

1 RF Exposure Report

This report is part of main report no. ULR-TC56882030000059F & ULR-TC56882030000060F

1.1 RF Exposure Measurement

The limit for Maximum Permissible Exposure (MPE) specified in FCC Part 1 Subpart I 1.1310 is followed. The gain of the antennas used in the product are extracted from the Antenna data sheets provided and also the maximum total power input to the antenna is measured. Through the Friis transmission formula and the maximum gain of the antenna, we can calculate the distance, away from the product, where the limit of MPE is reached.

Although the Friis Transmission formula is far field assumption, the calculated result of that is an over-prediction for near field power density. It is taken as worst case to specify the safety range.

Exemption limits for Routine Evaluation is applied according to RSS- 102 issue 5, section 2.5.2.

1.2 RF Exposure Limit

1) According to FCC Part 1 Subpart I 1.1310 The criteria listed in the following table shall be used to evaluate the environmental impact of the human exposure to radio-frequency (RF) radiation as specified in 1.1307 (b)

Table 1: Limits for Maximum Permissible Exposure (MPE) as per FCC

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm ²)
Limits for Occupational / controlled Exposures			
300 - 1500	--	--	F/300
1500 – 100000	--	--	5.0
Limits for General population / Uncontrolled Exposure			
300 - 1500	--	--	F/1500
1500 – 100000	--	--	1.0

F= Frequency in MHz

Table 2: Limits for Maximum Permissible Exposure (MPE) as per ISED Canada

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m ²)
Limits for Occupational / controlled Exposures			
100-6000	$15.60f^{0.25}$	$0.04138f^{0.25}$	$0.6455f^{0.5}$
Limits for General population / Uncontrolled Exposure			
300-6000	$3.142 f^{0.3417}$	$0.008335f^{0.3417}$	$0.02619f^{0.6834}$

F or f = Frequency in MHz

Prüfbericht - Nr.: Test Report No.:	Reference test report No: ULR-TC568820300000059F & ULR-TC568820300000060F	Seite 2 von 4 Page 2 of 4
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Friss Formula

Friss Transmission Formula: $P_d = (P_{out} * G) / (4\pi r^2)$

Where

P_d = power density in mW/cm^2

P_{out} = output power to antenna in mW

G = gain of antenna in linear scale

$\pi = 3.1416$

R = Distance between observation point and the center of radiator in cm

If we know the maximum gain of the antenna and the total output power to the antenna, through calculation, we will know MPE value at distance 20cm.

2) According to RSS 102 Issue 5 Section 2.5.2 The criteria listed in the following table shall be used to evaluate the environmental impact of the human exposure to radio-frequency (RF) radiation as specified in Section 2.5.2

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834} \text{ W}$ (adjusted for tune-up tolerance), where f is in MHz;

Table 2: Exemption Limits for Routine Evaluation – RSS 102 Issue 5 Section 2.5.2

Exemption calculation for standalone mode of operation

Protocol: Wi-Fi, BLE & BT

Protocol	Antenna Gain	Channel	Relative power level setting configured in the software	Maximum measured Pout	Tune up Value	Maximum e.i.r.p (dBm)	Maximum e.i.r.p	Exclusion threshold as per RSS-102
	(dBi)	(MHz)		(dBm)	(dB)		(W)	(W)
Wi-Fi	3.7	2412	18	17.92	1	22.62	0.18281	2.68403
BT	3.7	2480	4	1.90	1	6.60	0.00457	2.73551
BLE	3.7	2480	0	-11.47	1	-6.77	0.00021	2.73551

Exemption calculation for simultaneous mode operation of BT and Wi-Fi

RF Protocol	Total Calculated EIRP Ratio	Final EIRP ratio	Limit
Wi-Fi 2.4GHz+BT	=0.06811+0.00167	0.06978	<1

Hence RF exposure evaluation for ISED is not required for Wi-Fi & BT protocols

Note :

- For above table, to calculate EIRP For simultaneous operation following formula is used

$EIRP_{RF\ 1} / EIRP_{Limit\ of\ RF\ 1} + EIRP_{RF\ 2} / EIRP_{Limit\ of\ RF\ 2} + \dots + EIRP_{RF\ n} / EIRP_{Limit\ of\ RF\ n} < 1$

Prüfbericht - Nr.: Test Report No.:	Reference test report No: ULR-TC56882030000059F & ULR-TC56882030000060F	Seite 3 von 4 Page 3 of 4
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Note:

1. Antenna gain values are taken from Espreiff module FCC Test report (FCC ID: 2AC7Z-ESPWROOM32D)
2. Maximum Pout values are taken from the test Wi-Fi & BT test reports ULR-TC56882030000059F & ULR-TC56882030000060F

1.2.1 EUT Operation condition

EUT was enabled to transmit and receive at lowest, middle and highest channels.

1.2.2 Assessment Condition

The antenna of this product, under normal use condition, is at least 20cm away from the body of the user.

Warning statement to the user for keeping at least 20cm or more separation distance from the antenna should be included in the User manual. So, this device is classified as Mobile device.

Note: ± 1 dB tune up value is considered for MPE calculation, this value was declared by manufacturer

Table 3: Test Results for Maximum Permissible Exposure for standalone mode of operation

Protocol: Wi-Fi 2.4GHz, BLE & BT

Protocol	Antenna Gain	Antenna Gain in linear scale	Channel (MHz)	Relative power level setting configured in the software	Maximum Pout	Tune up Value in	Maximum Power including tune up value	Power Density	FCC Limit
	(dBi)				(dBm)	(dB)	(mW)	(mW/cm²)	(mW/cm²)
Wi-Fi	3.7	2.344	2412	18	17.92	1	77.98	0.03636	1
BT	3.7	2.344	2480	4	1.90	1	1.94	0.00090	
BLE	3.7	2.344	2480	0	-11.47	1	0.089	0.00004	

Note:

1. Antenna gain values are taken from Espreiff module FCC Test report (FCC ID: 2AC7Z-ESPWROOM32D)
2. Maximum Pout values are taken from the Wi-Fi & BT test reports ULR-TC56882030000059F & ULR-TC56882030000060F

Table 4: Test Results for Maximum Permissible Exposure for Simultaneous operating mode of BT and Wi-Fi

RF Protocol	Calculated MPE	Final MPE	Limit
Wi-Fi 2.4GHz+BT+BLE	= $(0.03636)+(0.00090)$	0.03726	<1

Note :

2. For above table, to calculate MPE following formula is used

$$\text{MPE RF 1 / Limit RF 1} + \text{MPE RF2 / LIMIT RF 2} + \dots + \text{MPE RFn / Limit RFn} < 1$$

Prüfbericht - Nr.: Test Report No.:	Reference test report No: ULR-TC568820300000059F & ULR-TC568820300000060F	Seite 4 von 4 Page 4 of 4
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1.3 Conclusion

Table 4 list possible combination; hence, the RF exposure analysis concluded that the RF exposure is compliant as per the limit specified in clause 1.2 of this report

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