

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
1	WWAN + 2.4 GHz WIFI	Yes	Yes	Yes	Yes
2	WWAN + 5 GHz WIFI	Yes	Yes	Yes	Yes
3	WWAN + 2.4 GHz Bluetooth	Yes	Yes	Yes	Yes
4	WWAN + 5 GHz WIFI + 2.4 GHz Bluetooth	Yes	Yes	Yes	Yes

Note: 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 the 1g SAR for all the simultaneous transmitting antennas in a specific 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. Unless otherwise noted, when 10g SAR measurement is considered, a factor of 2.5 is applied to the 1g thresholds for the equivalent test cases.

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 ("").

E.3. SAR to Peak Location Separation Ratio (SPLSR) analysis

Per FCC KDB Publication 447498 D04v01, when the sum SAR of a simultaneous transmission scenario is over the limit, SPLSR procedure can be evaluated to determine the additional text exemption.

$$SPLSR = \frac{(SAR_1 + SAR_2)^{1.5}}{R_i}$$

Where: SAR_1 and SAR_2 are the highest reported SAR values for the two sources in the pair i , and R_i is their distance in mm.

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

E.4. Hybrid SPLSR

Per TCB Workshop Note in November 2019 and April 2022, when simultaneous 1g SAR is >1.6 and does not meet the SPLSR criteria, a hybrid SPLSR allows for aggregate SAR distribution of a co-located antenna pair to be used in SPLRS calculation.

For those simultaneous scenarios of WWAN+5 GHz WIFI+2.4 GHz BT whose sum 1g SAR is over 1.6 W/kg, 5 GHz WIFI and 2.4 GHz BT are co-located on top of the device hence hybrid SPLSR is used to calculate SPLSR of this antenna pair with WWAN bands/modes on the bottom of the device as following:

- SAR for the co-located antenna pair used in SPLRS calculation is the algebraical sum of the SAR values of the co-located pair
- Peak separation distance is the minimum distance between the spatially separated antenna and the closest antenna of the co-located antenna pair to be conservative.

E.5. Simultaneous Transmission Analysis

Per FCC KDB Publication 648474 D04v01r03, phablet SAR tests were required when the wireless router mode does not apply or when the wireless router 1g SAR was >1.2 W/kg (when scaled to the maximum output power). 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-2 – WIFI/BT simultaneous transmission summation

Exposure Condition	Band/Mode	2.4 GHz WIFI (W/kg)	5 GHz WIFI (W/kg)	2.4 GHz Bluetooth (W/kg)	2.4 GHz Bluetooth + 5 GHz WIFI (W/kg)	Max BT/WIFI Simultaneous SAR (W/kg)
	Position	1	2	3	2+3	
Head (1g)	Right Cheek	0.140	0.289	0.089	0.378	0.378
Head (1g)	Right Tilt	0.166	0.348	0.088	0.436	0.436
Head (1g)	Left Cheek	0.152	0.314	0.078	0.392	0.392
Head (1g)	Left Tilt	0.226	0.370	0.094	0.464	0.464
Body-worn (1g)	Back	0.711	1.196	0.284	1.480	1.480
Hotspot (1g)	Back	0.231	0.653	0.284	0.937	0.937
Hotspot (1g)	Front	0.102	0.172	0.021	0.193	0.193
Hotspot (1g)	Top	0.219	0.812	0.048	0.860	0.860
Hotspot (1g)	Bottom	-	-	-	-	-
Hotspot (1g)	Right	-	-	-	-	-
Hotspot (1g)	Left	0.042	0.089	0.007	0.096	0.096
Phablet 10g	Back	-	0.632	-	0.632	0.632
Phablet 10g	Front	-	0.280	-	0.280	0.280
Phablet 10g	Top	-	0.652	-	0.652	0.652
Phablet 10g	Bottom	-	-	-	-	-
Phablet 10g	Right	-	-	-	-	-
Phablet 10g	Left	-	0.212	-	0.212	0.212

Table E-3 – Overall simultaneous transmission summation

Exposure Condition	Position	Max WWAN SAR (W/kg)	Max NFC SAR (W/kg)	Max BT/WIFI SAR (W/kg)	ΣSAR_{1g} (W/kg)	ΣSAR_{10g} (W/kg)
Head	Right Cheek	0.285	-	0.378	0.663	-
Head	Right Tilt	0.149	-	0.436	0.585	-
Head	Left Cheek	0.265	-	0.392	0.657	-
Head	Left Tilt	0.205	-	0.464	0.669	-
Body-worn	Back	1.394	-	1.480	See Table Below	-
Hotspot	Back	1.272	-	0.937	See Table Below	-
Hotspot	Front	0.268	-	0.193	0.461	-
Hotspot	Top	-	-	0.860	0.860	-
Hotspot	Bottom	0.520	-	-	0.520	-
Hotspot	Right	0.329	-	-	0.329	-
Hotspot	Left	0.223	-	0.096	0.319	-
Phablet	Back	1.968	0.000	0.632	-	2.600
Phablet	Front	-	0.000	0.280	-	0.280
Phablet	Top	-	0.000	0.652	-	0.652
Phablet	Bottom	-	-	-	-	-
Phablet	Right	-	-	-	-	-
Phablet	Left	-	0.000	0.212	-	0.212

Table E-4 – Simultaneous transmission summation for Back side Body-worn/Hotspot

Exposure Condition	Position	Band/Mode	Max WWAN SAR (W/kg)	2.4 GHz WIFI SAR (W/kg)	5 GHz WIFI SAR (W/kg)	Bluetooth SAR (W/kg)	Bluetooth + 5 GHz WIFI SAR (W/kg)	ΣSAR_{1g} (W/kg)			
			1	2	3	4	5	1+2	1+3	1+4	1+5
Body-worn	Back	GSM 850	0.317	0.711	1.196	0.284	1.480	1.028	1.513	0.601	See Table E-8
Body-worn	Back	GSM 1900	0.750	0.711	1.196	0.284	1.480	1.461	See Table E-6	1.034	See Table E-8
Body-worn	Back	UMTS Band 5	1.272	0.711	1.196	0.284	1.480	See Table E-5	See Table E-6	1.556	See Table E-8
Body-worn	Back	UMTS Band 4	0.804	0.711	1.196	0.284	1.480	1.515	See Table E-6	1.088	See Table E-8
Body-worn	Back	UMTS Band 2	1.122	0.711	1.196	0.284	1.480	See Table E-5	See Table E-6	1.406	See Table E-8
Body-worn	Back	LTE Band 12	0.734	0.711	1.196	0.284	1.480	1.445	See Table E-6	1.018	See Table E-8
Body-worn	Back	LTE Band 13	0.519	0.711	1.196	0.284	1.480	1.230	See Table E-6	0.803	See Table E-8
Body-worn	Back	LTE Band 26	0.596	0.711	1.196	0.284	1.480	1.307	See Table E-6	0.880	See Table E-8
Body-worn	Back	LTE Band 66	0.833	0.711	1.196	0.284	1.480	1.544	See Table E-6	1.117	See Table E-8
Body-worn	Back	LTE Band 2	1.394	0.711	1.196	0.284	1.480	See Table E-5	See Table E-6	See Table E-7	See Table E-8
Body-worn	Back	LTE Band 41	1.177	0.711	1.196	0.284	1.480	See Table E-5	See Table E-6	1.461	See Table E-8
Hotspot	Back	GSM 850	0.177	0.231	0.653	0.284	0.937	0.408	0.830	0.461	1.114
Hotspot	Back	GSM 1900	0.316	0.231	0.653	0.284	0.937	0.547	0.969	0.600	1.253
Hotspot	Back	UMTS Band 5	1.272	0.231	0.653	0.284	0.937	1.503	See Table E-6	1.556	See Table E-8
Hotspot	Back	UMTS Band 4	0.277	0.231	0.653	0.284	0.937	0.508	0.930	0.561	1.214
Hotspot	Back	UMTS Band 2	0.484	0.231	0.653	0.284	0.937	0.715	1.137	0.768	1.421
Hotspot	Back	LTE Band 12	0.734	0.231	0.653	0.284	0.937	0.965	1.387	1.018	See Table E-8
Hotspot	Back	LTE Band 13	0.519	0.231	0.653	0.284	0.937	0.750	1.172	0.803	1.456
Hotspot	Back	LTE Band 26	0.596	0.231	0.653	0.284	0.937	0.827	1.249	0.880	1.533
Hotspot	Back	LTE Band 66	0.312	0.231	0.653	0.284	0.937	0.543	0.965	0.596	1.249
Hotspot	Back	LTE Band 2	0.452	0.231	0.653	0.284	0.937	0.683	1.105	0.736	1.389
Hotspot	Back	LTE Band 41	1.177	0.231	0.653	0.284	0.937	1.408	See Table E-6	1.461	See Table E-8

Table E-5 – SPLSR for WWAN + 2.4 GHz WIFI Simultaneous transmission

Exposure Condition	Surface	Mode 1	Mode 2	Mode 1 SAR (W/kg)	Mode 2 SAR (W/kg)	Sum SAR (W/kg)	Peak Location Separation Distance (mm)	SPLSR	Plot #
Body-worn	Back	UMTS Band 5	2.4 GHz WIFI	1.272	0.711	1.983	166.90	0.02	-
Body-worn	Back	UMTS Band 2	2.4 GHz WIFI	1.122	0.711	1.833	156.75	0.02	-
Body-worn	Back	LTE Band 2	2.4 GHz WIFI	1.394	0.711	2.105	156.04	0.02	1
Body-worn	Back	LTE Band 41	2.4 GHz WIFI	1.177	0.711	1.888	162.94	0.02	-

Table E-6 – SPLSR for WWAN + 5 GHz WIFI Simultaneous transmission

Exposure Condition	Surface	Mode 1	Mode 2	Mode 1 SAR (W/kg)	Mode 2 SAR (W/kg)	Sum SAR (W/kg)	Peak Location Separation Distance (mm)	SPLSR	Plot #
Body-worn	Back	GSM 1900	5 GHz WIFI	0.750	1.196	1.946	155.65	0.02	-
Body-worn	Back	UMTS Band 5	5 GHz WIFI	1.272	1.196	2.468	159.78	0.02	-
Body-worn	Back	UMTS Band 4	5 GHz WIFI	0.804	1.196	2.000	148.85	0.02	-
Body-worn	Back	UMTS Band 2	5 GHz WIFI	1.122	1.196	2.318	149.45	0.02	-
Body-worn	Back	LTE Band 12	5 GHz WIFI	0.734	1.196	1.930	153.32	0.02	-
Body-worn	Back	LTE Band 13	5 GHz WIFI	0.519	1.196	1.715	159.17	0.01	-
Body-worn	Back	LTE Band 26	5 GHz WIFI	0.596	1.196	1.792	147.96	0.02	-
Body-worn	Back	LTE Band 66	5 GHz WIFI	0.833	1.196	2.029	148.55	0.02	-
Body-worn	Back	LTE Band 2	5 GHz WIFI	1.394	1.196	2.590	148.74	0.03	2
Body-worn	Back	LTE Band 41	5 GHz WIFI	1.177	1.196	2.373	155.64	0.02	-
Hotspot	Back	UMTS Band 5	5 GHz WIFI	1.272	0.653	1.925	164.51	0.02	-
Hotspot	Back	LTE Band 41	5 GHz WIFI	1.177	0.653	1.830	160.65	0.02	-

Table E-7 –SPLSR for WWAN + 2.4 GHz Bluetooth Simultaneous transmission

Exposure Condition	Surface	Mode 1	Mode 2	Mode 1 SAR (W/kg)	Mode 2 SAR (W/kg)	Sum SAR (W/kg)	Peak Location Separation Distance (mm)	SPLSR	Plot #
Body-worn	Back	LTE Band 2	2.4 GHz Bluetooth	1.394	0.284	1.678	155.54	0.01	3

Table E-8 – Hybrid SPLSR for WWAN + 5 GHz WIFI + 2.4 GHz Bluetooth Simultaneous transmission

Exposure Condition	Surface	Mode 1	Mode 2	Mode 1 SAR (W/kg)	Mode 2 SAR (W/kg)	Sum SAR (W/kg)	Peak Location Separation Distance (mm)	SPLSR	Plot #
Body-worn	Back	GSM 850	5 GHz WIFI + 2.4 GHz Bluetooth	0.317	1.480	1.797	159.39	0.02	-
Body-worn	Back	GSM 1900	5 GHz WIFI + 2.4 GHz Bluetooth	0.750	1.480	2.230	155.65	0.02	-
Body-worn	Back	UMTS Band 5	5 GHz WIFI + 2.4 GHz Bluetooth	1.272	1.480	2.752	159.78	0.03	-
Body-worn	Back	UMTS Band 4	5 GHz WIFI + 2.4 GHz Bluetooth	0.804	1.480	2.284	148.85	0.02	-
Body-worn	Back	UMTS Band 2	5 GHz WIFI + 2.4 GHz Bluetooth	1.122	1.480	2.602	149.45	0.03	-
Body-worn	Back	LTE Band 12	5 GHz WIFI + 2.4 GHz Bluetooth	0.734	1.480	2.214	153.32	0.02	-
Body-worn	Back	LTE Band 13	5 GHz WIFI + 2.4 GHz Bluetooth	0.519	1.480	1.999	159.17	0.02	-
Body-worn	Back	LTE Band 26	5 GHz WIFI + 2.4 GHz Bluetooth	0.596	1.480	2.076	147.96	0.02	-
Body-worn	Back	LTE Band 66	5 GHz WIFI + 2.4 GHz Bluetooth	0.833	1.480	2.313	148.55	0.02	-
Body-worn	Back	LTE Band 2	5 GHz WIFI + 2.4 GHz Bluetooth	1.394	1.480	2.874	148.74	0.03	2
Body-worn	Back	LTE Band 41	5 GHz WIFI + 2.4 GHz Bluetooth	1.177	1.480	2.657	155.64	0.03	-
Hotspot	Back	UMTS Band 5	5 GHz WIFI + 2.4 GHz Bluetooth	1.272	0.937	2.209	164.51	0.02	-
Hotspot	Back	LTE Band 12	5 GHz WIFI + 2.4 GHz Bluetooth	0.734	0.937	1.671	157.96	0.01	-
Hotspot	Back	LTE Band 41	5 GHz WIFI + 2.4 GHz Bluetooth	1.177	0.937	2.114	160.65	0.02	-

Note: Peak Location Separation distance for hybrid SPLSR is the minimum distance of between the WWAN mode to 5 GHz WIFI and WWAN to 2.4 GHz Bluetooth to be conservative. (See Section E.6)

The above analysis of the simultaneous transmission scenarios is sufficient to show 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.

E.6. Peak SAR Coordinates and hybrid SPLSR Peak Location separation distance calculation

Table E-9 Peak SAR Coordinates

Exposure Condition	Surface	Mode	x-coordinate (mm)	y-coordinate (mm)	z-coordinate (mm)
Body-worn	Back	GSM 850	-35.8	-85.3	-207
Body-worn	Back	GSM 1900	-4.9	-83.8	-207
Body-worn/Hotspot	Back	UMTS Band 5	-43	-84.3	-207
Body-worn	Back	UMTS Band 4	-2.2	-76.9	-207
Body-worn	Back	UMTS Band 2	-2.2	-77.5	-207
Body-worn/Hotspot	Back	LTE Band 12	-47.8	-76.5	-207
Body-worn	Back	LTE Band 13	-41.5	-84	-207
Body-worn	Back	LTE Band 26	-35.2	-73.8	-207
Body-worn	Back	LTE Band 66	-2.2	-76.6	-207
Body-worn	Back	LTE Band 2	-0.4	-76.7	-207
Body-worn/Hotspot	Back	LTE Band 41	-5.5	-83.8	-207
Body-worn	Back	2.4 GHz WIFI	-9	79.1	-207
Body-worn	Back	5 GHz WIFI	-8.9	71.8	-207
Body-worn	Back	2.4 GHz Bluetooth	-9	78.6	-207
Hotspot	Back	5 GHz WIFI	-9.7	76.8	-207

Table E-10 Peak Location separation distance for hybrid SPLSR

Exposure Condition	Surface	Mode 1	Mode 2	Peak Location Separation Distance (mm)
Body-worn	Back	GSM 850	2.4 GHz Bluetooth	166.08
Body-worn	Back	GSM 850	5 GHz WIFI	159.39
Body-worn	Back	GSM 1900	2.4 GHz Bluetooth	162.45
Body-worn	Back	GSM 1900	5 GHz WIFI	155.65
Body-worn	Back	UMTS Band 5	2.4 GHz Bluetooth	166.41
Body-worn	Back	UMTS Band 5	5 GHz WIFI	159.78
Body-worn	Back	UMTS Band 4	2.4 GHz Bluetooth	155.65
Body-worn	Back	UMTS Band 4	5 GHz WIFI	148.85
Body-worn	Back	UMTS Band 2	2.4 GHz Bluetooth	156.25
Body-worn	Back	UMTS Band 2	5 GHz WIFI	149.45
Body-worn	Back	LTE Band 12	2.4 GHz Bluetooth	159.88
Body-worn	Back	LTE Band 12	5 GHz WIFI	153.32
Body-worn	Back	LTE Band 13	2.4 GHz Bluetooth	165.82
Body-worn	Back	LTE Band 13	5 GHz WIFI	159.17
Body-worn	Back	LTE Band 26	2.4 GHz Bluetooth	154.64
Body-worn	Back	LTE Band 26	5 GHz WIFI	147.96
Body-worn	Back	LTE Band 66	2.4 GHz Bluetooth	155.35
Body-worn	Back	LTE Band 66	5 GHz WIFI	148.55
Body-worn	Back	LTE Band 2	2.4 GHz Bluetooth	155.54
Body-worn	Back	LTE Band 2	5 GHz WIFI	148.74
Body-worn	Back	LTE Band 41	2.4 GHz Bluetooth	162.44
Body-worn	Back	LTE Band 41	5 GHz WIFI	155.64
Hotspot	Back	UMTS Band 5	2.4 GHz Bluetooth	166.41
Hotspot	Back	UMTS Band 5	5 GHz WIFI	164.51
Hotspot	Back	LTE Band 12	2.4 GHz Bluetooth	159.88
Hotspot	Back	LTE Band 12	5 GHz WIFI	157.96
Hotspot	Back	LTE Band 41	2.4 GHz Bluetooth	162.44
Hotspot	Back	LTE Band 41	5 GHz WIFI	160.65

E.7. Peak Location separation distance Plots

For each simultaneous transmission scenario in table E-1 that requires SPLSR analysis for SAR test exemption, the antenna pair with highest SPLSR values and lowest peak separation distance was plotted for SPLSR visualization purpose.

