



Automating 1547.1 Compliance: End-to-End DER Testing with Integrated Oscilloscope Measurements from Tektronix

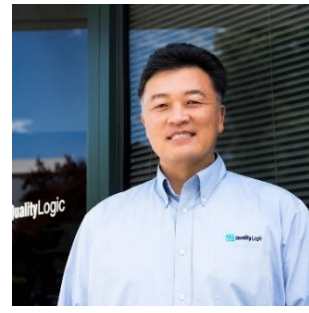
Agenda

- **Introductions**
- **Latest Updates of IEEE 1547 and UL 1741 SB Mandates**
- **New Features in QualityLogic's IEEE 1547.1 Test Tool**
- **Live Demonstration of QualityLogic's IEEE 1547.1 Test Tool with Tektronix Oscilloscope**
- **Presentation by Tektronix**
- **Q&A**

Today's Presenters

Steve Kang, GM, QualityLogic

Steve is a leading technical expert on IEEE 2030.5 and CA Rule 21 based Common Smart Inverter Profile (CSIP) implementation guide. He is the General Manager responsible for delivering leading testing products and services for the Smart Energy industry.



William Martins, Compliance Engineer, QualityLogic

William is the lead compliance engineer with extensive experience testing inverters for UL 1741 compliance testing. He has over 10 years of industry experience performing compliance testing of smart inverters for various regional codes. He is also a participant and contributor to many working groups that help correct existing standards and develop new ones.



Today's Presenters

Jeffrey Miller, Product Marketing Manager, Tektronix

Jeffrey has advocated for users and engineers throughout his career. In various roles as an Applications Engineer and oscilloscope Product Manager, he has promoted human-centered design and the importance of UX in Test and Measurement. He has a special interest in test automation and integrated instrumentation and is currently responsible for oscilloscope software development at Tektronix.



Shubha B, Senior Product Manager, Tektronix

Shubha is an experienced power electronics engineer with expertise in power management testing and validation. She has trained and mentored engineers globally on power electronics design and testing methodologies. As a Senior Product Manager at Tektronix, she leads the development of scope-based power electronics test solutions.



QualityLogic's Role in the Smart Energy Industry

- **Focused on providing the industry with Smart Energy Testing Products, Training and Consulting**
 - IEEE 2030.5, OpenADR, IEEE 1547/UL 1741 SB, V2G, and WiSUN
 - Used by NRTLs, Vendors, Utilities and Research labs to perform Testing/Certification
 - Technical Training and Consulting: 2030.5, 1547/UL 1741 SB, OpenADR and others
 - First vendor to offer 1547.1 Certification Test Tools
- **Contribute to development of international standards**
 - Member of IEEE 2030.5, 1547-2018 and 1547.1-2020 working groups
 - Member of UL 1741 STP (SB revisions)
 - SunSpec Modbus, SunSpec J3072 IEEE 2030.5 Profile
 - OpenADR, MESA-DER, UL 1741 SC, SAE J3072, CharIN
- **Founding member of V2G Forum to help harmonize V2G standards**
 - Includes EV/EVSE manufacturers, utilities, alliances and government agencies
- **Contributor to International Energy Association's Task53 V2G work group**

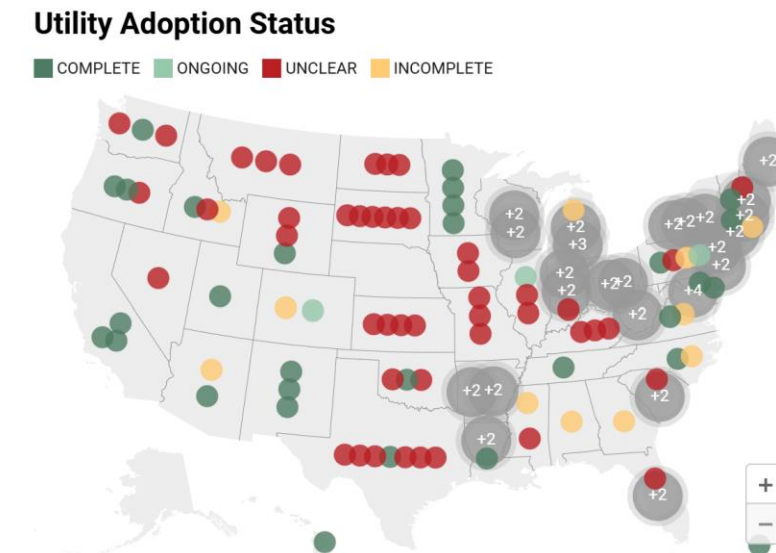
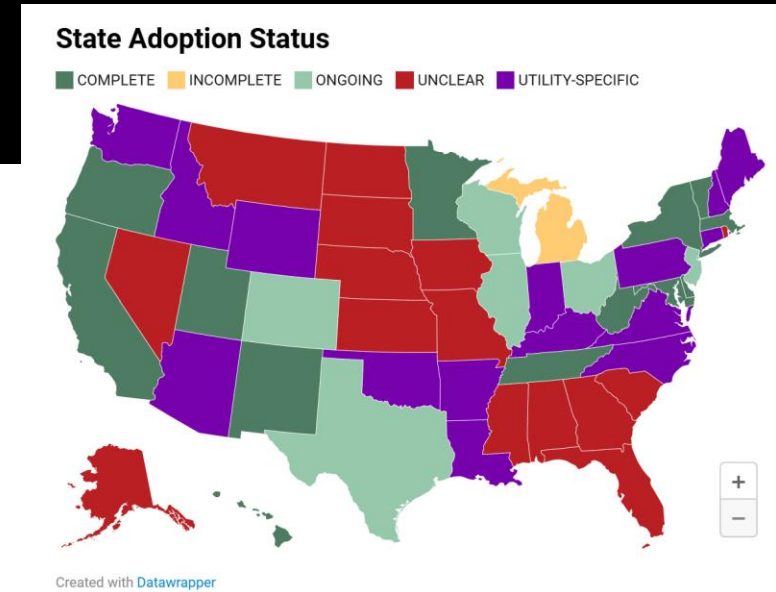


IEEE 1547 Background

- **IEEE 1547 and 1547.1 were initially approved in 2003 after 3 years of intense debate and development**
 - Standardized behavior of interconnected DER in abnormal conditions. Primary concerns were grid stability and safety.
- **For the United States, the Energy Policy Act of 2005 established IEEE 1547 as the interconnection standard for distributed generation resources**
 - Interconnection services shall be offered based upon ...IEEE Standard 1547 for Interconnecting Distributed Resources with Electric Power Systems, as they may be amended from time to time.
- **Revised in 2014 to address changing grid requirements for DER**
 - Addressed voltage regulation, voltage response and frequency response to Area EPS abnormal conditions.
 - IEEE 1547.1 was also revised in 2014 and 2015.
- **IEEE 1547 was revised again in 2018 and 1547.1 approved in 2020**
 - As DERs were seen as potential grid resources, the need for additional functionality and interoperability drove the most recent 1547 update.
 - The need for communications was recognized in the standard for the first time – interoperability tests
- **UL 1741 SB is the official safety certification standard for DERs to be compliant to IEEE 1547 requirements**
 - Directly references IEEE 1547-2018 and 1547.1-2020 standards

Adoption of IEEE 1547 in the US

- On February 12, 2020, NARUC approved a [resolution](#) recommending state commissions adopt IEEE 1547-2018
- UL 1741 SB Revision adopted September 28, 2021– certification testing started
- NRTLs are in full certification testing mode
- IREC survey Aug-Sep 2021 (3 leading NRTLs)
 - Estimates of 8-12 weeks testing per inverter family
 - >1 year to certify ~80% of inverter families tested on CEC list
 - Plus time for certification processing, listing by CEC and distribution of certified inverters
- **Currently, many states have required 1547-2018 as shown in the maps**
 - California, Hawaii, Oregon, Utah, New Mexico, New York, Minnesota, Massachusetts and other states require UL 1741SB with many more to follow
 - CEC’s listing has 1311 SB certified grid support inverters currently - growing



IEEE 1547.1 Type Tests for Grid Support Functions

- Type Tests are defined in Section 5 of the IEEE 1547.1 Standard
- Includes grid support functional testing plus other tests such as anti-islanding, temperature stability, EMI, open phase and others
- Focusing on grid support functional tests in this webinar
- 5.2 Priority of responses – specific order of priority of functions by DER (disable permit service, must trip, ride through, VoltWatt/FreqDroop, Limit Active Power then Reactive Power as lowest priority)
- 5.4 Test for response to voltage disturbances - Voltage trip and ride through functions
- 5.5 Test for response to frequency disturbances – Frequency trip and ride through functions + ROCOF
- 5.6 Enter service – DER energizes and ramps to produce power

IEEE 1547.1 Type Tests for Grid Support Functions

- **5.13 Limit active power – controlling DER’s active power generation**
- **5.14 Voltage regulation – grid voltage responses such as VoltVar, VoltVar Vref, VoltWatt, PF, WattVar**
- **5.15 Frequency support – grid frequency responses such as FreqDroop**
- **5.16 Test for prioritization of DER responses – testing of above 5.2 priority order, voltage frequency priority**
- **Type tests include testing of various test characteristics under various conditions**
- **Section 6 (Interoperability) leverages above tests and requires DER communication (2030.5, SunSpec Modbus 7xx, IEEE 1815 (DNP3). Interop tests sample two of the Type test settings**
 - DER must support at least one of the above protocols to pass
 - Combination of protocol communication and verification of type tests requirements
- **QualityLogic’s multiday IEEE 1547 workshop provides in depth training**
 - Includes walk through of IEEE 1547-2018, 1547.1-2020 and UL 1741 SB standards
 - Overview of all 3 communication protocols
 - Common implementation issues observed in the industry
 - Live inverter lab based training using QualityLogic’s IEEE 1547 Test Tool



1547.1 Interoperability Test Section

- **New section introduced in IEEE 1547.1-2020 standard to include communication requirements**
- **Requires the DER device to support at least one of IEEE 2030.5, SunSpec Modbus 700, IEEE 1815 (DNP3)**
- **Includes the following types of tests:**
 - Nameplate Tests – reporting of DER’s nameplate data
 - Configuration Tests – testing of configuration of different nameplate/settings of DER
 - Monitoring Tests – reporting of metering/status data by DER
 - Management Tests – testing of 10 of the Type Tests functions
- **If Type tests (Section 5) are executed using above DER protocol, the Management tests can be skipped**

Test	Management Function	Adjustable Settings (References to IEEE Std 1547-2018)	Criteria (References to functional test criteria within this document)
1	Constant Power Factor Mode	10.6.2, Table 30	5.14.3.3
2	Voltage-reactive power mode	10.6.3, Table 31	5.14.4.3 and 5.14.5.3
3	Active power-reactive power mode	10.6.4, Table 32	5.14.7.3
4	Constant reactive power mode	10.6.5, Table 33	5.14.8.3
5	Voltage-active power mode	10.6.6, Table 34	5.14.9.3
6	Voltage trip test	10.6.7, Table 35	5.4.2.4 (over voltage trip settings) and 5.4.3.4 (undervoltage trip settings)
8	Frequency trip test	10.6.8, Table 37	5.5.1.4 (over frequency trip) and 5.5.2.4 (under frequency trip)
9	Frequency droop (frequency/power or frequency-watt) test	10.6.9, Table 38	5.15.2.3 (above nominal frequency) and 5.15.3.3 (below nominal frequency)
10	Enter service and Cease to energize and trip tests	10.6.10, Table 39, 10.6.11	5.6.4
11	Limit maximum active power test	10.6.12, Table 40	5.13

Above figures cited from IEEE 1547-2018 standard

IEEE 1547.1A (Draft d3, Jan 2026) vs. IEEE 1547.1-2020

MODIFIED TEST PROCEDURES (Clause 5)

Voltage / frequency trip (§5.4 – §5.5)

When trip settings sit inside a ride-through region, ride-through applies until 160 ms or 1% of clearing time before the prescribed clearing time. Frequency-droop interaction has 4 explicit procedural workarounds (5.5.1.1 v).

Enter Service (§5.6)

98.5% of ES delay must elapse before export resumes; randomized-delay statistics now mean 400–600 s, $\sigma > 250$ s; +30 s allowance when testing exercises the local DER comm interface.

Unintentional islanding (§5.10)

Power-HIL is now an explicit option in 5.10.2. §5.10.5 reverse / minimum-import active-power flow protection is fully replaced; ANSI 32P/32R relay design evaluation is allowed in lieu of full test.

Current distortion (§5.12) + new Annex J

New incremental harmonic-voltage formula: $dV \leq 0.05 \times Z_{\text{base}} \times h \times I_{\text{max}}$. Equipment IEC 61000-4-30 Class A / 61000-4-7 Class 1. Annex J supplies the rationale and an adjustment calc when source can't meet the limit.

Fault current (§5.18) — Annex H Normative

Switched-impedance method now normative. Source must have 3LG fault VA $\geq 3 \times$ EUT rating; specified pre/unfaulted-phase tolerances; frequency stays in 59–61 Hz over any 10-cycle window.

DER INTEROPERABILITY (Clause 6)

Protocol versions pinned

2030.5-2018 / IEEE 1815-2025 with 1815.2-2025 / SunSpec models 701–712 (+713 if absorption). DNP3 update is backward-compatible — §6.8.3 says retest is not intended.

Multi-protocol = multi-test

If the EUT supports more than one of {2030.5, DNP3, SunSpec Modbus}, every Clause 6 requirement must be tested for each protocol, and the listing must identify which transport/physical layers passed.

Integrated with Clause 5

Interoperability tests may be folded into functional testing: disable / apply settings via protocol / run a Clause 5 case / repeat with a different setting. No need to fully repeat Clause 5 across non-standard interfaces.

Configuration / monitoring / management

§6.5 — read each parameter in Table 41 at 80% of initial value. §6.6 — verify monitoring at two operating points (Table 42). §6.7 — Table 43 ties each management function to its Clause 5 test criteria.

30-second rule

Mode or parameter changes must commence within 30 s of the command being received at the local DER comm interface (§4.6.3 of IEEE 1547). Modbus write responses must return within 30 s.

QualityLogic's IEEE 1547.1 Certification Test Product

- **Trusted by OEMs, NRTLs, utilities and research labs for official UL 1741 SB Certification for grid support tests**
- **Accelerates Testing of Type and Interoperability Tests through fully validated automation**
 - Supports all three DER protocols required in 1547 – IEEE 2030.5, SunSpec Modbus 700 and 1815 (DNP3)
 - Controls lab equipment connected to the DUT being tested – grid simulators, power analyzers, oscilloscope, DC Supply/PV simulators
 - Implements each step described in the 1547.1-2020 test procedures including UL 1741 SB clarifications
- **Automated Data Analysis that provides convenient 1547.1 measurement compliance to user**
 - Automatically determine if the DER device is compliant to the 1547.1 physical power responses
 - Methodology is based on the expertise gained through helping OEMs pass certification with NRTLs
 - OEMs have submitted the results from the QL 1547 Test Tool including our analysis to NRTLs to pass certification
 - Supported during live test execution or offline analysis

New Features in Version 4.8.2

- **New Lab Equipment Models from Tektronix**
 - Multi channel 4/5 B MSO Oscilloscope and Elektro-Automatik DC Supplies
- **Enhanced Must Trip Functions: For Tektronix Oscilloscopes**
 - Analysis is done by plotting vertical/horizontal cursers, adjusting time/division and adding automatic trigger. Includes List Command implementation
- **Automated 1547 Data Analysis Improvements**
 - Updated steady state detection and transient analysis logic across IEEE 1547 functions, including refinements to step-hold identification, clearing-time exclusion, and duration evaluation to improve overall analysis precision.
- **SunSpec Modbus Conformance Test**
 - Covers testing of SunSpec Modbus Conformance Tests
 - Convenient way to discover OEM's implementation issues
- **Enhance CSIP Server Implementation Detection**
 - Additional detection of failures based on CSIP test case requirements



1547.1 Product Details – Test Equipment Control Features

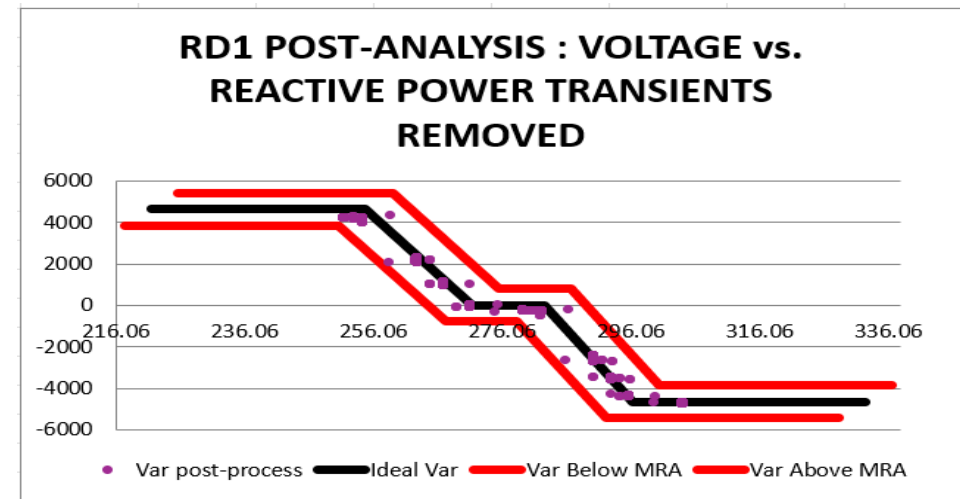
- **QLI 1547.1 FTS will remotely control and monitor each test equipment**
 - Grid simulator, power analyzer/meters, oscilloscope and DC/PV simulators
 - Remotely control through use of SCPI or OEM API
- **Each 1547.1 test case requires configuring and monitoring these equipment to analyze the DERs performance**
- **Monitor power data collected from data collection devices (power analyzer, oscilloscope) to analyze the test criteria**
- **Current list of equipment supported**
 - Grid Simulators - Ametek MX/RS/Sequoia Series, Chroma, ITech/Rexgear, Keysight, Pacific Power, NF, NHR Grid Simulator, Regatron
 - Power Analyzers - Yokogawa WTx000, PX8000, Dewetron, Virtrek
 - Oscilloscopes - Yokogawa DL, Tektronix, Keysight, Agilent, Instek, Virtrek, Teledyne & Lecroy, Rodhe&Schwarz
 - DC Power Supply – ITech, Chroma, Elektro Automatik/Tektronix, TerraSAS, Keysight, Regatron, Magna-power SL Series, TDK, Ametek SGX
 - New models added based on customer requests

Automated Data Analysis

- Monitoring the DUT's behavior at the output power level is central to determining the pass/fail of the 1547/UL 1741SB
- IEEE 1547/UL 1741SB calls for strict Minimum Required Accuracies (MRAs) that DUTs must fall within.
- QualityLogic's IEEE 1547 test tool fully controls all equipment and collects measurements at intervals supported by each equipment type
 - Customers/NRTLs have analyzed these collected data and performed analysis for the DUT being tested/certified – time intensive step when done manually.
 - QL has assisted many customers in performing these analysis for them before/during NRTL certification
- Based on the expertise, QualityLogic has developed an automated data analysis as a new feature to the IEEE 1547 test tool

Table 3—Minimum measurement and calculation accuracy requirements for manufacturers^a

Time frame	Steady-state measurements			Transient measurements		
	Minimum measurement accuracy	Measurement window	Range	Minimum measurement accuracy	Measurement window	Range
Voltage, RMS	(± 1% V_{nom})	10 cycles	0.5 p.u. to 1.2 p.u.	(± 2% V_{nom})	5 cycles	0.5 p.u. to 1.2 p.u.
Frequency ^b	10 mHz	60 cycles	50 Hz to 66 Hz	100 mHz	5 cycles	50 Hz to 66 Hz
Active Power	(± 5% S_{rated})	10 cycles	0.2 p.u. < P < 1.0 p.u.	Not required	N/A	N/A
Reactive Power	(± 5% S_{rated})	10 cycles	0.2 p.u. < Q < 1.0 p.u.	Not required	N/A	N/A
Time	1% of measured duration	N/A	5 s to 600 s	2 cycles	N/A	100 ms < 5 s



Accelerate Your 1547 Testing Through QualityLogic

- QualityLogic fully automates the end to end testing of DER systems for IEEE 1547 compliance**
 - Performs communication with DER to configure specific grid support function and test values
 - Controls grid simulator through each 1547.1 test step by changing grid conditions as required
 - Monitors and collects DER's behavior from the connected power analyzer and oscilloscope
 - Automatic data analysis of the collected power analyzer data to determine DER's pass or fail for all Management tests
- QualityLogic's test tool provides users with convenient and accelerating testing to meet UL 1741SB compliance saving customers valuable testing time**
 - All the grid support Types tests for a bidirectional inverter can be performed in 32 hours – based on actual testing using QualityLogic's 1547.1 Test Tool
 - IREC's estimate of 8-12 weeks of NRTL testing for SB compliance can be reduced significantly

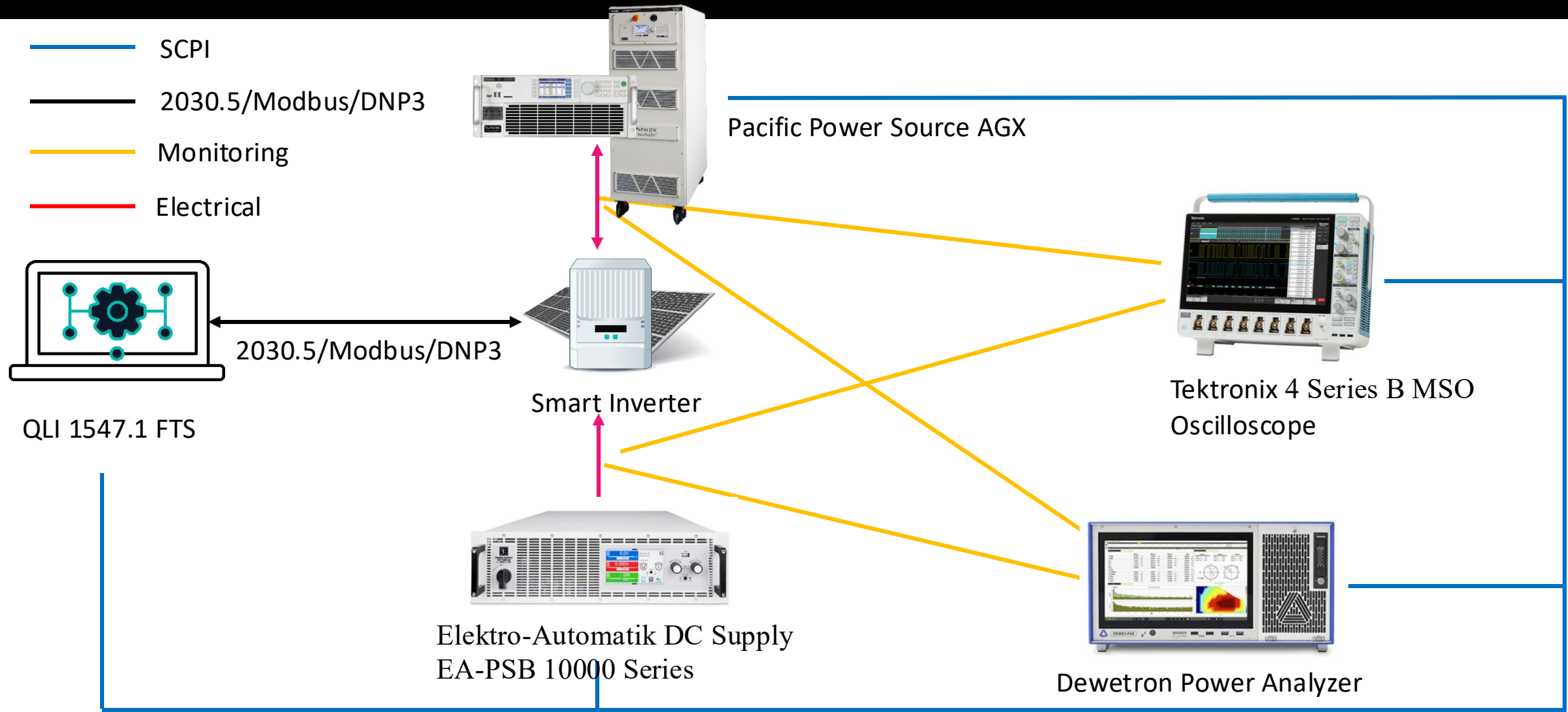


TYPE	TESTS	Test Function	No.Of Rounds	Measured time for execution in MODBUS (mins)
	1	Const PF	6	48
	2	Volt- Var	5	130
	3	Volt- Var Vref	1	45
	4	Watt- Var	3	42
	5	Const VAR	12	108
	6	Volt- Watt	5	115
	7	Volt Watt P'	5	116
	8	Freq Droop OF	6	15
	9	Freq Droop OF P'	7	17
	10	Freq Droop UF	2	7
	11	Freq Droop UF P'	3	10
	12	Max Limit Power	9	43
	13	HVMT (Neutral Disabled)	4	20
	14	LVMT (Neutral Disabled)	6	76
	15	HFMT	6	512
	16	LFMT	6	512
	17-22	Service test	6	200
	23	Abn HVRT (Neutral Disabled)	2	20
	24	Abn LVRT (Neutral Disabled)	2	20
	25	Abn HFRT	1	19
	26	Abn LFRT	1	19
	27	Volt Watt Imb P'	1	4
	28	Volt-Var Imb	1	3
	29	Volt- Watt Imb	1	2
	30	Volt-Freq Priority	1	18

Actual QL Test Results

Total Run time (Hours)	32.0166667
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Demonstration Inverter Lab Overview



Function Under Test – High Voltage Must Trip

Table 13—DER response (shall trip) to abnormal voltages for DER of abnormal operating performance Category III (see Figure H.9)

Shall trip—Category III				
Shall trip function	Default settings ^a		Ranges of allowable settings ^b	
	Voltage (p.u. of nominal voltage)	Clearing time (s)	Voltage (p.u. of nominal voltage)	Clearing time (s)
OV2	1.20	0.16	fixed at 1.20	fixed at 0.16
OV1	1.10	13.0	1.10–1.20	1.0–13.0
UV1	0.88	21.0	0.0–0.88	21.0–50.0
UV2	0.50	2.0	0.0–0.50	2.0–21.0

5.4.2.2 Procedure

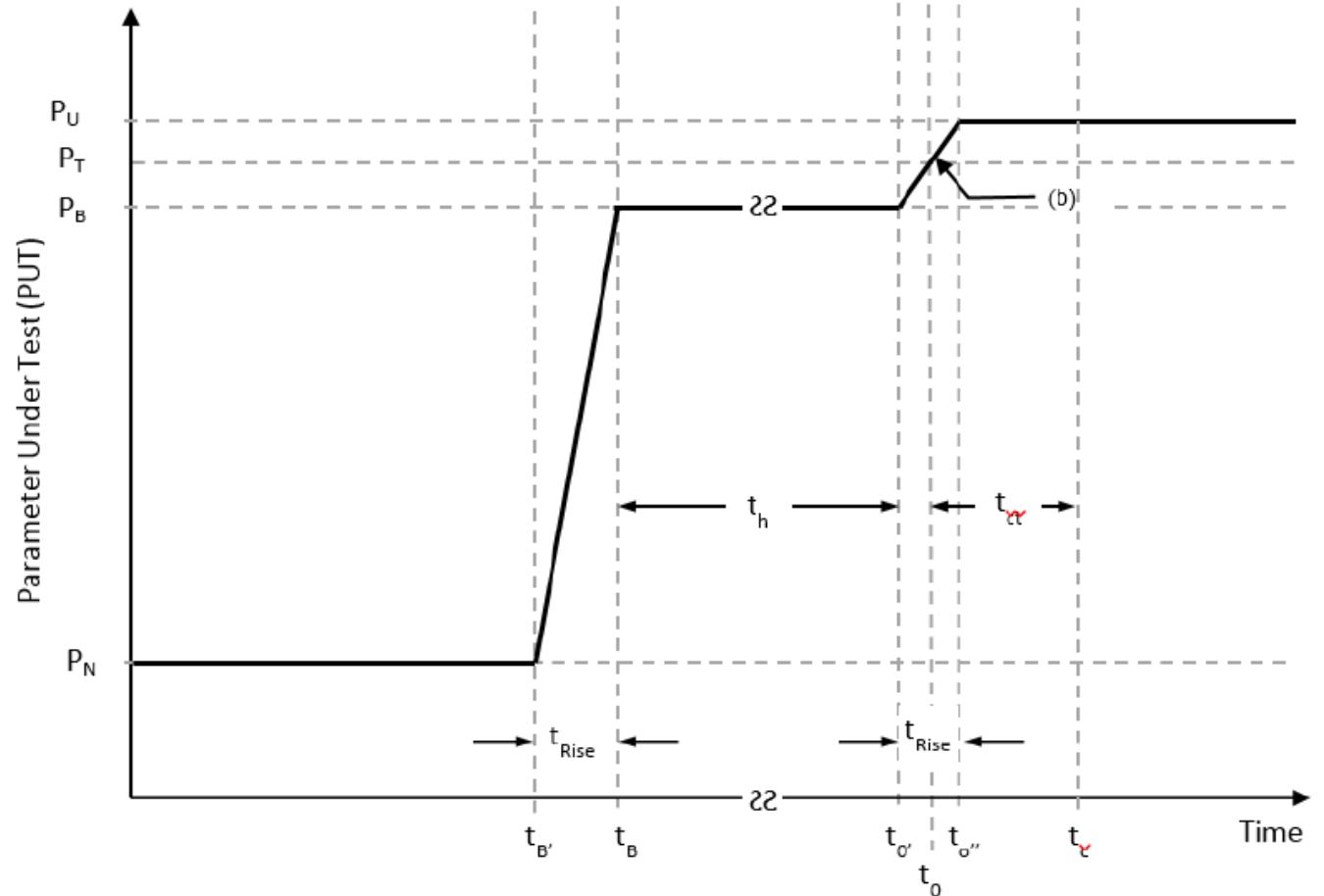
This procedure uses the step function defined in A.3. For these tests, voltage is substituted for the variable P as indicated in the procedures defined in Annex A.

- Connect the EUT according to the instructions and specifications provided by the manufacturer.
- Set all source parameters to the nominal operating conditions for the EUT.
- Set (or verify) all EUT parameters to the nominal operating settings. If the overvoltage setting is adjustable, set the EUT to the minimum overvoltage setting, but no less than the nominal voltage plus twice the *minimum required accuracy* for voltage.
- Set the trip time setting to the minimum.
- Record applicable settings.

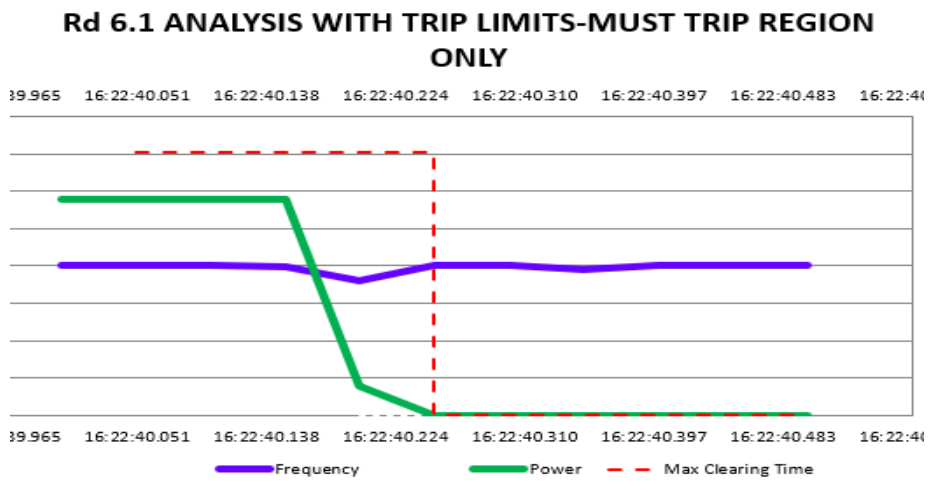
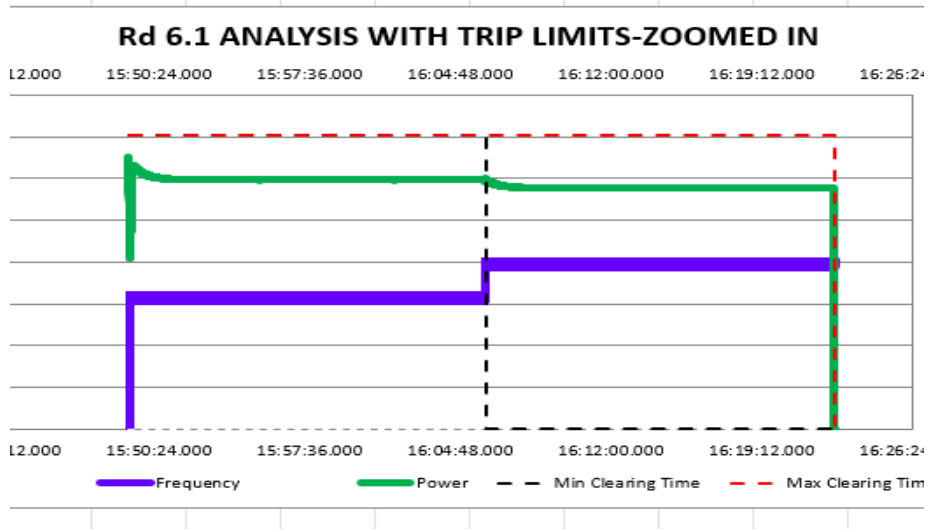
For single-phase units, adjust the applicable voltage to parameter starting point P_B , as defined in A.3, to a value greater than or equal to the setpoint value determined in step c) minus 200% of the MRA.²³ The source shall be held at this voltage for a period t_h .²⁴

At the end of this period, initiate a step of the voltage to a level less than or equal to the setpoint value plus 200% of the MRA using the procedure specified in A.3. For *multiphase* units, adjust voltage on one phase using the values above. Verify that remaining phases are held at nominal ± 0.02 p.u.

- Record all voltage magnitudes when the unit trips.
- Repeat steps e) through f) four times for a total of five tests.
- For *multiphase* units, repeat steps e) through g) for the applicable voltage on each phase or phase pair individually, and all phases simultaneously.
- If the trip magnitude is adjustable, repeat steps e) through h) at the maximum of the range.
- Set the trip time setting to the maximum and repeat steps e) through i).
- Repeat steps c) through k) for each overvoltage operating trip region.

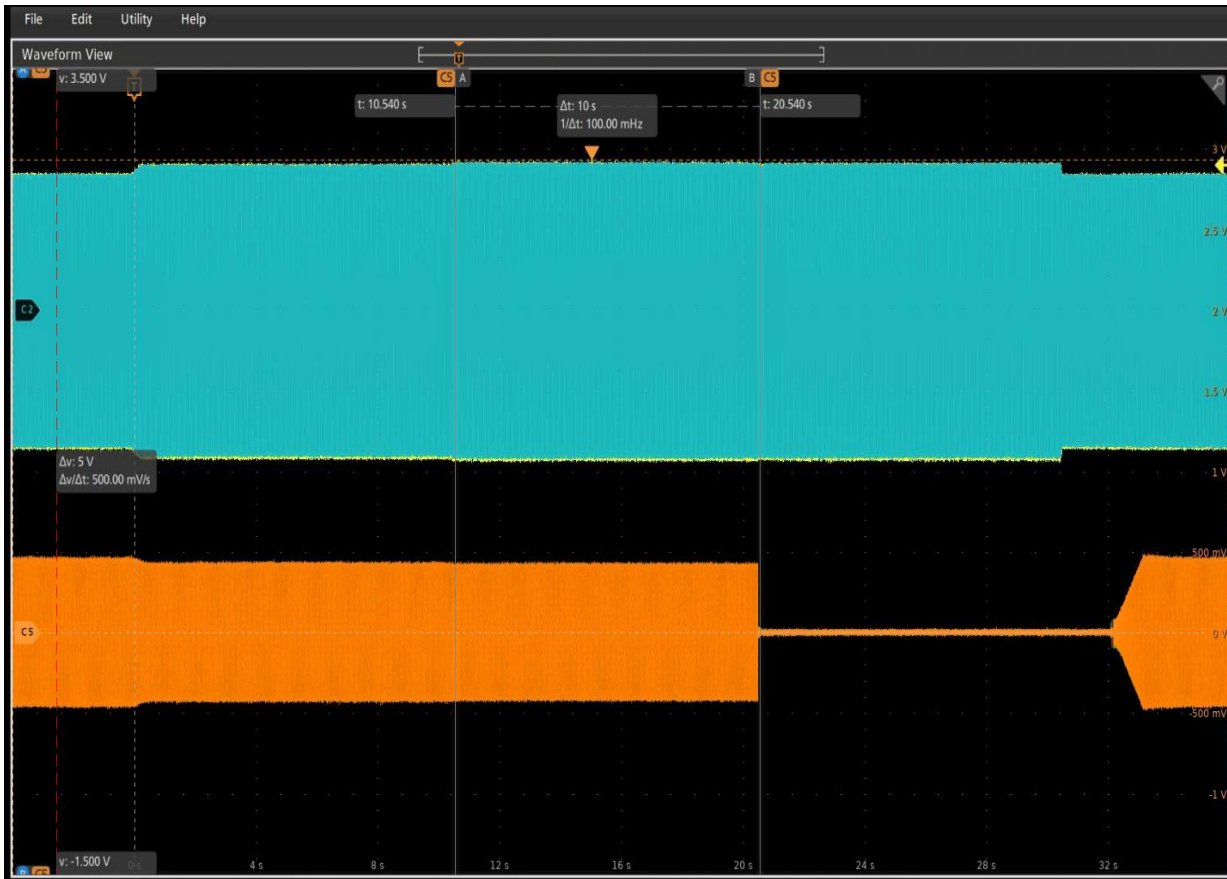


Must Trip Analysis Using Power Analyzer – Informational



- **RMS Data Representation (HFMT Example)**
 - Voltage, Frequency, and Power captured
 - Trip visually occurs before Max Clearing Time (red line)
- **Useful for Visualization**
 - Clear view of inverter response behavior
 - Supports trend analysis and quick validation
- **Considerations**
 - Lower sampling rates may not capture exact trip moment
 - Potential for false pass/fail interpretation
- **Recommended Practice**
 - Oscilloscope-based measurement is typically preferred for higher accuracy
 - NRTLs may require or favor high-speed waveform capture due to sampling limitations of power analyzers

Must Trip Analysis Using Tektronix Oscilloscope – New Feature

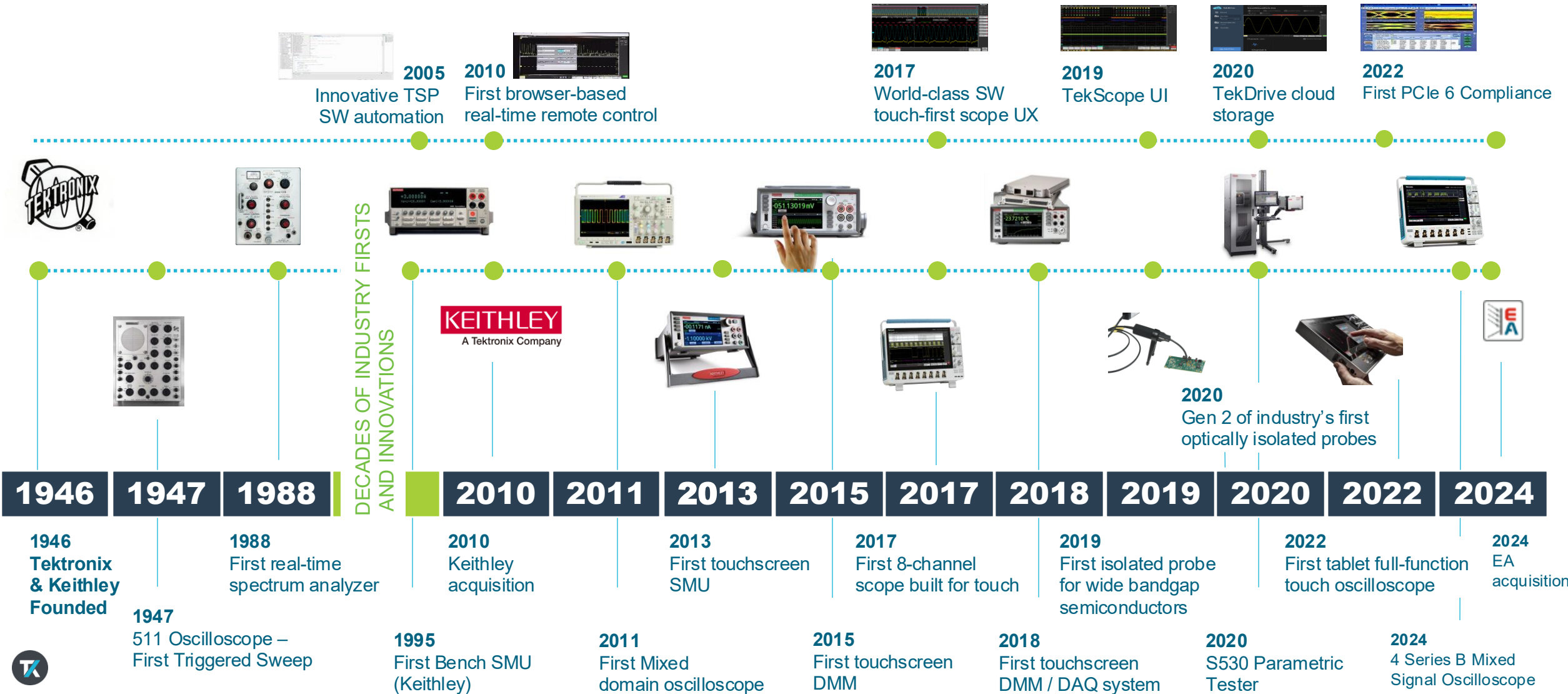


- **Automated Must Trip Analysis (QL Innovation)**
- **Full Scope Automation**
 - Start/Stop control + trigger elimination
 - Automated time/div and cursor placement
- **Precision Capture & Detection**
 - Repeatable waveform capture
 - Accurate must trip timing identification
- **Advanced Frequency Must Trip (No Math Required)**
- **Synchronized Voltage & Frequency Ramp**
 - Controlled rate change while staying in operating range
- **Voltage as Timing Reference**
 - Tracks frequency change without math channels
- **Simplified, Accurate Trip Detection**
 - Reliable frequency MT identification
 - Faster setup, consistent results



Demonstration of IEEE 1547 Testing using QualityLogic

Our History



Power Portfolio

TECHNOLOGY LEADERSHIP



Wide Bandgap

SiC and GaN Materials Research, Wafer, and Device Test

Materials Research



Wafer Parametric Test



I-V Characterization



Double Pulse Test



Power Management

Power Management ICs (PMIC), Battery Management Systems (BMS), Regulators, Converters

Power Management



Power Conversion



Data Center AI



Energy / Storage



Motors Drives & Inverters

Motor Drives, Inverters, Powertrain, grid-tied Inverters

Motors/Drives IMDA



Traction Inverter



Switching Loss



Grid Inverters



Battery

Cell, Pack, and Module, Fuel Cells

Materials Research



Battery Busbar Weld Test



Battery Test





Advanced Power Analysis



ADD MEASUREMENTS ?

Standard Jitter **Power** IMDA DPM PDN WBG-DPT

Power Quality
Power Quality measures the Frequency, RMS values of the voltage and current, Crest Factors of the voltage and current, Real Power, Reactive Power, Apparent Power, Power Factor, and Phase Angle of the AC signal.

Voltage Source: Ch 1
Current Source: Ch 2 Add

INPUT ANALYSIS

Power Quality Harmonics Inrush Current

AMPLITUDE ANALYSIS >

TIMING ANALYSIS >

SWITCHING ANALYSIS >

MAGNETIC ANALYSIS >

OUTPUT ANALYSIS >

FREQUENCY RESPONSE ANALYSIS >

GREEN POWER ANALYSIS >

All this and more included with Tektronix Advanced Power Analysis, software options:

- 4-PWR, 3-Phase : MS04B**
- 5-PWR, 5-IMDA : MS05B**
- 6-PWR, 6-IMDA : MS06B**

TIMING ANALYSIS

Period Frequency Positive Duty Cycle
Negative Duty Cycle Positive Pulse Width Negative Pulse Width

MAGNETIC ANALYSIS

Inductance Magnetic Property Magnetic Loss
I vs. JV

OUTPUT ANALYSIS

Line Ripple Switching Ripple Efficiency
Turn On Time Turn Off Time

GREEN POWER ANALYSIS

LVRT HVRT

FREQUENCY RESPONSE ANALYSIS

Control Loop Response PSRR Impedance

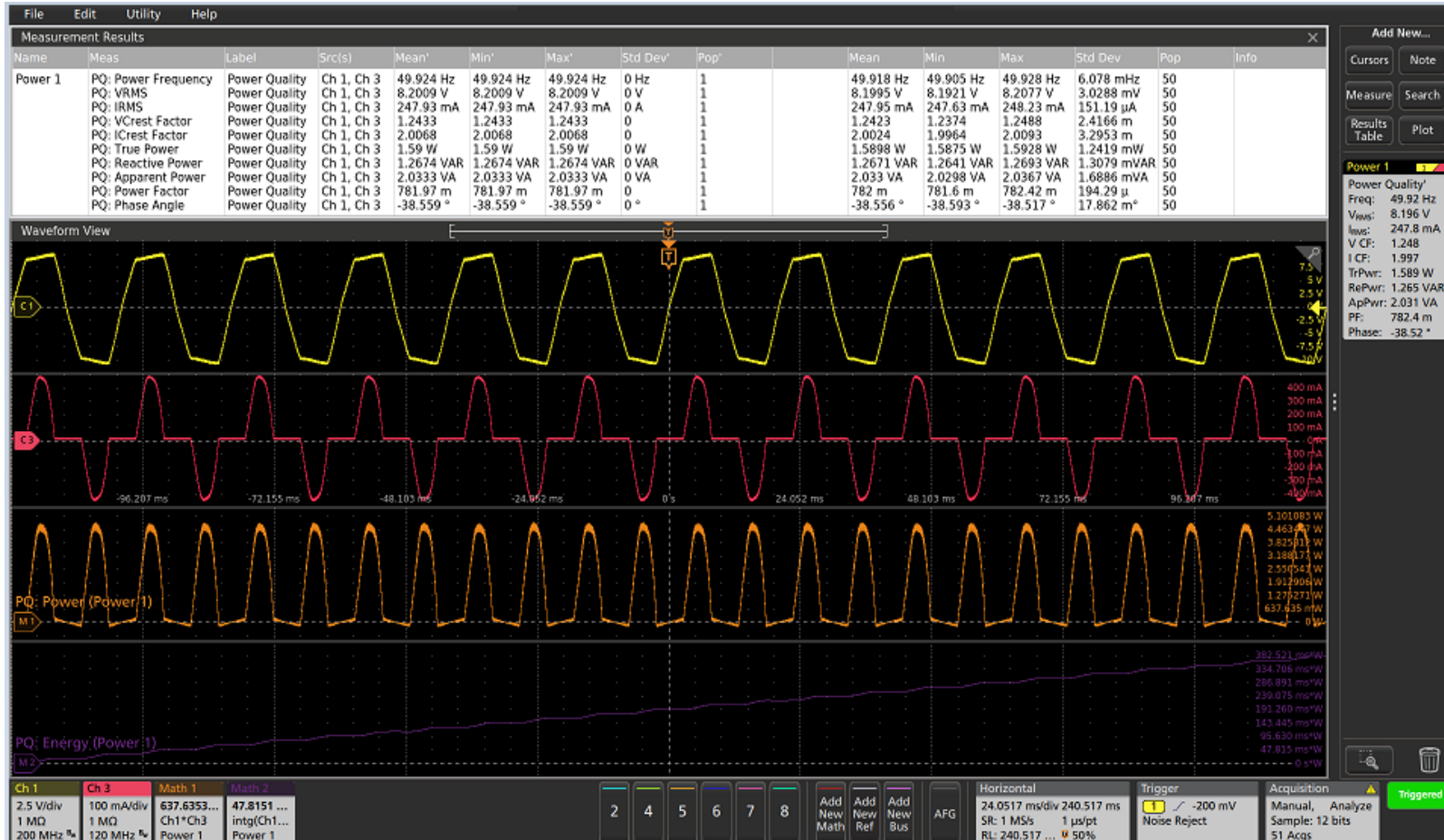
SWITCHING ANALYSIS

Switching Loss SOA RDS(on)

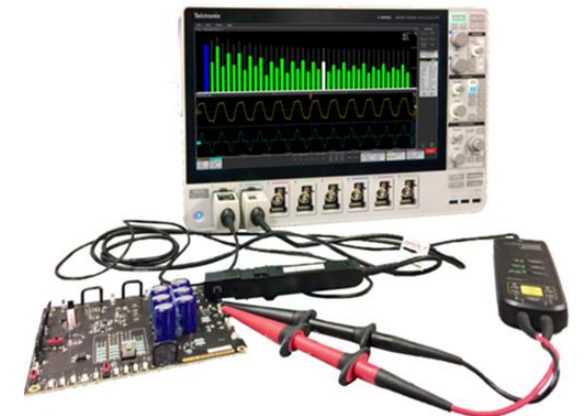


Power Quality

SINGLE PHASE INVERTERS



- ✓ Power Quality
- ✓ Frequency
- ✓ Vrms
- ✓ Irms
- ✓ Reactive Power
- ✓ Apparent Power
- ✓ True Power
- ✓ Power Factor
- ✓ Crest Factor
- ✓ Phase Angle

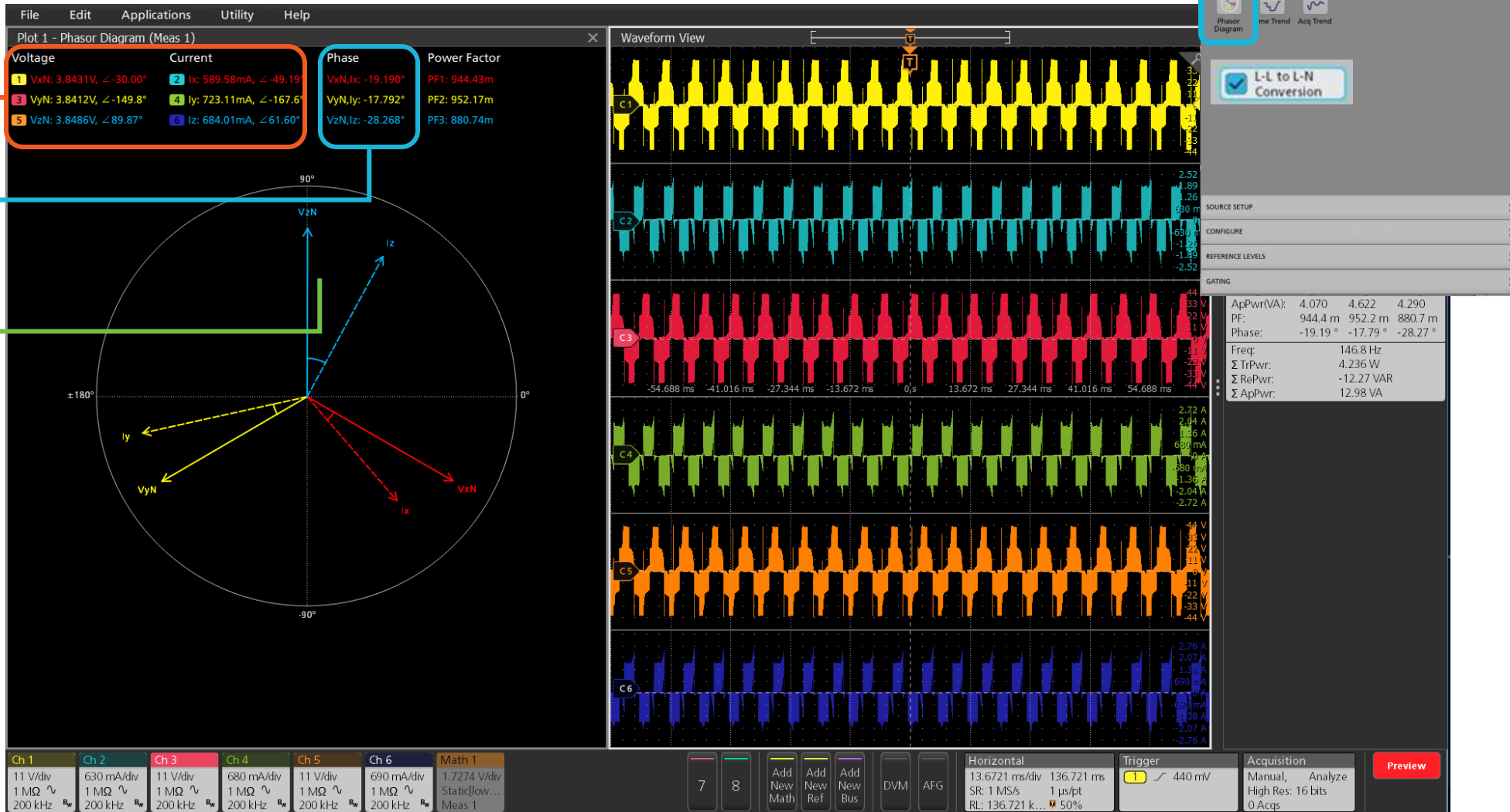


Power Quality

THREE PHASE INVERTERS

Understand V vs I relation for all 3-Phase

Phase Angle
Phase Difference

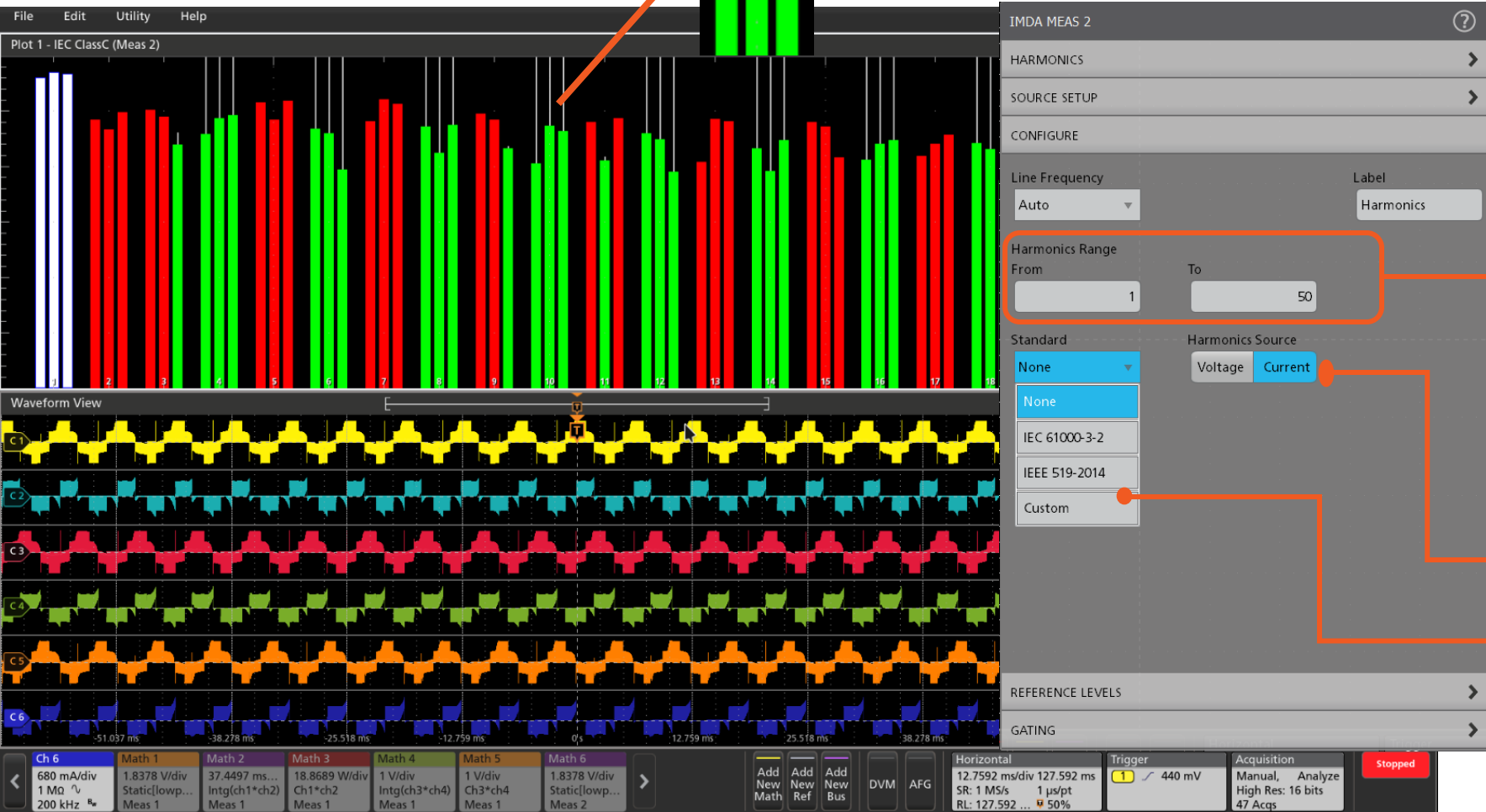


Harmonics

THREE PHASE INVERTERS



Compare the Harmonics of all 3-Phases together



Grey bars indicate the Harmonics limit as per the standard selected

Green - PASS
Red - FAIL

Specify the Harmonics Range

Specify the Harmonics Source
Specify the Harmonics Standard

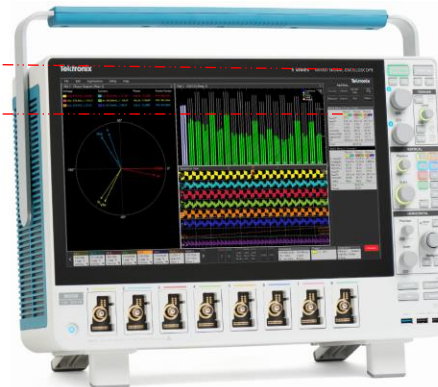
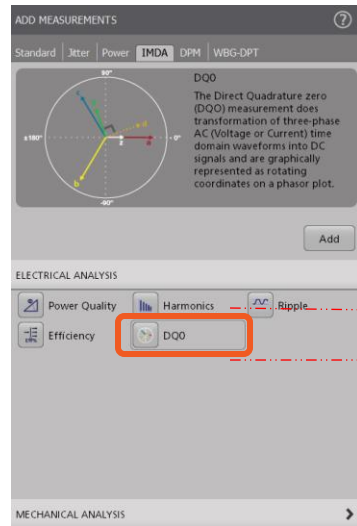
Specify custom limits which is user defined values



Real-Time DQ0 Transformation for Rapid Control Loop Validation



Typical DQ0 Test Setup
(Hardware Intensive)

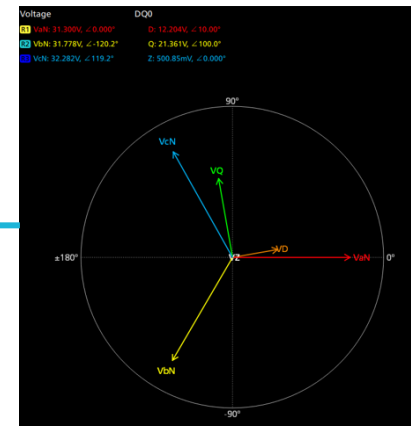


Tektronix 1-Box
DQ0 Solution!

D-Q-0 scalar results

IMDA Meas 2: DQ0'			
	D	Q	Z
RMS:	13.43 V	5.570 V	196.2 mV
Pk-Pk:	62.34 V	84.44 V	472.7 mV
Mean:	6.508 V	-929.4 mV	186.1 mV
Mag(D,Q):	10.27 V		

IMDA Meas 3: DQ0'			
	D	Q	Z
RMS:	546.4 mA	868.8 mA	5.967 mA
Pk-Pk:	4.189 A	3.672 A	24.48 mA
Mean:	218.1 mA	-621.1 mA	5.359 mA
Mag(D,Q):	744.5 mA		

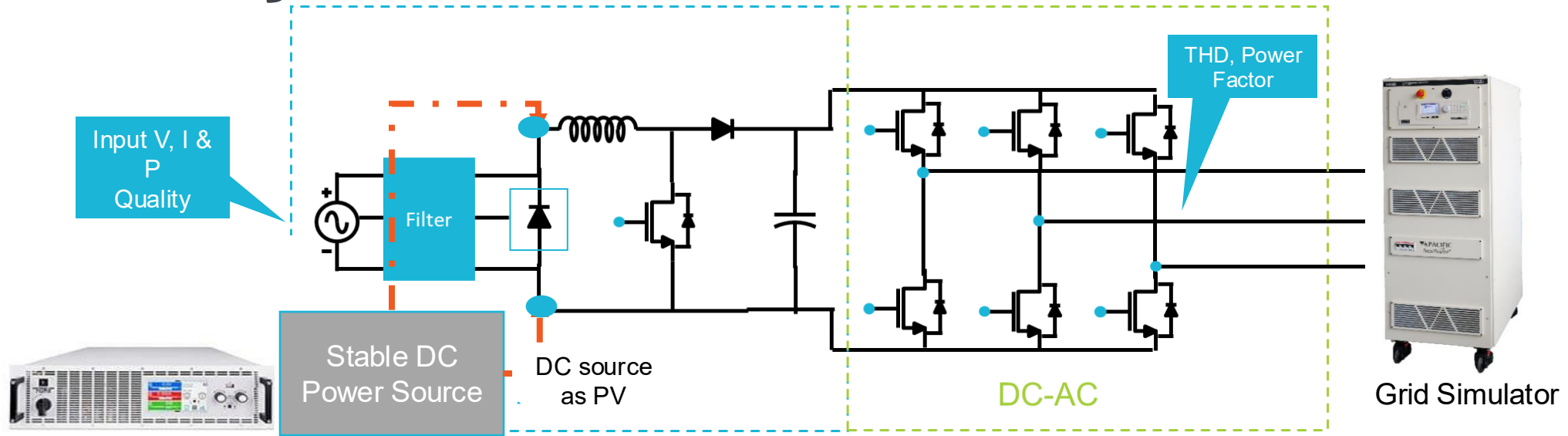


D-Q-0 on the
Phasor Diagram





Accelerating Grid-Tied Inverter Validation with Tektronix Power Analysis Solution



Timing/ Switching Analysis	Amplitude Analysis	Magnetic Analysis	Input Analysis	Output Analysis	Frequency Response Analysis
SW/Conduction losses	Peak-Peak	Magnetic Properties	Inrush current	Turn-on time	Bode Plot
Realtime SOA	RMS	Magnetic Losses	Input capacitance	Turn-off time	PSRR
Dynamic RdsON	Average	Inductance	Power Quality	Efficiency	2-port Impedance
Dead-time	Cycle Min-Max	I vs. $\int V$	Harmonics	Ripple	
d/dt	Cycle Amplitude	BH Plot	DQ0		





DC Power Supplies & Electronic Loads

FROM BENCH SUPPLY TO HIGH-POWER SYSTEM

Highly scalable device architecture



Bidirectional programmable DC power supplies



Programmable DC laboratory power supplies



Purpose-built battery test products



Programmable DC electronic loads



High power cabinet (rack) systems



~660 device variants to address any customer need



Oscilloscope Probes

Current Probes



AC/DC and AC-only current probes with a wide range of current levels and bandwidths.

High Voltage Differential Probes



Industry leading performance up to 6000V. Safety Certified.

Passive Probes



Single-ended, grounded probes for everyday measurements.

High Voltage Probes: Single-Ended



Low capacitance and best in class bandwidth. Safety Certified.

Low Voltage Differential Oscilloscope Probes



Differential probes for measuring high-speed I/O and low-amplitude signals.

IsoVu™ Isolated Current Probes



Probing systems make high-resolution measurements in the presence of common mode signals or noise.

IsoVu™ Isolated Voltage Probes



Probing systems make high-resolution measurements in the presence of common mode signals or noise.

Logic Probes



Connectivity options for flexible digital debug.





QualityLogic's Solutions for the Industry

Products and Services from QualityLogic to Accelerate 1547 Compliance

- **QualityLogic IEEE 1547.1 Test Product - for more info, click this [link](#)**
 - Fully automated for each of the Type and Interoperability tests for grid support functions including grid simulator and other lab equipment
 - Automated data analysis of the power measurements to determine your device's compliance
 - Licensed by NRTLs who certify UL 1741SB, OEMs in different domains including inverters, storage, EVSE/EV, Utilities and research organizations worldwide
- **Multiday Technical Workshop – for more info, click this [link](#)**
 - Deeper training on technical standards (IEEE 1547, 1547.1, UL 1741SB), protocols and execution of 1547 tests using a live inverter lab
 - Trained NRTLs, OEMs, Utilities and research organizations worldwide
 - NEW: SunSpec Modbus Technical Workshop including explanation of common Modbus implementation issues
 - Available onsite or remote
- **QualityLogic IEEE 2030.5/CSIP/CSIP-Australia Certification Test Product and Multiday Technical Workshop – click this [link](#)**
 - Only approved certification test tool for CSIP
 - Over 10 years of IEEE 2030.5 experience and contribution

Summary

- IEEE 1547/UL 1741 SB certification is well under way for various US states
- Overview of tests included in these standards today
- Demonstrated how QualityLogic 1547 Test Product can accelerate testing together with Tektronix
- Introduction to Tektronix product line
- Q&A
 - Please include them in the Q&A panel
 - Any questions we aren't able to cover today, we will review them and provide responses as follow-up to this webinar registrants
 - We will follow-up via email with information about webinar recording, Q&A responses
- Thank you! Contact smartenergy@qualitylogic.com for any further questions