

APPENDIX E: SIMULTANEOUS NUMERICAL CALCULATIONS

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 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.

This device is enabled with Qualcomm® Smart Transmit Gen2 with pre-defined sub6 antenna groups (AG0 and AG1). Simultaneous transmission analysis is performed per antenna groups. Appendix D contains analysis to demonstrate the AG0 and AG1 are operate mutually exclusive. Additional analysis is provided below to show compliance between AG0 and BT/WLAN and AG1 and BT/WLAN.

When operating in the same antenna group, 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 within an antenna group is demonstrated in the Part 2 Report during algorithm validation.

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E.3 Head Simultaneous Transmission Analysis

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

Configuration	1	2	3	4	5	6	7	8
	2.4 GHz WLAN Ant 1	2.4 GHz WLAN Ant 2	2.4 GHz WLAN MIMO at 19 dBm	2.4 GHz Bluetooth Ant 1	2.4 GHz Bluetooth Ant 2	2.4 GHz Bluetooth MIMO	5 GHz WLAN MIMO	6 GHz WLAN MIMO
Right Cheek	0.019	0.155	0.093	0.024	0.149	0.071	0.154	0.122
Right Tilt	0.022	0.024	0.043	0.026	0.048	0.007	0.154*	0.019
Left Cheek	0.010	0.086	0.105	0.011	0.166	0.071	0.091	0.078
Left Tilt	0.011	0.012	0.021	0.011	0.030	0.018	0.015	0.022

Configuration	2.4 GHz WLAN Ant 1	2.4 GHz WLAN Ant 2	2.4 GHz WLAN Ant 1 + 2.4 GHz WLAN Ant 2	5 GHz WLAN MIMO	6 GHz WLAN MIMO	2.4 GHz Bluetooth Ant 1	2.4 GHz Bluetooth Ant 2	2.4 GHz Bluetooth MIMO	2.4 GHz WLAN MIMO at 19 dBm + 5 GHz WLAN MIMO	2.4 GHz WLAN MIMO at 19 dBm + 6 GHz WLAN MIMO	2.4 GHz Bluetooth Ant 1 + 5 GHz WLAN MIMO	2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN MIMO	2.4 GHz Bluetooth MIMO + 5 GHz WLAN MIMO	2.4 GHz Bluetooth Ant 1 + 6 GHz WLAN MIMO	2.4 GHz Bluetooth Ant 2 + 6 GHz WLAN MIMO	2.4 GHz Bluetooth MIMO + 6 GHz WLAN MIMO	WLAN/BT Worst-case Combination
	1	2	1+2	7	8	4	5	6	3+7	3+8	4+7	5+7	6+7	4+8	5+8	6+8	
Right Cheek	0.019	0.155	0.174	0.154	0.122	0.024	0.149	0.071	0.247	0.215	0.178	0.303	0.225	0.146	0.271	0.193	0.303
Right Tilt	0.022	0.024	0.046	0.154	0.019	0.026	0.048	0.007	0.197	0.062	0.180	0.202	0.161	0.045	0.067	0.026	0.202
Left Cheek	0.010	0.086	0.096	0.091	0.078	0.011	0.166	0.071	0.196	0.183	0.102	0.257	0.162	0.089	0.244	0.149	0.257
Left Tilt	0.011	0.012	0.023	0.015	0.022	0.011	0.030	0.018	0.036	0.043	0.026	0.045	0.033	0.033	0.052	0.040	0.052

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

	Configuration	AG0	AG1	WLAN/BT Worst-case Combination	AG0 + WLAN/BT	AG1 + WLAN/BT
Head SAR	Right Cheek	0.345	0.941	0.303	0.648	1.244
	Right Tilt	0.219	0.850	0.202	0.421	1.052
	Left Cheek	0.267	1.049	0.257	0.524	1.306
	Left Tilt	0.232	1.186	0.052	0.284	1.238

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E.4 Body-worn Simultaneous Transmission Analysis

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

Configuration	1	2	3	4	5	6	7	8
	2.4 GHz WLAN Ant 1	2.4 GHz WLAN Ant 2	2.4 GHz WLAN MIMO at 19 dBm	2.4 GHz Bluetooth Ant 1	2.4 GHz Bluetooth Ant 2	2.4 GHz Bluetooth MIMO	5 GHz WLAN MIMO	6 GHz WLAN MIMO
Back	0.118	0.073	0.099	0.090	0.038	0.026	0.325	0.114

Configuration	2.4 GHz WLAN Ant 1	2.4 GHz WLAN Ant 2	2.4 GHz WLAN Ant 1 + 2.4 GHz WLAN Ant 2	5 GHz WLAN MIMO	6 GHz WLAN MIMO	2.4 GHz Bluetooth Ant 1	2.4 GHz Bluetooth Ant 2	2.4 GHz Bluetooth MIMO	2.4 GHz WLAN MIMO at 19 dBm + 5 GHz WLAN MIMO	2.4 GHz WLAN MIMO at 19 dBm + 6 GHz WLAN MIMO	2.4 GHz Bluetooth Ant 1 + 5 GHz WLAN MIMO	2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN MIMO	2.4 GHz Bluetooth MIMO + 5 GHz WLAN MIMO	2.4 GHz Bluetooth Ant 1 + 6 GHz WLAN MIMO	2.4 GHz Bluetooth Ant 2 + 6 GHz WLAN MIMO	2.4 GHz Bluetooth MIMO + 6 GHz WLAN MIMO	WLAN/BT Worst-case Combination
Back	1	2	1+2	7	8	4	5	6	3+7	3+8	4+7	5+7	6+7	4+8	5+8	6+8	0.424
	0.118	0.073	0.191	0.325	0.114	0.090	0.038	0.026	0.424	0.213	0.415	0.363	0.351	0.204	0.152	0.140	0.424

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

	Configuration	AG0	AG1	WLAN/BT Worst-case Combination	AG0 + WLAN/BT	AG1 + WLAN/BT
Bodyworn SAR	Back	1.076	0.190	0.424	1.500	0.614

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E.5 Hotspot Simultaneous Transmission Analysis

Table E-5
Simultaneous Transmission Scenarios of WLAN/BT (Hotspot at 1.0 cm)

Configuration	1	2	3	4	5	6	7	8
	2.4 GHz WLAN Ant 1	2.4 GHz WLAN Ant 2	2.4 GHz WLAN MIMO at 19 dBm	2.4 GHz Bluetooth Ant 1	2.4 GHz Bluetooth Ant 2	2.4 GHz Bluetooth MIMO	5 GHz WLAN MIMO	5 GHz WLAN MIMO at 16 dBm
Back	0.375	0.156	0.219	0.229	0.092	0.051	0.444	0.178
Front	0.004	0.134	0.081	-	0.058	0.022	0.444*	0.178*
Top	0.026	-	0.021	0.016	-	0.006	0.444*	0.178*
Bottom	-	-	-	-	-	-	-	-
Right	-	-	-	-	-	-	-	-
Left	0.003	0.185	0.134	0.001	0.103	0.035	0.085	0.018

Configuration	2.4 GHz WLAN Ant 1	2.4 GHz WLAN Ant 2	2.4 GHz WLAN Ant 1 + 2.4 GHz WLAN Ant 2	5 GHz WLAN MIMO	2.4 GHz Bluetooth Ant 1	2.4 GHz Bluetooth Ant 2	2.4 GHz Bluetooth MIMO	2.4 GHz WLAN MIMO at 19 dBm + 5 GHz WLAN MIMO at 16 dBm	2.4 GHz Bluetooth Ant 1 + 5 GHz WLAN MIMO	2.4 GHz Bluetooth Ant 2 + 5 GHz WLAN MIMO	2.4 GHz Bluetooth MIMO + 5 GHz WLAN MIMO	WLAN/BT Worst-case Combination
	1	2	1+2	7	4	5	6	3+8	4+7	5+7	6+7	
Back	0.375	0.156	0.531	0.444	0.229	0.092	0.051	0.397	0.673	0.536	0.495	0.673
Front	0.004	0.134	0.138	0.444	0.000	0.058	0.022	0.259	0.444	0.502	0.466	0.502
Top	0.026	0.000	0.026	0.444	0.016	0.000	0.006	0.199	0.460	0.444	0.450	0.460
Bottom	0.000	0.000	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	0.000	0.000	-
Left	0.003	0.185	0.188	0.085	0.001	0.103	0.035	0.152	0.086	0.188	0.120	0.188

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

	Configuration	AG0	AG1	WLAN/BT Worst-case Combination	AG0 + WLAN/BT	AG1 + WLAN/BT
Hotspot SAR	Back	0.737	0.380	0.673	1.410	1.053
	Front	0.621	0.302	0.502	1.123	0.804
	Top	0.000	0.756	0.460	0.460	1.216
	Bottom	1.258	0.000	-	1.258	0.000
	Right	0.459	0.154	-	0.459	0.154
	Left	0.458	0.674	0.188	0.646	0.862

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E.6 Phablet Simultaneous Transmission Analysis

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.

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 Scenarios of WLAN/BT

Configuration	1	2
	5 GHz WLAN MIMO	6 GHz WLAN MIMO
Back	1.303	0.553
Front	0.535	0.114
Top	0.072	0.029
Bottom	-	-
Right	-	-
Left	0.518	0.077

Configuraiton	5 GHz WLAN MIMO	6 GHz WLAN MIMO	WLAN/BT Worst-case Combination
	1	2	
Back	1.303	0.553	1.303
Front	0.535	0.114	0.535
Top	0.072	0.029	0.072
Bottom	0.000	0.000	-
Right	0.000	0.000	-
Left	0.518	0.077	0.518

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

	Configuration	AG0	AG1	WLAN/BT Worst-case Combination	AG0 + WLAN/BT	AG1 + WLAN/BT
Phablet SAR	Back	1.386	1.435	1.303	2.689	2.738
	Front	1.428	0.000	0.535	1.963	0.535
	Top	0.000	3.144	0.072	0.072	3.216
	Bottom	1.611	0.000	-	1.611	0.000
	Right	0.478	0.000	-	0.478	0.000
	Left	2.540	2.587	0.518	3.058	3.105

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

	Configuration	AG0	AG1	WLAN/BT Worst-case Combination	AG0 + WLAN/BT	AG1 + WLAN/BT
Phablet SAR	Back	3.010	1.435	1.303	See Note 1	2.738
	Front	2.402	0.000	0.535	2.937	0.535
	Top	0.000	3.144	0.072	0.072	3.216
	Bottom	3.144	0.000	-	3.144	0.000
	Right	0.478	0.000	-	0.478	0.000
	Left	2.540	2.587	0.518	3.058	3.105

Notes:

- For configurations where the sum an AG+WLAN/BT is greater than 4.0 W/kg, further breakdown evaluation of the simultaneous combinations was needed.

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Table E-10
Simultaneous Transmission Scenario with 5 GHz WLAN MIMO (Phablet Reduced DSI =1)

Configuration	Mode	2G/3G/4G/5G SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	Σ SAR (W/kg)	SPLSR
		1	2	1+2	1+2
Phablet SAR Back Side DSI = 1	GPRS 1900	1.646	1.303	2.949	N/A
	UMTS 1750	2.487	1.303	3.790	N/A
	UMTS 1900	2.439	1.303	3.742	N/A
	LTE Band 66 (AWS)	1.407	1.303	2.710	N/A
	LTE Band 25 (PCS)	2.146	1.303	3.449	N/A
	LTE Band 30	2.690	1.303	3.993	N/A
	LTE Band 7	3.010	1.303	See Note 1	0.06
	LTE Band 41	2.131	1.303	3.434	N/A
	NR Band n66 (AWS) Antenna A	2.870	1.303	See Note 1	0.06
	NR Band n25 (PCS) Antenna A	1.885	1.303	3.188	N/A
	NR Band n30 Antenna A	2.753	1.303	See Note 1	0.06
	NR Band n7 Antenna B	2.841	1.303	See Note 1	0.06
	NR Band n77 DoD Antenna D	0.758	1.303	2.061	N/A

Table E-11
Simultaneous Transmission Scenario with 6 GHz WLAN MIMO (Phablet Reduced DSI =1)

Configuration	Mode	2G/3G/4G/5G SAR (W/kg)	6 GHz WLAN MIMO SAR (W/kg)	Σ SAR (W/kg)
		1	2	1+2
Phablet SAR Back Side DSI = 1	GPRS 1900	1.646	0.553	2.199
	UMTS 1750	2.487	0.553	3.040
	UMTS 1900	2.439	0.553	2.992
	LTE Band 66 (AWS)	1.407	0.553	1.960
	LTE Band 25 (PCS)	2.146	0.553	2.699
	LTE Band 30	2.690	0.553	3.243
	LTE Band 7	3.010	0.553	3.563
	LTE Band 41	2.131	0.553	2.684
	NR Band n66 (AWS) Antenna A	2.870	0.553	3.423
	NR Band n25 (PCS) Antenna A	1.885	0.553	2.438
	NR Band n30 Antenna A	2.753	0.553	3.306
	NR Band n7 Antenna B	2.841	0.553	3.394
	NR Band n77 DoD Antenna D	0.758	0.553	1.311

Notes:

1. No evaluation was performed to determine the aggregate 10g SAR for these configurations as the SPLS ratio between the antenna pairs was not greater than 0.10 per FCC KDB 447498 D01v06. See Section E.7 for detailed SPLS ratio analysis.

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E.7 SPLSR Evaluation and Analysis

Per FCC KDB Publication 447498 D01v06, when the sum of the standalone transmitters is more than 1.6 W/kg for 1g and 4 W/kg for 10g, the SAR sum to peak locations can be analyzed to determine SAR distribution overlaps. When the SAR peak to location ratio (shown below) for each pair of antennas is ≤ 0.04 for 1g and ≤ 0.10 for 10g, simultaneous SAR evaluation is not required. The distance between the transmitters was calculated using the following formula.

$$\text{Distance}_{\text{Tx1} - \text{Tx2}} = R_i = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \text{ (Phablet)}$$

$$\text{SPLS Ratio} = \frac{(SAR_1 + SAR_2)^{1.5}}{R_i}$$

E.7.1 Phablet Back Side (Phablet Reduced DSI = 1) SPLSR Evaluation and Analysis

Table E-12
Peak SAR Locations for Phablet Back Side (Phablet Reduced DSI = 1)

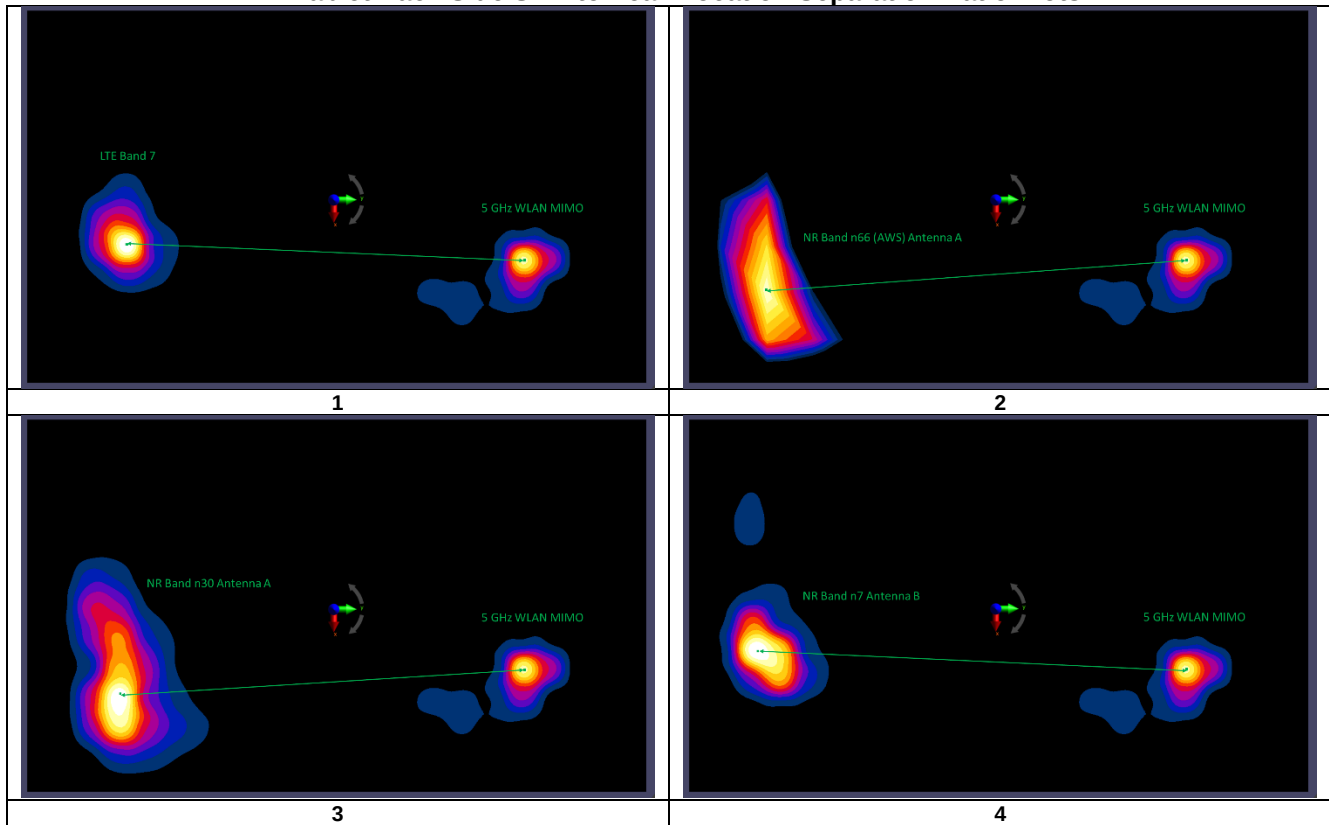
Mode/Band	x (mm)	y (mm)
5 GHz WLAN MIMO	-1.64	64.90
LTE Band 7	4.60	-73.10
NR Band n66 (AWS) Ant A	-10.00	-76.60
NR Band n30 Ant A	-5.20	-71.90
NR Band n7 Ant B	5.30	-76.90

Table E-13
Phablet Back Side SAR to Peak Location Separation Ratio Calculations (Phablet Reduced DSI = 1)

Antenna Pair		Standalone SAR (W/kg)		Standalone SAR Sum (W/kg)	Peak SAR Separation Distance (mm)	SPLS Ratio	Plot Number
Ant "a"	Ant "b"	a	b	a+b	D _{a-b}	(a+b) ^{1.5} /D _{a-b}	
LTE Band 7	5 GHz WLAN MIMO	3.010	1.303	4.313	138.14	0.06	1
NR Band n66 (AWS) Ant A	5 GHz WLAN MIMO	2.870	1.303	4.173	141.75	0.06	2
NR Band n30 Ant A	5 GHz WLAN MIMO	2.753	1.303	4.056	136.85	0.06	3
NR Band n7 Ant B	5 GHz WLAN MIMO	2.841	1.303	4.144	141.97	0.06	4

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Table E-14
Phablet Back Side SAR to Peak Location Separation Ratio Plots



E.8 Simultaneous Transmission Conclusion

The above numerical summed SAR results and SPLSR 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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