

APPENDIX D: MULTI-TX AND ANTENNA SAR CONSIDERATIONS

D.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.

D.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 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.

Qualcomm Smart Transmit algorithm in WWAN directly adds the time-averaged RF exposure from 4G and time-averaged RF exposure from 5G NR. Smart Transmit algorithm controls the total RF exposure from both 4G and 5G NR to not exceed FCC limit. Therefore, simultaneous transmission compliance between 4G+5G operations is demonstrated in the Part 2 Report during algorithm validation.

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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 at 12 dBm SAR (W/kg)	2.4 GHz WLAN Ant 2 at 12 dBm SAR (W/kg)	2.4 GHz WLAN MIMO at 15 dBm SAR (W/kg)	5 GHz WLAN Ant 1 at 10 dBm SAR (W/kg)	5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	2.4 GHz WLAN Ant 1 at 12 dBm + 5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	2.4 GHz WLAN Ant 2 at 12 dBm + 5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	2.4 GHz WLAN MIMO at 15 dBm + 5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 10.5 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 2 at 10.5 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 10.5 dBm + 2.4 GHz WLAN Ant 2 at 12 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 10.5 dBm + 5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 2 at 10.5 dBm + 5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 10.5 dBm + 2.4 GHz WLAN Ant 2 at 12 dBm + 5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 10.5 dBm + 2.4 GHz WLAN Ant 2 at 12 dBm + 5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)		
	1	2	3	4	5	1+5	2+5	3+5	6	7	6+2	6+4	6+5	8+4	8+5	6+2+4	6+2+5	
Right Cheek	0.191	0.057	0.304	0.169	0.243	0.434	0.300	0.547	0.192	0.090	0.249	0.361	0.435	0.259	0.333	0.418	0.492	0.547
Right Tilt	0.146	0.258	0.304	0.169	0.276	0.422	0.534	0.580	0.200	0.088	0.458	0.369	0.476	0.257	0.364	0.627	0.734	0.734
Left Cheek	0.090	0.258	0.292	0.169	0.276	0.366	0.534	0.568	0.083	0.253	0.341	0.252	0.359	0.422	0.529	0.510	0.617	0.617
Left Tilt	0.082	0.258	0.304	0.169	0.276	0.358	0.534	0.580	0.096	0.171	0.354	0.265	0.372	0.340	0.447	0.523	0.630	0.630

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

Head SAR	Configuration	Licensed SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Licensed + WLAN/BT SAR (W/kg)
	Right Cheek	1.015	0.547	1.562
	Right Tilt	0.729	0.734	1.463
	Left Cheek	0.887	0.617	1.504
	Left Tilt	0.204	0.630	0.834

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D.4 Open Body-worn Simultaneous Transmission Analysis

Table D-3
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 WLAN MIMO SAR (W/kg)	5 GHz WLAN Ant 1 SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN Ant 1 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN MIMO Ant 1 SAR (W/kg)	2.4 GHz WLAN MIMO Ant 2 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 5 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	
	1	2	3	4	5	1+5	2+5	3+5	6	8	6+2	6+4	6+5	8+4	8+5	6+2+4	6+2+5	0.219
Back	0.074	0.084	0.058	0.090	0.115	0.189	0.199	0.173	0.020	0.041	0.104	0.110	0.135	0.131	0.156	0.194	0.219	0.219

Table D-4
Simultaneous Transmission Scenario with WLAN/BT (Body-worn at 1.5 cm)

Bodyworn SAR	Configuration	Licensed SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Licensed + WLAN/BT SAR (W/kg)
Back		0.938	0.219	1.157

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D.5 Open Hotspot Simultaneous Transmission Analysis

Table D-5
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)	5 GHz WLAN Ant 1 SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 2 SAR (W/kg)
	1	2	3	4	5	6	7	9
Back	0.128	0.189	0.131	0.075	0.162*	0.013	0.041	0.092
Front	0.169	0.189*	0.171*	0.097*	0.162*	0.013*	0.038	0.077
Top	0.068	0.189*	0.171*	0.097*	0.162*	0.013*	0.045	0.093
Bottom	-	-	-	-	-	-	-	-
Right	-	0.052	0.171*	-	0.162*	0.013*	-	0.032
Left	0.295	-	0.171	0.097	0.162	0.013*	0.086	-

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)	5 GHz WLAN Ant 1 SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN Ant 1 + 5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	2.4 GHz WLAN MIMO + 5 GHz WLAN MIMO at 13 dBm 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 1 + 2.4 GHz WLAN Ant 2 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 5 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
	1	2	3	4	5	1+6	2+6	3+6	7	9	7+2	7+4	7+5	9+4	9+5	7+2+4	7+2+5	-
Back	0.128	0.189	0.131	0.075	0.162	0.141	0.202	0.144	0.041	0.092	0.230	0.116	0.203	0.167	0.254	0.305	0.392	0.392
Front	0.169	0.189	0.171	0.097	0.162	0.182	0.202	0.184	0.038	0.077	0.227	0.135	0.200	0.174	0.239	0.324	0.389	0.389
Top	0.068	0.189	0.171	0.097	0.162	0.081	0.202	0.184	0.045	0.093	0.234	0.142	0.207	0.190	0.255	0.331	0.396	0.396
Bottom	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Right	-	0.052	0.171	-	0.162	0.013	0.065	0.184	-	0.032	0.052	-	0.162	0.032	0.194	0.052	0.214	0.214
Left	0.295	-	0.171	0.097	0.162	0.308	0.013	0.184	0.086	-	0.086	0.183	0.248	0.097	0.162	0.183	0.248	0.308

Table D-6
Simultaneous Transmission Scenarios with WLAN/BT (Hotspot at 1.0 cm)

Hotspot SAR	Configuration	Licensed SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Licensed + WLAN/BT SAR (W/kg)
	Back		0.451	0.392
Front		0.393	0.389	0.782
Top		0.158	0.396	0.554
Bottom		0.834	-	0.834
Right		0.309	0.214	0.523
Left		0.383	0.308	0.691

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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.

Table D-7
Simultaneous Transmission Scenarios of WLAN/BT

Configuration	5 GHz WLAN Ant 1 SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)
	1	2
Back	0.731*	0.651
Front	0.731*	0.780
Top	0.731*	0.618
Bottom	-	-
Right	-	1.076*
Left	0.731	1.076

Configuration	5 GHz WLAN Ant 1 SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
	1	2	
Back	0.731	0.651	0.731
Front	0.731	0.780	0.780
Top	0.731	0.618	0.731
Bottom	-	-	-
Right	-	1.076	1.076
Left	0.731	1.076	1.076

Table D-8
Simultaneous Transmission Scenarios with WLAN/BT (Phablet Max DSI= 0)

Phablet SAR	Configuration	Licensed SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Licensed + WLAN/BT SAR (W/kg)
	Back		1.449	0.731
Front		1.800	0.780	2.580
Top		0.666	0.731	1.397
Bottom		1.487	-	1.487
Right		2.272	1.076	3.348
Left		2.341	1.076	3.417

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Table D-9
Simultaneous Transmission Scenarios with WLAN/BT (Phablet Reduced DSI= 1)

Phablet SAR	Configuration	Licensed SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Licensed + WLAN/BT SAR (W/kg)
	Back	2.694	0.731	3.430
	Front	2.239	0.780	3.019
	Top	0.666	0.731	1.397
	Bottom	2.988	-	2.988
	Right	2.272	1.076	3.348
	Left	2.341	1.076	3.417

D.7 Closed Body-worn Simultaneous Transmission Analysis

Table D-10
Simultaneous Transmission Scenarios of WLAN/BT (Body-worn at 1.5 cm)

Configuration	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)	5 GHz WLAN Ant 1 SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 2 SAR (W/kg)	
	1	2	3	4	5	6	7	8
Back	0.040	0.034	0.039	0.032	0.008	0.032	0.012	0.017

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)	5 GHz WLAN Ant 1 SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN Ant 1 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN MIMO + 5 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 1 + 2.4 GHz WLAN Ant 2 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 5 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
	1	3	4	5	6	1+6	3+6	4+6	7	8	7+3	7+5	7+6	8+5	8+6	7+3+5	7+3+6	
Back	0.040	0.039	0.032	0.008	0.032	0.072	0.071	0.064	0.012	0.017	0.051	0.020	0.044	0.025	0.049	0.059	0.083	0.083

Table D-11
Simultaneous Transmission Scenario with WLAN/BT (Body-worn at 1.5 cm)

Bodyworn SAR	Configuration	Licensed SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Licensed + WLAN/BT SAR (W/kg)
	Back		0.482	0.083

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D.8 Closed Hotspot Simultaneous Transmission Analysis

Table D-12
Simultaneous Transmission Scenarios of WLAN/BT (Hotspot at 0.5 cm)

Configuration	2.4 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz WLAN Ant 1 at 12 dBm SAR (W/kg)	2.4 GHz WLAN Ant 2 SAR (W/kg)	2.4 GHz WLAN Ant 2 at 12 dBm SAR (W/kg)	2.4 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN MIMO at 15 dBm SAR (W/kg)	5 GHz WLAN Ant 1 SAR (W/kg)	5 GHz WLAN Ant 1 at 10 dBm SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 2 SAR (W/kg)
	1	2	3	4	5	6	7	8	9	10	11	12
Back	0.148	0.034	0.488*	0.125*	0.340*	0.114*	0.299*	0.038*	0.438*	0.084*	0.056	0.065
Front	0.265	0.063	0.488	0.125	0.340	0.114*	0.299	0.038	0.438	0.084*	0.069	0.312
Top	-	-	-	-	-	-	-	-	-	-	-	-
Bottom	0.439	0.092	0.390	0.125*	0.340*	0.114	0.299*	0.038*	0.158	0.084*	0.143	0.179
Right	-	-	0.488*	0.027	0.340*	0.114*	-	-	0.438*	0.084*	-	0.056
Left	0.615	0.126	-	-	0.340*	0.114*	0.299*	0.038*	0.230	0.084	0.177	-

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)	5 GHz WLAN Ant 1 SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN Ant 1 at 12 dBm + 5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	2.4 GHz WLAN Ant 2 at 12 dBm + 5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	2.4 GHz WLAN MIMO at 15 dBm + 5 GHz WLAN MIMO at 13 dBm 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 1 + 2.4 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 5 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 at 12 dBm + 5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 at 12 dBm + 5 GHz WLAN MIMO at 13 dBm SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
	1	3	5	7	9	2+10	4+10	6+10	11	12	11+3	11+7	11+9	12+7	12+9	11+4+8	11+4+10	-
Back	0.148	0.488	0.340	0.299	0.438	0.118	0.209	0.198	0.056	0.065	0.544	0.355	0.494	0.364	0.503	0.219	0.265	0.544
Front	0.265	0.488	0.340	0.299	0.438	0.147	0.209	0.198	0.069	0.312	0.557	0.368	0.507	0.611	0.750	0.232	0.278	0.750
Top	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bottom	0.439	0.390	0.340	0.299	0.158	0.176	0.209	0.198	0.143	0.179	0.533	0.442	0.301	0.478	0.337	0.306	0.352	0.533
Right	-	0.488	0.340	-	0.438	0.084	0.111	0.198	-	0.056	0.488	0.488	0.438	0.056	0.494	0.027	0.111	0.494
Left	0.615	-	0.340	0.299	0.230	0.210	0.084	0.198	0.177	-	0.177	0.476	0.407	0.299	0.230	0.215	0.261	0.615

Table D-13
Simultaneous Transmission Scenarios with WLAN/BT (Hotspot at 0.5 cm)

Configuration	Licensed SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Licensed + WLAN/BT SAR (W/kg)
Back	1.027	0.544	1.571
Front	0.442	0.750	1.192
Top	0.047	-	0.047
Bottom	1.060	0.533	1.593
Right	0.909	0.494	1.403
Left	0.730	0.615	1.345

D.9 Simultaneous Transmission Conclusion

The above numerical summed SAR results 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.

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