FCC ID: A3LSMG991U

Part 0 Power Density Report
Power Density Characterization

Revision A

November 12, 2020

SAMSUNG ELECTRONICS

1. DEVICE UNDER TEST

1.1 Device Overview

This device uses the Qualcomm® Smart Transmit feature to control and manage transmitting power in real time and to ensure the time-averaged RF exposure is in compliance with the FCC requirement at all times for 2G/3G/4G/5G WWAN operations. Additionally, this device supports WLAN/BT/NFC technologies, but the output power of these modems is not controlled by the Smart Transmit algorithm.

1.2 Time-Averaging for SAR and Power Density

This equipment contains the Qualcomm SM8350 modem supporting ≤ 4G WWAN technologies and Sub6/ mmW 5G NR bands. This modems are enabled with Qualcomm Smart Transmit feature to control and manage transmitting power in real time and to ensure at all times the time-averaged RF exposure is in compliance with the FCC requirement. Qualcomm chipset of this device supports GEN2 Smart transmit. Please refer to the Simulation report for detailed Smart transmit GEN2 details.

This Part 0 report shows SAR and Power Density characterization of WWAN radios for2G/3G/4G/5G Sub-6 NR and 5G mmW NR respectively.

Characterization is achieved by determining PLimit for2G/3G/4G/5G Sub-6 NR and input.power.limit for 5G mmW NR that correspond to the exposure design targets after accounting for all device design related uncertainties, i.e., SAR_design_target (< FCC SAR limit) for sub-6 radio and PD_design_target (< FCC PD limit) for mmW radio.

The SAR characterization and PD characterizationare denoted as SAR Char and PD Char in this report. Section 1.3 includes a nomenclature of the specific terms used in this report.

The compliance test under the static transmission scenario and simultaneous transmission analysis are reported in Part 1 report. The validation of the time-averaging algorithm and compliance under the dynamic (time- varying) transmission scenario for WWAN technologies are reported in Part 2 report.

1.3 Nomenclature for Part 0 Report

Technology	Term	Description
5G mmW NR	*input.power.limit*	Power level at antenna element for each beam corresponding to the exposure design target (*PD_design_target)*
	PD_design_target	Target PD level < FCC PD limit after accounting for all device design related uncertainties
	Δmin	Housing material influence
	PD Char	Table containing *input.power.limit* for all beams and bands

2. Exposure Scenarios

2.1 Exposure Scenarios in Power Density Evaluation

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) antenna array.

As showed in Figure 2-1, the surfaces near-by each mmW antenna module for PD characterization are identified and listed in Table 2-1.

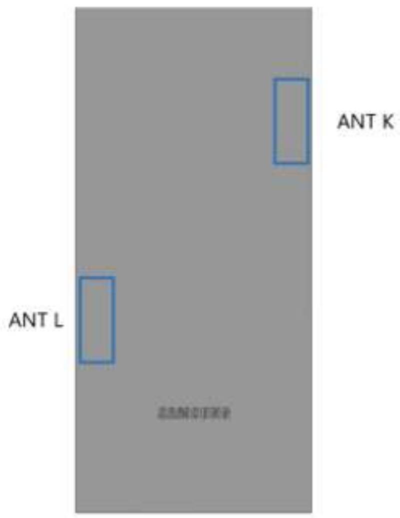
Table 2-1 Evaluation Surfaces for PD Characterization

Module	Front	Back	Left From Front View	Right From Front View	Top	Bottom
	S1	S2	S3	S4	S5	S6
Ant K	O	O	O	O	O	X
Ant L	O	O	O	O	X	O

Evaluation surfaces of mmW antenna modules looking from front of the DUT

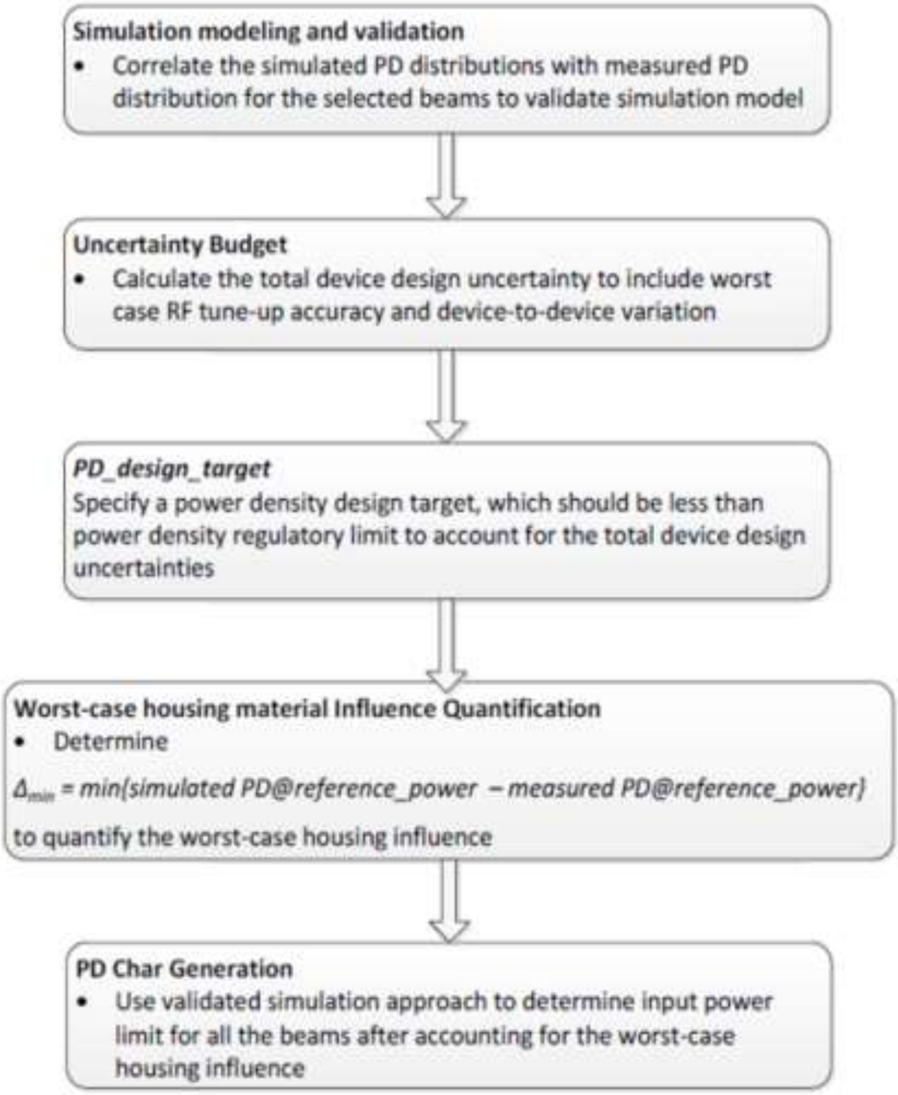
Figure 2-1: Location of mmW antenna modules of the DUT

Particular DUT edges were not required to be evaluated for power density if the edges were greater than 2.5 cm from the transmitting antenna according to FCC KDB Publication 941225 D06v02r01 Section III and FCC KDB Publication 648474 D04v01r03. The distances between the transmit antennas and the edges of the device are included in the filing. Per FCC guidance, additional edges with negligible psPD results could be excluded from testing towards Δmin calculations.



2.2 Power Density Characterization Method

An overview of power density characterization method could be found in Figure 2-2 below.



Note :* For 1st generation of Smart Transmit (GEN1) follow QUALCOMM Document 80-W2112-2Rev.J Section 4.4.4 and for 2nd generation of Smart Transmit (GEN2) follow Appendix D in addition to Section 4.4.4

For detailed GEN2 verification details, please refer to the simulation report of A3LSMG991U

Figure 2-2: Flow chart for Power density characterization

2.3 Codebook for all supported beams

All the beams that the DUT supports are specified in the pre-defined codebook. The codebook for this device is specified as below.

Table 2-2 5G mmW NR Band n261 Ant K Codebook

Band	Beam ID	Antenna	Ant_Type	Paired_With	# of Antenna Feed
n261	3	K	PATCH	131	1
n261	4	K	PATCH	132	1
n261	8	K	PATCH	136	2
n261	9	K	PATCH	137	2
n261	10	K	PATCH	138	2
n261	13	K	PATCH	141	2
n261	14	K	PATCH	142	2
n261	19	K	PATCH	147	5
n261	20	K	PATCH	148	5
n261	21	K	PATCH	149	5
n261	22	K	PATCH	150	5
n261	23	K	PATCH	151	5
n261	27	K	PATCH	155	5
n261	28	K	PATCH	156	5
n261	29	K	PATCH	157	5
n261	30	K	PATCH	158	5
n261	131	K	PATCH	3	1
n261	132	K	PATCH	4	1
n261	136	K	PATCH	8	2
n261	137	K	PATCH	9	2
n261	138	K	PATCH	10	2
n261	141	K	PATCH	13	2
n261	142	K	PATCH	14	2
n261	147	K	PATCH	19	5
n261	148	K	PATCH	20	5
n261	149	K	PATCH	21	5
n261	150	K	PATCH	22	5
n261	151	K	PATCH	23	5
n261	155	K	PATCH	27	5
n261	156	K	PATCH	28	5
n261	157	K	PATCH	29	5
n261	158	K	PATCH	30	5

Table 2-3 5G mmW NR Band n260 Ant K Codebook

Band	Beam ID	Antenna	Ant_Type	Paired_With	# of Antenna Feed
n260	3	K	PATCH	131	1
n260	4	K	PATCH	132	1
n260	5	K	PATCH	133	1
n260	9	K	PATCH	137	2
n260	10	K	PATCH	138	2
n260	11	K	PATCH	139	2
n260	14	K	PATCH	142	2
n260	15	K	PATCH	143	2
n260	21	K	PATCH	149	5
n260	22	K	PATCH	150	5
n260	23	K	PATCH	151	5
n260	24	K	PATCH	152	5
n260	25	K	PATCH	153	5
n260	30	K	PATCH	158	5
n260	31	K	PATCH	159	5
n260	32	K	PATCH	160	5
n260	33	K	PATCH	161	5
n260	131	K	PATCH	3	1
n260	132	K	PATCH	4	1
n260	133	K	PATCH	5	1
n260	137	K	PATCH	9	2
n260	138	K	PATCH	10	2
n260	139	K	PATCH	11	2
n260	142	K	PATCH	14	2
n260	143	K	PATCH	15	2
n260	149	K	PATCH	21	5
n260	150	K	PATCH	22	5
n260	151	K	PATCH	23	5
n260	152	K	PATCH	24	5
n260	153	K	PATCH	25	5
n260	158	K	PATCH	30	5
n260	159	K	PATCH	31	5
n260	160	K	PATCH	32	5
n260	161	K	PATCH	33	5

Table 2-4 5G mmW NR Band n261 Ant L Codebook

Band	Beam ID	Antenna	Ant_Type	Paired_With	# of Antenna Feed
n261	0	L	PATCH	128	1
n261	1	L	PATCH	129	1
n261	2	L	PATCH	130	1
n261	5	L	PATCH	133	2
n261	6	L	PATCH	134	2
n261	7	L	PATCH	135	2
n261	11	L	PATCH	139	2
n261	12	L	PATCH	140	2
n261	15	L	PATCH	143	5
n261	16	L	PATCH	144	5
n261	17	L	PATCH	145	5
n261	18	L	PATCH	146	5
n261	24	L	PATCH	152	5
n261	25	L	PATCH	153	5
n261	26	L	PATCH	154	5
n261	128	L	PATCH	0	1
n261	129	L	PATCH	1	1
n261	130	L	PATCH	2	1
n261	133	L	PATCH	5	2
n261	134	L	PATCH	6	2
n261	135	L	PATCH	7	2
n261	139	L	PATCH	11	2
n261	140	L	PATCH	12	2
n261	143	L	PATCH	15	5
n261	144	L	PATCH	16	5
n261	145	L	PATCH	17	5
n261	146	L	PATCH	18	5
n261	152	L	PATCH	24	5
n261	153	L	PATCH	25	5
n261	154	L	PATCH	26	5

Table 2-5 5G mmW NR Band n260 Ant L Codebook

Band	Beam ID	Antenna	Ant_Type	Paired_With	# of Antenna Feed
n260	0	L	PATCH	128	1
n260	1	L	PATCH	129	1
n260	2	L	PATCH	130	1
n260	6	L	PATCH	134	2
n260	7	L	PATCH	135	2
n260	8	L	PATCH	136	2
n260	12	L	PATCH	140	2
n260	13	L	PATCH	141	2
n260	16	L	PATCH	144	5
n260	17	L	PATCH	145	5
n260	18	L	PATCH	146	5
n260	19	L	PATCH	147	5
n260	20	L	PATCH	148	5
n260	26	L	PATCH	154	5
n260	27	L	PATCH	155	5
n260	28	L	PATCH	156	5
n260	29	L	PATCH	157	5
n260	128	L	PATCH	0	1
n260	129	L	PATCH	1	1
n260	130	L	PATCH	2	1
n260	134	L	PATCH	6	2
n260	135	L	PATCH	7	2
n260	136	L	PATCH	8	2
n260	140	L	PATCH	12	2
n260	141	L	PATCH	13	2
n260	144	L	PATCH	16	5
n260	145	L	PATCH	17	5
n260	146	L	PATCH	18	5
n260	147	L	PATCH	19	5
n260	148	L	PATCH	20	5
n260	154	L	PATCH	26	5
n260	155	L	PATCH	27	5
n260	156	L	PATCH	28	5
n260	157	L	PATCH	29	5

2.4 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 2-6

					4cm^2 avg. PD (mW/cm^2)		Delta = Simulated - Measured
Band	Beam ID	Antenna	Surface	Channel	Meas.	Sim	[dB]
n261	28	K (patch)	Back (S2)	Mid	1.180	1.764	**1.75**
			Left (S3)	Mid	1.060	1.720	2.10
	157		Back (S2)	Mid	0.542	1.106	3.10
	148		Left (S3)	Mid	0.610	1.383	3.55
	16	L (patch)	Back (S2)	Mid	1.370	1.822	1.24
			Right (S4)	Mid	1.300	1.674	**1.10**
	145		Back (S2)	Mid	0.654	1.479	3.54
			Right (S4)	Mid	0.906	1.691	2.71
n260	33	K (patch)	Back (S2)	Mid	0.510	0.712	1.45
			Left (S3)	Mid	0.680	0.960	1.50
	151		Back (S2)	Mid	1.020	1.356	**1.24**
			Left (S3)	Mid	1.030	1.398	1.33
	29	L (patch)	Back (S2)	Mid	0.552	1.016	2.65
			Right (S4)	Mid	0.810	1.190	1.67
	145		Back (S2)	Mid	1.150	1.674	**1.63**
			Right (S4)	Mid	1.090	1.658	1.82

2.5 *PD_design_target*

PD_design_target is determined by ensuring that it is less than FCC PD limit after accounting for total device design uncertainties including TxAGC and device-to-device variation, specified by the manufacturer

PD_design_target Calculations

PD_design_target	
PD_design_target <PD_regulatory_limit x 10-Total Uncertainty/10	
psPD over 4cm² Averaging Area (mW/cm²)	
Total Uncertainty	2.1 dB
PD_regulatory)limit	1.0 mW/cm²
PD_design_target	0.6166 mW/cm²

2.6 Worst-case Housing Influence Determination: *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 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 Δmin = Sim. PD − Meas. PD , is determined as

Table 2-7.

Table Δmin for Ant K, Ant L

Band	Ant	*Δmin* **(dB)**
n261	K(Patch Beam)	1.75
	L(Patch Beam)	1.10
n260	K(Patch Beam)	1.24
	L(Patch Beam)	1.63

Δmin 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*Δmin* 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 3 Simulated 4cm2 PD values in Table 2-2 ~ Table 2-5 in Power Density Simulation Report are scaled to input.power.limit and are listed in Tables 2-8 ~ 2-11 for all single beams for all identified surfaces (shown inTable 2-1), 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 (S1)
b. for K patch: Front (S1)

Then perform PD measurement for all determined worst-case beams, in Tables 2-8 ~2- 11on 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 2-12 shows that the all measured $4cm^2$ PD values are less than *PD_design_target* of 0.6166 mW/cm2, thus, the non-selected surfaces have no influence on the determined Δmin and input.power.limit in Section 3

Table 2-8

N261/mid channel, L patch simulates 4cm² PD at PD_Design_Target

(If simulation performed with correct housing material properties)Δmin

n261, Ant L,						
Beam ID	4cm2 PD(mW/cm2)					
	S4(Right)	S3(Left)	S5(Top)	S6(Bottom)	S1(Front)	S2(Rear)
0	0.451	0.004	0.004	0.006	0.021	0.557
1	0.472	0.002	0.003	0.009	0.028	0.574
2	0.465	0.002	0.002	0.016	0.023	0.573
5	0.506	0.001	0.001	0.012	0.036	0.560
6	0.442	0.002	0.001	0.001	0.021	0.530
7	0.436	0.005	0.006	0.018	0.031	0.589
11	0.447	0.003	0.001	0.003	0.024	0.514
12	0.426	0.004	0.006	0.001	0.027	0.556
15	0.484	0.005	0.001	0.022	0.052	0.547
16	0.483	0.003	0.000	0.002	0.036	0.525
17	0.487	0.003	0.001	0.001	0.035	0.543
18	0.416	0.007	0.007	0.010	0.036	0.576
24	0.487	0.003	0.001	0.006	0.043	0.539
25	0.485	0.003	0.001	0.003	0.034	0.528
26	0.475	0.003	0.001	0.005	0.036	0.564
128	0.539	0.009	0.007	0.007	0.256	0.422
129	0.549	0.005	0.002	0.007	0.216	0.472
130	0.588	0.007	0.002	0.009	0.215	0.512
133	0.563	0.005	0.004	0.012	0.293	0.485
134	0.521	0.008	0.002	0.003	0.228	0.441
135	0.554	0.008	0.005	0.011	0.239	0.466
139	0.520	0.008	0.002	0.007	0.288	0.409
140	0.543	0.012	0.002	0.002	0.188	0.464
143	0.575	0.005	0.003	0.026	0.268	0.539
144	0.546	0.007	0.001	0.002	0.228	0.453
145	0.561	0.006	0.001	0.002	0.191	0.491
146	0.590	0.015	0.008	0.004	0.257	0.546
152	0.567	0.010	0.001	0.004	0.253	0.488
153	0.568	0.005	0.001	0.002	0.213	0.493
154	0.582	0.011	0.003	0.003	0.222	0.510

Table 2-9

N261/mid channel, K patch simulates 4cm² PD at PD_Design_Target

(If simulation performed with correct housing material properties)Δmin

n261, Ant K						
Beam ID	4cm2 PD(mW/cm2)					
	S4(Right)	S3(Left)	S5(Top)	S6(Bottom)	S1(Front)	S2(Rear)
3	0.003	0.512	0.022	0.002	0.025	0.563
4	0.001	0.497	0.030	0.001	0.027	0.538
8	0.002	0.569	0.040	0.002	0.043	0.576
9	0.003	0.496	0.008	0.001	0.080	0.564
10	0.006	0.470	0.029	0.005	0.035	0.575
13	0.003	0.528	0.017	0.001	0.090	0.563
14	0.006	0.409	0.015	0.004	0.038	0.575
19	0.002	0.562	0.094	0.001	0.059	0.563
20	0.003	0.506	0.009	0.001	0.039	0.521
21	0.004	0.507	0.008	0.001	0.035	0.522
22	0.004	0.491	0.006	0.001	0.042	0.561
23	0.009	0.428	0.012	0.005	0.044	0.576
27	0.002	0.550	0.087	0.001	0.053	0.561
28	0.003	0.511	0.007	0.001	0.037	0.524
29	0.003	0.511	0.010	0.001	0.037	0.543
30	0.008	0.450	0.007	0.003	0.041	0.568
131	0.007	0.531	0.020	0.005	0.146	0.422
132	0.005	0.538	0.049	0.003	0.192	0.403
136	0.004	0.576	0.014	0.001	0.202	0.451
137	0.006	0.531	0.022	0.003	0.176	0.359
138	0.007	0.561	0.015	0.004	0.198	0.327
141	0.004	0.538	0.022	0.003	0.177	0.357
142	0.011	0.562	0.030	0.005	0.134	0.444
147	0.006	0.543	0.068	0.002	0.212	0.425
148	0.004	0.573	0.025	0.002	0.191	0.457
149	0.004	0.539	0.034	0.003	0.170	0.414
150	0.008	0.568	0.027	0.002	0.194	0.436
151	0.014	0.575	0.020	0.012	0.205	0.481
155	0.004	0.561	0.054	0.001	0.199	0.448
156	0.004	0.549	0.016	0.002	0.184	0.433
157	0.005	0.575	0.023	0.001	0.183	0.462
158	0.012	0.548	0.014	0.005	0.184	0.408

Table 2-10

N260/mid channel, L patch simulates 4cm² PD at PD_Design_Target

(If simulation performed with correct housing material properties)Δmin

n260, Ant L						
Beam ID	4cm2 PD(mW/cm2)					
	S4(Right)	S3(Left)	S5(Top)	S6(Bottom)	S1(Front)	S2(Rear)
0	0.490	0.006	0.009	0.003	0.158	0.388
1	0.589	0.006	0.006	0.015	0.154	0.485
2	0.585	0.012	0.005	0.030	0.193	0.565
6	0.589	0.009	0.007	0.010	0.143	0.502
7	0.589	0.011	0.002	0.005	0.179	0.484
8	0.589	0.005	0.011	0.011	0.167	0.453
12	0.589	0.011	0.006	0.011	0.212	0.523
13	0.589	0.006	0.006	0.005	0.145	0.463
16	0.535	0.007	0.019	0.025	0.229	0.456
17	0.525	0.013	0.010	0.012	0.218	0.528
18	0.530	0.012	0.003	0.012	0.204	0.460
19	0.590	0.012	0.003	0.022	0.225	0.481
20	0.589	0.012	0.012	0.021	0.158	0.500
26	0.589	0.010	0.011	0.015	0.246	0.498
27	0.496	0.015	0.004	0.017	0.191	0.458
28	0.579	0.011	0.003	0.019	0.218	0.483
29	0.590	0.013	0.005	0.020	0.180	0.503
128	0.452	0.004	0.006	0.004	0.034	0.532
129	0.538	0.003	0.003	0.011	0.031	0.588
130	0.485	0.003	0.002	0.011	0.050	0.589
134	0.478	0.003	0.002	0.011	0.043	0.588
135	0.547	0.003	0.001	0.005	0.035	0.589
136	0.428	0.005	0.009	0.012	0.041	0.516
140	0.519	0.002	0.003	0.005	0.034	0.589
141	0.488	0.006	0.005	0.010	0.040	0.536
144	0.385	0.004	0.007	0.019	0.052	0.500
145	0.583	0.003	0.001	0.003	0.053	0.589
146	0.503	0.006	0.002	0.004	0.040	0.544
147	0.466	0.007	0.002	0.014	0.063	0.505
148	0.511	0.008	0.014	0.031	0.081	0.530
154	0.533	0.004	0.002	0.005	0.053	0.566
155	0.573	0.003	0.002	0.004	0.049	0.588
156	0.474	0.008	0.003	0.010	0.057	0.514
157	0.491	0.009	0.004	0.023	0.070	0.548

Table 2-11

N260/mid channel, K patch simulates 4cm² PD at PD_Design_Target

(If simulation performed with correct housing material properties)Δmin

n260, Ant K						
Beam ID	4cm2 PD(mW/cm2)					
	S4(Right)	S3(Left)	S5(Top)	S6(Bottom)	S1(Front)	S2(Rear)
3	0.007	0.575	0.011	0.007	0.138	0.393
4	0.006	0.512	0.035	0.003	0.167	0.364
5	0.006	0.538	0.068	0.003	0.143	0.482
9	0.004	0.576	0.021	0.003	0.213	0.414
10	0.007	0.575	0.033	0.005	0.198	0.466
11	0.008	0.556	0.023	0.006	0.144	0.347
14	0.008	0.464	0.036	0.003	0.118	0.480
15	0.006	0.576	0.022	0.004	0.184	0.446
21	0.008	0.575	0.042	0.003	0.181	0.422
22	0.008	0.421	0.060	0.005	0.127	0.433
23	0.012	0.495	0.033	0.002	0.170	0.409
24	0.005	0.529	0.030	0.003	0.150	0.389
25	0.007	0.575	0.038	0.005	0.152	0.444
30	0.009	0.575	0.045	0.005	0.176	0.476
31	0.008	0.467	0.038	0.002	0.143	0.427
32	0.012	0.576	0.037	0.003	0.183	0.450
33	0.005	0.576	0.028	0.002	0.162	0.427
131	0.003	0.576	0.013	0.008	0.058	0.495
132	0.002	0.510	0.031	0.002	0.049	0.510
133	0.004	0.506	0.033	0.002	0.036	0.575
137	0.004	0.479	0.059	0.003	0.059	0.483
138	0.003	0.537	0.021	0.001	0.054	0.553
139	0.004	0.517	0.055	0.004	0.046	0.562
142	0.003	0.576	0.035	0.007	0.042	0.549
143	0.005	0.457	0.053	0.003	0.054	0.520
149	0.008	0.499	0.089	0.007	0.078	0.485
150	0.003	0.552	0.075	0.005	0.039	0.553
151	0.004	0.576	0.014	0.004	0.049	0.559
152	0.009	0.527	0.033	0.002	0.080	0.514
153	0.005	0.383	0.098	0.012	0.066	0.452
158	0.004	0.459	0.105	0.012	0.057	0.505
159	0.003	0.575	0.036	0.003	0.052	0.566
160	0.004	0.560	0.018	0.003	0.060	0.544
161	0.008	0.532	0.083	0.007	0.083	0.502

Table 2-12

4cm² PD of the selected Beam ids measured on the corresponding surfaces that

are not selected for Δ_{min} determination

Band	Antenna	Beam ID	Surface	Input.power.limit (dBm)	Meas.4 c ㎠ cm PD(Mw/㎠)
n261	L (Patch)	133	Front	7.4	0.315
	K (Patch)	147	Front	3.8	0.273
n260	L (Patch)	26	Front	5.1	0.234
	K (Patch)	9	Front	7.2	0.261

3 Power Density Characterization

3.1 Scaling Factor for Single Beams

To determine the input power limit at each antenna port, simulation was performed at low, mid, and high chann el
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

$$s(i)_{low\_or\_mid\_or\_high} = PD\_design\_target/Sim.PD\ surface(i), \quad i = \text{single beams} \qquad (1)$$

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

$$S(i) = \min\{S_{low}(i), S_{mid}(i), S_{high}(i)\}, \quad i = \text{single beams} \qquad (2)$$

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

3.2 Scaling Factor for 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 wasdetermined mathematically to ensure the compliance. The worst-case PD for MIMO operations was found bysweeping the relative phase for all possible angles to ensure a conservative assessment. The power densitysimulation report contains the worst-case power density for each surface after sweeping through all relative
phases between beams.

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

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*:

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

3.3 ***Input.Power.Limit*** **Calculations**

The PD Char specifies the limit of input power at antenna port that corresponds to *PD_design_target* for all t he 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 (Δmin) determined in Table 2-7, given by:

For n260 and n261

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

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*; Δmin is the worst-case housing influence factor

If simulation overestimates the housing influence, thenΔmin (= simulated PD – measured PD) is negative, whi ch
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 Δmin is positive (measured PD would be lower than th e
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 [illegible] 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,

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

else if Δ_{min} < -TxAGC uncertainty,

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

else if Δ_{min} > TxAGC uncertainty,

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

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

Input.power.limit Calculation

Band	Antenna	Δmin (dB)	TxAGC Uncertainty (dB)	*input.power.limit* *(dBm)*	Notes
n261	K (patch beam)	1.75	0.5	input.power.limit (i)=6dB+10*log(s(i)+1.25	Using Eq. 8
	L (patch beam)	1.10	0.5	input.power.limit (i)=6dB+10*log(s(i)+0.60	Using Eq. 8
n261	K (patch beam)	1.24	0.5	input.power.limit (i)=6dB+10*log(s(i)+0.74	Using Eq. 8
	L (patch beam)	1.63	0.5	input.power.limit (i)=6dB+10*log(s(i)+1.13	Using Eq. 8

Table 5-1 5G NR n261 K Patch *input.power.limit*

Antenna	Beam ID_1	Beam ID_2	Input.power.limit (dBm)
K Patch	3		8.5
	4		8.0
	8		6.4
	9		7.7
	10		6.5
	13		7.7
	14		7.9
	19		2.1
	20		1.3
	21		1.3
	22		1.8
	23		2.6
	27		1.9
	28		1.2
	29		1.7
	30		2.1
	131		9.0
	132		10.6
	136		5.6
	137		7.9
	138		7.9
	141		7.9
	142		7.2
	147		4.0
	148		2.7
	149		3.1
	150		2.9
	151		5.0
	155		3.3
	156		2.5
	157		2.7
	158		3.9
	3	131	5.7
	4	132	6.2
	8	136	2.4
	9	137	4.7
	10	138	4.2
	13	141	4.7
	14	142	4.2
	19	147	-0.9
	20	148	-1.2
	21	149	-0.9
	22	150	-0.9
	23	151	-0.8
	27	155	-1.0
	28	156	-1.2
	29	157	-1.0
	30	158	-0.6

Table 5-2 5G NR n261 L Patch *input.power.limit*

Antenna	Beam ID_1	Beam ID_2	Input.power.limit (dBm)
L Patch	0		9.6
	1		8.2
	2		8.4
	5		4.5
	6		5.9
	7		6.2
	11		5.9
	12		6.6
	15		1.8
	16		0.9
	17		1.2
	18		2.2
	24		1.3
	25		1.1
	26		1.5
	128		9.8
	129		10.3
	130		9.8
	133		7.6
	134		5.7
	135		7.6
	139		6.8
	140		5.5
	143		3.4
	144		2.1
	145		1.6
	146		3.7
	152		2.6
	153		1.7
	154		2.4
	0	128	6.7
	1	129	6.1
	2	130	5.8
	5	133	2.6
	6	134	2.9
	7	135	2.9
	11	139	3.4
	12	140	2.8
	15	143	-1.1
	16	144	-1.5
	17	145	-1.9
	18	146	-1.4
	24	152	-1.2
	25	153	-1.7
	26	154	-1.5

Table 5-35G NR n260 K Patch *input.power.limit*

Antenna	Beam ID_1	Beam ID_2	Input.power.limit (dBm)
K Patch	3		11.6
	4		11.1
	5		10.9
	9		7.4
	10		9.8
	11		7.8
	14		7.4
	15		8.7
	21		4.6
	22		4.9
	23		4.7
	24		4.2
	25		4.3
	30		5.3
	31		4.3
	32		4.6
	33		3.8
	131		8.0
	132		8.6
	133		9.5
	137		5.9
	138		6.0
	139		6.2
	142		5.9
	143		6.1
	149		3.0
	150		2.8
	151		2.1
	152		3.0
	153		2.4
	158		2.6
	159		2.5
	160		2.5
	161		3.3
	3	131	5.1
	4	132	5.0
	5	133	6.6
	9	137	1.6
	10	138	4.6
	11	139	4.2
	14	142	3.5
	15	143	4.6
	21	149	-0.8
	22	150	0.6
	23	151	-1.0
	24	152	-0.9
	25	153	-1.2
	30	158	0.1
	31	159	0.1
	32	160	-1.1
	33	161	-1.0

Table 5-4 5G NR n260 L Patch *input.power.limit*

Antenna	Beam ID_1	Beam ID_2	Input.power.limit (dBm)
L Patch	0		11.6
	1		11.6
	2		10.8
	6		7.5
	7		8.7
	8		8.2
	12		9.5
	13		8.0
	16		5.1
	17		5.5
	18		4.7
	19		4.8
	20		4.0
	26		5.3
	27		4.6
	28		4.9
	29		3.8
	128		8.3
	129		9.0
	130		8.7
	134		5.9
	135		5.3
	136		6.7
	140		5.8
	141		5.9
	144		3.0
	145		2.3
	146		2.7
	147		2.6
	148		4.1
	154		2.9
	155		2.5
	156		2.6
	157		3.3
	0	128	6.3
	1	129	6.0
	2	130	6.1
	6	134	3.2
	7	135	3.0
	8	136	3.8
	12	140	4.1
	13	141	2.8
	16	144	-0.3
	17	145	0.4
	18	146	-0.1
	19	147	-0.5
	20	148	-0.8
	26	154	-0.3
	27	155	-0.1
	28	156	-0.4
	29	157	-0.9