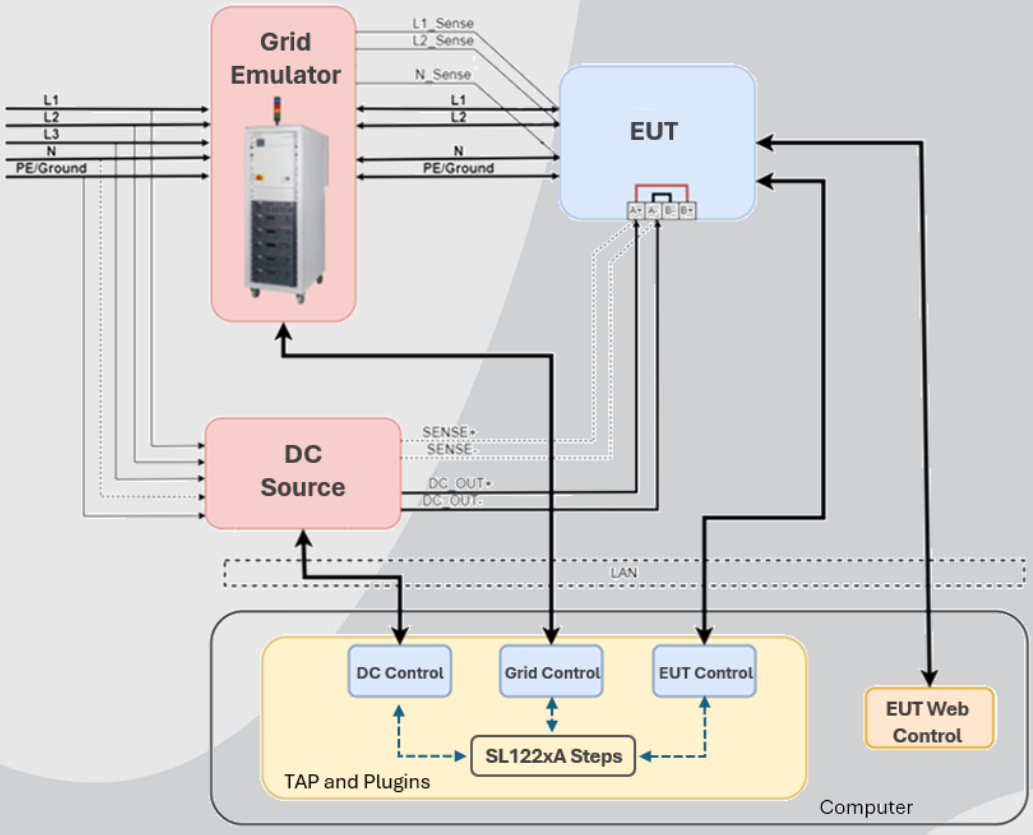
KS8400B Introduction with SL1200A Grid Integration and Compliance Test Automation Suite

SL1200A Grid Integration and Compliance Test Automation Suite includes the SL1220A AC/Grid Test Sequencing Plugin, SL1221A PHIL-based Anti-Islanding Compliance Test Plugin, and the SL1222A Automated IEEE 1547 Electric Type Test Plugin.



Provides detailed information to configure and use the KS8400B Test Automation software version 9.28.0 (release date 2025-04-14). It also provides installation, use, configuration, and examples for SL1220A, SL1221A, and SL1222A Plugins, version 4.0.0 (June 2026)

Notices

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Sales and Technical Support

To contact Keysight for sales and technical support, refer to the support links on the following Keysight websites:

www.keysight.com/find/SL1200A

(product-specific information and support, software and documentation updates)

www.keysight.com/find/assist (worldwide contact information for repair and service)

You can contact Keysight for warranty, service, or technical support.

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6 SL1220A Quick Start

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8 SL1222A Quick Start

A Additional TAP Functions

PathWave Test Automation Overview

Introduction

Welcome to the Keysight KS8400B PathWave Test Automation Getting Started Guide. In this guide, you will learn how to install the PathWave Test Automation software and the *SL1200A Grid Integration and Compliance Test Automation Suite.*

You will learn how to use the simple graphical user interface for PathWave Test Automation, called the Editor, and you will also learn how to create Test Plans within the Editor for the test steps in the *SL1200A Grid Integration and Compliance Test Automation Suite.*

The Test Plans make use of *resources*: *Instruments, Devices Under Test (DUTs), and Result Listeners*. These resources must be configured for the software to communicate with hardware, so you will also learn how to create resources.

SL1200A Grid Integration and Compliance Test Automation Suite

The Keysight SL1200A Grid Integration and Compliance Test Automation Suite package for the KS8400B PathWave Test Automation Platform (TAP) contains multiple licensed products which can be enabled by purchasing the associated licenses. That means all the software comes with each package, so you can see all the TAP Steps even if you don't have the associated license to run them.

As of the June 2026 (Version 4.0.0) release, the following software features are included in this TAP package. Numbers in bold represent the license associated with the Steps. All licenses are discussed in a Section that follows.

1 SL1220A Keysight SL1220A AC/Grid Test Sequencing

The **SL1220A AC/Grid Test Sequencing** package provides the foundational building blocks used to automate Keysight SL1200A Series Regenerative AC/Grid Emulators. Test steps are available for controlling all supported SL1200A models and emulation modes, including Voltage Priority, Current Priority, and AC/DC operation. These test steps can be combined with standard PathWave Test Automation functionality to create custom test plans and integrated automation solutions.

2 SL1221A PHIL-based Anti-Islanding Compliance Test

The **SL1221A PHIL-based Anti-Islanding Compliance Test** package automates IEEE 1547.1-2020 unintentional islanding testing. The **SL1221A** also supports altering both the resistive (R) and the reactive (LC) load adjustments to provide a level of support for the IEC 62116 International Standard. The package integrates directly into the IEEE 1547.1 Conformance Test framework and automates execution of RLC anti-islanding test sequences, report generation, and SunSpec

Modbus-based DUT configuration. This package focuses specifically on anti-islanding compliance testing and does not provide direct access to the DER Communication steps which require the **SL1241A** license.

3 SL1222A Automated IEEE 1547 Electric Type Test - Freq / Volt Disturbances

The **SL1222A Automated IEEE 1547 Electric Type Test** package provides automation for many IEEE 1547.1-2020 electrical type tests. Supported test categories include frequency disturbances, voltage disturbances, ROCOF, PCRT, Enter Service, and Nameplate Interoperability testing. The package generates test-specific reports and can operate either with automated EUT communications (requires **SL1282A** and **SL1241A** licenses) or with manual EUT control when communication licenses are not present.

4 SL1241A SunSpec Modbus DER Communications Library for IEEE 1547

The **SL1241A SunSpec Modbus DER Communications Library** provides standardized communications with IEEE 1547 distributed energy resources using SunSpec Modbus protocols. The package includes a collection of reusable test steps for direct control and configuration of supported EUTs and provides access to Grid Support Function settings, Nameplate information, and other IEEE 1547 communication parameters used by the automation packages.

5 SL1282A Automated Communications for SL1222A.

While the **SL1221A PHIL-based Anti-Islanding Compliance Test** includes DER communications, the **SL1222A Automated IEEE 1547 Electric Type Test** requires the **SL1241A** and the **SL1282A** licenses for automated control of the DER when executing those Test Steps.

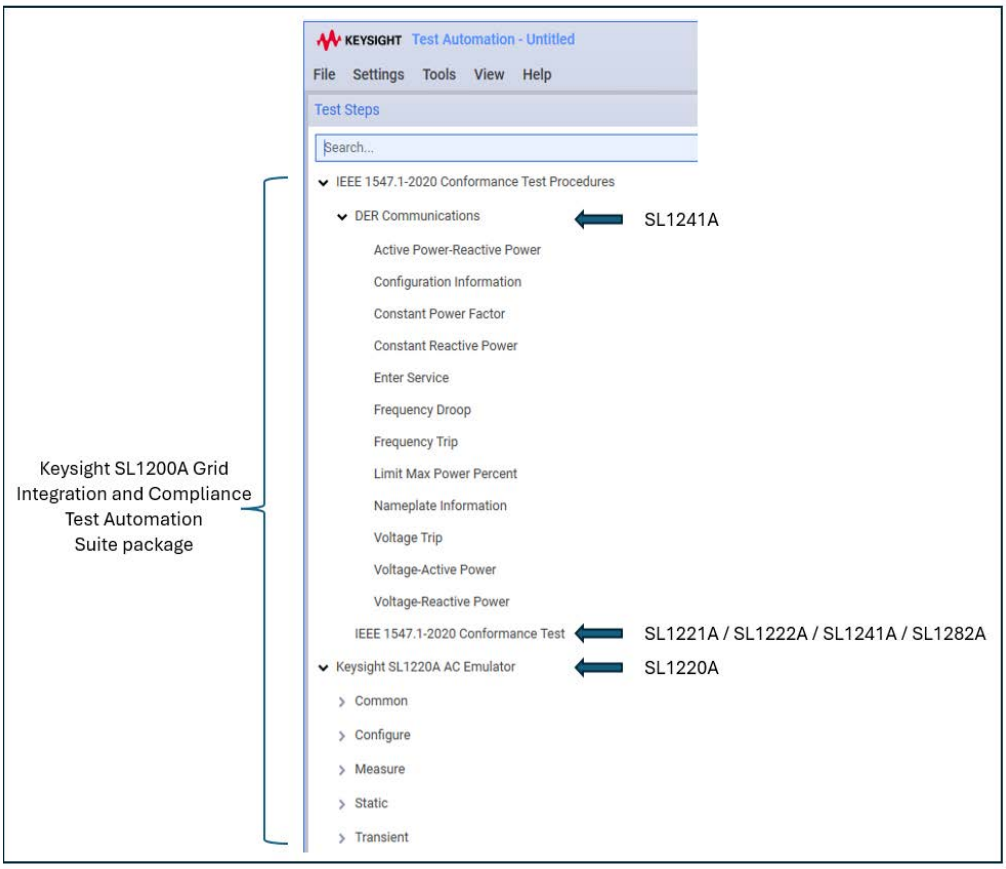


Figure 1 Relationship between SL122xA licenses and the associated Grid Integration and Compliance Test Automation functionality.

PathWave Test Automation Software

For information about Keysight PathWave Test Automation, go to:
www.keysight.com/find/tap

Download the latest KS8400B *PathWave Test Automation* software at:
https://www.keysight.com/us/en/product/KS8400B/pathwave-test-automation.html

Download the latest SL1200A Grid Integration and Compliance Test Automation Suite package from:
https://www.keysight.com/us/en/lib/software-detail/computer-software/sl1220a-ac---grid-test-sequencing-plugin.html

NOTE

IMPORTANT licensing information: The *SL1200A Grid Integration and Compliance Test Automation Suite* package includes all the SL122xA Plugin test steps. Plugin licenses are exclusive. Test steps for plugins not licensed are visible but not usable.

You must license the SL1220A plugin to use the *SL1220A AC/Grid Test Sequencing Plugin* test steps and you can use them without using any of the *SL1221A PHIL-based Anti-Islanding Compliance Test Automation Plugin* or any other plugin test steps.

Similarly, you must license the *SL1221A PHIL-based Anti-Islanding Compliance Test Automation Plugin* to use those IEEE 1547.1-2020 Compliance Test Automation Software test steps, and you can use them without using the *SL1220A AC/Grid Test Sequencing Plugin.* The same would be true for the *SL1222A Automated IEEE 1547 Electric Type Test*.

The *SL1241A* license enables using the DER Communication Steps. Both the *SL1241A* and *SL1282A* are required for automated control of the *SL1222A Automated IEEE 1547 Electric Type Test* Steps.

Additional Keysight Test Automation Platform (TAP) Resources

- Help with licenses: call **1-800-829-4444** for Keysightcare or email at: **usa_orders@keysight.com**
- http://www.youtube.com/@opentap158)
- https://www.keysight.com/us/en/support/KS8400B/pathwave-test-automation.html
- https://www.keysight.com/us/en/assets/3122-1326/application-notes/PathWave-Test-Automation-Training-Editor-Introduction.pdf

Definition of Terms

Bench Settings: Configure an instrument's address and other settings.

Log Panel: The Session Log is a text (.txt) file generated each time you start the Editor. It contains messages generated when the program runs.

Macro Step: One Test Step involves multiple Test Steps.

Package: Packages contain one or more Plugins and other related files (such as data files or README files), custom test steps, instruments, DUTs, result listeners and test plans. Packages are installed/removed with the Package Manager.

Package Manager: The Package Manager allows you easy access to packages. It can be configured to point to any server where packages are hosted. The Package Manager lets you download and install preexisting packages.

Plugin: Plugins provide additional TAP functionality. They are distributed in Packages that contain DLLs and other required files.

Resources: Resources are called before the Test Plan execution starts and are closed when the Test Plan execution ends.

Resource Bar: The Resource Bar at the bottom of the Editor shows the currently configured DUTs, Instruments, and Results Listeners. For example, the following graphic shows one DUT (*TimeDut*), two Instruments (*PSU, TEMP*), and three Results Listeners (*Log, SQLite, CS*V).

In the Resource Bar, you can: add additional resources, select a listed resource to open its settings to modify or remove it, etc.

Results Viewer: View results from executing the Test Plan. Lets you plot results, track trends, and find errors. Results may be stored as either a text log file, a CSV file, or an SQLite Database file.

Run Explorer: This window displays basic information about the history of the test plan runs stored in the SQLite database, including a Run ID, Test Plan Name and Verdict (Pass, Fail, or Error).

Test Plan: A Test Plan contains a sequence Test Steps and associated data. They are stored as XML files with the *.TapPlan* file extension.

Test Step: Individual steps in the Test Plan. Some Test Steps can have children. A Child Test Step is an ordinary step that is inserted as a child of another step. Child Test Steps are indented from the list of regular test steps.

Test Step Settings: Test Step Settings panel lets you edit the settings for the step selected in the test plan. Settings are properties that are automatically reflected in the TAP Editor. They are loaded and saved when the Test Plan is loaded/saved.

Timing Analyzer: Timing Analyzer results are based on log files.

Waveform Analysis: Provides visual analysis of Result Data from Test Steps. Can handle very large csv file data often associated with long testing.

1 Install and Launch PathWave Test Automation

Introduction

Before using any of the SL122xA plugins, you must first install and become familiar with the PathWave Test Automation (TAP) environment. The TAP Editor provides the framework used to create, configure, execute, and analyze automated test plans. All SL122xA functionality integrates directly into this platform.

This chapter introduces the basic components of the PathWave Test Automation environment, including installation, launching the Editor, understanding the user interface, and creating a simple test plan. Completing the exercises in this chapter will provide the foundational knowledge needed throughout the remainder of this guide.

In this chapter:

Installation

1. Uninstall any previous versions of KS8400B Pathwave Test Automation. On the machine you want to run Keysight Test Automation:
   - Select **Windows Start > Control Panel.**
   - Select **Programs and Features.**
   - Find **Keysight Test Automation.**
   - Click **Uninstall.**
2. Navigate to the KS8400B Pathwave Test Automation software at: https://www.keysight.com/us/en/product/KS8400B/pathwave-test-automation.html
3. Scroll down. Click the box *Details and Download.*
4. Click: Previous Versions
5. Select Version **9.28** and **V** drop-down

6 Click **Download** to download **Release 9.28** (64-bit).

7 Select: *Full Installer (PathWave Test Automation 9.28 (64-bit)* if you want to install later off-line; otherwise, you can select the smaller *Web Installer*.

8 Fill out the form then click **Download**.

9 After the software downloads:

- Launch (*Run as Administrator)* **TestAutomation.Developer.64.9.28.0.exe**.
- Follow the prompts to install PathWave Test Automation.
- The SL1200A Grid Integration and Compliance Test Automation Suite installs and uses OpenTAP 9.28.2 components. Installation and verification instructions are provided in Chapter 3..

Option	Recommended	Reason
SDK	No	Required only for users developing custom PathWave Test Automation software.
License Manager	Yes	Required for software license activation and management.
Check for Updates	No	Notifies users when new PathWave Test Automation releases become available and helps keep the software up to date.

10 Select and purchase a Keysight KS8400B license.

-- You will receive an *Entitlement Certificate* when you purchase a license.

-- Follow instructions in the *Entitlement Certificate* to redeem the license.

-- Save the license file (.lic) to a temporary location on the C: drive of the computer where you have installed the KS8400B software.

-- If you did not receive or cannot find your entitlement certificate, contact: https://www.keysight.com/us/en/contact.html

11 Update to using the new **Keysight Software Manager Utility**. With the installation of the older 9.28 version, you received the older Keysight PathWave License Manager. While that probably works fine, it is recommended you install the newer version of the tool. Navigate using the following link and follow the instructions for downloading and installing the latest version of this Utility: Keysight Software Manager Utility. When installing the new tool, the previous Keysight PathWave License Manager will be uninstalled

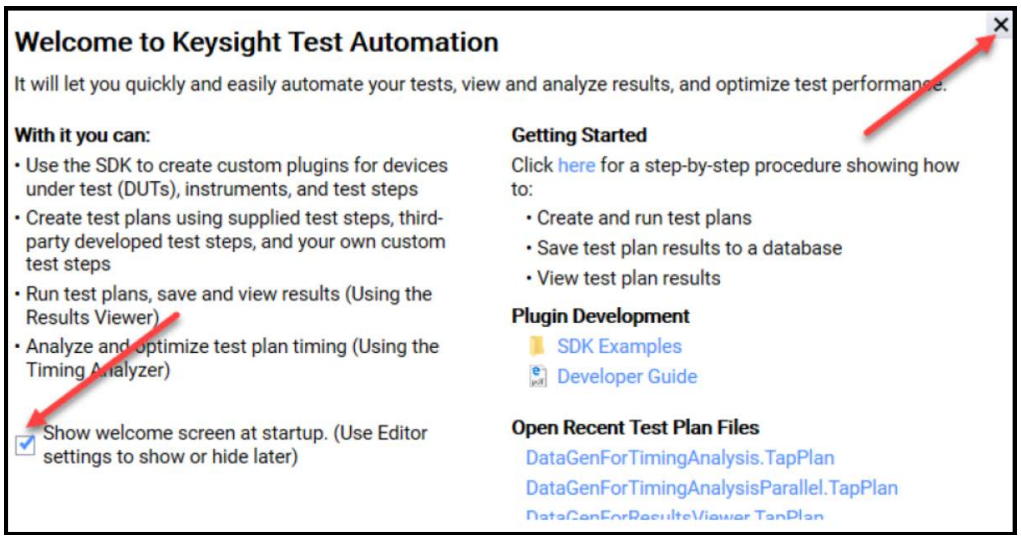
- Start Keysight Software Manager Utility.
- Click the **+Add a License File** button.

- Browse to your **.lic** file and click **Open** to install your license.

Congratulations! You are now ready to use KS8400B Pathwave Test Automation.

Start the Test Automation Editor

1. Select **Start > Keysight Test Automation** to start the **Editor**.
2. The **Editor** displays a welcome screen with an introduction of what is included in the Test Automation and useful links to help you get started.
   - Uncheck the *Show welcome screen at startup* checkbox to hide the welcome screen on startup.
   - Close the *Welcome screen*.

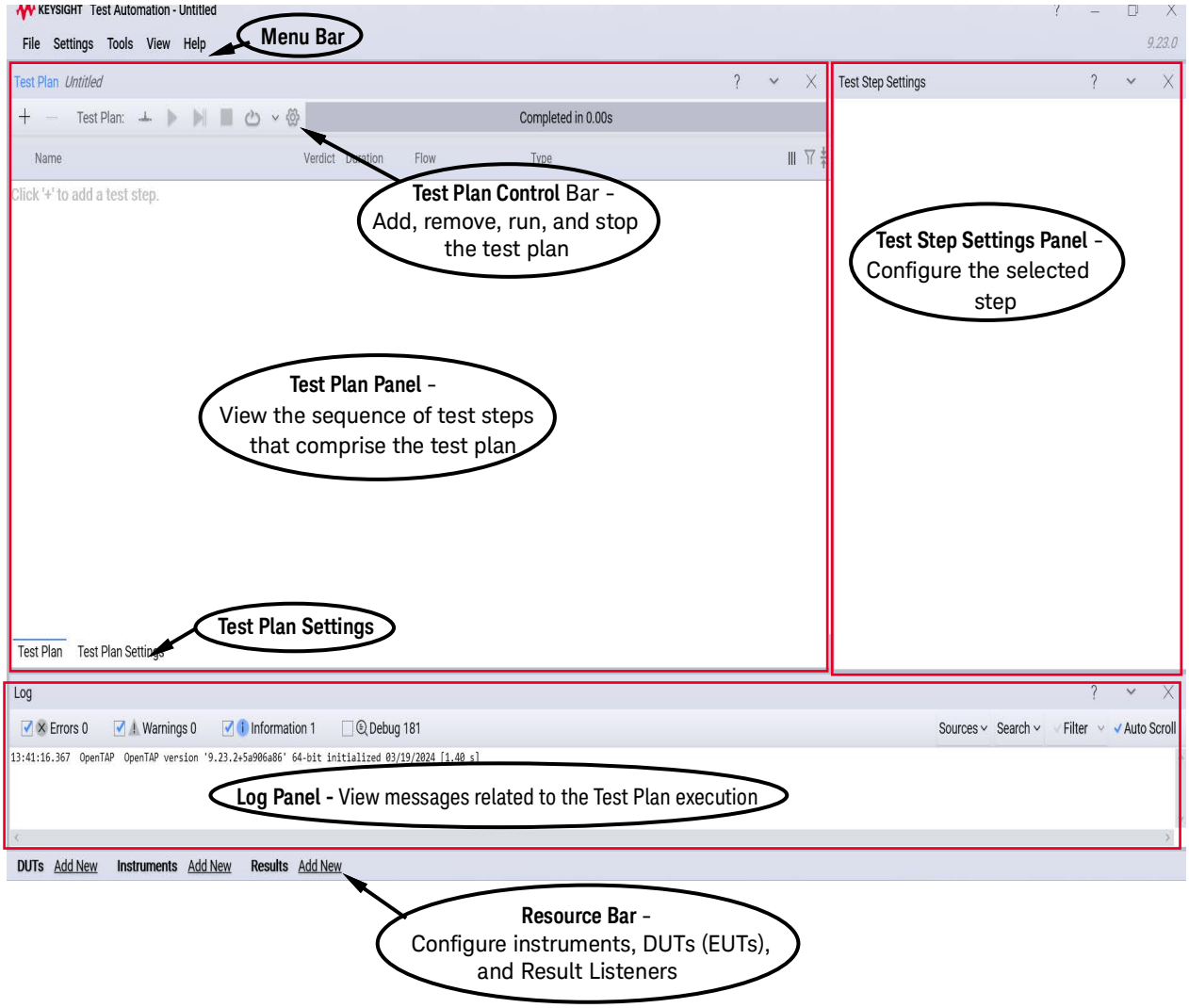


Introduction to the Test Automation Editor

The main Editor contains six components or panels:

- **Menu Bar**
- **Test Plan Control Bar**
- **Test Plan Panel**
- **Test Step Settings Panel**
- **Log Panel**

- **Resource Bar**



There is also a **Macro Test Steps** panel that is not shown above. It is used only with Macros and is not used in this tutorial.

Editor Panels

The *Test Plan Panel* displays the test steps that have been added to the current test plan. If you click on a test step, you can see the related configuration in the *Test Step Settings Panel*. A test step's configuration settings can include, but are not limited to, input and output settings, and resources such as DUTs and instruments. *Test Plan Settings Panel* lets you edit the settings of the entire test plan.

The *Log panel* displays log messages from PathWave Test Automation during startup and during test plan execution. Log messages are classified as **Error**, **Warning**, **Information**, and **Debug** level events. The content displayed in the log panel is also saved in the Session log, which can be found at **%TAP_PATH%/SessionLogs**.

Menu and Resource Bars

The *Menu Bar* provides the following:

- **File** - lets you open and save test plans among other options.
- **Settings** - let you configure the Editor, the Engine, and the Results settings and gives you the option to configure resources (connections, instruments, and DUTs) via *Bench Settings*.
- **Tools** - let you open the Package Manager, Results Viewer, Run Explorer, and Timing Analyzer.
- **View** - allows for panels to be shown/hidden or for custom panels to be displayed and docked.
- **Help** - provides links to OpenTAP documentation and any other installed package Help files, such as for the SL122xA plugins.

The *Resource Bar* shows what is currently configured for PathWave Test Automation. *Resource* is the general term for a Device Under Test (DUT), instrument, or result listener used by a test plan. Status indicators next to the resource indicate its state:

- Green light = in use
- Grey light = not currently in use

Dockable Panels

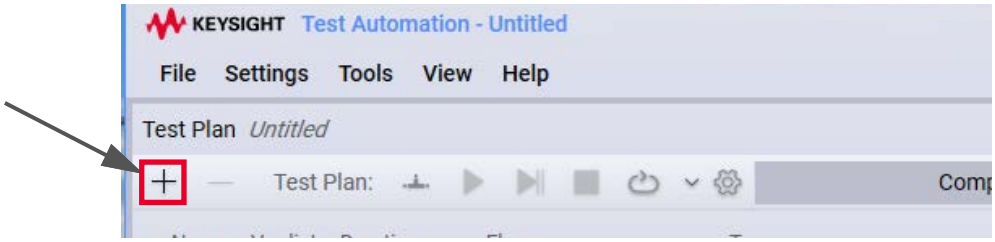
The *Test Plan*, *Test Plan Settings, Test Step Settings*, *Log*, and *Step* panels are dockable. This allows you to:

- **Float** the panels. They can be resized. They also minimize and close with the main window.
- **Preset** the desired layout. Select *View* > *Presets* to return hidden, floating, or docked panels to their default locations.

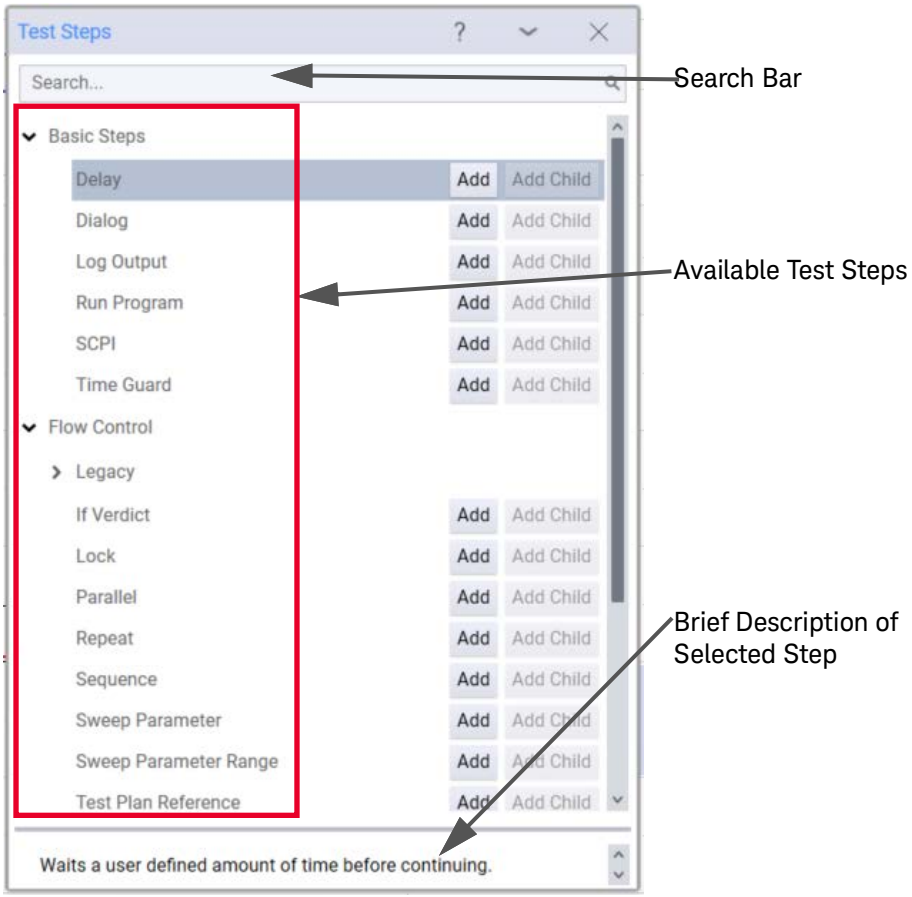
Create a Simple Test Plan

Let's take a closer look at creating a test plan formed by some test steps.

1 Click the + icon in the Test Plan panel or press **Ctrl+T**:



2 The *Test Steps* window opens, displaying a list of available test steps organized in expandable groups:



PathWave Test Automation comes preinstalled with the *Basic Steps* and *Flow Control* Plugins. Custom test steps are also displayed here. As your list of test steps grows, the search bar at the top becomes increasingly useful.

3 In the *Test Steps* dialog box, select *Flow Control* and scroll down. Add a *Repeat* step. Either:

- Select **Repeat** and click **Add**, or
- Double-click the **Repeat** step.

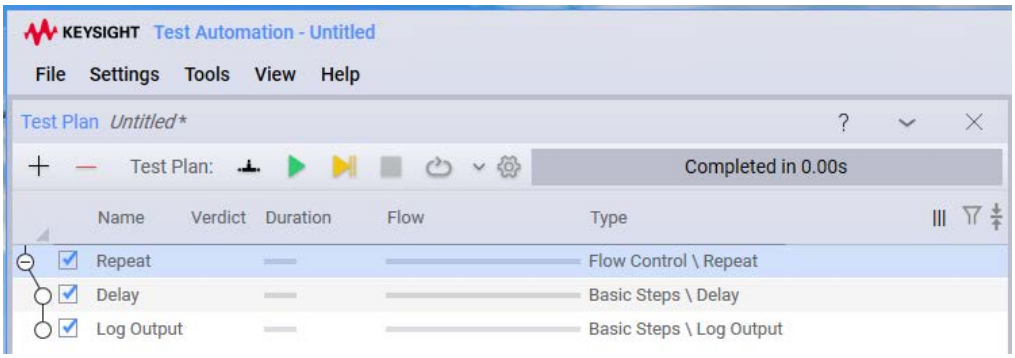
The description of the step appears at the bottom of the window.

4 Select *Basic Steps* and scroll down if necessary. Add a *Delay* child step:

- Select **Delay**
- Click **Add Child**

5 Add a **Log Output** step, using either the **Add** button, or by double-clicking. A *Step* is added based on the scope of the previous step. In this case *Delay* was a child step of **Repeat**, so *Log Output* will be a child step of **Repeat** as well.

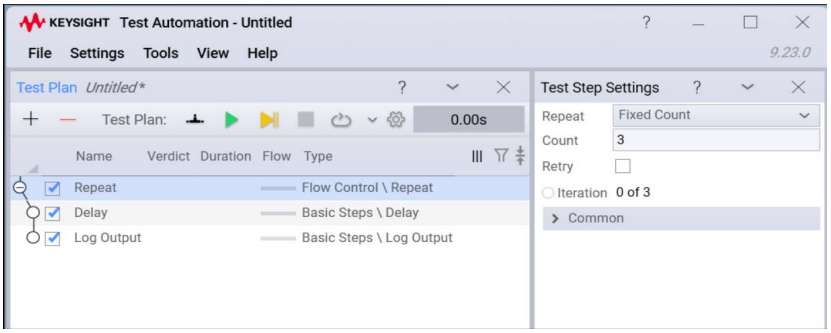
Your test plan should now look similar to this:



- Child steps are indented in the Editor.
- Reorder *Test Steps* by manually dragging them to a new location.

6 Close the **Test Steps** window.

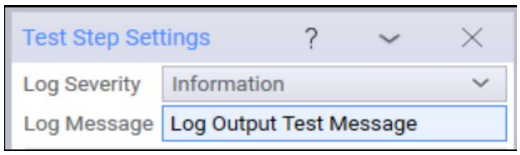
7 Select the **Repeat** step by clicking on it. The Test *Step Settings panel* now shows these settings:



This means that the **Delay** and **Log Output** steps will execute three times.

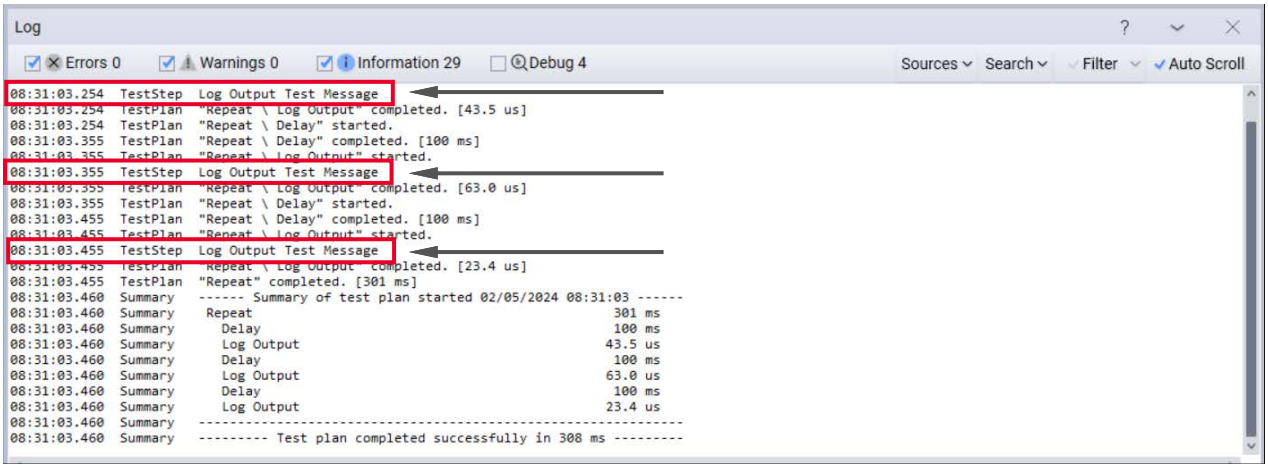
NOTE **If the *Step Settings* panel does not appear, click *View* > *Panels* > *Test Step Settings*.**

8 Select the **Delay** and **Log Output** steps respectively and inspect their *Step Settings*. Click on **Log Output** and enter your own **Log Message** in the text box:



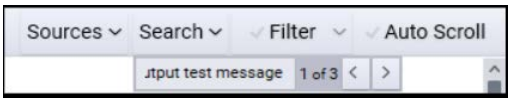
9 Run the test plan by clicking ▷ or by pressing **F5**.

10 After the run completes, scroll through the Log Panel to find your log message:



11 If you don't see your log message:

- Make sure that the *Information* tab in the Log panel is checked. This is needed because the Log Output step's *Log Severity* setting is set to *Information*.
- The *Search* button on the right of the *Log Panel* can also be used:



Congratulations! You have just run your first test plan!

2 Creating Your First TAP Test Plan

Introduction

Before working with the SL122xA Grid Integration and Compliance Test Automation plugins, it is helpful to understand the core concepts used by the PathWave Test Automation platform. Test plans are constructed from individual Test Steps, Resources, and Result Listeners that work together to automate tasks and collect data.

This chapter introduces the process of building and executing a simple test plan using the PathWave Test Automation environment. You will learn how to add resources, store results, view collected data, and use the built-in analysis tools provided by the platform. The concepts presented here form the basis for all SL122xA automation workflows.

In this chapter:

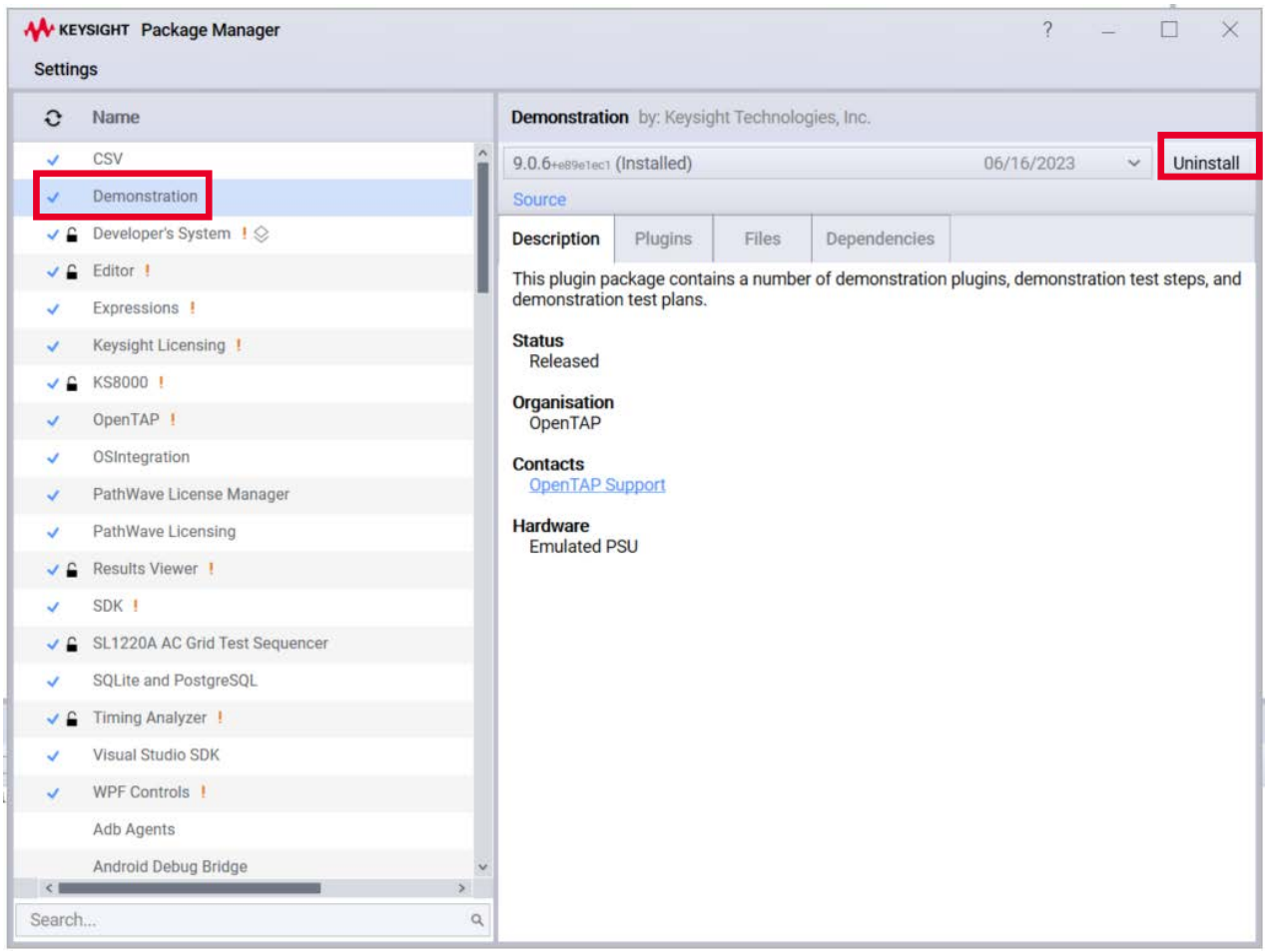
Install the TAP Demonstration Package

This chapter shows how to install a package containing demonstration test steps and instruments. We will use the Demonstration Plugin for simulating charging and discharging batteries that involves a power analyzer. You do not need access to instruments or other plugins for this example.

It is often required that the Test Automation Editor be closed before installing any plugin packages. Please close the Editor if it is open.

1 Click **Tools > Package Manager**.

2 The *Package Manager* opens. It can be configured to point to any server where packages are hosted. The *Package Manager* allows you easy access to packages. Packages typically contain one or more Plugins and other related files (such as data files or README files):


KEYSIGHT Package Manager
Settings
Name
CSV
Demonstration
Developer's System
Editor
Expressions
Keysight Licensing
KS8000
OpenTAP
OSIntegration
PathWave License Manager
PathWave Licensing
Results Viewer
SDK
SL1220A AC Grid Test Sequencer
SQLite and PostgreSQL
Timing Analyzer
Visual Studio SDK
WPF Controls
Adb Agents
Android Debug Bridge
Search...
Demonstration by: Keysight Technologies, Inc.
9.0.6+e89e1ec1 (Installed)
06/16/2023
Uninstall
Source
Description
Plugins
Files
Dependencies
This plugin package contains a number of demonstration plugins, demonstration test steps, and demonstration test plans.
Status
Released
Organisation
OpenTAP
Contacts
OpenTAP Support
Hardware
Emulated PSU

In the *Package Manager*:

- Selecting a *package* in the left panel displays information about that package. Packages can contain custom test steps, instruments, DUTs, result listeners and test plans.
- The *Description* tab gives a general overview of the package.
- The *Plugins* tab shows all the custom test steps, instruments, DUTs, result listeners and other components contained in the package.
- The *Files* tab shows all the files included in the package.
- The *Dependencies* tab shows if the package is dependent on any other packages.

3 Scroll down and select the *Demonstration* Plugin (which is included with the PathWave Test Automation installation) and click **Install**. After installation the *Demonstration* Plugin displays a check mark in front, indicating that it is installed.

4 Close the *Package Manager* window.

NOTE If you have trouble installing a Package, close the Test Automation Editor and re-install the package. You can run the *Package Manager* from the Windows list of applications.

Construct the Test Plan

1 Remove any test steps left over from the previous example. Select the *Test Step*, then either:

- Click the – button, or
- Press **Delete** on the keyboard.

2 Clear the **Log** panel. Right click on the Log panel then select *Clear Log Panel*.

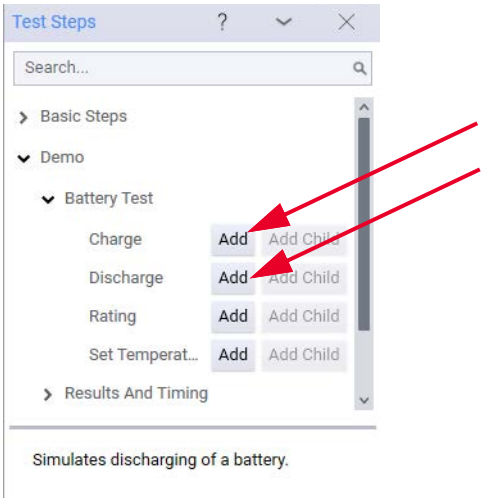
3 Click the + button (or press **Ctrl+T**) to open the *Test Steps* window. Notice that there is now a new group called *Demo*.

4 From the *Demo* group's *Battery Test* subgroup, add a:

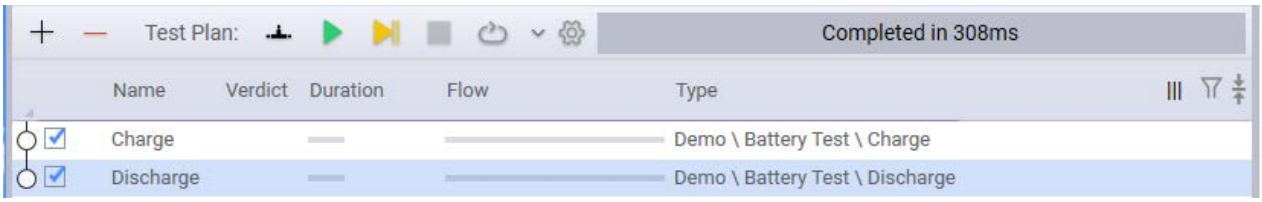
- *Charge* step

and a

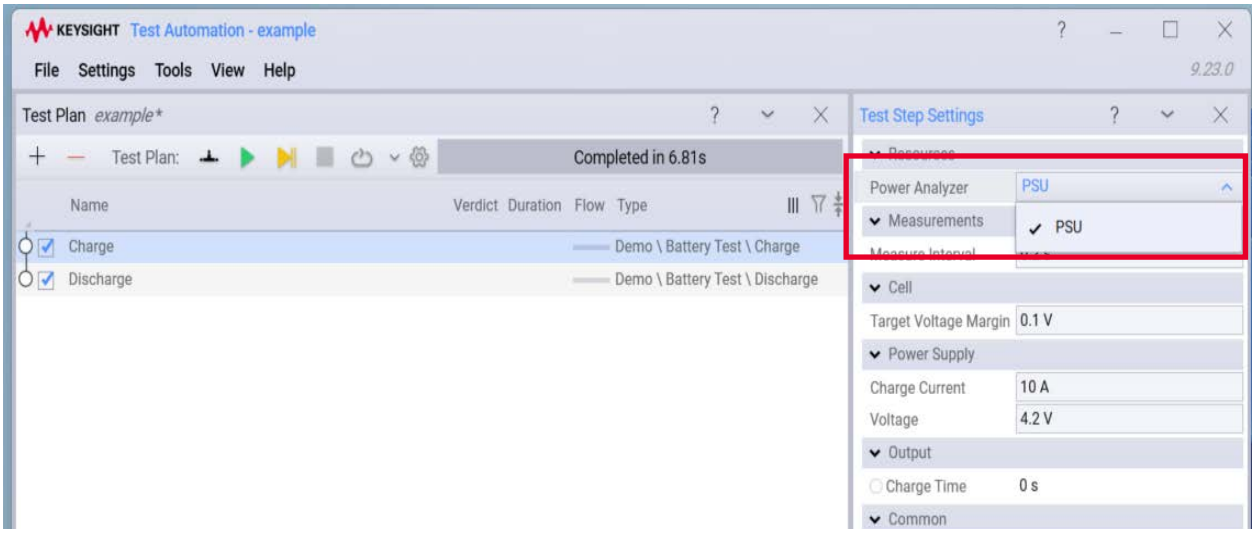
- *Discharge* step



5 Close the *Test Steps* window. Your test plan should now look like this:

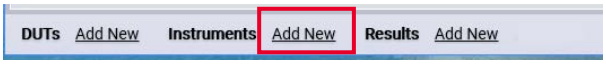


6 In the *Test Plan* panel, select either of the two test steps. You will notice that both steps reference an instrument resource — *Power Analyzer* in the Test Step Settings pane on the right side of the display.

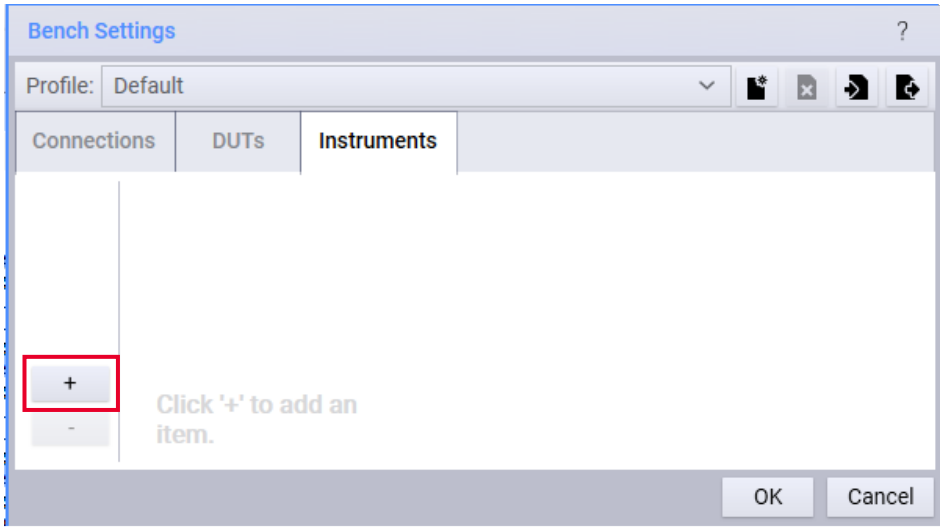


7 We need to add a Power Analyzer instrument as a resource.

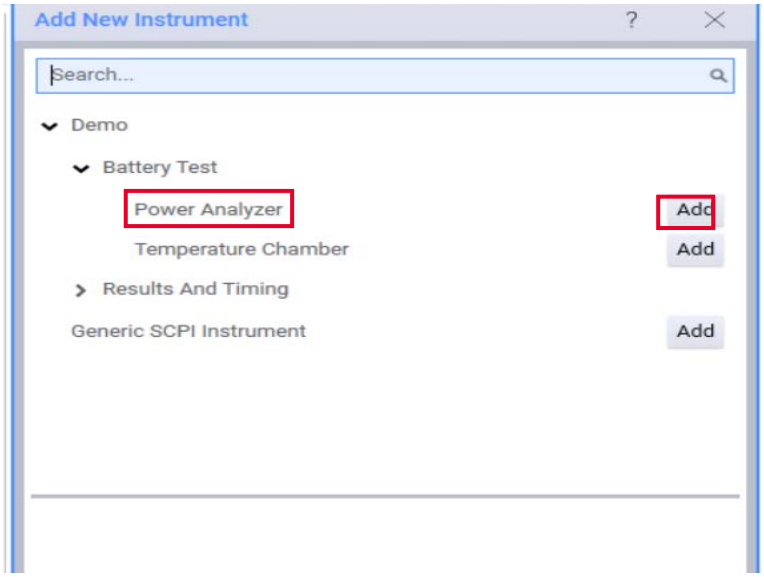
- In the *Resource Bar* at the bottom of the panel, select **Add New** next to *Instruments*.



- In the *Bench Settings* window (which also can be opened via **Settings > Bench > Instruments**), select the + in the lower-left corner.



- The *Add New Instrument* window opens. Select **Power Analyzer**, then **Add**.

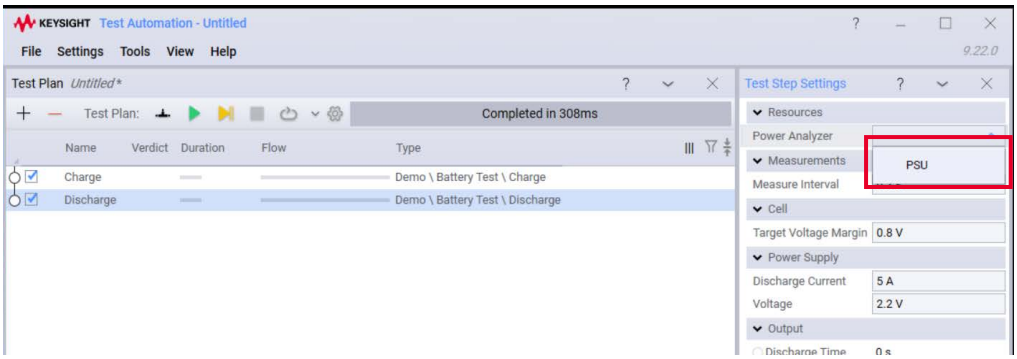


- Close the *Add New Instrument* window.

8 Next you would typically configure the instrument's address and other settings. Because this is a simulated instrument, click **OK** to close the *Bench Settings* window.

9 In the Test Plan panel, the *Resource Bar* now shows one Instrument: **PSU**.

10 In the *Step Settings* for both the *Charge* and *Discharge* steps select the **PSU** as the Power Analyzer resource from the drop down menu. Make certain that you do this for both *Charge* and *Discharge* steps.



Use the Results Viewer and Run Explorer

In PathWave Test Automation, a result listener is also a Resource, just like an instrument or DUT. Result listeners store data created by the test steps.

You can add database-style result listeners that allow for a more in-depth view of the data. This lets you plot results, track trends, and find errors. This can all be done in the *Results Viewer*.

To use the *Results Viewer* and the *Run Explorer*, a database *Result Listener* is needed. Let's add an **SQLite** result listener. **SQLite** is a lightweight database that consists of a single file that encapsulates the full data set. You can use other types of databases too.

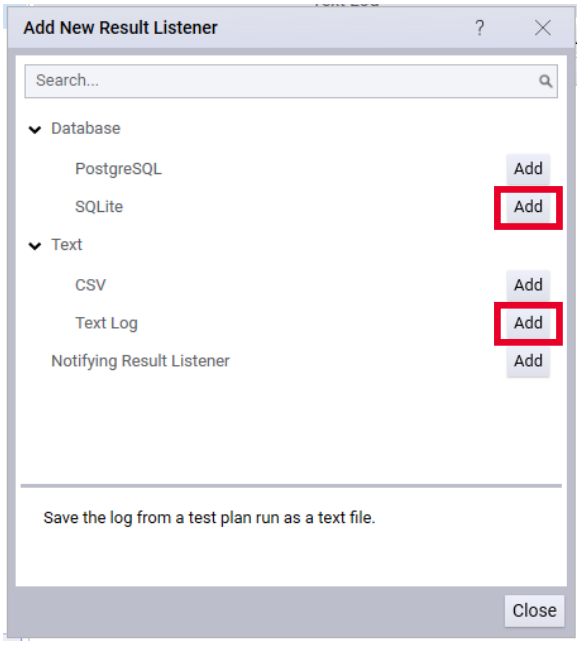
Let's add the Log result listener as well. Multiple result listeners can be configured at the same time and will process the data from PathWave Test Automation in parallel. This happens in a separate thread, so it doesn't impact the execution speed of the test plan.

1 Select **Results > Add New** from the *Menu Bar*. This opens the *Settings* dialog box:

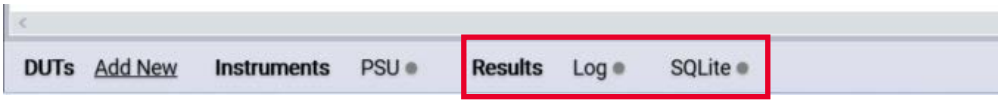
- Click the + in the bottom left corner of the dialog box. This opens the *Add New Results Listener* dialog box.
- Under the *Text* group, select *Text Log*, then **Add**.

2 In the *Add New Result Listener* window

- Expand the **Database** group.
- Add the *SQLite* Result Listener, then **Add**.

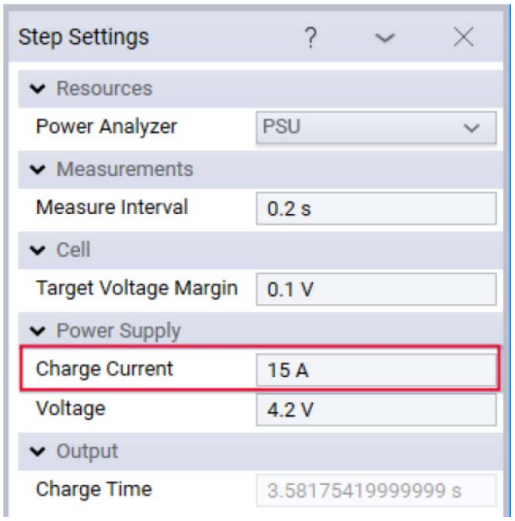


3 Close the *Add New Result Listener* window, then close the *Add New Results Listener* window.



4 Execute the test plan by clicking ▷ in the Test Plan panel or by pressing **F5**.

5 Let's make the results a little more interesting. Select the **Charge Test Step** and change the *Charge Current* from 10 A to 15 A.



This creates a separate run result when you run the test plan again.

6 Run the test plan again so you can look at the data that was captured.

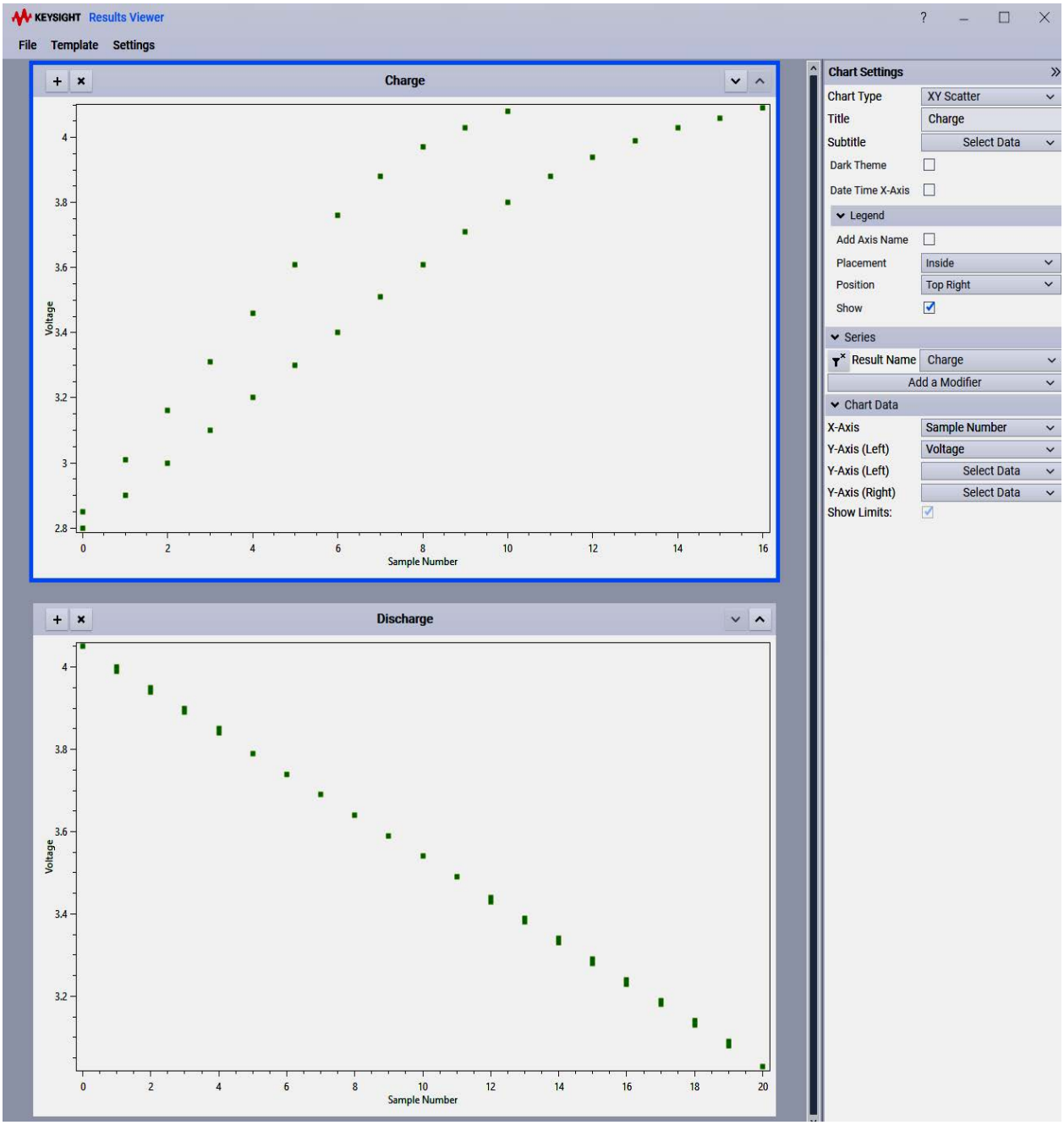
7 Select **Tools > Run Explorer**. The *Results Viewer* and *Timing Analyzer* also can be opened directly from the *Tools* menu.

The *Test Plan Run Explorer* opens. This window displays some basic information about the history of your test plan runs stored in the SQLite database, including a *Run ID, Test Plan Name* and *Verdict* (Pass, Fail, or Error). In our case, neither of the last two have been set:

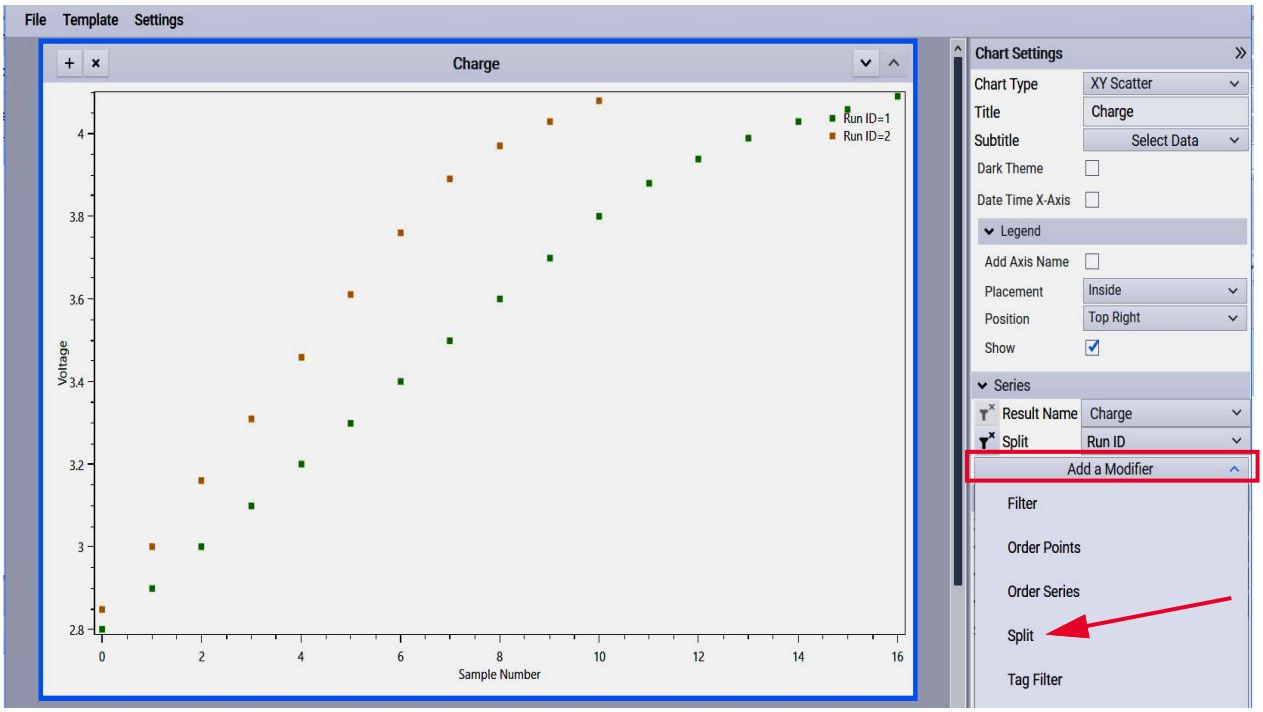
8 Now we will view the results of those test runs:

- Hold **Shift** and select both **Test Plan Runs** at the top of the *Test Plan Run Explorer* list (your *Run IDs* may be different).
- Open the *Results Viewer* by either:
  - -- Clicking the **View results from test plan** button — , or
  - -- Right clicking the test plan runs and selecting **Plot Selected**.

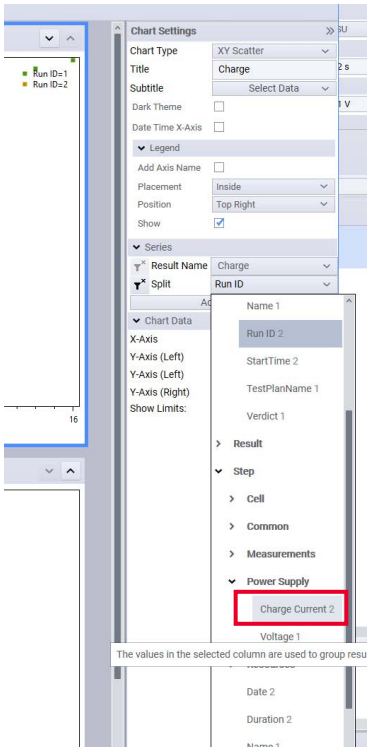
- The *Results Viewer* shows two different plots one under the other (one for *Charge* and one for *Discharge*), as well as some *Chart Settings* to the right:



- Select the *Charge* plot, a blue box appears around the chart.
- Locate the *Series* setting in the Charge Settings menu. Select **Add a Modifier** and click **Split**:

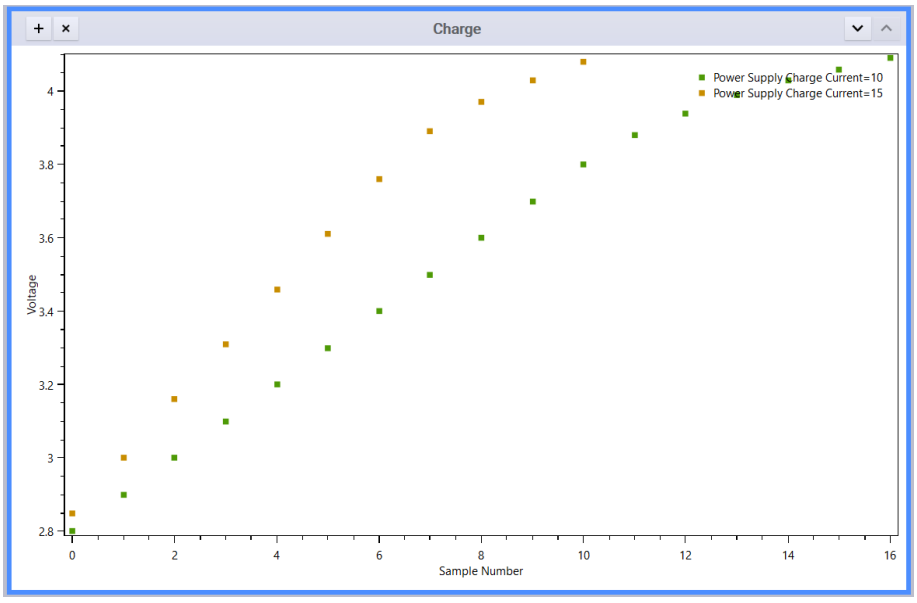


9 Click on the **Split > Run ID** drop-down arrow, navigate to **Step > Power Supply**, and select **Charge Current2**:



Charge Current is here because it is a *setting* in the Power Supply group of the Charge test step. The number “2” next to Charge Current indicates that there are two unique values in the data set.

10 The chart automatically updates:



11 Play around with the other *Chart Settings*. PathWave Test Automation provides powerful plotting capabilities that make evaluating data fast and easy. Some of the most commonly used are:

- Chart Types, such as XY Scatter, XY Line, Histogram, etc.
- Series Modifiers, particularly **Split** and **Filter**.
- Chart Data, which is based on what is passed in to the Result Listener by the test step.

  The *Chart Settings* only apply to the selected chart, which is highlighted in blue. This allows you to configure the charts individually.

12 Close the *Results Viewer*.

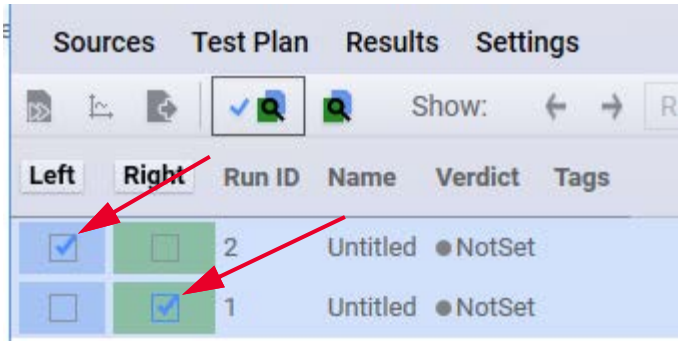
Timing Analyzer

The *Timing Analyzer* is another powerful tool built into PathWave Test Automation. It can optimize test plans, locate bottlenecks in execution, and identify areas for parallel execution.

1 Navigate back to the *Test Plan Run Explorer*.

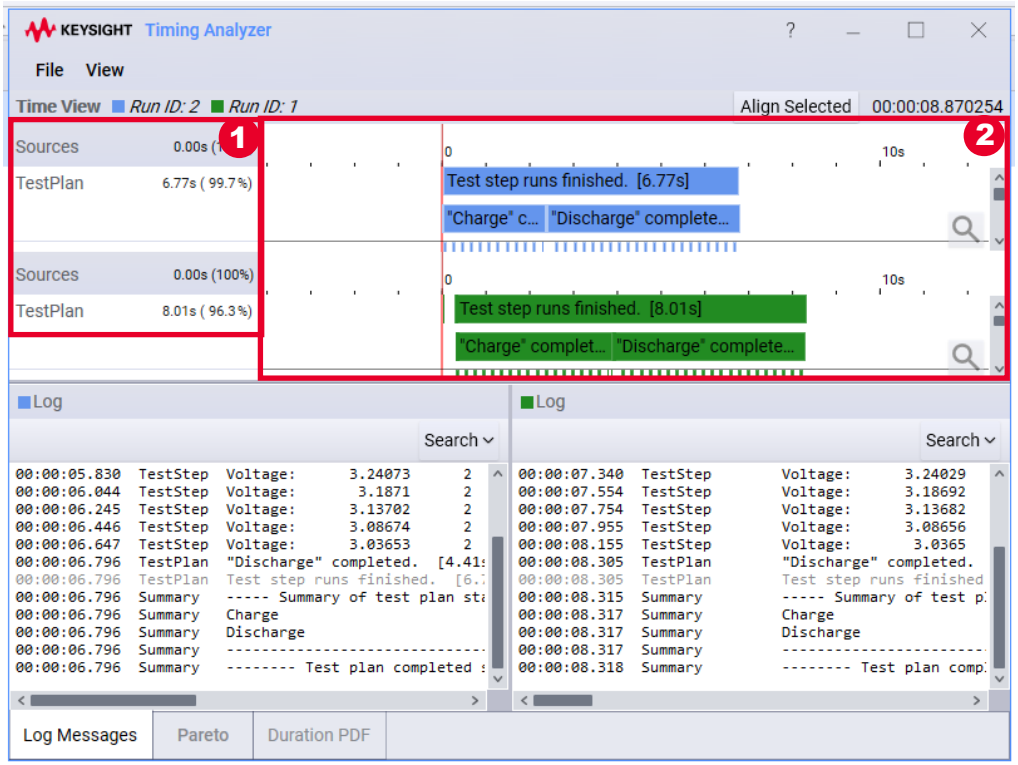
2 Click the **Compare logs selection mode** icon, that adds check boxes in front of each run:

3 Select the top test plan as *Left* and the other as *Right*:



4 Click the **Compare logs for selected runs** icon (the magnifying glass icon on the right) to open the *Timing Analyzer:*

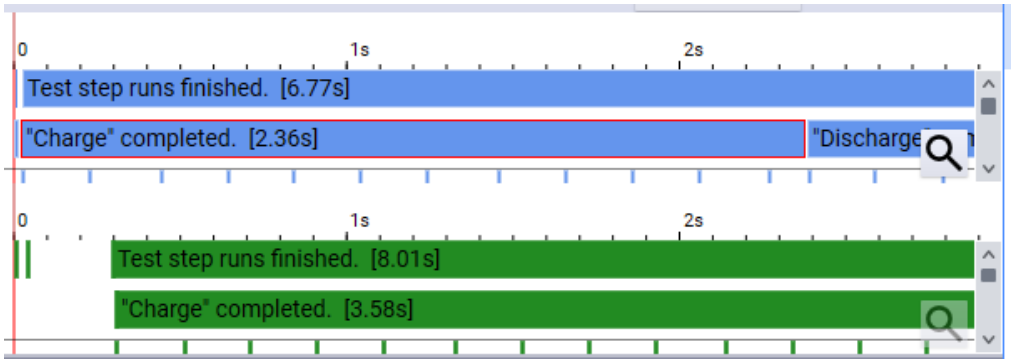
5 The *Timing Analyzer* displays each element of the test plan on the left. The *Time View* window on the right shows time sequentially, with a visual break down of how long each action took and when the action occurred:



6 The *Time View* window supports the standard zooming functionality with either a mouse wheel or by using **Ctrl+** or **Ctrl-**, as well as left and right scrolling.

7 The Log messages are also linked to the *Time View* graphs. Select one of the messages and notice that the associated bar becomes highlighted with a thin red box around it.

8 Zoom in on the *Charge completed time* bar:



9 The times for the *Charge* steps (your times may be slightly different):

- The top test run took 2.36 seconds
- The bottom test run took 3.58 seconds

This is because we changed the *Charge Current* between runs. A 5 A increase in charge current resulted in a 1.17 second decrease in charge time. This is an example of the type of timing analysis that can be done easily with the *Timing Analyzer*.

Saving Test Plans

Select *File* > *Save*, enter a file name for the test plan, and click **OK**.

Test Plans are saved with a *TapPlan* file extension. The default location is at the root folder of the installation folder, typically either"

- *C:\Program Files\Keysight\Test Automation* (for 64-bit)
- *C:\Program Files (x86)\Keysight\Test Automation* (for 32-bit)

NOTE **If the Editor closes improperly, it will try to restore the Test Plan that was last open.**

Optional: Add a Title to Your Test Plan

To assign a name to your test plan you must save it. Click: **File > Save As....** This opens a Windows Explorer dialog box where you can navigate to a folder and specify a file name for your test. This file name becomes the title for your Test Plan.

This Completes the Exercises on the Editor

We hope you found it interesting and are keen on learning more in the following labs and using PathWave Test Automation on your own!

3 Install the SL122xA Test Automation Plugins

Introduction

The SL1200A Grid Integration and Compliance Test Automation Suite extends the functionality of PathWave Test Automation with specialized plugins designed for AC/Grid Emulator control and IEEE 1547.1-2020 compliance testing. These plugins integrate directly into the TAP environment and provide the resources, instruments, and test steps used throughout the remainder of this guide.

This chapter describes how to install the SL1200A software package, required supporting software, and the associated licenses. After completing this chapter, the SL1220A, SL1221A, and SL1222A plugin functionality will be available within the PathWave Test Automation Editor.

In this chapter:

SL1200A Package Installation

NOTE

IMPORTANT licensing information: The *SL1200A Grid Integration and Compliance Test Automation Suite* package includes all the SL122xA Plugin test steps. Plugin licenses are exclusive. Test steps for plugins not licensed are visible but not usable.

You must license the SL1220A plugin to use the *SL1220A AC/Grid Test Sequencing Plugin* test steps and you can use them without using any of the *SL1221A PHIL-based Anti-Islanding Compliance Test Automation Plugin* or any other plugin test steps.

Similarly, you must license the *SL1221A PHIL-based Anti-Islanding Compliance Test Automation Plugin* to use those IEEE 1547.1-2020 Compliance Test Automation Software test steps, and you can use them without using the *SL1220A AC/Grid Test Sequencing Plugin*. The same would be true for the *SL1222A Automated IEEE 1547 Electric Type Test*.

The *SL1241A* license enables using the DER Communication Steps. Both the *SL1241A* and *SL1282A* are required for automated control of the *SL1222A Automated IEEE 1547 Electric Type Test* Steps.

SL1200A Package Installation Requirements

Install Keysight's IO Libraries Suite

Keysight IO Libraries Suite is required for full support of the variety of instruments that can be used for testing, and just about any version of the Keysight IO Libraries will work if you already have it installed.

1. Install the latest version of Keysight IO Libraries Suite from: IO Libraries Suite.
2. Scroll down to the **How to Download** section.
3. Click the **Download Windows x64 IOLS** button. 

4. Locate the **IOLibrariesSuite-xxxxxxx.exe** file in your **Downloads** folder.
5. Run the downloaded installer with **Admin Privilege**.
6. Follow all on-screen instructions.
7. Use **Keysight Connection Expert** to locate and identify test instruments[1] in your test system. Use **Keysight Connection Expert** to determine the IP Address or VISA address of instruments connected for IEEE 1547.1 Conformance Tests. Also,

1 The SL1200A Grid Emulator has its own discovery mechanism associated with the SL1200A Soft Front Panel. Please open the Keysight SL1200A Soft Front Panel and refer to the help file under help > View Help for more details.

refer to the instrument's documentation. This would typically involve connecting the DC Sources.

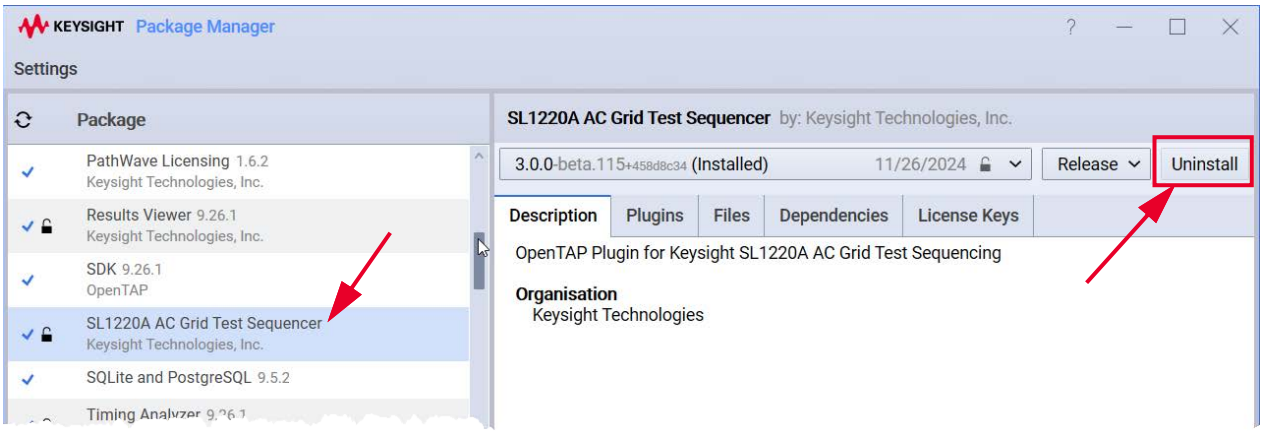
If you have trouble with this process, please contact KeysightCare.

Install SL1200A Grid Integration and Compliance Test Automation Suite

The following procedure provides instructions to install Version 4.0.0 (or later) of the SL1200A Grid Integration and Compliance Test Automation Suite. Follow these instructions whether you are installing the plugin for the first time or are upgrading from an earlier version.

NOTE **You won't be able to install a plug-in without the base license installed and active. That is: install** *KS8400B* **>** *Install KS8400B License* **>** *Install SL1221A* **>** *Install SL1221A License*.

1. If it is open, close the KS8400B Test Automation *Editor*.
2. If you had the previous version 2.1.11 or before of the SL1220A package (named SL1220A AC Grid Test Sequencing as seen below), it should be uninstalled before proceeding. If you did not have that previous version installed, you can skip these next bullets.
   - Navigate to *C:\Program Files\Keysight\Test Automation*.
   - Click *PackageManager.exe* to open the KS8400 **Package Manager** directly.
   - Select (highlight) any older SL1220A package, however it had been named.



   - Click the **Uninstall** to uninstall the old SL1220A package.

Download the latest SL1200A Grid Integration and Compliance Test Automation Suite package from:
https://www.keysight.com/us/en/lib/software-detail/computer-software/sl1220a-ac---grid-test-sequencing-plugin.html

- Select the current release of SL1200A Grid Integration and Compliance Test Automation Suite package (version 4.0.0 or later).
- Click the **Download** button.

3 Install the new version (4.0.0 or later) of the SL1200A Package:

- After it downloads, double-click: **SL1200A Grid Integration and Compliance Test Automation Suite.-***version***.TapPackage**. A new *Package Manager* window opens.
- Follow the prompts to install the package.
- During this process of installation, the Installer will upgrade the OpenTAP and the WPF Controls to versions 9.28.2, which is required for this software to run successfully in the Test Automation environment, which cannot run in any other version of OpenTAP

4 After the SL1200 package installs successfully, close the *Package Manager* window.

5 Reopen the Test Automation *Editor*.

6 Select and purchase an SL1220A AC/Grid Test Sequencing Plugin and/or the SL1221A PHIL-based Anti-Islanding Compliance Test Automation Plugin and/or the SL1222A Automated IEEE 1547 Electric Type Test - Freq / Volt Disturbances license.

-- You will receive an Entitlement Certificate when you purchase a license.
-- Follow instructions in the Entitlement Certificate to redeem the license.
-- Save the license file (*.*lic*) to the computer where you have installed the SL1200A package.
-- If you did not receive or cannot find your entitlement certificate, contact: https://www.keysight.com/us/en/contact.html

7 Install the plugin license(s):

- Start Keysight PathWave License Manager.
- Click the **+Add a License File** button.
- Browse to your **.lic** file and click **Open** to install your trial license.

NOTE

IMPORTANT: if you created test plans using versions 3.x or earlier of the SL1220A plug-in and experience Namespace errors, use the following conversion process and utility to migrate the test plan file(s) to version 4.0:

Navigate to: *C:\Program Files\Keysight\Test Automation\Packages/SL1200A Grid Integration and Compliance Test Automation Suite/Tools/testplan_migration.py*

Run the script with a single argument (which is the .TestPlan file you want to migrate to 4.x namespaces). For example:

```
python testplan_migration.py C:\TEMP\Old_TestPlan.TestPlan.
```

There may still be some residual errors related to the old plugin when loading the Test Plan, but those issues will be resolved when you re-save the plan from the new plugin.

4 What Do I Do Next?

Introduction

Congratulations! You have successfully installed the SL1200A Grid Integration and Compliance Test Automation Suite and verified that PathWave Test Automation (TAP), the SL1200A software package, licenses, and hardware are functioning correctly.

You are now ready to begin using the SL1200A Grid Integration and Compliance Test Automation Suite to create and execute automated test plans.

The SL1200A Grid Integration and Compliance Test Automation Suite includes two complementary sources of documentation.

This Getting Started Guide provides installation instructions, software verification procedures, and introductory workflows designed to help you become productive as quickly as possible.

The SL1200A Grid Integration and Compliance Test Automation Suite Help File (chm) provides complete product documentation, detailed workflows, configuration information, reference material, and advanced usage guidance for all licensed products.

The purpose of this guide is to help you achieve your first successful workflow with the SL1200A Grid Integration and Compliance Test Automation Suite. After completing the introductory chapters in this guide, the Help File should become your primary source of product documentation.

In this chapter:

NOTE

This Getting Started Guide focuses on software installation, verification, test environment preparation, and introductory workflows. Detailed feature descriptions, configuration options, workflow variations, and reference information are provided in the SL1200A Grid Integration and Compliance Test Automation Suite Help File

About the SL1200A Grid Integration Suite

The SL1200A Grid Integration and Compliance Test Automation Suite consists of multiple licensed software products that support different test automation and compliance testing workflows. Depending on the licenses purchased, your installation may include one or more of the products listed below:

SL1220A

AC/Grid Emulator Automation and Test Sequencing

SL1221A

IEEE 1547.1 Anti-Islanding Test Automation

SL1222A

IEEE 1547.1 Electrical Type Test Automation

SL1241A

SunSpec Modbus Communication Library

SL1282A

Automated EUT Communications

All software components are installed through the SL1200A software package. Access to individual capabilities is controlled through licensing.

Using This Guide and the Help File

This guide is intended to provide a structured introduction to the SL1200A Grid Integration and Compliance Test Automation Suite.

The chapters that follow are designed to help you

- **Prepare your test environment**
- **Configure the required resources**
- **Create introductory test plans**
- **Execute representative workflows**
- **Verify successful operation**

The introductory workflows are intended to help you become familiar with the software architecture and testing process. They are not intended to replace the detailed information provided within the Help File.

The Help File contains comprehensive information covering product features, configuration settings, workflow options, test plan development, EUT communications, reporting, measurement logging, and advanced test automation capabilities.

Choosing Your Workflow

Most users will not use every product included in the suite. Instead, users typically begin with the product associated with their testing requirements and licensed solution.

Use the following links to immediately access which chapter to read next:

Learn how to configure instruments, resources, and test environment settings

Chapter 5, “Understanding the SL122xA Test System”

Create custom SL1200A AC/Grid Emulator automation sequences

Chapter 6, “Introduction”

Perform automated IEEE 1547.1 anti-islanding testing

Chapter 7, “Introduction”

Perform automated IEEE 1547.1 electrical type testing

Chapter 8, “Introduction”

Next Steps

The next chapter introduces the common concepts required by all SL122xA workflows.

Proceed to Chapter 5, “Understanding the SL122xA Test System”, to learn how to configure resources, instruments, communications, and other foundational elements used throughout the SL1200A Grid Integration and Compliance Test Automation Suite.

Once your test environment has been configured, continue to the Quick Start chapter associated with your licensed product to complete your first successful workflow

5 Preparing for Your First Test

Introduction

Before executing any SL122xA workflow, the required test equipment and software resources must be configured within PathWave Test Automation.

Although the SL1220A, SL1221A, and SL1222A plugins perform different functions, they all share a common test architecture consisting of instruments, resources, communication interfaces, and one or more Devices Under Test (DUTs).

This chapter introduces the common concepts and resources used throughout the SL1200A Grid Integration and Compliance Test Automation Suite. Completing the setup activities described here will simplify creation of test plans and help ensure successful operation of the SL122xA plugins.

In this chapter:

Understanding the SL122xA Test System

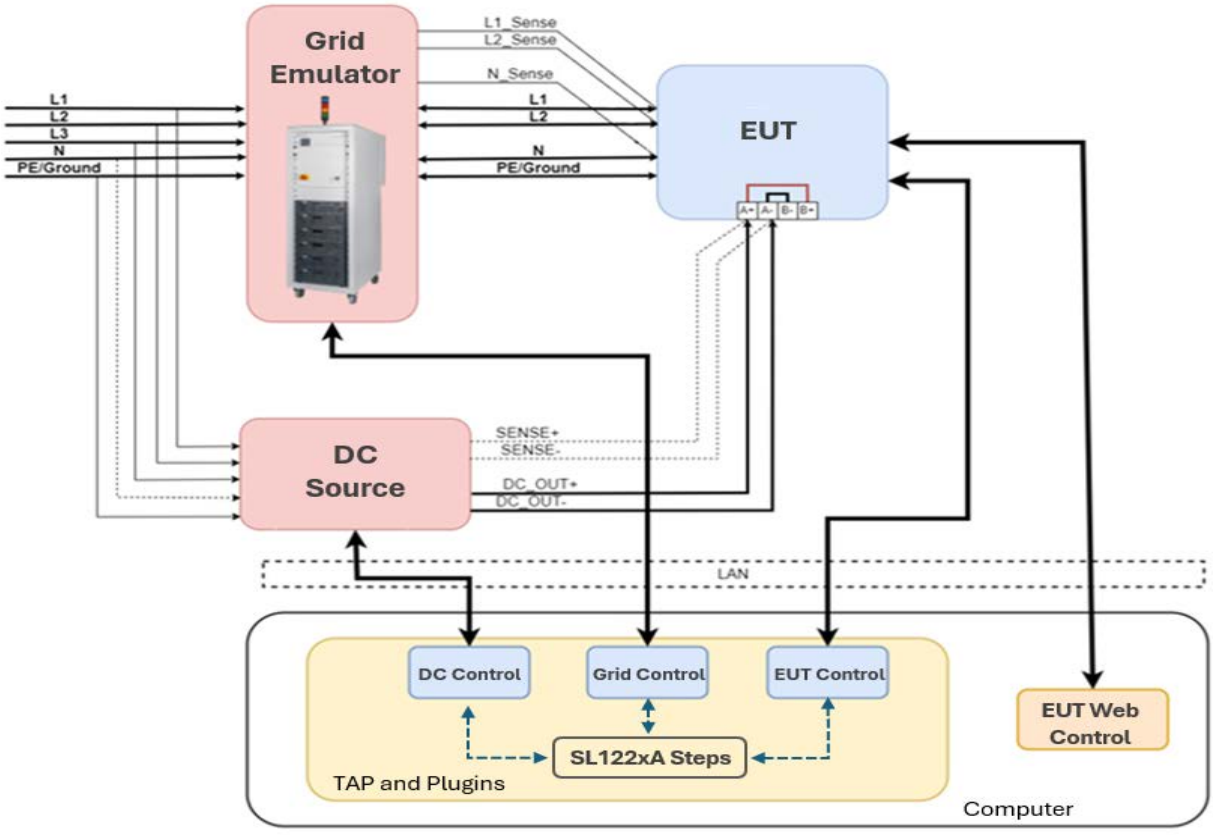
The SL122xA plugins automate interactions between the test system and the equipment under test.

A typical test environment consists of:

- AC Emulator
- Device Under Test (DUT/EUT)
- DC Source
- Other stimulus/measurement equipment

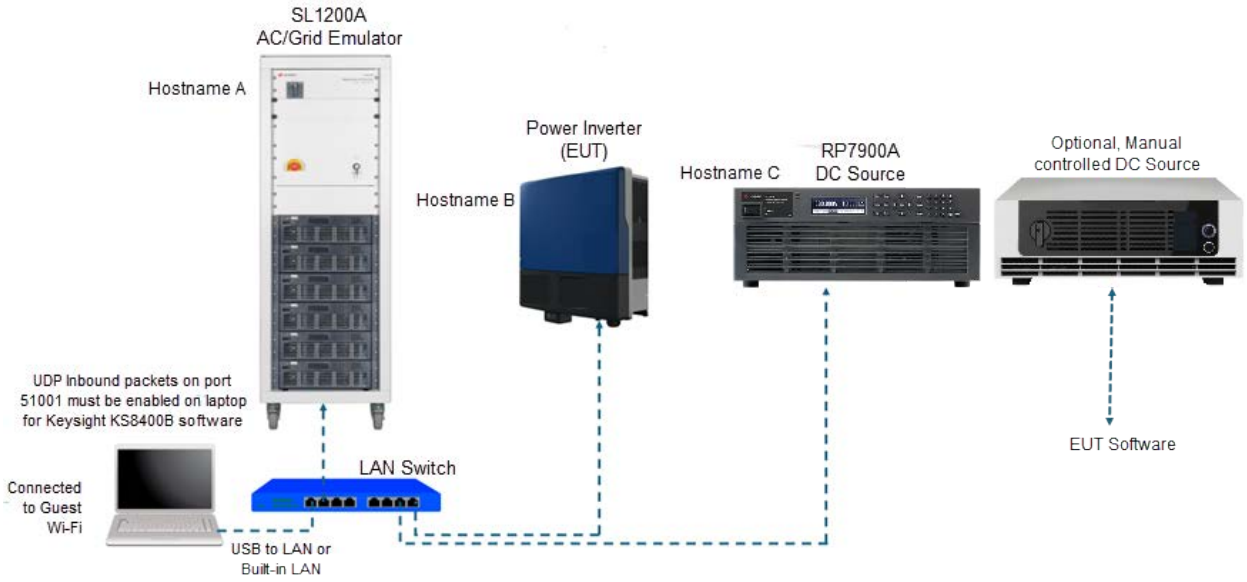
Each physical device is represented within PathWave Test Automation by one or more Resources.

Resources provide the connection between software test steps and physical hardware. The figure below illustrates a typical SL122xA test environment. While the exact hardware may differ depending on the licensed plugin and test application, all SL122xA workflows are based on the same fundamental architecture consisting of an AC Emulator, DUT/EUT, DC Source, and possibly other PathWave Test Automation resources.



Recommended LAN Configuration

Most SL122xA systems use LAN-based communications. Keysight recommends connecting the computer, SL1200A, DUT/EUT, and any LAN-capable instruments to the same LAN switch whenever possible.



All SL122xA plugins use UDP broadcast packets. Ensure that UDP inbound traffic on port 51001 is enabled when using Keysight PathWave Test Automation.

Setting a Static IP on Windows LAN Interfaces

Keysight SL1200A AC/Grid Emulators are shipped with a static IP address of 10.14.6.100 for a single system purchase. When purchasing multiple or paralleled configurations, the IP addresses are still static but are set such that they continue in a sequence. The systems are literally tested that way before shipping.

Many who purchase equipment from vendors such as Keysight actually prefer to leave the IP address the same as when received - whether static or DHCP. They prefer to change the LAN Interface settings rather than the instrument settings. They literally stamp the IP address information on the outside of the equipment and place the equipment in a resource pool for sharing. Users of the equipment are coached to avoid changing the instrument's IP address.

If the instruments are shipped with static IP addresses, a vendor can use a process to alter their computer's LAN interface settings. Sometimes users add USB-LAN adapters per instrument. Adding extra USB-LAN adapters is fine as long as the SL1200A is on the same subnet as the computer, so the UDP broadcast packets are properly routed.

To place the computer on the same subnet as the SL1200A when using static IP addresses, you will need to work with Windows network adapter settings for the interface connected to the SL1200A and assign it a compatible static IP address. For example, if the SL1200A is configured with an IP address of 10.14.6.100, the computer could be configured with a static address such as 10.14.6.10 and an appropriate subnet mask.

- Open the Windows Control Panel and go to Network and Sharing Center.
- Click Change adapter settings, right-click your network connection, and select Properties.
- Double-click Internet Protocol Version 4 (TCP/IPv4).
- Choose Use the following IP address and type your info.

Once both devices are on the same subnet, communication with the SL1200A can be verified using the SL1200A Soft Front Panel.

SL1200A Soft Front Panel for Discovery

You can actually discover what the IP address is for your SL1200A. Keysight's SL1200A Series Regenerative AC/Grid Emulator Soft Front Panel (SFP) provides a tool for discovering and configuring your SL1200A Systems on your local LAN. This SFP tool can be obtained as follows:

https://www.keysight.com/us/en/lib/software-detail/computer-software/sl1200a-regenerative-ac-emulator-soft-front-panel.html

The tool uses a broadcast discovery mechanism to determine IP addresses, even if the SL1200A is not on the same subnet during that process. Of course, once you know the IP address and it is static, you can follow the process described in the previous section. The tool provides a means of changing the IP address of the SL1200A AC/Grid Emulator, if desired.

Use this tool to also update the firmware and gateware of all components within the SL1200A rack. Refer to the SL1200A SFP and its Help file for LAN Discovery and especially for Safety information during startup.

Refer to SL1200A Series Scienlab Regenerative AC Emulator for detailed information. Also, refer to the SL1200A Grid Integration and Compliance Test Automation Suite Help File for more detailed information

What Resources Are Needed and Where?

To use any of the SL122xA plugins, you must have predefined the Resources using the Bench Settings Panel. Here are the requirements for each plugin. Each of these resources will be created and named, so they can be used in the Steps associated with the particular plugin.

Plugin	Required Resources
SL1220A	AC Emulator
SL1221A	AC Emulator, EUT, DC Source
SL1222A	AC Emulator, EUT, DC Source

Typical Setup Sequence

1. Configure LAN communications.
2. Add AC Emulator resource.
3. Add DC Source resource (if required).
4. Add Power Inverter (EUT).
5. Populate EUT Profile.
6. Create Test Plan.

Creating the AC Emulator Resource

The AC Emulator is the primary piece of equipment which is involved in all the SL122xA plugins. For the SL1220A, the Configure Steps assign its functionality as any of the following:

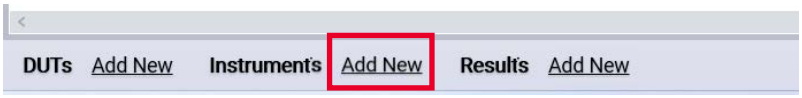
- AC Voltage Priority Single/Three Phase
- AC Current Priority Single/Three Phase
- DC Voltage/Current/Power Priority

Those represent 7 different configurations for the SL1200A Emulator. For the SL1221A and beyond, the AC Emulator is always a Grid Emulator.

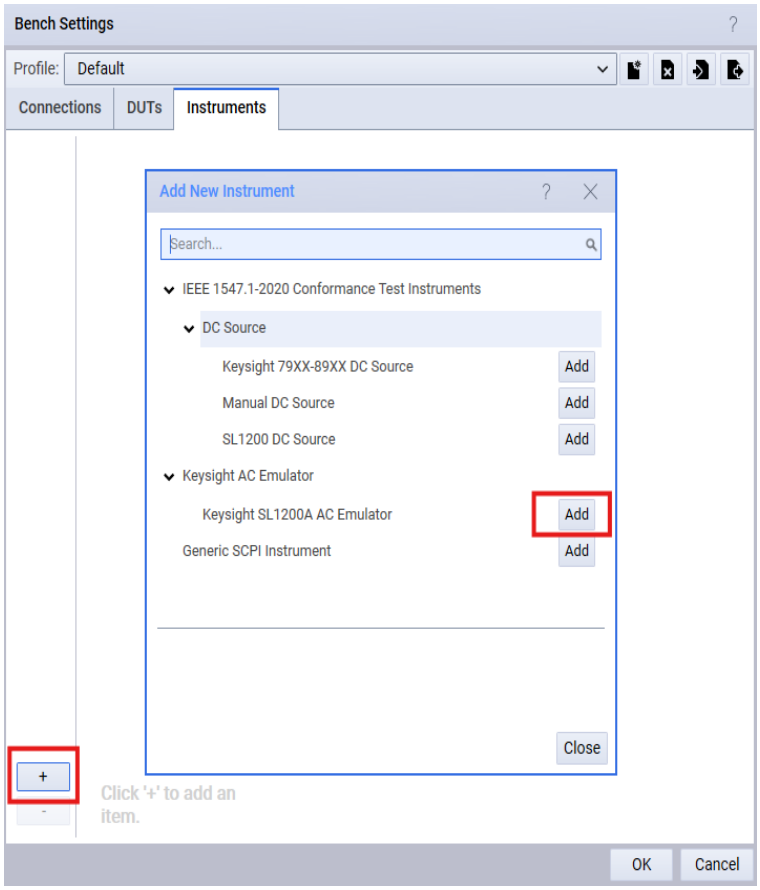
For the Test Plan to be functional, resource configuration is necessary. You must add an AC Emulator.

TAP software allows you to add an Instrument that gives you access to the Keysight SL1220A AC Emulator Plugin. Before any resources such as DUT, Instruments, or Results have been added, the bottom area of the Editor Window

will look as follows. Add an instrument by clicking the *Add New* button at the bottom of the Test Automation window. Alternately, you can select *Settings* > *Bench* > *Instruments* to open the Instruments tab in the Bench Settings panel:

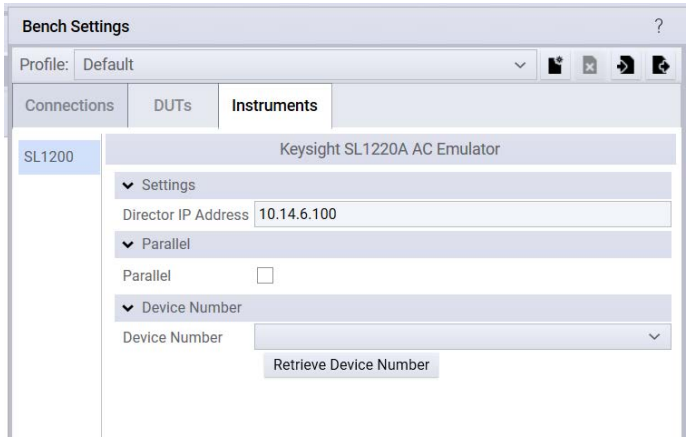


This opens the *Bench Settings* dialog box. Click the + button in the lower left to *Add New Instrument*.



Expand the *IEEE 1547.1-2020 Conformance Test Instruments menu.* Select the *Keysight SL1220A AC Emulator*. Click *Add*. Close the *Add New Instrument* box.

You will be presented with a dialog for setting the IP Address and choosing the model number of the system you want to program. The following screen capture shows entering the IP Address. If the system is already properly connected to your computer via LAN, click the *Retrieve Device Number* button to determine which model number it is at that IP Address.

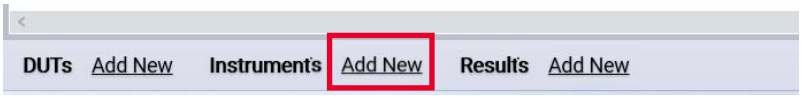


If desired, you can alter the default name of the instrument by double-clicking the name and changing it. Once you are done, click the **OK** button to return to the main *Test Automation* window

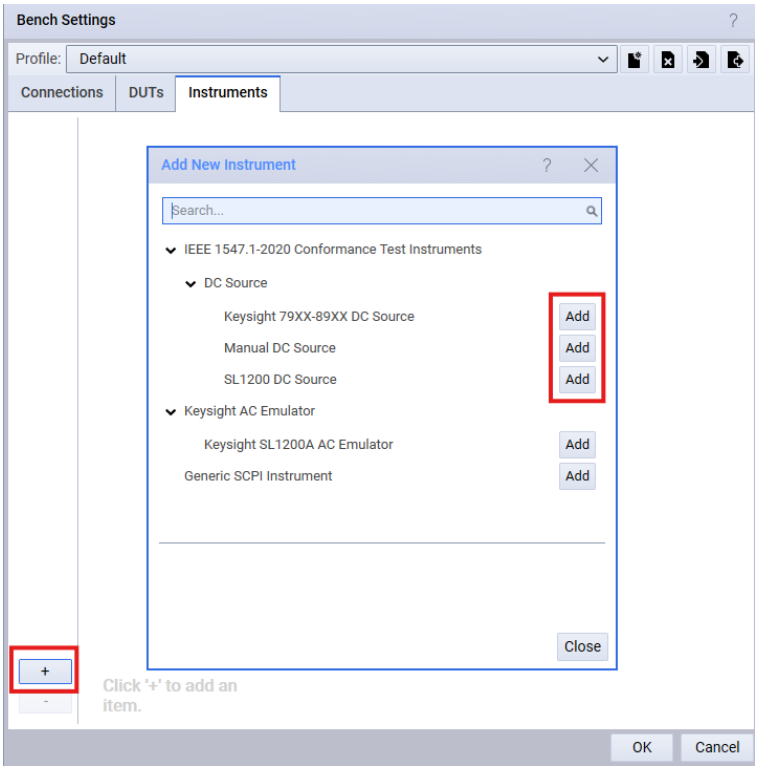
Creating the DC Source Resource

A DC Source is required when using the SL1221A, SL1222A, and follow-on plugins. It is a resource that must be identified in the IEEE 1547.1-2020 Conformance Test Step. It is also an **Instrument** and is added by following a similar process to adding an AC Emulator.

Add an instrument by clicking the *Add New* button at the bottom of the Test Automation window. Alternately, you can select *Settings* > *Bench* > *Instruments* to open the Instruments tab in the Bench Settings panel:



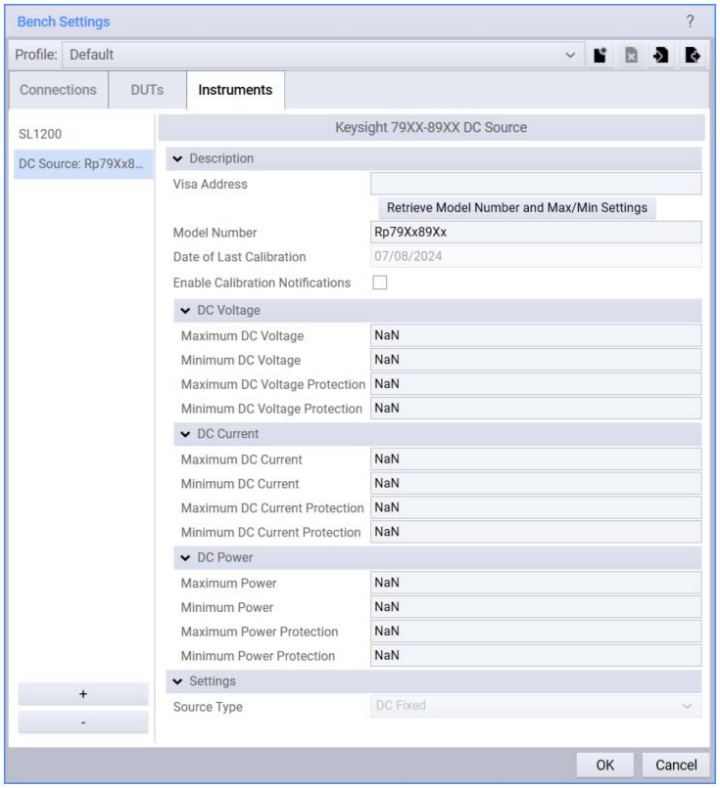
This opens the *Bench Settings* dialog box. Click the + button in the lower left to *Add New Instrument*.



If you have a DC Source other than a Keysight SL1200A or RP79XX/89XX, you can select Manual DC Source. Making that choice then tells the test software to put up a dialog window telling you what to do to set up that DC Source for testing. Even if you have the Keysight products listed, you can still use them as Manual DC Sources. Some prefer this approach, so they can always keep the DUT/EUT powered and completely under their control.

As long as you have a Keysight SL1200A or RP79XX/89XX instrument and choose one of those, the plugin can completely program the DC Source during each test.

1 For this example, select the **Keysight RP79Xx89Xx DC Source**. Click the **ADD** button.



2 Using the Keysight IO Libraries, you can discover the instrument by using the Keysight IO Connection Expert. You can also use the instrument's own front panel to find its LAN IP Address. Once you have the actual IP address, you can bring up the instrument's Web page. On that Web page, you will find valid VISA Instrument address strings that can be inserted into the VISA Address field in the dialog box.

3 Once you have the VISA Address assigned, you can press the Retrieve Model Number and Max/Min Settings button, and the panel software will query the instrument's information.

NOTE

Keysight's SL1200A Grid Emulator can be configured as a DC Source too. However, the SL1200A cannot provide PhotoVoltaic (PV) Simulation. Therefore, if you must operate the EUT in MPP mode, you need to provide a DC Source that has PhotoVoltaic (PV) Simulation, such as Keysight's RP79xx/RP89xx series power supplies or any other DC Source that is controlled manually.

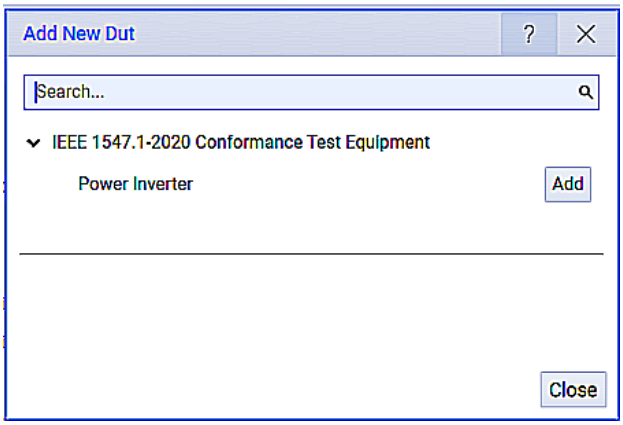
Add a Power Inverter (EUT)

You must specify the EUT (power inverter) you are testing. The EUT configuration is essential to properly operate the Grid Emulator and the DC Source as part of the IEEE 1547.1-2020 Conformance Test Steps.

The TAP environment creates a resource called a DUT (or EUT[1]). The EUT Device Profile provides the configuration information. A detailed description of creating profiles for the EUT, Grid Emulator, and DC Source can be found in the SL1200A Help File located in the Help tab menu of the TAP Editor.

Multiple EUTs may be created and populated with the necessary information for proper testing. The one to be tested can be selected and used in a Test Plan. The EUT Profile is the starting point for all information and represents the most important source of information to drive the IEEE 1547.1-2020 Conformance Test Steps.

1. Add an EUT by clicking the *DUTs Add New* button in the **Resources** panel at the bottom of the Test Automation window. Alternately, select *Settings* > *Bench* > *DUTs* to open the DUTs tab in the **Bench Settings** panel.
2. Select the **DUTs** tab in the Bench Settings panel. Then click the + icon. This opens the **Add New DUT** panel.
3. If necessary, expand the *IEEE 1547.1-2020 Conformance Test Equipment*.
4. Select **Power Inverter**, then click the **Add** button.



This adds a Power Inverter as a DUT device in the KS8400B Resources panel and automatically opens the DUT Bench Settings panel.

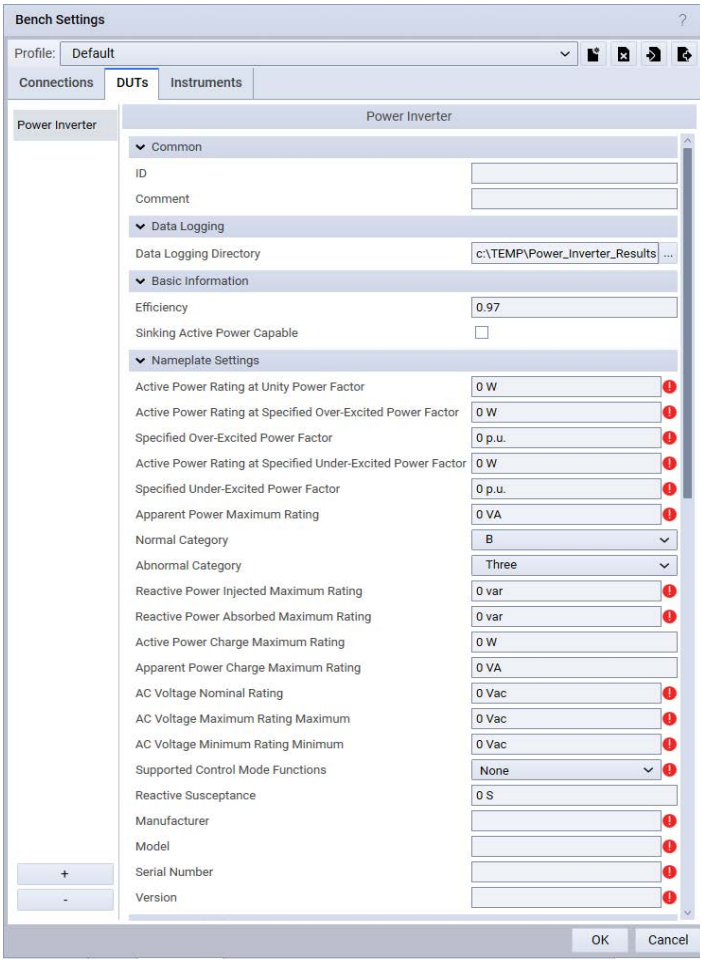
1 IEEE and other industries use EUT to specify the device being tested. Keysight's KS8400B uses "DUT", this is the same as an "EUT".

EUT Profile Settings

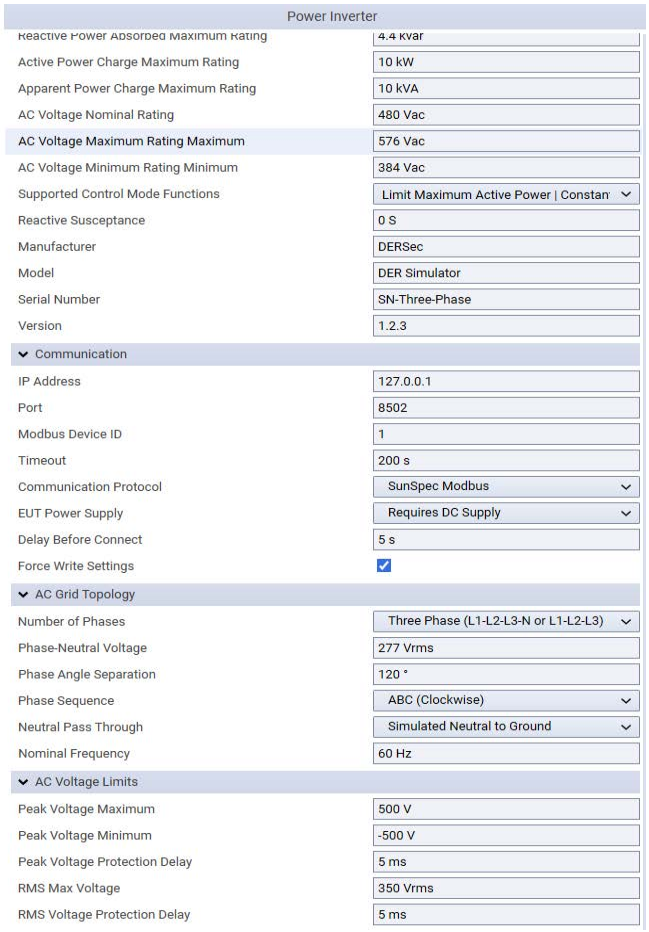
For any of the IEEE 1547.1-2020 Conformance Steps to work properly, you must fill in multiple settings about the EUT you are testing. This is by far the most important information that sets the configuration of the test.

It is beyond the scope of this document to get into all the EUT Panel settings. The settings are covered in greater detail in the Help > Keysight SL1200A Plugin Help.

The following image shows the EUT Profile after adding the Power Inverter. You will note there are many Red circles indicating information that should be filled out related to the performance characteristics of the EUT.

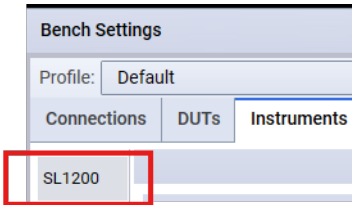


The next image shows a continuation of that same panel, but with typical settings related to the EUT Power, EUT Communications, and Grid Emulator setup.

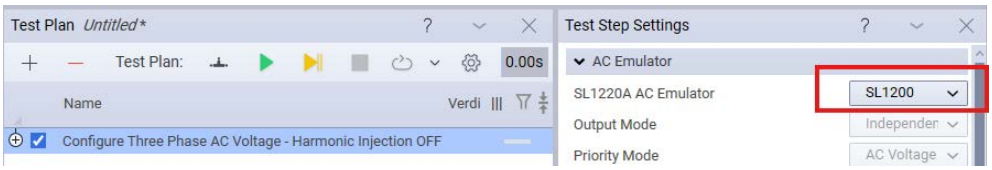


Bench Settings Summary

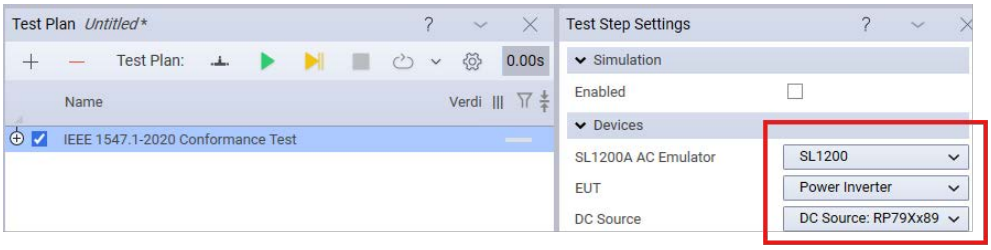
If you are using the SL1220A plugin for creating your own Test Plans with discrete SL1220A Steps, you only needed the AC Emulator Instrument:



If you drag or Add an SL1220A Step, such as the Configure Three Phase AC Voltage Step, into the Test Plan, it requires a resource called *SL1220A AC Emulator* setting. That SL1200 name device will be required in every SL1220A Step that programs the SL1200A AC/Grid Emulator:



Similarly, the IEEE 1547.1-2020 Conformance Step requires three resources, which must also be defined as discussed previously:



Next Steps

After the Bench Settings resources have been configured and verified, proceed to the Quick Start chapter associated with your licensed product:

Create custom SL1200A AC/Grid Emulator automation sequences

Chapter 6, “Introduction”

Perform automated IEEE 1547.1 anti-islanding testing

Chapter 7, “Introduction”

Perform automated IEEE 1547.1 electrical type testing

Chapter 8, “Introduction”

6 SL1220A Quick Start

Introduction

You will learn how to control the output voltage of the SL1200A Regenerative AC Emulator and set up measurement logging with live plotting panels by creating a simple Test Plan. Creating a simple example test plan can become a template or starting point for a larger Test Plan.

In this chapter:

Hardware Requirements

- One SL1200A Regenerative AC/Grid Emulator such as the SL1212A
- SL1200A Resource created as shown in Creating the AC Emulator Resource page 49

The example discussed in this section should first be run with an open output. This ensures that proper operation of the plug-in can be verified without risking damage to equipment from improper programming. Once the test plan has been run, it can be used as a template for subsequent operation with a DUT.

Software Requirements

- Keysight KS8400B Pathwave Test Automation Platform (TAP) software and license
- SL1200A Integrated Grid Test Automation Suite package and license for the SL1220A AC/Grid Test Sequencing Plugin

NOTE

IMPORTANT licensing information: The *SL1200A Grid Integration and Compliance Test Automation Suite* package includes all the SL122xA Plugin test steps. Plugin licenses are exclusive. Test steps for plugins not licensed are visible but not usable.

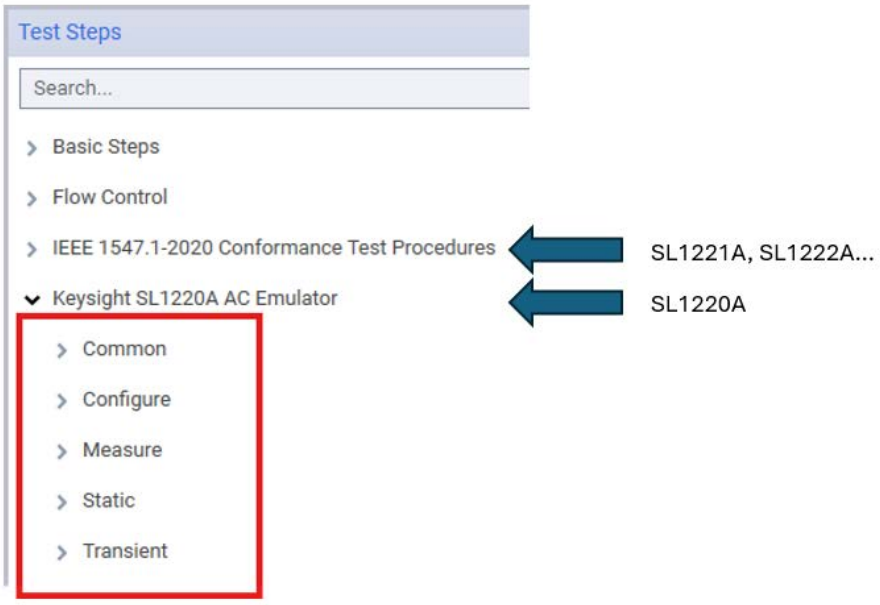
You must license the SL1220A plugin to use the *SL1220A AC/Grid Test Sequencing Plugin* test steps and you can use them without using any of the *SL1221A PHIL-based Anti-Islanding Compliance Test Automation Plugin* or any other plugin test steps.

Similarly, you must license the *SL1221A PHIL-based Anti-Islanding Compliance Test Automation Plugin* to use those IEEE 1547.1-2020 Compliance Test Automation Software test steps, and you can use them without using the *SL1220A AC/Grid Test Sequencing Plugin.* The same would be true for the *SL1222A Automated IEEE 1547 Electric Type Test*.

The *SL1241A* license enables using the DER Communication Steps. Both the *SL1241A* and *SL1282A* are required for automated control of the *SL1222A Automated IEEE 1547 Electric Type Test* Steps.

SL1220A Programming Overview

Keysight's *SL1220A Programming Overview* section in the Keysight SL1200A Help File details all the TAP Steps available for the SL1220A Plugin. There are five major groups or sub-sections of TAP Steps:



- **Common** - provides general purpose Step that can be used in multiple Emulation Modes
- **Configure** - provides a single configuration Step for each Emulation Mode, which configures the SL1220A system
- **Measure** - provides a wide variety of measurements from the built-in Power Analyzer of the SL1220A system
- **Static** - provides Steps for changing set-points, slew rates, etc. which control the system over the LAN connection and execute at the performance level of the TAP and Windows environment
- **Transient** - provides Steps that run inside the controller of the SL1220A and has time-precision and 50 μs time resolution for real-time operations

Programming always starts with *Configure* steps. These are described in the *Configuring the Emulation Model* section of the SL1220A Help File. *Configure* steps completely set up the SL1200A for a particular Emulation mode, where initial Set-points, Slew Rates, Control Limits, and Protection Limits are set. With a single Configure Step, the system is fully operational at that point. Understanding Set Points, Slew Rates, Limits, and Trip Times gives you an overview of the control parameters involved. *Protection* and *Control Limits* explains in greater detail the available *Limits* for monitoring and controlling the system, so you can avoid over-voltage or over-current, or you can cause the SL1200A system to open its output relay contactors to disconnect from the DUT if the Power Analyzer detects over-voltage or over-current.

Measurements and *Data Logging* explains the access to the built-in Power Analyzer of the SL1200A system. The *Data Logger* allows you to create .csv files with selected measurements for a particular test, and measurements are collected in background while other steps can be executed to stimulate the test environment. The Measure Steps provide a means of measuring results against limits, so your Test Plan can indicate success or failure.

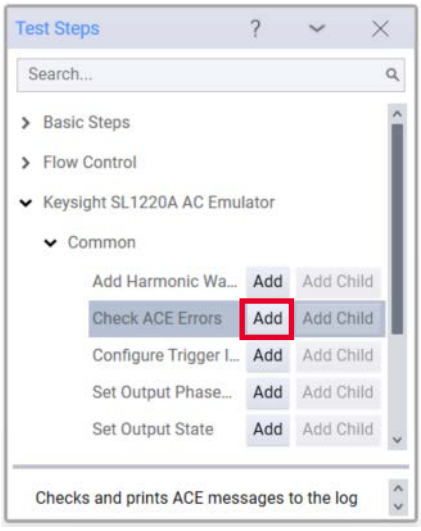
The *External Triggering* section of the Help file explains how to synchronize the SL1200A with your test environment.

Create the Example Test Plan

This example can become a template or starting point for a Test Plan.

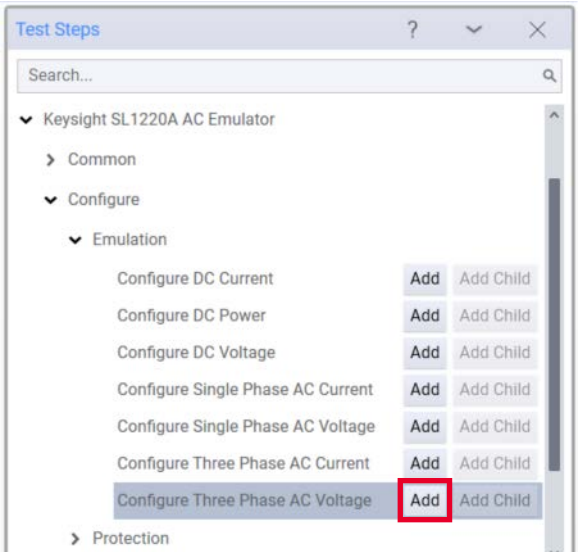
1. Go to *File* > *New* or press **CTRL+ N** on your keyboard to start a new Test Plan.
2. Clear the log panel. Right click on the log file panel then select *Clear Log Panel*.
3. Click the + button (or press **CTRL+ T**) to open the *Add New Steps* window. You will notice that there is now a new group called *Keysight SL1220A AC Emulator.*
4. Expand the *Keysight SL1220A AC Emulator* group's *Common* subgroup. Add a *Check ACE Errors* step[1].

NOTE Insert this step at the beginning of your Test Plan. This allows it to send any messages into the Log Viewer and clear any previous error conditions that may have occurred.



1 ACE refers to AC Emulator

5 Expand the *Configure* > *Emulation* subsection. Add the *Configure Three Phase AC Voltage* step.



6 Close the Test Steps box.

7 In the Test Plan panel, click on the newly added *Configure Three Phase AC Voltage* step — the step should be highlighted in light blue. The **Test Step Settings** panel at the right of the screen has several fields to configure. If you cannot see the **Test Step Settings** panel, go to *View* > *Panels* > *Test Step Settings* at the top of your screen. If you still can't see the panel, go to *View* > *Presets* > *Default* to reset the Test Automation GUI.

8 Use the SL1220A AC Emulator setting drop-down to select the instrument you want to control in this test. If you have configured just one SL1200, then it will be automatically selected. Default resource name is usually called SL1200.

   a Leave *Enable Harmonic Control* de-selected (we will not be injecting harmonics during this example).

   b Check the *Neutral Pass Through* (grounds the neutral).

   c Set the *Frequency* to either 50 or 60Hz.

   d Check *Set Voltage/Slew Rate same for all phases* to make programming easier.

   e Scroll down to the *Phase 1 Settings,* and set the *Voltage* to 277 V_{RMS}. This would be a L-N setting.

   f Leave the rest of the settings alone. By default the phases are programmed to operate balanced with a 120 degree phase difference.

9 In the Test Plan window, look to the left of the *Configure Three Phase AC Voltage* step. You should see a  icon. Click this icon to expand the test step. The main test step, *Configure Three Phase AC Voltage*, is considered the "parent" step, which executes first before the two tab-delineated steps underneath it which are its "child" steps[1].

10 Click on the child step *Set Three Phase AC Protection Parameters* step. We do not need to edit any of the default values for the example, but note that this is where you can set AC protection trip limits and delays.

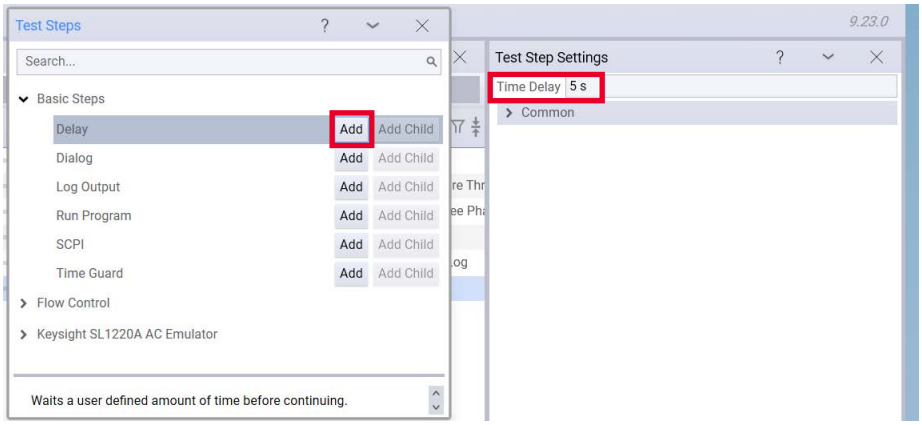
1 More information on parent and child steps can be found in the Keysight Test Automation Help file under *Help* > *Getting Started*.

11 Click on the Test Plan + icon again to open the *Test Steps* panel.

- **a** Navigate to and expand the *Measure* subsection.
- **b** Add a *Start Measurement Log* test step to your Test Plan.
- **c** Now, select it in the *Test Plan* panel to adjust its programmable parameters.
- **d** In the *Test Step Settings* panel, make sure the output mode is set to *Independent Three Phase Mode*.
- **e** You may change the log file name and location if you desire, otherwise the log will be written to the root of the test automation install directory (*C:\Program Files\Keysight\Test Automation*).
- **f** Select the *Choose CSV Log File Parameters* button to open the parameter selection menu.
- **g** You can alter the measurements taken, otherwise leave these settings alone for the example. Close the parameters box.
- **h** Check the *Add System Info* checkbox to add a header with firmware and serial number information of the SL1200A to the measurement log file.
- **i** Keep the *Sample Rate* at 50 ms.
- **j** Click the *Select Plot 1 Parameter* button to open the *Select Plot 1 Parameter* selection menu. This allows you to select one parameter to graph in a live-viewable panel.
- **k** Choose *V1 RMS L-N [V]*. Close the parameter box.
- **l** Click on the *Select Plot 2 Parameter* button and select another parameter you would like to view such as frequency. Close the parameter box.
- **m** Finally, click on the *Select Data Table Parameters* button to select which parameters should be shown continuously as a table.

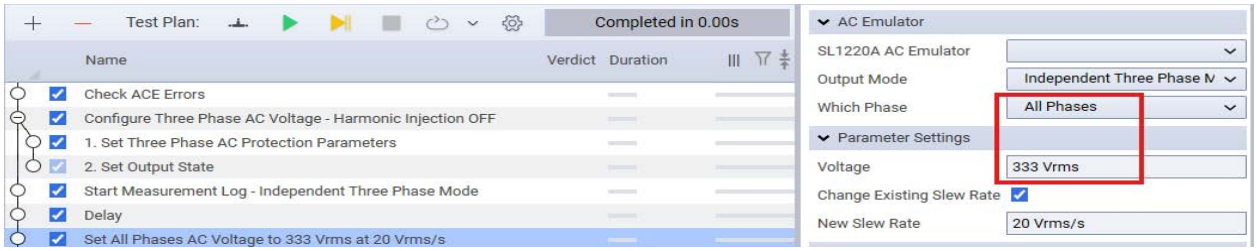
12 Go to *View* > *Panels* > *Keysight SL1200A* > *Keysight SL1220A* and enable all three panels - **Measurement Log Plot 1**, **Measurement Log Plot 2**, and **Measurement Log Plot Data Table**. You should see three floating panels at the middle of the screen. You can keep them floating and move them around to another monitor or part of your screen, or you may “dock” the panels into the UI as you’d like. Make sure to keep these panels visible later when the Test Plan is running.

13 Click on the + button once more. Add the **Delay** step. **Delay** is not part of the SL1220A Plugin and is under the *Basic Steps* drop-down in the test steps menu. Program the delay to 5 seconds.



14 Add the *Set AC Voltage Output* step from the **Static > AC** subsection of the SL1220A Plugin test step list.

15 Set all phases to 333 V_{RMS} .



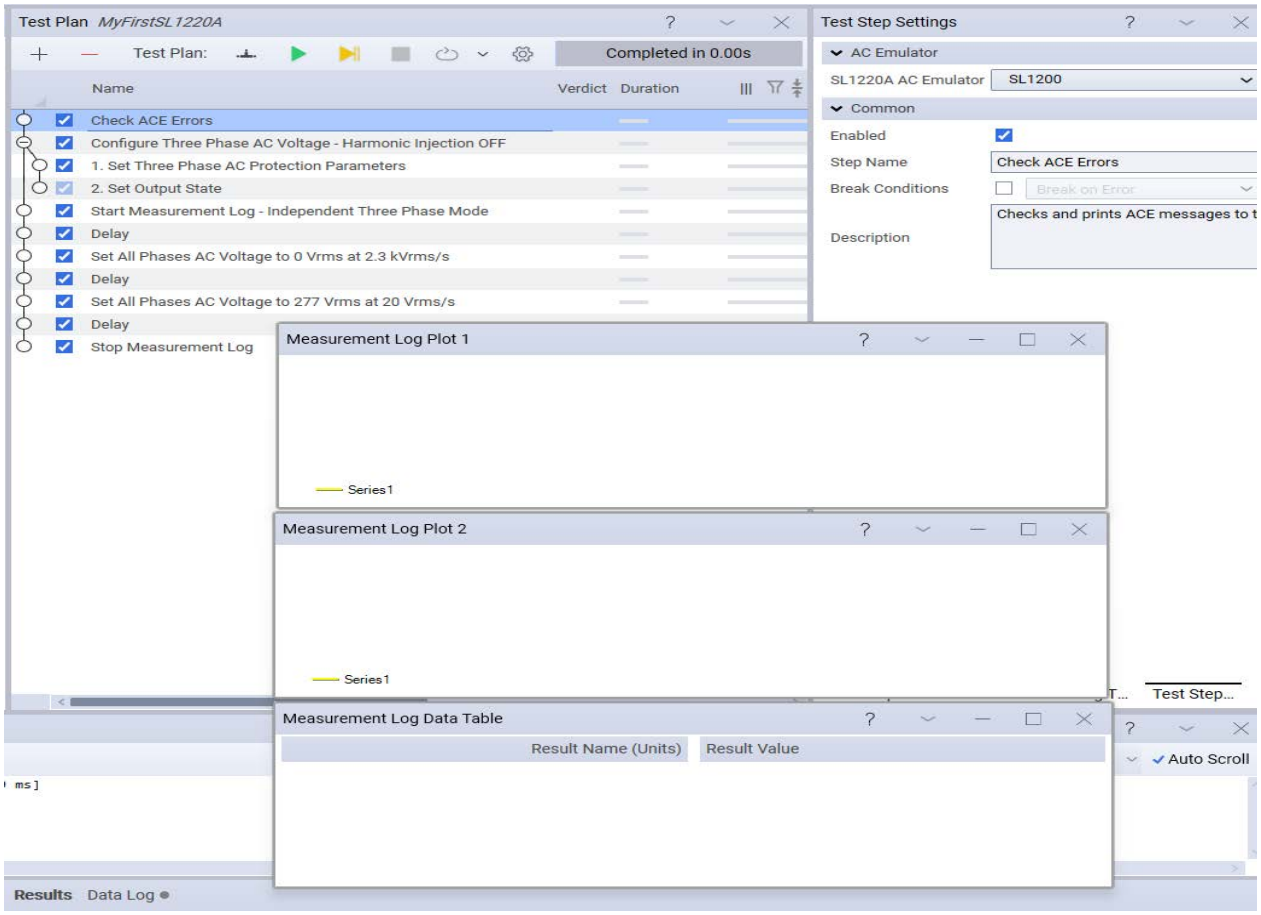
16 Check the **Change Existing Slew Rate** box. Set the slew rate to 20 V_{RMS}/s.

17 Add another 5 second delay step.

18 Add another **Set AC Voltage Output** step. You can add these steps from the *Test Steps* menu, or you can copy-paste existing steps from your Test Plan and change their values. In the new *Set AC Voltage Output* step, program the output to return to 277 V_{RMS} with a slew rate of 20 V_{RMS}/s once more.

19 Add one more 5 second delay.

20 Under the *Measure* subsection of the test steps menu, add a **Stop Measurement Log** step. The example Test Plan is now complete, and should look like the following:



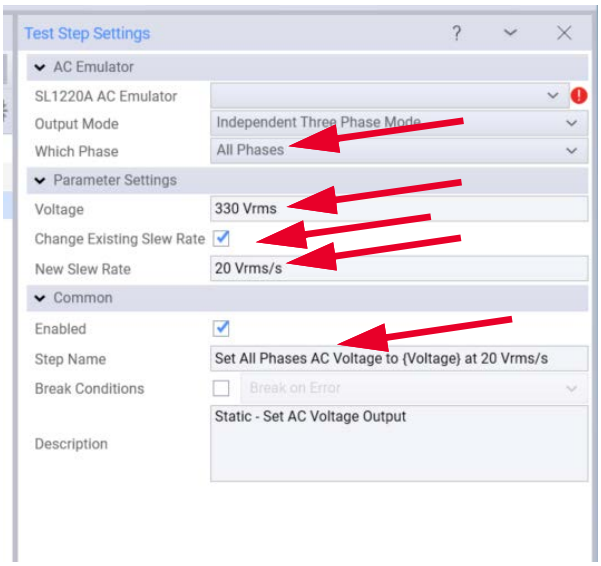
WARNING

RISK OF PROPERTY DAMAGE AND/OR DEATH: When you execute the example Test Plan, it will program the SL1200 to output high voltages capable of injuring or killing a person. Any load or DUT connected to the SL1200 may be damaged if it is not properly rated. The L1, L2, L3, N, G, DC+ and DC- terminals should all be fully disconnected during the example training lab. Please take all proper precautions before proceeding with this exercise

21 Run the Test Plan. During the runtime, the panels you added earlier should display real-time data from the system. At the end of the test, your view panels should look something like the below. The Test Automation Panel tab Settings > Editor > Color Theme was changed to Dark, so the Yellow plot lines would be more visible.

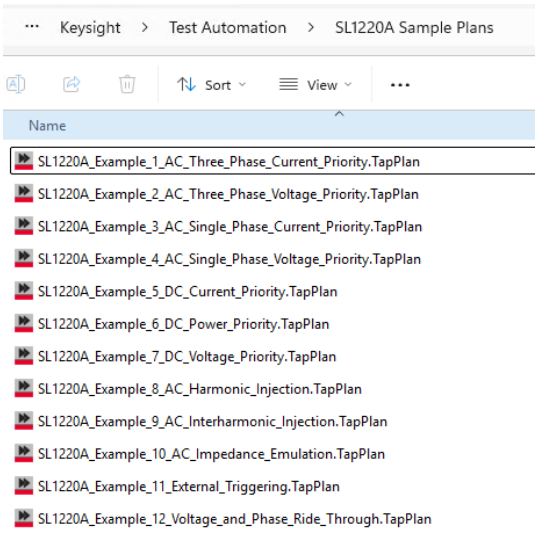
NOTE

Step Names, as shown below, are modified in the Test Step Settings panel in the Editor. For example, the name "*Set All Phases AC Voltage 330 V at 20 Vrms/s*" is actually the "*Set AC Voltage Output*" Test Step from the *SL1220A Static* subgroup. The *Step Name* changes according to the Test Step Settings, where the Setting is named within parentheses and inserted in the text of the Step Name under Test Plan.



Additional SL1220A Example TAP Test Plans

Additional, complete example Test Plans are located at the default installation location: **C:\Program Files\Keysight\Test Automation\SL1220A Sample Plans**.



7 SL1221A Quick Start

Introduction

The SL1221A PHIL-based Anti-Islanding Compliance Test Automation Plugin automates the unintentional islanding test procedures defined in IEEE 1547.1-2020. The plugin combines the capabilities of the SL1200A Grid Emulator, a DC Source, and a Power Inverter (EUT) to create a Power Hardware-in-the-Loop (PHIL) test environment capable of executing both Sustained Island and Clearing Time test sequences.

This chapter provides an overview of the SL1221A plugin and demonstrates how to create and execute a representative anti-islanding Test Plan. You will learn how the IEEE 1547.1-2020 Conformance Test framework is organized, how the required resources are used within the Test Plan, and how to run and analyze unintentional islanding test results. Resource configuration, communications setup, and EUT profile creation are discussed in Chapter 5, “Understanding the SL122xA Test System”

After completing this chapter, you should be able to create a basic SL1221A Test Plan, execute representative anti-islanding test cases, and locate the measurement and post-processing files generated during testing.

Important: This Chapter does not provide complete and detailed instructions. For detailed information, refer to the *SL1200A Grid Integration and Compliance Test Automation Suite* Help File.

In this chapter:

Hardware Requirements

- One SL1200A Regenerative AC/Grid Emulator such as the SL1212A
- One DC source such as the Keysight RP7900/8900A or SL1200A Grid Emulator in DC Emulation Mode (fixed DC only)
- One Power Inverter for the Device Under Test (DUT, also known as an EUT[1])
- How to create Resource identifiers for each of these devices is covered in Chapter 5, “Understanding the SL122xA Test System”

Software Requirements

- Keysight KS8400B Pathwave Test Automation Platform (TAP) software and license
- SL1200A Integrated Grid Test Automation Suite package and SL1221A PHIL-based Anti-Islanding Compliance Test license

NOTE

IMPORTANT licensing information: The *SL1200A Grid Integration and Compliance Test Automation Suite* package includes all the SL122xA Plugin test steps. Plugin licenses are exclusive. Test steps for plugins not licensed are visible but not usable.

You must license the SL1220A plugin to use the *SL1220A AC/Grid Test Sequencing Plugin* test steps and you can use them without using any of the *SL1221A PHIL-based Anti-Islanding Compliance Test Automation Plugin* or any other plugin test steps.

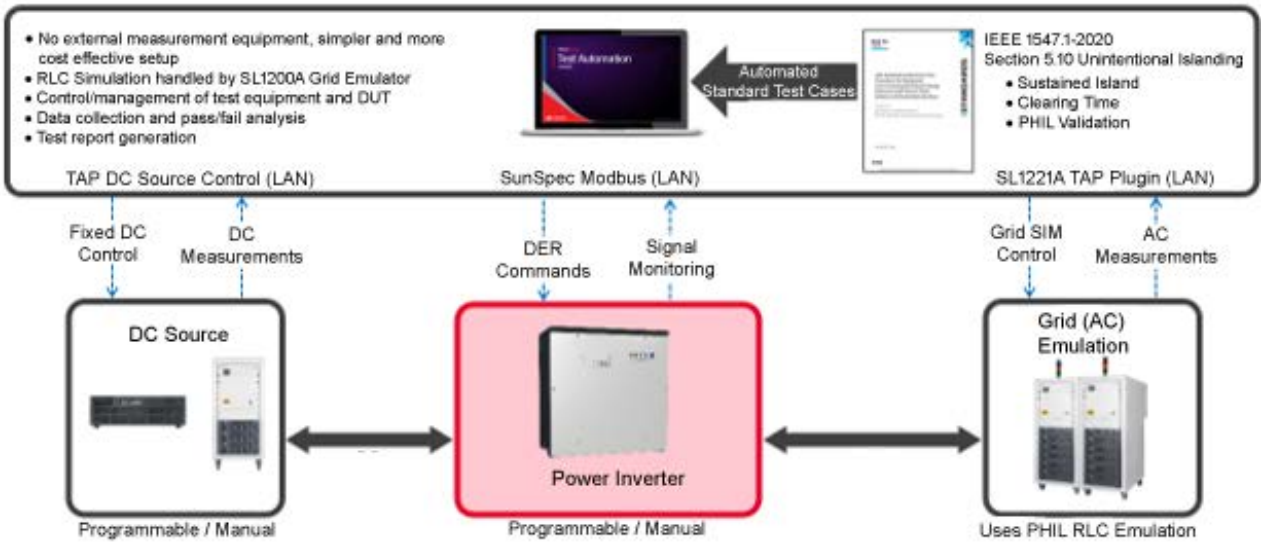
Similarly, you must license the *SL1221A PHIL-based Anti-Islanding Compliance Test Automation Plugin* to use those IEEE 1547.1-2020 Compliance Test Automation Software test steps, and you can use them without using the *SL1220A AC/Grid Test Sequencing Plugin.* The same would be true for the *SL1222A Automated IEEE 1547 Electric Type Test*.

The *SL1241A* license enables using the DER Communication Steps. Both the *SL1241A* and *SL1282A* are required for automated control of the *SL1222A Automated IEEE 1547 Electric Type Test* Steps.

1 "EUT" and "DUT" refer to the same device. EUT is used by IEEE, the SL1221A Plugin, and others to specify the device being tested. DUT is a common term and is used in Keysight's Test Automation Editor.

Keysight Unintentional Islanding Overview

The following graphic describes the Keysight solution for unintentional islanding. This graphic represents the translation of the unintentional island test procedures, setups, etc., found in the IEEE-1547.1-2020 into the Keysight Test Automation Platform (TAP). The SL1221A plugin automates the IEEE 1547.1-2020 unintentional islanding test procedures described in Section 5.10. The software runs in the Windows environment and interfaces to the various hardware components via LAN.



The SL1221A PHIL-based Anti-Islanding Compliance Test Automation Plugin provides an automated solution for performing IEEE 1547.1-2020 unintentional islanding testing. The solution combines Keysight's SL1200A Series Regenerative AC/Grid Emulator, a DC Source, and a Device Under Test (EUT) within a Power Hardware-in-the-Loop (PHIL) environment. The software integrates these components through the KS8400B PathWave Test Automation platform, allowing engineers to create, execute, and analyze anti-islanding tests using a structured and repeatable workflow.

The SL1221A plugin automates the test sequences required by IEEE 1547.1-2020 Section 5.10 and provides support for both Measure Sustained Island and Measure Clearing Time test methodologies. The software coordinates operation of the Grid Emulator, EUT, and DC Source, performs automatic RLC tuning, captures high-speed waveform data, records measurement results, and generates the files required for post-processing and analysis. Where supported, SunSpec Modbus communications can be used to automatically configure the EUT during testing. Manual EUT operation is also supported, allowing the solution to be used with a wide variety of inverter products and laboratory configurations

Creating an Unintentional Island Test Plan

1 Add the Resource identifiers using Bench Settings as covered in Chapter 5, "Understanding the SL122xA Test System".
   - Add an AC Emulator and DC Source in the TAP Editor
   - Add and configure the AC Emulator
   - Add and configure the DC Source

NOTE **Important**: Create the EUT Profile, Grid Emulator Profile, and DC Source Profile before you add the IEEE 1547.1-2020 Conformance Test Step into the Test Plan. Otherwise, Test Plan errors may occur.

2 Configure the EUT Profile Settings as covered in Chapter 5, "Understanding the SL122xA Test System"
3 Open the Test Step Status Panel
4 Load the IEEE 1547.1-2020 Conformance Test Step
5 Configure Test Step Settings
6 Run the Test Plan
7 Analyze the Test Data

Keysight's SL1200A Grid Integration and Compliance Test Automation Suite Help File describes each of these steps in detail. The Help guide is found under *Help > Keysight SL1200A Plugin Help*.

IEEE 1547.1-2020 Conformance Step

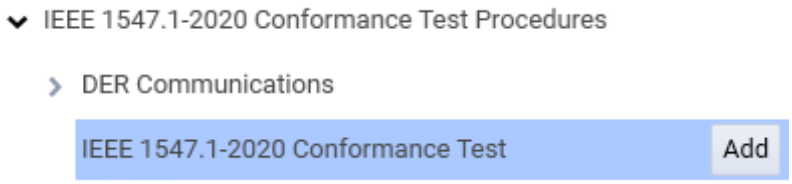
Only a single step called the IEEE 1547.1-2020 Conformance Test Step represents the complete IEEE 1547.1-2020 Test Plan. This step is called the "Grandparent" step[1], because there are multiple sub-steps involved:

- IEEE 1547.1-2020 Conformance Step. This is the top-level Step from which all Type Test Steps are run.
  - Section 5.10 Unintentional Island Test, known as the 'Parent' step
    -- Section 5.10.2 Measure Sustained Island Tests, known as 'Child' steps
    -- Section 5.10.2 Measure Clearing Time Tests, known as 'Child' steps

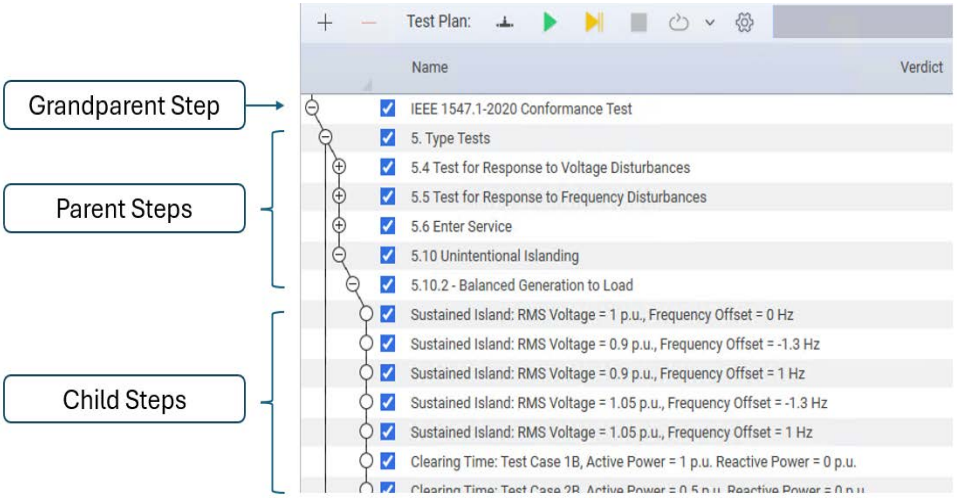
1 In the Test Automation editor, click the + button (or press **Ctrl+T**) to open the **Test Steps** panel.
2 Expand **IEEE 1547.1-2020 Conformance Test Procedures**.

1 It is also called a "Macro" step because there are multiple steps involved in this one step.

3 Select **IEEE 1547.1-2020 Conformance Test Step** then click the **Add** button.

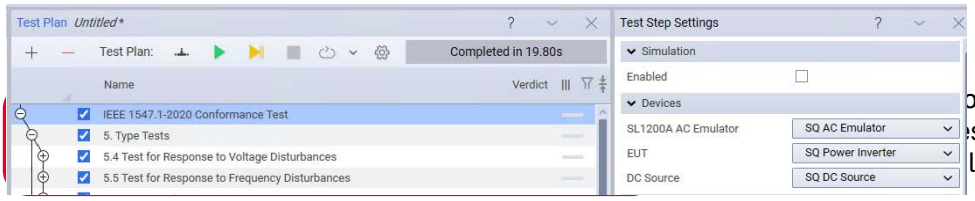


That operation brings the Step into the Test Plan Panel, and that single Step becomes the Test Plan! That is all that is needed to run the IEEE 1547.1-2020 Conformance tests.



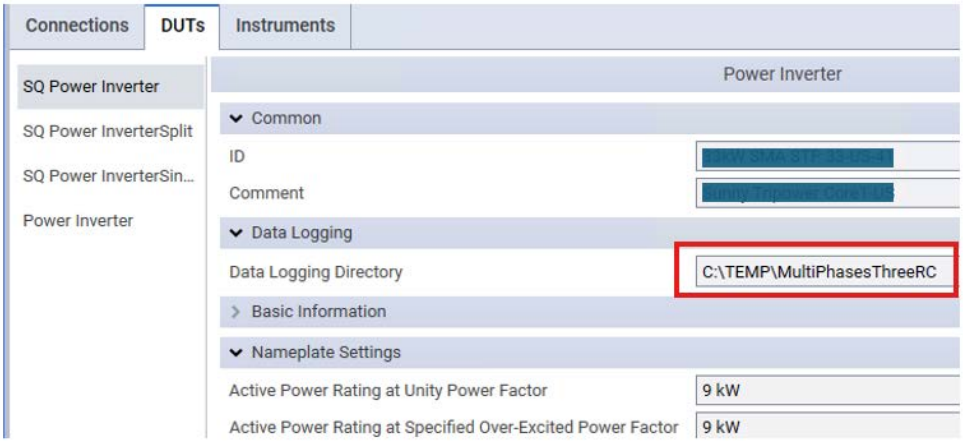
Grid Emulator, EUT, and DC Source Assignments

This IEEE 1547.1-2020 Conformance or Grandparent Test Step is the step where you select which Resources are used in the test.



The Resources defined in the Bench Settings are visible at the bottom of the TAP Editor Panel. The drop-down Devices selection allow you to pick from the defined Instruments, DUTs, etc.. Over time you will likely accumulate many such Devices.

When this Test Step or any step under this one is run, the Result data (measurements, reports, etc.) will be stored in a location specified in the selected EUT. For example, the selected EUT is SQ Power Inverter. Selecting EUT at the bottom of the TAP Editor panel will bring up that EUT Profile:



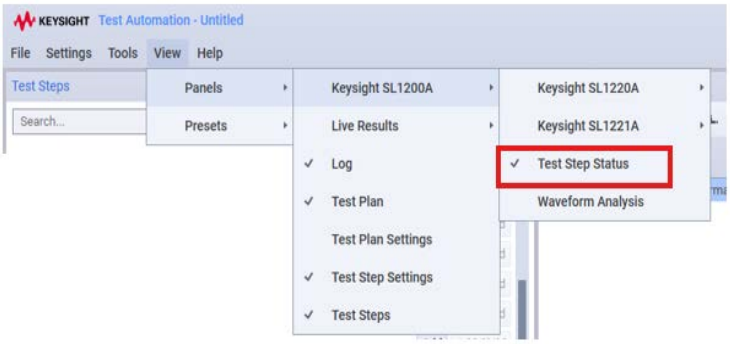
NOTE: You can specify the Data Logging Directory to anything accessible by your Windows File Explorer.

NOTE: Further down in this page under Communications, Manual mode vs. SunSpec Modbus can be selected. If Manual, the software prompts you to configure the EUT to the configuration for the particular Test Step. Otherwise, with EUT SunSpec ModBus operation, the EUT is automatically configured to specified settings for the particular Step.

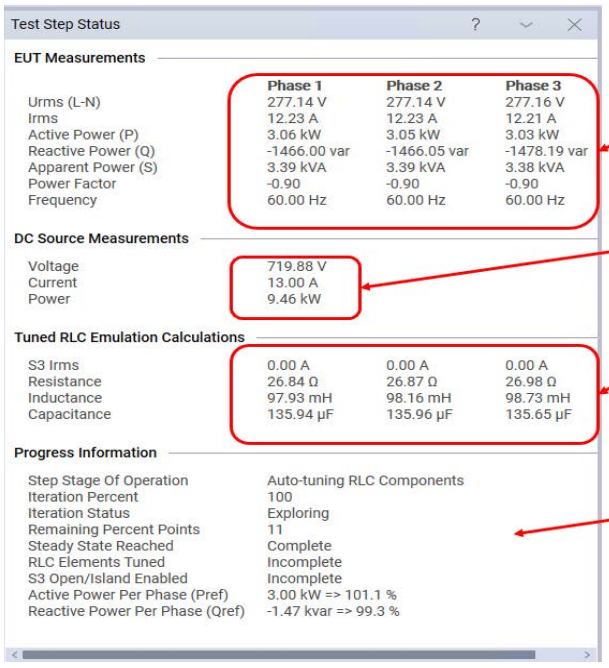
Open the Test Step Status Panel

An important aspect for all test steps is the *Test Step Status Panel*. This panel keeps track of all Grid and DC Source measurements. It also provides information on what tests and sub-tests are being performed and how long they have been executing.

Access this panel from the TAP Editor View tab:



When a Test Step is running, this panel will tell you what is happening.



For a single or split phase configuration, panel still shows all three phases, but unused phase should show near zero signals

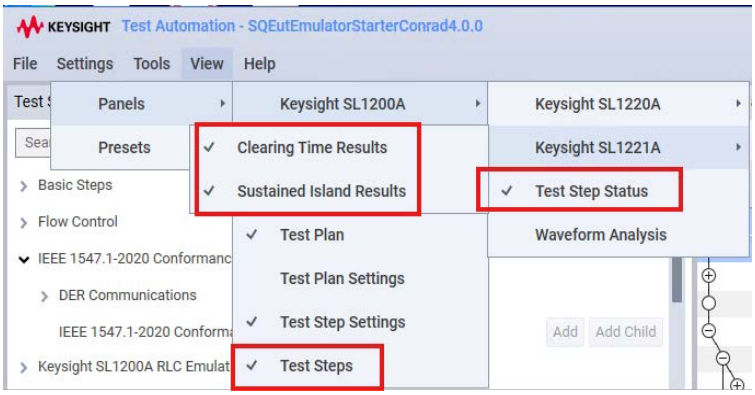
DC Source measurements only valid when SL1221A plugin is controlling the DC Source.

RLC components simulated for each phase according to Active and Reactive Power level at the specified frequency and the desired current Iteration Percent.

Progress information shows the sequence of operations for the current Test Step. Active and Reactive power must fall within +/- 5% of the expected power level before the step will proceed to simulating S3 Open and island condition.

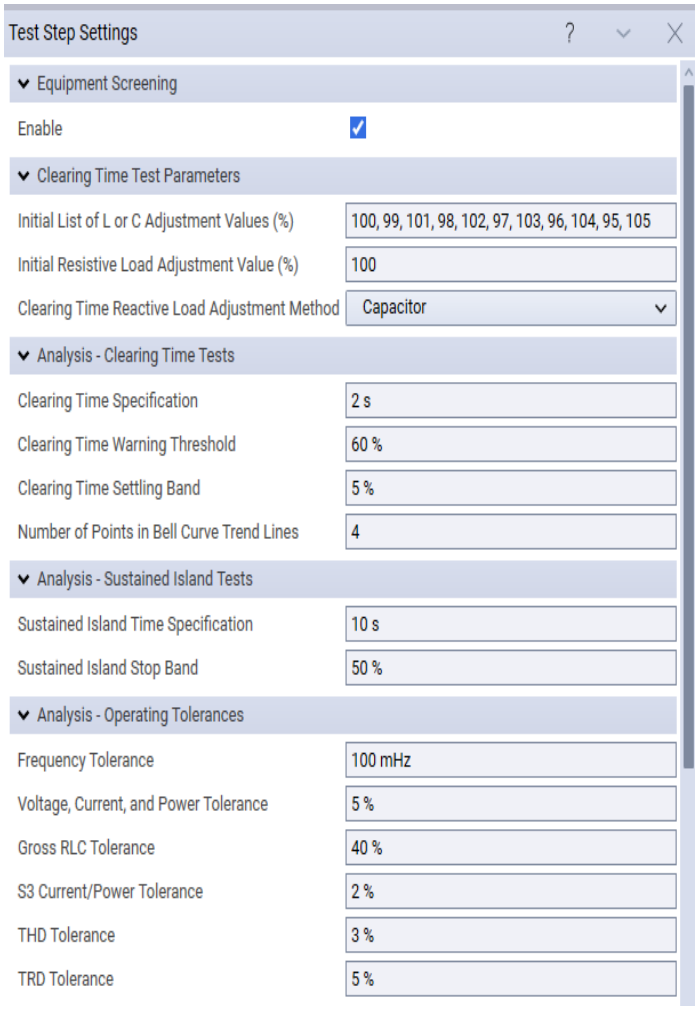
How to Enable all the Status Panels

The following image shows which panels are enabled and where to locate them in the TAP Editor. These panels should all be activated during your testing. Once enable, they can be stacked on top of each other by dragging and dropping them into the same TAP Editor window.



Configure Test Step Settings

Select the Parent Step *5.10.2 - Balanced Generation to Load.* The initial Test Step Settings of this Step affect the Child Steps below it.



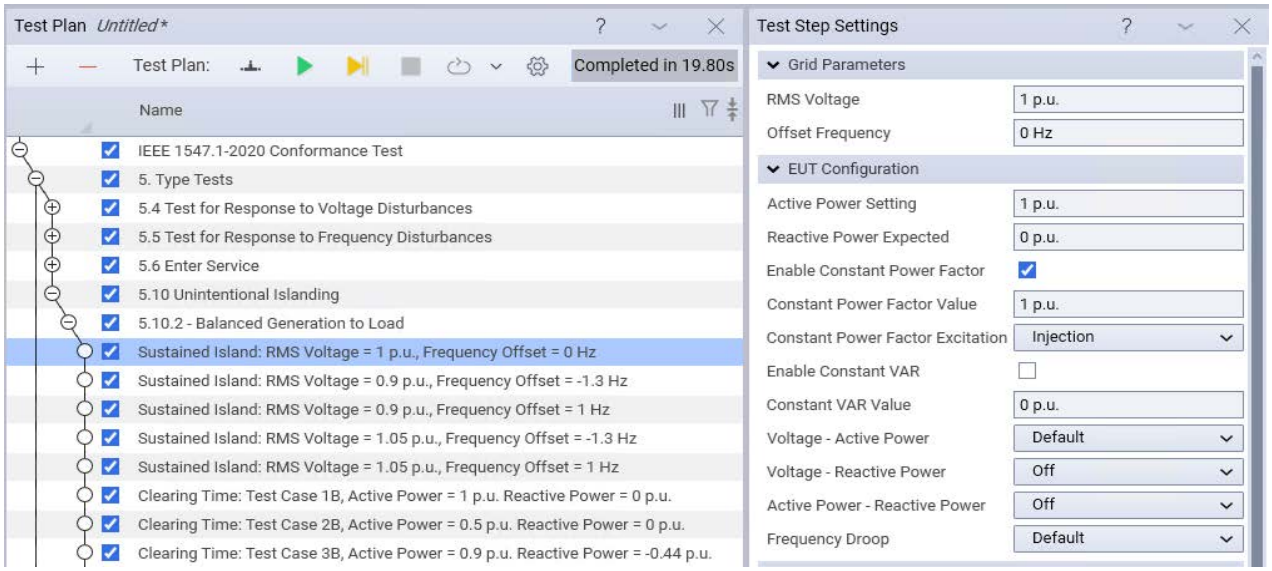
The default settings are according to the IEEE 1547.1-2020 Standard. You are allowed to change many of them, and the changes will be reflected in the Test Plan and in the Report. For example, if you wanted to see how well the EUT is operating, you could lower the Operating Tolerances from 5% to 3% to see if the EUT passes that stricter requirement. However, a Red circle (❗) will appear next the parameter changed, and the Test Report will reflect the change to the Standard. It would be up to the auditor of the test results to determine if any changes invalidate the test results.

You can see that some settings are associated with Clearing Time Steps and others with Sustained Island Steps.There is also a unique Equipment Screening setting that verifies your Grid and DC source can work properly with your EUT.

Section 5.10 Measure Sustained Island Test Step

When running one of these five Steps for the first time, the software prompts you to turn the Anti-Island Algorithm **OFF** in the Power Inverter. You don't want the Power Inverter to shut down within the specified two second time period. You want the Island to persist when the SL1221A RLC emulation matches the impedance of the Power Inverter. This is usually accomplished with an external Tool, Web Interface, etc., since it is not a programmable feature using the IEEE protocol.

The defaults for each Sustained Island Step are given when clicking each Step. Those settings are tied directly to the EUT Profile settings for Normal/Abnormal operations.

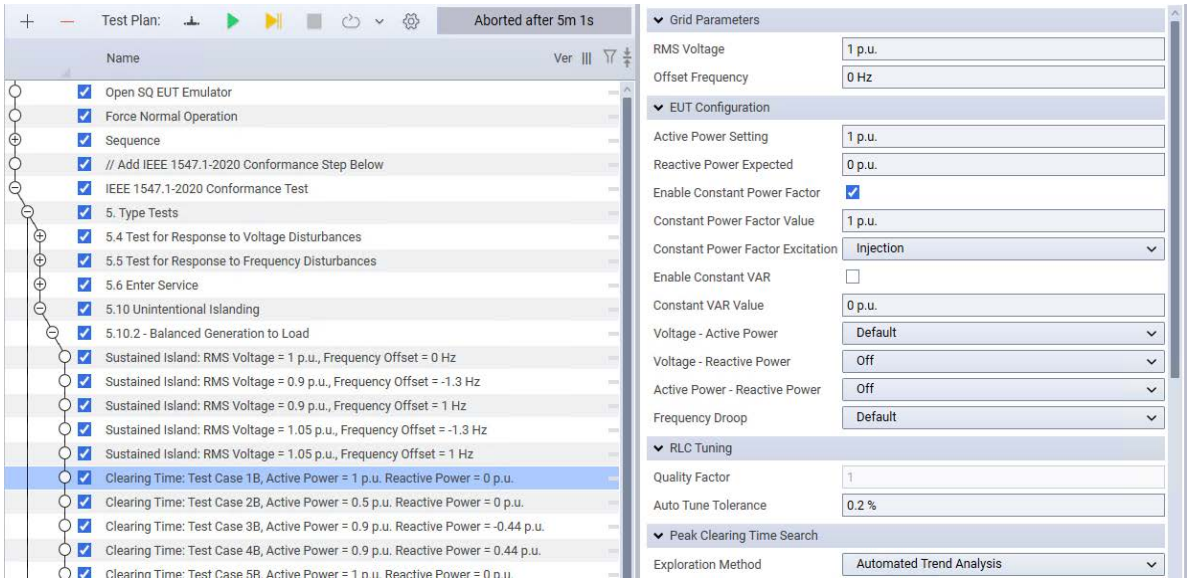


This Sustained Island Step specifies parameters that affect its operation. There are five Sustained Island Test Steps, and many of the parameters are changed dependent upon the type of test to be conducted. The first Step defaults to the IEEE 1547.1-2020 Test Case 1 configuration. The remainder of the Sustained Island steps push out the limits of voltage and frequency, so you can test the four corners of Voltage and Frequency. These Steps basically verify the PHIL capability of the Keysight solution.

Section 5.10 Measure Clearing Time Test Step

When running one of these ten Steps for the first time, the software prompts you to turn the Anti-Island Algorithm **ON** in the Power Inverter. That is, you want the Power Inverter to shut down within the specified 2 second time period if the Grid goes away. This is usually accomplished with an external Tool, Web Interface, etc., since it is not a programmable feature using the IEEE protocol.

The defaults for each Clearing Time Step are given when clicking each Step. Those settings are tied directly to the EUT Profile settings for Normal/Abnormal operations.

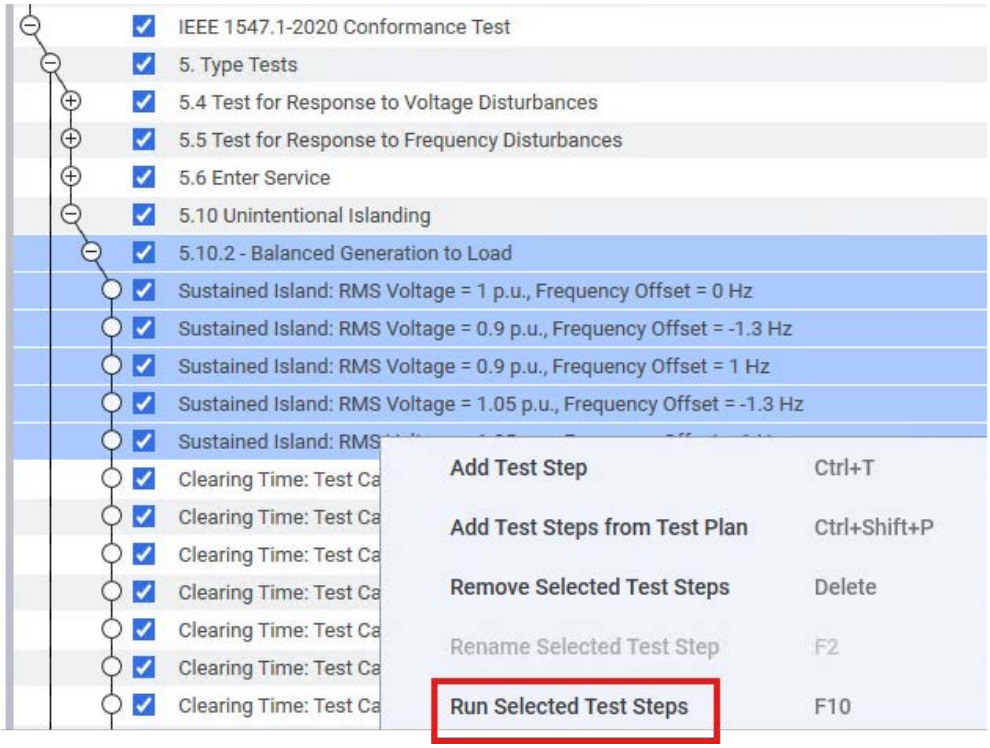


The Measure Clearing Time Step specifies parameters that affect its operation. There are ten Measure Clearing Time Test Steps, and many of the parameters are changed dependent upon the type of test to be conducted.

It is recommended that you run all five Measure Sustained Island Steps individually or as a group. It is also recommended that you run each Measure Clearing Time Step individually. Although the 10 Clearing Time Steps can be run automatically, you are likely to see issues with proper operation if this is the first time you have run the Step. Running them individually will give you confidence they are working properly, so you don't have to abort the Test Plan to stop all testing when one Step is not working properly. Therefore, right-click on any of the 10 lower-level Steps and select Run Selected Test Steps.

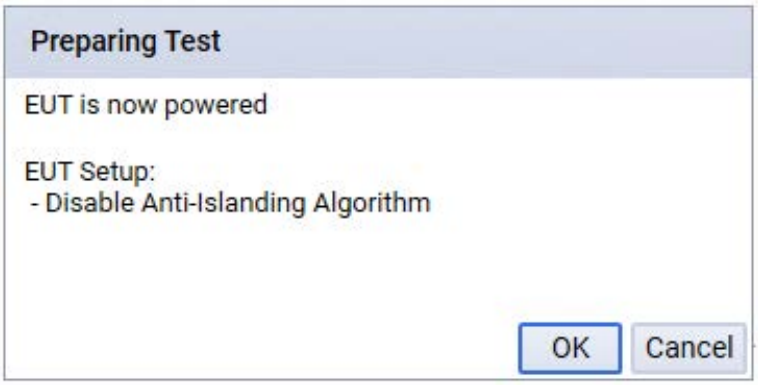
Running the Sustained Island Steps

It is recommended that you run all five Sustained Island Steps as a group.With TAP, you have a means of executing selected Steps. In the following image, you see that the Parent and the 5 Sustained Island Test Steps are selected first. Then, when right-clicking on the highlighted Blue area, you can selected *Run Selected Test Steps*:

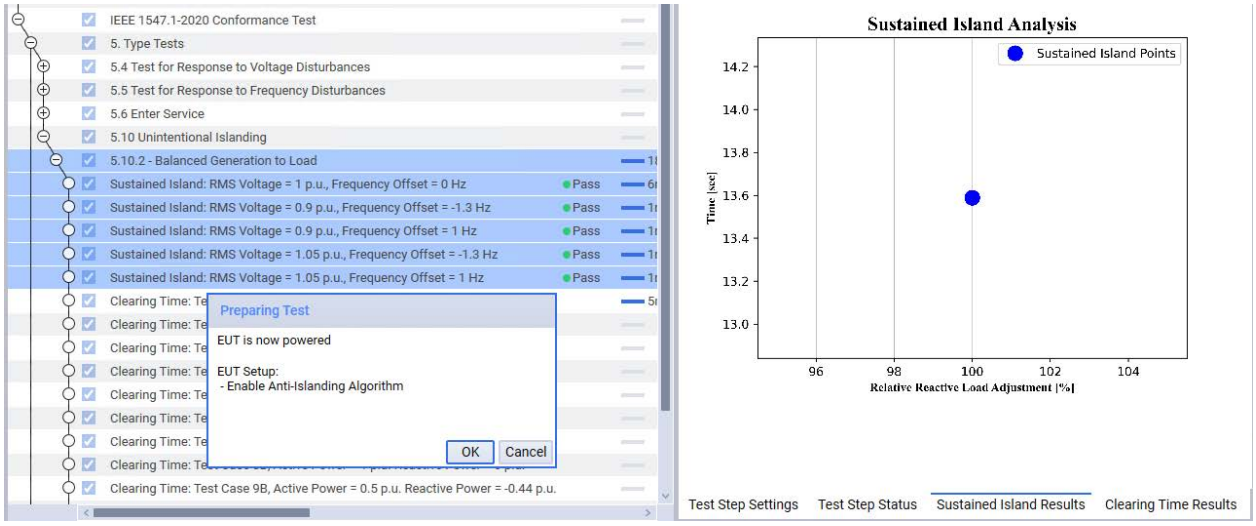


NOTE: The above selection will actually cause all the Clearing Time Steps to execute as well, because the Parent Step was selected. The Parent Step was included because the configuration of the DC Source occurs in that Step. If the Parent Step is executed, then ALL the Child Steps will be executed, whether or not they were selected. In this example, you actually have an easy way out of this condition without having to abort a running Clearing Time Step. When the Clearing Time Step starts to execute, it will bring up a dialog panel telling you to turn **ON** the Anti-Island Algorithm. It is a simple matter to press the Red Stop button to abort the Test Plan at that point.

Once the Sustained Island Step starts to execute, you will be prompted to turn **OFF** the Anti-Island Algorithm and any other mode that might cause the Power Inverter to shut OFF automatically. If you are running multiple Sustained Island Step in sequence, you will only see the following Dialog once.



When the *Sustained Island Test Step* is running, the *Test Step Status Panel* can be used to show the measurements and progress. However, you can also view the *Sustained Island Results Panel*, which gives you the quick results of the test.



In the image above, the Sustained Island Analysis is shown, which indicates the island condition lasted well over 10s. In fact, it only stopped around 13.6s because of the settings in the Parent Step. That is, the test software terminated the island condition which caused 13.6s results. You also note the 5 Sustained Island Steps all Passed.

Where are the Results? The Data Logging Directory in the EUT Profile has the location.

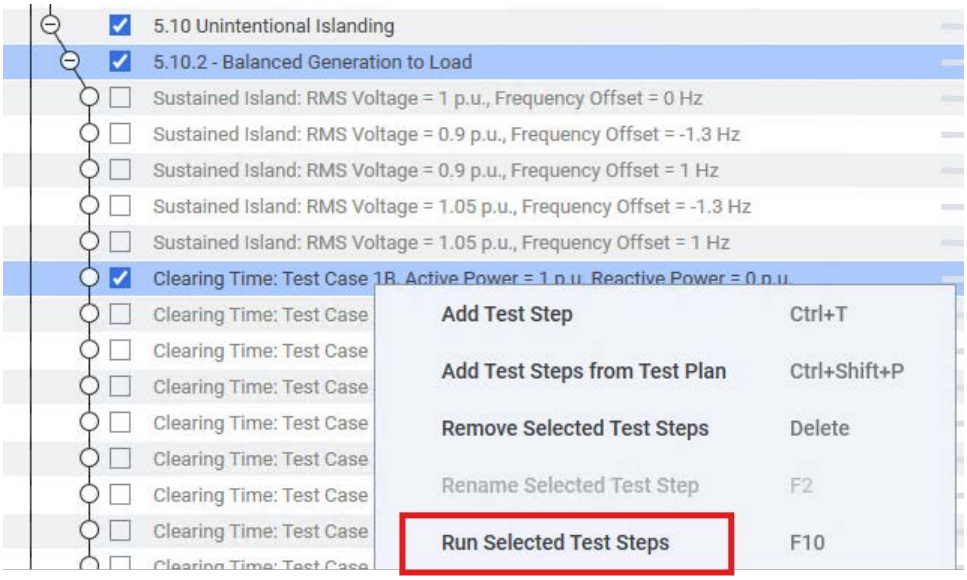
Running a Measure Clearing Time Step

It is recommended that you run one Clearing Time Step at a time when you are first testing your EUT. Each Clearing Time Step can take quite a while, dependent upon how quickly the EUT recovers from the Island Event. When the Island Event occurs, the EUT must cease to energize within 2s. It will then have to recover from the shutdown and begin to export power again waiting for the next test point.

Each Clearing Time Step MUST test at 17 points, minimum. The IEEE 1547.1-2020 Standard requires at least measurements from 95% to 105% in 1% increments. That's 11 points. Then, after completion, the test must determine the 3 longest clearing times and test them 2 more times each. That brings us to 17. If there are any anomalies during the test, more measurement points will have to be added.

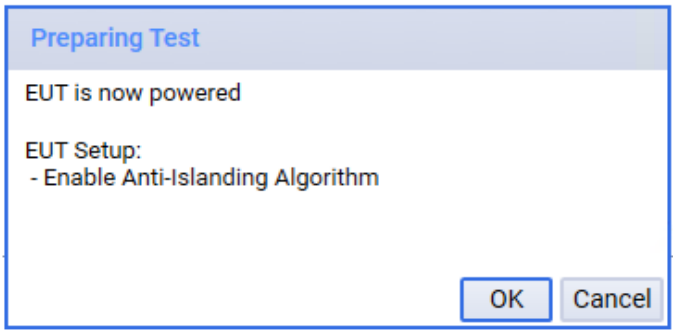
After the EUT has reached its stabilized power levels, the PHIL process is performed. The default setting is Capacitive variation, which is set in the Parent Step. PHIL establishes the 100% point - near perfect resonance. The other percentages are variations of that 100%: 95%, 105%, etc. by varying the Capacitive component of the RLC.

To run a single Clearing Time Step, you select the Parent Step and the desired Clearing Time Step and deselect all the Steps you don't want to execute. You then right-click on the highlighted Blue area and select *Run Selected Test Steps.*



The Parent Step is where the DC Source is configured, so that is why it too must be selected.

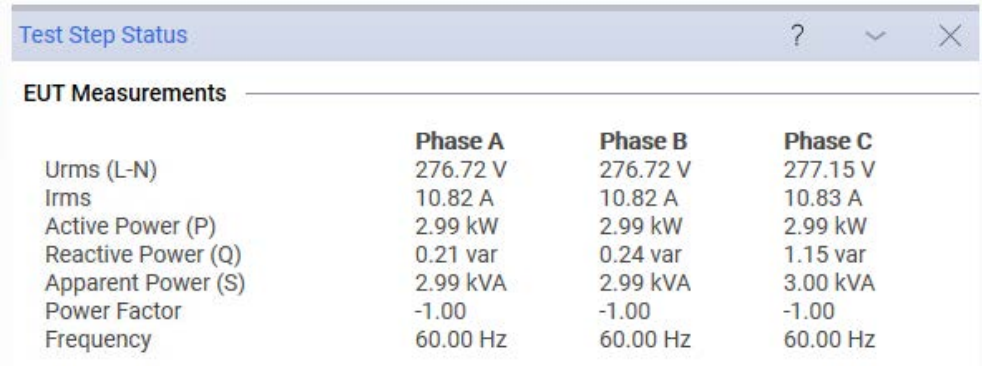
Once the Clearing Time Step begins, you will be prompted to turn **ON** the Anti-Island and any other mode that might cause the Power Inverter to shut OFF automatically. If you are running multiple Measure Clearing Time Steps in sequence, you will only see the following Dialog once.



You will also be asked to configure the Power Inverter for the specified test case when in Manual EUT Mode (from the EUT profile).

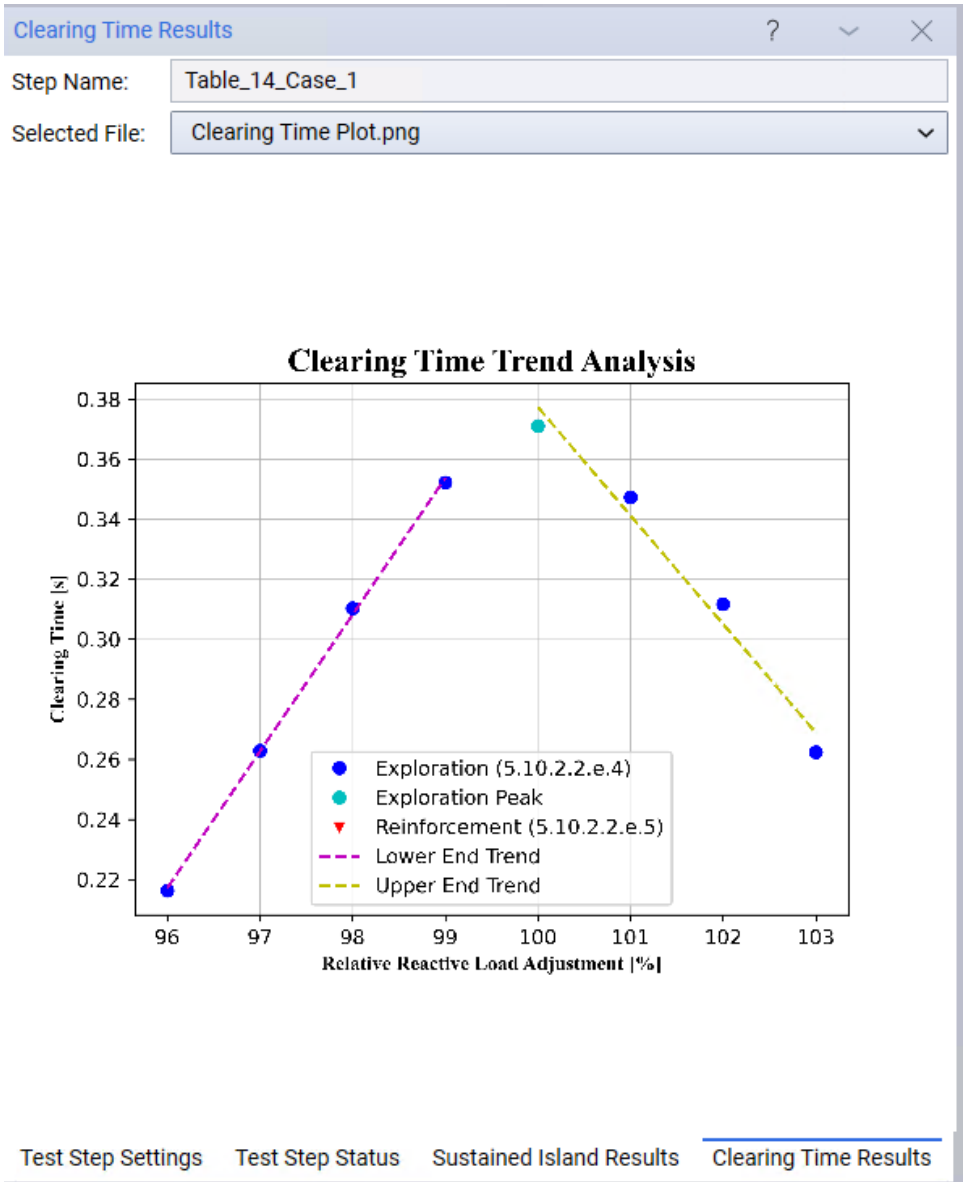
When the Measure Clearing Time Test Step is running, the **Test Step Status** panel shows the settings, measurements, and progress for each test iteration. Default is running iterations 95-105%. Note that the Parent Step holds this default List of Percentages for all Clearing Time Steps. Also note that the sequence of the percentages follows an alternating pattern, so you can see each side of the clearing time response being exercised during the test. This alternating on either side of 100% can allow you to abort the test quicker if you see one side or the other misbehaving.

Once the EUT stabilizes at its specified output power (within +/- 5% of Expected Power), you will see the EUT Measurements settling. The test software will then start the PHIL process of matching the RLC impedance of the EUT during this stable period.



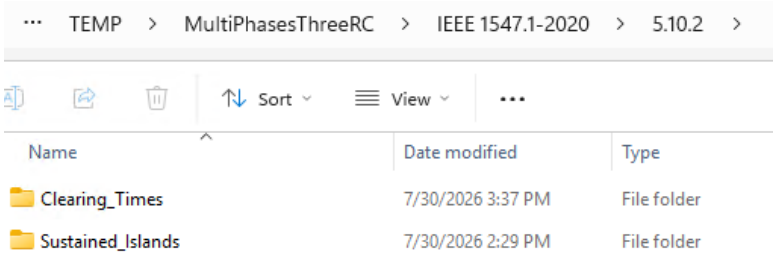
	Phase A	Phase B	Phase C
Urms (L-N)	276.72 V	276.72 V	277.15 V
Irms	10.82 A	10.82 A	10.83 A
Active Power (P)	2.99 kW	2.99 kW	2.99 kW
Reactive Power (Q)	0.21 var	0.24 var	1.15 var
Apparent Power (S)	2.99 kVA	2.99 kVA	3.00 kVA
Power Factor	-1.00	-1.00	-1.00
Frequency	60.00 Hz	60.00 Hz	60.00 Hz

This process will repeat at least 17 times. During this time, you can select the *Clearing Time Results* Panel, which will reveal the alternating percentage measurements points.

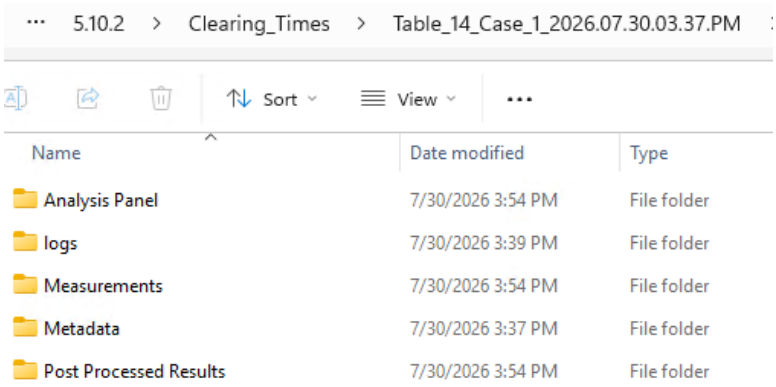


Measurement and Post Processing Directories

All the measurements and post processed results can be found at the following locations for either Clearing Time or Sustained Island Steps. The Data Logging Directory is specified in the EUT Profile:



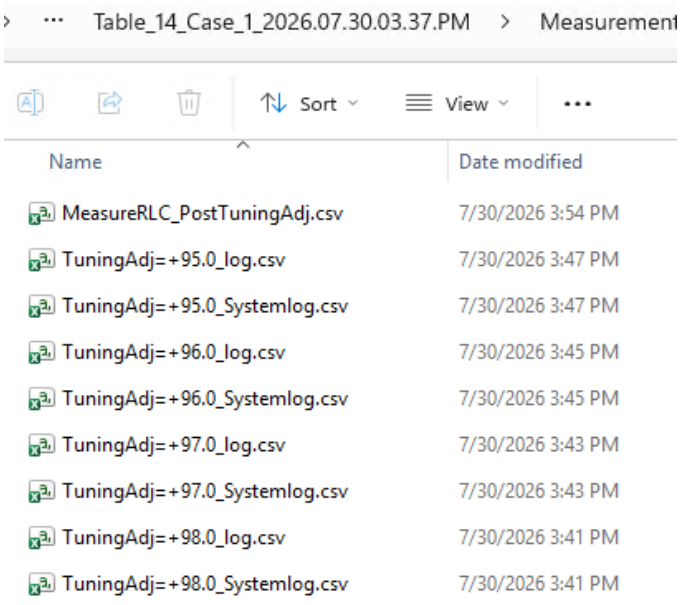
Walking down the directory hierarchy into the Clearing Time Test, we find Test Case 1:



Notice that this directory is time stamped, so that each time you run this Clearing Time Step, you do not interfere with any of the previous measurements.

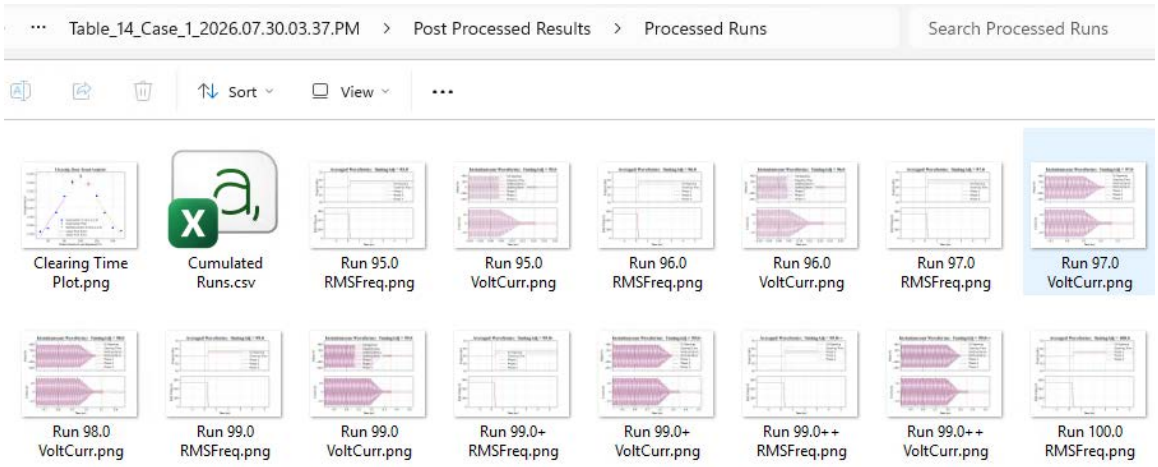
CSV Measurement Files

The Measurements directory contains the measurements from all the percentage iterations. The files with just “log” contain the 20 kSa/s measurements of Voltage and Current. The “Systemlog” files contain the 1kSa/s RMS, Frequency, and Marker measurements. The following is just a short list of this directory, where test percentages were from 95 - 105%. Each percentage creates a file name based upon that percent. During the Reinforcement or Verification period where points are repeated, plus signs (+) are added for each repeated test point.



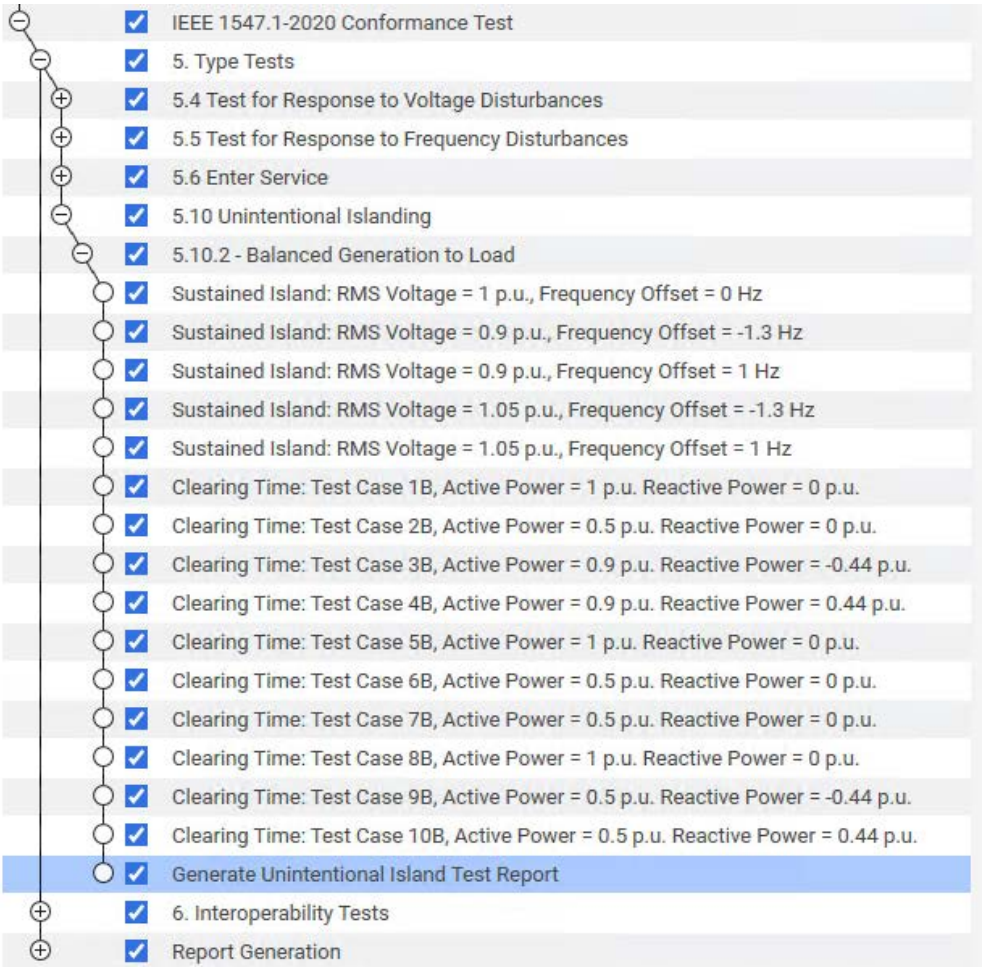
Post Processing Results

The Post Processed Results / Processed Runs directory would have all the results of the Exploration percentages and the final analysis csv files showing the performance of the EUT for this test case.



Report Generation

The last Child Step in the Section 5.10.2 Balanced Generation to Load (Parent Step) is the **Generate Unintentional Island Test Report** Step. You will notice it is separate from the *Report Generation* group at the bottom of the IEEE 1547.1-2020 Conformance Test Step. This is a temporary location for this version of the SL1200A Grid Integration and Compliance Test Automation Suite. In future versions, this step will move to the *Report Generation* group. The SL1221A was the first of such Test Types and was a stand-alone solution that included support for SunSpec Modbus communication as well.

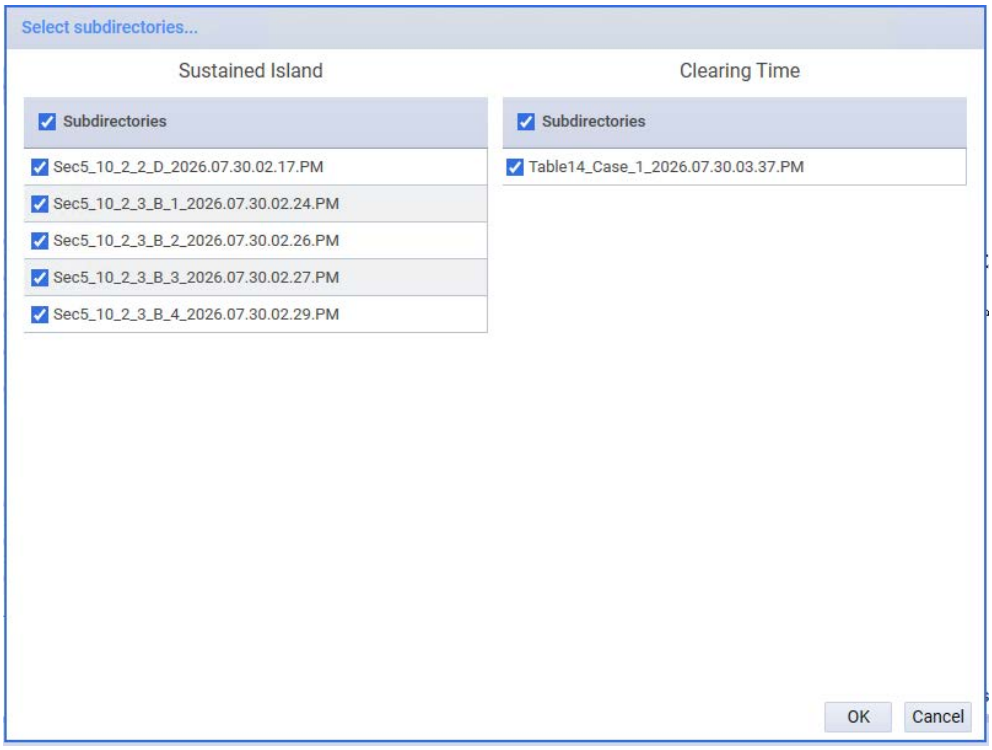


The report is generated from all the Results Data discussed in the previous sections. The report is comprehensive and includes both information on how various test parameters executed as well as the configuration under which the tests were conducted. For example, if several Clearing Time Steps were operated with a different configuration (Test Step Settings, Grid Setup, etc.) those conditions would be reflected in the report.

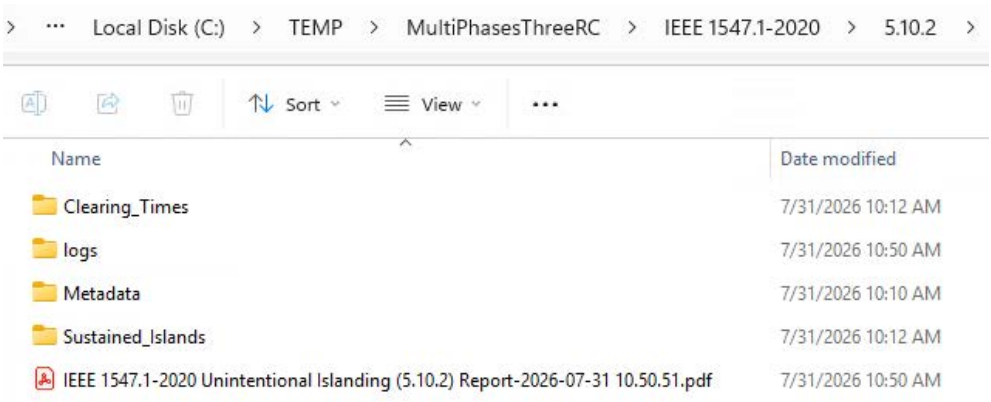
This analytical IEEE 5.10.2 report contains the following

- Title (the name of the IEEE Standard)
- Administrative information (if provided in the Test Report Step Settings panel, see below)
- A summary of the test cases and a final test verdict
- EUT information
- AC Emulator and DC Source configuration information
- Sustained Island Results
- Clearing Time Results
- Any user-modified test plan settings

As in previous examples in this section, you can selectively Run this Step. Given the examples illustrated above, just the Sustained Island Steps and Clearing Time Test Case 1B were executed. Running the Step would cause it to evaluate all the Section 5.20.2 test results, and those should be the only ones showing up in the following panel. This panel allows you to select which test cases you want to use in generating the report:



After choosing which test results to report upon, press OK. The resulting report can be found at the following directory level, which is based upon the Data Logging Directory specified in the EUT Profile:



Refer to the SL1200A Plugin Help for detailed information about this report.

8 SL1222A Quick Start

Introduction

The SL1222A Automated IEEE 1547 Electrical Type Test Plugin provides automation for many of the electrical type tests defined in IEEE 1547.1-2020. Supported test categories include voltage disturbances, frequency disturbances, Phase-Angle Change Ride-Through (PCRT), Rate of Change of Frequency (ROCOF), Enter Service, Nameplate Verification, and interoperability-related testing required for DER certification and compliance verification.

The SL1222A plugin operates within the Keysight KS8400B PathWave Test Automation (TAP) platform and uses the common resource architecture introduced in Chapter 5, “Understanding the SL122xA Test System”. The plugin coordinates operation of the Grid Emulator, DC Source, and Device Under Test (EUT) while automating test execution, data collection, post-processing, and report generation. Depending on the installed licenses, the EUT can be configured automatically through SunSpec Modbus communications or manually through user interaction during test execution.

In this chapter:

Hardware Requirements

- One SL1200A Regenerative AC/Grid Emulator such as the SL1212A
- One DC source such as the Keysight RP7900/8900A or SL1200A Grid Emulator in DC Emulation Mode (fixed DC only)
- One Power Inverter for the Device Under Test (DUT, also known as an EUT[1])
- How to create Resource identifiers for each of these devices is covered in Chapter 5, “Understanding the SL122xA Test System”

Software Requirements

- Keysight KS8400B Pathwave Test Automation Platform (TAP) software and license
- SL1200A Integrated Grid Test Automation Suite package and license for the SL1222A Automated IEEE 1547 Electric Type Test

NOTE

IMPORTANT licensing information: The *SL1200A Grid Integration and Compliance Test Automation Suite* package includes all the SL122xA Plugin test steps. Plugin licenses are exclusive. Test steps for plugins not licensed are visible but not usable.

You must license the SL1220A plugin to use the *SL1220A AC/Grid Test Sequencing Plugin* test steps and you can use them without using any of the *SL1221A PHIL-based Anti-Islanding Compliance Test Automation Plugin* or any other plugin test steps.

Similarly, you must license the *SL1221A PHIL-based Anti-Islanding Compliance Test Automation Plugin* to use those IEEE 1547.1-2020 Compliance Test Automation Software test steps, and you can use them without using the *SL1220A AC/Grid Test Sequencing Plugin.* The same would be true for the *SL1222A Automated IEEE 1547 Electric Type Test*.

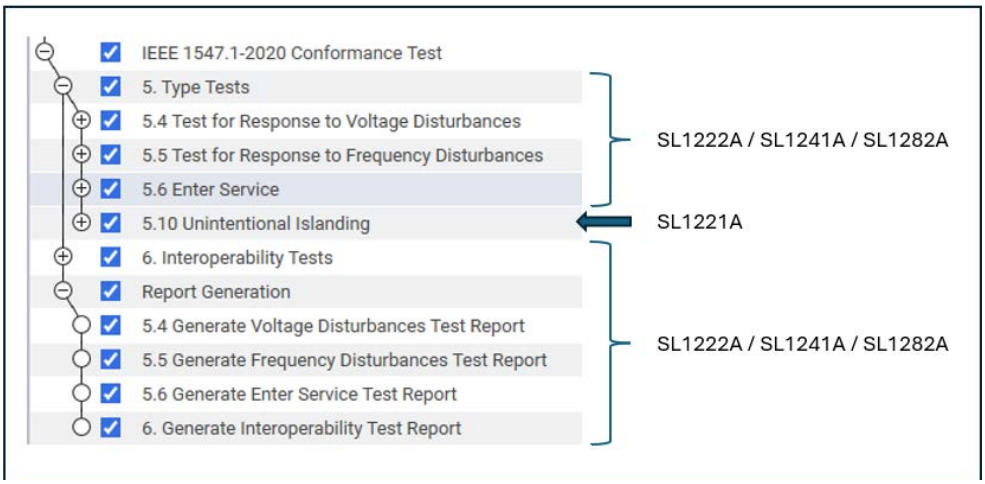
The *SL1241A* license enables using the DER Communication Steps. Both the *SL1241A* and *SL1282A* are required for automated control of the *SL1222A Automated IEEE 1547 Electric Type Test* Steps.

1 "EUT" and "DUT" refer to the same device. EUT is used by IEEE, the SL1221A Plugin, and others to specify the device being tested. DUT is a common term and is used in Keysight's Test Automation Editor.

SL1222A Test Steps

The SL1222A license enables Steps listed in the image below. You will also note the SL1241A and SL1282A licenses are also present, which enable the SL1222A Steps to be automated. Without those additional licenses, you would be required to operate the EUT in Manual Communications mode. In that case, you would be prompted by the test software what settings to use in configuring the EUT for each test case.

As discussed previously, the SL1221A license is all that is required for full automatic control of the EUT for Unintentional Island testing.



Creating a Test Plan

1 Add the Resource identifiers using Bench Settings as covered in Chapter 5, “Understanding the SL122xA Test System”.

- Add an AC Emulator and DC Source in the TAP Editor
- Add and configure the AC Emulator
- Add and configure the DC Source

NOTE

Important: Create the EUT Profile, Grid Emulator Profile, and DC Source Profile before you add the IEEE 1547.1-2020 Conformance Test Step into the Test Plan. Otherwise, Test Plan errors may occur.

2 Configure the EUT Profile Settings as covered in Chapter 5, “Understanding the SL122xA Test System”

3 Open the Test Step Status Panel

4 Load the IEEE 1547.1-2020 Conformance Test Step

5 Configure Test Step Settings

6 Run the Test Plan

7 Analyze the Test Data

Keysight's SL1200A Grid Integration and Compliance Test Automation Suite Help File describes each of these steps in detail. The Help guide is found under Help > Keysight SL1200A Plugin Help.

IEEE 1547.1-2020 Conformance Step

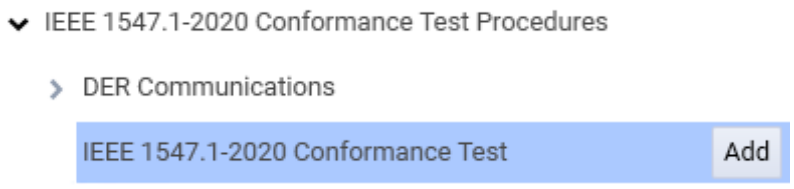
Only a single step called the IEEE 1547.1-2020 Conformance Test Step represents the complete IEEE 1547.1-2020 Test Plan. This step is called the "Grandparent" step[1], because there are multiple sub-steps involved:

- IEEE 1547.1-2020 Conformance Step. This is the top-level Step from which all Type Test Steps are run.
  - Section 5 Type Tests as the 'Parent' step
    - -- Section 5.4 Test for Response to Voltage Disturbances, known as 'Child' step
    - -- Section 5.5 Test for Response to Frequency Disturbances, another 'Child' step
    - -- etc.

1 In the Test Automation editor, click the + button (or press **Ctrl+T**) to open the **Test Steps** panel.

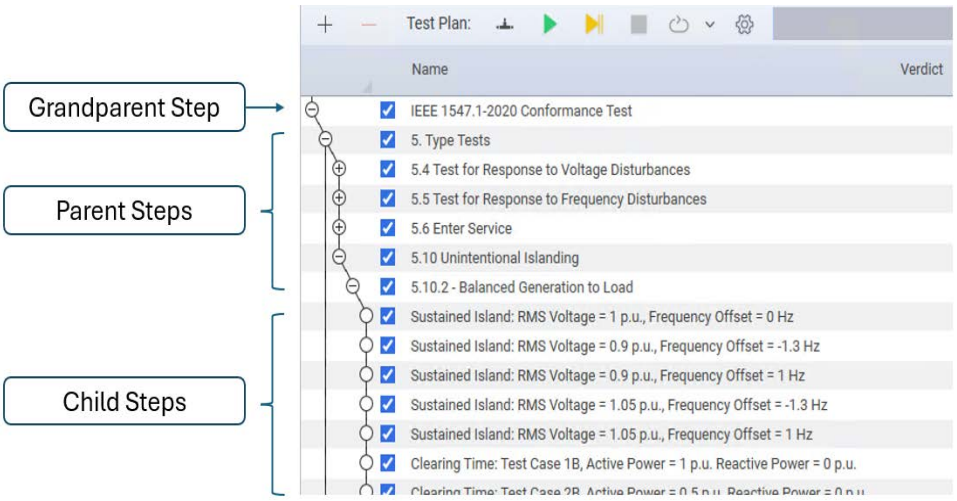
2 Expand **IEEE 1547.1-2020 Conformance Test Procedures**.

3 Select **IEEE 1547.1-2020 Conformance Test Step** then click the **Add** button.



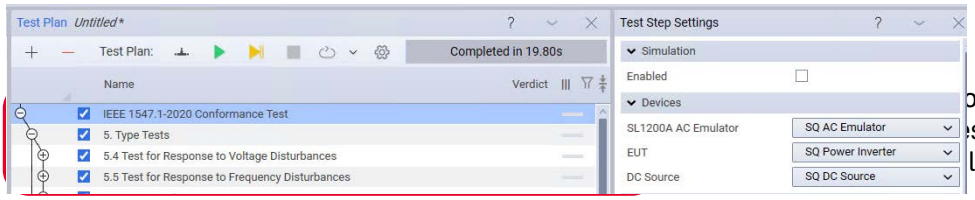
That operation brings the Step into the Test Plan Panel, and that single Step becomes the Test Plan! That is all that is needed to run the IEEE 1547.1-2020 Conformance tests.

1 It is also called a "Macro" step because there are multiple steps involved in this one step.

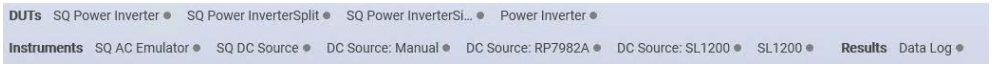


Grid Emulator, EUT, and DC Source Assignments

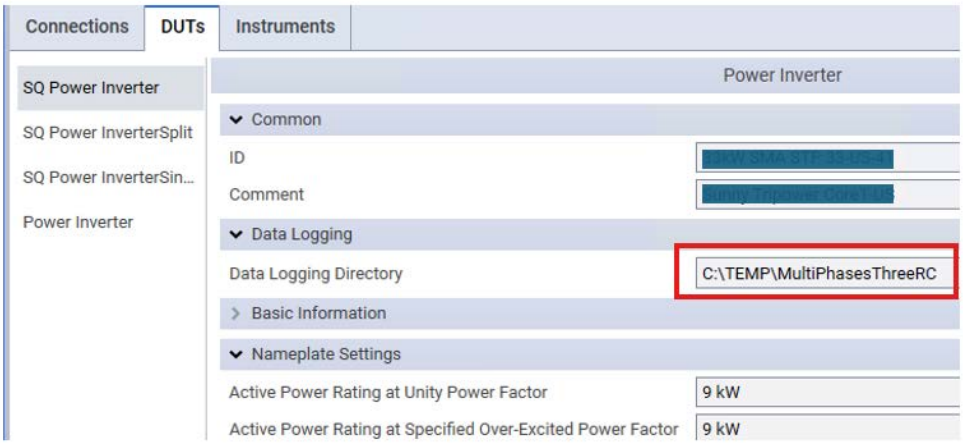
This IEEE 1547.1-2020 Conformance or Grandparent Test Step is the step where you select which Resources are used in the test.



The Resources defined in the Bench Settings are visible at the bottom of the TAP Editor Panel. The drop-down Devices selection allow you to pick from the defined Instruments, DUTs, etc.. Over time you will likely accumulate many such Devices.



When this Test Step or any step under this one is run, the Result data (measurements, reports, etc.) will be stored in a location specified in the selected EUT. For example, the selected EUT is SQ Power Inverter. Selecting EUT at the bottom of the TAP Editor panel will bring up that EUT Profile:



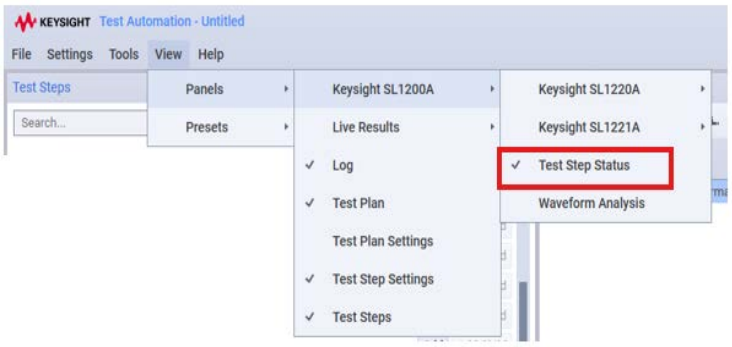
NOTE: You can specify the Data Logging Directory to anything accessible by your Windows File Explorer.

NOTE: Further down in this page under Communications, Manual mode vs. SunSpec Modbus can be selected. If Manual, the software prompts you to configure the EUT to the configuration for the particular Test Step. Otherwise, with EUT SunSpec ModBus operation, the EUT is automatically configured to specified settings for the particular Step.

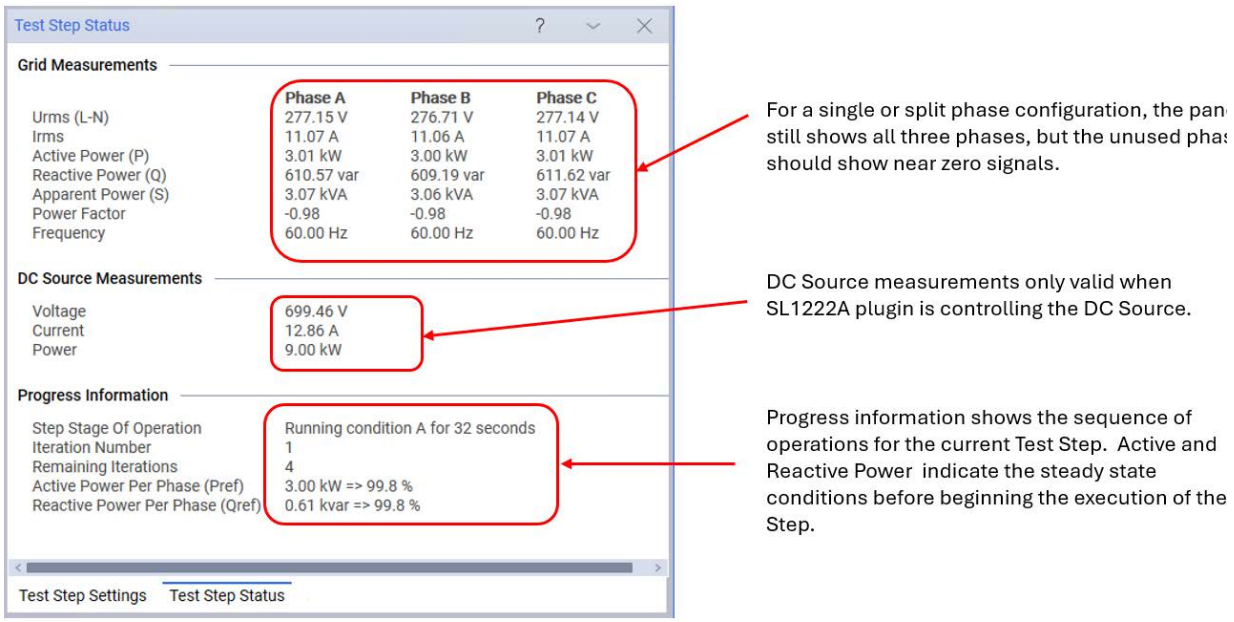
Open the Test Step Status Panel

An important aspect for all test steps is the *Test Step Status Panel*. This panel keeps track of all Grid and DC Source measurements. It also provides information on what tests and sub-tests are being performed and how long they have been executing.

Access this panel from the TAP Editor View tab:

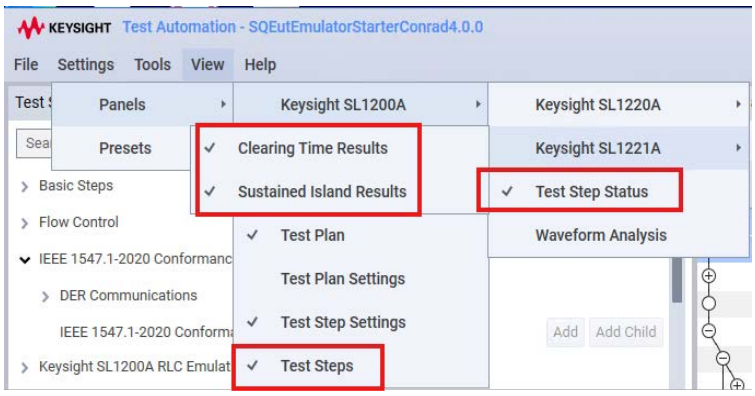


When a Test Step is running, this panel will tell you what is happening.



How to Enable all the Status Panels

The following image shows which panels are enabled and where to locate them in the TAP Editor. These panels should all be activated during your testing. Once enable, they can be stacked on top of each other by dragging and dropping them into the same TAP Editor window.



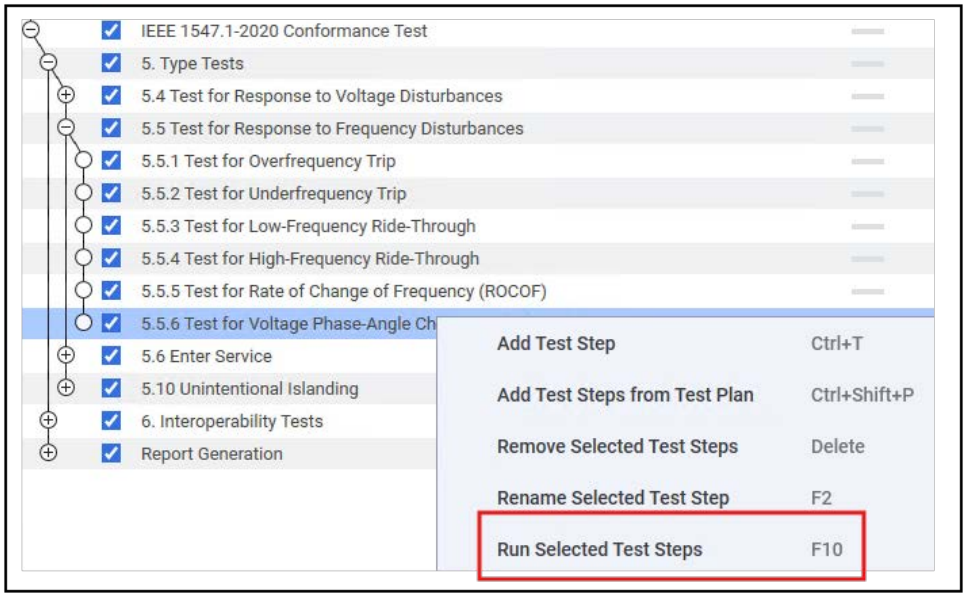
Configure Test Step Settings

Each of the SL1222A groups have their own Parent Step representing the particular IEEE 1547.1-2020 test function, such as *5.5 Test for Response to Frequency Disturbances.* Each of the Parent Steps may have Test Step Settings that will affect all the Child Steps below. The default Test Step Settings for Child Steps are set according to the IEEE 1547.1-2020 Standard for the particular test configuration.

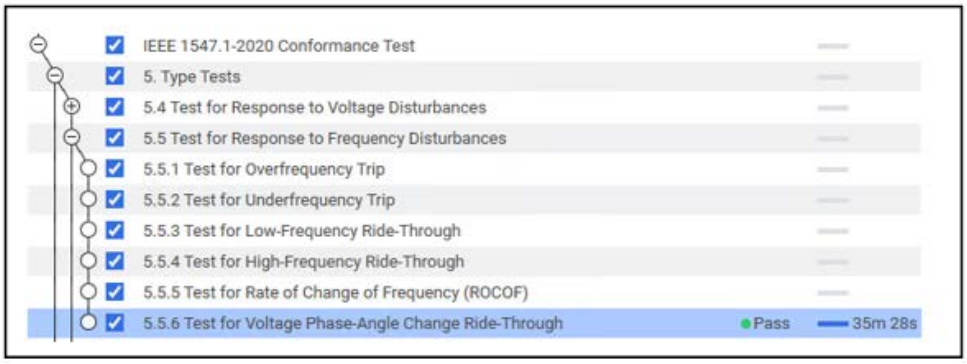
You are allowed to change many of them, and the changes will be reflected in the Test Plan and in the Test Report. A Red circle (❗) will appear next the parameter changed, and the Test Report will reflect the change to the Standard. It would be up to the auditor of the test results to determine if any changes invalidate the test results.

Running an SL1222A Step

You may run all IEEE 1547.1-2020 Conformance Test Steps in sequence simply by pressing the Green arrow button of the TAP Editor in the Test Plan Panel. You may want to run one group at a time when first starting. You may even want to run a single Step initially to see if things are working properly. Let's do just that for now and pick the *5.5.6 Test for Voltage Phase-Angle Change Ride-Through Step*. When right-clicking on the highlighted Blue area, you select *Run Selected Test Steps*:

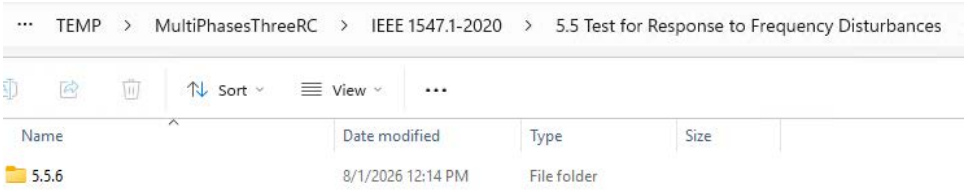


The PCRT Step defaults to running 5 iterations, which means it will execute all PCRT sequences 5 times. Repeated operations are often required by the IEEE 1547.1-2020 Standard to verify consistency of the EUT operation. Running the 5 iterations for this EUT took almost 36 minutes! Some tests can take hours to complete, and the overall time is often associated with how long the EUT takes to energize after ceasing to energize.

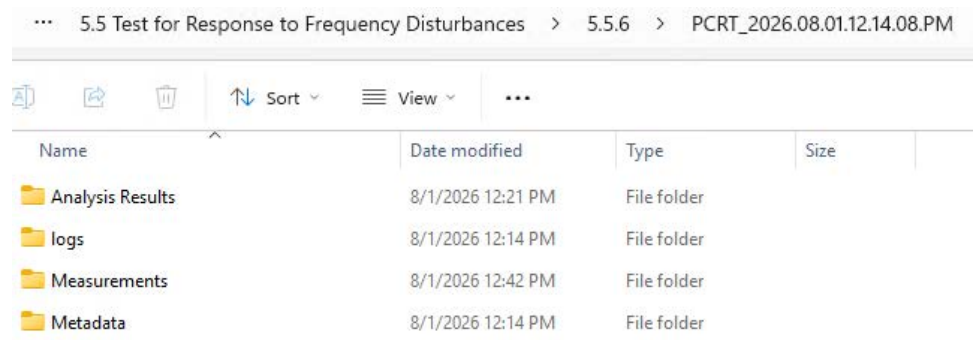


Measurement and Post Processing Directories

All the measurements and post processed results can be found at the following locations for either Clearing Time or Sustained Island Steps. The Data Logging Directory is specified in the EUT Profile:



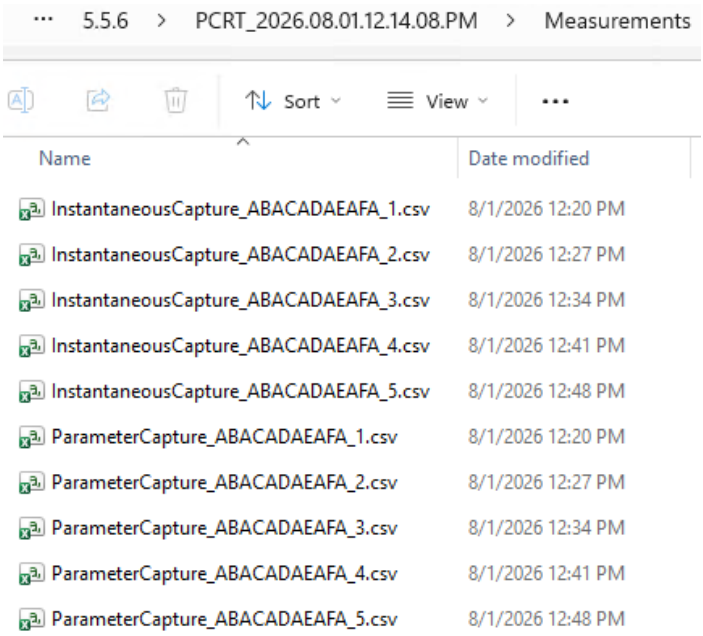
Walking down the directory hierarchy into the actual test case:



Notice that this directory is time stamped, so that each time you run this Step, you do not interfere with any of the previous measurements.

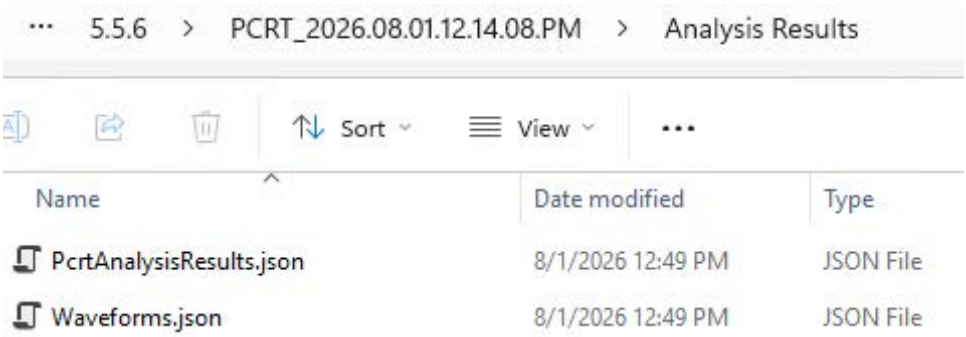
CSV Measurement Files

The Measurements directory contains the measurements from all iterations of the PCRT test. The files with just “log” contain the 20 kSa/s measurements of Voltage and Current. The “Systemlog” files contain the 1kSa/s RMS, Frequency, and Marker measurements.



Post Processing Results

The Analysis Results directory contains all the evaluations of the Measurement Data.



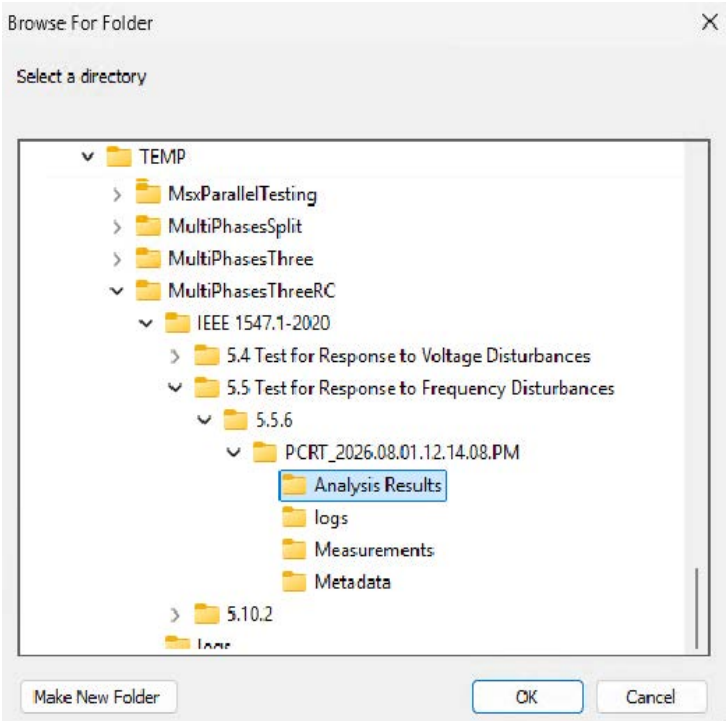
The PcrtAnalysisResults.json file contains the specific analysis of every sequence and every iteration. This file is used directly by the Test Report.

The Waveforms.json file can be read with the Waveform Analysis Panel, so you can view all 36 minutes of the data for any anomalies found during testing. Any inconclusive or Fail Verdict may be caused by signal distortions caused by the EUT. Use this powerful visual tool to see just what happened during the test.

The PcrtAnalysisResults.json file would contain the actual times when a failure occurred, so it would be easy to find in the 36 minutes of captured data.

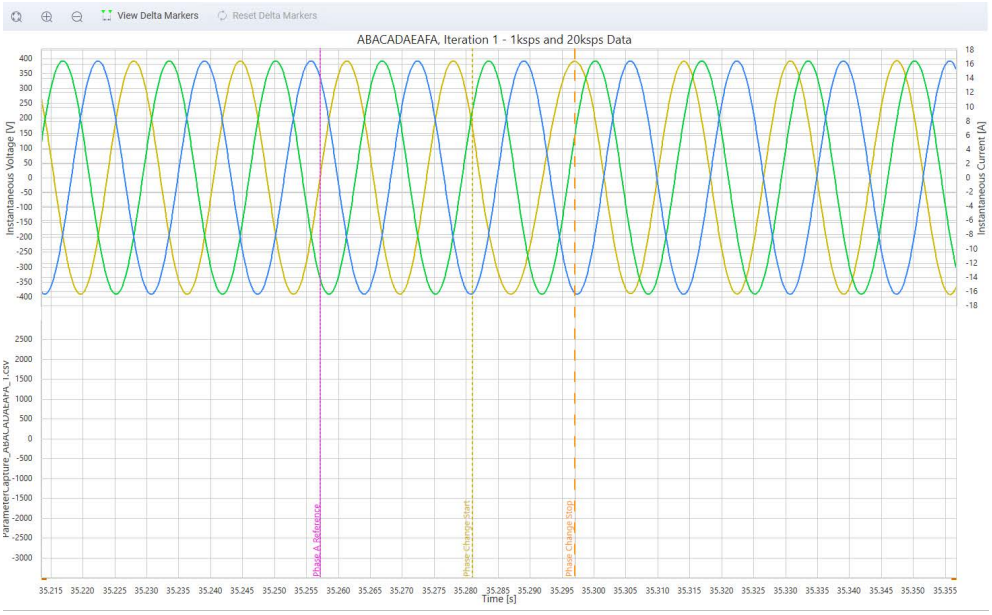
Waveform Analysis

Below is an example of using the Waveform Analysis Tool. You would import the results by selecting the Analysis Results directory, which contains the Waveforms.json file. This file tells the Waveform Analysis Tool where to find the measurement data and how to present it, including Markers and other labeling to help you identify operations.



Loading the 36 minutes of data might take a couple minutes, dependent upon the performance of your computer. However, once loaded, the zooming and waveform moving is very, very fast.

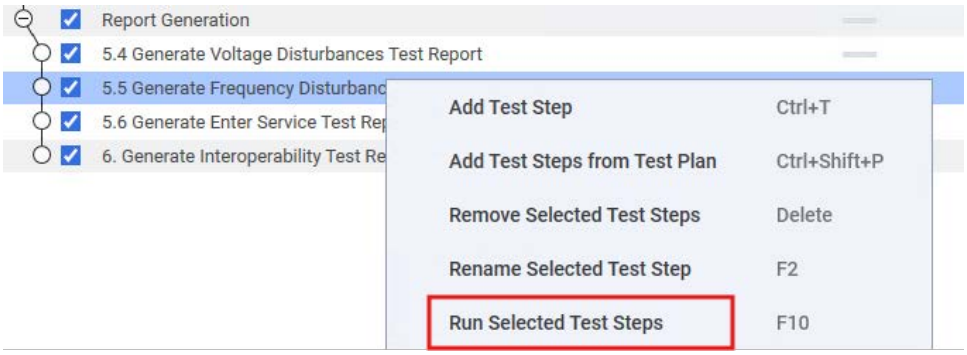
Below shows zooming in on the three 20kSa/s voltage waveforms representing the three phases.



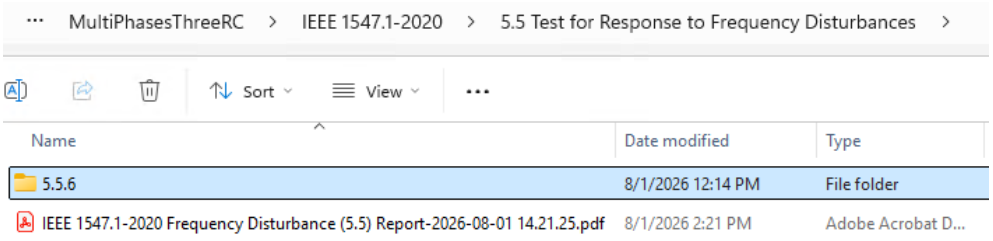
The *Help* > *Keysight SL1200A Plugin Help* details how to use this powerful tool.

Report Generation

To generate a report for any of the SL1222A plugin Steps, you use the Report Generation step.



Since only the PCRT Step was executed, the Test Report will be incomplete, but it will be located in the following location:



Once again, the *Help* > *Keysight SL1200A Plugin Help* details the Test Reports.

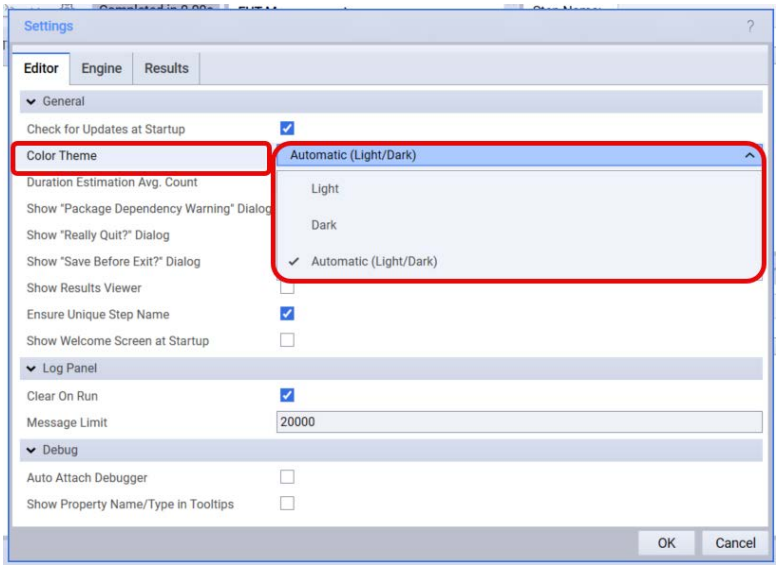
A Additional TAP Functions

In this Appendix:

Color Theme

Select a color theme for the Test Editor by selecting **Settings > Editor**. Then select either *Light*, *Dark*, or *Automatic* (default). Almost all of the screen captures in this manual use the *Light* theme.

Color Theme (Light) – *Light* is black text on white background. *Dark* is white text on black background.

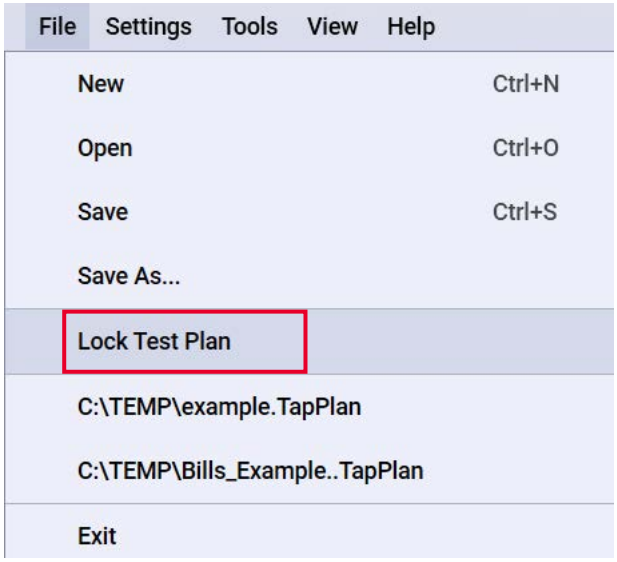


Locking a Test Plan

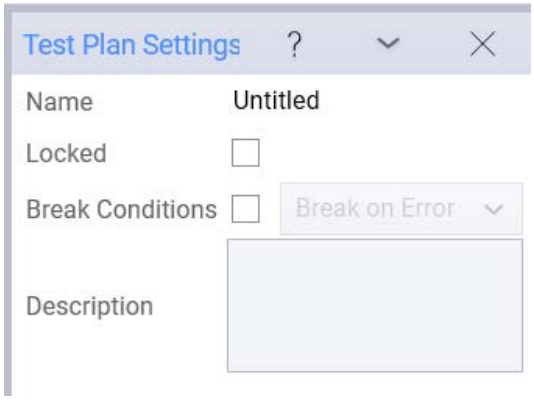
Keysight's KS8400 provides a Test plan locking mechanism. Its primary use is to prevent accidental editing by test plan developers. This lock can easily be bypassed by clicking **Unlock Test Plan**.

There are two ways to lock a test plan:

- **First Method:** in the Menu bar, select **File > Lock Test Plan**.



- **Second Method:** In the Menu bar, select **View > Panels > Test Plan Settings**. In this panel, there is a checkbox to Lock/Unlock the test plan labeled **Locked**.

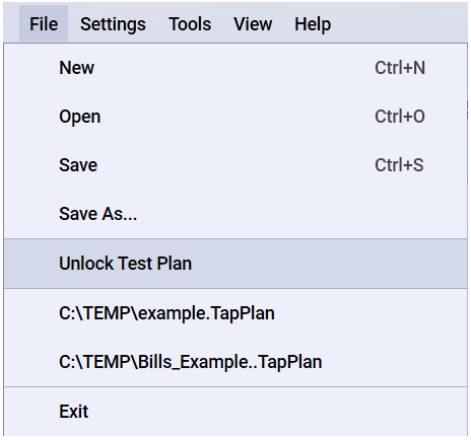


Alternatively, you can reach this panel by clicking the settings icon that is located next to the main test plan progress bar. This icon also provides a keyboard shortcut (**Alt + E**) to reach this same Test Plan Settings panel.

A locked Test Plan shows a closed lock next to the Test Plan name:

Unlocking a Test Plan

To unlock the Test plan, either select **File > Unlock Test Plan** or select the settings icon and uncheck the **Locked** checkbox.,



Run Time Estimation

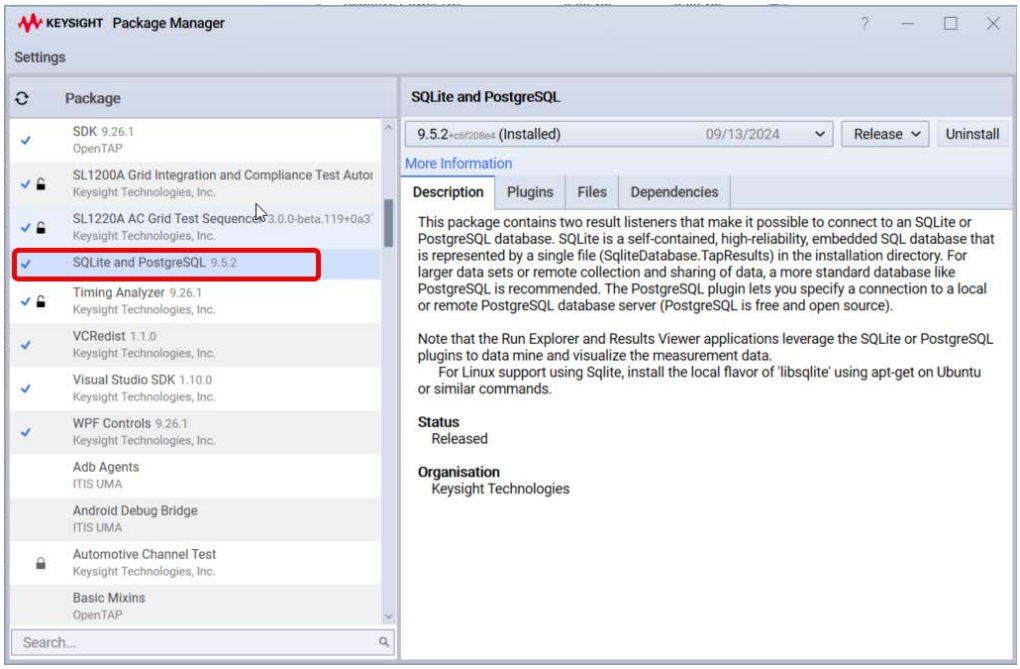
Keysight's KS8400B Developer's GUI (the Editor) has built-in functionality to estimate Test Plan running time.

Overview

To access this functionality, add a Result Listener to your configuration that implements IResultStore (interface that defines result listener plugins with the capability of storing result data). There are currently two result listener plugins that implement this: *SQLite* and *PostgreSQL*. *PostgreSQL* requires having the database type preconfigured to establish a connection; *SQLite* works without preconfiguration. The following example uses the *SQLite* result listener plugin.

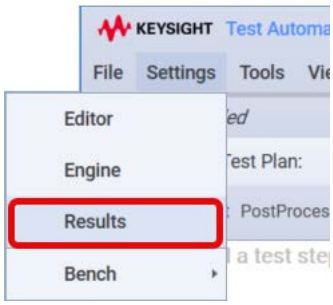
Usage

1 To add the *SQLite* and *PostgreSQL* Database Result Listener plugins, go to **Tools > Package Manager** and install this plugin.



2 Add an SQLite Result Listener plugin to your configuration. This can be done in one of two ways:

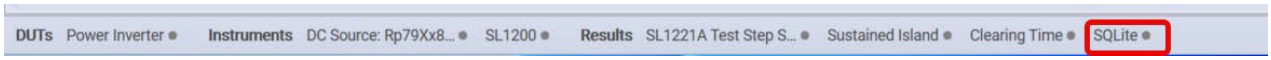
   a On the Menu bar on the top of the GUI, select **Settings > Results**.



   b On the Resource Bar at the bottom of the GUI, click on **Results Add New**.

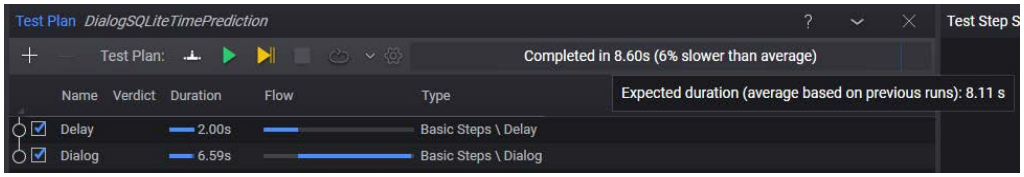
3 In the Settings window, within the Results tab, click the + icon to add a new Result Listener. Go to **Database > SQLite** and click **Add**.

4 Click **OK** in the Settings window to save your changes and add SQLite as a Result Listener.

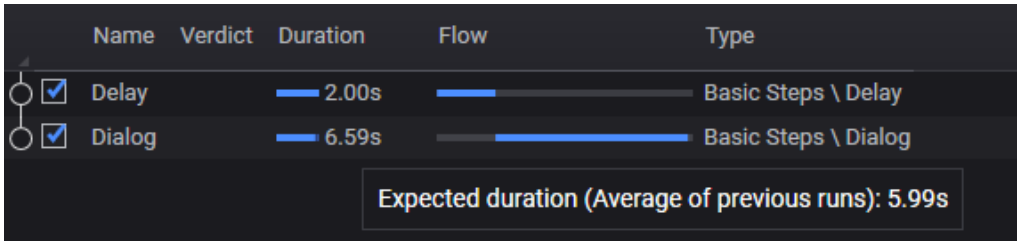


Run Your Test Plan.

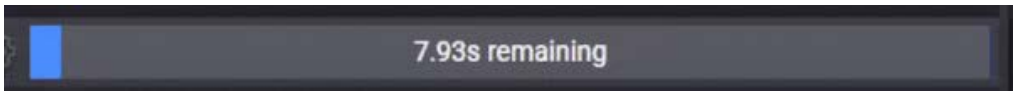
On the first test run, there is no predicted test time. The second test run, and any following test runs of that same test plan, show an estimation of test run duration. This shows up as a tooltip when you hover your mouse over the progress bar above the Test Plan. The progress bar also adds an additional comment about running *x*% faster/slower than the average.



Additionally, individual test steps also provide a tooltip showing the expected duration for that test step.



During the test plan run, the progress bar changes to show remaining time after the first run and shows the amount of time over the expected test duration.

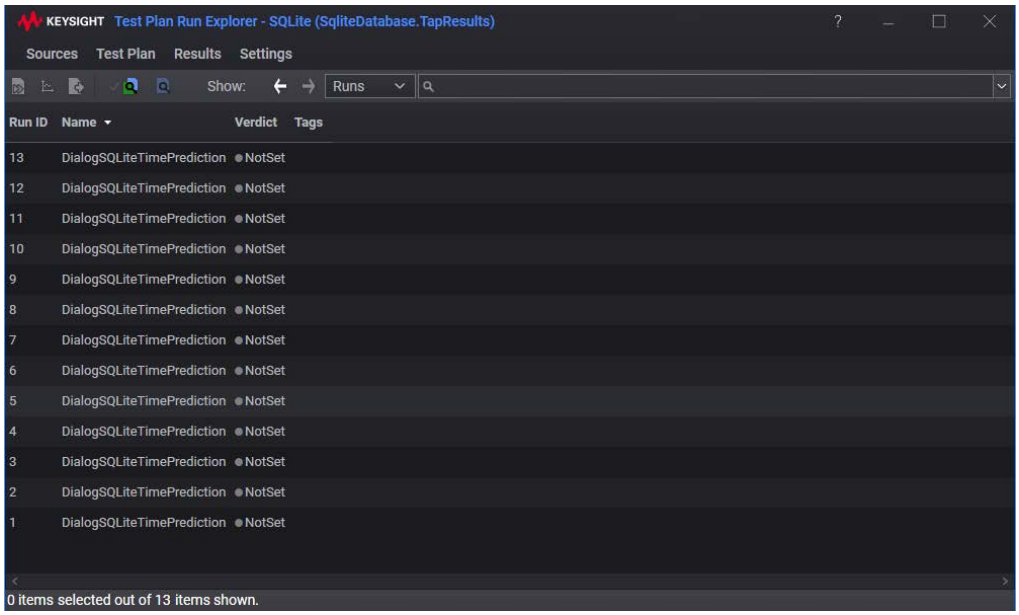


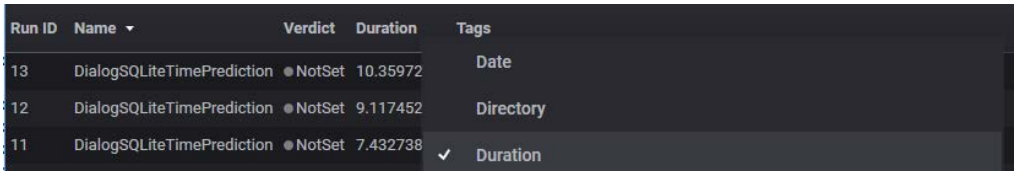
Additional Notes

Run Explorer

The SQLite database result listener stores TAP metadata related to the test run. View this data in KS8400B's Run Explorer. To view this, you can go to **Tools > Run Explorer** in the Menu bar.

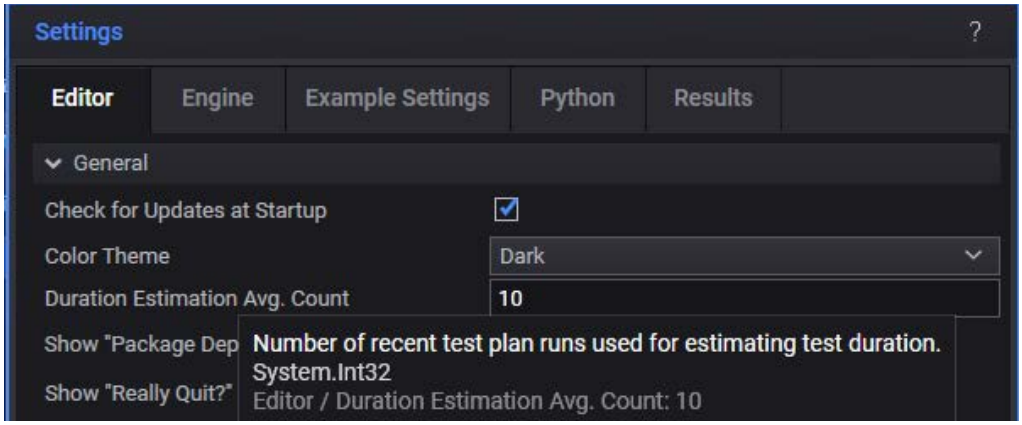
This view shows every test run stored within this *SQLite* database. Add additional column headers to view by right clicking the header bar and adding a new item. The image below shows the Duration column to get a quick view of the test times of all the Test Plan runs the *SQLite* database stored. The run data persists outside of the current session, so reopening the editor and running the same saved test plan will still give an test time estimation. Use the Run Explorer to delete test runs that are considered outliers in test time.





Editor Settings

You can control how many test runs are used to calculate the average test run time. This is configurable in **Settings > Editor** under **Duration Estimation Avg. Count**. The default value for this setting is the last 10 runs.



Test Plan Estimation Capturing

The Editor calculates test run time averages for test plans that are exactly the same. If you change a test step setting value in the test plan and run the updated plan, it counts as the first run of that test plan, therefore not calculating an average test duration (on its first run). Reverting the test plan back to its original state causes the estimation to use its previous duration values again.

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