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EM35x Development Kit User Guide

New in this Revision

Chapter 4: Silicon Labs part number changes in Table 4-1.

Chapter 7: usbaddr command added.

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1 About This Guide

1.1 Purpose

This document describes the Ember EM35x Development Kit and explains how to set up its hardware and use the Ember InSight Adapter (ISA3). For information on developing and debugging applications with InSight Desktop, see its on-line HTML help.

For information on designing and debugging an application based on Silicon Labs' EmberZNet PRO software stack, refer to documents 120-3029-000, *Ember Application Development Fundamentals,* and 120-035X-000, the *EM35x Datasheet*. See section 2.7, Documentation, for a list of other EM35x documents of interest.

1.2 Audience

This document is intended for embedded software and hardware engineers who are responsible for developing wireless applications with the Ember Development Kit. This document assumes that the reader has a solid understanding of embedded systems design and programming in the C language. Experience with networking and radio frequency systems is useful but not expected.

1.3 Documentation Conventions

Notation	Meaning	Example
Italics	Identifies on-screen software menu options.	*Connect*
UPPERCASE	Identifies a keyboard key.	ENTER
Right-angle bracket	Delimits a series of software program menu options to be clicked.	*Open* > *Save*
`Courier`	Identifies software code and, in body text, variables.	`void Main(String[] argv)` `the buffer variable`
`Courier Italics`	Identifies a variable name.	*`ipAddress`*

1.4 Getting Help

Development Kit customers are eligible for training and technical support. You can use the Silicon Labs web site www.silabs.com/zigbee to obtain information about all Ember products and services. You can also contact Customer Support at www.silabs.com/zigbee-support.

If you have any questions about your Development Kit, contact your account representative at one of the following locations:

United States	25 Thomson Place Boston, MA 02210 Telephone: 617-951-0200 Fax: 617-951-0999
Asia/Pacific	HK Spinners Industrial Bldg, Phase 5 5/F Flat D 760-762 Cheung Sha Wan Rd Kowloon Hong Kong Telephone: +852-8120-5375
Europe	Unit 300 Science Park Milton Road Cambridge CB4 0XL, UK Telephone: 44 (0) 1223 423322 Fax: 44 (0) 1223 423390

2 Introducing Ember Development Kits

2.1 Overview

The EM35x Development Kit is used for application design and development. The Development Kit contains a variety of hardware for quickly creating a prototype of the customer's hardware, EmberZNet PRO, Silicon Labs' implementation of the ZigBee Pro stack software specification, and various development tools which enable the development of the customer's application software.

EmberZNet PRO runs on top of an IEEE 802.15.4-compliant radio and link layer software. EmberZNet PRO is a self-organizing, self-healing mesh networking protocol stack. Combined with the powerful IEEE 802.15.4 compliant Ember radios, the EmberZNet network stack provides complete networking services from the physical layer up to a reliable application profile support layer. The stack produces networks that are reliable, flexible, secure, and easy to use.

EmberZNet PRO[1] provides a common Application Programming Interface (API) that utilizes the underlying layers. This API provides support for the following layers of the Open System Interconnection Reference Model (OSI Model):

- **PHY:** radio control
- **MAC:** medium access
- **LINK:** route discovery
- **NETWORK:** routing, association
- **APPLICATION:** Application Profile Support for reliable message delivery

The EmberZNet PRO stack can be used to build ZigBee-based applications. Applications that are built on this stack benefit from the following features:

- PHY and MAC layers comply with the IEEE 802.15.4-2003 standard
- LINK and NETWORK layers comply with the latest ZigBee specification
- The APS layer provides the interface to the application for data transfer and management, including reliable transport and binding.

The Development Kit includes InSight Desktop which facilitates application development and debugging. InSight Adapters (ISA3s) incorporate Power-over-Ethernet (PoE) capability, which can simplify node deployment in the test environment. Breakout Boards provide a direct connection for debugging customer-designed hardware. For detailed information about the Ember customer hardware debug interface, see document 120-2009-000, the *EM35x Breakout Board Technical Specification*.

[1] The release version of EmberZNet PRO at the time of this writing is 4.0.

2.2 Development Kit Contents

Table 2-1 summarizes the components and the specified count for each component in the EM35x Development Kit.

Table 2-1. EM35x Development Kit Components

Component	EM35x Development Kit
InSight Adapter (ISA3)	3
EM357 Sample Chip	10
EM35x Breakout Board	3
EM35x Modules	9[2]
Data Emulation Interface (DEI) Cable	3
Ember Happy Fun Ball	1
InSight Port (ISP) Cable	3
Radio Frequency Cable	1
Power-over-Ethernet Switch with Power Supply	1
USB Power Supply with Adapters	3
EM35x Quick Start Guide	1
InSight Desktop CD	1
IAR Embedded Workbench CD	1
US-to-multinational AC Plug Power Adapter Kit	1
AAA Battery Pack	3
Ethernet Cable	3
USB Cable	3

2.3 Hardware Requirements

- PC with Ethernet connectivity
- Network hub with DHCP server

2.4 Software Requirements

- Microsoft Windows XP
- Java, version 1.5V6 or later
- Adobe Acrobat Reader (available free from http://get.adobe.com/reader/)

[2] Three EM35x modules are installed on EM35x Breakout Boards; six EM35x modules are included in the EM35x Module Box.

2.5 Hardware

- **Breakout Boards** serve as test beds for network hardware and applications. Each Breakout Board has an associated EM35x Module, which can be deployed as a node within a network application. Each Breakout Board connects with an InSight Adapter (ISA3) through two communication links: the InSight Port (ISP) and the DEI Port. This allows the Breakout Board's EM35x Module to interface with InSight Desktop (ISD) through the ISA's InSight Port and its wired Ethernet connection. These interconnections are described later in this chapter. The Breakout Boards also have a prototype breadboard area for application-specific hardware development.
- **EM35x modules** contain the Ember EM35x System-on-Chip (SoC) solution providing a complete radio and microcontroller solution. All modules are pin-compatible, and they can be directly attached to a Breakout Board.
- **InSight Adapters** (ISA3s) each connect a Breakout Board to the Ethernet. Each adapter transmits network data collected via its InSight Port and conveys it over its Ethernet connection to InSight Desktop. It also picks up any messages or new software that is addressed to this Breakout Board.

The InSight Port is a cabled communication link between the ISA3 and the EM35x Module mounted on the Breakout Board.

- **InSight Port Cables** connect each ISA3 to a Breakout Board.
- **AAA Battery Packs** that attach to a Breakout Board enable deployment of battery-operated nodes.
- **USB Power Supply with Adapters** power Breakout Boards and / or ISA3s from wall sockets.
- **Ethernet Cables** connect ISA3s to an Ethernet subnet.
- **Data Emulation Interface (DEI) cables** provide a peripheral interface connection between the ISA3 and Breakout Board. The DEI cable supports UART functionality.

2.6 Software

The Ember Development Kit contains two CDs for:

- InSight Desktop
- IAR Embedded Workbench

2.6.1 InSight Desktop

Installation components and associated documentation:

- EmberZNet PRO network stack library and APIs: debug and release builds (see Table 3-2)
- HAL library
- InSight Desktop
- Sample programs (see Table 3-3)

2.6.2 IAR Embedded Workbench

Licenses and support are provided separately and can be obtained from IAR Systems at http://www.iar.com.

2.7 Documentation

Document 120-4031-000, *EM35x Quick Start Guide,* is shipped with the EM35x Development Kit. All other documents listed below are available from Silicon Labs' Ember support page (www.silabs.com/zigbee-support) as Adobe PDF files or as on-line HTML help:

- EM35x Development Kit User's Guide (this document)
- *Application Development Fundamentals* (120-3029-000)

- *Testing and Debugging Applications* (120-3030-000)
- *Advanced Application Programming with the Stack and HAL APIs* (120-3031-000)
- *EmberZNet API Reference: For the EM350 SoC Platform* (120-3022-000)
- *EM35x Breakout Board Technical Specification* (120-2009-000)
- *InSight Adapter (ISA3) Technical Specification* (120-2010-000)
- *EM35x Module Technical Specification* (120-2011-000)
- *EM35x Datasheet* (120-035X-000)
- *InSight Desktop User's Guide* (120-4005-000 and on-line HTML help)
- Application notes (various)

2.8 Before You Begin

The EM35x Development Kit is designed only for the operating conditions and interfaces specified in Ember documents 120-2010-000, the *InSight Adapter (ISA3) Technical Specification*, and 120-2009-000, the *EM35x Breakout Board Technical Specification*. Any modifications or alterations to the hardware are liable to cause irreparable damage to the EM35x Development Kit, and shall render its warranty null and void.

If you wish to use the EM35x Development Kit in a non-standard fashion, consult with Ember Customer Support or Ember Sales before starting custom development. This is especially true if you are embarking on an aggressive development cycle, plan to use custom hardware, or wish to use alternate software configuration files, images, or hardware configurations. Contact us and describe your plan, so we can help you minimize the risk of delays in your development cycle.

3 Development Kit Components

3.1 Overview

Figure 3-1 shows the components in the EM35x Series Development Kit.

Figure 3-1. EM35x Series Development Kit



This chapter describes the hardware and software components in the EM35x Series Development Kit.

3.2 Hardware

The EM35x Series Development Kit development board set has three major hardware components:

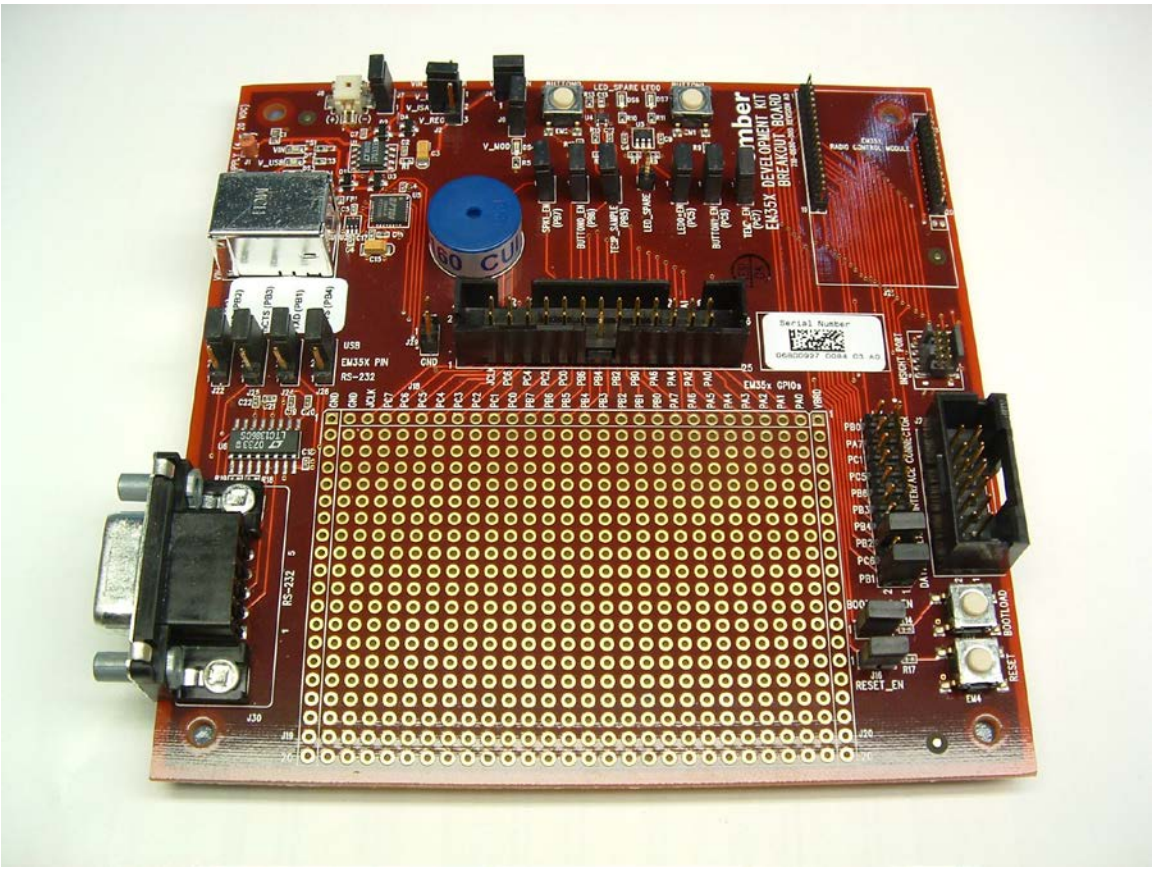
- Breakout Board
- EM35x Module
- InSight Adapter (ISA3)

The EM35x Series Development Kit also includes the following components:

- US-to-Multinational AC Plug Power Adapter Kit
- Power-Over-Ethernet (PoE) Switch
- USB Power Adapters
- Miscellaneous Cables (USB, DEI, InSight Port, and RF Coax)

3.2.1 EM35x Breakout Board

Figure 3-2. EM35x Breakout Board



The Breakout Board (Figure 3-2) has the following components:

- External power supply connectors
- One DB-9 serial port connector for RS-232 serial communication
- One header with TTL-compliant UART signals for SPI serial communication

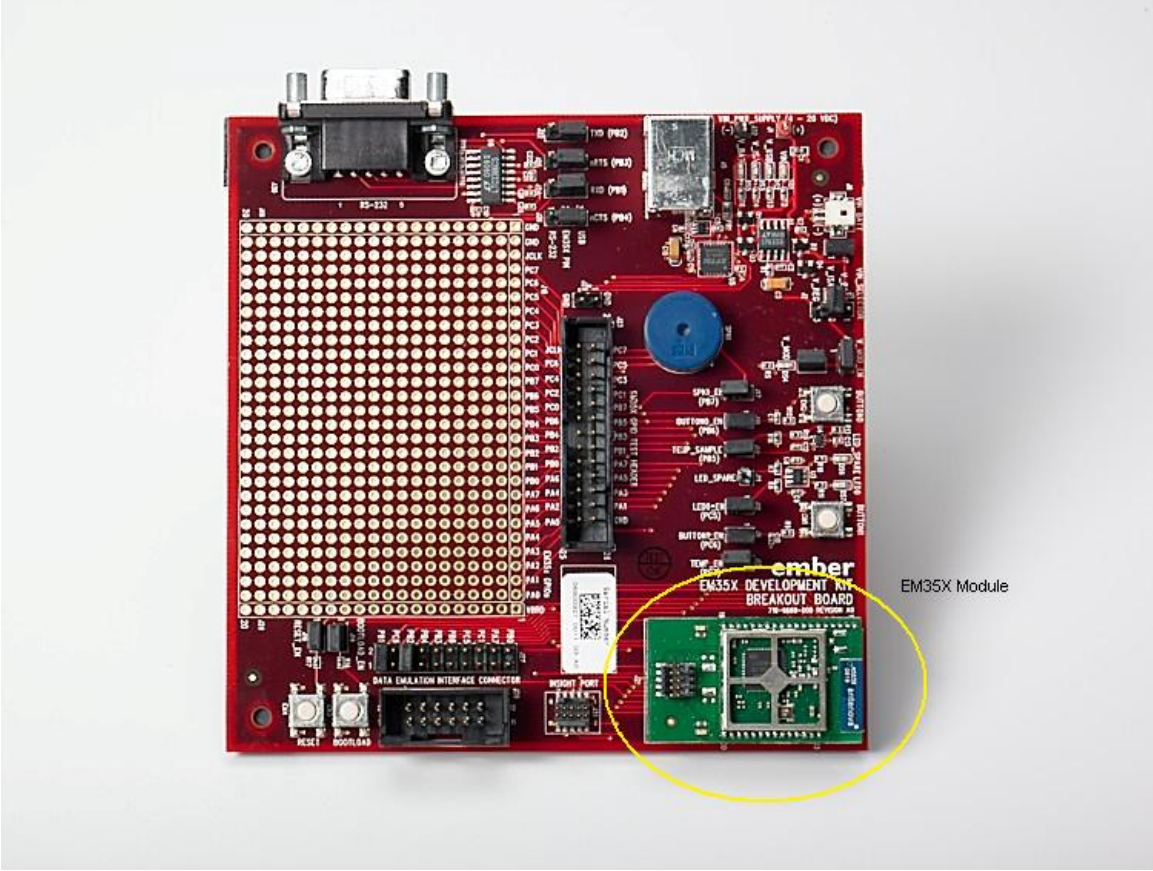
- A buzzer, two buttons, two LEDs, and a temperature sensor for application development purposes
- Hardware reset buttons for the EM35x module
- Prototype or breadboarding area (28 x 20, 0.1” pitch array) for application-specific hardware development
- One InSight data emulation interface connector

For detailed information about the Breakout Board, see document 120-2009-000, the *EM35x Breakout Board Technical Specification*.

3.2.2 EM35x Module

The EM35x Series Development Kit Module pictured in Figure 3-3 is used together with the Development Kit Breakout Board to prototype customer hardware, and to develop and debug application software. Its low-power design represents a good starting point for your own product design.

Figure 3-3. EM35x Breakout Board with EM35x Module installed



The EM35x Module includes these components:

- The Ember EM35x SoC (IEEE 802.15.4-compliant, 2.4 GHz radio transceiver with ARM® Cortex™-M3 microcontroller).
- All off-chip components required for optimum SoC performance
- Two LEDs
- InSight Port connector

For detailed information about the EM35x Module supplied with your kit, see document 120-2011-000, the *EM35x Module Technical Specification*.

Once you move away from the EM35x Module and toward application-specific hardware, refer to the extensive Ember reference design library at www.silabs.com/zigbee-support. Each reference design provides a schematic, Bill of Materials (BOM), characterization data, and layout files. They are designed and delivered in a manner that reduces both time to market and hardware implementation risk. For assistance in locating the best design for your needs, contact support at www.silabs.com/zigbee-support.

3.2.3 InSight Adapter (ISA3)

InSight Adapter (ISA3) provides an efficient and configurable Debug Interface to the Development Kit Breakout Board for processing emulation and debug commands. It also provides an interface to InSight Desktop for monitoring and managing network data.

The ISA3 has the following components:

- Debug Port interface to the Breakout Board's Extended Debug Interface Connector
- InSight Port interface to the radio communication module, providing programming and debugging services
- TCP/IP 10/100 Ethernet interface with Power-over-Ethernet functionality
- USB Interface

3.3 Acceptable Power Sources for Normal Operation

Table 3-1 lists all of the components and the acceptable combinations of power sources that yield normal operation. Potential power sources include the following:

- Power-Over-Ethernet (PoE) Switch
- AAA battery pack (3VDC)
- USB cable
    - Connected to PC
    - Connected to USB Power Supply with Adapters
- Power over Insight Port on ISA (the target power select switch on the front panel must be set to *Int (Internal)*).
- From RCM dedicated power
- External DC adapter (not supplied with the Development Kit)

Table 3-1. Safe combination of operating power

	PoE	External DC	AAA Battery Pack	ISA3 InSight Port	USB	Breakout Board
InSight Adapter (ISA3)	X	N/A	N/A	N/A	X	N/A
EM35x Module	N/A	N/A	N/A	X[1]	N/A	X
EM35x Breakout Board	N/A	X[2]	X	X[3]	X	N/A

3.3.1 Power-Over-Ethernet (PoE) Switch

The EM35x Series Development Kit contains a NETGEAR 8-port Power-over-Ethernet (PoE) switch that supplies power to an ISA3 over a standard TIA/EIA-568 category 5 cable. The ISA3 can, in turn, supply power to an EM35x Breakout Board and the Module that is mounted on it. Thus, you can place Breakout Boards wherever an Ethernet cable connection is available.

The DC operating power for data terminal units is fed through unused pairs 7/8 and 4/5. For more information about the NETGEAR switch, see its online technical specifications.

The NETGEAR PoE Switch that is supplied in the EM35x Series Development Kit is certified by Silicon Labs. If you wish to use a different PoE switch, consult Customer Support at www.silabs.com/zigbee-support.

3.3.1.1 US-to-Multinational AC Plug Power Adapter Kit

The US-to-Multinational AC Plug Power Adapter Kit (Figure 3-4) is a set of 3 power adapters for use with the NETGEAR PoE Switch. These three interchangeable plugs are provided with various port configurations suitable for various locales: North America, Europe, United Kingdom, and Australia.

[1] Power is sourced from ISA3 to the RCM module using the InSight Port cable connected to the ISA3 with its target power select switch set to *Int* (Internal).

[2] External DC power between 4V and 20V can be connected to clip leads J1 (+) and J32 (-) on the EM35x Breakout Board.

[3] Power is sourced from ISA3 to the EM35x Breakout Board using the InSight Port cable connected to the ISA3 with its target power select switch set to *Int* (Internal).

Figure 3-4. US-to-Multinational AC Plug Power Adapter Kit



3.3.2 USB Power Supply with Adapters

The USB power adapter (Figure 3-5) is a linear regulated wall plug power supply with 5V DC at 1A regulated output. It has a USB type-B connector for connecting power via a USB cable to the USB port of the ISA3 or Breakout Board. Four interchangeable snap-in input plugs are provided with various port configurations suitable for various locales: North America, Europe, United Kingdom, and Australia.

Figure 3-5. USB power supply with interchangeable AC adapters



3.4 Software

The EM35x Series Development Kit contains the following software components:

- Network Stack
- Hardware Abstraction Layer
- Sample Applications
- InSight Desktop

3.4.1 Network Stack

The EmberZNet PRO network stack is an advanced implementation of the ZigBee Pro wireless protocol stack which provides mesh routing algorithms for creating reliable, flexible, and secure networks. The stack's APS layer provides interfaces for delivering messages reliably. The network stack API is documented in documents 120-3009-000, *Advanced Application Programming with the Stack and HAL APIs,* and 120-3009-000, the *EZSP Reference Guide*, as well as 120-3022-000, *EmberZNet API Reference: For the EM35x SoC Platform*, also available in HTML.

The network stack is delivered as a collection of libraries that you can link to your applications. The libraries are available in both release and debug build versions:

- **Debug build** implements features that facilitate application debugging, such as error checking and an interface to InSight Desktop, which provides information about traffic flow, API traces, error conditions, and more.
- **Release build** omits debugging functionality, so it is smaller and runs more efficiently. Use this build in your application after it is fully debugged and ready for product release.

- **Stub library** is a library used for resolving references but which has no functionality. For those libraries which are not needed by the application, the stub library must be linked in order for the stack to build properly.

Table 3-2 lists the EmberZNet PRO stack and associated libraries.

Note: Table 3-2 shows the base library name, but it does not duplicate entries for the debug and stub libraries because they are self explanatory.

Table 3-2. EmberZNet PRO stack and associated libraries

Library Name	Description
`alarm-library`	Alarm library
`binding-table-library`	Binding table library
`end-device-bind-library`	End device bind library
`security-library-core`	Core security library
`security-library-core-end-device`	Core security library for end devices. This library is smaller than the full core security library.
`security-library-link-keys`	Library to handle optional link keys
`zigbee-pro-stack`	Core ZigBee Pro stack functionality

3.4.2 Hardware Abstraction Layer

The hardware abstraction layer (HAL) acts as a conduit between the network stack and the node processor and radio. Separating network stack functionality from the specific hardware implementation enables easy portability. HAL code is provided as a library that you can alter in order to customize, extend, or reduce device functionality across various hardware platforms. The HAL API is documented in document 120-3022-000, the *EmberZNet API Reference: For the EM35x SoC Platform*.

3.4.3 Sample Applications

The EM35x Series Development Kit contains sample applications. These demonstrate aspects of the network stack that show the breadth of stack functionality. Silicon Labs provides an IAR project and workspace file for each application. Table 3-3 lists the sample applications that are in the current distribution. All applications are in the `app` directory.

Table 3-3. Development Kit Sample Applications

Application name	Directory	Description
Smart Energy / Home Automation	`ha`	An Application Framework that can be set up to implement ZigBee Smart Energy devices or ZigBee Home Automation devices. This includes an implementation of the ZigBee Cluster Library that allows building of any of the SE or HA devices.
Nodetest	`nodetest`	A low-level test program meant for functional testing of RF modules.
Sensor & Sink	`sensor`	An example of a complete application that implements a distributed sensor network with one or more data collection points (called "sensors") and one or more data storage points (called "sinks").
ZigBee Device Object (ZDO) Sample	`zdo`	An example of how to send ZDO messages using the ZDO library.
Manufacturing Library Sample	`mfglib`	An example of how to use the manufacturing library.
Standalone Bootloader Demo	`standalone-bootloader-demo`	An example of how to use the bootloader library utilities.
Application Bootloader Demo	`app-bootloader-demo`	An example of how to integrate the application bootloader utility library into an application.

3.4.4 InSight Desktop

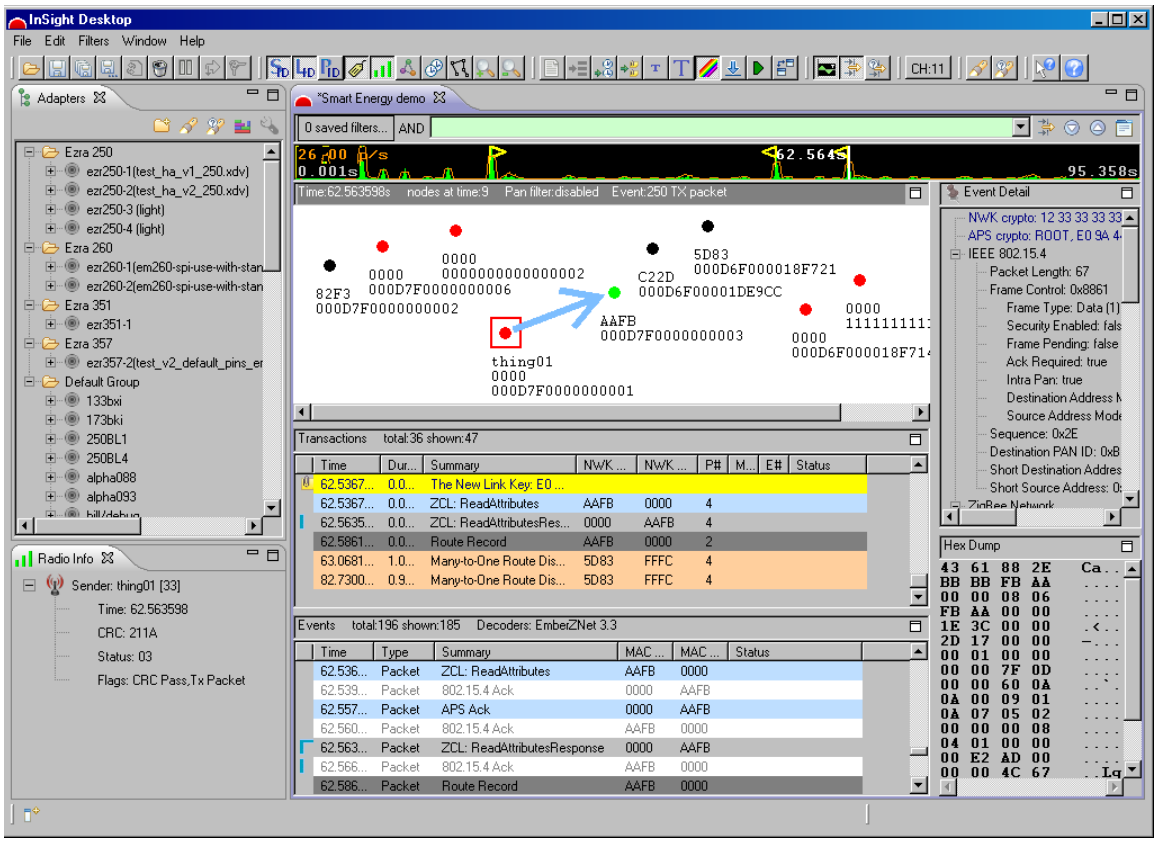
InSight Desktop (ISD) is a graphical tool that manages the Development Kit hardware and displays network and node activity in real time (see Figure 4-1). It provides a rich and flexible interface to Ember-embedded networks, which helps you develop and debug new network applications.

InSight Desktop includes these features:

- An Integrated Development Environment (IDE) with multiple editor panes that provide tiered views of network activity, letting you drill down from a high-level map of node interactions to the details of each packet.
- Customizable filters that let you specify exactly which network activities to display.
- Log files that save captured data, so you can step through transactions and events for detailed analysis.
- A file browser that lets you easily upload new applications to any connected node.

An Adapters view shown in Figure 3-6 allows you to interact with the ISA3s and RCM to download new firmware, reset, and manage each of the devices.

Figure 3-6. Insight Desktop



For detailed information about InSight Desktop, refer to document 120-4005-000, the *InSight Desktop User's Guide*, and InSight Desktop's on-line HTML help.

4 Setting Up Hardware Components

4.1 Overview

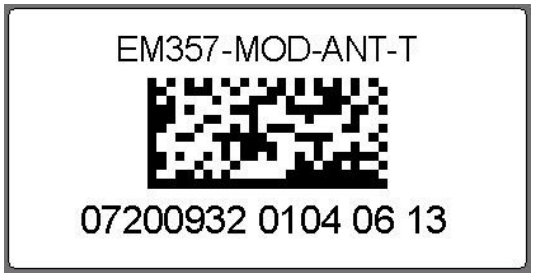
This chapter contains the following sections:

- ETRX3 Radio Communications Module (RCM)
- Hardware Connections
- Connecting the Breakout Board and RCM
- Breakout Board Power Configurations
- Breakout Board Serial Configurations
- Common Hardware Configurations
- Connecting the RF Cable to the RCM

4.2 ETRX3 Radio Communications Module (RCM)

The EM35x Series Development Kit contains various types of ETRX3 Radio Communications Modules (designed by Silicon Labs' partner, Telegesis). These modules contain either the EM357 or EM351 IC and are configured to use either the ceramic antenna or the on-board RF connector (U.FL). Some module variants also include a power amplifier. These configuration options are noted in the Module Product Label, as shown the example label in Figure 4-1. The top line contains the Silicon Labs Part Number, while the bottom line contains the Module Serial Number. The Module Serial Number is also listed in the Hardware Identification List attached to your *Quick Start Guide*. You can determine the EUI-64 of each module based on this list.

Figure 4-1. Module Product Serial Number Label



The modules shipped already installed on Breakout Boards are module variant EM357-MOD-ANT-T. All other module variants are contained in the Module Variety Pack. Refer to Table 4-1 for configuration comparisons of the modules included in your development kit. There are three additional EM351 module variants not included in the development kit that are available for purchase. Contact your sales representative or distributor for more details on these module variants.

Table 4-1. Module Product Variant Matrix

Silicon Labs Part Number	Telegesis Part Number	Silicon Labs Product Number	IC	Antenna or Connector	PA or non-PA	Qty Included in Kit
EM357-MOD-ANT-T	ETRX357+CB	0720	EM357	Antenna	Non-PA	3
EM357-MOD-RF-T	ETRX357-HR+CB	0721	EM357	Connector	Non-PA	1
EM357-MOD-LR-RF-T	ETRX357-LRS-HR+CB	0722	EM357	Connector	PA	1
EM357-MOD-LR-AN-T	ETRX357-LRS+CB	0723	EM357	Antenna	PA	2
EM351-MOD-ANT-T	ETRX351+CB	0724	EM351	Antenna	Non-PA	2
EM351-MOD-RF-T	ETRX351-HR+CB	0725	EM351	Connector	Non-PA	0
EM351-MOD-LR-RF-T	ETRX351-LRS-HR+CB	0726	EM351	Connector	PA	0
EM351-MOD-LR-AN-T	ETRX351-LRS+CB	0727	EM351	Antenna	PA	0

4.3 Hardware Connections

To avoid communication problems, verify that each radio communication module is firmly seated in its Breakout Board connector, and its InSight port cable is properly seated.

4.4 Connecting the Breakout Board and RCM

Refer to document 120-4031-000, *Quick Start Guide,* included in your development kit for detailed step-by-step instructions for setting up your hardware.

Two hardware modules attach to the EM35x Breakout Board:

- Radio Communication Module (RCM)
- InSight Adapter

Caution: Observe electrostatic discharge (ESD) precautions when removing, handling, or replacing RF communication modules.

To attach the radio communication module:

Align the radio communication module to its footprint outline on the Breakout Board, and then press it into place. Make sure that the RCM sits firmly in its mating connector.

To remove the radio communication module:

- Carefully pull the RCM away from the Breakout Board.

To attach the InSight Adapter:

1 Plug the InSight Port cable into the InSight Adapter.

2 Plug one end of the InSight Port cable into the 10 pin InSight Port (J31) on the Breakout Board, and the other end into the ISA. If desired, the InSight Port cable may be connected directly to the RCM instead of the Breakout Board, but the Breakout Board connector allows for straight cable paths and more convenient swapping of modules.

3 Verify that the InSight Adapter's Target Power Select switch is set to *Int* (Internal).

To remove the InSight Adapter:

1 Unplug the InSight Port cable from the Breakout Board (or radio communication module).

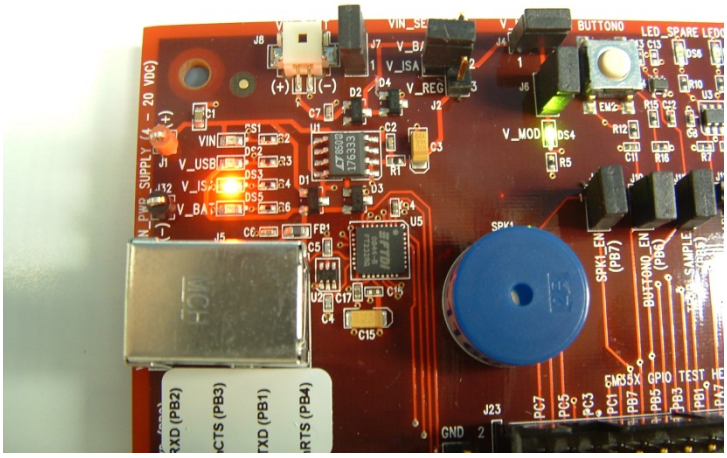
2 Unplug the InSight Port cable from the InSight Adapter.

4.5 Breakout Board Power Configurations

The Breakout Board may be powered in one of four ways:

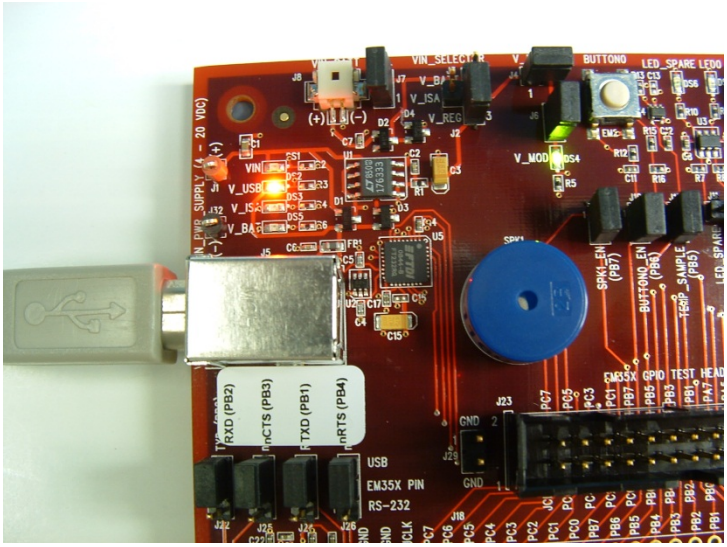
- **Breakout Board Power Supplied by ISA3** *(Figure 4-2):* The default configuration is to supply power via the InSight Adapter and InSight Port cable. Ensure the power switch on the InSight Adapter is in the INT (Internal) position. The power supply of the InSight Adapter is also controlled via the admin interface. You may need to connect to the admin port of the ISA and issue the "power on" command. No external power supply should be connected to the Breakout Board when supplying power from the ISA. The power supply jumper on the Breakout Board should be in the horizontal position, connecting V_ISA to the center pin. The V_ISA LED will illuminate when power is applied.

Figure 4-2. Breakout Board Power Supplied by ISA3



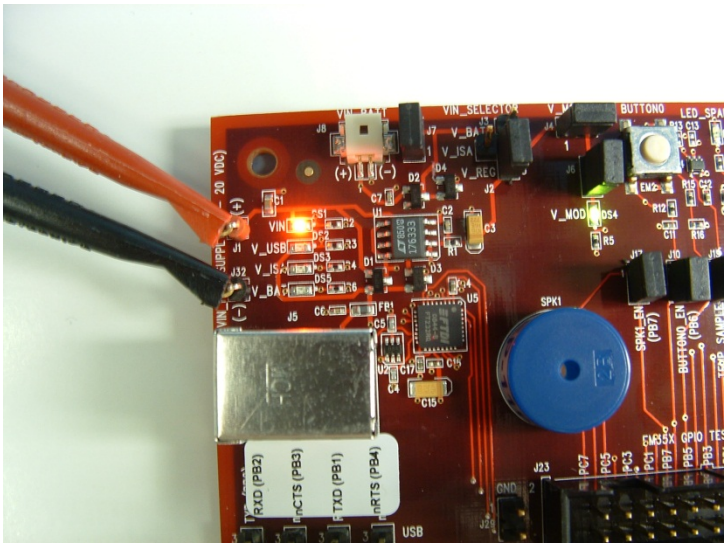
- **Breakout Board Power Supplied by USB** (Figure 4-3): The Breakout Board may also be powered via the USB connector, either using a USB cable plugged in to the USB power adapter included in the development kit, or by connecting it to your PC. The power supply jumper on the Breakout Board should be in the lower vertical position, connecting V_REG to the center pin. The V_USB LED will illuminate when power is applied. When powering the Breakout Board in this way, ensure the power switch on the InSight Adapter is in the EXT (External) position.

Figure 4-3. Breakout Board Power Supplied by USB



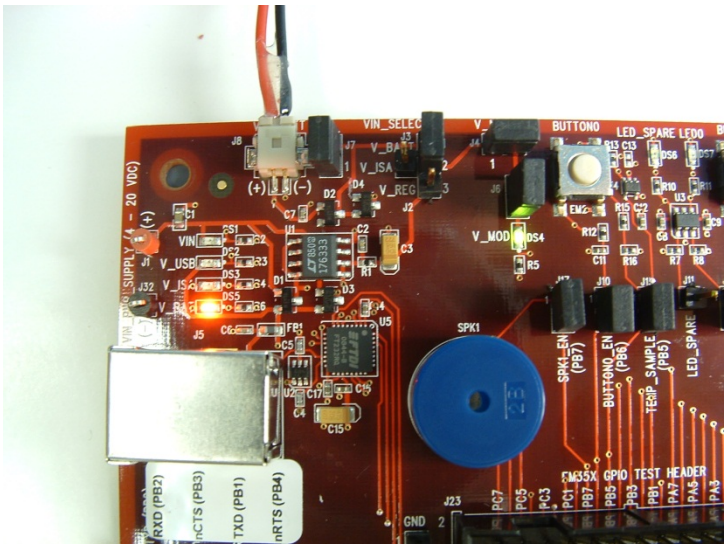
- **Breakout Board Power Supplied by DC Jumpers** (Figure 4-4): The Breakout Board may also be powered by an external power source that provides 4-20 volts DC. The power supply should be connected to jumpers J1 (+ supply) and J32 (ground). The power supply jumper on the Breakout Board should be in the lower vertical position, connecting V_REG to the center pin. The VIN LED will illuminate when power is applied. When powering the Breakout Board in this way, ensure the power switch on the InSight Adapter is in the EXT (External) position.

Figure 4-4. Breakout Board Power Supplied by DC Jumpers



- **Breakout Board Power Supplied by Battery Connector** (Figure 4-5): Finally, the Breakout Board may also be powered via the battery connector, using the supplied battery packs and 2x AAA batteries. The power supply jumper should be in the upper vertical position, connecting V_BATT to the center pin. The V_BAT LED will illuminate when power is applied. When powering the Breakout Board in this way, ensure the power switch on the InSight Adapter is in the EXT (External) position.

Figure 4-5. Breakout Board Power Supplied by Battery Connector



The V_MOD LED on the Breakout Board will also illuminate to indicate that power is properly applied to the board and the RCM.

4.6 Breakout Board Serial Configurations

Serial connectivity to the Breakout Board can be made in a number of ways. The default configuration of your development kit will match your expected usage scenario.

1. **To use the pass-through UART feature of the ISA:** plug the larger 12-pin DEI cable into the DEI header on the Breakout Board and the connector on the ISA. Ensure that jumpers are installed across the 8th (PB2) and 10th (PB1) rows of headers next to the DEI port on the Breakout Board to pass the UART RX and TX signals through. The serial port selection jumpers between the USB and DB-9 connectors should be removed, or placed on their center pins. Connection to the UART pass-through port can then be made using either of the two options below:
    a. Connect to the ISA using InSight Desktop. Launch the console. Choose the Serial 1 tab.
    b. Run a terminal application (for example, Microsoft Telnet Client, HyperTerminal, PuTTY). Connect to port 4901 on the ISA.
2. **To use the RS-232 interface:** connect a serial cable to the DB-9 connector on the Breakout Board. Ensure the 4 jumpers above the DB-9 connector are positioned towards the DB-9 connector to send the UART signals to the RS-232 transceiver, and remove the jumpers from the row of headers next to the DEI port or make sure the DEI cable is disconnected.
3. **To use the USB interface:** install the FTDI USB drivers as described in Section 5.5, “Installing FTDI USB Drivers”, and connect a USB cable to the Breakout Board and your PC. Ensure the four jumpers above the DB-9 connector are positioned towards the USB connector to send the UART signals to the FTDI chip, and remove the jumpers from the row of headers next to the DEI port or make sure the DEI cable is disconnected.

4.7 Common Hardware Configurations

Common configurations of the Breakout Board and ISA can be seen in the following figures.

Figure 4-6. ISA supplying power; pass-through UART being used for serial communication

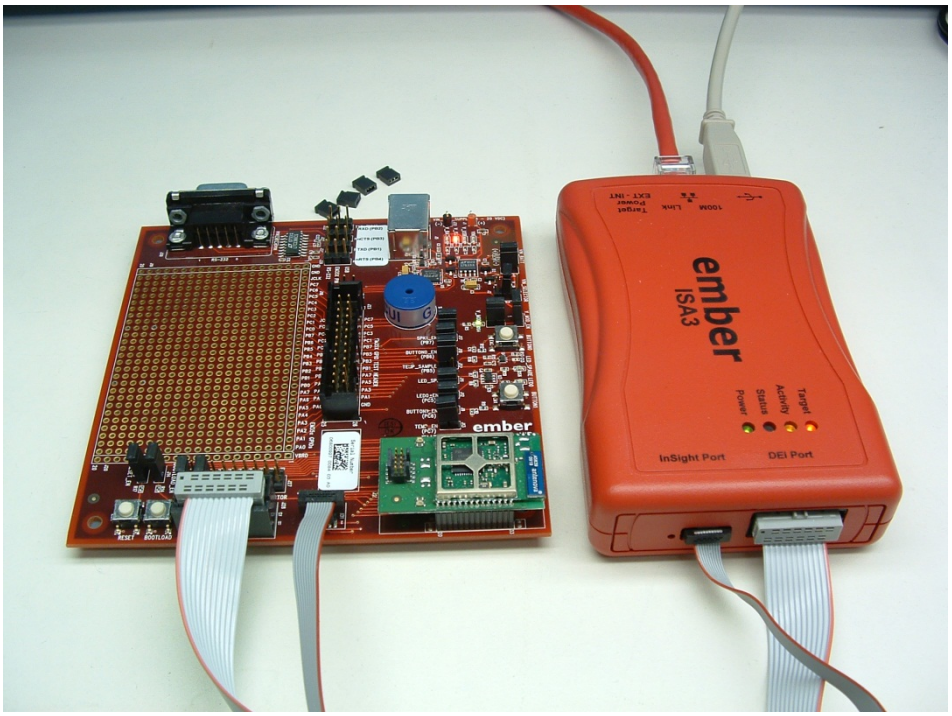


Figure 4-7. ISA supplying power; RS-232 serial communication

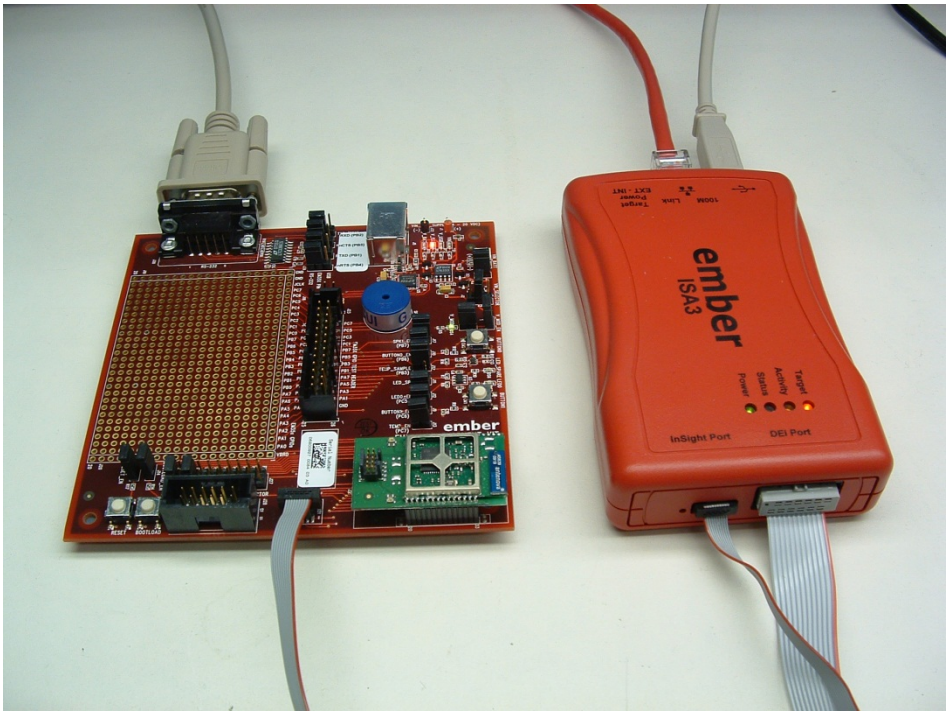


Figure 4-8. Power supplied via USB connector; pass-through UART being used for communication

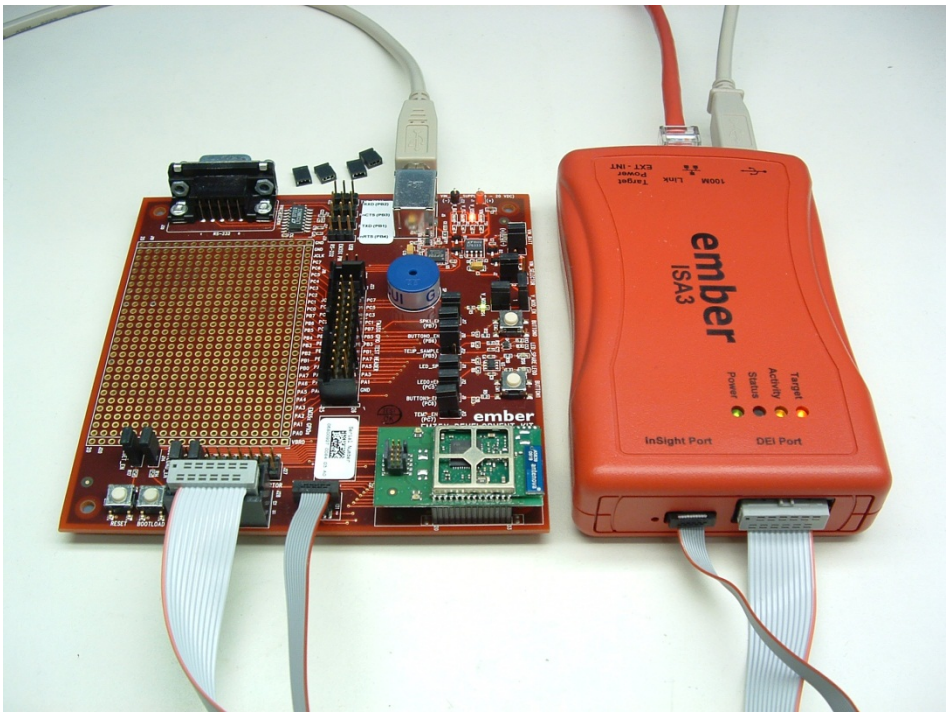
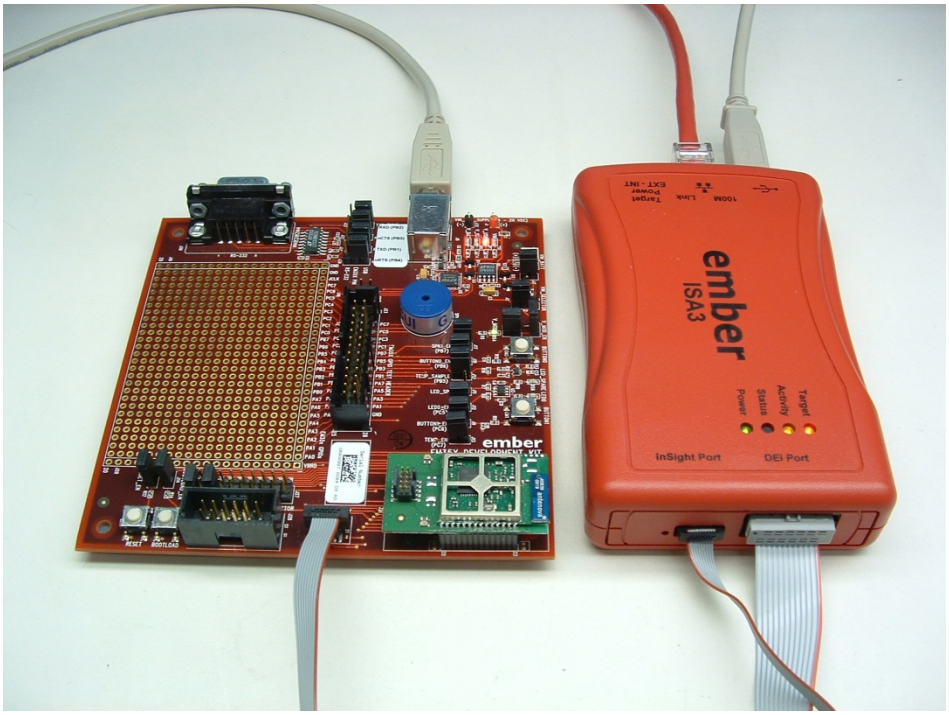


Figure 4-9. ISA supplying power; FTDI Serial <-> USB converter used for communication



4.8 Connecting the RF Cable to the RCM

As detailed in Table 4-1, depending on the configuration of the module, some RCMs include an internal antenna while others include an RF connector (type U.FL) where an external antenna can be connected via an RF adapter cable. See Figure 4-10 for an example of a module with an internal antenna. The RF connector may also be used as a connection to test equipment. The development kit contains an RF adapter cable (type U.FL) that plugs into the RF Connector on these modules. See Figure 4-11 for an example of a module with this RF connector.

Figure 4-10. Module with Internal Antenna

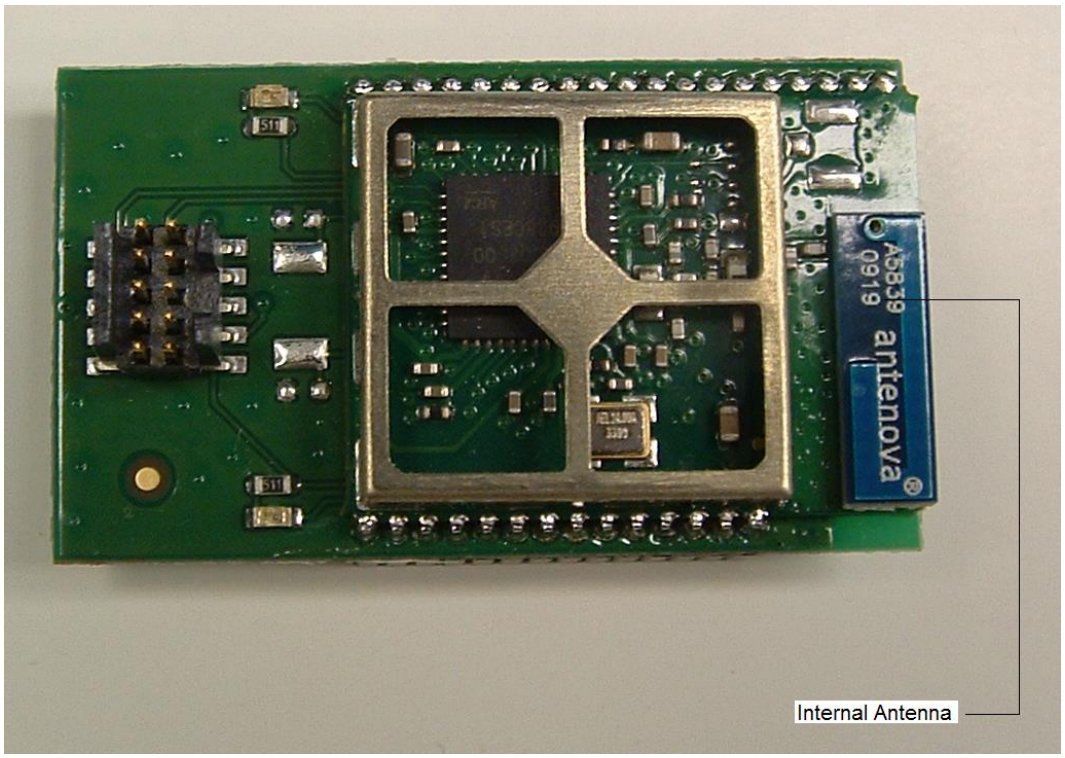
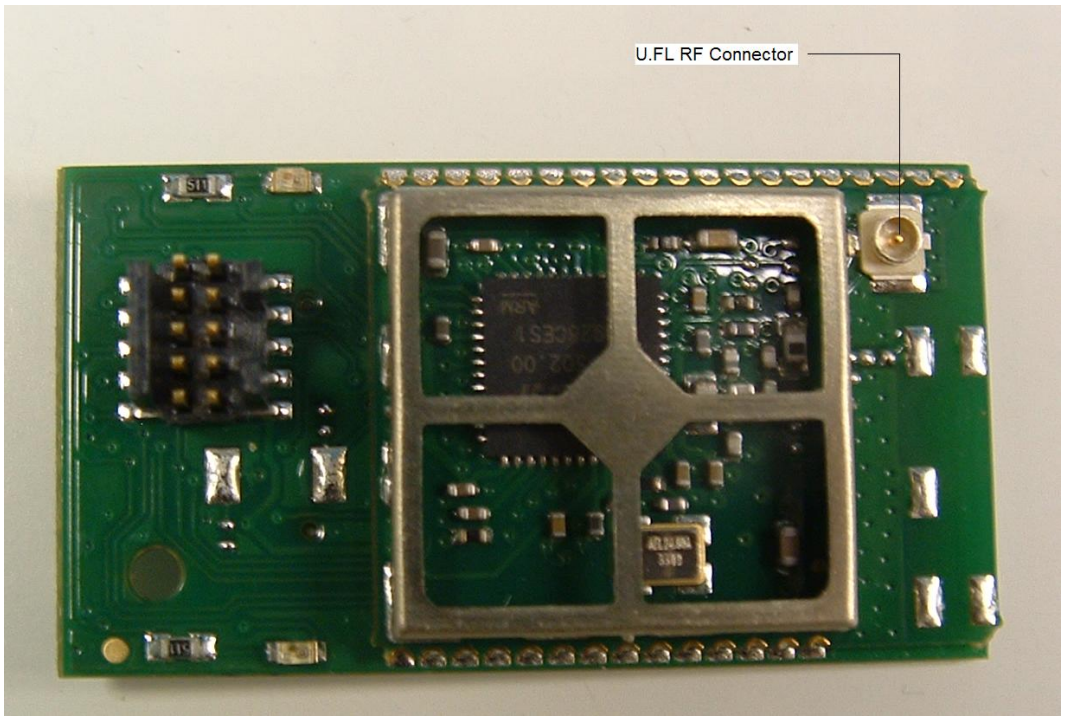


Figure 4-11. Module with U.FL RF Connector



5 Installing the Software

5.1 Overview

Ember software for the EM35x platform is distributed through Silicon Labs' Ember support portal at www.silabs.com/zigbee-support. You must contact Customer Support for a portal username.

5.2 Installing the Ember Stack

The Ember Stack installer, ember-stack-<version>-em35x-dev.exe, should be installed first. It performs the following actions:

1. Installs the files needed to develop applications on the Ember Stack into a directory specified by the user (The default location is C:\Program Files\Ember\{release version}\ em35x.)
2. Adds a shortcut to the Start Menu into the folder specified by the user (default directory is Ember\{release version}\em35x).
3. Adds an entry to "Add/Remove Programs" (accessed from Windows Control Panel) so the stack can be uninstalled.

This release should be installed in a different directory from prior installations. It is possible for multiple installations to exist together.

5.3 Installing InSight Desktop

InSight Desktop can be installed by running the Insight_Desktop_Installer_<version>.exe self extracting executable found on the portal. Document 120-4031-000, *EM35x Quick Start Guide,* included in your EM35x Series Development Kit provides details about installing InSight Desktop for the first time and running the First-Time Setup Wizard.

5.4 Installing IAR Embedded Workbench for ARM

A CD including IAR Embedded Workbench for ARM is included with your development kit. Depending on which development kit you ordered (IAR or not), you will receive either a 30-day evaluation version of EWARM or a licensed version.

To install the IAR Embedded Workbench for ARM:

1. Insert the CD into your CD Drive and follow the instructions on the installer that should automatically appear. If the Installer does not automatically start, browse to your CD Drive, and click on *autorun.exe*.
2. Refer to the "Quickstart Installation Information" section of the IAR installer for additional information about the installation process and how to configure your license.

5.5 Installing the ISA3 Utilities

The installer ISA3_Utilites_<version>.exe performs the following actions:

1. Installs the USB driver for the InSight Adapter (ISA3).
2. Installs the following command line utilities:
   - em3xx_load.exe
   - em3xx_isa.exe
   - em3xx_convert.exe
3. Adds an entry to “add/remove programs” (accessed from Windows Control Panel) so that the utilities can be uninstalled.
4. Modifies your PATH environment variable so that the command line utilities can be easily executed from a Windows Command Prompt.

Note: The ISA3 Utilities installer should always be run after all previous installers including after IAR Embedded Workbench for ARM.

5.6 Installing FTDI USB Drivers

To use the USB interface of the Breakout Board for UART connectivity, you must install the drivers for the FTDI USB<->Serial converter. You can obtain this driver from FTDI at http://www.ftdichip.com/Drivers/VCP.htm.

These drivers are not required if you connect to the UART of the Breakout Board using the RS-232 port or via the pass-through UART functionality of the InSight Adapter.

6 Using the InSight Adapter

6.1 Overview

The InSight Adapter (ISA3) provides an Ethernet connection to EM35x devices. You can use the InSight Adapter to perform the following tasks:

- Program and debug using Serial Wire or JTAG.
- Monitor packets sent and received by the radio.
- Send and receive serial port data.
- Send and receive debugging data.
- Turn power on and off.
- Control reset, bootloader and GPIO signals.

6.2 Connectivity and Power

All the features of the InSight Adapter are available via the Ethernet connection. The ISA3 can also be connected to a PC via USB to change the Ethernet settings.

When connected via USB, the InSight Adapter will also be powered via USB. It should be connected to a powered USB hub, or port on your PC that is capable of supplying full power to connected devices.

When connected via Ethernet, the InSight Adapter may be powered in one of two ways:

- Using an Ethernet switch that supplies Power Over Ethernet (PoE).
- Using a USB power supply.

The ISA3 will also supply power to the connected EM35x device when the power switch is in the INT (Internal) position. If the connected EM35x device has its own power supply, ensure the power switch is kept in the EXT (External) position.

You can connect via Ethernet to the ports listed in Table 6-1 using either InSight Desktop or a terminal application (for example, Microsoft Telnet Client, HyperTerminal, or PuTTY).

Table 6-1. InSight Adapter Ports

Port	Use
4900	Virtual serial port on EM35x via InSight Port cable.
4901	Physical serial port on EM35x via Data Emulation Interface cable.
4902 or 23	Admin interface.

6.3 Ethernet Settings

By default, InSight Adapters are configured to get an IP address via DHCP. They are assigned hostnames of EM-ISA3-00, EM-ISA3-01, etc. You can use InSight Desktop to discover the ISA3s on the network and see their IP addresses.

If you are unable to use DHCP, the Ethernet configuration may be changed using the admin interface over USB as described in “Using the admin interface over USB.” The following example changes the settings to a static IP address of 192.168.1.100 with a netmask of 255.255.255.0 and a gateway of 192.168.1.1.

```
>em3xx_isa.exe --admin "ip static 192.168.1.100 255.255.255.0 192.168.1.1"
em3xx_isa version 1.0.9
DLL version 1.0.13, compiled Aug 19 2009 19:42:00

Success: ip: (after reboot) Static 192.168.1.100 255.255.255.0 192.168.1.1

>em3xx_isa.exe --admin "ip dhcp off"
em3xx_isa version 1.0.9
DLL version 1.0.13, compiled Aug 19 2009 19:42:00

Success: ip: (after reboot) DHCP off
```

You can change the hostname to make it more descriptive or to avoid conflicts if ISA3s from multiple development kits are connected to the same network. To change the hostname, use the admin command `hostname set <hostname>`.

6.4 Using the Admin Interface over USB

1. Connect the ISA3 to the PC using USB. Only connect one ISA at a time by USB.
2. Run em3xx_isa.exe with the --admin option.
3. Configure the ISA3 using the commands described in Chapter 7, InSight Adapter Commands.

6.5 Using the Admin Interface over Ethernet

1. Connect the ISA3 to the network using Ethernet.
2. Connect to the admin port on the ISA3 using either InSight Desktop or a terminal application:
   - Connect to the ISA3 using InSight Desktop. Launch the console. Choose the Admin tab

   OR

   - Run a terminal application (e.g. Microsoft Telnet Client, HyperTerminal, PuTTY). Connect to port 4902 or 23 on the ISA3.
3. Configure the ISA3 using the commands described in Chapter 7, InSight Adapter Commands.

6.6 Using the Serial Ports

Connect to port 4900 or 4901 on the InSight Adapter using either InSight Desktop or a terminal application.

Port 4900 connects to the virtual serial port on the EM35x via the InSight Port cable. The virtual serial port has no baud rate or other settings.

Port 4901 connects to the physical serial port on the EM35x via the Data Emulation Interface (DEI) cable. The default settings are 115200 baud, 8-n-1 (8 data bits, no parity bit, 1 stop bit). To change the default settings, use the `port` admin command. For example, for 19200 baud, 8-n-1, use the command `port 1 19200 8-n-1`.

6.7 Updating the Firmware

Periodically, Silicon Labs provides updated firmware for the InSight Adapter. You can perform the update using em3xx_isa.exe or em3xx_load.exe. Both utilities automatically update the firmware to the latest version each time they run.

To update an InSight Adapter over USB, run em3xx_isa.exe with no options. For example:

```
>em3xx_isa.exe
em3xx_isa version 1.0.9
DLL version 1.0.13, compiled Aug 19 2009 19:42:00
Updating firmware: Ember InSight Adapter V1 compiled May 26 2009 13:47:00 V0.2b4
Replacing firmware: Ember InSight Adapter V1 compiled Feb 26 2009 21:54:00
... Firmware update successful. CRC=8DA7
Waiting for new firmware to boot
New firmware booted successfully
```

To update an InSight Adapter over Ethernet, run em3xx_isa.exe with the --ip option. For example:

```
>em3xx_isa.exe --ip 192.168.1.100
em3xx_isa version 1.0.9
DLL version 1.0.13, compiled Aug 19 2009 19:42:00
Connecting to IP address 192.168.1.100
Updating firmware: Ember InSight Adapter V1 compiled May 26 2009 13:47:00 V0.2b4
Replacing firmware: Ember InSight Adapter V1 compiled Feb 26 2009 21:54:00
... Firmware update successful. CRC=8DA7
Waiting for new firmware to boot
New firmware booted successfully
```

7 InSight Adapter Commands

7.1 Syntax Conventions

Element	Meaning	Example
`Literal`	A command or argument that is entered exactly as shown.	`hostname read`
`Variable`	An argument that is entered as the desired value for that variable.	`hostname set` *`hostname`*
`[ | ]`	An argument chosen from a list.	`[on|off]`

7.2 Entering Commands

- Commands can be entered over USB (see Section 6.4, “Using the Admin Interface over USB”) or Ethernet (see Section 6.5, “Using the Admin Interface over Ethernet”).
- Commands are not case sensitive.
- Arguments are separated with a single space.
- Backspace can be used to correct mistakes.

7.3 Command List

- button
- config
- help
- hostname
- ip
- port
- power
- quit
- reset
- usbaddr
- version

7.3.1 button

```
button [0|1] [press|release]
```

Description

Simulates button 0 or 1 on the Breakout Board being pressed or released.

The Data Emulation Interface cable must be connected.

Example

```
button 1 press
```

7.3.2 config

```
config
```

Description

Displays the configuration of the InSight Adapter (ISA3):

- hostname and static IP settings
- IP mode (static or DHCP) and current IP settings
- serial port settings
- firmware version
- serial number and Ethernet MAC address
- type, EUI and board name of the attached EM35x device

You can also view the configuration using InSight Desktop.

7.3.3 help

```
help
```

Description

Displays a list of all ISA3 commands.

7.3.4 hostname

```
hostname set hostname
```

```
hostname read
```

Description

Sets or displays the hostname of the InSight Adapter.

The ISA3 must be reset for a change to take effect.

You can also view the hostname using InSight Desktop.

Example

```
hostname set mydevice3
```

7.3.5 ip

```
ip static ipaddress netmask gateway
```

```
ip dhcp [on|off]
```

Description

Sets the static IP address, netmask and gateway. These are only used when DHCP is turned off.

Turns DHCP on or off.

The ISA3 must be reset for a change to take effect.

Examples

```
ip static 192.168.1.100 255.255.255.0 192.168.1.1
```

```
ip dhcp off
```

7.3.6 port

```
port 1
```

```
port 1 baud
```

```
port 1 baud [5|6|7|8]-[n|o|e]-[1|2]
```

Description

Displays the configuration of the serial port.

Sets the baud rate, data bits (5, 6, 7 or 8), parity (none, odd or even) and stop bits (1 or 2).

Examples

```
port 1
```

```
port 1 57600
```

```
port 1 115200 8-n-1
```

7.3.7 power

```
power [on|off|read]
```

Description

Turns the power to the attached EM35x device on or off. Displays the current power setting.

You can also turn the power on and off using InSight Desktop.

Example

```
power on
```

7.3.8 quit

```
quit
```

Description

Closes the connection to the admin interface (Ethernet only).

7.3.9 reset

```
reset
```

```
reset adapter
```

Description

Resets the attached EM35x device.

Resets theISA3.

You can also reset the device using InSight Desktop.

7.3.10 usbaddr

```
usbaddr read
```

```
usbaddr set [0|1|2|3|FF]
```

Description

Displays the USB address configuration of a specific ISA3.

Sets the USB address configuration, range is 0-3 or FF (default).

The ISA3 must be reset for a change to take effect. See document 120-5073-00, *Programming Options for the EM35x Platform*, for step by step instructions on setting the address of an ISA3.

7.3.11 version

```
version
```

Description

Displays the firmware version of the InSight Adapter.

You can also view the version using InSight Desktop.

8 Software Tools Overview

8.1 Using the EM357 Nodetest Application

The Nodetest Application replaces the Rangetest Application provided with earlier releases. This new application supports a more advanced command parser and provides results in a more consistent, easy to parse format.

The Nodetest application is pre-programmed on to the Radio Communication Modules (RCMs) included with your EM35x Development Kit. The pre-built application image is also located at {stack installation directory}\app\nodetest\nodetest.s37.

You may communicate with the serial interface of the Nodetest application using the methods described in Chapter 6. Ensure that the serial port is configured for 115200 baud, 8 data bits, No parity, and 1 stop bit. By default the InSight Adapter (ISA3) is configured in this way, but it can be adjusted in this manner:

- Connect to the admin interface of the ISA3.
- Issue the baud rate configuration comment for the pass-through UART (port 1): `port 1 115200`

The Nodetest application provides on-line help about the available commands that can be viewed by executing the command “help”. All input parameters to Nodetest are specified in hexadecimal.

8.2 Running a Packet Error Test

A typical usage scenario for the Nodetest application is measurement of Packet Error Rate (PER). PER is defined in 802.15.4 as the percentage of transmitted packets that are not detected correctly. The Nodetest application provides two commands "rx" and "tx" that are designed to interoperate with the "receive" and "transmit" commands from the EM250 Rangetest application.

PER measurement procedure:

1. Load the Nodetest application on two EM357 nodes.
2. Set the radio to the desired channel on both nodes with the "setchannel n" command where "n" is the desired channel number in hex.
3. Issue the "rx" command on the first node.
4. Issue the "tx a" command on the second node. (This command will transmit 10 (hex a) packets of the form required for PER analysis. For actual PER analysis, send 1000 or more packets.)
5. Observe the PER result in the third column of the "rx" command output, for example[1]:

```
> rx
{{(rx)} test start ('e'nd)}
#{{(rx)}
  {num}   {seq}   {per} {lqi}  {rssi}{gain} {status} {time}       {length}}
{ {    1} {    1} {  0} {0x00} {-22} {0x31} {0x4000} {0x000F3716} {0x12}  }
{ {    2} {    2} {  0} {0x00} {-22} {0x31} {0x4000} {0x000F9FE6} {0x12}  }
{ {    3} {    3} {  0} {0x00} {-22} {0x31} {0x4000} {0x000008B6} {0x12}  }
```

[1] This example may show different length packets than you see.

```
{ {    4} {    4} {  0} {0x00} {-22} {0x31} {0x4000} {0x00007186} {0x12}  }
{ {    5} {    5} {  0} {0x00} {-22} {0x31} {0x4000} {0x0000DA57} {0x12}  }
{ {    6} {    6} {  0} {0x00} {-22} {0x31} {0x4000} {0x00014327} {0x12}  }
{ {    7} {    7} {  0} {0x00} {-22} {0x31} {0x4000} {0x0001ABF6} {0x12}  }
{ {    8} {    8} {  0} {0x00} {-22} {0x31} {0x4000} {0x000214C6} {0x12}  }
{ {    9} {    9} {  0} {0x00} {-22} {0x31} {0x4000} {0x00027D96} {0x12}  }
{ {   10} {   10} {  0} {0x00} {-22} {0x31} {0x4000} {0x0002E666} {0x12}  }
{{(rx)} test end}

>
```

To end the rx test, press the 'e' key. To reset the rx test statistics, end and restart the rx test.

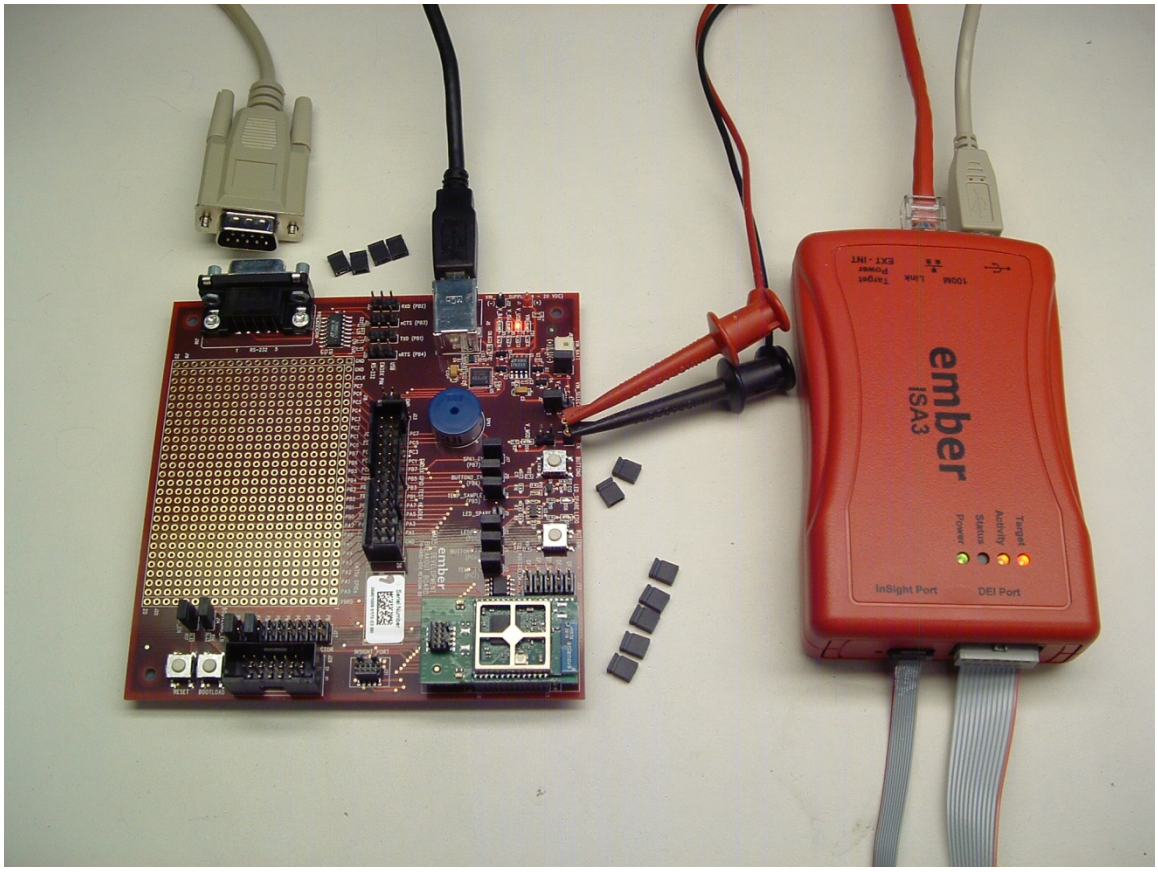
The test may also be run between an EM357 and an EM250 using the Rangetest application on the EM250. When using Rangetest, the commands names are "receive" and "transmit."

8.3 Testing Deep Sleep Current

- Deep sleep current can be easily measured using the Nodetest application running on a Breakout Board. Deep sleep current can only be measured when power is supplied to the board from a source other than the ISA3. The buffer logic on the ISA3 consumes extra current which will not allow for accurate measurements.
- If an ISA3 is connected to the Breakout Board, then the ISA3's Target Power Select Switch should be switched to *EXT* (External) so that the ISA3 is not supplying power.
- Supply power through the USB jack, the DC jack, or the AAA Battery Pack. (The USB jack is recommended and reviewed in these test steps because it is the simplest.)
- Rotate the VIN_SELECTOR jumper (J2/J3) on the Breakout Board to the V_REG position (pins 2 and 3). If power is supplied properly and all four power/LED jumpers (J2/J3, J4, J6, and J7) in the upper left corner of the board are installed, then only the red V_USB LED and the green V_MOD LED will be illuminated.
- To properly measure current, remove the V_MOD jumper (J6) from the Breakout Board. This ensures that the green V_MOD LED is not being driven. If supplying voltage through the J8 battery connector, also remove J7 so the V_BATT LED DS5 is not driven.
- Remove the V_MOD_EN jumper (J4) from the Breakout Board to take current measurements. Then, connect an ammeter in place of the jumper.
- If using EM35x Breakout Board revision B0 or later, remove the DataFlash jumpers at J33 to isolate the DataFlash IC from the rest of the circuit.

These jumper settings can be seen in Figure 8-1.

Figure 8-1. Jumper setting for Deep Sleep Current Testing



- Given an RCM programmed with Nodetest, execute the "shutdown" command:

```
> shutdown
Will wake from GPIO activity on the following port pins:
Port B, pin 6.
Port C, pin 6.
Entering SLEEPMODE_POWERDOWN via halSleep...
```

- Once the node is asleep, disconnect the InSight Port cable, the DEI cable, the RS232 cable, and remove all four UART jumpers (J22, J24, J25, and J26) from the Breakout Board between the USB and RS232 connectors to obtain the lowest current settings. All other jumpers may remain installed.
- Waking up is accomplished via either activity on the SerialWire debugger or pressing BUTTON0 or BUTTON1.

To measure deep sleep while the InSight Port cable is still attached, issue the "swjdisable 1" command in Nodetest to disable the SerialWire/JTAG port, and place the SWJ pins in a low current state. While the SWJ is disabled, the InSight Port/debugger will not be functional until either the command "swjdisable 0" is issued or the chip resets.

8.4 Example of Opening, Building, and Programming a Sample Application

Follow these steps to open, build, and program the sink example application from the standard Ember installer directory.

1. Open the sink.eww file (sink workspace) in IAR Embedded Workbench for ARM (IAR). This can be done by either double clicking the file C:\Program Files\Ember\EmberZNet4.0.0\em35x\app\sensor\ewb\sink.eww or from inside of IAR using File > Open > Workspace and navigating to the sink.eww file.
2. Select Project > Make (F7) from inside of IAR.
3. After making the project, the s37 file used for programming is found at C:\Program Files\Ember\EmberZNet4.0.0\em35x\build\sink-cortexm3-iar-em357-em350-dev0680\sink.s37
4. To program this file to the node, connect your ISA3 to the chip and your computer (this example assumes the ISA3 is connected via USB. See the next section for how to program if the ISA3 is connected via Ethernet.)
5. Open a command line of your choice (such as DOS or cygwin).
6. Navigate to the directory C:\Program Files\Ember\EmberZNet4.0.0\em35x.
7. Invoke the command "em3xx_load.exe" without any build options. This will ensure that em3xx_load.exe can be found in your path and will cause em3xx_load.exe to print its on-line help menu.
8. To download the s37 file to the EM357 chip, from the tool directory invoke the command "em3xx_load.exe ../build/sink-cortexm3-iar-em357-em350-dev0680/sink.s37".
9. Download will complete when em3xx_load prints the string "Run (by toggling nRESET)".

8.5 Programming your Application on the EM357

Programming EM357 flash is accomplished with the em3xx_load.exe utility. The em3xx_load utility is included as part of the ISA3 Utilities Installer, in the “bin” subdirectory. Note that em3xx_load is not directly compatible with the options used by em2xx_load for the EM250 platform.

A complete summary of em3xx_load functionality with brief descriptions of each option can be found in em3xx_load's own help menu. Invoking "em3xx_load.exe" without options or invoking "em3xx_load.exe --help" will print this help menu.

The most common usage of em3xx_load is to simply program flash. em3xx_load takes the S37 specific version of Motorola S-record file formats; which are files with the .s37 extension. If you are using a bootloader, em3xx_load can also load an .ebl file.

Given an S37 file called "file.s37", the most basic command for programming flash is simply:

```
em3xx_load.exe file.s37
```

Em3xx_load will then print out the versions it is using, the devices it is connected to, the steps it is performing, and programming progress. By default, the last step em3xx_load performs is to run the chip by toggling the nRESET pin.

By default, em3xx_load.exe assumes the InSight Adapter is connected via USB when no other options are given. If the ISA3 is connected via Ethernet, use the --ip option to specify the ip address or hostname of the ISA3 to be used. Given an ISA3 with an IP address of 123.123.123.123, programming can be accomplished with the command:

```
em3XX_load.exe --ip 123.123.123.123 file.s37
```

8.6 Programming Manufacturing Tokens

The em3xx_load utility has the ability to program manufacturing tokens much like the em2xx_patch tool did. In the case of the EM357, these tokens are contained in the Customer Information Block(CIB). For more information on using the em3xx_load utility, refer to document 120-4032-000, *EM3xx Utilities Guide*.

8.6.1 Programming Certificates & Installation Codes

Certificates and installation codes can be programmed using the same em3xx_load tool that is used to program other tokens. There is a separate application note which describes the process in detail. For more information, see document 120-5058-000, *Setting Manufacturing Certificates and Installation Codes*.

8.7 Using the Debugger in IAR Embedded Workbench with an Ember InSight Adapter

1. Start IAR Embedded Workbench. Open the workspace (*.eww).
2. Select Project > Options. Select the Debugger > J-Link/J-Trace category. Select the Connection tab.
3. Select TCP/IP Communication and enter the IP address of the ISA3. Click OK.
4. Embedded Workbench is not able to program the flash on the EM357. Every time the project is re-built, you must manually load it onto the EM357 (using em3xx_load.exe) before starting a debug session.
5. Once the correct image has been loaded onto the EM357, select Project > Debug without Downloading to start the debug session.