

APPENDIX D: SIMULTANEOUS NUMERICAL CALCULATIONS

D.1 Introduction

The following procedures adopted from FCC KDB Publication 447498 D01v06 are applicable to devices with built-in unlicensed transmitters such as 802.11 and Bluetooth devices which may simultaneously transmit with the licensed transmitter.

D.2 Simultaneous Transmission Procedures

This device contains transmitters that may operate simultaneously. Therefore, simultaneous transmission analysis is required. Per FCC KDB Publication 447498 D01v06 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 a 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.

Per FCC KDB Publication 941225 D06v02r01, the devices edges with antennas more than 2.5 cm from edge are not required to be evaluated for SAR (“-”).

(*) For test positions that were not required to be evaluated for WLAN SAR per FCC KDB publication 248227, the worst case WLAN SAR result for the applicable exposure conditions was used for simultaneous transmission analysis.

For inter-band ULCA and EN-DC, LTE B26 Ant A SAR represents LTE B5 Ant A since their frequency ranges are overlapped and they share the same transmission path and signal characteristics.

D.3 Head Simultaneous Transmission Analysis

Table D-1
Simultaneous Transmission Scenarios of WLAN/BT (Held to Ear)

Configuration	2.4 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz WLAN Ant 2 SAR (W/kg)	2.4 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 2 SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN MIMO + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN MIMO + 6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz Bluetooth Ant 2 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz Bluetooth Ant 2 + 6 GHz WLAN MIMO SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
	1	2	3	4	5	6	7	3+6	3+7	4+5	4+5+6	4+5+7	
Right Cheek	0.062	0.303	0.428	0.068	0.274	0.263	0.201	0.691	0.629	0.342	0.605	0.543	0.691
Right Tilt	0.036	0.090	0.135	0.039	0.054	0.070	0.005	0.205	0.140	0.093	0.163	0.098	0.205
Left Cheek	0.047	0.133	0.186	0.047	0.147	0.128	0.063	0.314	0.249	0.194	0.322	0.257	0.322
Left Tilt	0.034	0.043	0.078	0.035	0.028	0.041	0.027	0.119	0.105	0.063	0.104	0.090	0.119

Configuration	2.4 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz WLAN Ant 2 SAR (W/kg)	2.4 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 2 SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN MIMO + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN MIMO + 6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz Bluetooth Ant 2 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz Bluetooth Ant 2 + 6 GHz WLAN MIMO SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
	1	2	3	4	5	6	7	3+6	3+7	4+5	4+5+6	4+5+7	
Right Cheek	0.062	0.303	0.428	0.068	0.274	0.263	0.201	0.691	0.629	0.342	0.605	0.543	0.691
Right Tilt	0.036	0.090	0.135	0.039	0.054	0.070	0.005	0.205	0.140	0.093	0.163	0.098	0.205
Left Cheek	0.047	0.133	0.186	0.047	0.147	0.128	0.063	0.314	0.249	0.194	0.322	0.257	0.322
Left Tilt	0.034	0.043	0.078	0.035	0.028	0.041	0.027	0.119	0.105	0.063	0.104	0.090	0.119




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Table D-2
Simultaneous Transmission Scenario with WLAN/BT (Held to Ear)

	Configuration	Ant A SAR (W/kg)	Ant B SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Ant A + WLAN/BT SAR (W/kg)	Ant B + WLAN/BT SAR (W/kg)
Head SAR	Right Cheek	0.174	0.028	0.691	0.865	0.719
	Right Tilt	0.117	0.032	0.205	0.322	0.237
	Left Cheek	0.280	0.037	0.322	0.602	0.359
	Left Tilt	0.123	0.055	0.119	0.242	0.174

Table D-3
Simultaneous Transmission Scenario inter-band ULCA (Held to Ear)

Configuration	LTE Band 2 (PCS) Ant A + LTE Band 4 (AWS) Ant J SAR (W/kg)	LTE Band 5 (Cell) Ant A + LTE Band 66/4 (AWS) Ant A SAR (W/kg)	LTE Band 12 Ant A + LTE Band 66/4 (AWS) Ant A SAR (W/kg)	Inter-Band ULCA Worst-case Combination SAR (W/kg)
Right Cheek	0.339	0.255	0.217	0.339
Right Tilt	0.411	0.158	0.127	0.411
Left Cheek	0.606	0.285	0.222	0.606
Left Tilt	0.628	0.162	0.116	0.628

Table D-4
Simultaneous Transmission Scenario with inter-band ULCA and WLAN/BT (Held to Ear)

	Configuration	Inter-Band ULCA Worst-case Combination SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Inter-Band ULCA + WLAN/BT Worst-Case Combinations SAR (W/kg)
Head SAR	Right Cheek	0.339	0.691	1.030
	Right Tilt	0.411	0.205	0.616
	Left Cheek	0.606	0.322	0.928
	Left Tilt	0.628	0.119	0.747



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Table D-5
Simultaneous Transmission Scenario with EN-DC (Held to Ear)

Configuration	NR Band n5 (Cell) Ant A + LTE Band 2 (PCS) Ant A SAR (W/kg)	NR Band n5 (Cell) Ant A + LTE Band 66 (AWS) Ant A SAR (W/kg)	NR Band n66 (AWS) Ant J + LTE Band 2 (PCS) Ant A SAR (W/kg)	NR Band n66 (AWS) Ant J + LTE Band 5 (Cell) Ant A SAR (W/kg)	NR Band n66 (AWS) Ant J + LTE Band 12 Ant A SAR (W/kg)	NR Band n66 (AWS) Ant J + LTE Band 13 Ant A SAR (W/kg)	ENDC Worst-case Combination SAR (W/kg)
Right Cheek	0.181	0.221	0.537	0.656	0.618	0.663	0.663
Right Tilt	0.127	0.164	0.623	0.688	0.657	0.712	0.712
Left Cheek	0.293	0.251	0.847	0.972	0.909	1.026	1.026
Left Tilt	0.161	0.168	0.956	1.001	0.955	1.024	1.024

Table D-6
Simultaneous Transmission Scenario with EN-DC and WLAN/BT (Held to Ear)

	Configuration	ENDC Worst-case Combination SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	ENDC + WLAN/BT Worst-Case Combinations SAR (W/kg)
Head SAR	Right Cheek	0.663	0.691	1.354
	Right Tilt	0.712	0.205	0.917
	Left Cheek	1.026	0.322	1.348
	Left Tilt	1.024	0.119	1.143

D.4 Body-worn Simultaneous Transmission Analysis

Table D-7
Simultaneous Transmission Scenarios of WLAN/BT (Body-worn at 1.5 cm)

Configuration	2.4 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz WLAN Ant 2 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 2 SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	6 GHz WLAN MIMO SAR (W/kg)
	1	2	3	4	5	6
Back	0.039	0.126	0.015	0.085	0.170	0.015

Configuration	2.4 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz WLAN Ant 2 SAR (W/kg)	2.4 GHz WLAN Ant 1 + 2.4 GHz WLAN Ant 2 SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 2 SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN Ant 1 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN Ant 1 + 2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz Bluetooth Ant 2 + 6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz Bluetooth Ant 2 + 6 GHz WLAN MIMO SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
Back	1	2	1+2	5	6	3	4	4+5	1+2+5	1+2+6	3+4+5	3+4+6	0.335
Back	0.039	0.126	0.165	0.170	0.015	0.015	0.085	0.255	0.335	0.180	0.270	0.115	0.335




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Table D-8
Simultaneous Transmission Scenario with WLAN/BT (Body-worn at 1.5 cm)

	Configuration	Ant A SAR (W/kg)	Ant B SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Ant A + WLAN/BT SAR (W/kg)	Ant B + WLAN/BT SAR (W/kg)
Bodyworn SAR	Back	0.838	0.329	0.335	1.173	0.664

Table D-9
Simultaneous Transmission Scenario with inter-band ULCA (Body-worn at 1.5 cm)

Configuration	LTE Band 2 (PCS) Ant A + LTE Band 4 (AWS) Ant J SAR (W/kg)	LTE Band 5 (Cell) Ant A + LTE Band 66/4 (AWS) Ant A SAR (W/kg)	LTE Band 12 Ant A + LTE Band 66/4 (AWS) Ant A SAR (W/kg)	Inter-Band ULCA Worst-case Combination SAR (W/kg)
Back	0.855	1.150	1.052	1.150

Table D-10
Simultaneous Transmission Scenario with inter-band ULCA and WLAN/BT (Body-worn at 1.5 cm)




	Configuration	Inter-Band ULCA Worst-case Combination SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Inter-Band ULCA + WLAN/BT Worst-Case Combinations SAR (W/kg)
Bodyworn SAR	Back	1.150	0.335	1.485

Table D-11
Simultaneous Transmission Scenario with EN-DC (Body-worn at 1.5 cm)

Configuration	NR Band n5 (Cell) Ant A + LTE Band 2 (PCS) Ant A SAR (W/kg)	NR Band n5 (Cell) Ant A + LTE Band 66 (AWS) Ant A SAR (W/kg)	NR Band n66 (AWS) Ant J + LTE Band 2 (PCS) Ant A SAR (W/kg)	NR Band n66 (AWS) Ant J + LTE Band 5 (Cell) Ant A SAR (W/kg)	NR Band n66 (AWS) Ant J + LTE Band 12 Ant A SAR (W/kg)	NR Band n66 (AWS) Ant J + LTE Band 13 Ant A SAR (W/kg)	ENDC Worst-case Combination SAR (W/kg)
Back	1.050	1.058	0.942	0.536	0.438	0.476	1.058

Table D-12
Simultaneous Transmission Scenario with EN-DC and WLAN/BT (Body-worn at 1.5 cm)

	Configuration	ENDC Worst-case Combination SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	ENDC + WLAN/BT Worst-Case Combinations SAR (W/kg)
Bodyworn SAR	Back	1.058	0.335	1.393

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D.5 Hotspot Simultaneous Transmission Analysis

Table D-13
Simultaneous Transmission Scenarios of WLAN/BT (Hotspot at 1.0 cm)

Configuration	2.4 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz WLAN Ant 2 SAR (W/kg)	2.4 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 2 SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)
	1	2	3	4	5	6
Back	0.110	0.289	0.187	0.050	0.171	0.246
Front	0.040	0.186	0.117	0.028	0.143	0.090
Top	0.034	-	0.047	0.023	-	0.048
Bottom	-	-	-	-	-	-
Right	-	-	-	-	-	-
Left	0.043	0.404	0.295	0.025	0.292	0.158

Configuration	2.4 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz WLAN Ant 2 SAR (W/kg)	2.4 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 2 SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz Bluetooth Ant 2 SAR (W/kg)	2.4 GHz WLAN MIMO + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
	1	2	3	4	5	6	4+5	3+6	4+5+6	
Back	0.110	0.289	0.187	0.050	0.171	0.246	0.221	0.433	0.467	0.467
Front	0.040	0.186	0.117	0.028	0.143	0.090	0.171	0.207	0.261	0.261
Top	0.034	0.000	0.047	0.023	0.000	0.048	0.023	0.095	0.071	0.095
Bottom	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-
Right	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-
Left	0.043	0.404	0.295	0.025	0.292	0.158	0.317	0.453	0.475	0.475

Table D-14
Simultaneous Transmission Scenarios with WLAN/BT (Hotspot at 1.0 cm)

Configuration	Ant A SAR (W/kg)	Ant B SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Ant A + WLAN/BT SAR (W/kg)	Ant B + WLAN/BT SAR (W/kg)
	Hotspot SAR				
Back	1.065	0.304	0.467	1.532	0.771
Front	0.628	0.266	0.261	0.889	0.527
Top	-	-	0.095	0.095	0.095
Bottom	1.244	0.810	-	1.244	0.810
Right	0.198	0.183	-	0.198	0.183
Left	0.314	-	0.475	0.789	0.475




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Table D-15
Simultaneous Transmission Scenarios with inter-band ULCA (Hotspot at 1.0 cm)

Configuration	LTE Band 2 (PCS) Ant A + LTE Band 4 (AWS) Ant J SAR (W/kg)	LTE Band 5 (Cell) Ant A + LTE Band 66/4 (AWS) Ant A SAR (W/kg)	LTE Band 12 Ant A + LTE Band 66/4 (AWS) Ant A SAR (W/kg)	Inter-Band ULCA Worst-case Combination SAR (W/kg)
Back	0.276	1.031	0.716	1.031
Front	0.321	0.741	0.595	0.741
Top	0.240	0.000	0.000	0.240
Bottom	0.568	0.849	0.729	0.849
Right	0.061	0.187	0.250	0.250
Left	0.039	0.268	0.308	0.308

Table D-16
Simultaneous Transmission Scenarios with inter-band ULCA and WLAN/BT (Hotspot at 1.0 cm)

	Configuration	Inter-Band ULCA Worst-case Combination SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Inter-Band ULCA + WLAN/BT Worst-Case Combinations SAR (W/kg)
Hotspot SAR	Back	1.031	0.467	1.498
	Front	0.741	0.261	1.002
	Top	0.240	0.095	0.335
	Bottom	0.849	-	0.849
	Right	0.250	-	0.250
	Left	0.308	0.475	0.783

Table D-17
Simultaneous Transmission Scenarios with EN-DC (Hotspot at 1.0 cm)

Configuration	NR Band n5 (Cell) Ant A + LTE Band 2 (PCS) Ant A SAR (W/kg)	NR Band n5 (Cell) Ant A + LTE Band 66 (AWS) Ant A SAR (W/kg)	NR Band n66 (AWS) Ant J + LTE Band 2 (PCS) Ant A SAR (W/kg)	NR Band n66 (AWS) Ant J + LTE Band 5 (Cell) Ant A SAR (W/kg)	NR Band n66 (AWS) Ant J + LTE Band 12 Ant A SAR (W/kg)	NR Band n66 (AWS) Ant J + LTE Band 13 Ant A SAR (W/kg)	ENDC Worst-case Combination SAR (W/kg)
Back	0.845	0.922	0.335	0.863	0.548	0.691	0.922
Front	0.663	0.725	0.366	0.559	0.413	0.511	0.725
Top	0.000	0.000	0.400	0.400	0.400	0.400	0.400
Bottom	0.760	0.792	0.568	0.249	0.129	0.304	0.792
Right	0.124	0.148	0.082	0.189	0.252	0.213	0.252
Left	0.206	0.222	0.039	0.213	0.253	0.297	0.297




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Table D-18
Simultaneous Transmission Scenarios with EN-DC and WLAN/BT (Hotspot at 1.0 cm)

	Configuration	ENDC Worst-case Combination SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	ENDC + WLAN/BT Worst-Case Combinations SAR (W/kg)
Hotspot SAR	Back	0.922	0.467	1.389
	Front	0.725	0.261	0.986
	Top	0.400	0.095	0.495
	Bottom	0.792	-	0.792
	Right	0.252	-	0.252
	Left	0.297	0.475	0.772

D.6 Phablet Simultaneous Transmission Analysis

Per FCC KDB Publication 648474 D04 Handset SAR, Phablet SAR tests were not required if wireless router 1g SAR (scaled to the maximum output power, including tolerance) < 1.2 W/kg. Therefore, no further analysis beyond the tables included in this section was required to determine that possible simultaneous transmission scenarios would not exceed the SAR limit. For SAR summation, the highest reported SAR across all test distances was used as the most conservative evaluation for simultaneous transmission analysis for each device edge.

Table D-19
Simultaneous Transmission Scenarios of WLAN/BT

Configuration	5 GHz WLAN MIMO SAR (W/kg)	6 GHz WLAN MIMO SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
	1	2	
Back	1.148	0.097	1.148
Front	1.148*	0.110	1.148
Top	1.148*	0.012	1.148
Bottom	-	-	-
Right	-	-	-
Left	0.879	0.344	0.879






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Table D-20
Simultaneous Transmission Scenarios with WLAN (Phablet)

	Configuration	Ant A SAR (W/kg)	Ant B SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Ant A + WLAN/BT SAR (W/kg)	Ant B + WLAN/BT SAR (W/kg)
Phablet SAR	Back	2.556	2.128	1.148	3.704	3.276
	Front	2.462	1.199	1.148	3.610	2.347
	Top	-	-	1.148	1.148	1.148
	Bottom	3.254	2.307	-	3.254	2.307
	Right	0.773	0.963	-	0.773	0.963
	Left	0.410	-	0.879	1.289	0.879

D.7 Simultaneous Transmission Conclusion

The above numerical summed SAR results are 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 D01v06 and IEEE 1528- 2013 Section 6.3.4.1.

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