PV Inverter Anti-Islanding Test made Easy

AZX,GSZ SERIES

1 Overview

The AZX and GSZ Series regenerative grid simulator products support islanding condition emulation when operating in voltage mode by performing a real-time simulation of an RLC circuit and accurately measuring the disconnection time based on a programmable current threshold. This greatly simplifies the required setup and time needed to perform IEEE 1547 PV Inverter and other distributed energy resources (DER's) Anti-Islanding testing.

The RLC circuit is fully programmable, enabling multiple test conditions based on parameters such as Q factor, active power, reactive power, or current. By default, the system uses a Q factor of 1.0. When the test is initiated, the RLC values are automatically computed using RMS measurements and the configured nominal frequency.

An integrated advanced scope function allows triggering based on islanding initiation and detection, eliminating the need for an external oscilloscope. Additionally, a programmable trigger output can be configured to generate signals at these events, enabling synchronization with external test equipment if required.

Testing is supported in single-phase, split-phase, or three-phase configurations. In three-phase mode, the system emulates an independent RLC circuit per phase, with individual programmability and measurement of disconnection time.

The phase at which islanding begins is configurable via the "Update Phase" parameter on the configuration screen. By default, the event is synchronized to the zero crossing of phase A.

The diagram below illustrates the operation for a single-phase setup. To begin the test, ensure the AZX/GSZ is enabled with nominal settings, and the DUT is stabilized at the desired power or current level.

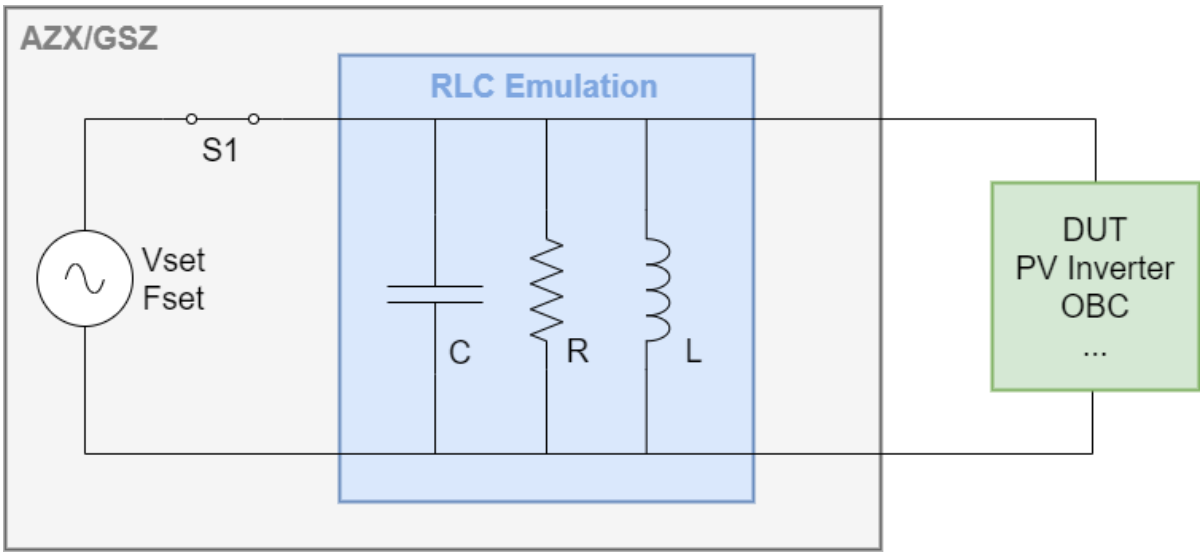


Figure 1-1: Single Phase PV Inverter Test Setup

When the islanding test is initiated, the internal switch **S1** is virtually opened, and the AZX/GSZ grid simulator begins real-time emulation of the RLC circuit. The DUT continues to inject current as a result, which is used by the system to generate the corresponding voltage, accurately mimicking the behavior of a physical RLC load.

The instantaneous current is continuously monitored, and the disconnection time is recorded as the moment when the last absolute value of current drops below the programmable threshold. This measurement is performed with a precision of 10 µs.

A programmable voltage safety margin is available to prevent the emulated voltage from exceeding safe levels. If the emulated RLC voltage surpasses this limit, the system automatically returns to voltage source mode and ends the RLC emulation. The default value is 1.25 (125% of the nominal voltage)

If the DUT disconnects as expected during the test, the voltage naturally decays toward zero. In this case, the system remains in RLC emulation mode until the user either stops the islanding operation or disables and re-enables the output to resume normal voltage source operation.

Figure 1-2 shows a simplified diagram illustrating a typical islanding test sequence voltage and current waveforms.

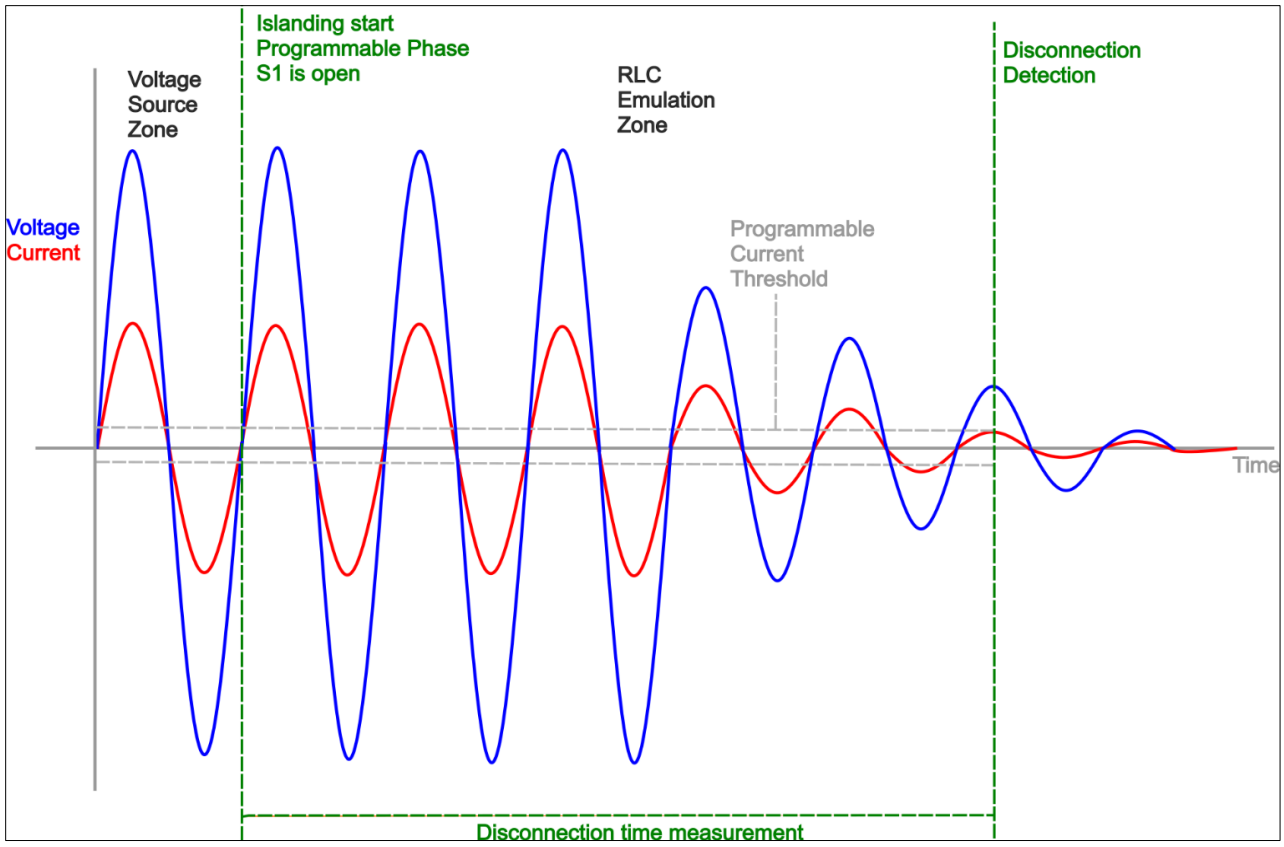


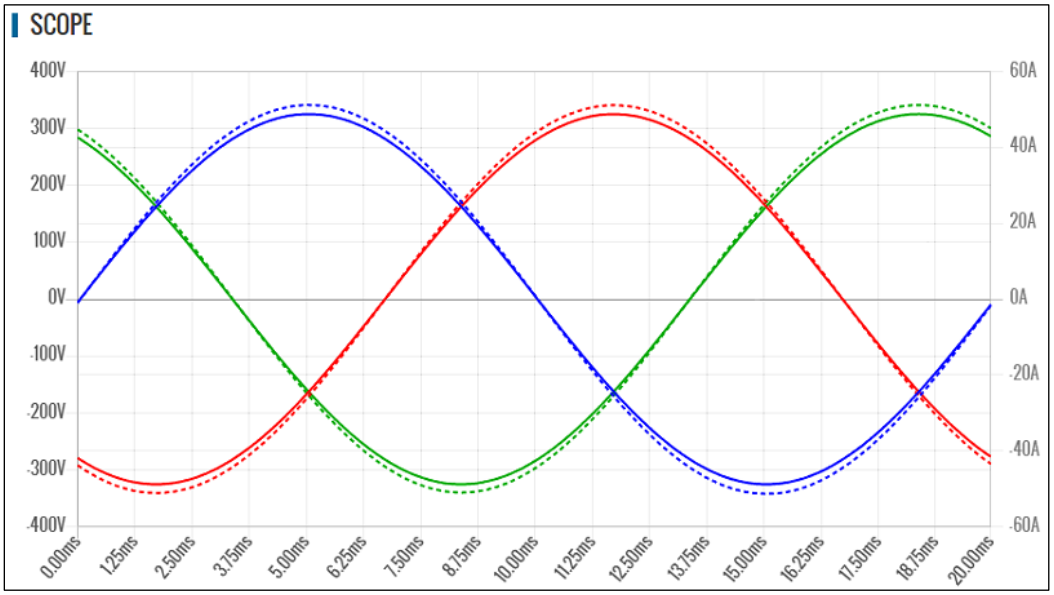
Figure 1-2: Anti-Islanding Test Sequence V,I waveforms

Note: *This feature is available in firmware version 5.4.0 and later. Firmware 5.5.48 incorporates the graphical user interface to perform the test.*

2 Typical Test Example

A) Configure the AZX/GSZ to its nominal settings and enable the output.
B) Set the DUT to deliver current and allow it to stabilize at the desired operating point for the islanding test.

MEASUREMENTS	Phase A	Phase B	Phase C
FREQUENCY	50.00 Hz	50.00 Hz	50.00 Hz
VOLTAGE L-N RMS (AC-DC)	230.00 V_{RMS}	229.99 V_{RMS}	230.00 V_{RMS}
VOLTAGE L-N RMS (AC)	230.00 V_{RMS}	229.99 V_{RMS}	230.00 V_{RMS}
VOLTAGE L-N THD	0.03 %	0.02 %	0.03 %
VOLTAGE L-N DC	0.00 V_{DC}	0.00 V_{DC}	0.00 V_{DC}
CURRENT RMS (AC-DC)	36.24 A_{RMS}	36.14 A_{RMS}	36.11 A_{RMS}
CURRENT RMS (AC)	36.24 A_{RMS}	36.14 A_{RMS}	36.11 A_{RMS}
CURRENT THD	0.03 %	0.03 %	0.02 %
CURRENT DC	-0.07 A_{DC}	0.02 A_{DC}	0.09 A_{DC}
POWER	8.34 kW	8.31 kW	8.31 kW
WATT-HOUR ON RST	0.14 kWh	0.14 kWh	0.14 kWh
ELAPSED TIME			
APP POWER	8.34 kVA	8.31 kVA	8.31 kVA
POWER FACTOR ▶	1.00	1.00	1.00
PEAK VOLTAGE L-N	-325.57 V	-325.56 V	-325.56 V
RECORDED PEAK VOLTAGE L-N RST	-325.61 V	-325.63 V	-325.61 V
CURRENT CF ▼	1.42	1.42	1.42
PEAK CURRENT	-51.37 A	51.15 A	51.19 A



C) In most cases, the RLC emulation results in the voltage collapsing toward zero after the disconnection of the DUT. However, depending on the configured RLC parameters and the DUT behavior, the voltage may rise instead. To protect the DUT from potential overvoltage conditions, it is recommended to configure both the islanding voltage margin and peak voltage protection settings appropriately.

By default, the islanding voltage margin is set to 1.25, allowing the output voltage to rise up to 125% of the nominal value. If this threshold is exceeded, the RLC emulation is automatically stopped, and the source reverts to voltage source mode at nominal settings.
The SCPIs to set and get this margin are:
TEST:AISL:VOLT:MARG <VALUE>
TEST:AISL:VOLT:MARG?

Additionally, it is recommended to configure the peak voltage protection from the Protection screen. In this example, it is set at 230*sqrt(2)*1.3 (130% of nominal value)



D) Configure the advanced scope to trigger on the islanding start event.
Ensure the scope interface (e.g., browser tab) is open and ready, then press Play to begin the capture sequence.

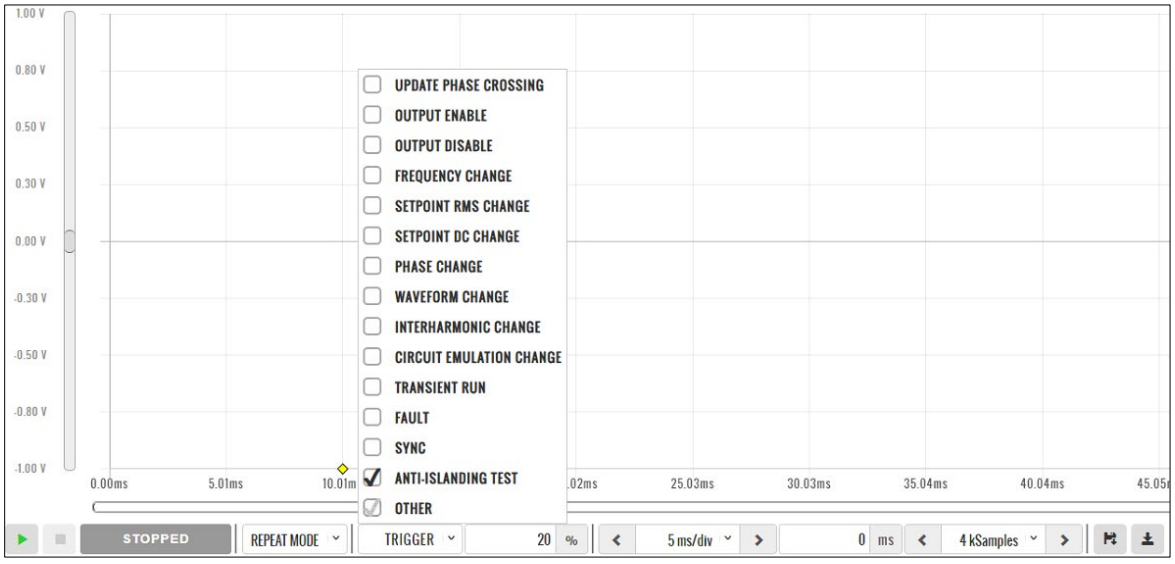


Figure 2-1: Advance Scope Trigger Mode Selection

E) By default, islanding mode is set to Q mode with a default Q factor of 1.0. In this mode, the RLC component values are automatically calculated based on the RMS power measurement, frequency setpoint and the configured Q factor.

$$R = \frac{P}{U} \qquad L = \frac{R}{Q * 2 * \pi * F} \qquad C = \frac{Q}{R * 2 * \pi * F}$$

Where:

R: Resistance in Ohms
P: Active power in Watts
U: Nominal voltage in RMS value
L: Inductance in Henry
C: Capacitance in Farads
F: Frequency in Hertz
Q: Quality factor

The SCPI commands available to set and get the Q are:
TEST:AISL:C# <VALUE>
TEST:AISL:Q#?

F) Configure the current threshold used to detect DUT disconnection. If the absolute value of the instantaneous current (in amps) falls below this threshold, the DUT is considered disconnected, and the disconnection time is recorded accordingly.
The default threshold is 2 A. The SCPI commands to set and get it are:
TEST:AISL:DISC:CURR:THRE# <VALUE>
TEST:AISL:DISC:CURR:THRE#?

G) Configure the start angle of the islanding with the “update phase” setting in the configuration screen By default, it is at the zero crossing of phase A. Not this setting affects any change applied, like setpoints, enable, etc.



H) Start the islanding test by executing the SCPI command **TEST:AISL RUN**
This command can be issued from a separate tab using the SCPI console available on the home screen of the interface.



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I) In this example, the DUT successfully disconnected, and as a result, the voltage collapsed, indicating a correct islanding response.

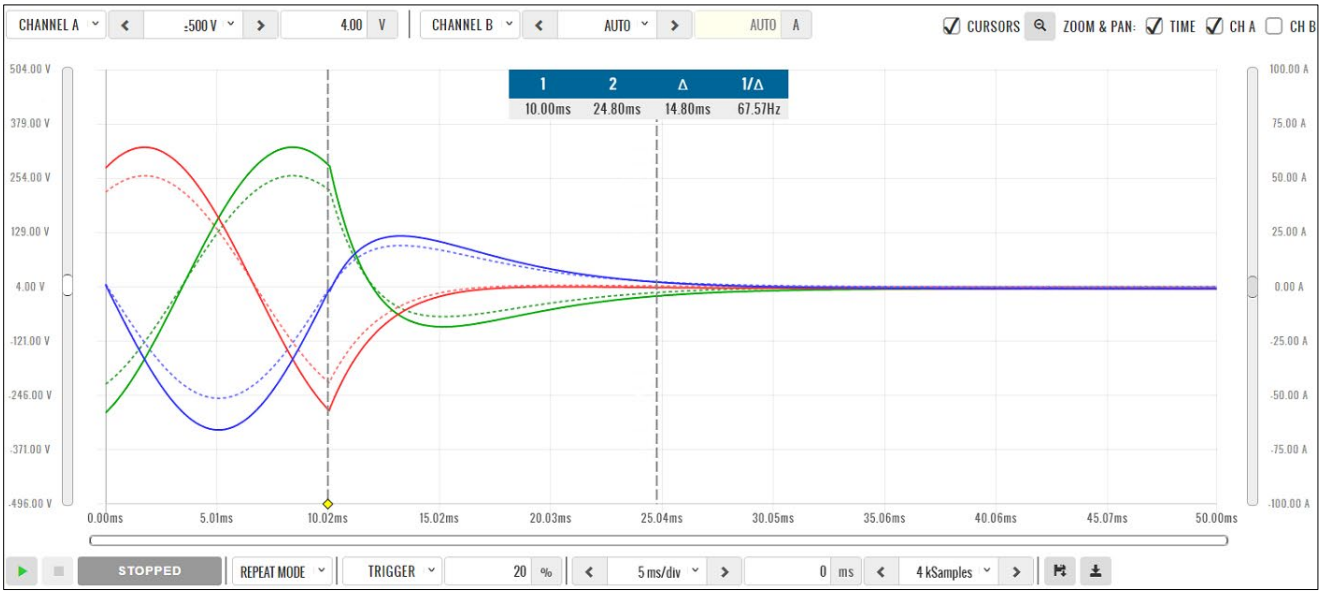
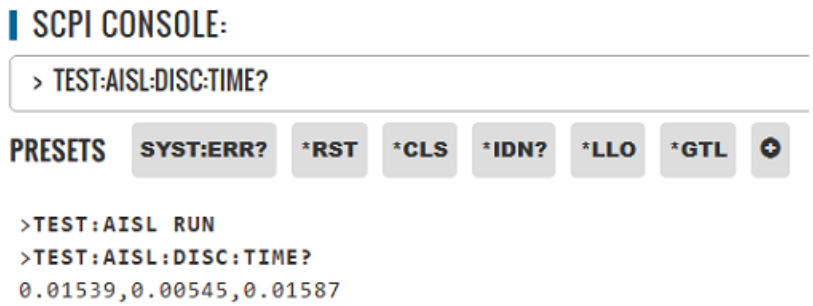


Figure 2-2: AZX/GSZ Scope Capture

J) The disconnection time can be retrieved using the SCPI **TEST:AISL:DISC:TIME#?**
This command returns the measured disconnection time in seconds.



K) After the test, the power source remains in RLC emulation mode with the voltage collapsed. To exit this state and return to nominal operation, use the following SCPI command **TEST:AISL# STOP.**
Alternatively, you can toggle the output off and back on to resume normal voltage source mode.



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3 SCPI commands

This section covers the available **A**nti **ISL**anding SCPI Command syntax and purpose of each command available to perform these tests.

- **TEST:AISLanding# <RUN|STOP>**
  This command initiates (RUN) or terminates (STOP) the anti-islanding test procedure.
  To execute the test, ensure the unit is operating in voltage mode with the output enabled and set to nominal conditions. Prior to starting the test, the Device Under Test (DUT) should stabilize the output current at the intended operating point.

- **TEST:AISLanding:RUNNing#?**
  Queries the current test status. Returns 1 if the anti-islanding test is active and the system is emulating the RLC circuit based on real-time current measurements; otherwise, returns 0.

- **TEST:AISLanding:DISConnected#?**
  Returns 1 if the system has detected that the DUT has ceased feeding current, indicating a disconnection. Otherwise, it returns 0.
  Disconnection is detected when the absolute instantaneous current remains below the user-defined threshold for a duration exceeding the configured disconnection window.

- **TEST:AISLanding:DISConnected:TIME#?**
  Returns the elapsed time, in seconds, between the initiation of the anti-islanding test and the moment the DUT is considered disconnected. The measurement resolution is 10 microseconds.

- **TEST:AISLanding:DISConnection:WINDowtime# <VALUE>**
  Sets the time window during which the absolute instantaneous current must remain below the programmable threshold to confirm disconnection. The default value is 0.1 seconds.
  This parameter is rarely modified and does not contribute to the disconnection time measurement itself.

- **TEST:AISLanding:DISConnection:WINDowtime#?**
  Returns the currently configured disconnection window time (default is 0.1 s).

- **TEST:AISLanding:DISConnection:CURRent:THREshold# <VALUE>**
  Sets the current threshold, in amperes, used to detect disconnection.
  Default value: 2 A.

- **TEST:AISLanding:DISConnection:CURRent:THREshold#?**
  Returns the configured current threshold.
  Default value: 2 A.

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- **TEST:AISLanding:MODE# <MODE>**
  Configure the anti-islanding test mode. By default, the mode is 0 or Q

  - **0 (Q)**
    This mode computes the RLC circuit before the test is run based on the RMS measurements, frequency, and the desired Q factor. See the SCPI **TEST:AISL:Q#** to configure it.

  - **1 (QP)**
    This mode computes the RLC circuit before the test is run based on the RMS measurements, frequency, the desired Q factor, and active power. See the SCPI **TEST:AISL:Q#** and **TEST:AISL:P#** to configure it.

  - **2 (QC)**
    This mode computes the RLC circuit before the test is run based on the RMS measurements, frequency, the desired Q factor, and the resistor RMS current. See the SCPI **TEST:AISL:Q#** and **TEST:AISL:CURR#** to configure it.

  - **3 (PVA)**
    This mode computes the RLC circuit before the test is run based on the RMS measurements, frequency, and the desired resistor, capacitor, and inductor powers. See the SCPI **TEST:AISL:P#, TEST:AISL:VAC#**, and **TEST:AISL:VAL#** to configure it.

  - **4 (CURR)**
    This mode computes the RLC circuit before the test is run based on the RMS measurements, frequency, and the resistor, capacitor, and inductor RMS currents. See the SCPI **TEST:AISL:CURR#, TEST:AISL:CURRC#,** and **TEST:AISL:CURRL#** to configure it.

  - **5 (RLC)**
    This mode computes the RLC circuit before the test is run based on the RMS measurements, frequency, and the resistor, capacitor, and inductor. See the SCPI **TEST:AISL:R#**, **TEST:AISL:L#**, and **TEST:AISL:C#** to configure it.

- **TEST:AISLanding:MODE#?**
  Returns the currently selected mode.

- **TEST:AISLanding:MODE#:CATalog?**
  Returns the list of supported modes: 0,Q,1,QP,2,QC,3,PVA,4,CURR,5,RLC.

- **TEST:AISLanding:Q# <VALUE>**
  Set the desired quality factor. The default value is 1.

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- **TEST:AISLanding:Q#?**
  Return the desired quality factor.

- **TEST:AISLanding:P#" <VALUE>**
  Set the desired resistor power in watts.

- **TEST:AISLanding:P#?**
  Return the desired resistor power in watts.

- **TEST:AISLanding:R# <VALUE>**
  Set the desired resistance in ohms.

- **TEST:AISLanding:R#?**
  Return the desired resistance in ohms.

- **TEST:AISLanding:L# <VALUE>**
  Set the desired inductance in millihenries.

- **TEST:AISLanding:L#?**
  Return the desired inductance in millihenries.

- **TEST:AISLanding:C# <VALUE>**
  Set the desired capacitance in microfarads.

- **TEST:AISLanding:C#?**
  Return the desired capacitance in microfarads.

- **TEST:AISLanding:VAC# <VALUE>**
  Set the desired capacitor power in volt-ampere.

- **TEST:AISLanding:VAC#?**
  Return the desired capacitor power in volt-ampere

- **TEST:AISLanding:VAL# <VALUE>**
  Set the desired inductor power in volt-ampere.

- **TEST:AISLanding:VAL#?**
  Return the desired inductor power in volt-ampere.

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- **TEST:AISLanding:CURR# <VALUE>**
  Set the desired resistor RMS current in RMS amps.

- **TEST:AISLanding:CURR#?**
  Return the desired RMS current of the resistor in RMS amps.

- **TEST:AISLanding:CURRC# <VALUE>**
  Set the desired capacitor RMS current in RMS amps.

- **TEST:AISLanding:CURRC#?**
  Return the desired RMS current of the capacitor in RMS amps.

- **TEST:AISLanding:CURRL# <VALUE>**
  Set the desired inductor RMS current in RMS amps.

- **TEST:AISLanding:CURRL#?**
  Return the desired RMS current of the inductor in RMS amps.

- **TEST:AISLanding:VOLTage:MARGin# <VALUE>**
  When emulating the RLC, it is expected that the DUT disconnects and the voltage collapses to zero; however, depending on the settings and the DUT behavior, the voltage can even go higher. This setting sets a margin for the emulation; if reached, the source returns to voltage mode at nominal settings. The default value is 1.25, which means that it will allow up to 125% voltage until it returns to nominal. This setting can be combined with the peak voltage protections for further protection of the DUT.

- **TEST:AISLanding:VOLTage:MARGin#?**
  Returns the voltage margin.

- **TEST:AISLanding:SCOPe:TRIGger# <VALUE>**
  This sets the anti-islanding active trigger for the advanced scope, it is bit-oriented.
  0 for anti-islanding test run start, 1 for disconnection detection, and 2 for intentional stop.
  The default value is 3 (binary 11), which enables the trigger for test start and disconnection detection.

- **TEST:AISLanding:SCOPe:TRIGger#?**
  Return the configured trigger for the advanced scope.

- **TEST:AISLanding:FILTer:FREQuency# <VALUE>**
  This command adds a digital filter to the RLC emulation. The default value is 100000 Hz, which means no filtering. Filtering could be useful to increase system stability in certain cases.

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- **TEST:AISLanding:FILTer:FREQuency#?**
  Return the RLC digital filter frequency.

- **TEST:AISLanding:P#:MEASure?**
  Return the computed resistor power in kilo watts.

- **TEST:AISLanding:VAC#:MEASure?**
  Return the computed capacitor reactive power in watts.

- **TEST:AISLanding:VAL#:MEASure?**
  Return the computed inductor reactive power in watts.

- **TEST:AISLanding:CURR#:MEASure?**
  Return the computed resistor current in amperes.

- **TEST:AISLanding:CURRC#:MEASure?**
  Return the computed capacitor current in amperes.

- **TEST:AISLanding:CURRL#:MEASure?**
  Return the computed inductor current in amperes.

- **TEST:AISLanding:Q#:MEASure?**
  Return the computed quality factor.

- **TEST:AISLanding:R#:MEASure?**
  Return the computed resistor in ohms.

- **TEST:AISLanding:C#:MEASure?**
  Return the computed capacitor in micro farads.

- **TEST:AISLanding:L#:MEASure?**
  Return the computed capacitor in mili henry.

- **TEST:AISLanding:STROBE <VALUE>**
  Enable/disable (1 or 0) external trigger 200uS pulse when test starts.

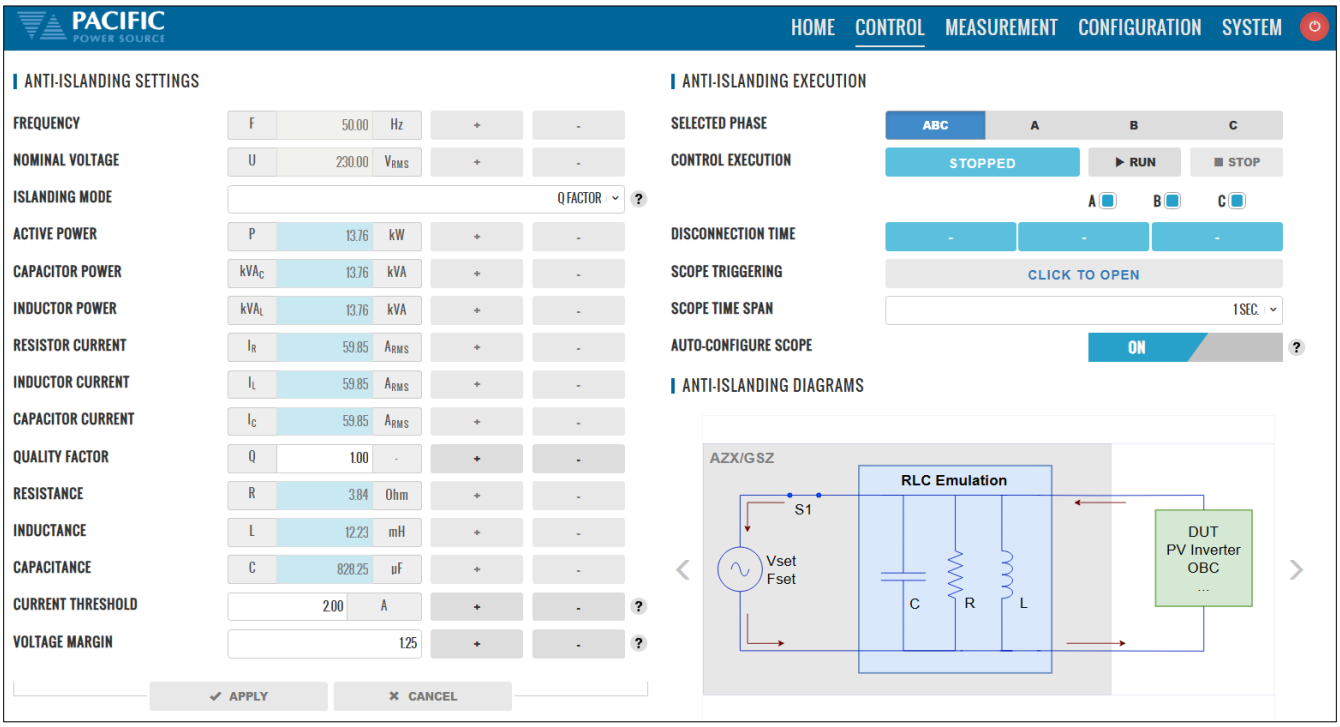
- **TEST:AISLanding:STROBE?**
  Query external trigger enable/disable state

Notes:

- *The symbol # is the suffix, not passing means a write/query for all three phases. For get/set a specific phase, replace # with 1,2, or 3. In single-phase mode, the # can be ignored and not used.*
- *Lower-case letters in the SCPIs can be ignored and not passed*

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4 Graphical user interface



5 Conclusions

The anti-islanding turnkey solution provided by the AZX/GSZ series enables comprehensive testing of islanding conditions with precise measurement of disconnection time across a continuous power range.
Its ability to automatically compute and fine-tune RLC parameters streamlines the test process, while the system's high-efficiency, regenerative power stage minimizes energy consumption and operating costs. Additionally, its rapid response enables efficient emulation of diverse islanding scenarios, making it an ideal platform for compliance and development testing.

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Figure shows another example of a PV inverter anti-islanding test for a Q factor of 1.0. The disconnection time is around 125ms.

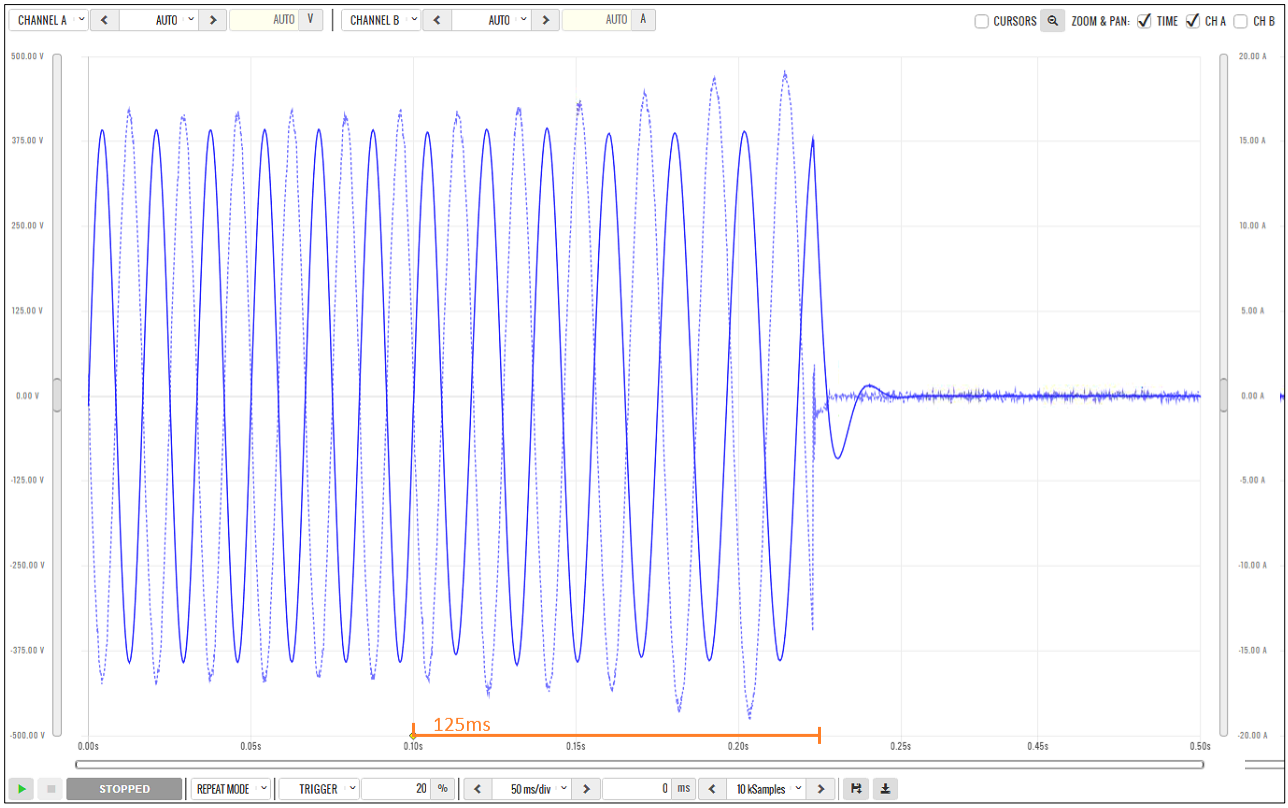


Figure 4-1: PV Inverter Anti-Islanding test AZX/GSZ scope capture

PACIFIC POWER SOURCE
2802 Kelvin Ave, Suite 100
Irvine, CA 92614 USA
Phone: +1 949.251.1800
Fax: +1 949.756.0756
Toll Free: 800.854.2433
E-mail: sales@pacificpower.com
www.pacificpower.com

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