

## 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 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  $\leq 1.6$  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 (“-“).

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. Below analysis demonstrates the mutually exclusive operation of AG0 and AG1 and the compliance between AG0 and BT/WLAN/NFC, and between AG1 and BT/WLAN/NFC.

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.

### E.3 Sub6 Antenna Groups

The 2nd generation of Smart Transmit (GEN2) operates based on pre-defined sub6 antenna groups (AG) and mmW module groups (MG). Sub6 Tx antennas in the device are grouped based on spatial variation of RF exposure distributions, where the RF exposure of one AG is mutually exclusive from other AG. This is accomplished by demonstrating either of below conditions for all exposure scenarios:

- a) Sum of SAR of one antenna from each of the sub6 AGs and the RF exposure from radios outside Smart Transmit is less than regulatory limits. This condition must be demonstrated for all antenna combinations of sub6 AGs.

(or)

- b) Every antenna from each sub6 AG meets SPLSR criteria (Section 4.3.2(c) in FCC KDB 447498 D01v06) with every antenna from another sub6 AG. This criteria must be demonstrated for all antenna combinations for each pair of AGs.

This device supports two sub6 AG: AG0 and AG1, with AG0 having 4 antennas (A, B, C, D) and AG1 having 3 antennas (E, F, I), and two WIFI/BT antennas outside of Smart Transmit. The conditions are verified through the following criteria:

- i) (SAR1 + SAR2 criteria): If SPLSR criteria is not used, then the highest reported SAR at  $P_{limit}$  (or  $P_{max}$  when  $P_{limit} > P_{max}$ ) for each antenna should be obtained out of all supported technologies and frequency bands for each DSI. Demonstrate that the sum of reported SAR of one antenna from

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each of the sub6 AGs and the sum of RF exposure from all supported radios outside of Smart Transmit should be less than the regulatory limit as given below for each DSI.

1. Obtain the worst-case reported SAR for each antenna group (i.e., maximum reported SAR at  $P_{limit}$  (or  $P_{max}$  when  $P_{limit} > P_{max}$ ) out of all supported technologies, frequency bands and antennas in AG0 and AG1), denoted as max.SAR.AG0 and max.SAR.AG1, and obtain the worst-case RF exposure for each external radio, and demonstrate that the sum of these RF exposures meets:  $\{ [ \text{max.SAR.AG0} + \text{max.SAR.AG1} ] + \text{WIFI/BT Ant 1} + \text{WIFI/BT Ant 2} \} \leq 1.6$  (for 1g, or 4.0 for 10g).

ii) (SPLSR criteria): For each antenna, obtain the highest reported SAR value at  $P_{limit}$  out of all supported technologies for each frequency band. Using these values, demonstrate for a given DSI that every antenna from one sub6 AG meets SPLSR criteria with every antenna in another sub6 AG for all frequency bands. This criteria must be demonstrated for all antenna pair combinations irrespective of supported simultaneous transmission scenarios as given below for each DSI:

- SPLSR criteria should be met for all antenna pair combinations of AG0 and AG1: {antenna (A, B, C, D) in AG0; antenna (E, F, I) in AG1. As it can be seen, these include all combinations of antenna groups, antennas, and frequency bands.

iii) (combination of SPLSR & SAR1+SAR2 criteria): If SPLSR criteria for all the combinations of sub6 antenna groups in (i) is demonstrated to show that each AG is mutually exclusive from other AGs, and if the WIFI/BT antennas supported outside of Smart Transmit do not meet SPLSR criteria, then the condition in (ii) reduces to:  $\{ \text{max.SAR.AG0} + \text{WIFI/BT Ant 1} + \text{WIFI/BT Ant 2} \} \leq 1.6$  and  $\{ \text{max.SAR.AG1} + \text{WIFI/BT Ant 1} + \text{WIFI/BT Ant 2} \} \leq 1.6$  for compliance demonstration (for 1g, or 4.0 for 10g).

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### E.4 Head (DSI = 1) SAR Antenna Group Analysis

**Table E-1**  
**DSI=1 Held-to-ear AG0 Highest Reported SAR**

AG0 SAR (W/kg)						
Head SAR	Configuration	A	B	C	D	Max
	Right Cheek	0.376	0.061	0.008	0.006	0.376
	Right Tilt	0.201	0.058	0.018	0.020	0.201
	Left Cheek	0.333	0.136	0.036	0.002	0.333
	Left Tilt	0.182	0.091	0.006	0.000	0.182

**Table E-2**  
**DSI=1 Held-to-ear AG1 Highest Reported SAR**

AG1 SAR (W/kg)					
Head SAR	Configuration	E	F	I	Max
	Right Cheek	0.270	0.744	0.742	0.744
	Right Tilt	0.219	0.802	0.016	0.802
	Left Cheek	0.720	0.473	0.328	0.720
	Left Tilt	0.537	0.613	0.000	0.613

**Table E-3**  
**Simultaneous Transmission Scenarios of WLAN/BT (Held to Ear)**

Configuration	2.4 GHz WLAN Ant 2 at 12 dBm SAR (W/kg)	2.4 GHz WLAN Ant 2 at 9 dBm SAR (W/kg)	2.4 GHz WLAN MIMO at 15 dBm SAR (W/kg)	2.4 GHz WLAN MIMO at 12 dBm SAR (W/kg)	5 GHz WLAN MIMO at 12 dBm SAR (W/kg)	5 GHz WLAN MIMO at 9 dBm SAR (W/kg)	6 GHz WLAN MIMO SAR (W/kg)	6 GHz WLAN MIMO at 9 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 9 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 2 at 6 dBm SAR (W/kg)
	1	2	3	4	5	6	7	8	9	10
Right Cheek	0.289	0.126	0.309	0.162	0.253	0.159	0.269	0.131	0.180	0.043
Right Tilt	0.031	0.009	0.327	0.171	0.144	0.130	0.117	0.097	0.129	0.000
Left Cheek	0.411	0.204	0.496	0.305	0.166	0.074	0.087	0.089	0.033	0.073
Left Tilt	0.051	0.018	0.089	0.038	0.043	0.039	0.079	0.055	0.038	0.001

Configuration	2.4 GHz Bluetooth Ant 1 at 9 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 2 at 6 dBm SAR (W/kg)	2.4 GHz WLAN MIMO at 15 dBm SAR (W/kg)	5 GHz WLAN MIMO at 12 dBm SAR (W/kg)	6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN MIMO at 12 dBm + 5 GHz WLAN MIMO at 9 dBm SAR (W/kg)	2.4 GHz WLAN MIMO at 12 dBm + 6 GHz WLAN MIMO at 9 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 9 dBm + 2.4 GHz WLAN Ant 2 at 12 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 9 dBm + 5 GHz WLAN MIMO at 12 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 2 at 6 dBm + 5 GHz WLAN MIMO at 12 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 9 dBm + 6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 2 at 6 dBm + 6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 9 dBm + 2.4 GHz WLAN Ant 2 at 9 dBm + 5 GHz WLAN MIMO at 9 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 at 9 dBm + 2.4 GHz WLAN Ant 2 at 9 dBm + 6 GHz WLAN MIMO at 9 dBm SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
	9	10	3	5	7	4+6	4+8	9+1	9+5	10+5	9+7	10+7	9+2+6	9+2+8	
Right Cheek	0.180	0.043	0.309	0.253	0.269	0.321	0.293	0.469	0.433	0.296	0.449	0.312	0.465	0.437	0.469
Right Tilt	0.129	0.000	0.327	0.144	0.117	0.301	0.268	0.160	0.273	0.144	0.246	0.117	0.268	0.235	0.327
Left Cheek	0.033	0.073	0.496	0.166	0.087	0.379	0.394	0.444	0.199	0.239	0.120	0.160	0.311	0.326	0.496
Left Tilt	0.038	0.001	0.089	0.043	0.079	0.077	0.093	0.089	0.081	0.044	0.117	0.080	0.095	0.111	0.117

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**Table E-4**  
**DSI=1 Held-to-ear AG Verification**

Head SAR	Configuration	AG0 SAR (W/kg)	AG1 SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	AG0 + AG1 + WLAN/BT SAR (W/kg)
	Right Cheek	0.376	0.744	0.469	<b>1.589</b>
	Right Tilt	0.201	0.802	0.327	1.330
	Left Cheek	0.333	0.720	0.496	1.549
	Left Tilt	0.182	0.613	0.117	0.912

Notes:

- For all combinations where the sum of AG0+AG1+WLAN/BT is less than 1.6 W/kg, there's no further analysis required for compliance demonstration.

### E.5 Body-worn (DSI = 0) SAR Antenna Group Analysis

**Table E-5**  
**DSI=0 Body-worn AG0 Highest Reported SAR**

AG0 SAR (W/kg)						
Bodyworn SAR	Configuration	A	B	C	D	Max
		Back	0.717	0.529	0.064	0.320

**Table E-6**  
**DSI=0 Body-worn AG1 Highest Reported SAR**

AG1 SAR (W/kg)					
Bodyworn SAR	Configuration	E	F	I	Max
		Back	0.068	0.369	0.143

**Table E-7**  
**Simultaneous Transmission Scenarios of WLAN/BT (Body-worn)**

Configuration	2.4 GHz WLAN Ant 2 SAR (W/kg)	2.4 GHz WLAN Ant 2 at 16 dBm SAR (W/kg)	2.4 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN MIMO at 19 dBm SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	5 GHz WLAN MIMO at 16 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)
	1	2	3	4	5	6	7	8	9
Back	0.120	0.058	0.299	0.134	0.368	0.175	0.013	0.139	0.026

Configuration	2.4 GHz Bluetooth Ant 1 SAR (W/kg)	2.4 GHz Bluetooth 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 WLAN MIMO at 19 dBm + 5 GHz WLAN MIMO at 16 dBm SAR (W/kg)	2.4 GHz WLAN MIMO at 19 dBm + 6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 2 + 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 2 + 6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 at 16 dBm + 5 GHz WLAN MIMO at 16 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 at 16 dBm + 6 GHz WLAN MIMO SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	
	8	9	3	5	7	4+6	4+7	8+1	8+5	9+5	8+7	9+7	8+2+6	8+2+7	0.507
Back	0.139	0.026	0.299	0.368	0.013	0.309	0.147	0.259	0.507	0.394	0.152	0.039	0.372	0.210	0.507

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**Table E-8**  
**DSI=0 Body-worn AG Verification**

Bodyworn SAR	Configuration	AG0 SAR (W/kg)	AG1 SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	AG0 + AG1 + NFC + WLAN/BT SAR (W/kg)
	Back	0.717	0.369	0.507	<b>1.593</b>

Notes:

1. For all combinations where the sum of AG0+AG1+WLAN/BT is less than 1.6 W/kg, there's no further analysis required for compliance demonstration.

**E.6 Hotspot (DSI = 3) SAR Antenna Group Analysis**

**Table E-9**  
**DSI=3 Hotspot AG0 Highest Reported SAR**

AG0 SAR (W/kg)						
Hotspot SAR	Configuration	A	B	C	D	Max
	Back	0.687	0.529	0.064	0.320	0.687
	Front	0.624	0.420	0.106	0.041	0.624
	Top	-	-	-	-	-
	Bottom	1.228	0.960	0.052	0.091	1.228
	Right	0.495	-	-	0.022	0.495
	Left	0.466	0.246	0.149	-	0.466

**Table E-10**  
**DSI=3 Hotspot AG1 Highest Reported SAR**

AG1 SAR (W/kg)					
Hotspot SAR	Configuration	E	F	I	Max
	Back	0.068	0.369	0.061	0.369
	Front	0.126	0.368	0.122	0.368
	Top	0.074	0.935	0.002	0.935
	Bottom	-	-	-	-
	Right	0.077	-	-	0.077
	Left	-	0.163	0.014	0.163

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**Table E-11**  
**Simultaneous Transmission Scenarios of WLAN/BT (Hotspot)**

Configuration	2.4 GHz WLAN Ant 2 SAR (W/kg)	2.4 GHz WLAN Ant 2 at 16 dBm SAR (W/kg)	2.4 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN MIMO at 19 dBm SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	5 GHz WLAN MIMO at 16 dBm SAR (W/kg)	2.4 GHz Bluetooth Ant 1 SAR (W/kg)
	1	2	3	4	5	6	7
Back	0.120	0.058	0.299	0.134	0.193	0.151	0.139
Front	0.177	0.103	0.275	0.203	0.108	0.071	0.160
Top	0.004	0.000	0.112	0.106	0.077	0.054	0.181
Bottom	-	-	-	-	-	-	-
Right	0.047	0.015	0.043	0.024	0.037	0.019	-
Left	-	-	0.325	0.211	0.153	0.150	0.300

Configuration	2.4 GHz Bluetooth Ant 1 SAR (W/kg)	2.4 GHz WLAN MIMO SAR (W/kg)	5 GHz WLAN MIMO SAR (W/kg)	2.4 GHz WLAN MIMO at 19 dBm + 5 GHz WLAN MIMO at 16 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 at 16 dBm + 5 GHz WLAN MIMO at 16 dBm SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
	7	3	5	4+6	7+1	7+5	7+2+6	
Back	0.139	0.299	0.193	0.285	0.259	0.332	0.348	0.348
Front	0.160	0.275	0.108	0.274	0.337	0.268	0.334	0.337
Top	0.181	0.112	0.077	0.160	0.185	0.258	0.235	0.258
Bottom	-	-	-	-	-	-	-	-
Right	-	0.043	0.037	0.043	0.047	0.037	0.034	0.047
Left	0.300	0.325	0.153	0.361	0.300	0.453	0.450	0.453

**Table E-12**  
**DSI=3 Hotspot AG Verification**

Hotspot SAR	Configuration	AGO SAR (W/kg)	AG1 SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	AGO + AG1 + NFC + WLAN/BT SAR (W/kg)
		Back	0.687	0.369	0.348
	Front	0.624	0.368	0.337	1.329
	Top	-	0.935	0.258	1.193
	Bottom	1.228	-	-	1.228
	Right	0.495	0.077	0.047	0.619
	Left	0.466	0.163	0.453	1.082

**Notes:**

- For all combinations where the sum of AG0+AG1+WLAN/BT is less than 1.6 W/kg, there's no further analysis required for compliance demonstration.

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## E.7 Phablet (DSI = 0) SAR Antenna Group 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-13**  
**DSI=0 Phablet AG0 Highest Reported SAR**

AG0 SAR (W/kg)						
Phablet SAR	Configuration	A	B	C	D	Max
	Back	1.776	1.369	-	1.763	1.776
	Front	1.850	0.844	-	0.000	1.850
	Top	-	-	-	-	-
	Bottom	2.074	2.336	-	0.000	2.336
	Right	0.000	-	-	0.000	-
	Left	0.000	0.378	-	-	0.378

**Table E-14**  
**DSI=0 Phablet AG1 Highest Reported SAR**

AG1 SAR (W/kg)					
Phablet SAR	Configuration	E	F	I	Max
	Back	-	1.281	-	1.281
	Front	-	0.000	-	-
	Top	-	2.961	-	2.961
	Bottom	-	0.000	-	-
	Right	-	0.000	-	-
	Left	-	0.000	-	-

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**Table E-15**  
**Simultaneous Transmission Scenarios of WLAN/BT (Phablet)**

Configuration	5 GHz WLAN MIMO SAR (W/kg)	5 GHz WLAN MIMO at 16 dBm SAR (W/kg)	6 GHz WLAN MIMO SAR (W/kg)	2.4 GHz Bluetooth Ant 2 SAR (W/kg)
	1	2	3	4
Back	0.693	0.445	0.083	0.218
Front	0.932	0.494	0.273	0.505
Top	0.252	0.117	0.015	0.002
Bottom	-	-	-	-
Right	0.191	0.070	0.003	0.087
Left	0.926	0.566	0.144	-

Configuration	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 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)
	4	1	3	4+1	4+3	
Back	0.218	0.693	0.083	0.911	0.301	0.911
Front	0.505	0.932	0.273	1.437	0.778	1.437
Top	0.002	0.252	0.015	0.254	0.017	0.254
Bottom	-	-	-	-	-	-
Right	0.087	0.191	0.003	0.278	0.090	0.278
Left	-	0.926	0.144	0.926	0.144	0.926

**Table E-16**  
**DSI=0 Phablet AG Verification**

Phablet SAR	Configuration	AG0 SAR (W/kg)	AG1 SAR (W/kg)	NFC SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	AG0 + AG1 + NFC + WLAN/BT SAR (W/kg)
		Back	1.776	1.281	0.024	0.911
	Front	1.850	-	0.000	1.437	3.287
	Top	-	2.961	-	0.254	3.215
	Bottom	2.336	-	-	-	2.336
	Right	-	-	0.000	0.278	0.278
	Left	0.378	-	0.000	0.926	1.304

Notes:

- For all combinations where the sum of AG0+AG1+WLAN/BT is less than 4.0 W/kg, there's no further analysis required for compliance demonstration.

## E.8 Conclusion

The above numerical summed SAR results and SPLSR for all the combinations of sub6 antenna groups are sufficient to show that AG0 is mutually exclusive from AG1 and 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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