



**TI Technology Days 2010**

# Überlegungen und Konzepte zu Funklösungen

TI Low Power RF

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# TI Low Power RF *at a glance...*

CC2.4 GHz

Sub 1 GHz

## 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

Low Power RF

CC8520

**PurePath™ Wireless**  
**Coming Soon**  
High Quality  
Wireless Audio

## Wireless Audio

CC2590

**2.4 GHz Range Extender**



CC2431

**Location Tracking**  
System on Chip  
Solutions

CC2480

**Network Processor**  
fully certified ZigBee 2006  
Software Stack



## Sport & HID

CC2540

**Bluetooth Low Energy**  
**Coming Soon**  
BTLE compliant



CC251x

**2.4 GHz Radio**  
8051 MCU,  
32 KB Flash, USB



## Home Automation & Lighting



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# TI Low Power RF

## Technology Solutions

**DEFINE**

Network  
Topology

Range and  
Data rate

Power  
Consumption

**SELECT**

Proprietary or  
Standard

Protocol SW

Regulations

Make or Buy

**DESIGN**

Products

Antenna  
Design

PCB Layout

Development  
Tools

Design  
Support

**TEST**

Certification

Coexistence

Production  
Test

**PRODUCE**

Obsolescence  
Policy

Quality

# Define

## RF Design Requirements

### Considerations when starting an RF design:

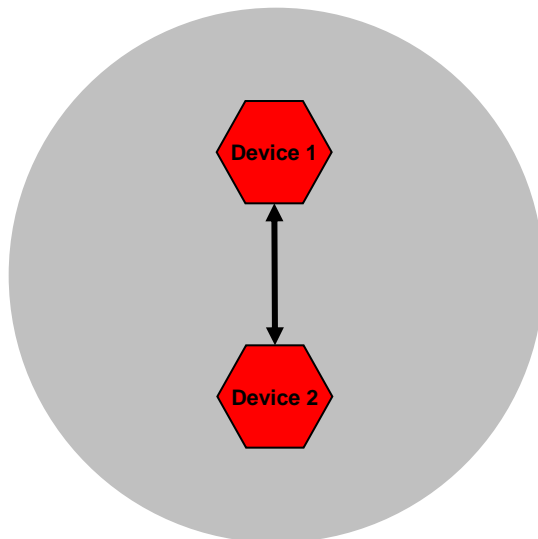
- How many **members/nodes** will participate the wireless network?
- What is the required **range** between the devices?
- Is there a special need for **low power** consumption?
- Are there common **standards** that have to be met?

# Define

## Network Topology

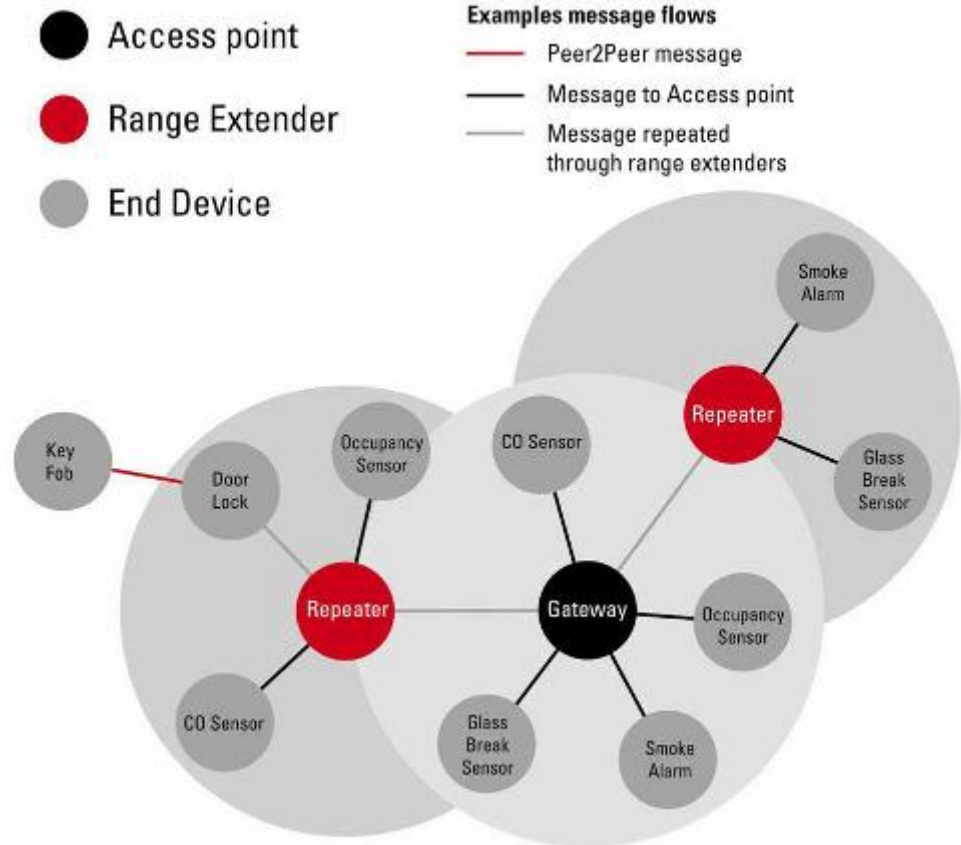
### Point to Point:

- one way or two way communication
- simple protocol using [SimpliciTI](#) or [TIMAC](#)



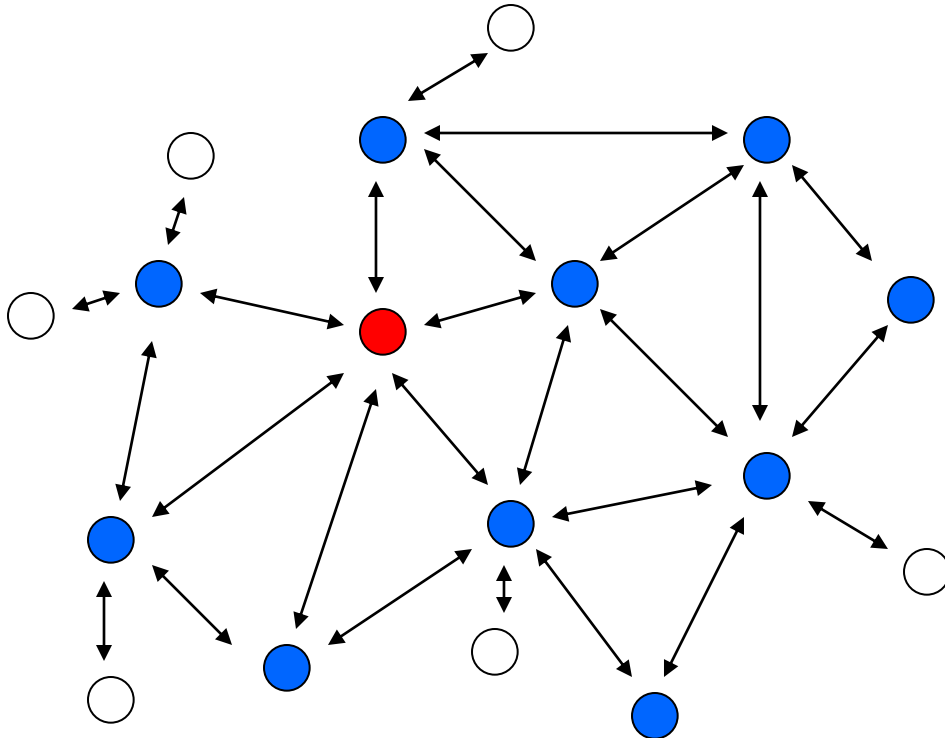
### Star network with multiple nodes:

- Host device with hub function
- simple end devices






# Define

## Network Topology: ZigBee Mesh



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

-  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

# Define

## Network Topology

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

# 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

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

$$d = \frac{\lambda}{4\pi} \sqrt{\frac{P_t G_t G_r}{P_r}} \quad d = \frac{3 \cdot 10^8 \text{ m}}{2.4 \cdot 10^9 \text{ s}^{-1} \cdot 4\pi \text{ s}} \sqrt{\frac{1 \text{ mW} \cdot 1 \cdot 1}{1 \text{ mW} \cdot 10^{-9.2}}} = 396 \text{ m}$$

- $P_t$  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  $\lambda = \frac{C}{f} = \frac{\text{Speed of light}}{\text{Frequency}}$

[or use the calculator at  
www.learnzigbee.com](http://www.learnzigbee.com)



# 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)

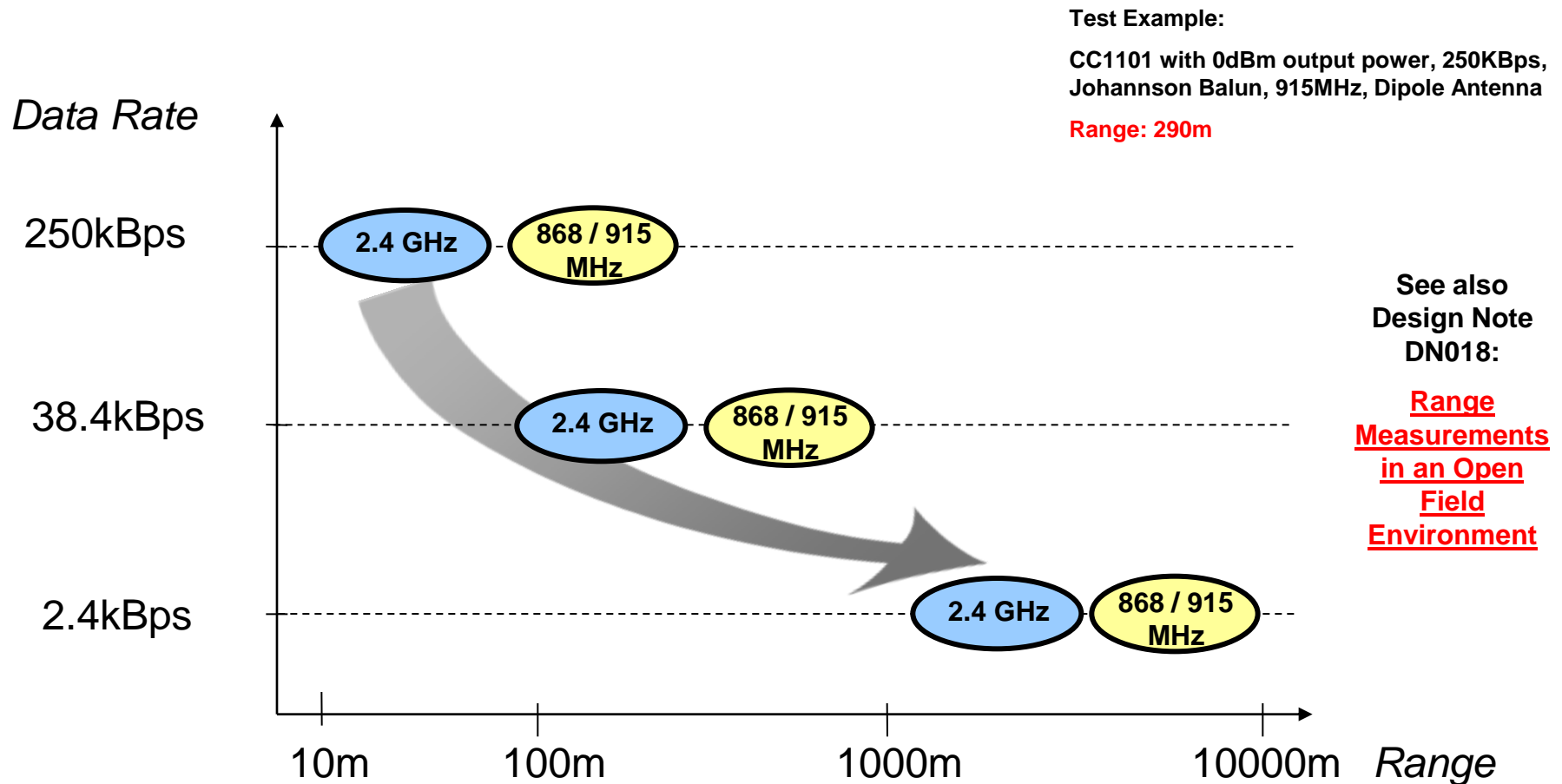
# Define

## 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



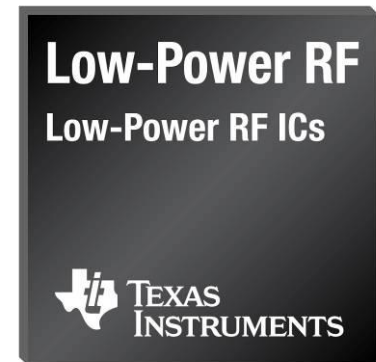
**Note:** These examples should be taken as a rough estimation as the final design is highly dependent on the antenna, frequency, output power and other parameters.

# Define

## Power Consumption

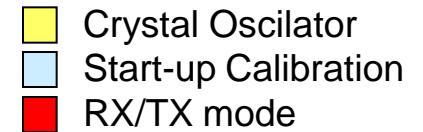
Low Power characteristics and features of TI's RF devices:

- 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)



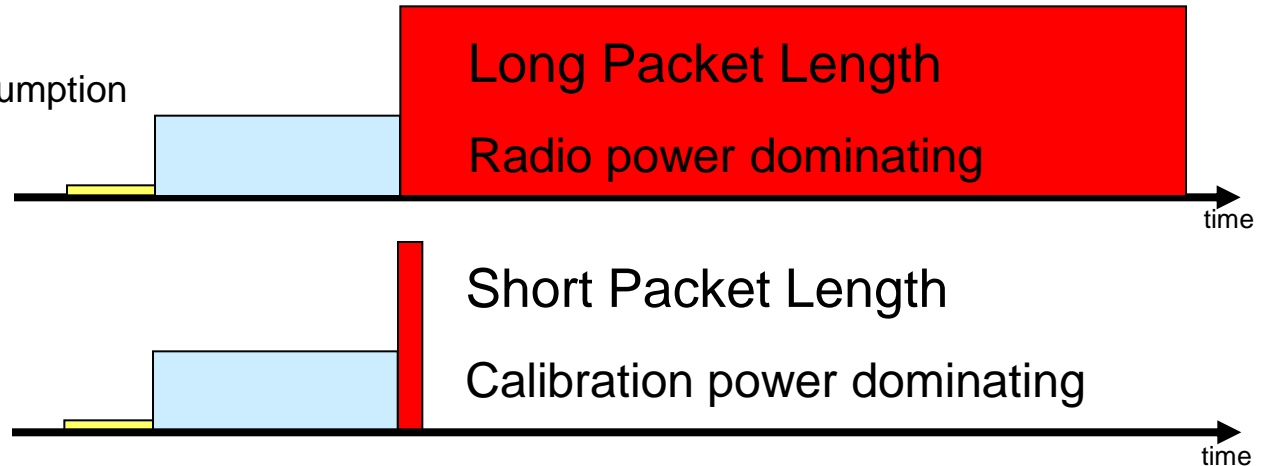
# Define

## Power Consumption: Application Scenarios



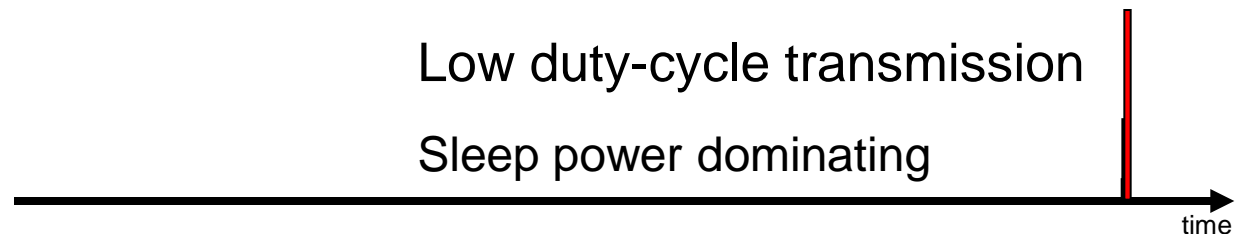
### High duty cycle applications:

- 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

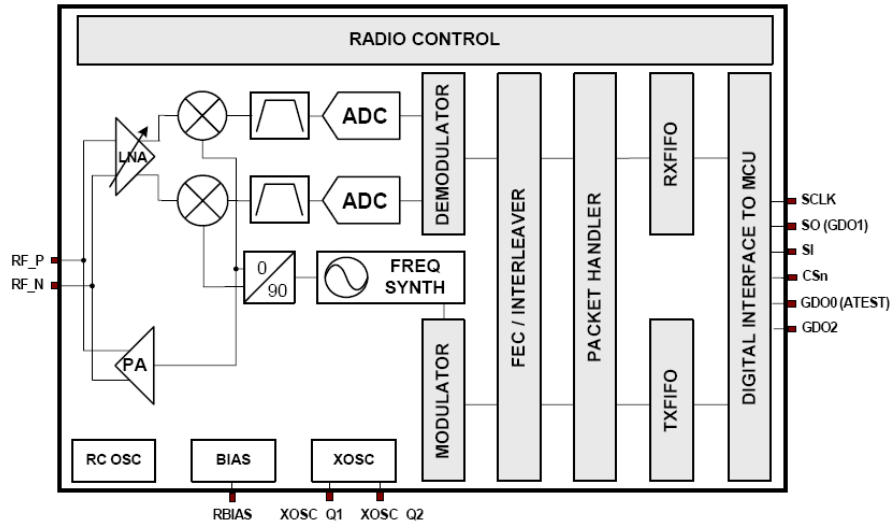
- Use the lowest possible duty cycle
  - Send data only when needed, do not send more data than necessary
  - Use the highest data rate you can (trade-off vs. range)
  - Watch out for protocol-related overhead
- Use the lowest possible voltage
  - RF chips have reduced current draw at lower voltages
  - 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

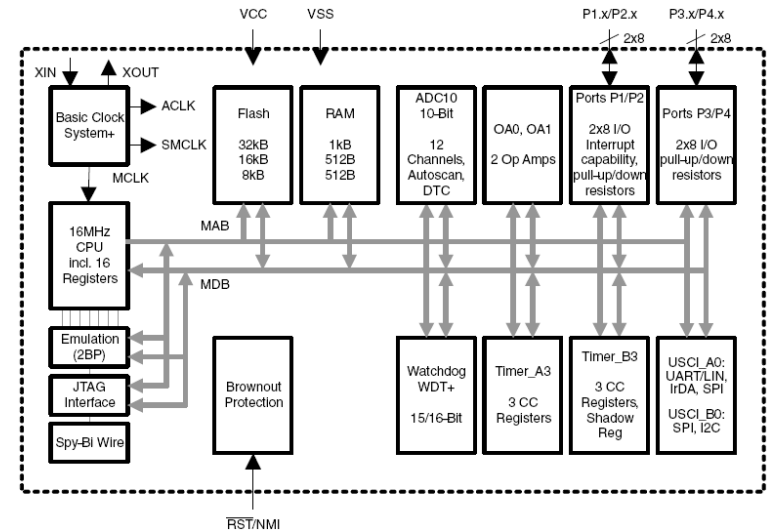
WOR Sleep Current: 900nA

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

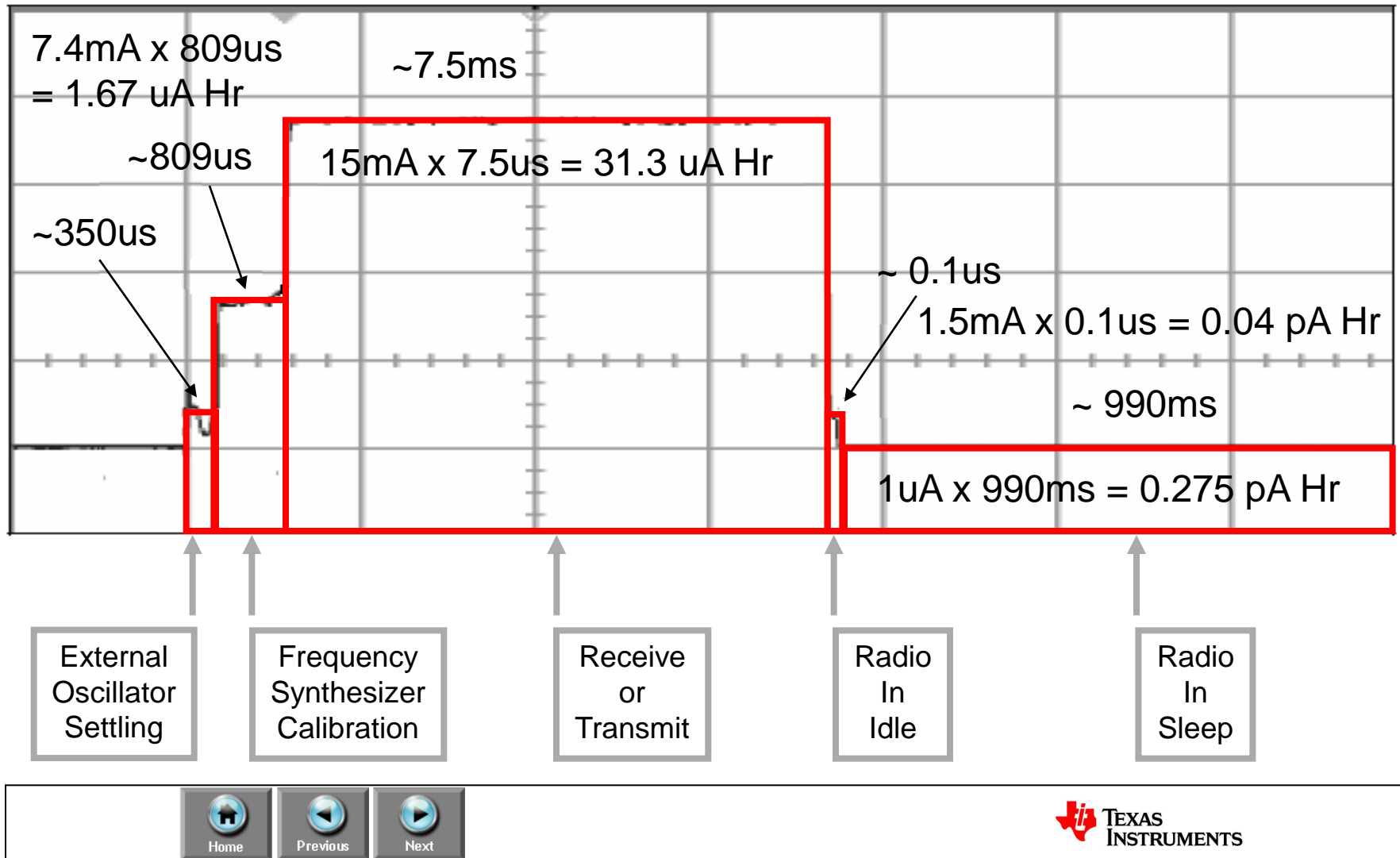
CPU off Current: 90uA @ 3V

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

<div>Solution</div> <div>Layer</div>	Proprietary	SimpliciTI	IEEE 802.15.4	RF4CE	ZigBee
Application	Design Freedom	Design Freedom	Design Freedom	Design Freedom	Design Freedom
Higher Layer Protocol	Design Freedom	Design Freedom	Design Freedom	Remo TI	Z-Stack + Simple API
Lower Layer Protocol	Design Freedom	SimpliciTI	TI MAC	TI MAC	TI MAC
Physical Layer	all LPRF devices	CC111x, CC251x, CC243x, CC253x, CC430, MSP430+CC1101, CC2500 or CC2520	CC253x CC243x MSP430+CC2520	CC253x CC243x	CC253x CC243x CC2480
RF Frequency	2.4 GHz Sub 1 GHz	2.4 GHz Sub 1 GHz	2.4 GHz	2.4 GHz	2.4 GHz

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# 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:



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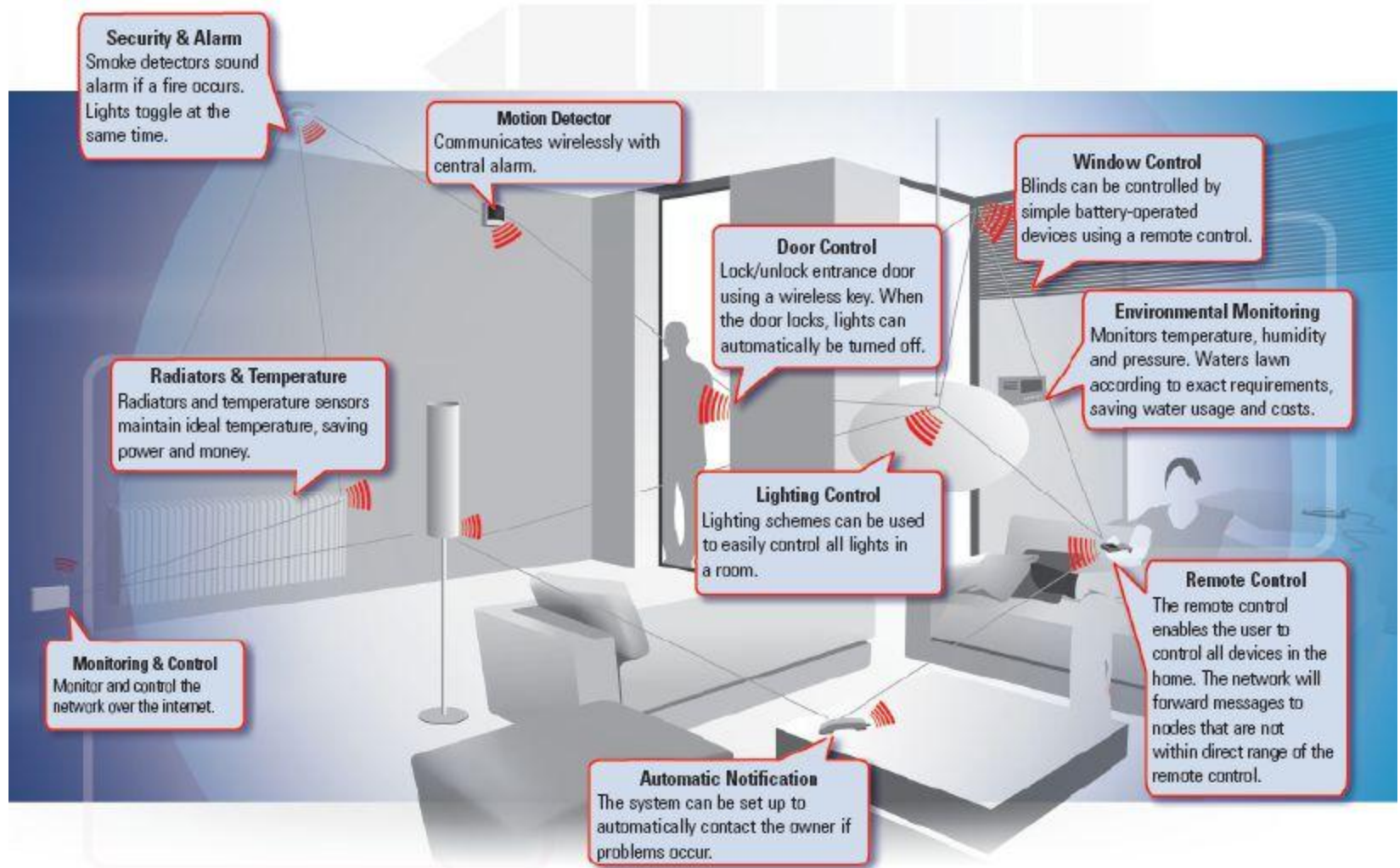
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# Select

## Proprietary or Standard: ZigBee



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# Select

Proprietary or Standard: RF4CE

- Founding Members

**SONY**

**PHILIPS**

**Panasonic**



- Invited Contributors



**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.

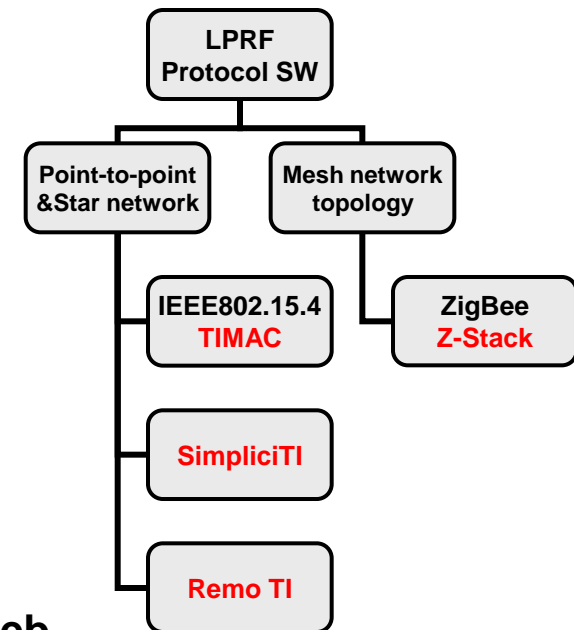
Visit [www.rf4ce.org](http://www.rf4ce.org) for more information on the RF4CE consortium

Visit [www.ti.com/rf4ce](http://www.ti.com/rf4ce) for more information on TI's RF4CE solution

# Select

## Protocol Software

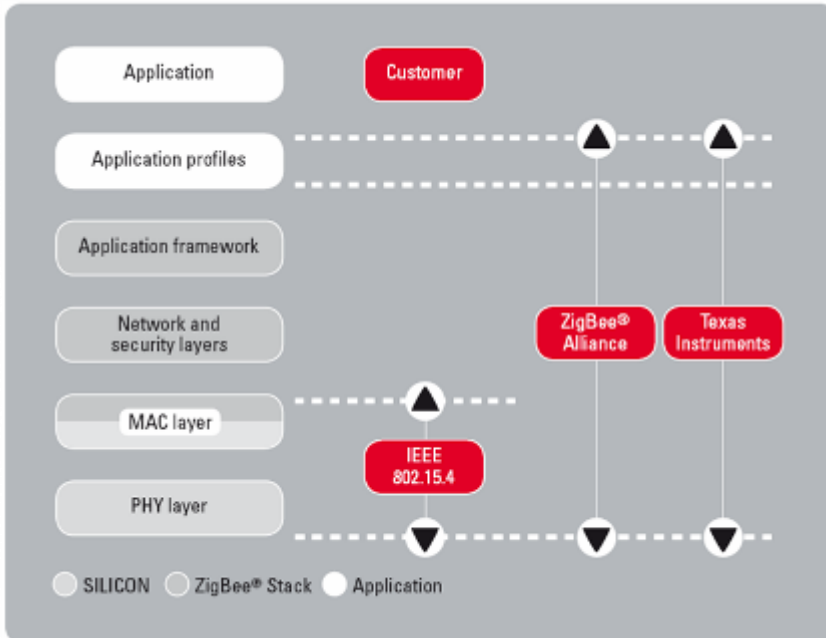
- Z-Stack - ZigBee Protocol Stack from TI
  - One of the first ZigBee stacks with the ZigBee 2006 certification
  - Supports multiple platforms such as CC2480, CC2431 and CC2520+MSP430 platform
  - ZigBee 2007/PRO available on MSP430+CC2520 (Golden Unit 2007) and CC2530 platforms
- TIMAC
  - A standardized 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
  - Compliant with RF4CE V1.0
  - Built on mature 802.15.4 MAC and PHY technology
  - Easy to use SW, development kits and tools



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

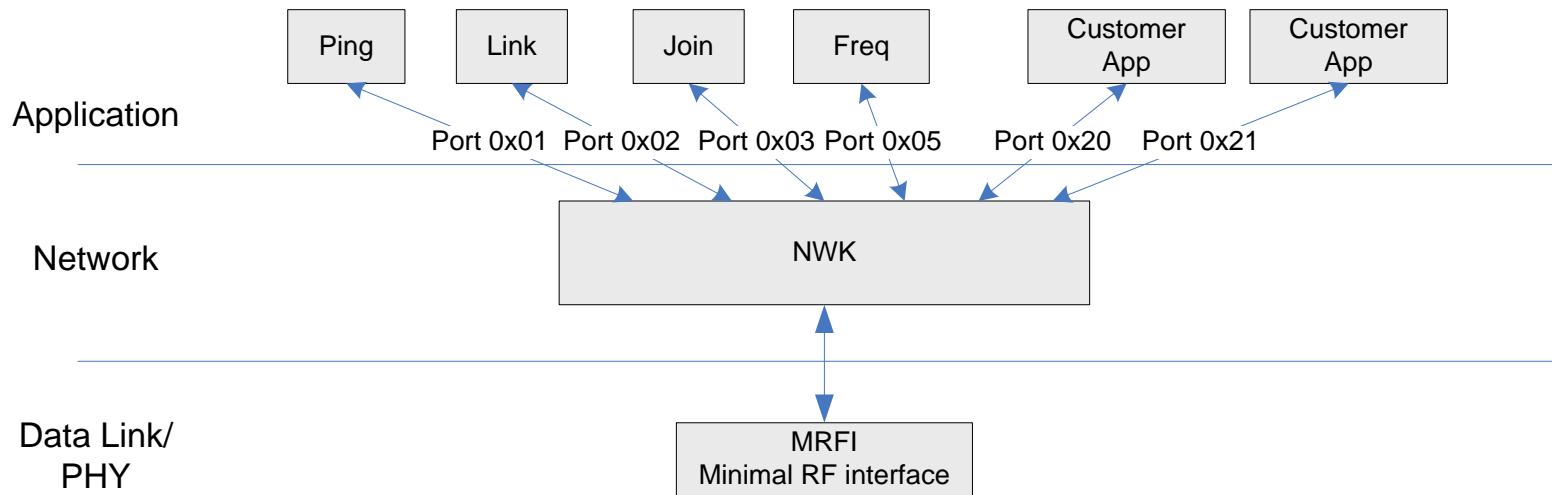
Supported LPRF devices:

MSP430+CC1101/CC2500  
/CC2520,

CC1110/CC1111,

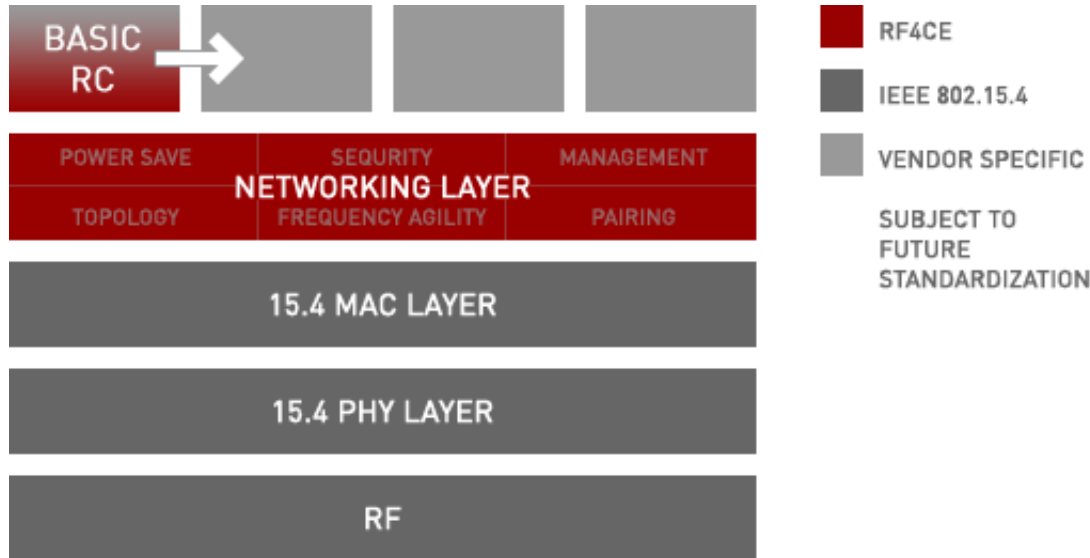
CC2510/CC2511,

CC2430, CC2530



# Select

## Protocol Software: RemoTI



### The RemoTI protocol:

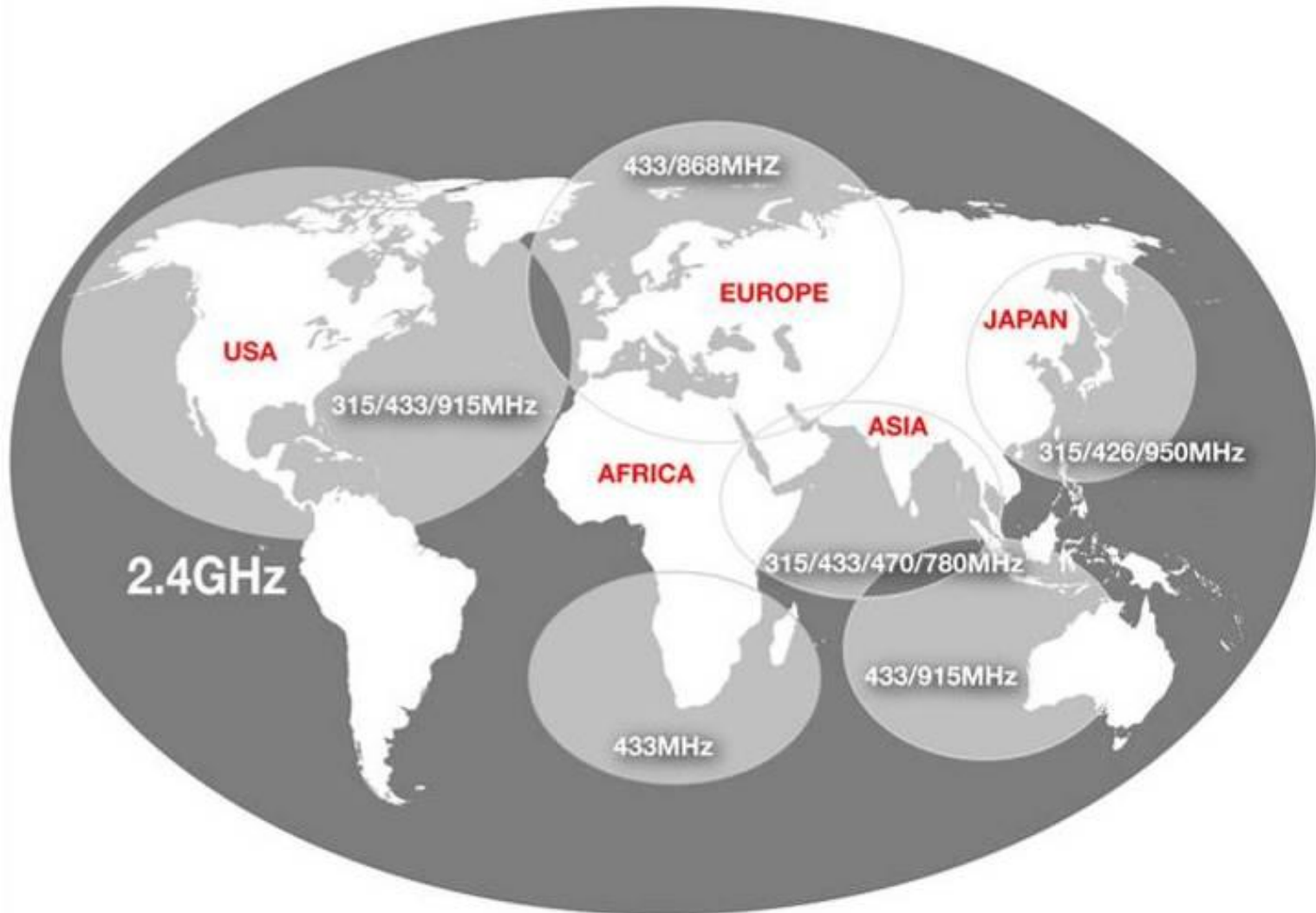
- Based on IEEE 802.15.4
- Includes a thin NWK layer
- Command Set Interface

### 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



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# 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 data rates
- 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  $\geq 50$  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  $\sim 0.75$  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, **Vers. 2.1.1**)
- 863.0 – 870.0 MHz (ETSI EN 300 220, **Vers. 2.1.1**)
- 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

<http://www.ero.dk>

<http://www.etsi.org>

<http://focus.ti.com/lit/an/swra090/swra090.pdf>  
(AN001)

<http://focus.ti.com/lit/an/swra060/swra060.pdf>  
(AN032)

<http://focus.ti.com/lit/an/swra048/swra048.pdf>



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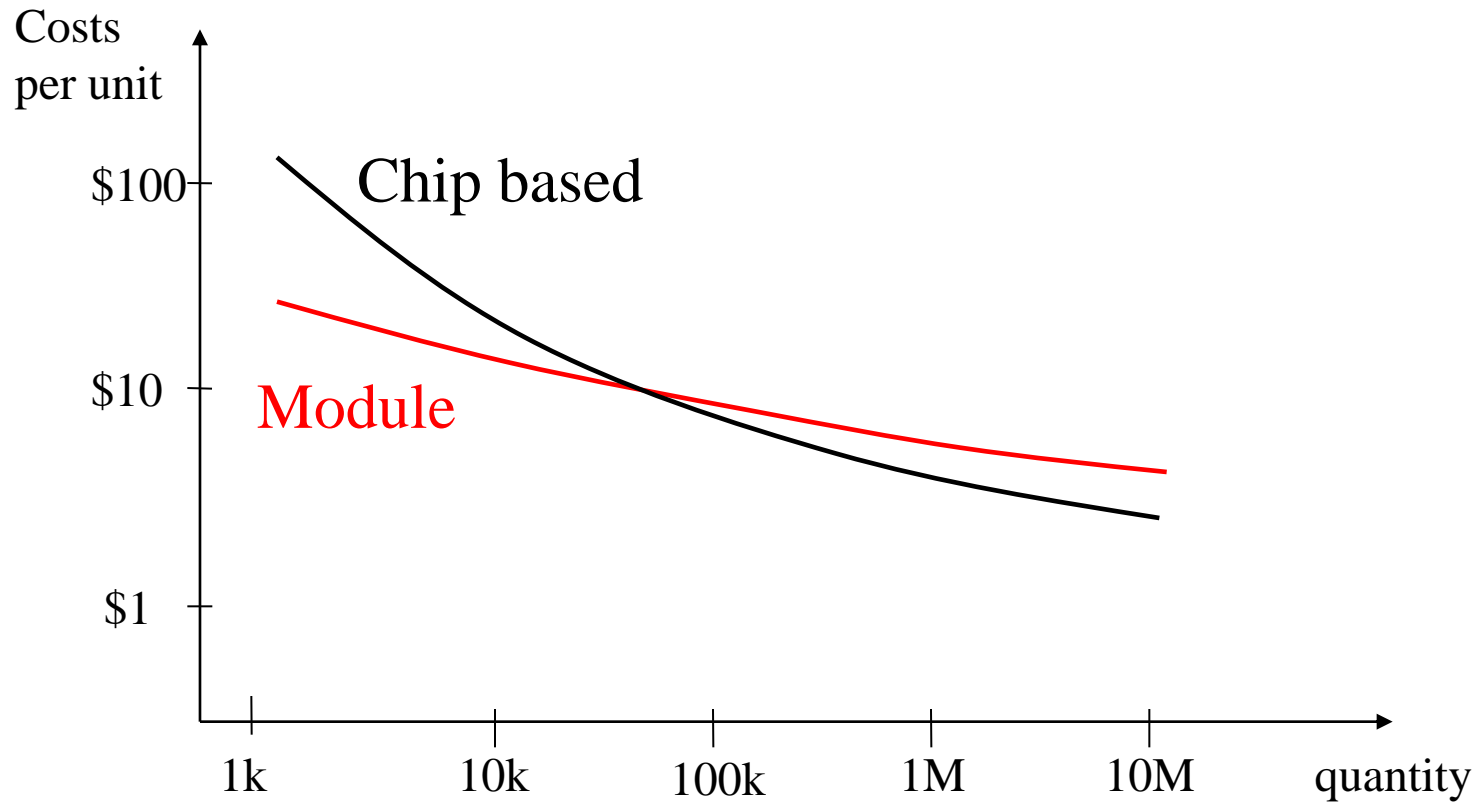
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# Select

## Make or Buy

Self development based on a chipset or buy a module?



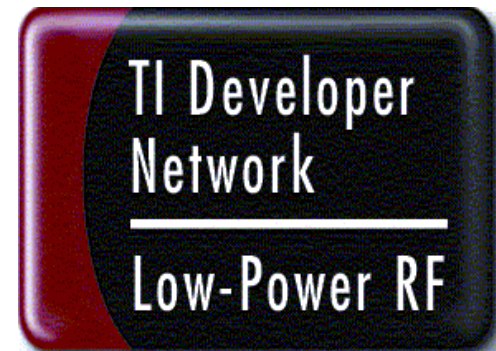


# Select

## Make or Buy

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

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



# Design

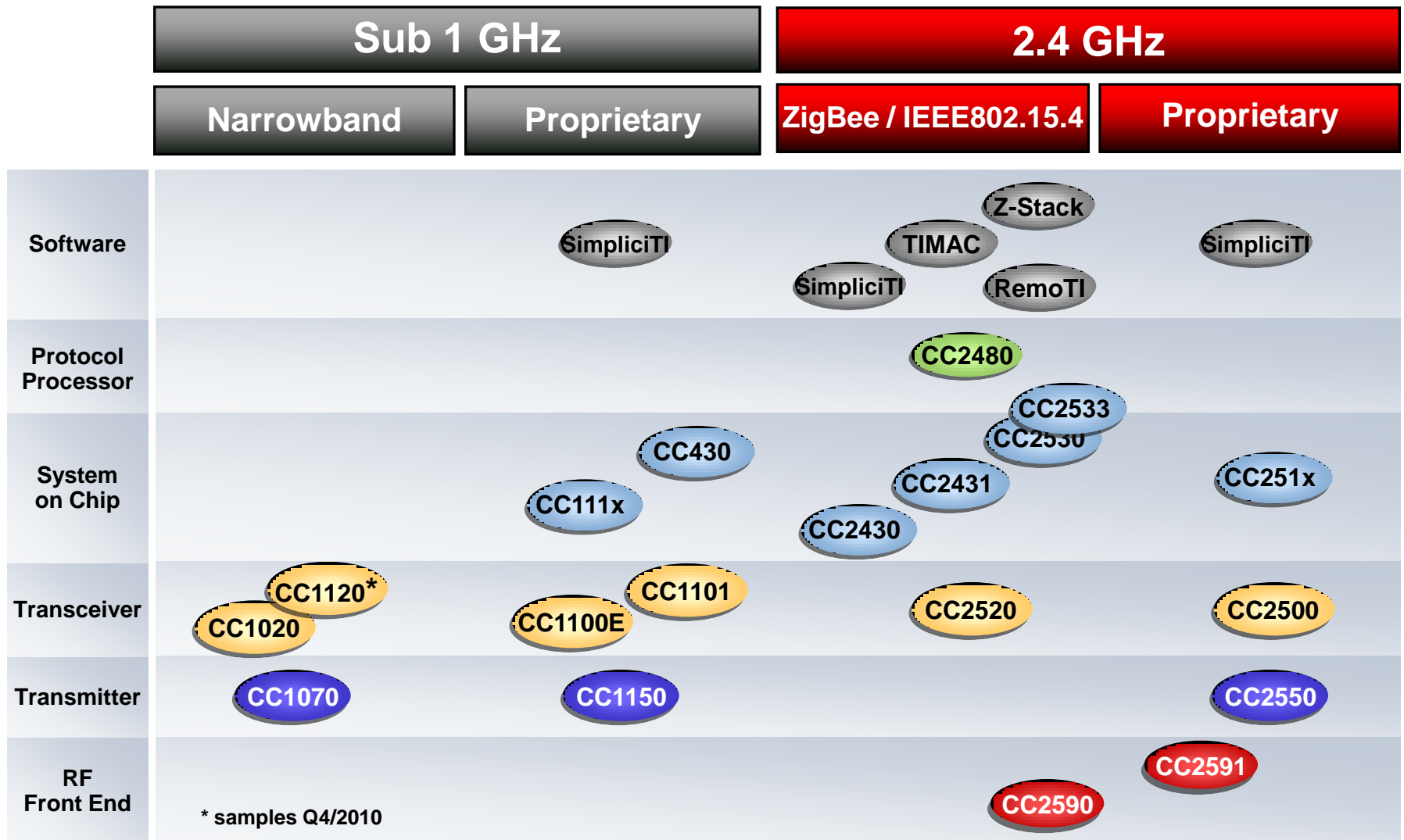
Build your Application

## 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



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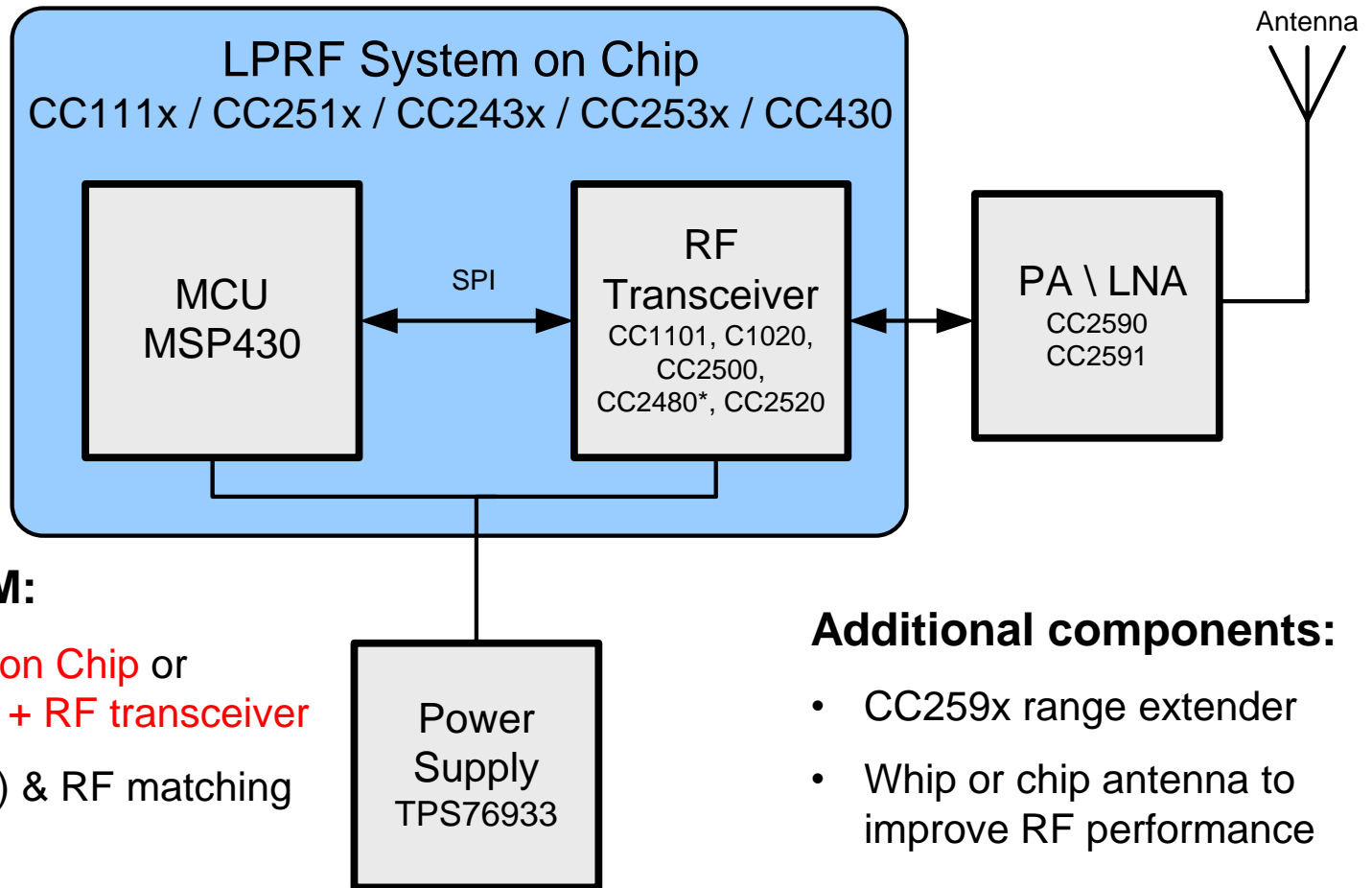
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# Design

## Block diagram of LPRF application example



\*ZigBee network processor

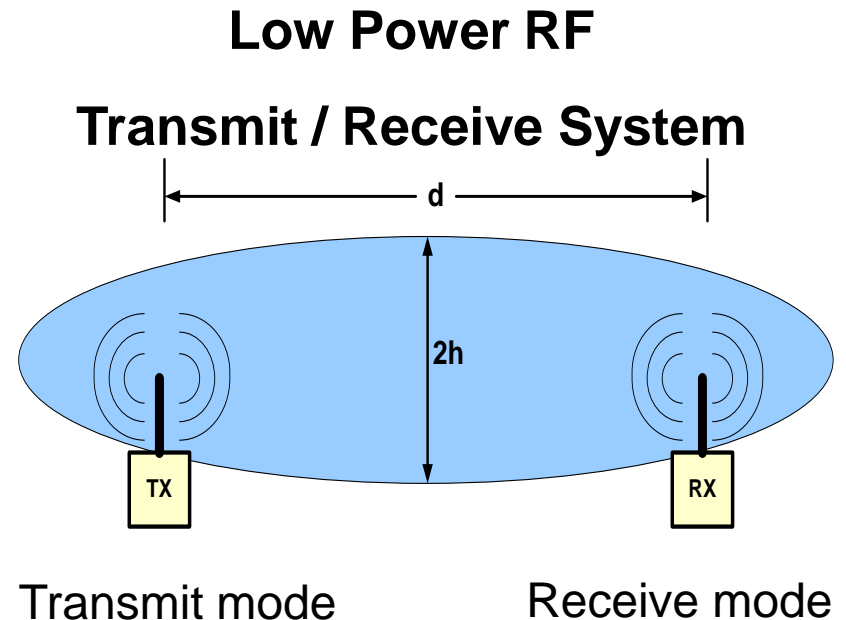
# Design

## Antenna Design

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

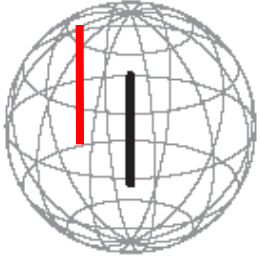
The **purpose** of an antenna is to provide two way transmission of data electromagnetically in free space

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

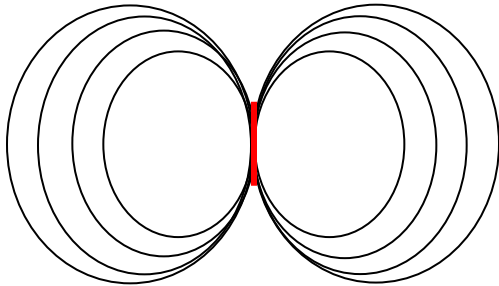


# Design

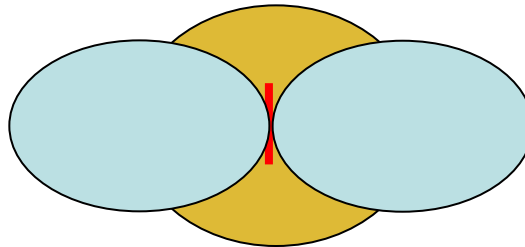
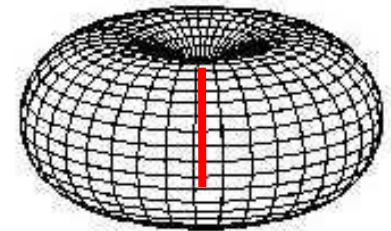
## Antenna Design



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

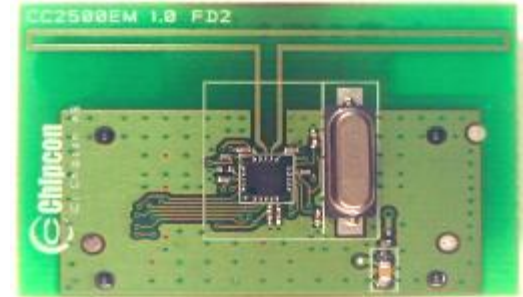
- Can be matched directly to the impedance at the RF pins
- Can be used to reduce the number of external components
- Complicated to make good design, might need to use a simulation
- Difficult to measure the impedance
- Possible to achieve equivalent performance of single-ended

# 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**

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

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

- $\lambda/4$  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

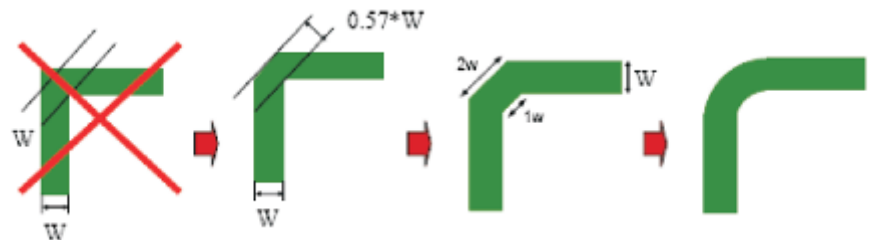
## PCB Layout: Do's and Don'ts of RF Layout

- 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  $\frac{1}{4}$  wavelength when possible.

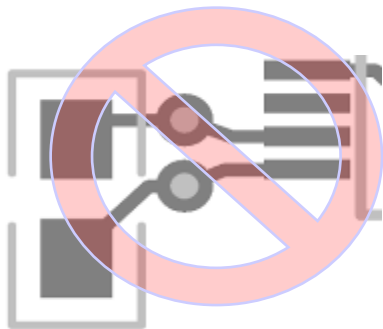
# Design

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

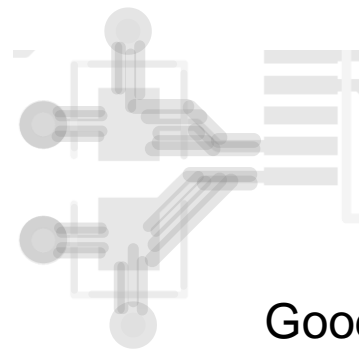
- Avoid discontinuities in **ground layers**
- Keep **vias spacing** to minimize E fields that acts as current barriers, good rule to follow keep spacing greater than 5.2 x greater than hole diameter for separations.
- Don't use sharp right **angle bends**



- Do not have **vias between bypass caps**



Poor Bypassing



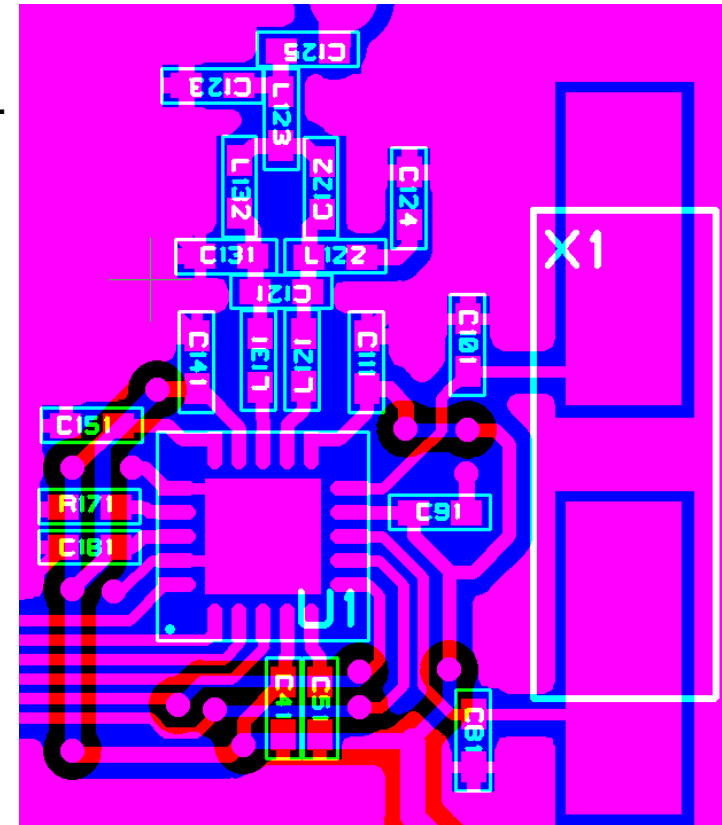
Good Bypassing

# 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.
- Note: 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 loses 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**

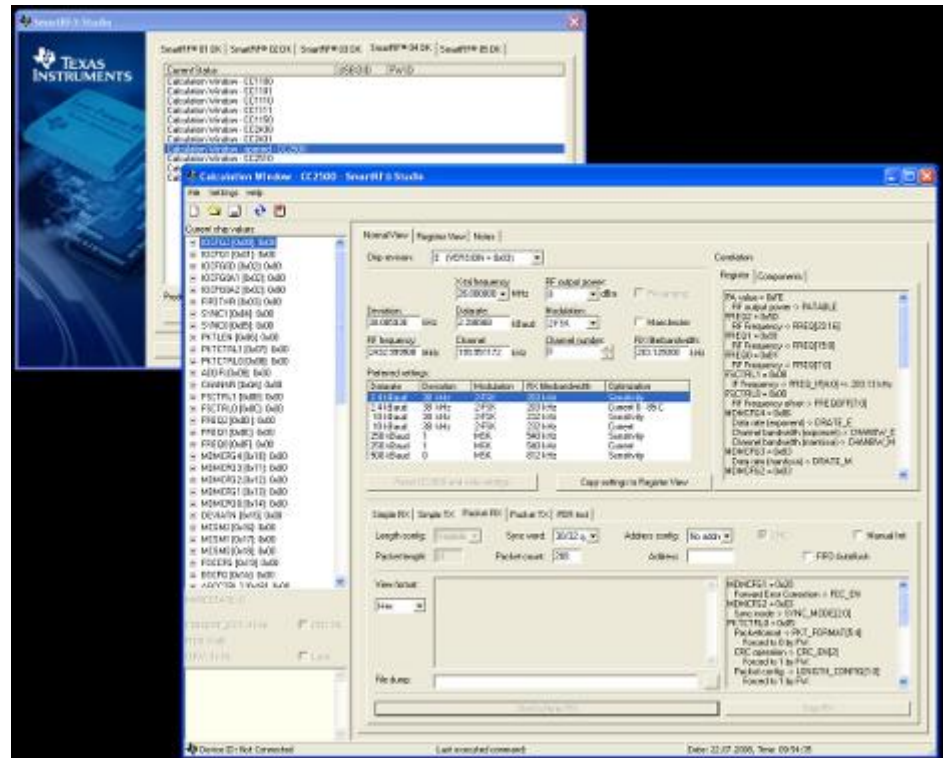
**SRD regulations for license free transceiver operation**



# 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
  - *Simple RX/TX*
  - *Packet RX/TX*
  - *Packet Error Rate (PER)*



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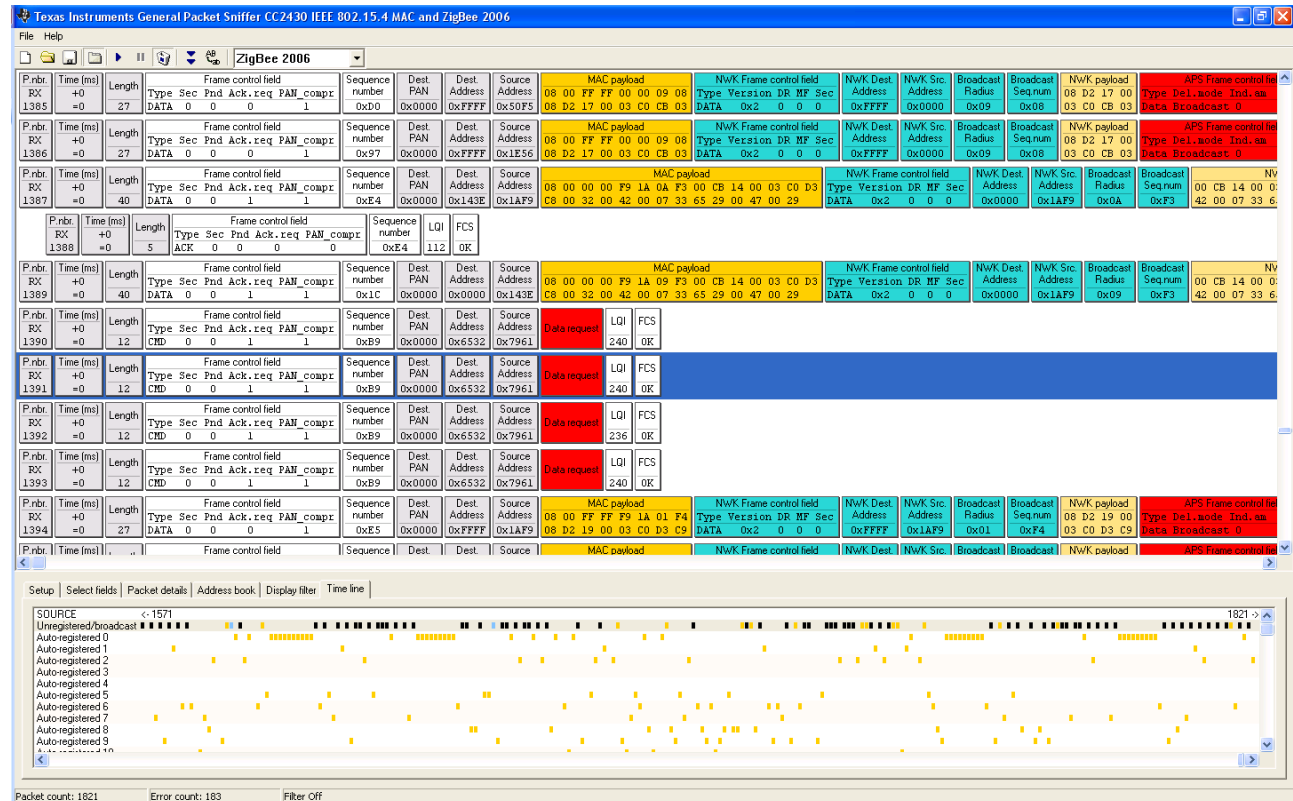
# Design

## Development Tools: Packet Sniffer

Packet sniffer captures packets going over the air

## Protocols:

- SimpliciTI
- TIMAC
- ZigBee
- RemoTI



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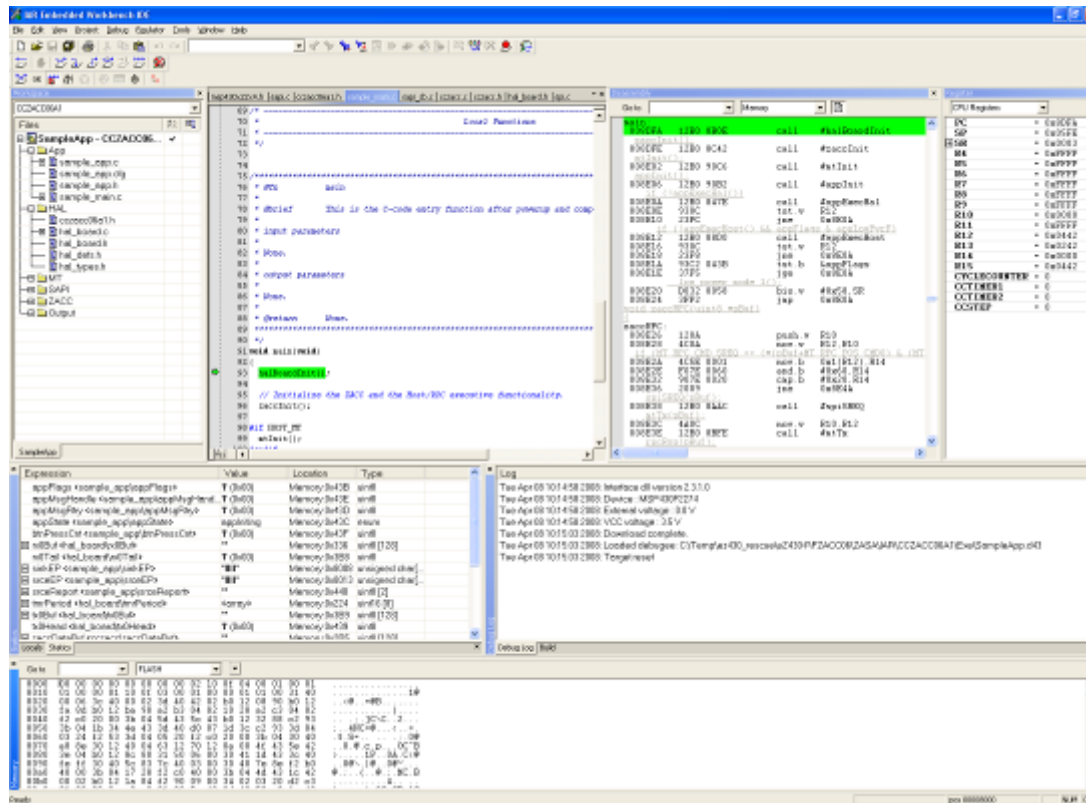
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# Design

## Development Tools: IAR Embedded Workbench



[www.IAR.com](http://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



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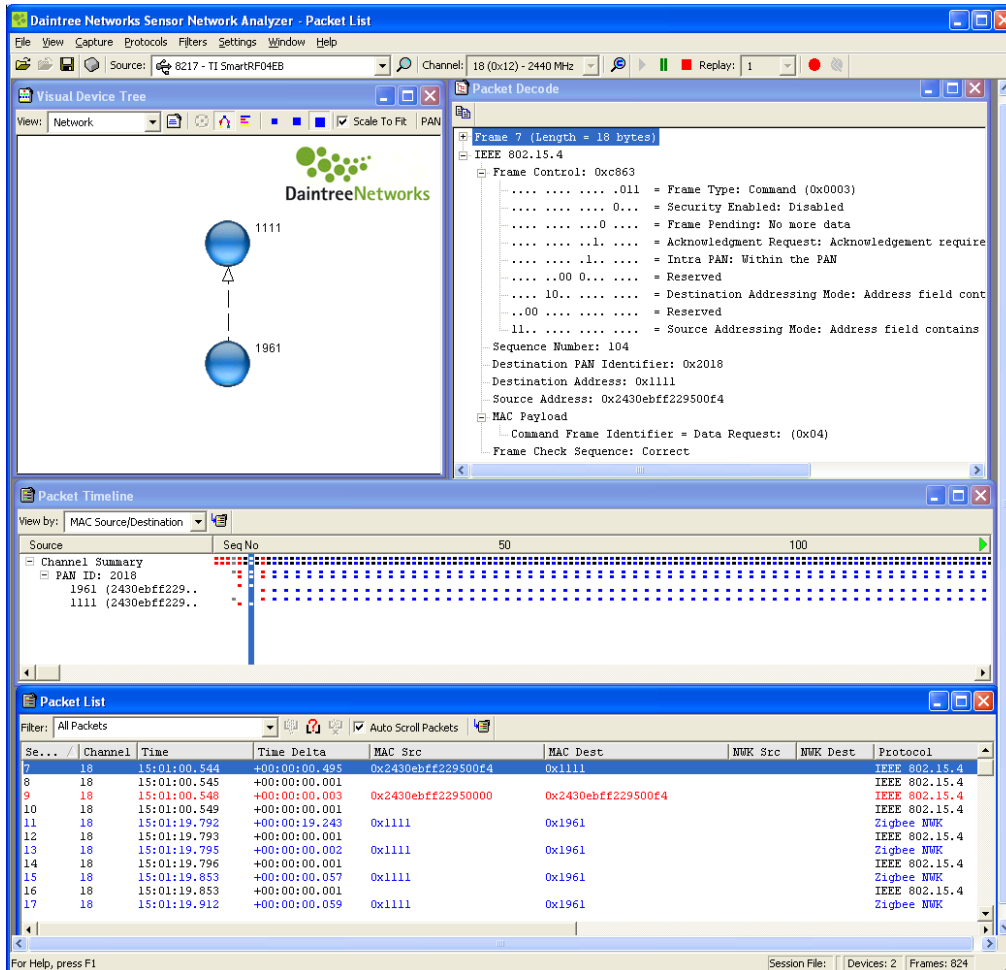
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# Design

## Development Tools: Daintree Sensor Network Analyzer



- Professional Packet Sniffer
- Supports commissioning
- Easy-to-use network visualization
- Complete and customizable protocol analyzer
- Large-scale network analysis
- Performance measurement system
- [www.daintree.net](http://www.daintree.net)

# Design

## Development Tools: Kits Overview

Part Number	Short Description	Development Kit	Evaluation Modules	Compatible Mother Boards
CC1020	Narrowband RF Transceiver	CC1020-CC1070DK433 CC1020-CC1070DK868	CC1020EMK433 / CC1020EMK868	
CC1070	Narrowband RF Transmitter	CC1020-CC1070DK433 CC1020-CC1070DK868	CC1070EMK433 / CC1070EMK868	
CC1101	Transceiver	CC1101DK433 / CC1101DK868	CC1101EMK433 / CC1101EMK868	MSP430FG4618 Exp Board
CC1150	Transmitter		CC1150EMK433 / CC1150EMK868	MSP430FG4618 Exp Board
CC1110	8051 MCU +RFTransceiver	CC1110-CC1111DK	CC1110EMK433 / CC1110EMK868	
CC1111	8051 MCU with built in RF Transceiver and USB	CC1110-CC1111DK	CC1111EMK868	
CC2500	Transceiver	CC2500-CC2550DK	CC2500EMK	MSP430FG4618 Exp Board
CC2550	Transmitter	CC2500-CC2550DK	CC2550EMK	MSP430FG4618 Exp Board
CC2510	8051 MCU +RFTransceiver	CC2510-CC2511DK	CC2510EMK	
CC2511	8051 MCU with built in RF Transceiver and USB	CC2510-CC2511DK	CC2511EMK	
CC2520	IEEE 802.15.4 compliant Transceiver	CC2520DK	CC2520EMK	
CC2430	8051 MCU with built in IEEE 802.15.4 compliant RF Transceiver	CC2430DK CC2430ZDK CC2430DBK	CC2430EMK	
CC2431	8051 SoC with IEEE 802.15.4 compliant radio and Location Engine	CC2431DK CC2431ZDK	CC2431EMK	
CC2480	ZigBee Network Processor	EZ430-RF2480		
CC2530	8051 SoC with 802.15.4 compliant radio	CC2530ZDK, CC2530DK, RemoTI-CC2530DK	CC2530EMK, CC2530-CC2591EMK	


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# Design

## Support

### Large selection of support collateral:

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



# 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.**



# Test

## Coexistence

### Coexistence of RF systems:

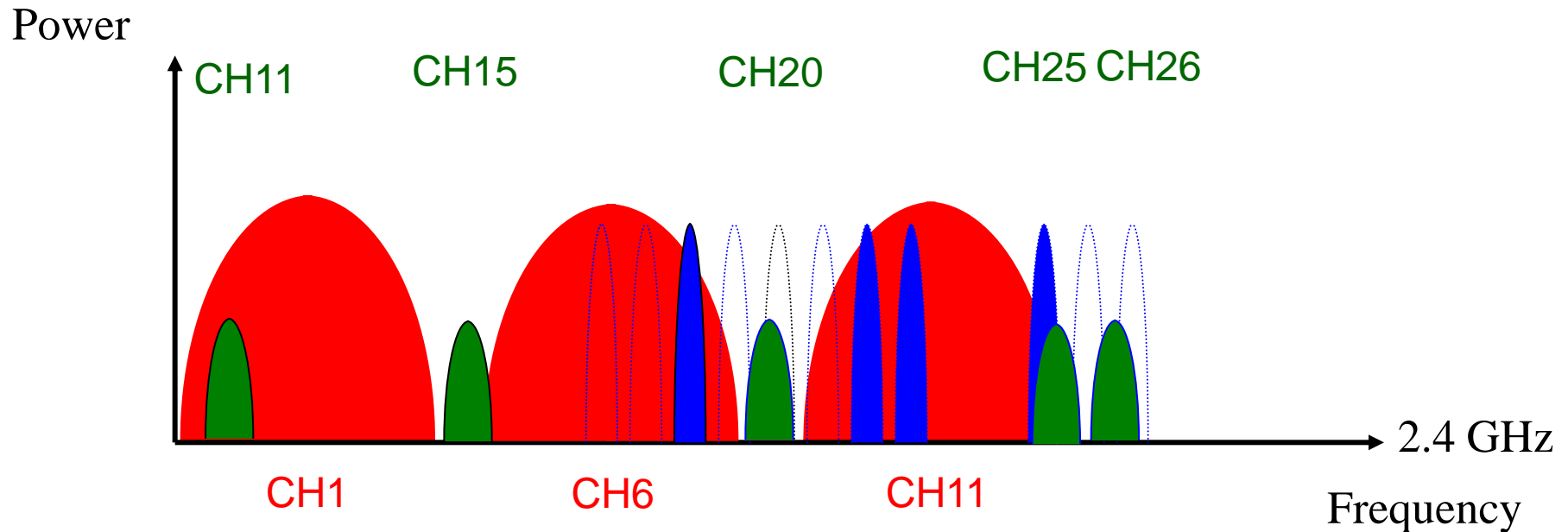
- How well does the radio operate in environments with interferers
- Selectivity and saturation important factors
- The protocol also plays an important part
  - Frequency hopping or frequency agility improves co-existing with stationary sources like WLAN
  - Listen Before Talk used to avoid causing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



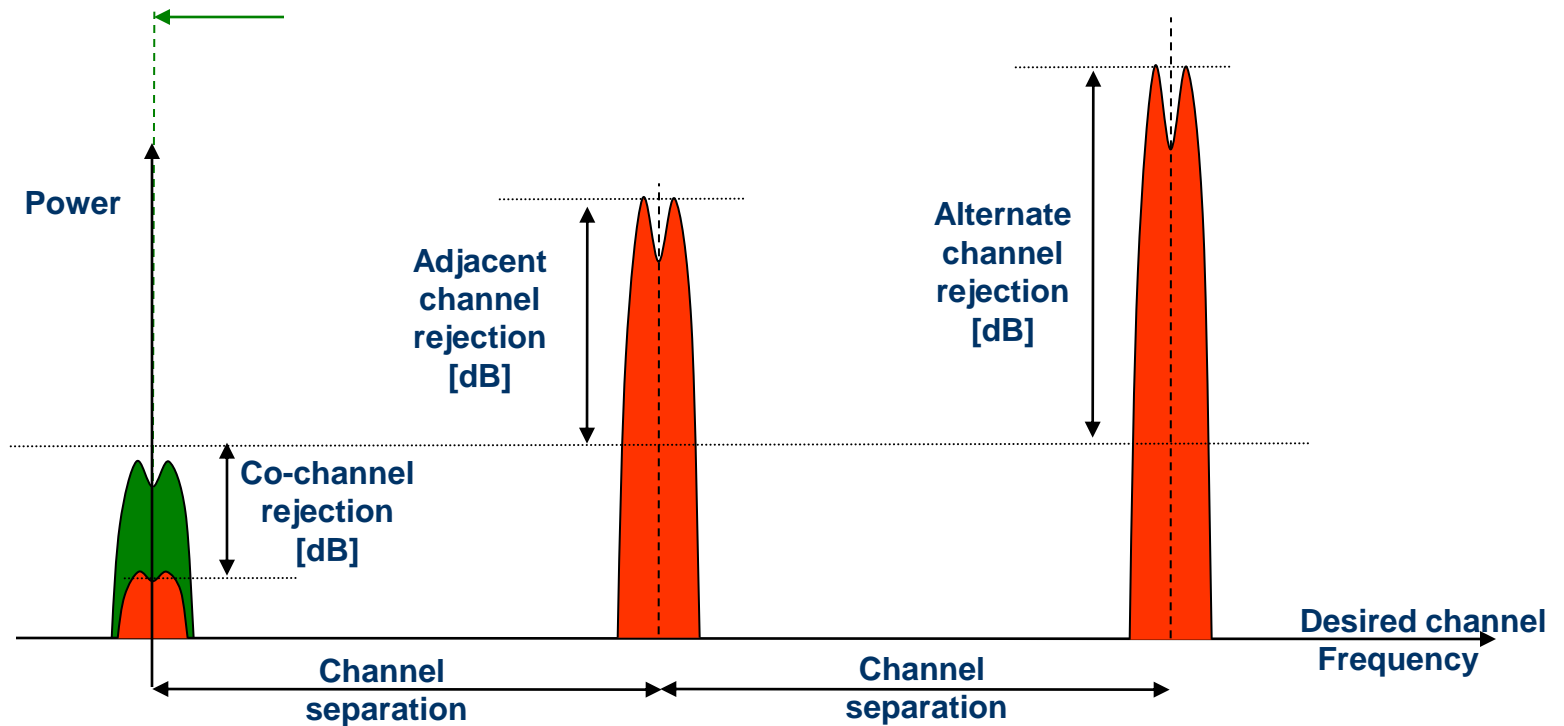
**WLAN vs ZigBee vs Bluetooth**

# 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 recommendations 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

- 3rd party tools
- TI obsolescence policy
- TI product change notification
- Huge Sales & Applications teams ready to help solving quality problems

# Produce / 3rd Parties - Tools

LPW - Low-Power RF Developer Network - Engineering Services - Texas Instruments - Microsoft Internet Explorer provided by Texas

File Edit View Favorites Tools Help Address http://www.ti.com/lprfnetwork Go

## Low-Power RF Developer Network - Engineering Services

TI has launched an extensive network of Low-Power RF development partners to help customers speed up their application development. The network consists of recommended companies, RF consultants, and independent design houses that provide a series of hardware module products and design services, including:

- RF circuit, low-power RF and ZigBee™ design services
- Low-power RF and ZigBee module solutions and development tools
- RF certification services and RF circuit manufacturing

Find a suitable partner for your design project.

Modules **Engineering Services** Development Tools

**Filter by Criteria** Reset

**Specialties**  
6LowPan  
Advanced Meter Reading (AMR)  
Automation  
Bluetooth  
Consumer Electronics

**Business Model**  
Tools  
Design Services  
Manufacturing Services  
Certification Services  
Modules

**Region**  
Europe

Use CTRL + click to choose more than one

Search Results - 43

**Tip:** To sort/re-order/resize columns, drag-&-drop or click column headers.

Company Name	Region	Specialties	Business Model
CSEM	Europe	Zigbee, Proprietary RF, Networking	Design Services
Tritech Technology AB	Europe	Zigbee, Proprietary RF, Networking, Engineering Services	Modules, Design Services
Radiocrafts AS	Europe	Zigbee, Proprietary RF, Networking, Engineering Services	Modules
Art of Technology AG	Europe	Proprietary RF, Engineering Services	Design Services, Manufacturing Services
CLEODE	Europe	Zigbee, Engineering Services, Software Development	Design Services, Manufacturing Services, Modules

Done Local intranet

start Inbox - Micros... Texas Instrum... LPRF\_Tools[1]... 2 Microsoft ... LPW - Low-Po... Search Desktop 12:43

### Interested in Joining?

Join the TI Low Power RF Third Party Network to enjoy various members-only benefits!

[> more](#)

### Visit the LPRF Online Forums

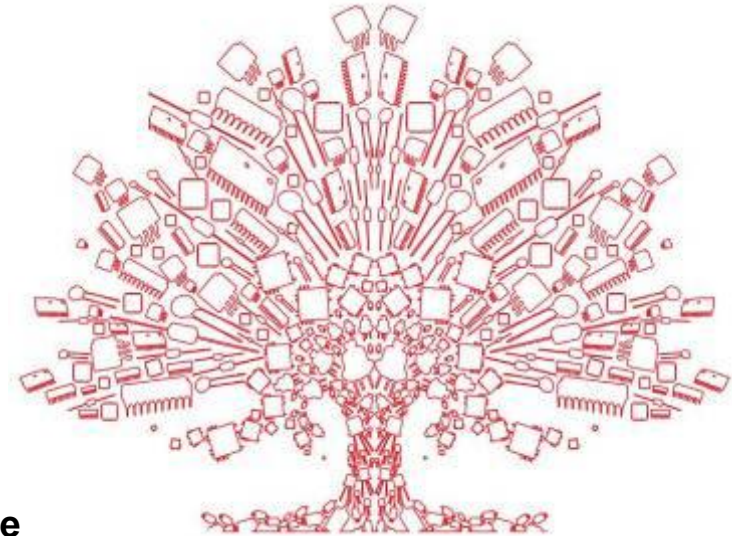
Share your designs and expertise with your peer engineers.

[> more](#)

# 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

