# CDB5480U Engineering Board and GUI Software

## Features
- Standalone Power Meter Application
- Voltage and Current Interfaces
- Low- and High-voltage Sensor Connections
- Adaptable Sensor Filters Onboard
- USB Communication with PC
- UART/SPI Isolated Communication
- Onboard C8051F342 Microcontroller
- Single Supply Operation from USB or an External +5V DC Supply
- Onboard DC-DC Converter and Regulator
- LCD Power Monitor Display
- LabWindows®/CVI® GUI Software
  - Full Register Setup & Chip Control
  - Simplified Register Access
  - Quick Calibration Control
  - FFT Analysis
  - Time Domain Analysis
  - Noise Histogram Analysis
- Voltage Reference Access

## General Description
The CDB5480U is an extensive tool designed to evaluate the functionality and performance of the Cirrus Logic CS5480 power/energy measurement device.

Multiple analog input connection options, configuration input filters, direct and isolated digital interfaces, multiple power supply options, an onboard programmable micro-controller, and visual LEDs with an LCD panel make the board a flexible and powerful customer development tool for various power/energy measurement applications.

The GUI software provides easy and complete access to the onboard CS5480 device. In addition, it includes the function of raw ADC data collection with time domain, frequency domain, and histogram analysis.


## Ordering Information
CDB5480U-Z Evaluation Board

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![CDB5480U Diagram](image)
IMPORTANT SAFETY INSTRUCTIONS

Read and follow all safety instructions prior to using this demonstration board.

This Engineering Evaluation Unit or Demonstration Board must only be used for assessing IC performance in a laboratory setting. This product is not intended for any other use or incorporation into products for sale.

This product must only be used by qualified technicians or professionals who are trained in the safety procedures associated with the use of demonstration boards.

**DANGER** Risk of Electric Shock

- The direct connection to the AC power line and the open and unprotected boards present a serious risk of electric shock and can cause serious injury or death. Extreme caution needs to be exercised while handling this board.

- Avoid contact with the exposed conductor or terminals of components on the board. High voltage is present on exposed conductor and it may be present on terminals of any components directly or indirectly connected to the AC line.

- Dangerous voltages and/or currents may be internally generated and accessible at various points across the board.

- Charged capacitors store high voltage, even after the circuit has been disconnected from the AC line.

- Make sure that the power source is off before wiring any connection. Make sure that all connectors are well connected before the power source is on.

- Follow all laboratory safety procedures established by your employer and relevant safety regulations and guidelines, such as the ones listed under, OSHA General Industry Regulations - Subpart S and NFPA 70E.

**WARNING** Suitable eye protection must be worn when working with or around demonstration boards. Always comply with your employer’s policies regarding the use of personal protective equipment.

**WARNING** All components and metallic parts may be extremely hot to touch when electrically active.

Contacting Cirrus Logic Support

For all product questions and inquiries contact a Cirrus Logic Sales Representative. To find the one nearest to you go to www.cirrus.com

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1. HARDWARE

1.1 Introduction

The CDB5480U evaluation board provides a convenient means of evaluating the CS5480 energy measurement IC. The CDB5480U evaluation board operates from a single USB or 5V power supply. An optional 3.3V power supply input is available for powering the CS5480 directly. The evaluation board interfaces the CS5480 to a PC via a USB cable. To accomplish this, the board comes equipped with a C8051F342 microcontroller and a USB interface. Additionally, the CDB5480U GUI software provides easy access to the internal registers of the CS5480. The software also provides a means to display the on-chip ADC performance in the time domain or frequency domain.

1.2 Evaluation Board Overview

The board is partitioned into two main sections: analog and digital. The analog section consists of the CS5480, passive anti-aliasing filters, and a high-voltage section with attenuation resistor networks. The digital section consists of the C8051F342 microcontroller, LCD, the test switches, the reset circuitry, and the USB interface. The board also has a user-friendly power supply connection. The assembly information and default configurations for jumpers are shown below.

![CDB5480U Assembly Drawing & Default Configuration](image_url)

Figure 1. CDB5480U Assembly Drawing & Default Configuration
1.3 Analog Section

The analog section of the CDB5480U is highly configurable. Onboard signal conditioning options for the voltage and current channels enable most applications to interface directly to the sensors. The following two sections define the voltage and current channels configurations.

1.3.1 Voltage Sensor Connection

There are three input signal options for the voltage channel input (VIN±): an external low-voltage signal (via screw terminals or XLR connections), high-voltage line input, or GND. Table 1 illustrates the options available.

<table>
<thead>
<tr>
<th>INPUT</th>
<th>Description</th>
<th>J11</th>
<th>J6</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIN±</td>
<td>Selects External Low-voltage Fully</td>
<td>VIN- O VIN-</td>
<td>GND O VIN+</td>
</tr>
<tr>
<td></td>
<td>Differential Signal</td>
<td>(Default)</td>
<td>VIN+</td>
</tr>
<tr>
<td>VIN±</td>
<td>Selects External Low-voltage Single-ended</td>
<td>VIN- O VIN-</td>
<td>GND O VIN+</td>
</tr>
<tr>
<td></td>
<td>Signal</td>
<td>(Default)</td>
<td>VIN+</td>
</tr>
<tr>
<td>GND</td>
<td>Selects Grounding the Input</td>
<td>VIN- O VIN-</td>
<td>GND O VIN+</td>
</tr>
<tr>
<td>High</td>
<td>Selects External High-voltage AC Line</td>
<td>VIN- O VIN-</td>
<td>GND O VIN+</td>
</tr>
<tr>
<td>Voltage</td>
<td>Signal</td>
<td>(Default)</td>
<td>VIN+</td>
</tr>
<tr>
<td>Line</td>
<td></td>
<td>VIN+</td>
<td>VIN+</td>
</tr>
</tbody>
</table>

The CDB5480U evaluation board provides screw-type terminals (J3) or XLR connectors (J30) to connect the low-voltage input signal to the voltage channel (see Figure 2). The screw terminals are labeled as VIN+ / VIN-. An R-C network at the channel input provides a simple configurable anti-alias filter. By installing jumpers on J6 to position VIN+ and J11 to position VIN-, the input voltage signal is supplied from the screw terminals or XLR connection.

![Figure 2. Voltage Channel — Low-voltage Input](image-url)
The CDB5480U evaluation board provides screw-type terminal (J4) to connect to the high-voltage line input. By installing jumpers on J6 to position LINE and J11 to position GND, the input voltage signal is supplied from the high-voltage input. Extreme care should be used when connecting high-voltage signals to the CDB5480U evaluation board (see Figure 3).

![Figure 3. Voltage Channel — High-voltage Input](image)

The on-board attenuation network provides the following attenuation:

\[
\frac{1k}{(4 \times 422k) + 1k} = \frac{1}{1689}
\]

With the CS5480 input range of 250mVp at maximum AC line input of:

\[
300V_{rms} = \frac{250mVp}{\sqrt{2}} \times 1689
\]

is acceptable. It is recommended to apply a 10% margin for the AC line input (270V_{rms}).

The CDB5480U evaluation board provides input shorting options for calibration and noise performance measurements. With a jumper on J6 and J11 in the GND position, the inputs are connected to analog ground (GND).
1.3.2 Current Sensor Connection

Current input options include an external signal (via screw terminals or XLR connectors) or GND. Table 2 shows the options available.

<table>
<thead>
<tr>
<th>INPUT</th>
<th>Description</th>
<th>J8</th>
<th>J7</th>
<th>J14</th>
<th>J13</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIN1± or IIN2±</td>
<td>Selects External Low-voltage, Fully Differential</td>
<td>IIN1+</td>
<td>IIN1+</td>
<td>GND</td>
<td>IIN1+</td>
</tr>
<tr>
<td></td>
<td>Signal</td>
<td></td>
<td></td>
<td></td>
<td>IIN1+</td>
</tr>
<tr>
<td></td>
<td>(Default)</td>
<td></td>
<td></td>
<td></td>
<td>IIN1+</td>
</tr>
<tr>
<td>IIN1± or IIN2±</td>
<td>Selects External Low-voltage, Single-ended</td>
<td>IIN1+</td>
<td>IIN1+</td>
<td>GND</td>
<td>IIN1+</td>
</tr>
<tr>
<td></td>
<td>Signal</td>
<td></td>
<td></td>
<td></td>
<td>IIN1+</td>
</tr>
<tr>
<td></td>
<td>(Default)</td>
<td></td>
<td></td>
<td></td>
<td>IIN1+</td>
</tr>
<tr>
<td>GND</td>
<td>Selects Grounding the Input</td>
<td>IIN1+</td>
<td>IIN1+</td>
<td>GND</td>
<td>IIN1+</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>IIN1+</td>
</tr>
</tbody>
</table>

There are two input signal options for current channels (IIN1±, IIN2±). The CDB5480U evaluation board provides screw-type terminals (J1 and J2) or XLR connectors (J28 and J31) to connect input signals to the current channels. The screw terminals are labeled as IIN1+ / IIN1-, and IIN2+ / IIN2-. An R-C network at each channel input provides a simple configurable anti-alias filter (see Figure 3).

By installing jumpers on J8 to position IIN1+, J7 to position IIN1-, J14 to position IIN2+, and J13 to position IIN2-, the input current signal is supplied from the screw terminals or XLR connectors.

**Figure 4. Current Channel — Low-voltage Input**

The CDB5480U evaluation board provides input shorting options for calibration and noise performance measurements. With a jumper on J8, J7, J14, and J13 in the GND position, the inputs are connected to analog ground (GND).
1.4 Digital Section

The digital section contains the microcontroller, USB interface, LCD, optical isolation, JTAG header, reset circuitry, and external interface headers (J17 and J19). The microcontroller interfaces the UART or SPI of the CS5480 with the USB connection to the PC, enabling the GUI software to access all of the CS5480 registers and functions.

1.4.1 Serial Port Selection

Communication to the CS5480 is provided through two serial port options — UART or SPI. It is necessary to establish communication with the MCU before establishing a serial port communication protocol with the CS5480 (see Figure 5).

![Figure 5. MCU Connection Window](image)

For UART communication, place the SSEL jumper to the UART position via J16, and select UART in the serial port selection window. To enable SPI communications, place the SSEL jumper to the SPI position via J16 and select SPI in the serial port selection window. Table 3 provides the serial communication options on the CDB5480U board.

<table>
<thead>
<tr>
<th></th>
<th>J16</th>
<th>J18</th>
<th>J20</th>
<th>J50</th>
</tr>
</thead>
<tbody>
<tr>
<td>UART</td>
<td>UART SSEL</td>
<td>OPTO RX DIGITAL</td>
<td>OPTO TX DIGITAL</td>
<td>VDDA EN2 GND</td>
</tr>
<tr>
<td></td>
<td>SPI (default)</td>
<td>(default)</td>
<td>(default)</td>
<td>(default)</td>
</tr>
<tr>
<td>SPI</td>
<td>UART SSEL</td>
<td>OPTO RX DIGITAL</td>
<td>OPTO TX DIGITAL</td>
<td>VDDA EN2 GND</td>
</tr>
<tr>
<td></td>
<td>SPI (default)</td>
<td>(default)</td>
<td>(default)</td>
<td>(default)</td>
</tr>
<tr>
<td>Low speed UART</td>
<td>UART SSEL</td>
<td>OPTO RX DIGITAL</td>
<td>OPTO TX DIGITAL</td>
<td>VDDA EN2 GND</td>
</tr>
<tr>
<td>(4800 Baud Max)</td>
<td>SPI (default)</td>
<td>(default)</td>
<td>(default)</td>
<td>(default)</td>
</tr>
</tbody>
</table>
1.4.2 Interface to Microcontroller

Interface headers J17 and J19 are provided to allow the CDB5480U to be connected to an external energy registration device or an external microcontroller. Interface header J17 provides direct access to the CS5480 pins while interface header J19 provides an isolated connection. It is imperative to use the isolated connection (J19) when high-voltage signals are used. Failure to use isolation can result in damage to components or electrical shock. Refer to “Digital Isolation” on page 9 for details on signal isolation.

Interface header J19 can be used to connect to the external microcontroller. To connect the CS5480 to an external microcontroller, R34, R35, R36, R37, R38, R39, R40, R41, R42, and R43 must be removed from the board.

1.4.3 Digital Isolation

Two types of isolation are provided, including a low-speed optical coupler for UART only and high-speed digital isolation for UART and SPI communication. Default jumper settings provide high-speed digital isolators. To enable high-speed digital isolators, place jumpers (J18 and J20) in the RX to DIGITAL position and TX to DIGITAL position. To enable the high-speed digital isolators, it is also necessary to install jumper (J50) in the VDDA position. To enable low-speed optical UART communication, place jumpers (J18 and J20) in the RX to OPTICAL position and TX to OPTICAL position.

The high-speed digital isolators operate from DC to 150Mbps. The low-speed optical couplers operate to a maximum speed of about 4.8kHz. All the signals supplied to the isolators are available to the MCU.

1.4.4 Additional Device Pin Access

The CS5480’s digital output pins DO1, DO2, and DO3 are routed to LEDs, which provide a simple visual check of the digital output. Jumpers J39, J40, J41, and J42 are equipped at the factory with jumpers to enable the LEDs. The DO1 digital output pin is supplied to the digital isolation using jumper J49.

The MODE pin jumper (J15) should be installed in the VDDA to MODE position.

The CS5480 system clock can be connected to an onboard quartz crystal or an external clock can be supplied to the CS5480 XIN pin through jumper J48. To connect the onboard quartz crystal, install jumper J43 in the XIN to CRYS TAL position. To connect XIN to an external clock, install jumper J43 in the XIN to XIN_EXT position.
1.5 Power Supply Selection

Table 4 illustrates the power supply connections on the evaluation board. The positive analog (VDDA) for the CS5480 can be supplied using the +3.3V binding post (J36 and J37) or the onboard +3.3V regulator. Jumper J38 allows the VDDA supply to be sourced from the +3.3V binding post (J37) or the regulated +3.3V supply. The DC-DC converter (U8) powers the onboard +3.3V regulator. Jumper J26 allows the +5V supply to be sourced from either the +5V EXT screw connector (J27) or the +5V USB supply. The +5V supplies the power for the microcontroller (8051_REGIN) and the DC-DC converter (U8). Jumper J21 is used to measure the CS5480 analog supply current and must be installed.

When connecting the CDB5480U board to the AC line through non-isolated sensors, it is strongly recommended that the CS5480 GND reference is connected to the neutral, the non-isolated current sensor is connected to the neutral, and the CS5480 is supplied by +3.3V isolated from the AC line. The DC-DC converter (U8) provides 1kVDC isolation, while no isolation is provided for the 3.3V binding post connections. If +3.3V is used from the binding post, then the external 3.3VDC power supply must be isolated from the AC line. To prevent electric shock and damages, always use an isolated power source.

<table>
<thead>
<tr>
<th>Supply Source</th>
<th>CS5480 Source</th>
<th>Binding post J36&amp;J37</th>
<th>USB Supply J24</th>
<th>5V Terminals J27</th>
<th>VDDA J21</th>
<th>VDDA J38</th>
<th>+3.3V_1 J26</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB</td>
<td>On-board 3.3 V Regulator</td>
<td>NC</td>
<td>+5V</td>
<td>NC</td>
<td>VDDA</td>
<td>VDDA</td>
<td>+5V EXT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(default)</td>
<td></td>
<td>+3.3V</td>
<td></td>
</tr>
<tr>
<td>External +3.3V &amp; USB</td>
<td>Binding Post</td>
<td>+3.3 V</td>
<td>+5V</td>
<td>NC</td>
<td>VDDA</td>
<td>VDDA</td>
<td>+5V EXT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(default)</td>
<td>+3.3V</td>
<td>VDDA</td>
<td>+5V EXT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(default)</td>
<td></td>
<td>+3.3V_2</td>
<td>+5V USB</td>
</tr>
<tr>
<td>External +5V</td>
<td>On-board 3.3V regulator</td>
<td>NC</td>
<td>NC</td>
<td>+5V</td>
<td>VDDA</td>
<td>VDDA</td>
<td>+5V EXT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+3.3V</td>
<td>+5V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>VDDA</td>
<td>+5V USB</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+3.3V_2</td>
<td></td>
</tr>
</tbody>
</table>
1.6 Typical Sensor Connections

The CDB5480U evaluation board provides connections directly to several types of sensors. Flexible onboard filter networks provide a convenient configuration for three common transducers, including current shunt, current transformer (CT), or Rogowski coil.

1.6.1 Shunt Power Meter Example

A low-cost current shunt configuration is easily achievable with the CDB5480U evaluation board. Figure 6 depicts the voltage and current connections for a shunt sensor and its associated filter configurations.

It is strongly recommended that a low-side (neutral path) current shunt is used — especially in high-voltage situations. Make sure that all signals are well connected before the power source is turned on. Extreme care should be taken when connecting high-voltage signals to the CDB5480U evaluation board.

In this configuration it is unnecessary to use a burden resistor. A single anti-alias filter is all that is required for the current channel. Below the filter corner frequency, the CS5480 inputs will see the same voltage that is across the shunt. Therefore, the shunt voltage should be kept below the maximum of 50mVp with I-Channel PGA = 50x. A 10% margin is recommended for the shunt voltage (45mVp).

![Diagram of Shunt Sensor Power Meter](Figure 6. Shunt Sensor Power Meter)
1.6.2 Current Transformer Power Meter Example

A slightly more expensive option is to use a current transformer (CT) to connect the AC current to the CDB5480U evaluation board. Figure 7 depicts the voltage and current connections for a CT sensor and its associated filter configurations.

NEVER “open circuit” a CT. Make sure that all signals are well connected before the power source is turned on. Extreme care should be taken when connecting high-voltage signals to the CDB5480U evaluation board.

The burden resistor (R11/R22) is necessary in a CT application to convert the secondary current into voltage. Knowledge of the current transformers turns ratio (N) is key to determining the proper CS5480 input voltage (V_burden) that the meter places on the system. The optimum secondary voltage (V_burden) at the maximum current input should be 10% less than the maximum channel voltage of 250mVp with I-channel PGA = 10x. The secondary voltage (V_burden) is determined by converting the primary current to the secondary current. Then the secondary current (I_burden) can be converted into a voltage by Ohm's Law.

\[ V_{\text{burden}} = I_{\text{burden}} \times R_{\text{burden}} = \frac{I_{\text{primary}}}{N} \times R_{\text{burden}} \]

The secondary voltage (V_burden) is sourced to the CS5480 through a simple low-pass, anti-alias filter, and this voltage should not exceed the 250mVp.

Figure 7. Current Transformer Power Meter
1.6.3 Rogowski Coil Power Meter Example

Rogowski coil power meter can be easily connected to the CDB5480U evaluation board. Figure 8 shows the voltage and current connections for the Rogowski sensor and its associated filter configurations.

For more information, see AN365: Using the CS5480/84/90 Energy Measurement IC with Rogowski Coil Current Sensors.
1.7 Standalone Meter Application

The CDB5480U evaluation board provides a standalone power meter using the CS5480, MCU, and LCD. The user can enable the power meter by connecting the sensors to the analog inputs, providing power to the board, and resetting the MCU by pressing the **RESET** switch. Refer to “Typical Sensor Connections” on page 11 for details on the sensor connections and “Power Supply Selection” on page 10 the details on supply options.

The user should not use the GUI to connect the CDB5480U board. If the GUI is connected to the CDB5480U board the standalone power meter function is disabled and the LCD on the CDB5480U will read "Cirrus Logic CS5480 Eval GUI". To re-enable the standalone power meter feature, close the GUI software. The standalone power meter feature will initially show the voltage channels’ RMS register values:

\[
V1_{\text{rms}} = \text{N.NNNNN} \quad \text{and} \quad V2_{\text{rms}} = \text{N.NNNNN}.
\]

By clicking the onboard switch S2, the standalone power meter will display the following measurement results:

1. RMS Voltage
2. RMS Current
3. Average Active Power
4. Average Reactive Power
5. Average Apparent Power
6. Power Factors
7. Total Active Power
8. Total Reactive Power
9. Total Apparent Power
10. Fundamental Frequency
11. CS5480 die Temperature

![Figure 9. Standalone Power Meter Measurements](image)
2. SOFTWARE

The evaluation board comes with software and a USB cable to link the evaluation board to the PC. The evaluation software was developed with LabWindows®/CVI®, a software development package from National Instruments. The evaluation software is designed to run with Windows XP™ and Windows 7™. The following procedure is based on Windows XP.

2.1 Installation Procedure

Follow the steps below to install the GUI:

2. Navigate to the CDB5480U software link under Energy Measurement. The Software License web page is displayed.
3. To agree with the terms and conditions, click the Agree button. The File Download window is displayed.
4. Click the Save button. The Save As window is displayed.
5. Select a location to store the compressed folder.
6. Click the Save button. The Download complete window is displayed.
7. Click the Open Folder button. The location where the compressed folder is stored is displayed.
8. Right-click on the compressed folder, and click Extract All.
9. Select a location to extract the files.
10. Navigate to the location where the extracted files are stored and double-click on the setup.exe file.
11. Click the Install button, and follow the installation instructions.
12. Execute the GUI using Section 2.1.1 Executing the GUI.

2.1.1 Executing the GUI

1. From the Start menu, click All Programs.
3. Click CDB5480U. The GUI is launched.

2.2 Using the Software

Before launching the software, check all jumper settings on the CDB5480U evaluation board as described in “Evaluation Board Overview” on page 4, and connect the board to an open USB port on the PC using the provided cable. Once the board is powered on, the software program can be launched.
2.3 Start-up Window
When the software is launched, the start-up window will appear. This window contains information concerning the software's title, revision number, and copyright date (see Figure 10).

![Start-up Window](image)

**Figure 10. GUI Start-up Window**
A menu bar at the top displays four items: System, Cirrus Test, Connect, and Quit. Initially System and Cirrus Test are disabled. After establishing a link to a data source, the System and Cirrus Test items will become available.

2.4 Connect Menu
The Connect menu allows the user to establish a USB communication link with CDB5480U board. After the USB communication has been established, the CS5480 serial port configuration needs to be entered according to the position of jumper J16. Connecting to the CDB5480 is a two-step process:

1. Use the “USB Item” to connect to the MCU.
2. Use the “CS5480 Serial Port Config Item” to connect the MCU to the CS5480.

2.4.1 USB Item
In the Connect menu, the USB item allows the user to establish USB communication. If the USB item in the Connect menu is selected, the evaluation software will poll the C8051F342 microcontroller, verifying the serial communication link is ready. When the Connect to the CDB board popup window appears (see Figure 11), the user should reset the CDB5480 using switch (S1) on the board, wait for Windows to
recognize the MCU (typically 3 seconds), and then select "OK."

![Connect to the CDB board Window](image)

**Figure 11. Connect to the CDB board Window**

At this point, the **USB** menu item is checked, indicating that the PC has successfully communicated with the CDB5480U evaluation board. The micro-code version information is read from the board and displayed on the screen. See Figure 12. Due to improvements to the software or new features being added, the version displayed may be different than the image shown here.

![Start-Up Window](image)

**Figure 12. Connect Menu Showing Successful USB Connection**

If the evaluation software is unable to establish a communication link with the CDB5480U board, a message will appear, indicating that the initial communication has failed. See Figure 13.

![Error Message](image)

**Figure 13. USB Error Message**

Check to verify that the USB cable is connected properly and the power supply is on and connected properly to the CDB5480U. Reset the board (press the **RESET** button on the board) and try to set up the USB connection again.
2.4.2 CS5480 Serial Port Config Item

In the Connect menu, the CS5480 Serial Port Config item allows the user to select different types of serial communication — UART or SPI. See Figure 14.

![Figure 14. Connect Menu Showing Serial Connection Options](image)

Before the software is configured, it is necessary to set J16 on the CDB5464U board to either UART or SPI communication. To select UART communication install jumper J16 in the SSEL to UART position. To select SPI communication install jumper J16 in the SSEL to SPI position.

To select UART communications, position jumper J16 to the SSEL to UART position and select UART in the Serial Port Selection window. See Figure 15.

![Figure 15. UART Serial Port Selection Window, UART Selected](image)
To select SPI communications, position jumper J16 to the SSEL to SPI position and select SPI in the Serial Port Selection window. See Figure 16.

![Serial Port Selection Window, SPI Selected](image)

**Figure 16. SPI Serial Port Selection Window, SPI Selected**

After the serial port has been selected, press the OK button. The MCU will try to read the chip ID from the CS5480. The chip revision number will be displayed in "Device:" in the Start-up window. If the red "Unknown CHIP ID" is shown, check the power supply and clock to the CS5480, MODE jumper J15, SSEL jumper J16, and the isolation jumpers J18, J51, and J20, click the RESET button, and go back to the USB connection process.

![Start-Up Window](image)

**Figure 17. Unknown Chip ID Error Message**
2.5 System Menu

The System pull-down provides three options: Setup CS5480, Calibration, and Conversion. Each window provides a means to evaluate the different functions and performance of the CS5480. See Figure 18.
2.5.1 Setup Window

The evaluation software provides access to the common CS5480’s internal registers through the Setup window. See Figure 19. Enter the Setup window by selecting the Setup CS5480 item from the System menu.

Figure 19. Setup Window

The Setup window displays all of the common CS5480 registers in hexadecimal notation and are decoded to provide easier readability. Refer to the CS5480 data sheet for information on register functionality and definitions. The Setup window is segmented by function. Each subsection may contain more than one CS5480 register in order to configure a particular function. Updating the hexadecimal value of a register will change the definitions display according to the new hexadecimal value of the register(s). Likewise, updating the definitions displayed from the list boxes will update the hexadecimal value(s) of the associated register(s).
2.5.1.1 Refresh Screen Button

The Refresh Screen button will update the contents of the screen by reading all the register values from the CS5480. It is a good idea to press the Refresh Screen button when entering the Setup window, or after modifying any registers, to reflect the current status of the CS5480.

2.5.1.2 Reset DUT Button

The Reset DUT button will software reset the CS5480. The CS5480 will perform a software reset as discussed in the CS5480 data sheet. After the software reset to the CS5480 device, the screen contents will be automatically refreshed with the updated status of the CS5480.

2.5.1.3 Save Config and Load Config Buttons

Clicking the Save Config button will save the current setup widow's configuration to a .txt file. Clicking the Load Config button will recall a saved configuration and store values into the CS5480.

2.5.1.4 CS5480 MCLK Frequency

The CS5480 accepts a wide range of MCLK input frequencies, and can therefore run at many different sample rates. The frequency being used on the CS5480 should be entered in this box to provide accurate frequency calculation in the FFT window. This will also help the software decide which functions the evaluation system can perform reliably.

2.5.1.5 Configuration Registers

In the Config0, Config1, and Config2 register boxes, the contents of the CS5480’s configuration registers can be modified by typing a hexadecimal value in the HEX: field, or by changing any of the values below the HEX: field to the desired settings. Although the CDB5480U software allows the modification of any of the bits in the configuration registers, changing certain reserved bits, such as the NO_OSC bit of Config0, may cause the software and board to behave erratically. This applies only to the CDB5480U evaluation system and not to the CS5480 chip itself.

2.5.1.6 Pulse Control Register

The Pulse Control Register section is used to make changes to and display the contents of the CS5480’s PulseCtrl register. The PulseCtrl register contains various bits used to select the input to each energy pulse generation block within the CS5480. Refer to the CS5480 data sheet for descriptions of the bits. The value of the PulseCtrl register is displayed in hexadecimal format. Most of the PulseCtrl register bits are reserved or unused. Only the usable bits are displayed in the Setup window.

2.5.1.7 Pulse Width and Pulse Rate Registers

The Pulse Width Register section is used to make changes to and display the contents of the CS5480’s PulseWidth register. The Pulse Width register is used to define the frequency range and pulse width of the energy pulses generated by the CS5480. The PulseWidth register should be configured before setting the PulseRate register. The Pulse Rate Register section is used to make changes to and display the contents of the CS5480’s PulseRate register. The PulseRate register defines the full-scale frequency of the energy pulses generated by the CS5480.
2.5.1.8 Phase Compensation

The Phase Comp Register section is used to make changes to and display the contents of the CS5480's PC (Phase Compensation Control) register. The PC register allows coarse and fine phase adjustment on each channel of the CS5480 data path. Refer to the CS5480 data sheet for descriptions of the PC register bits.

2.5.1.9 Integrator Gain, System Gain

The Integrator Gain and System Gain sections display the signal path gain in both hexadecimal and decimal format. Each register can be modified by typing a value in the corresponding Decimal or HEX: field.

2.5.1.10 Sample Count, Cycle Count, Settle Time

The Sample Count Register, Cycle Count Register, and Settle Time sections provide fields to display the values of registers associated with low-rate calculations. The SampleCount and CycleCount registers are entered or displayed in decimal format by default. The user may select to enter or view other number formats of the register by selecting the "d" within the field. The value of the $T_{\text{Settle}}$ register is displayed in both hexadecimal and decimal format. Each register can be modified by typing a value in the corresponding field.

2.5.1.11 Epsilon

The Epsilon section is used to display and adjust the Epsilon register (the ratio of the AC line frequency to the output word rate). The Epsilon register can be updated either through entering the AC line frequency in the Line Freq field or by entering the direct register value in the HEX: field.

2.5.1.12 ZX NUM

When Automatic Frequency Update is enabled, the ZXNUM section is used to adjust the number of zero crossings used in the Epsilon calculation. The update rate of Epsilon is increased by reducing the zero crossings. The register can be modified by typing the number of zero crossings.

2.5.1.13 Mask Register

The Mask Register box displays the value for the Mask register in hexadecimal and decodes them to indicate each bit's function. The Mask register can be modified by typing a value in the HEX: field, or by checking the appropriate check boxes for the bits that are to be masked. The value present in the Mask register may be changed by the GUI software during certain operations to provide correct functionality of the CDB5480U board.

2.5.1.14 Temperature Registers

The Temperature Registers box is used to adjust the temperature offset register ($T_{\text{OFF}}$) and temperature gain register ($T_{\text{GAIN}}$) to convert the temperature register ($T$) from the Celsius scale to the Fahrenheit scale, or vice versa, and to improve temperature measurement accuracy. Refer to the CS5480 data sheet for the details of the on-chip temperature sensor.

2.5.1.15 Zero-crossing Level and No Load Threshold

The Zero-crossing Level and No Load Threshold boxes display the values for these registers in hexadecimal and decimal. Each register can be modified by typing a value in the corresponding Decimal or HEX: field.
2.5.1.16 V1/V2 Sag, V1/ V2 Swell, and I1/I2 Overcurrent Registers

The registers for voltage sag, voltage swell, and overcurrent are displayed in the V1 Sag, V2 Sag, V1 Swell, V2 Swell, I1 Overcurrent, and I2 Overcurrent Register sections. These sections display the level and duration values of the corresponding registers in both hexadecimal and decimal format. Each register can be modified by typing a value in the corresponding decimal or HEX: field. Refer to the CS5480 data sheet for detailed descriptions of these registers.

2.5.1.17 Channel Selection Level, Channel Select Minimum Amplitude, and Voltage Fixed RMS Reference Registers

There are three register sections dedicated for setting anti-tampering features of the CS5480: Channel Selection Level \((I_{chan\,LEVEL})\), Channel Select Minimum Amplitude \((P_{MIN} (IRMS_{MIN}))\) and Voltage Fixed RMS Reference register \((VF_{RMS})\). Each register can be modified by typing a value in the corresponding decimal or HEX fields. The Channel Selection Level register section is used to make changes to and display the contents of the CS5480’s \(I_{chan\,LEVEL}\) register. The Channel Selection Level register sets the hysteresis level for automatic energy channel selection. The Channel Select Minimum Amplitude register \(P_{MIN} (IRMS_{MIN})\) section is used to make changes to and display the contents of the CS5480’s Channel Select Minimum Amplitude register. The Channel Select Minimum Amplitude register sets the minimum level for automatic energy channel selection. The Voltage Fixed RMS Reference register section is used to make changes to and display the contents of the CS5480’s \(VF_{RMS}\) register. When voltage tampering is detected, the \(VF_{RMS}\) register contains the internal voltage RMS reference used in the active power calculations.

2.5.1.18 Register Checksum, SerialCtrl Registers

The Register Checksum and SerialCtrl Register boxes provide control and status of critical serial port communication parameters and the register checksum. The SerialCtrl Register section provides control over RX pin, baud rate, and enabling checksum protection for serial communication. The Register Checksum section provides the calculated checksum of the critical registers inside the CS5480. The register checksum updates automatically after single or continuous conversion has been performed. The RegChk and SerialCtrl registers are displayed in hexadecimal form. Please note that if the opto-couplers are selected as the isolation (J18, J20), the maximum baud rate is 2400.

The baud rate field applies only to UART serial communication and can be changed by the pull-down field. It is recommended to set the baud rate setting to the highest setting possible. The default setting of 600 baud will cause some GUI functions to overflow the communication buffer and not function correctly.

2.6 Calibration Window

The Calibration window is used to display and write to the CS5480 offset and gain calibration registers. It is also possible to initiate the CS5480’s calibration sequences that are used to set the calibration values. AC offset, DC offset, and gain calibrations can be performed on either the voltage channel or the current channel, or both simultaneously. Refer to the CS5480 data sheet for more details on calibration. See Figure 20.
2.6.1 Save Cal and Load Cal Buttons
Clicking the Save Cal button will save the calibration window’s configuration to a .txt file. Clicking the Load Cal button will recall a saved configuration and store values into the CS5480.

2.6.2 Offset / Gain Register
In the Offset and Gain Calibration boxes, the offset and gain registers for all channels are displayed in hexadecimal and decimal formats. These registers can be modified directly by typing the desired value in the display boxes. There are three types of offset registers: DC offset, AC offset and power offset. The AC offset registers only affect the RMS register values. The active and reactive power offset registers only affect the active and reactive power register values, respectively. The DC, AC, and power offset registers are two’s complement numbers whose values range from -1 to +1. The gain register value ranges from 0 to 4.

Figure 20. Calibration Window
The Refresh Screen button will update the contents of the screen by reading all the register values from the part. It is a good idea to press the Refresh Screen button when entering the Calibration window, or after modifying any registers to reflect the current status of the CS5480.
2.6.3 Performing Calibrations

AC/DC offset and gain calibrations can be performed on both the voltage and current channels of the CS5480. It is generally a good idea to software-reset the CS5480 before running calibrations, because the initial values in the calibration registers will affect the results of the calibration. A software reset will reset these registers back to the default values of zero offset and unity gain. AC/DC offset calibration should be performed before gain calibration to ensure accurate results.

2.6.3.1 Offset Calibrations

1. Ground the channel(s) you want to calibrate directly at the channel header(s), J6 and J10 for the voltage channel and J7, J8, J13, and J14 for the current channels. The channel(s) could also be grounded directly at the screw-type terminals.

2. Press the corresponding AC or DC offset calibrate button (Cal V, Cal I, or Calibrate All Channels) in the corresponding Offset Calibration box(es).

3. The offset register value(s) will automatically update when the calibration is completed.

2.6.3.2 Gain Calibrations

1. Attach an AC or DC calibration signal to the screw-type terminals, and make sure the corresponding channel headers (J6, J7, J8, J10, J13, and J14) are set to the desired input position.

2. Press the corresponding gain calibrate button (Cal V, Cal I, or Calibrate All Channels) in the corresponding Gain Calibration box(es).

3. The gain register value(s) will automatically update when the calibration is completed.

The Calibration window also contains the Active and Reactive Power Offset Register 1 and Register 2 display and adjustment. The user can read and write the values in the CS5480 active and reactive power offset registers (P1OFF, P2OFF, Q1OFF, and Q2OFF).
2.7 Conversion Window

The Conversion window allows the user to see the results of single and continuous conversions and the CS5480 status, perform data averaging, and utilize the power-saving modes of the CS5480. The Conversion window can be accessed from the System menu pull-down, Conversion menu item. The Conversion window provides the active, apparent, and reactive energy calculations register results for each channel. In addition, the RMS, power factor, and peak signal amplitudes for each analog-to-digital converter channel, chip temperature (when temperature measurement function is enabled), AC line frequency (converted from the Epsilon register), and the values of each status register (Status0, 1, 2) are also displayed. The Conversion window also provides the total active, apparent, and reactive power register results.

![Conversion Window](image)

Figure 21. Conversion Window

2.7.1 Single Conversion Button

Pressing the Single Conversion button will cause a single conversion to be performed. After a single conversion is complete, the Result column will be updated with the values present in each data register.

2.7.2 Continuous Conversion Button

Pressing this button will cause continuous conversions to be performed until the user presses the Stop button. After each conversion is complete, the Result column will be updated with the values present in each data register. The Mean and STD. DEV columns will be updated every N cycle, where N is the...
number in the Samples to Average field. The user should stop continuous conversion before leaving this window. The Continuous Conversion button should not be used with BAUD rates less than 1200 Hz in UART mode. Using lower BAUD rates (including the default 600 baud) will result in overflowing the communication buffer and cause other window errors and/or communication failure.

Data logging can be enabled using the DATALOG On/Off check box and Filename field.

2.7.3 Standby Mode Button
When this button is pressed, the CS5480 will enter a standby power saving mode. To return to normal mode, press the Power Up button. The user should power up the device before leaving this window.

2.7.4 Power Up Button
The Power Up button is used to send the wake-up command to the CS5480. The CS5480 will return to normal operating mode.

2.7.5 Line Frequency Result
When the AFC bit in the Config2 register is set, the Epsilon register will be calculated automatically by the CS5480 and the Line Frequency fields will be updated automatically in continuous conversion mode. If the AFC bit in the Config2 register is not set and the line frequency is other than the default value (50 Hz), the line frequency must be set manually here to make Epsilon be the ratio of line frequency to the output word rate (OWR). This ensures the accuracy of the quadrature power (Q1, Q2) and the reactive power (Q1_AVG and Q2_AVG) calculations. Refer to the CS5480 data sheet for more details.

2.7.6 Temperature Result
The Temperature field displays the CS5480’s die temperature in the top right corner of the Conversion window.

2.7.7 Samples to Average
The Samples to Average field allows the user to average a number of measurement results.
2.8 Cirrus Test Window

The Cirrus Test window provides three options: Test and Debug, ADC Data Collection, and ADC Data Collection to File. Each window provides a means to evaluate the different functions and performance of the CS5480. See Figure 22.

![Cirrus Test Pull-down Options](image)

Figure 22. *Cirrus Test Pull-down Options*

2.8.1 Data Collection Window

The Data Collection window allows the user to collect sample sets of data from the CS5480 and analyze them using time domain, FFT, and histogram plots. The Data Collection window can be accessed by pulling down the CirrusTest menu, and selecting the ADC Data Collection item. See Figure 23.

![Data Collection Window](image)

Figure 23. *Data Collection Window*
The Data Collection window can only be accessed when operating in SPI mode. When UART serial communication is enabled, an error window will be displayed. See Figure 24. To enable SPI refer to “Serial Port Selection” on page 8.

Figure 24. Data Collection UART Error Message

2.8.1.1 Time Domain / FFT/ Histogram Selector
The Time Domain/FFT/Histogram selector selects the type of data processing to perform on the collected data and displays the results in the plot area. Refer to “Analyzing Data” on page 32 for more information.

2.8.1.2 Config Button
The Config button will bring up the Configuration window, in which the user can modify the data collection specifications. Refer to “Configuration Window” on page 31 for more information.

2.8.1.3 Collect Button
The Collect button will collect data from the part, to be analyzed in the plot area. See “Collecting Data Sets” on page 32 for more information.

2.8.1.4 Output Button
The Output button will bring up a window in which the user can output the data to a file for later use, print out a plot, or print out the entire screen. When saving data, only the data channel being displayed on the plot will be saved to a file.

2.8.1.5 Zoom Button
The Zoom button allows the user to zoom in on the plot by selecting two points in the plot area. Press the Restore button to return to the normal data plot, or press the Zoom button again to zoom in even further.

2.8.1.6 Channel Select Button
After data collection, the two buttons labeled as “No Data” will be replaced with Current and Voltage buttons, allowing the user to choose the appropriate channel for display. In the time domain mode, an additional Overlay button will be present which allows the user to display all the channels on the same plot.

2.8.1.7 Output Button & Window
The Output button allows the user to:
   1. Output Time Domain File
   2. Output FFT File
   3. Output Histogram
   4. Print Screen
   5. Print Graph

Figure 25. Data Collection Output Window
2.8.1.8  Configuration Window

The Configuration window allows the user to set up the data collection and analysis parameters. See Figure 26.

![Configuration Window Image](image)

**Figure 26. Data Collection Configuration Window**

2.8.1.8.1  Number of Samples

The *Number of Samples* field allows the user to select the number of samples to collect, between 16 and 524288.

2.8.1.8.2  Average

When performing FFT analyses, the *Average* field determines the number of FFTs to average. FFTs will be collected and averaged when the *Collect* button is pressed.

2.8.1.8.3  FFT Window

The *FFT Window* box allows the user to select the type of windowing algorithm for FFT processing. Windowing algorithms include the Blackman, Blackman-Harris, Hanning, 5-term Hodie, and 7-term Hodie. The 5-term Hodie and 7-term Hodie are windowing algorithms developed at Crystal Semiconductor, now Cirrus Logic.

2.8.1.8.4  Histogram Bin Width

This field determines the "bin width" when plotting histograms of the collected data. Each vertical bar in the histogram plot will contain the number of output codes entered in this field. Increasing this number may allow the user to view histograms with larger input ranges.

2.8.1.8.5  Seconds to Delay

This field specifies the amount of time the system waits to begin data collection after the CS5480 starts continuous conversions.

2.8.1.8.6  Data to Collect

The *Data to Collect* check boxes allow the user to select the data types that will be collected and returned to the PC for processing.

2.8.1.8.7  Accept Button

When the *Accept* button is pressed, the current settings will be saved and the user will return to the *Data Collection* window.
2.8.1.9 Collecting Data Sets

To collect a sample data set:

1. In the Data Collection window, press the Config button to bring up the Configuration window and view the current settings.
2. Select the appropriate settings from the available options (see “Configuration Window” on page 31) and press the Accept button.
3. The Data Collection window should still be visible. Press the Collect button to begin collecting data.
4. Once the data has been collected, it can be analyzed, printed, or saved to disk.

2.8.1.10 Analyzing Data

The evaluation software provides three types of analysis tests: Time Domain, Frequency Domain, and Histogram. The time domain analysis processes acquired conversions to produce a plot of magnitude versus conversion sample number. The frequency domain analysis processes acquired conversions to produce a plot of magnitude versus frequency using the Fast-Fourier transform (results up to Fs/2 are calculated and plotted). Also statistical noise calculations are calculated and displayed. The histogram analysis processes acquired conversions to produce a histogram plot. Statistical noise calculations are also calculated and displayed.

2.8.1.11 Histogram Information

The following is a description of the indicators associated with histogram analysis. Histograms can be plotted in the Data Collection window by setting the analysis type pull-down menu to Histogram. See Figure 27. The histogram plot information includes:

- BIN: displays the x-axis value of the cursor on the histogram.
- MAGNITUDE: displays the y-axis value of the cursor on the histogram.
- MEAN: indicates the mean of the data sample set. The mean is calculated using the following formula:

\[
\text{Mean} = \frac{\sum_{i=0}^{n-1} X_i}{n}
\]

- STD_DEV: indicates the standard deviation of the collected data set. The standard deviation is calculated using the following formula:

\[
\text{STDDEV} = \sqrt{\frac{\sum_{i=0}^{n-1} (X_i - \text{Mean})^2}{n}}
\]

- VARIANCE: indicates the variance of the current data set. The variance is calculated using the following formula:

\[
\text{Variance} = \frac{\sum_{i=0}^{n-1} (X_i - \text{Mean})^2}{n}
\]

- MAXIMUM: indicates the maximum value of the collected data set.
2.8.1.12 Frequency Domain Information

The following describe the indicators associated with FFT (Fast-Fourier Transform) analysis. FFT data can be plotted in the Data Collection window by setting the analysis type selector to FFT. See Figure 28. The FFT information includes:

- FREQUENCY: displays the x-axis value of the cursor on the FFT display.
- MAGNITUDE: displays the y-axis value of the cursor on the FFT display.
- S/PN: indicates the signal-to-peak noise ratio (decibels).
- SINAD: indicates the signal-plus-noise-plus-distortion to noise-plus-distortion ratio (decibels).
- S/D: indicates the signal-to-distortion ratio, 4 harmonics are used in the calculations (decibels).
- SNR: indicates the signal-to-noise ratio, first 4 harmonics are not included (decibels).
• FS-PdB: indicates the full-scale to signal Ratio (decibels).

Figure 28. FFT Analysis
2.8.1.13  Time Domain Information

The following controls and indicators are associated with time domain analysis. Time domain data can be plotted in the Data Collection window by setting the analysis type selector to Time Domain. See Figure 29. The time domain plot includes:

- COUNT: displays current x-position of the cursor on the time domain display.
- MAGNITUDE: displays current y-position of the cursor on the time domain display.
- MAXIMUM: indicates the maximum value of the collected data set.
- MINIMUM: indicates the minimum value of the collected data set.

![Figure 29. Time Domain Analysis](image)
2.8.2 Data Collection to File Window

The Data Collection to File window allows the user to collect instantaneous voltage and current register data over an extended period of time to a data file. See Figure 30. The following steps are necessary for data collection to a file:

1. Provide the Time to Collect in seconds.
2. If a delay before data collection is needed, enter the time in seconds for the Delay.
3. Select the voltage and current channel 1 (V1,I1) or voltage and current channel2 (V2,I2).
4. Browse to a directory and enter the file name of the desired file to save.
5. Start the data collection by pressing the START button.
6. The data collection status will be provided in Samples Collected and Time Remaining.
7. The collection will complete without any further interaction by the user or the user may stop the data collection at any time by pressing the STOP button.

![Data Collection to File Window](image)

Figure 30. Data Collection to File Window
2.8.3 Setup and Test Window

The Setup and Test window allows the user a way to access CS5480 registers and send commands to the CS5480 directly. See Figure 31.

![Setup and Test Window](image)

Figure 31. Setup and Test Window

There are three types of transactions: Write, Read, and Send. The CS5480 memory is organized by pages. In order to properly write a register it is necessary to set the Page, Address, and Value to Write field and then press the Write button. To read a register it is necessary to set the Page and Address and then press the Read button. The register result will be displayed in the Value Read field. To send a command to the CS5480, enter the command in the Command field and press the SEND button. Refer to the CS5480 data sheet for more details on registers and commands.
## APPENDIX A. BILL OF MATERIALS

### BILL OF MATERIAL

<table>
<thead>
<tr>
<th>Item</th>
<th>Cirrus P/N</th>
<th>Rev</th>
<th>Description</th>
<th>Qty</th>
<th>Reference Designator</th>
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Figure 32. Schematic - Analog Inputs
Figure 33. Schematic - CS5480 & Socket
Figure 34. Schematic - Microcontroller & USB Interface
APPENDIX C. LAYER PLOTS

Figure 35. Top Silkscreen
Figure 36. Top Routing
Figure 37. Bottom Routing
## REVISION HISTORY

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<td>Updated screen shots and circuit diagrams to align with B0 silicon.</td>
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