

Appendix E: Simultaneous Transmission Analysis

E.1. Introduction

According to FCC KDB Publication 447498 D04v01, transmitters are considered to be operating simultaneously when there is overlapping transmission, with the exception of transmissions during network hand-offs with maximum hand-off duration less than 30 seconds.

Table E-1 - Supported Simultaneous Transmission Scenarios

Scenario	Head	Body-worn	Hotspot	Phablet
WWAN + 2.4 GHz WIFI_SISO	Yes	Yes	Yes	Yes
WWAN + 2.4 GHz WIFI_MIMO	Yes	Yes	Yes	Yes
WWAN + 5 GHz WIFI_SISO	Yes	Yes	Yes	Yes
WWAN + 5 GHz WIFI_MIMO	Yes	Yes	Yes	Yes
WWAN + 6 GHz WIFI_SISO	Yes	Yes	Yes	Yes
WWAN + 6 GHz WIFI_MIMO	Yes	Yes	Yes	Yes
WWAN + 2.4 GHz Bluetooth_SISO	Yes	Yes	Yes*	Yes
WWAN + 2.4 GHz Bluetooth_MIMO	Yes	Yes	N/A	Yes
WWAN + 2.4 GHz WIFI_SISO + 5 GHz WIFI_SISO	Yes	Yes	Yes	Yes
WWAN + 2.4 GHz WIFI_SISO + 6 GHz WIFI_SISO	Yes	Yes	Yes	Yes
WWAN + 2.4 GHz WIFI_SISO + 5 GHz WIFI_MIMO	Yes	Yes	Yes	Yes
WWAN + 2.4 GHz WIFI_SISO + 6 GHz WIFI_MIMO	Yes	Yes	Yes	Yes
WWAN + 2.4 GHz WIFI_MIMO + 5 GHz WIFI_SISO	Yes	Yes	Yes	Yes
WWAN + 2.4 GHz WIFI_MIMO + 6 GHz WIFI_SISO	Yes	Yes	Yes	Yes
WWAN + 5 GHz WIFI_SISO + 2.4 GHz Bluetooth_SISO	Yes	Yes	Yes*	Yes
WWAN + 6 GHz WIFI_SISO + 2.4 GHz Bluetooth_SISO	Yes	Yes	Yes*	Yes
WWAN + 5 GHz WIFI_SISO + 2.4 GHz Bluetooth_MIMO	Yes	Yes	N/A	Yes
WWAN + 6 GHz WIFI_SISO + 2.4 GHz Bluetooth_MIMO	Yes	Yes	N/A	Yes
WWAN + 2.4 GHz WIFI_I + 2.4 GHz Bluetooth_G	Yes	Yes	Yes	Yes
WWAN + 5 GHz WIFI_MIMO + 2.4 GHz Bluetooth_SISO	Yes	Yes	Yes*	Yes
WWAN + 6 GHz WIFI_MIMO + 2.4 GHz Bluetooth_SISO	Yes	Yes	Yes*	Yes
WWAN + 5 GHz WIFI_MIMO + 2.4 GHz Bluetooth_MIMO	Yes	Yes	N/A	Yes
WWAN + 6 GHz WIFI_MIMO + 2.4 GHz Bluetooth_MIMO	Yes	Yes	N/A	Yes
WWAN + 5 GHz WIFI_SISO + 2.4 GHz WIFI_I + 2.4 GHz Bluetooth_G	Yes	Yes	Yes	Yes
WWAN + 6 GHz WIFI_SISO + 2.4 GHz WIFI_I + 2.4 GHz Bluetooth_G	Yes	Yes	Yes	Yes
WWAN + 2.4 GHz WIFI_MIMO + 5 GHz WIFI_MIMO	Yes	Yes	Yes	Yes
WWAN + 2.4 GHz WIFI_MIMO + 6 GHz WIFI_MIMO	Yes	Yes	Yes	Yes
WWAN + 5 GHz WIFI_MIMO + 2.4 GHz WIFI_I + 2.4 GHz Bluetooth_G	Yes	Yes	Yes	Yes
WWAN + 6 GHz WIFI_MIMO + 2.4 GHz WIFI_I + 2.4 GHz Bluetooth_G	Yes	Yes	Yes	Yes

Note:

- * Bluetooth tethering only supported on Ant G
- NFC can simultaneously transmit with all the above combinations and was evaluated for phablet based on usage conditions.

E.2. Procedures

This device contains transmitters that may operate simultaneously. Therefore, simultaneous transmission analysis is required. Per FCC KDB Publication 447498 D04v01 and IEEE 1528-2013 Section 6.3.4.1.2, simultaneous transmission SAR test exclusion may be applied when the sum of SAR for all the simultaneous transmitting antennas in a specific physical test configuration is ≤ 1.6 W/kg for 1g and 4 W/kg for 10g. 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 sub6 antenna groups (AG0 and AG1).

Simultaneous transmission analysis is performed per antenna group. 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.

When operating in the same antenna group, simultaneous transmission compliance between radio operations within an antenna group is demonstrated in the Part 2 Report during algorithm validation. Therefore, no further simultaneous analysis is needed within an antenna group.

E.3. Smart Transmit Antenna Grouping

The 2nd generation of Smart Transmit (GEN2) operates based on pre-defined sub6 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 the conditions below for all exposure scenarios:

- a) Sum of SAR of each 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. This criterion 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 having 4 antennas (E,F,G,I). The conditions are verified through the following criteria for a given exposure position:

- i) Summation criteria:
 - 1. Obtain the SAR Ratio to Limit for all supported Sub6/WLAN/BT frequency bands from all antennas supported in each antenna group. SAR Ratio to Limit is determined by *adjusted* SAR at *reported* P_{limit} dividing with the appropriate regulatory limit. Since $multi_Tx_factor = 1.13 > 1$ for this model, *reported* P_{limit} is $\min\{P_{limit} + unc + 10 \cdot \log(multi_Tx_factor), P_{max} + unc\}$. Hence:

- If $EFS P_{limit} \leq P_{max}$, reported $P_{limit} = EFS P_{limit} + unc + 10 \cdot \log(\text{multi_Tx_factor})$;
 - Otherwise $reported P_{limit} = \max\{EFS P_{limit}, P_{max} + unc\}$.
2. Determine the overall maximum adjusted SAR from all Sub6/WLAN/BT radios for each antenna on each antenna group, denoted as $max.exp.ant_{AG0}(i)$ and $max.exp.ant_{AG1}(j)$
 3. Obtain reported SAR for each external radio, denoted as $reported.exp.NFC$
 4. Demonstrate that the sum of these exposures meets: $max.exp.ant_{AG0}(i) + max.exp.ant_{AG1}(j) + reported.exp.NFC \leq 1.6 \text{ W/kg}$ for 1g and 4 W/kg for 10g

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

1. SPLSR analysis for Sub6/WLAN/BT Antenna pairs:

- On an exposure position for each antenna group, obtain the highest adjusted SAR from all supported frequency bands on all antennas irrespective of supported simultaneous transmission scenarios for each DSI, along with the peak SAR locations.
- Per Qualcomm guidance, only Y-axis coordinates are used in the analysis for calculation simplicity. For bottom Antenna group, Y_max coordinate represents the worst-case hotspot location that is closest to the top antenna group. Similarly, for top antenna group, Y_min coordinate represents the worst-case hotspot location that is closest to the bottom antenna group.
- Using the above 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. The following formula is used to calculate the SPLSR between AG0 and AG1 for each exposure configuration:

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

- When $SPLSR \leq 0.04$ (rounded to 2 decimal places) for 1g SAR, or 0.1 for 10g SAR, the antenna pair qualifies for test exemption.

E.4. Simultaneous Transmission Analysis

Table E-2 –AG0 Maximum Reported SAR Values

Exposure Condition	Position	AG0 SAR (W/kg)		
		A	B	Maximum
Head	Right Cheek	0.300	0.300	0.300
Head	Right Tilt	0.165	0.135	0.165
Head	Left Cheek	0.300	0.153	0.300
Head	Left Tilt	0.163	0.191	0.191
Body-worn	Back	1.108	0.957	1.108
Body-worn	Front	1.068	0.497	1.068
Hotspot	Back	1.211	0.957	1.211
Hotspot	Front	1.102	0.497	1.102
Hotspot	Top	-	-	-
Hotspot	Bottom	1.112	0.469	1.112
Hotspot	Right	0.338	-	0.338
Hotspot	Left	0.299	0.102	0.299

Table E-3 –AG1 Maximum Reported SAR Values

Exposure Condition	Position	AG1 (W/kg)						Maximum SAR
		E	F	G	I	MIMO (G&I)	MIMO (G&E)	
Head	Right Cheek	0.973	1.104	1.052	0.67	0.565	0.947	1.104
Head	Right Tilt	0.945	1.208	0.619	0.086	0.207	0.6	1.208
Head	Left Cheek	1.237	0.673	0.334	0.902	0.732	0.762	1.237
Head	Left Tilt	1.132	0.801	0.258	0.154	0.133	0.637	1.132
Body-worn	Back	1.354	1.228	1.203	0.625	1.114	1.008	1.354
Body-worn	Front	0.982	0.854	1.023	0.998	0.998	0.637	1.023
Hotspot	Back	1.354	1.228	0.999	0.295	1.114	0.912	1.354
Hotspot	Front	0.982	0.854	0.945	0.457	0.998	0.551	0.998
Hotspot	Top	1.048	0.588	0.226	0.01	0.118	0.18	1.048
Hotspot	Bottom	-	-	-	-	-	-	-
Hotspot	Right	0.738	-	-	0.051	0.06	0.059	0.738
Hotspot	Left	-	0.132	0.497	-	0.431	0.347	0.497
Phablet 10g	Back	1.18	-	1.814	0.785	1.29	1.249	1.814
Phablet 10g	Front	0.781	-	1.858	1.54	1.23	1.211	1.858
Phablet 10g	Top	0.359	-	0.76	0.011	0.41	0.449	0.760
Phablet 10g	Bottom	-	-	-	-	-	-	-
Phablet 10g	Right	0.463	-	-	0.503	0.333	0.323	0.503
Phablet 10g	Left	-	-	2.281	-	1.682	1.772	2.281

Table E-4 –AG0+AG1 + NFC

Exposure Condition	Position	SAR (W/kg)			
		AG0	AG1	NFC	Sum
Head	Right Cheek	0.300	1.104	-	1.404
Head	Right Tilt	0.165	1.208	-	1.373
Head	Left Cheek	0.300	1.237	-	1.537
Head	Left Tilt	0.191	1.132	-	1.323
Body-worn	Back	1.108	1.354	-	See Table E-5
Body-worn	Front	1.068	1.023	-	See Table E-5
Hotspot	Back	1.211	1.354	-	See Table E-5
Hotspot	Front	1.102	0.998	-	See Table E-5
Hotspot	Top	-	1.048	-	1.048
Hotspot	Bottom	1.112	-	-	1.112
Hotspot	Right	0.338	0.738	-	1.076
Hotspot	Left	0.299	0.497	-	0.796
Phablet	Back	-	1.814	0.011	1.825
Phablet	Front	-	1.858	0.000	1.858
Phablet	Top	-	0.760	0.000	0.760
Phablet	Bottom	-	-	-	-
Phablet	Right	-	0.503	-	0.503
Phablet	Left	-	2.281	0.000	2.281

Table E-5 SPLSR

Exposure Condition	Position	Combination	AG0 SAR (W/kg)	Max Y coordinate for AG0	AG1 SAR (W/kg)	Min Y coordinate for AG1	Sum SAR (W/kg)	SPLSR
Body-worn	Back	AG0 + AG1	1.108	-64.6	1.354	36.7	2.462	0.04
Body-worn	Front	AG0 + AG1	1.068	-72.6	1.023	29.7	2.091	0.03
Hotspot	Back	AG0 + AG1	1.211	-64.6	1.354	39.8	2.565	0.04
Hotspot	Front	AG0 + AG1	1.102	-72.3	0.998	39.9	2.100	0.03

Notes:

1. For all combinations where the SAR sum of AG0+AG1 +NFC is not greater than regulatory limits or SPLRS is under the limit, there's no further analysis required for compliance demonstration
2. See section E.5 for coordinates details for all bands/modes.

E.5. Y-coordinates

AG0 Ymax coordinates [mm]								
Exposure	Body-worn				Hotspot			
Position	Back		Front		Back		Front	
Band	Antenna							
	A	B	A	B	A	B	A	B
GSM 850	-73.7	-	-75.9	-	-70.7	-	-72.3	-
GSM 1900	-75.4	-	-80	-	-77.2	-	-78.1	-
UMTS Band 5	-66.7	-	-72.6	-	-66.7	-	-72.6	-
LTE Band 12	-73.9	-	-82.5	-	-73.9	-	-82.5	-
LTE Band 13	-68.2	-	-75.9	-	-68.2	-	-75.9	-
LTE Band 5	-64.6	-	-73.8	-	-64.6	-	-73.8	-
LTE Band 66	-79.5	-	-83.8	-	-79.5	-	-83.8	-
LTE Band 2	-73.9	-	-77.2	-	-73.9	-	-77.2	-
LTE Band 41	-	-72.7	-	-76.3	-	-72.7	-	-76.3
NR Band n5	-67.6	-	-72.6	-	-67.6	-	-72.6	-
NR Band n66	-80.5	-	-84.7	-	-80.5	-	-84.7	-
NR Band n41	-	-70.8	-	-82.3	-	-70.8	-	-82.3
Overall Coordinates	-64.6		-72.6		-64.6		-72.3	

AG1 Ymin Coordinates [mm]																									
Exposure	Body-worn												Hotspot												
Position	Back						Front						Back						Front						
Band	Antenna																								
	E	F	G	I	MIMO (G&I)	MIMO (G&E)	E	F	G	I	MIMO (G&I)	MIMO (G&E)	E	F	G	I	MIMO (G&I)	MIMO (G&E)	E	F	G	I	MIMO (G&I)	MIMO (G&E)	
GSM 850	72.4	-	-	-	-	-	74.1	-	-	-	-	-	75.6	-	-	-	-	-	84.7	-	-	-	-	-	
UMTS Band 5	79.8	-	-	-	-	-	77	-	-	-	-	-	79.8	-	-	-	-	-	77	-	-	-	-	-	
LTE Band 12	79.4	-	-	-	-	-	79.4	-	-	-	-	-	79.4	-	-	-	-	-	79.4	-	-	-	-	-	
LTE Band 13	76.1	-	-	-	-	-	80.2	-	-	-	-	-	76.1	-	-	-	-	-	80.2	-	-	-	-	-	
LTE Band 5	79.5	-	-	-	-	-	80.6	-	-	-	-	-	75.5	-	-	-	-	-	80	-	-	-	-	-	
LTE Band 41	-	70.4	-	-	-	-	-	75.8	-	-	-	-	-	70.4	-	-	-	-	-	75.8	-	-	-	-	
NR Band n5	75.2	-	-	-	-	-	77.8	-	-	-	-	-	75.2	-	-	-	-	-	77.8	-	-	-	-	-	
NR Band n66	-	71.7	-	-	-	-	-	76.4	-	-	-	-	-	71.7	-	-	-	-	-	76.4	-	-	-	-	
NR Band n41	-	71.1	-	-	-	-	-	73.9	-	-	-	-	-	71.1	-	-	-	-	-	73.9	-	-	-	-	
2.4 GHz WIFI	-	-	39.8	43.4	39.8	-	-	-	43.3	42.9	39.9	-	-	-	39.8	43.4	39.8	-	-	-	43.3	42.9	39.9	-	
5 GHz WIFI	57.5	-	53.3	-	-	58.7	58.1	-	53	-	-	60.2	57.7	-	53.3	-	-	58.7	65.4	-	56.9	-	-	60.3	
6 GHz WIFI	65	-	61.2	-	-	63.7	66.8	-	67.5	-	-	66.1	65	-	61.2	-	-	63.7	66.8	-	67.5	-	-	66.1	
2.4 GHz Bluetooth	-	-	40.5	44.3	36.7	-	-	-	43	29.7	32.5	-	-	-	40.5	N/A	N/A	-	-	-	43	N/A	N/A	-	
Overall Coordinates	36.7						29.7						39.8						39.9						

E.6. Conclusion

The above numerical summed 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. Therefore, no measured volumetric simultaneous SAR summation is required per FCC KDB Publication 447498 D04v01 and IEEE 1528- 2013 Section 6.3.4.1.