

APPENDIX D: ANTENNA GROUPING ANALYSIS & JUSTIFICATION

D.1 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 D01) 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 4 antennas (E, F, I, J), and two WIFI/BT antennas outside of Smart Transmit. The conditions are verified through the following criterias:

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 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, G, H) 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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If SPLSR criteria evaluation and analysis is needed to determine compliance for a certain DSI configuration, SPLSR is performed by taking the highest reported SAR for each of the supported technologies and bands per antenna, along with the peak SAR locations. Per Qualcomm guidance, only Y-axis coordinates are recorded in the analysis for calculation simplicity (assumes all 0mm of separation on the x-axis). Peak locations are documented in Section D.7 below for each DSI configuration.

For bottom AG0, Y_max coordinate represents the worst case hotspot location that is closest to the top AG1. Similarly, for top AG1, Y_min coordinate represents the worst case hotspot location that is closest to the bottom AG0.

The following formula is used to calculate the SPLSR between AG0 and AG1 for each exposure configuration:

$$SPLSR = \frac{(Max\ SAR\ AG0 + Max\ SAR\ AG1)^{1.5}}{|Y_{max} - Y_{min}|}$$

D.2 Head (DSI = 2) SAR Antenna Group Analysis

Table D-1
DSI=2 Held-to-ear AG0 Highest Reported SAR

AG0						
Head SAR	Configuration	A	B	C	D	Max
	Right Cheek	0.232	0.059	0.007	0.000	0.232
	Right Tilt	0.190	0.045	0.004	0.000	0.190
	Left Cheek	0.348	0.053	0.000	0.000	0.348
	Left Tilt	0.209	0.066	0.002	0.000	0.209

Table D-2
DSI=2 Held-to-ear AG1 Highest Reported SAR

AG1						
Head SAR	Configuration	E	F	I	J	Max
	Right Cheek	0.451	0.724	0.630	0.645	0.724
	Right Tilt	0.317	0.347	0.626	0.757	0.757
	Left Cheek	0.262	0.318	0.519	0.881	0.881
	Left Tilt	0.226	0.182	0.374	1.176	1.176

Please refer to Table E-1 in Appendix E for highest reported simultaneous held-to-ear SAR of WLAN/BT antennas.

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Table D-3
DSI=2 Held-to-ear AG Verification

	Configuration	AG0	AG1	WLAN/BT Worst-case Combination	AG0 + AG1 + WLAN/BT Worst- case
Head SAR	Right Cheek	0.232	0.724	0.484	1.440
	Right Tilt	0.190	0.757	0.181	1.128
	Left Cheek	0.348	0.881	0.323	1.552
	Left Tilt	0.209	1.176	0.073	1.458

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.

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D.3 Body-worn (DSI = 0) SAR Antenna Group Analysis

Table D-4
DSI=0 Body-worn AG0 Highest Reported SAR

AG0						
Bodyworn SAR	Configuration	A	B	C	D	Max
	Back	0.977	0.473	0.008	0.048	0.977

Table D-5
DSI=0 Body-worn AG1 Highest Reported SAR

AG1						
Bodyworn SAR	Configuration	E	F	I	J	Max
	Back	0.009	0.197	0.072	0.120	0.197

Please refer to Table E-3 in Appendix E for highest reported simultaneous body-worn SAR of WLAN/BT antennas.

Table D-6
DSI=0 Body-worn AG Verification

	Configuration	AG0	AG1	WLAN/BT Worst-case Combination	AG0 + AG1 + WLAN/BT Worst-case
Bodyworn SAR	Back	0.977	0.197	0.337	1.511

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.

D.4 Hotspot (DSI = 3) SAR Antenna Group Analysis

Table D-7
DSI=3 Hotspot AG0 Highest Reported SAR

AG0						
Hotspot SAR	Configuration	A	B	C	D	Max
	Back	1.137	0.354	0.016	0.112	1.137
	Front	0.634	0.400	0.007	0.013	0.634
	Top	0.000	0.000	0.000	0.000	-
	Bottom	1.215	1.057	0.011	0.029	1.215
	Right	0.228	0.216	0.037	0.000	0.228
	Left	0.400	0.039	0.000	0.005	0.400

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Table D-8
DSI=3 Hotspot AG1 Highest Reported SAR

AG1						
Hotspot SAR	Configuration	E	F	I	J	Max
	Back	0.025	0.390	0.256	0.220	0.390
	Front	0.020	0.197	0.083	0.202	0.202
	Top	0.022	0.189	0.040	0.677	0.677
	Bottom	0.000	0.000	0.000	0.000	-
	Right	0.000	0.000	0.000	0.082	0.082
	Left	0.009	0.598	0.009	0.000	0.598

Please refer to Table E-5 in Appendix E for highest reported simultaneous hotspot SAR of WLAN/BT antennas.

Table D-9
DSI=3 Hotspot AG Verification

	Configuration	AG0	AG1	WLAN/BT Worst-case Combination	AG0 + AG1 + WLAN/BT Worst-case
Hotspot SAR	Back	1.137	0.390	0.701	See Table Below
	Front	0.634	0.202	0.604	1.44
	Top	0.000	0.677	0.529	1.206
	Bottom	1.215	0.000	-	1.215
	Right	0.228	0.082	-	0.31
	Left	0.400	0.598	0.458	1.456

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Back							
	AG0		AG1		WLAN/BT Worst-case Combination	AG0 + AG1 + WLAN/BT Worst-case	SPLSR
Ant Combination	SAR	Position	SAR	Position			
Ant A-Ant E	1.137	-66.000	0.025	67.000	0.701	See Note 2	0.01
Ant A-Ant F	1.137	-66.000	0.390	59.500	0.701	See Note 2	0.02
Ant A-Ant I	1.137	-66.000	0.256	65.500	0.701	See Note 2	0.01
Ant A-Ant J	1.137	-66.000	0.220	83.000	0.701	See Note 2	0.01
Ant B-Ant E	0.354	N/A	0.025	N/A	0.701	1.080	N/A
Ant B-Ant F	0.354	N/A	0.390	N/A	0.701	1.445	N/A
Ant B-Ant I	0.354	N/A	0.256	N/A	0.701	1.311	N/A
Ant B-Ant J	0.354	N/A	0.220	N/A	0.701	1.275	N/A
Ant C-Ant E	0.016	N/A	0.025	N/A	0.701	0.742	N/A
Ant C-Ant F	0.016	N/A	0.390	N/A	0.701	1.107	N/A
Ant C-Ant I	0.016	N/A	0.256	N/A	0.701	0.973	N/A
Ant C-Ant J	0.016	N/A	0.220	N/A	0.701	0.937	N/A
Ant D-Ant E	0.112	N/A	0.025	N/A	0.701	0.838	N/A
Ant D-Ant F	0.112	N/A	0.390	N/A	0.701	1.203	N/A
Ant D-Ant I	0.112	N/A	0.256	N/A	0.701	1.069	N/A
Ant D-Ant J	0.112	N/A	0.220	N/A	0.701	1.033	N/A

Notes:

1. For all combinations where the sum of AG0+AG1+WLAN/BT is less than 1.6, there's no further analysis required for compliance demonstration.
2. No evaluation was performed to determine the aggregate 1g SAR for these configurations as the SPLSR ratio between the antenna pairs was not greater than 0.04 per FCC KDB 447498 D01v06. Please see Section D.7 for Y-axis peak locations.

D.5 Max 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 D-10
DSI=0 Max Phablet AG0 Highest Reported SAR

AG0						
Phablet SAR	Configuration	A	B	C	D	Max
	Back	1.333	0.683	0.000	0.000	1.333
	Front	1.447	0.884	0.000	0.000	1.447
	Top	0.000	0.000	0.000	0.000	-
	Bottom	3.062	1.040	0.000	0.000	3.062
	Right	0.874	1.486	0.000	0.000	1.486
	Left	0.442	0.000	0.000	0.000	0.442

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Table D-11
DSI=0 Max Phablet AG1 Highest Reported SAR

AG1						
Phablet SAR	Configuration	E	F	I	J	Max
	Back	0.000	0.924	1.568	0.000	1.568
	Front	0.000	0.000	0.000	0.000	-
	Top	0.000	0.161	0.000	2.939	2.939
	Bottom	0.000	0.000	0.000	0.000	-
	Right	0.000	0.000	0.000	0.000	-
	Left	0.000	2.466	0.000	0.000	2.466

Please refer to Table E-15 in Appendix E for highest reported simultaneous phablet SAR of WLAN/BT antennas.

Table D-12
DSI=0 Max Phablet AG Verification

	Configuration	AG0	AG1	WLAN/BT Worst-case Combination	AG0 + AG1 + WLAN/BT Worst-case
Phablet SAR	Back	1.333	1.568	0.848	3.749
	Front	1.447	0.000	0.848	2.295
	Top	0.000	2.939	0.848	3.787
	Bottom	3.062	0.000	-	3.062
	Right	1.486	0.000	-	1.486
	Left	0.442	2.466	0.848	3.756

Notes:

1. 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.

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D.6 Reduced Phablet (DSI = 1) 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 D-13
DSI=1 Reduced Phablet AG0 Highest Reported SAR

AG0						
Phablet SAR	Configuration	A	B	C	D	Max
	Back	2.848	2.144	0.000	0.000	2.848
	Front	2.515	1.829	0.000	0.000	2.515
	Top	0.000	0.000	0.000	0.000	-
	Bottom	3.098	2.772	0.000	0.000	3.098
	Right	0.874	1.486	0.000	0.000	1.486
	Left	0.442	0.000	0.000	0.000	0.442

Table D-14
DSI=1 Reduced Phablet AG1 Highest Reported SAR

AG1						
Phablet SAR	Configuration	E	F	I	J	Max
	Back	0.000	0.924	1.568	0.000	1.568
	Front	0.000	0.000	0.000	0.000	-
	Top	0.000	0.161	0.000	2.939	2.939
	Bottom	0.000	0.000	0.000	0.000	-
	Right	0.000	0.000	0.000	0.000	-
	Left	0.000	2.466	0.000	0.000	2.466

Please refer to Table E-15 in Appendix E for highest reported simultaneous phablet SAR of WLAN/BT antennas.

Table D-15
DSI=1 Reduced Phablet AG Verification

	Configuration	AG0	AG1	WLAN/BT Worst-case Combination	AG0 + AG1 + WLAN/BT Worst-case
Phablet SAR	Back	2.848	1.568	0.848	See Table Below
	Front	2.515	0.000	0.848	3.363
	Top	0.000	2.939	0.848	3.787
	Bottom	3.098	0.000	-	3.098
	Right	1.486	0.000	-	1.486
	Left	0.442	2.466	0.848	3.756

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Back							
	AG0		AG1		WLAN/BT Worst-case Combination	AG0 + AG1 + WLAN/BT Worst-case	SPLSR
Ant Combination	SAR	Position	SAR	Position			
Ant A-Ant F	2.848	-79.800	0.924	60.400	0.848	See Note 2	0.05
Ant A-Ant I	2.848	-79.800	1.568	53.300	0.848	See Note 2	0.07
Ant B-Ant F	2.144	N/A	0.924	N/A	0.848	3.916	N/A
Ant B-Ant I	2.144	-72.300	1.568	53.300	0.848	See Note 2	0.06

Notes:

1. 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.
2. 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. Please see Section D.7 for Y-axis peak locations.

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D.7 Highest Report SAR and SAR Hotspot Locations

As a conservative assessment, the distances between AG0 and AG1 were determined using the y-axis coordinates of the peak locations only (assumes 0 mm separation on x/z axis)

Table D-16
DSI=3 Back Side Peak Y Coordinates

Back						
		AG0	AG1			
		A	E	F	I	J
Mode/Band	Distance (mm)	10	10	10	10	10
GSM 850	SAR	1.137				
	Y-Axis	-70.500				
GSM 1900	SAR	0.293				
	Y-Axis	-85.500				
UMTS 850	SAR	0.741				
	Y-Axis	-77.000				
UMTS 1750	SAR	0.495				
	Y-Axis	-81.000				
UMTS 1900	SAR	0.388				
	Y-Axis	-80.900				
LTE Band 71	SAR	0.407				
	Y-Axis	-70.500				
LTE Band 12	SAR	0.442				
	Y-Axis	-66.000				
LTE Band 13	SAR	0.656				
	Y-Axis	-70.500				
LTE Band 14	SAR	0.789				
	Y-Axis	-70.500				
LTE Band 26 (Cell)	SAR	0.839				
	Y-Axis	-69.000				
LTE Band 5 (Cell)	SAR	0.877				
	Y-Axis	-75.000				
LTE Band 66 (AWS)	SAR	0.539				
	Y-Axis	-82.500				
LTE Band 25 (PCS)	SAR	0.361				
	Y-Axis	-82.000				
LTE Band 30	SAR	0.405				
	Y-Axis	-80.500				
LTE Band 48	SAR			0.390		
	Y-Axis			59.500		
NR Band n71	SAR	0.553				
	Y-Axis	-78.000				
NR Band n12	SAR	0.486				
	Y-Axis	-70.500				
NR Band n5 (Cell)	SAR	1.048				
	Y-Axis	-67.500				
NR Band n66 (AWS)	SAR	0.503				
	Y-Axis	-82.500				
NR Band n25 (PCS)	SAR	0.376				
	Y-Axis	-88.500				
NR Band n30	SAR	0.522				
	Y-Axis	-83.500				
NR Band n66 (AWS)	SAR					0.159
	Y-Axis					85.500
NR Band n25 (PCS)	SAR					0.195
	Y-Axis					85.500
NR Band n30	SAR					0.142
	Y-Axis					83.000
NR Band n41	SAR					0.220
	Y-Axis					83.000
NR Band n41	SAR		0.025			
	Y-Axis		67.000			
NR Band n77 DoD	SAR			0.293		
	Y-Axis			63.500		
NR Band n77 DoD	SAR				0.256	
	Y-Axis				67.000	
NR Band n77	SAR			0.265		
	Y-Axis			66.400		
NR Band n77	SAR				0.148	
	Y-Axis				65.500	

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Table D-17
DSI=1 Back Side Reduced Phablet Peak Y Coordinates

		Back			
		AG0		AG1	
		A	B	F	I
Mode/Band	Distance (mm)	0	0	0	0
UMTS 1750	SAR	2.087			
	Y-Axis	-81.000			
UMTS 1900	SAR	2.402			
	Y-Axis	-85.000			
LTE Band 66 (AWS)	SAR	2.215			
	Y-Axis	-81.000			
LTE Band 25 (PCS)	SAR	1.811			
	Y-Axis	-81.900			
LTE Band 30	SAR	2.848			
	Y-Axis	-79.800			
LTE Band 7	SAR		2.144		
	Y-Axis		-78.400		
LTE Band 41	SAR		1.976		
	Y-Axis		-72.300		
NR Band n66 (AWS)	SAR	2.373			
	Y-Axis	-82.500			
NR Band n25 (PCS)	SAR	2.168			
	Y-Axis	-79.900			
NR Band n30	SAR	2.771			
	Y-Axis	-81.400			
NR Band n7	SAR		2.034		
	Y-Axis		-75.000		
NR Band n77 DoD	SAR			0.924	
	Y-Axis			64.100	
NR Band n77 DoD	SAR				1.568
	Y-Axis				53.300
NR Band n77	SAR			0.865	
	Y-Axis			60.400	

D.8 Conclusion

The above SPLSR criteria for all of the combinations of sub6 antenna groups is demonstrated to show that AG0 is mutually exclusive from AG1. Additional analysis for simultaneous analysis for the antenna groups and WIFI/BT antennas compliance demonstration is included in Appendix E.

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