Integrity Measurements

USED TODAY: INFINIIUM S-SERIES HIGH-DEFINITION OSCILLOSCOPE

- Low noise front end at small vertical settings
- Full 10-bit ADC support with full BW down to 16 mV full screen
- Analog and DSP-based bandwidth limit filters
- Measurement capability including FFTs, axis annotation, dynamic delta markers

Keysight N7020A Power Rail Probe:
www.keysight.com/find/N7020A

Keysight Power Integrity Application:
www.keysight.com/find/solution-powerintegrityanalyzer



KEYSIGHT TECHNOLOGIES

Power Integrity Measurements

N7020A POWER RAIL PROBE

Also Compatible With:

InfiniiVision 3000T X-Series Oscilloscopes

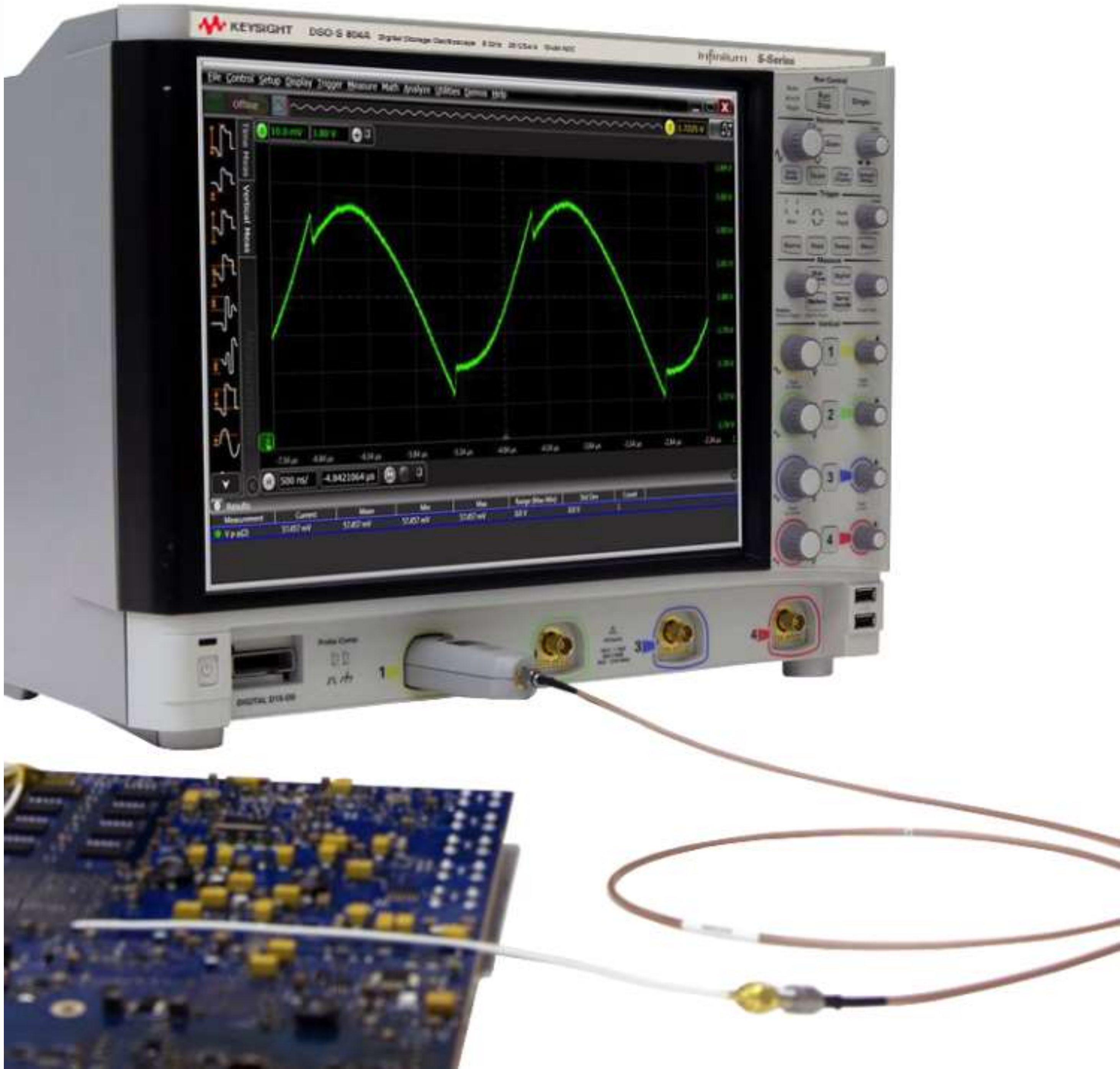
InfiniiVision 4000 X-Series Oscilloscopes

InfiniiVision 6000 X-Series Oscilloscopes

Power Integrity Measurements

THINGS YOU CAN DO.

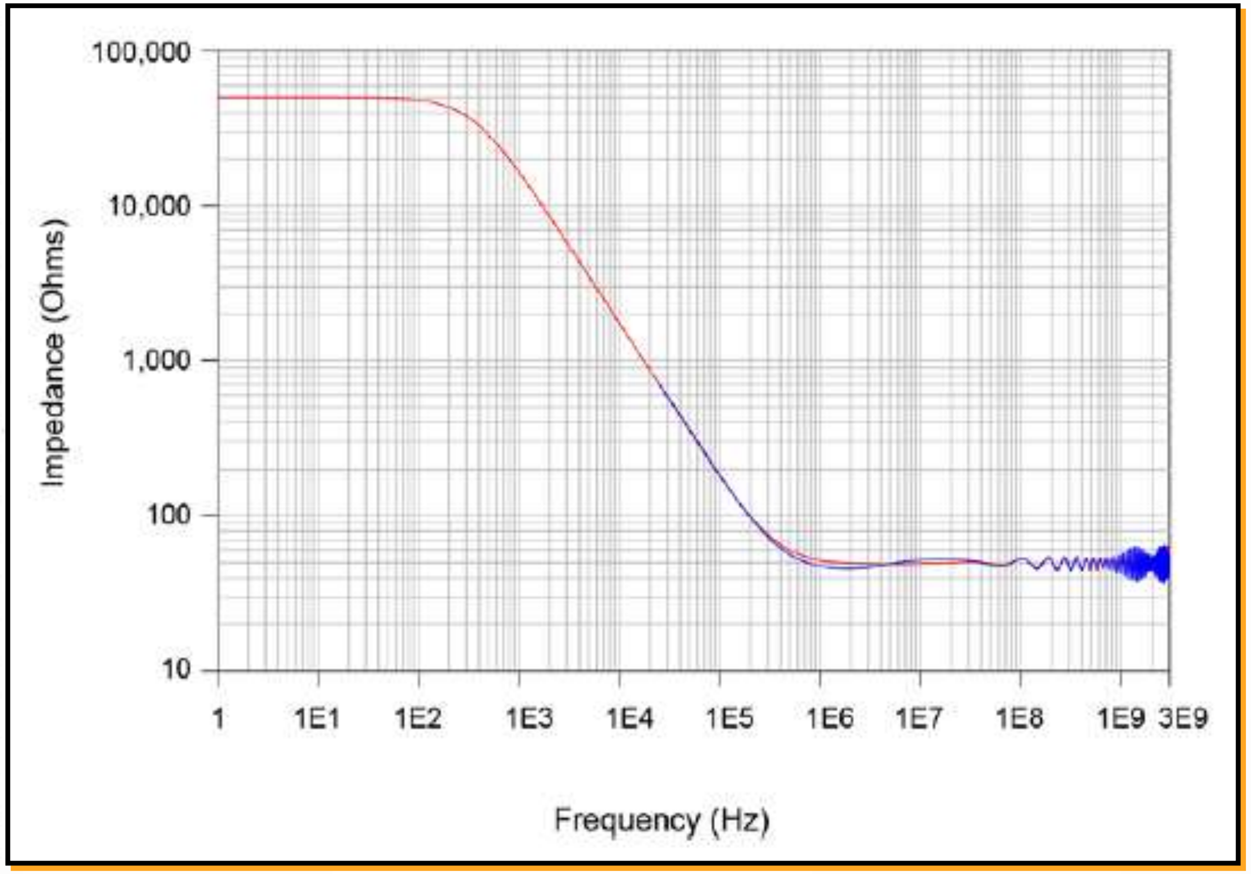
Thank you for your time!
- Demo station up front -



KEYSIGHT
TECHNOLOGIES

Low Loading

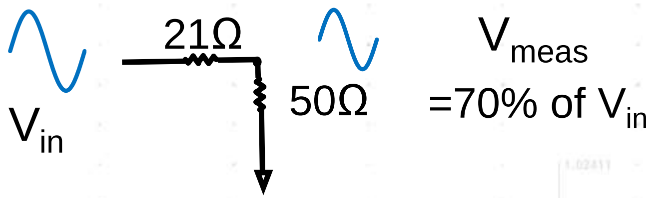
Input Impedance @ DC	50kΩ +/-2%
@ >1 MHz	50Ω

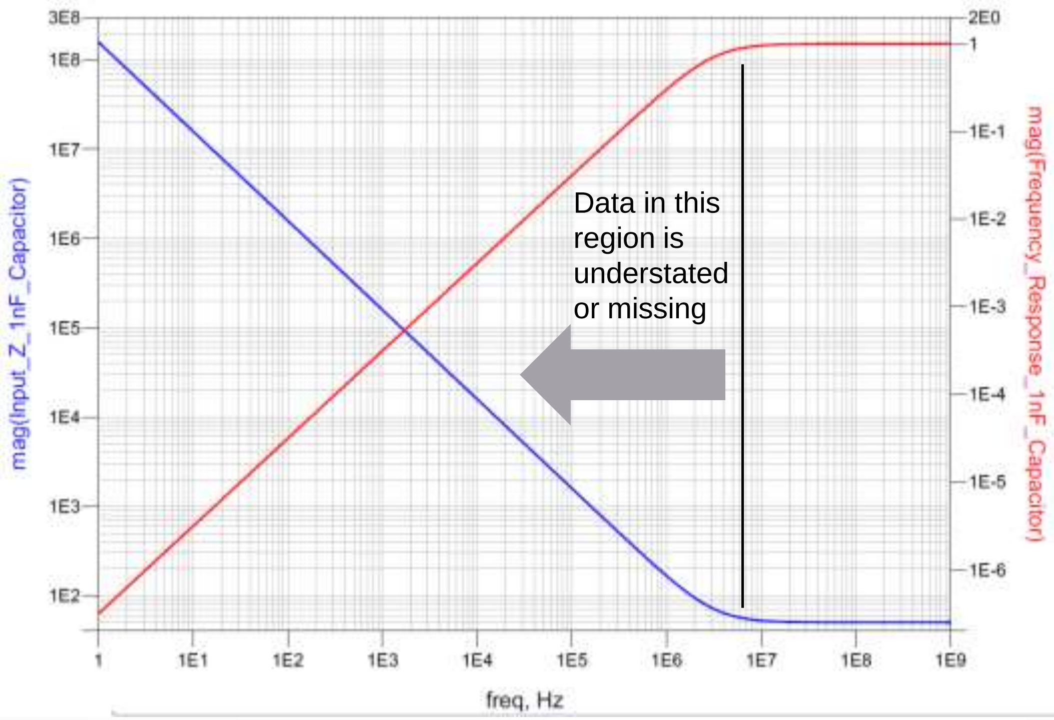


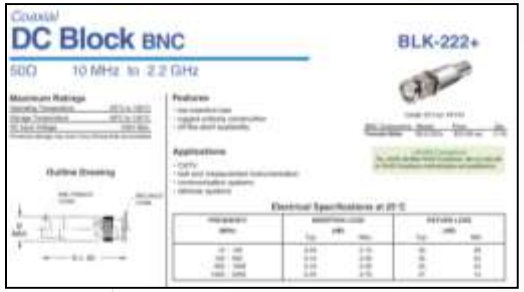
Support For Popular Rail Voltages

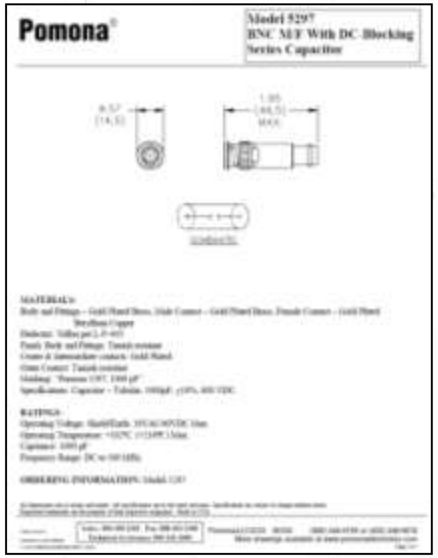
LARGE DC OFFSET—PROBE OFFSET OR DC BLOCK

Capacitance: 1000pf
Impedance @ 7.5MHz = 21Ω






Coaxial
DC Block BNC
BLK-222+
50Ω 10 MHz to 2.2 GHz


Pomona
Model 5297
BNC M/F With DC Blocking Series Capacitor