Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Revision of Part 15 of the Commission's	)	
Rules Regarding Ultra-Wideband	)	ET Docket No. 98-153
Transmission Systems	)	

NOTICE OF INQUIRY

Adopted: August 20, 1998 Released: September 1, 1998

By the Commission:

Comment date: [insert date 75 days from publication in Federal Register]
Reply comment date: [insert date 105 days from publication in Federal Register]

INTRODUCTION

1.1.1 The Commission is initiating this inquiry on its own motion to investigate the possibility of permitting the operation of ultra-wideband (UWB) radio systems on an unlicensed basis under Part 15 of its rules. Such systems could provide an improved method for providing radar applications where precise distance resolution is required and for providing covert voice or data communications that overcome multipath problems. Through this inquiry, we are seeking input to help us evaluate UWB technology and what standards and operating requirements are necessary to prevent interference to other users of the radio spectrum. Upon review of the responses to this inquiry, we will determine whether to propose any changes to the rules.

BACKGROUND

1.1.2 Part 15 of the rules permits the operation of low power radio frequency devices without a license from the Commission or the need for frequency coordination.[1] The technical standards for Part 15 are designed to ensure that there is a low probability that these devices will cause harmful interference to other users of the spectrum.[2] Intentional radiators, *i.e.*, transmitters, are

[1] *See* 47 CFR Section 15.1 *et seq.*

[2] The primary operating conditions under Part 15 are that the operator must accept whatever interference is received and must correct whatever interference is caused. Should harmful interference occur, the operator is required to

permitted to operate under a set of general emission limits[3] or under provisions that allow higher emission levels in certain frequency bands.[4] Intentional radiators generally are not permitted to operate in certain sensitive[5] or safety-related bands, designated as restricted bands,[6] or in the bands allocated for television broadcasting.[7] The measurement procedures for determining compliance with the technical requirements for Part 15 devices are provided or referenced within the rules.[8]

1.1.3 Recently, we have learned of advances in the development of UWB technology. UWB radio systems typically use extremely narrow pulse (impulse) modulation or swept frequency modulation that employs a fast sweep over a wide bandwidth. Because of the type of modulation employed, the emission bandwidths of UWB devices generally exceed one gigahertz and may be greater than ten gigahertz.[9] In some cases, these pulses do not modulate a carrier. Instead, the radio frequency emissions generated by the pulses are applied to an antenna, the resonant

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immediately correct the interference problem, even if correction of the problem requires ceasing operation of the system causing the interference. *See* 47 CFR § 15.5.

[3] *See* 47 CFR § 15.209.

[4] *See* 47 CFR §§ 15.215-15.407. In some cases, operation at the higher emission levels within these designated frequency bands is limited to specific applications.

[5] The sensitive bands referenced here are bands employed by radio services that must function, as a nature of their operation, using extremely low received signal levels. These systems may be passive, such as radio astronomy, or active, such as satellite down links and wildlife tracking systems.

[6] *See* 47 CFR § 15.205.

[7] *See* 47 CFR § 15.209(a).

[8] *See* 47 CFR §§ 15.31-15.35.

[9] Typical pulse widths currently are on the order of 2-0.1 nanoseconds, or less, in width. The emission spectrum appears as a fundamental lobe with adjacent side lobes that can decrease slowly in amplitude. Annex J of Chapter 5 of the National Telecommunications and Information Administration Manual calculates the 20 dB bandwidth of a non-FM pulsed radar as $B = 1.79/\sqrt{(\tau_r \tau)}$ or $6.36/\tau$, whichever is less, where B is the bandwidth in megahertz, τ is the emitted pulse duration, in microseconds, at the 50% amplitude (voltage) points and τ_r is the emitted pulse rise time in microseconds from the 10% to the 90% amplitude points on the leading edge. As an example, for a pulse with τ = 1.0 nS, ignoring rise time, the 20 dB bandwidth of the emission is calculated to be 6.36 gigahertz. The spectrum produced by a pulsed emission consists of a line spectrum with the spectral lines separated by 1/T where T is the time, in seconds, of the pulse spacing.

frequency of which determines the center frequency of the radiated emission. The bandwidth characteristics of the antenna will act as a low-pass filter, further affecting the shape of the radiated signal.

1.1.4 UWB technology can be employed for radar systems, permitting the precise measurement of distances, the detection of objects within a defined range of distances, or high resolution imaging of objects that are behind or under other surfaces. When combined with appropriate modulation techniques, UWB devices also may be used for communications purposes, such as the transmission of voice, control signals, and data. Most of the current equipment designs that have been investigated by the Commission contain high level, distinct spectral lines concentrated near the center of the emission. However, we recognize that, as the technology advances, this type of modulation is capable of spreading the signal levels over such a wide bandwidth that the emissions would appear to be similar to background noise. For such systems, the amount of energy appearing in any particular band should be extremely low. Such signals are not easily detected or intercepted.

1.1.5 The current Part 15 rules pose two primary obstacles to the implementation of UWB technology. First, the wide bandwidth of UWB systems emissions may result in their fundamental emissions[10] being transmitted into the TV broadcast and in restricted frequency bands which is prohibited under the Part 15 rules. It is difficult to avoid operating in these bands as the ultra-wide bandwidth is intrinsic to the operation of UWB equipment. Second, the current emission measurement procedures specified in our Part 15 rules were developed for narrowband systems and may be inappropriate for, and pose unnecessary restrictions to, UWB technology. For example, the measurement procedures require the application of a pulse desensitization correction factor.[11] This correction factor will cause UWB systems to exceed the peak emission limits currently permitted under Part 15.[12]

1.1.6 The Commission now has before it three requests for waivers of the Part 15 rules to permit the operation of UWB systems.[13] U.S. Radar Inc., on January 28, 1998, filed a Petition for

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[10] Fundamental emissions consist of the carrier and modulation products but exclude unwanted emissions. In other words, the fundamental emission is equivalent to the necessary bandwidth. The necessary bandwidth is defined and calculated in 47 CFR § 2.202, and the definition of unwanted emissions, consisting of out-of-band emissions and spurious emissions, is contained in 47 CFR § 2.1.

[11] *See* the measurement procedure specified in 47 CFR § 15.31(a)(6). This procedure references the use of HP Application Note 150-2 which specifies the use of a pulse desensitization correction factor.

[12] *See* 47 CFR §§ 15.35(b) and 15.209. Because ultra-wideband systems normally have a low duty cycle, the peak levels are quite high compared to the average emission levels.

[13] In addition, there have been several applications for grants of equipment authorization and an even greater number of inquiries to the staff to permit these systems.

Waiver to permit the operation of a surface penetrating radar system that could be used to detect buried objects and objects hidden behind walls.[14] On February 2, 1998, Time Domain Corp. filed a Petition for Waiver to permit systems that would be used by public safety personnel for communications, location determination and high resolution imaging radar.[15] On April 14, 1998, Zircon Corporation also filed a Request for Waiver to permit radar systems that would be used by the construction industry to detect objects hidden behind walls and other building materials.[16] These petitions for waiver will be addressed separately from this proceeding.

DISCUSSION

1.1.7 We believe that UWB technology has unique attributes that could lead to a wide variety of new beneficial uses that may be in the public interest. Radar systems are currently being developed to detect buried objects such as plastic gas pipes or hidden flaws in airport runways or highways. Other radar systems would be used as fluid level sensors in difficult-to-measure situations such as oil refinery tanks and other storage tanks. Public safety personnel have expressed a desire for radar systems that can detect people hidden behind walls or covered with debris, such as from an earthquake. Public safety personnel also have expressed a need for UWB communications systems that can operate covertly. These communications systems could also be employed by heavy industrial manufacturers to overcome multipath[17] and machinery-generated radio noise.

1.1.8 The Commission has a long history of facilitating the introduction of new technologies under Part 15 of its rules. For example, in the mid-1980's the Commission provided new rules for spread spectrum technology that led to the growth of an industry and a wide array of products. In

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[14] The U.S. Radar system employs different antennas, depending on the specific application. While the bandwidth employed by the radar can occupy up to several gigahertz of spectrum, the antennas are centered at 250 MHz, 500 MHz, 1000 MHz and 2000 MHz. U.S. Radar predicts that approximately 25 systems per year would be imported into the U.S. over a ten year period. The U.S. Radar petition was placed on Public Notice for comments on February 6, 1998.

[15] The Time Domain systems have emissions centered in the 2-4 GHz band and occupy several gigahertz of spectrum. Time Domains indicates that sales would be restricted to no more than 2500 units which would be marketed to fire and police departments. The Time Domain petition was placed on Public Notice for comments on February 6, 1998.

[16] The Zircon system has its emissions centered within the 200 MHz to 4 GHz band and emits an average radiated power of approximately 125 uW. Zircon states that it would limit sales to "professional tradespeople for use primarily in high noise construction environments." The Zircon petition was placed on Public Notice for comments on May 18, 1998.

[17] Multipath is the propagation phenomenon that results in signals reaching the receiving antenna by two or more paths, usually due to reflections of the transmitted signal. The ability to time-gate the receiver would allow it to ignore signals arriving outside a prescribed time interval, such as signals due to multipath reflections.

the past few years, the Commission has amended Part 15 to provide for unlicensed personal communication service devices, unlicensed national information infrastructure devices and millimeter wave technology. We are initiating this Notice of Inquiry to determine what, if any, changes to our rules may be appropriate to facilitate the development of UWB technology and what standards and operating requirements are necessary to prevent interference to other users of the radio spectrum. We seek information on the topics identified below to help us determine whether to propose any changes to our Part 15 rules.

1.1.9 Applications and general characteristics. Currently, two general types of UWB systems have been presented to the Commission: radar systems and communications systems that can be used for voice, data and control signals. These products are comparable to spread spectrum modulated systems. Like spread spectrum systems, UWB systems are able to employ gain processing on the received signal and can operate in the presence of higher powered transmission systems without receiving interference. UWB systems also may have a low potential, relative to the total peak powers employed, for causing harmful interference to other users of the spectrum if the transmitted signal is spread over a wide bandwidth which may result in a relatively low spectral power density. We invite comments on the following issues:

- What types of UWB devices can we expect to be developed?

- What are the frequency ranges and bandwidths expected to be used by UWB devices?

- What are the expected total power levels and spectral power densities, peak and average, of UWB devices?

- What are the expected or desired operating distances?

1.1.10 Regulatory treatment. We understand that UWB systems will operate at very low spectral power densities, producing noise-like signals. Further, it appears that UWB systems will operate over very short distances.[18] Because of this, it appears appropriate to provide for UWB technologies under Part 15 of the rules. We invite comments on whether it would be appropriate to apply our Part 15 rules to UWB technologies.

- Are there certain types of UWB devices or applications that should be regulated on a licensed basis under some other rule part? If so, which rule parts?

- If provisions are made for UWB technology under Part 15, how should we define UWB technology?

1.1.11 TV broadcast and restricted bands. Part 15 designates certain sensitive and safety-

[18] While Part 15 does not specifically restrict operating distance, the technical standards inherently limit the range for most devices to 100 meters or less. We recognize, however, that certain Part 15 devices use high gain, directional antennas to achieve operating distances of 30 kilometers or more for point-to-point operations.

related frequency bands as restricted bands.[19] Only spurious emissions[20] not exceeding the general emission limits are permitted within these restricted bands or, with few exceptions, within the frequency bands allocated for TV broadcasting. However, it is difficult, if not impossible, for UWB systems to avoid placing fundamental emissions within the restricted bands or the TV broadcast bands. Accordingly, comments are requested on whether the Commission should eliminate the requirement that only spurious emissions be permitted to fall within the restricted bands and the TV broadcast bands.

- Should the rules generally continue to prohibit operation of UWB systems within the restricted bands and the TV broadcast bands?

- Are there certain restricted bands where operation could be permitted, but not others? If so which bands and what is the justification?

- If certain restricted bands were retained, what impact would this have on the viability of UWB technology?

1.1.12 Emission limits. The wide bandwidth of the emission from a UWB system, especially when combined with a modulation technique that pseudorandomizes the time position of the pulses, can make the signal appear to be broadband noise.[21] The current Part 15 rules are based on the equivalent of a spectral power density, *i.e.*, a field strength limit is specified along with a measurement bandwidth. In most cases, emissions at or below 1000 MHz are based on the use of a quasi-peak detector which employs a designated measurement bandwidth.[22] Above 1000 MHz, emissions are based on average field strength limits with a minimum measurement bandwidth of one megahertz.[23] Where an average limit applies, there is also a limit on peak emission levels.[24]

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19 *See* 47 CFR § 15.205.

20 Spurious emissions are emissions outside of the necessary bandwidth, the level of which may be reduced without affecting the transmission of information. *See* 47 CFR § 2.1.

21 The shape of the emission spectrum is dependent on the type of modulation employed, *e.g.*, whether the system uses pulsed modulation or swept frequency FM, and the method used to encode information on the transmission. For example, a pulse train without modulation or with minimal pulse position modulation will produce a line spectrum whereas modulation that shifts these pulses over larger time frames results in a spectral output that appears closer to noise.

22 *See* 47 CFR § 15.35(a).

23 *See* 47 CFR § 15.35(b). Some rule sections also specify the application of a total peak power limit over a wider bandwidth. *See*, for example, 47 CFR § 15.247(b).

24 *See* 47 CFR § 15.35(b).

These emission bandwidths were chosen to approximate the bandwidths of receivers that could receive interference. Further, the emission limits were established based on the potential interference from a single Part 15 device and do not take into account cumulative effects that could occur if there is a high level of equipment proliferation. The Commission requests comments on the appropriateness of applying the existing general emission limits to UWB systems.

- Are the existing general emission limits sufficient to protect other users of the spectrum, especially radio operations in the restricted bands, from harmful interference?

- Should different limits be applied to UWB systems?

- Should we specify a different standard for UWB devices based on spectral power density? Should these standards be designed to ensure that the emissions appear to be broadband noise?

- What is the potential for harmful interference due to the cumulative impact of emissions if there is a large proliferation of UWB devices? Could the cumulative impact result in an unacceptably high increase in the background noise level? Should the Commission limit proliferation by restricting the types of products or should the rules permit manufacturers to design products for any application as long as the equipment meets the standards?

- Should a limit on the total peak level apply to UWB devices?

- Can emissions below or above a certain frequency range be further filtered to reduce the potential for interference to other users of the radio spectrum without affecting the performance of the UWB systems?

- Are the existing limits on the amount of energy permitted to be conducted back onto the AC power lines appropriate for UWB devices?

- What operational restrictions, if any, should be required to protect existing users?

- Is the use of UWB modulation techniques necessary for certain types of communication systems; if so, for what purposes?

1.1.13 Measurements. The testing procedures for measuring compliance with the technical requirements applicable to Part 15 intentional radiators are specified in Sections 15.31-15.35 of the rules. Among other things, these rules reference the specific measurement procedure to be employed,[25] the frequency range over which measurements are to be made,[26] and the

[25] *See* 47 CFR § 15.31(a)(6).

[26] *See* 47 CFR § 15.33.

measurement detector functions and bandwidths to be employed.[27] As indicated above, the measurement procedures require the use of a pulse desensitization correction factor to measure the total peak power emitted by a device. With conventional Part 15 intentional radiators, the peak level provides an indication of the interference potential of a device by measuring the total amount of power that may appear in the passband of a receiver. However, a UWB system's emission spreads the energy over a wide bandwidth, and these transmitters typically operate with a low duty cycle. Thus, comments are requested on whether the peak output level continues to be indicative of the interference potential of a UWB system. Comments are also requested on the following issues:

- Is a pulse desensitization correction factor appropriate for measuring emissions from a UWB device? Should any modifications be made to this measurement procedure for UWB devices?

- Would another measurement procedure that does not apply a pulse desensitization correction factor be more appropriate for determining the interference potential of an UWB device?

- The frequency range over which measurements are required to be made depends on the frequency of the fundamental emission. Is the frequency of the fundamental emission readily discernible for UWB devices? Are the current frequency measurement ranges specified in the rules appropriate for UWB devices or should these ranges be modified?

- Are the measurement detector functions and bandwidths appropriate for UWB devices? Should these standards be modified and, if so, how?

- Are there any other changes to the measurement procedures that should be applied to UWB devices?

1.1.14 Other matters. There is a prohibition in the rules against the use of a Class B, damped wave emission.[28] This prohibition stems from a similar International Telecommunication Union regulation and is a throwback to the days when spark gap transmitters were employed.[29] Such transmitters were noisy and generated a wide emission bandwidth. There is no longer a clear definition of a Class B, damped wave emission.[30] While UWB systems produce broadband

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27 *See* 47 CFR § 15.35.

28 *See* 47 CFR §§ 2.201(f) and 15.5(d).

29 *See* Chapter II, Article 5, Section 8 of the Radio Regulations of the International Telecommunication Union.

30 The term "damped waves (Type B)" was last defined in Article 5, Section 1 of the 1938 version of the ITU regulations

emissions, we do not believe they should be considered as generating Class B, damped wave emissions. The prohibition against Class B emissions was intended to prevent the generation of wasteful radio frequency energy and the use of inefficient transmission techniques. This does not appear to be the case for the current UWB products. Comments are requested on the following issues:

- Should the prohibition against Class B, damped wave emissions apply to UWB systems or is the prohibition irrelevant, especially in light of the relatively low power levels employed by UWB devices?

- Comments are invited on any other matters or issues that may be pertinent to the operation of UWB systems.

PROCEDURAL MATTERS

1.1.15 This is a non-restricted notice and comment rule making proceeding. *Ex parte* presentations are permitted, except during the Sunshine Agenda period, provided they are disclosed as provided in the Commission's rules. *See generally* 47 CFR §§ 1.1202, 1.1203, and 1.2306(a).

1.1.16 Pursuant to Sections 1.415 and 1.419 of the Commission's Rules, 47 CFR §§ 1.415 and 1.419, interested parties may file comments on or before [insert date 75 dates from date of publication in the Federal Register] and reply comments on or before [insert date 105 days from date of publication in the Federal Register]. Comments may be filed using the Commission's Electronic Comment Filing System (ECFS) or by filing paper copies. *See Electronic Filing of Documents in Rulemaking Proceedings*, 63 Fed. Reg. 23,121 (1998).

1.1.17 Comments filed through the ECFS can be sent as an electronic file via the Internet to <http://www.fcc.gov/e-file/ecfs.html>. Generally, only one copy of an electronic submission must be filed. If multiple docket or rule making numbers appear in the cation of this proceeding, however, commenters must transmit one electronic copy of the comments to each docket or rule making number referenced in the caption. In completing the transmittal screen, commenters should include their full name, Postal Service mailing address, and the applicable docket or rule making number. Parties may also submit an electronic comment by Internet e-mail. To get filing instructions for e-mail comments, commenters should send an e-mail to ecfs@fcc.gov, and should including the following words in the body of the message, "get form <your e-mail address." A sample form and directions will be sent in reply.

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as "[w]aves composed of successive series of oscillations the amplitude of which, after obtaining a maximum, decreases gradually, the wave trains being keyed according to a telegraph code." A more modern version of the term "damped wave" is defined in the IEEE Standard Dictionary of Electrical and Electronic Terms, IEEE Std 100-1972, as "[a] wave in which, at every point, the amplitude of each sinusoidal component is a decreasing function of time."

1.1.18 Parties who choose to file by paper must file an original and four copies of each filing. If more than one docket or rule making number appear in the caption of this proceeding, commenters must submit two additional copies for each additional docket or rule making number. All filings must be sent to the Commission's Secretary, Magalie Roman Salas, Office of Secretary, Federal Communications Commission, 1919 M St., N.W., Room 222, Washington, D.C. 20554. Comments and reply comments will be available for public inspection during regular business hours in the FCC Reference Center of the Federal Communications Commission, Room 239, 1919 M Street, N.W., Washington, D.C. 20554.

1.1.19 The proposed action is authorized under Sections 4(i), 301, 302, 303(e), 303(f), 303(r), 304 and 307 of the Communications Act of 1934, as amended, 47 USC Sections 154(i), 301, 302, 303(e), 303(f), 303(r), 304, and 307.

1.1.20 For further information regarding this Notice of Inquiry, contact John A. Reed, Office of Engineering and Technology, (202) 418-2455.

FEDERAL COMMUNICATIONS COMMISSION

Magalie Roman Salas
Secretary