

High Voltage Solar Inverter System GUI Overview

Getting Started Guide



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High Voltage Solar Inverter System GUI Overview

The High Voltage (HV) Solar Inverter System GUI provides a simple interface to evaluate some of the functionalities of the system from Texas Instruments. The system includes two EVMs from TI: an HV Solar Maximum Power Point Tracking (MPPT) DC-DC and an HV Solar DC-AC Inverter. **The GUI is located at: `..\controlSUITE\development_kits\HV_SOLAR_DCAC\~GUI\~Source\`.**

The GUI can:

- Start or stop the inverter system.
- Monitor these system parameters: boost stage DC BUS voltage, panel voltage, panel current, panel power, isolated DC BUS voltage, inverter stage output voltage, output current, output power, and frequency.
- Monitor the operating mode or status of the inverter and DC-DC stages.
- Restart the inverter system once the fault condition has been cleared.
- Configure the inverter output for two utility settings, 120 V/60 Hz and 220 V/50 Hz.
- Enable or disable the grid-tie function for the DC-AC inverter.

CAUTION

The HV Solar Inverter System produces high voltages. The system should only be handled by experienced power supply professionals in a lab environment. The system has been tested to work only with a solar panel emulator such as Agilent Technologies E4360A SAS Mainframe with two solar array simulator DC modules (E4362A, 0 to 130 V, 0 to 5 A). This system has not been tested to work with an actual solar PV panel.

Prior to applying the panel emulator output to this system, connect a voltmeter across the DC-DC EVM output to monitor the DC-DC BUS voltage. Then, turn on the panel emulator to output only 100 to 150 V. This output will allow the bias supplies on both the EVMs to turn on. Once the bias supplies start drawing power from the DC BUS, slowly increase the panel emulator voltage to its maximum open circuit voltage (200 to 300 V) while monitoring the DC-DC output. This DC-DC output voltage should not exceed more than 410 V when the inverter and its output load are connected to avoid any overvoltage condition at the DC-DC output (during start-up).

This overvoltage condition tends to happen when the DC-AC Inverter EVM output remains under open circuit (no load connected) until the minimum DC-DC BUS voltage is established, and then a start command is issued from the GUI. The DC-AC output's open circuit is caused by its output relays remaining in an off condition prior to the start command issued from the GUI.

Also, the DC-DC board has no output overcurrent protection, so take appropriate measures to prevent any output short circuits across the DC-DC EVM output.

1 Getting Started

For the jumper and switch configurations needed to power on the C2000™ HV Solar Inverter System, refer to the individual EVM's quick start guides (LIT# and LIT#). Before applying any power, make sure these jumpers and switches are installed properly.

1.1 Setting up the Solar Inverter System

Connect the two EVMs according to [Figure 1](#) and [Figure 2](#).

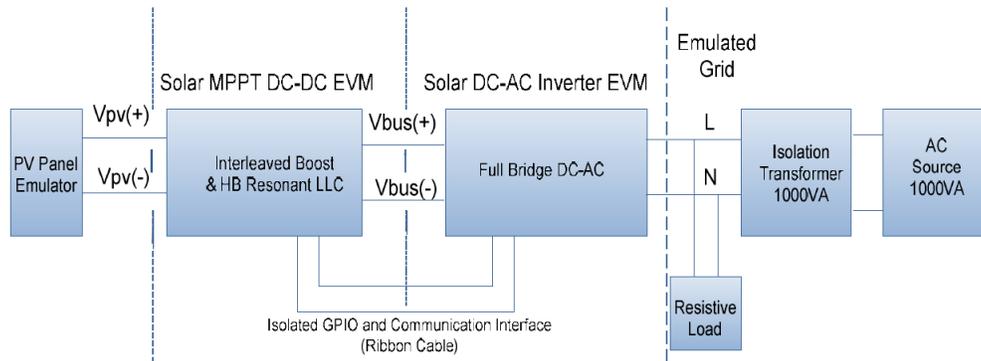


Figure 1. Block Diagram of Solar Inverter System Setup

For safety, use an isolation transformer between the external AC source and the inverter output. For noise immunity, connect small inductors for common mode filters at the interface between the two boards as shown in [Figure 2](#).

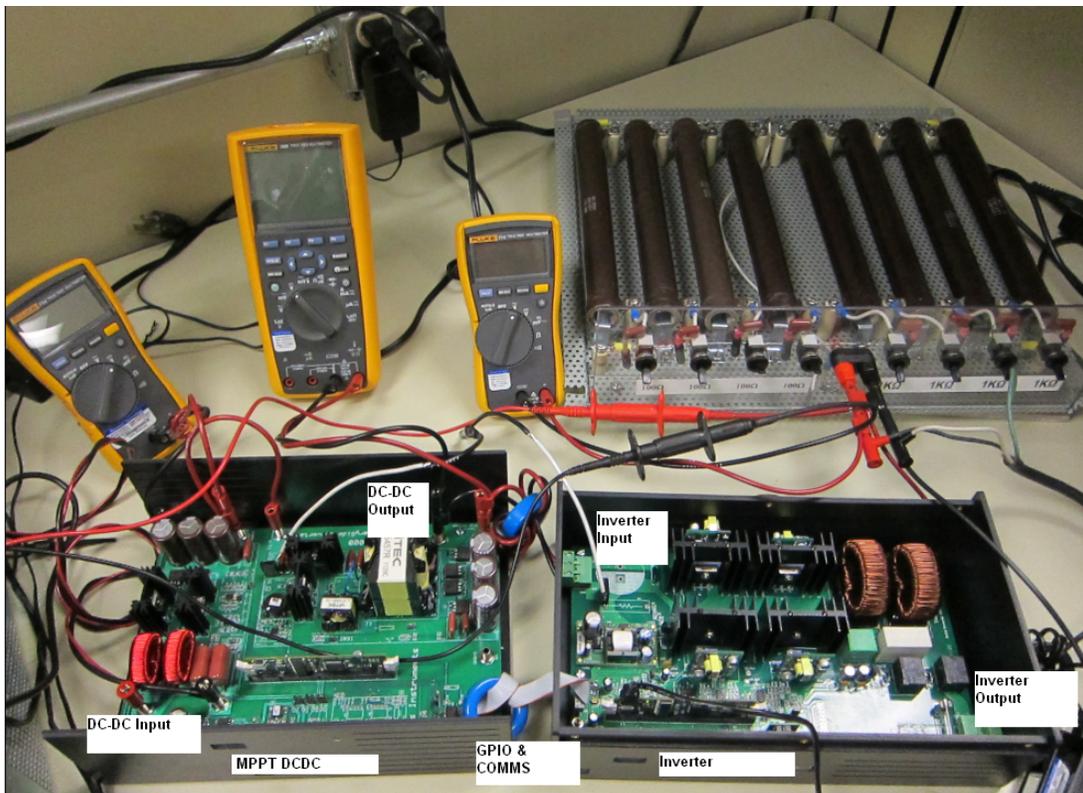


Figure 2. Solar Inverter System Test Setup

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1.2 Setting Up the DC-DC EVM and the PV Panel Emulator

Use an external 12-V DC supply at JP1 to power up temporarily all the control circuits on the DC-DC EVM. By default, the Piccolo™ controller is enabled to boot from flash and run the HV Solar DC-DC code. Turn on the switch SW1 (in the PCB section or macro labeled M3) by placing it towards the electrolytic caps (C5, C6, and C7 located in M3). This action will apply the external 12-V DC supply to the DC-DC EVM. Check the LED LD3 on the control card. If the LED does not flash, check the auxiliary power and configure the control card jumper to boot from flash, or reload the program. Otherwise, continue to do the next steps.

Use a solar panel emulator (200 to 300 V, 500-W maximum) to provide input power to the EVM. One possible emulator could be Agilent Technologies' Solar Array Simulator Mainframe E4360A, with two Solar Array Simulator DC Modules (E4362A, 0 to 130 V, 0 to 5 A). Configure the panel emulator to emulate the solar panel characteristics in Table 1 and connect it to the EVM input. Do not power on the panel at this time.

Table 1. Example Panel Emulator Parameters 1

VALUE	PURPOSE	MEASUREMENT
Voc	Open circuit panel voltage	260 V
Vmpp	Panel voltage for MPPT	220 V
Impp	Panel current for MPPT	0.75 A
Isc	Short circuit panel current	1 A

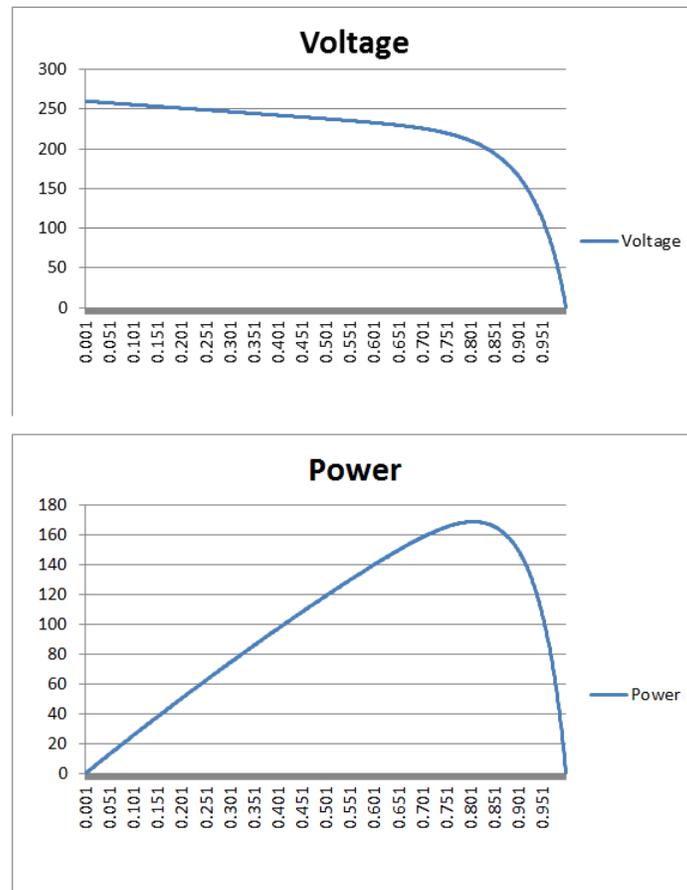


Figure 3. Example of Panel Emulator Characteristics

1.3 Setting Up the DC-AC Inverter EVM and the Load

The DC-AC Inverter EVM can be controlled either by a Piccolo (CC2803x) control card or a Concerto™ (CCF28M35xx) control card. For jumper and switch configurations related to these control cards, please refer to the DC-AC Inverter EVM Quick Start Guide (LIT#). Select the desired control card and connect it to the 100-pin header U2 on the inverter EVM.

Now connect the USB connector to the control card on the DC-AC Inverter EVM. Use the ribbon cable to connect the 10-pin header CN5 on the Inverter EVM to the other 10-pin header H2 on the DC-DC EVM. Ensure that the ribbon cable is installed properly so that all 10 pins on both headers are connected one to one (pin 1 on CN5 connects to pin 1 of H2, and so on). Use an external 15-V DC supply at J1 to temporarily power up all the control circuits on the DC-AC Inverter EVM.

By default, the controller (Piccolo or Concerto) is enabled to boot from flash and run the HV Solar DC-AC Inverter code. Turn on the switch S1 by placing it away from J1 and toward the 10-pin header CN5. This switch will apply the external 15-V DC supply to the DC-AC Inverter EVM. Check the LED LD2 on the control card. If the LED flashes every second then continue to do the next steps. Otherwise, check the auxiliary power, **the control card jumper configuration for boot from flash**, or reload the program. At this point, the LED LD2 on the DC-DC EVM should start flashing, indicating the communication between the two EVMs. If LD2 does not flash, check the ribbon cable connection between the two EVMs.

Connect an appropriate resistive load to the DC-AC Inverter EVM output connector CON2 (LINE.L and LINE.N terminals). As in the previous example, if the panel emulator is configured to supply 165 W of power at the MPPT point, select a load resistor value of 100 Ω . This value will make the EVM output voltage to rise to about 120 V_{RMS} when delivering 165 W of output power. The resistor power rating should be at least 200 W. Connect the DC-DC output terminals Vo-R and GND-S to the DC-AC input connector (CON1) terminals +BUS and GND, respectively.

As shown in [Figure 1](#), connect the external AC source and the isolation transformer across this resistive load of 100 Ω . Set the AC source to output 120 V, 60 Hz but do not turn on AC source power at this time.

2 Running the Application using the GUI

By default the hardware is configured to boot from a pre-Flashed code. The GUI only works with the Flash configuration in the corresponding CCS project.

1. Browse to ..\controlSUITE\development_kits\HV_SOLAR_DCAC\~GUI and double-click on SOLAR-GUI.exe. Figure 4 shows a screenshot for the GUI.

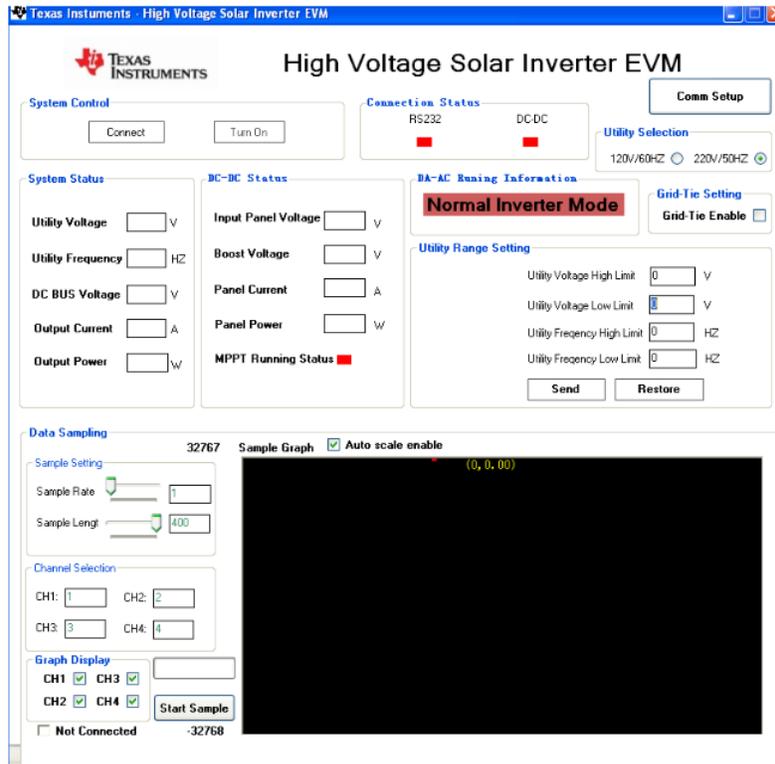


Figure 4. HV Solar Inverter GUI

2. Set up the GUI communication by clicking on the *Comm Setup* button at the top right. Then choose the COM port (COM51, for example). Click *OK*.

NOTE: The COM port will be different for different PCs. Check the COM port number in the PC hardware resources window.

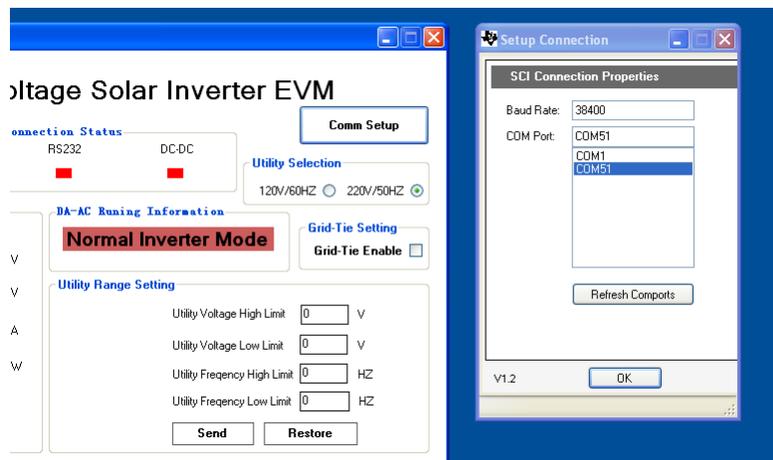


Figure 5. HV Solar Inverter GUI Setup

3. Connect the system and the GUI by clicking the *Connect* button (see [Figure 6](#)).
 - A green *Connected Status* box means the connection succeeded.
 - A yellow *Connected Status* box means the connection failed.

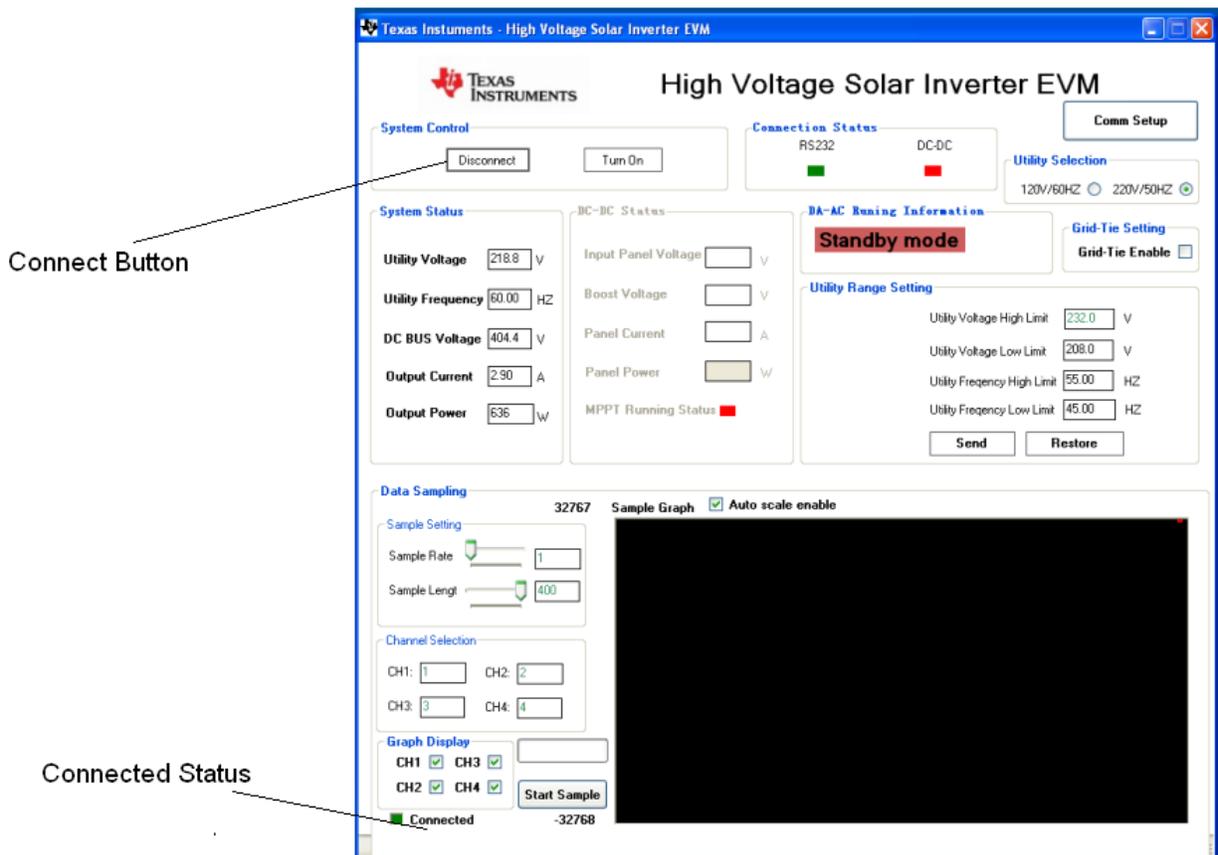


Figure 6. HV Solar Inverter GUI Connection

2.1 Using the GUI for Off-Grid Operation

1. Once the hardware is set up correctly and the application program (pre-Flashed code) is tested to run with the GUI, close the GUI, turn off the switches SW1 on DC-DC EVM and S1 on DC-AC Inverter EVM, and disconnect the external bias supplies from both EVMs.
2. Verify that the two jumpers (J1 on the DC-DC EVM and JP1 on the Inverter EVM) are connected so that the onboard isolated bias supplies (mounted on both EVMs) can now provide the bias power (12 V for the DC-DC EVM and 15 V for the Inverter EVM) when the PV panel emulator power is turned on.
3. For the off-grid test, disconnect the external AC source and the isolation transformer from the load. The resistive load will only be powered from the solar inverter. Now turn on only one of the Solar Array Simulator DC Modules (Agilent E4362A) with the configuration (for the panel emulator and the load resistor) described previously.
 - This module will apply a maximum input voltage of 130 V (with an open circuit voltage from each of the Solar Array Simulator DC Modules) to the DC-DC input and allow the bias supplies on both EVMs to power up.
4. When both bias supplies for the EVMs power up, connect the GUI as described and monitor the GUI status. LD2 on the Inverter control card will be flashing every second. LD2 and LD3 on the DC-DC EVM will also be flashing, although **at a different rate**.

5. If the *DC-AC Running Information* section displays *Standby Mode*, the DC-AC is ready to be turned on. To do this, click the *Turn On* button on the GUI and then power on the second Solar Array Simulator DC Module with the configuration (for the panel emulator and the load resistor) described above.
 - This step will apply the full open circuit panel voltage (Voc) of 260 V (open circuit voltage of both Solar Array Simulator DC Modules when connected in series) to the DC-DC input. The *DC-AC Running Information* section on the GUI will show the *Soft-Start Mode*, and then the *Normal Inverter Mode*. The *DC-AC Running Information* section will change to *Normal Inverter Mode* when the DC-DC EVM starts an MPPT operation and the DC-AC Inverter delivers power to the load.
6. The DC-DC EVM output should now ramp to about 380-V DC, and the Inverter EVM output should be about 120 V_{RMS}.
7. On the GUI, verify some of the system parameters. For example, the input panel voltage should be about 220 V, the panel power should be about 165 W, and the DC BUS voltage should be about 380 V. The GUI snapshot on [Figure 7](#) shows these parameters under this condition.
8. Turn off the PV panel emulator before anything else. Then wait for a few minutes before disconnecting the GUI.

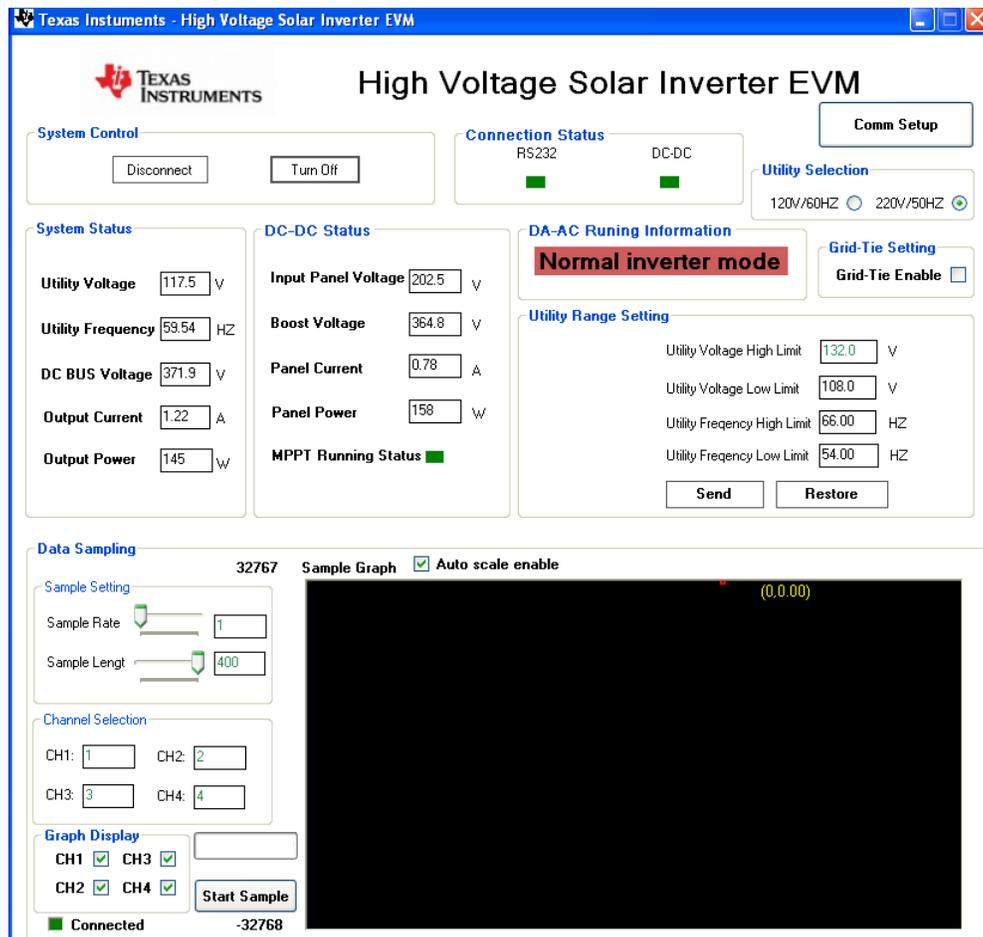


Figure 7. HV Solar Inverter GUI Snapshot for Off-Grid Operation

2.2 Using the GUI for Grid-Tie Operations

1. Turn off the PV panel emulator power. For the grid-tie test, reconnect the external AC source and the isolation transformer to the load. Change the load resistor from 100 Ω to 50 Ω . Set the AC source to output 120 V, 60 Hz and turn it on. With a 50- Ω load resistor, the AC source will now deliver 100% load power of about 290 W.
2. Now turn on one of the Solar Array Simulator DC Modules (Agilent E4362A) with the configuration (for the panel emulator and the load resistor) described above.
3. When both bias supplies for the EVMs power up, connect the GUI (as described before) and monitor the GUI status. LD2 on the Inverter control card will be flashing every second. LD2 and LD3 on the DC-DC EVM will also be flashing, **although at a different rate**.
4. On the *GUI Grid-Tie Setting* section, click on the *Grid-Tie Enable* box. Then on the *GUI Utility Selection* section click on the *120-V/60-Hz* setting.
 - These two selections must be done after connecting the GUI to the HV Solar Inverter System. If these sections are selected before connecting the GUI to the inverter system, repeat these two selections one more time in order to ensure the inverter system has been communicated of the grid-tie condition and the utility setting.
5. Turn on the DC-AC at this point if the *DC-AC Running Information* section shows the *Standby Mode*. To do this, power on the second Solar Array Simulator DC Modules, and click the *Turn On* button on the GUI.
 - The *DC-AC Running Information* section will show the *Soft-Start Mode*, and then the *Normal Inverter Mode*. The *DC-AC Running Information* section will change to *Normal Inverter Mode* when the DC-DC EVM starts an MPPT operation and the DC-AC inverter delivers power to the load.
6. For this grid-tie test, set the PV panel emulator to deliver 165 W of power.
 - The inverter will deliver 165 W of load power at 120 V/60 Hz, which will drop the AC source output power from an initial 290 W to 125 W. The AC source output will thus be 120 V_{RMS} /60 Hz at a load current of about 1.04 A_{RMS} . The waveforms in [Figure 8](#) show the grid voltage and the inverter output current under this condition.
7. Check the DC-DC EVM output to match about 380-V DC.
8. On the GUI, verify the system parameters.
 - For example, the *Utility Voltage* will show about 120 V_{RMS} , the *Utility Frequency* will read 60 Hz, the *Input Panel Voltage* will be about 220 V, the *Panel Power* will be about 165 W, the *DC BUS Voltage* will read about 380 V, and so on. The GUI snapshot on [Figure 9](#) shows these parameters under this condition.
9. To turn off the system, first turn off the external AC source, which will create an undervoltage condition. The inverter will report this on the GUI. This fault condition will also shut off both the inverter and the DC-DC outputs. At this point, turn off the PV panel emulator power. Then wait for a few minutes before disconnecting the GUI.

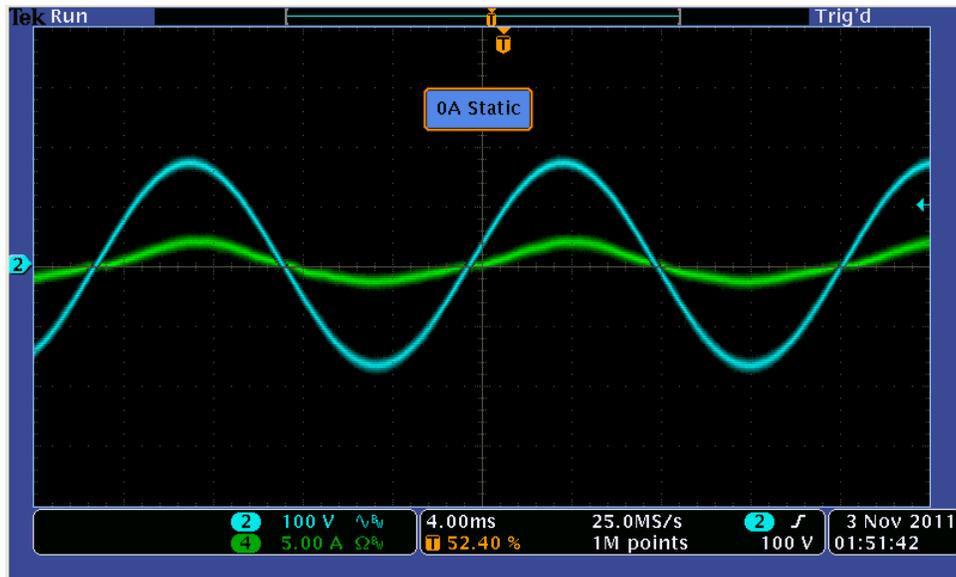


Figure 8. Tie Test 1, Ch2: Grid Voltage, Ch4: Solar Inverter Output Current, MPPT Panel Power 165 W

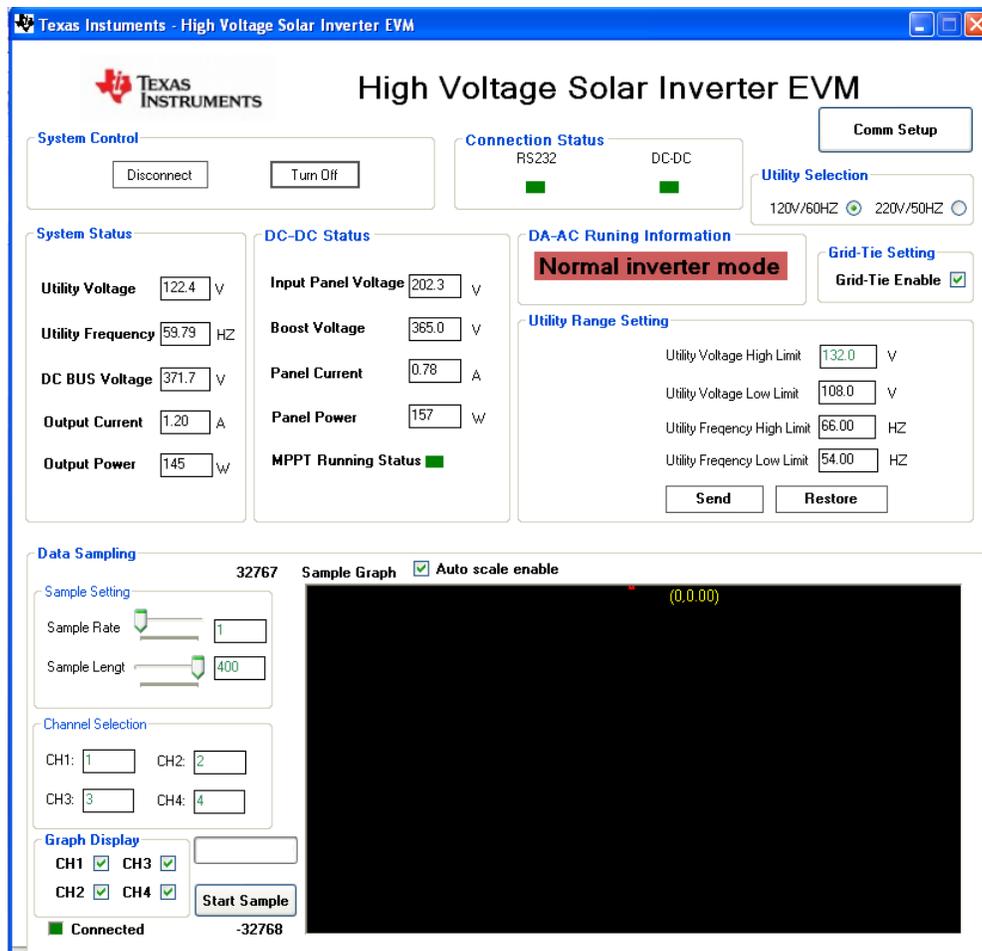


Figure 9. HV Solar Inverter GUI Snapshot for Grid-Tie Operation

10. Repeat the test for a higher load and higher PV panel power setting. Change the load resistor from 50 Ω to 30 Ω . Set the AC source to output 120 V, 60 Hz and turn it on.
 - With a 30- Ω load resistor, the AC source will now deliver 100% load power of about 480 W.
11. Change the PV panel emulator parameter to emulate the following solar panel characteristics:

Table 2. Example Panel Emulator Parameters 2

VALUE	PURPOSE	MEASUREMENT
Voc	Open circuit panel voltage	260 V
Vmpp	Panel voltage for MPPT	220 V
Impp	Panel current for MPPT	1.5 A
Isc	Short circuit panel current	1.75 A

12. Repeat the steps as described for the previous load set up. For this test, the PV panel emulator is set up to deliver 330 W of power.
 - Therefore, the Inverter, when turned on, will deliver about 330 W load power at 120 V/60 Hz, and the AC source output power will drop from initial 480 W to about 150 W. The waveforms in [Figure 10](#) show the grid voltage and the inverter output current under this condition.

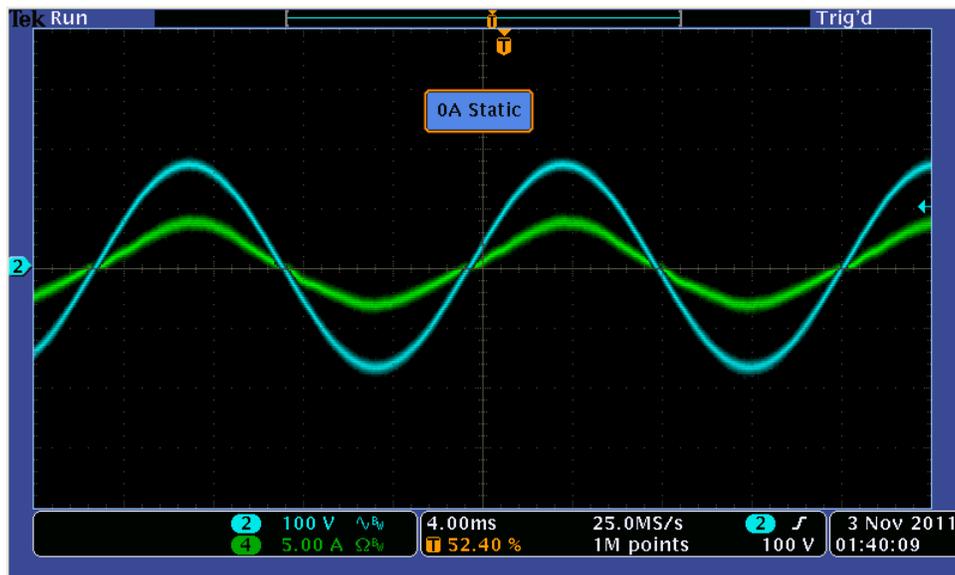


Figure 10. Grid-Tie Test 2, Ch2: Grid Voltage, Ch4: Solar Inverter Output Current, MPPT Panel Power 330 W

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