

# Phase-Shifted Full Bridge DC-DC Power Converter Quick Start Guide

## 1 HVPSFB Kit Overview

This document describes the HVPSFB development kit designed to work with Texas Instruments C2000 Micro-controllers. This kit converts a 400V DC input to a 12V DC output and is rated for operations up to 600W. Voltage mode control (VMC) and peak current mode control (PCMC) methods are implemented. This highly integrated micro-controller based realization features adaptive zero voltage switching (ZVS), various synchronous rectification schemes, complex gate drive waveform generation for PCMC, and intelligent timing control, to optimize system performance under changing operating conditions. A step by step guide to run and get familiar with the HVPSFB project is also provided in the accompanying software package. A constant high system efficiency above 10% rated load, novel PCMC waveform generation based on on-chip hardware mechanisms, and simple system implementation are the highlights of this solution.

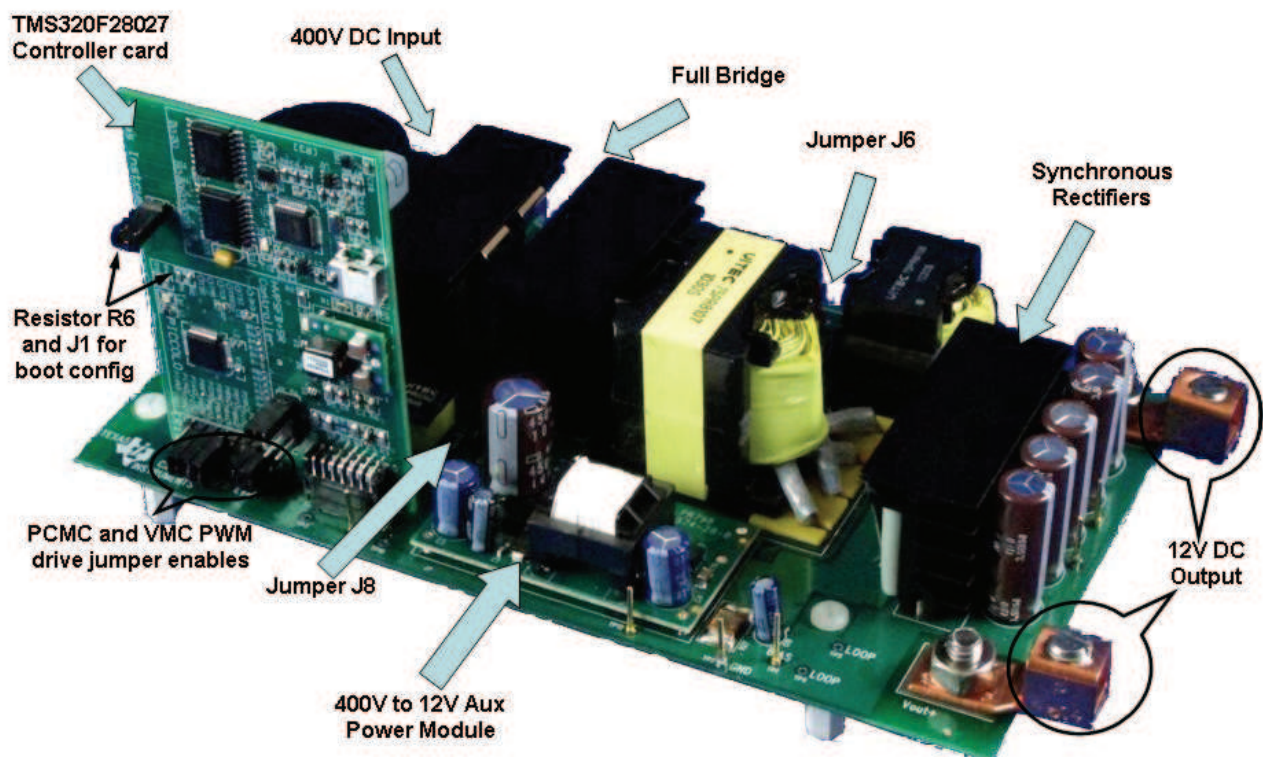


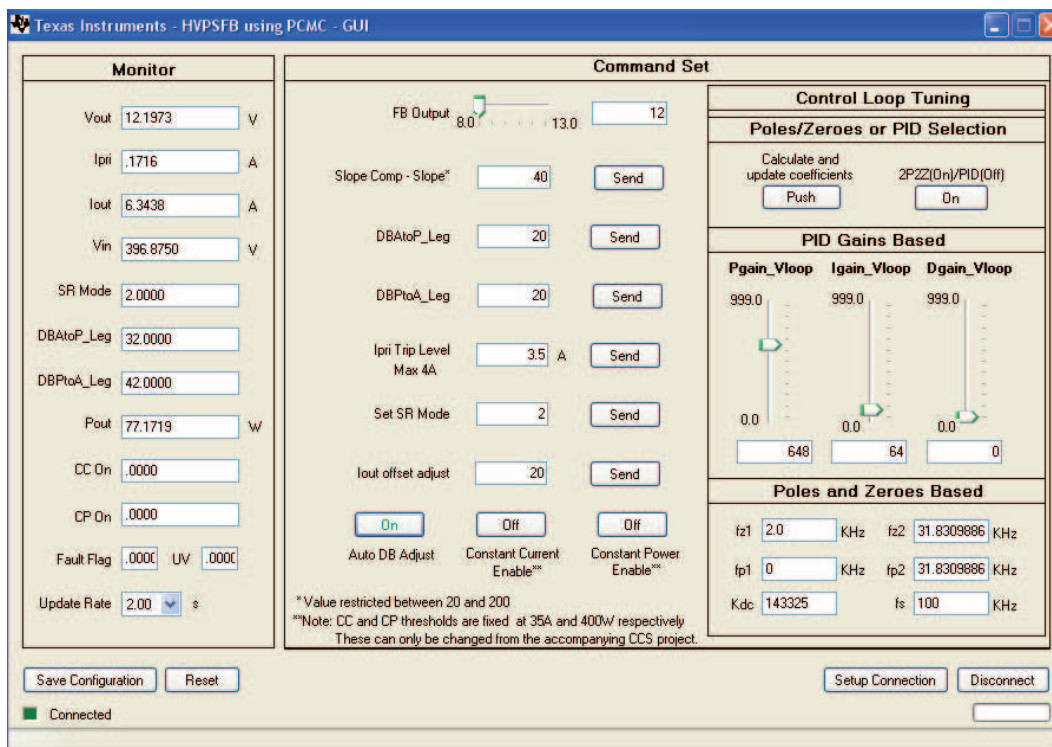
Figure 1. HVPSFB Kit

The high voltage phase shifted full bridge (HVPSFB) GUI provides a convenient way to evaluate the functionality of the HVPSFB development Kit and the TMS320F28027 device without having to learn and configure the underlying project software. The GUI is written in C# using Microsoft Visual Studio .NET. There are two GUIs: one that works with the voltage mode (VMC) project and the other works with the peak current mode control (PCMC) project. By default the kit works in PCMC mode and this QSG describes operations with the PCMC GUI. The source codes for these GUIs are located at (please use the latest version of the software package. Version 1.1 is the latest software version as of March 2012):

```
..\controlSUITE\development_kits\HVPSFB_v1.1\~GUI_PCMC\~Source\, and
..\controlSUITE\development_kits\HVPSFB_v1.1\~GUI_VMC\~Source\
```

The HVPSFB GUI features:

- Interactive interface using sliders, buttons and textboxes to easily control/demo the HVPSFB system
- GUI variables directly tied to framework variables, allowing simplified software development
- Ability to save connection settings and startup configuration.



## 2 Getting Started

### 2.1 Setting Up the Hardware

#### **WARNING**

There are high voltages present on the board. It should only be handled by experienced power supply professionals in a lab environment. To safely evaluate this board an appropriate isolated high voltage DC source should be used. Before DC power is applied to the board a voltmeter and an appropriate resistive or electronic load must be attached to the output. The unit should never be handled when power is applied to it.

- Ensure jumper J8 (+12V auxiliary power derived from 400V input) and J6 (no DC blocking capacitor in transformer primary circuit for PCMC) on the main board are populated.
- Verify that resistor R6 on Piccolo Macro of the controller card and jumper J1 are removed to enable – boot from FLASH. Jumper (J2, J3 – PCMC and VMC PWM drive jumper enables) on the controller card need to be correctly configured for PCMC mode (Default jumper positions are set for PCMC operation). Here are the jumper configurations for the two modes:
- **PCMC:** J2(1) -> J3(1), J2(2) -> J3(2), J2(3) -> J3(3), J2(4) -> J3(4), J2(7) -> J3(7), J2(8) -> J3(8)
- **VMC:** J2(1) -> J3(3), J2(2) -> J3(4), J2(3) -> J3(1), J2(4) -> J3(2), J2(7) -> J3(8), J2(8) -> J3(7)

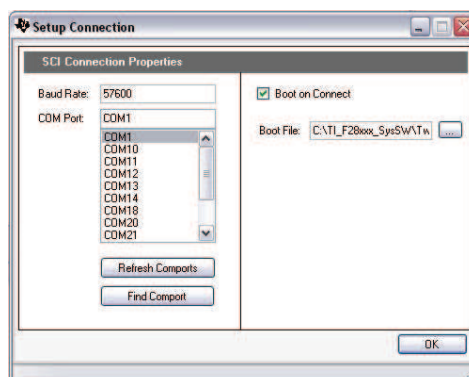
Connect USB connector to the controller card. Use of an appropriate isolated DC power supply set to output around 400V DC is recommended. DC power supply needs to remain off before it is connected to J1 and J2 on the main board. Use at least a 20AWG 600V wire to connect the Power Source to J1 and J2. Make sure that the polarity of this connection is correct. Apply an appropriate resistive/DC electronic load to the phase shifted full bridge system at the DC output at J3 and J4. A load that draws around 6A current at 12V is a good starting point. Connect the fan included in this kit to a 12V DC source. As a precaution, use of this fan (or one rated for 400LFM or greater) is required under all operating conditions and, especially, when operating above 250W load. Do not turn on 400V DC power at this time.

### 2.2 Running the Application (PCMC Mode)

By default the hardware is configured to boot from a pre-Flashed code for PCMC operation.

Note that the GUI requires Microsoft .NET framework 2.0 or higher to run. Please ensure that this software is installed prior to running this program.

1. Browse to `..\controlSUITE\development_kits\HVPSFB_v1.1\~GUI_PCMC\`, and double-click on *Texas Instruments C2000 – HVPSFB\_PCMC - GUI.exe*.
2. Click "Setup Connection" on the GUI

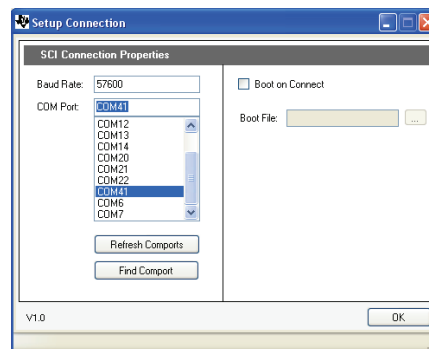


3. Ensure the Baud Rate is set to 57600

4. Next, you will need to select your serial comport.
  - (a) If the comport that the target is connected to is known, select that comport.
  - (b) Use the "Find Comport" tool to find the serial port connection that is connected to the EVM board. For this procedure connect a 12V secondary bias supply at TP1 and TP2 and turn it ON. Do **not** use the 400V DC supply at this stage.
    - (i) Disconnect the emulator from the target board.
    - (ii) Ensure the target F2802x MCU is pre-flashed.
    - (iii) Click "Find Comport" then follow the instructions shown at the bottom of the window. This will run through a short, automated test to find the COM port that is connected to the EVM board.
    - (iv) Once complete you should see "Comport Found: COMXX" appear near the bottom of the window. If the GUI is unable to find a valid comport after fixing/checking all errors received then retrying this process try to find the proper comport using option c.
  - (c) Manually find the comport by going to:

Control Panel->System->Hardware tab->Device Manager->Ports(COM & LPT)

If using a serial port directly connected to a PC, look for a comport which shows up as "Communications Port" and select this comport in the Setup Connection window. If using a USB to Serial adapter look for the com port which shows "USB-to-Serial Bridge", then select this comport in the Setup Connection window.



5. Ensure "Boot on Connect" is unchecked.
6. Click "OK"

### 3 Reference Guide

**Save Configuration** – Saves the current values of all settable attributes. The next time the application runs these settings will be used as the default settings.

**Reset** – Reloads the application with the last saved configuration.

**Setup Connection** – Opens a new window which contains the serial port and boot settings

**Connect/Disconnect** – Begins serial port communication with the target board.

#### 3.1 GUI Structure

**Command Set** – Section allows the user to set the PSFB output voltage via a slider. Notice the text box for variable Slope Comp - Slope. This parameter sets the slope used for slope compensation using on-chip resources when controlling the power stage in peak current mode control (PCMC). The Auto DB Adjust button provides for an easy means to experiment with/without the automatic dead-band adjustment for achieving zero voltage switching (ZVS)/low voltage switching (LVS) across the load range. The dead-bands for the two full TMS320C2000™ Systems Applications Collateral v1.1 bridge legs can be changed directly by simply turning this Auto DB Adjust button OFF and using DBAtoP\_Leg and DBPtoA\_Leg set textboxes to change these values. The Ipri Trip Level set textbox sets the over current shut-down level for the system. When working in peak current mode control this works as a second layer of protection. The lout offset adjust text box sets the amount of offset correction required to provide an accurate output current read out. The Set SR Mode text box allows changing between different synchronous rectifier switching modes. Valid values are 1, 2 and 3. Do not change between different SR modes when operating at very low loads (below 3A). In these cases use the default SR mode 2. The Constant Current Enable and Constant Power Enable buttons allow experimenting with constant current and constant power functionalities. The constant power threshold is fixed at 400W, while constant current threshold is fixed around 35-36A. These thresholds can only be changed from the accompanying CCS project. When these functions are disabled (default) the system can work normally up to full load current.

**Monitor** – Section displays various system parameter values being monitored. These include the output voltage, transformer primary current, output current, input voltage, dead-band values for the two full bridge legs, SR mode, the output power, constant current operation indication, constant power operation indication, the fault status flag and the under voltage shutdown flag.

In case of a fault condition or if the “Fault Flag” is set, GUI should be closed and the system must be restarted. GUI can then be re-connected.

**Update Rate** – Changes the rate at which GUI updates the parameters in the Monitor section.

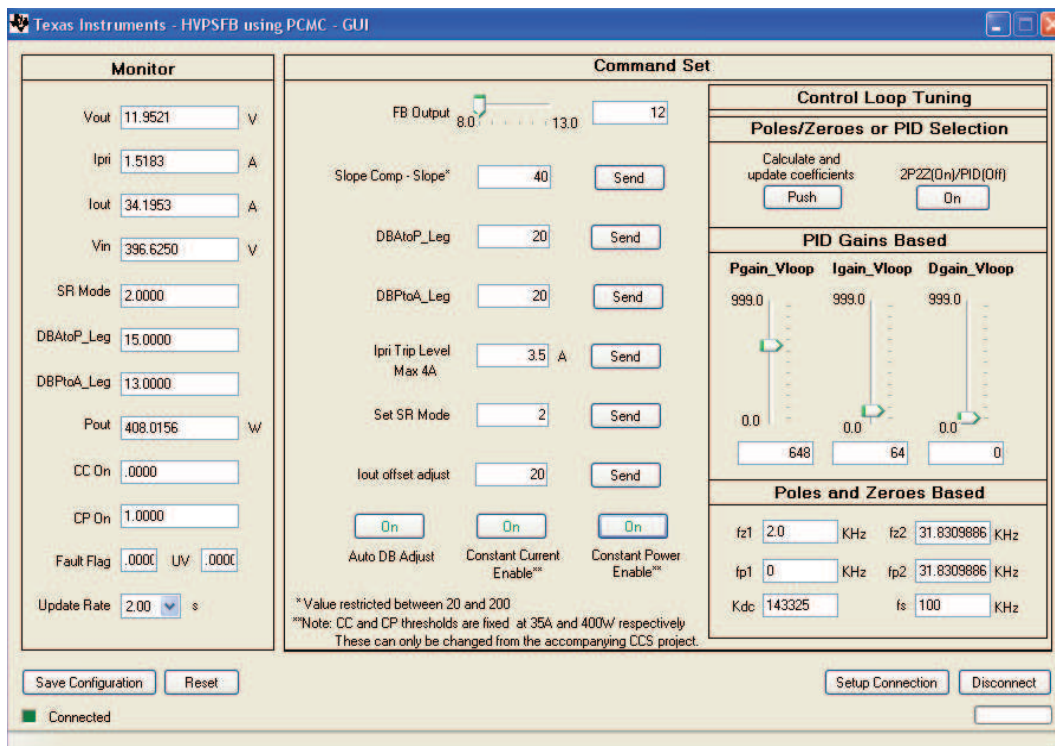
**Control Loop Tuning** – In this system implementation the voltage loop controller may be tuned by directly changing poles, zeroes and gain or by using PID gains. This is achieved by simply pushing the 2P2Z(On)/PID(OFF) button. By default the system uses coefficients based on poles, zeroes and gain method. In this case the poles and zeroes can be easily changed from the GUI using the parameters fz1, fz2, fp1, fp2 and Kdc during system operation. Every time a new set of coefficients is to be used and one or more of these values are changed, the Calculate and Update Coefficients pushbutton has to be used for the values to be calculated and sent across to the controller. The value for parameter fs should never be changed when working with this power stage.

When the 2P2Z(On)/PID(OFF) button is in the OFF position, the PID gains are mapped to the 2-pole 2-zero coefficients. The Pgain\_Vloop, Igain\_Vloop and Dgain\_Vloop allow for the P, I and D coefficients to be adjusted using a slider in the GUI environment during system operation. Acceptable range for these parameters is 0 – 999. The default 2-pole 2-zero controller coefficients obtained using the poles, zeroes and gain method for tuning provide much better transient response than the default PID coefficients. Both sets of coefficients provide stable operation.

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**NOTE:** When tuning the system using the 2-pole 2-zero controller coefficient adjustments, if a choice of poles, zeroes and Kdc values is made in the GUI such that it result in the magnitude of any of the coefficients (b2, b1, b0, a2, a1) to be greater than or equal to 32, then these coefficient values are not sent to the controller by the GUI.

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### 3.2 Using the GUI

- Once the hardware is set-up correctly turn the 400V DC input ON. After a delay of a few seconds the output voltage should start ramping up to 12V.
- Open the GUI by clicking on .exe file in the ~GUI-PCMC folder. Select an update rate of 2 sec by clicking on the drop down arrow next to Update Rate.
- Iout offset adjust value can be changed to correctly reflect the output current. This also helps in correctly adjusting dead-band values to achieve ZVS/LVS across the load range.
- Observe the effect of varying load\* on the output voltage. There should be virtually no effect on the output voltage. Similarly observe the effect of varying input voltage\*. Again there should be virtually no effect on the output voltage.

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**NOTE:** Ensure these changes are made within the abilities of this board.

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- You may experiment with constant current and constant power functionalities by turning them on or off using respective buttons on the GUI. When these functions are disabled (default) the system can work normally up to full load current.
- To turn the system OFF, turn OFF the DC supply. If a 12V secondary bias supply was used, always turn OFF the 400V DC supply first and then, after waiting for a few seconds, turn OFF the bias supply.

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**NOTE:** As a result of the constant power function implementation, the output voltage set value may not be changed when using the default software. To achieve this, software should be changed and reprogrammed (programming the controller from the CCS environment is described in HVPSFB\_User's Guide\_v1.1.pdf)

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