Sandia National Laboratories

DWEA DISTRIBUTED WIND ENERGY ASSOCIATION

Distributed Wind 2025
Residence Inn Capital View, Arlington, VA

Automating Interconnection Standards Testing for Distributed Wind Power Converters

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U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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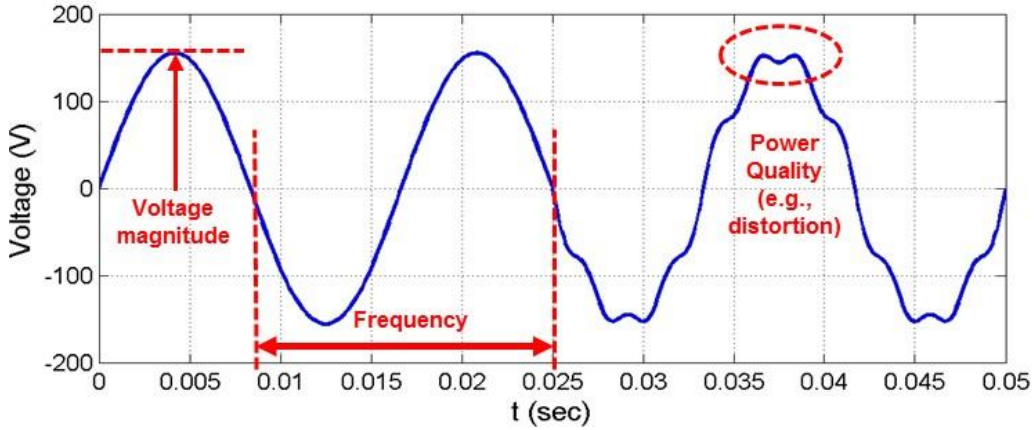
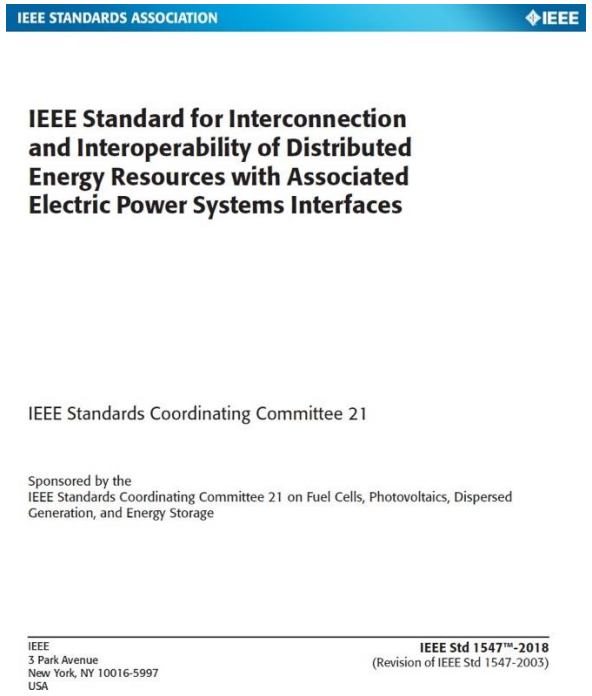
Importance of DER Certification

- **Standardized certification to verify the performance of distributed energy resources (DERs) is critical**
- This process **ensures DER equipment will operate and communicate as anticipated** in the field by inspecting "corner cases" that could lead to unexpected device behavior:
  - Vendors can be certain their equipment will function as designed
  - Provides grid operators confidence the equipment is reliable
- The American interconnection standard, IEEE Std. 1547, was updated in 2018 with new grid-support functionality and interoperability requirements.
- IEEE Std. 1547.1 is nearly updated to include the conformance testing requirements for 1547. This includes hundreds of test cases for each DER.




IEEE STANDARDS ASSOCIATION IEEE

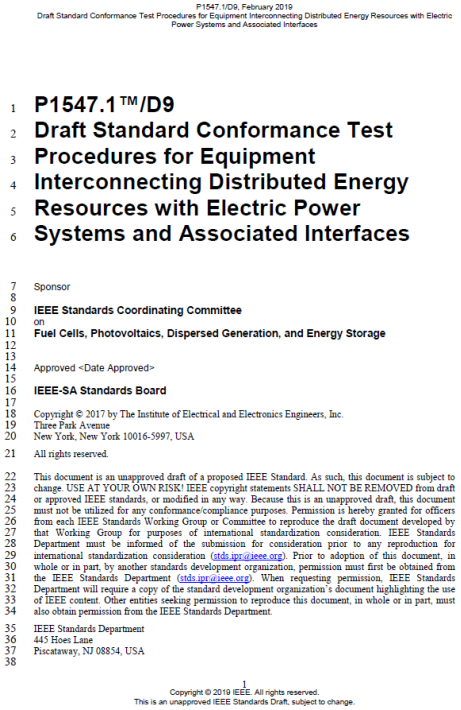
IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

IEEE Standards Coordinating Committee 21

Sponsored by the
IEEE Standards Coordinating Committee 21 on Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 1547™-2018
(Revision of IEEE Std 1547-2003)


P1547.1/D9, February 2019
Draft Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces

P1547.1™/D9
Draft Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces

Sponsor

IEEE Standards Coordinating Committee
on
Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage

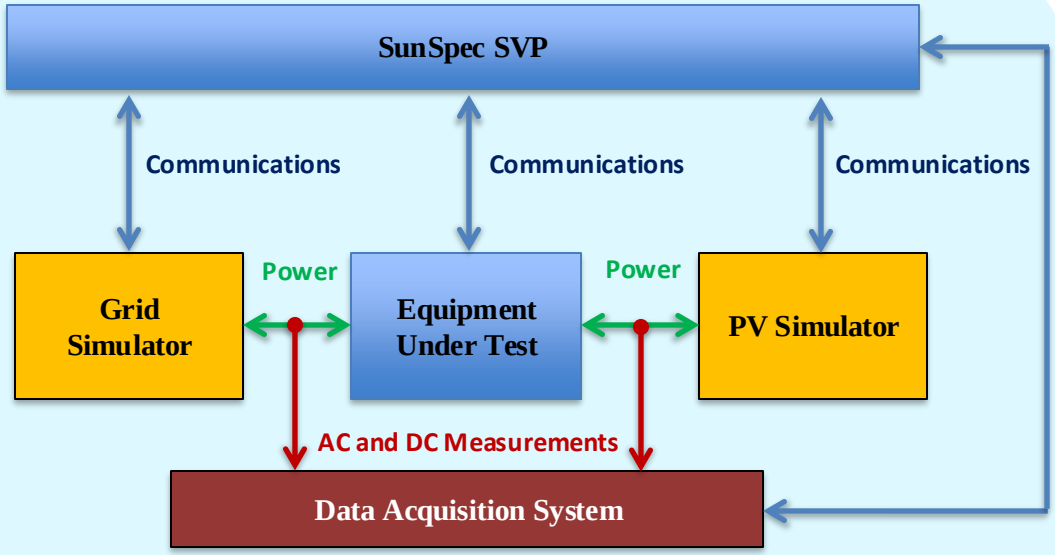
Approved <Date Approved>

IEEE-SA Standards Board

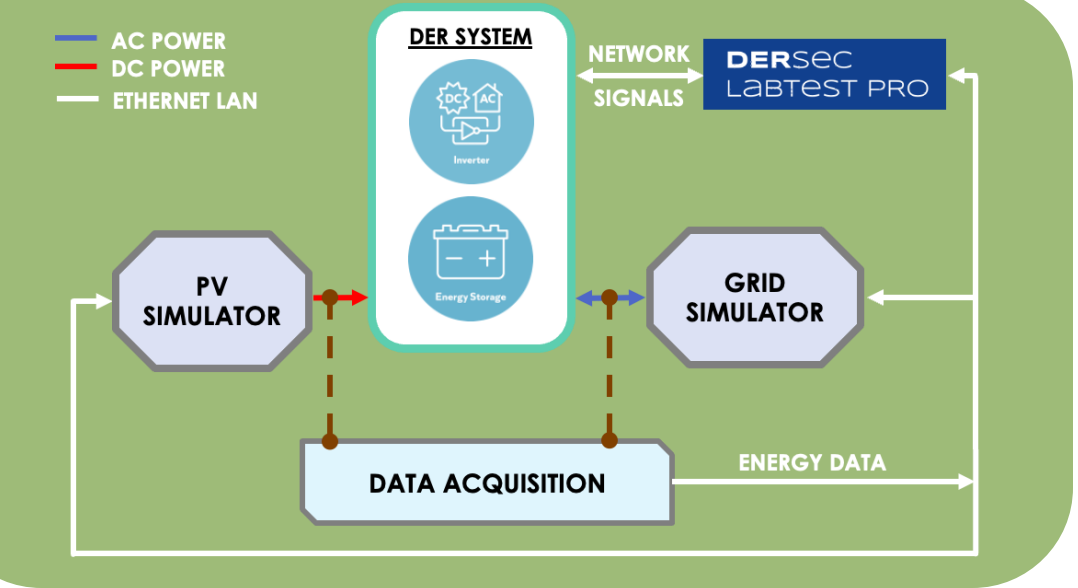
What is the System Validation Platform?

- ***The System Validation Platform (SVP) is a fully scriptable automated certification interoperability platform.***

- The SVP communicates to:
  - *Grid simulators, battery/PV simulators*
  - *Equipment under test*
  - *Data acquisition systems*
  - *Others (loads, switches, HIL environments, etc.)*



- ***The Wind Interconnection System Platform (WISP) project, funded by the Department of Energy (DOE)/Office of Technology Transition (OTT) is an effort to enable testing distributed wind.***



Links:

http://sunspec.org/sunspec-svp
https://dersec.io/dersec-labtest

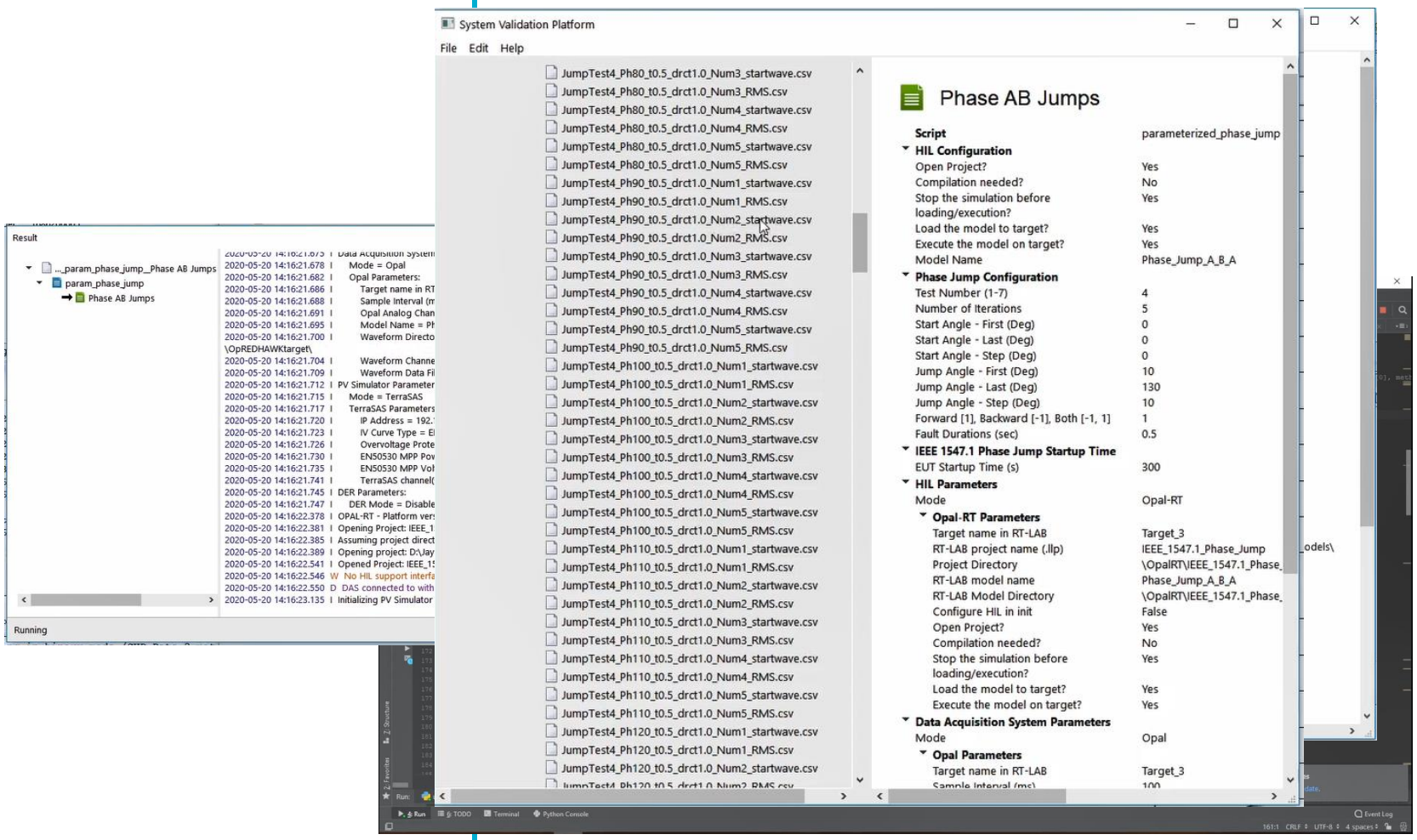
How does this project helps testing power converters?

Impacts:

- Although testing procedures such as IEEE 1547.1 have been developed to facilitate the testing process, executing these tests for a given device can be challenging.
- As DER technology advances, standards are updated and require amendments, meaning that newer devices need to be recertified.
- This platform can facilitate the certification and re-certification of distributed wind power converters, reduce costs and execution time for the distributed wind industry, and ultimately increase the adoption of DW technology.

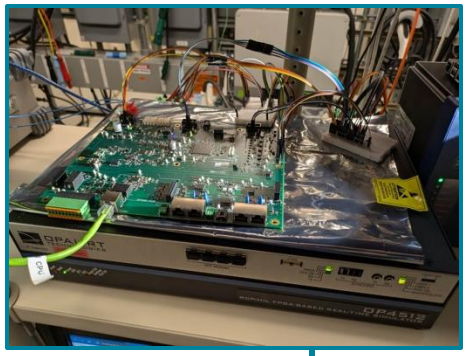
Example:

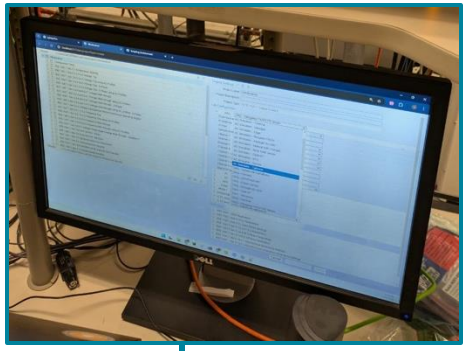
The SVP can be modified to automate interconnection standards testing for wind turbine power converters.

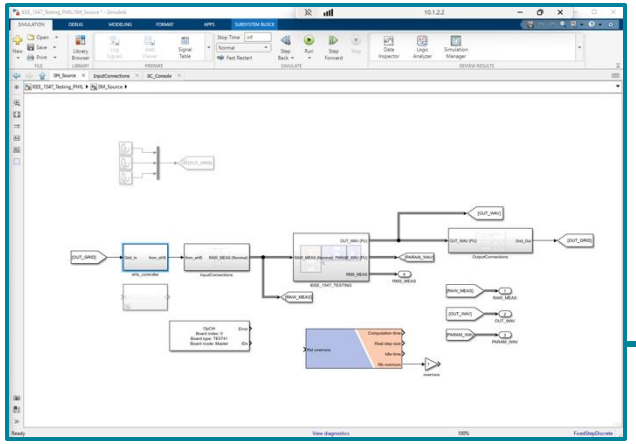


Implementing it in Control Hardware-in-the-Loop

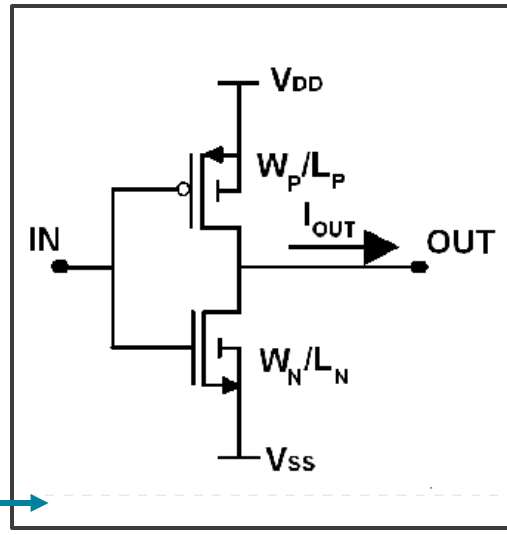
This diagram illustrates how Control Hardware-in-the-Loop can be used to test a distributed wind power converter controller.







Opal-RT FPGA



PWM

Feedback Signals

Hardware Controller

Settings

Data

DERSec LabTest

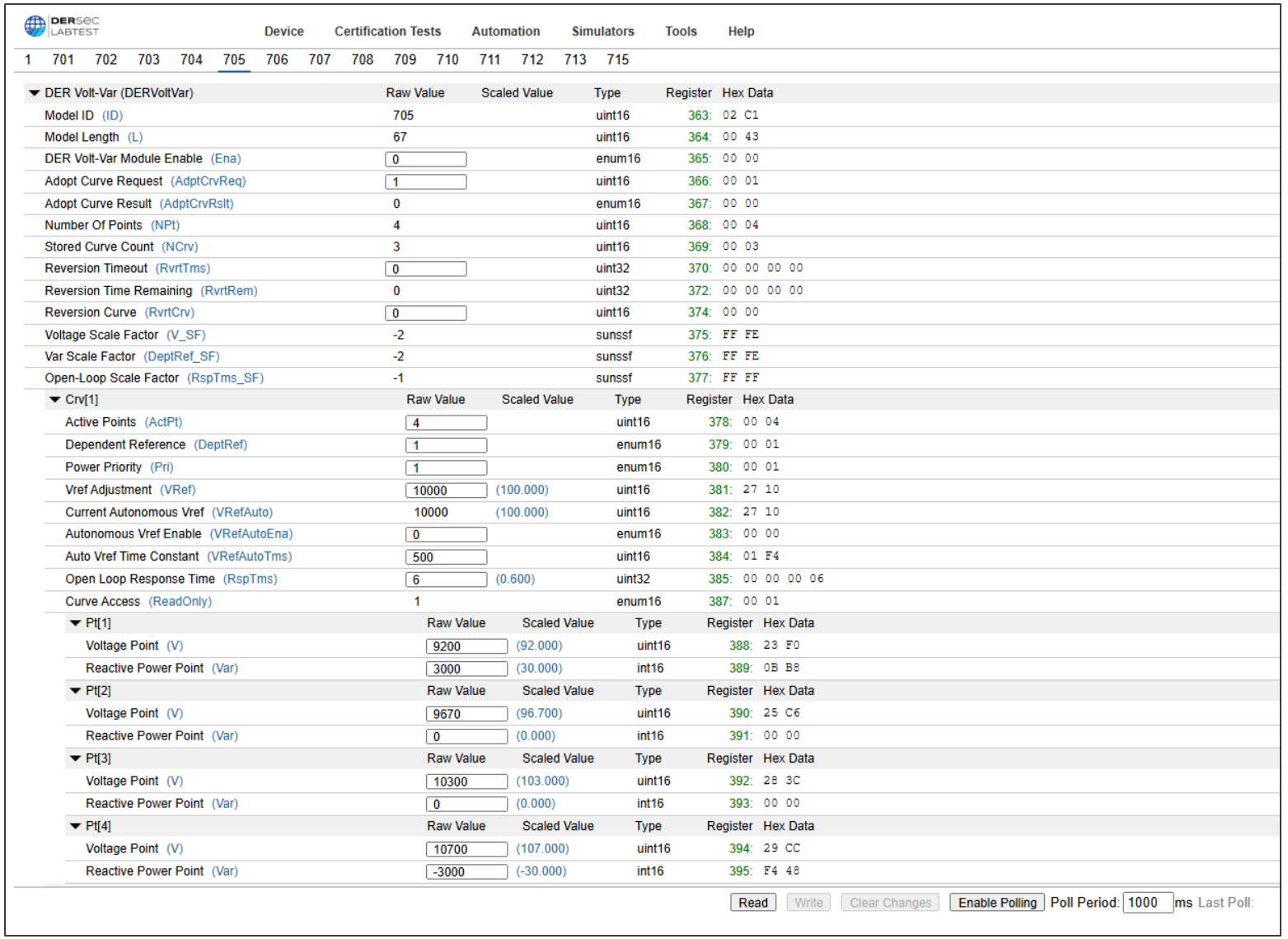
User Interface

Data

DERSec LabTest Test Interface

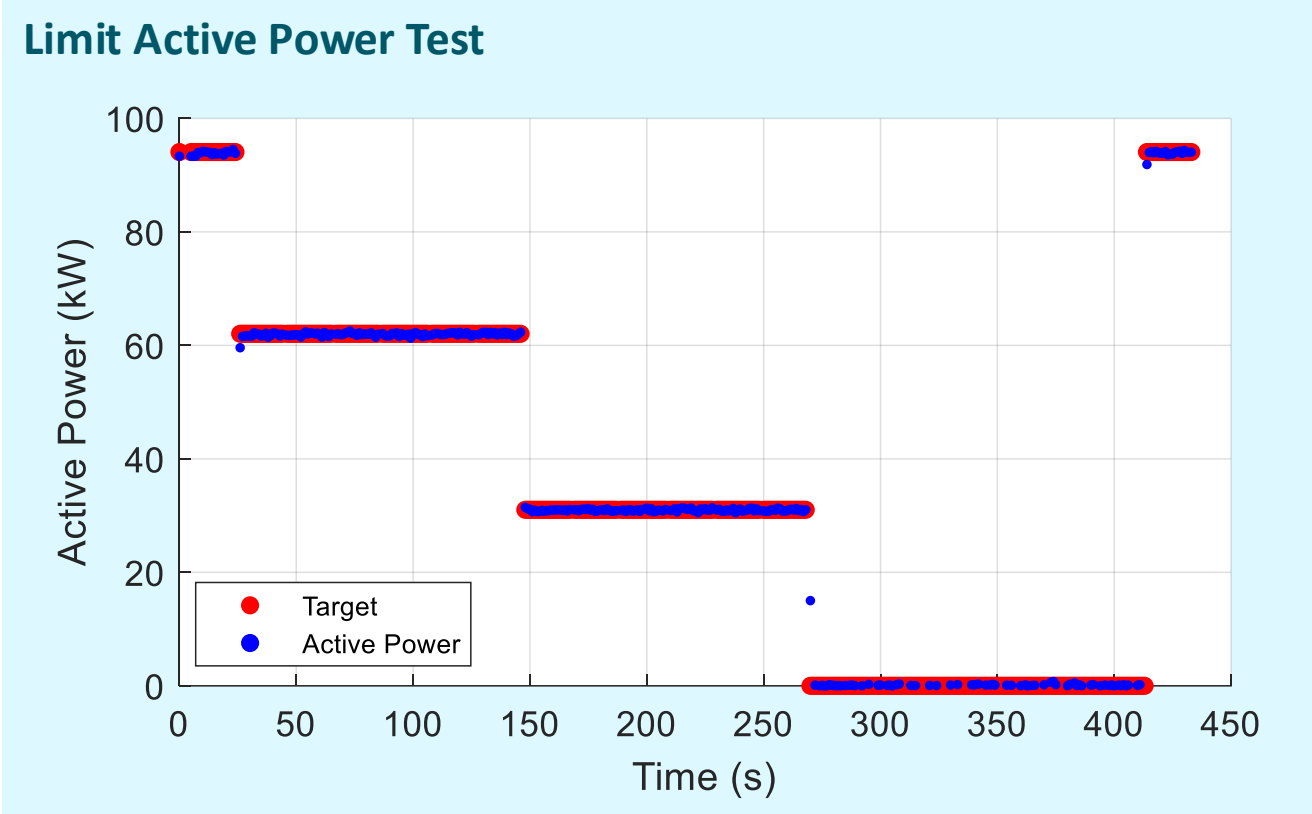
- The DERSec LabTest software allows setting a variety of parameters depending on the test.

- In this example, the software allows setting a variety of volt-var curve settings:
  - *Voltage points*
  - *Reactive power points*
  - *Power priority*
  - *Open loop response time*
  - *Time constants*



Control Hardware-in-the-Loop Results

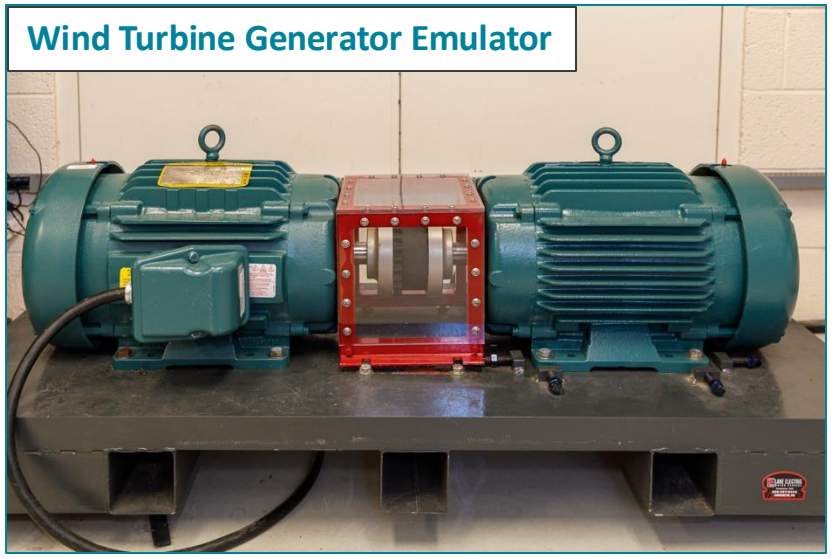
- The following example illustrates a representation of the *Limit Active Power Test*.
- For this test, three levels of power curtailment are shown (100%, 66%, 33%, and 0%).
- These tests are initiated by the SunSpec Modbus interface.
- Notice from the *Target (red)* and *Active Power (blue)*, that they produce the desired response from the Windurance controller connected to the Control Hardware-in-the-Loop system.



Testing the Power Converter in Power Hardware-in-the-Loop

Next step include:

- Connecting the control board to Sandias Power Hardware-in-the-Loop platform and testing the Windurance power converter.
- Performing a variety of IEEE1547 and UL1741 experimental tests.
- Comparing Control Hardware-in-the-Loop and Power Hardware-in-the-Loop results.



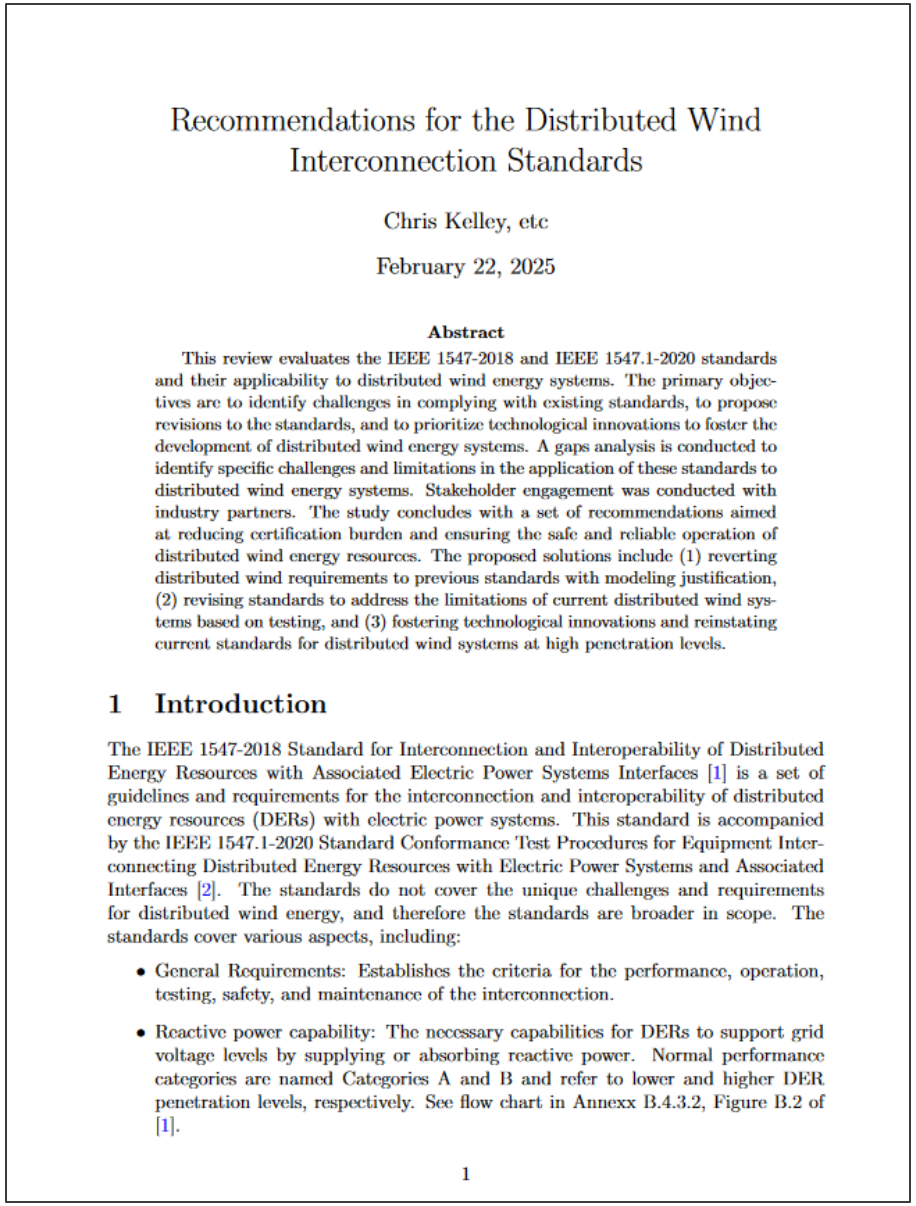
Wind Turbine Generator Emulator

Windurance Power Converter

Distributed Wind Interconnection Standards (DWIS)

In addition, this work is also evaluating recommendations to interconnection standards:

1. *What are the main challenges you face in your distributed wind products or research?*
2. *What distributed wind energy technologies are most important to enabling safe and reliable growth of distributed wind interconnection with other DERS and electric power systems?*
3. *What research opportunities are there to better integrate distributed wind with battery storage and PV solar?*
4. *What parts of the IEEE 1547 and 1547.1 standards are difficult to meet or add significant cost to your product?*
5. *What recommendations would you make for improving the IEEE 1547 and 1547.1 standards to better accommodate distributed wind energy systems?*



Recommendations for the Distributed Wind Interconnection Standards

Chris Kelley, etc

February 22, 2025

Abstract

This review evaluates the IEEE 1547-2018 and IEEE 1547.1-2020 standards and their applicability to distributed wind energy systems. The primary objectives are to identify challenges in complying with existing standards, to propose revisions to the standards, and to prioritize technological innovations to foster the development of distributed wind energy systems. A gaps analysis is conducted to identify specific challenges and limitations in the application of these standards to distributed wind energy systems. Stakeholder engagement was conducted with industry partners. The study concludes with a set of recommendations aimed at reducing certification burden and ensuring the safe and reliable operation of distributed wind energy resources. The proposed solutions include (1) reverting distributed wind requirements to previous standards with modeling justification, (2) revising standards to address the limitations of current distributed wind systems based on testing, and (3) fostering technological innovations and reinstating current standards for distributed wind systems at high penetration levels.

1 Introduction

The IEEE 1547-2018 Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces [1] is a set of guidelines and requirements for the interconnection and interoperability of distributed energy resources (DERs) with electric power systems. This standard is accompanied by the IEEE 1547.1-2020 Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces [2]. The standards do not cover the unique challenges and requirements for distributed wind energy, and therefore the standards are broader in scope. The standards cover various aspects, including:

- General Requirements: Establishes the criteria for the performance, operation, testing, safety, and maintenance of the interconnection.
- Reactive power capability: The necessary capabilities for DERs to support grid voltage levels by supplying or absorbing reactive power. Normal performance categories are named Categories A and B and refer to lower and higher DER penetration levels, respectively. See flow chart in Annexx B.4.3.2, Figure B.2 of [1].

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What do we need and what can we do with your help?

We are currently working on automating compliance testing of distributed wind power converters and in recommendations for interconnection standards for distributed wind:

- **Partner with us:** Lets work together to find solutions that will benefit you and have a significant industry impact.
- **Form part of the discussions:** Your participation can have a significant impact on a project and help guide its direction.
- **Stakeholder engagement:** Help us understand what are your challenges and specific needs in terms of system interconnection.

Thank You

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