Understanding Regulations when Designing a Wireless Product in the Unlicensed Frequency Bands

The unlicensed frequency bands have special regulations; this article explains how they relate to product design

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The last few years have witnessed a proliferation of wireless standards and products with diverse types of applications. This proliferation can be explained by the fact that consumers realize that any wireline communication link can be potentially replaced by a wireless link. The wireless unlicensed frequency bands—especially the industrial, scientific, medical (ISM) bands—are the most appropriate for these new applications and products.

The ISM bands are part of the frequency spectrum that can be used without a license. However, products developed in these bands still are required to be compliant with rules defined by the country's regulatory bodies before being deployed in the field. In this article we will focus on the US region, which is regulated by the Federal Communication Commission (FCC). 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. Colloquially, it is often referred to as FCC Part 15.

We will review the classification of devices operating in the unlicensed band and the key points engineers need to understand in order to design FCC-compliant products. The unlicensed wireless operating devices are classified into four main groups: 1) FCC-classified control devices; 2) FCC-classified periodic devices; 3) FCC-classified general purpose devices with single frequency; and 4) general purpose devices using spread-spectrum techniques.

This classification helps define key parameters that are monitored by the FCC in order to ensure that the product will not cause harmful interference to other users, especially in the adjacent licensed bands. The most monitored parameters are: maximum output power, maximum acceptable spurious emission, and duty cycle.

1) FCC-classified control devices

Control devices are used to transmit simple control signals, like alarm systems, door openers, or remote switches. Also data may be sent along with the control signals. Control devices are allowed to transmit only for a period of time that can not exceed five seconds, without a predetermined interval. **Table 1** illustrates the level of output power and the maximum spurious emission allowed for this group of devices. Notice that the higher the frequency of operation, the higher are the allowed maximum output power and the maximum spurious emission.

Table 1: FCC-classified Control Devices Emissions

Fundamental Frequency (MHz)	Maximum Fundamental Emission (dBm)	Maximum Spurious Emission (dBm)
260 – 470	–25.9 to –15.4	–45.9 to –35.4
470+	–15.4	–35.4

2) FCC classified periodic devices

Periodic devices are characterized as various control and signaling devices with very limited transmission times. Periodic devices must transmit for a period no greater than one second with a silent period of 30 times the transmit period TX, or 10 seconds, whichever is greater.

As described in **Table 2**, the periodic devices are limited in their output power as well as maximum level of the spurious emission. Like the control devices, the maximum output power and maximum spurious emission are proportional to the frequency of operation.

Table 2: FCC Classified Periodic Devices Emissions

Fundamental Frequency (MHz)	Maximum Fundamental Emission (dBm)	Maximum Spurious Emission (dBm)
260 – 470	–33.9 to –23.4	–53.9 to –43.4
470+	–23.4	–43.4

3) FCC classified general purpose devices with single frequency

Most general purpose devices operate in the 915 MHz or 2.4 GHz bands, even though other bands are available for their operation. These two frequency bands have no restriction for the duty cycle and allow a much higher output power limit. The lack of restriction on the duty cycle, combined with an allowed higher output power, makes these bands very popular for unlicensed short range applications including audio and video transmission.

General purpose devices can transmit an output power of up to –1.25 dBm when operating with a single frequency. The FCC requires a maximum harmonic power of –43.4 dBm with a spurious output 50 dB below the fundamental.

It is important to note that a higher peak output power is allowed in the 2.4 GHz band, if an averaging detector is used. However, the peak electrical field strength should not be more than 20 dB above the average value.

4) General purpose devices using spread spectrum techniques

When using spread spectrum techniques such as frequency-hoping spread-spectrum (FHSS) and direct-sequence spread-spectrum (DSSS), the FCC allows the design engineer to transmit a higher output power. The reason such allowances are made is that, unlike single-frequency transmitters, spread-spectrum systems are less likely to interfere with other systems, due to power-density reduction. The transmitted signal is seen by other users as an acceptable level of noise. Spread-spectrum systems also have the advantage that they are often more immune to interference from other systems. An application qualifies as a frequency hopping system if:

- the transmitter pseudo-randomly hops between frequencies separated from each other by at least the 20-dB bandwidth of the data channel, but not less than 25 kHz. For 2.4 GHz band operation, the transmitter should hop pseudo-randomly between at least 15 non-overlapping frequency channels;

- the 20 dB bandwidth of hopping channel is less than 500 kHz;

- the 20 dB bandwidth of the hopping channel is less than 250 kHz, then the system must use at least 50 hopping frequencies. The average time of occupancy at any frequency (dwell time) must not be larger than 0.4 seconds within any 20-second period;

- the bandwidth of the hopping channel is larger than 250 kHz, then the system must use at least 25 hopping frequencies. The average time of occupancy at any frequency must not be larger than 0.4 seconds within any 10-second period;

- operating in 2.4 GHz, the dwell time must not be larger than 0.4 second within a period of 0.4 second multiplied by the number of channels,

As far as the DSSS is concerned, the FCC set the following requirements:

- Transmitter power density averaged over one second shall not exceed 8 dBm in any 3 kHz bandwidth.

- Minimum bandwidth is 500 kHz.

An option called “digital modulation techniques,” similar to spread-spectrum techniques, is becoming increasingly popular. The digital modulation works a lot like the DSSS, but without the requirement of coding gain. Because of their spectrum characteristics similar to the DSSS system, the FCC has determined digital modulation techniques can operate under the same rules as DSSS devices in the 915 MHz, 2.4 GHz and 5.7 GHz bands.

Figure 1 and **Figure 2** illustrate the maximum output power allowed for devices using spread-spectrum techniques, respectively, in the 915 MHz and 2.4 GHz bands. In the 915 MHz band, a maximum output power of 36 dBm is allowed, if DSSS or FHSS with 50

channels is used. If the FHSS uses less than 50 channels, the maximum output power drops to 30 dBm. When operating in the 2.4 GHz band, the maximum output allowed is fixed at 36 dBm for DSSS systems, and for FHSS systems with a minimum number of 75 channels. For FHSS with less than 75 channels, the device is allowed to transmit up to 30 dBm.

Regarding spurious emissions for this class of devices, FCC regulations require that for both the 915 MHz and the 2.4 GHz bands the emission in any 100-kHz bandwidth outside the band must only be at least 20 dB below the emission in the 100-kHz bandwidth within the band that contains the highest power operation.

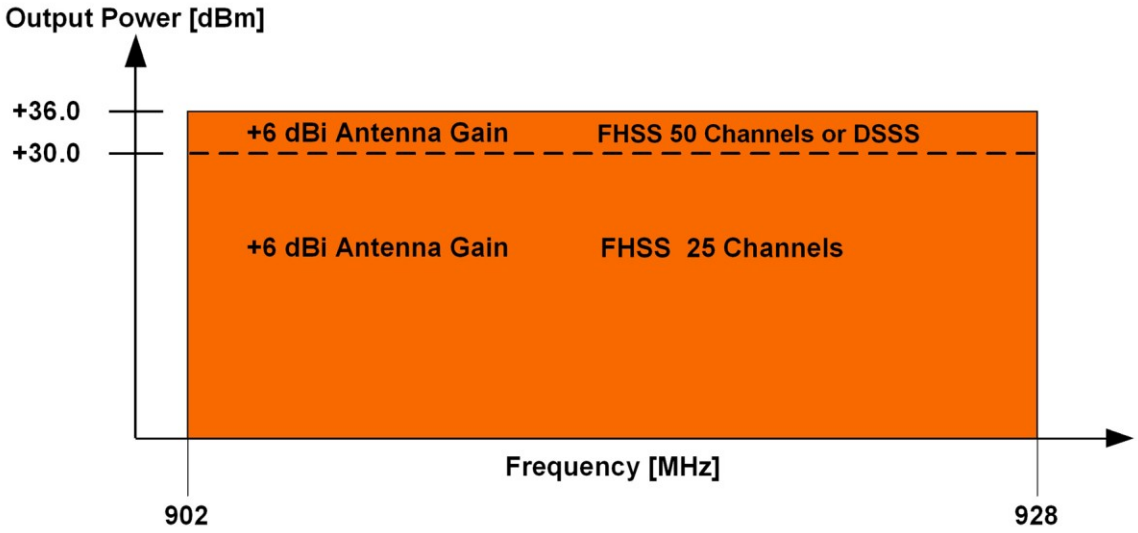

Figure 1: Maximum output power allowed by FCC in the 915 MHz when using a spread spectrum technique

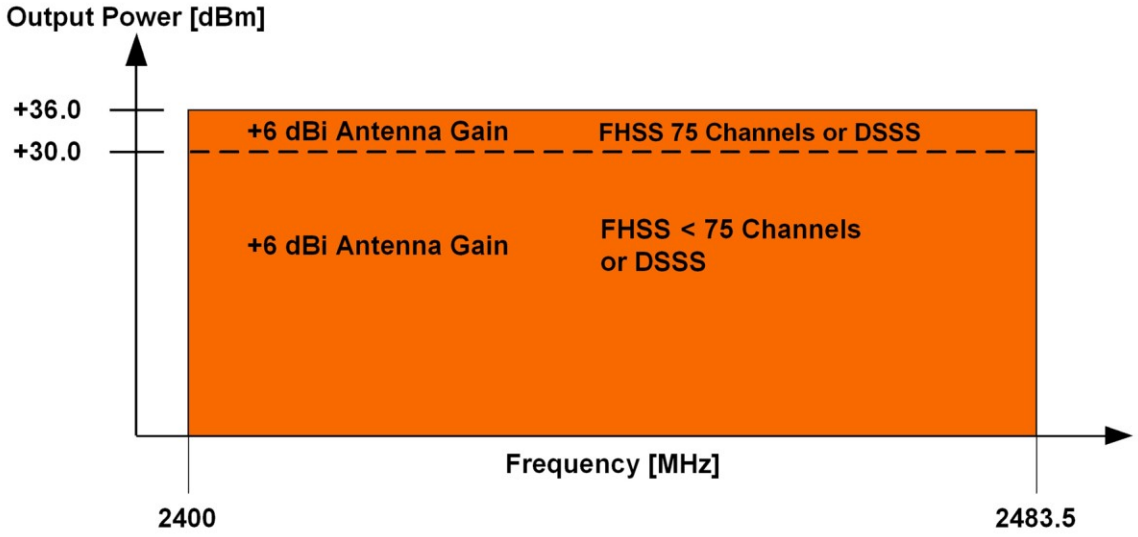

Figure 2: Maximum output power allowed by FCC in the 2.4 GHz when using a spread spectrum technique

Conclusion

We just described the four categories of wireless unlicensed devices. We discussed the main parameters being monitored by the FCC (maximum output power, duty cycle, and spurious emission) in order to ensure that other users are protected. Understanding this classification, as well as the parameters limits, is very important in order to release a product that will be approved by the FCC for field deployment.

References

- Federal Communication Commission: http://www.fcc.gov/
- Download the Low-Power RF and Communications Infrastructure Solutions Guides here: www.ti.com/lprf-ca.

About the Author

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