Quick Start Guide for High Voltage Solar Inverter DC-AC Board EVM

TIDU401 - Version 1.3
Introduction

This document talks about the quick start principles for the high voltage solar inverter DC-AC board. From this document, the user can get how to run this DC-AC board independently. The following topics will be presented:

1. The board introduction and hardware setting.
2. Quick Start Running.
3. GUI Introduction

Notes: This DC-AC board can just realize the DC bus control and the grid-tie function. If the user wants to run the whole solar inverter kit, another DC-DC board which deals with MPPT and DC-DC control must be connected. Please refer to the solar inverter user guide for more information.

WARNING

This EVM is meant to be operated in a lab environment only and is not considered by TI to be a finished end-product fit for general consumer use.

This EVM must be used only by qualified engineers and technicians familiar with risks associated with handling high voltage electrical and mechanical components, systems and subsystems.

This equipment operates at voltages and currents that can result in electrical shock, fire hazard and/or personal injury if not properly handled or applied. Equipment must be used with necessary caution and appropriate safeguards employed to avoid personal injury or property damage.

It is the user’s responsibility to confirm that the voltages and isolation requirements are identified and understood, prior to energizing the board and or simulation. When energized, the EVM or components connected to the EVM should not be touched.
1. Board Introduction

1.1 The Board Picture

The board picture of the DC-AC board is shown in Fig 1.1.

Figure 1.1 Board Picture
1.2 The Key Points of the Board

<table>
<thead>
<tr>
<th>Item No</th>
<th>Points Name</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CON1</td>
<td>The DC bus connector for the DC-DC input.</td>
</tr>
<tr>
<td>2</td>
<td>CON2</td>
<td>The Utility connector L and N.</td>
</tr>
<tr>
<td>3</td>
<td>JP1</td>
<td>Onboard +15V Jumper</td>
</tr>
<tr>
<td>4</td>
<td>JP3</td>
<td>Onboard +5V Jumper</td>
</tr>
<tr>
<td>5</td>
<td>JP2</td>
<td>IGBT Driver +15V Jumper</td>
</tr>
<tr>
<td>6</td>
<td>CN5</td>
<td>DC-DC board signal interface</td>
</tr>
<tr>
<td>7</td>
<td>S1</td>
<td>External +15V Adapter Switch</td>
</tr>
<tr>
<td>8</td>
<td>J1</td>
<td>External +15V input Jack</td>
</tr>
<tr>
<td>9</td>
<td>SW1</td>
<td>Operation Button</td>
</tr>
<tr>
<td>10</td>
<td>JTAG1</td>
<td>JTAG interface for external emulator</td>
</tr>
<tr>
<td>11</td>
<td>PLC AFE Systems Module</td>
<td>Not used in this version</td>
</tr>
<tr>
<td>12</td>
<td>JP6</td>
<td>TRST Jumper</td>
</tr>
<tr>
<td>13</td>
<td>JP5</td>
<td>-15V Power Jumper</td>
</tr>
<tr>
<td>14</td>
<td>CN6</td>
<td>RS232 Port</td>
</tr>
<tr>
<td>15</td>
<td>U2</td>
<td>The DIM100 28035 Control Card Port</td>
</tr>
</tbody>
</table>

Table 1.1 The Key Points
1.3 The Hardware Configuration

1.3.1 The main board setting

There are 2 ways to get the auxiliary power for the board, the one is using the external +15V adapter, the other is using the onboard auxiliary power supply. Besides, the user can run the board in the real time, or it can run the board by the program in the flash with the GUI support, the following table summarizes the configuration for different running requirement.

<table>
<thead>
<tr>
<th>Jumper</th>
<th>External +15V Adapter</th>
<th>Onboard +15V</th>
<th>Real Time</th>
<th>GUI Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>JP1</td>
<td>×</td>
<td>√</td>
<td>Unaffected</td>
<td>Unaffected</td>
</tr>
<tr>
<td>JP2</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>JP3</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>JP4</td>
<td>√</td>
<td>×</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>JP5</td>
<td>√</td>
<td>×</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>JP6</td>
<td>Unaffected</td>
<td>×</td>
<td>√</td>
<td>×</td>
</tr>
</tbody>
</table>

Table 1.2 The Jumper Setting for the board

(Notes: The √ means the jumper need to be shorted, × means the jumper should be opened)

1.3.2 The Concerto Controller Card Configuration

If the control card is the concerto version, the user needs to short the jumper to enable the GPIO_PA6 to act as the GPIN which is used to detect the DC-DC board.
Short the No.18 pins of the Port A and Port B, besides, short the No.4 pins of the Port A and Port B. please see the picture below:
2 Quick Running Guide

2.1 The equipments

In order to run the DC-AC board independently, the following equipments must be provided.

<table>
<thead>
<tr>
<th>Equipment Name</th>
<th>Requirement</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC-Source</td>
<td>At least 400V/2A output capacity</td>
<td>Isolated output is better</td>
</tr>
<tr>
<td>AC-Source[1]</td>
<td>120V/5A or 220V/3A output capacity</td>
<td>The output be isolated</td>
</tr>
<tr>
<td>Transformer</td>
<td>1000VA, Isolation</td>
<td></td>
</tr>
<tr>
<td>Resistor Load</td>
<td>20ohm~50ohm/1000W for 120V</td>
<td>Adjustable resistor load</td>
</tr>
<tr>
<td></td>
<td>80ohm~100ohm/1000W for 220V</td>
<td></td>
</tr>
<tr>
<td>Output Breaker</td>
<td>10A/250VAC</td>
<td></td>
</tr>
<tr>
<td>Oscilloscope</td>
<td>With the current probe and high voltage probe</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.1 The quick running equipments

[1] If the user wants to do the grid-tie test, the AC source will act as the grid. We strongly suggest the user should use the AC source to simulate the grid condition with this board.

2.2 The connection of the board

The user must connect the test tool to the board like the following diagram.

For the safety, we strongly suggest the user use a breaker between the grid and the inverter output.

2.3 Quick running guide in off-grid condition

The first test can be the off-grid test, then the breaker in Fig 2.1 will be opened. The inverter will take the resistor load without the grid support. The program will set the inverter output to be the constant frequency(60Hz) and constant current automatically when the grid is not connected to the inverter’s output.

The user can start the test by following the steps below:
1. Connect all the equipment and the board as shown in Fig2.1.
2. Connect 440ohm resistor load to the output, and cut off the Breaker.
3. Open the JP1, JP3, if external +15V adapter is used. Short the JP1, open the JP3, if the on board power supply is used.
4. If the external +15V adapter is used, please power the adapter and turn on the S1 to power up the auxiliary power. If the on board power supply is used, turn on the S1 first, then power on the DC source, and regulate the DC source voltage to about 300V to let the power module work. After the successfully power up, the power LED on the board will be lightened.
5. Check if the LD2 on the control card is flashing in very 1 second. If yes, continue to do the next steps. If no, please check the auxiliary power, or please reload the program of the MCU.
6. Regulate the DC source voltage to 380V.
7. Press the SW1 for over 1 seconds to turn on the board, if turning on is successful, the LD2 will be always lightened. If failed, the LD3 will be lightened.
8. Test the output current waveform. If it is running normally, the output voltage will be about 120VAC, and the output current will be about 2.71A RMS. The reference current waveform is below.

![Current Waveform](image)

**Notes:** Whenever the LD3 is lightened, please cut off the power and check the connection again.
2.4 Quick running guide in grid-tie condition

If the user finish the test in 2.3, they can do the grid-tie test by following the steps below.

1. Connect all the equipment and the board as shown in Fig2.1.
2. Connect 25 ohm resistor load to the output. Cut off the breaker.
3. Open the JP1, JP3, if external +15V adapter is used. Short the JP1, open the JP3, if the on board power supply is used.
4. If the external +15V adapter is used, please power the adapter and turn on the S1 to power up the auxiliary power. If the on board power supply is used, turn on the S1 first, then power on the DC source, and regulate the DC source voltage to about 300V to let the power module work. After the successfully power up, the power LED on the board will be lightened.
5. Check if the LD2 on the control card is flashing in very 1 second. If yes, continue to do the next steps. If no, please check the auxiliary power, or please reload the program of the MCU.
6. Regulate the DC source voltage to 380V.
7. Regulate the AC source voltage to 120V/60Hz, Set the output current limit to 6A.
8. Close the Breaker, check the output current of the AC source is about 4.8A.
9. Press the SW1 for over 1 seconds to turn on the board, if turning on is successful, the LD2 will be always lightened. If failed, the LD3 will be lightened.
10. Test the output current waveform. If it is running normally, and the output current of the inverter will be about 2.7A RMS, then there will be 2.1A load current for the AC source.

Notes: Whenever the LD3 is lightened, please cut off the power and check the connection again.
3. The GUI introduction

3.1 The GUI overview

The GUI for the high voltage solar inverter EVM can be used to inquiry the status of the DC-DC and DC-AC board, execute the system turn on/off command, get the real time value of the DC-AC board.

3.2 Connect the GUI to the board

Step1>
Connect the USB cable to the DC-AC board. Power on the auxiliary power of the board. Set the communication by clicking the Comm Setup Button, then choose the COM port: COM51. Then click OK.
Note: the COM port will be different in different PC. You can check the COM port number in the PC hardware resources window.
Step 2>
Connect the board and the GUI by clicking the Connect button. If the board is connected successfully, the connect status textbox will be shown as green with the connected warning. Or the connect status textbox will be yellow with the disconnected warning.

Fig 3.2 Setup the communication

3.3 Check the status of the DC-AC board

If the DC-AC board is connected successfully, the GUI will show the DC-AC status in the DC-AC board status area.
3.4 Turn On and Turn Off

If the status of the DC-AC board is normal, the user can turn on the DC-AC by click the Turn On/Off Button.

3.4.1 Turn On

When the DC-AC running information shows the Standby Mode, the DC-AC can be turned on. When the Turn On button clicked the DC-AC running information will show the SoftStart Mode or Normal Inverter Mode. When it get the normal inverter mode, then the turning on is successful.
3.4.2 Turn Off

When the Turn On/Off button shows the Turn Off, then can click the button to turn off the DC-AC board.

3.5 Get the Real Time Data

The GUI has the real time data getting function. In the MCU, the data will be sampled at the PWM switching frequency. The user can click the “Start Sample” Button to sample the default real time values. The following is the default real time data meaning in different channels.

CH1: The inverter current; (Q24)
CH2: The Utility Voltage; (Q24)
CH3: The DC BUS voltage; (Q24)
CH4: The Bus voltage loop controller output; (Q24)
Fig 3.5 Get the real time data in the MCU
References and Files Structure

For more information, please refer to the following guides and folders:

**Solar_HV_DCAC_Concerto_SCI_Rev_0** - The source code for the Concerto Control Card.
..\controlSUITE\development_kits\HV_SOLAR_DC_AC\Solar_HV_DCAC_Concerto_SCI_Rev_0

**SolarHv_DCAC_PiccoloB_Rev_02** – The source code for the Piccolo B Control Card.
..\controlSUITE\development_kits\HV_SOLAR_DC_AC\Solar_HV_DCAC_PicB_SCI_Rev_0

..\controlSUITE\development_kits\HV_SOLAR_DC_AC\docs\Solar_HV_DCAC_PicB_SCIL_Rev_0

**GUI** – The GUI for the DC-AC kit and system running.
..\controlSUITE\development_kits\HV_SOLAR_DC_AC\GUI

**SOLAR_HV_DC_AC_HWDevPkg** – The folder for the hardware package, including the schematic, PCB, gerbers and BOM.
..\controlSUITE\development_kits\HV_SOLAR_DC_AC\SOLAR_HV_DC_AC_HWDevPkg
IMPORTANT NOTICE FOR TI REFERENCE DESIGNS

Texas Instruments Incorporated (“TI”) reference designs are solely intended to assist designers (“Buyers”) who are developing systems that incorporate TI semiconductor products (also referred to herein as “components”). Buyer understands and agrees that Buyer remains responsible for using its independent analysis, evaluation and judgment in designing Buyer’s systems and products.

TI reference designs have been created using standard laboratory conditions and engineering practices. TI has not conducted any testing other than that specifically described in the published documentation for a particular reference design. TI may make corrections, enhancements, improvements and other changes to its reference designs.

Buyers are authorized to use TI reference designs with the TI component(s) identified in each particular reference design and to modify the reference design in the development of their end products. HOWEVER, NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY THIRD PARTY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT, IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI reference designs are provided “AS IS”. TI MAKES NO WARRANTIES OR REPRESENTATIONS WITH REGARD TO THE REFERENCE DESIGNS OR USE OF THE REFERENCE DESIGNS, EXPRESS, IMPLIED OR STATUTORY, INCLUDING ACCURACY OR COMPLETENESS. TI DISCLAIMS ANY WARRANTY OF TITLE AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, QUIET ENJOYMENT, QUIET POSSESSION, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS WITH REGARD TO TI REFERENCE DESIGNS OR USE THEREOF. TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY BUYERS AGAINST ANY THIRD PARTY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON A COMBINATION OF COMPONENTS PROVIDED IN A TI REFERENCE DESIGN. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, INCIDENTAL, CONSEQUENTIAL OR INDIRECT DAMAGES, HOWEVER CAUSED, ON ANY THEORY OF LIABILITY AND WHETHER OR NOT TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, ARISING IN ANY WAY OUT OF TI REFERENCE DESIGNS OR BUYER’S USE OF TI REFERENCE DESIGNS.

TI reserves the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale. TI reserves the right to make corrections, enhancements, improvements and other changes to its reference designs.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications using TI components, TI recommends necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications using TI components, TI recommends necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

Reproduction of significant portions of TI information in TI data books, data sheets or reference designs is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards that anticipate dangerous failures, monitor failures and their consequences, lessen the likelihood of dangerous failures and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in Buyer’s safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed an agreement specifically governing such use.

Only those TI components that TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components that have not been so designated is solely at Buyer’s risk, and Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2014, Texas Instruments Incorporated