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March 9, 2004

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Marlene Dortch, Esq.
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: ET Docket No. 98-153
Written *Ex Parte* of Siemens VDO Automotive

Dear Ms. Dortch:

Siemens VDO Automotive AG ("Siemens VDO"), pursuant to Section 1.1206(b) of the Commission's rules, submits this *ex parte* to respond to proposals and technical conclusions contained in the *ex parte* comments filed by the National Telecommunications and Information Administration ("NTIA") on January 15, 2004 in the above-referenced docket ("NTIA *Ex Parte*"). Overall, Siemens VDO is largely in agreement with NTIA's thorough and thoughtful comments. VDO is particularly pleased that NTIA has: (1) generally endorsed the use of a 10 ms root mean square ("RMS") averaging time for measuring pulsed frequency hopping ("FH") systems; and (2) determined that the interference potential to EESS sensors of pulsed FH vehicular radars is comparable to that of impulse vehicular radars. These conclusions provide support for a Commission decision to amend the UWB rules to permit the operation of Siemens VDO's pulsed FH vehicular radar system. Nevertheless, Siemens VDO does disagree with NTIA on one point: unlike NTIA, Siemens VDO supports the Commission's proposal to eliminate the UWB minimum bandwidth requirement, which unnecessarily limits the design of UWB devices without providing any concomitant benefit in terms of limiting the likelihood of harmful interference. If, however, the Commission concludes that the minimum bandwidth requirement should be maintained, Siemens VDO reiterates its proposal for measuring compliance with such requirement by pulsed FH vehicular radar systems. Siemens VDO's specific comments on the various sections of the NTIA *Ex Parte* are laid out in the text below, and in the supporting technical annexes appended hereto.

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Compliance Measurement Procedure for Pulsed FH Vehicular Radars. Siemens VDO supports NTIA's proposed procedures for measuring compliance for pulsed FH vehicular radar systems. In particular, Siemens VDO is pleased that NTIA has generally endorsed the use of a 10 ms root mean square ("RMS") averaging time as proposed in the FNPRM, except in the 23.6-24 GHz EESS band, where NTIA suggests a 1 ms averaging time. Notably, NTIA does not support the proposal by the Committee on Radio Frequencies ("CORF") to impose a 0.1 ms averaging time for pulsed FH devices.

In its Comments and Reply Comments, Siemens VDO has already indicated its willingness to accept the 1 ms averaging time in the 23.6 – 24 GHz EESS band,[1] even though it does not believe that such a short averaging time is needed to protect EESS sensors. Siemens VDO's EESS non-interference analysis is predicated largely on the effects of spatial integration, rather on the relative length of the integration time. Due to the spatial integration the aggregated power from multiple transmitters received at the victim receiver is averaged over large geographic areas (such as the EESS antenna footprint), resulting in completely uncorrelated frame time periods of the individual radar sensors, thereby making it impossible for the EESS sensor to distinguish individual modulation techniques[2].

Impact on EESS Sensors from Pulsed FH Vehicular Radars. Siemens VDO fully supports NTIA's conclusion, based on NTIA's detailed comparative analysis, that the interference potential to EESS sensors of pulsed FH vehicular radars – like Siemens VDO's system – is comparable to that of impulse vehicular radars.[3] This conclusion is consistent with positions previously advanced by Siemens VDO in the record, and Siemens VDO presents additional information here in Annex 4 that further supports this conclusion. Given NTIA's unequivocal statement that it "believes that the operation of pulsed FH vehicular radar systems that comply with the technical standards specified in Section 15.515 of the Commission's Rules is possible,"[4] the Commission should have no further concern with regard to the potential impact of Siemens VDO's system on EESS.

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1 Siemens VDO Comments at 10; Reply Comments at 3.

2 This spatial aggregation effect holds true also for shorter distances between many pulsed FH SRRs and terrestrial victim receivers. As the individual SRRs are operated asynchronous (each has its own clock frequency and is started at an arbitrary point in time), their frame times are also uncorrelated in time, thereby reducing the individual frame time length by the square root of the number of devices.

3 NTIA *Ex Parte* at 16-19 and Appendix E.

4 NTIA *Ex Parte* at 18-19.

Minimum Instantaneous Bandwidth. NTIA opposes the Commission's proposal to eliminate the minimum bandwidth requirement contained in Section 15.503(d), noting that its prior analyses did not consider the potential effects that could result from narrowband signals which may employ signal types other than impulse signals.[5] As Siemens VDO has explained previously,[6] however, interference potential is defined by the distribution and absolute power of the individual spectral lines (*i.e.*, the single line power ("SLP")) of the generated spectrum, not by the occupied bandwidth. The distribution of the SLPs is governed by the pulse width and the PRF. Only the SLPs falling within a victim receiver's bandwidth are of concern. Thus, one UWB device with a 500 MHz occupied bandwidth and another with a 50 MHz bandwidth will have the same interference potential if the SLPs within the victim receiver's bandwidth are identical. Both Annex 4 and Annex 5 provide technical support and justification for this statement.

While the current minimum bandwidth requirement is largely irrelevant to protecting victim receivers, this requirement nevertheless effectively limits the design of UWB devices to those that accomplish power spreading solely by emitting short pulses. As a result, even devices such as the Siemens VDO pulsed FH system – which produce a level and distribution of SLPs identical to that produced by impulse systems – are barred from operating as UWB devices.[7] NTIA's claim that the proposal to eliminate the minimum bandwidth requirement "does not appear to have a benefit to the public"[8] ignores the clear public interest benefits of enabling a variety of devices (with different designs) to compete in the marketplace. Accordingly, Siemens VDO respectfully disagrees with NTIA's position that the minimum bandwidth requirement should be maintained.

Should the Commission nevertheless decide not to remove the minimum bandwidth requirement at this time, Siemens VDO reminds the Commission that, as an alternative, the Commission could enable the market entry of the Siemens VDO pulsed FH system by adopting either of the bandwidth measurement procedures originally suggested by Siemens VDO in its Petition for Reconsideration.[9] Based on a review of its *Ex Parte*, NTIA appears to have no concern with either of these proposals. Specifically, Siemens VDO proposed that

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5 NTIA *Ex Parte* at 24-25.

6 Siemens VDO Comments at 3-5.

7 Siemens VDO Comments at 3.

8 NTIA *Ex Parte* at 25.

9 *See* Siemens VDO Comments at 20-21; Petition for Reconsideration, Appendix A at 16.

the minimum bandwidth for pulsed FH systems could be measured during a 10 ms observation interval using either of the two methods described below:

Method A:

- Spectrum analyzer is set to zero span mode
- RBW is set to 3 MHz, VBW ≥ 3 MHz
- Detector mode is maximum peak
- Sweep time of 10 ms
- Center frequency is set to several “test points“ within the indicated occupied bandwidth

Notes:

For all selected frequency test points at least two burst signals should be within the required time period of 10 ms.

If the entire bandwidth of 500 MHz has to be verified (with a 1 MHz RBW), in total 500 frequency test points would have to be tested, which is very time consuming if measurement automation is not available.

Method B:

- The span of the spectrum analyzer is set to accommodate the occupied bandwidth of the DUT (device under test)
- RBW is set to 3 MHz, VBW ≥ 3 MHz
- Detector mode is maximum peak
- The number of points of the spectrum analyzer is selected so that each point represents at maximum the RBW (example: Span = 1.8 GHz => minimum 600 points necessary)
- The sweep time is set to 10 ms multiplied by the number of points
- A single sweep is conducted

Notes:

The occupied spectrum should be flat without any holes in between, as for each frequency pixel (or bucket) within the 10 ms observation time at least one peak value should be detected, independent of the kind of modulation pattern applied. If the device doesn’t fill up the minimum required bandwidth of 500 MHz within 10 ms, some holes will appear in the spectrum because no peak value occurred. The shape of the RBW filter and the effective observation time per pixel (bucket) is spectrum analyzer-dependent. Thus, a correction factor for the sweep time might be necessary.

Methods A and B can serve as a means to prove that the 500 MHz bandwidth is filled up smoothly and evenly in any 10 ms time period. The primary emphasis is on the smoothness of the power distribution and the frequency points where the –10 dB points are reached for the first time.

Amendment of Section 15.35(b). Siemens VDO agrees with NTIA's suggested clarifying changes to the Commission's proposed revision of Section 15.35(b).[10] However, Siemens VDO believes that additional clarification in this section is desirable. In particular, Siemens VDO believes that the rules should permit an increase in the resolution bandwidth ("RBW") in order to prevent an artificially high peak power reading in the transient region that occurs when the pulse repetition frequency ("PRF") approaches parity with the RBW.[11] Accordingly, Siemens VDO recommends that the following text be added at the end of the text in NTIA's proposed Section 15.35(b)(2):

> No further pulse desensitization correction factor (PDCF) is required to be applied to the measured peak power readings. Where the pulse repetition frequency (PRF) of the device is equal to or greater than the postulated 1 MHz resolution bandwidth, the resolution bandwidth may be increased up to the instantaneously occupied bandwidth of the device, thereby reducing the artifact of a power reading increase in the transient region where the PRF attains parity with the RBW. When the postulated 1 MHz resolution bandwidth is increased to a higher resolution bandwidth RBW_{high}, the permitted EIRP level shall be adjusted to the 20 Log (RBW_{high}/50) dBm limit.

Defining the Peak Power in a 1 MHz Bandwidth. Siemens VDO agrees with NTIA's conclusion that the Commission's proposal to define the peak power in a 1 MHz bandwidth will not impact compatibility with wideband Federal systems, so long as a duty cycle limit of 1% in the victim receiver bandwidth is established.[12] NTIA is correct that the impact of the Commission's proposal will depend on the type of signal (*e.g.*, pulsed, noise, continuous wave), as well as the device's operational parameters (*e.g.*, duty cycle, PRF, instantaneously occupied

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10 NTIA *Ex Parte* at 5-6.

11 *See* Siemens VDO Comments (July 21, 2003) at 29, Figure 11 (The red triangle, marked with "note 3," describes the transient zone from the 10 log to the 20 log peak readings relationship that occurs when the RBW/PRF ratio is around parity.)

12 NTIA *Ex Parte* at 6-13.

bandwidth, etc.). Siemens VDO agrees with the NTIA analysis indicating that the proposed peak limit of –21.3 dBm measured in a 1 MHz bandwidth will have a greater impact on victim receivers with a bandwidth above 1 MHz.[13] Annex 3 contains additional technical analysis relating to the interference potential to wideband Part 15 devices.

Future Vehicular Radar Operations at 77-81 GHz. NTIA correctly summarizes the comments of the Short Range Automotive Radar Frequency Allocation Group ("SARA") filed in WT Docket No. 01-102.[14] In those comments, SARA explained that European regulators appear poised to adopt a decision that would provide for an immediate vehicular radar allocation at 24 GHz, although that allocation would later be phased out. Under the draft decision, radars manufactured after 2014 would be limited to an allocation in the 77-81 GHz band. Given the economies of scale that can be achieved through common international frequency allocations, Siemens VDO appreciates the commitment of NTIA to "work with the Commission to ensure that an adequate frequency allocation in the 77-81 GHz band is available for the operation of vehicular radar systems."[15] However, Siemens VDO cautions against any conclusion that the entire industry in the U.S. and other non-European countries will necessarily transition to the 77-81 GHz band by 2014. Some manufacturers may not be influenced by the

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13 As can be seen in Annex 3, only devices spreading their energy over an instantaneous occupied bandwidth greater than 4.3 MHz (while not taking into account the requirement of a minimum 500 MHz bandwidth currently in force for the UWB rules) can take advantage of the UWB peak power limit of 0 dBm/50 MHz. For all other devices, the -21.3 dBm peak power limit measured over the entire BW pursuant to § 15.35(b) in the general Part 15 rules is more favorable. The proposal to reference the peak power to a 1 MHz bandwidth with a -21.3 dBm limit would result in an amended peak power limit of 12.67 dBm/50MHz, in contrast to the current 0 dBm/50 MHz limit. Victim receivers with less than a 1 MHz bandwidth are not affected by this change. Victim receivers with more than a 4.3 MHz bandwidth have to cope with a peak interference that is 12.67 dB higher. However, due to the PDCF, any victim receiver above 1 MHz bandwidth automatically "sees" a higher interference peak power. Thus, the main question is which reference victim receiver should be the "standard" reference, either the 1 MHz or the 4.3 MHz (see Annex 3 for more details).

14 NTIA *Ex Parte* at 19-22; *see also* Amendment of Part 2 of the Commission's Rules to Realign the 76-81 GHz Band and the Frequency Range Above 95 GHz Consistent with International Allocation Changes, *Notice of Proposed Rulemaking*, WT Docket No. 01-102 (rel. Apr. 28, 2003).

15 NTIA *Ex Parte* at 22-23.

developments affecting the European market. Moreover, some of the future technical advancements that the industry hopes will occur to lower the cost of millimeter wave equipment may not materialize as quickly as expected. For this reason, the Commission should do nothing that would jeopardize the future availability of the 24 GHz band for UWB vehicular radars.

Amendments to Section 15.521. In its *Ex Parte*, NTIA suggested clarifying amendments to Section 15.521, which relates to digital circuitry used in UWB devices.[16] Siemens VDO has no objection to NTIA's proposed revision.

Conclusion. The Commission should find the NTIA comments helpful in reaching a decision on the issues raised in the current UWB *Further Notice*. In particular, the comments should help the Commission conclude that its rules should be amended to permit the operation of the Siemens VDO pulsed FH vehicular radar device, without any fear that the device will be more likely to cause harmful interference than pure pulsed devices.

Respectfully Submitted,

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16 NTIA *Ex Parte* at 26.

Annex 1
Peak-Average Power Limitation Criteria for Impulse UWB Devices

The turnover value where a UWB pure impulse device is either limited by the peak power or the average power limit can be mathematically determined with the following calculations:

A) Definitions:

$P_{pk\ EIRP}$	=	Peak power over entire bandwidth
RBW	=	Resolution Band Width (*i.e.*, either the spectrum analyzer or victim receiver bandwidth)
$P_{pk\ RBW}$	=	Peak power in a given RBW
$P_{rms\ EIRP}$	=	Average power over entire bandwidth
PSD_{RBW}	=	Power Spectral Density measured in a given RBW
τ	=	pulse width of the intermittent signal
PRF	=	pulse repetition frequency of the intermittent signal
P_{SLP}	=	Single Line Power (individual spectral lines that are controlled by PRF and τ).
$1/\tau$	=	instantaneous occupied bandwidth (due to pulse spreading)
DC	=	duty cycle (in dB as fractional value; *i.e.*, 0.1 = - 10 dB)
CF	=	Crest Factor (in dB; ratio of peak to average power)

B) Mathematical relationships between the different measurement conditions:

$$DC = 10 \cdot \log (PRF \cdot \tau)$$

$$P_{rms\ EIRP} = P_{pk\ EIRP} + DC$$

$$PSD_{RBW} = P_{rms\ EIRP} + 10 \cdot \log (RBW \cdot \tau)$$

$$P_{SLP} = P_{pk\ EIRP} + 20 \cdot \log (PRF \cdot \tau)$$

$$PSD_{RBW} = P_{SLP} + 10 \cdot \log (RBW / PRF)$$

$$P_{pk\ RBW} = P_{SLP} + 20 \cdot \log (RBW / PRF)$$

$$CF = P_{pk\ RBW} - PSD_{RBW}$$

$$CF = P_{SLP} + 20 \cdot \log (RBW_{pk} / PRF) - P_{SLP} - 10 \cdot \log (RBW_{PSD} / PRF)$$

$$= 20 \cdot \log (RBW_{pk} / PRF) - 10 \cdot \log (RBW_{PSD} / PRF)$$

$$= 10 \cdot \log [(RBW_{pk})^2 / PRF^2] - 10 \cdot \log (RBW_{PSD} / PRF)$$

$$= 10 \cdot \log [(RBW_{pk})^2 / (PRF \cdot RBW_{PSD})]$$

$$= \quad 10 \cdot \log\left(\frac{RBW_{pk}^2}{PRF \cdot RBW_{PSD}}\right)$$

[Note: all values in the formula are in dB and not in absolute units]

C) PRF turnover point for pure impulse UWB device:

With the FCC's R&O UWB limits:

$P_{pk\ 50\ MHz}$ = 0 dBm

$PSD_{1\ MHz}$ = -41.3 dBm

the CF results to 41.3 dB.

For a CF of exactly 41.3 dB, the impulse UWB device is both limited by the peak and the average power criterion.

If CF > 41.3 dB, then the impulse UWB device is only peak power limited

If CF < 41.3 dB, then the impulse UWB device is only average power limited

By changing the equation

$$CF = \quad 10 \cdot \log\left(\frac{RBW_{pk}^2}{PRF \cdot RBW_{PSD}}\right)$$

to

$$PRF = \left(\frac{RBW_{pk}^2}{RBW_{PSD} \cdot 10^{\frac{CF}{10}}}\right)$$

and solving with CF = 41.3 dB, RBW_{pk} = 50 MHz and RBW_{PSD} = 1 MHz results in

PRF = 185.327 kHz

An impulse UWB radar with a PRF below 185.327 kHz will be limited by the peak power criterion (0dBm/50 MHz) and for a higher PRF the impulse radar will be limited by the average peak criterion (-41.3 dBm/MHz).

Thus, both for dithered and undithered impulse UWB devices the following general rule applies:

If PRF < 185.327 kHz, then the impulse UWB device is only peak power limited

If PRF = 185.327 kHz, then the impulse UWB device is peak and average power limited

If PRF > 185.327 kHz, then the impulse UWB device is only average power limited

Annex 2
Peak Power Limit of -21.3 dBm in 1 MHz for General Part 15 Rules

In its MO&O /FNPRM, the Commission proposed a new peak power definition for wideband Part 15 devices that is not measured over the entire signal bandwidth but within a 1 MHz RBW.

This new limit will express to:

$P_{pk\ 1\ MHz} = -21.3$ dBm

$PSD_{1\ MHz} = -41.3$ dBm

and the CF results to 20 dB.

For a CF of exactly 20 dB the impulse UWB device is limited both by the peak and the average power criteria.

If CF > 20 dB, then the impulse UWB device is only peak power limited

If CF < 20 dB, then the impulse UWB device is only average power limited

By changing the equation

$$CF = \quad 10 \cdot \log\left(\frac{RBW_{pk}^2}{PRF \cdot RBW_{PSD}}\right)$$

to

$$PRF = \left(\frac{RBW_{pk}^2}{RBW_{PSD} \cdot 10^{\frac{CF}{10}}}\right)$$

and solving with CF = 20 dB, RBW_{pk} = 1 MHz and RBW_{PSD} = 1 MHz results in

PRF = 10 kHz

An impulse UWB radar with a PRF below 10 kHz will be limited by the peak power criterion (-21.3 dBm/1 MHz) and for a higher PRF the impulse radar will be limited by the average peak criterion (-41.3 dBm/MHz).

So both for dithered and undithered impulse UWB devices the following general rule will apply:

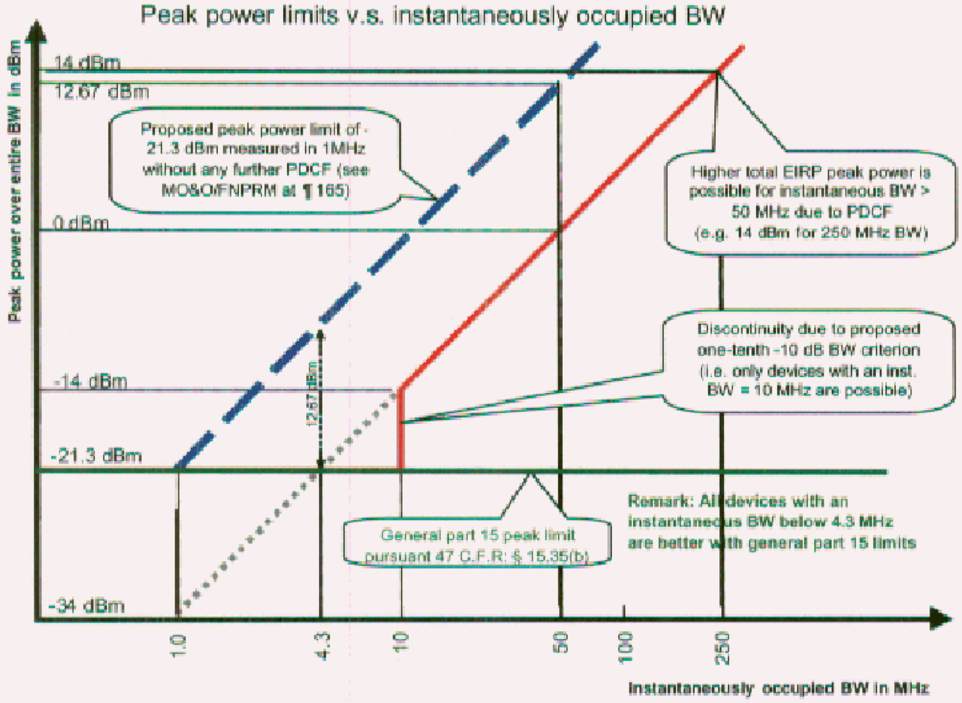
If PRF < 10 kHz, then the impulse UWB device is only peak power limited

If PRF = 10 kHz, then the impulse UWB device is peak and average power limited

If PRF > 10 kHz, then the impulse UWB device is only average power limited

Annex 3
Peak Power Limit of -21.3 dBm in 1 MHz for General Part 15 Rules

The proposed peak power limit of 5000 µV/ m at 3m (equivalent to -21.3 dBm) based on a measurement using a peak detector, a 1 MHz resolution bandwidth and a video bandwidth no less than 1 MHz is sketched in the figure below as the blue dashed line.



The three different limits in the above figure are related to:

Green double line: General Part 15 peak limit pursuant to 47 C.F.R. § 15.35(b) which specifies the maximum peak power limit over the entire bandwidth to -21.3 dBm with the requirement to apply a PDCF for signals with an instantaneously occupied bandwidth greater than the used measurement bandwidth. Thus, independent of the actual instantaneously occupied bandwidth all possible devices will have a maximum peak power limit of -21.3 dBm.

Red solid line: This is the Commission's proposal for amending § 15.35(b)(2) (see MO&O/FNPRM at ¶164) for wideband Part 15 transmission systems. In

contrast to the UWB R&O the 500 MHz minimum instantaneously occupied bandwidth does not apply. Also, no further PDCF has to be applied on the measured peak power readings. The peak power can be measured with a RBW between 1 and 50 MHz with an EIRP limit of 20 Log (RBW/50) dBm. Due to the further restriction in the proposed § 15.35(b)(2) (MO&O/FNPRM at ¶164) that the RBW used in the measurement instrument shall not be greater than one-tenth of the -10 dB bandwidth of the device under test, only such devices with an instantaneously occupied bandwidth greater than 10 MHz can qualify for this proposed rule.
The dotted red line in the figure above shows the continuation of the proposed peak power limit with the assumption that the one-tenth of the -10 dB bandwidth of the device under test criterion is withdrawn. In this case the red dotted line will hit the 1 MHz instantaneously occupied bandwidth at a peak power level of – 34 dBm. It is evident that only devices with an instantaneously occupied bandwidth greater than 4.3 MHz may profit from this rule change, while all other devices with an instantaneously occupied bandwidth below 4.3 MHz perform better with the actual Part 15 peak limit pursuant to 47 C.F.R. § 15.35(b) with a PDCF applied.
Consequently, the proposed amendment of § 15.35(b) will only apply to devices with an instantaneously occupied bandwidth greater than 4.3 MHz, or, if the one-tenth of the -10 dB bandwidth of the device under test is maintained, only for devices with an instantaneously occupied bandwidth greater than 10 MHz.

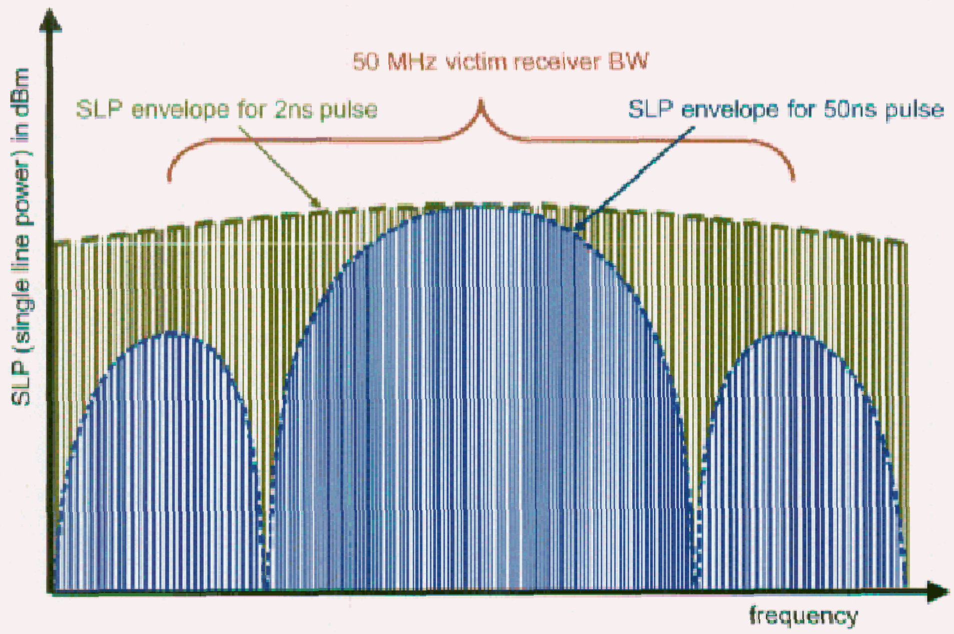
Blue dashed line: The blue dashed line represents the MSSI proposal in the MO&O/FNPRM at ¶165 for wideband Part 15 transmission systems. As can be seen from the figure, this limit is in parallel to the proposal for § 15.35(b)(2) and has an offset of ca. 12.7 dB. This proposal already favors devices with an instantaneously occupied bandwidth greater than 1 MHz to profit from the PDCF effect (that is not to be applied to the peak power readings). Indeed, a device with an instantaneously occupied bandwidth of 10 MHz can use a total peak power limit over the entire bandwidth of -1.3 dBm, resulting in a -21.3 dBm/MHz peak limit in a 1 MHz victim receiver bandwidth. The interference potential for victim receivers with a bandwidth below 1 MHz will therefore not be affected by this rule amendment; however, all victim receivers with a bandwidth above 4.3 MHz have to cope with a peak power increase that is 12.67 dB higher than the peak power interference in the UWB rules currently in force.
Some mitigation effects, like a duty cycle limitation, could be used to compensate for this additional peak power increase. The amendment of the 0 dBm/50MHz peak power limit to a value of 12.67 dBm in a 50 MHz bandwidth leads to a better self contained peak limit rule that is focused on a 1 MHz victim receiver. Furthermore, there will be no discontinuity from the general Part 15 peak limit pursuant to § 15.35(b) that is -21.3 dBm over the entire bandwidth to the new proposed UWB peak limits that would start with the -21.3 dBm/MHz limit. For the 0 dBm/50MHz peak limit the value

for a 1 MHz bandwidth is -34 dBm resulting in a stepping down from 21.3 dBm to – 34 dBm at the 1 MHz bandwidth point.

It is worth noting that increasing the peak power limit from 0 dBm/50 MHz to 12.67 dBm/50 MHz will also increase the Crest Factor from 20 dB to 32.67 dB. As a consequence, the duty cycle (or the peak to average ratio) will also increase. There is little knowledge regarding what impact the Crest Factor will have on wideband victim receivers above several MHz and whether the interference criterion is mainly determined by the average power interference with a t.b.d. Crest Factor.

Annex 4
Technical Support on Interference Perspectives

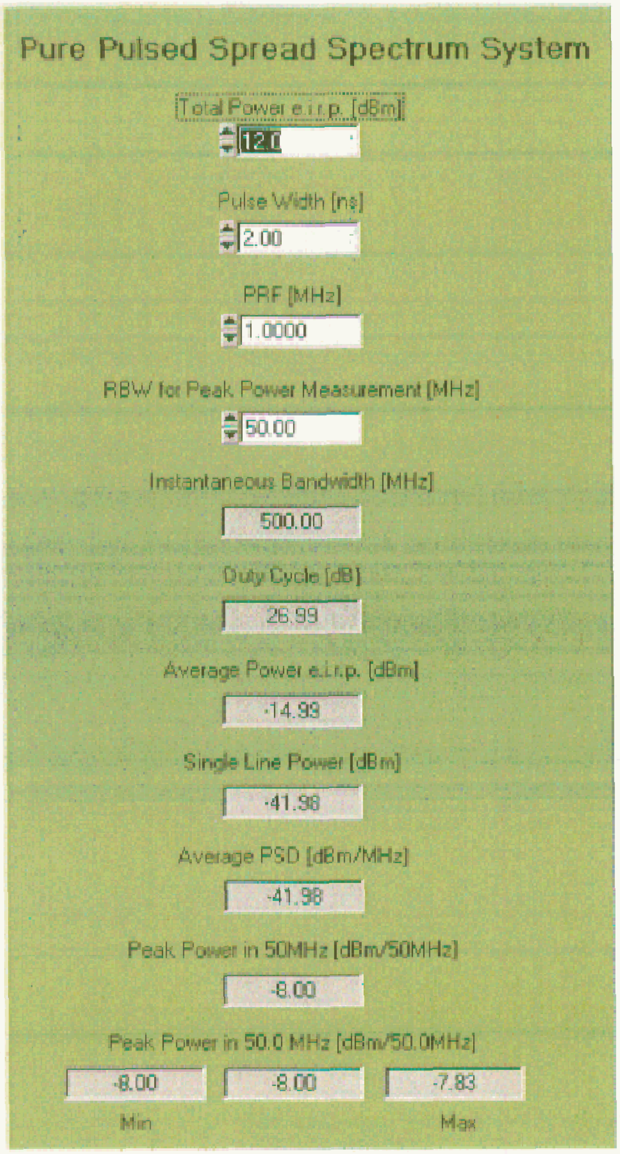
In Annex 1, the basic mathematical relationships that govern the peak and average power values in a given bandwidth are defined. For a pulsed signal the so -called single line power (SLP) is the key parameter. Regarding the interference potential of a given signal, all relevant data can be extracted with the help of the SLP. It is important to note that the generation process of the SLP is of no concern. Furthermore, with the help of system theory, different SLP distributions can be transformed into each other by having the same interference impact (see the mathematical formula in Annex 1 for details).

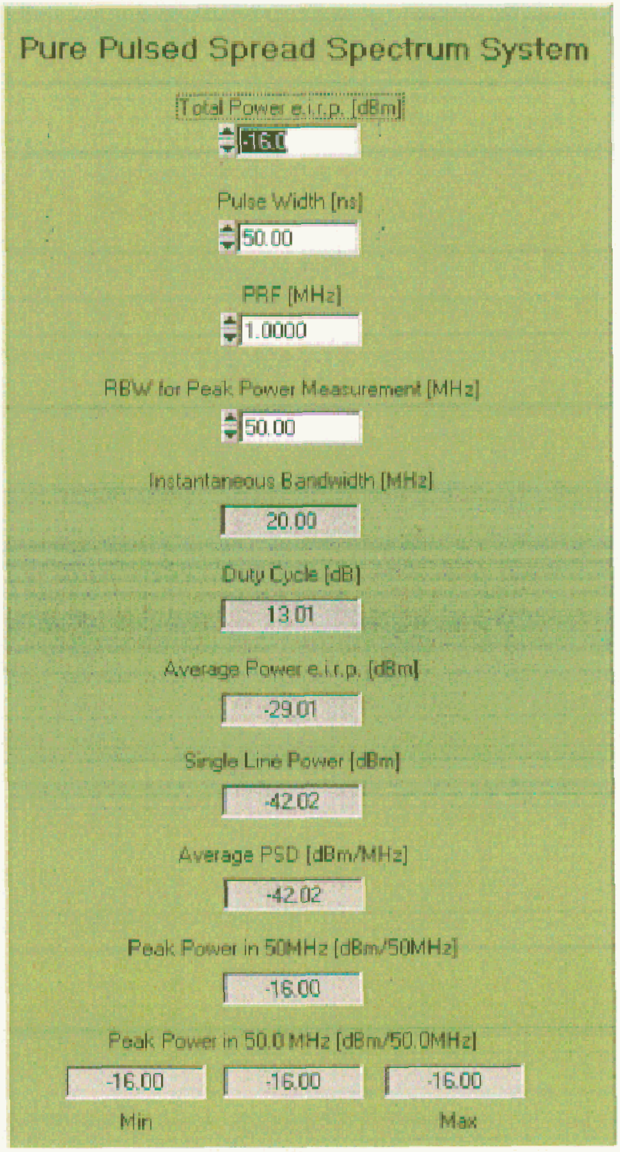


In the above picture the interference of two pulsed UWB systems is compared in the frequency space. A 2 ns pulsed UWB device (green lines) and a 50 ns pulsed UWB device (blue lines) have the same, arbitrary PRF. So the individual spectral lines (SLP) are identically spaced in the spectrum. Due to the different pulse width the SLP envelope is also different, resulting in faster zero crossings for the 50 ns pulse length.

With regard to the 50 MHz victim receiver bandwidth (red zone), the SLP of the 2 ns and 50 ns pulsed UWB are almost identical.[1] Consequently, the interference potential of the 50 ns UWB cannot be higher than the interference potential of the 2 ns UWB.

In order to achieve a similar SLP for the 2 ns and the 50 ns UWB, the total EIRP power has to be adjusted accordingly. An example for a 1 MHz PRF is shown in the image below.

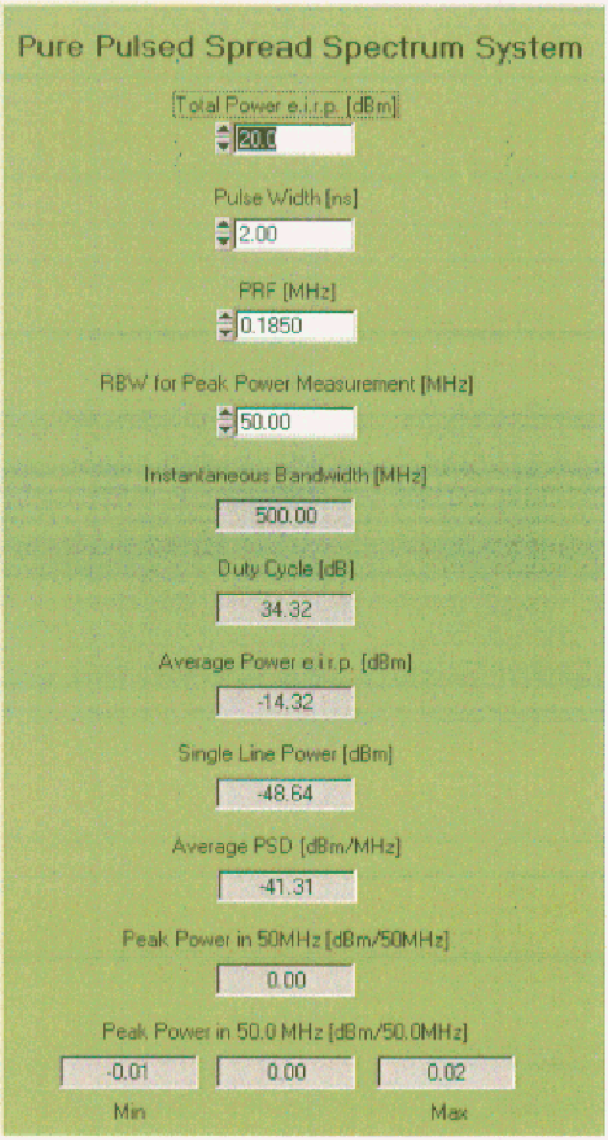


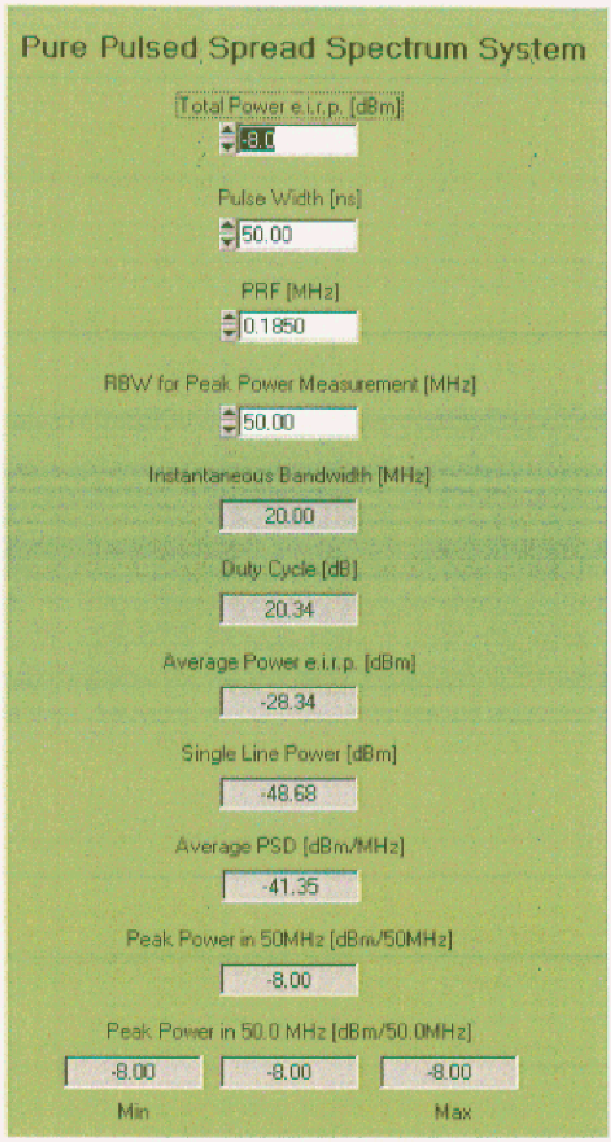


[1] The smaller SLP envelope of the 50 ns UWB device makes the SLP in the victim receiver bandwidth even smaller than the SLPs of the 2 ns UWB device.

As the PRF is greater than 185 kHz (see Annex 1) for both the 2 ns and 50 ns UWB devices, they are average power limited and still have some margin to the 0 dBm/50 MHz peak power criterion. To get the same SLP, the 50 ns UWB system must use a total EIRP peak power that is 28 dB lower compared to the 2 ns UWB case.

In the image below the situation for a peak power limitation is shown, *i.e.*, the PRF is below 185 kHz.





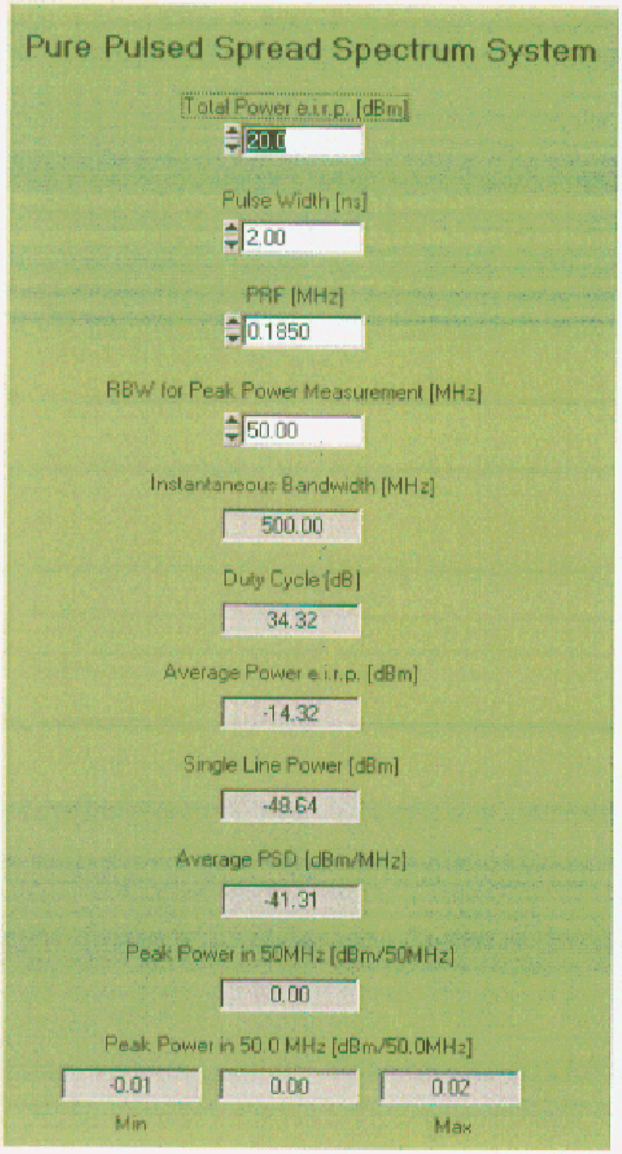
To get the same SLP the 50 ns UWB system must use a total EIRP peak power that is 28 dB lower compared to the 2 ns UWB case. The 2 ns UWB is now limited by the peak power criterion of 0 dBm/50 MHz. The 50 ns UWB is also limited by the peak power, but has to stay 8 dB below the limit as it only fills up 20 MHz of the 50 MHz instantaneously (i.e. 20 log (20/50) = -8 dB).

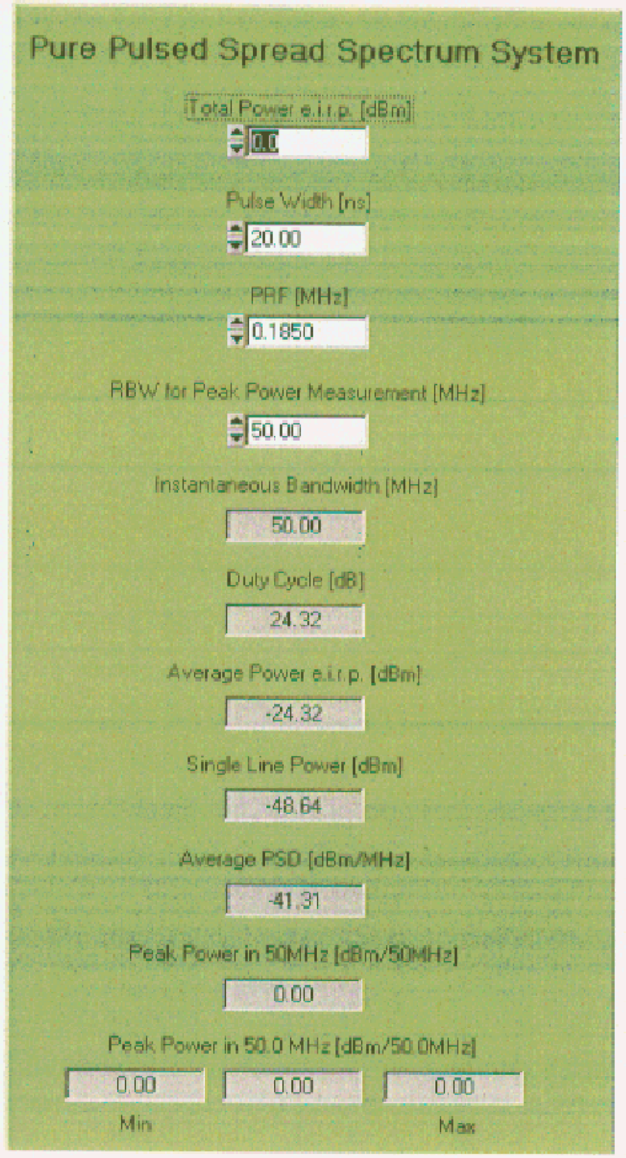
Annex 5
Technical Support for the Minimum Instantaneous Bandwidth

As already mentioned in Annex 4, the interference potential to a victim receiver doesn't depend on the interferer's total occupied bandwidth, but only on the number and the absolute power level of the SLPs that fall within the victim receiver's bandwidth. This is based on system theory and is explained in Annex 1. All additional occupied bandwidth outside the victim receiver's bandwidth will not affect or interfere the victim receiver and is superfluous. To fulfill the 500 MHz instantaneously occupied bandwidth requirement pursuant to Section 15.503(d), at least 9 similar replica of the 50 MHz SLP spectrum are necessary. Only 1 of the 10 replica will actually interfere with the victim receiver's bandwidth.

To turn it the other way around, 90 % of the total EIRP power is outside the victim receiver's bandwidth. As can be seen in the examples in Annex 4 for the 2 ns and the 50 ns pulsed UWB, the total EIRP power emitted by the 2 ns device is 28 dB higher. Furthermore, it can be observed that if a device does not completely fill up the entire 50 MHz of the victim receiver's bandwidth, it has to reduce the total EIRP power accordingly by 20 log (instantaneous interferer BW / 50 MHz). In other words, interference power can be scaled to any bandwidth by having the same interference potential.

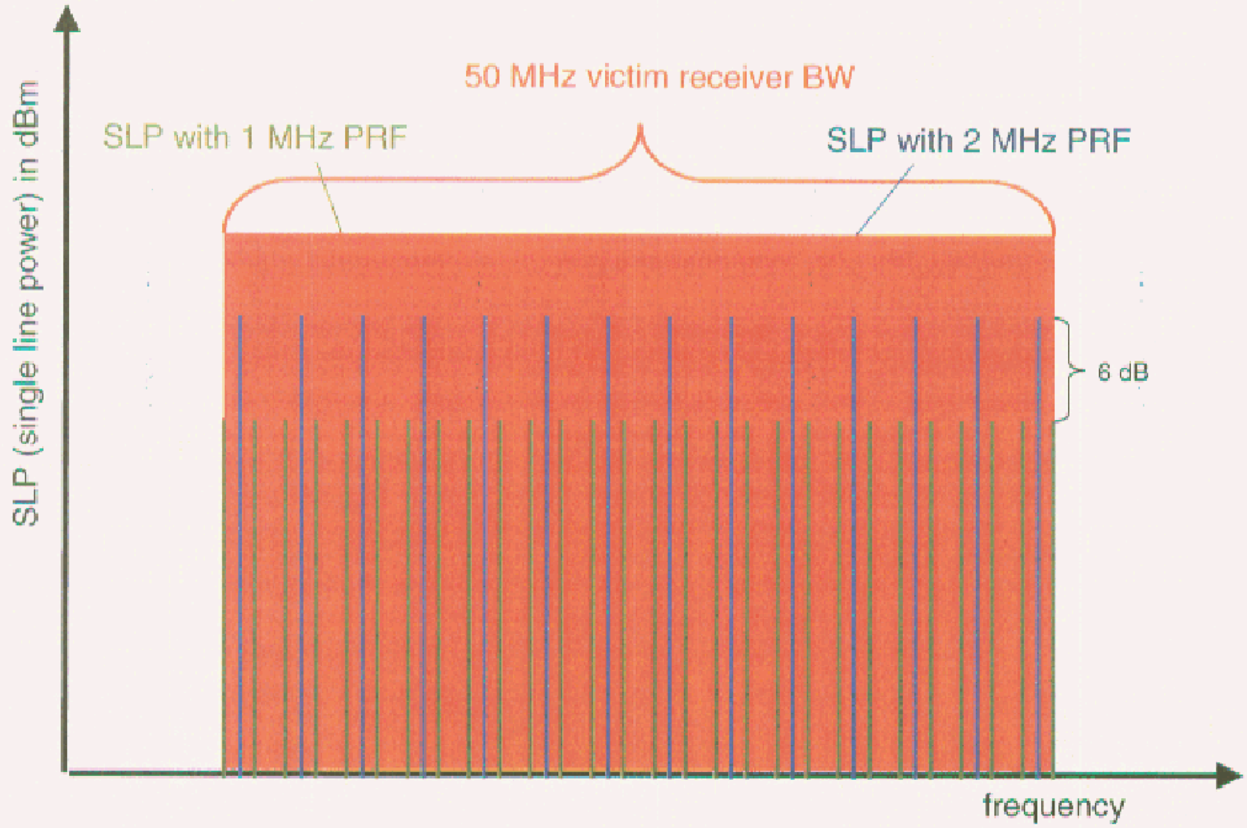
In the image below, the 20 dB total EIRP power difference between a 2 ns and a 20 ns UWB device with identical SLP levels is shown. Because the 20 ns UWB occupies an instantaneous bandwidth of 50 MHz, no further total EIRP power reduction (due to not filling up the whole victim receiver bandwidth) is required.





All calculations and comparisons shown up to this point have been based on identical PRF and SLP levels. Yet it is even possible to show that combinations of PRF and SLP can be found that have the same interference potential. Depending on the absolute PRF value (either peak power limited if PRF < 185 kHz or average power limited if PRF > 185 kHz) the SLP level has to be adjusted to meet either the peak or the average power limit.

A typical example with different PRF and SLP levels is shown in the graph below.



In the above picture the interference of the blue SLPs and the green SLPs is identical for the 50 MHz victim receiver in case the average peak power limit applies. It should be noted that due to measurement artifacts when PRF and RBW reach parity some compensation or measurement bandwidth increase is necessary to achieve correct values and relationships.