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# **802.15.4/ZigBee Evaluation Kit (13193EVK)**

User's Guide

802154EVKUG/D  
Rev. 0.0, 11/2004

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## About This Book

This guide provides a detailed description of how to use the Freescale 802.15.4/Zigbee Evaluation Kit (13193EVK), part number 13193EVK-A00.

The 13193EVK provides a flexible demonstration and development environment for the Freescale ZigBee family of products. In addition to the hardware, the kit provides utilities and sample applications that demonstrate functionality from simple proprietary applications, 802.15.4 applications, all the way to full ZigBee compatible solutions.

## Audience

This document is intended for application developers.

## Organization

This document is organized into 6 chapters.

- |           |   |
|-----------|---|
| Chapter 1 | <b>Safety Information</b> — This chapter provides operating guidelines for the 13193EVK.                                    |
| Chapter 2 | <b>13193EVK Components</b> — This chapter gives an overview of the 13193EVK and its components.                             |
| Chapter 3 | <b>Board Overview</b> — This chapter describes the boards that ship with the 13193EVK.                                      |
| Chapter 4 | <b>Software Installation</b> — This chapter describes how to install the software found on the 13193EVK CD.                 |
| Chapter 5 | <b>Demonstration Applications</b> — This chapter describes the various demonstration applications pre-loaded on the boards. |
| Chapter 6 | <b>Solution Development</b> — This chapter shows users how to begin development of an MC13192 system solution.              |

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## Conventions

This document uses the following notational conventions:

- Courier monospaced type indicates commands, command parameters, code examples, expressions, data types, and directives.
- Italic type indicates replaceable command parameters.
- All source code examples are in C.

## Definitions, Acronyms, and Abbreviations

BDM debugger	A debugger using the BDM interface for communication with the MCU. An example is the P&E BDM Multilink debugger for HCS08.
BDM	Background Debug Module
13193EVK	The 802.15.4/Zigbee Evaluation Kit
GUI	Graphical User Interface
MAC	Medium Access Control
MCU	MicroController Unit
NVM	None-Volatile Memory
PC	Personal Computer
PCB	Printed Circuit Board
S19	'S19' is the file extension used for the Motorola binary image format. The S19 file encapsulates the binary image as a list of ASCII records. Each record contains a length -, address -, data - and checksum field. The 16 bit address field allows a memory space for up to 64 KB. The S19 can be generated with Metroworks Codewarrior IDE and is the product from the linking process. S19 does not contain additional information to a debugger (where to look for source files).
Safe Mode Boot	The Embedded Bootloader boots up using safe default system values.
HIWAVE	P&E HCS08 debugger GUI.
CPROG	P&E HCS08 flash programming tool called from HIWAVE. The tool is also available in a command line version where scripts can be made.

---

## References

- [1] ZigBee.hlp (see Test Tool installation directory .\help)
- [3] Freescale MC908HCS08GB60/GT60 MCU Data Sheet, MC9S08GB60/D
- [4] Freescale Application Note, Handling MAC Address Erasure, AN2825/D
- [5] Freescale Application Note, ZigBee/802.15.4 Evaluation Kit, Quick Start Guide, AN2772/D
- [6] Freescale Embedded Bootloader Reference Manual, MC13192EBRM/D
- [7] Freescale Switch Demo Application, AN2773/D
- [8] Freescale Accelerometer Demo Application, AN2774/D
- [9] Freescale Compact, Integrated Antennas, Designs and Applications, AN2731/D
- [10] IEEE™ 802.15.4 specification 1.0

## Revision History

The following table summarizes revisions to this manual since the previous release (Rev. 0.0).

**Revision History**

Location	Revision
Entire Document	New document. 0.0





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# Chapter 1

## Safety Information

Any modifications to this product may violate the rules of the Federal Communications Commission and make operation of the product unlawful.

47 C.F.R. Sec. 15.21

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

47 C.F.R. Sec.15.105(b)

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. The antenna(s) used for this equipment must be installed to provide a separation distance of at least 8 inches (20cm) from all persons.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.
3. This device is susceptible to electrostatic discharge (ESD) and surge phenomenon.



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## Chapter 2

# 13193EVK Components

The boards shipped with the 13193EVK are delivered with pre-loaded demonstration applications. More applications can be uploaded with either the Embedded Bootloader utility which is located in the Test Tool application, or with CodeWarrior using the USB Multilink programmer (provided). The CodeWarrior CD requires that users register to get a 30-day evaluation key. After that time, users must purchase a standard key to use the CodeWarrior Software. See the CodeWarrior documentation for more detailed information. The CodeWarrior software is not required to run the demonstrations and utilities described in this guide. Some applications are board dependent and will only run on specific target boards. The 13193EVK contains the 13192-EVB and the 13192-SARD boards.

Demonstration applications for the 13192-EVB include, but are not limited to:

- Range Test
- Switch Demonstration
- Wireless UART
- Test Tool Utility
  - Protocol Test Client (PTC) Demonstration (pre-loaded)

Demonstration applications for the 13192-SARD include, but are not limited to:

- Accelerometer Application (pre-loaded)
- Range Test
- Switch Demonstration
- Wireless UART
- Test Tool Utility
  - Protocol Test Client (PTC) Demonstration

Additional applications can be run with the Figure 8 Wireless Z-Stack software. For more information, refer to the Z-Stack Users Guide for the Freescale 13193EVK which is shipped with the 13193EVK.

---

## 2.1 13193EVK Contents

Table 1. shows the boards contained in the 13193EVK-A00 development kit.

**Table 1. 13193EVK Boards**

P/N	Description	QTY
13192-EVB	802.15.4/ZigBee Evaluation Board	3
13192-SARD	802.15.4/ZigBee Sensor Application Board	2

- In addition to the boards, the kit contains the necessary power adapters, cables, and software. See the packing list included with the kit for a complete list of contents.

---

## Chapter 3

# Board Overview

The 13193EVK contains two different boards.

1. 13192-EVB
2. 13192-SARD

These boards include the following on-board components except where noted otherwise:

- MC13192 2.4GHz transceiver
- MC9S08GT60 Micro Controller Unit (MCU)
- MMA6261Q accelerometer (13192-SARD only)
- MMA1260D accelerometer (13192-SARD only)

### 3.1 Common Board Components

#### 3.1.1 MC9S08GT60 MCU

The MC9S08GT60 MCU is contained on both the 13192-SARD and 13192-EVB. The MC9S08GT60 MCU is a member of Freescale's 8 bit, low cost, low power family of HCS08 MCUs. It has 60KB of embedded flash and 4KB of RAM. For more information, refer to the MC9S08GB60 data sheet, at [www.freescale.com/mcu](http://www.freescale.com/mcu).

#### 3.1.2 MC13192 RF Data Modem

The MC13192 is contained on both the 13192-SARD and 13192-EVB. The MC13192 is an 802.15.4 compliant, ZigBee-ready transceiver. It has a four-wire SPI interface to connect to a variety of microcontrollers, creating a low power, low cost solution for a range of applications. For more information on the MC13912, see the MC13192DS/D data sheet at [www.freescale.com/ZigBee](http://www.freescale.com/ZigBee).

#### 3.1.3 MMA1260D and MMA6261Q Acceleration Sensors

The MMA6261Q Acceleration Sensors are contained only on the 13192-SARD. The MMA1260D and the MMA6261Q Acceleration Sensors provide the 13192-SARD with unique applications to demonstrate wireless sensing solutions. For more information on the MMA1260D and the MMA6261Q, see the data sheets included with the 13193EVK CD or visit [www.freescale.com/sensors](http://www.freescale.com/sensors).

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## 3.2 13192-EVB Description

The 13192-EVB is an 802.15.4/ZigBee evaluation board based on the MC13192, 2.4GHz transceiver and the MC9S08GT60 MCU. The 13192-EVB board provides both serial and USB connectivity to a PC for easy evaluation. It also includes the necessary circuitry to enable the MBC13900 Low Noise Amplifier (LNA) for improved sensitivity and range. It also has an external SMA connector for an external antenna connection which allows easy connectivity to a scope for test and measurement.

The 13192-EVB contains the following interfaces

- 1.1 USB port
- RS232 Serial Connection
- 4 push buttons (S1, S2, S3, S4)
- 1 Reset button (Reset)
- 4 LEDs, (LED1, LED2, LED3, LED4)
- One power switch (S106)
- Printed F antenna (Refer to AN2731/D for more information)
- Optional MBC13900 LNA (disabled by default, visit [www.freescale.com/rf](http://www.freescale.com/rf) for more information)
- SMA RF connector (disabled by default)
- Background Debug Module (BDM) connection (allows flash programming and in-circuit debug via the included USB Multilink Cable). See USBMULTECHSUM/D document included in the kit for more details).
- Power connector (5-9 Volts)
- 10-pin header strip for access to specific MCU and RF pins

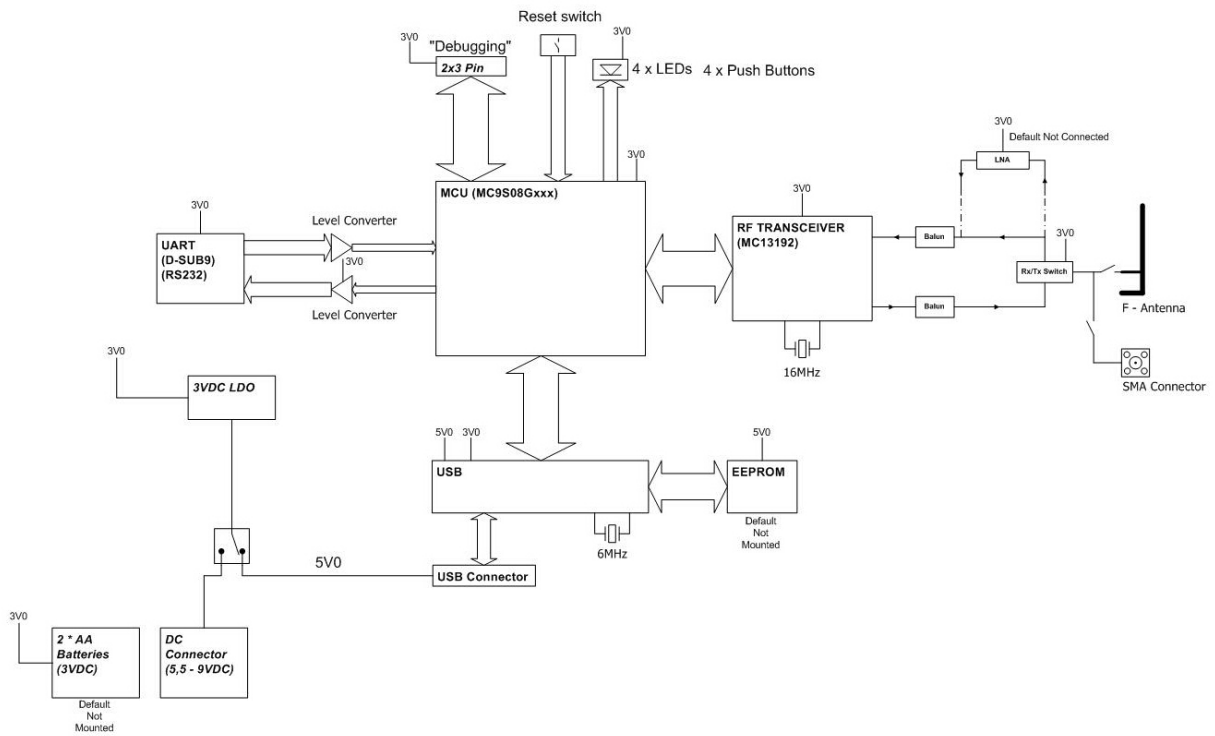


Figure 1 13192-EVB Block Diagram

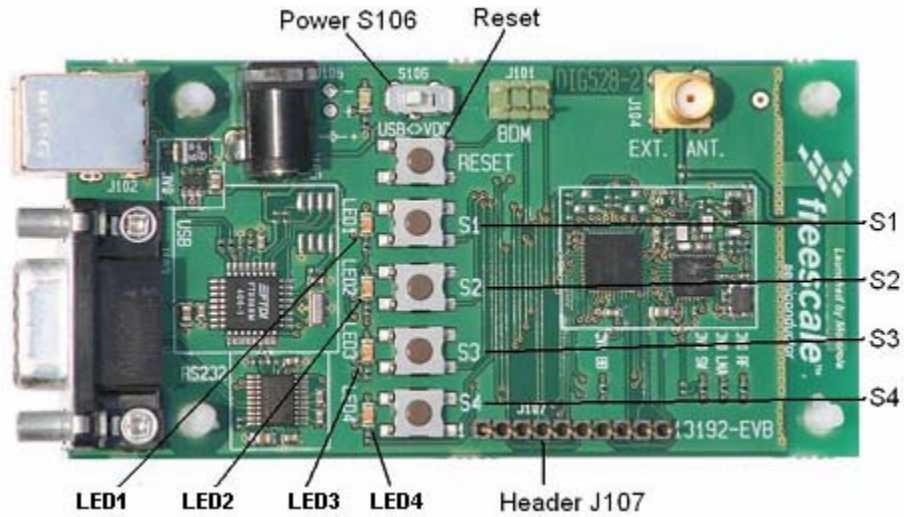


Figure 2 13192-EVB Board Layout



**Table 2. 13192-EVB Board Labels**

Common Name	Board Designation
LED 1	LED1
LED 2	LED2
LED 3	LED3
LED 4	LED4
Button 1	S1
Button 2	S2
Button 3	S3
Button 4	S4
Reset Button	Reset
Power Toggle	S106

Switch S106 toggles power between the USB connector and the power connector. Refer to the *MC13192 Evaluation Board Reference Manual*, MC13192EVBRM/D for more info.

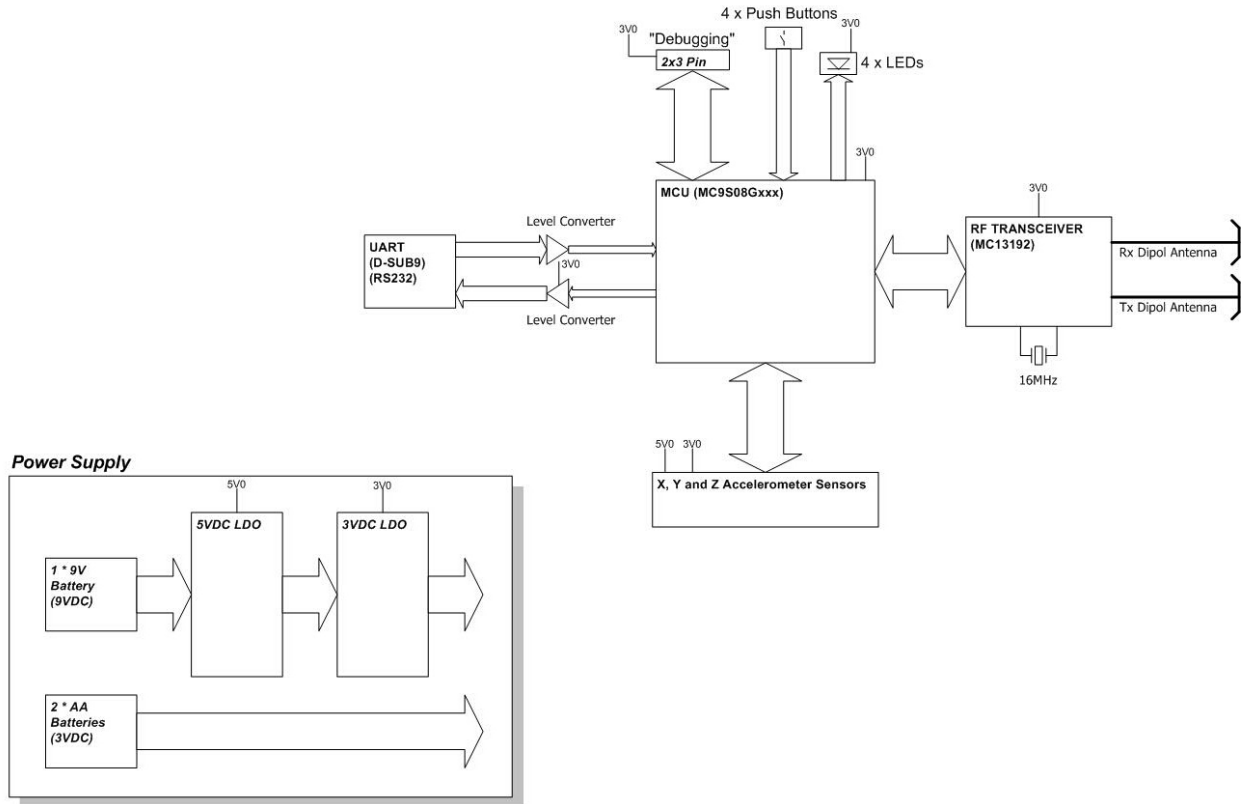
### 3.3 13192-SARD Description

The 13192-SARD is a demonstration board based on the MC13192 2.4GHz transceiver, MC9S08GT60 MCU, and the MMA6261Q and MMA1260D Acceleration Sensors.

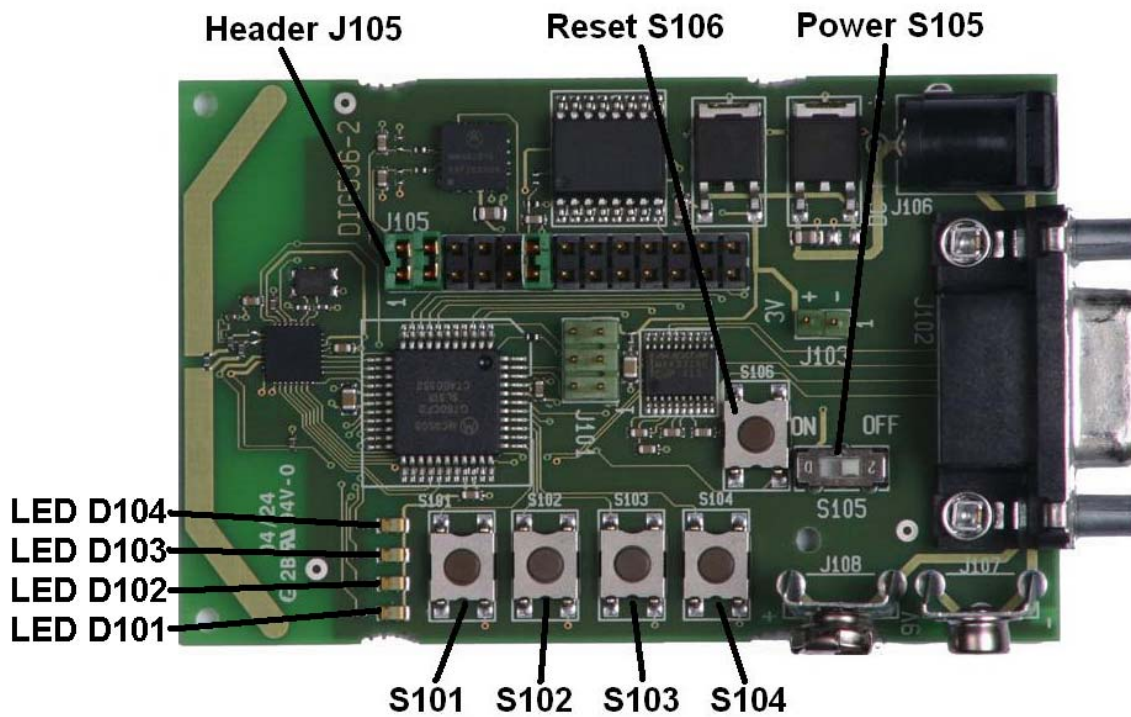
The 13192-SARD contains the following interfaces:

- RS232 Serial Connection
- 4 push buttons (S101, S102, S103, S104)
- 1 Reset button (S106)
- 4 LEDs (D101, D102, D103, D104)
- One power switch (S105)
- Printed Dipole antenna (Refer to AN2731/D for more information)
- Background Debug Module (BDM) connection (allows flash programming and in-circuit debug via the included USB Multilink Cable). See USBMULTECHSUM/D document included in the kit for more details).
- Power Connections
  - Power connector (5.5-9 Volts)
  - 9-Volt battery connector
  - 3-Volt power connector (MMA1260D Acceleration Sensor disabled)

- 26-pin header strip (J105), for access to specific RF, MCU, and sensor pins



**Figure 3 13192-SARD Block Diagram**



**Figure 4 13192-SARD Board Layout**

**Table 3. 13192-SARD Board Labels**

Common Name	Board Designation
LED 1	LED D101
LED 2	LED D102
LED 3	LED D103
LED 4	LED D104
Button 1	S101
Button 2	S102
Button 3	S103
Button 4	S104
Reset Button	S106
Power Switch	S105

See the SARD Users Guide, MC13192SARDUG/D for more information.

## Chapter 4 Software Installation

This chapter describes how to install the software contained on the 13193EVK CD. Before connecting the hardware to the PC, the software on the 13193EVK CD must be installed on a PC. This installs the Test Tool application, object and source code, sample applications, and documentation.

To install the software, perform the following steps.

1. Insert the 13193EVK CD into your CD-ROM drive.
2. If the program does not run automatically, run CDBrowser.exe from the Autorun directory.
3. Select INSTALL/UNINSTALL from the menu options. The following window appears.

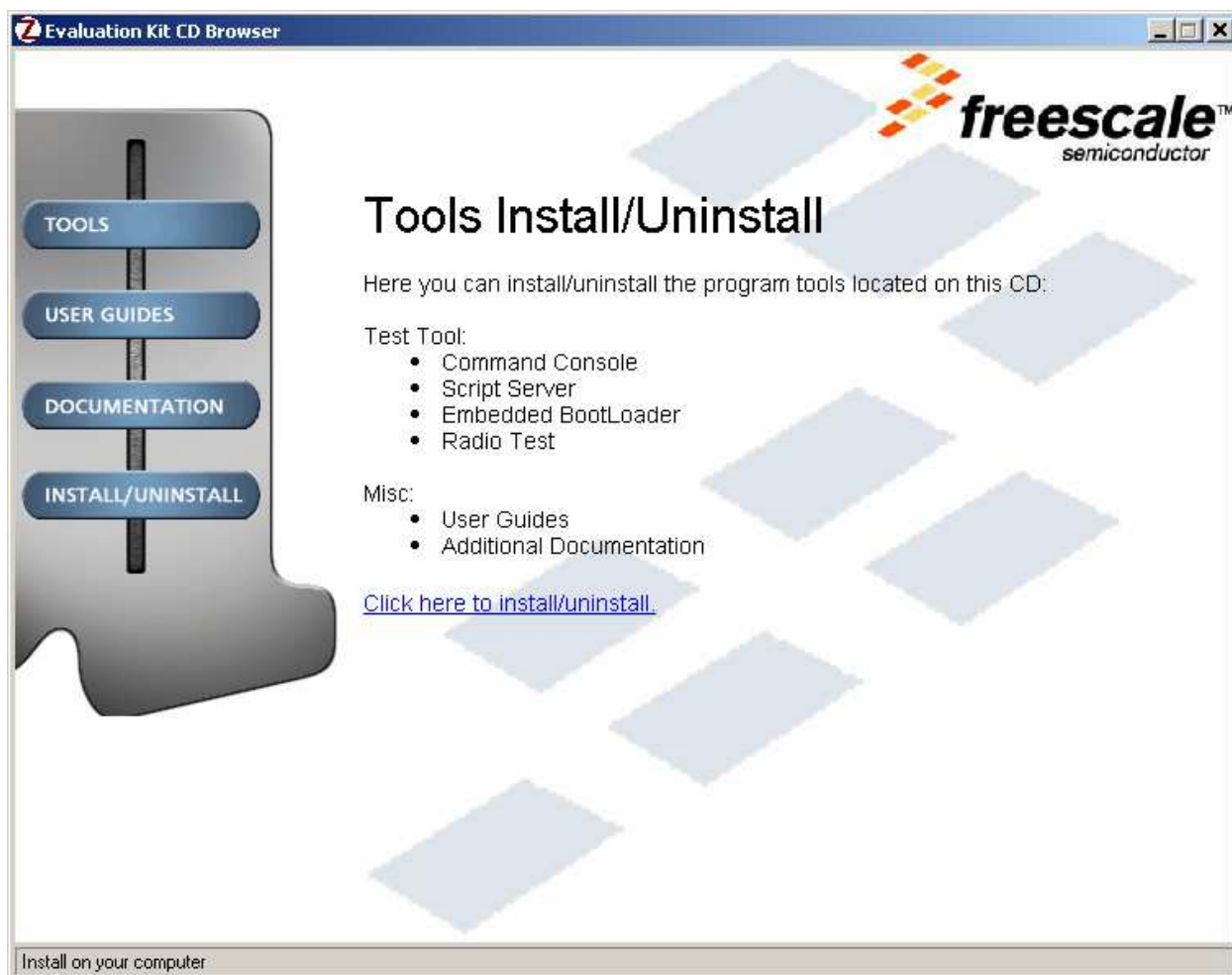
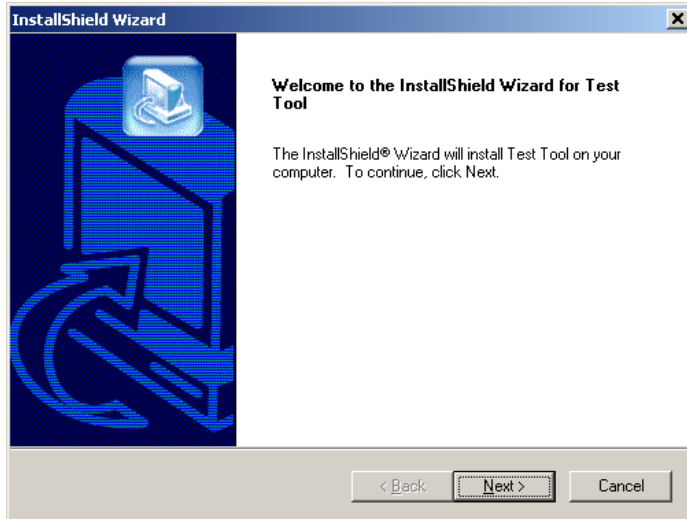


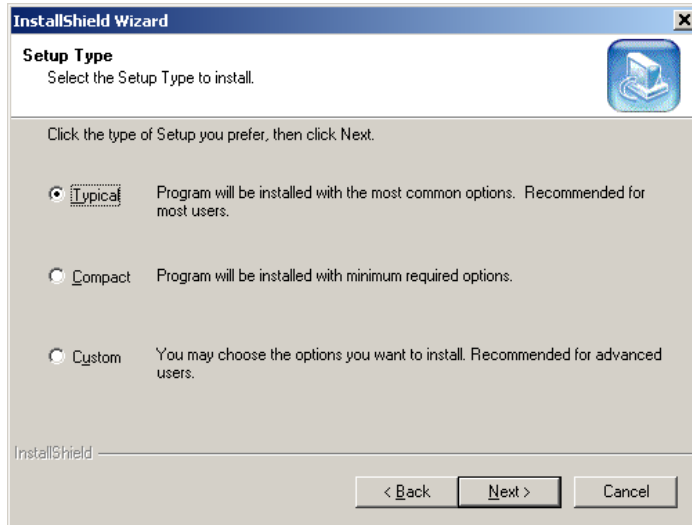
Figure 5 Evaluation Kit CD Browser Main Window

4. Select the “Click here to Install/Uninstall” option. The following window appears.



**Figure 6 Installation Wizard Window**

5. Click on the “Next” button. The following window appears.



**Figure 7 Setup Type Window**

6. Select the “Typical” radio button and click on the “Next” button. Follow the directions in the InstallShield Wizard until the software installation is complete.

## Chapter 5

# Demonstration Applications

The 13192-EVB and 13192-SARD boards ship with several pre-loaded demonstration applications. This chapter describes how to run the included applications as well as loading and running additional applications included in the 13193EVK.

This section uses the Test Tool's Embedded Bootloader application to flash new firmware into the

13192-SARD and 13192-EVB. The bootloader provides an alternative method to flash your applications with the need for a BDM cable. To flash the boards via the supplied BDM programmer and CodeWarrior, see the USBMULTILINK HCS08/HCS12 Technical Summary User Manual and the CodeWarrior™ Development Studio for 68HC08 Quick Start Guide. Flashing the board with the BDM programmer overwrites all code residing in the embedded flash including the Embedded Bootloader code. In order to use the Embedded Bootloader utility to flash the board, you must reload the Embedded Bootloader code via the BDM. See the Embedded Bootloader Reference Manual (802154EMRM/D) for more details.

### NOTE

Ensure that you have already installed the software from the 13193EVK CD. (See [Chapter 4](#) for more information.)

The sample applications provided on the 13193 Evaluation Kit CD are based on Freescale's Simple MAC (SMAC) and/or 802.15.4 MAC software. For the ZigBee stack and application examples, see the Figure 8 Wireless Z-Stack CD included in the 13193EVK.

The following applications are included on the 13193EVK CD.

- SMAC Applications
  - Accelerometer Demonstration Application
  - Range Test
  - Additional SMAC based applications can be downloaded at [www.freescale.com/ZigBee](http://www.freescale.com/ZigBee).
- 802.15.4 Applications
  - PTC Demonstration
  - Switch Demonstration
  - Wireless UART
- Windows Application
  - Test Tool
  - Command Console
  - Script Server
  - Embedded Bootloader
  - Radio Test

---

## 5.1 Accelerometer Demonstration Application (SMAC)

The Accelerometer Demonstration is designed to run with 13192-SARD and is pre-flashed on the board. The Accelerometer Demonstration Application uses two 13192-SARD boards that transmit X, Y, and Z-axis accelerometer data from 13192-SARD board one to 13192-SARD board two. The 13192-SARD board two is connected to a PC via a serial port. The PC runs a GUI interface that displays the acceleration sensor data on the PC screen. The Accelerometer Demonstration application is optimized for low power consumption, not range evaluation. The output power on the Accelerometer Demonstration application is optimized for low power consumption and set below the nominal 0dBm level. To test the effective range of the boards, use the Range Demo Plus application, as described later in this chapter.

### 5.1.1 Board Setup Overview

To setup both boards for operation, (transmit and receive) perform the steps shown in this section.

#### NOTE

This section is based on the 13192-SARD board with the factory loaded Accelerometer Demonstration. If you have re-flashed the 13192-SARD board with another application, you will need to reload the Accelerometer Application. See [Section 5.8](#) for more information.

### 5.1.2 Board One Setup (Transmit)

1. Connect a 9V battery or the 9V power supply and set switch S105 to the “ON” position.
2. While holding down button S101, press and release the Reset Button S106 then release S101. LED D104 should be blinking. Board One is now in transmit mode.

### 5.1.3 Board Two Setup (Receive)

1. Connect the other 13192-SARD board to a PC’s serial port using a DB9 male/female serial cable included in the kit.
2. Connect a 9V battery or the 9V power supply and set switch S105 to the “ON” position.
3. Press the Reset Button S106. Board Two is now in receive mode.

### 5.1.4 Verifying Operation

1. Verify that the boards are communicating by ensuring that LED D103 on the receive board (Board Two) is blinking. If it is not, press the Reset Button S106 on Board Two again. (The board connected to the PC.)

## 5.1.5 Running the TRIAX Software

1. Run the TRIAX Software from Windows Start menu ->Programs->Freescale->Triax. After execution of the Triax program, the software prompts users to select the proper communications port for their PC. This is the RS232 serial COM port to which the receiver board (Board One) is connected.

## 5.1.6 Viewing Data

After selecting the appropriate communications port, several methods are available to view the data being sent from the accelerometers on the transmitter board (Board One).

1. Sensor Data – This application shows the raw data that is sent from the accelerometer and sampled by the MCU analog/digital converter. The following data is provided.
  - X, Y, and Z accelerometer analog outputs in volts.
  - 8-bit A/D readings (0-255).
  - The output of each axis converted into g's.
2. G Mouse – This application displays the location of the board based on movement of the transmitter board (Board One). To move the boxes on the display which represents the X, Y axis, pick up the transmitter board and tilt it through different angles.
3. Tilt – This application translates the g's experienced in each axis to an angle of rotation. To view different angles, rotate/tilt the transmitter board.
4. Shipping – This application timestamps when a pre-determined threshold is violated or when the board is turned upside down.

### NOTE

If using batteries as the power source and the accelerometer demonstration behavior becomes erratic, replace the batteries.

## 5.2 Range Demo Plus (SMAC)

The Range Demo Plus is a simple application that transmits data from one board to the other. Signal strength is displayed via the LEDs on the board. This test can be performed on either the 13192-SARD or the 13192-EVB.

Before running the Range Demo Plus, the 13192-SARD board must be flashed with the following:

- range\_demo\_plus\_rx\_13192SARD\_loader.s19
- range\_demo\_plus\_tx\_13192SARD\_loader.s19

Before running the Range Demo Plus, the 13192-EVB board must be flashed with the following:

- range\_demo\_plus\_rx\_13192EVB\_loader.s19
- range\_demo\_plus\_tx\_13192SEVB\_loader.s19

Follow the instructions shown in [Section 5.8.2](#) to flash the board using the Embedded Bootloader.



## 5.3 Embedded Bootloader

The Embedded Bootloader allows users to flash the MCU on the 13192-EVB and 13192-SARD without the BDM programmer/debugger. The Embedded Bootloader is located in a protected 4KB flash block in the highest memory area (0xF000-0xFFFF) of the MC9S08GT60 MCU located on both the 13192-SARD and 13192-EVB boards.

See the Embedded Bootloader Reference Manual (802154EBRM/D) for more information.

### 5.3.1 Board One Setup (Receive)

1. Connect a 13192-SARD or 13192-EVB to an RS232 serial COM port on the PC via the included serial cable.
2. Connect a power source (9V battery or the 9V power supply to the board).
3. Power on the board. If all four LEDs are not on, press all four buttons (S101-S104 on the 13192-SARD and S1-S4 on the 13192-EVB). The SMAC applications call the Embedded Bootloader with two buttons presses. The 13192-SARD use S102 and S104 while the 13192-EVB uses S2 and S4. Press and release the Reset Button, then release the appropriate pushbuttons. All four LEDs should now be on. The board is now ready for flash programming.
4. Run the “Test Tool” utility from the Start->Programs->Freescale Zigbee->Test Tool Windows menu.
5. If running “Test Tool” for the first time, setup the board connection by selecting Communication Settings from the Tools menu as shown in [Figure 8](#). From the “List of Devices” window, select the “Add Internal” option and click on the “Serial” button. Choose the appropriate Com Port and click on the “OK” button.

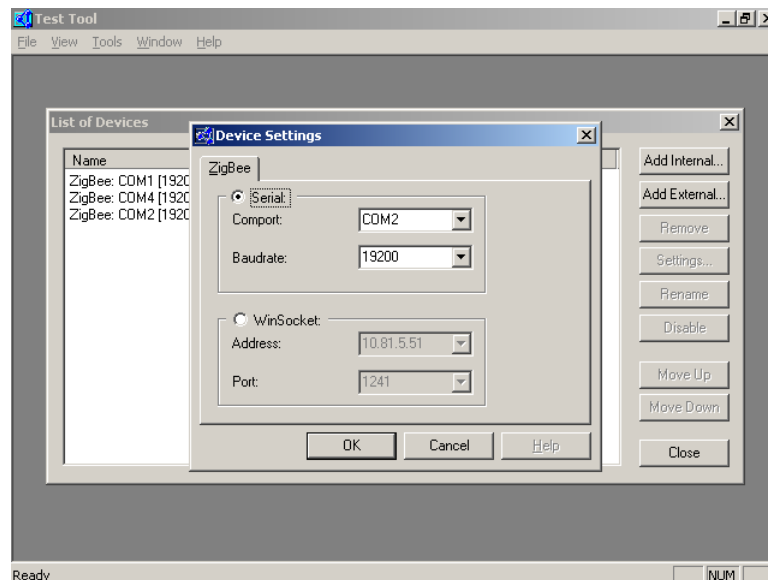


Figure 8 Running Test Tool for the First Time

6. Click the “Close” button.
7. From the Test Tool program, run the Embedded Bootloader application by selecting the “Embedded Bootloader” option from the “View” menu.
8. Select the ZigBee device and click on the “OK” button.
9. To flash the board for the Range Plus Demo, select the *rx\_range\_demo\_plus\_13192SARD\_SE\_loader.s19* application file and click on the “Upload” button.  
If you receive a Timeout error, highlight the file and click on the “Upload” button again.
10. While the board is flashed, a progress indicator appears in the Embedded Bootloader application.
11. After the board is flashed, press the “Reset” button.

### 5.3.2 Board Two Setup (Transmit)

1. Connect the 13192-SARD or 13192-EVB to an RS232 serial COM port on the PC via the included serial cable.
2. Connect a power source (9V battery or the 9V power supply) to the board.
3. Power on the board. If all 4 LEDs are not on, press and hold down all 4 buttons (S101-S104 on the 13192-SARD and S1-S4 on the 13192-EVB) and press and release the Reset Button. Then release all four buttons. All four LEDs should be on and the board is ready for flash programming.
4. Run the “Test Tool” utility from the Start->Programs->Freescale Zigbee->Test Tool Windows menu.
5. From the “Test Tool” program, run the Embedded Bootloader application by selecting “Embedded Bootloader” option from the “View” menu.
6. Select the ZigBee device and click on the “OK” button.
7. To flash the board for the Range Plus Demo, select the *tx\_range\_demo\_plus\_13192SARD\_SE\_loader.s19* application file and click on the “Upload” button.
8. If you receive a Timeout error, highlight the file and click on the “Upload” button again.
9. While the board is being flashed, a progress indicator appears in the Embedded Bootloader application.
10. After the board is flashed, press and release the reset button.

### 5.3.3 Verifying Operation

Verify that the boards are communicating by ensuring that LED 1 on both boards is blinking. LEDs 2 through 4 are signal strength indicators. As the boards are moved further apart, LEDs 4 through 2 will turn off in order. When the range of the boards is exceeded, LED 1 stops blinking.