FCC ID: A3LSMS711U

Part 0 Power Density Report
Power Density Characterization

Revision A

August 1, 2023

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 1 patch antenna arrays (K 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 n258	**K**	Yes	Yes	Yes	No	No	Yes
NR n261	**K**	Yes	Yes	Yes	No	No	Yes
NR n260	**K**	Yes	Yes	Yes	No	No	Yes

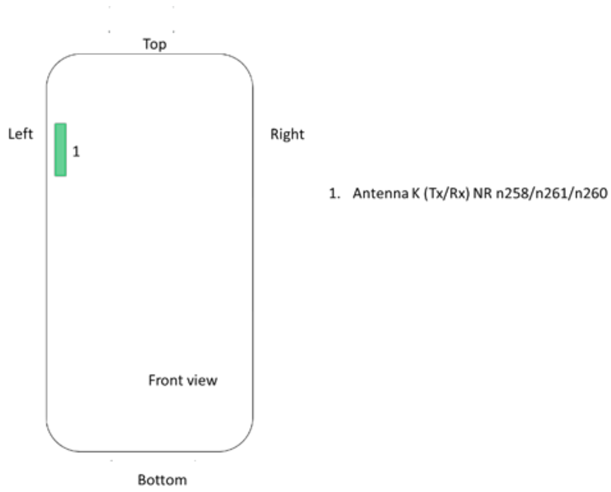
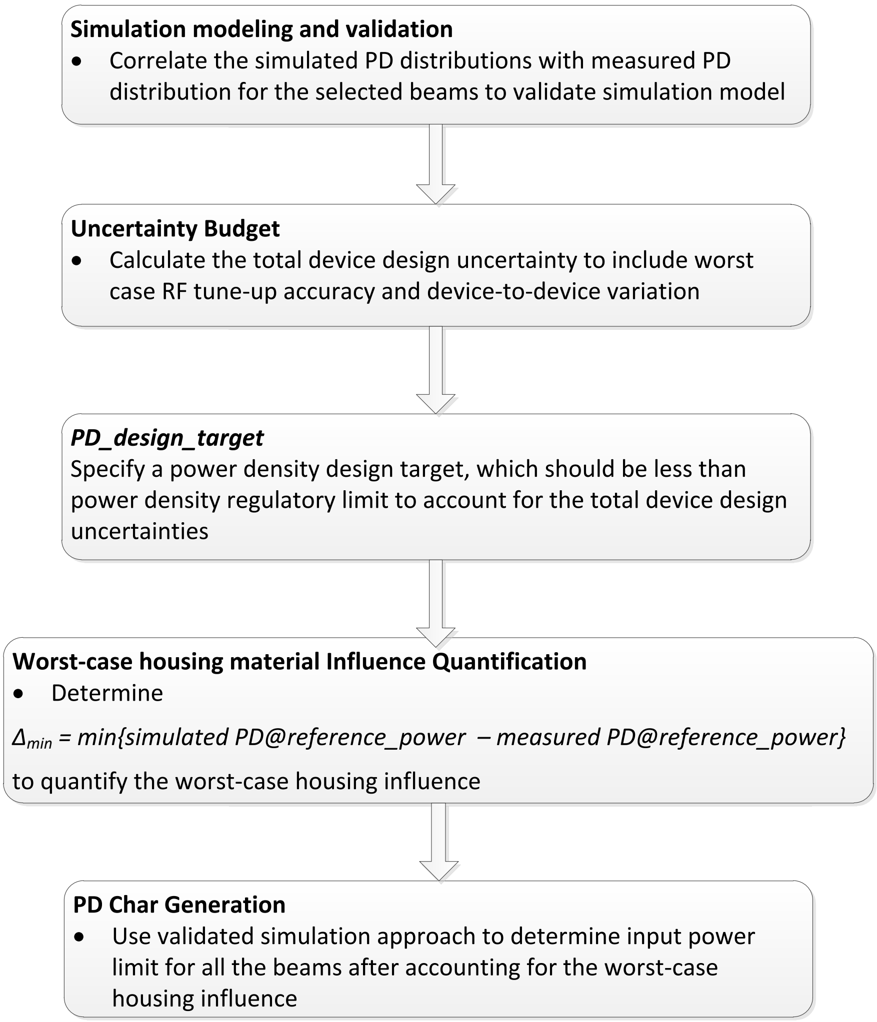


Figure 1: Location of mmW antenna modules looking from front of the DUT

2 Power Density Characterization Method



3 Codebook for all supported beams

Table 2
5G mmW NR Band n258 Ant K Codebook

Band	Antenna Module	Antenna Type	Beam ID	Feed no.	Paired With
n258	K	Patch	0	1	128
n258	K	Patch	1	1	129
n258	K	Patch	2	1	130
n258	K	Patch	3	1	131
n258	K	Patch	4	1	132
n258	K	Patch	5	2	133
n258	K	Patch	6	2	134
n258	K	Patch	7	2	135
n258	K	Patch	8	2	136
n258	K	Patch	9	2	137
n258	K	Patch	10	2	138
n258	K	Patch	11	2	139
n258	K	Patch	12	5	140
n258	K	Patch	13	5	141
n258	K	Patch	14	5	142
n258	K	Patch	15	5	143
n258	K	Patch	16	5	144
n258	K	Patch	17	5	145
n258	K	Patch	18	5	146
n258	K	Patch	19	5	147
n258	K	Patch	20	5	148
n258	K	Patch	128	1	0
n258	K	Patch	129	1	1
n258	K	Patch	130	1	2
n258	K	Patch	131	1	3
n258	K	Patch	132	1	4
n258	K	Patch	133	2	5
n258	K	Patch	134	2	6
n258	K	Patch	135	2	7
n258	K	Patch	136	2	8
n258	K	Patch	137	2	9
n258	K	Patch	138	2	10
n258	K	Patch	139	2	11
n258	K	Patch	140	5	12
n258	K	Patch	141	5	13
n258	K	Patch	142	5	14
n258	K	Patch	143	5	15
n258	K	Patch	144	5	16
n258	K	Patch	145	5	17
n258	K	Patch	146	5	18
n258	K	Patch	147	5	19
n258	K	Patch	148	5	20

Table 3
5G mmW NR Band n261 Ant K Codebook

Band	Antenna Module	Antenna Type	Beam ID	Feed no.	Paired With
n261	K	Patch	0	1	128
n261	K	Patch	1	1	129
n261	K	Patch	2	1	130
n261	K	Patch	3	1	131
n261	K	Patch	4	1	132
n261	K	Patch	5	2	133
n261	K	Patch	6	2	134
n261	K	Patch	7	2	135
n261	K	Patch	8	2	136
n261	K	Patch	9	2	137
n261	K	Patch	10	2	138
n261	K	Patch	11	2	139
n261	K	Patch	12	5	140
n261	K	Patch	13	5	141
n261	K	Patch	14	5	142
n261	K	Patch	15	5	143
n261	K	Patch	16	5	144
n261	K	Patch	17	5	145
n261	K	Patch	18	5	146
n261	K	Patch	19	5	147
n261	K	Patch	20	5	148
n261	K	Patch	128	1	0
n261	K	Patch	129	1	1
n261	K	Patch	130	1	2
n261	K	Patch	131	1	3
n261	K	Patch	132	1	4
n261	K	Patch	133	2	5
n261	K	Patch	134	2	6
n261	K	Patch	135	2	7
n261	K	Patch	136	2	8
n261	K	Patch	137	2	9
n261	K	Patch	138	2	10
n261	K	Patch	139	2	11
n261	K	Patch	140	5	12
n261	K	Patch	141	5	13
n261	K	Patch	142	5	14
n261	K	Patch	143	5	15
n261	K	Patch	144	5	16
n261	K	Patch	145	5	17
n261	K	Patch	146	5	18
n261	K	Patch	147	5	19
n261	K	Patch	148	5	20

Table 4
5G mmW NR Band n260 Ant K Codebook

Band	Antenna Module	Antenna Type	Beam ID	Feed no.	Paired With
n260	K	Patch	0	1	128
n260	K	Patch	1	1	129
n260	K	Patch	2	1	130
n260	K	Patch	3	1	131
n260	K	Patch	4	1	132
n260	K	Patch	5	2	133
n260	K	Patch	6	2	134
n260	K	Patch	7	2	135
n260	K	Patch	8	2	136
n260	K	Patch	9	2	137
n260	K	Patch	10	2	138
n260	K	Patch	11	2	139
n260	K	Patch	12	5	140
n260	K	Patch	13	5	141
n260	K	Patch	14	5	142
n260	K	Patch	15	5	143
n260	K	Patch	16	5	144
n260	K	Patch	17	5	145
n260	K	Patch	18	5	146
n260	K	Patch	19	5	147
n260	K	Patch	20	5	148
n260	K	Patch	128	1	0
n260	K	Patch	129	1	1
n260	K	Patch	130	1	2
n260	K	Patch	131	1	3
n260	K	Patch	132	1	4
n260	K	Patch	133	2	5
n260	K	Patch	134	2	6
n260	K	Patch	135	2	7
n260	K	Patch	136	2	8
n260	K	Patch	137	2	9
n260	K	Patch	138	2	10
n260	K	Patch	139	2	11
n260	K	Patch	140	5	12
n260	K	Patch	141	5	13
n260	K	Patch	142	5	14
n260	K	Patch	143	5	15
n260	K	Patch	144	5	16
n260	K	Patch	145	5	17
n260	K	Patch	146	5	18
n260	K	Patch	147	5	19
n260	K	Patch	148	5	20

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 n258 band, 6 dBm for n261 band, and 6 dBm for n260 band, PD measurements are conducted for at least one single beam per antenna module 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 5

Band	Antenna	Beam ID	Surface	4cm^2 psPD		Delta = Simulated - Measured
				Measured	Simulated	
				(mW/cm^2)		(dB)
n258	K	13	Left	1.360	2.106	**1.90**
		14	Front	0.376	1.017	4.32
		143	Rear	0.360	0.661	2.64
		143	Left	0.428	0.889	3.17
n261	K	19	Rear	0.232	0.744	5.06
		15	Left	0.878	1.449	**2.18**
		144	Rear	0.327	0.656	3.02
		144	Left	0.593	1.091	2.65
n260	K	18	Left	0.760	1.265	2.21
		18	Front	0.357	0.645	2.57
		147	Left	0.678	0.910	**1.28**
		146	Front	0.332	0.537	2.09

5 *PD_design_target*

Table 6

PD_design_target	
$PD\_design\_target < PD\_regulatory\_limit \ x \ 10^{\frac{-\ Total\ Uncertainty}{10}}$	
psPD over 4 cm2 Averaging Area (mW/cm^2)	
Total Uncertainty	2.0 dB
PD_regulatory_limit	1.0 mW/cm^2
PD_design_target	0.631 mW/cm^2

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 the 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 n258, n261, and n260 bands are identified in the following table:

Table 7

Worst-surface(s) for Ant K

Band/Mode	Antenna Module	Back	Front	Top	Bottom	Right	Left
NR n258	**K**	Yes	Yes	No	No	No	Yes
NR n261	**K**	Yes	No	No	No	No	Yes
NR n260	**K**	No	Yes	No	No	No	Yes

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 the table below. 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

Band	Antenna	Δmin (dB)
n258	K	**1.90**
n261	K	**2.18**
n260	K	**1.28**

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 the Power Density Simulation Report are scaled to input.power.limit and are listed in the tables below 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), identified in the table below:

Table 9

Non-Selected Surface(s) for Ant K

Band/Mode	Antenna Module	Antenna Type	Back (S2)	Front (S1)	Top (S5)	Bottom (S6)	Right (S4)	Left (S3)
NR n258	**K**	**Patch**	Yes	Yes	Yes	No	No	No
NR n261	**K**	**Patch**	No	Yes	Yes	No	No	No
NR n260	**K**	**Patch**	Yes	No	Yes	No	No	No

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

Table 0
n258/mid channel, Antenna K Patch simulated 4cm2 PD at PD_Design_Target
(if simulation performed with correct housing material properties) (Δmin)

Antenna	Beam ID_1	Simulated 4cm^2 PD (mW/cm^2) 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)
K	0	0.005	0.623	0.020	0.002	0.277	0.236
K	1	0.004	0.631	0.037	0.002	0.174	0.241
K	2	0.006	0.621	0.037	0.002	0.240	0.192
K	3	0.012	0.611	0.026	0.004	0.287	0.195
K	4	0.009	0.603	0.028	0.002	0.275	0.213
K	5	0.006	0.631	0.068	0.004	0.225	0.284
K	6	0.007	0.631	0.031	0.001	0.318	0.215
K	7	0.009	0.596	0.012	0.003	0.304	0.205
K	8	0.006	0.631	0.022	0.003	0.194	0.278
K	9	0.007	0.631	0.040	0.002	0.228	0.269
K	10	0.003	0.631	0.008	0.002	0.286	0.244
K	11	0.007	0.535	0.036	0.006	0.218	0.196
K	12	0.006	0.631	0.098	0.002	0.245	0.291
K	13	0.006	0.629	0.058	0.001	0.291	0.237
K	14	0.006	0.612	0.005	0.001	0.342	0.252
K	15	0.004	0.595	0.007	0.002	0.262	0.238
K	16	0.007	0.610	0.034	0.009	0.177	0.470
K	17	0.004	0.631	0.084	0.001	0.267	0.243
K	18	0.005	0.610	0.021	0.001	0.306	0.254
K	19	0.007	0.631	0.006	0.001	0.328	0.275
K	20	0.005	0.591	0.010	0.004	0.205	0.283
K	128	0.006	0.600	0.040	0.003	0.266	0.168
K	129	0.012	0.525	0.037	0.004	0.159	0.623
K	130	0.015	0.553	0.068	0.005	0.252	0.456
K	131	0.018	0.539	0.057	0.004	0.202	0.429
K	132	0.022	0.582	0.114	0.005	0.348	0.522
K	133	0.018	0.534	0.118	0.005	0.347	0.432
K	134	0.021	0.585	0.044	0.000	0.252	0.620
K	135	0.007	0.572	0.021	0.003	0.195	0.305
K	136	0.008	0.572	0.057	0.004	0.159	0.316
K	137	0.017	0.563	0.139	0.006	0.365	0.532
K	138	0.022	0.587	0.070	0.002	0.311	0.468
K	139	0.015	0.486	0.041	0.004	0.203	0.445
K	140	0.013	0.532	0.184	0.003	0.288	0.476
K	141	0.027	0.616	0.063	0.003	0.363	0.476
K	142	0.031	0.605	0.014	0.002	0.246	0.549
K	143	0.013	0.604	0.016	0.001	0.223	0.449
K	144	0.013	0.549	0.034	0.007	0.179	0.414
K	145	0.014	0.542	0.171	0.005	0.297	0.587
K	146	0.027	0.583	0.030	0.003	0.314	0.500
K	147	0.024	0.604	0.011	0.003	0.228	0.501
K	148	0.010	0.588	0.024	0.003	0.192	0.440

Note: For Front Side, only H beams were considered for non-selected surface testing. For Back Side, only V beams were considered for non-selected surface testing.

Table 11

n261/mid channel, Antenna K Patch simulated 4cm2 PD at PD_Design_Target

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

Antenna	Beam ID_1	Simulated 4cm^2 PD (mW/cm^2) 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)
K	0	0.002	0.602	0.016	0.002	0.224	0.210
K	1	0.003	0.631	0.019	0.002	0.223	0.188
K	2	0.006	0.595	0.030	0.002	0.198	0.202
K	3	0.008	0.549	0.040	0.002	0.210	0.222
K	4	0.014	0.522	0.022	0.003	0.275	0.215
K	5	0.008	0.569	0.070	0.002	0.207	0.210
K	6	0.008	0.621	0.052	0.001	0.225	0.255
K	7	0.009	0.579	0.008	0.001	0.267	0.271
K	8	0.007	0.528	0.044	0.003	0.220	0.211
K	9	0.005	0.631	0.056	0.004	0.178	0.183
K	10	0.007	0.610	0.028	0.001	0.248	0.290
K	11	0.003	0.631	0.006	0.002	0.286	0.241
K	12	0.003	0.631	0.118	0.002	0.234	0.207
K	13	0.005	0.572	0.101	0.002	0.244	0.232
K	14	0.007	0.600	0.010	0.001	0.250	0.337
K	15	0.011	0.603	0.007	0.001	0.302	0.279
K	16	0.006	0.593	0.015	0.005	0.283	0.212
K	17	0.004	0.631	0.115	0.001	0.247	0.215
K	18	0.006	0.532	0.037	0.001	0.213	0.274
K	19	0.011	0.622	0.005	0.001	0.306	0.321
K	20	0.007	0.528	0.010	0.002	0.264	0.220
K	128	0.010	0.628	0.032	0.013	0.210	0.175
K	129	0.007	0.624	0.017	0.003	0.193	0.242
K	130	0.006	0.587	0.029	0.003	0.165	0.242
K	131	0.010	0.569	0.026	0.003	0.260	0.181
K	132	0.015	0.596	0.043	0.008	0.263	0.201
K	133	0.007	0.631	0.037	0.012	0.248	0.200
K	134	0.007	0.615	0.021	0.005	0.239	0.247
K	135	0.004	0.598	0.006	0.003	0.217	0.246
K	136	0.010	0.551	0.041	0.005	0.188	0.333
K	137	0.009	0.548	0.059	0.005	0.230	0.219
K	138	0.008	0.609	0.013	0.002	0.237	0.238
K	139	0.015	0.555	0.018	0.007	0.269	0.270
K	140	0.018	0.600	0.099	0.015	0.272	0.222
K	141	0.012	0.568	0.070	0.007	0.239	0.284
K	142	0.007	0.617	0.010	0.001	0.285	0.209
K	143	0.008	0.617	0.008	0.002	0.252	0.248
K	144	0.010	0.558	0.012	0.008	0.144	0.335
K	145	0.015	0.601	0.096	0.011	0.265	0.245
K	146	0.009	0.611	0.046	0.003	0.239	0.283
K	147	0.006	0.606	0.011	0.002	0.286	0.198
K	148	0.012	0.625	0.016	0.003	0.228	0.341

Table 12

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

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

Antenna	Beam ID_1	Simulated 4cm^2 PD (mW/cm^2) 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)
K	0	0.002	0.601	0.007	0.002	0.243	0.191
K	1	0.005	0.593	0.027	0.002	0.192	0.204
K	2	0.004	0.532	0.031	0.002	0.163	0.223
K	3	0.006	0.472	0.032	0.002	0.153	0.212
K	4	0.006	0.486	0.020	0.002	0.201	0.201
K	5	0.003	0.430	0.042	0.002	0.135	0.200
K	6	0.002	0.558	0.010	0.001	0.263	0.227
K	7	0.004	0.626	0.018	0.003	0.272	0.200
K	8	0.004	0.616	0.021	0.004	0.215	0.163
K	9	0.003	0.561	0.014	0.003	0.206	0.207
K	10	0.004	0.528	0.029	0.001	0.217	0.199
K	11	0.004	0.489	0.045	0.002	0.157	0.193
K	12	0.005	0.448	0.069	0.009	0.159	0.282
K	13	0.004	0.476	0.008	0.001	0.221	0.213
K	14	0.003	0.554	0.005	0.000	0.274	0.220
K	15	0.010	0.631	0.040	0.001	0.305	0.253
K	16	0.003	0.593	0.077	0.008	0.230	0.242
K	17	0.006	0.406	0.064	0.006	0.145	0.271
K	18	0.003	0.541	0.005	0.000	0.276	0.224
K	19	0.008	0.523	0.011	0.002	0.222	0.225
K	20	0.005	0.631	0.087	0.002	0.301	0.222
K	128	0.010	0.453	0.019	0.002	0.318	0.108
K	129	0.006	0.470	0.020	0.003	0.351	0.146
K	130	0.003	0.477	0.024	0.003	0.212	0.170
K	131	0.007	0.447	0.025	0.002	0.228	0.166
K	132	0.011	0.513	0.020	0.003	0.308	0.241
K	133	0.003	0.537	0.043	0.001	0.236	0.164
K	134	0.006	0.495	0.009	0.002	0.342	0.176
K	135	0.011	0.456	0.021	0.001	0.235	0.203
K	136	0.010	0.433	0.037	0.004	0.314	0.123
K	137	0.003	0.504	0.032	0.001	0.251	0.183
K	138	0.006	0.421	0.018	0.001	0.235	0.197
K	139	0.006	0.482	0.036	0.001	0.208	0.139
K	140	0.012	0.579	0.089	0.007	0.315	0.177
K	141	0.013	0.531	0.016	0.001	0.352	0.206
K	142	0.009	0.426	0.013	0.001	0.265	0.165
K	143	0.014	0.458	0.014	0.001	0.279	0.192
K	144	0.010	0.460	0.066	0.003	0.272	0.143
K	145	0.011	0.582	0.063	0.006	0.300	0.225
K	146	0.010	0.461	0.010	0.002	0.320	0.184
K	147	0.010	0.484	0.015	0.002	0.275	0.183
K	148	0.009	0.422	0.034	0.002	0.235	0.179

The test results in the table below shows that the all measured 4cm2 PD values are less than PD_design_target of 0.631 mW/cm2, thus, the non-selected surfaces have no influence on the determined Δ_{min} and input.power.limit in Section 7.

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)
n258	K	16	Rear	5.4	5.4	0.365
		137	Front	12.3	12.3	0.217
		140	Top	7.5	7.5	0.156
n261	K	19	Front	4.7	4.7	0.185
		12	Top	5.3	5.3	0.124
n260	K	12	Back	2.8	2.8	0.090
		140	Top	4.8	4.8	0.043

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 n258 band, 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:

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

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

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

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 ∅, the scaling factor was obtained by the below equation for low, mid and high channels:

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

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:

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

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}), given by:

- For n258, n261, and n260

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

where 6 dBm is the input power used in simulation for n258, 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 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,

$$input.power.limit(i) = sim.power_{limit}(\mathrm{i}), \ i \in all\ beams, \text{ for n258, n261, and n260} \quad (6)$$

else if Δmin < -TxAGC uncertainty,

$$input.power.limit(i) = sim.power_{limit}(\mathrm{i}) + (\Delta_{min} + \text{TxAGC uncertainty}),$$
$$i \in all\ beams, \text{ for n258, n261, and n260} \quad (7)$$

else if Δmin > TxAGC uncertainty,

$$input.power.limit(i) = sim.power_{limit}(\mathrm{i}) + (\Delta_{min} - \text{TxAGC uncertainty}),$$
$$i \in all\ beams, \text{ for n258, n261, and n260} \quad (8)$$

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)	
n258	K	1.90	0.63	*input.power.limit(i) = sim.power_limit + 1.27*	Using Eq.8
n261	K	2.18	0.63	*input.power.limit(i) = sim.power_limit + 1.55*	Using Eq.8
n260	K	1.28	0.63	*input.power.limit(i) = sim.power_limit + 0.65*	Using Eq.8

Table 15
Permanent backoff applied to calculated input.power.limit

Band	Antenna	backoff (dB)
n258	K	1.0
n261	K	0.7
n260	K	1.0

Table 16
Additional per beam backoff applied to calculated input.power.limit

Band	Antenna	Beam ID	backoff (dB)
n260	K	128	1.5
n260	K	129	1.0
n260	K	134	0.5
n260	K	136	1.5
n260	K	142	1.0
n260	K	143	0.5
n260	K	144	0.5
n260	K	146	0.5
n260	K	148	0.5
n260	K	20/148	0.5

Note: The above backoff values have been permanently applied to the input.power.limits calculated from the equations above. The final input.power.limits implemented in the EFS are in the tables below.

Table 17

5G mmWave NR n258 K Patch *input.power.limit*

Band	Beam ID 1	Beam ID 2	input.power.limit
n258	0	-	10.0
n258	1	-	10.9
n258	2	-	10.7
n258	3	-	10.8
n258	4	-	10.3
n258	5	-	8.8
n258	6	-	7.0
n258	7	-	7.1
n258	8	-	7.8
n258	9	-	7.4
n258	10	-	6.6
n258	11	-	8.5
n258	12	-	4.3
n258	13	-	2.6
n258	14	-	3.1
n258	15	-	2.5
n258	16	-	5.4
n258	17	-	3.4
n258	18	-	2.8
n258	19	-	3.1
n258	20	-	3.5
n258	-	128	12.7
n258	-	129	13.9
n258	-	130	14.7
n258	-	131	14.2
n258	-	132	15.2
n258	-	133	11.9
n258	-	134	11.0
n258	-	135	10.2
n258	-	136	10.9
n258	-	137	12.3
n258	-	138	11.7
n258	-	139	10.5
n258	-	140	7.5
n258	-	141	7.2
n258	-	142	7.8
n258	-	143	6.1
n258	-	144	6.6
n258	-	145	7.4
n258	-	146	8.0
n258	-	147	7.1
n258	-	148	6.2
n258	0	128	7.4
n258	1	129	8.4
n258	2	130	8.5
n258	3	131	8.6
n258	4	132	8.8
n258	5	133	7.2
n258	6	134	5.3
n258	7	135	5.9
n258	8	136	5.4
n258	9	137	6.6
n258	10	138	5.9
n258	11	139	6.0
n258	12	140	1.9
n258	13	141	0.6
n258	14	142	1.4
n258	15	143	0.1
n258	16	144	1.6
n258	17	145	1.5
n258	18	146	1.0
n258	19	147	0.9
n258	20	148	0.4

Table 18

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

Band	Beam ID 1	Beam ID 2	input.power.limit
n261	0	-	10.9
n261	1	-	10.8
n261	2	-	11.4
n261	3	-	11.6
n261	4	-	12.7
n261	5	-	8.7
n261	6	-	8.8
n261	7	-	8.7
n261	8	-	9.0
n261	9	-	9.4
n261	10	-	8.6
n261	11	-	7.7
n261	12	-	5.3
n261	13	-	4.9
n261	14	-	5.0
n261	15	-	4.6
n261	16	-	4.7
n261	17	-	5.2
n261	18	-	4.7
n261	19	-	4.7
n261	20	-	4.5
n261	-	128	13.4
n261	-	129	13.6
n261	-	130	13.1
n261	-	131	13.6
n261	-	132	14.3
n261	-	133	10.8
n261	-	134	10.5
n261	-	135	10.0
n261	-	136	10.7
n261	-	137	10.9
n261	-	138	10.4
n261	-	139	10.6
n261	-	140	8.0
n261	-	141	7.2
n261	-	142	6.7
n261	-	143	6.6
n261	-	144	5.5
n261	-	145	7.9
n261	-	146	6.7
n261	-	147	6.8
n261	-	148	6.3
n261	0	128	8.3
n261	1	129	8.6
n261	2	130	8.9
n261	3	131	9.3
n261	4	132	10.0
n261	5	133	5.9
n261	6	134	5.9
n261	7	135	6.1
n261	8	136	6.3
n261	9	137	6.3
n261	10	138	6.7
n261	11	139	5.9
n261	12	140	2.4
n261	13	141	2.4
n261	14	142	2.1
n261	15	143	2.2
n261	16	144	1.8
n261	17	145	2.3
n261	18	146	1.9
n261	19	147	2.2
n261	20	148	1.8

Table 19

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

Band	Beam ID 1	Beam ID 2	input.power.limit
n260	0	-	8.4
n260	1	-	9.2
n260	2	-	9.1
n260	3	-	8.5
n260	4	-	8.6
n260	5	-	5.3
n260	6	-	5.9
n260	7	-	5.9
n260	8	-	5.8
n260	9	-	5.9
n260	10	-	5.9
n260	11	-	5.8
n260	12	-	2.8
n260	13	-	2.0
n260	14	-	2.1
n260	15	-	3.5
n260	16	-	2.9
n260	17	-	2.4
n260	18	-	2.0
n260	19	-	2.9
n260	20	-	3.1
n260	-	128	8.0
n260	-	129	9.4
n260	-	130	9.9
n260	-	131	9.2
n260	-	132	10.2
n260	-	133	7.2
n260	-	134	7.1
n260	-	135	6.2
n260	-	136	5.7
n260	-	137	7.2
n260	-	138	6.4
n260	-	139	6.6
n260	-	140	4.8
n260	-	141	4.0
n260	-	142	1.7
n260	-	143	3.1
n260	-	144	3.2
n260	-	145	4.8
n260	-	146	2.9
n260	-	147	3.0
n260	-	148	3.3
n260	0	128	5.0
n260	1	129	5.4
n260	2	130	5.2
n260	3	131	4.7
n260	4	132	5.1
n260	5	133	2.8
n260	6	134	3.5
n260	7	135	4.1
n260	8	136	2.2
n260	9	137	3.4
n260	10	138	2.1
n260	11	139	2.4
n260	12	140	-0.6
n260	13	141	-0.6
n260	14	142	-1.7
n260	15	143	-0.8
n260	16	144	-1.3
n260	17	145	0.3
n260	18	146	-1.0
n260	19	147	-1.6
n260	20	148	-1.5