

CC112x/CC1175/CC120x Operation in 274-320 MHz Frequency Band

By Charlotte Stephansen

Keywords

- *FCC Section 15.231*
 - *CC1120*
 - *CC1121*
- *CC1125*
 - *CC1175*
 - *CC120x*

1 Introduction

The CC1120 is a fully integrated single-chip radio transceiver designed for high performance at very low power and low voltage operation in cost effective wireless systems. The CC1120 provides extensive hardware support for packet handling, data buffering, burst transmissions, clear channel assessment, link quality indication and Wake-On- Radio.

This application note outlines the expected performance when using the CC1120EM 274-320 MHz reference design (see Section 6). The CC1120 can be used in

applications targeting compliance with FCC section 15.231. This application note assumes the reader is familiar with CC1120 and FCC 15.231 regulatory requirements. The reader is referred to [1] and [2] for details.

The application note is also applicable for CC1121, CC1125, CC1175 (TX part only), 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
4.4 TRANSMIT PARAMETERS.....	4
4.5 TYPICAL RX PERFORMANCE.....	5
4.6 TYPICAL TX PERFORMANCE.....	7
5 FCC PART 15.231.....	8
6 CC1120EM 274-320 MHZ REFERENCE DESIGN.....	9
7 DISCLAIMER.....	11
8 REFERENCES.....	11
9 GENERAL INFORMATION.....	11
9.1 DOCUMENT HISTORY.....	11

2 Abbreviations

FCC	Federal Communications Commission
EM	Evaluation Module
RX	Receive, Receive Mode
TX	Transmit, Transmit Mode
BER	Bit Error Rate
RF	Radio Frequency
BOM	Bill of Material

3 Absolute Maximum Ratings

The absolute maximum ratings and operating conditions listed in the CC1120 datasheet [1] must be followed at all times. Stress exceeding one or more of these limiting values may cause permanent damage to the device.

4 Electrical Specifications

Note that the characteristics given in Chapter 4 are only valid when using the CC1120EM 274-320 MHz reference design (see Section 6) with a 50 Ω load and register settings recommended by the SmartRF Studio software [3]. $T_C = 25^\circ\text{C}$, $V_{DD} = 3.0\text{ V}$ and $f = 315\text{ MHz}$ if nothing else is stated.

4.1 Operating Conditions

Parameter	Min	Max	Unit
Operating Frequency ¹	274	320	MHz
Operating Supply Voltage	2.0	3.6	V
Operating Temperature	-40	+85	$^\circ\text{C}$

Table 4.1. Operating Conditions

4.2 Current Consumption

Parameter	Condition	Typical	Unit
RX Peak Current	1.2 kbps, Reception at the Sensitivity Level	22.5	mA
Transmit Current ²	PA_CFG2 = 0x7F (+16 dBm)	53	mA
	PA_CFG2 = 0x7A (+15 dBm)	50	
	PA_CFG2 = 0x68 (+10 dBm)	34	
	PA_CFG2 = 0x5C (+5 dBm)	27	
	PA_CFG2 = 0x51 (0 dBm)	23	
	PA_CFG2 = 0x46 (-5 dBm)	21	
	PA_CFG2 = 0x42 (-20 dBm)	19	

Table 4.2. Current Consumption

¹ There will be spurious signals at $n/2$ -crystal oscillator frequency (n is an integer number). RF frequencies at $n/2$ -crystal oscillator frequency should therefore be avoided.

² The CC1120 RF output power is controlled by the 6 bit value in the PA_CFG2[5:0] register. The power settings are a small subset of all the possible PA register settings.

4.3 Receive Parameters

Parameter	Condition	Typical	Unit
Sensitivity, High Performance Mode ³	1.2 kbps, 2FSK, ± 4 kHz deviation, 10 kHz channel filter. See Figure 4.1.	-124	dBm
	38.4 kbps, 2GFSK ⁴ , ± 20 kHz deviation, 100 kHz channel filter. See Figure 4.2.	-111	dBm
	200 kbps, 4GFSK ³ , ± 83 kHz deviation (outer symbols), 200 kHz channel filter. See Figure 4.3.	-104	dBm
Selectivity and Blocking	1.2 kbps, 2FSK, ± 4 kHz deviation, 10 kHz channel filter. Wanted signal 3 dB above the sensitivity level. Unmodulated interferer. See Figure 4.4 and Figure 4.5.		
	± 12.5 kHz from wanted signal	60	dB
	± 25 kHz from wanted signal	61	
	± 1 MHz from wanted signal	81	
	± 2 MHz from wanted signal	84	
± 10 MHz from wanted signal	86		

Table 4.3. Receive Parameters

4.4 Transmit Parameters

Parameter	Condition	Typical	Unit
Output power	PA_CFG2 = 0x7F	+16	dBm
	PA_CFG2 = 0x7A	+15	
	PA_CFG2 = 0x68	+10	
	PA_CFG2 = 0x5C	+5	
	PA_CFG2 = 0x51	0	
	PA_CFG2 = 0x46	-5	
	PA_CFG2 = 0x42	-20	
Harmonics and Spurious Emission with PA_CFG2 = 0x7F	Conducted Harmonics except 2 nd and 3 rd	< -54	dBm
	Conducted 2 nd Harmonic	33	dBc
	Conducted 3 rd Harmonic	-54	dBm

Table 4.4. Transmit Parameters

³ Sensitivity limit is defined as 1% bit error rate (BER). RF frequencies at $n/2$ crystal oscillator frequency (n is an integer number) should be avoided due to spurious signals at these frequencies which could lead to degraded sensitivity.

⁴ BT = 0.5 used in all GFSK measurements

4.5 Typical RX Performance

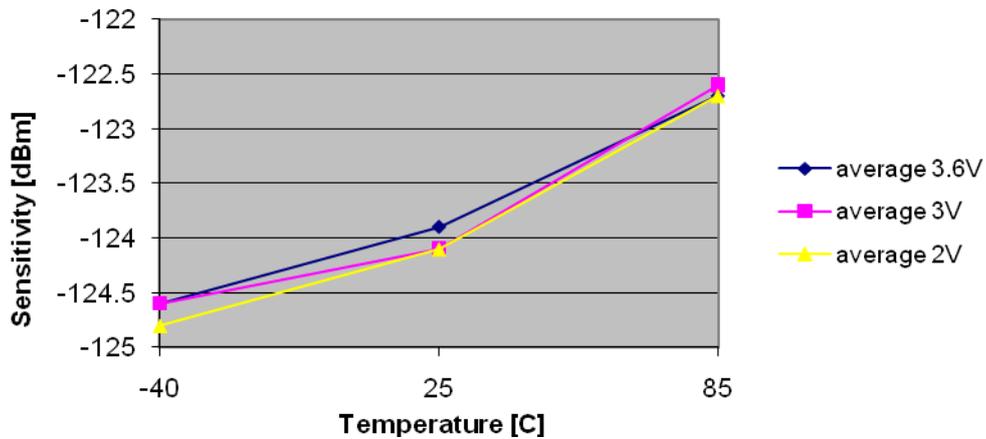


Figure 4.1. Typical Sensitivity vs. Temperature and Power Supply Voltage, 1.2 kbps

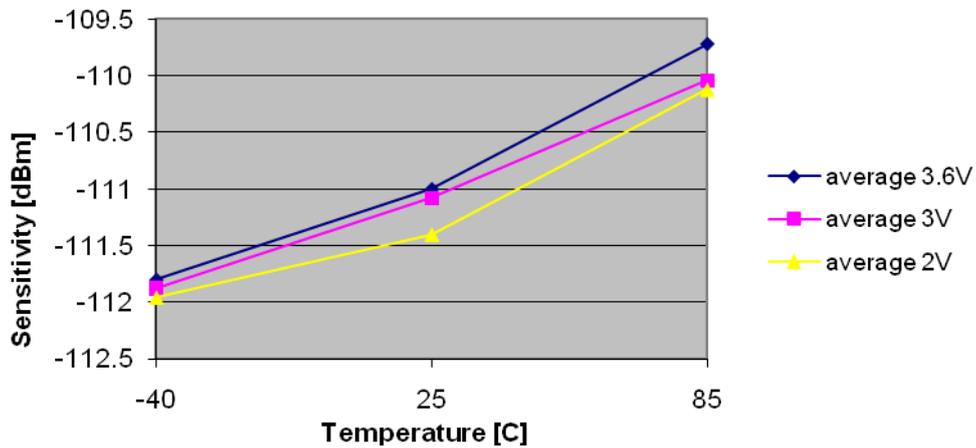


Figure 4.2. Typical Sensitivity vs. Temperature and Power Supply Voltage, 38.4 kbps

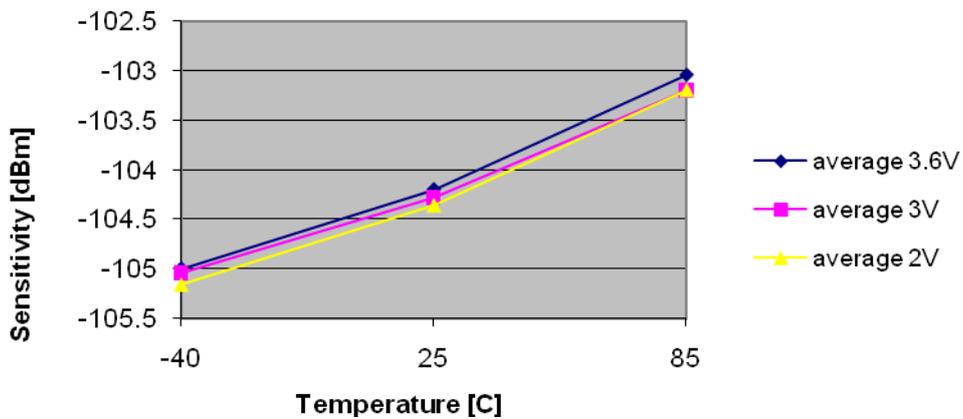


Figure 4.3. Typical Sensitivity vs. Temperature and Power Supply Voltage, 200 kbps

Application Note AN115

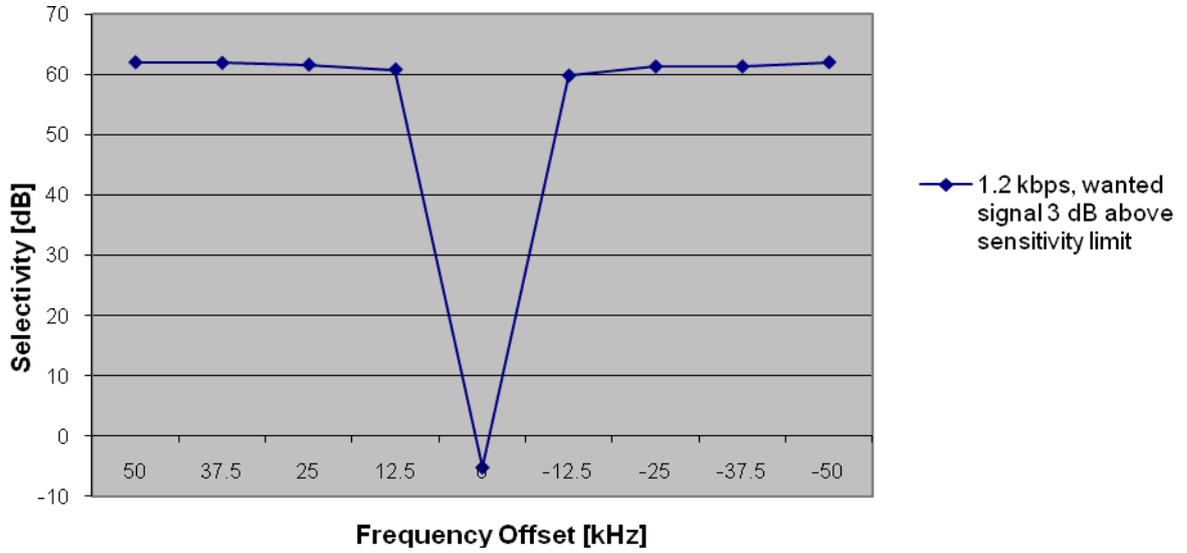


Figure 4.4. Typical Selectivity, 1.2 kbps, Unmodulated Interferer

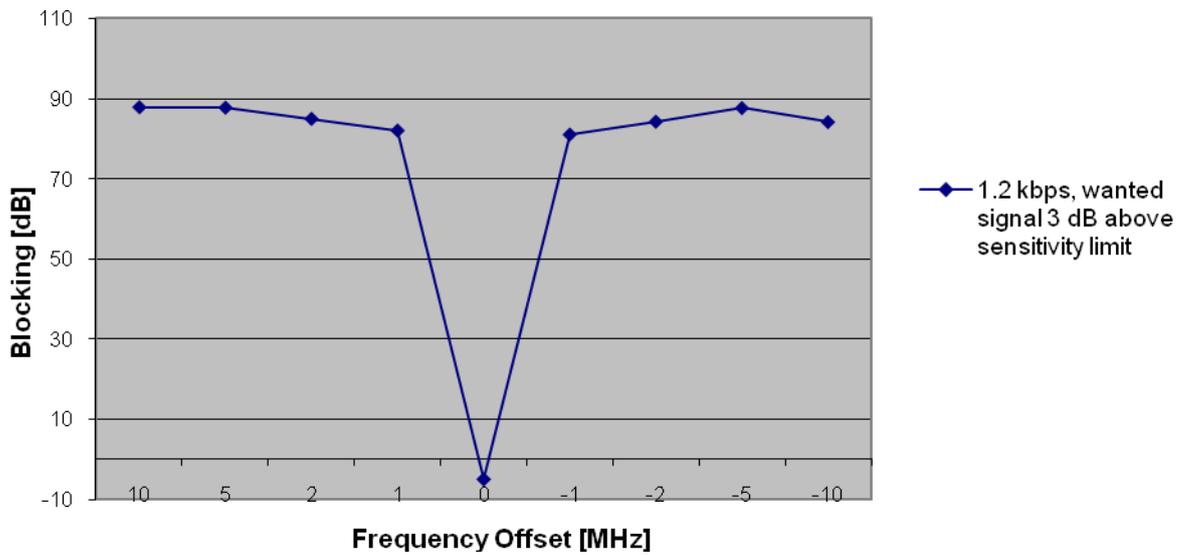


Figure 4.5. Typical Blocking 1.2 kbps, Unmodulated Interferer

4.6 Typical TX Performance

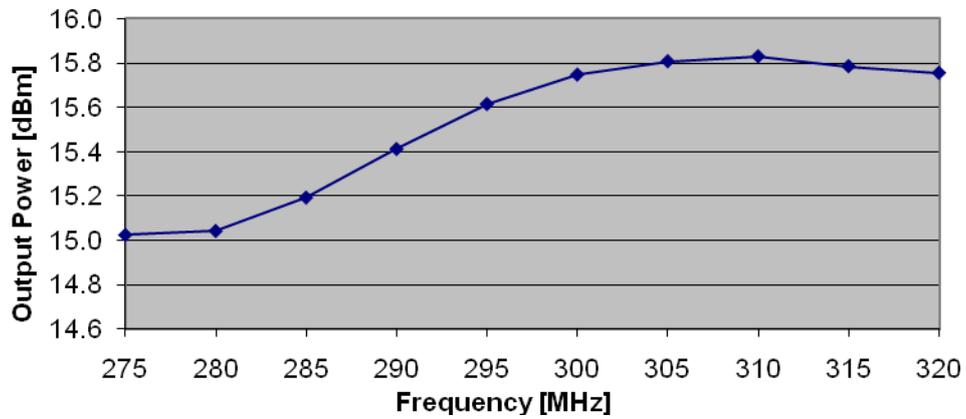


Figure 4.6. Typical Output Power vs. Frequency. PA_CFG2 = 0x7F

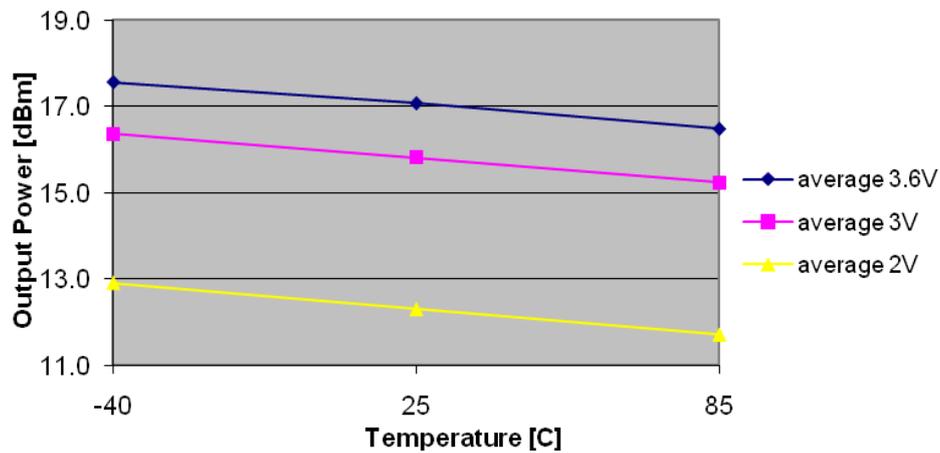


Figure 4.7. Typical Output Power vs. Temperature and Power Supply Voltage. PA_CFG2 = 0x7F

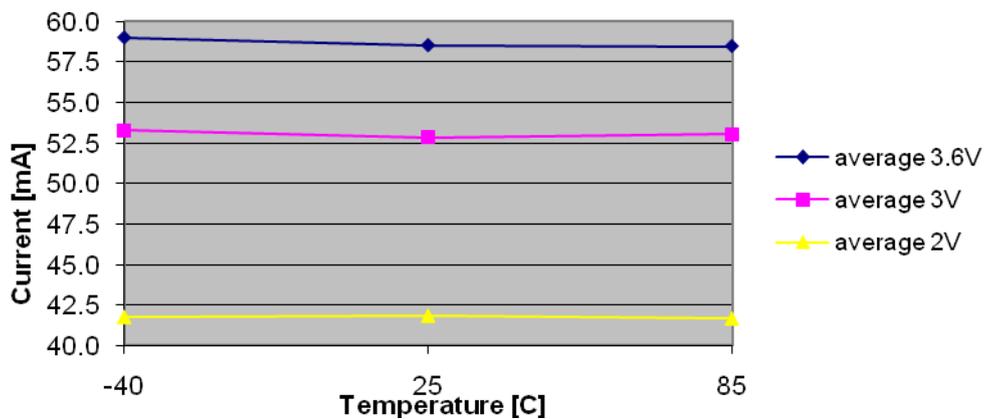


Figure 4.8. Typical TX Current vs. Temperature and Power Supply Voltage. PA_CFG2 = 0x7F

5 FCC Part 15.231

In the US, the Federal Communications Commission (FCC) regulates the use of frequencies for wireless communication. The FCC rules and regulations are codified in Title 47 of the Code of Federal Regulations (CFR). Part 15 of this code applies to radio frequency devices operating at unlicensed frequencies and is often colloquially referred to as *FCC Part 15*. This section gives a short summary of FCC section 15.231 regulatory requirements. For more in depth information refer to FCC rules (www.fcc.gov) [2] and [4].

The EIRP limits for the fundamental frequency according to FCC section 15.231 are given Figure 5.1. Section 15.231(a) defines control applications. Other periodic applications fall under section 15.231(e). As an example, 15.231(a) and 15.231(e) limit the output power at 315 MHz to -19.6 dBm and -27.6 dBm respectively.

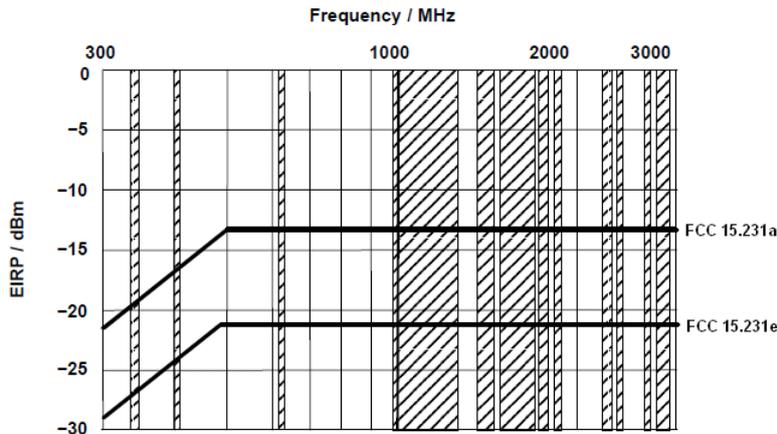


Figure 5.1. EIRP Limits According to Section 15.231 and Restricted Bands According to Section 15.205

With pulsed transmissions, it may be possible to transmit at power levels above the prescribed limits given by section 15.231. This is because an averaging detector is called for in the measurements. The averaging window of this detector is 100 ms. If the transmission burst is less than 100 ms, the transmit power can be increased by $20 \cdot \log(100 \text{ ms}/\text{TX on-time})$, up to a maximum increase of 20 dB.

As an example, if the transmit duration in any 100 ms window is maximum 10 ms you can transmit up to $-19.6 \text{ dBm} + 20 \cdot \log(100/10) = +0.4 \text{ dBm}$ output power under 15.231(a) at 315 MHz.

The spurious emission limit, when operating in the frequency bands defined by section 15.231, must be at least 20 dB below the fundamental unless it falls within one of the restricted bands defined in section 15.205 (see shaded areas in Figure 5.1). The spurious emissions that falls within the restricted bands defined in section 15.205 must fulfil the spurious emission limits given in section 15.209, see Table 5.1.

Frequency	Electrical Field Strength	Corresponding EIRP
30 ... 88 MHz	100 $\mu\text{V}/\text{m}$	- 55.2 dBm
88 ... 216 MHz	150 $\mu\text{V}/\text{m}$	- 51.7 dBm
216 ... 960 MHz	200 $\mu\text{V}/\text{m}$	-49.2 dBm
> 960 MHz	500 $\mu\text{V}/\text{m}$	-41.2 dBm

Table 5.1. Spurious Emission Limits According to Section 15.209

6 CC1120EM 274-320 MHz Reference Design

The CC1120EM 274-320 MHz reference design is based on the CC1120EM 420-470 MHz reference design [5] with changes to component values in the TX and RX path only. The changes in the BOM are described in Table 6.1 and also shown in Figure 6.1. For the full schematic design and also the recommended layout, please refer to the CC1120EM 420-470 MHz [5]. The reference design also includes the gerber files. It is highly recommended to follow the reference design for optimum performance.

Component	CC1120EM 420-470 MHz BOM	CC1120EM 274-320 MHz BOM
L191	56nH +/- 5%, 0402, Murata LQW15xx series	82nH +/- 5%, 0402, Murata LQW15xx series
L192, L201	27nH +/- 5%, 0402, Murata LQW15xx series	56nH +/- 5%, 0402, Murata LQW15xx series
L193	15nH +/- 5%, 0402, Murata LQW15xx series	27nH +/- 5%, 0402, Murata LQW15xx series
C181, C191, C201	5.1pF +/- 0.25%, 0402 NPO, Murata GRM1555C series	6.8pF +/- 0.25%, 0402 NPO, Murata GRM1555C series

Table 6.1. BOM CC1120EM 274-320 MHz vs. CC1120EM 420-470 MHz

Application Note AN115

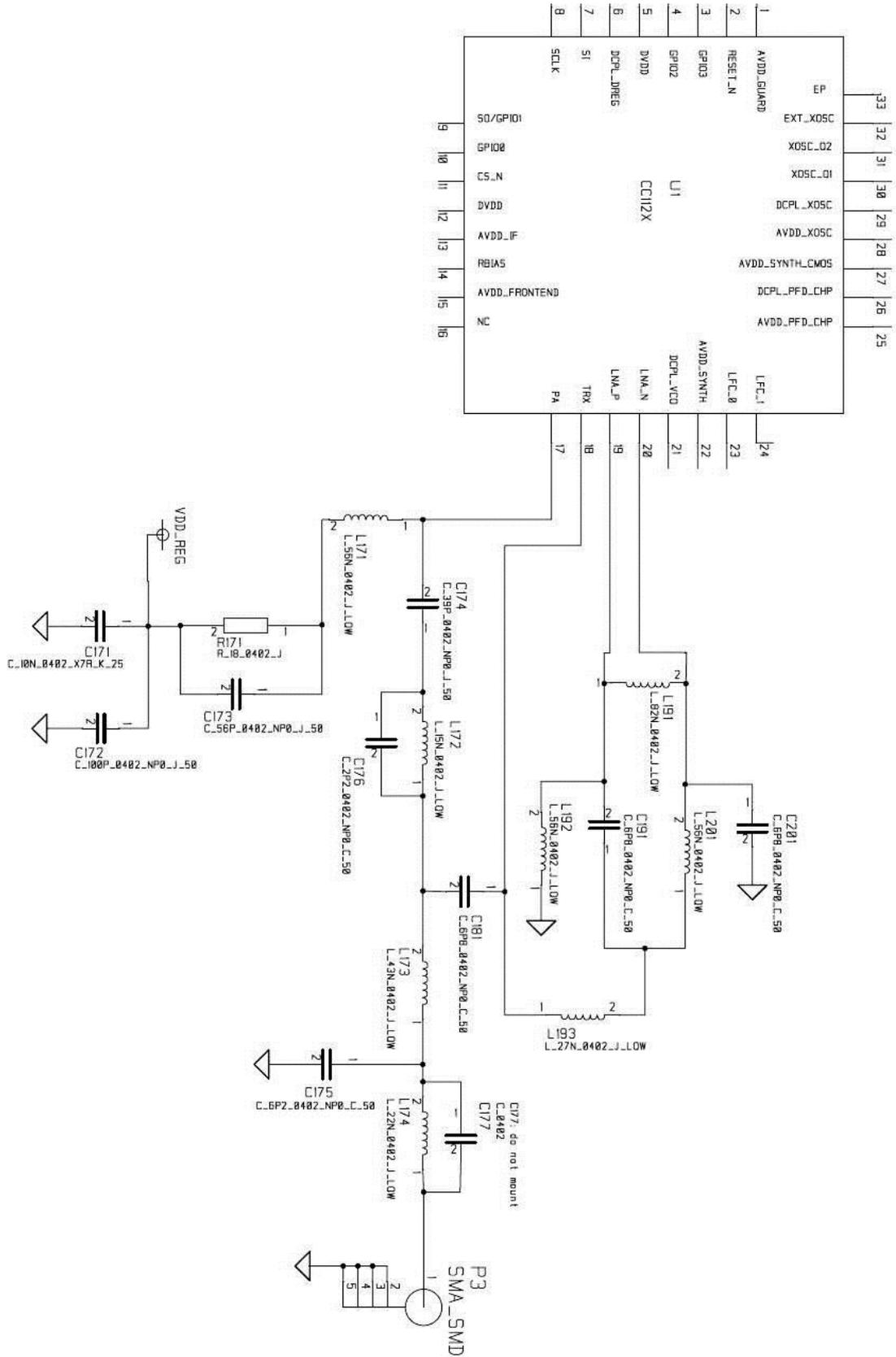


Figure 6.1. CC1120EM 274-320 MHz Schematic, TX and RX path only

7 Disclaimer

The CC1120EM 274-320 MHz reference design 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 using the reference design must have electronics training and observe good engineering practice standards. This reference design has been tested against FCC section 15.231, 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.

8 References

- [1] CC1120 Datasheet (SWRS112.pdf)
- [2] FCC rules (www.fcc.gov)
- [3] SmartRF™ Studio 7 (SWRC176.zip)
- [4] ISM-Band and Short Range Device Regulatory Compliance Overview (SWRA048.pdf)
- [5] CC1120EM 420-470 MHz Reference Design (SWRC221.zip)

9 General Information

9.1 Document History

Revision	Date	Description/Changes
SWRA398	2012.06.08	Initial release.
SWRA398A	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