




APPENDIX C: TOTAL EXPOSURE RATIO

FCC ID: A3LSMF711U	 PCTEST Proud to be part of  NEAR-FIELD POWER DENSITY EVALUATION REPORT		Approved by: Technical Manager
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The Total Exposure Ratio (TER) is calculated by combining all SAR measurements and power density measurements after normalizing to their respective limits. The general expression is below.

$$TER = \sum_{a=1}^A \frac{SAR_a}{SAR_a, limit} + \sum_{b=1}^B \frac{psPD_b}{psPD_b, limit} < 1$$

The TER shall be less than unity to ensure compliance with the limits.

$$\sum_{n=1}^N \frac{4G SAR_n}{4G SAR_n, limit} + \sum_{m=1}^M \frac{5G mmW NR psPD_m}{5G mmW NR psPD_m, limit} + \sum_{p=1}^P \frac{WLAN SAR_p}{WLAN SAR_p, limit} < 1$$

Qualcomm® Smart Transmit algorithm for WWAN adds directly the time-averaged RF exposure from 4G and time-averaged RF exposure from 5G mmW NR. Smart Transmit algorithm controls the total RF exposure from both 4G and 5G mmW NR to not exceed FCC limit. Therefore, per FCC guidance, TER does not need to be evaluated directly for the 4G and 5G simultaneous compliance via summation. The following equations are derived later in Appendix C. The validation of the time-averaging algorithm and compliance under the Tx varying transmission scenario for WWAN technologies are reported in Part 2 report. The report SN could be found in Bibliography section.




$$\sum_{n=1}^N \frac{4G SAR_n}{4G SAR_n, limit} + \sum_{p=1}^P \frac{WLAN SAR_p}{WLAN SAR_p, limit} < 1$$

$$\sum_{m=1}^M \frac{5G mmW NR psPD_m}{5G mmW NR psPD_m, limit} + \sum_{p=1}^P \frac{WLAN SAR_p}{WLAN SAR_p, limit} < 1$$

For 5G mmW NR, since there is total design-related uncertainty arising from TxAGC and device-to-device variation, the worst-case RF exposure should be determined by accounting for device uncertainty. For this device, the manufacturer has added an additional permanent back-off (indicated below as WWAN backoff) for every beam in the calculations for input.power.limits used in the EFS file. The back-off levels can be found in the Part 0 Test report. Therefore, 5G mmW NR RF exposure for this DUT is evaluated by reported psPD calculated as:

$$reported_psPD = (PD_design_target + PD_uncertainty) \times 10^{(-WWAN\ backoff\ in\ dB)/10}$$

Note that since not all the beams supported by this EUT are measured, *reported_psPD* cannot be computed based on limited *measured psPD* data. Alternatively, since *measured psPD* for all the beams will be $\leq PD_design_target + PD_uncertainty$ uncertainty, *reported_psPD* is computed based on this worst-case psPD as shown above.

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The compliance analysis for simultaneous transmission scenarios of WWAN (4G LTE & 5G mmW NR) with Smart Transmit and 4G & WLAN can be found in two reports indicated in the table below. This appendix demonstrates compliance for the 5G + WLAN scenarios. The report SNs can be found in Bibliography section.




	Simultaneous Scenario	Evaluation Report
1.	4G LTE WWAN + WLAN	FCC SAR Evaluation Report (Part 1)
2.	4G LTE WWAN + 5G mmW NR WWAN	RF Exposure Part 2 Test Report

RF exposure compliance with 5G mmW NR WWAN+WLAN simultaneous transmission scenarios is demonstrated for various radio configurations below.

Note that the above *reported psPD* applies to the worst-case surfaces of the DUT at 2mm evaluation distance.

Worst-case PD on other surfaces of the DUT are calculated from simulated PD data (see Power Density Simulation Report), by multiplying reported psPD with the highest proportion out of all beams and out of all three channels in each band, where the adjustment for each beam/channel is computed as the proportion of “simulated PD on desired surface” to “simulated PD on worst-surface”. For example, to determine worst-case PD on front surface (needed for Head RF Exposure evaluation during simultaneous transmission), highest proportion of (simulated PD on front surface)/(simulated PD on worst surface) was determined out of all supported beams and out of all three channels by the DUT in each band.




In some cases, the simulation vs measurement for some surfaces can exceed the device's total uncertainty. In those cases, if the measured psPD > simulated adjusted psPD (assuming a linear congruency of the psPD across surfaces), then measured psPD should be used towards the simultaneous TX analysis. Table C-1 lists the relevant worst-case reported psPD values based on the additional surfaces and evaluation distances needed to perform the TER analysis. The highest of the adjusted Reported psPD and Measured Total psPD was chosen for TER analysis and the chosen values are indicated by bolded psPD values.

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**Table C-1
5G mmW NR psPD - Closed**

<u>NR Band</u>	<u>Antenna</u>	<u>Surface</u>	<u>Evaluation Distance (mm)</u>	<u>Adjustment Factor due to Simulation</u>	<u>Adjusted Reported psPD (mW/cm²)</u>	<u>Measured Total psPD (mW/cm²)</u>	<u>Final Reported psPD (mW/cm²)</u>
n261	K	Back	2	0.338	0.269	0.131	0.269
n261	K	Front	2	1.000	0.794	0.160	0.794
n261	K	Top	2	0.168	0.133	0.144	0.144
n261	K	Bottom	2	0.118	0.094	-	0.094
n261	K	Right	2	0.057	0.045	-	0.045
n261	K	Left	2	1.000	0.794	0.388	0.794
n260	K	Back	2	0.327	0.260	0.187	0.260
n260	K	Front	2	0.619	0.492	-	0.492
n260	K	Top	2	0.143	0.113	0.078	0.113
n260	K	Bottom	2	0.081	0.064	-	0.064
n260	K	Right	2	0.032	0.026	-	0.026
n260	K	Left	2	1.000	0.794	0.592	0.794
n261	L	Back	2	0.022	0.018	0.046	0.046
n261	L	Front	2	1.000	0.794	0.548	0.794
n261	L	Top	2	0.461	0.367	0.280	0.367
n261	L	Bottom	2	0.019	0.015	-	0.015
n261	L	Right	2	0.161	0.128	0.110	0.128
n261	L	Left	2	0.136	0.108	-	0.108
n260	L	Back	2	0.017	0.013	0.028	0.028
n260	L	Front	2	1.000	0.794	0.511	0.794
n260	L	Top	2	0.452	0.359	0.128	0.359
n260	L	Bottom	2	0.071	0.057	-	0.057
n260	L	Right	2	0.176	0.140	0.077	0.140
n260	L	Left	2	0.156	0.124	-	0.124
n261	K	Front	5	0.662	0.526	0.131	0.526
n261	K	Left	5	0.793	0.630	0.348	0.630
n260	K	Front	5	0.424	0.337	0.094	0.337
n260	K	Left	5	0.797	0.633	0.122	0.633
n261	L	Front	5	0.812	0.645	0.362	0.645
n261	L	Left	5	0.108	0.086	0.060	0.086
n260	L	Front	5	0.736	0.585	0.335	0.585
n260	L	Left	5	0.121	0.096	0.013	0.096

Note: Adjusted factor is (simulated PD on desired exposure plane)/(PD on worst-surface at 2mm evaluation distance) out of all beams and out of all channels. See Power Density Simulation Report.

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**Table C-2
5G mmW NR psPD - Open**

NR Band	Antenna	Surface	Evaluation Distance (mm)	Adjustment Factor due to Simulation	Adjusted Reported psPD (mW/cm²)	Measured Total psPD (mW/cm²)	Final Reported psPD (mW/cm²)
n261	K	Back	2	0.666	0.529	-	0.529
n261	K	Front	2	0.660	0.524	-	0.524
n261	K	Top	2	0.077	0.061	-	0.061
n261	K	Bottom	2	0.041	0.033	-	0.033
n261	K	Right	2	0.036	0.029	-	0.029
n261	K	Left	2	1.000	0.794	0.176	0.794
n260	K	Back	2	0.792	0.629	0.159	0.629
n260	K	Front	2	0.707	0.562	0.246	0.562
n260	K	Top	2	0.091	0.073	-	0.073
n260	K	Bottom	2	0.022	0.017	-	0.017
n260	K	Right	2	0.030	0.024	-	0.024
n260	K	Left	2	1.000	0.794	0.538	0.794
n261	L	Back	2	1.000	0.794	0.491	0.794
n261	L	Front	2	0.026	0.021	0.030	0.030
n261	L	Top	2	0.019	0.015	-	0.015
n261	L	Bottom	2	0.023	0.018	-	0.018
n261	L	Right	2	0.133	0.106	0.079	0.106
n261	L	Left	2	0.136	0.108	-	0.108
n260	L	Back	2	1.000	0.794	0.318	0.794
n260	L	Front	2	0.042	0.033	0.028	0.033
n260	L	Top	2	0.057	0.046	-	0.046
n260	L	Bottom	2	0.053	0.042	-	0.042
n260	L	Right	2	0.171	0.136	0.034	0.136
n260	L	Left	2	0.197	0.156	-	0.156

Note: Adjusted factor is (simulated PD on desired exposure plane)/(PD on worst-surface at 2mm evaluation distance) out of all beams and out of all channels. See Power Density Simulation Report.

Note: Additional beams with highest adjustment factors for n260 Antenna K were evaluated at 2mm front side to show that measured psPD is lower than adjusted reported psPD for those specific beams. The worst case adjustment factor due to simulation of the non-selected beams was used in the above table for n260 Antenna K (Front).






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Table C-3
5G mmW NR Head Total Exposure Ratio - Open

	psPD	2.4 GHz WLAN Ant 2 Reported SAR		2.4 GHz WLAN MIMO Reported SAR		Bluetooth Ant 1 Reported SAR		Bluetooth Ant 2 Reported SAR		5 GHz WLAN Ant 1 Reported SAR		5 GHz WLAN MIMO Reported SAR		psPD + 2.4 GHz WLAN MIMO		psPD + BT Ant 1		psPD + BT Ant 2		psPD + 5 GHz WLAN Ant 1		psPD + 5 GHz WLAN MIMO		psPD + 2.4 GHz WLAN Ant 2 + BT Ant 1		psPD + 2.4 GHz WLAN Ant 2 + BT Ant 1 + 5 GHz WLAN Ant 1		psPD + BT Ant 1 + SGH WLAN Ant 1		psPD + BT Ant 2 + SGH WLAN Ant 1		psPD + BT Ant 1 + SGH WLAN MIMO		psPD + BT Ant 2 + SGH WLAN MIMO																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
		14.0 dBm		17.0 dBm		13.0 dBm		16.0 dBm		14.0 dBm		17.0 dBm		1+4		1+5		1+6		1+7		1+8		1+4+8		1+3+5		1+3+5+7		1+3+5+8		1+5+7		1+6+7		1+5+8		1+6+8																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
		W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg	W/m ²	W/kg																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
Applicable Limit	1	3	4	5	6	7	8	1+4	1+5	1+6	1+7	1+8	1+4+8	1+3+5	1+3+5+7	1+3+5+8	1+5+7	1+6+7	1+5+8	1+6+8	0.999	0.732	0.781	0.806	0.858																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
Reported Value	0.369	0.051	0.072	0.093	0.123	0.161	0.203	0.259	0.326	0.414	0.523	0.664	0.838	1.062	1.347	1.702	2.137	2.672	3.327	4.132	5.117	6.412	8.057	10.092	12.567	15.542	19.167	23.512	28.657	35.632	43.607	53.682	65.857	79.932	96.007	114.082	134.157	156.232	180.307	206.382	243.457	282.532	333.607	396.682	472.757	561.832	664.907	782.982	917.057	1068.132	1236.207	1422.282	1627.357	1852.432	2097.507	2462.582	2847.657	3352.732	3987.807	4752.882	5647.957	6672.032	7837.107	9152.182	10617.257	12242.332	14027.407	15972.482	18087.557	20372.632	22837.707	26482.782	30317.857	34352.932	39597.007	45052.082	50817.157	56892.232	63287.307	70002.382	77037.457	84392.532	92067.607	100052.682	108357.757	116982.832	125927.907	135182.982	144747.057	154622.132	164807.207	175292.282	186087.357	197182.432	208587.507	220292.582	232297.657	244592.732	257187.807	270082.882	283277.957	296773.032	310568.107	324663.182	339058.257	353753.332	368748.407	384043.482	399638.557	415533.632	431728.707	448223.782	465018.857	482113.932	499509.007	517204.082	535199.157	553494.232	572089.307	590984.382	610179.457	629574.532	649269.607	669264.682	689559.757	710154.832	730949.907	751944.982	773139.057	794534.132	816129.207	837924.282	859919.357	882114.432	904509.507	927104.582	949899.657	972894.732	996089.807	1019484.882	1043079.957	1066875.032	1090870.107	1115065.182	1139460.257	1164055.332	1188850.407	1213845.482	1239040.557	1264435.632	1289930.707	1315525.782	1341220.857	1367015.932	1392910.007	1418905.082	1445000.157	1471195.232	1497490.307	1523885.382	1550380.457	1576975.532	1603670.607	1630465.682	1657360.757	1684355.832	1711450.907	1738645.982	1765941.057	1793336.132	1820831.207	1848426.282	1876121.357	1903916.432	1931811.507	1959806.582	1987901.657	2016096.732	2044391.807	2072786.882	2101281.957	2129877.032	2158572.107	2187367.182	2216262.257	2245257.332	2274352.407	2303547.482	2332842.557	2362237.632	2391732.707	2421327.782	2451022.857	2480817.932	2510713.007	2540708.082	2570803.157	2600998.232	2631293.307	2661688.382	2692183.457	2722778.532	2753473.607	2784268.682	2815163.757	2846158.832	2877253.907	2908448.982	2939744.057	2971139.132	3002634.207	3034229.282	3065924.357	3097719.432	3129614.507	3161609.582	3193704.657	3225899.732	3258194.807	3290589.882	3323084.957	3355679.032	3388374.107	3421169.182	3454064.257	3487059.332	3520154.407	3553349.482	3586644.557	3620039.632	3653534.707	3687129.782	3720824.857	3754619.932	3788515.007	3822510.082	3856605.157	3890800.232	3925095.307	3959490.382	3993985.457	4028580.532	4063275.607	4098070.682	4132965.757	4167960.832	4203055.907	4238250.982	4273546.057	4308941.132	4344436.207	4379931.282	4415526.357	4451221.432	4487016.507	4522911.582	4558906.657	4595001.732	4631196.807	4667491.882	4703886.957	4740382.032	4776977.107	4813672.182	4850467.257	4887362.332	4924357.407	4961452.482	4998647.557	5035942.632	5073337.707	5110832.782	5148427.857	5186122.932	5223918.007	5261813.082	5299808.157	5337903.232	5376098.307	5414393.382	5452788.457	5491283.532	5529878.607	5568573.682	5607368.757	5646263.832	5685258.907	5724354.082	5763549.157	5802844.232	5842239.307	5881734.382	5921329.457	5961024.532	6000819.607	6040714.682	6080709.757	6120804.832	6160999.907	6201294.982	6241689.057	6282184.132	6322779.207	6363474.282	6404269.357	6445164.432	6486159.507	6527254.582	6568449.657	6609744.732	6651139.807	6692634.882	6734229.957	6775925.032	6817720.107	6859615.182	6901610.257	6943705.332	6985800.407	7027995.482	7070290.557	7112685.632	7155180.707	7197775.782	7240470.857	7283265.932	7326160.007	7369155.082	7412250.157	7455445.232	7498740.307	7542135.382	7585630.457	7629225.532	7672920.607	7716715.682	7760610.757	7804605.832	7848700.907	7892896.082	7937191.157	7981586.232	8026081.307	8070676.382	8115371.457	8160166.532	8205061.607	8249956.682	8294951.757	8340046.832	8385241.907	8430537.082	8475932.157	8521427.232	8567022.307	8612717.382	8658512.457	8704407.532	8750402.607	8796497.682	8842692.757	8888987.832	8935382.907	8981878.082	9028473.157	9075168.232	9121963.307	9168858.382	9215853.457	9262948.532	9310143.607	9357438.682	9404833.757	9452328.832	9499923.907	9547619.082	9595414.157	9643309.232	9691304.307	9739399.382	9787594.457	9835889.532	9884284.607	9932779.682	9981374.757	10030069.832	10078964.907	10127959.982	10177055.057	10226250.132	10275545.207	10324940.282	10374435.357	10424030.432	10473725.507	10523520.582	10573415.657	10623410.732	10673505.807	10723700.882	10773995.957	10824391.032	10874886.107	10925481.182	10976176.257	11026971.332	11077866.407	11128861.482	11179956.557	11231151.632	11282446.707	11333841.782	11385336.857	11436931.932	11488627.007	11540422.082	11592317.157	11644312.232	11696407.307	11748602.382	11800997.457	11853592.532	11906387.607	11959282.682	12012277.757	12065372.832	12118567.907	12171863.082	12225258.157	12278753.232	12332348.307	12386043.382	12439838.457	12493733.532	12547728.607	12601823.682	12656018.757	12710313.832	12764708.907	12819203.982	12873799.057	12928494.132	12983289.207	13038184.282	13093179.357	13148274.432	13203469.507	13258764.582	13314159.657	13369654.732	13425249.807	13480944.882	13536739.957	13592635.032	13648630.107	13704725.182	13760920.257	13817215.332	13873610.407	13930105.482	13986690.557	14043375.632	14100160.707	14157045.782	14214030.857	14271115.932	14328301.007	14385586.082	14442971.157	14500456.232	14558041.307	14615726.382	14673511.457	14731396.532	14789381.607	14847466.682	14905651.757	14963936.832	15022321.907	15080807.082	15139392.157	15198077.232	15256862.307	15315747.382	15374732.457	15433817.532	15492902.607	15552087.682	15611372.757	15670757.832	15730242.907	15789827.982	15849513.057	15909298.132	15969183.207	16029168.282	16089253.357	16149438.432	16209723.507	16270108.582	16330593.657	16391178.732	16451863.807	16512648.882	16573533.957	16634519.032	16695604.107	16756789.182	16818074.257	16879459.332	16940944.407	16992529.482	17054214.557	17115999.632	17177884.707	17239869.782	17301954.857	17364139.932	17426425.007	17488810.082	17551295.157	17613880.232	17676565.307	17739350.382	17802235.457	17865220.532	17928305.607	17991490.682	18054775.757	18118160.832	18181645.907	18245231.082	18308916.157	18372701.232	18436586.307	18500571.382	18564656.457	18628841.532	18693126.607	18757511.682	18821996.757	18886581.832	18951266.907	19016052.082	19080937.157	19145922.232	19211007.307	19276192.382	19341477.457	19406862.532	19472347.607	19537932.682	19603617.757	19669402.832	19735287.907	19801273.082	19867358.157	19933543.232	20009828.307	20076213.382	20152698.457	20229283.532	20305968.607	20382753.682	20459638.757	20536623.832	20613708.907	20690894.082	20768179.157	20845564.232	20923049.307	21000634.382	21078319.457	21156104.532	21234089.607	21312274.682	21390559.757	21468944.832	21547429.907	21626015.082	21704700.157	21783485.232	21862370.307	21941355.382	22020440.457	22099625.532	22178910.607	22258295.682	22337880.757	22417565.832	22497350.907	22577236.082	22657221.157	22737306.232	22817491.307	22897776.382	22978161.457	23058646.532	23139231.607	23219916.682	23300701.757	23381586.832	23462571.907	23543657.082	23624842.157	23706127.232	23787512.307	23869097.382	23950782.457	24032567.532	24114452.607	24196437.682	24278522.757	24360707.832	24442992.907	24525378.082	24607863.157	24690448.232	24773133.307	24855918.382	24938803.457	25021788.532	25104873.607	25188058.682	25271343.757	25354728.832	25438213.907	25521799.082	25605484.157	25689269.232	25773154.307	25857139.382	25941224.457	26025409.532	26109694.607	26194079.682	26278564.757	26363149.832	26447834.907	26532619.982	26617505.057	26702490.132	26787575.207	26872760.282	26958045.357	27043430.432	27128915.507	27214500.582</

**Table C-8
5G mmW NR Phablet Total Exposure Ratio - Open**



		psPD	5 GHz WLAN Ant 1 Reported SAR	5 GHz WLAN MIMO Reported SAR	psPD + 5 GHz WLAN Ant 1	psPD + 5 GHz WLAN MIMO
			14.0 dBm	17.0 dBm		
		mW/cm ²	W/kg	W/kg		
		1	2	3	1 + 2	1 + 3
Applicable Limit		1.0	4.0	4.0	1.0	1.0
Back Side	Reported Value	0.794	0.196	0.419		
	Ratio to Limit	0.794	0.049	0.105	0.843	0.899
Front Side	Reported Value	0.562	0.196	0.662		
	Ratio to Limit	0.562	0.049	0.166	0.611	0.728
Top Edge	Reported Value	0.073	0.166	0.662		
	Ratio to Limit	0.073	0.042	0.166	0.115	0.239
Bottom Edge	Reported Value	0.042	0.000	0.000		
	Ratio to Limit	0.042	0.000	0.000	0.042	0.042
Right Edge	Reported Value	0.136	0.196	0.662		
	Ratio to Limit	0.136	0.049	0.166	0.185	0.302
Left Edge	Reported Value	0.794	0.000	0.662		
	Ratio to Limit	0.794	0.000	0.166	0.794	0.960

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Notes:

1. Worst-case power density results for each test configuration among all antenna arrays and among all supported bands were considered for TER analysis.
2. If test positions were not required to be evaluated for WLAN SAR per FCC KDB publication 248227, the worst-case WLAN SAR result for the applicable exposure conditions was used for simultaneous transmission analysis. Any such values are indicated in the above tables in blue.
3. If Part 1 SAR report does not include standalone WLAN MIMO results, then per KDB Publication 248227 D01v02r02, SAR for MIMO was evaluated by following the simultaneous SAR provisions from KDB Publication 447498 D01v06 by evaluating the sum of the 1g SAR values of each antenna transmitting independently. Any such values are indicated in the above tables in green.
4. When additional sides were tested at a distance greater than 2mm for hotspot and body-worn configurations, those power density results were used for TER. Otherwise, power density results at 2mm were considered as a more conservative evaluation.
5. Per FCC guidance, the bands/modes that are not required to be evaluated for Phablet SAR are not considered for TER analysis.
6. Per FCC guidance, for power density measurements, a test separation distance of 2 mm was used for phablet configuration due to probe restraints.
7. Beams with highest adjustment factor were evaluated at 2mm front side to demonstrate that measured psPD for front side was low and head exposure conditions would not exceed FCC TER limit. Front side with worst case psPD adjustment factor of the remaining beams was used for head TER analysis.
8. The worst-case between Adjusted Reported_psPD and Measured Total psPD was chosen for TER analysis. The bolded psPD values in Table C-1 indicate the worst-case Reported psPD used in TER analysis.
9. In WLAN MIMO operations, each antenna transmits at target powers to achieve the MIMO target powers as indicated above.

The above numerical summed PD and SAR for all the worst-case simultaneous transmission conditions were below the Total Exposure Ratio. Therefore, the above analysis is sufficient to determine no further test cases are required and that simultaneous transmission is compliant to the FCC RF Exposure Limit.

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Mathematical Derivation of TER Compliance

$$\text{Total Normalized RFx} = \text{Normalized RFx}_{\text{Time Averaged WWAN}} + \text{Normalized RFx}_{\text{WLAN}} \leq 1.0 \quad (1)$$

Since WWAN Smart Transmit algorithm adds directly the time-averaged RF exposure from 4G and time-averaged RF exposure from 5G mmW NR, per chipset manufacturer's guidance, Normalized RF exposure from 4G and from 5G mmW NR could be assumed as

$$\text{Normalized RFx}_{\text{Time Averaged WWAN}} = \frac{4G \text{ SAR}}{4G \text{ SAR Limit}} + \frac{5G \text{ mmW NR psPD}}{5G \text{ mmW NR psPD Limit}} \leq 1.0 \quad (2)$$

Smart Transmit algorithm assumes that 4G and 5G mmW NR hotspots are co-located and therefore:

$$\text{Time Averaged WWAN} = [x(t) \times A] + [(1-x(t)) \times B] \leq 1.0 \text{ Normalized Limit} \quad (3)$$

A = Max normalized time-averaged SAR exposure from 4G

B = Max normalized time-averaged PD exposure from 5G mmW NR

$x(t)$ = Ranges between $[0,1]$

$x(t) \times A$ = Percentage of normalized time-averaged RF exposure from 4G

$(1-x(t)) \times B$ = Remaining percentage of RF exposure contribution from 5G mmW NR

Smart Transmit controls "x" in real time such that the sum of these exposures never exceeds 1.0 Normalized Limit. If the equations below (4a, 4b) are proven, then, mathematically equation (5) would be proven.

$$A + \text{norm. SAR from WLAN} \leq 1.0 \text{ normalized limit} \quad (4a)$$

$$B + \text{norm. SAR from WLAN} \leq 1.0 \text{ normalized limit} \quad (4b)$$

$$[x(t) \times A] + [(1-x(t)) \times B] + \text{norm. SAR from WLAN} \leq 1.0 \text{ normalized limit} \quad (5)$$

Without 5G mmW NR, Smart Transmit limits the maximum RF exposure contributed from 4G to 100% normalized exposure. For this device, the manufacturer has added an additional permanent back-off (indicated below as WWAN backoff) for every beam in the calculations for input.power.limits used in the EFS file. Therefore,

$$\text{Smart Tx WWAN: } A = \max(\text{normalized SAR exposure from 4G}) \leq 1.0 \text{ normalized limit} \quad (6a)$$

$$\text{Smart Tx WWAN: } B = \max(\text{normalized PD exposure from 5G mmW NR}) \times 10^{(-\text{WWAN backoff in dB})/10} \leq 1.0 \text{ normalized limit} \quad (6b)$$

To demonstrate simultaneous transmission compliance in equation (1), below equations (7a & 7b) obtained by combining equations (4a & 4b) and (6a & 6b), should be proven for simultaneous transmission compliance:

$$\text{Total Normalized RFx} = \text{Normalized SAR}_{4G \text{ WWAN}} + \text{Normalized SAR}_{\text{WLAN}} < 1.0 \quad (7a)$$




$$\text{Total Normalized RFx} = 10^{(-\text{WWAN backoff in dB})/10} \times \text{Normalized psPD}_{5G \text{ mmW NR WWAN}} + \text{Normalized SAR}_{\text{WLAN}} < 1.0 \quad (7b)$$

which are re-written as:

$$\text{Total Normalized RFx} = \frac{4G \text{ SAR}}{4G \text{ SAR Limit}} + \frac{\text{WLAN SAR}}{\text{WLAN SAR Limit}} < 1 \quad (8a)$$

$$\text{Total Normalized RFx} = 10^{(-\text{WWAN backoff in dB})/10} * \frac{5G \text{ mmW NR psPD}}{5G \text{ mmW NR psPD Limit}} + \frac{\text{WLAN SAR}}{\text{WLAN SAR Limit}} < 1 \quad (8b)$$

Analysis for equation (8a) is performed in Section 12 of FCC SAR Evaluation Report (Part 1). Analysis for equation (8b) is performed in this appendix.

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