

# Module Introduction

## Purpose

- This training module provides an overview of Freescale's scalable solutions for low data rate 2.4 GHz connectivity.

## Objectives

- Understand Freescale's approach to ZigBee architecture and scalable solutions.
- Describe Freescale's first generation ZigBee solution including our 2.4 GHz transceiver and HCS08 family of processors.
- Understand Freescale's scaleable software options for simple proprietary, IEEE 802.15.4 MAC-based connectivity and fully ZigBee compliant solutions.
- Present Freescale's second generation platform.

## Content

- 29 pages
- 5 questions

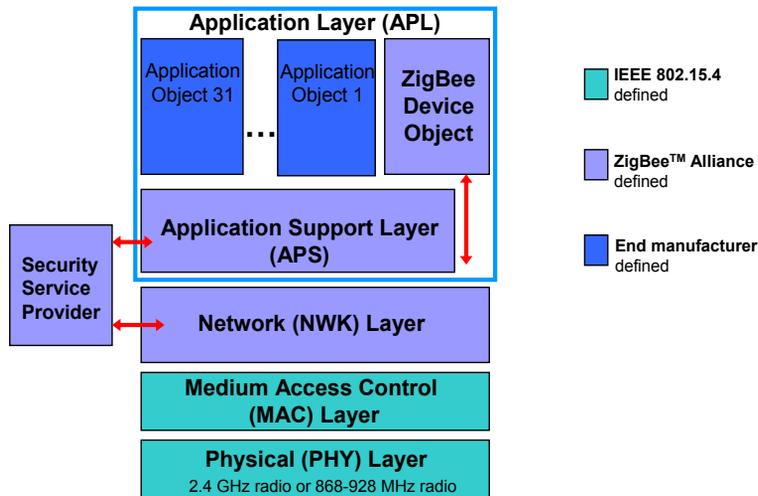
## Learning Time

- 45 minutes

This course, Freescale's ZigBee™ Product Offering, will introduce you to Freescale's scalable 2.4 GHz low data rate connectivity solutions.

In this course, we will discuss Freescale's approach to the ZigBee architecture and related solutions. We will describe Freescale's first generation ZigBee solution including the 2.4 GHz transceiver offering, the new HCS08 family of 8-bit MCUs, and our three-tiered software options. Finally, we will examine Freescale's second generation ZigBee solution.

# ZigBee Stack Architecture

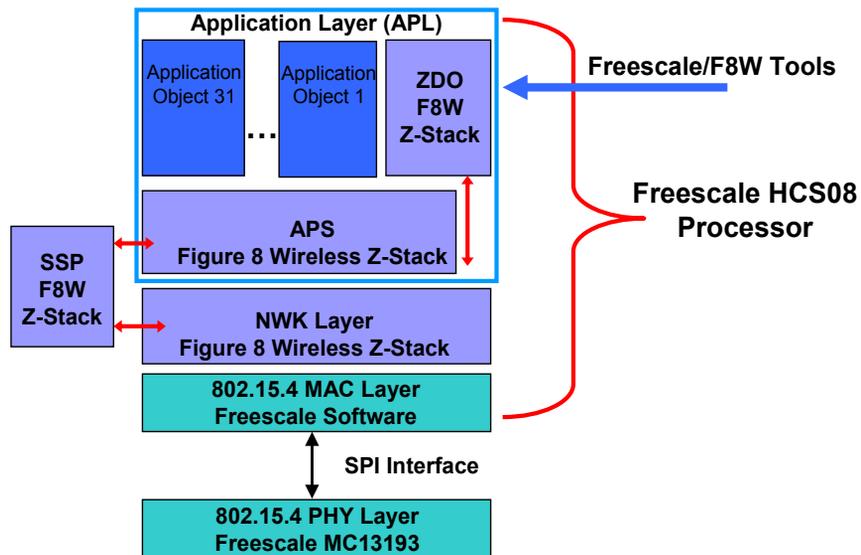


Let's review the ZigBee architecture with this simplified block diagram. The Physical (PHY) layer and Medium Access Control (MAC) layer are based on the IEEE 802.15.4 PAN standard. This includes the actual radio hardware.

Above the MAC and PHY are the Network (NWK) and application layers defined by ZigBee.

The software and hardware vendor will provide the software stack with appropriate tools to allow an original equipment manufacturer (OEM) to create applications, which are added to the APL.

## Freescale's First Generation



The Freescale first generation approach to ZigBee architecture is to split the hardware and software at the PHY layer. The MC13193 is a 2.4 GHz transceiver that contains most of the PHY functionality while the MAC, NWK and APL layers reside as software on an MCU. The interface from the MCU to the transceiver is the common 4-wire Serial Peripheral Interface (SPI). This architecture allows the most flexibility in choosing an MCU. For simple end devices, you can use a low memory 8-bit MCU. For a network bridge or gateway application, you can apply the power of a 32-bit processor.

In the software stack, Freescale has written the MAC software. Figure 8 Wireless, a Freescale partner, has integrated the MAC with their Network layer to produce our first generation stack called Z-Stack. Since simplicity of design is a ZigBee requirement, a toolset is available which has been co-authored by Figure 8 and Freescale to assist OEMs in creating applications.

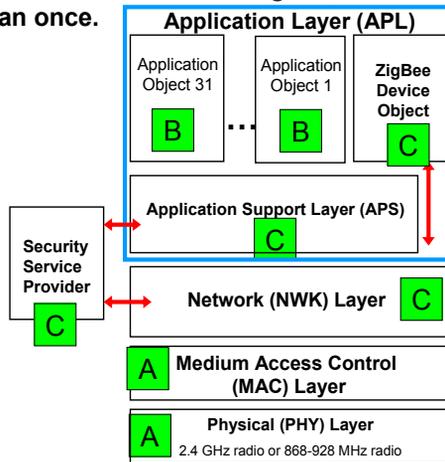
## Question

Who defines the layers in the ZigBee architecture? Label the diagram by dragging the letters on the left to their correct location on the diagram, and then click Done. Each letter may be used more than once.

**A** IEEE 802.15.4 defined

**B** End manufacturer defined

**C** ZigBee™ Alliance defined



Done

Reset

Show Solution

Here is a question to check your understanding of the ZigBee architecture.

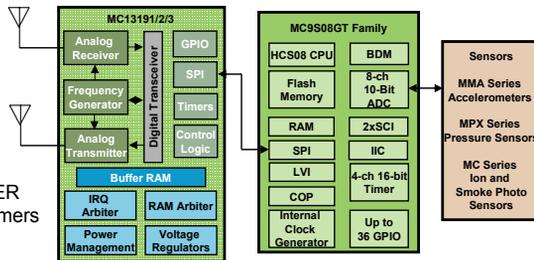
Correct.

In the ZigBee architecture, the PHY layer and MAC layer are based on the IEEE 802.15.4 WPAN standard. ZigBee defines the NWK and APS layers. The End Manufacturer defines and creates applications, which are added to the APL.

## First Generation Details

- Key Features

- RFIC plus MCU for maximum application flexibility
- IEEE® 802.15.4 Compliant Transceiver
  - 2.4GHz
  - 16 selectable channels
  - 250Kbps 0-QPSK DSSS
  - Up to -92 Rx sensitivity at 1% PER
  - Two Data Modes and Internal Timers for reduced MCU resources
- World Class HC(S)08 family of MCUs
- Multiple Power Saving Modes in RFIC and MCU
- Low Component count
  - On-chip regulator
  - Requires single 16 MHz Xtal (Auto Trim)
- 2V to 3.4 operating voltage



- -40°C to +85°C operating temperature
- Reduced design time
  - Flexible network support
  - Complete set of design tools and reference designs
- World Class sensor technology

Let's now look at the subsystems that make up Freescale's First Generation ZigBee scalable platform solution. As explained earlier, the architecture uses a separate RFIC transceiver and MCU for maximum application flexibility. This is critical in an emerging market.

A family of transceiver ICs is offered to allow cost and performance trade-off by application. All have the same basic design which offers high sensitivity and a wide range of operating voltages. Features include a 16 channel 2.4 GHz radio with a 250 kbps Offset QPSK Direct Sequence Spread Spectrum modem. Physical layer packet assembly/disassembly features reduce the demands on the microprocessor. Interface with the MCU is by way of a 4-wire SPI connection and control lines. The high level of integration reduces the off-chip component count and a Clock Output feature allows the transceiver's 16 MHz crystal oscillator to provide a reference to the MCU. The low-profile QFN-32 package is not only small, it meets the new lead-free standards now in place around the world.

Freescale's new HC(S)08 low power core provides a family of MCUs with excellent power savings and scalability. Any device in the family that has an SPI interface can be paired with one of the transceiver ICs to create a "right sized" wireless solution.

To support long battery life, multiple power saving modes are available in the RFIC and MCU. These can be mixed and matched to provide customized power management for a wide variety of applications.

Due to the excellent on-chip regulators and crystal reference sharing feature of the transceiver design, off-chip component count is minimized. Manufacturability is improved through a crystal trim feature of the reference oscillator.

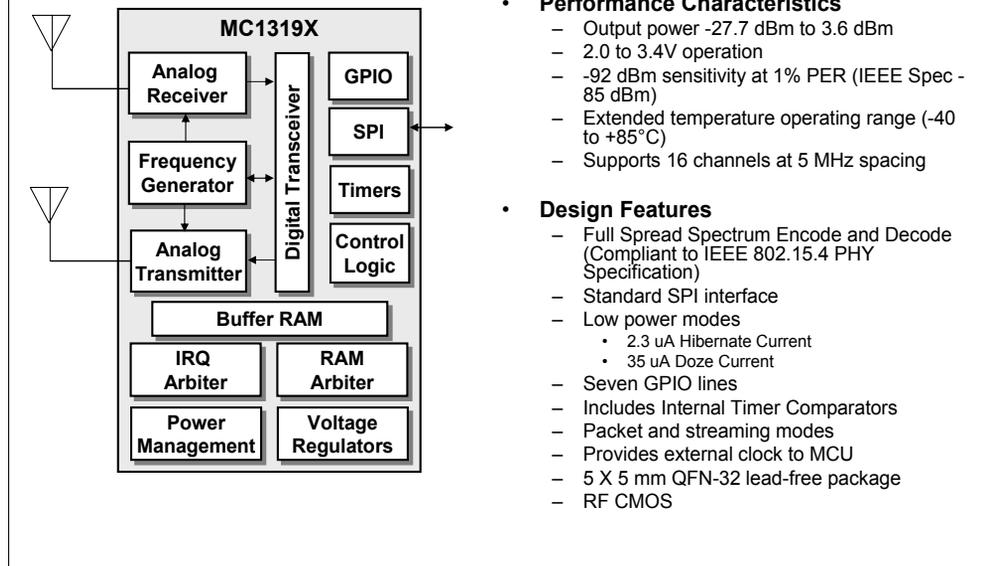
Both IC families work over a wide range of voltages, easing design constraints.

The operating temperature range of the ICs also makes the solutions useful for a wide range of applications.

Complete reference designs, including a number of different antennas, are available to reduce design time. And, to complete the solution, Freescale offers world class sensor technology.

## 2.4 GHz Transceivers

Mouse over the diagram to learn more about the performance characteristics and design features of these transceivers.



Let's review in more detail the RF transceivers of the Freescale Scalable 2.4 GHz platform. Three device options are available: the full-featured MC13192 and 193, and the reduced function, reduced cost MC13191.

All share a common architecture. The nominal output power of 1 mW, or 0 dBm, can be varied from around -28 dBm to around 4 dBm. Both operate at voltages as low as 2V with no degradation in performance. Both support 16 channels in the 2.4 GHz band and have a full data modem which operates at a 250 kbps over the air rate. Both have SPI interface to the MCU of choice. Both have multiple low power standby modes for power savings. Both are housed in a 5 x 5 mm QFN-32 package which meets lead-free requirements. Roll your mouse pointer over the diagram to learn more about the performance characteristics and design features of these transceivers.

## MC13191, 2 and 3 Comparison

Feature	MC13191	MC13192	MC13193
250 kbps, 16 channel DSSS Packet Modem	Yes	Yes	Yes
2.0 to 3.4 V operation	Yes	Yes	Yes
Low current Idle, Doze, and Hibernate modes	Yes	Yes	Yes
SPI Interface	Yes	Yes	Yes
Sensitivity for 1% PER	-92 dBm typ	-92 dBm typ	-92 dBm typ
Star and Point-to-Point Networking	Yes	Yes	Yes
IEEE 802.15.4 Support	No	Yes	Yes
ZigBee Support	No	No	Yes
Timer Comparators	2	4	4

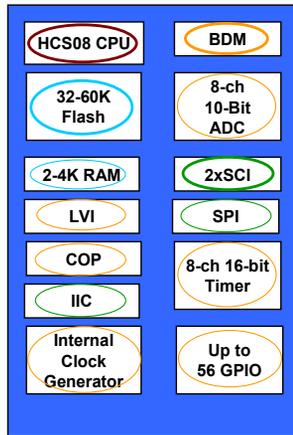
Here is a feature set comparison for the MC13191, 2 and 3.

Note that all have on-chip Direct Sequence Spread Spectrum (DSSS) packet modems. Also, they operate from 2 to 3.4V supplies, they have multiple low current operating modes, and they have an SPI interface to allow solutions with a variety of MCUs. Additionally, all have the same better-than-standard sensitivity and they can be used for simple point-to-point networking.

The 13192 and 3 will support the Freescale 802.15.4 MAC. MC13193 alone supports Z-Stack, allowing the power of ZigBee networking to be employed. Lastly, all devices have on-chip timer comparators, which can be used to trigger transceiver operations or be put to general use, but the 191 has only 2.

## MC9S08GB Series

Mouse over each circle to learn more about the MC9S08GB series.

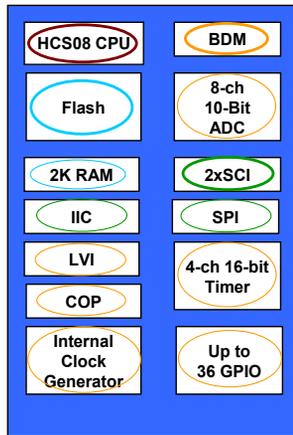


- Supply Voltage/ Performance**
  - 3.0 V  $\pm$ 10%, -40 to 85°C
- Packages**
  - 64 LQFP
- Development Tools/ Documentation**
  - M68DEMO908GB60
  - M68EV908GB60
- Target Applications:**
  - Electronic power meters, Sensors, Wireless communications, Home appliances, Security systems, etc...
- Core**
  - 20MHz HCS08 Core
- Memory**
  - 32-60k Flash
- Communications**
  - (2)SCI, SPI, IIC
- Features/ Benefits**
  - 8-ch, 16-bit, IC/OC, or PWM
  - Computer Operating Properly (COP), Analog to Digital Converter (ADC), Internal Clock Generator, Low Voltage Inhibit (LVI), Background Debug Mode (BDM)
  - Up to 56 GPIO

The Freescale 802.15.4 MAC and Z-stack are designed to take advantage of the new series of MCUs designed around the HCS08 core. This core operates at 3V with a bus speed of up to 20 MHz. This low voltage operation is a perfect fit for battery operated wireless applications using the MC13191 or MC13192. The GB series has the usual feature set expected in a high performance MCU. The many features and options enable a wide variety of applications. The GB60 is the basis for the family's development toolset.

## MC9S08GT Series

Mouse over each circle to learn more about the MC9S08GT series.



- Supply voltage/ performance**
  - 3.0 V  $\pm$ 10%, -40 to 85°C
- Available packages**
  - 42 SDIP, 44 QFP
- Development tools/documentation**
  - M68DEMO908GB60
  - M68EVB908GB60
- Target applications:**
  - Electronic power meters, sensors, wireless communications, home appliances, security systems, etc...
- Core**
  - 20MHz HCS08 core
- Memory**
  - 16-60k Flash
- Communications**
  - (2)SCI, SPI, IIC
- Features/Benefits**
  - 4-ch, 16-bit, IC/ OC, or PWM
  - Computer Operating Properly (COP), Analog to Digital Converter (ADC), Internal Clock Generator, Low Voltage Inhibit (LVI), Background Debug Mode (BDM)
  - Up to 36 GPIO

The GT series has a somewhat reduced feature set and fits in smaller 44-pin packages. The series is based on the same HCS08 core. Flash options range from 16 to 60 KB in the same package. Roll your mouse pointer over each circle to learn more.

## State/Mode Features

MC1319X		
Hibernate	Reference oscillator is off, SPI inactive. Will respond to Attention line only	2.3µA typ
Doze	Reference oscillator running, Clock output option (higher current), SPI inactive. Timer or Attention line wake up	35µA typ
Idle	Reference oscillator running and sourcing reference frequency outside of IC, SPI bus active	500 µA typ
Receive	Ref oscillator running, receiver on, SPI bus paused	37mA typ
Transmit	Ref oscillator running, transmitter on, SPI bus active	30mA typ
HC(S)08		
Stop2 w/ RTI	External clock is off. MCU is inactive, but can respond to KBI input. RTI runs off internal clock.	750nA
Stop3 w/ Osc enabled	External clock is on or 32kHz oscillator is operating; TBM is operating. Can respond to interrupts if desired	5µA
Wait	MCU activity halted, clock and other peripherals maintained	560 µA
Run	Core is fully functional at 8MHz bus speed	6mA

The HCS08 family combined with the MC13191, 2 or 3 can provide very long battery life in low data rate applications through the use of the many reduced current modes of operation.

Idle is the normal “standby” state in which the transceiver is programmed and transitions to its other states.

Doze is a unique, particularly useful feature of the MC1319X that allows very fast wake up for extended battery life. The transceiver can wake up from Doze mode and transmit or receive in around 0.5 ms whereas transmit or receive from Off would take around 23 ms. Many options exist in combining MCU and transceiver low power modes. For example, the transceiver can issue a timer initiated interrupt from Doze mode to wake up the MCU, which is in Stop 3.

Hibernate has lower current than Doze but takes longer - about 20 ms - to return to Idle.

## Question

Complete the table by dragging the letters on the left to their correct locations on the right and click Done.

**A** Yes

**B** No

Feature	MC13191	MC13192	MC13193
250 kbps, 16 channel DSSS Packet Modem	Yes	Yes	Yes
2.0 to 3.4 V operation	Yes	Yes	Yes
Low current Idle, Doze, and Hibernate modes	<b>A</b>	<b>A</b>	<b>A</b>
SPI Interface	Yes	Yes	Yes
Star and Point to Point Networking Using SMAC	Yes	<b>A</b>	<b>A</b>
802.15.4 MAC Support	<b>B</b>	<b>A</b>	<b>A</b>
ZigBee Z-Stack Support	<b>B</b>	<b>B</b>	<b>A</b>

Done

Reset

Show Solution

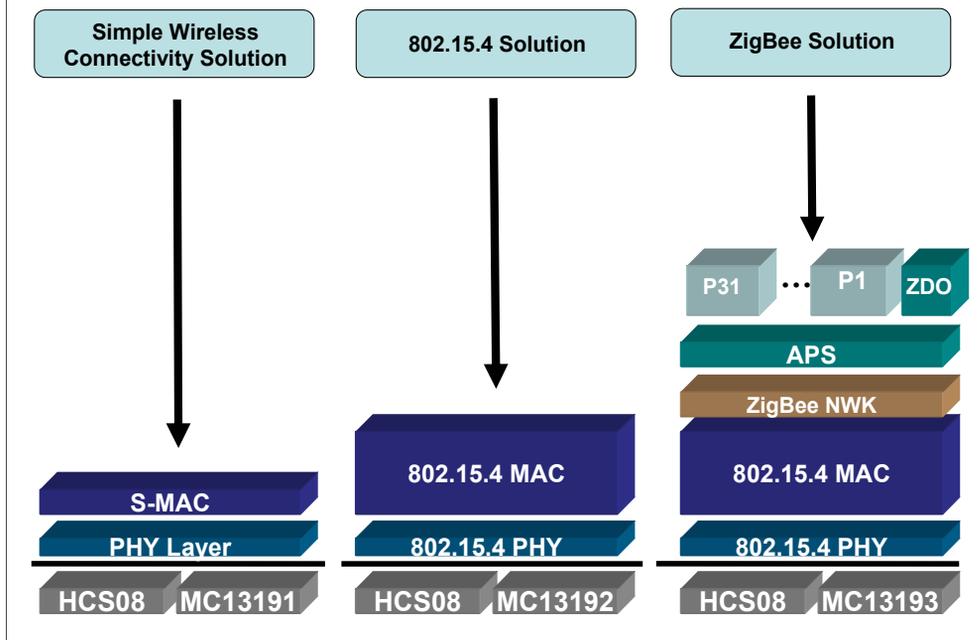
Here is a question to check your understanding of the material presented so far. Can you compare and contrast the MC13191, 192 and 193?

Correct.

All have Low Current Idle, Doze, and Hibernate modes. However, the MC13191 only supports point-to-point networking with SMAC. The MC13192 will support SMAC and 802.15.4 applications while the MC13193 is required for Z-Stack ZigBee applications. It supports all three software options.

## Scaleable Approach to 802.15.4 / ZigBee

Click each button to learn about the solution it offers.



What makes Freescale's ZigBee approach scalable? By combining a Transceiver with an MCU and matching these with the appropriate software, a range of solutions can be optimized for different wireless networking applications.

For simple point-to-point and STAR networks, our Simple MAC software, a low-end HC(S)08 MCU, and the MC13191 is a low cost solution that takes advantage of the IEEE 802.15.4-defined RF and battery savings characteristics. However, it isn't burdened by the overhead of the full software stack.

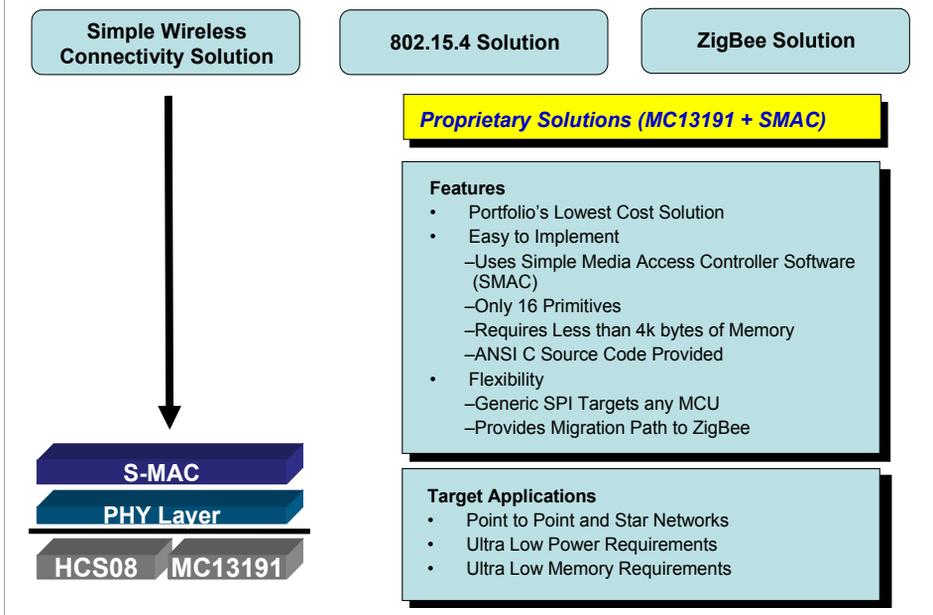
The MC13192 with Freescale's 802.15.4 MAC software running on an upscale HC(S)08 MCU allows customers to create proprietary wireless networks which make use of the IEEE defined channel access services.

Finally the MC13193 plus the ZigBee stack, including 802.15.4 MAC, is for ZigBee compatible wireless networks. It takes advantage of the network management and application environment defined by the ZigBee Alliance.

Note that all of these solutions can be pin-compatible and upgradeable from one to the other. In other words, with the proper choice of MCU and package, say the GT series, the same hardware design can be used with 16 k of flash memory for an SMAC application, with up to 60 k of flash for a full ZigBee implementation. This offers the opportunity for application sophistication to grow with only changes to the software. Click each button at the top of the screen to learn more. After you have viewed all three pages by clicking the three buttons, click the forward arrow to advance to the next page.

## Scaleable Approach to 802.15.4 / ZigBee

Click each button to learn about the solution it offers.



The lowest cost solution combines the MC13191 with a low-end HC(S)08 MCU. The software is a PHY layer toolset we call Simple MAC, or SMAC. From this toolset the wireless designer can create simple MAC and Network functionality along with their application in as little as 4 k code space. SMAC provides a number of radio control primitives making basic transceiver operation simple.

Code examples for a number of useful applications are provided in ANSI C. Essentially, any embedded systems engineer can become a wireless embedded designer with this example code.

The solution is flexible and can be made as simple or sophisticated as desired for the application. The software is easily ported to the MCU of choice so long as that MCU has an SPI interface.

To summarize, this solution is best for simple point-to-point or point-to-multipoint wireless applications requiring low power and low memory.

After you have viewed all three pages by clicking the three buttons at the top of the screen, click the forward arrow to advance to the next page.

# Scaleable Approach to 802.15.4 / ZigBee

Click each button to learn about the solution it offers.

Simple Wireless  
Connectivity Solution

802.15.4 Solution

ZigBee Solution

**IEEE 802.15.4 Standards-Based Proprietary**

## Hardware Features

- 802.15.4 PHY Compliant
  - MC13192/3 Transceiver
  - Supports Packet and Streaming Mode
  - Compliant to all RF Specs
- Targets the HCS08GT60

## Target Applications

- Custom/Proprietary NWKs
- Robust Communication & Timing Critical Protocol
- NWK Standard not needed
- Interoperability not needed

## Software Features

- 802.15.4 MAC Compliant
  - Standardized Communication Protocol
  - Supports Beaconed and Non-Beaconed NWKs
  - GTS, 128 AES Encryption
  - Co-existence Mitigation Algorithm CSMA-CA
  - Mesh & Clustertree NWKs
- Option to Remove Unnecessary Features to reduce code size
- Provided in Object Code

802.15.4 MAC

802.15.4 PHY

HCS08

MC13192

If more sophisticated MAC functionality is required, the designer may find that time can be saved by moving up to Freescale's IEEE 802.15.4 compliant solution. With this solution, all the features of 802.15.4 are available and standardized. The features include acknowledgement, beaconed networks, commands frames, security, and guaranteed time slots.

This solution, being standards based, requires the timing advantages available in the MC13192 or 193. A mid to high end HC(S)08 MCU with 32 to 64 k memory is also required making this a somewhat more expensive solution.

This solution is well suited to proprietary applications requiring the MAC features mentioned and support for proprietary star, tree or mesh networking.

After you have viewed all three pages by clicking the three buttons at the top of the screen, click the forward arrow to advance to the next page.

## Scaleable Approach to 802.15.4 / ZigBee

Click each button to learn about the solution it offers.

Simple Wireless  
Connectivity Solution

802.15.4 Solution

ZigBee Solution

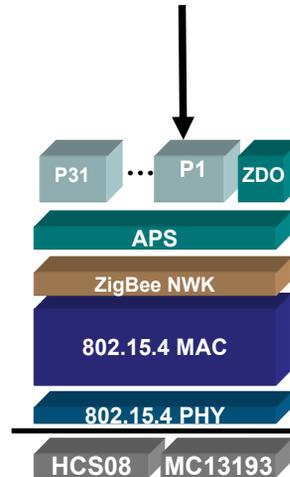
### Fully Embedded ZigBee

#### Features

- ZigBee Compliant Platform
- Complete Wireless Networking Standard – from Antenna to API
- Wireless Embedded or Dongle Options

#### Target Applications

- Mesh & Clustertree NWKs
- Established Routing Algorithm
- Network Recovery and Healing
- Device Interoperability



The MC13193 plus Z-Stack software provides ZigBee compatible wireless networks, taking full advantage of the network management and application environment defined by the ZigBee Alliance.

This solution requires the MC13193 and a high-end HC(S)08 MCU. Code size with application is 50 – 60 kbytes. While the most costly of the three solutions, it is also the most sophisticated. It targets applications where interoperability, mesh networking, or ZigBee logo certification are required.

After you have viewed all three pages by clicking the three buttons at the top of the screen, click the forward arrow to advance to the next page.

## MC1319x Pricing and Availability

Feature	MC13191	MC131912	MC13193
Availability	Now	Now	Now
802.15.4 PHY/MAC in object code for HCS08 MCU	NA	Yes	Yes + ZigBee Stack in object code
MC1319xFC	Bulk part with 490 per tray	Bulk part with 490 per tray	Bulk part with 490 per tray
MC1319xFCR2	Tape and Reel with 2500 per reel	Tape and Reel with 2500 per reel	Tape and Reel with 2500 per reel
SRP per 10K units	\$2.28 MPQ	\$2.70 MPQ	\$3.26 MPQ

Here's a summary of the MC1319X family of transceivers, their application, orderable part numbers and 10,000 unit pricing. Both tray and tape and reel packaging are available. Note again the use of the MC13192 with 802.15.4 MAC and MC13193 with Z-Stack.

## Question

**When is it most appropriate to use each of the ZigBee family solutions? Select all that apply and then click Done.**

If MAC functionality is desired but full ZigBee networking is not, use the MC13192 and Freescale's 802.15.4 compliant MAC.

Use the MC13193 along with the Z-stack, which runs on top of the 802.15.4 MAC, for the most sophisticated solutions. This approach allows full use of ZigBee networking and tools to help with application and profile development.

For simple point-to-point or star network applications, the MC13191 or MC13192 can be used with Freescale's SMAC.

If MAC functionality is desired but full ZigBee networking is not, use the MC13191 and Freescale's SMAC.

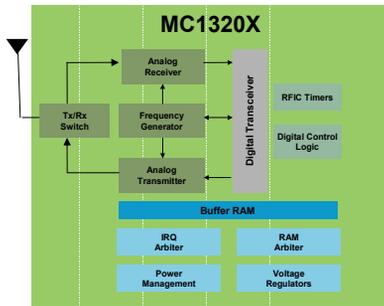
Done

When is it most appropriate to use each of the ZigBee family solutions?

Correct.

For simple point-to-point or star network applications, the MC13191 or MC13192 can be used with Freescale's SMAC. If MAC functionality is desired but full ZigBee networking is not, use the MC13192 and Freescale's 802.15.4 compliant MAC. Finally, use the MC13193 along with the Z-stack, which runs on top of the 802.15.4 MAC, for the most sophisticated solutions. This approach allows full use of ZigBee networking and tools to help with application and profile development.

## MC1320X Overview



- Software compatible to the MC1319X

- Proprietary Applications using SMAC
- IEEE® 802.15.4 Compliant Modem
- ZigBee Compliant Platform

- Availability

- Samples: Q4 2005
- Production: Q1 2006

Overview	2.4 GHz Transceiver with integrated Tx/Rx switch
RF Component Count (No Controller)	9 external components: 6 caps, 1 inductor, 1 balun, 1 crystal
Network Support	Point-to-Point, Star, Cluster Tree and Mesh
Low Power Modes	Off, Hibernate, Doze, Idle
Sensitivity	Up to -92 dBm
Power Output	-27 dBm to +4 dBm
Operating Voltage	2.0 to 3.4 V
Operating Temp	-40° to +85°C
Package	5x5x1 32-pin QFN (Meets RoHS requirements)

Now let's move to Freescale's second generation ZigBee compliant platform: The MC13200 series is an updated 2.4 GHz transceiver with an optional on-chip transmit/receive switch.

While the specifications and features remain the same, the integrated Transmit/Receive Switch can result in fewer off-chip components. Note that the package is the same as in the MC1319X family.

To make the MC13200 family easy to use, it is toolset and software compatible with the MC1319X solutions. SMAC is still usable for proprietary applications, Freescale's MAC for 802.15.4 compliant applications, and Z-Stack for ZigBee compliant applications. MCU flexibility is the same as with the MC1319X family.

First samples of the MC13200 family are available at the end of 2005. Production release is in Q1 2006.

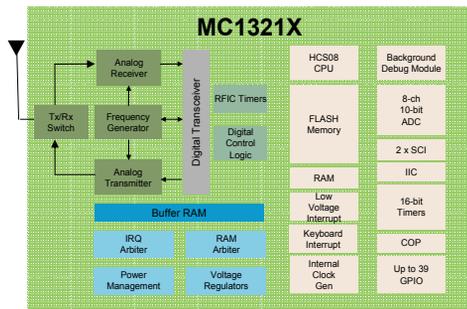
## MC1320x Pricing and Availability

Feature	MC13201	MC13202	MC13203
Availability	Samples Q405 Production Q106	Samples Q405 Production Q106	Samples Q405 Production Q106
Support	Simple MAC (SMAC)	SMAC & IEEE 802.15.4 MAC	SMAC, IEEE 802.15.4 MAC & Figure 8 Wireless Z- Stack
MC1320xFC	Bulk part	Bulk part	Bulk part
MC1320nFCR2	Tape and Reel	Tape and Reel	Tape and Reel
SRP per 10K units	\$2.35	\$2.75	\$3.28

**All Prices are budgetary and subject to change**

Here is a summary of the MC13200 series pricing and orderable part numbers. Note that, as with the MC1319X series, part numbers are paired with software solutions starting with the MC13201 paired with SMAC, moving up to MC13202 targeting our IEEE 802.15.4 MAC and finishing with MC13203 and Z-Stack. Prices listed are budgetary and subject to changes.

## MC1321X Overview



- Software compatible to the MC1319X
  - Proprietary Applications using SMAC
  - IEEE® 802.15.4 Compliant Modem
  - ZigBee Compliant Platform
- Availability
  - Samples: Q4 2005
  - Production: Q1 2006

<b>Overview</b>	2 <sup>nd</sup> Generation ZigBee platform with 2.4 GHz Transceiver and MC9S08GT Family 8-bit MCU
<b>Component Count</b>	10 external components: 7 caps, 1 inductor, 1 balun, 1 crystal
<b>Network Support</b>	Point-to-Point, Star, Cluster Tree and Mesh
<b>Sensitivity</b>	Up to -92 dBm
<b>Power Output</b>	-27 dBm to +4 dBm (software selectable)
<b>Memory</b>	Up to 60 KB FLASH, 4 KB RAM
<b>Low Power Modes</b>	4-RF (Off, Hibernate, Doze, Idle) and 4-MCU (Run, Wait, STOP2, STOP3)
<b>I/O</b>	Up to 39 GPIO, 8-channel 10-bit ADC, 9 Timers, 2 SCI, IIC, LVI, ICG, COP
<b>Operating Volt.</b>	2.0 to 3.4 V
<b>Operating Temp</b>	-40° to +85°C
<b>Package</b>	9x9x1 mm 71-pin LGA Meets RoHS requirements

The MC13210 series combines the world-class HC(S)08 GT family with MC13200 series 2.4 GHz transceiver to form a System in a Package, or SiP. This interim step on the path to a full single chip solutions has the advantage of reduced application cost through reduced component count and board space as compared to the first generation solution. Note the MC13210 family shares the key features with our first generation solutions and simply improves the ease of use. The MC13210 family is housed in a 9 by 9 mm 71-pin LGA package.

As with the MC13200 family, the MC13210 series is fully compatible with first generation tools and software.

The MC13210 series is available as samples at the end of 2005 and in production quantities in the first quarter of 2006.

## MC1321x Pricing and Availability

Feature	MC13211	MC13212	MC13213	MC13214
<b>Availability</b>	Samples Q405 Production Q106	Samples Q405 Production Q106	Samples Q405 Production Q106	Samples Q405 Production Q106
<b>Support</b>	Simple MAC (SMAC)	SMAC & IEEE 802.15.4 MAC	SMAC & IEEE 802.15.4 MAC	SMAC, IEEE 802.15.4 MAC & Figure 8 Wireless Z- Stack
<b>MC1321xFC</b>	Bulk part	Bulk part	Bulk part	Bulk part
<b>MC1321nFCR2</b>	Tape and Reel	Tape and Reel	Tape and Reel	Tape and Reel
<b>SRP per 10K units</b>	\$3.61	\$3.94	\$4.32	\$4.85

**All Prices are budgetary and subject to change**

Here is a summary of the pricing, availability, and orderable part numbers for the MC1321X series. Note the alignment with software solutions, which includes scaling of flash memory size appropriate for each solution. There are two options for use with our 802.15.4 MAC software: The MC13212 with 32k of flash and MC13213 with 60k of Flash. MC13214 also has 60k of flash but includes the production use of Z-Stack ZigBee software stack.

## ZigBee Family Comparison

	MC13192	MC13202	MC13213
<b>Package Size</b>	25 mm <sup>2</sup> 5x5x1 mm	25 mm <sup>2</sup> 5x5x1 mm	81 mm <sup>2</sup> 9x9x1 mm
<b>8-bit MC9S08GT60 Package Size</b>	49 mm <sup>2</sup> 7x7x1 mm	49 mm <sup>2</sup> 7x7x1 mm	Internal
<b>Platform External Part Count for 50ohm Single-Ended Output (antenna not included)</b>	17 (includes MCU & bypass cap)	11 (Includes MCU & bypass cap)	10 (includes bypass cap)
<b>Integrated Tx/Rx Switch</b>	No	Yes	Yes
<b>Sensitivity</b>	-92 dBm	-92 dBm	-92 dBm
<b>Total Solution Size (antenna not included)</b>	300 mm <sup>2</sup>	250 mm <sup>2</sup>	200 mm <sup>2</sup>
<b>Silicon Cost (2006 10K SRP)</b>	\$6.10	\$6.28	\$4.32
<b>External Component Cost (antenna not included)</b>	\$1.06	\$0.77	\$0.77

Here is a comparison chart of our first and second generation solutions. In this case, we've chosen a full-featured IEEE 802.15.4 MAC solution.

Focusing on component count, look at our first generation solution of Transceiver plus MCU. This solution requires 17 components other than the MCU.

Moving to our second generation transceiver solution, only 11 components, including the MCU, are required. While this solution is slightly more expensive in terms of silicon cost, board space and complexity are reduced which results in lower cost.

Finally, moving to our SiP solution, which includes the GT60 die, component count and silicon cost are reduced making this the lowest cost implementation.

So why do we continue to offer a stand-alone transceiver when the SiP solution clearly has a cost benefit? Because the integrated solution may not be suitable for all applications. The stand-alone transceiver still offers the flexibility of interface with any MCU that will support the software.

## Question

**Which of the following are features of Freescale's Second Generation ZigBee compliant platform? Select all that apply and then click Done.**

An updated transceiver that offers reduced off-chip component count.

A one-size-fits-all System in a Package that can be applied to all ZigBee related applications.

A family of System in a Package devices which scale from 16kbytes of flash memory for SMAC applications up to 60kbytes of flash for high-end MAC and ZigBee applications.

New software stacks to compensate for the lack of backwards software compatibility.

Done

Which of the following are features of Freescale's second generation ZigBee family solutions?

Correct.

Our second generation solution offers an improved transceiver chip and a family of System in a Package devices with flash sizes appropriate for SMAC, MAC and ZigBee applications. This second generation supports the same software options as the first generation making migration simple.

## 1319x Development Tools

Feature	13192DSK 13192DSK-BDM	13193EVB 13193EVB-BDM	13193EVK 13193EVK-SFTW	FSL-ZB-SNF
13192-SARD	2	N/A	2	N/A
13192-EVB	N/A	2	3	N/A
1319x Development Kit Software	Yes	Yes	Yes	N/A
CodeWarrior IDE	Special Edition	Special Edition	Special Edition, Standard Edition (1321x EVK-SFTW only)	N/A
F8 Z-Stack Software Suite	90-day Eval	90-day Eval	90-day Eval, Full Version (1321x EVK-SFTW only)	N/A
ZigBee Packet Analyzer Hardware	No	No	Yes	Yes
Daintree Basic Protocol Analyzer	No	No	Yes	Yes
Out-of Box Application	Sensor Application Demo	Range Test Demo*	ZigBee Application Network Demo*	N/A
Price	\$199 – 13192DSK \$299 – 13192DSK-BDM	\$499 – 13193EVB \$549 – 13193EVB-BDM	\$1499 – 13193EVK \$2999 – 13193EVK-SFTW	\$495

World-class tools are essential for any embedded systems design. Freescale has lead the industry in price and performance for ZigBee tools by listening to our customers. To provide such a flexible offering, our evaluation kit offering for our first generation platform has grown from two at our launch in 2003 to seven today.

Our economical 13192DSK provides an economical way to get started with 802.15.4-based applications. The original basic kit is still available but we now have a version available with the Background Debug Module, or BDM, required for full functionality of the CodeWarrior IDE, and an EVK with all software licenses included.

By popular demand, we have added an EVB kit which includes two of our superior range EVB evaluation boards. Versions are available with and without the BDM.

Our award-winning EVK is still available but we have added a version which includes software and tool licenses. Pricing is \$2000 less than the equivalent from the competition, thus reducing the cost of entry into ZigBee.

Finally, our packet sniffer hardware is now offered on a stand-alone basis. This essential piece of network debug hardware with evaluation licenses for PC based software was previously available only in the EVK.

## MC13192 Developers Starter Kit

- Affordable demonstration system
- SMAC and IEEE 802.15.4 network development
- 2 Sensor Applications Reference Boards (SARD)
  - Based on Freescale's MC13192 and MC9S08GT60 MCU
  - Integrated X-Y and Z-axis acceleration sensors (MMA6261Q, MMA1260D) with Accelerometer Demo
  - LEDs and switches for demonstration monitoring and control
  - Onboard Background Debug Module port for MCU flash reprogramming and in-circuit hardware debugging
  - RS-232 port for monitoring and Flash programming
  - Dual printed antenna reference design
    - Range approximately 125m line-of-sight
- SMAC Source Code and Sample Apps
- Also usable for MAC and Z-Stack
- BDM version includes USB Multilink BDM Programmer/Debugger
- Includes CodeWarrior™ Development Studio for HCS08 Special Edition
- IEEE 802.15.4 Object Code and Test Tools
- Power Adapters, Batteries and Cables
- Orderable part number:
  - 13192DSK-A00: Suggested resale: \$199
  - 13192DSK-BDM-A00: Suggested resale \$299



Let's review in detail several of the kits available to support our first generation platform and the board level hardware they include.

The Developers Starter Kit, or DSK, is an ideal development system for observing the capabilities of the MC13191 plus SMAC or 802.15.4 plus MC13192 solutions.

The Kit includes two Sensor Applications Reference Design boards, or SARDs. The SARD design includes the MC13192 transceiver and the MC9S08GT60 MCU, and integrated X-Y, and Z-axis acceleration sensors. The MCU comes preprogrammed with a sample application that tracks the positioning of the board by using the sensors. It reports that information to a GUI that resides on a PC. The sensors can be disabled via jumpers for development of applications not needing this feature.

The design also includes LEDs. Switches are also provided for visual and manual monitoring of applications. A Background Debug Module port is provided for programming and debug and an RS-232 port for monitoring and Flash programming.

The SARD has a printed folded dipole antenna which provides 125 meter range, line-of-sight. This low-cost implementation requires a minimum number of off-chip components to create a functional wireless node. Gerber format files are available for the SARD for use as a design starting point.

Through downloadable SMAC sample applications, the capabilities of the MC1319X series of Transceivers can be explored. This is useful in understanding the capabilities of the 2.4 GHz version of the 802.15.4 PHY. The hardware can also be used for 802.15.4 MAC or Z-Stack and it represents cost effective nodes for experimental network deployment.

Tools are also included. The kit also includes CodeWarrior Special Edition IDE which is adequate for work with SMAC. Reasonably priced upgrades are available with support the MAC and Z-Stack software. The BDM version of the kit includes the BDM programming hardware. Freescale's 802.15.4 test tools are downloadable and may be used with the kit.

All the batteries, power supplies and cables required for experimentation are included.

## MC13193 Evaluation Board Kit

- Affordable demonstration system for SMAC, MAC and ZigBee Z-Stack network development
- 2 Evaluation Board (EVB)
  - Based on Freescale's MC13192 and MC9S08GT60 MCU
  - Optimized antenna implementation using single printed-F antenna
  - Optional LNA to increase sensitivity
  - SMA connector for RF measurement
  - LEDs and switches for demonstration monitoring and control
  - Onboard Background Debug Module port for MCU flash reprogramming and in-circuit hardware debugging
  - RS-232 and USB port for monitoring and Flash programming
  - Range approximately 600 line-of-sight
- USB Multilink BDM Programmer/Debugger
  - 13193EVB-BDM-A00 only
- Includes CodeWarrior™ Development Studio for HCS08 Special Edition
- IEEE 802.15.4 Object Code and Test Tools
- Power Adapters, Batteries and Cables
- Orderable part number:
  - 13193EVB-A00: Suggested resale \$499
  - 13193EVB-BDM-A00: Suggested resale \$549



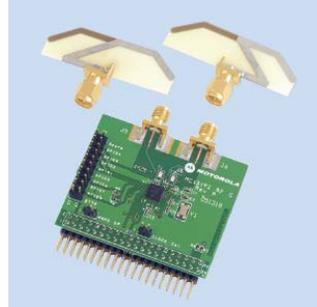
By popular demand, we have created a developers starter kit with our superior performance Evaluation Boards or EVBs. This kit is appropriate for development with any of our scaleable software solutions. It can also be used to provide extra boards for development.

The EVB board includes a small form factor reference design with Transceiver and MCU plus an "F" antenna which gives up to 600 meters line-of-site range. An optional LNA design is included on the board. The F antenna and the associated RF design are the focus of this board design and the source of the exceptional range. The design also includes an SMA connector for measurement of the radio and multiple I/Os from the MCU. Both RS-232 and USB ports are included for flexible interface with computer hardware. Gerber format files are available for the board design.

As with the Developer's Starter Kit, CodeWarrior IDE Special Edition is included, as is the Background Debug Module in the BDM version. The 802.15.4 Test Tools are downloadable and supported. The required batteries, power adapter and cables are also included.

## MC13192 RF Daughter Card Kit

- Ideal for thorough RF evaluation or external customer antenna development
- Plug-in directly to M68EVB908GB60 Development board or other Freescale MCU development systems
- MC13192 RF Daughter Card
  - Includes the MC13192 2.4Ghz Transceiver
  - IEEE 802.15.4 PHY compliant
  - Dual antenna design
  - Range approximately 300m line-of-sight
- All software examples include GB60 boards as a target
- 1 daughter card and 2 antenna boards per kit
- Suggested resale: \$149
- Orderable part number: 13192RFC-A00



The MC13192 RF Daughter card is ideal for thorough RF characterization of the transceiver and for interface with MCUs development boards. The board is designed to interface directly with the HC(S)08 development board but it can be adapted to just about any other MCU. This makes it appropriate for initial interface and control development prior to the development of a transceiver plus MCU board.

The board design includes the MC13192 transceiver and associated RF circuitry. The MCU interface is brought out to a 40-pin header. With the provided dipole antennas attached, range is approximately 300 meters. However, the board lends itself to external antenna evaluation and development. The board contains SMA connectors which can be used to interface directly to laboratory equipment such as a network analyzer.

The RF Daughter card supports all Freescale SMAC, MAC and Z-Stack software stacks with the GB60 Development Board as the target.

The kit contains one transceiver board and two detachable dipole antennas.

## MC13193 Evaluation Kit

- Complete IEEE 802.15.4 and ZigBee™ Hardware and Software Development System
- Five 2.4GHz wireless nodes based on the Freescale ZigBee-compliant platform
  - 3 EVBs with Printed single ended F-antenna, USB and RS-232 interface
  - 2 SARDs with Integrated X-Y and Z-axis acceleration sensors and printed dipole antenna, RS-232 interface
- Supports all Freescale's ZigBee Compliant Platform software stacks:
  - SMAC Source and Sample Apps
  - IEEE 802.15.4 Object Code and Test Tools
  - Z-Stack ZigBee protocol stack sample apps and utilities
- 90 day eval license for Z-Stack
- Includes CodeWarrior™ Development Studio for HCS08 Special Edition
- Full Software Licenses (Z-Stack and CodeWarrior) with -SFTW version
- Freescale's 802.15.4 Packet Sniffer with eval software from Daintree and Frontline
- Power adapters, batteries and cables
- Suggested resale:
  - 13193EVK-A00 \$1499
  - 13193EVK-SFTW \$2999



The MC13193 Evaluation Kit, or EVK, is our award winning full-feature development kit. Included is everything a developer needs to get started with Freescale's ZigBee Compliant Platform.

The kit contains 3 SARDs and 2 EVBs with the features previously mentioned.

The kit can be used for development with any of Freescale's ZigBee Compliant Platform software stacks from SMAC through Z-Stack. With the five included boards, full network functionality with routers and end devices can be demonstrated.

CodeWarrior Special Edition is included as well as a 90 day evaluation license for Z-Stack. With the -SFTW version, CodeWarrior Standard Edition and one Z-Stack seat are included. Even with the software licenses, Freescale's EVK is \$2000 cheaper than the nearest competitor.

Also included is Freescale's 802.15.4 Packet Sniffer hardware and an evaluation licenses for Daintree and Frontline packet analyzer software. These tools are indispensable for debugging network applications.

## 1321x Development Kits

- 2nd generation development hardware Based on MC13213 ZigBee-compliant 2.4GHz SiP
- 13213-SRB (Sensor Reference Board)
  - Temperature Sensor
  - MMA7260Q 3-axis Acceleration Sensor
- 13213-NCB (Network Coordinator Board)
  - LCD for demonstration messaging
  - RS-232 and USB interface
- Printed F antenna
- Connections for battery or external power supply
- Onboard expansion capabilities for external application-specific development activities
- LEDs and switches for demonstration monitoring and control
- Scalable Software support for easy development of customer specific network topologies
- USB Multilink BDM Debugger/Programmer (-BDM kits only)



13213-NCB

New hardware with new features is available for support of Freescale's Second Generation platform based on the MC13213 SiP.

The new boards focus on network functions with two basic designs. The Sensor Reference Board or SRB targets end device functionality. This board builds on the first generation SARD hardware with end device functionality including an integrated temperature sensor and Freescale's new integrated three-axis accelerometer, MMA7260Q. The sensors can be disabled to allow lowest power development and measurements.

The Network Coordinator Board is full-featured and includes an LCD display to allow messaging. Both USB and RS-232 interfaces are provided. The NCB can also function as a router.

Features common to both boards include our high-performance printed F antenna, connections for battery or external power, headers for interface to MCU I/O blocks and LEDs, and switches for demonstration and debugging. These features make these boards scaleable and adaptable for just about any application.

As with the MC13193 kits, versions are available with and without BDM hardware.

## 1321x Development Tools

Feature	1321x-DSK 1321x-DSK-BDM	1321x-NSK 1321x-NSK-BDM	1321x-EVK 1321x-EVK-SFTW
13213-SRB (boards per kit)	2	2	4
13213-NCB (boards per kit)	N/A	1	3
1321x Development Kit Software	Yes	Yes	Yes
USB Cables per kit	2	3	7
CodeWarrior IDE	Special Edition	Special Edition	Special Edition, Standard Edition (1321x EVK-SFTW only)
F8 Z-Stack Software Suite	90-day Eval	90-day Eval	90-day Eval, Full Version (1321x EVK-SFTW only)
ZigBee Packet Analyzer Hardware	No	No	Yes
Daintree Basic Protocol Analyzer	No	No	Yes
Out-of Box Application	Sensor Application Demo	Range Test Demo	ZigBee Application Network Demo
Price	\$249 – 1321x-DSK \$349 – 1321x-DSK-BDM	\$449 – 1321x-NSK \$549 – 1321x-NSK-BDM	\$1499 – 1321xEVK \$3299 – 1321xEVK-SFTW

Here is a summary of the kits available for Freescale's second generation platform. As with our first generation kits, the range will fit most every need starting at the low end where the focus is providing several boards a reasonable cost for the high end EVK where everything required will be in the box. Each kit includes pre-loaded out-of-box applications as a starter demo.

The Developer's Starter Kits includes two SRBs and it is a cost effective way to get started with our second generation platform. All the appropriate cables and adapters are included as are CodeWarrior Special Edition and an evaluation versions of Z-Stack. Both BDM and non-BDM versions are available.

The Network Starter Kits include three boards to allow basic networking. One NCB and two SRBs are included. All the appropriate cables and adapters are included as are CodeWarrior Special Edition and an evaluation versions of Z-Stack. Both BDM and non-BDM versions are available.

The full-featured EVK includes seven boards and everything needed for do ZigBee development. The SFTW version also includes CodeWarrior Standard Edition and Z-Stack licenses.

## Question

Match the development kits with its description:

- |                            |                             |                                       |   |
|----------------------------|-----------------------------|---------------------------------------|---|
| <input type="checkbox"/> A | Developer Starter Kit - DSK | <input checked="" type="checkbox"/> C | Full Featured Kit with 5 to 7 boards, and everything needed for full ZigBee development |
| <input type="checkbox"/> B | Evaluation Board Kit - EVB  | <input checked="" type="checkbox"/> A | Low-cost kit which allow basic evaluation of ZigBee technology                          |
| <input type="checkbox"/> C | Evaluation Kit - EVK        | <input checked="" type="checkbox"/> B | Special starter kit with two evaluation boards, EVBs, with superior RF performance      |

Done

Reset

Show  
Solution

Let's see how well you've understood the kinds of development hardware available for Freescale's ZigBee Compliant Platform. Match the letter of the Kit with the best description.

Correct:

The DSK is a low-cost starter kit for introduction to ZigBee technology. The EVB kit contains two EVBs with superior RF performance. The EVK is used for full embedded development.

## Module Summary

- ZigBee architecture
- Freescale's First Generation Platform
  - 2.4 GHz transceiver plus HCS08 line of 8-bit MCUs
- Freescale's scalable solutions:
  - Proprietary 2.4 GHz low data rate
  - IEEE 802.15.4 standard-based
  - ZigBee
- Freescale's Second Generation Platform
- Development Tools

In this course, you learned about Freescale's ZigBee product offering. Freescale's approach to the ZigBee architecture is to split the hardware and software at the PHY Layer.

Freescale's first generation ZigBee compliant platform was presented. This scaleable platform is based on the three versions of a 2.4 GHz Transceiver design with a fully integrated 802.15.4 packet modem that interfaces through SPI to MC(S)08 MCUs. The MC13191 targets simple, low-cost applications where star or point-to-point networking are acceptable. The MC13192 also performs in proprietary star and point-to-point applications, and it supports the Freescale 802.15.4 MAC. MC13193 supports Z-stack as well as the other software options.

You also learned about Freescale's three scalable solutions based on ZigBee technology: Proprietary 2.4 GHz low data rate, IEEE 802.15.4 standard-based, and ZigBee. With proper choice of transceiver and MCU, all three can run on the same PC layout.

You learned about Freescale's second generation platform where the ICs are combined in one package, thus creating a system in a package. This second generation will allow smaller, more cost effective solutions and will support the same software.

You were also presented with the wide variety of development tools available from Freescale. These range from low-cost starter kits to full-featured development kits.