

Using the CC1190 Front End with CC112x and CC120x under FCC 15.247

By Torstein Ermesjø

Keywords

- *Range Extender*
- *FCC Section 15.247*
- *External PA*
- *External LNA*
- *CC1120*
- *CC1121*
- *CC1125*
- *CC120x*
- *CC1190*

1 Introduction

The CC112x family of devices is fully integrated single-chip radio transceivers designed for high performance at very low power and low voltage operation in cost effective wireless systems. All filters are integrated, removing the need for costly external IF filters. The device is mainly intended for the ISM (Industrial, Scientific and Medical) and SRD (Short Range Device) frequency bands at 164-192 MHz, 410-480 MHz and 820-960 MHz.

The CC1190 is a range extender for 850-950 MHz RF transceivers, transmitters, and System-on-Chip devices from Texas Instruments. It increases the link budget by providing a power amplifier (PA) for increased output power, and a low-noise amplifier (LNA) with low noise figure for

improved receiver sensitivity in addition to switches and RF matching for simple design of high performance wireless systems.

This application note outlines the expected performance when using a CC1120-CC1190 design under FCC Section 15.247 in the 902-928 MHz frequency band. This application note assumes the reader is familiar with CC1120 and FCC 15.247 regulatory limits. The reader is referred to [1] and [5] for details.

The application note is also applicable for CC1121, CC1125, and CC120x.

Table of Contents

KEYWORDS.....	1
1 INTRODUCTION.....	1
2 ABBREVIATIONS.....	2
3 ABSOLUTE MAXIMUM RATINGS.....	3
4 ELECTRICAL SPECIFICATIONS.....	3
4.1 OPERATING CONDITIONS.....	3
4.2 CURRENT CONSUMPTION.....	3
4.3 RECEIVE PARAMETERS.....	4
4.3.1 <i>Typical RX Performance vs. Temperature and VDD.....</i>	<i>5</i>
4.3.2 <i>Received Signal Strength Indicator (RSSI).....</i>	<i>9</i>
4.4 TRANSMIT PARAMETERS.....	11
4.4.1 <i>Typical TX Performance vs. Temperature and VDD.....</i>	<i>12</i>
4.4.2 <i>Duty Cycling.....</i>	<i>16</i>
4.4.3 <i>Typical TX Parameters vs. Load Impedance.....</i>	<i>17</i>
4.5 MEASUREMENT EQUIPMENT.....	19
5 CONTROLLING THE CC1190.....	19
6 SMARTRF STUDIO AND TRXEB.....	19
6.1 SMARTRF STUDIO.....	19
6.2 TRXEB.....	20
7 REFERENCE DESIGN.....	20
7.1 POWER DECOUPLING.....	20
7.2 INPUT/ OUTPUT MATCHING AND FILTERING.....	20
7.3 BIAS RESISTOR.....	21
7.4 SAW FILTER.....	21
7.5 PCB LAYOUT CONSIDERATIONS.....	21
7.6 SHIELDING.....	21
8 DISCLAIMER.....	22
9 REFERENCES.....	22
10 GENERAL INFORMATION.....	22
10.1 DOCUMENT HISTORY.....	22

2 Abbreviations

EB	Evaluation Board
EM	Evaluation Module
FCC	Federal Communications Commission
HGM	High Gain Mode
LNA	Low Noise Amplifier
LGM	Low Gain Mode
PA	Power Amplifier
PCB	Printed Circuit Board
PER	Packet Error Rate
RF	Radio Frequency
RSSI	Receive Signal Strength Indicator
RX	Receive, Receive Mode
TrxEB	SmartRF Transceiver EB
TX	Transmit, Transmit Mode

3 Absolute Maximum Ratings

The absolute maximum ratings and operating conditions listed in the CC1120 datasheet [1] and the CC1190 datasheet [3] 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 the characteristics in Chapter 4 are only valid when using the CC1120-CC1190EM 915 MHz reference design [4] and register settings recommended by the SmartRF Studio software [6].

4.1 Operating Conditions

Parameter	Min	Max	Unit
Operating Frequency	850	950	MHz
Operating Supply Voltage	2.0	3.6	V
Operating Temperature	-40	+85	°C

Table 4.1. Operating Conditions

4.2 Current Consumption

$T_C = 25^\circ\text{C}$, $V_{DD} = 3.0\text{ V}$, $f = 915\text{ MHz}$ if nothing else is stated. All parameters are measured on the CC1120-CC1190EM 915 MHz reference design [4] with a $50\ \Omega$ load.

Parameter	Condition	Typical	Unit
Receive Current, HGM ¹	1.2 kbps, 2FSK, $\pm 4\text{ kHz}$ deviation	24	mA
	50 kbps, 2GFSK, $\pm 25\text{ kHz}$ deviation	25	mA
	200 kbps, 4GFSK, $\pm 82.76\text{ kHz}$ deviation	25	mA
Receive Current, LGM	1.2 kbps, 2FSK, $\pm 4\text{ kHz}$ deviation	23	mA
	50 kbps, 2GFSK, $\pm 25\text{ kHz}$ deviation	24	mA
	200 kbps, 4GFSK, $\pm 82.76\text{ kHz}$ deviation	24	mA
Transmit Current	PA_CFG2 = 0x77 (+26dBm)	401	mA
	PA_CFG2 = 0x71 (+25dBm)	361	
	PA_CFG2 = 0x6B (+24dBm)	317	
	PA_CFG2 = 0x67 (+23dBm)	284	
	PA_CFG2 = 0x63 (+22dBm)	232	
	PA_CFG2 = 0x60 (+21dBm)	253	
	PA_CFG2 = 0x5D (+20dBm)	210	
	PA_CFG2 = 0x5A (+19dBm)	190	
	PA_CFG2 = 0x58 (+18dBm)	177	
	PA_CFG2 = 0x55 (+17dBm)	160	
PA_CFG2 = 0x53 (+16dBm)	150		
Power Down Current		370	nA

Table 4.2. Current Consumption

¹ Input signal at -80 dBm

4.3 Receive Parameters

$T_C = 25^\circ\text{C}$, $V_{DD} = 3.0\text{ V}$, $f = 915\text{ MHz}$ if nothing else is stated. All parameters are measured on the CC1120-CC1190EM 915 MHz reference design [4] with a $50\ \Omega$ load.

Parameter	Condition	Typical	Unit
Sensitivity ² , HGM	1.2 kbps, 2FSK, $\pm 4\text{ kHz}$ deviation, 10 kHz RX filter bandwidth. See Figure 4.1	-125.5	dBm
	9.6 kbps, 4GFSK, $\pm 2.1\text{ kHz}$ deviation, 9.615 kHz RX filter bandwidth	-118.1	dBm
	50 kbps, 2GFSK, $\pm 25\text{ kHz}$ deviation, 100 kHz RX filter bandwidth. See Figure 4.2	-112.2	dBm
	150 kbps, 4GFSK, $\pm 82.76\text{ kHz}$ deviation, 200 kHz RX filter bandwidth	-106.8	dBm
	200 kbps, 4GFSK, $\pm 82.76\text{ kHz}$ deviation, 200 kHz RX filter bandwidth	-105.7	dBm
	4.8 kbps, ASK, 66.6 kHz RX filter bandwidth	-117.1	dBm
Sensitivity ² , LGM	1.2 kbps, 2FSK, $\pm 4\text{ kHz}$ deviation, 10 kHz RX filter bandwidth	-113.9	dBm
	50 kbps, 2GFSK, $\pm 25\text{ kHz}$ deviation, 100 kHz RX filter bandwidth	-100.8	dBm
	200 kbps, 4GFSK, $\pm 82.76\text{ kHz}$ deviation, 200 kHz RX filter bandwidth	-94.3	dBm
Saturation, HGM	Maximum input power level for 1% BER	+10	dBm
Saturation, LGM	Maximum input power level for 1% BER	+10	dBm
Selectivity and Blocking, HGM	1.2 kbps, 2FSK, $\pm 4\text{ kHz}$ deviation (see Figure 4.7 and Figure 4.8) $\pm 2\text{ MHz}$ from wanted signal $\pm 10\text{ MHz}$ from wanted signal	74 80	dB
	50 kbps, 2GFSK, $\pm 25\text{ kHz}$ deviation (see Figure 4.9 and Figure 4.10) $\pm 2\text{ MHz}$ from wanted signal $\pm 10\text{ MHz}$ from wanted signal	65 68	dB
Spurious emission, HGM	Radiated measurement @3.6 GHz	-61	dBm

Table 4.3. Receive Parameters

² Sensitivity limit is defined as 1% bit error rate (BER). Packet length is 3 bytes.

Application Note AN110

4.3.1 Typical RX Performance vs. Temperature and VDD

$T_C = 25^\circ\text{C}$, $V_{DD} = 3.0\text{ V}$, $f = 915\text{ MHz}$ if nothing else is stated. All parameters are measured on the CC1120-CC1190EM 915 MHz reference design [4] with a $50\ \Omega$ load.

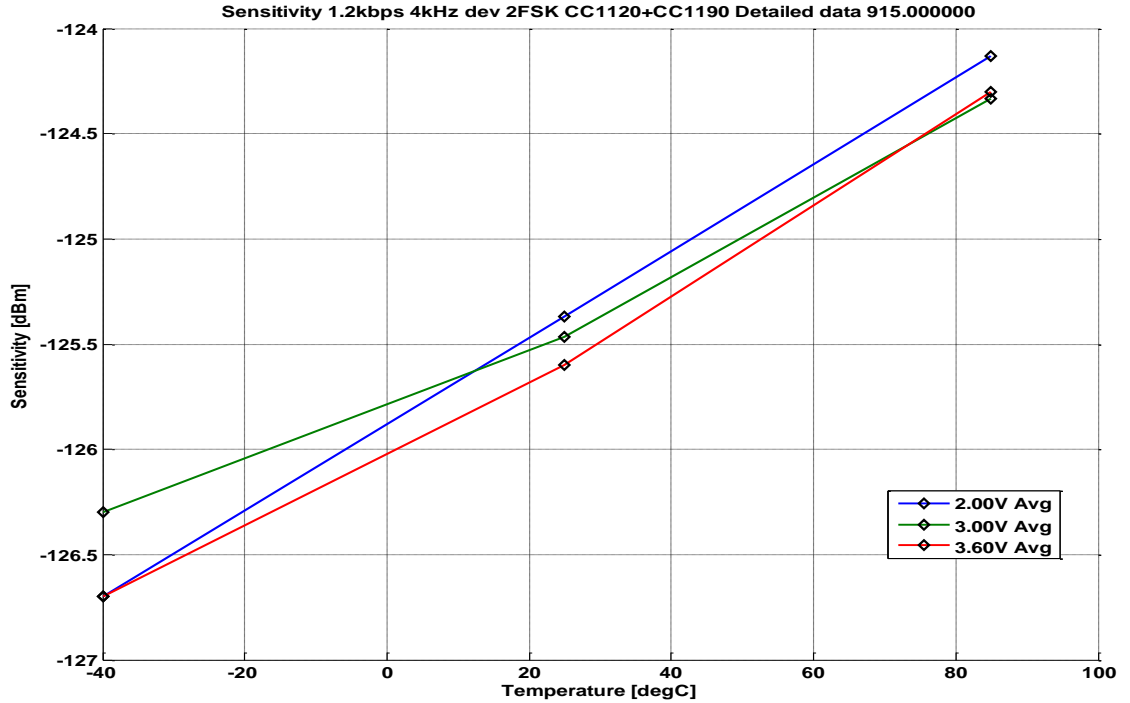


Figure 4.1. Typical Sensitivity vs. Temperature and Power Supply Voltage, HGM, 1.2 kbps

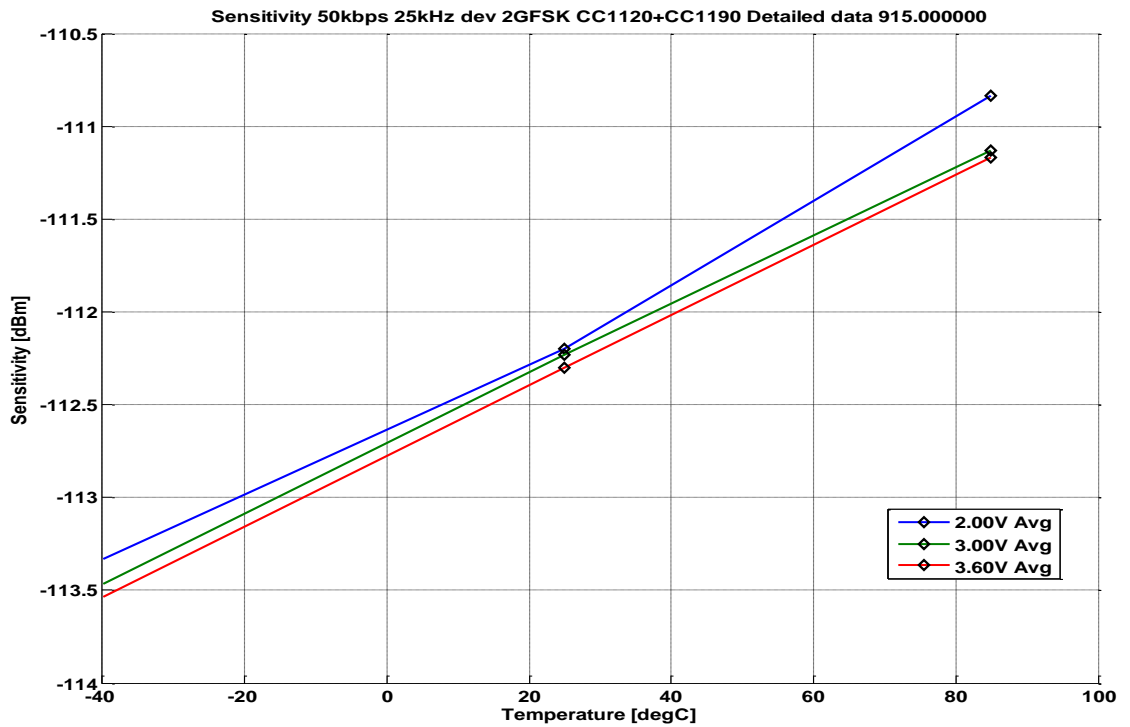


Figure 4.2. Typical Sensitivity vs. Temperature and Power Supply Voltage, HGM, 50 kbps

Application Note AN110

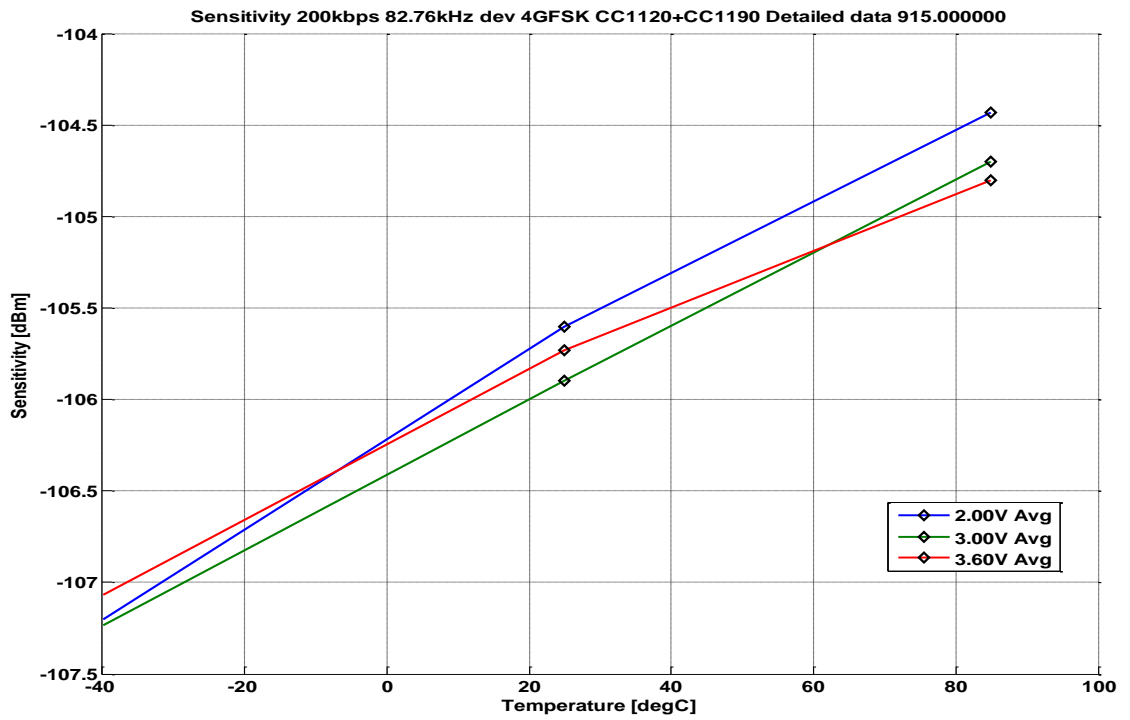


Figure 4.3. Typical Sensitivity vs. Temperature and Power Supply Voltage, HGM, 200 kbps

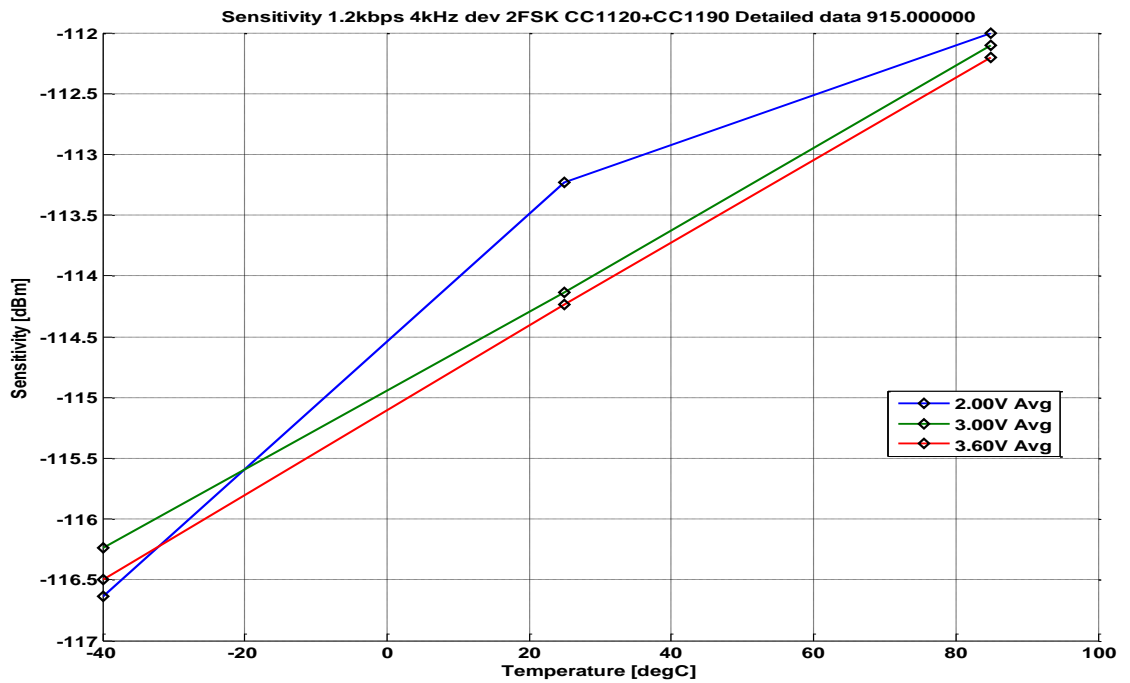


Figure 4.4. Typical Sensitivity vs. Temperature and Power Supply Voltage, LGM, 1.2 kbps

Application Note AN110

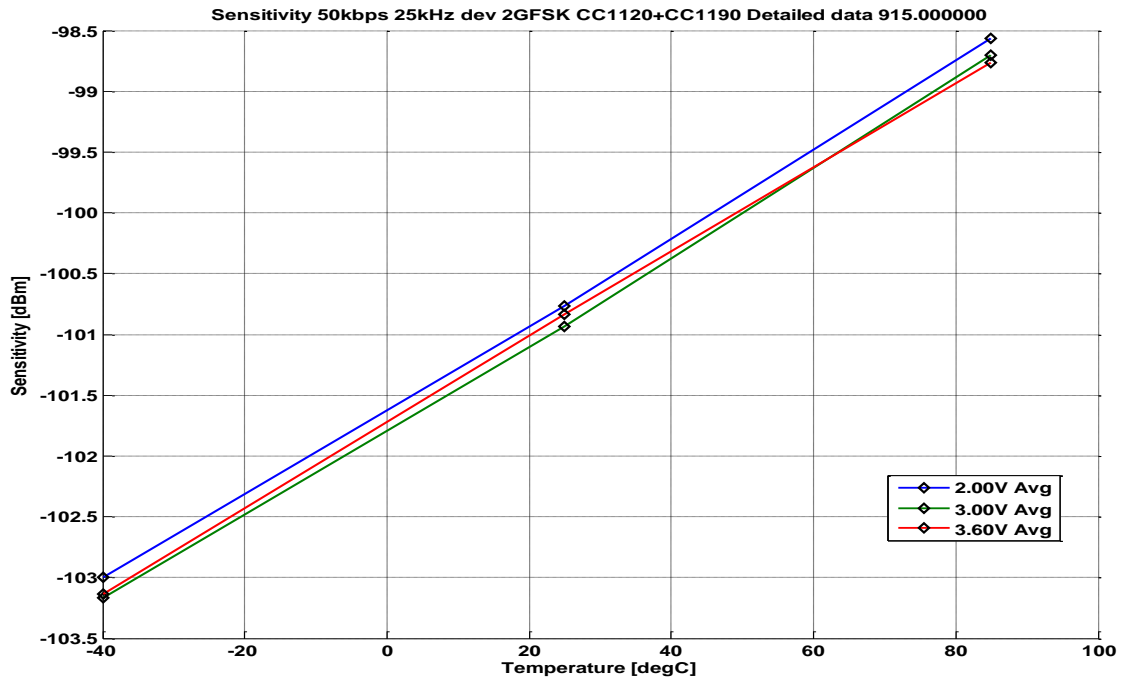


Figure 4.5. Typical Sensitivity vs. Temperature and Power Supply Voltage, LGM, 50 kbps

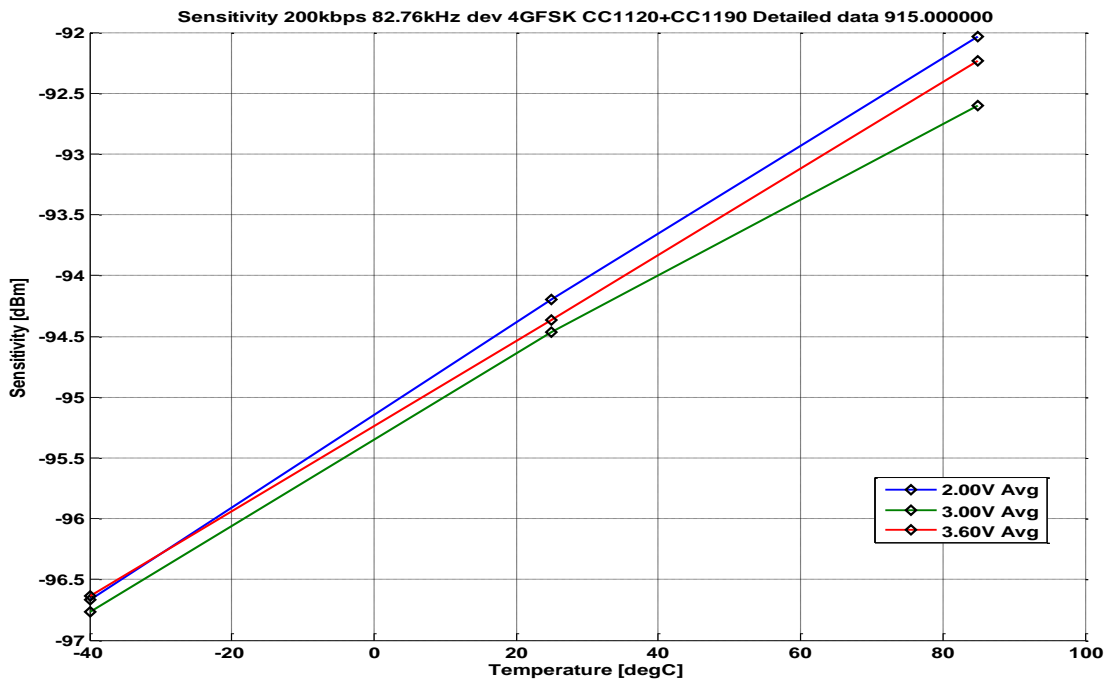


Figure 4.6. Typical Sensitivity vs. Temperature and Power Supply Voltage, LGM, 200 kbps

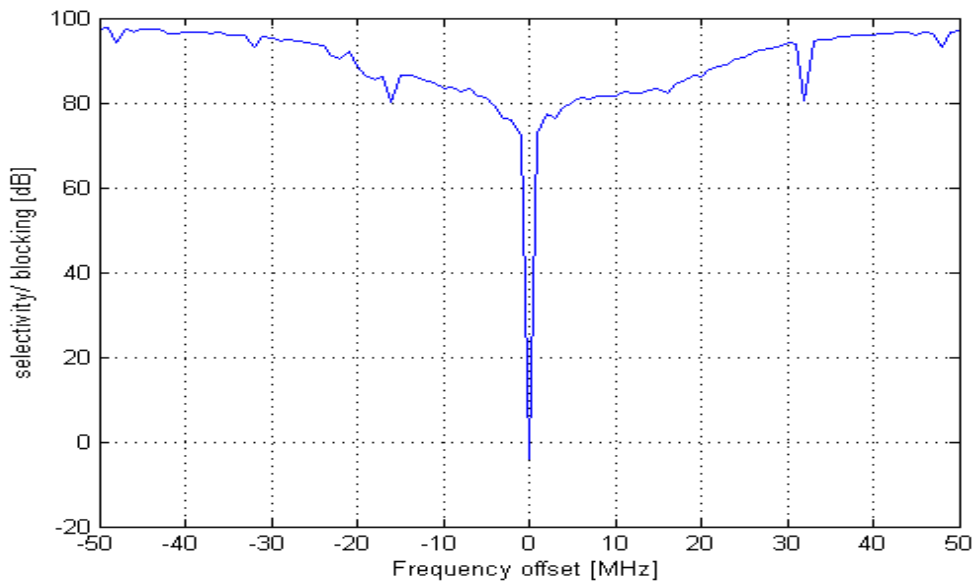


Figure 4.7. Typical Blocking, 1.2 kbps

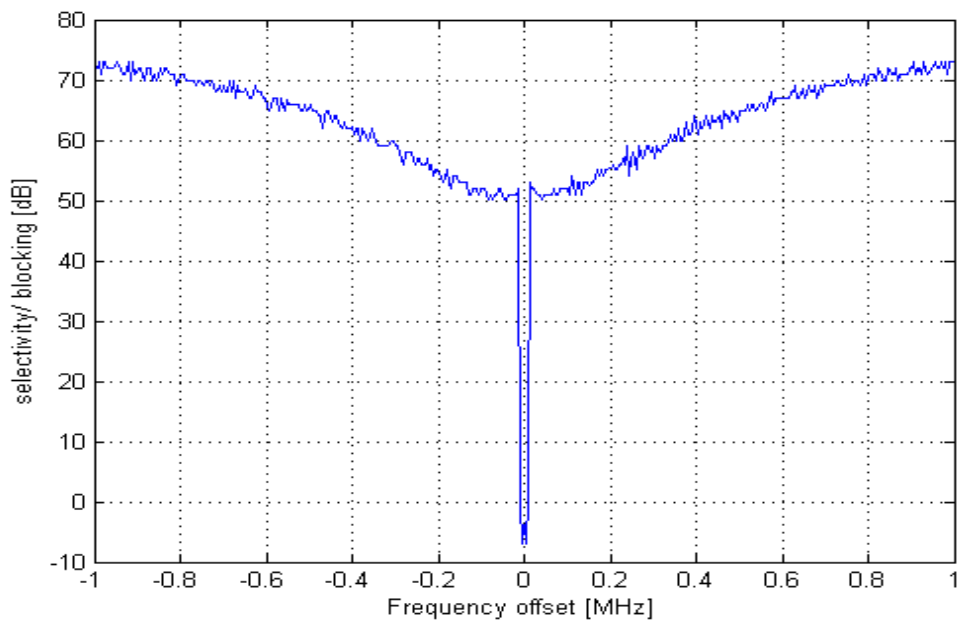


Figure 4.8. Typical Selectivity, 1.2 kbps

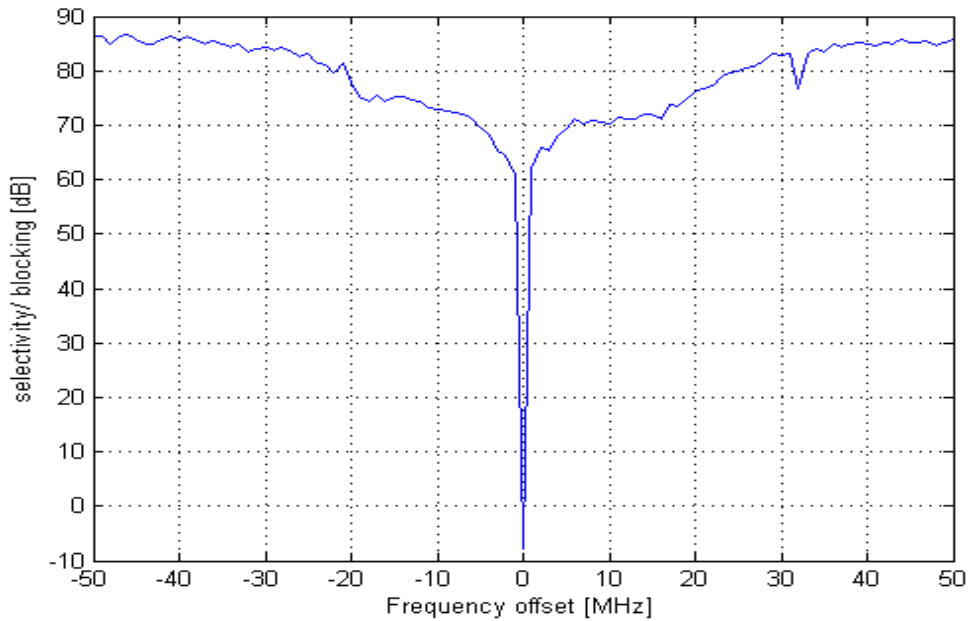


Figure 4.9. Typical Blocking, 50 kbps

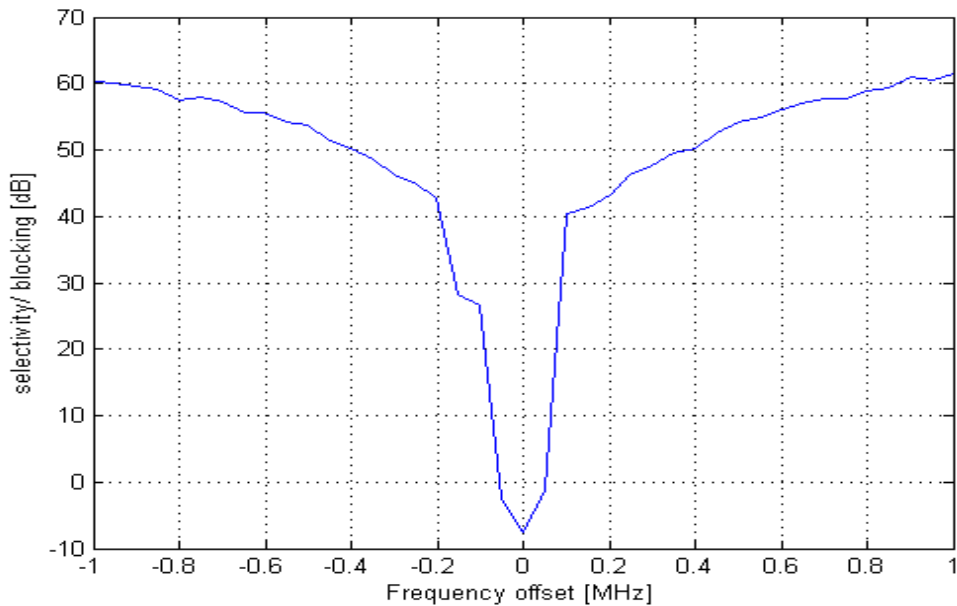


Figure 4.10. Typical Selectivity, 50 kbps

4.3.2 Received Signal Strength Indicator (RSSI)

The CC1120-CC1190 RSSI readouts can be converted to an absolute level in dBm by subtracting an offset. A CC1120-CC1190 design has a different offset value compared to a standalone CC1120 design due to the CC1190 external LNA gain and the SAW filter insertion loss. Table 4.4 gives the typical offset value for HGM and LGM. Refer to the CC1120 data sheet [1] for more details on how to convert the RSSI readout to an absolute power level in dBm.

Application Note AN110

HGM	LGM
107.5	91.5

Table 4.4. Typical RSSI Offset Values

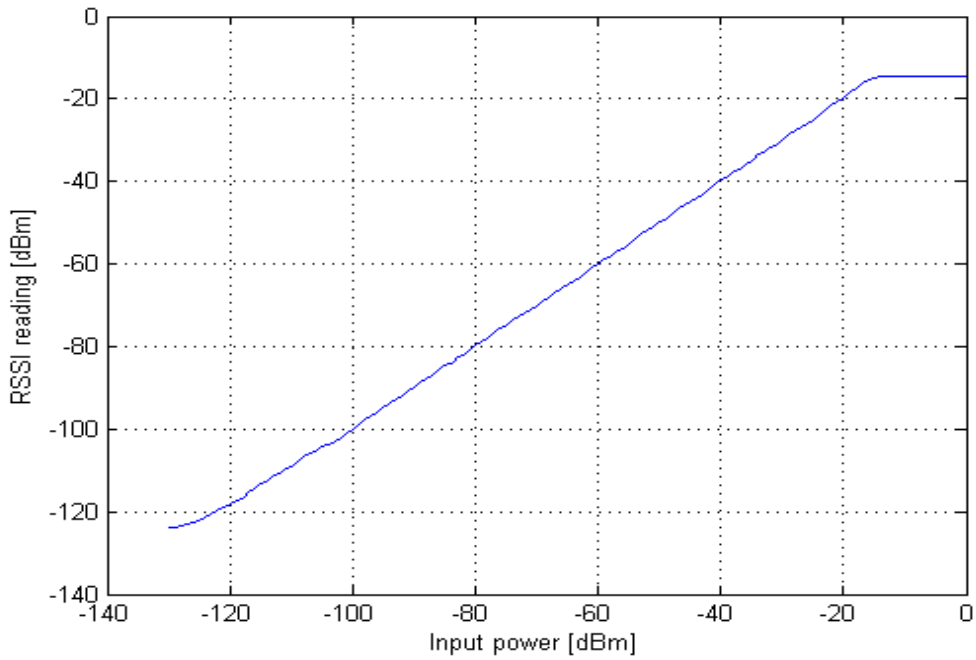


Figure 4.11. Typical RSSI vs. Input Power Level, HGM, 1.2 kbps, 20 kHz RX BW

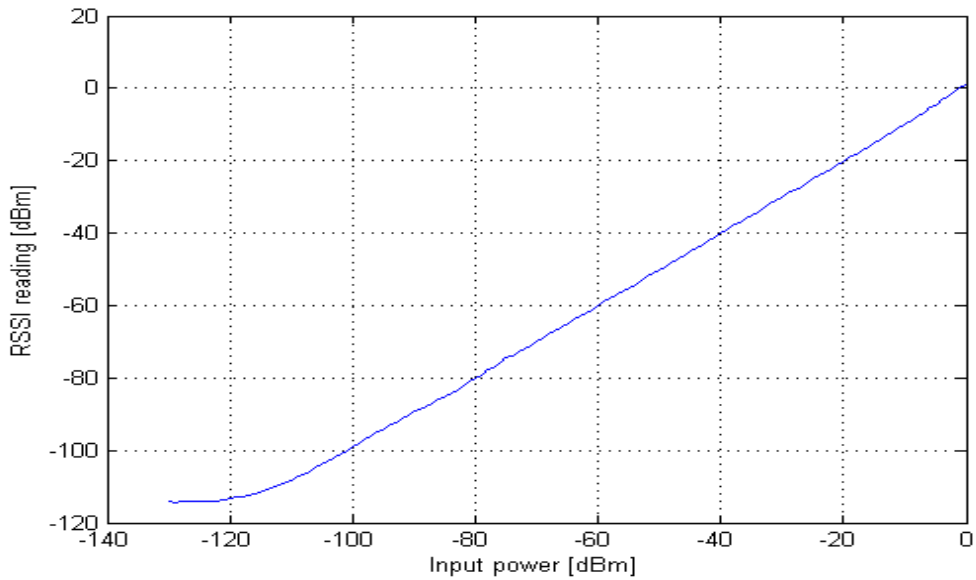


Figure 4.12. Typical RSSI vs. Input Power Level, LGM, 1.2 kbps, 20 kHz RX BW

4.4 Transmit Parameters

$T_C = 25^\circ\text{C}$, $V_{DD} = 3.0\text{ V}$, $f = 915\text{ MHz}$ if nothing else is stated. All parameters are measured on the CC1120-CC1190EM 915 MHz reference design [4] with a $50\ \Omega$ load, except for the load-pull measurements. Radiated measurements are done with the kit antenna.

Parameter	Condition	Typical	Unit
Output power; HGM	PA_CFG2 = 0x77, 3.6 V	27.0	dBm
	PA_CFG2 = 0x77	25.7	
	PA_CFG2 = 0x71	25.0	
	PA_CFG2 = 0x6B	24.0	
	PA_CFG2 = 0x67	23.1	
	PA_CFG2 = 0x63	22.0	
	PA_CFG2 = 0x60	21.1	
	PA_CFG2 = 0x5D	20.1	
	PA_CFG2 = 0x5A	19.0	
	PA_CFG2 = 0x58	18.2	
	PA_CFG2 = 0x55	17.0	
	PA_CFG2 = 0x53	16.1	
Efficiency, HGM	PA_CFG2 = 0x77	31	%
	PA_CFG2 = 0x71	29	
	PA_CFG2 = 0x6B	27	
	PA_CFG2 = 0x67	24	
	PA_CFG2 = 0x63	21	
	PA_CFG2 = 0x60	19	
Spurious emission with PATABLE = 0x6B, HGM	Conducted below 1 GHz	-65	dBm
	Conducted above 1 GHz	-52	
	Conducted 2 nd harmonic	-10	
	Conducted 3 rd harmonic	-47	
	Radiated 2 nd harmonic	-22	
	Radiated 3 rd harmonic	-44	
20 dB bandwidth, HGM	1.2 kbps, 2FSK, $\pm 4\text{ kHz}$ deviation	12.5	kHz
	9.6 kbps, 4GFSK, $\pm 2.1\text{ kHz}$ deviation	9.6	
	50 kbps, 2GFSK, $\pm 25\text{ kHz}$ deviation	115	
	150 kbps, 4GFSK, $\pm 82.76\text{ kHz}$ deviation	250	
	200 kbps, 4GFSK, $\pm 82.76\text{ kHz}$ deviation	320	
Stability, HGM Maximum VSWR with PA_CFG = 0x77	+85°C:		
	VDD: 3.6 V	7	
	VDD: 3.0 V	10	
	+25°C:		
	VDD: 3.6 V	7	
	VDD: 3.0 V	5	
	-40°C:		
	VDD: 3.6 V	4	
	VDD: 3.0 V	2.8	

Table 4.5. Transmit Parameters

Application Note AN110

4.4.1 Typical TX Performance vs. Temperature and VDD

$T_C = 25^\circ\text{C}$, $V_{DD} = 3.0\text{ V}$, $f = 915\text{ MHz}$ if nothing else is stated. All parameters are measured on the CC1120-CC1190EM 915 MHz reference design [4] with a $50\ \Omega$ load.

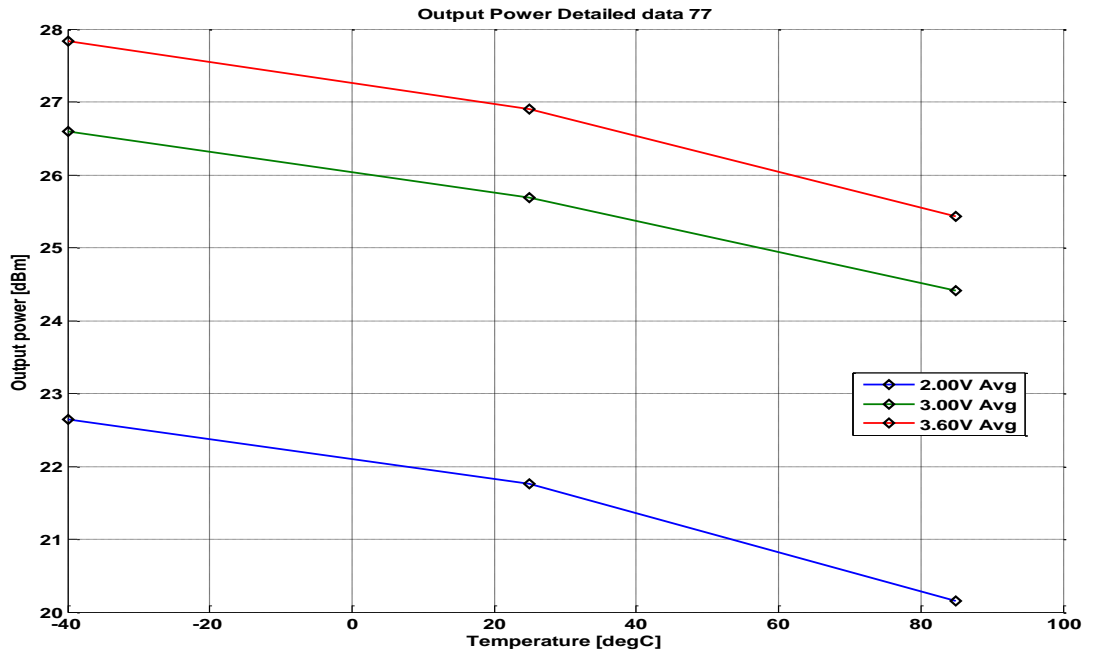


Figure 4.13. Typical Output Power vs. Temperature and Power Supply Voltage. PA_CFG2 = 0x77

Application Note AN110

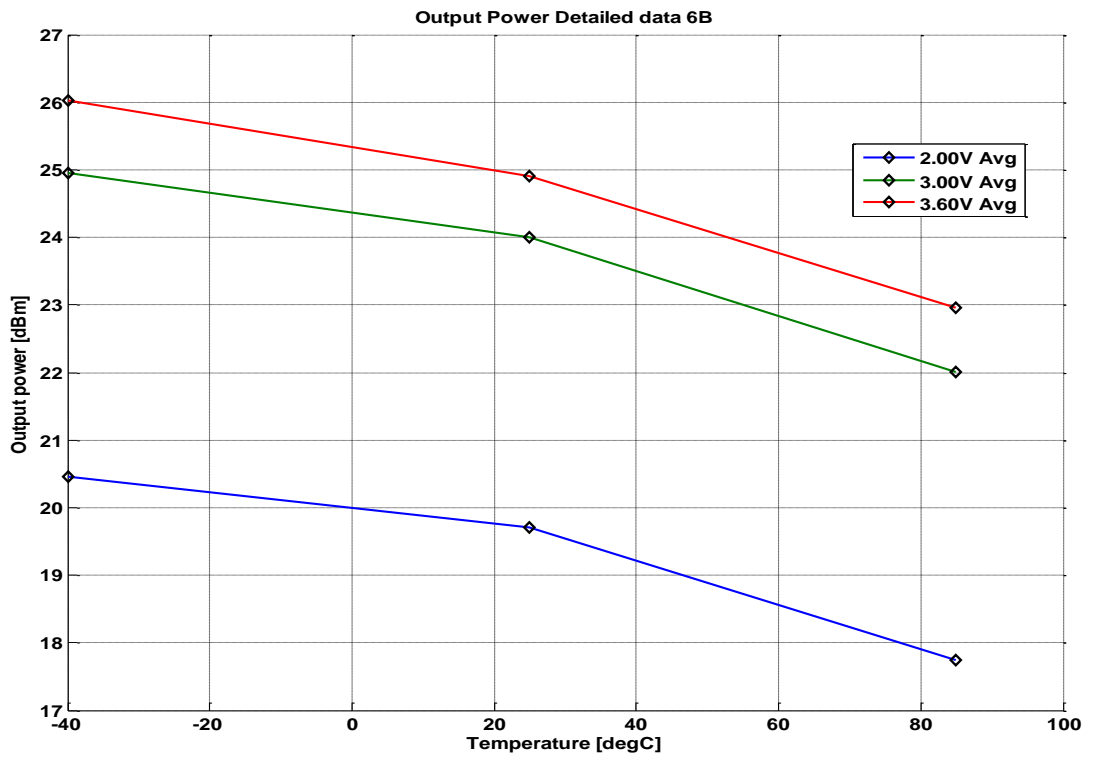


Figure 4.14. Typical Output Power vs. Temperature and Power Supply Voltage. PA_CFG2 = 0x6B

Application Note AN110

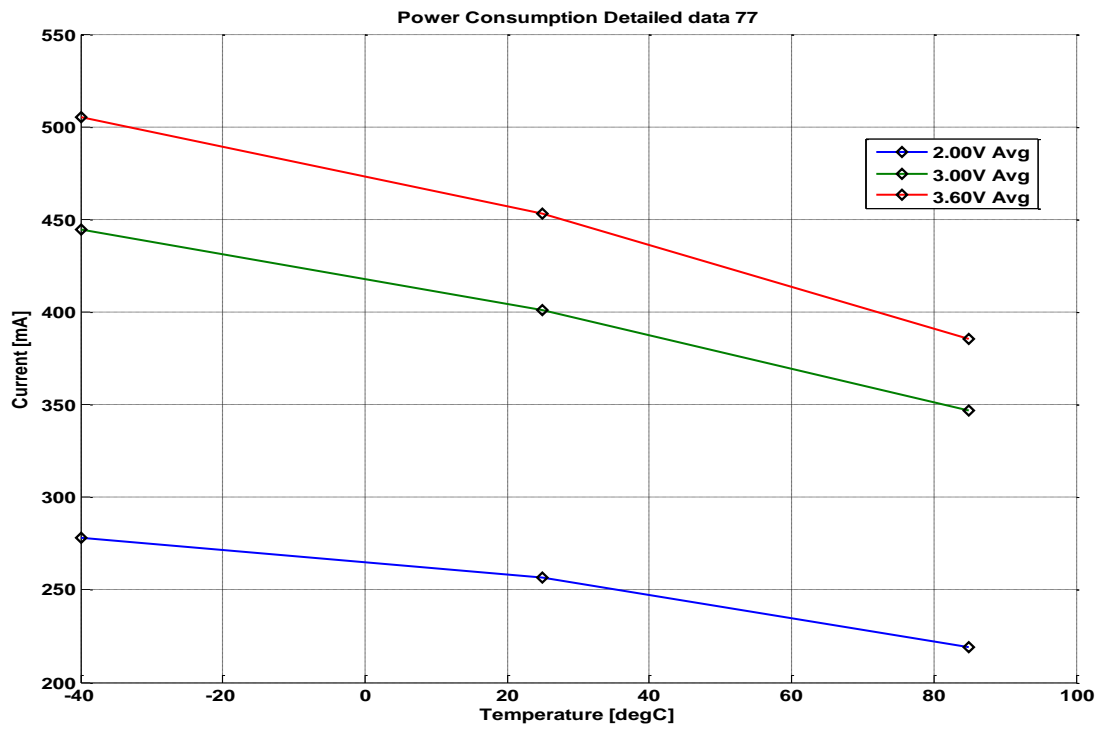


Figure 4.15. Typical TX Current Consumption vs. Temperature and Power Supply Voltage.
PA_CFG2 = 0x77

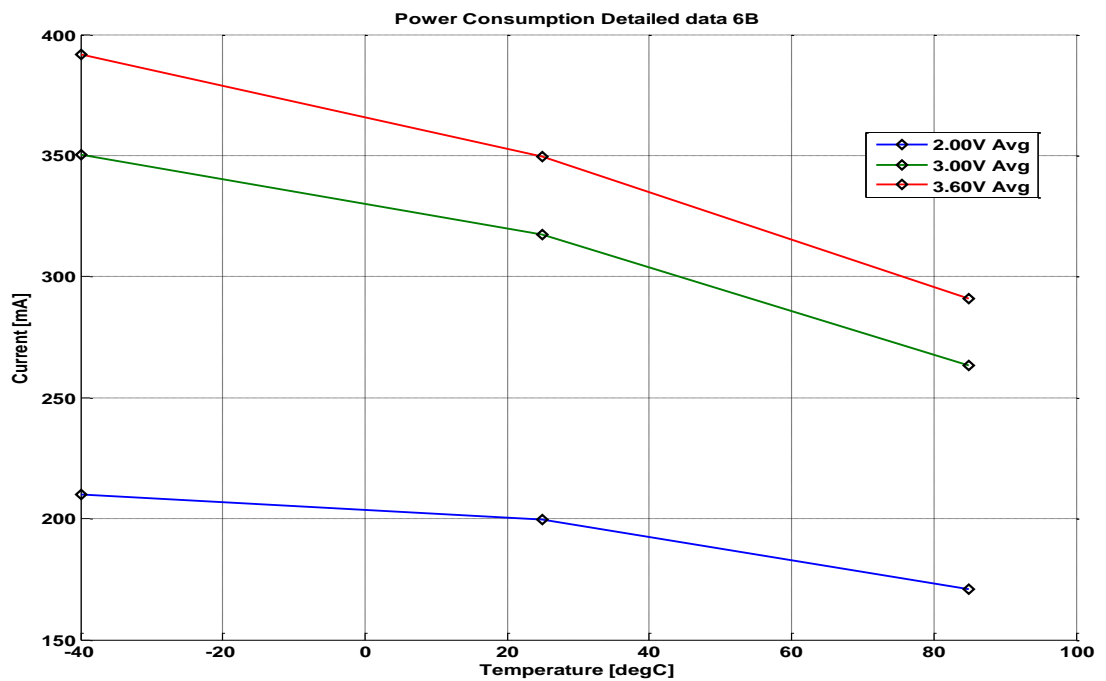
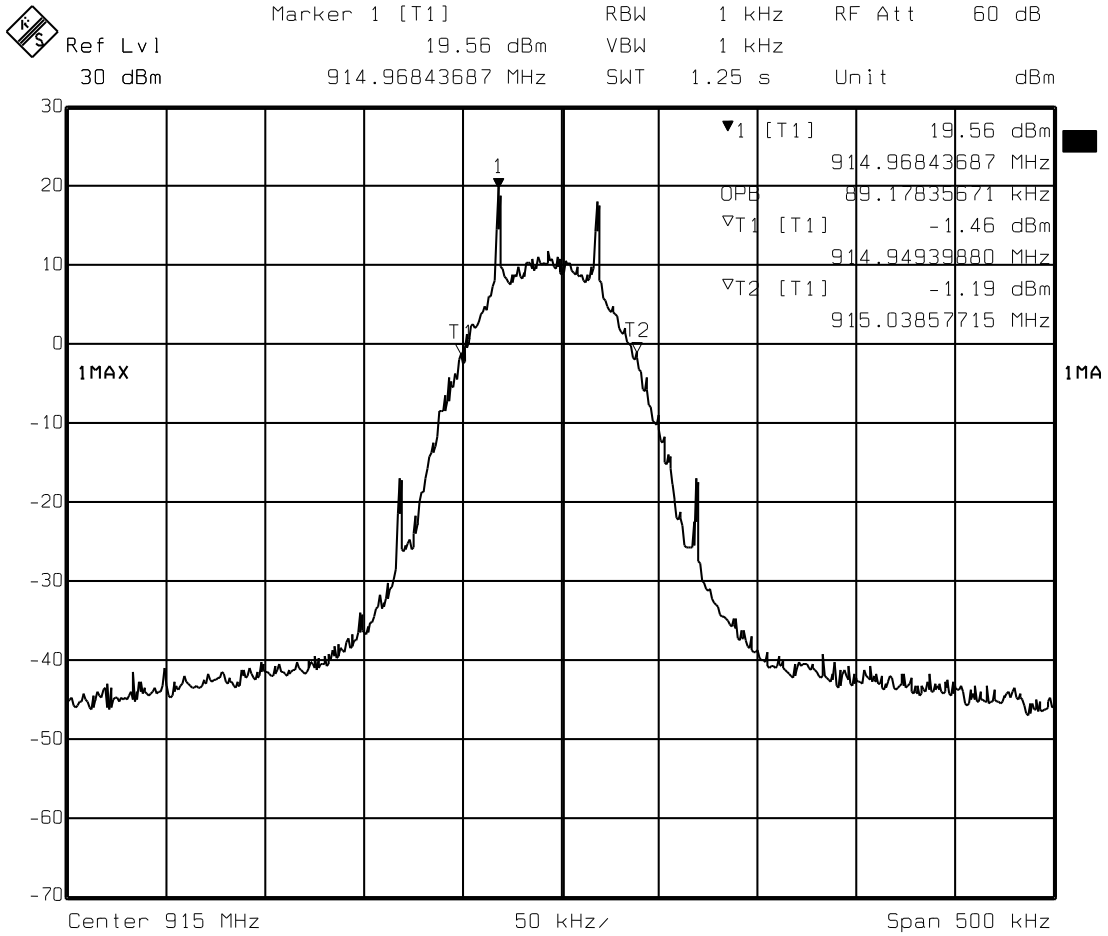


Figure 4.16. Typical TX Current Consumption vs. Temperature and Power Supply Voltage.
PA_CFG2 = 0x6B

Application Note AN110



Date: 11.OCT.1911 07:23:01

Figure 4.17. 20 dB Bandwidth, 50 kbps, PA_CFG2 = 0x6B. Measured According to FCC 15.247

4.4.2 Duty Cycling

Section 15.209 gives the general limits for the emission of intentional or unintentional radiators. Above 960 MHz the limit is -41.2 dBm (500 uV/m at 3 m distance). When operating under Section 15.247 the spurious emission must be 20 dB below the carrier unless it falls within one of the restricted bands defined in Section 15.205. When operating in the 902-928 MHz frequency range the 3rd, 4th, 5th, and 6th harmonics fall within restricted bands. In the restricted bands the general limits of -41.2 dBm apply.

Pulsed transmissions allow higher peak harmonic and spurious emissions above 1 GHz because an averaging detector is called for in the measurements. The average limit must be below -41.2 dBm, but maximum peak spurious level for pulsed transmission is 20 dB above the average limit. If the duty cycle factor of the periodic signal is known, measuring the peak value and adding a duty cycle relaxation factor determines the average value. The relaxation factor applies to the TX on-time as measured over a 100 ms period. The relaxation factor is 20 log (TX on-time/100 ms) [dB].

As an example, a 50 % duty cycle allows for 6 dB higher peak emission than without duty cycling. Figure 4.18 gives the relaxation factor for different transmission on-times over a 100 ms period.

If the TX on-time is above 100 ms duty cycle relaxation cannot be applied and the maximum output power, when using the CC1120+CC1190 915 MHz reference design, is limited to approximately +24 dBm (see Table 4.5).

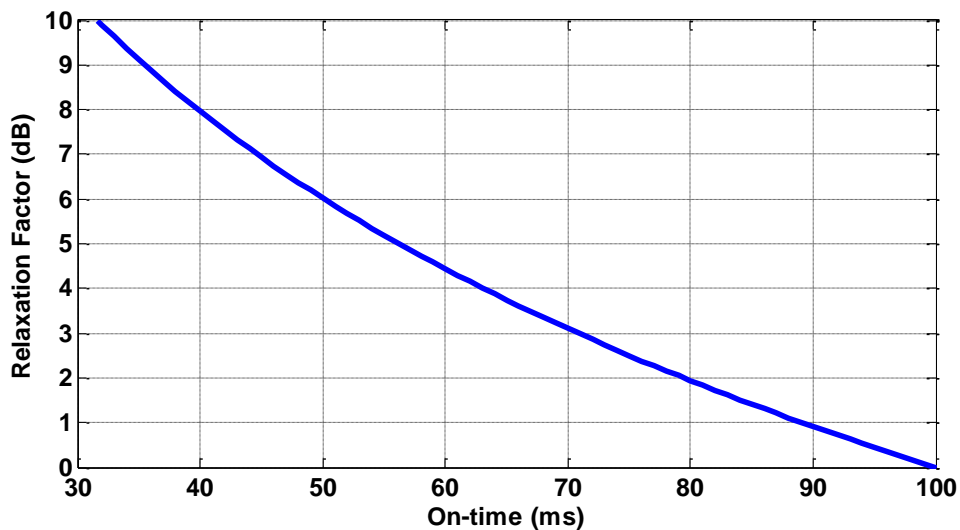


Figure 4.18. Relaxation Factor vs. Duty Cycling

4.4.3 Typical TX Parameters vs. Load Impedance

The load impedance presented to the CC1190 PA output is critical to the TX performance of the reference design. The load impedance is selected as a compromise between several criteria, such as output power, efficiency and the level of the harmonics. The matching components between the PA output and the antenna should transform 50 ohm antenna impedance to the selected impedance which the CC1190 PA should see. This is taken care of by the reference design and the user should provide a well matched antenna to get the required performance.

In order to measure the performance under different mismatch conditions the CC1120-CC1190EM 915 MHz reference design is loaded with different impedances at the SMA connector reference plane. A well matched antenna will have impedance inside the black circle in the Smith chart, which illustrates the limit for 10 dB return loss. At each load the output power, current and spurious frequency components are measured. These measurements are known as load-pull measurements.

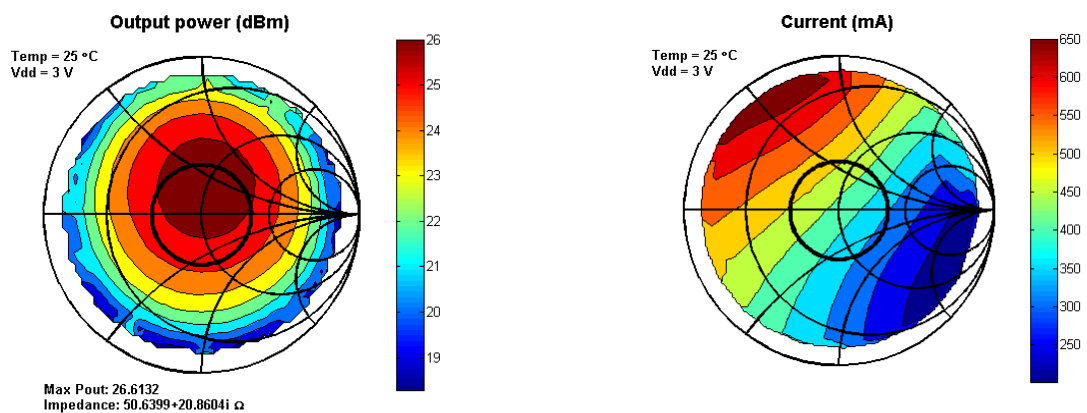


Figure 4.19. Output Power (left) and Current (right) vs. Load Impedance at SMA Connector at 25°C. PA_CFG2 = 0x77.

Most PAs have the ability to oscillate at unwanted frequencies under certain conditions. The worst conditions are usually high output power, low temperatures, and high VDD. The spurious frequency components are measured under different mismatch conditions as illustrated in Figure 4.20 and Figure 4.21. The blue colors indicate that the spurious levels are at the noise floor. The CC1120-CC1190EM 915 MHz reference design is a very robust design which tolerates high mismatch ratios at high output power, low temperatures and high VDD.

Application Note AN110

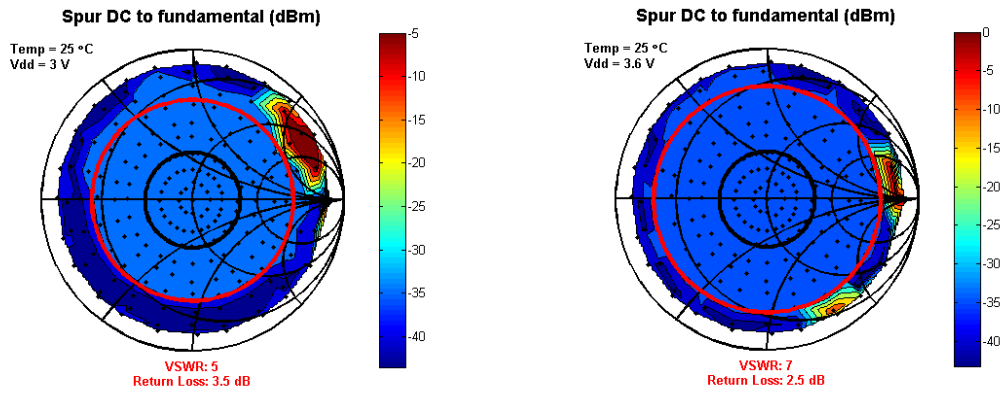


Figure 4.20. Spurious Frequency Components vs. Load Impedance at SMA Connector at 25°C. PA_CFG2 = 0x77.

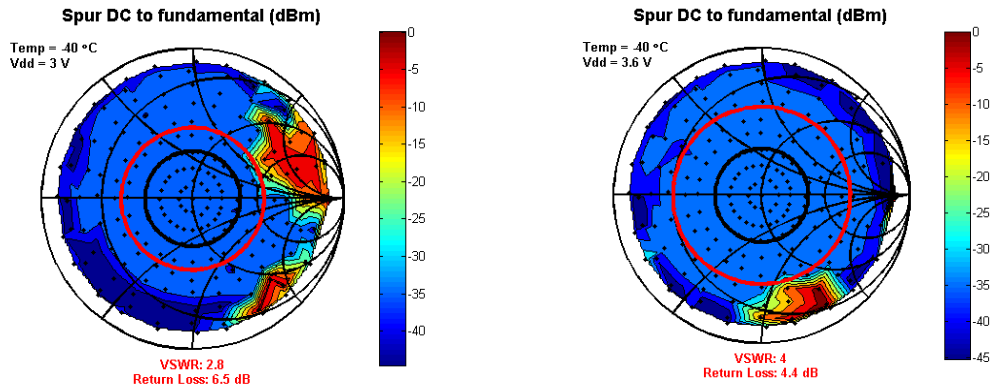


Figure 4.21. Spurious Frequency Components vs. Load Impedance at SMA Connector at -40°C. PA_CFG2 = 0x77.

4.5 Measurement Equipment

The following equipment was used for the measurements.

Measurement	Instrument Type	Instrument Model
RX	Signal Generator	Rohde & Schwarz SMIQ 03B Rohde & Schwarz FSEM30
TX	Signal Analyzer	Rohde & Schwarz FSG
RX/TX	Power Supply	Agilent E3631A
	Multimeter	Keithley 2000
Stability	Automatic Tuner	Maury MT986EU32
Radiated spurious Emissions	EMC chamber	

Table 4.6. Measurement Equipment

5 Controlling the CC1190

There are three digital control pins (PA_EN, LNA_EN, and HGM) that sets the CC1190 mode of operation.

PA_EN	LNA_EN	HGM	Mode of Operation
0	0	X	Power Down
0	1	0	RX LGM
0	1	1	RX HGM
1	0	0	TX LGM
1	0	1	TX HGM

Table 5.1. CC1190 Control Logic

There are different ways of controlling the CC1190 mode of operation in a CC1120-CC1190 design.

- Using CC1120 GPIO0/ GPIO2/ GPIO3³ pins to set two of the CC1190 control signals (e.g. PA_EN and LNA_EN). The third control signal (e.g. HGM) can be hardwired to GND/VDD or connected to an external MCU.
- Using an external MCU to control PA_EN, LNA_EN, and HGM.

Using an external MCU to set one (or more) digital control signals is the recommended solution for a CC1120-CC1190 design since GPIO0 or GPIO2 are typically programmed to provide a signal related to the CC1120 packet handler engine to the interfacing MCU and GPIO1 is the same pin as the SO pin on the SPI interface. The GPIO pin not used to provide information to the interfacing MCU can be used to control the CC1190.

6 SmartRF Studio and TrxEB

The CC1120-CC1190EM 915 MHz together with SmartRF™ Studio 7 software [6] and TrxEB can be used to evaluate performance and functionality.

6.1 SmartRF Studio

The CC1120-CC1190 can be configured using the SmartRF Studio 7 software [6]. The SmartRF Studio software is highly recommended for obtaining optimum register settings. A screenshot of the SmartRF Studio user interface for CC1120-CC1190 is shown in Figure 6.1.

³ GPIO1 is not used since this is the same pin as the SO pin on the SPI interface. The output programmed on this pin will only be valid when CSn is high. For a system where eWOR is used the LNA_EN pin on the CC1190 should be controlled by GPIO3. This is related to the polarity of the CC1120 GPIO pins in SLEEP.

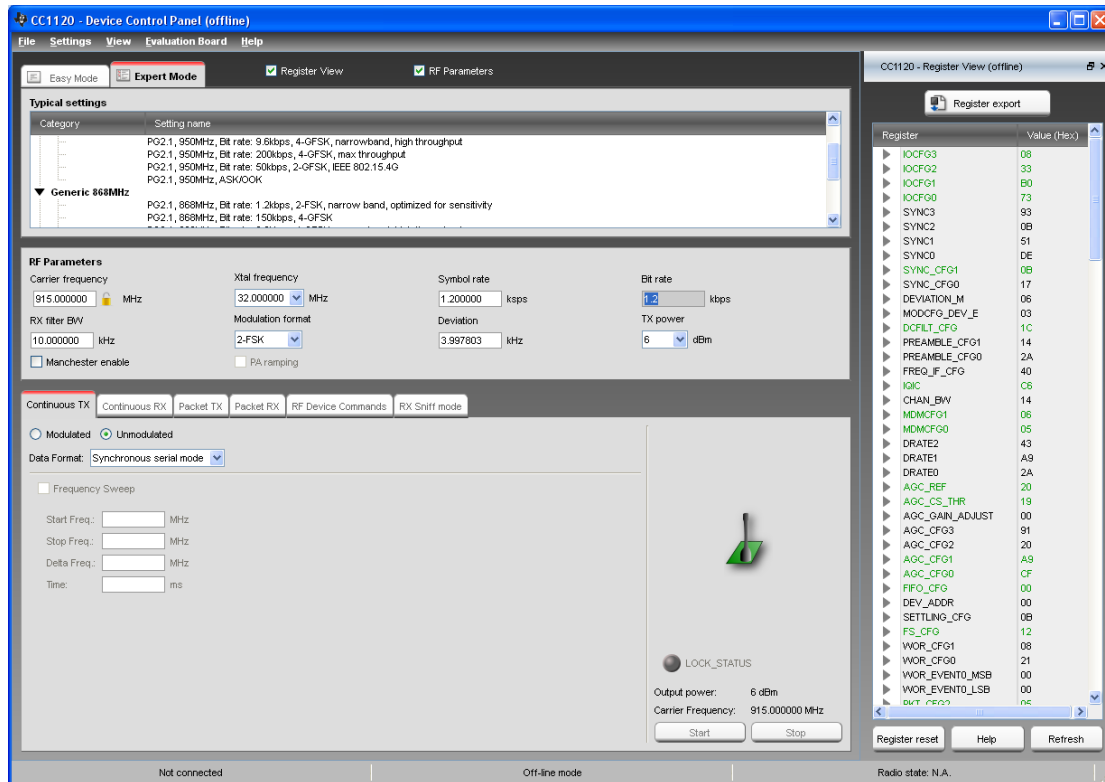


Figure 6.1. SmartRF Studio 7 [6] User Interface

In order to control the CC1190 the user needs to set GPIO2=0x33 and GPIO0=0x73 to set CC1190 in TX and GPIO2=0x73 and GPIO0=0x33 to set CC1190 in RX.

6.2 TRxEB

If CC1120-CC1190 is used with the TrxEB and the USB controller the supply range is 3.0 V to 3.6 V.

7 Reference Design

The CC1120-CC1190EM 915 MHz reference design includes schematic and gerber files [4]. It is highly recommended to follow the reference design for optimum performance. The reference design also includes bill of materials with manufacturers and part numbers.

7.1 Power Decoupling

Proper power supply decoupling must be used for optimum performance. The capacitors C26, C27 and C30 ensure good RF ground after L21 and thus prevent RF leakage into the power supply lines causing oscillations. The power supply filtering consisting of C2, C3 and L2 ensure well defined impedance looking towards the power supply.

7.2 Input/ Output Matching and Filtering

The PA and the LNA of the CC1190 are single ended input/output. A balun is required to transform the differential LNA input of the CC1120 to single ended output of the CC1190 PA. The values of the matching components between the SAW filter and the CC1190 PA input are chosen to present optimum source impedance to the CC1190 PA input with respect to stability.

The CC1190 PA performance is highly dependent on the impedance presented at the output, and the LNA performance is highly dependent on the impedance presented at the input. The

Application Note AN110

impedance is defined by L21 and all components towards the antenna. These components also ensure the required filtering of harmonics to pass regulatory requirements.

The layout and component values need to be copied exactly to obtain the same performance as presented in this application note.

7.3 Bias Resistor

R141 is a bias resistor. The bias resistor is used to set an accurate bias current for internal use in the CC1190.

7.4 SAW Filter

A SAW is recommended for the CC1120-CC1190 design to attenuate spurs below the carrier frequency that will otherwise violate spurious emission limits under Section 15.209 and 15.205. The SAW filter is matched to the CC1190 PA input/LNA output impedance using a series inductor and a shunt capacitor.

7.5 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 recommended to follow the recommendation given in the CC1120–CC1190EM 915 MHz reference design [4] 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 CC1190 is given in the CC1190 datasheet [3].

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.

Layer three is a power plane. The power plane ensures low impedance traces at radio frequencies and prevents unwanted radiation from power traces. Two different power planes for CC1120 and CC1190 are used and they are surrounded by ground to reduce unwanted radiation from the board.

Layer four is used for routing, and as for layer one, open areas are filled with metallization connected to ground using several vias.

7.6 Shielding

RF shielding is necessary to keep the radiated harmonics below the regulatory limits.

8 Disclaimer

The CC1120-CC1190EM evaluation board is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end-product fit for general consumer use. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board has been tested against FCC Section 15.247, 15.209, and 15.205 regulations, but there has been no formal compliance testing at an external test house. It is the end user's responsibility to ensure that his system complies with applicable regulations.

9 References

- [1] CC1120 Datasheet (SWRS112.pdf)
- [2] CC1120 User Guide (SWRU295.pdf)
- [3] CC1190 Datasheet (SWRS089.pdf)
- [4] CC1120–CC1190EM 915 MHz Reference Design (SWRR089.zip)
- [5] FCC rules (www.fcc.gov)
- [6] SmartRF™ Studio 7 (SWRC176.zip)

10 General Information

10.1 Document History

Revision	Date	Description/Changes
SWRA387	2011.11.03	Initial release.
SWRA387A	2011.11.24	Changes to Chapter 5 (Controlling the CC1190)
SWRA387B	2013.06.13	Added CC120x to the list of devices

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com