CC1101+CC1190 600 kbps Data Rate, +19 dBm Transmit Power without FHSS in 902-928 MHz Frequency Band

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Keywords

- *FCC Section 15.247*
- *Digital Modulation*
- *FHSS*
- *4-FSK*
- *+19 dBm Output Power*
- *CC1101*
- *CC1100*
- *CC1110*
- *CC1111*
- *CC430*
- *CC1190*

1 Introduction

In the 902-928 MHz ISM band, FCC Section 15.247 specifies requirements that allows for up to 1 W transmit output power.

High output power can be used if the system employs Frequency Hopping Spread Spectrum (FHSS) or use a digital modulation technique that gives a 6 dB bandwidth of minimum 500 kHz [1], [6].

The CC1101 transceiver together with the CC1190 range extender can be set up with 4-FSK modulation. This digital modulation technique allows the combined CC1101 and CC1190 solution to comply with Section 15.247 requirements with a +19 dBm (79 mW) transmit output power without the need frequency hopping.

In this design note the data rate is set to 600 kbps using 4-FSK modulation.

Design Note DN006 [7] shows how CC1101 can be configured for 2-ary modulation formats and meet requirements for digital modulation systems defined under FCC Section 15.247.

The CC1101-CC1190EM 915 MHz reference design [4] is used as an example in this design note, but the results are also applicable if CC1101 is replaced with CC1100, CC1110, CC1111, or CC430 as they use the same radio as the CC1101.

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2 Abbreviations

EM	Evaluation Module
FCC	Federal Communications Commission
FHSS	Frequency hopping Spread Spectrum
ISM	Industrial, Scientific, Medical
PSD	Power Spectral Density
RBW	Resolution Bandwidth
VBW	Video Bandwidth

3 FCC 15.247 Digital Modulation Requirements

Table 1 gives the FCC 15.247 digital modulation requirements.

Section	Requirement
15.247a2	The 6 dB bandwidth shall be at least 500 kHz
15.247b3	The maximum conducted power shall not exceed 1 W (+30 dBm)
15.247e	The power spectral density (PSD) shall not be greater than 8 dBm in any 3 kHz band during any time interval during continuous transmission

Table 1. FCC 15.247 Digital Modulation Requirements [6]

4 FCC 15.247 Measurement Setup

- All measurements were performed at 3V, 25^{o}C
- Measurements were performed on the CC1101-CC1190EM 915 MHz reference design [4]
- Rohde & Schwarz FSEM spectrum analyzer was used in the measurements
- Results presented are the average values of 6 modules
- Register settings used are given in the appendix. It is recommended to increase the CC1101 loop filter BW when operating at 600 kbps, 4-FSK. This is achieved by setting FIFOTHR[7] = 1 and TEST2[1] = 1. (Note: for CC1110 the settings are MCSM0[3] = 1 and TEST2[1] = 1).

Table 2 gives the CC1101 system parameters used in the tests.

System Parameter	Value	Comment
RF Frequency	915 MHz	
Output Power	Up to +20 dBm	Different CC1101 PATABLE settings
Modulation Format	4-FSK	MDMCFG2.MOD_FORMAT = 4 [1]
Data Rate	600 kbps	Corresponds to 300 kBaud
Frequency Deviation	228 kHz	‘01’ - Deviation ‘00’ - 1/3· Deviation ‘10’ + 1/3· Deviation ‘11’ + Deviation
RX Filter Bandwidth	812 kHz	

Table 2. CC1101 System Parameters Used in the Tests

Table 3 gives the spectrum analyzer settings used in the tests.

Requirement	RBW	VBW	Comment
6 dB Bandwidth	100 kHz	1 MHz	
Output Power	3 MHz	3 MHz	
PSD	3 kHz	100 kHz	Span 1.5 MHz Sweep time of 500 s Max hold Peak detector

Table 3. Spectrum Analyzer Settings Used in the Measurements [6]

5 FCC 15.247 Measurement Results

Table 4 gives the measurement results.

CC1101 PATABLE	6 dB Bandwidth [kHz]	Output Power [dBm]	PSD [dBm/3 kHz]	Sensitivity [dBm]
0x2B	718	18.0	6.6	-95.2
0x2C	717	18.5	7.2	
0x2D	717	18.9	7.7	
0x39	717	19.3	7.9	

Table 4. Typical CC1101-CC1190 FCC 15.247 Measurement Results

See Application Note AN096 [5] for more performance figures for the CC1101-CC1190EM 915 MHz reference design.

6 Conclusion

The CC1101+CC1190 combination is suited for systems targeting compliance with digital modulation systems defined under FCC Section 15.247. The combined CC1101 and CC1190 solution complies with Section 15.247 requirements with a +19 dBm transmit output power without the need frequency hopping.

The link budget, assuming 0 dB antenna gain, is up to 114 dB when operating the CC1101+CC1190 design at 600 kbps, 4-FSK.

7 References

[1] FCC rules (www.fcc.gov)
[2] CC1101 Data Sheet (SWRS061.pdf)
[3] CC1190 Datasheet (SWRS089.pdf)
[4] CC1101–CC1190EM 915 MHz Reference Design (SWRR077.zip)
[5] Using the CC1190 Front End with CC1101 under FCC 15.247 (SWRA361.pdf)
[6] Measurement of Digital Transmission Systems Operating under Section 15.247
[7] DN006 CC11xx Settings for FCC 15.247 Solutions (SWRA123.pdf)

8 General Information

8.1 Document History

Revision	Date	Description/Changes
SWRR078	2011.05.11	Initial release.
SWRR078A	2011.11.07	Added information in section 4 on how to increase CC1110 loop filter bandwidth

9 Appendix

Register settings used in the test.

IOCFG2	2F	LNA off
IOCFG1	2E	
IOCFG0	6F	PA on
FIFOTHR	87	TX: 0x87. RX: 0x07
SYNC1	D3	
SYNC0	91	
PKTLEN	14	
PKTCTRL1	4	
PKTCTRL0	22	
ADDR	0	
CHANNR	0	
FSCTRL1	D	
FSCTRL0	0	
FREQ2	21	
FREQ1	62	
FREQ0	76	
MDMCFG4	0D	300 kBaud, 812 kHz RX BW
MDMCFG3	7A	
MDMCFG2	43	4FSK
MDMCFG1	22	
MDMCFG0	F8	
DEVIATN	71	228 kHz
MCSM2	7	
MCSM1	30	
MCSM0	18	
FOCCFG	1D	
BSCFG	1C	
AGCCTRL2	C7	
AGCCTRL1	0	
AGCCTRL0	B0	
WOREVT1	87	
WOREVT0	6B	
WORCTRL	FB	
FREND1	B6	
FREND0	10	
FSCAL3	EA	
FSCAL2	2A	
FSCAL1	0	
FSCAL0	1F	
RCCTRL1	41	
RCCTRL0	0	
FSTEST	59	
PTEST	7F	
AGCTEST	3F	
TEST2	8A	TX: 0x8A. RX: 0x88
TEST1	31	
TEST0	9	
# PATABLE	39	

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