5-PWR and 6-PWR Advanced Power Measurements and Analysis

-Get more visibility into your power supply designs

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Agenda

- Market Overview
- SMPS challenges
- Tektronix solution
- Summary

Understanding Power

240/120V AC

12V DC

SMPS

440V AC

Large Motors

240/120V AC

Small Motors

400V AC

Wind Power

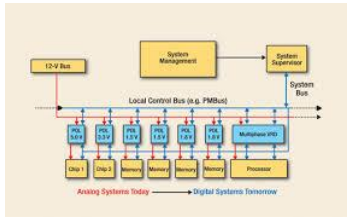
1500V DC

Solar Power

24V DC

250V AC

Inverters



12V DC

5/3.3/1.3V DC

DPM

SMPS- Devices and Industry Profiles

- Typical Power Electronics Modules / Systems
  - DC-DC converters
    - Voltage Regulators
  - AC-DC converters
    - Power supplies
    - Power factor correction (PFC) controllers
    - LED drivers
  - DC-AC Inverters
    - PV / Solar inverters

- Power semiconductor device manufacturers
  - Integrated device manufacturers
  - Foundries
  - Fabless
  - Automotive
  - Military, aerospace

- Research & education
  - Research consortiums, power semiconductor labs in universities, government research labs

SMPS Testing Challenges

DESIGN AND DEBUG CHALLENGES

- New devices are designed for boosting performance and simplifying the design.
  - High efficiency, compact, switch-mode power supplies.
  - Applications requiring peak power capability.
  - Ability to handle extreme voltages and currents.
  - **Reduce loss in the loops (transformers and inductance)**
  - Lowering no-load power consumption.
  - SoC
  - New wide bandgap devices
    - SiC and GaN
  - EMI/EMC
  - Power Integrity
    - Power artifact impact on HSS

Stages of Power Hardware Design

Component Selection
- Select and characterize power components.

Porotype Testing
- Prototype board debug and testing

Efficiency and Consumption testing
- AC & DC Energy consumption and efficiency testing

Compliance Testing
- Compliance testing (pre)

Production
- Production test


Source Measure Units (SMU)


Parametric Testers


Scopes


IsoVu Probe


Application Software


PA3000 Po


7510 DMM


RSA – Spectrum Analyzer


PA1000 Power Analyzer

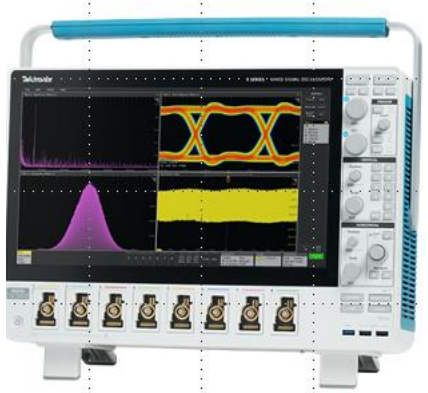

Scopes


7510 DMM


Source Measure Units

Elements of a Complete Power Solution

- Best in Class Acquisition System
  - Oscilloscope



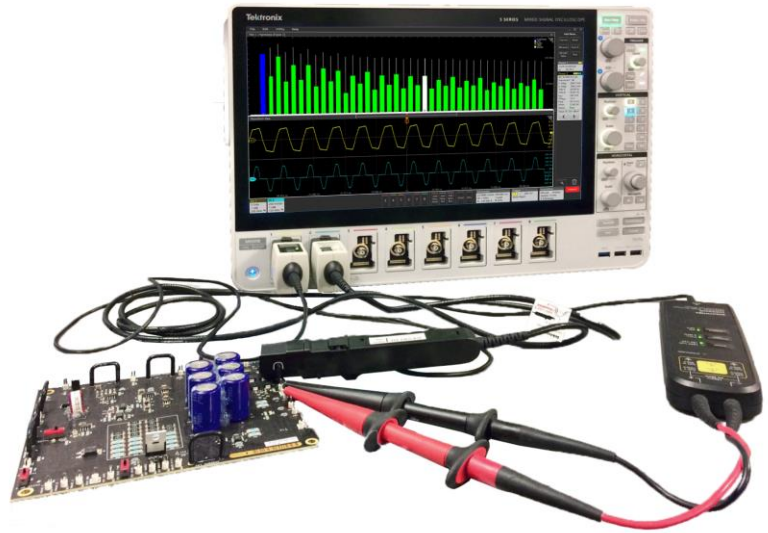
- Best In Class Probing capability
  - Ability to meet new design needs

- Automated Application Software
  - Ease of Use
  - Repeatable
  - Report
- Complete Solution

Tektronix Solution- 5/6 Series MSO with 5-PWR, 6-PWR and Power probes

- Multiple FlexChannel® and path breaking GUI of 5/6 series MSO enables Power designers to test multiple test points simultaneously thereby ensuring faster validation and test times desired to meet quicker GTM needs.
- Leverage the 6/8 channel capability
- 12-bit ADC ensures better resolution.
- Automated power and harmonic measurements reduce time to answer and guar MSO scopes

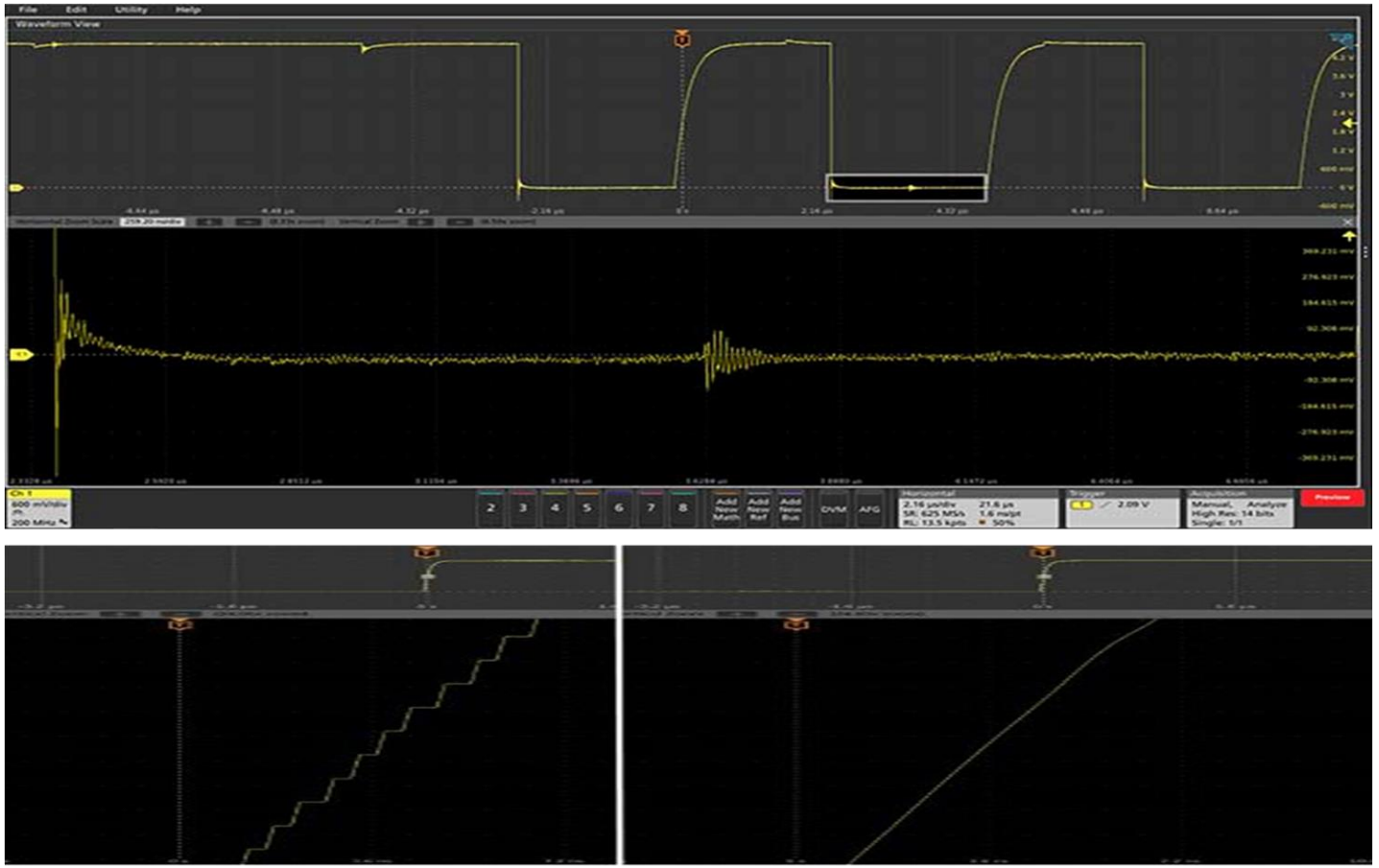
Get more visibility into your power supply designs



- Complete set of differential, high voltage and current probes including IsoVu™ and Rogowski probes delivers superior performance probe tip to scope for new generation wide bandgap designs
- **1 BOX Solution for Power Measurements and Frequency Response Measurements.**

Good Measurement Requirements and Practices

- Optimize vertical resolution
  - Using only half of the display vertically reduces vertical resolution by one bit
  - Driving the signal off-screen may distort the signal and invalidate measurements
  - Use AC coupling or DC Reject to remove uninteresting DC signal components
  - Use scope Offset to account for important DC signal components.
- Small Details on large signals requires High Resolution!
  - 12-bit analog-digital converter (ADC) delivers 16 times the resolution of conventional 8-bit ADC.
  - New High Res mode delivers up to 16 bits of vertical resolution for finer view of lower frequency signals.
  - Next generation front end amplifier reduces noise to help resolve small signal details ~4.5 dB lower noise from previous generation oscilloscopes



8 Bits **(16x more digitizing levels)** 12 Bits

All Great Measurements Start With Probing

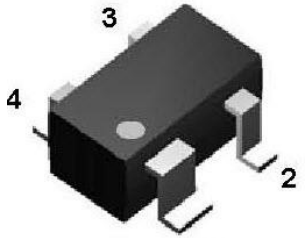
- Choose adequate bandwidth for your signal
- Differential / Single-ended probes (ground referenced or not)
- Make sure probe is within its voltage operating range (safety!!)
- Low probe loading to reduce effects on circuit
- A probe that communicates to your scope ensures probe parameters are automatically captured
- Differential/Floating measurements measure the difference in voltage between two nodes
  - **Method 1**: Floating the Scope **(DO NOT DO THIS!)**
  - **Method 2:** Use two single-ended probes and scope math (CH1-CH2) to measure the difference
  - **Method 3:** Using an isolated input and an isolated probe.
  - **Method 4:** Using a differential probe/amplifier **(PREFERRED)**

THDP0100 (± 6000 V / ± 6000 V, 100 MHz)

TCP0030A (1mA to 30 A, 120 MHz)

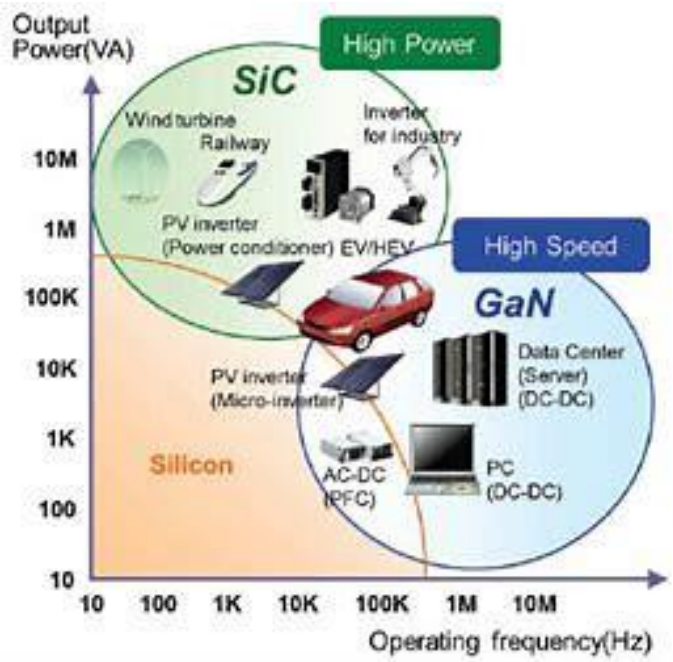
TiVH08L (+/- 2500V, ≤ 60kV, 800 MHz)

Wideband GAP devices getting into designs



Silicon Dual Channel MoSFET

Silicon Carbide Chip



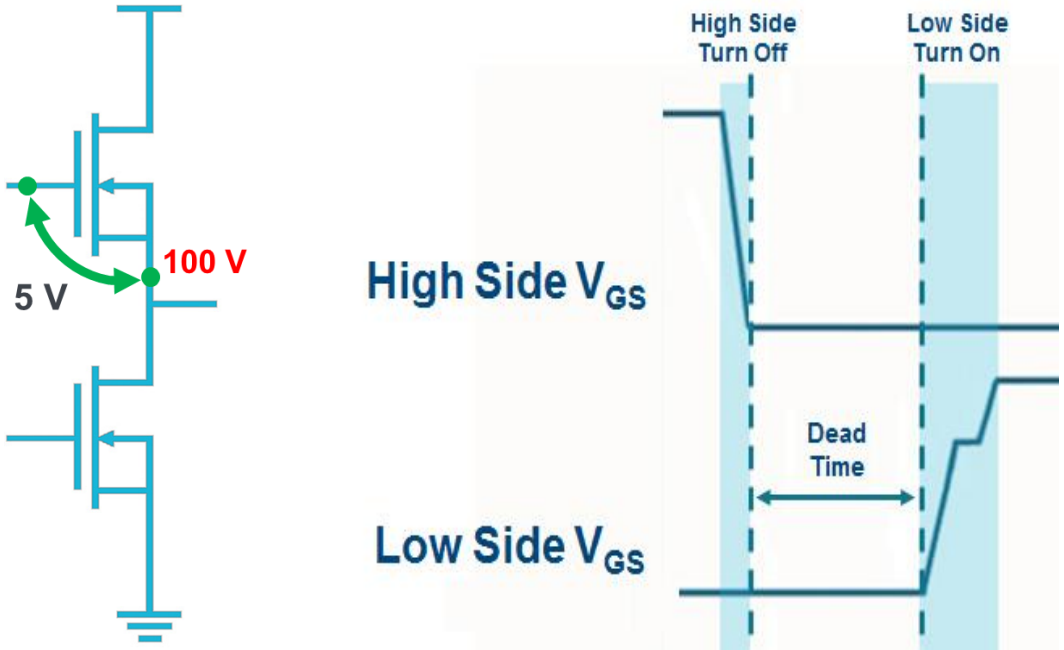
SiC for high power voltages (>1kV) with high current
= niche market

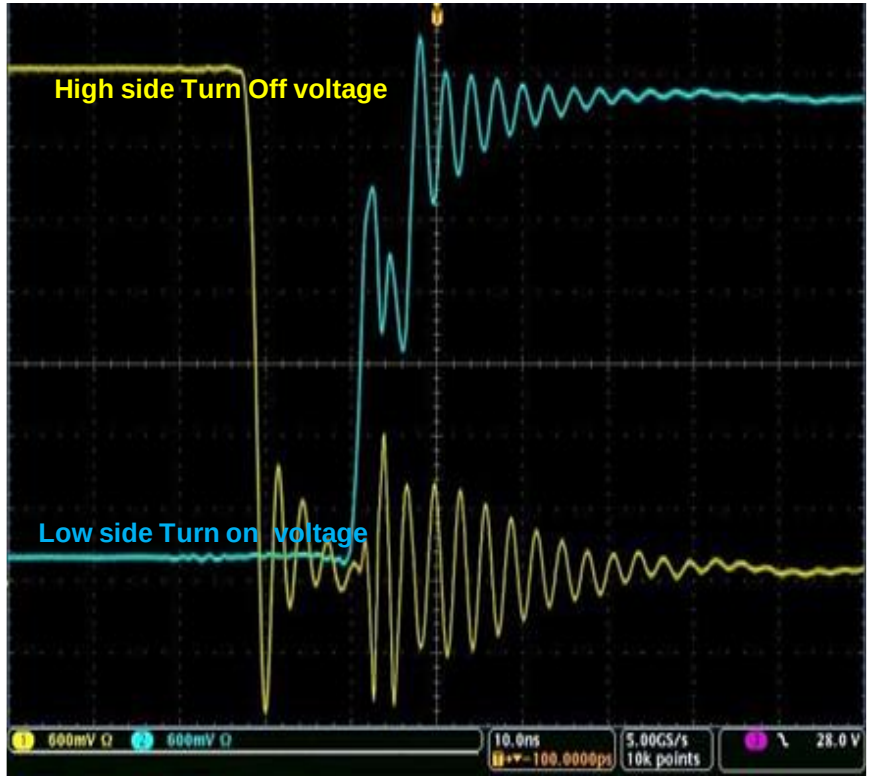
GaN on Si for high frequency at midrange voltages (<1kV, up to 100A)
= mass market

New Probing Challenges: Wide Bandgap Measurements

INTERACTION BETWEEN THE HIGH AND LOW SIDE

- Violation of specifications can lead to simultaneous conduction (it blows up), switch loss, loss of efficiency, and device degradation
- Parasitic coupling between switch node and both FETs



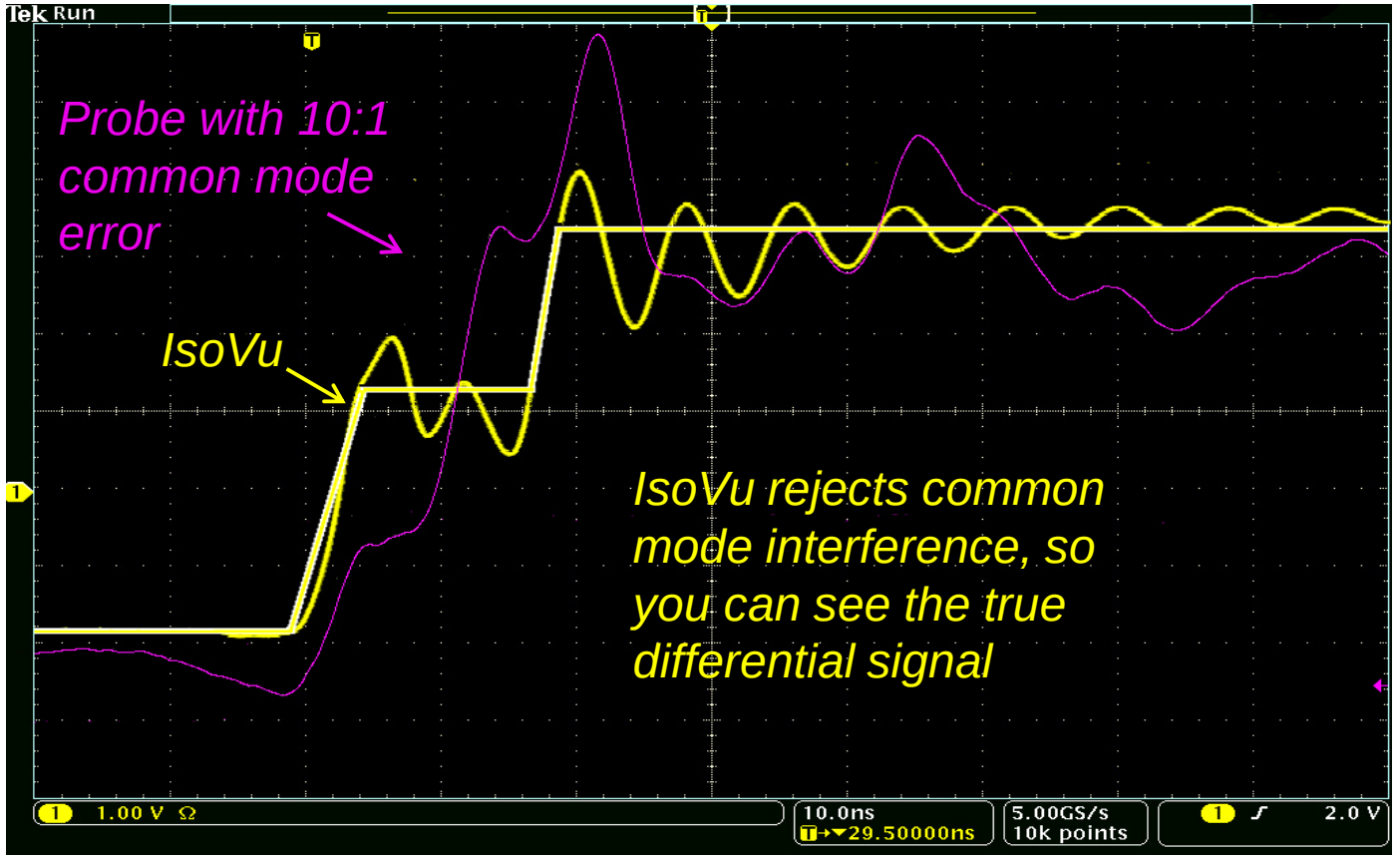


New Probing Challenges

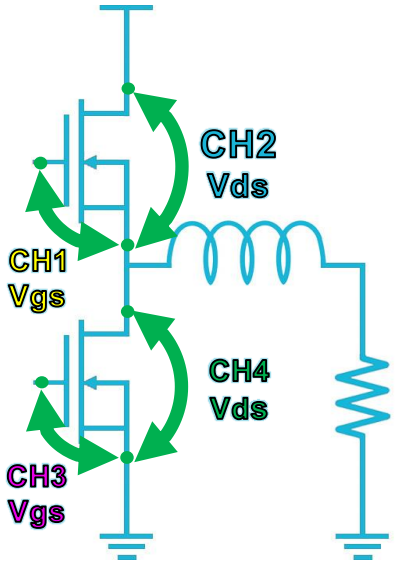
DO YOUR WIDEBAND GAP MEASUREMENTS MATCH YOUR EXPECTED RESULTS?

- IsoVu gives you an accurate, repeatable measurement providing meaningful correlation with expected performance

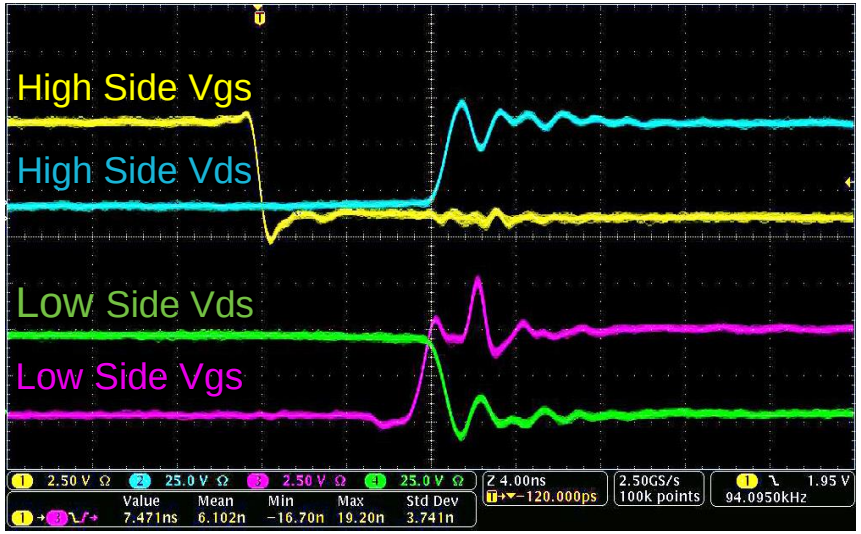
Expected Simulation Results

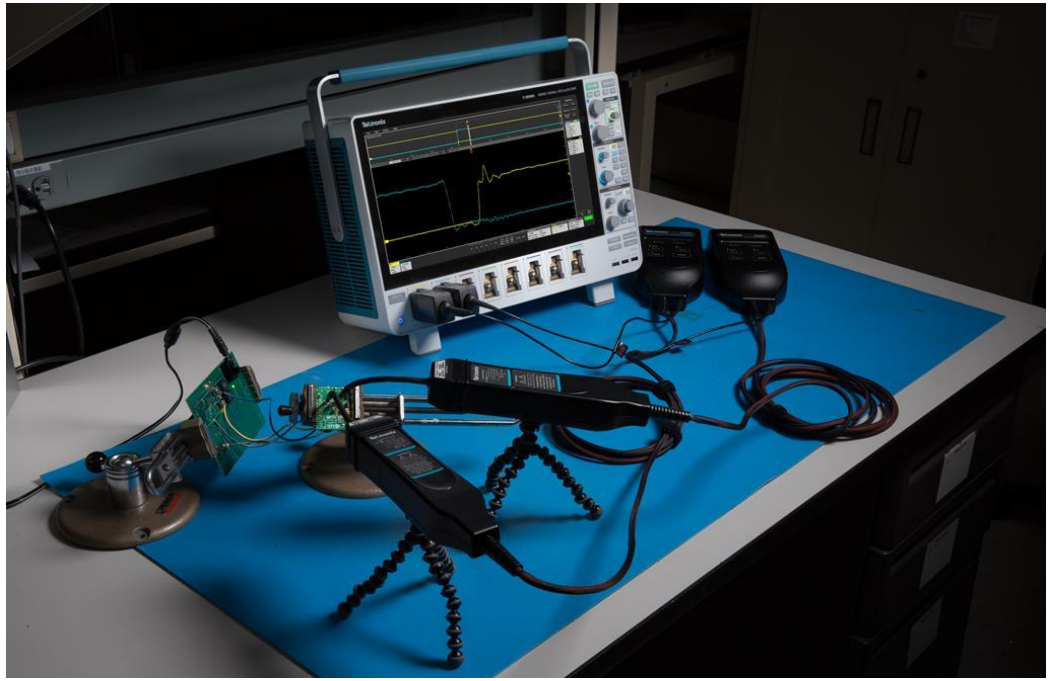


Characterize the Entire Wideband GAP Switching Circuit



- Characterize the gate voltages, Vds, and Is
- Characterize the time alignment of high and low side events
- Optimize and tune switching characteristics (edge rates, overshoot, ringing and dead time)
- Combination of IsoVu with 5 Series and Power Application Software ensures effective solution

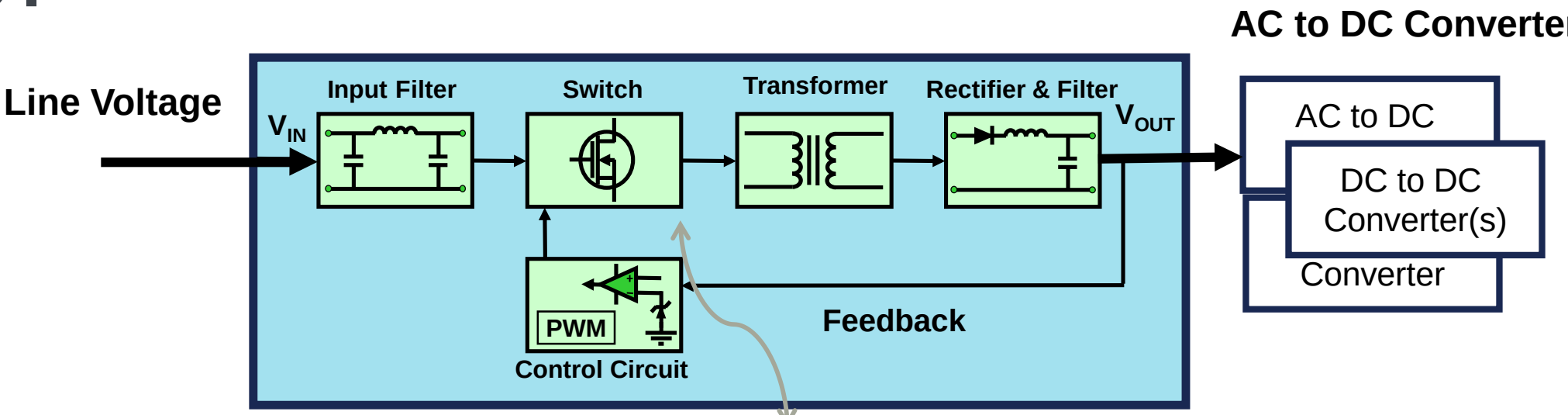




Power Measurement Automation

- Automation gives the user application expertise
  - Algorithms and measurement techniques are automatically selected
  - Includes test limits for relevant industry standards
  - Simplifies probe deskew
- Automation ensures optimum setup for measurements
  - Automatically sets vertical scales, offsets, bandwidth limits, and triggering
  - Automatically sets horizontal scale, sample rate, and record length
  - Automatically selects acquisition mode (High Res), measurement thresholds, cursor gating
- Automation ensures consistent measurement technique
  - The application executes the same steps,
    in single-shot and repetitive operation
- Automation enables efficient documentation of measurement results
  - Create reports easily

Typical SMPS Circuit



- **Input / AC Power**
  - Current /Voltage Harmonics
  - Power Quality
  - Inrush Current
  - Input Capacitance
- **Active Components (Switch)**
  - Switching Loss
  - Safe Operating Area
  - d/dt
  - RDSon
- **Magnetic Analysis**
  - Magnetic Loss
  - Magnetic Property
  - Inductance
  - I vs. ∫V
- **Output DC Voltage**
  - Ripple
  - Efficiency
  - Turn on Time
  - Turn off Time
- **Frequency response Analysis**
  - Control Loop response(Bode Plot)
  - Power Supply Rejection Ratio (PSRR)

Designers need the ability to access multiple test points and analyze them simultaneously to ensure quicker validation/testing cycles to meet faster GTM need.

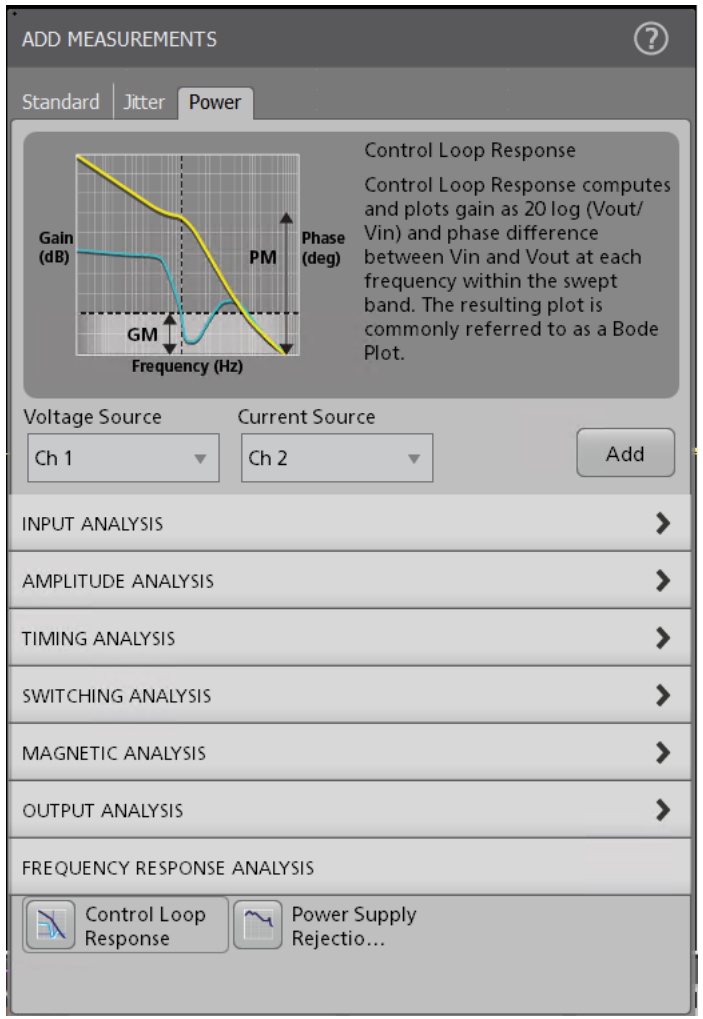
Introducing Advanced Power Measurements and Analysis Software

- Option 5-PWR,6-PWR,5-PS2,6-PS2 and upgrades SUP5-PWR, SUP5-PWR-FL and SUP6-PWR-FL

  - Input Analysis
    - Power Quality
    - Harmonics
      - No standard
      - IEC61000-3-2
      - MIL-STD-1399
      - AM14
      - DO-160
    - Inrush Current
    - Input Capacitance
  - Amplitude Analysis
    - Cycle Amplitude, Cycle Top, Cycle Base, Cycle Peak-to-Peak, Cycle Maximum, Cycle Minimum
  - Magnetic Analysis
    - Magnetic Loss
    - Magnetic Property
    - Inductance
    - I vs. ∫V
  - Timing Analysis
    - Period, Frequency, Positive Duty Cycle, Negative Duty Cycle, Positive Pulse Width, Negative Pulse Width
  - Switching Analysis
    - Switching Loss
    - SOA
    - dv/dt
    - di/dt
    - RDSon
  - Output Analysis
    - Line Ripple
    - Switching Ripple
    - Efficiency
    - Turn on Time
    - Turn off Time
  - Frequency Response Analysis
    - Control Loop response(Bode plot)
    - Power Supply Rejection Ratio (PSRR)

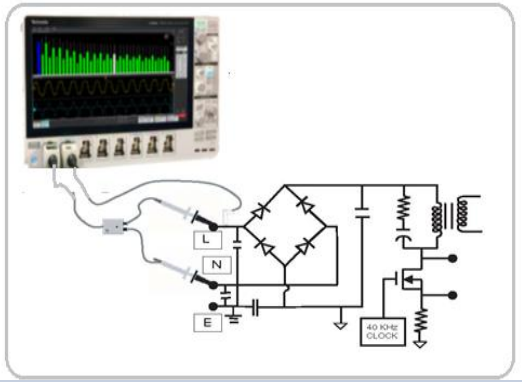
new

updates

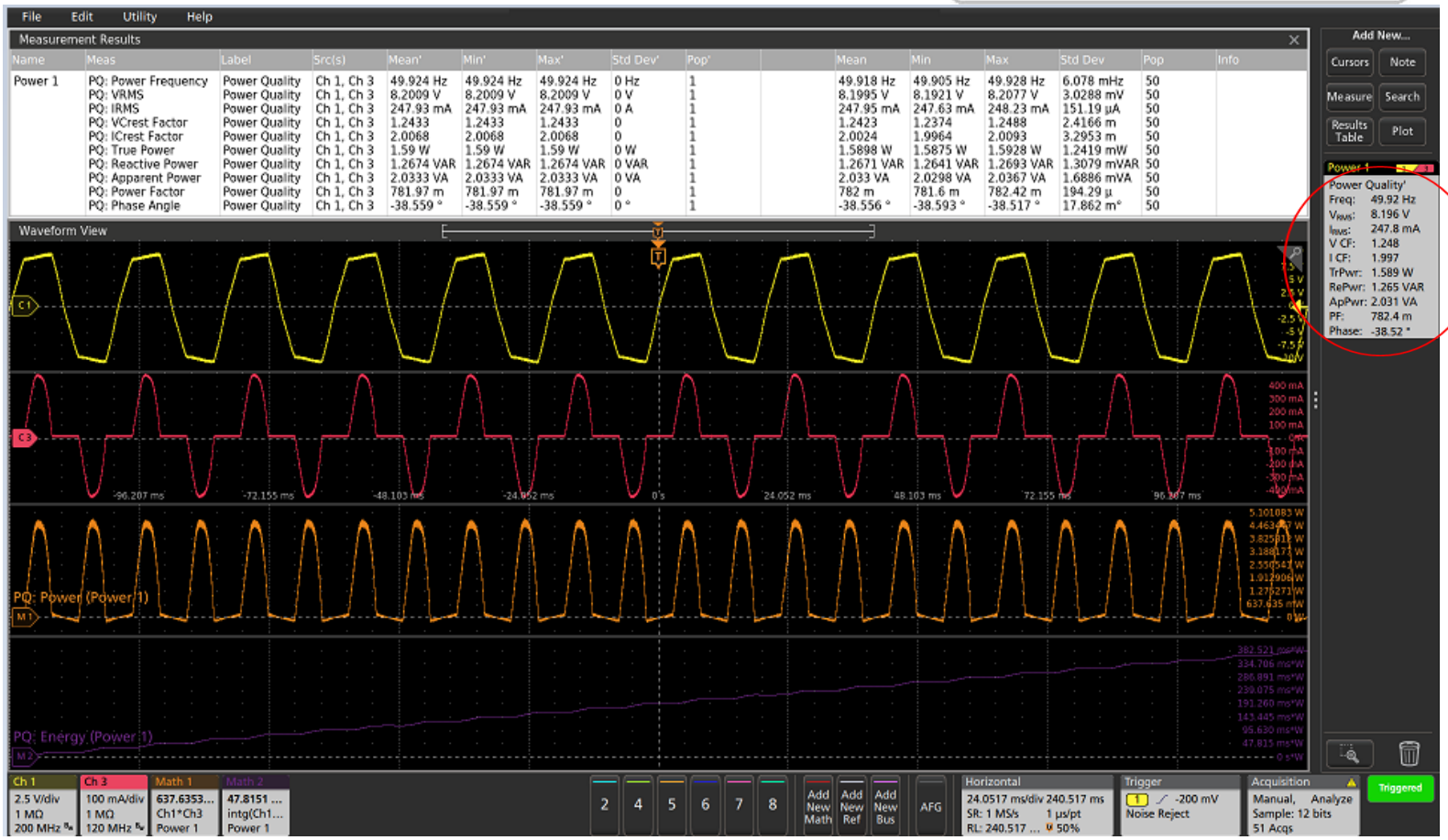


Significance of Power Quality

THE BENEFITS OF GOOD POWER QUALITY

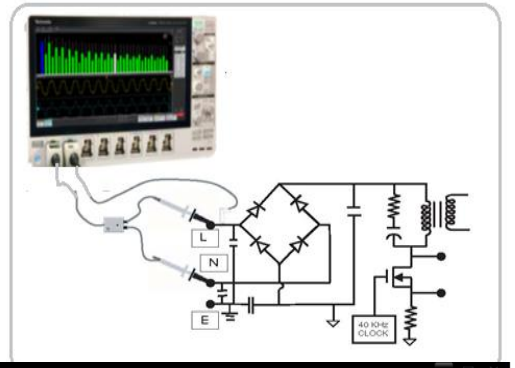


- Reduce the line & equipment current and losses and hence lower energy bills
- Improve Power Factor & avoid penalty for low power factor
- Prevent of malfunction of equipment
- Reduce the losses in equipment
- Increase the power equipment life



Significance of Harmonics (updated)

NON-IDEAL INPUT CURRENTS INCREASE BURDEN ON POWER GRID AND WASTE ENEGRGY



- Ideally, when Power Factor =1,load appears resistive,
- voltage and current in phase.
- Real Power = Apparent Power so Relative Power =0
- No Current Harmonics

BUT..

- In practice, loads are not always resistive
  - AC-DC converters present non-linear impedance
  - Power factor correction is complex

Update: Handle current only signal when standard is none.

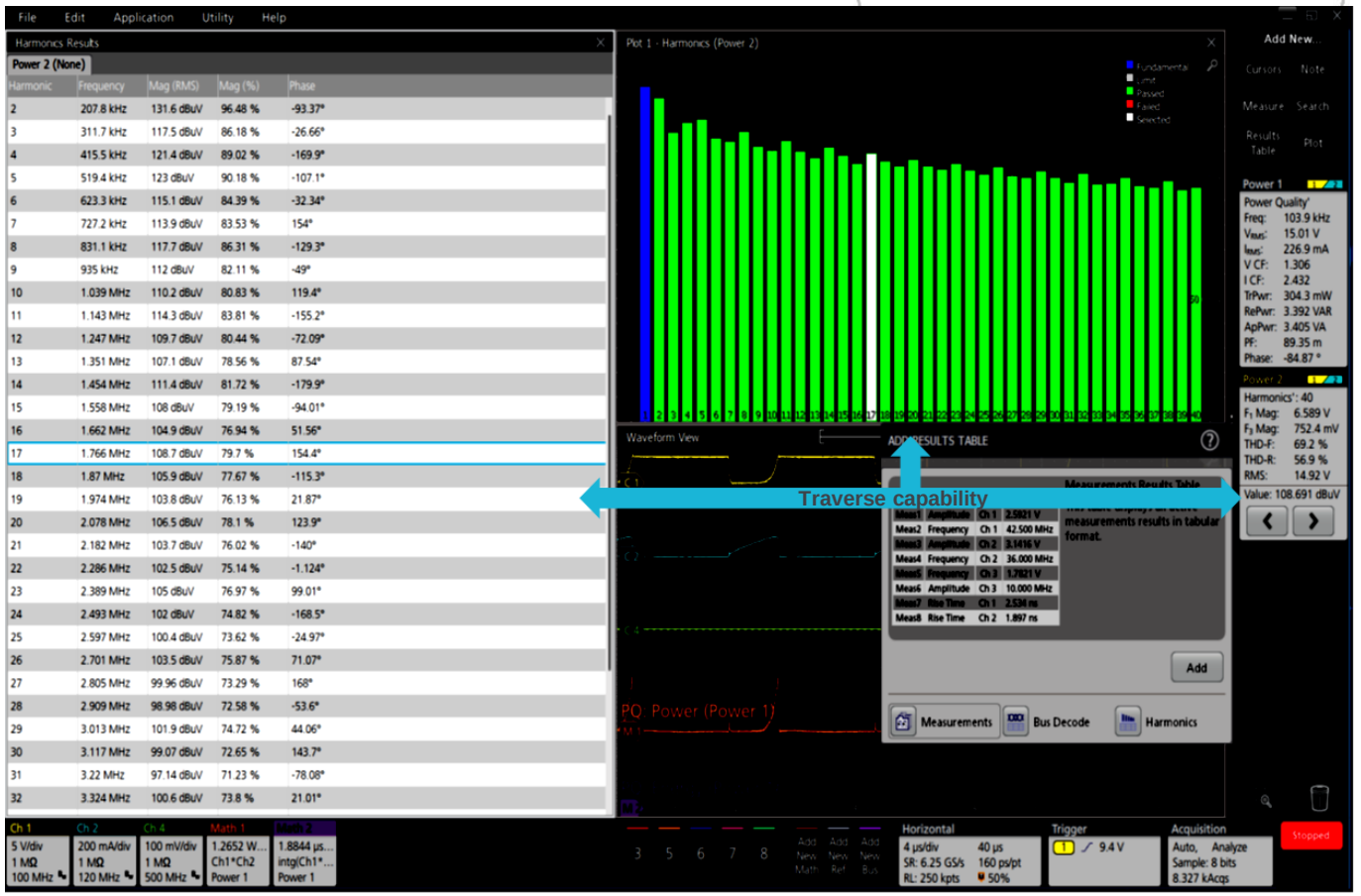
Various Standards of Current and Voltage Harmonics

- **61000-3-2 [1}**
  Deals with limitation of harmonic currents injected into the power supply system. Supplied from mains network with voltage not less than 220V and current up to 16A (including) to limit the harmonic component emission.
  - ✓ Equipment with rated powerless than 75W, except class C equipment
  - ✓ Professional equipment with power >1 kW
  - ✓ Symmetrically controlled heating elements with power ≤ 200W
  - ✓ Independent dimmers for incandescent luminaries with power ≤ 1 kW

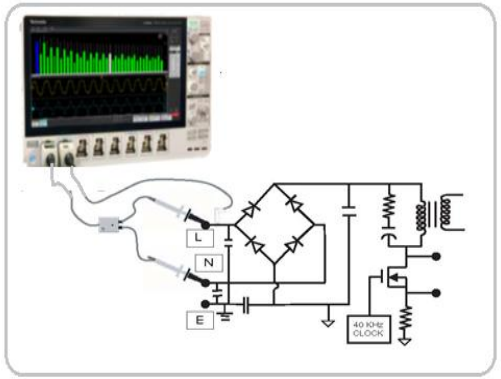
- **AM 14 [2]**
  Harmonics – Including AM14, < 16 Amps/Phase

- **MIL 1399 [3]**
  Establishes electrical interface characteristics for shipboard equipment

- **DO-160(Airborne standards)-New capability**



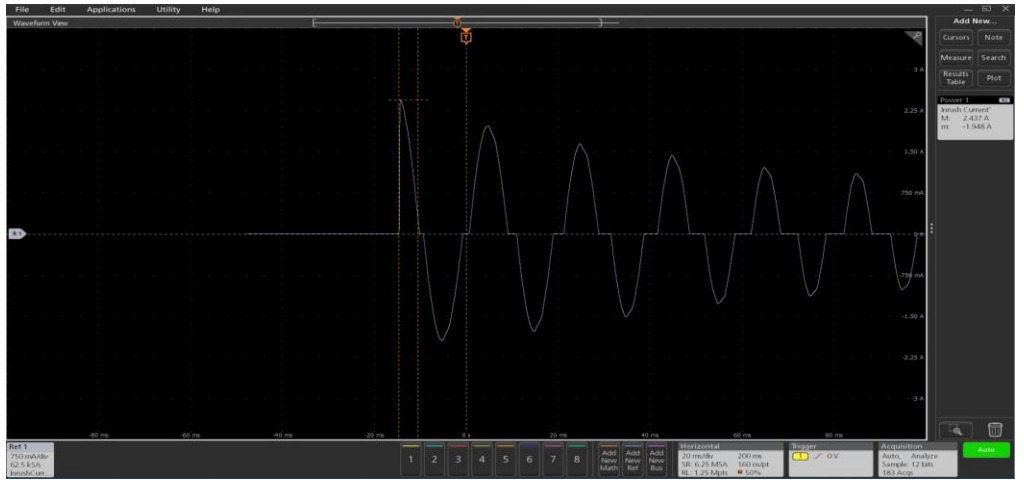
Significance of Inrush current and Input Capacitance (updated)

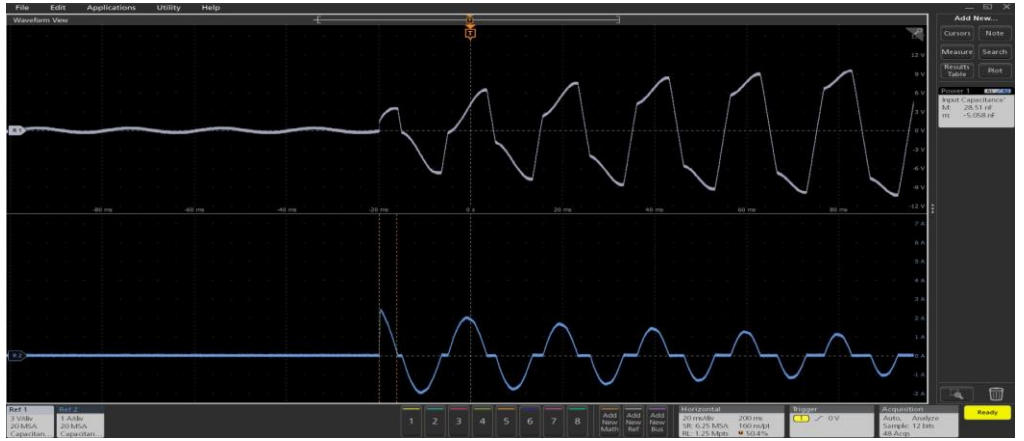


INPUT CURRENT AND INPUT CAPACITANCE ARE KEY TO ENSURING DESIGN SAFETY

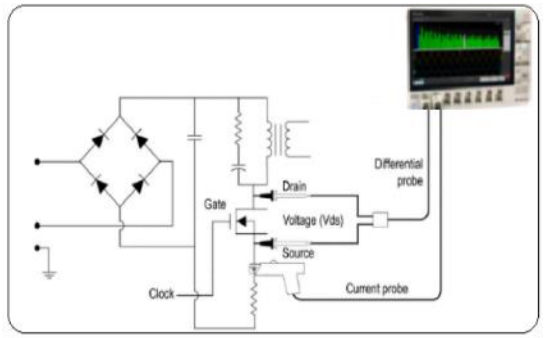
- **Inrush Current and Input Capacitance** measurements are important to ensure the design protection circuitry is in place.
- Power designers need insights to the peak current surge that needs to be handled for protection circuitry.
- Designers need to ensure the correct capacitor is used in the circuit which can handle the peak current surge effectively.
- Enables designers to traverse across cycles to identify and isolate problems effectively.

Update: User interface updated. Start the measurement using Run/Stop button of Oscilloscope.





Switching Loss Measurements(updated)

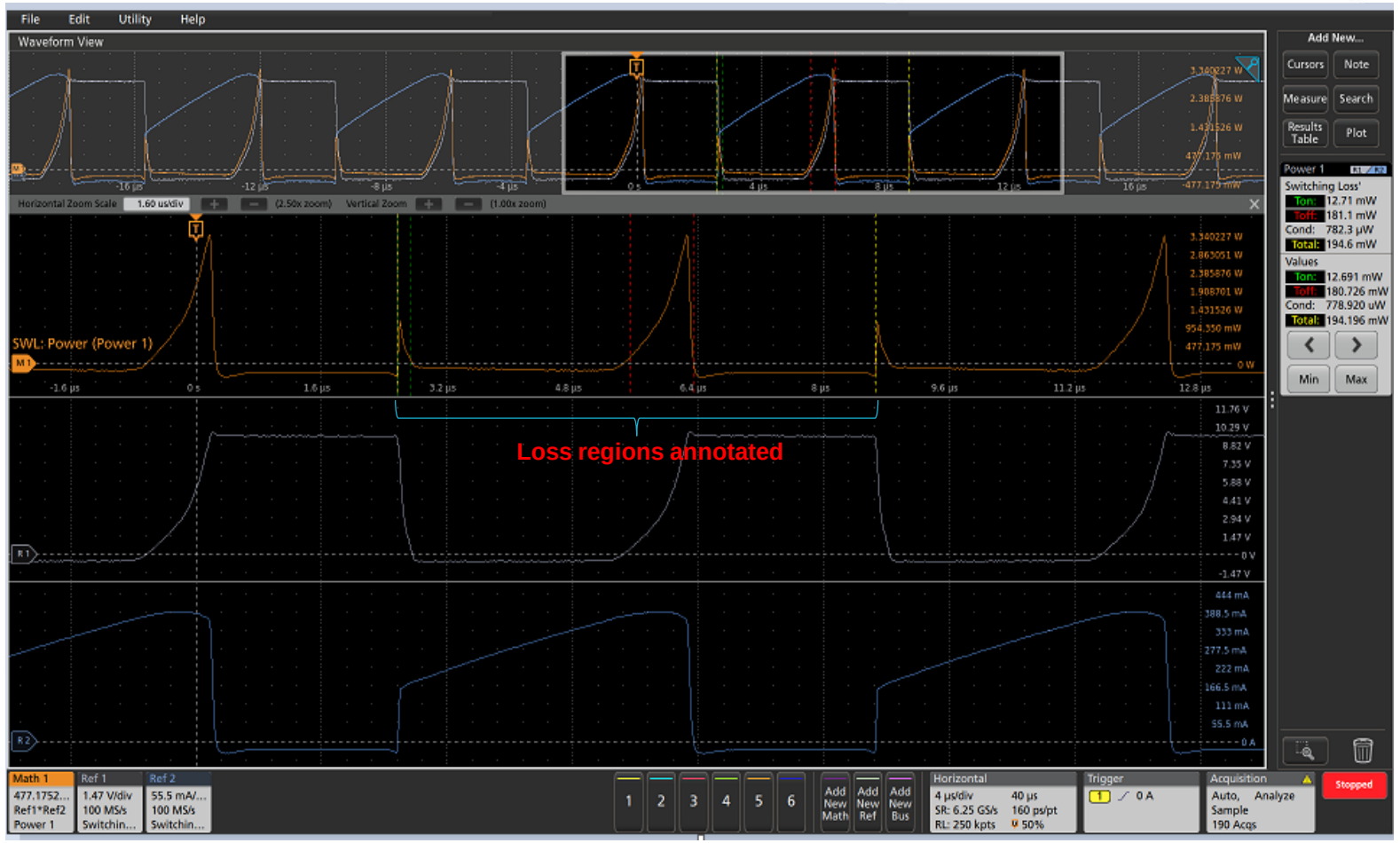


- **Turn-on loss :** Energy losses when the switching device changes from its non-conducting state to its conducting state.

- **Conduction loss :** Losses in the switching device when it is in saturation.

- **Turn-off loss:** Energy losses when the switching device changes from its conducting state to its non-conducting state

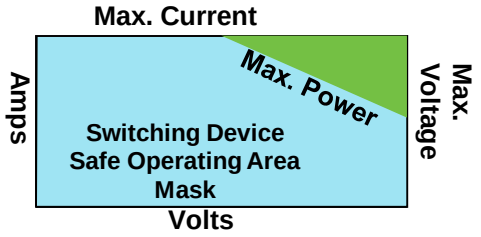
Update: RDSon value in configure is now able to be set from 1mOhm.

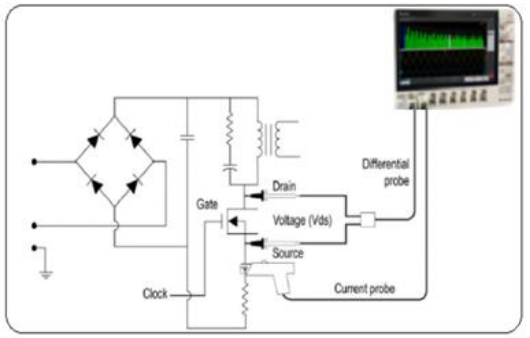


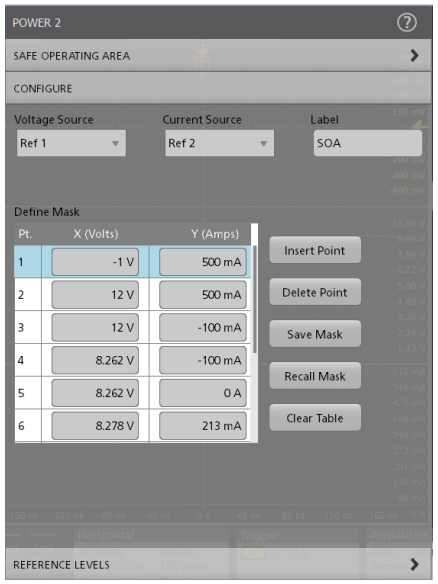
Switching Analysis

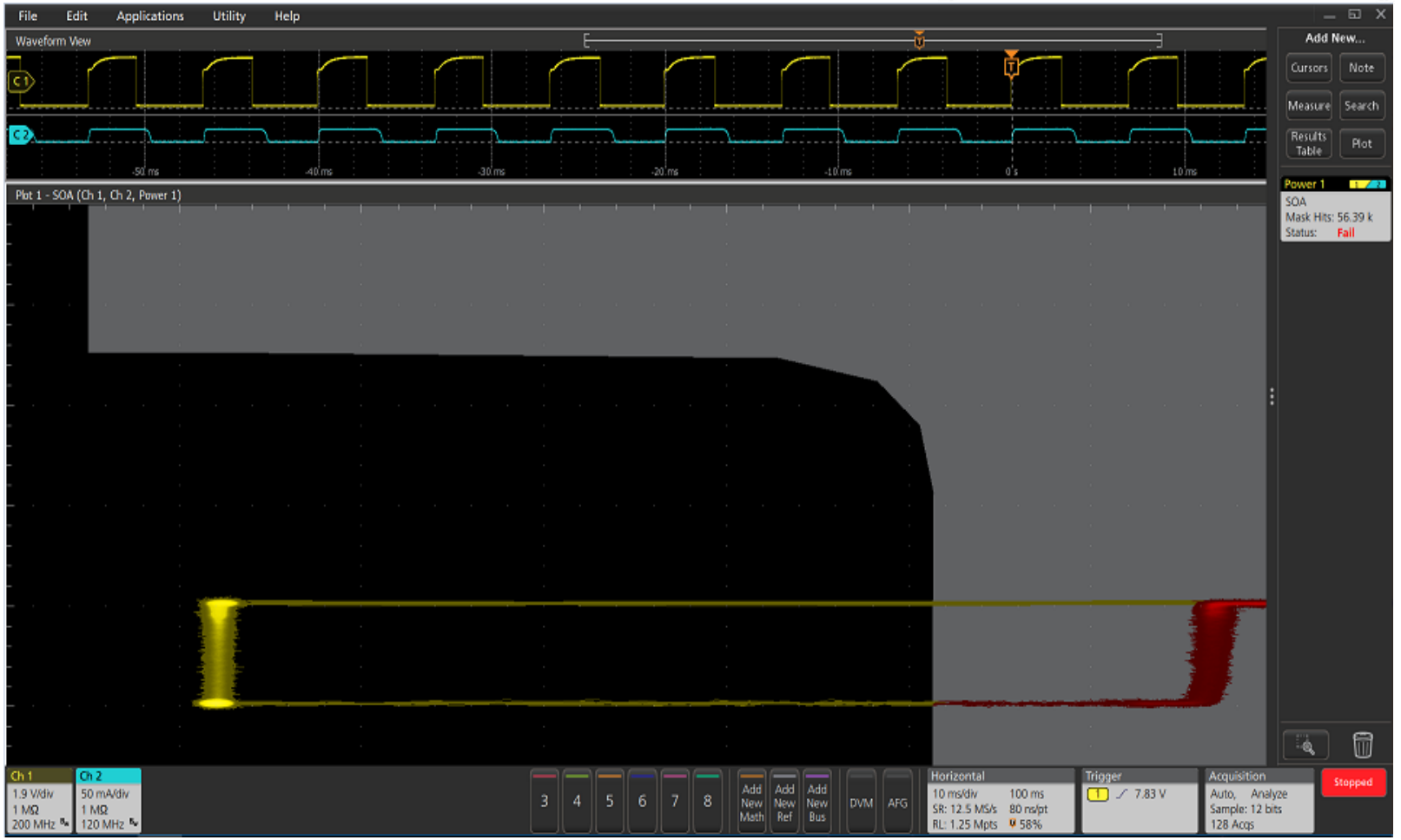
SAFE OPERATING AREA (SOA)

- Switching device operating region
- Plot of voltage versus current
- SOA mask is a graphic representation of the switching device's limits on a SOA plot

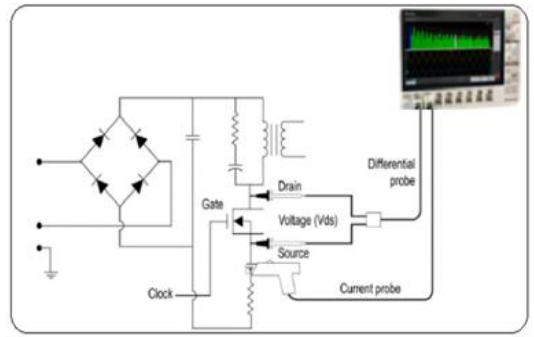






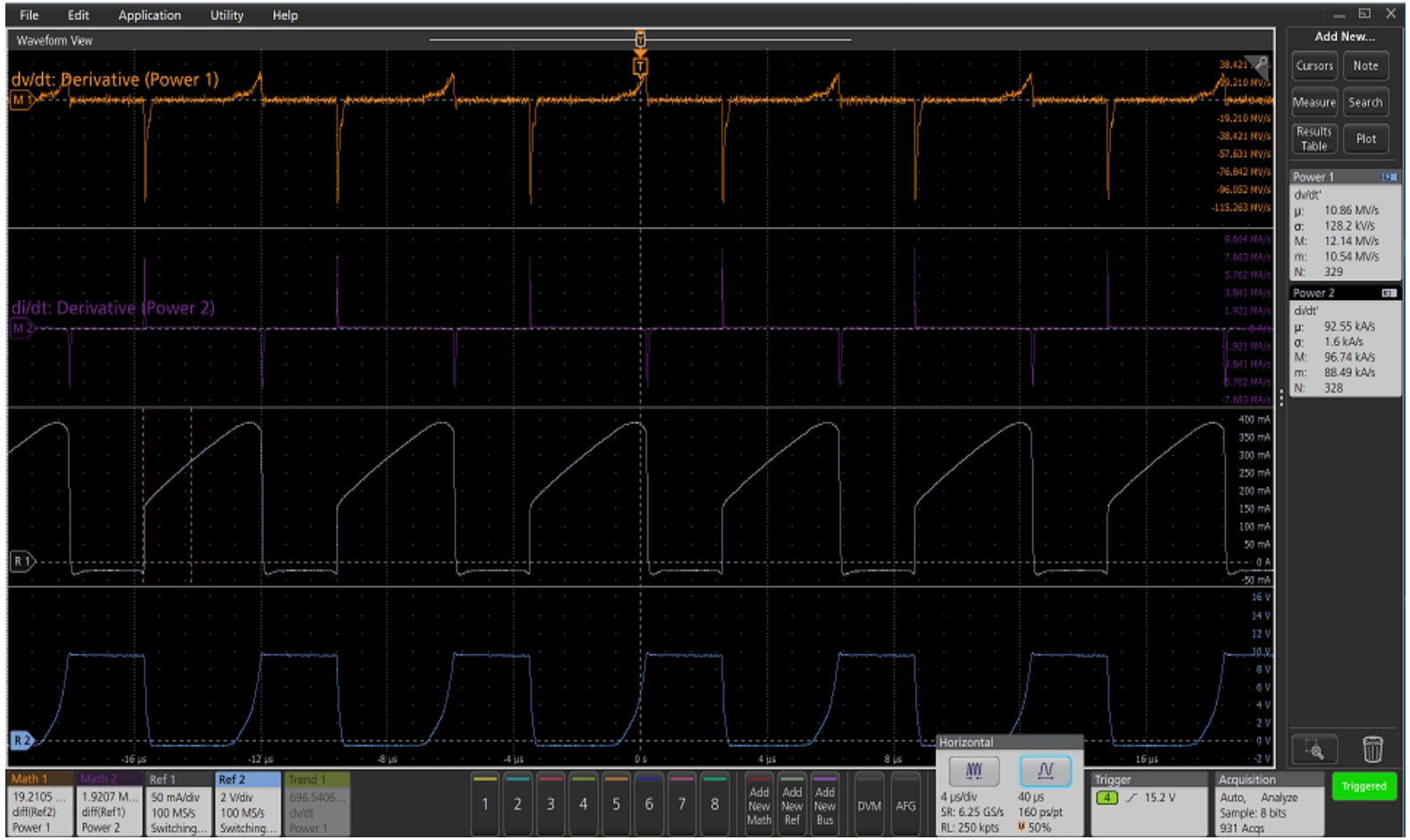


Switching Analysis



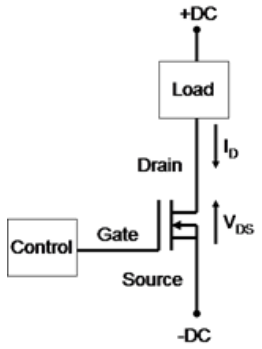
Di/dt and Dv/dt

- Rate of Change of Current and Voltage
- Need to look at the Slew rate of the Voltage and Current signals.
- Helps designers to optimize the rate of change of Current or Voltage signals to meet the fast switching design needs.
  - Ensures Loss is minimized



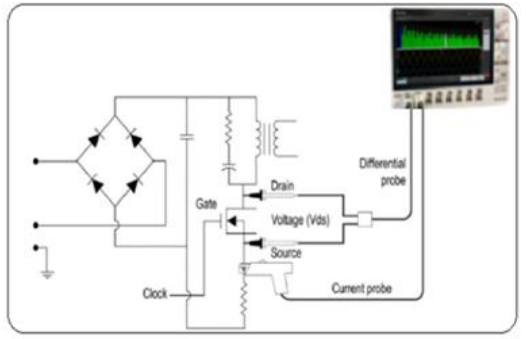
Switching Analysis– $RDS_{(on)}$

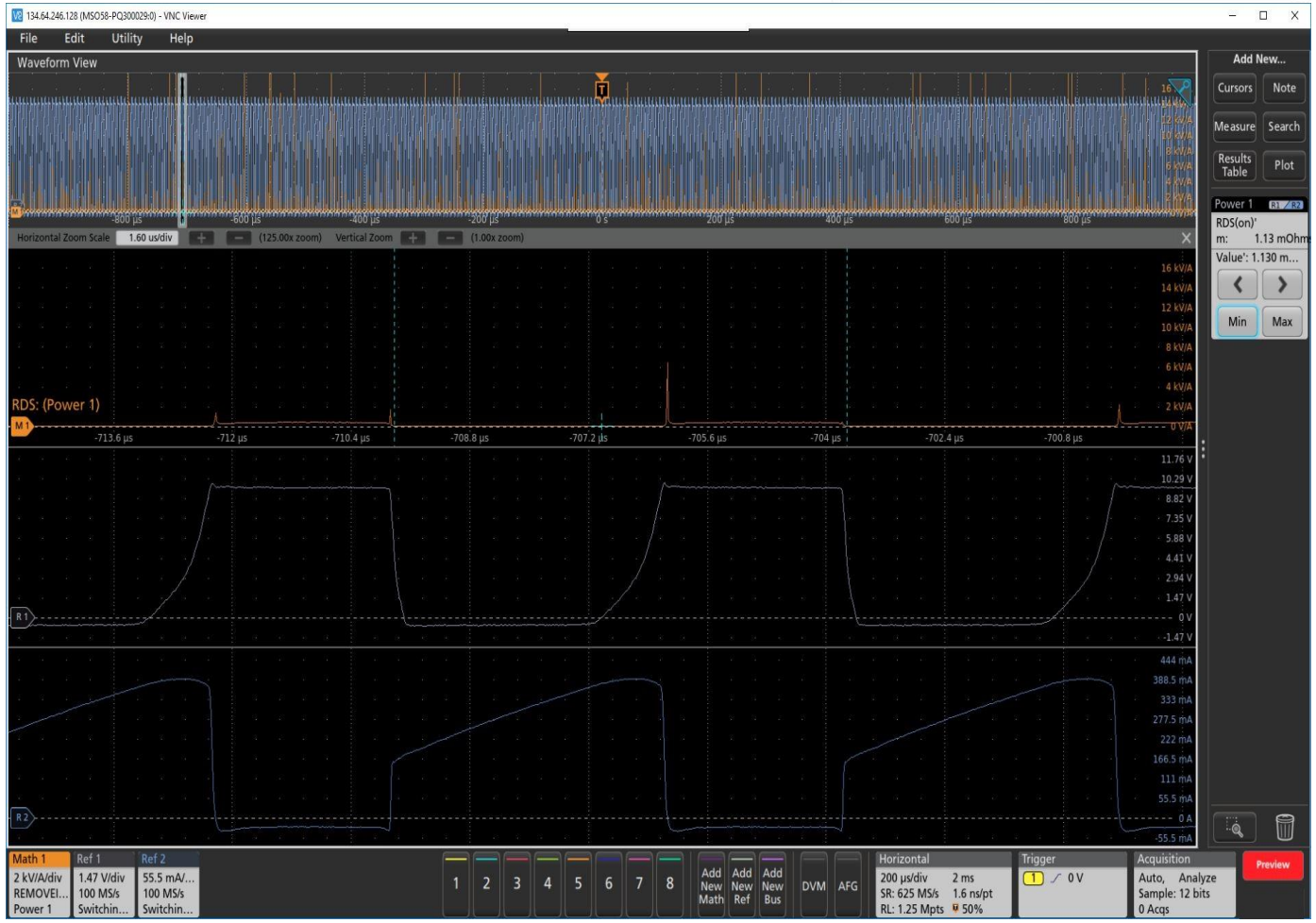
- This **updated** measurement provides a simple way to verify the minimum dynamic on-resistances in switching devices. $R_{DS(on)}$ is simply voltage divided by current



- Measurement is gated during conduction regions

- Spikes in time trend are where current approaches zero





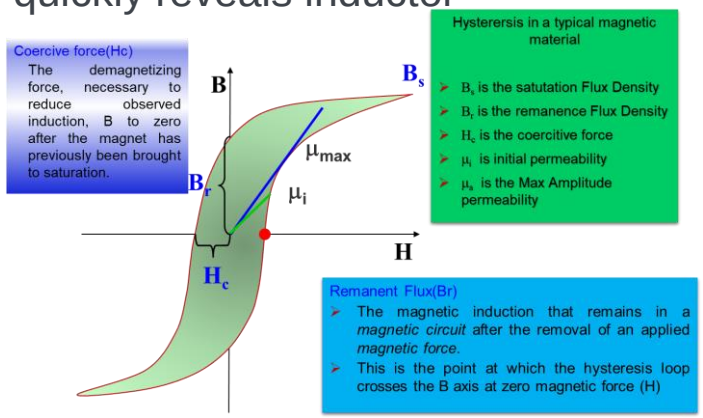
Magnetic Analysis

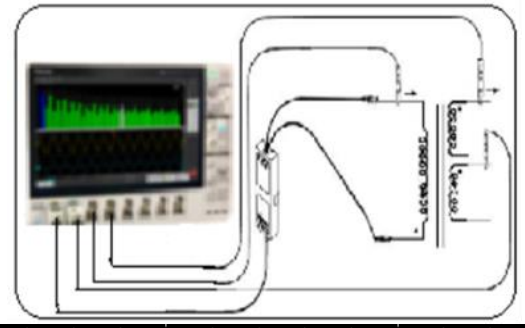
Computing Power Loss at the Magnetic Component

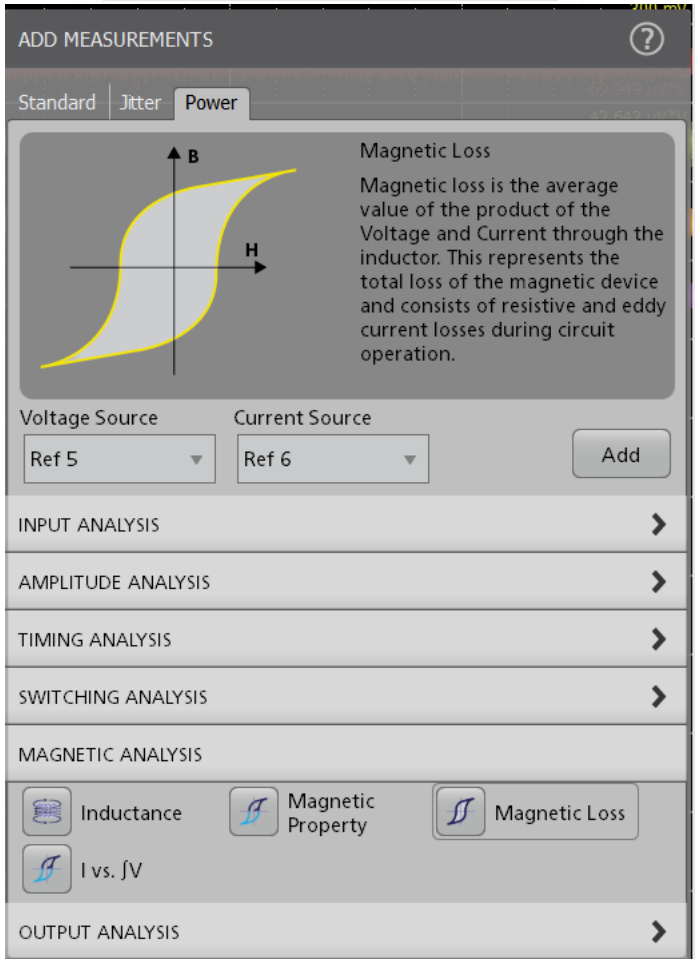
- **Aim is to reduce power dissipation in the core area**
  - In a typical Power conversion circuit, the inductor and transformer will dissipate power
  - Affects power efficiency and causing thermal runaway.

Methods of monitoring the behavior of the core

- LCR meter- simulation
- B-H curve, because the B-H curve quickly reveals inductor behavior in a power supply

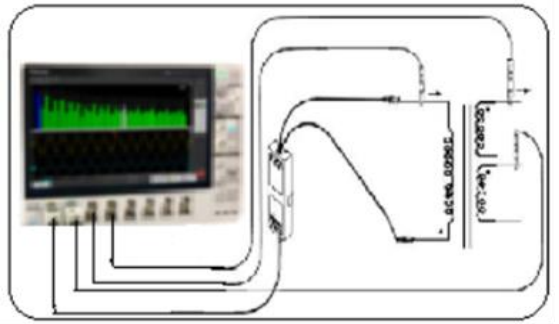






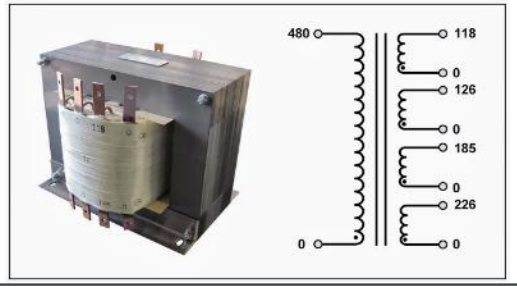
Magnetic Analysis (updated)

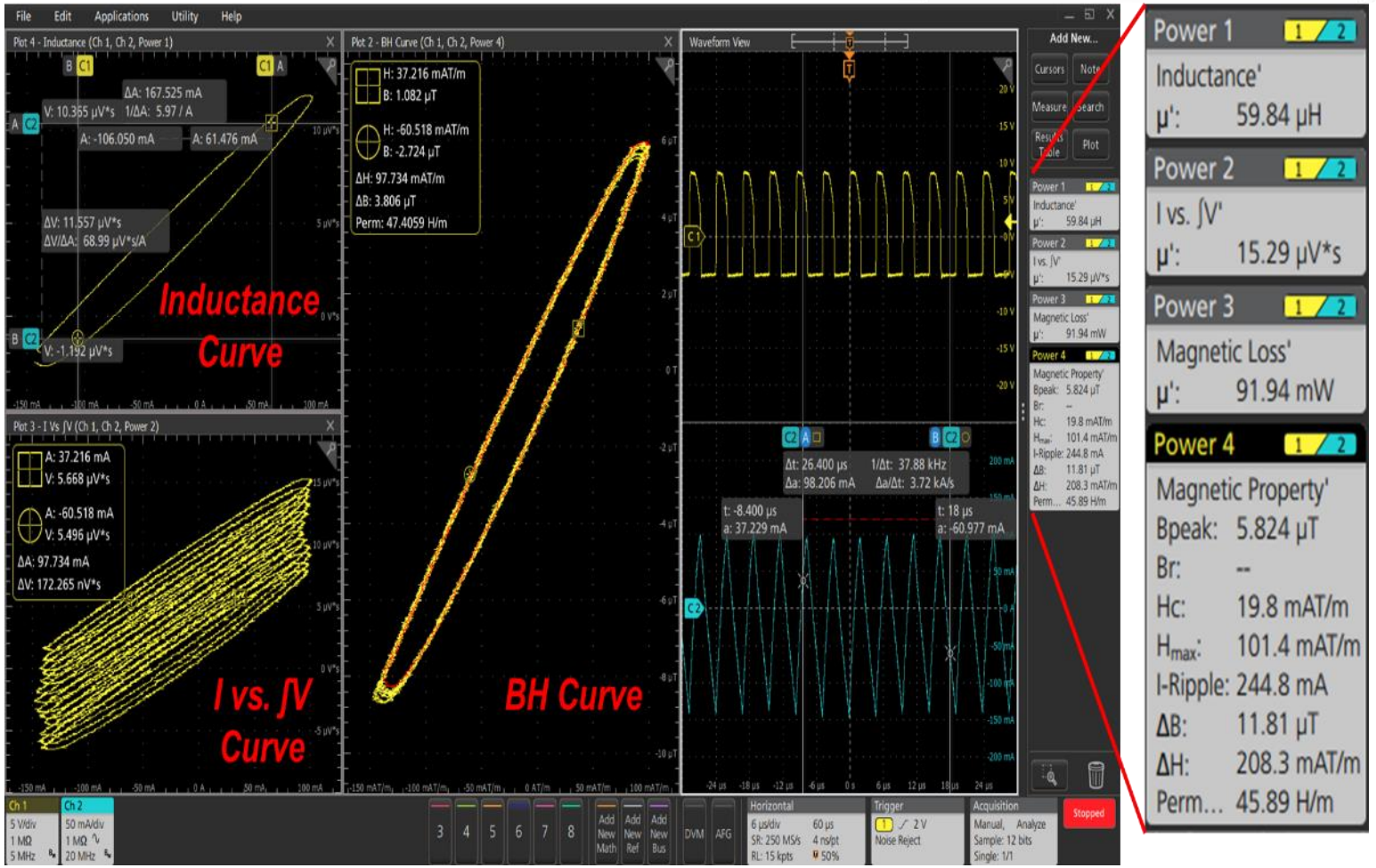
Computing Power Loss at the Magnetic Component



- Magnetic Property (BH Curve) **Update: Cross sectional area and magnetic length can be set from 1mm**
- Inductance
- I Vs Int V
- Magnetic Loss
  - **Get insight to Total Magnetic Loss**
  - **Derive Core Loss from vendor's data sheet**
  - **Solve for Copper Loss**
- **Ability to test multiple secondary windings in one go - ensures faster test times**

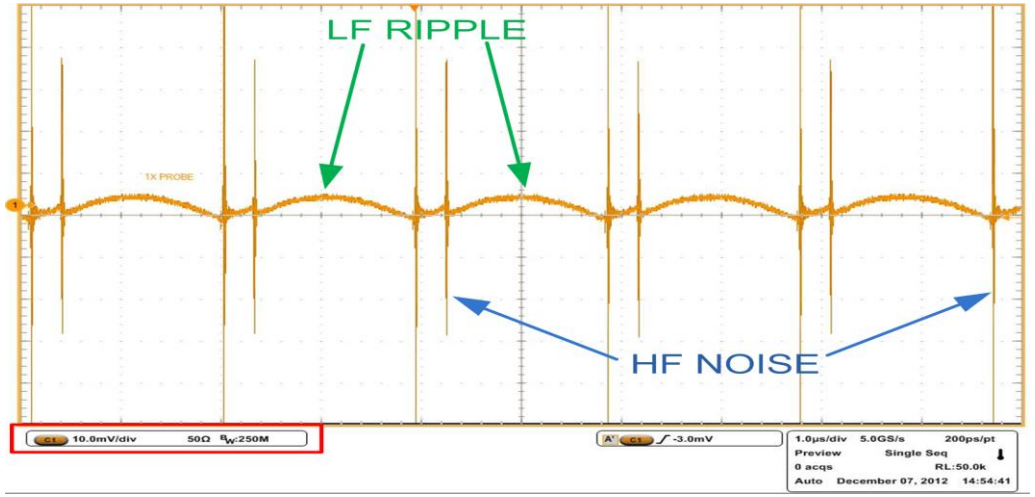
$$TotalPowerLoss = PowerLoss_{L1} + PowerLoss_{L2} + PowerLoss_{L3} + \cdots$$

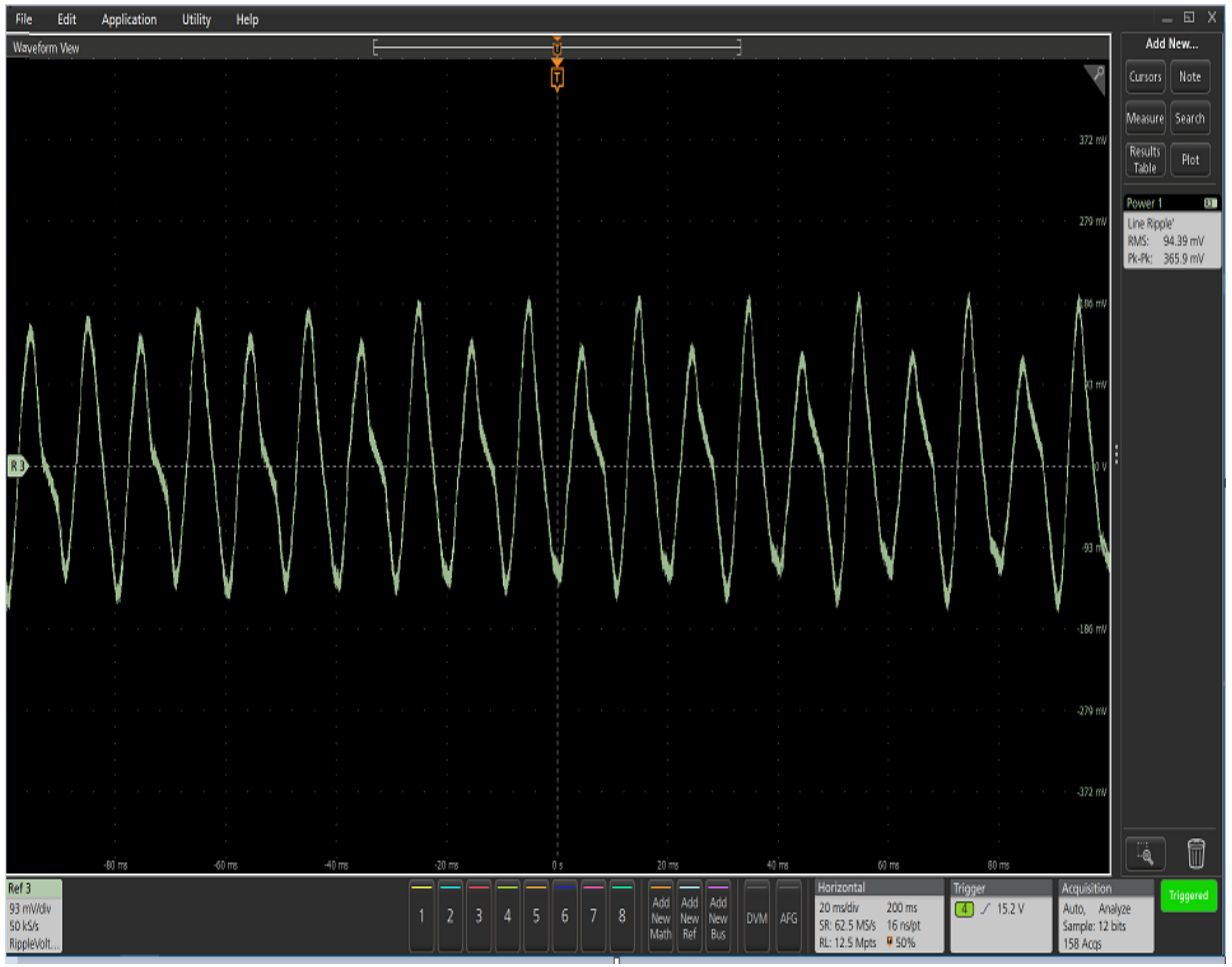




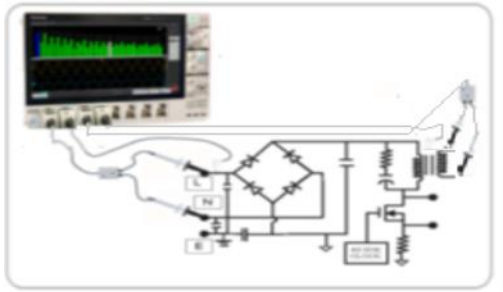
Significance of Ripple

- Need to look at the output voltage ripple on the power supply's output or load.
- Ripple is the AC voltage that is superimposed onto the DC output of a power supply. Linear power supplies usually see a ripple that is close to twice the line frequency, whereas switching power supplies may see a switching ripple in the hundreds of kHz.
- The output voltage ripple has two components: Low Frequency "ripple" and High Frequency "noise".
-





Power Efficiency

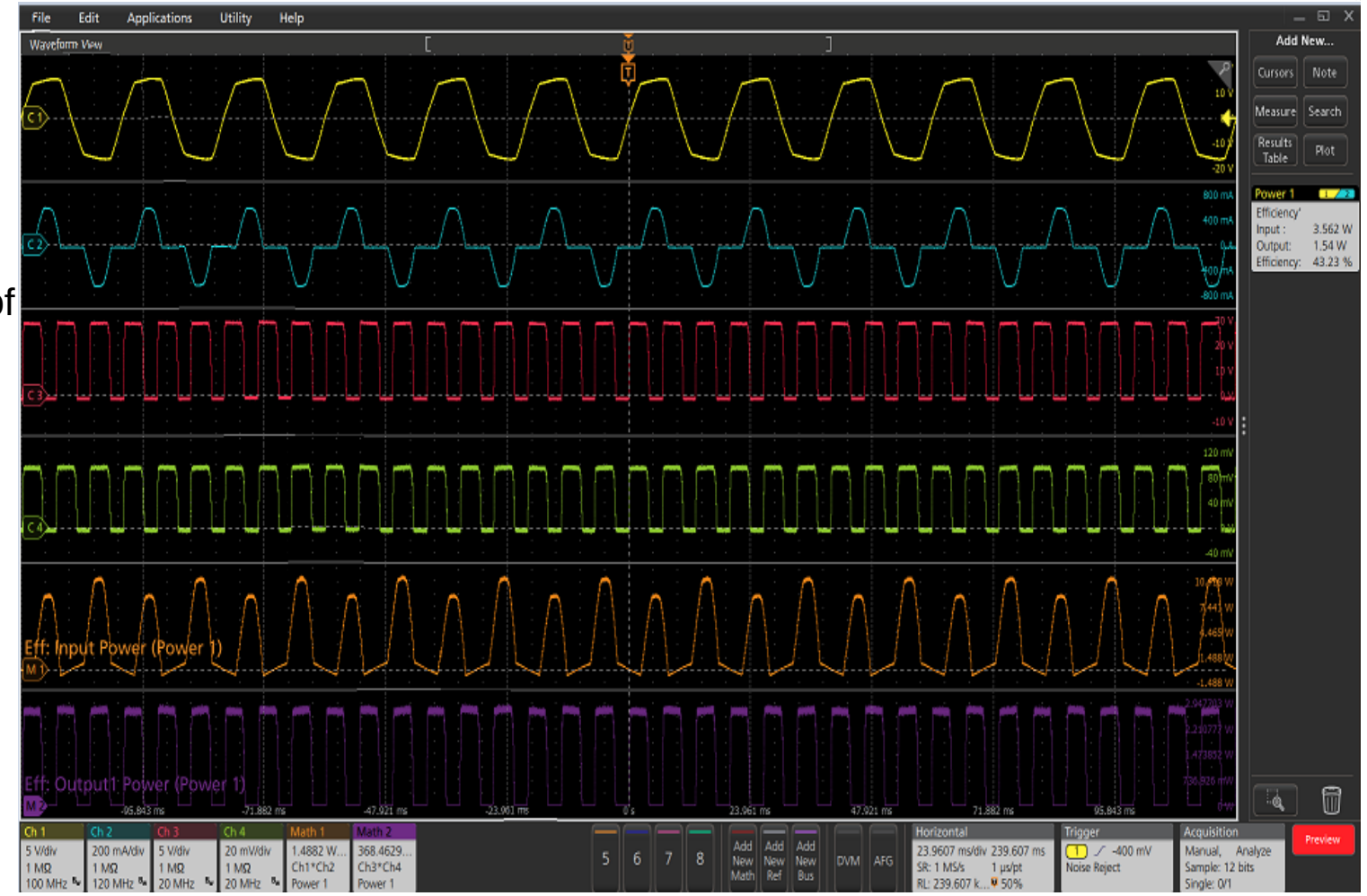


- Efficiency is a measure of how much power at the input appears at the output.
  - **less waste.**
- **Conserve energy** - considered technologically **“green”.**

- **Power supply efficiency** has a direct effect upon the **upper limit of output power** given **a package size** and mode of **cooling.**

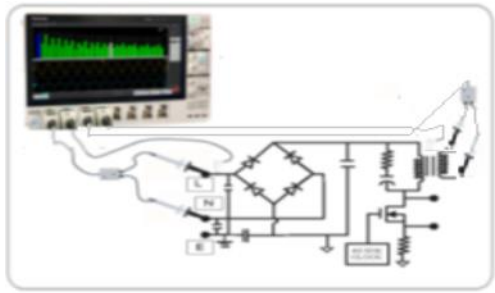
- **Energy Efficient products**

- **Test multiple output products in ONE go-FASTER TIME TO MARKET**

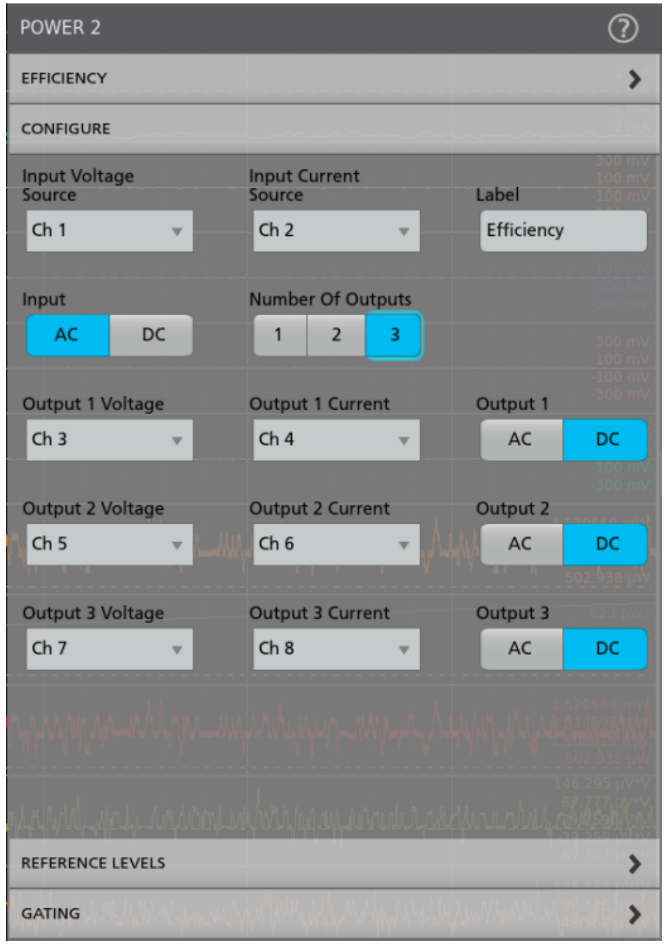


Power Efficiency

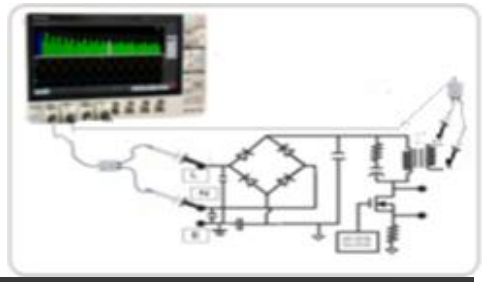
- Efficiency measurement capability increases with channel count of instrument and **the updated flexibility to configure each output independently.**
- 4-channel scope
  - 1 input, 1 output
- 6-channel scope
  - 1 input, 2 outputs
- 8-channel scope
  - 1 input, 3 outputs



1-input, 3-output device

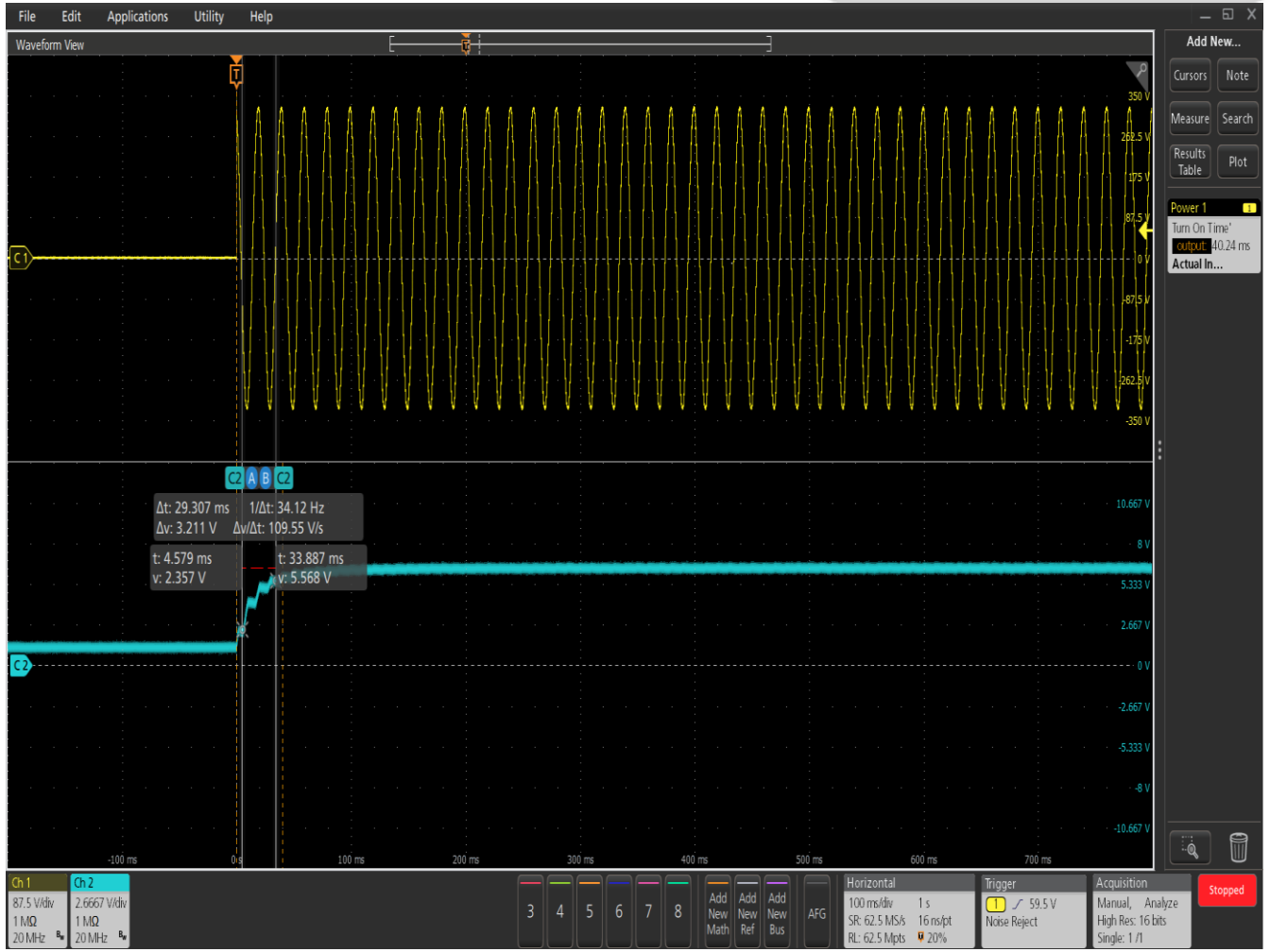


Significance of Turn on Time (Updated)

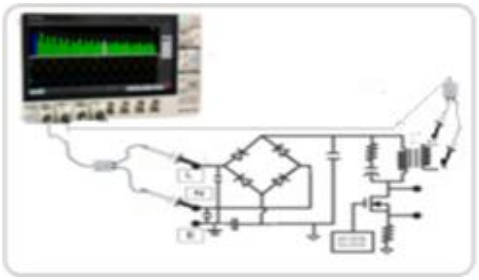


- **Turn on Time** is the time taken to get the output voltage of the power supply after the input voltage is applied.
- The timing and sequencing of power supply outputs during turn-on is critical to the reliable operation of the end-products.
- Supports testing of up to 7 outputs simultaneously there by enabling system testing and faster validation times.

Update: User interface updated. Start the measurement using Run/Stop button of Oscilloscope.

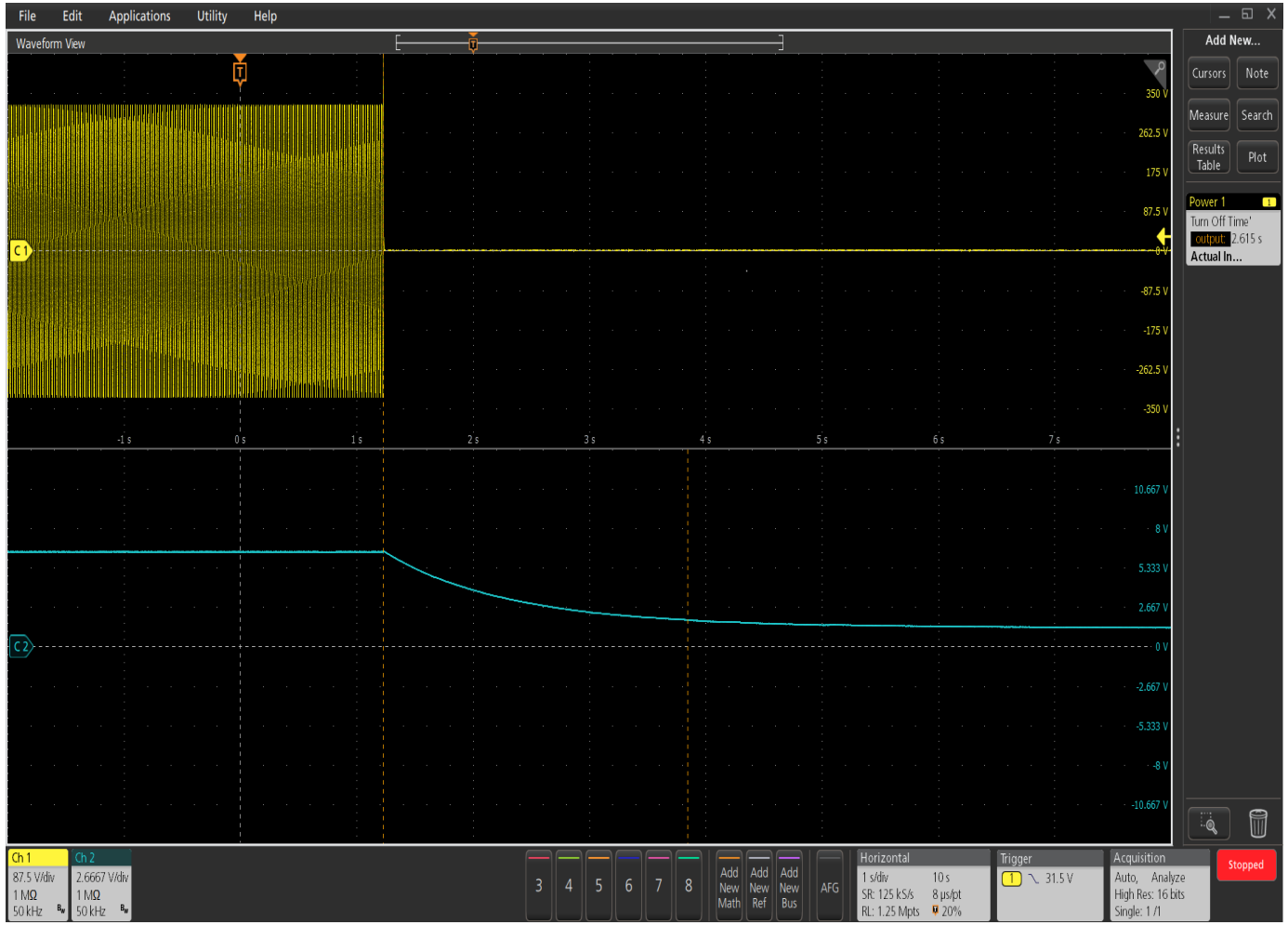


Significance of Turn off Time (Updated)



- **Turn off Time** is the time taken to get the output voltage of the power supply close to zero after the input voltage is removed.
- The timing and sequencing of power supply outputs during turn-off is critical to the reliable operation of the end-products.
- Supports testing of up to 7 outputs simultaneously there by enabling system testing and faster validation times.

Update: User interface updated. Start the measurement using Run/Stop button of Oscilloscope



New Measurements

- Frequency Response Analysis
  - Control Loop Response(Bode Plot)
  - Power Supply Rejection Ratio(PSRR)

These are typically performed using stand alone Frequency Response Analyser or VNA.

- Customer Pain Points
  - Separate test setup.
  - Long test times as the Frequency Response Analyers or VNAs are shared.

Control Loop Response (Bode Plot Capability)

Power supply engineers rely on the Bode plot for the assessment of stability.

CUSTOMER NEED:

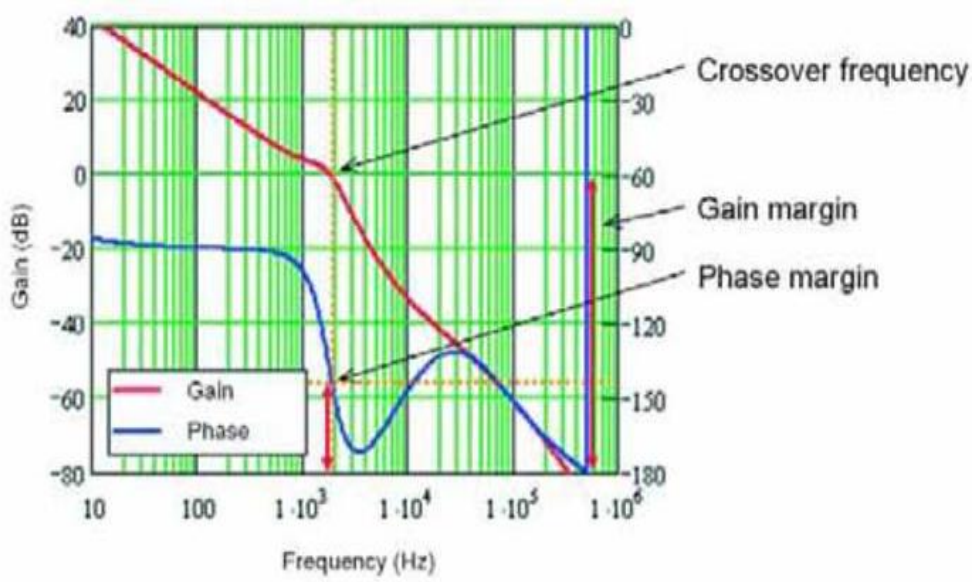
- The regulation characteristics of most power management circuits are defined by the converter loop transfer function which can be plotted in a Bode plot.

- The compensation network should be optimized in order to meet the static and dynamic performance requirements while maintaining stability.

Ideal Loop Gain shall have:

1. Fast Loop Response, achieved by a high BW (high cross zero frequency)
2. Loop Gain slope of 20dB/decade from low frequency to half the switching fre
3. Large DC gain to achieve high DC accuracy over load and line variations.
4. Good noise immunity.
5. Flat phase curve near cross over frequency
6. Good phase margin – have good stability with minimum overshoot.

This representation of the gain of the loop as well as of the phase shift of the loop taken over frequency gives valuable information about the speed of the control loop and stability of the power supply.



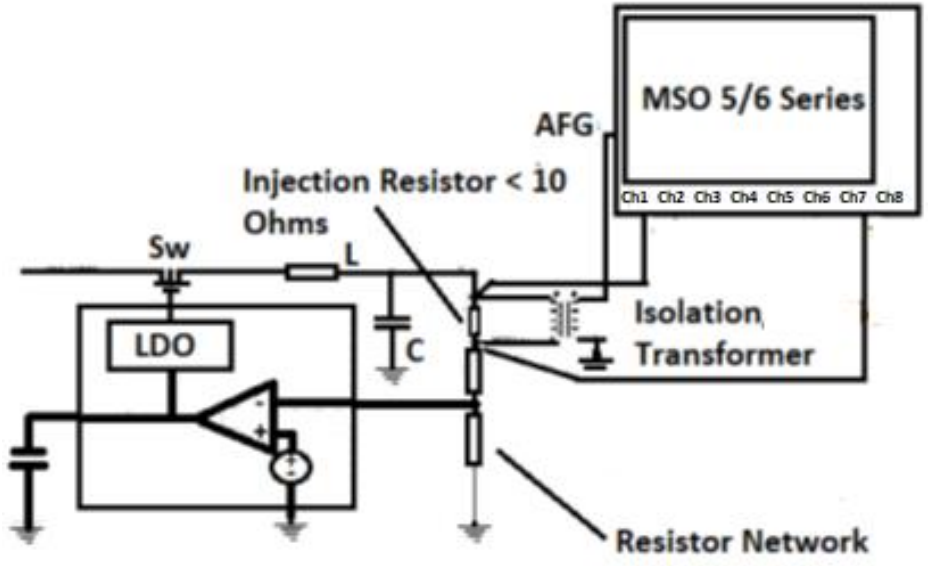
Control Loop Response (BODE Plot Capability)

Power supply engineers rely on the Bode plot for the assessment of stability.

Features	Rationale	Solution Options
BODE(Frequency Response Plot) **AFG** **Picotest J2101A** **injection transformer.** **define the test parameters including *Start Frequency*, *Stop Frequency*, and *AFG signal* amplitude.**	**Need a low cost alternative to FRA/VNA setup. Ease of use. Preferably 1 BOX solution.**	**1. Option 1: Leverage built-in SG of 5-series.** **2. Option 2: Control external AFG with 5 series.**

BODE plot :

1. Part of 5-PWR for power designers.



BODE(Frequency Response)

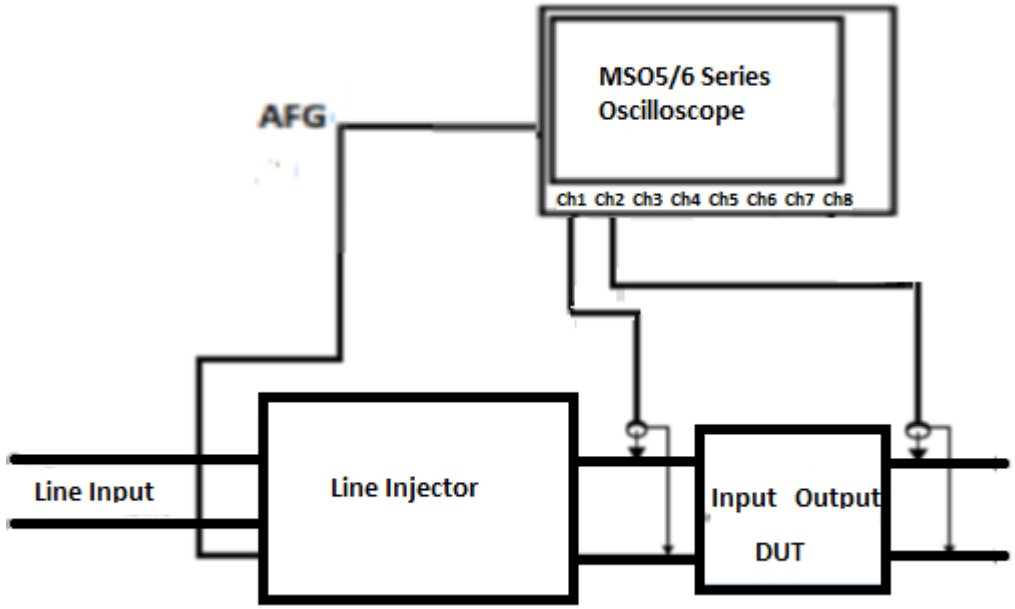
Power Supply Rejection Ratio (PSRR)

CUSTOMER NEED:

- Want to see how their DUT such as a DC-to-DC converter or a low-voltage drop-out regulator (LDO), rejects various frequency components injected at the DC input of the device-under-test.
In other words, how much of a disturbance signal injected at the DC input reaches the regulated DC output.
- Helps ensure their design works optimally.

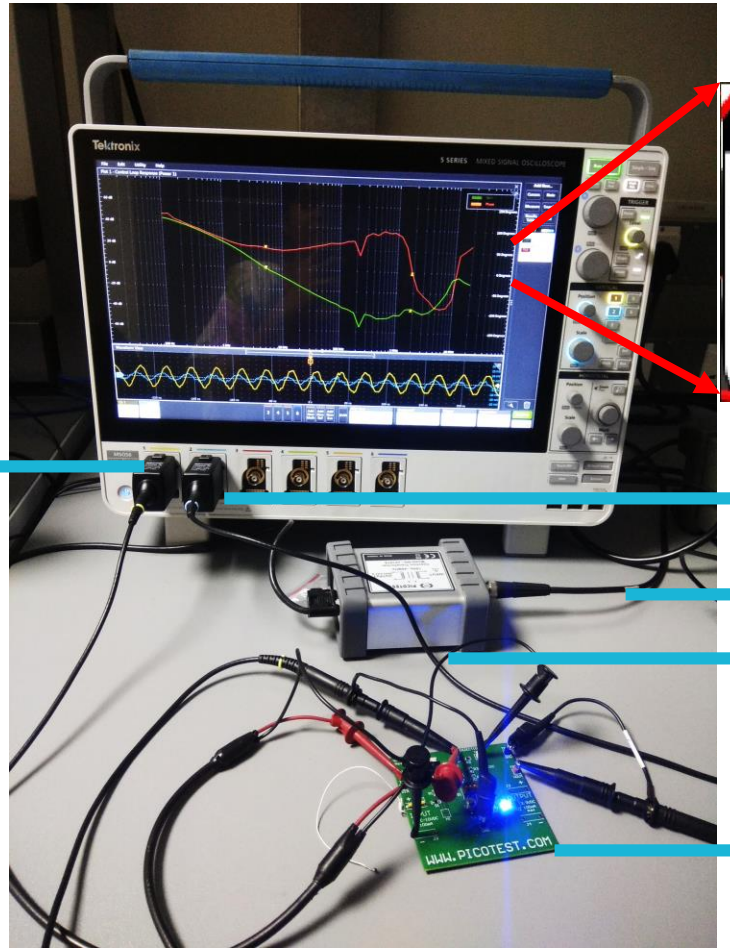
To perform a PSRR test, a sine wave must be injected at the DC input and then swept from a low frequency to a high frequency. A DC + AC network summing device, such as Picotest's J2120A line injector, is required for this measurement.

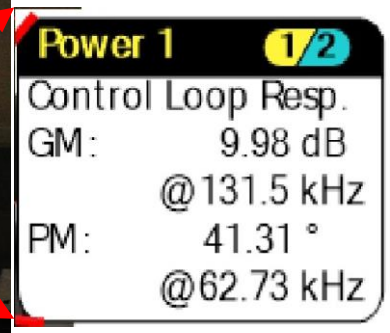
The measurement system measures both the modulated input and output AC voltage levels and then computes the rejection ratio as 20Log(Vin/Vout) at each frequency within the swept band. .



BODE plot and PSRR Tektronix 1 BOX Solution

- MSO58 series with built-in AFG
- 2#TPP0502 probes
- External components
  - Pico test injector
  - Isolation transformer
  - Programmable Power Supply(for PSRR)





DUT input

DUT output

AFG output

Picotest Injection transformer

DUT

5-PWR/6-PWR-New measurement

FREQUENCY RESPONSE ANALYSIS (FRA)

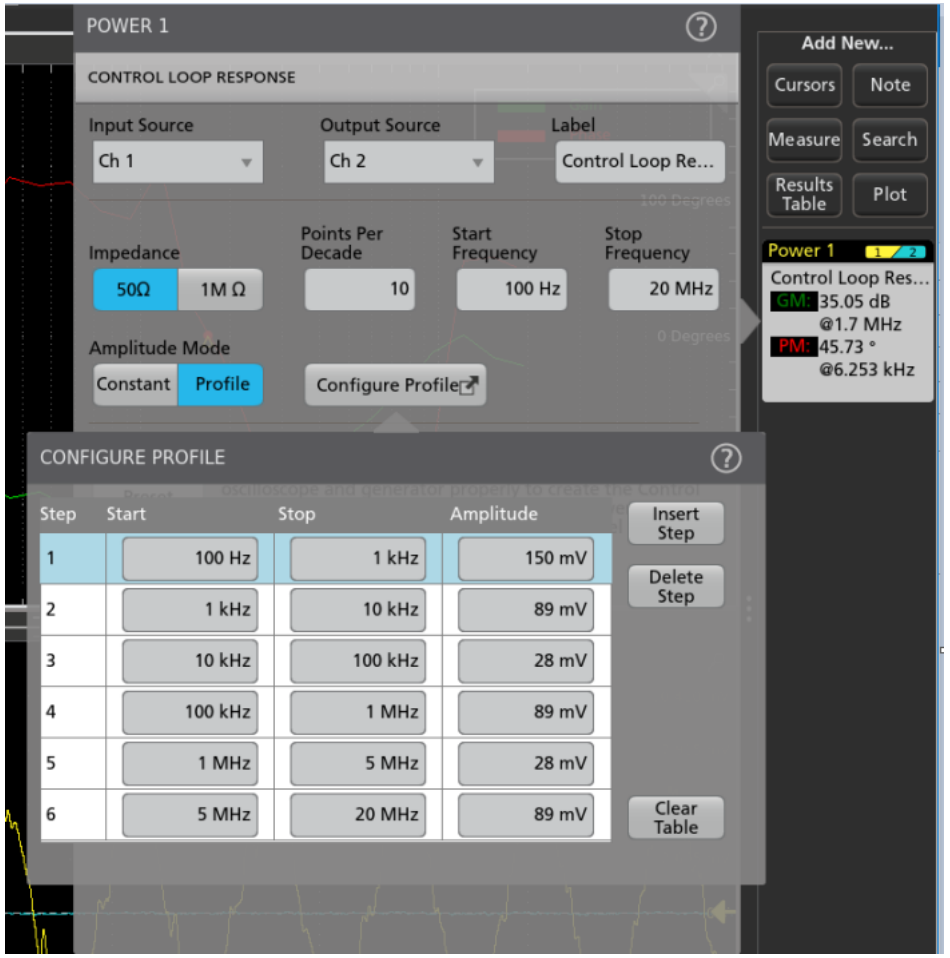
- Control Loop Response (BODE Plot)
  - Gain Margin, Phase Margin, Gain and Phase @ frequency

-Needs Option AFG on 5 series/6 series MSO

-2# TPP0502 probes (2x attenuation and very low input capacitance)

-Pico Test Injection transformer and Isolation transformer:(https://www.picotest.com/)

- J2100A or J2101A for BODE Plot



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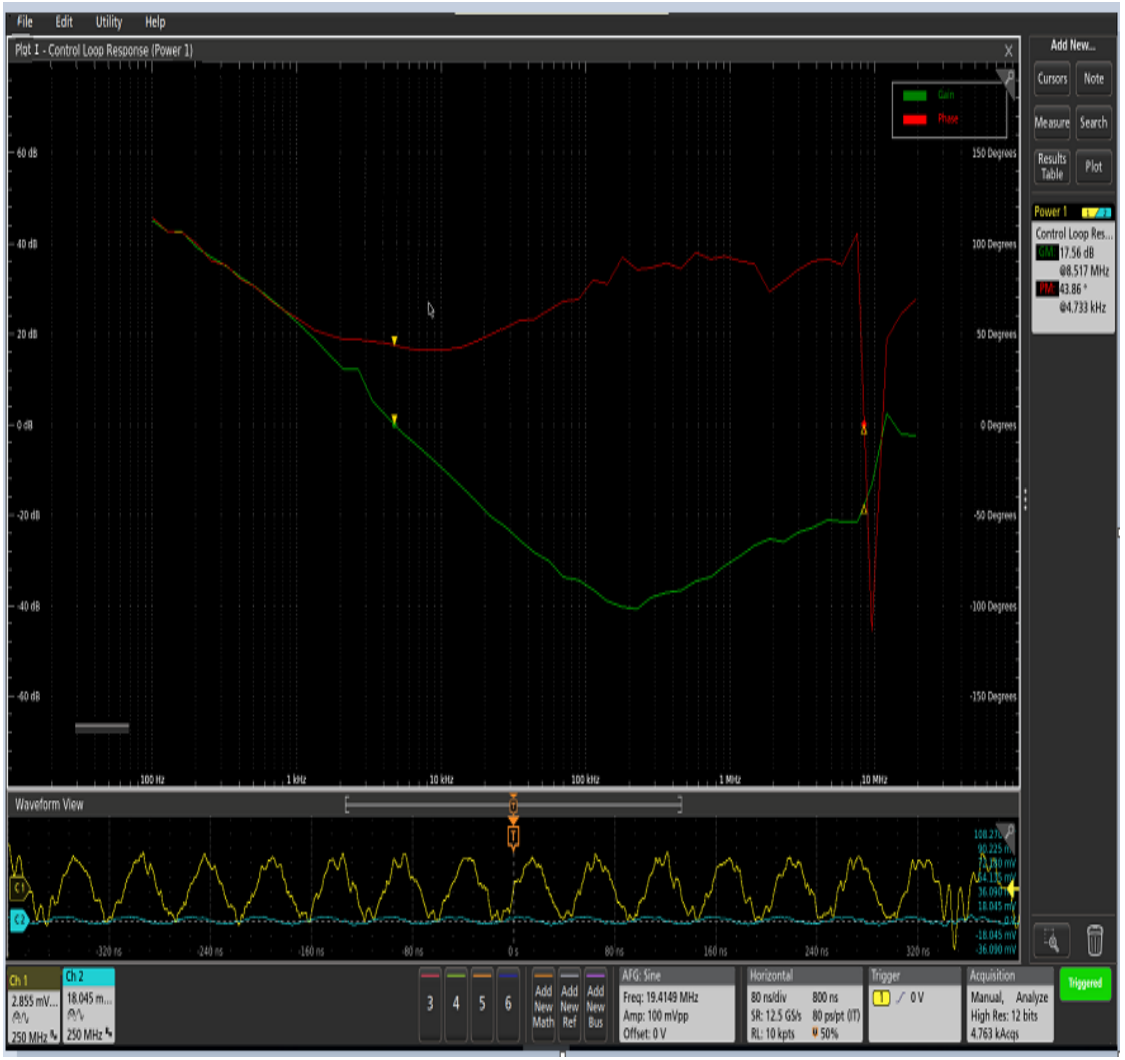


5-PWR/6-PWR-New measurement

FREQUENCY RESPONSE ANALYSIS (FRA)

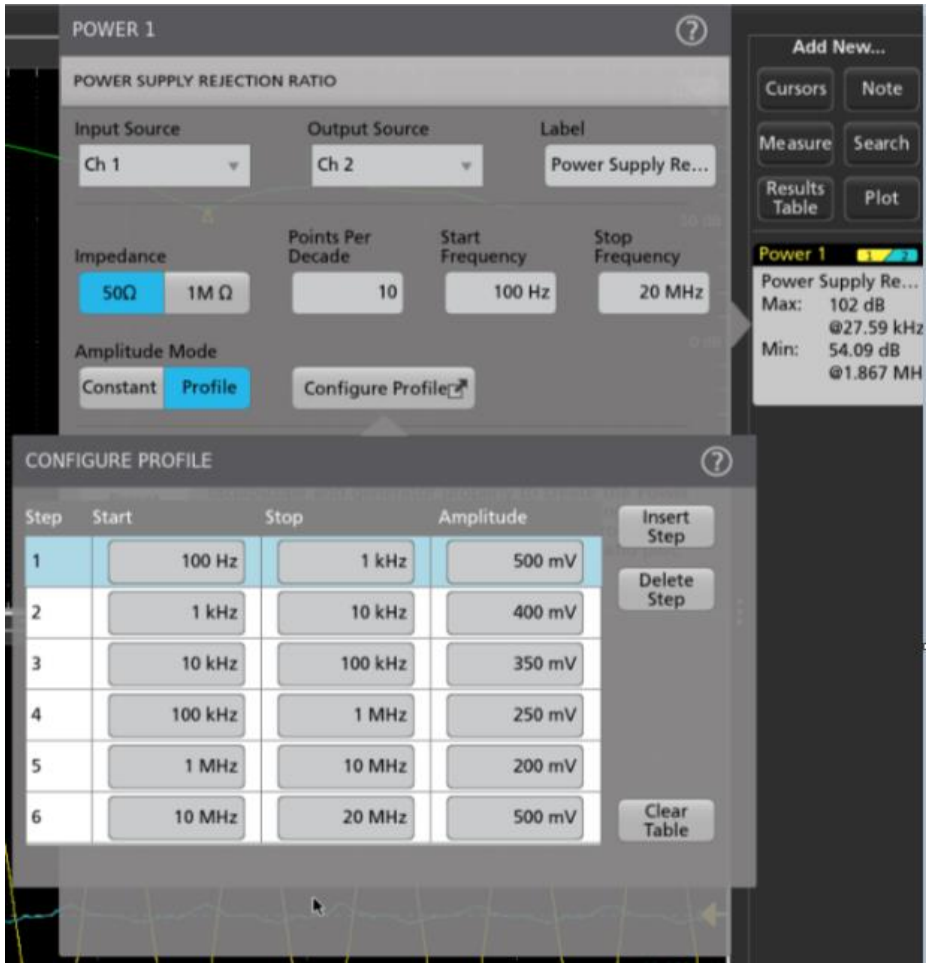
- Power Supply Rejection Ratio (PSRR)
  - Ripple rejection by DC-DC circuit

-Needs Option AFG on 5 series/6 series MSO

-2# TPP0502 probes (2x attenuation and very low input capacitance)

-Pico Test Injection transformer and Isolation transformer:(https://www.picotest.com/)

- J2120A for PSRR
- Keithley Power Supply



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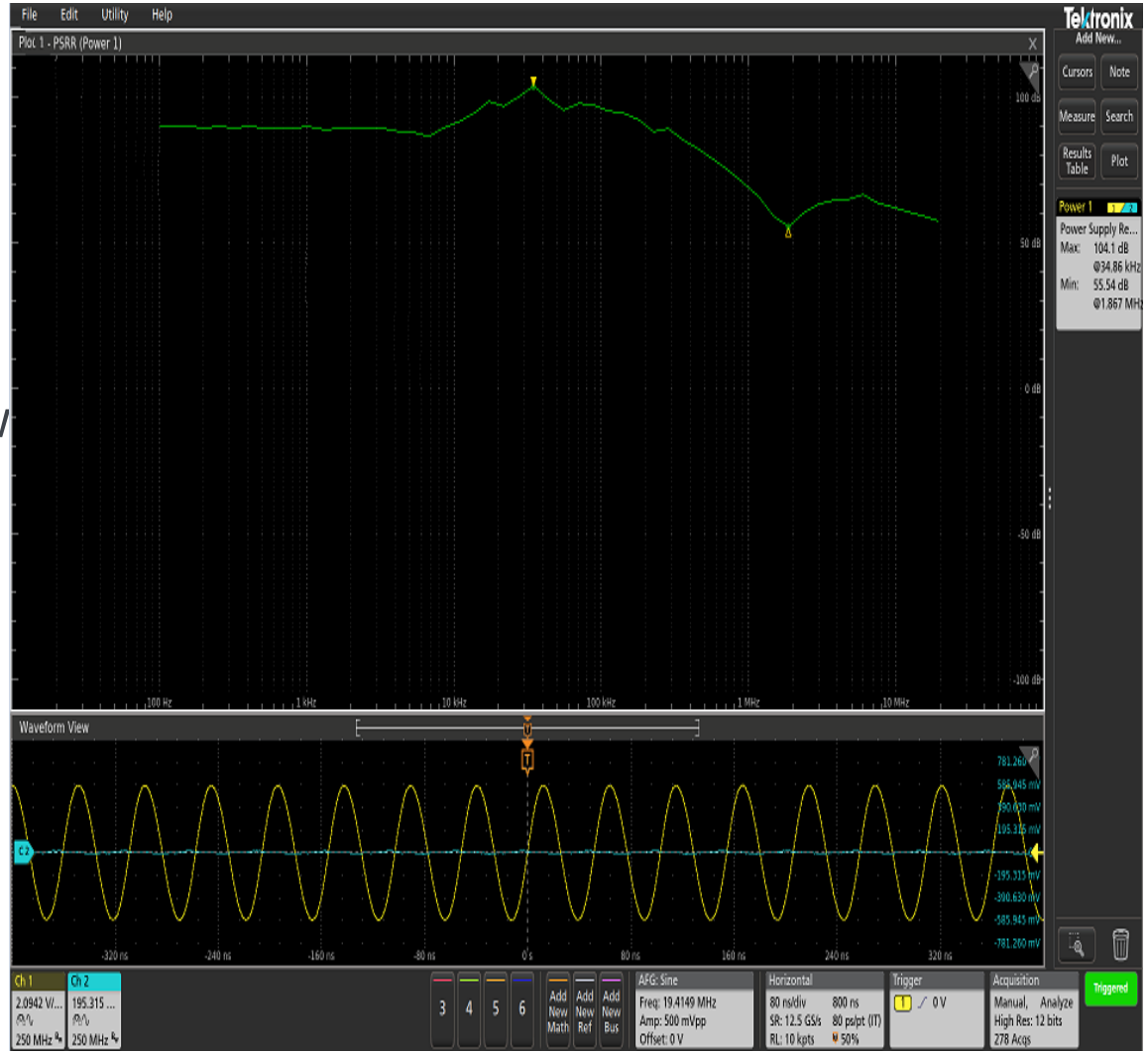


Frequency Response Analyser

- Our 1 BOX solution will be leveraging the built-in AFG
- Needs external pico test injector and Isolation transformer.
- Addresses customer pain point of using multiple setups.
- Will control Power supply needed for PSRR.

Note: **Customers need to invest in isolation/injection transformers and LDO demo board available from Pico Test (https://www.picotest.com/) as per table:**

Pico test model	Image
J2100A: 1Hz to 5MHz (Bode)	
J2101A: 10Hz to 45MHz (Bode)	
J2120A **for PSRR**	
VRTS1.5 Voltage Regulator test Std	

Amplitude and Timing Measurements for Power

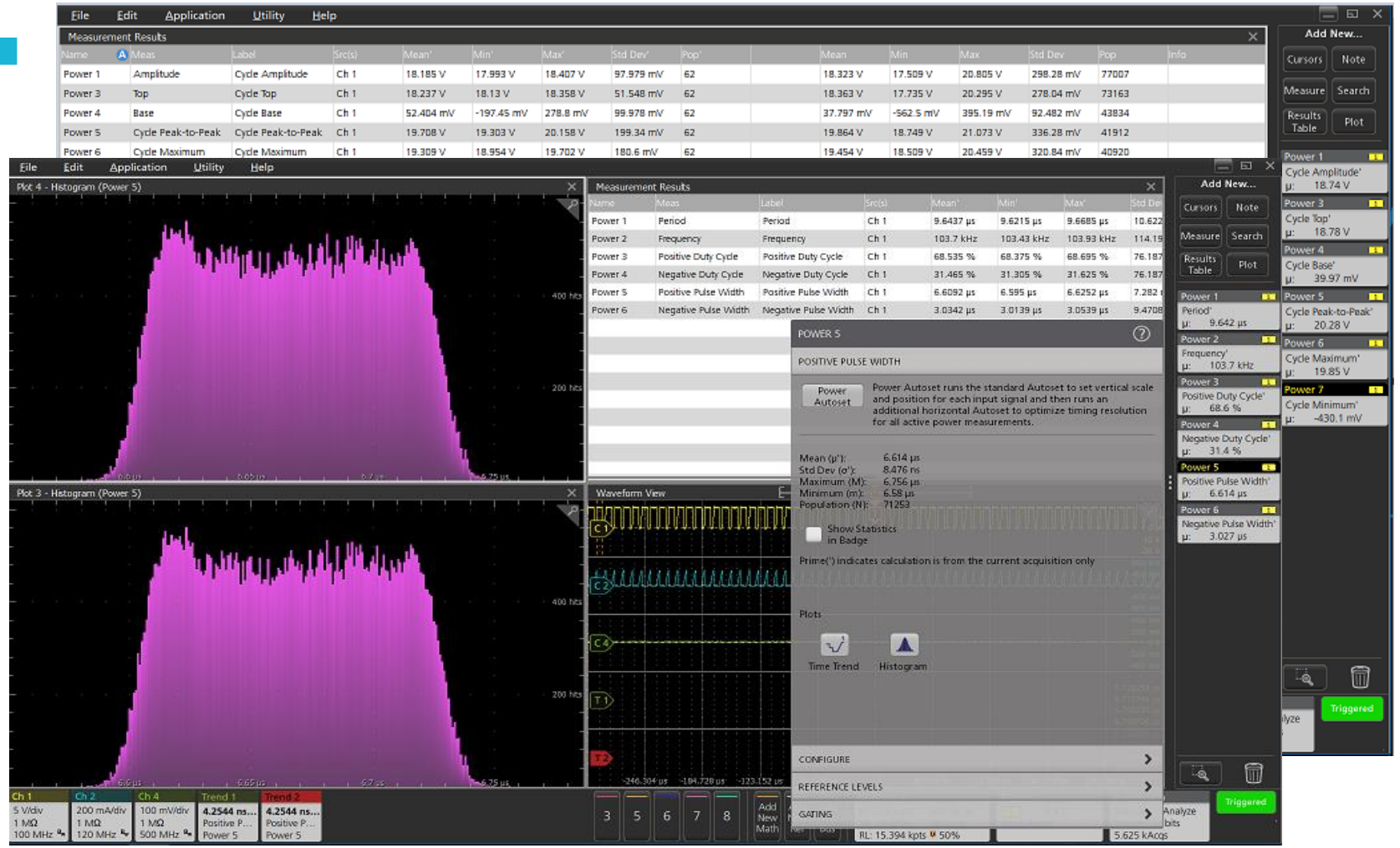
Amplitude Analysis

- Cycle Amplitude
- Cycle Top
- Cycle Base
- Cycle pk-pk
- Cycle Maximum
- Cycle Minimum

Timing Analysis

- Period
- Frequency
- Positive Duty Cycle
- Negative Duty Cycle
- Positive Pulse width
- Negative Pulse width

- Configure
  - Time Trends
  - Histogram



Advanced Power Measurements and Analysis Software - Ordering Information

5 series Oscilloscopes	Bandwidth options	Record Length option	Recommended Options
MSO54 MSO56 MSO58	350 MHz : 5-BW-350 500 MHz : 5-BW-500 1 GHz : 5-BW-1000 2 GHz : 5-BW-2000	5-RL-125M: Extend record length to 125 Mpoints/channel	5-WIN: Add removable SSD with Windows 10 license
MSO58LP	1 GHz	125 Mpoints/channel (standard)	

6 series Oscilloscopes	Bandwidth options	Record Length option	Recommended Options
MSO64	1 GHz : 6-BW-1000 2.5 GHz : 6-BW-2500 4GHz : 6-BW-4000 6GHz : 6-BW-6000 8GHz : 6-BW-8000	6-RL-125M: Extend record length to 125 Mpoints/channel	6-WIN: Add removable SSD with Windows 10 license

Advanced Power Measurements and Analysis Software - Ordering Information

New Instrument order option	Product upgrade option	Supported Instruments
5-PWR, 5-PS2,5-PS2FRA	SUP5-PWR	5 Series MSO oscilloscopes (MSO54,MSO56, MSO58, MSO58LP)
	SUP5-PWR-FL	Floating licenses are transferrable from any 5 Series scope to any other 5 Series scope **PS**: They are not transferrable to DPO/MSO5k/7k/70k products

New Instrument order option	Product upgrade option	Supported Instruments
6-PWR, 6-PS2,6-PS2FRA	SUP6-PWR	6 Series MSO oscilloscopes (MSO64)
	SUP6-PWR-FL	Floating licenses are transferrable from any 6 Series scope to any other 6 Series scope **PS**: They are not transferrable to DPO/MSO5k/7k/70k products

Additional information about power analysis is available at www.tek.com/applications/design_analysis/power.html

5 Series MSO PS bundle options	Description
5-PS2	5-PWR, TCP0030A, THDP0200, 067-1688-xx deskew fixture
6-PS2	6-PWR, TCP0030A, THDP0200, 067-1688-xx deskew fixture
5-PS2FRA	5-PWR, TCP0030A, THDP0200, 2#TPP0502 passive probes,067-1688-xx deskew fixture
6-PS2FRA	6-PWR, TCP0030A, THDP0200, 2#TPP0502 passive probes067-1688-xx deskew fixture

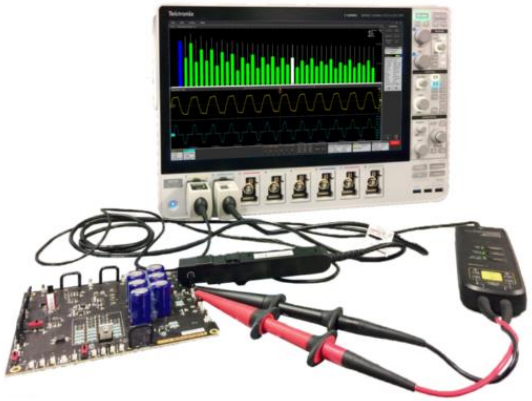
Summary

- **Best in class 5/6 Series Oscilloscope with multiple FlexChannel® and state of the art GUI**
  - Up to 8 (5 Series) and 4 (6 Series) analog channels enables multi point probing capability leading to faster validation and test times hence achieve faster time to market.
  - 6 Series with its best in class front end amplifier enables designers to look at signals not seen before.
  - Digital Channels allow insights to the protocol decode of power buses.

- **Isovu™ probes enables to captures signals which were not possible earlier**
  - Best in class CMRR specification
  - Ideally suited for WBG testing

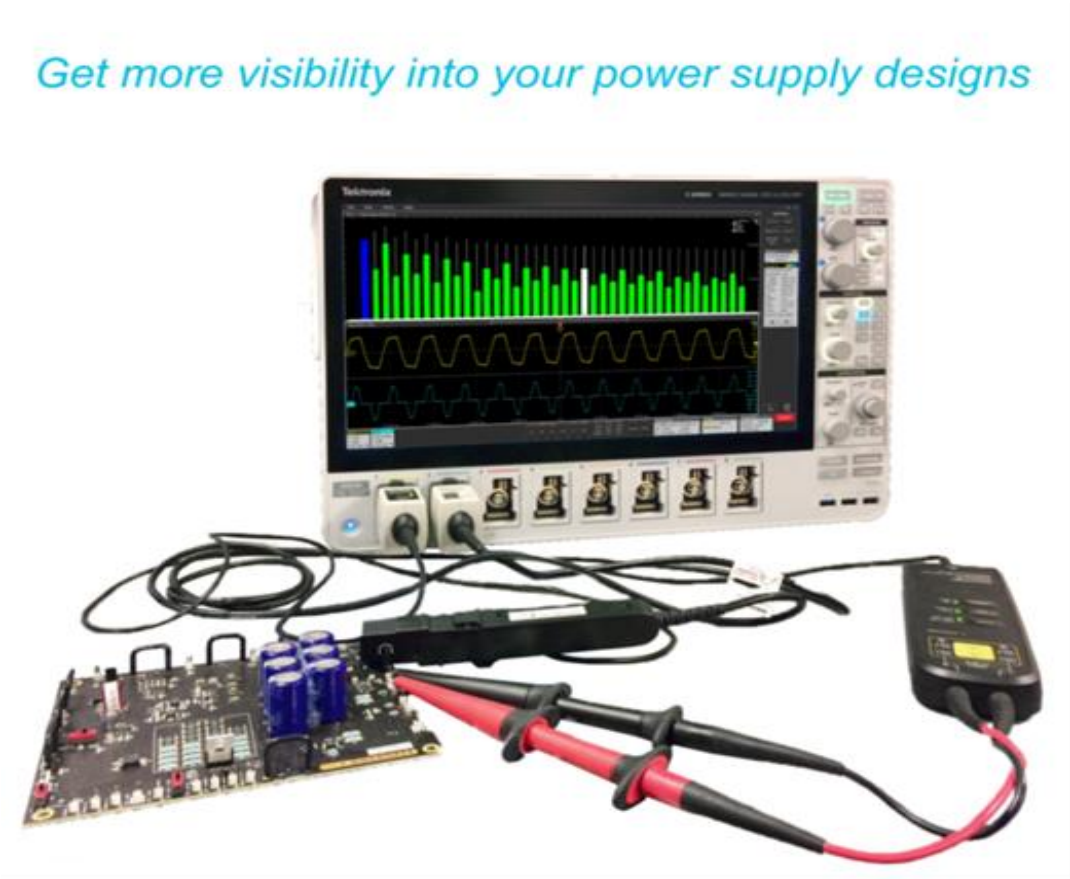
Get more visibility into your power supply designs

- **Integrated Advanced Power Analysis and Measurement software**
  - Ease of use
  - Accuracy
  - Repeatability
  - Reports



- **1 BOX Solution for Power measurements and Frequency Response Analysis**

Complete solution including Oscilloscopes, Probes, Power Analyzers, SMUs, AFGs, DMMs, Power Supplies and Parametric Test setups meeting Power design workflow needs.



Reference Materials :

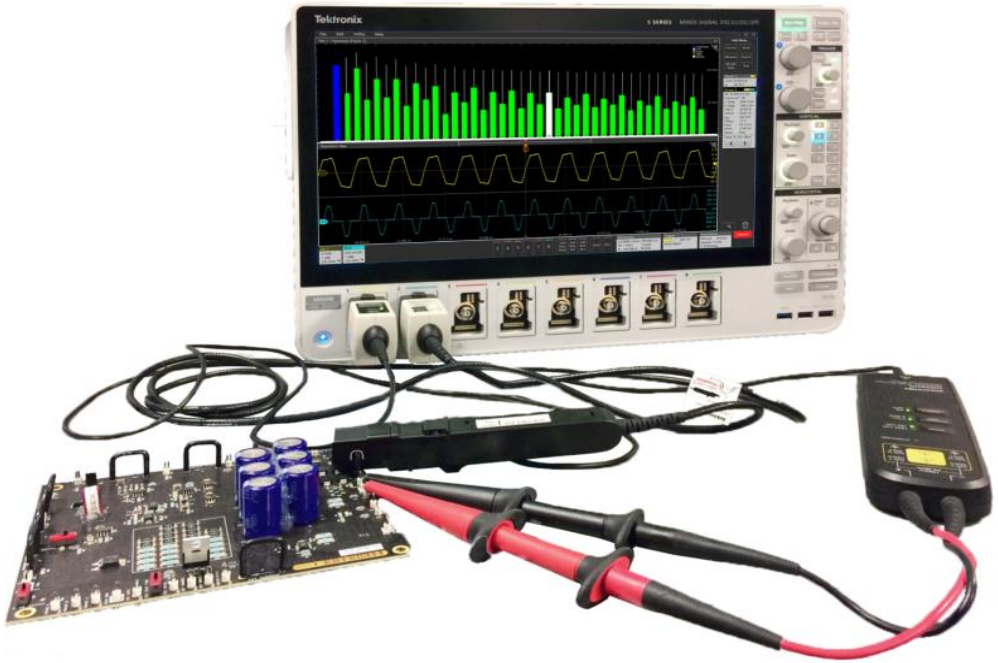
1. **5 Series MSO Data sheet:** https://www.tek.com/datasheet/5-series-mso
2. **6 Series MSO Data sheet:** https://www.tek.com/datasheet/6-series-mso
3. **5-PWR and 6-PWR Advanced Power Measurements and Analysis Data sheet.** https://www.tek.com/datasheet/advanced-power-measurement-and-analysis
4. **Isolated Probes:** https://www.tek.com/isolated-measurement-systems
5. https://www.tek.com/power-efficiency/trends
6. **Application Notes:1.)** https://www.tek.com/document/application-note/power-supply-measurement-and-analysis-5-pwr-application-software
   2.) https://www.tek.com/document/application-note/circuit-measurement-inductors-and-transformers-oscilloscope

Thank You

Back-up

Advanced Power Measurements and Analysis- Complete Solution

Get more visibility into your power supply designs



End-to-End Power Electronics Test Solutions