

APPENDIX E: MULTI-TX AND ANTENNA SAR CONSIDERATIONS

E.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.

E.2 Simultaneous Transmission Procedures

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 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 447498 D01v06, when the sum of the standalone transmitters exceeds 1.6 W/kg for 1g SAR or 4.0 W/kg for 10g SAR, SAR peak location analysis may be performed to determine whether SAR distributions overlap. Simultaneous SAR evaluation is not required when the SAR Peak Location Separation Ratio (SPLSR) for each transmitter pair is ≤ 0.04 for 1g SAR and ≤ 0.10 for 10g SAR. The SPLSR is calculated using the highest reported standalone SAR values and the separation distance between the peak SAR locations of the transmitting antennas.

$$Distance = R_i = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$$

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

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E.3 Head Simultaneous Transmission Analysis

Table E-1
WWAN Head SAR Data

Antenna A (W/Kg)													
	Configuration	GSM 850	GSM 1900	UMTS 850	UMTS 1750	UMTS 1900	LTE Band 12	LTE Band 13	LTE Band 26	LTE Band 66	LTE Band 2	LTE Band 41	Max
Head	Right Cheek	0.248	0.088	0.353	0.208	0.124	0.180	0.167	0.242	0.227	0.184	0.120	0.353
	Right Tilt	0.134	0.061	0.163	0.173	0.110	0.095	0.090	0.110	0.163	0.125	0.059	0.173
	Left Cheek	0.217	0.068	0.298	0.191	0.169	0.160	0.185	0.208	0.156	0.143	0.193	0.298
	Left Tilt	0.141	0.087	0.158	0.206	0.162	0.068	0.091	0.116	0.191	0.166	0.084	0.206

Table E-2
Simultaneous Transmission Scenario of WLAN/BT for Head

Configuration	2.4 GHz WLAN Head SAR (W/kg)	5 GHz WLAN Head SAR (W/kg)	2.4 GHz Bluetooth Head SAR (W/kg)	5 GHz WLAN Head + 2.4 GHz Bluetooth Head SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
Right Cheek	0.529	0.666	0.106	0.772	0.772
Right Tilt	0.489	1.076	0.118	1.194	1.194
Left Cheek	0.290	0.837	0.048	0.885	0.885
Left Tilt	0.341	1.035	0.051	1.086	1.086

Table E-3
Head Verification

Head SAR	Configuration	WWAN SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	WWAN + WLAN/BT SAR (W/kg)
	Right Cheek	0.353	0.772	1.125
	Right Tilt	0.173	1.194	1.367
	Left Cheek	0.298	0.885	1.183
	Left Tilt	0.206	1.086	1.292

Notes:

- For all combinations where the sum of WWAN + WLAN/BT is less than 1.6, there's no further analysis required for compliance demonstration.

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E.4 Body-worn Simultaneous Transmission Analysis

Table E-4
WWAN Body-worn SAR Data

Antenna A (W/Kg)													
Configuration	GSM 850	GSM 1900	UMTS 850	UMTS 1750	UMTS 1900	LTE Band 12	LTE Band 13	LTE Band 26	LTE Band 66	LTE Band 2	LTE Band 41	Max	
Body-worn Back	1.198	0.621	1.181	0.773	0.602	0.663	0.545	0.989	1.086	1.044	0.543	1.198	

Table E-5
Simultaneous Transmission Scenario of WLAN/BT for Body-worn

Configuration	2.4 GHz WLAN Body-worn SAR (W/kg)	5 GHz WLAN Body-worn SAR (W/kg)	2.4 GHz Bluetooth Body-worn SAR (W/kg)	5 GHz WLAN Body-worn + 2.4 GHz Bluetooth Body-worn SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
Back	0.300	1.101	0.113	1.214	1.214

Table E-6
Body-worn Verification

Bodyworn SAR	Configuration	WWAN SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	WWAN + WLAN/BT SAR (W/kg)
	Back	1.198	1.214	See Table Below

Back							
WWAN			WLAN/BT Worst Case		Standalone Sum	Peak separation Distance (mm)	SPLSR
Band/Mode	SAR (W/Kg)	Position Y_coord	SAR (W/Kg)	Position Y_coord			
GSM 850_Ant A	1.198	83.7	1.214	-78.0	2.412	161.70	0.02
GSM 1900_Ant A	0.621	77.5	1.214	-78.0	1.835	155.50	0.02
UMTS Band 5_Ant A	1.181	83.4	1.214	-78.0	2.395	161.40	0.02
UMTS Band 4_Ant A	0.773	78.3	1.214	-78.0	1.987	156.30	0.02
UMTS Band 2_Ant A	0.602	73.1	1.214	-78.0	1.816	151.10	0.02
LTE Band 12_Ant A	0.663	82.5	1.214	-78.0	1.877	160.50	0.02
LTE Band 13_Ant A	0.545	79.2	1.214	-78.0	1.759	157.20	0.01
LTE Band 26_Ant A	0.989	83.0	1.214	-78.0	2.203	161.00	0.02
LTE Band 66_Ant A	1.086	74.1	1.214	-78.0	2.300	152.10	0.02
LTE Band 2_Ant A	1.044	77.5	1.214	-78.0	2.258	155.50	0.02
LTE Band 41_Ant A	0.543	76.8	1.214	-78.0	1.757	154.80	0.02

Notes:

- For all combinations where the sum of WWAN+ WLAN/BT is less than 1.6, there's no further analysis required for compliance demonstration
- No evaluation was performed to determine the aggregate 1g SAR for these configurations as the SPLS ratio between the antenna pairs was not greater than 0.04 per FCC KDB 447498 D04v01. Please see the Highest Report SAR and Hotspot Location Section for Y-axis peak locations

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E.5 Hotspot Simultaneous Transmission Analysis

Table E-7
WWAN Hotspot SAR Data

Antenna A (W/Kg)													
Configuration	GSM 850	GSM 1900	UMTS 850	UMTS 1750	UMTS 1900	LTE Band 12	LTE Band 13	LTE Band 26	LTE Band 66	LTE Band 2	LTE Band 41	Max	
Back	1.198	0.621	1.181	0.773	0.602	0.663	0.545	0.989	1.086	1.044	0.543	1.198	
Front	0.544	0.355	0.546	0.455	0.328	0.288	0.232	0.401	0.500	0.489	0.218	0.546	
Bottom	0.766	0.636	0.681	0.669	0.521	0.385	0.240	0.501	0.931	1.008	0.330	1.008	
Right	0.511	0.056	0.312	0.146	0.050	0.450	0.290	0.266	0.163	0.107	0.055	0.511	
Left	0.253	0.210	0.181	0.324	0.252	0.247	0.166	0.153	0.373	0.345	0.131	0.373	

Table E-8
Simultaneous Transmission Scenario of WLAN/BT for Hotspot

Configuration	2.4 GHz WLAN Hotspot SAR (W/kg)	5 GHz WLAN Hotspot SAR (W/kg)	2.4 GHz Bluetooth Hotspot SAR (W/kg)	5 GHz WLAN Hotspot + 2.4 GHz Bluetooth Hotspot SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)
Back	0.300	0.636	0.113	0.749	0.749
Front	0.249	0.446	0.045	0.491	0.491
Top	0.123	0.881	0.053	0.934	0.934
Left	0.091	0.460	0.010	0.470	0.470

Table E-9
Hotspot Verification

Configuration	WWAN SAR (W/kg)	WLAN/BT Worst-case Combination SAR (W/kg)	WWAN + WLAN/BT SAR (W/kg)
Back	1.198	0.749	See Table Below
Front	0.546	0.491	1.037
Top	-	0.934	0.934
Bottom	1.008	-	1.008
Right	0.511	-	0.511
Left	0.373	0.470	0.843

Back							
WWAN			WLAN/BT Worst Case		Standalone Sum	Peak separation Distance (mm)	SPLSR
Band/Mode	SAR (W/Kg)	Position Y_coord	SAR (W/Kg)	Position Y_coord			
GSM 850_Ant A	1.198	83.7	0.749	-78.0	1.947	161.70	0.02
GSM 1900_Ant A	0.621	77.5	0.749	-78.0	1.370	155.50	N/A
UMTS Band 5_Ant A	1.181	83.4	0.749	-78.0	1.930	161.40	0.02
UMTS Band 4_Ant A	0.773	78.3	0.749	-78.0	1.522	156.30	N/A
UMTS Band 2_Ant A	0.602	73.1	0.749	-78.0	1.351	151.10	N/A
LTE Band 12_Ant A	0.663	82.5	0.749	-78.0	1.412	160.50	N/A
LTE Band 13_Ant A	0.545	79.2	0.749	-78.0	1.294	157.20	N/A
LTE Band 26_Ant A	0.989	83.0	0.749	-78.0	1.738	161.00	0.01
LTE Band 66_Ant A	1.086	74.1	0.749	-78.0	1.835	152.10	0.02
LTE Band 2_Ant A	1.044	77.5	0.749	-78.0	1.793	155.50	0.02
LTE Band 41_Ant A	0.543	76.8	0.749	-78.0	1.292	154.80	N/A

Notes:

- For all combinations where the sum of WWAN+ WLAN/BT is less than 1.6, there's no further analysis required for compliance demonstration
- No evaluation was performed to determine the aggregate 1g SAR for these configurations as the SPLS ratio between the antenna pairs was not greater than 0.04 per FCC KDB 447498 D04v01. Please see the Highest Report SAR and Hotspot Location Section for Y-axis peak locations

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E.6 Phablet Simultaneous Transmission Analysis

Table E-10
WWAN Phablet SAR Data

Antenna A													
	Configuration	GSM 850	GSM 1900	UMTS 850	UMTS 1750	UMTS 1900	LTE Band 12	LTE Band 13	LTE Band 26	LTE Band 66	LTE Band 2	LTE Band 41	Max
Phablet	Back	1.176	1.267	1.295	1.483	1.268	0.837	1.271	1.269	1.796	1.752	0.986	1.796
	Front	0.947	1.529	0.851	2.489	1.434	0.459	0.616	0.659	1.685	1.326	1.044	2.489
	Bottom	0.999	0.875	1.119	1.169	0.714	0.668	0.822	1.060	1.297	1.301	0.701	1.301
	Right	1.032	0.229	1.069	0.258	0.129	0.479	0.686	0.862	0.197	0.219	0.167	1.069
	Left	0.194	1.031	0.145	1.302	1.050	0.108	0.110	0.117	1.009	0.821	0.580	1.302

Table E-11
NFC Phablet SAR Data

NFC (W/Kg)			
	Configuration	NFC	Max
Phablet	Back	0.034	0.034
	Front	0.000	0.000
	Top	0.000	0.000
	Left	0.000	0.000

Table E-12
Simultaneous Transmission Scenario of WLAN/BT for Phablet

Configuration	2.4 GHz WLAN Phablet SAR (W/kg)	5 GHz WLAN Phablet SAR (W/kg)	WLAN Worst-case Combination SAR (W/kg)
Back	0.308	0.500	0.500
Front	0.502	0.449	0.502
Top	0.207	0.693	0.693
Left	0.121	0.328	0.328

Table E-13
Phablet Verification

	Configuration	WWAN SAR (W/kg)	NFC SAR (W/kg)	WLAN Worst-case Combination SAR (W/kg)	WWAN + WLAN + NFC SAR (W/kg)
Phablet SAR	Back	1.796	0.034	0.500	2.330
	Front	2.489	0.000	0.502	2.991
	Top	-	0.000	0.693	0.693
	Bottom	1.301	-	-	1.301
	Right	1.069	-	-	1.069
	Left	1.302	0.000	0.328	1.630

Notes:

- For all combinations where the sum of WWAN+ WLAN + NFC is less than 4.0, there's no further analysis required for compliance demonstration

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E.7 SAR Hotspot Locations

Table E-14
Body-worn Back side Peak Y Coordinates

Antenna	Mode/Band	SAR(W/Kg)	Y-Coord
A	GSM 850	1.198	83.7
A	GSM 1900	0.621	77.5
A	UMTS 850	1.181	83.4
A	UMTS 1750	0.773	78.3
A	UMTS 1900	0.602	73.1
A	LTE Band 12	0.663	82.5
A	LTE Band 13	0.545	79.2
A	LTE Band 26	0.989	83.0
A	LTE Band 66	1.086	74.1
A	LTE Band 2	1.044	77.5
A	LTE Band 41	0.543	76.8
C	2.4 GHz WIFI	0.300	-75.5
C	5 GHz WIFI	1.101	-80.2
C	2.4 GHz Bluetooth	0.113	-78.0

Table E-15
Hotspot Back side Peak Y Coordinates

Antenna	Mode/Band	SAR(W/Kg)	Y-Coord
A	GSM 850	1.198	83.7
A	GSM 1900	0.621	77.5
A	UMTS 850	1.181	83.4
A	UMTS 1750	0.773	78.3
A	UMTS 1900	0.602	73.1
A	LTE Band 12	0.663	82.5
A	LTE Band 13	0.545	79.2
A	LTE Band 26	0.989	83.0
A	LTE Band 66	1.086	74.1
A	LTE Band 2	1.044	77.5
A	LTE Band 41	0.543	76.8
C	2.4 GHz WIFI	0.300	-75.5
C	5 GHz WIFI	0.636	-80.2
C	2.4 GHz Bluetooth	0.113	-78.0

E.8 Conclusion

The above numerical summed SAR results is sufficient to determine 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.

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