

APPENDIX E: MULTI-TX AND ANTENNA SAR CONSIDERATIONS

E.1 Introduction

The following procedures adopted from FCC KDB Publication 447498 D04v01 are applicable to devices with built-in unlicensed transmitters such as 802.11 and Bluetooth devices which may simultaneously transmit with the licensed transmitter.

E.2 Simultaneous Transmission Procedures

This device contains transmitters that may operate simultaneously. Therefore, simultaneous transmission analysis is required. Per FCC KDB Publication 447498 D04v01 and IEEE 1528-2013 Section 6.3.4.1.2, simultaneous transmission SAR test exclusion may be applied when the sum of the 1g SAR for all the simultaneous transmitting antennas in a specific physical test configuration is ≤ 1.6 W/kg. The different test positions in an exposure condition may be considered collectively to determine SAR test exclusion according to the sum of 1g or 10g SAR.

When standalone SAR is not required to be measured, per FCC KDB 447498 D04v01 Appendix E, the following equation must be used to estimate the standalone 1g SAR for simultaneous transmission assessment involving that transmitter. When 10g SAR is needed, a factor of 2.5 is applied.

$$\text{Estimated SAR} = 1.6 * \frac{P_{ant}}{P_{th}}, \quad [W/kg] \quad (1)$$

Where:

- P_{ant} is the maximum time-averaged power or effective radiated power (ERP)
- P_{th} is the threshold power defined in equation 2.

$$P_{th}(mW) = \begin{cases} ERP_{20cm}(d/20cm)^x & d \leq 20 \text{ cm} \\ ERP_{20cm} & 20 < d \leq 40 \text{ cm} \end{cases} \quad (2)$$

Where:

- x is defined in equation 3
- $ERP_{20 \text{ cm}}$ is defined in equation 4
- d is the separation distance (cm)

$$x = -\log_{10} \left(\frac{60}{ERP_{20cm} \cdot \sqrt{f}} \right) \quad (3)$$

$$ERP_{20 \text{ cm}}(mW) = \begin{cases} 2040f & 0.3 \text{ GHz} \leq f < 1.5 \text{ GHz} \\ 3060 & 1.5 \text{ GHz} \leq f \leq 6 \text{ GHz} \end{cases} \quad (4)$$

Where:

- f is the frequency in GHz

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Table E-1
Estimated Extremity SAR

Mode	Frequency	Maximum Allowed Power	Separation Distance (Body)	Estimated SAR (Body)
	[MHz]	[dBm]	[mm]	[W/kg]
ANT/ANT+	2441	6	5	2.314

E.3 SAR Simultaneous Transmission Analysis

Table E-1
Simultaneous Transmission Scenarios of LTE-M/BT/BLE (Head)

Head	LTE-M B12 SAR (W/kg)	LTE-M B4 SAR (W/kg)	LTE-M B2 SAR (W/kg)	BT SAR (W/kg)	LTE-M + BT + SAR
	0.003	0.014	0.063	0.004	0.067

Notes:

- For all combinations where the sum is less than 1.6 W/kg, there's no further analysis required for compliance demonstration.

Table E-3
Simultaneous Transmission Scenarios of LTE-M/BT/BLE (Extremity)

Extremity	LTE-M B12 SAR (W/kg)	LTE-M B4 SAR (W/kg)	LTE-M B2 SAR (W/kg)	BT SAR (W/kg)	LTE-M + BT SAR
	0.054	0.168	0.334	0.017	0.351

Table E-4
Simultaneous Transmission Scenarios of LTE-M/ANT/ANT+ (Extremity)

Extremity	LTE-M B12 SAR (W/kg)	LTE-M B4 SAR (W/kg)	LTE-M B2 SAR (W/kg)	ANT/ANT+ SAR (W/kg)	LTE-M + ANT/ANT+ SAR
	0.054	0.168	0.334	2.314	2.648

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Table E-5
Simultaneous Transmission Scenarios of LTE-M/2.4 WIFI (Extremity)

Extremity	LTE-M B12 SAR (W/kg)	LTE-M B4 SAR (W/kg)	LTE-M B2 SAR (W/kg)	2.4 WIFI SAR (W/kg)	LTE-M + 2.4 WIFI SAR
	0.054	0.168	0.334	0.108	0.442

Table E-6
Simultaneous Transmission Scenarios of LTE-M/NFC (Extremity)

Extremity	LTE-M B12 SAR (W/kg)	LTE-M B4 SAR (W/kg)	LTE-M B2 SAR (W/kg)	NFC SAR (W/kg)	LTE-M + NFC SAR
	0.054	0.168	0.334	0.000	0.334

Table E-7
Simultaneous Transmission Scenarios of LTE-M/NFC/BT/BLE (Extremity)

Extremity	LTE-M B12 SAR (W/kg)	LTE-M B4 SAR (W/kg)	LTE-M B2 SAR (W/kg)	NFC SAR (W/kg)	BT SAR (W/kg)	LTE-M + NFC + BT SAR
	0.054	0.168	0.334	0.000	0.017	0.351

Table E-8
Simultaneous Transmission Scenarios of LTE-M/NFC/ANT/ANT+ (Extremity)

Extremity	LTE-M B12 SAR (W/kg)	LTE-M B4 SAR (W/kg)	LTE-M B2 SAR (W/kg)	NFC SAR (W/kg)	ANT/ANT+ SAR (W/kg)	LTE-M + NFC + ANT/ANT+ SAR
	0.054	0.168	0.334	0.000	2.314	2.648

Table E-9
Simultaneous Transmission Scenarios of LTE-M/NFC/2.4 WIFI (Extremity)

Extremity	LTE-M B12 SAR (W/kg)	LTE-M B4 SAR (W/kg)	LTE-M B2 SAR (W/kg)	NFC SAR (W/kg)	2.4 WIFI SAR (W/kg)	LTE-M + NFC + 2.4 WIFI SAR
	0.054	0.168	0.334	0.000	0.108	0.442

Table E-10
Simultaneous Transmission Scenarios of NTN/BT/BLE (Extremity)

Extremity	NTN B255 SAR (W/kg)	NTN B23 SAR (W/kg)	BT SAR (W/kg)	NTN + BT SAR
	0.162	0.362	0.017	0.379

Table E-11
Simultaneous Transmission Scenarios of NTN/ANT/ANT+ (Extremity)

Extremity	NTN B255 SAR (W/kg)	NTN B23 SAR (W/kg)	ANT/ANT+ SAR (W/kg)	NTN + ANT/ANT+ SAR
	0.162	0.362	2.314	2.678

Table E-12
Simultaneous Transmission Scenarios of NFC/BT/BLE (Extremity)

Extremity	NFC (W/kg)	BT (W/kg)	NFC + BT SAR
	0.000	0.017	0.017

Table E-13
Simultaneous Transmission Scenarios of NFC/ANT/ANT+ (Extremity)

Extremity	NFC SAR (W/kg)	ANT/ANT+ SAR (W/kg)	NFC + ANT/ANT+ SAR
	0.000	2.314	2.314

Table E-14
Simultaneous Transmission Scenarios of NFC/2.4 WIFI (Extremity)

Extremity	NFC SAR (W/kg)	2.4 WIFI SAR (W/kg)	NFC + 2.4 WIFI SAR
	0.000	0.108	0.108

Notes:

- For all combinations where the sum is less than 4 W/kg, there's no further analysis required for compliance demonstration.

E.4 Conclusion

The above numerical summed SAR results for all the combinations are sufficient to show that simultaneous transmission cases will not exceed the SAR limit and therefore no measured volumetric simultaneous SAR summation is required per FCC KDB Publication 447498 D04v01 and IEEE 1528- 2013 Section 6.3.4.

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