

Introduction

This document describes a proposed test plan with regards to rf exposure for three modules (WWAN, WLAN and Bluetooth) that are to be installed in the Juniper Systems TK6000 hand-held field computer shown below.

This version of test plan (version 4) updates the previous version due to a change in the WWAN cell modem being used (different model with lower output power in both bands) and the use of a 0dBi antenna. Additional edits were made to version 4.2.1 to include comments from the FCC's response to the KDB enquiry¹.



The WLAN (FCC ID: VSF19782MX) and Bluetooth (FCC ID: VSF19799AR) modules both have limited modular approvals that include allowance for being co-located in the field computer. RF exposure evaluations were limited to MPE calculations based on the following:

- The host system is for hand-held use with no body-worn accessories;
- The expected operating conditions would ensure at least a 20cm separation from the WLAN and Bluetooth antennas from the body;
- The Bluetooth module's output power is below the $(60/f)$ threshold;
- The WLAN output power is below the $300 \cdot [f(\text{GHz})]^{-0.5}$ and $1000 \cdot [f(\text{GHz})]^{-0.5}$ thresholds detailed in KDB 447498 section 4(c);
- The separation distance between WLAN and Bluetooth antennas exceeded 5cm;
- KDB response from the FCC reference KDB tracking number 458876.

The addition of the WWAN module (FCC ID: **VSF22455**) will require an additional rf exposure evaluation for the WWAN module that must also consider the co-location with the Bluetooth and WLAN modules.

¹ Removed references to eirp in the summary paragraphs discussing the output power of the various modules with respect to the hand-held threshold levels. Made clear that the MPE calculations were to address exposure to the body and that the device is still considered to operate in portable exposure conditions, i.e. because user's hand is within 20 cm from device.

Antenna Separation Distances

The following photographs show the separation distances between WLAN, WWAN and Bluetooth antennas as summarized in the table below. They also show the expected separation distance between the WWAN antenna and the hand.

Antenna 1	Antenna 2	Separation (cm)
WWAN	WLAN	6.3
WWAN	Bluetooth	10.3
WLAN	Bluetooth	10.0
WWAN	Hand	~7.5

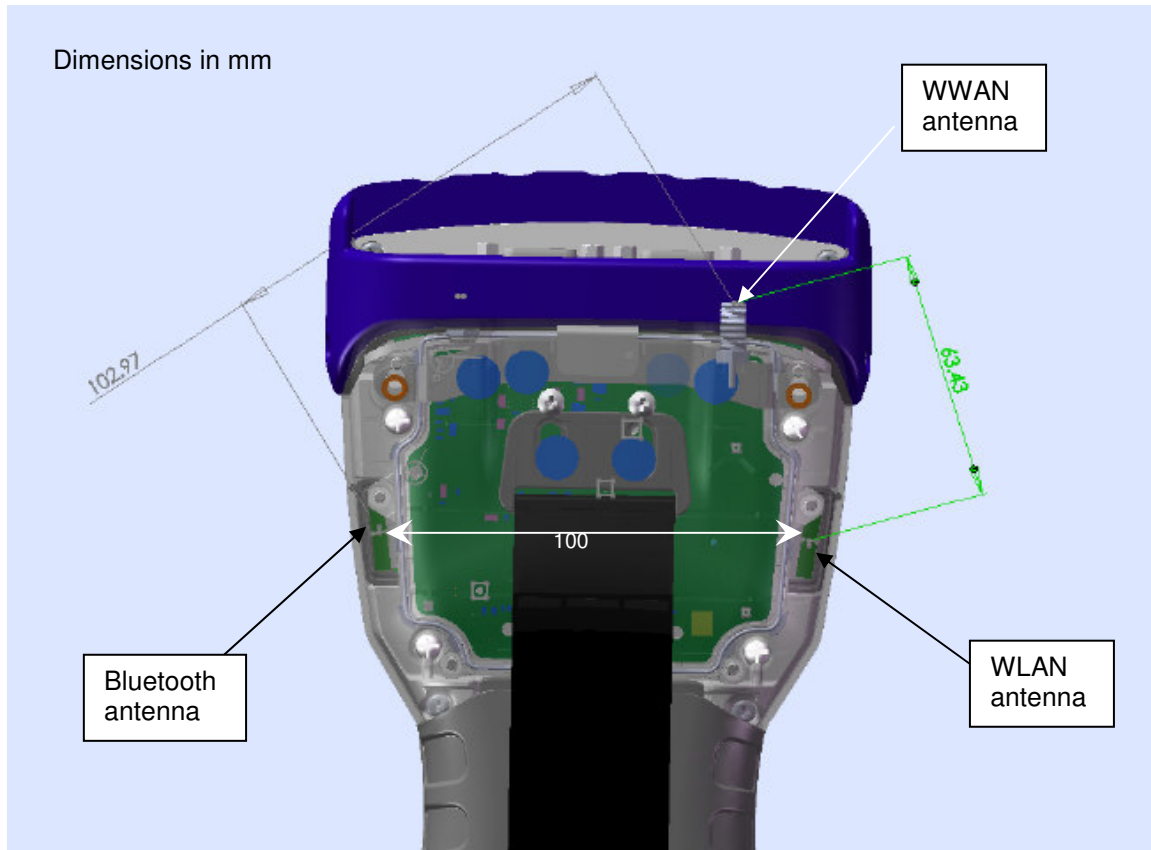


Figure 1: WWAN, WLAN and Bluetooth Antenna Separations

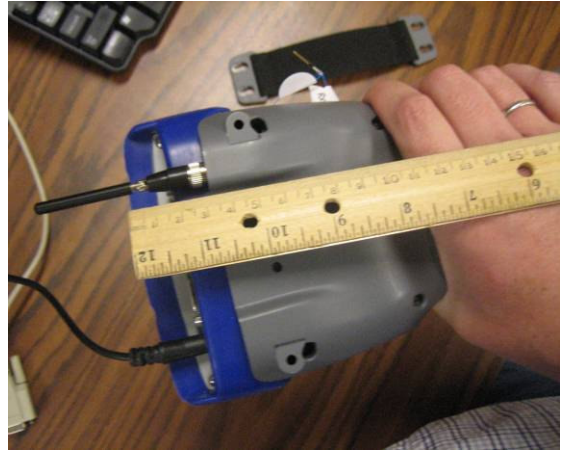


Figure 2: WWAN Antenna-to-Hand Separation For Left- and Right-Handed Use and With Antenna Angled



RF Exposure Evaluation

SAR Thresholds

The host is a hand-held device, and has no accessories for the device to be body-worn during operation. Referencing FCC publication KDB447498 SAR is not required for a stand-alone device operating at $P < 60/f$ (GHz) or for devices that operate simultaneously with other transmitters that operate at $P < \frac{1}{2}60/f$ (GHz).

Paragraph 4(c) of KDB447498 states that SAR evaluation is not required for hand-held transmitters that operate closer than 5 cm to the body when they have an output power that is $< 300[f(\text{GHz})]^{-0.5}$ mW. For devices that could be within 5cm of the hand (but > 5 cm from the body) the threshold increases to $1000 [f(\text{GHz})]^{-0.5}$ mW

The output power, antenna gains and the thresholds for each module are detailed in the tables on the next page. These show that:

- The Bluetooth module is below the $60/f$, and both of the hand-held SAR thresholds.
- The WiFi module is below both of the hand-held SAR thresholds.
- The WWAN module is above the $60/f$ and $300[f(\text{GHz})]^{-0.5}$ thresholds but below the $1000 [f(\text{GHz})]^{-0.5}$

Output Power And Threshold for General SAR Exemption

Device	Operating Frequency (MHz)		Output power mW	Duty Cycle %	Output power for rf exposure mW	SAR threshold (60/f) mW
	From	To				
Cell Modem	824.2	848.8	1350	12.5%	70.7	168.8
Cell Modem	1850.2	1909.8	660	*See note	31.4	82.5
WiFi Module	2412	2462	39.6	100.0%	24.4	39.6
Bluetooth Module	2402	2480	10.58	100.0%	24.2	10.6

Only the Bluetooth module's output power falls below the power level threshold that exempts devices from SAR evaluation under any exposure condition.
 * The duty cycle correction for the WWAN module is based on the device using a single time slot out of the eight available. The module can use multiple time slots, however the peak output power is reduced by $1/n$, where n is the number of time slots, so that the average output power remains constant, regardless of the number of time slots used.

TK6000 Test Plan For Cellular Modem Module, Rev 4.2.1

Output Power And Threshold for Hand-Held Use, Antenna Within 5cm of Body

Device	Operating Frequency (MHz)		Output power for rf exposure mW	Hand-held, < 5cm from body threshold $300 \cdot [f(\text{GHz})]^{-0.5}$	
	From	To		Threshold	% of Threshold
Cell Modem	824.2	848.8	168.8	325.6 mW	52%
Cell Modem	1850.2	1909.8	82.5	217.1 mW	38%
WiFi Module	2412	2462	39.6	191.2 mW	21%
Bluetooth Module	2402	2480	10.6	190.5 mW	6%

All four modules' output powers fall below the power level threshold that exempts devices from SAR evaluation when used in hand-held devices that might come within 5cm of the body. This does not allow for body-worn configurations. The threshold for body-worn configurations is the general threshold for SAR (60/f).

Output Power And Threshold for Hand-Held Use, Antenna Within 5cm of Hand

Device	Operating Frequency (MHz)		Output power for rf exposure mW	Hand-held, < 5cm from hand threshold $1000 \cdot [f(\text{GHz})]^{-0.5}$	
	From	To		Threshold	% of Threshold
Cell Modem	824.2	848.8	168.8	1085.4 mW	16%
Cell Modem	1850.2	1909.8	82.5	723.6 mW	11%
WiFi Module	2412	2462	39.6	637.3 mW	6%
Bluetooth Module	2402	2480	10.6	635.0 mW	2%

All four modules' output powers fall below the power level threshold that exempts devices from SAR evaluation when used in hand-held devices that might come within 5cm of the hand.

Proposed RF Exposure Evaluation

KDB 447498 states that the simultaneous transmission SAR evaluation procedures for cellphones in KDB 648474 may be applied to antennas that are built-in within a PDA or UMPC. The field PC should be considered as an Ultra mobile PC (UMPC).

WWAN Module – Stand Alone

Based on previous responses from the FCC with regards to this KDB enquiry, provided the WWAN module is below the SAR thresholds applicable to the intended use of the host device. After accounting for the source-based averaging of the WWAN transmitter output power, the WWAN module falls below the SAR thresholds for hand-held use for devices with antennas within 5cm of the hand and within 5cm of the body.

An MPE assessment is required to demonstrate that the rf exposure hazard 20cm from the device is below the relevant limit.

As previously requested by the FCC the eirp and/or erp shall be measured for the combination of WWAN module, host device and antenna.

Buetooth Module – Stand Alone

Based on both KDB 447498 and KDB 648474 the Bluetooth module does not require a SAR assessment or an MPE assessment.

WiFi Module – Stand Alone

As the WiFi module being well below the *hand-held, within 5cm of the body* ($300[f(\text{GHz})]^{-0.5}$ mW) and the *hand-held, within 5cm of the hands* ($1000 [f(\text{GHz})]^{-0.5}$ mW) threshold the WiFi module is exempt from a stand-alone SAR assessment.

An MPE assessment is required to demonstrate that the rf exposure hazard 20cm from the device is below the relevant limit.

Co-Located Simultaneous Transmissions

As WWAN, Bluetooth and/or WLAN modules can operate simultaneously, the effects of simultaneous transmissions must also be taken into consideration.

For whole-body exposure an MPE calculation to demonstrate compliance with the limits, based on summing the percentage of the limit for each transmitter and verifying that the total is less than 100%, will be performed and is included at the end of this document.

For localized rf exposure, SAR evaluations are expected. KDB 648474 states: *When stand-alone SAR evaluation is not required and the antenna is 5 cm from other antennas, simultaneous transmission SAR evaluation is also not required for that antenna.* While it does assume this exemption is based on the 60/f threshold, the document is written for body and head exposure and not for extremities.

It is proposed that, unless the evaluation of the WWAN module in stand-alone mode indicates a high level of rf exposure (i.e. greater than 70% of the limit), simultaneous SAR evaluation should not be required because:

- the total output power from the remaining two modules is less than 30% of the ***threshold value*** that would require stand-alone SAR for a hand-held device used within 5cm of the body;

and

- the separation of each individual antenna from any other antenna is greater than 5cm.

MPE Calculations

The device can operate in a portable exposure condition because it comes within 20cm of the hand. The previous sections have evaluated the rf exposure with respect to the extremities and concluded that SAR measurements are not required based on the output powers of the three rf modules used within the system. An MPE estimation has been made to address exposures to persons' bodies due to operation of the hand-operated device..

FCC part 1.1310, Table 1 limits the power density for uncontrolled exposure. The power density, P_d (mW/cm²) calculated from the maximum EIRP, P_t (mW) and the distance, d (m), between the transmitting antenna and the closest person, can be calculated using:

$$P_d = P_t / (4 \pi d^2)$$

Bluetooth, WWAN (850MHz) and WLAN Modules Operating Simultaneously

Frequency	MPE Limit (mW/cm ²)	Output Power (mW)	Max. Antenna Gain (dBi)	EIRP (mW) ²	Pd at 20cm (mW/cm ²)	% of limit
2402 to 2480 MHz	1.00	10.6	0.0	10.6	0.002	0.2%
2412 to 2462 MHz	1.00	39.6	0.0	39.6	0.008	0.8%
824 to 849 MHz	0.55	168.8	0	168.8	0.03	6.1%

The total of the rf exposure power density of each device, expressed as a percentage of their respective limits, is 7.1%. As this is below 100% the total power density at 20cm from the device is below the levels permitted for uncontrolled exposure.

Bluetooth, WWAN (1900MHz) and WLAN Modules Operating Simultaneously

Frequency	MPE Limit (mW/cm ²)	Output Power (mW)	Max. Antenna Gain (dBi)	EIRP (mW) ²	Pd at 20cm (mW/cm ²)	% of limit
2402 to 2480 MHz	1.00	10.6	0.0	10.6	0.002	0.2%
2412 to 2462 MHz	1.00	39.6	0.0	39.6	0.008	0.8%
1850 to 1910 MHz	1.00	82.5	0	82.5	0.02	1.6%

The total of the rf exposure power density of each device, expressed as a percentage of their respective limits, is 2.6 %. As this is below 100% the total power density at 20cm from the device is below the levels permitted for uncontrolled exposure.

² The measured eirp may be used for this calculation once final measurements have been made. The eirp for the 850MHz band, based on preliminary measurements, is 0.8W (peak, not corrected for duty cycle) for the 850MHz band and 0.2W for the 1950MHz band.