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Part 0 Power Density Report
Power Density Characterization
Revision B

May 4, 2020

SAMSUNG ELECTRONICS

Power Density Characterization

1 Exposure Scenarios

At frequencies > 6 GHz, the total peak spatial averaged power density (psPD) is required to be assessed for all antenna configurations (beams) from all mmW antenna modules installed inside the device. This device has 2 patch antenna arrays (L Patch, M Patch).

As showed in Figure 1, the surfaces near-by each mmW antenna module for PD characterization are identified and listed in Table 1.

Table 1
Evaluation Surfaces for PD Characterization

Band/Mode	Antenna Module	Back	Front	Top	Bottom	Right	Left
NR n261	L	Yes	Yes	No	No	No	Yes
NR n261	M	Yes	Yes	No	No	Yes	No
NR n260	L	Yes	Yes	No	No	No	Yes
NR n260	M	Yes	Yes	No	No	Yes	No

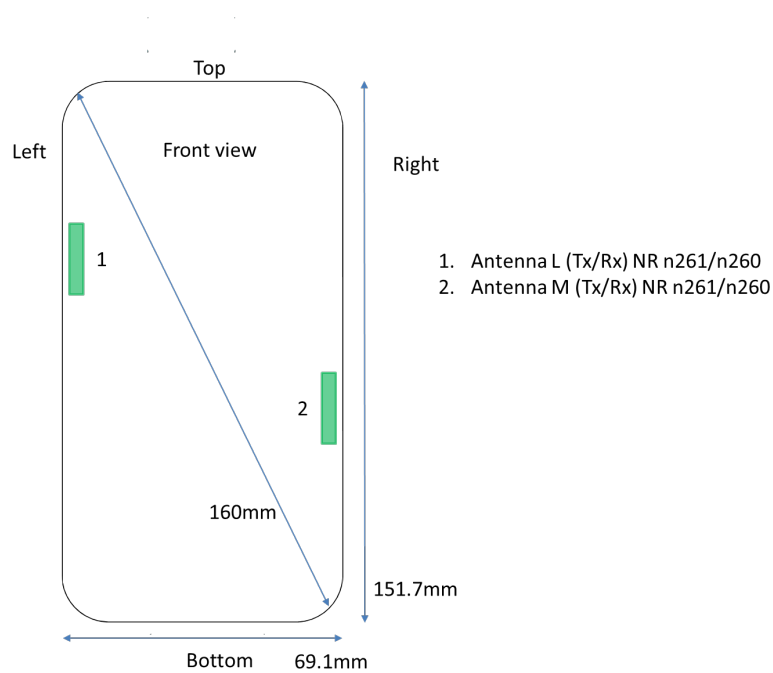
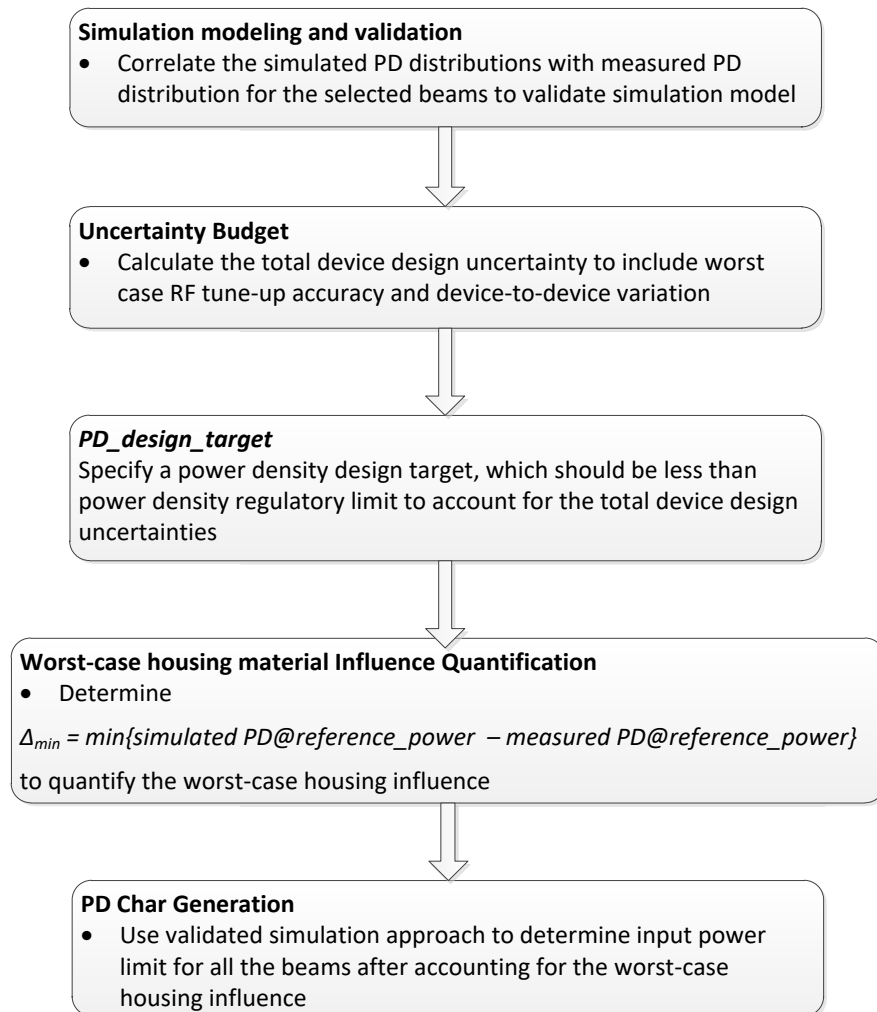


Figure 1: Location of mmW antenna modules looking from front of the DUT

2 Power Density Characterization Method



3 Codebook for all supported beams

Table 2
5G mmW NR Band n261 Ant L Codebook

Band	Beam ID	Antenna Module	Antenna Type	# of Antenna Feed	Paired With
n261	1	L	Patch	1	129
n261	4	L	Patch	2	134
n261	5	L	Patch	2	133
n261	6	L	Patch	2	132
n261	8	L	Patch	2	137
n261	9	L	Patch	2	136
n261	15	L	Patch	4	147
n261	16	L	Patch	4	146
n261	17	L	Patch	4	145
n261	18	L	Patch	4	144
n261	19	L	Patch	4	143
n261	24	L	Patch	4	155
n261	25	L	Patch	4	154
n261	26	L	Patch	4	153
n261	27	L	Patch	4	152
n261	129	L	Patch	1	1
n261	132	L	Patch	2	4
n261	133	L	Patch	2	5
n261	134	L	Patch	2	6
n261	136	L	Patch	2	8
n261	137	L	Patch	2	9
n261	143	L	Patch	4	15
n261	144	L	Patch	4	16
n261	145	L	Patch	4	17
n261	146	L	Patch	4	18
n261	147	L	Patch	4	19
n261	152	L	Patch	4	24
n261	153	L	Patch	4	25
n261	154	L	Patch	4	26
n261	155	L	Patch	4	27

Table 3
5G mmW NR Band n261 Ant M Codebook

Band	Beam ID	Antenna Module	Antenna Type	# of Antenna Feed	Paired With
n261	0	M	Patch	1	128
n261	2	M	Patch	2	131
n261	3	M	Patch	2	130
n261	7	M	Patch	2	135
n261	10	M	Patch	2	142
n261	11	M	Patch	2	141
n261	12	M	Patch	4	139
n261	13	M	Patch	4	138
n261	14	M	Patch	4	140
n261	20	M	Patch	4	151
n261	21	M	Patch	4	150
n261	22	M	Patch	4	149
n261	23	M	Patch	4	148
n261	128	M	Patch	4	0
n261	130	M	Patch	4	2
n261	131	M	Patch	1	3
n261	135	M	Patch	2	7
n261	138	M	Patch	2	10
n261	139	M	Patch	2	11
n261	140	M	Patch	2	12
n261	141	M	Patch	2	13
n261	142	M	Patch	4	14
n261	148	M	Patch	4	20
n261	149	M	Patch	4	21
n261	150	M	Patch	4	22
n261	151	M	Patch	4	23

Table 4
5G mmW NR Band n260 Ant L Codebook

Band	Beam ID	Antenna Module	Antenna Type	# of Antenna Feed	Paired With
n260	1	L	Patch	1	129
n260	5	L	Patch	2	134
n260	6	L	Patch	2	133
n260	7	L	Patch	2	135
n260	10	L	Patch	2	138
n260	11	L	Patch	2	139
n260	17	L	Patch	4	148
n260	18	L	Patch	4	147
n260	19	L	Patch	4	146
n260	20	L	Patch	4	145
n260	21	L	Patch	4	149
n260	26	L	Patch	4	156
n260	27	L	Patch	4	155
n260	28	L	Patch	4	154
n260	29	L	Patch	4	157
n260	129	L	Patch	1	1
n260	134	L	Patch	2	5
n260	133	L	Patch	2	6
n260	135	L	Patch	2	7
n260	138	L	Patch	2	10
n260	139	L	Patch	2	11
n260	148	L	Patch	4	17
n260	147	L	Patch	4	18
n260	146	L	Patch	4	19
n260	145	L	Patch	4	20
n260	149	L	Patch	4	21
n260	156	L	Patch	4	26
n260	155	L	Patch	4	27
n260	154	L	Patch	4	28
n260	157	L	Patch	4	29

Table 5
5G mmW NR Band n260 Ant M Codebook

Band	Beam ID	Antenna Module	Antenna Type	# of Antenna Feed	Paired With
n260	0	M	Patch	1	128
n260	2	M	Patch	2	131
n260	3	M	Patch	2	130
n260	4	M	Patch	2	132
n260	8	M	Patch	2	136
n260	9	M	Patch	2	137
n260	12	M	Patch	4	143
n260	13	M	Patch	4	142
n260	14	M	Patch	4	141
n260	15	M	Patch	4	140
n260	16	M	Patch	4	144
n260	22	M	Patch	4	153
n260	23	M	Patch	4	151
n260	24	M	Patch	4	150
n260	25	M	Patch	4	152
n260	128	M	Patch	1	0
n260	130	M	Patch	2	2
n260	131	M	Patch	2	3
n260	132	M	Patch	2	4
n260	136	M	Patch	2	8
n260	137	M	Patch	2	9
n260	140	M	Patch	4	12
n260	141	M	Patch	4	13
n260	142	M	Patch	4	14
n260	143	M	Patch	4	15
n260	144	M	Patch	4	16
n260	150	M	Patch	4	22
n260	151	M	Patch	4	23
n260	152	M	Patch	4	24
n260	153	M	Patch	4	25

4 Simulation and Modeling Validation

Power density simulations of all beams and surfaces were performed. Details of these simulations and modeling validation can be found in the Power Density Simulation Report. Table below includes a summary of the validation results to support worst-case housing influence quantification in power density characterization for this model.

With an input power of 6 dBm for n261 band and 6 dBm for n260 band, PD measurements are conducted for at least one single beam per antenna module (L, M) on worst-surface(s). PD measurements are performed at mid channel of each mmW band and with CW modulation. All measured PD values are listed in table below along with corresponding simulated PD values for the same configuration.

PD value will be used to determine worst-case housing influence for conservative assessment.

Table 6

Band	Antenna	Beam ID	Surface	4cm ² psPD		Delta = Simulated - Measured
				Measured	Simulated	
				(mW/cm2)		
n261	L (Patch)	26	Back	0.559	1.30	3.67
			Left	0.632	1.46	3.64
		153	Back	0.500	1.25	3.98
			Left	0.763	1.46	2.82
	M (Patch)	22	Back	0.558	1.38	3.93
			Right	0.691	1.45	3.22
		149	Back	0.517	1.35	4.17
			Right	0.735	1.46	2.98
n260	L (Patch)	29	Back	0.638	1.210	2.78
			Left	0.727	1.55	3.29
		148	Back	0.480	1.180	3.91
			Left	0.765	1.57	3.12
	M (Patch)	25	Back	0.621	1.340	3.34
			Right	0.906	1.59	2.44
		153	Back	0.453	1.33	4.68
			Right	1.060	1.57	1.71

5 PD_design_target

Table 7

PD_design_target	
$PD\_design\_target < PD\_regulatory\_limit \times 10^{\frac{-Total\ Uncertainty}{10}}$	
psPD over 4 cm² Averaging Area (mW/cm²)	
<i>Total Uncertainty</i>	2.1 dB
<i>PD_regulatory_limit</i>	1.0 mW/cm ²
<i>PD_design_target</i>	0.6166 mW/cm ²

6 Δ_{min}

For non-metal material, the material property cannot be accurately characterized at mmW frequencies to date. The estimated material property for the device housing is used in the simulation model, which could influence the accuracy in simulation for PD amplitude quantification. Since the housing influence on PD could vary from surface to surface where the EM field propagates through, the most underestimated surface is used to quantify the worst-case housing influence for conservative assessment.

Since the mmW antenna modules are placed at different locations, only surrounding material/housing has impact on EM field propagation, and in turn power density. Furthermore, depending on the type of antenna array, i.e., dipole antenna array or patch antenna array, the nature of EM field propagation in the near field is different. Therefore, the worst-case housing influence is determined per antenna module and per antenna type.

For this DUT, the below procedure was used to determine worst-case housing influence, Δ_{min} :

1. Based on PD simulation, for each module and antenna type, determine one or more worst-surface(s) that has highest 4cm² PD for all the single beams per antenna module and per antenna type in the mid channel of each band.
2. For identified worst surface(s) per antenna module and per antenna type group,
 - a. First determine Δ_{min} based on identified worst surface(s), and derive input.power.limit
 - b. Then prove all other near-by surface(s), i.e., non-selected surface(s), is not required for housing material loss quantification (in other words, these non-evaluated surfaces have no influence on the determined input.power.limit) by:

- i. re-scale all simulated 4cm2 PD values to input.power.limit to identify the worst-PD beam per each non-evaluated surface
 - ii. Measure 4cm2 PD at input.power.limit on identified worst-PD beam per each non-evaluated surface
 - iii. Demonstrate all measured 4cm2 PD values are below PD_design_target
3. If any of the above surface(s) in Step (2.b.iii) have measured 4cm2 PD $\geq$ PD_design_target, then those surfaces must be included in the Δ_{min} determination in Step (2.a), and re-evaluate input.power.limit with these added surfaces.

Following above procedure, based on Table 2 ~ Table 5 in Samsung PD simulation report, the worst-surface(s) having highest 4cm2 PD for all the single beams per each antenna type and each antenna module group in the mid channel of n261 and n260 bands are identified as:

- a. for L patch: Back (S2) & Left (S3)
- b. for M patch: Back (S2) & Right (S4)

Thus, when comparing a simulated 4cm2-averaged PD and measured 4 cm2-averaged PD for the identified worst surface(s), the worst error introduced for each antenna type and each antenna module group when using the estimated material property in the simulation is highlighted in bold numbers in Table 8. Thus, the worst-case housing influence, denoted as $\Delta_{min} = \text{Sim. PD} - \text{Meas. PD}$, is determined as

Table 8
 Δ_{min} for Ant J, Ant K and Ant L

Band	Antenna	Δ_{min}
		(dB)
n261	L (Patch)	2.82
	M (Patch)	2.98
n260	L (Patch)	2.78
	M (Patch)	1.71

Δ_{min} represents the worst case where RF exposure is underestimated the most in simulation when using the estimated material property of the housing. For conservative assessment, the Δ_{min} is used as the worst-case factor and applied to all the beams in the corresponding antenna type and antenna module group to determine input power limits in PD char for compliance.

The detail input.power.limit derivation is described in Section 7.

Simulated 4cm² PD values in Table 2 ~ Table 5 in Power Density Simulation Report are scaled to input.power.limit and are listed in Tables 9 – 12 for all single beams for all identified surfaces, when assuming the simulation is performed with correct housing influence.

Determine the worst beam for each of non-selected surface(s), i.e.,

- a. for L patch: Front
- b. for M patch: Front

Then perform PD measurement for all determined worst-case beams, highlighted in orange in Tables 9 – 12, on the corresponding surface. Measurement is performed in the mid channel of each band with CW modulation. The evaluation distance is at 2 mm.

The test results in Table 13 shows that the all measured 4cm² PD values are less than PD_design_target of 0.6166 mW/cm², thus, the non-selected surfaces have no influence on the determined Δ_{min} and input.power.limit in Section 7.

Table 9
n261/mid channel, L Patch simulated 4cm2 PD at PD_Design_Target
(if simulation performed with correct housing material properties) (Δ_{min})

No.	Antenna	Beam ID_1	Simulated 4cm2 PD(mW/cm2) Corresponding to PD_design_target if the simulation was performed with correct No. Module Type housing material properties					
			S4(Right)	S3(Left)	S5(Top)	S6(Bottom)	S1(Front)	S2(Back)
1	L	1	0.005	0.617	0.011	N/A	0.088	0.530
2	L	4	0.002	0.555	0.022	N/A	0.109	0.378
3	L	5	0.003	0.602	0.009	N/A	0.117	0.468
4	L	6	0.004	0.599	0.018	N/A	0.078	0.525
5	L	8	0.002	0.568	0.018	N/A	0.114	0.408
6	L	9	0.005	0.593	0.008	N/A	0.104	0.536
7	L	15	0.003	0.617	0.059	N/A	0.136	0.452
8	L	16	0.005	0.554	0.007	N/A	0.115	0.467
9	L	17	0.006	0.616	0.008	N/A	0.096	0.539
10	L	18	0.007	0.617	0.005	N/A	0.078	0.585
11	L	19	0.005	0.577	0.021	N/A	0.075	0.581
12	L	24	0.004	0.596	0.038	N/A	0.144	0.479
13	L	25	0.005	0.590	0.009	N/A	0.102	0.509
14	L	26	0.006	0.608	0.006	N/A	0.087	0.541
15	L	27	0.007	0.593	0.011	N/A	0.080	0.582
16	L	129	0.004	0.607	0.031	N/A	0.100	0.546
17	L	132	0.005	0.617	0.030	N/A	0.123	0.476
18	L	133	0.002	0.614	0.009	N/A	0.075	0.531
19	L	134	0.004	0.595	0.036	N/A	0.100	0.489
20	L	136	0.003	0.613	0.013	N/A	0.103	0.519
21	L	137	0.002	0.591	0.021	N/A	0.060	0.498
22	L	143	0.008	0.617	0.123	N/A	0.182	0.402
23	L	144	0.005	0.611	0.005	N/A	0.121	0.508
24	L	145	0.005	0.617	0.008	N/A	0.095	0.531
25	L	146	0.004	0.589	0.006	N/A	0.063	0.531
26	L	147	0.005	0.601	0.052	N/A	0.071	0.583
27	L	152	0.005	0.617	0.047	N/A	0.143	0.471
28	L	153	0.005	0.617	0.003	N/A	0.115	0.526
29	L	154	0.005	0.617	0.009	N/A	0.072	0.550
30	L	155	0.005	0.588	0.036	N/A	0.067	0.551

Table 10
n261/mid channel, M Patch simulated 4cm2 PD at PD_Design_Target
(if simulation performed with correct housing material properties) (Δ_{min})

No.	Antenna	Beam ID_1	Simulated 4cm2 PD(mW/cm2) Corresponding to PD_design_target if the simulation was performed with correct No. Module Type housing material properties					
			S4(Right)	S3(Left)	S5(Top)	S6(Bottom)	S1(Front)	S2(Back)
46	M	0	0.561	0.004	N/A	0.013	0.120	0.445
47	M	2	0.524	0.004	N/A	0.009	0.120	0.411
48	M	3	0.611	0.007	N/A	0.014	0.070	0.617
49	M	7	0.603	0.007	N/A	0.002	0.084	0.599
50	M	10	0.559	0.010	N/A	0.030	0.141	0.463
51	M	11	0.551	0.008	N/A	0.005	0.121	0.496
52	M	12	0.611	0.010	N/A	0.003	0.099	0.575
53	M	13	0.615	0.009	N/A	0.003	0.087	0.614
54	M	14	0.495	0.005	N/A	0.028	0.073	0.561
55	M	20	0.523	0.009	N/A	0.020	0.135	0.451
56	M	21	0.580	0.008	N/A	0.004	0.116	0.537
57	M	22	0.615	0.009	N/A	0.005	0.089	0.586
58	M	23	0.550	0.008	N/A	0.010	0.073	0.594
61	M	128	0.609	0.005	N/A	0.017	0.076	0.563
62	M	130	0.617	0.005	N/A	0.034	0.114	0.551
63	M	131	0.558	0.008	N/A	0.043	0.086	0.563
64	M	135	0.589	0.005	N/A	0.003	0.077	0.577
65	M	138	0.585	0.007	N/A	0.049	0.125	0.533
66	M	139	0.591	0.010	N/A	0.001	0.107	0.548
67	M	140	0.593	0.007	N/A	0.008	0.087	0.572
68	M	141	0.573	0.006	N/A	0.008	0.072	0.565
69	M	142	0.547	0.005	N/A	0.027	0.065	0.617
70	M	148	0.586	0.008	N/A	0.019	0.114	0.542
71	M	149	0.613	0.008	N/A	0.002	0.105	0.566
72	M	150	0.569	0.007	N/A	0.011	0.074	0.558
73	M	151	0.587	0.006	N/A	0.010	0.070	0.597

Table 11
n260/mid channel, L Patch simulated 4cm2 PD at PD_Design_Target
(if simulation performed with correct housing material properties) (Δ_{min})

No.	Antenna	Beam ID_1	Simulated 4cm2 PD(mW/cm2) Corresponding to PD_design_target if the simulation was performed with correct No. Module Type housing material properties					
			S4(Right)	S3(Left)	S5(Top)	S6(Bottom)	S1(Front)	S2(Back)
1	L	1	0.002	0.617	0.022	N/A	0.086	0.419
2	L	5	0.002	0.617	0.030	N/A	0.102	0.394
3	L	6	0.001	0.617	0.009	N/A	0.130	0.463
4	L	7	0.003	0.587	0.043	N/A	0.088	0.398
5	L	10	0.002	0.617	0.024	N/A	0.127	0.409
6	L	11	0.002	0.607	0.023	N/A	0.100	0.435
7	L	17	0.003	0.562	0.078	N/A	0.111	0.400
8	L	18	0.003	0.617	0.015	N/A	0.116	0.474
9	L	19	0.002	0.617	0.014	N/A	0.141	0.457
10	L	20	0.002	0.609	0.054	N/A	0.100	0.482
11	L	21	0.004	0.587	0.078	N/A	0.110	0.426
12	L	26	0.002	0.600	0.054	N/A	0.096	0.430
13	L	27	0.003	0.617	0.010	N/A	0.129	0.466
14	L	28	0.001	0.611	0.017	N/A	0.131	0.470
15	L	29	0.003	0.617	0.075	N/A	0.105	0.482
16	L	129	0.002	0.570	0.006	N/A	0.097	0.395
17	L	133	0.002	0.617	0.011	N/A	0.075	0.452
18	L	134	0.003	0.617	0.009	N/A	0.108	0.480
19	L	135	0.002	0.587	0.013	N/A	0.097	0.376
20	L	138	0.002	0.578	0.003	N/A	0.104	0.471
21	L	139	0.001	0.617	0.013	N/A	0.097	0.409
22	L	145	0.002	0.583	0.011	N/A	0.094	0.422
23	L	146	0.005	0.617	0.005	N/A	0.112	0.481
24	L	147	0.003	0.617	0.005	N/A	0.119	0.482
25	L	148	0.003	0.617	0.023	N/A	0.106	0.465
26	L	149	0.003	0.569	0.022	N/A	0.098	0.450
27	L	154	0.003	0.570	0.012	N/A	0.089	0.419
28	L	155	0.003	0.593	0.006	N/A	0.116	0.469
29	L	156	0.002	0.617	0.013	N/A	0.111	0.463
30	L	157	0.003	0.604	0.026	N/A	0.104	0.461

Table 12
n260/mid channel, M Patch simulated 4cm2 PD at PD_Design_Target
(if simulation performed with correct housing material properties) (Δ_{min})

No.	Antenna	Beam ID_1	Simulated 4cm2 PD(mW/cm2) Corresponding to PD_design_target if the simulation was performed with correct No. Module Type housing material properties					
			S4(Right)	S3(Left)	S5(Top)	S6(Bottom)	S1(Front)	S2(Back)
46	M	0	0.617	0.004	N/A	0.020	0.109	0.487
47	M	2	0.617	0.006	N/A	0.030	0.108	0.472
48	M	3	0.617	0.008	N/A	0.004	0.137	0.498
49	M	4	0.617	0.005	N/A	0.021	0.107	0.495
50	M	8	0.617	0.008	N/A	0.019	0.126	0.479
51	M	9	0.617	0.005	N/A	0.016	0.116	0.495
52	M	12	0.610	0.011	N/A	0.053	0.128	0.508
53	M	13	0.617	0.007	N/A	0.023	0.126	0.539
54	M	14	0.617	0.007	N/A	0.015	0.143	0.510
55	M	15	0.617	0.007	N/A	0.007	0.117	0.525
56	M	16	0.617	0.008	N/A	0.041	0.131	0.524
57	M	22	0.605	0.013	N/A	0.051	0.132	0.531
58	M	23	0.617	0.010	N/A	0.023	0.125	0.532
59	M	24	0.617	0.004	N/A	0.005	0.135	0.511
60	M	25	0.617	0.005	N/A	0.022	0.123	0.520
61	M	128	0.617	0.004	N/A	0.004	0.108	0.474
62	M	130	0.617	0.004	N/A	0.007	0.110	0.516
63	M	131	0.617	0.008	N/A	0.004	0.117	0.520
64	M	132	0.617	0.004	N/A	0.006	0.113	0.454
65	M	136	0.617	0.004	N/A	0.004	0.117	0.527
66	M	137	0.617	0.004	N/A	0.006	0.108	0.496
67	M	140	0.617	0.005	N/A	0.005	0.135	0.514
68	M	141	0.617	0.007	N/A	0.006	0.123	0.522
69	M	142	0.616	0.007	N/A	0.004	0.118	0.520
70	M	143	0.617	0.006	N/A	0.008	0.121	0.521
71	M	144	0.617	0.005	N/A	0.007	0.139	0.520
72	M	150	0.617	0.004	N/A	0.007	0.114	0.504
73	M	151	0.617	0.009	N/A	0.006	0.125	0.527
74	M	152	0.617	0.007	N/A	0.011	0.122	0.525
75	M	153	0.617	0.005	N/A	0.008	0.129	0.524

Table 13
4cm² PD of the selected beams measured on the corresponding surfaces
that are not selected for Δ_{min} determination

Band	Antenna	Beam ID	Surface	Tested Power Level (dBm)	input.power.limit (dBm)	Meas. 4cm ² PD (mW/cm ²)
n261	L (Patch)	143	Front	7.4	7.4	0.090
	M (Patch)	10	Front	6.6	6.6	0.060
n260	L (Patch)	19	Front	4.5	4.5	0.070
	M (Patch)	14	Front	4.0	4.0	0.160

7 PD Char

7.1 Single Beams

To determine the input power limit at each antenna port, simulation was performed at low, mid, and high channel for each mmW band supported, with 6 dBm input power per active port for n261 band and 6 dBm input power per active port for n260 band:

1. Obtained PD_{surface} value (the worst PD among all identified surfaces of the DUT) at all three channels for all single beams specified in the codebook.
2. Derived a scaling factor at low, mid and high channel, $s(i)_{low\_or\_mid\_or\_high}$, by:

$$s(i)_{low\_or\_mid\_or\_high} = \frac{PD\ design\ target}{sim.PD_{surface(i)}}, \quad i \in single\ beams \quad (1)$$

3. Determined the worst-case scaling factor, $s(i)$, among low, mid and high channels:

$$s(i) = \min\{s_{low}(i), s_{mid}(i), s_{high}(i)\}, \quad i \in single\ beams \quad (2)$$

and this scaling factor applies to the input power at each antenna port.

7.2 Beam Pairs

Per the manufacturer, the relative phase between beam pair is not controlled in the chipset design and could vary from run to run. Therefore, for each beam pair, based on the simulation results, the worst-case scaling factor was determined mathematically to ensure the compliance. The worst-case PD for MIMO operations was found by sweeping the relative phase for all possible angles to ensure a conservative assessment. The power density simulation report contains the worst-case power density for each surface after sweeping through all relative phases between beams.

Once the power density was determined for the worst-case $\emptyset$, the scaling factor was obtained by the below equation for low, mid and high channels:

$$s(i)_{low\_or\_mid\_or\_high} = \frac{PD\ design\ target}{total\ PD\ (\emptyset(i)_{worstcase})}, i \in beam\ pairs \quad (3)$$

The *total PD* ($\emptyset_{worstcase}$) varies with channel and beam pair, the lowest scaling factor among all three channels, $s(i)$, is determined for the beam pair i :

$$s(i) = \min\{s_{low}(i), s_{mid}(i), s_{high}(i)\}, i \in beam\ pairs \quad (4)$$

7.3 Input.Power.Limit Calculations

The PD Char specifies the limit of input power at antenna port that corresponds to PD_design_target for all the beams.

Ideally, if there is no uncertainty associated with hardware design, the input power limit, denoted as *input.power.limit(i)*, for beam i can be obtained after accounting for the housing influence (Δ_{min}) determined in Table 8, given by:

- For n260 and n261

$$input.power.limit(i) = 6\ dBm + 10 * \log(s(i)) + \Delta_{min}, i \in all\ beams \quad (5)$$

where $6\ dBm$ is the input power used in simulation for n261 and n260, respectively; $s(i)$ is the scaling factor obtained from Eq. (2) or Eq. (4) for beam i ; Δ_{min} is the worst-case housing influence factor (determined in Table 10) for beam i .

If simulation overestimates the housing influence, then Δ_{min} (= simulated PD – measured PD) is negative, which means that the measured PD would be higher than the simulated PD. The input power to antenna elements determined via simulation must be decreased for compliance.

Similarly, if simulation underestimates the loss, then Δ_{min} is positive (measured PD would be lower than the simulated value). Input power to antenna elements determined via simulation can be increased and still be PD compliant.

In reality the hardware design has uncertainty which must be properly considered. The device design related uncertainty is embedded in the process of Δ_{min} determination. Since the device uncertainty is already accounted for in PD_design_target, it needs to be removed to avoid double counting this uncertainty.

Thus, Equation 5 is modified to:

If -TxAGC uncertainty < Δ_{min} < TxAGC uncertainty,

$$input.power.limit(i) = 6 \text{ dBm} + 10 * \log(s(i)), \quad i \in \text{all beams, for n260 and n261} \quad (6)$$

else if Δ_{min} < -TxAGC uncertainty,

$$input.power.limit(i) = 6 \text{ dBm} + 10 * \log(s(i)) + (\Delta_{min} + \text{TxAGC uncertainty}),$$

$$i \in \text{all beams, for n260 and n261} \quad (7)$$

else if Δ_{min} > TxAGC uncertainty,

$$input.power.limit(i) = 6 \text{ dBm} + 10 * \log(s(i)) + (\Delta_{min} - \text{TxAGC uncertainty}),$$

$$i \in \text{all beams, for n260 and n261} \quad (8)$$

Following above logic, the input.power.limit for this DUT can be calculated using Equations (6), (7), and (8), i.e.,

Table 14
***input.power.limit* Calculation**

Band	Antenna	Δ_{min}	TxAGC Uncertainty	<i>input.power.limit</i>	Notes
		(dB)	(dB)	(dBm)	
n261	L (Patch Beam)	2.82	0.5	$input.power.limit(i) = 6 \text{ dBm} + 10 \times \log(s(i)) + 2.32$	Using Eq.8
	M (Patch Beam)	2.98	0.5	$input.power.limit(i) = 6 \text{ dBm} + 10 \times \log(s(i)) + 2.48$	Using Eq.8
n260	L (Patch Beam)	2.78	0.5	$input.power.limit(i) = 6 \text{ dBm} + 10 \times \log(s(i)) + 2.28$	Using Eq.8
	M (Patch Beam)	1.71	0.5	$input.power.limit(i) = 6 \text{ dBm} + 10 \times \log(s(i)) + 1.21$	Using Eq.8

Table 15
5G NR n261 L Patch *input.power.limit*

Band	Beam ID1	Beam ID2	input.power.limit (dBm)
n261	1		11.4
n261	4		7.7
n261	5		8.0
n261	6		9.1
n261	8		7.6
n261	9		8.7
n261	15		6.5
n261	16		4.7
n261	17		4.7
n261	18		5.2
n261	19		5.7
n261	24		5.5
n261	25		4.8
n261	26		4.6
n261	27		5.7
n261		129	12.3
n261		132	7.7
n261		133	6.9
n261		134	7.9
n261		136	7.1
n261		137	7.2
n261		143	7.4
n261		144	5.1
n261		145	4.6
n261		146	4.8
n261		147	5.0
n261		152	6.2
n261		153	4.6
n261		154	4.8
n261		155	5.0
n261	1	129	9.5
n261	4	134	3.9
n261	5	133	3.1
n261	6	132	4.2
n261	8	137	3.4
n261	9	136	3.5
n261	15	147	1.1
n261	16	146	0.2
n261	17	145	0.3
n261	18	144	0.4
n261	19	143	2.0
n261	24	155	0.6
n261	25	154	0.2
n261	26	153	0.5
n261	27	152	1.1

Table 16
5G NR n261 M Patch *input.power.limit*

Band	Beam ID1	Beam ID2	input.power.limit (dBm)
n261	0		11.2
n261	2		8.0
n261	3		8.3
n261	7		7.6
n261	10		6.6
n261	11		4.8
n261	12		4.9
n261	13		5.2
n261	14		5.5
n261	20		5.9
n261	21		4.9
n261	22		4.8
n261	23		5.5
n261		128	10.6
n261		130	7.6
n261		131	8.0
n261		135	6.9
n261		138	5.8
n261		139	4.8
n261		140	4.9
n261		141	4.9
n261		142	4.9
n261		148	5.5
n261		149	4.8
n261		150	4.8
n261		151	5.1
n261	0	128	7.0
n261	2	131	4.2
n261	3	130	4.2
n261	7	135	3.5
n261	10	142	1.2
n261	11	141	0.4
n261	12	139	0.9
n261	13	138	1.3
n261	14	140	2.6
n261	20	151	1.3
n261	21	150	0.4
n261	22	149	0.4
n261	23	148	1.0

Table 17
5G NR n260 L Patch *input.power.limit*

Band	Beam ID1	Beam ID2	input.power.limit (dBm)
n260	1		9.5
n260	5		7.0
n260	6		7.3
n260	7		6.4
n260	10		7.2
n260	11		7.0
n260	17		5.0
n260	18		4.8
n260	19		4.5
n260	20		4.4
n260	21		4.6
n260	26		5.0
n260	27		5.1
n260	28		4.4
n260	29		4.3
n260		129	9.0
n260		133	6.8
n260		134	6.8
n260		135	6.4
n260		138	7.0
n260		139	6.5
n260		145	4.8
n260		146	4.8
n260		147	4.4
n260		148	4.3
n260		149	4.5
n260		154	4.7
n260		155	4.7
n260		156	4.3
n260		157	4.3
n260	1	129	5.2
n260	5	134	3.0
n260	6	133	3.0
n260	7	135	2.8
n260	10	138	3.1
n260	11	139	3.0
n260	17	148	0.9
n260	18	147	0.4
n260	19	146	0.5
n260	20	145	0.8
n260	21	149	1.7
n260	26	156	0.6
n260	27	155	0.6
n260	28	154	0.4
n260	29	157	0.8

Table 18
5G NR n260 M Patch *input.power.limit*

Band	Beam ID1	Beam ID2	input.power.limit (dBm)
n260	0		8.2
n260	2		5.5
n260	3		6.4
n260	4		5.7
n260	8		6.5
n260	9		5.8
n260	12		3.7
n260	13		4.0
n260	14		4.0
n260	15		3.2
n260	16		3.2
n260	22		3.7
n260	23		4.2
n260	24		3.4
n260	25		3.1
n260		128	8.0
n260		130	5.6
n260		131	5.8
n260		132	5.3
n260		136	6.2
n260		137	5.2
n260		140	3.3
n260		141	3.8
n260		142	3.8
n260		143	3.2
n260		144	3.2
n260		150	3.7
n260		151	3.9
n260		152	3.4
n260		153	3.2
n260	0	128	5.8
n260	2	131	2.6
n260	3	130	1.9
n260	4	132	2.2
n260	8	136	1.9
n260	9	137	1.9
n260	12	143	-0.3
n260	13	142	-0.7
n260	14	141	-0.9
n260	15	140	-0.3
n260	16	144	0.0
n260	22	153	0.0
n260	23	151	-0.9
n260	24	150	-0.6
n260	25	152	0.5