

APPENDIX D: ANTENNA GROUPING ANALYSIS & JUSTIFICATION

D.1 Sub6 Antenna Groups

The standalone reported SAR and antenna group separation distances in the original filing was used to determine simultaneous transmission compliance as they are more conservative. Please see the original filing for complete evaluation of simultaneous transmission analysis and standalone reported SAR for modes and bands not evaluated for this permissive change.

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, H, I), 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, H, 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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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 SAR (W/kg)						
Head SAR	Configuration	A	B	C	D	Max
	Right Cheek	0.326	0.016	0.047	0.011	0.326
	Right Tilt	0.162	0.015	0.051	0.012	0.162
	Left Cheek	0.335	0.023	0.092	0.020	0.335
	Left Tilt	0.203	0.029	0.025	0.027	0.203

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

AG1 SAR (W/kg)						
Head SAR	Configuration	E	F	H	I	Max
	Right Cheek	0.126	0.398	0.000	0.369	0.398
	Right Tilt	0.068	0.204	0.000	0.527	0.527
	Left Cheek	0.071	0.191	0.000	0.642	0.642
	Left Tilt	0.062	0.179	0.000	0.960	0.960

Table D-3
DSI=2 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	0.326	0.398	0.868	1.592
	Right Tilt	0.162	0.527	0.454	1.143
	Left Cheek	0.335	0.642	0.450	1.427
	Left Tilt	0.203	0.960	0.408	1.571

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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 SAR (W/kg)						
Bodyworn SAR	Configuration	A	B	C	D	Max
	Back	0.936	0.107	0.088	0.305	0.936

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

AG1 SAR (W/kg)						
Bodyworn SAR	Configuration	E	F	H	I	Max
	Back	0.009	0.159	0.025	0.254	0.254

Table D-6
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 + WLAN/BT SAR (W/kg)
	Back	0.936	0.254	0.306	1.496

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

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



AG0 SAR (W/kg)						
Hotspot SAR	Configuration	A	B	C	D	Max
	Back	0.676	0.315	0.248	0.748	0.748
	Front	0.480	0.302	0.138	0.042	0.480
	Top	-	-	-	-	-
	Bottom	1.133	0.748	0.051	0.100	1.133
	Right	0.486	-	-	0.028	0.486
	Left	0.410	0.301	0.325	0.006	0.410

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

AG1 SAR (W/kg)						
Hotspot SAR	Configuration	E	F	H	I	Max
	Back	0.014	0.282	0.059	0.491	0.491
	Front	0.018	0.144	0.004	0.434	0.434
	Top	0.006	0.211	0.014	0.809	0.809
	Bottom	-	-	-	-	-
	Right	0.001	-	-	0.147	0.147
	Left	0.013	0.563	0.008	-	0.563

Table D-9
DSI=3 Hotspot AG Verification




Hotspot 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)
	Back	0.748	0.491	0.466	See Note 1
	Front	0.480	0.434	0.363	1.277
	Top	-	0.809	0.363	1.172
	Bottom	1.133	-	-	1.133
	Right	0.486	0.147	-	0.633
	Left	0.410	0.563	0.403	1.376

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Back							
Ant Combination	AG0		AG1		WLAN/BT Worst-case Combination SAR	AG0 + AG1 + WLAN/BT Worst-case SAR (W/kg)	AG0 + AG1 SPLSR
	SAR	Position	SAR	Position			
Ant A-Ant E	0.676	N/A	0.014	N/A	0.466	1.156	N/A
Ant A-Ant F	0.676	N/A	0.282	N/A	0.466	1.424	N/A
Ant A-Ant H	0.676	N/A	0.059	N/A	0.466	1.201	N/A
Ant A-Ant I	0.676	-60.600	0.491	62.400	0.466	See Note 2	0.01
Ant B-Ant E	0.315	N/A	0.014	N/A	0.466	0.795	N/A
Ant B-Ant F	0.315	N/A	0.282	N/A	0.466	1.063	N/A
Ant B-Ant H	0.315	N/A	0.059	N/A	0.466	0.840	N/A
Ant B-Ant I	0.315	N/A	0.491	N/A	0.466	1.272	N/A
Ant C-Ant E	0.248	N/A	0.014	N/A	0.466	0.728	N/A
Ant C-Ant F	0.248	N/A	0.282	N/A	0.466	0.996	N/A
Ant C-Ant H	0.248	N/A	0.059	N/A	0.466	0.773	N/A
Ant C-Ant I	0.248	N/A	0.491	N/A	0.466	1.205	N/A
Ant D-Ant E	0.748	N/A	0.014	N/A	0.466	1.228	N/A
Ant D-Ant F	0.748	N/A	0.282	N/A	0.466	1.496	N/A
Ant D-Ant H	0.748	N/A	0.059	N/A	0.466	1.273	N/A
Ant D-Ant I	0.748	-63.000	0.491	62.400	0.466	See Note 2	0.01

Notes:

1. For all combinations where the sum of AG0+AG1+WLAN/BT is less than 1.6 W/kg no further analysis is required for compliance demonstration.
2. No evaluation was performed to determine the aggregate 1g SAR for these configurations as the SPLS 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.

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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 SAR (W/kg)						
Phablet SAR	Configuration	A	B	C	D	Max
	Back	1.333	0.138	-	1.942	1.942
	Front	1.310	0.133	-	-	1.310
	Top	-	-	-	-	-
	Bottom	1.600	0.138	-	-	1.600
	Right	0.500	-	-	-	0.500
	Left	1.159	0.803	-	-	1.159

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

AG1 SAR (W/kg)						
Phablet SAR	Configuration	E	F	H	I	Max
	Back	-	1.317	-	-	1.317
	Front	-	-	-	-	-
	Top	-	-	-	1.824	1.824
	Bottom	-	-	-	-	-
	Right	-	-	-	-	-
	Left	-	3.130	-	-	3.130

Table D-12
DSI=0 Max Phablet AG Verification

Phablet 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)
	Back	1.942	1.317	1.192	See Note 1
	Front	1.310	-	0.752	2.062
	Top	-	1.824	0.133	1.957
	Bottom	1.600	-	-	1.600
	Right	0.500	-	-	0.500
	Left	1.159	3.130	0.549	See Note 1




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Back							
Ant Combination	AG0		AG1		WLAN/BT Worst-case Combination SAR	AG0 + AG1 + WLAN/BT Worst-case SAR (W/kg)	AG0 + AG1 SPLSR
	SAR	Position	SAR	Position			
Ant A-Ant F	1.333	N/A	1.317	N/A	1.192	3.842	N/A
Ant B-Ant F	0.138	N/A	1.317	N/A	1.192	2.647	N/A
Ant D-Ant F	1.942	-66.000	1.317	61.400	1.192	See Note 2	0.05

Left							
Ant Combination	AG0		AG1		WLAN/BT Worst-case Combination SAR	AG0 + AG1 + WLAN/BT Worst-case SAR (W/kg)	AG0 + AG1 SPLSR
	SAR	Position	SAR	Position			
Ant A-Ant F	1.159	-56.500	3.130	59.800	0.549	See Note 2	0.08
Ant B-Ant F	0.803	-63.500	3.130	59.800	0.549	See Note 2	0.06

Notes:

1. For all combinations where the sum of AG0+AG1+WLAN/BT is less than 4 W/kg no further analysis is required for compliance demonstration.
2. No evaluation was performed to determine the aggregate 10g SAR for these configurations as the SPLSR 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.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 SAR (W/kg)						
Phablet SAR	Configuration	A	B	C	D	Max
	Back	2.461	3.105	-	1.942	3.105
	Front	2.230	0.906	-	-	2.230
	Top	-	-	-	-	-
	Bottom	2.958	1.980	-	-	2.958
	Right	0.500	-	-	-	0.500
	Left	1.159	0.803	-	-	1.159

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

AG1 SAR (W/kg)						
Phablet SAR	Configuration	E	F	H	I	Max
	Back	-	1.317	-	-	1.317
	Front	-	-	-	-	-
	Top	-	-	-	1.824	1.824
	Bottom	-	-	-	-	-
	Right	-	-	-	-	-
	Left	-	3.130	-	-	3.130

Table D-15
DSI=1 Reduced Phablet AG Verification

Phablet 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)
	Back	3.105	1.317	1.192	See Note 1
	Front	2.230	-	0.752	2.982
	Top	-	1.824	0.133	1.957
	Bottom	2.958	-	-	2.958
	Right	0.500	-	-	0.500
	Left	1.159	3.130	0.549	See Note 1



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Back							
Ant Combination	AG0		AG1		WLAN/BT Worst-case Combination SAR	AG0 + AG1 + WLAN/BT Worst-case SAR (W/kg)	AG0 + AG1 SPLSR
	SAR	Position	SAR	Position			
Ant A-Ant F	2.461	-72.600	1.317	61.400	1.192	See Note 2	0.05
Ant B-Ant F	3.105	-75.500	1.317	61.400	1.192	See Note 2	0.07
Ant D-Ant F	1.942	-66.000	1.317	61.400	1.192	See Note 2	0.05

Left							
Ant Combination	AG0		AG1		WLAN/BT Worst-case Combination SAR	AG0 + AG1 + WLAN/BT Worst-case SAR (W/kg)	AG0 + AG1 SPLSR
	SAR	Position	SAR	Position			
Ant A-Ant F	1.159	-56.500	3.130	59.800	0.549	See Note 2	0.08
Ant B-Ant F	0.803	-63.500	3.130	59.800	0.549	See Note 2	0.06

Notes:

1. For all combinations where the sum of AG0+AG1+WLAN/BT is less than 4 W/kg no further analysis is required for compliance demonstration.
2. No evaluation was performed to determine the aggregate 10g SAR for these configurations as the SPLSR 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	D	I
Mode/Band	Distance	10 mm	10 mm	10 mm
GSM 850	SAR	0.676		
	Y-Axis	-65.800		
GSM 1900	SAR	0.406		
	Y-Axis	-82.300		
UMTS 850	SAR	0.493		
	Y-Axis	-67.400		
UMTS 1750	SAR	0.657		
	Y-Axis	-83.400		
UMTS 1900	SAR	0.453		
	Y-Axis	-81.600		
LTE Band 12	SAR	0.413		
	Y-Axis	-61.770		
LTE Band 13	SAR	0.633		
	Y-Axis	-65.880		
LTE Band 26 (Cell)	SAR	0.616		
	Y-Axis	-64.490		
LTE Band 66 (AWS)	SAR	0.480		
	Y-Axis	-78.000		
LTE Band 4 (AWS)	SAR			0.093
	Y-Axis			79.800
LTE Band 25 (PCS)	SAR	0.390		
	Y-Axis	-76.500		
NR Band n5 (Cell)	SAR	0.448		
	Y-Axis	-60.600		
NR Band n66 (AWS)	SAR	0.523		
	Y-Axis	-79.500		
NR Band n66 (AWS)	SAR			0.491
	Y-Axis			79.700
NR Band n25 (PCS)	SAR	0.545		
	Y-Axis	-74.700		
NR Band n41	SAR			0.156
	Y-Axis			62.400
NR Band n41	SAR		0.047	
	Y-Axis		-71.500	
NR Band n77 DoD	SAR		0.748	
	Y-Axis		-63.000	
NR Band n77	SAR		0.270	
	Y-Axis		-64.500	



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Table D-17
DSI=0 Back Side Max Phablet Peak Y Coordinates

Back		
	AG0	AG1
	D	F
Mode/Band	8 mm	0 mm
NR Band n77 DoD	1.942	
	-66.000	
NR Band n77		1.317
		61.400

Table D-18
DSI=0 Left Edge Max Phablet and DSI=1 Left Edge Reduced Phablet Peak Y Coordinates

Left			
	AG0		AG1
	A	B	F
Mode/Band	0 mm	0 mm	0 mm
GSM 1900	0.506		
	-69.000		
UMTS 1750	1.159		
	-56.500		
UMTS 1900	0.908		
	-68.700		
LTE Band 66 (AWS)	0.508		
	-64.500		
LTE Band 25 (PCS)	0.806		
	-63.000		
LTE Band 41		0.803	
		-63.500	
NR Band n66 (AWS)	1.099		
	-63.000		
NR Band n25 (PCS)	0.776		
	-72.200		
NR Band n77 DoD			2.571
			67.000
NR Band n77			3.130
			59.800





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Table D-19
DSI=1 Back Side Reduced Phablet Peak Y Coordinates

Back				
	AG0			AG1
	A	B	D	F
Mode/Band	0 mm	0 mm	0 mm	0 mm
GSM 1900	0.976			
	-73.800			
UMTS 1750	2.461			
	-75.200			
UMTS 1900	1.898			
	-79.900			
LTE Band 66 (AWS)	1.624			
	-73.500			
LTE Band 25 (PCS)	1.485			
	-76.600			
LTE Band 41		3.105		
		-75.500		
NR Band n66 (AWS)	1.403			
	-78.000			
NR Band n25 (PCS)	2.253			
	-72.600			
NR Band n77 DoD			1.942	
			-66.000	
NR Band n77				1.317
				61.400

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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