This document describes the ac/dc developer's kit evaluation board designed to work with Texas Instruments C2000™ DSP platform devices. This kit is a part of the digital power tools package from TI, designed to give customers an opportunity to quickly evaluate C2000 products for power conversion applications at a safe input voltage and power level.

WARNING

This equipment may generate voltages and currents that can be injurious to humans, and must be used with extreme caution. The user must employ appropriate safeguards to avoid serious injury.

Trademarks

TMS320C2000, C2000, Code Composer Studio are trademarks of Texas Instruments.

Blackhawk is a trademark of EWA Technologies, Inc.

All other trademarks are the property of their respective owners.
1 Features

The ac/dc developer’s kit contains a motherboard which accepts any of the plug-in controlCARDs. The board is divided into a power factor correction (PFC) section and an isolated dc-dc conversion full bridge (FB) section. Features of the ac/dc developer’s kit include:

- Voltage and current measurements via ADC
- Over-current and over-voltage protection on the PFC side and over-current protection on the FB side via trip zone (TZ) pins
- Closed loop digital control with feedback using 28x on-chip ePWM and ADC
- UART communications header available for host control
- A learning platform allowing the user to easily probe the most significant wave forms within a board that is laid out conservatively and contains many test points.
- An analog and a digital header to provide easy interconnection with the EZDSP board if desired.
- Host GUI, a friendly way to control / demo the application, based on open source C# freeware
- Special hardware circuit allows experimentation with peak-current-mode control operation, if desired
- Hardware Developer’s Package is available and includes schematics, bill of materials, Gerber files,…etc

2 Hardware Overview

The PFC section accepts an ac input of 11 – 33 Vrms, while the FB section accepts a 48-V dc input. Figure 1 shows the acdc board identifying the key components.

![Figure 1. Components](image-url)
Hardware Overview

Auxiliary Supply: A 12-V auxiliary supply connection at J9 to power the control and drive circuit. Optional 5-V supply connection at J10 to only power the control circuit.

3.3-V ISO Supply: A 3.3-V isolated supply is generated on-board for serial communication. See the Hardware Setup section of this document.

PFC section: Two-phase interleaved boost power stage for power factor correction

11 – 33 Vrms ac I/P: ac input for the PFC section at connector J13-J14

FB section: Phase shifted full bridge power stage for dc-dc conversion

48-V dc I/P: dc input for the FB section at connector J26-J27

Boot Jumpers: Controls how the F280x boots. (J31)

- If no jumpers are placed, the target boots from flash.
- If a jumper is placed at 84, the target boots from the SCI.

2.1 Hardware Set Up

To be able to run the various software builds for the projects included in this package a 12-V dc regulated bench power supply, an isolated 11-33 Vrms ac power supply, a 48-V dc power supply, a bank of appropriately rated resistive loads and an emulator are required apart from the hardware included in this package (suggested emulators are listed near the end of this document).

CAUTION

Do not connect 110-V or 220-V main supply to the ac input on the ACDC board. It is designed to handle a low voltage ac input, and the connection configuration must ensure this. If voltages exceeding 33 V ac are applied to the PFC section or voltages exceeding 50 V dc are applied to the FB section, the board can be damaged.

The application-specific motherboard provided in this kit can be used in one of two ways:

1. Test Drive – Using the provided GUI application, you do not require Code Composer Studio™ or emulation tools. This provides a great way to run or demo the application code quickly and see what functionality the hardware offers. Note: exactly the same functionality can be achieved by using the Code Composer Studio Watch Window and graphing features during emulation in the second mode.

2. Code Composer Studio Software Development Platform – With the project code provided, the application can be modified, compiled, loaded and run in a development environment. Code Composer Studio and emulation hardware tools are required for this.

**Note:** By default, the $V_{DD}$ is connected to $VDD\_ISO$ (isolated supply for serial communications) on the controlCARD through resistor R13. Similarly GND and GND\_ISO are connected together using resistor R16. Therefore if a non-isolated input ac supply is used, replace R16 on the controlCARD with around 2200pF capacitor and also remove resistor R13. If emulation is desired in this case, you must use an isolated emulator.

Follow these steps to set up the hardware for either the GUI or software development platform:

Step 1. Unpack the DIMM style controlCARD.

Step 2. Spread open the winged retaining clips on controlCARD U23 connector.

Step 3. Sit the DIMM card loosely in the connector slot. Make sure to align the two keyed notches and position the card bottom corners inside the retaining clips (see Figure 2).

Step 4. Push vertically down using even pressure from both ends of the card until the clips snap and lock. (To remove or eject the card, spread open the retaining clips with thumbs.)
2.2 Test Drive With GUI – (skip this if you need only emulation support)

- **Step 1.** Plug in the serial cable provided to connector J18 making sure the red wire aligns with the pin 4 of J18 (marked in Figure 3) on EVM (or use a DB9 serial cable at J21).
- **Step 2.** Insert a jumper in position 84 on Boot pins.
- **Step 3.** Insert a jumper between pins 1 and 2 of J19.
- **Step 4.** Similarly insert a jumper between pins 3 and 4 of J19.
- **Step 5.** Plug the DB9 connector into your PC using either a serial port or a serial-to-USB converter dongle.
- **Step 6.** Connect the PFC output at J24-J25 to the FB input at J26-J27 using appropriate wires. Make sure to match the PFC output and FB input polarity.
- **Step 7.** Apply a resistive load to the phase shifted full bridge system at connector J28-J29. Choose the value of the resistors and their power rating to present a load of about 10 W-30 W at 6 V.
- **Step 8.** See Software Setup GUI-TestDrive

**Figure 3. Pin 4 Location**

---

**Note:** If you are not using an isolated ac supply, you must replace R16 on the controlCARD with around 2200 pF capacitor. You also need to remove resistor R13 on the controlCARD. If emulation is desired in this case, you must use an isolated emulator.
2.3 Code Composer Studio Software Development Platform emulation - additional steps

1. Connect the JTAG emulator cable to connector J20.
2. See Software Set-up Code Composer Studio - Development.

For full details (schematics, pin-out table, etc) of the hardware, see the Hardware Developer’s Package, ACDC-HWdevPkg. See Section 3 for download location.

3 Software Set Up

The ac/dc kit application software example, GUI, step-by-step lab style documentation, and other useful soft collateral is available on the TI website. If you already have your own software project and do not require this collateral, skip this section. As explained in the hardware set up section, the target motherboard can be run either with the GUI or Code Composer Studio. The GUI executable file is found as part of the main software download. Follow the steps below for either case.

To run any of the application-specific software in Code Composer Studio, first install the baseline code that contains the header files, libraries, etc. If you already have the base-line software installed, skip the baseline install steps and go to the acdc Kit section.

To download the free TI soft collateral follow these steps:

   Step 1. Baseline soft collateral and hardware documents (skip this if you already have this software installed)
   b. At the C2000 collateral page, choose the ACDC Developer’s Kit download link.
   c. When prompted, fill in the TI customer registration details and click ok.
   d. Save the .zip file to the directory of your choice
   e. Unzip the file and run the install program baseline software set up.
   f. The installer creates the following default directories:

   C:\TI_F28xxx_SysSW
      ~Docs
      ~GeneralPurposeGUI
      ~HexConverterUtility
      ~SupportFiles
      FlashingLeds

   C:\TI_F28xxx_SysHW
      CC280xxHWdevPkg
      CC2833xHWdevPkg
      DockingStnHWdevPkg
2. ACDC Kit soft collateral and hardware documents
   b. Choose the ACDC Kit link
   c. When prompted, fill in the TI customer registration details and click ok
   d. Save the .zip file to the directory of your choice
   e. Unzip the file and run the install program acdc software set up

1. The installer creates the following default directories:

   C:\TI_F28xxx_SysSW
   ~SupportFiles
     lib
     PowerLib
   PFC2PHIL
     ~Docs
     ~GUI
   FBPS
     ~Docs
     ~GUI
   ACDC
     ~Docs
     ~GUI
   C:\TI_F28xxx_SysHW
   ACDC-HWdevPkg

4 Running the Application

To run the application specific hardware, choose either “TestDrive-GUI” or “CCS-Development” options below and follow the appropriate steps.

Step 1. TestDrive-GUI
   a. Open the GUI Quick Start Guide, QSG-ACDC-GUI.pdf, found in:
      C:\TI_F28xxx_SysSW\ACDC\~Docs\GUI
   b. Browse to the directory: C:\TI_F28xxx_SysSW\ACDC\~Docs\GUI
   c. Open ACDC-GUI.exe
   d. Follow the step-by-step instructions found in the Quick Start Guide

Step 2. Code Composer Studio - Development
   a. If you have emulation tools and Code Composer Studio already installed and active, load
      the project file PFC2PHIL.pjt in: C:\TI_F28xxx_SysSW\PFC2PHIL\ or FBPS.pjt in:
      C:\TI_F28xxx_SysSW\FBPS\ or ACDC.pjt in: C:\TI_F28xxx_SysSW\ACDC\~Docs\GUI
   b. See the corresponding (PFC2PHIL.pdf/FBPS.pdf/ACDC.pdf) user guide for a step-by-step
      walk through of how to compile and run the various labs. This document is in the
      corresponding documents folder for the project (~Docs\).

5 Emulators

The following companies provide low cost, full-featured emulators designed specifically for C2000 controllers:

* Blackhawk™
  - USB2000 Controller (orderable through TI as part number TMDSEMU2000U)
References

For more information, see the following guides:

- **PFC2PHIL** – provides detailed information on the PFC2PHIL project within an easy to use lab-style format.
  C:\TI_28xxx_SysSW\PFC2PHIL\~Docs\PFC2PHIL.pdf
- **FBPS** – provides detailed information on the FBPS (phase shifted full bridge) project within an easy to use lab-style format.
  C:\TI_28xxx_SysSW\FBPS\~Docs\FBPS.pdf
- **ACDC** – provides detailed information on the ACDC (PFC + FB) project
  C:\TI_28xxx_SysSW\ACDC\~Docs\ACDC.pdf
- **QSG-ACDC-GUI** – gives an overview on how to quickly demo the ACDC project using an intuitive GUI interface.
  C:\TI_28xxx_SysSW\ACDC\~Docs\QSG-ACDC-GUI.pdf
- **ACDC-HWdevPkg** – a folder containing various files related to the hardware on the ACDC Kit board (schematics, bill of materials, Gerber files, PCB layout, etc).
  C:\TI_28xxx_SysSW\ACDC-HWdevPkg\n- **System Framework Overview Guide** – presents more information on the system framework found in F28xxx EVM projects
  C:\TI_28xxx_SysSW\~Docs\SystemFrameworkOverview.pdf
- **F28xxx User’s Guides**
  http://www.ti.com/f28xuserguides
IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI’s standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI 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.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or “enhanced plastic.” Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer’s risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

<table>
<thead>
<tr>
<th>Products</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplifiers</td>
<td>Audio</td>
</tr>
<tr>
<td>Data Converters</td>
<td>Automotive</td>
</tr>
<tr>
<td>DSP</td>
<td>Broadband</td>
</tr>
<tr>
<td>Clocks and Timers</td>
<td>Digital Control</td>
</tr>
<tr>
<td>Interface</td>
<td>Medical</td>
</tr>
<tr>
<td>Logic</td>
<td>Military</td>
</tr>
<tr>
<td>Power Mgmt</td>
<td>Optical Networking</td>
</tr>
<tr>
<td>Microcontrollers</td>
<td>Security</td>
</tr>
<tr>
<td>RFID</td>
<td>Telephony</td>
</tr>
<tr>
<td>RF/I and ZigBee® Solutions</td>
<td>Video &amp; Imaging</td>
</tr>
<tr>
<td></td>
<td>Wireless</td>
</tr>
</tbody>
</table>