



***NOVATEL WIRELESS***

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# T1114 and external antenna

FCC MPE Calculations

August 27, 2013

Rev.4

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## Document Revision History

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Revision	Date	Description of Change	Originator
1.0	March 22, 2013	Initial Draft	Todd Gallagher
2.0	April 3, 2013	Updated antenna gain numbers	Todd Gallagher
3.0	August 13, 2013	Updated antenna gain numbers.	Todd Gallagher
4.0	August 27, 2013	Updated based on 802.11 and WWAN measured conducted data	Todd Gallagher

## Reference Documents

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

- [1] KDB941225 D05
- [2] 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	Router	
Platform Code Name	Tasman	
Marketing Name	T1114	
FCC ID	PKRNVWT1114	
Antenna Type	Fixed internal antenna (with external antenna option)	
		Antenna Peak Gain (dBi)
Internal Antenna Information	Cell (BC0)	-0.59
	PCS (BC1)	-0.82
	WiFi 802.11 b,g,n	2.99
	WiFi 802.11 a,n	3.02
	LTE B13	1.21
	LTE B4	2.44

**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 also categorizes the use of the device based upon the user's awareness and ability to control his or her exposure. 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 <sup>2</sup> )	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

### **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.



## 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.

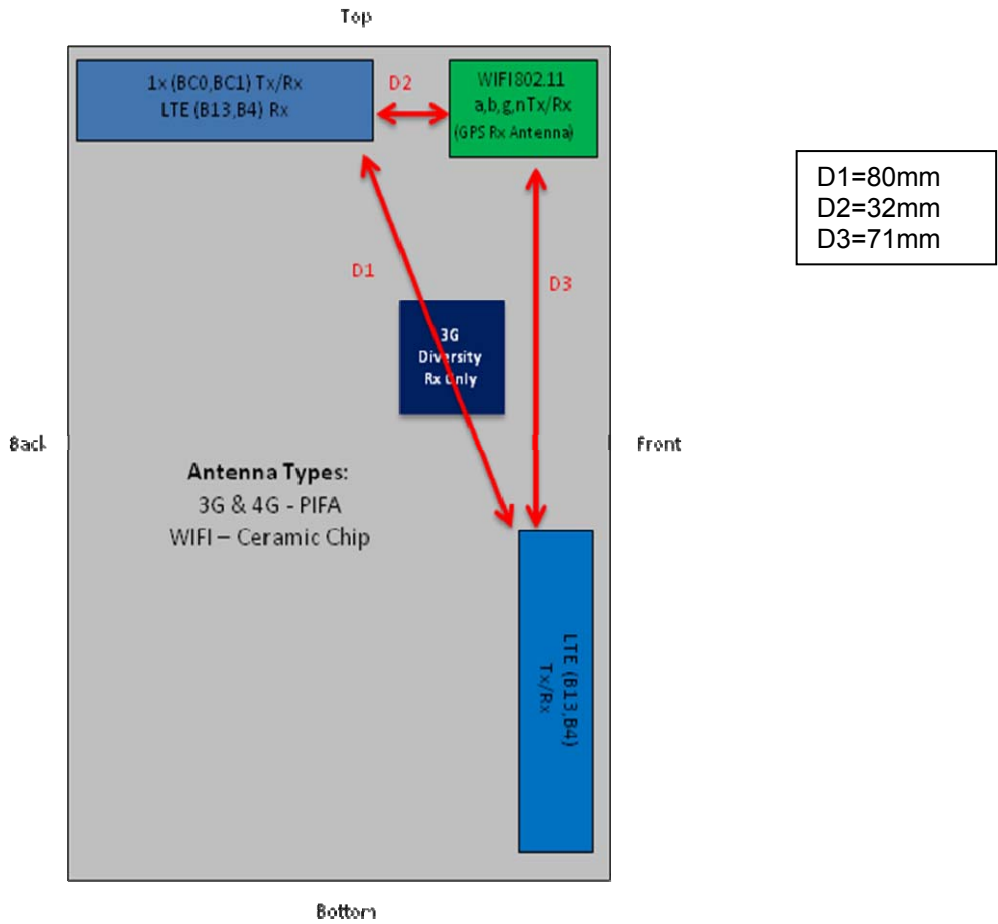
**Table 3: WWAN Transmitter Declarations**

Mode	Equipment Category	Band Name	Transmitter Frequency Range (MHz)	Maximum Conducted Power		Maximum Antenna Gain (dBi)	Duty Cycle
				dBm	Watts		
CDMA2000	1x	BC0 850 MHz	824-849	24.50	0.282	-0.59	1.00
		BC1 1900 MHz	1850-1910	24.50	0.282	-0.82	1.00
LTE	LTE	Band 13	777-787	24.00	0.251	1.21	1.00
		Band 4	1710-1755	24.76	0.299	2.44	1.00

**Table 4: WLAN Transmitter Declarations**

Mode	Equipment Category	Transmitter Frequency Range (MHz)	Maximum Conducted Power		Maximum Antenna Gain (dBi)	Duty Cycle
			dBm	Watts		
WLAN	802.11 b/g/n	2400	20.12	0.103	2.99	1.00
WLAN	802.11 a/n	5180	16.30	0.043	3.02	1.00
		5240	16.40	0.044	3.02	1.00
		5750	14.85	0.031	3.02	1.00
		5800	14.70	0.030	3.02	1.00

## 2.2 Antenna locations



**Table 5: Antenna transmission configurations.**

Antenna port	CDMA		LTE (Band 4/13)		802.11 a/b/g/n		GPS
	TX	RX	TX	RX	TX	RX	RX
#1 WWAN (CDMA)	Yes	Yes	No	Yes	No	No	No
#2 WWAN (LTE B4/13)	No	No	Yes	Yes	No	No	No
#3 WLAN Main	No	No	No	No	Yes	Yes	Yes
#4 Diversity	No	Yes	No	No	No	No	No

## 2.3 Simultaneous Transmission Table

**Table 6: Antenna simultaneous transmission configurations.**

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

## 3.0 MPE Calculations

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### 3.1 Individual MPE Calculations - Definitions:

The individual Maximum Permissible Exposure (MPE) calculations are performed according to the power density equation defined in FCC OET Bulletin 65.

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

Where,

- $P_d$  = power density (mW/cm<sup>2</sup>)
- $P_{out}$  = 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
LTE	100%
CDMA	100%
WLAN	100%

### 3.2 Simultaneous transmission - Definitions

Collocated Power density –

Simultaneous transmitters = Fractional MPE ratio 1 + Fractional MPE ratio 2 + Fractional MPE ratio 3 ≤ 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.

For frequency dependent limits, the lowest transmitter frequency was used to represent the lowest MPE limit (i.e. f/1500, 782 MHz = 0.521 mW/cm<sup>2</sup>).

**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 <sup>2</sup> )	FCC MPE Limit (mW/cm <sup>2</sup> )	FCC MPE Margin (dB)
			dBm	W	EIRP (dBm)	EIRP (W)		EIRP (dBm)	EIRP (W)			
LTE	782	1.21	24.00	0.251	25.21	0.332	100	25.21	0.332	0.066	0.521	0.445
LTE	1745	2.44	24.76	0.299	27.02	0.525	100	27.20	0.525	0.104	1.000	0.896
CDMA2000	824	-0.59	24.50	0.282	23.91	0.246	100	23.91	0.246	0.049	0.549	0.500
CDMA2000	1850	-0.82	24.50	0.282	23.68	0.233	100	23.68	0.233	0.046	1.000	0.954
WLAN	2400	2.99	20.12	0.103	23.11	0.205	100	23.11	0.205	0.041	1.000	0.959
WLAN	5180	3.02	16.30	0.043	19.29	0.085	100	19.29	0.085	0.017	1.000	0.983
WLAN	5240	3.02	16.40	0.044	19.39	0.087	100	19.39	0.087	0.017	1.000	0.983
WLAN	5750	3.02	14.85	0.031	17.84	0.061	100	17.84	0.061	0.012	1.000	0.988
WLAN	5800	3.02	14.70	0.030	17.69	0.059	100	17.69	0.059	0.012	1.000	0.988

**Table 9: Power Density (Fractional Calculations) – Individual**

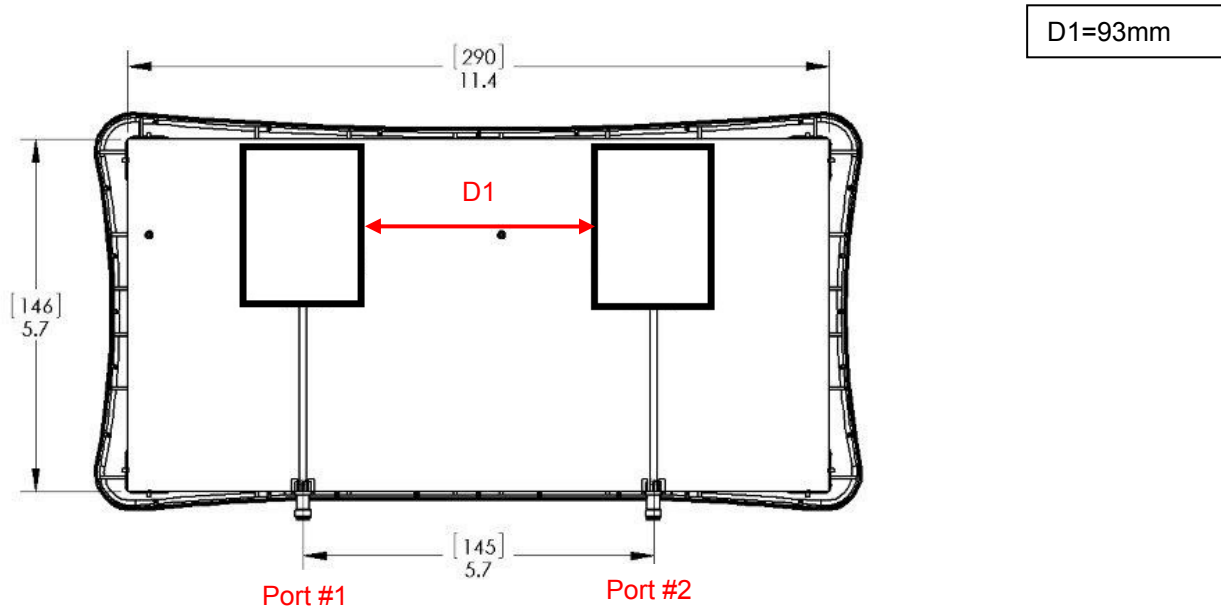
Technology	Band	WWAN P <sub>d</sub> (mW/cm <sup>2</sup> )	FCC MPE Limit (mW/cm <sup>2</sup> )	WWAN P <sub>d</sub> / MPE Limit
LTE	782	0.066	0.521	<b>0.127</b>
LTE	1745	0.104	1.000	0.104
Technology	Band	WWAN P <sub>d</sub> (mW/cm <sup>2</sup> )	FCC MPE Limit (mW/cm <sup>2</sup> )	WWAN P <sub>d</sub> / MPE Limit
CDMA	850MHz	0.049	0.549	<b>0.089</b>
CDMA	1900MHz	0.046	1.000	0.046
	Band	WLAN P <sub>d</sub> (mW/cm <sup>2</sup> )	FCC MPE Limit (mW/cm <sup>2</sup> )	WLAN P <sub>d</sub> / MPE Limit
WLAN	2.4 GHz	0.041	1.000	<b>0.041</b>
WLAN	5.1 GHz	0.017	1.000	0.017
WLAN	5.2 GHz	0.017	1.000	0.017
WLAN	5.7 GHz	0.012	1.000	0.012
WLAN	5.8 GHz	0.012	1.000	0.012

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

Band	Frequency (MHz)	LTE P <sub>d</sub> / MPE Limit	CDMA P <sub>d</sub> / MPE Limit	WLAN P <sub>d</sub> / MPE Limit	LTE Fraction +CDMA Fraction +WLAN Fraction	FCC Limit	Pass/Fail
LTE	700	0.127	-	-	0.127	-	-
CDMA	850	-	0.089	-	0.089	-	-
WLAN	2400	-	-	0.041	0.041	-	-
Total					0.257	1	Pass

## 4.0 External Antenna

### 4.1 Antenna location



**Table 11: Antenna transmission configurations.**

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

### 4.2 Simultaneous Transmission Table

**Table 12: External antenna simultaneous transmission configurations.**

TX Modes	CDMA	LTE	802.11 a/b/g/n
1 – External Antenna only	ON	ON	Off
2 – External antenna with router WiFi	ON	ON	ON

## 5.0 MPE Calculations

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### 5.1 Individual MPE Calculations - Definitions:

The individual Maximum Permissible Exposure (MPE) calculations are performed according to the power density equation defined in FCC OET Bulletin 65.

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

Where,

- $P_d$  = power density (mW/cm<sup>2</sup>)
- $P_{out}$  = 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
LTE	100%
CDMA	100%

### 5.2 Simultaneous transmission - Definitions

Collocated Power density –

Simultaneous transmitters = Fractional MPE ratio 1 + Fractional MPE ratio 2 + Fractional MPE Ration (WLAN) ≤ 1

Note: When the external antenna is connected to the router the internal LTE and CDMA 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 3 and 4.

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

For frequency dependent limits, the lowest transmitter frequency was used to represent the lowest MPE limit (i.e. f/1500, 782 MHz = 0.521 mW/cm<sup>2</sup>).

**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 <sup>2</sup> )	FCC MPE Limit (mW/cm <sup>2</sup> )	FCC MPE Margin (dB)
			dBm	W	EIRP (dBm)	EIRP (W)		EIRP (dBm)	EIRP (W)			
LTE	782	2.9	24.00	0.251	26.90	0.490	100	26.90	0.490	0.097	0.521	0.424
LTE	1745	4.1	24.76	0.299	28.86	0.769	100	28.86	0.769	0.153	1.000	0.847
CDMA2000	824	1.81	24.50	0.282	26.31	0.428	100	26.31	0.428	0.085	0.549	0.464
CDMA2000	1850	4.5	24.50	0.282	29.00	0.794	100	29.00	0.794	0.158	1.000	0.842

Peak Antenna gains and antenna loss as reported by the antenna manufacturer.

- LTE Band 4 - 750MHz Measured Peak Gain = 3.70dBi - 0.8dB (Cable loss) = **2.9dBi**
- LTE Band 13 - 1750MHz Measured Peak Gain= 5.6dBi - 1.5db (Cable loss) = **4.1dBi**
- CDMA - 850MHz Measured Peak Gain= 2.81dBi - 1.0dB (Cable loss) = **1.81dBi**
- CDMA - 1900MHz Measured Peak Gain=6.0dBi - 1.5db (Cable loss) = **4.5dBi**



**Table 15: Power Density (Fractional Calculations) – Individual**

Technology	Band	WWAN P <sub>d</sub> (mW/cm <sup>2</sup> )	FCC MPE Limit (mW/cm <sup>2</sup> )	WWAN P <sub>d</sub> / MPE Limit
LTE	782	0.097	0.521	<b>0.186</b>
LTE	1745	0.153	1.000	0.153
Technology	Band	WWAN P <sub>d</sub> (mW/cm <sup>2</sup> )	FCC MPE Limit (mW/cm <sup>2</sup> )	WWAN P <sub>d</sub> / MPE Limit
CDMA	850MHz	0.085	0.549	<b>0.155</b>
CDMA	1900MHz	0.158	1.000	<b>0.158</b>
Router*	Band	WLAN P <sub>d</sub> (mW/cm <sup>2</sup> )	FCC MPE Limit (mW/cm <sup>2</sup> )	WLAN P <sub>d</sub> / MPE Limit
WLAN	2.4 GHz	0.041	1.000	<b>0.041</b>
WLAN	5.1 GHz	0.017	1.000	0.017
WLAN	5.2 GHz	0.017	1.000	0.017
WLAN	5.7 GHz	0.012	1.000	0.012
WLAN	5.8 GHz	0.012	1.000	0.012

\*WLAN data is calculated from the router (page 13). 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 P <sub>d</sub> / MPE Limit	CDMA P <sub>d</sub> / MPE Limit	WLAN P <sub>d</sub> / MPE Limit (ROUTER)	LTE Fraction +CDMA Fraction	FCC Limit	Pass/Fail
LTE	782	0.186	-		0.186	-	-
CDMA	1900	-	0.158		0.158	-	-
WLAN*	2400	-	-	0.041	0.041		-
Total					0.385	1	Pass