APPENDIX E: MULTI-TX AND ANTENNA SAR CONSIDERATIONS

E.1 Introduction

The following procedures adopted from FCC KDB Publication 447498 D04v01 are applicable to devices with built-in unlicensed transmitters such as 802.11 and Bluetooth devices which may simultaneously transmit.

E.2 Simultaneous Transmission Procedures

This device contains transmitters that may operate simultaneously. Therefore, simultaneous transmission analysis is required. Per FCC KDB Publication 447498 D04v01 4.3.2 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.

Note:
SAR Summations for some scenarios when the output power levels are reduced, SAR values at the maximum output power level were used as the most conservative evaluation for simultaneous transmission analysis.

For each position, the highest SAR value across all modes for the applicable cellular band antenna was considered for summation to determine simultaneous SAR test exclusion.

*The SAR distributions for at least one of the antennas are spatially separated from the other antennas per FCC KDB Publication 248227 Section 6.1 procedures. Therefore, simultaneous transmission was treated independently for this configuration. See section E.4 for more information about the Spatial Separation Analysis.

In some cases where simultaneous transmission scenarios overlap with the same power level the most conservative SAR summation scenario was evaluated.

Simultaneous scenarios between 2.4 GHz WLAN and 5 GHz WLAN is sufficiently evaluated for SAR compliance in the Part 2 RF Exposure Report Band Handover Test scenario.

E.3 Body SAR Simultaneous Transmission Analysis

Table E-1
Simultaneous Transmission Scenario with 2.4 GHz Bluetooth and 2.4 GHz WIFI

Simult Tx	Configuration	2.4 GHz Bluetooth Ant WF7b ER	2.4 GHz WIFI Ant WF8 ER	∑ ER
		1	2	1+2
Body SAR	Back	0.023	0.069	0.092
	Top	0.131	0.745	0.876
	Bottom	0.000	0.001	0.001
	Right	0.000	0.010	0.010
	Left	0.119	0.000	0.119

Table E-2
Simultaneous Transmission Scenario with 2.4 GHz Bluetooth and 5 GHz WIFI

Simult Tx	Configuration	2.4 GHz Bluetooth Ant WF8 ER	5 GHz WIFI Ant WF8 ER	∑ ER
		1	2	1+2
Body SAR	Back	0.011	0.062	0.073
	Top	0.095	0.744	0.839
	Bottom	0.000	0.016	0.016
	Right	0.001	0.019	0.020
	Left	0.000	0.003	0.003

Table E-3
Simultaneous Transmission Scenario with 2.4 GHz Bluetooth and 5 GHz WIFI

Simult Tx	Configuration	2.4 GHz Bluetooth Ant WF8 ER	5 GHz WIFI Ant WF7a ER	∑ ER
		1	2	1+2
Body SAR	Back	0.011	0.063	0.074
	Top	0.095	0.743	0.838
	Bottom	0.000	0.004	0.004
	Right	0.001	0.000	0.001
	Left	0.000	0.004	0.004

Table E-4
Simultaneous Transmission Scenario with 2.4 GHz Bluetooth and 5 GHz WIFI

Simult Tx	Configuration	2.4 GHz Bluetooth Ant WF7b ER	5 GHz WIFI Ant WF8 ER	∑ ER
		1	2	1+2
Body SAR	Back	0.023	0.062	0.085
	Top	0.131	0.744	0.875
	Bottom	0.000	0.016	0.016
	Right	0.000	0.019	0.019
	Left	0.119	0.003	0.122

Table E-5
Simultaneous Transmission Scenario with 2.4 GHz Bluetooth and 5 GHz WIFI

Simult Tx	Configuration	2.4 GHz Bluetooth Ant WF7b ER	5 GHz WIFI Ant WF7a ER	∑ ER
		1	2	1+2
Body SAR	Back	0.023	0.063	0.086
	Top	0.131	0.743	0.874
	Bottom	0.000	0.004	0.004
	Right	0.000	0.000	0.000
	Left	0.119	0.004	0.123

Table E-6
Simultaneous Transmission Scenario with 2.4 GHz WIFI MIMO

Simult Tx	Configuration	2.4 GHz WIFI Ant WF7b ER	2.4 GHz WIFI Ant WF8 ER	∑ ER
		1	2	1+2
Body SAR	Back	0.149	0.069	0.218
	Top	0.744	0.745	0.745*
	Bottom	0.005	0.001	0.006
	Right	0.016	0.010	0.026
	Left	0.683	0.000	0.683

Table E-7
Simultaneous Transmission Scenario with 2.4 GHz Bluetooth WF8 and 5 GHz WIFI MIMO

Simult Tx	Configuration	2.4 GHz Bluetooth Ant WF8 ER	5 GHz WIFI Ant WF8 ER	5 GHz WIFI Ant WF7a ER	∑ ER
		1	2	3	1+2+3
Body SAR	Back	0.011	0.062	0.063	0.136
	Top	0.095	0.744	0.743	See Table Below
	Bottom	0.000	0.016	0.004	0.020
	Right	0.001	0.019	0.000	0.020
	Left	0.000	0.003	0.004	0.007
Simult Tx	Configuration	2.4 GHz Bluetooth Ant WF8 ER	5 GHz WIFI MIMO ER		∑ ER
		1	2		1+2
Body SAR	Top	0.095	0.744		0.839

Table E-8
Simultaneous Transmission Scenario with 2.4 GHz Bluetooth WF7b and 5 GHz WIFI MIMO

Simult Tx	Configuration	2.4 GHz Bluetooth Ant WF7b ER	5 GHz WIFI Ant WF8 ER	5 GHz WIFI Ant WF7a ER	∑ ER
		1	2	3	1+2+3
Body SAR	Back	0.023	0.062	0.063	0.148
	Top	0.131	0.744	0.743	See Table Below
	Bottom	0.000	0.016	0.004	0.020
	Right	0.000	0.019	0.000	0.019
	Left	0.119	0.003	0.004	0.126
Simult Tx	Configuration	2.4 GHz Bluetooth Ant WF7b ER	5 GHz WIFI MIMO ER		∑ ER
		1	2		1+2
Body SAR	Top	0.131	0.744		0.875

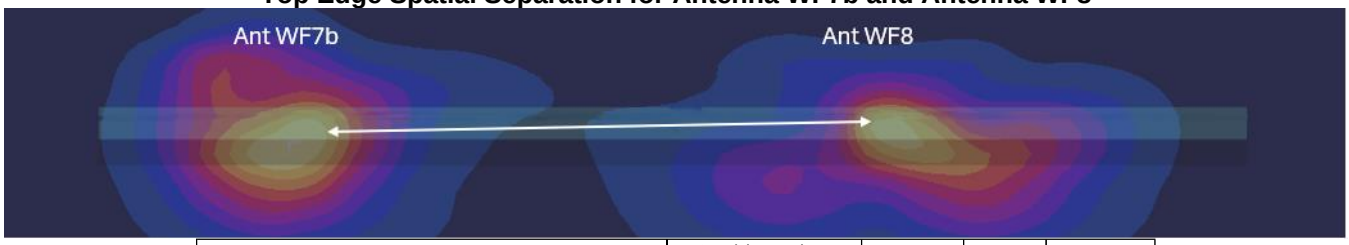
E.4 Spatial Separation Analysis

Per FCC KDB Publication 248227, antennas may be considered spatially separated when the aggregate SAR from multiple antennas at any location in the combined SAR distribution is either ≤ 1.2 W/kg where at least 90% of the SAR is attributed to a single SAR distribution or ≤ 0.4 W/kg where no more than one SAR distribution is contributing > 0.1 W/kg.

Spatial separation was determined by inspection of the area scan SAR distributions to confirm that at all locations, SAR was < 1.2 W/kg, where at least 90% of the SAR is attributed to a single SAR distribution. See below for illustrations of the spatial separated antennas considered.

E.4.1 Top Edge Spatial Separation Analysis

Figure E-1
Top Edge Spatial Separation for Antenna WF7b and Antenna WF8



Antenna Pair		Standalone Values		Standalone ER Sum	Peak Separation Distance (mm)	SPLS Ratio
		Exposure Ratio (ER)	Exposure Ratio (ER)			
Ant "a"	Ant "b"	a	b	a+b	D_{a-b}	$(a+b)^{1.5}/D_{a-b}$
2.4 GHz WIFI/a Ant WF7b	2.4 GHz WIFI/a Ant WF8	0.744	0.745	1.489	94.86	0.02
2.4 GHz Bluetooth/a Ant WF7b	2.4 GHz WIFI/a Ant WF8	0.131	0.745	0.876	98.2	0.01

E.5 Simultaneous Transmission Conclusion

The above numerical summed SAR results for all the worst-case simultaneous transmission conditions were below the SAR limit. Therefore, the above analysis 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 D04v01 and IEEE 1528-2013 Section 6.3.4.1.2.