SimpleLink™

Bluetooth low energy device:

CC2640

SimpleLink™ Bluetooth low energy CC2640 wireless MCU

THE easiest to design with

Comprehensive design support

Complete SW stack, sample apps, wiki guides, dynamic design kits, low-cost tools, & software starting points

THE lowest power

Multi-year operation on a coin cell

Ultra low power by Cortex M3 MCU, radio, sleep current and unique Sensor Controller

THE most integrated

Complete Bluetooth low energy system in a finger tip size

A single-chip Flash-based 4x4 QFN with one crystal

Connect More with TI

CC2640

Improving the three key challenges for a *Bluetooth* low energy product:

Easiest to design with	Lowest Power	Most Integrated
• Qualified BT 4.2 BLE • Get-Started Documentation & Wiki • Dynamic Design Kits	• ~ 6mA Radio peaks and 1uA Sleep • ~ 61µA/MHz ARM Cortex M3 • <10 uA avg. Current @ 1s Conn. Int	• 4x4 QFN, 2.7 x 2.7 WCSP • On-Chip Flash • Single Ended Output
Comprahensive Design Support	*Multi-year operation on a coin cell*	*Complete Bluetooth low energy system on a finger-tip size*

"CC2640 lowest power wireless MCU"

SimpleLink™ *Bluetooth*® low energy
CC2640 Ultra low Power Wireless MCU

Features/Benefits

- **Easiest to design with** – Get faster to market: Complete SW stack, wiki guides, dynamic design kits, low-cost tools, & software starting points
- **Lowest power** – Use a coin cell for multi-year, always-on operation or go battery-less with energy harvesting
- **Most integrated wireless MCU** – Less board space, more possibilities, single-chip Flash-based, 4x4 QFN

Design Kits & EVMs

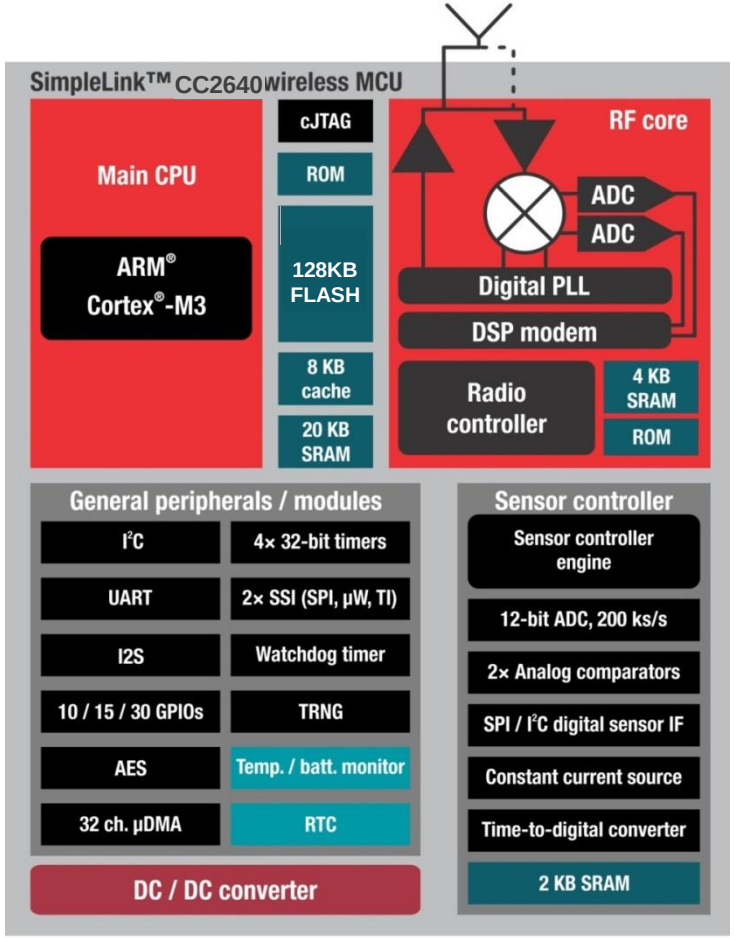
CC2650STK $29

SensorTag: For Smartphone app development and initial hardware evaluation

CC2650 LaunchPad
Advanced development platform

Dev Tools & Software

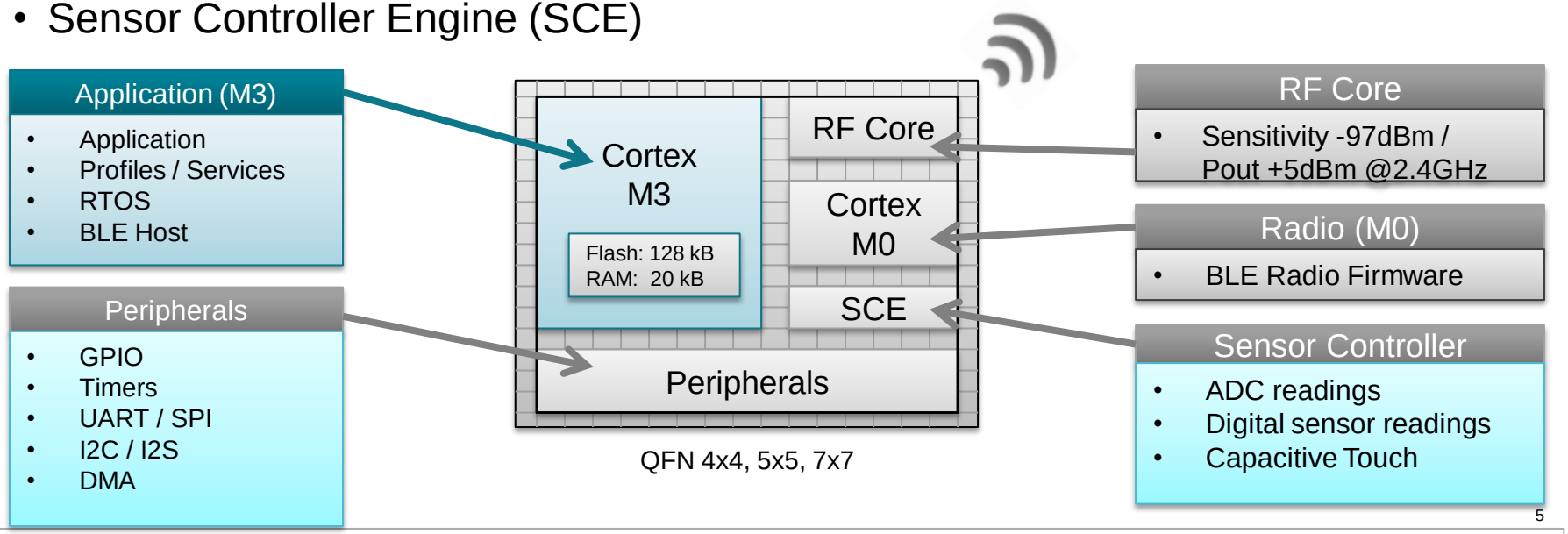
- Software Development Kit, including royalty free Stack,
- SmartRF Studio
- Sensor Controller Studio
- TI iOS/Android Multitool
- Extensive library of SW examples and sample code



SimpleLink™ CC2640

One-chip Wireless MCU

- ARM Cortex M3 Application Processor
- ARM Cortex M0 Radio Processor
- Sensor Controller Engine (SCE)



TI's *Bluetooth*® 5 overview

SimpleLink™ CC2640R2F & CC2640R2F-Q1

Bluetooth low energy wireless MCUs

www.ti.com/ble

Bluetooth 5 is the future

Source www.bluetooth.com/bluetooth5

New *Bluetooth*® 5 features

Longer range

- ***Improved sensitivity*** through coding – same TX/RX current
- Whole-house coverage

Faster data transfer

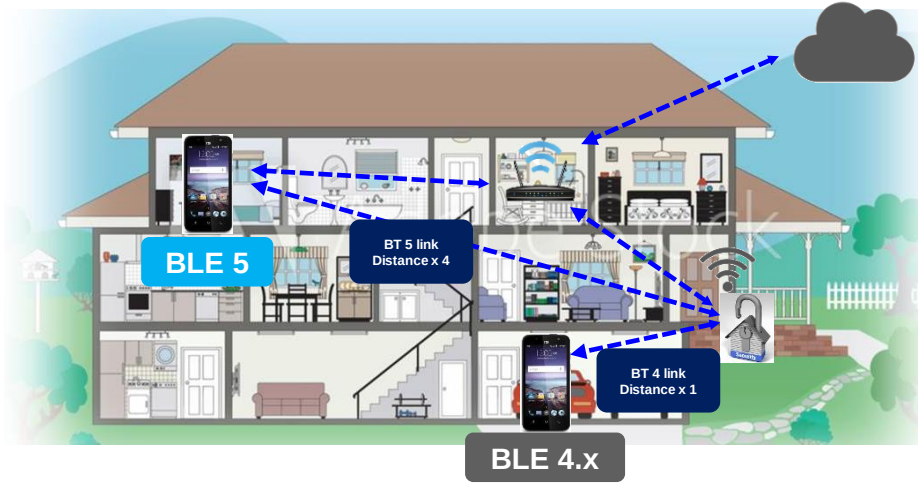
- 500% increase in data throughput vs. Bluetooth 4.0 using **2Mbps**
- CC2640R2F supports even higher throughput up to 5Mbps (proprietary)

Advertising extension

- Transmit more intelligent data over a beacon with **increased broadcasting capacity**
- Enable rich location/navigation applications

Learn more

Long Range use case: door lock



- **Reliable house coverage**
  - Reach your lock from anywhere in the house with your phone
  - Remove repeaters
  - Door lock can reach access point and integrates Smart Home system

- **Less retransmission, less power**

Benefits for additional applications

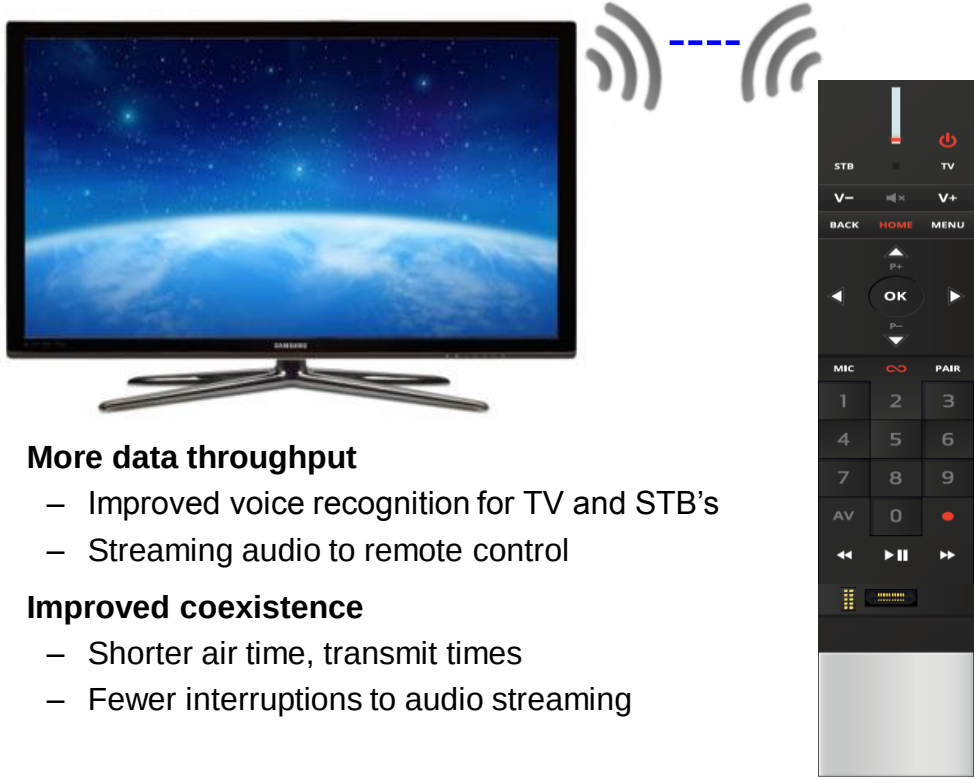
Appliance

HVAC

Industrial sensor network

- Reliable *building automation* coverage
- Improved range in noisy 2.4GHz space
- Wider tracking zone, improves coverage

Faster data transfer use case: audio

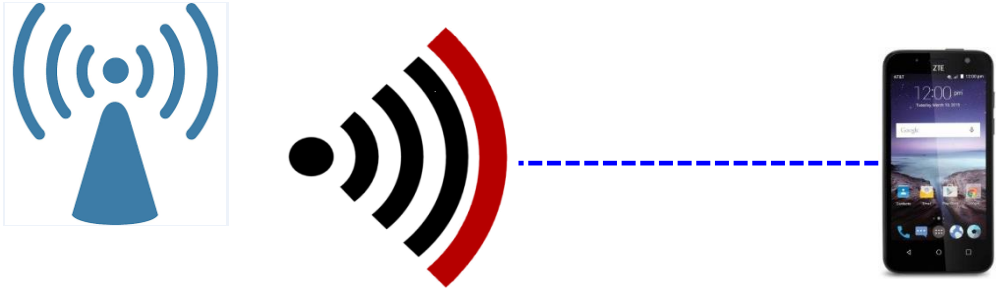


- **More data throughput**
  - Improved voice recognition for TV and STB's
  - Streaming audio to remote control
- **Improved coexistence**
  - Shorter air time, transmit times
  - Fewer interruptions to audio streaming

Benefits for additional applications

- Audio streaming to remote control from streaming media players

Advertising extension use case: Beacon



- **Advertising Extension**
  - Transmit more information over beacon (31 bytes to 255 bytes).
  - More personalized experience (locationing beacon gives more precise information)
  - Connection-less beacons: beacon always sending information w/o hand-shake leading to quicker, richer notification

Benefits for additional applications

- Advanced beacon applications for asset tracking & indoor navigation

- Connection-less applications

….*limitless* other use cases

- **High data rate**
  - Faster Data Logging and Diagnostic
  - Faster firmware upgrade

- **Long range**
  - Improved RF noise/ Interference immunity to electromagnetic interference in industrial environments

More applications, more Innovation

More data for Biometric authorization systems

Low latency application-level cryptographic key/certificate exchanges

Faster user experience

TI's *Bluetooth* Development Resources overview

Development Kits *SensorTag or LaunchPad?*

CC2650STK
$29

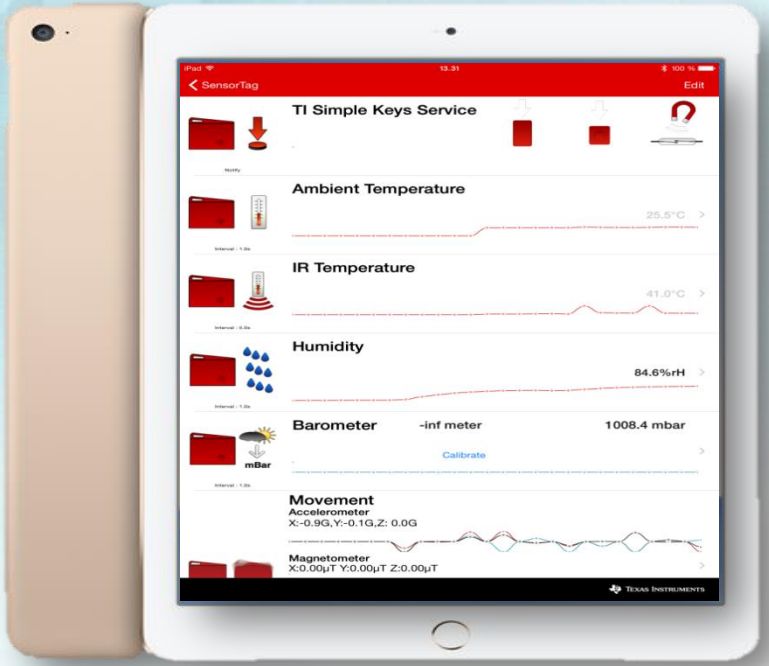
CC-DEVPACK-DEBUG
$15

CC2650 SensorTag		CC2650 LaunchPad
Coin Cell Battery (CR2032)	**Power Suppy**	USB
External required ($15 DevPack)	**Debugger**	Includes onboard (XDS110)
Peripherals • 6-axis MEMS motion • Humidity (TI) • IR temperature (TI) • Light Sensor (TI) • Microphone • Pressure • Reed Relay • External Flash (512kB)	**On-board Features**	All IOs available on pin headers (Boosterpack connectors) Peripherals • External Flash (1MB)
DevPack	**Add-on type**	BoosterPack, LaunchPad
• Well suited for SW development for coin cell operated applications • Good platform for evaluating RF performance for a physically small device	**Pros**	• Well suited for HW prototyping • Best RF performance due to large ground plane • Well suited for current consumption measurements • Can be used as stand-alone debugger

CC2650LP
$29

Both development kits are supported by accompanying iOS/Android apps

Small, Simple & Splendid for the IoT – next generation SimpleLink™ **SensorTag**!



SensorTag – IoT made easy

- $29 Complete IoT development kit
- Access Sensor data in the cloud in 3 minutes
- 9 Low Power Sensors
  - 1 year battery life
- Expandable with DevPacks
  - Lowest cost $15 debugger
  - Watch/Display
  - LED/Audio
  - Interchangable between SensorTags
- Complete designs at www.ti.com/tidesign
  - Including 3D files
  - Print your own SensorTag

Existing Bluetooth low energy TI Designs

Bluetooth® Low Energy

RS-485

Haptic Feedback

Gas Sensor

Keyfob

Light Harvesting

BLE Light

Postage Stamp

Long Range

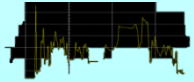
Mini Broadcaster

Biometric Wheel

USB Dongle

SensorTag iBeacon

Heart Monitor



Body Composition

Optical Heart Rate

Weight Scale

Pulse Oximeter

CC2640: Reduce your time to market

Easy to design with: Do your final prototype within 10 days (checkout the wiki)

Get Started

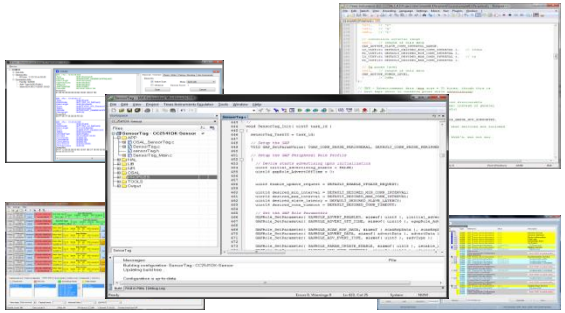
- Order Kit
- Download SDK
- Evaluate & Learn *Bluetooth* low energy

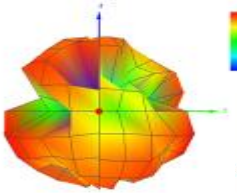
Develop

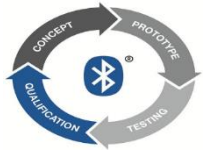
- Define Application
- Choose/Design Profiles
- Implement Prototype

Test & Release

- FCC/ETSI Certification
- *Bluetooth* Listing

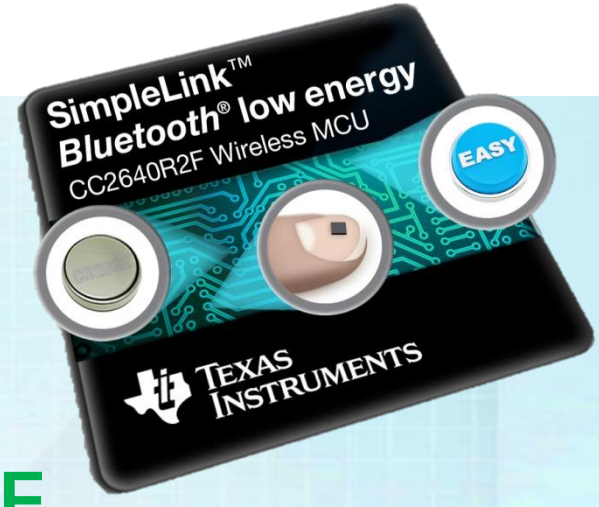






Extensive Online Knowledge Base & E2E Support – ti.com/ble-forum

SimpleLink™

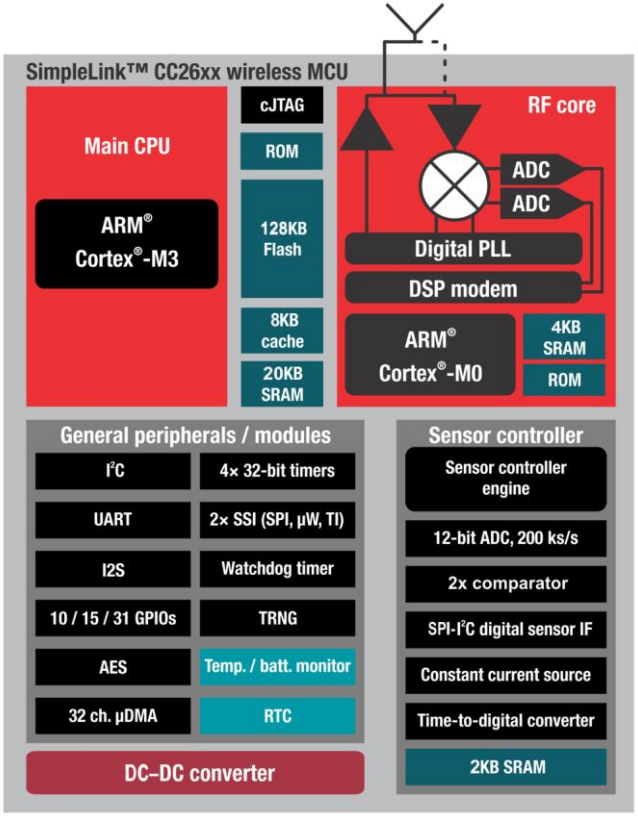


BLE device: CC2640/CC2640R2F

硬件射频——从设计到成型

Speaker: TI engineer, Albin Zhang

CC2640/CC2640R2F *Bluetooth low energy*



Quick Facts

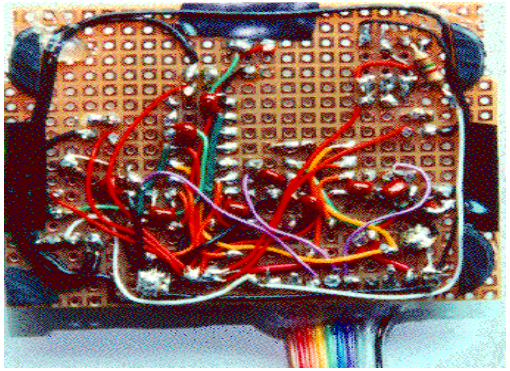
Ultra-low Power Consumption
- 61 µA/MHz ARM Cortex M3
- 8.2 µA/MHz Sensor Controller
- 1 µA sleep with retention and RTC
- 5.9 mA RX (single-ended)
- 6.1 mA TX (single-ended@0dBm)

SoC Key Features
- Autonomous sensor controller engine
- 4x4 mm to 7x7 mm QFN
- 1.7 – 3.8 V supply range
- 128 kB Flash
- 20 kB RAM+ 8 kB Cache

RF Key Features
- +5 dBm output power
- -97 dBm sensitivity
- **-103dBm** RX sensitivity @125 kbps (BT 5.0)
- QFN and WCSP package
- Pin compatible with CC13xx

Why need to consider hardware design guideline

- Get as expected performance
- Get your design to market on time
- Ensure a good experience with TI products
- So that your board does not look like this →



Hardware basics

关于无线芯片布板关键指导的相关基础知识，请观看网上培训资料　无线芯片性能布板关键

1. 21Dianyuan： http://edu.21dianyuan.com/index/course_info/cid/118
2. 21IC：http://edu.21ic.com/lesson/1637
3. eeWorld： http://training.eeworld.com.cn/TI/show/course/3613

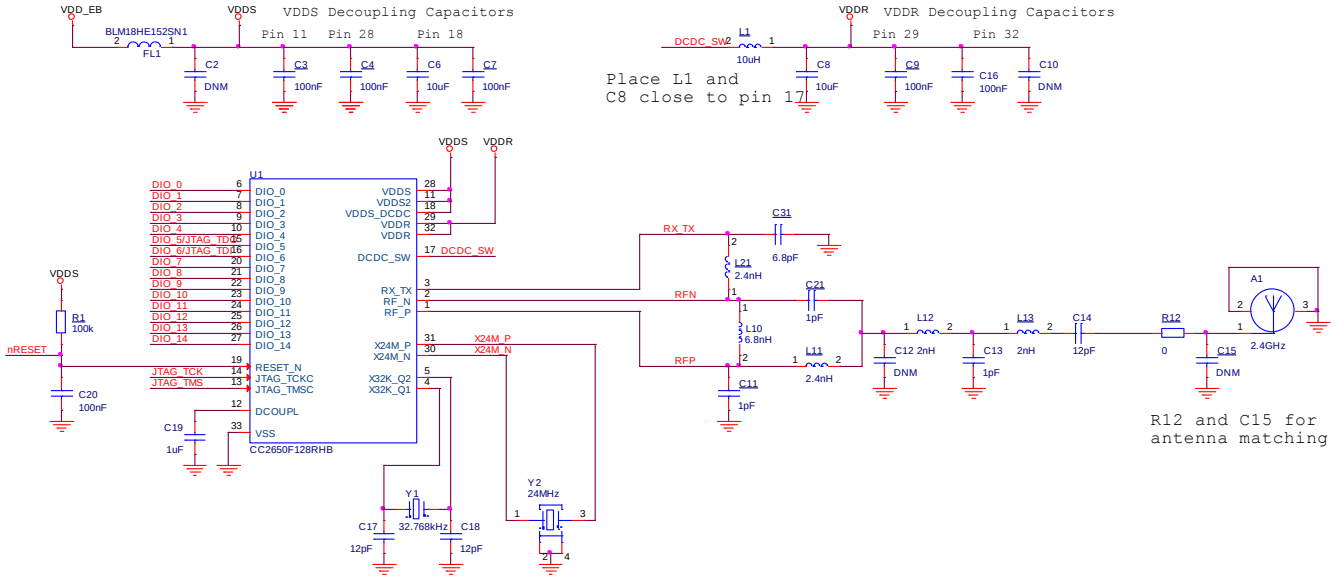
CC2640/CC2640R2F HW Training

1. 原理图；器件选型；参考设计
2. layout布板关键准则
3. 从CC2640到CC2640R2F的硬件移植; BT5.0PHY
4. 天线套件介绍
5. 硬件设计流程及认证简介
6. 在线资源介绍

Agenda

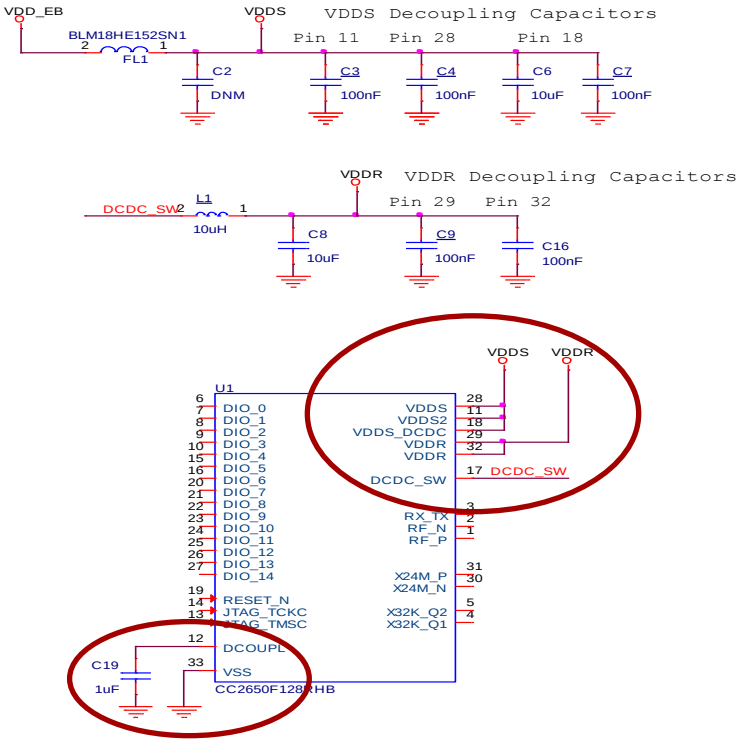
- **Schematic overview**
  - **Walkthrough of external components**
  - **RF front end alternatives**
- CC2640EM PCB designs with layout considerations
- Hardware Migration From CC2640F128 to CC2640R2F
- Antanna kits
- Design process, testing briefing and certification
- Launch with on-line resources

Reference Schematic



Texas Instruments

Power Supply - Decoupling



VDDS:

- Main device supply pin, input voltage = 1.8 V – 3.8 V
- Decoupling: 100 nF

VDDS2 / VDDS3:

- Supply for a set of DIO pins. May be at a different voltage potential than VDDS
- Decoupling: 100 nF (each)

VDDS_DCDC:

- Input to internal DC/DC regulator
- Decoupling: 10 uF + 100 nF

DCDC_SW:

- Output of internal DC/DC regulator
- Connect to 10 uH inductor and 10 uF capacitor
- Output is supply to the VDDR pins

VDDR:

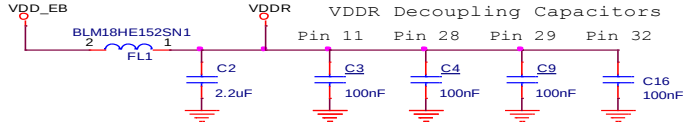
- Regulated supply pins, input voltage = 1.7 V – 1.95 V
- Decoupling: 100 nF (each)

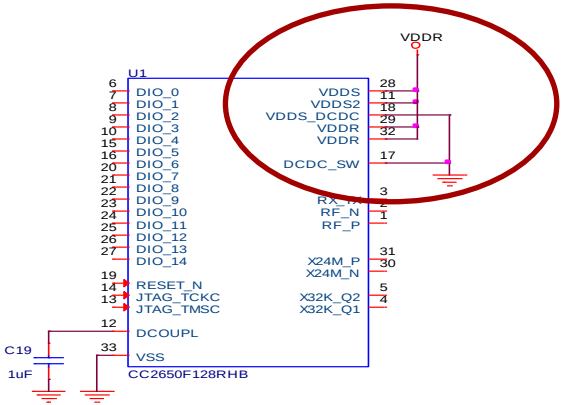
DCOUPL:

- Decoupling of internal LDO. Connect to 1 uF capacitor

Texas Instruments

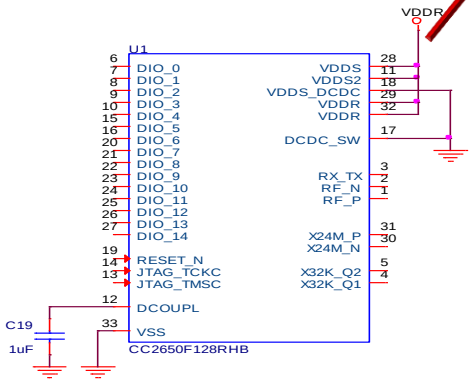
External Regulator Mode, 1.8 V supply

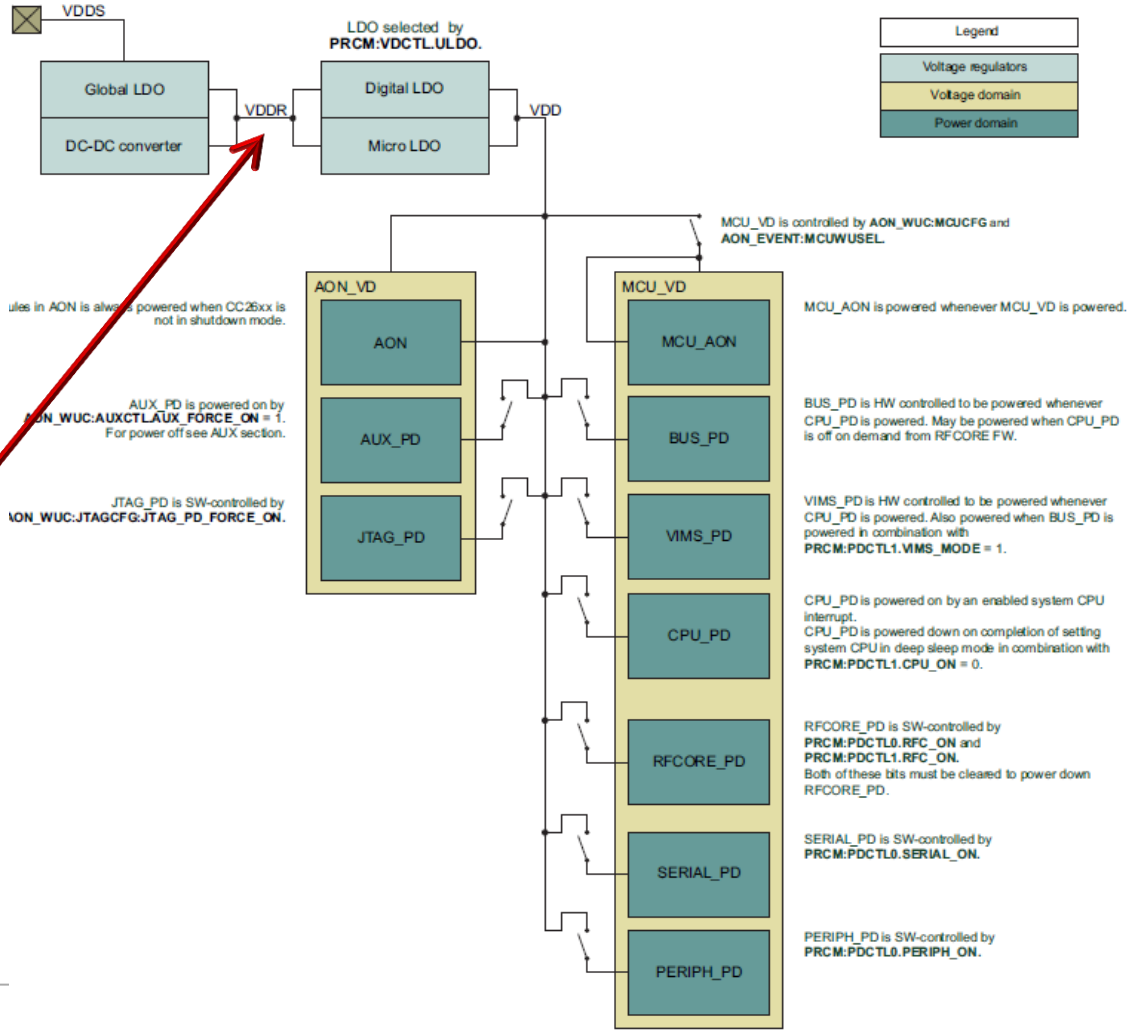




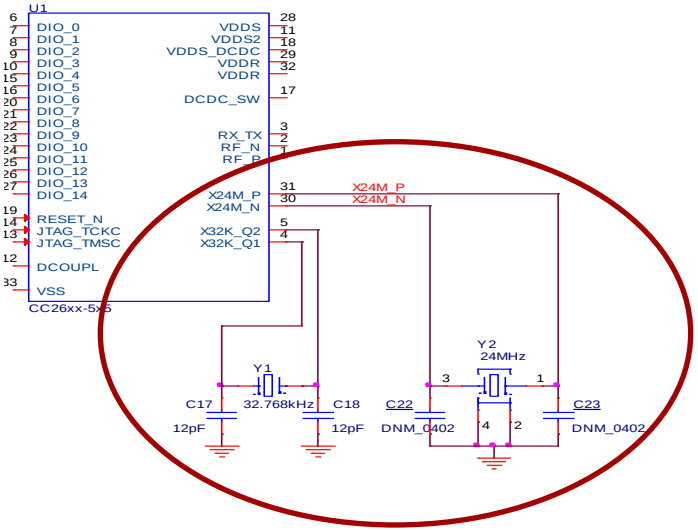
- Input voltage = 1.7 V – 1.95 V
- VDDS and VDDR pins tied together
- VDDS_DCDC and DCDC_SW must be connected to ground
- Typically used in applications with existing 1.8 V rail
- Recommended regulator: TPS62740

Power Supply - Overview





Reference Schematic - oscillators



32 kHz RC Oscillator (internal):

http://www.ti.com/lit/an/swra499a/swra499a.pdf

- Where the lowest possible BOM cost is desired or when board layout space is limited.
- Peripheral role devices (slave) that maintain short (fast) connection intervals or enter BLE connections infrequently and remain idle or advertising most of the time. Example devices include door locks, light bulbs, blood glucose meters (BGMs) and fitness/activity trackers.
- Beacon or broadcast role devices, such as Apple iBeacon® location and proximity detection technology and Eddystone™ an open beacon format by Google. These devices do not typically form connections and spend most of the time performing BLE advertising. These devices will achieve better (lower) current consumption with the RCOSC_LF than using an external 32 kHz crystal.

32 kHz XOSC:

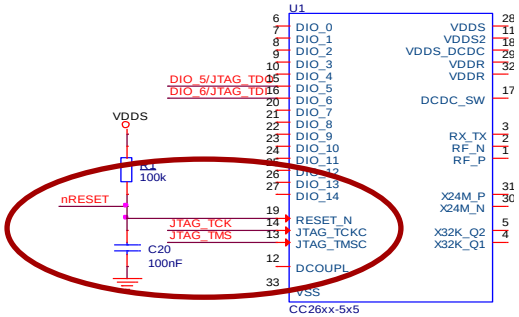
- Will increase the sleep clock accuracy and thus reduce the power consumption for BLE (shorter RX windows around connection events)
- Connect to crystal and load capacitors. Lower CL will give lower power consumption
- Externally generated clock signal is supported (digital clock). Input is through DIO-pin

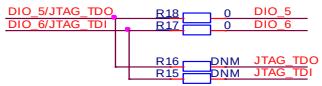
24 MHz XOSC:

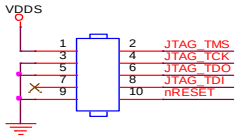
http://www.ti.com/lit/an/swra495e/swra495e.pdf

- 24 MHz, +/- 40 ppm, CL = 5 – 10 pF, ESR_max = 60 ohm
- Internal, adjustable, cap array (no need for external load caps)

Reference Schematic – JTAG / Reset







JTAG:

- Used for programming and debugging
- Default is cJTAG, 2-pin JTAG, using TCKC and TMSC
- 4-pin JTAG can be enabled, 2 of the DIOs are used for TDI and TDO (these are fixed pins, refer to the Technical Reference Manual)
- Supported debuggers:
  - XDS100 v3 (cJTAG)
  - XDS110
  - XDS200 (cJTAG)
  - IAR I-Jet (4-pin JTAG)
  - Segger J-Link (4-pin JTAG)

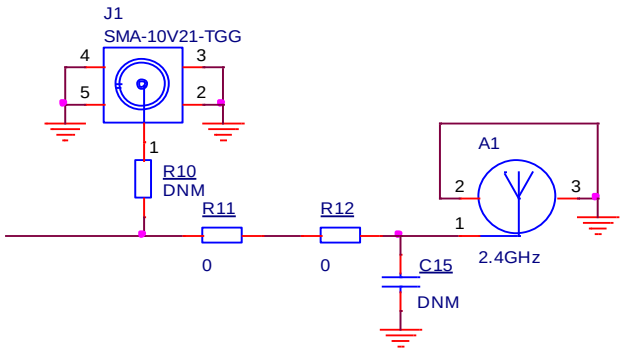
Reset Pin:

- Active low
- No internal pull-up
- Reset is a low power state
- Not strictly required for programming and debugging, but it is highly recommended as it is the only way to halt during boot

Recommended Debug Header:

- 10 pin 1.27 mm pitch header
- Official name: «Cortex Debug Connector»

Reference Schematic – Antenna / SMA



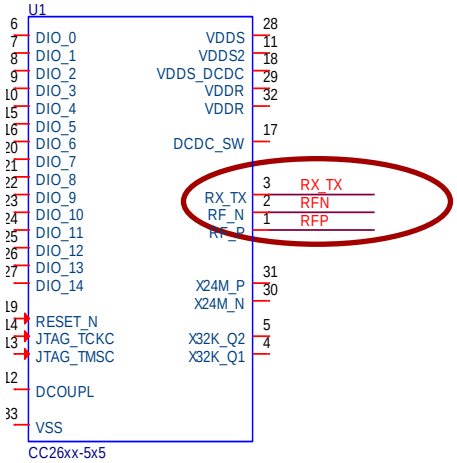
SMA connector:

- R10 and R11 are used to select SMA connector or PCB antenna
- Only one of R10 and R11 should be mounted
- Default in kits is R11, ie. PCB antenna

PCB antenna:

- R12 and C15 are used for PCB antenna impedance matching
- On the EM no tuning is required, however we recommend putting these components in in all customer designs

RF pins



RF_P: RF positive output / input

RF_N: RF negative output / input

RX_TX: Optional RF bias pin

Several options on output configuration:

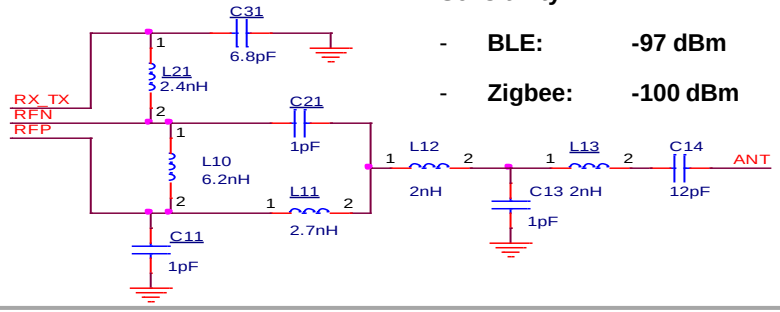
- Differential output: Both RF pins are used and a balun + a pi-filter is required between the CC26xx and the antenna
- Single ended output: Only one of the RF pins is used for RF output. Only a pi-filter is required between the CC26xx and the antenna. Output power is reduced and sensitivity is degraded
- External biasing of the RF pins can be applied through the RX_TX pin. This will improve sensitivity, but requires an additional inductor.
- For single ended configuration, the unused RF pin may alternatively be used as bias pin
- RX_TX can be used for external control of for example an RF switch

Note:

- The CC26xx 7x7 package does not have RX_TX-pin, while the CC13xx 7x7 package does.

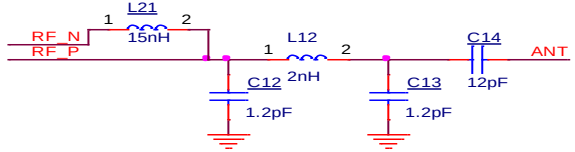
RF Frontend options

External bias



Sensitivity:

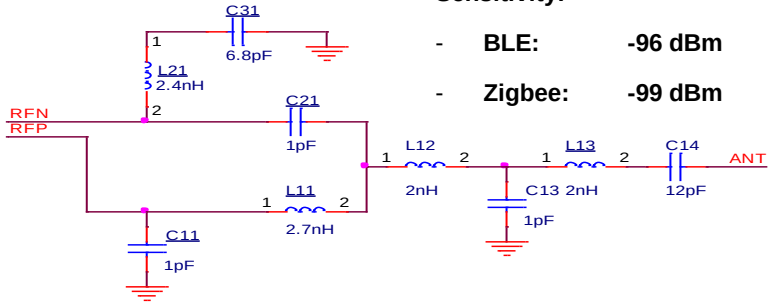
- **BLE: -97 dBm**
- **Zigbee: -100 dBm**



Sensitivity:

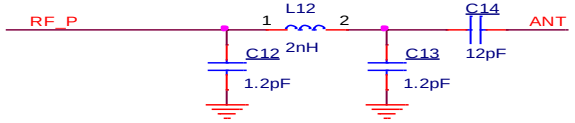
- **BLE: -96 dBm**
- **Zigbee: -97 dBm**

Internal bias



Sensitivity:

- **BLE: -96 dBm**
- **Zigbee: -99 dBm**



Sensitivity:

- **BLE: -94 dBm**
- **Zigbee: -95 dBm**

Pout_max = 5 dBm

Differential output

Pout_max = 2 dBm

Single-ended output

Texas Instruments

RF Frontend options

	Differential		Single Ended		
	Ext. Bias	Int. Bias	Ext. Bias	Int. Bias	
Output Power	5	5	2	2	[dBm]
BLE Sensitivity	-97	-96	-96	-94	[dBm]
Zigbee Sensitivity	-100	-99	-97	-95	[dBm]
Inductors	5	4	2	1	
Capacitors	5	5	3	3	
	10	9	5	4	

Agenda

- Schematic overview
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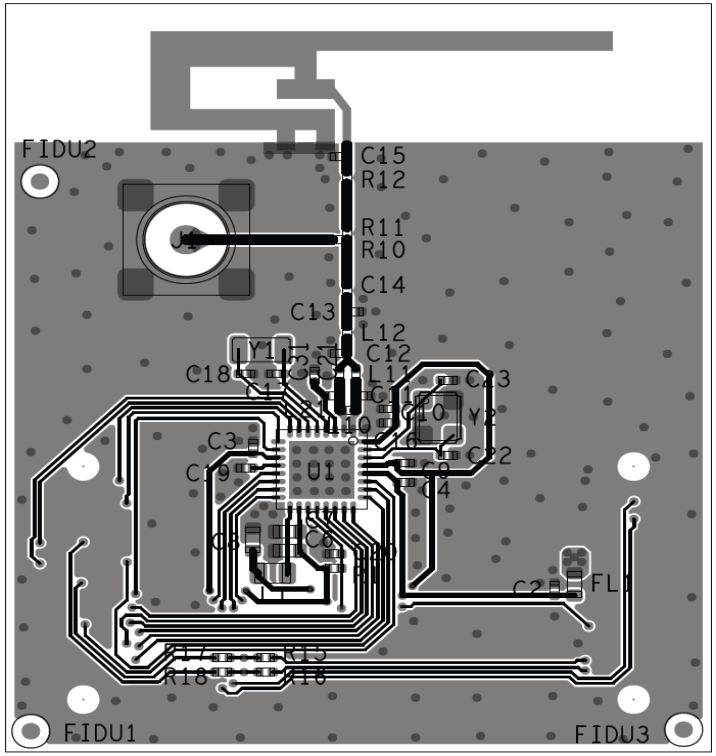
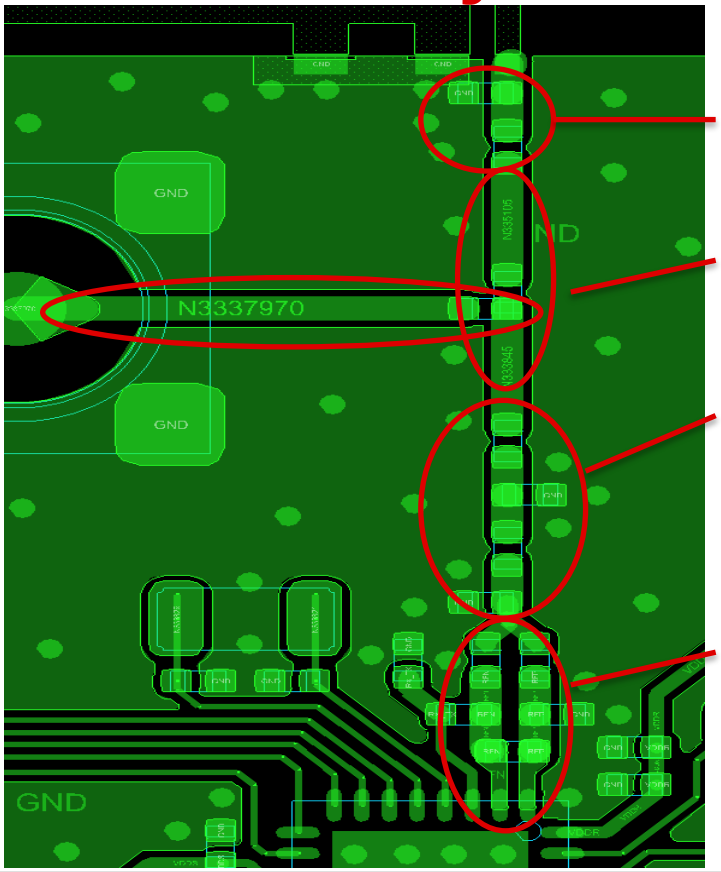
Reference Layout



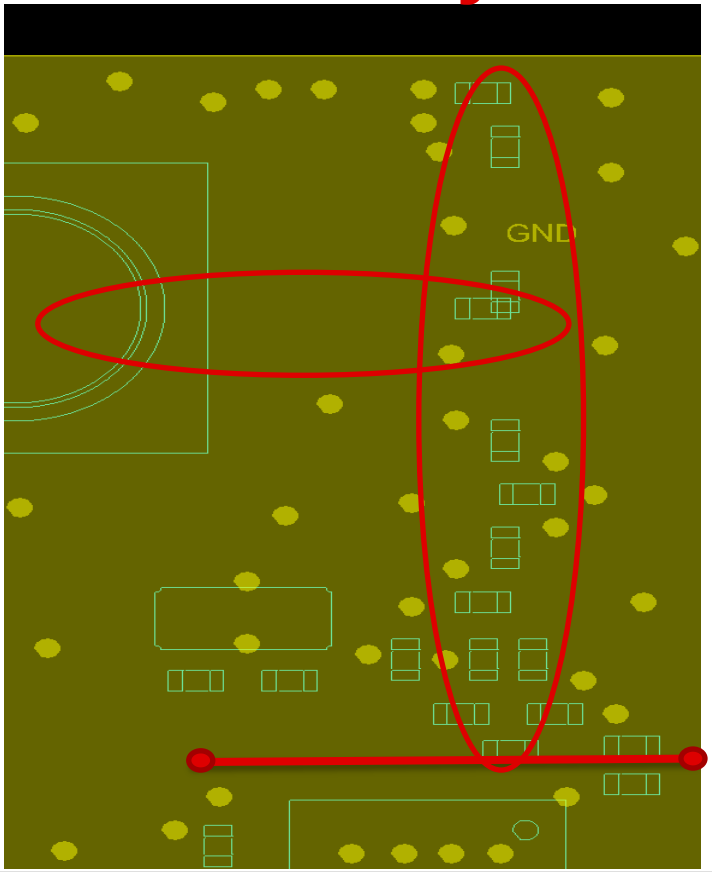
- Follow the reference layout!
- All reference designs are for 2-layer PCBs
  - Thickness = 0.8 mm
  - 4 (or more) layers is also ok
- Place the RF match close to the RF pins
- Solid ground plane
  - No signal traces underneath the RF path!
  - Ground return paths between the antenna / RF-components and CC26xx must be uninterrupted
  - Keep as much signal- and power routing on the top layer as possible
- Place decoupling caps as close to the VDD pins as possible
  - Ground return paths between decoupling caps and CC26xx should be short and direct
- DC/DC-regulator must have a short and direct ground connection to CC26xx

Reference Layout – Differential output



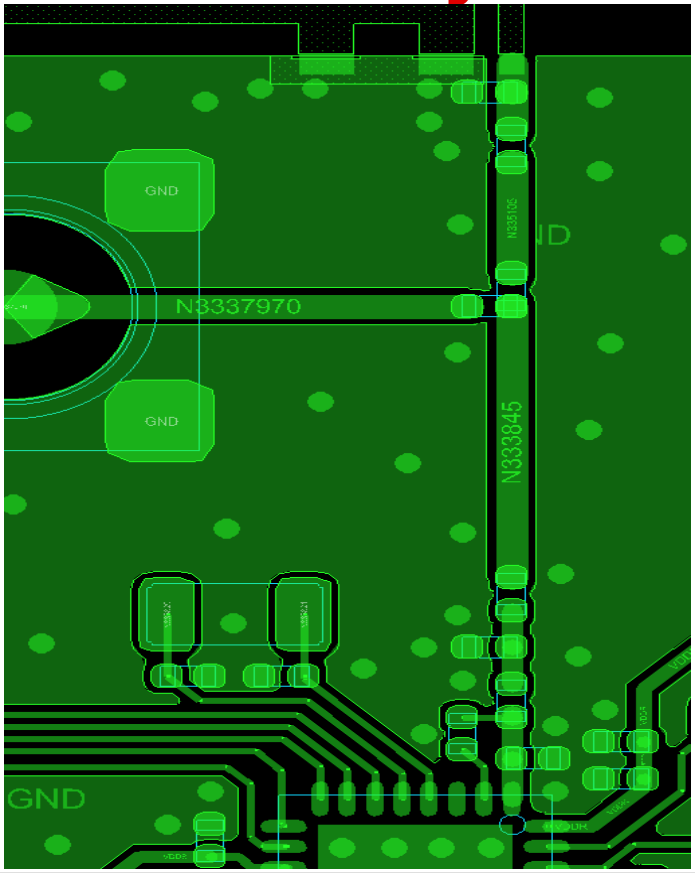
- Antenna match components
- Longer RF traces must have 50 ohm impedance
- Notice orientation of pi-filter layout
  - Shunt components oriented opposite way to avoid crosstalk
- “Copy/Paste” the balun circuit is quite necessary.
  - Symmetry
  - Length

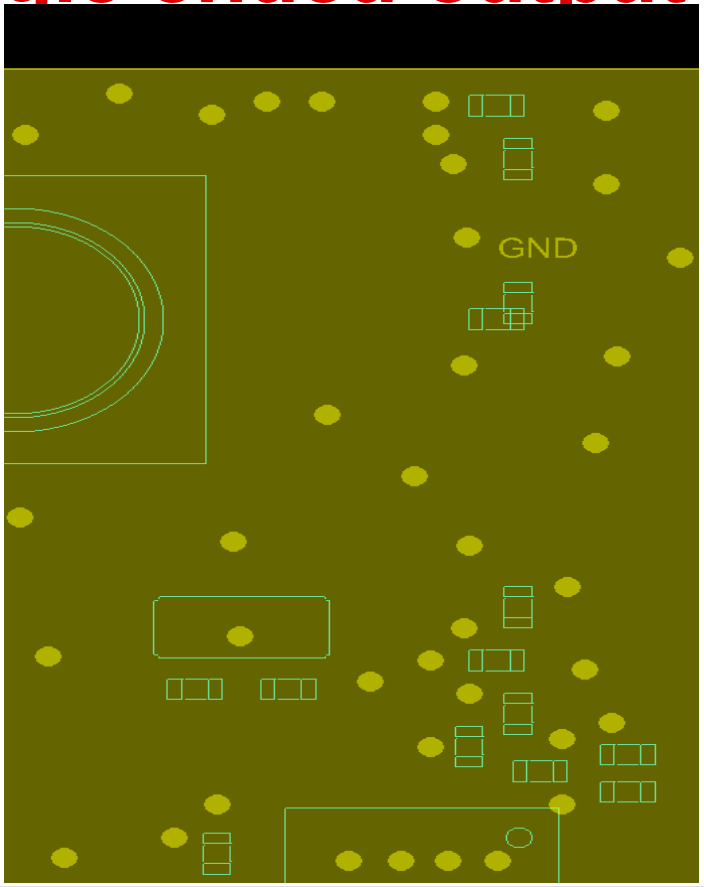
Reference Layout – Differential output



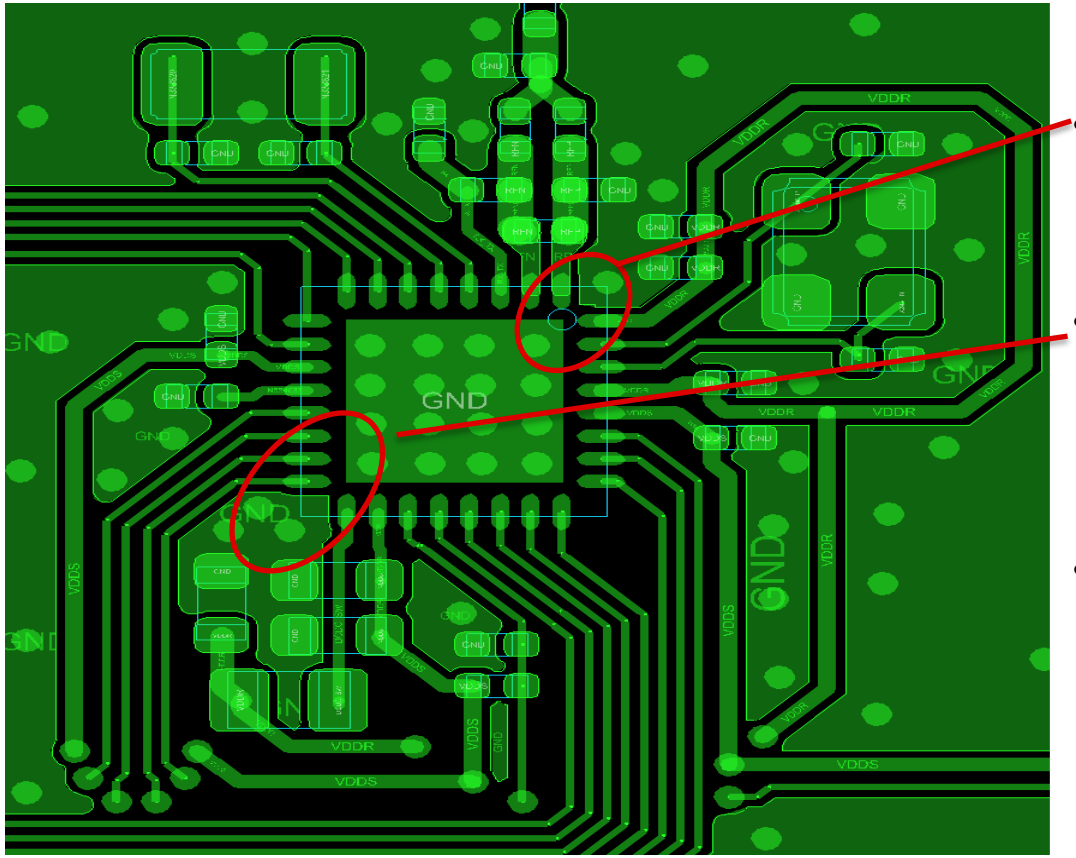
- No traces underneath the RF path
  - Will increase the impedance of the RF ground return paths and, even worse, create current loops
  - May lead to reduced RF performance and spuriuos emission

Reference Layout – Single ended output



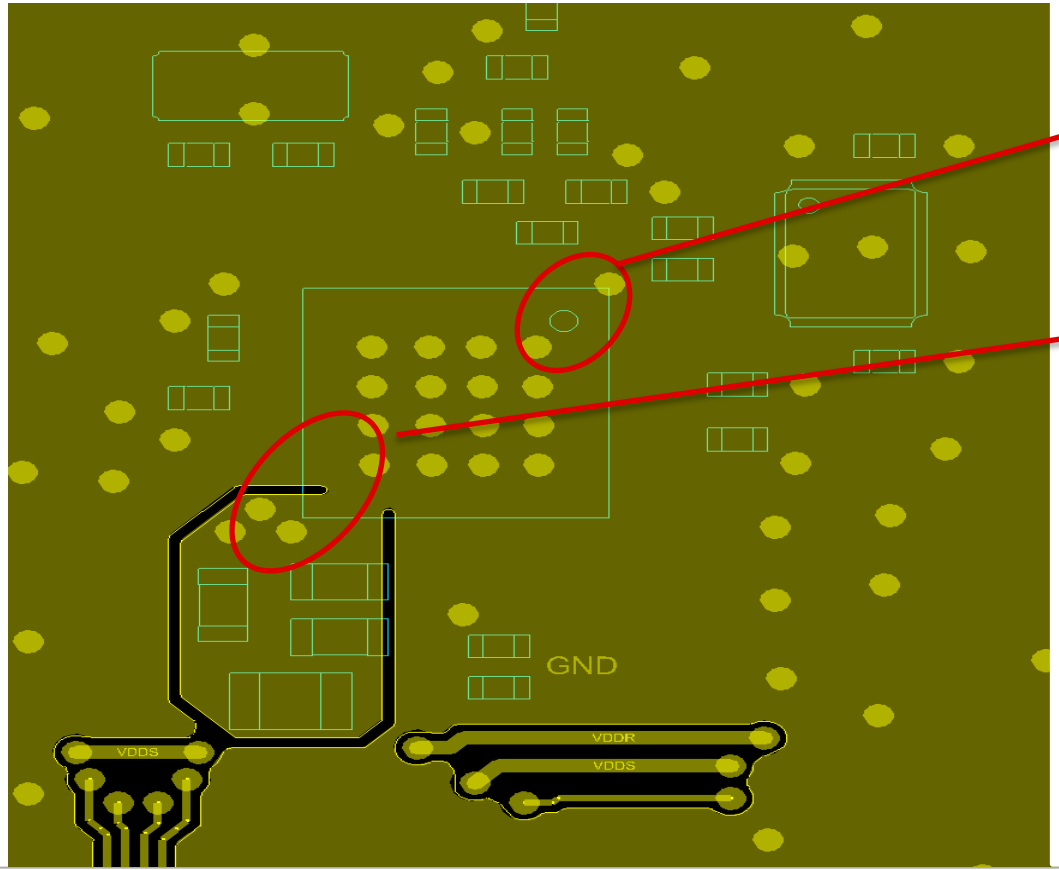


Reference Layout – Everything else



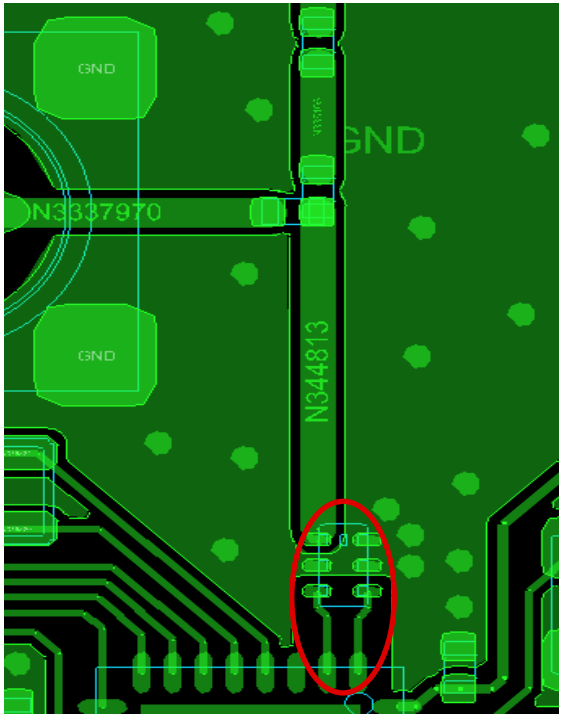
- Make sure decoupling ground paths are short and direct (low impedance)
- Make sure the DCDC switch ground path is short and direct (low impedance)
- Try to locate as much routing as possible on the top layer in 2-layer PCBs

Reference Layout – Everything else



- Make sure decoupling ground paths are short and direct (low impedance)
- Make sure the DCDC switch ground path is short and direct (low impedance)
- Try to locate as much routing as possible on the top layer in 2-layer PCBs

Reference Layout – Integrated Balun



- Integrated Baluns have been available.
- Form factor: 6 pins 0603-package
- RF performance compared to discrete solution (may change):
  - 0.5 dB to 1 dB insertion loss
  - Improved surpression of harmonic emission

Available reference designs

Design files
SimpleLink CC2640R2F WCSP EVM v1.1.0 Design Files
LAUNCHXL-CC2640R2 Design Files
SimpleLink CC2650 EVM Kit JohBal (CC2650EM-JohBal) v2.0.0 Design Files
SimpleLink CC2650 EVM Kit MurBal (CC2650EM-MurBal) v1.0.1 Design Files
SimpleLink CC2650 EVM Kit 4XD (CC2650EM-4XD) v1.0.3 Design Files
SimpleLink CC2650 EVM Kit 4XS_Ext_Reg (CC2650EM-4XS_Ext_Reg) v2.0.0 Design Files
SimpleLink CC2650 EVM Kit 4XS (CC2650EM-4XS) v1.0.4 Design Files
SimpleLink CC2650 EVM Kit 5XD (CC2650EM-5XD) v1.0.5 Design Files
SimpleLink CC2650 EVM Kit 7ID (CC2650EM-7ID) v1.2.6 Design Files

Boards marked in **Green** is orderable in TI estore. http://estore.ti.com/

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Hardware Migration From CC2640F128 to CC2640R2F

The Same!

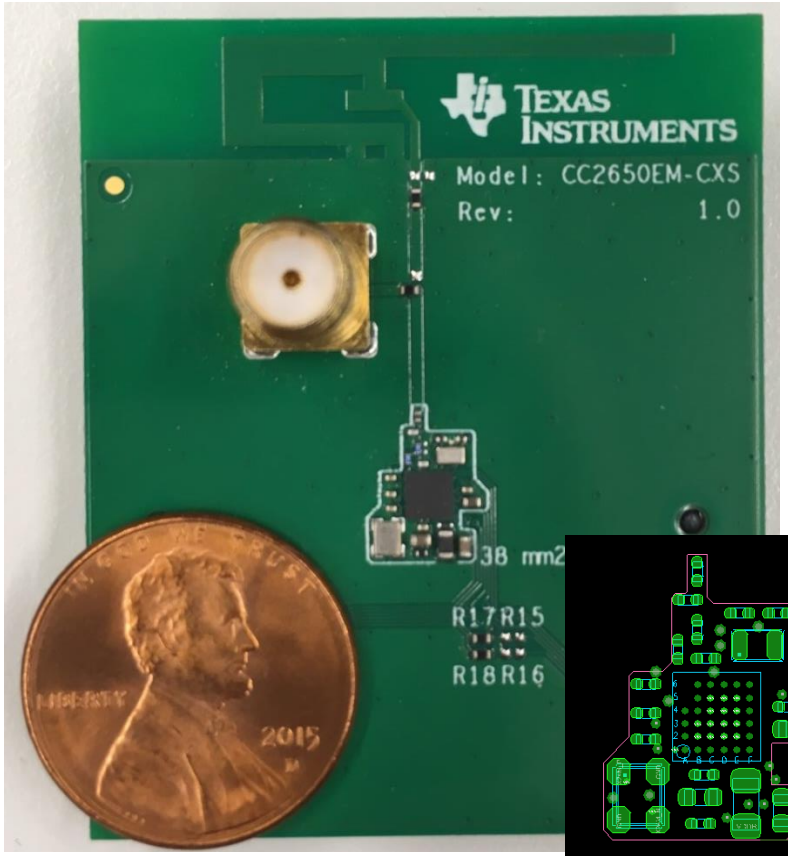
- The CC2640R2F comes in the same **three QFN packages** as the CC2640F128 and these are all pin and function compatible.
- The requirements to the external components, including crystals, DCDC- and RF components, are the same between the two devices.
- For an existing well-functioning PCB design, the CC2640F128 can simply be replaced with the CC2640R2F without any other hardware changes.

What's New

1. CC2640R2F in WCSP package
2. CC2640R2F-Q1——Automotive Qualified SimpleLink™ Bluetooth® low energy Wireless MCU

CC2640R2F in WCSP package

- Smallest area WCSP package with only 2.7x2.7mm footprint
- Thinnest package, only 0.575 mm hight vs 1mm for QFN package
- 14 GPIOs (4 more than the 4x4 QFN package)
- Complete reference design available with 38mm2 footprint, including crystal and passives



CC2640R2F is ready for *Bluetooth*® 5

Longer range

- 6 dB improved sensitivity through coding – same TX/RX current
- Whole-house coverage

Higher speeds

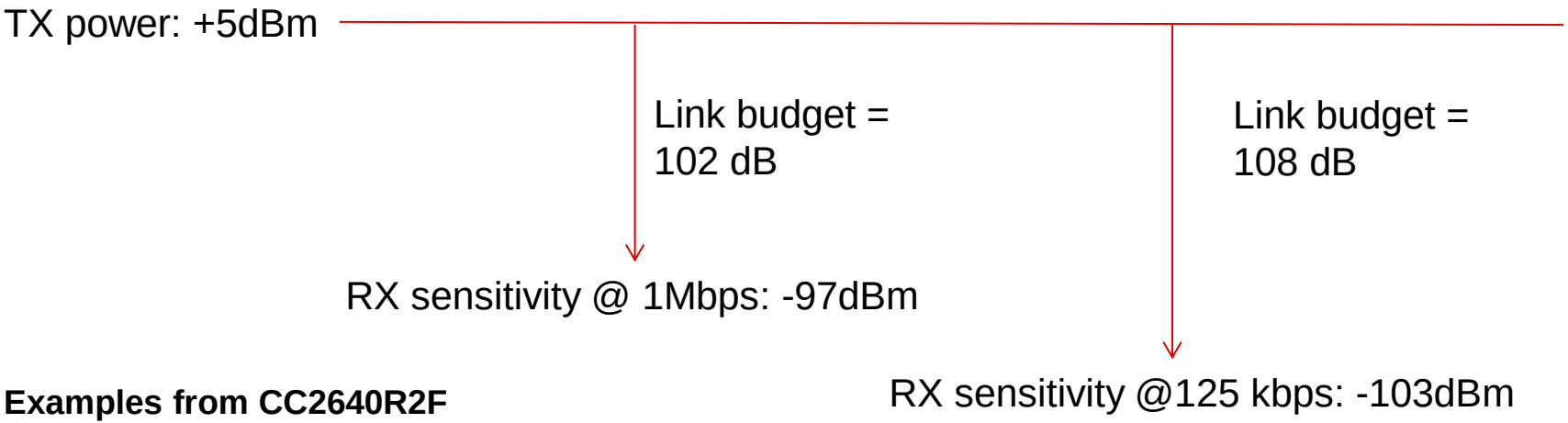
- 500% increase in data throughput vs. Bluetooth 4.0 using 2Mbps
- CC2640R2F supports even higher throughput up to 5Mbps in proprietary mode

Increased broadcasting capacity

- Transmit more intelligent data over a beacon using Advertisement Extensions
- Enable rich location/navigation applications

Sensitivity and RF link budget

- RF Link budget is the ratio between the transmit RF power and the receiver sensitivity level.
- *Link budget = TX Power - Sensitivity level. Ex: 5 dBm - (-103 dBm) = 108 dB.*



Examples from CC2640R2F

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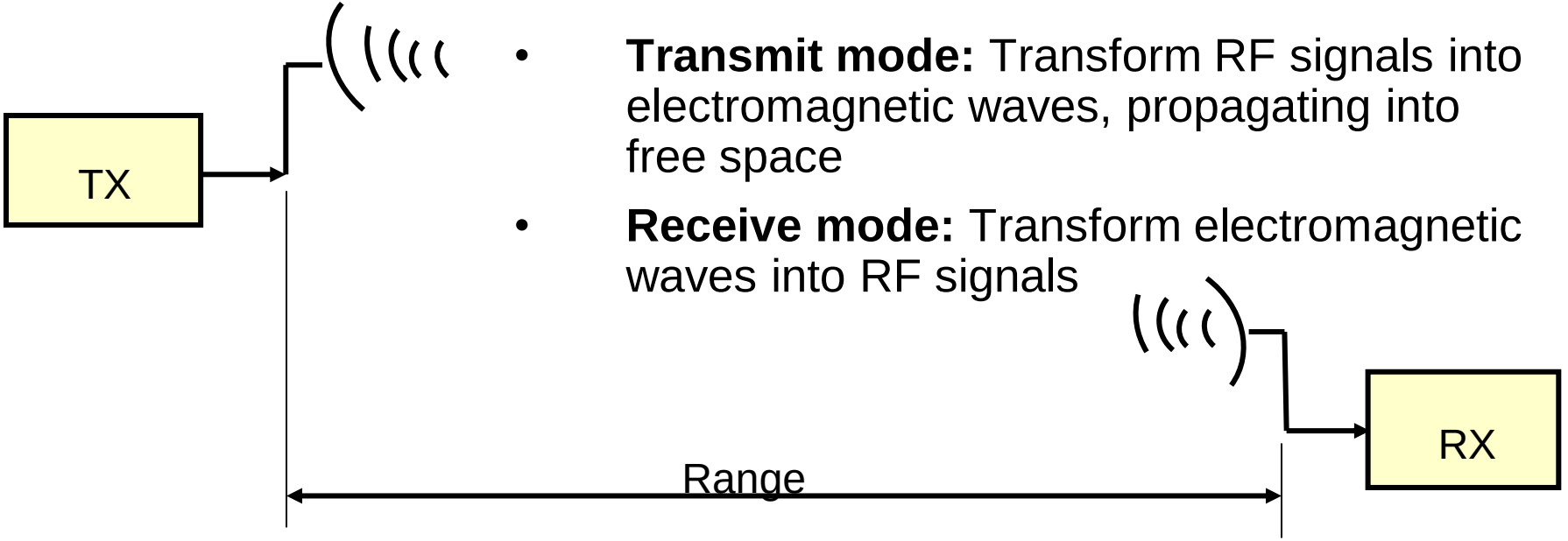
Basic Function of an Antenna



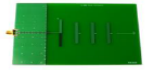
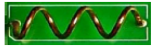
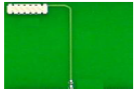
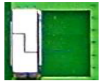
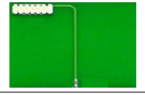
- **Transmit mode:** Transform RF signals into electromagnetic waves, propagating into free space
- **Receive mode:** Transform electromagnetic waves into RF signals

- The antenna is a key component for the successful design of a wireless communication system.

Antenna Selection Quick Guide

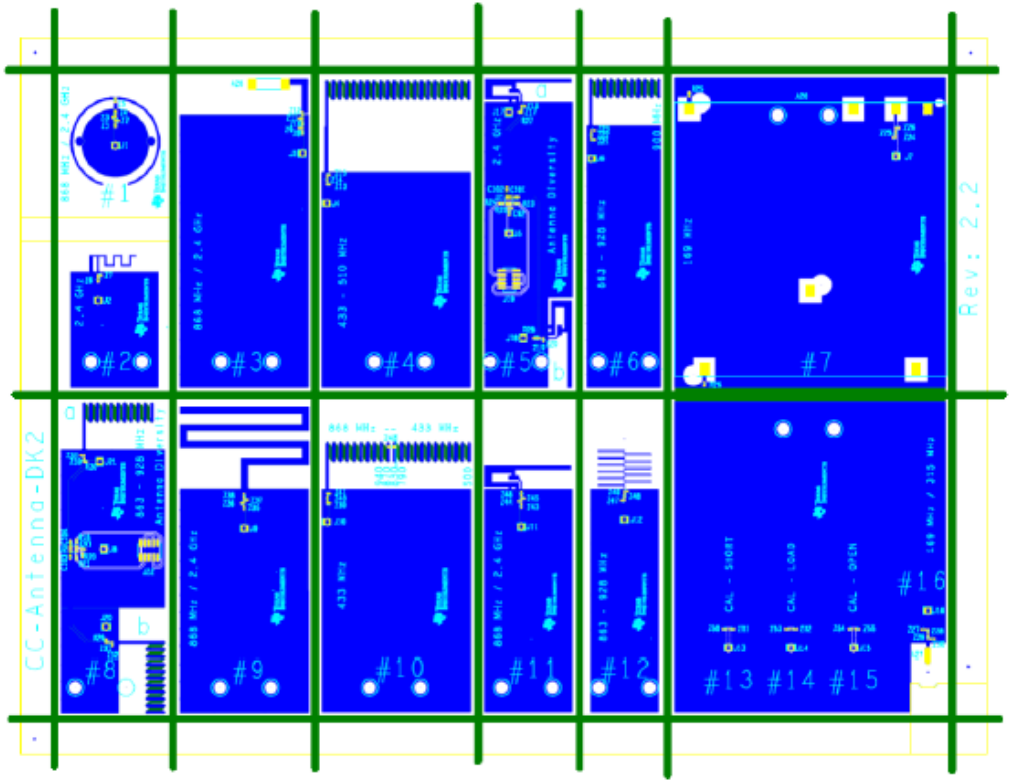
DN035

Antenna Selection Quick Guide — DN035

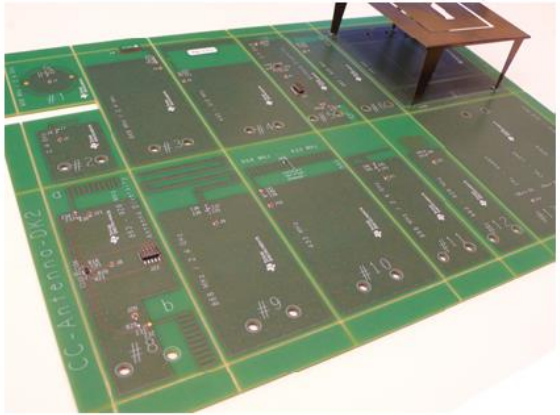
							
Design / Application Note	DN007 *1	AN043 *2	DN004	DNxxx	DN024	DN034	AN048
Frequency	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz
Typical Efficiency	80%(EB) 94%(SA)	68%(EB)	80%(EB)	65%(Zlight2)	76%(EB) 94%(SA)	72%(SA)	55%(USB)
Bandwidth@ VSWR 2:0	280 MHz	101 MHz	100 MHz	150 MHz	354 MHz (SA)	497 MHz	150 MHz
Dimensions (mm)	26 x 8	15 x 6	46 x 9	45 x 2.5	38 x 25	150 x 100	7 x 3
							
Design / Application Note	DN024 *1	DN023	DN031	DN031	DN033	DN031	DN038 *2
Frequency	868 / 915 / 920 MHz	868 / 915 / 920 MHz	868 / 915 / 920 MHz	868 / 915 / 920 MHz	868 / 915 / 920 MHz	868 / 915 / 920 MHz	868 / 915 / 920 MHz
Typical Efficiency	64%(EB) 98%(SA)	80%(SA)	69%(EB)	64%(EB)	48%(EB)	63%(EB)	66%(EB)
Bandwidth @ VSWR 2:0	88 MHz (SA)	40 MHz	62 MHz	56 MHz	56 MHz	6 MHz	40 MHz
Dimensions (mm)	38 x 25	43 x 20	10 x 28	48 x 8	15 x (5 to 29)	10 x 14	19 x 12
						Antenna Support Documentation Antenna Selection Comprehensive Guide AN058 Antenna Selection Quick Guide DN035 CC-Antenna-DK & Antenna Measurements Summary DN031 Range Measurements in an Open Field DN018 Antenna Reference Designs AN040, AN043, AN048, DN004, DN007, DN016, DN023, DN024, DN031, DN034, DN038, DNxxx OTA Measurement Reports DN6xx	
Design / Application Note	DN031	DN031 *1	DN031	DN031 *1	DN031 *1		
Frequency	433 MHz	433 MHz	433 MHz	315 MHz	136 - 240 MHz		
Typical Efficiency	20%(EB)	26%(EB)	15%(EB)	15%(EB)	7%(EB)		
Bandwidth @ VSWR 2:0	23 MHz	38 MHz	30 MHz	4 MHz	3 MHz		
Dimensions (mm)	37 x 9	42 x (10 to 29)	15 x (5 to 29)	37 x 9	42 x (22 to 29)		
EB: SmartRF Evaluation Board SA: Stand Alone	*1 First Choice Recommended Antenna	*2 Second Choice Recommended Antenna		SWRA351A	By Richard Wallace		

All the antenna documentation can be hyperlinked through DN035

Reference Designs – *CC-Antenna-DK2*



SWRA496



Antenna Performance

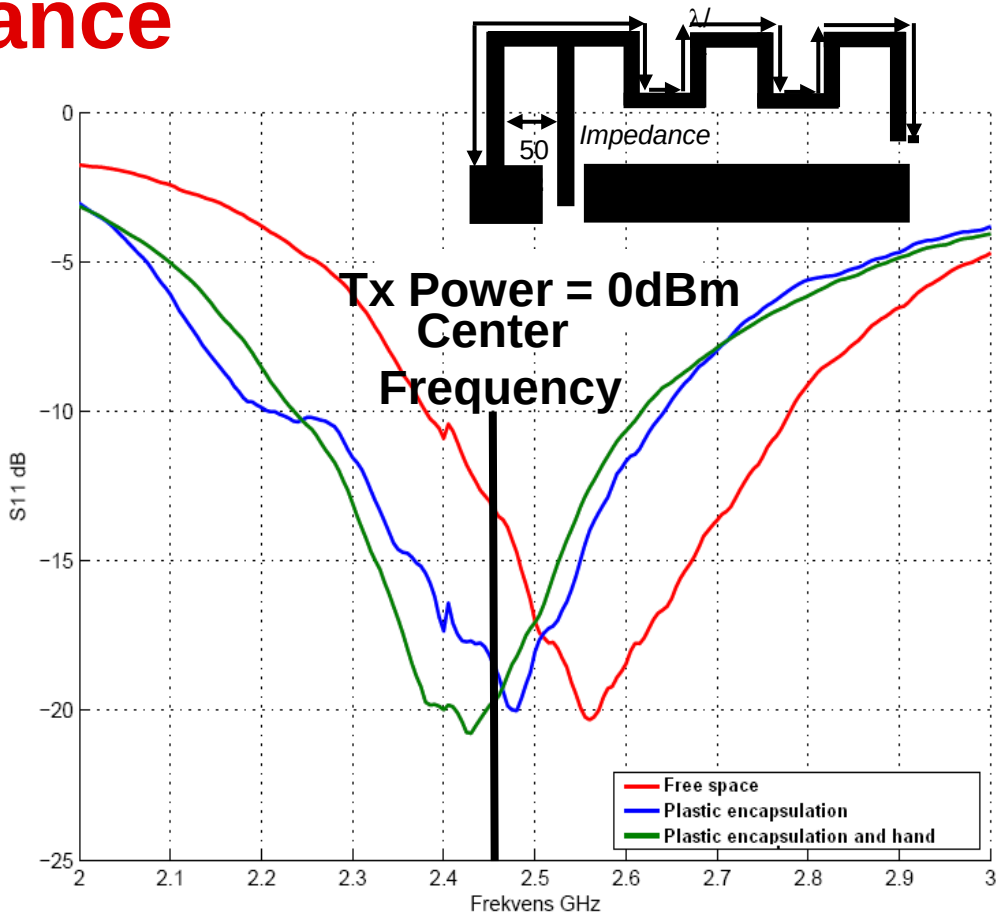
Tuning the antenna:

•Make sure the metals, plastics and human body close to the antenna are factored into the tuning

•The impedance and resonance frequency of the antenna get affected

•Need to re-tune in your realistic product in most of cases

•Strong recommend to involve the professional Antenna Manufacture for a serious product.



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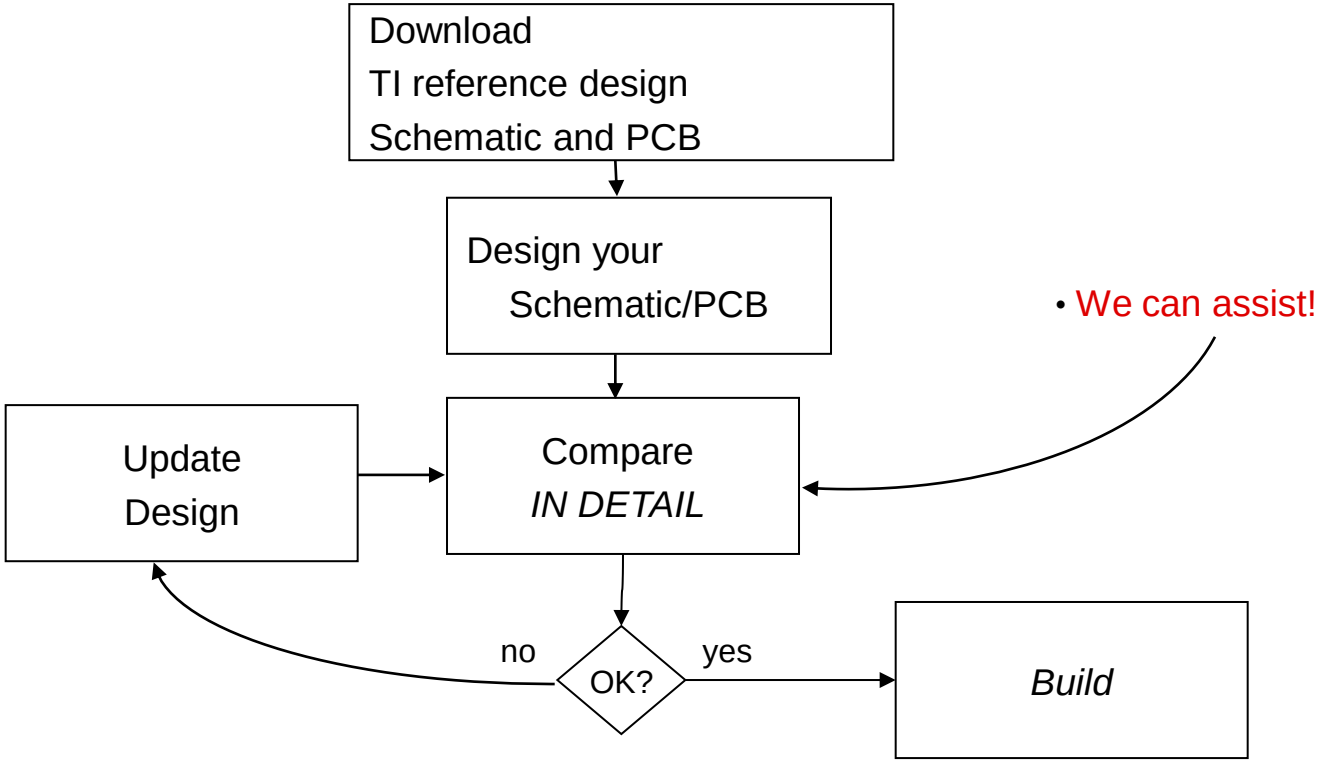
Design Process



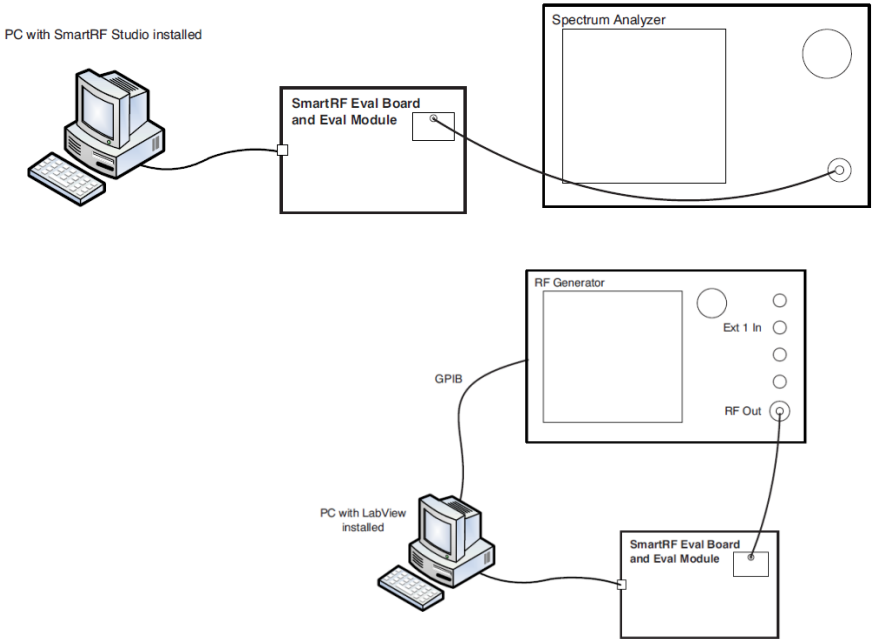
How and What to Debug?

- Testing shall be divided up into separate parts, independent of each other
- Hardware, software, and antenna shall be tested separately
- Test the SW with well-known working HW.
  - E.g. evaluation modules
- Test the HW with well-known working SW.
  - E.g. SmartRF® Studio, SW examples from TI
- Test the antenna with a network analyzer

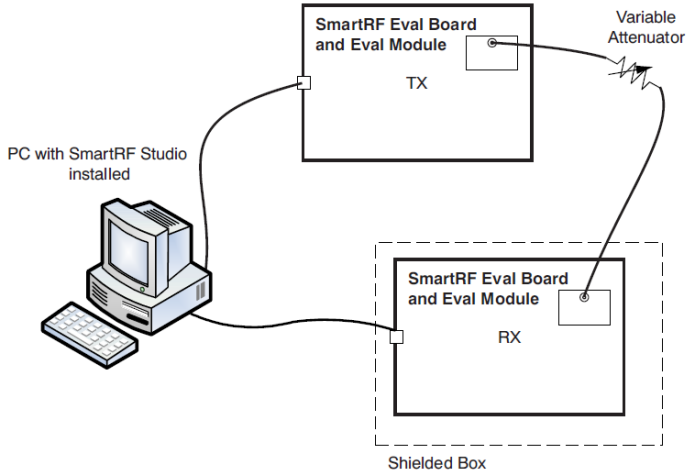
How and What to Test - 1

- SIG specification testing
  - http://edu.21ic.com/lesson/1765
  - http://training.eeworld.com.cn/TI/video/9104
  - http://edu.21dianyuan.com/index/course_info/cid/390

How and What to Test - 2



General RF tester

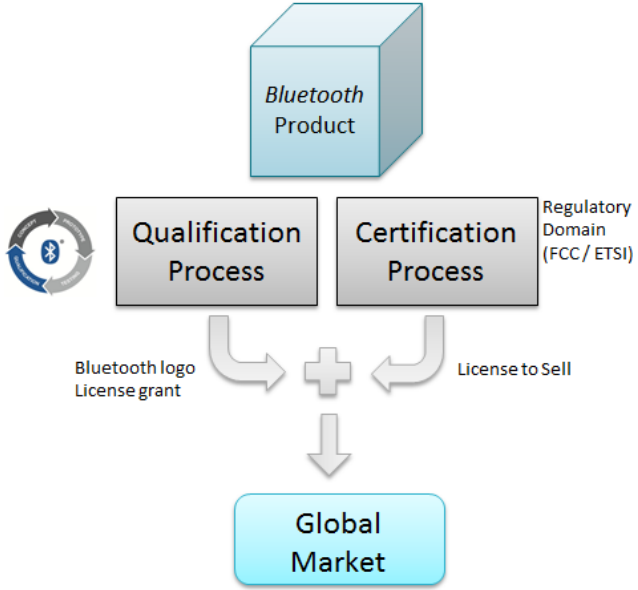


Golden Sample

Qualification

http://processors.wiki.ti.com/index.php/How_to_Certify_your_Bluetooth_product

1. Become Bluetooth SIG Member (It's free!)
2. Follow the instructions on www.bluetooth.com



Radio Certification

CE FC

Industry Canada

TELEC Empower the wave!

SRRC

CHINA RADIO MANAGEMENT

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Quick starter on-line!

Once you have your **myTI account**, you will get

On line resources:

HW and system documentations:

www.ti.com/CC2640

http://processors.wiki.ti.com/index.php/Category:BluetoothLE

SW SDK and documentations:

Under the SDK installation folder

On line training:

Training in English: http://training.ti.com

Training in Chinese: http://www.TI.com.cn/training link to **21Dianyuan/21IC/eeWorld**

Academy: http://www.ti.com/lsds/ti/wireless-connectivity/simplelink-solutions/simplelink-academy.page

Technical support forum:

E2E in English:

https://e2e.ti.com/support/wireless_connectivity/bluetooth_low_energy/

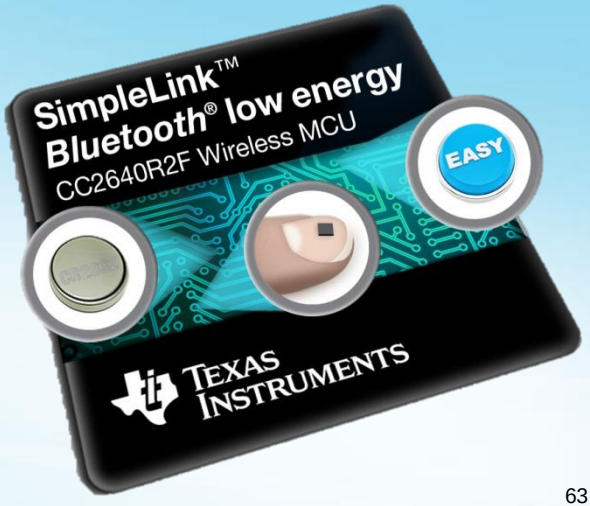
Deyisupport in Chinese:

http://www.deyisupport.com/question_answer/wireless_connectivity/default.aspx

Thank you!

CC2640R2F 软件开发介绍

SimpleLink™ 系列低功耗蓝牙SOC



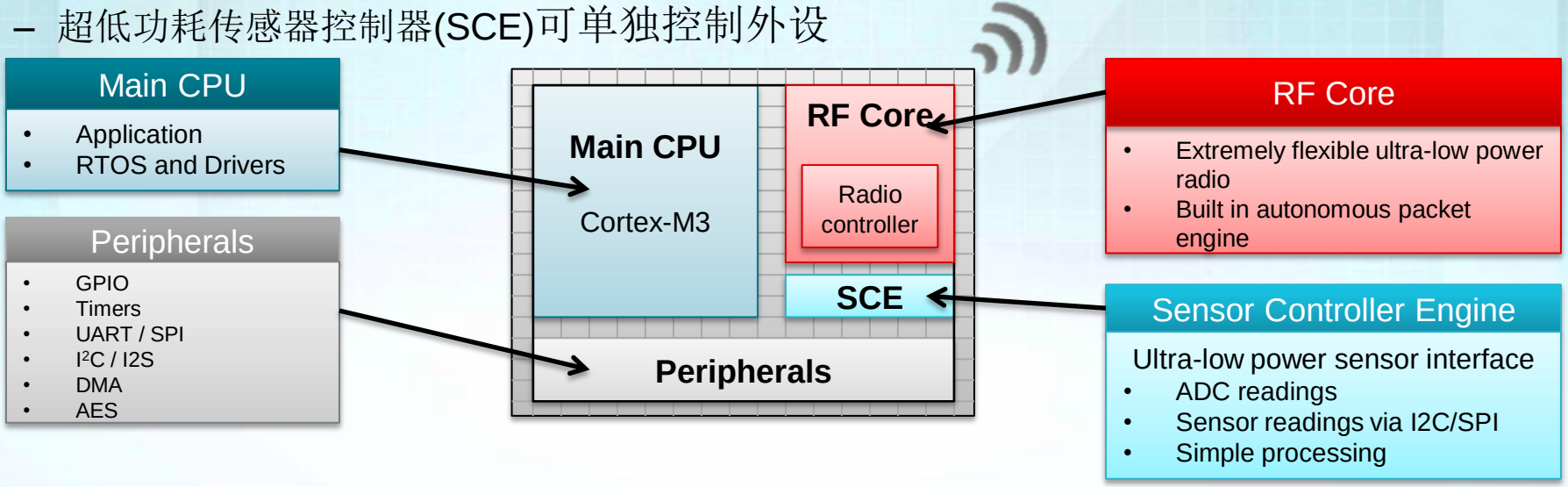
April, 2017

Barbara Wu

CC2640/CC2640R2F 概况

ULP Wireless MCU

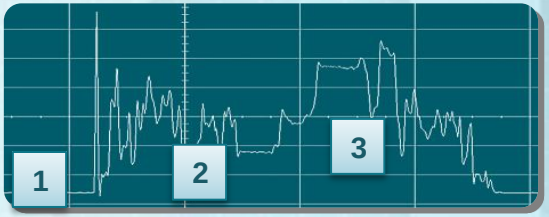
- 专用处理器处理相应任务:
  - 低功耗 ARM Cortex-M3用于应用软件
  - 低功耗 ARM Cortex-M0 控制RF核
  - 超低功耗传感器控制器(SCE)可单独控制外设



蓝牙功耗综述

以下几个方面为你带来极致的功耗性能

1. When in Standby (with RTC and RAM retention)
2. When processing with MCU
3. When radio is in Receive or Transmit
4. When peripheral is polled for data



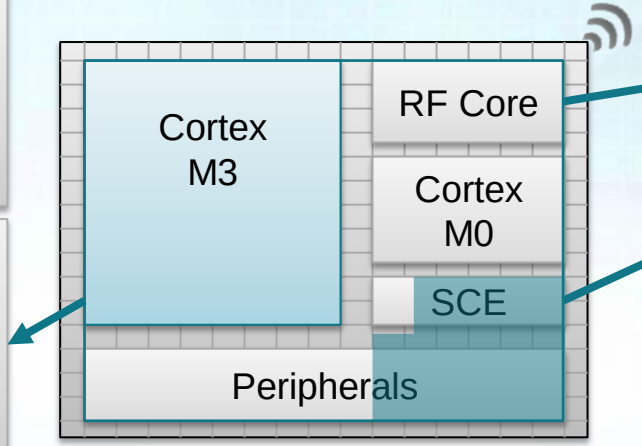
1

- **Standby Current**
- **1 µA** Standby with RTC and full retention
- Less than **0.15 µA** in Shutdown

2

ARM Cortex M3

- Fast processing using less than **3 mA** @ 48MHz
- Less time used for stack and application processing and BLE connection events



3

Radio

- ~**6mA** RX / TX current

4

Sensor Controller Engine

- Sensor controller and its peripherals can be powered while rest of system is power off.
- Run Sensor Reading with **5 µA** current consumption <

Sensor Controller Engine *(SCE)-传感控制器*

独立于M3主核的低功耗处理器

主要特性

- 可对外设进行控制并对数据进行处理
- 在芯片其他系统休眠时候单独工作

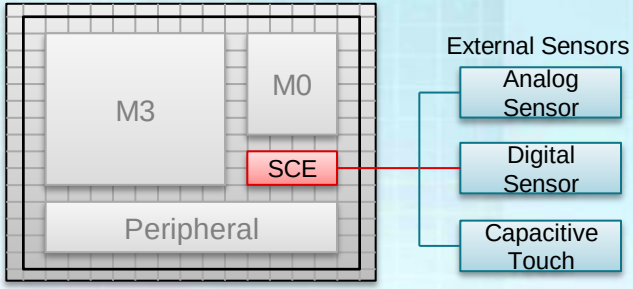
以下应用情景非常适合传感控制器:

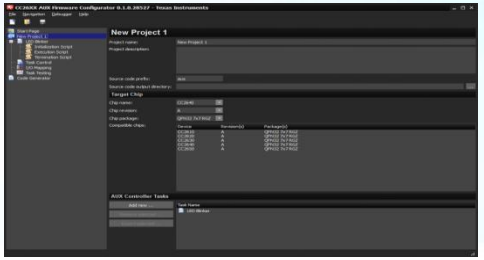
- PIR (motion detector)
- Capacitive touch keys
- Proximity sensors
- Accelerometers
- ADC measurements
- Pulse counting

- 基于Sensor Controller Studio进行配置

数据手册– 主要特性

- 16位精简指令集处理器
- 2 KB SRAM (code + data)
- 时钟频率:
  - 32kHz-24MHz
  - 8.2uA / MHz





What is Sensor Controller Studio (SCS) ?

SCS是一个集成编译和调试能力的集成开发环境。SCS拥有一个友好直观的用户界面，内置了许多供参考的应用开发工程。

1

开发

- White 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 shw how to control the various peripherals

2

测试

- Visualize output from tasks in the Task Testing pane
- Debug assembly code if neccessary

3

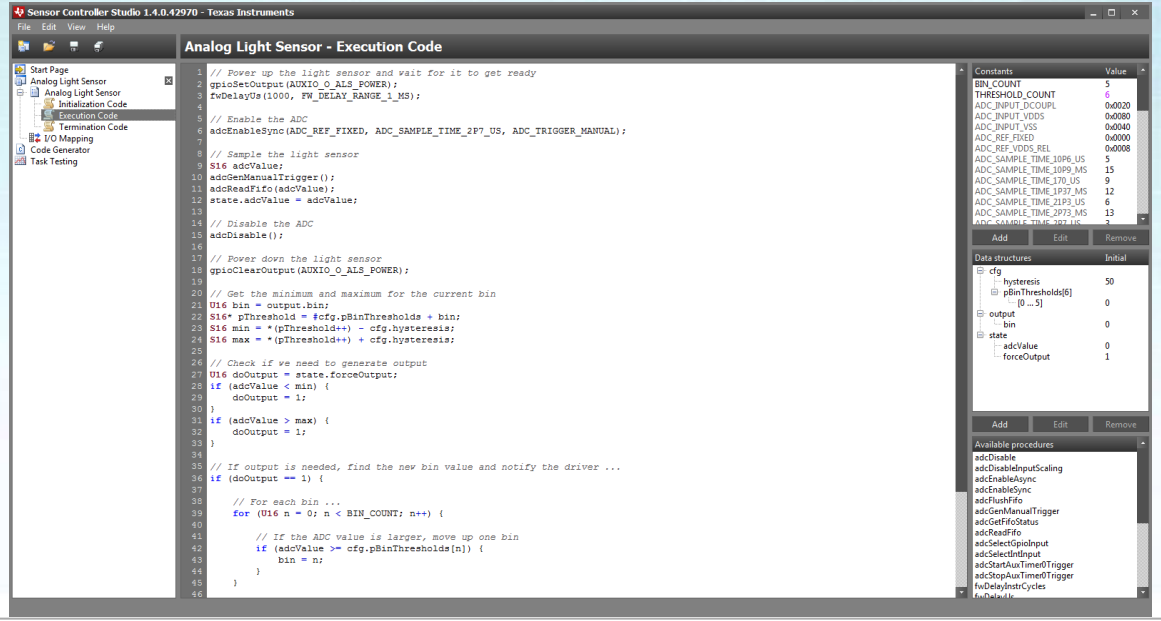
程序导出

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

SCS 1 开发代码

SC的编程语言类C, 基于任务的开发(初始化, 执行，终结)

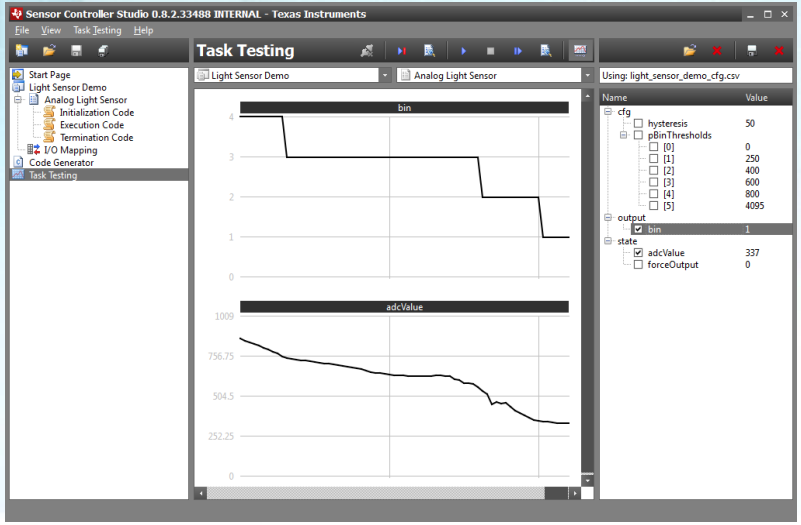
- 任务是从SC的RAM里运行的一段小程序
- SCS里面自带很多外设控制的工程示例
- 一个工程可支持最多8个任务

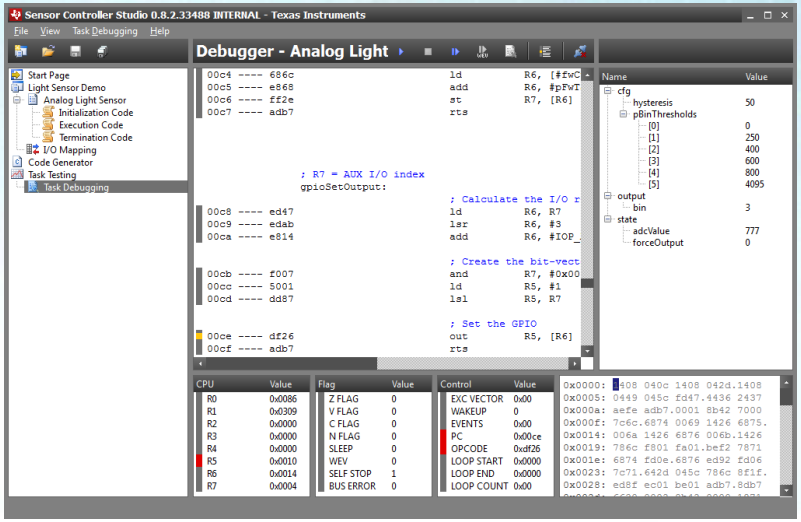


SCS 2 任务调试

可从任务测试面板图形化查看任务输出

- 支持汇编调试
- 单步执行, 可设断点
- 任务按预先定义好的时间间隔执行。如果有多个任务，每个任务可在各自设定的时间间隔执行。



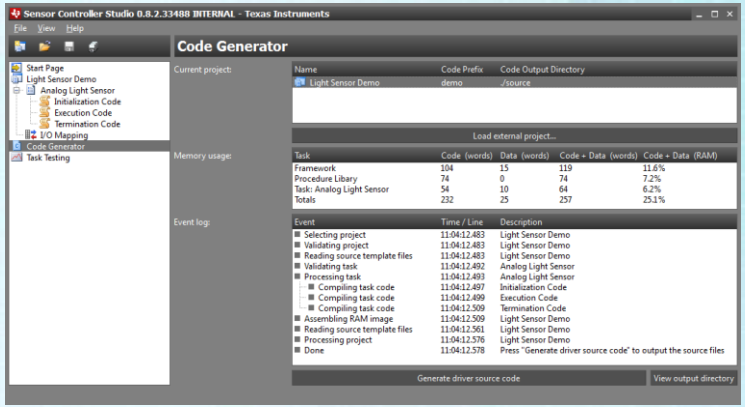


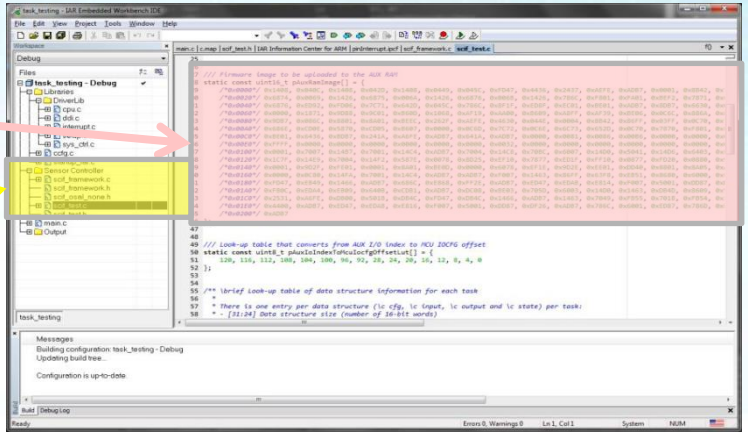
SCS 3 代码导出

- SCS可生成代码用于主MCU开发环境
- 支持IAR和CCS, 可带或不带TI-RTOS

固件在芯片启动时候导入SC的RAM中运行

工程文件从SCS导出





开发套件-SensorTag or LaunchPad?

截止 4/23
WCCN17：9款开发板9折优惠
FREESHIPALL：全场免邮费

CC2650STK
$29

CC-DEVPACK-DEBUG
$15

CC2650 SensorTag		CC2650/CC2640R2 LaunchPad
Coin Cell Battery (CR2032)	供电	USB
External required ($15 DevPack)	调试/下载工具	Includes onboard (XDS110)
Peripherals • 6-axis MEMS motion • Humidity (TI) • IR temperature (TI) • Light Sensor (TI) • Microphone • Pressure • Reed Relay • External Flash (512kB)	板上资源及板子特点	All IOs available on pin headers (Boosterpack connectors) Peripherals • External Flash (1MB)
DevPack	配套开发板	BoosterPack, LaunchPad
• Well suited for SW development for coin cell operated applications • Good platform for evaluating RF performance for a physically small device	开发优势	• Well suited for HW prototyping • Best RF performance due to large ground plane • Well suited for current consumption measurements • Can be used as stand-alone debugger

CC2650LP
CC2640R2LP
$29

Both development kits are supported by accompanying iOS/Android apps

CC2640 与 CC2640R2F的不同?

	CC2640R2F	CC2640	Comment
封装	2.7 x 2.7mm chip scale package or QFN (4x4, 5x5, 7x7mm)	QFN (4x4, 5x5, 7x7mm)	所有QFN的封装PIN2PIN兼容
BLE 开发包兼容性	v. 3.0.0	v. 2.2.1	这两个协议栈的特性一样, 但是 v.3.0.0. 可为用户应用层提供更多的应用存储空间
LaunchPad™ 开发板	LAUNCHXL-CC2640R2	LAUNCHXL-CC2650	
蓝牙标准支持	4.2 **Future BT 5 SDK Support**	4.2	CC2640R2F 支持最新的 BLE5.0 的PHY, 且将来会支持 BLE 5.0协议栈

CC2640 与 CC2640R2F的区别

- CC2640R2F 支持BLE5.0要求的广播拓展
- CC2640R2F 拥有更多的Flash空间供应用层使用
- CC2640R2F 拥有2.7*2.7mm的芯片级超小封装(14GPIOs)

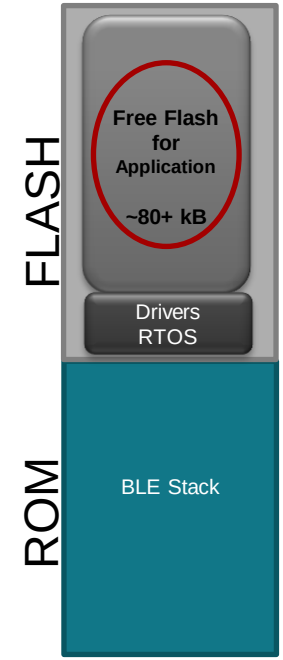
CC2640R2F 数据手册第三节 – 芯片比较:

Table 3-2. Typical(1) Flash Memory Available for Customer Applications

Device	Simple BLE peripheral (BT 4.0)(2)	Simple BLE peripheral (BT 4.2)(2) (3)
CC2640R2Fxxx(4)	83KB	80KB
CC2640/CC2650F128xxx	41KB	31KB

(1) Actual use of ROM and flash by the protocol stack will vary depending on device software configuration. The values in this table are provided as guidance only.
(2) Application example with 2 services (GAP and Simple Profile). Compiled using IAR.
(3) BT4.2 configuration including Secure Pairing, Privacy 1.2, and Data Length Extension
(4) BLE applications running on the CC2640R2F device make use of up to 115kB of system ROM and up to 32kB of RF Core ROM in order to minimize the flash usage. The maximum amount of non-volatile memory avialable for BLE applications on CC2640R2F is thus 275KB (128KB flash + 147KB ROM).

SimpleLink™ *Bluetooth*® low energy
CC2640R2F: Ultra-low power wireless MCU



TI CC2640R2F

- 256kB flash comparable BLE SoC
- Bluetooth 4.2 protocol stack in ROM
- ~80kB free flash for application use
- BLE-Stack upgradable via ROM patches

Table 3-2. Typical(1) Flash Memory Available for Customer Applications

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BLE-Stack 2.2 *BT4.2 特性*

LE 安全连接

- Fixes **passive eavesdropping** vulnerabilities in legacy pairing methods used in BT 4.0 & 4.1
- Adds Numeric Comparison pairing authentication method to **prevent Man-in-the-Middle (MITM) attack**
- Elliptical Curve Diffie-Hellman (ECDH) algorithm used for key exchange during pairing process
- Uses same FIPS compliant AES-128 encryption as BT4.0
- **Backwards compatible** with LE legacy paring methods

LE 隐私1.2

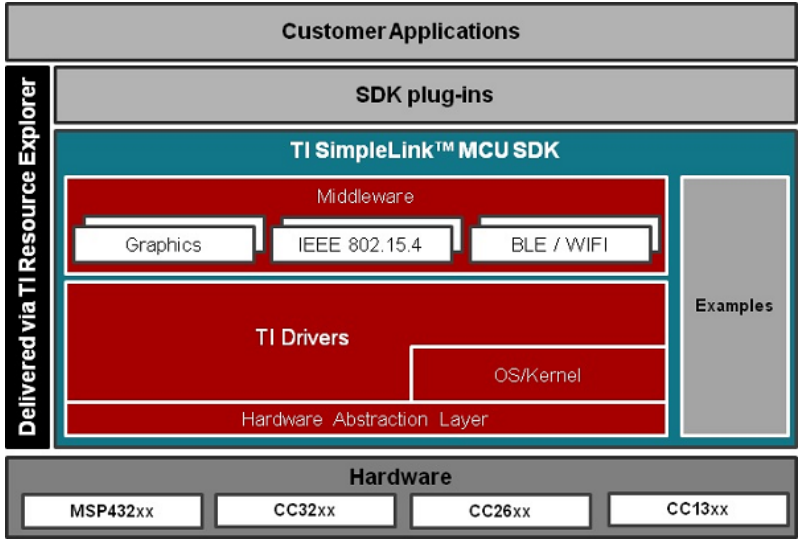
- **Keeps devices from being tracked** by using random BT device addresses that change over time
- Fixes confusing privacy implementation from earlier specifications
- Improves **power efficiency** by filtering out unwanted device connections or scans in the Controller
- Allows whitelisting of bonded iOS and Android devices that implement privacy

LE 数据长度拓展

- **Improves throughput** up to 2.5x compared to BT 4.0 & 4.1
  - Uses same 1 Mbps PHY rate
  - Connection packet payload (PDU) increases from 27 to a max 251 bytes
  - PDU size negotiated by both devices during connection
- Allows for higher level applications that require more throughput
- Improves existing applications, such as **firmware update (OAD)** when supported by both devices

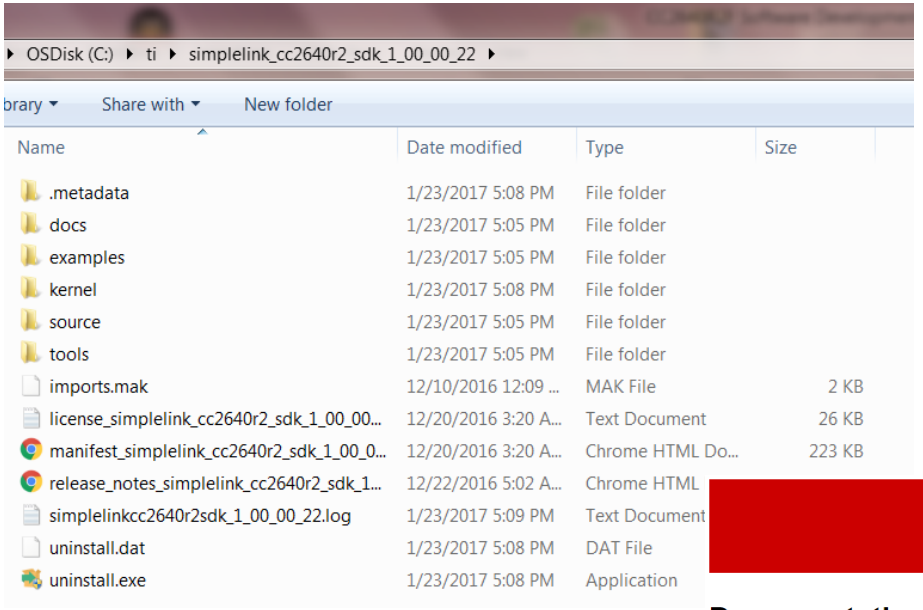
SimpleLink CC2640R2 SDK

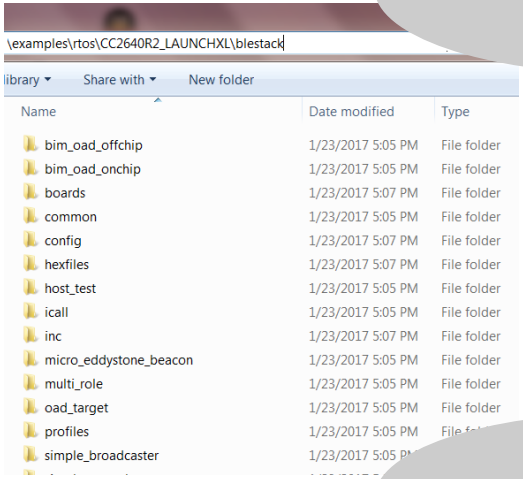
- 与SimpleLink家族成员一致的MCU SDK 架构
  - 每个类别MCU有独自的SDK 安装包
- 默认安装目录 C:\ti
- TI-RTOS 内置于SDK中
  - 底层驱动
  - SYS/BIOS 内核
- BLE-Stack v3 连接元件
  - 参考应用实例
  - Optional Application Pack with additional sample applications
- 只支持CC2640R2F



Simplelink CC2640R2 SDK 内容简介

示例工程





开发文档

Documentation Overview for SimpleLink™ CC2640R2 SDK

Table of Contents

- SimpleLink™ CC2640R2 SDK
- SDK Components
- Additional Online Support

如何在客户板子上运行CC2640R2 SDK

- CC2640R2F 可以使用任意的 CC26xx EM 参考设计: 7ID, 5XD, 4XS, 等等.
- 修改board.c中板子类型定义已符合参考设计:

```
64 /** ============================================================================
65  *  Symbol by generic Board.c to include the correct kit specific Board.c
66  *  ============================================================================*/
67 // #define CC2650EM_7ID (Default for CC2640R2 LaunchPad 7x7 QFN
68 #define CC2650EM_5XD
```

- 调整管脚映射以符合客户板子的可用GPIO

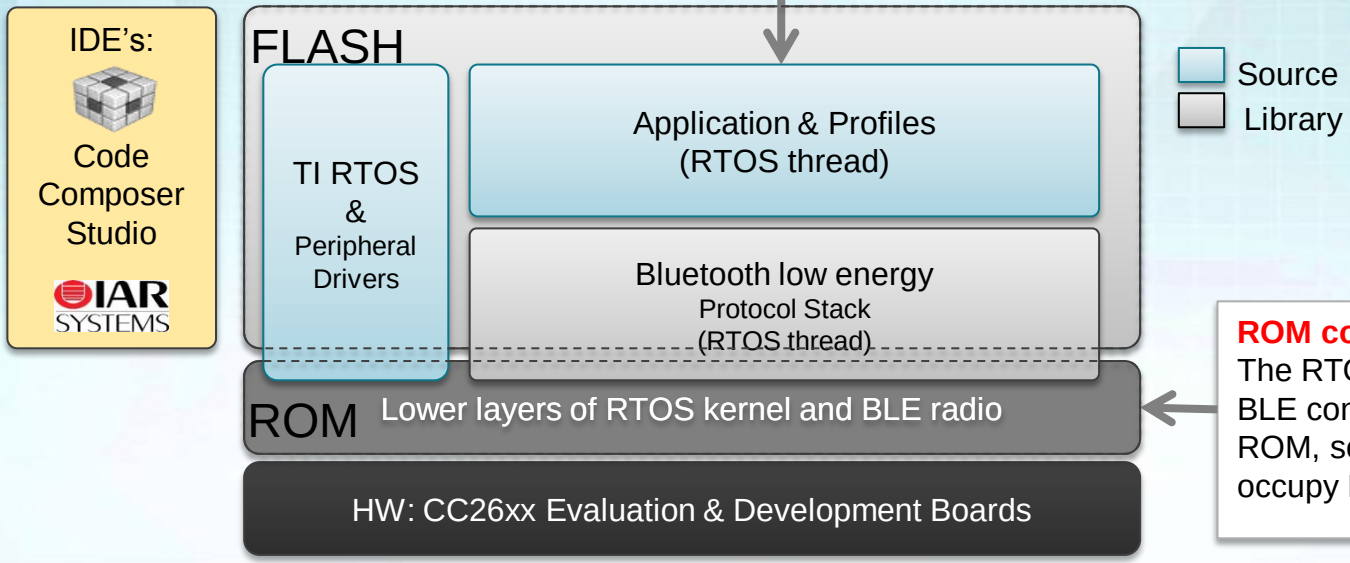
Package Option	Total GPIO Pins	MAX IOID
7x7 mm QFN	31	IOID_30
5x5 mm QFN	15	IOID_14
4x4 mm QFN	10	IOID_9
2.7 x 2.7 mm WCSP	14	IOID_13

- GitHub上有EM板子的对应示例参考

软件平台 CC2640/CC2640R2F

Royalty free from TI, ready for application development

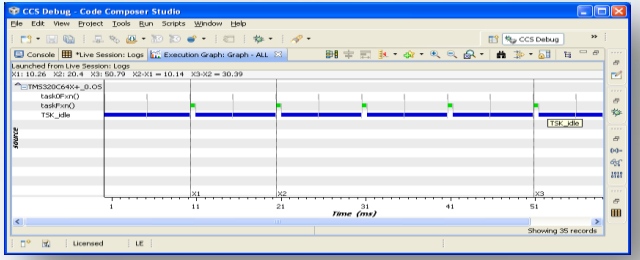
Over-the-air download
The FLASH can be partially updated over-the-air, which means that the application can be updated separately from the BLE stack.



ROM code
The RTOS kernel and parts of the BLE controller are stored in CC2640 ROM, so these components do not occupy FLASH space.

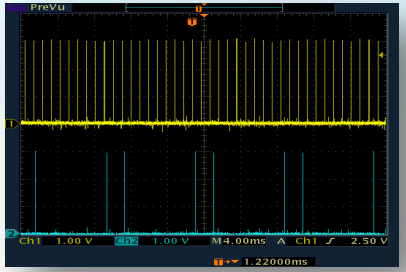
TI-RTOS 灵活软件解决方案

- Real Time Operating System (RTOS)
  - 抢先式多进程
  - 确定性调度
  - 优化的 TI-RTOS 内核
- 零延时中断
  - 硬件: 定时器功能
  - 软件: 时钟功能 (Ex. One shot or periodic timer)



系统分析仪

- 信号量(Semaphores)
  - 任务同步
- 外设驱动
  - GPIO, I2C, SPI, UART, WATCHDOG, LCD
- 功耗状态管理
  - 自动管理芯片的功耗状态



Getting Started *with CC2640/CC2640R2F SW Development*

CCS Cloud + Project Zero

- No software needed. Only a $29 Launchpad and a browser
- Click a button to flash device with Project Zero and follow instructions for your first iOS / Android interaction with BLE
- Import project to CCS Cloud editor and develop / build / debug, or:
- Download all needed project files in one archive file for CCS Desktop development

SimpleLink Academy

- Training modules integrated with CCS
- Explanations and theory
- Interactive quizzes
- Tasks with step by step instructions
- Learn about:
  - TI-RTOS concepts (Task, Semaphore etc)
  - BLE Services
  - Simple Network Processor
  - Sensor Controller Studio
  - BLE Security
  - Over the Air Download
  - Bluetooth Developer Studio

BLE-Stack SDK + GitHub

- Example usage of adopted profiles included in the BLE SDK installer
  - Blood Pressure
  - HID Keyboard / Mouse
  - Heart Rate
  - Cycling / Running Sensor
  - Glucose Sensor / Collector
  - .. and more
- Advanced / specialized examples on `github.com/ti-simplelink`
  - Simple Network Processor
  - Log application events to UART
  - Simultaneous Master/Slave

Resource Explorer *Project Zero*

Visit dev.ti.com/tirex

- 五分钟内搭建并运行Launchpad 作为BLE外设连接至手机的示例
  1. Locate Project Zero in Resource Explorer
  2. Optionally download or import to CCS Cloud editor
  3. Build and download to the CC2650 LaunchPad
- Project Zero also used in SimpleLink Academy

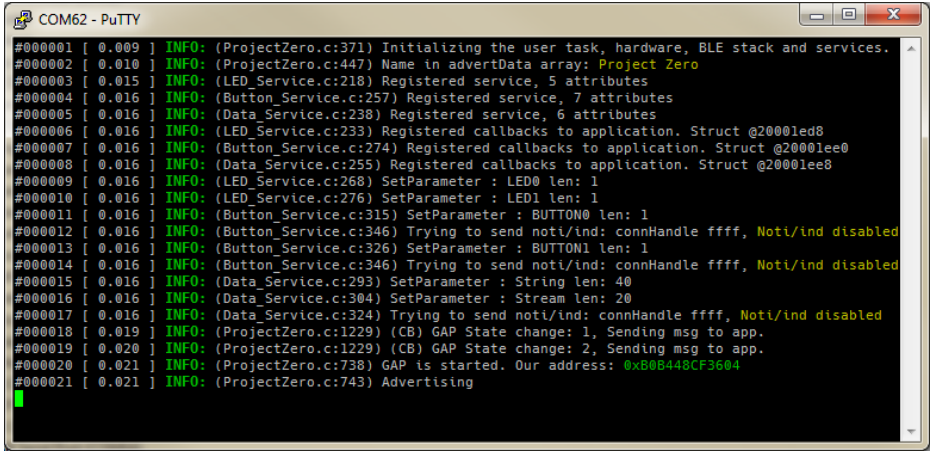
Project Zero *Details*

三个示例服务

- 亮灯服务
  - LED0 and LED1 characteristic
  - Writeable, set LED states
- 按键服务
  - BUTTON0 and BUTTON1 chars
  - Readable, Notifications
- 数据服务
  - Long write/read
  - Streaming

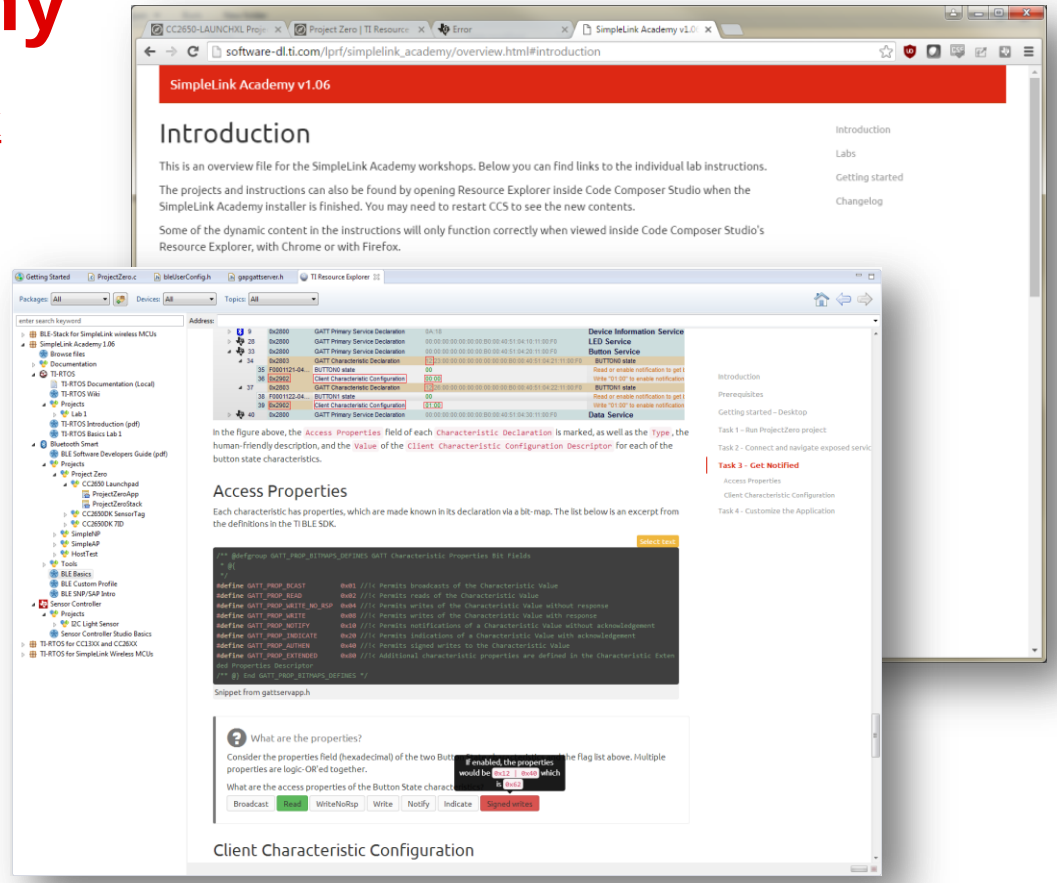
用于调试跟踪CODE的Logs

- 显示文件名, 行数和消息
- 帮助理解程序流程



SimpleLink Academy

- Available at: SimpleLink Academy link
- Gets «anybody» up to speed on SW development for CC2640/CC2640R2
- Integrated with CCS Desktop via separate installer
- Continuous roll-out of new labs and features.
- Richly formatted lab instructions
- Theory of operation
- Interactive quiz
- Learning by doing
- Quick links to further documentation



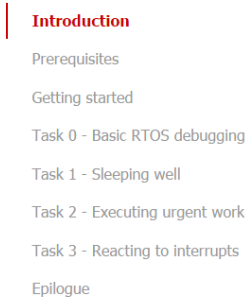
SimpleLink™ Academy 入门

TI-RTOS 基础

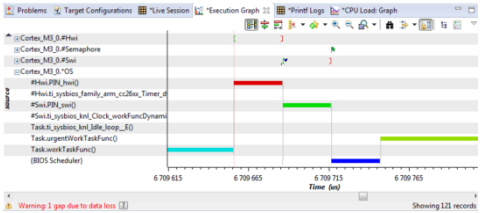
- Learn RTOS concepts
  - Task (thread)
  - Semaphore
  - Interrupt
  - Execution graphing

BLE 基础

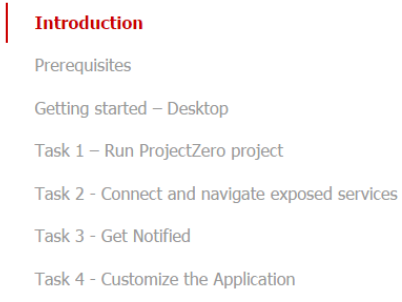
- Learn how to set up a debug environment
- Connect to Project Zero
- Read and write characteristic data



Course content



Execution graph



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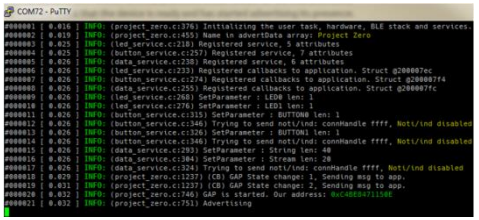


Project Zero

Your first BLE project implementing a simple BLE peripheral

Download at www.ti.com/simplelink-academy

Texas Instruments

SimpleLink Academy培训

基于TI-RTOS的红外开发

- 在CC2650的LaunchPad开发板上产生红外调制信号

Introduction

Prerequisites

Getting started

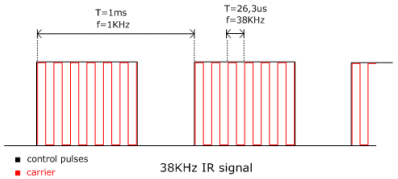
Task 0 - Integrate IR generation driver

Task 1 - Generate IR signal

Task 2 - Keep transmitting IR signal

Task 3 - IR generation debugging signals

课程内容



IR 信号I

使用 Bluetooth® Developer Studio (BDS)

- Learn how to use Bluetooth SIG's BDS with TI's plug-in
- Graphical user interface used to design BLE profiles

Introduction

Prerequisites

Getting started

New Project

Creating a Custom Service

Generate Some Code

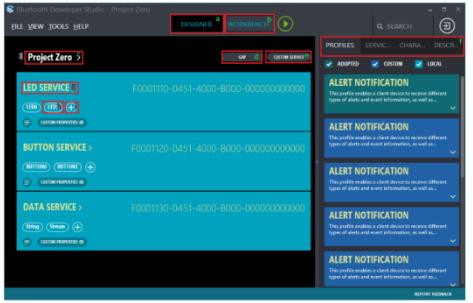
Compile the Code

Explore the Service over BLE

Add Everything Else

Using the Workbench and PTS dongle

课程内容

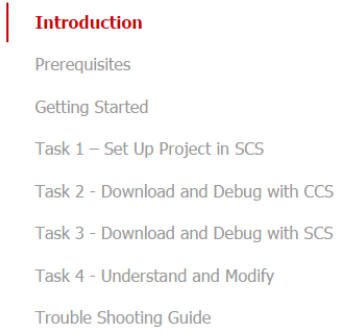


BDS 界面

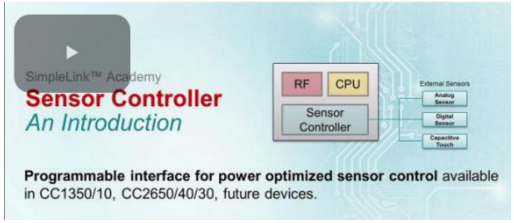
SimpleLink Academy进阶

传感控制器示例 (Sensor Controller)

- 学习基于SCS的SC开发
- 从I2C光传感器读取数据



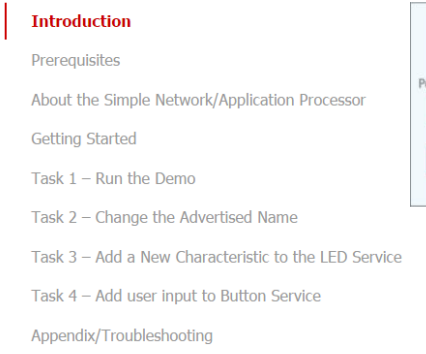
Course content



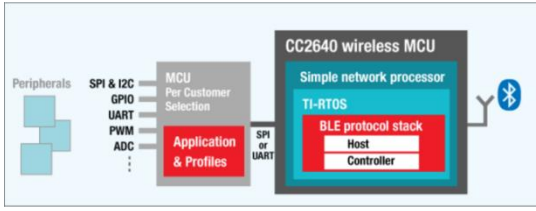
Intro video

网络处理器模式(Simple Network Processor)

- 学习如何在现有MCU方案添加蓝牙功能
  - BLE customer profile managment
  - Unified network processor interface
  - SAPLib



Course content



CC2640 + external MCU

全面方便的软件工具

BTool

Run and test all possible *Bluetooth* low energy functionality controlled from the PC tool.

BLE Device Monitor

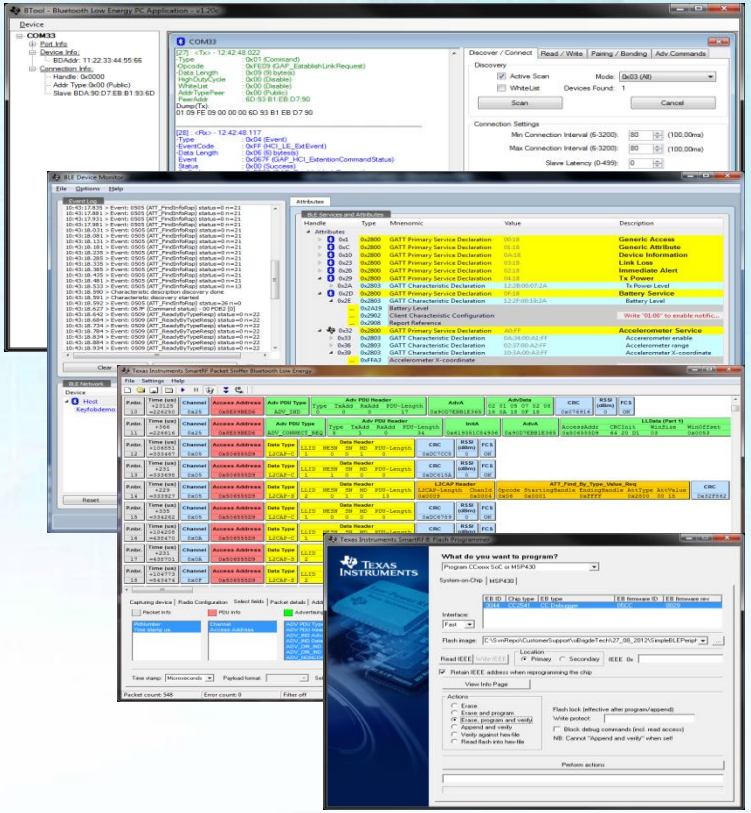
Provides an intuitive and graphical way to explore *Bluetooth* low energy Services and Characteristics.

SmartRF™ Protocol Packet Sniffer

Capture Bluetooth low energy communication live with full overview.

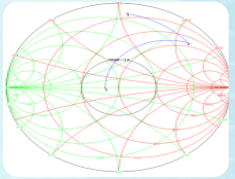
SmartRF™ Flash Programmer

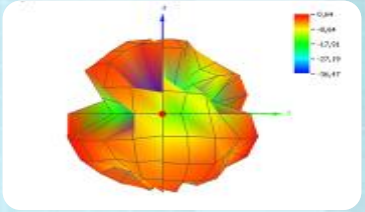
Program devices and Read/write IEEE addresses

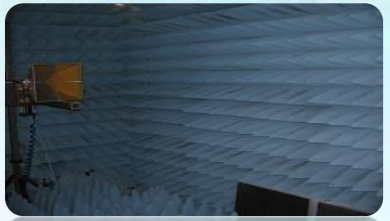


Bluetooth low energy 支持

- 独有的硬件和射频支持
  - Schematic and Layout Review
  - Pre-compliance testing in RF Chamber
  - Perform Bluetooth pre-testing
- 协议栈安装包内置丰富的开发参考文档 (www.ti.com/ble-stack)
  - Software Developers Guide
  - Sample Applications Guide
  - Vendor Specific HCI Guide
- 在线文档资源 (www.ti.com/ble-wiki)
  - Code Examples
  - Training videos
  - Walkthorugh Guides
- 在线技术支持社区 (www.ti.com/ble-forum (英文)
  http://www.deyisupport.com/question_answer/wireless_connectivity/bluetooth/f/103.aspx (中文))
  - Supervised by TI Software and Hardware Experts







TI技术支持社区

[SOLVED] CC2640 Power consumption

✓ Answered

32.768 KHz clock on one of the GPIO of CC2640

✓ Answered

[CC2640] Confirm the maximum simultaneous connections number

✓ Answered

RTOS/CC2640: CC2640 Power Management in Standby

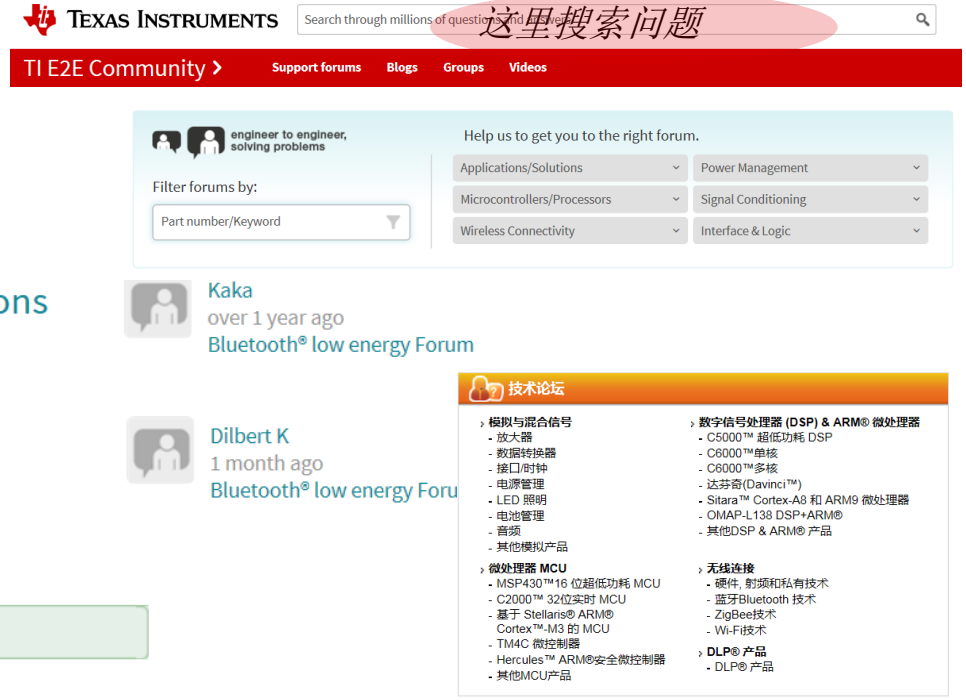
✓ Answered

CC2640做成产品在量产时如何测试RF性能？

✓ 此问题已被解答

cc2640 如何设置和手机配对后自动连接

✓ 此问题已被解答



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