FCC ID: A3LSMN981U

Part 0 Power Density Report
Power Density Characterization

Revision C

June 23, 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 (K Patch, L 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	**K**	Yes	Yes	No	No	No	Yes
NR n261	**L**	Yes	Yes	No	No	Yes	No
NR n260	**K**	Yes	Yes	No	No	No	Yes
NR n260	**L**	Yes	Yes	No	No	Yes	No

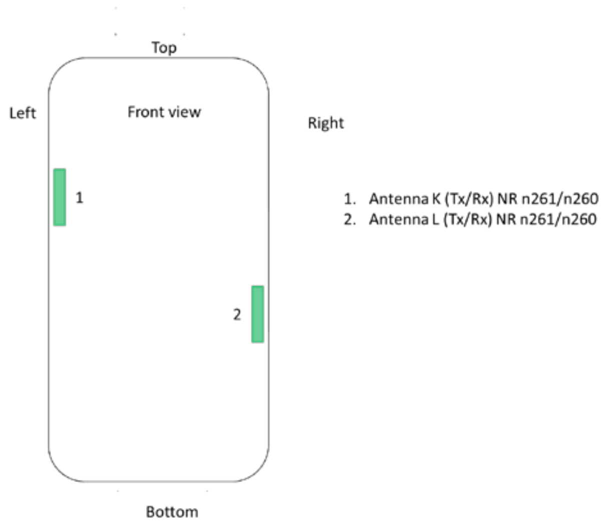

Figure 1: Location of mmW antenna modules looking from front of the DUT

2 Power Density Characterization Method

Simulation modeling and validation

- Correlate the simulated PD distributions with measured PD distribution for the selected beams to validate simulation model

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Uncertainty Budget

- Calculate the total device design uncertainty to include worst case RF tune-up accuracy and device-to-device variation

↓

PD_design_target

Specify a power density design target, which should be less than power density regulatory limit to account for the total device design uncertainties

↓

Worst-case housing material Influence Quantification

- Determine

Δ_{min} = *min{simulated PD@reference_power – measured PD@reference_power}*

to quantify the worst-case housing influence

↓

PD Char Generation

- Use validated simulation approach to determine input power limit for all the beams after accounting for the worst-case housing influence

3 Codebook for all supported beams

Table 2
5G mmW NR Band n261 Ant K Codebook

Band	Beam ID	Antenna Module	Antenna Type	# of Antenna Feed	Paired With
n261	1	K	Patch	1	129
n261	5	K	Patch	2	139
n261	6	K	Patch	2	138
n261	7	K	Patch	2	133
n261	10	K	Patch	2	134
n261	11	K	Patch	2	135
n261	17	K	Patch	4	156
n261	18	K	Patch	4	147
n261	19	K	Patch	4	146
n261	20	K	Patch	4	154
n261	21	K	Patch	4	149
n261	26	K	Patch	4	148
n261	27	K	Patch	4	155
n261	28	K	Patch	4	145
n261	29	K	Patch	4	157
n261	129	K	Patch	1	1
n261	133	K	Patch	2	7
n261	134	K	Patch	2	10
n261	135	K	Patch	2	11
n261	138	K	Patch	2	6
n261	139	K	Patch	2	5
n261	145	K	Patch	4	28
n261	146	K	Patch	4	19
n261	147	K	Patch	4	18
n261	148	K	Patch	4	26
n261	149	K	Patch	4	21
n261	154	K	Patch	4	20
n261	155	K	Patch	4	27
n261	156	K	Patch	4	17
n261	157	K	Patch	4	29

Table 3
5G mmW NR Band n261 Ant L Codebook

Band	Beam ID	Antenna Module	Antenna Type	# of Antenna Feed	Paired With
n261	0	L	Patch	1	128
n261	2	L	Patch	2	130
n261	3	L	Patch	2	131
n261	4	L	Patch	2	137
n261	8	L	Patch	2	136
n261	9	L	Patch	2	132
n261	12	L	Patch	4	141
n261	13	L	Patch	4	150
n261	14	L	Patch	4	142
n261	15	L	Patch	4	143
n261	16	L	Patch	4	153
n261	22	L	Patch	4	140
n261	23	L	Patch	4	151
n261	24	L	Patch	4	152
n261	25	L	Patch	4	144
n261	128	L	Patch	1	0
n261	130	L	Patch	2	2
n261	131	L	Patch	2	3
n261	132	L	Patch	2	9
n261	136	L	Patch	2	8
n261	137	L	Patch	2	4
n261	140	L	Patch	4	22
n261	141	L	Patch	4	12
n261	142	L	Patch	4	14
n261	143	L	Patch	4	15
n261	144	L	Patch	4	25
n261	150	L	Patch	4	13
n261	151	L	Patch	4	23
n261	152	L	Patch	4	24
n261	153	L	Patch	4	16

Table 4
5G mmW NR Band n260 Ant K Codebook

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

Table 5
5G mmW NR Band n260 Ant L Codebook

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

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 (K, L) 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)		(dB)
n261	K (Patch)	18	Back	0.675	1.15	2.30
			Left	0.897	1.40	**1.92**
		156	Back	0.571	1.20	3.23
			Left	0.828	1.39	2.24
	L (Patch)	23	Back	0.661	1.25	2.78
			Right	0.973	1.32	1.31
		142	Back	0.722	1.22	2.29
			Right	1.030	1.32	**1.09**
n260	K (Patch)	20	Back	0.702	1.014	1.60
			Left	1.140	1.66	1.63
		148	Back	0.496	0.936	2.76
			Left	1.170	1.65	**1.50**
	L (Patch)	15	Back	0.817	1.259	1.88
			Right	1.040	1.45	1.45
		143	Back	0.703	1.23	2.44
			Right	1.230	1.38	**0.51**

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)	
Total Uncertainty	2.1 dB
PD_regulatory_limit	1.0 mW/cm²
PD_design_target	0.6166 mW/cm²

6 Δmin

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, Δmin:

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 Δmin 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 ≥ PD_design_target, then those surfaces must be included in the Δmin 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 K patch: Back (S2) & Left (S3)

b. for L 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 $\Delta_{min} = \mathrm{Sim.PD} - \mathrm{Meas.PD}$, is determined as

Table 8

Δ_{min} for Ant K, Ant L

Band	Antenna	Δmin (dB)
n261	K (Patch)	1.92
	L (Patch)	1.09
n260	K (Patch)	1.50
	L (Patch)	0.51

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 K patch: Front

b. for L 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, K Patch simulated 4cm2 PD at PD_Design_Target

(if simulation performed with correct housing material properties) (Δmin)

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	K	1	0.002	0.598	0.018	N/A	0.090	0.481
2	K	5	0.003	0.592	0.032	N/A	0.140	0.408
3	K	6	0.006	0.548	0.003	N/A	0.095	0.467
4	K	7	0.007	0.533	0.024	N/A	0.051	0.444
5	K	10	0.005	0.588	0.010	N/A	0.121	0.467
6	K	11	0.003	0.610	0.010	N/A	0.073	0.576
7	K	17	0.005	0.613	0.029	N/A	0.153	0.481
8	K	18	0.005	0.601	0.006	N/A	0.137	0.492
9	K	19	0.007	0.591	0.004	N/A	0.107	0.533
10	K	20	0.007	0.564	0.008	N/A	0.055	0.517
11	K	21	0.008	0.551	0.007	N/A	0.051	0.503
12	K	26	0.006	0.613	0.007	N/A	0.142	0.499
13	K	27	0.006	0.599	0.004	N/A	0.121	0.519
14	K	28	0.005	0.567	0.009	N/A	0.061	0.527
15	K	29	0.008	0.557	0.007	N/A	0.051	0.505
16	K	129	0.003	0.617	0.016	N/A	0.076	0.442
17	K	133	0.007	0.589	0.044	N/A	0.137	0.398
18	K	134	0.003	0.598	0.011	N/A	0.090	0.499
19	K	135	0.008	0.600	0.034	N/A	0.073	0.459
20	K	138	0.004	0.608	0.006	N/A	0.109	0.494
21	K	139	0.006	0.610	0.029	N/A	0.060	0.509
22	K	145	0.009	0.617	0.040	N/A	0.136	0.450
23	K	146	0.006	0.602	0.006	N/A	0.133	0.473
24	K	147	0.004	0.597	0.005	N/A	0.110	0.503
25	K	148	0.004	0.584	0.057	N/A	0.059	0.519
26	K	149	0.004	0.558	0.067	N/A	0.054	0.488
27	K	154	0.006	0.599	0.005	N/A	0.136	0.453
28	K	155	0.005	0.594	0.015	N/A	0.121	0.483
29	K	156	0.003	0.617	0.015	N/A	0.088	0.535
30	K	157	0.004	0.563	0.067	N/A	0.055	0.500

Table 10
n261/mid channel, L Patch simulated 4cm2 PD at PD_Design_Target
(if simulation performed with correct housing material properties) (Δmin)

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	L	0	0.533	0.006	N/A	0.008	0.070	0.484
47	L	2	0.549	0.005	N/A	0.012	0.082	0.490
48	L	3	0.567	0.010	N/A	0.003	0.093	0.556
49	L	4	0.551	0.006	N/A	0.013	0.095	0.483
50	L	8	0.558	0.006	N/A	0.003	0.061	0.591
51	L	9	0.558	0.007	N/A	0.012	0.106	0.491
52	L	12	0.512	0.006	N/A	0.010	0.056	0.617
53	L	13	0.542	0.006	N/A	0.004	0.065	0.537
54	L	14	0.566	0.012	N/A	0.002	0.092	0.528
55	L	15	0.569	0.009	N/A	0.009	0.124	0.520
56	L	16	0.611	0.006	N/A	0.032	0.144	0.617
57	L	22	0.526	0.005	N/A	0.007	0.050	0.586
58	L	23	0.568	0.011	N/A	0.003	0.076	0.540
59	L	24	0.566	0.009	N/A	0.004	0.105	0.524
60	L	25	0.602	0.008	N/A	0.031	0.151	0.525
61	L	128	0.608	0.004	N/A	0.009	0.074	0.577
62	L	130	0.578	0.006	N/A	0.023	0.097	0.537
63	L	131	0.588	0.005	N/A	0.002	0.083	0.568
64	L	132	0.525	0.004	N/A	0.018	0.055	0.540
65	L	136	0.597	0.005	N/A	0.010	0.095	0.565
66	L	137	0.553	0.004	N/A	0.011	0.063	0.555
67	L	140	0.611	0.013	N/A	0.051	0.140	0.582
68	L	141	0.586	0.008	N/A	0.003	0.109	0.554
69	L	142	0.569	0.010	N/A	0.003	0.088	0.526
70	L	143	0.547	0.008	N/A	0.003	0.075	0.514
71	L	144	0.560	0.004	N/A	0.021	0.069	0.568
72	L	150	0.573	0.009	N/A	0.016	0.120	0.544
73	L	151	0.577	0.009	N/A	0.001	0.102	0.541
74	L	152	0.565	0.009	N/A	0.002	0.080	0.527
75	L	153	0.553	0.006	N/A	0.010	0.072	0.533

Table 11
n260/mid channel, K Patch simulated 4cm2 PD at PD_Design_Target
(if simulation performed with correct housing material properties) (Δmin)

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	K	1	0.003	0.582	0.020	N/A	0.101	0.360
2	K	5	0.002	0.583	0.041	N/A	0.112	0.295
3	K	6	0.002	0.616	0.011	N/A	0.132	0.431
4	K	7	0.002	0.583	0.041	N/A	0.112	0.295
5	K	10	0.002	0.592	0.034	N/A	0.090	0.357
6	K	11	0.001	0.582	0.037	N/A	0.121	0.352
7	K	17	0.001	0.617	0.087	N/A	0.146	0.315
8	K	18	0.002	0.581	0.019	N/A	0.116	0.413
9	K	19	0.002	0.614	0.023	N/A	0.147	0.424
10	K	20	0.001	0.617	0.070	N/A	0.156	0.377
11	K	21	0.001	0.617	0.083	N/A	0.133	0.313
12	K	26	0.004	0.460	0.045	N/A	0.102	0.291
13	K	27	0.002	0.586	0.030	N/A	0.132	0.419
14	K	28	0.002	0.617	0.047	N/A	0.176	0.389
15	K	29	0.001	0.617	0.071	N/A	0.138	0.350
16	K	129	0.002	0.617	0.018	N/A	0.105	0.291
17	K	133	0.002	0.617	0.014	N/A	0.122	0.338
18	K	134	0.002	0.609	0.014	N/A	0.140	0.384
19	K	135	0.003	0.617	0.013	N/A	0.116	0.332
20	K	138	0.002	0.550	0.005	N/A	0.115	0.380
21	K	139	0.002	0.617	0.018	N/A	0.143	0.347
22	K	145	0.003	0.607	0.010	N/A	0.097	0.308
23	K	146	0.002	0.580	0.011	N/A	0.125	0.410
24	K	147	0.002	0.606	0.020	N/A	0.146	0.408
25	K	148	0.002	0.617	0.025	N/A	0.161	0.350
26	K	149	0.003	0.617	0.010	N/A	0.105	0.347
27	K	154	0.003	0.555	0.011	N/A	0.116	0.371
28	K	155	0.003	0.509	0.018	N/A	0.101	0.375
29	K	156	0.002	0.617	0.026	N/A	0.182	0.347
30	K	157	0.002	0.617	0.015	N/A	0.126	0.357

Table 12

n260/mid channel, L Patch simulated 4cm2 PD at PD_Design_Target

(if simulation performed with correct housing material properties) (Δmin)

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	L	0	0.617	0.004	N/A	0.017	0.118	0.487
47	L	2	0.614	0.005	N/A	0.030	0.107	0.499
48	L	3	0.614	0.007	N/A	0.003	0.152	0.527
49	L	4	0.617	0.002	N/A	0.023	0.126	0.464
50	L	8	0.617	0.007	N/A	0.014	0.146	0.508
51	L	9	0.602	0.007	N/A	0.014	0.116	0.528
52	L	12	0.591	0.005	N/A	0.037	0.123	0.487
53	L	13	0.617	0.005	N/A	0.010	0.157	0.537
54	L	14	0.590	0.007	N/A	0.004	0.148	0.484
55	L	15	0.617	0.004	N/A	0.024	0.123	0.535
56	L	16	0.617	0.004	N/A	0.049	0.145	0.494
57	L	22	0.617	0.005	N/A	0.011	0.147	0.534
58	L	23	0.617	0.005	N/A	0.007	0.177	0.490
59	L	24	0.589	0.006	N/A	0.005	0.103	0.517
60	L	25	0.617	0.004	N/A	0.045	0.138	0.507
61	L	128	0.617	0.006	N/A	0.013	0.113	0.500
62	L	130	0.617	0.006	N/A	0.007	0.120	0.497
63	L	131	0.580	0.005	N/A	0.008	0.105	0.506
64	L	132	0.617	0.007	N/A	0.005	0.087	0.541
65	L	136	0.584	0.006	N/A	0.004	0.124	0.515
66	L	137	0.602	0.004	N/A	0.007	0.118	0.448
67	L	140	0.587	0.010	N/A	0.005	0.097	0.513
68	L	141	0.617	0.006	N/A	0.007	0.149	0.526
69	L	142	0.576	0.005	N/A	0.011	0.137	0.495
70	L	143	0.617	0.004	N/A	0.010	0.105	0.550
71	L	144	0.601	0.008	N/A	0.003	0.124	0.523
72	L	150	0.602	0.007	N/A	0.004	0.141	0.521
73	L	151	0.594	0.006	N/A	0.018	0.170	0.478
74	L	152	0.617	0.004	N/A	0.011	0.089	0.554
75	L	153	0.617	0.005	N/A	0.006	0.123	0.538

Table 13
4cm2 PD of the selected beams measured on the corresponding surfaces that are not selected for Δmin determination

Band	Antenna	Beam ID	Surface	Tested Power Level (dBm)	input.power.limit (dBm)	Meas. 4cm^2 PD (mW/cm^2)
n261	K (Patch)	17	Front	4.2	4.2	0.100
	L (Patch)	25	Front	4.9	4.9	0.120
n260	K (Patch)	156	Front	3.0	3.0	0.280
	L (Patch)	23	Front	3.3	3.3	0.110

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 PDsurface 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:

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

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

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

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 ∅, 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:

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

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

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

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 < Δmin < TxAGC uncertainty,

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

else if Δmin < -TxAGC uncertainty,

$$input.power.limit(i) = 6\ dBm + 10 * \log\big(s(i)\big) + (\Delta_{min} + \text{TxAGC uncertainty}),$$
$$i \in all\ beams, \text{ for n260 and n261} \quad (7)$$

else if Δmin > TxAGC uncertainty,

$$input.power.limit(i) = 6\ dBm + 10 * \log\big(s(i)\big) + (\Delta_{min} - \text{TxAGC uncertainty}),$$
$$i \in all\ beams, \text{ for n260 and n261} \quad (8)$$

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	Δmin	TxAGC Uncertainty	*input.power.limit*	Notes
		(dB)	(dB)	(dBm)	
n261	K (Patch)	1.92	0.5	*input.power.limit(i) = 6 dBm + 10 x log(s(i)) + 1.42*	Using Eq.8
	L (Patch)	1.09	0.5	*input.power.limit(i) = 6 dBm + 10 x log(s(i)) + 0.59*	Using Eq.8
n260	K (Patch)	1.50	0.5	*input.power.limit(i) = 6 dBm + 10 x log(s(i)) + 1*	Using Eq.8
	L (Patch)	0.51	0.5	*input.power.limit(i) = 6 dBm + 10 x log(s(i)) + 0.01*	Using Eq.8

Table 15

5G NR n261 K Patch *input.power.limit*

Band	V Beam ID	H Beam ID	input.power.limit (dBm)
n261	1	-	9.3
n261	5	-	7.0
n261	6	-	7.2
n261	7	-	7.8
n261	10	-	7.7
n261	11	-	6.7
n261	17	-	4.2
n261	18	-	3.8
n261	19	-	4.1
n261	20	-	4.2
n261	21	-	4.4
n261	26	-	4.1
n261	27	-	3.9
n261	28	-	4.2
n261	29	-	4.3
n261	-	129	9.5
n261	-	133	8.1
n261	-	134	6.3
n261	-	135	7.0
n261	-	138	6.2
n261	-	139	6.8
n261	-	145	4.9
n261	-	146	3.9
n261	-	147	3.9
n261	-	148	4.2
n261	-	149	4.6
n261	-	154	4.3
n261	-	155	3.9
n261	-	156	4.0
n261	-	157	4.2
n261	1	129	6.4
n261	5	139	2.7
n261	6	138	2.4
n261	7	133	5.3
n261	10	134	2.5
n261	11	135	3.9
n261	17	156	0.1
n261	18	147	-0.2
n261	19	146	0.0
n261	20	154	0.0
n261	21	149	2.6
n261	26	148	0.2
n261	27	155	-0.1
n261	28	145	0.7
n261	29	157	2.1

Table 16

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

Band	V Beam ID	H Beam ID	input.power.limit (dBm)
n261	0	-	9.7
n261	2	-	7.5
n261	3	-	6.8
n261	4	-	7.4
n261	8	-	6.2
n261	9	-	7.1
n261	12	-	3.8
n261	13	-	3.2
n261	14	-	3.1
n261	15	-	3.7
n261	16	-	5.8
n261	22	-	3.6
n261	23	-	3.0
n261	24	-	3.3
n261	25	-	4.9
n261	-	128	9.2
n261	-	130	6.5
n261	-	131	5.4
n261	-	132	6.1
n261	-	136	5.6
n261	-	137	5.7
n261	-	140	5.3
n261	-	141	3.3
n261	-	142	3.0
n261	-	143	3.0
n261	-	144	3.2
n261	-	150	3.8
n261	-	151	3.0
n261	-	152	3.0
n261	-	153	3.1
n261	0	128	5.5
n261	2	130	3.3
n261	3	131	1.8
n261	4	137	2.2
n261	8	136	1.9
n261	9	132	2.1
n261	12	141	-0.3
n261	13	150	-0.8
n261	14	142	-1.2
n261	15	143	-0.9
n261	16	153	0.6
n261	22	140	0.0
n261	23	151	-1.2
n261	24	152	-1.0
n261	25	144	-0.4

Table 17

5G NR n260 K Patch *input.power.limit*

Band	V Beam ID	H Beam ID	input.power.limit (dBm)
n260	1	-	9.9
n260	5	-	6.5
n260	6	-	6.9
n260	7	-	6.5
n260	10	-	6.9
n260	11	-	6.3
n260	17	-	3.5
n260	18	-	4.7
n260	19	-	3.7
n260	20	-	2.7
n260	21	-	3.7
n260	26	-	4.6
n260	27	-	4.5
n260	28	-	3.1
n260	29	-	2.9
n260	-	129	10.2
n260	-	133	6.3
n260	-	134	6.4
n260	-	135	6.5
n260	-	138	6.9
n260	-	139	6.0
n260	-	145	3.8
n260	-	146	4.7
n260	-	147	3.8
n260	-	148	2.8
n260	-	149	3.6
n260	-	154	5.0
n260	-	155	3.8
n260	-	156	3.0
n260	-	157	3.2
n260	1	129	8.4
n260	5	133	3.7
n260	6	138	2.8
n260	7	135	3.7
n260	10	134	2.5
n260	11	139	3.3
n260	17	156	0.1
n260	18	155	0.1
n260	19	154	0.1
n260	20	148	0.0
n260	21	149	1.4
n260	26	147	-0.2
n260	27	146	0.7
n260	28	145	-0.3
n260	29	157	0.6

Table 18

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

Band	V Beam ID	H Beam ID	input.power.limit (dBm)
n260	0	-	7.6
n260	2	-	5.2
n260	3	-	5.9
n260	4	-	4.8
n260	8	-	6.0
n260	9	-	5.3
n260	12	-	3.5
n260	13	-	3.2
n260	14	-	2.6
n260	15	-	2.3
n260	16	-	2.6
n260	22	-	3.2
n260	23	-	3.3
n260	24	-	2.4
n260	25	-	2.4
n260	-	128	8.4
n260	-	130	5.9
n260	-	131	5.5
n260	-	132	5.0
n260	-	136	5.7
n260	-	137	5.2
n260	-	140	3.5
n260	-	141	3.4
n260	-	142	2.7
n260	-	143	2.6
n260	-	144	3.0
n260	-	150	3.4
n260	-	151	3.0
n260	-	152	2.8
n260	-	153	2.6
n260	0	128	3.7
n260	2	137	1.6
n260	3	136	1.4
n260	4	132	2.9
n260	8	131	1.3
n260	9	130	2.8
n260	12	152	-1.0
n260	13	151	-1.4
n260	14	150	-1.1
n260	15	153	-1.0
n260	16	143	-0.6
n260	22	142	-1.1
n260	23	141	-1.3
n260	24	140	-1.2
n260	25	144	-0.2