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 Transmission	)	ET Docket No. 98-153
Systems	)	

SECOND REPORT AND ORDER AND SECOND MEMORANDUM OPINION AND ORDER

Adopted: December 15, 2004 **Released: December 16, 2004**

By the Commission: Chairman Powell issuing a statement.

TABLE OF CONTENTS

I. INTRODUCTION

1. By this action, we are amending Part 15 of our rules to provide greater flexibility for the introduction of new wide-bandwidth devices and systems. These amendments respond to comments received in response to the *Memorandum Opinion and Order and Further Notice of Proposed Rule Making* in this proceeding.[1] In the *FNPRM* portion we invited comment as to whether we should provide this flexibility by amending our rules for ultra-wideband (UWB) devices, or alternatively, by making changes to the general provisions for unlicensed devices. We have chosen the latter course. As stated previously, we are reluctant to change the existing UWB rules until we have more experience with UWB devices.[2] We continue to believe that any major changes to the rules for existing UWB product categories at this early stage would be disruptive to current industry product development efforts. However, we are amending the Part 15 non-UWB regulations to better accommodate devices and systems that use wide bandwidths. Specifically, we are permitting the use of peak emission levels, similar to the levels applied to UWB devices, for wideband emissions in the 5925-7250 MHz, 16.2-17.7 GHz and 23.12-29.0 GHz bands. This action will facilitate the introduction of some of the operating systems sought by the commenting parties, including radar systems that would be used to improve automotive safety and tracking systems that could be employed for personnel location, such as hospital patients and emergency rescue crew, as well as for such functions as inventory control. Limiting these devices to certain frequency bands will minimize the interference potential to critical authorized radio systems. We also are taking the opportunity provided by this order to address the petitions for reconsideration of the *First Report and Order* (*1st R&O*) in this proceeding filed by Cingular, Inc. and by the Satellite Industry Association.[3]

II. BACKGROUND

2. On February 14, 2002, the Commission adopted the *1st R&O* in this proceeding, amending Part 15 of its rules to permit the marketing and the unlicensed operation of products incorporating UWB technology.[4] UWB radio systems generally employ pulse modulation where extremely narrow (short) bursts of RF energy are modulated and emitted to convey information.[5] The

---

1 *See Memorandum Opinion and Order and Further Notice of Proposed Rule Making* ("*MO&O*" and "*FNPRM*") in ET Docket No. 98-153, 18 FCC Rcd 3857 (2003).

2 *Id.* at para. 1, 29, 33, 54, and 169. We are, however, instituting a minor change to the rules applicable to UWB vehicular radar systems. This change will conform the measurement procedures used for both UWB radars to the provisions for non-UWB radars being adopted in this order.

3 *See First Report and Order* in ET Docket No. 98-153, 17 FCC Rcd 7435 (2002). An *Erratum* to the *First Report and Order* was adopted on May 30, 2002. *See Erratum* in ET Docket No. 98-153, 17 FCC Rcd 10505 (2002). *See*, also, *Order* in ET Docket No. 98-153, 17 FCC Rcd 13522 (2002), adopted July 12, 2002, regarding who may operate a ground penetrating radar ("GPR") and for what purpose. A petition for reconsideration filed by Multispectral Solutions, Inc. ("MSSI") was dismissed under delegated authority of the Chief, Office of Engineering and Technology, by letter dated August 4, 2003. The MSSI petition was found to be repetitious, addressing issues that had already been considered by the Commission and containing no new information or arguments. Further, the changes sought by MSSI were proposed in the *FNPRM* and, consequently, are being addressed in this instant proceeding without the need for reconsideration of the *MO&O*.

4 In order to be classified as UWB, the emission, at any point in time, must have a fractional bandwidth of at least 0.20 or a -10 dB bandwidth of at least 500 MHz. *See* 47 C.F.R. §15.501(d).

5 The rules adopted in the *1st R&O* also permit UWB devices to comply with the minimum bandwidth requirement by use of a high speed data rate or other modulation techniques instead of the width of the pulse or impulse signal.

emission bandwidths from these systems are large and may often exceed one gigahertz.[6] The frequency response characteristics of the UWB antenna provide band-pass filtering, further affecting the shape of the radiated signal. UWB devices can be used for precise measurement of distances or locations and for obtaining images of objects buried under ground or behind surfaces. UWB devices can also be used for wireless communications and, in particular, for short-range high-speed data transmissions suitable for broadband access to networks.

3. Several categories of UWB devices are permitted to be operated under the Part 15 regulations: imaging systems,[7] vehicular radars and indoor and outdoor communication systems. Because of their wide operating bandwidths, UWB devices operate in frequency bands that are allocated both to U.S. Government and to non-government operations.[8] In order to permit the operation of UWB devices, it was necessary to amend two standards in the former Part 15 rules: the prohibition against operation in the restricted frequency bands[9] and the limitation on peak power.[10] UWB devices must be permitted to operate in the restricted frequency bands in order to accommodate the extremely wide bandwidths employed by these devices.[11]

4. For non-UWB unlicensed devices, the regulations limit the total peak power produced by the unlicensed transmitter.[12] It was determined that the total peak power for UWB devices was not relevant; it is the power into a victim receiver that is important.[13] Thus, the Commission amended its rules to increase the peak power level measured in a 50 MHz band centered on the frequency at which the highest average emission level is produced by the UWB device.[14] This change increased the allowable

---

[6] Typical pulse widths used by UWB devices currently are on the order of 0.1-2 nanoseconds, or less, in width. The emission spectrum of these devices appears as a fundamental lobe with adjacent side lobes that can decrease slowly in amplitude. The rise time of the leading edge of the pulse and the passband of the radiating antenna are major factors in determining the bandwidth of the UWB emission.

[7] Imaging systems consist of GPRs, wall imaging systems, through-wall imaging systems, surveillance systems, and medical imaging systems.

[8] The operation of Government radio stations is regulated by the National Telecommunications and Information Administration (NTIA), while operation of stations by private industry, by state and local governments and by the public is regulated by the FCC.

[9] *See* 47 C.F.R. § 15.205. The restricted bands are frequency bands employed for safety of life applications and for use by radio services that must function, as a nature or their operation, using extremely low received signal levels. The latter systems may be passive, such as radio astronomy, or active, such as satellite down links and wildlife tracking systems. Unlicensed devices generally are not allowed to operate in these bands.

[10] *See* 47 C.F.R. § 15.35(b).

[11] There is sufficient spectrum between restricted bands to allow for the operation of non-UWB devices without having to permit such devices to operate in the restricted frequency bands. *See 1st R&O, supra*, at para. 30-32 for additional discussion on this issue.

[12] While 47 C.F.R. § 15.35(b) specifies that a minimum 1 MHz resolution bandwidth is employed for emission measurements above 1000 MHz, when pulse widths are narrower than the inverse of the resolution bandwidth employed by a spectrum analyzer it is necessary to apply a pulse desensitization correction factor ("PDCF") to the peak level measured on the spectrum analyzer in order to compensate for the analyzer's inability to respond fast enough to reflect the true peak power, *i.e.*, the spectrum analyzer does not have sufficient bandwidth to measure all of the energy in the pulsed signal.

[13] *See 1st R&O, supra*, at para. 214-220 for additional discussion on this issue.

[14] 47 C.F.R. §§ 15.509(f), 15.510(d)(5). 15.511(e), 15.513(f), 15.515(f), 15.517(e), and 15.519(e). *See*, also, 47 C.F.R. § 15.521(g) for measurements employing a bandwidth narrower than 50 MHz. There is no requirement for equipment operating below 960 MHz to measure peak emission levels since emissions below that frequency are based on measurements employing a quasi-peak detector function. There also is no requirement to apply a pulse desensitization correction factor to the peak measurement since the total peak power is not being measured.

peak power and modified the peak measurement procedure.

5. The authorization for UWB devices to operate in the restricted bands and the amendment to the peak power limit and peak measurement procedures raised concerns that harmful interference could be caused to critical safety systems. Several parties performed various analyses and tests to determine the interference potential from wideband sources.[15] In response to these interference concerns, the Commission, in cooperation with NTIA and other U.S. Government agencies, implemented the current UWB standards along with various operational restrictions on UWB devices. For example, UWB devices used outdoors for non-imaging applications are limited to hand-held devices that engage in two-way communications using the 3.1-10.6 GHz band.[16] No outdoor fixed use of non-imaging UWB devices is permitted. These operational restrictions, in combination with conservative technical standards, were established to ensure that UWB devices can coexist with the authorized radio services without the risk of harmful interference while we gain additional experience with this technology.

6. On February 13, 2003, the Commission adopted a *MO&O* and *FNPRM* in this proceeding. The *MO&O* portion of that action responded to fourteen petitions for reconsideration that were filed in response to the *1st R&O*. Several changes to the UWB regulations were adopted to facilitate the operation of UWB devices used as through-wall imaging systems by law enforcement, emergency rescue and firefighter personnel in emergency situations or as ground penetrating radar ("GPR") systems. The regulations also were clarified regarding the coordination requirements for imaging systems and the limits on emissions produced by digital circuits associated with UWB operation. Two issues raised by the petitioners and denied in the *MO&O* were addressed in the *FNPRM*. Multispectral Solutions, Inc. ("MSSI") requested that the Commission not restrict UWB operations in the 3.1-10.6 GHz band to hand-held devices but instead permit the operation of any type of device, including radar systems, as long as the device operated with a low pulse repetition frequency ("PRF"); Siemens VDO Automotive AG ("Siemens VDO") requested that the Commission permit the emission bandwidths and emission levels of a frequency hopping 22-29 GHz vehicular radar system to be measured while the transmitter is actively hopping. To obtain further comments, the Commission proposed the changes sought by MSSI and Siemens VDO in the *FNPRM* portion. In addition, on its own motion the Commission proposed: 1) to amend its peak power limits for Part 15 transmitters that employ wide operating bandwidths but do not operate under the UWB regulations; and 2) to eliminate the UWB definition[17] to permit any transmission

---

[15] These analyses and tests have been filed in the record for this proceeding. *See*, for example, NTIA Special Publication 01-43, *Assessment of Compatibility between Ultrawideband Devices and Selected Federal Systems*, January 2001; NTIA Special Publication 01-45, *Assessment of Compatibility between Ultrawideband (UWB) Systems and Global Positioning System (GPS) Receivers*, February 2001; NTIA Special Publication 01-47, *Assessment of Compatibility between Ultrawideband (UWB) Systems and Global Positioning System (GPS) Receivers (Report Adendum)*, November 2001; NTIA Report 01-383, *The Temporal and Special Characteristics of Ultrawideband Signals*, January 2001; NTIA Report 01-384, *Measurements to Determine Potential Interference to GPS Receivers from Ultrawideband Transmission Systems*, February 2001; NTIA Report 01-389, *Addendum to NTIA Report 01-384: Measurements to Determine Potential Interference to GPS Receivers from Ultrawideband Transmission Systems*, September 2001; *Final Report UWB-GPS Compatibility Analysis Project*, 8 March 2001, Strategic Systems Department, The Johns Hopkins University/Applied Physics Laboratory; the study submitted by NTIA on March 21, 2001, on behalf of the Department of Transportation regarding tests performed at Stanford University; *A Model for Calculating the Effect of UWB Interference on a CDMA PCS System*, September 12, 2000, Dr. Jay Padgett, Senior Research Scientist, Telcordia Technologies attached to the Sprint comments of September 12, 2000; measurements and analysis submitted by Qualcomm in its comments of March 5, 2001; the analyses submitted by the Satellite Industry Association in several of its comments; and multiple others.

[16] 47 C.F.R. § 15.519. Imaging systems consist of ground penetrating radars (GPRs) and wall imaging systems under 47 C.F.R. § 15.509, through-wall imaging systems under 47 C.F.R. § 15.510, surveillance systems under 47 C.F.R. § 15.511, medical imaging systems under 47 C.F.R. § 15.513, and vehicular radar systems under 47 C.F.R. § 15.515.

[17] 47 C.F.R. 15.503(d).

system, regardless of its bandwidth, to operate under the UWB standards. In response to the *NPRM*, six parties filed comments, eight filed reply comments, and NTIA submitted a late-filed comment.[18] Because of our desire to coordinate with NTIA any changes to the regulations that could impact spectrum allocated for U.S. Government operations, we are accepting NTIA's late filed comment. All comments filed in this proceeding were considered by the Commission in its decisions. A list of the commenting parties, along with the abbreviations used to identify them, is attached as Appendix B.

7. Two parties filed petitions for reconsideration of the actions taken by the Commission in the *MO&O*. Cingular, Inc. ("Cingular") objects to the presence and level of emissions from UWB devices that may appear in the frequency bands allocated for the Cellular Radiotelephone Service ("cellular") and for the Personal Communications Services ("PCS"), claiming that the Commission can not legally permit the unlicensed operation of radio frequency ("RF") devices except as specifically authorized by Congress under 47 U.S.C. 307(e). Cingular also believes that cellular and PCS licensees have exclusive use of the spectrum assigned to their respective operations and that any emissions from UWB devices undermine this exclusivity. The Satellite Industry Association ("SIA") argues that the UWB emission limits in the 3650-4200 MHz band used by C-band fixed satellite systems ("FSS") are excessive and will result in harmful interference. XSI filed comments in response to the Cingular petition and Cingular filed a reply comment.[19] XSI also filed comments in response to the SIA petition, the Coalition of C-Band Constituents filed a letter supporting SIA's petition,[20] and SIA filed a late reply comment along with a motion for an extension of the reply comment period. That motion is granted and SIA's reply comment is accepted.

III. SECOND REPORT AND ORDER

8. In the *FNPRM* the Commission proposed four amendments to Part 15 of its regulations. These amendments addressed: 1) the operation of low PRF systems in the 3.1-10.6 GHz band; 2) the measurement procedures applied to frequency hopping vehicular radar systems operating in the 22-29 GHz band; 3) the peak power limits applicable to wide-bandwidth, non-UWB Part 15 transmitters; and 4) the elimination of the UWB definition. These subjects are discussed below.

A. Low PRF systems in the 3.1-10.6 GHz band

9. Under the current regulations, UWB consumer devices, other than vehicular radar systems, are required to operate with their -10 dB bandwidth in the 3.1-10.6 GHz band and are limited to hand-held systems and to indoor-only systems.[21] In its petition for reconsideration of the *1st R&O*, MSSI requested that UWB systems employing a low pulse repetition frequency (PRF) be permitted to operate in the 3.1 GHz to 10.6 GHz band for any type of application.[22] MSSI argued that low PRF systems have less potential to cause interference than UWB devices operating at a high PRF. In the *FNPRM*, the Commission disagreed with MSSI that all low PRF systems have a low potential for causing interference, however, the Commission sought to develop a more complete record on this issue. In the *FNPRM*, the Commission specifically invited comment on whether to amend the rules to permit the operation of any UWB product under the UWB standards currently designated for hand-held devices[23] as long as the PRF

[18] Siemens VDO, Delphi, MS Sedco, M/A-COM and SARA filed *ex parte* comments to the *FNPRM*. Siemens VDO and Delphi also filed *ex parte* comments in response to the submission from NTIA.

[19] XSI filed *ex parte* comments in response to Cingular's reply comments.

[20] This letter was filed in the time frame for reply comments to SIA's petition.

[21] 47 C.F.R. §§ 15.517-15.519.

[22] MSSI Petition for Reconsideration of the *1st R&O* at pg. 10-11. MSSI specifically mentioned vehicular radar systems as an example of such equipment. MSSI defined a low PRF as being less than 100 kpps.

[23] 47 C.F.R. § 15.519.

does not exceed 200 kHz and the equipment employs a pulsed or an impulse modulation.[24] Comments were requested on whether a different PRF limit should be employed, if additional changes to the standards, including changes to the emission limits, are necessary to permit low-PRF outdoor applications, or if the expansion of outdoor UWB devices should be limited to include only low PRF vehicular radar systems. Specific technical analyses supporting the comments were requested.

10. Comments. MSSI comments that the restrictions on operating applications were implemented because the Commission was led to believe that UWB equipment must operate within the restricted frequency bands.[25] However, MSSI argues that it is practical to build UWB devices that can operate outside of the restricted bands, citing its indoor-only certified UWB radar system operating at 6.020-6.699 GHz and the non-restricted unlicensed availability of the 5.46-7.25 GHz band. MSSI is concerned that the restrictions placed on the use of UWB devices mean that its radar cannot be used in vehicles for collision avoidance and blind spot detection, nor can it be used onboard aircraft or ships. MSSI adds that it is not possible to certify its radar under the non-UWB regulations because the device would have to reduce its power to meet the peak power limit if the Commission were to apply a pulse desensitization correction factor ("PDCF").[26] In its reply comments, MSSI supplies a copy of a DARPA study[27] demonstrating that interference potential is in most cases determined by the average power of a UWB signal in the narrowest passband of a receiver and that UWB signals using very low PRFs are unlikely to cause interference to receivers of any kind.[28] MSSI requests that the Commission not limit the type or application of low-PRF UWB devices employed in the 3.1-10.6 GHz band, specifically citing vehicular radars and tagging systems[29] as examples of technologies that could operate in the 3.1-10.6 GHz band as a result of this change.

11. SARA supports expanding the permitted UWB usage in the 3.1-10.6 GHz band under the emission standards for hand-held devices.[30] Delphi also requests that the Commission amend the UWB rules to permit the operation of radar systems in the 3.1-10.6 GHz band and wants UWB transmitters employing any modulation type, including high PRF systems, to be permitted to operate outdoors in the 3.1-10.6 GHz band.[31] Delphi adds that permitting certain waveforms while excluding others constitutes an arbitrary, impermissible distinction unsupported by the technical characteristics of the signal and provides an unfair bias towards certain manufacturers. SIA opposes such a change, believing that high peak levels would expose fixed satellite service (FSS) receivers to harmful interference.[32] SIA opposes

---

[24] The current UWB regulations do not contain a limit on PRF nor do they restrict the type of modulation provided that the UWB emitter, at any point in time, has a fractional bandwidth of at least 0.20 or a -10 dB bandwidth of at least 500 MHz. *See* 47 C.F.R. § 15.503(a), (c) and (d).

[25] 47 C.F.R. § 15.205. MSSI comments of 7/21/03at pg. 1-2.

[26] The PDCF is a technique used to determine the true pulse amplitude based on measurements taken from a spectrum analyzer. If the pulse width is narrower than the inverse of the resolution bandwidth, the analyzer does not use sufficient bandwidth to measure all of the energy in the pulsed signal. Thus, when narrow pulses are employed it may be necessary to apply a PDCF to obtain the total peak emission level. The level obtained from the spectrum analyzer measurement of the peak emission can be considerably increased by the addition of the PDCF to obtain the true peak emission level.

[27] *UWB Parameters for EMC Coexistance* [sic] *with Legacy Systems*, Final Report, 31 June 2003, Defense Advanced Research Projects Agency ("DARPA"), NETEX Program.

[28] MSSI reply comments of 7/25/03at pg. 1-2.

[29] The tagging systems described by MSSI employ a transmitter incorporated into a "tag" that can be attached to persons or objects for tracking purposes.

[30] SARA comments of 7/21/03 at pg. 2-3.

[31] Delphi comments of 7/18/03at pg. 1-5: reply comments of 8/20/03 at pg. 1-2.

[32] SIA reply comments of 8/20/03 at pg. 1-3.

the elimination of a PDCF above 1 GHz and wants the PDCF to continue to be applied to UWB devices.[33] XM and Sirius also object to an expansion of the potential UWB applications until the proponents provide information regarding the technical configurations of their systems along with an analysis demonstrating how interference to the Satellite Digital Audio Radio Service (SDARS) can be avoided.[34] James Page states that the reason for a low PRF is to obtain a high peak level to achieve longer transmission ranges and that this results in larger noise increases to the licensed services.[35] James Page adds that the DARPA study only considers defense systems.

12. NTIA states that the emission limits applicable to hand-held UWB devices are adequate to protect Government systems from interference independent of the PRF or the application of the device.[36] NTIA adds that the modulation employed in these systems must be limited to impulse modulation or to high speed chipping rates with bandwidths that comply with the existing UWB requirements. NTIA further states that the Commission needs to retain its existing prohibition against fixed outdoor infrastructures and the use of UWB devices in toys.

13. Discussion. The interference potential of UWB devices is controlled by several factors. Limits on the average and peak emission levels produced by the devices are only one method of controlling potential interference. The potential for interference also can be reduced by limiting the proliferation of products, the applications for which the device may be employed and the manner in which the devices may be operated. While we determined that the emission limits established for UWB operation are sufficient to prevent interference to the authorized services, we also believe that our introduction of UWB devices should be conservative to further ensure that no interference will occur, especially to critical radio services operating in the restricted bands, from what could be widely prolific devices. For that reason, the Commission, in cooperation with NTIA, limited outdoor UWB operation to hand-held communication systems, severely curtailing outdoor proliferation. We find no evidence in the comments to support changing our UWB standards at this time. We note that UWB devices for consumer applications have not yet been placed on the market and, thus, we still have not gained the desired experience with these devices that we believe is necessary before it would be appropriate to consider whether the standards should be relaxed.

14. As previously stated by the Commission, low PRF UWB systems can have a higher potential for causing interference than high PRF UWB systems. Operation with a low PRF results in closer frequency spacing of the spectral emission lines. This, in turn, increases the probability that emissions will appear within the bandwidth of a victim receiver. Further, as the PRF decreases, the peak to average ratio increases. For UWB systems employing a low PRF, the peak emission limit becomes the defining standard and the average emission level decreases below the limit specified in the regulations. Accordingly, UWB devices employing a low PRF are constrained in their output levels by the limit on peak emission levels, not by the limit on average emission levels.[37] Further, if the pulse repetition frequency of the UWB signal is much greater than the bandwidth of a receiver, the emission may appear to be random noise or a continuous wave (CW) signal, the effect of which is proportional to the average power in the UWB signal within the receiver's bandwidth. However, if the PRF is much less than the

---

[33] *Id.* at pg. 4. It should be noted that a PDCF is not required to be used in the measurement of peak power from UWB devices since the peak power is based on the peak power density over a 50 MHz bandwidth and not on the total peak power produced by a UWB device.

[34] XM and Sirius reply comments of 8/20/03 at pg. 1, 7-8.

[35] James Page comments of 7/18/03 at pg. 1 and reply comments of 7/30/03 at pg. 1.

[36] NTIA comments of 1/15/04 at pg. iv and 4-5.

[37] Conversely, high PRF systems would be limited by the average limit established under the rules and not by the peak limit.

receiver's bandwidth, the UWB signal may appear to the receiver as impulsive noise and the effect is proportional to the peak power of the UWB signal unless some type of signal processing is incorporated in the victim receiver. The examples provided by MSSI demonstrating no harmful interference from low PRF UWB devices rely solely on receivers incorporating signal processing techniques, such as GPS receivers, and may not be applicable to many types of receivers in use today. The DARPA study submitted by MSSI does indeed demonstrate that radio receivers used in defense applications are not sensitive to peak emissions from UWB devices that operate with a PRF that is no greater than one percent of the victim receiver bandwidth.[38] However, this finding may not be generally applicable to all radio operations. As stated in the DARPA study, "error correction coding reduces the probability of interference even more. Receivers that respond to peak signals are more susceptible to interference from low PRF UWB devices, but even these can benefit from interference cancellation techniques." It is because of the incorporated signal processing that many systems are able to reject interference from low PRF emissions. Indeed, the analyses performed by NTIA regarding the susceptibility of Government systems to peak emission levels referenced possible mitigation effects from signal processing.[39]

15. The existing UWB rules limit outdoor consumer products in the 3.1 to 10.6 GHz range to hand-held devices that employ two-way communications.[40] Typically, such products are expected to employ high PRFs in order to maximize data through-put. Consequently, these products generally would be constrained primarily by the average emission limit and would have peak emissions well below the peak limit. Also, the PRF used in the UWB hand-held devices generally would be greater than the bandwidth of the receivers used in the authorized radio services, resulting in any interference impact being proportional to the average power in the UWB signal. The same is not true for UWB systems employing a low PRF. No measurement or other data has been submitted which demonstrates that high-proliferation systems operating outdoors at the UWB levels could be added anywhere within the 3.1-10.6 GHz without increased interference risks.[41] While some receivers may not be susceptible to interference from UWB systems that employ very low PRFs, this is dependent on both the bandwidth of the victim receiver and the error correction techniques employed in that receiver. There is not sufficient information to state that UWB devices, simply because they operate below some specified PRF, can not be a source of harmful interference to all receivers over a broad part of the spectrum. Accordingly, we do not agree that the UWB regulations should be amended at this time to permit any type of low PRF device to operate anywhere in the 3.1-10.6 GHz band under the standards for hand-held UWB devices. We do, however, believe that some relief may be possible in a limited portion of this frequency band. It appears that the primary goal of MSSI, SARA and Delphi is for the Commission to permit wide bandwidth systems to operate outdoors at the peak power limit permitted under the UWB regulations. As indicated above, the Commission also proposed in the *FNPRM* to increase the peak limit for non-UWB devices. We believe that changes to the non-UWB peak power level, as discussed in the following paragraphs, will accommodate the equipment designs sought by MSSI, SARA and Delphi.

---

38 *UWB Parameters for EMC Coexistance* [sic] *with Legacy Systems, supra*, at pg. 20. The DARPA study also concluded that high PRF, non-dithered systems have a reduced potential for causing interference due to the lower probability that a spectral line will appear in the passband of the victim receiver but found that interference could occur if the spectral line did appear in the receiver passband more than one percent of the time.

39 NTIA comments of 1/15/04 at pg. A-4, A-6, A-8, and B-3.

40 47 C.F.R. § 15.519(a)(1).

41 For example, amending the rules to permit the UWB devices operating in the 3.1-10.6 GHz band to be use for vehicular radar systems, as requested by MSSI, could result in tens of millions of new UWB transmitters emitting outdoors.

B. Non-UWB peak power emission limits in the 5925-7250 MHz and 16.2-17.7 GHz bands

16. Unless otherwise specified, the emissions below 1000 MHz from Part 15 unlicensed devices, other than UWB devices, are measured using a CISPR quasi-peak detector and all emission limits at 1000 MHz and higher are based on average measurements.[42] When an average emission limit is specified, the rules also specify a limit on peak power that is 20 dB greater than the average limit.[43] For Part 15 devices other than UWB devices, the total peak output power of the transmission must be measured. In some cases, peak measurement by a spectrum analyzer requires the application of a pulse desensitization correction factor (PDCF) in order to compensate for the analyzer's inability to respond fast enough to measure the true peak for pulse widths narrower than the inverse of the resolution bandwidth. The level obtained from the spectrum analyzer measurement of the peak emission can be considerably increased by the addition of the PDCF to obtain the true peak emission level. This standard was implemented when Part 15 devices primarily employed narrowband emissions.

17. Throughout this proceeding, the Commission recognized that the peak emission limit specified in 47 C.F.R. § 15.35(b) was established based on the operation of narrowband transmission systems and may unfairly penalize some wideband operations, effectively prohibiting the operation of these devices.[44] Indeed, the Commission noted that the existing limit on the total peak power level is not well suited to measure the operation of, or represent the interference potential of, transmitters that employ extremely wide bandwidths. It is for that reason that the UWB standards permit the peak power to be measured over a bandwidth of 50 MHz, rather than over the entire bandwidth of the transmission. As stated in the *1st R&O*, the total peak power produced by the UWB device is not relevant to interference potential as there are no receivers employed in the authorized radio services that operate at the bandwidths used by UWB systems.[45] The widest bandwidth that normally would be employed by victim radio receivers is about 50 MHz. Thus, the Commission expressed its belief that the current limit on peak emissions from Part 15 intentional radiators could be amended to reflect a limit similar to that adopted in the *1st R&O* for UWB systems, eliminating the bias under the Part 15 regulations towards non-UWB wideband operations.

18. Under the UWB regulations, the EIRP limit on peak emissions is 0 dBm based on the use of a 50 MHz resolution bandwidth (RBW).[46] To facilitate testing, the rules permit the application of a lower RBW, down to as low as 1 MHz, provided the peak limit is similarly reduced to the level 20 log (RBW/50) dBm EIRP, where RBW is the resolution bandwidth in megahertz.[47] This peak limit applies to the 50 MHz bandwidth centered at the UWB highest radiated emission level. The Commission proposed to amend 47 C.F.R. § 15.35(b) to permit an equivalent peak limit for non-UWB wideband Part 15

---

42 47 C.F.R. § 15.35(a) and (b).

43 47 C.F.R. § 15.35(b).

44 For example, a wideband device that occupies a 1 GHz bandwidth with emissions that appear as Gaussian noise is permitted to operate at an average limit of –41.3 dBm/MHz which is equivalent to an average limit of -11.3 dBm/GHz; however, the transmitter also must comply with a total peak limit of –21.3 dBm. Thus, its average emission level may comply with the standards even though the average emission level exceeds the limit on peak emissions.

45 *1st R&O, supra*, at para. 214.

46 In order to accurately measure a peak signal, the video bandwidth must not be less than the RBW. Ideally, the video bandwidth should be at least 3 times the RBW.

47 While some types of emissions have a peak-to-average level that changes based on 10 log (RBW/50), others change at a rate of 20 log (RBW/50). The use of the (20 log) formula ensures that the peak level will not exceed the actual UWB standard, 0 dBm in a 50 MHz bandwidth, regardless of the type of modulation employed.

transmission systems.

19. For the peak emission measurement for wideband devices, the Commission proposed that the RBW may not exceed 10 percent of the -10 dB bandwidth of the emission. This proposal was based on the requirement that UWB emitters, which must employ a minimum -10 dB bandwidth of 500 MHz, have a peak limit based on a 50 MHz bandwidth, *i.e.*, they use a resolution bandwidth that is not greater than 10 percent of the minimum -10 dB bandwidth. Comments were requested on this proposal. Comments also were requested on the alternative proposal presented by MSSI, namely the rules should be amended to permit devices operating above 1000 MHz under the Part 15 general emission standards in 47 C.F.R. § 15.209 to comply with a peak emission limit of 5000 uV/m at 3 meters based on a measurement using a peak detector, a 1 MHz resolution bandwidth and a video bandwidth of no less than 1 MHz.[48] The Commission requested comments on any changes to the interference potential of wideband Part 15 devices that may occur as a result of these proposals and requested technical support for comments arguing interference concerns.

20. Comments. Delphi and Siemens VDO support the proposed change to permit wideband non-UWB devices to operate under the same limit as applied to UWB devices, agreeing that the current rules unnecessarily constrain non-UWB devices, but request that the peak emission level be measured using an RBW as wide as the -10 dB bandwidth of the emission.[49] Siemens VDO indicates that a peak limit based on a RBW that is 10 percent of the -10 dB bandwidth should apply only to the emissions in the restricted bands with the caveat that the total EIRP must be reduced by 20 log (50 MHz/instantaneously occupied bandwidth) dB.[50] Siemens notes that some systems would have as much as a 6 dB measurement penalty on the peak level by basing the power limit on the 20 log (RBW/50) proposed by the Commission, but states that this error would be reduced below 0.5 dB if the RBW is based on the -10 dB bandwidth of the emission.[51] Alternatively, Siemens VDO suggests that the Commission adopt a peak limit of -28 dBm/MHz. James Page states that peak signals can cause more interference in some systems and requests that all peak emissions be limited to -34 dBm/MHz.[52] Delphi opposes as inappropriate the proposal from MSSI to employ a 1 MHz bandwidth to measure peak power under current non-UWB rules, indicating that this change could allow extremely high peak emissions that are as much as 20 times greater for low PRF radars than what was contemplated by the Commission.[53] NTIA requests that the optional peak limit be established as -34 dBm/MHz instead of the 20 log (RBW/50) dBm proposed in the *FNPRM*. NTIA supplies extensive analyses to demonstrate that the peak power limit should not be increased to 5000 uV/m/MHz, as requested by MSSI, unless the duty cycle of the Part 15 emitter is one percent or less than the bandwidth of the victim receiver.[54] MSSI expresses an interest in manufacturing low power, unlicensed radar systems, tracking devices and other equipment in the 5460-7250 MHz band, citing its UWB radar imaging system that operates in the 6020-6699 MHz band.[55] Delphi expresses a similar interest in manufacturing high-PRF radar systems in the

---

48 A field strength limit of 5000 uV/m, as measured at 3 meters, is equivalent to an EIRP of –21.3 dBm.

49 Delphi comments of 7/18/03 at pg. 2 and 7; Siemens VDO comments of 7/21/03 at pg. 15-16.

50 In other words, systems employing a bandwidth of less than 50 MHz would be required to operate at a peak power level that is reduced below 0 dBm by an amount that is dependent on the actual emitted bandwidth.

51 Siemens VDO comments of 7/21/03 at pg. 28-30. Siemens VDO conditions this statement on the specific case where the PRF is equal to or greater than the RBW, referencing NTIA Report 01-383, *supra*, at figure 8.86 on pg. 8-46 through 8-48.

52 James Page comments of 7/18/03 at pg. 1.

53 Delphi comments of 7/18/03 at pg. 7-8; Delphi reply comments at pg. 3.

54 NTIA comments of 1/15/04 at pg. 6-13 and at Appendices A and B.

55 MSSI comments of 7/2103 at pg. 1-2. MSSI also has obtained certification for an indoor-only UWB tracking system operating in the 5751-7001 MHz band.

5460-7250 MHz band[56] and also requests that a higher peak power level be applied to its vehicular Back-Up Aid radar system operating in the 16.2-17.7 GHz band.[57] No objections were raised in the comments regarding operation within these frequency bands.

21. Discussion. We continue to believe that the current rules unnecessarily discriminate against the use of wideband unlicensed systems. For example, a transmission system operating above 1000 MHz with more than a 1 GHz bandwidth and a white Gaussian noise energy distribution is subject to an average emission limit of -41.3 dBm/MHz which is equivalent to an average emission level of -11.3 dBm/GHz. However, the total peak power limit for this emission is only -21.3 dBm. Thus, the average signal in this 1 GHz bandwidth complies with the standards but is, by itself, already 10 dB greater than the limit on the total peak power from the device. As already demonstrated by the Commission, the total peak power of such a wideband system is not relevant to the interference potential of the device. Rather, it is the potential power in the bandwidth of the victim receiver that is relevant. Recognizing that the widest receiver bandwidths generally encountered are less than 50 MHz,[58] we determine that this discrimination against wideband systems can be eliminated by amending the rules to specify the peak power from a wideband Part 15 device based on the power density in a 50 MHz bandwidth, as specified for UWB devices. However, we also recognize that allowing increased peak power levels could have an impact on some radio services. Further, we are concerned that allowing higher peak power levels could result in a significant increase in the number of consumer products along with a corresponding increase in interference potential. We conclude that some cautious constraints on the permitted frequency bands of operation and the standards for operation within those bands are necessary while we gain this experience.

22. As noted earlier, if the pulse repetition frequency of the UWB signal is much greater than the bandwidth of a receiver, the emission may appear to be random noise or a CW signal, the effect of which is proportional to the average power in the UWB signal within the receiver's bandwidth. However, if the PRF is much less than the receiver's bandwidth, the UWB signal may appear to the receiver as impulsive noise and the effect is proportional to the peak power of the UWB signal. Further, interference effects can be mitigated if error correction techniques are incorporated in the victim receiver. As noted earlier, receivers that employ error encoding techniques have some immunity to peak power levels, responding instead to the average emission levels.[59]

23. We conclude that higher peak emission levels can be permitted in the 5925-7250 MHz band without a corresponding increase in the potential that harmful interference would be caused.[60] The fixed, fixed-satellite, and mobile systems employed in this band likely incorporate a sufficient level of signal processing to reduce, if not eliminate, their vulnerability to increased peak emission levels,[61] or it is expected that such authorized systems would generally be located in remote areas or with the receiving antennas situated in such a manner that they would not be routinely subject to emissions from nearby Part

---

[56] Delphi comments of 7/18/03 at pg. 2-5. While the levels of the emissions from high-PRF systems would be constrained based on our average emission limits under the standards adopted for UWB devices, the current non-UWB peak limit prevents such systems from being employed.

[57] Delphi *ex parte* comments of 4/13/04 at pg. 2.

[58] EESS passive receivers were cited by NTIA as an exception to this specification.

[59] The examples provided by MSSI demonstrating no harmful interference from low PRF UWB devices were based on receivers incorporating signal processing techniques, such as GPS receivers and U.S. Government receivers used in defense applications.

[60] Operation in this frequency band currently is permitted under the Part 15 general emission limits in 47 C.F.R. § 15.209.

[61] This, of course, requires that the peak emission levels be low enough that the front ends of the receivers are not saturated.

15 devices. While the comments request that we also permit higher peak emission limits in the 5460-5925 MHz band, we determine that it is not prudent to do so until we have gained more experience with the unlicensed devices that may be developed. Authorized services in the 5460-5925 MHz band include the Amateur Radio Service and the Intelligent Transportation Systems, both of which could be operating in close proximity to, and susceptible to interference from, unlicensed devices.

24. We also conclude that higher peak emission levels can be permitted in the 16.2-17.7 GHz band, as requested by Delphi. However, it is not clear that sufficient signal processing would be employed to negate the increase in peak emission levels to radiolocation and Earth Exploration Satellite Systems ("EESS") operating in this band.[62] Thus, we determine that a more cautious approach should be employed. Limiting operation in the 16.2-17.7 GHz band to vehicular back-up assistance radars that operate only when the vehicle is in reverse will significantly limit the proliferation of such devices which should ensure that harmful interference does not occur to the authorized radio services. In addition, potential equipment manufacturers should be forewarned that the 17.3-17.7 GHz portion of the 16.2-17.7 GHz band has been allocated in Region 2 and the United States for the Broadcast Satellite Service, effective April 1, 2007. Once this allocation becomes effective, there is a possibility that the 17.3-17.7 GHz band may become designated as a restricted band[63] and that Part 15 fundamental emissions will be prohibited in this portion of the spectrum.

25. Based on the above, we are adopting a peak limit for the 5925-7250 MHz and 16.2-17.7 GHz bands that is equal to 20 log (RBW/50) dBm EIRP with RBW, the resolution bandwidth of the measurement instrument, being 1 to 50 MHz, as proposed in the *FNPRM*. This peak level is consistent with the peak limit applied to UWB operation. As with UWB devices, this peak limit would apply to the 50 MHz band centered at the frequency at which the highest average emission level occurs. We agree with the commenting parties that a RBW not wider than the -10 dB bandwidth of the emission should be permitted, instead of an RBW based on 10 percent of the -10 dB bandwidth as was proposed in the *FNPRM*. If frequency hopping or stepped frequency modulation is employed, the frequency hop or step function shall be disabled and the transmitter shall operate continuously on a fundamental frequency to measure the -10 dB bandwidth that is used to determine the maximum RBW that may be employed for the peak emission level.

26. We recognize that the above actions will increase the proliferation of unlicensed devices operating in the 5925-7250 MHz band. Thus, we conclude that a cautious approach to the emission standards is appropriate. As discussed above, we also conclude that a cautious approach is necessary for the emission standards adopted for vehicular back-up assistance radars operating in the 16.2-17.7 GHz band. Operation currently is permitted within the 5925-7250 MHz and 16.2-17.7 GHz bands at an emission level of -41.3 dBm/MHz based on a linear average.[64] However, we note that the UWB technical standards, established based on several interference analyses, represent a cautious approach to preventing harmful interference.[65] The UWB standards permit lower fundamental emissions and unwanted

---

[62] We believe that the satellite systems operating in the 17.3-17.7 GHz band will employ sufficient signal processing techniques to demonstrate some immunity to increased peak signal levels.

[63] 47 C.F.R. § 15.205.

[64] 47 C.F.R. § 15.209. The maximum specified emission limit in these frequency bands is 500 uV/m, as measured at 3 meters using a 1 MHz resolution bandwidth. This field strength level is equivalent to an EIRP of -41.25 dBm/MHz.

[65] Emissions above 960 MHz from UWB devices are based on the use of an RMS average. Emissions above 1000 MHz from non-UWB devices are based on a linear average. As previously indicated by NTIA, RMS levels are proportional to the measurement bandwidth and the spectral power density, irrespective of pulse rate or modulation. *See* NTIA Report 01-383, *supra*, at pg. 8-44. Agilent also states that an RMS detector reports the true average power for each part of the measurement span which is particularly useful when measuring non-continuous waveforms such as those produced by frequency switching or packet based transmissions. Agilent adds that the (continued....)

emissions than those currently permitted for non-UWB devices. Further, NTIA requests that unwanted emissions from transmitters operating in the 5925-7250 MHz be subject to the emission limits applicable to hand-held UWB devices and that unwanted emissions from transmitters operating in the 16.2-17.7 GHz band be subject to the unwanted limits applicable to UWB vehicular radars.[66] Accordingly, we are adopting the more stringent specifications requested by NTIA, requiring that emissions from unlicensed transmitters operating within these bands comply with the same average emission limit and measurement standards that were established for UWB communication systems.[67] The level of the fundamental emission shall not exceed an EIRP emission limit of –41.3 dBm/MHz and emissions above 960 MHz shall be based on the RMS average signal level. Emissions below 960 MHz shall be subject to the Part 15 general emission limits. For equipment operating in the 5925-7250 MHz band, emissions outside of this band and within the 3.1-10.6 GHz band shall not exceed an EIRP of -51.3 dBm/MHz, and emissions outside of the 3.1-10.6 GHz band and above 960 MHz shall not exceed the limits applicable to handheld UWB devices.[68] For transmitters operating in the 16.2-17.7 GHz band, emissions between 960 MHz and 16.2 GHz shall not exceed the limits applicable to UWB vehicular radars; emissions above 17.7 GHz shall not exceed an EIRP of –61.3 dBm/MHz. As with UWB devices, emissions from digital circuitry will be subject to the Part 15 general emission limits[69] or to the limits for digital devices,[70] as appropriate, provided those emissions are not intended to be radiated from the antenna.

27. In keeping with our cautious approach, we are implementing several additional requirements to further protect the authorized radio services. First, we are requiring that the -10 dB bandwidth of the transmission be contained within the 5925-7250 MHz or the 16.2-17.7 MHz band, as appropriate, under all conditions of modulation and effects from frequency stability. We recognize that the levels of the emissions generally will continue to decrease as displacement from these bands increases and that this decrease will further reduce the interference potential to other radio services.[71] Second, we

---

(...continued from previous page)
RMS average detector is well behaved when measuring noise-like signals. *See* Agilent APP Note 1488, *Ultra-Wideband Communication RF Measurements*, at pg. 43. We also observe that measurements made on the same equipment using an RMS detector generally may be slightly higher than similar measurements obtained using a linear detector, particularly for noise-like emissions. Thus, the requirement to use an RMS detector can be a more stringent specification than emission limits based on the use of a linear average detector.

66 47 C.F.R. §§ 15.515 and 15.519. These comments from NTIA were stated verbally to the Commission's staff on December 2, 2004, and on subsequent dates. We do not believe that such stringent limits are necessary to prevent harmful interference. The emission levels requested by NTIA are extremely conservative, being based on multiple worst case conditions at detection levels below what may be considered harmful interference. Further, as stated in the *1st R&O*, the analyses and standards applied to UWB are unique to that proceeding and will not be considered as a basis for determining or revising standards for other radio frequency devices, including other Part 15 devices.

67 As described above, we also are adopting the same peak emission limit that applies to UWB operations.

68 Normally, transmission systems operating under the general emission limits are not required to reduce their emissions below the limits specified in 47 C.F.R. § 15.209, and instead are subject to a requirement that the spurious emissions not exceed the level of the fundamental emission. *See* 47 C.F.R. § 15.209(c). The requirement in 47 C.F.R. § 15.215(c) to attenuate emissions outside of the operating band by at least 20 dB was established for transmitters that operate at signal levels greater than those specified in 47 C.F.R. § 15.209.

69 47 C.F.R. § 15.209.

70 47 C.F.R. § 15.109.

71 We believe that emissions appearing within the frequency bands below 3.1 GHz, which are of particular concern to NTIA, will consist solely of emissions from digital circuitry and, thus, will be subject to the standards in 47 C.F.R. § 15.209. For this reason, the more stringent limits requested by NTIA should have a minimal impact on equipment designed to operate under these provisions.

are requiring that the -10 dB bandwidth of the transmission be at least 50 MHz for systems operating in the 5925-7250 MHz band and at least 10 MHz for systems operating in the 16.2-17.7 GHz band. If frequency hopping or stepped frequency modulation is employed, these minimum bandwidth limits shall be determined with the frequency hop or step function disabled and the transmitter operating continuously on a fundamental frequency. These minimum bandwidth standards should accommodate existing product designs and will assure that devices operating at the higher peak power limits are indeed wideband devices that could be penalized by the current Part 15 restriction on peak power levels.[72] No provision is provided to permit transmitters employing swept frequency modulation to perform measurements with the sweep stopped; these devices must continue to comply with the standards following the provisions of 47 C.F.R. § 15.31(c).[73] Third, as noted above we are restricting operation in the 16.2-17.7 GHz band to vehicular back-up assistance radars that only operate upon engagement of the vehicle in reverse. We also are restricting operation in the 5925-7250 MHz band to terrestrial and to maritime applications and, like UWB devices, are prohibiting the use of these devices onboard aircraft or satellites or for the operation of toys. Operation onboard aircraft or satellites would result in much greater signal propagation distances and an increased likelihood of alignment with the receiving antennas of the authorized services. The operation of toys under these provisions could cause a significant increase in the proliferation of devices along with a corresponding increase in interference potential. There are ample provisions elsewhere in the regulations that permit the operation of toys and we see no need to expand their operation to include this frequency band. While we do not believe that the power levels being permitted in the 5925-7250 MHz band are sufficient to permit the establishment of wide-area communication systems, we also want to ensure that such systems cannot develop until greater experience is gained with unlicensed operation in this band. To ensure that this does not occur, as requested by NTIA[74] we are prohibiting the use of fixed outdoor infrastructures in the 5925-7250 MHz band under the rules we are adopting herein with one exception: operation onboard a ship or within a terrestrial transportation vehicle shall not be considered a fixed infrastructure.[75] This should be sufficient to prevent the establishment of wide area communication systems, yet will not prevent the use of these devices for vehicular radar and maritime applications, as desired by the commenting parties.

28. We do not agree with Siemens VDO that a 10 log ratio should be used to determine the applicable peak power level for unlicensed devices. While we agree that, under certain conditions, *e.g.*, noise-like signals, a 10 log ratio is appropriate for determining the peak power with changes in RBW, this is not always the case. Indeed, the study by NTIA concluded that peak power follows a 20 log relationship for pulse-like emissions.[76] We recognize that NTIA's proposed peak limit of -34 dBm/MHz

---

[72] Devices that operate with an emission bandwidth in excess of 500 MHz would not be required to operate under the UWB regulations but may operate under the provisions being adopted herein. Separate standards were implemented for UWB devices because these extremely wideband devices, by necessity, must operate within the restricted frequency bands. That is not the case here. The parameters for wideband operation are being designed only for use within frequency bands where unlicensed non-UWB Part 15 operation currently is permitted.

[73] Frequency hopping, stepped frequency and gated transmissions have relatively similar interference profiles. The interference potential for swept frequency has not been evaluated nor have measurement procedures been proposed in this proceeding.

[74] NTIA comments of 1/15/04 at pg. 5.

[75] Operation in the 16.2-17.7 GHz band is limited to field disturbance sensors that are used only on terrestrial transportation vehicles for back-up assistance. Terrestrial use is limited to earth surface-based, non-aviation applications. Thus, there is no need to prohibit the use of fixed infrastructures.

[76] *See* NTIA Report 01-383, *supra*, at figure 8.86 on pg. 8-46 through 8-48. This report states that the peak relationship follows a 20 log ratio when the RBW is much greater than the PRF and that the non-dithered average and the peak signal levels are equal when the RBW is much lower than the PRF, *i.e.*, when the output level of the system would be constrained by our limit on average emission levels, not by our limit on peak emission levels. For a non-dithered UWB emission, when RBW is much lower than the PRF the emissions appear to be discrete CW (continued....)

was based on the possible operation of non-UWB systems through the entire 3.1 – 10.6 GHz band. We conclude that it is not necessary to adopt this more stringent limit, particularly given the limited frequency bands where we are allowing such operation. Further, as discussed throughout this proceeding, we are concerned with the level of the peak power that appears in the bandwidth of a victim receiver. Our intent is to ensure that the total peak power emitted over a 50 MHz bandwidth does not exceed an EIRP of 0 dBm, as we required for UWB devices. Because of the difficulty in measuring peak output levels based on a 50 MHz RBW, we permit the use of a lower RBW with proper adjustment of the peak limit. Because many systems attenuate the power measurement with reductions in the RBW based on a 20 log ratio, we apply this ratio to all cases, ensuring that the peak power over a 50 MHz bandwidth will never exceed 0 dBm. MSSI, Delphi and others are permitted to employ a wider RBW, up to 50 MHz or up to the –10 dB bandwidth of the emission or, for frequency hopping or stepped frequency systems, up to the –10 dB bandwidth of an individual hopping or stepped channel, whichever is less, to obtain a higher peak power level. It may be to their advantage to do so if a noise-like emission is employed. For pulse-like systems, the peak level being implemented is equivalent to -34 dBm/MHz, the level requested by NTIA and by James Page. For noise-like systems with a PRF less than 50 MHz, the relationship of peak power in a 50 MHz bandwidth to the RBW corresponds to 10 log (RBW/50) dBm and a peak power as high as -17 dBm/MHz could be achieved, depending on what value is used for RBW. We are not implementing the -28 dBm/MHz limit requested by Siemens VDO as this could, depending on the exact modulation characteristics, result in a peak level of up to +6 dBm in a 50 MHz bandwidth.

C. Vehicular radar systems in the 22-29 GHz band

29. The UWB regulations permit the operation of vehicular radar systems in the 22-29 GHz band.[77] UWB vehicular radar systems are required to operate with a minimum instantaneous bandwidth of 500 MHz and may employ any modulation technique that results in this minimum bandwidth.[78] The Commission concluded that it was necessary to establish a minimum UWB bandwidth to prevent narrowband Part 15 devices from operating in the restricted frequency bands, as is currently allowed for UWB devices.[79] In the *1st R&O*, the Commission specifically precluded the operation of swept frequency systems, stepped frequency systems, and frequency hopping systems under the UWB rules unless the transmissions comply with the minimum bandwidth requirement and the emission limits when measured

---

(...continued from previous page)
lines and further reductions in the RBW do not result in any change to the measured values. Dithered peak emissions follow a 10 log ratio only when the RBW is much less than the PRF. Thus, the maximum 6 dB "error" cited by Siemens VDO occurs only when the RBW is much lower than the PRF and the UWB impulses are dithered. The situation where RBW and PRF are approximately equal, as cited by Siemens VDO, represents a transition region between a Gaussian probabilistic region and a deterministic impulsive environment and does not follow a precise mathematical model. In *Assessment of Compatibility between Ultrawideband Devices and Selected Federal Systems*, NTIA Special Publication 0-43, January 2001, at pg. D-1 and D-2, NTIA employed a 10 log ratio to represent the peak power in a 50 MHz bandwidth when RBW is less than or equal to 0.45 PRF (non-dithered) and when RBW is less than or equal to 2.0 PRF (dithered).

[77] 47 C.F.R. § 15.515. Non-UWB vehicular radar systems are permitted to operate under 47 C.F.R. § 15.245 in the 24.075-24.175 GHz band, under 47 C.F.R. § 15.249 in the 24.0-24.25 GHz band, or under 47 C.F.R. § 15.209 in the 24.0-31.2 GHz band.

[78] 47 C.F.R. § 15.503 defines a UWB transmitter as an intentional radiator that, at any point in time, has a fractional bandwidth equal to or greater than 0.2 or has a UWB bandwidth equal to or greater than 500 MHz, regardless of the fractional bandwidth.

[79] 47 C.F.R. § 15.205. *See*, also, *1st R&O*, *supra*, at para. 30-32. As noted by the Commission, there are sufficient spaces between the restricted bands to permit the operation of Part 15 systems employing bandwidths narrower than 500 MHz. Accordingly, unlike UWB devices, there is no necessity to permit narrowband systems to operate in the restricted bands.

with the sweep, step function or hopping sequence stopped.[80] The Commission indicated that this was necessary as no measurement procedure had been established to permit the emission levels from such devices to be determined while the transmitter is sweeping, stepping or hopping. Further, the interference aspects had not been evaluated based on the different emission level results that would be obtained if measurements were taken with the sweep, step function or hopping active.[81]

30. In its petition for reconsideration of the *1st R&O*, Siemens VDO requested that we allow pulsed frequency hopping vehicular radars to be included under the definition of a UWB device under a plan that would permit such transmitters to occupy the minimum required bandwidth within any 10 millisecond period rather than at any instantaneous point in time.[82] This change would require a reversal of the decision that frequency hopping systems must be measured with the frequency hop stopped.[83] Siemens VDO also requested that the Commission revise its rules to permit emissions to be averaged over a 10 millisecond period, with the hopping sequence active, instead of over a one millisecond period.[84] Siemens VDO argued that it must operate with a center frequency of 24.125 GHz, necessitating operation in the 23.6-24.0 GHz restricted band, and that operation at a higher frequency would increase cost and hardware complexity.[85] Siemens VDO added that the Earth Exploration Satellite Service (EESS) systems at 23.6-24.0 GHz were the only identified potential interference victims of UWB radar systems operating in the 22-29 GHz band and that these systems employ integration times which are too long to distinguish between pulsed and pulsed frequency hopping modulation types.[86] Siemens VDO provided a technical analysis to support its request to permit measurements of emission levels averaged over a 10 millisecond period with the system hopping in frequency.

31. As detailed in the *MO&O*, the type of modulation requested by Siemens was not considered in the notice and comments leading to the adoption of the UWB regulations, and there was no opportunity for the public to comment on Siemens VDO's proposal.[87] Accordingly, the Commission denied Siemens VDO's petition for reconsideration as being beyond the scope of the issues addressed in this proceeding. However, the Commission agreed that the type of operation sought by Siemens VDO merited consideration. Accordingly, the Commission indicated that it would address Siemens VDO's proposal in the *FNPRM* to obtain public comment. In addition, the Commission's Office of Engineering and Technology issued a waiver of the UWB rules to permit the operation of Siemens VDO's vehicular radar system under technical criteria different from those requested in its petition for reconsideration.[88]

---

[80] *See 1st R&O, supra*, at para. 32 and *MO&O, supra*, at para. 45 and 48. *See*, also, 47 C.F.R. § 15.31(c).

[81] The Commission expressed similar concerns in the *Notice of Proposed Rule Making* ("*Notice*") in this proceeding, and declined to include transmitters employing swept frequency and similar modulation types from consideration as UWB devices. *See Notice of Proposed Rule Making* in ET Docket No. 98-153, 65 Fed. Reg. 37332, June 14, 2000, at para. 21.

[82] Siemens VDO Petition for Reconsideration of the *1st R&O* at pg. 5-6.

[83] *Id.* at pg. 6-8. Also, *1st R&O, supra*, at para. 32 and 47 C.F.R. § 15.31(c).

[84] *Id.* at pg. 4 and 8-10. The "averaging time" actually refers to the integration period employed by each sampling bin in a spectrum analyzer. For a 1 ms averaging period, the sweep time divided by the number of bins must be less than 1 millisecond, *i.e.*, if the analyzer employs 601 bins, the minimum sweep time is 601 milliseconds.

[85] *Id.* at pg. 10-11.

[86] *Id.* at pg. 13-14. It should be noted that there is a wide range of integration times possible for space borne passive sensors. For example, the AMSR sensor has a 2.6 millisecond integration time in the 23.6-24.0 GHz band. However, the AMSU-A sensor has an integration time of 158-165 milliseconds.

[87] *See MO&O, supra*, at para. 48.

[88] A waiver was issued to Siemens VDO on June 25, 2003, by letter under delegated authority of the Chief, Office of Engineering and Technology. That waiver, based on an agreement between NTIA and Siemens VDO, (continued....)

32. In the *FNPRM*, the Commission proposed to adopt Siemens VDO's proposal. The Commission stated that its primary concern was not that the Siemens VDO equipment does not comply with the definition of a UWB system. Rather, its concern was that the Siemens VDO radar system does not comply with the UWB standards using the measurement procedures currently employed for frequency hopping systems [89] and the possible interference aspects of this type of operation. For example, a UWB vehicular radar system that complies with the existing regulations will place a low level emission on a frequency at any given time. However, the Siemens VDO system momentarily can place a much higher level emission on that frequency. The measurement procedure requested by Siemens VDO entails the emissions being measured in the investigated frequency band over a time period where the transmitter is both active and quiescent within that band, resulting in an additional time averaging being applied to the RMS average measurement. For that reason, the Commission indicated that a victim receiver with a fast transient response may be more susceptible to interference from the Siemens VDO system than from other UWB systems. On the other hand, Siemens VDO argued that EESS systems operating in the 23.6-24.0 GHz band will not be able to tell the difference between a distributed number of frequency hopping systems operating under the standards it has requested and a similarly distributed number of wideband radars complying with existing vehicular radar standards. The Commission also noted that there is a potential impact on terrestrial users which may be exposed to relatively few, but nearby, vehicular radars as well as the impact to EESS operations. It requested comments on whether the higher instantaneous power delivered by a frequency hopping system would cause harmful interference to these systems.[90]

33. The interference potential of a transmitter can vary significantly due to slight differences in modulation techniques or changes in the frequency of operation where the victim receivers may have different susceptibility characteristics. Because of this, the Commission indicated that the proposed changes to the rules to accommodate frequency hopping systems would apply only to vehicular radar systems operating in the 22-29 GHz band. Further, the Commission did not propose to change any of the emission limits currently applied to UWB vehicular radar systems. Rather, it proposed new measurement techniques to accommodate frequency hopping UWB vehicular radar systems. Specifically, it proposed to permit frequency hopping systems to operate under the provisions for UWB vehicular radar systems provided the minimum UWB bandwidth is achieved in no greater than 10 milliseconds and the transmitter complies with all other technical standards for UWB operation in the 22-29 GHz band. Compliance with the average emission limit would be based on measurements using a one megahertz resolution bandwidth

---

(...continued from previous page)
specified operation under different technical standards than those requested by Siemens VDO in its petition for reconsideration of the *1st R&O* and from those proposed by the Commission in the *FNPRM*. For example, the waiver limits the emissions from the Siemens vehicular radar transmitter to a -34 dBm peak EIRP limit and to a -61.3 dBm RMS average EIRP limit in the 23.6-24.0 GHz band with lower emission levels permitted for elevation angles above 30 degrees, bases RMS average emission limits on a one millisecond integration period, and includes a requirement that the -10 dB bandwidth be contained within the 24-29 GHz frequency band with the center frequency located above 24.075 GHz. NTIA also specified the measurement procedures that would be used to determine the bandwidth and emission levels.

[89] As noted in para. 32 of the *1st R&O*, *supra*, the emissions from transmitters employing frequency hopping modulation are measured with the frequency hop stopped. *See* 47 C.F.R. § 15.31(c). While this regulation specifically addresses swept frequency devices, having been established prior to frequency hopping systems being permitted under the regulations, it also has been applied to frequency hopping systems. *See* Public Notice of March 30, 2000, *Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems*, DA 00-705. At the time of the *1st R&O*, no other measurement procedures had been proposed or established for frequency hopping systems.

[90] At any point in time, there would be fewer hopping channel radars transmitting on the same frequency, but there would be a higher output level from these devices. Our concern for interference to terrestrial services is based on nearby vehicular radars rather than a general cumulative impact.

(RBW), a video bandwidth equal to or greater than the RBW, an RMS detector function, and a maximum 10 millisecond averaging period. The peak measurement would be performed as currently specified in the rules using a peak hold detector applied over a sufficiently long period that the measured levels cease increasing. Comments were requested on these proposed measurement procedures. For example, should the peak measurement be performed with the hopping sequence stopped; should a different averaging time be employed; should the averaging time be based on the number of hops and the dwell time of the hops; and should a maximum time be specified within which all hopping channels must be used?

34. Comments also were sought on the measurement procedure to be used to demonstrate compliance with the UWB minimum bandwidth standard.[91] Siemens VDO requested that the bandwidth be measured based on two procedures described in the appendix to its petition.[92] Both of the procedures suggested by Siemens are performed with the frequency hopping system active. However, the Commission expressed its concern that those procedures may not indicate the actual bandwidth employed by the system and the corresponding distribution of RF energy, depending on various technical parameters of the actual hopping system, *e.g.*, the distribution of the hopping channels, the dwell times for the hops, the number of hopping channels, the separation of the channels. the bandwidth of a single hopping channel, the number of hops in a specified time period, etc. Thus, the Commission proposed to require that the bandwidth be determined by first measuring the -10 dB bandwidth of a single hopping channel based on use of a peak hold detector and a 1 MHz resolution bandwidth and multiplying this value by the number of non-overlapping hops that occur within a 10 millisecond period. Comments were requested on this proposed measurement procedure as well as the procedures described by the petitioner. Comments also were requested on any interference concerns that arise from this modulation type or its method of measurement. Comments were requested on: the adequacy of the measurement results for the purpose of quantifying the impact to systems that could receive interference from frequency hopping vehicular radar systems operating under the proposed rules; any limits that should be applied regarding the number of hopping channels; the maximum occupancy time permitted for a hopping channel during any full hopping sequence; the maximum time it takes to complete a full hopping sequence; and any other pertinent technical characteristics.

35. Comments. In its comments, Siemens reiterates the opinion from its petition for reconsideration of the *1st R&O* that its frequency hopping system poses no greater risk of harmful interference than UWB systems generated by pulsed emissions, stating that the power level and distribution of each discrete spectral line component within the passband of a victim receiver are identical for these different emitters.[93] Siemens VDO argues that the Commission's statement that the frequency hopped emission levels were similar to time averaged emissions is unsupported, stating that the frequency hopping duty cycle acts as a "blanking" interval that occurs when the emission does not appear within the victim receiver's bandwidth.[94] Siemens VDO states that this does not influence the RMS measurement adding that the distribution of individual emissions over the observation (or integration) time is not important as the main purpose of an RMS measurement is to compare the energy content of different wave forms in a given time period. Siemens VDO requests that frequency hopping vehicular radar systems be permitted in the 22-29 GHz band with measurements made with the hopping active and a 10 millisecond averaging period.[95] Siemens VDO argues that a 10 millisecond averaging period is

---

[91] The Commission also proposed to eliminate the minimum UWB bandwidth standards which could make this issue moot.

[92] Siemens VDO Petition for Reconsideration of the *1st R&O* at Appendix A, pg. 16-17. These measurement procedures were incorporated by reference into the *FNPRM*.

[93] Siemens VDO comments of 7/21/03 at pg. 3.

[94] *Id.* at pg. 7-8.

[95] *Id.* at pg. 10-11.

necessary to avoid measurement errors, stating that a 1 millisecond integration period is not long enough to permit an accurate RMS power measurement of pulsed frequency hopping systems that require a longer period to complete a hopping cycle and that too short an averaging time results in inaccurately high power readings.[96] Siemens VDO agrees that a 1 millisecond period can be applied to emissions in the 23.6-24.0 GHz band. It provides a comparison of the emission levels produced by a frequency hopped system to that of a non-hopped UWB system.[97] Siemens VDO states that the emissions from its system will be limited by the peak emission standard because of the low duty cycle associated with the frequency hopping rate.[98] Further, Siemens VDO believes that the aggregate power averaged over a large geographical area would make it impossible for an EESS sensor in the 23.6-24.0 GHz band to distinguish between emissions from a hopped system and a pulsed UWB system.[99] Siemens also states that SARA commissioned an interference study by a third party, CETECOM ICT Services, which concluded that there is no increased interference to amateur or to police radar operation, assuming "real" road conditions.[100] As in its earlier petition for reconsideration, Siemens VDO recommends measurement procedures for determining peak and average emission levels, noting that it does not matter if the peak measurement is made with the frequency hop active or stopped.[101] However, Siemens VDO believes that it is necessary to make RMS measurements with the hop active to obtain accurate readings, citing NTIA's statement that the radiated emissions from a pulsed frequency hopping radar can be accurately measured in the frequency hopping mode.[102] SARA supports the comments of Siemens VDO, indicating that a 10 millisecond averaging taken with the hopping sequence active is necessary to obtain an accurate reading.[103]

36. CORF opposes permitting frequency hopping systems to operate in the 22-29 GHz band, arguing that these devices are an interference threat to EESS remote sensing instruments.[104] CORF indicates that the 22-24 GHz band is of particular concern, citing the allocation of the 23.6-24.0 GHz band to passive observations including EESS and radio astronomy as well as the EESS allocation at 22.21-22.5 GHz.[105] CORF argues that the averaging time of the emissions must be shorter than the integration time of the victim receivers, citing EESS integration times as low as 1.2 milliseconds and the possibility of shorter integration periods in future equipment.[106] Because of possible future short integration periods, CORF requests that a 0.1 millisecond averaging period be applied.[107] CORF states that a preferred method of measurement would be through the use of a fast response (0.1 millisecond or faster) power detector measurement with the signal entering the power detector head filtered to define the

---

96 *Id.* at pg. 8-11.

97 *Id.* at pg. 6.

98 *Id.* at pg. 11-12.

99 *Id.* at pg. 12-13.

100 *Id.* at pg. 13-15 and the attachment to these comments summarizing the Cetecom interference study.

101 *Id.* at pg. 16-27.

102 *Measurements of Siemens Pulsed Frequency Hopping Vehicular Radar Prototype*, NTIA, March 20, 2003, at pg. 37, as cited in Siemens VDO comments of 7/21/03 at pg. 25. This report exists in draft form only and has not been released by NTIA. Neither Siemens VDO nor NTIA has submitted this test report into the record for this proceeding.

103 SARA comments of 7/21/03 at pg. 4.

104 CORF comments of 7/16/03 at pg. 1.

105 *Id.* at pg. 2-3.

106 *Id.* at pg. 5-6.

107 *Id.* at pg. 7.

passband of interest.[108] Northrop Grumman and Raytheon oppose allowing frequency hopping systems in the 23.6-24.0 GHz band absent strict limits to reduce the potential for interference.[109] They support the measurement intervals and techniques suggested by CORF to prevent frequency hopping devices from momentarily emitting at much higher levels.[110] Siemens VDO responds that it has already indicated its willingness to accept a one millisecond integration period in the 23.6-24.0 EESS band, a limit that is less than the integration time of any EESS receiver in existence.[111] However, Siemens VDO also notes that as integration times decrease, so does the receiver's sensitivity to interference so that a receiver with a 0.1 ms integration time will experience a decrease in sensitivity of 5 dB.[112] Siemens VDO adds that spatial integration due to the aggregate power from multiple emitters being averaged over a large geographic area results in a smoothing of individual pulses and makes it impossible for the sensor to distinguish individual modulation techniques.[113] Finally, Siemens VDO states that it is not practical to use a fast response power detector, as proposed by CORF, as it is not aware of any such commercially available device.[114]

37. In its comments, NTIA states that frequency hopping transmitters must not be permitted to operate in the 23.6-24.0 GHz restricted band.[115] NTIA adds that frequency hopping transmitters are not UWB devices and are capable of avoiding operation in the restricted bands. NTIA also requested that the transmitters comply with the emission limits applicable to UWB devices along with an average RMS EIRP emission limit of -61.3 dBm/MHz for the 23.6-24.0 GHz band. NTIA states that its interference analysis applies only to EESS operations in the 23.6-24.0 GHz band and can not be applied to ground based receivers where a single frequency hopping transmitter would be dominant.[116] For ground based receivers NTIA notes that the establishment of power limits in a narrow frequency range is a primary concern. NTIA also states that the emission characteristics of the frequency hopped pulsed emissions will vary with pulse width, pulse repetition frequency, frequency hopping bandwidth, frequency hopping pattern, number of frequency hopping channels, hopping channel frequency separation, and the time duration of the hopping sequence. However, NTIA does not provide any suggestions as to the values that should be established for these parameters.

38. Discussion. The UWB regulations were implemented to permit systems that, because of their extremely wide bandwidths, are unable to avoid operation within the restricted bands.[117] A UWB transmitter must operate with a fractional bandwidth of at least 0.20 or a -10 dB emission bandwidth of at least 500 MHz.[118] The Commission implemented this minimum bandwidth requirement recognizing that transmitters that operate with less bandwidth could do so without having to transmit in the restricted

---

108 *Id.*

109 Northrop Grumman and Raytheon reply comments of 8/20/03 at pg. 1.

110 *Id.* at pg. 5-6.

111 Siemens VDO reply comments of 8/20/03 at pg. 3.

112 *Id.* at pg. 4.

113 *Id.*

114 *Id.* at pg. 5.

115 These comments were stated verbally to the Commission's staff on December 2, 2004, and on subsequent dates. These comments replace the 1/15/04 comments NTIA filed formally in this proceeding indicating that interference impact to EESS passive receivers from frequency hopped pulsed radar systems is comparable to that of impulse radars operating under the current UWB regulations.

116 NTIA comments of 1/15/04 at pg. 13-19.

117 47 C.F.R. § 15.205.

118 47 C.F.R. §§ 15.503(d).

bands.[119]

39. Systems that employ frequency hopping modulation are required to demonstrate compliance with the UWB bandwidth limit when measured with the frequency hopping stopped.[120] Unlike conventional UWB devices, frequency hopping systems have greater flexibility in determining which frequency bands will be employed and which will not. As indicated above, a waiver was issued earlier to Siemens VDO to permit the introduction of its vehicular radar system. As a condition of that waiver, the Commission, in cooperation with NTIA, required that the -10 dB bandwidth of the system be located between 24-29 GHz, avoiding all restricted bands. Siemens VDO agreed that its equipment can function in compliance with this condition. Thus, Siemens has already demonstrated that its equipment can be designed to function without having to operate within the restricted bands. We are unwilling at this time to classify as a UWB device a frequency hopping transmitter that emits relatively narrowband signals. We determine that changes to the UWB definition at this nascent stage in its development would be disruptive and could further delay the introduction of devices. Accordingly, we do not conclude that the Siemens VDO frequency hopping system should be classified as a UWB device. However, we continue to believe that the type of operation proposed by Siemens VDO merits authorization. Vehicular radar systems have the potential to enhance collision avoidance techniques and should be accommodated under the rules if this can be accomplished without increasing the potential for harmful interference to the authorized services. We believe that the Siemens VDO system can be accommodated as a non-UWB Part 15 device under the proposal in the *FNPRM* to allow the operation of wideband systems at the peak power level permitted for UWB operation. However, as requested by NTIA, this will not permit the fundamental emission from the Siemens VDO radar to operate in the restricted bands. Thus, the frequency band of operation that is being established for this vehicle radar system is 23.12-29.0 GHz, exclusive of the restricted band at 23.6-24.0 GHz.

40. *Emission standards*. Emission limits capable of preventing harmful interference to the authorized radio services were developed in the *1st R&O* for the operation of UWB vehicular radar systems in the 22-29 GHz band. We conclude that similar standards should continue to apply to wideband, but not necessarily UWB, vehicular radar systems operating in this band. Accordingly, we are implementing a fundamental EIRP RMS average emission limit of -41.3 dBm/MHz for such devices. We also are implementing our proposal for a peak limit of 20 log (RBW/50) dBm EIRP where RBW is the resolution bandwidth of the measuring instrument.[121] RBW shall not be less than 1 MHz or greater than 50 MHz. In addition, RBW shall not be greater than the -10 dB bandwidth of the device under test, as supported by the comments. If frequency hopping or stepped frequency modulation is employed, the frequency hop or step function shall be disabled and the transmitter shall operate continuously on a fundamental frequency to measure the -10 dB bandwidth that is used to determine the maximum RBW that may be employed for the peak emission level. Further, we are requiring that the -10 dB bandwidth of the fundamental emission be contained within the 23.12-29 GHz band under all conditions of modulation and effects from frequency stability and that the frequency at which the highest level emission appears be greater than 24.075 GHz. As requested by NTIA, we will require that emissions outside of the operating band comply with the emission standards applicable to UWB vehicular radar systems.[122] The limit

---

119 *1st R&O, supra*, at para. 30-31.

120 *1st R&O, supra*, at para. 32.

121 In performing a peak measurement, there is no need to stop the hopping function as long as the measurement is taken for a sufficiently long time period to ensure that all of the energy that will appear in that frequency band is measured.

122 47 C.F.R. § 15.515. As with the emission standards for operation in the 6 GHz and 17 GHz band, we do not believe that such stringent limits are necessary to prevent harmful interference. The emission levels requested by NTIA are extremely conservative, being based on multiple worst case conditions at detection levels below what may be considered harmful interference. Further, as stated in the *1st R&O*, the analyses and standards applied to (continued....)

applicable to the 22-23.12 GHz and to the 23.6-24.0 GHz bands shall be the same as that applied to UWB emissions below 22 GHz, *i.e.*, an EIRP of -61.3 dBm/MHz.[123] As with UWB devices, emissions from digital circuitry will be subject to the Part 15 general emission limits[124] or to the limits for digital devices,[125] as appropriate. Emissions below 960 MHz will be subject to the Part 15 general emission limits.

41. As with operation in the 5925-7250 MHz and 16.2-17.7 GHz bands, we conclude that a minimum bandwidth should be required to ensure that systems operating under the higher peak limit are wideband systems that could be penalized by the current Part 15 restriction on peak power levels. Siemens VDO states that its system occupies a bandwidth that is greater than 10 MHz for a single hopping channel. We believe that this is a reasonably wide bandwidth. Based on this, we are implementing a requirement that the -10 dB channel bandwidth of a system operating in the 23.12-29.0 GHz band under these new provisions be at least 10 MHz. If frequency hopping or stepped frequency modulation is employed, this 10 MHz minimum bandwidth limit shall be determined with the frequency hop or step function disabled and the transmitter operating continuously on a fundamental frequency. We determine that this limit is sufficient to provide protection to existing authorized services while permitting the implementation of the Siemens VDO and other possible vehicular radar systems. We also are retaining our current requirement that these vehicular radar systems be used only for ground-based applications.

42. *Methods of measurement.* We agree with Siemens VDO that its frequency hopping vehicular radar system should be permitted under the Part 15 regulations based on measurements performed with the frequency hopping active. However, we also believe that we must be cautious in this approach due to the paucity of interference data. Siemens VDO and SARA cite a statement from NTIA that the emissions from a frequency hopping system can be accurately measured with the hop active. However, this statement means only that emission levels can be detected and measured on a repeatable basis; it can not be inferred that such measurements provide emission levels with comparable interference potential. As previously stated by the Commission, the interference aspects of frequency hopping systems have not been thoroughly evaluated based on the different results that would be obtained from measurements made with the hopping active.[126] While NTIA performed an analysis demonstrating that there is no increased impact to EESS operations below 24 GHz, no information has been submitted in this proceeding regarding the impact frequency hopping emissions may have on any other radio service.[127] As

---

(...continued from previous page)
UWB are unique to that proceeding and will not be considered as a basis for determining or revising standards for other radio frequency devices, including other Part 15 devices.

123 Normally, transmission systems operating under the general emission limits are not required to reduce their emissions below the limits specified in 47 C.F.R. § 15.209, and instead are subject to a requirement that the spurious emissions not exceed the level of the fundamental emission. *See* 47 C.F.R. § 15.209(c).

124 47 C.F.R. § 15.209. As with transmisison systems operating in the 6 and 17 GHz bands being implemented in this order, we believe that emissions appearing within the frequency bands below 3.1 GHz, which are of particular concern to NTIA, will consist solely of emissions from digital circuitry and, thus, will be subject to the standards in 47 C.F.R. § 15.209. For this reason, the more stringent limits requested by NTIA should have a minimal impact on equipment designed to operate under these provisions.

125 47 C.F.R. § 15.109.

126 *1st R&O, supra*, at para. 32.

127 While Siemens VDO makes reference to a study demonstrating that there is no interference to Amateur and radar applications under "real" road conditions, Siemens VDO does not provide a copy of this study nor does it describe the "real" road conditions it indicates are necessary to demonstrate a lack of interference. We are unable to determine whether this study addresses interference based on the instantaneous vehicular radar emission levels or the time averaged levels nor can we determine the emission levels and other modulation characteristics that were
(continued....)

stated by NTIA, the establishment of power limits in a narrow frequency range is a primary concern for ground based receivers.[128] Further, the emission characteristics of the frequency hopped pulsed emissions will vary with pulse width, pulse repetition frequency, frequency hopping bandwidth, frequency hopping pattern, number of frequency hopping channels, hopping channel frequency separation, and the time length of the hopping sequence.

43. We note that the instantaneous average emission levels of the hopping channels could be considerably higher than the levels permitted under our rules if measurements are made with the frequency hop active, as requested by Siemens VDO. Because the transmission hops to a different frequency range during the measurement, the time that the signal is not transmitted on a frequency is averaged with the time that the transmission occurs. This time averaging is in addition to the RMS average of the active signal.[129] Further, any increase to the time over which signals are averaged, *e.g.*, from 1 millisecond to 10 milliseconds, would permit a greater number of hopping channels to be included within the averaging with a corresponding increase in the instantaneous emission levels.[130] No information or interference evaluation has been provided to justify the use of an averaging period longer than the 1 millisecond already adopted for UWB operations. Accordingly, we do not agree with Siemens VDO that the averaging period should be extended from 1 millisecond to 10 milliseconds.

44. The interference aspects of a transmitter employing frequency hopping, stepped frequency modulation or gating are quite similar, as viewed by a receiver, in that both appear to the receiver to emit for a short period of time followed by a quiet period.[131] Gating the transmitter on and off produces the same effect on the measured data as would hopping the transmitter to a frequency outside of the measurement range. If emissions are permitted to be measured with the gating active, no emissions would be produced on the frequency being measured during the time the transmitter is gated off and the measured emission level would be reduced just like what occurs when a frequency hopping transmitter is measured with the hopping active. Conversely, requiring the emissions to be measured with the system operating continuously and the gating disabled produces the same results as measuring a frequency hopping system with the hopping stopped, *i.e.*, the "instantaneous" emission levels are determined. Consequently, permitting the emissions from frequency hopping systems to be measured with the hopping active could give such systems a competitive advantage by permitting higher instantaneous average power levels than what are allowed for gated systems. Since hopped, stepped and gated systems have similar interference effects and we have concluded that hopped systems may be measured with the hopping active, we also are eliminating the requirement that gated or stepped systems be tested with the

---

(...continued from previous page)
employed for the vehicular radar. In particular, we have no information to demonstrate whether the victim receivers are sensitive to potential interference from the instantaneous vehicular radar emission levels or from the time-averaged levels. CORF and Northrop Grumman and Raytheon continue to argue against allowing devices to operate in the 22-24 GHz band, but these comments are akin to late filed petitions for reconsideration of the decisions made in the *1st R&O* and present no new information to justify changes to the Commission's earlier decisions.

128 EESS receivers are satellite receivers located orbiting the earth and, obviously, are not ground-based.

129 As an example, depending on the averaging time of the measuring instrument and the hopping rate a frequency hopping system employing 50 hopping channels could, through time averaging of the emission levels, increase its signal level by as much as 17 dB above the average limit.

130 With a 1 millisecond averaging period, any hopping rate in excess of 1 kHz could permit a higher instantaneous average signal level on the individual hopping channels. With a 10 milliseconds averaging period, a higher instantaneous signal level could occur for any hopping rate in excess of 100 Hz. However, any increase in the instantaneous average level also could be limited by the peak UWB emission limit.

131 Gating refers to the transmitter's emission being turned on and off.

gating or step function turned off.[132] We concur that stepped frequency, frequency hopped and gated systems can be permitted to operate under the same standards and measurement procedures. As with operation in the 5925-7250 MHz band, no provision is provided to permit transmitters employing swept frequency modulation to perform measurements with the sweep stopped; these devices must continue to comply with the standards following the provisions of 47 C.F.R. § 15.31(c).

45. We also recognize that the UWB regulations for operation in the 22-29 GHz band require vehicular radar systems that employ gating to be measured with the transmitter gated on.[133] The interference potential of a UWB gated system is similar to that of a wideband gated system. We see no reason that these similar systems should not be subject to the same measurement procedures. Thus, we are amending the UWB regulations to permit the emissions from gated vehicular radar systems to be measured with the gating active. However, as requested by NTIA we do not agree that similar provisions should be applied to UWB systems that employ frequency hopping, stepped frequency or similar modulation techniques. Provisions were made in the regulations to permit UWB vehicular radars to operate within the 22.10-23.12 GHz and 23.6-24.0 GHz restricted bands because their extremely wide bandwidths combined with their operation centered near 24.125 GHz resulted in the transmitters not being able to avoid operation within those restricted bands. However, frequency hopping and frequency stepped transmitters have direct control over where they operate in the radio spectrum. Further, there is sufficient spectrum to support their operation in the 22-29 GHz band without having to operate within the restricted bands. Accordingly, these transmitters must continue to be measured with the frequency hop or step function disabled and with the transmitter operating in a continuous mode if they are authorized under the UWB regulations.[134] However, any vehicular radar employing frequency hopping, stepped frequency or similar modulation methods may be authorized to operate in the 23.12-29 GHz band, exclusive of the 23.6-24.0 GHz band, with the emission levels determined based on the transmitter's normal operating mode, under the non-UWB provisions being adopted in this order.

46. One of the primary reasons for requiring frequency hopping systems to be measured with the hop stopped was to ensure that the emissions are detected by the spectrum analyzer during the time period that the analyzer swept the frequency. In its comments, NTIA proposed a measurement procedure to ensure that the signal is detected at the proper level. Under this procedure, the RMS average and peak emission measurements are to be repeated with the analyzer in the maximum hold mode until there is no significant increase, *i.e.*, less than 3 dB, in any of the maximum hold values. We concur with the use of these measurement procedures and are implementing them in our regulations. Additional measurement guidance is expected to be provided by our Laboratory in the near future.

47. *Operation in the restricted bands.* As noted earlier, NTIA argues that there is no basis for permitting non-UWB devices to operate in the restricted bands. We concur and are not amending our regulations to permit such operation. Instead, we are specifying a frequency band of operation from 23.12-29 GHz, except for the 23.6-24.0 GHz band. This is comparable to what was provided to Siemens in its earlier waiver.[135]

48. *Additional modulation types.* Based on the above, we are establishing a new rule section under Subpart C of Part 15 that permits the operation of vehicular radar systems in the 23.12-29 GHz

---

[132] SARA and M/A-COM, in their *ex parte* filings, requested that UWB vehicular radar systems operating in the 22-29 GHz band be tested with the gating active.

[133] The requirement to measure gated UWB transmitters with the gating disabled is contained in 47 C.F.R. § 15.521(d).

[134] The requirement to stop the frequency hopping or step function is contained in the UWB measurement procedures, as stated in the *1st R&O, supra*, at para. 32.

[135] Under the conditions of its waiver, Siemens VDO vehicular radars had to operate in the 24-29 GHz band.

band, except for 23.6-24.0 GHz, under similar emission limits that are applicable to UWB vehicular radar systems. This action resolves the request from Siemens VDO to permit the operation of frequency hopping vehicular radar systems in the 22-29 GHz band. However, we note that Delphi also requests that our regulations accommodate in the 22-29 GHz band non-hopping vehicular radar systems that employ a bandwidth less than the 500 MHz required for operation under the UWB standards.[136] We see no reason that modulation types other than frequency hopping should be prohibited from operating under the same standards. Accordingly, we are amending the regulations to permit the operation of vehicular radar systems in the 23.12-29 GHz band, except for 23.6-24.0 GHz, regardless of the type of modulation that is employed. As noted above, transmitters employing swept frequency modulation must continue to be measured with the frequency sweep stopped at the frequency of measurement. We believe that these changes to the rules are consistent with our earlier UWB decisions to remain conservative in our implementation of the technical standards while we gain additional experience with this technology.

49. *Disposition of the waiver previously granted to Siemens VDO.* Siemens VDO was granted a waiver on June 23, 2003, under delegated authority of the Chief, Office of Engineering and Technology. The standards associated with that waiver were implemented in cooperation with NTIA. Among other things, these standards reflect compliance with the emission limits applicable to UWB vehicular radar systems. Any device that was designed to comply with the provisions of the waiver also will comply with the standards being adopted in this proceeding. For this reason, the termination of the existing waiver will not have any impact on Siemens VDO. Accordingly, the waiver previously issued to Siemens VDO to permit the operation of its frequency hopping vehicular radar in the 24-29 GHz band shall expire upon the effective date of these regulations.

D. Clarification of existing non-UWB peak power emission limits

50. In its petition for reconsideration of the *1st R&O*, MSSI requested that the peak emission measurements of its pulsed emission system operating under the non-UWB Part 15 regulations, *i.e.*, Subpart C of Part 15, be performed using a 1 MHz resolution bandwidth without the application of a pulse desensitization correction factor (PDCF).[137] While the Commission denied MSSI's request in the *MO&O*, it agreed with MSSI that the existing rule should be clarified rather than continue to rely on the spectrum analyzer operating instructions to indicate when a PDCF must be applied. Accordingly, the Commission in the *FNPRM* proposed to clarify that the peak emission limit for non-UWB operation is based on the total peak energy radiated by the device and that a PDCF may be needed to obtain the actual total peak emission level.

51. Comments/discussion. MSSI requests an interpretation of Section 15.35(b) of the Commission's rules that a PDCF does not apply above 1 GHz, stating that this would permit it to commercially deploy its wideband devices.[138] As proposed in the *FNPRM*, we are amending Section 15.35(b) to clarify that the peak power requirement applies to the total peak power produced by the device and may necessitate the use of a PDCF. This clarification does not result in any changes to the current Part 15 standards.

52. The PDCF originally was designed for measuring the peak output level of pulsed radar transmissions. The PDCF is a technique used to determine the true pulse amplitude based on measurements taken from a spectrum analyzer. The analyzer is unable to respond fast enough and therefore does not use sufficient bandwidth to measure all of the energy in the pulsed signal. Thus, when pulse widths are narrower than the inverse of the resolution bandwidth employed by a spectrum analyzer

136 Delphi Comments of 7/18/03 at pg. 8.

137 MSSI Petition for Reconsideration of 6/14/2002 at pg. 9.

138 MSSI comments of 7/21/03 at pg. 1-2.