TI Designs

System on Module for Power Line Communication (CENELEC Frequency Band)

TI Designs

TI Designs provide the foundation that you need including methodology, testing and design files to quickly evaluate and customize the system. TI Designs help you accelerate your time to market.

Design Resources

<table>
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<th>Design Folder</th>
<th>Tool Folder</th>
<th>Product Folder</th>
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</thead>
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<tr>
<td>TIDM-SOMPLC-F28PLC84</td>
<td>TMDSPLCKIT-V4</td>
<td>TMS320F28PLC84</td>
</tr>
<tr>
<td>AFE031</td>
<td>TPS62240</td>
<td>TPS3828-33</td>
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<tr>
<td>SN74LVC2G07</td>
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</tbody>
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Design Features

- Small Size: 1.5” x 1.9”
- G3-PLC Compatible
- F28PLC84 PLC Engine With VCU
- Supports Cenelec A Frequency Band
- AFE031 Integrated Analog Front-End (AFE)
- 34-Pin Mini Header for Interfacing Other Designs
- Multiple Serial Communications Interfaces Available Including UART, SPI, I2C, and CAN
- Additional ADC Interface
- Additional GPIO Interfaces

Featured Applications

- PLC Modem
- Smart E-Meter: AMR and AMI
- Solar Power Inverter

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1 SOMPLC Description

The SOMPLC-F28PLC84 is a single-board System on Module (SOM) for PLC in the Cenelec A frequency band. This single hardware design supports several popular PLC industry standards including G3-PLC. TI's certified PLC software is available along with the SOMPLC-F28PLC84. Engineers can take the SOM design and integrate it into their overall system board or keep the design as an add-on board to their application. The only additional hardware required is the AC mains line coupling circuitry. The included hardware schematics and Gerber files simplify the task for engineers to add PLC to their end system. OEMs will benefit from having the ability to rapidly evaluate and prototype PLC technology in their application.

2 System Description

The TMS320F28PLC84 PLC MCU is optimized to meet the requirements for PLC networks in Smart Grid deployments around the world. The F28PLC84 MCU features the C28x 32-bit CPU and ROM codes for application boot loader and some PHY libs, which is capable of executing the narrowband OFDM PLC modem standards. These modem standards adhere to key international and industry standards such as PRIME, G3-PLC, IEEE-1901.2, and ITU G.9903/9904 in the CENELEC frequency bands. The F28PLC84 MCU is optimized to work with the AFE031. The AFE031 is an integrated PLC AFE that is capable of a transformer coupled connected to the AC mains power line. The device is ideal for driving high-current, low-impedance lines driving up to 1.9 A into reactive loads. The AFE031 is compliant to CENELEC A, B, C, and D (EN50065-1, -2, -3, and -7, respectively).

2.1 PLC Development Kit Components

The development kit includes the following hardware:

- Two sets of development board with each set containing:
  - SOMPLC-F28PLC84 (TMS320F28PLC84+AFE031)
  - One docking board

The development kit includes the following software:

- PLC binaries
- PC software and GUI
  - Zero configuration GUI

The PLC software package includes the following documents:

- Software API specification
  - Host message protocol specifications
- Hardware documents
  - AFE daughter card schematics and Gerber files
  - Docking board/SOM schematics and Gerber files
  - Bill of Materials (BOM)
3 Boot Modes (SW1 Positions)

Boot mode can be selected using the switch SW1. Figure 1 describes the available settings:

![Flash Boot Mode (Default Setting)]

Position 1: OFF
Position 2: OFF

![SCI-A Boot Mode]

Position 1: OFF
Position 2: ON

Figure 1. Boot Modes

4 UART SCI Communication

To communicate with the SCI, meet the following requirements:

- Baud Rate = 57600
- Message Data Bits = 8
- Stop Bits = One
- Parity = None
- Handshake = None
- RTS Enable = True

NOTE: The SOMPLC does not have a RS-232 driver. Consider communications to RS-232 devices external to this design.
5 SOMPLC 34-Pin Definition

This module supports the following interfaces:

<table>
<thead>
<tr>
<th>Required Connections</th>
<th>Optional Connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>• SCI (UART)</td>
<td>• ADC</td>
</tr>
<tr>
<td>• Line</td>
<td>• GPIOs</td>
</tr>
<tr>
<td>• 15 V</td>
<td>• SCI (UART)</td>
</tr>
<tr>
<td>• 3V3</td>
<td>• CAN</td>
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<tr>
<td>• GND</td>
<td>• SPI</td>
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<td></td>
<td>• I^2C</td>
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<td>• Zero Cross</td>
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<td>• Analog GND</td>
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<td>RX-A</td>
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<td>TX-A</td>
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<td>13</td>
<td>Phase B/GPIO</td>
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<td>I/O</td>
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<td>O</td>
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</table>
6 Mechanical Specification

The connectors used on the SOMPLC are as follows:

- A male 0.05-mil header (2×17) is placed on the SOMPLC module.
  - This connector is keyed so that the module cannot be placed backwards.
  - An example part that will fit this design is a Sullins Connector Solutions, Part number: SBH31-NBPB-D17-SP-BK, Digikey Part number: S9108-ND

- A female 0.05-mil receptacle (2×17) should be used on the host board to mate with the SOMPLC module.
  - This connector is keyed and should follow the appropriate orientation as the male connector.
  - An example part that will fit this design is a Sullins Connector Solutions, Part Number: SFH31-NPPB-D17-SP-BK, Digikey Part Number:S9117-ND

The top view of the female connector which would be placed on the host board is shown in Figure 2.

![Figure 2. Pin Female Connector Top View](image-url)
7  PLC SOM Programming

Depending on the end use of the SOM, different versions of the PLC software may be programmed to the module.

For this design, download the G3-PLC software package from the link given in Section 10.6 and check out the G3-PLC binaries (.hex/.out/.sbin) under installation directory.

7.1  Using the XDS100 and CodeSkin to Program the F28PLC84 MCU

Programming with this method eliminates the need for Code Composer Studio™ (CCS) to load the release(.out) file. A .hex release file is used instead; therefore, installing CCS is not necessary.

1. Install the desired Texas Instruments PLC Development Package from www.ti.com/plc.
3. Set switch SW1 to “FLASH Boot Mode” as described in Section 3.
4. Connect a Texas Instruments XDS100 class emulator to the SOM module using the 14-Pin JTAG header.
5. Power up SOM module by applying both 15 V and 3.3 V through the 34-pin host connector.
6. Program the *.hex (located in c:\Texas Instruments\<PackageName>\SW\bin) as shown in Figure 3. Select “28069,67,66” in the Target pull-down and “JTAG” in the Options pull-down.

![Figure 3. Selecting G3-PLC Binary to be Flashed (Through XDS100)](image-url)
7. Click on the *Configure Ports* button and set the JTAG port to "XDS100v1".

![Port Configuration](image)

Figure 4. Selecting JTAG Port (Through XDS100)

8. Start flashing the F28069.

![Figure 5. Flashing G3-PLC Firmware (Through XDS100)](image)

9. Once the programming procedure is complete, power cycle the device.
7.2 Using CCS and JTAG Emulator to Program the F28PLC84 MCU

If the XDS100 emulator is not available, it will be necessary to use CCS and a XDS510 or XDS560 emulator to program the device. Install CCS V5.5 or higher before following this procedure:

1. Install the desired Texas Instruments PLC Development Package from www.ti.com/plc.
2. Set switch SW1 to “FLASH Boot Mode” as described in Section 3. When a JTAG emulator is used, it is capable of interrupting the set boot mode to gain control of the MCU. When the programming procedure is complete, set the mode to “FLASH Boot Mode” for the SOM module to continue to work properly.
3. Power up SOM module by applying both 15 V and 3.3 V through the 34-pin host connector.
4. Connect the emulator to the SOM module with the 14-pin JTAG cable.
5. Open CCS.
6. Create a F28069 target configuration.
7. Connect to the F28069 device.
8. Load the PLC specific .out firmware located in c:\Texas Instruments\<PackageName>\SW\bin. CCS will automatically flash the firmware onto the F28069 device.
8 Test Setup

To test the SOM modules, the operator will need the following items:

• A host computer running Windows® XP® or Windows 7® and two available USB ports
• Two SOM docking stations
• 15-V external power supply for each docking station
• Power line connector for each docking station
• USB cable for connecting to Host PC for each docking station
  – A single Host PC can be shared between the two kits
• Zero configuration GUI
  – Requires a modified .config file
8.1 Setup

1. Plug in the included SOM module to each 34-pin SOM module connector.

2. Connect Neutral and Line (marked with words on AC Power Cable) to the power grid connector P1 of each kit; make sure the neutral and line connections are not shorted.

3. Ensure the position of switches SW1 and SW2 are set to default setting as shown in fig to communicate to PC GUI through SCI-A.

Figure 6. SOMPLC Docking Station

Figure 7. Line Connection

Figure 8. Software Configuration
8.2 **Power Up**

1. Connect the 15-V wall-mounted power supply to the AC receptacle of each kit.

![Image of SW3 switch positions](image)

*Figure 9. SW3*

2. Turn ON Switch SW3 of each kit to power the boards.

8.3 **Connecting to a PC**

1. Plug in the micro-USB to the kit and connect the USB cable to the PC. Repeat this step for the second kit.

**NOTE:** The program may ask for USB-Serial drivers to be installed. If this occurs, please proceed to install the drivers. The drivers can be found in C:\Texas Instruments\PackageName\XDS100 Drivers. Reboot your PC after the drivers are installed, even if you are not asked by windows to do so.

2. Verify the modems have been installed correctly by using the *Device Manager* (*Start*→*Control Panel*→*System*→*Device Manager*→*Ports*)

**NOTE:** The four ports on picture are for two boards.

![Image of Device Manager](image)

*Figure 10. Device Manager: Port Configuration*
Testing

1. Install the "Zero Configuration" tool from C:\TexasInstruments\<PackageName>\Tools, and launch it. When operating one PC, it will be necessary to launch two instances, one for each modem.

2. When the Zero Configuration GUI opens, it will use the first available COM port to attach to a PLC.

**NOTE:** Ensure Diagnostic Port/Data Port is configured to SCI-A by selecting CTRL+A in GUI window.

**Figure 11. Zero Configuration GUI**
3. Connect each PLC kit to the power line. Ensure that devices are connected on same power line phase.

**WARNING**

HIGH VOLTAGE! Use caution when connecting to the power grid. If there is concern about connecting to the power grid, use a power strip to connect the two modems together. In this case, the power strip does *not* need to be plugged into the power grid.

Figure 12. Testing Setup
4. Enter the desired text into the Message Window. Press the Send Message button. The message will then be received by the other GUI.

Figure 13. P2P Test With Zero Configuration GUI
The *File Transfer* function contained in the bottom left hand corner of GUI option can be used to transfers files.

![Figure 14. File Transfer TX](image)

The diagram shows the File Transfer window with details such as file paths, file transfer status, and key performance metrics. The window also includes options for sending, canceling, and browsing files.
5. Click on the **Browse** button to display the standard windows file chooser dialog to choose the file you wish to transfer. Only one file at a time may be chosen for the file transfer.

After the file is chosen, click on the **Transfer File** button. The other PLC must also be controlled by the Zero Configuration GUI.

When the transfer starts the GUI will display a progress bar on both Zero Configuration GUIs. The GUI in Figure 15 is the receiving Zero Configuration GUI and displays the path and file name where the received file is being copied. The user is not allowed to change the directory path of the received file.

![Figure 15. File Transfer RX](image-url)
When the file transfer is complete the message box shown in Figure 16 will be displayed on both Zero Configuration GUIs.

**Figure 16. Message Box**

If the file transfer fails, one of the following message boxes will be displayed by the sending GUI.

**Figure 17. Case 1: File Transfer Failed**

**Figure 18. Case 2: File Transfer Failed**
10 Design Files

10.1 Schematics
To download the most recent schematics, see the design files at TIDM-SOMPLC-F28PLC84.

NOTE: The transformer may not be necessary in a production design.

10.2 Bill of Materials
To download the most recent bill of materials (BOM), see the design files at TIDM-SOMPLC-F28PLC84.

10.3 Layer Plots
To download the most recent layer plots, see the design files at TIDM-SOMPLC-F28PLC84.

10.4 Gerber Files
To download the most recent Gerber files, see the design files at TIDM-SOMPLC-F28PLC84.

10.5 Assembly Drawings
To download the most recent assembly drawings, see the design files at TIDM-SOMPLC-F28PLC84.

10.6 Software Files
To download the most recent software files, see the design files at TIDM-SOMPLC-F28PLC84.

11 About the Author

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