Appendix D: Total Exposure Ratio (TER) Analysis and Smart Transmit Verifications

D.1. Total Exposure Ratio (TER) Analysis

Total exposure ratio (TER) is the method used to show compliance with the regulatory limits by combining SAR and power density measurements after normalizing them to their respective limits. TER should be less than 1 to ensure compliance.

$$TER = \sum_{a=1}^{A} \frac{SAR}{SAR\_limit} + \sum_{b=1}^{B} \frac{PD}{PD\_limit}$$

NR FR2 and WLAN/BT simultaneous transmission analysis can be found in this appendix. 4G WWAN and WLAN/BT simultaneous transmission analysis can be found in SAR Part 1 report. 4G WWAN and NR FR2 simultaneous transmission analysis can be found in SAR Part 2 report.

For this DUT, the OEM has applied permanent backoff to the initially calculated input.power.limits for specific beams (see power density part 0 test report). Worst case adjusted reported_psPD is based on the worst case surface from simulation at 2mm.

$$reported_{psPD} = (PD\_design\_target + PD\_uncertainty) \times 10^{(-backoff\ dB)/10}$$

The adjusted reported_psPD for each edge/surface was calculated by taking the reportedpsPD and multiplying it by the highest ratio across all beams of the PD simulation on that edge and the PD simuluation on the worst case surface for that beam. Not all beams for each band and antenna were evaluated for power density during part 1 testing, thus the final reported_psPD used for TER analysis should be the worst case of measured psPD and adjusted reported_psPD. See below table for final reported_psPD analysis.

Table D-1
Reported psPD Analysis

	Distance	Adjusted Reported_psPD (W/m^2)	Adjusted Reported_psPD (W/m^2)	Adjusted Reported_psPD (W/m^2)	Adjusted Reported_psPD (W/m^2)	Adjusted Reported_psPD (W/m^2)	Adjusted Reported_psPD (W/m^2)	Worst case Measured psPD (W/m^2)	Final Reported_psPD (W/m^2)	Final Reported_psPD Ratio to Limit
Surface/Edge	mm	Ant 0	Ant 0	Ant 0	Ant 1	Ant 1	Ant 1	Ant 0 / Ant 1	Ant 0 / Ant 1	
		n258	n261	n260	n258	n261	n260	n258/n261/n260	n258/n261/n260	
Back	2	1.162	1.862	1.785	2.317	1.387	1.834	-	2.317	0.232
Front	2	3.938	3.470	3.565	3.790	5.580	5.513	-	5.580	0.558
Top	2	0.135	0.100	0.116	1.085	1.356	1.529	-	1.529	0.153
Bottom	2	0.392	0.647	0.673	0.081	0.063	0.122	-	0.673	0.067
Right	5	0.117	0.142	0.032	7.286	7.795	8.367	4.310	8.367	0.837
Left	5	6.325	6.352	6.351	0.091	0.055	0.085	4.000	6.352	0.635

For this DUT, TER was performed at 5mm distance. Power density results for some surface/edges at 2mm distance may have been used as a more conservative result.

Table D-2
WLAN/BT SAR Results

	2.4 GHz MIMO SAR (W/kg)	2.4 GHz MIMO SAR (W/kg)	5 GHz MIMO SAR (W/kg)	6 GHz MIMO SAR (W/kg)	BT chain0 SAR (W/kg)	BT chain1 SAR (W/kg)
Surface/Edge	Maximum Power	Reduced Power	Maximum Power	Maximum Power	Maximum Power	Maximum Power
Back	0.337	0.107	0.036	0.035	0.082	0.046
Front	0.058	0.023	0.043	0.025	0.019	0.011
Top	0.048	0.016	0.010	0.013	0.013	0.000
Bottom	0.082	0.028	0.041	0.019	0.000	0.000
Right	0.033	0.012	0.002	0.001	0.000	0.015
Left	0.337	0.138	0.128	0.111	0.087	0.000
Bottom (10g)	0.082	0.082	0.019	0.012	0.000	0.034

Note: 2.4 GHz bottom edge 10g SAR result at maximum power was also used in the TER analysis for simultaneous scenarios involving 2.4 GHz bottom edge 10g SAR at reduced power as a more conservative value, shown in blue in above table.

Table D-3
WLAN/BT Ratio-to-limit

	2.4 GHz MIMO Ratio-to-limit	2.4 GHz MIMO Ratio-to-limit	5 GHz MIMO Ratio-to-limit	6 GHz MIMO Ratio-to-limit	BT chain0 Ratio-to-limit	BT chain1 Ratio-to-limit
Surface/Edge	Maximum Power	Reduced Power	Maximum Power	Maximum Power	Maximum Power	Maximum Power
Back	0.211	0.067	0.023	0.022	0.051	0.029
Front	0.036	0.014	0.027	0.016	0.012	0.007
Top	0.030	0.010	0.006	0.008	0.008	0.000
Bottom	0.051	0.018	0.026	0.012	0.000	0.000
Right	0.021	0.008	0.001	0.001	0.000	0.009
Left	0.211	0.086	0.080	0.069	0.054	0.000
Bottom (10g)	0.021	0.021	0.005	0.003	0.000	0.009

Table D-4
WLAN/BT Simultaneous Ratio-to-limit

	2.4 GHz MIMO Ratio-to-limit + 5 GHz MIMO Ratio-to-limit	2.4 GHz MIMO Ratio-to-limit + 6 GHz MIMO Ratio-to-limit	2.4 GHz MIMO Ratio-to-limit	5 GHz MIMO Ratio-to-limit + BT chain0 Ratio-to-limit	5 GHz MIMO Ratio-to-limit + BT chain1 Ratio-to-limit	6 GHz MIMO Ratio-to-limit + BT chain0 Ratio-to-limit	6 GHz MIMO Ratio-to-limit + BT chain1 Ratio-to-limit	Worst Case SAR Simultaneous Ratio-to-limit
Surface/Edge	Reduced Power + Maximum Power	Reduced Power + Maximum Power	Maximum Power	Maximum Power + Maximum Power	Maximum Power + Maximum Power	Maximum Power + Maximum Power	Maximum Power + Maximum Power	
Back	0.090	0.089	0.211	0.074	0.052	0.073	0.051	0.211
Front	0.041	0.030	0.036	0.039	0.034	0.028	0.023	0.041
Top	0.016	0.018	0.030	0.014	0.006	0.016	0.008	0.030
Bottom	0.044	0.030	0.051	0.026	0.026	0.012	0.012	0.051
Right	0.009	0.009	0.021	0.001	0.010	0.001	0.010	0.021
Left	0.166	0.155	0.211	0.134	0.080	0.123	0.069	0.211
Bottom (10g)	0.026	0.024	0.021	0.005	0.014	0.003	0.012	0.026

Note: See SAR Part 1 Simultaneous Transmission appendix for details of supported scenarios for WLAN/BT.

Table D-5
Total Exposure Ratio (TER)

Surface/Edge	Final Reported_psPD Ratio to Limit	Worst Case SAR Simultaneous Ratio-to-limit	SAR Ratio-to-limit + PD Ratio-to-limit
			TER
Back	0.232	0.211	0.443
Front	0.558	0.041	0.599
Top	0.153	0.03	0.183
Bottom	0.067	0.051	0.118
Right	0.837	0.021	0.858
Left	0.635	0.211	0.846
Bottom (10g)	0.067	0.026	0.093

D.2. Smart Transmit Verifications

Per 80-w2112-4, this DUT requires the below verifications. psPD was measured at the final input.power.limit and then scaled up to the original calculated input.power.limit without backoff applied. See Power Density Part 0 report for more information.

The first verification ensures measured psPD meets the below criteria:

$$measured\ psPD\ \leq b_j \times (PD\_design\_target + total\ uncertainty) < FCC\ limit$$

Table D-6
Verification Criteria 1 – Power Density Per Beam

Module/Antenna	Mode/Band	b_j	Beam ID	Paired Beam ID	Measured psPD (W/m^2)	Permanent Backoff (dB)	psPD adjusted to calculated input.power.limit (W/m^2)	b_j*(PD_design_target + total uncertainty) (W/m^2)	FCC limit (W/m^2)
0	n258	0.9772	14	142	4.450	0.1	4.554	9.772	10
0	n261	0.9772	135	N/A	5.680	0.3	6.086	9.772	10
0	n260	0.9772	41	N/A	5.650	0.1	5.782	9.772	10
1	n258	0.9772	132	N/A	4.450	0.7	5.228	9.772	10
1	n261	0.9772	153	N/A	4.930	0.1	5.045	9.772	10
1	n260	0.9772	28	N/A	4.890	0.1	5.004	9.772	10

The second verification ensures that the combined psPD results meet the below criteria:

$$combined\ psPD = \left(c(p,j) \times measured.psPD.beam_p + c(q,j) \times measured.psPD.beam_q\right) \leq PD_{design_{target}} + total\ uncertainty$$

$$measured.psPD.beam_i = measured\ psPD\ for\ beam\ i, i = p, q$$
$$and$$
$$c(i,j) = contribution\ factor\ from\ beam_i\ and\ antenna_j, i = p, q\ and\ j = 0,1$$

Table D-7
Verification Criteria 2 – Combined Power Density

Mode/Band	Module/Antenna	Beam ID	Paired Beam ID	Surface/Edge	Contribution Factor at Module/Antenna 0	Contribution Factor at Module/Antenna 1	Measured psPD (W/m^2)	Permanent Backoff (dB)	psPD adjusted to calculated input.power.limit (W/m^2)	Combined psPD at location Module/Antenna 0 - Left	Combined psPD at location Module/Antenna 1 - Right	PD_design_target + total uncertainty (W/m^2)
n258	0	14	142	Left	1	0.0012	4.450	0.1	4.554	4.558	5.234	10
	1	132	N/A	Right	0.0008	1	4.450	0.7	5.228			
n261	0	135	N/A	Left	1	0.0006	5.680	0.3	6.086	6.087	5.048	10
	1	153	N/A	Right	0.0001	1	4.930	0.1	5.045			
n260	0	41	N/A	Left	1	0.0002	5.650	0.1	5.782	5.782	5.005	10
	1	28	N/A	Right	0.0001	1	4.890	0.1	5.004			