TI Designs
G3-PLC (CENELEC Band) Data Concentrator Reference Design

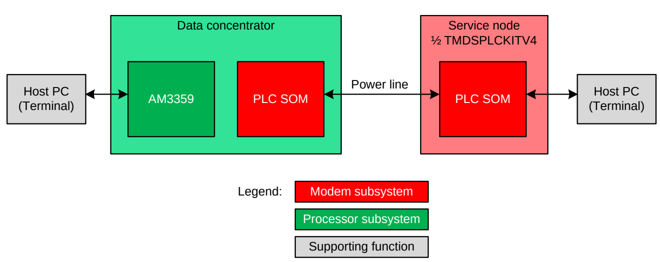
TI Designs

The G3-CENELEC Data Concentrator is an evaluation and development platform for data concentrator designs. The design provides developers the ultimate level of flexibility and scalability with numerous performance, cost, and connectivity options for their data concentrator designs. It operates in the 36- to 91-kHz band defined by CENELEC for Smart Grid Communications. It includes advanced hardware and software that reduce development time by up to nine months while still supporting connectivity to more than 1,000 smart meters. Developers can easily plug in different connectivity modules, including sub-1-GHz (LPRF), general packet radio service (GPRS), near field communication (NFC), and TI's power line communication (PLC) system-on-module (SOM) with G3-CENELEC support.

Design Resources

TIDEP0059	Design Folder
AM3359	Product Folder
TMS320F28375S	Product Folder
AFE032	Product Folder

TI E2E™ Community — ASK Our E2E Experts

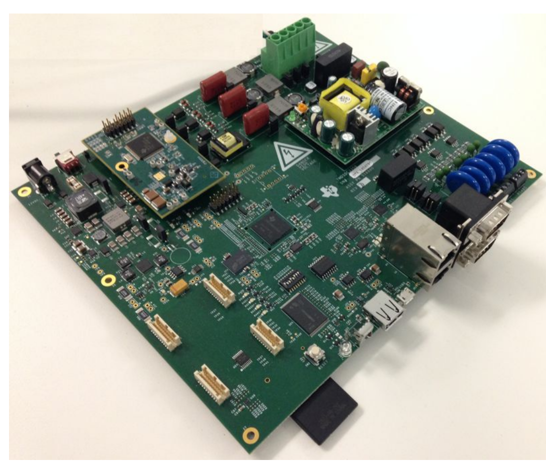


Design Features

- AM335x ARM® Cortex®-A8 Processor-Based Design Reduces Development Time by up to Nine Months
- Integrated Communication Interfaces Include Two Ethernet (MAC) Ports, USB, and up to Eight UARTs to Easily Connect to Other Systems on the Smart Grid
- PLC Stacks for MAC and PHY Layers Let Developers Create Designs That Support G3-FCC
- IPv4, IPv6, and 6LoWPAN Protocols Allow Developers to Connect Their Data Concentrator Products to a Wide Range of Home and Building Automation Applications
- PLC SOM for Narrowband PLC in CENELEC Frequency Band

Featured Applications

- Grid Communication Infrastructure — Data Concentrator
- Grid Communication Module — PLC



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1 System Description

This TI Design is an evaluation and development platform for data concentrator designs based on the AM335x ARM Cortex-A8 microprocessor family of devices. The board can interface with multiple nodes (electricity meter) though PLC, low-power RF, or serially using RS-485. All of the board design information is freely available and can be used as the starting point for an AM335x-based data concentrator product. For more details of hardware, see the *Smart Data Concentrator EVM (TMDSDC3359) Hardware Manual* [1].

Data concentrators play a key role in advanced metering infrastructure (AMI) networks as they are the point of interaction between the utility's central operations and individual end points. The data concentrator nodes securely aggregate data from a network of meters over the power line and send it to utility servers.

Data concentrator software architecture separates the real-time functions into the TMS320F28375S MCU while keeping the upper levels of the stack on the AM335x host MPU running Linux.

2 Block Diagram

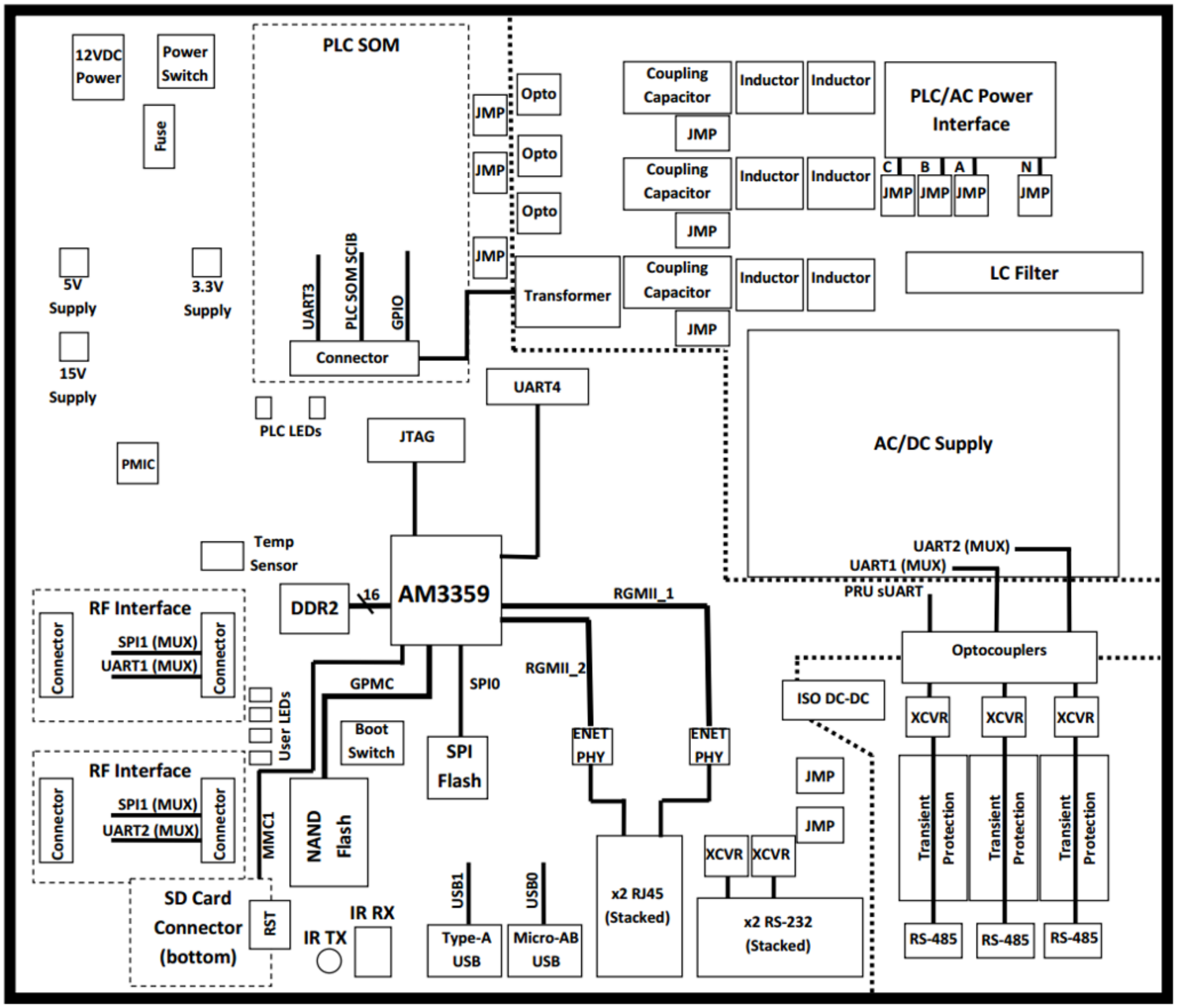

Figure 1. System Block Diagram

The Data Concentrator EVM comes with a full variety of onboard devices that suit multiple application environments. Key features include:

- An AM3359 ARM Cortex-A8 microprocessor (MPU) running at 300 MHz
- Support for 3-phase PLC
- Support for lower-power 2.4-GHz and sub-GHz RF communication
- 2 Gb of DDR2 SDRAM memory
- 2 Gb of NAND flash memory, 64 Mb of SPI flash, and a 256-kb I^{2}C EEPROM
- Three RS-485 ports, two RS-232 ports
- Two 1-Gb Ethernet interfaces
- One SD/MMC connector
- Two USB ports
- Temperature sensor
- Four user LEDs
- Onboard 120-/240-V AC/DC supply; 12-V external DC supply also supported

3 System Design Theory

The Data Concentrator EVM consists of one main PCB assembly housing the AM3359 Cortex-A8 processor, DDR2 memory, NAND flash, and other peripherals. The AM3359 processor interfaces to the onboard peripherals through its integrated device interfaces. The processor's DDR 16-bit bus connects directly to the DDR2 memory, while the GPMC bus is connected to the NAND flash.

With the addition of a PLC SOM, the EVM can communicate with other devices using PLC on a single- or three-phase system. All three phases are capacitively coupled into a single input, which is fed to the PLC SOM connector (P2). The AM3359 processor communicates with the PLC SOM using a UART interface. The PLC section is electrically isolated from the rest of the board.

The EVM supports two low-power RF wireless daughter cards for 2.4-GHz and sub-1-GHz communication. The AM3359 processor can communicate with the RF daughtercards using either a UART or SPI.

The EVM supports two RS-232 ports and three RS-485 ports. One RS-232 ports is reserved for Linux kernel debugging, while the second RS-232 port can be used other user-defined purposes. Both RS-232 ports are connected to UART interfaces on the AM3359 processor. Two RS-485 ports are connected to UART interfaces; the third port requires a programmable real-time unit (PRU) software UART. All RS-485 ports are electrically isolated from the rest of the board.

The two USB ports on the processor are connected to a microUSB AB connector and a standard A connector to connect to peripheral and USB OTG devices. Additionally, the EVM includes an SD card, which can be used for boot file and application storage.

The EVM includes four user LEDs to provide visual feedback. Two additional LEDs are reserved for PLC SOM use. The user LEDs connect directly to the AM3359 processor for ease of use. The board can be powered through either a 12-V DC external supply or directly from a 120-/240-V AC power source. Onboard switching regulators and power management IC (PMIC) provide the necessary voltage rails to power the processor, memory, and onboard peripherals. The processor is held in reset until all voltage rails are within operating specifications.

Texas Instruments' Code Composer Studio™ (CCS) can debug code running on the EVM. CCS communicates with the board through an external JTAG emulator. There is no onboard emulation on the EVM.

4 Test Setup

Required hardware:

- One Data Concentrator EVM (see http://www.ti.com/tool/TIDEP0006)
- Two PLC SOM modules (see http://www.ti.com/tool/TIDM-SOMPLC-FCC), one for the Data Concentrator EVM and one for the PLC motherboard with AC power line coupling.

NOTE: PLC SOM requires replacing the components listed in Table 1 to obtain improved system performance in CENELEC band.

Table 1. Components to Replace

COMPONENT	DIGIKEY OR MOUSER
R100: 150 Ω	RHM150CFCT-ND
L46: 330 µH	495-1762-1-ND
C140: 0.022 µF	478-1255-1-ND
C141: 0.033 µF	1276-2042-1-ND or 490-6435-1-ND
L45: 180 µH	445-16562-1-ND
L53: 1 mH	445-15760-1-ND
C166: 8200 pF	1276-2119-1-ND
C167: 0.015 µF	1276-1967-1-ND
L52: 470 µH	490-2499-1-ND or 490-4067-1-ND
R121: 150 Ω	RHM150CFCT-ND

- One PLC motherboard with AC power line coupling (see the TIDA-00192 design)

Step-by-step description:

1. Plug in the PLC SOM onto the Data Concentrator EVM and power the board. For more details on the Data Concentrator hardware, see the *Smart Data Concentrator EVM (TMDSDC3359) Hardware Manual* [1].
2. Connect the Data Concentrator EVM to the PC through RS-232 to connector P8 (lower port of P8) and Ethernet cable to connector P7 (upper port of stack connector).
3. Open Tera Term on the PC, select the Serial option, and set the Serial Baud Rate to 115200 as shown in Figure 2 to obtain the IP address.

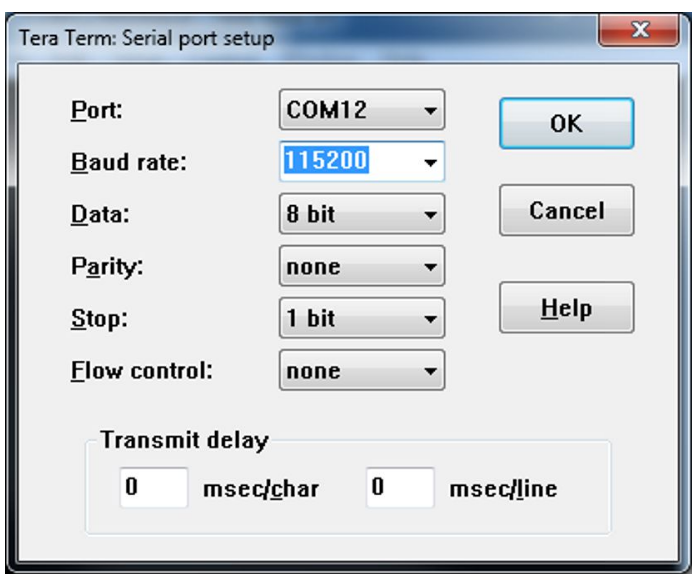

Figure 2. Tera Term Serial Port Setup

4. With the IP address determined in Step 3, return to the New connection window (Tera Term) and enter the IP address as shown in Figure 3.

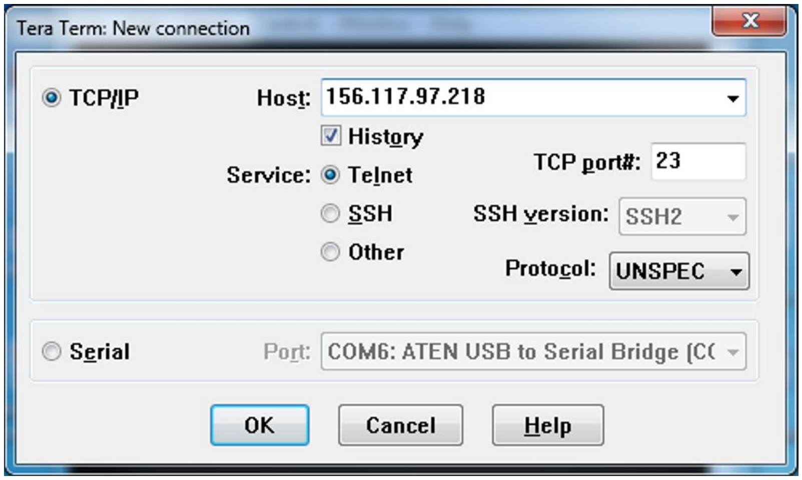

Figure 3. Tera Term: New Connection Setup — TCP/IP

5. Log in as "root" with the password "root".
6. Start the G3 Data Concentrator application by executing the following command in the terminal window of host machine:
   >./g3_dc_AM335X_aes_msb_loading.exe –c/dev/ttyO3

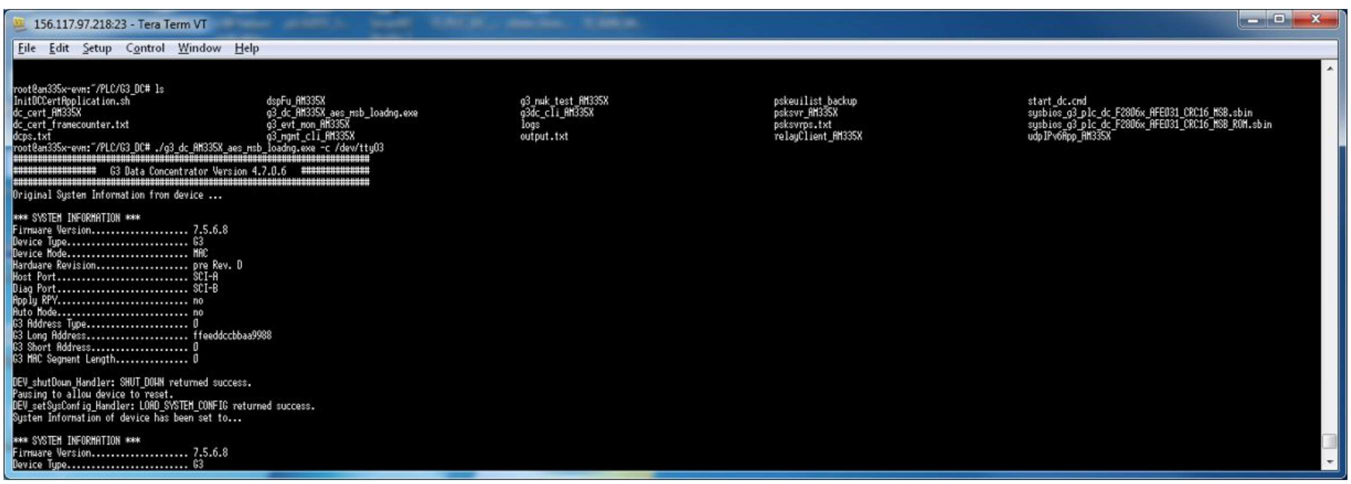

Figure 4. Tera Term VT – DC CENELEC Setup

Find more options in the user's guide in the software package (http://www.ti.com/tool/ti-plc-g3-dc).

7. Now a service node can join the network using another PLC modem with the service node software installed. Plug in the PLC SOM onto the PLC motherboard with an AC power line coupling to complete the service node setup.
   (a) Connect the service node to the host PC and open the Intermediate GUI installed on the PC. For details on connecting the service node to the PC, see "Section 8: Test Setup" of the TIDM-SOMPLC-FCC design guide (TIDU812).
   (b) Open the Intermediate GUI on the PC (see Figure 5).

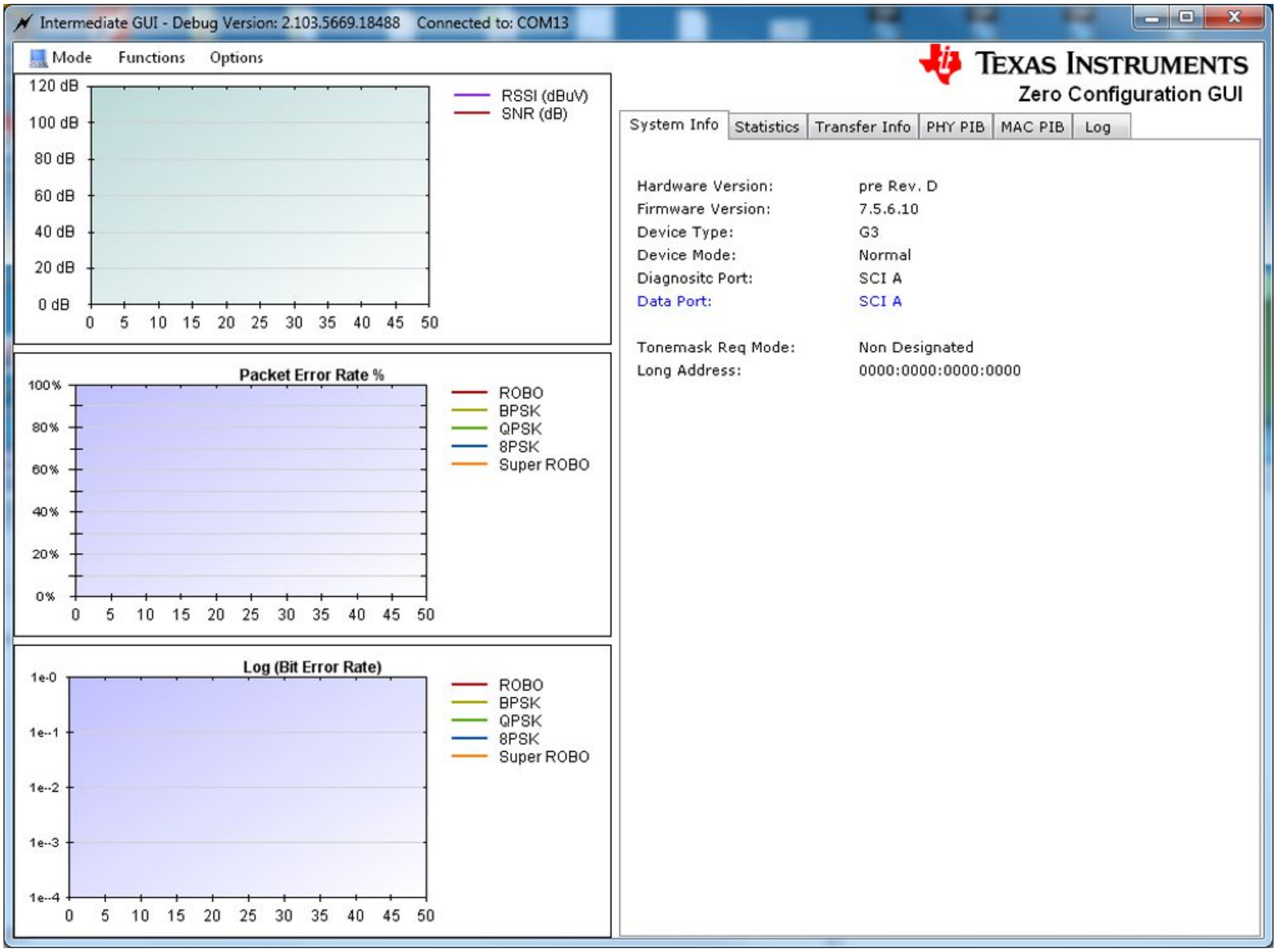

Figure 5. Intermediate GUI

(c) Select Options → PHY Parameters and ensure CENELEC band is selected.

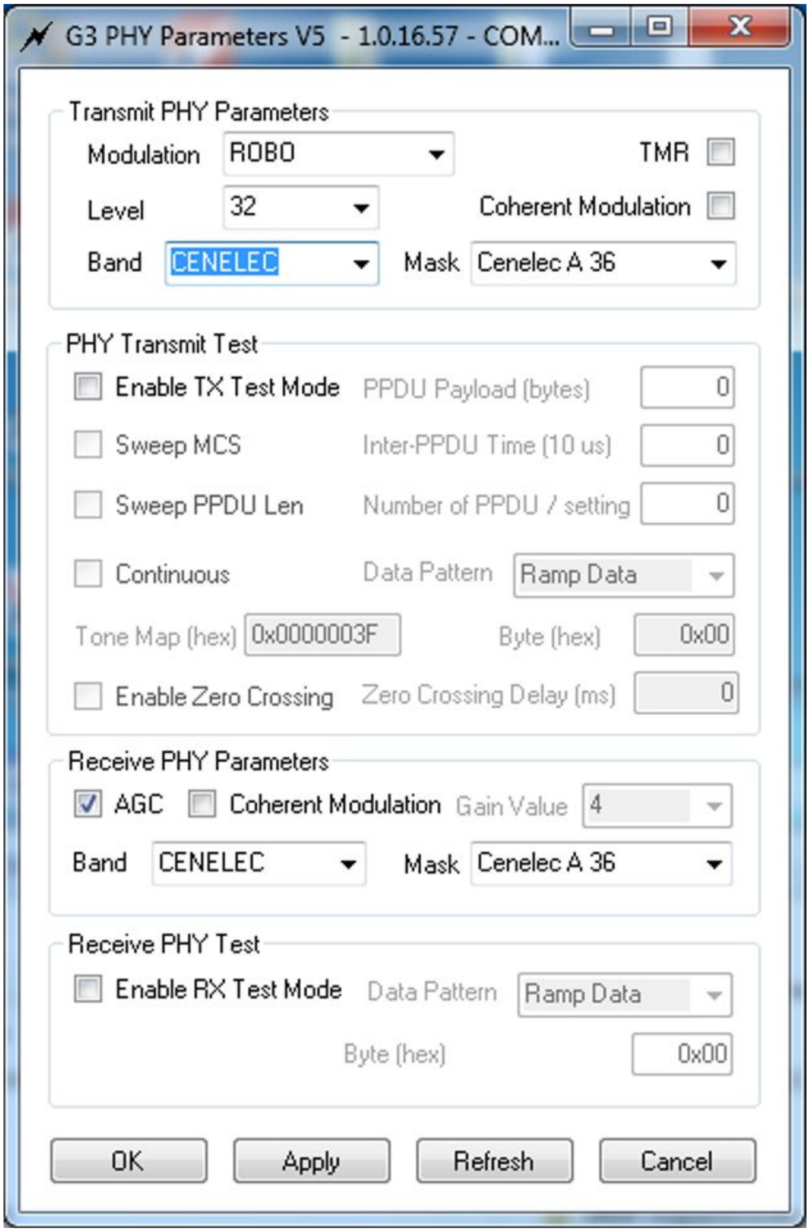

Figure 6. G3 PHY Parameters Configuration

(d) Select Function → Service Node to start service node and wait until it joins the Data Concentrator.

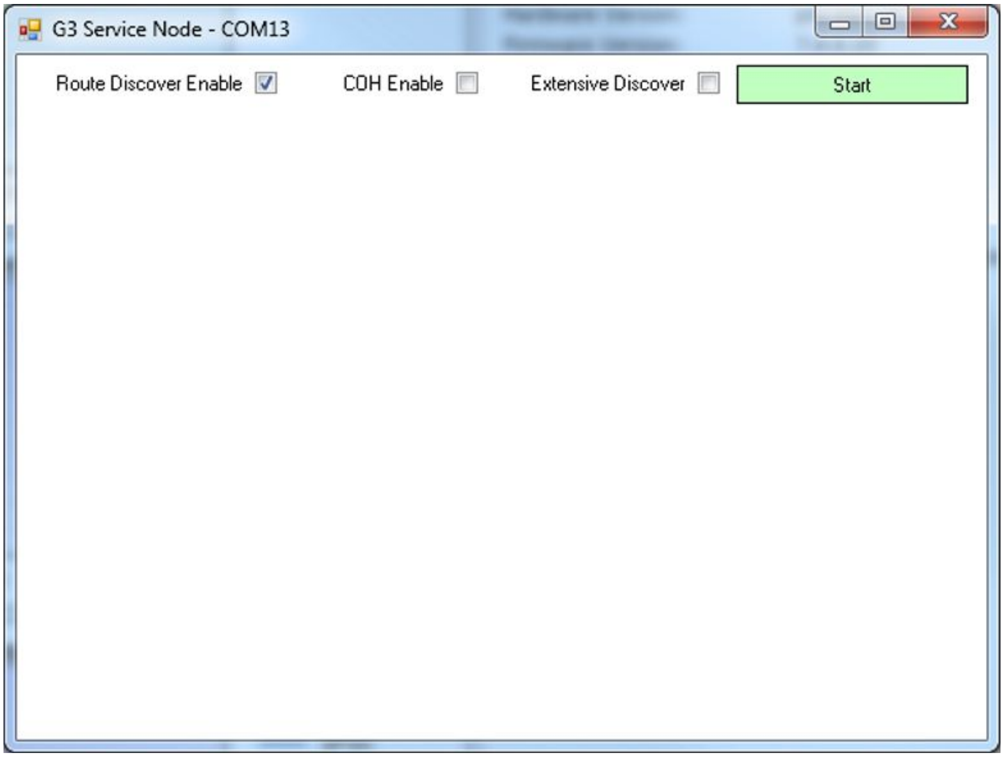

Figure 7. G3 Service Node

See Figure 8 for successful completion of joining service node to DC.

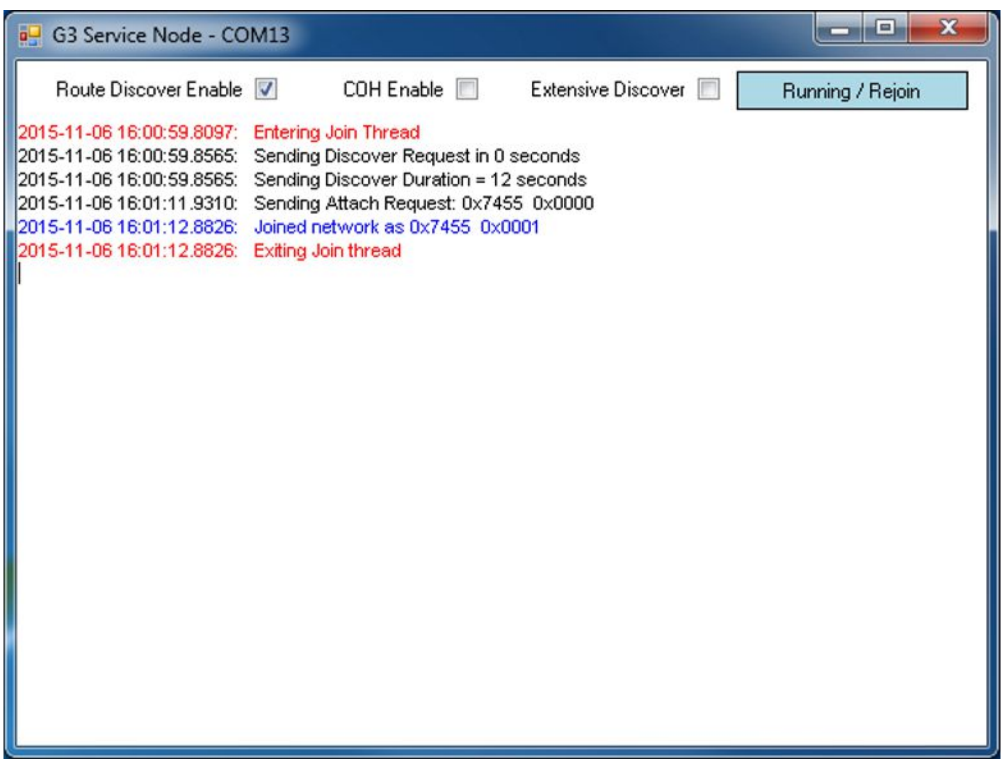

Figure 8. G3 Service Node Status Window

8. To transfer data: Once the service node has joined, trigger a simple data transfer by using the application "udpIPv6App_AM335X > ./udpIPv6App_AM335x –l 100 –s 0x1". The packet length is 100 and short address is 0x1.

Find more options in the user's guide in the software package (http://www.ti.com/tool/ti-plc-g3-dc).

5 Test Data

Once the service node has joined over the network, the user can trigger a simple data transfer over the network by using the application "udpIPv6App_AM335X > ./udpIPv6App_AM335x –l 100 –s 0x1".

With data transfer initiated, the round trip time to send data from the Data Concentrator to the service node is displayed in milliseconds as shown in Figure 9.

Figure 9. Test Data

6 Design Files

6.1 Schematics

To download the schematics. see the design files at TIDEP0059.

6.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDEP0059.

6.3 Layout Prints

To download the layout prints, see the design files at TIDEP0059.

6.4 Gerber Files

To download the Gerber files, see the design files at TIDEP0059.

6.5 Assembly Drawings

To download the assembly drawings, see the design files at TIDEP0059.

7 Software Files

To download the software files, see the design files at TIDEP0059.

8 References

1. Texas Instruments, *Smart Data Concentrator EVM (TMDSDC3359) Hardware Manual*, TMDSDC3359 Wiki (http://processors.wiki.ti.com/index.php/Smart_Data_Concentrator_EVM_(TMDSDC3359)_Hardware_Manual)

9 About the Author

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