

APPENDIX C: TOTAL EXPOSURE RATIO

FCC ID: PY7-57325M	NEAR-FIELD POWER DENSITY EVALUATION REPORT	Approved by: Technical Manager
DUT Type: Portable Handset		APPENDIX C: Page 1 of 7



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 RFexposure 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.

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

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

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:

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 ≤ PD_design_target + PD_uncertainty uncertainty, reported_psPD is computed based on this worst-case psPD as shown above.

FCC ID: PY7-57325M	NEAR-FIELD POWER DENSITY EVALUATION REPORT	Approved by: Technical Manager
DUT Type: Portable Handset		APPENDIX C: Page 2 of 7



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.

FCC ID: PY7-57325M	NEAR-FIELD POWER DENSITY EVALUATION REPORT	Approved by: Technical Manager
DUT Type: Portable Handset		APPENDIX C: Page 3 of 7



Table C-1 5G mmW NR FR2 psPD

NR Band	<u>Antenna</u>	<u>Surface</u>	Evaluation Distance (mm)	Adjustment Factor due to Simulation	Adjusted Reported psPD (mW/cm²)	Measured Total psPD (mW/cm²)	Final Reported psPD (mW/cm²)
n261	0	Back	2	0.476	0.476	0.142	0.476
n261	0	Front	2	0.426	0.426	0.156	0.426
n261	0	Тор	2	0.125	0.125	1	0.125
n261	0	Bottom	2	0.209	0.209	•	0.209
n261	0	Right	2	1.000	1.000	0.477	1.000
n261	0	Left	2	0.036	0.036	-	0.036
n261	1	Back	2	1.000	0.794	0.429	0.794
n261	1	Front	2	0.054	0.043	-	0.043
n261	1	Тор	2	0.114	0.091	0.053	0.091
n261	1	Bottom	2	0.093	0.074	-	0.074
n261	1	Right	2	0.035	0.028	-	0.028
n261	1	Left	2	0.248	0.197	0.075	0.197
n260	0	Back	2	0.426	0.426	0.124	0.426
n260	0	Front	2	0.401	0.401	0.148	0.401
n260	0	Тор	2	0.137	0.137	-	0.137
n260	0	Bottom	2	0.136	0.136	-	0.136
n260	0	Right	2	1.000	1.000	0.434	1.000
n260	0	Left	2	0.007	0.007	-	0.007
n260	1	Back	2	1.000	0.759	0.391	0.759
n260	1	Front	2	0.081	0.061	-	0.061
n260	1	Тор	2	0.112	0.085	0.033	0.085
n260	1	Bottom	2	0.148	0.112	-	0.112
n260	1	Right	2	0.092	0.070	-	0.070
n260	1	Left	2	0.218	0.166	0.052	0.166

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.

FCC ID: PY7-57325M	NEAR-FIELD POWER DENSITY EVALUATION REPORT	Approved by: Technical Manager
DUT Type: Portable Handset		APPENDIX C: Page 4 of 7



Table C-2 5G mmW NR FR2 Head Total Exposure Ratio

		NR FR2	2.4 GHz WLAN Chain 0 Reported SAR	2.4 GHz WLAN Chain 0 for Simitaneous Scenarios with 5/6 GHz WLAN Reported SAR	2.4 GHz WLAN Chain 1 Reported SAR	Bluetooth Chain 0 Reported SAR	Bluetooth Chain 1 Reported SAR	5 GHz WLAN Chain 0 Reported SAR	Chain 1		NR FR2 + 2.4 GHz WLAN Chain 0 + 2.4 GHz WLAN Chain 1	NR FR2 + Bluetooth Chain 0		WLAN Chain 0 + 5	GHz WLAN Chain 1 +	WLAN Chain 0 + 2.4 GHz WLAN Chain 1 +	Chain 0 + 5 GHz WLAN Chain 0 + 5	Chain 1+5 GHz WLAN Chain 0+5	NR FR2 + 6 GHz WLAN MIMO	NR FR2 + Blustooth Chain 0 + 6 GHz WLAN MIMO	NR FR2 + Bluetooth Chain 1 + 6 GHz WLAN MIMO
			14.5 dBm	11.0 dBm	12.7 dBm	14.0 dBm	14.0 dBm	11.5 dBm	11.5 dBm	14.5 dBm					1						
		mW/cm²	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	Ī										ĺ
		1	2	3	4	5	6	7	8	9	1+2+4	1+5	1+6	1+7+8	1+3+4+7+8	1+3+4+9	1+5+7+8	1+6+7+8	1+9	1+5+9	1+6+9
-	Applicable Limit	1.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Front Side	Reported Value	0.426	0.816	0.390	0.010	0.361	0.014	0.353	0.010	0.137											
TTOTA JIDE	Ratio to Limit	0.426	0.510	0.244	0.006	0.226	0.009	0.221	0.006	0.096	0.943	0.652	0.435	0.663	0.903	0.763	0.970	0.663	0.512	0.727	0.520

Table C-3 5G mmW NR FR2 Body-Worn Total Exposure Ratio

		NR FR2	2.4 GHz WLAN Chain 0 Reported SAR	2.4 GHz WLAN Chain 0 for Simitaneous Scenarios with 5/6 GHz WLAN Reported SAR	2.4 GHz WLAN Chain 1 Reported SAR	2.4 GHz WLAN Chain 1 for Simitaneous Scenarios with 5/6 GHz WLAN Reported SAR	Bluetooth Chain 0 Reported SAR	Bluetooth Chain 1 Reported SAR	S GHz WLAN Chain 0 Reported SAR	S GHz WLAN Chain 0 for Simitaneous Scenarios with 2.4GHz WLAN Reported SAR	5 GHz WLAN Chain 1 Reported SAR	5 GHz WLAN Chain 1 for Simitaneous Scenarios with 2.4GHz WLAN Reported SAR	6 GHz WLAN MIMO Reported SAR	NR FR2 + 2.4 GHz WLAN Chain 0 + 2.4 GHz WLAN Chain 1	NR FR2 + Bluetooth Chain 0			NR FR2 + 2.4 GHz WLAN Chain 0 + 2.4 GHz WLAN Chain 1 + 5 GHz WLAN Chain 0 + 5 GHz WLAN Chain 1		NR FR2 + Bluetooth Chain 0 + 5 GHz WLAN Chain 0 + 5 GHz WLAN Chain 1	Chain 1+5 GHz WLAN	NR FR2 + 6 GHz WLAN MIMO	NR FR2 + Eluetooth Chain 0 + 6 GNz WLAN MIMO	
l			14.5 dBm	11.0 dBm	12.7 dBm	11.0 d8m	14.0 dBm	14.0 dBm	11.5 dBm	9.5 dBm	11.5 dBm	9.5 dbm	14.5 dBm	Ī				una mona citati 1						
		military.	W/kg	W/kg	W/kg	W/kg	W/kg	W/M	W/M	W/kg	W/kg	W/kg	W/kg											
		- 1	2	3		5	6	7		0	10	11	12	1+2+4	1+6	1+7	1+8+10	1+3+5+9+11	1+3+4+12	1+6+8+10	1+7+8+10	1+12	1+6+12	1+7+12
A	pplicable Limit	1.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Back Side	Reported Value	0.794	0.119	0.052	0.082	0.048	0.066	0.016	0.026	0.019	0.155	0.108	0.061											
BBCK SIDE	Ratio to Limit	0.794	0.087	0.033	0.051	0.030	0.041	0.010	0.016	0.012	0.097	0.068	0.038	0.932	0.835	0.804	0.907	0.936	0.916	0.948	0.917	0.832	0.873	0.842
Front Side	Reported Value	0.426	0.119	0.052	0.082	0.048	0.051	0.014	0.017	0.009	0.155	0.108	0.008											
Front Side	Ratio to Limit	0.426	0.067	0.033	0.051	0.030	0.032	0.009	0.011	0.006	0.097	0.068	0.005	0.564	0.458	0.435	0.534	0.562	0.515	0.565	0.542	0.431	0.463	0.440

Table C-4 5G mmW NR FR2 Hotspot Total Exposure Ratio

		NR FR2	2.4 GHz WLAN Chain 0 Reported SAR	2.4 GHz WLAN Chain 0 for SimItaneous Scenarios with 5GHz WLAN Reported SAR	2.4 GHz WLAN Chain 1 Reported SAR	2.4 GHz WLAN Chain 1 for SimItaneous Scenarios with 5GHz WLAN Reported SAR	Bluetooth Chain 0 Reported SAR	Bluetooth Chain 1 Reported SAR	5 GHz WLAN Chain 0 Reported SAR	5 GHz WLAN Chain 0 for Simitaneous Scenarios with 2.4GHz WLAN Reported SAR	5 GHz WLAN Chain 1 Reported SAR		NR FR2 + 2.4 GHz WLAN Chain 0 + 2.4 GHz WLAN Chain 1		NR FR2 + Bluetooth Chain 1	NR FRZ + 5 GHz WLAN Chain 0 + 5 GHz WLAN Chain 1			
			14.5 dBm	11.0 dBm	12.7 dBm	11.0 dBm	14.0 dBm	14.0 dBm	11.5 dBm	9.5 dBm	11.5 dBm	9.5 dBm							l i
		mW/cm ¹	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg							
		1	2	3	4	5	6	7	8	9	10	11	1+2+4	1+6	1+7	1+8+10	1+3+5+9+11	1+6+8+10	1+7+8+10
	Applicable Limit	1.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Back Side	Reported Value	0.794	0.232	0.052	0.082	0.048	0.066	0.016	0.106	0.065	0.087	0.039							
DIECK STOR	Ratio to Limit	0.794	0.145	0.033	0.051	0.030	0.041	0.010	0.066	0.041	0.054	0.024	0.990	0.835	0.804	0.915	0.922	0.956	0.925
Front Side	Reported Value	0.426	0.139	0.103	0.082	0.048	0.051	0.014	0.014	0.009	0.087	0.039							
Profit side	Ratio to Limit	0.426	0.087	0.064	0.051	0.030	0.032	0.009	0.009	0.006	0.054	0.024	0.564	0.458	0.435	0.489	0.550	0.521	0.498
To a Calma	Reported Value	0.137	0.232	0.103	0.000	0.000	0.001	0.000	0.106	0.065	0.000	0.000							
Top Edge	Ratio to Limit	0.137	0.145	0.064	0.000	0.000	0.001	0.000	0.066	0.041	0.000	0.000	0.282	0.138	0.137	0.203	0.242	0.204	0.203
Bottom Edge	Reported Value	0.209	0.000	0.000	0.082	0.048	0.000	0.014	0.000	0.000	0.087	0.039							
Bottom Eage	Ratio to Limit	0.209	0.000	0.000	0.051	0.030	0.000	0.009	0.000	0.000	0.054	0.024	0.260	0.209	0.218	0.263	0.263	0.263	0.272
	Reported Value	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000							
Right Edge	Ratio to Limit	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Left Edge	Reported Value	0.197	0.232	0.103	0.082	0.048	0.117	0.014	0.106	0.065	0.087	0.039							
reir Edge	Ratio to Limit	0.197	0.145	0.064	0.051	0.030	0.073	0.009	0.066	0.041	0.054	0.024	0.393	0.270	0.206	0.318	0.356	0.391	0.326

Table C-5 5G mmW NR FR2 Phablet Total Exposure Ratio

			5 GHz WLAN Chain 0 Reported SAR 11.5 dBm	5 GHz WLAN Chain 1 Reported SAR 11.5 dBm	6 GHz WLAN MIMO Reported SAR 14.5 dBm	NFC Reported SAR	NR FR2 +5 GHz WLAN Chain 0 +5 GHz WLAN Chain 1	NR FR2 + 6 GHz WLAN MIMO	NR FR2 +5 GHz WLAN Chain 0 +5 GHz WLAN Chain 1 + NFC	NR FR2 + 6 GHz WLAN MIMO + NFC
		mW/cm²	2	3	4	5	1+2+3	1+4	1+2+3+5	1+4+5
Арі	olicable Limit	1.0	4.0	4.0	4.0	4.0	1.0	1.0	1.0	1.0
Back Side	Reported Value	0.794	0.322	0.288	0.304	0.010				
Dack Side	Ratio to Limit	0.794	0.081	0.072	0.076	0.003	0.947	0.870	0.949	0.945
Front Side	Reported Value	0.426	0.322	0.288	0.040	0.000				
FIUIT Side	Ratio to Limit	0.426	0.081	0.072	0.010	0.000	0.579	0.436	0.579	0.508
Top Edge	Reported Value	0.137	0.322	0.000	0.018	0.000				
Top Euge	Ratio to Limit	0.137	0.081	0.000	0.005	0.000	0.218	0.142	0.218	0.142
Bottom Edge	Reported Value	0.209	0.000	0.288	0.002	0.000				
BOLLOTTI Euge	Ratio to Limit	0.209	0.000	0.072	0.001	0.000	0.281	0.210	0.281	0.282
Right Edge	Reported Value	1.000	0.000	0.000	0.000	0.000				
Rigitt Euge	Ratio to Limit	1.000	0.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000
Left Edge	Reported Value	0.197	0.322	0.288	0.199	0.000				
Left Euge	Ratio to Limit	0.197	0.081	0.072	0.050	0.000	0.350	0.247	0.350	0.319

FCC ID: PY7-57325M	NEAR-FIELD POWER DENSITY EVALUATION REPORT	Approved by: Technical Manager
DUT Type: Portable Handset		APPENDIX C: Page 5 of 7



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.
- 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.
- 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.
- Per FCC guidance, the bands/modes that are not required to be evaluated for Phablet SAR are not considered for TER analysis.
- 5. Per FCC guidance, for power density measurements, a test separation distance of 2 mm was used for phablet configuration due to probe restraints.
- 6. Worst-case front side reported psPD was considered for Head TER analysis.
- 7. 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.
- 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.

FCC ID: PY7-57325M	NEAR-FIELD POWER DENSITY EVALUATION REPORT	Approved by: Technical Manager
DUT Type: Portable Handset		APPENDIX C: Page 6 of 7



Mathematical Derivation of TER Compliance

Total Normalized RFx = Normalized RFx
$$_{Time\ Averaged\ WWAN}$$
 + Normalized RFx $_{WLAN}$ ≤ 1.0 (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

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

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

Time Averaged WWAN =
$$\int x(t) \times A \int + \int (1-x(t)) \times B \int \le 1.0 \text{ Normalized Limit}$$
 (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.

$$A + norm. SAR from WLAN \le 1.0 normalized limit$$
 (4a)

$$B + norm. SAR from WLAN \le 1.0 normalized limit$$
 (4b)

$$[x(t) \times A] + [(1-x(t)) \times B] + norm. SAR from WLAN \le 1.0 normalized limit$$
 (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,

Smart Tx WWAN:
$$A = max$$
 (normalized SAR exposure from $4G$) ≤ 1.0 normalized limit (6a) Smart Tx WWAN: $B = max$ (normalized PD exposure from $5G$ mmW NR) $x10^{(-WWAN backoff in dB)/10} \leq 1.0$ normalized limit (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:

Total Normalized RFx = Normalized SAR
$$_{4G\ WWAN}$$
 + Normalized SAR $_{WLAN}$ < 1.0 (7a)
Total Normalized RFx = $10^{(-WWAN\ backoff\ in\ dB)/10}x$ Normalized psPD $_{5G\ mmW\ NR\ WWAN}$ +

Normalized
$$SAR_{WLAN} < 1.0$$
 (7b)

which are re-written as:

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

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

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

FCC ID: PY7-57325M	NEAR-FIELD POWER DENSITY EVALUATION REPORT	Approved by: Technical Manager
DUT Type: Portable Handset		APPENDIX C: Page 7 of 7