HCT
Testing and Certification

TEST REPORT

Part 0 Power Density Test for Characterization

APPLICANT
Samsung Electronics. Co., Ltd.

REPORT NO.
HCT-SR-2404-FC007

DATE OF ISSUE
Apr. 26, 2024

Tested by Byeong Chul, Yoon	(signature)
Technical Manager Yun Jeang, Heo	(signature)

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TEST REPORT

FCC Part 0 PD Test for certification

REPORT NO.
HCT-SR-2404-FC007

DATE OF ISSUE
Apr. 26, 2024

FCC ID
A3LSMF741U

Applicant	SAMSUNG Electronics Co., Ltd 129, Samsung-ro, Yeongtong-gu, Suwon-Si, Gyeonggi-do, 16677, Korea
Product Name Model Name Additional Model Name	Mobile Phone SM-F741U SM-F741U1
Date of Test	Apr. 12, 2024 ~ Apr. 23, 2024
Location of Test	■ Permanent Testing Lab ☐ On Site Testing Lab (Address: 74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si,
FCC Rule Part(s)	CFR §2.1093
Test Results	PASS (Power Density Limit : 1.0 ㎽/㎠)

REVISION HISTORY

The revision history for this test report is shown in table.

Revision No.	Date of Issue	Description
0	Apr. 26, 2024	Initial Release

Notice

Content
The results shown in this test report only apply to the sample(s), as received, provided by the applicant, unless otherwise stated. The test results have only been applied with the test methods required by the standard(s). The laboratory is not accredited for the test results marked *. Information provided by the applicant is marked **. Test results provided by external providers are marked ***. When confirmation of authenticity of this test report is required, please contact www.hct.co.kr The test results in this test report are not associated with the ((KS Q) ISO/IEC 17025) accreditation by KOLAS (Korea Laboratory Accreditation Scheme) / A2LA (American Association for Laboratory Accreditation) that are under the ILAC (International Laboratory Accreditation Cooperation) Mutual Recognition Agreement (MRA).

CONTENTS

1. Test Location

Test Laboratory

Company Name	HCT Co., Ltd.
Address	74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si, Gyeonggi-do, 17383 KOREA
Telephone	031-645-6300
Fax.	031-645-6401

Test Facilities

Our laboratories are accredited and approved by the following approval agencies according to ISO/IEC 17025.

Korea	National Radio Research Agency (Designation No. KR0032)
	KOLAS (Testing No. KT197)

Information of the EUT

Model Name	SM-F741U
Additional Model Name	SM-F741U1
Equipment Type	Mobile Phone
FCC ID	A3LSMF741U
Application Type	Certification
Applicant	SAMSUNG Electronics Co., Ltd.

NR FR2 Device Description.

Item.			Description				
Frequency Range		NR Band n258	24 250 ㎒ ~ 24 450 ㎒; 24 750 ㎒ ~ 25 250 ㎒				
		NR Band n260	37 000 ㎒ – 40 000 ㎒				
		NR Band n261	27 000 ㎒ – 28 500 ㎒				
Channel Bandwidths		NR Band n258	50 ㎒, 100 ㎒				
		NR Band n260	50 ㎒, 100 ㎒				
		NR Band n261	50 ㎒, 100 ㎒				
Ch. No.& Freq		Low channel		Middle channel		High Channel	
		Channel	Frequency	Channel	Frequency	Channel	Frequency
NR Band n261	100 ㎒	2071667	27550.08	2077915	27924.96	2084165	28299.96
	50 ㎒	2071249	27525	2077915	27924.96	2084581	28324.92
NR Band n260	100 ㎒	2229999	37050	2254165	38499.96	2278331	39949.92
	50 ㎒	2229853	37025.04	2254165	38499.96	2278749	39975
NR Band n258	100 ㎒	2018333	24350.04	2025833	24800.04	2032499	25200
	50 ㎒	2018333	24350.04	2025417	24775.08	2032915	25224.96

Subcarrier Spacing (㎑)	120
Total Number of Supported Uplink CCs (SISO)	4 (DFT-s-OFDM, CP-OFDM)
Total Number of Supported Uplink CCs (MIMO)	4 (DFT-s-OFDM, CP-OFDM)
Total Number of Supported DL CCs	4 (CP-OFDM)
Modulations Supported in UL	DFT-S-OFDM: Pi/2 BPSK, QPSK,16QAM, 64QAM CP-OFDM: QPSK, 16QAM, 64QAM
LTE Anchor Bands (n260)	LTE Band 2/5/12/13/14/30/48/66
LTE Anchor Bands (n261)	LTE Band 2/4/5/12/13/48/66
LTE Anchor Bands (n258)	LTE Band 2/5/12/66/71
NR FR1 Anchor Bands (n258)	NR Band n2/12/25/41/66/77
NR FR1 Anchor Bands (n260)	NR Band n2/5/12/25/30/41/48/66/77
NR FR1 Anchor Bands (n261)	NR Band n2/5/25/41/48/66/77
Duplex Type (mmWave)	TDD
Device Serial Numbers	XCJ1368M
	The manufacturer has confirmed that the devices tested have the same physical, mechanical and thermal characteristics are within operational tolerances expected for production units.

Power Density Characterization

1 Exposure Scenarios

At frequencies>6GHz, 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: 5G mmWave NR Device Surfaces

Band	Antenna	Condition	Rear (S2)	Front (S1)	Left (S3)	Right (S4)	Bottom (S6)	Top (S5)
NR n261	Patch K	Open	No	Yes	Yes	No	No	No
NR n260	Patch K	Open	Yes	No	Yes	No	No	No
NR n258	Patch K	Open	Yes	Yes	Yes	No	No	No
NR n261	Patch K	Closed	No	No	Yes	No	No	No
NR n260	Patch K	Closed	No	No	Yes	No	No	No
NR n258	Patch K	Closed	No	Yes	Yes	No	No	No

Note: All test configurations are based on front position view.

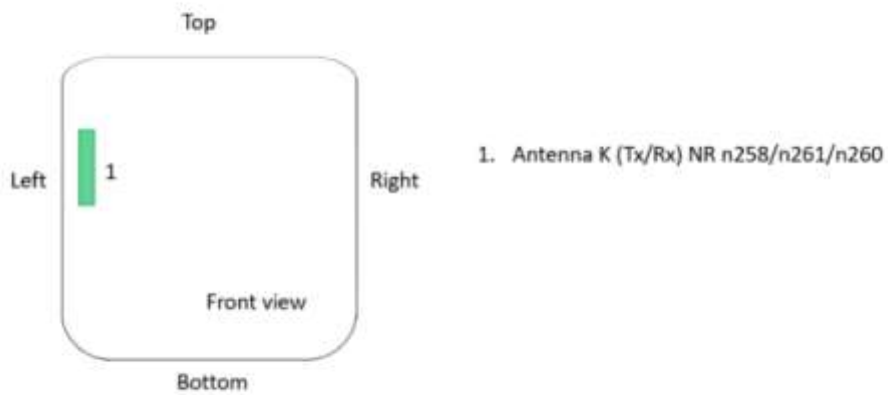
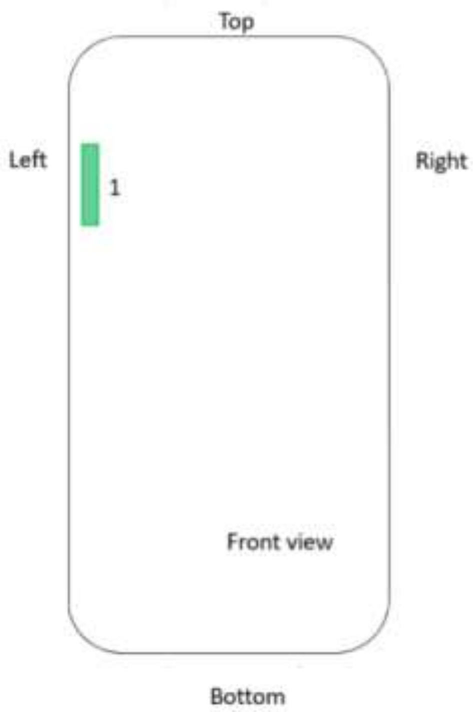


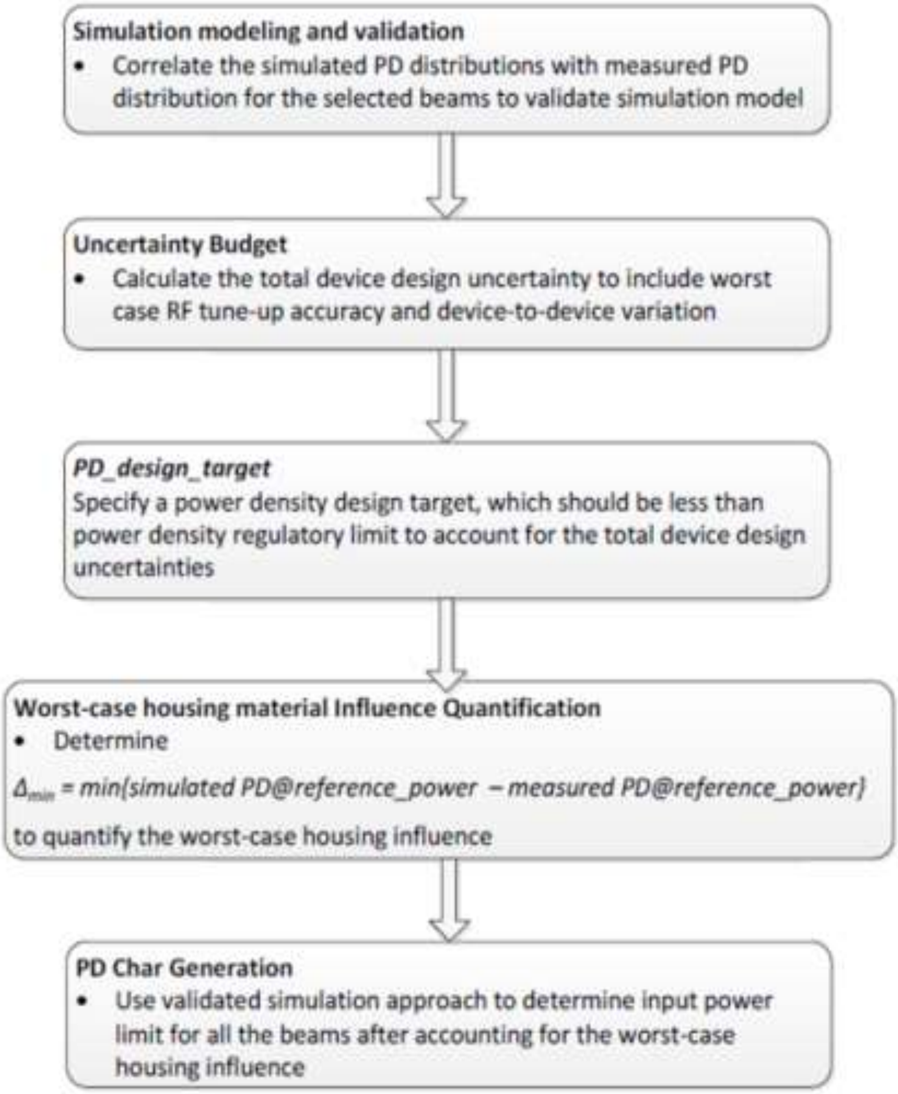
Figure 1: Location of mmW antenna modules looking from front of the DUT – Closed



1. Antenna K (Tx/Rx) NR n258/n261/n260

Figure 2: Location of mmW antenna modules looking from front of the DUT – Open

2. Power Density Characterization Method



3. Codebook for all supported beams

Band	Beam_ID	Module	Ant_Type	Paired_With
258	0	K	PATCH	256
258	1	K	PATCH	257
258	2	K	PATCH	258
258	3	K	PATCH	259
258	4	K	PATCH	260
258	5	K	PATCH	261
258	6	K	PATCH	262
258	7	K	PATCH	263
258	8	K	PATCH	264
258	9	K	PATCH	265
258	10	K	PATCH	266
258	11	K	PATCH	267
258	12	K	PATCH	268
258	13	K	PATCH	269
258	14	K	PATCH	270
258	15	K	PATCH	271
258	16	K	PATCH	272
258	17	K	PATCH	273
258	18	K	PATCH	274
258	19	K	PATCH	275
258	20	K	PATCH	276
258	256	K	PATCH	0
258	257	K	PATCH	1
258	258	K	PATCH	2
258	259	K	PATCH	3
258	260	K	PATCH	4
258	261	K	PATCH	5
258	262	K	PATCH	6
258	263	K	PATCH	7
258	264	K	PATCH	8
258	265	K	PATCH	9
258	266	K	PATCH	10
258	267	K	PATCH	11
258	268	K	PATCH	12
258	269	K	PATCH	13
258	270	K	PATCH	14
258	271	K	PATCH	15
258	272	K	PATCH	16
258	273	K	PATCH	17
258	274	K	PATCH	18
258	275	K	PATCH	19
258	276	K	PATCH	20

Band	Beam_ID	Module	Ant_Type	Paired_With
260	0	K	PATCH	256
260	1	K	PATCH	257
260	2	K	PATCH	258
260	3	K	PATCH	259
260	4	K	PATCH	260
260	5	K	PATCH	261
260	6	K	PATCH	262
260	7	K	PATCH	263
260	8	K	PATCH	264
260	9	K	PATCH	265
260	10	K	PATCH	266
260	11	K	PATCH	267
260	12	K	PATCH	268
260	13	K	PATCH	269
260	14	K	PATCH	270
260	15	K	PATCH	271
260	16	K	PATCH	272
260	17	K	PATCH	273
260	18	K	PATCH	274
260	19	K	PATCH	275
260	20	K	PATCH	276
260	256	K	PATCH	0
260	257	K	PATCH	1
260	258	K	PATCH	2
260	259	K	PATCH	3
260	260	K	PATCH	4
260	261	K	PATCH	5
260	262	K	PATCH	6
260	263	K	PATCH	7
260	264	K	PATCH	8
260	265	K	PATCH	9
260	266	K	PATCH	10
260	267	K	PATCH	11
260	268	K	PATCH	12
260	269	K	PATCH	13
260	270	K	PATCH	14
260	271	K	PATCH	15
260	272	K	PATCH	16
260	273	K	PATCH	17
260	274	K	PATCH	18
260	275	K	PATCH	19
260	276	K	PATCH	20

Band	Beam_ID	Module	Ant_Type	Paired_With
261	0	K	PATCH	256
261	1	K	PATCH	257
261	2	K	PATCH	258

261	3	K	PATCH	259
261	4	K	PATCH	260
261	5	K	PATCH	261
261	6	K	PATCH	262
261	7	K	PATCH	263
261	8	K	PATCH	264
261	9	K	PATCH	265
261	10	K	PATCH	266
261	11	K	PATCH	267
261	12	K	PATCH	268
261	13	K	PATCH	269
261	14	K	PATCH	270
261	15	K	PATCH	271
261	16	K	PATCH	272
261	17	K	PATCH	273
261	18	K	PATCH	274
261	19	K	PATCH	275
261	20	K	PATCH	276
261	256	K	PATCH	0
261	257	K	PATCH	1
261	258	K	PATCH	2
261	259	K	PATCH	3
261	260	K	PATCH	4
261	261	K	PATCH	5
261	262	K	PATCH	6
261	263	K	PATCH	7
261	264	K	PATCH	8
261	265	K	PATCH	9
261	266	K	PATCH	10
261	267	K	PATCH	11
261	268	K	PATCH	12
261	269	K	PATCH	13
261	270	K	PATCH	14
261	271	K	PATCH	15
261	272	K	PATCH	16
261	273	K	PATCH	17
261	274	K	PATCH	18
261	275	K	PATCH	19
261	276	K	PATCH	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 Folder Open Position

Band	Channel	Module	Type(P or D)	Side	Beam ID	PLS (10 dBm)	Sim. PD (mW/cm2)	Meas. PD (mW/cm2)
n261	Mid Ch. 2077915 (27924.96MHz)	K	Patch	Left	15	60	2.395	1.340
				Front	15		1.359	0.805
				Left	269		1.562	1.010
n260	Mid Ch. 2254165 (38499.96 MHz)	K	Patch	Left	15	60	2.164	1.280
				Left	271		1.973	1.230
				Rear	270		1.126	0.808
n258	Mid Ch. 2025833 (24800.04 MHz)	K	Patch	Left	19	60	2.231	1.110
				Front	19		1.278	0.548
				Left	276		1.307	1.010
				Rear	272		0.752	0.708

Table 6 Folder Closed Position

Band	Channel	Module	Type(P or D)	Side	Beam ID	PLS (10 dBm)	Sim. PD (mW/cm2)	Meas. PD (mW/cm2)
n261	Mid Ch. 2077915 (27924.96MHz)	K	Patch	Left	15	60	2.449	1.440
				Left	274		1.491	1.070
n260	Mid Ch. 2254165 (38499.96 MHz)	K	Patch	Left	15	60	2.234	1.450
				Left	272		1.879	1.450
n258	Mid Ch. 2025833 (24800.04 MHz)	K	Patch	Left	20	60	2.007	1.060
				Left	276		1.503	0.946
				Front	276		0.843	0.639

5. PD_design_target

PD_design_target	
PD_design_target <PD_regulatory_limit x 10-Total Uncertainty/10	
psPD over 4cm^2 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 $4cm^2$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 8: Worst-surface(s) for Ant K

Band	Antenna	Condition	Rear (S2)	Front (S1)	Left (S3)	Right (S4)	Bottom (S6)	Top (S5)
NR n261	Patch K	Open	No	Yes	Yes	No	No	No
NR n260	Patch K	Open	Yes	No	Yes	No	No	No
NR n258	Patch K	Open	Yes	Yes	Yes	No	No	No
NR n261	Patch K	Closed	No	No	Yes	No	No	No
NR n260	Patch K	Closed	No	No	Yes	No	No	No
NR n258	Patch K	Closed	No	Yes	Yes	No	No	No

Note: All test configurations are based on front position view.

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 Δmin =Sim. PD− Meas. PD, is determined as

Table 9: Δmin for Ant K (Considered both folder open and close conditions)

Band	Antenna	Δmin[dB]
NR n261	Patch K	1.89
NR n260	Patch K	1.44
NR n258	Patch K	0.26

Table 9 Δmin for Ant K 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 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:

[B6] Non-Selected Surface Validation for folder close

Band	Channel	Module	Type	Side	Beam ID	PLS (10 dBm)	Meas. PD (mW/cm2)
n261	mid	K	Patch	Rear	17	1.4	0.149
				Front	274	3.1	0.272
				Top	12	1.8	0.0691
n260	mid	K	Patch	Rear	14	1.5	0.113
				Front	263	5.2	0.291
				Top	12	2.3	0.0510
n258	mid	K	Patch	Rear	15	1.2	0.0939
				Top	273	6.5	0.120

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.

Folder Close

n261, Ant K, Scaled-up Power Density with Sim.power.limit							
Beam ID	S4(Right)	S3(Left)	S5(Top)	S6(Bottom)	S1(Front)	S2(Rear)	Sim.power.limit (dBm)
0	0.005	0.611	0.021	0.005	0.157	0.112	6.87
1	0.009	0.625	0.019	0.016	0.119	0.109	8.04
2	0.006	0.631	0.028	0.009	0.114	0.089	7.64
3	0.005	0.631	0.020	0.010	0.154	0.084	7.12
4	0.005	0.631	0.012	0.016	0.130	0.124	7.81
5	0.007	0.613	0.037	0.005	0.155	0.120	5.16
6	0.006	0.631	0.022	0.003	0.180	0.132	3.94
7	0.006	0.618	0.005	0.011	0.165	0.136	4.08
8	0.006	0.607	0.028	0.017	0.119	0.100	5.08
9	0.010	0.599	0.035	0.005	0.149	0.127	4.29
10	0.004	0.587	0.014	0.003	0.175	0.141	4.10
11	0.004	0.610	0.003	0.012	0.199	0.160	4.46
12	0.007	0.597	0.076	0.009	0.181	0.182	0.89
13	0.012	0.597	0.022	0.003	0.189	0.193	0.50
14	0.008	0.603	0.009	0.002	0.187	0.180	0.41
15	0.007	0.592	0.006	0.011	0.176	0.180	-0.16
16	0.005	0.631	0.008	0.045	0.137	0.157	0.76
17	0.010	0.593	0.041	0.004	0.171	0.199	0.50
18	0.007	0.631	0.010	0.002	0.207	0.178	0.64
19	0.007	0.627	0.008	0.002	0.196	0.192	0.18
20	0.003	0.631	0.007	0.033	0.165	0.174	0.27
256	0.008	0.631	0.024	0.027	0.215	0.075	10.49
257	0.009	0.525	0.013	0.017	0.158	0.058	8.97
258	0.007	0.590	0.021	0.011	0.173	0.062	8.94
259	0.010	0.573	0.029	0.007	0.177	0.071	8.90
260	0.009	0.575	0.041	0.009	0.183	0.080	9.09
261	0.013	0.525	0.021	0.029	0.172	0.104	6.82
262	0.008	0.591	0.012	0.005	0.220	0.096	5.79
263	0.010	0.548	0.012	0.006	0.229	0.102	5.56
264	0.010	0.559	0.049	0.013	0.233	0.059	6.40
265	0.009	0.573	0.012	0.009	0.184	0.095	5.68
266	0.006	0.580	0.012	0.005	0.246	0.090	5.33
267	0.009	0.552	0.030	0.010	0.241	0.080	5.98
268	0.012	0.510	0.035	0.020	0.127	0.118	2.68
269	0.016	0.573	0.011	0.007	0.214	0.151	2.03
270	0.006	0.562	0.012	0.007	0.249	0.134	2.16
271	0.008	0.517	0.017	0.009	0.215	0.095	2.39
272	0.007	0.526	0.016	0.028	0.227	0.094	1.61
273	0.016	0.540	0.018	0.012	0.174	0.139	2.22
274	0.010	0.620	0.007	0.004	0.266	0.159	2.19
275	0.006	0.546	0.013	0.008	0.241	0.128	2.07
276	0.006	0.495	0.015	0.022	0.202	0.097	1.73

n260, Ant K, Scaled-up Power Density with Sim.power.limit							
Beam ID	S4(Right)	S3(Left)	S5(Top)	S6(Bottom)	S1(Front)	S2(Rear)	Sim.power.limit (dBm)
0	0.002	0.631	0.006	0.003	0.200	0.205	7.72
1	0.003	0.611	0.008	0.003	0.199	0.219	7.62
2	0.002	0.631	0.006	0.004	0.189	0.216	6.91
3	0.006	0.601	0.005	0.003	0.206	0.205	7.51
4	0.003	0.631	0.007	0.002	0.201	0.210	7.71
5	0.008	0.631	0.007	0.006	0.202	0.208	4.63
6	0.007	0.631	0.004	0.004	0.240	0.255	4.97
7	0.002	0.631	0.007	0.001	0.245	0.269	4.27
8	0.003	0.631	0.011	0.004	0.192	0.206	4.19
9	0.004	0.631	0.006	0.003	0.208	0.222	5.28
10	0.003	0.631	0.002	0.001	0.259	0.264	4.68
11	0.003	0.631	0.011	0.003	0.213	0.226	4.23
12	0.007	0.622	0.017	0.010	0.209	0.273	1.54
13	0.010	0.560	0.003	0.002	0.260	0.246	2.02
14	0.003	0.631	0.002	0.001	0.297	0.264	1.26
15	0.003	0.631	0.003	0.000	0.280	0.287	0.65
16	0.003	0.559	0.021	0.001	0.215	0.279	0.54
17	0.011	0.615	0.006	0.004	0.236	0.294	1.34
18	0.010	0.589	0.003	0.002	0.269	0.249	2.19
19	0.002	0.631	0.003	0.001	0.287	0.275	0.89
20	0.003	0.576	0.009	0.000	0.240	0.289	0.39
256	0.003	0.562	0.007	0.003	0.187	0.213	8.67
257	0.002	0.588	0.007	0.002	0.200	0.220	7.57
258	0.006	0.536	0.006	0.001	0.193	0.208	6.75
259	0.004	0.577	0.008	0.002	0.210	0.220	6.88
260	0.002	0.582	0.010	0.001	0.194	0.218	7.33
261	0.004	0.523	0.009	0.002	0.199	0.153	4.12
262	0.006	0.569	0.003	0.002	0.240	0.296	4.50
263	0.003	0.609	0.003	0.001	0.218	0.344	4.77
264	0.003	0.582	0.011	0.003	0.195	0.182	5.12
265	0.004	0.552	0.007	0.002	0.207	0.212	4.35
266	0.008	0.585	0.003	0.001	0.240	0.353	4.69
267	0.004	0.592	0.009	0.002	0.207	0.239	4.47
268	0.002	0.461	0.022	0.007	0.231	0.128	0.61
269	0.004	0.608	0.005	0.002	0.286	0.283	1.17
270	0.008	0.542	0.002	0.001	0.175	0.376	1.23
271	0.004	0.631	0.004	0.001	0.251	0.344	1.05
272	0.003	0.505	0.012	0.001	0.216	0.212	0.53
273	0.003	0.532	0.009	0.003	0.286	0.201	0.68
274	0.004	0.601	0.003	0.002	0.216	0.336	1.29
275	0.005	0.631	0.004	0.000	0.246	0.358	1.16
276	0.003	0.588	0.008	0.001	0.252	0.278	0.94

n258, Ant K, Scaled-up Power Density with Sim.power.limit							
Beam ID	S4(Right)	S3(Left)	S5(Top)	S6(Bottom)	S1(Front)	S2(Rear)	Sim.power.limit (dBm)
0	0.008	0.617	0.009	0.002	0.296	0.333	10.89
1	0.002	0.568	0.009	0.002	0.274	0.108	7.68
2	0.006	0.611	0.012	0.001	0.313	0.124	7.92
3	0.005	0.523	0.005	0.001	0.279	0.119	7.66
4	0.003	0.532	0.010	0.001	0.270	0.149	8.33
5	0.004	0.606	0.002	0.001	0.323	0.160	4.06
6	0.007	0.575	0.005	0.002	0.334	0.125	4.99
7	0.004	0.584	0.003	0.001	0.350	0.155	4.17
8	0.007	0.584	0.016	0.001	0.321	0.126	5.00
9	0.008	0.631	0.016	0.005	0.250	0.218	8.16
10	0.008	0.557	0.007	0.004	0.337	0.116	7.08
11	0.003	0.547	0.006	0.001	0.290	0.167	4.73
12	0.005	0.631	0.004	0.002	0.348	0.127	1.00
13	0.003	0.582	0.004	0.004	0.314	0.128	1.01
14	0.004	0.626	0.001	0.003	0.348	0.148	0.56
15	0.006	0.566	0.001	0.000	0.343	0.200	0.48
16	0.004	0.572	0.025	0.001	0.335	0.135	0.27
17	0.003	0.595	0.003	0.004	0.318	0.127	0.96
18	0.003	0.587	0.004	0.004	0.319	0.129	0.97
19	0.005	0.628	0.002	0.001	0.360	0.171	0.50
20	0.005	0.554	0.004	0.000	0.303	0.175	0.11
256	0.007	0.594	0.021	0.004	0.220	0.156	11.23
257	0.005	0.631	0.015	0.003	0.126	0.257	9.85
258	0.016	0.556	0.011	0.003	0.135	0.246	10.88
259	0.011	0.631	0.012	0.003	0.161	0.304	10.48
260	0.012	0.603	0.010	0.006	0.144	0.296	11.16
261	0.005	0.590	0.009	0.001	0.157	0.280	6.49
262	0.012	0.631	0.006	0.005	0.199	0.381	8.12
263	0.011	0.595	0.004	0.003	0.175	0.324	6.96
264	0.011	0.607	0.019	0.002	0.145	0.298	7.87
265	0.015	0.631	0.025	0.008	0.190	0.320	9.16
266	0.005	0.612	0.020	0.005	0.202	0.238	8.03
267	0.010	0.597	0.011	0.002	0.156	0.280	7.17
268	0.025	0.613	0.056	0.013	0.191	0.282	7.83
269	0.012	0.625	0.014	0.016	0.202	0.312	4.72
270	0.014	0.609	0.011	0.005	0.190	0.407	4.25
271	0.007	0.584	0.007	0.001	0.245	0.258	4.05
272	0.009	0.599	0.030	0.002	0.145	0.359	2.79
273	0.018	0.601	0.021	0.017	0.179	0.287	5.53
274	0.012	0.631	0.014	0.014	0.216	0.343	4.73
275	0.013	0.621	0.007	0.001	0.197	0.393	3.87
276	0.006	0.582	0.011	0.001	0.165	0.319	2.49

[B6] Non-Selected Surface Validation for folder open

Band	Channel	Module	Type	Side	Beam ID	PLS (10 dBm)	Meas. PD (mW/cm2)
n261	mid	K	Patch	Rear	275	3.4	0.361
				Top	16	1.7	0.0343
n260	Mid	K	Patch	Front	14	2.1	0.242
				Top	268	1.5	0.0332
n258	mid	K	Patch	Top	268	7.9	0.0694

n261, Ant K, Scaled-up Power Density with Sim.power.limit							
Beam ID	S4(Right)	S3(Left)	S5(Top)	S6(Bottom)	S1(Front)	S2(Rear)	Sim.power.limit (dBm)
0	0.002	0.604	0.005	0.002	0.235	0.190	6.83
1	0.003	0.619	0.013	0.004	0.286	0.111	7.71
2	0.003	0.558	0.006	0.003	0.225	0.111	7.19
3	0.004	0.604	0.009	0.001	0.252	0.142	6.84
4	0.002	0.573	0.010	0.001	0.314	0.111	7.69
5	0.003	0.587	0.004	0.004	0.273	0.154	4.54
6	0.004	0.611	0.003	0.001	0.327	0.182	3.87
7	0.005	0.592	0.010	0.000	0.327	0.159	3.98
8	0.004	0.541	0.015	0.003	0.226	0.122	4.47
9	0.004	0.576	0.003	0.004	0.247	0.175	3.98
10	0.003	0.631	0.004	0.002	0.314	0.208	4.49
11	0.003	0.631	0.012	0.001	0.350	0.212	4.55
12	0.002	0.598	0.006	0.003	0.298	0.194	0.36
13	0.005	0.601	0.002	0.001	0.341	0.213	0.32
14	0.005	0.577	0.002	0.001	0.351	0.185	0.43
15	0.004	0.595	0.010	0.000	0.337	0.183	-0.05
16	0.003	0.571	0.037	0.001	0.258	0.136	0.37
17	0.004	0.610	0.003	0.001	0.340	0.196	0.12
18	0.004	0.606	0.002	0.001	0.338	0.211	0.74
19	0.006	0.601	0.002	0.001	0.358	0.199	0.22
20	0.002	0.596	0.029	0.000	0.285	0.162	-0.02
256	0.005	0.631	0.024	0.003	0.202	0.198	10.54
257	0.006	0.616	0.020	0.005	0.208	0.176	9.24
258	0.008	0.624	0.013	0.003	0.205	0.197	9.03
259	0.005	0.594	0.009	0.004	0.178	0.207	9.03
260	0.007	0.548	0.013	0.004	0.174	0.211	9.18
261	0.008	0.631	0.026	0.007	0.287	0.197	7.05
262	0.006	0.621	0.004	0.001	0.217	0.251	5.60
263	0.003	0.589	0.010	0.001	0.212	0.257	5.48
264	0.007	0.571	0.020	0.003	0.161	0.268	6.40
265	0.006	0.592	0.009	0.001	0.249	0.200	5.78
266	0.005	0.610	0.006	0.001	0.194	0.265	5.07
267	0.005	0.579	0.016	0.002	0.182	0.270	5.86
268	0.009	0.557	0.019	0.002	0.237	0.170	3.16
269	0.007	0.610	0.004	0.002	0.296	0.245	1.91
270	0.003	0.613	0.008	0.002	0.239	0.279	2.14
271	0.004	0.558	0.007	0.002	0.210	0.253	2.20
272	0.006	0.571	0.034	0.001	0.219	0.274	1.86
273	0.009	0.592	0.009	0.003	0.286	0.226	2.18
274	0.004	0.625	0.003	0.000	0.281	0.274	2.11
275	0.003	0.611	0.009	0.002	0.238	0.282	2.07
276	0.004	0.528	0.024	0.001	0.203	0.222	1.66

n260, Ant K, Scaled-up Power Density with Sim.power.limit							
Beam ID	S4(Right)	S3(Left)	S5(Top)	S6(Bottom)	S1(Front)	S2(Rear)	Sim.power.limit (dBm)
0	0.002	0.631	0.006	0.003	0.200	0.205	7.72
1	0.003	0.611	0.008	0.003	0.199	0.219	7.62
2	0.002	0.631	0.006	0.004	0.189	0.216	6.91
3	0.006	0.601	0.005	0.003	0.206	0.205	7.51
4	0.003	0.631	0.007	0.002	0.201	0.210	7.71
5	0.008	0.631	0.007	0.006	0.202	0.208	4.63
6	0.007	0.631	0.004	0.004	0.240	0.255	4.97
7	0.002	0.631	0.007	0.001	0.245	0.269	4.27
8	0.003	0.631	0.011	0.004	0.192	0.206	4.19
9	0.004	0.631	0.006	0.003	0.208	0.222	5.28
10	0.003	0.631	0.002	0.001	0.259	0.264	4.68
11	0.003	0.631	0.011	0.003	0.213	0.226	4.23
12	0.007	0.622	0.017	0.010	0.209	0.273	1.54
13	0.010	0.560	0.003	0.002	0.260	0.246	2.02
14	0.003	0.631	0.002	0.001	0.297	0.264	1.26
15	0.003	0.631	0.003	0.000	0.280	0.287	0.65
16	0.003	0.559	0.021	0.001	0.215	0.279	0.54
17	0.011	0.615	0.006	0.004	0.236	0.294	1.34
18	0.010	0.589	0.003	0.002	0.269	0.249	2.19
19	0.002	0.631	0.003	0.001	0.287	0.275	0.89
20	0.003	0.576	0.009	0.000	0.240	0.289	0.39
256	0.003	0.562	0.007	0.003	0.187	0.213	8.67
257	0.002	0.588	0.007	0.002	0.200	0.220	7.57
258	0.006	0.536	0.006	0.001	0.193	0.208	6.75
259	0.004	0.577	0.008	0.002	0.210	0.220	6.88
260	0.002	0.582	0.010	0.001	0.194	0.218	7.33
261	0.004	0.523	0.009	0.002	0.199	0.153	4.12
262	0.006	0.569	0.003	0.002	0.240	0.296	4.50
263	0.003	0.609	0.003	0.001	0.218	0.344	4.77
264	0.003	0.582	0.011	0.003	0.195	0.182	5.12
265	0.004	0.552	0.007	0.002	0.207	0.212	4.35
266	0.008	0.585	0.003	0.001	0.240	0.353	4.69
267	0.004	0.592	0.009	0.002	0.207	0.239	4.47
268	0.002	0.461	0.022	0.007	0.231	0.128	0.61
269	0.004	0.608	0.005	0.002	0.286	0.283	1.17
270	0.008	0.542	0.002	0.001	0.175	0.376	1.23
271	0.004	0.631	0.004	0.001	0.251	0.344	1.05
272	0.003	0.505	0.012	0.001	0.216	0.212	0.53
273	0.003	0.532	0.009	0.003	0.286	0.201	0.68
274	0.004	0.601	0.003	0.002	0.216	0.336	1.29
275	0.005	0.631	0.004	0.000	0.246	0.358	1.16
276	0.003	0.588	0.008	0.001	0.252	0.278	0.94

n258, Ant K, Scaled-up Power Density with Sim.power.limit							
Beam ID	S4(Right)	S3(Left)	S5(Top)	S6(Bottom)	S1(Front)	S2(Rear)	Sim.power.limit (dBm)
0	0.008	0.617	0.009	0.002	0.296	0.333	10.89
1	0.002	0.568	0.009	0.002	0.274	0.108	7.68
2	0.006	0.611	0.012	0.001	0.313	0.124	7.92
3	0.005	0.523	0.005	0.001	0.279	0.119	7.66
4	0.003	0.532	0.010	0.001	0.270	0.149	8.33
5	0.004	0.606	0.002	0.001	0.323	0.160	4.06
6	0.007	0.575	0.005	0.002	0.334	0.125	4.99
7	0.004	0.584	0.003	0.001	0.350	0.155	4.17
8	0.007	0.584	0.016	0.001	0.321	0.126	5.00
9	0.008	0.631	0.016	0.005	0.250	0.218	8.16
10	0.008	0.557	0.007	0.004	0.337	0.116	7.08
11	0.003	0.547	0.006	0.001	0.290	0.167	4.73
12	0.005	0.631	0.004	0.002	0.348	0.127	1.00
13	0.003	0.582	0.004	0.004	0.314	0.128	1.01
14	0.004	0.626	0.001	0.003	0.348	0.148	0.56
15	0.006	0.566	0.001	0.000	0.343	0.200	0.48
16	0.004	0.572	0.025	0.001	0.335	0.135	0.27
17	0.003	0.595	0.003	0.004	0.318	0.127	0.96
18	0.003	0.587	0.004	0.004	0.319	0.129	0.97
19	0.005	0.628	0.002	0.001	0.360	0.171	0.50
20	0.005	0.554	0.004	0.000	0.303	0.175	0.11
256	0.007	0.594	0.021	0.004	0.220	0.156	11.23
257	0.005	0.631	0.015	0.003	0.126	0.257	9.85
258	0.016	0.556	0.011	0.003	0.135	0.246	10.88
259	0.011	0.631	0.012	0.003	0.161	0.304	10.48
260	0.012	0.603	0.010	0.006	0.144	0.296	11.16
261	0.005	0.590	0.009	0.001	0.157	0.280	6.49
262	0.012	0.631	0.006	0.005	0.199	0.381	8.12
263	0.011	0.595	0.004	0.003	0.175	0.324	6.96
264	0.011	0.607	0.019	0.002	0.145	0.298	7.87
265	0.015	0.631	0.025	0.008	0.190	0.320	9.16
266	0.005	0.612	0.020	0.005	0.202	0.238	8.03
267	0.010	0.597	0.011	0.002	0.156	0.280	7.17
268	0.025	0.613	0.056	0.013	0.191	0.282	7.83
269	0.012	0.625	0.014	0.016	0.202	0.312	4.72
270	0.014	0.609	0.011	0.005	0.190	0.407	4.25
271	0.007	0.584	0.007	0.001	0.245	0.258	4.05
272	0.009	0.599	0.030	0.002	0.145	0.359	2.79
273	0.018	0.601	0.021	0.017	0.179	0.287	5.53
274	0.012	0.631	0.014	0.014	0.216	0.343	4.73
275	0.013	0.621	0.007	0.001	0.197	0.393	3.87
276	0.006	0.582	0.011	0.001	0.165	0.319	2.49

7. PD Char

7.1 single beam

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 = PD_design_target/Sim.PD surface(i), i = single beams (1)

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

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

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

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

The Total PD(∅ 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 (Δmin) given by:

For n258, n260 and n261

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

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;
Δmin is the worst-case housing influence factor for beam i.

If simulation overestimates the housing influence, then Δmin (= 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 Δmin 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 Δmin 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,

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

else if Δmin < -TxAGC uncertainty,

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

else if Δmin > TxAGC uncertainty,

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

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

Table 20: Input.power.limit calculation (Considered both folder open and close conditions)

Band	Antenna	Δmin (dB)	TxAGC Uncertainty (dB)	*input.power.limit* *(dBm)*	Notes
n261	Patch K	1.89	0.63	input.power.limit (i)=sim.power.limit+1.26	Using Eq. 8
N250	Patch K	1.44	0.63	input.power.limit (i)= sim.power.limit+0.81	Using Eq. 8
n258	Patch K	0.26	0.63	input.power.limit (i)= sim.power.limit+0.89	Using Eq. 8

Table 21: Permanent back-off applied to calculated input.power.limit

Band	Antenna	Permanent back-off (dB)
n261	Patch K	0.1
n260	Patch K	0.1
n258	Patch K	0.1

Note: The above back-off 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.

n258 K Patch input.power.limit

Antenna	Beam ID_1	Beam ID_2	Input.power.limit(dBm)
K Patch	0		12.5
	1		9.4
	2		9.6
	3		9.4
	4		10.1
	5		5.8
	6		6.7
	7		5.9
	8		6.7
	9		9.9
	10		8.8
	11		6.5
	12		2.7
	13		2.7
	14		2.3
	15		2.2
	16		2.0
	17		2.7
	18		2.7
	19		2.2
	20		1.8
	256		13.0
	257		11.4
	258		12.6
	259		12.2
	260		12.5
	261		8.2
	262		9.8
	263		8.7
	264		9.5
	265		10.9
	266		9.3
	267		8.6
	268		9.6
	269		6.4
	270		6.0
	271		5.8
	272		4.3
	273		7.3
	274		6.4
	275		5.6
	276		4.1
	0	256	8.6
	1	257	7.0
	2	258	7.1
	3	259	6.9
	4	260	7.2
	5	261	3.2
	6	262	4.1
	7	263	3.8
	8	264	4.1
	9	265	6.6
	10	266	5.9
	11	267	4.7
	12	268	1.3
	13	269	0.4
	14	270	-0.1
	15	271	-0.1
	16	272	-0.9
	17	273	0.5
	18	274	0.4
	19	275	-0.3
	20	276	-1.0

n261 K Patch input.power.limit

Antenna	Beam ID_1	Beam ID_2	Input.power.limit(dBm)
K Patch	0		8.4
	1		9.6
	2		9.1
	3		8.7
	4		9.3
	5		6.4
	6		5.5
	7		5.6
	8		6.4
	9		5.8
	10		5.6
	11		6
	12		2.2
	13		2
	14		1.9
	15		1.4
	16		2.2
	17		2
	18		2.2
	19		1.7
	20		1.8
	256		12
	257		10.5
	258		10.5
	259		10.4
	260		10.6
	261		8.4
	262		7.3
	263		7.1
	264		7.9
	265		7.2
	266		6.9
	267		7.5
	268		4.2
	269		3.6
	270		3.7
	271		3.9
	272		3.1
	273		3.8
	274		3.7
	275		3.6
	276		3.3
	0	256	5.6
	1	257	6.1
	2	258	5.5
	3	259	5.6
	4	260	6.1
	5	261	3.6
	6	262	2.7
	7	263	2.9
	8	264	3.5
	9	265	3.1
	10	266	3
	11	267	3.7
	12	268	-0.9
	13	269	-1.1
	14	270	-1.1
	15	271	-1.3
	16	272	-1.3
	17	273	-1.1
	18	274	-0.9
	19	275	-1.2
	20	276	-1.2

NR n260 K Patch input.power.limit

Antenna	Beam ID_1	Beam ID_2	Input.power.limit(dBm)
K Patch	0		9.7
	1		9.6
	2		8.9
	3		9.5
	4		9.7
	5		6.6
	6		6.9
	7		6.2
	8		6.2
	9		7.3
	10		6.7
	11		6.2
	12		3.5
	13		4
	14		3.2
	15		2.6
	16		2.5
	17		3.3
	18		4.2
	19		2.9
	20		2.4
	256		10.6
	257		9.6
	258		8.7
	259		8.9
	260		9.3
	261		6.1
	262		6.5
	263		6.7
	264		7.1
	265		6.3
	266		6.7
	267		6.4
	268		2.6
	269		3.2
	270		3.2
	271		2.9
	272		2.5
	273		2.7
	274		3.3
	275		3
	276		2.9
	0	256	6.6
	1	257	6.3
	2	258	5.7
	3	259	5.6
	4	260	6
	5	261	3
	6	262	3.5
	7	263	3.4
	8	264	3.2
	9	265	3.3
	10	266	3.4
	11	267	3.2
	12	268	-1.1
	13	269	-0.4
	14	270	0
	15	271	-0.8
	16	272	-1.2
	17	273	-0.8
	18	274	-0.4
	19	275	-0.7
	20	276	-1