Navigating IEEE 1547.1 & UL 1741SB Certification for Inverters and V2G

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 has trained many companies worldwide in understanding IEEE 2030.5, CSIP and IEEE 1547 technical standards. He is the General Manager responsible for delivering leading testing products and services for the Smart Energy industry.

James Mater, Director of Strategy, QualityLogic

James is one of the industry-leading experts on smart grid standards, interoperability, and the maturity of eco-systems of products based on these standards. James has given dozens of presentations and authored multiple papers on interoperability in the smart grid. He is a member of IEEE 2030.5 WG, the IEEE 1547.1 and 1547.2 Work Groups, UL 1741 SC, SunSpec J3072 Profile, OpenADR Profile WG and more.

Today's Presenters

William Martins, Compliance Engineer, QualityLogic

William is the lead compliance engineer with extensive experience testing inverters for UL 1741 compliance testing. He has over 8 years of industry experience performing compliance testing of smart inverters for various regional codes.

Luis Veliz, Director of Sales, Rexgear

Currently serving as Director of Sales for Rexgear, Luis is dedicated to providing cutting-edge automated test equipment solutions to clients across the industry. His expertise in power supply testing and his ability to build strong relationships have made him a trusted advisor to customers seeking reliable and efficient testing solutions.

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**

- **V2G Standard and Technology Update**

- **Introduction to Rexgear/ITECH Products**

- **Q&A**

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**

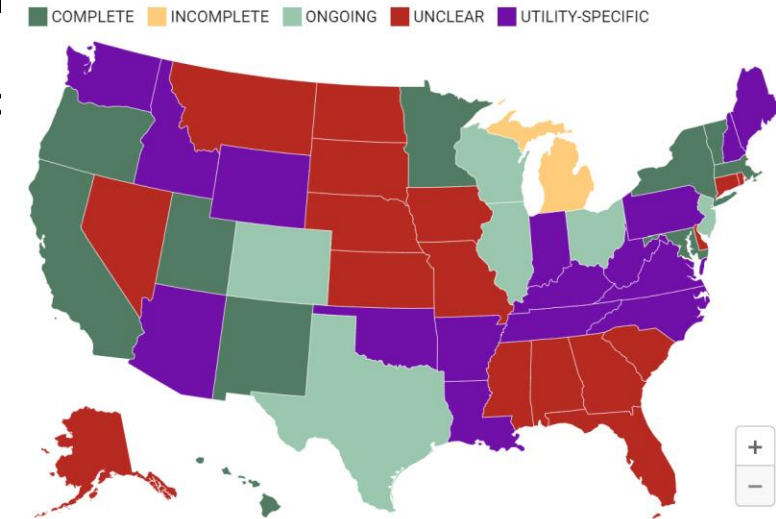 - Includes EV/EVSE manufacturers, utilities, alliances and government agencies

- **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**

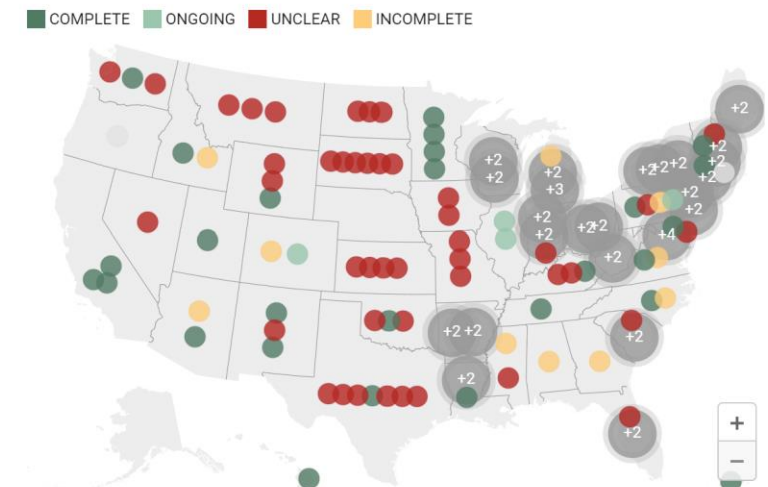 - Directly references IEEE 1547-2018 and 1547.1-2020 standards

Adoption of IEEE 1547 in the US

- **On February 12, 2020, NARUC approved a [resolution](#) recommending state commissions ad**

- **UL 1741 SB Revision adopted September 28, 2021– certification testing starts**

- **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 and other states require UL 1741SB with many more to follow
  - CEC's listing has 548 SB certified grid support inverters currently - growing


State Adoption Status
COMPLETE · INCOMPLETE · ONGOING · UNCLEAR · UTILITY-SPECIFIC

Utility Adoption Status
COMPLETE · ONGOING · UNCLEAR · INCOMPLETE

https://irecusa.org/resources/ieee-1547-2018-adoption-tracker/

IEEE 1547 Goals

- Interconnection and interoperability of DERs with electric power systems

- Different categories of devices and abnormal conditions to qualify

- Reference Point of Applicability (RPA) is location where interconnection/interoperability requirements shall be met – at the PCC

- Performance requirements apply to interconnection of either single DER unit based on that unit's ratings or multiple DERs within a single local EPS based on aggregate rating of all the DER units, ex. microgrid or EMS.

- Communication interface must be local to the DER unit itself, ex. not living on the cloud

- Measurement accuracies are specified in IEEE 1547-2018 Section 4.4
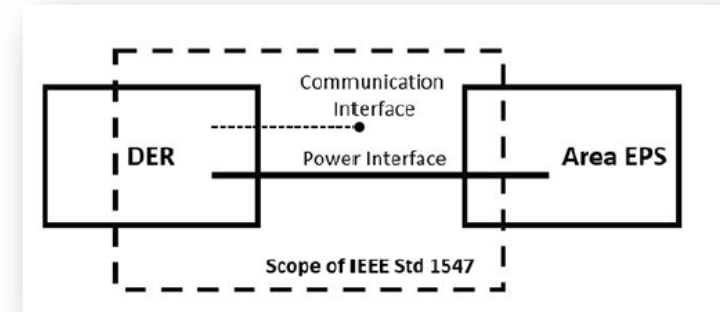
Cited from IEEE 1547-2018 standard

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

- **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**

- **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

- **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

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

- **Multi-day technical workshop provides essential training for staff**
  - Includes instruction using QualityLogic's Test Tool in a live inverter lab
  - Many NRTLs, OEMs, Utilities and other have taken this course to provide training for staff

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 inverter's electrical behavior**

- **Monitor power data collected from data collection devices (power analyzer, oscilloscope) to analyze the test criteria**

- **Current list of equipment supported**
  - Ametek MX/RS Series, Chroma, Keysight, NHR Grid Simulator, NF, Regatron grid simulators
  - Yokogawa WTx000, PX8000, Chroma, Dewetron, Virtrek, Power Analyzers
  - Yokogawa DL, Tektronix, Agilent, Instek, Virtrek, Teledyne & Lecroy, Rodhe&Schwarz, oscilloscopes
  - Magna-power SL Series, Chroma, TerraSAS, Keysight, Regatron, TDK, Ametek SGX DC power supply
  - New models added based on customer requests

New Features in Version 4.6

- **New Lab Equipment Models from Ametek and Rexgear/ITECH**
  - Ametek Sequioa Grid Simulator product lines
  - Rexgear/ITECH IT7900 grid simulator product line
  - Rexgear/ITECH IT6000C-IT6600C DC supply product line (including bidirectional)

- **Offline Analysis – ability to import and process previously collected power analyzer files**
  - Performs automatic data analysis to determine pass/fail for each of the supported 1547.1 grid support test

- **Pretest –Detects transient time after each volt/frequency step. Data collection accuracy information. Reports any voltage/frequency offsets found in grid simulator.**

- **Version 4.6 will be released to customers with active maintenance contract**

- **Coming soon**
  - SunSpec Modbus conformance test – free for those with modbus option
 - Additional grid simulator products from leading equipment vendors

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

- **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

		Test Function	No.Of Rounds	Measured time for execution in MODBUS (mins)
TYPE TESTS	MANAGEMENT TESTS	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 Prioirity	1	18

Total Run time (Hours)	32.0166667

Actual QL Test Results

Demonstration Inverter Lab Overview
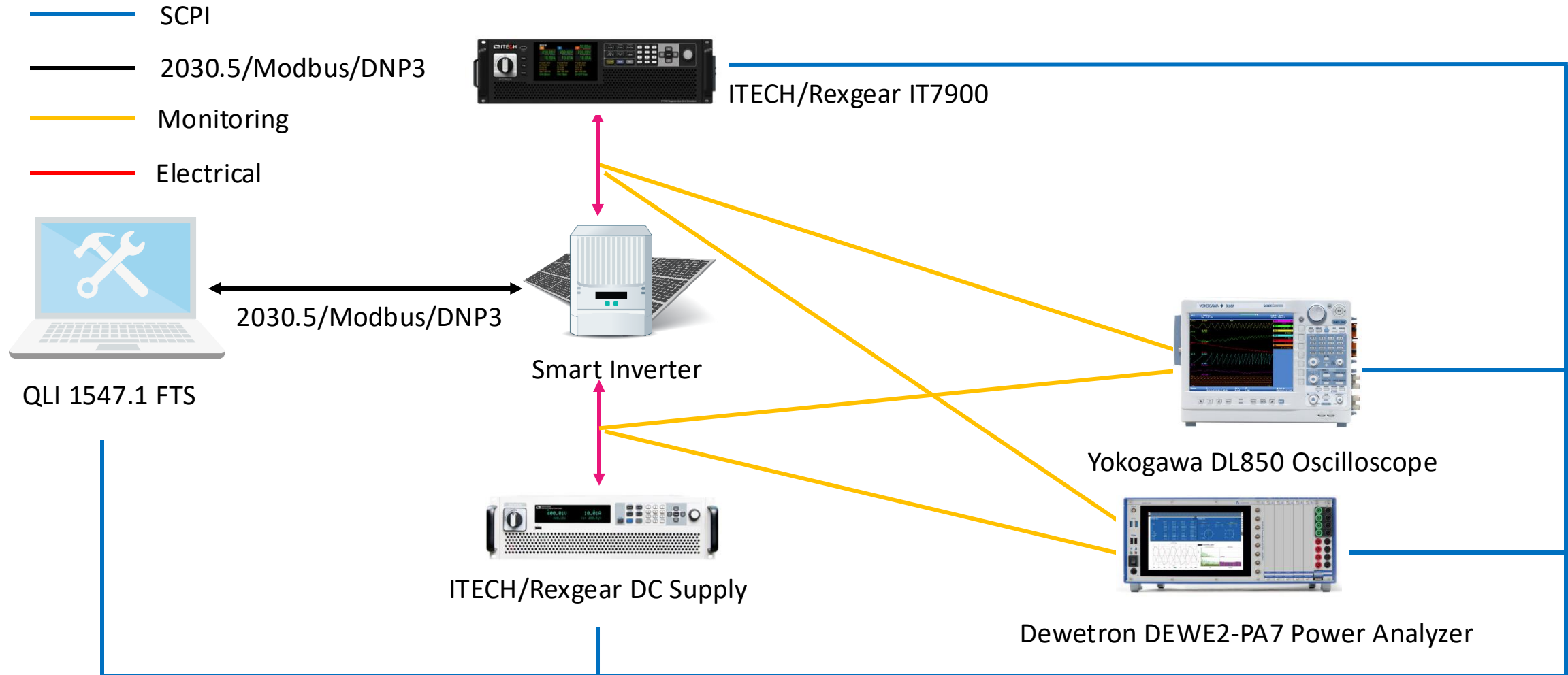
EVSE / EV Testing Lab Overview
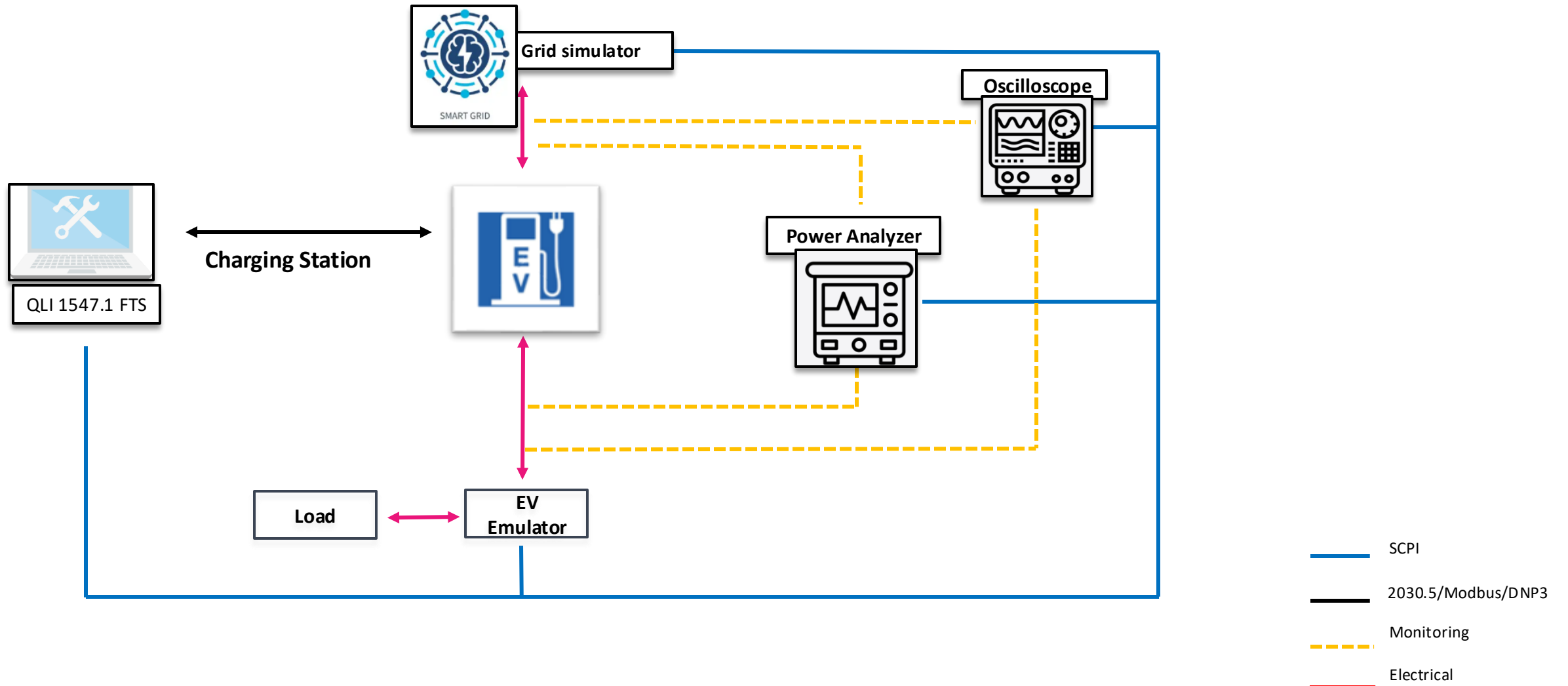
Automated Data Analysis – New Feature

- **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, QL has developed an automated data analysis as a new feature to IEEE 1547 test tool**

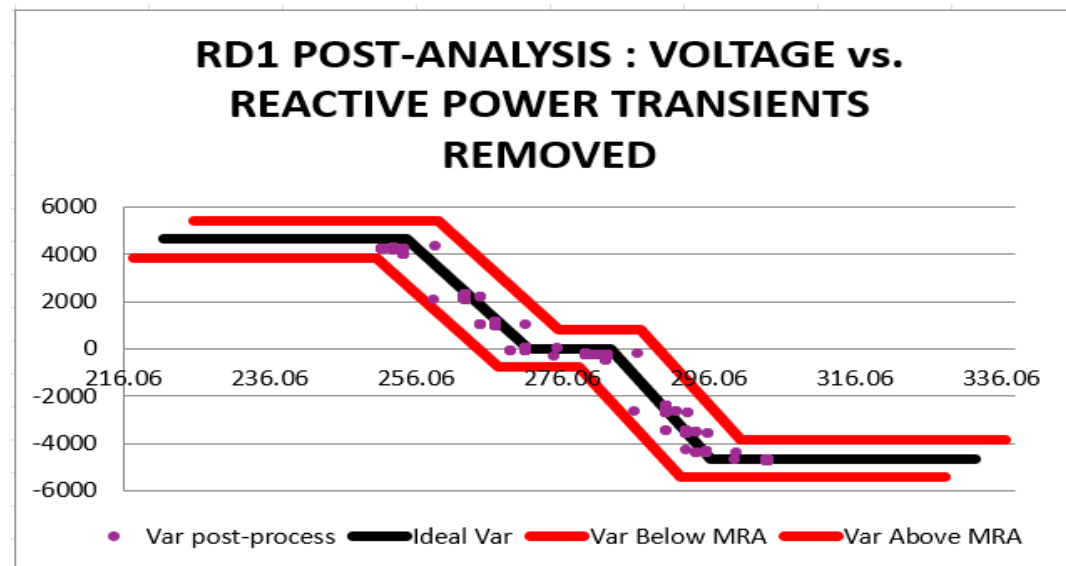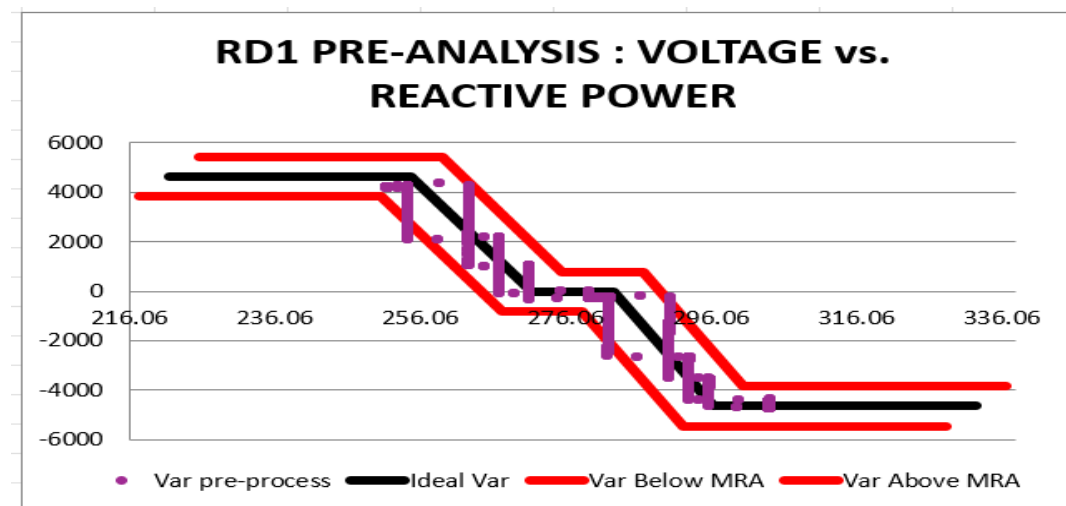**Table 3—Minimum measurement and calculation accuracy requirements for manufacturers[a]**

Time frame	Steady-state measurements			Transient measurements		
Parameter	Minimum measurement accuracy	Measure-ment window	Range	Minimum measurement accuracy	Measure-ment window	Range
Voltage, RMS	$(\pm 1\% \, V_{nom})$	10 cycles	0.5 p.u. to 1.2 p.u.	$(\pm 2\% \, V_{nom})$	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	$(\pm 5\% \, S_{rated})$	10 cycles	$0.2 \, \text{p.u.} < P < 1.0$ p.u.	Not required	N/A	N/A
Reactive Power	$(\pm 5\% \, S_{rated})$	10 cycles	$0.2 \, \text{p.u.} < Q < 1.0$ 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
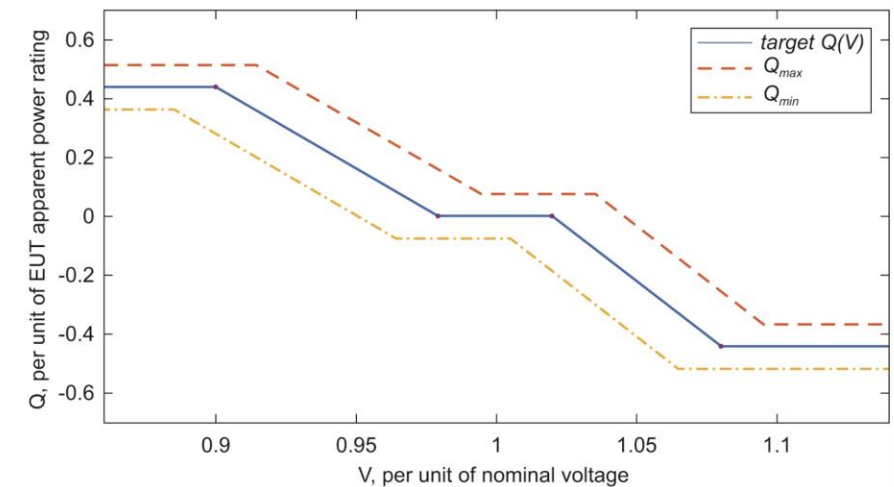
Automated Data Analysis from QualityLogic

- Covers each of the 1547.1 Type Tests including Management

- Analysis files are generated at the completion of each function test in 1547

- Compatible with all DAS QL test tool currently supports

- All analysis files generated are calculated using the strict MRA requirements of the 1547 standard.

- Auto removes all allowed transient points

- Auto detects and calculates steady state measurements

- New version 4.6 includes:

  - Offline analysis feature to process previously run tests

  - Compliant results are displayed and flagged as PASS

  - Noncompliant results are displayed and flagged as FAIL

RD1 PRE-ANALYSIS : VOLTAGE vs. REACTIVE POWER

• Var pre-process ——Ideal Var ——Var Below MRA ——Var Above MRA

RD1 POST-ANALYSIS : VOLTAGE vs. REACTIVE POWER TRANSIENTS REMOVED

• Var post-process ——Ideal Var ——Var Below MRA ——Var Above MRA

Challenges Observed During 1547 Testing

- Interoperability execution – Typical failures that commonly happens are scale factor issues, adopting of curve, number of curve points, 2030.5 event creation and ending, and many more. QL test tool enables OEMs to find these issues early on during development.

- Analyzing data – Volt Var has 5 rounds when running type test. Each round collects a data file that needs manual processing. Processing data includes plotting MRA boundaries, removing transients, zooming in and out specific areas. This is done automatically when running QL test tool.

- Must trip tests have many corner cases that make testing difficult to execute. For example, how to test OV1 at 1.2p.u. at 13s when OV2 is fixed at 1.2p.u. at .16s. The QL test tool provides multiple methods to perform Must Trip tests that enables options for users to select.

- Equipment Automation – Creating voltage and frequency scripts that follow the strict standard requirements prove to be difficult. In 1547.1-2020, there now is a ROCOF (rate of change of frequency) requirement for all frequent steps that is done. There are also many voltage changes. QL test tool automates all voltage/frequency transient steps required in 1547 compliance testing.

Live Demonstration of QualityLogic 1547.1 Test Tool

Standardization of V2G (and VGI)

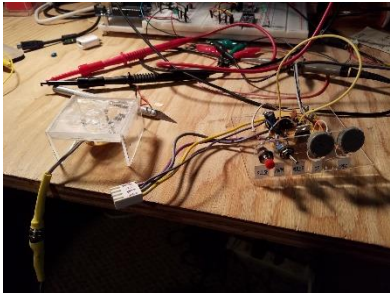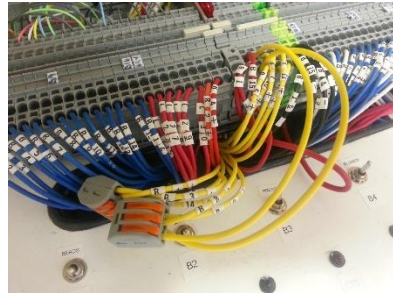**Building a scalable, interoperable, secure V2G infrastructure**

Use Case: V1G Charge Management

- One directional EVSE power flow
- Grid Operator interactions – when to charge, charge rate, etc
- Mitigation of demand spikes – duck curve
- But no energy/power support for the grid

Use Case: V2G Grid Support Systems

- Bi-directional power flow
- Grid Operator interactions – when to charge, export, etc
- UL 1741 certification for interconnections to NA Grids
- Energy/power support for the grid

Utility DERMS

CNO/Aggregator

Power Flow

V1G: Managed Charging

V2G: DER Interconnection

Power Flow

V2G: Integrated Bi-Directional Inverter

Telematics

Importance of Standardization for V2G

The Current V2G Model

- Non-standardized interconnections and operations – unique projects
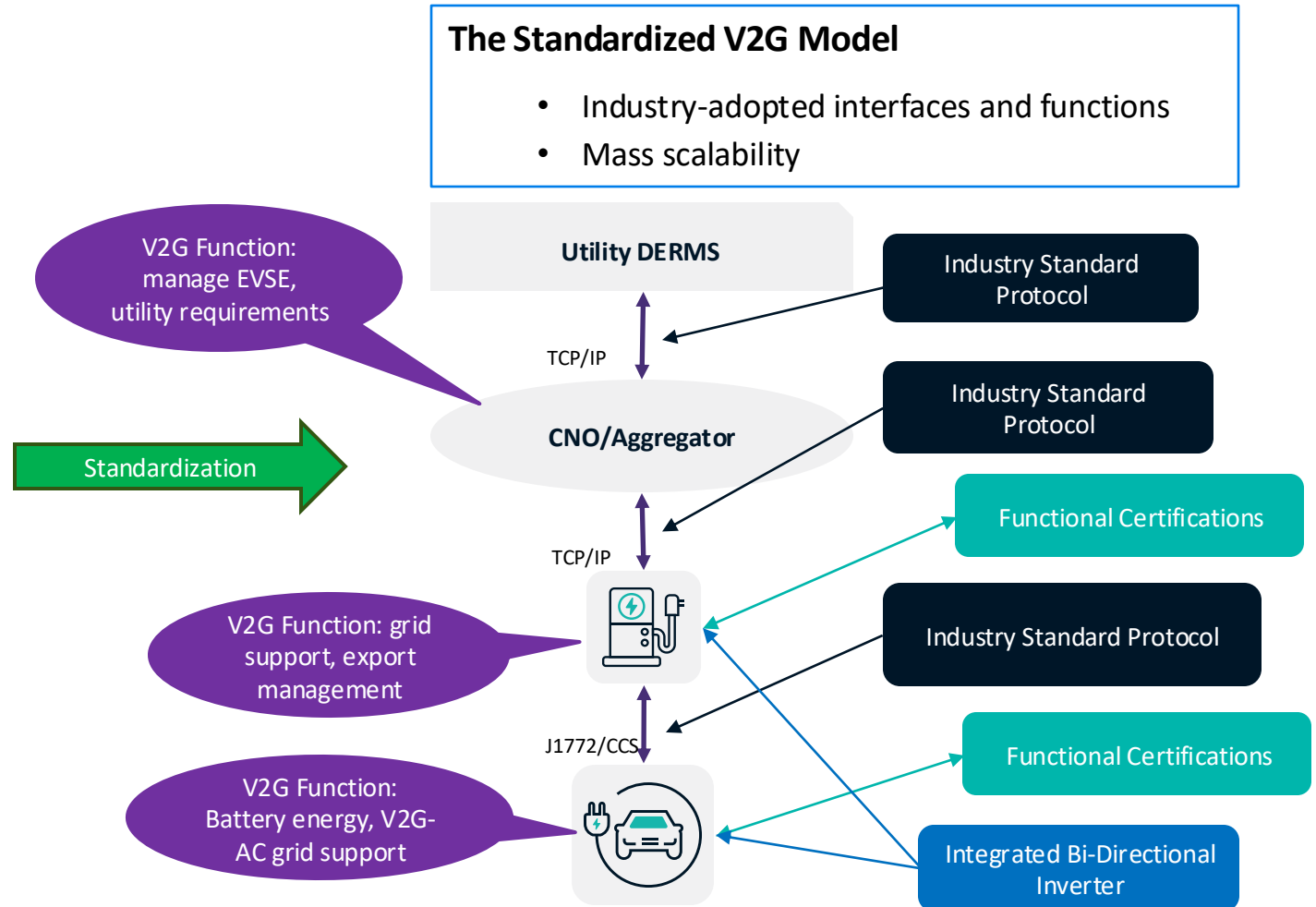- Costly to scale

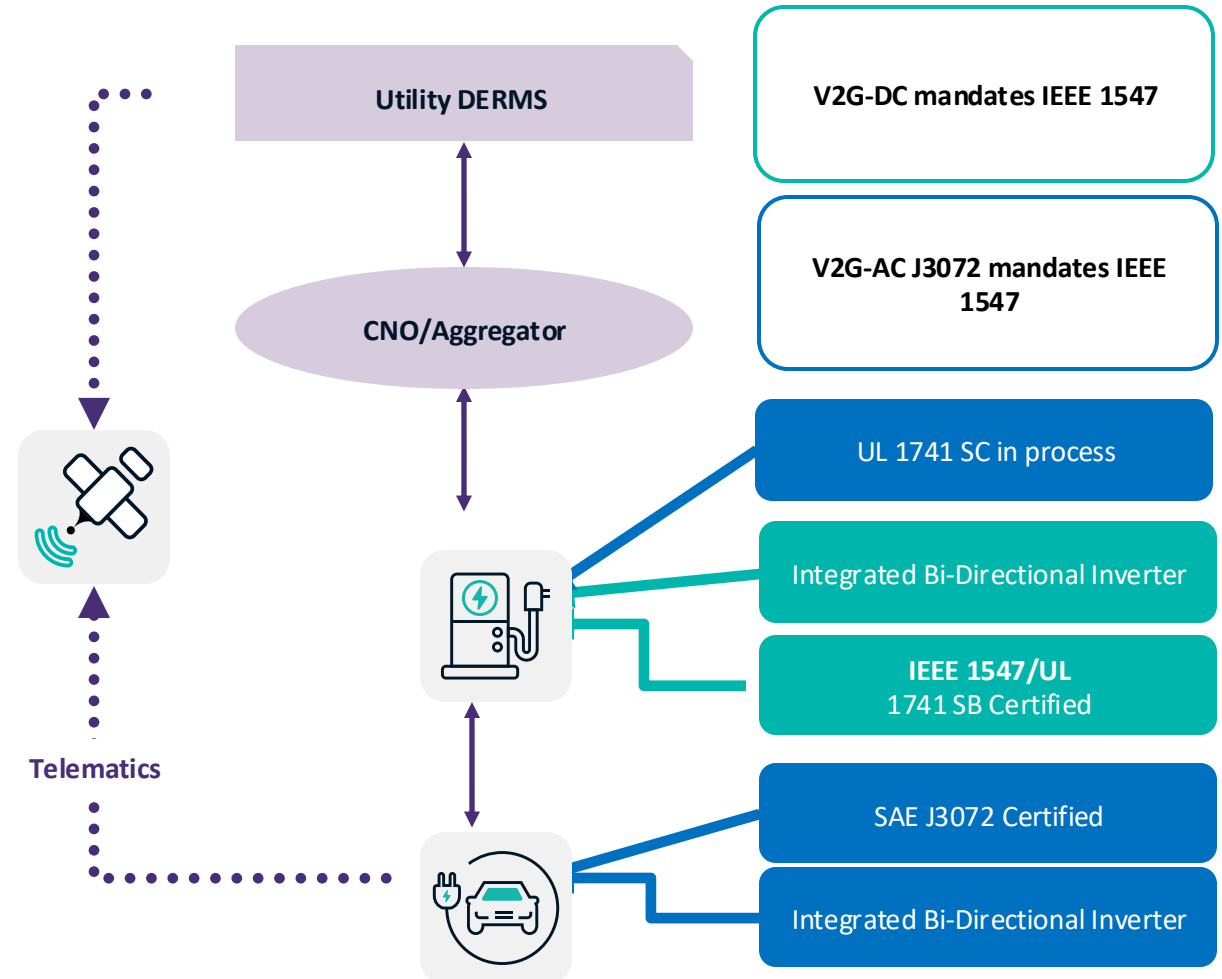**V2G System A**

V2G System B

V2G System C

Standardization

The Standardized V2G Model

- Industry-adopted interfaces and functions
- Mass scalability

Utility DERMS

TCP/IP

CNO/Aggregator

TCP/IP

J1772/CCS

V2G Function: manage EVSE, utility requirements

V2G Function: grid support, export management

V2G Function: Battery energy, V2G-AC grid support

Industry Standard Protocol

Industry Standard Protocol

Functional Certifications

Industry Standard Protocol

Functional Certifications

Integrated Bi-Directional Inverter

US Interconnection Standards for EVSE as DER

IEEE 1547 is a REQUIREMENT for V2G in the US

- Interconnection standard for all DERs
- ANY EXPORT to the Grid requires IEEE 1547 compliance.
- IEEE 1547-2018 is the latest version and is required starting in 2022
- SAE J3072 requires IEEE 1547 conformance in onboard grid support inverters

EVs as DERs are treated like other DERs: subject to Utility Interconnection requirements

- UL 1741 SB is the new certification requirement – certifies IEEE 1547 Compliance
- V2G-DC can be interconnected with UL 1741 certification TODAY!

Utility DERMS

CNO/Aggregator

Telematics

V2G-DC mandates IEEE 1547

V2G-AC J3072 mandates IEEE 1547

UL 1741 SC in process

Integrated Bi-Directional Inverter

IEEE 1547/UL 1741 SB Certified

SAE J3072 Certified

Integrated Bi-Directional Inverter

Bi-Directional EVs

Only a limited number of EVs sold in the US offer any form of bidirectional charging. They include:

- Ford F-150 Lightning (V2G)
- Genesis GV60 (V2L)
- Hyundai Ioniq 5 (V2L)
- Hyundai Ioniq 6 (V2L)
- Kia EV6 (V2L)
- Kia Niro (V2L)
- Mitsubishi Outlander PHEV (V2L)
- Nissan Leaf (V2H, V2G)
- VW ID.4 (V2H)
- Polestar 3 (V2G)
- Tesla Cybertruck (V2L) (all models will support bidirectional by 2025)
- BMW, Volvo, and Ford all testing bidirectional functionality

Standards

- SAE J3072 V3 Published in June 2024. Includes placeholder for ISO 15118-20 Amend 1. Expect 2-25 update with UL 1741 SC and ??

- SAE J3400 in balloting.

- UL 1741 SC still in development with intent to publish first review draft ASAP (Q3?)

- OCA hosting Plugfest with V2.1 (IEEE 1547 support) in September - September 2024 Plugfest Hosted by Vector registration (office.com)

- IEEE 2030.5-2023? Approved. Not yet implemented in CSIP or IEEE 1547.

- IEEE 1547-2025(6) includes V2G Task Group dealing with V2G-AC. Informative Annex EV in draft form. Recognizes J3072; UL 1741 SC; attempting to define a "dynamic" interconnection recognizing J3072 compliant EVs and UL 1741 SC compliant EVSEs.

- CharIN ISO 15118 certification programs being supported by key auto OEMs.

- ISO 15118 continuing to develop Amendment 1 to ISO 15118-20 to address IEEE 1547.

Policy

- Maryland is first to pass V2G legislation - Maryland is first US state to pass vehicle-to-grid legislation (energy-storage.news).

- CA SB 59 will enable requirement of bi-directional EVs - https://sd09.senate.ca.gov/news/20240831-ca-legislature-greenlights-skinners-climate-bills-including-sb-59-using-evs-power.

Implementations

- Tesla has confirmed all its electric vehicle models will support bidirectional charging functionality by 2025.

- Latest list of V2X vehicles Everything You Need to Know About Bidirectional Charging and the EVs That Support It (msn.com)

- **Implementations**
    - V2GForum in October will likely feature live demos of V2G technology from Fermata Energy, Wallbox/Kia/Weavegrid and QualityLogic/Keysight and an EVSE vendor.
    - QualityLogic and Keysight planning to demonstrate V2G certification testing for UL 1741 SB. More at V2G Business, Policy & Technology Forum 2024 (v2gforum.com).
    - Most EVSE vendors are developing bidirectional capabilities and have V2G on their roadmaps.

QLI 1547.1 FTS

Service Panel

DTE/ACM

Keysight EV Emulator

Service Panel

DTE/ACM

Power Analyzer

Keysight Grid Simulator

—— (blue)	SCPI
—— (black)	2030.5/Modbus/DNP3
- - - (yellow)	Monitoring
—— (red)	Electrical
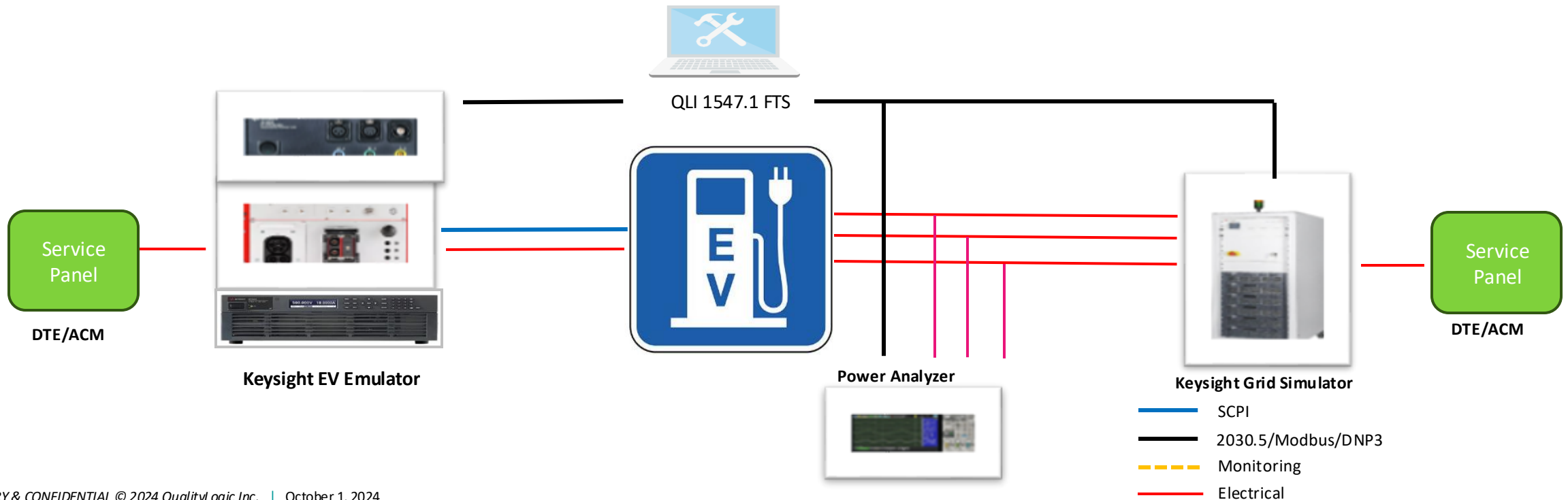
Introduction to Rexgear Equipment Product Line

~ by Luis Veliz of Rexgear

Grid Simulators

- **Highest Power Density in the Market**

2KVA / 3KVA / 4KVA / 5KVA, 1ø
6KVA, 1ø or 3ø all in 1U Size (No Front Panel)

2KVA / 3KVA / 4KVA / 5KVA, 1ø
6KVA, 1ø or 3ø all in 2U Size (Touch Screen)

6KVA / 9KVA / 12KVA / 15KVA / 21KVA, 1ø or 3ø all in 3U Size (Touch Screen)

Scalable up to 165KVA or 231KVA in a single 37U Cabinet, parallelable up to 1.155MVA

Features

- **ITECH IT7900 Series**
  - Four-Quadrant grid simulator
  - From 2KVA, 1ø (1U) up to 21KVA (3U) 3ø
  - Scalable to 231KVA in a single 37U Cabinet and up to 1MVA total power
  - AC, DC, AC+DC or DC+AC Output Modes
  - Pre-Compliance anti-islanding test mode
  - Programmable Output Impedance
  - Compliance tests such as LVRT / Phase Jump / Frequency variations and Harmonic Injection
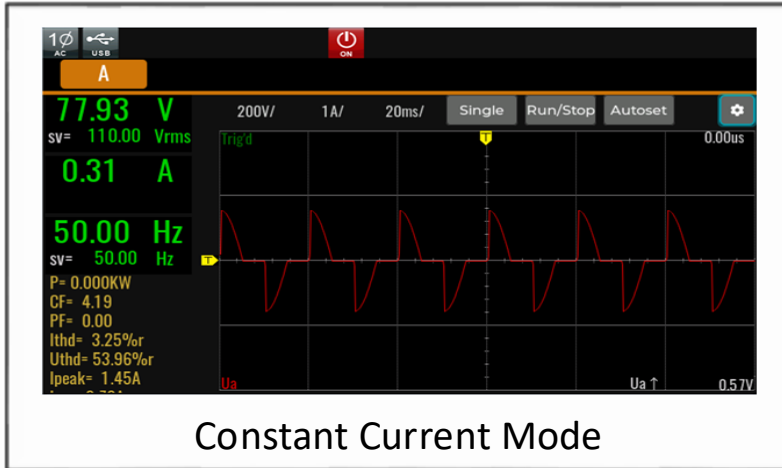 - Supports CC / CV / CP modes
  - Power Amplifier function for PHiL applications

- **ITECH IT7900P Series**
  - *Includes all features from our IT7900 Series plus:
  - Higher Frequency bandwidth from 16Hz – 2400HZ as a source and 16Hz to 500Hz as a Regenerative Load
  - CC / CP / CR / CS / CC+CR / CE mode

REXGEAR
Your Power Solution Expert
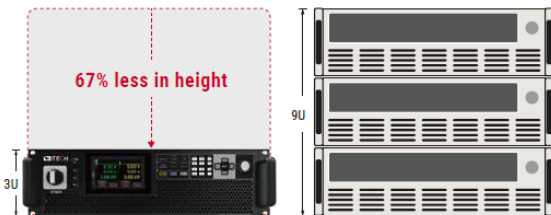
Main Differentiators

Constant Current Mode

Harmonic Analysis Function (LIST)

CV and CC Harmonic Simulation

Anti-Islanding Function
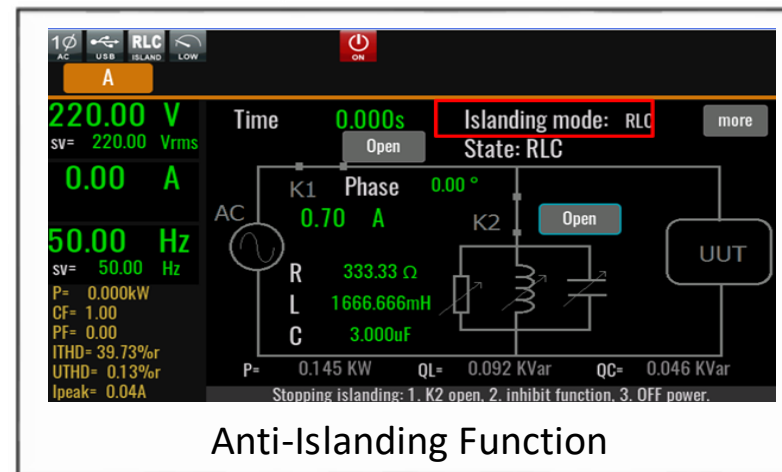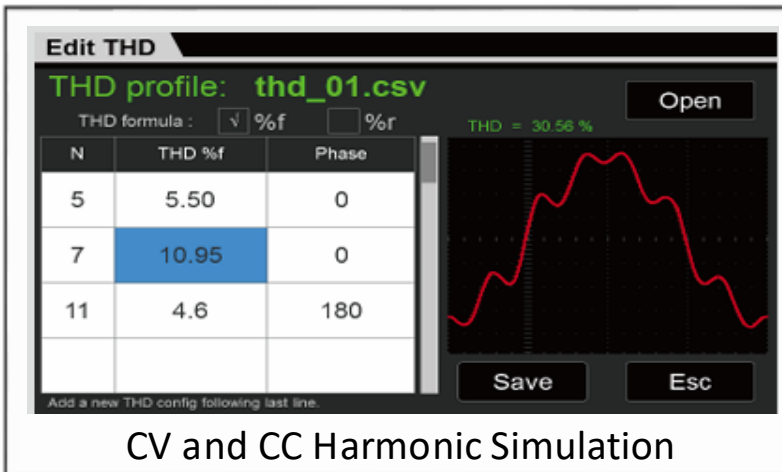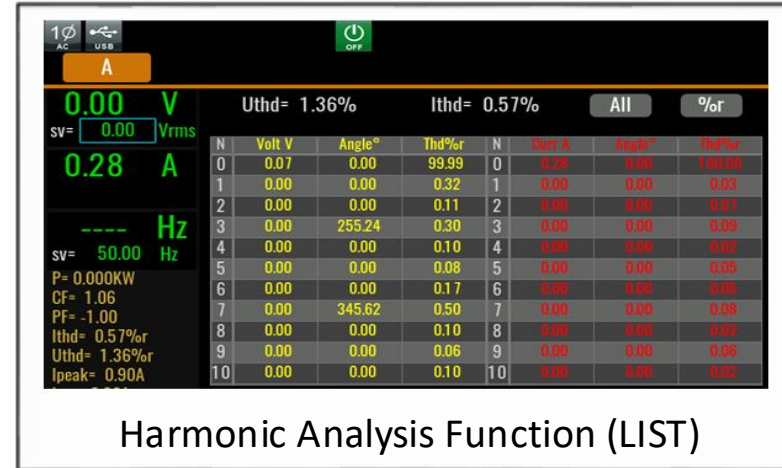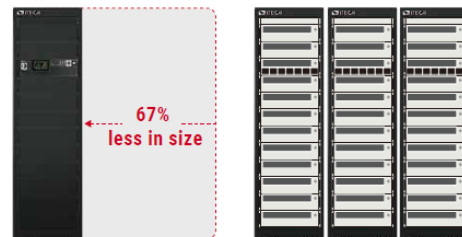
- **Highest Power Density in the Market**

Dual Output 42KW in 3U Size
- 600VDC / 1200VDC
- 800VDC / 1600VDC
- 1200VDC / 2250VDC

Independent / Series / Parallel Config

IT6600C/3U **VS** Others/9U

67% less in height

3U   9U

IT6600C/420kW **VS** Others/420kW

67% less in size

Scalable up to 420KW in a single 37U Cabinet, parallelable up to 10MW

Battery and SAS Sim

- **ITECH 6600C Series**
    - Bi-Directional Power Supply and Regenerative Load
    - Highest Power Density at 42KW (3U)
    - Independent dual-channel design with independent, series and parallel control
    - Dynamic response ≤200us
    - Rise time ≤1ms
    - CC/CV priority
    - Battery Simulation, Battery Cycling, SAS and Fuel Cell Simulation
    - Built-in IEC 61000-4-17/IEC 61000-4-29 waveforms
    - Built-in Automotive voltage curves, including LV123, LV148, ISO21498-2, etc.
   - Programmable Output Impedance

REXGEAR
Your Power Solution Expert
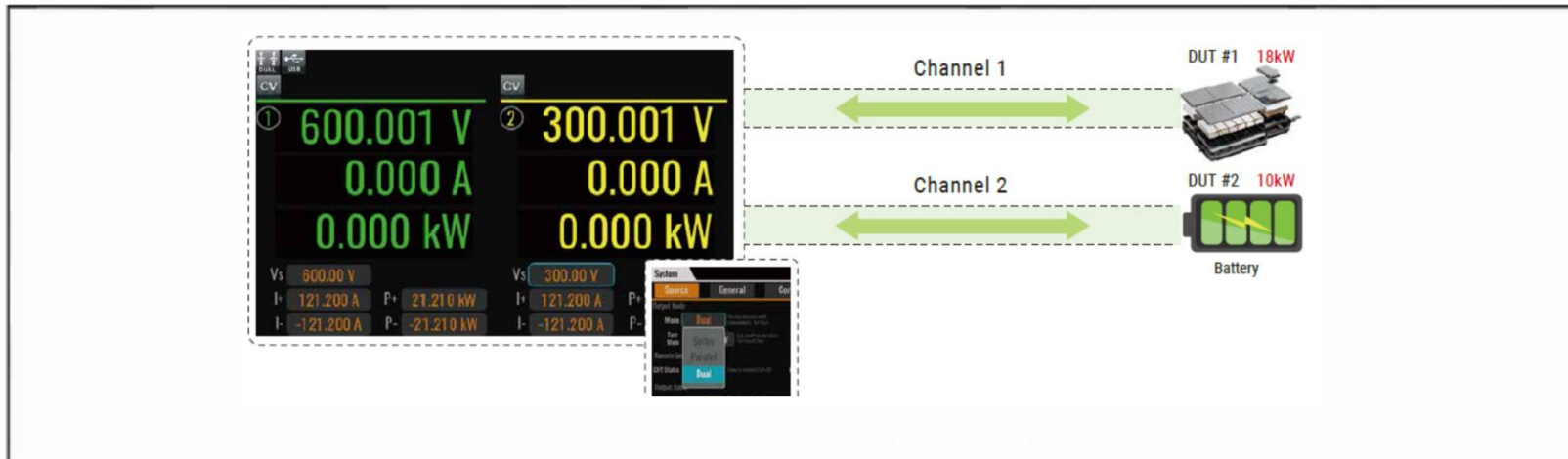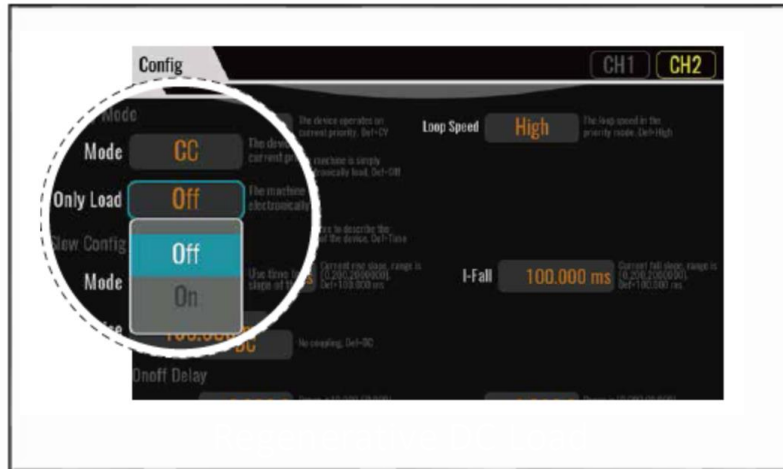
- **Fiber Optic Communication for Paralleling**

  - Seamless Primary to Secondary communication

  - No voltage or current spikes due to communication latency due to slow speed or poor accuracy of traditional paralleling methods

  - No voltage or current spikes due to communication latency due to slow speed
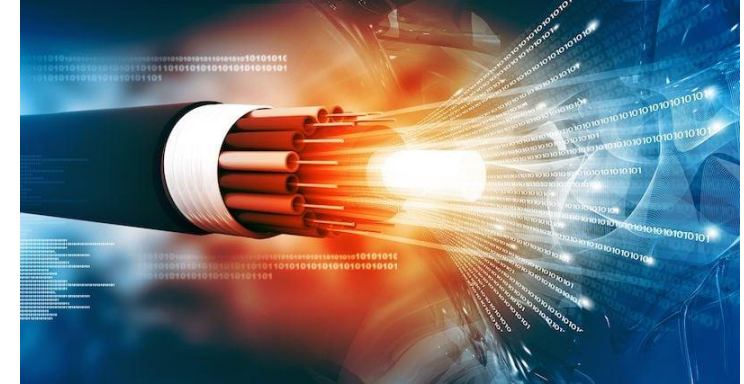
- **Hardware-in-the-Loop**

  - ITECH's products are ready to be used in with any Hardware-in-the-Loop controllers to take you modeling simulation to the real world as a grid simulator, Battery Simulator or Solar Array Simulator

  - Our units can be controlled via Analog control and readback for real-world testing and fault simulation

- **Questions?**

  - For more information about Rexgear, email luis@rexgear.com

Closing Summary

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 IEEE 1547 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

  - 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**

- **V2G technology overview**

- **Introduction to Rexgear 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 info@qualitylogic.com for any further questions**