TI PLC Development Kit User Guide

Version 0.7

April 30, 2011

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1.1 Features

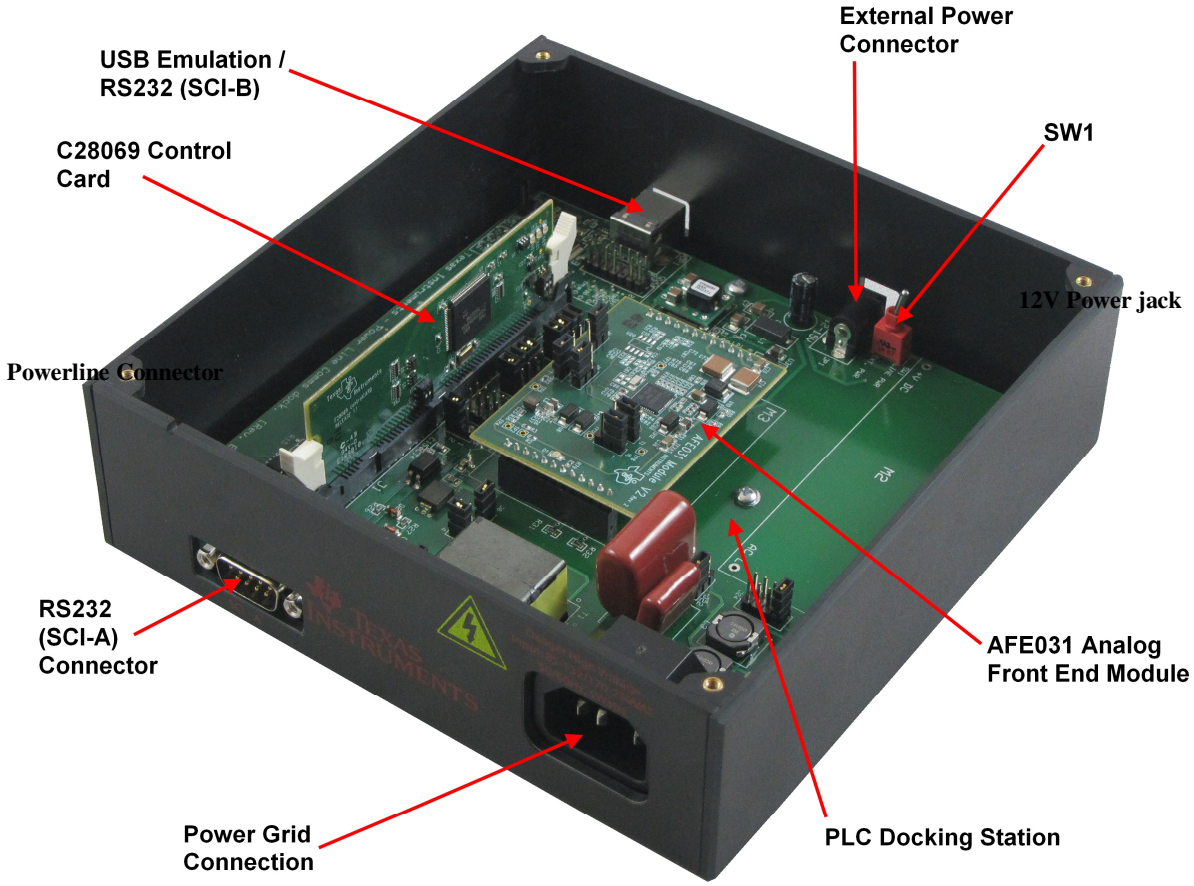


Figure 1 TI PLC Development Kit[1]

The TI PLC Development Kit for PRIME contains the following main components and supported features:

- DSP control card with Texas Instruments F28069 microcontroller
- AFE daughter card with Texas Instruments integrated powerline communications analog front-end AFE031
- Operating frequency range 40-90 kHz (CENELEC A band)

[1] Docking board Revision E and AFE031 Module V2 are shown here.

- Data rates from 21 kbps to 128 kbps
- Transmission with OFDM and FEC
- Number of used data carriers is 96
- Differential Phase modulation (DBPSK/DQPSK/D8PSK)
- PRIME-ROBO mode provides Repetition code with DBPSK
- Convolutional encoder/Viterbi decoder
- Bit interleaving for noise effect reduction
- CRC8 in headers and CRC32 in data for error detection
- Data randomization for uniform power distribution
- Automatic gain control
- Zero-crossing detection
- Supports PRIME PHY, MAC, and IEC61334 -4-32 LLC layer
- RS-232 interface for diagnostic port interface
- Serial interface for host data port interface: UART, SPI, etc.
- LEDs and test points for firmware and hardware debug
- USB/JTAG for custom firmware download

1.2 PLC Development Kit Components

The development kit includes the following hardware:

- Two sets of development board, each set contains:
  - 1 F28069 MCU control card: flashed with PRIME PLC image of: *prime_iec432_f2806x.out*
  - 1 docking station
  - 1 AFE board

The development kit includes the following software:

- PRIME PLC Binaries
  - PRIME IEC61334-4-32 project binary image
    (prime_iec432_f2806x.out)
    (prime_iec432_f2806x.srec)
    (prime_iec432_f2806x.hex)

  - Firmware upgrade binary image (only used for HW platforms that does not have pre-flashed image)
    (dfu_prime_f2806x.hex)

- PRIME PLC Software Libraries
  - PRIME PHY Library: prime_phy_f2806x.lib
  - PRIME MAC Library: prime_mac.lib
  - PRIME IEC61334-4-32 LLC Library: prime_cl_llc.lib
  - PRIME AFE Library: hal_afe031_f2806x.lib

- F28069 Support libraries: csl_f2806x.lib, uart_f2806x.lib

- PC Software/GUI
  - Zero Configuration GUI v2.2
  - TI PLC Quality Monitor GUI v1.17.9.3
  - HostAppEMU (Emulate eMeter application running on host)

- Example projects:
  - PRIME PHY projects: example of using PHY lib only
  - eAPPEMU: example of emulated eMeter application on F28069

The development kit includes the following documentations:

- PRIME SW API Specifications
  - HAL API Spec
  - PHY API Spec
  - MAC API Spec
  - IEC432/LLC API Spec
  - Host Message Protocol Spec

- PRIME HW documentations
  - AFE daughter card schematics and Gerber files
  - Docking board schematics and Gerber files
  - BOM

1.3 System Installation Requirements

To install SW package on PC to communicate with the PLC Development Kit, your computer must meet the following minimum requirements:

- Microsoft® Windows® XP (SP2) or Windows 2000 (SP4)
- Pentium® IV 1GHz processor
- 128 MB RAM (256MB RAM recommended)
- USB 2.0 interface (If using JTAG debug interface)
- CD-ROM drive
- Screen resolution 1024x768 (or better)
- 1MB of free space on the HDD for the applications and more for LOG files.

1.4 Software Installation

To install the PRIME PLC software package, run the PLC tool installer “PLC_Host_Tools.msi” and “ZeroConfiguration_Setup.msi” that are included in the CD.

The PRIME PLC software package includes the followings:

1. Software documentation and API specification (PRIME PHY/PRIME MAC/PRIME CL/Host Message Protocol) under “doc” directory

2. Hardware documents (Docking board and AFE daughter card) under “HW” directory
3. Software binaries under “SW” directory:
    a. prime_iec432_f2806x.out – This image supports IEC61334-4-32 LLC and convergence layer stack on top of PRIME MAC and PRIME PHY operations. It demonstrates the followings:
        i. Point to point and point to multi-points operation: Demonstration of PLC device PHY layer performance, file transfer and message transmission through PRIME PHY/MAC/IEC432-CL/IEC432-LLC without a PRIME Base Node. This is to be run with the PLC Quality Monitor (PQM) PC tool.
        ii. Embedded eMeter application example LLC: eAppEmu example is running in PC communicating to the PLC device **at the LLC (IEC61334-4-32) layer** as a PRIME service node. This application emulates meter readings, file downloading, etc. This configuration requires a PRIME Base Node that supports the same application emulation at the LLC layer.
        iii. Embedded eMeter application example MAC: eAppEmu example is running in F28069 and communicating to the PLC device **at the MAC layer** as a PRIME service node. This application emulates meter readings, file downloading, etc. This configuration requires a PRIME Base Node that supports the same application emulation at the MAC layer (used in Iberdrola field test).
        iv. Hosted eMeter Application for IEC61334-4-32 LLC operation: This is PLC device normal operation mode. There is an automatic flag where PLC device boots up and perform initialization, network registration and connection establishment and waits for host applications (e.g. DLMS/COSEM) to initiate data transfer or other message communications to the PLC device **at the LLC layer** using TI host message protocol. In non-automatic case, PLC device will wait for host to start network registration and connection establishment. An example eMeter application “hostAPPEMU” can be started to run on PC to emulate meter readings, file download, etc.
        v. Hosted eMeter Application for MAC operation: Under this operation, PLC device boots up and perform initialization and waits for host applications to initiate network registration and connection establishment to the PLC device **at the MAC layer** using TI host message protocol. An example eMeter application “hostAPPEMU” can be started to run on PC to emulate meter readings, file download, etc. **This is the default operation mode in prime_iec432_f2806x.out**
4. Example projects under “SW” directory zip files
    a. PRIME PHY example project – Demonstrates the usage of PHY library API
    b. Host application example project – demonstrate the usage of host message protocol to communicate to PLC
5. Tool
    a. PLC host tool installer – This installs PLC eMeter GUI and “HostAppEmu” application

b. Zero configuration GUI tool installer – This installs PLC Zero Configuration GUI

1.5 Hardware Setup

The following shows steps of how to setup PLC-DK hardware (make sure system is un-powered):

1. Insert the F28069 control card in connector J1 on the docking station
2. Insert the AFE card on the docking board. Connector J2 (AFE card) to connector J4 (docking station). Connector J3 (AFE card) to J10 (docking station)
3. Connect 12V DC power supply to 12V power jack (make sure the board power supply switch is OFF)
4. Connect power cables to connector TB1.
5. Connect the serial cable to the serial connector on the docking station. Note that a NULL modem cable (TX/RX cross connected) is used between host PC UART port and the PLC-DK. Note that for Dock HW Rev-C, a ribbon cable is provided for serial connection and for Dock HW Rev- D/E, null modem serial cable should be used.
6. Turn on the board power supply switch (ON/OFF Switch)
7. Check that the LED on the F28069 control card is blinking

1.5.1 PRIME PLC Point-to-Point HW Setup

The PLC-DK can be used to demonstrate point-to-point or point-to-multipoint communication over power line. This is to be used with PLC Quality Monitor GUI Tools to test PHY/MAC operability and send data between the two boards over the power line media[2]. It requires 2 PCs, and 2 null modem cables.

If the host PC can be configured to use two serial ports, then the demo setup can be ran on a single PC, using a different serial port to communicate with each board.

[2] Note that the DSP control cards are pre-loaded with “Prime_iec432_f2806x.out” and ready to be used.

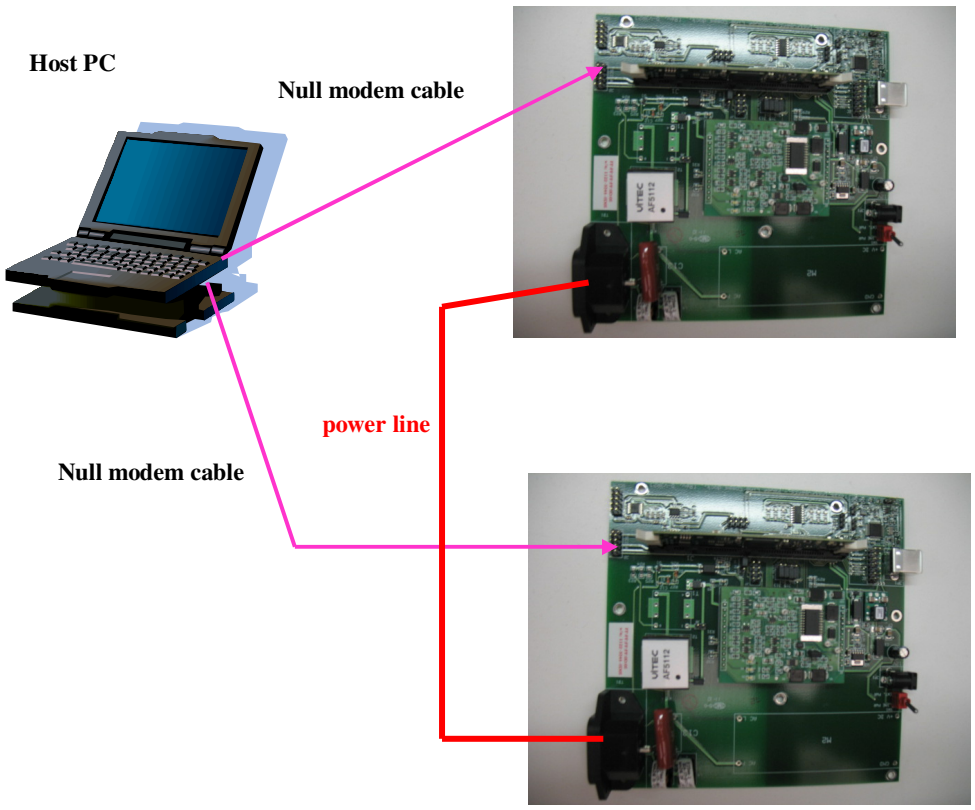


Figure 2 PLC-DK Point-to-Point HW Setup

1.5.2 PRIME PLC Service Node and Base node HW Setup

The PLC Development Kit can be used to demonstrate PRIME service node operation over power line together with a PRIME base node or concentrator (from 3rd party company). Under this configuration, there are two modes of operation: one mode is self-contained with an embedded application emulation "AppEmu" called eAppEMU running on the F28069; and a second mode runs the "AppEmu" called hostAPPEMU from application processor (in this case a host PC). The hostAPPEMU requires 1 PC and 1 null modem cable. Refer to section 1.4 for more information.

The following diagram illustrates the setup:

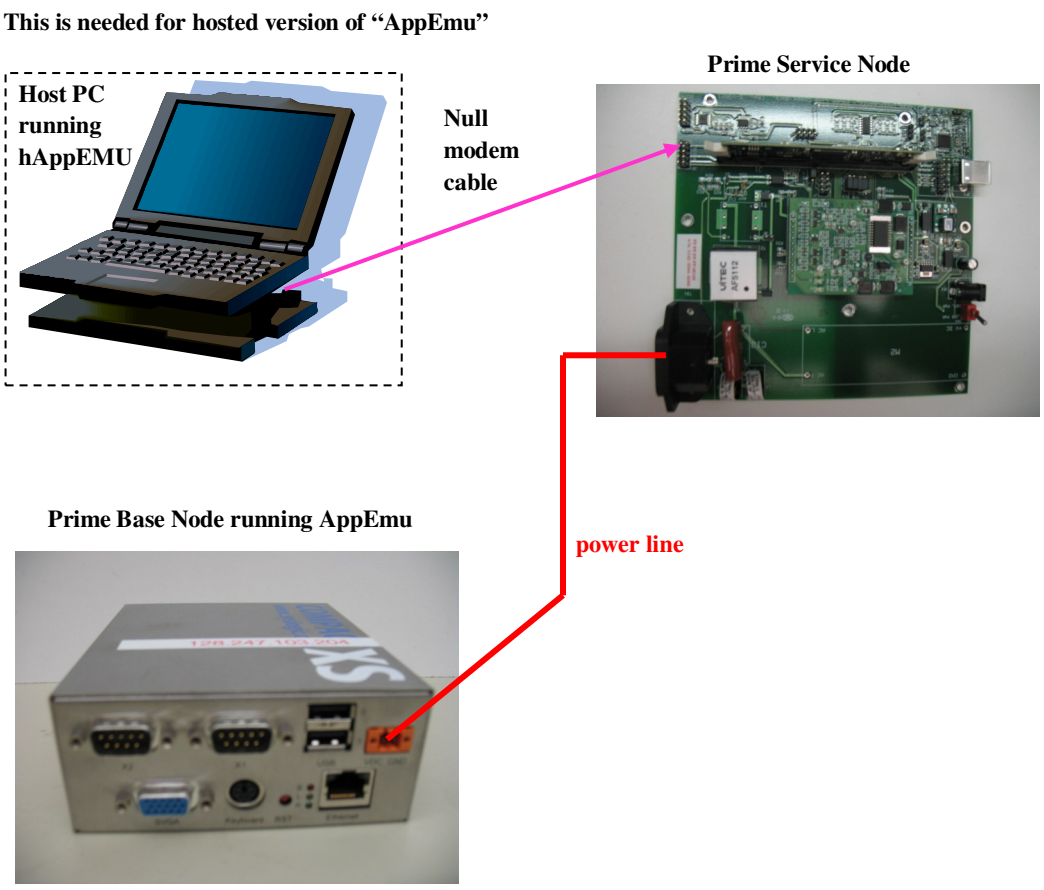


Figure 3 PLC-DK setup for PRIME Network Concentrator or Base Node

1.5.3 PLC-DK Default Jumper/Connector Settings

The PLC Development Kit provided is configured with the default jumper/connector positions. The following three tables describe the connector/jumper name, descriptions, default positions and other options if available.

AFE Connector/Jumper	Descriptions	*Default Position*
J4	DAC/PWM selection	2-3 DAC
J6	RX filter input selection	1-2 from PGA1
J7	RX PGA1 input selection	1-2 from front end
J8	RX PGA2 input selection	1-2 from RX filter
J9	ADC input selection	1-2 from PGA2 output

Table 1 PLC AFE Connector/Jumper

PLC Dock Connector/Jumper	Descriptions	Default Position	Options	
J1	DSP Control Card	**Connector**		
J2	SCI-A	**Connector**		
J3	F28335 Boot Options	**Open**	Open 1-2 2-3	Boot from Flash Boot from SPI-A Boot from SCI-A
J5	ECAP Channel Selection	**2-3**	1-2 2-3	ECAP1 ECAP3
J6	SCI-CCAN Bus	**Connector**		
J7	GPIO Test Pin	**Open**	2 4 6	GPIO1 GPIO3 GPIO4
J8	Transformer Connection	**Close**	Open Close	T1/ T2 Not Used T1/ T2 Is Used
J9	External Isolated RS232 Power	**Open**	Open Close	External Power NOT used for RS232 External Power used for RS232
J10	AC Mains	**Close**	Open Close	Mains Not Connected Mains Connected
J12	ADC Input Selection	**1-2**	1-2 2-3	ADC-A1 (F28069) ADC-A0 (F28335)
J13, J14, J15, J16	SPI-A / McBSP-B to AFE031 Selection	**2-3**	1-2 2-3	SPI – A Select (F2803x) McBSP B Select (F28335)
J17	AC Mains	**Close**	Open Close	Mains Not Connected Mains Connected
J18, J19, J20, J21	SPI-A/McBSP-A to PGA AFE031 Selection	**1-2**	1-2 3-4	SPI McBSP- A to AFE (F28069) PGA McBSP Other to PGAAFE (F28335/03x)
J22	Output Capacitor Band Selection	**1-2**	1-2 2-3	CENELEC/FCC Less Than 20kHz
J23	Transformer Primary Ratio Configuration Selection	**1-3**	1-3 3-4	T1 – 1:3, T2 – 1.5:1 T1 – 1:2
J24	Output Inductor Band Selection	**7-8**	1-2 3-4 5-6 7-8	CENELEC B/C Less than 20kHz FCC CENELEC A
J25	Transformer Secondary Ratio Configuration Selection	**2-4**	2-4	T1 – 1:4 & 1:2, T2 – 1.5:1

M3	AFE Daughter Card	**Connector**		
JP1	Power Supply	**Connector**		
TB1	Power Line	**Connector**		

Table 2 PLC Dock Connector/Jumper

USB/JTAG/SCI Macro	**Descriptions**	***Default Position***	**Options**	
J1	Boot Selection	**Open**	Open Close	Boot from Flash Boot from SCI-A
J2	JTAG	**Connector**		
J3	N/A	**Open**		Connected to GPIO34
J4	USB/SCI-B Selection	**Close**	Open Close	SCI-B Not Connected to USB SCI-B Connected to USB
J5	XDS100 Reset	**Open**	Open Close	XDS100 Held in RESET XDS100 operating

Table 3 PLC USB/JTAG/SCI Macro

2. Using Demo Application – Zero Configuration GUI

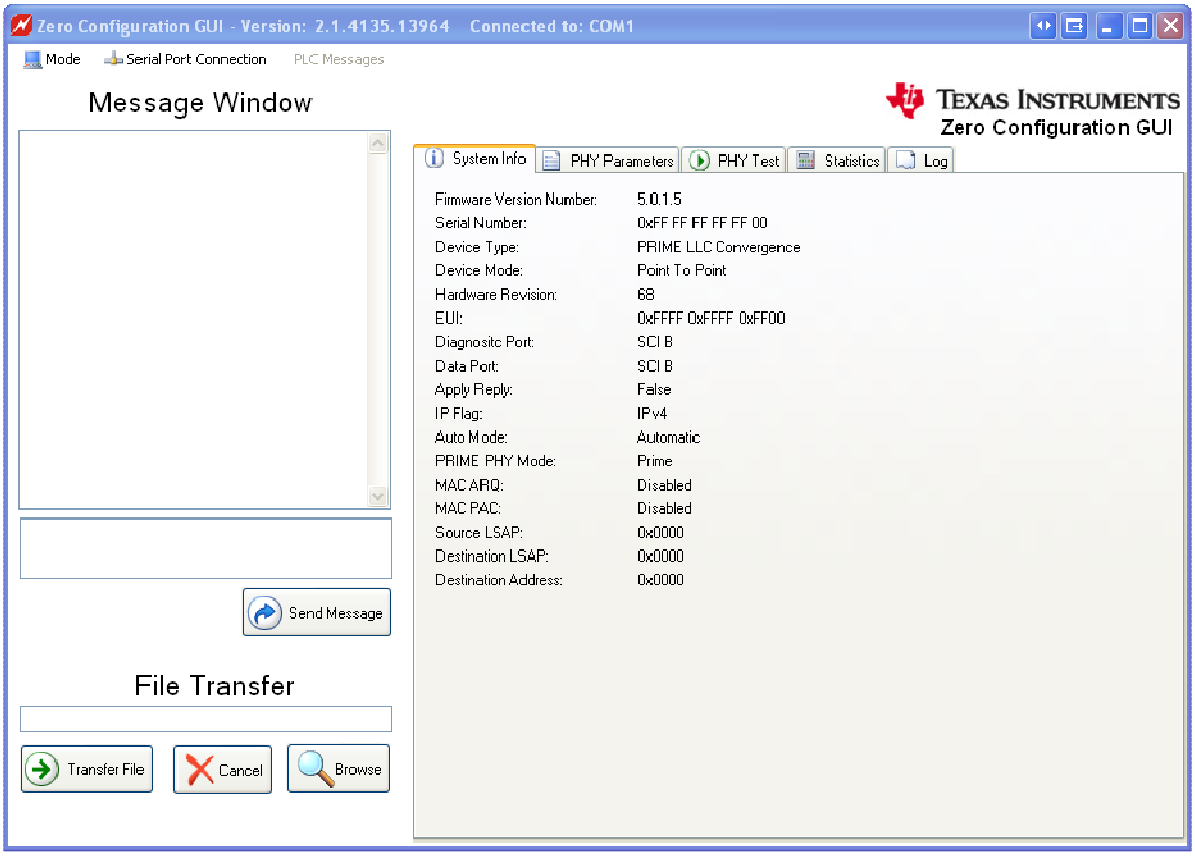


Figure 4 Zero Configuration GUI – Starting Screen

The Zero Configuration GUI is a windows application that the PLC-DK user may 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 log information.

Note that both transmit and receive stations should be running zero configuration GUI and should not be paired with PQM

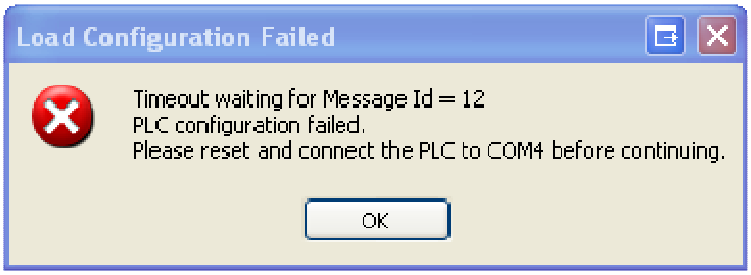
2.1 Configuration

There is no software or PLC configuration is needed to use the Zero Configuration GUI. The only assumption is that the USB ports (SCI-B) 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, will be used to connect to the PCL.

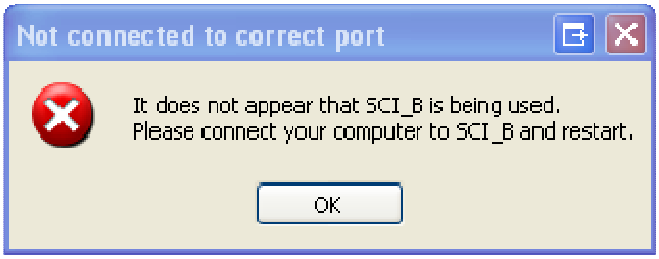
If no available serial ports are found on the PC the Zero Configuration GUI will display an error and exit.

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



If the PLC is connected to another COMM port you may 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.

If the PLC is connected by the PLC serial ports instead of the default USB ports this message will be displayed.



If you wish to use the PLC serial ports instead of the USB ports the Zero Configuration GUI configuration file must be changed. This is a XML file that has a number of configuration items that may be changed and some that should not be changed.

To change the default PLC port to be used, change the “DefaultSCIPort” to “SCI_A” (PLC serial port connection) or to “SCI_B” (PLC USB port connection) in the configuration file.

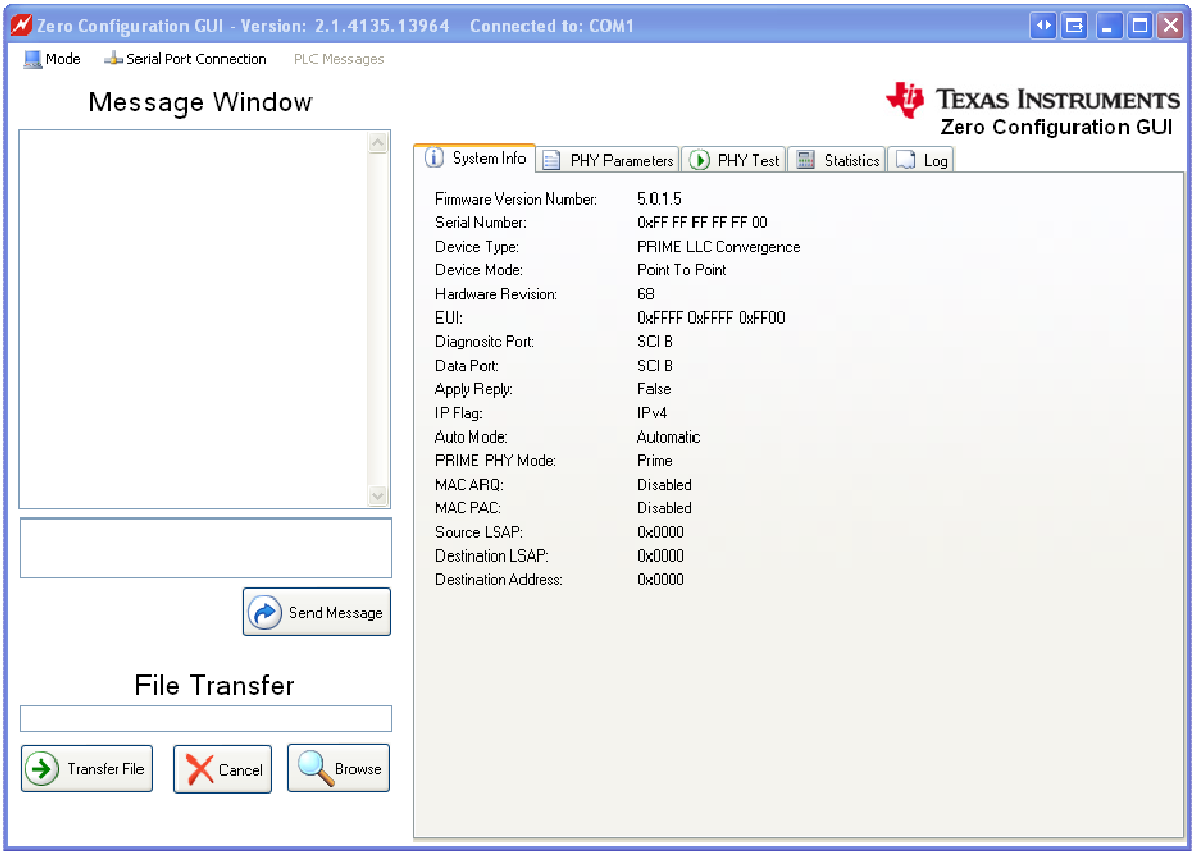
The Zero Configuration GUI configuration file will be found here:

“C:\Program Files\Texas Instruments\PLC Application Suite\ PLC_Application_Suite.exe.config”.

Below is the table of the items that may be changed and their description.

XML Tag	Description	Default Value	Range of Values
ConnectionAttempts	This is the number of retries the GUI will attempt to connect, initialize, and configure the PLC before displaying the failed initialization message box.	3	1- ####
DefaultG3Security	This will set the default security value for G3 data messages. Security G3 for data transfers is normally enabled for G3 firmware versions greater than 1.3.1.0. This setting can override this behavior and disable security. If the version is less than 1.3.1.0 the security is disabled even if this value is enabled.	Disabled	Enabled Disabled
FileTransferPageSize	This is the number of bytes transferred at a time during a file transfer. This does not count the extra data sent in the data packet during a file transfer. 24 bytes of the data packet is used for the file transfer protocol.	256	1 – Max Packet Size
CloseAllOnExit	If this is set to true than all instances of the Zero Configuration GUI will close when any instance on a PC is closed.	False	True or False
DefaultSCIPort	This is the default SCI port to use. The data and diagnostic ports must be set to the same port for the file transfer	SCI_B	SCI_A SCI_B

2.2 Main Screen



The Zero Configuration GUI consists of the main screen where text and file transfers may be performed. The tabs on the right display significant information about the PLC.

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.

From this screen you can 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 three modes, Zero Configuration, Intermediate, and Expert.

The Zero Configuration mode is the mode described. Any available COMM port 1-99 will work with the Zero Configuration GUI.

The intermediate mode executes the PLC Quality Monitor using the same COMM port as the Zero Configuration GUI. When the intermediate mode exits the Zero Configuration reopens the COMM port and takes control once again. If the COMM port is 10 or above the PLC Quality Monitor will not be able to open the COMM port and will not function. The COMM port assignment must be changed to a port assignment 1-9 using the Device manager for the PLC Quality Monitor to function.

The Expert is currently disabled for this release.

2.3 Hot Keys

There are several hot keys available. The alpha key is not case sensitive.

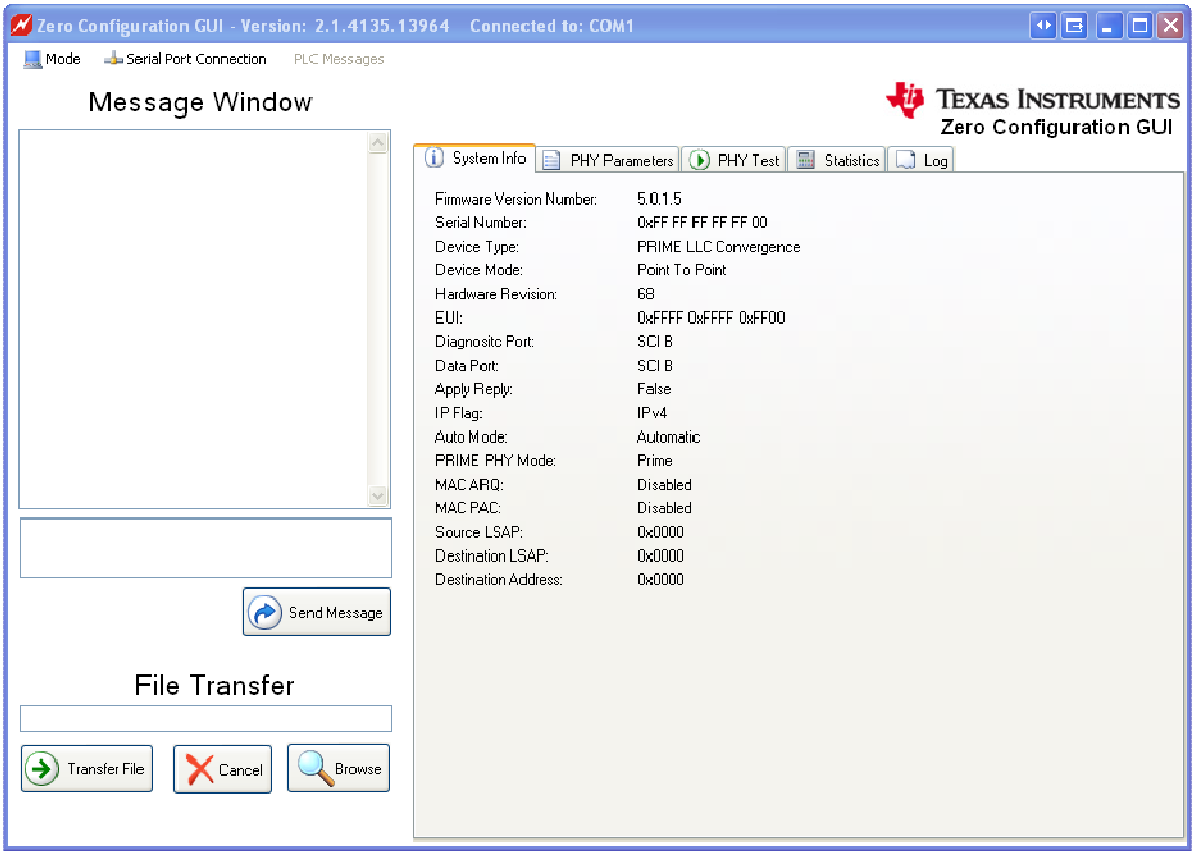
<Control I> will close this GUI and execute the PLC Quality Monitor GUI as the intermediate tool.

<Control R> will reset the file transfer statistics. The Statistics received in the Link Quality Report are not reset. This key stroke combo will reset the statistics screen regardless of what screen has focus in the GUI..

<Control T> will toggle the expert mode menu items on/off depending on their current state.

<Control S> will send a System Information request to the PLC and update the System Info panel when received.

2.4 System Info Panel

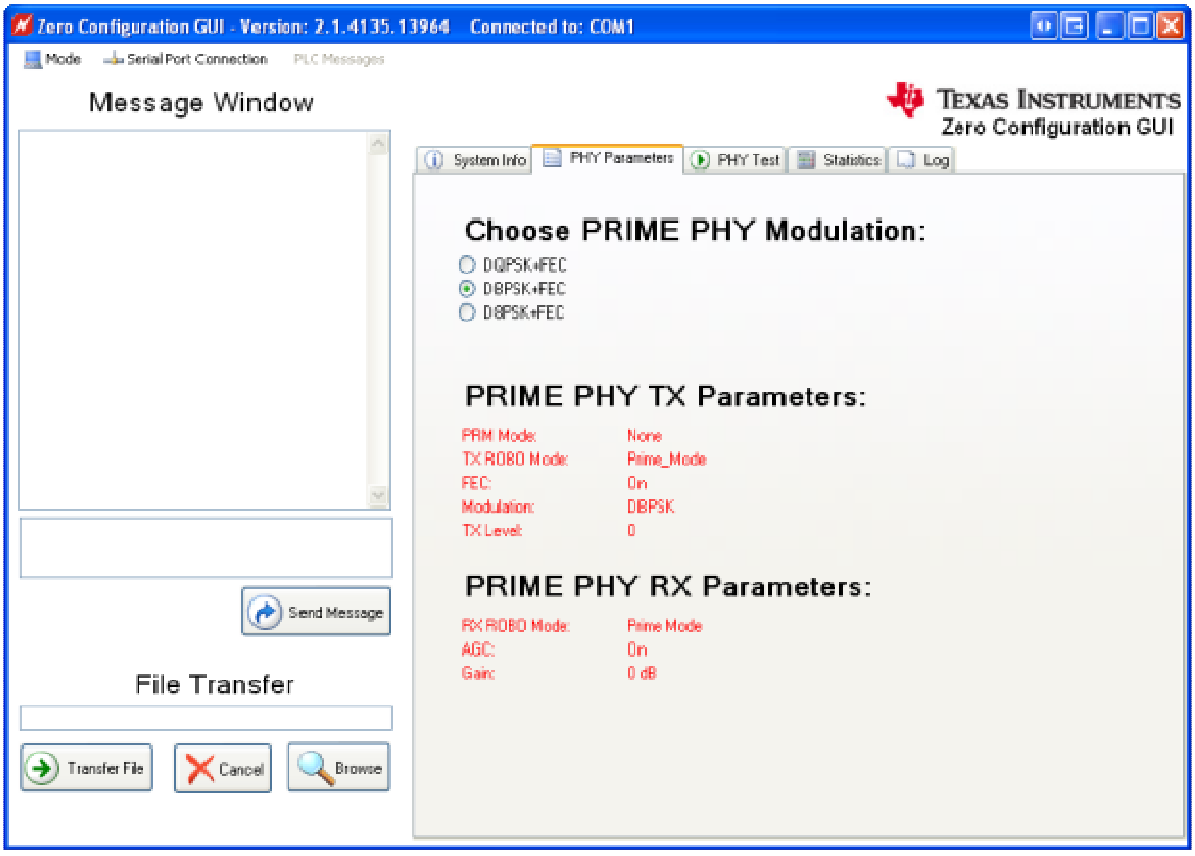


The PLC System information is displayed in the first tab. Right clicking on the System Info panel will expose a context menu with one menu item “Refresh System Information”. This will resend a system information request to the PLC and refresh the system info panel with the updated information.

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

Any value changed will be displayed in red text.

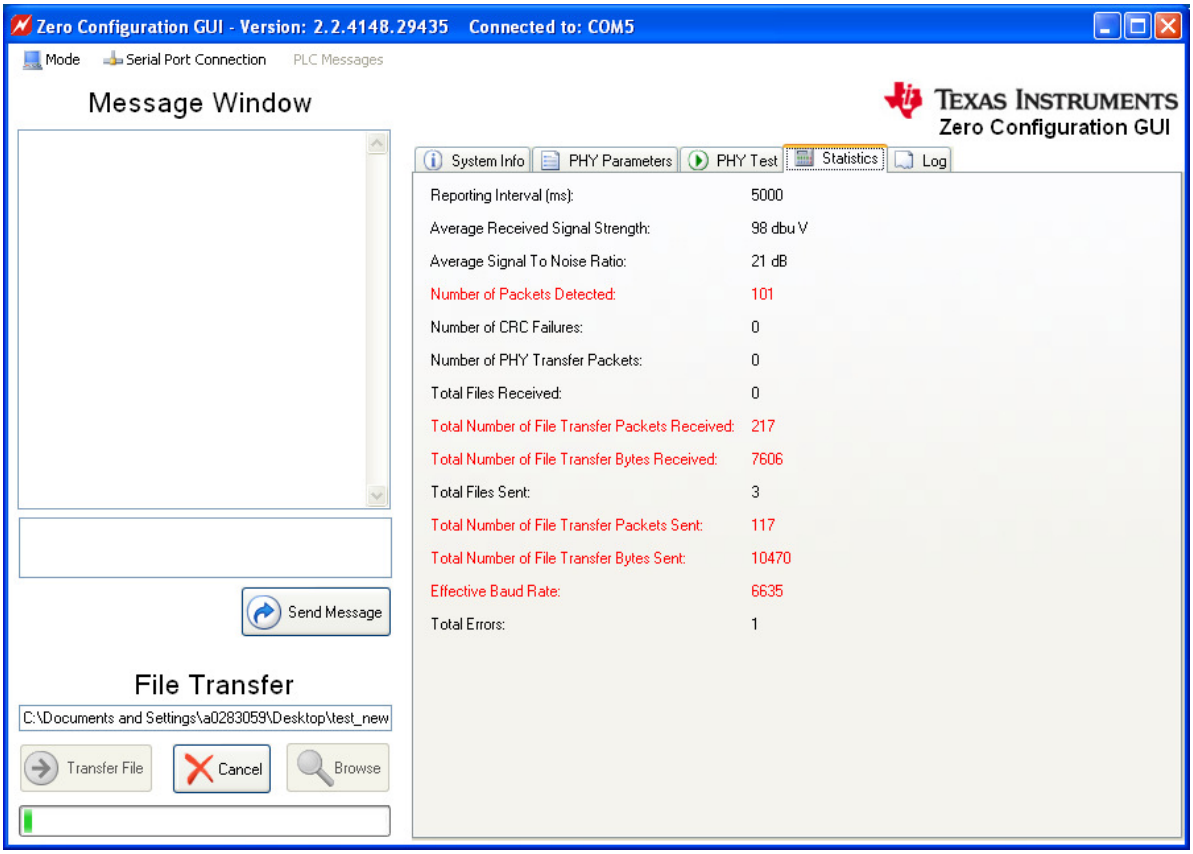
2.5 PHY Parameters Panel



The PHY TX and RX parameters are displayed in the second tab.

The TX modulation may be changed using the radio boxes. Changing the modulation schemes will affect the reliability and baud rate of the power line transmission

2.6 Statistics Panel

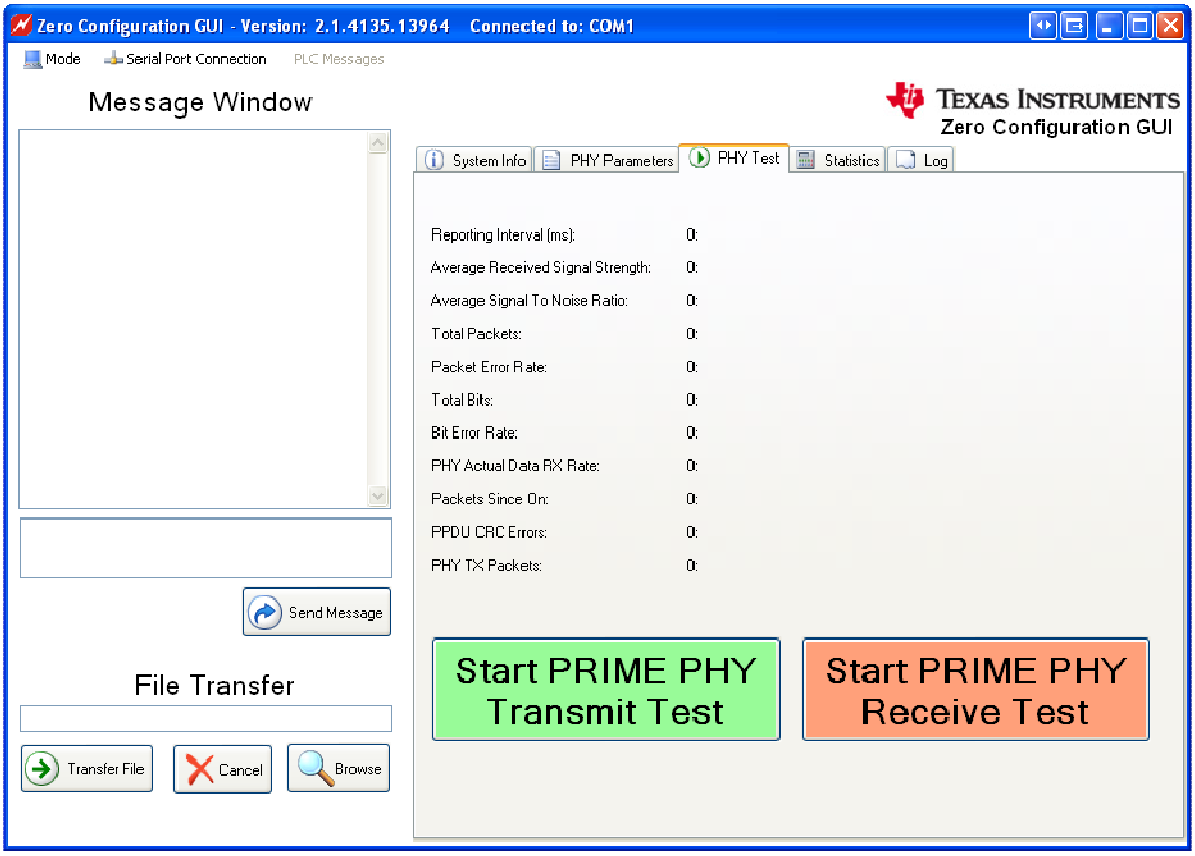


The Statistic panel displays information concerning the text and file transfers. Items that have changed are displayed in red.

Right clicking on the Statistics panel will expose a context menu with a single menu item “Reset Application Totals”. This will reset totals.

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

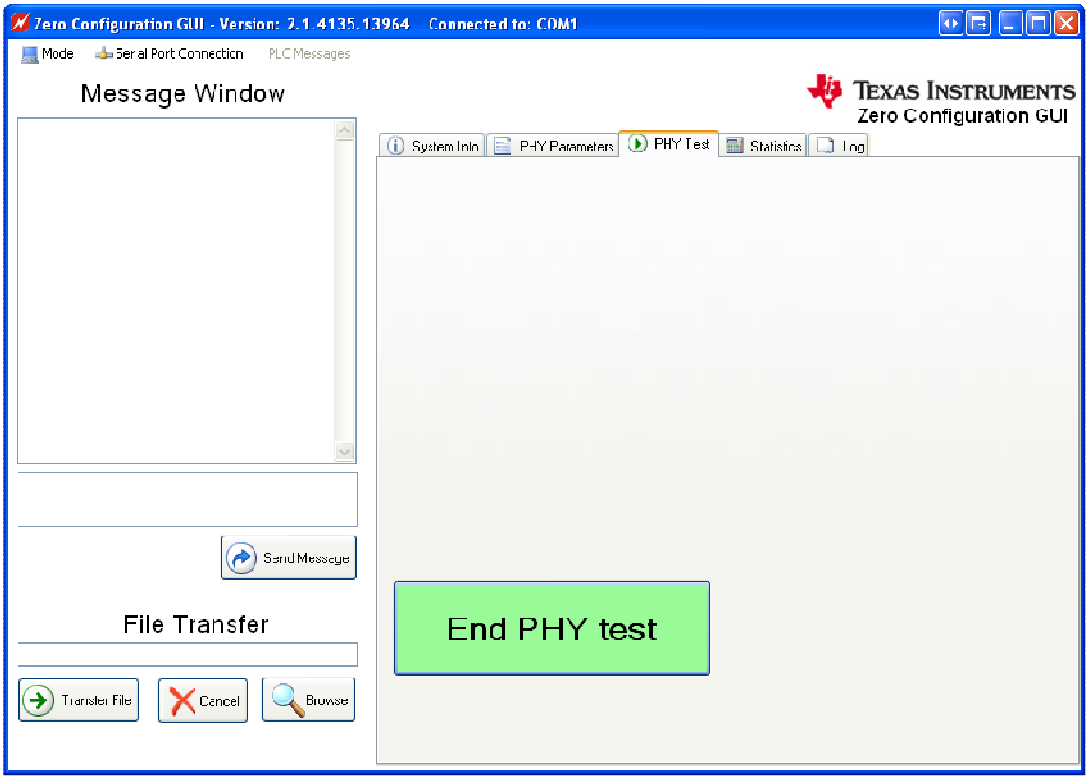
2.7 PHY Test Panel



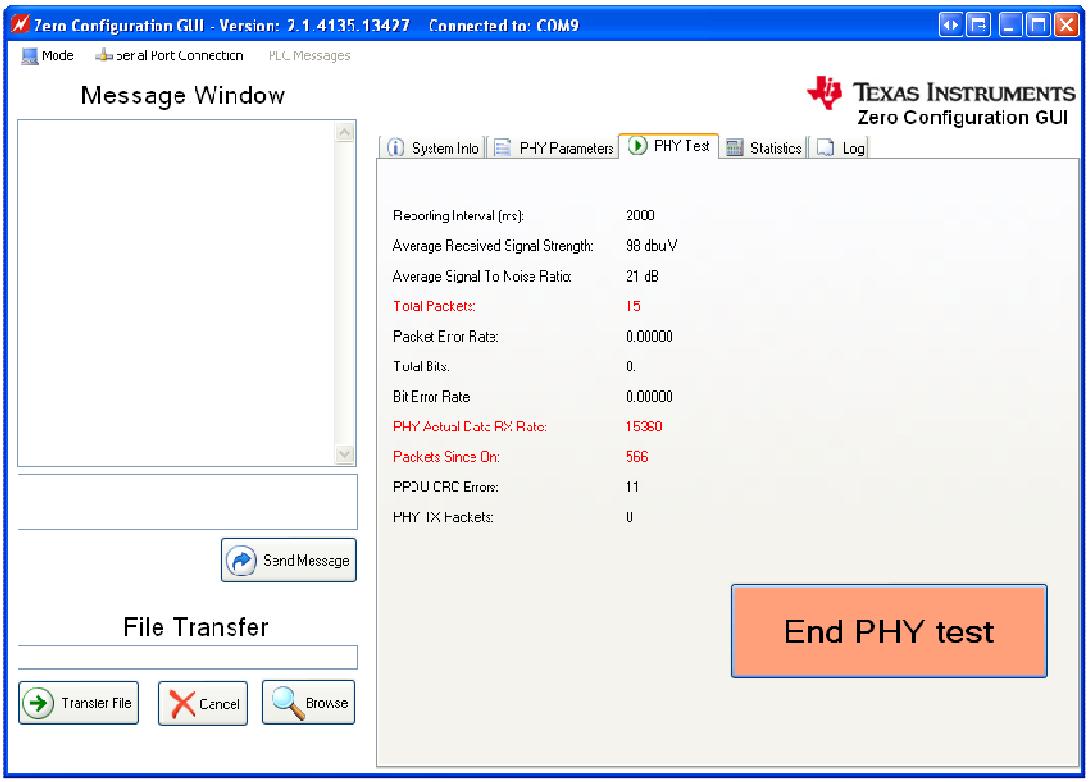
The PHY Test panel will test communications between two PLC's using PHY packets. One PLC will transmit the PHY packets while the other will receive the PHY packets.

To start the test click on the Start PRIME PHY Transmit Test button on either PLC. The statistics will disappear from the panel since there are no statistics collected on the transmitting PLC. See the figure below.

It is important to note that Text and File transfers will not work during PHY testing.

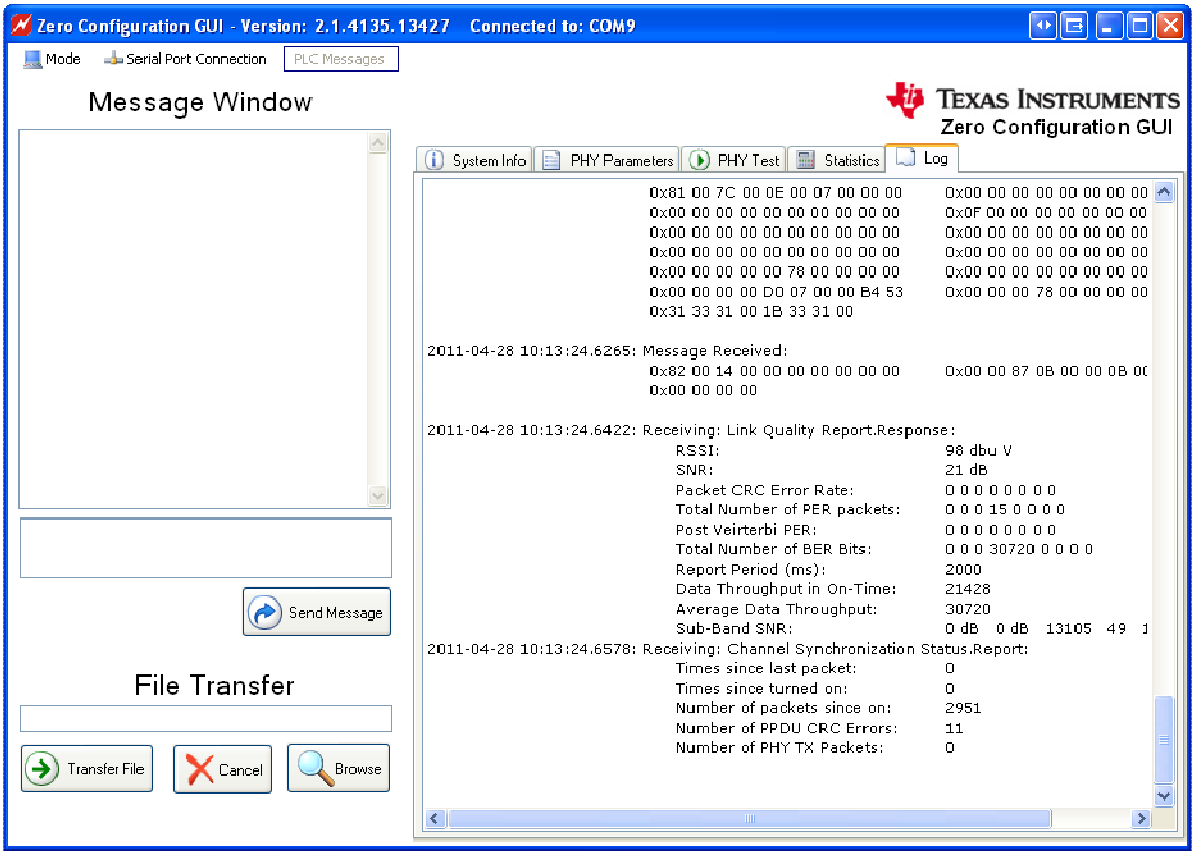


On the receiving PLC click the Start PRIME PHY Receive Test buttons. The button will change to the "End PHY Test" state and the statistics will start updating. See below.



To end the test click the "End PHY Test" button on both PLC's.

2.8 Log Panel



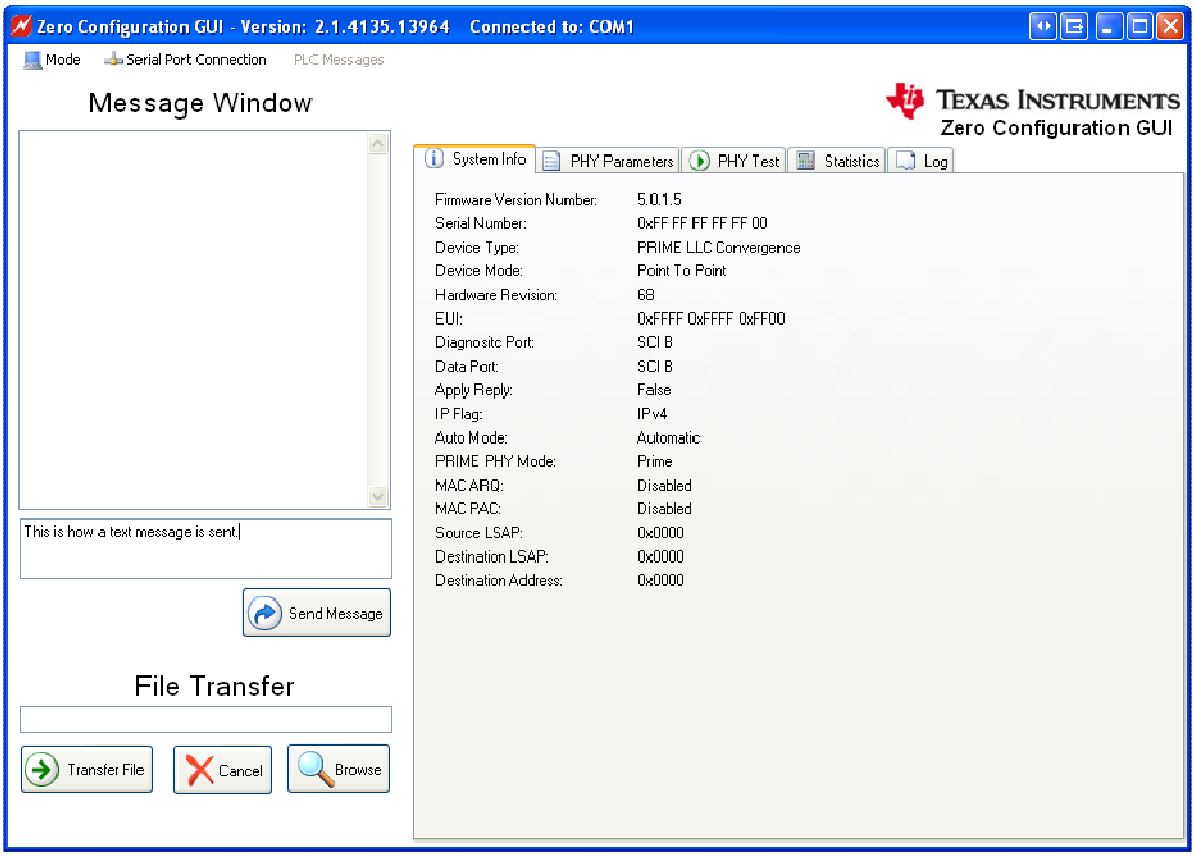
The log panel will hold about 100,000 characters then it will refresh the display. This prevents the panel from consuming large amounts of memory and keeps the log panel responsive to new input.

The Log panel by default displays very little information but right clicking on the log panel will display the log context menu. Using this menu you can enable the display of the formatted messages that are being sent and received by the Zero Configuration GUI. Below is the table of features exposed by the log pane context menu.

Enable Message Data Display	This will enable the log panel to display the message transfers, sending and receiving. Depending on the other options selected the raw data, formatted data, or both will be displayed. By default this option is turned off.
Enable Logging to a File	When selected the user will be prompted for a file to save the logged information. When enabled all messaged data, sent and received will be saved and will be written to the log.

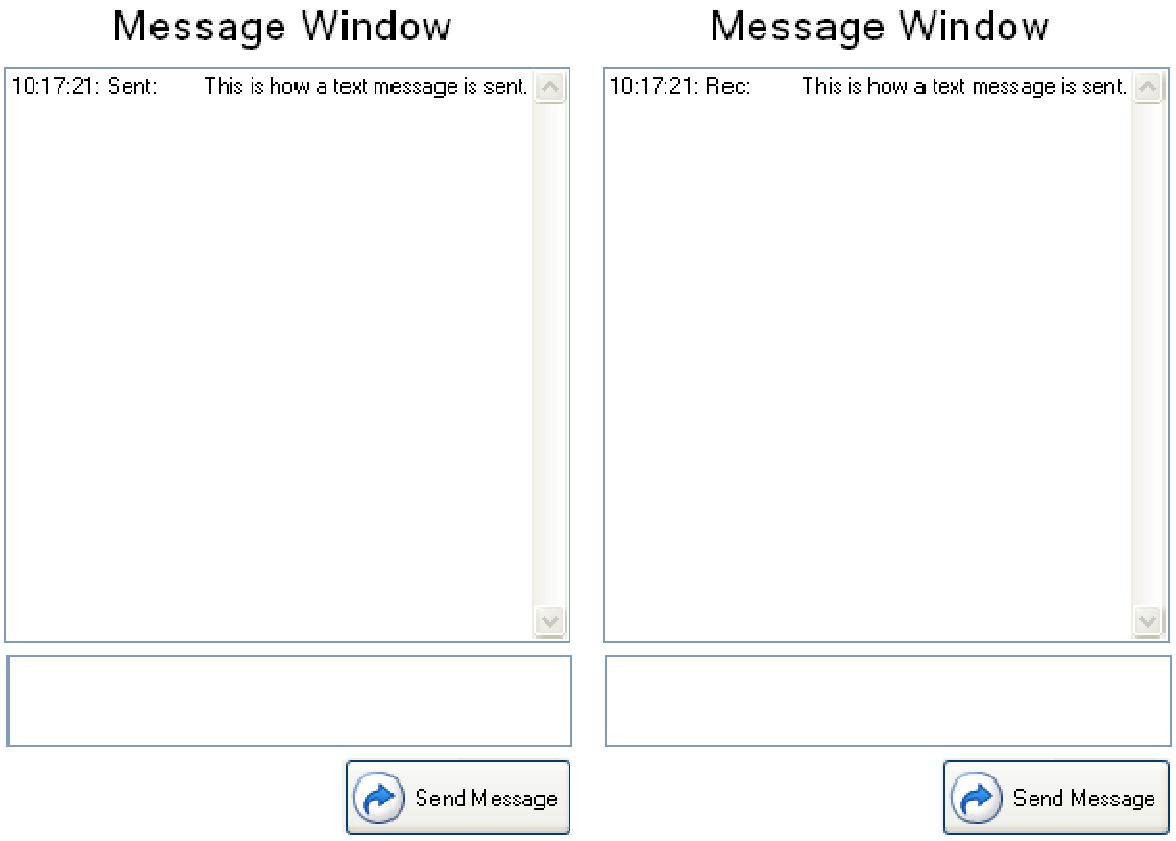
Log Full Message Data	This will display the formatted message data in the log panel. No data will be displayed unless the “Enable Message Data Display” is enabled.
Log Condensed Data	This will only display the message type and no actual message data. This reduces the amount of data logged to the screen.
Log Raw Message Data	This will display the unformatted message data as a byte stream.
Clear Display	This will clear the log panel. This does not affect data being logged to a file.
Save to File	This will save the current contents of the log panel to a file of the user’s choosing.

2.9 Sending Text Messages



To transfer text between two connected PLC devices using the Zero Configuration GUI, simply type your text in the small text box and click on the “Send Message” button. Pressing ‘Enter’ while entering the text will not send the text message but add a line to your text.

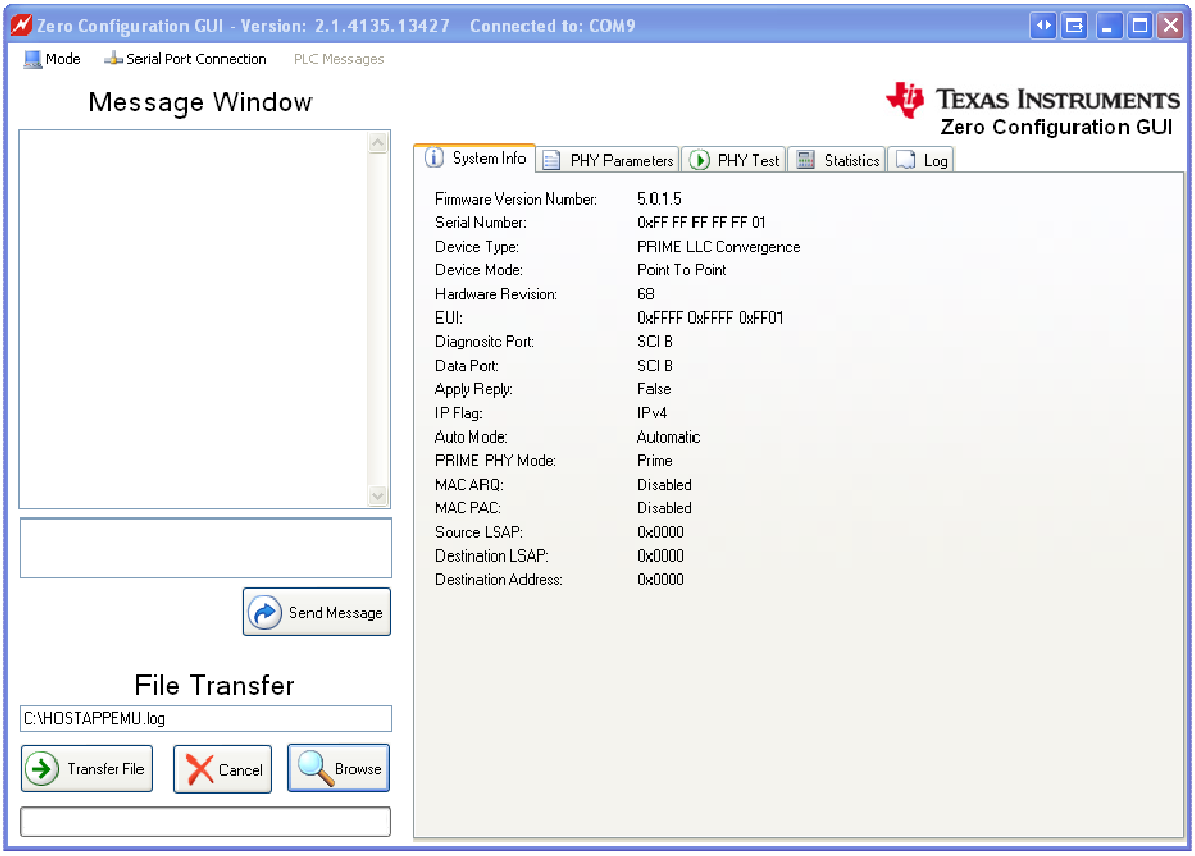
When the text is sent the text is moved to the top text box and displayed by the receiving PLC



The form on the left is the sender and the form on the right is the PLC message box receiving the text. You may send text from either PLC device.

If the text transfer fails the message box below will be displayed.

2.10 File Transfers



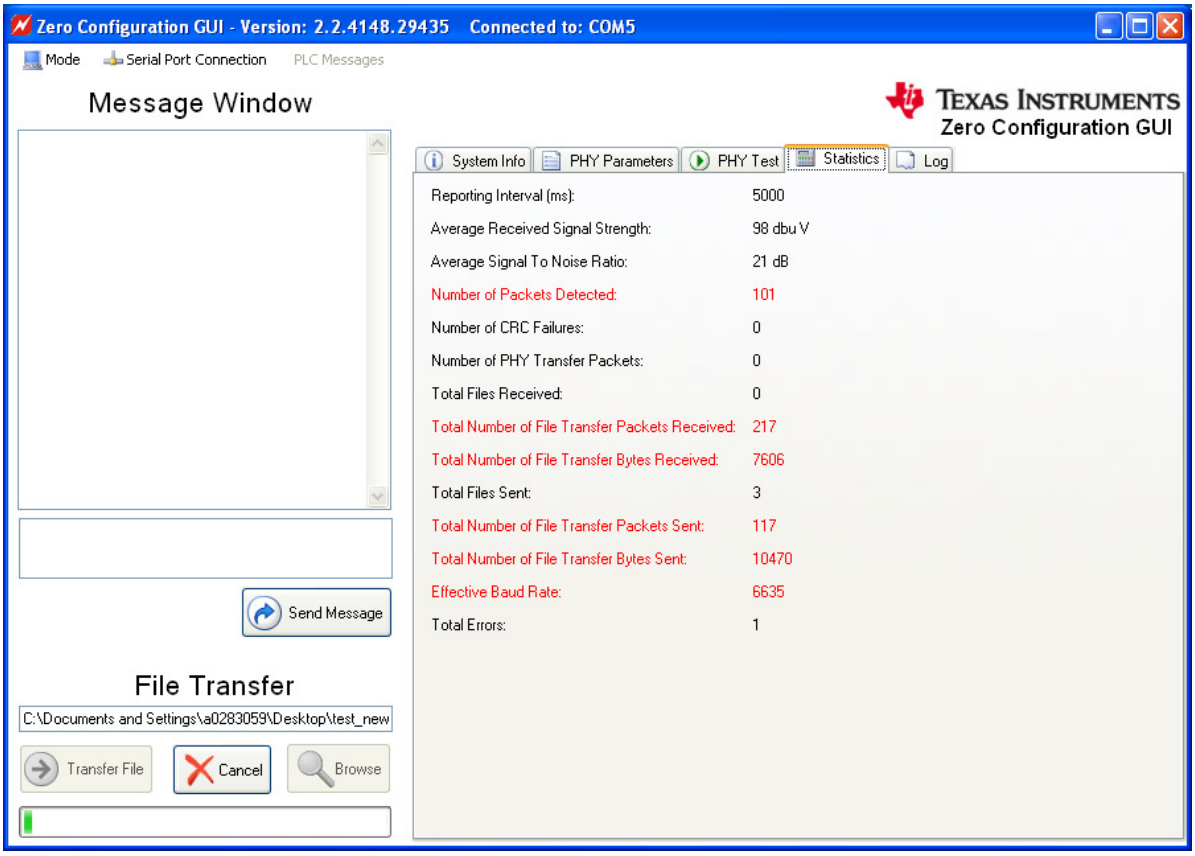
The file transfer function is contained in the bottom left hand corner.

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.

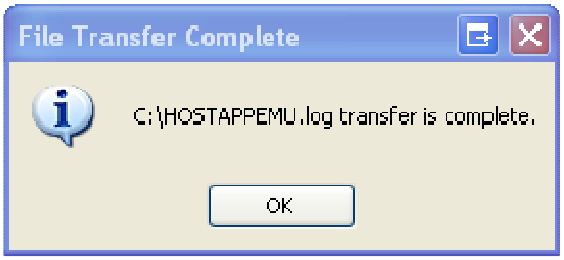
After the file is chosen, click on the 'Transfer File' button.

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 below 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.



When the file transfer is complete the message box below will be displayed on both Zero Configuration GUIs.



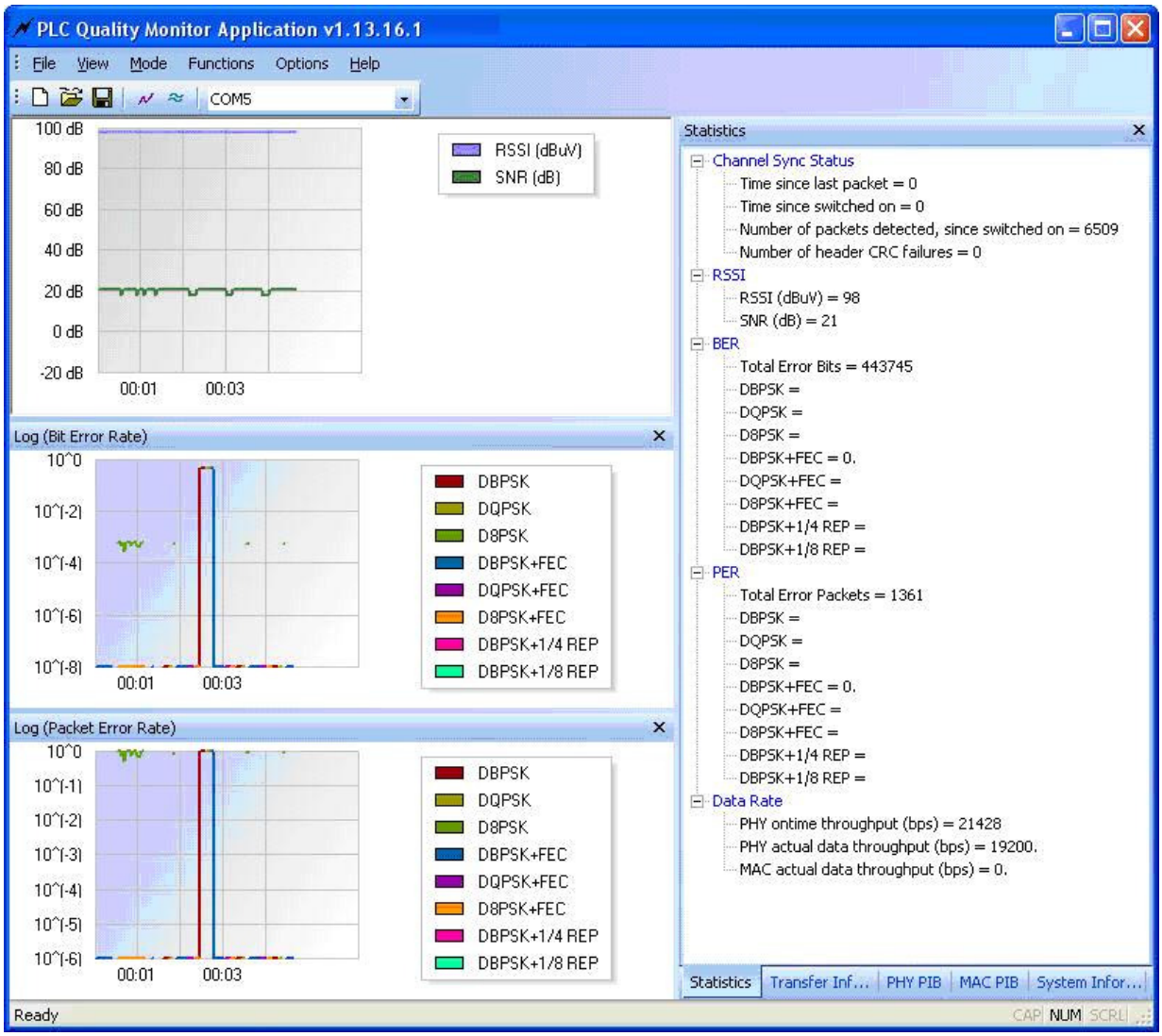
If the file transfer fails the following message box will be displayed by the sending GUI.

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

3. Using Demo Application

The PLC Quality Monitor GUI diagnostic tool - PQM is the window to the PLC-DK user to provide graphical displays, system information, PHY and MAC parameter configurations and statistics.

3.1 User Interface



The PLC quality monitor consists of the followings:

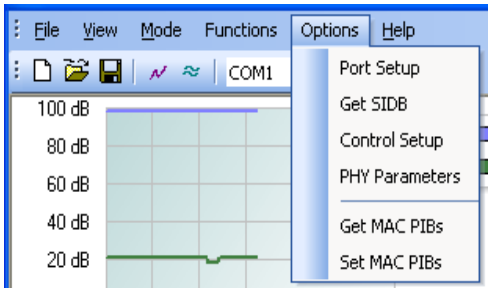
- Main Menu – All operations are initiated from the main menu with toolbars and buttons.
- Graphical Displays
    - PHY Parameters – PHY parameters configuration (see details below)
    - RSSI graph – Plot is in dBuV. Note this is limited between 70 dBuV and 98 dBuV.

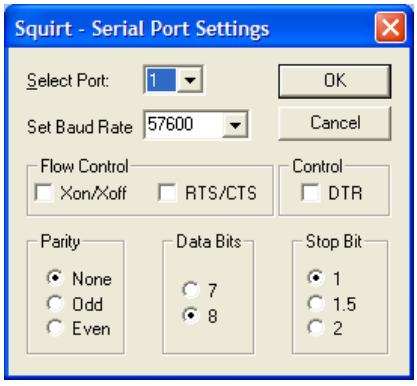
- SNR graph – Plot is in dB.
- Bit Error Rate graph – Plots of PHY layer bit error rate, one line for each MCS (only applicable to PHY test mode operation)
- Packet Error Rate graph – Plots of PHY layer packet error rate, one line for each MCS

- PHY statistics – This panel provides statistics in the physical link.
- MAC statistics – This panel provides statistics in the MAC and CL layers
- Transfer statistics – This panel provides statistics when file transfer is in operation.
- System Information – This panel provides system version information and PHY/MAC/CL IPv4/LLC configurations.

3.2 Port Set Up

The Port Setup option provides a way to configure the serial port (Menu->Options->Port Setup). You may configure the baud, data bits, parity, stop bits and handshaking mode. There are 2 serial ports on the hardware; both ports baud rate should be set to 57600 bps as shown in the figure below.

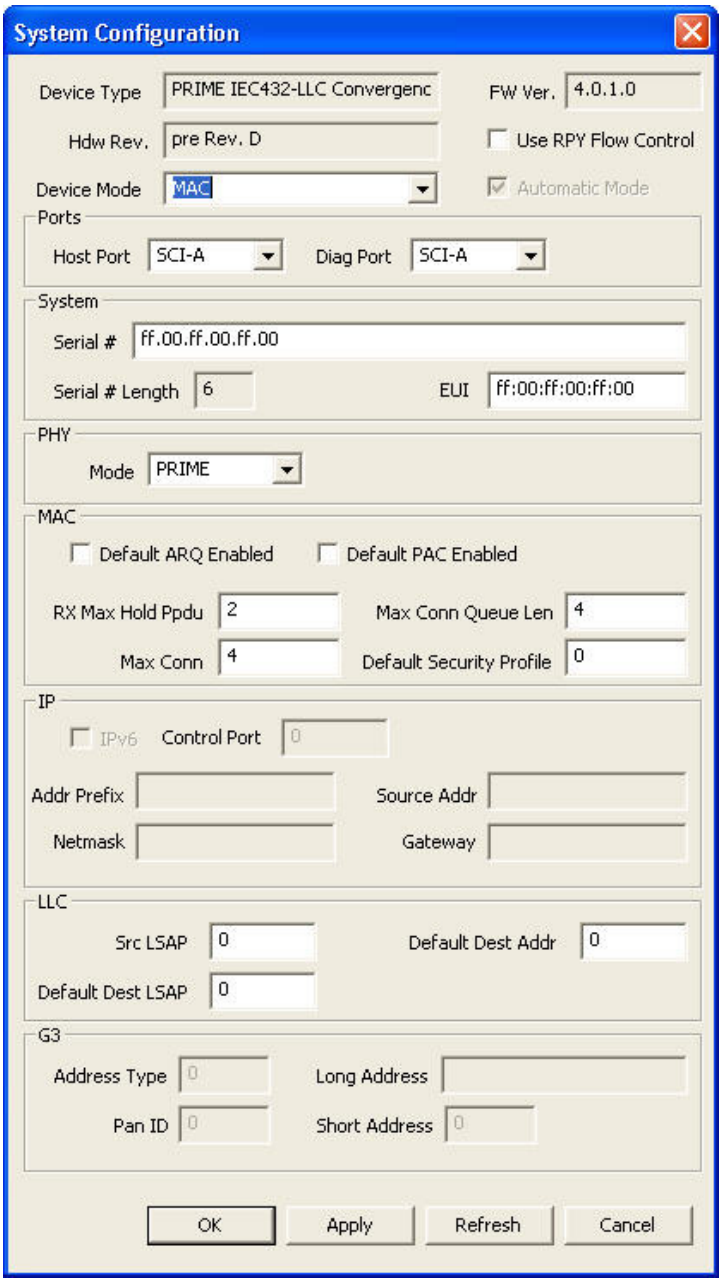




Note that the only selection that should be changed is the port number and baud rate (in red box above). The rest of the port settings should not be modified for PLC device compatibility.

3.3 System Configuration

The system configuration provides a way to configure the PLC device (Menu -> Options -> Set System Config).



The following describes the configuration settings:

- Application PIB Attributes
  - AppFwVersion – Textual description of firmware version running on device
  - AppVendorId - PRIME Alliance assigned unique vendor identifier.
  - AppProductId - Vendor assigned unique identifier for specific product.
- Hardware Revision – Docking board revision ID (default: Rev.D)
- Firmware Version – Firmware version ID
- Device Type – The current type of the device
  - **PRIME IEC-432 LLC Convergence** – PRIME standard in IEC432-LLC convergence layer
  - **PRIME IP Convergence** – PRIME standard in IP convergence layer

- Device Mode (Automatic flag is only applicable to PRIME IEC432-LLC) - The current mode of the device.
    - **PRIME IEC-432 Point-to-Point –** using the end-to-end setup between the two PLC devices. This mode interfaces with the eMeter GUI performing its functions such as PHY testing, File Transfer, Message Transfer, etc.
    - **PRIME_ IEC432 - eAppEMU MAC mode** – embedded AppEMU application is running, in F28069 and interfaces directly with MAC layer in PRIME network with the base node.
    - **PRIME IEC543 - eAppEmu IEC432-LLC mode** – embedded AppEMU application is running in F28069 and interfaces with IEC432-LLC layer in PRIME network with the base node.
    - **PRIME IEC432-LLC - AUTO** – for host eMeter applications such as hostAPPEMU running in PC and communicate with TI PLC at IEC61334-4-32 LLC layer through UART based on TI Host Message Protocol. It performs network registration and connection establishment automatically.
    - **PRIME IEC432-LLC** – for host eMeter applications such as hostAPPEMU running in PC and communicate with TI PLC at IEC61334-4-32 LLC layer through UART based on TI Host Message Protocol. It does not perform network registration and connection establishment automatically.
    - **PRIME IEC432 MAC** – for host eMeter applications such as hostAPPEMU running in PC and communicate with TI PLC at PRIME MAC layer through UART based on TI Host Message Protocol.
- Use Message Header RPY Bit As Flow Control
    - When selected or enabled, the PLC device will set message header RPY bit to 1 during DATA_TRANSFER message used for Data.Indicate (Rx Data Path) to provide flow control for host device. (Host has to send an ACK to PLC before next DATA_TRANSFER.Indicate will be sent to host).
- Serial Ports
    - Data port
        - The Data Port is the serial port the PLC device used for host and PLC communication following “plcSUITE host message protocol”. This can be either SCI-A or SCI-B on Rev C. hardware and newer. This port is used by a host application (hostAPPEMU) to communicate with the PLC device.
    - Diagnostic port
        - The Diagnostic Port is the serial port the PLC device uses to transfer diagnostic messages to the PLC Quality Monitor or Logger Tools. This can be either SCI-A or SCI-B on Rev C. hardware and newer. If using IEC432/LLC, the Diagnostic port can be shared with Data port if required, however, if using IPv4, the Data port and Diagnostic port must be different and cannot be shared.

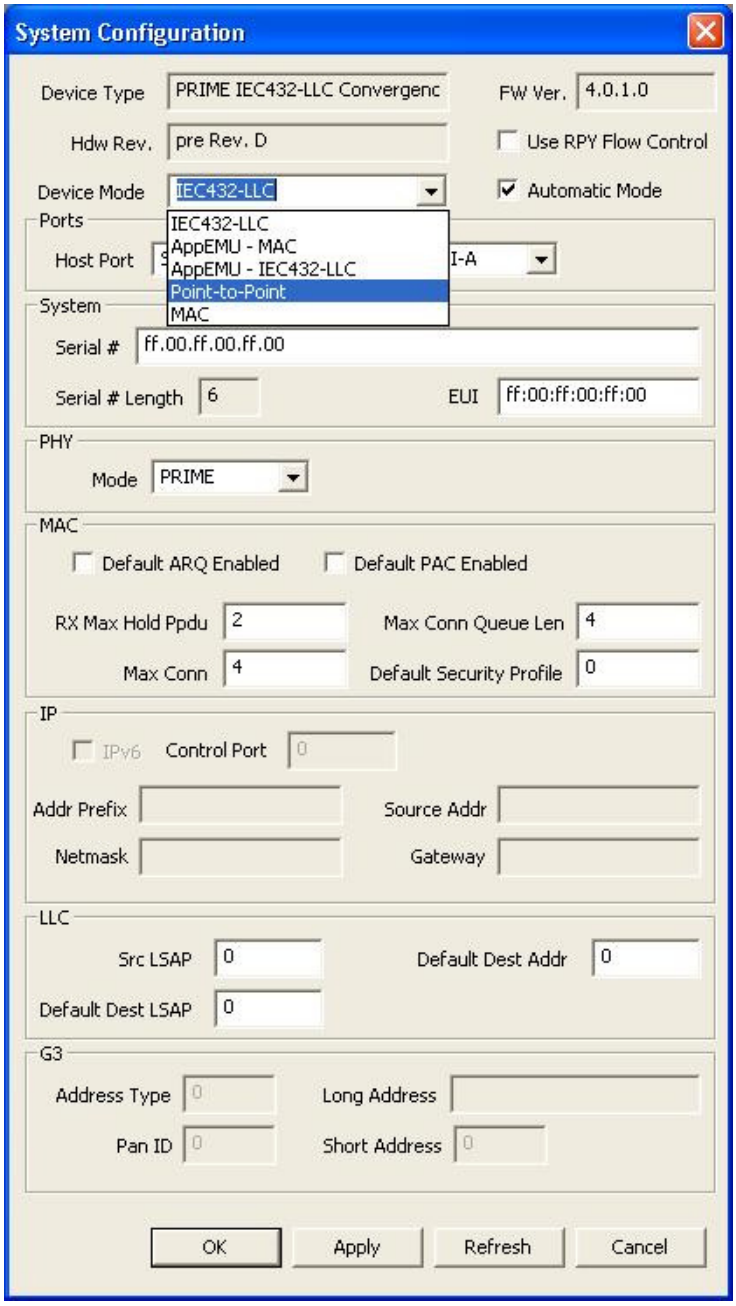
Note that SCI-B shall not be selected for docking board HW prior to Revision C

- System
    - Serial Number

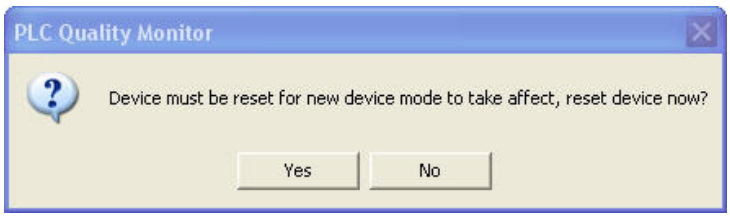
        - A maximum 16 octet string representing the device serial number, . entered as ####-####-####, where # can be 0-9, a-f.
    - Serial Number Length
        - The length of valid octets in the 16 octet serial number
    - EUI address
        - The hexadecimal EUI-48 of the PLC device, entered as ##:##:##:##:##:##, where # can be 0-9, a-f.
- PHY
    - PRIME – PRIME standard mode
    - PRIME ROBO – non-PRIME standard PHY robust mode
- MAC
    - Default ARQ enabled: ARQ is enabled by default
    - Default PAC enabled: Packet Aggregation enabled by default
    - Rx Max Hold PPDU: maximum number of PPDUs Rx MAC can hold
    - Maximum number of connection: default maximum number of simultaneous connections
    - Maximum connection queue length: default maximum queue sizes
    - Default Security profile
- CL IPv4
    - Source address
    - Netmask
    - Gateway
- IEC61334-4-32 LLC
    - Src LSAP – The local LSAP involved in the data unit transmission
    - Default destination LSAP
        - The default destination LSAP used by the eAppEMU when in eAppEMU interfaces with IEC61334-4-32 LLC
    - Default destination MAC address
        - The default destination node address used by the eAppEMU when in eAppEMU interfaces with IEC61334-4-32 LLC

The following example illustrates how to change the device type from “IEC432-LLC” to “Point-to-Point”:

1. Menu -> Options -> Set System Config
2. Pull down menu from Device Type
3. Select Point to Point
4. Click OK

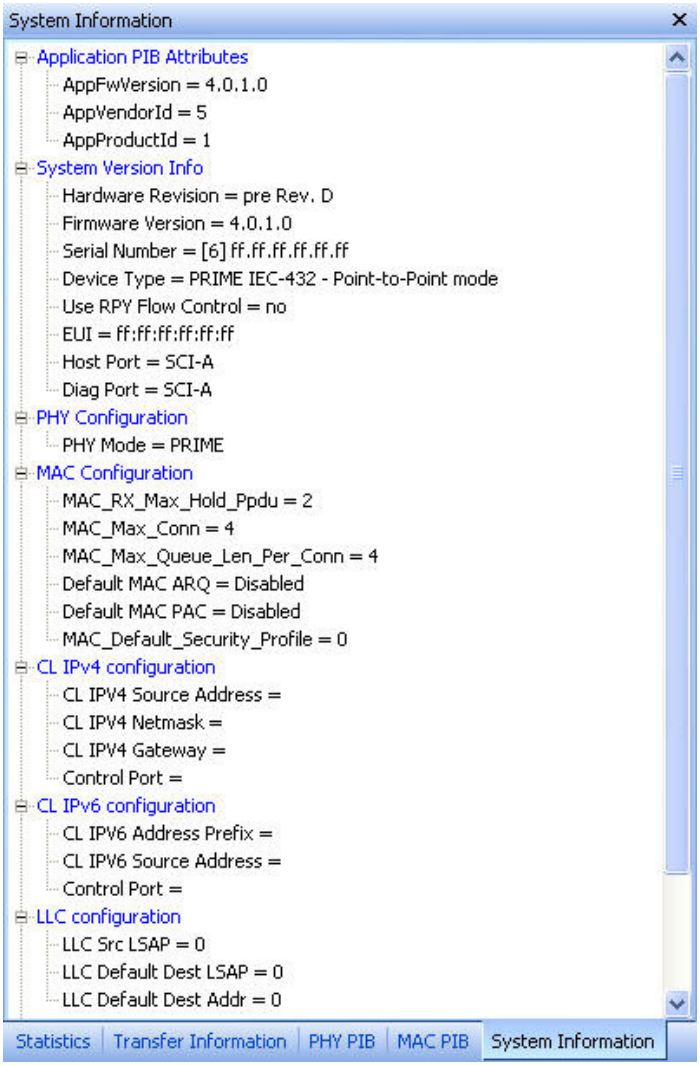


The following window will pop up and selecting “YES” will reset the PLC device and new device mode will be in effect.



3.4 Getting System Information

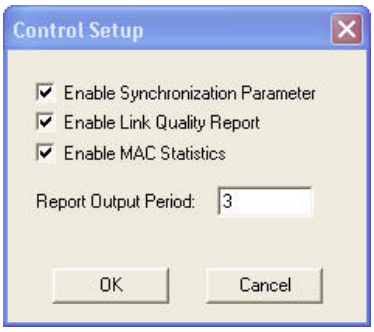
The Get System Info option (Menu->Options->Get System Info) retrieves the current System Information values from the PLC-DK. These are represented in the System Information view. These values may be set using the Set System Config (Menu->Options->Set System Config).



3.5 Control Set Up

The Control Setup option (Menu->Options->Control Set up) allows the followings:

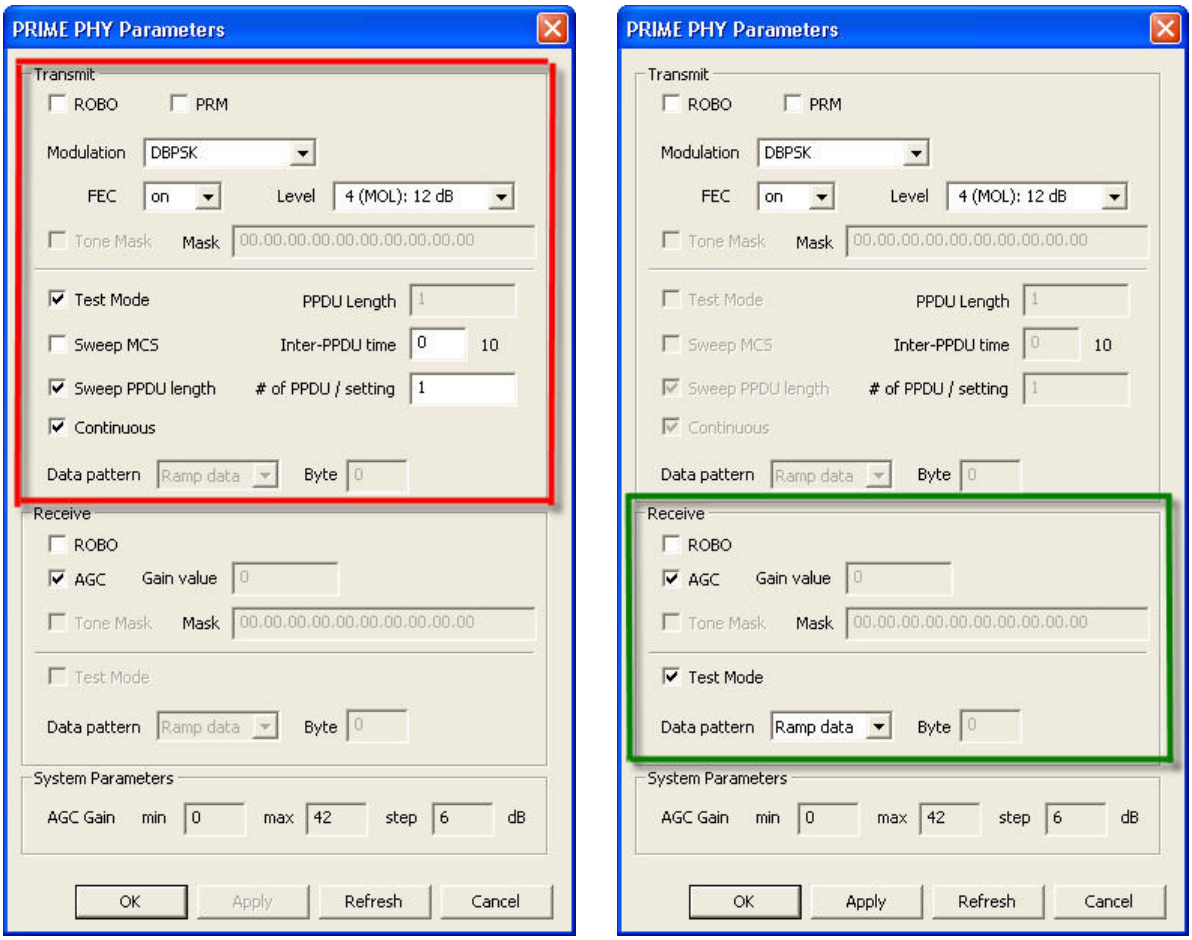
- Channel status update - Select “Enable Synchronization Parameters” check box for status display in statistic window.
- Link quality report update - Select “Enable Link Quality Report” check box for RSSI/SNR/BER/PER display in the statistics window.
- MAC statistic update – Select “Enable MAC statistics” check box for MAC statistics display in MAC statistic window.
- Update period in seconds – Enter duration between statistics updates.



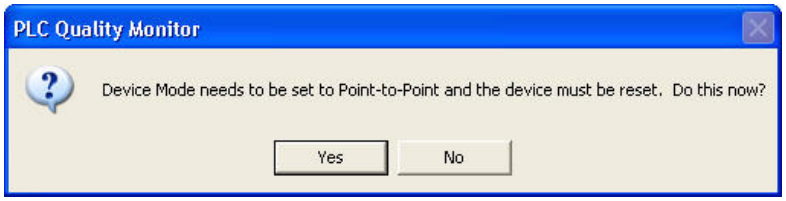
Note that if both transmit and receive PLC LQM tool is running on the same PC, it is recommended to use a larger update periods (e.g. 3 seconds) to avoid too many traffic between device and host PC.

3.6 Configuring PHY Parameters

The PHY parameters configuration (Menu->Options->PHY parameters) is used for configuring the PHY transmitter (Red Box below) and receiver parameters (Green Box below).



Note that the enabling of PHY "Test Mode" on the Transmit or Receive would require the device mode to be "Point to Point". The following window will be prompted if device is not already in "Point to Point". Click "Yes" to reset the device and "Point to Point" mode will be set. The PHY test can now be continued,



The following describes the PHY TX parameters that can be configured:

- ROBO – PHY Robust mode (non-PRIME standard)
- PRM – When enabled, it performs PHY Robustness Management as described in the PRIME standard and manages the modulation and FEC selections. The modulation/FEC selection from this panel will be ignored. PRM will not take effect if PHY test mode is selected.
- Modulation – DBPSK, DQPSK, D8PSK. Note this field is ignored if sweep MCS is selected. If ROBO mode is selected, then DBPSK + 1/4 repetition or DBPS + 1/8 repetition can be selected.
- FEC - ON or OFF. Note this field is ignored if sweep MCS is selected. If ROBO mode is selected, this field is not valid since FEC is always on.
- Level – Transmit Level

  (Note that the maximum transmit level should be set to 2 for AFE HW prior to Revision C)

  0 : Maximum Output Level (MOL)
  1 : MOL – 3dB
  2 : MOL – 6dB
  3 : MOL – 9dB
  4 : MOL – 12dB
  5 : MOL – 15dB
  6 : MOL – 18dB
  7 : MOL – 21dB

The following describes the PHY TX parameters that can be configured for PHY Tx test mode only:

- Test Mode - When enabled, it configures the transmitter in test mode and it transmits fixed data pattern (selected in data pattern box) for BER testing
- Sweep MCS – When enabled, test will sweep through all MCS for the packets transmitted. The order of MCS used is DBPSK, DQPSK, D8PSK, DBPSK+FEC, DQPSK+FEC and D8PSK+FEC.
- Sweep PPDU length - When enabled, test will sweep through all valid PPDU length in increasing order for the MCS used.
- Continuous – When enabled, test will continuously transmit PPDUs as specified. When disabled, test will transmit the "Number of PPDUs per setting" (see below) as specified and stop. .
- Data Pattern – When PHY test mode is enabled, data pattern for the packet payload to be transmitted can be selected. The following data patterns are available:

  - A ramp data pattern from 0 to 255
  - A fixed data byte set by octet value

- PRIME certification data pattern (PRIME IS A WONDERFUL TECHNOLOGYPRIME IS A WONDERFUL TECHNOLOGY) with no space between 2 sentences.

The data pattern is repeated for the duration of the payload.

- PPDU length – PPDU length in bytes. Note this field will be ignored when sweep PPDU length is selected. The current firmware version supports a PPDU length of 1 byte to 756 bytes. It is also governed by maximum length allowed for the selected modulation scheme.
- Inter-PPDU time – The gap time between PPDU in unit of 10 microseconds.
- Number of PPDUs per setting – The number of PPDU per setting during MCS sweep, PPDU length sweep or MCS/PPDU length sweep.

The following describes the PHY Rx Parameters can be configured:

- AGC – If selected, receiver performs automatic gain control. If unselected, manual gain setting is used. Valid gain values are from 0 to 7 with step of 6dB.

The following describes the PHY Rx Parameters can be configured in PHY Rx Test mode only:

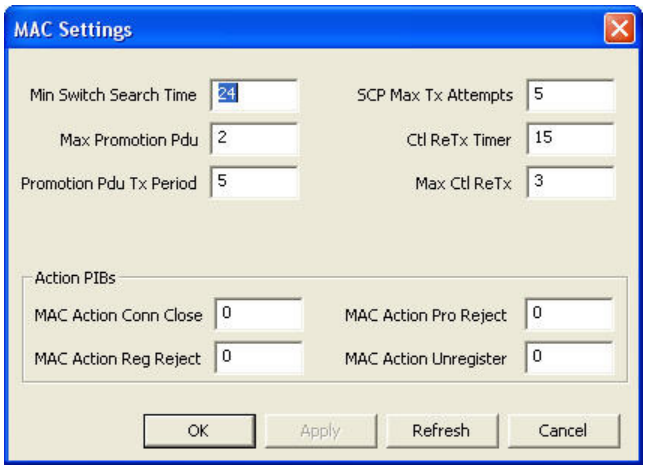
- Test Mode - When enabled, receiver will start comparing receive packet using the data pattern selected and compute BER for BER testing.
- Data Pattern – When test mode is enabled, it can select data pattern used for comparison in computing BER. A ramp data patter from 0 to 255 or a fixed data byte set by octet value. Note this should be identical to the selection in the transmitter for valid BER result.

The following describes the PHY System Parameters:

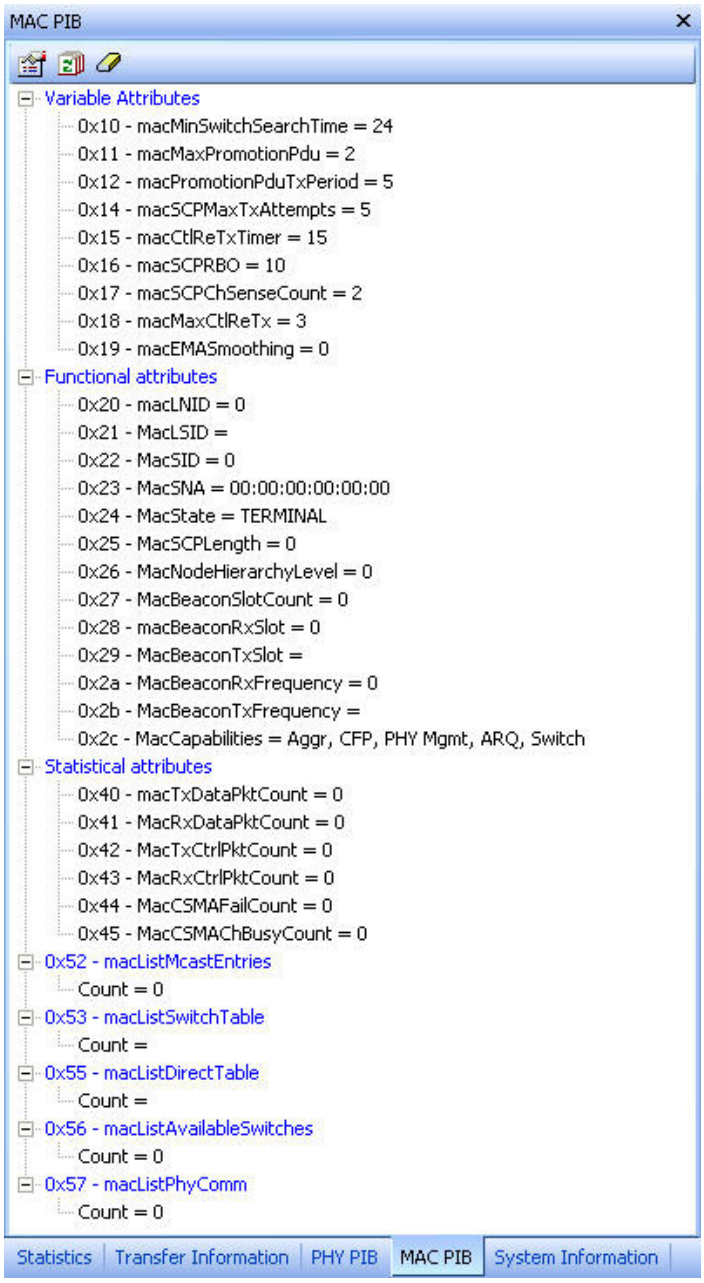
- AGC Gain Min – Minimum AGC gain in dB
- AGC Gain Max – Maximum AGC gain in dB
- AGC Gain Step – Step size of AGC in dB

3.7 Get/Set MAC PIB

MAC PIB (PRIME standard Section 4.5.1-MAC variable attributes) can be configured as follows (Menu->Function->Set MAC PIBs):

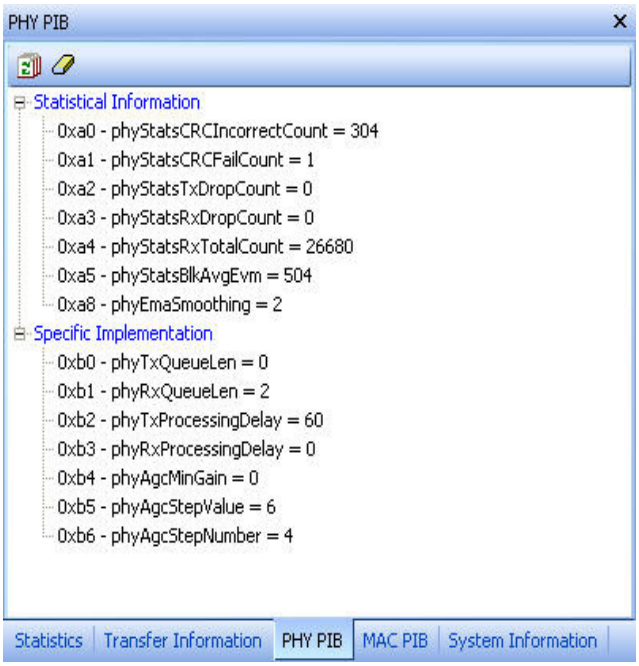


MAC PIB (PRIME standard Section 4.5.1 – MAC variable attributes) can be retrieved as follows (Menu->Function->Get MAC PIBs):



3.8 Get PHY PIB

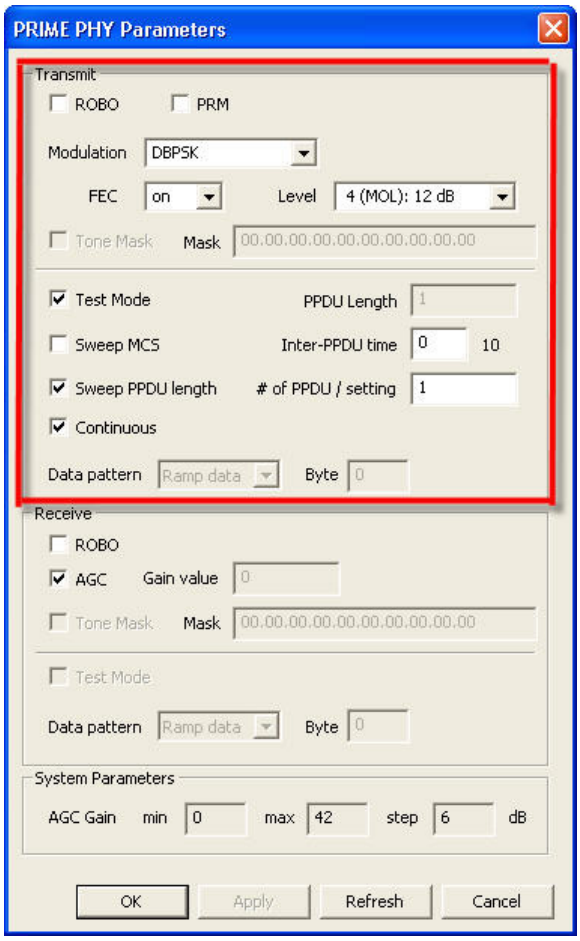
PHY PIB (PRIME standard Section 3.10.1 PHY statistical attributes and 3.10.2 PHY Implementation attributes) can be retrieved as follows (Menu->Function->Get PHY PIBs):

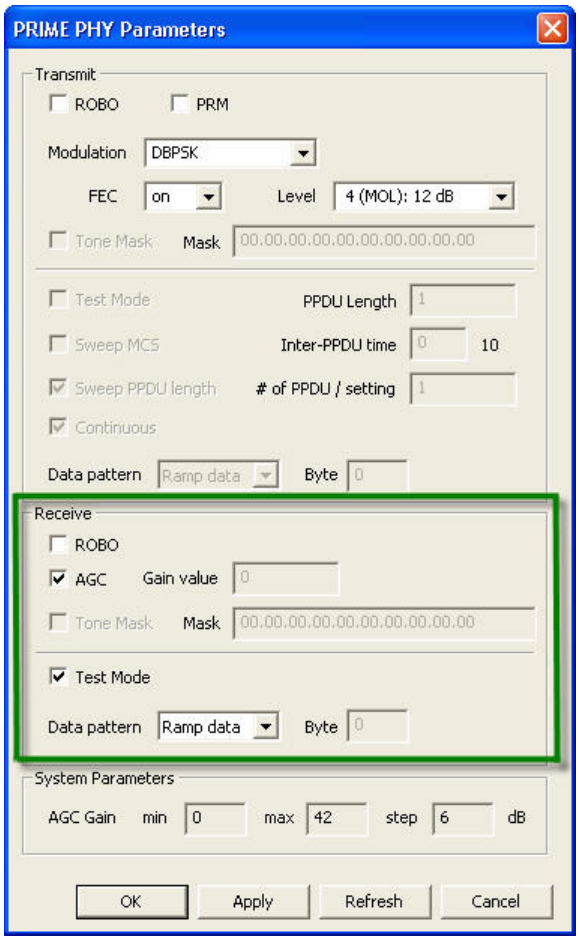


3.9 Testing PHY Performance

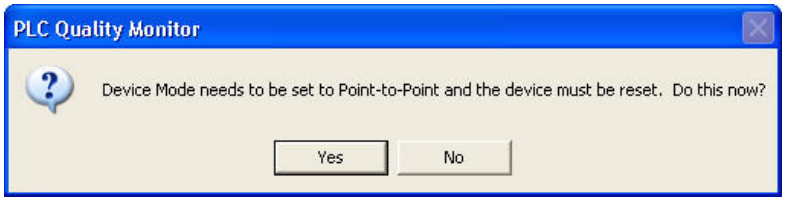
The PHY performance can be tested in a point-to-point configuration where system configuration steps described on Section 2.3 should be used. One modem should be configured as transmitter in test mode and the other modem as receiver in test mode (Menu->Options->PHY Parameters). The HW should be set up as described in Section 1.5.1. An example for PHY test with DBPSK+FEC, transmitting at level -9 dB, PPDU length of 100 bytes and inter-PPDU interval of 100 us in continuous mode is shown.

Note it does not support concurrent bi-directional data transfer.





Note that the enabling of PHY “Test Mode” on the Transmit or Receive would require the device mode to be “Point to Point”. The following window will be prompted if device is not already in “Point to Point”. Click “Yes” to reset the device and “Point to Point” mode will be set. The PHY test can now be continued.

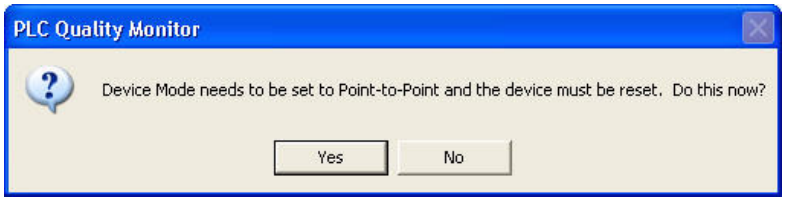


By enabling the channel status and link quality report and setting report period (as described in Section 4.2), the PHY performance (SNR/RSSI/PER/BER) will be displayed in the graphs and the statistics will be displayed in the statistics panel.

3.10 Sending and Receiving Message

The Send Message function (Menu->Function->Send Message) sends a small text message from the one device to another in point-to-point configuration. It is intended to test and verify communication between the two systems in a point-to-point configuration.

Note that this operation would require the device mode to be “Point to Point”. On the transmitting device, the following window will be prompted if device is not already in “Point to Point”. Click “Yes” to reset the device and “Point to Point” mode will be set. Message send can then be continued,



On the receiving device, the device mode must be set to “Point to Point” following steps described in Section 2.3

Note that the connection type such as ARQ enabled, PAC enabled or security profile used for the message send can be modified via System configuration settings using steps described in Section 2.3.

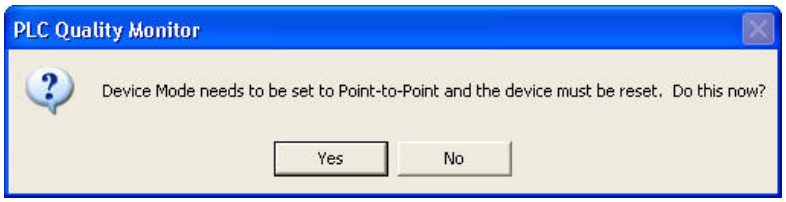
When this option is selected, you may fill in a message and press send, and the other host will display the message.

Note that the connection type such as ARQ enabled, PAC enabled or security profile used for the message send can be modified via System configuration settings using steps described in Section 2.3.

3.11 Sending and Receiving File

The Send File function (Menu->Function->Send File) sends file from one device to another in a point-to-point configuration.

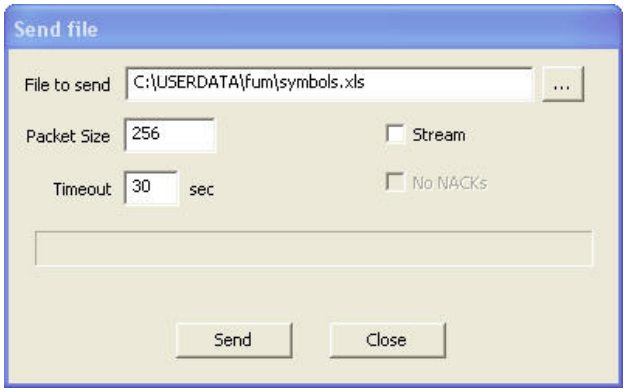
Note that this operation would require the device mode to be “Point to Point”. On the transmitting device, the following window will be prompted if device is not already in “Point to Point”. Click “Yes” to reset the device and “Point to Point” mode will be set. Message send can then be continued,



On the receiving device, the device mode must be set to “Point to Point” following steps described in Section 2.3

Note that the connection type such as ARQ enabled, PAC enabled or security profile used for file transfer can be modified via System configuration settings using steps described in Section 2.3.

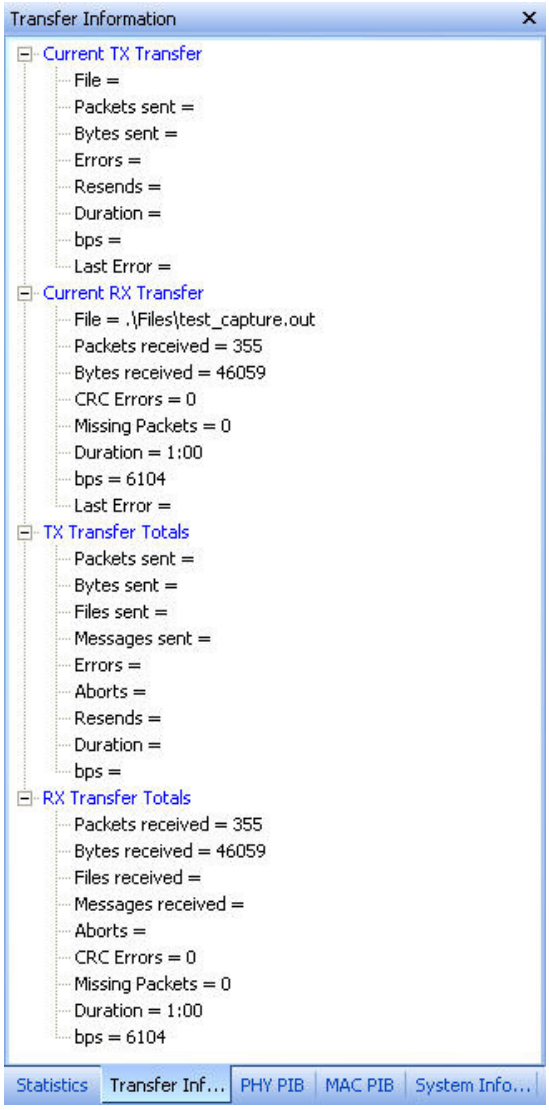
This function is not a guaranteed error-free delivery (the file received may have dropped packets) and is a means to push data from one board to another. The receiver will note both payload CRC and missing packet errors and will attempt to notify the sender of these errors.



There are two modes for file transfer, stream and non-stream. Stream mode streams packets to the receiver without waiting for the receiver to acknowledge receipt. A No NACKS option is also allowed in stream mode. If un-selected, it requests receiver to only send NAKs when there is error. In non-stream mode the receiver must ACK each packet before the sender will send the next.

The packet size may also be specified. This value represents the total packet size, including any protocol headers. If an invalid size is entered, when Send is pressed, the following error will be displayed.

Once the file transfer begins, the Transfer Information section reflects transfer statistics.

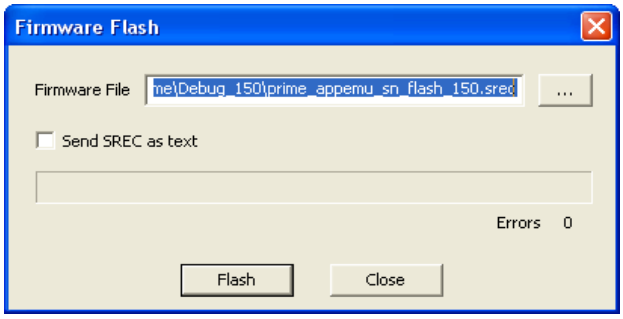


Statistics may be cleared by selecting “File/New” or by pressing the New File button.

The transfer may be aborted by either the sender or receiver. The sender may abort by pressing the Abort button and the receiver may abort by selecting the menu option “Functions/Abort file receive”.

3.12 Flash Firmware

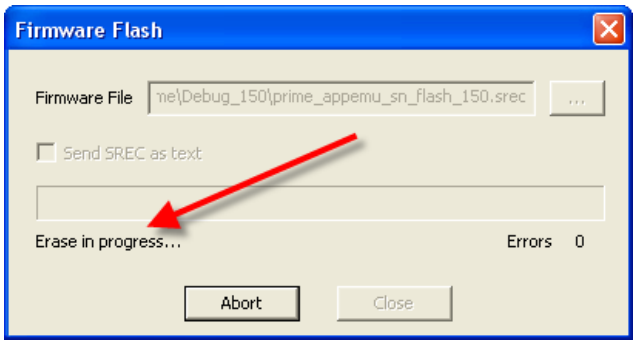
The flash firmware function (Menu->Function->Flash Firmware) downloads the new firmware image to the DSP control.



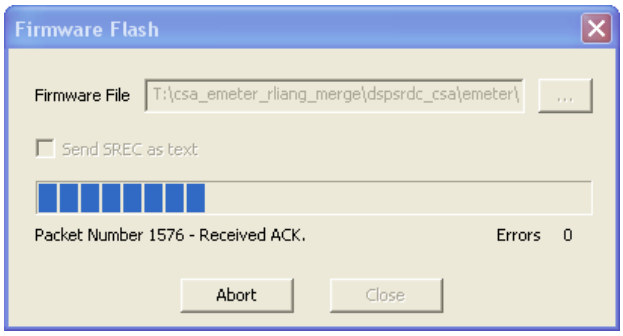
The following steps should be used:

1. Enter the PRIME application *"s record file"* and press the Flash button, you will see that Flash upgrade application is erasing the Flash.

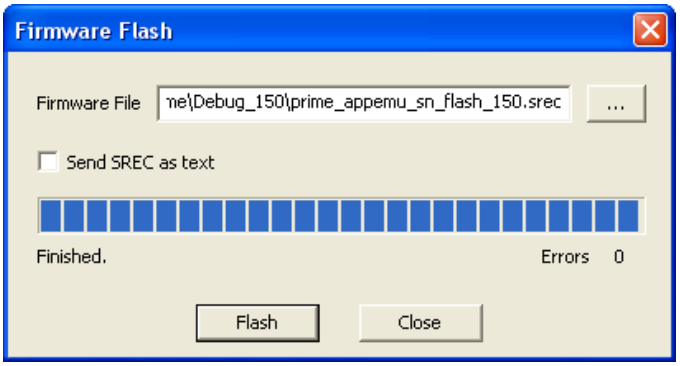
   For example, the ***"prime_appemu_sn_flash.srec"*** should be used for the PRIME service node test



2. After Flash is erased, you will see the programming is in progress (packet by packet).



3. After programming is complete, you will see the following window. The new downloaded firmware will boot up.



4. Running PRIME Service Node “AppEmu” Application

The “AppEmu” application demonstrates eMeter reading and other operations in a PRIME network that composed of one base node and several service nodes. The binary “prime_iec432_f2806x.out” should be flashed onto the F28069 and the HW should be set up as described in Section 1.5.2. It requires a PRIME compliant Base Node also running similar “AppEmu” application. This demo includes the following PRIME procedures:

- Registration
- Keep Alive
- Connection/Disconnect
- CSMA/CA access in PRIME SCP period
- Application data traffic

There are two versions of “APPEMU”, one version is a self contained embedded application (eAppEMU) and a second version is a host based application (hostAppEMU).

Note that both eAppEMU and hostAppEMU supports the following two modes:

- AppEmu interfaces to IEC61334-4-32 LLC layer with data traffic of LLC L_SDU
- AppEmu interfaces directly to PRIME MAC with data traffic of MAC MPDU

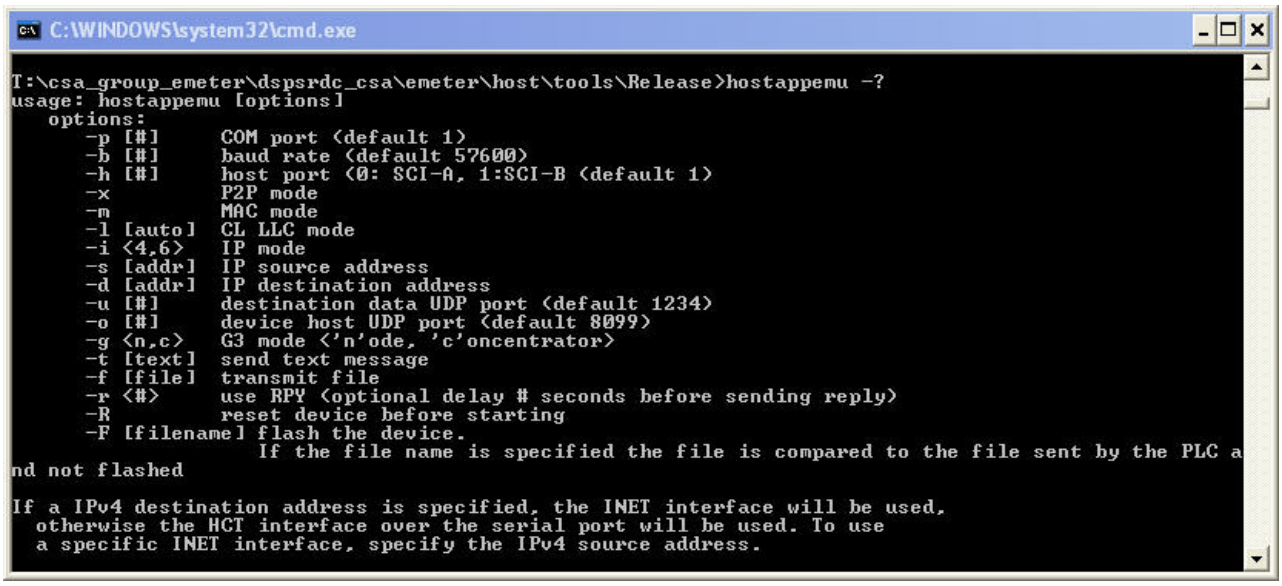
The system configuration described in Section 3.3 should be used to configure for the above modes and a device reset from the GUI is required for the system configuration change to take effect. In order to inter-operate against a PRIME Base Node, the PRIME Base Node needs to support both types of emulation.

4.1 Embedded AppEmu

This is a self contained version running embedded “eAppEmu” on the target device. No host machine is required to run eAppEMU.

4.2 Host Based AppEmu

Host based AppEMU is running on a Windows console application called “HostAppEMU”. The host tool “HostAppEMU” should be run when PLC device is set as: “IEC432-LLC” or “MAC” and the PLC will communicate with the HostAppEMU through UART according to TI Message Protocol. The application has several command line options available:



-p [#]

Sets the COM port. Appropriate values are “1” for COM1, “2” for COM2, etc.

-b [#]

Set baud rate (default to 57600)

-h [#]

Sets the Host Port. The Host Port is the port (SCI-A or SCI-B) that is designated to receive Host Messages, as defined by the PLC Suite Host Message Protocol Specification.

-x

Sets HostAppEMU to P2P (Point-To-Point). In this mode, the application will operate as if connected to another PLC device. You can sendc a text message or transfer a file to another HostAppEMU application running with another device..

-m

Sets HostAppEMU to MAC Mode. In this mode, the application will interface the MAC layer to perform its tasks. For example, when opening a connection to the Base Node, the MAC Open Connection will be used.

-l

Sets HostAppEMU to LLC Mode. In this mode, the application will interface the IEC432 LLC layer on the device to perform its tasks. For example, when transferring data to the Base Node, the LLC Data_Transfer.Request will be used, and the LLC Layer will take care of sending the data to the Base Node.

-i

Sets HostAppEMU to IP Mode. In this mode, the application will interface the IP CL layer on the device to perform its tasks. For example, when transferring data to the Base Node, normal IP datagrams are used, such as UDP, TCP, ICMP, etc. A source and destination address must be specified.

-s [addr]

Sets the IP source address. This determines which interface the datagrams will be sent on and should reflect the source address of the device.

-d [addr]

Sets the IP destination address. This determines which IP address datagrams are destined for.

-u [#]

Sets the UDP destination port.

-o [#]

Sets the UDP host port.

-t [text]

Sends a text message to another device. The device must be in P2P mode for this option.

-f [file]

Sends a file in stream mode to another device. The device must be in P2P mode for this option.

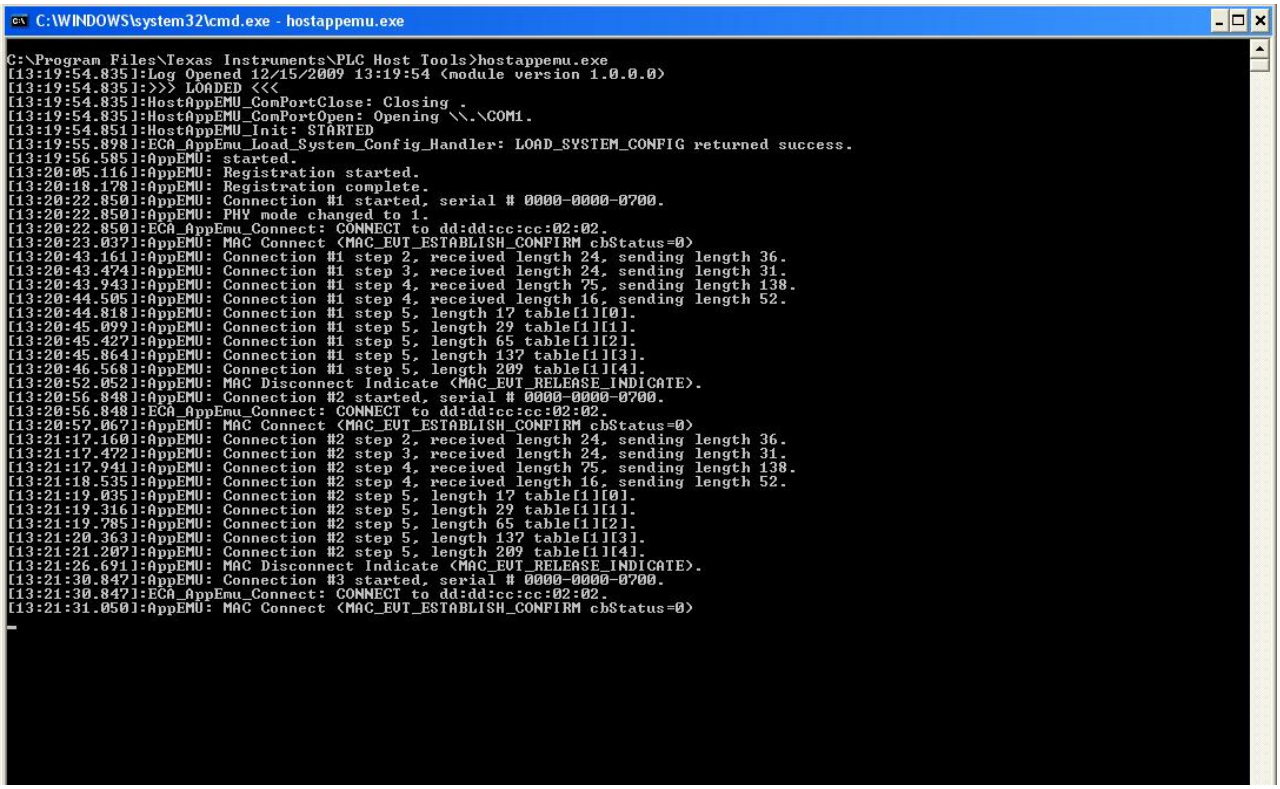
-r <#>

Use RPY <optional delay # sec before sending reply>

-F [filename]

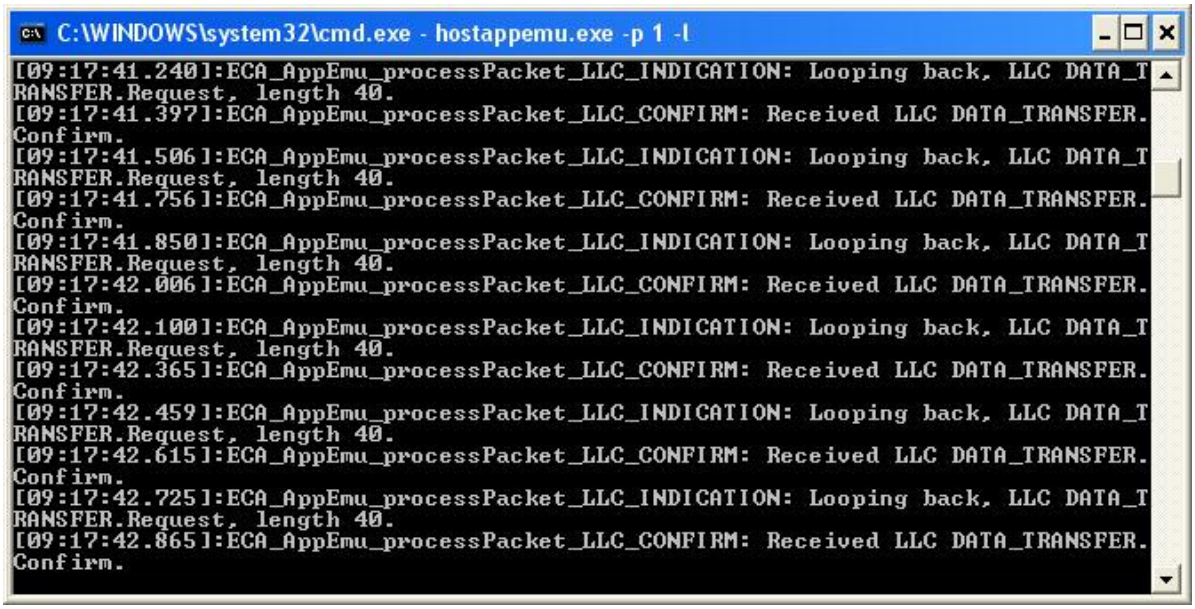
Flash the device after a firmware download from power line is received. If the file name is specified, the is compared to the file sent by the PLC and not flashed.

The following window shows when the –m option is selected where HostAppEmu MAC mode is used:



The following window shows when the –l option is selected where HostAppEmu LLC mode is used:

Note that the first LLC reply will show timeout error and it should be ignored.



4. Running a Point to Point file transfer with Host Application

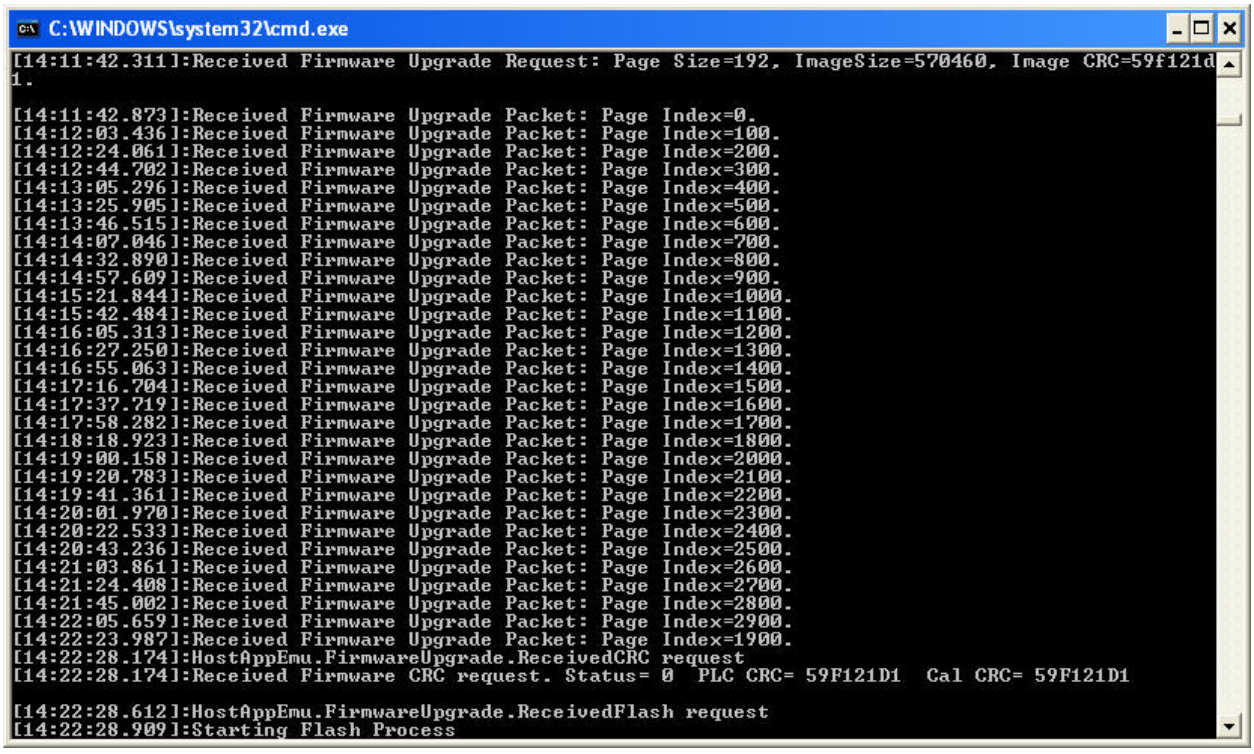
The HostAppEMU application demonstrates file transfer in a point to point configuration. The binary "prime_iec432_f2806x.out" should be flashed onto the F28069 and the HW should be set up as described in Section 1.5.1.

5. Running Firmware Download from Power line with Host Application Support

Note this is not supported in current release.

The HostAppEMU application supports firmware download from power line from Base Node as specified in the PRIME spec. The binary "prime_iec432_f2806x.out" should be flashed onto the F28335. When Base node initiates the firmware download procedure, the received sectors are being transferred to the host and stored in host memory. Once the download is completed, the firmware instructs the host to update the flash and continue to complete the remaining handshakes with the Base node.

The following window shows when the –F option is selected where HostAppEmu LLC mode is used:



6. Running Serial Profile Communication

Note this is not supported in current release.

Prime management PIB retrieval/set via serial profile communication requires the following set up:

1. Connect PLC Quality Monitor (PLCQM) to SCI-A (Serial D connector) and launch PLCQM
2. Options->Set System configuration, Configure Host Port and Diag Port to SCI-A port
3. Connect test tool to SCI-B (USB connector). Management PIB retrieval/set using serial profile communication can be proceeded.
4. When test is done, connect PLCQM to SCI-A (Serial D connector) and PLCQM can resume. The port can be configured back to SCI-B if desired.

7. System Trouble Shoot

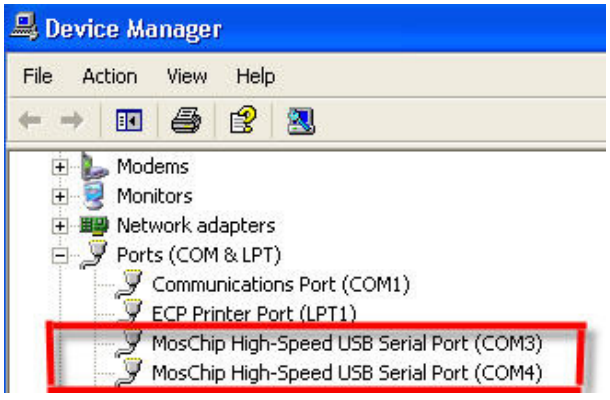
7.1 Trouble shoot for squirt

The Serial Port is muxed by a driver called Squirt. The driver's interface is on the windows taskbar. There may be times that the driver has to be reset because no data is being forwarded to/from the applications. To reset the Squirt driver, either right click the Squirt Taskbar Icon and select "Reset" or double click the Squirt Taskbar Icon (which will momentarily turn green to indicate reset).

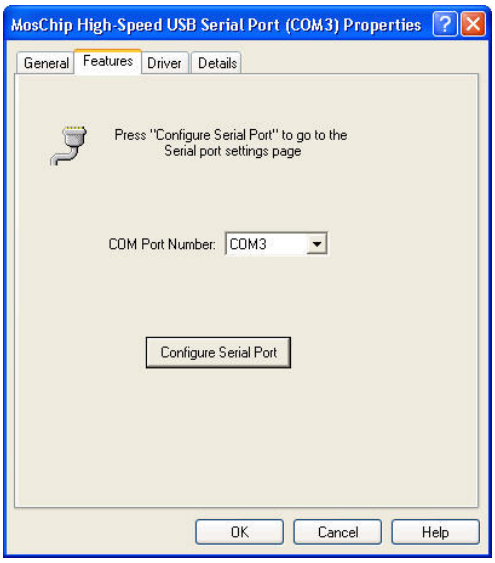
In the event of application exception (conditions where the applications have encountered a severe error and is terminated), the Squirt Driver may require termination cleanup. When this occurs, you must exit any PLC Host tools (PQM, Logger, etc.) and terminate the Squirt Driver by selecting all Squirt tasks (both SQUIRT*.exe and SquirtSerialPort.exe) from the Task Manager and ending their process.

7.2 Trouble shoot for USB to Serial Dongle Communications

When the USB to serial dongle is plugged into the PC, the enumerated COM port can be found from system properties->Hardware->device manager as follows:



Note that the enumerated COM port needs to be lower than "COM19". If not, it can be changed by selecting the corresponding serial port, right click and click on "properties". Then select the "features" panel and the COM port can changed.



Note that it is recommended to power off the device prior to unplugging the USB serial dongle from the PC.

7.3 Trouble shoot for PLC Quality Monitor Diagnostic Tool to Device Communications

To check that the PLC Quality Monitor tool is communicating to the device, check that it can read system information following steps in Section 2.4.

If USB serial converter is being used, check that the correct COM port has been selected. Note that the COM port may not be enumerated to the same port number when its unplugged an re-plugged or a new USB port is being used.

If PLC Quality Monitor tool has previously been communicating to the device and it was kept opened while device has been reset or power cycled, it is recommended to close the PLC Quality Monitor tool and re-opened.

APPENDIX A - PLC-DK Hardware Resource Usages

Table 4 PLC-DK GPIO pins configurations

GPIO PIN	Connected to	Pull Up	PRIME Build Usage
GPIO00	PWM_1A	Enabled	Transmit
GPIO01	TP	Enabled	
GPIO02	PWM_2A	Enabled	Transmit
GPIO03	TP	Enabled	XINT2, TFLAG
GPIO04	TP	Disabled	XINT1, HALT
GPIO05	ZeroCross (opt)	Disabled	Alternate Zero Cross Input
GPIO06	LED_AFE1	Disabled	Beacon Indication (toggle per rx beacon)
GPIO07	LED_AFE2	Disabled	Beacon Acquired (on)
GPIO08	LED_AFE3	Disabled	Registration with BN completed (on)
GPIO09	ZeroCross (main)	Enabled	Zero crossing capture input
GPIO10		Disabled	
GPIO11		Disabled	
GPIO12	TXDRVEN	Enabled	OPA enable pin
GPIO13		Disabled	
GPIO14	SCI (SCITXDB)	Enabled	UART host port
GPIO15	SCI (SCIRXDB)	Enabled	UART host port
GPIO16	SPI (SPISIMOA)	Enabled	PGA (option)
GPIO17	SPI (SPISOMIA)	Enabled	PGA (option)
GPIO18	SPI (SPICLK)	Enabled	PGA (option)
GPIO19	SPI (SPISTEA)	Enabled	PGA (option)
GPIO20	McBSP (MDXA)	Enabled	F28069 AFE031 connection
GPIO21	McBSP (MDRA)	Enabled	F28069 AFE031 connection
GPIO22	McBSP (MCLKXA)	Enabled	F28069 AFE031 connection
GPIO23	McBSP (MFSXA)	Enabled	F28069 AFE031 connection

GPIO24	McBSP (MDXB)	Enabled	F28335 AFE031 connection
GPIO25	McBSP (MDRB)	Enabled	F28335 AFE031 connection
GPIO26	McBSP (MCLKXB)	Enabled	F28335 AFE031 connection
GPIO27	McBSP (MFSRB)	Enabled	F28335 AFE031 connection
GPIO28	SCI (SCIRXDA)	Enabled	UART diagnostic port
GPIO29	SCI (SCITXDA)	Enabled	UART diagnostic port
GPIO30	CAN RX	Enabled	CAN Bus Rx Port
GPIO31	CAN TX	Enabled	CAN Bus Tx Port
GPIO32	(I2C) SDAA	Enabled	EEPROM
GPIO33	(I2C) SCLA	Enabled	EEPROM
GPIO34	LED	Enabled	LED ?
GPIO35		Enabled	
GPIO36		Enabled	
GPIO37		Enabled	
GPIO38		Enabled	
GPIO39		Enabled	
GPIO40		Enabled	
GPIO87	LED	Enabled	LED available on F28335 ControlCard

Table 5 PLC-DK Peripherals and Interrupts Usage

Peripherals	PRIME Build Usage	Interrupt
32-bit CPU Timers		
Timer 0	1. During packet transmission - Trigger Tx DMA to ePWM/HRPWM @ 500 kHz 2. CSMA - Track PRIME frame structure	PIE 1.7
Timer 1	Absolute timer (PRIME PHY Time Stamp)	
Timer 2	DSP-BIOS Systick	INT14
Watchdog Timer		
	TBD (Reset)	
ADC		
	Rx ADC samples @ 250 kHz	

McBSP		
McBSPA	AFE031 inteface (SPI mode)	
SCI		
SCIA	Diagnostic port	PIE 9.1 - Rx PIE 9.2 - Tx
SCIB	Host port	PIE 9.3 - Rx PIE 9.4 - Tx
I2C		
	Interface to EEPROM	
Ecap		
eCAP3	Zero crossing measure	
eCAP4	Zero crossing measure	
DMA		
Channel 1	ADC	PIE 7.1
Channel 2	DAC (McBSPA)	PIE 7.2

Table 6 PLC-DK Flash Configurations and Usage

Sectors	Size (words)	Prime Build Usage
A	16K	Code Start Image
B	16K	
C	16K	
D	16K	
E	16K	
F	16K	Prime image
G	16K	
H	16K	Firmware upgrade image

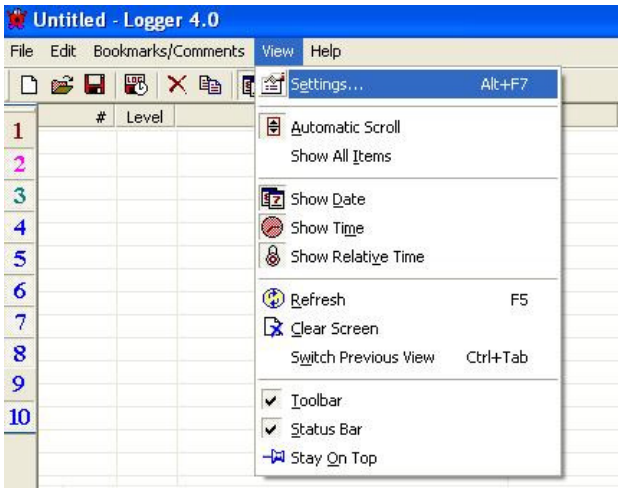
Table 7 PRIME System Memory and MIPs usage

MEM/MIPS	BenchMark
FLASH	190 kB
RAM	68 kB
MIPS	Average 82 MIPs

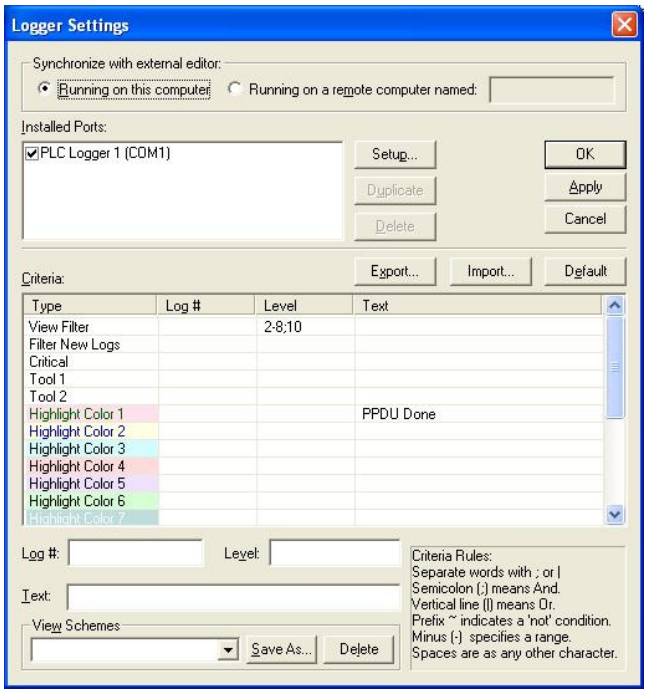
APPENDIX B – Logger Setup

A PLC Event Logger can be used for diagnostic purpose. Set up communication Port (via Logger Settings).

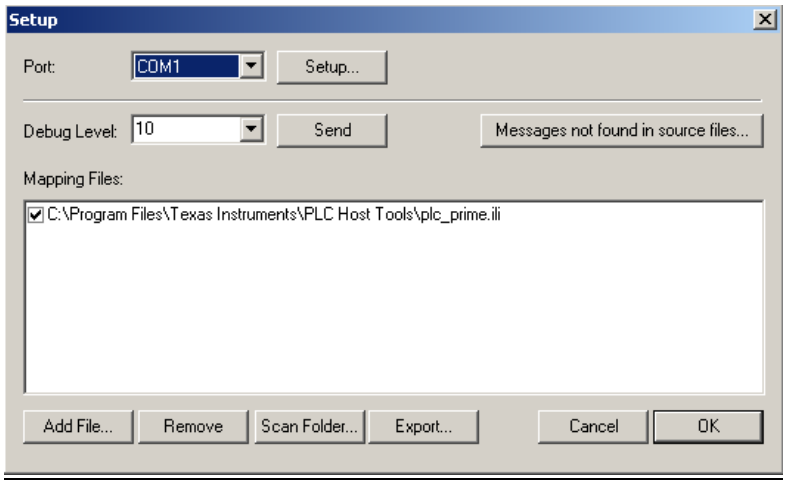
- Goto View



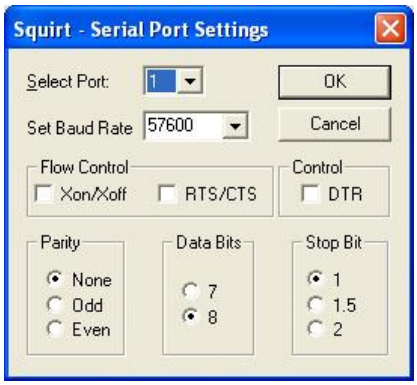
- Click on Settings
- Select the check box for PLC Logger 1(COM1)
- Highlight PLC Logger 1



- Click Setup and select communication port used for connecting to the serial connection on the docking board. In this example, it uses COM1 port.



- Click on Setup and configure serial port as follows:



APPENDIX C – PHY Example Project

The PHY examples demonstrate the calling of PHY library API when HW is setup with 2 devices connected via power line. One device will send one packet and wait for one receive packet and then transmit another packet. This alternates between Tx and Rx. The packet is of size of 756 bytes with a repeating ramp data pattern using the followings:

Modulation: DBPSK with FEC enabled

PPDU payload length: 40 bytes

1. Unzip ti_prime_phy_example.zip
2. Start CCS4 and create new workspace
3. In CCS4, import prime phy test project into workspace (Menu Project->Import Existing CCS/CCE Eclipse Project)
4. In CCS4, Build project (Menu Project->Project->Build Project)
5. In CCS4, launch debugger for the selected target configuration
6. In CCS4 debugger, connect target (Menu->Target->Connect target)
7. In CCS4, Load phy_tx_rx_lib.out (Menu->Target->Load Program)
8. In CCS4, Reset, Run (Menu->Target->->Run) and LED flashes.
9. Load the same code to the second board.
10. Connect the two boards via power line cables. Both boards should be alternating between Rx and Tx and the LEDs should be blinking.

Source File Description

- Test bench
  - Project file: .cdtbuild, .cdtproject, .project, .ccsproject
  - Test bench: test_tx_rx.c demonstrates alternating PRIME PHY Tx and PHY rx using provided PHY library
  - Linker command:F28069.cmd
  - Test example for flash

- Header files
  - PHY common: phy.h
  - PHY Tx: phy_tx.h
  - PHY Rx: phy_rx.h
  - HAL: hal_afe.h
  - Chip support library header files

- Libraries
  - PHY lib: phy_lin_afe031_f2806x.lib
  - HAL lib: hal_afe031_f2806x.lib
  - Chip Support lib: csl.lib

PHY Library Demonstration

- The PHY library example project demonstrates packet transmission and reception at the physical layer in a TDD fashion.

- Flash 2 F28069 boards with PHY library example executable.

- Connect via powerline

- Sequence of operation
  - Board A sends a packet
  - Board B receives packet and sends a packet back to board A
  - This will be repeated.
  - LED on DSP control card will blink if packet transmission and reception is ongoing

Hardware Resource Usage

The PHY library uses the following HW resources:

- DMA Channels
  - Channel 1 – Receive ADC input
  - Channel 2 – Transmit DAC (McBSPA) output

- CPU Timers
  - Timer 0 – PHY
  - Timer 1 – PRIME PHY System Timer 20-bits in 10us increment
  - Timer 2 – Not Used

- GPIO
  a. GPIO 00 – PWM_1A

b. GPIO 02 – PWM_2A
c. GPIO 12 – OPA Enable

PHY Library Test Bench Steps

- HW initialization (F28069 specifics)
- Flash configuration
- ISR Installation
  - Timer 0 (PHY_tx_cpuTimer0_isr)
  - DMA channel 1 (PHY_rx_dintch1_isr)
  - DMA channel 2 (PHY_tx_dintch2_isr)

- AFE initialization
  - HAL_afeTxInit
  - HAL_afeRxInit

- PHY library initialization
  - PHY_txInit
  - PHY_rxInit

- Generate packet for transmission

- Start PHY Rx to listen to line
  - PHY_rxStart(0xFFFF, cb_sync)

- Callback for PHY_rxStart- cb_sync

- If status is success, start PPDU decode (only 1 time)

  - PHY_rxPpduStart(cb_ppdu)

- Callback for PHY_rxStart - cb_ppdu

- If status is success, do some processing if needed and release buffer back to PHY

  -PHY_rxPpduRelease

  - LED toggle

Start packet transmission

- PHY_txPpdu(&PHY_tx_ppdu_s, cb_tx);

- Callback for PHY_txPpdu - cb_tx
- If status is success, do some processing if needed.

- Enable system interrupt
- Main loop repeats

ISR Descriptions

- CPU Timer 0 ISR – Start packet transmission @ specified time

```
interrupt void PHY_tx_cpuTimer0_isr(void)
{
 txSymbDone = 1;
 HAL_cpuTint0Func();
}
```

- DMA1 Channel ISR – Incoming ADC samples ready for process @ symbol rate

```
interrupt void PHY_rx_dintch1_isr(void)
{
 /* Set ready flag */
 afeReadyFlag = 1;

 /* Call HAL AFE function for dma handling */
 HAL_afeRxDmaCh1IntFunc();
}
```

- DMA2 Channel ISR – Outgoing PWM completed @ symbol rate

```
interrupt void PHY_tx_dintch2_isr(void)
{
 txSymbDone = 1;
 HAL_afeTxDmaCh2IntFunc();
}
```

Main Loop

- Wait for DMA channel 1 ready (incoming ADC samples ready)
  - Perform PHY Rx processing
    - PHY_rxSmRun

- If Incoming packet is completed

  - Initiate a packet transmission
    - PHY_txPpdu

- Wait for DMA channel 2 ready (output PWM samples done)
  - Perform PHY Rx processing
    - PHY_txSmRun
  - Note that when packet transmission, PHY Rx will be suspended and when packet transmission is completed, PHY Rx will be resumed.

APPENDIX D – Host Example Project

The Host Example Project (hAppEMU) is the host based eMeter Application Emulator. It provides the same functionality as the embedded AppEMU except it is written as an external host application that communicates to the PLC device via Host Messages over the serial port.

Host AppEMU is a Windows console application. The project is a Visual Studio 2008 solution.

1. Unzip host_appemu.zip
2. From Visual Studio 2008, open the hostappemu.sln Solution file.
3. Rebuild the project (Build->Rebuild Solution)
4. Once the project has built, the Host AppEMU executable (hostappemu.exe) may be ran.
5. Reference the section above detailing the command line options and operation.

The following shows examples of host messages send sequences. The corresponding replies should follows.

Scenario 1: Host Applications communicating to the device with device in "***PRIME IEC432 LLC Convergence" mode with automatic flag set***:

1. "LOAD_SYSTEM_CONFIG" , Config Type 0x0003 (System Configuration), to configure device in "PRIME IEC432 LLC Convergence" mode with "automatic flag" enabled
2. "SHUT_DOWN" with soft reset
3. "DATA_TRANSFER"

Scenario 2: Host Applications communicating to the device with device in *"**PRIME IEC432 LLC Convergence**" mode with **non-automatic flag set:***

1. "LOAD_SYSTEM_CONFIG", Config Type 0x0003 (System Configuration), to configure device in "PRIME IEC432 LLC Convergence" mode with "automatic flag" disabled.
2. "SHUT_DOWN" with soft reset
3. "CL_ESTABLISH"
4. "DATA_TRANSFER"
5. "CL_RELEASE" when the connection is to be torn down

Scenario 3: Host Applications communicating to the device with device in "***PRIME IEC432 MAC***":

1. "LOAD_SYSTEM_CONFIG" , Config Type 0x0003 (System Configuration), to configure device in "PRIME IEC432_MAC" mode
2. "SHUT_DOWN" with soft reset
3. "NETWORK_REGISTER"
4. "CONNECT"
5. "DATA_TRANSFER"

6. “DISCONNECT” when connection is to be torn down
7. “UNREGISTER” when device to leave the network

APPENDIX E –Packet Examples: File/Message Tranfer

The PLC Quality Monitor tool provides two simple applications: message transfer and file transfer. These applications operate in a point to point configuration. The HW should be set up as described in Section 1.5.1.These applications communicate with the host message protocol on top of Prime software stack via UART. The basic packet format used for file/message transfer follows that described in PLC Suite Host Message Protocol Specification. Here, some packet examples are provided.

Message Transfer

Example 1: Data Transfer Request ("HI")

	Header (Host Message Protocol)							
Octet	0	1	2	3	4	5	6	7
Data (in hex)	00	82	28	00	75	DA	C6	3B
Description	Message Type (Data Transfer)	ORG=1, RPY=0, REV=0, SEQ=2	Length(LSB)	Length(MSB)	Header CRC16 (LSB)	Header CRC16 (MSB)	Payload CRC16 (LSB)	Payload CRC16 (MSB)

*Length=Header CRC(2B)+Payload CRC(2B)+Mode(2B)+LSAP(2B)+Destination Addr. (2B)+Rsvd(4B)+Data Payload(26B)=40B

	Payload (Host Message Protocol)							
Octet	8	9	10	11	12	13	14	15
Data (in hex)	01	00	00	00	00	00	00	00
Description	(LSB) Mode (MSB)		Dst. LSAP	Src. LSAP	Destination Address		Reserved	

* Mode 0x0001: Data Transfer Request

	Payload (Host Message Protocol)							
Octet	16	17	18	19	20	21	22	23
Data (in hex)	00	00	AA	AA	00	00	00	00
Description	Reserved		Type (Message Transfer App)		Subtype (Transfer)		Status	

	Payload (Host Message Protocol)							
Octet	24	25	26	27	28	29	30	31
Data (in hex)	00	00	00	00	00	00	01	00
	Status		Message Id (=0)				(LSB) Page number	

	Payload (Host Message Protocol)							
Octet	32	33	34	35	36	37	38	39
Data (in hex)	00	00	01	00	00	00	02	00
Description	Page number (MSB)		(LSB)	Total # of pages		(MSB)	(LSB)Message size (=2B)	

	Payload (Host Message Protocol)							
Octet	40	41	42	43				
Data (in hex)	00	00	48	49				
Description	Message size (MSB)		"H"	"I"				

*Blue color: Application Protocol Data Unit, which is part of message control protocol payload.

File Transfer

Example 1: File Transfer (the first packet)

	Header (Host Message Protocol)							
Octet	0	1	2	3	4	5	6	7
Data (in hex)	00	81	32	00	9D	6F	CE	18
Description	Message Type (Data Transfer)	ORG=1, RPY=0, REV=0, SEQ=1	Length(LSB)	Length(MSB)	Header CRC16 (LSB)	Header CRC16 (MSB)	Payload CRC16 (LSB)	Payload CRC16 (MSB)

*Length=Header CRC(2B)+Payload CRC(2B)+Mode(2B)+LSAP(2B)+Destination Addr. (2B)+Rsvd(4B)+Data Payload(36B)=50B

	Payload (Host Message Protocol)							
Octet	8	9	10	11	12	13	14	15
Data (in hex)	01	00	00	00	00	00	00	00
Description	(LSB) Mode (MSB)		Dst. LSAP	Src. LSAP	Destination Address		Reserved	

* Mode 0x0001: Data Transfer Request

	Payload (Host Message Protocol)							
Octet	16	17	18	19	20	21	22	23
Data (in hex)	00	00	BB	BB	00	00	00	00
Description	Reserved		Type (File Transfer App)		Subtype (Transfer)		Status	

* status 0x00000000: success

	Payload (Host Message Protocol)							
Octet	24	25	26	27	28	29	30	31
Data (in hex)	00	00	01	00	00	00	00	00
	Status		Message Id (=1)				(LSB) Page number	

	Payload (Host Message Protocol)							
Octet	32	33	34	35	36	37	38	39
Data (in hex)	00	00	08	00	00	00	F7	07
Description	Page number (MSB)		(LSB)	Total # of pages		(MSB)	(LSB)Message size (=2KB)	

*page number 0x00000000: the first page

	Payload (Host Message Protocol)							
Octet	40	41	42	43	44	45	46	47
Data (in hex)	00	00	43	3A	5C	65	72	72
Description	Message size (MSB)		File message					

	Payload (Host Message Protocol)							
Octet	48	49	50	51	52	53	54	55
Data (in hex)	6F	72	2E	6C	6F	67		
Description	File message							

*Blue color: Application Protocol Data Unit, which is part of message control protocol payload.

Example 2: File Transfer (the last packet)

	Header (Host Message Protocol)							
Octet	0	1	2	3	4	5	6	7
Data (in hex)	00	89	1D	01	C5	C0	71	9C
Description	Message Type (Data Transfer)	ORG=1, RPY=0, REV=0, SEQ=9	Length(LSB)	Length(MSB)	Header CRC16 (LSB)	Header CRC16 (MSB)	Payload CRC16 (LSB)	Payload CRC16 (MSB)

*Length=Header CRC(2B)+Payload CRC(2B)+Mode(2B)+LSAP(2B)+Destination Addr. (2B)+Rsvd(4B)+Data Payload(271B)=285B

	Payload (Host Message Protocol)							
Octet	8	9	10	11	12	13	14	15
Data (in hex)	01	00	00	00	00	00	00	00
Description	(LSB) Mode (MSB)		Dst. LSAP	Src. LSAP	Destination Address		Reserved	

* Mode 0x0001: Data Transfer Request

	Payload (Host Message Protocol)

Octet	16	17	18	19	20	21	22	23
Data (in hex)	00	00	BB	BB	00	00	00	00
Description	Reserved		Type (File Transfer App)		Subtype (Transfer)		Status	

* status 0x00000000: success

	Payload (Host Message Protocol)							
Octet	24	25	26	27	28	29	30	31
Data (in hex)	00	00	01	00	00	00	08	00
	Status		Message Id (=1)				(LSB) Page number	

	Payload (Host Message Protocol)							
Octet	32	33	34	35	36	37	38	39
Data (in hex)	00	00	08	00	00	00	F7	07
Description	Page number (MSB)		(LSB)	Total # of pages		(MSB)	(LSB)Message size (=2KB)	

*page number 0x00000008: the last page

	Payload (Host Message Protocol)							
Octet	40	41	42	43	44	45	46	47
Data (in hex)	00	00	6F	64	65	3A	09	09
Description	Message size (MSB)		File message					

	Payload (Host Message Protocol)							
Octet	48	49	50	51	52	53	…	288
Data (in hex)								
Description	File message							

*Blue color: Application Protocol Data Unit, which is part of message control protocol payload.