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Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

APPLICATIONS

- IEEE 802.15.4 systems
- ZigBee® systems
- Industrial monitoring and control
- Home and building automation
- Automatic Meter Reading
- Low-power wireless sensor networks
- Set-top boxes and remote controls
- Consumer electronics

KEY FEATURES

- State-of-the-art selectivity/co-existence
  Adjacent channel rejection: 49 dB
  Alternate channel rejection: 54 dB
- Excellent link budget (103dB)
  400 m Line-of-sight range
- Extended temp range (-40 to +125°C)
- Wide supply range: 1.8 V – 3.8 V
- Extensive IEEE 802.15.4 MAC hardware support to offload the microcontroller
- AES-128 security module
- CC2420 interface compatibility mode

Low Power

- RX (receiving frame, -50 dBm) 18.5 mA
- TX 33.6 mA @ +5 dBm
- TX 25.8 mA @ 0 dBm
- <1µA in power down

General

- Clock output for single crystal systems
- RoHS compliant 5 x 5 mm QFN28 (RHD) package

Radio

- IEEE 802.15.4 compliant DSSS baseband modem with 250 kbps data rate
- Excellent receiver sensitivity (-98 dBm)
- Programmable output power up to +5 dBm
- RF frequency range 2394-2507 MHz
- Suitable for systems targeting compliance with worldwide radio frequency regulations: ETSI EN 300 328 and EN 300 440 class 2 (Europe), FCC CFR47 Part 15 (US) and ARIB STD-T66 (Japan)

Microcontroller Support

- Digital RSSI/LQI support
- Automatic clear channel assessment for CSMA/CA
- Automatic CRC
- 768 bytes RAM for flexible buffering and security processing
- Fully supported MAC security
- 4 wire SPI
- 6 configurable IO pins
- Interrupt generator
- Frame filtering and processing engine
- Random number generator

Development Tools

- Reference design
- IEEE 802.15.4 MAC software
- ZigBee® stack software
- Fully equipped development kit
- Packet sniffer support in hardware

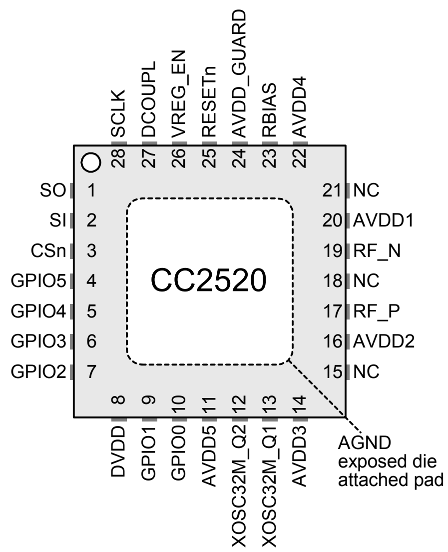
DESCRIPTION

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, excellent link budget, operation up to 125°C and low voltage operation.

In addition, the CC2520 provides extensive hardware support for frame handling, data buffering, burst transmissions, data encryption, data authentication, clear channel assessment, link quality indication and frame timing information. These features reduce the load on the host controller.

In a typical system, the CC2520 will be used together with a microcontroller and a few additional passive components.

QFN28 (RHD) PACKAGE
TOP VIEW



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ZigBee® is a registered trademark owned by ZigBee Alliance, Inc.

TABLE OF CONTENTS

1 Abbreviations

AAF	Anti Aliasing Filter
ACK	Acknowledge
ADC	Analog to Digital Converter
ADI	Analog-Digital Interface
AES	Advanced Encryption Standard
AGC	Automatic Gain Control
AM	Active Mode
ARIB	Association of Radio Industries and Businesses
BER	Bit Error Rate
BIST	Built In Self Test
CBC-MAC	Cipher Block Chaining Message Authentication Code
CCA	Clear Channel Assessment
CCM	Counter mode + CBC-MAC
CDM	Charged Device Model
CFR	Code of Federal Regulations
CHP	Charge Pump
CMOS	Complementary Metal Oxide Semiconductor
CRC	Cyclic Redundancy Check
CSMA-CA	Carrier Sense Multiple Access with Collision Avoidance
CTR	Counter mode (encryption)
CW	Continuous Wave
DAC	Digital to Analog Converter
DC	Direct Current
DPU	Data Processing Unit
DSSS	Direct Sequence Spread Spectrum
ECB	Electronic Code Book (mode of AES operation)
ESD	Electro Static Discharge
ESR	Equivalent Series Resistance
ETSI	European Telecommunications Standards Institute
EU	European Union
EVM	Error Vector Magnitude
FCC	Federal Communications Commission
FCF	Frame Control Field
FCS	Frame Check Sequence
FFCTRL	FIFO and Frame Control
FIFO	First In First Out
FS	Frequency Synthesizer
FSM	Finite State Machine
GPIO	General Purpose Input/Output
HBM	Human Body Model
HSSD	High Speed Serial Debug
I/O	Input / Output
I/Q	In-phase / Quadrature-phase
IEEE	Institute of Electrical and Electronics Engineers
IF	Intermediate Frequency
ISM	Industrial, Scientific and Medical
ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
kbps	kilo bits per second
LB	Loop Back
LF	Loop Filter
LNA	Low-Noise Amplifier
LO	Local Oscillator
LPF	Low Pass Filter
LPM	Low-Power Mode

LQI	Link Quality Indication
LSB	Least Significant Bit / Byte
LUT	Look-Up Table
MAC	Medium Access Control
MCU	Micro Controller Unit
MFR	MAC Footer
MHR	MAC Header
MIC	Message Integrity Code
MISO	Master In Slave Out
MM	Machine Model
MOSI	Master Out Slave In
MPDU	MAC Protocol Data Unit
MSB	Most significant Bit / Byte
MSDU	MAC Service Data Unit
NA	Not Available
NC	Not Connected
O-QPSK	Offset - Quadrature Phase Shift Keying
PA	Power Amplifier
PAN	Personal Area Network
PCB	Printed Circuit Board
PD	Power Down, Phase Detector
PER	Packet Error Rate
PHR	PHY Header
PHY	Physical Layer
PLL	Phase Locked Loop
PQFP	Plastic Quad FlatPack
PSDU	PHY Service Data Unit
PUE	Pull-Up Enable
QLP	Quad Leadless Package
RAM	Random Access Memory
RBW	Resolution BandWidth
RF	Radio Frequency
RHD	Not actually an acronym. This is the package name used in TI.
RISC	Reduced Instruction Set Computer
RoHS	Restriction of Hazardous Substances Directive
ROM	Read Only Memory
RSSI	Received Signal Strength Indicator
RX	Receive
SFD	Start of Frame Delimiter
SHR	Synchronization Header
SI	Serial In
SO	Serial Out
SPI	Serial Peripheral Interface
S-PQFP	Plastic Quad Flat Pack
T/R	Transmit / Receive
TBD	To Be Decided / To Be Defined
TX	Transmit
UI	User Interface
VCO	Voltage Controlled Oscillator
VGA	Variable Gain Amplifier
XOSC	Crystal Oscillator
LR	Low Rate
NaN	Not any Number

2 References

[1] IEEE std. 802.15.4 - 2003: Wireless Medium Access Control (MAC) and Physical Layer (PHY) specifications for Low Rate Wireless Personal Area Networks (LR-WPANs)
http://standards.ieee.org/getieee802/download/802.15.4-2003.pdf

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

[3] CC2420 datasheet
http://www.ti.com/lit/pdf/swrs041

[4] NIST FIPS Pub 197: Advanced Encryption Standard (AES), Federal Information Processing Standards Publication 197, US Department of Commerce/N.I.S.T., November 26, 2001.
http://csrc.nist.gov/publications/fips/fips197/fips-197.pdf

[5] CC2520 reference designs
http://focus.ti.com/docs/prod/folders/print/cc2520.html#applicationnotes

[6] CC2520 Errata note
http://www.ti.com/lit/pdf/swrz024

[7] CC2520 Product folder
http://focus.ti.com/docs/prod/folders/print/cc2520.html

[8] NIST software package for randomness testing:
http://csrc.nist.gov/rng/

[9] The diehard software package for randomness testing:
http://stat.fsu.edu/~geo/diehard.html

[10] MSP430F2618 Product folder
http://focus.ti.com/docs/prod/folders/print/msp430f2618.html

[11] 2.4 GHz Inverted F Antenna
http://www.ti.com/lit/pdf/swru120

[12] Antenna selection guide
http://www.ti.com/lit/pdf/swra161

3 Features

2394-2507MHz transceiver

- DSSS transceiver
- 250kbps data rate, 2 MChip/s chip rate
- O-QPSK with half sine pulse shaping modulation
- Very low current consumption
  RX (receiving frame, -50 dBm): 18.5 mA
  RX (waiting for frame): 22.3 mA
  TX (+5 dBm output power): 33.6 mA
  TX (0 dBm output power): 25.8 mA
- Three flexible power modes for reduced power consumption
- Low power fully static CMOS design
- Very good sensitivity (-98dBm)
- High adjacent channel rejection (49 dB)
- High alternate channel rejection (54 dB)
- On chip VCO, LNA, PA and filters.
- Low supply voltage (1.8 - 3.8 V)
- Programmable output power up to +5 dBm
- I/Q direct conversion transceiver

Small Size

- QFN 28 (RHD) package, 5 x 5 mm
- Very few external components
    - minimized number of passives
    - Only reference crystal needed
- Clock output for other ICs to limit the number of crystals needed in a system
- No external filters needed.

Easy and Flexible User Interface

- 4-wire SPI
- Serial clock up to 8 MHz
- 6 GPIO pins with full flexibility
- Interrupt generator
- Full control of automatic responses to different events
- Embedded packet sniffer mode
- CC2420 compatibility mode

Data Processing Unit For Advanced Data Handling

- Spacious (768 byte) on-chip RAM allows powerful on-chip frame processing
- 128 byte transmit data FIFO
- 128 byte receive data FIFO
- Full read and write access to RAM
- 128 bit AES

IEEE 802.15.4 MAC Hardware Support

- Automatic preamble generator
- Synchronization word insertion and detection
- CRC-16 computation and verification over the MAC payload
- Frame filtering
- Automatic ACK and setting of the pending-bit
- Clear Channel Assessment (CCA)
- Energy detection / RSSI
- Link Quality Indication (LQI)
- Fully automatic MAC security (CTR, CBC-MAC, CCM)

Development Tools

- See product folder [7]

Suited For Use in Systems That Target Compliance to the Following Standards

- IEEE 802.15.4 PHY
- ETSI EN 300 328
- ETSI EN 300 440 class 2
- FCC CFR47 part 15
- ARIB STD-T66

4 Absolute Maximum Ratings

over operating free-air temperature range unless otherwise noted (1)

PARAMETER	LIMITS	UNIT
Supply voltage (2)	-0.3 to 3.9	V
Voltage on any digital pin	-0.3 to VDD + 0.3 (Max 3.9)	V
Voltage on 1.8 V pins	-0.3 to 2.0	V
Input RF level	+10	dBm
Storage temperature range	-50 to 150	°C
Reflow soldering temperature	260	°C
ESD HBM	800	V
ESD CDM	500	V
ESD MM	100	V

1) Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
2) All voltage values are with respect to network ground terminal.

This device has limited built-in gate protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

5 Electrical Characteristics

Note that these characteristics are only valid when using the recommended register settings presented in section 28.1.

5.1 Recommended Operating Conditions

PARAMETER	MIN	NOM	MAX	UNIT
Operating supply voltage	1.8		3.8	V
Ambient temperature	-40		125	°C

5.2 DC Characteristics

T_A =25°C, VDD=3.0 V, f_c=2440 MHz if nothing else stated. All parameters measured on Texas Instruments' CC2520 EM 2.1 reference design with 50 Ω load.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Logic "1" input voltage	Valid for all pads (both GPIOs and fixed-input pads)			80%	of VDD
Logic "0" input voltage	Valid for all pads (both GPIOs and fixed-input pads)	30%			of VDD
Input pad hysteresis	Only for fixed-input pads like RESET_N, CSn etc		0.5		V
Logic "0" input current	Input equals 0V	-25		25	nA
Logic "1" input current	Input equals VDD	-25		25	nA

5.3 Wake-Up and Timing

T_A =25°C, VDD=3.0 V, f_c =2440 MHz if nothing else stated. All parameters measured on Texas Instruments' CC2520 EM 2.1 reference design with 50 Ω load.

PARAMETER	COMMENTS	MIN	TYP	MAX	UNIT
LPM2 → AM time	Internal regulator startup time + XOSC startup time		0.3		ms
LPM1 → AM time	XOSC startup time		0.2		ms
AM → RX time				192	µs
AM → TX time				192	µs
RX/TX turnaround time				192	µs
TX/RX turnaround time				192	µs
Radio bit rate			250		kbps
Radio chip rate			2.0		MChip/s

5.4 Current Consumptions

T_A =25°C, VDD=3.0 V, f_c =2440 MHz if nothing else stated. All parameters measured on Texas Instruments' CC2520 EM 2.1 reference design with 50 Ω load.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Receive current	Wait for sync		22.3	24.8	mA
	T_A=-40 to 125°C, VDD=1.8 to 3.8 V, f_c =2394 to 2507 MHz			26.3	mA
	Wait for sync, Low-current RX setting		18.8		mA
	Receving frame, -50 dBm input level		18.5		mA
Transmit current	0 dBm setting		25.8	28.8	mA
	+5 dBm setting		33.6	37.2	mA
	T_A=-40 to 125°C, VDD=1.8 to 3.8 V, f_c =2394 to 2507 MHz			37.5	mA
Active Mode current	XOSC on, digital regulator on.		1.6	1.9	mA
	T_A=-40 to 125°C, VDD=1.8 to 3.8 V, f_c =2394 to 2507 MHz			2.6	mA

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
LPM1 current	XOSC off, digital regulator on. State retention.		175	250	µA
	T_A=-40 to 125°C, VDD=1.8 to 3.8 V, f_c =2394 to 2507 MHz			1000	µA
LPM2 current	XOSC off, digital regulator off. No state retention.		30	120	nA
	T_A=-40 to 125°C, VDD=1.8 to 3.8 V, f_c =2394 to 2507 MHz			4.5	µA

5.5 Receive Parameters

T_A =25°C, VDD=3.0 V, f_c =2440 MHz if nothing else stated. All parameters measured on Texas Instruments' CC2520 EM 2.1 reference design with 50 Ω load.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Receiver sensitivity	[2] requires -85 dBm	-99	-98	-95	dBm
	T_A=-40 to 125°C, VDD=1.8 to 3.8V, f_c =2394 to 2507 MHz			-88	dBm
Saturation	[2] requires -20 dBm		6		dBm
Interferer Rejection	Wanted signal 3 dB above the sensitivity level, 802.15.4 modulated interferer at 802.15.4 channels:				
	±5 MHz from wanted signal. [2] requires 0 dB		49		dB
	±10 MHz from wanted signal. [2] requires 30 dB		54		dB
	±20MHz or above. Wanted signal at -82dBm.		55		dB
Maximum Spurious Emission	30 – 1000 MHz		< -80		dBm
Conducted measurement in a 50Ω single ended load. Complies with EN 300 328, EN 300 440 class 2, FCC CFR47, Part 15 and ARIB STD-T-66	1 – 12.75 GHz		-56		dBm
Frequency error tolerance	Input level is 3 dB above sensitivity level.		+/-400		kHz
IIP3			-24		dBm

5.6 Frequency Synthesizer Parameters

T_A =25°C, VDD=3.0 V, f_c =2440 MHz if nothing else stated. All parameters measured on Texas Instruments' CC2520 EM 2.1 reference design with 50 Ω load.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Phase noise. Unmodulated carrier	At ±1 MHz offset from carrier		-111		dBc/Hz
	At ±2 MHz offset from carrier		-118		dBc/Hz
	At ±5 MHz offset from carrier		-128		dBc/Hz
RF Frequency range	Programmable in 1 MHz steps. Use 5 MHz steps for compliance with [2].	2394		2507	MHz

5.6.1 Transmit Parameters

T_A =25°C, VDD=3.0 V, f_c =2440 MHz if nothing else stated. All parameters measured on Texas Instruments' CC2520 EM 2.1 reference design with 50 Ω load.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Output power	0 dBm setting	-3	1	5	dBm
Note: to reduce the output power variation over temperature, it is suggested that different settings are used at different temperatures. The on-chip temperature sensor can be used for this purpose. Please see section 5.11 for more information.	+5 dBm setting	2	5	7	dBm
	T_A=-40 to 85°C, VDD=2.0 to 3.8 V, f_c =2394 to 2507 MHz	-3		8	dBm
	T_A=-40 to 85°C , VDD=1.8 to 3.8 V, f_c =2394 to 2507 MHz	-4		8	dBm
	T_A=-40 to 125°C, VDD=2.0 to 3.8 V, f_c =2394 to 2507 MHz	-6		8	dBm
	T_A=-40 to 125°C, VDD=1.8 to 3.8 V, f_c =2394 to 2507 MHz	-9		8	dBm

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Largest spurious emission at maximum output power. Texas Instruments CC2520 EM reference design complies with EN 300 328, EN 300 440, FCC CFR47 Part 15 and ARIB STDT-66. Transmit on 2480 MHz under FCC at +5 dBm is supported by duty-cycling, or by reducing output power. The peak conducted spurious emission might violate ETSI and FCC restricted band limits at frequencies below 1GHz. All radiated spurious emissions are within the limits of ETSI/FCC/ARIB. Applications that must pass conducted requirements are suggested to use a simple 50 Ω high pass filter between matching network and RF connector.	25 MHz – 1 GHz (outside restricted bands)		-40		dBm
	25 MHz – 1 GHz (within FCC restricted bands)		-53		dBm
	47-74, 87.5-118, 174-230, 470-862 MHz (ETSI restricted bands)		-42		dBm
	1800 MHz-1900 MHz (ETSI restricted band)		-56		dBm
	5150 MHz-5300 MHz (ETSI restricted band)		-54		dBm
	At 2483.5 MHz and above (FCC restricted band)				
	f_c=2480 MHz, +5 dBm		-37		dBm
	f_c=2480 MHz, 0 dBm		-41		dBm
	At 2·RF and 3·RF (FCC restricted band)		-54		dBm
Error Vector Magnitude (EVM)	[2] requires max. 35%. Measured as defined by [2].				
	+5 dBm setting. f_c =IEEE 802.15.4 channels		6		%
	0 dBm setting. f_c =IEEE 802.15.4 channels		2		%

5.7 RSSI/CCA Parameters

T_A =25°C, VDD=3.0 V, f_c =2440 MHz if nothing else stated. All parameters measured on Texas Instruments' CC2520 EM 2.1 reference design with 50 Ω load.

PARAMETER	COMMENTS	MIN	TYP	MAX	UNIT
RSSI range			100		dB
RSSI/CCA accuracy			+/-4		dB
RSSI/CCA offset	Real RSSI = Register value - offset		76		dB
LSB value			1		dB

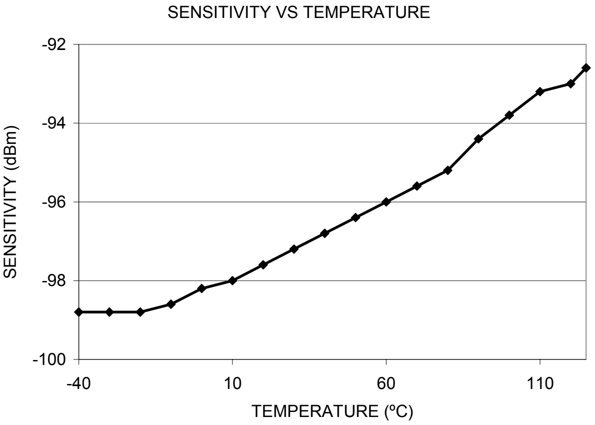
5.8 FREQEST Parameters

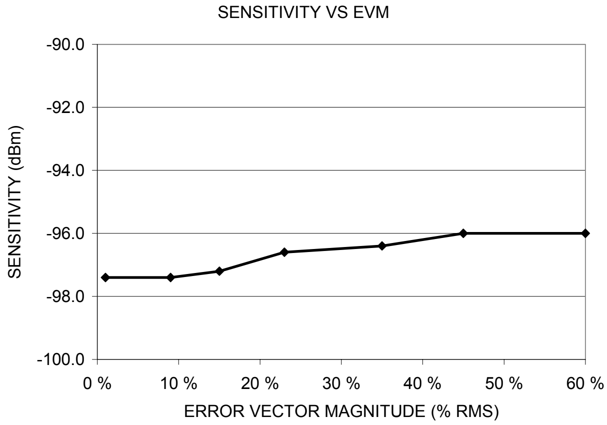
T_A =25°C, VDD=3.0 V, f_c =2440 MHz if nothing else stated. All parameters measured on Texas Instruments' CC2520 EM 2.1 reference design with 50 Ω load.

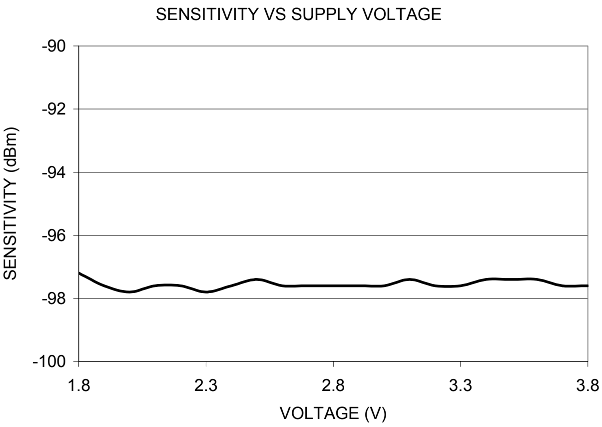
PARAMETER	COMMENTS	MIN	TYP	MAX	UNIT
FREQEST range			+/-300		kHz
FREQEST accuracy			+/-10		kHz
FREQEST offset	Real frequency offset = FREQEST value - offset		64		kHz
LSB value			7.8		kHz

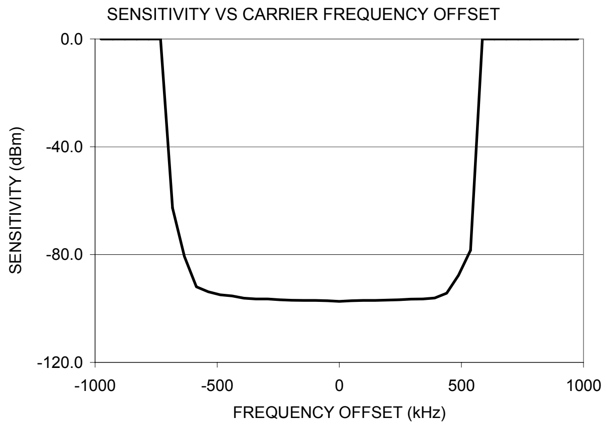
5.9 Typical Performance Curves

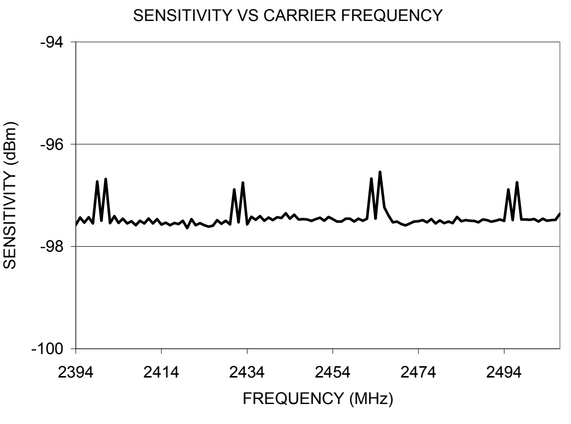
T_A =25°C, VDD=3.0 V, f_c =2440 MHz if nothing else stated. All parameters measured on Texas Instruments' CC2520 EM 2.1 reference design with 50 Ω load.

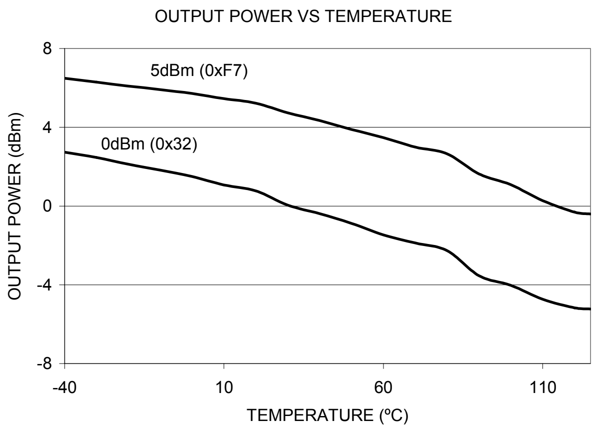


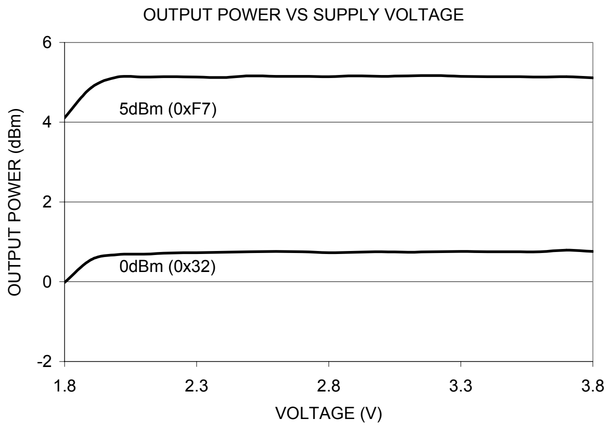


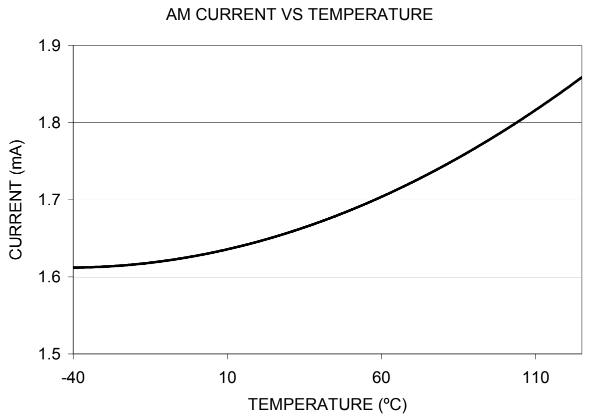


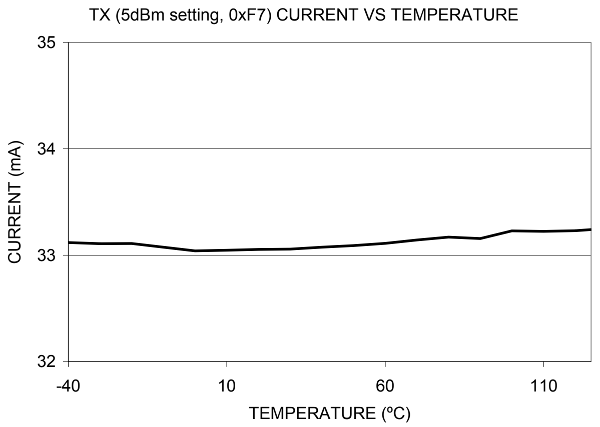


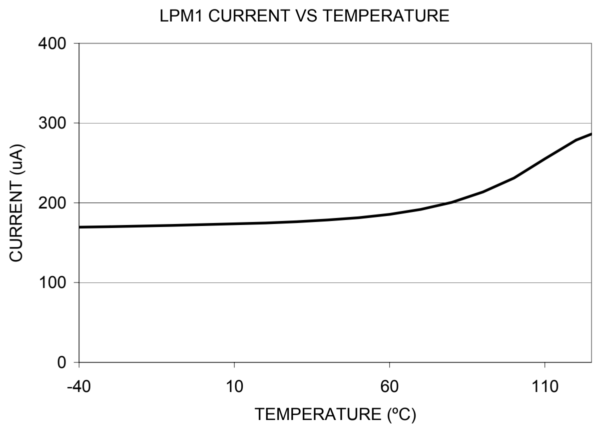


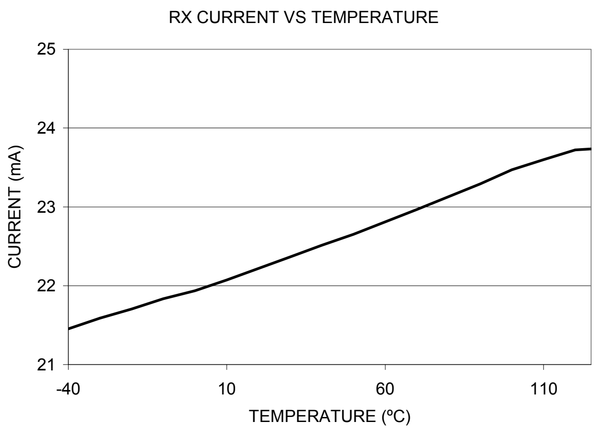


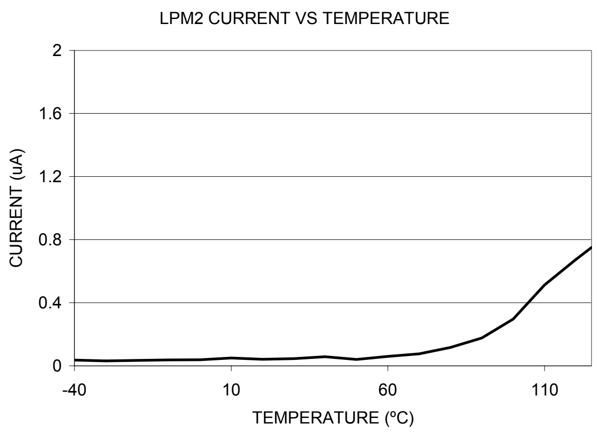

OUTPUT POWER VS SUPPLY VOLTAGE
OUTPUT POWER (dBm)
VOLTAGE (V)
5dBm (0xF7)
0dBm (0x32)
6
4
2
0
-2
1.8
2.3
2.8
3.3
3.8

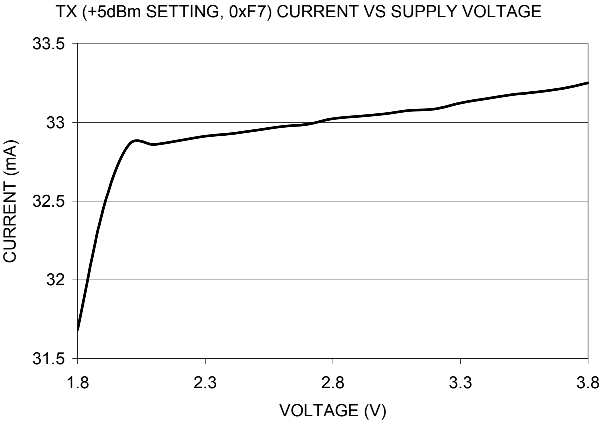

AM CURRENT VS TEMPERATURE
CURRENT (mA)
TEMPERATURE (ºC)
1.9
1.8
1.7
1.6
1.5
-40
10
60
110

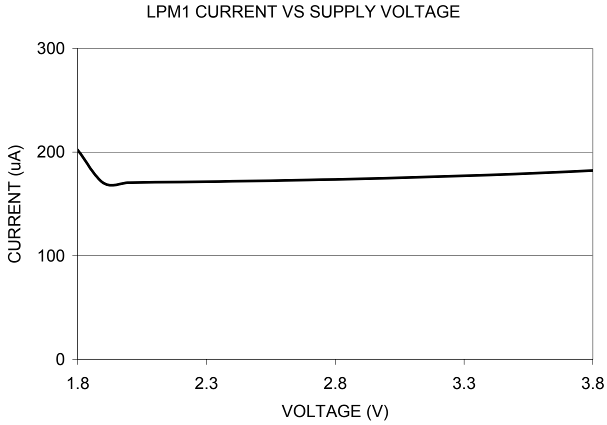

TX (5dBm setting, 0xF7) CURRENT VS TEMPERATURE
CURRENT (mA)
TEMPERATURE (ºC)
35
34
33
32
-40
10
60
110

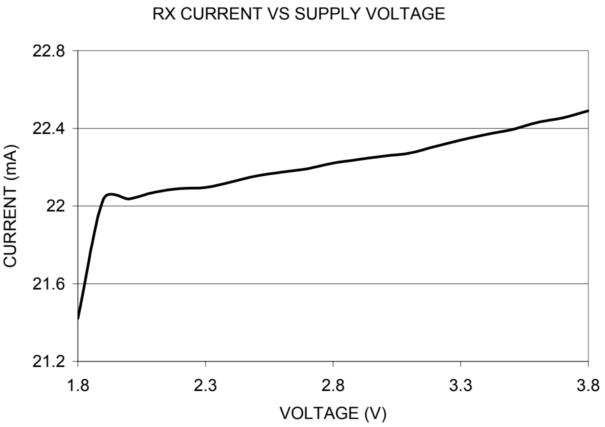

LPM1 CURRENT VS TEMPERATURE
CURRENT (uA)
TEMPERATURE (ºC)
400
300
200
100
0
-40
10
60
110

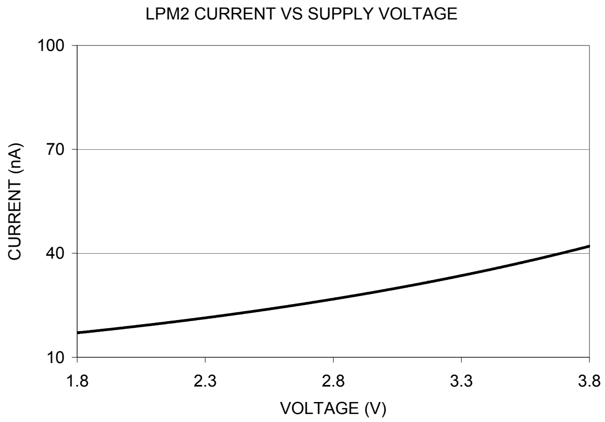

RX CURRENT VS TEMPERATURE
CURRENT (mA)
TEMPERATURE (ºC)
25
24
23
22
21
-40
10
60
110

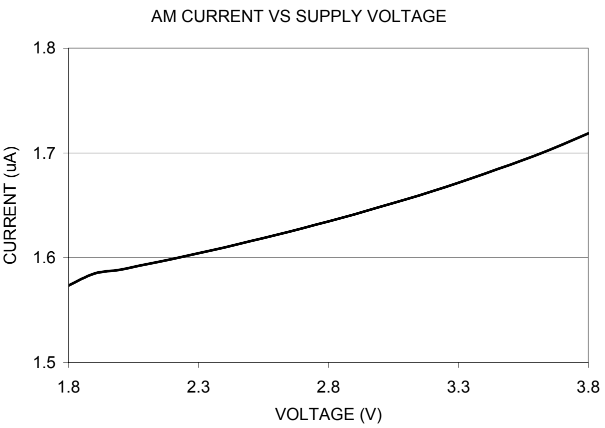

LPM2 CURRENT VS TEMPERATURE
CURRENT (uA)
TEMPERATURE (ºC)
2
1.6
1.2
0.8
0.4
0
-40
10
60
110

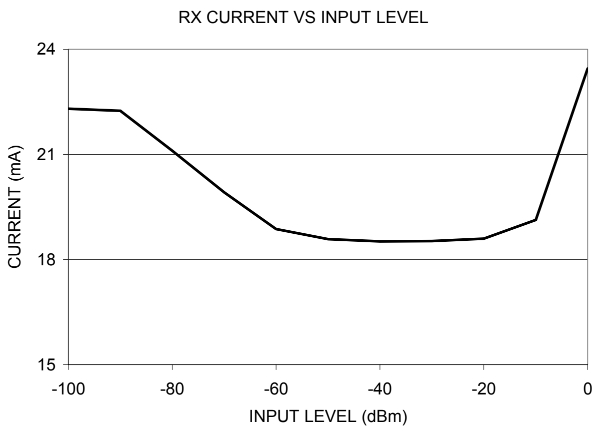

TX (+5dBm SETTING, 0xF7) CURRENT VS SUPPLY VOLTAGE
CURRENT (mA)
33.5
33
32.5
32
31.5
1.8
2.3
2.8
3.3
3.8
VOLTAGE (V)


LPM1 CURRENT VS SUPPLY VOLTAGE
CURRENT (uA)
300
200
100
0
1.8
2.3
2.8
3.3
3.8
VOLTAGE (V)

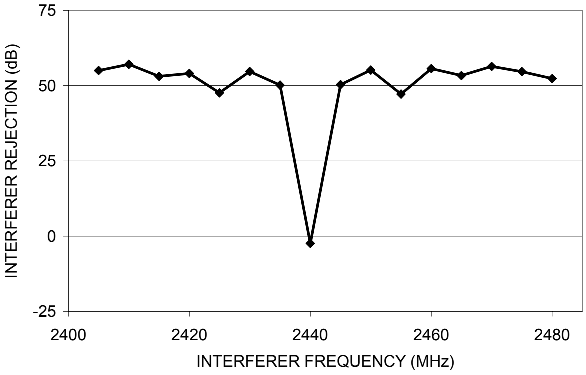

RX CURRENT VS SUPPLY VOLTAGE
CURRENT (mA)
22.8
22.4
22
21.6
21.2
1.8
2.3
2.8
3.3
3.8
VOLTAGE (V)


LPM2 CURRENT VS SUPPLY VOLTAGE
CURRENT (nA)
100
70
40
10
1.8
2.3
2.8
3.3
3.8
VOLTAGE (V)

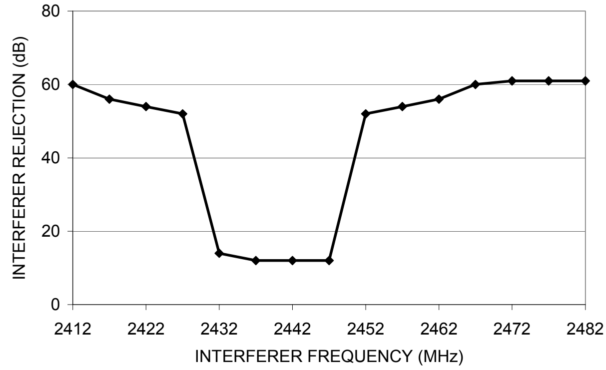

AM CURRENT VS SUPPLY VOLTAGE
CURRENT (uA)
1.8
1.7
1.6
1.5
1.8
2.3
2.8
3.3
3.8
VOLTAGE (V)


RX CURRENT VS INPUT LEVEL
CURRENT (mA)
24
21
18
15
-100
-80
-60
-40
-20
0
INPUT LEVEL (dBm)

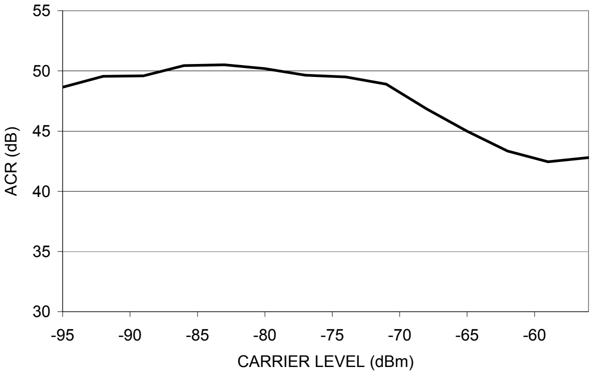
INTERFERER REJECTION (802.15.4 INTERFERER) VS INTERFERER FREQUENCY. CARRIER AT -82dBm/2440MHz.



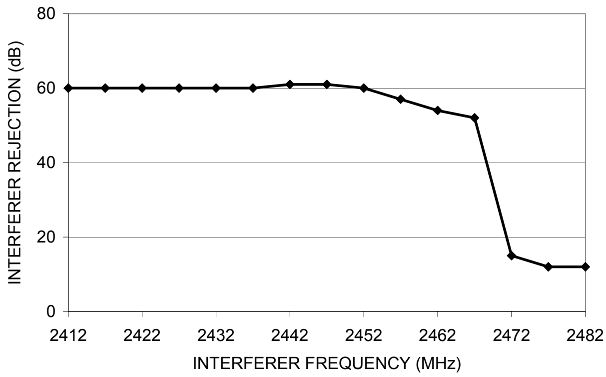
INTERFERER REJECTION VS 802.11g CARRIER AT -82dBm/2440MHz



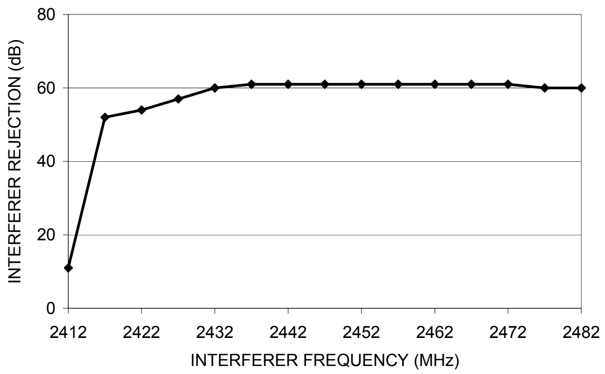
ADJACENT CHANNEL REJECTION (802.15.4 INTERFERER) VS CARRIER LEVEL



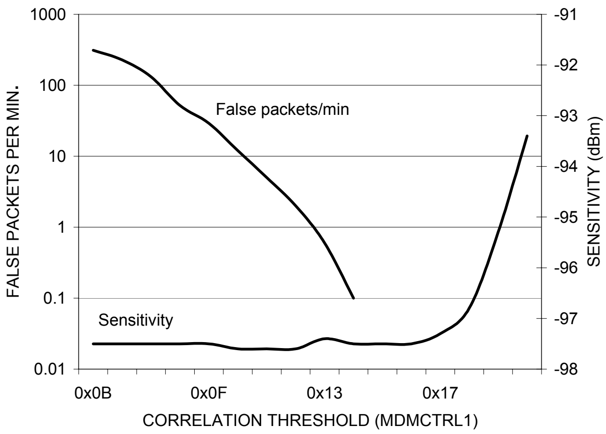
INTERFERER REJECTION VS 802.11g CARRIER AT -82dBm/2480MHz



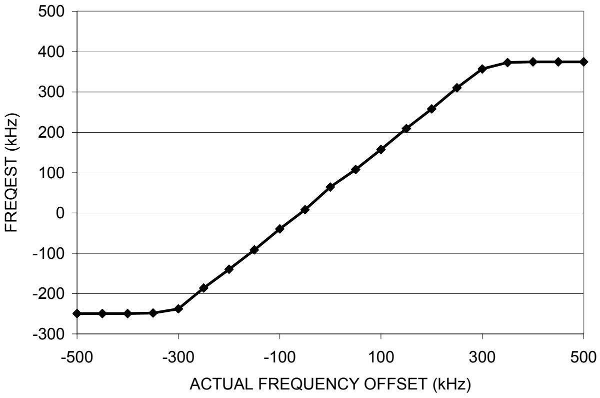
INTERFERER REJECTION VS 802.11g CARRIER AT -82dBm/2405MHz



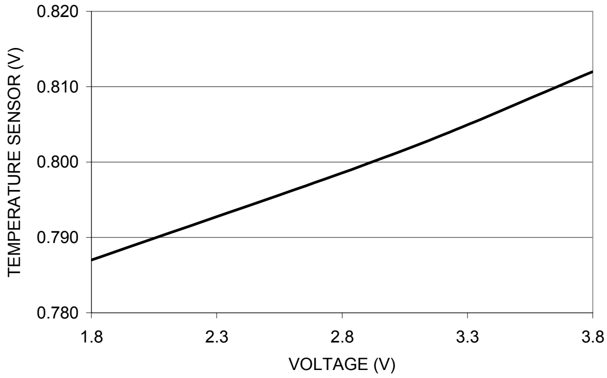
FALSE PACKET RATE AND SENSITIVITY vs CORRELATION THRESHOLD



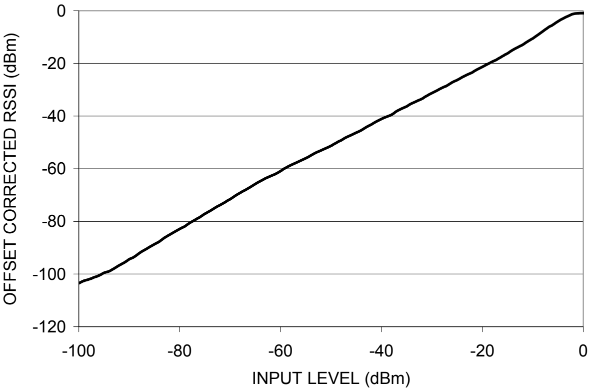
FREQEST VS ACTUAL OFFSET FREQUENCY



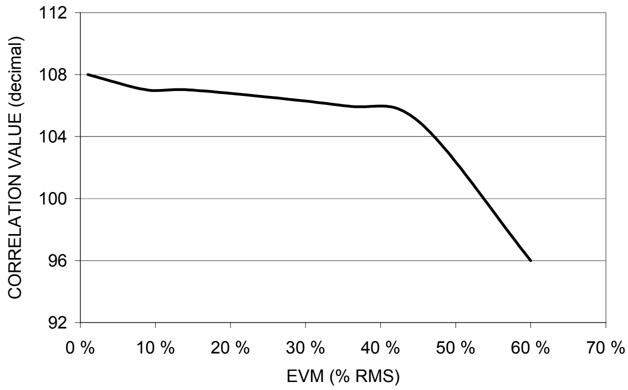
TEMPERATURE SENSOR OUTPUT VS SUPPLY VOLTAGE
(TEMPERATURE = 25ºC)



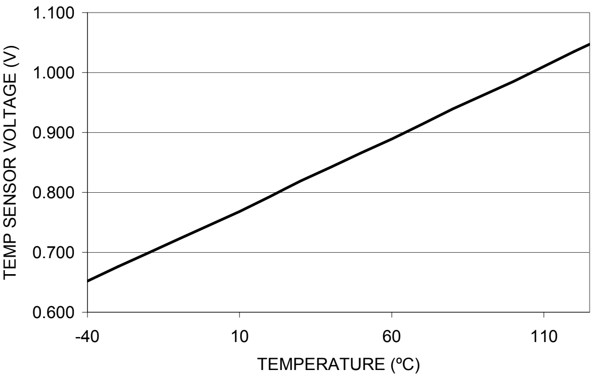
OFFSET CORRECTED RSSI VS INPUT LEVEL



CORRELATION VALUE VS ERROR VECTOR
MAGNITUDE OF INPUT SIGNAL



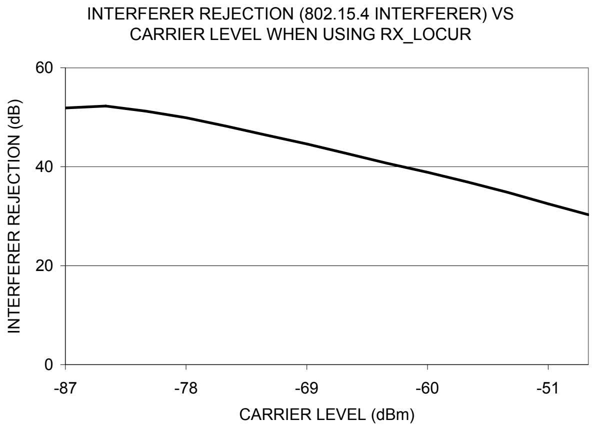
TEMPERATURE SENSOR OUTPUT VS TEMPERATURE
(SUPPLY VOLTAGE = 3V)



5.10 Low-Current Mode RX

Applications that spend more time waiting for an input signal than actually receiving it, might benefit from using the special low-current RX mode. This mode draws less current at the expense of sensitivity.

Note that when using this mode, neither RSSI nor CCA is valid. This means that these settings can not be used in conjunction with STXONCCA, for instance. Also note that the interferer rejection will drop at stronger input signal levels compared to when using the regular recommended settings.



Important: The low-current RX mode is only valid from -40 to 85ºC !

5.10.1 Low-Current RX Mode Parameters

T_A =25°C, VDD=3.0 V, f_c=2440 MHz if nothing else stated. All parameters measured on Texas Instruments' CC2520 EM 2.1 reference design with 50 Ω load.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
RX current	Wait for sync		18.8		mA
Sensitivity	[2] requires -85 dBm		-90		dBm
Interferer Rejection	Wanted signal 3 dB above the sensitivity level, 802.15.4 modulated interferer at 802.15.4 channels:				
	±5 MHz from wanted signal. [2] requires 0 dB		52		dB
	±10 MHz from wanted signal. [2] requires 30 dB		54		dB
	±20MHz or above.		55		dB

Table 1: Low-current RX mode. Use in addition to regular recommended settings.

Register	Setting (hex)	Comment
RXCTRL	33	Reduces sensitivity and current consumption
FSCTRL	12	Reduces current consumption and valid temperature range
AGCCTRL2	EB	Reduces sensitivity and current consumption

5.11 Optional Temperature Compensation of TX

Using the on-chip temperature sensor (or any other sensor), it is possible to adapt the settings to the actual temperature. This will reduce the variation in output power over temperature, which in the range -40ºC to 125ºC can be significant.

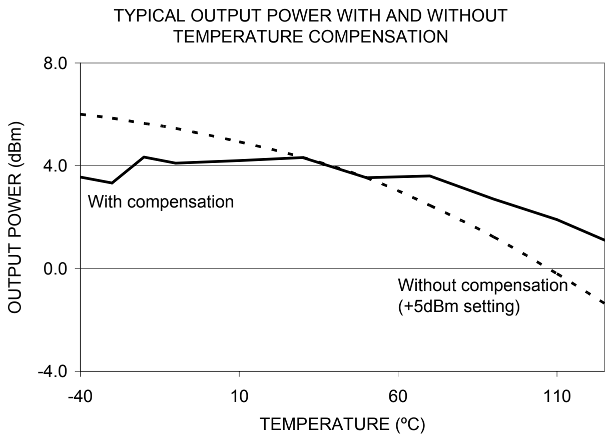
For this purpose, a TX setting only suited for high-temperature operation has been found (F7125deg). This setting should only be used above 70 degrees, but will significantly reduce the drop in output power at high temperatures.

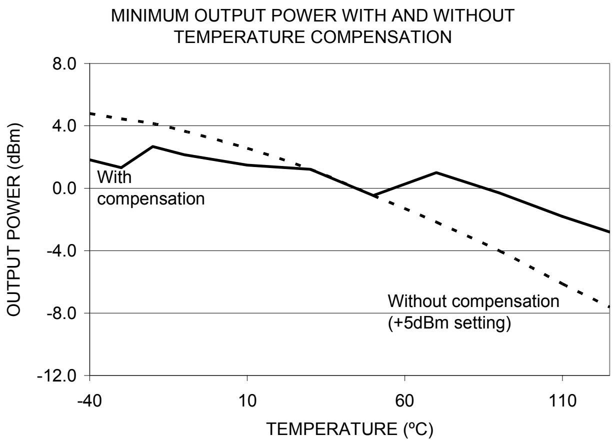
Table 2: F7125deg setting, only suited for high temperature operation (only changes from recommended settings shown)

Register	Setting (hex)	Comment
TXCTRL	94	Increased output power at high temperatures.
FSCTRL	7B	Increased output power at high temperatures.

Table 3: Suggested TXPOWER register settings for different temperatures

Temperature	-40	-30	-20	-10	10	30	50	70	90	110	125	ºC
Recommended Setting	13	13	AB	AB	F2	F7	F7	F7125deg	F7125deg	F7125deg	F7125deg	-
Typical Output Power	3.6	3.3	4.3	4.1	4.2	4.3	3.5	3.6	2.7	1.9	1.1	dBm





5.11.1 Using the Temperature Sensor

The on-chip temperature sensor can be accessed via the GPIO0 and GPIO1 pins by following this procedure:

- Configure GPIO0 and GPIO1 as inputs by writing 0x80 to the GPIOCTRL0 and GPIOCTRL1 registers.
- Enable analog output functionality for these two pins by setting GPIOCTRL.GPIO_ACTRL='1'.
- Select temperature sensor output by writing 0x01 to the ATEST register. This will make GPIO1 output GND and GPIO0 will output a voltage proportional to the temperature.
- Use an ADC in the microcontroller to measure the output voltage on GPIO0 and then calculate the temperature.

The output from the temperature sensor is shown in graph form in section 5.9, but as a basis for calculating the temperature, the following numbers can be used:

Tc=-40 – 125°C, VDD=1.8 – 3.8 V

Parameter	Min	Typ	Max	Unit
Temp sensor voltage at 25°C		0.8		V
Temp. sens. output vs temperature		25		mV/10°C
Temp. sens. output vs supply voltage		6		mV/V
Temp. sens accuracy no calibration (at fixed voltage)		+/-12		°C
Temp, sens. accuracy with 1-point calibration (at fixed voltage)		+/-1		°C

6 Crystal Specific Parameters

6.1 Crystal Requirements

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Crystal frequency			32		MHz
Crystal frequency accuracy requirement	Including initial tolerance, aging and temperature dependency, as specified by [2]. Can be relaxed using on-chip crystal tuning (see below).	- 40		40	ppm
ESR				60	Ohm
C_0				7	pF
C_L				16	pF

6.2 On-chip Crystal Frequency Tuning

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Crystal tuning range (C_{tune})	Only adding capacitance is possible		7		pF
Crystal tuning step size			0.4		pF
Crystal tuning drift	In % of applied tuning		+/-10		%
CRYSTAL TUNING USING CC2520 EM 2.1 REFERENCE DESIGN (NX3225DA, C_L = 16 pF) :					
Start-up time	NDK crystal NX3225DA, C_L=16 pF		0.2		ms
Crystal tuning step size			3		ppm
Crystal tuning range			-45		ppm
CRYSTAL TUNING USING OTHER CRYSTALS, ALL NUMBERS ARE ESTIMATES :					
Start-up time	NDK crystal NX4025DA, C_L=13 pF		0.2		ms
Crystal tuning step size			8		ppm
Crystal tuning range			-120		ppm
Start-up time	NDK crystal NX5032SA, C_L=10 pF		0.1		ms
Crystal tuning step size			10		ppm
Crystal tuning range			-160		ppm

See section 22 for further details on using the crystal oscillator.

7 Pinout

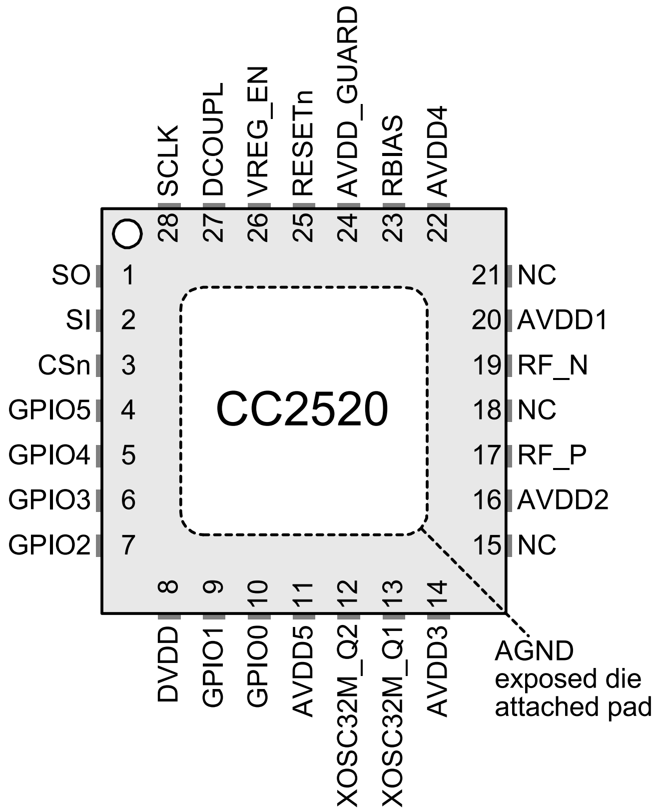


Figure 1: Pinout of CC2520 (top view)

Table 4: CC2520 Pinout

Signal	Pin #	Type	Description
			SPI
SCLK	28	I	SPI interface: Serial Clock. Maximum 8 MHz
SO	1	O	SPI interface: Serial Out
SI	2	I	SPI interface: Serial In
CSn	3	I	SPI interface: Chip Select, active low
			General Purpose digital I/O
GPIO0	10	IO	General purpose digital I/O
GPIO1	9	IO	General purpose digital I/O
GPIO2	7	IO	General purpose digital I/O
GPIO3	6	IO	General purpose digital I/O
GPIO4	5	IO	General purpose digital I/O
GPIO5	4	IO	General purpose digital I/O
			Misc
RESETn	25	I	External reset pin, active low
VREG_EN	26	I	When high, digital voltage regulator is active.
NC	15, 18, 21		Not Connected.

Signal	Pin #	Type	Description
			Analog
RBIAS	23	Analog IO	External precision bias resistor for reference current. 56 kΩ, ±1%
RF_N	19	RF IO	Negative RF input signal to LNA in receive mode Negative RF output signal from PA in transmit mode
RF_P	17	RF IO	Positive RF input signal to LNA in receive mode Positive RF output signal from PA in transmit mode
XOSC32M_Q1	13	Analog IO	Crystal oscillator pin 1
XOSC32M_Q2	12	Analog IO	Crystal oscillator pin 2
			Power/ground
AVDD	11, 14, 16, 20, 22	Power (Analog)	1.8 V to 3.8 V analog power supply connections
AVDD_GUARD	24	Power (Analog)	Power supply connection for digital noise isolation and digital voltage regulator.
DCOUPL	27	Power (Digital) O	1.6 V to 2.0 V digital power supply output for decoupling. Note: this pin can not be used to supply any external devices.
DVDD	8	Power (Digital)	1.8 V to 3.8 V digital power supply for digital pads.
AGND	Die pad	Ground (Analog)	

8 Functional Introduction

8.1 Integrated 2.4 GHz IEEE 802.15.4 Compliant Radio

CC2520 features a Direct Conversion Transceiver operating in the 2.4 GHz band with excellent receiver sensitivity and robustness to interferers. The CC2520 radio complies with the IEEE 802.15.4 PHY specification. The radio has 250 kbps data rate, 2 Mchip/s chip rate, and is suitable for systems targeting compliance with worldwide radio frequency regulations covered by ETSI EN 300 328 and EN 300 440 class 2 (Europe), FCC CFR47 Part 15 (US) and ARIB STD-T66 (Japan).

8.2 Comparison to CC2420

CC2520 represents significant improvement over the CC2420 features and performance. A comparison is given in the table below.

Table 5: Comparison of CC2420 and CC2520

Feature	CC2420	CC2520
Standard	IEEE 802.15.4-2003	IEEE 802.15.4-2006
Maximum output power	0 dB	+5 dB
Typical sensitivity	-95 dBm	-98 dBm
General clock output	No	Yes, configurable frequency 1-16MHz
User interface	Command strobes and configuration registers. All user control goes through the SPI.	Instruction set (which includes the command strobes as a subset) and configuration registers. Command strobes may be triggered by GPIO pins, which gives excellent timing control. Improved status information.
Register access	Possible without crystal oscillator running.	Only possible when crystal oscillator is running.
Digital inputs	No Schmitt triggers	Schmitt triggers on all digital inputs.
Digital outputs	Fixed configuration	Highly flexible and configurable
Start up	Manual start of XOSC	XOSC starts automatically after reset (by reset_n pin). Manual start of XOSC after SRES instruction.
Crystal frequency	16 MHz	32 MHz
Packet sniffing	No hardware support	Hardware support for non-intrusive sniffing of both transmitted and received frames.
Maximum SPI clock speed	10 MHz	8 MHz
RAM size	364 byte	768 byte
Operating voltage	2.1 – 3.6 V	1.8 – 3.8 V
Maximum operating temperature	85°C	125°C
Security	Limited flexibility	Highly flexible security instructions. More RAM available allows more flexible processing.
Package	QLP-48, 7x7 mm	QFN 28 (RHD), 5x5 mm
RF frequency range	2400-2483.5 MHz	2394-2507 MHz