

Novatel Wireless, Inc. PCI Express Mini-card

Installation Guidelines for E351

Version 2.1

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Document Revision History

Rev.	Date	Brief Description of Change	Originator	Approved by
1.0	August 6, 2011	Initial Draft	Todd Gallagher	
2.0	February 3, 2012	Responses to FCC Inquiries Tracking# 409406	Roman Olmos	Todd Gallagher
2.1	February 22, 2012	Update made to 1900MHz Antenna Gain Information	Roman Olmos	Todd Gallagher

FCC KDB Publication Reference

KDB Title	Version	Date	Attachment Number	Version Number
SAR Evaluation Considerations for Laptop/Notebook and Tablet computers	KDB 616217	11/13/2009	D03	v01
Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies	KDB 447498	11/13/2009	D01	v04
SAR Considerations for LTE Handsets and Data modems	KDB 941225	12/15/2010	D05	v01
Modular Transmitter Approvals	KDB 996369	07/12/2011	D01	v01r03
Permissive Change Policy	KDB 178919	06/08/2011	D01	v05r01
Software Configuration Control	KDB 594280	06/08/2011	D01	v01r01

E351 Module Installation and Collocation Guidelines

1.0 Introduction

This document provides collocation and installation instructions for future laptop computers through a FCC Class I or a Class II Permissive Change based on the PKRNVWE351 SAR data and evaluation. This process is documented in FCC KDB 616217 D03 and KDB 447498. Other configurations not specifically described in this document may be authorized in a Class I permissive changes through coordination with Novatel Wireless Inc. to verify that all technical requirements defined in FCC KDB 616217 D03 or other relevant FCC specifications are adequately addressed.

For other basics and details about FCC RF exposure compliance requirements for mobile and portable devices, see FCC OET Bulletin 65 Supplement C.

The following installation host configurations are addressed in this document.

- 1) The E351 module can be installed as a standalone transmitter in notebooks meeting the following conditions:
 - a. Mobile device notebooks where $>20\text{cm}$ separation distance is provided between the WWAN antenna and the end user can be processed as a Class I change. The technical parameters for mobile measurements are defined in Section 2.1.1.
 - b. Portable device notebooks where $\leq 20\text{cm}$ separation distance is provided between the WWAN transmitting antenna that meet the technical parameters defined in Section 2.1.2. These parameters define the conservative notebook configuration used as the baseline host to evaluate SAR.

Note: "Standalone" condition is defined where a single transmitter is transmitting, as opposed to two or more transmitters transmitting simultaneously.

- 2) This module was evaluated with a PIFA antenna (manufacturer xx, model xxx). As the antenna is an integral part of the integration each antenna type will be subject to will be subject to additional RF exposure evaluation and certification if applicable. The E351 will allow collocated transmission through a Class I or Class II permissive change. The collocated transmitters must meet the technical requirements defined in Section 4.0. and only after such Class I or Class II is complete and according to its conditions.
- 3) Allow end-user installation provided module/notebook Two-Way Authentication has been addressed so that modules can only be activated in approved notebooks
- 4) The FCC ID must be permanently affixed on the exterior of the notebook so that it cannot be separated from the host device itself. The label used must state; **Contains FCC ID: PKRNVWE351**
- 5) Per KDB 594280 Novatel Wireless Inc. will maintain control over settings that could allow the product to operate outside the FCC rules.
- 6) **These installation guidelines are not applicable to non-notebook host devices or tablet PCs. The installation guidelines are applicable for notebook computers where the E351 antennas and collocated antennas are located in the display portion of a notebook computer. SAR evaluation is completed with the display open at a ninety-degree angle as defined in KDB pub 616217 and Section 4 of KDB pub 447498.**

2.0 Module Installation Guidelines

This section defines host installation limitations for mobile device and portable device hosts. (See section 3.0 for mobile and portable definitions).

2.1 Installation Guidelines

2.1.1 Mobile Device Hosts (WWAN to user separation distance >20cm)

The E351 module can be installed for use in any authenticated mobile device notebook as long as the antenna gain of the host antenna does not exceed the gain listed in table 1. (See section 3.0 for the measurement guidelines of separation between the transmitting antenna and the user.) The modem must not be collocated with other antennas or transmitters unless the guidelines are followed within this document. Please refer to Section 4 for collocated information.

The maximum E351 conducted power and host antenna gain is listed in Table 1.

Table 1 Maximum Conducted Power and Antenna Gain

Technology	Frequency (MHz)	Maximum Conducted Power (dBm)	Conducted Power (W)	Maximum Antenna Gain (dBi)
LTE Band 13 (5MHz)	779.5	24.25	0.266	5.0
LTE Band 13 (5MHz)	784.5	24.25	0.266	5.0
LTE Band 13 (10MHz)	782	24.25	0.266	5.0
CDMA2000	824	24.50	0.282	3.5
CDMA2000	1850	24.50	0.282	3.5

2.1.2 Portable Device Hosts (WWAN to user separation distance ≤20cm)

The E351 module can be installed for use in a portable device notebook as a Class I change if the antenna separation distance is ≤20cm or >1.8cm. Table 2.0 describes the limitations if there are no collocated transmitters. For collocated restrictions please see section 4.0.

Table 2 Portable Device Notebook Limitations – No collocated transmitters

Parameter	Requirement	RF Exposure Justification
Device type	Notebook	
Display size	Any	
WWAN Antenna locations	Display	
Exterior Display Material	(Non metal)	
WWAN module location	Anywhere	
Minimum WWAN to User Distance	1.8cm	Section 3.0
Maximum WWAN to User Distance (Portable application)	20cm	Section 3.0
SAR evaluation required	No	
Collocated Transmitter Condition	Restricted.	Section 4.0

2.1.3 Portable Device Hosts (WWAN to user separation distance $\leq 1.8\text{cm}$)

The E351 module can be installed in a portable device notebook as a Class II change if the antenna separation distance from the user is $\leq 1.8\text{cm}$. Table 3.0 describes the limitations if there are no collocated transmitters. Collocated radios must be considered as per FCC KDB 616217 D03 supplemental note and section 3 of KDB 447498. Section 2.1.3 does not apply to tablets or non-notebook devices.

Table 3 Portable Device Notebook Limitations – No collocated transmitters

Parameter	Requirement	RF Exposure Justification
Device type	Notebook	
Display size	Any	
WWAN Antenna locations	Display	
Exterior Display Material	(Non metal)	
WWAN module location	Anywhere	
Maximum WWAN to User Distance	1.8cm†	Section 3.0
SAR evaluation required	Yes	
Collocated Transmitter Condition	KDB 616217 D03 KDB 447498 section 3.	

†Based on the SAR data collected during the original application.

2.1.4 End User Installation

Two-way authentication documentation must be submitted as part of a Class I or a Class II Permissive Change allowing end-user installation into notebooks that utilize the method of authentication. Installation by an end user will be allowed once a Class I permissive change has been approved upon an evaluation by Novatel Wireless. If a Class II Permissive Change is required installation by end user will be allowed only after such C2PC is and according to its conditions.

Authentication occurs in two methods:

1. Software installed on the modem:
 - a) Installation Software including list of pre-approved Notebooks and Modules.
 - b) PID/VID identification numbers in Module: Factory Installed
 - c) Module identification numbers in Notebook: Factory Installed
2. Implementation:

When a Module Upgrade Kit is procured the module is available for End-User installation in approved Notebook computers.

The connection manager software is run on the Notebook and the Module ID numbers are checked against a pre-determined list of approved ID numbers in the installation software. Both the Notebook and the Module are checked. If either ID does not match, the installation of the Driver is halted and the Module will not work.

Moving the Module to other NON approved notebooks will not allow the module to operate. Since the driver will ONLY operate in pre-approved Notebooks with the proper ID and while a properly ID-checked Module is resident, you cannot load the driver for NON-approved Modules or Notebooks.

2.1.5 Instructions provided to the user

Instructions provided to the end user must contain information to satisfy FCC RF exposure requirements for Mobile or portable devices.

3.0 Individual SAR Evaluation

Portable RF exposure evaluation has been completed based on SAR measurements on a representative antenna and a representative notebook computer that provided 1.8 cm of separation distance between the edge of the WWAN antenna and the end user orientated at 90 degrees as illustrated in Figure 1. The measured SAR value was 0.764W/kg.

As indicated in KDB 447498 section 2 a), ii) when SAR values are $<0.8\text{W/kg}$ for a conservative exposure measurement the devices can be used in multiple host platforms with similar attributes. These instructions are restricted to laptop and notebook type devices. Please refer to section 4.0 for collocation guidelines.

Figure 1-1

Portable Device Notebook Antenna Location – Horizontal orientation

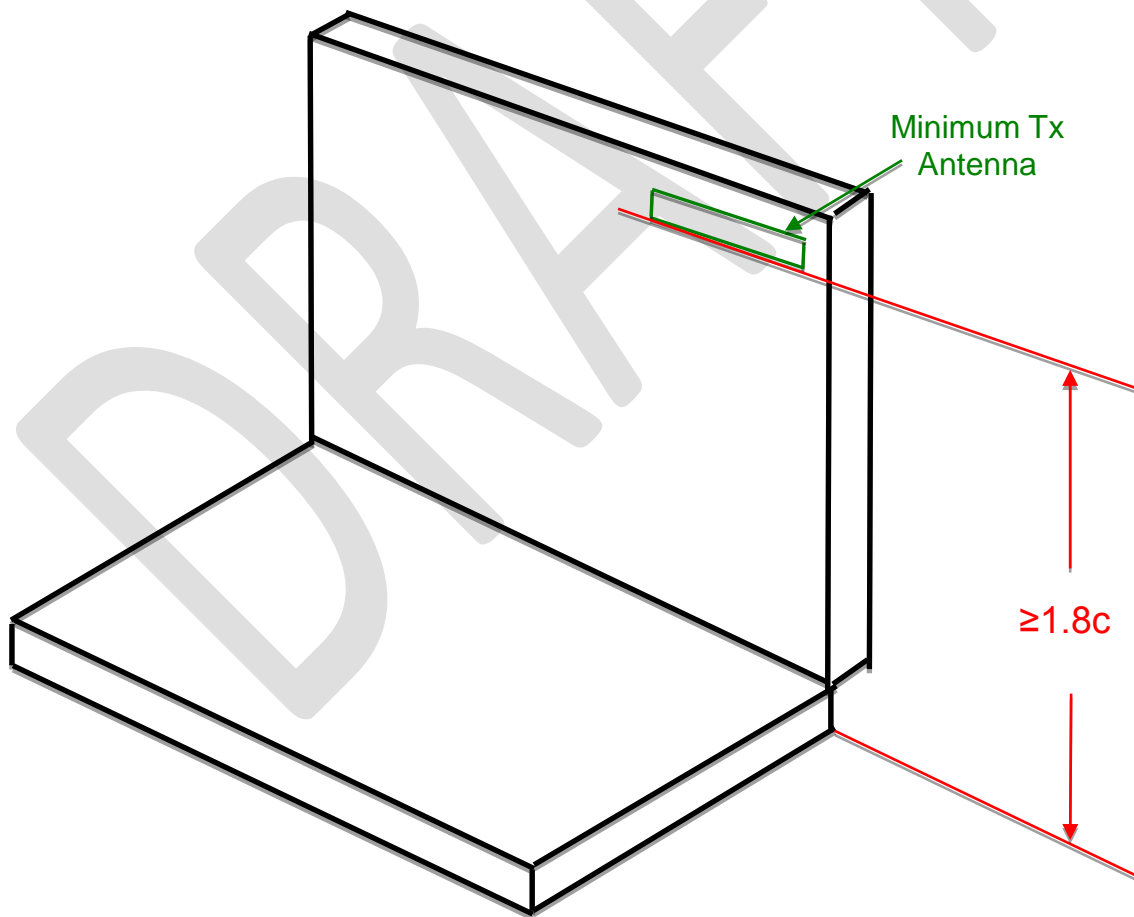
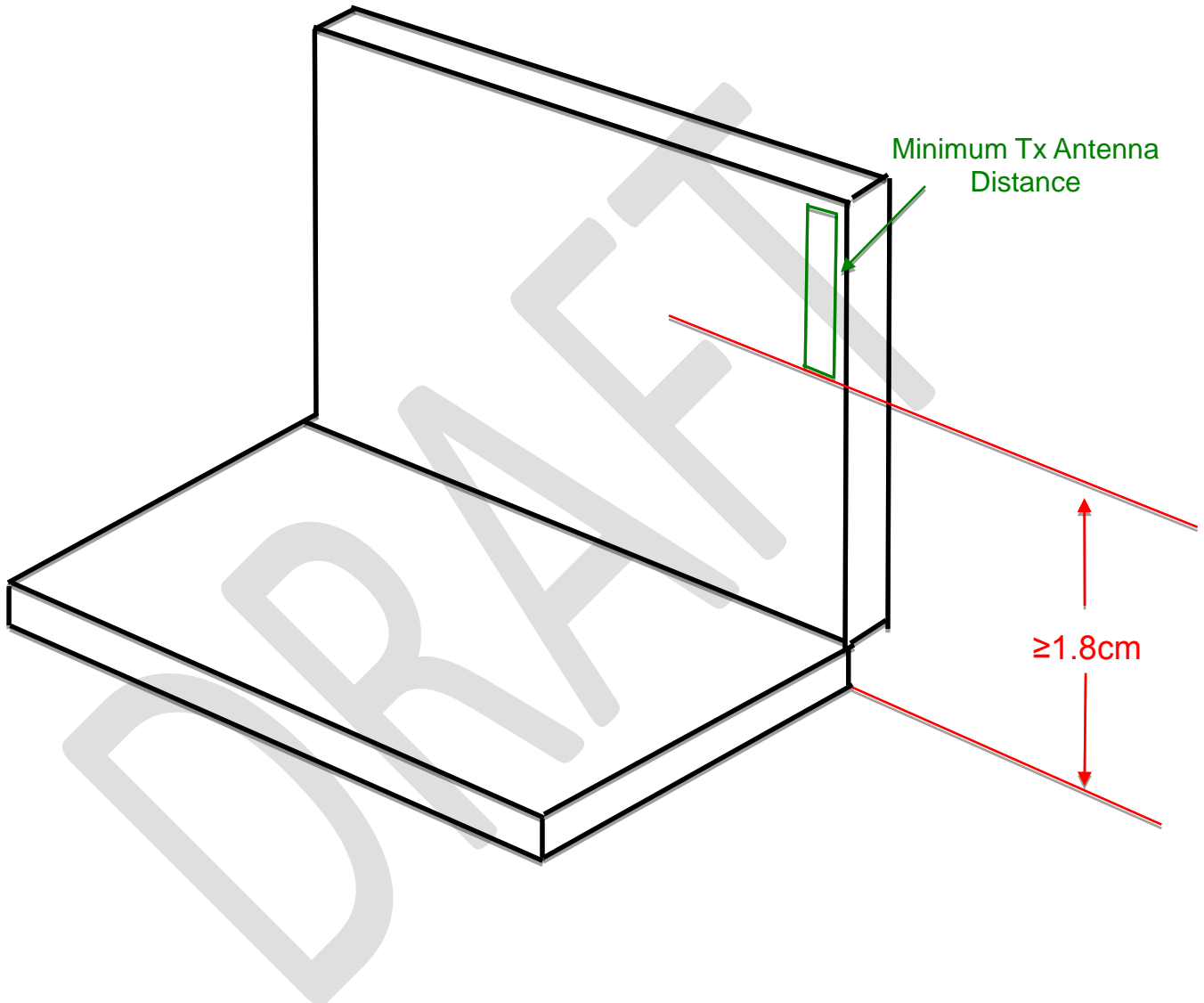


Figure 1-2

Portable Device Notebook Antenna Location – Vertical orientation



Mobile Device Definition - FCC defines as a transmitting antenna located at a distance greater than $\geq 20\text{cm}$ from the user.

Portable Device Definition - FCC defines as a transmitting antenna is located at a distance less than $\leq 20\text{cm}$ from the user.

4.0 Collocated Installation Guidelines

4.1 Collocated transmitter application

Collocated transmitters can be operated simultaneously with the E351 module, provided the technical parameters listed in Table 4 are maintained and the information specified in Section 5.0 is on file as part of a Class I permissive change. A Class II permissive change is required if the host device does not meet the requirements specified in Table 4 and in section 6.

Table 4 Host Device Limitations – Collocated transmitters

Parameter	Requirement	RF Exposure Justification
Device type	Notebook	
Display size	Any	
WWAN Antenna locations	Display	
Exterior Display Material	(Non metal)	
WWAN module location	Anywhere	
Minimum WWAN to User Distance	1.8cm†	Section 3.0
Maximum WWAN SAR	0.764W/kg (1g)*	Section 3.0
Maximum RF coaxial cable loss	1.41dBi*	
Mobile Collocated Transmitter Condition (Mixed mobile and WWAN portable)	<0.523 W/kg (1g)	Section 6.5 and 6.6
Portable Collocated Transmitter Condition	SAR < 0.836W/kg (1g)	Section 6.4 or Section 6.6
Mobile Collocated antenna gain (mobile WWAN)	TBD based on conducted power and maximum MPE	Section 6.5 Table 0
Mobile Collocated antenna gain (Portable WWAN)	5 dBi	Section 6.1
Distance to external card slots	>5cm	N/A

†Based on the SAR data collected during the original application.

*Based on the original antenna tested with the module.

Other devices may be approved as collocated transmitters, provided the technical requirements of FCC KDB 616217 D03 are satisfied. Please contact Novatel Wireless for additional installation instructions.

5.0 Class I Permissive Change Documentation Requirements

The following documentation from KDB pub 616217 must be kept on file to account for simultaneous transmission as part of a Class I permissive change. A Class II permissive change is required if the technical requirements cannot be met.

1. List of all collocated transmitters with FCC and IC IDs
2. Verification that all WWAN and WLAN antennas are >5cm from external USB, PCMCIA or other notebook I/O ports that support an external plug-in transmitter.
3. Drawings showing antenna locations and separation distances
4. Antenna types with respective dimensions and far field antenna gains
5. Specific module to antenna RF coaxial cable losses
6. RF exposure analyses demonstrating compliance with Section 4 of FCC KDB 616217 D03 as shown below

For each simultaneous transmission configuration identified in (1) above, if the conditions in (a) or (b) below are satisfied and fully documented in the SAR report or Class I permissive change documentation, simultaneous transmission SAR evaluation is not required for that configuration¹¹

- a. when the $[(\sum \text{ of the highest measured 1-g SAR for each portable transmitter/antenna included in the simultaneous transmission configuration}) / 1.6 \text{ W/kg}] + \sum \text{ of } [(the \text{ highest MPE for each mobile transmitter/antenna included in the simultaneous transmission configuration}) / (the \text{ corresponding MPE limit})] < 1$; or
- b. for antennas included in the simultaneous transmitting configuration that require SAR evaluation, when the separation distance between each antenna pair is
 - i. greater than $5 \cdot [(SAR_1 + SAR_2) / 1.6]^{1.5}$ cm, rounded to the nearest cm, and
 - ii. the $\sum \text{ of } [(the \text{ highest MPE for each mobile transmitter/antenna included in the simultaneous transmission configuration}) / (the \text{ corresponding MPE limit})] < 1$

where: \sum in a. above excludes antennas that do not require SAR evaluation, and MPE does not apply to displays < 10" diagonal for both a. and b. above

6.0 Simultaneous RF Exposure Evaluation Guidelines For Collocated Transmitters Allowable through a Class I Permissive change

6.1 Mobile Simultaneous Transmission guidelines

Collocated transmitters can be operated simultaneously with the E351 module in mobile configurations, provided the technical parameters listed in KDB pub 447498 section 8 are met. These procedures apply to antennas in the display screen for laptop devices.

These parameters are:

- a) Transmitters and modules certified for mobile or portable exposure conditions and categorically excluded by § 2.1091(c) can be incorporated in mobile device notebooks without further testing or certification when:
 - i. The closest separation among all simultaneous (radiating) transmitting antennas is $\geq 20\text{cm}$, or
 - ii. The antenna separation distance and MPE compliance boundary requirements that enable all simultaneous transmitting antennas incorporated within the host to comply with MPE limits are specified in the application filing of at least one of the certified transmitters incorporated in the host device. In addition, when transmitters certified for portable use are incorporated in a mobile device notebook the antenna(s) must be $\geq 5\text{ cm}$ from all other simultaneous transmitting antennas.
- b) All transmitters in the final product must be at least 20cm from users and nearby persons. For antenna distance instructions please refer section 4.0 Collocated Installation Guidelines.

6.2 Mobile Hosts calculations through power density calculations

The power density calculations for standalone transmitters at an exposure separation distance of 20 cm are shown in table 5 with the declared transmit power and antenna gain values. The calculations are based on a cable loss of 0 dBi. The collocated transmitter values represent worst-case transmit power and antenna gains allowable for use with the E351 WWAN module.

For frequency dependent limits, the lowest transmitter frequency was used to represent the lowest MPE limit (e.g. 778MHz = 0.519 mW/cm^2). The WLAN power levels listed represent the worst-case values for the corresponding frequency ranges.

Per OET 65, when RF sources have different frequencies, the fraction of the FCC power density limit shall be determined and the sum of all fractional components shall be less than 1. The fractional MPE calculation is also addressed in FCC KDB 616217 D03 (Simultaneous Transmission Considerations).

Table 5 WWAN and WLAN Standalone MPE Calculations

Technology	Frequency (MHz)	Maximum Conducted Power (dBm)	Conducted Power (W)	Maximum Antenna Gain (dBi)	Duty Cycle	Average EIRP (dBm)	Average EIRP (W)	Power Density @ 20cm (mW/cm ²)	FCC MPE Limit (mW/cm ²)
LTE	778	24.25	0.266	5.0	1.00	29.25	0.841	0.167	0.519
CDMA	824	24.50	0.282	3.5	1.00	28.00	0.631	0.126	0.549
CDMA	1850	24.50	0.282	3.5	1.00	28.00	0.631	0.126	1.000
WLAN	2400	29.00	0.794	5.0	1.00	34.00	2.51	0.500	1.000
WLAN	5150	29.00	0.794	5.0	1.00	34.00	2.51	0.500	1.000
WLAN	5250	29.00	0.794	5.0	1.00	34.00	2.51	0.500	1.000
WLAN	5500	29.00	0.794	5.0	1.00	34.00	2.51	0.500	1.000
WLAN	5800	29.00	0.794	5.0	1.00	34.00	2.51	0.500	1.000
WIMAX	2600	29.00	0.794	5.0	1.00	34.00	2.51	0.500	1.000

*The maximum antenna gain has been reduced to compensate for the collocated transmitters.

Table 6 WWAN 700 MHz Collocation Power Density

WLAN Band	WLAN Pd (mW/cm ²)	FCC MPE Limit (mW/cm ²)	(WLAN Pd) / (MPE Limit)	700 MHz WWAN Pd (mW/cm ²)	FCC MPE Limit (mW/cm ²)	(WWAN 700 MHz) / (MPE Limit)	(700 MHz WWAN fraction) + (WLAN fraction)	Limit	Pass/Fail
2.4 GHz	0.500	1.000	0.500	0.167	0.519	0.322	0.822	1	Pass
5.1 GHz	0.500	1.000	0.500	0.167	0.519	0.322	0.822	1	Pass
5.2 GHz	0.500	1.000	0.500	0.167	0.519	0.322	0.822	1	Pass
5.5 GHz	0.500	1.000	0.500	0.167	0.519	0.322	0.822	1	Pass
5.8 GHz	0.500	1.000	0.500	0.167	0.519	0.322	0.822	1	Pass
2.6 GHz	0.500	1.000	0.500	0.167	0.519	0.322	0.822	1	Pass

Table 7 WWAN 850 MHz Collocation Power Density

WLAN Band	WLAN Pd (mW/cm ²)	FCC MPE Limit (mW/cm ²)	(WLAN Pd) / (MPE Limit)	850 MHz WWAN Pd (mW/cm ²)	FCC MPE Limit (mW/cm ²)	(WWAN 850 MHz) / (MPE Limit)	(850 MHz WWAN fraction) + (WLAN fraction)	Limit	Pass/Fail
2.4 GHz	0.500	1.000	0.500	0.126	0.549	0.229	0.729	1	Pass
5.1 GHz	0.500	1.000	0.500	0.126	0.549	0.229	0.729	1	Pass
5.2 GHz	0.500	1.000	0.500	0.126	0.549	0.229	0.729	1	Pass
5.5 GHz	0.500	1.000	0.500	0.126	0.549	0.229	0.729	1	Pass
5.8 GHz	0.500	1.000	0.500	0.126	0.549	0.229	0.729	1	Pass
2.6 GHz	0.500	1.000	0.500	0.126	0.549	0.229	0.729	1	Pass

Table 8 WWAN 1900 MHz Collocation Power Density

Band	WLAN Pd (mW/cm ²)	FCC MPE Limit (mW/cm ²)	(WLAN Pd) / (MPE Limit)	1900 MHz Pd (mW/cm ²)	FCC MPE Limit (mW/cm ²)	(WWAN 1900 MHz) / MPE Limit	(1900 MHz WWAN fraction) + (WLAN fraction)	Limit	Pass/Fail
2.4 GHz	0.500	1.000	0.500	0.126	1.000	0.126	0.626	1	Pass
5.1 GHz	0.500	1.000	0.500	0.126	1.000	0.126	0.626	1	Pass
5.2 GHz	0.500	1.000	0.500	0.126	1.000	0.126	0.626	1	Pass
5.5 GHz	0.500	1.000	0.500	0.126	1.000	0.126	0.626	1	Pass
5.8 GHz	0.500	1.000	0.500	0.126	1.000	0.126	0.626	1	Pass
2.6 GHz	0.500	1.000	0.500	0.126	1.000	0.126	0.626	1	Pass

6.3 Portable Simultaneous Transmission guidelines

Collocated transmitters can be operated simultaneously with the E351 module in portable configurations, provided the technical parameters listed in KDB pub 447498 section 3 are met. These procedures apply to antennas in the display screen for laptop devices.

These parameters are:

Transmitters and modules for use in portable exposure conditions that allow simultaneous transmission:

- a) Except during network hand-offs where the maximum hand-off duration is less than 30 seconds, simultaneous transmission applies when there is overlapping transmission. SAR is evaluated for simultaneous transmission using volume scan measurements.
- b) SAR is not required for the following simultaneous transmission conditions
 - i) When excluded by the procedures in FCC KDB 616217 D03 or KDB 648474.
 - ii) When specific requirements for simultaneous transmission SAR evaluation have not been established for the host platform or device configuration:
 - (1) for the antennas that are located < 5 cm from persons, where
 - (a) The closest antenna separation distance is ≥ 5 cm for all simultaneous transmitting antennas within the host or device; and
 - (b) The sum of the 1-g SAR is < 1.6 W/kg for all simultaneous transmitting antennas that require stand-alone SAR evaluation or the SAR to peak location separation ratios are < 0.3 for all simultaneous transmitting antenna pairs; and
 - (c) The output power is $\leq 60/f(\text{GHz})$ mW for any simultaneous transmitting antenna(s) for which stand-alone SAR evaluation is not required.
 - (2) for the antennas that are located ≥ 5 cm from persons, contact the FCC Laboratory to determine if the simultaneous transmission SAR exclusion procedures for laptop/notebook/netbook computers in FCC KDB 616217 D03 and its supplement may be applied.¹⁹

- c) The operating and installation requirements, including restrictions, must be provided for OEM integrators and end users to comply with simultaneous transmission SAR requirements.

6.4 Portable Device Hosts: Sum of Total SAR < SAR Limit

A portable collocated transmitter can be operated simultaneously with the WWAN transmitter provided the individual SAR results for the portable collocated transmitter are less than the value specified below based on Section 4)a) of FCC KDB 616217 D03. The maximum individual SAR value is based on the worst case SAR recorded on the notebook computer at 1.8cm (0.764 W/kg).

$$SAR_{collocated} \leq 1.6 - SAR_{WWAN}$$

$$SAR_{collocated} \leq 1.6 - 0.764W / kg$$

$$SAR_{collocated} \leq 0.836W / kg$$

6.5 Portable Device Hosts Sum of WWAN SAR + Collocated MPE < 1

(Mobile Collocated transmitter with a portable transmitter)

For mobile collocated transmitters operating greater than 1 GHz, mobile collocated transmitter can be operated simultaneously with the portable WWAN transmitter, provided the individual MPE results for the mobile collocated transmitter are less than the value specified below based on Section 4)a) of FCC KDB 616217 D03. The maximum individual SAR value is based on the worst case SAR recorded on the HSTNN-F05C notebook computer at 18.5cm (0.345 W/kg).

$$\frac{SAR_{WWAN}}{1.6} + \frac{MPE_{collocated}}{1} \leq 1$$

$$MPE_{collocated} \leq 1 - \frac{SAR_{WWAN}}{1.6}$$

$$MPE_{collocated} \leq 0.523W / kg$$

6.6 Portable Device Hosts Max Collocated SAR Vs. Distance

If the summation of SAR exceeds the FCC limit, collocation is permitted through a Class I permissive change provided the minimum allowable separation distance derived from the equation below is satisfied. An alternate equation provides the maximum collocated SAR based on a specified separation distance. In addition, the sum of the highest MPE must be less than the corresponding MPE limit as defined in section 4. B) ii) of FCC KDB 616217 D03.

Minimum separation distance for Collocated Transmitters

$$5 * \left(\left[\frac{SAR_{WWAN} + SAR_{collocated}}{1.6} \right]^{1.5} \right) \leq Ant_Separation_{WWAN-to-Collocated}$$

Maximum collocated SAR vs distance

$$5 * \left(\left[\frac{SAR_{WWAN} + SAR_{collocated}}{1.6} \right]^{1.5} \right) \leq Ant_Separation_{WWAN-to-Collocated}$$

$$SAR_{collocated} = 1.6 * \left(\frac{Ant_Separation_{WWAN-to-Collocated}}{1.5} \right)^{\frac{2}{3}} - SAR_{WWAN}$$

7.0 Regulatory Statements - Federal Communications Commission Notice (FCC—United States)

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.

However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Contact your service provider for help.

Notice to Consumers: Changes or modifications made to this equipment not expressly approved by Novatel Wireless may void the FCC authorization to operate this equipment.

This device complies with Part 15 of the FCC Rules and with Industry Canada ICES-003.

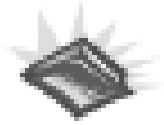
Operation is subject to the following two conditions:

- (1) this device may not cause harmful interference, and
- (2) this device must accept any interference received, including interference that may cause undesired operation.

The E351 is compliant to the relevant sections of the FCC rules:

- FCC CFR47 Part 2 (General Rules and Regulations, RF Exposure Evaluation)
- FCC CFR47 Part 15 (All Radio Frequency Devices)
- FCC CFR47 Part 24 (Narrow and wideband PCS modules)
- FCC CFR47 Part 22 (Cellular Service)
- FCCCFR47 Part 27 (Wireless Communications Services)

8.0 Technical Support Contacts



WWW: <http://www.nvtl.com/support/index.html>

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DRAFT