TI Low Power RF

Designer's Guide to LPRF

TI Low-Power RF *at a glance…*

CC2.4 GHz

Sub 1 GHz

Low-Power RF

Alarm and Security

CC111x
Sub 1 GHz SoC
32KB Flash, USB 2.0
0.3 uA sleep current

CC1101
Sub 1 GHz Transceiver
+ MSP430 MCU,
500 Kbps
-112dBm sensitivity

Remote Controls

CC2530
RF4CE
IEEE 802.15.4 compliant
System on Chip
RemoTI SW

CC2500
2.4 GHz Transceiver
+MSP430 MCU
Proprietary solution

Smart Metering

CC2530
ZigBee
System on Chip
IEEE 802.15.4 compliant
+ CC259x Range Extenders

CC1020
Narrowband
12.5 KHz channel spacing
-118dBm sensitivity

Wireless Audio

CC8520
PurePath™ Wireless
Coming Soon
High Quality
Wireless Audio

CC259x
2.4 GHz Range Extender

Home Automation & Lighting

CC2530ZNP
Network Processor
fully certified ZigBee Pro
Software Stack

CC2431
Location Tracking
System on Chip
Solutions

Medical, Health & HID

CC2540
Bluetooth Low Energy
Coming Soon
BLE compliant SoC

CC251x
2.4 GHz Radio
Complete SoC,
32 KB Flash, USB

TI Low-Power RF

Technology Solutions

DEFINE	SELECT	DESIGN	TEST	PRODUCE
Network Topology	Proprietary or Standard	Products	Certification	Obsolescence Policy
Range and Data rate	Protocol SW	Antenna Design	Coexistence	Quality
Power Consumption	Regulations	PCB Layout	Production Test	
	Make or Buy	Development Tools		
		Design Support		

Define

RF Design Requirements

Considerations when starting an RF design:

- How many **members/nodes** will participate the wireless network?
- What is the required **range** between the devices?
- Is there a special need for **low power** consumption?
- Are there common **standards** that have to be met?

Define

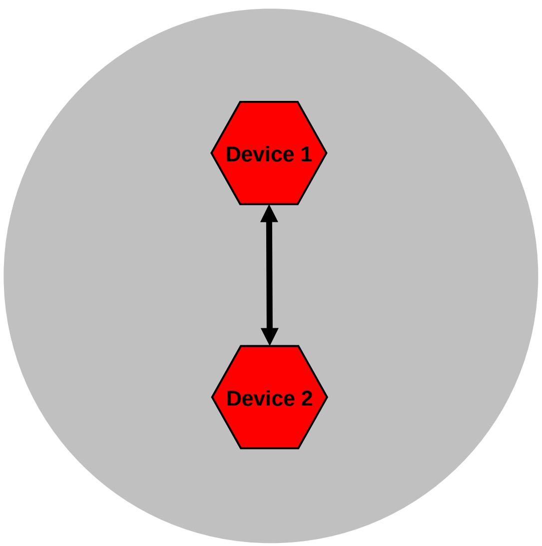
Network Topology

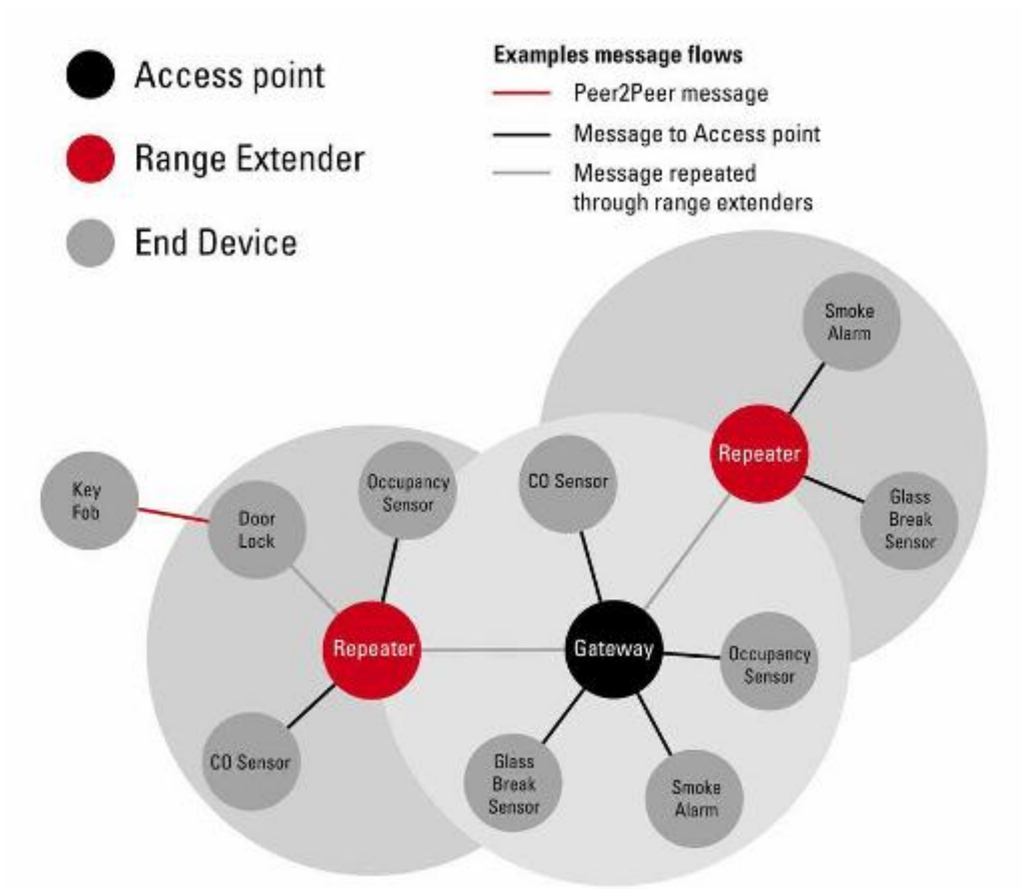
Star network with multiple nodes:

- Host device with hub function
- simple end devices

Point to Point:

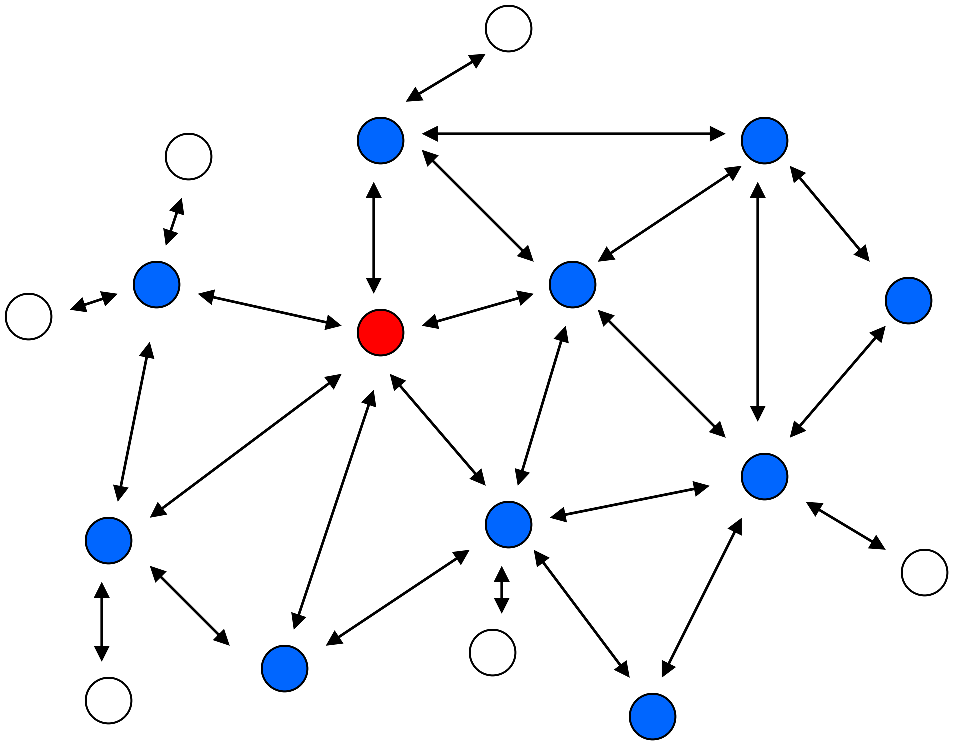
- one way or two way communication
- simple protocol using SimpliciTI or TIMAC





Define

Network Topology: ZigBee Mesh



ZigBee **Coordinator**
Starts the Network
Routes packets
Manages security
Associates Routers and End Devices
Example: Heating Central

ZigBee **Router**
Routes packets
Associates Routers and End Devices
Example: Light

ZigBee **End Device**
Sleeps most of the time
Can be battery powered
Does not route
Example: Light switch

- Devices are pre-programmed for their network function
- Coordinator can be removed

Define

Network Topology

	Any Radio HW + Proprietary SW	SimpliciTI	802.15.4 TIMAC	RF4CE	ZigBee
Topology	**Any Topology**	**Point to Point** **Star Network**	**Star Network**	**Star Network**	**Mesh**
Code Size	**variable**	**< 8 KByte**	**<32 KByte**	**<64 KByte**	**>64 KByte**
Complexity	**variable**	**Low**	**Low**	**Low**	**Medium**

Define

Range and Data rate: Range propagation

- How far can TX and RX be apart from each other?
- Friis' transmission equation for free space propagation:

$$P_r = P_t + G_t + G_r + 20\log\left(\frac{\lambda}{4\pi}\right) - 20\log d \quad \textbf{or} \quad P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2}$$

$$d = \frac{\lambda}{4\pi}\sqrt{\frac{P_t G_t G_r}{P_r}}$$

- P_t is the transmitted power, P_r is the received power
- G_t is the transmitter, G_r is the receiver antenna gain
- d is the distance between transmitter and receiver, or the range
- Lambda is the wavelength $\lambda = \frac{c}{f} = \frac{\text{Speed of light}}{\text{Frequency}}$

Define

Range and Data rate: “Real life”

Compared to the estimated range we should get in theory here are some ”real life” rules and experiences on RF range:

- 120 dB link budget at 433 MHz gives approximately 2000 meters (TI rule of thumb)
- Based on the emperical results above and Friis’ equation estimates on real range can be made
- Rule of Thumb:
  - 6 dB improvement ~ twice the distance
  - Double the frequency ~ half the range (433 MHz longer range than 868 MHz)

Define

Range and Data rate: Important factors

- Antenna (gain, sensitivity to body effects etc.)
- Sensitivity: Lowest input power with acceptable link quality (typically 1% PER)
- Channel Selectivity: How well a chip works in an environment with interference
- Output power
- Environment (Line of sight, obstructions, reflections, multi-path fading)

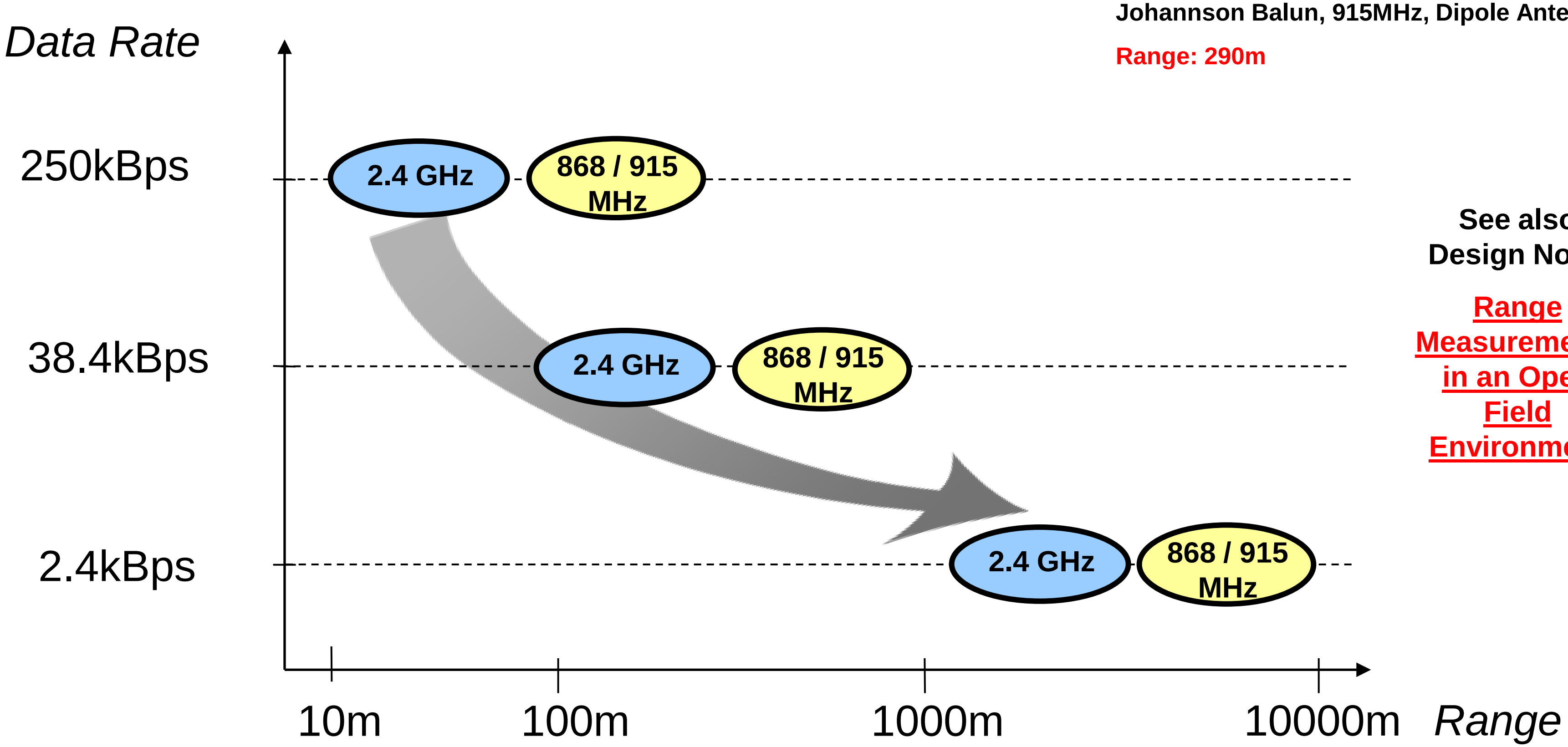
Define

Range and Data rate: Estimated LOS

Test Example:

CC1101 with 0dBm output power, 250KBps, Johannson Balun, 915MHz, Dipole Antenna

Range: 290m



See also Design Note:

Range Measurements in an Open Field Environment

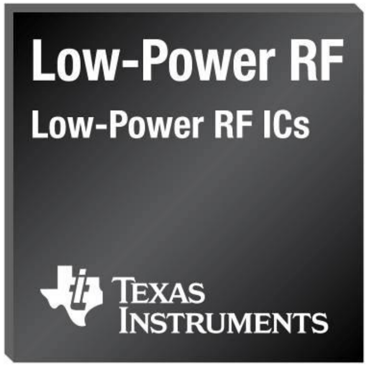
Note: These examples should be taken as a rough estimation as the final design is highly dependent on the antenna, frequency, output power and other parameters.

Define

Power Consumption

Low Power characteristics and features of TI’s RF devices:

- Low sleep current
- Minimum MCU activity
- RX/TX turn around time
- Adaptive output power using RSSI
- Fast crystal start-up time
- Fast PLL calibration (and settling)
- Carrier sense recognition
- Low RX peak current
- Minimum duty cycle
- Wake on radio (new devices)



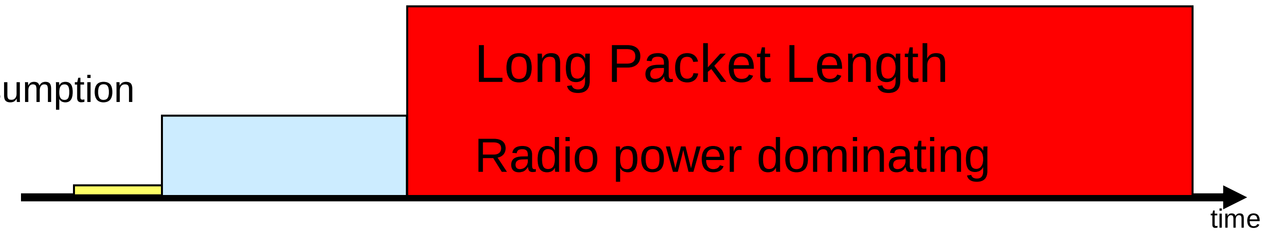
Define

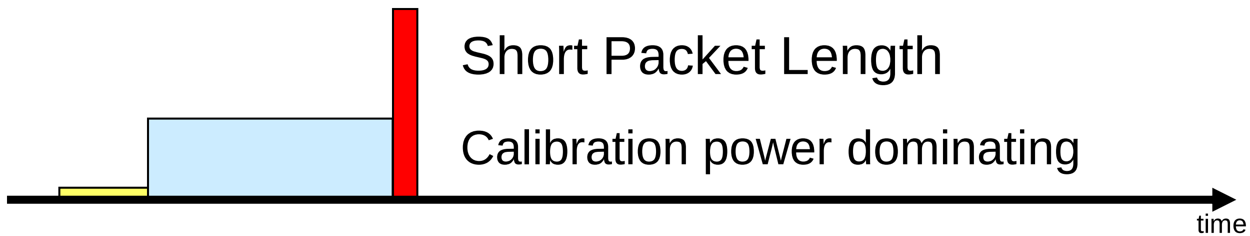
Power Consumption: Application Scenarios

- Crystal Oscillator
- Start-up Calibration
- RX/TX mode

High duty cycle applications:

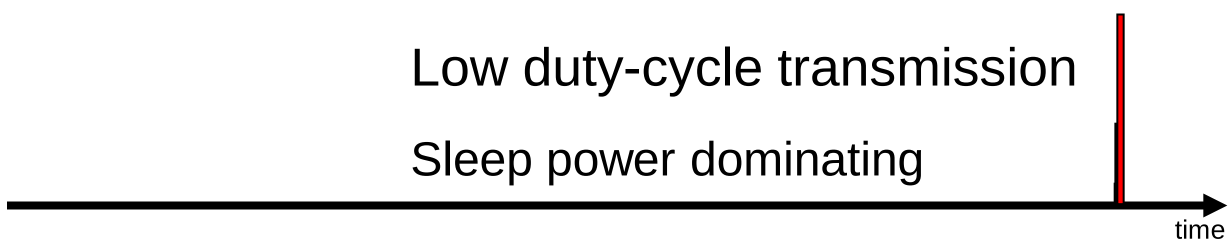
- Active radio current consumption
- RX/TX and Calibration





Low duty cycle applications:

- MCU sleep current
- Regulator quiescent current
- Average radio current consumption



Define

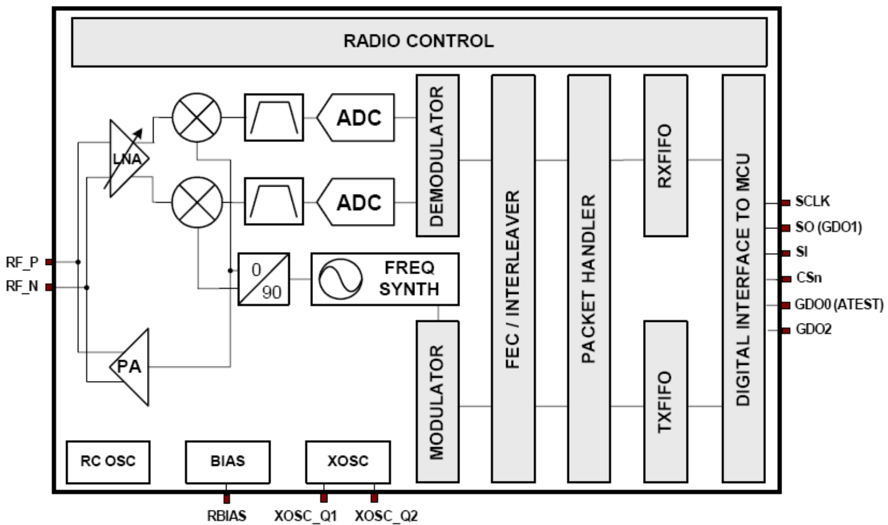
Power Consumption: Low-Power Essentials

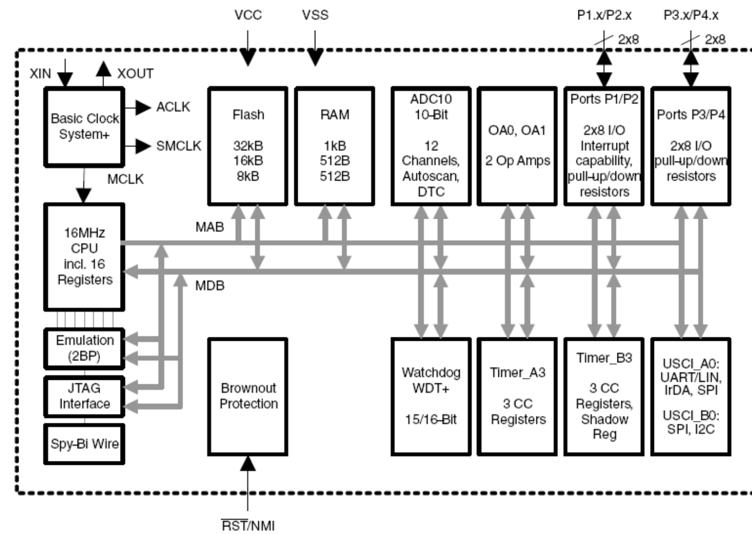
- Use the lowest possible duty cycle
  - Send data only when needed, do not send more data than necessary
  - Use the highest data rate you can (trade-off vs. range)
  - Watch out for protocol-related overhead
- Use the lowest possible voltage
  - RF chips have reduced current draw at lower voltages
  - Low voltage degrades RF performance
  - Above not a problem if on-chip regulator
- Use a switch-mode regulator with low quiescent current to maximize battery lifetime

Define

Power Consumption: Example

The Challenge of Powering a LPRF System





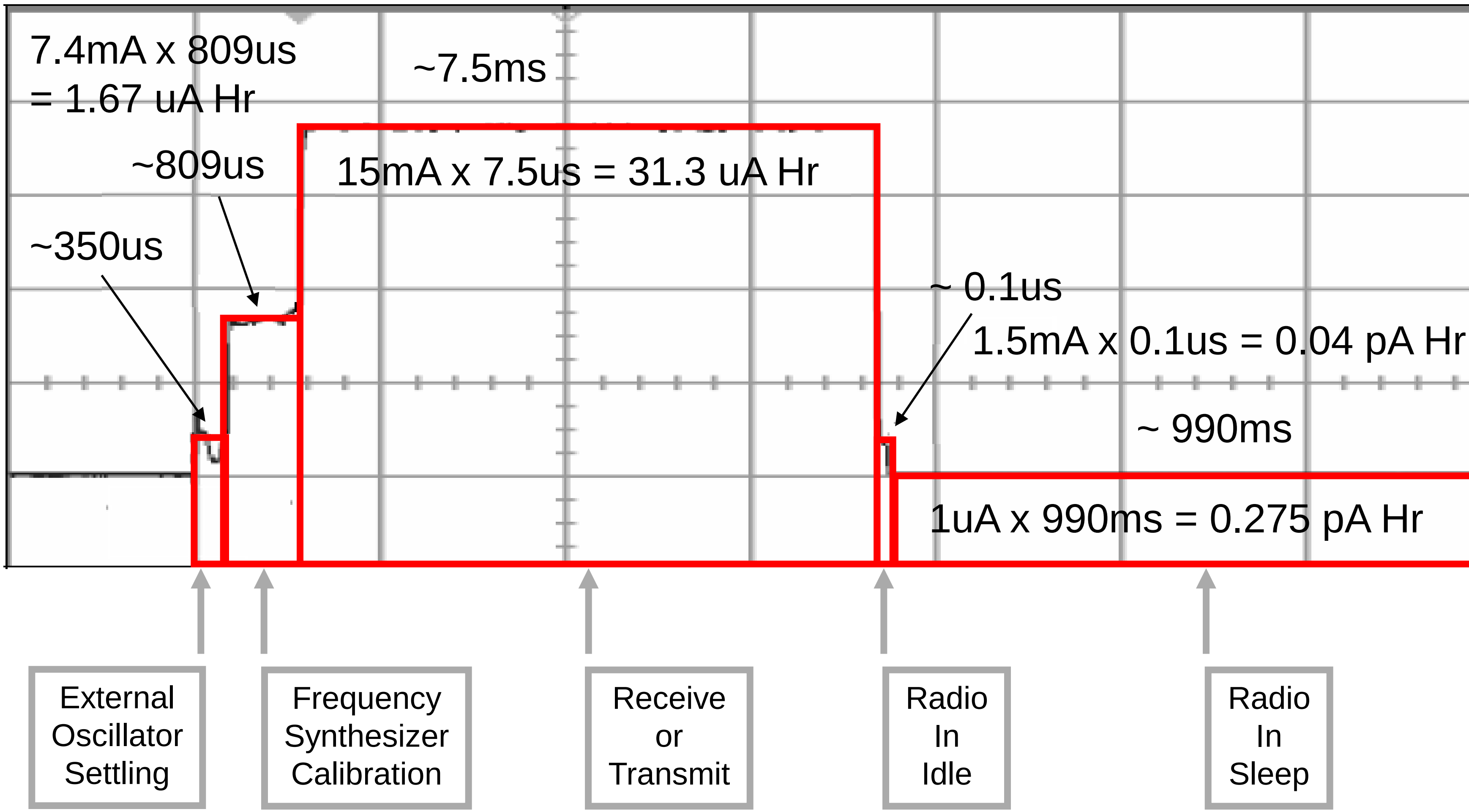
CC2500 Typicals:
Vcc Range: 1.8V to 3.6V
WOR Sleep Current: 900nA
Idle Current: 1.5mA
FSTXon Current: 7.4mA
Rx Current: 15mA @ 2.4kB/s
Tx Current: 21mA @ 0dB

MSP430F2274 Typicals:
Vcc Range: 1.8V to 3.6V
Sleep Current: 0.1uA @ 3V
32kOsc Current: 0.9uA @ 3V
CPU off Current: 90uA @ 3V
Active Current: 390uA @ 3V

Define

Power Consumption

Typical Power Profile of a LPRF System



Select

Choose the right RF solution

How to choose the perfect RF solution:

- Does the application need to **associate** with an existing system?
- What kind of **software protocols** fit the application best?
- Are there **regulations** to be considered?
- How much **time/resources** are available to get the product to market?

Select

Proprietary or Standard

TI LPRF offers several low power RF solutions by providing the required Hardware and Software.

As a result there is no need to promote any specific low power RF protocol as the solution for all applications.

However, it is important to make the customer choose the best fitting protocol for the targeted application in order to get optimal performance and meet expectations.

Select

Proprietary or Standard

ZigBee	RF4CE	IEEE 802.15.4	SimpliciTI	Proprietary	Solution
Design Freedom	Design Freedom	Design Freedom	Design Freedom	Design Freedom	Application
Z-Stack + Simple API	Remo TI	Design Freedom	Design Freedom	Design Freedom	Higher Layer Protocol
TI MAC	TI MAC	TI MAC	SimpliciTI	Design Freedom	Lower Layer Protocol
CC2530 CC2430	CC2530 CC2530ZNP	CC2530 CC2430 MSP430+CC2520	CC111x, CC251x MSP430+CC1101 or CC2500	all LPRF devices	Physical Layer
2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz Sub 1 GHz	2.4 GHz Sub 1 GHz	RF Frequency

Select

Proprietary or Standard: ZigBee

"The ZigBee Alliance is an association of companies working together to enable reliable, cost-effective, low-power, wirelessly networked monitoring and control products based on an open global standard"

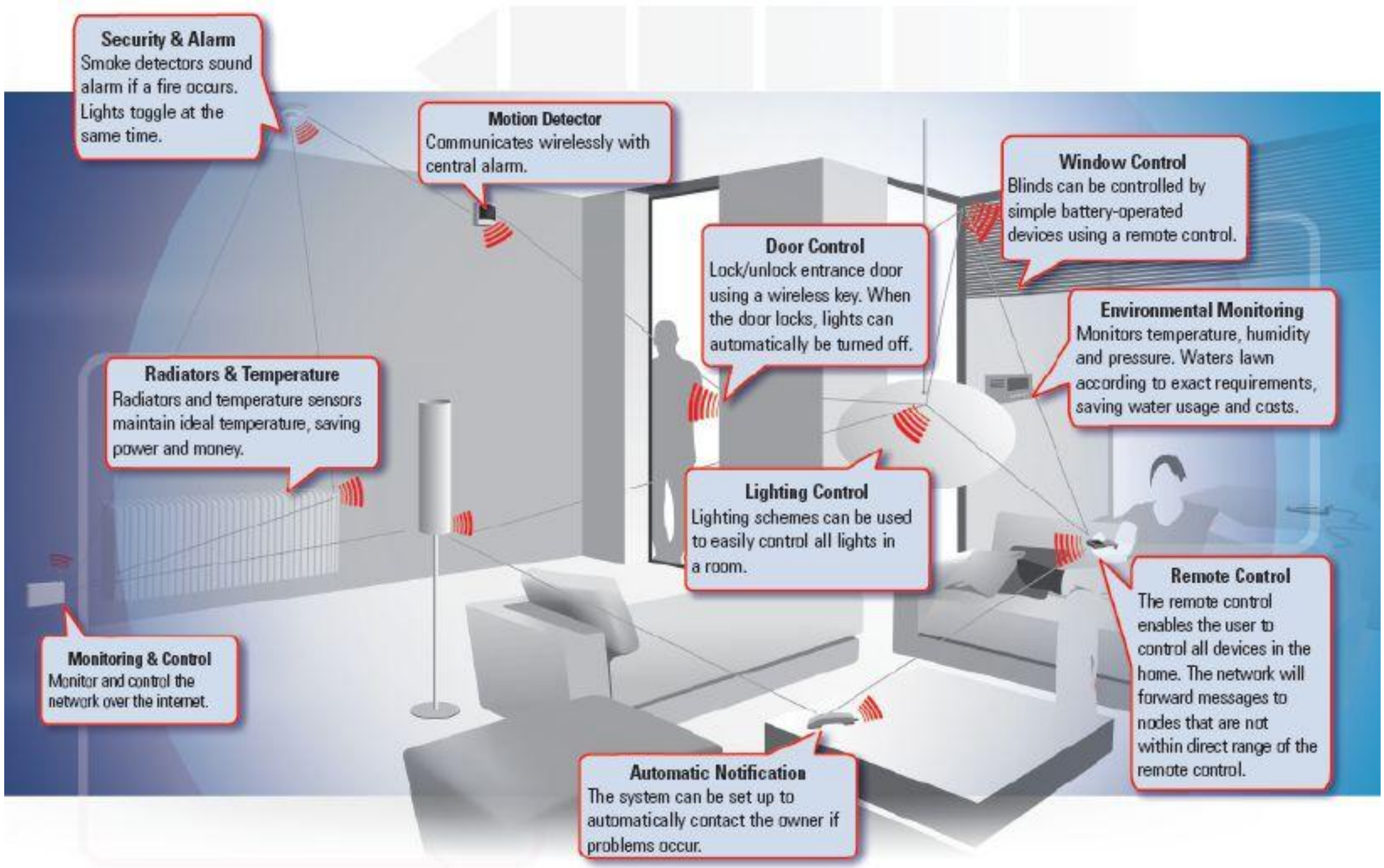
Source: ZigBee Alliance homepage

Promoters of the ZigBee alliance are:

Schneider Electric, Honeywell, PHILIPS, SAMSUNG, ember, ST, MOTOROLA, MITSUBISHI ELECTRIC Changes for the Better, Itron, TENDRIL, freescale semiconductor, Texas Instruments, Landis+Gyr manage energy better, HUAWEI, Reliant Energy, SIEMENS

Select

Proprietary or Standard: ZigBee



Select

Proprietary or Standard: RF4CE

- Founding Members

SONY PHILIPS Panasonic SAMSUNG

- Invited Contributors

Texas Instruments freescale OKI

The RF4CE industry consortium has been formed to develop a new protocol that will further the adoption of radio frequency remote controls for audio visual devices.

The consortium will create a standardized specification for radio frequency-based remote controls that deliver richer communication, increased reliability and more flexible use.

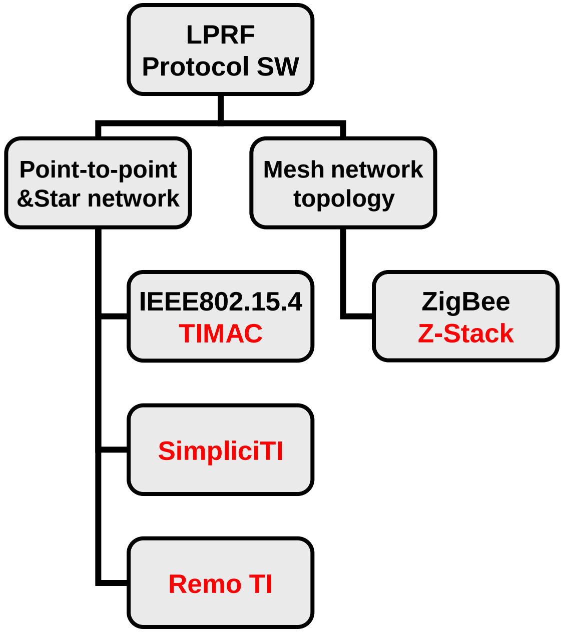
Visit www.rf4ce.org for more information on the RF4CE consortium
Visit www.ti.com/rf4ce for more information on TI's RF4CE solution

Select

Protocol Software

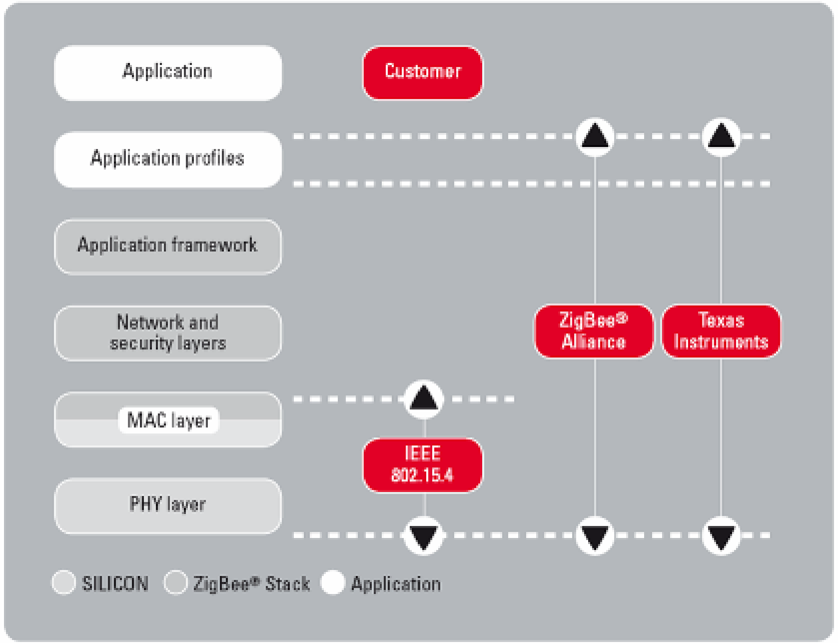
- Z-Stack - ZigBee Protocol Stack from TI
  - Mesh networking
  - Golden Unit certification for ZigBee-2006, ZigBee-2007 and ZigBee PRO
  - Supports multiple platforms including the CC2530ZNP, CC2530 and CC2520+MSP430 platforms
  - ZigBee 2007/PRO available on MSP430 platform
- TIMAC
  - A standardized wireless protocol for battery-powered and/or mains powered nodes
  - Suitable for applications with low data-rate requirements
  - Support for IEEE 802.15.4-2003/2006
- SimpliciTI Network Protocol – RF Made Easy
  - A simple low-power RF network protocol aimed at small RF networks
  - Typical for networks with battery operated devices that require long battery life, low data rate and low duty cycle
- RemoTI Remote control
  - RF4CE is built on the well-tested, reliable software, the TIMAC, which is based on the IEEE 802.15.4 protocol stack and runs in millions of devices worldwide

All software solutions can be downloaded free from TI web



Select

Protocol Software: ZigBee™ Z-Stack



- Application
- ZigBee™ Stack
  - Network functionality
- IEEE 802.15.4
  - Physical layer/Radio
  - Standardized point to point link
- ZigBee™ devices from TI
  - CC2480 (network processor)
  - CC243x System on Chip
  - CC253x System on Chip

Key Benefits:

- **Self healing (Mesh networks)**
- **Low node cost**
- **Easy to deploy (low installation cost)**
- **Supports large networks (hundreds of nodes)**
- **Intended for monitoring & control applications**
- **Standardized protocol (interoperability)**

Select

Protocol Software: SimpliciTI

- Low Power: a TI proprietary low-power RF network protocol
- Low Cost: uses < 8K FLASH, 1K RAM depending on configuration
- Flexible: simple star w/ extendor and/or p2p communication
- Simple: Utilizes a very basic core API
- Low Power: Supports sleeping devices

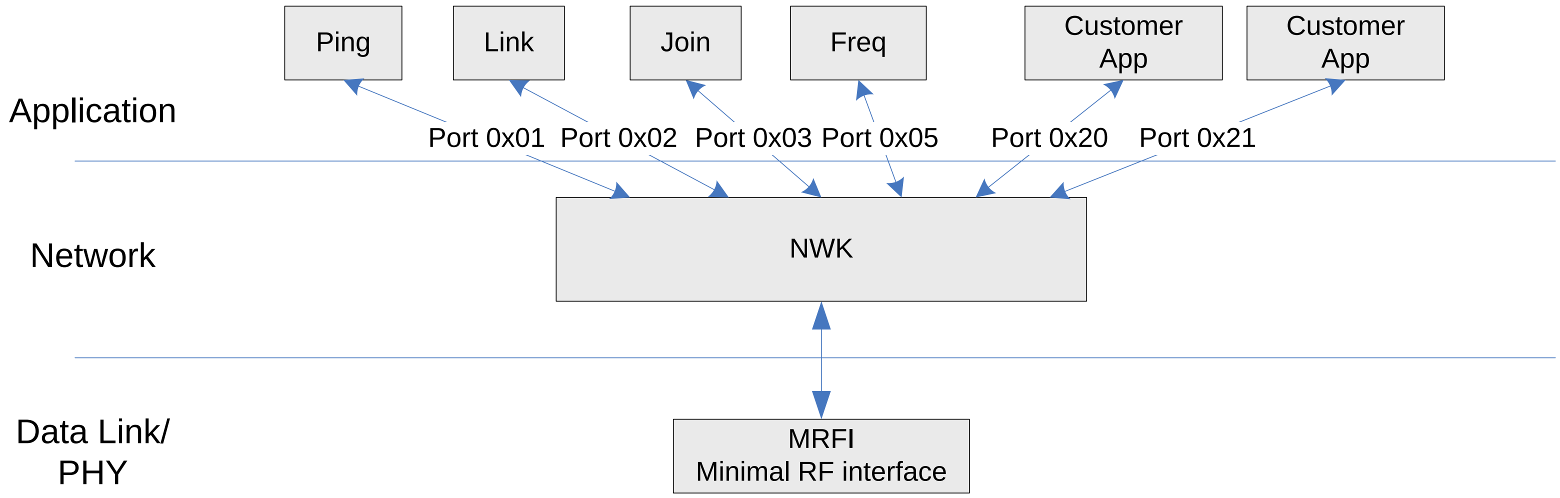
Supported LPRF devices:

MSP430+CC1101/CC2500 /CC2520,

CC1110/CC1111,

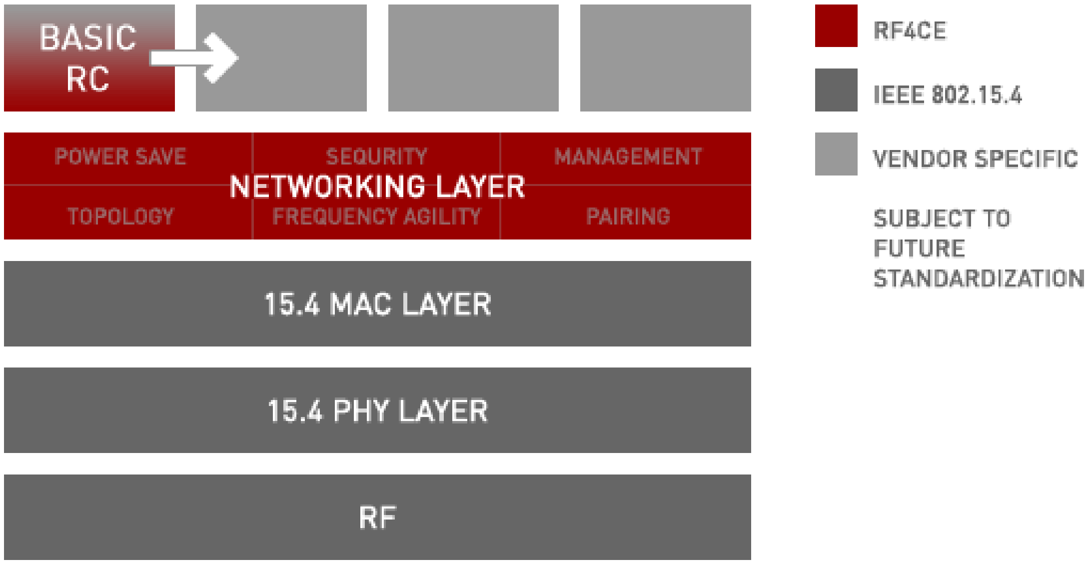
CC2510/CC2511,

CC2430, CC2530



Select

Protocol Software: RemoTI



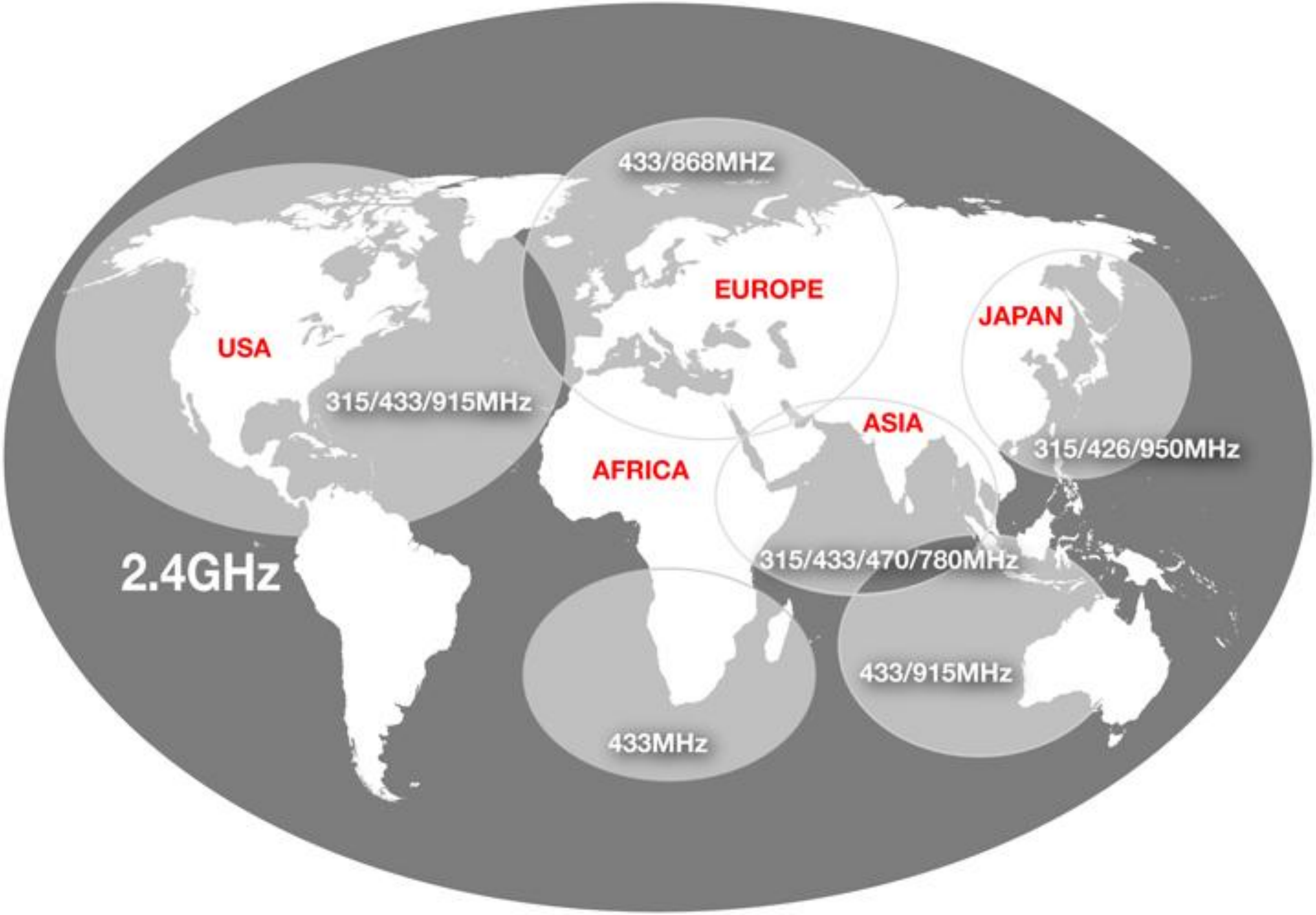
The RemoTI protocol:

- **Based on IEEE 802.15.4**
- **Includes a thin NWK layer**
- **Command Set Interface**

RemoTI (RF4CE) Standard Includes:
- **Frequency agility for multi-channel operation to avoid interference**
- **A mechanism for secure transactions**
- **A power save mechanism for power efficient implementations**
- **A simple and intuitive pairing mechanism**

Select

Regulations: ISM/SRD frequency bands



Select

Regulations: 2.4 GHz ISM band

The 2400–2483.5 MHz band is available for license-free operation in most countries

- **2.4 GHz Pros**
  - Same solution for all markets without SW/HW alterations
  - Large bandwidth available, allows many separate channels and high datarates
  - 100% duty cycle is possible
  - More compact antenna solution than below 1 GHz
- **2.4 GHz Cons**
  - Shorter range than a sub 1 GHz solution (with the same current consumption)
  - Many possible interferers are present in the band

Select

Regulations: Sub 1GHz ISM bands

The ISM bands under 1 GHz are not world-wide. Limitations vary a lot from region to region and getting a full overview is not an easy task

- **Sub 1GHz Pros**
  - Better range than 2.4 GHz with the same output power and current consumption
  - Lower frequencies have better penetration through concrete and steel (buildings and office environments) compared to 2.4 GHz

- **Sub 1GHz Cons**
  - No worldwide solution possible. Since different bands are used in different regions a custom solution has to be designed for each area
  - Duty cycle restrictions in some regions

Select

Regulations: Sub 1GHz ISM bands

902-928 MHz is the main frequency band in the US

- The 260-470 MHz range is also available, but with more limitations

The 902-928 MHz band is covered by FCC CFR 47, part 15

Sharing of the bandwidth is done in the same way as for 2.4 GHz:

- *Higher output power is allowed if you spread your transmitted power and don't occupy one channel all the time*FCC CFR 47 part 15.247 covers wideband modulation
- Frequency Hopping Spread Spectrum (FHSS) with ≥50 channels are allowed up to 1 W, FHSS with 25-49 channels up to 0.25 W
- Direct Sequence Spread Spectrum (DSSS) and other digital modulation formats with bandwidth above 500 kHz are allowed up to 1W

FCC CFR 47 part 15.249

- "Single channel systems" can only transmit with ~0.75 mW output power

Select

Regulations: Unlicensed ISM/SRD bands

USA/Canada:

- 260 – 470 MHz (FCC Part 15.231; 15.205)
- 902 – 928 MHz (FCC Part 15.247; 15.249)
- 2400 – 2483.5 MHz (FCC Part 15.247; 15.249)

Europe:

- 433.050 – 434.790 MHz (ETSI EN 300 220)
- 863.0 – 870.0 MHz (ETSI EN 300 220)
- 2400 – 2483.5 MHz (ETSI EN 300 440 or ETSI EN 300 328)

Japan:

- 315 MHz (Ultra low power applications)
- 426-430, 449, 469 MHz (ARIB STD-T67)
- 2400 – 2483.5 MHz (ARIB STD-T66)
- 2471 – 2497 MHz (ARIB RCR STD-33)

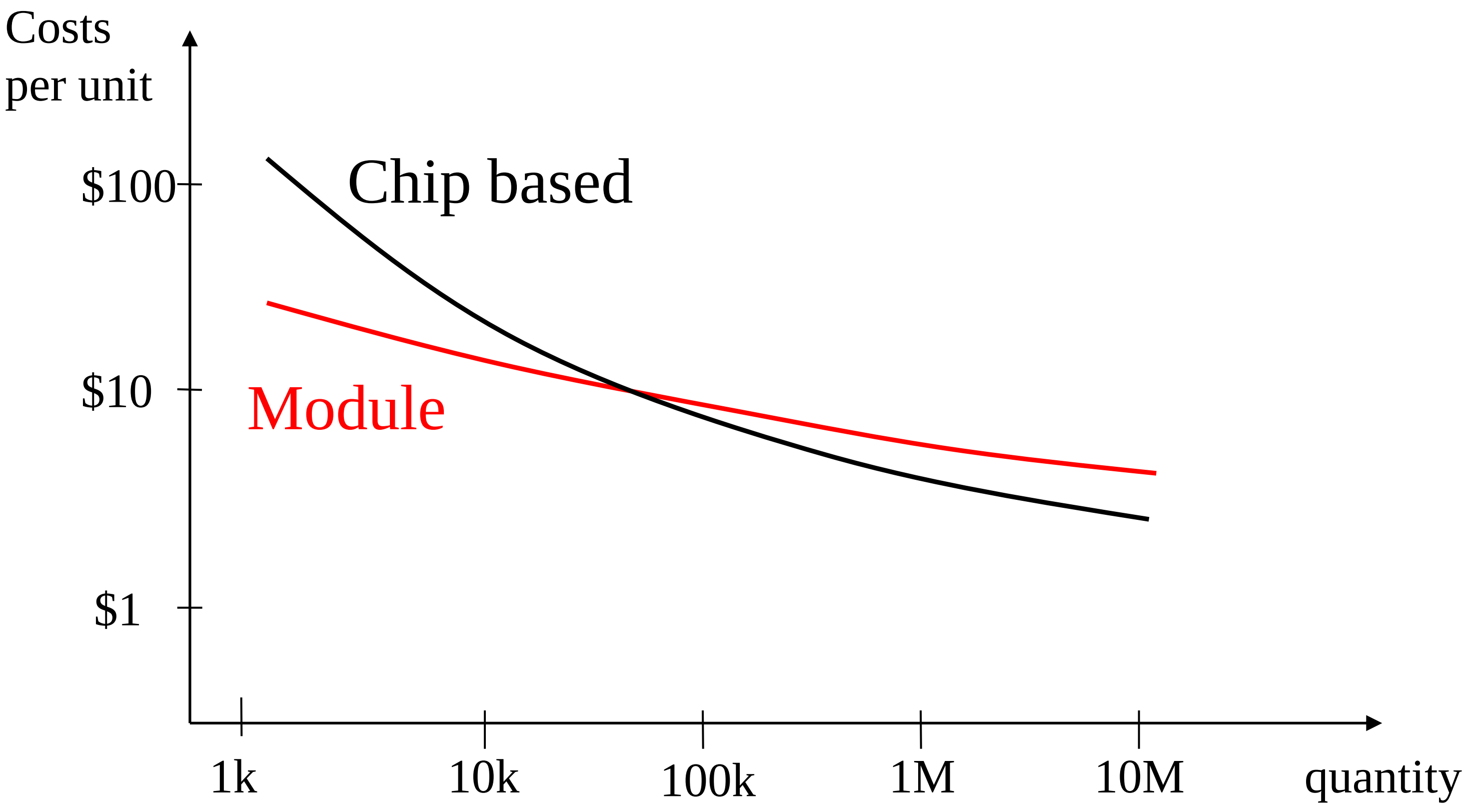
ISM = Industrial, Scientific and Medical

SRD = Short Range Devices

Select

Make or Buy

Self development based on a chipset or buy a module?



Select

Make or Buy

Benefits of a module based solution compared to a self development:

TI Developer Network

Low-Power RF

- Shortest time to market
- Focus on core competence
- 100% RF yield
- FCC/CE re-use
- Field proven technology: Temperature, antenna loads,...

Design

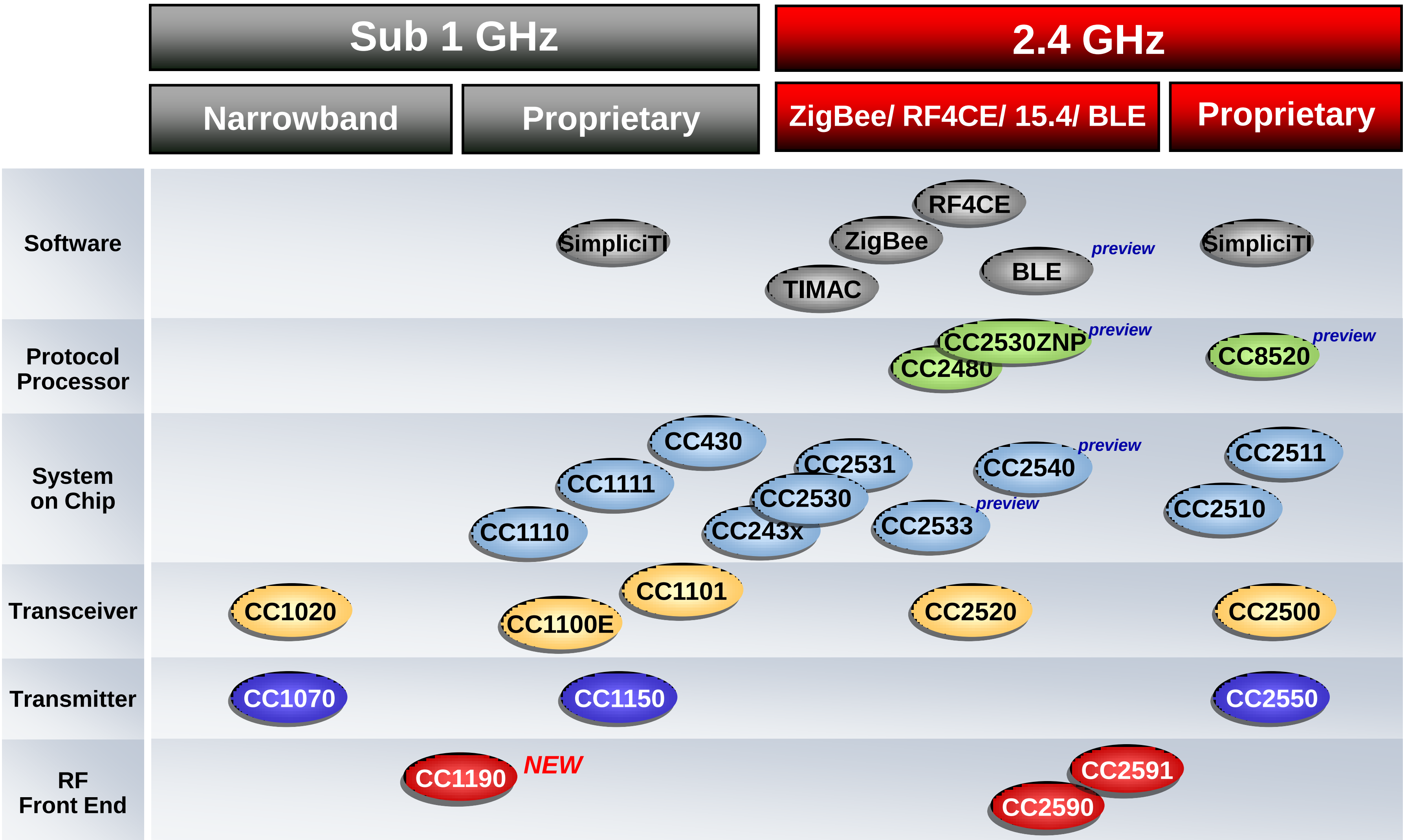
Build your Application

Design your application using TI technology:

- Low Power RF IC documentation
- Design notes supporting your RF Antenna design
- PCB reference designs help to accelerate your hardware layout
- Powerful and easy to use development tools
- Worldwide TI support organization

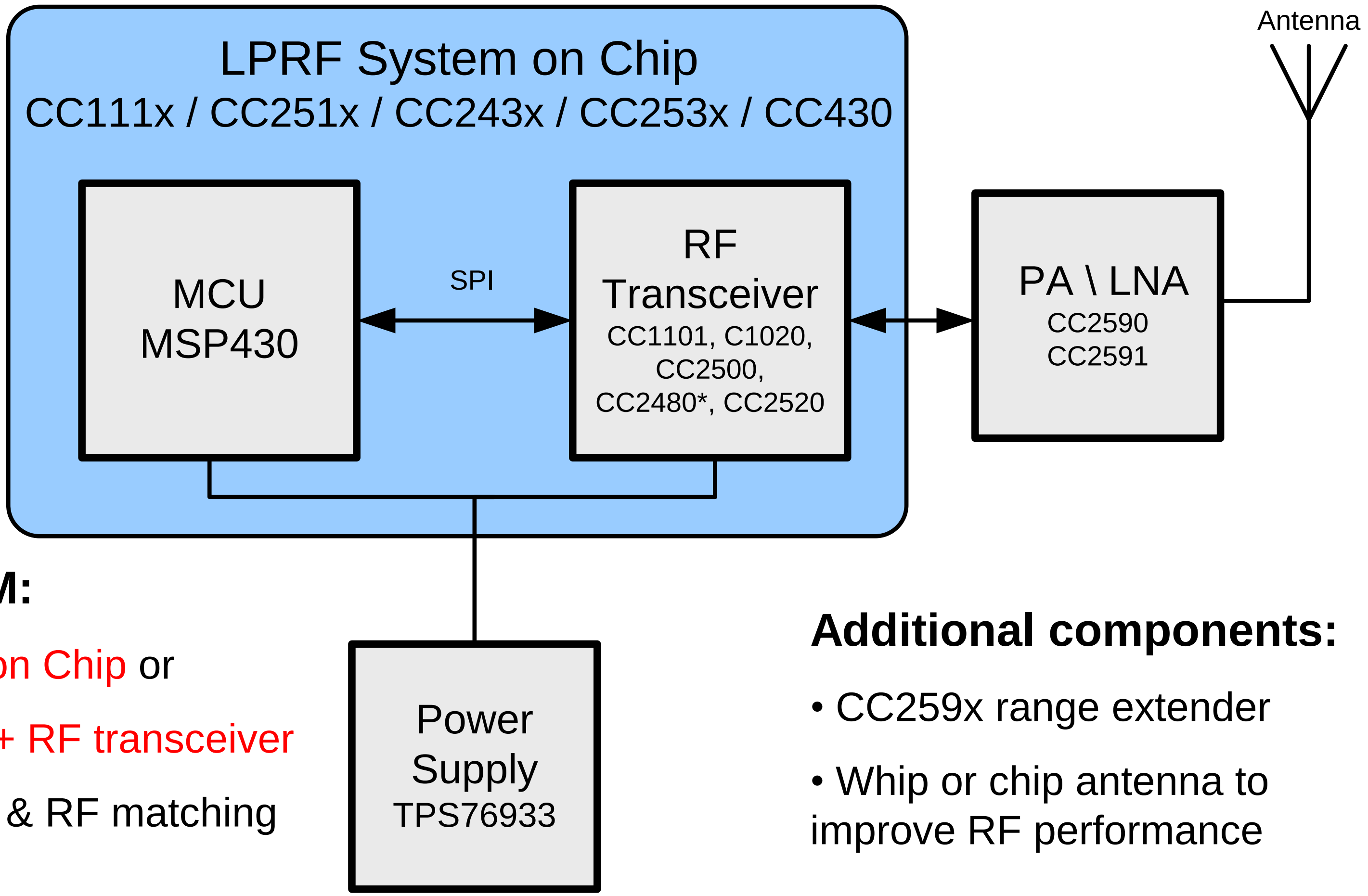
Design

LPRF Product Portfolio



Design

Block diagram of LPRF application example



Minimum BOM:

- LPRF System on Chip or MSP430 MCU + RF transceiver
- Antenna (PCB) & RF matching components
- Battery or power supply

Additional components:

- CC259x range extender
- Whip or chip antenna to improve RF performance

*ZigBee network processor

Design

Antenna Design

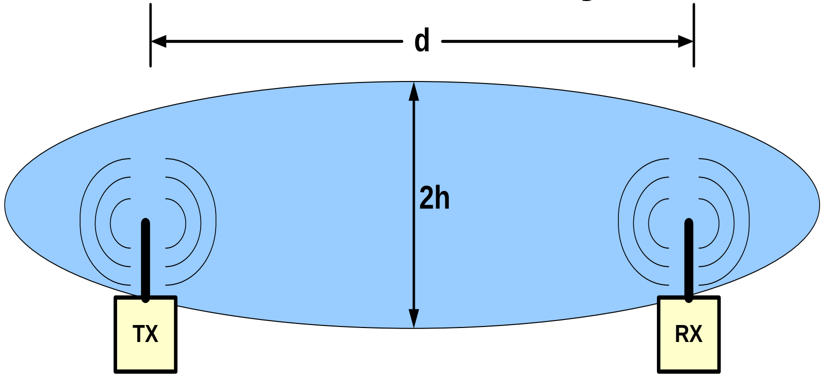
The **antenna** is a **key** component for the successful design of a wireless communication system

The **purpose** of an antenna is to provide two way transmission of data electromagnetically in free space

- Transform electrical signals into RF electromagnetic waves, propagating into free space (**transmit mode**)
- Transform RF electromagnetic waves into electrical signals (**receive mode**)

Low Power RF

Transmit / Receive System

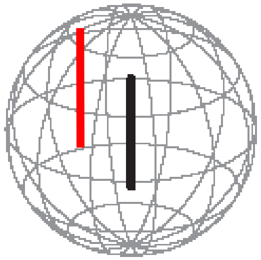


Transmit mode

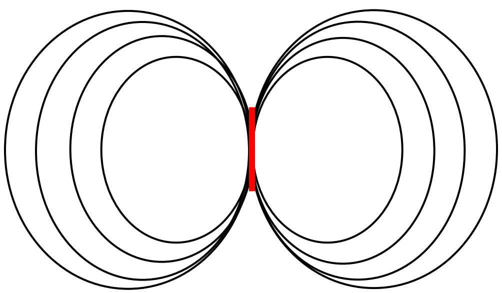
Receive mode

Design

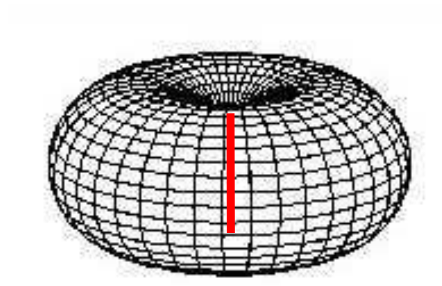
Antenna Design

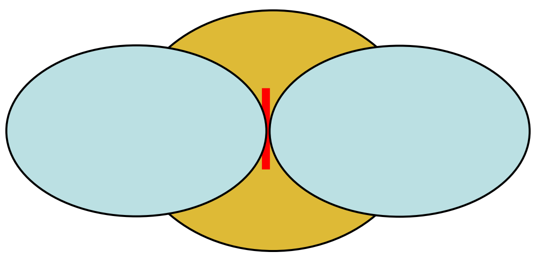


An Isotropic Antenna is a theoretical antenna that radiates a signal equally in all directions.



A Dipole Antenna is commonly used in wireless systems and can be modeled similarly to a doughnut





The Dipole represents a directional antenna with a further reach in the X&Y Plane (at the cost of a smaller reach in the Z plane) to the Isotropic.

Power measurements are referenced to isotropic antenna (dBi) as a theoretical model for comparison with all other antennas

Power Measurements of a Dipole Antenna (dBd) = 2.14 dBi.

Design

Antenna Design: Types

Two fundamental connection types for low power RF systems

Single-ended antenna connection

- Usually matched to 50 ohm
- Requires a balun if the Chipcon-chip has a differential output
- Easy to measure the impedance with a network analyzer
- Easy to achieve high performance

Differential antenna connection

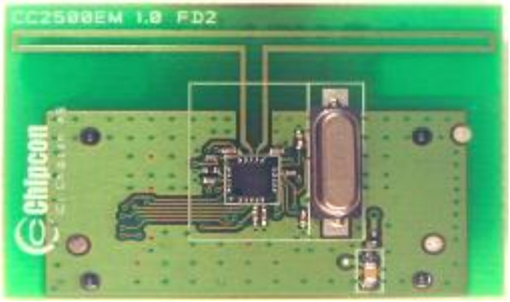
- Can be matched directly to the impedance at the RF pins
- Can be used to reduce the number of external components
- Complicated to make good design, might need to use a simulation
- Difficult to measure the impedance
- Possible to achieve equivalent performance of single-ended

Design

Antenna Design: Types

PCB antennas

- No extra cost development
- Requires more board area
- Size impacts at low frequencies and certain applications
- Good to high range
- Requires skilled resources and software

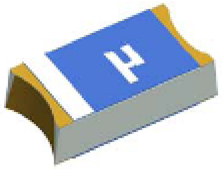


Whip antennas

- Cost from (starting~ $1)
- Best for matching theoretical range
- Size not limiting application

Chip antennas

- Less expensive (below $1)
- Lower range



Design

Antenna Design: Frequency vs. Size

Lower frequency **increases** the antenna range

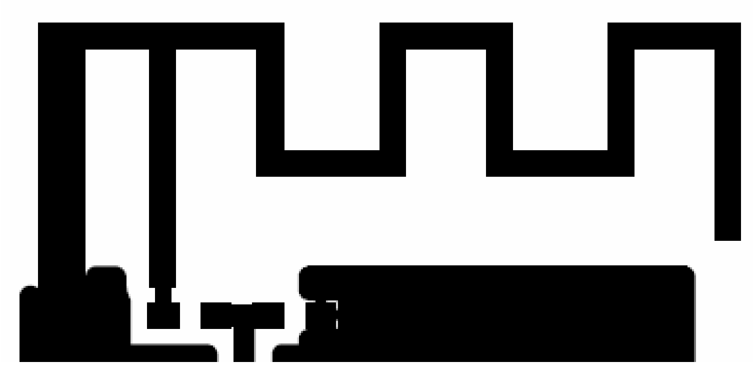
- Reducing the frequency by a factor of two doubles the range

Lower frequency requires a **larger antenna**

- λ/4 at 433 MHz is 17.3 cm (6.81 in)
- λ/4 at 915 MHz is 8.2 cm (3.23 in)
- λ/4 at 2.4 GHz is 3.1 cm (1.22 in)

A **meandered** structure can be used to reduce the size

- λ/4 at 2.4 GHz



Design

Antenna Design: TI Resources

General Antennas

- AN003: SRD Antennas (SWRA088)
- Application Report ISM-Band and Short Range Device Antennas (SWRA046A)

2.4 GHz

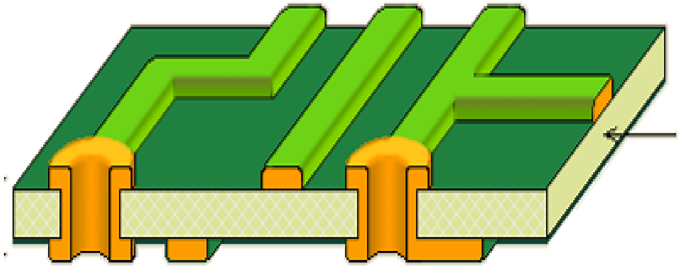
- AN040: Folded Dipole for CC24xx (SWRA093)
- AN043: PCB antenna for USB dongle (SWRA0117d)
- DN001: Antenna measurement with network analyzer (SWRA096)
- DN004: Folded Dipole Antenna for CC25xx (SWRA118)
- DN0007: Inverted F Antenna for 2.4 GHz (SWRU120b)
- AN058: Antenna Selection Guide (SWRA161)
- AN048: Chip Antenna (SWRA092b)

868/915 MHz

- DN008: 868 and 915 MHz PCB antenna (SWRU121)
- DN016: 915 MHz Antenna Design (SWRA160)
- DN023: 868 MHz and 915 MHz PCB inverted-F antenna (SWRA228)

Design

PCB Layout: Rules of thumb for RF Layout



- Keep via inductance as low as possible. Usually means larger holes or multiple parallel holes)
- Keep top ground continuous as possible. Similarly for bottom ground.
- Make the number of return paths equal for both digital and RF
  - Current flow is always through least impedance path. Therefore digital signals should not find a lower impedance path through the RF sections.
- Compact RF paths are better, but observe good RF isolation between pads and or traces.

Design

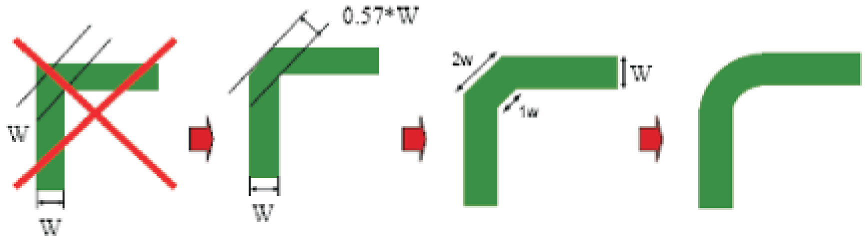
PCB Layout: Do's and Don'ts of RF Layout

- Keep copper layer continuous for grounds. Keep connections to supply layers short
- Use SMT 402 packages which have higher self-resonance and lower package parasitic components.
- Use the chips star point ground return
- Avoid ground loops at the component level and or signal trace.
- Use vias to move the PCB self resonance higher than signal frequencies
- Keep trace and components spacing nothing less than 12 mils
- Keep via holes large at least 14.5 mils
- Separate high speed signals (e.g. clock signals) from low speed signals, digital from analog. Placement is critical to keep return paths free of mixed signals.
- Route digital signals traces so antenna field lines are not in parallel to lines of magnetic fields.
- Keep traces length runs under a ¼ wavelength when possible.

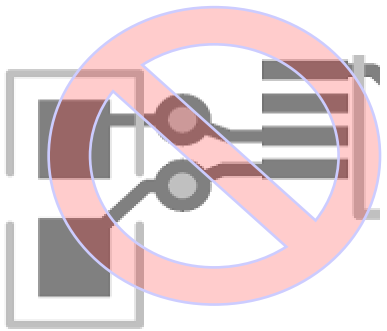
Design

PCB Layout: Do's and Don'ts of RF Layout

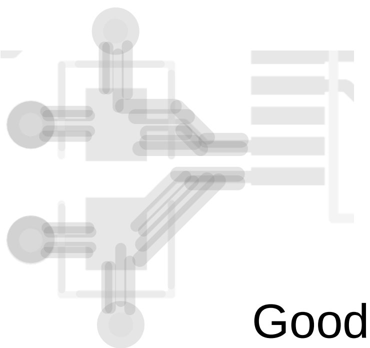
- Avoid discontinuities in ground layers
- Keep vias spacing to mimimize E fields that acts as current barriers, good rule to follow keep spacing greater than 5.2 x greater than hole diameter for separations.
- Don't use sharp right angle bends



- Do not have vias between bypass caps



Poor Bypassing



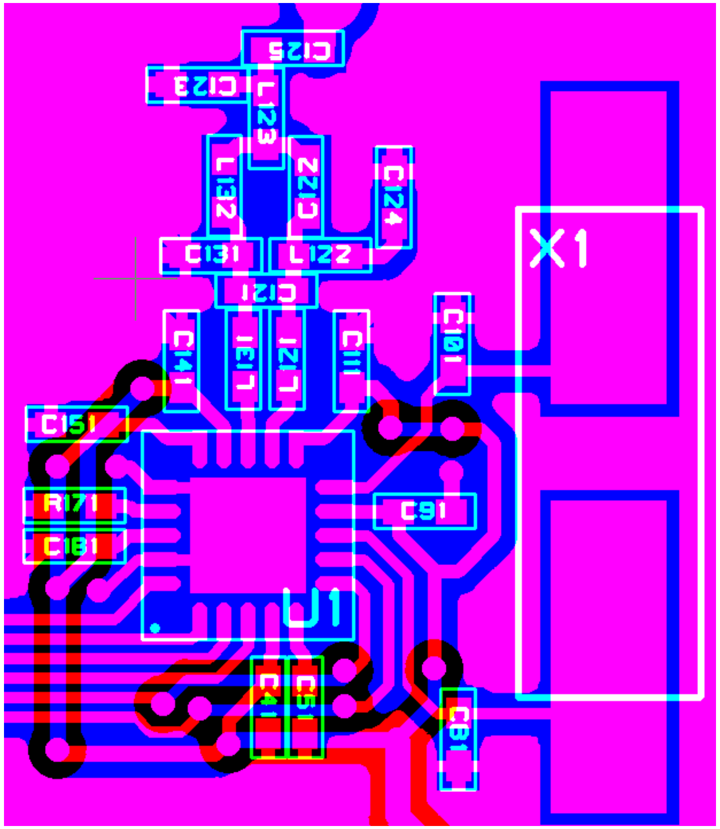
Good Bypassing

Design

PCB Layout: Example

Copy (for example) the CC1100EM reference design!

- Use the exact same values and placement on decoupling capacitors and matching components.
- Place vias close to decoupling capacitors.
- Ensure 50 ohm trace from balun to antenna.
- Remember vias on the ground pad under the chip.
- Use the same distance between the balun on layer 1 and the ground layer beneath.
- Implement a solid ground layer under the RF circuitry.
- Ensure that useful test pins are available on the PCB.
- Connect ground on layer 1 to the ground plane beneath with several vias.
- <u>Note:</u> different designs for 315/433 MHz and 868/915 MHz



Layout: CC1100EM 868/915MHz reference design

Design

PCB Layout: RF Licensing

Design guidelines to meet the RF regulation requirements:

- Place Decoupling capacitors close to the DC supply lines of the IC
- Design a solid ground plane and avoid cutouts or slots in that area
- Use a low-pass or band-pass filter in the transmit path to suppress the harmonics sufficiently
- Choose the transmit frequency such that the harmonics do not fall into restricted bands
- In case of shielding may be necessary filter all lines leaving the shielded case with decoupling capacitors to reduce spurious emissions.
- Chose values of decoupling capacitors in series resonance with their parasitic inductance at the RF frequency that needs to be filtered out
- Design the PLL loop filter carefully according to the data rate requirements
- In case of a battery driven equipment, use a brownout detector to switch off the transmitter before the PLL looses lock due to a low battery voltage

Design

PCB Layout: RF Licensing

Documentation on LPRF frequency bands and licensing:

ISM-Band and Short Range Device Regulations

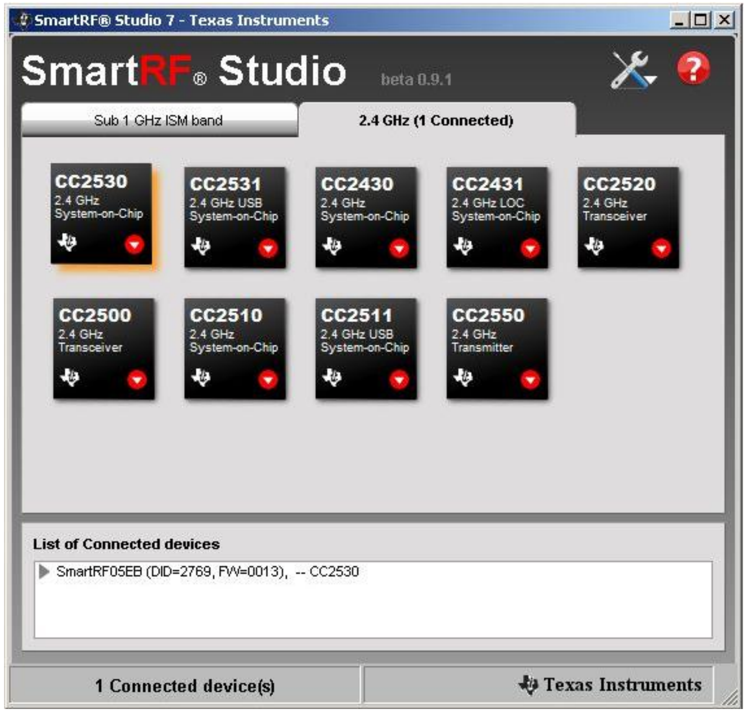
Using CC1100/CC1150 in European 433/868 MHz bands

SRD regulations for license free transceiver operation

Design

Development Tools: SmartRF® Studio

- SmartRF® Studio is a PC application to be used together with TI's development kits for ***ALL*** CCxxxx RF-ICs.
- Converts user input to associated chip register values
  - *RF frequency*
  - *Data rate*
  - *Output power*
- Allows remote control/ configuration of the RF chip when connected to a DK
- Supports quick and simple performance testing
  - *Simple RX/TX*
  - *Packet RX/TX*
  - *Packet Error Rate (PER)*



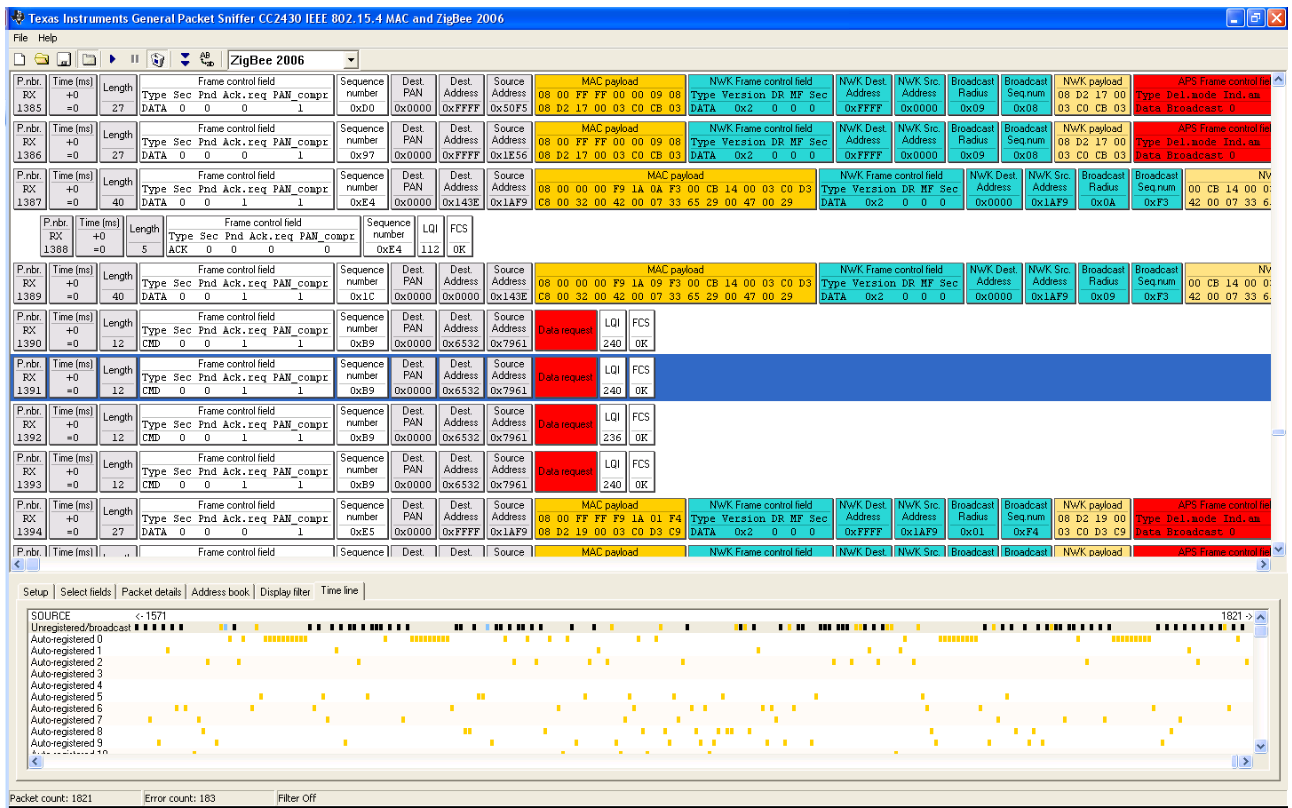
Design

Development Tools: Packet Sniffer

Packet sniffer captures packets going over the air

Protocols:

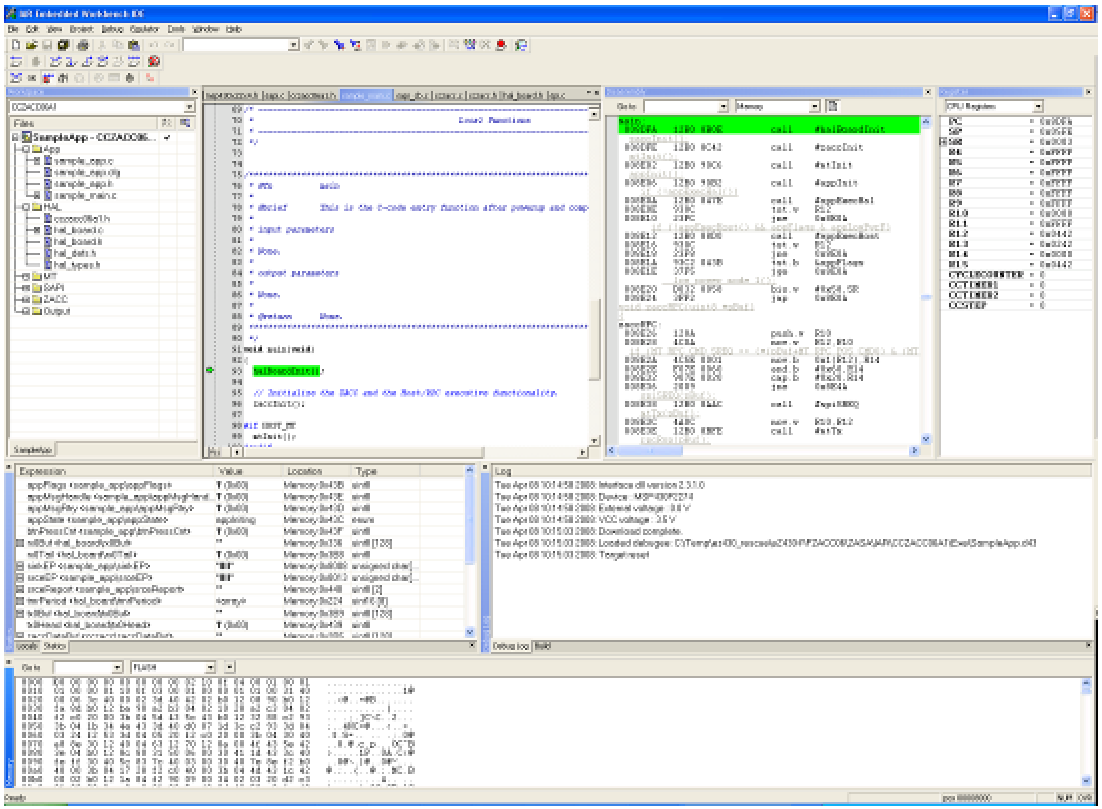
- SimpliciTI
- TIMAC
- ZigBee
- RemoTI



Texas Instruments

Design

Development Tools: IAR Embedded Workbench



www.IAR.com

- IDE for software development and debugging
- Supports
  - All LPRF SoCs
  - All MSP430s
- 30 day full-feature evaluation version
  - Extended evaluation time when buying a SoC DK or ZDK
- Free code-size limited version

Design

Development Tools: Kits Overview

Part Number	Short Description	Development Kit	Evaluation Modules
CC1020 **CC1070**	Narrowband RF Transceiver Narrowband RF Transmitter	CC1020-CC1070DK433 CC1020-CC1070DK868	CC1020EMK433 / CC1020EMK868 CC1070EMK433 / CC1070EMK868
CC1101	<1 GHz Transceiver	CC1101DK433 / CC1101DK868	CC1101EMK433 / CC1101EMK868
CC1110 **CC1111**	8051 MCU + <1 GHz Radio 8051 MCU + <1 GHz Radio + USB	CC1110-CC1111DK CC1110DK-MINI-868	CC1110EMK433 / CC1110EMK868 CC1111EMK868
CC2500	2.4 GHz Transceiver	CC2500-CC2550DK	CC2500EMK
CC2510 **CC2511**	8051 MCU + 2.4 GHz Radio 8051 MCU + 2.4 GHz Radio + USB	CC2510-CC2511DK CC2510DK-MINI	CC2510EMK CC2511EMK
CC2520	IEEE 802.15.4 compliant Transceiver	CC2520DK	CC2520EMK
CC2530 **CC2531**	8051 MCU + IEEE 802.15.4 8051 MCU + IEEE 802.15.4 + USB	CC2530DK CC2530ZDK RemoTI-CC2530DK	CC2530EMK CC2531EMK
CC1190	PA/LNA RF frontend		CC1190EMK-915
CC2591	PA/LNA RF frontend		CC2591EMK, CC2430-CC2591EMK CC2520-CC2591EMK, CC2530-CC2591EMK
CC2590	PA/LNA RF frontend		CC2590EMK, CC2430-CC2590EMK

Design

Support

Large selection of support collatoral:

- Development tools
- Application & Design Notes
- Customer support
- LPRF Developer Network
- LPRF Community

Texas Instruments

Test

Get your products ready for the market

Important points before market release:

- Test the product on meeting certification standards
- Check Co-existence with other wireless networks
- Solutions to test products in production line

Test

Certification

Perform in-house product characterization on key regulatory parameters to reveal any potential issues early on.

Pre-testing at an accredited test house can shave off considerable time in the Development cycle.

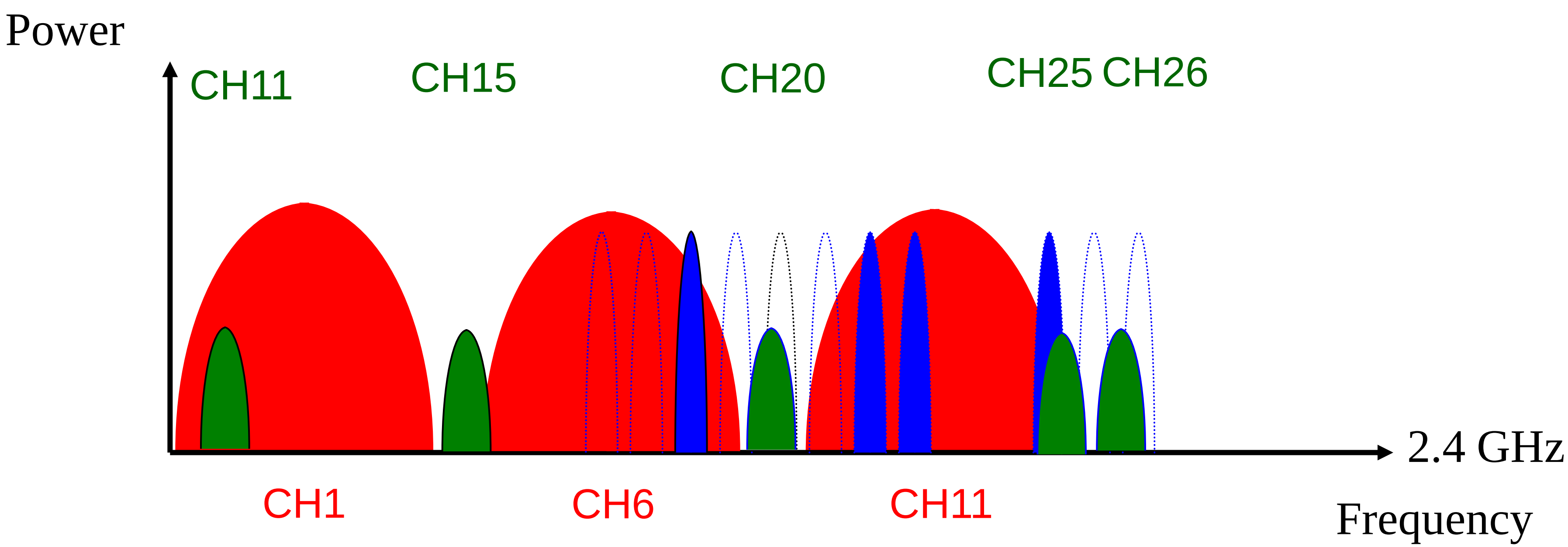
Coexistence of RF systems:

- How well does the radio operate in environments with interferers
- Selectivity and saturation important factors
- The protocol also plays an important part
  - Frequency hopping or frequency agility improves co-existing with stationary sources like WLAN
  - Listen Before Talk used to avoid causing collisions
- GOOD COEXISTENCE = RELIABILITY

Test

Coexistence

Due to the world-wide availability the 2.4GHz ISM band it is getting more crowded day by day.
Devices such as Wi-Fi, Bluetooth, ZigBee, cordless phones, microwave ovens, wireless game pads, toys, PC peripherals, wireless audio devices and many more occupy the 2.4 GHz frequency band.



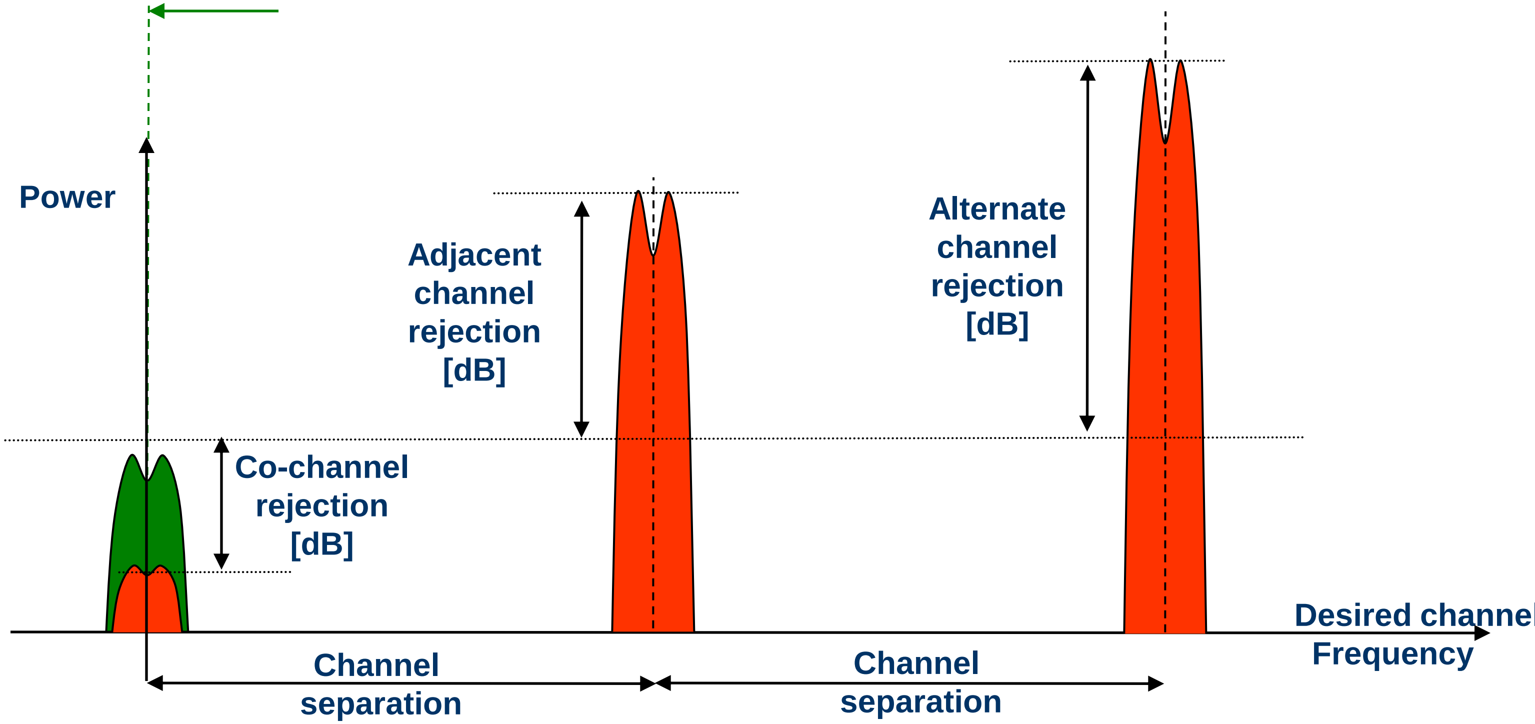
WLAN vs ZigBee vs Bluetooth

Test

Coexistence: Selectivity / Channel rejection

How good is the receiver at handling interferers at same frequency and close by frequencies?

Desired signal / Interferer



Test

Production Test

Good quality depends highly on a good Production Line Test. Therefore a Strategy tailored to the application should be put in place. Here are some recommandations for RF testing:

- Send / receive test
- Signal strength
- Output power
- Interface test
- Current consumption (especially in RX mode)
- Frequency accuracy

Produce

Production support from TI

- TI obsolescence policy
- TI product change notification
- Huge Sales & Applications teams ready to help solving quality problems

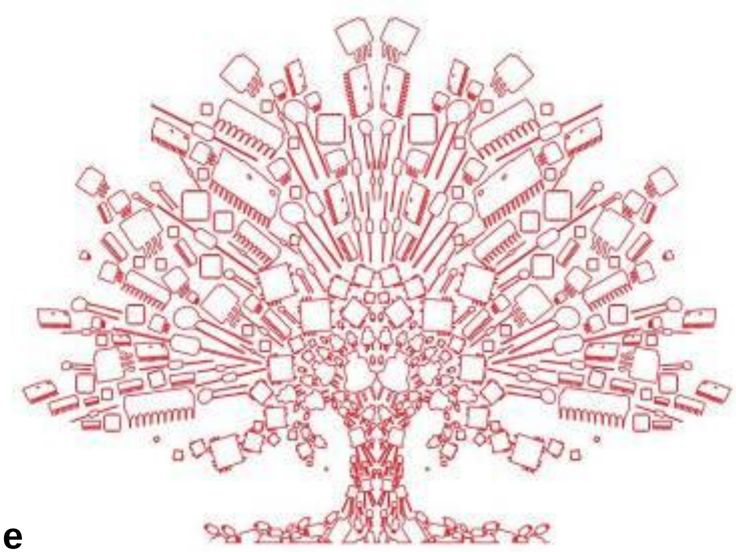
Produce

TI Obsolescence Policy

- **TI will not obsolete a product for "convenience" (JESD48B Policy)**

- **In the event that TI can no longer build a part, we offer one of the most generous policies providing the following information:**
  - **Detailed Description**
  - **PCN Tracking Number**
  - **TI Contact Information**
  - **Last Order Date (12 months after notification)**
  - **Last Delivery Date**

    (+6 month after order period ends)
  - **Product Identification (affected products)**
  - **Identification of Replacement product, if applicable**

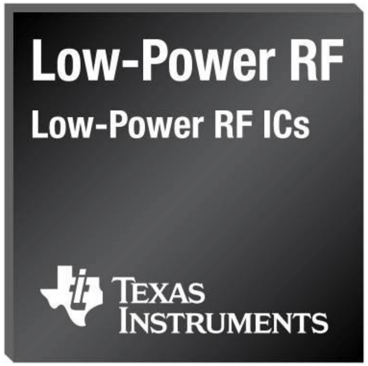


- **TI will review each case individually to ensure a smooth transition**

Produce

TI Product Change Notification

TI complies with JESD46C Policy and will provide the following information a minimum of 90 days before the implementation of any notifiable change:



- **Detailed Description**
- **Change Reason**
- **PCN Tracking Number**
- **Product Identification (affected products)**
- **TI Contact Information**
- **Anticipated (positive/negative) impact on Fit, Form, Function, Quality & Reliability**
- **Qualification Plan & Results (Qual, Schedule if results are not available)**
- **Sample Availability Date**
- **Proposed Date of Production Shipment**

Produce

Quality: TI Quality System Manual (QSM)

- TIs Semiconductor Group Quality System is among the finest and most comprehensive in the world. This Quality System satisfied customer needs long before international standards such as ISO-9001 existed, and our internal requirements go far beyond ISO-9001.
- The Quality System Manual (QSM) contains the 26 top-level SCG requirement documents.... What must be done.... for its worldwide manufacturing base to any of our global customers.
- Over 200 Quality System Standards (QSS), internal to TI, exist to support the QSM by defining key methods... How to do things... such as product qualification, wafer-level reliability, SPC, and acceptance testing.
- The Quality System Manual is reviewed routinely to ensure its alignment with customer requirements and International Standards.

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RFID	www.ti-rfid.com	Space, Avionics & Defense	www.ti.com/space-avionics-defense
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