

## 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 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 each antenna group with non-Smart Transmit Radios. For this model, WWAN/WLAN/BT Radios are managed under Smart Transmit. Non-Smart Transmit Radios include NFC/UWB.

When operating in the same antenna group, the compliance under dynamic transmission condition, including all supported simultaneous transmission scenarios, should be assessed and demonstrated in the Part 2 Report during algorithm validation. Therefore, no further simultaneous analysis is needed within an antenna group.

### E.3 Antenna Groups

The 2nd generation of Smart Transmit (GEN2) operates based on pre-defined antenna groups (AG). Sub6/WLAN/BT 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 D04) with every antenna from another sub6 AG. These criteria must be demonstrated for all antenna combinations for each pair of AGs.

This device supports two AGs: AG0 and AG1, with AG0 having 2 antennas (A, B) and AG1 has 4 antennas (E, F, H, J). The conditions are verified through the following criteria:

- i) Sum of SAR: Demonstrate that the sum of *max.norm.exp.AG0* and *max.norm.exp.AG1* and the reported normalized SAR values from radios outside Smart Transmit (denoted as *reported.norm.exp.ER*) should be less than the regulatory limit for each supported DSI following the below procedure:

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1. Obtain the worst-case *adjusted SAR* for each antenna group, i.e., maximum *reported SAR* at EFS  $P_{limit} + unc$  (or max of  $\{P_{max} + unc, EFS P_{limit}\}$  when  $EFS P_{limit} > P_{max}$ ) out of all supported technologies, frequency bands and antennas in AG0 and AG1, then normalized to the regulatory limit to get the maximum normalized SAR for each antenna group, denoted as *max.norm.exp.AG0* and *max.norm.exp.AG1*
2. For external radios outside of Smart Transmit (NFC/UWB): Obtain the worst-case RF exposure for each external radio normalized to regulatory limit to get the normalized SAR for each external radio, denoted as *reported.norm.exp.NFC* and *reported.norm.exp.UWB*
3. Demonstrate that the sum of these RF exposures meets:  $\{max.norm.exp.AG0 + max.norm.exp.AG1 + normalized\ NFC\ SAR + normalized\ UWB\ SAR\} \leq 1$ .

ii) SPLSR or composite exposure distribution criteria: when TER sum of an antenna pair is over the limit for a DSI/exposure position, SPLSR or composite exposure distribution can be done to demonstrate simultaneous transmission compliance.

1. SPLSR analysis for sub6 antenna pairs: For each antenna, obtain the highest *adjusted SAR* at EFS  $P_{limit} + unc$  (or max of  $\{P_{max} + unc, EFS P_{limit}\}$  when  $EFS P_{limit} > P_{max}$ ) out of all supported technologies for each frequency band. Using these values, demonstrate for a given DSI that every antenna from one AG meets SPLSR criteria with every antenna in another AG for all frequency bands. This criterion must be demonstrated for all antenna pair combinations irrespective of supported simultaneous transmission scenarios as given below for each DSI. As it can be seen, these include all combinations of antenna groups, antennas, and frequency bands.
  - 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 the Highest Report SAR and Hotspot Location Section below for each DSI configuration. For bottom AG0, Y\_max coordinates 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:

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

When SPLSR is  $\leq 0.02$  for head/body-worn/hotspot and/or  $\leq 0.013$  for phablet, volumetric SAR evaluation is not required.

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

**Table E-1**  
**DSI=1 Held-to-ear AG0 Highest Adjusted ER**

AG0 Ratio to Limit				
Head SAR	Configuration	A	B	Max
	Right Cheek	0.262	0.259	0.262
	Right Tilt	0.207	0.083	0.207
	Left Cheek	0.232	0.091	0.232
	Left Tilt	0.209	0.125	0.209

**Table E-2**  
**DSI=1 Held-to-ear AG1 Highest Adjusted ER**

AG1 Ratio to Limit						
Head SAR	Configuration	E	F	H	J	Max
	Right Cheek	0.622	0.734	0.614	0.609	0.734
	Right Tilt	0.539	0.779	0.490	0.351	0.779
	Left Cheek	0.764	0.370	0.598	0.624	0.764
	Left Tilt	0.689	0.482	0.470	0.246	0.689

**Table E-3**  
**DSI=1 Held-to-ear AG Verification**

Head SAR	Configuration	AG0 Ratio to Limit	AG1 Ratio to Limit	AG0 + AG1 Ratio to Limit
	Right Cheek	0.262	0.734	0.996
	Right Tilt	0.207	0.779	0.986
	Left Cheek	0.232	0.764	0.996
	Left Tilt	0.209	0.689	0.898

**Notes:**

1. For all combinations where the TER sum of AG0+AG1 is not greater than 1, there's no further analysis required for compliance demonstration.

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

**Table E-4**  
**DSI=0 Body-worn AG0 Highest Adjusted ER**

AG0 Ratio to Limit				
Bodyworn SAR	Configuration	A	B	Max
		Back	0.443	0.286

**Table E-5**  
**DSI=0 Body-worn AG1 Highest Adjusted ER**

AG1 Ratio to Limit						
Bodyworn SAR	Configuration	E	F	H	J	Max
		Back	0.611	0.211	0.393	0.318

**Table E-6**  
**DSI=0 Body-worn AG Verification**

Bodyworn SAR	Configuration	AG0 Ratio to Limit	AG1 Ratio to Limit	AG0 + AG1 Ratio to Limit
		Back	0.443	0.611

  

Back				
AG0 Ratio to Limit		AG1 Ratio to Limit		AG0 + AG1 Ratio to Limit
Ant A	0.443	Ant E	0.611	See Note 1
Ant A	0.443	Ant F	0.211	0.654
Ant A	0.443	Ant H	0.393	0.836
Ant A	0.443	Ant J	0.318	0.761
Ant B	0.286	Ant E	0.611	0.897
Ant B	0.286	Ant F	0.211	0.497
Ant B	0.286	Ant H	0.393	0.679
Ant B	0.286	Ant J	0.318	0.604

	Bottom Set		Top Set			
	Back Side					
	Ant A	Ant B	Ant E	Ant F	Ant H	Ant J
Distance (mm)	10 mm	10 mm	10 mm	10 mm	10 mm	10 mm
Max Ratio to Limit	0.443	0.286	0.611	0.211	0.393	0.318
Max Y Axis (mm)	-71.600	-76.500				
Min Y Axis (mm)			69.800	82.100	45.000	34.000
Bottom Set and Top Set Max Ratio to Limit	0.443		0.611			
Bottom Set Max Y Axis (mm)	-71.600					
Top Set Min Y Axis (mm)			34.000			
SPLSR	0.01					

Notes:

1. No evaluation was performed to determine the aggregate 1g SAR for these configurations as the SPLSR between the antenna pairs was not greater than 0.02 per FCC KDB 447498 D01v06. Please see the Highest Report ER and Hotspot Location Section for Y-axis peak locations.
2. For all combinations where the TER sum of AG0+AG1 is not greater than 1, there's no further analysis required for compliance demonstration.

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## E.6 Hotspot (DSI = 0) SAR Antenna Group Analysis

**Table E-7  
DSI=0 Hotspot AG0 Highest Adjusted ER**

AG0 Ratio to Limit				
Hotspot SAR	Configuration	A	B	Max
	Back	0.443	0.286	0.443
	Front	0.336	0.261	0.336
	Top	-	-	-
	Bottom	0.784	0.401	0.784
	Right	0.310	0.376	0.376
	Left	0.246	-	0.246

**Table E-8  
DSI=0 Hotspot AG1 Highest Adjusted ER**

AG1 Ratio to Limit						
Hotspot SAR	Configuration	E	F	H	J	Max
	Back	0.513	0.211	0.332	0.289	0.513
	Front	0.583	0.249	0.286	0.352	0.583
	Top	0.623	0.622	0.215	0.102	0.623
	Bottom	-	-	-	-	-
	Right	0.509	-	0.047	0.091	0.509
	Left	0.473	0.132	0.579	0.486	0.579

**Table E-9  
DSI=0 Hotspot AG Verification**

Hotspot SAR	Configuration	AG0 Ratio to Limit	AG1 Ratio to Limit	AG0 + AG1 Ratio to Limit
	Back	0.443	0.513	0.956
	Front	0.336	0.583	0.919
	Top	-	0.623	0.623
	Bottom	0.784	-	0.784
	Right	0.376	0.509	0.885
	Left	0.246	0.579	0.825

Notes:

1. For all combinations where the TER sum of AG0+AG1 is not greater than 1, 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-10**  
**DSI=0 Phablet AG0 Highest Adjusted ER**

AG0 Ratio to Limit				
Phablet SAR	Configuration	A	B	Max
	Back	-	-	-
	Front	-	-	-
	Top	-	-	-
	Bottom	0.548	-	0.548
	Right	-	-	-
	Left	-	-	-

**Table E-11**  
**DSI=0 Phablet AG1 Highest Adjusted ER**

AG1 Ratio to Limit						
Phablet SAR	Configuration	E	F	H	J	Max
	Back	0.514	-	0.367	0.432	0.514
	Front	0.375	-	0.504	0.610	0.610
	Top	0.203	-	0.216	0.216	0.216
	Bottom	-	-	-	-	-
	Right	0.088	-	0.038	0.153	0.153
	Left	0.752	-	0.776	0.617	0.776

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**Table E-12**  
**DSI=0 Phablet AG Verification**

	Configuration	AG0 Ratio to Limit	AG1 Ratio to Limit	NFC Ratio to Limit	UWB Ratio to Limit	AG0 + AG1 + NFC + UWB Ratio to Limit
Phablet SAR	Back	-	0.514	0.003	0.000	0.517
	Front	-	0.610	0.000	0.001	0.611
	Top	-	0.216	0.000	0.000	0.216
	Bottom	0.548	-	-	-	0.548
	Right	-	0.153	-	-	0.153
	Left	-	0.776	0.000	0.001	0.777

Notes:

1. For all combinations where the TER sum of AG0+AG1 is not greater than 1, there's no further analysis required for compliance demonstration.

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## E.8 Highest Report ER and SAR Hotspot Locations

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

**Table E-13**  
**DSI=0 Back Side Body-worn Peak Y Coordinates**

	Distance	Bottom Set		Top Set			
		AG0		AG1			
		A	B	E	F	H	J
Mode/Band		10 mm	10 mm	10 mm	10 mm	10 mm	10 mm
GSM 850	ER	0.316		0.498			
	Y-Axis	-73.800		84.400			
GSM 1900	ER	0.268					
	Y-Axis	-84.100					
UMTS 850	ER	0.443		0.503			
	Y-Axis	-72.300		83.900			
LTE Band 12	ER	0.373		0.255			
	Y-Axis	-74.500		86.200			
LTE Band 13	ER	0.371		0.445			
	Y-Axis	-75.100		87.000			
LTE Band 5	ER	0.381		0.470			
	Y-Axis	-71.600		85.300			
LTE Band 66	ER	0.365					
	Y-Axis	-79.600					
LTE Band 2	ER	0.380					
	Y-Axis	-79.100					
LTE Band 41	ER		0.266		0.104		
	Y-Axis		-82.500		82.100		
NR Band n5	ER	0.380		0.433			
	Y-Axis	-73.800		82.600			
NR Band n66	ER	0.311			0.211		
	Y-Axis	-80.900			83.800		
NR Band n41	ER		0.286		0.168		
	Y-Axis		-76.500		84.500		
2.4 GHz WIFI	ER					0.308	0.289
	Y-Axis					45.000	34.000
5 GHz WIFI	ER			0.611		0.393	
	Y-Axis			69.800		62.400	
6 GHz WIFI	ER			0.107		0.096	
	Y-Axis			76.200		71.300	
2.4 GHz Bluetooth	ER					0.296	0.318
	Y-Axis					51.700	35.500

## E.9 Conclusion

The above numerical summed SAR results and SPLSR for all the combinations of 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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