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

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). 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 the 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 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 the 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 (Main1, Main 2) and AG1 having 4 antennas (Sub 1, Sub 2, Sub 4, Sub 6) for DSI=1 and 0 conditions. 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 Plimit +uncertainty (or max of {Pmax +uncertainty, EFS Plimit }, when EFS Plimit > Pmax) 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:
{m$ax.norm.exp.AG0$ +$max.norm.exp.AG1$+normalized NFC SAR } ≤ 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:

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

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 speag 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.

3. Antenna Groups for Cellular mode

AG0	
MAIN1	GSM850, GSM1900, WCDMA 5, LTE 2/4/5/12/13/26/66, NR n5/n66
MAIN2	LTE 41, NR n41

AG1	
SUB1	GSM850, WCDMA 5, LTE 5/12/13/26, NR n5, WLAN 5 ㎓/6 ㎓ Ant 2
SUB2	LTE 41 NR n41/n66
SUB4	WLAN 2.4 ㎓/5 ㎓/6 ㎓, Bluetooth Ant 1
SUB6	WLAN 2.4 ㎓, Bluetooth Ant 2
SUB4+SUB6	WLAN 2.4 ㎓ MIMO
SUB4+SUB1	WLAN 5 ㎓/6 ㎓ MIMO

ER(External Radio)	
ANT.L	NFC

4. TER Analysis

4.1 Head SAR Simultaneous Transmission TER Analysis

AG0 Ratio to Limit			
Position	MAIN1	MAIN2	Max
Left Touch	0.359	0.131	0.359
Left Tilt	0.138	0.056	0.138
Right Touch	0.255	0.111	0.255
Right Tilt	0.148	0.046	0.148

AG1 Ratio to Limit							
Position	SUB1	SUB2	SUB4	SUB6	SUB4+SUB6	SUB4+SUB1	Max
Left Touch	0.614	0.181	0.160	0.574	0.319	0.190	0.614
Left Tilt	0.555	0.279	0.199	0.087	0.119	0.209	0.555
Right Touch	0.531	0.486	0.568	0.399	0.302	0.558	0.568
Right Tilt	0.425	0.649	0.278	0.021	0.277	0.412	0.649

AG0 + AG1 Simultaneous SAR Results			
Position	AG0 Max	AG1 Max	∑ AG0+AG1
Left Touch	0.359	0.614	**0.973**
Left Tilt	0.138	0.555	0.693
Right Touch	0.255	0.568	0.823
Right Tilt	0.148	0.649	0.797

Note:

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.

4.2 Body-Worn Simultaneous Transmission TER Analysis

AG0 Ratio to Limit			
Position	MAIN1	MAIN2	Max
Rear	0.524	0.326	0.524
Front	0.456	0.241	0.456

AG1 Ratio to Limit							
Position	SUB1	SUB2	SUB4	SUB6	SUB4+SUB6	SUB4+SUB1	Max
Rear	0.691	0.209	0.340	0.123	0.399	0.461	0.691
Front	0.549	0.152	0.310	0.239	0.409	0.309	0.549

AG0 + AG1 Simultaneous SAR Results			
Position	AG0 Max	AG1 Max	∑ AG0+AG1
Rear	0.524	0.691	#see Table Below
Front	0.456	0.549	#see Table Below

Position Rear				
AG 0 Ratio to Limit		AG 1 Ratio to Limit	AG0+AG1 Ratio to Limit	Max.total.norm.exp Result
MAIN1	0.524	SUB1	0.691	See note 1	0.809
	0.524	SUB2	0.209	0.733	N/A
	0.524	SUB4	0.340	0.864	N/A
	0.524	SUB6	0.123	0.647	N/A
	0.524	SUB4+SUB6	0.399	0.923	N/A
	0.524	SUB4+SUB1	0.461	**0.985**	N/A
MAIN2	0.326	SUB1	0.691	See note 1	0.924
	0.326	SUB2	0.209	0.535	N/A
	0.326	SUB4	0.340	0.666	N/A
	0.326	SUB6	0.123	0.449	N/A
	0.326	SUB4+SUB6	0.399	0.725	N/A
	0.326	SUB4+SUB1	0.461	0.787	N/A

Position Front				
AG 0 Ratio to Limit		AG 1 Ratio to Limit	AG0+AG1 Ratio to Limit	Max.total.norm.exp Result
MAIN1	0.456	SUB1	0.549	See note 1	0.893
	0.456	SUB2	0.152	0.608	N/A
	0.456	SUB4	0.310	0.766	N/A
	0.456	SUB6	0.239	0.695	N/A
	0.456	SUB4+SUB6	0.409	0.865	N/A
	0.456	SUB4+SUB1	0.309	0.765	N/A
MAIN2	0.241	SUB1	0.549	0.790	N/A
	0.241	SUB2	0.152	0.393	N/A
	0.241	SUB4	0.310	0.551	N/A
	0.241	SUB6	0.239	0.480	N/A
	0.241	SUB4+SUB6	0.409	0.650	N/A
	0.241	SUB4+SUB1	0.309	0.550	N/A

Note:

1. The aggregate of normalized composite exposure distribution for this antenna pair yields maximum total exposure at all locations in space $\leq$ 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.

4.3 Hotspot SAR Simultaneous Transmission TER Analysis

AG0 ratio to TER			
Position	MAIN1	MAIN2	Max
Rear	0.524	0.326	0.524
Front	0.456	0.241	0.456
Left	0.360	0.560	0.560
Right	0.292		0.292
Top			0.000
Bottom	0.738	0.743	0.743

AG1 Ratio to Limit							
Position	SUB1	SUB2	SUB4	SUB6	SUB4+SUB6	SUB4+SUB1	Max
Rear	0.691	0.209	0.340	0.123	0.399	0.461	0.691
Front	0.549	0.152	0.310	0.239	0.409	0.309	0.549
Left		0.043	0.464		0.358	0.347	0.529
Right	0.649			0.061	0.092	0.034	0.649
Top	0.553	0.310	0.387	0.003	0.451	0.144	0.553
Bottom							0.000

AG0 + AG1 Simultaneous SAR Results			
Position	AG0 Max	AG1 Max	∑ AG0+AG1
Rear	0.524	0.691	#see Table Below
Front	0.456	0.549	#see Table Below
Left	0.560	0.529	#see Table Below
Right	0.292	0.649	0.941
Top	0.000	0.553	0.553
Bottom	0.743	0.000	0.743

Position Rear				
AG 0 Ratio to Limit	AG 1 Ratio to Limit		AG0+AG1 Ratio to Limit	Max.total.norm.exp Result
MAIN1	0.524	SUB1	0.691	See note 1	0.809
	0.524	SUB2	0.209	0.733	N/A
	0.524	SUB4	0.340	0.864	N/A
	0.524	SUB6	0.123	0.647	N/A
	0.524	SUB4+SUB6	0.399	0.923	N/A
	0.524	SUB4+SUB1	0.461	**0.985**	N/A
MAIN2	0.326	SUB1	0.691	See note 1	0.691
	0.326	SUB2	0.209	0.535	N/A
	0.326	SUB4	0.340	0.666	N/A
	0.326	SUB6	0.123	0.449	N/A
	0.326	SUB4+SUB6	0.399	0.725	N/A
	0.326	SUB4+SUB1	0.461	0.787	N/A

Position Front				
AG 0 Ratio to Limit	AG 1 Ratio to Limit		AG0+AG1 Ratio to Limit	Max.total.norm.exp Result
MAIN1	0.456	SUB1	0.549	See note 1	0.893
	0.456	SUB2	0.152	0.608	N/A
	0.456	SUB4	0.310	0.766	N/A
	0.456	SUB6	0.239	0.695	N/A
	0.456	SUB4+SUB6	0.409	0.865	N/A
	0.456	SUB4+SUB1	0.309	0.765	N/A
MAIN2	0.241	SUB1	0.549	0.790	N/A
	0.241	SUB2	0.152	0.393	N/A
	0.241	SUB4	0.310	0.551	N/A
	0.241	SUB6	0.239	0.480	N/A
	0.241	SUB4+SUB6	0.409	0.650	N/A
	0.241	SUB4+SUB1	0.309	0.550	N/A

Position Left				
AG 0 Ratio to Limit	AG 1 Ratio to Limit		AG0+AG1 Ratio to Limit	Max.total.norm.exp Result
MAIN1	0.360	SUB1	-	0.360	N/A
	0.360	SUB2	0.043	0.403	N/A
	0.360	SUB4	0.464	0.824	N/A
	0.360	SUB6	-	0.360	N/A
	0.360	SUB4+SUB6	0.358	0.718	N/A
	0.360	SUB4+SUB1	0.347	0.707	N/A
MAIN2	0.560	SUB1	-	0.560	N/A
	0.560	SUB2	0.043	0.603	N/A
	0.560	SUB4	0.464	See note 1	0.680
	0.560	SUB6	-	0.560	N/A
	0.560	SUB4+SUB6	0.358	0.918	N/A
	0.560	SUB4+SUB1	0.347	0.907	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.

4.4 Phablet SAR Simultaneous Transmission TER Analysis

AG0 Ratio to Limit			
Position	MAIN1	MAIN2	Max
Rear	0.000	0.000	0.000
Front	0.000	0.000	0.000
Left	0.000	0.000	0.000
Right	0.000		0.000
Top			0.000
Bottom	0.000	0.000	0.000

AG1 Ratio to Limit			
Position	SUB1	SUB4	SUB4+SUB1	Max
Rear	0.197	0.211	0.230	0.230
Front	0.200	0.248	0.283	0.283
Left		0.596	0.633	0.633
Right	0.090		0.048	0.090
Top	0.161	0.138	0.144	0.161
Bottom				0.000

ER(External Radio) Ratio to Limit		
Position	ANT.L(NFC)	Max
Rear	0.005	0.005
Front	0.000	0.000
Left	0.000	0.000
Right	0.000	0.000
Top	0.000	0.000
Bottom	0.000	0.000

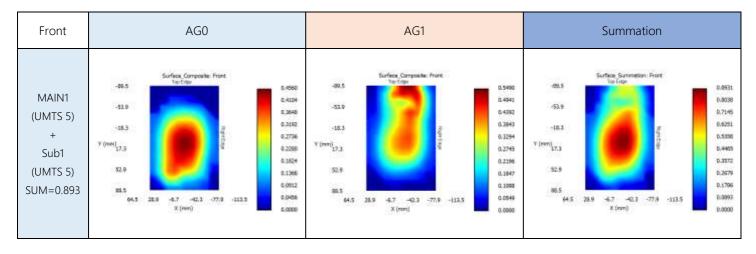| AG0 + AG1 + ER Simultaneous SAR Results			
Position	AG0 Max	AG1 Max	ER Ratio to Limit	∑ AG0+AG1+ER
Rear	0.000	0.230	0.005	0.235
Front	0.000	0.283	0.000	0.283
Left	0.000	0.633	0.000	**0.633**
Right	0.000	0.090	0.000	0.090
Top	0.000	0.161	0.000	0.161
Bottom	0.000	0.000	0.000	0.000

Note :

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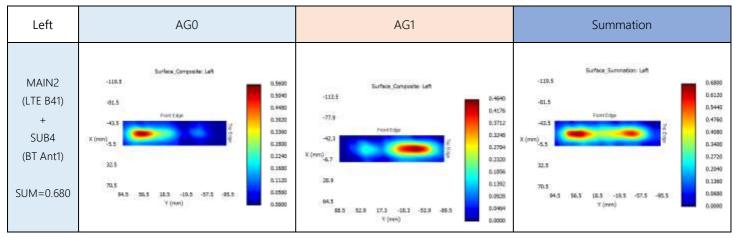
4.5 Aggregate of normalized composite exposure distribution

REAR	AG0	AG1	Summation
MAIN1 (UMTS 5) + SUB1 (LTE B13) SUM=0.809			
MAIN2 (LTE B31) + SUB1 (LTE B13) SUM=0.691			

Front	AG0	AG1	Summation
MAIN1 (UMTS 5) + Sub1 (UMTS 5) SUM=0.893			

Left	AG0	AG1	Summation
MAIN2 (LTE B41) + SUB4 (BT Ant1) SUM=0.680			

5. 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 IEC/IEEE 62209-1528- 2020 Section 7.4.4.2.