CRD5463PM Power Monitor
Reference Design and Software

Features

- Easy Plug-and-play Design
- USB Communication with PC
- Real-time Measurements:
  - Line Voltage
  - Load Current
  - Active Power
  - Reactive Power
  - Apparent Power
  - Power Factor
  - Line Frequency
  - Temperature
- Operational Voltage: 90 ~ 260 VAC
- Maximum Load Current: 15 A RMS
- Active Power Measurement Accuracy:
  - 0.2%, 3 ~ 3900 W
- Lab Windows™/CVI™ GUI Software
- Factory Calibrated, Re-calibration Capable

General Description

The CRD5463PM demonstrates the CS5463 power measurement IC. It has an integrated AC-DC power supply, voltage and current sensors, and isolated UART/USB interface. Working with the GUI software, it provides accurate real-time measurements of line voltage, load current, line frequency, active power, reactive power, apparent power, power factor, and temperature.

The CRD5463PM includes two power cords, a USB cable, and a plug adaptor. When used with a PC, the CRD5463PM immediately becomes a high-precision power meter. The UART interface communication protocol, GUI, and MCU software source codes are also available from Cirrus Logic. The CRD5463PM is a useful design reference and evaluation tool for customers to develop power metering/monitoring systems that use the CS5463 IC.

ORDERING INFORMATION

CRD5463PM Power Monitor Reference Design
1. CHARACTERISTICS AND SPECIFICATIONS

1.1 Recommended Operating Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>Typ</th>
<th>Max</th>
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<td>Current Range</td>
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1.2 Electrical Characteristics

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</table>

NOTES:
1. Measured at V_{AC} = 240 V and T_{A} = 25° C.

WARNING

High Voltage Hazard

When the CRD5463PM is connected to AC lines, high voltage is present inside the box.
DO NOT REMOVE THE PROTECTIVE COVER FROM THE CRD5463PM WHEN POWER IS CONNECTED.

Figure 1. Calibration and Test Connection Diagram

NOTES:
1. Voltage drop and power loss in the cable connecting the CRD5463PM and the reference meter may introduce additional error.
2. The measurement bandwidth of the CS5463 is 2 kHz. At low power factor, the CRD5463PM may measure lower current and higher power factor than the reference meter if the reference meter has a measurement bandwidth greater than 2 kHz.
3. When testing at low power factor, the peak load current shall never exceed 22 A.
2. SYSTEM OVERVIEW

As illustrated in Figure 1, the CRD5463PM is composed of voltage and current sensors, a CS5463 power measurement device, an ATtiny2313 microcontroller, opto-coupler isolation, and UART-USB converter.

2.1 DC Power Supplies

There are two isolated +5V DC power domains in the CRD. One is converted from AC power lines through capacitor-dropper AC/DC power supply and provides +5VDC supply to the CS5463 and MCU. The other is directly from PC through USB interface and provides +5VDC to the UART-USB converter.

This capacitor type of DC power supply is very low-cost but not efficient. Total power consumption drew from the AC line is 2.3 Watt and 79mA (tested with 240 VAC input).

2.2 Voltage Sensor

The high AC line voltage must be converted to small voltage signal before being applied onto the CS5463 voltage channel inputs (VIN±). The CRD5463PM uses resistor voltage divider as the voltage sensor.

\[
V_{out} = V_{in} \times \frac{R_2}{R_1 + R_2}
\]

Figure 3. CRD5463PM Resistive Divider Voltage Sensor

The divider ratio is determined by the maximum \(V_{in}\) and the maximum input range of the CS5463 voltage channel. The maximum input range of the CS5463 voltage channel is 176 mV RMS. The division ratio shall be chosen to satisfy the equation:

\[
V_{in, max} \times \frac{R_2}{R_1 + R_2} < 176mV_{rms}
\]

To leave some margin, the Vout is normally set around 150 mVrms with the maximum \(V_{in}\). In the CRD5463PM, R2 is 1 kΩ. R1 is composed of four 422 kΩ resistors to increase the total voltage rating of the voltage sensor.

When \(V_{in} = 260 \text{ V RMS}, V_{out} = 260 \text{ V} \times 1 / [1 + (4 \times 422)] = 154 \text{ mV RMS.}
2.3 **Current Sensor**

The AC load current must be converted into a low-level voltage signal before being applied to the CS5463. A shunt resistor is a very common choice for current sensing in power monitoring applications because it is inexpensive, small, linear, and normally doesn't introduce phase shift.

![Figure 4](image)

**Figure 4. CRD5463PM Shunt Resistor Current Sensor**

Benefiting from its 50x gain amplifier and the low noise level on the current channel, the CS5463 can accommodate the ultra low-value shunt to achieve both low power dissipation at high current and high accuracy at low current.

The shunt resistance is determined by the maximum peak load current ($I_{peak}$) and the CS5463 current channel’s maximum input range. With the 50x PGA setting, the maximum input range of the CS5463’s current channel is 50 mVp. Therefore, the $R_{shunt}$ is chosen to satisfy the equation:

$$I_{peak} \times R_{shunt} < 50 \text{ mVp}$$

The power rating of the shunt should be at least twice the actual power dissipation of the shunt with the maximum continuous load current.

To measure the maximum of 15 A RMS and 23 A peak load current, the CRD5463PM uses a 2 mΩ, 1.5 W shunt resistor as the current sensor.

2.4 **CS5463 Power Measurement IC**

The power measurement device CS5463 is on the daughter board. The CS5463 is an integrated power measurement device which combines two ΔΣ analog-to-digital converter, power calculation engine and a serial interface on a single chip. The sensed line voltage and load current are first converted into 24-bit instantaneous values. The powerful on-chip DSP calculates voltage and current RMS values, active power, reactive power, apparent power, power factor, etc.

All these measurement values are available in specifically addressed 24-bit registers which can be accessed through SPI interface.

For more detailed information of the CS5463, please refer to the CS5463 datasheet.

2.5 ATtiny2313 Microcontroller

In addition to the CS5463 on the daughter board, an Atmel™ ATtiny2313 microcontroller is used to initialize the CS5463, convert the SPI into UART, and provide nonvolatile memory for the calibrations.

The ATtiny2313 is an MCU with SPI and UART interfaces, 2 kB Flash program memory and 128 bytes EEPROM data memory. The MCU acts as a communication bridge between the CS5463’s SPI interface and the UART of the UART-to-USB converter. The EEPROM data memory is used to store calibration information.

The hardware connections between the ATtiny2313 and the CS5463 are \text{RESET}, SCLK, \text{CS}, SDI, SDO, INT \text{(interrupt)}, and connection-configurable clock signals. Through the population of the 0 ohms resistor R15 or R16, the clock source can be shared between the CS5463 and the ATtiny2313. In the current version of the CRD5463PM, the CS5463 and ATtiny2313 are configured to use their own clock sources. The CS5463 uses a 4.096 MHz crystal and the ATtiny2313 uses its internal 8 MHz R-C oscillator.

On the daughter board, connector J4 is provided for programming and debugging the ATtiny2313 MCU.

\footnotesize{
\begin{center}
\textbf{WARNING}

High Voltage Hazard

The signal ground for the daughter board is the power line.

DO NOT CONNECT ANY DEBUGGING OR PROGRAMMING TOOLS TO THE J4 CONNECTOR WHEN AC LINE POWER IS CONNECTED.
\end{center}
}

Please consult with Cirrus Logic engineering if re-programming the MCU is desired.

For more detailed information of ATtiny 2313, please refer to the ATtiny2313 datasheet.

2.6 Isolated UART

Because the CRD5463PM uses non-isolated components as the current and voltage sensors, the signal ground of the CS5463 and MCU is the live connection to the main power. However, the signal ground of the PC USB port is normally chassis ground or earth ground. The electrical isolation must be fulfilled on the UART communication interface to allow the CRD5463PM to be connected to a PC through a USB cable without short-circuit and safety problems. The CRD5463PM uses 2 opto-couplers to isolate the UART interface. The isolation rating is 5300 V RMS.

2.7 UART-USB Interface- FT232R

A USB-to-UART interface IC, FT232R, is used on the main board to interface the CRD to a PC as a virtual COM port through the USB connection.

3. SOFTWARE CONTROL

The CRD5463PM comes with GUI software and a USB cable to link the CRD to a PC. The GUI was developed with Lab Windows™/CVI™, a software development package from National Instruments Corporation. The GUI software is available for download on the Cirrus Logic web site at:

\url{http://www.cirrus.com/industrialsoftware}

The software was designed to run under Windows 2000™ or Windows XP® operating system.
4. INSTALLATION PROCEDURE

4.1 Software Installation Procedure

FTDI drivers must be installed before the GUI software is launched. Please refer to the following document for details of how to install the drivers.

4.1.1 GUI Installation

1) Go to Cirrus Industrial Software download website (http://www.cirrus.com/industrialsoftware).
2) Click the link for the GUI desired.
3) Download the file onto the PC and unzip it. A new folder will be created.
4) Open the new folder and run the setup.exe file.
5) Follow the instructions presented by the installation wizard.
6) To Run the GUI, navigate to:
   Start > All Programs > Cirrus Power Monitoring Reference (CRD5463PM) > CRD5463PM

4.1.2 Driver Installation

Important: FTDI drivers must be installed before the GUI software is launched. Please refer to the following document for details of how to install the drivers.

4.2 Using the Software

Before launching the software, connect the CRD to an open USB port on the PC using the provided cable. Connect the CRD to the main power and the load using provided power cord and plug adaptor. Once the power has been switched on, the software program can be launched.

4.3 Main Window

When the software is launched, the Main window will appear. This window contains information concerning the software's title, revision number, copyright date, etc.

- At the top of the screen is a menu bar which displays user options. The menu bar has three items: System, Connect, and Help.
4.3.1 Connect Menu

The Connect menu allows user to establish a serial communication connection with CRD5463PM.

![Figure 6. CRD5463PM GUI Connect Menu](image)

4.3.2 System Menu

The System menu allows user to operate the power monitoring and re-calibrate the CRD when necessary.

![Figure 7. CRD5463PM GUI System Menu](image)
Quit allows the user to exit the evaluation software. Upon selecting Quit, a message window appears and queries if exiting the evaluation software is desired.

![Figure 8. CRD5463PM GUI Quit Dialog](image8.png)

### 4.4 Connect

After Connect to the CRD is selected under this menu, a sub-window will appear.

![Figure 9. CRD5463PM GUI Connect to CRD5463PM Window](image9.png)

Follow the instructions on the Connect to CRD5463PM window and the The CRD is connected. message will pop up if the connection has been established correctly.

![Figure 10. CRD5463PM GUI Successful Connection Message](image10.png)

Otherwise a error message will appear, indicating that the initial communication has failed.

![Figure 11. CRD5463PM GUI Connection Error Message](image11.png)

Check to verify that the USB cable and power cord are connected properly and the power switch is at the ON position.
4.5 Power Monitoring Window

After Monitor is selected under the System menu, the Power Monitoring window will appear. The Power Monitoring window provides the real time measurements.

![Power Monitoring Window](image1)

Figure 12. CRD5463PM GUI Power Monitoring Window

4.5.1 START and STOP Buttons

To start power monitoring, click the green START button in the window. The CRD will start continuous analog-to-digital conversion, compute the power parameters every N samples, and send calculation results to the GUI. The GUI software receives the data block from the CRD through the connected USB port (virtual COM port), convert the raw register values into true power values based on the calibration information read from the MCU internal EEPROM, and display the final measurement results in the window.

![Power Monitoring Window, Results Displayed](image2)

Figure 13. Power Monitoring Window, Results Displayed
4.5.2 Define Fundamental Frequency

During initialization, the CS5463 is configured to measure the fundamental frequency automatically – the AFC bit of the Mode register is set by the MCU. The Define Fundamental Frequency selection box enables the user to disable the automatic frequency calculation function and define the specific line frequency by changing the Epsilon register value.

![Power Monitoring Window, Define Fundamental Frequency Menu](image)

4.5.3 Change Measurement Period

The power measurement period or register refreshing rate depends on the CS5463 sample rate and the configuration of the CS5463 CycleCount (N) register. By default, N is 4000 and the measurement period is 1 second. The Measurement Period selection box is used to change the CS5463 CycleCount register value (N) and therefore, change the measurement period.

<table>
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<tr>
<th>Cycle Count (N)</th>
<th>Measurement Period (Seconds)</th>
<th>Refresh Rate (Hz)</th>
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<tr>
<td>8000</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>4000</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2000</td>
<td>0.5</td>
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<td>800</td>
<td>0.2</td>
<td>5</td>
</tr>
<tr>
<td>400</td>
<td>0.1</td>
<td>10</td>
</tr>
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</table>

![Power Monitoring Window, Measurement Period Menu](image)
4.6 Calibration Window

When Calibration is selected from the System menu in the main widow, the Calibration window will appear. The Calibration window is used to re-calibrate the CRD.

![Calibration Window](image)

**Figure 16. System Calibration Window**

4.6.1 Calibration Connections

A stable AC source, an accurate reference power meter, and a stable AC load are needed for calibration. Follow the connection diagram in the System Calibration window to connect the equipment and CRD. To minimize calibration error introduced by the voltage drop on the connection wires, the power cable between the CRD and the reference meter should be as short and as large gauge as possible.

4.6.2 Irms Offset Calibration

The CRD5463PM Irms offset calibration is to detect and save the residual value in the Irms register when the load is zero. This value represents the current channel noise level of the CRD. In normal power monitoring operation, this offset will be removed from the Irms register readings. The GUI also forces all the power measurements to be zero if the Irms register value is smaller than the offset. Follow the procedure below to operate the Irms offset calibration.

1) Turn on the power source and adjust the voltage to the nominal operation voltage.
2) Switch on the CRD5463PM.
3) Launch the GUI.
4) Open the System Calibration window
5) Turn off or remove the AC load.
6) Click the Irms Offset CAL button, the GUI will prompt the following message to confirm the load has been removed from the system.

![Calibration Process Confirmation](image)

**Figure 17. Calibration Process Confirmation Dialog**
7) Click the Yes button to proceed with the calibration process.
8) Wait for the completion of the process. The Irms Offset calibration takes about 4 seconds.

![Calibration Message]

The Calibration Completed.

Figure 18. Calibration Completed Dialog

4.6.3 Gain Calibration

The CRD5463PM gain calibration process is to detect and save the Vrms and Irms register values and associated true voltage and current values. In normal power monitoring operation, the GUI will use these values to convert the raw register data into true measurement results. The CRD needs gain calibration under one voltage and load condition only. Follow the procedure below to operate the gain calibration.

1) Turn on the AC source and adjust the voltage to the nominal operation voltage.
2) Switch on the CRD5463PM.
3) Launch the GUI.
4) Open the System Calibration window.
5) Turn on the load. The power factor of the load should be 1 and the load level should be in the range of your accuracy interest.
6) Enter the calibration condition, AC voltage and AC current with the voltage and current measurements from the reference meter.
7) Click the GAIN CAL button. The following message will pop up.

![Calibration process confirmation]

Please confirm that reference meter reading (V and A) matches the calibration condition entered. Do you want to proceed with the calibration process?

Yes  No

Figure 19. Calibration Process Confirmation Dialog

8) Wait for the completion of the process. The gain calibration takes about 5 seconds.

![Calibration Message]

The Calibration Completed.

Figure 20. Calibration Completed Dialog
5. SCHEMATIC

Figure 21. Schematic (Page 1 of 2)
Figure 22. Schematic (Page 2 of 2)
<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
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<th>Unit</th>
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7. BOARD LAYOUT

Figure 23. Component Placement (Top Silkscreen)
8. REVISION HISTORY

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<td>RD2</td>
<td>OCT 2010</td>
<td>Updated BOM, schematic, and layer plots to rev B.</td>
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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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