

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

TIDM-SOMPLC-F28PLC84	Design Folder
TMDSPCLKIT-V4	Tool Folder
TMS320F28PLC84	Product Folder
AFE031	Product Folder
TPS62240	Product Folder
TPS3828-33	Product Folder
SN74LVC2G07	Product Folder

Design Features

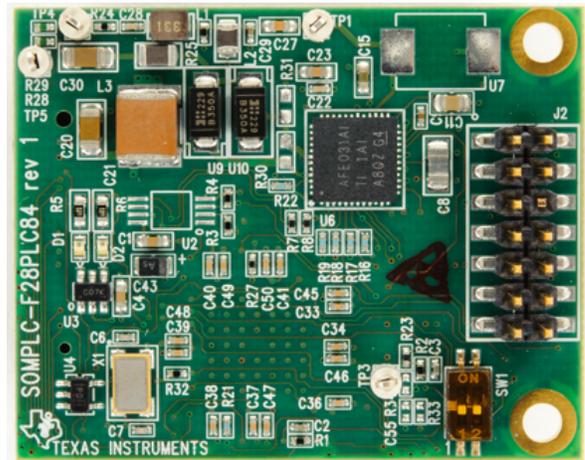
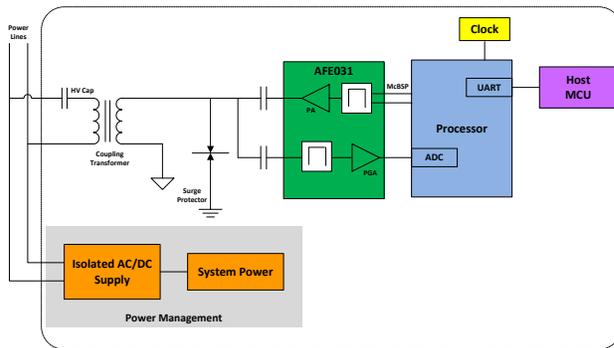
- Small Size: 1.5" x 1.9"
- G3-PLC Compatible
- F28PLC84 PLC Engine With VCU
- Supports Cenelec A Frequency Band
- AFE031 Integrated Analog Front-End (AFE)
- 34-Pin Mini Header for Interfacing Other Designs
- Multiple Serial Communications Interfaces Available Including UART, SPI, I2C, and CAN
- Additional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

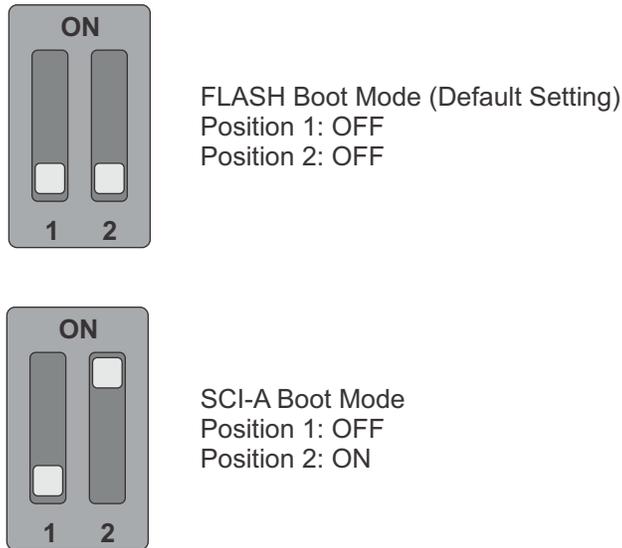


Figure 1. Boot Modes

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:

Required Connections

- SCI (UART)
- Line
- 15 V
- 3V3
- GND

Optional Connections

- ADC
- GPIOs
- SCI (UART)
- CAN
- SPI
- I²C
- Zero Cross
- Analog GND

Table 1. 34-Pin Connector

PIN#	NAME	I/O	ELECTRICAL	DESCRIPTION
1	L1	I/O	0 V (GND)	Neutral (analog ground), connected to the PL coupler
2	L2	I/O	0 V (±6-V Peak)	Analog PLC signal, connected to the PL coupler
3	NC	NC	—	Unused
4	NC	NC	—	Unused
5	GND	—	—	Ground
6	GND	—	—	Ground
7	V15	—	15 to 18 V	Power supply pin (15 V). Peak current 400 mA in transmit mode (average 100 mA).
8	3V3	—	3.14 to 3.47 V	CPU and Logic Digital Power pin (3.3 V). Max current 1000 mA.
9	EN	I-I/O	-0.3 V to VCC+0.3 V	System enable (logical level, active high). Controls power up/down function of the module. When low, the module goes to power down mode. This feature is not yet implemented in software or GPIO13.
10	ZC	I	-0.5 to 6.5 V	Buffered ZC input. This input must be isolated from the power line before entering this pin.
11	RX-A	I	-0.3 V to VCC+0.3 V	Asynchronous serial host-transmit, SCI-A
12	TX-A	O	-0.3 V to VCC+0.3 V	Asynchronous serial host-receive, SCI-A
13	Phase B/GPIO	I-I/O	-0.3 V to VCC+0.3 V	Phase B Enable signal (for 3-phase selection) or GPIO5
14		I/O	-0.3 V to VCC+0.3 V	Phase C enable signal (for 3-phase selection) or GPIO10
15		I/O	-0.3 V to VCC+0.3 V	I ² C data pin
16		I	-0.3 V to VCC+0.3 V	I ² C clock pin
17		I	-0.3 V to VCC+0.3 V	Unused ADC input. (ADC-B0)
18		—	—	Analog ground
19		I/O	-0.3 V to VCC+0.3 V	Unused multi-purpose I/O, GPIO26
20		—	—	Ground
21		I/O	-0.3 V to VCC+0.3 V	Unused multi-purpose I/O, GPIO27
22		—	—	Ground
23		I-I/O	-0.3 V to VCC+0.3 V	CAN RX interface or GPIO30
24		O-I/O	-0.3 V to VCC+0.3 V	CAN TX interface or GPIO31
25		I	-0.3 V to VCC+0.3 V	SPI clock or general purpose I/O (GPIO18)
26		I	-0.3 V to VCC+0.3 V	SPI slave transmit enable or general purpose I/O (GPIO19)
27		I	-0.3 V to VCC+0.3 V	SPI slave in, master out or general purpose I/O (GPIO16)
28		O	-0.3 V to VCC+0.3 V	SPI master in, slave out or general purpose I/O (GPIO17).
29		I	-0.3 V to VCC+0.3 V	Reset of SOMPLC (active low)
30		I/O	-0.3 V to VCC+0.3 V	Unused multi-purpose I/O pin, GPIO04.
31		NC	—	Unused
32		NC	—	Unused
33		I	-0.3 V to VCC+0.3 V	Asynchronous serial host-receive, SCI-B
34		O	-0.3 V to VCC+0.3 V	Asynchronous serial host-transmit, SCI-B

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](#).

	1	2
	3	4
	5	6
	7	8
	9	10
	11	12
	13	14
	15	16
	17	18
	19	20
	21	22
	23	24
	25	26
	27	28
	29	30
	31	32
	33	34

Figure 2. Pin Female Connector Top View

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.
2. Download, install, and start the latest C2Prog from <http://www.codeskin.com>.
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.

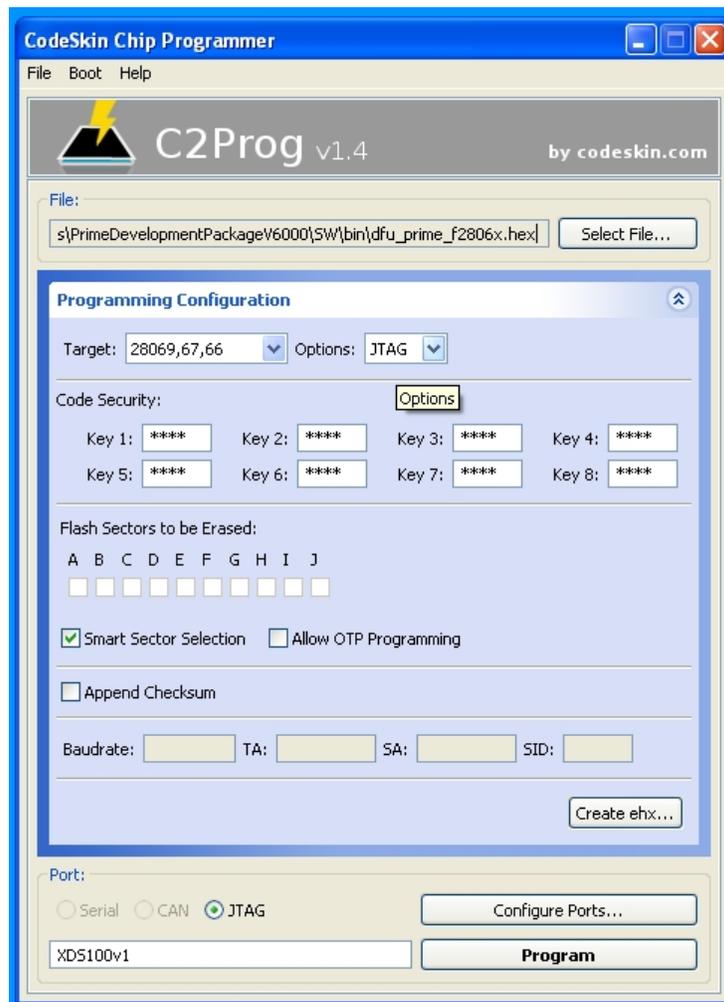


Figure 3. Selecting G3-PLC Binary to be Flashed (Through XDS100)

- Click on the *Configure Ports* button and set the JTAG port to "XDS100v1".

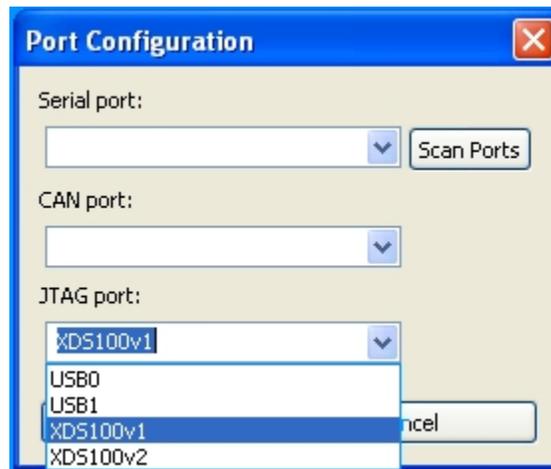


Figure 4. Selecting JTAG Port (Through XDS100)

- Start flashing the F28069.

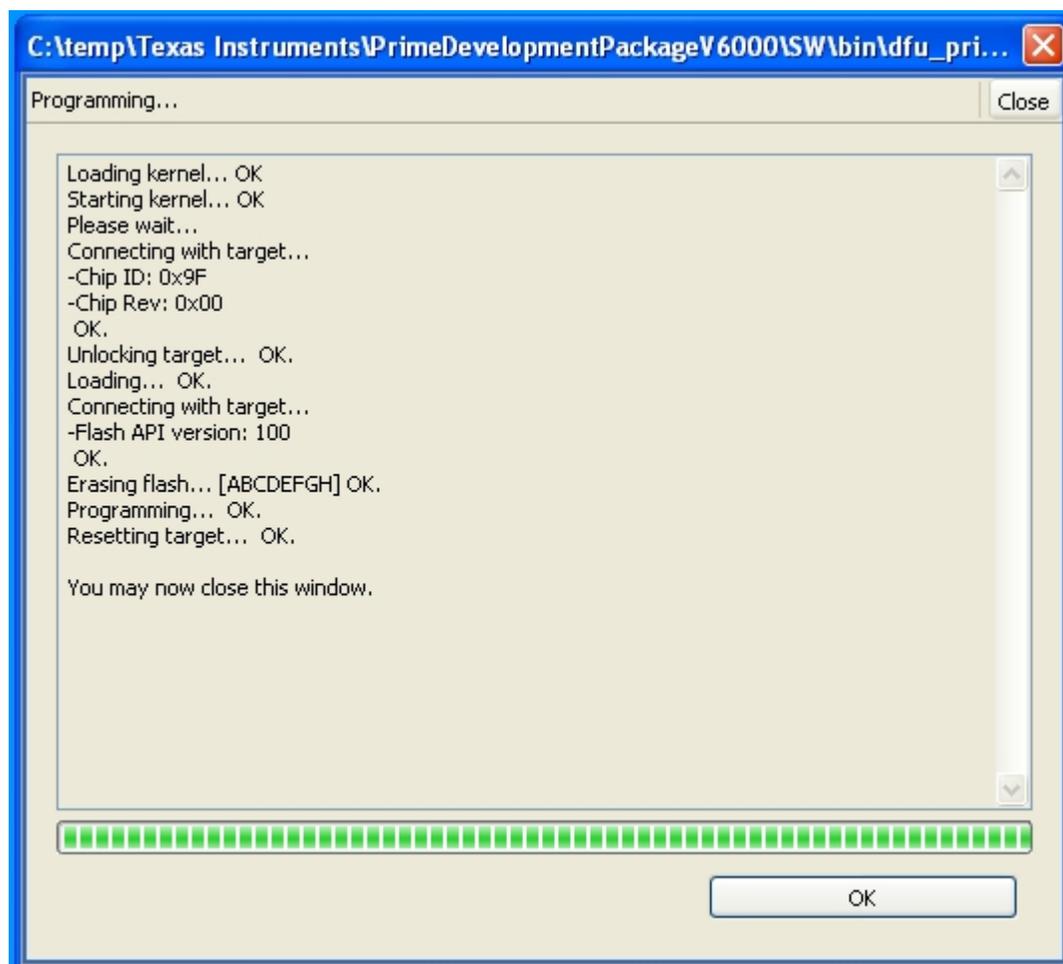


Figure 5. Flashing G3-PLC Firmware (Through XDS100)

- 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\\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.

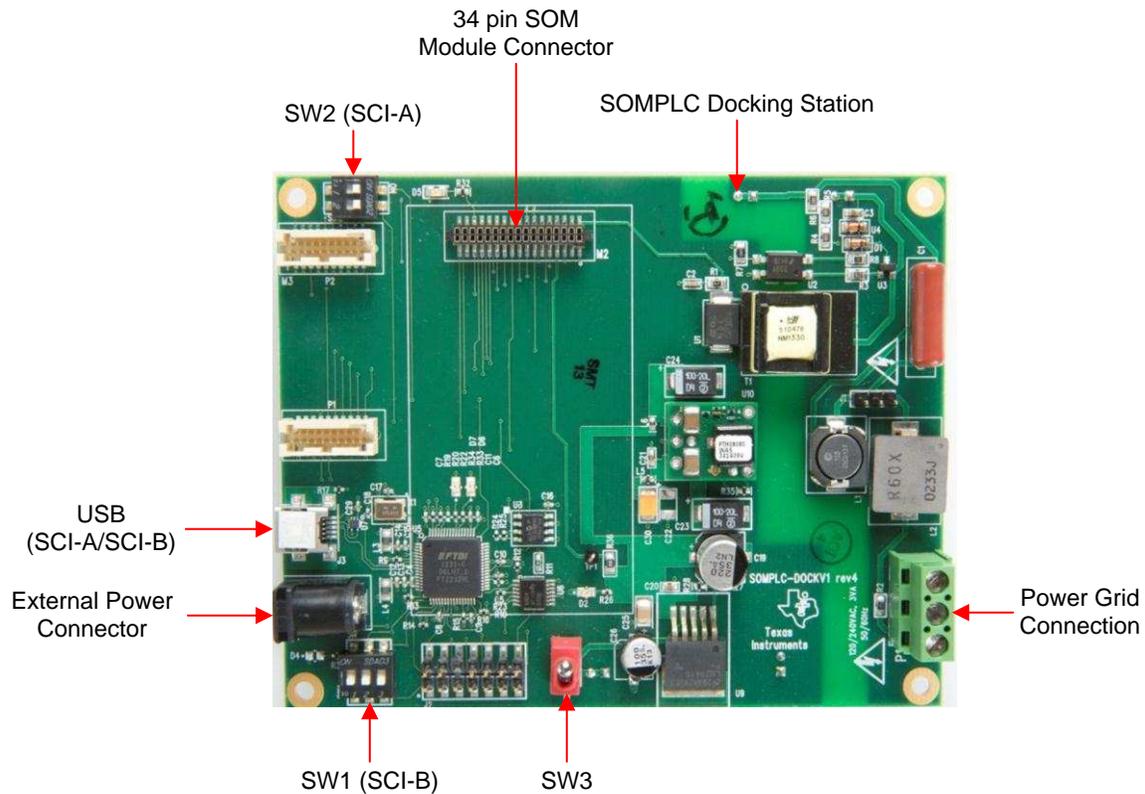


Figure 6. SOMPLC Docking Station

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.



Figure 7. Line Connection

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.

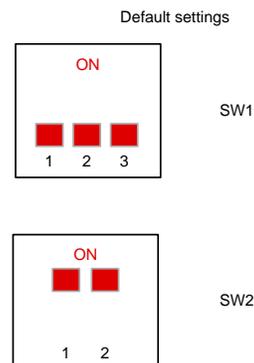


Figure 8. Software Configuration

8.2 Power Up

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

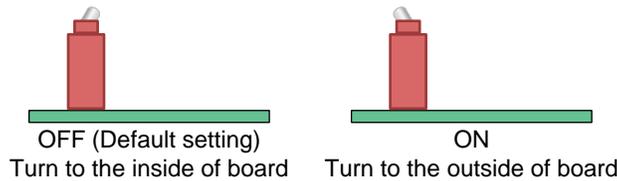


Figure 9. SW3

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.

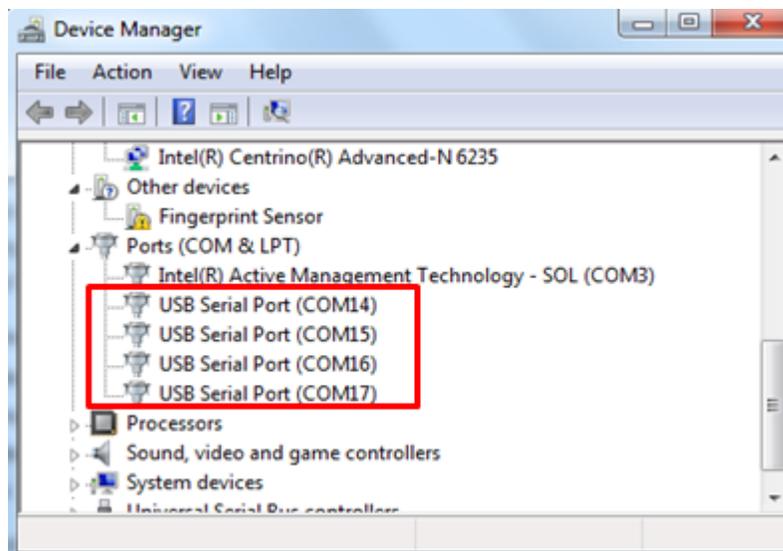


Figure 10. Device Manager: Port Configuration

9 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.

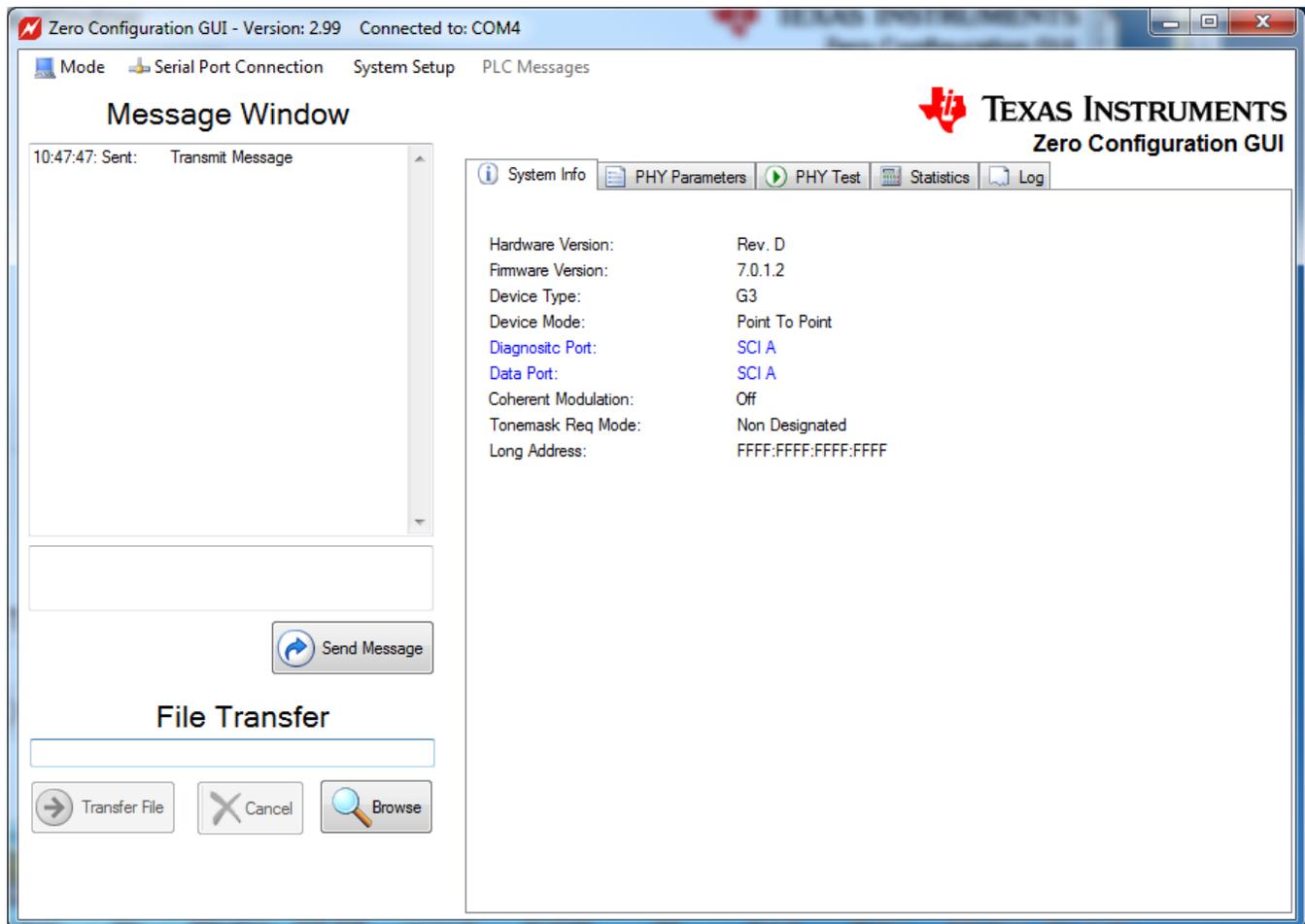


Figure 11. Zero Configuration GUI

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.

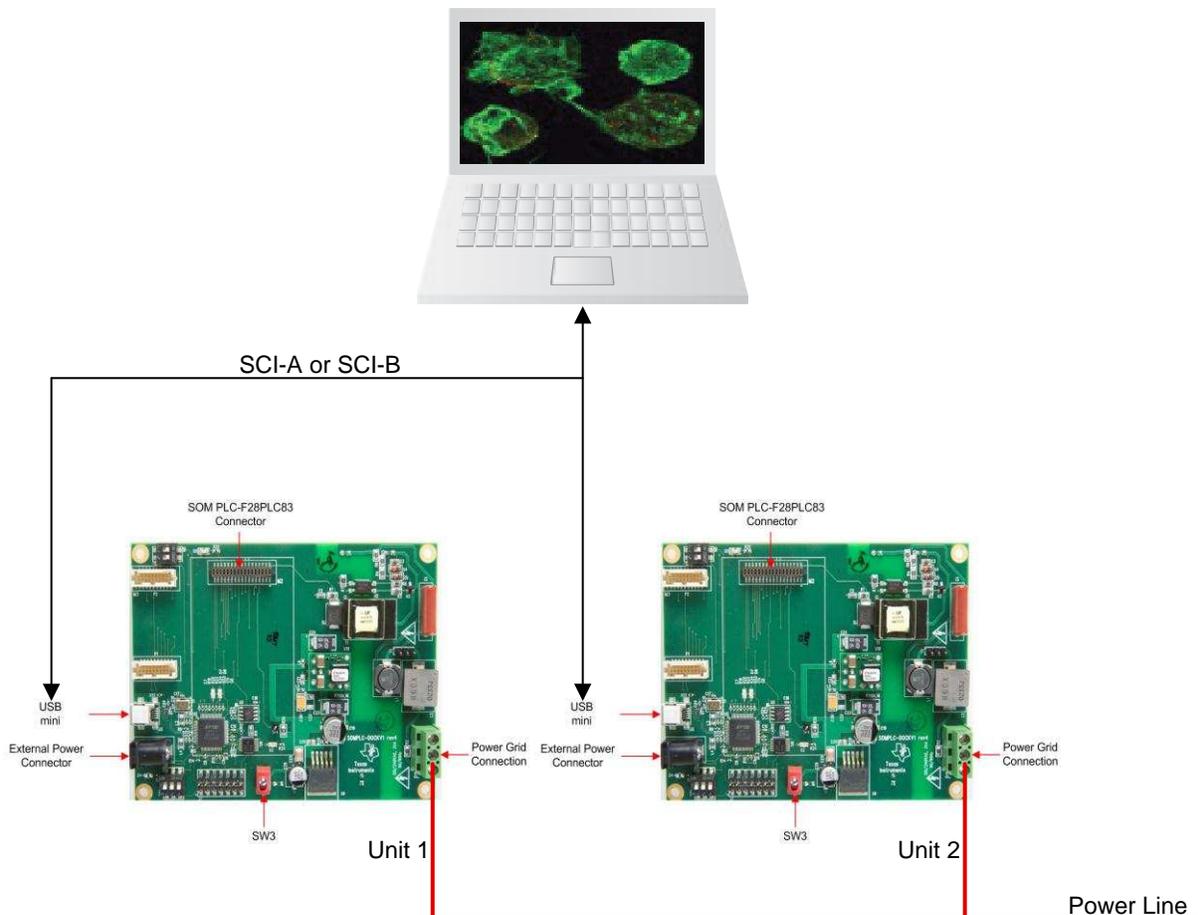


Figure 12. Testing Setup

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

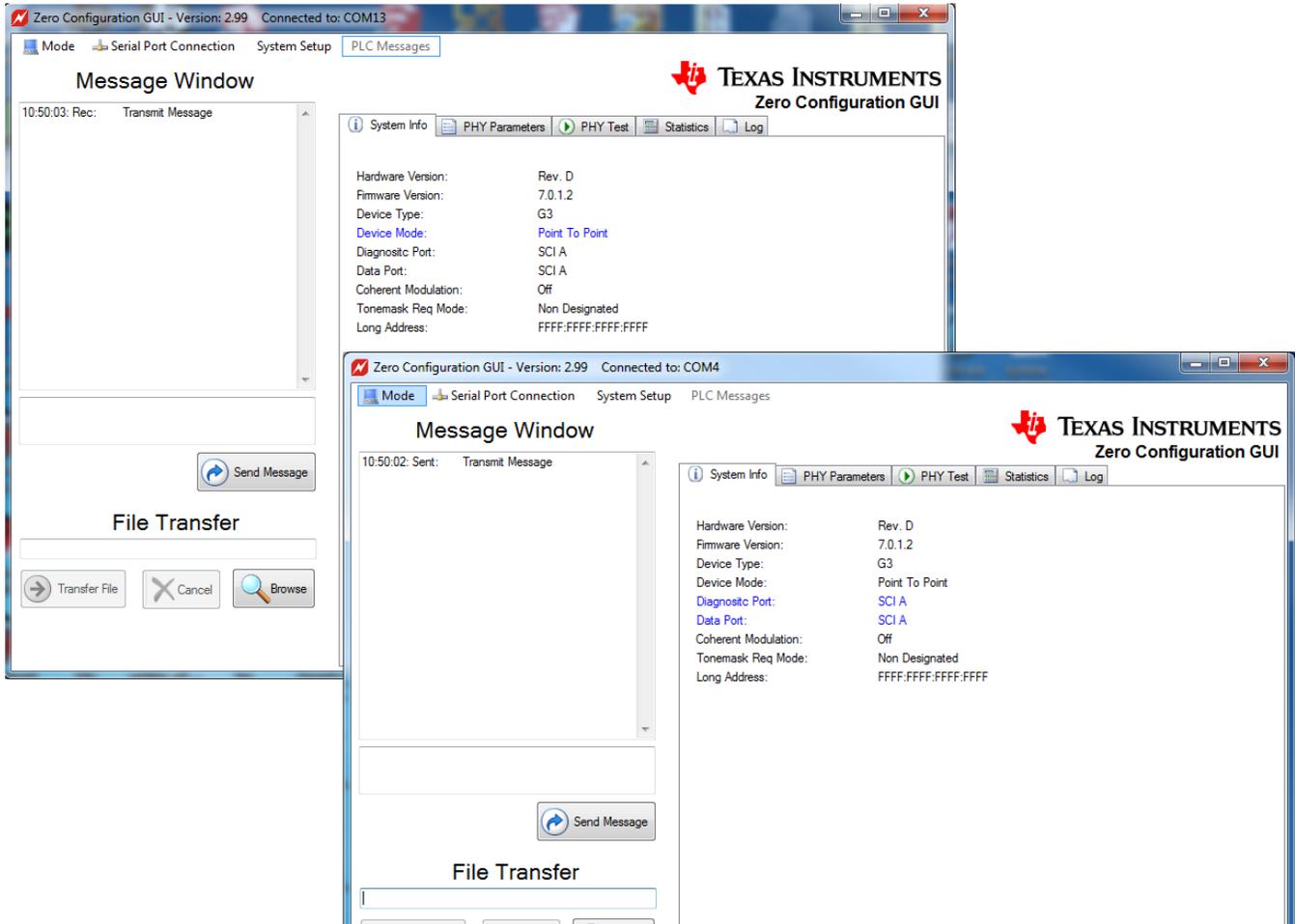


Figure 13. P2P Test With Zero Configuration GUI

The *File Transfer* function contained in the bottom left hand corner of GUI option can be used to transfers files.

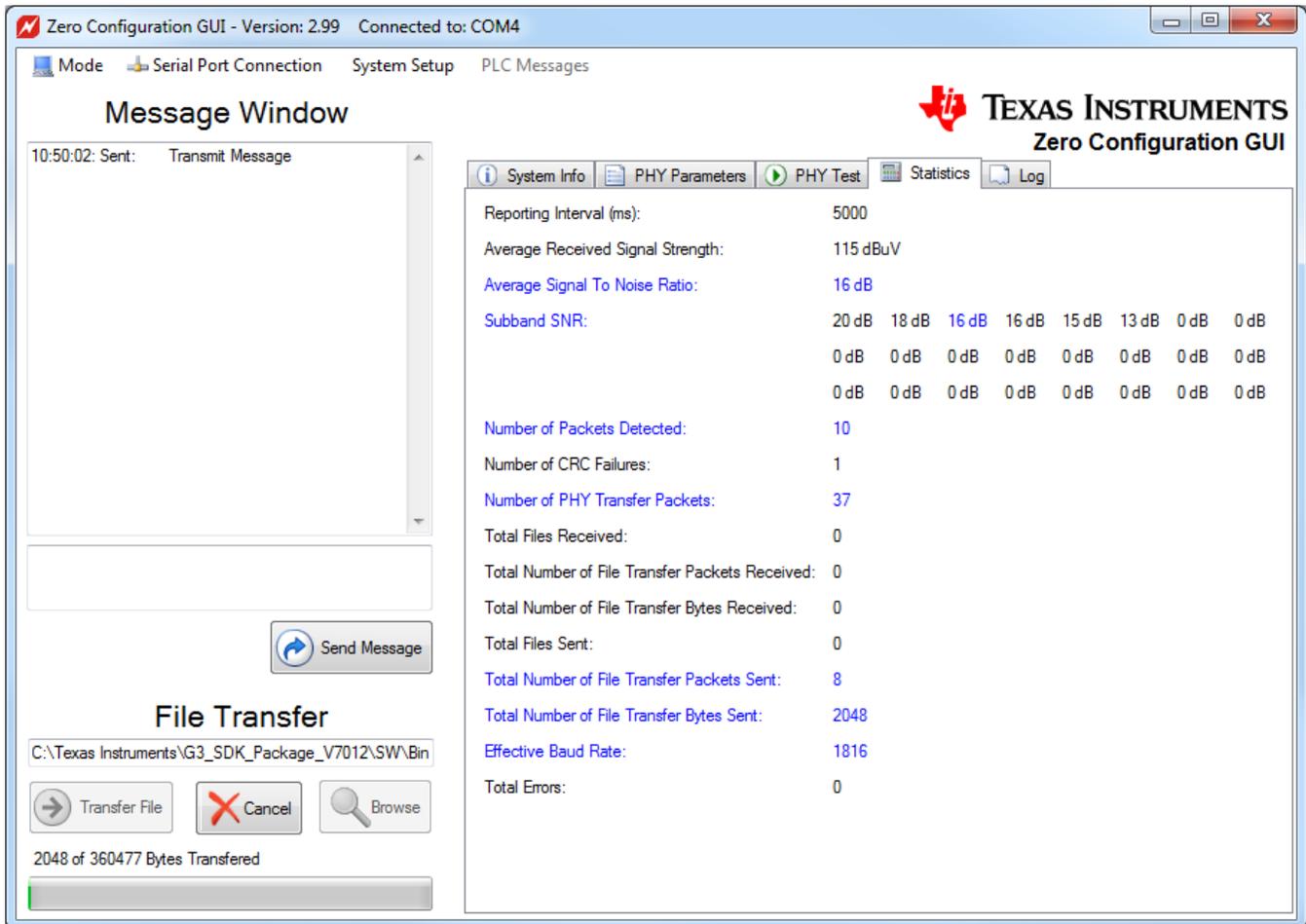


Figure 14. File Transfer TX

- 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

When the file transfer is complete the message box shown in [Figure 16](#) will be displayed on both Zero Configuration GUIs.

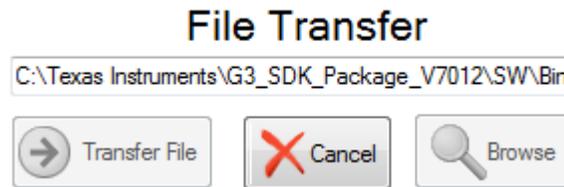


Figure 16. Message Box

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

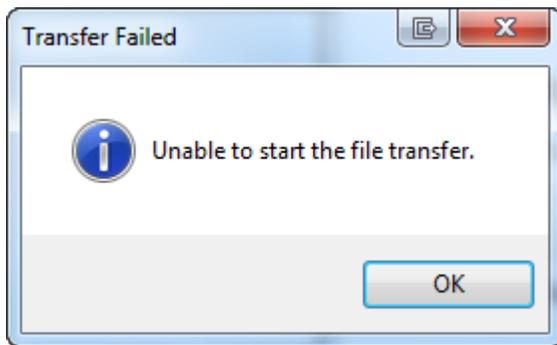


Figure 17. Case 1: File Transfer Failed

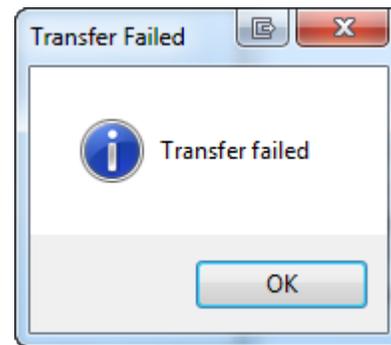


Figure 18. Case 2: File Transfer Failed

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

WONSOO KIM is a system applications engineer at Texas Instruments, where he is responsible for providing technical support and training on communication software and system for smart grid applications and driving solutions for Smart Grid and Metering, and working on defining future requirements in roadmap. He received the Ph.D. degree in electrical and computer engineering, the University of Texas at Austin.

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