

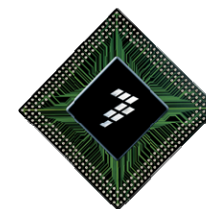


Freescal Technology Forum

Collaboration. Innovation. Inspiration.

July 2009

Introduction to ZigBee® RF4CE



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Freescal Wireless Connectivity Marketing and Applications Manager

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Home Entertainment Control

Today with IR	Today with RF
<ul style="list-style-type: none"> ▶ Line of sight transmission <ul style="list-style-type: none"> • Decades-old technology • Short transmission distance • Many consumers want devices hidden ▶ Field of vision limitations <ul style="list-style-type: none"> • Remote needs to be pointed at IR receiver 	<ul style="list-style-type: none"> ▶ No line-of-sight or field of vision limitations <ul style="list-style-type: none"> • Control components behind walls or in cabinets • Control over extended ranges
<ul style="list-style-type: none"> ▶ Unidirectional unacknowledged transfers <ul style="list-style-type: none"> • Unreliable communication • Cannot send information to remote control or between components (DTV, set top box, etc.) 	<ul style="list-style-type: none"> ▶ Bi-directional capability <ul style="list-style-type: none"> • Reliable communications • Send program guides, playlists stock quotes, etc to remote/components • Allows for communications between devices • Over-the-air firmware updates possible • Remote locator
<ul style="list-style-type: none"> ▶ Technology Challenge <ul style="list-style-type: none"> • Plasma DTV contains high frequency inverter that obstructs IR signals • LCD back lighting saturates DTV IR receiver 	<ul style="list-style-type: none"> ▶ Faster more reliable communications <ul style="list-style-type: none"> • Transmit commands until received • Many times faster response than IR • Enables enhanced user interfaces • Touchpad or pointing capability
<ul style="list-style-type: none"> ▶ Power consumption <ul style="list-style-type: none"> • Multiple redundant transmissions for each command • Higher TX power required to avoid interference created by plasma/LCD screens 	<ul style="list-style-type: none"> ▶ 802.15.4 RF consumes 25% of the power used by IR solutions
<ul style="list-style-type: none"> ▶ Requires manufacturer-specific IR databases <ul style="list-style-type: none"> • Each product has its own commands • Requires larger memory for storing lookup tables 	<ul style="list-style-type: none"> ▶ Allows for true interoperability between vendors products

RF4CE Consortium

- ▶ Mission – Create an RF remote control standard based on IEEE 802.15.4 MAC/PHY radio technology and replace IR over next 5 years
- ▶ Founders – Panasonic, Philips, Samsung and Sony representing over 50% market share for DTV's
- ▶ Contributing Members – Freescale Semiconductor, OKI Semiconductor, Texas Instruments, NTS & TÜV
- ▶ Freescale Participation – Freescale's SynkroRF protocol became basis of RF4CE specification.
- ▶ Specification – Announced formation of Consortium on June 12th. R1.0 specification ratified in Dec 2008.
- ▶ ZigBee Alliance – RF4CE merged with the ZigBee Alliance in March. R1.0 Specification now available to ZigBee Alliance Membership.

Members
Panasonic
ideas for life

PHILIPS

SAMSUNG

SONY

freescale™
semiconductor

OKI

 **TEXAS INSTRUMENTS**

NTS

 **TÜVRheinland®**
Precisely Right.

ZigBee® RF4CE Use Cases

- ▶ CE products can now directly communicate
 - One step theater experience
 - Simply insert a DVD into player
 - TV automatically selects correct input for viewing DVD
 - Surround sound system automatically switches to DVD listening mode
 - Remote control automatically switches modes to control DVD
 - Set top box and other components not needed switch off
 - Lights dim to desired setting
 - Curtains/shades close
- ▶ Set top boxes that require phone connection can now communicate to devices that have outside connection
 - Communicate directly to internet enabled devices (TV, PC, gateway, router) for pay-per-view billing
 - Update controlled device and remote controls from outside the network
- ▶ Cellular phones interact with entertainment system
 - Overlay caller ID on DTV/set top box when call comes in
 - Automatically turn volume down on DTV/STB to talk on phone
 - Control your entertainment system from phone
 - Conduit for over the air updates
 - Gateway to cellular network

SynkroRF Adoption

- ▶ Sony Adopts RF Remote Control for New "BRAVIA".
- ▶ Sony Corp. announced 15 new models of its LCD television "BRAVIA" Aug. 29, 2007.
 - Of the 15 models release, 13 were accompanied by an RF remote control.
- ▶ Spring products announced in February 2008 and include RF control in new F, V1 & J1 Bravia LCDs.
- ▶ Currently shipping over 40 products with Freescale RF solution including DTVs, Blu-ray DVD recorders, set back boxes and HD wireless link module.
- ▶ All products use Freescale's MC13213 + SynkroRF Platform.



SynkroRF Adoption

- ▶ EchoStar adopts SynkroRF for RF control of next generation DISH Network satellite set top box.
- ▶ VIP922S Set top Box announced at CES 2009.
- ▶ State of the art user interface using touchpad technology to reduce the number of buttons and enhance the user experience.
- ▶ CES Awards
 - Best Home Video Product
 - Best Remote Control
 - Best User Interface
- ▶ VIP922S use Freescale's MC13213 + SynkroRF Platform
- ▶ Expected to be available to DISH Network subscribers in June 2009



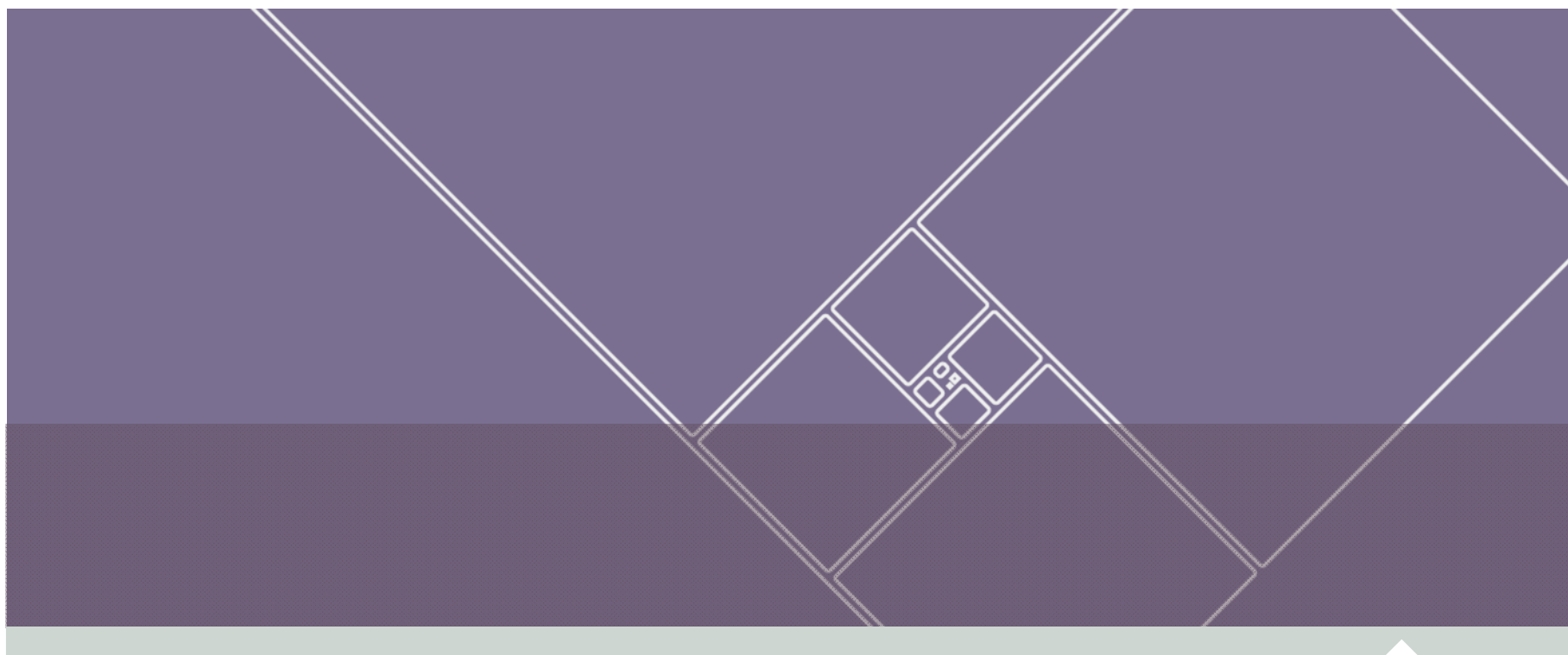
RF4CE Adoption



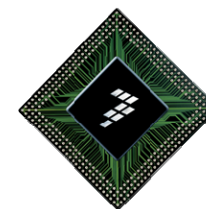
Z1's separate input/output module with integrated QAM/ATSC tuner (top) and matching wireless transmitter (left)

Panasonic Ultra-thin Z1 Series 1080p Plasma HDTV (TC-P54Z1)

- World's First RF4CE production product
- Launched in Japan in April. Expected globally in summer.
- Requires RF remote
 - DTV too thin for tuner electronics
 - Uses Wireless HD (60 GHz) to transmit uncompressed 1080p HD content
- Uses Freescale MC13213 + BeeStack Consumer (ZigBee RF4CE) Platform



ZigBee RF4CE Architecture

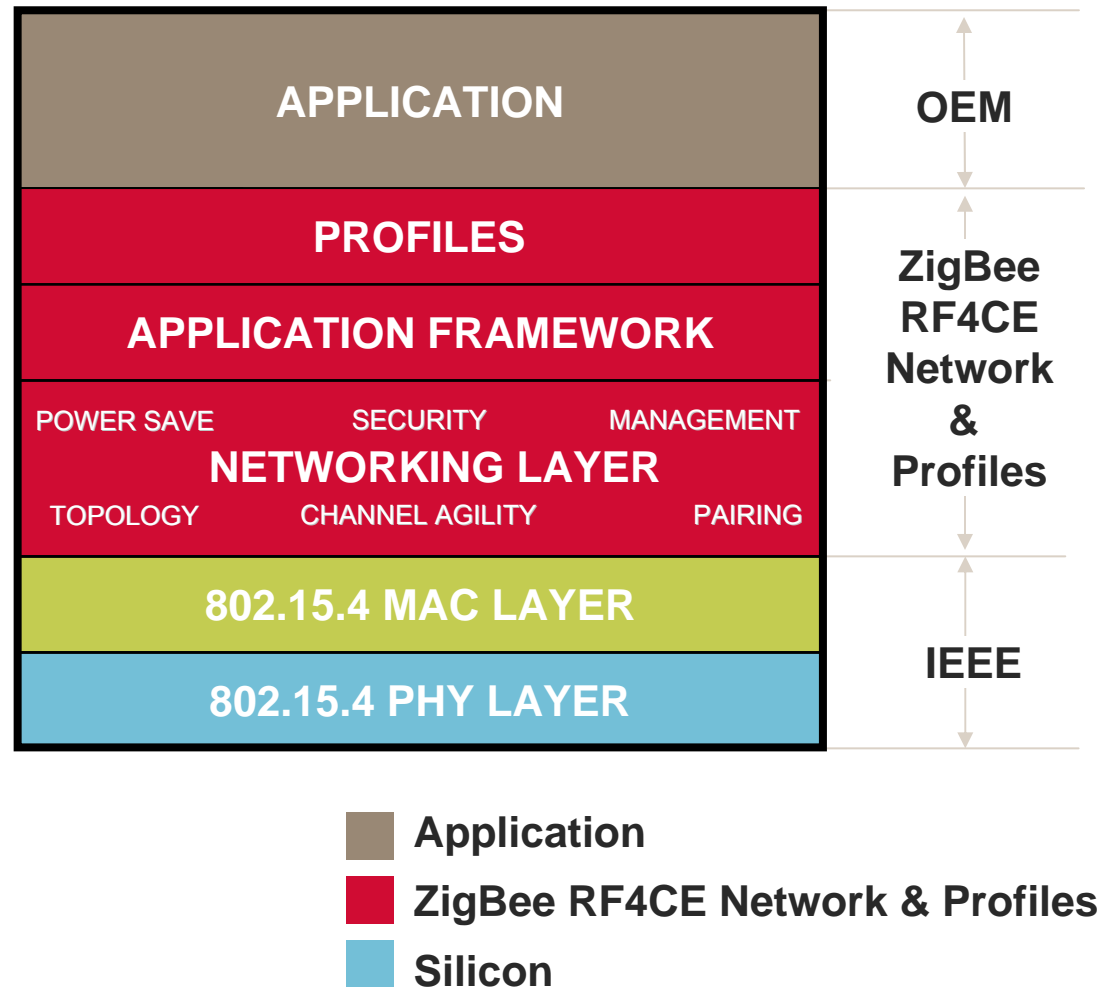


ZigBee RF4CE Overview

► ZigBee RF4CE Features:

Based on 2.4 GHz MAC/PHY IEEE 802.15.4 standard

- Networking layer is thin, flexible and future-proof
- Co-exists with other 2.4 GHz technologies
- Support for interoperability
- Support for secure communications
- Power save mechanisms implemented in network layer
- Simple and intuitive pairing mechanism
- Allow for vendor specific applications and transactions
- Support for many different applications



ZigBee RF4CE Platform

► Purpose

- Provide a standardized RF networking layer for consumer electronics products
- Emphasis on robustness and ease of use
- Essential functionality to build and support a CE network

► General Features

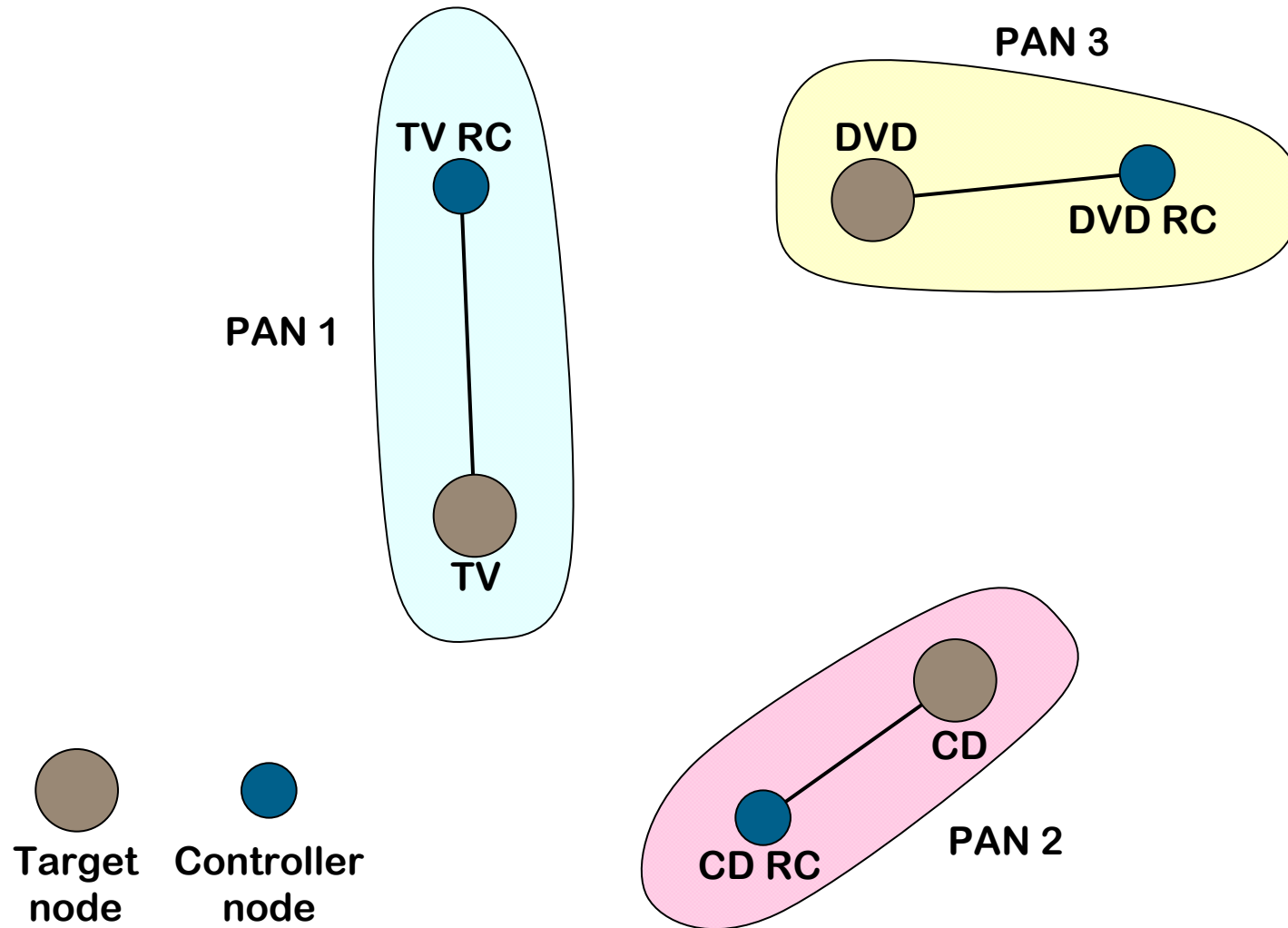
- Based on IEEE 802.15.4 – 2006 MAC/PHY standard
- Less than 40 KB code including 802.15.4 MAC, ZigBee RF4CE networking stack & CERC profile
- Supported Device types
 - Controller node
 - Target node
- Network services
 - Network Creation
 - AES 128-bit secured and non-secured Inter-device communications (2-way)
 - Power Management
- Interference avoidance
 - DSSS (provided by IEEE 802.15.4 MAC layer)
 - CSMA-CA (provided by IEEE 802.145.4 MAC layer)
 - Channel Agility

ZigBee RF4CE Platform

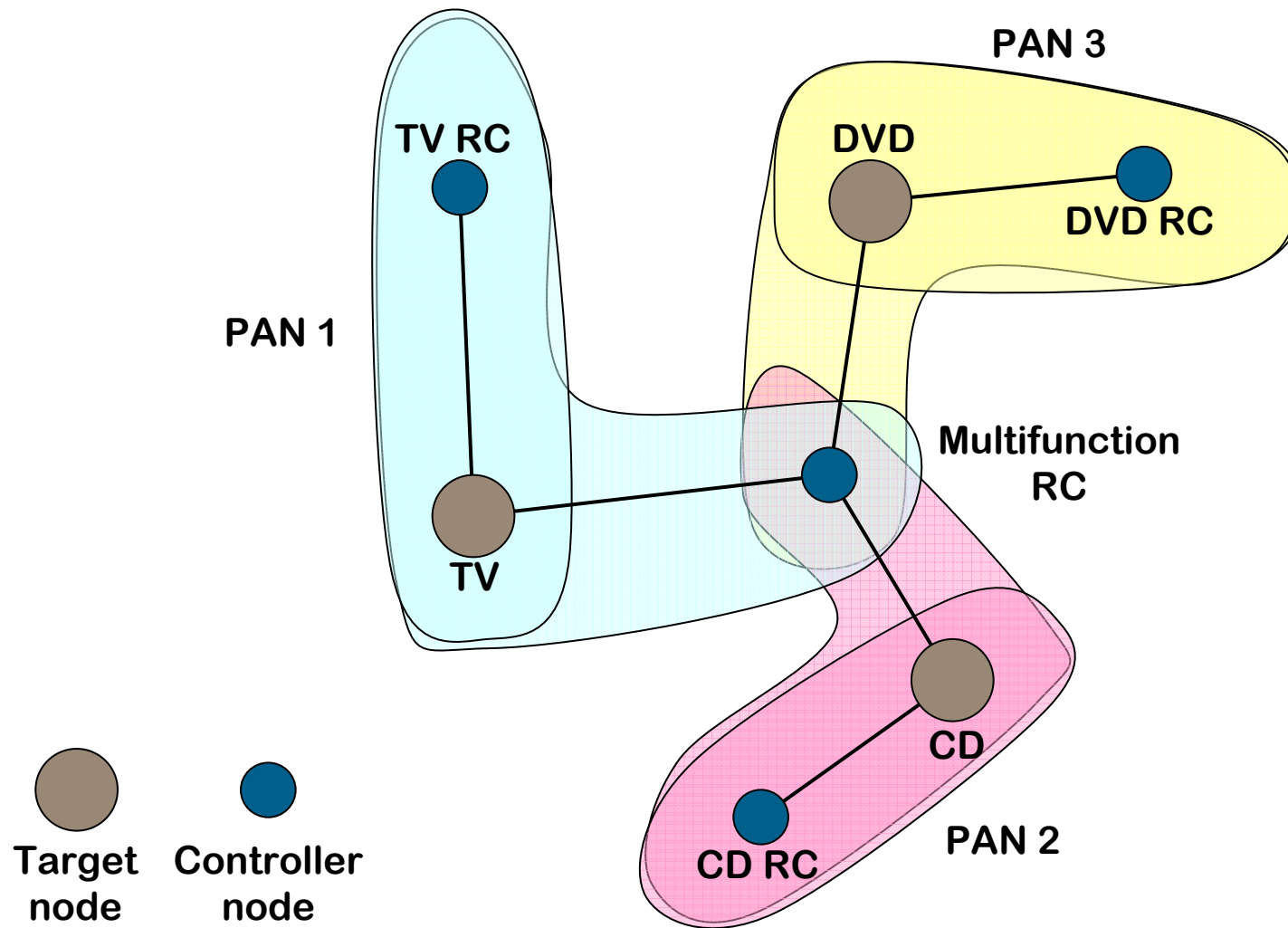
► Detailed Features

- Device initialization
 - Target devices start the network.
- Device pairing
 - Required prior to communication
 - Performed only once. Information stored in NVM.
 - Controller devices discovers available Target devices.
 - Controller devices request pairings from available Target devices.
 - Target devices accept/decline pairing requests.
 - Secure link setup during pairing process.
 - CERC Profile defines a “push button” pairing acceptance process.
- Device communications
 - Supported between paired devices only
 - Bi-directional communication
 - Transmissions can be acknowledged or non acknowledged.
 - Transmissions can be secure or unsecured.
 - Direct and broadcast addressing supported for all packets.
- Built in Power Save Mechanism to meet strict industry low power requirements

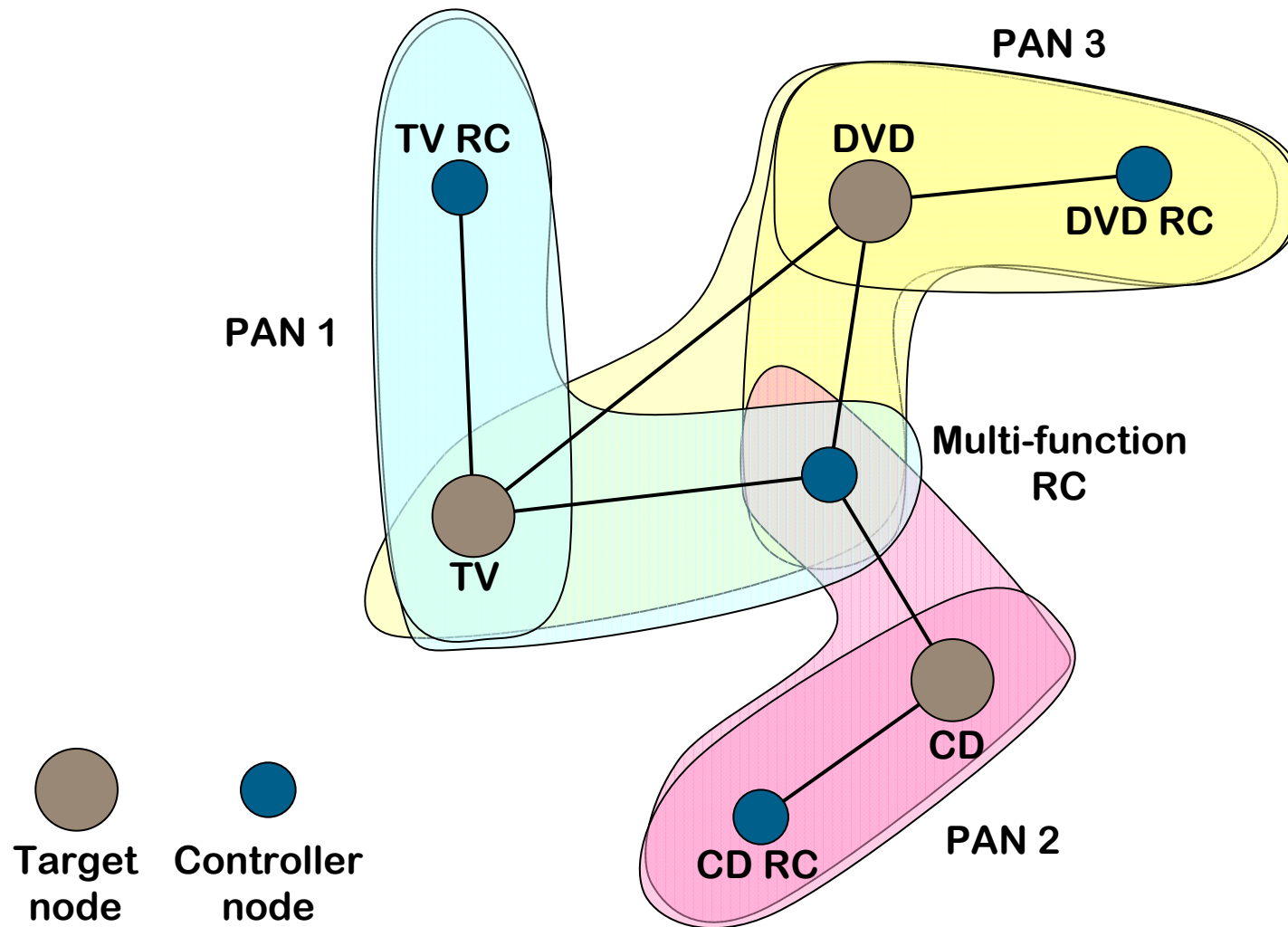
ZigBee RF4CE Network Topology



ZigBee RF4CE Network Topology



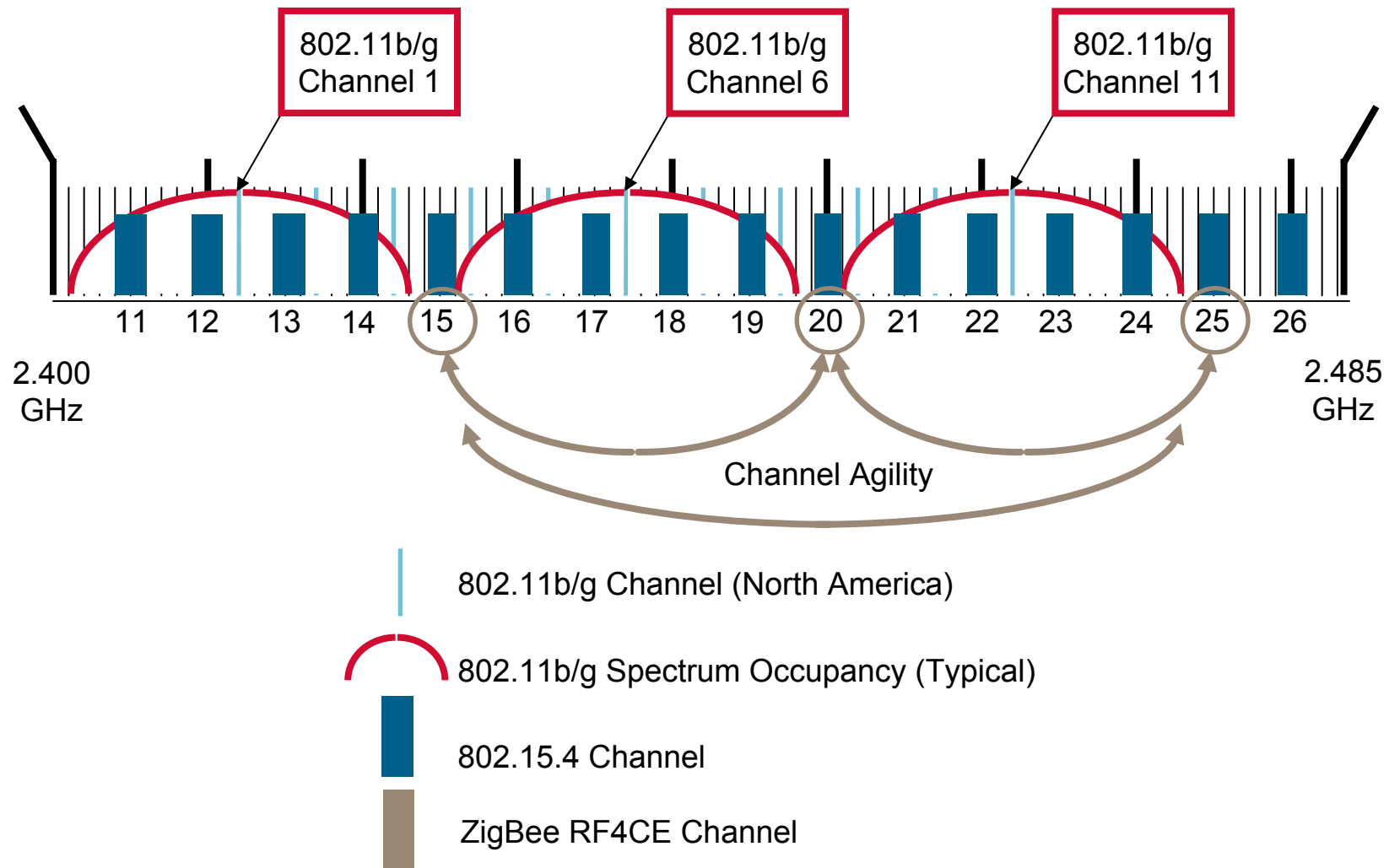
ZigBee RF4CE Network Topology

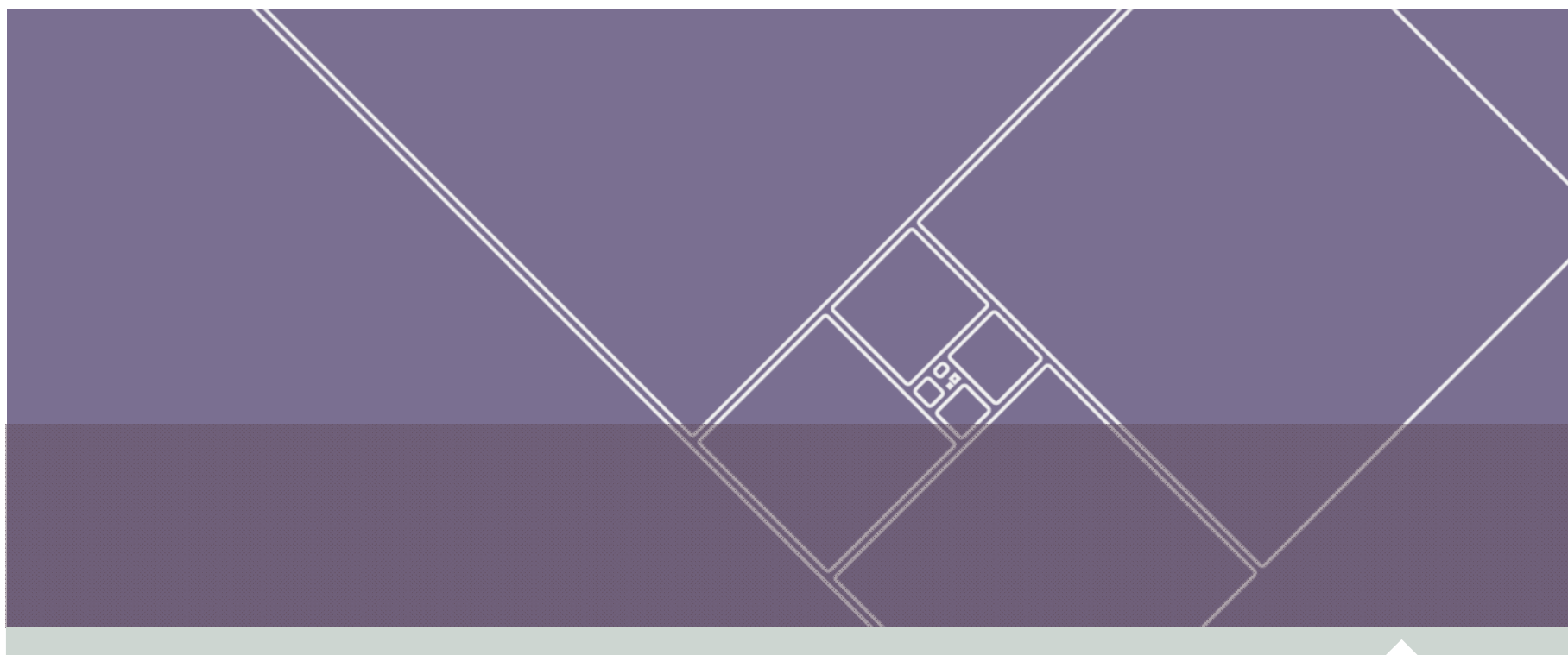


ZigBee RF4CE Channel Agility

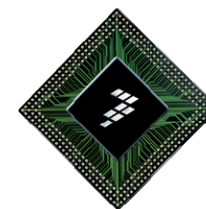
- ▶ RF4CE devices can communicate on IEEE 802.15.4 channels 15, 20 & 25.
 - Channel 15 – 2.425 GHz
 - Channel 20 – 2.450 GHz
 - Channel 25 – 2.475 GHz
- ▶ Target node selects the initial communication channel, based on start channel conditions.
- ▶ Target node can switch to another channel if surrounding environment changes.
- ▶ Each device that is paired to the Target communicates on last successful channel.
- ▶ If Target device has changed channels, the device trying to communicate will go look for Target on other RF4CE channels until communication is established.
 - Node will store new channel for Target device

ZigBee RF4CE Channel Agility





Freescal[™]'s ZigBee[®] RF4CE Supported Devices



MC1321x Overview

MCU Features

- 40 MHz HCS08 low-voltage, low-power core
- Flash and memory dependent on part
- Multiple 16-bit timers
- Up to 38 GPIO
- 8-bit port keyboard interrupt (KBI)
- 8-channel 10-bit analog-to-digital converter (ADC)
- SCI interface supporting up to 115.2 kBaud
- I2C with 100 kbps maximum bus loading
- Low-voltage detection
- In-circuit debug and Flash programming
- Common on-chip processor (COP) watchdog timer

RF Features

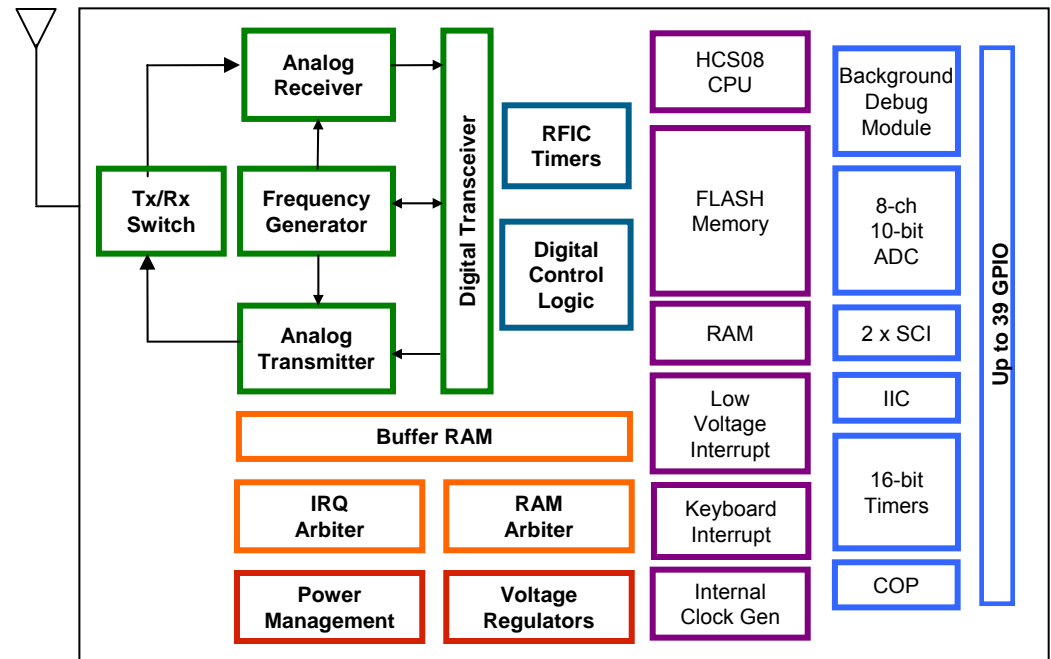
- 802.15.4 compliant 2.4 GHz RF transceiver
 - 250 kbps O-PQSK modulation
 - 16 selectable channels
- Auto-trim feature for crystal accuracy
 - Eliminate need for external variable capacitors
 - Allows for automated production frequency calibration
- Programmable from -27 dBm to +3 dBm
- RX sensitivity of -92 dBm
- Integrated Transmit/Receive switch
 - Supports single-ended or full differential operation

Features

- -40 to +85 degrees C operating temperature
- 2V to 3.4V
- Low external component count
 - Requires a single 16 MHz crystal
 - Programmable frequency clock output for MCU
- 9x9x1 mm 71-pin LGA package
- RoHS compliant

Availability

- Shipping in volume since September 2006



Features	MC13211	MC13212	MC13213
Protocol Stack	SMAC	SMAC IEEE 802.15.4	SMAC SynkroRF IEEE 802.15.4 ZigBee RF4CE ZigBee
Memory	16 KB Flash 1KB RAM	32 KB Flash 2 KB RAM	60 KB Flash 4KB RAM
2009 1K SRP	\$3.10	\$3.38	\$3.71

MC1321x Development Tools Summary

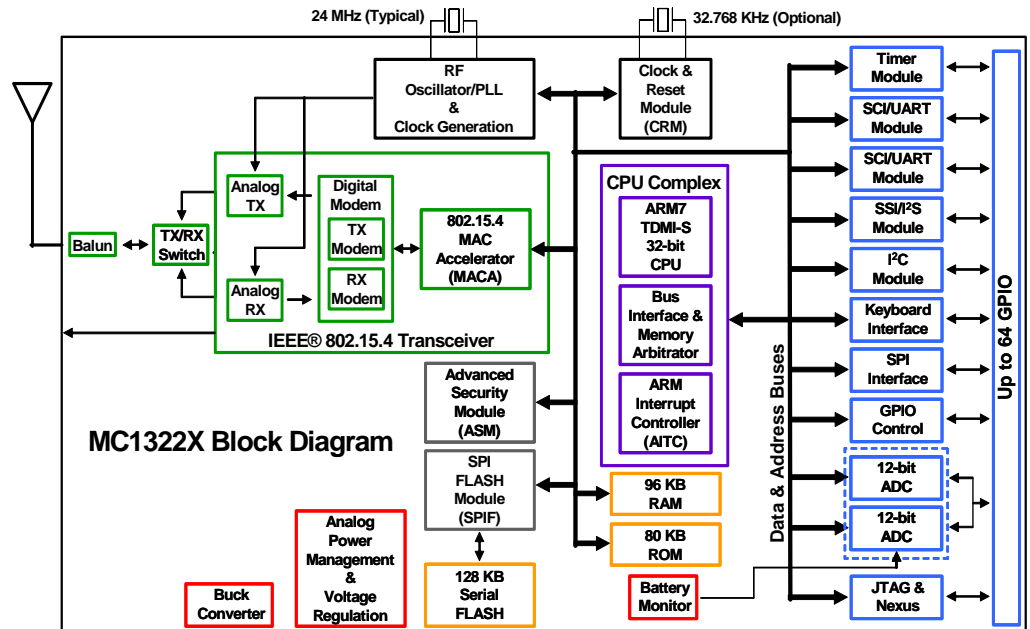
Feature	1321x Developer's Starter Kit	1321x Consumer Starter Kit	1321x Network Starters Kit	1321x 802.15.4/ZigBee Development Kit
13213-SRB	2	1	2	4
13213-NCB	N/A	1	1	3
CodeWarrior IDE	Special Edition	Special Edition	Special Edition	Special Edition, Standard Edition (1321XEVK-SFTW only)
BeeKit with BeeStack ZigBee Protocol Stack (Available Dec 06)	BeeKit with 90-day evaluation of Bee-Stack	BeeKit with 90-day evaluation of Bee-Stack	BeeKit with 90-day evaluation of Bee-Stack	BeeKit with 90-day evaluation of BeeStack, Full Node Lock Version (1321XEVK-SFTW only)
ZigBee Packet Analyzer Hardware	No	No	No	Yes
Protocol Analyzer	No	No	No	Daintree Standard Edition
Out-of Box Application	Accelerometer Demo	RF4CE Remote Control	802.15.4 Wireless UART	ZigBee Environment Demonstration (ZeD)
RoHS Compliant	Yes	Yes	Yes	Yes
Price	\$249 – 1321XDSK \$349 – 1321XDSK-BDM	\$399 – 1321XCSK-BDM ↑	\$499 – 1321XNSK \$549 – 1321XNSK-BDM	\$1749 – 1321XEVK \$3299 – 1321XEVK-SFTW

Recommended for ZigBee RF4CE Development

MC1322x Platform in a Package (PiP)

► Features

- Integrated 2.4 GHz transceiver with 32-bit CPU
 - 802.15.4 Compliant transceiver
 - ARM7TDMI up to 26Mhz
- Lowest power
 - Significant power reduction
 - 21 mA Rx & 29 mA Tx with radio and MCU
 - <1uA hibernate current
- Large Memory
 - 128KB Serial Flash, 96KB RAM
 - 80KB ROM containing 802.15.4 MAC, device drivers and boot code
- Improved RF performance
 - 96 dBm sensitivity (DCD mode)
 - 100 dBm (NCD mode, +2-3 mA current)
 - +5 dBm power output
- Hardware accelerator reduces MCU overhead
 - MAC accelerator
 - AES 128-bit hardware encryption/decryption
- Best in class peripherals
 - UART, SPI, KBI, 8 channel 12-bit ADC, 4x16-bit timer, I²C, SSI (I2S), 64 GPIO
- Unique platform in a package
 - RF matching in package
 - Requires power, crystal and 50 Ohm antenna
 - 9.5 mm x 9.5 mm 99-pin LGA



Features	MC13224V
Protocol Stack	SMAC SynkroRF IEEE 802.15.4 ZigBee RF4CE (Q209) ZigBee ZigBee Pro
Memory	128 KB Serial Flash 96 KB RAM 80 KB ROM
2009 1K SRP	\$4.74

MC1322x Development Tools Summary

Feature	1322x USB Kit	1322x Developer Starter Kit	1322x Network Starter Kit	1322x 802.15.4/ZigBee EVK
End Node	N/A	1	1	4
Coordinator	N/A	1	1	3
Low Power Node	N/A	N/A	1	2
USB Node	1	N/A	1	1
J-Link JTAG Debugger	No	Yes	Yes	Yes
IAR IDE	IAR 32K Edition	IAR 32K Edition	IAR 32K Edition	IAR 32K Edition (256K Edition – 1322xEVK-SFTW only)
BeeKit with BeeStack ZigBee Protocol Stack	BeeKit with 90-day evaluation of BeeStack	BeeKit with 90-day evaluation of BeeStack	BeeKit with 90-day evaluation of BeeStack	BeeKit with 90-day evaluation of BeeStack (Full Node Locked Version – 1322xEVK-SFTW only)
Protocol Analyzer	No	No	No	Daintree Basic Edition
Out-of Box Application	None	Weather Station Sensor Demo	802.15.4 Network Demo	ZigBee environment Demonstration (ZeD)
RoHS Compliant	Yes	Yes	Yes	Yes
Price	\$79 – 1322xUSB	\$379 – 1322xDSK-DBG	\$579 – 1322xNSK-DBG	\$1999 – 1322xEVK \$3999 – 1322xEVK-SFTW

Recommended for ZigBee
RF4CE Development

Reference Designs

▶ Development Board Reference Design

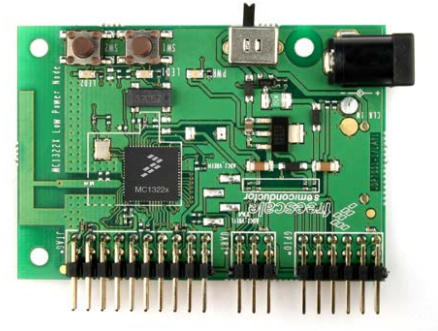
- Based on development boards and include I/O, headers and additional functionality
- FCC and CE certified
- Provide
 - Schematic in OrCAD
 - Layout in Gerber
 - BOM
 - Direct support in BeeKit

▶ Form Factor Reference Designs

- Form factor design with minimal I/O and headers
- Focus is on RF design
 - Single Port Design
 - Chip or F Antenna
- Basic Interfaces
 - UART, I2C
- Provide
 - Reference Manual
 - Schematic in OrCAD
 - Layout in Gerber and Allegro
 - BOM
 - BeeKit Platform Editor Configuration File

▶ Dev Board Reference Design

- 1319xEVB
- 1320x-QE128DSK
- 1320xRFC
- 1321xNCB
- 1321xSRB
- 1322xLPB
- 1322xNCB
- 1322xSRB
- 1322xUSB



▶ Form Factor Reference Design

- 1320xQE128-IPB
- 1321x-ICB
- 1321x-IPB
- 1321x-UCB
- 1321x-UPB (Pending)
- 1322x-IPB
- 1322x-ICB
- 1322x-ERB (Pending)



<http://www.freescale.com/802154>

Freescalé's BeeKit™

- ▶ BeeKit provides customers an exceptional development tool which offers a simplified implementation of Freescale 802.15.4 based technologies including SMAC, 802.15.4 MAC, SynkroRF, ZigBee RF4CE, ZigBee & ZigBee Pro.

- FEATURES

- Graphical user interface (GUI) for the creation, modification and updating of wireless networking implementations
- Comprehensive code base of wireless networking libraries, application templates, and sample applications
- Automated validation of configuration parameters
- Generation of workspace files to be imported into an Integrated Development Environment (IDE) for continued development and debugging
- Easily scalable to support new code bases and functionality
- Complementary tool to CodeWarrior (CW) or IAR EWARM IDEs for MCU development

- BENEFITS

- Provides a cost effective wireless design solution
- Reduces complexity of wireless implementation
- Allows focus on MCU application software via complementary IDE
- Eases start up time and reduces tool learning curve
- Gets you to market fast
- Backed by premiere design support

Q&A

- ▶ Thank you for attending this presentation. We'll now take a few moments to review the audience questions, and then we'll begin the question and answer session.

