Quick Start Guide

ZigBee™ Environment Demonstration (ZeD) Smart Energy

freescale™
semiconductor

Contents

About This Guide

This guide provides and introduction to the Freescale's ZigBee® environment Demonstration (ZeD) for the Smart Energy profile. This guide describes what ZeD is, how to install it, launch it, and how to run a simple demonstration. This guide also shows how to download embedded files to the demonstration boards.

For more information on ZigBee, visit www.freescale.com/802154.

The 1322x-EVK or 13226PRO-EVK is required to run the ZeD Smart Energy profile.

Audience

This document is intended for ZigBee, IEEE® 802.15.4 MAC and SMAC custom software and application developers.

Revision History

Current document revision number: 1.3

The following table summarizes revisions to this document since the previous release (Rev 1.2).

Revision History

Location	Revision
Load Control and Pricing	Various updates.

Conventions

This document uses the following notational conventions:

- `Courier monospaced type` indicate commands, command parameters, code examples, expressions, datatypes, and directives.
- *Italic type* indicates replaceable command parameters.
- All source code examples are in C.

Definitions, Acronyms, and Abbreviations

The following list defines the abbreviations used in this document.

BDM	Background Debug Module
C	Coordinator
ED	End Device
EVB	MC13192 Evaluation Board with S08GT60 MCU
EVK	Evaluation Kit
GUI	Graphical User Interface
LED	Light Emitting Diode
MCU	MicroController Unit
NCB	MC1321x Network Controller Board with S08GT60 MCU
PC	Personal Computer
PCB	Printed Circuit Board
QE128-EVB	MC1320x Evaluation Board with S08QE128 MCU
R	Router
SARD	MC13192 Sensor Application Reference Design with S08QE128 MCU
SRB	MC1321x Sensor Reference Board with S08GT60 MCU
USB	Universal Serial Bus
ZeD	ZigBee environment Demonstration

ZeD for Smart Energy Introduction

This guide shows how to install ZeD for Smart Energy, program the boards using the embedded image files, how to use the ZeD for Smart Energy Windows GUI to monitor and view the ZigBee network, and demonstrate the functionality of the ZigBee applications.

For a more information about the ZeD GUI and the Home Automation mode for ZeD, see the following documents:

- ZeD Software User's Guide
- ZeD Embedded Software Design User's Guide
- ZeD Quick Start Guide

System Overview

The Freescale ZigBee environment Demonstration (ZeD) is a set of software components designed to visualize, monitor, and demonstrate how a ZigBee network functions. This document describes using ZeD to accomplish these tasks for the Smart Energy ZigBee profile. ZeD functions are closely tied to the capabilities of the Freescale BeeStack and the Freescale BeeKit Wireless Connectivity Toolkit to offer an intuitive view of how a ZigBee network is formed and how that network operates. ZeD also allows users to see how the Smart Energy Profile applications operate on the ZigBee layer while these applications perform various functions.

ZeD for Smart Energy supports the ZigBee 2007 (ZigBee Feature Set) standard as implemented in the Freescale BeeStack and the Smart Energy Profile for ZigBee applications. ZigBee 2007 and the Smart Energy Profile are defined by the ZigBee Alliance. See www.zigbee.org for more details. As part of the BeeKit Wireless Connectivity Toolkit, ZeD operates with the other BeeKit components to offer a comprehensive and easy to use platform for ZigBee development.

Hardware and Software Requirements

The following is a list of the minimum software and hardware requirements required by ZeD as shown in this guide:

• A PC running Microsoft Windows XP®, Microsoft Windows Vista® or Microsoft Windows 2000®

• BeeKit with ZeD and Test Tool installation package provided with a ZigBee EVK or downloaded from the Freescale web site at www.freescale.com/zigbee

• Three MC1322x Network Node boards and two MC1322x Sensor Node boards. MC13226 Network Node and MC13226 Sensor Node boards are also supported

• At least 1 USB cable to connect the Energy Service Portal (ESP) board to the PC. More cables are needed if users choose to power their other boards using the USB ports on the boards

• Eight AA batteries if users choose to use battery power for their boards.

ZeD Installation

Using ZeD with the Smart Energy profile is designed for use with the Freescale MC1322x ZigBee evaluation boards.

To run the ZeD Home Automation profile, the MC1321x boards can also be used. See the *ZeD Quick Start Guide* for more information.

ZeD software consists of the following two components:

• Embedded software running on the physical evaluation boards. Each board runs a ZigBee Smart Energy Application which runs on top of the Freescale BeeStack

• ZeD Windows GUI software running on a PC that allows users to see the state of the network and the functions performed by the embedded applications as these applications communicate over the air using ZigBee

When installing Freescale BeeKit with ZeD, both software components are deployed to the system. The ZeD embedded software consists of embedded image files used to program the boards. The embedded image files are located in the ZeD installation folder on the PC.

Software Requirements

Before installing ZeD, ensure that the following items are in place. ZeD will not function if these requirements are not met.

- A PC running Microsoft Windows XP®, Microsoft Windows Vista® or Microsoft Windows 2000®.

- Three MC1322x Network Node boards and two MC1322x Sensor Node boards. At a minimum, one of boards must be configured as the ZigBee Coordinator running the Energy Service Portal (ESP) application. The other boards are needed to demonstrate ZigBee networks and Smart Energy "over the air" functionality.

The boards need to be loaded with ZigBee applications running a specific configuration for ZeD. The image files for these applications are provided in the Embedded Images folder of the ZeD installation folder. See the next section, "Downloading an Embedded Image File" for more details on how to configure and program a board.

Test Tool 11.2.5 or later is required to reprogram the boards using the ZeD embedded software image files for Smart Energy.

If users intend to customize the existing applications or develop their own ZigBee applications, they will also need the following items:

- The Freescale BeeKit Wireless Connectivity Toolkit and codebases with a license for Freescale BeeStack development. Refer to the *BeeKit Wireless Connectivity ToolKit User's Guide* for details on how to install and use BeeKit

- IAR Embedded Workbench for ARM Version 5.20/5.30 (for BeeStack Codebases 3.0.8 or earlier) or Version 5.4 or later for BeeStack Codebases 3.0.9 or later. A Full License is required. Refer to the BeeStack 2007 documentation for information about the network stack and template applications that come with the BeeStack codebase.

Installing on the PC

ZeD is installed by default with the BeeKit Wireless Connectivity Toolkit software. To install ZeD, make sure that while installing BeeKit, the ZeD component check box is selected as shown in Figure 1.
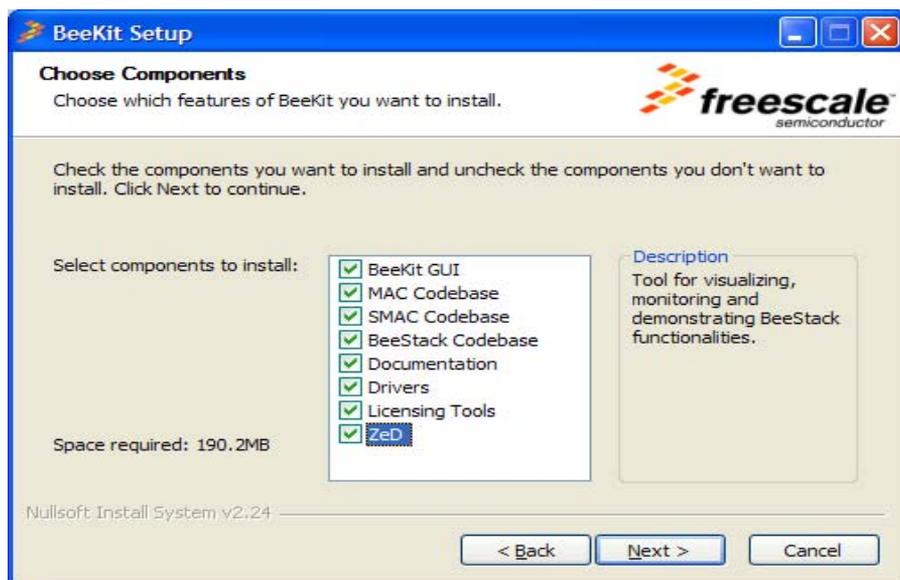
Figure 1. Selecting ZeD to be Installed From the BeeKit Installer

Refer to the *BeeKit Wireless Connectivity Toolkit Quick Start Guide* for details on how to use the BeeKit installer.

By default, the installation program copies the ZeD software to the PC hard drive in the following folder location:

```
Program Files\Freescale\ZeD v.v.v
```

The installation program also creates shortcuts to the ZeD PC GUI and the embedded image file folder in the following Windows Start Menu location.

```
Start -> Programs -> Freescale BeeKit -> ZeD v.v.v -> Freescale ZeD
v.v.v
```

The installation program can also place a shortcut to the ZeD application on the PC desktop. In the above path examples, v.v.v designates a 3-digit version number, for example, 1.4.0. Smart Energy applications must be run using ZeD 1.4.0 or later.

Downloading a Embedded Image File

This section shows how to load the ZeD Smart Energy embedded image files to the development board using the Test Tool MC1322x Firmware Loader program.

Smart Energy ZeD Image Files

The ZeD Smart Energy embedded image files are placed in the `Embedded/MC1322xSE` folder which is located in the ZeD installation folder. ZeD also comes with BeeKit solution files which can be used to customize the applications and generate user-defined applications. When using 3 (three) MC1322x Network Node boards and 2 (two) MC1322x Sensor Node boards, the following image file - board correspondence is to be performed:

• Se `EnergyServicePortal_SN.bin` to be loaded on a MC1322x Sensor Node (SN)

• Se `InPremiseDisplay_NN.bin` to be loaded on a MC1322x Network Node (NN)

• Se `PCT_NN.bin` (Programmable Communicating Thermostat) to be loaded on a MC1322x Network Node (NN)

• Se `MeteringDevice_SN.bin` to be loaded on a MC1322x Sensor Node (SN)

• Se `LoadControl_NN.bin` to be loaded on a MC1322x Network Node (NN)

Erasing the Boards FLASH

Before downloading the new code, the FLASH on the 5 boards needs to be erased. To erase the FLASH, perform the following tasks for each board:

1. Connect the board to a USB port and power it on.
2. Use 2 (two) jumpers and short together the pin pairs marked VREFH (ADC2_VrefH) and VREFL (ADC2_VrefL) on the board. These pin pairs are clearly marked on the board and can be found next to the JTAG port.
3. Press the Reset Switch on the board and wait 5 seconds.
4. Unplug the board from the USB port.
5. Remove the two jumpers.
6. Plug the board back in the USB port.
7. Press the Reset Switch on the board again.

Starting the Test Tool MC1322x Firmware Loader

To begin loading the embedded images to the boards, launch the Test Tool application: choose Programs -> Freescale Test Tool -> Test Tool.

1. From the Test Tool main menu choose View -> Firmware Loader -> MC1322x Firmware Loader. The Firmware Loader window appears as shown in Figure 2.

Figure 2. Test Tool MC1322x Firmware Loader

Loading an Application

This example uses the Energy Service Portal application. To load the `Se EnergyServicePortal_SN.bin` application image file on a MC1322x Sensor node :

1. Connect the MC1322x Sensor Node board to the PC using a USB cable and power it on. The board flash must be erased as described in the previous section.

2. If the board drivers are not already installed, the Windows "Found New Hardware" wizard appears. Steer the system to the driver location (Freescale Drivers folder) which by default is at the following location:

   ```
   Program Files\Freescale\Drivers
   ```

3. Disconnect any other boards from the PC.

4. In the Test Tool MC1322x Firmware Loader set the chip revision to 2.0.

5. Click Browse... and explore to choose `x:\Program Files\Freescale\ZeD v.v.v\Embedded\MC1322xSE\SE EnergyServicePortal_SN.bin`.

6. Set the MAC address to the address on the label on the board (the number starting with 00 50 C2).

7. Set the board connection to "Use USB COM port" connection. Make sure the board COM port is displayed on the right side of the connection controls. Configuration must look as in Figure 3.
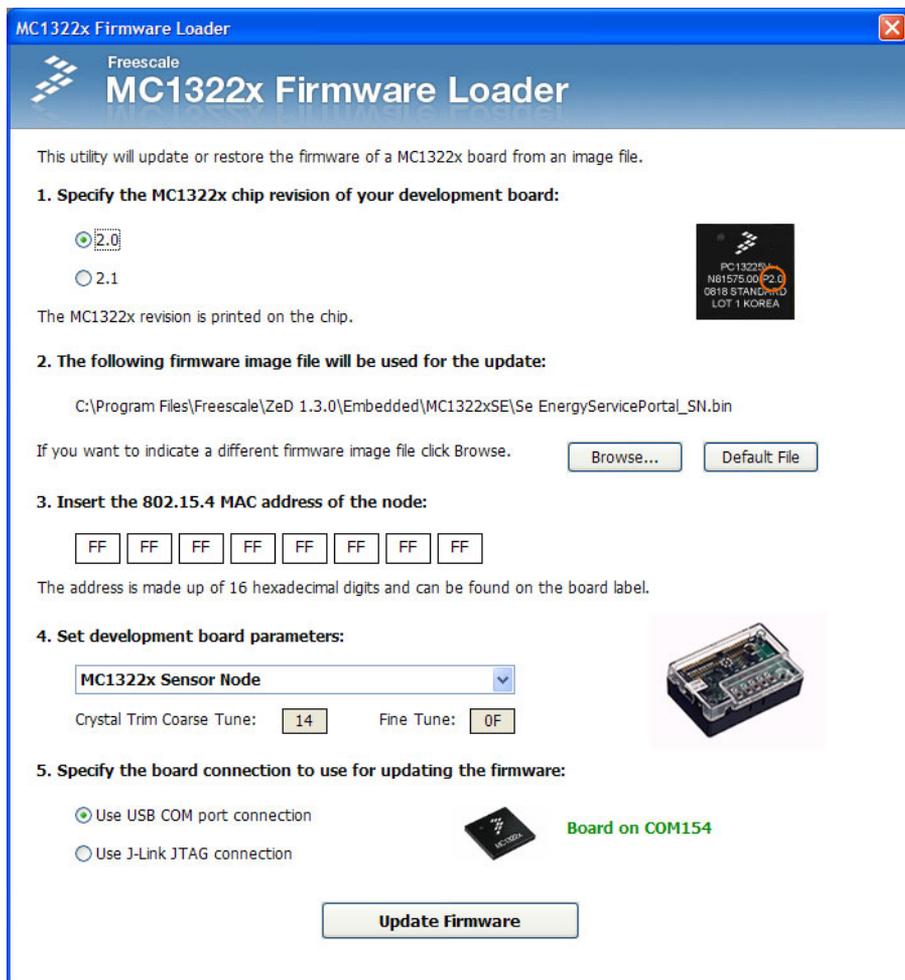
Figure 3. Firmware Loader Configuration for ESP Image Loading

8. Press the Update Firmware button.

9. Press the Reset switch on the board when indicated by the status message as shown in Figure 3. The message also contains the flash erase procedure details if that has not been yet performed.
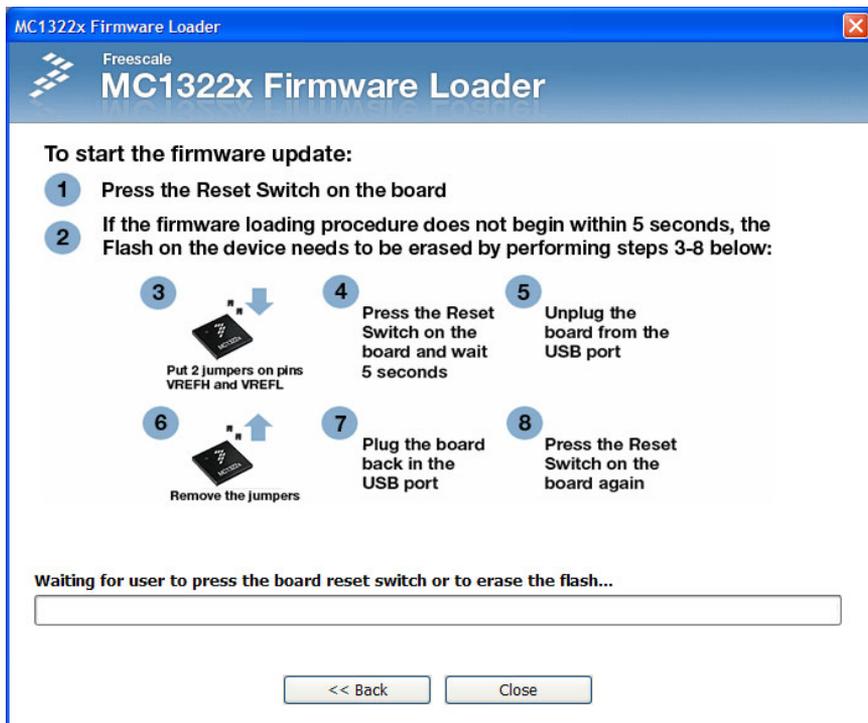

Figure 4. Image Loader (Reset Board Message)

10. Wait until the firmware update completes.

11. Reset the board when done. LED1 on the board should flash.

12. Press the Back button to return to the main Firmware Loader page and repeat Steps 1-11 to load the other four embedded images to the other boards.

Forming a Network and Starting ZeD

This section provides the steps required to form a Smart Energy network using the evaluation boards running the Freescale BeeStack and the ZigBee sample applications. This section also shows how to start ZeD to monitor and view network status.

Starting the Network on the ESP

To start the ZigBee network, perform the following steps:

1. Select the MC1322x Sensor Node board loaded with the Energy Service Portal (ESP) application. This board serves as the ZigBee Coordinator.
2. Using a USB cable, connect the ESP to the computer that will be running ZeD. For the board drivers to work correctly, ensure that the USB cable is connected directly to the PC and not to a USB external hub.
3. Press SW1 on the ESP. Wait for the LED1 and LED 2 to be on. The network is now started.

Running ZeD

Before joining the other nodes to the network, run the ZeD Graphical User Interface by performing the following tasks.

1. Start ZeD from the Windows Start Menu at:

```
Start -> Programs -> Freescale BeeKit -> ZeD v.v.v -> Freescale ZeD v.v.v
```

or by using the Freescale ZeD application shortcut on the Windows desktop.

In the above path examples, v.v.v designates a 3-digit version number, for example, 1.5.0. Smart Energy applications must be run using ZeD 1.5.0 or later

2. If ZeD is started for the first time, it displays a short introduction message on how to connect the ESP board (ZigBee Coordinator) to the PC as shown in Figure 5.
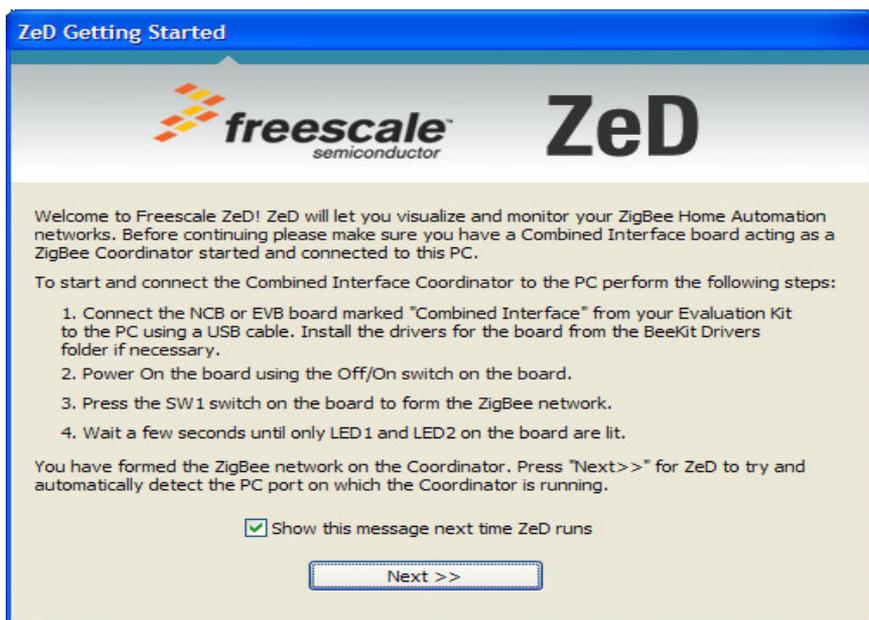
Figure 5. ZeD Getting Started Message

3. After pressing the Next>> button, ZeD tries to automatically detect the COM port that corresponds to the ESP board serving as the ZigBee Coordinator. Figure 6 shows the ZeD window as it tries to autodetect the ESP board.
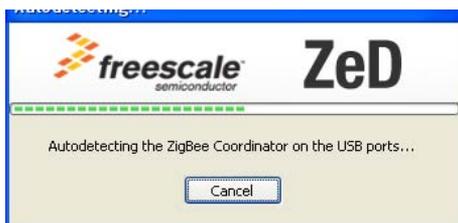
Figure 6. Automatic Detection of the ZigBee Coordinator Port

4. If the ESP board is detected, the board port is displayed in the list as having the type "ZigBee Coordinator (Autodetected)" as shown in the Coordinator Selection window (Figure 7).
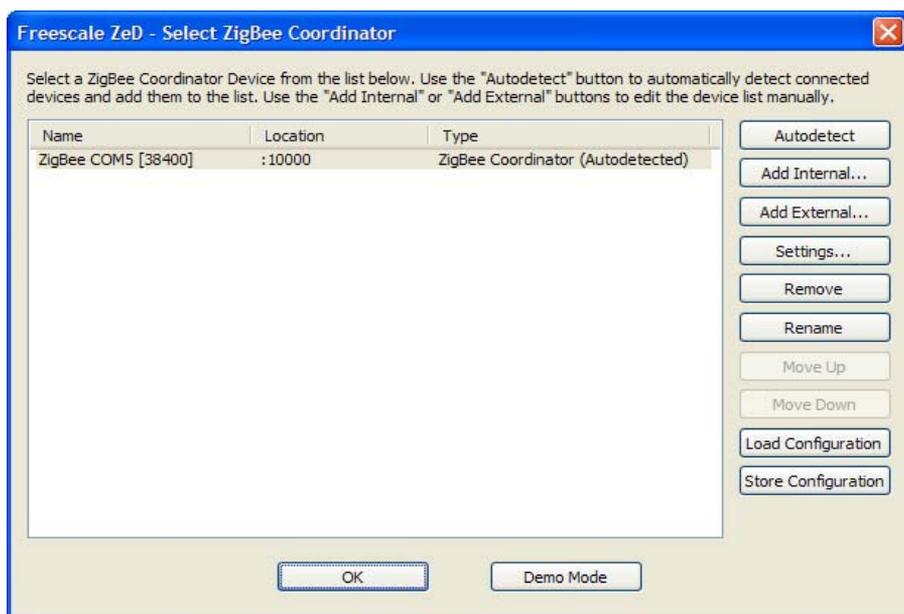
Figure 7. ZigBee Coordinator Selection Window

If no port appears in the list, or the first port in the list has the type "ZigBee Device" and not "ZigBee Coordinator (Autodetected)", then ZeD has not been able to detect the coordinator board. If this occurs, check for the following:

— The board is properly connected via the USB cable to the PC and that the board drivers are correctly installed. See the *ZeD Software User's Guide* for a detailed description of virtual board ports and how they are assigned.

— The ZigBee network is formed on the ESP coordinator board. LED1 and LED2 on the boards are on when the network is properly formed.

— There are no other instances of ZeD running on the PC.

— The port of the coordinator is not in use by other software such as Freescale Test Tool.

After checking these items, press the Autodetect button on the Coordinator Selection Window to repeat the Coordinator autodetection process.

5. Ensure that the COM port of the ZigBee Coordinator is highlighted and click the OK button. This launches the ZeD main window. ZeD connects to the ZigBee Coordinator and will use it as a gateway to find out information about the other nodes in the network. Once the coordinator application type is detected, the ZeD main view changes to reflect the fact that it has detected a Smart Energy Profile ESP as shown in Figure 8.
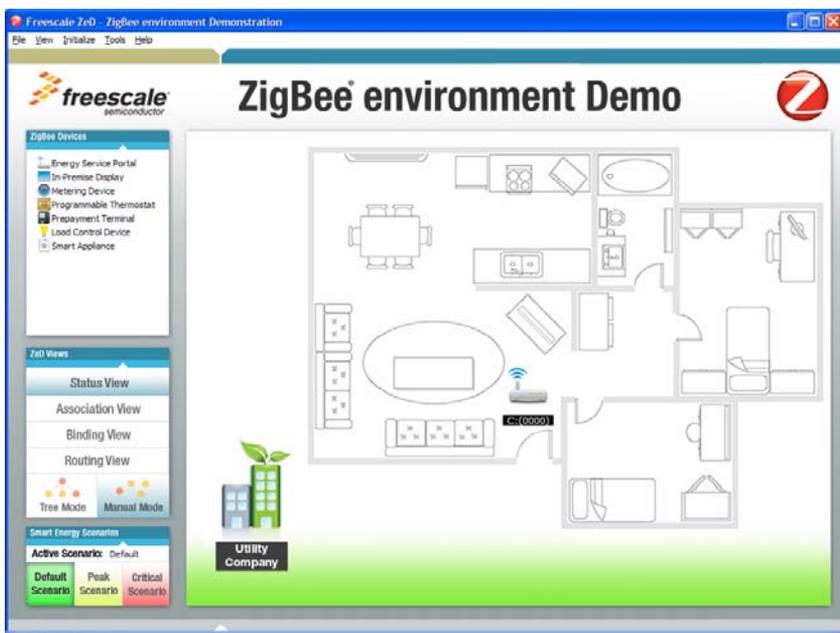

Figure 8. ZigBee Main Window After ESP Detection

Joining the Other Nodes to the Network

Users can now continue to form the Smart Energy ZigBee network by joining the other four boards.

1. Power on the other boards by connecting them to other USB ports or using AA batteries.

2. Turn ON the other boards using the OFF/ON switch.

3. Press SW1 on the InPremiseDisplay MC1322x Network Node. That board joins the network. When the board has joined, LED1 and LED2 on the board turn continuously on and the "Running Device" message is shown on the board LCD.

4. Wait until the node is detected in the ZeD GUI where it appears as a new icon as shown in Figure 9.
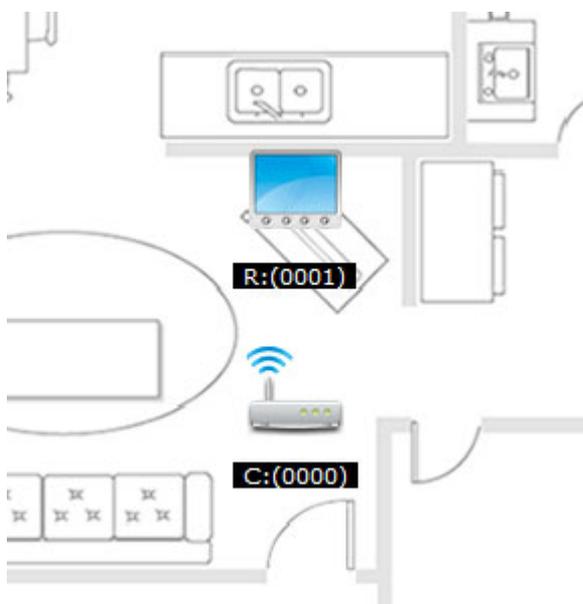
Figure 9. InPremiseDisplay Joined the Network as a New Node

5. Notice how the InPremiseDisplay time on the last line of the LCD is synchronized to the PC time via the ESP.

6. Press SW1 on the SePCT (Programmable Communicating Thermostat) MC1322x Network Node. The boards joins the network.

7. Wait until the node is detected in the ZeD GUI where it appears as a new icon as shown in Figure 10.
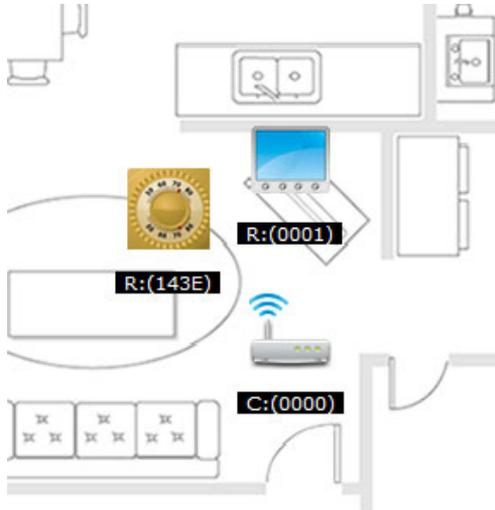

Figure 10. PCT Joined the Network as a New Node

8. Press SW1 on the SeLoadControl MC1322x Network Node.
9. Wait until the node is detected in the ZeD GUI where it appears as a new icon as shown in Figure 11.
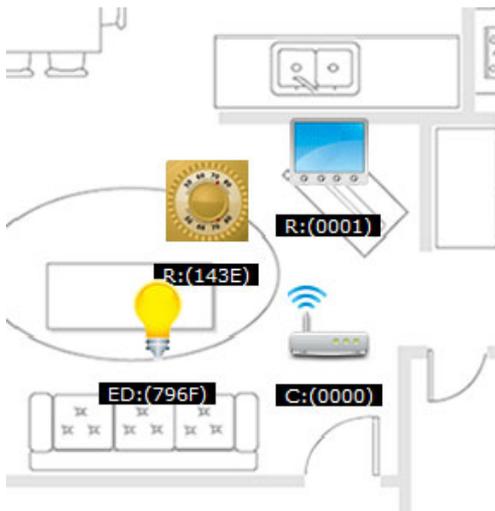
Figure 11. LoadControl Joined the Network as a New Node

10. Press SW1 on the MeteringDevice MC1322x Sensor Node. That board joins the network. When the board has joined, LED1 on the board turns continuously on.

11. Wait until the node is detected in the ZeD GUI where it appears as a new icon as shown in Figure. The MeteringDevice is a low power applications which means that it communicates using data polling and the update of the device properties in the GUI can take longer.

12. Notice how the MeteringDevice icon in the ZeD GUI displays the meter reports from the node. The node reports the data periodically as shown in Figure 12.

Figure 12. MeteringControl Showing Meter Data

13. Users have now successfully formed a five node, Smart Energy ZigBee network.

ZeD Use Case

This section describes how to use ZeD to initialize some standard Smart Energy scenarios. The PC GUI will send energy management control messages to the ESP as if those were sent by a utility company. The ESP will at its turn send the messages via the ZigBee network to the Smart Energy nodes which will simulate updating their properties in response to the messages.

Use Case Requirements

Before running through the use case, follow the steps described in Forming a Network and Starting ZeD, to first form the five node network and run the ZeD GUI. The boards also must be placed in Application Mode as described in the next section.

Placing the Boards in Application Mode

This section describes how to place the boards in Application Mode so that the user interface on the boards can perform application specific functions. After starting the network or being joined to a network, the boards are in Configuration Mode and the switches and LEDs on the boards have functions related to the network formation process. By placing the boards in Application Mode, the functions of the switches and LEDs change to application related functions.

For example, in Application Mode, LED2 on the LoadControl board shows the duty cycle of the node. Refer to the ZigBee Application User Guide for more details on the user interface of the boards.

To switch between board modes, press and hold SW1 on each board for about 2 seconds.

When the boards go from Configuration Mode to Application Mode, there should be a change in the state of the LED1 on the board which goes off. For all the Network Node boards, the second line of the LCD displays "App" instead of "Cfg".

Sending Messages to the InPremiseDisplay

To simulate sending a message from the utility company to the consumer using the InPremiseDisplay perform the following steps:

1. Ensure the board has been placed in ApplicationMode as described above.
2. Double-click the InPremiseDisplay icon on the ZeD GUI. The Endpoint Properties window appears as shown in Figure 13.
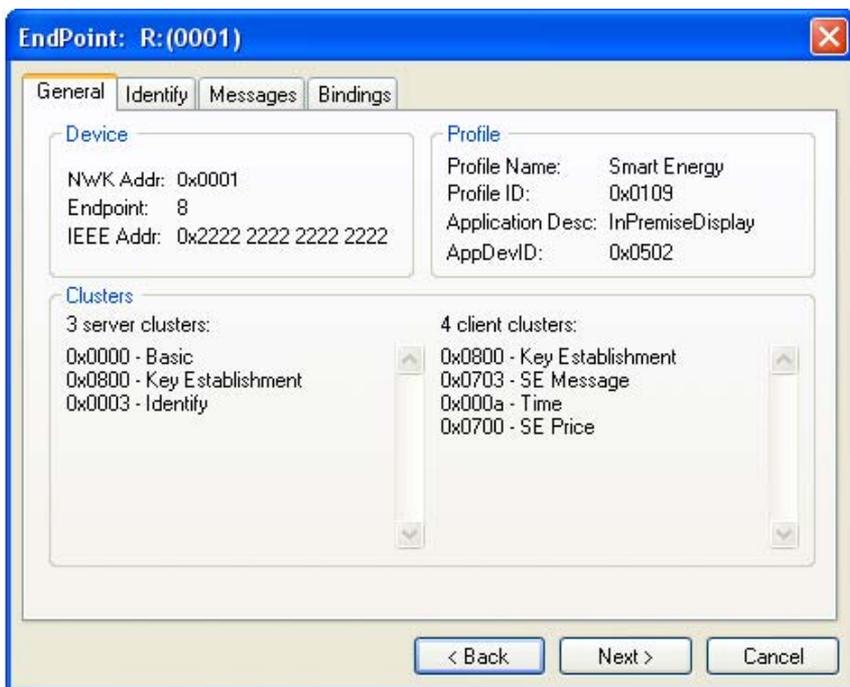
Figure 13. InPremiseDisplay Endpoint Properties Tab

3. Select the Messages tab as shown in Figure 14.
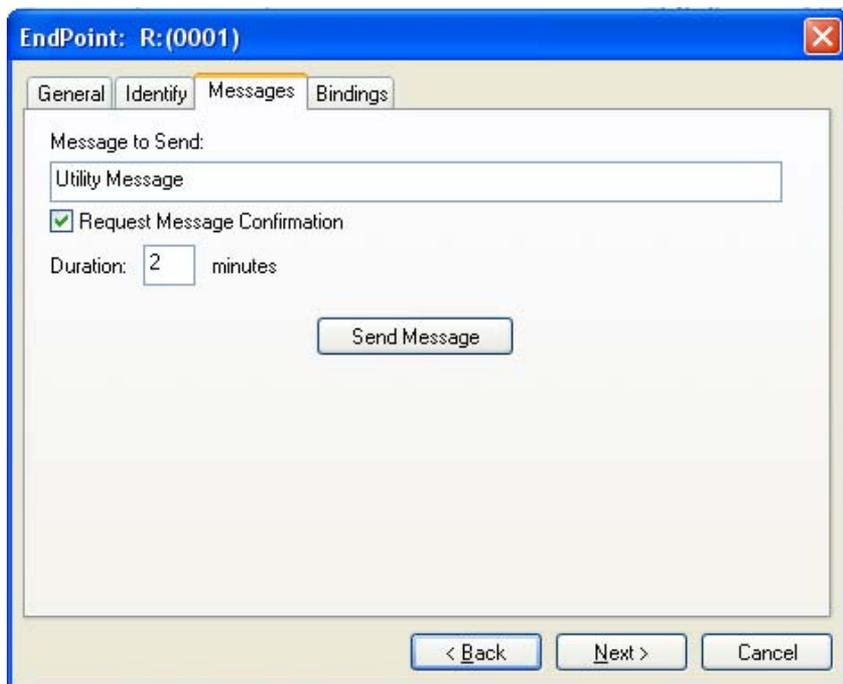
Figure 14. Messages Tab

4. Enter the text "Utility Message" in the "Message to Send" box.
5. Check the "Request Message Confirmation" check-box.
6. Set the message Duration to 2 minutes.
7. Press the Send Message button and close the Properties window by clicking Cancel.
8. Notice how the message is sent over the Smart Energy network to the InPremiseDisplay board which displays it on the LCD screen.
9. Confirm the message on the board by pressing SW2. The "Confirm" text disappears from the InPremiseDisplay icon to signal the utility company has received the message confirmation.

Using Load Control and Price Scenarios

The scenario buttons on the bottom-left of the ZeD GUI shown in Figure 15, let the user simulate changing the energy management parameters by the utility company.
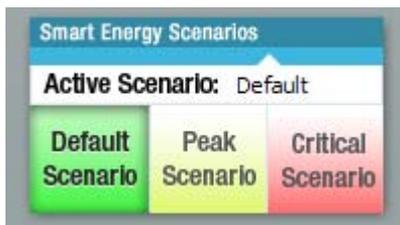
Figure 15. Smart Energy Scenarios Controls

To use the scenarios perform the following steps:

1. Ensure the PCT and LoadControl boards are joined to the network and have been placed in Application Mode as described above.

2. The PCT displays the Desired Temperature of the Thermostat DT=24 degrees Celsius. The LoadControl displays the duty cycle of the node as 90%

3. Press and hold SW4 for 2 seconds on the LoadControl board to place the board in price control mode.

4. Click the Peak Scenario button in the ZeD GUI. This has as effect sending the boards two messages:

   • Load Control Event Request with the following parameters:

     — Cooling Offset: = 2°C

     — Heating Offsets = 2°C

     — Cooling Set Point = 21°C

     — Heating Set Point = 23°C

     — Duty Cycle = 50%

     — Criticality Level 3

     — Duration = 5 minutes

   • Price Response indication with the following parameters:

     — Tier = 1

     — Price = 0.18$

— Duration = 5 minutes

5. The boards will receive the messages and display "Event Started" or "Price Started" on the LCD.

6. The PCT will show a new DT=22°C lowered by 2°C and a duty cycle set to 50% as indicated by the Load Control Event.

7. The LoadControl will show that it has reduced the duty cycle to 70% as a result of the price increase (the default price is set to 0.12$)

8. Click the Critical Scenario button in the ZeD GUI. This has as effect sending the boards two messages:

   — Load Control Event Request with the following parameters:

   — Cooling Offset: = 3°C

   — Heating Offsets = 3°C

   — Cooling Set Point = 19°C

   — Heating Set Point = 21°C

   — Duty Cycle = 25%

   — Criticality Level = Emergency

   — Duration = 5 minutes

   • Price Response indication with the following parameters:

   — Tier = 1

   — Price = 0.30$

   — Duration = 5 minutes

9. The boards will receive the messages and display "Event Started" or "Price Started" on the LCD.

10.The PCT will change the DT and set the duty cycle to 25 % as indicated by the Load Control Event.

11.The LoadControl will also show the Critical Load Control Event as this supersedes the Price message as a result of the Emergency Level criticality. The duty cycle of the LoadControl is also set to 25%.

12.Click the Default Scenario button in the ZeD GUI. This has as effect sending the boards two messages:

   • Cancel All Load Control Messages

   • Price Response indication with the following parameters:

   — Tier = 1

— Price = 0.12$

13. The boards will receive the messages and cancel the load control events if they are still active as well as set the price to the default value.

Using Custom Smart Energy Load Control Events

In Smart Energy mode, ZeD also allows users to create custom Smart Energy Load Control Events by allowing users to adjust all parameters of the event and send the event to a Load Control endpoint. To create a custom Load Control event:

1. Ensure that there is at least one device in the network that has a Demand Response/Load Control client cluster on an endpoint (for example, a LoadControl application).

2. Double click the ESP coordinator icon or right-click the icon and choose Properties.

3. Click the SE Load Control Events tab as shown in Figure 16.
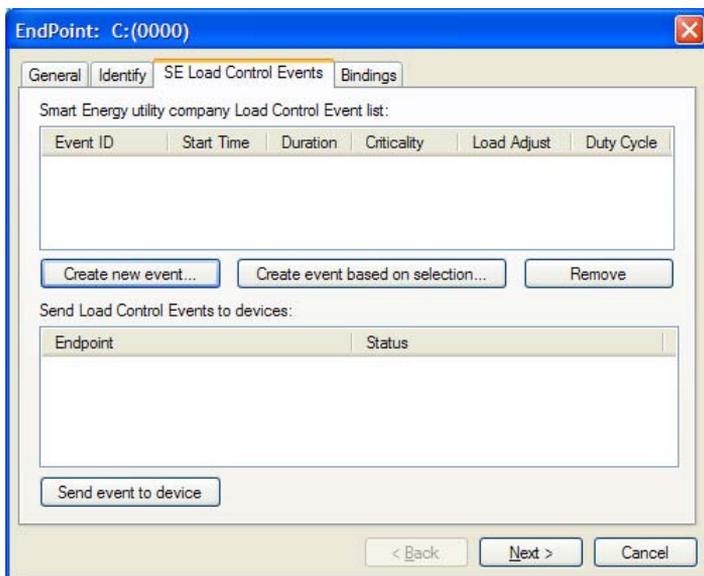
Figure 16. Smart Energy Load Control Events Tab Page

5. Click the Create new event... button. The Create New SE Load Control Event window appears as shown in Figure 17.

Figure 17. Create New Load Control Event Window

6. Fill in the new load control event parameters. See the Demand/Response/Load Control cluster documentation in the Smart Energy Specification document for a detailed explanation of the parameters.

7. After editing the parameters, click the Create Event button to add the new event to the event list.

8. Select a Load Control endpoint in the Endpoints list in the SE Load Control Events tab.

9. Send the event to the remote node by clicking the "Send event to device" button.

Using the TCP Smart Energy Utility Control Panel

Users can control and obtain reports from multiple ZeD Smart Energy instances over the local TCP network using the ZeD Smart Energy Utility Company Control Panel. The Control Panel acts as a TCP client for ZeD GUI instances on the network acting as servers.

1. To launch the Control Panel, from the ZeD Tools menu choose Start -> SE Utility Control Panel. The panel appears as shown in Figure 18.
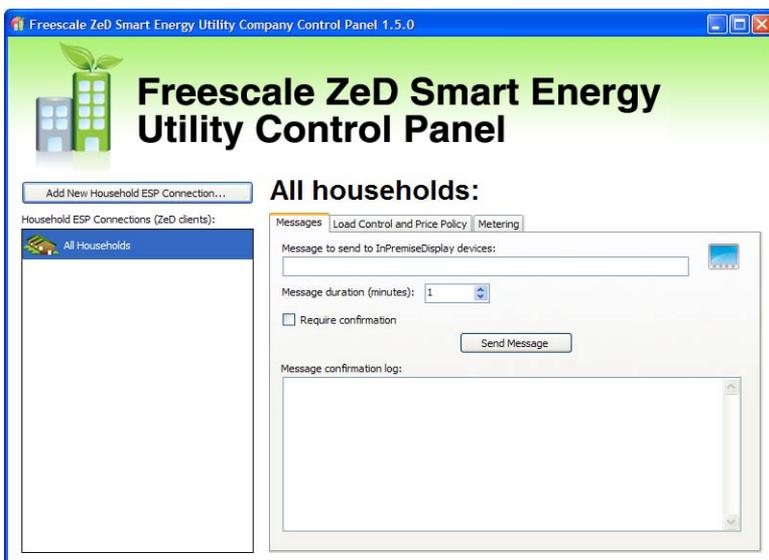
Figure 18. ZeD SE Control Panel

To connect from the Control Panel to networked Smart Energy ZeD instances, users must know the TCP server port of the Energy Service Portal board which is the Coordinator of the ZigBee network on the server. To find out the TCP connection port, in each server ZeD instance, choose Tools->Select Device from the ZeD menu. In the Select ZigBee Coordinator window, the port number of the ESP is specified in the Location column of the Autodetected Coordinator entry as shown in Figure 19.
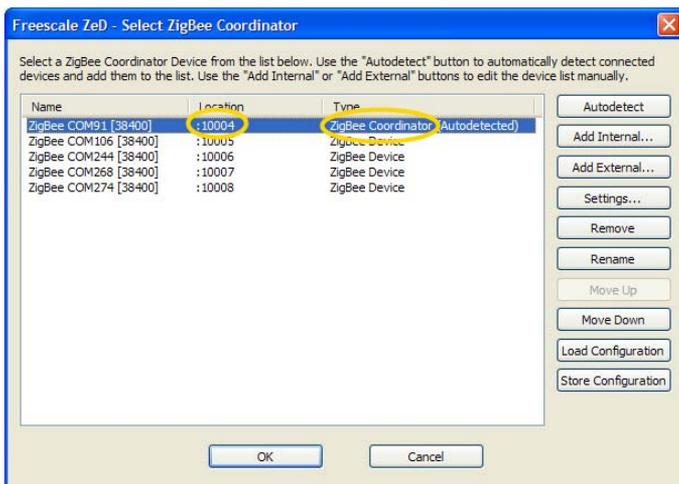
Figure 19. Determining ESP ZeD Server Port

3. In the Utility Control Panel, add each connection to the ZeD server by using the "Add New Household ESP Connection..." button. (Figure 20) Enter the host name or IP address of the machine on which the server is running and the previously determined port of the ESP on the server and click Connect:

Figure 20. Entering ZeD Server Information

5. If the connection to the server is successful, the ZeD server is added as a new household in the list on the left side of the Control Panel window. Select the server entry in the list and using the controls on the right side of the Control Panel, control or obtain information about the Smart Energy devices running on the ZeD server as shown in Figure 21.
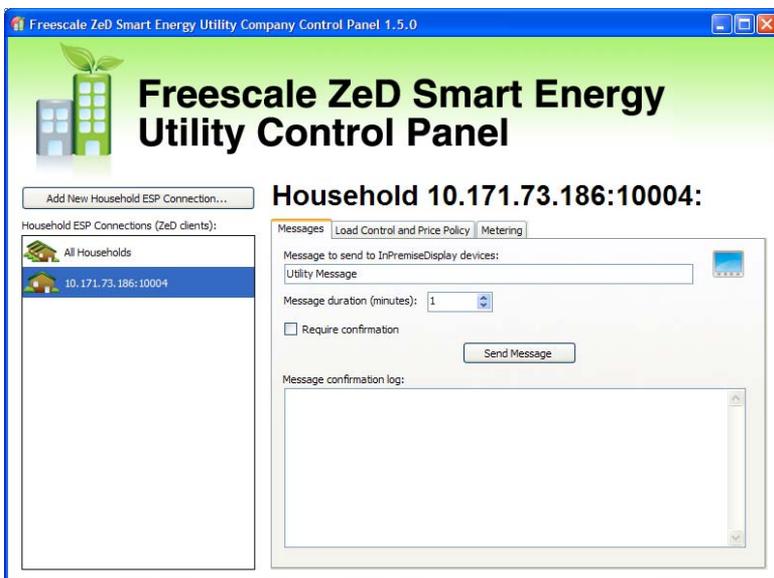

Figure 21. Sending a Message to the ZeD server from the Utility Control Panel

For more details about the functionality of the applications see the *ZigBee Application User Guide for ZigBee 2007* (ZAUGZB2007) and the Smart Energy Specification.

NOTES