Chipcon Products from Texas Instruments

RF System Design

Low Power Wireless

Texas Instruments

- **Agenda**
  - Development
  - Testing
  - Debugging

Development

- **Choose correct chip**
  - Operating frequency
    - Range
    - Market
  - Data rate
  - Standard or proprietary solution
  - Available board size
    - Radio+uC or SoC solution
    - Antenna solution

- **Use Low-Power RF Selection Guide:**.
  - Available at: http://www.ti.com/lpw

Comparison Guide

PRODUCT COMPARISON GUIDE FOR 2.4 GHz

FEATURES/PRODUCT	CC2400	CC2420	CC2430	CC2431	CC2550	CC2500	CC2510
Product type	Transceiver	Transceiver	SoC	SoC	Transmitter	Transceiver	SoC
Programmable frequency, MHz	2400 – 2483	2400 – 2483.5	2400 – 2483	2400 – 2483	2400 – 2483	2400 – 2483	2400 – 2483
Frequency resolution	1 MHz	1 MHz	1 MHz	1 MHz	427 Hz	427 Hz	427 Hz
Operating supply voltage	1.6 – 2.0 V	2.1 – 3.6 V	2.0 – 3.6 V	2.0 – 3.6 V	1.8 – 3.6 V	1.8 – 3.6 V	2.0 – 3.6 V
Current consumption (RX) at 0 dBm (TX)	24.0 mA 19 mA	19.7 mA 17.4 mA	27 mA 24.7 mA	27 mA 24.7 mA	N/A 22.8 mA	12.8 mA 21.6 mA	22 mA 23 mA
Data rate (max)	1.0 Mbps	250 kbps	250 kbps	250 kbps	500 kbps	500 kbps	500 kbps
Receiver sensitivity	-101 dBm at 10 kbps and BER = 10-3 -85 dBm at TMbps and BER = 10-3	-94 dBm at PER < 1%	-94 dBm at PER < 1%	-94 dBm at PER < 1%	N/A	-89 dBm at 250 kbps BER =10-3 -99 dBm at 10 kbps	-88 at 250 kbps BER = 10-3 -98 dBm at 10 kbps
Programmable output power ranging from	-25 to 0 dBm	-25 to 0 dBm	-24 to 0 dBm	-24 to 0 dBm	-20 to 1 dBm	-20 to 1 dBm	-30 to 1 dBm
Multi channel systems/FHSS	Yes	Yes	Yes	Yes	Yes	Yes	Yes
RSSI output	Digital	Digital	Digital	Digital	N/A	Digital	Digital
Integrated bit synchronizer	Yes	Yes	Yes	Yes	N/A	Yes	Yes
Integrated packet handling	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Data buffering	32 bytes FIFO	128 bytes TX 128 bytes RX	128 bytes TX 128 bytes RX DMA	128 bytes TX 128 bytes RX DMA	64 bytes	64 bytes TX 64 bytes RX	128 bytes (TX) 128 bytes RX DMA
Internal RF switch/IF Filter	Yes	Yes	Yes	Yes	N/A	Yes	Yes
RF chip interface	Differential	Differential	Differential	Differential	Differential	Differential	Differential
Package type	QFN-48, 7x7 mm	QLP-48, 7x7 mm	QLP-48, 7x7 mm	QLP-48, 7x7 mm	QLP-16, 4x4 mm	QLP-20, 4x4 mm	QLP-36, 6x6 mm
Complies with EN 300 220, FCC CFR 47, part 15 and ARIB STD-T66	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Integrated microcontroller	-	-	Yes	Yes	-	-	Yes
Voltage regulator	-	2.1 – 3.6 V input voltage	2.0 – 3.6 V input voltage	2.0 – 3.6 V input voltage	1.8 – 3.6 V input voltage	1.8 – 3.6 V input voltage	2.0 – 3.6 V input voltage
IEEE 802.15.4 compliant	-	Yes	Yes	Yes	-	-	-
Hardware MAC encryption/ authentification	-	Yes	Yes	Yes	-	-	-
Program memory	-	-	32 kB/64 kB/ 128 kB Flash	128kB Flash	-	-	32 kB Flash
Data memory	-	-	4 kB + 4 kB SRAM	4 kB + 4 kB SRAM	-	-	4 kB SRAM

Development

- **Get an overview of available resources**
  - Software libraries and example code
  - EM Reference design
  - Antenna reference designs
  - Application Notes
  - Design Notes
  - Development kit
  - Development software
- **Read available documentation**
  - Data sheet
  - User manuals
  - FAQ

Development

- **Software development**
  - Use or port our software functions.
  - Plan how to test the software before writing it.
  - We recommend IAR as compiler and debugger for our SoCs.
  - Use SmartRF Studio to calculate register settings.
  - Texas Instruments offers free software that can be used to program the flash on SoC.

Development

- **Choice of protocol**
  - Standard or proprietary solution
  - Mesh or star network
  - Battery or main powered devices
  - How to handle binding and addressing
  - Single channel, frequency agility or frequency hopping

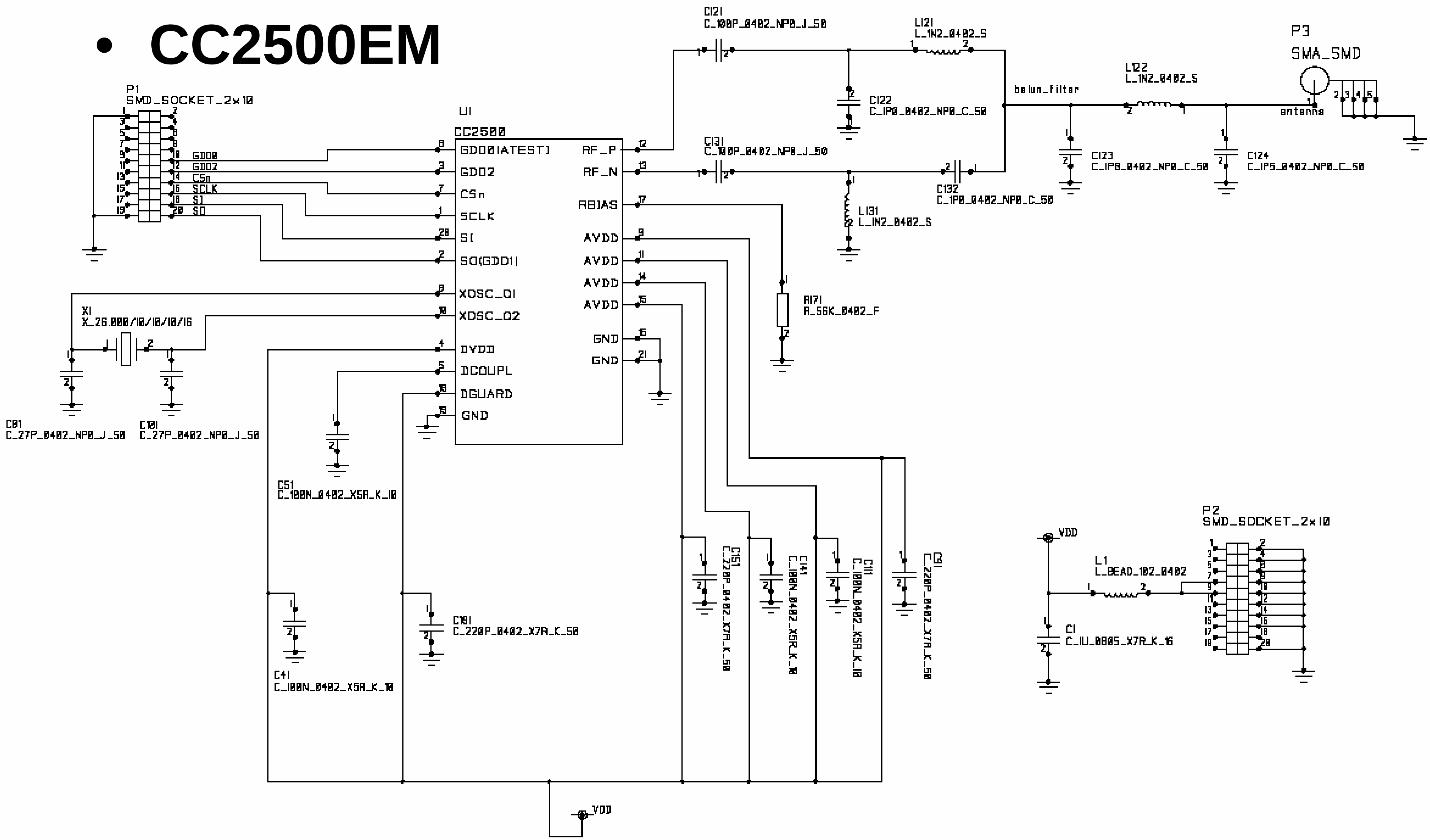
Development

- **Copy the reference design**
  - TI provides a reference design for all LPW products
  - Important to make an exact copy of both layout and schematics
  - The balun, matching and decoupling should be implemented exactly as on the reference design.

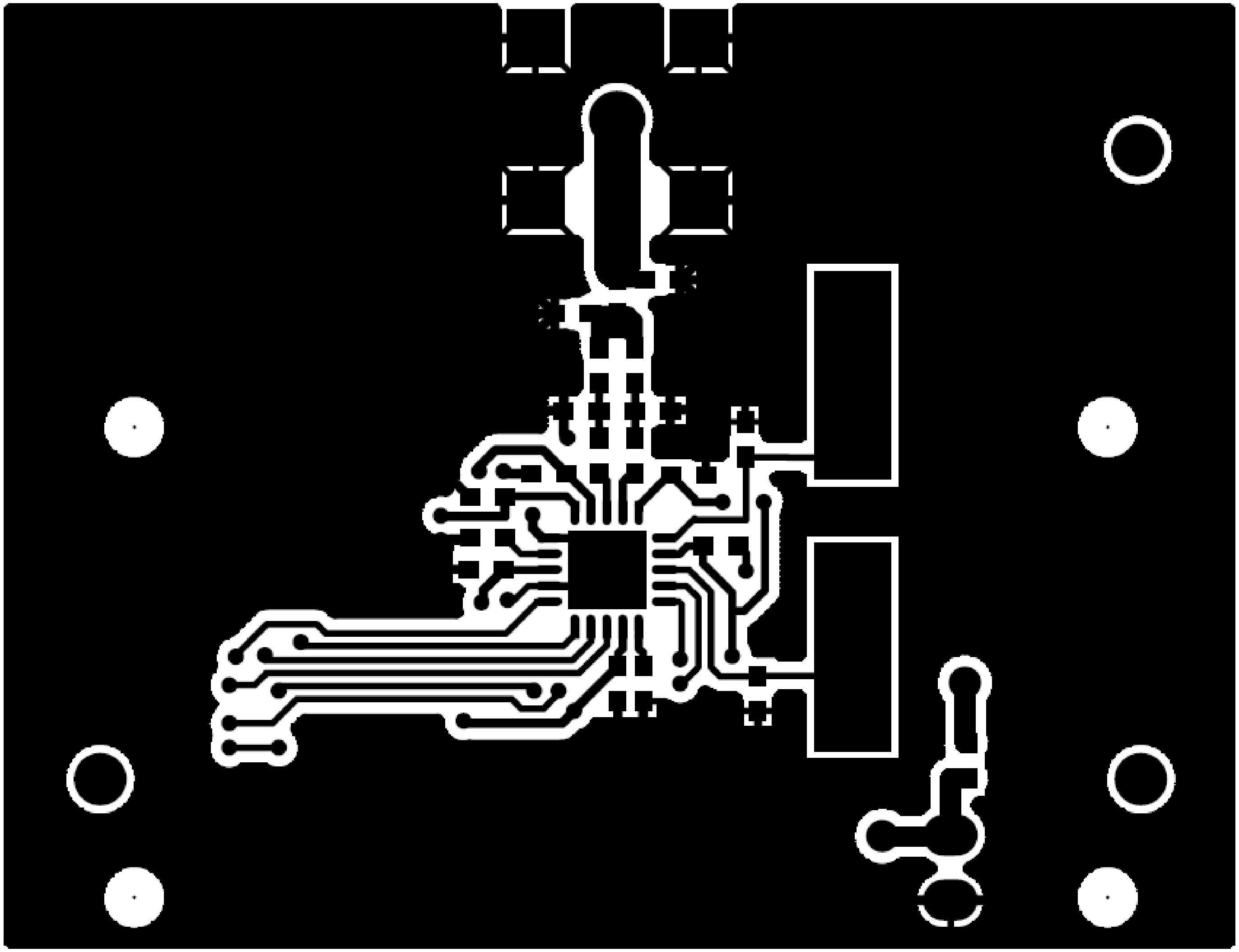
Chipcon Products from Texas Instruments

Development

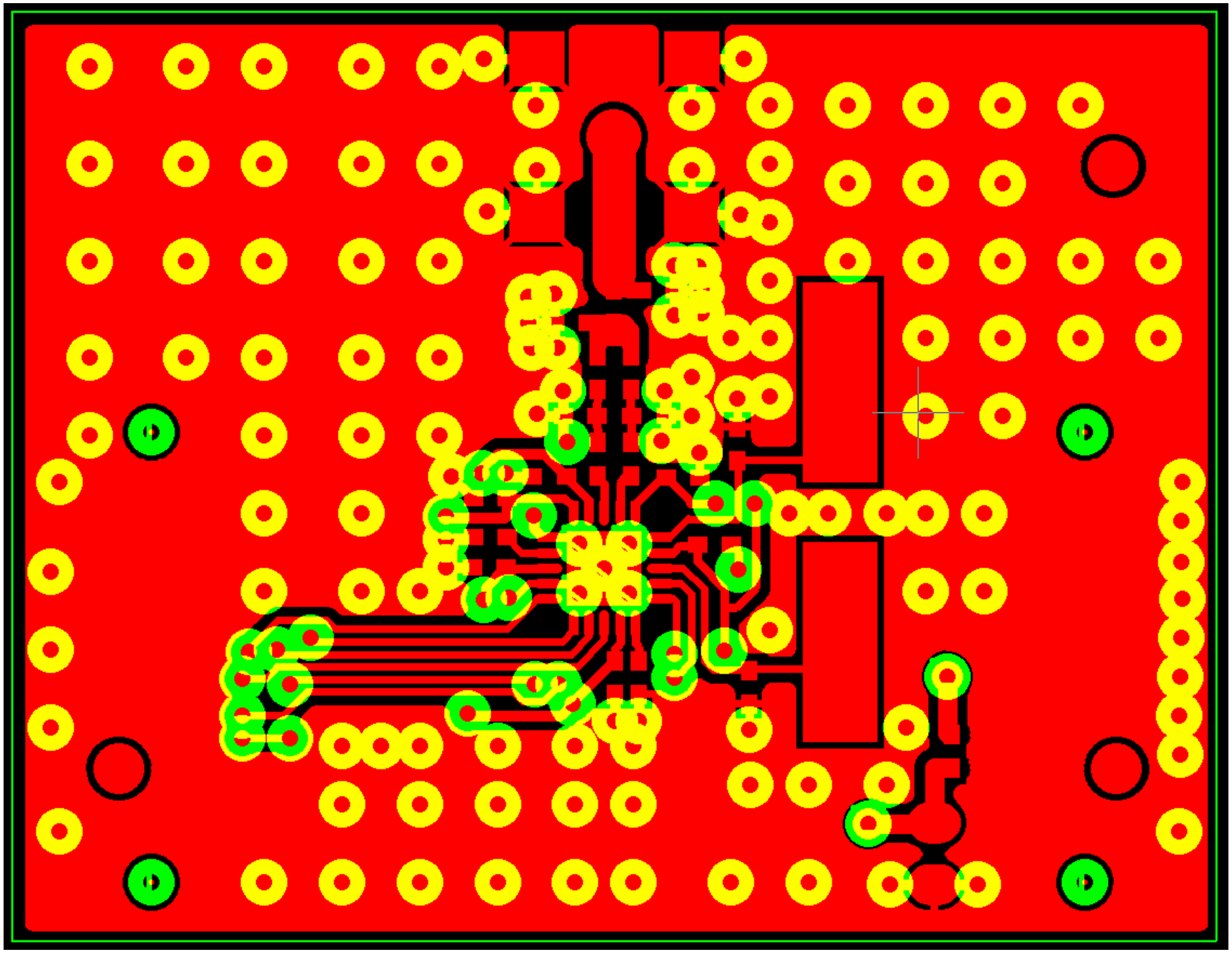
- **CC2500EM**



Development



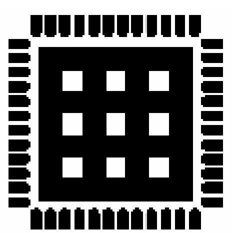
Development



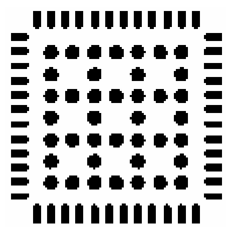
Development

- **Recommended layout for solder resist and solder paste**

CC2430

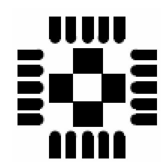


Solder resist

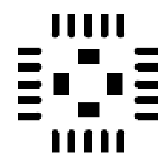


Paste

CC2500/CC1100



Solder resist



Paste

Development

- **Choice of antenna**
  - Big impact on the total system performance
  - Lower frequency requires larger antennas
  - Not straight forward to simulate PCB antennas
  - Cost and performance vs board size
  - Several reference designs available at: www.ti.com/lpw

- **Agenda**
  - Development phase
  - Testing
  - Debugging

Testing

- **How and what to test**
  - Testing should be divided up in separate parts, independent on each other.
  - Hardware and software should be tested separately.
  - Hardware testing should be done with known working software, e.g. SmartRF Studio.
  - Software testing should be performed with known working hardware, e.g. evaluation modules.

Testing

- **Software Testing**
  - Verify that the IO interface, typically SPI, is working, by ensuring that register acess (writing and reading) functions are working correctly.
  - Test RX and TX functionality before the whole protocol is tested.
  - Use test signals when testing the software (GDO).

Testing

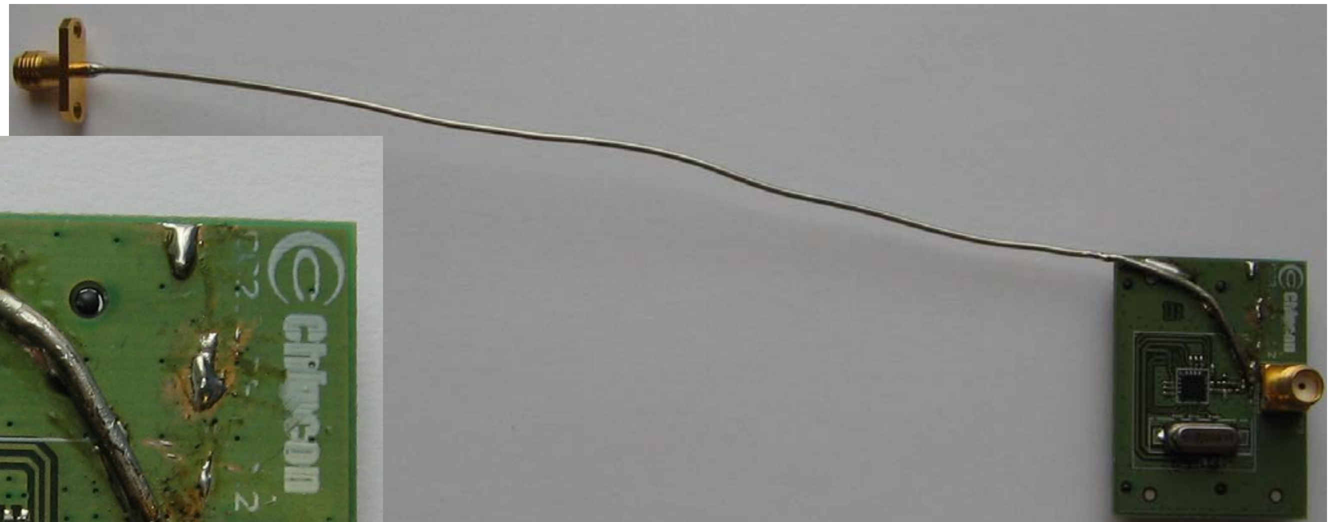
- **Hardware Testing**
  - Output power
    - Solder a semi rigid coax cable to the connection point of the antenna and disconnect the antenna.
    - Transmit a carrier, deviation = 0.
    - Measure with a spectrum analyzer or power meter.
  - Sensitivity
    - Solder a semi rigid coax cable to the connection point of the antenna and disconnect the antenna.
    - Use a RF generator or development kit as transmitter
    - Monitor the received data on an oscilloscope or a dedicated BER/PER tester.

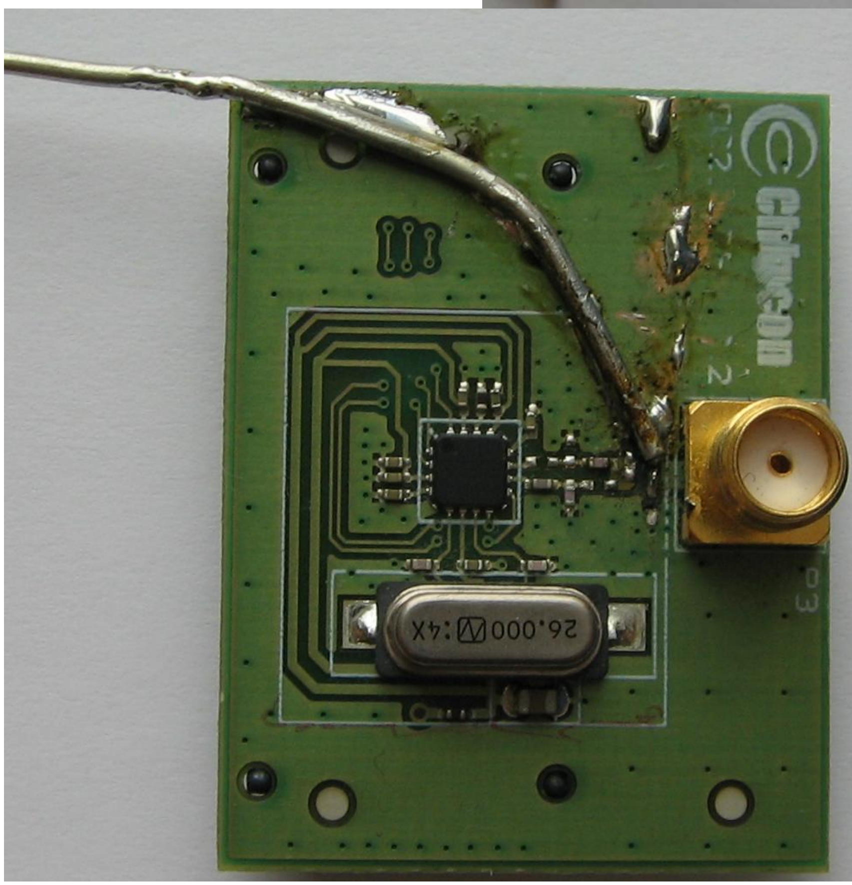
Testing

- **Antenna testing**
  - Reflection
    - Measured with a network analyzer.
    - Should be less than -10dB or VSWR=2 across the desired frequency band.
  - Radiation pattern
    - Should be measure in an anechoic chamber.
  - Bandwidth
    - Use a test program that steps a carrier across the desired frequency band. Use max hold on spectrum analyzer to measure the variation in output power.

Testing

- **Mounting of semi rigid coax cable**





- Important to solder the shielding to ground as close as possible to the end of the cable.

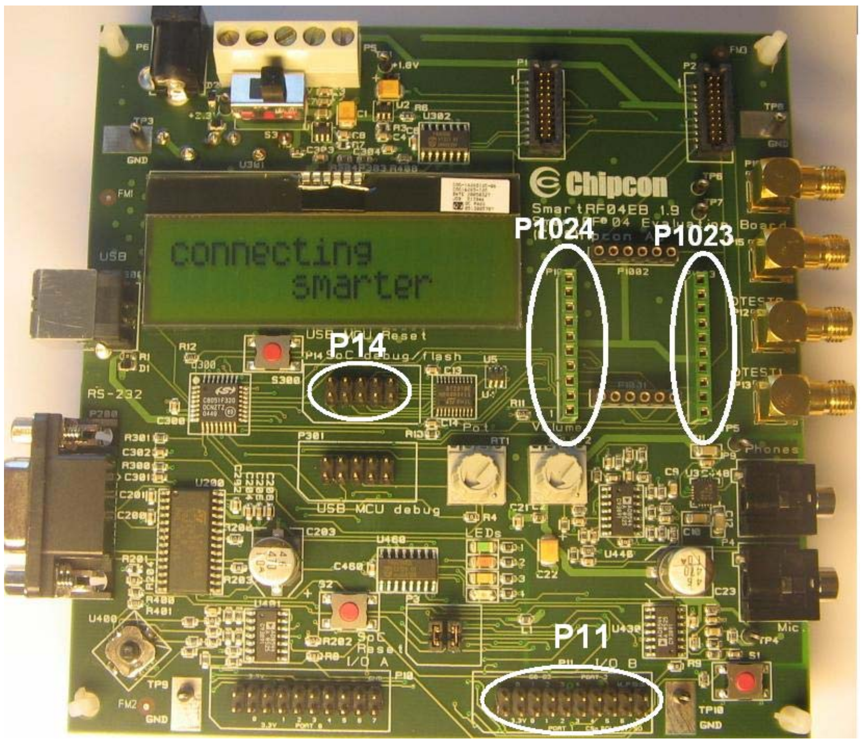
- **Agenda**
  - Development phase
  - Testing
  - Debugging

Debugging

- **Check if the problem is SW or HW related.**
  – Test the SW with well known working HW, evaluation modules
  – Test the HW with well known working SW, SmartRF Studio
- **If it is hardware related:**
  – Compare the design with our reference design.
  – Check mounting of the chip and other components.
  – Mount the radio on our EM to check if the chip is damaged.
- **If it is software related:**
  – Compare the code with our software examples and libraries.
  – Test the functionality of each “module” to isolate the problem.
  – Compare register settings with values in SmartRF Studio.

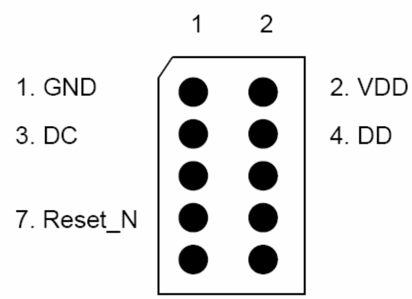
Debugging

- **Connecting a custom module to SmartRF04EB**
  - Transceivers: CSn, SCLK, SI, SO, VCC, GND.
  - SoC: DD, DC Reset_n, VCC, GND.



Pin	Function	Note
1	**GND**	
2	**VDD**	Used to set correct voltage for the voltage level converter
3	**Debug Clock (DC)**	
4	**Debug Data (DD)**	
5	CSn	
6	SCLK	
7	**Reset_N**	
8	MOSI	
9	3.3V VDD, alt. NC	Delivers VDD from SmartRF04EB
10	MISO	

Table 4: P14 SoC debug connector pin-out



Debugging

- **Common problems withSmartRF04EB.**
  - The jumper on the power terminal is not in place.
  - SoC EM is not removed when upgrading the SmartRF04EB firmware.
  - The SmartRF04EB boot loader has been erased.
  - CCXX50 is used instead of CCXX00.
  - Different voltage level on SmartRF04EB and prototype

Thank you for your attention.

Questions?

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