

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..

E.3 Head Simultaneous Transmission Analysis

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

SAR Measurement Results for Various Configurations (Worst-case)																
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 SAR (W/kg)		2.4 GHz Bluetooth Ant 1 SAR (W/kg)		2.4 GHz Bluetooth Ant 2 SAR (W/kg)				
		1b		2b		3b		4a		5a		6a				
		Right Cheek		0.031		0.061		0.351		0.049		0.067		0.031		
		Right Tilt		0.029		0.036		0.318		0.043		0.040		0.029		
		Left Cheek		0.099		0.083		0.178		0.033		0.011		0.100		
		Left Tilt		0.058		0.043		0.165		0.017		0.008		0.051		
Configuration	2.4 GHz Bluetooth Ant 1 SAR (W/kg)	2.4 GHz Bluetooth Ant 2 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 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 SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 at 8 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 5 GHz WLAN MIMO at 14 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN MIMO at 14 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 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 + 2.4 GHz WLAN Ant 2 at 8 dBm + 6 GHz WLAN MIMO SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	
	5a	6a	2b	3b	4a	2b+3b	2b+4a	5a+1b	5a+3b	6a+3b	5a+4a	6a+4a	5a+1b+3b	5a+1b+4a		
	Right Cheek	0.067	0.031	0.061	0.351	0.049	0.412	0.110	0.098	0.418	0.382	0.116	0.080	0.449	0.147	0.449
	Right Tilt	0.040	0.029	0.036	0.318	0.043	0.354	0.079	0.069	0.358	0.347	0.083	0.072	0.387	0.112	0.387
	Left Cheek	0.011	0.100	0.083	0.178	0.033	0.261	0.116	0.110	0.189	0.278	0.044	0.133	0.288	0.143	0.288
	Left Tilt	0.008	0.051	0.043	0.165	0.017	0.208	0.060	0.066	0.173	0.216	0.025	0.068	0.231	0.083	0.231

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Table E-2
Simultaneous Transmission Scenario of 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	0.719	0.449	1.168
	Right Tilt	0.284	0.387	0.671
	Left Cheek	1.050	0.288	1.338
	Left Tilt	0.275	0.231	0.506

E.4 Open Body-worn Simultaneous Transmission Analysis

Table E-3
Simultaneous Transmission Scenario 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	0.040	0.100	0.264	0.063	0.032	0.025

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 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)	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	0.100	0.264	0.063	0.032	0.025	0.364	0.163	0.072	0.296	0.095	0.336	0.135	0.289	0.088	0.364

Table E-4
Simultaneous Transmission Scenario of 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	0.423	0.364	0.787

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E.5 Open Hotspot Simultaneous Transmission Analysis

Table E-5
Simultaneous Transmission Scenario 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)	5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)
	1a	2a	3a	5a
Back	0.089	0.211	0.201	0.056
Front	0.128	0.203	0.145	0.060
Top	0.078	0.255	0.096	0.042
Right	0.042	0.025	0.100	-
Left	-	0.224	0.187	0.113

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 + 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	2a+3a	5a+1a	5a+3a	5a+1a+3a	
Back	0.211	0.201	0.056	0.412	0.145	0.257	0.346	0.412
Front	0.203	0.145	0.060	0.348	0.188	0.205	0.333	0.348
Top	0.255	0.096	0.042	0.351	0.120	0.138	0.216	0.351
Bottom	-	-	-	-	-	-	-	-
Right	0.025	0.100	-	0.125	0.042	0.100	0.142	0.142
Left	0.224	0.187	0.113	0.411	0.113	0.300	0.300	0.411

Table E-6
Simultaneous Transmission Scenario of 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	0.454	0.412	0.866
	Front	0.310	0.348	0.658
	Top	0.073	0.351	0.424
	Bottom	0.746	-	0.746
	Right	0.632	0.142	0.774
	Left	0.390	0.411	0.801

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E.6 Open 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 E-7
Simultaneous Transmission Scenario of WLAN/BT (Phablet at 0.0 cm)

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	0.924	0.432	0.369
Front	0.669	0.130	0.636
Top	0.474	0.126	0.509
Bottom	-	-	-
Right	0.511	0.118	0.088
Left	0.808	0.172	-

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	0.924	0.432	0.369	1.293	0.801	1.293
Front	0.669	0.130	0.636	1.305	0.766	1.305
Top	0.474	0.126	0.509	0.983	0.635	0.983
Bottom	-	-	-	-	-	-
Right	0.511	0.118	0.088	0.599	0.206	0.599
Left	0.808	0.172	-	0.808	0.172	0.808

Table E-8
Simultaneous Transmission Scenario of NFC (Phablet at 0.0 cm)

Configuration	NFC SAR (W/kg)
Back	0.012
Front	0.000
Top	-
Bottom	0.000
Right	0.000
Left	0.000

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Table E-9
Simultaneous Transmission Scenario of 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	2.681	0.012	1.293	3.986
	Front	2.470	0.000	1.305	3.775
	Top	0.282	-	0.983	1.265
	Bottom	2.256	0.000	-	2.256
	Right	3.025	0.000	0.599	3.624
	Left	1.947	0.000	0.808	2.755

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E.7 Closed Body-worn Simultaneous Transmission Analysis

Table E-10
Simultaneous Transmission Scenario 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	0.020	0.044	0.048	0.000	0.032	0.025

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	0.044	0.048	0.000	0.032	0.025	0.092	0.044	0.052	0.080	0.032	0.100	0.052	0.073	0.025	0.100

Table E-11
Simultaneous Transmission Scenario of 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	0.462	0.100	0.562

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E.8 Closed Hotspot Simultaneous Transmission Analysis

Table E-12
Simultaneous Transmission Scenario 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)	5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)
	1a	2a	3a	5a
Back	0.046	0.145	0.076	0.052
Front	0.324	0.395	0.417	0.099
Top	-	-	-	-
Bottom	0.178	0.159	0.263	0.102
Right	0.099	0.152	0.356	-
Left	-	0.478	0.298	0.204

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 + 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	2a+3a	5a+1a	5a+3a	5a+1a+3a	
Back	0.145	0.076	0.052	0.221	0.098	0.128	0.174	0.221
Front	0.395	0.417	0.099	0.812	0.423	0.516	0.840	0.840
Top	-	-	-	-	-	-	-	-
Bottom	0.159	0.263	0.102	0.422	0.280	0.365	0.543	0.543
Right	0.152	0.356	-	0.508	0.099	0.356	0.455	0.508
Left	0.478	0.298	0.204	0.776	0.204	0.502	0.502	0.776

Table E-13
Simultaneous Transmission Scenario of 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	1.051	0.221	1.272
	Front	0.603	0.840	1.443
	Top	0.060	-	0.060
	Bottom	0.967	0.543	1.510
	Right	1.009	0.508	1.517
	Left	0.672	0.776	1.448

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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