*TI Designs*

# *Power Line Communication Motherboard with AC Mains Line Coupling*

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## Design Resources

| | |
|---|---|
| TIDA-00192 Tools Folder | Tool Folder Containing Design Files |
| TIDM-SOMPLC-F28PLC83 | Related TI Design |
| TIDM-SOMPLC-F28M35-F28M35 | Related TI Design |
| PTH08080W | Product Folder |
| SN74HC03 | Product Folder |
| SN74LVC1G57 | Product Folder |
| TPD2E001 | Product Folder |

## Design Features

- Line Coupling Circuitry to Connect to Mains Power
- 15-V Input Voltage
- Supports CENELEC, FCC, and ARIB Frequency Bands
- Supports PRIME, G3, and IEEE-1901.2 PLC industry Standards
- USB Serial Port
- 5-V and 3.3-V Power Conversion
- Zero Crossing Circuitry
- 34-pin Mini-Header Provides Flexibility for Interfacing to Custom Board and Other TI Designs such as SOMPLC-F28PLC83 and SOMPLC-F28M35

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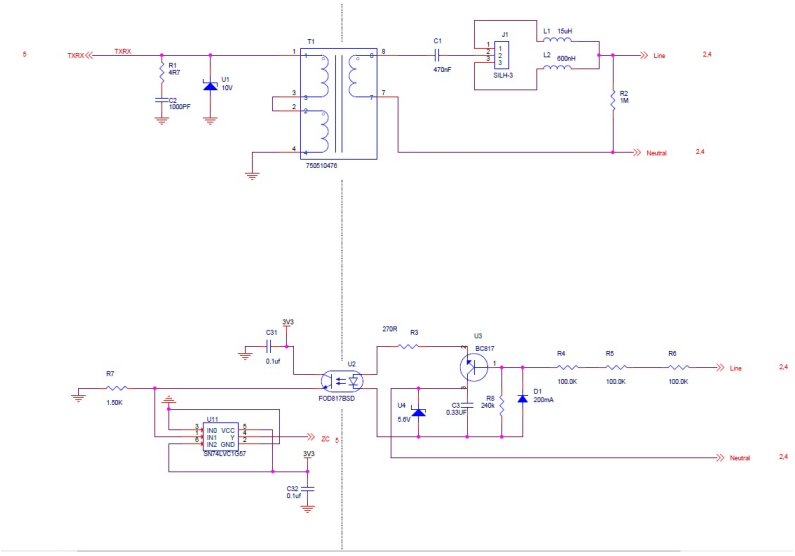


An IMPORTANT NOTICE at the end of this TI reference design addresses authorized use, intellectual property matters and other important disclaimers and information.

# 1 System Description

The Power Line Communication (PLC) motherboard is designed to complement TI Designs TIDM-SOMPLC-F28PLC83 and TIDM-SOMPLC-F28M35-F28M35. The PLC motherboard implements the key AC line coupling circuitry necessary for the System on Module (SoM) to connect to the mains power (line power). The PLC motherboard also includes expansion headers for RF modules, which simplifies the development of a combined PLC+RF system.

The hardware for TIDA-00192 can be ordered at TIDA-00192.

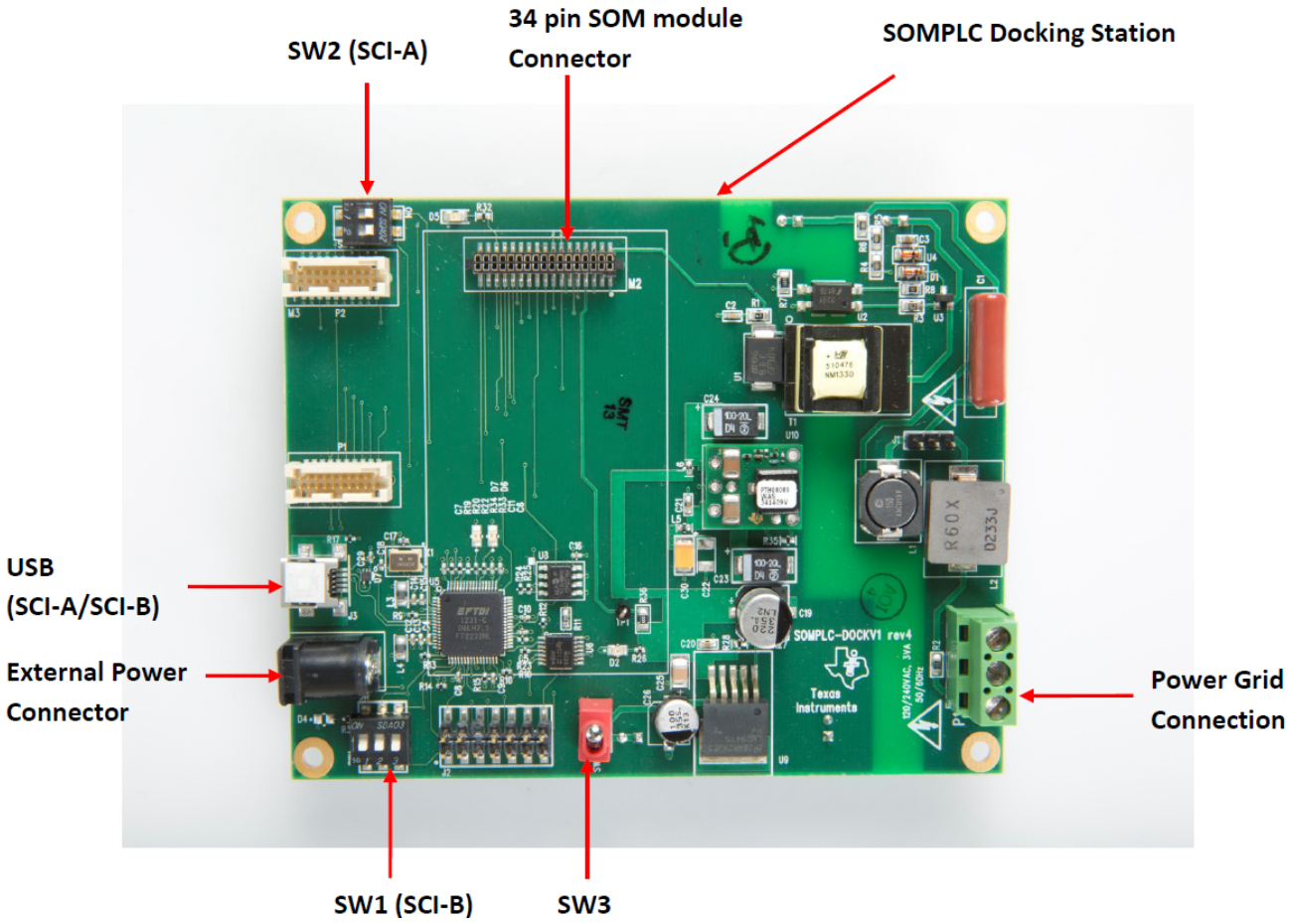



**Figure 1. TIDA-00192 PLC Docking Board**

The PLC docking board contains the following main components and supported features:

- The 34-pin connector provides flexibility to plug in SOM modules to evaluate CENELEC/FCC/ARIB solutions. Some of the supported SOM modules are TIDM-SOMPLC-F28PLC83 and TIDM-SOMPLC-F28M35-F28M35.
- Examples of operating frequency range are shown below:

| | CENELEC | | | | FCC | | | ARIB | |
|---|---|---|---|---|---|---|---|---|---|
| **Band** | **A** | **B** | **BC** | **BCD** | **Low** | **High** | **Full** | **Low** | **High** |
| Frequency (kHz) | 35.9 to 90.6 | 98.4 to121.9 | 98.4 to 137.5 | 98.4 to 146.9 | 145.3 to 314 | 314 to 478.1 | 145.3\ to 478.1 | 10 to 200 | 20 to 450 |

- Data rates from 5.592 kbps to 34.16 kbps (at 36 tones per symbol) for Cenelec A band and up to 289 kbps for FCC band
- Transmission with OFDM and FEC
- Number of used data carriers up to 36 for Cenelec and 72 for FCC
- Differential phase modulation (ROBO/DBPSK/DQPSK/D8PSK)
- Reed Solomon encode/decode and repetition code
- Convolutional encoder/Viterbi decoder
- Bit interleaving for noise effect reduction
- CRC5 in FCH and CRC16 in data for error detection
- Data randomization for uniform power distribution
- Tone mask for SFSK coexistence
- Adaptive tone mapping and transmit power control
- Automatic gain control
- Zero-crossing detection
- Supports G3 PHY, MAC and adaptation layer
- SCI-A/SCI-B serial interface to communicate to PC GUI

## 2 34-Pin Definition

The interfaces supported on this module are the following:

| REQUIRED CONNECTIONS | OPTIONAL CONNECTIONS |
|---|---|
| ● SCI (UART) | ● ADC |
| ● Line | ● GPIOs |
| ● 15V | ● SCI (UART) |
| ● 3V3 | ● CAN |
| ● GND | ● SPI |
| | ● I2C |
| | ● Zero Cross |
| | ● Analog GND |

**Table 1. 34-Pin Connector**

| PIN# | NAME | I/O | ELECTRICAL | DESCRIPTION |
|---|---|---|---|---|
| 1 | L1 | I/O | 0V (GND) | Neutral (Analog Ground), connected to the PL coupler |
| 2 | L2 | I/O | 0V (±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 V to 18 V | Power supply pin (15 V). Peak current 400 mA in transmit mode (average 100 mA). |
| 8 | 3V3 | – | 3.14 V to 3.47 V | CPU and Logic Digital Power pin (3.3V). Max current 1000 mA. |
| 9 | EN | I-I/O | –0.3 V to ($V_{CC}$ + 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 V 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 ($V_{CC}$ + 0.3 V) | Asynchronous serial host-transmit, SCI-A |
| 12 | TX-A | O | –0.3 V to ($V_{CC}$ + 0.3 V) | Asynchronous serial host-receive, SCI-A |
| 13 | Phase B/GPIO | I-I/O | –0.3 V to ($V_{CC}$ + 0.3 V) | **Phase B Enable signal (for 3 phase selection) or GPIO5** |
| 14 | Phase C/GPIO | I/O | –0.3 V to ($V_{CC}$ + 0.3 V) | Phase C Enable signal (for 3phase selection ) or GPIO10 |
| 15 | SDAA | I/O | –0.3 V to ($V_{CC}$ + 0.3 V) | $I^2C$ data pin |
| 16 | SCLA | I | –0.3 V to ($V_{CC}$ + 0.3 V) | $I^2C$ clock pin |
| 17 | ADC-B0 | I | –0.3 V to ($V_{CC}$ + 0.3 V) | Unused ADC input. (ADC-B0). |
| 18 | AGND | – | – | Analog ground |
| 19 | GPIO26 | I/O | -0.3 V to ($V_{CC}$ + 0.3 V) | Unused multi-purpose IO, GPIO26 |
| 20 | GND | – | – | Ground |
| 21 | GPIO27 | I/O | -0.3 V to ($V_{CC}$ + 0.3 V) | Unused multi-purpose IO, GPIO27 |
| 22 | GND | – | – | Ground |
| 23 | CAN RX/GPIO | I-I/O | -0.3 V to ($V_{CC}$ + 0.3 V) | CAN RX interface or GPIO30 |
| 24 | CAN TX/GPIO | O-I/O | -0.3 V to ($V_{CC}$ + 0.3 V) | CAN TX interface or GPIO31 |
| 25 | CLKA/GPIO | I | -0.3 V to ($V_{CC}$ + 0.3 V) | SPI clock or general purpose I/O (GPIO18). |
| 26 | STEA/GPIO | I | -0.3 V to ($V_{CC}$ + 0.3 V) | SPI Slave Transmit Enable or general purpose I/O (GPIO19). |
| 27 | SIMOA/GPIO | I | -0.3 V to ($V_{CC}$ + 0.3 V) | SPI Slave in, Master out or general purpose I/O (GPIO16). |
| 28 | SOMIA/GPIO | O | -0.3 V to ($V_{CC}$ + 0.3 V) | SPI Master in, Slave out or general purpose I/O (GPIO17). |
| 29 | System RESET | I | -0.3 V to ($V_{CC}$ + 0.3 V) | Reset of SOMPLC (active Low) |
| 30 | GPIO04 | I/O | -0.3 V to ($V_{CC}$ + 0.3 V) | Unused multi-purpose IO pin, GPIO04. |
| 31 | NC | NC | – | Unused |
| 32 | NC | NC | – | Unused |
| 33 | RX-B | I | -0.3 V to ($V_{CC}$ + 0.3 V) | Asynchronous serial host-receive, SCI-B |
| 34 | TX-B | O | -0.3 V to ($V_{CC}$ + 0.3 V) | Asynchronous serial host-transmit, SCI-B |

## 3 34-Pin Connector Mechanical Specification

The connectors used in this design are as follows:

- A female 0.05 mm receptacle (2 rows × 17 pins) 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 fits 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 placed on the host board is shown in Table 2.

**Table 2. 34-Pin Female Connector Top View**

| | | |
|---|---|---|
| | 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 |

## 4 Test Procedure

In order to test the SOM modules, the operator will need the following items (the test procedure will be the same, depending on the SOM module under test, but the results will vary):

- A host computer running Windows XP or Windows 7 and two available USB ports
- 2 TMDSPLC docking boards
- 2 PLC SOM modules (SOMPLC-F28PLC83, SOMPLC-F28M35.....)
  - To test the CENELEC band, 2 SOMPLC-F28PLC83 modules are required
  - To test the FCC band, 2 SOMPLC-F28M35 modules are required
- 15-V external power supply for each docking station
- Power line connector for each docking station
- USB cable for connecting to the 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

### 4.1 Hardware Setup

This reference design can be configured for multiple applications. The steps on how to setup the design hardware are as follows:

1. Ensure the system is unpowered.
2. Connect the AC power cable to Line and Neutral of connector P1 as shown in Figure 2 and Figure 3 (ensure Line and Neutral connections are not shorted).

**NOTE:** Depending on the manufacturer, the power cord can have markings on the cord for Line (See Figure 3).

| | | |
|---|---|---|
|  | Danger<br>High Voltage | Electric shock possible when connecting board to live wire. |

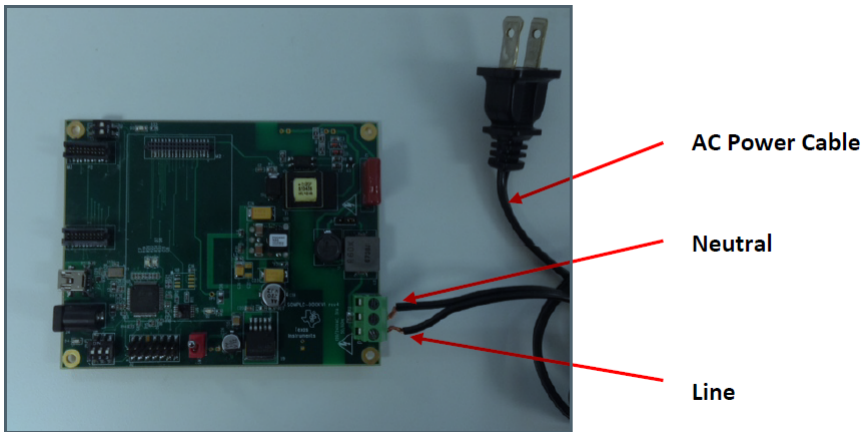



**Figure 2. AC Power Cable Connections**

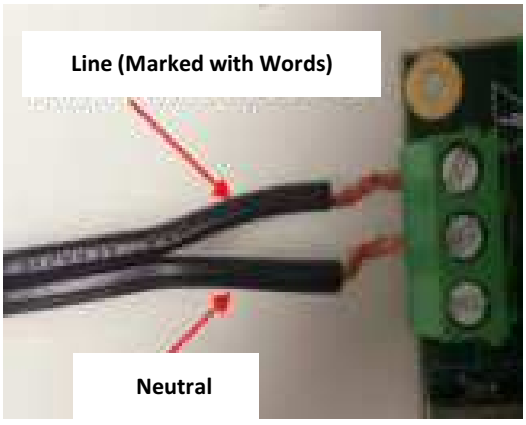



**Figure 3. Neutral and Line Connections**

3. Plug in the corresponding SOM module (CENELEC/FCC/ARIB) into the 34-pin connector as shown in Figure 4. In Figure 4, SOMPLC-F28PLC83 is plugged onto the dock.

**NOTE:** Refer to the respective SOM Module Guide for steps to program each SOM module.

**Figure 4. Dock + SOMPLC-F28PLC83 Module Plugged**

4. Depending on the type of SOM module plugged into the dock, the jumper settings for J1 required for standard operation are shown in Table 3.

**Table 3. J1 Jumper Settings**

| BAND | J1 JUMPER SETTING |
|---|---|
| CENELEC Band | 2,3 |
| FCC Band | 1,2 |

5. Details of SCI-A/SCI-B jumper settings for UART communication with a PC can be found in the following paragraphs.

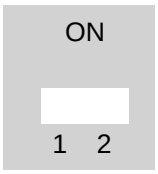
**UART SCI Communication**

In order to use the SCI USB interface, the host must be configured with the following parameters:

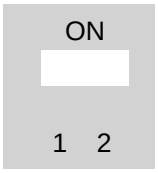
Baud Rate = 57600
Message Data Bits = 8
Stop Bits = One
Parity = None
Handshake = None
RTS Enable = True

**SCI A Communication (SW2 Positions)**

SCI A communication to Intermediate GUI can be selected using the Switch SW2. The available settings are described as follows:



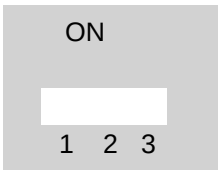

SCI A-EXT
Position 1: OFF
Position 2: OFF



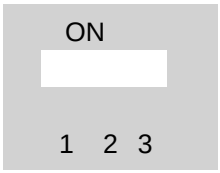

SCI A – USB (Default Setting)
Position 1: ON
Position 2: ON

**SCI B Communication (SW1 Positions)**

SCI B communication to Intermediate GUI can be selected using the Switch SW2. The available settings are described as follows:




SCI B – EXT
Position 1: OFF
Position 2: OFF
Position 3: OFF




SCI B – USB
Position 1: ON
Position 2: ON
Position 3: ON

### 4.2 Power Up

- Connect 15-V wall mounted power supply to the AC receptacle of each kit.
- Turn ON Switch SW3 of each kit to power the boards.

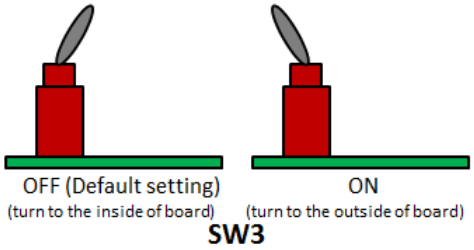



**Figure 5. Switch SW3**

### 4.3 Connecting to a PC

- Plug in the micro-USB to the kit and connect the USB cable to the PC (repeat this step for the second kit).

**NOTE:** There may be a dialog asking to install USB-Serial drivers. If there is a dialog asking to install USB-Serial drivers, install the drivers. The drivers can be found in the corresponding SW package downloaded from the SW section of the product web page. For example, if the G3 SW development package is downloaded from the product web page, then the drivers can be obtained from C:\Texas Instruments\G3DevelopmentEvalPackageVxxxx\XDS100 Drivers.

It is necessary to reboot the PC after the drivers are installed, even if there is no dialog in Windows to do so.

- Verify the modems have been installed correctly by using Microsoft Windows Device Manager (Start -> Control Panel -> System -> Device Manager -> Ports)

**NOTE:** The four ports in Figure 6 are for two boards.

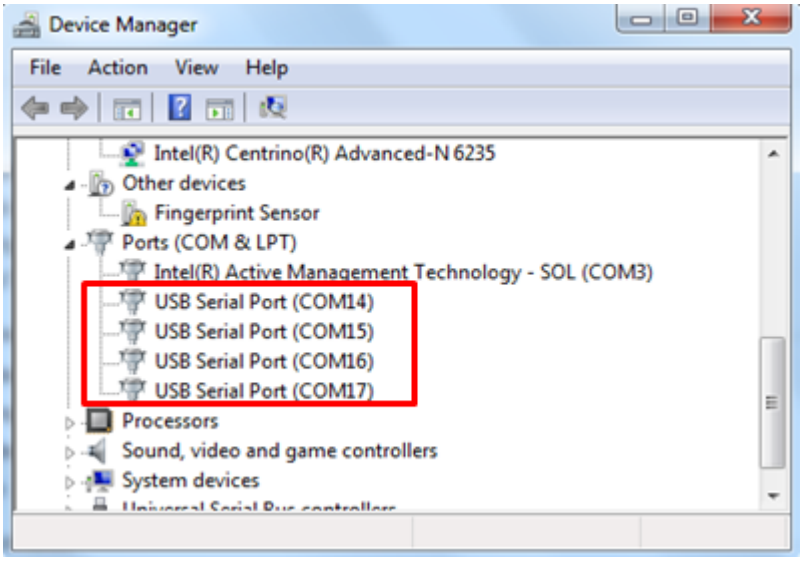



**Figure 6. Serial Ports for Two Boards**

## 4.4 Connection to Zero Configuration GUI

**NOTE:** Refer to the Zero Configuration User Guide in the PLC SW package for more details.

As shown in Figure 7, Zero Configuration GUI (ZCG) is a Windows application that the designer can use to immediately start performing text and file transfers, examine the current system information, display the PHY parameters, change the PHY modulation, display the file and text transfer statistics, and display and save the log information.

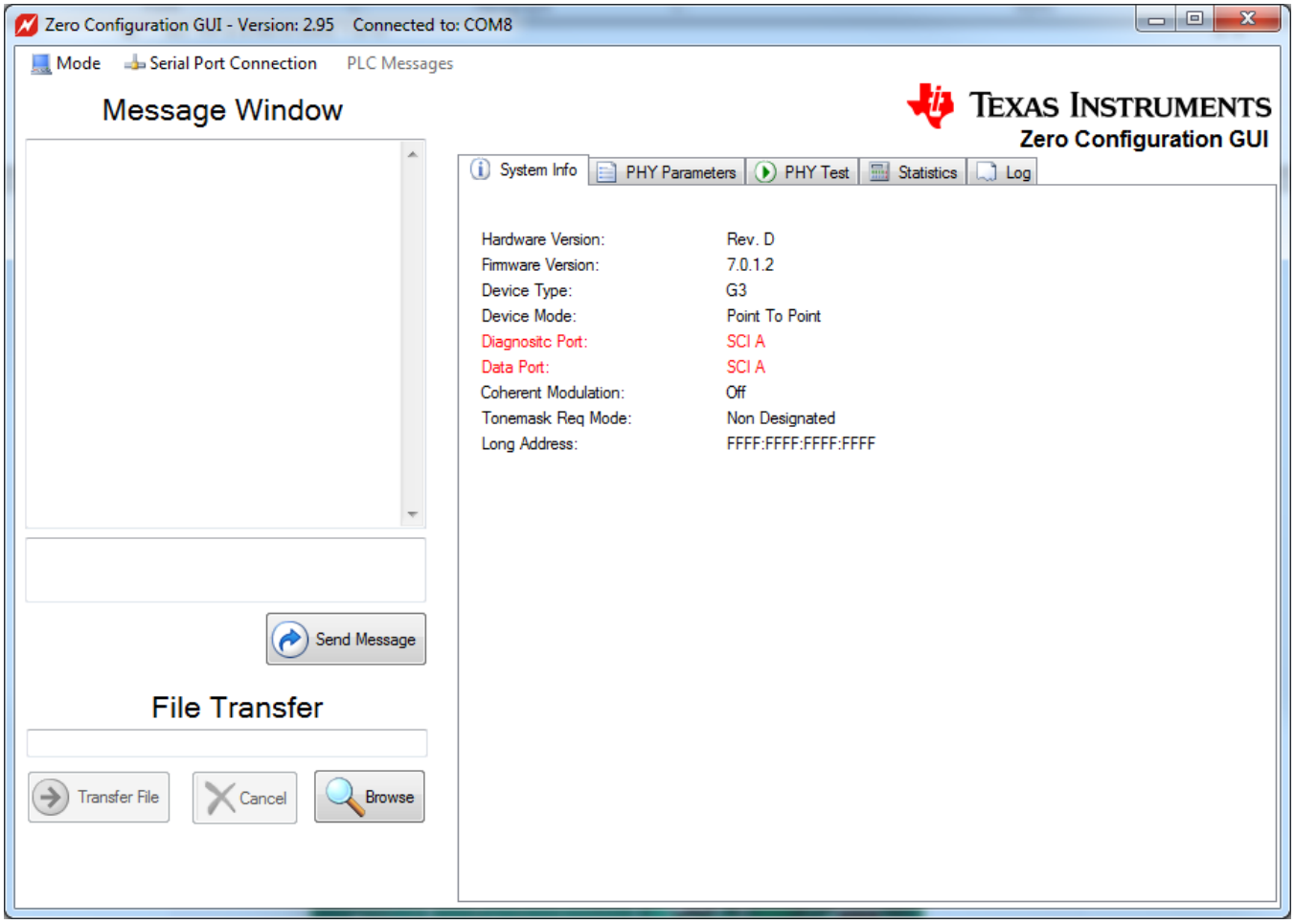



**Figure 7. Zero Configuration GUI**

### 4.4.1 Zero Config GUI Configuration

There is no software or PLC configuration needed to use the Zero Configuration GUI.

**NOTE:** There is an assumption is that the USB ports (SCI-A) on the PLC are being used.

The first available COMM port on the PC, which may be a USB to Serial Port or a standard COMM port, is used to connect to the PCL.

If no available serial ports are found on the PC, the ZCG displays an error, as shown in Figure 8.

If the PLC is reset while connected to the ZCG, the ZCG must be restarted or reconnected using the Serial Port Connection menu.


**Figure 8. No Available Serial Ports Error**

If there is no response on the COMM port selected, the Zero Configuration GUI will display a timeout error and remain active, as shown in Figure 9.

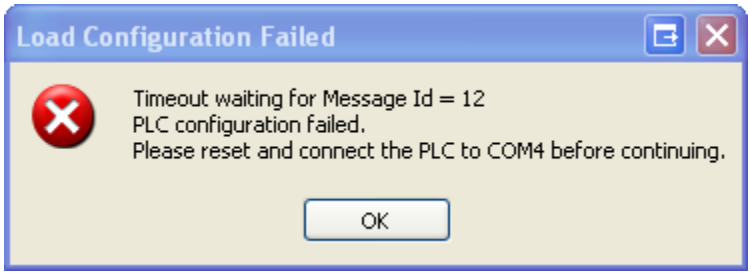



**Figure 9. Timeout Error**

If the PLC is connected to another COMM port, use the use the “Serial Port Connection” drop down menu to connect to the desired COMM port. If the PLC is not connected, connect the PLC to the desired port and try again. If the PLC is connected to the correct COMM port, reset the PLC.

### 4.4.2 Main Screen

The ZCG consists of the main screen where text and file transfers may be performed, as shown in Figure 10. The tabs on the right display significant information about the PLC.

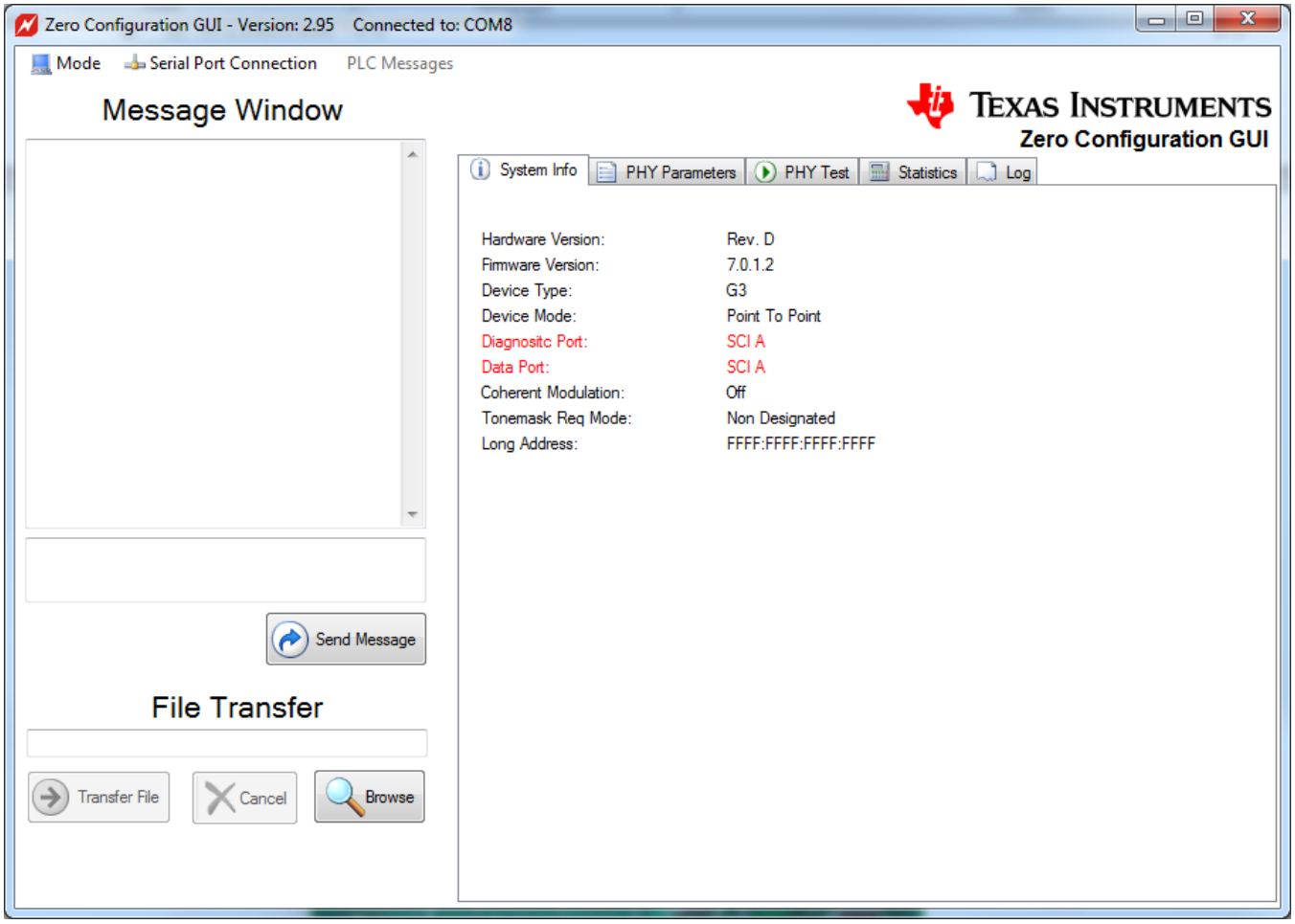



**Figure 10. Zero Configuration GUI Main Screen**

The COMM port attached to is displayed in the title bar. The first available and unopened COMM port is automatically chosen. The “Serial Port Connection” drop down menu may be used to change the selection to another COMM port.

The design engineer can use this screen to perform text message transfers and file transfers with another PLC controlled by the Zero Configuration GUI.

You may also change the mode by using the "Mode" drop down menu. There are two modes, Zero Configuration and Intermediate.

The Zero Configuration mode is the mode described in this reference design. Any available COMM port 1-## will work with the Zero Configuration GUI. The COMM port number does not have to be less than ten.

The Intermediate mode runs from a different dialog and gives the designer many more configuration options and functions to perform.

### 4.4.3 System Info Panel

The PLC system information is displayed in the first tab, as shown in Figure 11.

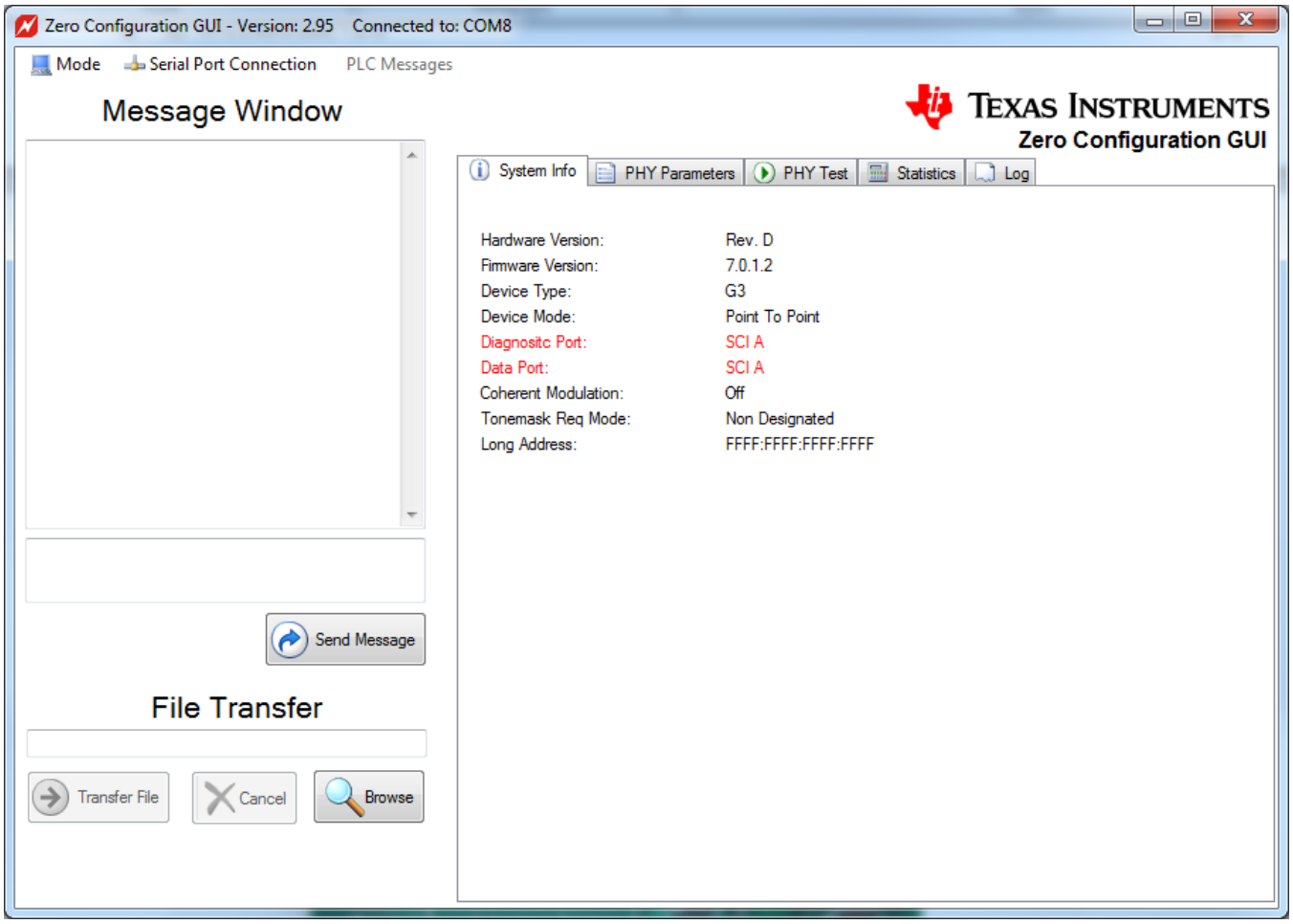



**Figure 11. PLC System Information**

Right clicking on the System Info panel will expose a context menu with one menu item: “Refresh System Information”. The Refresh System Information menu item resends a system information request to the PLC and refreshes the System Info panel with the updated information.

Pressing “Ctrl S” will perform the same function, without displaying the context menu.

Any value changed will be displayed in red text.

## 4.5 Testing

**NOTE:** Testing was conducted with 2 SOMPLC-F28PLC83 SOM modules. Testing results will vary, depending on the PLC SOM module being tested.

- Ensure the boards are powered and connected to the PC. Launch the Zero Configuration GUI. When using one PC to operate the test, it is necessary to launch two instances, one for each modem.
- When the Zero Configuration GUI opens, ZCG uses the first available COM port to attach to a PLC.

**NOTE:** Ensure the Diagnostic Port and the Data Port are configured to SCI-A by selecting CTRL+A in the GUI window, as shown in Figure 12.

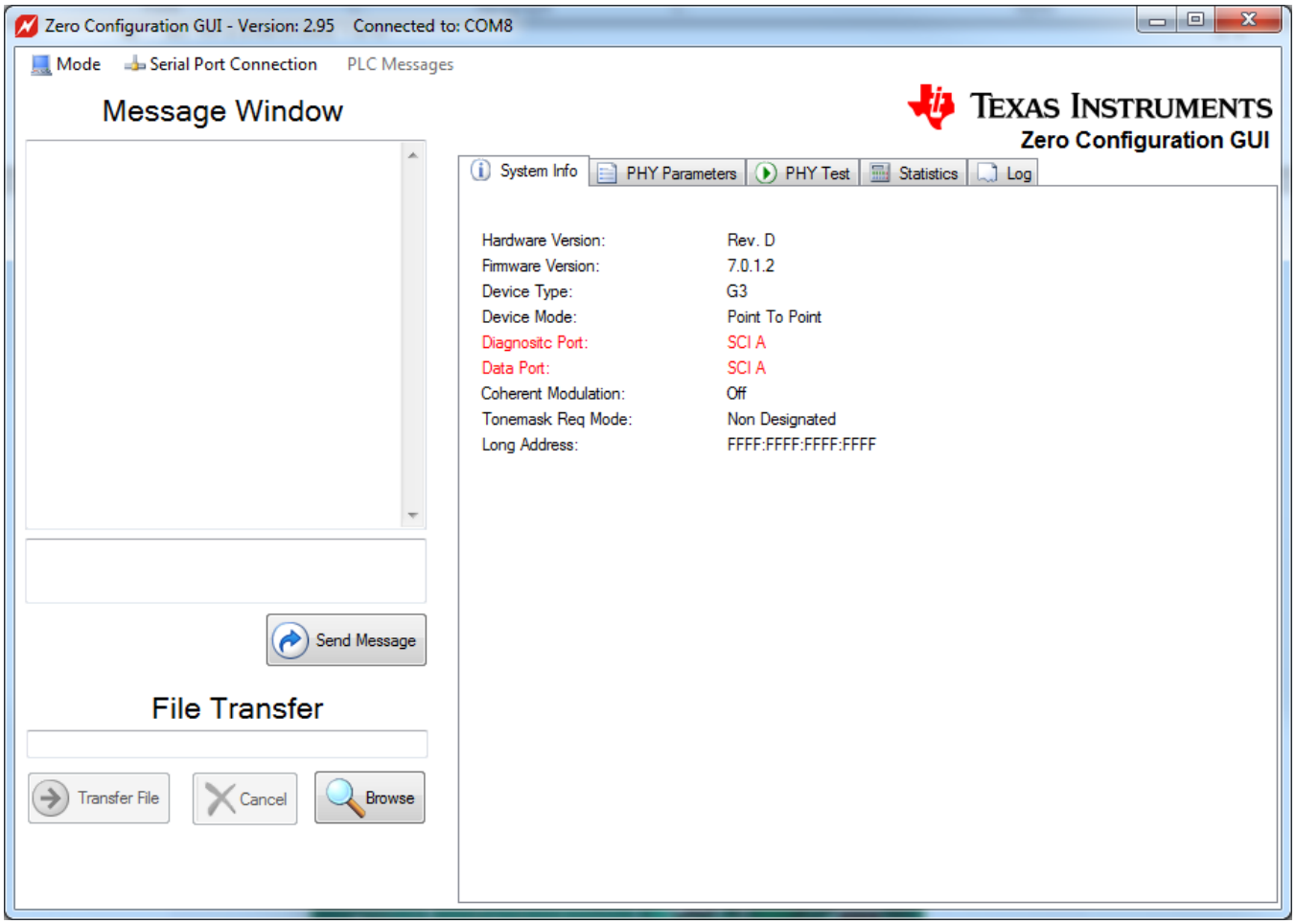



**Figure 12. SCI-A Ports Configuration**

- Connect each PLC kit to power line, as shown in Figure 13. Please ensure that devices are connected on same power line phase.

| | | |
|---|---|---|
|  | Danger<br>High Voltage | Use caution when connecting to the power grid. If there is concern about connecting to the power grid, a power strip can be used to connect the two modems together. In this case, the power strip does NOT need to be plugged into the power grid. Connect each PLC kit to power line . as shown in Figure 13. |

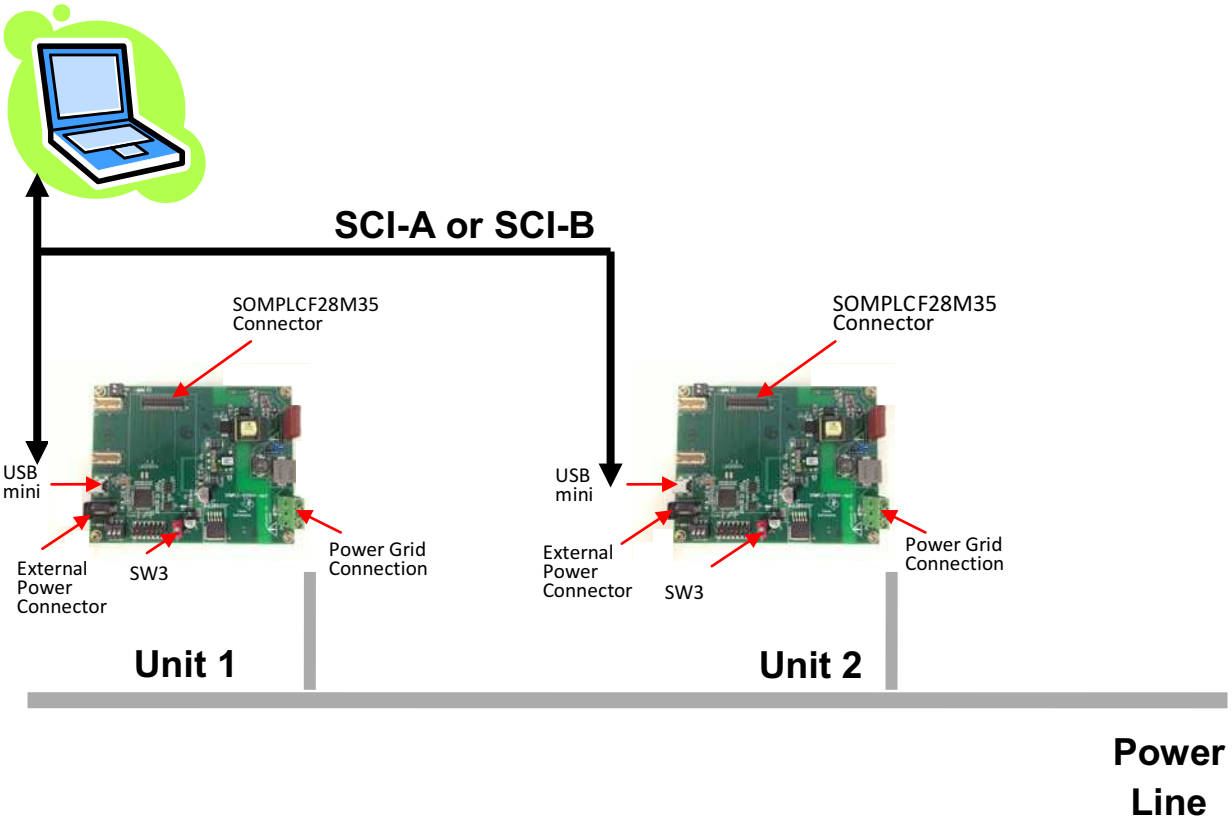



**Figure 13. PLC Kits to Power Line Connections**

- Enter the desired text into the Message Window.
- Press the Send Message button.
- The message will then be received by the other GUI, as shown in Figure 14.

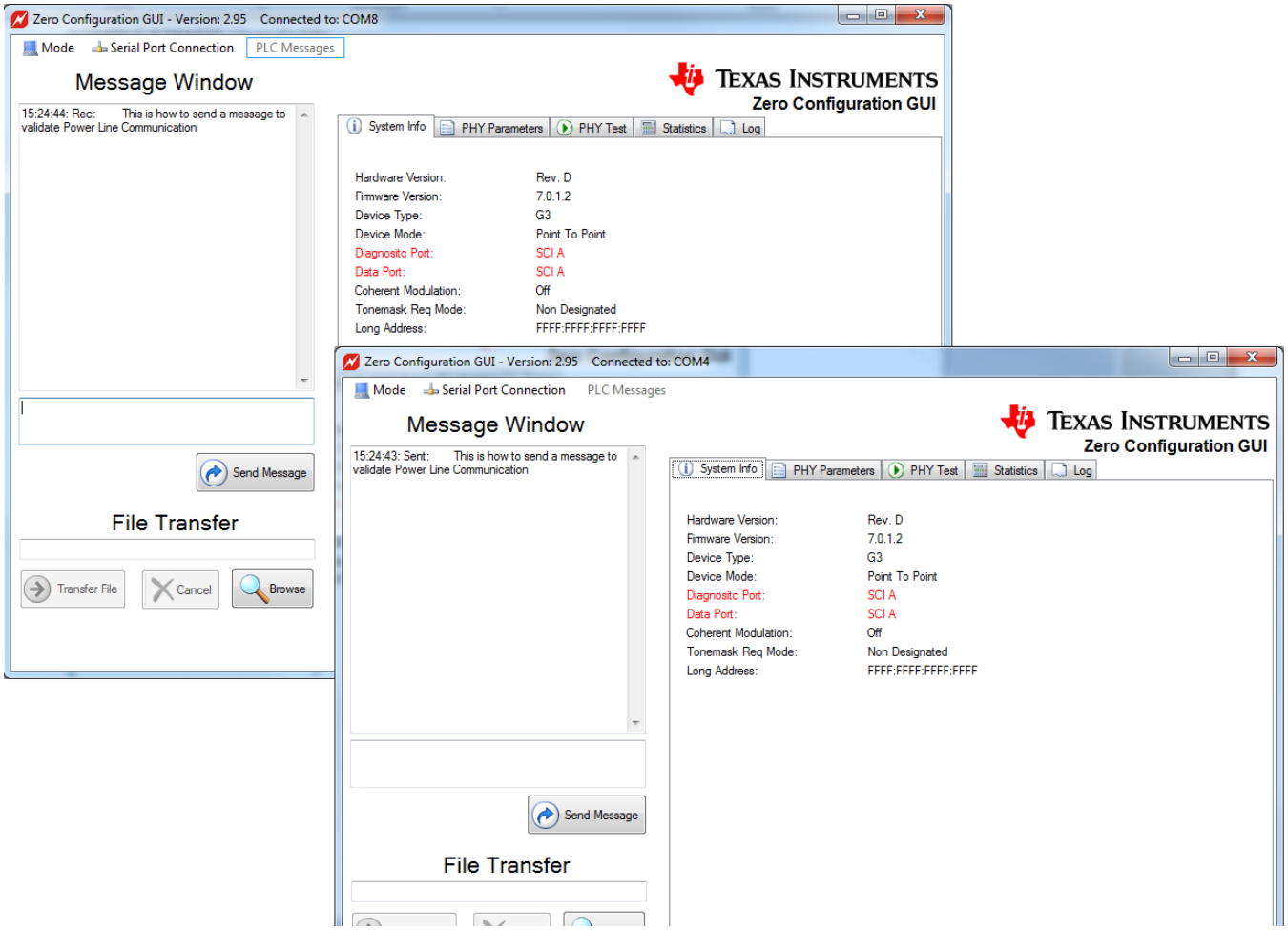



**Figure 14. Send Message Dialog**

- The File Transfer function contained in the bottom left hand corner of GUI can be utilized to transfers files, as shown in Figure 15.

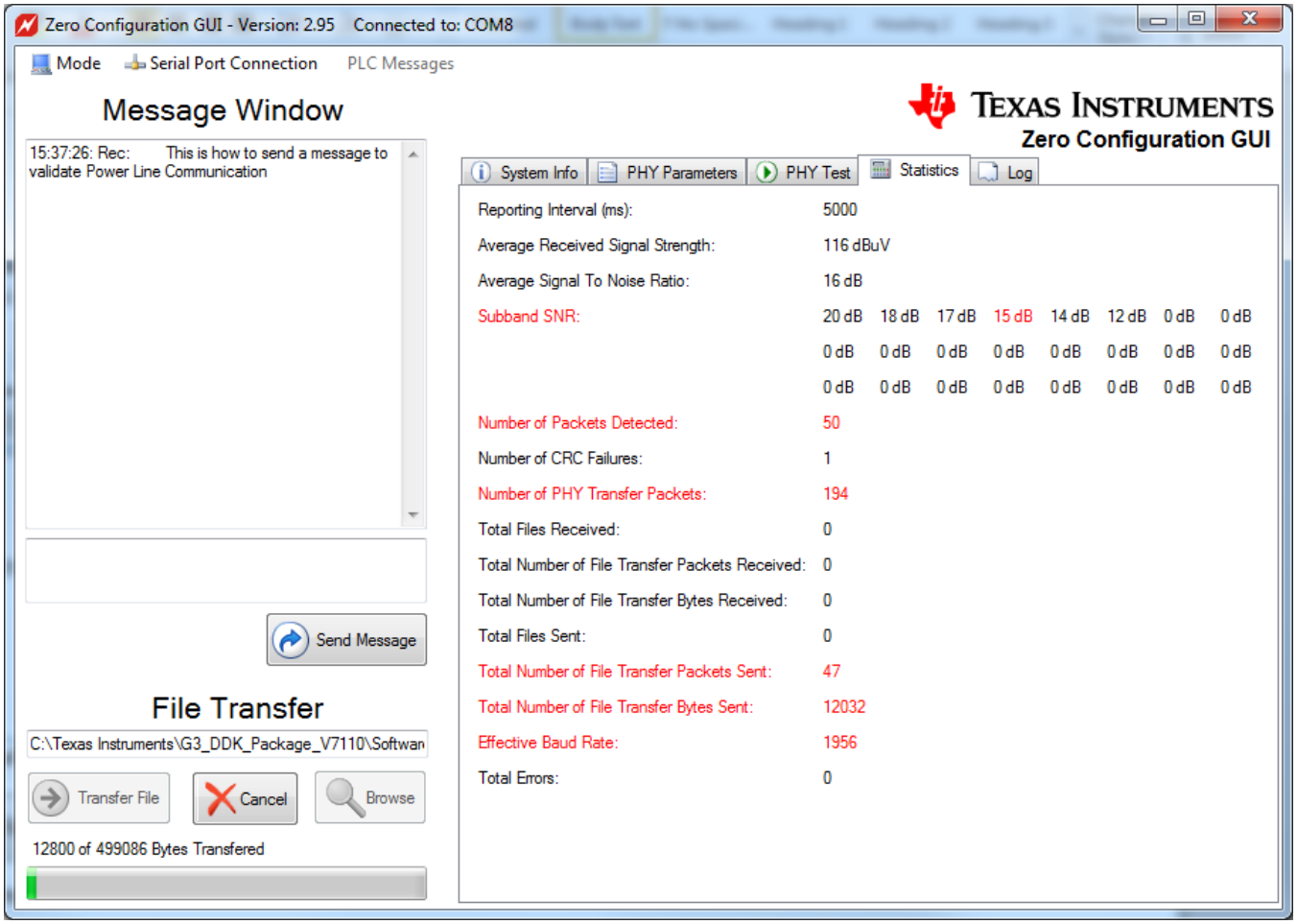



**Figure 15. File Transfer Function Part 1**

Click on the "Browse" button to display the standard Windows file chooser dialog to choose the file 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. As shown in Figure 16, the receiving Zero Configuration GUI displays the path and file name where the received file is being copied to. The user cannot change the directory path of the received file.

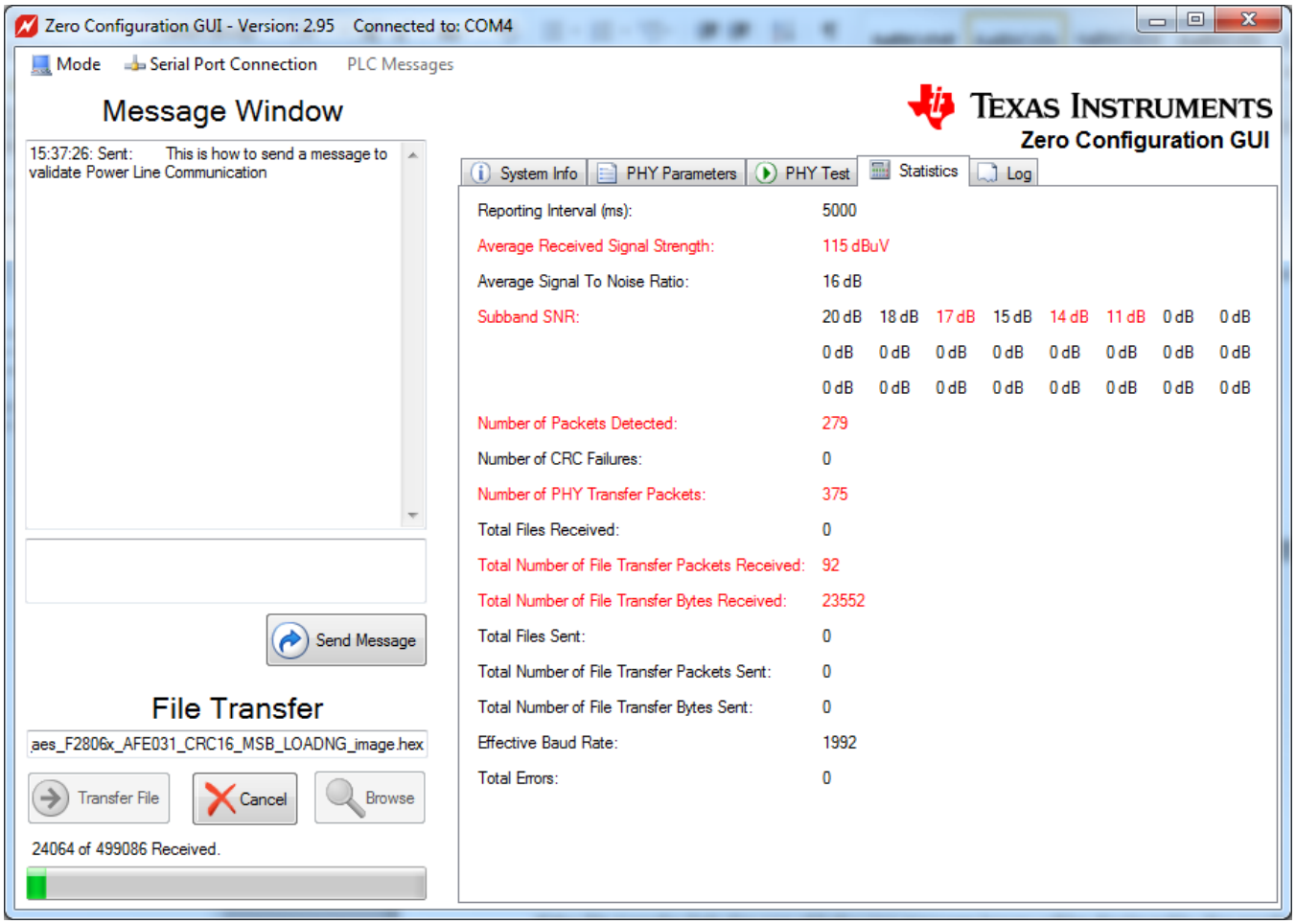



**Figure 16. File Transfer Function Part 2**

When the file transfer is complete, the message box below will be displayed on both Zero Configuration GUIs, as shown in Figure 17.

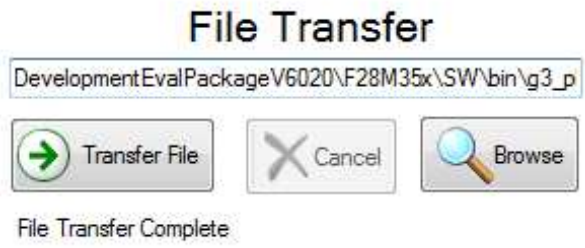



**Figure 17. File Transfer Complete**

If the file transfer fails, one of following message boxes is displayed by the sending GUI, as shown in Figure 18 and Figure 19.

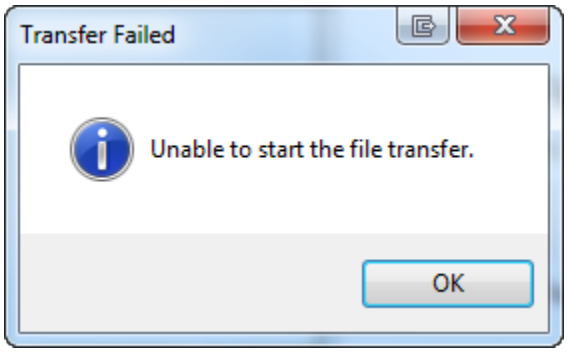



**Figure 18. File Transfer Failure Message 1**

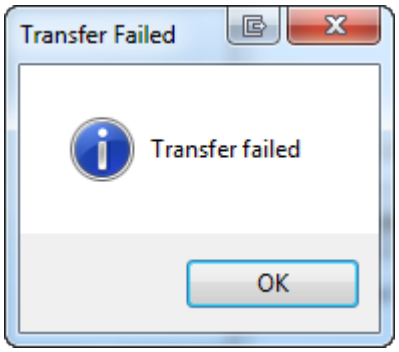



**Figure 19. File Transfer Failure Message 2**

The file transfer may be canceled by clicking on the "Cancel" button on either GUI.

## 5 Schematics

To download the schematics for the reference design, see the design files at TIDA-00192.

# 6 Bill of Materials (BOM)

**Table 4. BOM**

| Part No. | QTY. | Part Type | Part Reference | Vendor | Vendor PN | Description | Value | PCB Footprint | Tolerance | Voltage | Distributor Part No. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 300-00047 | 1 | CAP | C1 | Panasonic | ECQ-E4474KF | 0.47 µF/400VDC METAL POLY CAP | 470nF | Axial 0.591" (15.00mm) Spacing | 0 | 400V | EF4474-ND |
| 100-00025 | 1 | CAP | C2 | AVX | 06035C102KAT*A | Capacitor,1000PF, 50 V,10%,X7R,0603 | 1000PF | C0603 | 0.1 | 50V | |
| 100-00126 | 1 | CAP | C3 | Murata | GRM188R71C334KA01D | Capacitor,0.33µF,16V,10 %,0603, X7R | 0.33µF | C0603 | 0.1 | 16V | 490-3294-1-ND |
| 300-00073 | 3 | CAP | C4 C12 C14 | Murata | GRM155R60J475ME87D | CAP CER 4.7µF 6.3V X5R 0402 | 4.7µF | C0402 | 0 | 6.3V | 490-5408-2-ND |
| 100-00108 | 11 | CAP | C5 C6 C7 C8 C9 C10 C11 C13 C15 C16 C29 | Kemet | C0402C104K4RACTU | Capacitor,0.1µF, X7R, 16 V, 0402, 10% | 0.1µF | C0402 | 0.1 | 16V | 399-3521-2-ND |
| 300-00074 | 2 | CAP | C17 C18 | Kemet | C0402C270J5GACTU | CAP CERAMIC 27PF 50V NP0 0402 | 27PF | C0402 | 0 | 50V | 399-1016-2-ND |
| 300-00115 | 1 | CAP | C19 | Panasonic | EEE-1VA221UP | CAP ALUM 220µF 35V 20% SMD | 220µF | Radial | 0 | 35V | PCE3955CT-ND |
| 300-00113 | 2 | CAP | C20 C21 | TDK | C1608Y5V1H104Z | CAP CER 0.1µF (100nF) 50V Y5V 0603 | 0.1µF | C0603 | 0 | 50V | 445-1324-2-ND |
| 300-00116 | 1 | CAP | C25 | Kemet | C1210C225K3RACTU | CAP CER 2.µF 25V 10% X7R 1210 | 22µF | C1210 | 0 | 25V | 399-3084-1-ND |
| 300-00123 | 1 | CAP | C30 | AVX | TLNT227M010R1300 | Tantalum Capacitors - Solid SMD 220µF 10v 20% Tol ESR = 1300 | 220µF | T3528 | 20% | 10V | 581-TLNT227M010R1300 |
| 300-00117 | 2 | CAP | C23 C24 | Vishay | 293D107X9020D2TE3 | CAP TANT 100µF 20V 10% 2917 | 100µF | C2917P | 0 | 20V | 718-1744-1-ND |
| 300-00114 | 1 | CAP | C26 | Panasonic | EEE-1VA101XP | CAP ALUM 100µF 35V 20% SMD | 100µF | Radial | 0 | 35V | PCE3951CT-ND |
| 400-00010 | 1 | FET_DIODE | D1 | NXP Semi | PMLL4148L,115 | DIODE STANDARD 200mA LL-34 | 200mA | LL-34 | 0 | | 568-1749-1-ND |
| 400-00002 | 4 | FET_DIODE | D2 D4 D6 D7 | Stanley | BR1112H-TR | LEDs SMD 0805 - Red | LED_RED | LED0805 | 0 | 2.1V | 404-1017-1 |
| 400-00001 | 1 | FET_DIODE | D5 | Stanley | PG1112H-TR | LED SMD 0805 - Green | LED_GRN | LED0805 | 0 | 2.1V | 404-1021-1 |
| 320-00008 | 1 | CONN | J1 | | | 3 pin 100mill standard header | SILH-3 | HDR_1x3_100MILL_THRU_HOLE | 0 | | |
| 120-00068 | 1 | CONN | J2 | SAMTEC | TSM-107-01-S-DV | CONN. 2X7 HEADER, SMT, DSP JTAG, Pin 6 removed | DSP JTAG Header | hdr_14p | 0 | | |
| 320-00004 | 1 | CONN | J3 | Hirose Electric Co Ltd | UX60-MB-5ST | CONN RECEPT MINI USB2.0 5POS | USB-B-mini-smt | female? | 0 | | H2959TR-ND |
| 320-00039 | 1 | CONN | J4 | CUI | PJ-037A | CON PWR JCK 2.0 × 6.5MM W/O SW | PWR | thru-hole | 0 | | CP-037A-ND |
| 330-00027 | 1 | MAGNETICS | L1 | Coiltronics/Cooper | DR1040-150-R | INDUCTOR POWER SHIELD 15µH SMD | 15µH | DR1040 | 0 | | 513-1400-1-ND |
| 330-00020 | 1 | MAGNETICS | L2 | Panasonic - ECG | ETQ-P5LR60XFA | COIL POWER CHOKE 600nH 27A SMD | 600nH | 0.571" L x 0.492" W x 0.197" H | 0 | | PCD2022CT-ND |
| 330-00025 | 2 | MAGNETICS | L3 L4 | Laird-Signal Integrity Products | HZ0805E601R-10 | FERRITE 500mA 600 OHM 0805 SMD | HZ0805E601R-10 | 805 | 0 | 500mA | 240-2399-2-ND |
| 330-00041 | 2 | MAGNETICS | L5 L6 | Murata | BLM15AX700SN1D | FERRITE CHIP 70 Ω 0402 | BEAD | IND0402 | 0 | | 490-5438-2-ND |

## Table 4. BOM (continued)

| Part No. | QTY. | Part Type | Part Reference | Vendor | Vendor PN | Description | Value | PCB Footprint | Tolerance | Voltage | Distributor Part No. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 403-00013 | 1 | POWER | M1-1 | | | Conn header female 2 pos 0.100 mill, Header for PMP7190 custom module AC/DC | PMP7190_Module | HDR_1x2 | 0 | | S7035-nd |
| 403-00013 | 1 | POWER | M1-2 | | | Conn header female 2 pos 0.100 mill, Header for PMP7190 custom module AC/DC | PMP7190_Module | HDR_1x2 | 0 | | S7035-nd |
| 403-00013 | 1 | POWER | M1-3 | | | Conn header female 2 pos 0.100 mill, Header for PMP7190 custom module AC/DC | PMP7190_Module | HDR_1x2 | 0 | | S7035-nd |
| 403-00013 | 1 | POWER | M1-4 | | | Conn header female 2 pos 0.100 mill, Header for PMP7190 custom module AC/DC | PMP7190_Module | HDR_1x2 | 0 | | S7035-nd |
| 320-00014 | 1 | CONN | M2 | Sullins Connector Solutions | SFH31-NPPB-D17-SP-BK | CONN HDR FMAL 34PS 1.27MM SMD AU | SFH31-NPPB-D17-SP-BK | Female | 0 | | S9117-ND |
| 406-00002 | 1 | Module | M3,P1 | FCI | 87409-110LF | 2x 20P SMT HDR | EM Module | Male | 0 | | 649-87409-110LF |
| 406-00002 | 1 | Module | M3,P2 | FCI | 87409-110LF | 2x 20P SMT HDR | EM Module | Male | 0 | | 649-87409-110LF |
| 480-00002 | 4 | MTG_HOLE_TP | MH1 MH2 MH3 MH4 | TI | 280-00002 | MTG_HOLE,0.141 hole, 0.25 pad, plated | MH_PL_141 | MH_141 | 0 | | |
| 320-00036 | 1 | CONN | P1 | TE Connectivity | 282841-3 | TERM BLOCK 3POS SIDE ENT 5.08MM | HV Connector | see datasheet | 0 | | A98343-ND |
| 310-00075 | 1 | RES | R1 | Panasonic | ERJ-6GEYJ4R7V | RESISTOR 4.7 Ω 1/8W 5% 0805 | 4R7 | R0805 | 0 | | P4.7ACT-ND |
| 110-00031 | 1 | RES | R2 | AVX | CR21-105J-* | RESISTOR, 1M, 0.125W, 5%, 0805 | 1M | R0805 | 0.05 | 0.125W | |
| 110-00238 | 1 | RES | R3 | Rohm | MCR10EZPJ271 | Resistors 270R, 0.125W, 5%, 0805 | 270R | R0805 | 0 | 0.125W | RHM270ARCT-ND |
| 110-00018 | 3 | RES | R4 R5 R6 | AVX | CR21-1003F-* | RESISTOR, 100.0K,0.125 W,1 %,0805 | 100.0K | R0805 | 0.01 | 0.125W | |
| 110-00048 | 1 | RES | R7 | AVX | CR21-1501F-* | RESISTOR,1.50K, 0.125 W,1 %,0805 | 1.50K | R0805 | 0.01 | 0.125W | |
| 110-00239 | 1 | RES | R8 | Rohm | MCR10EZPF2403 | Resistors 240K, 0.125W, 1%, 0805 | 240k | R0805 | 0 | 0.125 | RHM240KCRCT-ND |
| 310-00104 | 7 | RES | R9 R10 R12 R15 R19 R20 R24 | Panasonic | ERJ-2GEJ103X | RES 10kΩ 1/10W 5% 0402 SMD | 10k | R0402 | 0 | | P10KJTR-ND |
| 110-00179 | 1 | RES | R11 | Panasonic | ERJ-3GEYJ104V | RESISTOR,100K, 0.1W, 5%, 0603 | 100K | R0603 | 0.05 | 0.1W | P100KGTR-ND |
| 310-00080 | 3 | RES | R13 R16 R27 | Panasonic | ERJ-2RKF1001X | RES 1.00kΩ 1/10W 1% 0402 SMD | 1k | R0402 | 0 | | P1.00KLCT-ND |
| 310-00102 | 2 | RES | R14 R17 | Panasonic - ECG | ERJ-2GE0R00X | RES 0.0 Ω 1/10W 0402 SMD | 0 | R0402 | 0 | | P0.0JCT-ND |
| 0402_NP | 2 | RES | R22 R23 | | | NO POP | 0402_NP | R0402 | | | |
| 310-00100 | 1 | RES | R25 | Panasonic - ECG | ERJ-2RKF2211X | RES 2.21kΩ 1/10W 1% 0402 SMD | 2.21k | R0402 | 0 | | P2.21KLCT-ND |
| 310-00103 | 1 | RES | R26 | Rohm Semiconductor | MCR01MZPJ681 | RES 680 Ω 1/16W 5% 0402 SMD | 680 | R0402 | 0 | | RHM680JCT-ND |

## Table 4. BOM (continued)

| Part No. | QTY. | Part Type | Part Reference | Vendor | Vendor PN | Description | Value | PCB Footprint | Tolerance | Voltage | Distributor Part No. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 310-00138 | 1 | RES | R28 | Panasonic | ERJ-2RKF1072X | RES 10.7kΩ 1/10W 1% 0402 SMD | 10.7k | R0402 | 0 | | P10.7KLCT-ND |
| 310-00115 | 3 | RES | R31 R33 R34 | | | RES 82 Ω 0402 | 82R | R0402 | 0 | | |
| 310-00139 | 1 | RES | R32 | Panasonic | ERJ-2GEJ680X | RES 68 Ω 1/10W 5% 0402 SMD | 68R | R0402 | 0 | | P68JCT-ND |
| 310-00140 | 1 | RES | R35 | Panasonic | ERJ-2RKF1871X | RES 1.87kΩ 1/10W 1% 0402 SMD | 1.87k | R0402 | 0 | | P1.87KLCT-ND |
| 310-00113 | 1 | RES | R36 | Yageo | RC0805JR-070RL | RES 0.0 Ω 1/8W 0805 SMD | 0R | R0805 | 0 | | 311-0.0ARCT-ND |
| 206-00013 | 1 | SWITCH | SW1 | C&K Components | SDA03H1SBD | SWITCH DIP TOP SLIDE 3POS SMD | 3POS_DIPSW | 3PDIPSW | 0 | | CKN6062-ND |
| 206-00014 | 1 | SWITCH | SW2 | C&K Components | SDA02H1SBD | SWITCH DIP TOP SLIDE 2POS SMD | 2POS_DIPSW | 2PDIPSW | 0 | | CKN6056-ND |
| 206-00015 | 1 | SWITCH | SW3 | Mountain Switch | 108-2AS1T1203-EVX | Toggle switch SPDT | SPDT | 2 thru-hole | 0 | | 108-2AS1T1203-EVX |
| 330-00033 | 1 | MAGNETICS | T1 | WURTH ELEKTRONIK | 750510476 | Transformer PLC | 750510476 | see datasheet | 0 | | |
| 280-00010 | 1 | MTG_HOLE_TP | TP1 | TI | TI-TP-60mil | 60 mil round test point, SMT | TP_60 | TP_60 | 0 | | DNP |
| 400-00014 | 1 | FET_DIODE | U1 | STMicroelectronics | SM6T10CA | TRANSIL 600W 10V BIDIR SMB | 10V | DO-214AA, SMB | 0 | | 497-7427-2-ND |
| 402-00069 | 1 | IC | U2 | Fairchild Opto | FOD817BSD | Optoisolator, 5000Vrms, 70V | FOD817BSD | 4-SMD | 0 | | 512-FOD817BSD |
| 402-00070 | 1 | IC | U3 | On Semi | BC817-40LT1G | BJT, NPN, Ic=500mA, SOT-23-3 | BC817 | SOT-23-3 | 0 | | BC817-40LT1GOSCT-ND |
| 400-00009 | 1 | FET_DIODE | U4 | NXP Semi | BZV55-C5V6,115 | DIODE ZENER 500mW 5.6V LL-34 | 5.6V | LL-34 | 0 | | 568-3797-1-ND |
| 402-00045 | 1 | IC | U5 | FTDI | FT2232HL | IC USB HS DUAL UART/FIFO 64-LQFP | JTAG/UART | 64-LQFP | 0 | | 768-1024-2-ND |
| 402-00043 | 1 | IC | U6 | TI | SN74HC03PWR | IC GATE POS-NAND QD 2IN 14-TSSOP | Quad NAND | 14-TSSOP | 0 | | SN74HC03PWR-ND |
| 402-00047 | 1 | IC | U7 | TI | TPD2E001DRLR | IC ESD-PROT ARRAY 2CH SOT-5 | ESD-PROT | SOT-553 | 0 | | 296-21883-2-ND |
| 402-00046 | 1 | IC | U8 | micro chip | 93LC56C-I/SN | IC EEPROM 2KBIT 3MHz 8SOIC | EEPROM | 8-SOIC | 0 | | 93LC56C-I/SN-ND |
| 402-00072 | 1 | IC | U9 | National Semiconductor | LM2941SX/NOPB | IC REG LDO ADJ 1A TO-263-5 | LM2941 | TO-263-5 | 0 | | LM2941SXCT-ND |
| 403-00012 | 1 | POWER | U10 | TI | PTH08080WAS | MODULE PIP 0.9-5.5V 2.25A SMD | PTH08080W | PTH_5 | 0 | | 296-19803-ND |
| 405-00013 | 1 | OSC_XTAL | X1 | ECS | ECS-120-20-30B-TR | CRYSTAL 12.000 MHz 20PF SMD | 12MHz OSC | 4-SMD | 0 | | XC1118TR-ND |
| 300-00131 | 2 | CAP | C31 C32 | Kemet | C0805C104K3RACTU | CAP CER 0.1µF 25V 10% X7R 0805 | 0.1µF | C0805 | | 25V | 399-1168-1-ND |
| 402-00056 | 1 | IC | U11 | TI | SN74LVC1G57DBVR | Configurable Multiple-function Gate | SN74LVC1G57 | SOT-23-6 (DBV) | | | 296-15574-1-ND |

## 7 Gerber Files

To download the Gerber files for each board, see the design files at TIDA-00192.

## 8 Software Files

To download the software files for the reference design, see the design files at TIDA-00192.

## 9 About the Author

**NAVEEN KUMAR KALA** is System Applications Engineer at Texas Instruments, where he is responsible for designing new reference design solutions and software in the Smart Grid segment. He earned his Master of Science in Electrical and Computer Engineering from The University of Iowa, IA.

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