



RF Exposure Calculation

M2SmartSE + M2UHF-RFID

V1.06



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Dieses Dokument darf ohne Zustimmung weder vervielfältigt noch Dritten zugänglich gemacht werden.



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1 Test Standard

KDB 447498 D01 v06

RSS-102, Issue 5, March 2015

2 Description of the product:

The M2UHF-RFID is a plug-on Module for the mobile handheld Computer M2Smart@SE. It contains a UHF RFID Module which uses frequencies from 902.75 MHz to 927.25 MHz.

The UHF RFID Module Impinj Indy® RS500 is pre-certified (FCC ID: TWY-IPJRS500, IC: 6324A-IPJRS500).

After plugging on the M2UHF-RFID Module to the M2Smart@SE the M2Smart@SE will recognize the module but won't power up the UHF-RFID part. While starting the ACD M2UHF-RFID App the UHF-RFID part will be powered up and initialized, the RF part is still not active.

To activate the RF part the user has to navigate into the "Scan" Menu and press a "Start" button to read a tag. If the user forgets to deactivate the reading, it will be automatically turned off after 118 seconds.

The M2Smart@SE in combination with the M2UHF-RFID Module does not have a bag, holster or any other accessory, that is sold in any FCC or IC relevant country, which brings the device closer to the human body than stated in this report.



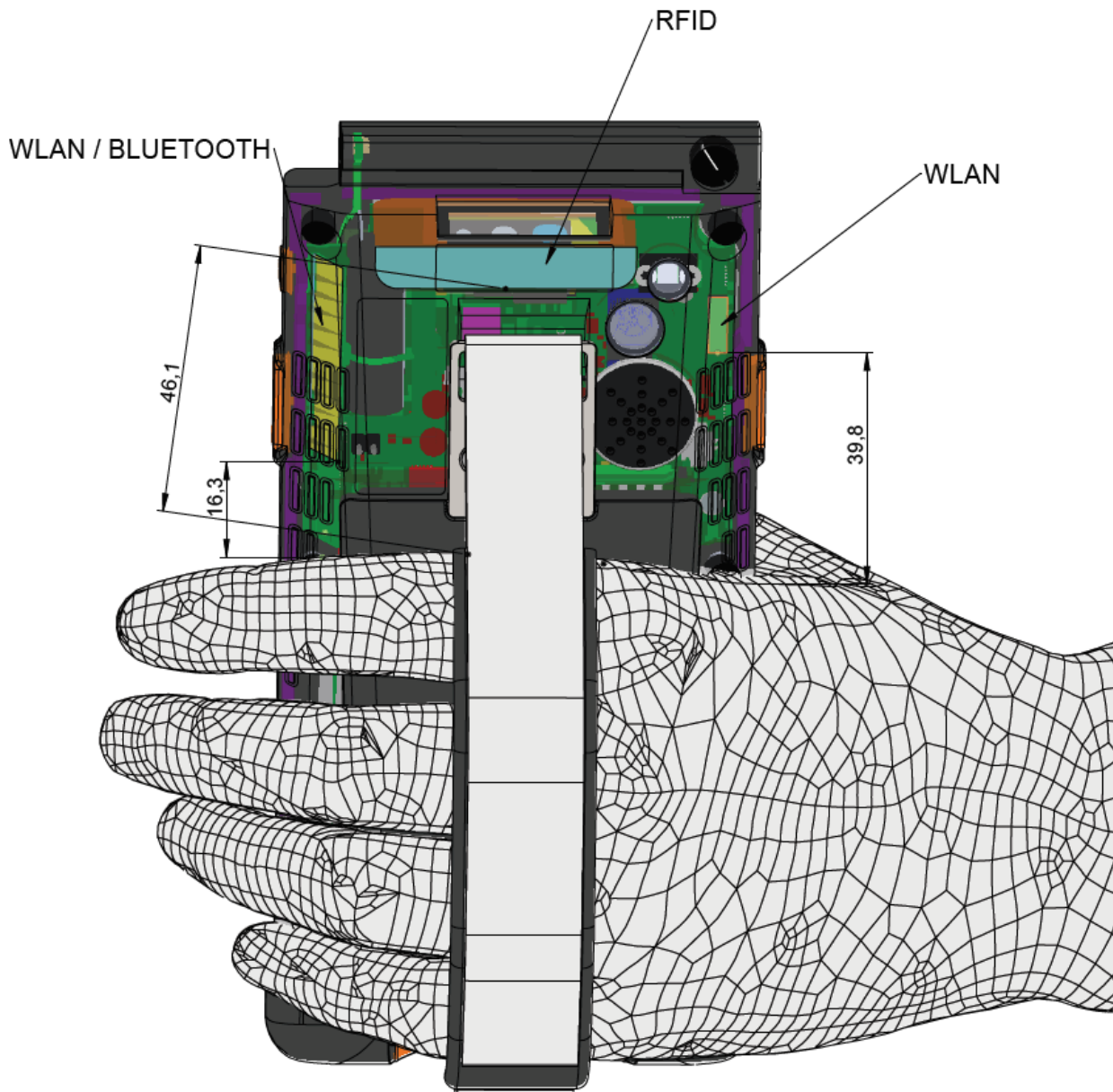
3 SAR test exclusion considerations

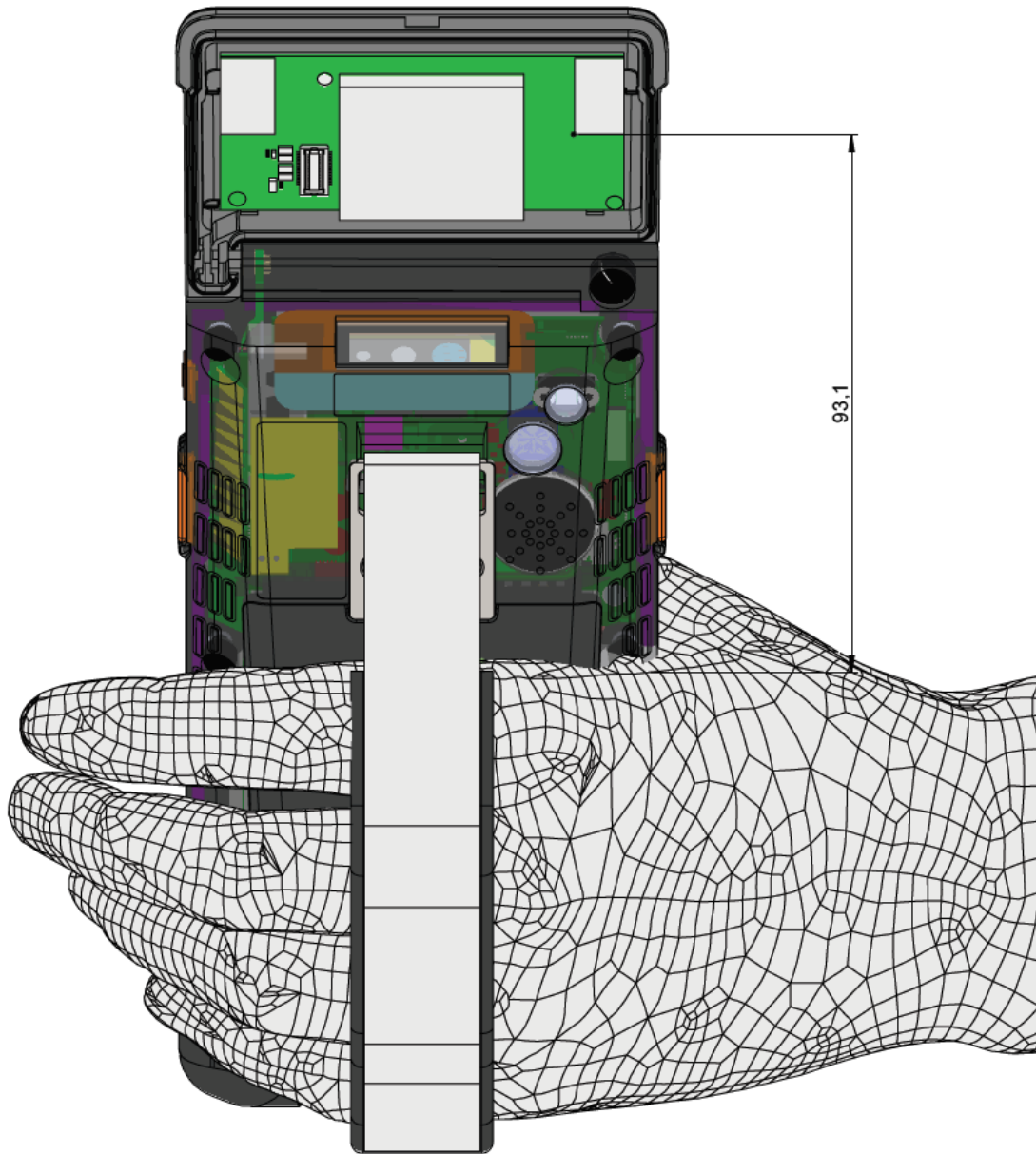
3.1 Evaluation according to KDB 447498 D01 v06

According to RF exposure guidance:

Systems operating under the provisions of this section shall be operated in a manner that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

3.1.1 Determination of the SAR test exclusion threshold





Antenna	Technology	Distance r (mm)	Gain (dBi)
A	WLAN	39.8	3.2 (2.4 GHz) 4.2 (5 GHz)
B	WLAN / BLE	16.3	2.5 (2.4 GHz) 4.4 (5 GHz)
C	RFID	46.1	-
D	UHF RFID	93.1	-0.47

The hand of the user is the nearest extremity of a human being therefore the threshold for 10-g us determined.



Formula under 4.3.1 b) for 100 MHz to 6 GHz for standalone equipment is used:

Step a):

$[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})}] \leq 7.5$ for 10-g extremity SAR

Step b):

$\{[\text{Power allowed at numeric threshold for 50 mm in step a)}] + [(\text{test separation distance} - 50 \text{ mm}) \cdot (f(\text{MHz})/150)]\}$ mW, for 100 MHz to 1500 MHz

The formula under 4.3.1 c) for frequencies below 100 MHz is used:

step a):

$\{[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] \cdot [\sqrt{f(0.1 \text{ GHz})}]\} \leq 7.5$ for 10-g extremity SAR;

Step b):

$\{[\text{Power allowed at numeric threshold for 50 mm in step a)}] + [(\text{test separation distance} - 50 \text{ mm}) \cdot (f(100 \text{ MHz})/150)] \cdot [1 + \log(100/f(\text{MHz}))]\}$ mW

BLE 5.0 (Antenna B):

Power allowed at numeric threshold for 16.3 mm:

max. power = $\{7.5 / \sqrt{f(\text{GHz})} \cdot [\text{min. test separation distance (mm)}]\}$ mW
= $\{7.5 / \sqrt{2.480} \cdot 16.3\}$ mW
= 77.63 mW

The max conducted average power is according the equipment:

Rated output power:	4.0 mW	6.0 dBm
Tune-up tolerance:	1.0 dB / -3.0 dB	
Maximum output power:	7.0 dBm	5.0 mW
Antenna gain max:	2.5 dBi	

Conclusion: The maximum output power, 5.0 mW is much lower than the limit of 77.63 mW, thus SAR measurement is NOT necessary.

WLAN 2.4 GHz – Antenna A:

Power allowed at numeric threshold for 39.8 mm:

max. power = $\{7.5 / \sqrt{f(\text{GHz})} \cdot [\text{min. test separation distance (mm)}]\}$ mW
= $\{7.5 / \sqrt{2.480} \cdot 39.8\}$ mW
= 189.55 mW

The max conducted average power is according the equipment:

Rated output power:	40.0 mW	16.0 dBm
Tune-up tolerance:	1.0 dB / -3.0 dB	
Maximum output power:	17.0 dBm	50.4 mW
Antenna gain max:	3.2 dBi	

Conclusion: The maximum output power, 50.4 mW is much lower than the limit of 189.55 mW, thus SAR measurement is NOT necessary.



WLAN 2.4 GHz – Antenna B:

Power allowed at numeric threshold for 16.3 mm:

$$\begin{aligned} \text{max. power} &= \{7.5 / \sqrt{f(\text{GHz})} * [\text{min. test separation distance (mm)}]\} \text{ mW} \\ &= \{7.5 / \sqrt{2.480} * 16.3\} \text{ mW} \\ &= 77.63 \text{ mW} \end{aligned}$$

The max conducted average power is according the equipment:

Rated output power:	40.0 mW	16.0 dBm
Tune-up tolerance:	1.0 dB / -3.0 dB	
Maximum output power:	17.0 dBm	50.4 mW
Antenna gain max:	3.2 dBi	

Conclusion: The maximum output power, 50.4 mW is much lower than the limit of 77.63 mW, thus SAR measurement is NOT necessary.

WLAN 5 GHz – Antenna A:

Power allowed at numeric threshold for 39.8 mm:

$$\begin{aligned} \text{max. power} &= \{7.5 / \sqrt{f(\text{GHz})} * [\text{min. test separation distance (mm)}]\} \text{ mW} \\ &= \{7.5 / \sqrt{5.825} * 39.8\} \text{ mW} \\ &= 123.68 \text{ mW} \end{aligned}$$

The max conducted average power is according the equipment:

Rated output power:	31.5 mW	15.0 dBm
Tune-up tolerance:	1.0 dB / -3.0 dB	
Maximum output power:	16.0 dBm	39.7 mW
Antenna gain max:	4.2 dBi	

Conclusion: The maximum output power, 39.7 mW is much lower than the limit of 123.68 mW, thus SAR measurement is NOT necessary.

WLAN 5 GHz – Antenna B:

Power allowed at numeric threshold for 16.3 mm:

$$\begin{aligned} \text{max. power} &= \{7.5 / \sqrt{f(\text{GHz})} * [\text{min. test separation distance (mm)}]\} \text{ mW} \\ &= \{7.5 / \sqrt{5.825} * 16.3\} \text{ mW} \\ &= 50.65 \text{ mW} \end{aligned}$$

The max conducted average power is according the equipment:

Rated output power:	31.5 mW	15.0 dBm
Tune-up tolerance:	1.0 dB / -3.0 dB	
Maximum output power:	16.0 dBm	39.7 mW
Antenna gain max:	4.4 dBi	

Conclusion: The maximum output power, 39.7 mW is much lower than the limit of 50.65 mW, thus SAR measurement is NOT necessary.



RFID (Antenna C):

The calculation of the EIRP level of the fundamental frequency is done according to KDB 412172 D01 subclause 1.3.1 formula (1). The used field strength is taken from the test report T47042-00-02SK issued by CSA Group Bayern GmbH.

Field strength at a test distance of 3 m: 60.1 dB μ V/m

$$\text{EIRP} = (E \times d)^2 / 30$$

where EIRP = equivalent isotropically radiated power in Watts
E = electrical field strength in V/m
d = measured distance in metres

$$\text{EIRP} = (0.001012 \times 3)^2 / 30 \text{ W} = \mathbf{921 \text{ nW}}$$

Power allowed at numeric threshold for 46.1 mm:

$$\begin{aligned} \text{max. power} &= \{7.5 / \sqrt{f(\text{GHz})} [\text{min. test separation distance (mm)}]\} \text{ mW} \\ &= \{7.5 / \sqrt{0.1} * 46.1\} \text{ mW} \\ &= 1093.36 \text{ mW} \end{aligned}$$

The max conducted average power is according the equipment:

Maximum EIRP:	-30.4 dBm	921.0 nW
Minimum distance r:	49.9 mm	

Conclusion: The maximum output power, 921.0 nW is much lower than the limit of 1093.36 mW, thus SAR measurement is NOT necessary.



UHF-RFID (Antenna D):

Power allowed at numeric threshold for 50 mm in step a):

$$\begin{aligned} \text{max. power} &= \{7.5 / \sqrt{f(\text{GHz})} * [\text{min. test separation distance (mm)}]\} \text{ mW} \\ &= \{7.5 / \sqrt{0.90275} * 50.0\} \text{ mW} \\ &= 394.68 \text{ mW} \end{aligned}$$

Power allowed for 93.1 mm separation distance:

$$\begin{aligned} &\{[\text{Power allowed at numeric threshold for 50 mm in step a)}] + [(\text{test separation distance} - 50 \\ &\text{mm}) \cdot (f(\text{MHz})/150)]\} \text{ mW} \\ &= [394.68 + (93.1-50.0) \cdot (902.75/150)] \text{ mW} \\ &= 654.07 \text{ mW} \end{aligned}$$

The max conducted average power is according the equipment:

Rated output power:	23 dBm	200.0 mW
Maximum output power stated in Datasheet of the RF module:	23 dBm	
Tune-up tolerance:	0.5 dBm	223.87 mW

Maximum output power measured by CSA Group Bayern GmbH:	24.5 dBm	281.84 mW
Tune-up tolerance:	0.5 dBm	
Maximum output power:	25.0 dBm	316.2 mW

Antenna gain max: -0.47 dBi

Conclusion: The maximum output power, 316.2 mW is much lower than the limit of 654.07 mW, thus SAR measurement is NOT necessary.

Remarks: As worst case the power values are not averaged over time.



3.1.2 Determination of the SAR test exclusion for simultaneous transmission

Simultaneous transmission SAR test exclusion considerations according to KDB 447498 4.3.2

Formulas according to KDB 447498 4.3.2 b)

1) $[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})/x}] \text{ W/kg}$, for test separation distances $\leq 50 \text{ mm}$;
where $x = 7.5$ for 1-g SAR and $x = 18.75$ for 10-g SAR

2) 0.4 W/kg for 1-g SAR and 1.0 W/kg for 10-g SAR, when the test separation distance is $> 50 \text{ mm}$

BLE:

$$[(5 \text{ mW}) / 16.3 \text{ mm}] \cdot [\sqrt{f(2.480 \text{ GHz})/18.75}] = \mathbf{0.026 \text{ W/Kg}}$$

WIFI 2.4 GHz:

$$[(50.4 \text{ mW}) / 16.3 \text{ mm}] \cdot [\sqrt{f(2.480 \text{ GHz})/18.75}] = \mathbf{0.26 \text{ W/Kg}}$$

WIFI 5 GHz:

$$[(39.7 \text{ mW}) / 16.3 \text{ mm}] \cdot [\sqrt{f(5.825 \text{ GHz})/18.75}] = \mathbf{0.31 \text{ W/Kg}}$$

HF-RFID:

$$[(0.921 \text{ mW}) / 50 \text{ mm}] \cdot [\sqrt{f(0.1 \text{ GHz})/18.75}] = \mathbf{0.0003 \text{ W/Kg}}$$

UHF-RFID:

$$[(281.84 \text{ mW}) / 50 \text{ mm}] \cdot [\sqrt{f(0.90275 \text{ GHz})/18.75}] = \mathbf{0.29 \text{ W/Kg}}$$

Summary:

$$\begin{aligned} \text{BLE} + \text{WIFI} + \text{HF-RFID} + \text{UHF-RFID} &= 0.026 \text{ W/Kg} + 0.31 \text{ W/Kg} + 0.0003 \text{ W/Kg} + 0.29 \text{ W/Kg} \\ &= \mathbf{0.6263 \text{ W/Kg}} \end{aligned}$$

0.6263 W/Kg is under the limit of 1 W/Kg for 10-g SAR.

The requirements are **FULFILLED**.

Remarks:

BLE (antenna B) can only be in simultaneous transmission for WLAN with antenna A.
WIFI power level refers to the total power on both antenna ports (antenna A + antenna B). WIFI 2.4 GHz and WIFI 5 GHz are not working simultaneously.
Worst case for WIFI is total power to Antenna B at 5 GHz.



3.2 Evaluation according to RSS-102, item 2.5.1

Table 1: SAR evaluation — Exemption limits for routine evaluation based on frequency and separation distance^{4,5}

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of 30 mm	At separation distance of 35 mm	At separation distance of 40 mm	At separation distance of 45 mm	At separation distance of ≥50 mm
≤300	223 mW	254 mW	284 mW	315 mW	345 mW
450	141 mW	159 mW	177 mW	195 mW	213 mW
835	80 mW	92 mW	105 mW	117 mW	130 mW
1900	99 mW	153 mW	225 mW	316 mW	431 mW
2450	83 mW	123 mW	173 mW	235 mW	309 mW
3500	86 mW	124 mW	170 mW	225 mW	290 mW
5800	56 mW	71 mW	85 mW	97 mW	106 mW

For Bluetooth, WIFI and RFID the stringent limits of the table above are used because the benefits of using linear interpolation would be negligible since the exemption limits of the next step are nearly the same.

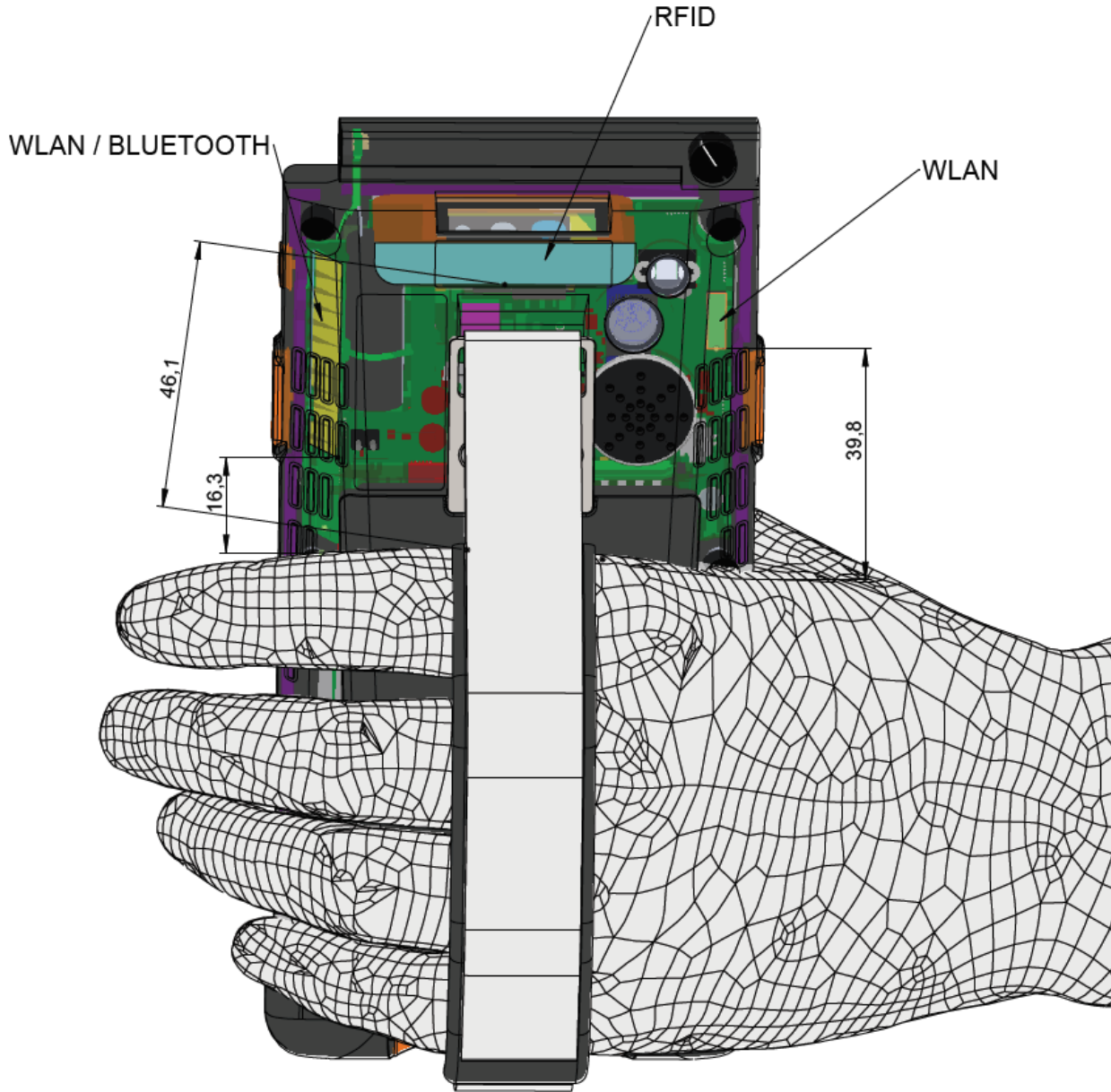
For UHF-RFID Linear Interpolation is used:

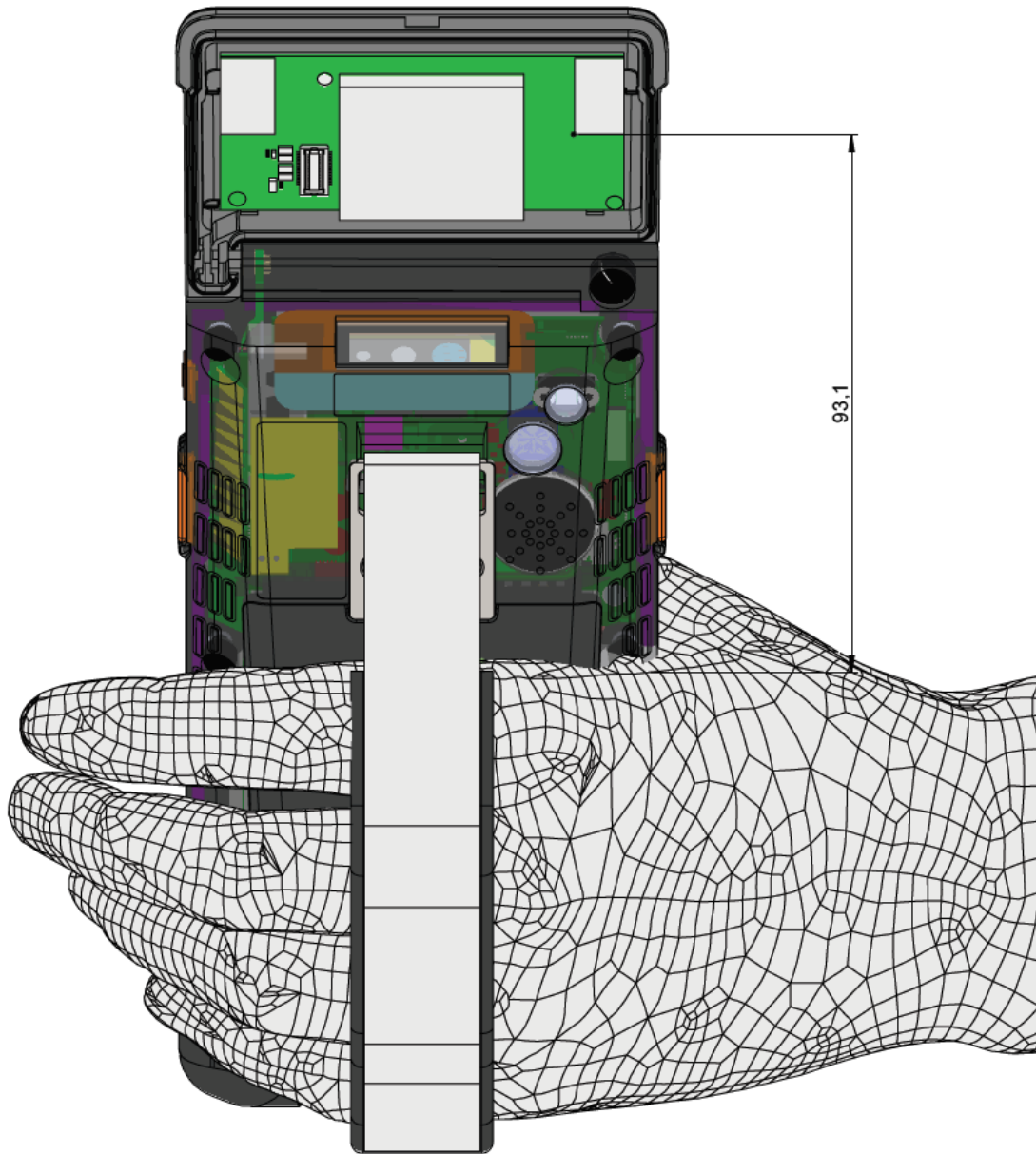
Linear Interpolation to 902.25 MHz for separation distance of ≥50 mm:

= 148.83 mW, for Limb-Worn devices it will be multiplied by a factor 2.5 = **372.07 mW**



Determination of minimum distance r:





Antenna	Technology	Distance r (mm)	Gain (dBi)
A	WLAN	39.8	3.2 (2.4 GHz) 4.2 (5 GHz)
B	WLAN / BLE	16.3	2.5 (2.4 GHz) 4.4 (5 GHz)
C	RFID	45.1	-
D	UHF RFID	93.1	-0.47 dB



BLE 5.0 (Antenna B):

Rated output power:	4.0 mW	6.0 dBm
Tune-up tolerance:	1.0 dB / -3.0 dB	
Maximum output power:	7.0 dBm	5.0 mW
Antenna gain max:	2.5 dBi	
Maximum EIRP:	9.5 dBm	9.0 mW
Minimum distance r:	16.3 mm	

Maximum EIRP at 2450 MHz, **9.0 mW**, is lower than the Exemption Limit of **37.5 mW**.

WLAN 2.4 GHz:

Antenna A:

Rated output power:	40.0 mW	16.0 dBm
Tune-up tolerance:	1.0 dB / -3.0 dB	
Maximum output power:	17.0 dBm	50.4 mW
Antenna gain max:	3.2 dBi	
Maximum EIRP:	20.2 dBm	105.2 mW
Minimum distance r:	39.8 mm	

Maximum EIRP at 2450 MHz, **105.2 mW**, is lower than the Exemption Limit of **307.5 mW**.

Antenna B:

For Operation in Canada (IC) the rated output power of antenna B at 2.4 GHz is reduced to 12 dBm = 15.85 mW

Rated output power:	15.8 mW	12.0 dBm
Tune-up tolerance:	1.0 dB / -3.0 dB	
Maximum output power:	13.0 dBm	20.0 mW
Antenna gain max:	2.5 dBi	
Maximum EIRP:	15.5 dBm	35.5 mW
Minimum distance r:	16.3 mm	

Maximum EIRP at 2450 MHz, **35.5 mW**, is lower than the Exemption Limit of **37.5 mW**.

WLAN 5 GHz

Antenna A:

Rated output power:	31.5 mW	15.0 dBm
Tune-up tolerance:	1.0 dB / -3.0 dB	
Maximum output power:	16.0 dBm	39.7 mW
Antenna gain max:	4.2 dBi	
Maximum EIRP:	20.2 dBm	104.3 mW
Minimum distance r:	39.8 mm	

Maximum EIRP at 5800 MHz, **104.3 mW**, is lower than the Exemption Limit of **177.5 mW**.



Antenna B:

For Operation in Canada (IC) the rated output power of antenna B at 5 GHz is reduced to 10 dBm = 10 mW

Rated output power:	10.0 mW	10.0 dBm
Tune-up tolerance:	1.0 dB / -3.0 dB	
Maximum output power:	11.0 dBm	12.6 mW
Antenna gain max:	4.4 dBi	
Maximum EIRP:	15.4 dBm	34.7 mW
Minimum distance r:	16.3 mm	

Maximum EIRP at 5800 MHz, **34.7 mW**, is lower than the Exemption Limit of **37.5 mW**.

RFID 13.56 MHz:

Maximum EIRP:	-30.4 dBm	921.0 nW
Minimum distance r:	49.9 dBm	

Maximum EIRP at ≤ 300 MHz, **921.0 nW**, is lower than the Exemption Limit of **787.5 mW**.

UHF-RFID:

Rated output power:	23 dBm	200.0 mW
Maximum output power stated in Datasheet of the RF module:	23 dBm	
Tune-up tolerance:	0.5 dBm	
Maximum output power:	23.5 dBm	223.87 mW
Maximum output power measured by CSA Group Bayern GmbH:	24.5 dBm	281.84 mW
Tune-up tolerance:	0.5 dBm	
Antenna gain max:	-0.47 dBi	
Maximum EIRP	25.0 dBm	316.2 mW
Minimum distance r:	93.1 mm	

Maximum EIRP at 902.25 MHz, **316.2 mW**, is lower than Exemption Limit of **372.07 mW**.

Remarks: As worst case the power values are not averaged over time.



3.2.1 Simultaneous transmission

The SAR exemption limits outlined in clause 2.5.1 of RSS-102 have been derived based on an approximate SAR value of 0.4 W/kg using half-wave dipole antennas. As such, when simultaneous transmitter SAR evaluations include transmitters that have been exempt from routine SAR evaluation, the SAR must be estimating based on the ratio between the maximum tune-up tolerance limit of the transmitter that has been exempt and the exemption limit at the specific distance and frequency for that transmitter. This ratio must be multiplied by 0.4 W/kg(2.0 W/kg for controlled use and 1.0 W/kg for limb worn devices) in order to calculate the estimated SAR level.

The estimate SAR value is calculated based the following equation:

(maximum power level including tune-up tolerance for transmitter A / maximum power level of exemption at the same frequency and distance) * (0.4W/kg* 2.5)

For limb worn devices.

Maximum ration BLE	Maximum ration WLAN	Maximum ratio HF-RFID	Maximum ratio UHF-RFID	Sum of exposure ratios	Limit of exposure ratios	Margin
mW/kg	mW/kg	mW/kg	mW/kg	mW/kg	mW/kg	mW/kg
240.00	946.67	1.17	849.84	2037.68	4000	1962.32

The requirements are **FULFILLED**.

Remarks: BLE (Antenna B) can only be in simultaneous transmission for WLAN (Antenna A)
WIFI power level refers to the total power on both antenna ports (antenna A + antenna B).
Worst case for Wifi: total power to Antenna B at 2.4 GHz.