for the difference in the measurement bandwidth (20 MHz) and the bandwidth used in the analysis (1 MHz). Section 2.2.2.1 provides a more detailed discussion of the adjustments made to the measured susceptibility levels based on the UWB signal structure. Table 3-11 provides the equations as a function of the interfering signal structure that are necessary to compute the UWB interference thresholds used in the analysis for GPS receivers employing the C/A-code architecture.

The P-code signals at the L1 and L2 frequencies have a chipping rate of 10.23 Mchips/sec and a code repetition rate of 1 week. The P-code signals have a sinc^2 power spectral envelope with a null-to-null bandwidth of 20.46 MHz. Unlike the C/A-code, the P-code signal has essentially no spectral lines. As a result of the correlation process all of the UWB signals will appear to be pulse-like or noise-like at the output of the correlator. Table 3-12 provides the equations as a function of the interfering signal structure that are necessary to compute the UWB interference threshold used in the analysis for GPS receivers employing the semi-codeless architecture.

TABLE 3-11. Equations Used to Compute the Single-Entry UWB Interference Threshold for C/A-code GPS Receiver Architecture

Interfering Signal Structure	UWB Interference Threshold Equation
Broadband Noise	$I_T = I_{meas}$ (dBm/20MHz) -30 (dBW/dBm) - 10 Log (20 MHz/1 MHz)
PRF: 100 kHz Modulation: None Gating: 100%	$I_T = I_{meas}$ (dBm/20MHz) - 30 (dBW/dBm) - 10 Log (20 MHz/1 MHz)
PRF: 1, 5, and 20 MHz Modulation: None Gating: 100%	$I_T = I_{meas}$ (dBm/20MHz) -30 (dBW/dBm) - 10 Log (# of lines in a 20 MHz bandwidth) 1 line (20 MHz), 5 lines (5 MHz), and 21 lines (1 MHz)
PRF: 100 kHz and 1MHz Modulation: None Gating: 20%	$I_T = I_{meas}$ (dBm/20MHz) - 30 (dBW/dBm) - 10 Log (20 MHz/1 MHz) + 10 Log (Gating %)
PRF: 5 and 20 MHz Modulation: None Gating: 20%	$I_T = I_{meas}$ (dBm/20MHz) -30 (dBW/dBm) - 10 Log (# of lines in a 20 MHz bandwidth) + 10 Log (Gating %) - 7 dB[1] 1 line (20 MHz) and 5 lines (5 MHz)
PRF: 100 kHz, 1, 5, and 20 MHz Modulation: 2% Rel. and 50% Abs. Dithering Gating: 100%	$I_T = I_{meas}$ (dBm/20MHz) -30 (dBW/dBm) - 10 Log (20 MHz/1 MHz)
PRF: 100 kHz, 1, 5, and 20 MHz Modulation: 2% Rel. and 50% Abs. Dithering Gating: 20%	$I_T = I_{meas}$ (dBm/20MHz) -30 (dBW/dBm) - 10 Log (20 MHz/1 MHz) + 10 Log (Gating%)
PRF: 100 kHz and 1MHz Modulation: OOK Gating: 100%	$I_T = I_{meas}$ (dBm/20MHz) -30 (dBW/dBm) - 10 Log (20 MHz/1 MHz)
PRF: 5 and 20 MHz Modulation: OOK Gating: 100%	$I_T = I_{meas}$ (dBm/20MHz) -3dB[2] - 30 (dBW/dBm) - 10 Log (# of lines in a 20 MHz bandwidth) 1 line (20 MHz) and 5 lines (5 MHz)
PRF: 100 kHz and 1MHz Modulation: OOK Gating: 20%	$I_T = I_{meas}$ (dBm/20MHz) -30 (dBW/dBm) - 10 Log (20 MHz/1 MHz) + 10 Log (Gating %)
PRF: 5 and 20 MHz Modulation: OOK Gating: 20%	$I_T = I_{meas}$ (dBm/20MHz) -3dB[2] - 30 (dBW/dBm) - 10 Log (# of lines in a 20 MHz bandwidth) + 10 Log (Gating %) - 7dB[1] 1 line (20 MHz) and 5 lines (5 MHz)

Notes:
1. Adjustment to compute the power in a single spectral line that is spread in frequency by the gating period resulting in a $sinc^2$ shape around each line.
2. Adjustment for the division of power between discrete spectral lines and continuous spectrum for OOK modulated UWB signal.

TABLE 3-12. Equations Used to Compute the Single-Entry UWB Interference Threshold for Semi-Codeless GPS Receiver Architectures

Interfering Signal Structure	UWB Interference Threshold Equation
Broadband Noise	$I_T = I_{meas}$ (dBm/20MHz) -30 (dBW/dBm) - 10 Log (20 MHz/1 MHz)
PRF: 100 kHz, 1, 5, and 20 MHz Modulation: None Gating: 100%	$I_T = I_{meas}$ (dBm/20MHz) -30 (dBW/dBm) - 10 Log (20 MHz/1 MHz)
PRF: 100 kHz, 1, 5 and 20 MHz Modulation: None Gating: 20%	$I_T = I_{meas}$ (dBm/20MHz) -30 (dBW/dBm) - 10 Log (20 MHz/1 MHz) + 10 Log (Gating %)
PRF: 100 kHz, 1, 5, and 20 MHz Modulation: 2% Rel. and 50% Abs. Dithering Gating: 100%	$I_T = I_{meas}$ (dBm/20MHz) -30 (dBW/dBm) - 10 Log (20 MHz/1 MHz)
PRF: 100 kHz, 1, 5, and 20 MHz Modulation: 2% Rel. and 50% Abs. Dithering Gating: 20%	$I_T = I_{meas}$ (dBm/20MHz) -30 (dBW/dBm) - 10 Log (20 MHz/1 MHz) + 10 Log (Gating %)
PRF: 100 kHz, 1, 5 , and 20 MHz Modulation: OOK Gating: 100%	$I_T = I_{meas}$ (dBm/20MHz) - 30 (dBW/dBm) - 10 Log (20 MHz/1 MHz)
PRF: 100 kHz, 1, 5, and 20 MHz Modulation: OOK Gating: 20%	$I_T = I_{meas}$ (dBm/20MHz) - 30 (dBW/dBm) - 10 Log (20 MHz/1 MHz) + 10 Log (Gating %)

Tables 3-13 and 3-14 provide the UWB interference thresholds for each of the GPS receiver architectures measured. The single-entry UWB interference threshold and the GPS receiver criteria used to determine the levels are shown for the different interfering signal structures considered in this analysis.

TABLE 3-13. Single-Entry UWB Interference Thresholds for C/A-code Receiver Architectures

Interfering Signal Structure	UWB Interference Threshold	GPS Receiver Criteria
Broadband Noise	-134.5 dBW/MHz	Reacquisition
0.1 MHz PRF, No Mod, 100% Gate	-112.6 dBW/MHz	Break-Lock
0.1 MHz PRF, No Mod, 20% Gate	-106.5 dBW/MHz[a]	Did Not Break-Lock At Maximum Available UWB Power
0.1 MHz PRF, OOK, 100% Gate	-102.6 dBW/MHz[a]	Did Not Break-Lock At Maximum Available UWB Power
0.1 MHz PRF, OOK. 20% Gate	-109.4 dBW/MHz[a]	Did Not Break-Lock At Maximum Available UWB Power
0.1 MHz PRF, 50% abs, 100% Gate	-100 dBW/MHz[a]	Did Not Break-Lock At Maximum Available UWB Power
0.1 MHz PRF, 50% abs, 20% Gate	-107 dBW/MHz[a]	Did Not Break-Lock At Maximum Available UWB Power
0.1 MHz PRF, 2% rel, 100% Gate	-100 dBW/MHz[a]	Did Not Break-Lock At Maximum Available UWB Power
0.1 MHz PRF, 2% rel, 20% Gate	-107 dBW/MHz[a]	Did Not Break-Lock At Maximum Available UWB Power
1 MHz PRF, No Mod, 100% Gate	-143.7 dBW	Break-Lock
1 MHz PRF, No Mod, 20% Gate	-97.6 dBW/MHz[a]	Did Not Break-Lock At Maximum Available UWB Power
1 MHz PRF, OOK, 100% Gate	-121.2 dBW/MHz	Break-Lock
1 MHz PRF, OOK, 20% Gate	-101.1 dBW/MHz[a]	Did Not Break-Lock At Maximum Available UWB Power
1 MHz PRF, 50% abs, 100% Gate	-113 dBW/MHz	Reacquisition
1 MHz PRF, 50% abs, 20% Gate	-97.5 dBW/MHz[a]	Did Not Break-Lock At Maximum Available UWB Power
1 MHz PRF, 2% rel, 100% Gate	-131 dBW/MHz	Reacquisition
1 MHz PRF, 2% rel, 20% Gate	-97 dBW/MHz	Reacquisition
5 MHz PRF, No Mod, 100% Gate	-145.5 dBW	Break-Lock
5 MHz PRF, No Mod, 20% Gate	-145.2 dBW	Break-Lock
5 MHz PRF, OOK, 100% Gate	-144.5 dBW	Break-Lock
5 MHz PRF, OOK, 20% Gate	-144.2 dBW	Break-Lock
5 MHz PRF, 50% abs, 100% Gate	-137 dBW/MHz	Reacquisition
5 MHz PRF, 50% abs, 20% Gate	-105 dBW/MHz	Reacquisition
5 MHz PRF, 2% rel, 100% Gate	-136.5 dBW/MHz	Reacquisition
5 MHz PRF, 2% rel, 20% Gate	-89 dBW/MHz[a]	Did Not Break-Lock At Maximum Available UWB Power
20 MHz PRF, No Mod, 100% Gate	-145 dBW	Break-Lock
20 MHz PRF, No Mod, 20% Gate	-145.8 dBW	Break-Lock
20 MHz PRF, OOK, 100% Gate	-144.5 dBW	Break-Lock
20 MHz PRF, OOK, 20% Gate	-146.3 dBW	Break-Lock
20 MHz PRF, 50% abs, 100% Gate	-138 dBW/MHz	Reacquisition
20 MHz PRF, 50% abs, 20% Gate	-135 dBW/MHz	Reacquisition
20 MHz PRF, 2% rel, 100% Gate	-136 dBW/MHz	Reacquisition
20 MHz PRF, 2% rel, 20% Gate	-133 dBW/MHz	Reacquisition

Note: a. Interference threshold not reached at maximum available UWB generator power.

TABLE 3-14. Single-Entry UWB Interference Thresholds for Semi-Codeless Receiver Architectures

Interfering Signal Structure	UWB Interference Threshold	GPS Receiver Criteria
Broadband Noise	-150 dBW/MHz	Reacquisition
0.1 MHz PRF, No Mod, 100% Gate	-118 dBW/MHz	Reacquisition
0.1 MHz PRF, No Mod, 20% Gate	-116.5 dBW/MHz[a]	Did Not Break-Lock At Maximum Available UWB Power
0.1 MHz PRF, OOK, 100% Gate	-112 dBW/MHz[a]	Did Not Break-Lock At Maximum Available UWB Power
0.1 MHz PRF, OOK. 20% Gate	-118.5 dBW/MHz[a]	Did Not Break-Lock At Maximum Available UWB Power
0.1 MHz PRF, 50% abs, 100% Gate	-121 dBW/MHz	Reacquisition
0.1 MHz PRF, 50% abs, 20% Gate	-116 dBW/MHz[a]	Did Not Break-Lock At Maximum Available UWB Power
0.1 MHz PRF, 2% rel, 100% Gate	-119 dBW/MHz	Reacquisition
0.1 MHz PRF, 2% rel, 20% Gate	-138 dBW/MHz	Reacquisition
1 MHz PRF, 50% abs, 100% Gate	-151 dBW/MHz	Reacquisition
1 MHz PRF, 50% abs, 20% Gate	-132 dBW/MHz	Reacquisition
1 MHz PRF, 2% rel, 100% Gate	-149 dBW/MHz	Reacquisition
1 MHz PRF, 2% rel, 20% Gate	-134 dBW/MHz	Reacquisition
5 MHz PRF, 50% abs, 100% Gate	-151 dBW/MHz	Reacquisition
5 MHz PRF, 50% abs, 20% Gate	-151 dBW/MHz	Reacquisition
5 MHz PRF, 2% rel, 100% Gate	-149 dBW/MHz	Reacquisition
5 MHz PRF, 2% rel, 20% Gate	-142.5 dBW/MHz	Reacquisition
20 MHz PRF, No Mod, 100% Gate	-145 dBW/MHz	Break-Lock
20 MHz PRF, No Mod, 20% Gate	-148 dBW/MHz	Break-Lock
20 MHz PRF, OOK, 100% Gate	-137 dBW/MHz	Break-Lock
20 MHz PRF, OOK, 20% Gate	-146 dBW/MHz	Break-Lock
20 MHz PRF, 50% abs, 100% Gate	-149.5 dBW/MHz	Reacquisition
20 MHz PRF, 50% abs, 20% Gate	-148 dBW/MHz	Reacquisition
20 MHz PRF, 2% rel, 100% Gate	-149.5 dBW/MHz	Reacquisition
20 MHz PRF, 2% rel, 20% Gate	-143.5 dBW/MHz	Reacquisition

Note: a. Interference threshold not reached at maximum available UWB generator power.

Sections 3.3.1 through 3.3.5 present the results of the analysis. Each section gives the analysis results for one of the five categories of GPS receiver applications considered. For each GPS receiver application several operational scenarios were analyzed. The analysis results are presented in the form of graphs where the bar represents the value of maximum allowable EIRP (e.g., a longer bar represents a lower value of maximum allowable EIRP). Both single and multiple UWB device interactions were considered. In a multiple UWB device interaction, the maximum allowable EIRP level of a single UWB device as shown on the graph was determined by partitioning the total interference allotment in accordance with the multiple (aggregate) UWB device factor as discussed in Section 3.1.4.

The maximum allowable EIRP (based on average power) of a single UWB device is displayed on the x-axis. The UWB signal permutations examined are displayed on the y-axis. Each UWB signal permutation is identified by three parameters: PRF, gating percentage, and modulation type. For example, a UWB signal employing a PRF of 1 MHz, 20% gating, and on-off keying modulation is identified as: 1MHz, 20%, OOK.

In addition to identifying the UWB signal parameters, each entry on the y-axis identifies the criteria used in the single-entry interference measurements, which were then used to compute the UWB interference thresholds. As discussed in Section 1.3.1, the two GPS receiver criteria used in this assessment are break-lock and reacquisition identified on the y-axis as BL and RQT respectively. UWB signal permutations for which neither a break-lock or reacquisition condition could be measured are identified on the y-axis as DNBL. For these signal permutations, the maximum available UWB signal power was used in the analysis. When multiple UWB devices were considered, resulting in noise-like interference, the UWB interference threshold was computed based on the broadband noise reacquisition threshold. This is identified as NRQT on the y-axis.

The results of the spreadsheet analysis program used to generate the graphs are provided in Appendix B.

There is a vertical dashed line shown on each graph that represents the current Part 15 level of -71.3 dBW/MHz. UWB signals that have been characterized as causing noise-like or pulse-like interference can be directly compared to the current Part 15 level. UWB signals that have been characterized as causing CW-like interference can be compared to the current level, if it is assumed that there is only a single spectral line in the measurement bandwidth. When the value of maximum allowable EIRP associated with a UWB signal permutation is located on the left side of the dashed line, additional attenuation below the current Part 15 level is not necessary in order to protect the GPS receiver architecture under consideration. When the value of maximum allowable EIRP associated with a UWB signal permutation is located on the right side of the dashed line, additional attenuation below the current Part 15 level is necessary to protect the GPS receiver architecture under consideration. For example, if the value of maximum allowable EIRP is -93 dBW/MHz, 21.7 dB of additional attenuation below the current Part 15 level is necessary to protect the GPS receiver architecture under consideration.

Three graphs are given for each of the operational scenarios that were analyzed. The first graph presents the analysis results for the UWB signal permutations that have been characterized as causing pulse-like interference. The second graph presents the analysis results for the UWB signal permutations that have been characterized as causing noise-like interference. The third graph presents the analysis results for the UWB signal permutations that have been characterized as causing CW-like interference.

3.3.1 Terrestrial Applications

In the operational scenarios for the terrestrial applications, the C/A-code receiver architecture is considered. The analysis results for the C/A-code receiver architecture are given in Figures 3-3 through 3-11. The operational scenarios considered both single and multiple UWB device interactions as well as indoor and outdoor UWB device operation. The values of maximum allowable EIRP shown in Figures 3-3 through 3-11 are for a single UWB device and are based on average power.

The values of maximum allowable EIRP that are required to protect the C/A-code receiver architecture considered in the terrestrial application operational scenarios will vary depending on the UWB signal parameters, single versus multiple UWB device interactions, and whether the UWB devices are used indoors or outdoors. The analysis results for the operational scenarios associated with terrestrial applications can be discussed in terms of the characterization of the UWB signal interference effects. As shown in Figure 3-3 the maximum allowable EIRP for the UWB signals that have been characterized as causing pulse-like interference range from -95.6 to -49.6 dBW/MHz for single UWB device interactions. Figures 3-6 and 3-9 show that for multiple UWB device interactions resulting in pulse-like interference, the values of maximum allowable EIRP range from -62.3 to -49.7 dBW/MHz for outdoor UWB device operation and -57.6 to -45 dBW/MHz for indoor UWB device operation. As shown in Figure 3-4 for UWB signals that have been characterized as causing noise-like interference, the values of maximum allowable EIRP range from -98.6 to- 96.6 dBW/MHz for single UWB device interactions. As shown in Figures 3-7 and 3-10, for multiple UWB interactions resulting in noise-like interference, the values of maximum allowable EIRP range from -89 to -85.5 dBW/MHz for indoor UWB operation and -93.7 to -90.2 dBW/MHz for outdoor UWB device operation. Figures 3-5, 3-8, and 3-11 give the analysis results for the UWB signals that have been characterized as causing CW-like interference. As shown in Figure 3-5, the values of maximum allowable EIRP range from -106.9 to -104.3 dBW for single UWB device interactions. Figures 3-8 and 3-11 show that for multiple UWB device interactions, the values of maximum allowable EIRP range from -91.3 to -88.7 dBW for indoor UWB device operation and -96 to -93.4 dBW for outdoor UWB operation.

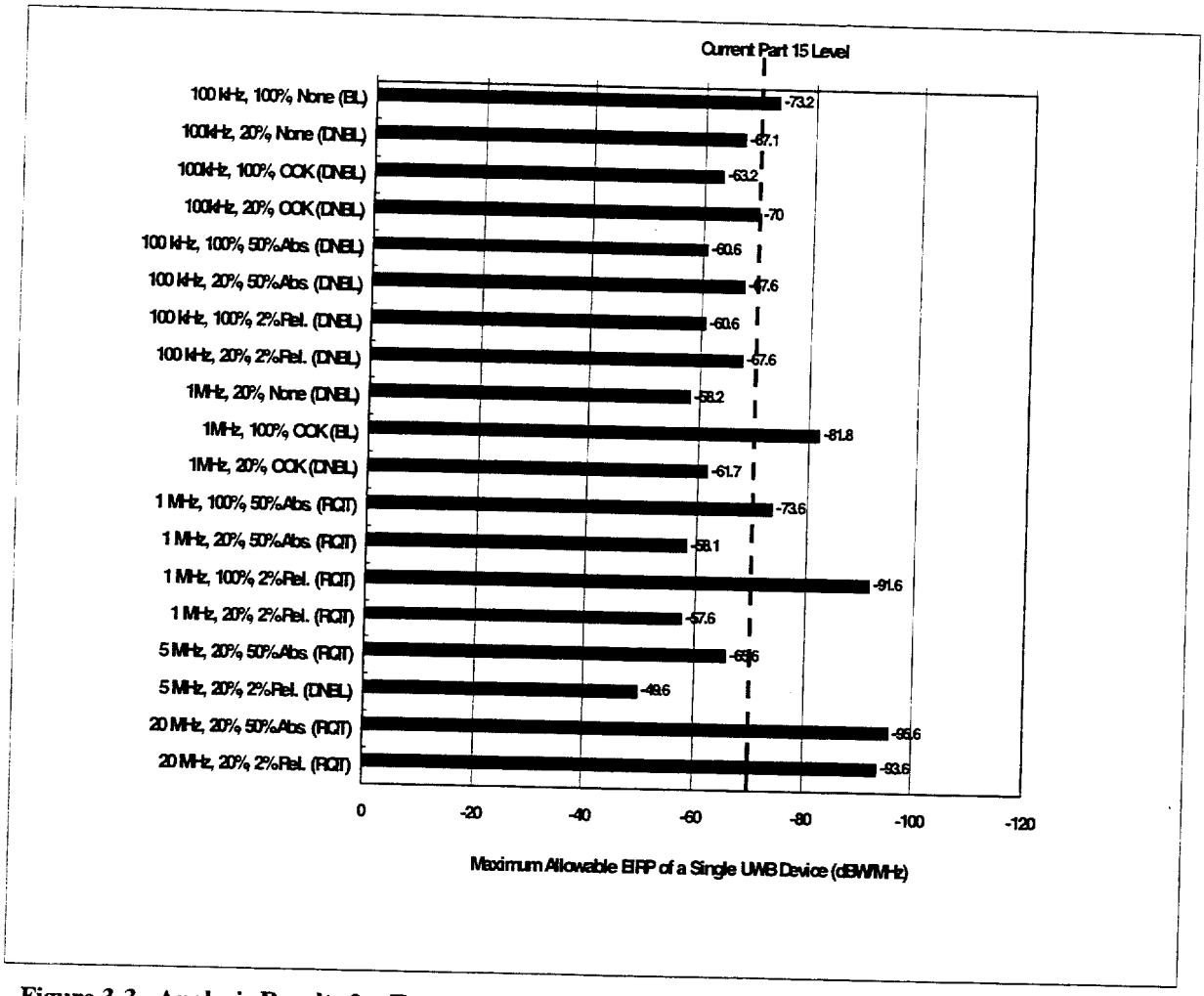

Figure 3-3. Analysis Results for Terrestrial Operational Scenario: C/A-code Receiver and Single UWB Device (Pulse-Like UWB Signals)

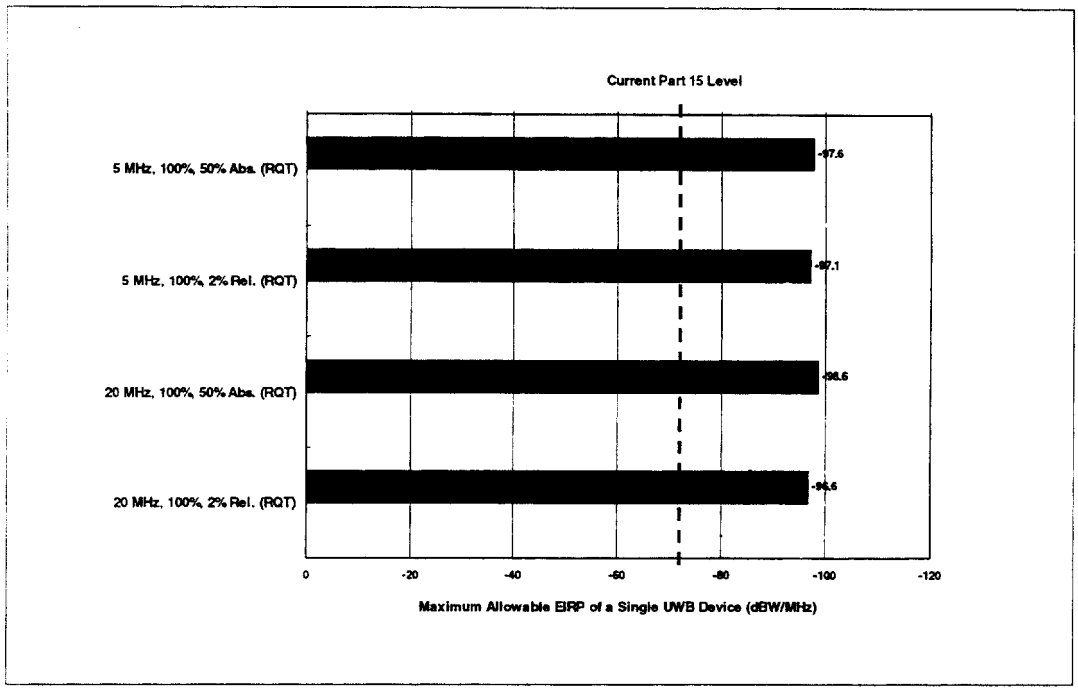

Figure 3-4. Analysis Results for Terrestrial Operational Scenario: C/A-code Receiver and Single UWB Device (Noise-Like UWB Signals)

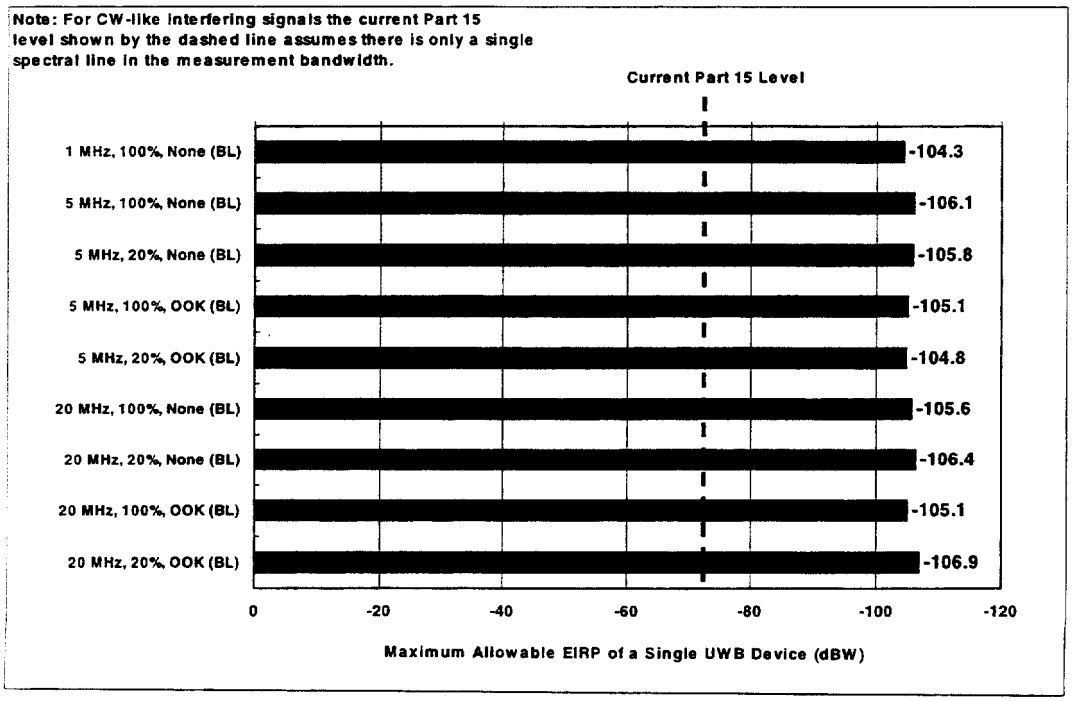

Figure 3-5. Analysis Results for Terrestrial Operational Scenario: C/A-code Receiver and Single UWB Device (CW-Like UWB Signals)

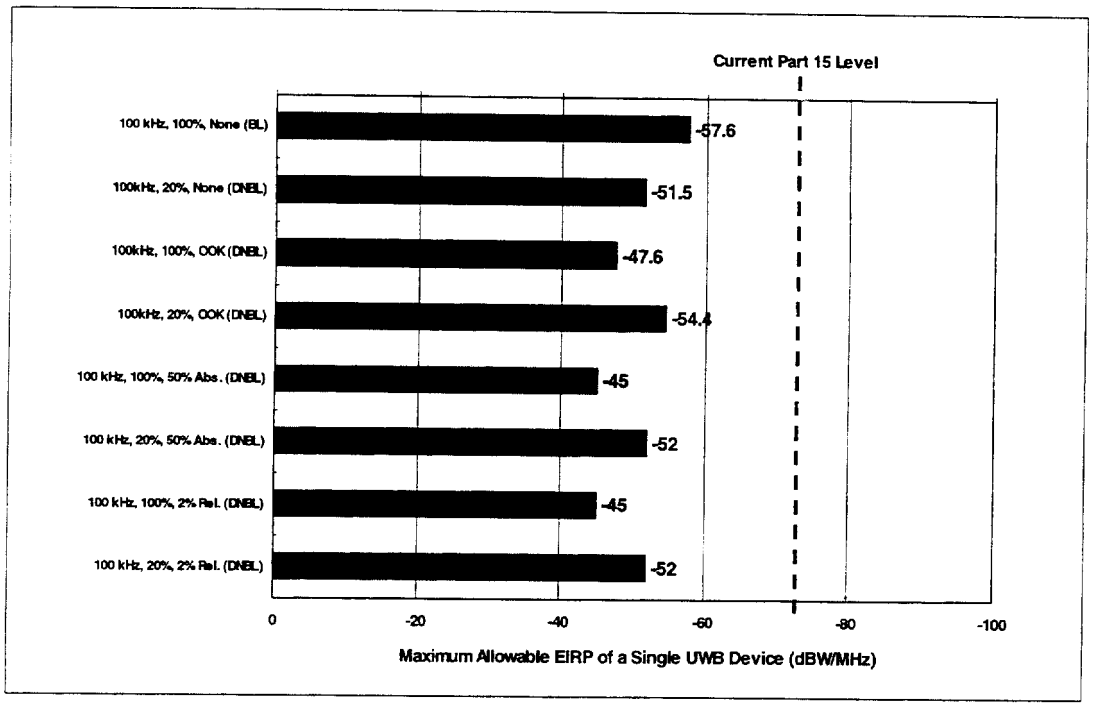

Figure 3-6. Analysis Results for Terrestrial Operational Scenario: C/A-code Receiver and Multiple UWB Devices - Indoor Operation (Pulse-Like UWB Signals)

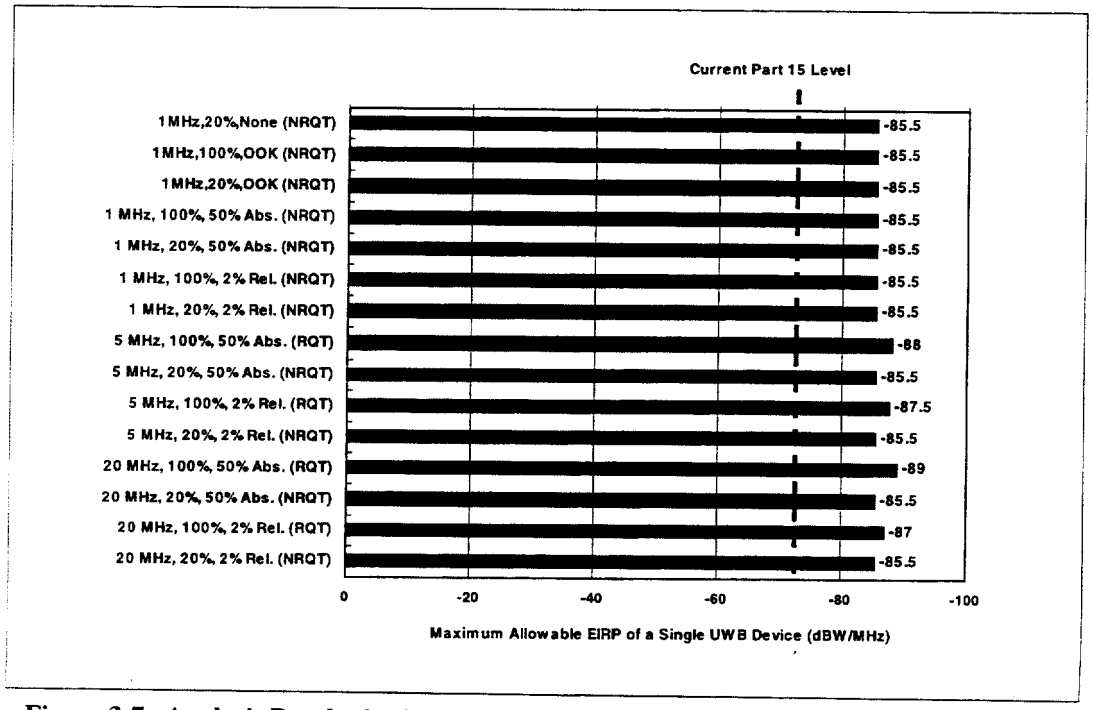

Figure 3-7. Analysis Results for Terrestrial Operational Scenario: C/A-code Receiver and Multiple UWB Devices - Indoor Operation (Noise-Like UWB Signals)

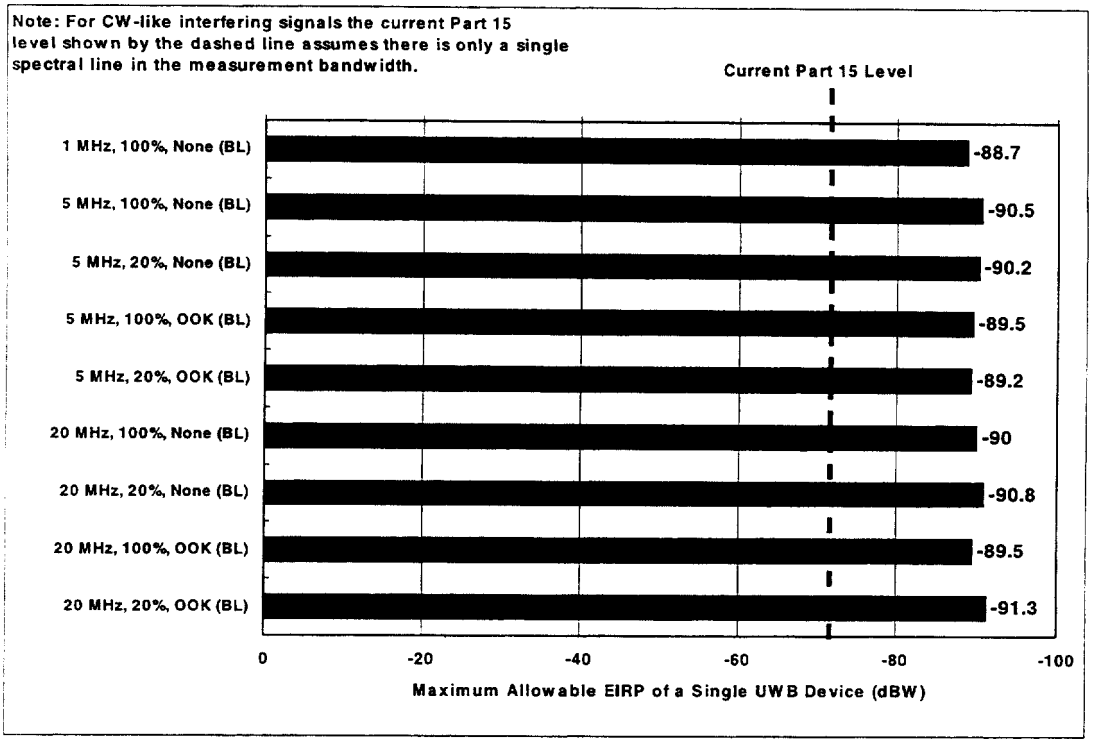

Figure 3-8. Analysis Results for Terrestrial Operational Scenario: C/A-code Receiver and Multiple UWB Devices - Indoor Operation (CW-Like UWB Signals)

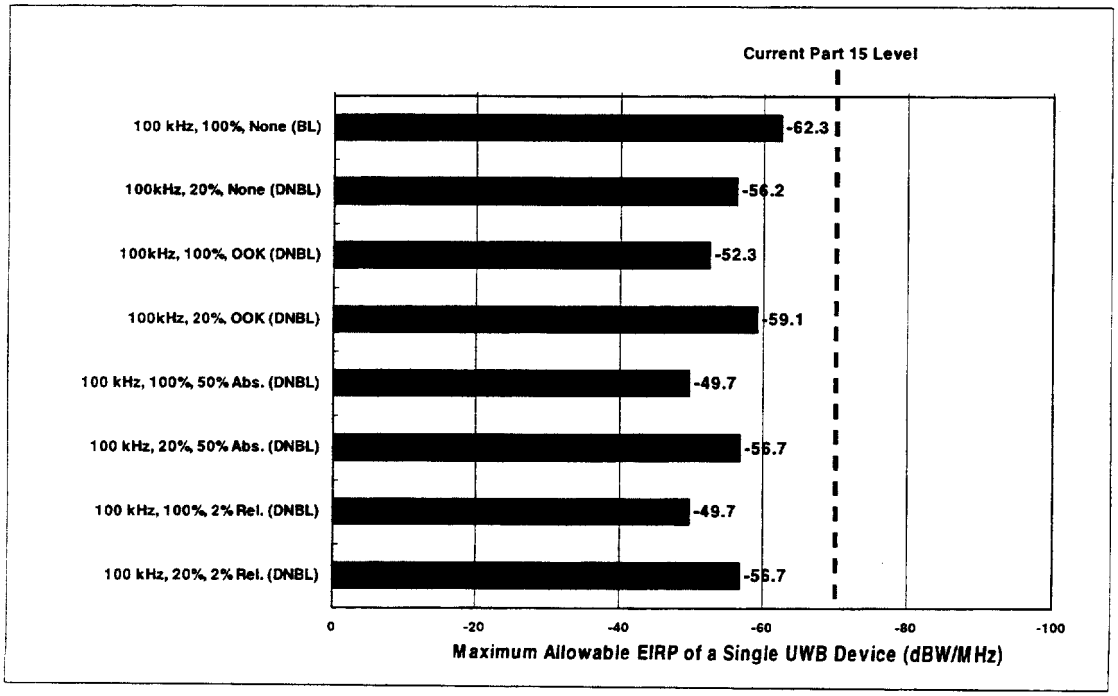

Figure 3-9. Analysis Results for Terrestrial Operational Scenario: C/A-code Receiver and Multiple UWB Devices - Outdoor Operation (Pulse-Like UWB Signals)

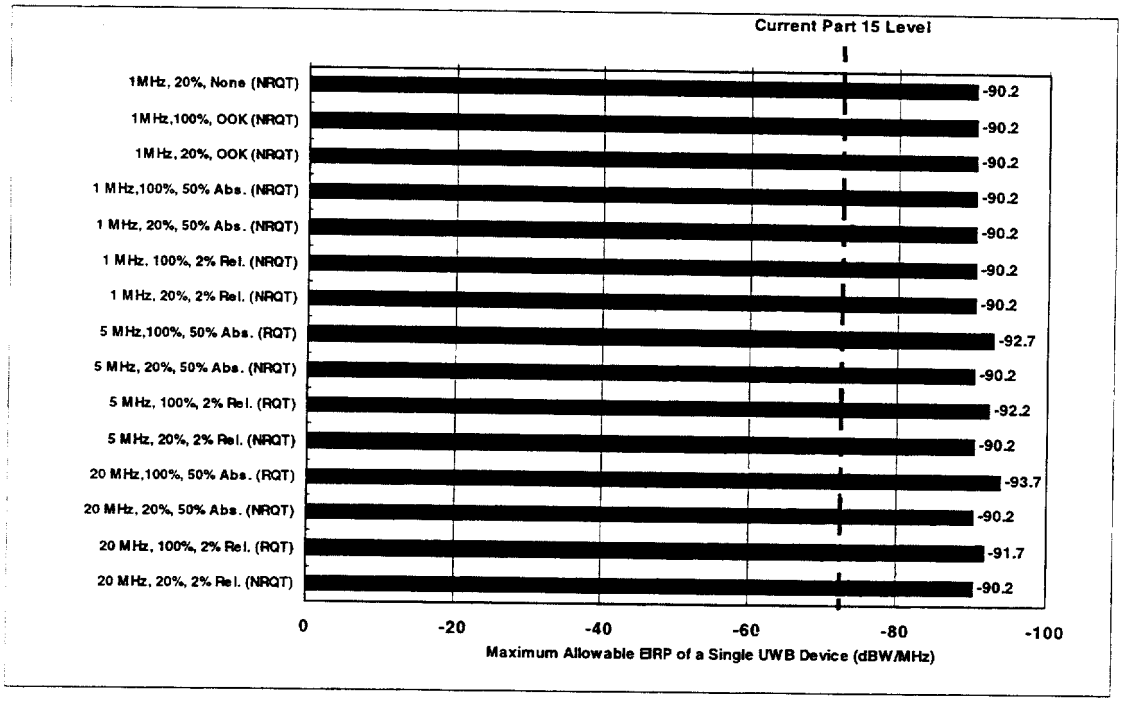

Figure 3-10. Analysis Results for Terrestrial Operational Scenario: C/A-code Receiver and Multiple UWB Devices - Outdoor Operation (Noise-Like UWB Signals)

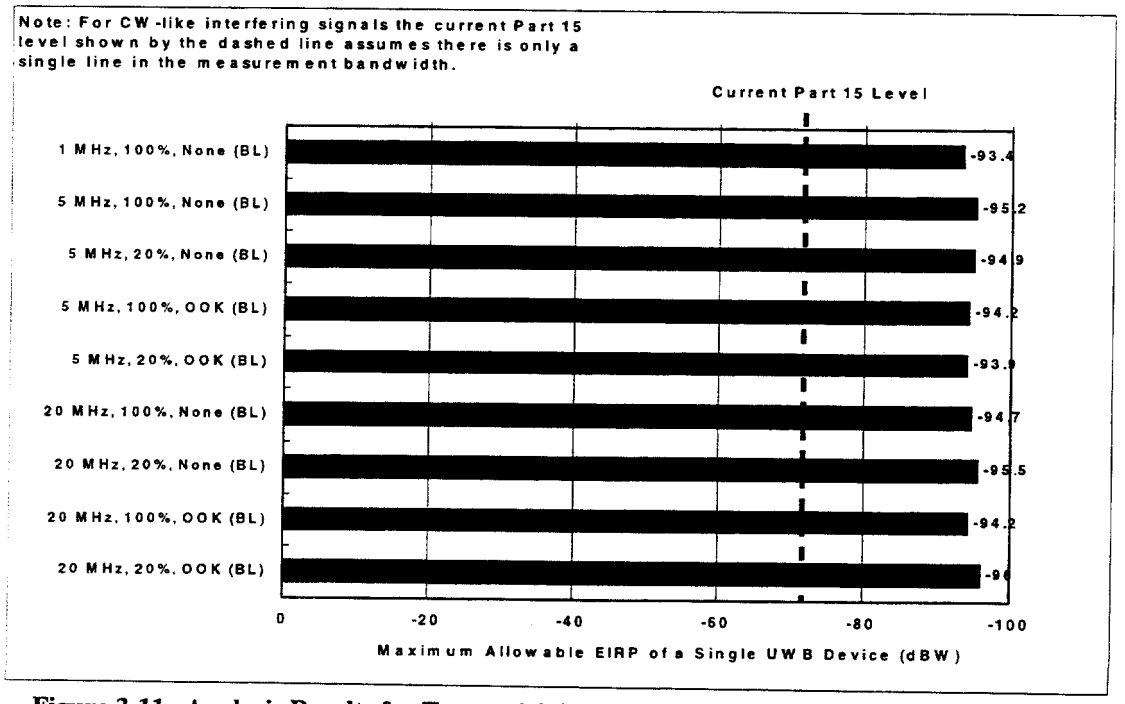

Figure 3-11. Analysis Results for Terrestrial Operational Scenario: C/A-code Receiver and Multiple UWB Devices - Outdoor Operation (CW-Like UWB Signals)

3.3.2 Maritime Applications

In the operational scenarios for the maritime applications, the C/A-code receiver architecture is considered. The analysis results for the C/A-code receiver architecture are given in Figures 3-12 through 3-23. Two antenna locations for the maritime use of GPS receivers were analyzed. The operational scenarios are designated as Maritime Operational Scenario I and II. The operational scenarios considered multiple UWB device interactions as well as indoor and outdoor UWB device operation. The values of maximum allowable EIRP shown in Figures 3-12 through 3-23 are for a single UWB device and are based on average power.

The values of maximum allowable EIRP that are required to protect the C/A-code receiver architecture considered in the maritime application operational scenarios will vary depending on the UWB signal parameters and whether the UWB devices are used indoors or outdoors. The analysis results for the operational scenarios associated with maritime applications can be discussed in terms of the characterization of the UWB signal interference effects. As shown in Figures 3-12, 3-15, 3-18, and 3-21, the values of maximum allowable EIRP for the UWB signals that have been characterized as causing pulse-like interference range from -41.7 to -26.5 dBW/MHz for indoor UWB device operation and -48.1 to -34.8 dBW/MHz for outdoor UWB device operation. Figures 3-13, 3-16, 3-19, and 3-22 show that for the UWB signals that have been characterized as causing noise-like interference, the values of maximum allowable EIRP range from -73.1 to -67.0 dBW/MHz and -79.5 to -75.3 dBW/MHz for indoor and outdoor use of UWB devices respectively. Figures 3-14, 3-17, 3-20, and 3-23 show that for the UWB signals that have been characterized as causing CW-like interference, the values of maximum allowable EIRP range from -75.4 to -70.2 dBW for indoor UWB operation and -81.8 to -78.5 dBW for outdoor UWB device operation.

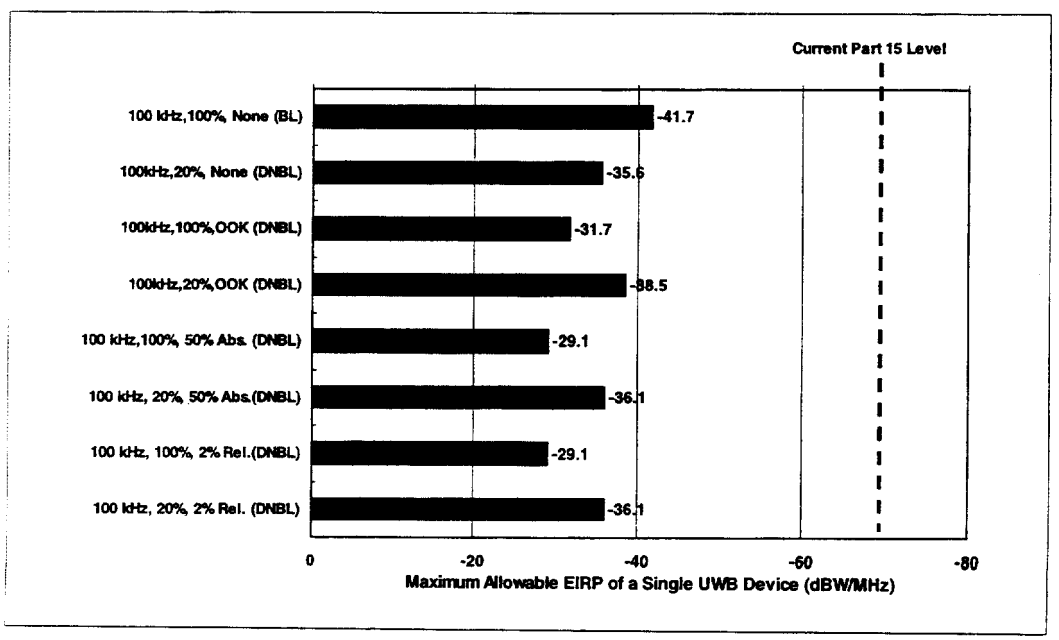

Figure 3-12. Analysis Results for Maritime Operational Scenario I: C/A-code Receiver and Multiple UWB Devices - Indoor Operation (Pulse-Like UWB Signals)

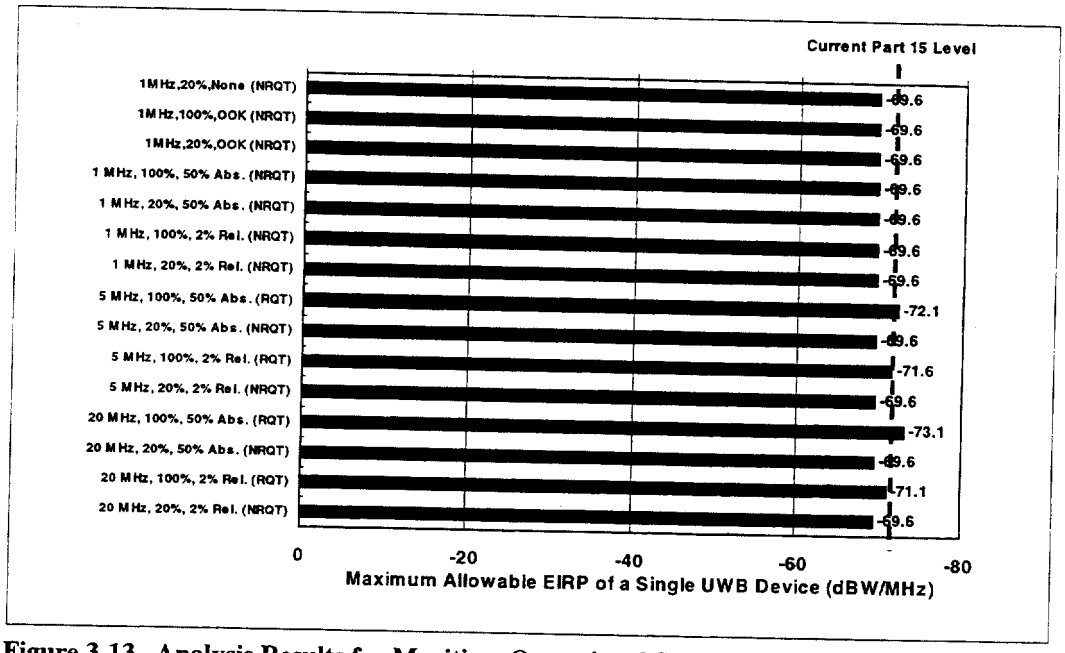

Figure 3-13. Analysis Results for Maritime Operational Scenario I: C/A-code Receiver and Multiple UWB Devices - Indoor Operation (Noise-Like UWB Signals)

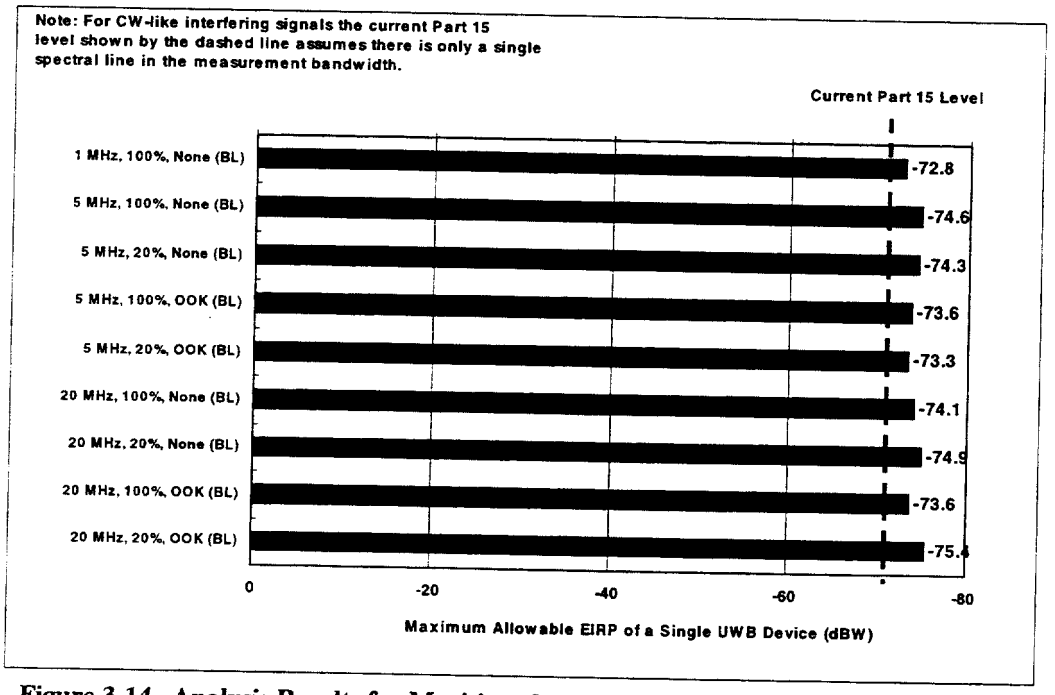

Figure 3-14. Analysis Results for Maritime Operational Scenario I: C/A-code Receiver and Multiple UWB Devices - Indoor Operation (CW-Like UWB Signals)

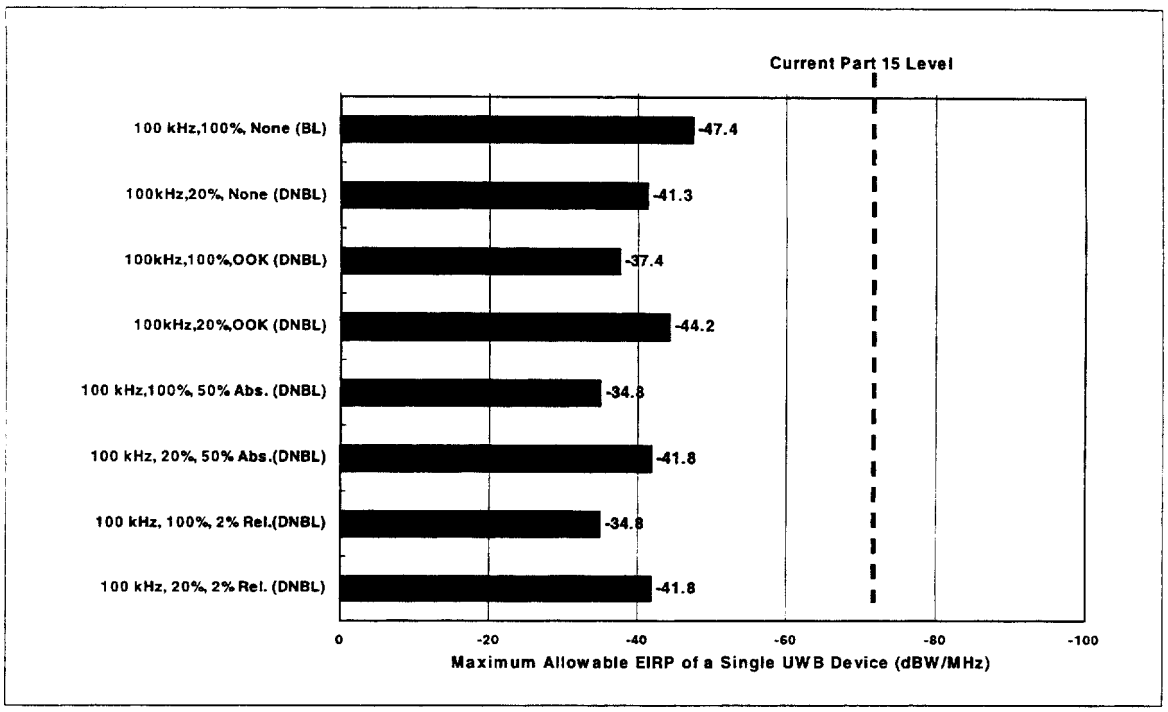

Figure 3-15. Analysis Results for Maritime Operational Scenario I: C/A-code Receiver and Multiple UWB Devices - Outdoor Operation (Pulse-Like UWB Signals)

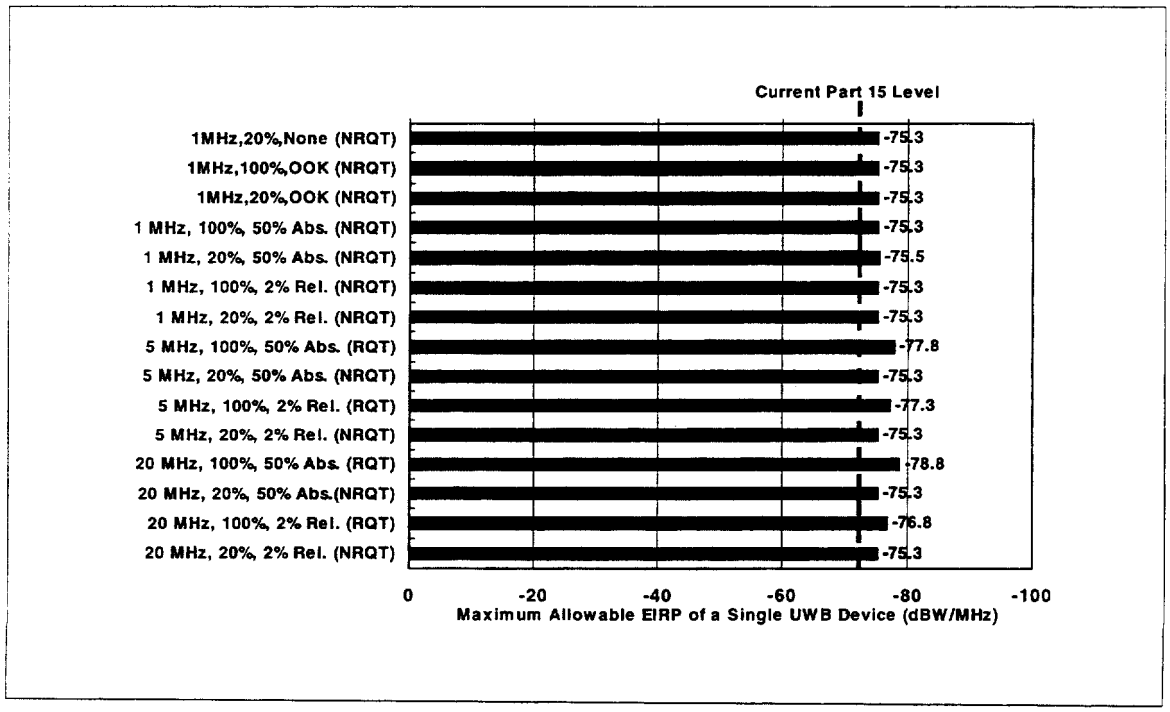

Figure 3-16. Analysis Results for Maritime Operational Scenario I: C/A-code Receiver and Multiple UWB Devices - Outdoor Operation (Noise-Like UWB Signals)

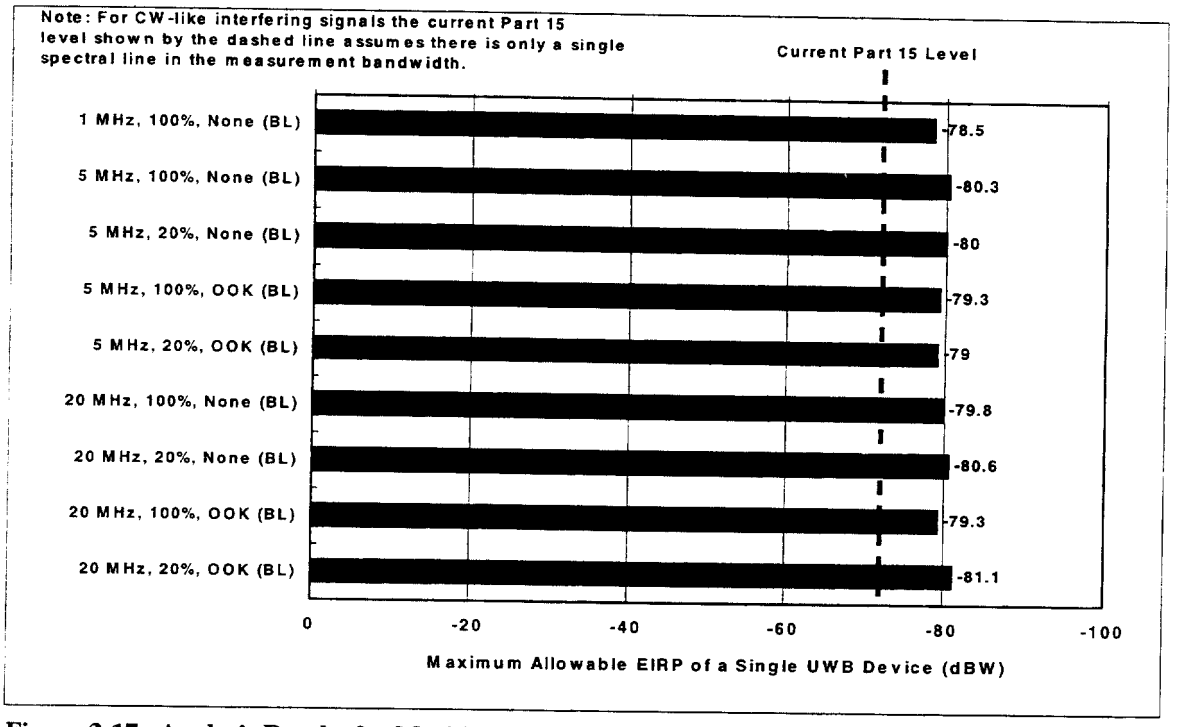

Figure 3-17. Analysis Results for Maritime Operational Scenario I: C/A-code Receiver and Multiple UWB Devices - Outdoor Operation (CW-Like UWB Signals)

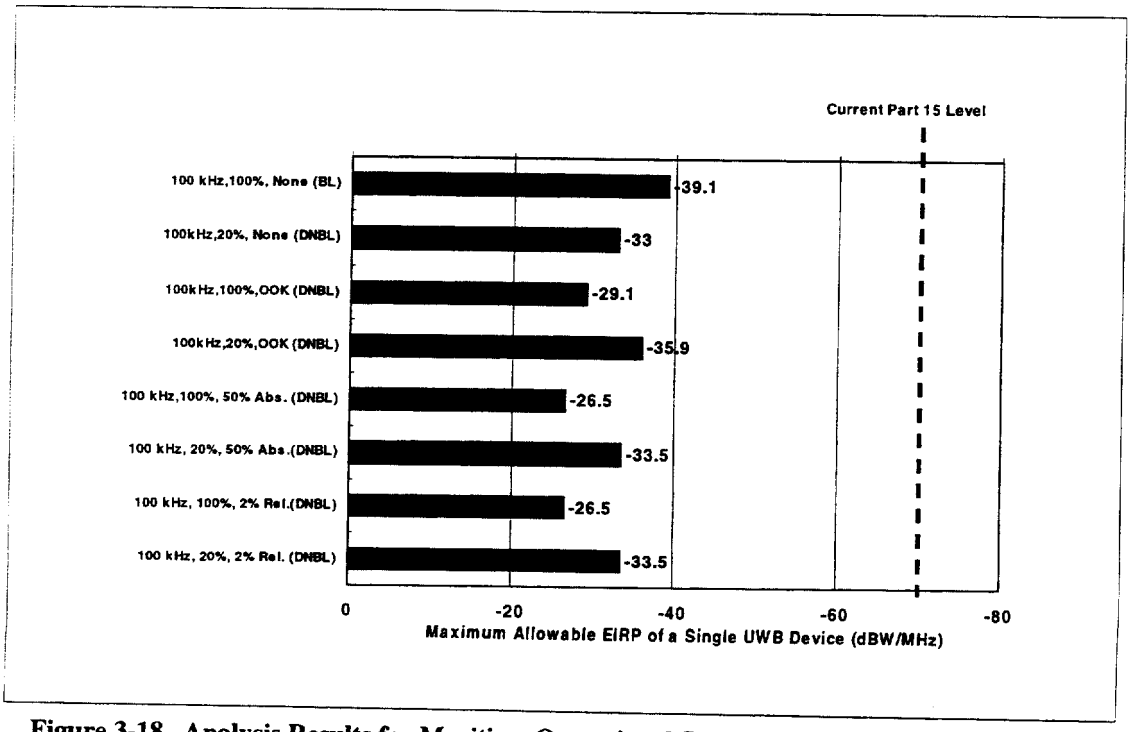

Figure 3-18. Analysis Results for Maritime Operational Scenario II: C/A-code Receiver and Multiple UWB Devices - Indoor Operation (Pulse-Like UWB Signals)

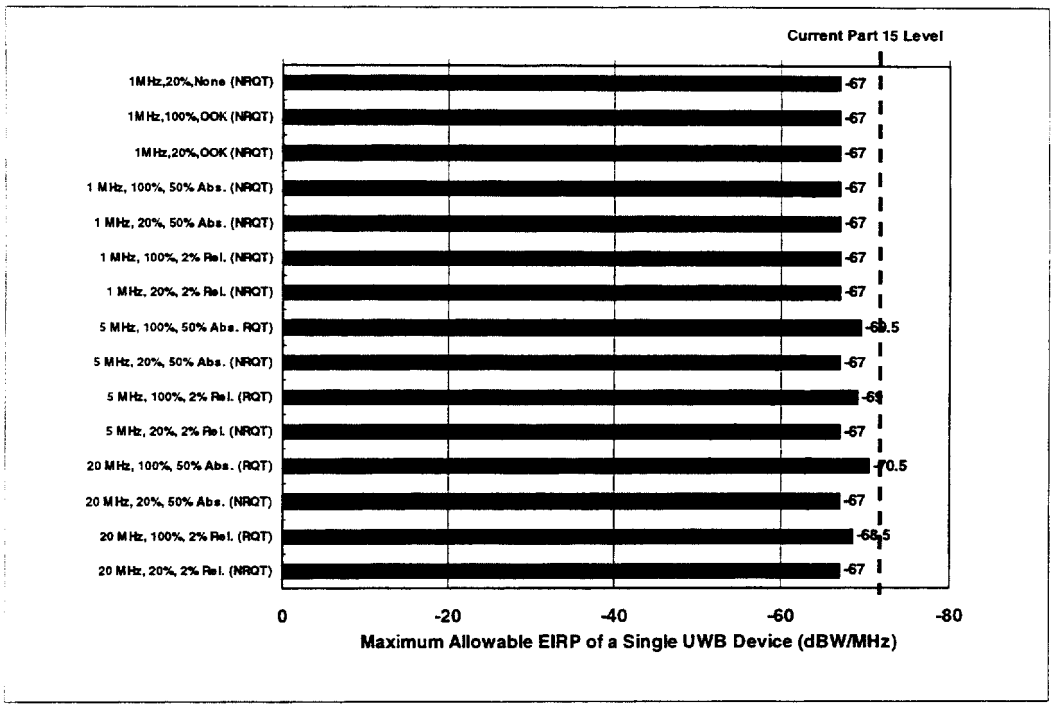

Figure 3-19. Analysis Results for Maritime Operational Scenario II: C/A-code Receiver and Multiple UWB Devices - Indoor Operation (Noise-Like UWB Signals)

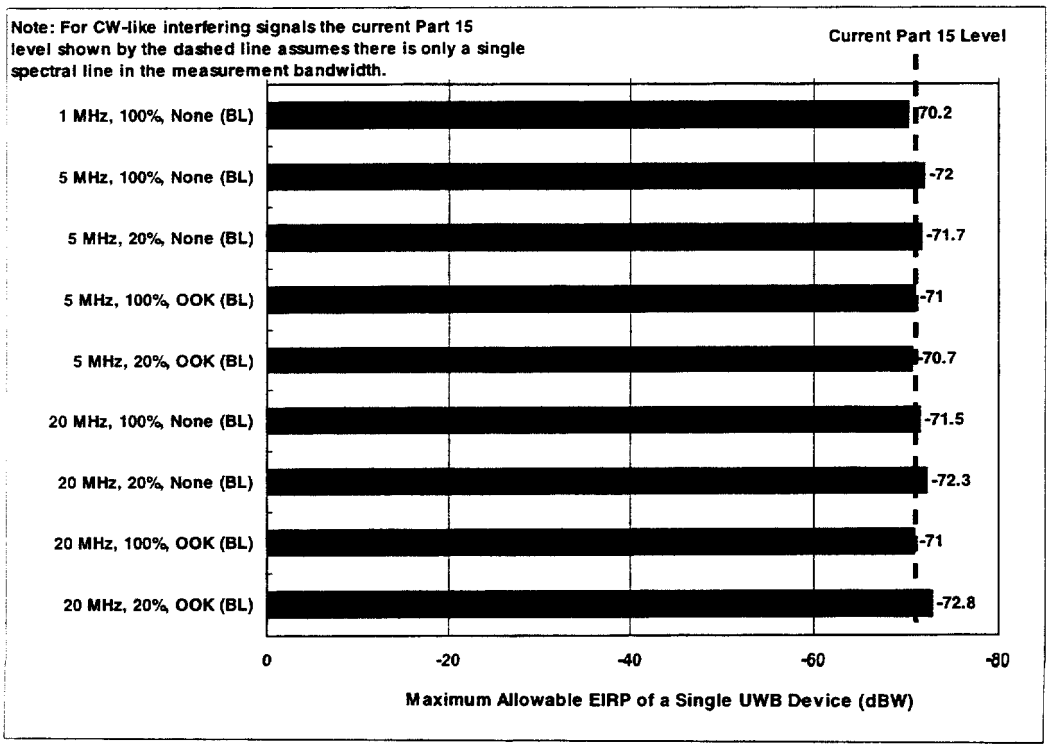

Figure 3-20. Analysis Results for Maritime Operational Scenario II: C/A-code Receiver and Multiple UWB Devices - Indoor Operation (CW-Like UWB Signals)

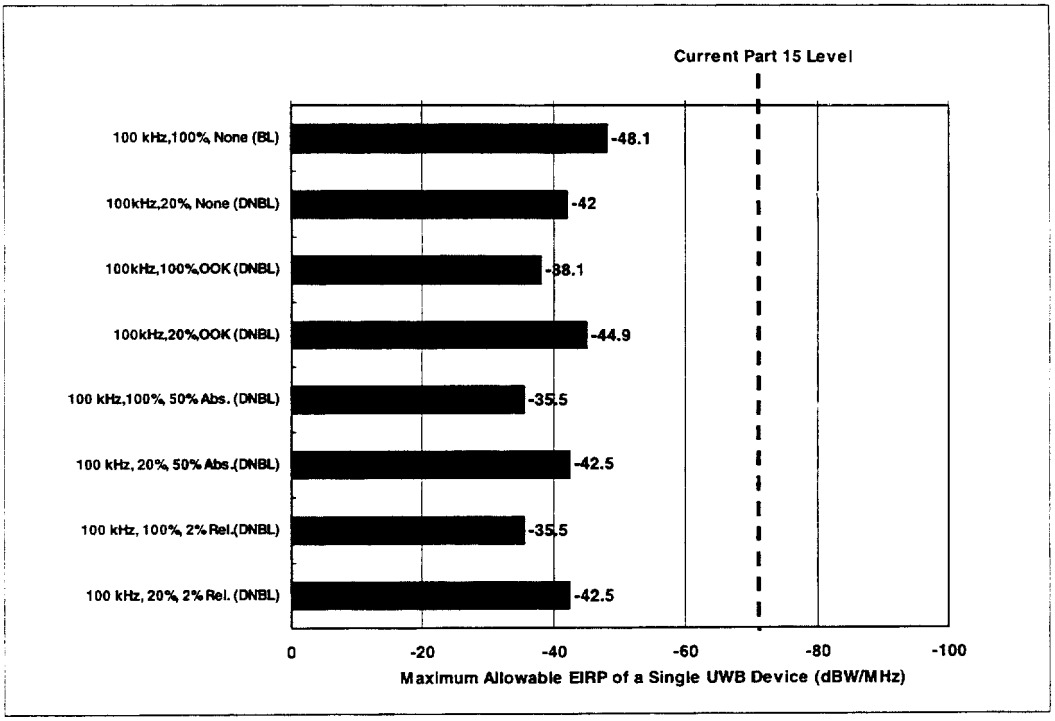

Figure 3-21. Analysis Results for Maritime Operational Scenario II: C/A-code Receiver and Multiple UWB Devices -Outdoor Operation (Pulse-Like UWB Signals)

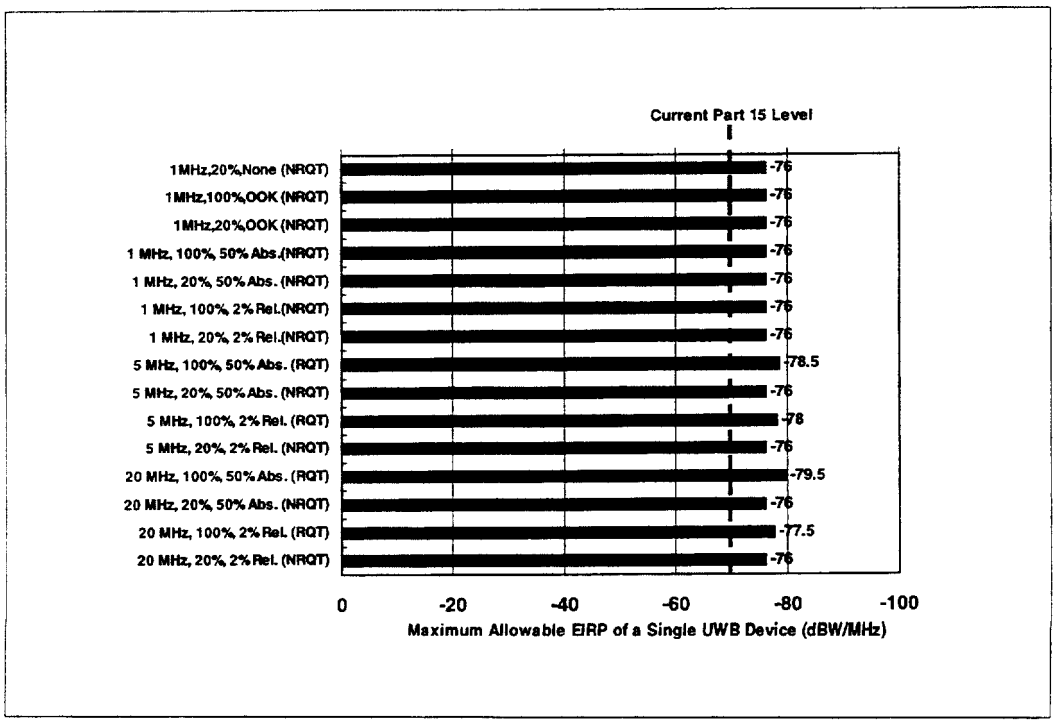

Figure 3-22. Analysis Results for Maritime Operational Scenario II: C/A-code Receiver and Multiple UWB Devices -Outdoor Operation (Noise-Like UWB Signals)

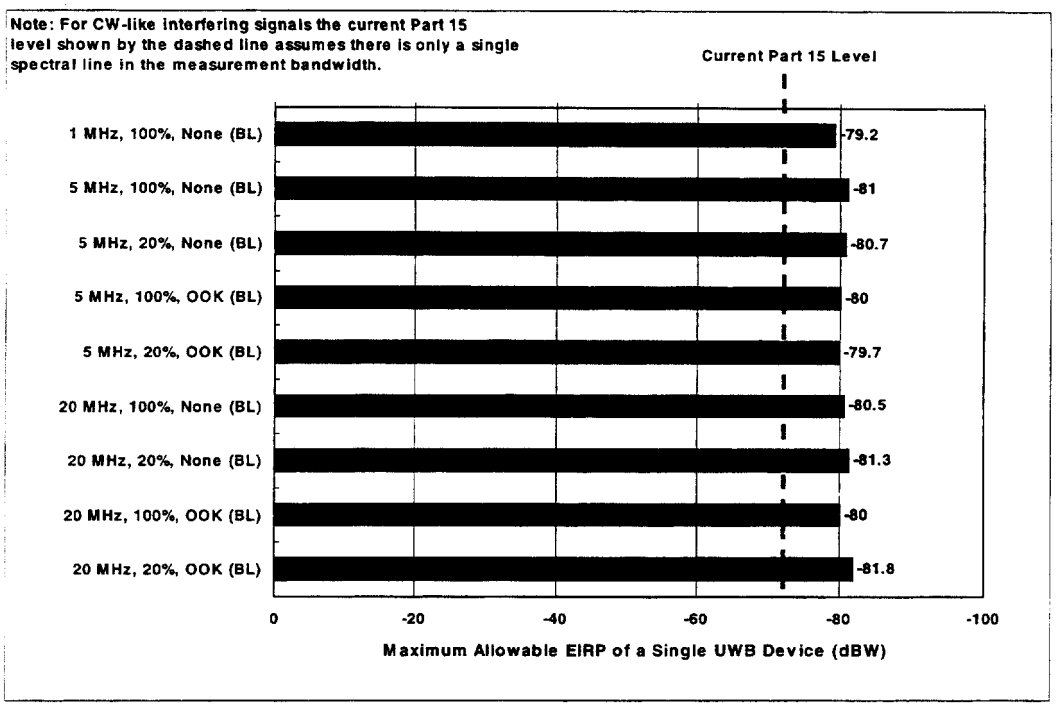

Figure 3-23. Analysis Results for Maritime Operational Scenario II: C/A-code Receiver and Multiple UWB Devices - Outdoor Operation (CW-Like UWB Signals)

3.3.3 Railway Applications

In the operational scenarios for the railway applications, the C/A-code receiver architecture is considered. The analysis results for the C/A-code receiver architecture are given in Figures 3-24 through 3-29. The operational scenarios considered multiple UWB device interactions as well as indoor and outdoor UWB device operation. The values of maximum allowable EIRP shown in Figures 3-24 through 3-29 are for a single UWB device and are based on average power.

The values of maximum allowable EIRP that are required to protect the C/A-code receiver architecture considered in the railway operational scenarios will vary depending on the UWB signal parameters and whether the UWB devices are being used indoors or outdoors. The analysis results can be discussed in terms of the characterization of the UWB signal interference effects. As shown in Figures 3-24 and 3-27, the values of maximum allowable EIRP for UWB signals that have been characterized as causing pulse-like interference range from -56.3 to -43.7 dBW/MHz for indoor UWB device operation and -57.8 to -45.2 dBW/MHz for outdoor UWB device operation. Figures 3-25 and 3-28 show that for UWB signals that have been characterized as causing noise-like interference, the values of maximum allowable EIRP range from -86.5 to -83.0 dBW/MHz for indoor UWB device operation and -88 to-84.5 dBW/MHz for outdoor UWB device operation. Figures 3-26 and 3-29 show that for UWB signals that have been characterized as causing CW-like interference, the values of maximum allowable EIRP range from -90 to -87.4 dBW for indoor UWB device operation and -91.5 to -88.9 dBW for outdoor UWB device operation.

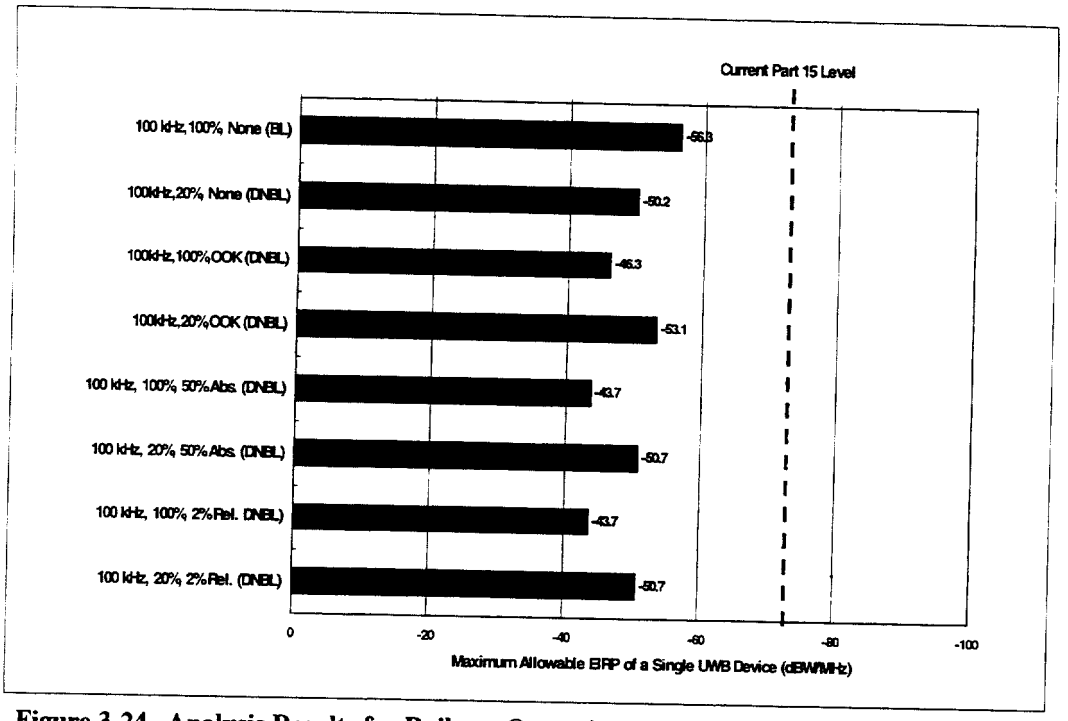

Figure 3-24. Analysis Results for Railway Operational Scenario: C/A-code Receiver and Multiple UWB Devices -Indoor Operation (Pulse-Like UWB Signals)

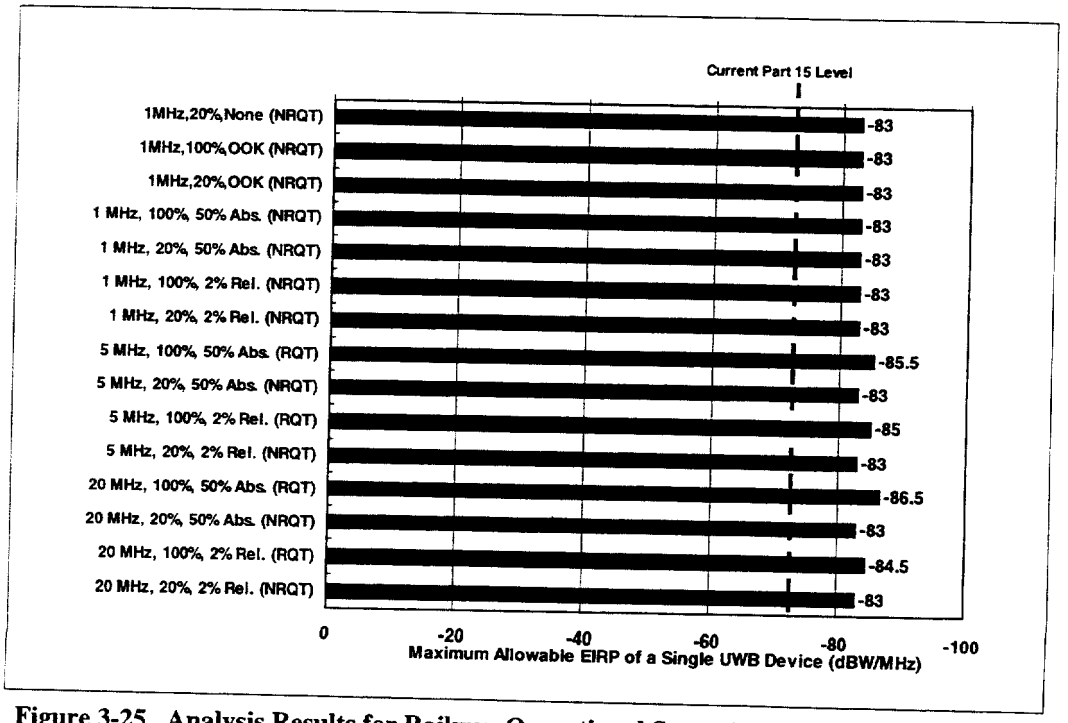

Figure 3-25. Analysis Results for Railway Operational Scenario: C/A-code Receiver and Multiple UWB Devices -Indoor Operation (Noise-Like UWB Signals)

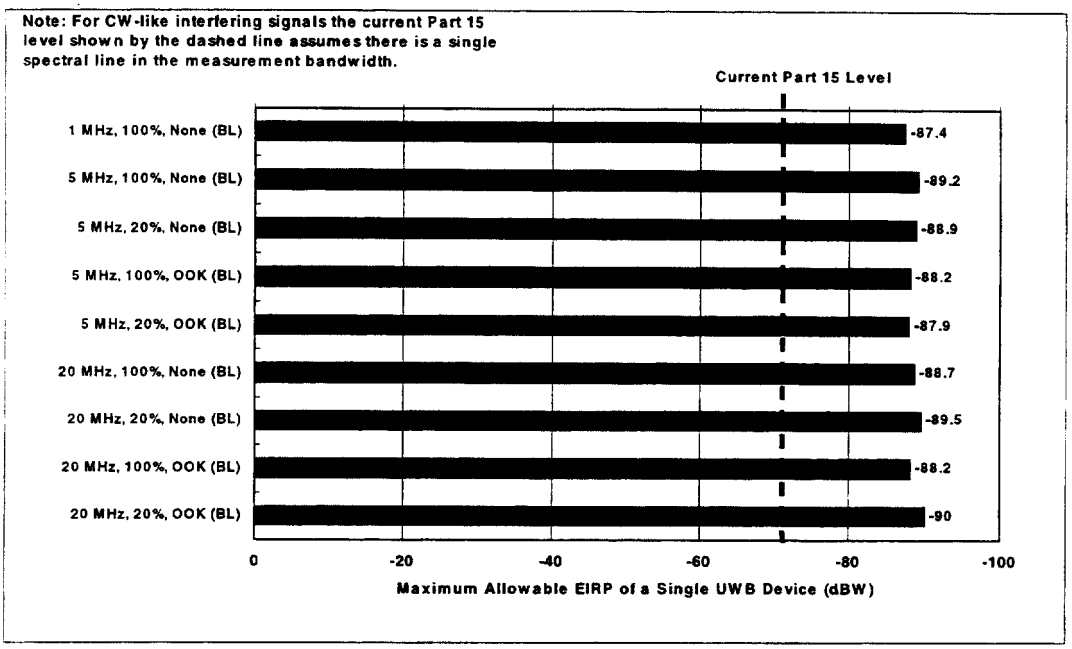

Figure 3-26. Analysis Results for Railway Operational Scenario: C/A-code Receiver and Multiple UWB Devices - Indoor Operation (CW-Like UWB Signals)

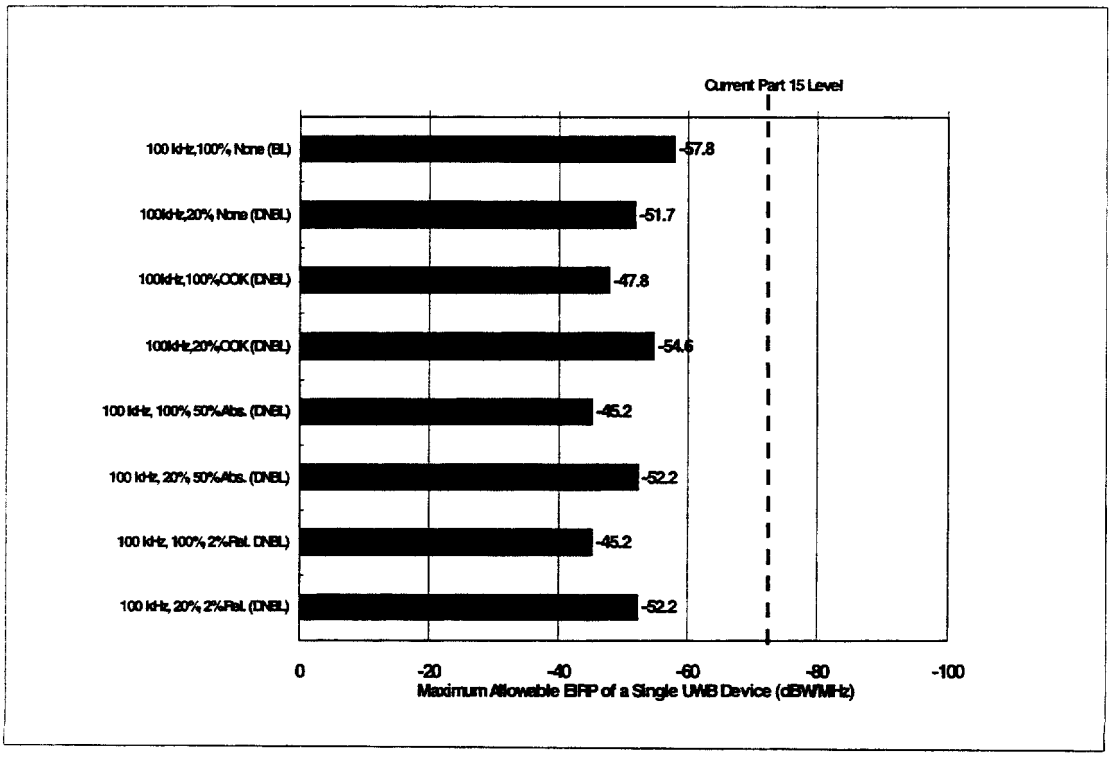

Figure 3-27. Analysis Results for Railway Operational Scenario: C/A-code Receiver and Multiple UWB Devices - Outdoor Operation (Pulse-Like UWB Signals)

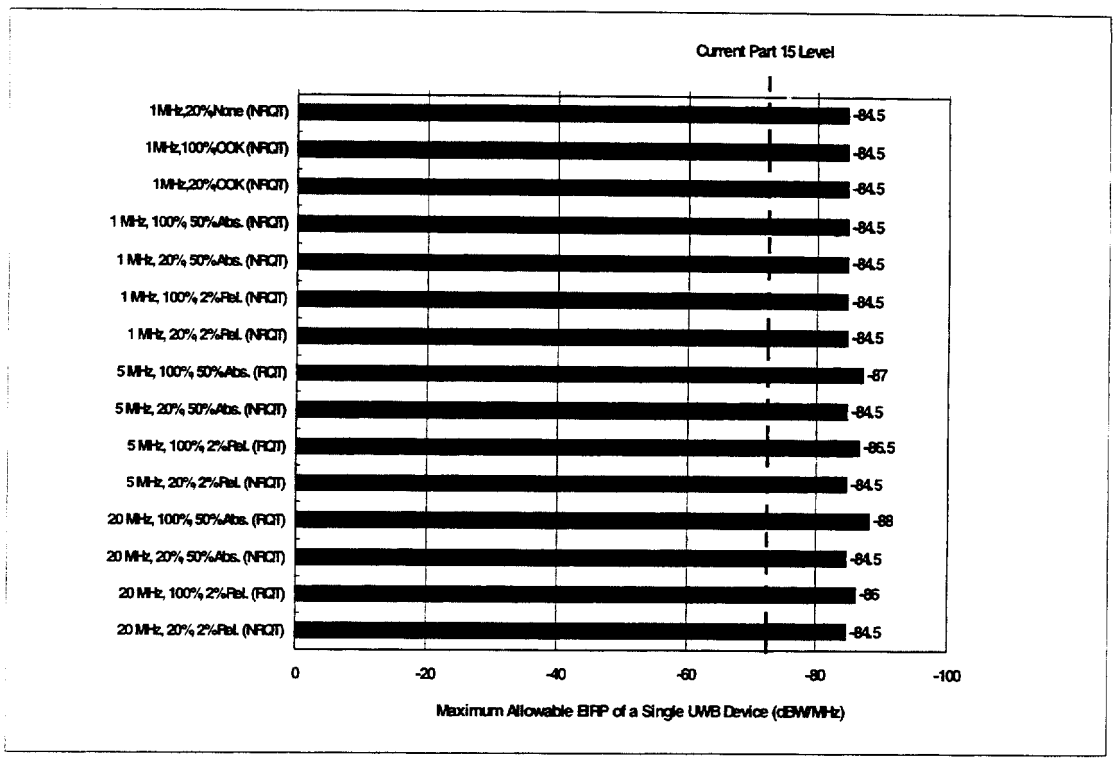

Figure 3-28. Analysis Results for Railway Operational Scenario: C/A-code Receiver and Multiple UWB Devices - Outdoor Operation (Noise-Like UWB Signals)

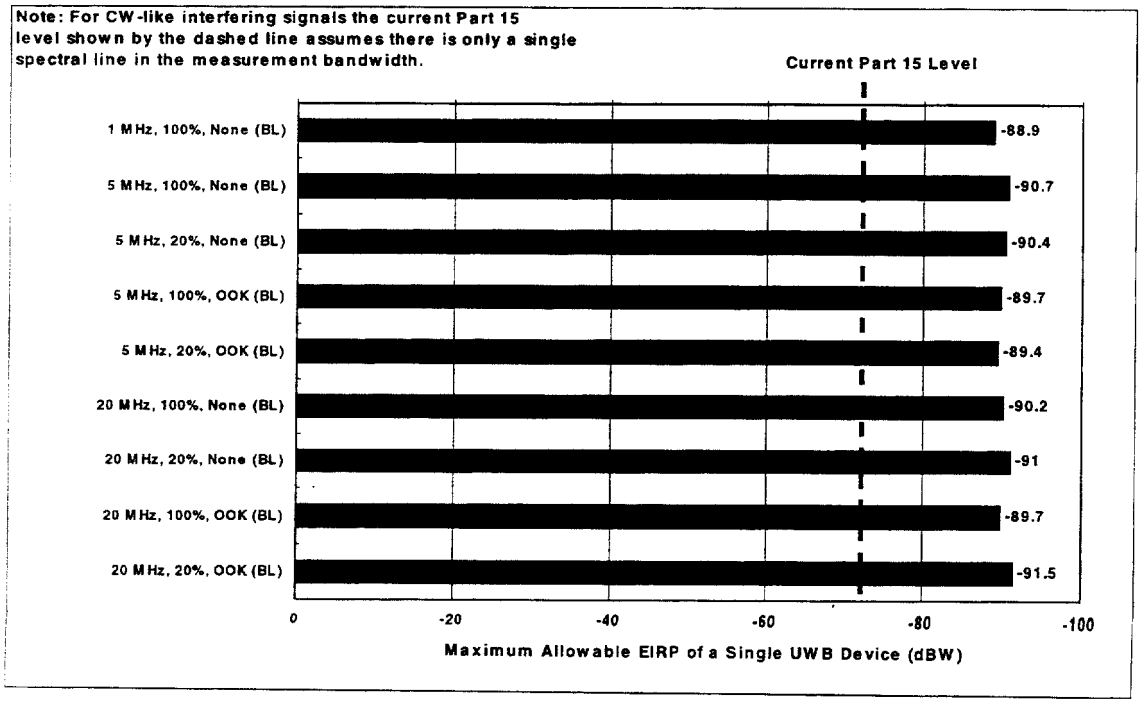

Figure 3-29. Analysis Results for Railway Operational Scenario: C/A-code Receiver and Multiple UWB Devices - Outdoor Operation (CW-Like UWB Signals)

3.3.4 Surveying Applications

In the operational scenarios for the surveying applications, the semi-codeless receiver architecture is considered. The analysis results are given in Figures 3-30 through 3-33. The operational scenarios considered single and multiple UWB device interactions. The values of maximum allowable EIRP shown in Figures 3-30 through 3-33 are for a single UWB device and are based on average power. For the semi-codeless receiver architecture the UWB signals have been characterized as causing pulse-like or noise-like interference. As shown in Figures 3-30 and 3-31, the values of maximum allowable EIRP range from -94.1 to -55.1 dBW/MHz for single UWB device interactions. For multiple UWB device interactions, Figures 3-32 and 3-33 show that the values of maximum allowable EIRP range from -94.2 to -55.2 dBW/MHz.

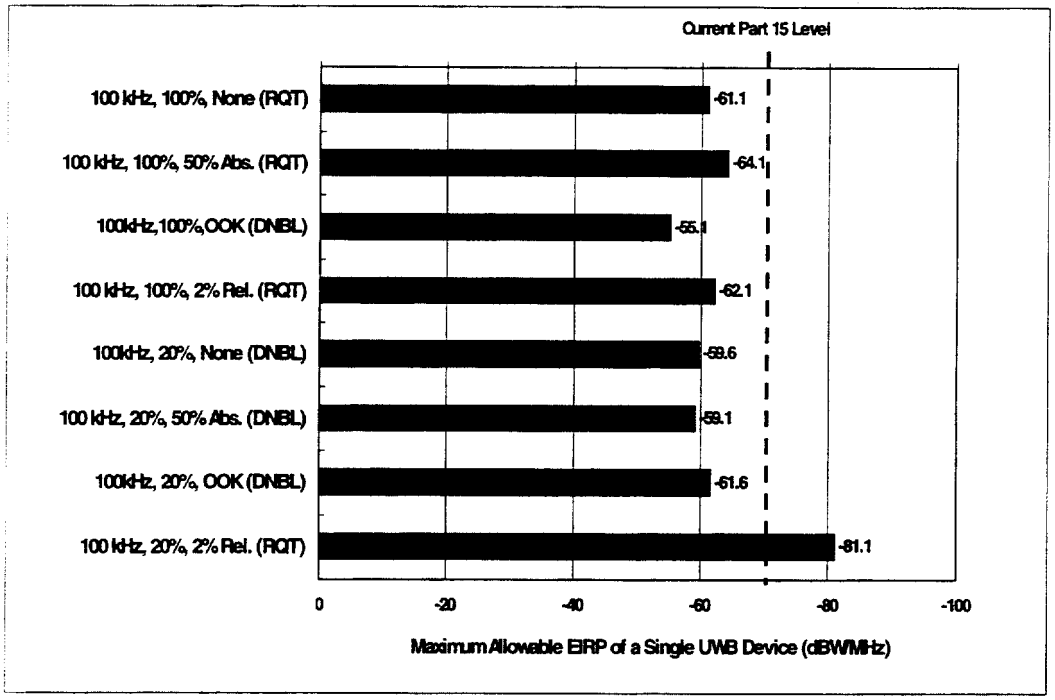

Figure 3-30. Analysis Results for the Surveying Operational Scenario: Semi-Codeless Receiver and Single UWB Device (Pulse-Like UWB Signals)

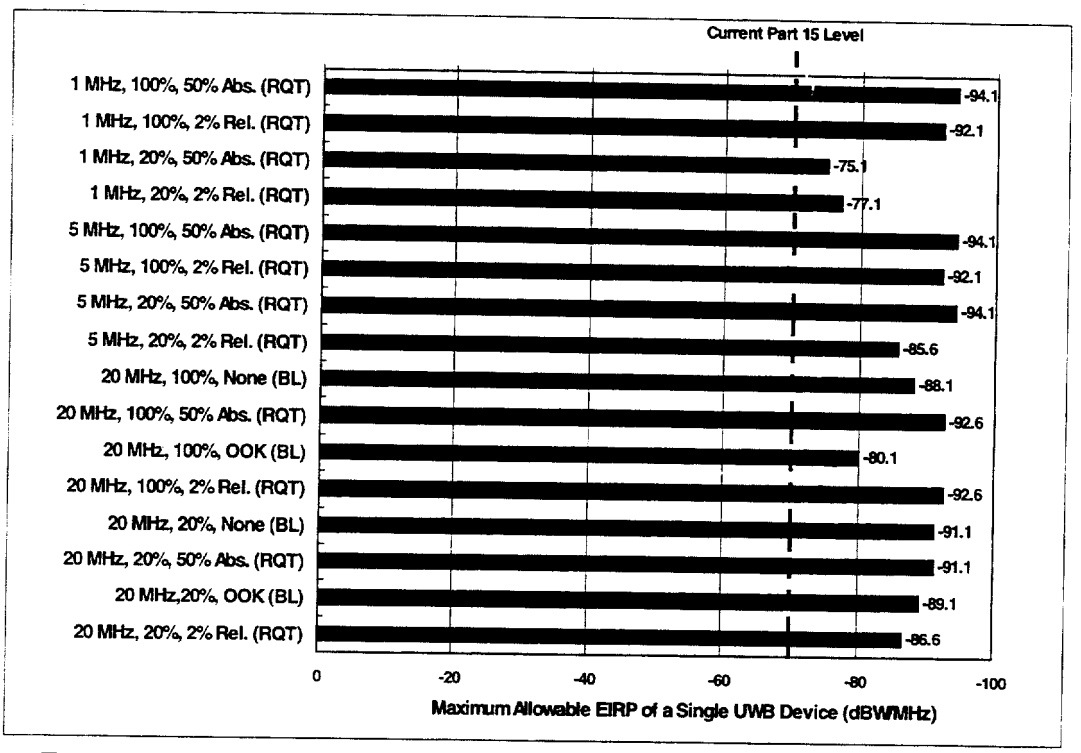

Figure 3-31. Analysis Results for the Surveying Operational Scenario: Semi-Codeless Receiver and Single UWB Device (Noise-Like UWB Signals)

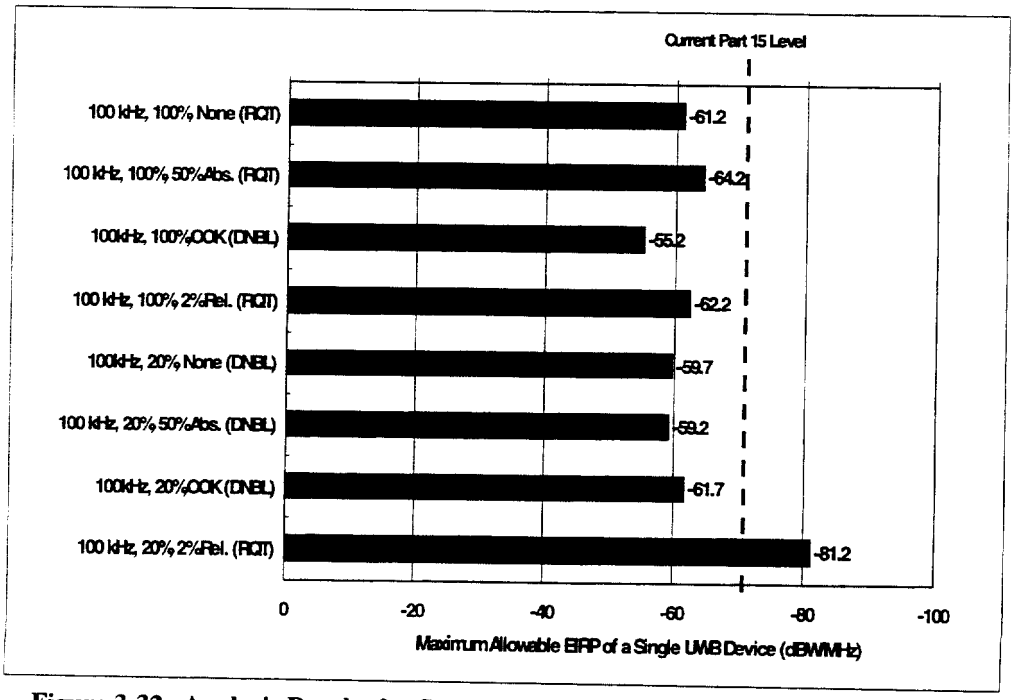

Figure 3-32. Analysis Results for Surveying Operational Scenario: Semi-Codeless Receiver and Multiple UWB Devices (Pulse-Like UWB Signals)

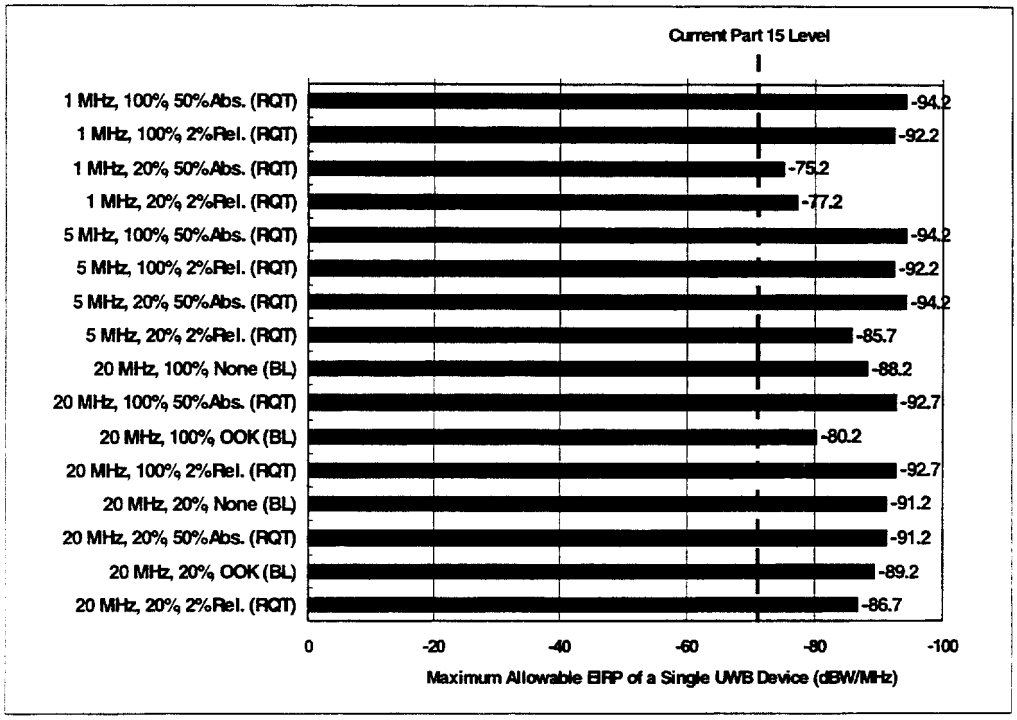

Figure 3-33. Analysis Results for the Surveying Operational Scenario: Semi-Codeless Receiver and Multiple UWB Devices (Noise-Like UWB Signals)

3.3.5 Aviation Applications

In the aviation non-precision approach landing operational scenario, the C/A-code receiver architecture is considered. The analysis results for the C/A-code receiver architecture are given in Figures 3-34, 3-35, and 3-36. The values of maximum allowable EIRP shown in Figures 3-34 through 3-36 are for a single UWB device and are based on average power. As shown in Figure 3-34, for UWB signals that have been characterized as causing pulse-like interference, the values of maximum allowable EIRP range from -52.9 to -40.3 dBW/MHz. For UWB signals that have been characterized as causing noise-like interference, Figure 3-35 shows that the values of maximum allowable EIRP range from -84.3 to -80.8 dBW/MHz. As shown in Figure 3-36, the values of maximum allowable EIRP for UWB signals that have been characterized as causing CW-like interference range from -86.6 to -84 dBW.

In the aviation en-route navigation operational scenario, the C/A-code receiver architecture is considered. The analysis results for the C/A-code receiver architecture are given in Figures 3-37 and 3-38. The analysis results are presented in terms of the maximum EIRP as a function of active UWB device density. In this operational scenario, the aircraft is at an altitude of 1,000 feet. The operational scenarios consider both the indoor and outdoor operation of UWB devices. In this operational scenario it is assumed that there is a large enough number of UWB devices, such that independent of the parameters of the individual UWB signals the aggregate effect causes noise-like interference. The values of maximum allowable EIRP shown in Figures 3-37 and 3-38

are for a single UWB device and are based on average power. Figure 3-37 shows the analysis results when all of the UWB devices are operating outdoor. Figure 3-38 shows the analysis results when all of the UWB devices are operating indoors. As discussed earlier, determining the active number of UWB devices to consider when establishing the maximum allowable EIRP level is difficult and depends on factors such as population, the rate of penetration of the technology, and the appropriate activity factor. For example, assuming a population density of 2000 people per square kilometer and an assumed technology penetration of 10%, the UWB device density would be 200 devices per square kilometer. Based on this UWB device density, the EIRP of a single UWB device would be -76.6 dBW/MHz for indoor UWB device operation (Figure 3-37) and -85.6 dBW/MHz for outdoor UWB device operation (Figure 3-38). These values of maximum allowable EIRP assume that the UWB devices are transmitting simultaneously. An appropriate value for the activity factor could also be considered, depending on the UWB device application.

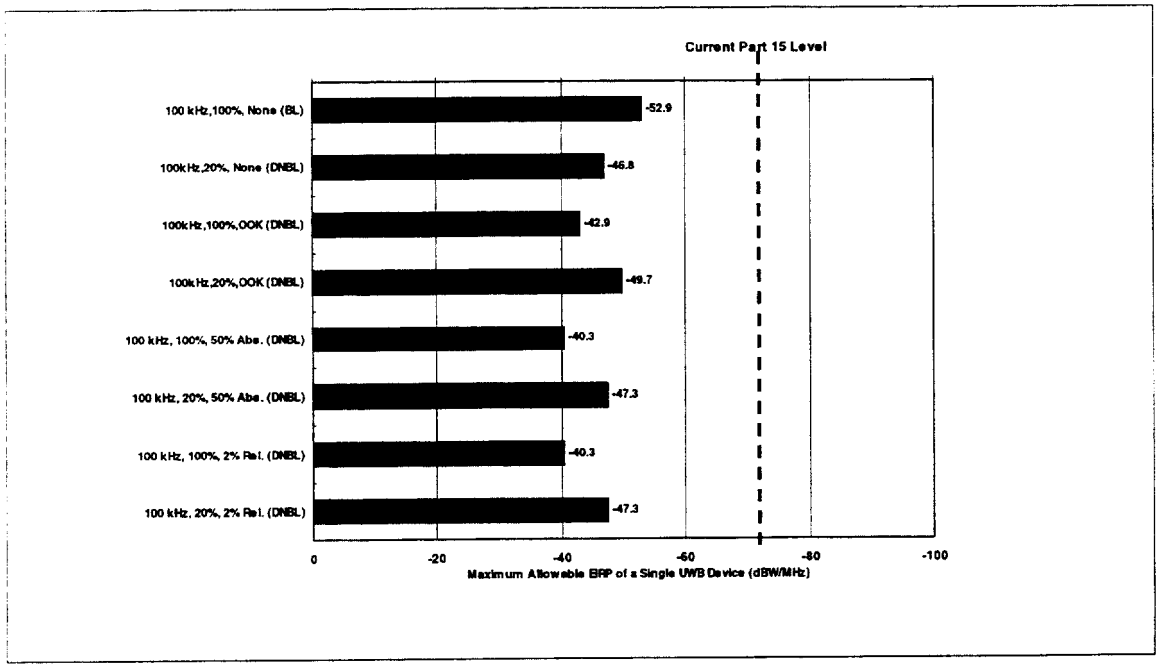

Figure 3-34. Analysis Results for Aviation (Non-Precision Approach Landing) Operational Scenario: C/A-code Receiver and Multiple UWB Devices (Pulse-Like UWB Signals)