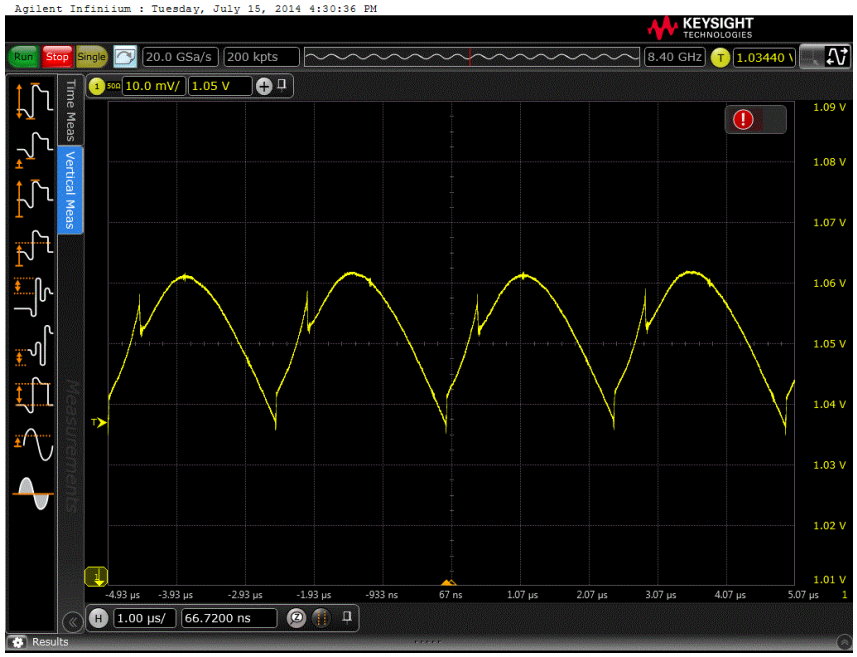
DC 전압에 실린 미세 노이즈 측정 (Power rail 신호 무결성 측정)

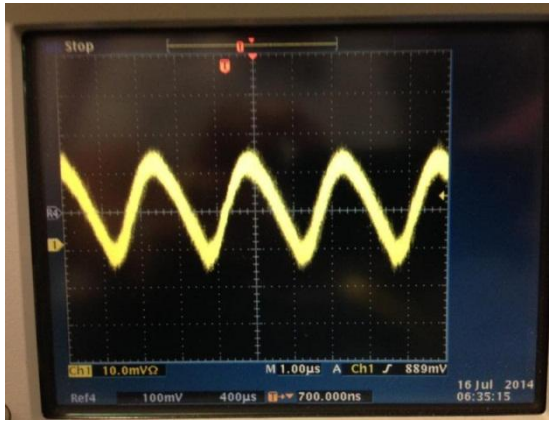
KEYSIGHT TECHNOLOGIES

Power Rail Measurements

We'll show you how to make measurements like this.



Instead of like this



Comprehensive Probe Portfolio

Power Rail Probe

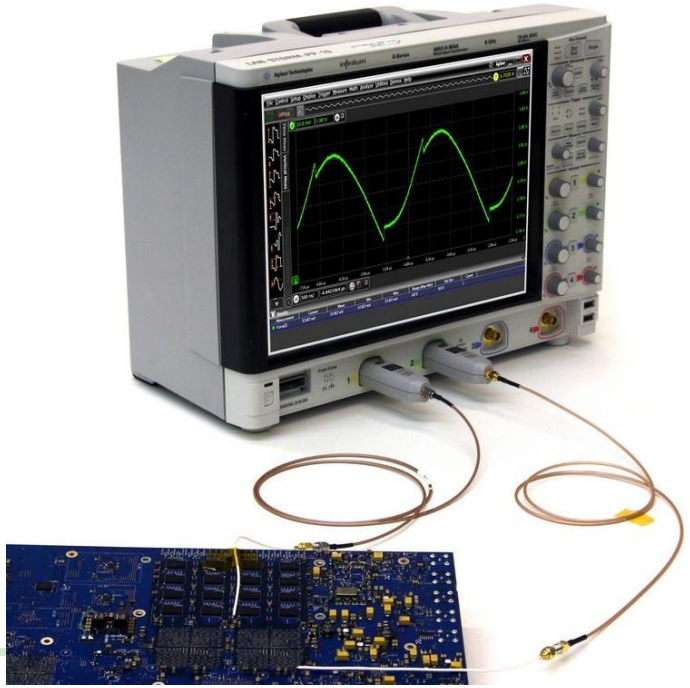
N7020A Specifications

…and implications for power rail measurements

- Low noise
  - 1:1 attenuation ratio
  - Adds ~10% to the oscilloscope frame noise
- Large offset range
  - +/- 24V
- Excellent input impedance
  - 50 KΩ at DC

Keysight Oscilloscope Portfolio

Extreme Value to Extreme Performance



iniium
500 MHz to 63 GHz
Deep memory
Win7 OS

DCA-X Sampling

90000 Z-Series

90000 X-Series

90000A Series

S-Series

U1600 Series | U2700 Series | 1000 Series | 2000 X-Series | 3000 X-Series | 4000 X-Series | 6000 X-Series

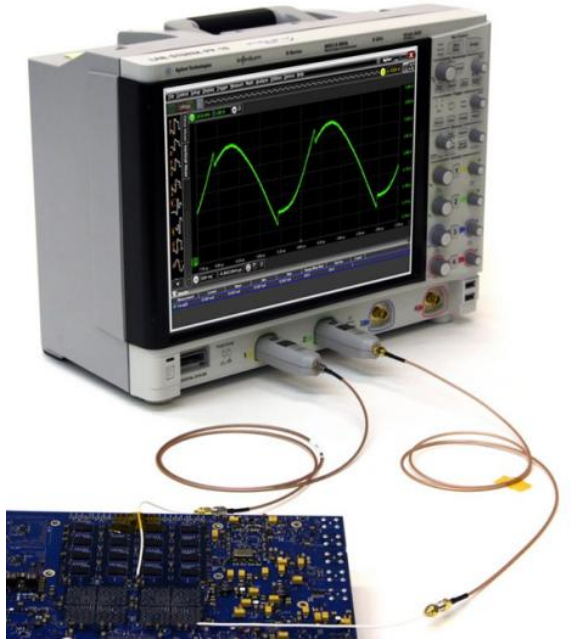
Infiniium S-Series

Ideal oscilloscope for power rail measurements

Infiniium S-Series Specifications

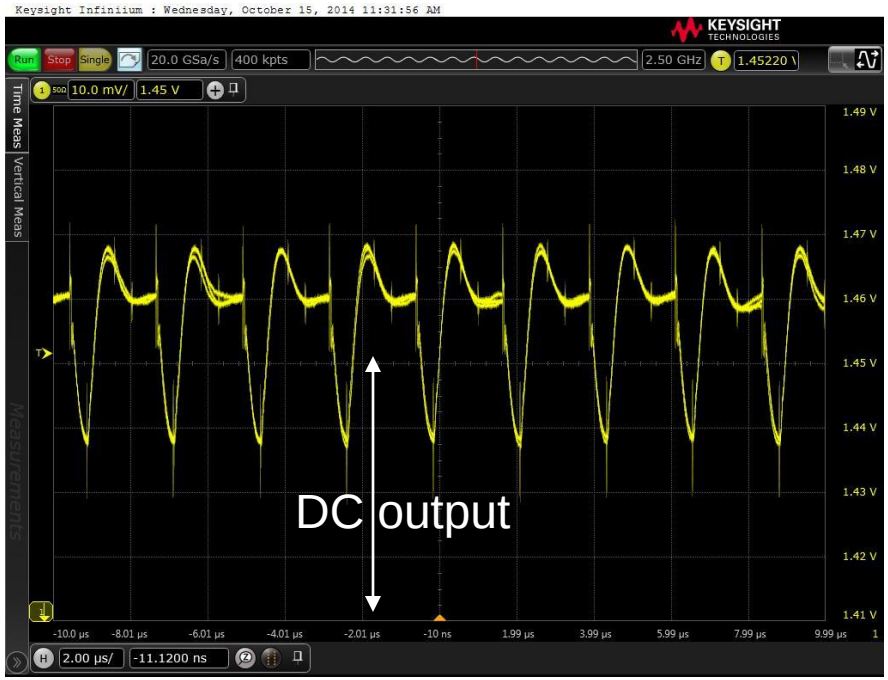
...and implications for power rail measurements

- 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



The Need for Power Integrity Measurements

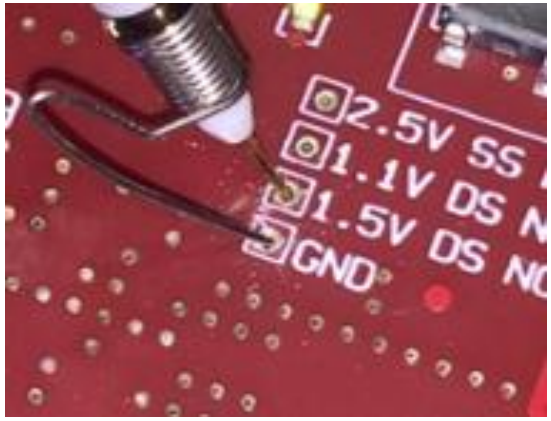
- Noise on the power rails can be the top cause of clock and data jitter
- Smaller voltages with tighter tolerances
- High frequency transients
- Rail voltages change (drift, droop, sag) as supply load varies



PARD

Top Concerns for Power Rail Measurements

1. Low noise
2. Support for popular rail voltages
3. Loading & connectivity
4. Bandwidth



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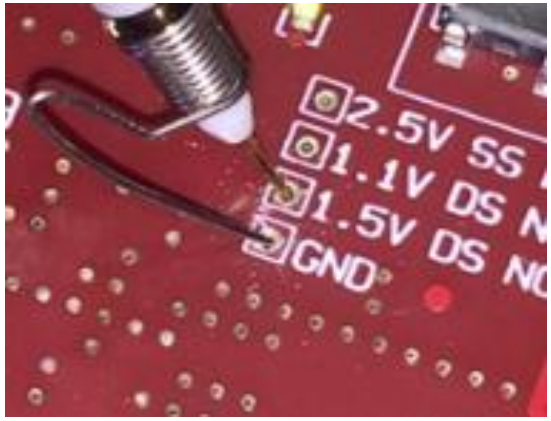
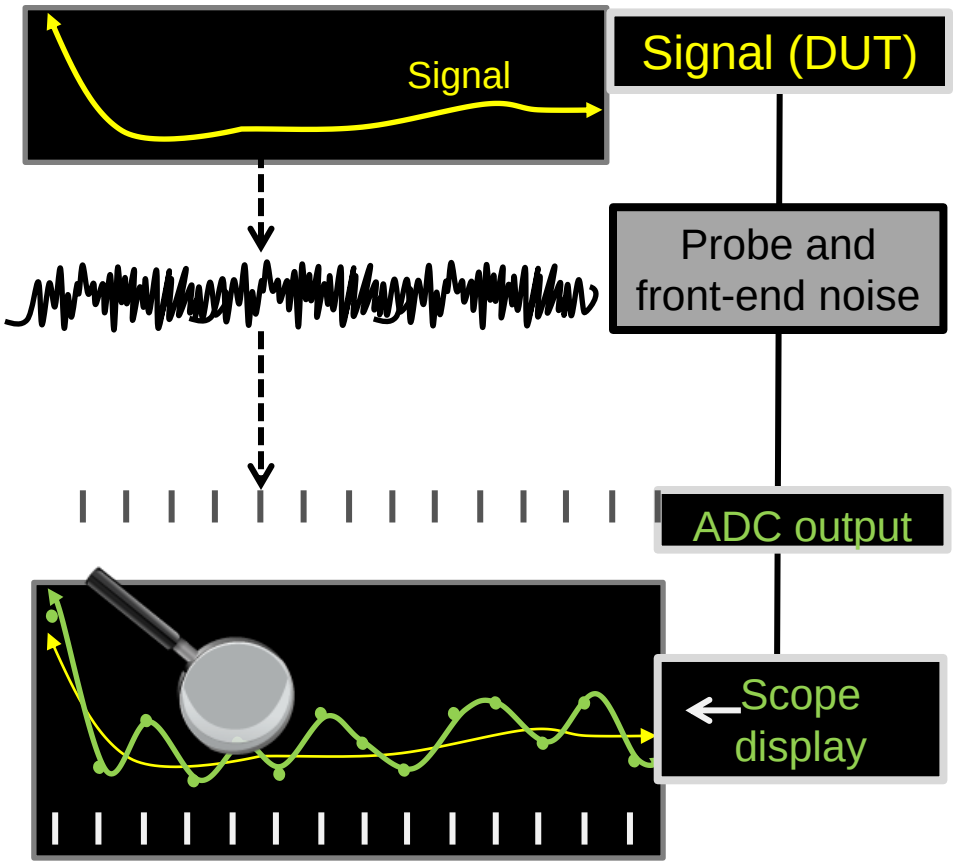
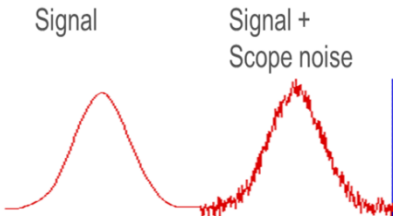


Oscilloscope/Probe Noise

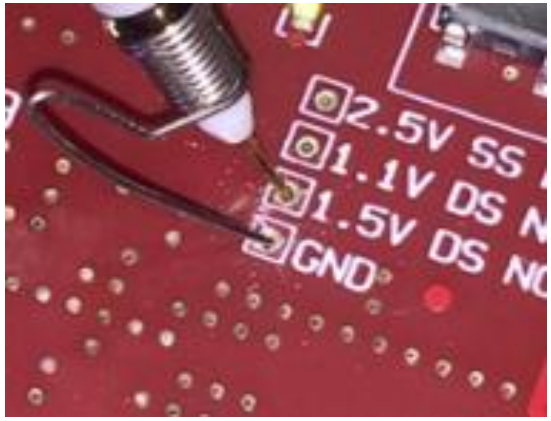
Produces higher Vpp measurements and masks transients





Top Concerns for Power Rail Measurements

1. Low noise
   - – how to characterize



Choose Scope that has Lowest Noise

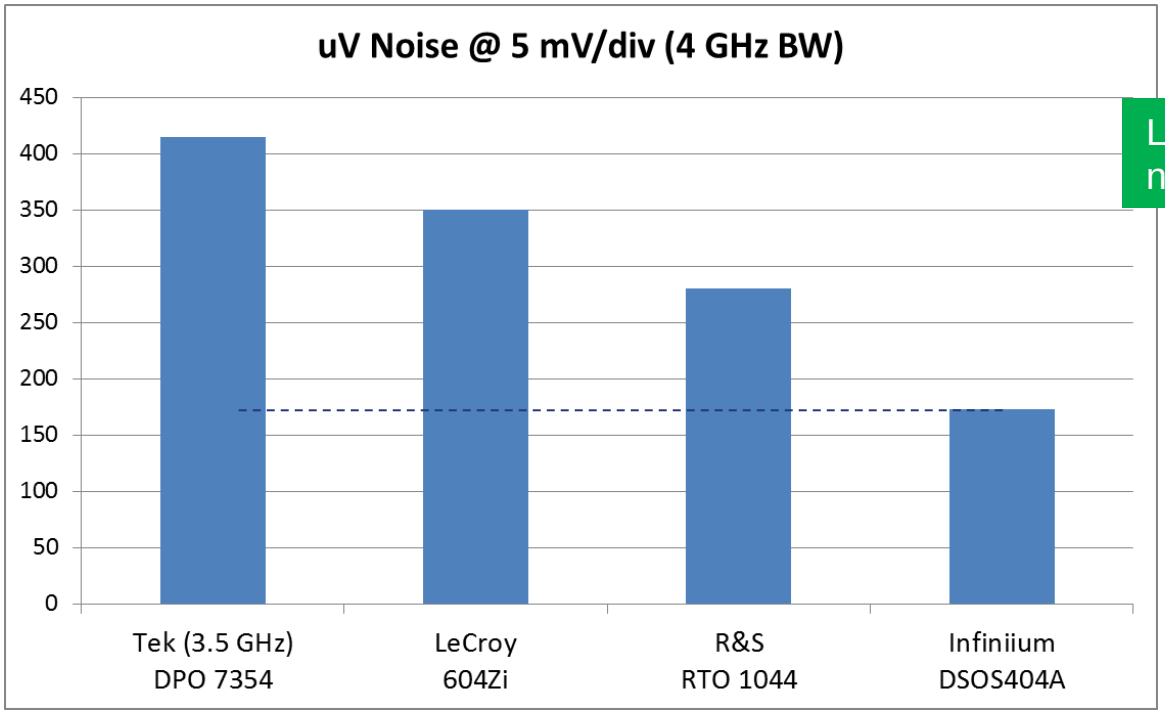
5 minutes

Disconnect all inputs

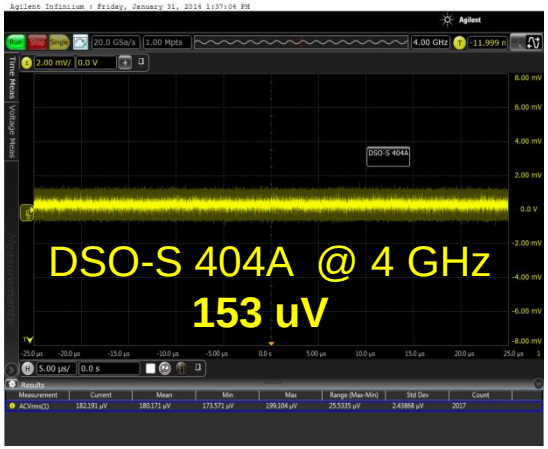
1. Measure at each V/div setting
2. Measure V_{rms} AC at:
   - 20 mV/div
   - 10 mV/div
   - 5 mV/div
   - 2 mV/div
   - 1 mV/div

Noise	Full Scale V

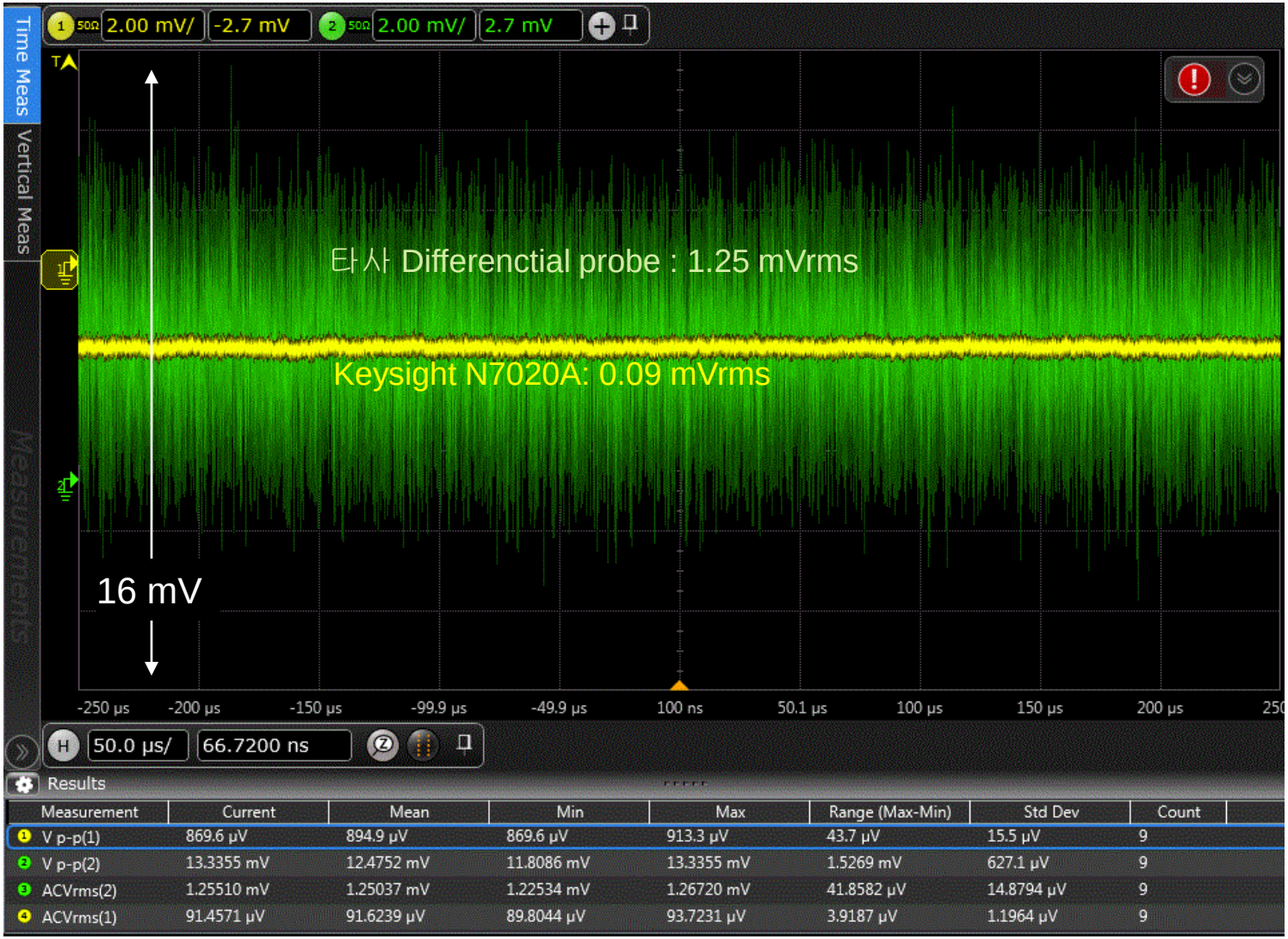
Oscilloscope Noise Comparison



Low noise



Probe Noise Adds to Scope Noise



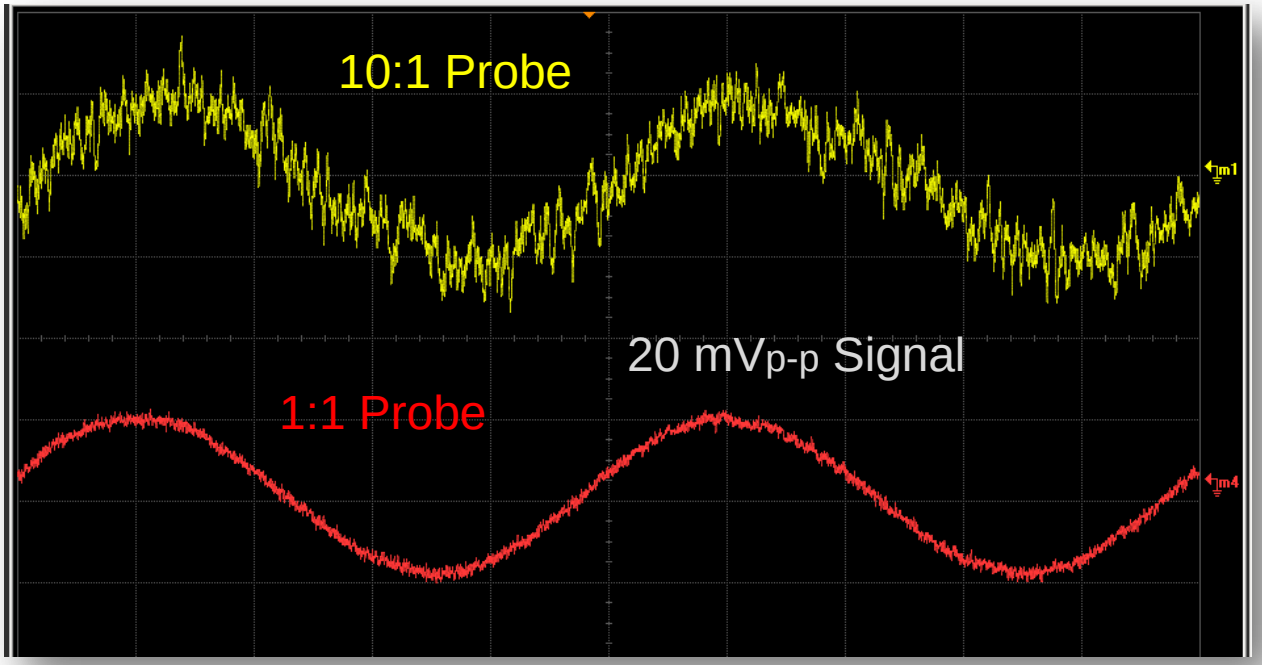
Measurement	Current	Mean	Min	Max	Range (Max-Min)	Std Dev	Count
V p-p(1)	869.6 µV	894.9 µV	869.6 µV	913.3 µV	43.7 µV	15.5 µV	9
V p-p(2)	13.3355 mV	12.4752 mV	11.8086 mV	13.3355 mV	1.5269 mV	627.1 µV	9
ACVrms(2)	1.25510 mV	1.25037 mV	1.22534 mV	1.26720 mV	41.8582 µV	14.8794 µV	9
ACVrms(1)	91.4571 µV	91.6239 µV	89.8044 µV	93.7231 µV	3.9187 µV	1.1964 µV	9

Both probe on S-Series

(Using N2744A T2A Adapter) with 500 MHz BW limit

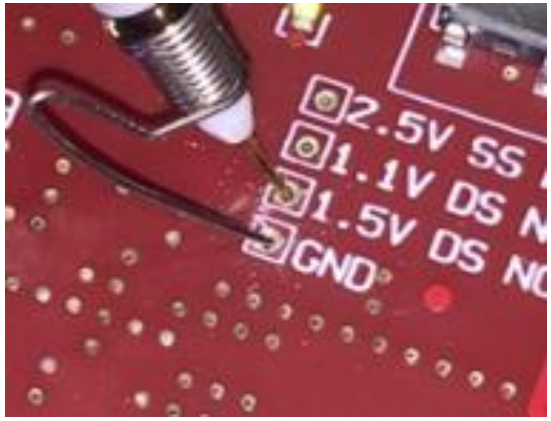
Probe Attenuation Ratio: High Impact on Noise

N7020A: Attenuation ratio:1:1 down to 1.09 mV/div



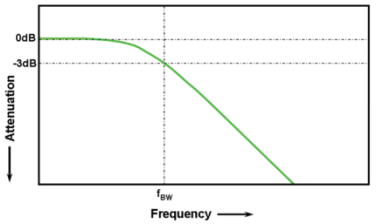
Top Concerns for Power Rail Measurements

1. Low noise –
   - How to reduce
     - BW limiting
     - Scaling to full screen
     - Averaging



Eliminating Noise via BW Reduction

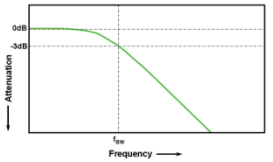
BW Reduction

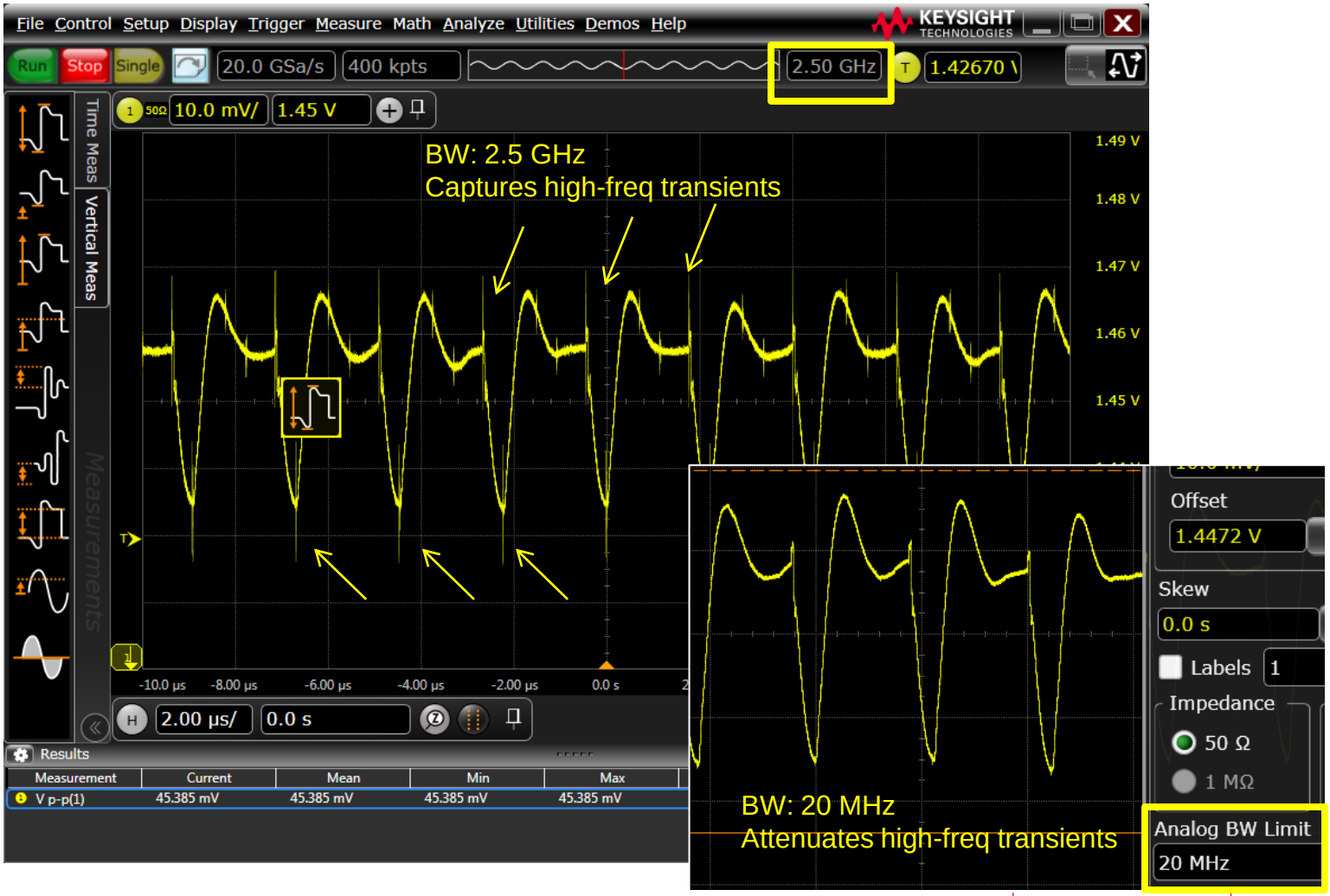


Bandwidth Reduction

Power Rail Examples

Tradeoff with BW Limiting





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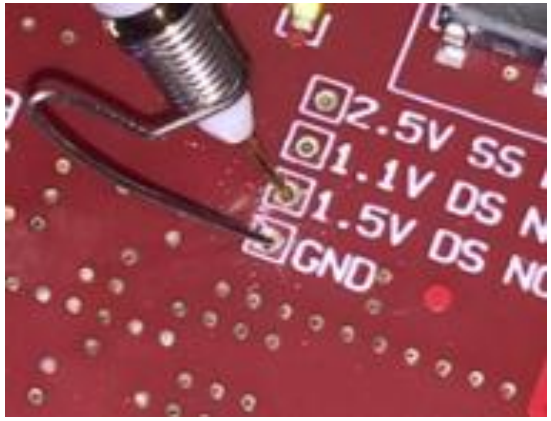
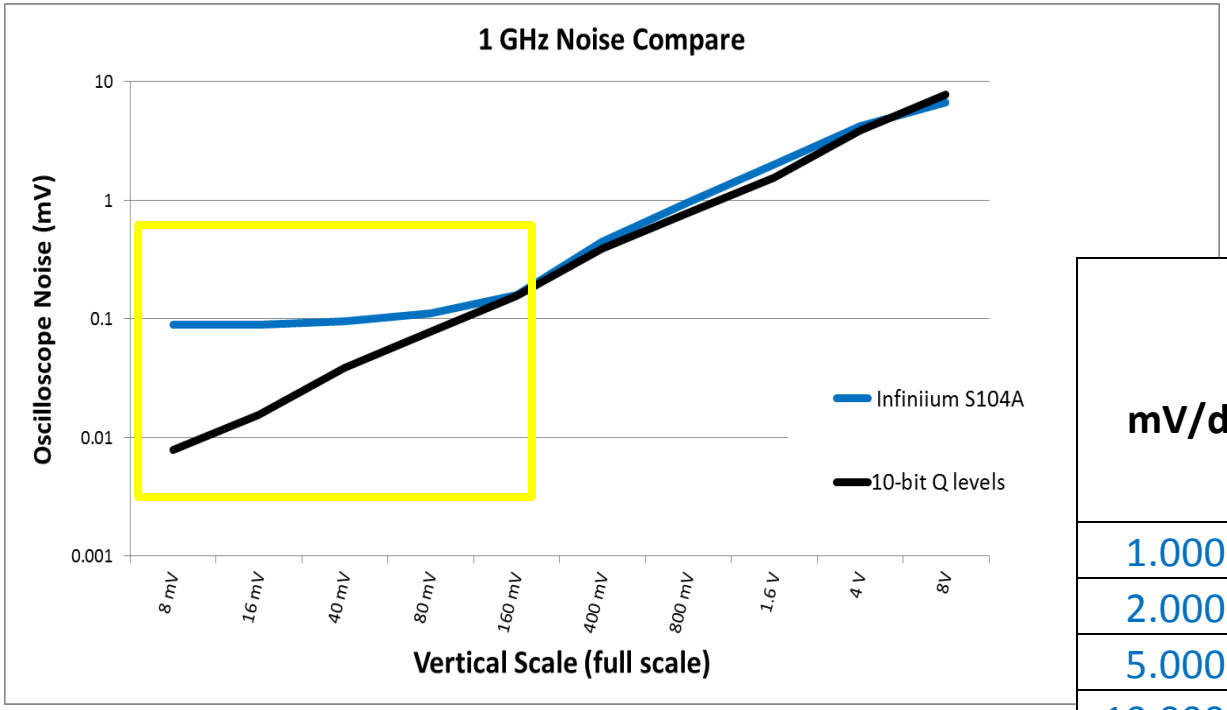


Scale for Lowest Noise

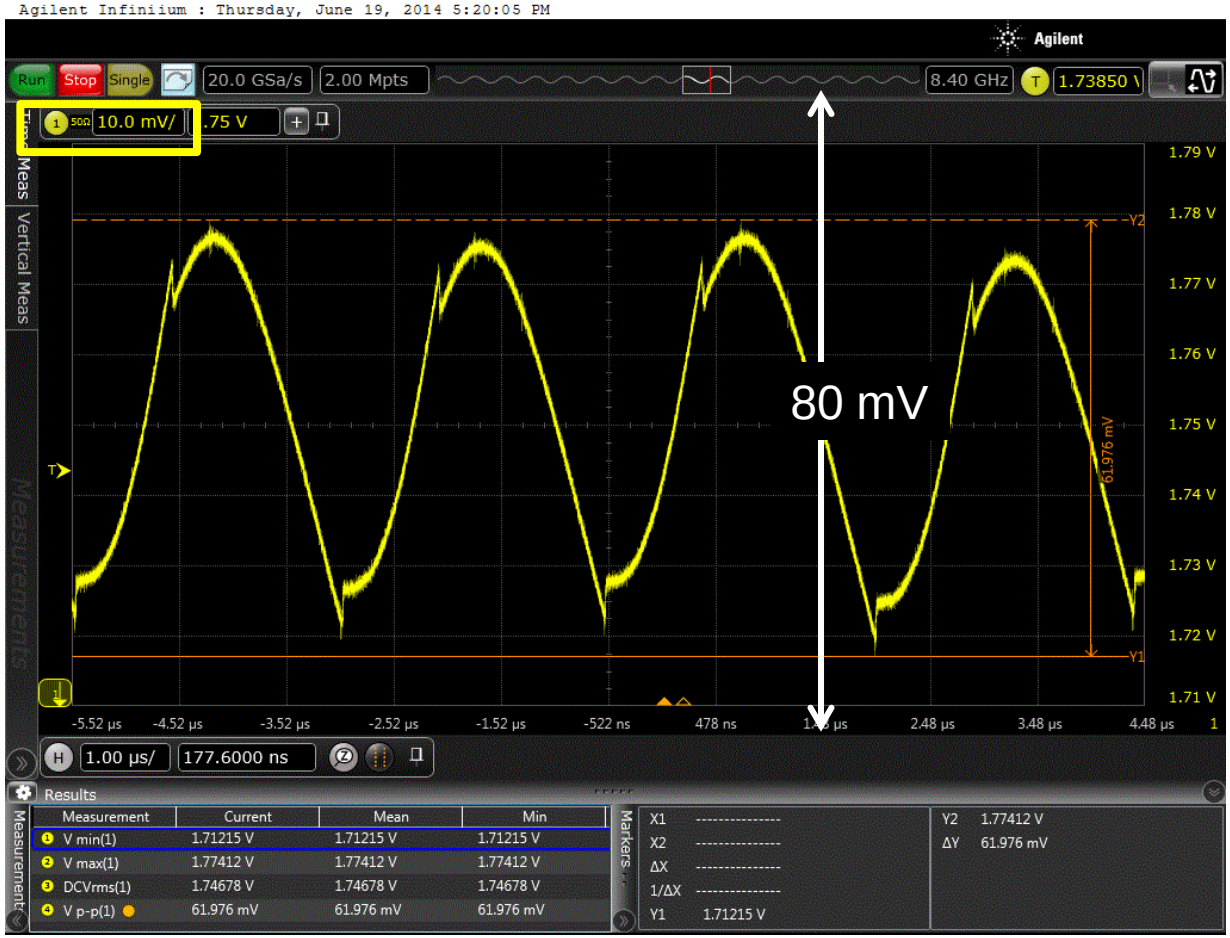


SW Magnification

mV/div	Full scale value (Volts)	Infiniium S104A noise (mV)
1.000E-03	8 mV	0.09
2.000E-03	16 mV	0.09
5.000E-03	40 mV	0.095
10.000E-03	80 mV	0.111
20.000E-03	160 mV	0.16
50.000E-03	400 mV	0.45

Scaling for Lowest Noise

….also Results in Maximum Vertical Resolution



S-Series

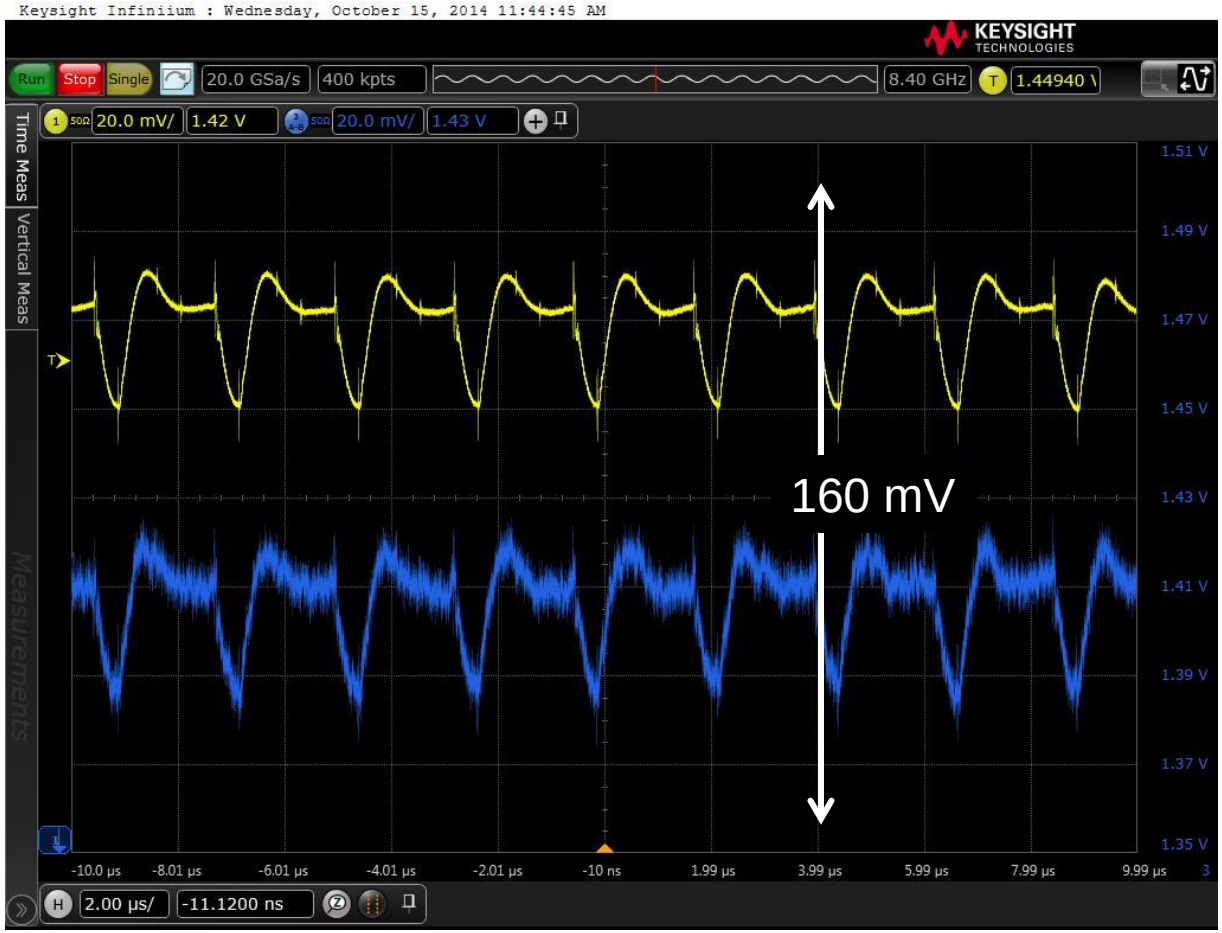
- Vertical setting = 10 mV/div
- 8 divisions
- Full scale = 80 mV

Resulting noise:
111 uV noise

…and we're using full resolution from the 10-bit ADC

Scaling for Maximum ADC Resolution with 2 Waveforms

… stacking decreases resolution, and adds noise



S-Series

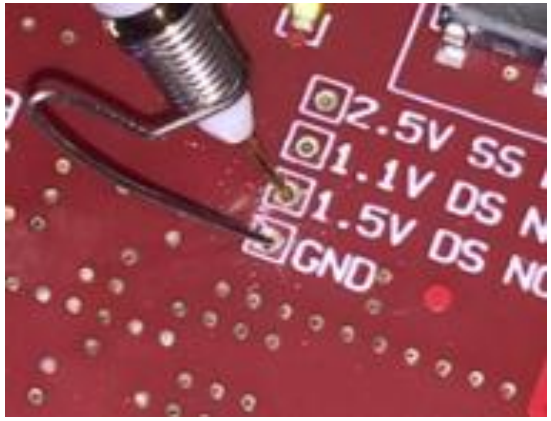
- 20 mV/div
- 8 divisions
- Full scale = 160 mV

Resulting noise:
160 uV noise

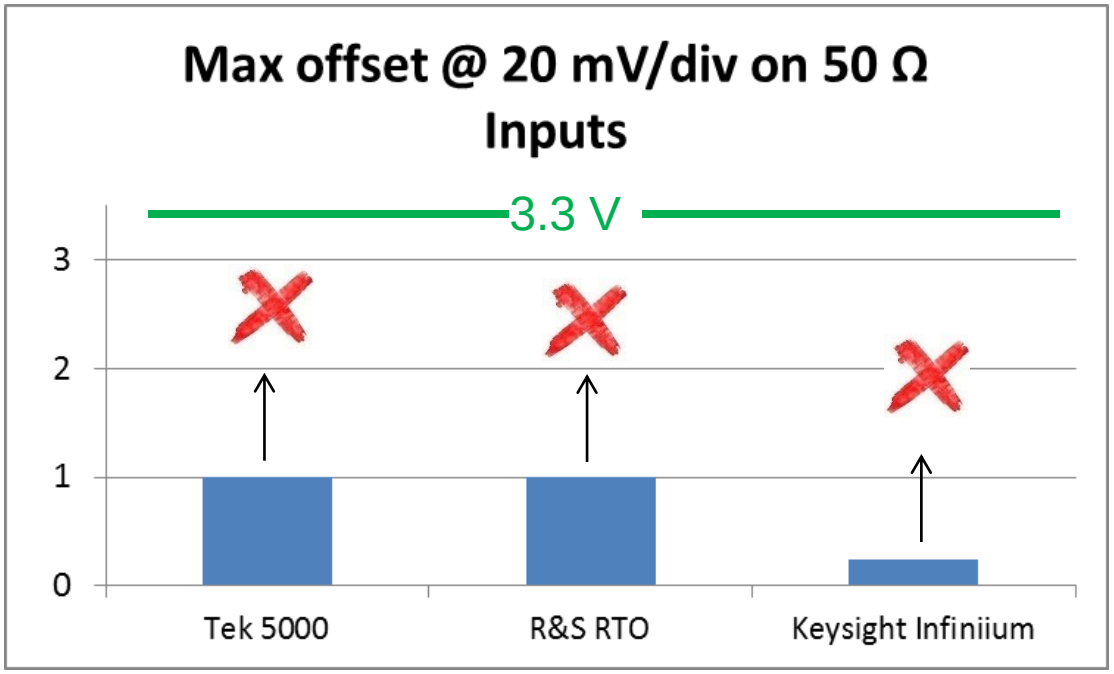
Increased noise by 44% (10mV/div to 20 mV/div)

Top Concerns for Power Rail Measurements

1. Low noise
2. Support for popular rail voltages
3. Loading & connectivity
4. Bandwidth



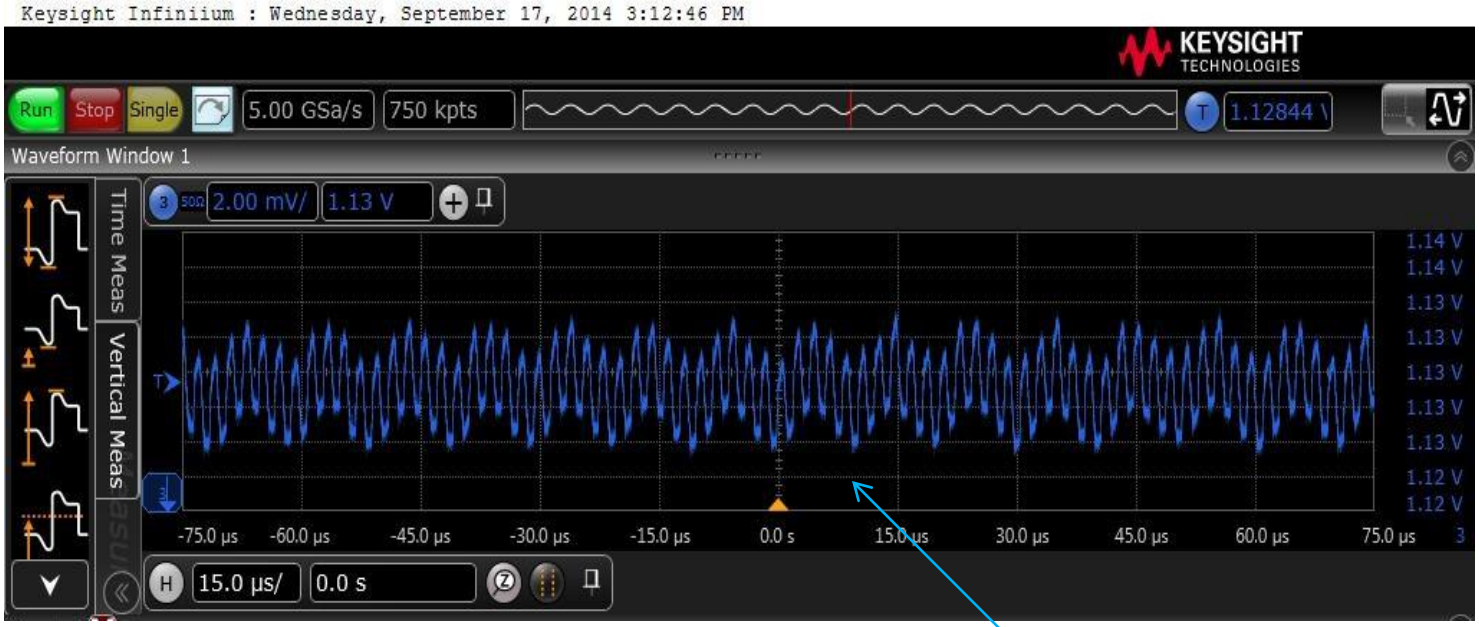
Oscilloscopes Typically Do Not Offer Sufficient Offset Power Rails



Offset Options

- DC Blocking cap
- Probe with offset

DC Blocking Cap Removes DC Component

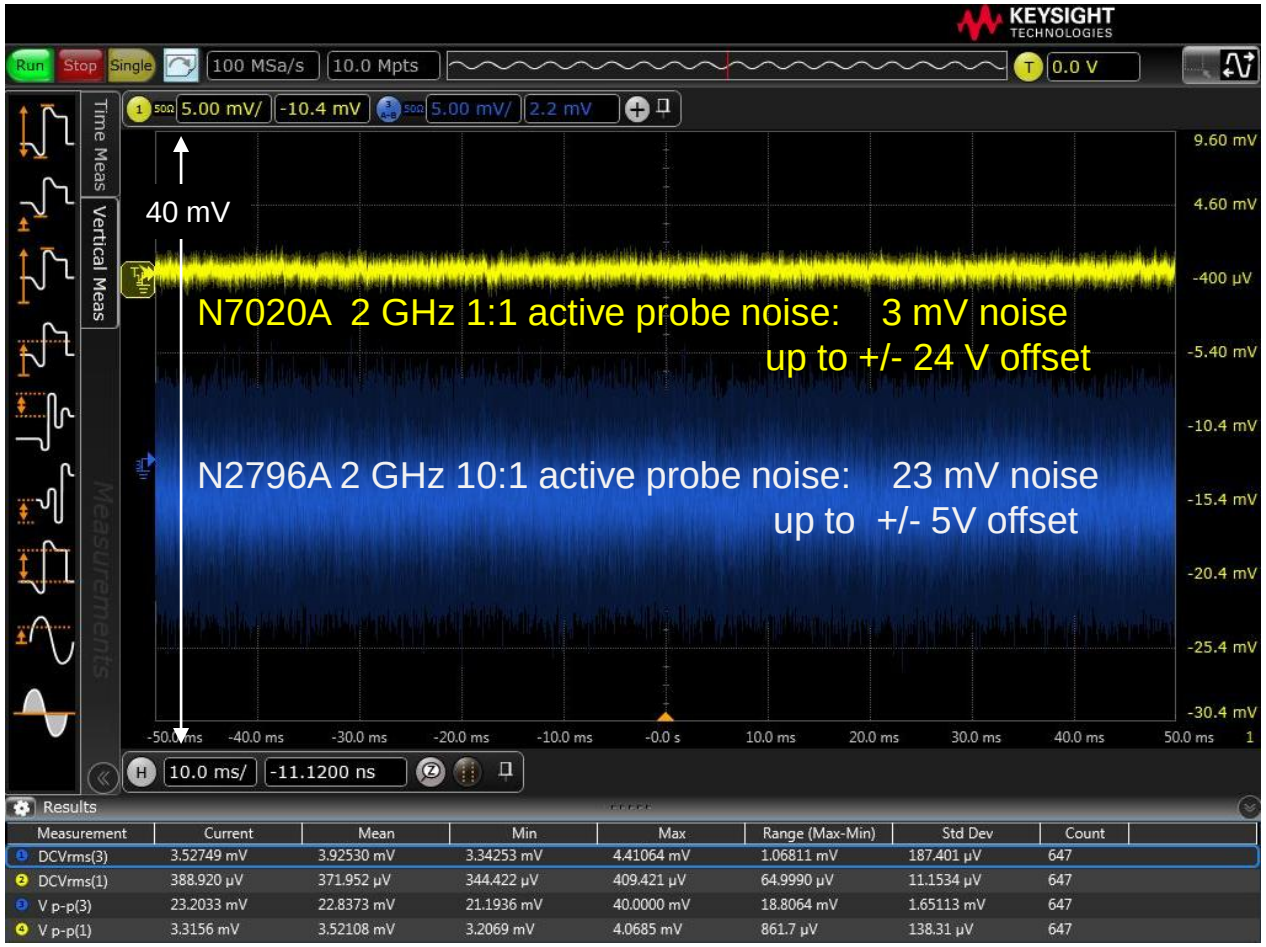


Blocking cap hides DC drift
Potential for damaging front-end of scope with large DC values

Probes with Offset

….Choose the one with Lowest Noise

N7020A: Offset range: +/-24V



Measurement	Current	Mean	Min	Max	Range (Max-Min)	Std Dev	Count
DCVrms(3)	3.52749 mV	3.92530 mV	3.34253 mV	4.41064 mV	1.06811 mV	187.401 µV	647
DCVrms(1)	388.920 µV	371.952 µV	344.422 µV	409.421 µV	64.9990 µV	11.1534 µV	647
V p-p(3)	23.2033 mV	22.8373 mV	21.1936 mV	40.0000 mV	18.8064 mV	1.65113 mV	647
V p-p(1)	3.3156 mV	3.52108 mV	3.2069 mV	4.0685 mV	861.7 µV	138.31 µV	647

Top Concerns for Power Rail Measurements

1. Low noise
2. Support for popular rail voltages
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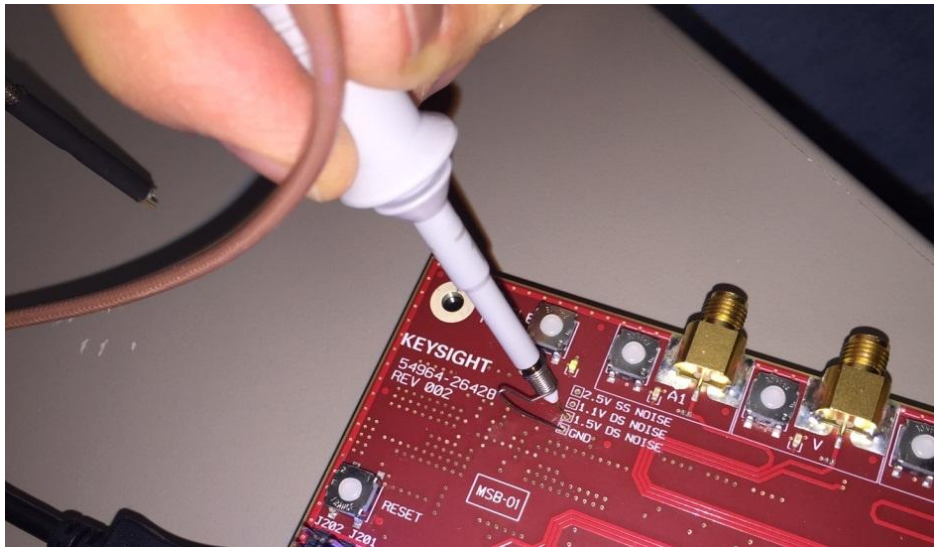
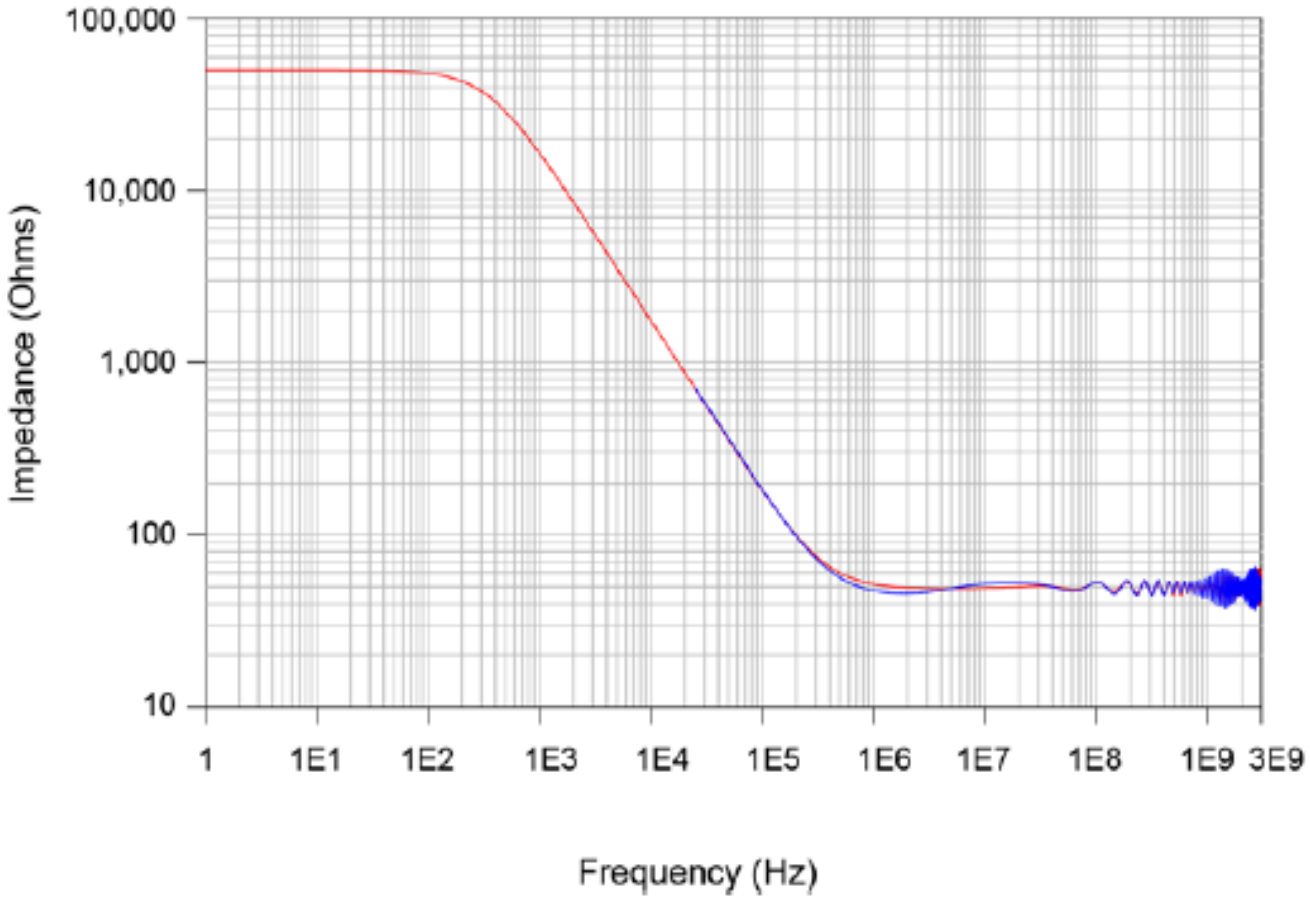


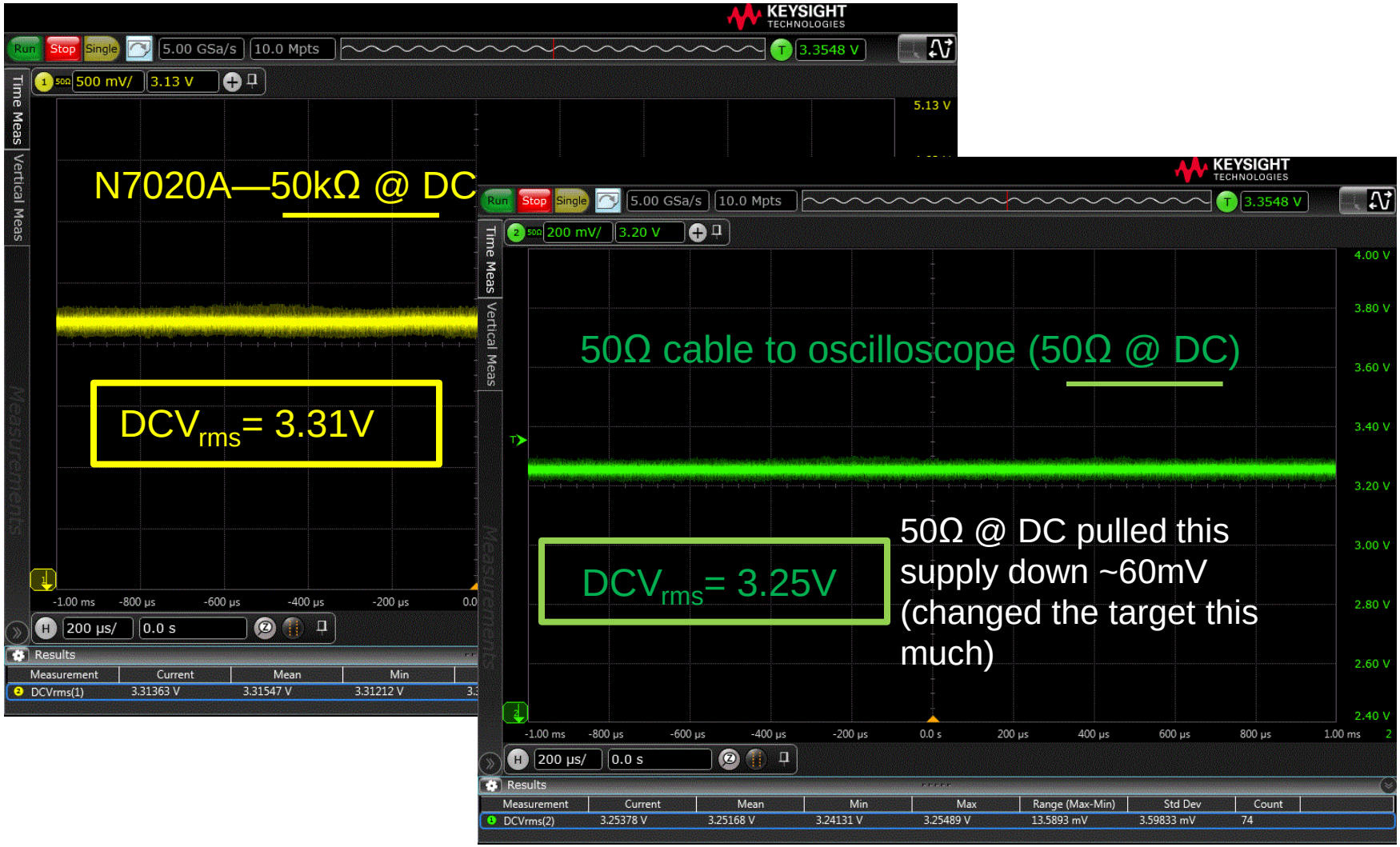
N7020A Input Impedance vs. Frequency

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

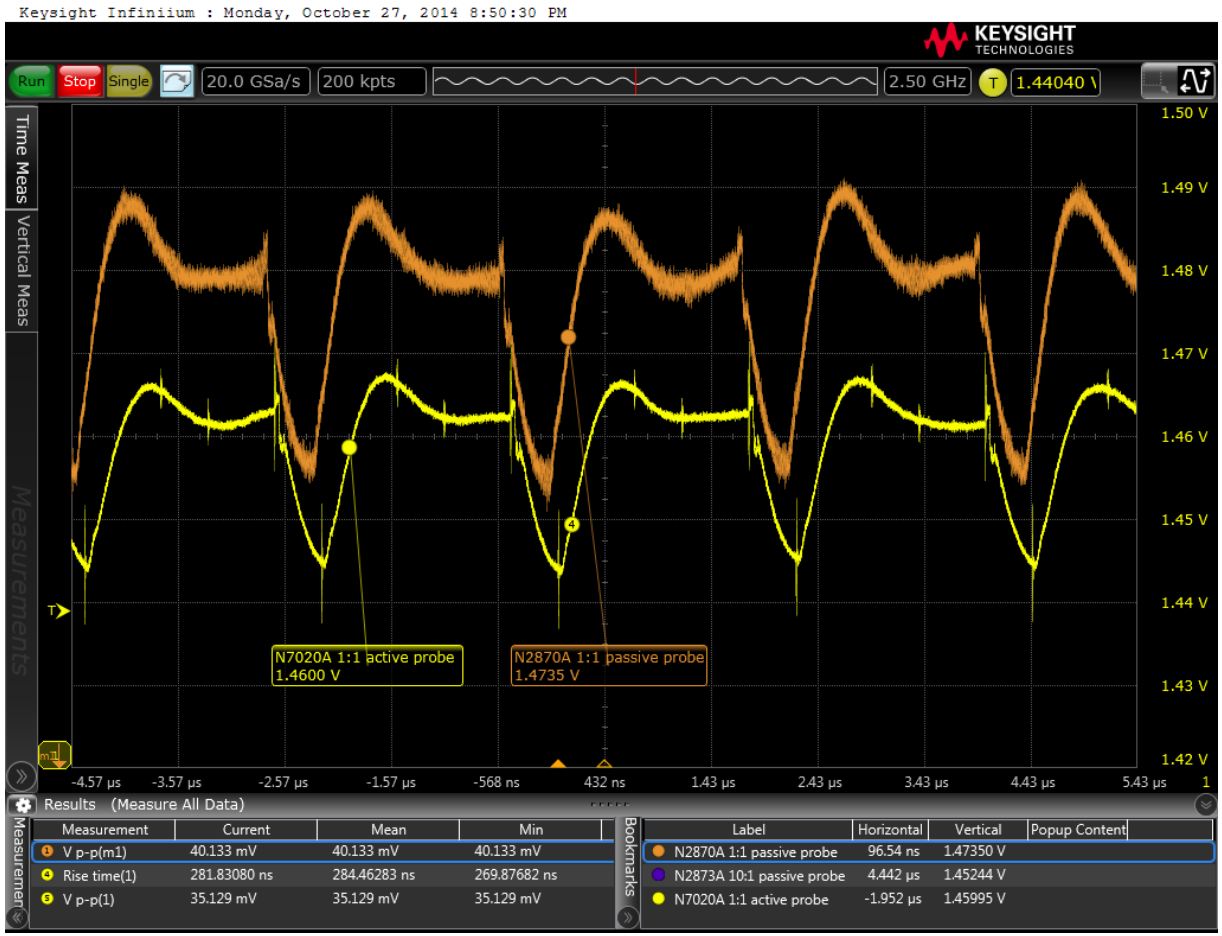


Probe/Connection Loading

Impedance At DC



Having Enough BW is Critical



N2870A **35 MHz**, 1:1

N7020A **2 GHz**, 1.1:1

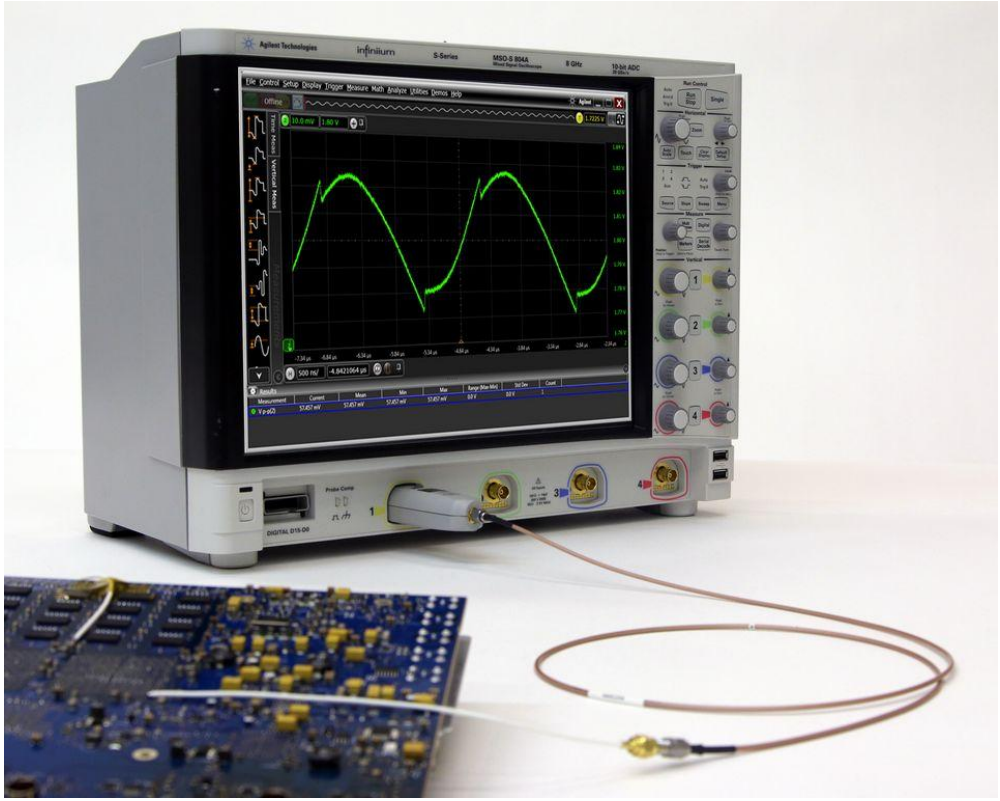
Emergence of Dedicated Power Rail Power Rail Probes

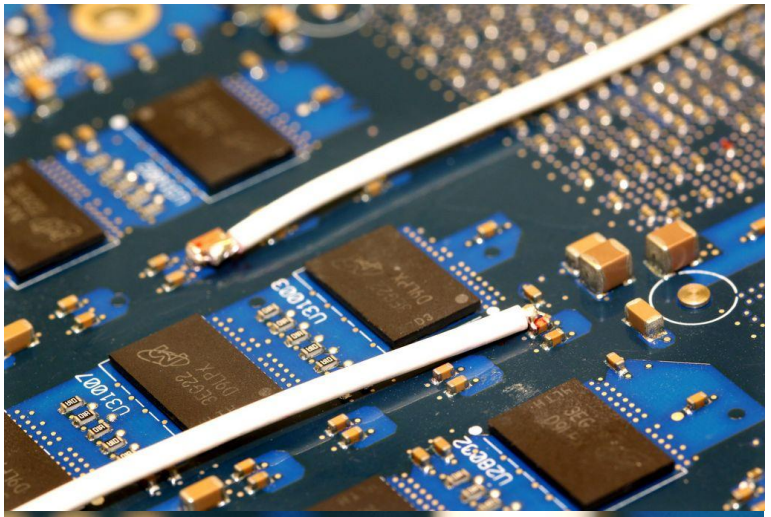
Example: Keysight N7020A

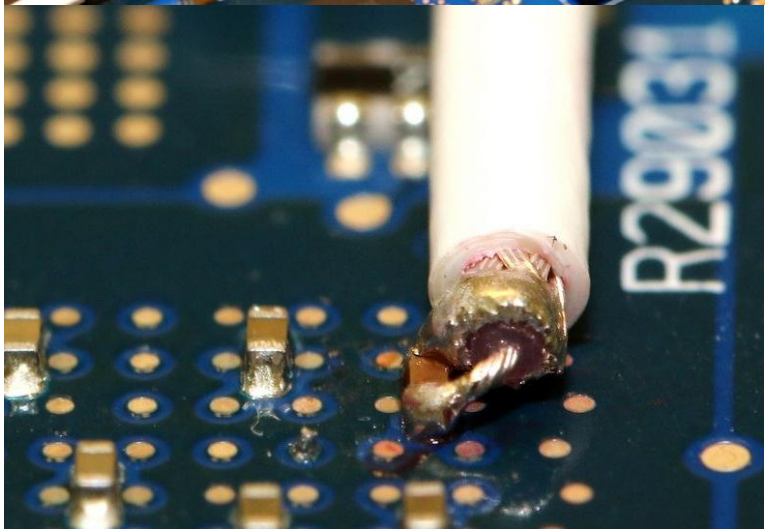
- **Low Noise:** The N7020A Power Rail Probe is1.1:1 attenuation ratio active probe. As a general rule, the higher a probes attenuation ratio, the nosier the signal will be on the oscilloscope.
- **Large Offset Range:** 24V of probe offset. This enables users to center the signal on screen while placing the oscilloscope at it's maximum vertical sensitivity and zoom-in on the signal.
- **Low DC Loading:** 50kΩ input impedance at DC minimizing the probes DC loading of the power rail.
- **Large Input Dynamic Range:** +/-850mV input dynamic range means that users can measure up to 850mV deviations of their DC supplies. This is very useful for measuring programmable supplies like those used in microcontroller power saving modes.
- **High Operating Temperature: C**oaxial probe head and N7022A main cable operate up to +85 °C. These included accessories can be used to make power integrity measurements inside of environmental chambers.

N7020A Power Rail Probe

Coaxial Probe Head & Solder-In Connection

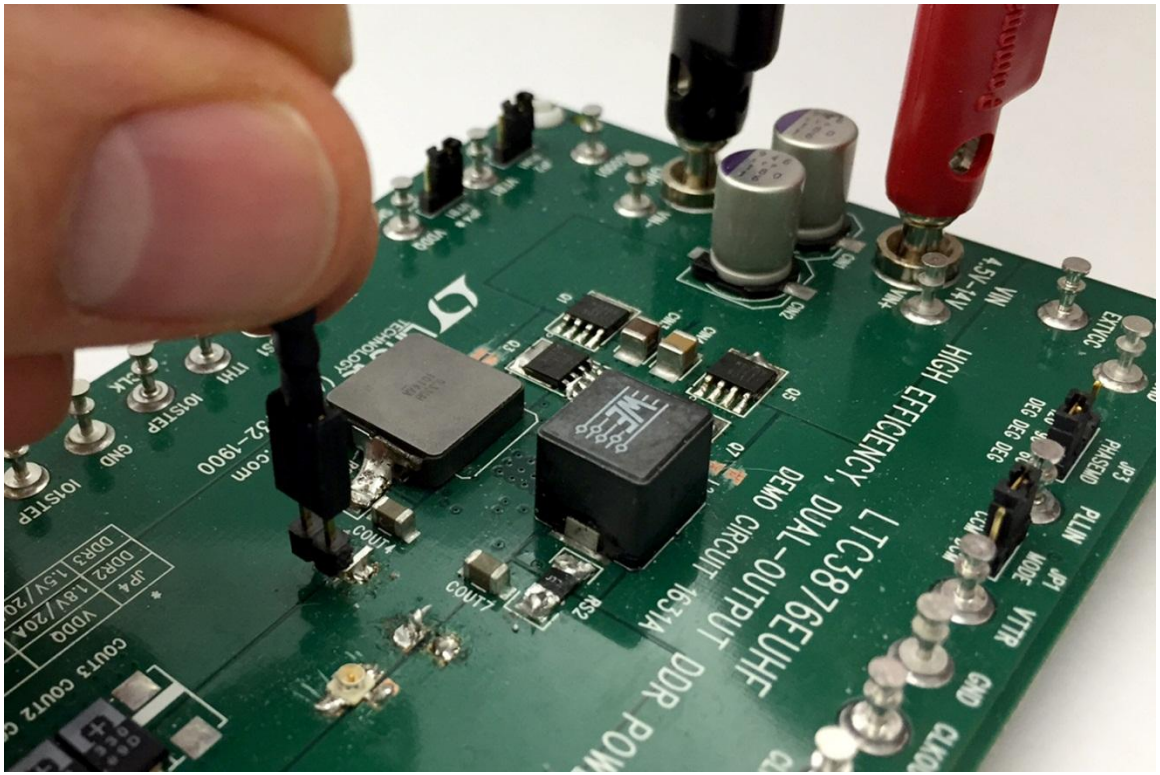






N7020A Two Pin Header

Browser Probe Head



Additional Tips for Scope Measurement of Power Rails

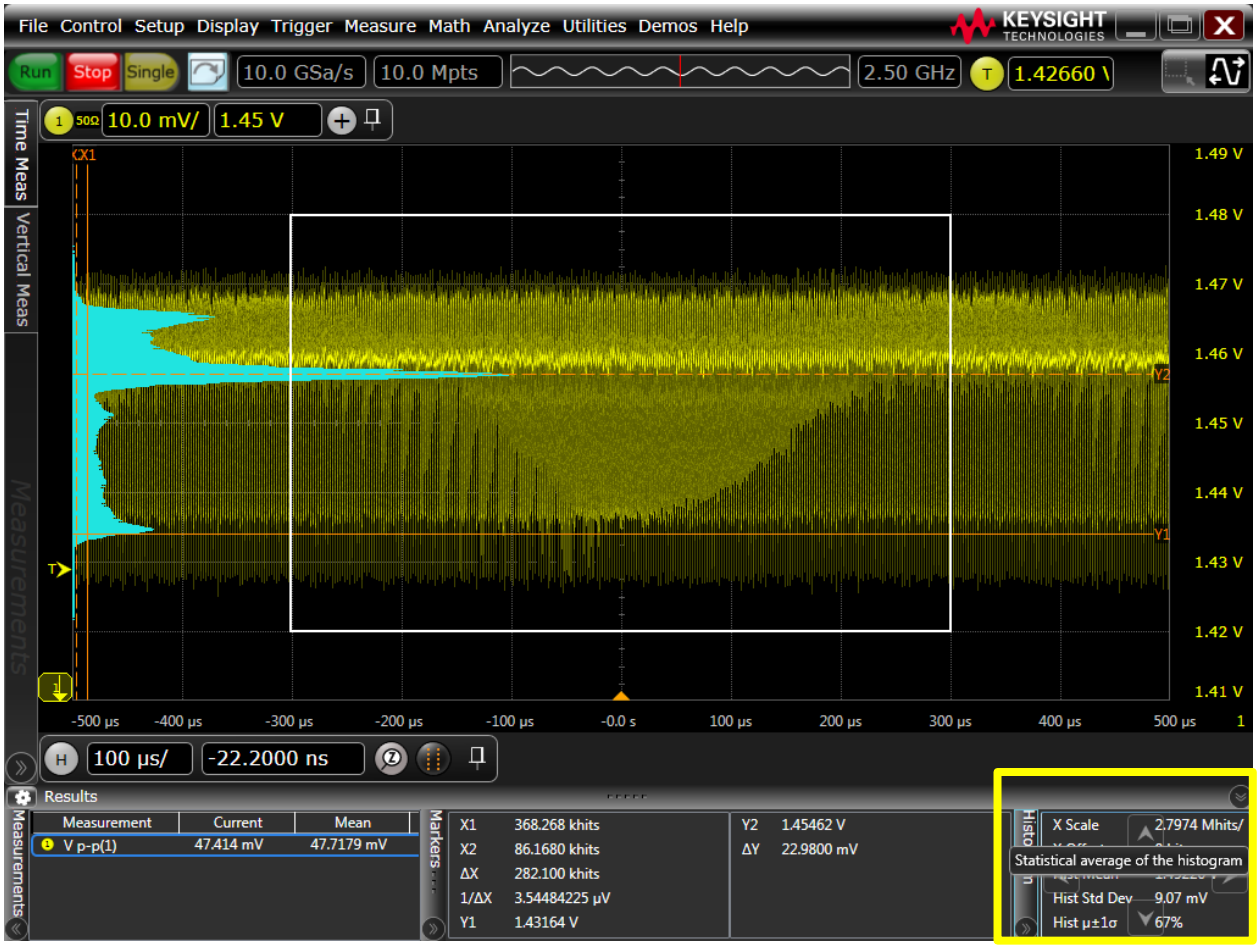
- Infinite persistence
- Histograms
- FFTs

Infinite Persistence

…change will states can paint larger Vpp than expected how bad did it get over time….

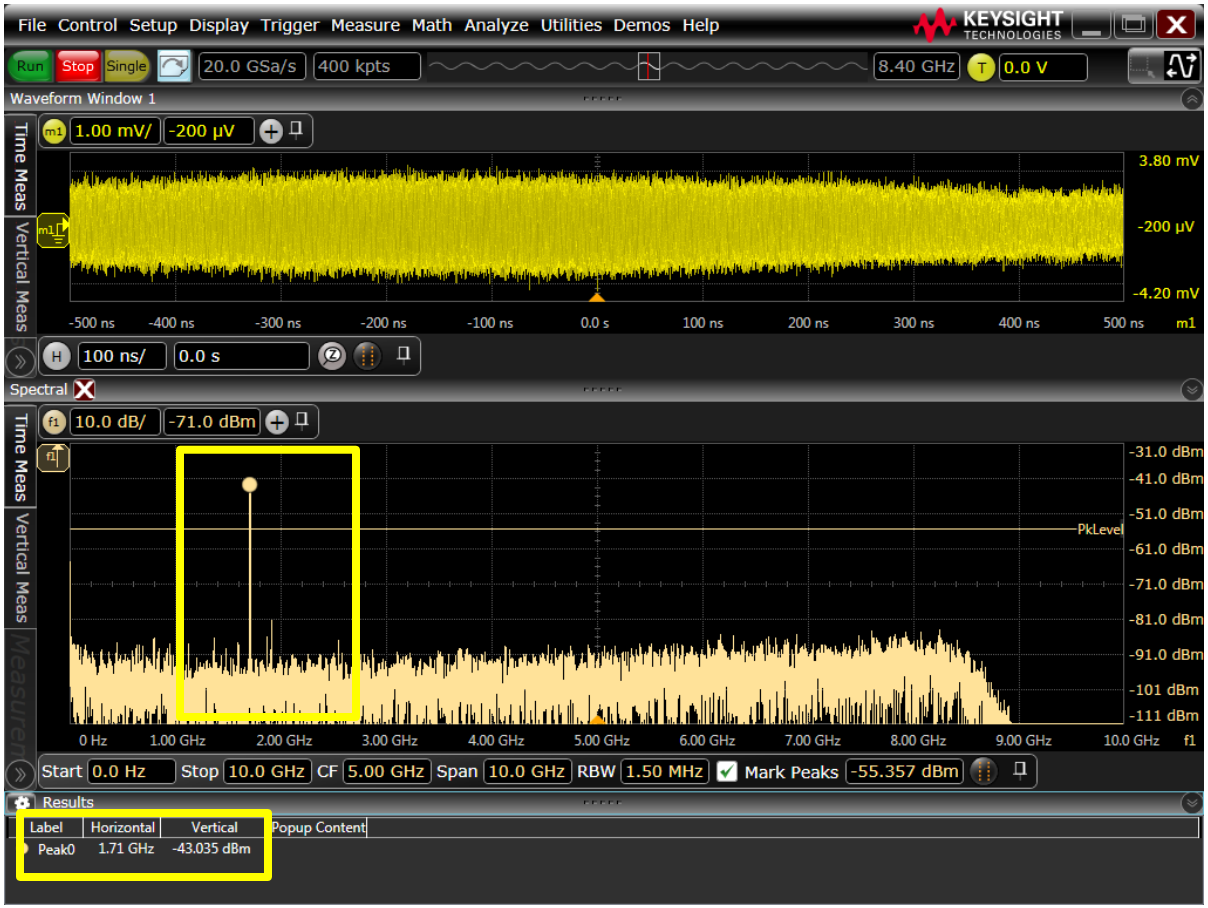
Histograms

Statistical Overview of Waveform Distribution



Power Rail FFTs

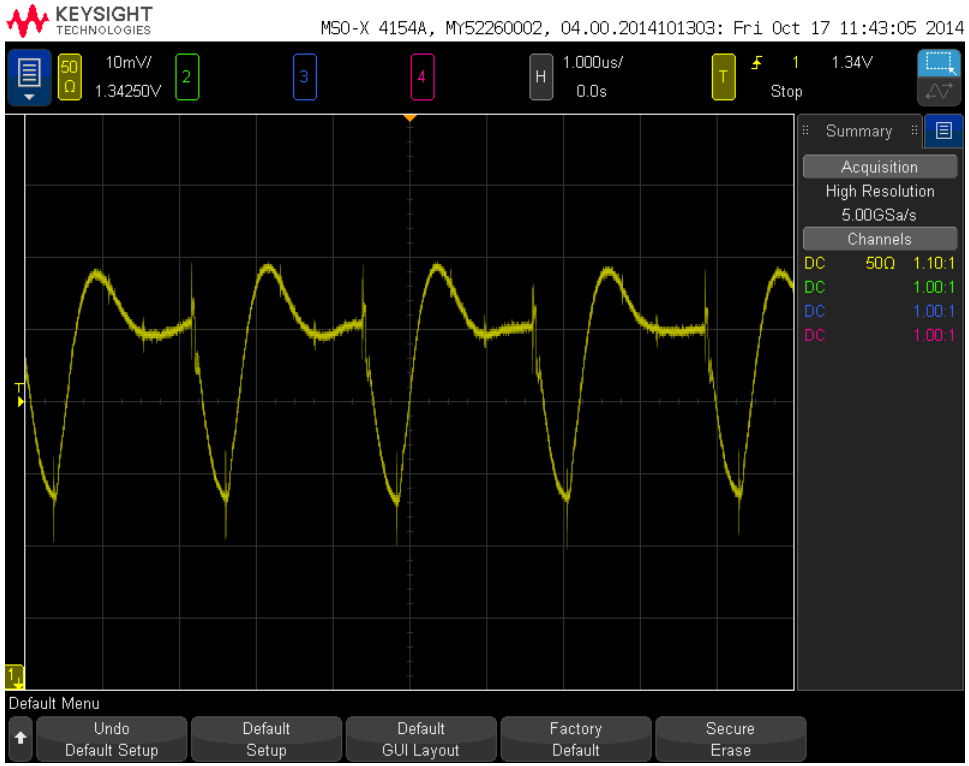
See coupling source frequencies



Other Compatible Oscilloscopes

Keysight 4000-X Series (200 MHz to 1.5 GHz)

Fastest Update Rate:1M wf/s, more portable, lower price



Q&A