Using CC2591 Front End with CC2520

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Keywords

- *2.4 GHz IEEE 802.15.4 systems*
- ZigBee® systems
- Z-Stack
- TI-MAC
- *Range Extender*
- *External PA*
- *External LNA*
- *CC2520*
- *CC2591*

1 Introduction

The CC2520 is TI's second generation ZigBee® / IEEE 802.15.4 RF transceiver for the 2.4 GHz unlicensed ISM band. This chip enables industrial grade applications by offering state-of-the-art selectivity/co-existence, an excellent link budget, and low voltage operation.

CC2591 is a range extender for 2.4-GHz RF transceivers, transmitters and SoC products from Texas Instruments. CC2591 increases the link budget by providing a Power Amplifier (PA) for improved output power and a Low Noise Amplifier (LNA) for improved receiver sensitivity. CC2591 further contains RF switches, RF matching, and a balun for a seamless interface with the CC2520. This allows for simple design of high performance wireless applications.

This application note describes how to combine the CC2520 and the CC2591 in the same design. It further describes the expected performance from this combination as well as important factors to consider with respect to the layout and regulatory requirements. The combined CC2520 and CC2591 solution is suitable for systems targeting compliance with FCC CFR47 Part 15.

For more details regarding the SW aspects concerning how to implement the CC2520 and the CC2591 in the same design, the reader is referred to the application note AN066 TI-MAC SW modifications for using CC2591 PA/LNA with MSP430F2618+CC2520 [8]. This application note describes how to modify the TI-MAC (www.ti.com/timac) and Z-Stack (www.ti.com/z-stack) software releases for the MSP430F2618 together with the CC2520 to support CC2591 PA/LNA controls. Remark: The latest TI-MAC (beyond 1.2.1) and Z-Stack releases (beyond 2.2.0) include support for the CC2591. It is easily enabled by adding the compile option *HAL_PA_LNA*. No additional files need to be added, as described in AN066 for TI-MAC 1.2.1 based releases.

Table of Contents

2 Abbreviations

SoC	System-on-Chip
DSSS	Direct Sequence Spread Spectrum
EIRP	Equivalent Isotropically Radiated Power
EM	Evaluation Module
EVM	Error Vector Magnitude
ISM	Industrial, Scientific, Medical
FCC	Federal Communications Commission
FHSS	Frequency Hopping Spread Spectrum
LNA	Low Noise Amplifier
PA	Power Amplifier
PCB	Printed Circuit Board
PSD	Power Spectral Density
RF	Radio Frequency
RSSI	Receive Signal Strength Indicator
RX	Receive, Receive Mode
TX	Transmit, Transmit Mode

3 Absolute Maximum Ratings

The absolute maximum ratings and operating conditions listed in the CC2520 datasheet [1] and the CC2591 datasheet [2] must be followed at all times. Stress exceeding one or more of these limiting values may cause permanent damage to any of the devices.

4 Electrical Specifications

Note that these characteristics are only valid when using the recommended register settings presented in Section 4.6 and in Chapter 8, and the CC2520 - CC2591EM reference design [3].

4.1 Operating Conditions

Parameter	Min	Max	Unit
Operating Frequency	2405	2483.5	MHz
Operating Supply Voltage	2.0	3.6	V
Operating Temperature	-40	85	°C

Table 4.1 Operating Conditions

4.2 Current Consumption

T_C = 25°C, VDD = 3.0 V, f = 2440 MHz if nothing else is stated. All parameters are measured on the CC2520 - CC2591EM reference design [3] with a 50 Ω load.

Parameter	Condition	Typical	Unit
Receive Current	Wait for sync, -90 dBm input level Wait for sync, -50 dBm input level	26 23	mA mA
Transmit Current[1]	TXPOWER = 0xF9 TXPOWER = 0xF0 TXPOWER = 0xA0 TXPOWER = 0x2C TXPOWER = 0x03 TXPOWER = 0x01	136 121 102 78 57 55	mA mA mA mA mA mA
Power Down Current[2]	LPM2 Mode	<1	uA

Table 4.2 Current Consumption

[1] The RF output power of the CC2520 - CC2591EM is controlled by the 8 bit value in the CC2520 TXPOWER register.

[2] Note that GPIO5, which is configured as an input in LPM2, should be tied either to GND or VDD when entering LPM2. If GPIO5 (or any other input) is left floating, the current consumption in LPM2 will be unpredictable. On the CC2520 - CC2591EM reference design revision 1.0, the GPIO5 is connected to the CC2591 PAEN signal and it is not tied to VDD or GND. On future revisions of this reference design, a pull-down resistor is added to ensure correct measurements of the LPM2 current.

4.3 Receive Parameters

T_C = 25°C, VDD = 3.0 V, f = 2440 MHz if nothing else is stated. All parameters are measured on the CC2520 - CC2591EM reference design [3] with a 50 Ω load.

Parameter	Condition	Typical	Unit
Receive Sensitivity HGM	1 % PER, IEEE 802.15.4 [6] requires -85 dBm	-97.7	dBm
Receive Sensitivity LGM	1 % PER, IEEE 802.15.4 [6] requires -85 dBm	-88.5	dBm
Saturation	IEEE 802.15.4 [6] requires -20 dBm	-12	dBm
Interferer Rejection	Wanted signal 3 dB above the sensitivity level, IEEE 802.15.4 modulated interferer at IEEE 802.15.4 channels ±5 MHz from wanted signal, IEEE 802.15.4 [6] requires 0 dB ±10 MHz from wanted signal, IEEE 802.15.4 [6] requires 30 dB ±20 MHz from wanted signal. Wanted signal at -82dBm	 50 55 58	 dB dB dB

Table 4.3 Receive Parameters

4.4 Received Signal Strength Indicator (RSSI)

Due to the external LNA and the offset in CC2520 the RSSI readouts from CC2520 - CC2591 are different from RSSI offset values for standalone CC2520 design, the offset values are shown in Table 4.4.

CC2520-CC2591EM LNA mode	RSSI offset[3]
High Gain Mode	79
Low Gain Mode	90

Table 4.4 RSSI Compensation

[3] Real RSSI = Register value – RSSI offset

4.5 Transmit Parameters

T_C = 25°C, VDD = 3.0 V, f = 2440 MHz if nothing else is stated. All parameters are measured on the CC2520 - CC2591EM reference design [3] with a 50 Ω load, radiated measurements are done with the kit antenna.

Parameter	Condition	Typical	Unit
Radiated Emission with TXPOWER = 0xF9 Complies with FCC 15.247. See Chapter 7 for more details about regulatory requirements and compliance	Conducted 2·RF (FCC restricted band) Conducted 3·RF (FCC restricted band) Radiated 2·RF (FCC restricted band)	-49 -47 -39.2[4]	dBm dBm dBm
Max Error Vector Magnitude (EVM)[5]	IEEE 802.15.4 [6] requires max. 35% Measured as defined by IEEE 802.15.4 [6] TXPOWER = 0xF9, f = IEEE 802.15.4 channels TXPOWER = 0xF0, f = IEEE 802.15.4 channels TXPOWER = 0xA0, f = IEEE 802.15.4 channels TXPOWER = 0x2C, f = IEEE 802.15.4 channels TXPOWER = 0x03, f = IEEE 802.15.4 channels TXPOWER = 0x01, f = IEEE 802.15.4 channels	 6 5 5 6 9 20	 % % % % % %

Table 4.5 Transmit Parameters

4.6 Output Power Programming

The RF output power of the CC2520 - CC2591EM is controlled by the 8 bit value in the CC2520 TXPOWER register. Table 4.6 shows the typical output power and current consumption for the recommended power settings. The results are given for T_C = 25°C, VDD = 3.0 V and f = 2440 MHz, and are measured on the CC2520 - CC2591EM reference design [3] with a 50 Ω load. For recommendations for the remaining CC2520 registers, see Chapter 8 or use the settings given by SmartRF Studio.

TXPOWER	Power [dBm]	Current [mA]
0xF9	17	136
0xF0	16	121
0xA0	14	102
0x2C	11	78
0x03	-1	57
0x01	-8	55

Table 4.6 Power Table

Note that the recommended power settings given in Table 4.6 only are a small subset of all the possible TXPOWER register settings. However, using other settings than those

[4] Duty cycling might be needed to comply with FCC 15.247 with certain types of antennas and filter configurations, for more information about duty cycling see section 7.1
[5] Tested at IEEE 802.15.4 channels 11 till 26 in the 2.4GHz band

recommended might result in unexpected problems such as high current consumption, high EVM, and high spurious emission.

4.7 Typical Performance Curves

T_C = 25°C, VDD = 3.0 V, f = 2440 MHz if nothing else is stated. All parameters are measured on the CC2520 - CC2591EM reference design [3] with a 50 Ω load.

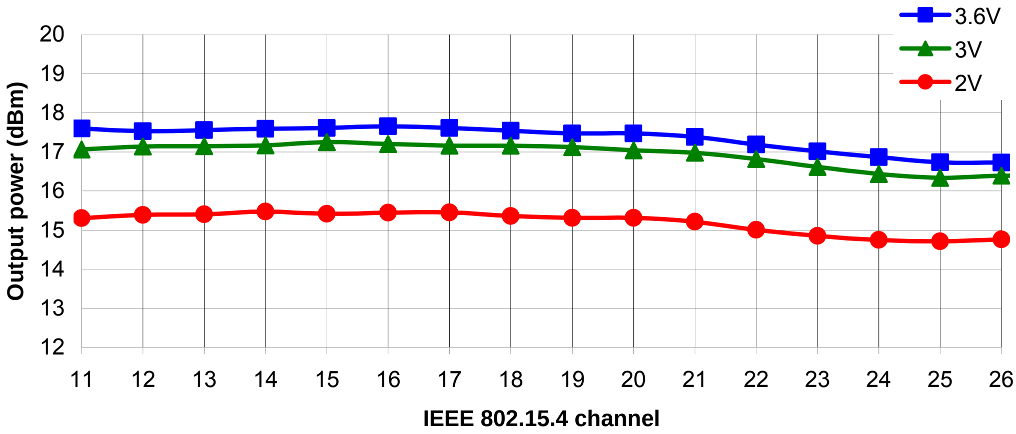

Figure 4.1 Output Power vs. Frequency and Power Supply Voltage, TXPOWER = 0xF9

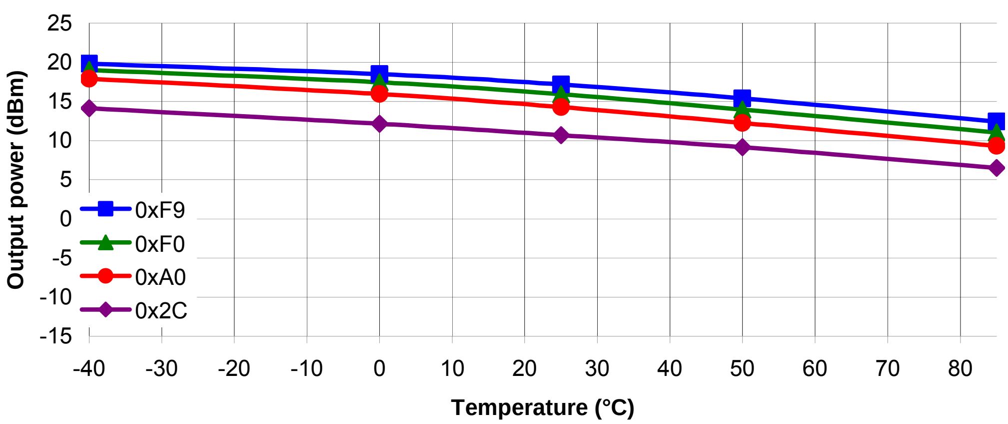

Figure 4.2 Output Power vs. Temperature

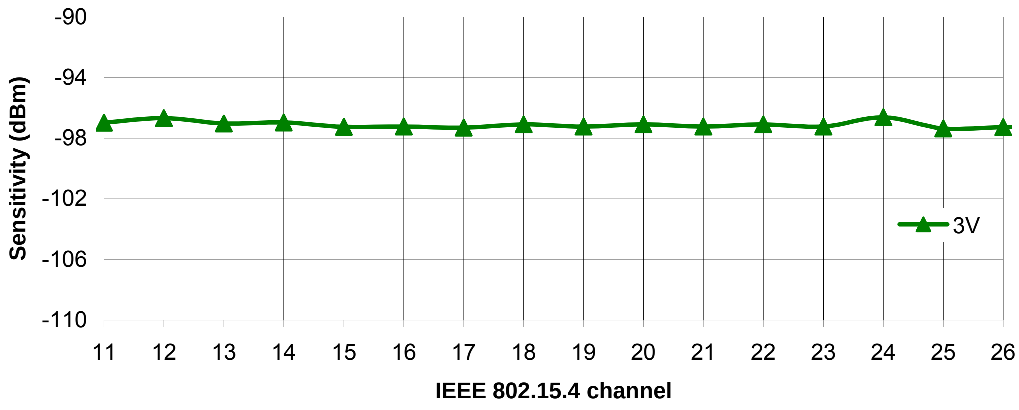

Figure 4.3 Sensitivity vs. Frequency

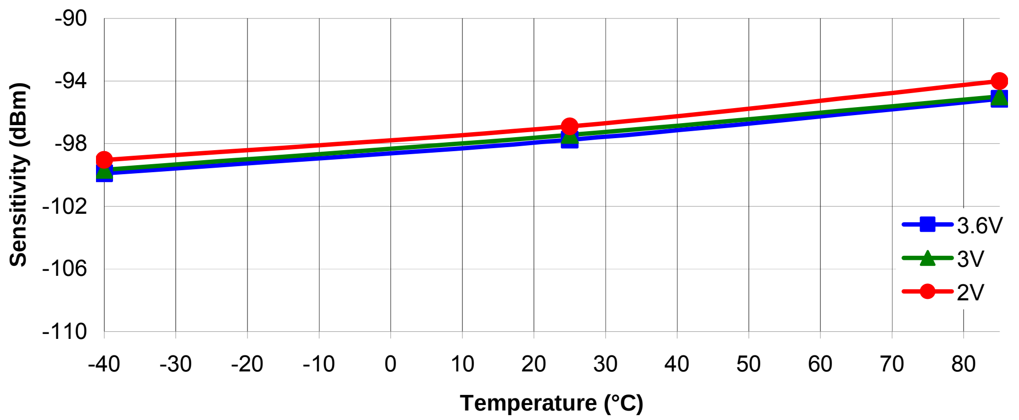

Figure 4.4 Sensitivity vs. Temperature and Power Supply Voltage

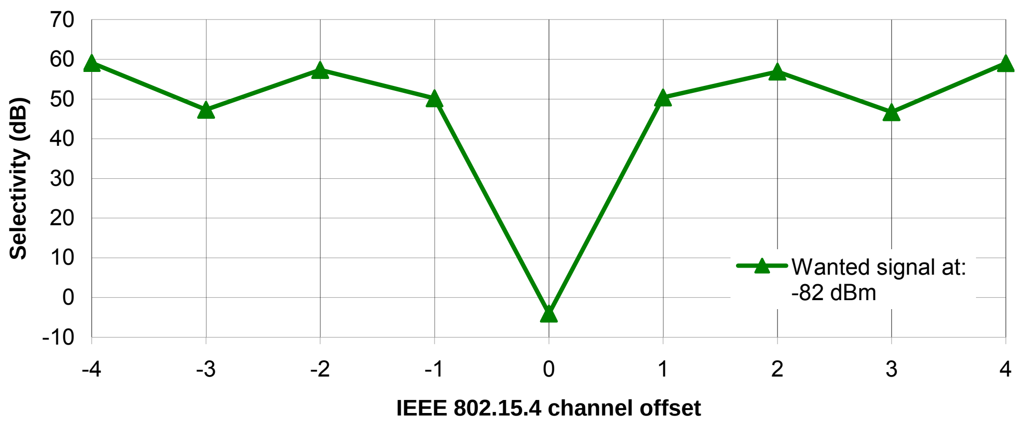

Figure 4.5 Selectivity Operating at Channel 18 (2440 MHz)

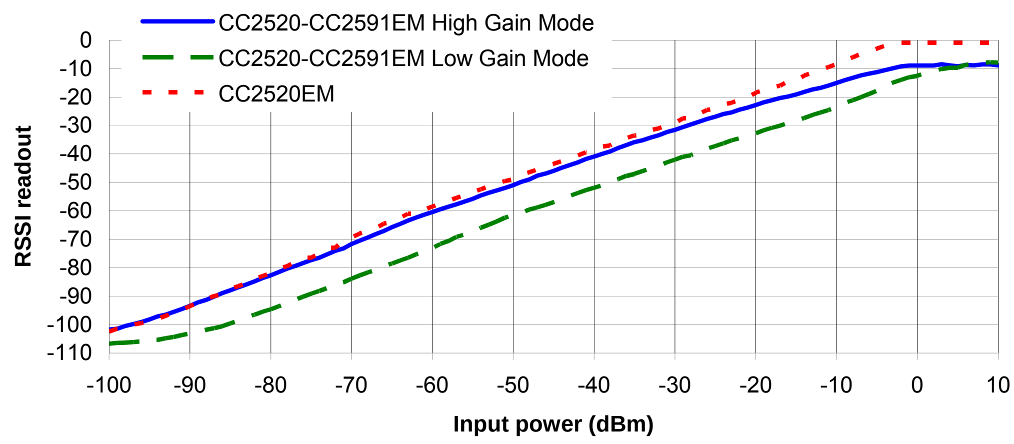

Figure 4.6 RSSI Readout vs. Input Power

5 Application Circuit

Only a few external components are required for the CC2520 - CC2591 reference design. A typical application circuit is shown below in Figure 5.1. Note that the application circuit figure does not show how the board layout should be done. The board layout will greatly influence the RF performance of the CC2520 - CC2591EM. TI provides a compact CC2520 - CC2591EM reference design [3] that it is highly recommended to follow. The layout, stack-up and schematic for the CC2591 need to be copied exactly to obtain good performance. Note that the reference design [3] also includes bill of materials with manufacturers and part numbers.

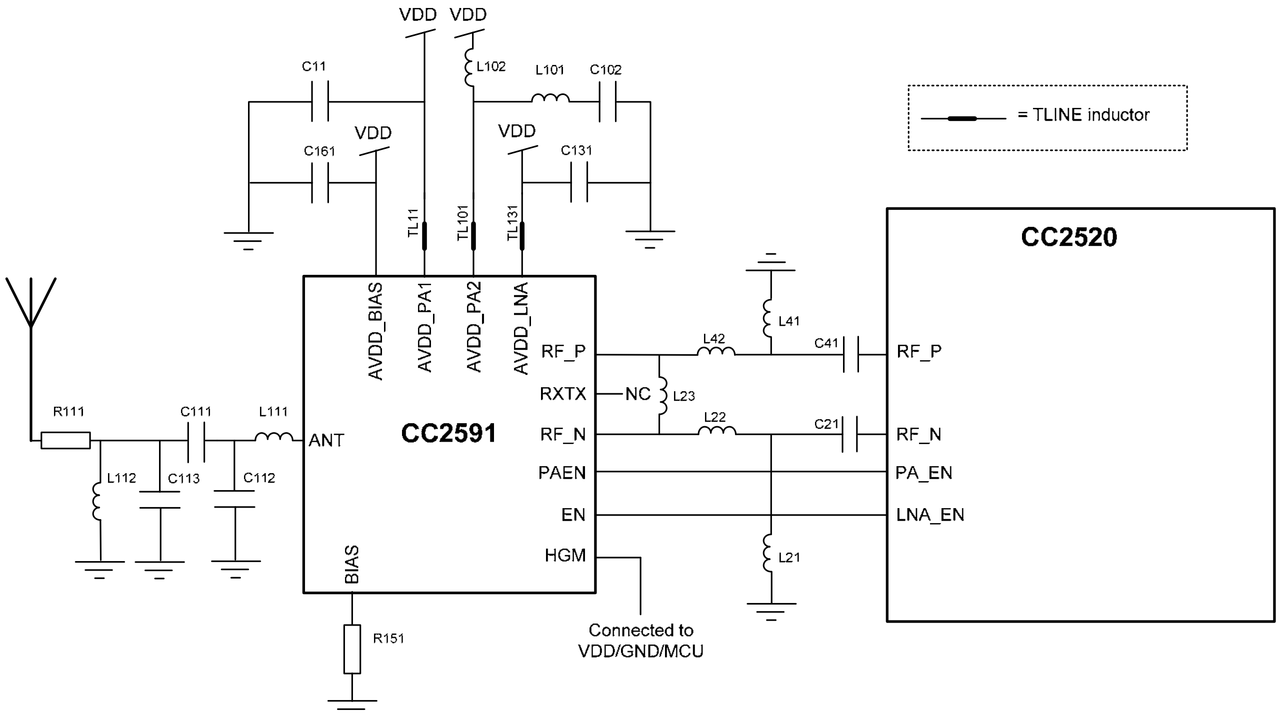

Figure 5.1 Application Circuit for the CC2520 with CC2591

5.1 Power Decoupling and RF Loading

Proper power supply decoupling must be used for optimum performance. In Figure 5.1, only the decoupling components for the CC2591 are shown. This is because, in addition to decoupling, the parallel capacitors C11, C101 and C131 together with L101, L102, TL11, TL101 and TL131 also work as RF loads. These therefore ensure the optimal performance from the CC2591. C161 decouples the AVDD_BIAS power.

The placement and size of the decoupling components, the power supply filtering and the PCB transmission lines are very important to achieve the best performance. Details about the importance of copying the CC2520 - CC2591EM reference design [3] exactly and potential consequences of changes are explained in chapter 6.

5.2 Input/ Output Matching and Filtering

The RF input/output of CC2520 is high impedance and differential. The CC2591 includes a balun and a matching network in addition to the PA, LNA and RF switches which makes the interface to the CC2520 seamless. Only a few components between the CC2520 and CC2591 are necessary for RF matching. Note that the PCB transmission lines that connect the two devices also are part of the RF matching. It is therefore important to copy the distance between the devices, the transmission lines and the stack-up of the PCB according to the reference design [3] to ensure optimum performance.

The network between the CC2591 and the antenna (L111, C112, C111 C113, L112 and R111) matches the CC2591 to a 50 Ω load and provides filtering to pass regulatory demands. C111 also works as a DC-block.

5.3 Bias resistor

R151 is a bias resistor. The bias resistor is used to set an accurate bias current for internal use in the CC2591.

5.4 Antenna Considerations

The TI reference design contains two antenna options. As default, the SMA connector is connected to the balun through a 3.3 Ω resistor. This resistor can be soldered off and rotated 90° clockwise in order to connect to the PCB antenna, which is a planar inverted F antenna (PIFA). Note that all testing and characterization has been done using the SMA connector. The PCB antenna has only been functionally tested by establishing a link between two EMs. Please refer to the antenna selection guide [4] and the Inverted F antenna design note [5] for further details on the antenna solutions.

6 PCB Layout Considerations

The Texas Instruments reference design uses a 1.6 mm (0.062") 4-layer PCB solution. Note that the different layers have different thickness; it is important to follow the recommendation given in the CC2520 - CC2591EM reference design [3] to ensure optimum performance.

The top layer is used for components and signal routing, and the open areas are filled with metallization connected to ground using several vias. The areas under the two chips are used for grounding and must be well connected to the ground plane with multiple vias. Footprint recommendation for the CC2591 is given in the CC2591 datasheet [2].

Layer two is a complete ground plane and is not used for any routing. This is done to ensure short return current paths. The low impedance of the ground plane prevents any unwanted signal coupling between any of the nodes that are decoupled to it. A dedicated ground plane is also needed to improve stability (see Section 6.1). Layer three is a power plane. The power plane ensures low impedance traces at radio frequencies and prevents unwanted radiation from power traces. Layer four is used for routing, and as for layer one, open areas are filled with metallization connected to ground using several vias.

Important Notice

Changes in the PCB stack-up, component value, vendors, sizes or placements can cause significant effects on the performance of the combined CC2520 and CC2591 solution. Any change can cause higher current consumption, oscillations of the CC2591, unwanted spurious emissions and generally degraded performance. It is strongly advised that the reference design [3] is followed as closely as possible in order to obtain the best performance.

6.1 CC2520 – CC2591 Stability

When a common, center ground-pin/paddle is used, all inductance seen between this ground paddle and the ground plane will give rise to feedback. This feedback might give rise to oscillations. There is no general rule that tells exactly how much inductance that exists between the ground paddle and the ground plane – it depends on the chip design. Still, a general rule of thumb is that chances of oscillations increase when the RF currents increase. The stability issue is the main reason for using a 4-layer PCB with a ground-plane close to the top layer of the CC2520 - CC2591EM reference design [3].

It is generally accepted that an antenna is useful only within the bandwidth at which the VSWR is 2:1 or lower, with 1.5:1 often cited as the maximum acceptable VSWR. The CC2520 - CC2591EM reference design [3] has been tested with three different matching conditions and with a slider to ensure that all phases were tested for the different matching conditions: One with only a 50 Ω connection, two others that have a mismatch of VSWR 2:1 within the operating frequency band and the mismatch out of the operating area is between 4:1 and 6:1 and between 6:1 and 12:1 respectively, see Figure 6.2. The stable regions of the CC2520-CC2591EM is shown in Figure 6.1 where the register setting in the figure show the maximum acceptable power setting and the mismatch region where the CC2520-CC2591EM is stable.

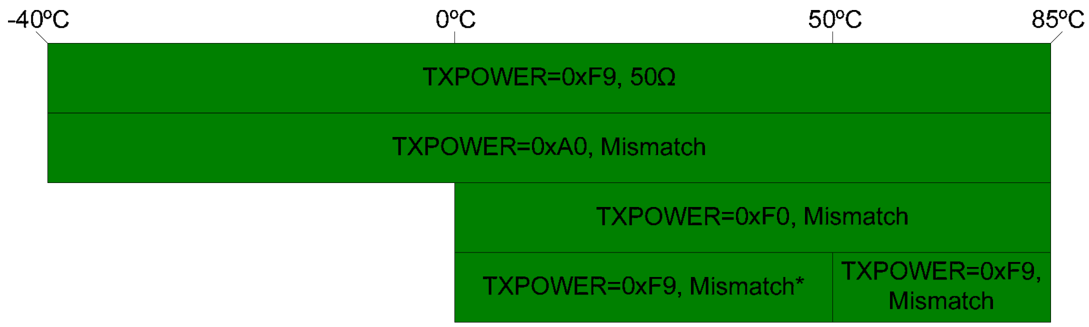

Figure 6.1 Stability vs. temperature[6]

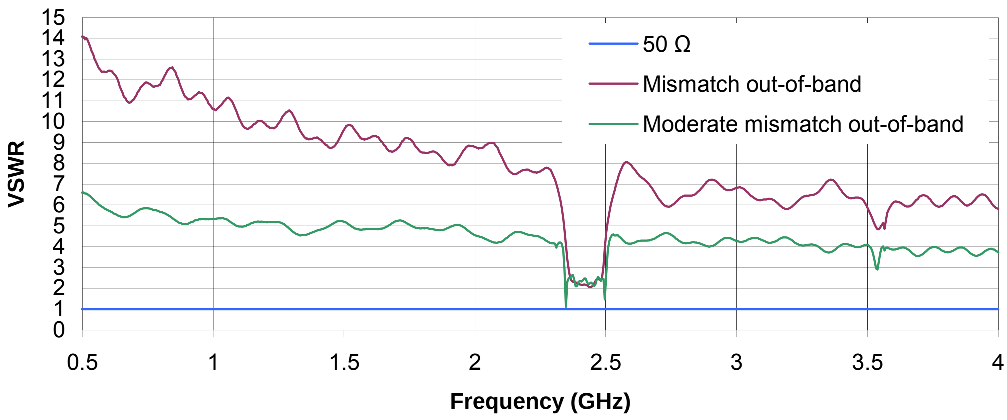

Figure 6.2 VSWR

6.2 The Gain of the CC2591

Changing the layout or the stack-up of the reference design [3] affects the gain of the CC2591. This is because the gain of the CC2591 can be viewed as a function of both the on-chip capacitance and impedance and the external impedance contributions. Internal on-chip routing and capacitance, bondwires (often several in parallel), the PCB transmission lines, the thermal relieves on the decoupling capacitors' ground nodes, capacitance and parasitics of the decoupling capacitors, the inductance of the vias to the ground plane and the soldering of the chip will therefore contribute to the actual performance of the CC2591. A simplified model of all of these contributions is shown in Figure 6.3.

Due to all the contributors to the CC2591 performance, several observations can be made on how changing layout and PCB stack-up affects the amplifier:

- Misplacing the decoupling capacitor or using an arbitrary capacitor will change the inductance, and hence move the resonance frequency of the amplifier, i.e. the frequency with maximum gain.
- Bad soldering of the ground paddle can reduce the gain significantly.
- Too few or too long vias will reduce the gain dramatically. This is why a checkered pattern of vias/ solder paste and a 4-layer PCB with the ground plane close to the top layer has been chosen for the CC2520 - CC2591EM reference design.

[6] *stable when input voltage is ≤3V or with moderate mismatch out-of-band

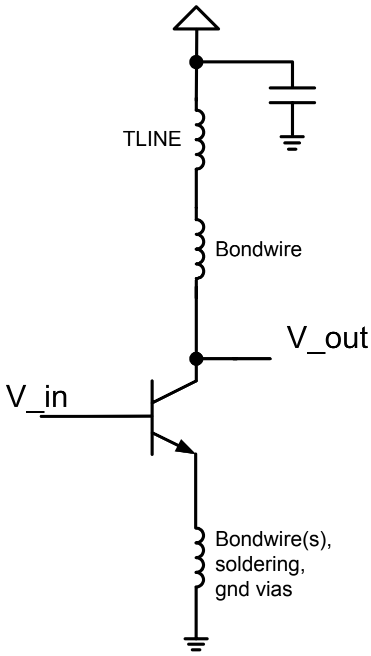

Figure 6.3 Simplified Model of the Impedance Contributors in the CC2591 Design

7 Regulatory Requirements

In the United States, the Federal Communications Commission (FCC) is responsible for the regulation of all RF devices. CFR 47, Part 15, regulates RF products intended for unlicensed operation. A product intended for unlicensed operation has to be subject to compliance testing. If the product is approved, the FCC will issue an identification number.

The specific frequency bands used for unlicensed radio equipment for the 2.4 GHz band are regulated by section 15.247 and 15.249. General rules for certification measurements are found in section 15.35. Restricted bands and general limits for spurious emissions are found in sections 15.205 and 15.209.

The CC2520 - CC2591EM reference design [3] has been tested for compliance with FCC Part 15.247. While it is not a formal certification, it does give a good representation of emissions with respect to compliance requirements. The FCC Part 15.247 compliance is generally a tougher requirement than ETSI compliance (EN 300 328) due to the restricted bands of operation. There are however requirements with regards to ETSI compliance (EN 300 328) that prevents operation at maximum output power. The clause 4.3.2.2 Maximum Power Spectral Density requirement of EN 300 328 requires maximum +10 dBm/ 1 MHz. The output power must therefore be reduced to approximately +12 dBm in order to get CE approval. The final output power level will depend on the antenna used.

The CC2590 is pin and function compatible device that is optimized for operation in systems designed to be ETSI compliant.

FCC Part 15.247 limits the output power to 1 W or +30 dBm when Direct Sequence Spread Spectrum (DSSS) modulation or Frequency Hopping Spread Spectrum (FHSS) with at least 75 hop channels is used. The spectral density of digital modulation systems (not including FHSS) shall not exceed 8 dBm/ 3 kHz. The minimum 6 dB bandwidth of such systems is 500 kHz. Since the CC2520 is a ZigBee compliant transceiver, it uses DSSS modulation. The +30 dBm limit therefore apply for the CC2520 with the CC2591 combination.

When complying with Part 15.247, in any 100 kHz bandwidth outside the operating band, the power level shall be at least 20 dB below the level in the 100 kHz bandwidth with the highest power level in the operating band. Attenuation below limits given in 15.209 is not required. Emission that fall within restricted bands (15.205) must meet general limits given in 15.209. This is summarized in Table 7.1 below. More details about the 2.4 GHz FCC regulations are found in application note AN032 [7].

Standard	Relevant Frequency	Radiated Power (EIRP)	Conducted Power	Comment
FCC 15.247	2400 – 2483.5 MHz		+30 dBm	Maximum 6 dBi antenna gain
	Restricted bands defined by 15.205, including the 2^{nd}, 3^{rd} and 5^{th} harmonics	-41.2 dBm		
	All frequencies not covered in above cells		-20 dBc	

Table 7.1 Summarized FCC 15.247 Regulations for the 2.4 GHz Band

7.1 Duty Cycling when Complying with FCC

For frequencies above 1 GHz, the field strength limits are based on average limits. When using an averaging detector, a minimum bandwidth of 1 MHz shall be employed and the measurement time shall not exceed 100 ms.

Due to the averaging detector, pulsed transmissions are allowed higher peak fundamental, harmonic, and spurious power. This is a benefit for duty-cycled transmissions. The relaxation factor is 20 log (TX on-time/100 ms) [dB]. A 50 % duty cycle will therefore allow for 6 dB higher peak emission than without duty cycling. Notice however that, even when an averaging detector is called for, there is still a limit on emissions measured using a peak detector function with a limit 20 dB above the average limit.

7.2 Compliance of FCC Part 15.247 when using the CC2520 with the CC2591

When using CC2520 with the CC2591, duty cycling or back-off is needed for IEEE 802.15.4 channels to comply with FCC at maximum output power (TXPOWER = 0xF9). Table 7.2 below shows the duty cycling or back-off needed to comply with the FCC Part 15.247 limits at typical conditions (T_C = 25°C, VDD = 3.0 V, TXPOWER = 0xF9). ZigBee and IEEE 802.15.4 systems are however typically low duty cycle systems. Note that the numbers in Table 7.2 are based on conducted emission measurements from the CC2520 - CC2591EM reference design [3]. The real required duty cycling or back-off may be different for applications with different antennas, plastic covers, or other factors that amplify/ attenuate the radiated power.

Figure 7.2 below shows the level of the conducted spurious emission and margins to the FCC Part 15.247 limits for the IEEE 802.15.4 channels under typical conditions (T_C = 25°C, VDD = 3.0 V) when transmitting at maximum recommended power (TXPOWER = 0xF9) using the CC2520 - CC2591EM [3]. Figure 7.3 and Figure 7.4 show the margins versus the FCC 15.247 for the lowest frequency channels at the lower band edge and for the upper frequency channels at the upper band edge respectively. At the band edge the FCC allows for a Marker-delta method measurement [9] to determine the amount of back off or duty cycle needed to comply with the FCC Part 15.247. With Marker-delta method the field strength of the in-band fundamental frequency is subtracted from the difference between the highest fundamental emission level measured with a lower resolution bandwidth and the emission level at the band edge, as shown in Figure 7.4.

Note that channel 11, 12, and 25 will need duty cycling due to spurious emission even though they pass the band edge requirements.

Frequency [MHz]	Back-Off [dB]	Duty Cycle
2405	6.1	49 %
2410	6.7	46 %
2415	6.6	47 %
2420	2.7	73 %
2425	3.1	70 %
2430	3.2	69 %
2435	3.8	64 %
2440	4.4	60 %
2445	3.7	65 %
2450	3.8	64 %
2455	3.6	66 %
2460	1.5	84 %
2465	2.6	74 %
2470	0	100 %
2475	2.4	76 %
2480	9.8	32 %

Table 7.2 Duty-Cycle or Back-Off Requirement for FCC Part 15.247 Compliance under Typical Conditions

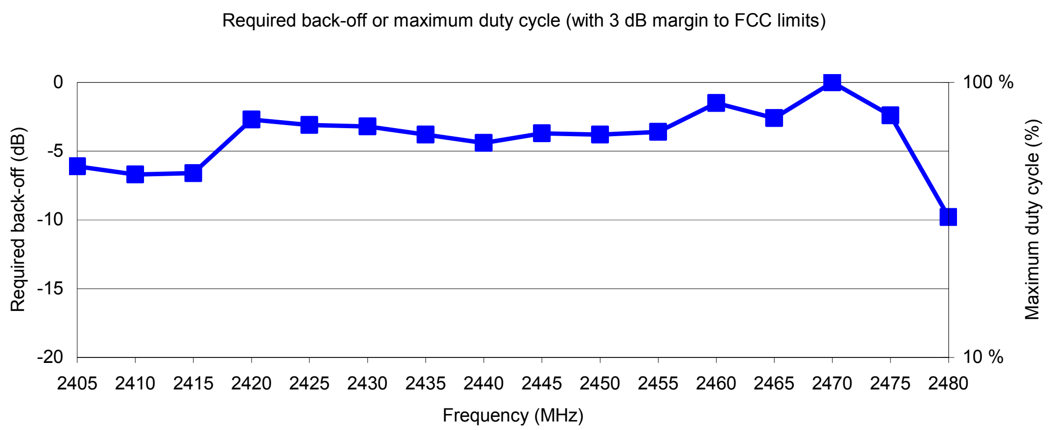

Figure 7.1 Visualization of Table 7.2

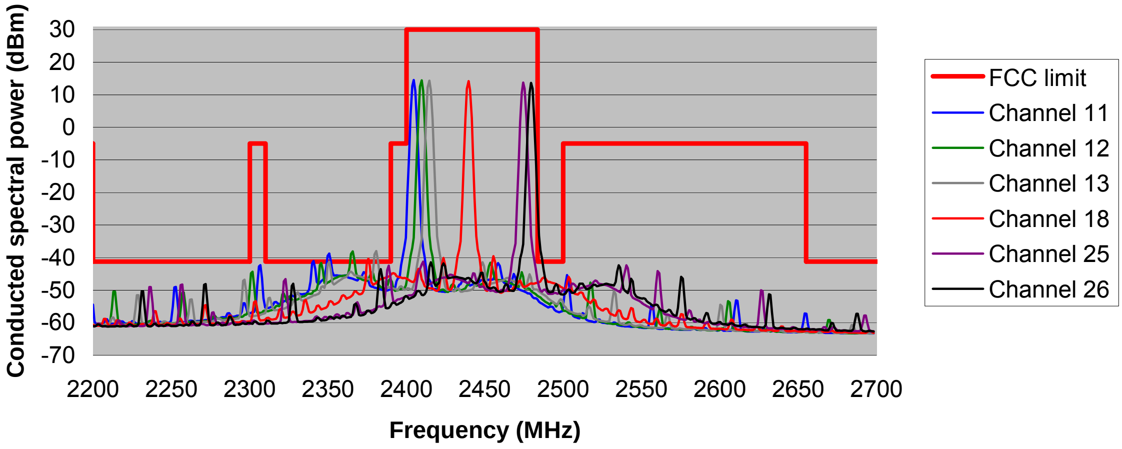

Figure 7.2 Conducted Spurious Emission vs. FCC Part 15.247 Limit (TXPOWER = 0xF9, RBW = 1 MHz, VBW = 10 Hz)

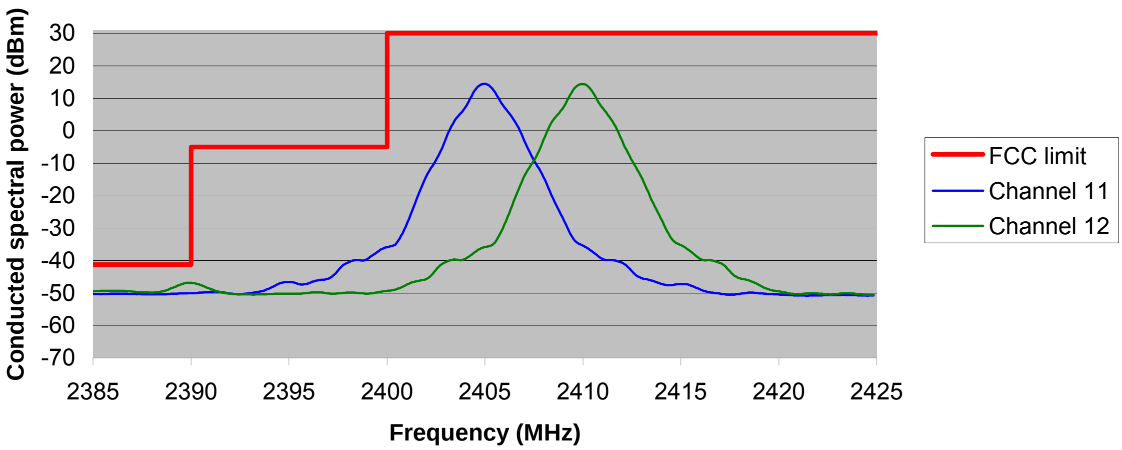

Figure 7.3 Conducted Spurious Emission, Lower Band Edge (TXPOWER = 0xF9, RBW = 1 MHz, VBW = 10 Hz)

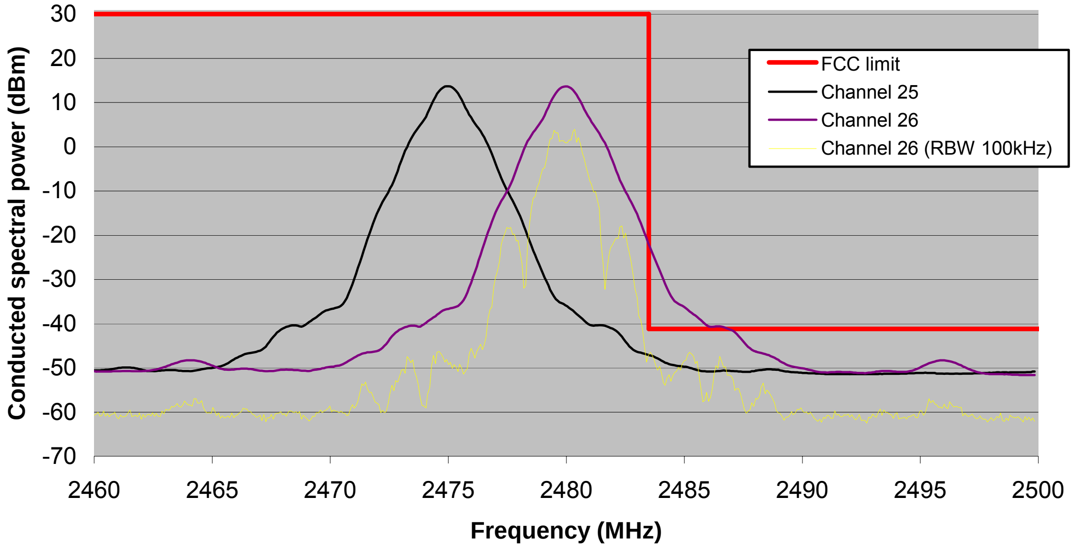

Figure 7.4 Conducted Spurious Emission, Upper Band Edge (TXPOWER = 0xF9, RBW = 1 MHz, VBW = 10 Hz)

8 Controlling the CC2591

There are four digital control pins (PAEN, EN, HGM, and RXTX) on the CC2591 controls the state the chip is in. Table 8.1 below shows the control logic when connecting the CC2591 to a CC2520 device.

PAEN	EN	RXTX	HGM	Mode of Operation
0	0	NC	X	Power Down
0	1	NC	0	RX LGM
0	1	NC	1	RX HGM
1	0	NC	X	TX
1	1	NC	X	Not allowed

Table 8.1 Control Logic for Connecting the CC2591 to a CC2520 Device

The CC2520 – CC2591EM reference design [3] from TI uses three of the CC2520 GPIO pins on the CC2520 to control the CC2591. The CC2591 can alternatively be controlled by an external MCU.

When using the configuration used in the CC2520 – CC2591EM reference design [3], the registers listed in Table 8.2 need to be changed from the recommended CC2520 settings to control the CC2591 and give optimum performance. The new recommended values are also listed in Table 8.2. The same register settings can be used in both TX and RX. If using an external MCU to control the CC2591, the CC2520 GPIO register settings can be kept unaltered. TXCTRL is changed to increase the stability and reduce the EVM, while the change in the AGCCTRL1 register is due to the increased noise floor introduced by the CC2591. If this register is left unaltered, the RX performance will be degraded.

CC2520 REGISTER	ADDRESS	RECCOMMENED VALUE
GPIOCTRL3	0x023	0x7F
GPIOCTRL4	0x024	0x46
GPIOCTRL5	0x025	0x47
GPIOPOLARITY	0x026	0xF
TXPOWER	0x030	See Table 4.6
TXCTRL	0x031	0xC1
AGCCTRL1	0x053	0x16

Table 8.2 New Recommended Register Settings for the CC2520 - CC2591 combination

All the recommended register CC2520 settings when including the CC2591 are automatically implemented in SmartRF Studio when checking the Range Extender box. SmartRF Studio is available on the TI website www.ti.com. Application note AN066 [8] further describes how to modify the TI-MAC software releases for the MSP430F2618 together with the CC2520 to support CC2591 PA/LNA controls.

9 References

[1] CC2520 Datasheet (SWRS068.pdf)

[2] CC2591 Datasheet (SWRS070.pdf)

[3] CC2520 – CC2591EM Reference Design (Rev. B) (SWRU190.zip)

[4] AN058 Antenna Selection Guide (SWRA161.pdf)

[5] DN007 2.4 GHz Inverted F Antenna (SWRU120.pdf)

[6] IEEE std. 802.15.4 – 2006: Wireless Medium Access Control (MAC) and Physical Layer (PHY) specification for Low Rate Wireless Personal Area Networks (LR-WPANs) (http://standards.ieee.org/getieee802/download/802.15.4-2006)

[7] AN032 SRD Regulations for License-free Transceiver Operation in the 2.4 GHz Band (SWRA060.pdf)

[8] AN066 TI-MAC SW modifications for using CC2591 PA/LNA with MSP430F2618+CC2520 (SWRA230.pdf)

[9] DA 00-705 (http://www.fcc.gov/Bureaus/Engineering_Technology/Public_Notices/2000/da000705.doc)

10 General Information

10.1 Document History

Revision	Date	Description/Changes
SWRA229	2008.10.09	Initial release.
SWRA229A	2010-01-07	The document is changed so that the results reflect the current reference design (Rev. B).

IMPORTANT NOTICE