CC2420 with external PA

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Keywords

- *CC2420*
- *Power amplifier*
- *IEEE 802.15.4*
- *ZigBee™*
- *Battery operated nodes*
- *EN 300 328*
- *FCC CFR47 Part 15*

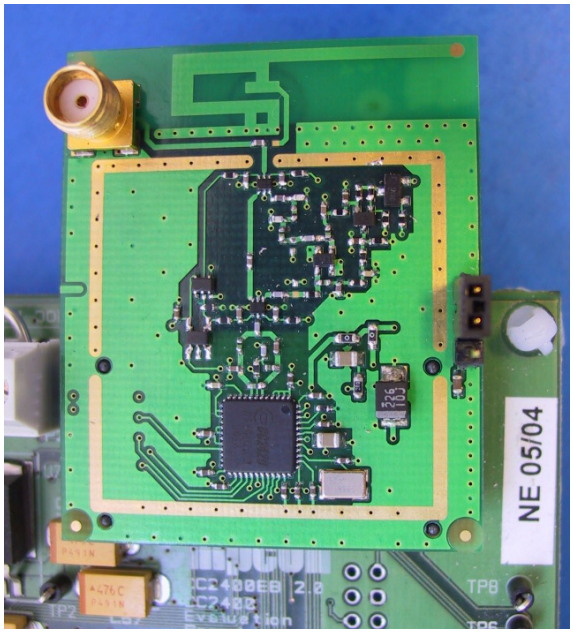
1 Introduction

The ***CC2420*** is a true single-chip 2.4 GHz IEEE 802.15.4 compliant RF transceiver designed for low-power and low-voltage wireless applications. ***CC2420*** includes a digital direct sequence spread spectrum baseband modem providing a spreading gain of 9 dB and an effective data rate of 250 kbps.

The CC2420 with external Power Amplifier (PA) solution has been developed to comply with the IEEE 802.15.4 and ZigBee™ standards' requirements as well as worldwide regulatory requirements. Compliance has been tested against regulations covered by ETSI EN 300 328 (Europe) and FCC CFR47 Part 15 (US).

The CC2420 with external PA has been developed with a form factor and connectors suitable to be plug-in compatible with the CC2400EB for ease of testing with SmartRF® Studio. A discrete transistor has been used as PA.

The CC2420 with external PA has a nominal output of 10dBm and a current consumption of 27-34mA across temperature at 3.3V making it highly suitable for battery operated nodes. The range measured outside (line-of-sight) extended as far as 580m.



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2 Abbreviations

FET	Field Effect Transistor
PA	Power Amplifier
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances directive
RX	Receive mode
TX	Transmit mode

3 Design Requirements

The following requirements were defined for the CC2420 with external PA:

- RoHS compliant module (Pb-free design)
- Operation across industrial temperature range: -40 to +85°C
- Low power consumption
  - Suitable for battery operated nodes
- Unconditionally stable PA design
- Maximum output power: ~10dBm
  - Provide extended range
  - Reduce number of nodes (application dependant)
  - Relays / router nodes
- Compliance with IEEE 802.15.4 and ZigBee
  - Maximum output power limited by transmit spectral density mask: <-30 dBm @ +/- 3.5 MHz
- Compliance with regulatory regulations
  - FCC CFR15, part 15
  - ETSI EN 300 328
  - ARIB STD-T66
- Plug in compatible with CC2400EB
  - Can be configured from SmartRF Studio and tested directly using CC2400EB as motherboard

4 Overview

The principal overview of the CC2420 with external PS design is shown in figure 1 below.

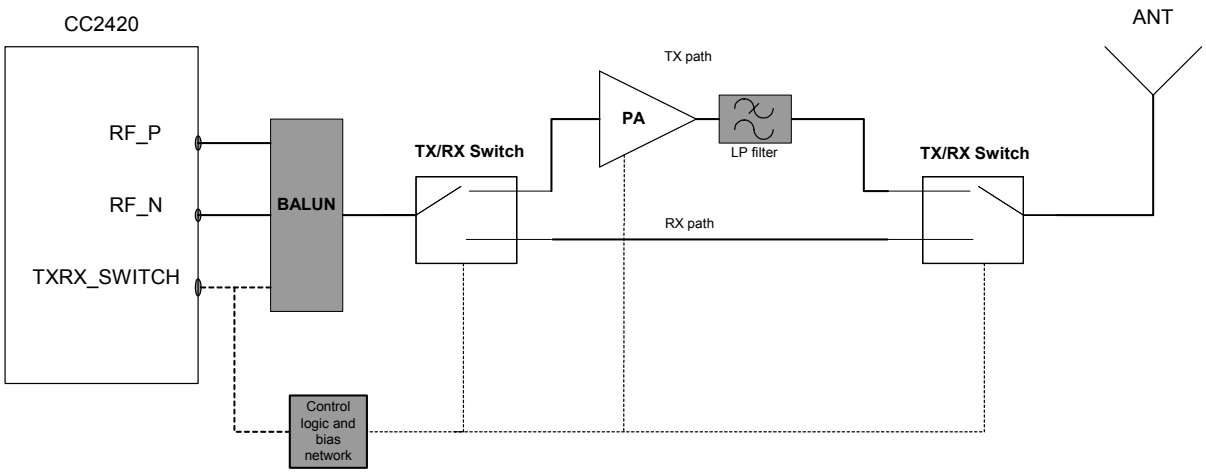

Figure 1: Schematic overview of CC2420 with external PA

The power amplifier network consists of two 2/1 switches separating the TX and RX branches, a discrete transistor amplifier long with a low-pass filter in the TX branch and control logic and bias network. The signal from the TXRX_SWITCH pin is level shifted and buffered. The level in TX is 1.8V and 0V in all other modes. The GaAs FET switches used assures low RX current consumption.

5 Specifications

The specifications of the CC2420 with external PA are given below.

5.1 Environmental Specifications

Parameter	Min.	Typ.	Max.	Units	Condition
Operating ambient temperature range	-40		+85	°C	
Operating humidity range	5		95	%	Relative

5.2 Operating Specifications

Parameter	Min.	Typ.	Max.	Units	Condition
Supply voltage for CC2420 on-chip voltage regulator and external PA	3.0	3.3	3.6	V	DC; Voltage can be varied from the CC2400EB
Supply voltage (VDDIO) for digital I/Os	2.1		3.6	V	DC
Supply voltage (VDD) on AVDD_VCO, DVDD1.8, etc	1.6	1.8	2.0	V	DC
Current consumption RX @3.3V		19.5 19.7 19.9		mA	-40°C 25°C 85°C
Current consumption TX @10 dBm, 3.3V		27 30.5 34		mA	-40°C 25°C 85°C CC2420 + PA (stabilized current)

5.3 RF Transmit Section

Parameter	Min.	Typ.	Max.	Units	Condition
Carrier Modulation Type					Offset Quadrature Phase Shift Keying (OQPSK), IEEE 802.15.4 compliant
Carrier frequency range	2405		2480	MHz	Using IEEE 802.15.4 channel definition
Transmit channel power		10		dBm	RMS, typ. Note: P_{1dB} 9dBm typ.
Channel power steps		8		steps	Utilising CC2420 power control
Programmable output power range	-24		0	dB	Relative to the max output power
Static reference frequency		16.0		MHz	Nominal
Crystal frequency accuracy	-40		+40	ppm	
Carrier frequency tuning resolution		5		MHz	Nominal, assuming IEEE 802.15.4 modulation format
Adjacent channel power ratio (ACPR)			40	dB	Adjacent IEEE 802.15.4 channel
Harmonics 2^{nd} harmonic 3^{rd} harmonic		 -55 -53		 dBm dBm	Measured conducted at max output power delivered to a single ended 50 Ω load through a balun.
Spurious emission[1] 30-1000MHz 1–12.75GHz 1.8–1.9GHz 5.15–5.3GHz			 -36 -30 -47 -47	 dBm dBm dBm dBm	Maximum output power. Complies with EN 300 328, EN 300 440, CFR47 Part 15
Error Vector Magnitude		16	35	%	
Turnaround time			192	µs	TX to RX

[1] The FCC restricted band beginning at 2483.5MHz is violated when the channel is set to 2480 MHz. It is 4.8 dB above the limit at the spectrums maximum level. The restricted band requirement is met with the channel set to 2475 MHz.

5.4 RF Receive Section

Parameter	Min.	Typ.	Max.	Units	Condition
Input power level			+10	dBm	At RF pins of CC2420
Static reference frequency		16.0		MHz	Nominal
Crystal frequency accuracy	-40		+40	ppm	
Receiver tuning range	2405		2480	MHz	Using IEEE 802.15.4 channel definition
Carrier frequency tuning resolution		5		MHz	Nominal
Frequency error tolerance			200	kHz	Max.
Sensitivity		-92		dBm	
Adjacent channel rejection		31/35		dB	-5/+5MHz
Alternate channel rejection		55/62		dB	-10/+10MHz
Turnaround time			192	µs	RX to TX

6 Comparison with CC2420

A comparison of important parameters for a typical CC2420EM to one specific CC2420 with external PA is given below:

	CC2420EM	CC2420EM w/PA
TX current	**17.4 mA**	**30.8 mA**
RX current	**19.7 mA**	**19.7 mA**
Output power	**0 dBm**	**9.5 dBm**
Sensitivity	**-94 dBm**	**-93.1 dBm**
Range (Line-of-Sight)[2]	**230 meter**	**580 meter**

7 Conclusion

The CC2420 with external PA is a very power efficient design delivering 10dBm of output power with a typical current consumption of 27-34mA across the full temperature range of -40 to +85°C. Due to the low power consumption (it is actually lower than competing solutions at 0dBm!) this solution is highly suitable for IEEE 802.15.4 and ZigBee™ nodes.

[2] The range measurements were conducted in an open area outside using GigAnt's 2.4 GHz Titanis antennas.

8 General Information

8.1 Document History

Revision	Date	Description/Changes
1.0	2005-07-22	Initial release.

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