APPLICATION NOTE AN-00125
Considerations For Operation Within the 260-470MHz Band

INTRODUCTION

This application note is designed to give the reader a basic understanding of the technical and legal issues that apply to the operation of RF devices in the 260MHz to 470MHz band. Since the allowed use of these frequency bands varies considerably worldwide, it should be recognized that this application note is intended for designers planning for operation in the United States under the rules of CFR47 Part 15.

When working with RF, a clear distinction must always be made between what is technically possible and what is legally acceptable. Since consideration of technical issues serves little purpose if the chosen frequency cannot be legally used for your intended purpose, let us consider issues of legality first.

LEGAL CONSIDERATIONS

In the United States, the Federal Communications Commission (FCC) is responsible for the regulation of all RF devices. These regulations are contained in the Code of Federal Regulations (CFR), Title 47. Title 47 is made up of numerous volumes, however, all regulations applicable to operation in the 260 to 470MHz band are contained in volume 0-19. It is strongly recommended that a copy be obtained and reviewed in its entirety. You can get a full copy of the code from your local government bookstore, the Government Printing office in Washington (http://bookstore.gpo.gov/) or the FCC web site at: http://wireless.fcc.gov/rules.html

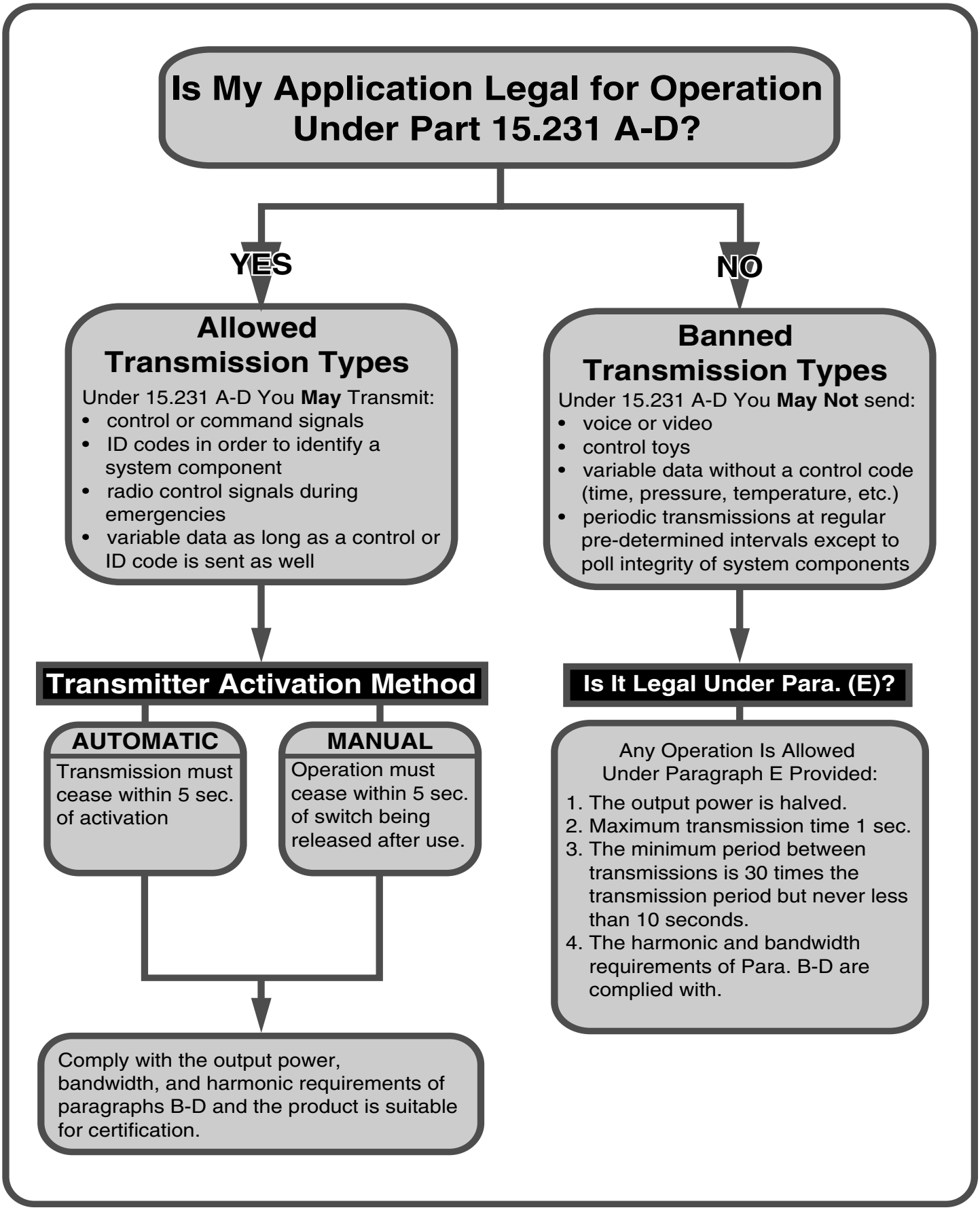
WHAT IS UNLICENSED OPERATION?

Here in the United States, the FCC requires any device that intentionally radiates RF energy to be tested for compliance with FCC rules. Certain bands within the RF spectrum are available for “unlicensed” operation. The term “Unlicensed” is often misunderstood. The manufacturer of a product designed for “Unlicensed” operation is not exempt from the certification procedure. Indeed, both the transmitter and receiver must be tested by a qualified testing laboratory and an FCC ID number obtained before the product can be legally sold. Once this has been done, however, the end user of the product can operate it without obtaining a license for its use.

Unlicensed operation in the frequencies from 260 to 470MHz is governed by Part 15, section 231. Part 15 is what is termed “Living Legislation”. This means it is subject to interpretation on a case-by-case basis. If your application is not clearly in compliance, it is best to consult the FCC directly before proceeding with a design.

WHAT MUST I DO TO BE UNLICENSED?

The regulations of Part 15.231 are rather unusual. In many bands the FCC specifies only fundamental power, harmonic levels, and allowed bandwidth. In the case of the 260-470MHz band, the FCC actually considers what the data being sent originally consisted of and what their intended function is. You will want to review the text of 15.231 in its entirety. (It has been included at the end of this application note for your convenience.) When reviewing this section, it is critical to realize that paragraphs (A)-(D) are intended to be read as a unit, while paragraph (E) applies only if the rules of paragraph (A) are being violated. Because of the complexity and application-dependent nature of the rules, they are best illustrated in a flowchart style as follows.


Is My Application Legal for Operation Under Part 15.231 A-D?
YES
NO
Allowed Transmission Types
Under 15.231 A-D You May Transmit:
• control or command signals
• ID codes in order to identify a system component
• radio control signals during emergencies
• variable data as long as a control or ID code is sent as well
Banned Transmission Types
Under 15.231 A-D You May Not send:
• voice or video
• control toys
• variable data without a control code (time, pressure, temperature, etc.)
• periodic transmissions at regular pre-determined intervals except to poll integrity of system components
Transmitter Activation Method
AUTOMATIC
Transmission must cease within 5 sec. of activation
MANUAL
Operation must cease within 5 sec. of switch being released after use.
Comply with the output power, bandwidth, and harmonic requirements of paragraphs B-D and the product is suitable for certification.
Is It Legal Under Para. (E)?
Any Operation Is Allowed Under Paragraph E Provided:
1. The output power is halved.
2. Maximum transmission time 1 sec.
3. The minimum period between transmissions is 30 times the transmission period but never less than 10 seconds.
4. The harmonic and bandwidth requirements of Para. B-D are complied with.

By reviewing Part 15 and the preceding flow chart, you have, hopefully, determined that your application is appropriate for operation in the 260 to 470MHz band. If you are still uncertain or feel your application falls into a “gray” area, you may wish to consult directly with an FCC engineer. You may do so by contacting the FCC directly at:

Federal Communications Commission
Office of Engineering and Technology
7435 Oakland Mills Road
Columbia, MD 21046
Phone: (301) 362-3000
Fax: (301) 344-2050
E-mail: Labhelp@fcc.gov
Web Site: www.fcc.gov/oet/

FUNCTIONAL REQUIREMENTS

Once you are certain your application is allowed in principle, you will want to focus on understanding the specific functional requirements that must be met in order for your completed device to receive certification.

DETERMINE AND COMPLY WITH ALLOWED OUTPUT POWER

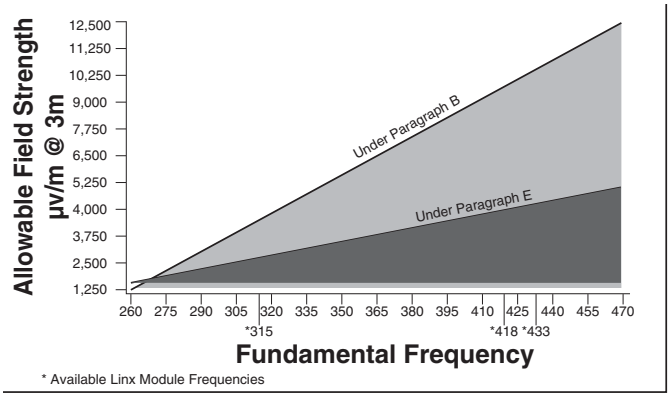


Figure 1: Output Power vs. Frequency

The above table illustrates the linear relationship between the fundamental frequency of operation and the allowed output power. Since the output power is allowed to climb as the frequency increases, it might at first appear that selecting the highest frequency would give the best range performance. This is not the case, however, since free space attenuation increases proportional to frequency. Thus, linear interpolation serves only to equalize the transmission’s propagation characteristics so that range performance is similar across the band.

It is important to note that the RF level radiated into free space is dependent not only on raw output power but also on the type of antenna employed. Most transmitter modules, including those manufactured by Linx, have an output level that is sufficient to produce a radiated RF level that is non-compliant. The transmitter is purposely set high because many designers may wish to utilize inefficient antenna styles, such as a loop-trace or helical, for cost or cosmetic reasons. If the module is matched to a highly efficient antenna, such as a full whip or yagi, the output power may need to be reduced externally by an attenuation pad. For further details review Linx application note #00150.

In addition to the restrictions on fundamental output power, the FCC also regulates allowed harmonic levels and occupied bandwidth. Since this application note is oriented toward users of Linx products, little detail is needed or will be given on these points as our modules are inherently designed to meet these requirements. It is important, however, to note that there are several ways in which a user can adversely affect harmonic content. The most common is the use of a poorly matched antenna. Consider, for example, an antenna that has a high Standing Wave Ratio (SWR) at the fundamental frequency and a low SWR at a harmonic frequency. When the transmitter’s output power is raised to achieve maximum legal output at the fundamental, the harmonic may rise to an unacceptable level by virtue of the antenna’s misplaced efficiency. Harmonics can also be affected by noise present in the transmitter supply. This noise can cause oscillator instability and subsequent spurs and harmonic events.

While these issues of legality may appear formidable, they generally are not. By choosing a correct operational frequency and using a pre-made RF module, a product designer’s burden is greatly reduced. With proper attention to such basics as good layout, clean supply lines, and a properly matched antenna, RF success is a nearly painless process.

Now that your application has, hopefully, survived the legal considerations outlined above, let’s consider the actual technical issues of operation in these frequencies.

BENEFITS OF OPERATION WITHIN THE 260-470MHZ BAND

First, it should be recognized that the unusual restrictions placed on the band by the FCC do more than just make your life miserable. They also help to keep this set of frequencies quite clear of interference. Other Part 15 bands, such as the 902-928MHz band, are crowded with continuous transmissions of voice, data, video and hi-level interference from microwave ovens to Spread Spectrum devices.

Second, longer transmission distances are achieved with less power. The free space propagation of frequencies in this range is significantly better than at higher frequencies, such as 900MHz or 2.4GHz. Therefore, lower output power is needed to attain any particular distance. Since less output power is needed, transmitter power consumption is significantly reduced and battery life extended.

Third is cost effectiveness. The components used at these frequencies are significantly lower in cost than those designed for operation at higher frequencies. This allows an excellent balance between product cost and performance.

Fourth is ease of export. Many countries worldwide have allocated these frequencies for similar uses. If your product will be sold abroad, this band will provide a wide range of international compatibility.

COMMON FREQUENCIES WITHIN THE BAND AND THEIR USES

As you review Linx product offerings, you will notice three standard frequencies within the band from 260 to 470MHz. These frequencies are 315, 418, and 433.92MHz.

- 315MHz is commonly used for gate/garage door openers, security and keyless entry systems.
- 418MHz is a very clean frequency here in the US and also appropriate for operation in Canada.
- 433.92MHz is used throughout all of Europe. While it is appropriate for use here in the US and Canada, interference from amateur radio, the nearby pager band, and active RFID tags may sometimes pose a problem.

If you are a high volume user (500k+/yr.), you may wish to further reduce the potential for interference by selecting a custom frequency within the band.

SUMMARY

The 260-470MHz band is ideal for instances where control, command or status signals need to be sent. In addition, it should also be given consideration for all applications where periodic short-range analog or digital transmissions are required.

SECTION 15.231

Periodic operation in the band 40.66 - 40.70MHz and above 70MHz.

(a) The provisions of this Section are restricted to periodic operation within the band 40.66 - 40.70MHz and above 70MHz. Except as shown in paragraph (e) of this Section, the intentional radiator is restricted to the transmission of a control signal such as those used with alarm systems, door openers, remote switches, etc. Continuous transmissions, voice, video and the radio control of toys are not permitted. Data is permitted to be sent with a control signal. The following conditions shall be met to comply with the provisions for this periodic operation:

(1) A manually operated transmitter shall employ a switch that will automatically deactivate the transmitter within not more than 5 seconds of being released.

(2) A transmitter activated automatically shall cease transmission within 5 seconds after activation.

(3) Periodic transmissions at regular predetermined intervals are not permitted. However, polling or supervision transmissions, including data, to determine system integrity of transmitters used in security or safety applications are allowed if the total duration of transmissions does not exceed more than two seconds per hour for each transmitter. There is no limit on the number of individual transmissions, provided the total transmission time does not exceed two seconds per hour.

(4) Intentional radiators which are employed for radio control purposes during emergencies involving fire, security, and safety of life, when activated to signal an alarm, may operate during the pendency of the alarm condition.

(b) In addition to the provisions of Section 15.205, the field strength of emissions from intentional radiators operated under this Section shall not exceed the following:

Fundamental Frequency (MHz)	Field Strength of Fundamental (microvolts/meter)	Field Strength of Spurious Emission (microvolts/meter)
40.66 - 40.70	2,250	225
70 - 130	1,250	125
130 - 174	1,250 to 3,750**	125 to 375**
174 - 260	3,750	375
260 - 470	3,750 to 12,500**	375 to 1,250**
Above 470	12,500	1,250

** linear interpolations

[Where F is the frequency in MHz, the formulas for calculating the maximum permitted fundamental field strengths are as follows: for the band 130-174MHz, uV/m at 3 meters = 56.81818(F) - 6136.3636; for the band 260-470MHz, uV/m at 3 meters = 41.6667(F) - 7083.3333. The maximum permitted unwanted emission level is 20dB below the maximum permitted fundamental level.]

(1) The above field strength limits are specified at a distance of 3 meters. The tighter limits apply at the band edges.

(2) Intentional radiators operating under the provisions of this Section shall demonstrate compliance with the limits on the field strength of emissions, as shown in the above table, based on the average value of the measured emissions. As an alternative, compliance with the limits in the above table may be based on the use of measurement instrumentation with a CISPR quasi-peak detector. The specific method of measurement employed shall be specified in the application for equipment authorization. If average emission measurements are employed, the provisions in Section 15.35 for averaging pulsed emissions and for limiting peak emissions apply. Further, compliance with the provisions of Section 15.205 shall be demonstrated using the measurement instrumentation specified in that section.

(3) The limits on the field strength of the spurious emissions in the above table are based on the fundamental frequency of the intentional radiator. Spurious emissions shall be attenuated to the average (or, alternatively, CISPR quasi-peak) limits shown in this table or to the general limits shown in Section 15.209, whichever limit permits a higher field strength.

(c) The bandwidth of the emission shall be no wider than 0.25% of the center frequency for devices operating above 70MHz and below 900MHz. For devices operating above 900MHz, the emission shall be no wider than 0.5% of the center frequency. Bandwidth is determined at the points 20dB down from the modulated carrier.

(d) For devices operating within the frequency band 40.66 - 40.70MHz, the bandwidth of the emission shall be confined within the band edges and the frequency tolerance of the carrier shall be + 0.01%. This frequency tolerance shall be maintained for a temperature variation of -20 degrees to +50 degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery operated equipment, the equipment tests shall be performed using a new battery.

(e) Intentional radiators may operate at a periodic rate exceeding that specified in paragraph (a) and may be employed for any type of operation, including operation prohibited in paragraph (a), provided the intentional radiator complies with the provisions of paragraphs (b) through (d) of this Section, except the field strength table in paragraph (b) is replaced by the following:

Fundamental Frequency (MHz)	Field Strength of Fundamental (microvolts/meter)	Field Strength of Spurious Emission (microvolts/meter)
40.66 - 40.70	1,000	100
70 - 130	500	50
130 - 174	500 to 1,500 **	50 to 150 **
174 - 260	1,500	150
260 - 470	1,500 to 5,000 **	150 to 500 **
Above 470	5,000	500

** linear interpolations

[Where F is the frequency in MHz, the formulas for calculating the maximum permitted fundamental field strengths are as follows: for the band 130-174MHz, uV/m at 3 meters = 22.72727(F) - 2454.545; for the band 260-470MHz, uV/m at 3 meters = 16.6667(F) - 2833.3333. The maximum permitted unwanted emission level is 20dB below the maximum permitted fundamental level.]

In addition, devices operated under the provisions of this paragraph shall be provided with a means for automatically limiting operation so that the duration of each transmission shall not be greater than one second and the silent period between transmissions shall be at least 30 times the duration of the transmission but in no case less than 10 seconds.