

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.
- NTN only transmits when the device is set to satellite mode and does not transmit with any other radios simultaneously.

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/ NTN 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.

Since NTN is only available and the only radio in satellite mode hence no further simultaneous analysis is needed for this mode.

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/NTN 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 3 antennas (A,B,D) and AG1 having 4 antennas (E,F,G,I), two shared antennas (C,H) between AGs. 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 $\min\{P_{limit} + unc + 10*\log(multi_Tx_factor), P_{max} + unc\}$. Hence:
 - If $EFS P_{limit} \leq P_{max}$, *reported* $P_{limit} = EFS P_{limit} + unc + 10*\log(multi_Tx_factor)$;
 - 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* ≤ 1.6 W/kg for 1g and 4 W/kg for 10g
5. For shared antennas/module between the 2 antenna groups, demonstrate the following:
 - *max.exp.ant_{AG0}(i) + max.exp.ant_{AG1}(j) + reported.exp.NFC* ≤ 1.6 W/kg for 1g and 4 W/kg for 10g where *ant_{AG0}(i)* and *ant_{AG1}(j)* are not shared antennas/module
 - *max.exp.ant_{shared}(k) + reported.exp.NFC* ≤ 1.6 W/kg for 1g and 4 W/kg for 10g where *ant_{shared}(k)* is the shared antennas between the 2 antenna groups

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	D	Maximum
Head	Right Cheek	0.300	0.269	0.000	0.300
Head	Right Tilt	0.186	0.227	0.000	0.227
Head	Left Cheek	0.300	0.300	0.000	0.300
Head	Left Tilt	0.184	0.289	0.000	0.289
Body-worn	Back	1.356	1.275	0.862	1.356
Body-worn	Front	1.339	0.771	0.023	1.339
Hotspot	Back	1.315	1.275	0.862	1.315
Hotspot	Front	1.339	0.771	0.023	1.339
Hotspot	Top	-	-	-	-
Hotspot	Bottom	1.242	0.984	0.017	1.242
Hotspot	Right	0.480	-	0.003	0.480
Hotspot	Left	0.523	0.349	-	0.523

Table E-3 –AG1 Maximum Reported SAR Values

Exposure Condition	Antenna Group Position	AG1 (W/kg)						Maximum
		E	F	G	I	MIMO (G&I)	MIMO (G&E)	
Head	Right Cheek	0.906	1.105	0.964	0.635	0.694	0.962	1.105
Head	Right Tilt	0.777	1.349	0.493	0.093	0.366	0.631	1.349
Head	Left Cheek	1.222	0.687	0.242	1.008	1.267	0.79	1.267
Head	Left Tilt	0.965	0.843	0.266	0.148	0.127	0.869	0.965
Body-worn	Back	1.258	1.319	0.998	0.645	0.898	0.946	1.319
Body-worn	Front	1.069	1.086	0.788	0.905	0.998	0.529	1.086
Hotspot	Back	1.258	1.319	0.998	0.544	0.796	0.644	1.319
Hotspot	Front	1.069	1.086	0.788	0.76	0.68	0.421	1.086
Hotspot	Top	0.565	0.82	0.149	0	0.108	0.119	0.820
Hotspot	Bottom	-	-	-	-	-	-	-
Hotspot	Right	0.694	-	-	0.075	0.075	0.082	0.694
Hotspot	Left	-	0.203	0.508	-	0.417	0.359	0.508
Phablet 10g SAR	Back	1.069	-	1.127	1.191	1.682	1.4	1.682
Phablet 10g SAR	Front	0.384	-	0.859	2.493	1.118	0.924	2.493
Phablet 10g SAR	Top	0.236	-	0.371	0.046	0.429	0.432	0.432
Phablet 10g SAR	Bottom	-	-	-	-	-	-	-
Phablet 10g SAR	Right	0.228	-	-	0.713	0.429	0.286	0.713
Phablet 10g SAR	Left	-	-	1.803	-	1.642	2.036	2.036

Table E-4 –AG0+AG1 + NFC

Exposure Condition	Position	SAR (W/kg)			
		AG0	AG1	NFC	Sum
Head	Right Cheek	0.300	1.105	-	1.405
Head	Right Tilt	0.227	1.349	-	1.576
Head	Left Cheek	0.300	1.267	-	1.567
Head	Left Tilt	0.289	0.965	-	1.254
Body-worn	Back	1.356	1.319	-	See Table E-5
Body-worn	Front	1.339	1.086	-	See Table E-5
Hotspot	Back	1.315	1.319	-	See Table E-5
Hotspot	Front	1.339	1.086	-	See Table E-5
Hotspot	Top	-	0.820	-	0.820
Hotspot	Bottom	1.242	-	-	1.242
Hotspot	Right	0.480	0.694	-	1.174
Hotspot	Left	0.523	0.508	-	1.031
Phablet 10g SAR	Back	-	1.682	0.011	1.693
Phablet 10g SAR	Front	-	2.493	0.000	2.493
Phablet 10g SAR	Top	-	0.432	0.000	0.432
Phablet 10g SAR	Bottom	-	-	-	-
Phablet 10g SAR	Right	-	0.713	-	0.713
Phablet 10g SAR	Left	-	2.036	0.000	2.036

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	1.356	-60.6	1.319	41.9	2.675	0.04
Body-worn	Front	AG0 + AG1	1.339	-65.2	1.086	30.4	2.425	0.04
Hotspot	Back	AG0 + AG1	1.315	-60.6	1.319	41.9	2.634	0.04
Hotspot	Front	AG0 + AG1	1.339	-65.2	1.086	30.4	2.425	0.04

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 condition	Body-worn						Hotspot					
Position	Back			Front			Back			Front		
Band	Antenna											
	A	B	D	A	B	D	A	B	D	A	B	D
GSM 850	-67.9	-	-	-73.2	-	-	-72.9	-	-	-83.1	-	-
GSM 1900	-74.8	-	-	-76.4	-	-	-77.6	-	-	-83.2	-	-
UMTS Band 5	-70.2	-	-	-66.5	-	-	-70.2	-	-	-66.5	-	-
UMTS Band 4	-77.2	-	-	-83.2	-	-	-77.2	-	-	-83.2	-	-
UMTS Band 2	-74	-	-	-76.9	-	-	-74	-	-	-76.9	-	-
LTE Band 71	-71.1	-	-	-69.2	-	-	-71.1	-	-	-69.2	-	-
LTE Band 12	-70.5	-	-	-76	-	-	-70.5	-	-	-76	-	-
LTE Band 13	-70.5	-	-	-75.8	-	-	-70.5	-	-	-75.8	-	-
LTE Band 14	-72.3	-	-	-72.1	-	-	-72.3	-	-	-72.1	-	-
LTE Band 26	-69.6	-	-	-71.3	-	-	-69.6	-	-	-71.3	-	-
LTE Band 66	-85.5	-	-	-90.3	-	-	-85.5	-	-	-90.3	-	-
LTE Band 25	-76.4	-	-	-82.9	-	-	-76.4	-	-	-82.9	-	-
LTE Band 30	-79.5	-	-	-82.7	-	-	-79.5	-	-	-82.7	-	-
LTE Band 7	-	-69.9	-	-	-79.1	-	-	-69.9	-	-	-79.1	-
LTE Band 41	-	-78	-	-	-80	-	-	-78	-	-	-80	-
NR Band n71	-71	-	-	-71.8	-	-	-71	-	-	-71.8	-	-
NR Band n12	-68.5	-	-	-73.5	-	-	-68.5	-	-	-73.5	-	-
NR Band n14	-64.1	-	-	-78	-	-	-64.1	-	-	-78	-	-
NR Band n26	-60.6	-	-	-73.8	-	-	-60.6	-	-	-73.8	-	-
NR Band n70	-76.9	-	-	-81.5	-	-	-76.9	-	-	-81.5	-	-
NR Band n66	-81.7	-	-	-79.6	-	-	-81.7	-	-	-79.6	-	-
NR Band n25	-77.7	-	-	-82.7	-	-	-77.7	-	-	-82.7	-	-
NR Band n30	-78.8	-	-	-79.6	-	-	-78.8	-	-	-79.6	-	-
NR Band n7	-	-84.1	-	-	-76.1	-	-	-84.1	-	-	-76.1	-
NR Band n41	-	-66.8	-64.3	-	-73.2	-73.2	-	-66.8	-64.3	-	-73.2	-73.2
NR Band n48	-	-	-62.7	-	-	-65.2	-	-	-62.7	-	-	-65.2
NR Band n77	-	-	-67	-	-	-78.1	-	-	-67	-	-	-78.1
Overall Coordinate	-60.6			-65.2			-60.6			-65.2		

AG1 Ymin Coordinates [mm]																									
Exposure condition	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	68.7	-	-	-	-	-	75.7	-	-	-	-	-	70.2	-	-	-	-	-	83.2	-	-	-	-	-	-
UMTS Band 5	77	-	-	-	-	-	82.4	-	-	-	-	-	77	-	-	-	-	-	82.4	-	-	-	-	-	-
LTE Band 71	69.8	-	-	-	-	-	75.3	-	-	-	-	-	69.8	-	-	-	-	-	75.3	-	-	-	-	-	-
LTE Band 12	72.9	-	-	-	-	-	74.3	-	-	-	-	-	72.9	-	-	-	-	-	74.3	-	-	-	-	-	-
LTE Band 13	75.8	-	-	-	-	-	78.2	-	-	-	-	-	75.8	-	-	-	-	-	78.2	-	-	-	-	-	-
LTE Band 14	75.5	-	-	-	-	-	77.9	-	-	-	-	-	75.5	-	-	-	-	-	77.9	-	-	-	-	-	-
LTE Band 26	69.8	-	-	-	-	-	75.4	-	-	-	-	-	69.8	-	-	-	-	-	75.4	-	-	-	-	-	-
LTE Band 66	-	72	-	-	-	-	-	74.6	-	-	-	-	-	72	-	-	-	-	-	74.6	-	-	-	-	-
LTE Band 25	-	75	-	-	-	-	-	78.9	-	-	-	-	-	75	-	-	-	-	-	78.9	-	-	-	-	-
LTE Band 30	-	69.7	-	-	-	-	-	74.8	-	-	-	-	-	69.7	-	-	-	-	-	74.8	-	-	-	-	-
LTE Band 7	-	66.6	-	-	-	-	-	69.5	-	-	-	-	-	66.6	-	-	-	-	-	69.5	-	-	-	-	-
LTE Band 41	-	73.1	-	-	-	-	-	78	-	-	-	-	-	73.1	-	-	-	-	-	78	-	-	-	-	-
LTE Band 48	-	68.8	-	-	-	-	-	71.5	-	-	-	-	-	68.8	-	-	-	-	-	71.5	-	-	-	-	-
NR Band n71	71	-	-	-	-	-	82.2	-	-	-	-	-	71	-	-	-	-	-	82.2	-	-	-	-	-	-
NR Band n12	73.6	-	-	-	-	-	71.7	-	-	-	-	-	73.6	-	-	-	-	-	71.7	-	-	-	-	-	-
NR Band n14	75.5	-	-	-	-	-	83.3	-	-	-	-	-	75.5	-	-	-	-	-	83.3	-	-	-	-	-	-
NR Band n26	77.3	-	-	-	-	-	80.9	-	-	-	-	-	77.3	-	-	-	-	-	80.9	-	-	-	-	-	-
NR Band n70	-	71	-	-	-	-	-	75.5	-	-	-	-	-	71	-	-	-	-	-	75.5	-	-	-	-	-
NR Band n66	-	73.8	-	-	-	-	-	71.7	-	-	-	-	-	73.8	-	-	-	-	-	71.7	-	-	-	-	-
NR Band n25	-	70.1	-	-	-	-	-	67.7	-	-	-	-	-	70.1	-	-	-	-	-	67.7	-	-	-	-	-
NR Band n30	-	73	-	-	-	-	-	75.2	-	-	-	-	-	73	-	-	-	-	-	75.2	-	-	-	-	-
NR Band n7	-	74.9	-	-	-	-	-	72.6	-	-	-	-	-	74.9	-	-	-	-	-	72.6	-	-	-	-	-
NR Band n41	67.7	70.2	-	-	-	-	77.3	78.8	-	-	-	-	67.7	70.2	-	-	-	-	77.3	78.8	-	-	-	-	-
NR Band n48	-	68.7	-	-	-	-	-	69.1	-	-	-	-	-	68.7	-	-	-	-	-	69.1	-	-	-	-	-
NR Band n77	-	50.6	-	-	-	-	-	74.6	-	-	-	-	-	50.6	-	-	-	-	-	74.6	-	-	-	-	-
2.4 GHz WIFI	-	-	46.7	41.9	43.6	-	-	-	47.2	30.4	47.5	-	-	-	46.7	41.9	43.6	-	-	-	47.2	30.4	47.5	-	-
5 GHz WIFI	52.7	-	54.5	-	-	53	61.3	-	46.6	-	-	61.1	52.7	-	54.5	-	-	55	61.3	-	46.6	-	-	63.4	-
6 GHz WIFI	66.4	-	62.1	-	-	68.6	66.5	-	57.5	-	-	64	66.4	-	62.1	-	-	68.6	66.4	-	62.1	-	-	68.6	-
2.4 GHz Bluetooth LE	-	-	52.4	50.6	42.1	-	-	-	43.9	32	30.9	-	-	-	52.4	N/A	N/A	-	-	-	52.4	N/A	N/A	-	-
Overall Coordinate	41.9						30.4						41.9						30.4						

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.