C2000™ Solar Micro Inverter

Quick Start Guide

Literature Number: TIDU406
September 2014

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1 Introduction

This document presents procedure for running the Texas Instruments C2000 Solar Micro Inverter EVM (TMDSSOLARUINVKIT) and using the graphical user interface (GUI) for a quick demonstration. The Solar Micro Inverter kit enables the user to evaluate C2000 microcontrollers on how they apply converted solar power to connected grids. Figure 1 shows the power stages present on the kit, which includes a DC-DC stage (isolated flyback) and DC-AC stage (secondary side). The kit also includes these items:

- TMDSSOLARUINVKIT base board
- TMDSCNCD28035ISO control card
- USB mini to A cable
- 15-V DC external isolated bias supply
- 12-V DC external isolated bias supply
- AC cord

Software for the kit is available through controlSUITE and is found under: controlSUITE\development\development_kits\TMDSSOLARUINVKIT_v100.

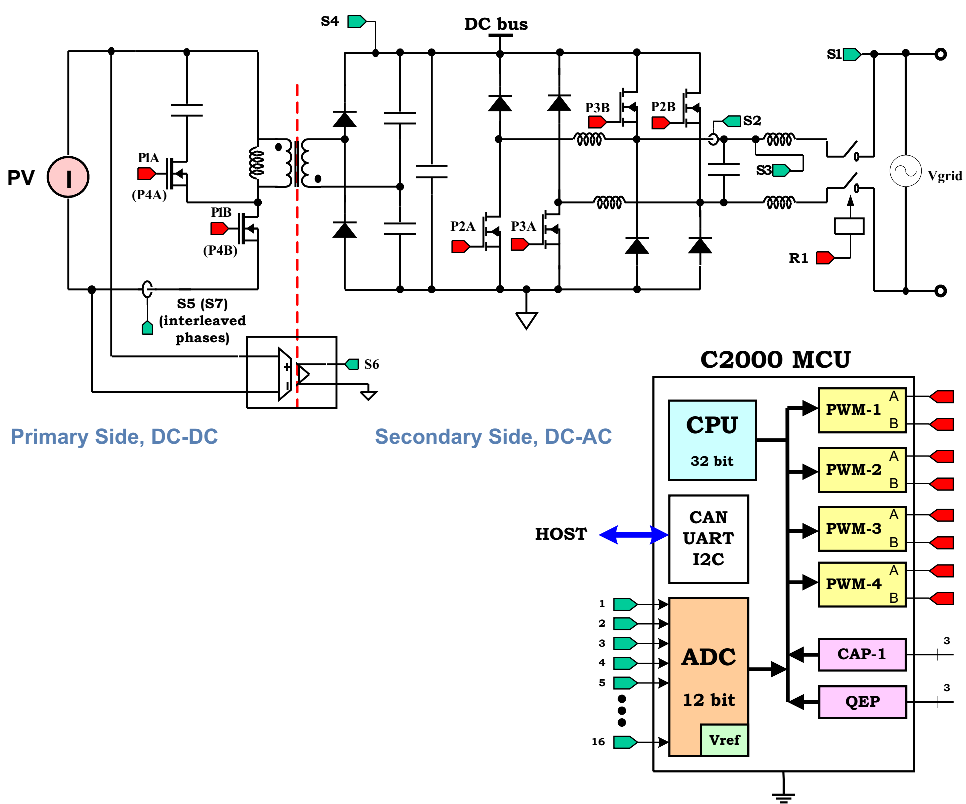

Figure 1. Solar Micro Inverter Kit Power Stage Diagram

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CAUTION

The TI Solar Micro Inverter board produces high voltages and should only be handled by experienced power supply professionals in a lab environment. Power may also produce high temperatures in some components, so take appropriate safety measures before working with this board.

2 Equipment Required

The following equipment is required to run the Solar Micro Inverter kit demo:

- Input power source: this can be supplied using one of the following options
  - Isolated DC power supply rated 25- to 44-V DC, 20 A, and 400 W minimum (Agilent programmable DC source, model N5769A or similar).

    NOTE: Disable the MPPT in the GUI before starting the inverter when using the DC power supply.

  - Solar panel emulator: Agilent E4360 Modular Solar Array Simulator or similar
  - Solar panel of 25-V to 44-V output, rated for approximately 140 W (maximum) if connecting to grid at 110 V_{RMS} or approximately 240 W (maximum) if connecting to 220 V_{RMS}.
- 200-Ω power resistor: required when connecting to 220 V_{RMS}, optional for 110 V_{RMS}

Connect the following recommended equipment to the micro inverter board:

- Voltmeters of up to 500-V input range
- Oscilloscope with approximately 200-MHz bandwidth
- High volt differential probe, Tektronix P5205 or similar
- Current probe, Tektronix TCP202 or similar
- Current meter for output AC current, up to 5-A (RMS) range
- Current meter for input DC current, up to 12-A (DC) range

3 Hardware Setup

1. Inspect and install the jumpers. Before applying any power, ensure that these jumpers are configured properly. Table 1 lists the jumper configuration needed to run the GUI for the Micro Inverter EVM. Figure 2 shows the jumper locations on the PCB.

Table 1. List of Jumper Settings for C2000 Solar Micro Inverter EVM

JUMPER NO.	JUMPER SETTINGS	COMMENTS
J15	Install jumper	Jumper for 12-V external bias.
J38, J39	Do not install jumpers	
J40	Install jumper	Jumper for 15-V external bias.
J41, J42	Do not install jumpers	
TP8, TP9	Jumper wire must be installed	This connects VBUS (flyback stage output) to inverter input
J17, J19, J32, J33	Install all four jumpers	Jumpers for inverter stage PWM outputs from C2000
J30, J31	Install both jumpers	Jumpers for flyback stage PWM outputs from C2000

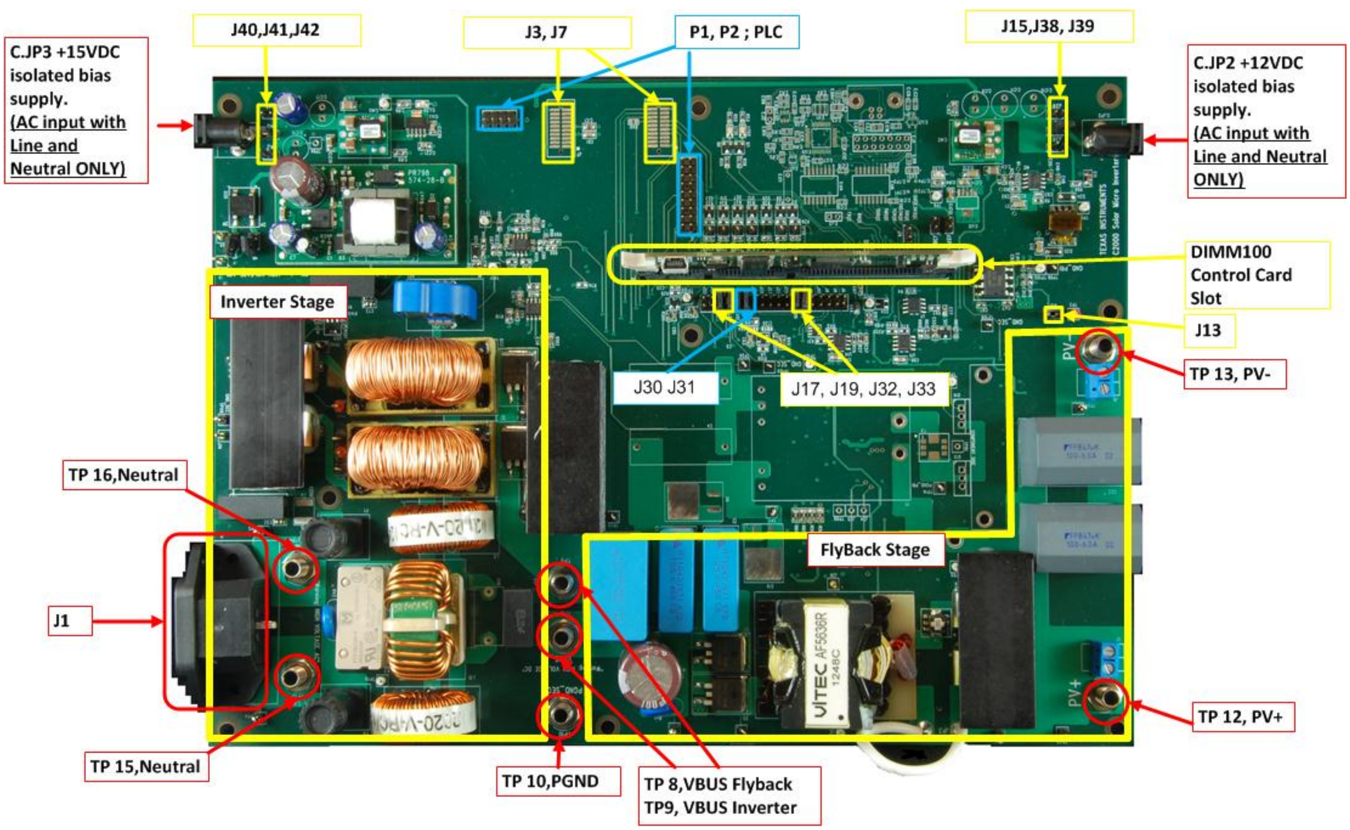

Figure 2. Jumper Positions for C2000 Solar Micro Inverter

2. Install and verify the F28035 ISO Control Card is connected to the EVM header U6.
3. Check the switch SW3 is set to the on position on the control card to enable the JTAG connection.
4. Connect the USB cable from the ISO control card to the PC the GUI needs to run. Verify that the LED LD4 on the control card is on, indicating a successful USB connection.

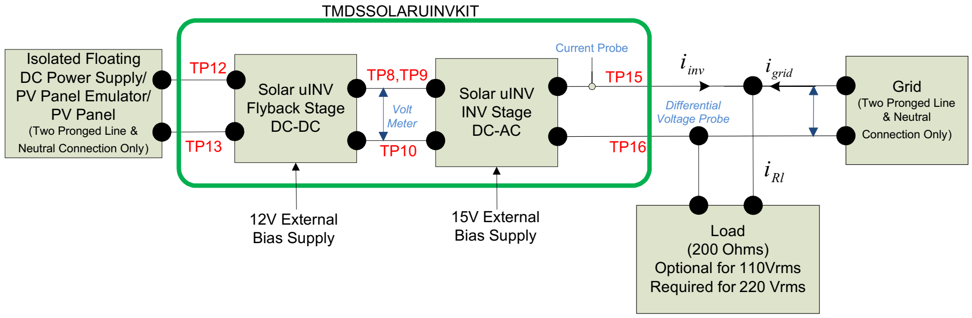

Figure 3. Solar Micro Inverter Kit Demo Setup

5. Verify the jumper cable is connected between TP8 and TP9 to connect the DC-DC stage output to the DC-AC stage input as shown in Figure 3.
6. With the EVM powered off, connect a resistive load of 200 Ω to the EVM AC output terminals (TP15 and TP16) when connecting to the 220-V_{RMS} grid (for the 110-V_{RMS} grid, connecting the resistor is not required).

NOTE: Because the 220-V/50-Hz grid was not available operation, the EVM was tested only with an emulated grid. Therefore, an external AC source (at least 600-VA rating) with a load resistor (200-Ω, 600-W rating) was used to emulate the grid. For a 100-V/60-Hz grid operation no resistive load was connected to the EVM output and grid was directly connected to the EVM.

7. Connect a voltmeter across the DC-BUS, such as the DC-DC stage output or the DC-AC stage input (TP8, TP9: VBUS) and the ground (TP10: GND_SEC), also shown in Figure 3. Set the voltmeter to measure DC voltage (range: 200- to 400-V DC).

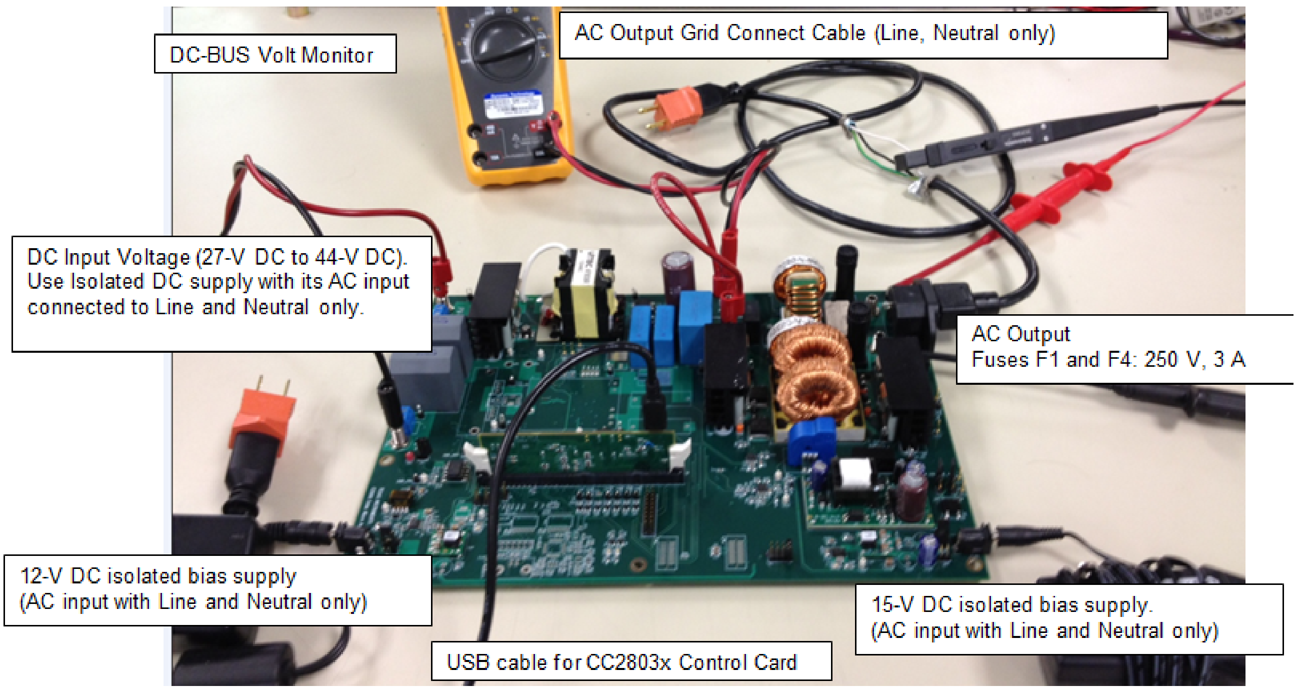

Figure 4. Solar Micro Inverter Test Setup

8. Connect a voltmeter to the EVM AC output terminals (TP15 and TP16). Set the voltmeter to measure AC voltage (100 to 240 V_{RMS}). Check fuses F1 and F4 for 250 V, 3 A (maximum).

9. Connect the current probe and high volt differential probe to the scope to capture the EVM output current and the grid voltage waveforms. The voltage probe can be connected across TP4 (line) and TP5 (neutral).
10. Connect the external 12-V DC isolated bias supply to the C:JP2 connector and power it on using a 110 or 220-V AC input (Figure 4, lower left). Make sure the supply uses line and neutral connections only (no earth connections).
11. Connect the external 15-V DC isolated bias supply to the C:JP3 connector and power it on using 110 or 220-V AC input (Figure 4, lower right). Make sure the supply uses line and neutral connection only (no earth connections).
12. Verify the control card is now powered by checking if the LD1 on the control card is on.
13. Connect the input power source across TP12(+) and TP13(-). This could be a DC power supply, a panel emulator, or a PV panel. Use #16 gauge wires for all connections.
    (a) If using DC source: keep it off, and set the supply for 35-V DC output and the output current limit of 10 A.
    (b) If using a panel emulator: keep the emulator off, and set the panel emulator characteristics for approximately 120 W peak power. Typical characteristic used are:
        (i) Open circuit voltage: 40 V
        (ii) Maximum power point voltage: 30 V
        (iii) Short circuit current: 5.2 A
        (iv) Maximum power point current: 4 A
    (c) If the solar panel is available: select one of the 25- to 44-V outputs rated for approximately 140 W (max) if connecting to grid at 110 V_{RMS} or approximately 240 W (max) if connecting to 220 V_{RMS}.

NOTE: Use extreme caution when dealing with solar panels as they are energized sources.

14. Use a two-prong AC connector (line and neutral only) across the output of the EVM. Do not connect the other end of the cord to the grid yet.

4 Software Setup and Running the GUI

1. Browse to the SolarMicroInv folder file located inside controlSUITE at: C:\ti\controlSUITE\development\development_kits\TMDSSOLARUINVKIT_v100\GUI
2. Use the required GUI Composer Runtime v5.5 to run this GUI. Install GUI Composer Runtime from the Texas Instruments Wiki.
3. Once the GUI composer is installed, browse to the location of GUI Composer Runtime install, named “guicomposer” by default, and copy the GUI project folder into the {guicomposer}/webapps directory so the launcher application resides at: C:\ti\guicomposer\webapps\SolarMicroInvGUI\launcher
4. Execute the “launcher” application by double clicking. This application will connect to the board and flash the release image on the board. A screenshot of the Release GUI is shown in Figure 5.
5. If a DC power supply is used, uncheck the *MPPT Enable* check box on the GUI. Now, power the DC side first by inputting 35-V DC (between TP12 and TP13). The input voltage can be read on the GUI. Otherwise, if a panel emulator is used, make sure it is programmed with characteristics described in Step 13 in Section 3. Turn the panel emulator on so the GUI will display the open circuit voltage. If a solar panel is available, connect a solar panel to the input. Make sure the ratings match those described in Step 13 in Section 3.

NOTE: Use extreme caution when dealing with solar panels as they are energized sources.

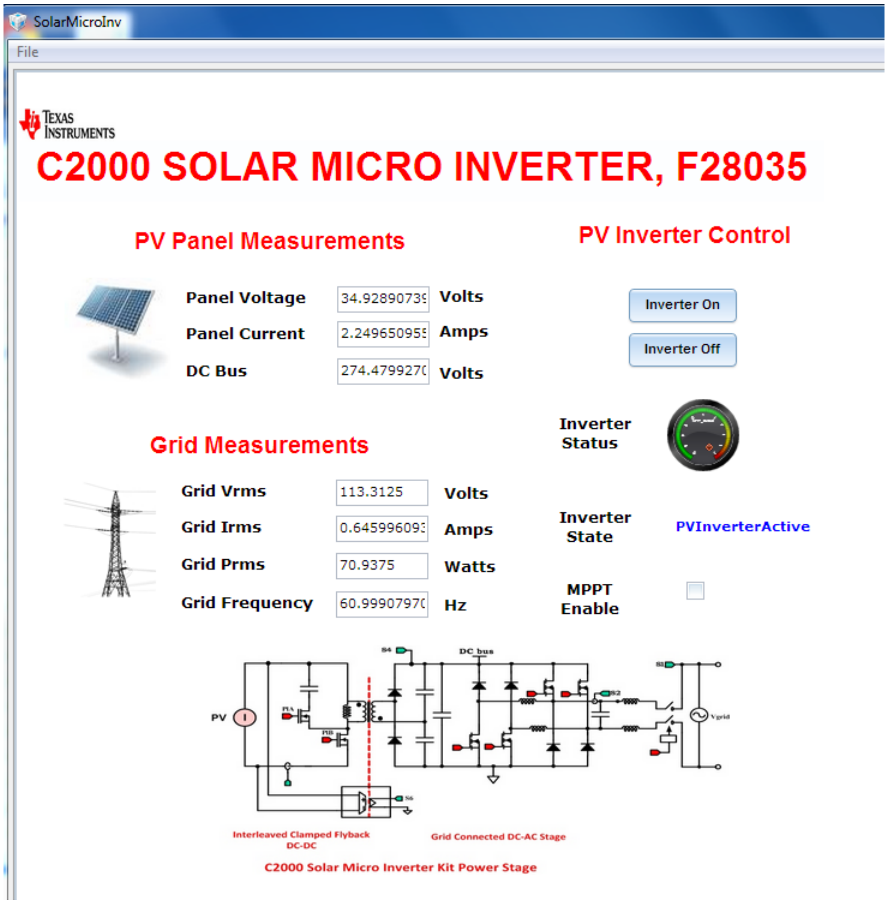

Figure 5. Solar Micro Inverter Release GUI

6. Connect the EVM output to the local grid (AC 110 V/60 Hz or 220 V/50 Hz). Use a two-prong AC connector (line and neutral only) across the output of the EVM.

NOTE: As described in Step 6 in Section 3, a resistive load is required at the output for 220-V_{RMS} grid.

7. Notice the reading of the V_{RMS} and grid frequency in the GUI. The software detects the grid frequency and changes the necessary control parameters like the DC-BUS reference.
8. Now click on *Inv Start* on the GUI.
9. The board will draw a fixed amount of power (preprogrammed value) if a 35-V DC source is used for the input power supply.
10. Check the DC-BUS voltage. The EVM detects grid AC voltage and automatically sets the DC-BUS voltage. For grid voltage of 110 V/60 Hz, the DC-BUS voltage should be about 270 V ±2.5%.
11. Observe the voltage and current probes to see the AC output voltage and current waveforms (set the probe to **1 A/div**). When the input voltage is 35-V DC and the grid voltage is 120 V_{RMS}/60 Hz, the output waveforms should look like the ones shown in Figure 6.
12. Vary the input voltage (if using a DC voltage source) between 27 to 44-V DC. Check the DC-BUS output voltage. This should be regulated at 270 V ±2.5%.
13. Use the voltage and current probes to see the AC output voltage and current waveforms (set the probe to **1 A/div**). For an input voltage of 44-V DC and grid voltage of 125 V_{RMS}/60 Hz, the output waveforms should look like the ones shown in Figure 7.

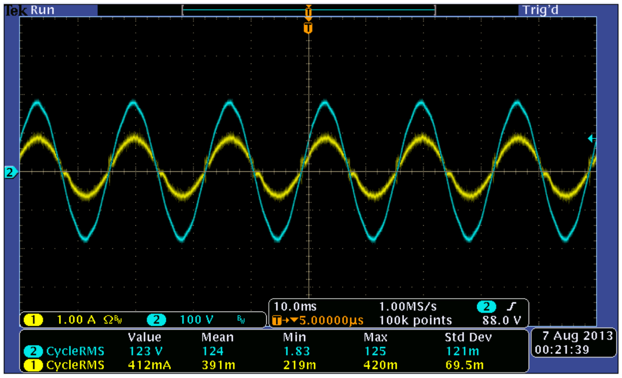

Figure 6. Output Volt and Current at 110-V, 60-Hz Grid Volt. Input 35-V DC, Input Current 2.25-A DC, Ch2 Vout, Ch4 Iout

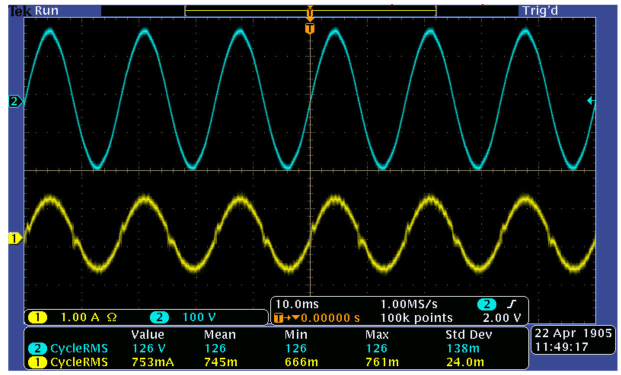

Figure 7. Output Volt and Current at 126-V_{RMS}, 60-Hz Grid Volt. Input 44-V DC, Input Current 2.0-A DC, Ch2 Vout, Ch4 Iout

14. Click on *Inv Stop* on the GUI to de-energize the board. Disconnect and remove the 110-V AC and then turn off the DC supply voltage.

CAUTION

Wait for the DC-BUS to reduce to 1.0 to 2.0 V before disconnecting the board and handling it. A resistive load to discharge the bus capacitor could be required. Close the GUI, then disconnect both the external bias supplies (12 and 15-V DC).

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