TI Wireless Connectivity Solutions for the Internet of Things

Arrow event in Bologna on June 25th 2015

Erling Simensen
Product Marketing
Wireless Connectivity

Wirelessly connecting everything

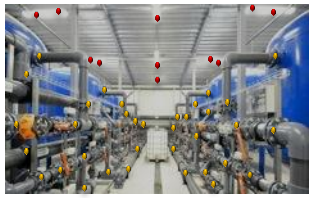
IoT is an enabling technology

Wearables
- Entertainment
- Fitness
- Smart watch
- Location and tracking

Building & Home Automation
- Access control
- Light and temp control
- Energy optimization
- Predictive maintenance
- Connected appliances

Smart Cities
- Residential E-meters
- Smart street lights
- Pipeline leak detection
- Traffic control
- Surveillance cameras
- Centralized and integrated system control

Smart Manufacturing
- Flow optimization
- Real-time inventory
- Asset tracking
- Employee safety
- Predictive maintenance
- Firmware updates



Health Care
- Remote monitoring
- Ambulance telemetry
- Drugs tracking
- Hospital asset tracking
- Access control
- Predictive maintenance

Automotive
- Infotainment
- Wire replacement
- Telemetry
- Predictive maintenance
- C2C and C2I

What are some factors driving IoT ?

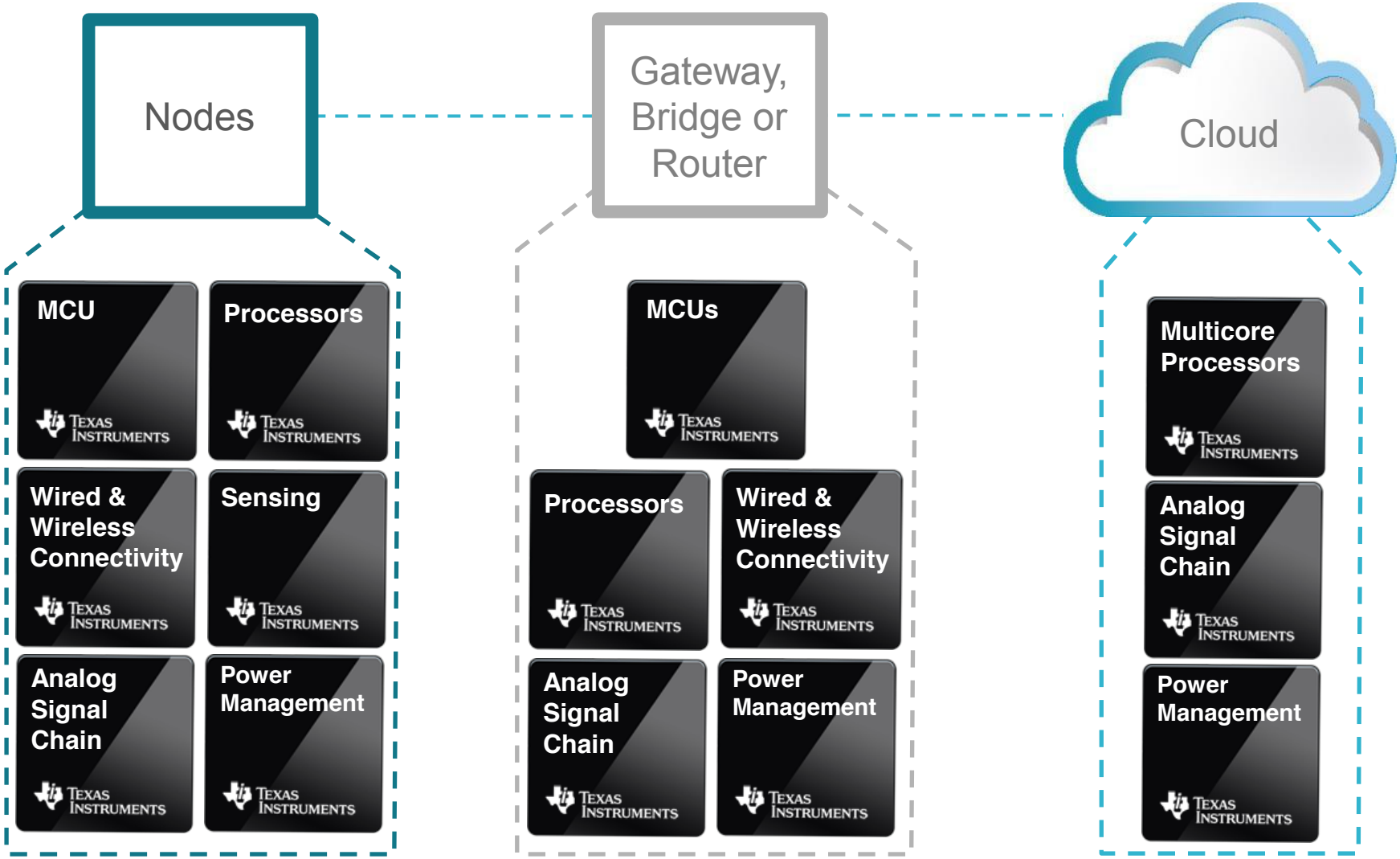
Users

- Improved product experience
- New «connected» features
- Reduce expenses

Businesses

- Optimized customer support
- Keep product up-to-date
- Sell new services

Only TI has all the IoT building blocks



No one connectivity standard will win in the IoT

CHALLENGE

Connectivity:
One size doesn't fit all

WHAT IS NEEDED

Broad variety of wired or wireless standards

TI DELIVERS

Wi Fi
- Fast – 10Mbps++
- Direct Internet connection
- Home & enterprise apps

ZigBee™
- Low power mesh network
- Smart metering & lighting
- Moving into home automation

Bluetooth SMART
- Lowest power BLE
- Connect to tablet/phone
- Moving to industrial, automotive

6LoWPAN
- Low power & long range
- Native IP-based network
- Home gateways and security

PRIME ALLIANCE / **G3-PLC Alliance**
- Data over power lines (OFDM)
- Developed for smart grid
- Lighting, solar, appliances

EtherCAT / **ETHERNET**
- Fast, low latency Ethernet
- Real-time industrial control
- Information technology

NFC · GPS · RFid · 2.4GHz · Bluetooth · Sub-1GHz · IEEE P1901.2 · EtherNet/IP · ANT+ · PurePath Wireless Audio · RF4CE · IEEE 802.15.4

TI Wireless portfolio: broadest in the industry

THE Largest selection

Support for all key technologies and standards for industrial, automotive and consumer

A solution for any application.
Future Proof
Leverage your investment

Easiest to design with

Quickest learning-curve and development time with full broad market ecosystem

Software, Tools, E2E, Modules,
TI Designs, SensorTag

THE lowest power

Use a coin cell for multi-year, always-on operation or go battery-less with energy harvesting

Ultra-low power by design

Connect More with TI

Wireless Connectivity Portfolio

Proximity	Personal area networks		Local area networks			Neighborhood area networks
NFC RFID	***Bluetooth*® *Bluetooth* LE**	**Proprietary 2.4GHz**	**ZigBee®**	**Wi-Fi®**	**6LoWPAN**	**Proprietary Sub-1 GHz**
Identification	*Personal Connection*	*Customizable*	*Mesh*	*Existing Infrastructure*	*IP Mesh*	*Customizable*
Key Differences						
Data Up to 848 Kbps No battery to coin cell	Data or Voice Up to 3 Mbps Coin cell to AAA	Data Up to 1 Mbps Coin cell	Data Up to 256 Kbps Energy harvesting to AAA	Voice or video Up to 100 Mbps AA battery	Data Up to 256 Kbps Energy harvesting to AAA	Data Up to 1 Mbps Coin cell
Key Attributes						
• Passive operation & data storage • Dedicated multi-tag read zone • In Portable devices	• Interoperable with other Bluetooth devices • Large install base • In mobile devices	• Customizable to application • Robust RF	• Standards based • Self-healing mesh • Low power • Large area coverage	• Existing infrastructure • High throughput	• IPv6 stack • Ultra low power • IoT platform	• Longest range • Customizable to application • Robust RF

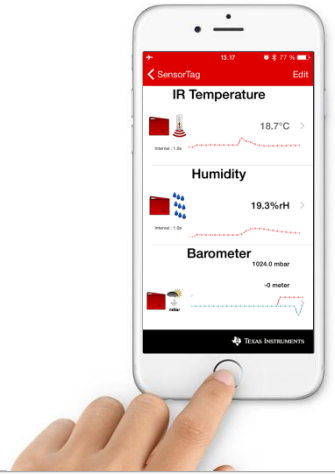
cm — Up to 100m — **Range** — km

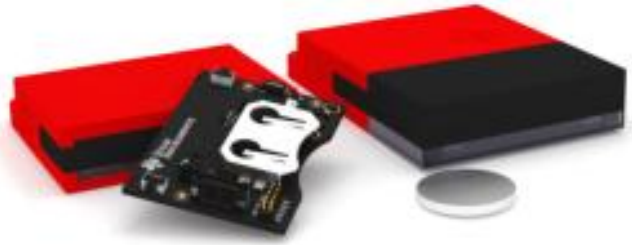
Portfolio positioning

SimpleLink™ Solutions			WiLink™ Solutions
Existing Products – proven foundation of millions of devices shipped in the market			
Smart RF Transceivers	Wireless Network Processors (WNPs)	Wireless Microcontrollers (MCUs)	Wi-Fi Combo Devices
			
Application	Application	Application	Application
Wireless Stack	Wireless Stack	Wireless Stack	Wireless Stack
RF Radio	RF Radio	RF Radio	RF Radio

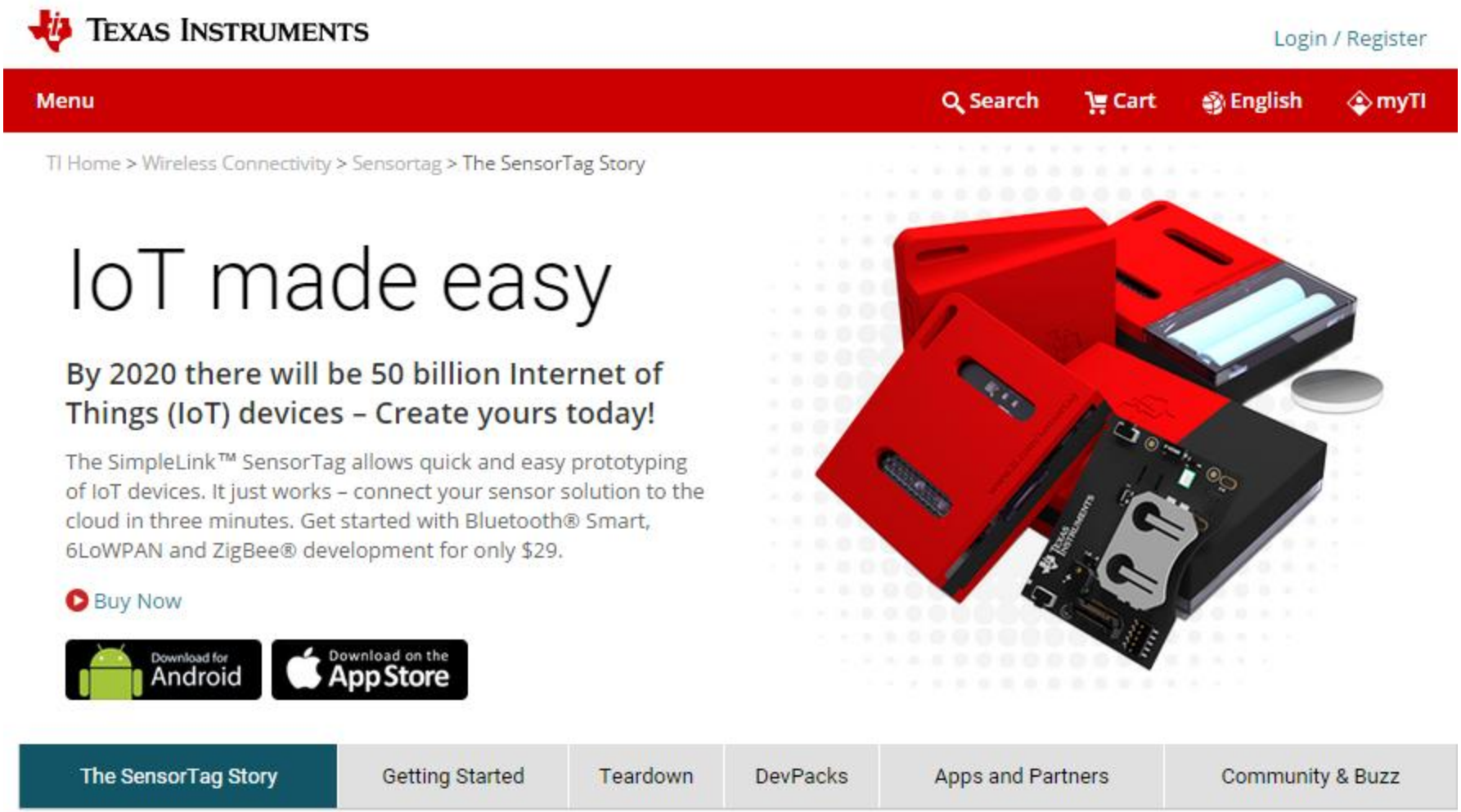
- **SimpleLink**: Broad offering of RF transceiver, wireless network processors and wireless microcontrollers
- **WiLink**: High performance Wi-Fi + Bluetooth/BLE combo devices

Simplelink SensorTag – IoT made easy





ti.com/sensortag



Resources for the whole dev. team

Web/App developers

Access data from your SensorTag through our cloud partners or directly using JavaScript and jquery examples. Use our mobile app examples as a starting point for your own IoT projects, or write your own HTML5 platform-independent code based on the source code from the sample projects.

Learn more

Embedded Software Developers

The SensorTag includes open source hardware and software reference designs for low-cost and low-power IoT nodes. Use the SensorTag with the Debug DevPack for low-cost hardware development. The SensorTag application can easily be ported between Bluetooth Smart, 6LoWPAN and ZigBee to allow you to quickly evaluate which wireless connectivity technology is right for your design.

Learn more

Hardware Developers

Use the SensorTag hardware as the development platform for your first IoT project. The open source hardware demonstrates the use of 10 low-power sensors. Also, the DevPack interface makes it easy to hook up your own sensors and actuators into the IoT cloud. Use the 3D SensorTag enclosure design files to print your own variants of the SensorTag.

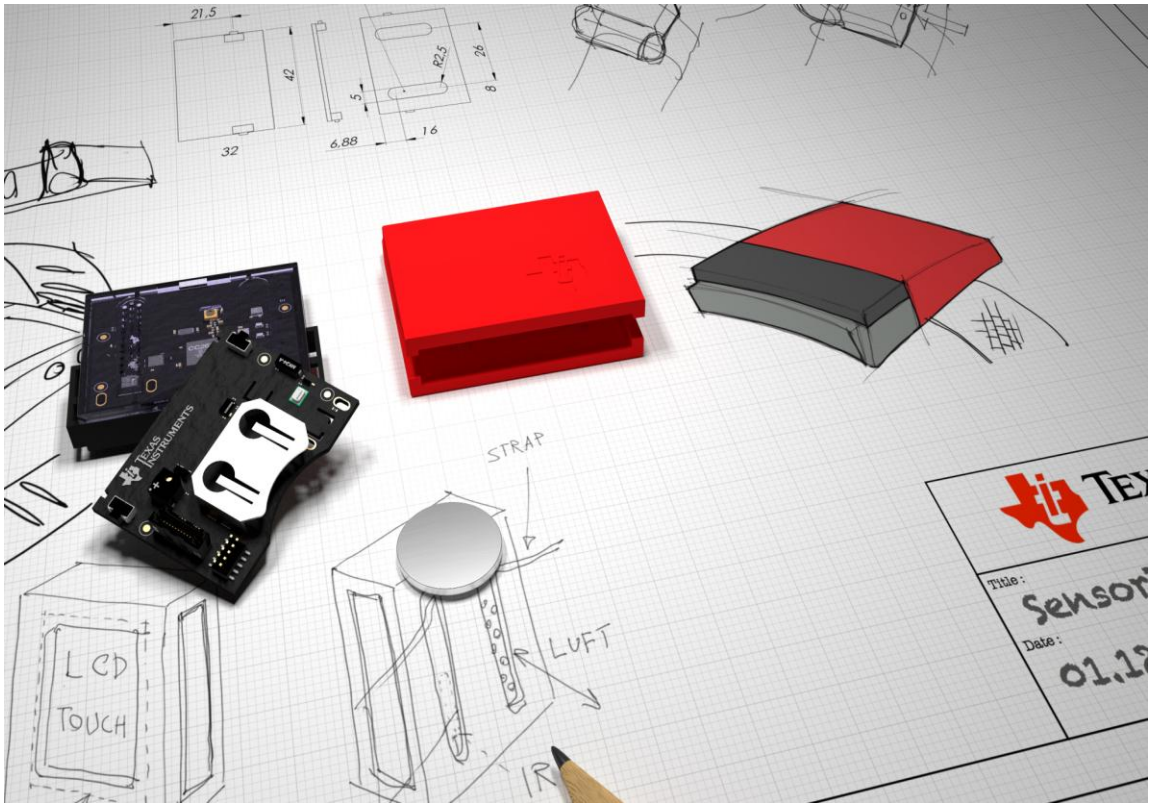
Learn more

Create – develop - prototype – 3D print

Intuitive cloud interface

3D printable

Expandable



Small size

Open design files

Low cost

SensorTag Teardown

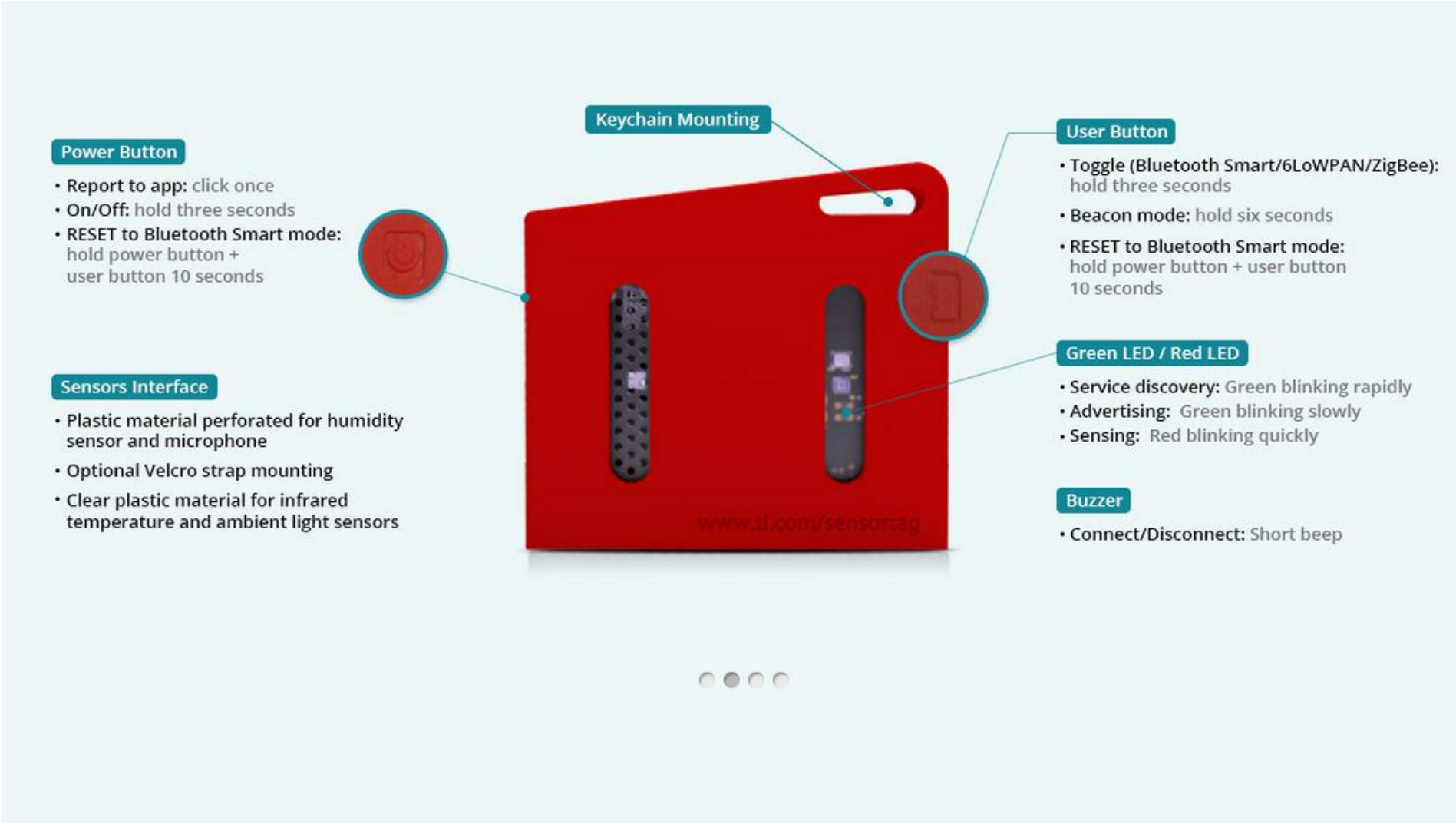
Small size

1.97 x 2.64 x 0.55 inch
5 x 6.7 x 1.4 cm
(WxHxD)

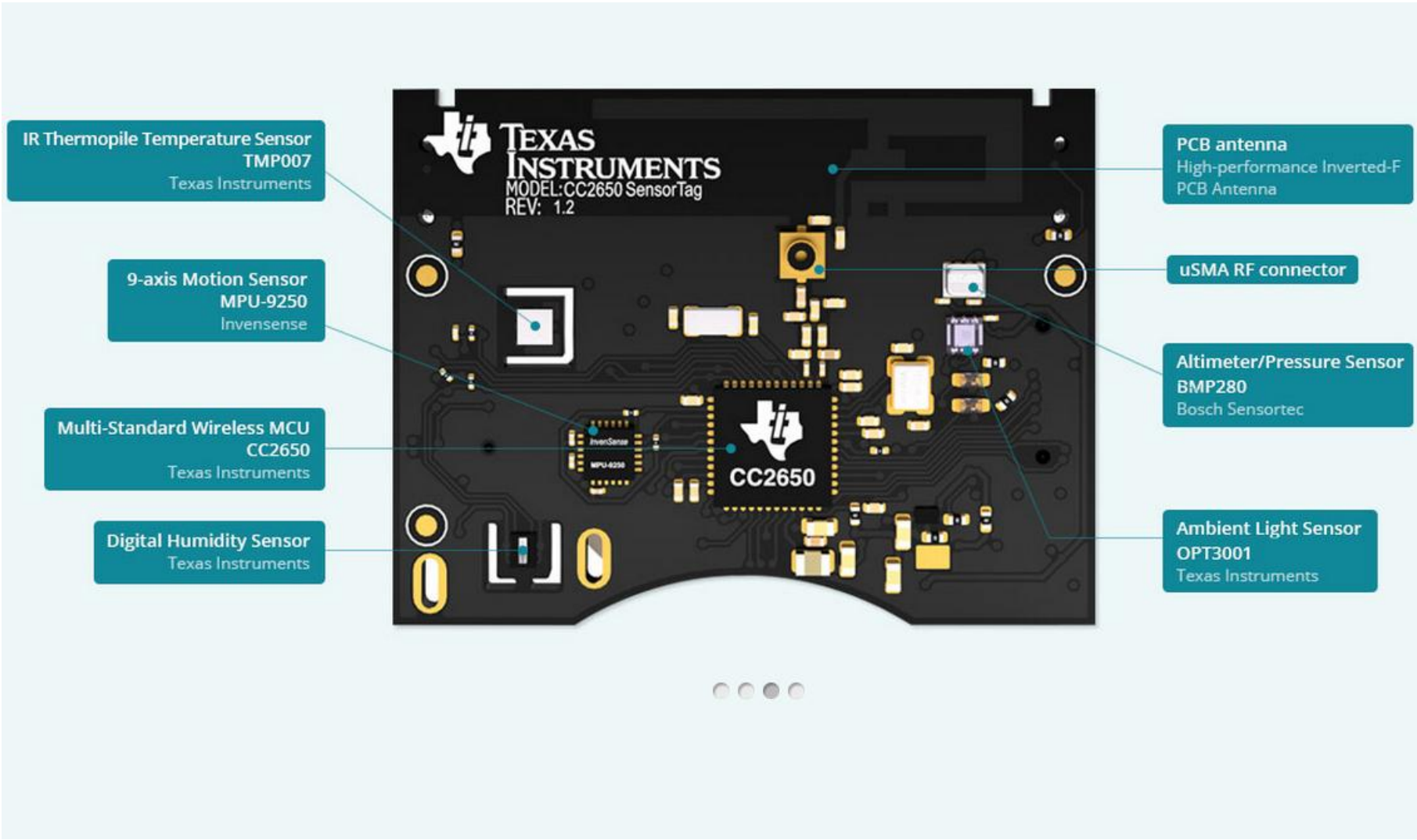
Benefits

- Low-power design, years of battery life
- Easy-to-use, get started in three minutes
- Download app and connect
- No programming required

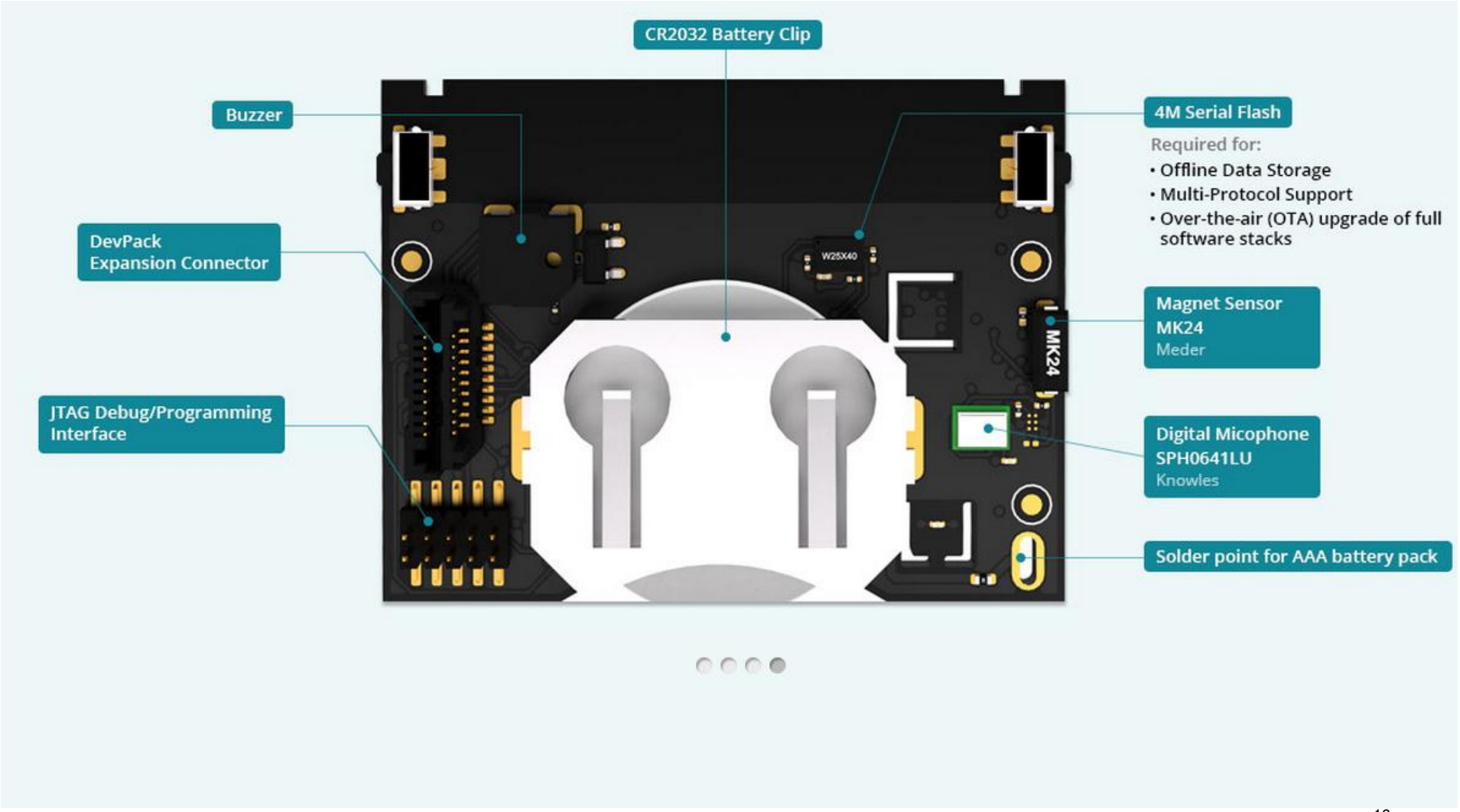
SensorTag Teardown



SensorTag Teardown

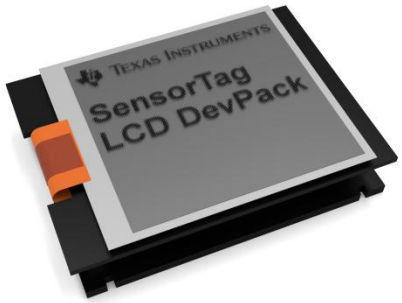


SensorTag Teardown



DevPacks

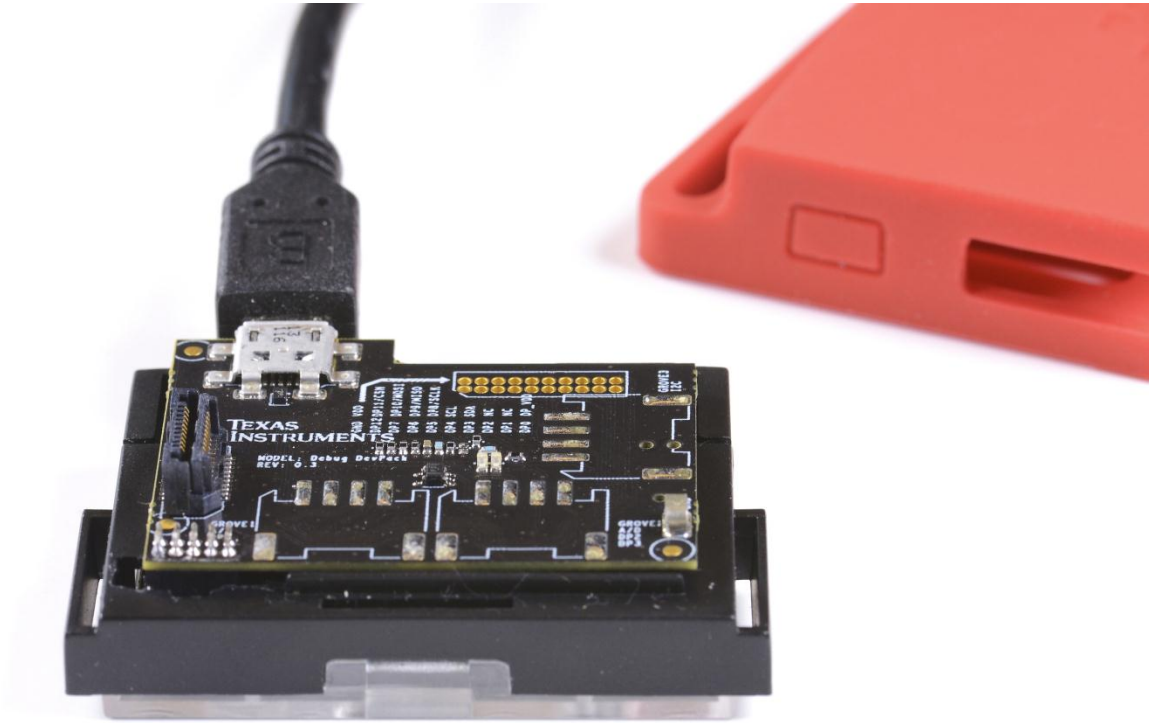
- Debug DevPacks
  - Low cost $15 debugger
  - TI Cloud Tools support
    - Compile SensorTag firmware on dev.ti.com
    - CCS and IAR IDE support
- Display(Watch) Devpack
  - Prototype wearable applications
  - 96 x 96 graphical display
- LED DevPack
  - Enable lighting applications
  - 4 color high power LEDs



Getting Started

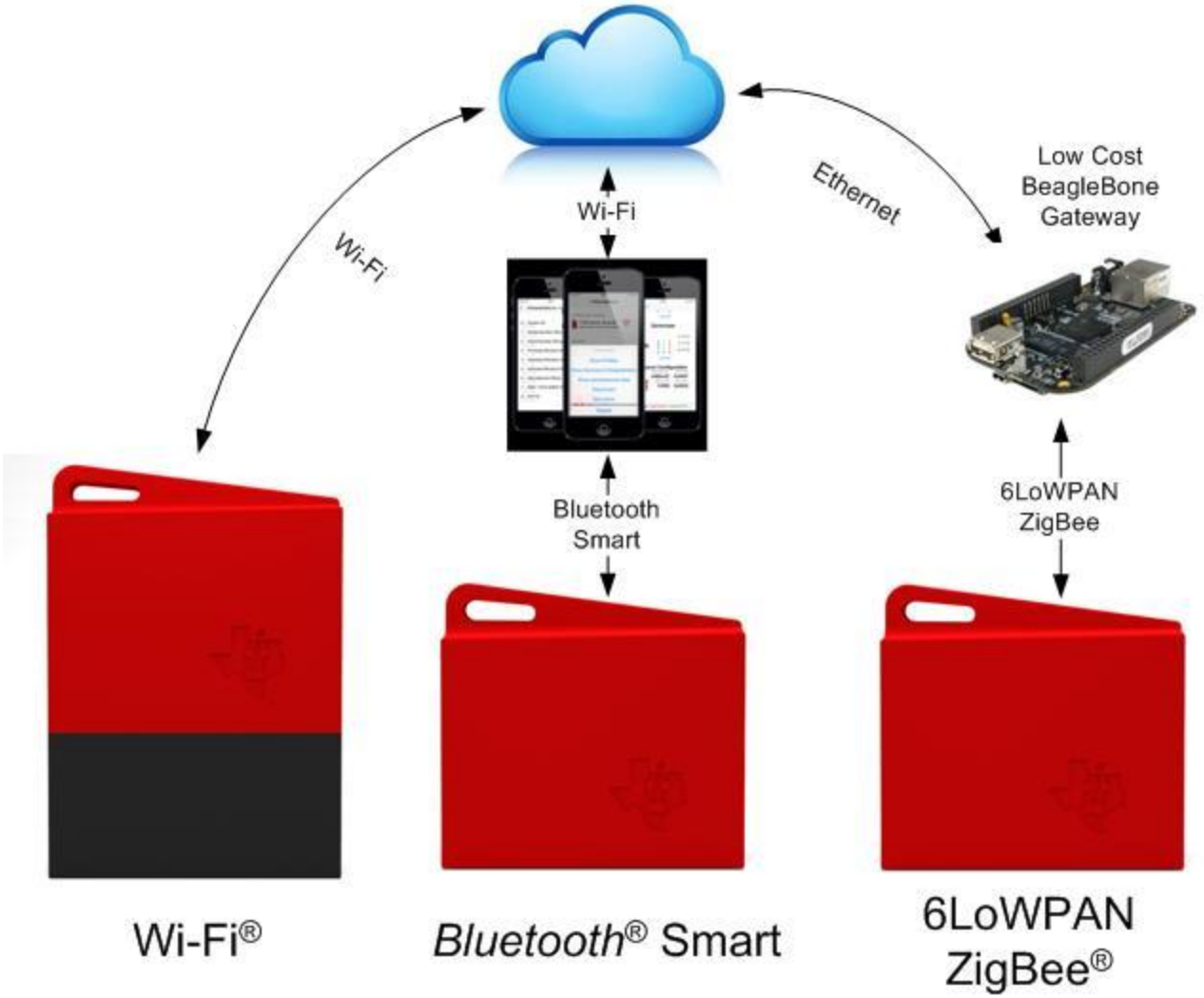
Hardware/Firmware development

- Debug DevPack
  - Access to I/Os
  - Add Sensors
  - Grove Connectors
- Stackable
- CCS Cloud Support
- Dev.ti.com



CCS Cloud: dev.ti.com

Whats next?


Wi-Fi
Wi-Fi
Ethernet
Low Cost
BeagleBone
Gateway
Bluetooth
Smart
6LoWPAN
ZigBee
Wi-Fi®
Bluetooth® Smart
6LoWPAN
ZigBee®

SensorTag – IoT made easy

- $29 Complete IoT development kit
- Access Sensor data in the cloud in 3 minutes
- Interchangable DevPacks
- 10 Low Power Sensors
  - 1 year battery life
- www.ti.com/sensortag
  - iOS and Android apps
  - Source code
  - Design files
    - Including 3D files
    - Print your own SensorTag

Wireless Connectivity TI Designs *per Technology*

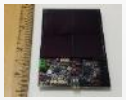
Bluetooth® Low Energy / *Bluetooth*® Dual Mode


RS-485


Haptic Feedback


Gas Sensor


Keyfob


Light Harvesting


BLE Light


Postage Stamp


Long Range


Mini Broadcaster


Biometric Wheel


USB Dongle


Heart Monitor


Body Composition


Audio Sink


Optical Heart Rate


Weight Scale


Audio Source


Pulse Oximeter


SensorTag iBeacon


CC256x EM

WiFi®

CC3200MOD LaunchPad

CC3100MOD BoosterPack


Smart Electric Meter


Smart Plug


Wi-Fi® Camera


Audio Streaming

CC3200 Battery Power

ZigBee®


Network Range Extender


Home Automation Gateway


Light Link Development Kit


Low End In-Home Display

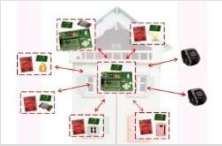

CC2538 EM

Sub-1 GHz


ETSI Cat. 1 Receiver


RF Layout Reference Design for 420-470 MHz


RF Layout Reference Design for 868-930 MHz


Connected Home Network

More resources: www.ti.com/wiki

Designing a Product with SimpleLink CC26xx or CC13xx Wireless MCUs

A 10-step guide

This is a step by step guide to designing a low power RF product based on the CC26xx/CC13xx family of SimpleLink wireless MCU devices. The goal is to present you with the resources that are relevant at the different stages of design. If you get stuck or have questions anywhere along the line, please post your questions to our e2e forum:

http://e2e.ti.com/support/wireless_connectivity/

Contents [hide]

1 Step 1 - Decide on which RF technology you want to use
2 Step 2 - Buy the relevant development kit
3 Step 3 - Download an evaluation tool
4 Step 4 - Download a software development environment:
5 Step 5 - Design the hardware
6 Step 6 - Test the hardware
7 Step 7 – Test the software and application functionality
8 Step 8 – Certify your product
9 Step 9 – Production Test and Programming
10 Step 10 – Production

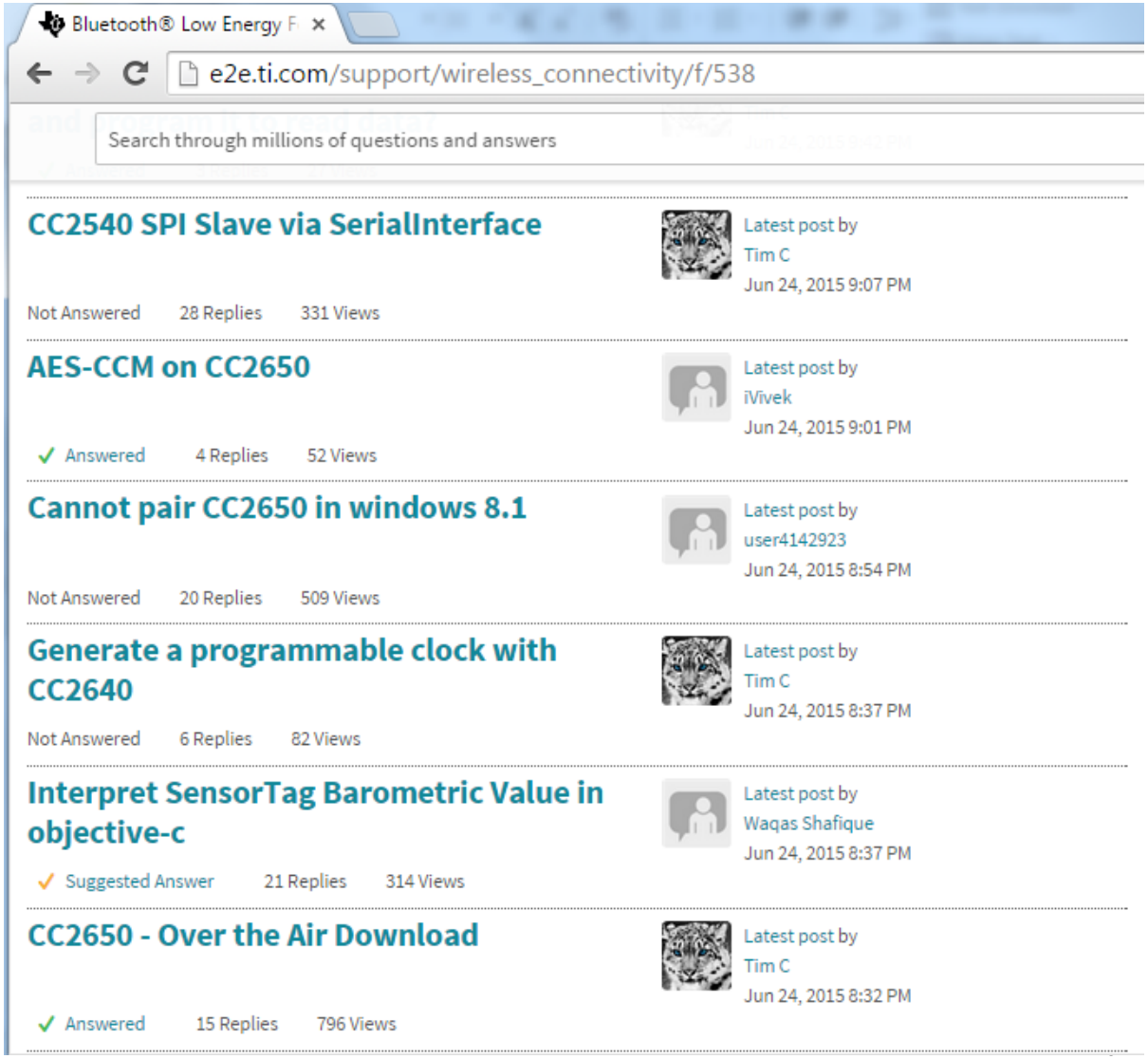
Getting Started	Hardware	Software	Test & Certification
CC26xx Bluetooth Smart -*New!*			

Where to Start
• Get the kit from TI Store:
  • SensorTag 2.0 - $29
  • CC2650DK - $299
  • CC2650EMK-7ID - $99
  • CC2650EMK-4XS - $99
• Read the 10-step guide to designing with the CC2640
Product Information
• CC2640 Product Folder
• CC2650 Product Folder
• CC2640 Module Folder from LSR
Tools and IDEs
• IAR Embedded Workbench for ARM
• Code Composer Studio
• Complete Tools Overview
Support
• E2E Forum
	Technical Documentation
	• CC2640 Datasheet
	• CC2650 Datasheet
	• CC26xx Family Technical Reference Manual
	Application Notes
	• Measuring Bluetooth Smart Power Consumption
	• Bluetooth Smart Beacons
	Design Resources
	• CC26XX Frequently Asked Questions
	• CC26XX Known bugs and issues
	• Crystals for CC2640
	• HW design checklist for CC2640
	• CC26xx Layout Considerations
	• CC26xx RF Frontends and Antennas
	• CC26xx Crystal Load Cap Tuning
	• CC2650 EMK Design Files
	• CC26xx Optimal Load Impedance
		Releases
		• BLE-Stack 2.0
		User Guides
		• Software Developers Guide (Also bundled with BLE-Stack 2.0 installer)
		• CC26xx Family SW Quick start Guide
		CC2640 Examples
		• Getting Started & Create Custom Profile
		• Adding a UART/SPI driver to a project **NEW**
		• Adding basic printf over UART with TI-RTOS **NEW**
		• MultiRole Demo **NEW**
		• Cc2640 ANCS demo & sample project with ID & Message content & time stamp **NEW**
		• NPI UART Echo Example
		• AES Encryption Example
			Bluetooth Qualification
			• BLE-Stack 2.x Design Listing
			  • Specification: v4.1
			  • Declaration ID: D024979
			  • Qualified Design ID: 61713
			• How to Certify Your Bluetooth Product
			• Using Production Test Mode (PTM)

Support! e2e.ti.com

Most extensive knowledge base in the industry?

Very high probability of getting an answer in less than 24h!



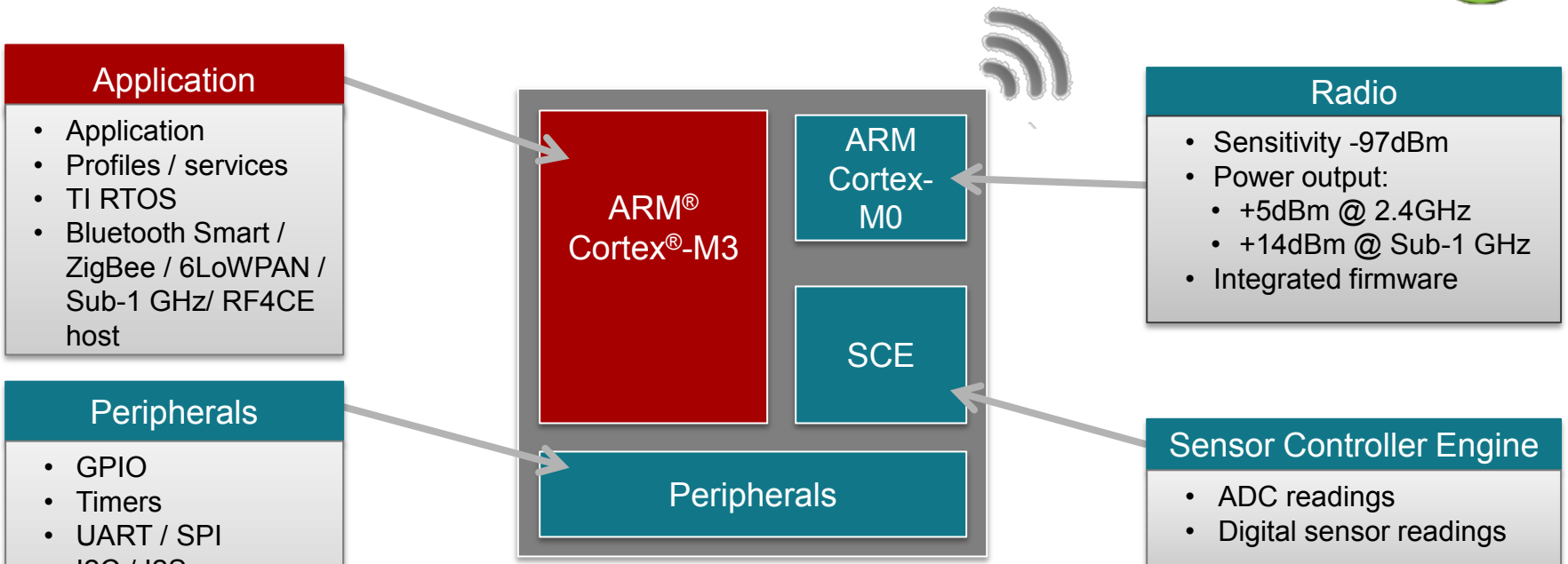
Power: Bringing wireless MCUs to a new low

Designed for low-power operation

- Multi-year on a coin cell
- Faster processing
- Optimized radio
- Ultra low sleep current
- Unique integrated Sensor Controller

Ultra-low power		
When	**Parameter @ 3V**	**Value**
While processing	µA/MHz on ARM® Cortex®-M3	61 µA/MHz
	Coremark / mA	48.5
	Coremark @ 48MHz CPU	142
While communicating	Peak current RX	5.9 mA
	Peak current TX	6.1 mA
While sleeping	µA/MHz on Sensor Controller	8.2 µA/MHz
	Sleep mode with RTC and full memory retention	1 µA

Multi-standard: Five technologies, one architecture



QFN package options:
4mm x 4mm, 5mm x 5mm, 7mm x 7mm

1 µA Standby current with RTC and full retention

Bluetooth SMART — **CC2640**

6LoWPAN — **CC2630**

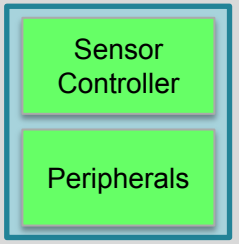
ZigBee — **CC2630**

Sub-1 GHz — **CC1310**

RF4CE — **CC2620**

What is the Sensor Controller?

- The Sensor Controller is a low-power CPU which is fully independent of the system CPU.
- Can operate while entire MCU system is powered down
- Full access to oscillators and analog peripherals (comparators, ADC, capacitive sensing)
- SW support for SPI, UART, I2C to extend the functionality of the device
- Interface to system CPU for wake-up on events + data transfer
- Programmable with Sensor Controller Studio



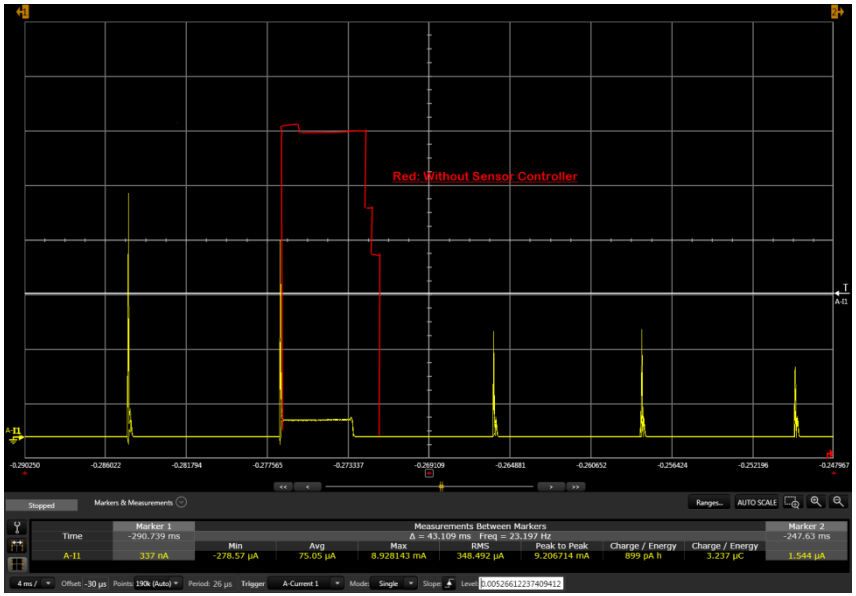
- Autonomous 16-bit RiSC CPU
- 2 kB SRAM (code + data)
- 32kHz-24MHz clock frequency
- (500uA)+8.2uA / MHz

Why integrate the Sensor Controller?

- Reduce current consumption!
- Application Processor (CM3) can stay in powerdown
- Sensor controller offloads application processor (CM3).
- Extend functionality of device

Parameter	Value
µA/MHz on CM3	61 µA/MHz
µA/MHz on SensorController	8.2 µA/MHz

Example: Read ADC

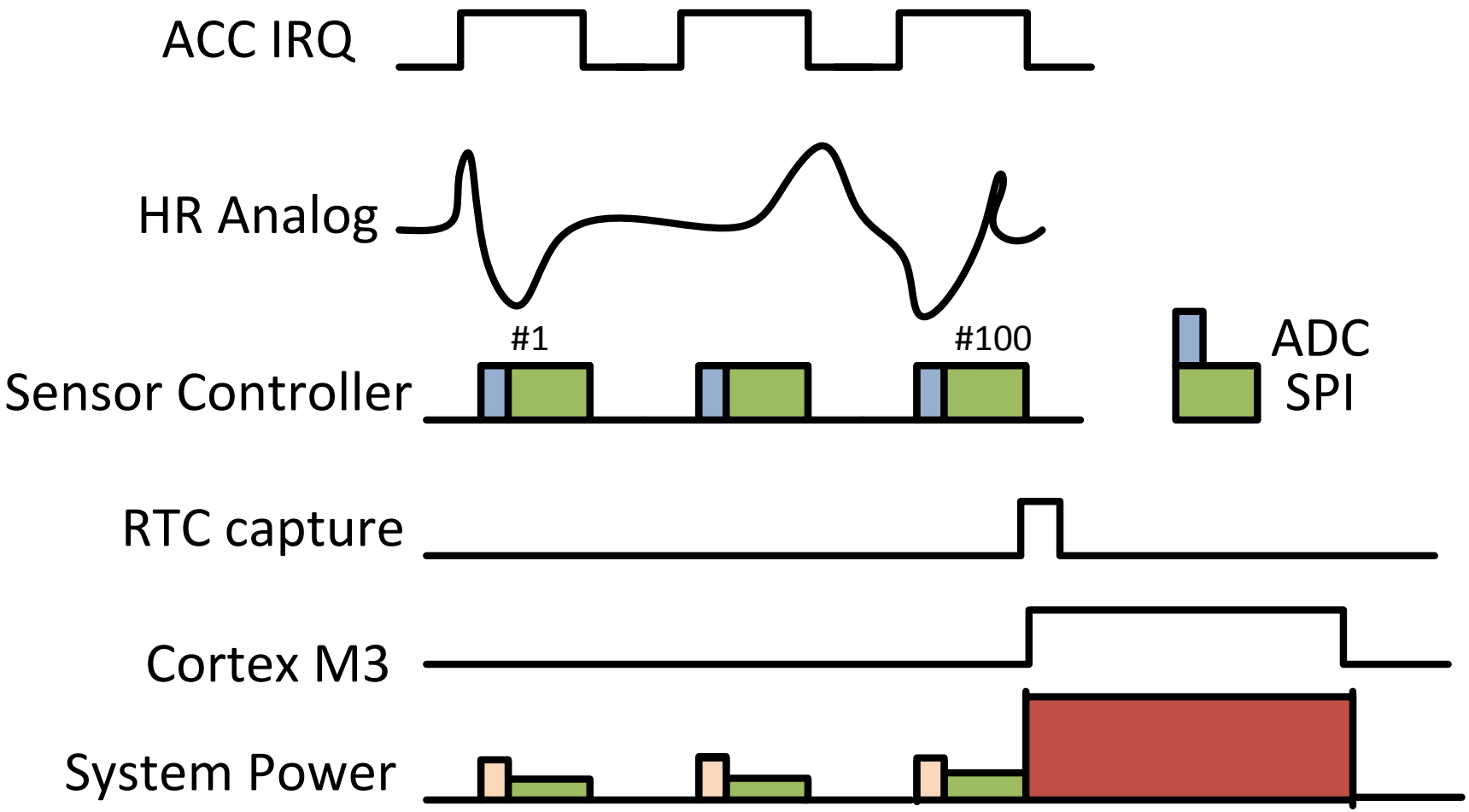


Highly differentiated module allowing reduced BOM cost and lower power

Use case example – Sensor Controller Heart-rate monitor customer

- SPI accelerometer + analog HR circuit connected to ADC
- Accelerometer with FIFO sets IO high when sample is ready (100Sps)
- Sensor Controller wakes up periodically on RTC
  - Reads accelerometer using bit-banged SPI
  - Does ADC conversion
  - Timestamping
    - Sensor Controller timer 0 counts IO events from accel
    - Timer event routed to RTC capture input
- System CPU wakes up on separate RTC event for radio event:
  - Copies over ADC+accel samples
  - Reads out RTC capture value, back-tracks and tags samples assuming 100Sps.

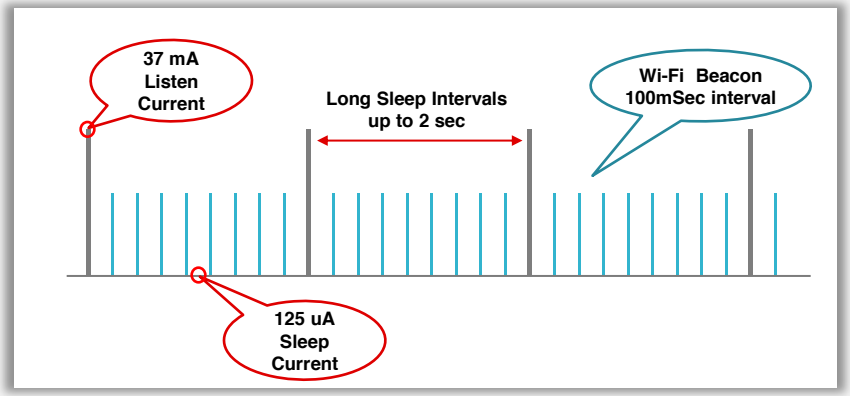
Use case example continued..



Power: Bringing Wi-Fi power to a new low

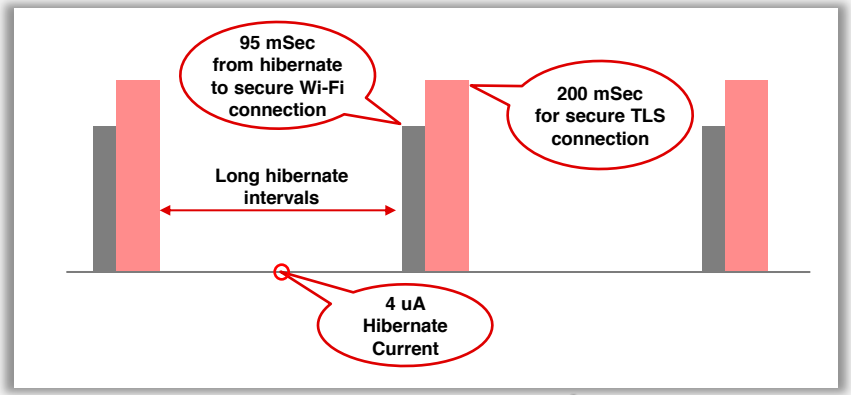
Always Connected

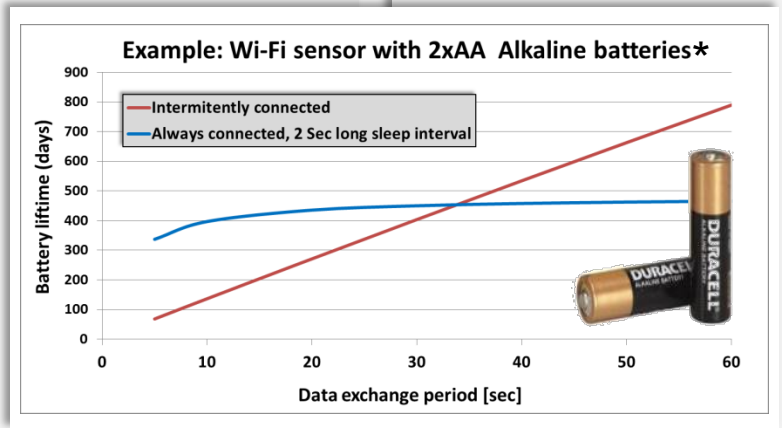
- 120uA sleep current while connected to the network
- 37 mA Rx listen current for beacon reception
- Long Sleep Intervals up to 2 seconds (typical wake up is every 100mSec)

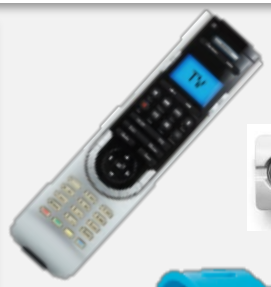


Intermittently Connected

- 4 uA hibernate current, with multiple wake up sources
- 95 mSec wake up time from hibernate till secure Wi-Fi connection
- 200 mSec TLS connection time







*battery life can vary significantly depending on use case and system design

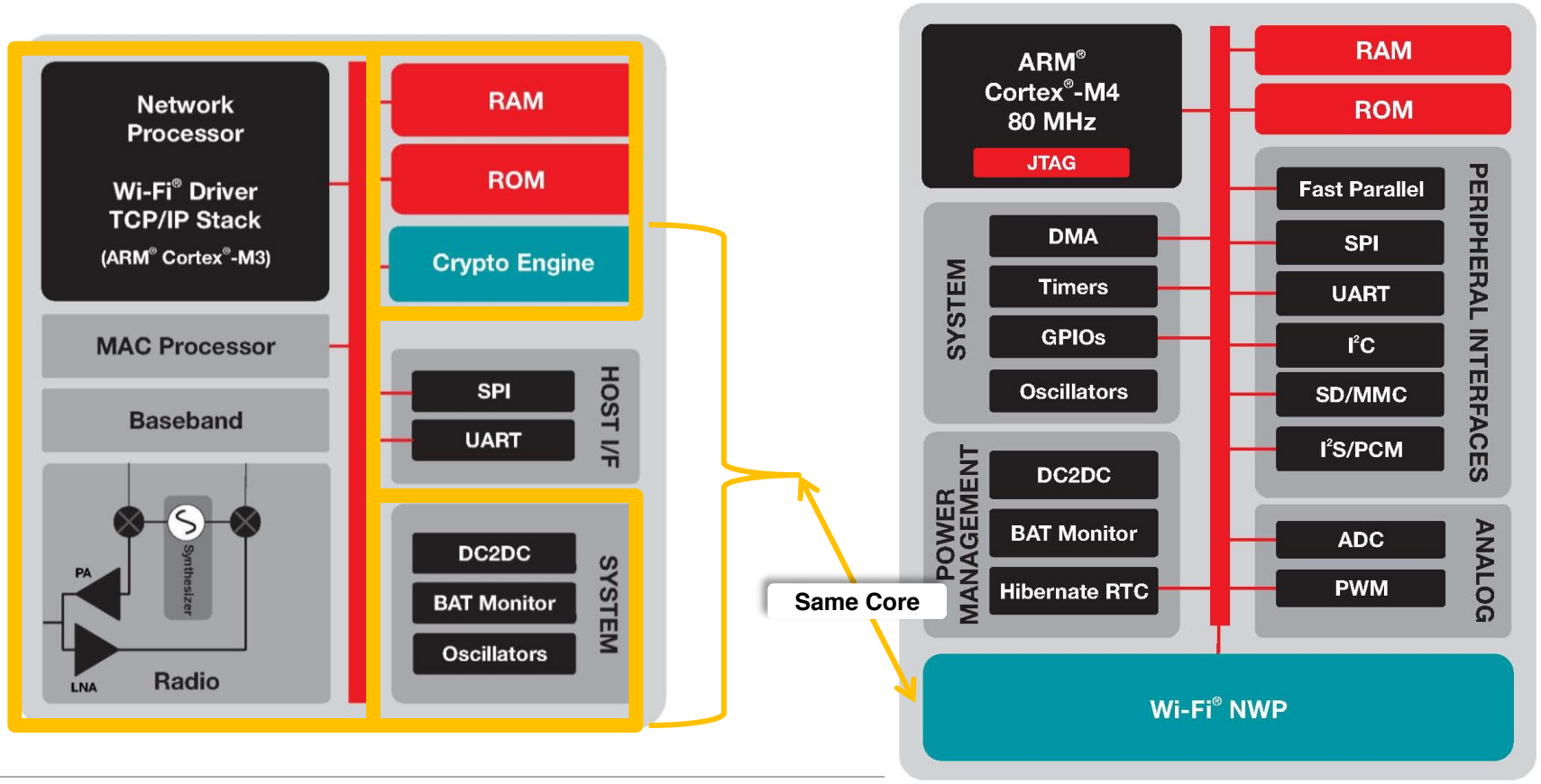
Texas Instruments

Deep dive into CC3100 & CC3200

Two pin compatible products based on the same Wi-Fi network processor

CC3100 Internet on a chip
Wi-Fi Network Processor
Embedded TCP/IP stack for systems using external low-cost MCU

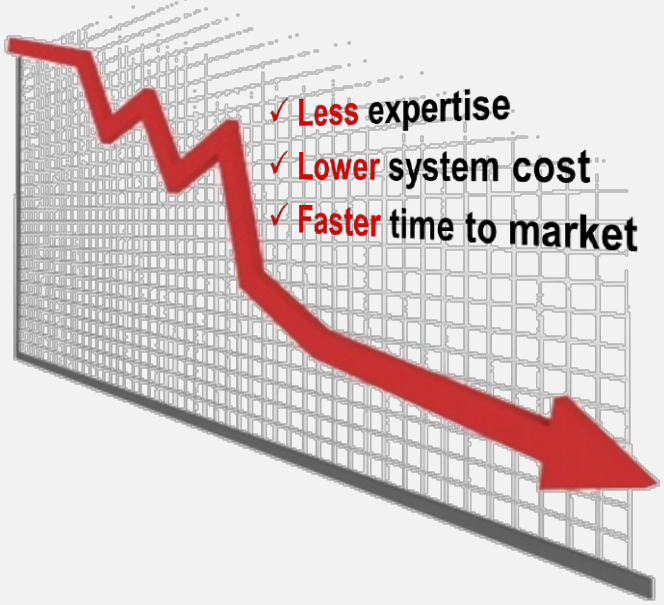
CC3200 Internet on a chip + MCU
Wireless MCU
80MHz ARM® Cortex™-M4 integrated + Wi-Fi network processor

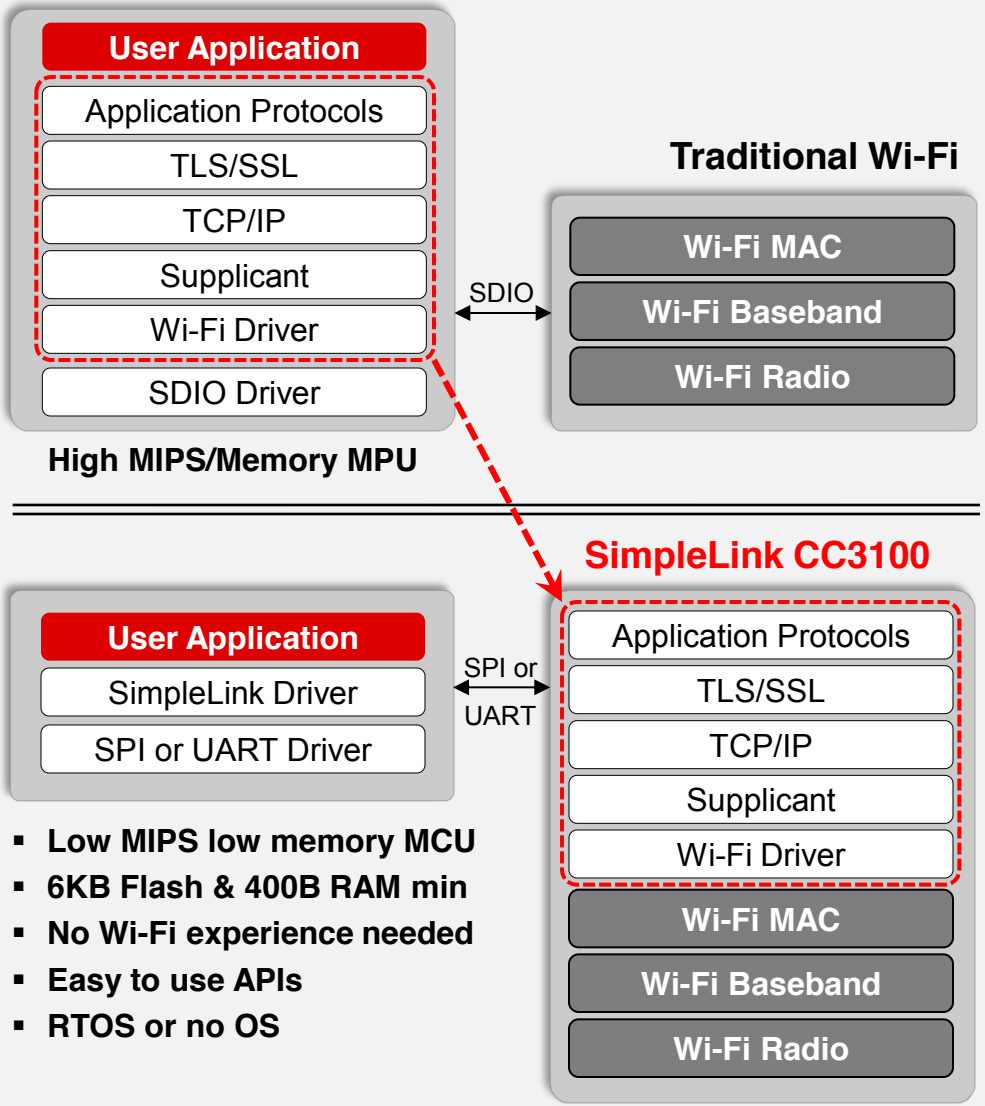


The SimpleLink™ embedded Wi-Fi® revolution

Traditional Wi-Fi solutions are designed for powerful microprocessors

SimpleLink™ CC31xx/CC32xx moves nearly all functions required for Wi-Fi and networking off the host processor





- **Low MIPS low memory MCU**
- **6KB Flash & 400B RAM min**
- **No Wi-Fi experience needed**
- **Easy to use APIs**
- **RTOS or no OS**

Thank you! Learn more here:

www.ti.com/sensortag

IoT made easy

By 2020 there will be 50 billion Internet of Things (IoT) devices – Create yours today!

The SimpleLink™ SensorTag allows quick and easy prototyping of IoT devices. It just works – connect your sensor solution to the cloud in three minutes. Get started with Bluetooth® Smart, 6LoWPAN and ZigBee® development for only $29.

Buy Now

Download for Android | Download on the App Store

www.ti.com/wireless

The Lowest Power

Enables multi-year operation on a coin cell battery with wireless connectivity

The Largest Selection

14 standards and technologies with various system partitioning options

The Easiest to Use

No RF expertise required – software, tools, reference designs, technical support and more

Bonus

SimpleLink Sub-1 GHz: CC1200 details

Features	Benefits
High performance • Up to 1.25 Mbps radio • Supports 169 / 433 / 868 / 915 / 920 MHz ISM/SRD bands with possible support for additional frequency bands: 137-160, 205-240 and 274-320 MHz	• High effective data rate for large sensor networks • Hardware support for upcoming Sub-1 GHz standards
Best-in-class range and co-existence • +16 dBm output power • -127 dBm sensitivity • 60 dB selectivity and 90 dB blocking	• Up to 143 dB link budget for long range communication • Best-in-class co-existence for handling noisy RF environments
Leading low power consumption • 0.3 µA power down current with retention, 0.5 µA sleep current with timer running, 2 mA RX sniff mode • Quick transition between power modes	• Reduced system power consumption while maintaining best-in-class RF performance
Low cost design • Compact reference design with few external components, small and efficient PCB antenna	• No need for expensive SAW and IF filters • Reduce external component cost and count

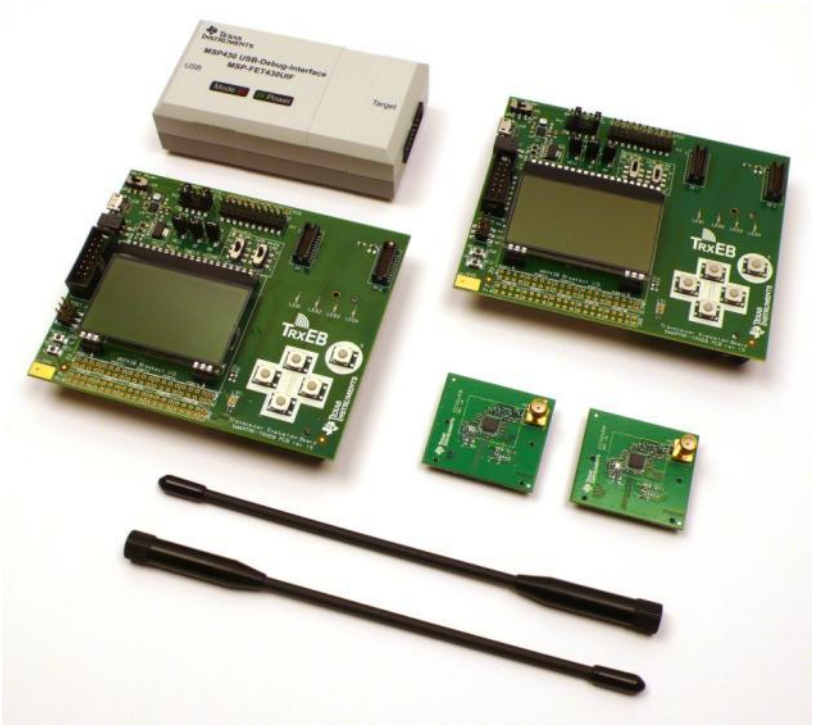
Pricing & Availability

- **5x5mm QFN 32 package for $2.20 in 1,000 unit volumes**
- **The CC1200DK and CC1200EMK are available for $299 and $99 respectively**

Get Started with a development kit:

(Supports CC112x and CC120x devices)

- Peripherals available for development:
  - MSP430F5438 MCU
  - USB interface
  - 128 x 64 dot matrix LCD
  - 3 axis digital accelerometer
  - Ambient light sensor
- Easy to use menu system and navigation interface
- Example SW for quick prototyping
- Multiple supported software tools
  - SmartRF Studio 7 PC tool for generation RF settings & testing (free download)
  - Packet sniffer PC software (free download)
  - IAR Embedded workbench or CCS for code development on MSP430



CC1200DK

- Kit contains:
  - 2 x SmartRF Transceiver EB (TrxEB)
  - 2 x CC1120EM 868/915 MHz
  - 2 x Pulse Antennas
  - 1 x MSP430 Debug Probe (FET)
  - Cables & Documentation

Test TI's range immediately !

- More than 25 km range out-of-the-box using our preprogrammed device; Range test from Table Mountain in South Africa:
  - http://focus.ti.com/general/docs/video/Portal.tsp?lang=en&entryid=1_8ysxrmyk%20
- 10 km range test in Oslo:
  - http://www.youtube.com/watch?v=zMcRYLHCsw0
- Practical demo of co-existence; Interference making a competitor solution fail, while TI RF Performance Line is unaffected
  - http://www.youtube.com/watch?v=af6mb9eqelM

Backup

Sub-1 GHz Performance Line

Industrial 169/ 315/ 433/ 470/ 868/ 915/ 920 MHz solutions

Value Propositions

- **Longest real-world range:** Beyond 25km range, full-building to city-wide RF coverage
- **Robust low-power communication**: Less retransmissions of RF packets means less power consumption in the application
- **Supports more standards:** 6LoWPAN, 802.15.4g, WiSun, wM-Bus, ETSI Cat 1, FCC Part 90 and more

Sub-1GHz
Low Power, Robustness, Long Range

Products

- Smart RF transceiver
  - CC1120
- Smart RF transceiver for 802.15.4.g
  - CC1200
- Smart RF transceiver for ultra narrowband
  - CC1125
- Software stacks
  - Free SimpliciTI software stack
  - wM-Bus software

Features

- High sensitivity & narrowband support, the de facto standard for long range communication
- Advanced wavematch receiver gives best selectivity and blocking including low power sniff mode
- Low-power RX sniff mode enable automatic duty-cycling of the receiver
- SmartRF software tools enable fast RF development and testing

Applications

- Wireless meter reading

- Alarm and security

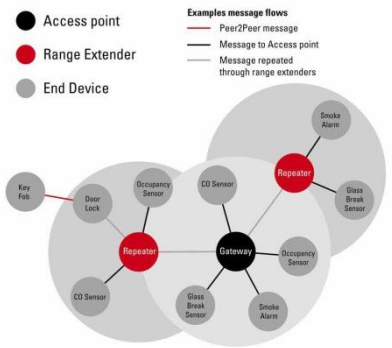
- Home, building and industrial automation

Sub-1 GHz Value Line

315/ 433/ 470/ 868/ 915/ 920 MHz solutions for consumer applications

Value Propositions

- **Robust RF range** in your house: Longer range than 2.4 GHz. Stable wireless links that go through walls
- **Most complete design support**: 15 years of accumulated knowledge documented on the web: 100+ app notes, dedicated E2E forum, SmartRF tools
- **Most optimized** Sub-1 GHz solutions: Tx, Rx, Trx, wireless MCU + small SW stack



Products

- Smart RF transceiver
  - CC110L
- Wireless MCU
  - CC1110
  - CC430
- Wireless MCU with USB
  - CC1111
- Free software examples
  - SimpliciTI software stack

Features

- Complete solutions for 315, 433, 470, 868, 915 and 950 MHz
- SimpliciTI network protocol on CC11xx devices. Only 0.5kB RAM, 8kB Flash MCU needed. 5yr battery life on AA cells
- SmartRF Studio windows software enable fast RF development and testing
- Flexible RF packet sniffer helps debug RF solutions quicker

Applications

- Home and building automation

- Safety and security

- Consumer applications

Single Mode – Bluetooth Smart (BLE)

Low Power, Low Latency, Low Throughput

Value Propositions

Large Tools and ref designs Ecosystem

SensorTag

- **Easiest to design with:** proven and robust BT 4.1 compatible stack with over the air capability (100 Million devices shipped), RTOS and low cost tool
- **The lowest power:** multi-year operation on smaller coin-cell
- **The most Integrated:** single chip wireless MCU, integrated flash, small package
- Strong roadmap with more integration, lower power, Cortex M

Products

- **SimpleLink™ Wireless MCU**
  - Flash based wireless MCU
  - CC2540 (USB interface)
  - CC2541 (I2C interface)
  - CC2540T (up to 125°C)
  - CC2640 (Ultra Low Power)
- **Apps developer tools**
- **Broad TI Designs portfolio**

Features

- Lowest Power down to 1/10th of BT Classic
- Run BT stack and application on one single chip down to 4x4mm QFN package
- Bluetooth 4.1 compatible
- Industrial and extended temp range: -40 to 85°C and 125°C
- Automotive qualification option

Applications

- **Home & Building**

- **Health & Medical**

- **Remote**

BLE-Stack™ v2.0

- **Mature and Robust Software Package**
  - Golden unit for Bluetooth low energy interoperability test
  - Fully BT 4.1 Qualified Solution

Example Application	Description
SimpleBLEPeripheral	Generic Peripheral using proprierary Profile example
SimpleBLECentral	Generic Central
SimpleBLEBroadcaster	Generic Broadcaster
SimpleBLEObserver	Generic Observer
SensorTag	SensorTag 2.0 Firmware
HostTestApp	Wireless Network Processor (Application via SPI/UART)
BloodPressure	Example using Blood Pressure Profile (BSP)
CyclingSensor	Example using Cycling Speed and Cadence Profile (CSCP)
GlucoseCollector	Example using Glucose Profile (GLP) as Collector
GlucoseSensor	Example using Glucose Profile (GLP) as Sensor
HeartRate	Example using Heart Rate Profile (HRP)
HIDEmuKbd	Example using HID over GATT Profile (HOGP)
ProximityTag	Example using Proximity Profile (PXP)
RunningSensor	Example using Running Speed and Cadence Profile (RSCP)
Thermometer	Example using Health Thermometer Profile (HTP)
TimeApp	Example using Time Profile (TIP)

Additional Services

Proprietary
Accelerometer
Barometer
Gyrometer
Humidity
IR Temperature
Magnetometer
Movement
Optics
Connection Control
Simple Keys

BT SIG Adopted
Find me
Alert Notification
Battery Status
Device Information

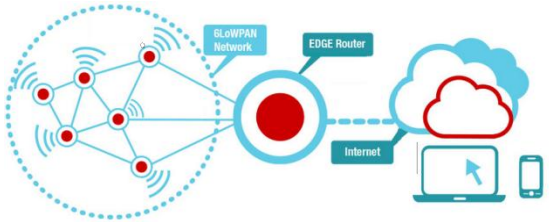
44

6LoWPAN

IP cloud connection, largest network, longest range

Value Propositions

- **IP cloud connection**: Complete solution from end nodes through edge router to the cloud
- **Large and secure mesh network**: Connect up to 1000s of nodes
- **Longest range**: With sub-1 GHz PHY, solution scales for building, street or city-wide networks



Products

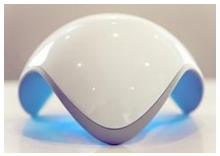
- **Wireless MCUs**
  - CC2538 (high performance 2.4GHz)
  - CC2630 (Ultra Low Power 2,45GHz)
  - CC1200 (Sub-1 GHz long-range)
  - CC1330 (Ultra Low Power 2,45GHz)
- **Range extender**
  - CC2592 (2.4 GHz extends up to 4x range)
- Contiki software: Open source solution

Features

- Complete solution for both 2.4 GHz and Sub-1GHz
- An edge router connects the 6LoWPAN network to IP applications. No gateway needed
- Mesh routing that is robust and self-healing
- Can achieve multi-year operation on a coin-cell battery
- Open Source Contiki Operating System, including IPv6 protocol stack
  - Can be customized if needed
  - **No license cost, 3-clause BSD license**

Applications

- Internet of Things (IoT)
- Home and building automation
- Safety and security
- Low-power sensor networks



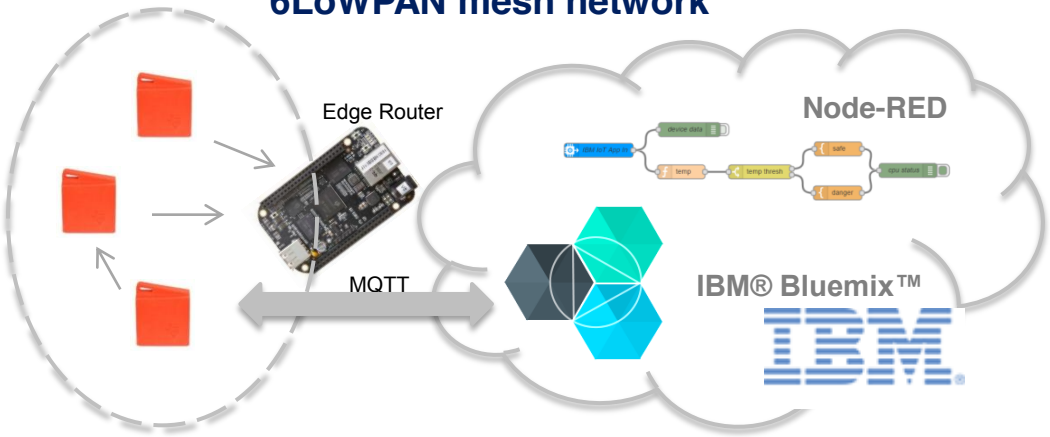
Home Automation and Monitoring

tado°

Connecting to the Internet (e.g. IBM Cloud)

- Gateway, Edge Router:
  - Beaglebone Black with CC2531 USB dongle, running Debian Linux.
  - Optionally translates between IPv4 and IPv6, using NAT64
- CC2650 SensorTag and SRF06EB + CC2538EM/CC2650EM are supported platforms
- Expandable to sub-1GHz in future
  - Same demo/applications available

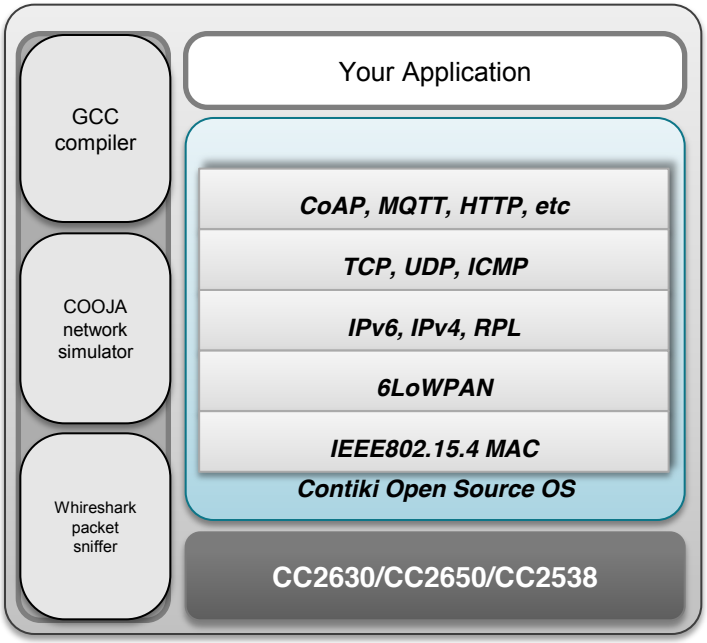
6LoWPAN mesh network



Other Cloud Partners

ARM
EXOSITE
spark
xively by LogMeIn
2lemetry
thingsquare
ARRAYENT

Contiki Open Source Software *Solution*

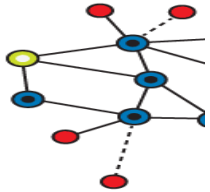


ZigBee

Lowest power, large secure mesh network, easiest to use

Value Propositions

- **The lowest power**: Multi-year operation on small coin-cell
- **Robust and standardized mesh network**: Connect up to 100s of nodes in industrial settings
- **Easiest to design with**: Proven and robust 'copy-paste' kits, reference designs together with Golden Unit software stack



TIDesigns

Products

- **Wireless MCUs**
  - CC2530 (Wireless MCU)
  - CC2531 (with USB)
  - CC2538 (High performance, large memory)
  - CC2630 (Ultra Low Power)
- **Range extender**
  - CC2592 (Extends up to 7x range)
- Z-Stack: Royalty-free and robust TI ZigBee stack

Features

- Run Z-Stack and application on one single chip
- Secure Over-the-air software update capability
- Industrial temp range: -40 to 125 C
- Certified ZigBee Golden Unit
- USB support

Applications

- Home automation
  - Comfort
  - Security
  - Energy efficiency
- Lighting networks
  - Lights
  - Switch/sensor
- Generic mesh
- IP-to-ZigBee gateways

ZigBee® Software

Z-Stack™ ZigBee Software Stacks (www.ti.com/tool/z-stack)

Z-Stack Home is TI's ZigBee Home Automation (ZHA) compliant protocol stack for the CC2530/1 and CC2538 System-on-Chip.
Z-Stack Lighting is TI's ZigBee Light Link (ZLL) compliant protocol stack for the CC2530/1 System-on-Chip.
Z-Stack Energy is TI's ZigBee Smart Energy (ZSE) compliant protocol stack for the CC2530/1 and CC2538 System-on-Chip.

They are based on Z-Stack™, fully compliant ZigBee 2012 protocol stack with ZCP (ZigBee Compliant Platform) certification.

CC2538 Foundation Firmware

The CC2538 foundation firmware is an extensive collection of software libraries for the CC2538 - an ARM Cortex-M3 based IEEE 802.15.4 compliant RF system-on-chip.

IEEE802.15.4 Medium Access Control (MAC) Software Stack

TIMAC is the Texas Instruments IEEE 802.15.4 Medium Access Control (MAC) software stack, available for multiple platforms.

It provides basic star network management enables development of custom protocol that can scale to up to 5000 nodes.

CC26xx Sensor Controller Studio (SCS)

SCS is an Integrated Development Enviroment (IDE) with integrated compiler and debug capability. The tool has an intuitive GUI interface and the installer includes application examples.

"SCS Leverage the complexity that arises in a multi-CPU system by providing a seamless tool for development and test of sensor controller applications."

1

Develop

- Write C style code to initialize, execute and terminate tasks
- A task is a small program running from RAM in the SC
- Many examples exist to show how to control the various peripherals
- Up to 8 tasks are possible to export from 1 project

2

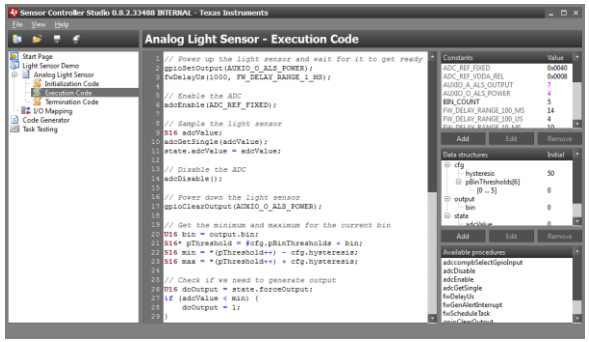
Test

- Visualize output from tasks in the Task Testing pane
- Debug assembly code if neccessary
- Single step, set breakpoints etc

3

Export

- Generate driver and machine code.
- Export to main IDE for your software project



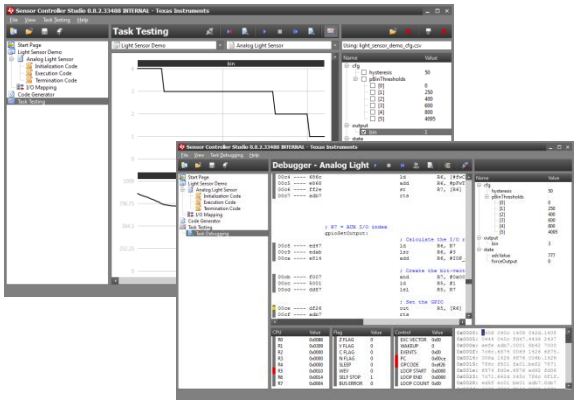
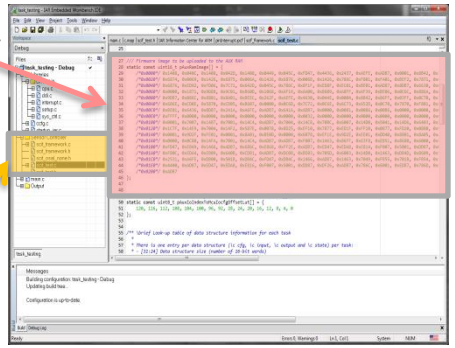


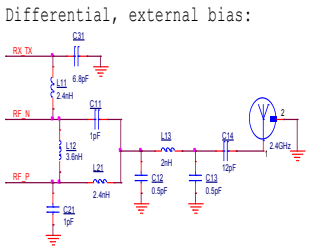
Image loaded to Sensor Controller RAM on startup

Project files exported from Sensor Controller Studio

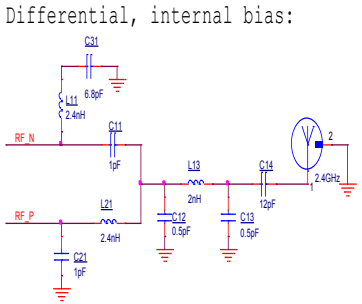


CC26xx Radio Frontend *Flexibility*

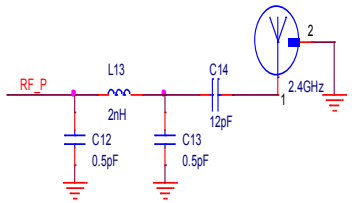
- **Differential, external bias:**
  - Best performance
  - 5 dBm output power, -97 dBm BLE sensitivity
  - Available for 4x4 and 5x5

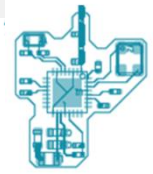
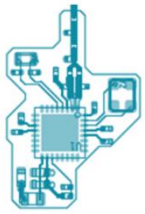
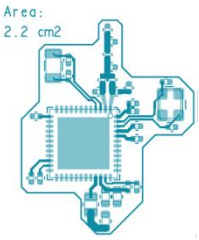


- **Differential, internal bias:**
  - Reduced BOM (shunt inductor not required)
  - 5 dBm output power, -96 dBm BLE sensitivity
  - Available for 4x4, 5x5 and 7x7



- **Single ended:**
  - Lowest cost BOM and smallest size
  - 2.4 dBm output power, -94 dBm BLE sensitivity
  - Both RF pins can be used for TX/RX antenna diversity
  - Available for 4x4, 5x5 and 7x7



Evaluation Module		CC2650EM-4XD	CC2650EM-5XD	CC2650EM-7ID
CC2650 Package Type		4x4	5x5	7x7
Pitch [mm]		0.4	0.5	0.5
GPIOs		10	15	31
Design Example	RF Frontend Option	Single Ended External Bias	Differential External Bias	Differential Internal Bias
	Area [cm²]	1.3	1.5	2.3
	Illustration			
	Crystals	2	2	2
	Capacitors	14	17	18
	Inductors	3	6	5
	Resistors	1	1	1
	Total	**20**	**26**	**26**

Development Kits *CC2650*

Supports development for BLE, 6LoWPAN and ZigBee

CC2650DK
$299

C2650EMK
$99

CC2650STK
$29

\+

CC-DEVPACK-DEBUG
$15

Full feature development kit with embedded TI XDS emulator for development and debugging.

SmartRF06 Features:

- Dot matrix LCD
- 4 LEDs
- 5 buttons
- Accelerometer
- Ambient Light Sensor
- UART backchannel
- Micro SD card reader
- I/O breakout headers

Powered by CR2032 Coin Cell Battery
Native sensor support for:

- 6-axis MEMS motion tracking (Invensense)
- Humidity (TI)
- IR temperature (TI)
- Light Sensor (TI)
- Buzzer (Changzhou Tianyin)
- Microphone (Knowles)
- Pressure (Bosch)
- Reed Relay (Meder)

Dev. Pack for custom functionality.
Supported by accompanying iOS/Android apps

Wilink™ Combo solutions

high-performance WiFi + Bluetooth/Bluetooth Low Energy

Value Propositions

Tools/modules for easy development

- **Performance and low power:** 100Mbps with the lowest power (800uA IDLE)
- **Certified and easy to use:** Pre-integrated, certified, production ready solutions, software downloadable. Open documentation (Wiki), Forums (E2E), TI and 3rd party network
- **Integrated and scalable**: single chip multi-combo with pin to pin compatible variants, consumer, industrial (85 degree C) and automotive grade (Q100)

Products

- WilinkTM 8 Combo
  - WL18xx Combo
- TI Modules
  - WL1801MOD
  - WL1805MOD
  - WL1831MOD
  - WL1835MOD
  - WL1807MOD
  - WL1837MOD
- 3d Parties modules

Features

- Combo BT Dual Mode + WiFi on one single-chip
- Performance over long range
- Connect to processors(high level OS) and MCUs running the stack
- Industrial temp -40 to 85 C
- 2.4GHz and 5GHz support
- Fully certified module (FCC, IC, CE, Bluetooth)

Applications

- Security Camera
- Portable Data Terminal
- Gateways
- Audio
- Industrial Panel/ HMI
- Professional Camera
- Wearable

Connecting applications with TI Wi-Fi®

Wi-Link™

WL183xMOD

Highest Performance & Integration

Wi-Fi, BT/BLE combos
Attaches to MPUs (Sitara)
TI certified module

WL180xMOD

Highest Performance

Wi-Fi
Attaches to MPUs (Sitara)
TI certified module

Portable consumer & enterprise, Automotive, Connected Home, Smart Energy, Health




SimpleLink™

CC3100

Wi-Fi Network Processor

Internet-on-a-chip™ solution
Integrated Wi-Fi, internet and security protocols
Attaches to MCUs

CC3200

Wireless MCU

Same features as C3100 + customer programmable Cortex M4 MCU

Home automation, Smart energy, connected appliances, M2M communication, Health & fitness