

IEEE 802.11
Wireless Access Methods and Physical Layer Specifications

TITLE: Interpretation of Part 15.247
of the Rules of the FCC
as related to Compliance Testing

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Introduction

This submission is intended to shed some light on the interpretation of the FCC rules for operation in the 2400-2483.5 MHz ISM band. It is a summary of various discussions and communications with representatives from the FCC regarding the certification and compliance testing of devices intended to operate in this band. It is NOT a statement of compliance or operation by the FCC, but rather an interpretation by Apple Computer as to the operation of devices under Part 15.247 of the Rules of the FCC for intentional radiators in the band of interest.

1.0 Emissions within the 2400-2483.5 MHz ISM Band

For emissions within the 2400-2483.5 MHz ISM band, the only requirements are that the harmonics and spurs are at least 20 dBc down from the fundamental carrier as measured in a 100 kHz RBW under conducted measurement conditions. For example, a transmitter using upconversion with a 350 MHz IF would need a 7th harmonic (2450 MHz) to be at least 20 dB below the transmitted fundamental carrier frequency as measured in a 100 kHz RBW. This is measured relative to the peak output power in the occupied channel bandwidth. Such spurs need to be minimized because of their effects on other hopping channels which affects co-location of similar WLAN's. The effects of transmitter and receiver phase noise, receiver selectivity, blocking and intermodulation provide a practical bound to the required spur levels.

As for making conducted versus radiated emissions tests within the ISM band, the rule of thumb to follow is that if the harmonic or spur is within 10 dB of the fundamental, as measured from the conducted test outlined above, then it should be re-measured using the conditions and rules that govern the radiated test.

2.0 Emissions outside of the 2400-2483.5 MHz ISM Band

For emissions outside of the 2400-2483.5 MHz ISM band, there are two types of measurements made:

First, there is the conducted measurement that is done by connecting the spectrum analyzer directly to the output port of the transmitter, like the above mentioned test for spurs within the ISM band. Under this test, all harmonics and spuri outside of the designated band of operation must be at least 20 dBc below the fundamental frequency. This test is also measured with a 100 kHz RBW and is performed with the transceiver set to three fixed center frequencies within the band of operation. The FCC recommends that you use the lowest transmit channel, the highest transmit channel and one located somewhere in the middle of the band. These channels are static and the transceiver is not being exercised as a frequency hopper during this test. The test is performed over a span of 9.0 kHz up to the 10th harmonic of the highest possible fundamental frequency. In the proposed IEEE 802.11 system, that would be a span covering 9.0 kHz to 24.82 GHz.

Secondly, there is a radiated measurement that is governed by Parts 15.209 and 15.205 of the Rules of the FCC. Basically, this measurement is in place to protect the restricted bands listed in subpart 15.205 from high level unwanted emissions. The limits imposed on harmonic and spuri signals in the restricted bands are listed in subpart 15.209. For frequencies that specify measurements made at 30 meters, the FCC will allow you to make measurements at 3 meters and extrapolate out to 30 meters. In addition, if a harmonic or spur is a product of the digital electronics and can be identified as such, then that particular emission can be tested under the limits of Class A or B certification, depending upon which approval the company is seeking. This is to distinguish between intentional radio and unintentional digital emissions.

Remember, that under Part 15.247 the FCC is primarily concerned with emissions from the radio transmitter. Even though the FCC rules distinguish between a quasi-peak (< 1000 MHz) and average (> 1000 MHz) measurement procedure depending upon the emission frequency, we can do all of our testing with a peak measurement and apply a peak-to-average correction factor because we are using an FSK system in which the average and peak outputs are roughly the same in magnitude. To obtain the value of the emission, the RBW is set to 1.0 MHz and the VBW is set equal to or greater than the RBW. The measurement is swept from 9.0 kHz up to the 10th harmonic of the highest emitted fundamental frequency. The FCC recommends that you use the lowest transmit channel, the highest transmit channel and one located somewhere in the middle of the band. These channels are static and the transceiver is not being exercised as a frequency hopper during this test.

The correction factor that is applied to the peak measurement specified above depends upon the dwell time of the transceiver on a given logical channel. As stated, if the dwell time on a given channel is less than 100 mseconds, then you must average the emissions on that channel over the 100 msecond period for the amount of time that the channel will be occupied. For example, if a system stays on a given frequency/channel for a maximum time period of about 5.0 mseconds, and revisits that same frequency again 2 more times in a 100 msecond window for a total dwell time of 15.0 mseconds, then a correction factor for the actual emission amplitude is applied as follows:

$$20 * \text{LOG}(15/100) = -16.48 \text{ dB}$$

Therefore, we would be able to subtract 16.48 dB from the peak emission measurement. This is based on the premise that a system employing this type of hopping protocol would actually produce less energy on a given channel/frequency over the same time interval as a system that transmits for 100 mseconds on that channel/frequency.

3.0 General Comments about Part 15.247 Rules

Finally, the last set of tests to be performed, **if necessary**, have to do with testing the system as a frequency hopping transceiver. Again this will be a radiated emissions test and will be governed by the same rules as stated in the previous paragraphs. The only requirement for performing this last test is that if during the operation of the system as a frequency hopping transceiver additional spurs are generated that would not appear during the previous two static tests. If this is the case, then the transceiver must be exercised as a hopping transceiver and the radiated emissions test must be repeated on the newly generated spurs. This could be used as an argument for insuring that the transmitter is de-keyed prior to changing/hopping to another frequency.

In addition, with regards to certifying various products in a similar product family, a company can specify that the device operates with a variety of hosts and only perform the compliance testing with a representative host model. Therefore, a company would not have to do compliance testing for all of the models in its product line, as long as the company can insure that these models will not produce any unwanted emissions that violate the FCC limits. This will greatly reduce the cost and time associated with obtaining FCC approval.

APPENDIX A**15.205 Restricted Bands:**

0.090 - 0.110	MHz	2310 - 2390	MHz
0.49 - 0.51	MHz	2483.5 - 2500	MHz
2.1735 - 2.1905	MHz	2655 - 2900	MHz
8.362 - 8.366	MHz	3260 - 3267	MHz
13.36 - 13.41	MHz	3332 - 3339	MHz
25.5 - 25.67	MHz	3345.8 - 3358	MHz
37.5 - 38.25	MHz	3600 - 4400	MHz
73 - 75.4	MHz	4500 - 5250	MHz
108 - 121.94	MHz	5350 - 5460	MHz
123 - 138	MHz	7250 - 7750	MHz
149.9 - 150.05	MHz	8025 - 8500	MHz
156.7 - 156.9	MHz	9000 - 9200	MHz
162.0125 - 167.17	MHz	9.3 - 9.5	GHz
167.72 - 173.2	MHz	10.6 - 12.7	GHz
240 - 285	MHz	13.25 - 13.4	GHz
322 - 335.4	MHz	14.47 - 14.5	GHz
399.9 - 410	MHz	15.35 - 16.2	GHz
608 - 614	MHz	17.7 - 21.4	GHz
960 - 1240	MHz	22.01 - 23.12	GHz
1300 - 1427	MHz	23.6 - 24.0	GHz
1435 - 1626.5	MHz	31.2 - 31.8	GHz
1660 - 1710	MHz	36.43 - 36.5	GHz
1718.8 - 1722.2	MHz	Above 38.6	GHz
2200 - 2300	MHz		

APPENDIX B**15.209 Emissions Limits:**

Frequency [MHz]	Field Strength [μ V/m]	Distance [m]
0.009 - 0.490	2400 / F(kHz)	300
0.490 - 1.705	24000 / F(kHz)	30
1.705 - 30.0	30	30
30.0 - 88.0	100	3
88.0 - 216.0	150	3
216.0 - 960.0	200	3
Above 960.0	500	3

NOTES:

- 1) The tighter limit applies at the band edge.
- 2) The limits in this table are based on the frequency of the unwanted emission and not the fundamental frequency. These limits apply to the appropriate bands listed in Appendix A.
- 3) Since this incorporates a digital device, we will have to measure up to the 10th harmonic of the highest fundamental frequency when measuring emissions. It should also be noted that when emissions can be identified as being solely from the digital electronics, then they should be specified as such since they are only required to meet the limits of Class A or B certification and not the more stringent 15.247 requirements.
- 4) Measurements required at distances of greater than 3.0 meters may be measured at 3.0 meters and extrapolated out to 30 meters. The 300 meter distance will probably not be required for emissions testing of this transceiver.

