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NEAR-FIELD POWER DENSITY PART 0 REPORT

Applicant Name
Apple, Inc.
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Date of Testing
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Test Site/Location
PCTEST Lab, Morgan Hill, CA, USA
Document Serial No:
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FCC ID:	**BCGA2379**
APPLICANT:	**APPLE, INC.**

DUT Type:	Tablet Device
Report Type:	Part 0 Power Density Characterization
Model:	A2379

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them. Test results reported herein relate only to the item(s) tested.

Randy Ortanez
President

ACCREDITED
CERT #2041.02

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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.

1.2 Time-Averaging Algorithm for RF Exposure Compliance

This device is enabled with Qualcomm® Smart Transmit algorithm to control and manage transmitting power in real time and to ensure that the time-averaged RF exposure from 2G/3G/4G/5G NR WWAN is in compliance with FCC requirements. This Part 0 report shows Power Density characterization of WWAN radios for mmW NR. Characterization is achieved by determining input.power.limit for 5G mmW NR that correspond to the exposure design target after accounting for all device design related uncertainties, i.e., PD_design_target (< FCC PD limit) for mmW radio. The PD characterization is denoted as PD Char 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
	Δ_{min}	Housing material influence
	PD Char	Table containing *input.power.limit* for all beams and bands

1.4 Bibliography

Table 1-9
5G mmWave NR Bibliography

Report Type	Serial Number
Part 0 SAR	1C2101020005-34.BCG
Part 1 SAR	1C2101020005-01.BCG
Part 0 PD	1C2101020005-18.BCG
Part 1 PD	1C2101020005-19.BCG
Power Density Simulation Report	
RF Exposure Compliance Summary Report	1C2101020005-21.BCG
Part 2	1C2101020005-20.BCG

2 MEASUREMENT SYSTEM

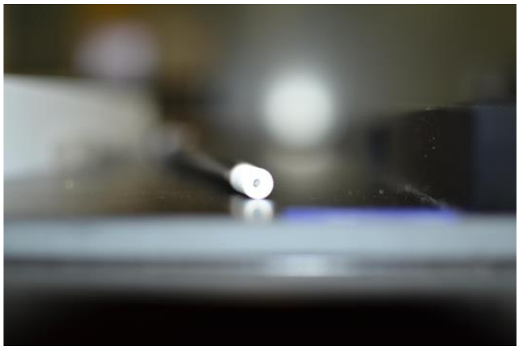
2.1 Measurement Setup

Peak spatially averaged power density (psPD) measurements for mmWave frequencies were performed using the DASY6 with cDASY6 5G module. The DASY6 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland and consists of a high precision robotics system (Staubli), robot controller, desktop computer, near-field probe, probe alignment sensor, and the 5G phantom. The robot is a six-axis industrial robot, performing precise movements to position the probe to the location (points) of maximum electromagnetic field (EMF).

2.2 SPEAG EUmmWV3 Probe / E-Field 5G Probe

The EUmmWV3 probe consists of two dipoles optimally arranged to obtain pseudo-vector information.

Frequency Range	750 MHz – 110 GHz
Dynamic Range	< 20 V/m – 10,000 V/m with PRE-10 (min < 50 V/m – 3,000 V/m)
Position Precision	< 0.2 mm (cDASY6)
Dimensions	Probe Overall Length: 320 mm Probe Body Diameter: 8 mm Probe Tip Length: 23 mm Probe Tip Diameter: Encapsulation 8 mm Distance from Probe Tip to Sensor X Calibration Point: 1.5 mm Distance from Probe Tip to Sensor Y Calibration Point: 1.5 mm
Applications	E-field measurements of 5G devices and other mm-wave transmitters operating above 10 GHz in < 2 mm distance from device (free-space) Power density, H-field and far-field analysis using total field reconstruction
Compatibility	cDASY6 + 5G-Module



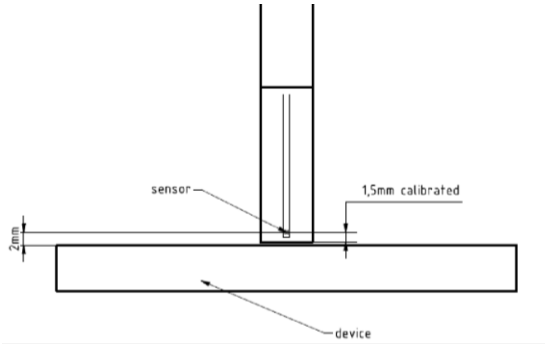


Figure 2-1
EUmmWV3 Probe

2.3 Peak Spatially Averaged Power Density Assessment Based on E-field Measurements

Within a short distance from the transmitting source, power density was determined based on both electric and magnetic fields. Generally, the magnitude and phase of two components of either the E-field or H-field were needed on a sufficiently large surface to fully characterize the total E-field and H-field distributions. Nevertheless, solutions based on direct measurement of E-field and H-field can be used to compute power density. The general measurement approach used for this device was:

a) The local E field on the measurement surface was measured at a reference location where the field is well above the noise level. This reference level was used at the end of this procedure to assess output power drift of the DUT during the measurement.

b) The electric field on the measurement surface was scanned. Measurements are conducted according to the instructions provided by the measurement system manufacturer. Measurement spatial resolution can depend on the measured field characteristic and measurement methodology used by the system. The planar scan step size was configured at λ/4.

c) For cDASY6, H-field was calculated from the measured E-field using a reconstruction algorithm. As the power density calculation requires knowledge of both amplitude and phase, reconstruction algorithms can also be used to obtain field information from the measured E-field data (e.g. the phase from the amplitude if only the amplitude is measured). H-field and phase data was reconstructed from repeated measurements (three per measurement point) on two measurement planes separated by λ/4.

d) The total Peak spatially averaged power density (psPD) distribution on the evaluation surface is determined per the below equation. The spatial averaging area, *A*, is specified by the applicable exposure limits or regulatory requirements. A circular shape was used.

$$psPD = \frac{1}{2A_{av}} \iint_{A_{av}} || Re\{E \times H^*\} || \, dA$$

e) The maximum spatial-average on the evaluation surface is the final quantity to determine compliance against applicable limits.

f) The local E field reference value, at the same location as step 2, was re-measured after the scan was complete to calculate the power drift. If the drift deviated by more than 5%, the power density test and drift measurements were repeated.

2.4 Reconstruction Algorithm

Computation of the power density in general requires measurement information from the both E-field and H-field amplitudes and phases in the plane of incidence. Reconstruction of these quantities from pseudo-vector E-field measurements is feasible according to the manufacturer, as they are determined via Maxwell's equations. As such, the SPEAG reconstruction approach was based on the Gerchberg-Saxton algorithm, which benefits from the availability of the E-field polarization ellipse information obtained with the EUmmWV3 probe.

3 POWER DENSITY CHARACTERIZATION

3.1 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.

The surfaces near-by each mmW antenna module for PD characterization are identified below.

Table 3-1
Evaluation Surfaces for PD Characterization

Band & Mode	Antenna	Back (S2)	Front (S1)	Top (S5)	Bottom (S6)	Right (S4)	Left (S3)
5G NR Band n261	M0	Yes	Yes	No	No	Yes	No
	M2	Yes	Yes	Yes	No	No	Yes
	M3	Yes	Yes	No	Yes	Yes	No
5G NR Band n260	M0	Yes	Yes	No	No	Yes	No
	M2	Yes	Yes	Yes	No	No	Yes
	M3	Yes	Yes	No	Yes	Yes	No

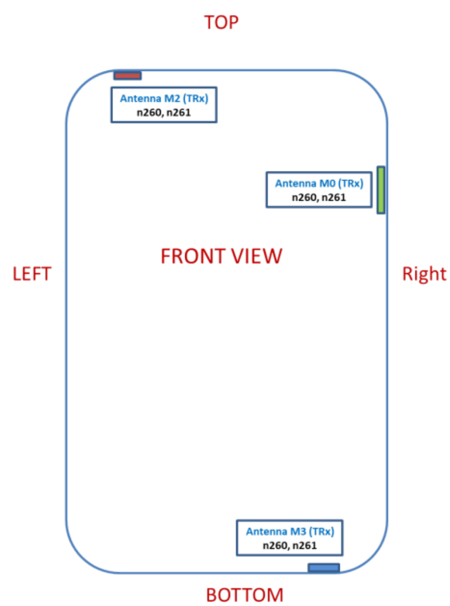


Figure 3-1
Location of mmW antenna modules

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 Δ_{min} calculations.

3.2 Power Density Characterization Method

An overview of power density characterization method could be found below.

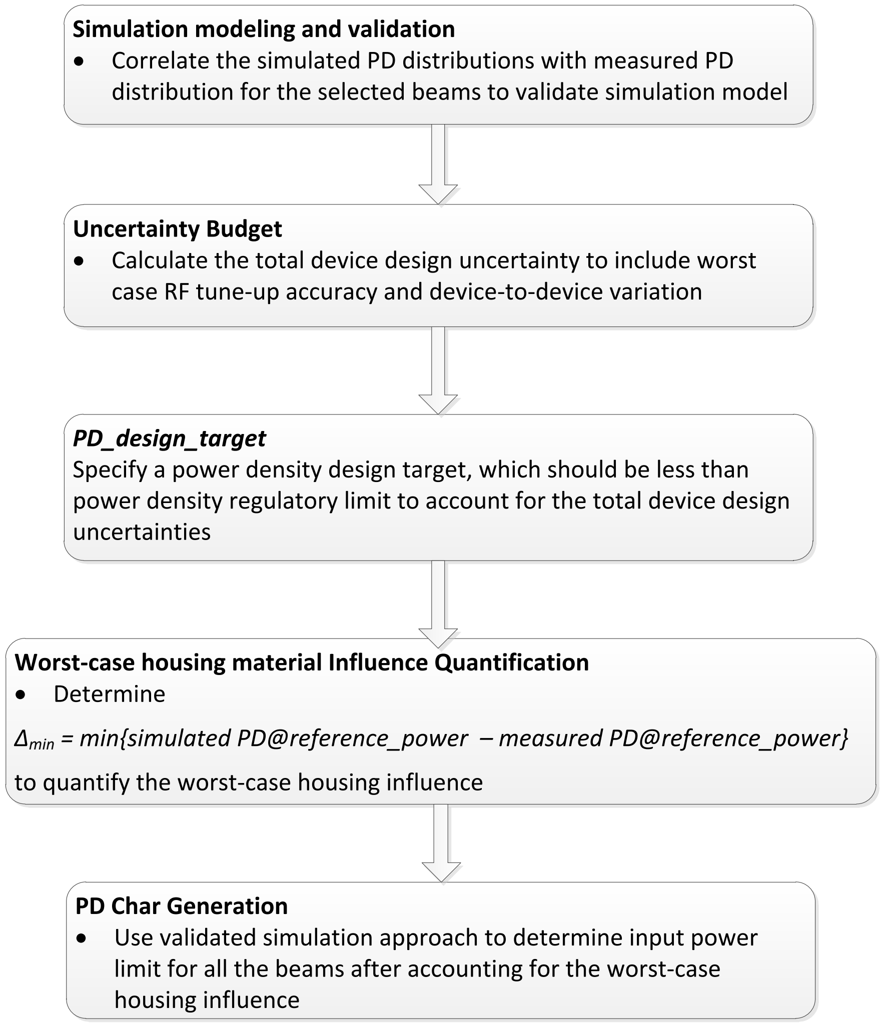


Figure 3-2
Flow Chart for Power Density Characterization

3.3 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 3-2
5G mmW NR Band n261 Ant M0 Codebook

Band	Antenna Module	Beam ID	Paired With	Antenna Type	# of Antenna Feed
n261	M0	3	131	Patch	1
		4	132	Patch	1
		11	139	Patch	2
		12	140	Patch	2
		13	141	Patch	2
		18	146	Patch	2
		19	147	Patch	2
		30	158	Patch	4
		31	159	Patch	4
		32	160	Patch	4
		33	161	Patch	4
		42	170	Patch	4
		43	171	Patch	4
		44	172	Patch	4
		131	3	Patch	1
		132	4	Patch	1
		139	11	Patch	2
		140	12	Patch	2
		141	13	Patch	2
		146	18	Patch	2
		147	19	Patch	2
		158	30	Patch	4
		159	31	Patch	4
		160	32	Patch	4
		161	33	Patch	4
		170	42	Patch	4
		171	43	Patch	4
		172	44	Patch	4

Table 3-3
5G mmW NR Band n261 Ant M2 Codebook

Band	Antenna Module	Beam ID	Paired With	Antenna Type	# of Antenna Feed
n261	M2	0	128	Patch	1
		5	133	Patch	2
		6	134	Patch	2
		7	135	Patch	2
		14	142	Patch	2
		15	143	Patch	2
		20	148	Patch	4
		21	149	Patch	4
		22	150	Patch	4
		23	151	Patch	4
		24	152	Patch	4
		34	162	Patch	4
		35	163	Patch	4
		36	164	Patch	4
		37	165	Patch	4
		128	0	Patch	1
		133	5	Patch	2
		134	6	Patch	2
		135	7	Patch	2
		142	14	Patch	2
		143	15	Patch	2
		148	20	Patch	4
		149	21	Patch	4
		150	22	Patch	4
		151	23	Patch	4
		152	24	Patch	4
		162	34	Patch	4
		163	35	Patch	4
		164	36	Patch	4
		165	37	Patch	4

Table 3-4
5G mmW NR Band n261 Ant M3 Codebook

Band	Antenna Module	Beam ID	Paired With	Antenna Type	# of Antenna Feed
n261	M3	1	129	Patch	1
		2	130	Patch	1
		8	136	Patch	2
		9	137	Patch	2
		10	138	Patch	2
		16	144	Patch	2
		17	145	Patch	2
		25	153	Patch	4
		26	154	Patch	4
		27	155	Patch	4
		28	156	Patch	4
		29	157	Patch	4
		38	166	Patch	4
		39	167	Patch	4
		40	168	Patch	4
		41	169	Patch	4
		129	1	Patch	1
		130	2	Patch	1
		136	8	Patch	2
		137	9	Patch	2
		138	10	Patch	2
		144	16	Patch	2
		145	17	Patch	2
		153	25	Patch	4
		154	26	Patch	4
		155	27	Patch	4
		156	28	Patch	4
		157	29	Patch	4
		166	38	Patch	4
		167	39	Patch	4
		168	40	Patch	4
		169	41	Patch	4

Table 3-5
5G mmW NR Band n260 Ant M0 Codebook

Band	Antenna Module	Beam ID	Paired With	Antenna Type	# of Antenna Feed
n260	M0	4	132	Patch	1
		5	133	Patch	1
		12	140	Patch	2
		13	141	Patch	2
		14	142	Patch	2
		19	147	Patch	2
		20	148	Patch	2
		31	159	Patch	4
		32	160	Patch	4
		33	161	Patch	4
		34	162	Patch	4
		35	163	Patch	4
		44	172	Patch	4
		45	173	Patch	4
		46	174	Patch	4
		47	175	Patch	4
		132	4	Patch	1
		133	5	Patch	1
		140	12	Patch	2
		141	13	Patch	2
		142	14	Patch	2
		147	19	Patch	2
		148	20	Patch	2
		159	31	Patch	4
		160	32	Patch	4
		161	33	Patch	4
		162	34	Patch	4
		163	35	Patch	4
		172	44	Patch	4
		173	45	Patch	4
		174	46	Patch	4
		175	47	Patch	4

Table 3-6
5G mmW NR Band n260 Ant M2 Codebook

Band	Antenna Module	Beam ID	Paired With	Antenna Type	# of Antenna Feed
n260	M2	0	128	Patch	1
		1	129	Patch	1
		6	134	Patch	2
		7	135	Patch	2
		8	136	Patch	2
		15	143	Patch	2
		16	144	Patch	2
		21	149	Patch	4
		22	150	Patch	4
		23	151	Patch	4
		24	152	Patch	4
		25	153	Patch	4
		36	164	Patch	4
		37	165	Patch	4
		38	166	Patch	4
		39	167	Patch	4
		128	0	Patch	1
		129	1	Patch	1
		134	6	Patch	2
		135	7	Patch	2
		136	8	Patch	2
		143	15	Patch	2
		144	16	Patch	2
		149	21	Patch	4
		150	22	Patch	4
		151	23	Patch	4
		152	24	Patch	4
		153	25	Patch	4
		164	36	Patch	4
		165	37	Patch	4
		166	38	Patch	4
		167	39	Patch	4

Table 3-7
5G mmW NR Band n260 Ant M3 Codebook

Band	Antenna Module	Beam ID	Paired With	Antenna Type	# of Antenna Feed
n260	M3	2	130	Patch	1
		3	131	Patch	1
		9	137	Patch	2
		10	138	Patch	2
		11	139	Patch	2
		17	145	Patch	2
		18	146	Patch	2
		26	154	Patch	4
		27	155	Patch	4
		28	156	Patch	4
		29	157	Patch	4
		30	158	Patch	4
		40	168	Patch	4
		41	169	Patch	4
		42	170	Patch	4
		43	171	Patch	4
		130	2	Patch	1
		131	3	Patch	1
		137	9	Patch	2
		138	10	Patch	2
		139	11	Patch	2
		145	17	Patch	2
		146	18	Patch	2
		154	26	Patch	4
		155	27	Patch	4
		156	28	Patch	4
		157	29	Patch	4
		158	30	Patch	4
		168	40	Patch	4
		169	41	Patch	4
		170	42	Patch	4
		171	43	Patch	4

3.4 Simulation and modeling validation

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

With an input power of 12 dBm for n261 band and 11 dBm for n260 band, PD measurements are conducted for at least one single beam per antenna type and 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 below along with corresponding simulated PD values for the same configuration. Beams are chosen based on worst case simulation value of mid channel only.

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

Table 3-8
Measured and Simulated 4cm^2 psPD for Selected Beams
with 12 dBm Input Power for n261 and 11 dBm Input Power for n260

Band	Antenna	Beam ID	Surface	4 cm^2 psPD Measured (mW/cm^2)	4 cm^2 psPD Simulated (mW/cm^2)	Delta = Simulated - Measured (dB)
n261	M0	44	Front	5.84	8.04	**1.39**
		158	Front	4.28	7.02	2.15
	M2	23	Top	6.85	11.87	**2.39**
		164	Top	5.61	11.24	3.02
	M3	28	Bottom	6.74	11.93	**2.48**
		168	Bottom	4.72	11.31	3.80
n260	M0	45	Front	4.84	4.36	**-0.45**
		161	Front	2.88	5.37	2.71
	M2	24	Top	5.05	6.55	**1.13**
		149	Top	4.1	6.39	1.93
	M3	30	Bottom	3.87	6.83	2.47
		154	Bottom	3.96	6.66	**2.26**

3.5 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.

Table 3-9
***PD_design_target* Calculations**

PD_design_target	
$PD\_design\_target < PD\_regulatory\_limit \times 10^{\frac{-Total\ Uncertainty}{10}}$	
psPD over 4 cm^2 Averaging Area (mW/cm^2)	
Total Uncertainty	2.2 dB
PD_regulatory_limit	1.0 mW/cm^2
PD_design_target	0.6 mW/cm^2

3.6 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 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, per beam polarization, and per antenna type group,
    a. First determine Δ_{min} based on identified worst surface(s), and derive *input.power.limit*
    b. Then prove all other near-by surface(s), i.e., non-selected surface(s), is not required for housing material loss quantification (in other words, these non-evaluated surfaces have no influence on the determined *input.power.limit*) by:
        i. re-scale all simulated 4cm^{2}PD values to *input.power.limit* to identify the worst-PD beam per each non-evaluated surface
        ii. Measure 4cm^{2}PD at *input.power.limit* on identified worst-PD beam per each non-evaluated surface
        iii. Demonstrate all measured 4cm^{2}PD values are below *PD_design_target*
3. If any of the above surface(s) in Step (2.b.iii) have measured 4cm^2 PD ≥ *PD_design_target*, then those surfaces must be included in the Δ_{min} determination in Step (2.a), and re-evaluate *input.power.limit* with these added surfaces.

Following above procedure, the worst-surface(s) having highest 4cm^2 psPD 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 Antenna M0: Front

b. for Antenna M2: Top

c. for Antenna M3: Bottom

Thus, when comparing a simulated 4cm^2-averaged psPD and measured 4 cm^2-averaged psPD 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 are chosen for Δ_{min}. Thus, the worst-case housing influence, denoted as $\Delta_{min} = \mathrm{Sim.PD} - \mathrm{Meas.PD}$, is determined as

Table 3-10
Δ_{min} for all antennas

Band	Antenna	Δmin (dB)
n261	M0 (V Beams)	1.39
	M0 (H Beams)	2.15
	M2 (V Beams)	2.39
	M2 (H Beams)	3.02
	M3 (V Beams)	2.48
	M3 (H Beams)	3.80
n260	M0 (V Beams)	-0.45
	M0 (H Beams)	2.71
	M2 (V Beams)	1.13
	M2 (H Beams)	1.93
	M3 (V Beams)	2.47
	M3 (H Beams)	2.26

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.

Simulated 4cm^2 psPD values in Power Density Simulation Report are scaled to *input.power.limit* and are listed in 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), i.e.,

a. for antenna M0: Back, Right

b. for antenna M2: Back, Front, Left

c. for antenna M3: Back, Front, Right

Then perform PD measurement for all determined worst-case beams, highlighted in orange in 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.

The test results show that the all measured 4cm^2 psPD values are less than *PD_design_target* of 0.6 mW/cm^2, thus, the non-selected surfaces have no influence on the determined Δ_{min} and *input.power.limit*..

Table 3-11
n261, mid channel, antenna M0 simulated 4cm^2 PD at PD_Design_Target
(if simulation performed with correct housing material properties) (Δ_{min})

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					
		S1 (Front)	S2 (Back)	S3 (Left)	S4 (Right)	S5 (Top)	S6 (Bottom)
M0	3	0.53	0.01	-	0.11	-	-
	4	0.48	0.00	-	0.09	-	-
	11	0.48	0.01	-	0.11	-	-
	12	0.53	0.00	-	0.11	-	-
	13	0.54	0.01	-	0.08	-	-
	18	0.52	0.01	-	0.12	-	-
	19	0.54	0.00	-	0.09	-	-
	30	0.51	0.01	-	0.15	-	-
	31	0.48	0.01	-	0.12	-	-
	32	0.50	0.01	-	0.12	-	-
	33	0.49	0.01	-	0.08	-	-
	42	0.49	0.01	-	0.13	-	-
	43	0.49	0.01	-	0.11	-	-
	44	0.53	0.01	-	0.09	-	-
	131	0.47	0.01	-	0.08	-	-
	132	0.60	0.00	-	0.14	-	-
	139	0.52	0.01	-	0.15	-	-
	140	0.53	0.01	-	0.13	-	-
	141	0.53	0.01	-	0.10	-	-
	146	0.57	0.01	-	0.14	-	-
	147	0.51	0.01	-	0.13	-	-
	158	0.59	0.01	-	0.16	-	-
	159	0.56	0.01	-	0.18	-	-
	160	0.57	0.02	-	0.17	-	-
	161	0.48	0.01	-	0.11	-	-
	170	0.59	0.01	-	0.18	-	-
	171	0.56	0.01	-	0.18	-	-
	172	0.49	0.02	-	0.13	-	-

Please note the above scaled simulation values correspond to PD_design_target if the simulation was performed with correct housing material properties.

Table 3-12
n261, mid channel, antenna M2 simulated 4cm^2 PD at PD_Design_Target
(if simulation performed with correct housing material properties) (Δ_{min})

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					
		S1 (Front)	S2 (Back)	S3 (Left)	S4 (Right)	S5 (Top)	S6 (Bottom)
M2	0	0.18	0.18	0.02	-	0.60	-
	5	0.13	0.13	0.03	-	0.56	-
	6	0.17	0.20	0.03	-	0.59	-
	7	0.15	0.17	0.04	-	0.54	-
	14	0.12	0.15	0.04	-	0.55	-
	15	0.24	0.22	0.01	-	0.60	-
	20	0.17	0.20	0.06	-	0.53	-
	21	0.18	0.20	0.06	-	0.54	-
	22	0.20	0.22	0.02	-	0.58	-
	23	0.25	0.22	0.01	-	0.60	-
	24	0.21	0.16	0.01	-	0.54	-
	34	0.17	0.19	0.05	-	0.53	-
	35	0.19	0.22	0.05	-	0.58	-
	36	0.23	0.21	0.01	-	0.58	-
	37	0.23	0.18	0.01	-	0.58	-
	128	0.17	0.16	0.03	-	0.60	-
	133	0.19	0.21	0.00	-	0.59	-
	134	0.14	0.18	0.02	-	0.60	-
	135	0.23	0.18	0.01	-	0.60	-
	142	0.19	0.21	0.00	-	0.60	-
	143	0.20	0.14	0.03	-	0.58	-
	148	0.22	0.26	0.00	-	0.52	-
	149	0.22	0.25	0.00	-	0.52	-
	150	0.13	0.19	0.08	-	0.60	-
	151	0.27	0.19	0.05	-	0.60	-
	152	0.23	0.23	0.02	-	0.59	-
	162	0.22	0.25	0.01	-	0.60	-
	163	0.19	0.25	0.01	-	0.60	-
	164	0.24	0.13	0.08	-	0.60	-
	165	0.26	0.23	0.02	-	0.60	-

Please note the above scaled simulation values correspond to PD_design_target if the simulation was performed with correct housing material properties.

Table 3-13
n261, mid channel, antenna M3 simulated 4cm^2 PD at PD_Design_Target (if simulation performed with correct housing material properties) (Δ_{min})

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					
		S1 (Front)	S2 (Back)	S3 (Left)	S4 (Right)	S5 (Top)	S6 (Bottom)
M3	1	0.17	0.16	-	0.02	-	0.58
	2	0.18	0.18	-	0.02	-	0.60
	8	0.13	0.13	-	0.03	-	0.56
	9	0.17	0.20	-	0.03	-	0.59
	10	0.23	0.18	-	0.00	-	0.58
	16	0.22	0.22	-	0.01	-	0.58
	17	0.24	0.22	-	0.01	-	0.60
	25	0.18	0.20	-	0.06	-	0.54
	26	0.18	0.21	-	0.05	-	0.56
	27	0.20	0.22	-	0.02	-	0.59
	28	0.25	0.21	-	0.01	-	0.60
	29	0.20	0.16	-	0.01	-	0.53
	38	0.18	0.21	-	0.06	-	0.55
	39	0.20	0.23	-	0.04	-	0.60
	40	0.21	0.21	-	0.02	-	0.58
	41	0.24	0.19	-	0.02	-	0.58
	129	0.17	0.16	-	0.02	-	0.59
	130	0.17	0.16	-	0.03	-	0.60
	136	0.18	0.21	-	0.01	-	0.59
	137	0.14	0.18	-	0.02	-	0.60
	138	0.23	0.18	-	0.01	-	0.60
	144	0.14	0.17	-	0.04	-	0.60
	145	0.20	0.13	-	0.03	-	0.58
	153	0.22	0.25	-	0.00	-	0.60
	154	0.23	0.28	-	0.00	-	0.60
	155	0.16	0.18	-	0.09	-	0.60
	156	0.27	0.19	-	0.05	-	0.60
	157	0.25	0.23	-	0.02	-	0.59
	166	0.22	0.25	-	0.00	-	0.60
	167	0.17	0.23	-	0.02	-	0.60
	168	0.24	0.17	-	0.09	-	0.60
	169	0.26	0.22	-	0.01	-	0.60

Please note the above scaled simulation values correspond to PD_design_target if the simulation was performed with correct housing material properties.

Table 3-14
n260, mid channel, antenna M0 simulated 4cm² PD at PD_Design_Target
(if simulation performed with correct housing material properties) (Δ_{min})

Module	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					
		S1 (Front)	S2 (Back)	S3 (Left)	S4 (Right)	S5 (Top)	S6 (Bottom)
M0	4	0.52	0.01	-	0.13	-	-
	5	0.56	0.01	-	0.15	-	-
	12	0.52	0.00	-	0.18	-	-
	13	0.55	0.01	-	0.13	-	-
	14	0.58	0.01	-	0.09	-	-
	19	0.60	0.00	-	0.10	-	-
	20	0.43	0.01	-	0.16	-	-
	31	0.56	0.00	-	0.18	-	-
	32	0.59	0.01	-	0.21	-	-
	33	0.59	0.01	-	0.14	-	-
	34	0.41	0.01	-	0.13	-	-
	35	0.48	0.01	-	0.15	-	-
	44	0.53	0.01	-	0.20	-	-
	45	0.60	0.01	-	0.13	-	-
	46	0.48	0.01	-	0.14	-	-
	47	0.39	0.00	-	0.15	-	-
	132	0.52	0.01	-	0.13	-	-
	133	0.39	0.00	-	0.06	-	-
	140	0.53	0.01	-	0.19	-	-
	141	0.51	0.01	-	0.11	-	-
	142	0.59	0.02	-	0.16	-	-
	147	0.49	0.00	-	0.17	-	-
	148	0.60	0.01	-	0.07	-	-
	159	0.50	0.01	-	0.20	-	-
	160	0.51	0.00	-	0.18	-	-
	161	0.60	0.00	-	0.07	-	-
	162	0.47	0.01	-	0.08	-	-
	163	0.47	0.01	-	0.18	-	-
	172	0.51	0.00	-	0.19	-	-
	173	0.50	0.00	-	0.11	-	-
	174	0.54	0.01	-	0.08	-	-
	175	0.48	0.01	-	0.10	-	-

Please note the above scaled simulation values correspond to PD_design_target if the simulation was performed with correct housing material properties.

Table 3-15
n260, mid channel, antenna M2 simulated 4cm^2 PD at PD_Design_Target
(if simulation performed with correct housing material properties) (Δ_{min})

Module	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					
		S1 (Front)	S2 (Back)	S3 (Left)	S4 (Right)	S5 (Top)	S6 (Bottom)
M2	0	0.28	0.18	0.02	-	0.60	-
	1	0.12	0.18	0.01	-	0.42	-
	6	0.23	0.23	0.00	-	0.53	-
	7	0.18	0.13	0.02	-	0.45	-
	8	0.18	0.19	0.02	-	0.51	-
	15	0.21	0.19	0.01	-	0.50	-
	16	0.13	0.15	0.02	-	0.45	-
	21	0.24	0.26	0.00	-	0.57	-
	22	0.25	0.17	0.03	-	0.54	-
	23	0.14	0.18	0.02	-	0.41	-
	24	0.23	0.24	0.01	-	0.56	-
	25	0.21	0.25	0.01	-	0.50	-
	36	0.27	0.25	0.02	-	0.60	-
	37	0.14	0.20	0.03	-	0.49	-
	38	0.18	0.21	0.01	-	0.51	-
	39	0.21	0.23	0.01	-	0.46	-
	128	0.20	0.21	0.01	-	0.60	-
	129	0.18	0.15	0.01	-	0.47	-
	134	0.24	0.21	0.00	-	0.56	-
	135	0.20	0.17	0.01	-	0.51	-
	136	0.21	0.23	0.02	-	0.58	-
	143	0.23	0.19	0.01	-	0.56	-
	144	0.11	0.13	0.03	-	0.45	-
	149	0.24	0.25	0.01	-	0.55	-
	150	0.21	0.18	0.01	-	0.50	-
	151	0.16	0.14	0.02	-	0.45	-
	152	0.17	0.16	0.02	-	0.44	-
	153	0.15	0.16	0.04	-	0.40	-
	164	0.24	0.22	0.00	-	0.54	-
	165	0.19	0.13	0.01	-	0.47	-
	166	0.18	0.15	0.02	-	0.45	-
	167	0.16	0.17	0.02	-	0.39	-

Please note the above scaled simulation values correspond to PD_design_target if the simulation was performed with correct housing material properties.

Table 3-16
n260, mid channel, antenna M3 simulated 4cm^2 PD at PD_Design_Target
(if simulation performed with correct housing material properties) (Δ_{min})

Module	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					
		S1 (Front)	S2 (Back)	S3 (Left)	S4 (Right)	S5 (Top)	S6 (Bottom)
M3	2	0.28	0.18	-	0.02	-	0.60
	3	0.14	0.21	-	0.01	-	0.50
	9	0.23	0.23	-	0.00	-	0.53
	10	0.17	0.13	-	0.02	-	0.44
	11	0.18	0.20	-	0.01	-	0.51
	17	0.22	0.20	-	0.01	-	0.50
	18	0.14	0.15	-	0.02	-	0.46
	26	0.24	0.28	-	0.00	-	0.56
	27	0.27	0.21	-	0.03	-	0.60
	28	0.14	0.20	-	0.04	-	0.45
	29	0.21	0.23	-	0.01	-	0.54
	30	0.22	0.25	-	0.01	-	0.52
	40	0.25	0.25	-	0.01	-	0.60
	41	0.18	0.13	-	0.03	-	0.41
	42	0.17	0.20	-	0.02	-	0.51
	43	0.23	0.24	-	0.01	-	0.49
	130	0.20	0.21	-	0.01	-	0.60
	131	0.21	0.16	-	0.02	-	0.54
	137	0.24	0.21	-	0.00	-	0.56
	138	0.21	0.17	-	0.01	-	0.53
	139	0.22	0.22	-	0.02	-	0.59
	145	0.23	0.20	-	0.00	-	0.57
	146	0.19	0.17	-	0.00	-	0.44
	154	0.25	0.26	-	0.01	-	0.54
	155	0.24	0.18	-	0.01	-	0.51
	156	0.15	0.14	-	0.02	-	0.45
	157	0.18	0.15	-	0.01	-	0.44
	158	0.20	0.23	-	0.03	-	0.45
	168	0.23	0.24	-	0.00	-	0.49
	169	0.19	0.14	-	0.01	-	0.46
	170	0.18	0.13	-	0.02	-	0.45
	171	0.15	0.17	-	0.02	-	0.40

Please note the above scaled simulation values correspond to PD_design_target if the simulation was performed with correct housing material properties.

Table 3-17
4cm² psPD of the selected beams measured on the corresponding surfaces that are not selected for Δ_{min} determination

Band	Antenna	Beam ID	Surface	input.power.limit (dBm)	Meas. 4cm² PD (mW/cm²)
n261	M0	160	Back	4	0.0116
	M0	159	Right	3.2	0.264
	M2	149	Back	2.6	0.168
	M2	151	Front	2.1	0.221
	M2	164	Left	1.3	0.0078
	M3	166	Back	3.4	0.198
	M3	156	Front	2.6	0.235
	M3	155	Right	3.2	0.0111
n260	M0	142	Back	7.5	0.0104
	M0	32	Right	2.8	0.224
	M2	21	Back	1.1	0.152
	M2	0	Front	7.2	0.2
	M2	153	Left	1	0.0418
	M3	26	Back	2.3	0.134
	M3	2	Front	8.6	0.219
	M3	41	Right	3.2	0.0131

3.7 PD Char

3.8 Scaling Factor for 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 12 dBm input power per active port for n261 band and 11 dBm input power per active port for n260 band:

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

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

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.

3.9 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 was determined mathematically to ensure the compliance. The worst-case PD for MIMO operations was found by sweeping the relative phase for all possible angles to ensure a conservative assessment. The power density simulation report contains the worst-case power density for each surface after sweeping through all relative phases between beams.

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

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

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*:

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

3.10 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 n261

$$input.power.limit(i) = 12\ dBm + 10 * \log\big(s(i)\big) + \Delta_{min},\ i \in all\ beams \qquad (5)$$

- For n260

$$input.power.limit(i) = 11\ dBm + 10 * \log\big(s(i)\big) + \Delta_{min},\ i \in all\ beams \qquad (6)$$

where $12\ dBm$ is the input power used in simulation for n261 and $11\ dBm$ is the input power used in 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 < Δ_{min} < TxAGC uncertainty,

$$input.power.limit(i) = 12\ dBm + 10 * \log(s(i)),\ i \in all\ beams, \text{for n261} \quad (6)$$

else if Δ_{min} < -TxAGC uncertainty,

$$input.power.limit(i) = 12\ dBm + 10 * \log(s(i)) + (\Delta_{min} + \text{TxAGC uncertainty}),$$
$$i \in all\ beams, \text{for n261} \quad (7)$$

else if Δ_{min} > TxAGC uncertainty,

$$input.power.limit(i) = 12\ dBm + 10 * \log(s(i)) + (\Delta_{min} - \text{TxAGC uncertainty}),$$
$$i \in all\ beams, \text{for n261} \quad (8)$$

Thus, Equation 6 is modified to:

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

$$input.power.limit(i) = 11\ dBm + 10 * \log(s(i)),\ i \in all\ beams, \text{for n260} \quad (9)$$

else if Δ_{min} < -TxAGC uncertainty,

$$input.power.limit(i) = 11\ dBm + 10 * \log(s(i)) + (\Delta_{min} + \text{TxAGC uncertainty}),$$
$$i \in all\ beams, \text{for n260} \quad (10)$$

else if Δ_{min} > TxAGC uncertainty,

$$input.power.limit(i) = 11\ dBm + 10 * \log(s(i)) + (\Delta_{min} - \text{TxAGC uncertainty}),$$
$$i \in all\ beams, \text{for n260} \quad (11)$$

Following above logic, the *input.power.limit* for this DUT can be calculated using Equations (6), (7), (8), (9), (10), and (11) i.e.,

Table 3-18
***input.power.limit* Calculation**

	Antenna	Δmin	TxAGC Uncertainty	*input.power.limit*	Notes
		(dB)	(dB)	(dBm)	
n261	M0 (V Beams)	1.39	1	*input.power.limit(i) = 12 dBm + 10 x log(s(i)) + 0.39*	Using Eq.8
	M0 (H Beams)	2.15	1	*input.power.limit(i) = 12 dBm + 10 x log(s(i)) + 1.15*	Using Eq.8
	M2 (V Beams)	2.39	1	*input.power.limit(i) = 12 dBm + 10 x log(s(i)) + 1.39*	Using Eq.8
	M2 (H Beams)	3.02	1	*input.power.limit(i) = 12 dBm + 10 x log(s(i)) + 2.02*	Using Eq.8
	M3 (V Beams)	2.48	1	*input.power.limit(i) = 12 dBm + 10 x log(s(i)) + 1.48*	Using Eq.8
	M3 (H Beams)	3.80	1	*input.power.limit(i) = 12 dBm + 10 x log(s(i)) + 2.8*	Using Eq.8
n260	M0 (V Beams)	-0.45	1	*input.power.limit(i) = 11 dBm + 10 x log(s(i))*	Using Eq.6
	M0 (H Beams)	2.71	1	*input.power.limit(i) = 11 dBm + 10 x log(s(i)) + 1.71*	Using Eq.8
	M2 (V Beams)	1.13	1	*input.power.limit(i) = 11 dBm + 10 x log(s(i)) + 0.13*	Using Eq.8
	M2 (H Beams)	1.93	1	*input.power.limit(i) = 11 dBm + 10 x log(s(i)) + 0.93*	Using Eq.8
	M3 (V Beams)	2.47	1	*input.power.limit(i) = 11 dBm + 10 x log(s(i)) + 1.47*	Using Eq.8
	M3 (H Beams)	2.26	1	*input.power.limit(i) = 11 dBm + 10 x log(s(i)) + 1.26*	Using Eq.8

Thus, the DUT PD Char for n261 and n260 bands is as shown in the tables below. The full simulation results used to support this calculation can be found in the Power Density Simulation Report.

Table 3-19
5G NR n261 Antenna M0 *input.power.limit*

Band	V Beam ID	H Beam ID	input.power.limit (dBm)
n261	3	-	7.8
n261	4	-	5.9
n261	11	-	5.2
n261	12	-	4
n261	13	-	4.7
n261	18	-	3.7
n261	19	-	4.4
n261	30	-	1.6
n261	31	-	1.6
n261	32	-	1.8
n261	33	-	1.2
n261	42	-	1.5
n261	43	-	2.3
n261	44	-	1.1
n261	-	131	8.1
n261	-	132	7.1
n261	-	139	5.4
n261	-	140	5.5
n261	-	141	4.7
n261	-	146	5.3
n261	-	147	5.5
n261	-	158	2.5
n261	-	159	3.2
n261	-	160	4
n261	-	161	2.2
n261	-	170	2.8
n261	-	171	3.4
n261	-	172	4.7
n261	3	131	5.2
n261	4	132	2.9
n261	11	139	2.7
n261	12	140	1.3
n261	13	141	1.6
n261	18	146	0.9
n261	19	147	1.6
n261	30	158	-1.3
n261	31	159	-0.8
n261	32	160	0
n261	33	161	-0.7
n261	42	170	-1.3
n261	43	171	-0.2
n261	44	172	-0.7

Table 3-20
5G NR n261 Antenna M2 *input.power.limit*

Band	V Beam ID	H Beam ID	input.power.limit (dBm)
n261	0	-	6.3
n261	5	-	3.1
n261	6	-	2.9
n261	7	-	3.8
n261	14	-	3.3
n261	15	-	2.9
n261	20	-	1.3
n261	21	-	1
n261	22	-	0.4
n261	23	-	0.4
n261	24	-	1.2
n261	34	-	1.8
n261	35	-	0.6
n261	36	-	0.4
n261	37	-	0.4
n261	-	128	7
n261	-	133	5.2
n261	-	134	4.3
n261	-	135	5.1
n261	-	142	5
n261	-	143	4.4
n261	-	148	2.7
n261	-	149	2.6
n261	-	150	2.1
n261	-	151	2.1
n261	-	152	2.8
n261	-	162	2.7
n261	-	163	2
n261	-	164	1.3
n261	-	165	2.8
n261	0	128	3.1
n261	5	133	1
n261	6	134	0.1
n261	7	135	2.6
n261	14	142	1
n261	15	143	-0.1
n261	20	148	-0.7
n261	21	149	-1
n261	22	150	-2.1
n261	23	151	-2.3
n261	24	152	-0.9
n261	34	162	-0.6
n261	35	163	-1.4
n261	36	164	-2.5
n261	37	165	-1.8

Table 3-21
5G NR n261 Antenna M3 *input.power.limit*

Band	V Beam ID	H Beam ID	input.power.limit (dBm)
n261	1	-	6
n261	2	-	6.4
n261	8	-	3.2
n261	9	-	3
n261	10	-	3.2
n261	16	-	3.7
n261	17	-	3
n261	25	-	1.1
n261	26	-	0.8
n261	27	-	0.6
n261	28	-	0.5
n261	29	-	1.1
n261	38	-	1.1
n261	39	-	0.7
n261	40	-	0.4
n261	41	-	0.7
n261	-	129	8
n261	-	130	7.8
n261	-	136	5.9
n261	-	137	5
n261	-	138	5.8
n261	-	144	5
n261	-	145	5.1
n261	-	153	3.4
n261	-	154	3.4
n261	-	155	3.2
n261	-	156	2.6
n261	-	157	3.6
n261	-	166	3.4
n261	-	167	2.4
n261	-	168	2
n261	-	169	3.3
n261	1	129	3
n261	2	130	3.2
n261	8	136	1
n261	9	137	0.2
n261	10	138	0.7
n261	16	144	0.9
n261	17	145	-0.1
n261	25	153	-1
n261	26	154	-1.2
n261	27	155	-1.9
n261	28	156	-2.2
n261	29	157	-1.1
n261	38	166	-1.3
n261	39	167	-1.5
n261	40	168	-2.5
n261	41	169	-1.7

Table 3-22
5G NR n260 Antenna M0 *input.power.limit*

Band	V Beam ID	H Beam ID	input.power.limit (dBm)
n260	4	-	7
n260	5	-	8
n260	12	-	4.5
n260	13	-	4.2
n260	14	-	5
n260	19	-	4.1
n260	20	-	4
n260	31	-	2.7
n260	32	-	2.8
n260	33	-	2.6
n260	34	-	2.4
n260	35	-	1.9
n260	44	-	2.6
n260	45	-	2.4
n260	46	-	2.4
n260	47	-	2.4
n260	-	132	9.2
n260	-	133	8.1
n260	-	140	6.7
n260	-	141	6.1
n260	-	142	7.5
n260	-	147	6.2
n260	-	148	7
n260	-	159	3.7
n260	-	160	3.4
n260	-	161	3.2
n260	-	162	4
n260	-	163	4
n260	-	172	3.4
n260	-	173	3.5
n260	-	174	3.6
n260	-	175	4.1
n260	4	132	4.1
n260	5	133	4.4
n260	12	140	2.3
n260	13	141	1.2
n260	14	142	3.1
n260	19	147	1.1
n260	20	148	1.8
n260	31	159	-0.8
n260	32	160	-1.2
n260	33	161	-1.9
n260	34	162	-0.4
n260	35	163	-0.6
n260	44	172	-0.9
n260	45	173	-1.6
n260	46	174	-1.1
n260	47	175	-0.4

Table 3-23
5G NR n260 Antenna M2 *input.power.limit*

Band	V Beam ID	H Beam ID	input.power.limit (dBm)
n260	0	-	7.2
n260	1	-	5.2
n260	6	-	3.2
n260	7	-	3.5
n260	8	-	3
n260	15	-	3.5
n260	16	-	3.2
n260	21	-	1.1
n260	22	-	2.4
n260	23	-	0.8
n260	24	-	0.7
n260	25	-	0.6
n260	36	-	1.8
n260	37	-	2.2
n260	38	-	0.7
n260	39	-	0.5
n260	-	128	7.2
n260	-	129	6.6
n260	-	134	3.3
n260	-	135	4
n260	-	136	3.7
n260	-	143	4
n260	-	144	3.6
n260	-	149	1.7
n260	-	150	1.5
n260	-	151	0.9
n260	-	152	1.3
n260	-	153	1
n260	-	164	1.8
n260	-	165	1.1
n260	-	166	0.9
n260	-	167	1.2
n260	0	128	2.9
n260	1	129	3.2
n260	6	134	0.8
n260	7	135	0.3
n260	8	136	1.3
n260	15	143	0.1
n260	16	144	1.5
n260	21	149	-2.2
n260	22	150	-1.5
n260	23	151	-2
n260	24	152	-2.4
n260	25	153	-2.3
n260	36	164	-2.1
n260	37	165	-1.3
n260	38	166	-2.3
n260	39	167	-2.3

Table 3-24
5G NR n260 Antenna M3 *input.power.limit*

Band	V Beam ID	H Beam ID	input.power.limit (dBm)
n260	2	-	8.6
n260	3	-	7.3
n260	9	-	4.6
n260	10	-	4.8
n260	11	-	4.3
n260	17	-	4.8
n260	18	-	4.5
n260	26	-	2.3
n260	27	-	3.5
n260	28	-	3.3
n260	29	-	2.2
n260	30	-	1.9
n260	40	-	2.6
n260	41	-	3.2
n260	42	-	2.2
n260	43	-	2.1
n260	-	130	7.6
n260	-	131	7
n260	-	137	3.7
n260	-	138	4.3
n260	-	139	3.9
n260	-	145	4.4
n260	-	146	3.7
n260	-	154	1.8
n260	-	155	1.8
n260	-	156	1.2
n260	-	157	1.6
n260	-	158	1.3
n260	-	168	1.7
n260	-	169	1.4
n260	-	170	1.2
n260	-	171	1.5
n260	2	130	4
n260	3	131	4
n260	9	137	2
n260	10	138	1.4
n260	11	139	2.3
n260	17	145	1.1
n260	18	146	1.8
n260	26	154	-1.2
n260	27	155	-0.7
n260	28	156	-0.8
n260	29	157	-1.2
n260	30	158	-1.2
n260	40	168	-1.2
n260	41	169	-0.3
n260	42	170	-1.2
n260	43	171	-1.2

4 EQUIPMENT LIST

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
-	WL25-1	Conducted Cable Set (25GHz)	09/16/20	Annual	09/16/21	WL25-1
-	WL40-1	Conducted Cable Set (40GHz)	09/16/20	Annual	09/16/21	WL40-1
Agilent	N9038A	MXE EMI Receiver	08/11/20	Annual	08/11/21	MY51210133
Agilent	N9030A	PXA Signal Analyzer (44GHz)	08/17/20	Annual	08/17/21	MY52350166
Emco	3116	Horn Antenna (18 - 40GHz)	06/07/18	Triennial	06/07/21	9203-2178
Rohde & Schwarz	ESU40	EMI Test Receiver (40GHz)	9/92020	Annual	09/09/21	100348
Rohde & Schwarz	SFUNIT-Rx	Shielded Filter Unit	02/21/20	Annual	02/21/21	102133
Rohde & Schwarz	FSW67	Signal / Spectrum Analyzer	08/10/20	Annual	08/10/21	103200
Sunol	JB5	Bi-Log Antenna (30M - 5GHz)	07/27/20	Biennial	07/27/22	A051107
SPEAG	EUmmWV3	EUmmWV3 Probe	03/17/20	Annual	03/17/21	9421
SPEAG	SM 003 100 AA	30GHz System Verification Ka- Band Source Antenna	10/20/2020	Annual	10/20/2021	1015
SPEAG	DAE4	Dasy Data Acquisition Electronics	4/15/2020	Annual	4/15/2021	501
Agilent	N9030A	PXA Signal Analyzer (44GHz)	08/17/20	Annual	08/17/21	MY52350166
Emco	3115	Horn Antenna (1-18GHz)	06/18/20	Biennial	06/18/22	9704-5182
Keysight Technologies	N9030A	3Hz-44GHz PXA Signal Analyzer	07/17/20	Annual	07/17/21	MY49430494
Rohde & Schwarz	ESU26	EMI Test Receiver (26.5GHz)	07/15/20	Annual	07/15/21	100342
Sunol	JB5	Bi-Log Antenna (30M - 5GHz)	07/27/20	Biennial	07/27/22	A051107

Note:
1. Each equipment item was used solely within its respective calibration period.

5 MEASUREMENT UNCERTAINTIES

a	b	c	d	e	f = b x e/d	g
Uncertainty Component	Unc. (± dB)	Prob. Dist.	Div.	ci	ui (± dB)	vi
Calibration	0.49	N	1	1.0	0.49	∞
Probe correction	0	R	1.73	1.0	0.00	∞
Frequency Response (BW ≤ 1 GHz)	0.20	R	1.73	1.0	0.12	∞
Sensor cross coupling	0	R	1.73	1.0	0.00	∞
Isotropy	0.50	R	1.73	1.0	0.29	∞
Linearity	0.20	R	1.73	1.0	0.12	∞
Probe Scattering	0	R	1.73	1.0	0	∞
Probe Positioning Offset	0.30	R	1.73	1.0	0.17	∞
Probe Positioning Repeatability	0.04	R	1.73	1.0	0.02	∞
Sensor Mechanical Offset	0	R	1.73	1.0	0	∞
Probe Spatial Resolution	0	R	1.73	1.0	0	∞
Field Impedance Dependence	0	R	1.73	1.0	0	∞
Amplitude and phase drift	0	R	1.73	1.0	0	∞
Amplitude and phase noise	0.04	R	1.73	1.0	0.02	∞
Measurement area truncation	0	R	1.73	1.0	0	∞
Data acquisition	0.03	N	1	1.0	0.03	∞
Sampling	0	R	1.73	1.0	0	∞
Field Reconstruction	0.60	R	1.73	1.0	0.35	∞
Forward Transformation	0	R	1.73	1.0	0	∞
Power Density Scaling	-	R	1.73	1.0	-	∞
Spatial Averaging	0.10	R	1.73	1.0	0.06	∞
System Detection Limit	0.04	R	1.73	1.0	0.02	∞
Test Sample and Environmental Factors						
Probe Coupling with DUT	0	R	1.73	1.0	0	∞
Modulation Response	0.40	R	1.73	1.0	0.23	∞
Integration Time	0	R	1.73	1.0	0	∞
Response Time	0	R	1.73	1.0	0	∞
Device Holder Influence	0.10	R	1.73	1.0	0.06	∞
DUT Alignment	0	R	1.73	1.0	0	∞
RF Ambient Conditions	0.04	R	1.73	1.0	0.02	∞
Ambient Reflections	0.04	R	1.73	1.0	0.02	∞
Immunity / Secondary Reception	0	R	1.73	1.0	0	∞
Drift of the DUT	0.22	R	1.73	1.0	0.13	∞
Combined Standard Uncertainty (k=1)		RSS			0.76	∞
(95% CONFIDENCE LEVEL)		k=2			**1.53**	

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[7] FCC KDB 865664 D02 v01r04: SAR Measurement Requirements for 100 MHz to 6 GHz. Federal Communications Commission – Office of Engineering and Technology, Laboratory Division.

[8] FCC KDB 447498 D01 v02r01: RF Exposure Procedures and Equipment Authorization Policies for Mobile and Portable Devices. Federal Communications Commission – Office of Engineering and Technology, Laboratory Division.

[9] November 2017 Telecommunications Certification Body Council (TCBC) Workshop Notes

[10] October 2018 Telecommunications Certification Body Council (TCBC) Workshop Notes

[11] April 2019 Telecommunications Certification Body Council (TCBC) Workshop Notes

[12] November 2019 Telecommunications Certification Body Council (TCBC) Workshop Notes

[13] SPEAG DASY6 System Handbook (September 2019)