

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 4.3.2 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.

Note:

SAR Summations for some scenarios when the output power levels are reduced, SAR values at the maximum output power level were used as the most conservative evaluation for simultaneous transmission analysis.

For each position, the highest SAR value across all modes for the applicable cellular band antenna was considered for summation to determine simultaneous SAR test exclusion.

*The SAR distributions for at least one of the antennas are spatially separated from the other antennas per FCC KDB Publication 248227 Section 6.1 procedures. Therefore, simultaneous transmission was treated independently for this configuration. See section E.4 for more information about the Spatial Separation Analysis.

In some cases where simultaneous transmission scenarios overlap with the same power level (for example, cellular band + 2.4 GHz WIFI SISO and cellular band + 2.4 GHz WIFI MIMO), the most conservative SAR summation scenario was evaluated.

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E.3 Body SAR Simultaneous Transmission Analysis

Table E-1
Simultaneous Transmission Scenario with 2.4 GHz Bluetooth TxBF and wPT

Simult Tx	Configuration	2.4 GHz Bluetooth Ant WF7b ER	2.4 GHz Bluetooth Ant WF8 ER	wPT ER	Σ ER (W/kg)
		1	2	3	1+2+3
Body SAR	Back	0.098	0.088	0.015	0.201
	Top	0.636	0.715	0.000	0.715*
	Bottom	0.001	0.007	0.000	0.008
	Right	0.006	0.009	0.001	0.016
	Left	0.433	0.001	0.000	0.434

Table E-2
Simultaneous Transmission Scenario with NB U-NII TxBF and wPT

Simult Tx	Configuration	NB U-NII Ant WF7a ER	NB U-NII Ant WF8 ER	wPT ER	Σ ER (W/kg)
		1	2	3	1+2+3
Body SAR	Back	0.039	0.027	0.015	0.081
	Top	0.416	0.365	0.000	0.781
	Bottom	0.001	0.006	0.000	0.007
	Right	0.000	0.003	0.001	0.004
	Left	0.006	0.001	0.000	0.007

Table E-3
Simultaneous Transmission Scenario with 2.4 GHz WIFI, 2.4 GHz Bluetooth and wPT

Simult Tx	Configuration	2.4 GHz WIFI Ant WF8 ER	2.4 GHz Bluetooth Ant WF7b ER	wPT ER	Σ SAR (W/kg)
		1	2	3	1+2+3
Body SAR	Back	0.086	0.098	0.015	0.199
	Top	0.713	0.636	0.000	0.713*
	Bottom	0.001	0.001	0.000	0.002
	Right	0.008	0.006	0.001	0.015
	Left	0.001	0.433	0.000	0.434

Table E-4
Simultaneous Transmission Scenario with 2.4 GHz WIFI, 802.15.4 and wPT

Simult Tx	Configuration	2.4 GHz WIFI Ant WF8 ER	802.15.4 Ant WF7b ER	wPT ER	Σ SAR (W/kg)
		1	2	3	1+2+3
Body SAR	Back	0.086	0.073	0.015	0.174
	Top	0.713	0.629	0.000	0.713*
	Bottom	0.001	0.004	0.000	0.005
	Right	0.008	0.006	0.001	0.015
	Left	0.001	0.303	0.000	0.304

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Table E-5
Simultaneous Transmission Scenario with 5 GHz WIFI MIMO, 2.4 GHz Bluetooth TxBF and wPT

Simult Tx	Configuration	5 GHz WIFI Ant WF7a ER	5 GHz WIFI Ant WF8 ER	2.4 GHz Bluetooth Ant WF7b with 7 dB backoff ER	2.4 GHz Bluetooth Ant WF8 with 7 dB backoff ER	wPT ER	Σ ER (W/kg)
		1	2	3	4	5	1+2+3+4+5
Body SAR	Back	0.064	0.090	0.021	0.018	0.015	0.208
	Top	0.744	0.746	0.124	0.139	0.000	See Table Below
	Bottom	0.000	0.004	0.001	0.007	0.000	0.012
	Right	0.000	0.004	0.006	0.009	0.001	0.020
	Left	0.027	0.059	0.089	0.001	0.000	0.176
Simult Tx	Configuration	5 GHz WIFI MIMO ER	2.4 GHz Bluetooth Ant WF7b with 7 dB backoff ER	2.4 GHz Bluetooth Ant WF8 with 7 dB backoff ER	wPT ER		Σ ER (W/kg)
		1	2	3	4		1+2+3+4
Body SAR	Top	0.726	0.124	0.139	0.000		0.989

Table E-6
Simultaneous Transmission Scenario with 6 GHz WIFI MIMO, 2.4 GHz Bluetooth TxBF and wPT

Simult Tx	Configuration	6 GHz WIFI Ant WF7a ER	6 GHz WIFI Ant WF8 ER	2.4 GHz Bluetooth Ant WF7b with 7 dB backoff ER	2.4 GHz Bluetooth Ant WF8 with 7 dB backoff ER	wPT ER	Σ ER (W/kg)
		1	2	3	4	5	1+2+3+4+5
Body SAR	Back	0.028	0.027	0.021	0.018	0.015	0.109
	Top	0.670	0.554	0.124	0.139	0.000	See Table Below
	Bottom	0.003	0.012	0.001	0.007	0.000	0.023
	Right	0.003	0.025	0.006	0.009	0.001	0.044
	Left	0.006	0.001	0.089	0.001	0.000	0.097
Simult Tx	Configuration	6 GHz WIFI MIMO ER	2.4 GHz Bluetooth Ant WF7b with 7 dB backoff ER	2.4 GHz Bluetooth Ant WF8 with 7 dB backoff ER	wPT ER		Σ ER (W/kg)
		1	2	3	4		1+2+3+4
Body SAR	Top	0.634	0.124	0.139	0.000		0.897

Table E-7
Simultaneous Transmission Scenario with 802.15.4, 5 GHz WIFI MIMO and wPT

Simult Tx	Configuration	802.15.4 Ant WF7b with 7 dB backoff ER	5 GHz WIFI Ant WF8 ER	5 GHz WIFI Ant WF7a ER	wPT ER	Σ ER (W/kg)
		1	2	3	4	1+2+3+4
Body SAR	Back	0.020	0.090	0.064	0.015	0.189
	Top	0.105	0.746	0.744	0.000	See Table Below
	Bottom	0.004	0.004	0.000	0.000	0.008
	Right	0.006	0.004	0.000	0.001	0.011
	Left	0.088	0.059	0.027	0.000	0.174
Simult Tx	Configuration	802.15.4 Ant WF7b with 7 dB backoff ER	5 GHz WIFI MIMO ER	wPT ER		Σ ER (W/kg)
		1	2	3		1+2+3
Body SAR	Top	0.105	0.726	0.000		0.831

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Table E-8
Simultaneous Transmission Scenario with 802.15.4, 5 GHz WIFI MIMO and wPT

Simult Tx	Configuration	802.15.4 Ant WF8 with 7 dB backoff ER	5 GHz WIFI Ant WF8 ER	5 GHz WIFI Ant WF7a ER	wPT ER	Σ ER (W/kg)
		1	2	3	4	1+2+3+4
Body SAR	Back	0.018	0.090	0.064	0.015	0.187
	Top	0.110	0.746	0.744	0.000	See Table Below
	Bottom	0.008	0.004	0.000	0.000	0.012
	Right	0.011	0.004	0.000	0.001	0.016
	Left	0.001	0.059	0.027	0.000	0.087
Simult Tx	Configuration	802.15.4 Ant WF8 with 7 dB backoff ER	5 GHz WIFI MIMO ER	wPT ER		Σ ER (W/kg)
		1	2	3		1+2+3
Body SAR	Top	0.110	0.726	0.000		0.836

Table E-9
Simultaneous Transmission Scenario with 802.15.4, 6 GHz WIFI MIMO and wPT

Simult Tx	Configuration	802.15.4 Ant WF7b with 7 dB backoff ER	6 GHz WIFI Ant WF8 ER	6 GHz WIFI Ant WF7a ER	wPT ER	Σ ER (W/kg)
		1	2	3	4	1+2+3+4
Body SAR	Back	0.020	0.027	0.028	0.015	0.090
	Top	0.105	0.554	0.670	0.000	See Table Below
	Bottom	0.004	0.012	0.003	0.000	0.019
	Right	0.006	0.025	0.003	0.001	0.035
	Left	0.088	0.001	0.006	0.000	0.095
Simult Tx	Configuration	802.15.4 Ant WF7b with 7 dB backoff ER	6 GHz WIFI MIMO ER	wPT ER		Σ ER (W/kg)
		1	2	3		1+2+3
Body SAR	Top	0.105	0.634	0.000		0.739

Table E-10
Simultaneous Transmission Scenario with 802.15.4, 6 GHz WIFI MIMO and wPT

Simult Tx	Configuration	802.15.4 Ant WF8 with 7 dB backoff ER	6 GHz WIFI Ant WF8 ER	6 GHz WIFI Ant WF7a ER	wPT ER	Σ ER (W/kg)
		1	2	3	4	1+2+3+4
Body SAR	Back	0.018	0.027	0.028	0.015	0.088
	Top	0.110	0.554	0.670	0.000	See Table Below
	Bottom	0.008	0.012	0.003	0.000	0.023
	Right	0.011	0.025	0.003	0.001	0.040
	Left	0.001	0.001	0.006	0.000	0.008
Simult Tx	Configuration	802.15.4 Ant WF8 with 7 dB backoff ER	6 GHz WIFI MIMO ER	wPT ER		Σ ER (W/kg)
		1	2	3		1+2+3
Body SAR	Top	0.110	0.634	0.000		0.744

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Table E-11
Simultaneous Transmission Scenario with 2.4 GHz WIFI MIMO, NB U-NII TxBF and wPT

Simult Tx	Configuration	2.4 GHz WIFI Ant WF7b ER	2.4 GHz WIFI Ant WF8 ER	NB U-NII Ant WF7a with 7 dB backoff ER	NB U-NII Ant WF8 with 7 dB backoff ER	wPT ER	Σ SAR (W/kg)
		1	2	3	4	5	1+2+3+4+5
Body SAR	Back	0.109	0.086	0.039	0.027	0.015	0.276
	Top	0.738	0.713	0.122	0.113	0.000	0.860*
	Bottom	0.001	0.001	0.001	0.006	0.000	0.009
	Right	0.013	0.008	0.000	0.003	0.001	0.025
	Left	0.516	0.001	0.006	0.001	0.000	0.524

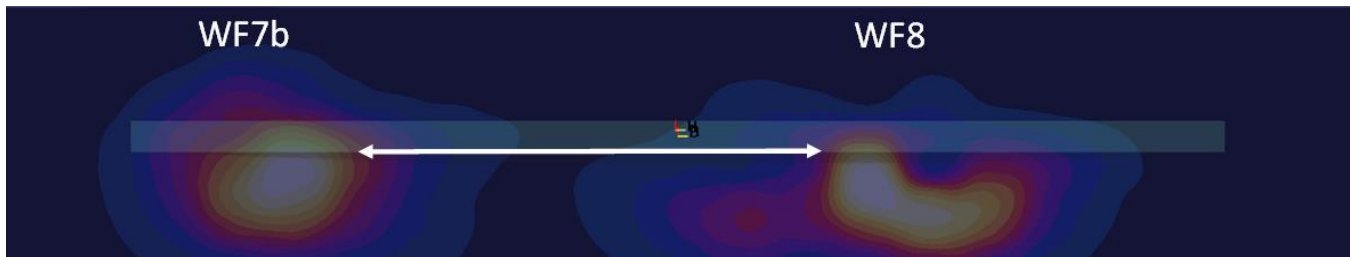
E.4 Spatial Separation Analysis

Per FCC KDB Publication 248227, antennas may be considered spatially separated when the aggregate SAR from multiple antennas at any location in the combined SAR distribution is either ≤ 1.2 W/kg where at least 90% of the SAR is attributed to a single SAR distribution or ≤ 0.4 W/kg where no more than one SAR distribution is contributing > 0.1 W/kg.

Spatial separation was determined by inspection of the area scan SAR distributions to confirm that at all locations, SAR was < 1.2 W/kg, where at least 90% of the SAR is attributed to a single SAR distribution. See below for illustrations of the spatial separated antennas considered.

E.4.1 Top Edge Spatial Separation Analysis

Figure E-1
Top Edge Spatial Separation for Antenna WF8 and Antenna WF7b



E.5 Simultaneous Transmission Conclusion

The above numerical summed SAR results for all the worst-case simultaneous transmission conditions were below the SAR limit. Therefore, the above analysis is sufficient to determine 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 6.3.4.1.2.

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