KEYSIGHT WORLD 2020

Improve Device Performance Using Power Integrity Test Tools

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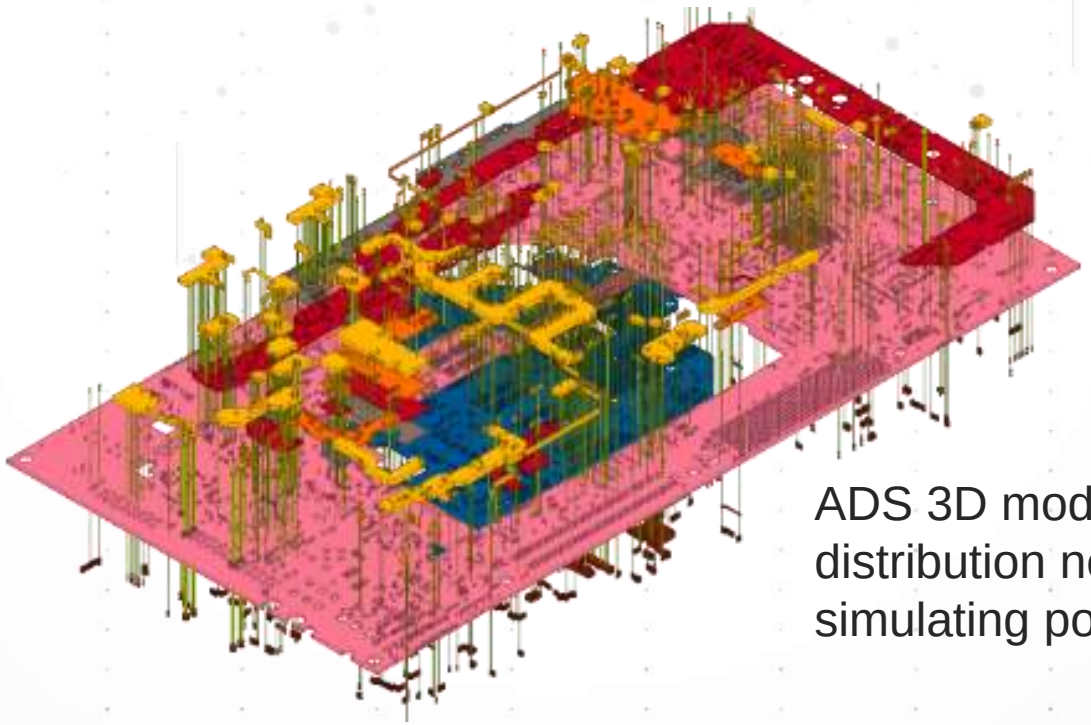
Sr. Application Engineer / Keysight Technologies

Power Integrity (PI)

WHAT ARE WE TALKING ABOUT

Power Integrity: The study of the conversion, delivery and consumption of DC power in an electronic system. *Kenny Johnson, Keysight*

Product Functional Reliability α Quality of the system power



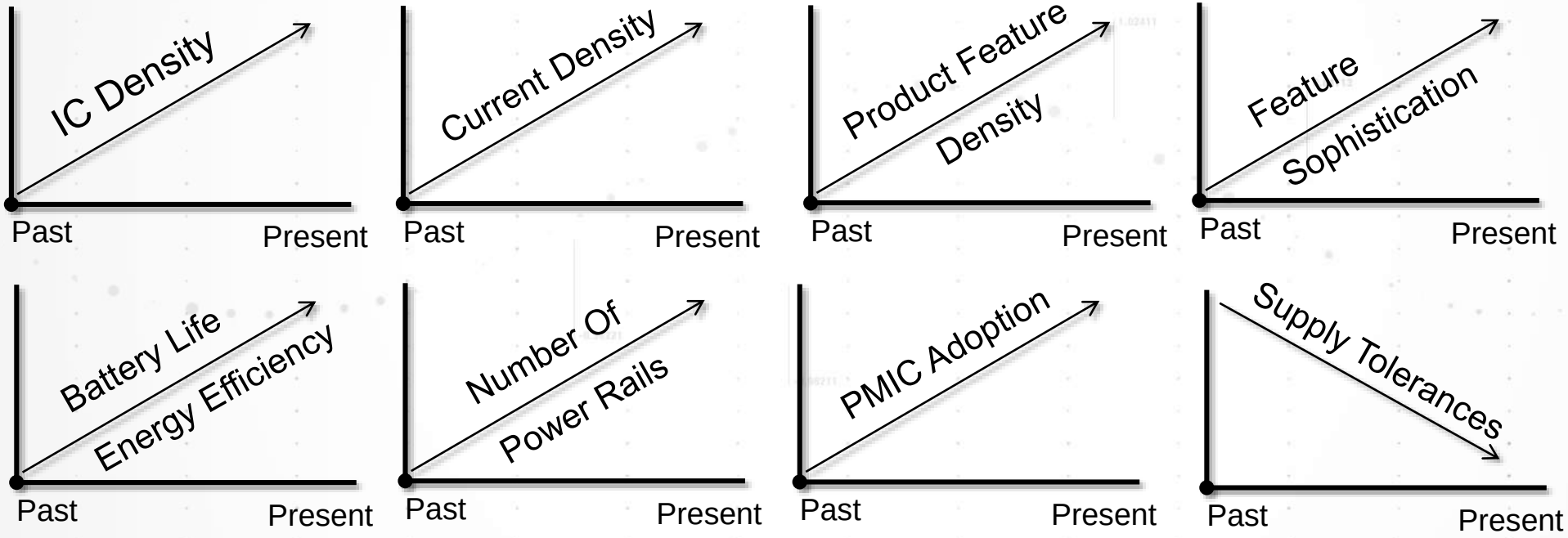
ADS 3D model of power distribution network (PDN) for simulating power integrity

Why is Power Integrity critical to your design

Power Integrity

WHY?

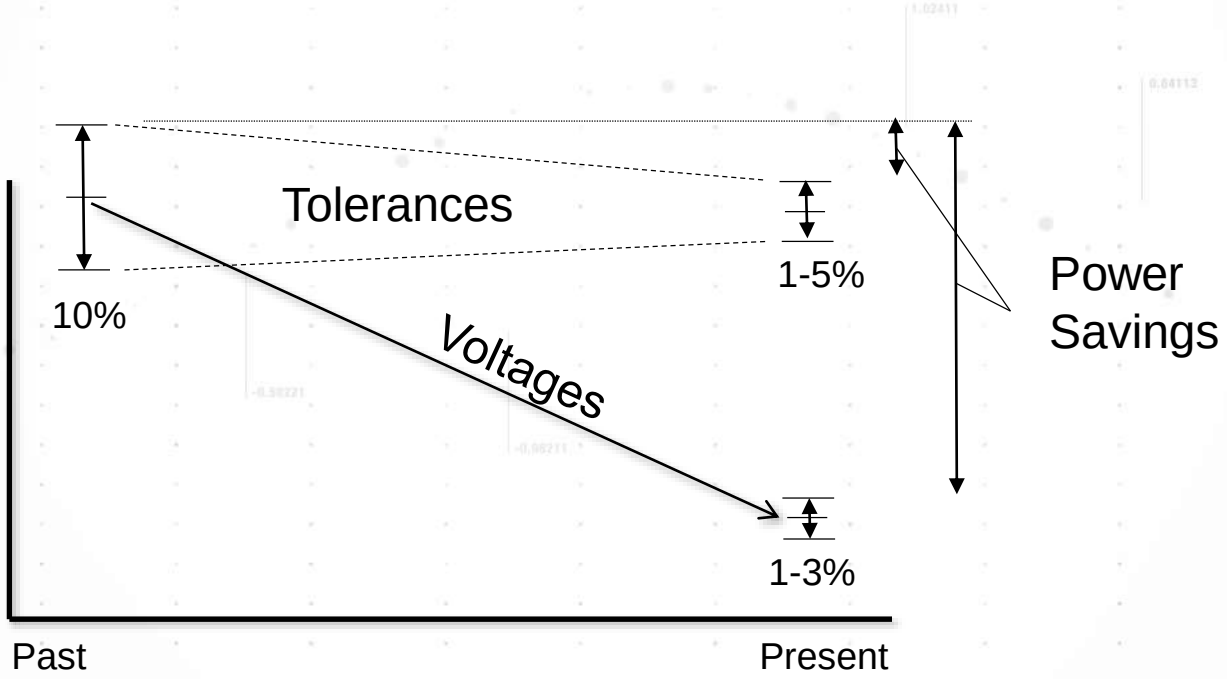
- Moore's Law: transistors on an integrated circuit will double every two years.



Power Integrity

WHY? POWER AND CURRENT DENSITY

- Operating voltages are decreasing to reduce power and/or in support of finer pitch IC processes.

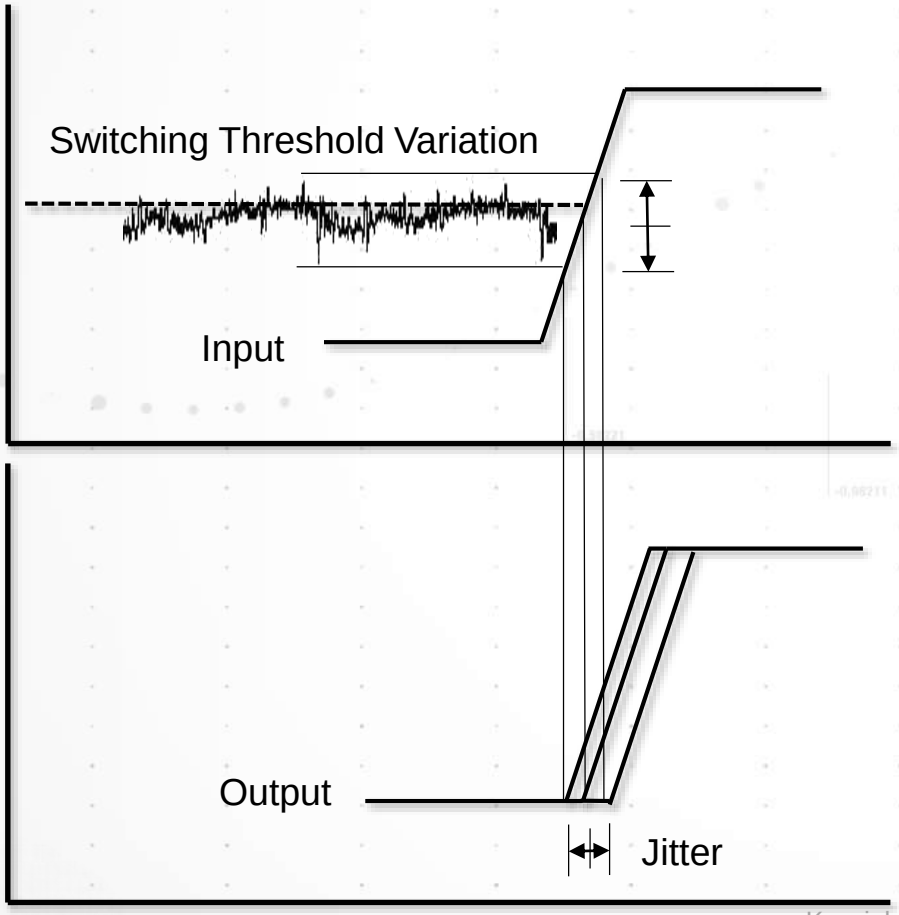


Power Integrity

WHY? POWER SUPPLY INDUCED JITTER (PSIJ)

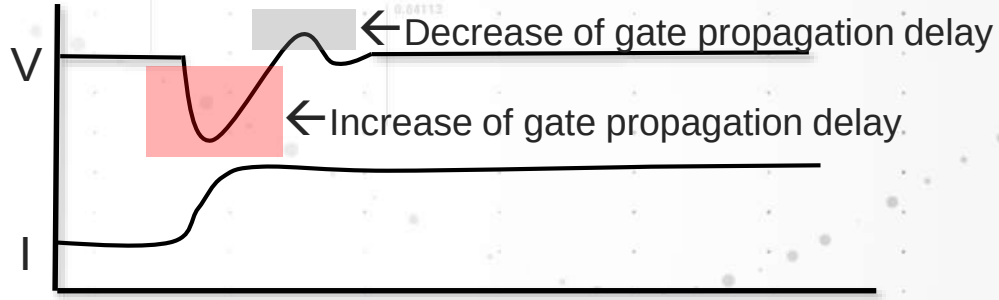
- Power supply noise causes clock/data jitter

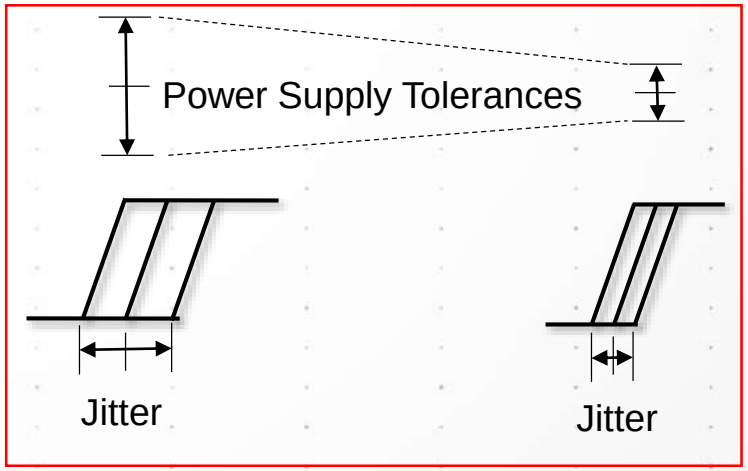
Example 1:



Example 2: CPU/APU/µ

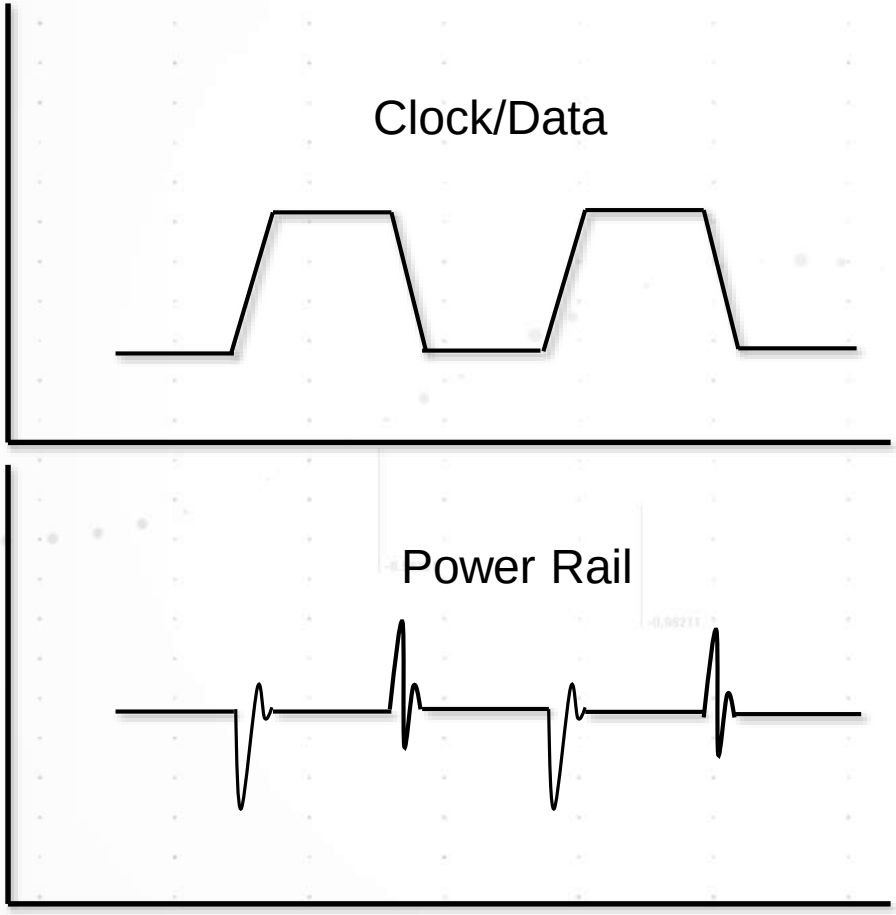
Variations in core voltages cause variations in propagation delay through the gates of the processor.





Power Integrity

NOT JUST DC: SWITCHING LOADS

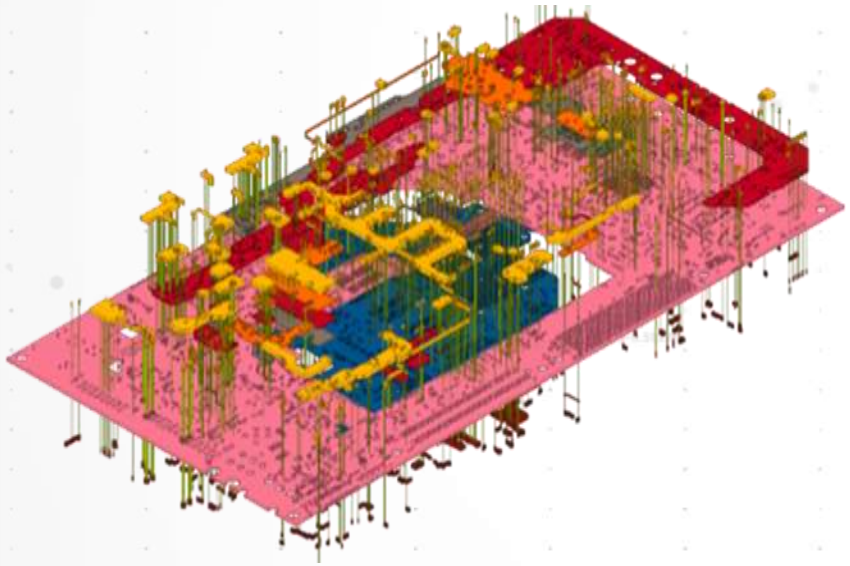


Switching loads can cause high frequency supply noise with content easily exceeding 1GHz

Power rails must be stable from DC to the BW of the switching current

Power Integrity

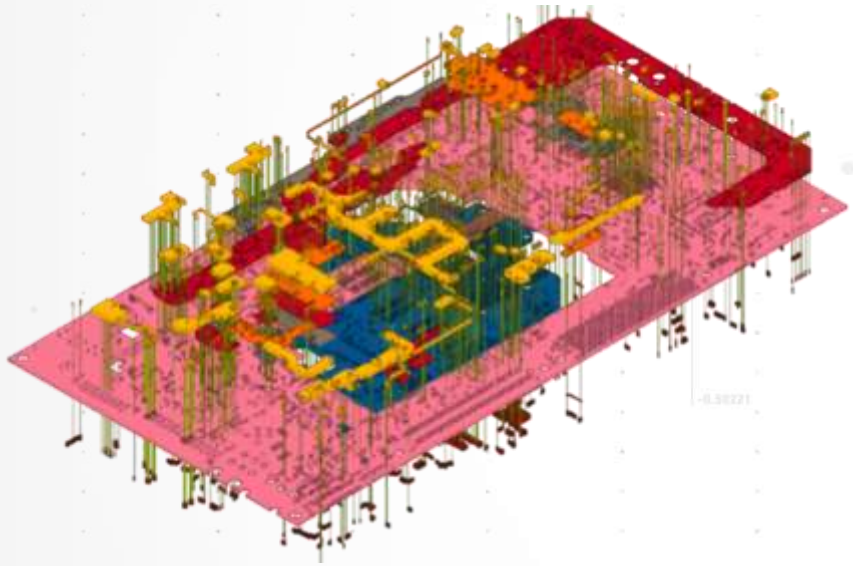
WHY? EMI



- PDN is likely to be the biggest conducting structure.
- PDN is likely to carry high current.
- PDN is likely to have high frequency noise.

Power Integrity

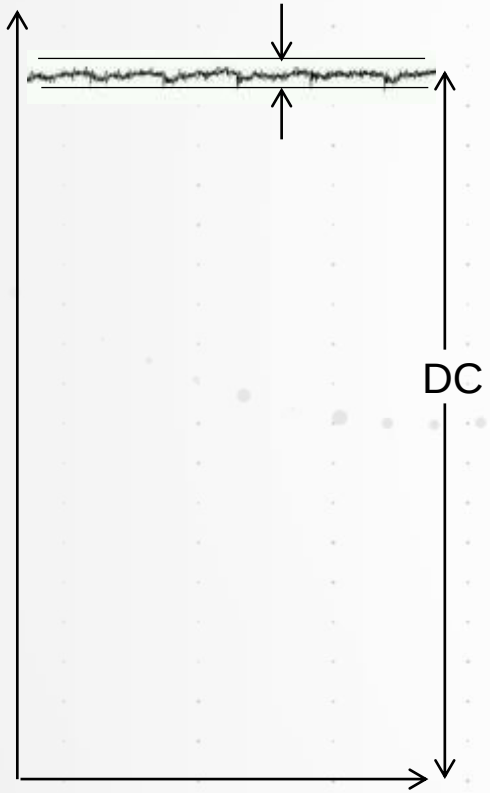
A WELL DESIGNED PDN

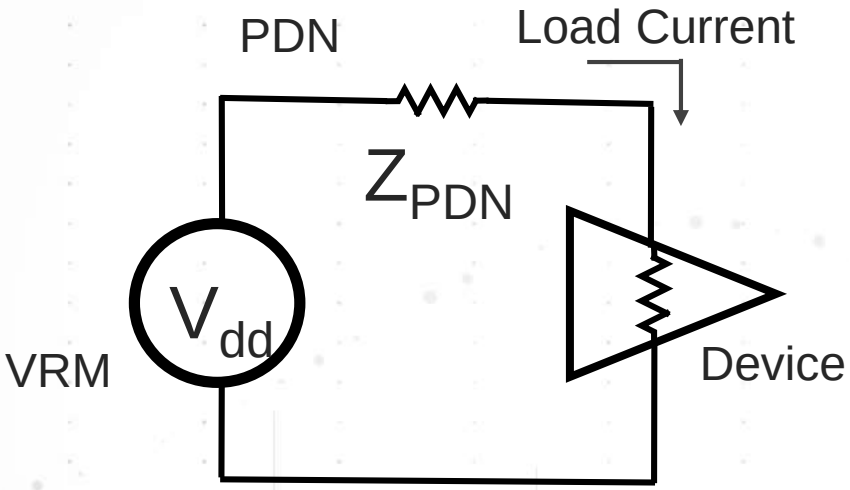


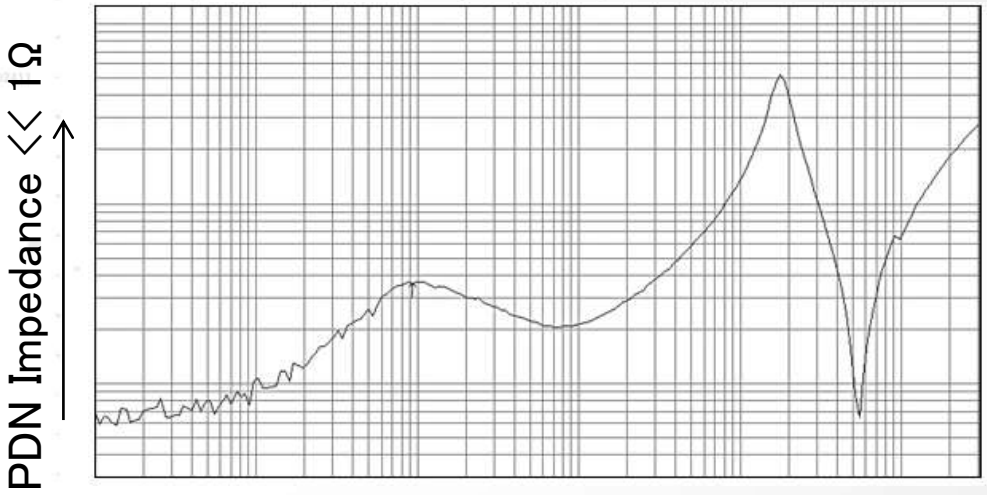
- A well designed PDN will maintain a stable voltage (within tolerance) from DC to the bandwidth of the switching current (typically above 1GHz).
- This will help:
  - Optimize power consumption
  - Minimize switching noise (SSN—simultaneous switching noise)
  - PSIJ (dropped bits, missed clock …)
  - Minimize EMI problems
- Therefore, one the primary validation tasks is measuring power rail quality.

Power Integrity

PDN THEORY AND MODELING







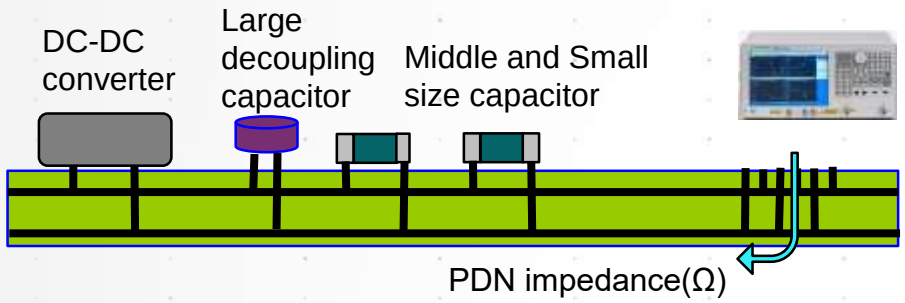
$$Z_{target}(f) = Z_{PDN}(f) < \frac{V_{Ripple}}{I(f)}$$

$$I_{transient} \sim (1/2)*I_{max}$$

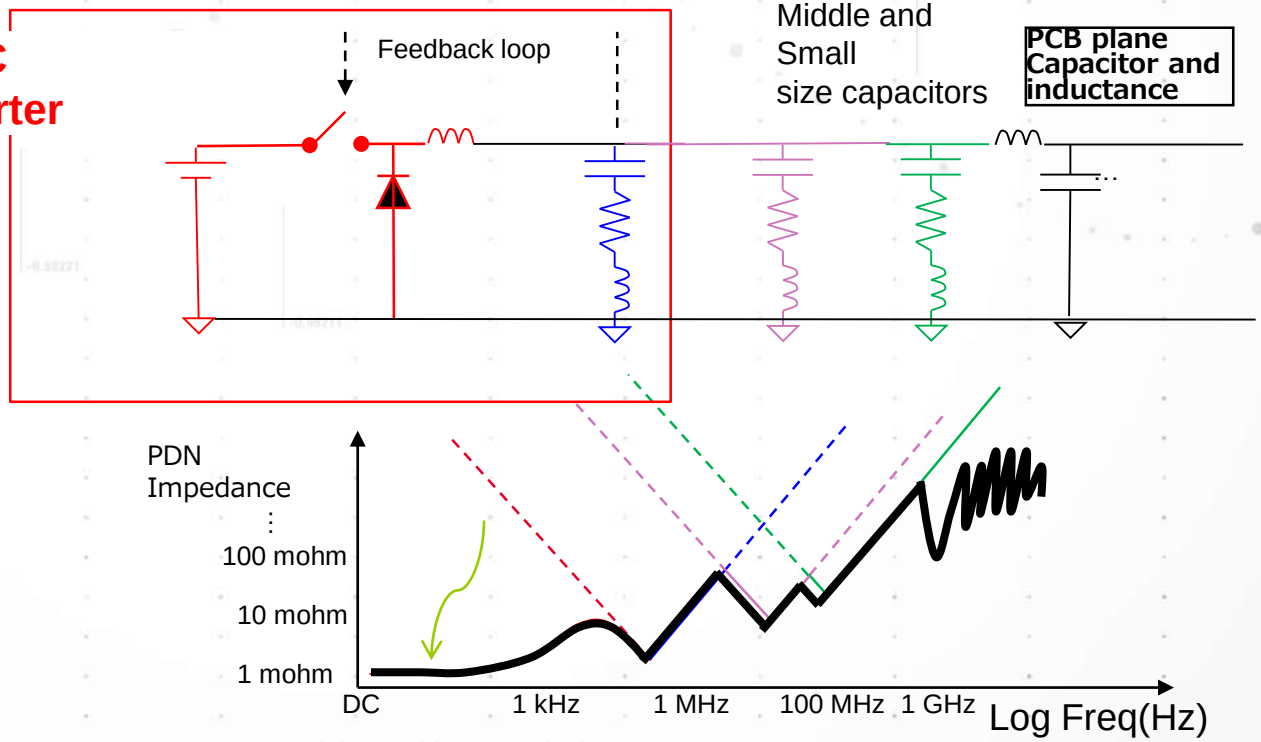
$$I_{peak} = P_{max}/V_{dd} \rightarrow Z_{target}(f) = \frac{2*(V_{dd})^2*(ripple\%)}{P_{max}}$$

Power Integrity

PDN IMPEDANCE



PDN impedance measurement at IC position.

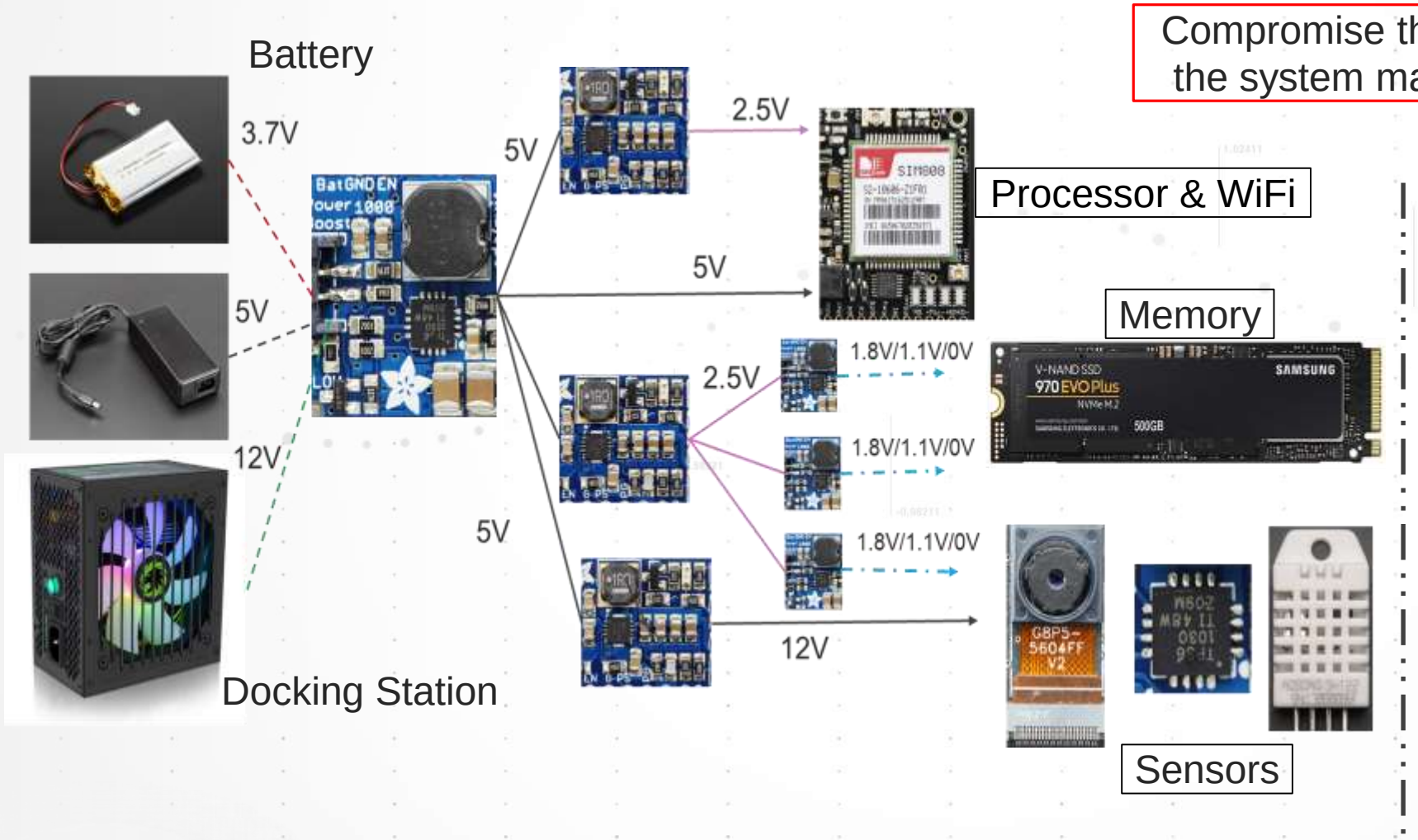


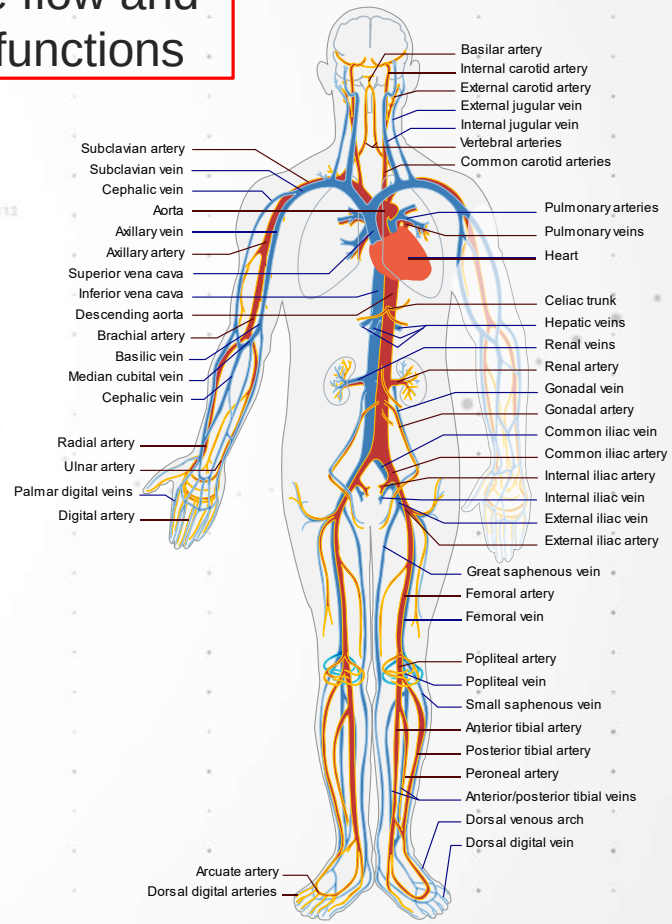
PDN impedance measurement at IC position.

Power Integrity (PI)

SIGNIFICANCE OF DC POWER

Compromise the flow and the system malfunctions





Power Integrity (PI)

JOB OF PI ENGINEER

3.7V

5V

12V

5V

2.5V

5V

5V

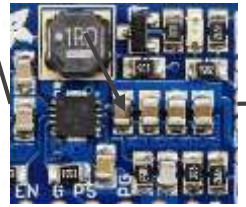
2.5V

1.8V/1.1V/0V

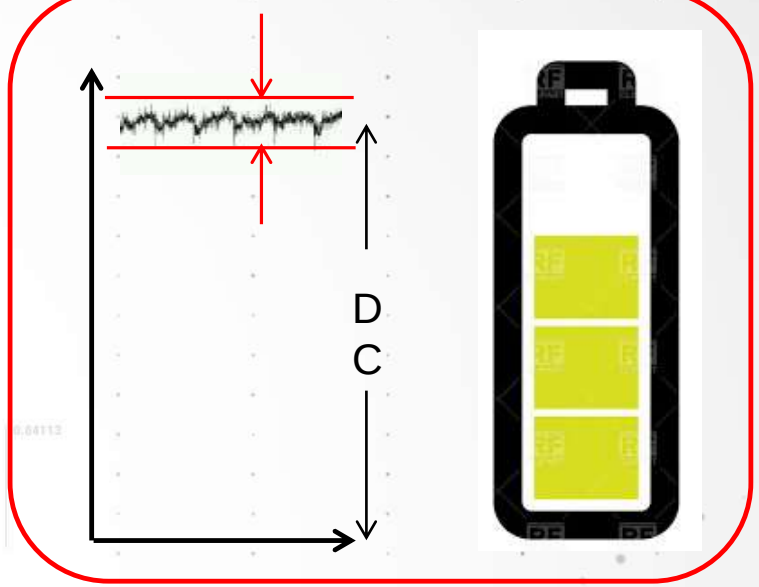
1.8V/1.1V/0V

1.8V/1.1V/0V

5V



12V

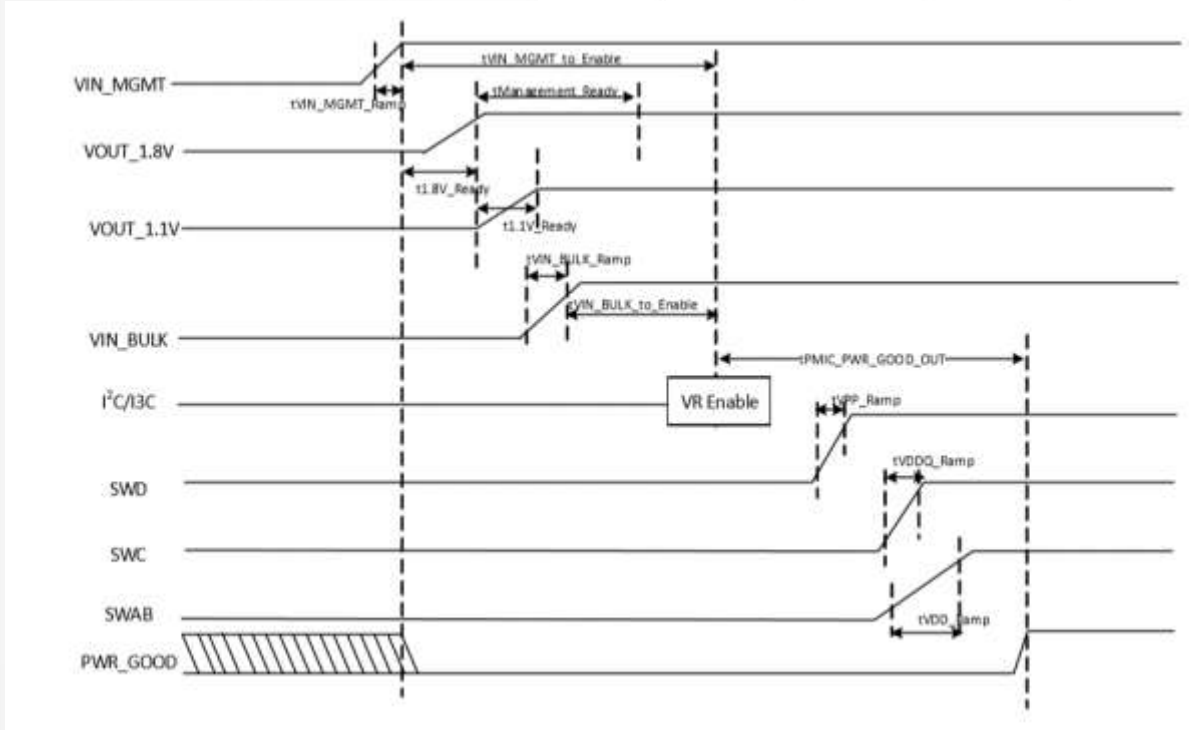


Power Sequencing

Power Integrity (PI)

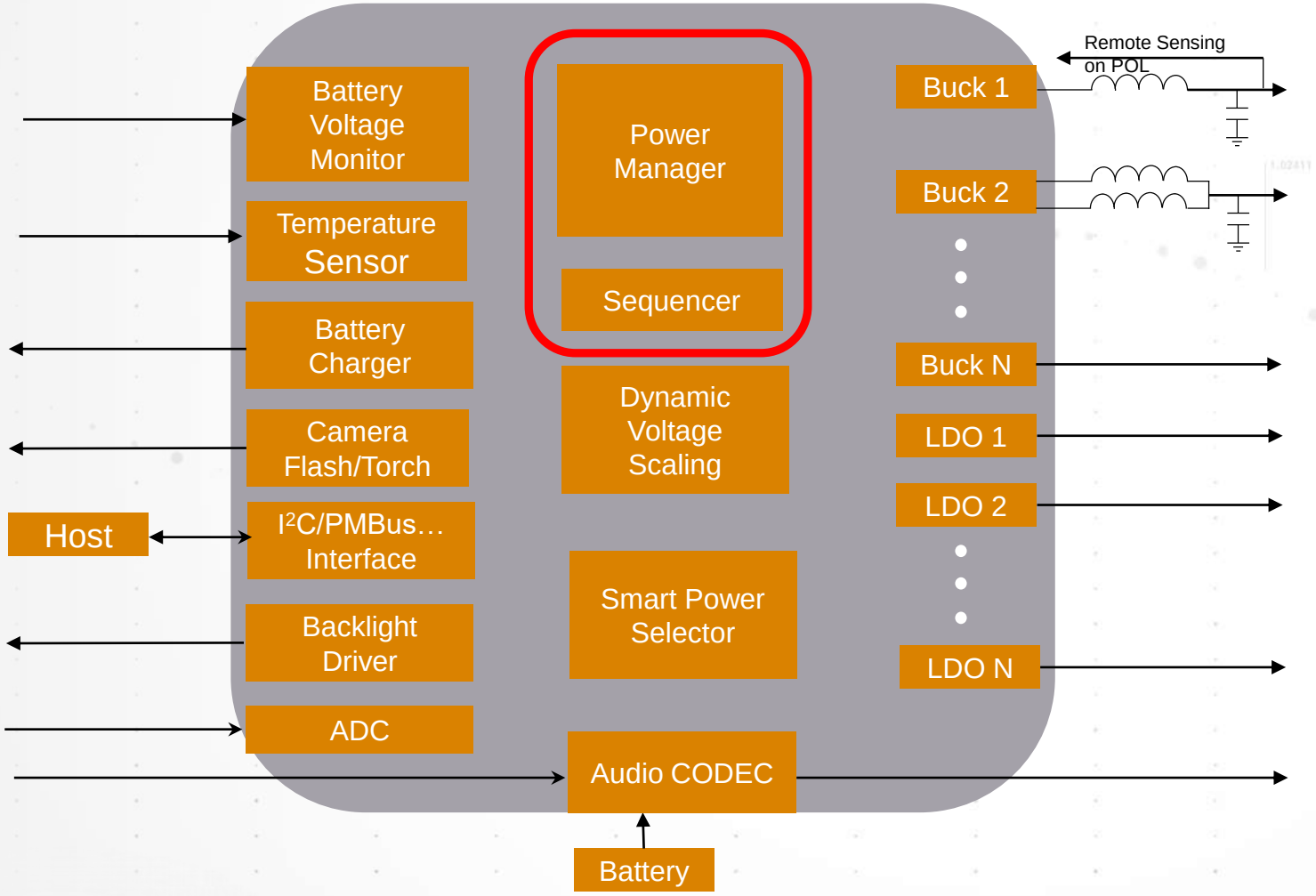
ADDED COMPLEXITY—POWER SEQUENCING

Power Sequence Specification



Power Integrity (PI)

POWER MANAGEMENT IC (PMIC)



Power Integrity (PI)

PMIC IS THE TRAFFIC OFFICER

3.7V

5V

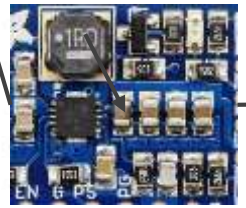
12V

5V

5V

5V

5V



2.5V

5V

2.5V

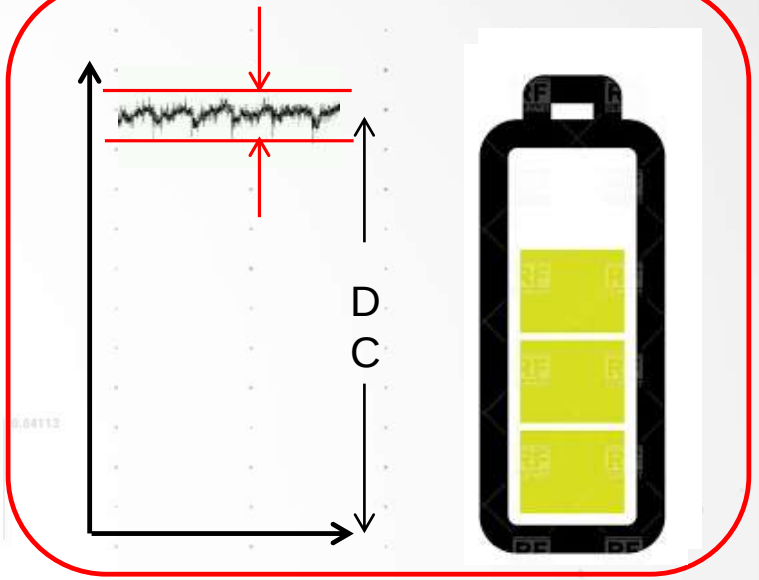
12V

1.8V/1.1V/0V

1.8V/1.1V/0V

1.8V/1.1V/0V

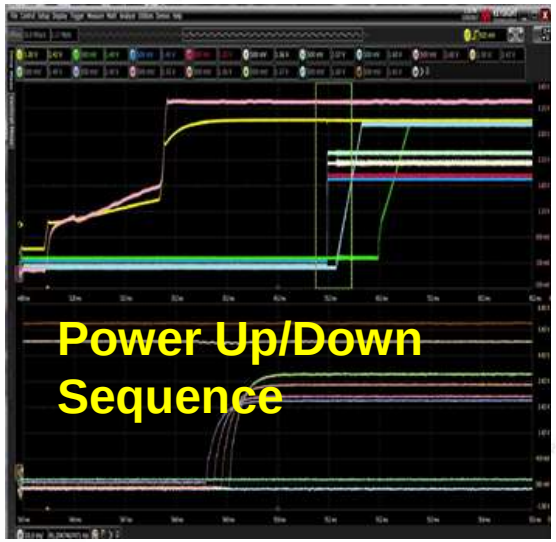
PMIC

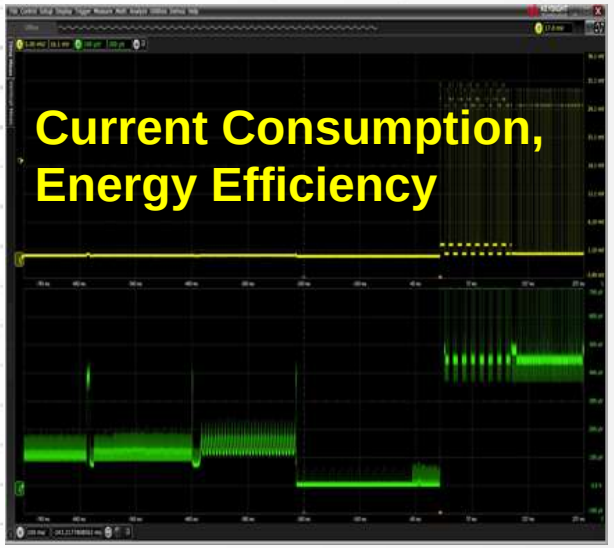


Power Integrity Test Flow

Power Integrity (PI)

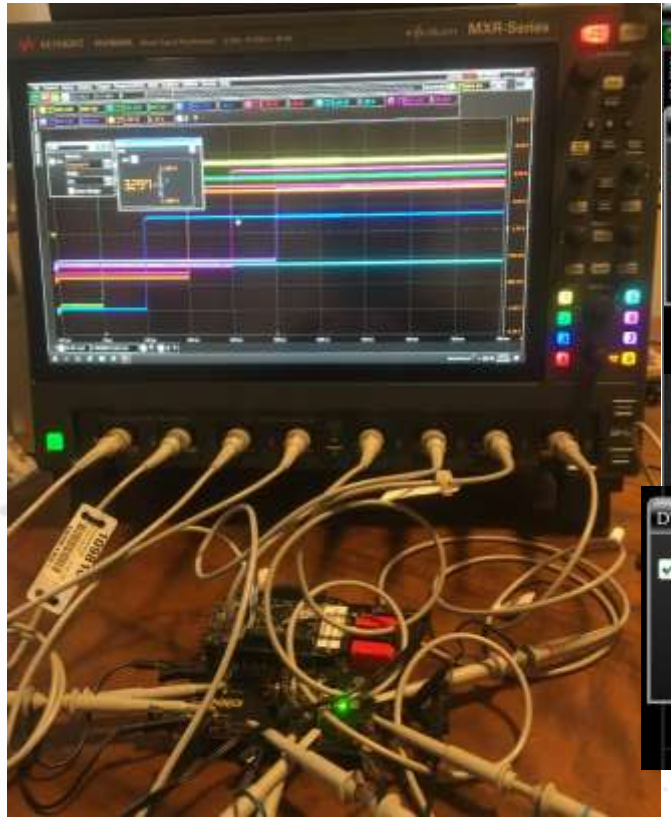
TYPICAL TEST FLOW





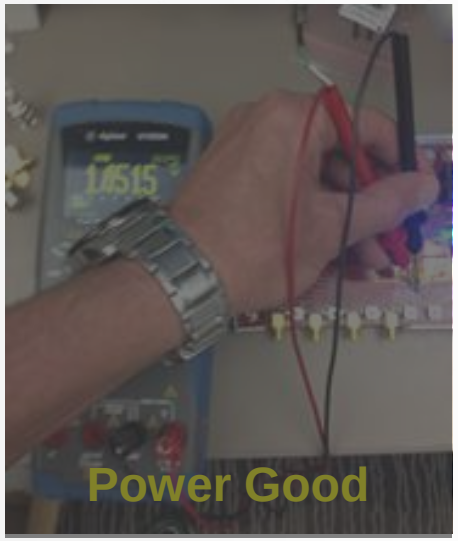
Power Integrity

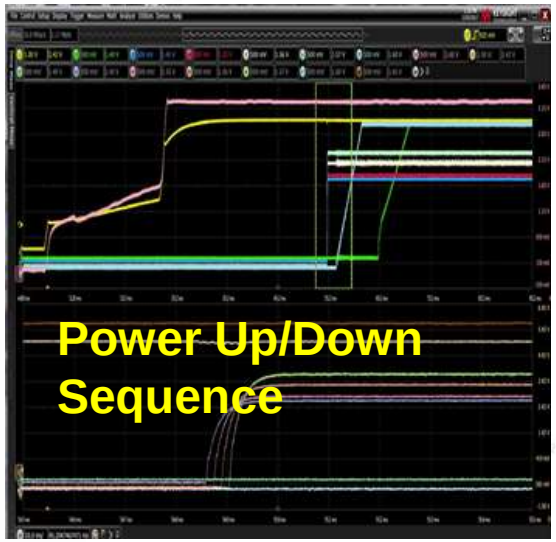
POWER-GOOD USING MXR DVM



Power Integrity (PI)

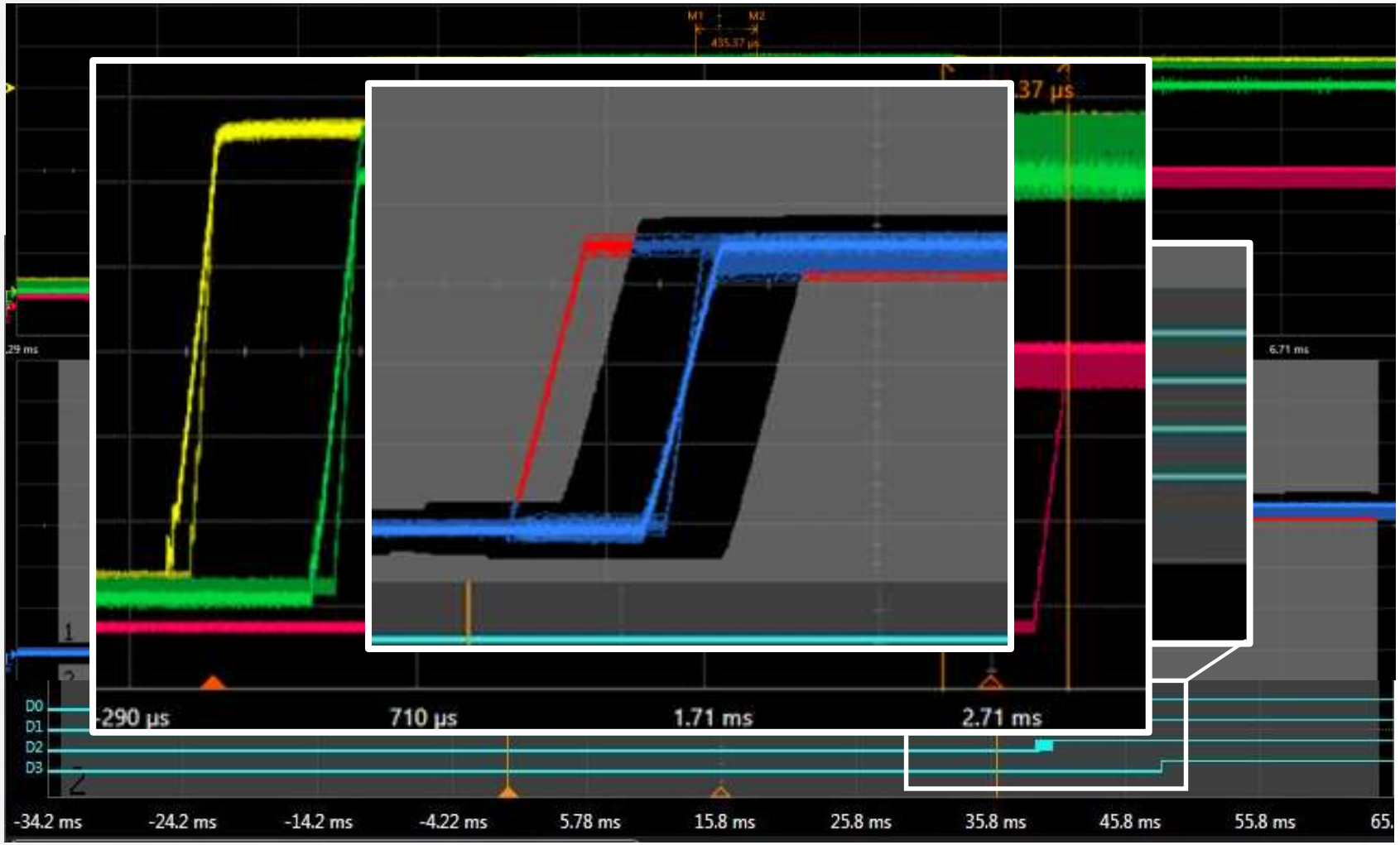
TYPICAL TEST FLOW





PMIC Testing

POWER SEQ.—EX. 8 RAILS, PERSISTENCE & DIGITAL



Issues

- Only one mask available

PMIC Testing

POWER SEQUENCE TESTING—MASK ON EVERY CH.

Mask for every channel

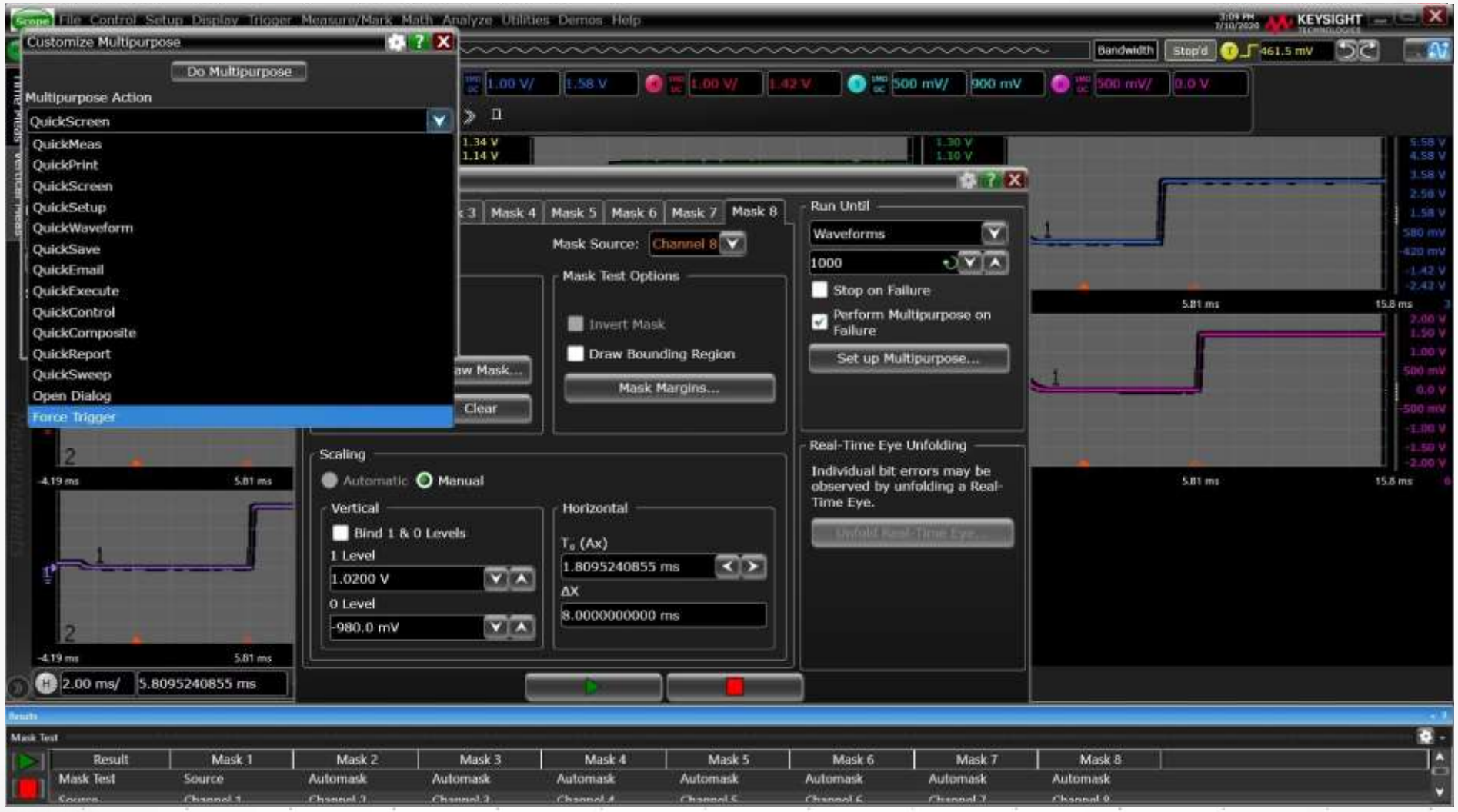
- Saves time
- Eliminates uncertainty
- Complete test report in one screen shot

Automask

- Saves time
- Simple and easy mask setup

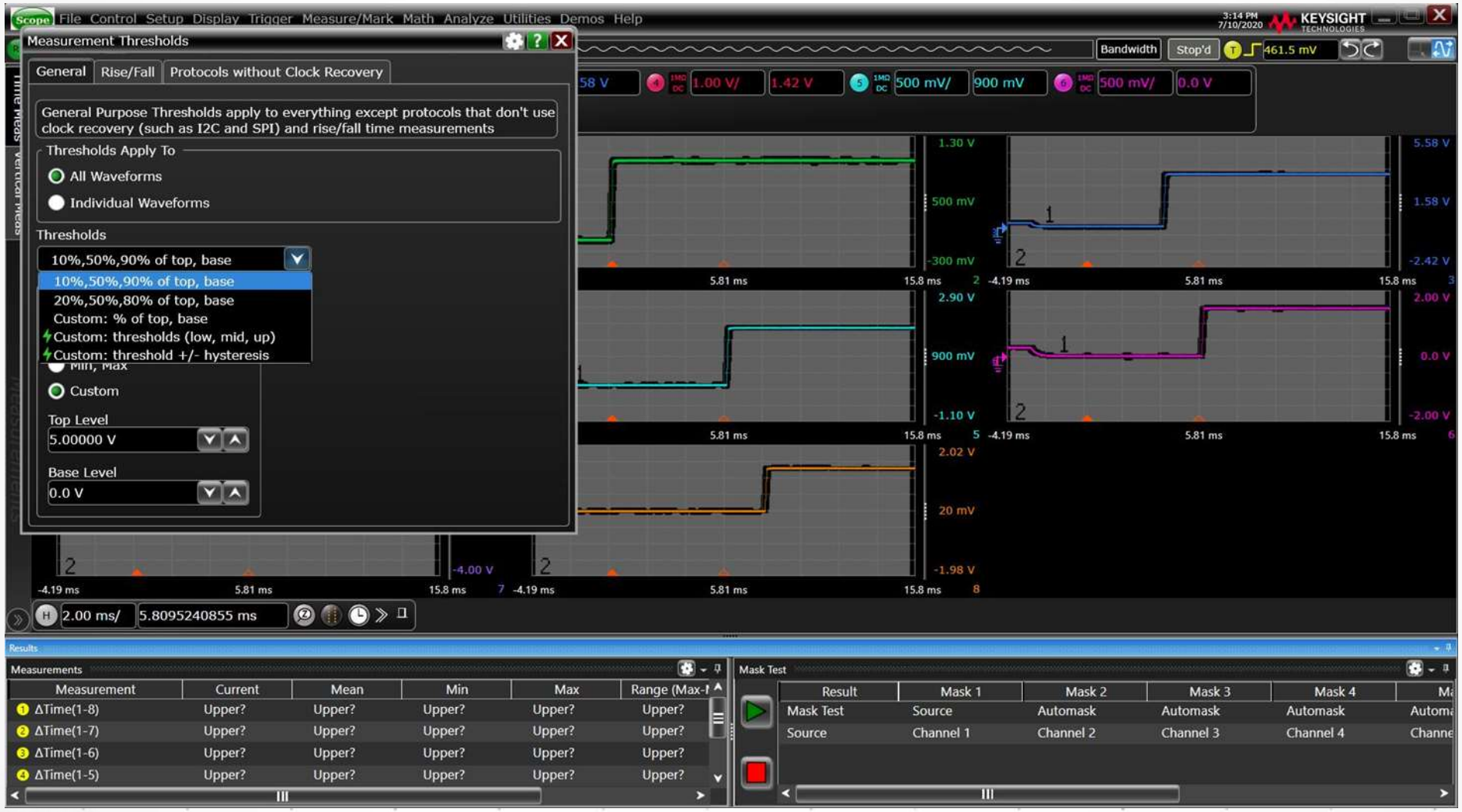
PMIC Testing

POWER SEQUENCE TESTING—MASK ON EVERY CH.



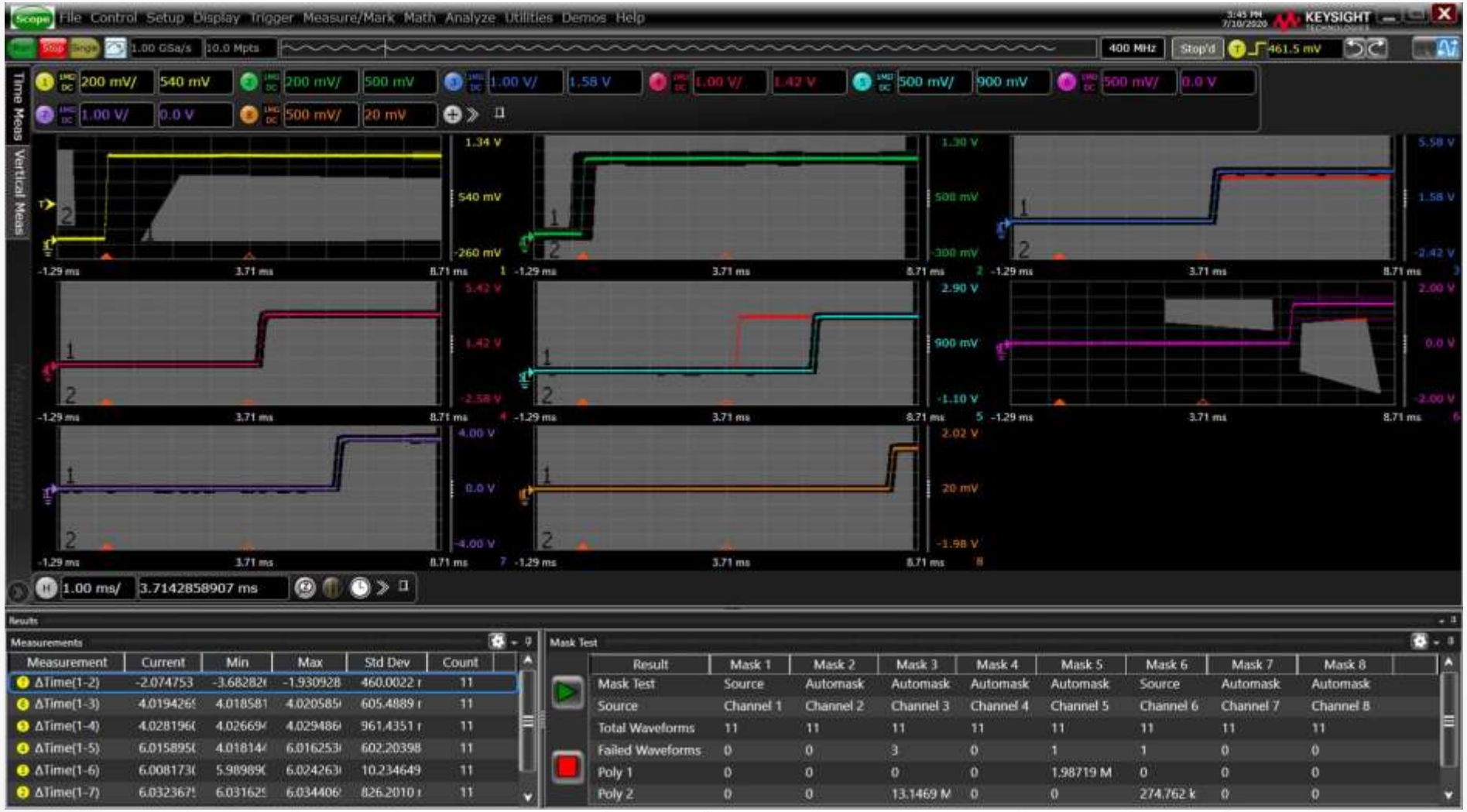
PMIC Testing

POWER SEQUENCE TESTING—ΔTIME MEASUREMENTS



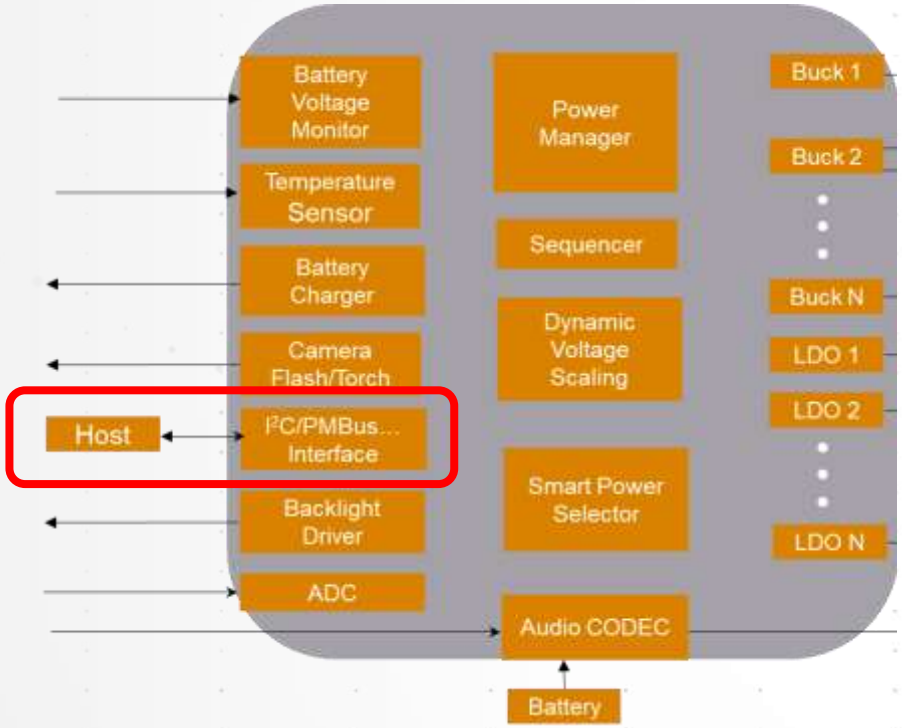
PMIC Testing

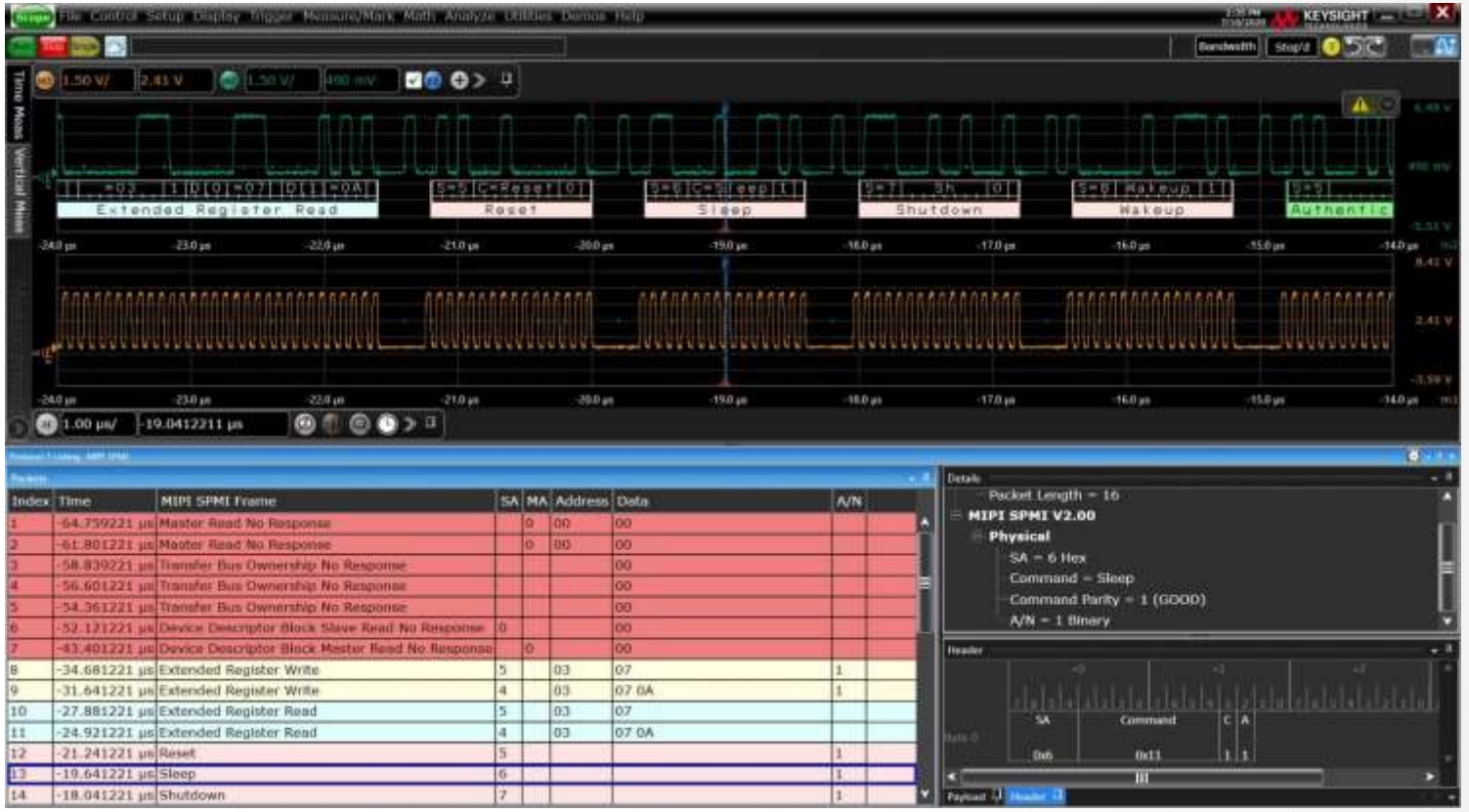
POWER SEQUENCE TESTING—ONE PAGE REPORT.



PMIC Testing

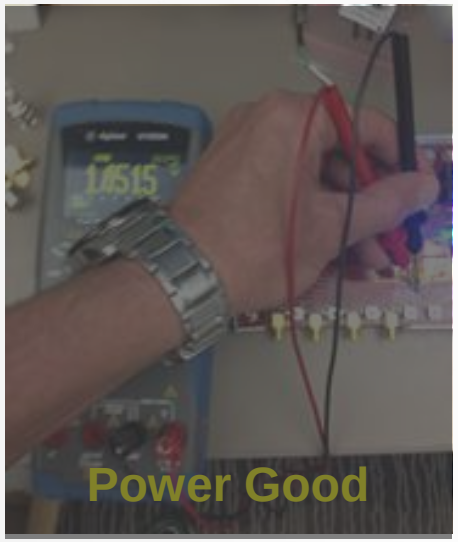
PROTOCOL DECODE AND ANALYSIS—SPMI EXAMPLE

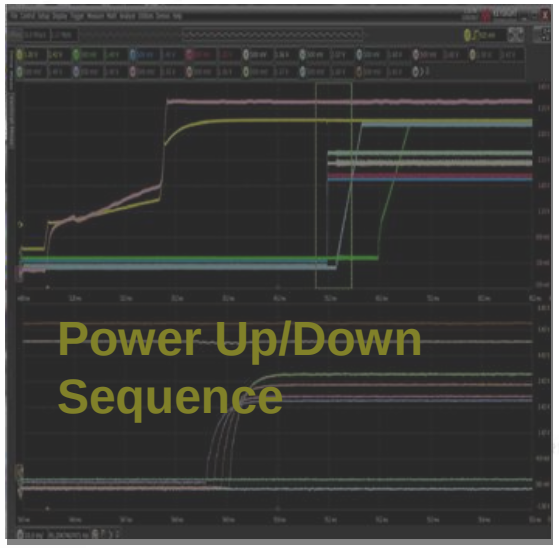




Power Integrity (PI)

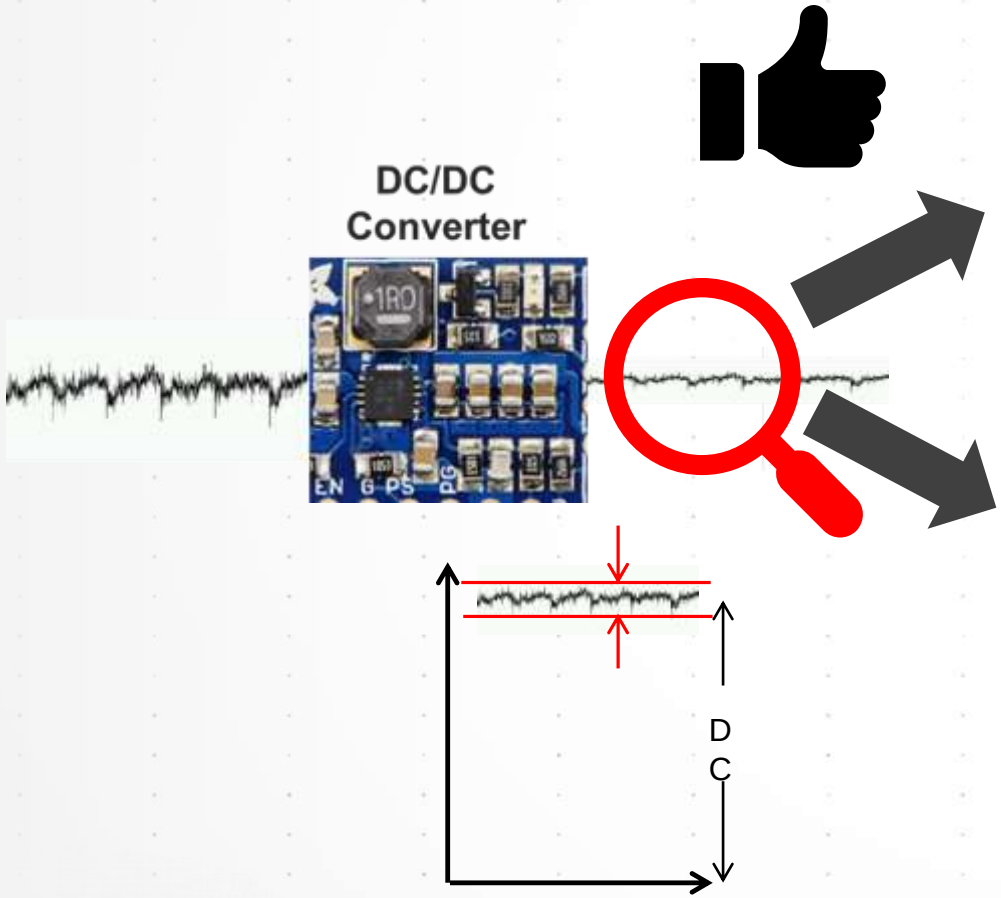
TYPICAL TEST FLOW

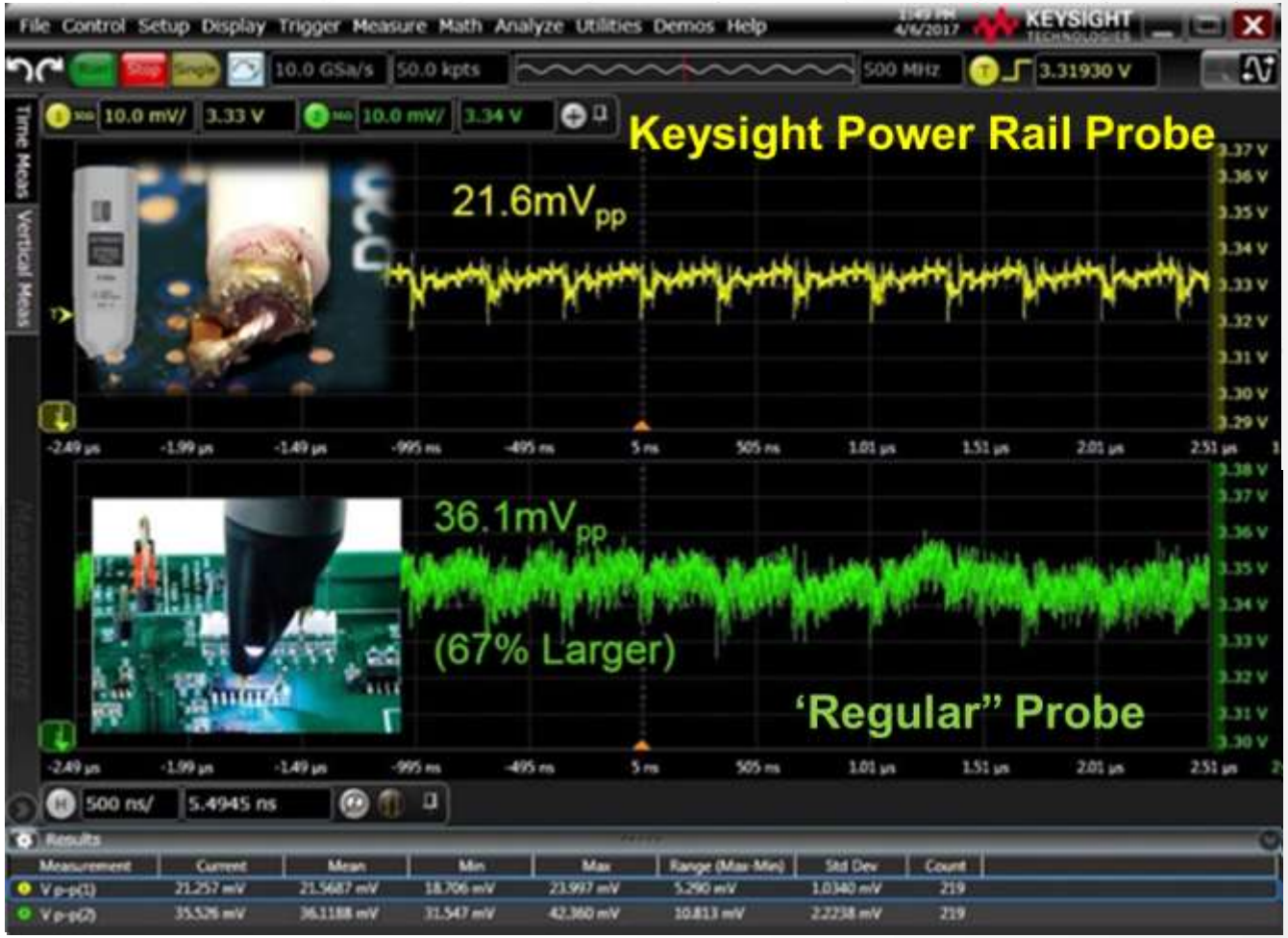




Power Integrity

POWER RAIL QUALITY





Power Integrity

KEYSIGHT POWER RAIL PROBES FOR MXR-SERIES

- Keysight invented the Power Rail probe and their use with oscilloscopes
- Optimized for measuring the quality of power rails

N7020A

2GHz

N7024A

6GHz

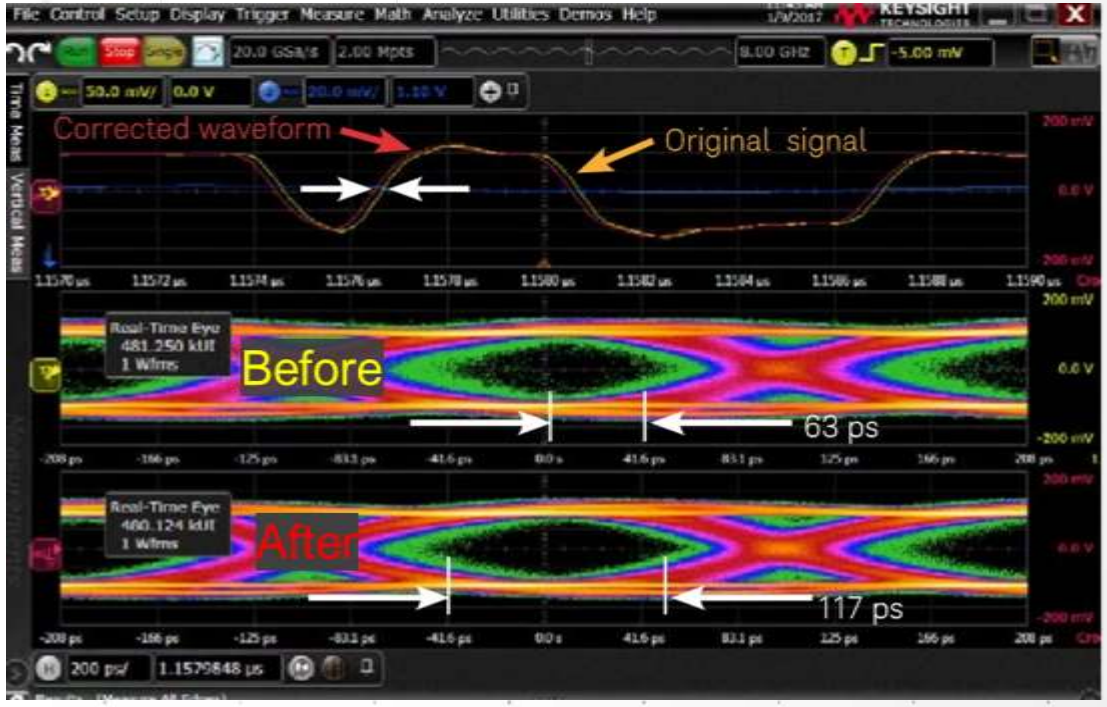
Power Integrity

D9010POWA POWER INTEGRITY ANALYSIS APP

- Helps you understand power rail noise sources and power rail noise effects

Power Rail, before (with switching loads) & after (effects of switching loads removed

Data Line before (with the effects of power rail noise) & after (effects of power rail noise removed).



Power Integrity

D9010POWA POWER INTEGRITY ANALYSIS APP

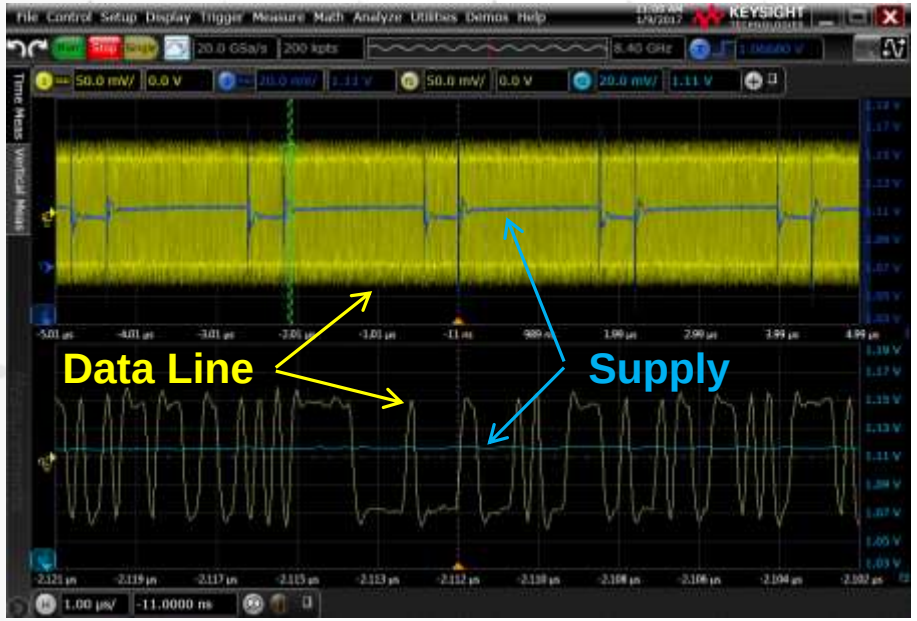
Power Integrity

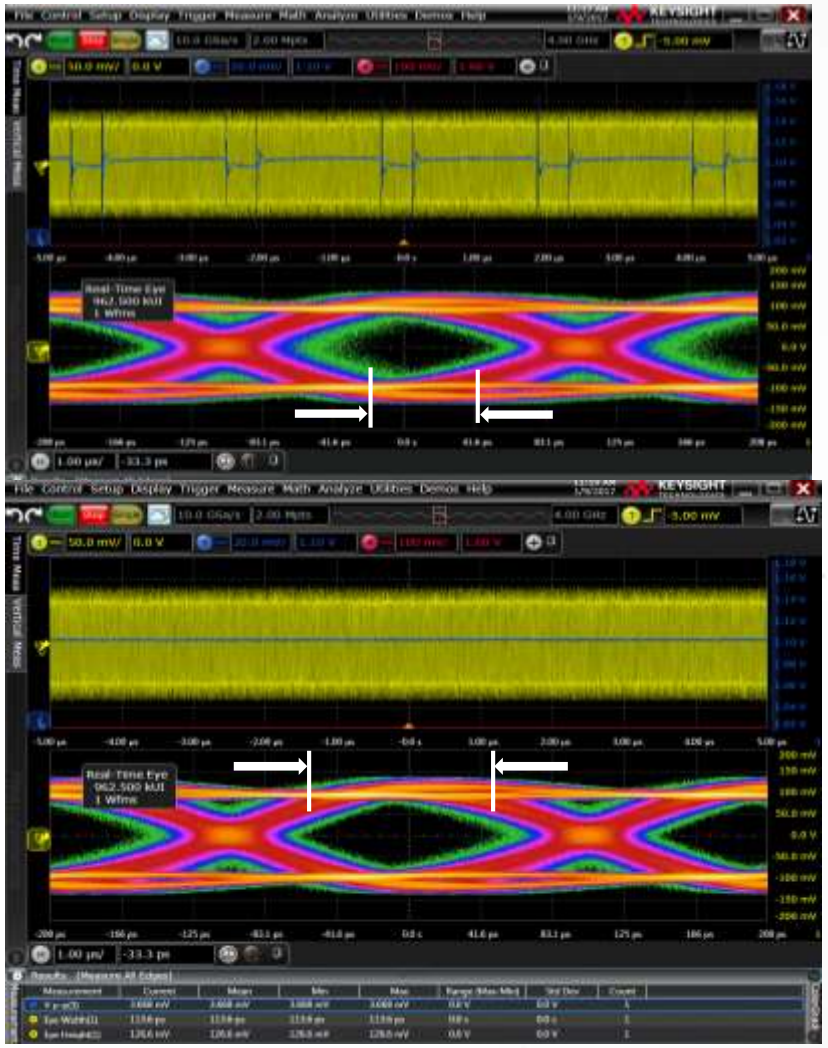
D9010POWA POWER INTEGRITY ANALYSIS APP

Power Integrity

D9010POWA POWER INTEGRITY ANALYSIS APP

1.10V Supply with 115mV$_{pp}$ Noise (±5%)





1.10V Supply with 3mV$_{pp}$ Noise

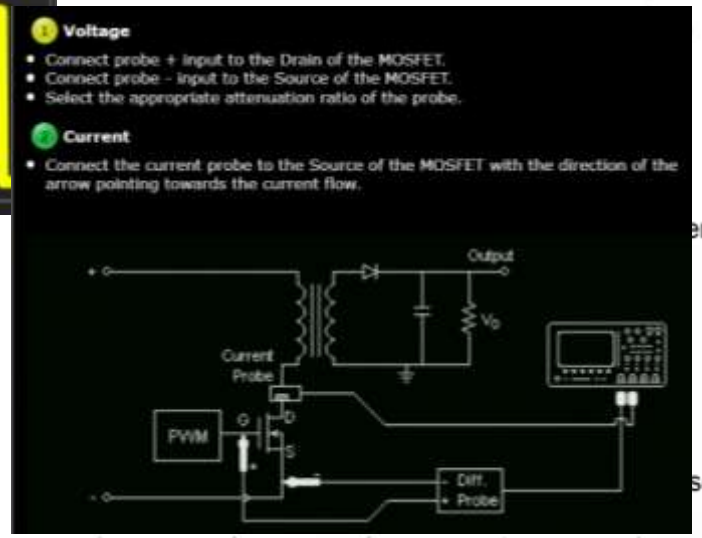
Power Integrity

D9010POWA POWER INTEGRITY ANALYSIS APP

Power Integrity

D9010PWRA—POWER ANALYSIS APPLICATION

- Automated, time saving analysis of switch mode and linear power supplies
  - 20 measurements



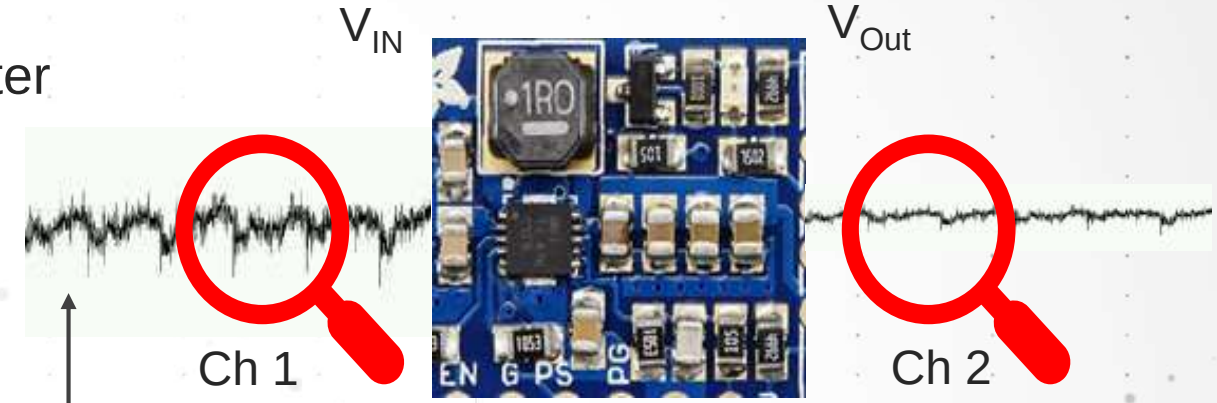
- ‘Setup Wizard’ provides clear directions.

Type of analysis	Measurement
Input measurements	Power quality • Real power • Apparent power • Reactive power • Power factor • Crest factor • Phase angle
	Current harmonics
	Inrush current
Switching measurements	Switching loss
	Rds(on)
	Vce(sat)
	Slew rate
	Safe operating area
	Output ripple
	Turn-on time
	Turn-off time
	Efficiency
	Transient response settling time
	Power supply rejection ratio (PSRR)
	Control loop response (gain and phase)

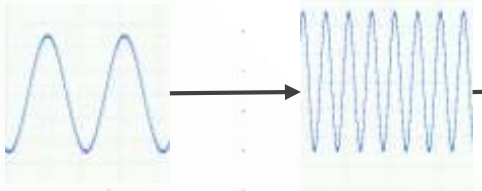
Power Integrity

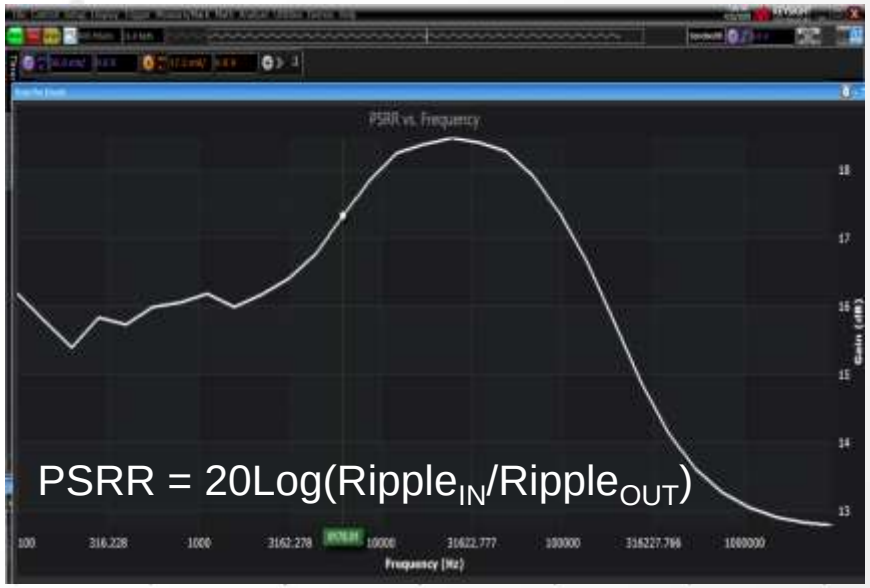
POWER SUPPLY REJECTION RATIO--PSRR

- PSRR is a measure of how well a DC-DC converter can reject noise on the input from getting to the output.



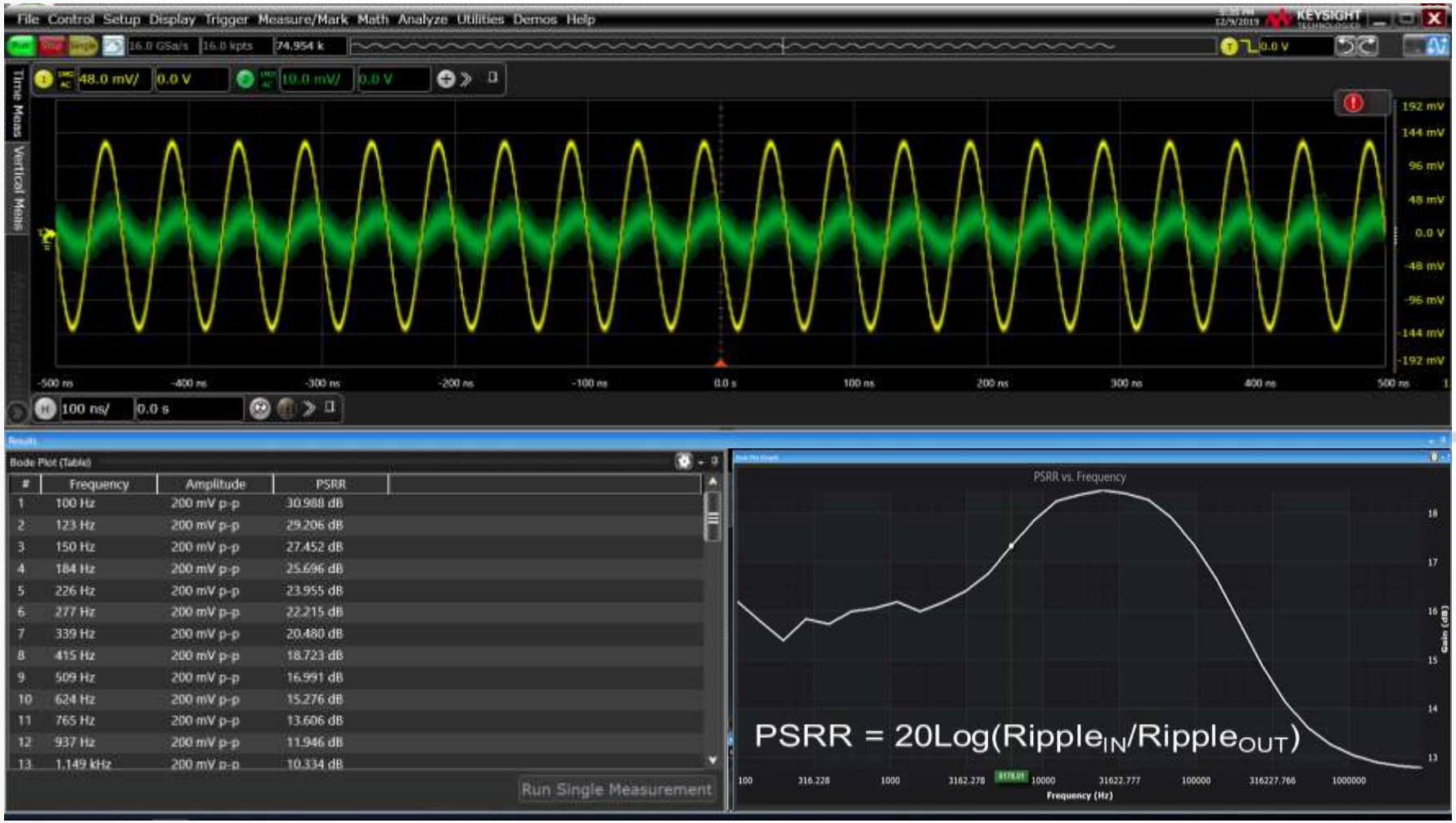
WaveGen





Power Integrity

POWER SUPPLY REJECTION RATIO--PSRR

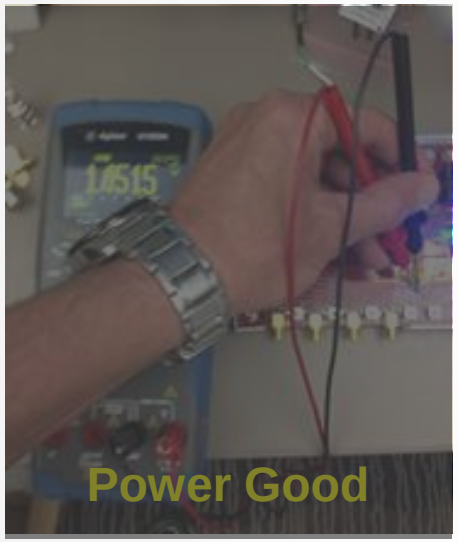


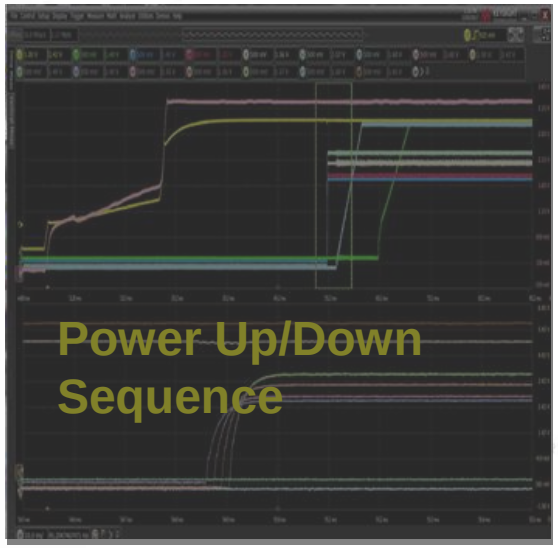
Power Integrity

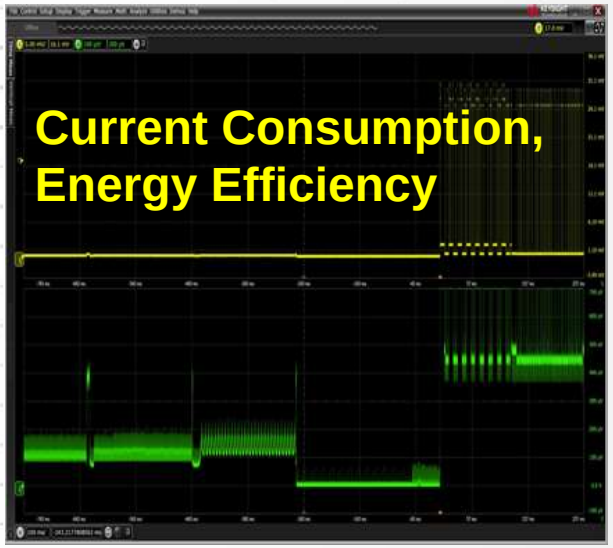
CONTROL LOOP RESPONSE (BODE)

Power Integrity (PI)

TYPICAL TEST FLOW

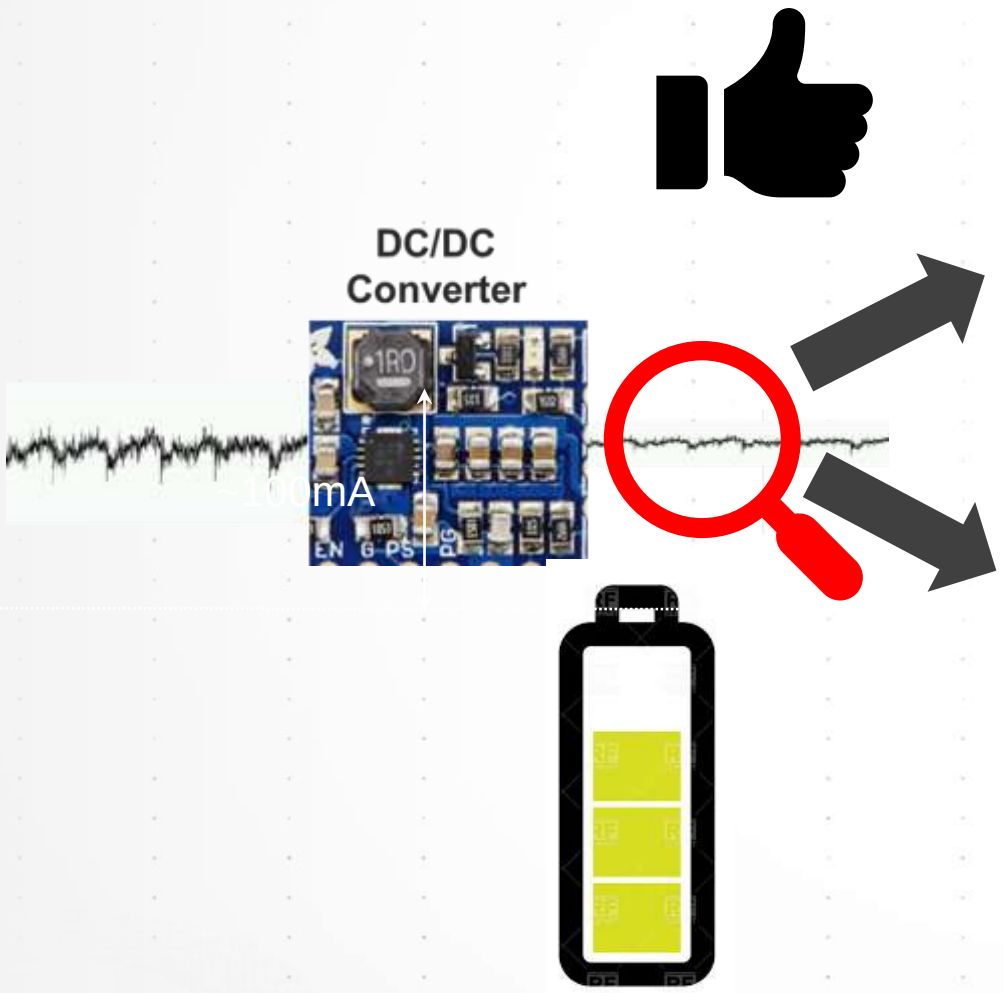


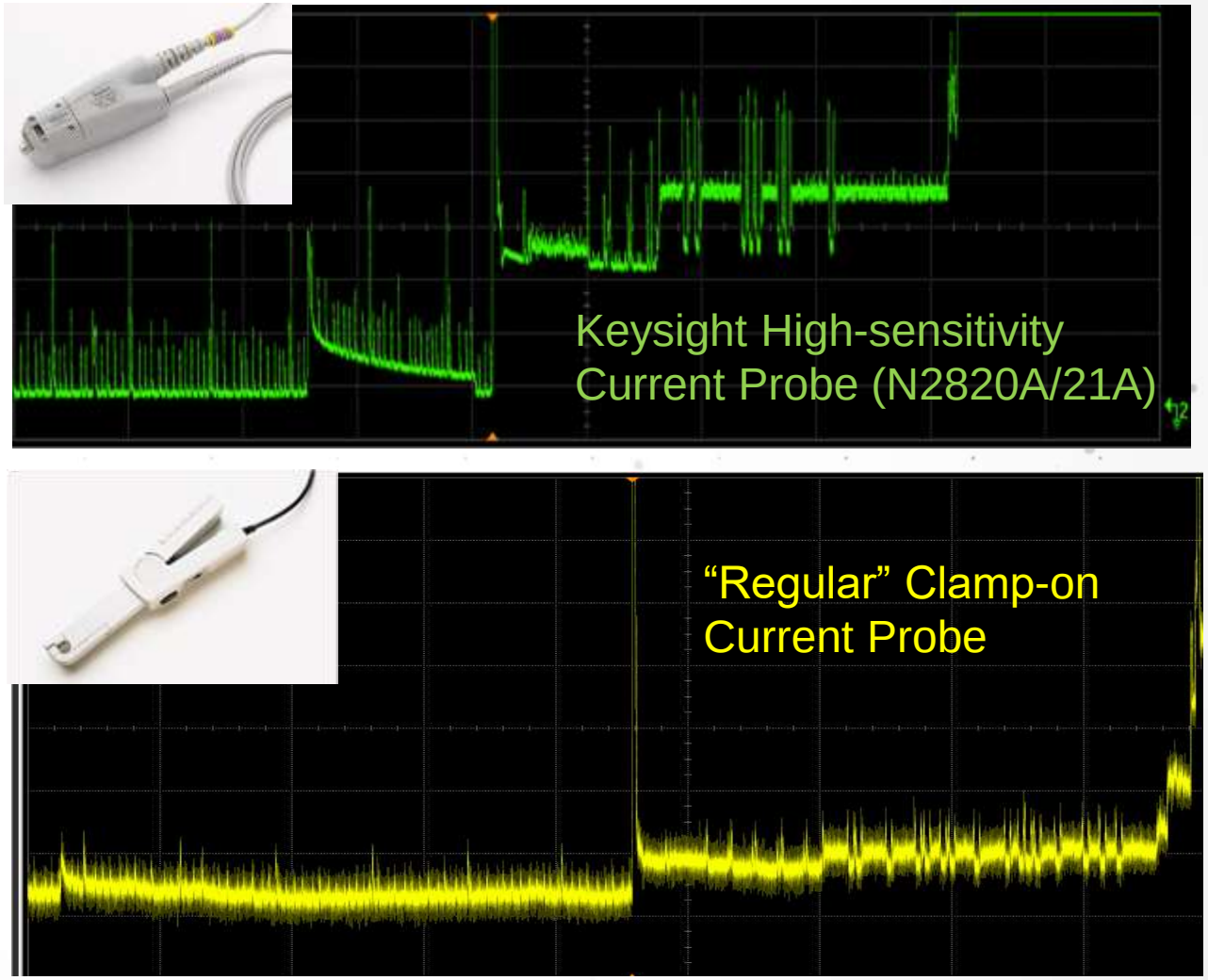




Power Integrity (PI)

CURRENT CONSUMPTION, ENERGY EFFICIENCY

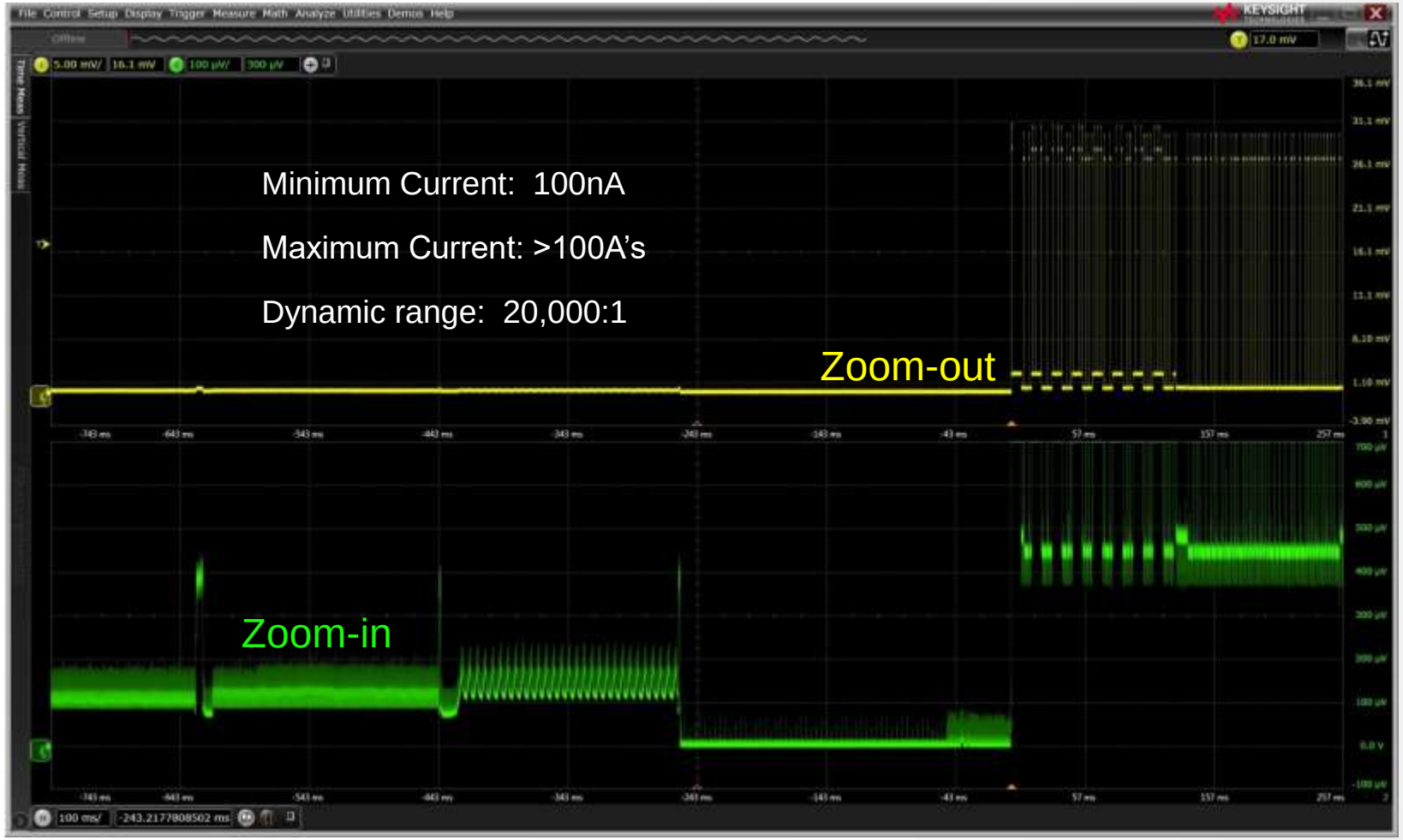




Power Integrity

HIGH-SENSITIVITY CURRENT PROBES

- N2820A-Series Current Probes
  - High Sensitivity
  - High Dynamic Range
  - R_{SENSE}: 1mΩ to 1MΩ

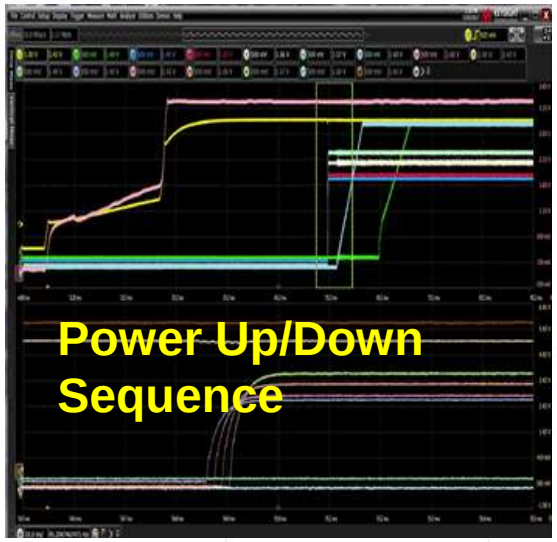


Power Integrity (PI)

SUMMARY

MXR With:

- Built-in Digital Volt Meter (standard feature).

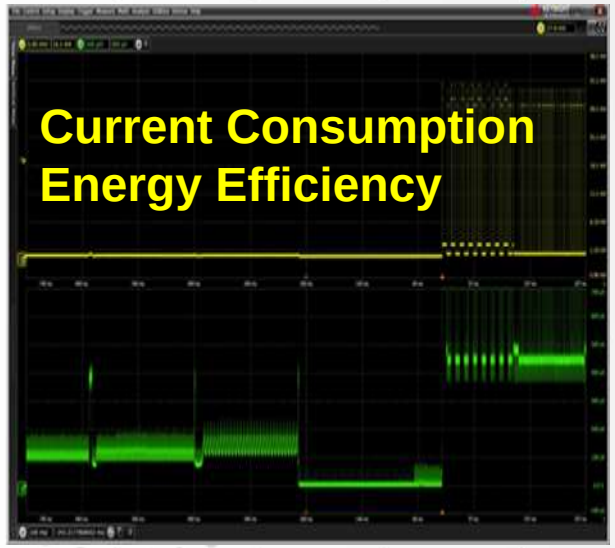


MXR With:

- Simultaneous mask testing on every channel and automatic mask generation (standard feature)

MXR With:

- 2Ghz & 6GHz Power Rail Probes (N7020A, N7024A)
- PI App--D9010POWA
- Power App-D9010PWRA
  - PSRR, etc.



MXR with:

- High-sensitivity current probes (N2820A, N2821A)


KEYSIGHT
WORLD 2020