

Radiocrafts sub-1GHz modules for FCC compliance

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Introduction

Radiocrafts offers a wide range of wireless modules targeting different solutions world-wide. This Application Note informs how to select and use Radiocrafts modules for FCC compliance in US.

FCC regulation

FCC is responsible for regulation of all RF devices in US operation. CFR 47, Part 15 is regulating unlicensed operation. The modules can operate unlicensed under FCC Section 15.247 or Section 15.249 in the 902-928 MHz band. In the 260-470 MHz band the modules can operate unlicensed under Section 15.231. A product intended for unlicensed operation must be FCC compliance tested and issue an FCC identification number to be marked on the final product. RC1140/RC1190/RC1190HP and RC1240/RC1290 can operate under CRF 47, Part 15.

CRF 47, Part 90 is a licenced band for narrow band operation. Strict requirements on spectral mask makes this compliance challenging, but the new RC1760HP can operate under CRF 47, Part 90 in the 450 – 470 MHz band.

CRF 47 section 15.249 (902 – 928 MHz)

RC1290 and RC1190 up to -1 dBm. No duty-cycle relaxation factor applies for fundamental frequency, only for harmonics.

CRF 47 section 15.247 (902 – 928 MHz)

FCC allow up to 1W, but the actual max output power is limited by how you use the module. Highest output power can be achieved when implementing Frequency Hopping Spread Spectrum (FHSS) outside the module. In this approach, RC1190HP can use max output power (+27 dBm) if implementing FHSS in the host controller. No duty-cycle relaxation factor applies for fundamental frequency, only for harmonics.

An alternative approach is to implement a digital modulation technique that gives a 500 kHz bandwidth. The Power Spectral Density (PSD) will in this case limit the max output power to +20 dBm. No duty-cycle relaxation factor applies for fundamental frequency, only for harmonics.

RC1190 up to +10 dBm and RC1190HP up to +20 dBm.

CRF 47 section 15.231 (260 – 470 MHz)

RC1240 and RC1140 up to -14 dBm @ 433 MHz. Max output power is depending on frequency to give the same range independent of frequency of operation inside the band (-19.6 dBm @ 315 MHz). Duty-cycle relaxation factor applies for fundamental frequency and harmonics.

FCC Part90 (450 – 470 MHz)

RC1760HP complies with all requirement up to +27 dBm at 450-470 MHz. Max data rate is 9.6 kbps using 4GFSK. No duty-cycle relaxation factor required.

Duty Cycle Relaxation Factor

The output power limitation for CRF 47 section 15 above is when using 100% duty cycle in a 100 ms TX window. For shorter TX packet length than 100 ms a relaxation factor up to 20 dB applies on fundamental and/or harmonics. The Relaxation factor is calculated as:

$$RF [dBm] = 20 \cdot \log(TXtime/100 \text{ ms}) \text{ if } TXtime < 100 \text{ ms}$$

Table 1 below informs about the relaxation factor that applies depending on TX time of RF packet.

Tx time per 100 ms window [ms]	Dyty Cycle Relaxation Factor (RL) [dB]
10	20
20	14
30	10,5
40	8
50	6
60	4,4
70	3,1
80	1,9
90	0,9
100	0

Table 1: TX time vs Duty cycle relaxation factor

The TX time is further depending on number of byte in the RF packet and the RF data rate. Some examples given in table 2.

Bytes in RF packet	RF data rate	TX time
128	100 kbps	10,2 ms
128	19,2 kbps	53,3 ms
128	9,6 kbps	106 ms
64	100 kbps	5,2 ms
64	19,2 kbps	26,6 ms
64	9,6 kbps	53,5 ms
64	4,8 kbps	106 ms
32	76,8 kbps	3,3 ms
32	19,2 kbps	13,3 ms
32	9,6 kbps	26,6 ms
32	4,8 kbps	53,3 ms
16	19,2 kbps	6,6 ms
16	9,6 kbps	13,3 ms
16	4,8 kbps	26,6 ms
16	2,4 kbps	53,3 ms

Bytes in RF packet	RF data rate	TX time
16	1,2 kbps	106 ms
8	9,6 kbps	6,6 ms
8	4,8 kbps	13,3 ms
8	2,4 kbps	26,6 ms
8	1,2 kbps	53,3 ms
4	4,8 kbps	6,6 ms
4	2,4 kbps	13,3 ms
4	1,2 kbps	26,6 ms

Table 2: Duty-cycle relaxation factor examples

Note that number of bytes is the payload and additional bytes used by the Radiocrafts embedded protocol for addressing/CRC etc. For details, see User manual for your selected embedded protocol.

Selecting module for US

For some application, range is an important parameter. Range depending parameters when selecting module is frequency of operation, TX Output power and RX sensitivity.

Link Margin can be defined in dB as:

$$\text{Link Margin} = \text{Sensitivity} - \text{Output Power}$$

Link Margin will in this case help to select module for best range since other parameter in link budget is the same (antenna gain, path loss, frequency etc).

Rule of thumb is that:

1. Double the frequency reduce the range by factor 2 (due to different path loss)
2. Improve Link Margin by 6 dB increase the range by factor 2

Link Margin can be improved by either increasing output power and/or improving sensitivity.

As seen in this application note, frequency and output power must comply with FCC regulation and the user must ensure this by using the module correctly. The sensitivity is depending on data rate and is best for lower data rates. Table 3-7 list up all possible Radiocrafts modules for US and include max output power, sensitivity, duty cycle restriction and Link Margin.

The table informs that RC1190HP at max output power gives same range as RC1190 at low data rate under 15.247 without frequency hopping. FHSS is needed when using RC1190HP up to +27 dBm. All in all the best achievable range is not surprisingly the narrow band module RC1760HP due to the ultra-narrow band radio with excellent sensitivity.

CRF 47 section 15.231 (260 – 470 MHz)					
Module	Data rate [kbps]	Sensitivity [dBm]	Output Power [dBm]	MaxTX time[ms]	Link Margin [dB]
RC1140	100	-97	6	10	103
	4.8	-106	-14	N.A	92
RC1240	4,8	-115	-14	N.A	101

Table 3: Radiocrafts module for CRF 47 section 15.231

CRF 47 section 15.249 (902 – 928 MHz)					
Module	Data rate [kbps]	Sensitivity [dBm]	Output Power [dBm]	MaxTX time[ms]	Link Margin [dB]
RC1190	100	-97	-1	N.A	96
	4,8	-106	-1	N.A	105
RC1290	4,8	-110	-1	N.A	109

Table 4: Radiocrafts module for CRF 47 section 15.249

CRF 47 section 15.247 (902 – 928 MHz) (FHSS)					
Module	Data rate [kbps]	Sensitivity [dBm]	Output Power [dBm]	MaxTX time[ms]	Link Margin [dB]
RC1190HP	100	-97	27	80*)	124
	4.8	-106	27	80*)	133
RC1190	100	-97	10	N.A	107
	4.8	-106	10	N.A	116

Table 5: Radiocrafts module for CRF 47 section 15.247 FHSS

*) Must be reduced to 80 ms or less in order to relax harmonic requirement.

CRF 47 section 15.247 (902 – 928 MHz) (500 kHz bandwidth modulation technique)					
Module	Data rate [kbps]	Sensitivity [dBm]	Output Power [dBm]	MaxTX time[ms]	Link Margin [dB]
RC1190HP	250 **)	-95	20	80*)	115
RC1190	100	-97	10	N.A	107
	4.8	-106	8	N.A	114

Table 6: Radiocrafts modules for CRF 47 section 15.247 for 500 kHz bandwidth

*) Must be reduced to 80 ms or less in order to relax harmonic requirement.

***) Supported only by RC1190HP-TM

CRF 47 part 90 (450-470 MHz)					
Module	Data rate [kbps]	Sensitivity [dBm]	Output Power [dBm]	MaxTX time[ms]	Link Margin [dB]
RC1760HP	9,6	-114	+27	100	141

Table 7: Radiocrafts modules for CRF 47 part 90

Document Revision History

Document Revision	Changes
1.0	First release
1.1	Design Update
1.2	Updated typos. Clarified information regarding RC1190HP datarate

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