

Appendix N. – Simultaneous Transmission Analysis

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

2 Simultaneous Transmission Analysis Guidance for 2nd Generation of Qualcomm Smart Transmit

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 a 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 ("–").

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/mmWave Radios are managed under Smart Transmit. The validation of the time-averaging algorithm and compliance under the Tx varying transmission scenario for 5G mmWave/WWAN/WLAN/BT technologies are reported in Part 2 Report. Non-Smart Transmit Radios include NFC and NTN.

The model operates in two modes: "cellular mode", a normal usage mode controlled by WWAN including 5G FR2 and WLAN/BT Smart transmit algorithm, and "satellite mode", which supports only satellite communication in Special circumstances when cellular mode is not available.

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.

The 2nd generation of Smart Transmit (GEN2) operates based on pre-defined sub6 antenna groups (AG) and/or mmW module groups (MG). Sub6 Tx antennas in UE 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 below conditions for all exposure positions under each DSI for a given exposure category.

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 KDB447498 D04) with every antenna from another sub6 AG. These criteria must be demonstrated for all antenna combinations for each pair of AGs

The 2nd generation of Smart Transmit (GEN2) operates based on pre-defined antenna groups (AG). Sub6/mmWave Module/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 4 antennas (Main 1, Main 2, Main 3, Main 4) and AG1 having 5 antennas (Sub 1, Sub 2, Sub 4, Sub 5, Sub 6) for DSI=0,1 condition. 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:

1. For a given Obtain the worst-case adjusted SAR for each antenna group, i.e., maximum reported SAR at EFS P_{limit} +uncertainty (or max of {P_{max} +uncertainty, 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(*max.norm.exp.AG0* and *max.norm.exp.AG1*)

2.For external radios outside of Smart Transmit : Obtain the worst-case RF exposure for each external

radio normalized to regulatory limit to get the normalized SAR for each external radio

3. Demonstrate that the sum of these RF exposures meets:

$$\{ \text{max.norm.exp.AG0} + \text{max.norm.exp.AG1} + \text{normalized NFC SAR} \} \leq 1.$$

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 Plimit + uncertainty (or max of {Pmax+uncertainty, EFS Plimit } when EFS Plimit > Pmax) 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:

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

2. Composite exposure distributions for SAR or mmWave antenna pairs, or SAR-mmWave antenna pairs: determine the composite exposure distributions for each antenna, normalized each composite distribution with the regulatory limit, then overlay/align these distributions in space relative to the device, and then sum them up in space to determine the aggregate distribution. Demonstrate the maximum normalized exposure out of all points in space on the aggregate distribution ≤ 1
3. For a given exposure condition, the composite exposure distribution for an antenna is determined by aligning the exposure distributions in space relative to the device and taking the maximum value of each point in space out of all supported radio configurations from all supported technologies/bands.

4. To determine composite SAR distribution for an antenna on a given DSI/exposure position:
5. Perform "Fast Volume Scan" in the mid channel using SPEAG DASY to obtain 1g/10g SAR distribution for each technology/band supported on the antenna.
Export the 1gSAR or 10gSAR distribution from the "Fast Volume Scan" and divide it by the maximum value in the distribution to obtain normalized 1gSAR or 10gSAR distribution for each technology/band.
6. Scale this normalized 1gSAR or 10gSAR distribution with the "adjusted SAR" value obtained from maximum reported SAR at EFS Plimit +uncertainty (or max of {Pmax+uncertainty, EFS Plimit } when EFS Plimit > Pmax) out of all supported technologies/bands for that antenna.
Determine composite SAR exposure distribution for the antenna given by maximum exposure distribution out of all supported technologies/bands at each point in space.
7. Determine normalized composite SAR distribution by dividing step 4) result with the regulatory limit.

This device supports two AGs: AG0 and AG1, with AG0 having 4 antennas (Main1, Main 2, Main 3, Main 4) and AG1 having 5 antennas (sub 1, sub 2, sub 4, sub 5, sub 6) for DSI=1 and 0 conditions, The M patch antenna was not considered in the TER analysis because it is considered to be collocated with antenna groups AG0 and AG1, The M patch modules is assumed to be collocated with each sub6 AG.

The model operates in two modes: "cellular mode", a normal usage mode controlled by WWAN including 5G FR2 and WLAN/BT Smart transmit algorithm, and "satellite mode", which supports only satellite communication in Special circumstances when cellular mode is not available.

cellular mode	satellite mode
WWAN including 5G FR2 and WLAN/BT with Smart transmit algorithm And NFC	NTN B255 NFC

3. Antenna Groups for Cellular mode

AG0	
Main 1	GSM850, GSM1900, WCDMA 2/4/5, LTE 2/4/5/12/13/14/25/26/30/66/71 NR n2/n5/n12/n14/n25/n26/n30/n66/n70/n71
Main 2	LTE 7/38/41, NR n7/n41, NR n41 SRS 2
Main 3	NR 48 SRS 2, NR 77 SRS 2, NR 78 SRS 2
Main 4	NR n41 SRS 3, NR n48 SRS 4, NR n77 SRS 4, NR n78 SRS 4

AG1	
Sub 1	GSM 850, WCDMA 5, LTE 12/13/14/26//71, NR n12/n14/n26/n71 NR 41 SRS 4, WLAN 5GHz/6GHz ANT 2
Sub 2	LTE 2/4/7/25//30/38/41/66, NR n2/n7/n25/n30/n41/n48/n77/n78, NR n41 SRS 2
Sub 4	WLAN 2.4GHz/ ANT 1, Bluetooth ANT 1, WLAN 5GHz/6GHz ANT 1
Sub 5	NR n48 SRS 3, NR n77 SRS 3, NR 78 SRS 3
Sub 6	WLAN 2.4GHz ANT 2, Bluetooth ANT 2

ER(External Radio)	
ANT L	NFC

3.1. Antenna Groups for satellite mode

Satellite mode Radio	
ANT L	NFC
Sub 2	NTN B255

*The NTN satellite communication mode of this model does not operate simultaneously with WWAN/WLAN/BT.

4. Power density Theoretical Calculations

To determine composite PD distribution for an antenna on a given DSI/exposure position:

- 1) For all technologies/bands supported by the antenna, obtain the 4cm2PDdistribution from validated simulated results.
- 2) Export the 4cm2PD distribution and divide it by the maximum value in the distribution to obtain the normalized 4cm2PD distribution.
- 3) Scaled this normalized 4cm2PD distribution with the “adjusted PD” value obtained from:

For dominant surface/position:

$PD_{\text{exposure}} = PD_{\text{design_target}} + \text{uncertainty}$ when $input.power.limit \leq P_{max}$, otherwise $PD_{\text{exposure}} = PD_{\text{design_target}}$

For non-dominant surfaces/positions: calculate exposure ratio of non-worst case surface over worst-case surface from validated simulated results. Then multiply this exposure ratio with the PD exposure on the worst-case surface.

To obtain adjusted PD at test distance at 10mm, apply the (PD sim at 10mm/PD sim at 2mm) ratio to $PD_{\text{design_target}} + \text{uncertainty}$

- 4) Determine composite PD distribution for the antenna given by the maximum exposure distribution out of all supported technologies/bands at each location in space.
- 5) Determine normalized composite PD distribution by dividing step d) result with the regulatory limit.

After determining normalized composite exposure distribution for each antenna of the pair, then align the composite distributions of both the antennas in space and perform the summation and determine the maximum of all locations in space. This maximum value must be ≤ 1 for the simultaneous transmission of the 2 antennas to be in compliance.

Antenna Module	Antenna Group	Bands	PD Design Target (mW/cm ²)	PD Uncertainty (dB)	Permanent Back-off (dB)	PD Limit (mW/cm ²)	Theoretical Ratio To Limit
M	Considering both AG0 and AG1 as collocated	N258/n261/n260	0.724	1.4	0.5	1.0	0.891

The worst-case reported psPD values – 2mm				
Antenna Module	Configuration	Evaluation Distance	Adjustment Factor due to Simulation	Theoretical Exposure Ratio to limit
M (mmwave)	Rear	2 mm	1	0.891
	Front	2 mm	0.58	0.517
	Bottom	2 mm	0.031	0.028
	Top	2 mm	0.307	0.273
	Left	2 mm	1	0.891
	Right	2 mm	0.073	0.065

The worst-case reported psPD values – 10mm				
Antenna Module	Configuration	Evaluation Distance	Adjustment Factor due to Simulation	Theoretical Exposure Ratio to limit
M (mmwave)	Rear	10 mm	0.618	0.55
	Front	10 mm	0.295	0.263
	Bottom	10 mm	0.023	0.02
	Top	10 mm	0.2	0.178
	Left	10 mm	0.668	0.595
	Right	10 mm	0.06	0.053

The M patch antenna was not considered in the TER analysis because it is considered to be collocated with antenna groups AG0 and AG1, The M patch modules is assumed to be collocated with each sub6 AG.

5. TER Analysis

5.1 Head SAR TER Analysis

AG 0 Ratio to Limit					
Position	Main 1	Main 2	Main 3	Main 4	Max
Left Touch	0.219	0.08	0.003	0.002	0.219
Left Tilt	0.102	0.066	0.004	0.000	0.102
Right Touch	0.209	0.066	0.000	0.003	0.209
Right Tilt	0.108	0.056	0.001	0.001	0.108

AG 1 Ratio to Limit						
Position	Sub 1	Sub 2	Sub 4	Sub 5	Sub 6	Max
Left Touch	0.667	0.467	0.111	0.045	0.609	0.667
Left Tilt	0.579	0.589	0.134	0.005	0.084	0.589
Right Touch	0.450	0.702	0.572	0.187	0.298	0.702
Right Tilt	0.384	0.690	0.308	0.004	0.039	0.690

AG0+AG1 Ratio to Limit			
Position	AG 0 Ratio to Limit	AG 1 Ratio to Limit	SUM
Left Touch	0.219	0.667	0.886
Left Tilt	0.102	0.589	0.691
Right Touch	0.209	0.702	0.911
Right Tilt	0.108	0.690	0.798

Note:

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

5.2 Body-Worn Simultaneous Transmission Analysis

AG 0 Ratio to Limit					
Position	Main 1	Main 2	Main 3	Main 4	Max
Rear	0.509	0.224	0.054	0.130	0.509
Front	0.424	0.176	0.037	0.078	0.424

AG 1 Ratio to Limit						
Position	Sub 1	Sub 2	Sub 4	Sub 5	Sub 6	Max
Rear	0.713	0.574	0.357	0.063	0.239	0.713
Front	0.518	0.315	0.134	0.046	0.197	0.518

AG0+AG1 Ratio to Limit			
Position	AG 0 Ratio to Limit	AG 1 Ratio to Limit	SUM
Rear	0.509	0.713	#see Table Below
Front	0.424	0.518	0.942

Position Rear					
AG 0 Ratio to Limit		AG 1 Ratio to Limit		AG0+AG1 Ratio to Limit	Max.total.norm.exp Result
Main 1	0.509	Sub 1	0.713	1.222	0.713
	0.509	Sub 2	0.574	1.083	0.575
	0.509	Sub 4	0.357	0.866	N/A
	0.509	Sub 5	0.063	0.572	N/A
	0.509	Sub 6	0.239	0.748	N/A
Main 2	0.224	Sub 1	0.713	0.937	N/A
	0.224	Sub 2	0.574	0.798	N/A
	0.224	Sub 4	0.357	0.581	N/A
	0.224	Sub 5	0.063	0.287	N/A
	0.224	Sub 6	0.239	0.463	N/A
Main 3	0.054	Sub 1	0.713	0.767	N/A
	0.054	Sub 2	0.574	0.628	N/A
	0.054	Sub 4	0.357	0.411	N/A
	0.054	Sub 5	0.063	0.117	N/A
	0.054	Sub 6	0.239	0.293	N/A
Main 4	0.064	Sub 1	0.713	0.777	N/A
	0.064	Sub 2	0.574	0.638	N/A
	0.064	Sub 4	0.357	0.421	N/A
	0.064	Sub 5	0.063	0.127	N/A
	0.064	Sub 6	0.239	0.303	N/A

Note :

1. The aggregate of normalized composite exposure distribution for this antenna pair yields maximum total exposure at all locations in space ≤ 1 . Hence simultaneous transmission of this antenna pair is in compliance per Qualcomm Guidance 80-W2112-4. Please see Appendix K. TER based Antenna Grouping Evaluation for Radios under Smart Transmit section.
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.

5.3 Hotspot Simultaneous Transmission Analysis

AG 0 Ratio to Limit					
Position	Main 1	Main 2	Main 3	Main 4	Max
Rear	0.509	0.224	0.054	0.130	0.509
Front	0.424	0.176	0.037	0.078	0.424
Left	0.322	0.101	0.056	-	0.322
Right	0.390	-	-	0.074	0.390
Bottom	0.675	0.266	0.026	0.046	0.675
Top	-	-	-	-	-

AG 1 Ratio to Limit						
Position	Sub 1	Sub 2	Sub 4	Sub 5	Sub 6	Max
Rear	0.713	0.574	0.357	0.063	0.239	0.713
Front	0.518	0.315	0.134	0.046	0.197	0.518
Left	-	0.121	0.521	0.033	-	0.521
Right	0.571	-	-	-	0.068	0.571
Bottom	-	-	-	-	-	-
Top	0.598	0.613	0.112	-	0.008	0.613

AG0+AG1			
Position	AG 0 Ratio to Limit	AG 1 Ratio to Limit	SUM
Rear	0.509	0.713	#see Table Below
Front	0.424	0.518	0.942
Left	0.322	0.521	0.843
Right	0.390	0.571	0.961
Bottom	0.675	-	0.675
Top	-	0.613	0.613

Position Rear					
AG 0 Ratio to Limit		AG 1 Ratio to Limit		AG0+AG1 Ratio to Limit	Max.total.norm.exp Result
Main 1	0.509	Sub 1	0.713	1.222	0.713
	0.509	Sub 2	0.574	1.083	0.575
	0.509	Sub 4	0.357	0.866	N/A
	0.509	Sub 5	0.063	0.572	N/A
	0.509	Sub 6	0.239	0.748	N/A
Main 2	0.224	Sub 1	0.713	0.937	N/A
	0.224	Sub 2	0.574	0.798	N/A
	0.224	Sub 4	0.357	0.581	N/A
	0.224	Sub 5	0.063	0.287	N/A
	0.224	Sub 6	0.239	0.463	N/A
Main 3	0.054	Sub 1	0.713	0.767	N/A
	0.054	Sub 2	0.574	0.628	N/A
	0.054	Sub 4	0.357	0.411	N/A
	0.054	Sub 5	0.063	0.117	N/A
	0.054	Sub 6	0.239	0.293	N/A
Main 4	0.064	Sub 1	0.713	0.777	N/A
	0.064	Sub 2	0.574	0.638	N/A
	0.064	Sub 4	0.357	0.421	N/A
	0.064	Sub 5	0.063	0.127	N/A
	0.064	Sub 6	0.239	0.303	N/A

Note:

1. The aggregate of normalized composite exposure distribution for this antenna pair yields maximum total exposure at all locations in space ≤ 1 . Hence simultaneous transmission of this antenna pair is in compliance per Qualcomm Guidance 80-W2112-4. Please see Appendix K. TER based Antenna Grouping Evaluation for Radios under Smart Transmit section.
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.

5.4 Phablet Simultaneous Transmission Analysis

AG 1 Ratio to Limit						
Position	Sub 1	Sub 2	Sub 4	Sub 5	Sub 6	Max
Rear	0.202	-	0.209	-	-	0.209
Front	0.135	-	0.231	-	-	0.231
Left	-	-	0.747	-	-	0.747
Right	0.077	-	-	-	-	0.077
Bottom	-	-	-	-	-	-
Top	0.067	-	0.099	-	-	0.099

ER(External Radio) Ratio to Limit	
Position	ANT L(NFC)
Rear	0.004
Front	0
Left	0
Right	0
Bottom	0

M patch(mmwave) Ratio to Limit		
Position	M(mmwave)	Max
Rear	0.891	0.891
Front	0.517	0.517
Left	0.891	0.891
Right	0.065	0.065
Bottom	0.028	0.028
Top	0.273	0.273

AG1+ER			
Position	AG 1 Ratio to Limit	ER Ratio to Limit	SUM
Rear	0.209	0.004	0.213
Front	0.231	0	0.231
Left	0.747	0	0.747
Right	0.077	0	0.077
Bottom	-	0	0
Top	0.099	0	0.099

M(mmwave) +ER			
Position	M Ratio to Limit	ER Ratio to Limit	SUM
Rear	0.891	0.004	0.895
Front	0.517	0	0.517
Left	0.891	0	0.891
Right	0.065	0	0.065
Bottom	0.028	0	0.028
Top	0.273	0	0.273

Note :

- For all combinations where the TER sum of AG1+ER, M(mmwave) +ER is not greater than 1, there's no further analysis required for compliance demonstration.

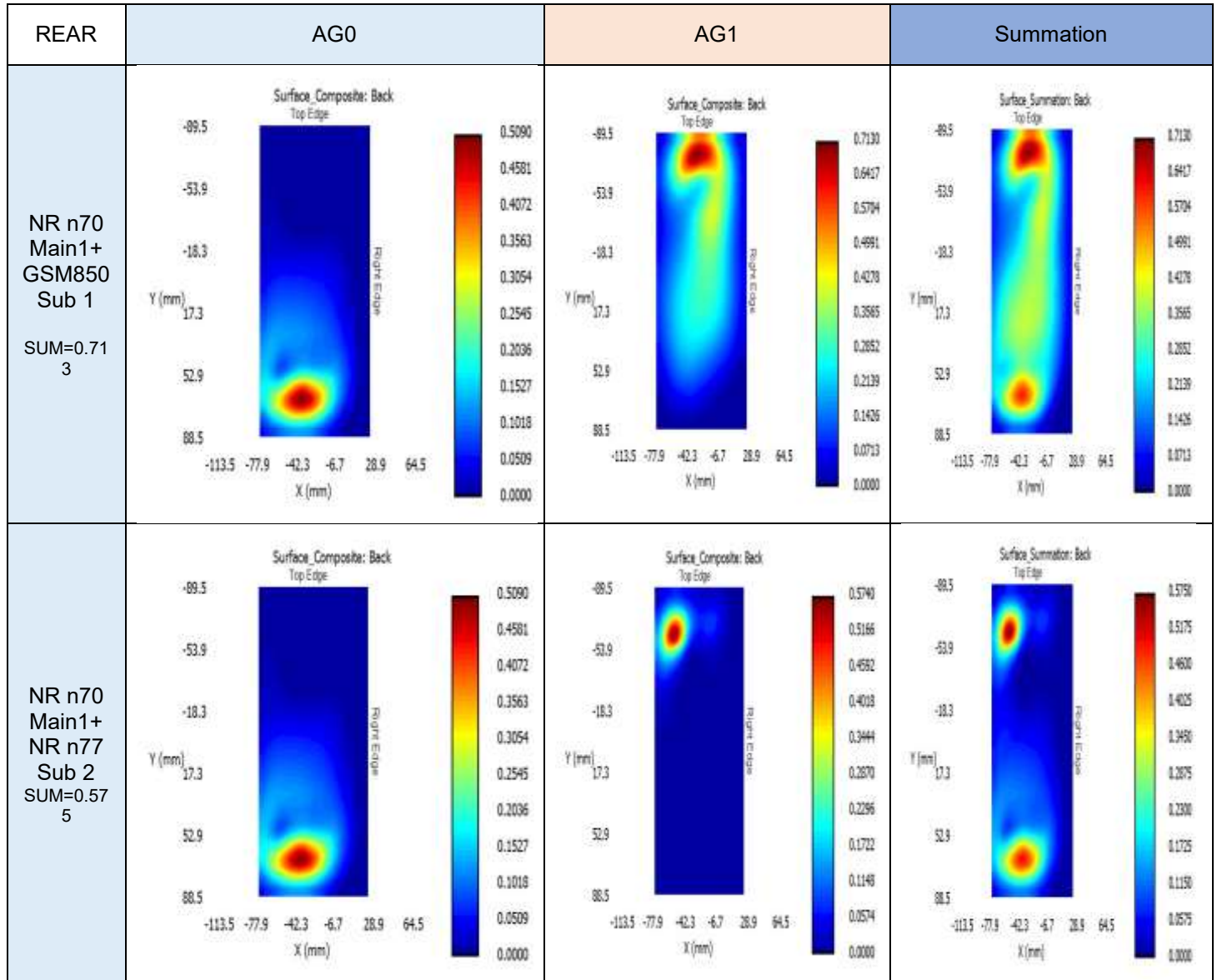
5.5 TER Analysis for satellite mode

Satellite Phablet Ratio to Limit			
Position	NTN B255 Ratio to Limit	NFC Ratio to Limit	SUM
Rear	0.430	0.004	0.434
Front	0.483	0	0.483
Left	0.212	0	0.212
Right	-	0	0
Bottom	-	0	0
Top	0.651	0	0.651

Note :

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

5.6 Aggregate of normalized composite exposure distribution



6 Conclusion

The above numerical summed SAR results and Qualcomm Guidance 80-W2112-4 Appendix K. TER based Antenna Grouping Evaluation for Radios under Smart Transmit section 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.