

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 WF2b ER	wPT ER	Σ SAR (W/kg)
		1	2	3	1+2+3
Body SAR	Back	0.049	0.060	0.016	0.125
	Top	0.272	0.005	0.000	0.277
	Bottom	0.003	0.284	0.000	0.287
	Right	0.000	0.341	0.001	0.342
	Left	0.023	0.003	0.000	0.026

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 WF2a ER	wPT ER	Σ SAR (W/kg)
		1	2	3	1+2+3
Body SAR	Back	0.033	0.070	0.016	0.119
	Top	0.288	0.000	0.000	0.288
	Bottom	0.000	0.425	0.000	0.425
	Right	0.000	0.055	0.001	0.056
	Left	0.003	0.000	0.000	0.003

Table E-3

Simultaneous Transmission Scenario with 2.4 GHz Bluetooth, 2.4 GHz WIFI and wPT

Simult Tx	Configuration	2.4 GHz Bluetooth Ant WF2b ER	2.4 GHz WIFI Ant WF7b ER	wPT ER	Σ SAR (W/kg)
		1	2	3	1+2+3
Body SAR	Back	0.060	0.155	0.016	0.231
	Top	0.005	0.741	0.000	0.746
	Bottom	0.284	0.021	0.000	0.305
	Right	0.341	0.001	0.001	0.343
	Left	0.003	0.059	0.000	0.062

Table E-4

Simultaneous Transmission Scenario with 802.15.4, 2.4 GHz WIFI and wPT

Simult Tx	Configuration	802.15.4 Ant WF2b ER	2.4 GHz WIFI Ant WF7b ER	wPT ER	Σ SAR (W/kg)
		1	2	3	1+2+3
Body SAR	Back	0.103	0.155	0.016	0.274
	Top	0.011	0.741	0.000	0.752
	Bottom	0.407	0.021	0.000	0.428
	Right	0.528	0.001	0.001	0.530
	Left	0.004	0.059	0.000	0.063

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

Simult Tx	Configuration	2.4 GHz Bluetooth Ant WF7b with 7 dB backoff ER	2.4 GHz Bluetooth Ant WF2b with 7 dB backoff ER	5 GHz WIFI Ant WF7a ER	5 GHz WIFI Ant WF2a ER	wPT ER	Σ SAR (W/kg)
		1	2	3	4	5	1+2+3+4+5
Body SAR	Back	0.049	0.060	0.108	0.101	0.016	0.334
	Top	0.118	0.005	0.719	0.006	0.000	0.848
	Bottom	0.003	0.113	0.004	0.724	0.000	0.844
	Right	0.000	0.119	0.002	0.110	0.001	0.232
	Left	0.023	0.003	0.009	0.019	0.000	0.054

Table E-6
Simultaneous Transmission Scenario with 2.4 GHz Bluetooth TxBF, 5 GHz WIFI MIMO and wPT

Simult Tx	Configuration	2.4 GHz Bluetooth Ant WF7b with 7 dB backoff ER	2.4 GHz Bluetooth Ant WF2b with 7 dB backoff ER	5 GHz WIFI Ant WF2a ER	5 GHz WIFI Ant WF7b ER	wPT ER	Σ SAR (W/kg)
		1	2	3	4	5	1+2+3+4+5
Body SAR	Back	0.049	0.060	0.101	0.068	0.016	0.294
	Top	0.118	0.005	0.006	0.733	0.000	0.862
	Bottom	0.003	0.113	0.724	0.014	0.000	0.854
	Right	0.000	0.119	0.110	0.002	0.001	0.232
	Left	0.023	0.003	0.019	0.143	0.000	0.188

Table E-7
Simultaneous Transmission Scenario with 2.4 GHz Bluetooth TxBF, 6 GHz WIFI MIMO and wPT

Simult Tx	Configuration	2.4 GHz Bluetooth Ant WF7b with 7 dB backoff ER	2.4 GHz Bluetooth Ant WF2b with 7 dB backoff ER	6 GHz WIFI Ant WF7a ER	6 GHz WIFI Ant WF2a ER	wPT ER	Σ SAR (W/kg)
		1	2	3	4	5	1+2+3+4+5
Body SAR	Back	0.049	0.060	0.004	0.034	0.016	0.163
	Top	0.118	0.005	0.739	0.000	0.000	0.862
	Bottom	0.003	0.113	0.000	0.531	0.000	0.647
	Right	0.000	0.119	0.000	0.016	0.001	0.136
	Left	0.023	0.003	0.006	0.000	0.000	0.032

Table E-8
Simultaneous Transmission Scenario with 2.4 GHz Bluetooth TxBF, 6 GHz WIFI MIMO and wPT

Simult Tx	Configuration	2.4 GHz Bluetooth Ant WF7b with 7 dB backoff ER	2.4 GHz Bluetooth Ant WF2b with 7 dB backoff ER	6 GHz WIFI Ant WF2a ER	6 GHz WIFI Ant WF7b ER	wPT ER	Σ SAR (W/kg)
		1	2	3	4	5	1+2+3+4+5
Body SAR	Back	0.049	0.060	0.034	0.051	0.016	0.210
	Top	0.118	0.005	0.000	0.489	0.000	0.612
	Bottom	0.003	0.113	0.531	0.001	0.000	0.648
	Right	0.000	0.119	0.016	0.001	0.001	0.137
	Left	0.023	0.003	0.000	0.073	0.000	0.099

Table E-9
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 WF7a ER	5 GHz WIFI Ant WF2a ER	wPT ER	Σ SAR (W/kg)
		1	2	3	4	1+2+3+4
Body SAR	Back	0.026	0.108	0.101	0.016	0.251
	Top	0.136	0.719	0.006	0.000	0.861
	Bottom	0.017	0.004	0.724	0.000	0.745
	Right	0.001	0.002	0.110	0.001	0.114
	Left	0.035	0.009	0.019	0.000	0.063

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Table E-10

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 WF2a ER	5 GHz WIFI Ant WF7b ER	wPT ER	Σ SAR (W/kg)
		1	2	3	4	1+2+3+4
Body SAR	Back	0.026	0.101	0.068	0.016	0.211
	Top	0.136	0.006	0.733	0.000	0.875
	Bottom	0.017	0.724	0.014	0.000	0.755
	Right	0.001	0.110	0.002	0.001	0.114
	Left	0.035	0.019	0.143	0.000	0.197

Table E-11

Simultaneous Transmission Scenario with 802.15.4, 5 GHz WIFI MIMO and wPT

Simult Tx	Configuration	802.15.4 Ant WF2b with 7 dB backoff ER	5 GHz WIFI Ant WF7b ER	5 GHz WIFI Ant WF2a ER	wPT ER	Σ SAR (W/kg)
		1	2	3	4	1+2+3+4
Body SAR	Back	0.023	0.068	0.101	0.016	0.208
	Top	0.011	0.733	0.006	0.000	0.750
	Bottom	0.098	0.014	0.724	0.000	0.836
	Right	0.119	0.002	0.110	0.001	0.232
	Left	0.004	0.143	0.019	0.000	0.166

Table E-12

Simultaneous Transmission Scenario with 802.15.4, 5 GHz WIFI MIMO and wPT

Simult Tx	Configuration	802.15.4 Ant WF2b with 7 dB backoff ER	5 GHz WIFI Ant WF7a ER	5 GHz WIFI Ant WF2a ER	wPT ER	Σ SAR (W/kg)
		1	2	3	4	1+2+3+4
Body SAR	Back	0.023	0.108	0.101	0.016	0.248
	Top	0.011	0.719	0.006	0.000	0.736
	Bottom	0.098	0.004	0.724	0.000	0.826
	Right	0.119	0.002	0.110	0.001	0.232
	Left	0.004	0.009	0.019	0.000	0.032

Table E-13

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 WF7a ER	6 GHz WIFI Ant WF2a ER	wPT ER	Σ SAR (W/kg)
		1	2	3	4	1+2+3+4
Body SAR	Back	0.026	0.004	0.034	0.016	0.080
	Top	0.136	0.739	0.000	0.000	0.875
	Bottom	0.017	0.000	0.531	0.000	0.548
	Right	0.001	0.000	0.016	0.001	0.018
	Left	0.035	0.006	0.000	0.000	0.041

Table E-14

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 WF2a ER	6 GHz WIFI Ant WF7b ER	wPT ER	Σ SAR (W/kg)
		1	2	3	4	1+2+3+4
Body SAR	Back	0.026	0.034	0.051	0.016	0.127
	Top	0.136	0.000	0.489	0.000	0.625
	Bottom	0.017	0.531	0.001	0.000	0.549
	Right	0.001	0.016	0.001	0.001	0.019
	Left	0.035	0.000	0.073	0.000	0.108

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Table E-15

Simultaneous Transmission Scenario with 802.15.4, 6 GHz WIFI MIMO and wPT

Simult Tx	Configuration	802.15.4 Ant WF2b with 7 dB backoff ER	6 GHz WIFI Ant WF7b ER	6 GHz WIFI Ant WF2a ER	wPT ER	Σ SAR (W/kg)
		1	2	3	4	1+2+3+4
Body SAR	Back	0.023	0.051	0.034	0.016	0.124
	Top	0.011	0.489	0.000	0.000	0.500
	Bottom	0.098	0.001	0.531	0.000	0.630
	Right	0.119	0.001	0.016	0.001	0.137
	Left	0.004	0.073	0.000	0.000	0.077

Table E-16

Simultaneous Transmission Scenario with 802.15.4, 6 GHz WIFI MIMO and wPT

Simult Tx	Configuration	802.15.4 Ant WF2b with 7 dB backoff ER	6 GHz WIFI Ant WF7a ER	6 GHz WIFI Ant WF2a ER	wPT ER	Σ SAR (W/kg)
		1	2	3	4	1+2+3+4
Body SAR	Back	0.023	0.004	0.034	0.016	0.077
	Top	0.011	0.739	0.000	0.000	0.750
	Bottom	0.098	0.000	0.531	0.000	0.629
	Right	0.119	0.000	0.016	0.001	0.136
	Left	0.004	0.006	0.000	0.000	0.010

Table E-17

Simultaneous Transmission Scenario with NB U-NII, 2.4 GHz WIFI MIMO and wPT

Simult Tx	Configuration	NB U-NII Ant WF7b with 7 dB backoff ER	2.4 GHz WIFI Ant WF7b ER	2.4 GHz WIFI Ant WF2b ER	wPT ER	Σ SAR (W/kg)
		1	2	3	4	1+2+3+4
Body SAR	Back	0.008	0.155	0.145	0.016	0.324
	Top	0.057	0.741	0.013	0.000	0.811
	Bottom	0.001	0.021	0.676	0.000	0.698
	Right	0.000	0.001	0.729	0.001	0.731
	Left	0.010	0.059	0.009	0.000	0.078

Table E-18

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

Simult Tx	Configuration	NB U-NII Ant WF7a with 7 dB backoff ER	NB U-NII Ant WF2a with 7 dB backoff ER	2.4 GHz WIFI Ant WF7b ER	2.4 GHz WIFI Ant WF2b ER	wPT ER	Σ SAR (W/kg)
		1	2	3	4	5	1+2+3+4+5
Body SAR	Back	0.033	0.019	0.155	0.145	0.016	0.368
	Top	0.149	0.000	0.741	0.013	0.000	0.903
	Bottom	0.000	0.167	0.021	0.676	0.000	0.864
	Right	0.000	0.055	0.001	0.729	0.001	0.786
	Left	0.003	0.000	0.059	0.009	0.000	0.071

E.4 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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