

APPENDIX E: MULTI-TX AND ANTENNA SAR CONSIDERATIONS

E.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

E.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 (“-”).

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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E.3 Head (DSI = 2) Simultaneous Transmission Analysis

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

Configuration		2.4 GHz WLAN Ant 2 at 8 dBm SAR (W/kg)		2.4 GHz WLAN MIMO at 11 dBm SAR (W/kg)		5 GHz WLAN MIMO at 14 dBm SAR (W/kg)		6 GHz WLAN MIMO at 12 dBm SAR (W/kg)		2.4 GHz Bluetooth Ant 1 at 6 dBm SAR (W/kg)		2.4 GHz Bluetooth Ant 2 at 9 dBm SAR (W/kg)				
		1c		2b		3b		4b		5b		6b				
Right Cheek		0.067		0.087		0.401		0.079		0.078		0.037				
Right Tilt		0.060		0.056		0.304		0.059		0.043		0.027				
Left Cheek		0.155		0.089		0.384		0.123		0.013		0.119				
Left Tilt		0.108		0.051		0.300		0.060		0.008		0.059				
Configuration	2.4 GHz WLAN MIMO at 11 dBm SAR (W/kg)	5 GHz WLAN MIMO at 14 dBm SAR (W/kg)	6 GHz WLAN MIMO at 12 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 6 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 2 at 9 dBm SAR (W/kg)	2.4 GHz WLAN MIMO at 11 dBm + 5 GHz WLAN MIMO at 14 dBm SAR (W/kg)	2.4 GHz WLAN MIMO at 11 dBm + 6 GHz WLAN MIMO at 12 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 6 dBm + 2.4 GHz WLAN Ant 2 at 8 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 6 dBm + 5 GHz WLAN MIMO at 14 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 6 dBm + 6 GHz WLAN MIMO at 12 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 6 dBm + 2.4 GHz WLAN Ant 2 at 8 dBm + 5 GHz WLAN MIMO at 14 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 6 dBm + 2.4 GHz WLAN Ant 2 at 8 dBm + 6 GHz WLAN MIMO at 12 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 2 at 9 dBm + 5 GHz WLAN MIMO at 14 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 2 at 9 dBm + 6 GHz WLAN MIMO at 12 dBm SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	
	2b	3b	4b	5b	6b	2b+3b	2b+4b	5b+1c	5b+3b	5b+4b	5b+1c+3b	5b+1c+4b	6b+3b	6b+4b		
	Right Cheek	0.087	0.401	0.079	0.078	0.037	0.488	0.166	0.145	0.479	0.157	0.546	0.224	0.438	0.116	0.546
	Right Tilt	0.056	0.304	0.059	0.043	0.027	0.360	0.115	0.103	0.347	0.102	0.407	0.162	0.331	0.086	0.407
	Left Cheek	0.089	0.384	0.123	0.013	0.119	0.473	0.212	0.168	0.397	0.136	0.552	0.291	0.503	0.242	0.552
Left Tilt	0.051	0.300	0.060	0.008	0.059	0.351	0.111	0.116	0.308	0.068	0.416	0.176	0.359	0.119	0.416	

Table E-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	0.842	0.546	1.388
	Right Tilt	0.598	0.407	1.005
	Left Cheek	0.788	0.552	1.340
	Left Tilt	0.286	0.416	0.702

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E.4 Open Body-worn (DSI = 0) Simultaneous Transmission Analysis

Table E-3
Simultaneous Transmission Scenarios of WLAN/BT (Body-worn at 1.5 cm)

Configuration	2.4 GHz WLAN Ant 2 SAR (W/kg)	2.4 GHz WLAN MIMO 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)
	1a	2a	3a	4a	5a	6a
Back	0.044	0.199	0.165	0.018	0.047	0.034

Configuration	2.4 GHz WLAN MIMO 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 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 WLAN Ant 2 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 6 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 + 6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 6 GHz WLAN MIMO SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
	2a	3a	4a	5a	6a	2a+3a	2a+4a	5a+1a	5a+3a	5a+4a	5a+1a+3a	5a+1a+4a	6a+3a	6a+4a	
Back	0.199	0.165	0.018	0.047	0.034	0.364	0.217	0.091	0.212	0.065	0.256	0.109	0.199	0.052	0.364

Table E-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	0.446	0.364	0.810

E.5 Closed Body-worn (DSI = 0) Simultaneous Transmission Analysis

Table E-5
Simultaneous Transmission Scenarios of WLAN/BT (Body-worn at 1.5 cm)

Configuration	2.4 GHz WLAN Ant 2 SAR (W/kg)	2.4 GHz WLAN MIMO 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)
	1a	2a	3a	4a	5a	6a
Back	0.021	0.065	0.024	0.001	0.013	0.011

Configuration	2.4 GHz WLAN MIMO 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 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 WLAN Ant 2 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 6 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 + 6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 6 GHz WLAN MIMO SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
	2a	3a	4a	5a	6a	2a+3a	2a+4a	5a+1a	5a+3a	5a+4a	5a+1a+3a	5a+1a+4a	6a+3a	6a+4a	
Back	0.065	0.024	0.001	0.013	0.011	0.089	0.066	0.034	0.037	0.014	0.058	0.035	0.035	0.012	0.089

Table E-6
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	0.396	0.089	0.485

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E.6 Open Hotspot (DSI =3) Simultaneous Transmission Analysis

Table E-7
Simultaneous Transmission Scenarios of WLAN/BT (Hotspot at 1.0 cm)

Configuration	2.4 GHz WLAN Ant 2 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 MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)
	1a	2a	2b	3a	5a
Back	0.125	0.353	0.033	0.134	0.030
Front	0.167	0.309	0.046	0.053	0.022
Top	0.113	0.235	0.055	0.033	0.022
Bottom	-	-	-	-	-
Right	0.077	0.100	0.011	0.036	-
Left	-	0.380	0.046	0.119	0.126

Configuration	2.4 GHz WLAN MIMO SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)	2.4 GHz WLAN MIMO at 15 dBm + 5 GHz WLAN MIMO 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 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)
	2a	3a	5a	2b+3a	5a+1a	5a+3a	5a+1a+3a	
Back	0.353	0.134	0.030	0.167	0.155	0.164	0.289	0.353
Front	0.309	0.053	0.022	0.099	0.189	0.075	0.242	0.309
Top	0.235	0.033	0.022	0.088	0.135	0.055	0.168	0.235
Bottom	-	-	-	-	-	-	-	-
Right	0.100	0.036	-	0.047	0.077	0.036	0.113	0.113
Left	0.380	0.119	0.126	0.165	0.126	0.245	0.245	0.380

Table E-8
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	0.444	0.353	0.797
	Front	0.354	0.309	0.663
	Top	0.231	0.235	0.466
	Bottom	0.659	-	0.659
	Right	0.558	0.113	0.671
	Left	0.389	0.380	0.769

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E.7 Closed Hotspot (DSI = 3) Simultaneous Transmission Analysis

Table E-9
Simultaneous Transmission Scenarios of WLAN/BT (Hotspot at 0.5 cm)

Configuration	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 MIMO SAR (W/kg)	5 GHz WLAN MIMO at 14 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)
	1a	1b	2a	2b	3a	3b	5a
Back	0.059	0.011	0.205	0.019	0.051	0.027	0.019
Front	0.285	0.099	0.583	0.097	0.406	0.172	0.076
Top	-	-	-	-	-	-	-
Bottom	0.199	0.045	0.565	0.061	0.101	0.083	0.051
Right	0.199	0.027	0.154	0.025	0.228	0.103	-
Left	-	-	0.793	0.107	0.366	0.126	0.186

Configuration	2.4 GHz WLAN MIMO SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)	2.4 GHz WLAN MIMO at 15 dBm + 5 GHz WLAN MIMO at 14 dBm 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 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)
	2a	3a	5a	2b+3b	5a+1a	5a+3a	5a+1a+3a	
Back	0.205	0.051	0.019	0.046	0.078	0.070	0.129	0.205
Front	0.583	0.406	0.076	0.269	0.361	0.482	0.767	0.767
Top	-	-	-	-	-	-	-	-
Bottom	0.565	0.101	0.051	0.144	0.250	0.152	0.351	0.565
Right	0.154	0.228	-	0.128	0.199	0.228	0.427	0.427
Left	0.793	0.366	0.186	0.233	0.186	0.552	0.552	0.793

Table E-10
Simultaneous Transmission Scenarios with WLAN/BT (Hotspot at 0.5 cm)

Hotspot SAR	Configuration	Licensed SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Licensed + WLAN/BT SAR (W/kg)
	Back	0.801	0.205	1.006
	Front	0.739	0.767	1.506
	Top	0.056	-	0.056
	Bottom	0.931	0.565	1.496
	Right	1.130	0.427	1.557
	Left	0.689	0.793	1.482

E.8 Phablet (DSI = 0) 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 E-11
Simultaneous Transmission Scenarios of WLAN/BT

Configuration	5 GHz WLAN MIMO SAR (W/kg)	6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 2 SAR (W/kg)
	3a	4a	6a
Back	0.584	0.040	0.554
Front	0.386	0.106	0.801
Top	0.512	0.089	0.688
Bottom	-	-	-
Right	0.244	0.201	0.149
Left	0.931	0.058	-

Configuration	5 GHz WLAN MIMO SAR (W/kg)	6 GHz WLAN MIMO 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 Bluetooth Ant 2 + 6 GHz WLAN MIMO SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
	3a	4a	6a	6a+3a	6a+4a	
Back	0.584	0.040	0.554	1.138	0.594	1.138
Front	0.386	0.106	0.801	1.187	0.907	1.187
Top	0.512	0.089	0.688	1.200	0.777	1.200
Bottom	-	-	-	-	-	-
Right	0.244	0.201	0.149	0.393	0.350	0.393
Left	0.931	0.058	-	0.931	0.058	0.931

Table E-12
Simultaneous Transmission Scenarios with WLAN/BT (Phablet at 0.0 cm)

Phablet SAR	Configuration	Licensed SAR (W/kg)	NFC SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	Licensed + NFC + WLAN/BT SAR (W/kg)
	Back	2.570	0.011	1.138	3.719
	Front	2.600	0.000	1.187	3.787
	Top	1.279	-	1.200	2.479
	Bottom	1.741	0.000	-	1.741
	Right	2.848	0.000	0.393	3.241
	Left	3.049	0.000	0.931	3.980

E.9 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 D01v06 and IEEE 1528- 2013 Section 6.3.4.1.

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