



NOVATEL WIRELESS

FCC MPE Calculations

FCC ID: PKRNVWSA2100V

NVTL SA 2100-V
&
External Antenna

December 13, 2013

Rev.2

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Printed and produced in Canada.

Table of Contents

Document Revision History	4
Reference Documents	5
1.0 Introduction	6
1.1 Product Information.....	6
1.2 RF Exposure Information and Limits.....	7
2.0 Product Declarations	9
2.1 Product Transmitters:.....	9
2.2 Simultaneous Transmission Table.....	9
3.0 MPE Calculations	10
3.1 Individual MPE Calculations - Definitions:	10
3.2 Simultaneous transmission - Definitions.....	10
3.3 MPE Calculations - Router.....	11
4.0 External Antenna	12
4.1 Antenna Configuration	12
4.2 Simultaneous Transmission Table.....	12
5.0 MPE Calculations	13
5.1 Individual MPE Calculations - Definitions:	13
5.2 Simultaneous transmission - Definitions.....	13
5.3 MPE Calculations – External Antenna.....	14
5.4 External antenna summary	15

Document Revision History

Revision	Date	Description of Change	Originator
1.0	December 13, 2013	Initial Report	Roman Olmos
2.0	December 13, 2013	Adjustments to Table 1 & Table 3	Roman Olmos

Reference Documents

The evaluations contained in this document were performed as specified in the following documents, as applicable;

- [1] KDB941225 D05 SAR test procedures for devices incorporating Long Term Evolution (LTE) capabilities
- [2] KDB447498 D01 RF Exposure Evaluation Guidance for Mobile Conditions
- [3] FCC OET Bulletin 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields

1.0 Introduction

The Maximum Permissible Exposure (MPE) calculations demonstrate compliance with FCC CFR 47 1.1310 and 2.1091 for standalone and collocated simultaneous transmission in mobile exposure conditions.

The mobile classification applies when there is 20 centimeters or more separation distance between the end user and both WWAN and WLAN transmission antennas.

The maximum conducted transmit power levels and maximum antenna gains were used in the MPE calculations to present a worst-case assessment.

1.1 Product Information

Table 1: Product Information

Product Information		
Host type	M2M Fixed Wireless Device	
Platform Code Name	SA 2100-V	
Marketing Name	SA 2100-V	
FCC ID	PKRNVWSA2100V	
Antenna Type	Fixed internal antenna (with external antenna option)	
Antenna Peak Gain (dBi)		
Internal Antenna Information	CDMA - 850MHz	-0.51
	CDMA -1900MHz	2.38
	LTE Band 13 – 700MHz	0.04
	LTE Band 4 – 1700MHz	1.64
	WiFi 802.11 b,g,n – 2.4GHz	2.83

NOTE: Peak gains include all system losses (cable, connector, etc.).

1.2 RF Exposure Information and Limits

The FCC defines 3 different categories of transmitters in OET Bulletin 65. The categories are fixed installation, mobile and portable devices.

1. Fixed Installation

Fixed installation means that the device including antenna is physically secured at a permanent location and is not easily moved to another location. The minimum distance between the antenna and humans is 2 meters.

2. Mobile Devices

A mobile device is defined as a transmitting device used in other than fixed locations, and is normally used in such a way that the minimum separation distance between the transmitter radiating structures and the body of the user or nearby persons is 20 centimeters. Transmitters designed to be used by consumers or workers that can be easily relocated are considered mobile devices if they meet the 20 centimeter separation requirement. FCC 47 CFR 2.1091 defines the rules for evaluating mobile devices for RF compliance.

3. Portable Devices

A portable device is defined as a transmitting device designed to be used so that the radiating structure(s) of the device is within 20 centimeters of the user's body. . FCC 47 CFR 2.1093 defines the rules for evaluating portable devices for RF compliance.

The FCC categorizes the use of the device based upon the user's awareness and ability to control his or her exposure.

Occupational / Controlled Exposure

In general, occupational / controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, and have been made fully aware of the potential for exposure. Awareness of the potential for RF exposure in a workplace or similar environment can be provided through training as part of a RF safety program. If appropriate, warning signs and labels can also be used to establish such awareness by providing prominent information on the risk of potential exposure, and instructions on methods to minimize exposure risks.

General Population / Uncontrolled Exposure

General population / uncontrolled exposure limits apply to situations in which the general public may be exposed, or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential to exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment related (for example, in the case where a wireless transmitter exposes persons in the vicinity). Warning labels placed on low power consumer devices are not considered sufficient to allow the device to be considered under the occupational / controlled exposure category.

FCC Rules:

According to CFR 47 1.1310, the criteria in Table 2 shall be used to evaluate the environmental impact of human exposure to radio frequency radiation specified in 1.1307(b).

Table 2: Limits for Maximum Permissible Exposure (MPE)

Frequency Range (MHz)	E-field Strength (V/m)	H-field Strength (A/m)	Power Density (mW/cm ²)	Average Time (minutes)
(A) Limits for Occupational / Controlled Exposure (f = frequency)				
30-300	61.4	0.163	1.0	6
300-1500	-	-	f/300	6
1500-100,000	-	-	5.0	6
(B) Limits for General Population / Uncontrolled Exposure (f = frequency)				
30-300	27.5	0.073	0.2	30
300-1500	-	-	f/1500	30
1500-100,000	-	-	1.0	30

2.0 Product Declarations

2.1 Product Transmitters:

The following tables summarize transmitter parameters associated with the MPE evaluation. The WWAN modes of operation reflect the applicable technologies and bands within the scope of the FCC rules.

The maximum conducted transmit power levels and maximum antenna gains were used in the MPE calculations to present a worst-case assessment.

Note that in the case of more than 1 antenna manufacturer, the manufacturer’s antenna that had the highest gain in a frequency range was used in the MPE calculations to present a worst-case assessment.

Table 3: WWAN Transmitter Declarations

Technology	Mode	Band	Transmitter Frequency Range (MHz)	Maximum Conducted Power		Maximum Antenna Gain (dBi)	Duty Cycle
				dBm	Watts		
CDMA	1x	BC0 850 MHz	824-849	24.50	0.282	-0.51	1.00
		BC1 1900 MHz	1850-1910	24.50	0.282	2.38	1.00
LTE	LTE	Band 13	777-787	24.50	0.282	0.04	1.00
		Band 4	1710-1755	24.50	0.282	1.64	1.00

Table 4: WLAN Transmitter Declarations

Technology	Mode	Transmitter Frequency Range (MHz)	Maximum Conducted Power		Maximum Antenna Gain (dBi)	Duty Cycle
			dBm	Watts		
WLAN	802.11b	2400	17.50	0.056	2.83	1.00
WLAN	802.11g/n	2400	15.00	0.032	2.83	1.00

Table 5: Antenna transmission configurations.

Antenna port	CDMA (BC0/BC1)		LTE (Band 4/13)		802.11 b/g/n		GPS
	TX	RX	TX	RX	TX	RX	RX
#1 WWAN (Main)	Yes	Yes	Yes	Yes	No	No	No
#2 WLAN Main	No	No	No	No	Yes	Yes	No
#3 Diversity/GPS	No	Yes	No	Yes	No	No	Yes

2.2 Simultaneous Transmission Table

Table 6: Antenna simultaneous transmission configurations.

TX Modes	CDMA/LTE	802.11 b/g/n
1	ON	ON

*The device is only capable of transmitting a single WWAN technology (CDMA/LTE) at one time.

3.0 MPE Calculations

3.1 Individual MPE Calculations - Definitions:

The individual Maximum Permissible Exposure (MPE) calculations are given by:

$$P_d = \frac{P_{out} \times G}{4\pi R^2}$$

Where,

- P_d = power density (mW/cm²)
- P_{out} = output power to antenna (mW) x Duty Cycle (%)
- G = gain of antenna in linear scale
- R = distance between observation point and center of the radiator (cm)

The following table shows duty cycles for typical technologies.

Table 7: Technology Duty Cycles for MPE Calculations

Technology	Duty Cycle
CDMA	100%
LTE	100%
WLAN	100%

3.2 Simultaneous transmission - Definitions

Collocated Power density –

Simultaneous transmitters = Fractional MPE ratio (WWAN) + Fractional MPE ratio (WLAN) ≤ 1

3.3 MPE Calculations - Router

The power density calculations for standalone transmitters at an exposure separation distance of 20 cm are shown in the following table per the WWAN transmitter powers and antenna gains declared in Table 3 and 4.

The WLAN power levels shown represent worst-case values for the given frequency ranges.

Table 8: WWAN and WLAN Standalone MPE Calculations

Technology	Frequency (MHz)	Maximum Antenna Gain (dBi)	Maximum Conducted Power		Peak Radiated Power		Duty Cycle (%)	Average Radiated Power		Power Density @ 20cm (mW/cm ²)	FCC MPE Limit (mW/cm ²)	FCC MPE Margin (dB)
			dBm	W	EIRP (dBm)	EIRP (W)		EIRP (dBm)	EIRP (W)			
LTE	782	0.04	24.5	0.282	24.54	0.284	100	24.54	0.284	0.057	0.521	0.464
LTE	1700	1.64	24.5	0.282	26.14	0.411	100	26.14	0.411	0.082	1.00	0.918
CDMA2000	824	-0.51	24.5	0.282	23.99	0.251	100	23.99	0.251	0.050	0.549	0.499
CDMA2000	1900	2.38	24.5	0.282	26.88	0.488	100	26.88	0.488	0.097	1.00	0.903
WLAN	2400	2.83	17.5	0.056	20.33	0.108	100	20.33	0.108	0.021	1.00	0.979

Table 9: Power Density (Fractional Calculations) – Individual

Technology	Frequency (MHz)	WWAN P _d (mW/cm ²)	FCC MPE Limit (mW/cm ²)	WWAN P _d / MPE Limit
LTE	782	0.057	0.521	0.109
LTE	1700	0.082	1.000	0.082
Technology	Frequency (MHz)	WWAN P _d (mW/cm ²)	FCC MPE Limit (mW/cm ²)	WWAN P _d / MPE Limit
CDMA	824	0.050	0.549	0.091
CDMA	1900	0.097	1.000	0.097
	Frequency (MHz)	WLAN P _d (mW/cm ²)	FCC MPE Limit (mW/cm ²)	WLAN P _d / MPE Limit
WLAN	2400	0.021	1.000	0.021

Table 10: Power Density (Fractional Calculations) – Worst Case Simultaneous

Band	Frequency (MHz)	LTE P _d / MPE Limit	CDMA P _d / MPE Limit	WLAN P _d / MPE Limit	LTE Fraction +CDMA Fraction +WLAN Fraction	FCC Limit	Pass/Fail
LTE	782	0.109	-	-	0.109	-	-
CDMA	1900	-	0.097	-	0.097	-	-
WLAN	2400	-	-	0.021	0.021	-	-
Total					0.227	1	Pass

4.0 External Antenna

4.1 Antenna Configuration

Table 11: Antenna transmission configurations.

External Antenna port	CDMA (BC0/BC1)		LTE (Band 2/4/5/13)		802.11 b/g/n		GPS
	TX	RX	TX	RX	TX	RX	RX
Port #1	Yes	Yes	Yes	Yes	No	No	No
Port #2	No	Yes	No	Yes	No	No	No

4.2 Simultaneous Transmission Table

Table 12: External antenna simultaneous transmission configurations.

TX Modes	CDMA/LTE	802.11 b/g/n
1 – External Antenna with router WiFi	ON	ON

*The device is only capable of transmitting a single WWAN technology (CDMA/LTE) at one time.

5.0 MPE Calculations

5.1 Individual MPE Calculations - Definitions:

The individual Maximum Permissible Exposure (MPE) calculations are given by:

$$P_d = \frac{P_{out} \times G}{4\pi R^2}$$

Where,

- P_d = power density (mW/cm²)
- P_{out} = output power to antenna (mW) x Duty Cycle (%)
- G = gain of antenna in linear scale
- R = distance between observation point and center of the radiator (cm)

The following table shows duty cycles for typical technologies.

Table 13: Technology Duty Cycles for MPE Calculations

Technology	Duty Cycle
CDMA	100%
LTE	100%

5.2 Simultaneous transmission - Definitions

Collocated Power density –

Simultaneous transmitters = Fractional MPE ratio (WWAN) + Fractional MPE Ration (WLAN) ≤ 1

Note: When the external antenna is connected to the router the internal main WWAN antenna will disconnect.

5.3 MPE Calculations – External Antenna

The power density calculations for standalone transmitters at an exposure separation distance of 20 cm are shown in the following table per the WWAN transmitter powers and antenna gains declared in Table 4 and 5.

The WLAN power levels shown represent worst-case values for the given frequency ranges.

Table 14: WWAN and WLAN Standalone MPE Calculations

Technology	Frequency (MHz)	Maximum Antenna Gain (dBi)	Maximum Conducted Power		Peak Radiated Power		Duty Cycle (%)	Average Radiated Power		Power Density @ 20cm (mW/cm ²)	FCC MPE Limit (mW/cm ²)	FCC MPE Margin (dB)
			dBm	W	EIRP (dBm)	EIRP (W)		EIRP (dBm)	EIRP (W)			
LTE	782	3.5	24.5	0.282	28.00	0.631	100	28.00	0.631	0.126	0.521	0.395
LTE	1700	3.5	24.5	0.282	28.00	0.631	100	28.00	0.631	0.126	1.00	0.874
CDMA2000	824	4.0	24.5	0.282	28.50	0.708	100	28.0	0.708	0.141	0.549	0.408
CDMA2000	1900	2.0	24.5	0.282	26.50	0.447	100	26.50	0.447	0.089	1.00	0.911

Table 15: Power Density (Fractional Calculations) – Individual

Technology	Frequency (MHz)	WWAN P _d (mW/cm ²)	FCC MPE Limit (mW/cm ²)	WWAN P _d / MPE Limit
LTE	782	0.126	0.521	0.241
LTE	1700	0.126	1.00	0.126
Technology	Frequency (MHz)	WWAN P _d (mW/cm ²)	FCC MPE Limit (mW/cm ²)	WWAN P _d / MPE Limit
CDMA	824	0.141	1.00	0.257
CDMA	1900	0.089	1.00	0.089
	Frequency (MHz)	WLAN P _d (mW/cm ²)	FCC MPE Limit (mW/cm ²)	WLAN P _d / MPE Limit
WLAN	2400	0.021	1.000	0.021

*WLAN data is referenced from the calculated results from the router (Page 11/Table 9). The LTE and CDMA antennas on the router are disconnected when the external antenna is attached.

Table 16: Power Density (Fractional Calculations) – Worst Case Simultaneous

Band	Frequency (MHz)	LTE Pd / MPE Limit	CDMA Pd / MPE Limit	WLAN Pd / MPE Limit	LTE Fraction +CDMA Fraction +WLAN Fraction	FCC Limit	Pass/Fail
LTE	782	0.241	-	-	0.241	-	-
CDMA	824	-	0.257	-	0.257	-	-
WLAN	2400	-	-	0.021	0.021	-	-
Total					0.519	1	Pass

5.4 External antenna summary

Based on the calculations above the maximum antenna gains cannot exceed the following values to comply with the FCC RF Exposure requirements for mobile device. The SA 2100-V will be sold exclusively with the Pulse (Part No.: WA700/2700SMA) antenna. The maximum gain including cable loss will not exceed the values shown in table 17.

Table 17 Maximum Permissible Exposure Summary Table

Frequency	Maximum Antenna Gain (dBi)
704 - 787	3.5
824 - 849	4.0
1710-1755	3.5
1850 - 1910	2.0